Learning Intention:

-To learn about cells and components of innate immune response.

-To explain the role and characteristics of cells involved in second line of defence.

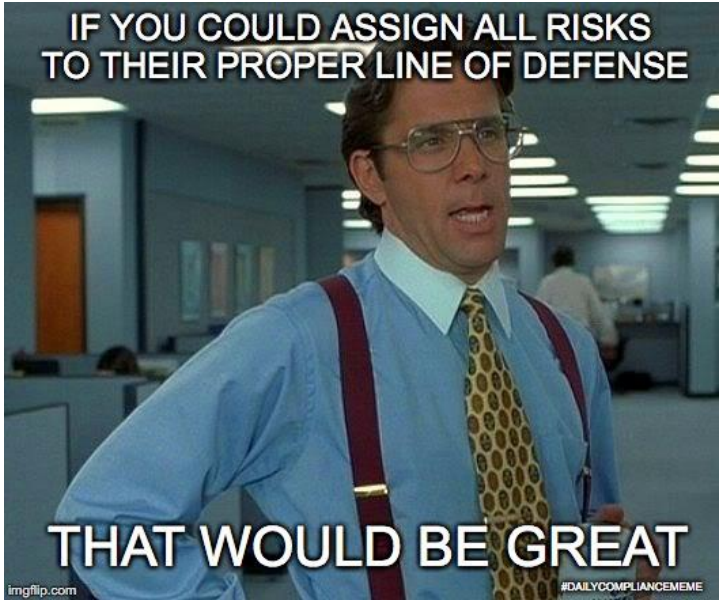
-To understand the steps in inflammatory response.

Success Criteria:

- I can name the cells that are involved in innate immune response.
- I can explain the role and characteristics of cells involved in second line of defence.

Study design dot point

the innate immune response including the steps in an inflammatory response and the characteristics and roles of macrophages, neutrophils, dendritic cells, eosinophils, natural killer cells, mast cells, complement proteins, and interferons



Pathogens are sometimes able to slip past or breach the first line of defence. Our bodies have a backup plan for when this happens – the second line of defence.

Second line of defence- A component of the innate immune system characterised by the nonspecific and immediate response to injury and pathogens by a variety of cells and molecules.

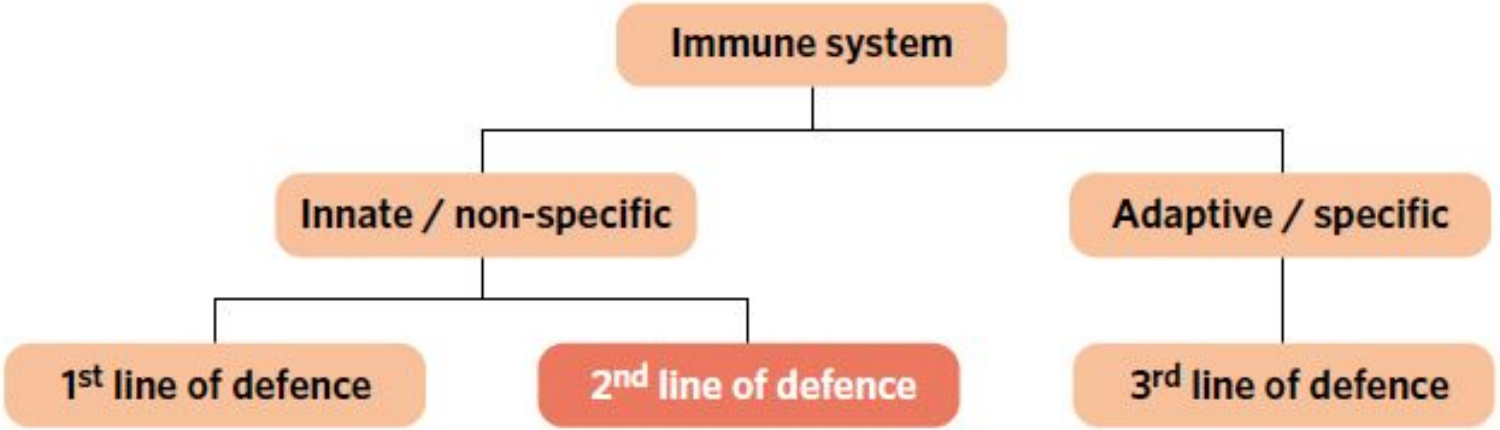


Figure 1 Breakdown of the immune system

There are two components of the second line of defence – cellular and non-cellular components.

Cellular components of the second line of defence:

The second line of defence involves a variety of different cell types. All of the cells involved are called **leukocytes**, or white blood cells.

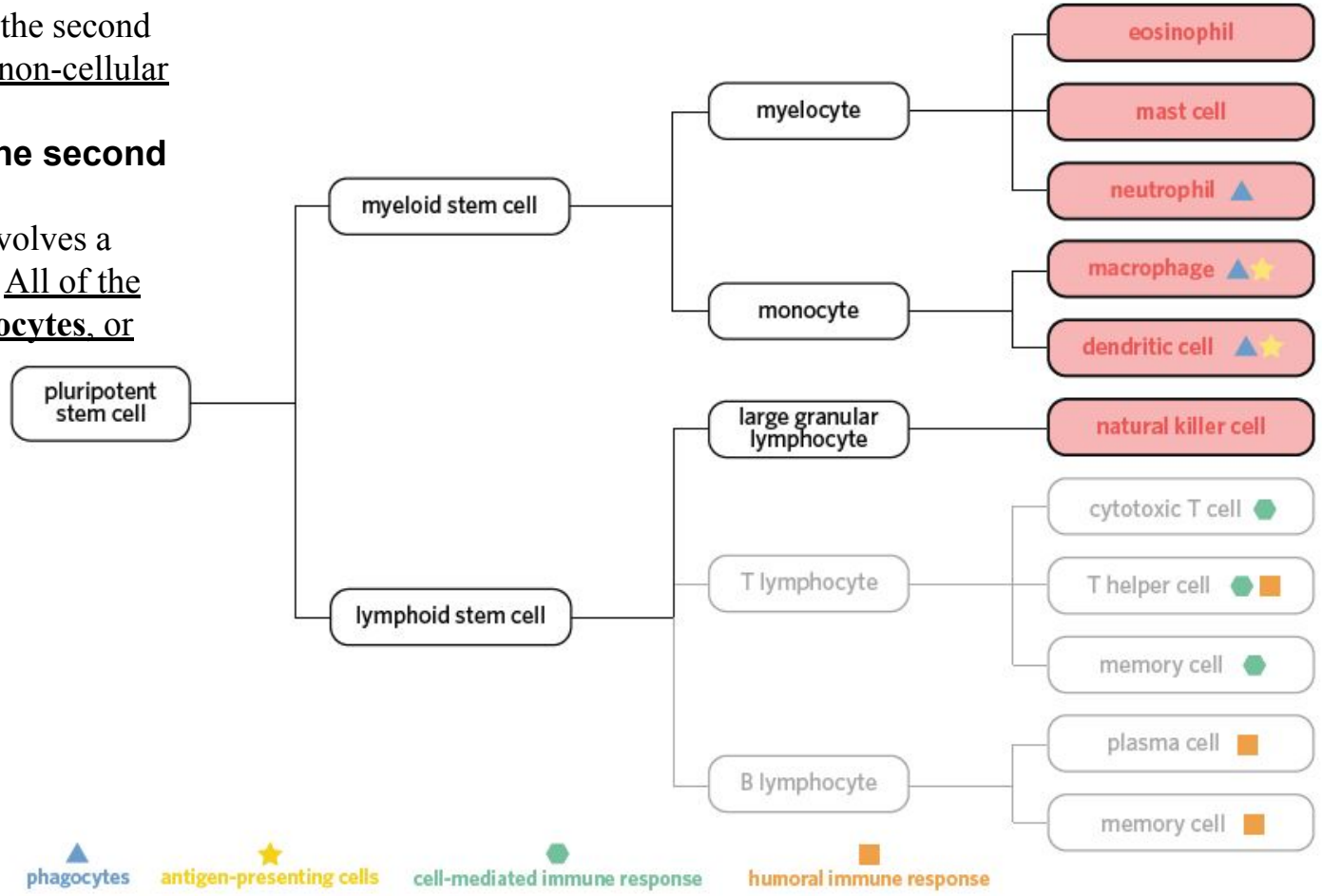


Figure 2 Highlighted are the cellular components of the innate immune system.

Phagocyte- A group of leukocytes responsible for the endocytosis and destruction of pathogens, foreign material, and cell debris.

Phagocytes engage in **phagocytosis,** a process in which they consume and destroy foreign or dead material by engulfing it through the process of endocytosis. Once engulfed, lysosomes containing lysozymes present in the cell destroy the foreign or dead material by fusing with the vesicles containing the engulfed material.

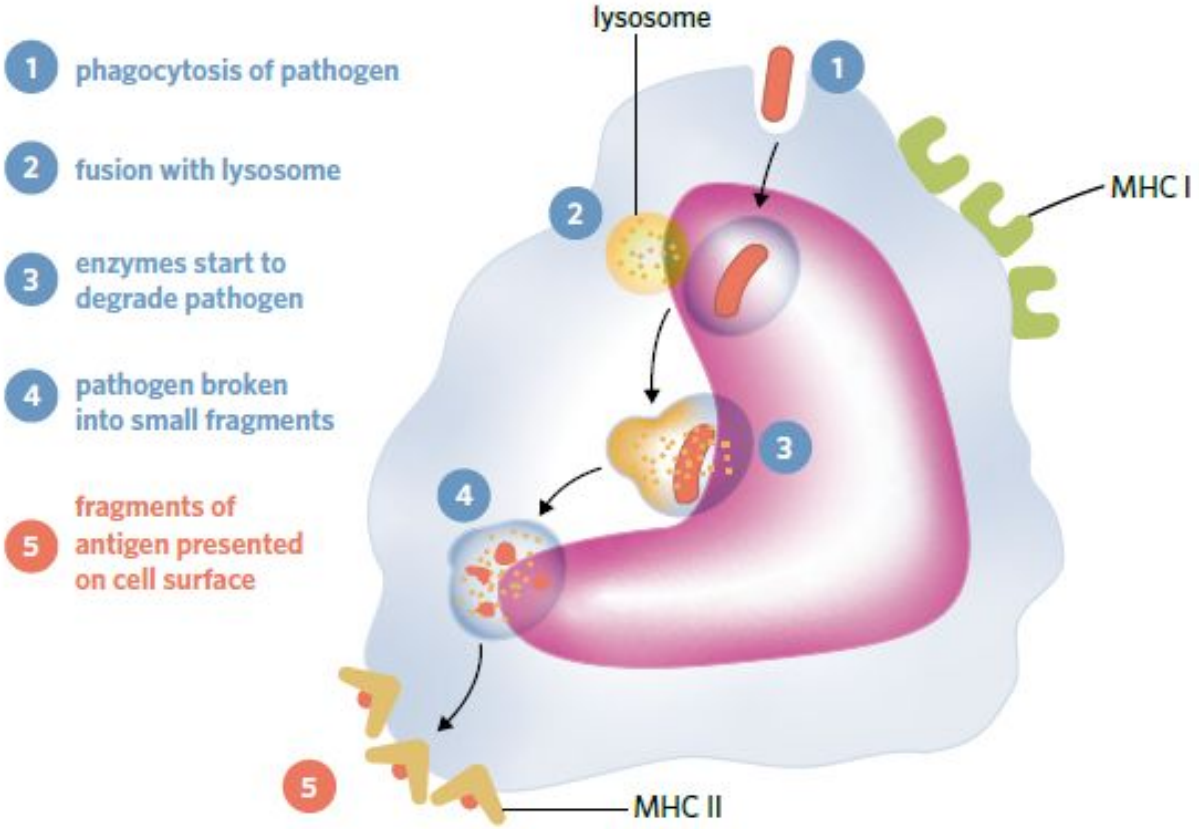


Figure 4 The process of phagocytosis and antigen presentation

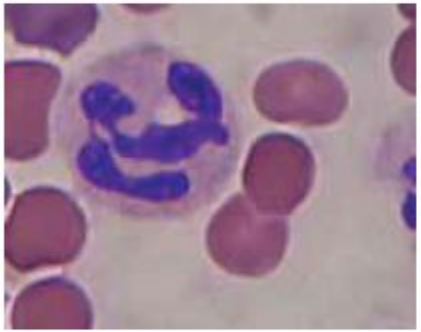
Three phagocytes are:

1. Neutrophils
2. Macrophages
3. dendritic cells.

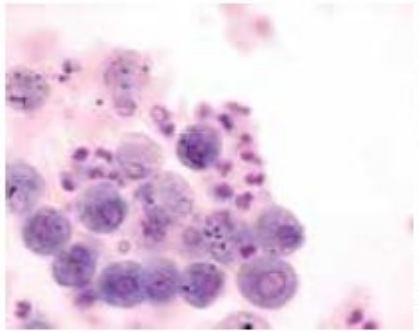
Macrophages and dendritic cells – are also known as **antigen-presenting cells**. These cells not only consume and destroy foreign material, but they also present antigens from consumed material on their surface.

Antigen-presenting cells are the specific immune cells which also express MHC II, using them to present the consumed antigens on their surface. These cells will then use their MHC II markers with the presented antigen to interact with the adaptive immune system.

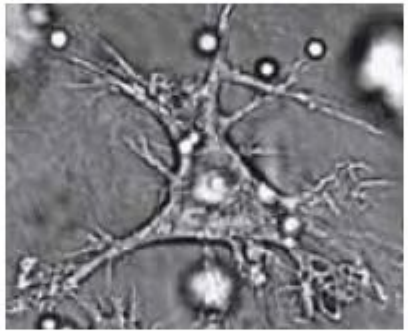
Phagocytes release a number of substances such as **cytokines**. Cytokine are signalling molecule released by cells (typically in the immune system) which aids in communication between immune cells and helps protect against pathogens.



neutrophils

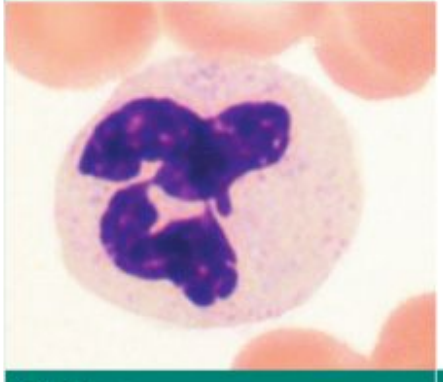
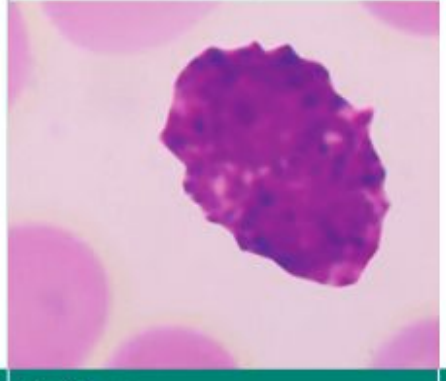
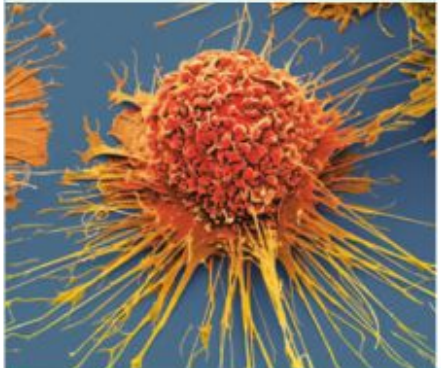
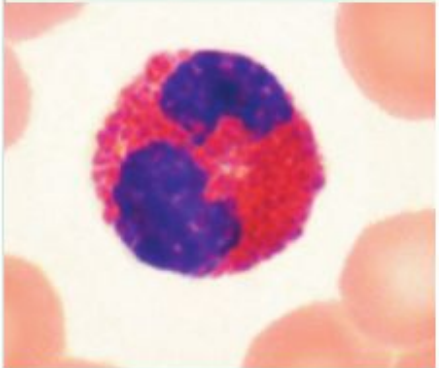


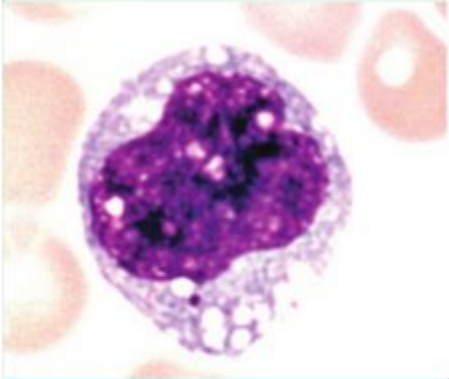
macrophages

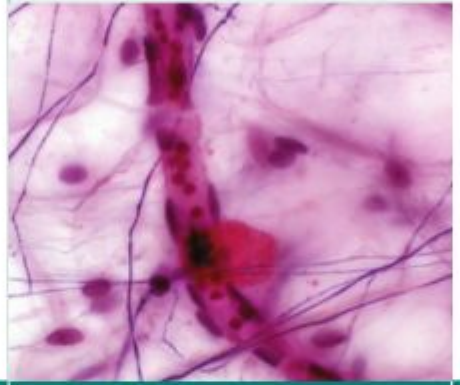


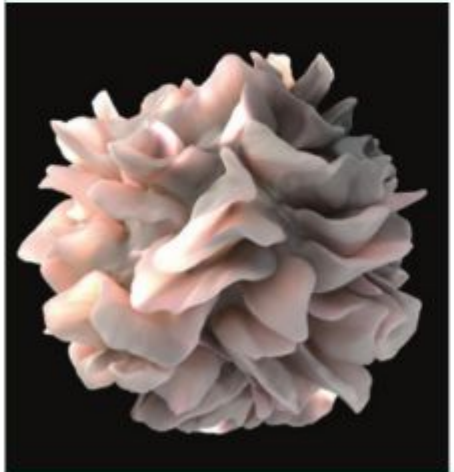
dendritic cells

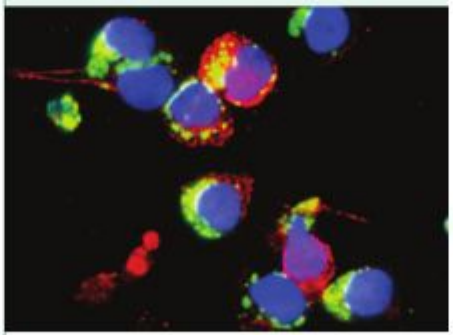
Some leukocytes involved in innate immune responses and their function

Cell type	Function
neutrophil (granulocyte) 	• phagocyte • secretes antimicrobial peptides such as defensins and reactive oxygen species that disrupt pathogen cell membranes • secretes a range of cytokines and chemokines • antigen presentation under certain conditions
basophil (granulocyte) 	• secretes histamine, which dilates blood vessels and promotes inflammation • involved in allergic responses • secretes a range of cytokines, chemokines and antimicrobial peptides • has a limited role in phagocytosis • antigen presentation under certain conditions
macrophage 	• phagocyte • antigen-presenting cell • secretes a range of cytokines, chemokines and antimicrobial peptides
eosinophil (granulocyte) 	• secretes a range of cytokines, chemokines and antimicrobial peptides • found in higher numbers in parasitic infections • has a limited role in phagocytosis • antigen presentation under certain conditions

Cell type	Function
monocyte 	• phagocyte • antigen-presenting cell • secretes a range of cytokines and chemokines

Cell type	Function
mast cell (granulocyte) 	• phagocyte • secretes histamine, which dilates blood vessels and promotes inflammation • involved in allergic responses • secretes a range of cytokines, chemokines and antimicrobial peptides • antigen presentation under certain conditions

Cell type	Function
dendritic cell 	• phagocyte • antigen-presenting cell • has many grooves that increase its surface area and permit contact with a large number of nearby cells • secretes a range of cytokines and chemokines

Cell type	Function
natural killer cell  Immunofluorescent LM of natural killer cells: cytotoxic granules (green), nuclei (blue), cytoplasm (red)	• recognises virus-infected and cancerous cells • secretes cytotoxic chemicals from granules, such as perforin, which punches holes in plasma membranes, triggering apoptosis and cell death of abnormal and virus-infected cells • not considered a granulocyte as its granules are far less numerous than true granulocytes • secretes a range of cytokines and chemokines

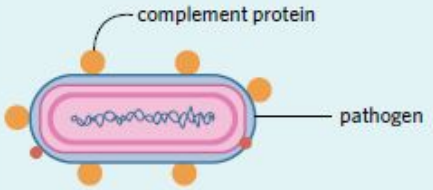
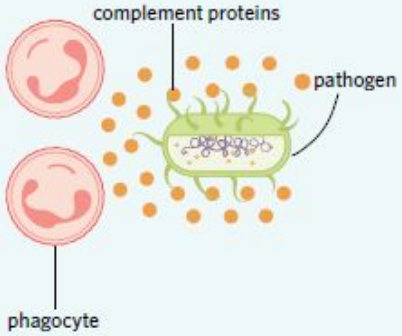
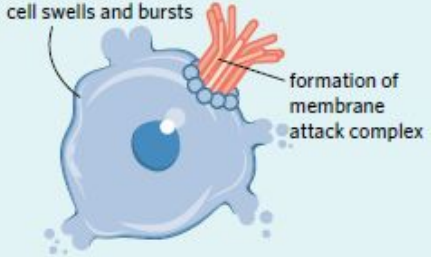
Non-cellular components of the second line of defence

Non-cellular component of second line of defence includes:

1. **Interferons:** A group of innate cytokines that are released by virus infected cells or immune cells. They warn neighbouring cells of the infection and activate other cells in the immune system.

2. The initiation of a fever: A fever is a temporary increase in body temperature. This is an innate response to potential infection, as many pathogens cannot survive at the elevated temperatures created by a fever. Fevers are also thought to help the immune system by activating certain proteins in the body that bolster the strength of the body's defences.

3. Complement proteins: The complement proteins are an array of more than 30 proteins that circulate in the blood and are able to help kill foreign cells. They are found in body fluids in an inactive form, and are activated as part of the non-specific (innate) immune response to certain antigens. In the presence of certain pathogens, these proteins begin reacting with each other in a series of reactions called the complement cascade.

Outcome	Description	Diagram
Opsonisation	Complement proteins stick on the outside surface of pathogens and make it easier for cells of the immune system, such as phagocytes, to recognise them as foreign.	 Figure 8 Opsonisation of a pathogen by complement proteins
Chemotaxis	Complement proteins gather near a pathogen and attract phagocytes to it, making it more likely to be destroyed.	 Figure 9 Chemotaxis of phagocytes towards a pathogen
Lysis	Complement proteins can join together on the surface of pathogens, forming a **membrane attack complex (MAC)**, which creates pores in their membrane. This destroys the pathogen by causing lysis via the sudden influx of fluid into the pathogen, causing it to burst.	 Figure 10 Formation of a membrane attack complex

Inflammatory response

The process of inflammation increases blood flow to an injured area, bringing a greater number of immune cells and components to help clear debris and fight pathogens that may have entered the body.

Characteristics of inflammation: Swelling, pain, heat, and redness.

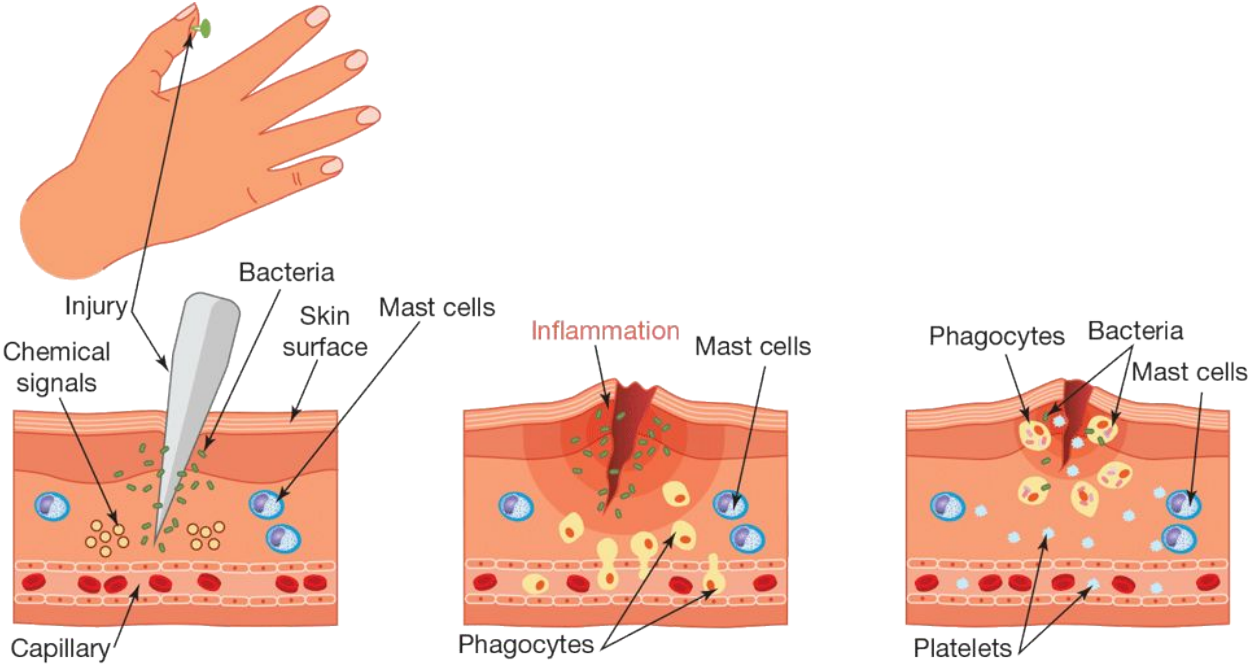
Functions:

- eliminate the effects of an injury
- defend against potential pathogens
- clear out cells that may have been damaged or destroyed
- initiate repair.

There are three main aspects of the inflammatory response:

1. Initiation
2. Vasodilation,
3. migration.

Summary of the stages in the inflammatory response



Vascular stage

Release of chemical signals such as histamine from mast cells attract phagocytes

Dilation and increased leakiness of capillary (vasodilation)

Cellular stage

Phagocytes migrate to the area

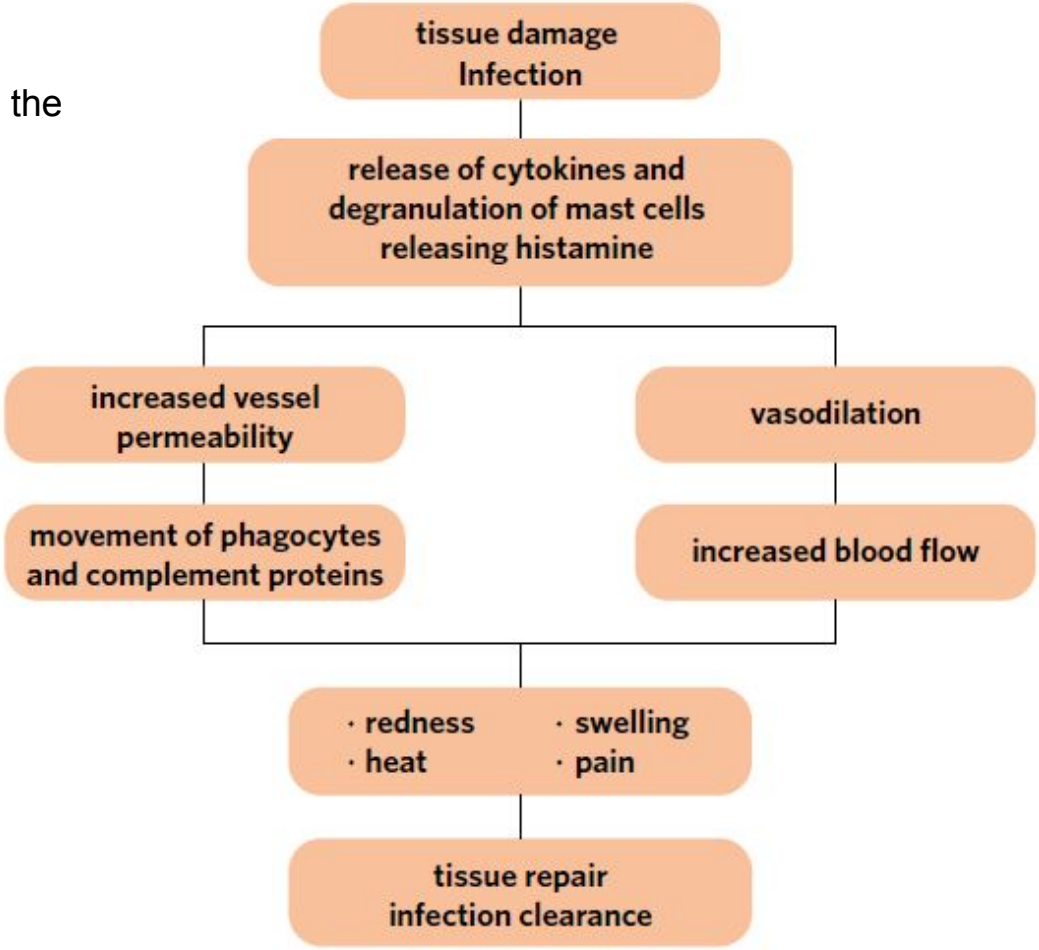
These phagocytes consume bacteria and cell debris

Resolution stage

Platelets move out of the capillary to seal the wound

An abscess forms, containing pus, with dead phagocytes and cell debris

Summary of the stages in the inflammatory response



Summary

Innate immune responses in vertebrates:

- are non-specific—they do not target a specific antigen
- are rapid—they occur within hours
- are present in all animals
- are fixed responses—they do not adapt
- do not result in immunological memory of the pathogen that caused the infection

The innate immune response in plants:
It is triggered when plant cells recognise certain molecules, such as certain lipopolysaccharides, or other common cell wall components, which form the cell walls of pathogens. These are called **pathogen-associated molecular patterns (PAMPs),** and they are recognised by **pattern recognition receptors (PRRs).** Plants possess specific genes called resistance genes. Resistance genes code for proteins (R proteins), which switch on a plant's defences when it recognises specific PAMPs. The specific pathogen molecules are generally proteins, known as **avirulence proteins (AVr),** and are coded for by AVr genes in the pathogen.

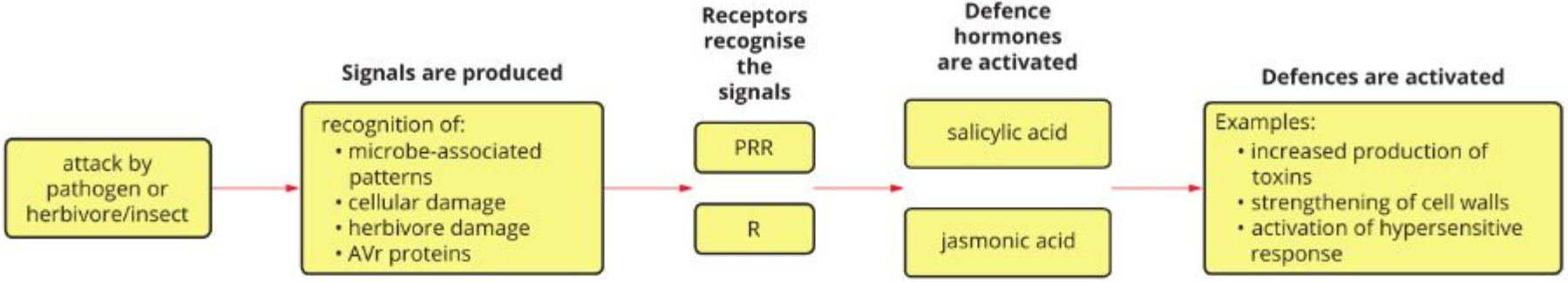


FIGURE 8.2.5 Plants recognise attack by pathogens or plant-eating organisms and mount defences that strengthen natural barriers and increase production of toxic and signalling chemicals.

Summary

Table 2 Components of the second line of defence and their roles

Cellular components	
Neutrophil	Phagocytosis of pathogens
Macrophage	Phagocytosis of pathogens and antigen presentation within the adaptive immune system
Dendritic cell	
Natural killer cell	Destroys infected or abnormal cells with insufficient MHC I markers
Mast cell	Causes inflammation through the release of histamine
Eosinophil	Releases toxic chemical mediators to destroy invading pathogens
Non-cellular components	
Interferons	Released by virally-infected cells and causes changes to neighbouring cells that make them less susceptible to infection
Complement proteins	React with each other and aid in the destruction of pathogens via opsonisation, attraction of phagocytes to pathogens, and the formation of membrane attack complexes (MAC)
Fever	An abnormally high body temperature used by the body to kill pathogens

Worked example

Q. Meningitis is a disease which causes the inflammation of tissue surrounding the brain and spinal cord in humans. There are many different pathogens which can cause meningitis. For example, a bacterium known as *Neisseria meningitidis*, which produces a variety of different bacterial enzymes, as well as a family of viruses known as coxsackieviruses can both cause meningitis.

Outline three changes that would occur during the inflammatory response in the tissue surrounding the brain.

Ans. An increase in mast cell activation would result in the release of histamine. This causes blood vessels to dilate allowing more blood to flow near the affected area. Migration of phagocytes to the area will then destroy the pathogen.

Reflection

Edrolo 7C Q 1,4, 11-17

Activity:
Students are to create either a flowchart (for the sequential learners) or a concept plan (for the global learners) that describes the inflammation response and includes diagrams, where appropriate, and details of all the cells and molecules involved, such as the following: cytokines, mast cells, histamines, macrophage, phagocyte, lysozyme, neutrophil, dendritic cell, eosinophil, natural killer cell, complement protein, interferons.