

These notes explain the **why** behind every concept, not just the what. They include **analogies**, **real-life examples**, and explanations of **common mistakes**. Use these alongside your revision notes for full understanding.

4.3.1 Communicable Disease — How Pathogens Cause Illness

A communicable disease is caused by a pathogen — a microorganism that can spread from one host to another. Understanding how pathogens cause disease helps us understand why symptoms occur, and why certain treatments work while others do not.

Bacteria — Reproducing and Releasing Toxins

Bacteria are single-celled prokaryotic organisms. When they infect the body, they reproduce rapidly by binary fission — one cell splitting into two, then four, then eight, doubling every 20 minutes or so under ideal conditions. Symptoms of bacterial infections are usually caused by toxins — poisonous chemicals the bacteria produce as waste products.

■ **Real-life example:** Salmonella bacteria in undercooked chicken reproduce in your gut and release toxins that cause vomiting, diarrhoea and fever. The symptoms are your immune system's response to the toxins, not the bacteria themselves directly damaging your gut.

Bacteria can be killed by antibiotics. Antibiotics are chemicals that interfere with specific processes in bacterial cells — for example, preventing them from building their cell walls. Because human cells do not have cell walls, antibiotics do not harm us.

Viruses — Hijacking Host Cells

Viruses are not technically living — they are strands of genetic material (DNA or RNA) surrounded by a protein coat. They cannot reproduce on their own. Instead, they inject their genetic material into a host cell and reprogramme it to produce thousands of copies of the virus. The host cell eventually bursts open (lyses), releasing new viruses to infect more cells.

■ **Think of it like this:** A virus is like a USB stick containing a computer virus. It cannot do anything on its own. But once you plug it into a computer (a cell), it takes over the computer's systems to copy itself and spread, eventually crashing the computer (killing the cell).

"Antibiotics will cure a viral infection like flu or COVID-19."

✓ **Actually:** have. Taking antibiotics for viral infections a

The Immune Response — Specific and Lasting

When a pathogen enters the body, the immune system launches a two-stage response. First, non-specific defences try to stop or slow the pathogen. Then, the specific immune response identifies and destroys the particular pathogen.

Step 1

Non-specific response

Phagocytes (a type of white blood cell) engulf and digest pathogens — a process called phagocytosis. This happens for ANY pathogen.

Step 2	Recognition	Lymphocytes (another type of white blood cell) detect antigens — specific protein markers on the pathogen's surface.
Step 3	Antibody production	Lymphocytes produce antibodies — Y-shaped proteins that fit exactly onto the antigens of that specific pathogen.
Step 4	Antibody action	Antibodies bind to pathogens, marking them for destruction, clumping them together, or directly neutralising them.
Step 5	Memory cells	Some lymphocytes become memory cells that remain in the body for years. If the same pathogen is encountered again, they produce antibodies MUCH faster — so fast that the infection is usually destroyed before you notice any symptoms.

■ **Why does this happen?** This is why you become immune to diseases like chickenpox after having them once. Your memory cells are ready with the correct antibodies to destroy the virus the moment it enters your body again.

Vaccination — Training the Immune System Safely

A vaccine contains a harmless version of a pathogen — this might be dead pathogens, weakened pathogens, a fragment of the pathogen's protein coat, or a piece of genetic code that tells your cells to produce a pathogen protein. The immune system responds by producing antibodies and memory cells. You become immune without ever having the actual disease.

■ **Think of it like this:** Vaccination is like a fire drill. The drill teaches you what to do without the danger of a real fire. When a real fire happens, you respond quickly and correctly because you have already practised.

Herd immunity: if a large enough proportion of a population is vaccinated, the pathogen cannot spread easily — even unvaccinated individuals are protected because they are unlikely to encounter the pathogen. This is why vaccination rates matter for the whole community.

Antibiotic Resistance — An Evolving Threat

When antibiotics are overused or misused, bacteria evolve resistance through natural selection. A random mutation in one bacterium may give it a slight resistance to an antibiotic. If antibiotics kill all other bacteria but not this one, the resistant bacterium survives and reproduces. Over time, the entire population may be resistant.

■ **Real-life example:** MRSA (methicillin-resistant *Staphylococcus aureus*) is a strain of bacteria resistant to most common antibiotics. It spreads in hospitals and is very difficult to treat. This is why hospitals have strict hygiene protocols and why doctors avoid prescribing antibiotics unnecessarily.

Pathogen	A microorganism that causes disease (bacteria, virus, fungus, protist)
Antigen	A protein on the surface of a pathogen that triggers an immune response
Antibody	A specific protein produced by lymphocytes that binds to one type of antigen
Phagocytosis	The process by which phagocytes engulf and digest pathogens
Memory cell	Long-lived lymphocyte that enables a rapid immune response on second exposure to a pathogen
Herd immunity	Protection of unvaccinated individuals because most of the population is immune

Antibiotic resistance

The ability of bacteria to survive antibiotic treatment — developed through natural selection