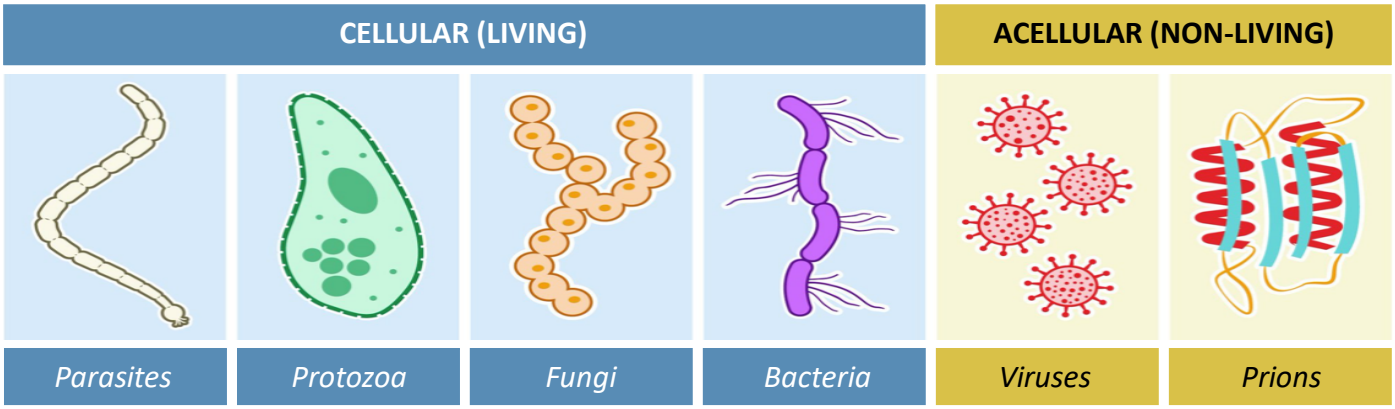
TOPIC: PATHOGEN BARRIERS

Key Knowledge:

- Physical, chemical and microbiota barriers as preventative mechanisms of pathogenic infection in animals and plants
- Initiation of an immune response, including antigen presentation, the distinction between self-antigens and non-self antigens, cellular and non-cellular pathogens and allergens

PATHOGENS

A pathogen is a **disease-causing agent** that disrupts the normal physiology of an infected organism. They can be either cellular (includes bacteria, fungi and parasites) or non-cellular (includes viruses and prions).



NON-CELLULAR PATHOGENS

A **virus** is an infective entity consisting of a core of genetic material (DNA or RNA) surrounded by a protein coat (capsid). Viruses are metabolically inert and incapable of independent reproduction – they must use the replication machinery of a host cell in order to multiply. Viruses spread among a host organism by producing infectious particles called **virions**. A virus that specifically infects plant tissue is called a **viroid**.

A **prion** is an infectious protein that has folded abnormally into a disease-causing structure. Prions cause normally folded proteins to refold into the abnormal form and propagate within a body. Prions aggregate together to form amyloid fibres that cause holes to form within the brain. Prions have a higher proportion of β-pleated sheets in their secondary structure than in the normal form, making them harder to denature.

CELLULAR PATHOGENS

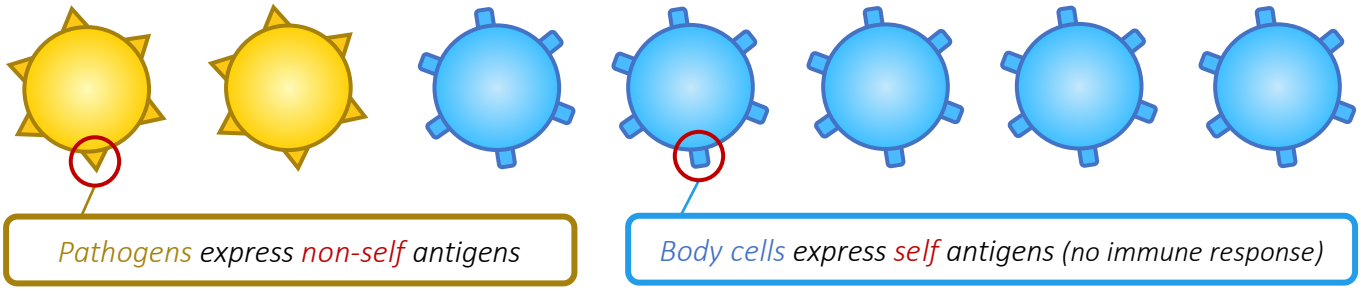
Bacteria are prokaryotic cells that reproduce quickly and compete with host cells for space or nutrition. Some bacteria may cause disease by producing toxic compounds (exotoxins) or releasing the substances when destroyed (endotoxins). Most bacteria are relatively harmless within the host (e.g. normal gut flora).

Disease-causing **fungi** usually attack the body surfaces and can be categorised according to whether they are unicellular (yeasts) or multicellular (moulds). Most infectious fungi are moulds that contain branching filaments (called hyphae) that are capable of forming a mass of invading threads called mycelium.

A **parasite** is an organism that grows and feeds on a host to the detriment of the host's survival. Parasites can be classed as either ectoparasites (living on the surface of the host) or endoparasites (living within the host). They can include single-celled microparasites (protozoa) or multicellular macroparasites (helminths).

ANTIGENS

Multicellular organisms typically possess functioning immune systems to allow the body to differentiate between necessary body cells and potentially destructive foreign bodies. Every cell that forms part of a multicellular collective will have specific molecular markers on their surface in order to identify that cell as being part of the organism. Foreign pathogens will have different molecular markers that are not common to the host and can be targeted by the immune system. Any substance that is recognised as foreign and is capable of triggering an immune response in called an antigen. Molecular markers that are unique to foreign bodies are hence described as **non-self antigens**. Conversely, molecular markers that identify a cell as being part of the host are somewhat erroneously regarded as **self-antigens** (they are not antigenic in the host, but will trigger an immune response within a different organism). An **allergen** is an environmental substance that triggers an immune response despite not being intrinsically harmful to the host.



IMMUNE SYSTEM

The immune system can be divided into three basic lines of defence against pathogenic infections:

- The first line of defence are the surface barriers that prevent the entry of pathogens into the host body
- The second line of defence are the non-specific defence mechanisms activated after infection occurs
- The third line of defence are the specific responses that target antigens produced by the pathogens

NON-SPECIFIC DEFENCES		SPECIFIC DEFENCES
First line of defence	**Second line of defence**	**Third line of defence**
• Physical barriers • Chemical barriers • Microbiological barriers	• Phagocytic leukocytes • Complement proteins • Inflammatory responses	• Lymphocytes (T and B cells) • Antibodies (via plasma cells) • Memory cells

PLANT SURFACE BARRIERS

Plants have no distinct immune system of the kind found in most animals – instead they rely on a number of structural and biochemical defences to isolate pathogens (the infected regions then undergo abscission).

Mechanical Barriers:

- The waxy cuticle and outer epidermal cells of leaf tissue provide a physical barrier to pathogenic entry
- Many plants employ certain structures (including thorns, spines and prickles) to deter biological vectors
- Layers of thickened cells (cork) may create protuberances (galls) at sites of entry to limit the spread

Chemical Barriers:

- Plants may secrete chemicals with antimicrobial properties (e.g. saponins, tannins, resins, defensins)
- Some trees will produce oils to repel biological vectors and others secrete gum around infected areas

ANIMAL SURFACE BARRIERS

Most animals possess three distinctive types of barriers to prevent pathogens from accessing body tissue:

Physical Barriers:

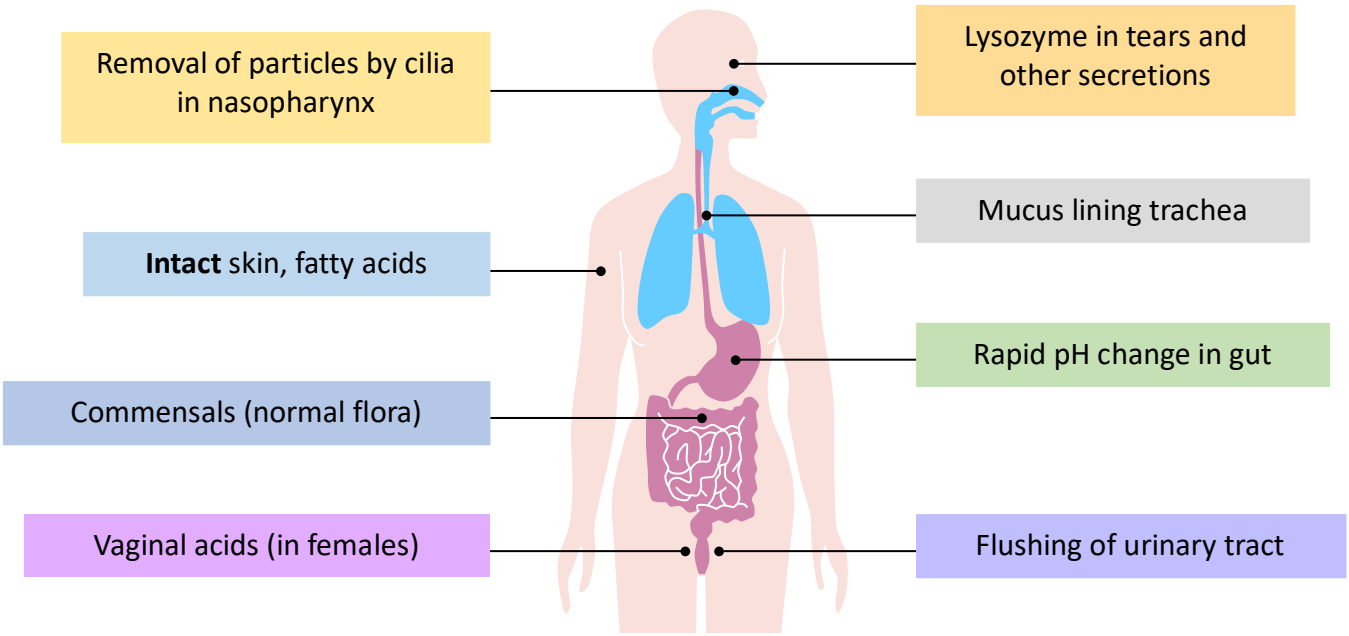
- Intact skin consists predominantly of dead cells that line the body surfaces to prevent pathogen entry
- Mucous membranes consist of living cells that line internal cavities and secrete trapping fluids (mucus)
- Internal surfaces may be ciliated to aid in the removal of pathogens (via physical actions like coughing)

Chemical Barriers:

- Gastric secretions contain strong stomach acids (pH < 2) that function to destroy ingested pathogens
- Sweat and tears contain biochemical agents (e.g. lysozymes, lactic acid) that inhibit microbial growth
- Mucus secreted into the digestive and genitourinary tracts also contain biochemical defence agents

Microbiological Barriers:

- Natural flora (commensals) lines the gut, taking up space and preventing colonisation by pathogens



CLOTTING

If surface barriers are penetrated and pathogens gain access to body tissues, then a clotting cascade is activated to restore an intact external layer. Clotting is initiated by the release of **clotting factors** from damaged cells or platelets. These factors cause platelets to become sticky and form a solid plug, while also triggering coagulation by converting an inactive enzyme precursor (prothrombin) into an activated enzyme (**thrombin**). This will in turn convert soluble fibrinogen strands in the blood into insoluble **fibrin fibres**. The fibrin then associates with the platelet plug to form a fibrous clot at the region where the skin has been broken. When the damage site has been completely repaired, enzymes will dissolve the clot, leaving behind a layer of skin to act as an impermeable barrier to further infection.