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VCE Biology ¾ Introduction to Immunity [3.1]

Workbook

Outline:

Introducing Disease Pg 3-5		
<u>Causes and Examples of Diseases</u> Pg 6-17 → Introduction to Pathogens	Overview of the Immune System	Pg 26-27
 Bacteria Viruses Fungi Protozoa Prions 	 Barriers to Infection in Plants Physical Barriers Chemical Barriers Microbiological Barriers 	Pg 28-31
Antigens Pg 18-25 What are Antigens? Major Histocompatibility Complex (MHC) Non-Self Antigens Errors with Antigens	 Barriers to Infection in Animals Physical Barriers Chemical Barriers Microbiological Barriers 	Pg 32-34

Study Design: Responding to Antigens



Physical, chemical and microbiota barriers as preventative mechanisms of pathogenic infection in plants and animals.

The distinction between self-antigens, cellular and non-cellular pathogens and allergens.



Learning Objectives:

■ **BI34 [3.1.1]** - Define the Terms Antigen, Pathogen, Allergen, Cellular & Non-Cellular, & Describe the Difference Between Self & Non-Self



- **BI34 [3.1.2]** Differentiate Between the Two Types of Major Histocompatibility Complex Proteins Displayed on Cells, and Explain Their Significance
- BI34 [3.1.3] Identify & Describe the Pathogens Assessed in VCE Bacteria, Fungi, Protists, Parasites, Viruses & Prions Including How They Cause Disease
- BI34 [3.1.4] Identify & Describe the Physical, Chemical, Microbiological Barriers to Infection Present in Both Animals & Plants



Section A: Introducing Disease

What exactly do we mean by "disease"?



Discussion: What is your understanding of disease?



- Talk to the person next to you for a couple of minutes before class starts to discuss these points!
- What causes a disease?
- What happens when you have a disease?
- Can you think of any examples of disease?

Disease



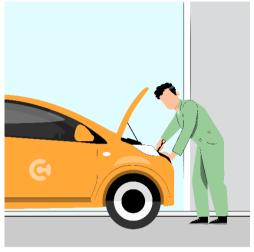
- A state of abnormality or dysfunction that negatively impacts part of or an entire organism's functioning.
 - What does this mean?
- Diseases can have many causes ______ or _____ or _____
- The immune system's primary objective is to ______



Analogy: Faulty Car



Think of disease like any problem with your car - it is where a part or system of the car is no longer functioning correctly!



"Say ahh."

Discussion: What do you know about the immune system?





How is our immune system coordinated?



Exploration: Cell Signalling

- How can cells actually communicate with each other?
- How can cells detect and respond to their external environment?

NOTE: Cellular Signalling is not directly assessed by VCAA, but it is useful in helping to understand immune processes!



Key Takeaways

- ☑ Disease is a disruption in the normal function of part or all of an organism's body.
- ✓ Causes may be pathogenic (infectious agents) or non-pathogenic (e.g. genetic, autoimmune).
- ✓ The immune system exists to prevent disease and limit its progression.
- ✓ The body is continuously monitored for threats by immune components spread across tissues and organs.





Section B: Causes and Examples of Diseases

History



- Hippocrates, the ancient Greek physician often considered the "Father of Medicine," believed that diseases were caused by an imbalance in the four **humours**: blood, phlegm, black bile, and yellow bile. This concept dominated medical thinking for centuries. Illness was thought to arise when these humours were out of balance, rather than from microorganisms. For example, an excess of black bile was linked to depression or melancholia.
- This shows us just how far our understanding of the causes of disease have come!

Space for Personal Notes	



Sub-Section: Introduction to Pathogens



Pathogens



Pathogens are any agents that are able to cause disease.

Type of Pathogen	<u>Description</u>
Cellular Pathogens	
Non-Cellular Pathogens	
Primary Pathogens	
Opportunistic Pathogens	

Active Recall: What is the difference between pathogenic and non-pathogenic disease?





Sub-Section: Bacteria

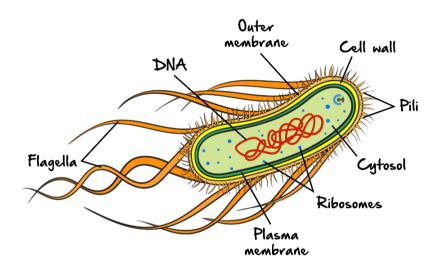


Bacteria



- These are ______ that are extremely common, and differ in their ability to be pathogenic to humans.
 - They cause disease through the production of _____ and ____ which the functioning of cells, potentially causing their death.

Bacteria



- Life Cycle Generally, the purpose is to divide and proliferate in the body.
- Not always pathogenic, we have a lot of bacteria inside us which are necessary for our functioning - but sometimes these ones can cause infection.
- What type of pathogen would they be?





Case Study: Tuberculosis and Bacterial Disease

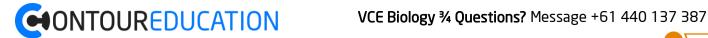


There are various ways in which pathogens can cause disease. Some of these are listed in Table 5.4.

FABLE 5.4 Factors involved in disease production by bacteria

TABLE 5.4 Factors involved in disease production by bacteria			
Disease	Bacterium responsible	Factor involved in disease	Mode of action
Botulism (one form of food poisoning)	Clostridium botulinum	Exotoxins that are neurotoxins	Paralysis
Salmonellosis (most common form of food poisoning)	Several species of Salmonella	Invasive properties	Invades tissue lining the intestine
Cholera (severe gastroenteritis)	Vibrio cholerae	Exotoxin	Alters intestinal permeability
Diphtheria (sore throat and fever)	Corynebacterium diphtheriae	Exotoxin	Prevents protein synthesis
Scarlet fever (fever and rash)	Streptococcus pyogenes	Exotoxin	Invades tissue and damage blood vessels
Tuberculosis (lesions in lung and other tissues)	Mycobacterium tuberculosis	Invasive properties	Invades tissue





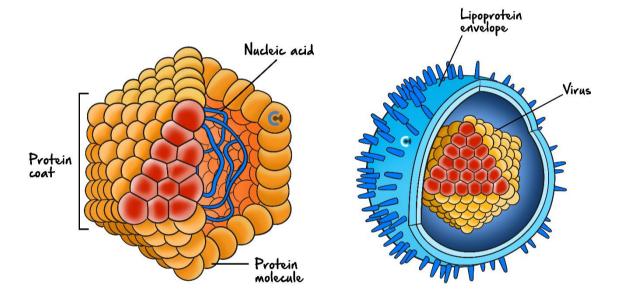
Sub-Section: Viruses



<u>Viruses</u>



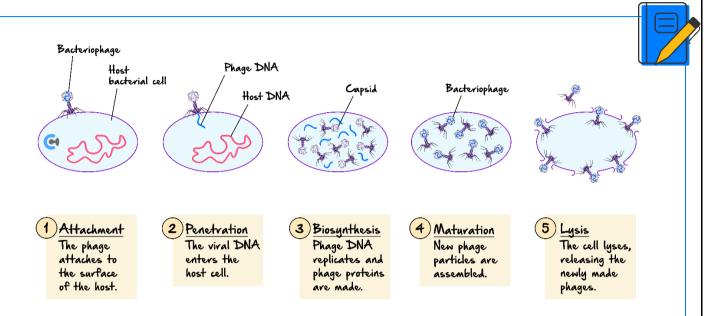
- _ pathogen viruses are considered ______ as they are just genetic material encased in a protein coat, sometimes with a further surrounding envelope.
 - They aim to infect cells and get them to reproduce copies of the virus, usually until death via lysis.
 - They can also permanently integrate their genetic material into the host cell's genome and make them produce viral particles continuously.



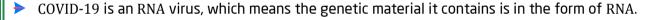


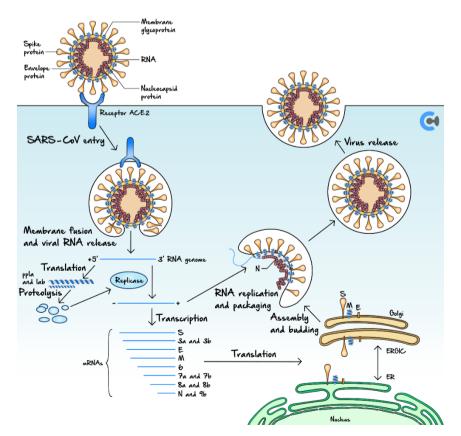
What is the life cycle of a virus?





Case Study: COVID-19





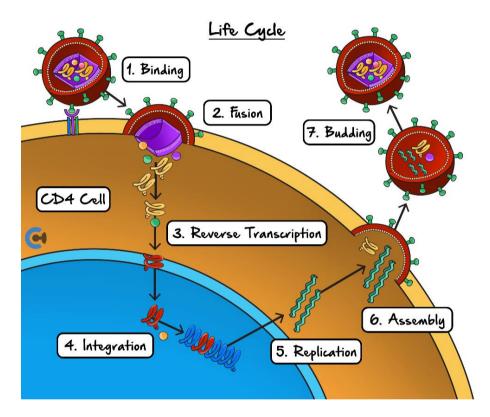
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- Target Cells Respiratory epithelium. Relate this to the symptoms of COVID-19.
- This is an acute infection. What could this mean?

Case Study: HIV



- A Retrovirus it contains RNA, but it's converted to DNA when put inside the cell.
- Overall, a similar process or idea as above, but it targets primarily T-cells (immune cells) which means it reduces immune function - leading to AIDS.



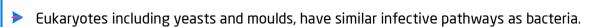
Acute infection, before it goes latent (chronic), re-emerging as a chronic infection which ultimately results in death.



Sub-Section: Fungi

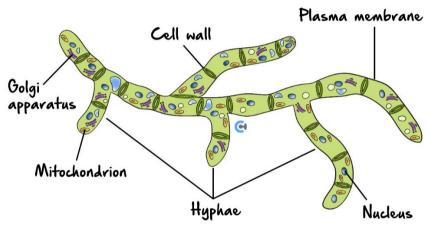


<u>Fungi</u>



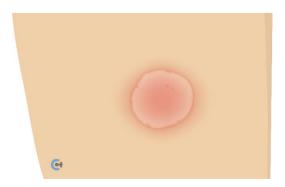


<u>Fungi</u>



Case Study: Ringworm (Tinea)

- 0
- **Cause**: Fungal infection, typically caused by *Trichophyton*, *Microsporum*, or *Epidermophyton* fungi.
- > **Symptoms:** Circular, red, itchy rash with raised edges, often with clear skin in the middle (giving it a "ring" appearance).
- Transmission: Spread through direct skin-to-skin contact or by touching contaminated surfaces like towels, clothes, or gym equipment.
- Risk Factors: Warm, moist environments, close contact sports, weakened immune system, sharing personal items.

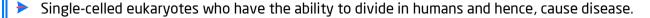


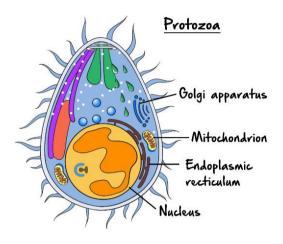


Sub-Section: Protozoa



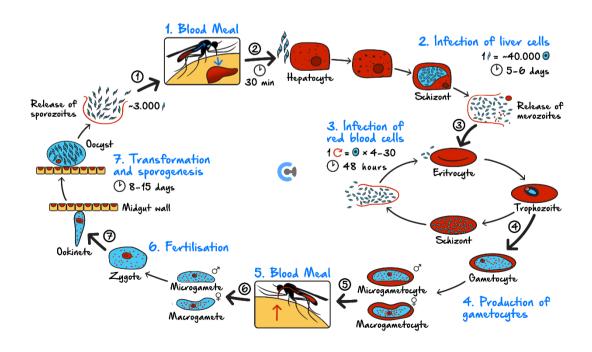
Protozoa





Exploration: Malaria

- Targets blood cells, transferred from person to person via mosquitoes.
- The life cycle simplified.







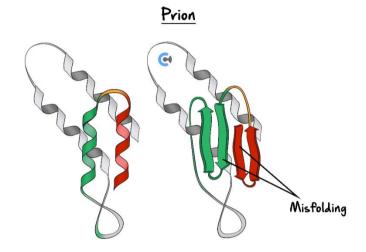
Sub-Section: Prions



Prion



These are just proteins, which have misfolded in the brain, and once they come into contact with other like proteins, they cause them to misfold.



Exploration: Mad Cow Disease



- Essentially, some cows can have these misfolded proteins and if you eat their meat, the proteins can still be transferred to your own brain - driving you mad as the name suggests.
- Other examples of prion disease include Kuru.

Key Takeaways



- ✓ Other than a few key exceptions, you do NOT need to know specific examples of diseases that we have discussed.
- Nor do you really need to know the exact mechanisms of each I believe that for understanding purposes, it helps to know the mechanism so you aren't flustered when you see a question.



Key Takeaways



- ✓ Introduction to Pathogens:
 - Pathogens are disease-causing agents and are classified as either cellular or non-cellular.
 - Cellular pathogens include bacteria, fungi, protozoa, and parasites.
 - Non-cellular pathogens include viruses and prions.
 - Primary pathogens can infect healthy individuals; opportunistic pathogens require a weakened immune system.
- ✓ Bacteria:
 - Bacteria are unicellular prokaryotes capable of both harmless and pathogenic roles.
 - Pathogenic bacteria cause disease by releasing toxins and enzymes that damage or disrupt host cells.
 - Many bacteria in the body are beneficial, but imbalances or breaches can cause infection.
- ✓ Viruses:
 - Viruses are non-cellular and considered non-living because they require host cells to replicate.
 - They enter host cells, replicate viral material, and often destroy the cell through lysis.
 - Some viruses insert their genetic material into the host DNA, leading to persistent infections.
- ✓ Fungi:
 - Fungi are eukaryotic organisms, including yeasts and moulds, that can cause disease.
 - Infections are often external (e.g. skin) and spread through contact with infected individuals or surfaces.
 - Fungal diseases share transmission and infection strategies with bacteria.
- Protozoa:
 - Protozoa are single-celled eukaryotes that reproduce inside the host, leading to disease.
 - Often transmitted via insect vectors and have complex life cycles.
 - Malaria is a major example, targeting red blood cells via mosquito transmission.



\checkmark	Prions:		

- Prions are misfolded proteins that can cause other proteins to misfold, especially in the brain.
- Prion diseases are rare but deadly, causing severe neurodegeneration.
- G Transmission can occur through ingestion of contaminated nervous tissue.

Space for Personal Notes		



Section C: Antigens

Sub-Section: What are Antigens?



How can the immune system tell when we are infected?



How can we tell the difference between our cells and pathogens?



What are Antigens?

Antigens are _____

generally being associated with the initiation of an immune response.

- How will the immune system interact or recognise a molecule?
- **@** _____
- This idea of antigens helps the immune system know the difference between us and a pathogen, as well as between pathogens.
- > Self-antigens are those which the immune system recognises as 'self', preventing them from getting attacked.

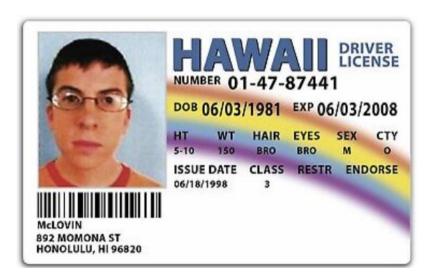




Analogy: ID Cards



- Imagine your body is like a large office building, and each employee (cell) needs an ID card to enter the building. These ID cards are the **antigens**. Each ID card is unique to the employee (the cell), and it helps security (your immune system) know who belongs and who doesn't.
 - **Self-antigens** are like valid ID cards issued by the building. The security guard (immune system) sees the ID and knows the employee is authorised to be there.
 - Non-self antigens are like fake ID cards, or having no ID card at all. If an intruder (pathogen) tries to enter the building with a fake ID, the security guard will recognise it as fraudulent and take action to remove them.









Sub-Section: Major Histocompatibility Complex (MHC)

These are proteins that are found on the **surface** of cells, which display antigens to other cells in the body.

How can we tell if our cells are healthy or not?



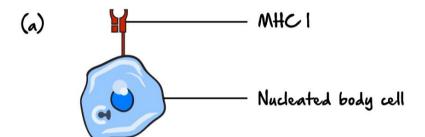
Classes of MHC Proteins

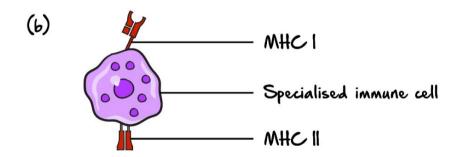


Also known as Human Leukocyte Antigens (HLA), there are two classes of MHC proteins:

G	MHC I	

G MHC II - _____





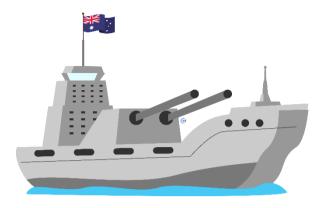




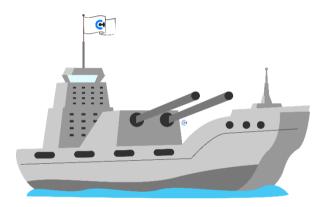
Analogy: Flags on Ships



Ships as they sail on the ocean need to display a flag which tells us what country they are from.



➤ All ships will have a flagpole - it's just the flag displayed that changes!



This is similar to what we see with MHC proteins - the MHC itself is the flagpole, each cell will display a protein (flag) to prove that it is healthy and not infected!



Sub-Section: Non-Self Antigens



Non-Self Antigens



- These are those that aren't recognised as self and, therefore, are eliminated by an immune response.
 - Can be various things proteins on the surface of a bacteria, toxins etc.
 - There is more depth to how these are recognised and used to be added later (stay tuned).



What happens if these antigens don't get recognised properly?



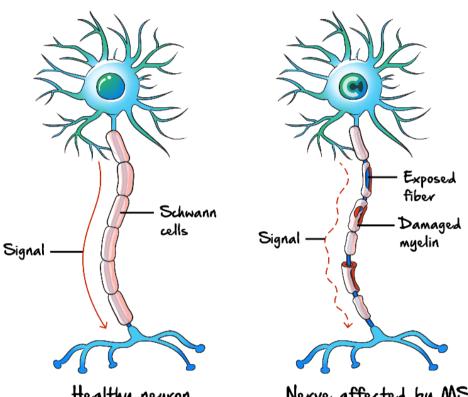
Sub-Section: Errors with Antigens



Errors with Antigens

Recognising self as non-self - _____

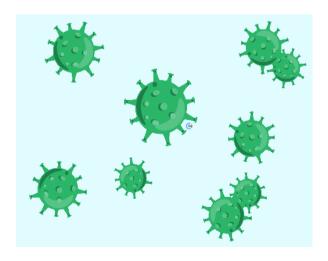
Multiple Sclerosis



Healthy neuron

Nerve affected by MS

Recognising non-pathogenic non-self antigens as pathogenic - _____





Exploration: Blood Types



All nucleated cells have MHC marker, what about those that don't?

Red Blood Cell and Antibodies

<u>Human Blood</u> <u>Type</u>	<u>A</u>	<u>B</u>	<u>AB</u>	<u>0</u>
Red Blood Cell with antigen	A antigens	B antigens	AB A antigens B antigens	0
Antibody Produced	Anti-B	Anti-A	None	Anti-B Anti-A

What happens if you have the wrong blood type donated?

Key Takeaways



- ✓ The immune system must be able to recognise the difference between foreign material and the material of the body itself it accomplishes this through the idea of antigens.
- ☑ Each organism will have different antigens specific to it which can be exploited then to target this organism in the immune defence.



Key Takeaways



- ✓ What are Antigens?
 - Antigens are molecules capable of interacting with or being recognised by the immune system.
 - They allow the body to distinguish between its own cells (self) and foreign invaders (non-self).
 - Recognition of antigens is essential for initiating appropriate immune responses.
- Major Histocompatibility Complex (MHC):
 - MHC proteins display antigens to immune cells, helping determine if a cell is healthy or infected.
 - MHC Class I proteins are found on all nucleated cells and present internal antigens to cytotoxic T-cells.
 - MHC Class II proteins are found on specialised immune cells and present external antigens to helper T-cells.
 - The MHC system enables targeted immune responses by 'flagging' internal and external threats.
- ✓ Non-Self Antigens:
 - Non-self antigens are recognised as foreign and targeted by the immune system.
 - They include pathogen surface proteins, toxins, and environmental substances like pollen.
 - Proper detection of non-self is key to immune defence; failure can result in disease.
- Errors with Antigens:
 - Autoimmune diseases occur when self-antigens are mistakenly recognised as foreign.
 - Allergies arise when harmless non-self antigens are misidentified as threats.
 - Blood type compatibility depends on correct antigen recognition; mismatches lead to dangerous immune reactions.





Section D: Overview of the Immune System

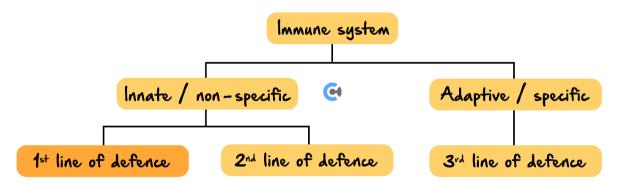
Active Recall: What is the aim of the immune system?

How is the immune system organised?



Overview

- The immune systems can be organised into a few layers and lines of defence, composing of proteins, cells and chemicals.
 - In VCE we can divide it as the innate and adaptive responses, as well as the 3 lines of defence against pathogens.



Analogy: Defence





Key Takeaways



- ✓ System Structure and Function:
 - The immune system detects and removes pathogens and abnormal cells throughout the body.
 - It is composed of cells, proteins, and signalling molecules spread across tissues and organs.
 - It includes two branches: Innate immunity (non-specific, immediate) and adaptive immunity (specific, delayed, memory-based).
 - G These components work together in layers or lines of defence against infection.

Space for Personal Notes		



Section E: Barriers to Infection in Plants

Sub-Section: Physical Barriers



What do we mean by specific and non-specific?



What is the best way to stop something from infecting you?



Physical Barriers

- Barriers to enter inside the organism i.e. plants trying to prevent the pathogen from entering the plant itself.
 - Bark.
 - Waxy cuticle.
 - Formation of galls.
 - Closing of the stomata.
 - Positioning of the leaves to prevent the collection of water.

Exploration: Why might galls be useful for a plant?





Sub-Section: Chemical Barriers



Chemical Barriers



- Barriers that involve the production of chemicals which are harmful to the pathogen, designed to prevent its proper functioning or development.
 - **©** Chitinases _______.
 - Phenols ______.
 - © Defensins -
 - G Saponins _______.
 - Oxalic Acid _______.
 - Glucanases _____





Sub-Section: Microbiological Barriers



What do we mean by good bacteria?



Microbiological Barriers

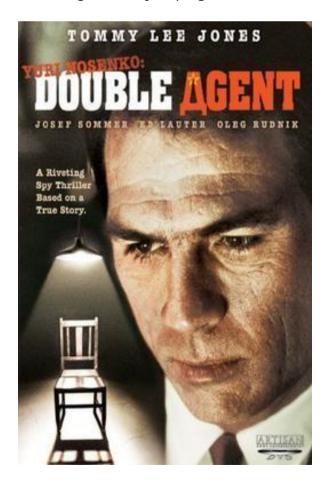


- Involves the normal flora of the plant providing protection against further pathogenic invasions.
 - Production of chemicals.
 - Competition.

Analogy



The good bacteria are like double agents! They help fight their own kind.





Kev Takeaways: Barriers to Infection in Plants



Physical Barriers

- Bark: Protective outer layer that prevents entry.
- Waxy Cuticle: Coating on leaves that limits pathogen access.
- Galls: Localised cell death to isolate infections.
- G Stomata Closure: Reduces entry points on leaf surfaces.
- Leaf Orientation: Minimises water pooling and microbial growth.

Chemical Barriers

- Chitinases: Enzymes that degrade fungal cell walls.
- Phenols: Secreted compounds toxic to microbes.
- Defensins: Antimicrobial peptides that disrupt pathogens.
- Saponins: Compounds that damage microbial membranes.
- Oxalic Acid: Toxic when ingested by pathogens.
- Glucanases: Break down glucans in fungal cell walls.

✓ Microbiological Barriers

- Beneficial Surface Microbes: Occupy plant surfaces to prevent pathogen colonisation.
- Chemical Production: Secrete substances to inhibit other microbes.
- Competitive Exclusion: Outcompete harmful microbes for space and nutrients.





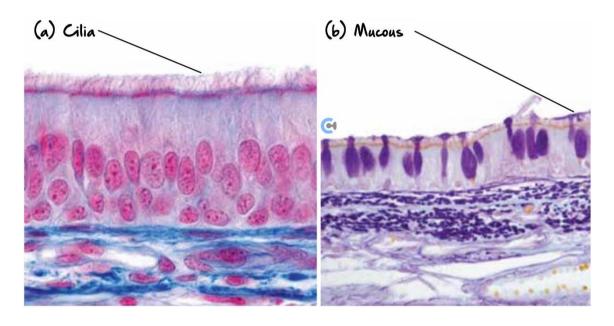
Section F: Barriers to Infection in Animals

Sub-Section: Physical Barriers



Physical Barriers

- Definition
- Blocking or hindering the pathogen from entering the internal environment of the organism.
 - Intact keratinised skin.
 - Mucous secretions.
 - Cilia.





Sub-Section: Chemical Barriers



Chemical Barriers



- Producing chemical substances that either make an environment unsuitable for a pathogen or kill it.
 - Acidic and basic nature of many places in the body including sweat and other secretions.
 - Antimicrobial peptides.
 - Lysozyme enzymes.
 - Stomach acid.

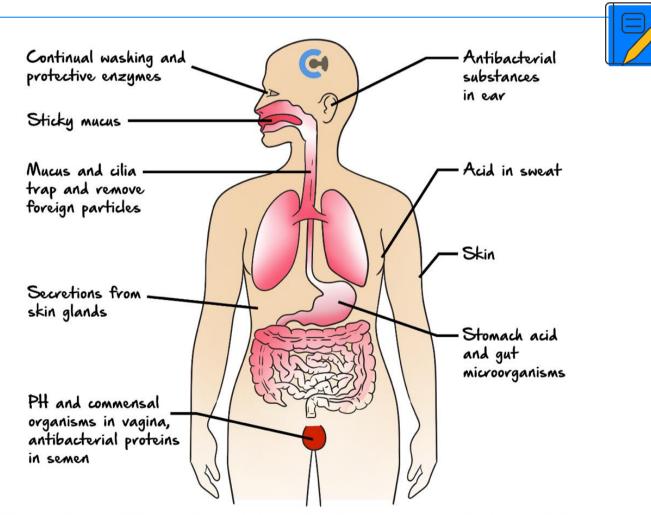


Figure: Some of the physical and chemical defence mechanisms that prevent foreign organisms from gaining access to the human body



Sub-Section: Microbiological Barriers



<u>Microbiological Barriers</u>

- Definition
- Non-pathogenic bacteria, your normal flora preventing colonisation by other bacteria.
 - Competition.
 - Secretions which make environments unliveable acidic environment on the skin.



Kev Takeaways: Barriers to Infection in Animals

Physical Barriers

- Intact Skin: Acts as a solid, impermeable layer.
- Mucous Membranes: Trap and remove microbes at entry points.
- Cilia: Hair-like structures that sweep pathogens out of airways.

Chemical Barriers

- Sweat: Creates acidic conditions that inhibit microbes.
- Stomach Acid: Destroys ingested pathogens with low pH.
- Lysozymes: Enzymes in saliva, tears, and mucus that break down bacterial walls.
- Antimicrobial Peptides: Kill or inhibit bacteria directly.

✓ Microbiological Barriers

- Normal Flora (Good Bacteria): Occupy body surfaces to prevent pathogen growth.
- Competitive Exclusion: Compete with pathogens for nutrients and space.
- Environmental Modification: Alter pH or oxygen levels to create hostile conditions.
- Secrete antimicrobial chemicals.





Contour Check

□ <u>Learning Objective</u>: [3.1.1] - Define the terms antigen, pathogen, allergen, cellular & non-cellular, & describe the difference between self & non-self

Study Design

"The distinction between self-antigens, cellular and non-cellular pathogens and allergens."

Key Takeaways

Wh	nat are Antigens?
0	Antigens are
0	They allow the body to distinguish between its own cells () and foreign invaders ().
0	Recognition of antigens is essential for initiating appropriate immune responses.
No	n-Self Antigens
0	Non-self antigens are recognised as foreign and targeted by the immune system.
0	They include pathogen surface proteins, toxins, and environmental substances like pollen.
0	Proper detection of non-self is key to immune defence; failure can result in disease.
Err	ors with Antigens
0	diseases occur when self-antigens are mistakenly recognised as foreign.
0	arise when harmless non-self antigens are misidentified as threats



Learning Objective: [3.1.2] - Differentiate between the two types of major histocompatibility complex proteins displayed on cells, and explain their significance					
	Study Design				
	"The distinction between self-antigens, cellular and non-cellular pathogens and allergens."				
Key Takeaways					
	MHC proteins display antigens to immune cells, helping determine if a cell is healthy or infected.				
	MHC Class I proteins are found on all nucleated cells and present internal antigens to cytotoxic T cells.				
	MHC Class II proteins are found on specialised immune cells and present external antigens to helper T cells.				
П	The MHC system enables targeted immune responses by 'flagging' internal and external threats				



■ Learning Objective: [3.1.3] - Identify & describe the pathogens assessed in VCE - bacteria, fungi, protists, parasites, viruses & prions - including how they cause disease

Study Design

"The distinction between self-antigens, cellular and non-cellular pathogens and allergens."

Key Takeaways						
Int	croduction to Pathogens					
1.	Pathogens are agents that cause [Disease] / [Healing]					
2.	Pathogens are classified as either or non-cellular. [Cellular] / [Chemical]					
3.	Cellular pathogens include bacteria, fungi, protozoa, and [Parasites] / [Viruses]					
4.	Non-cellular pathogens include viruses and [Prions] / [Protozoa]					
5.	Primary pathogens can infect individuals. [Healthy] / [Weakened]					
6.	Opportunistic pathogens typically infect individuals with immune systems. [Weakened] / [Strong]					
Ba	octeria					
1.	Bacteria are unicellular organisms. [Prokaryotic] / [Eukaryotic]					
2.	Pathogenic bacteria cause disease by releasing that damage host cells. [Toxins and Enzymes] / [Hormones and Water]					
3.	Many bacteria in the body are under normal conditions. [Beneficial] / [Harmful]					
Vir	ruses					
1.	Viruses are and considered non-living. [Non-Cellular] / [Cellular]					
2.	. Viruses replicate by entering host cells and causing cell [Lysis] / [Growth]					
3.	Some viruses insert their genetic material into the host's DNA, leading toinfections. [Chronic] / [Acute]					



C	I Fungi			
	1. Fungi are organisms that include yeasts and moulds. [Eukaryotic] / [Prokaryoti			
	2. Fungal infections are often and spread via contact. [External] / [Internal]			
	3. Fungal transmission and infection methods are similar to those of [Bacteria] / [Viruses]			
	Protozoa			
	. Protozoa are single-celled that reproduce in the host. [Eukaryotes] / [Prokaryotes]			
	They are often transmitted via, such as mosquitoes. [Insect Vectors] / [Airborne Particles]			
	3 is a disease caused by protozoa targeting red blood cells. [Malaria] / [Influenza]			
	Prions1. Prions are that cause other proteins to misfold. [Misfolded proteins] / [Viral particles]			
	2. Prion diseases lead to severe [Neurodegeneration] / [Inflammation]			
	3. Prions can be transmitted by ingesting [Contaminated nervous tissue] / [Contaminated water]			
С	[Insect Vectors] / [Airborne Particles] 3 is a disease caused by protozoa targeting red blood cells. [Malaria] / [Influenza] Prions 4. Prions are that cause other proteins to misfold. [Misfolded proteins] / [Viral particles] 5. Prion diseases lead to severe [Neurodegeneration] / [Inflammation] 6. Prions can be transmitted by ingesting			



Learning Objective: [3.1.4] - Identify & describe the physical, chemical, microbiological barriers to infection present in both animals & plants

Study Design

"Physical, chemical and microbiota barriers as preventative mechanisms of pathogenic infection in plants and animals."

Key Takeaways

- Barriers to Infection in Plants Physical Barriers Chemical Barriers



Microbiological Barriers	
-	
-	
-	
☐ Barriers to Infection in Animals	
O Physical Barriers	
-	
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-	
 Chemical Barriers 	
o	
-	
<u> </u>	
	
Microbiological Barriers	
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