papillae act as barriers, preventing the pathogens entering the plant cells around the site of infection. Large amounts continue to be deposited in cell walls after the initial infection. Lignin is added, making the mechanical barrier thicker and stronger. Callose blocks sieve plates in the phloem, sealing off the infected part and preventing the spread of pathogens. Callose is deposited in the plasmodesmata between infected cells and their neighbours, sealing them off from the healthy cells and helping to prevent the pathogen spreading.

Plant chemicals either repel insect vectors or kill invading pathogens. They can be extracted and synthesised to help control insects, fungi and bacteria:

- Insect repellents – pine resin and citronella from lemon grass
- Insecticides – pyrethrins made by chrysanthemums which act as insect neurotoxins and caffeine which is toxic to insects and fungi
- Antibacterial compounds including antibiotics – phenols made in different plants and antibacterial gossypol produced by cotton
- Antifungal compounds – phenols made in different plants and caffeine
- Anti-oomycetes – glucanases which are enzymes made by some plants that break down glucans (polymers in cell walls)
- General toxins – some chemicals found in plants that break down, forming cyanide compounds when the plant cell is attacked which is toxic to most living things

The primary non-specific defences against pathogens in animals

Non-specific defences to include skin, blood clotting, wound repair, inflammation, expulsive reflexes and mucous membranes (no detail of skin structure is required).

The skin covers the body and prevents the entry of pathogens; it has healthy microorganisms that outcompete with pathogens for space on the body surface and it produces sebum (oily substance) which stops the pathogen growing.

Blood clots seal the wound, preventing pathogens getting in. When platelets come into contact with collagen in the skin or wall of the damaged blood vessel, they adhere and begin secreting thromboplastin, an enzyme with triggers reactions which forms blood clots, and serotonin, which makes the smooth muscle walls of the blood vessels contract so they narrow and reduces the bloody supply to the area.

The clot dries out, forming a hard, tough scab. Epidural cells below start to grow, sealing the wound permanently, while damaged blood vessels regrow. Collagen fibres are deposited to give the new tissue strength. The scab sloughs off and the wound is healed, one the new epidermis reaches normal thickness.

Inflammation occurs when there is damage or irritants from pathogens on the site of the wound. Inflammation is characterised by pain, heat, redness, and swelling of tissue. A widespread infection causes a whole-body rash. Mast cells are activated in damaged tissue and release chemicals called histamines and cytokines:

- Histamines make blood vessels dilate causing localised heat and redness. The raised temperature prevents pathogens reproducing.
- Histamines make blood vessel walls leakier so blood plasma is forced out, once forced out it is known as tissue fluid. Tissue fluid causes swelling (oedema) and pain.
- Cytokines attract white blood cells (phagocytes) to the site where they dispose of the pathogens (phagocytosis)

Expulsive reflexes e.g. coughs and sneezes eject mucus containing pathogens from the gas exchange system. Vomiting and diarrhoea expels the contents of the gut along with any infective pathogens.

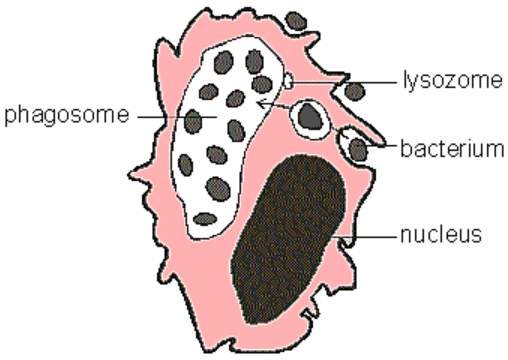
Many of the body tracts including the airways of the gas exchange system are lined by mucous membranes that secrete sticky mucus trapping microorganisms and contain lysozymes which destroy bacterial and fungal cell walls. Mucus also contains phagocytes removing remaining pathogens. There are also lysozymes in tears and urine, and stomach acid which prevent pathogens getting in.

Normal body temperature is around 37°C and is maintained by the hypothalamus in the brain. When a pathogen invades, cytokines stimulate the hypothalamus causing the body temperature to go up. This inhibits pathogen reproduction as most pathogens reproduce best as o below 37°C. The specific immune system also works faster at higher temperatures.

The structure and mode of action of phagocytes

To include neutrophils and antigen-presenting cells and the roles of cytokines, opsonins, phagosomes and lysosomes.

Phagocytes are specialised white blood cells. There are two main types – neutrophils and macrophages.



A phagocyte's response is non-specific because they are able to digest, break down and engulf a range of different pathogens.

Phagocytes are the secondary defence against pathogens because they are involved when the pathogen enters the body. Phagocytes build up at the site of an infection and attack pathogens. Sometimes pus is seen in a spot, cut or wound. Pus consists of dead neutrophils and pathogens.