Infections and Immunity
Infections and Immunity

Contents

- Keeping pathogens out
- Fighting infection
- Improving immunity
- Summary activities
Organisms that cause disease are called **pathogens**. What are the four major types of pathogen?

- **bacteria**
- **fungi**
- **virus**
- **protozoa**
Pathogens cause illness in three main ways:

**Toxins**
Toxins are harmful substances produced by the pathogen that poison the body’s tissue and enzymes.

**Reproduction**
A rise in the number of pathogens can damage a cell, even causing it to burst. Some pathogens hijack resources that the cell needs to survive.

**Immune response**
Sites of infection often become swollen, sore and hot as a result of increased blood flow.
How are pathogens spread?

Different pathogens have different transmission routes:

- Direct contact
- Indirect contact
- Food and water
- Insect bites
- Airborne droplets
Natural defences

What are the body's natural defence mechanisms?

Click on a body part label to find out how each part of the body defends itself against infection.

- skin
- eyes
- lungs
- blood
- stomach
Tuberculosis (TB) is an infectious disease caused by the bacteria *Mycobacterium tuberculosis*.

The bacterium has a thick waxy coat, allowing it to lie dormant in the body for many years.

The TB bacteria attack the respiratory system, causing coughing, fever and fatigue.

How do you think TB is transmitted?
TB is one of the world’s most serious diseases.

<table>
<thead>
<tr>
<th>Region</th>
<th>Incidence (thousands)</th>
<th>Prevalence (thousands)</th>
<th>Mortality (thousands)</th>
</tr>
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<tbody>
<tr>
<td>Africa</td>
<td>2,573</td>
<td>3,741</td>
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<td>Americas</td>
<td>363</td>
<td>466</td>
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<tr>
<td>Eastern Mediterranean</td>
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<td>1,090</td>
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<td>Europe</td>
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<td>575</td>
<td>69</td>
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<tr>
<td>South-East Asia</td>
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<td>4,965</td>
<td>535</td>
</tr>
<tr>
<td>Western Pacific</td>
<td>1,925</td>
<td>3,765</td>
<td>307</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8,918</strong></td>
<td><strong>14,602</strong></td>
<td><strong>1,692</strong></td>
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</table>
Healthy people can fight TB

Only 10% of healthy people exposed to TB develop the active disease. People most at risk are those who:

- have a weakened immune system
- live in squalid or overcrowded conditions.

1,000 people exposed to TB

900 uninfected  100 infected

90 dormant TB  10 active TB

7 survive  3 die
Infectious diseases usually decline as living conditions and standards of healthcare improve.
What is different about TB death rates in Africa compared with the rest of the world? They are increasing!
How is TB treated?

TB is treated with a 6-month course of antibiotics. Three or four different antibiotics are taken daily to fight the many drug-resistant strains.

Why does the treatment last for 6 months?

To ensure that dormant bacteria are also killed.

The BCG vaccine for TB was developed in 1921. It is 50-80% effective, but is too expensive for use by developing countries to vaccinate whole populations.
To lower the costs of treating TB in developing countries, healthcare workers are paid to make sure patients swallow every pill they are prescribed. This is the Directly Observed Treatments System (DOTS).

DOTS helps prevent drug-resistant TB from increasing, and limits the number of patients who relapse and need more expensive treatments.

Drug resistance can evolve in just three months but new antibiotics can take years to develop.
### Are these statements about TB true or false?

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>TB is an incurable infectious disease.</td>
</tr>
<tr>
<td>2.</td>
<td>People most at risk of catching TB have a weak immune system or live in squalid conditions.</td>
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<tr>
<td>3.</td>
<td>TB infection rates in developing countries have fallen in recent years.</td>
</tr>
<tr>
<td>4.</td>
<td>TB is treated with a six-month course of antibiotics.</td>
</tr>
<tr>
<td>5.</td>
<td>The DOTS system helps to reduce relapse rates.</td>
</tr>
<tr>
<td>6.</td>
<td>Drug-resistant TB could spread quickly around the world as a result of low-cost air travel.</td>
</tr>
</tbody>
</table>
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A pathogen enters your body through direct or indirect contact. What happens next?

The pathogen begins to reproduce and make toxins that destroy the body’s cells and make you feel unwell.

Painkillers can relieve the symptoms of an infection but do not kill the pathogen.

Your immune system begins to mount an attack.
Fighting infection

How does the body fight infection?
The body has many different lines of defence:

**Physical and chemical barriers**

- **Non-specific defences**: essential and most controllable.
  - Inflammation to attract white cells into tissues.
- **Pathogen-specific defences**: most controllable.
  - Involves antibodies and T- and B-cells.
  - Ingestion of bacteria by white cells.
What is phagocytosis?

How do macrophages destroy pathogens such as bacteria?

Click "play" to find out more about phagocytosis.
Resisting attack

TB bacteria have a number of adaptations that enable them to resist phagocytosis:

- They produce chemicals that prevent white cells from being attracted to sites of infection.
- They have a waxy cell wall that resists enzyme attack and secretes chemicals that block lysosomes from fusing with phagosomes.

Some TB bacteria are so successful at blocking one or more of the steps in phagocytosis that they are able to live and reproduce while ‘hidden’ inside macrophages.

How does the immune system deal with these bacteria?
What are lymphocytes?

Lymphocytes are a type of white blood cell found in the blood or lymph nodes and made by bone marrow. There are several types of lymphocyte, including:

- **T-lymphocytes** – recognise antigens on pathogens and either attack them directly or co-ordinate the activity of other cells of the immune system.

- **B-lymphocytes** – recognise antigens and produce special chemicals called antibodies.
Antibodies are special Y-shaped proteins produced by B-lymphocytes in response to antigens. Antibodies work by binding to antigens on pathogens, ‘labelling’ them and causing them to clump together. The pathogen can then be destroyed by:

- phagocytosis by macrophages
- T-lymphocytes
- the antibodies themselves.
Antibodies

Each different type of antigen causes a different type of antibody to be produced.

An antibody can only bind to the antigen that caused it to be produced.
**Delayed response**

The B-lymphocyte that produces the correct antibody for the antigen begins dividing to produce many more antibody-producing cells.

It takes a few days to produce enough antibodies to destroy the pathogen. This means there is delay between infection and the person beginning to feel better.

Once a pathogen has been destroyed, a few **memory cells** remain. These recognize the pathogen if it re-infects, and make the immune response much quicker and more effective. This is called **active immunity**.
Antibody levels during infection

Antibody count during two infections by the same pathogen

<table>
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<th>time (days)</th>
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Hidden pathogens

How does the body deal with pathogens that are inside cells?

Viruses and bacteria that infect cells leave antigens on the surface of the cell they infect.

T-lymphocytes recognize these antigens by receptors on their surface and destroy the whole infected cell.
What is the order of stages in fighting an infection?

1. Pathogens enter the body
2. B-lymphocytes make antibodies
3. The antibodies help destroy the pathogens
4. The pathogens reproduce and make toxins
5. The person begins to feel well again
6. T-lymphocytes recognize the pathogens
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Passive immunity

Many snakes produce a powerful nerve toxin that can be lethal to humans.

People bitten by poisonous snakes can be treated with antivenin.

Antivenin contains antibodies to give instant immunity. It is produced by injecting horses with small, non-lethal doses of venom. Over time, the horses produce antibodies, which are extracted and processed.

Because the person didn’t make the antibodies themselves, this is called passive immunity.
What are vaccines?

Vaccines contain a small amount of dead or weakened pathogen particles.

A vaccine stimulates the production of antibodies and memory cells against the target pathogen, without making the person ill.

If a vaccinated person is later infected by the same pathogen, their immune system can destroy it very quickly.

Parents of two-year-old children are offered a combined measles, mumps and rubella (MMR) vaccine to protect their child. What has happened to MMR vaccination rates recently?
Measles, mumps and rubella

MMR vaccination rates used to be high, but fell following a media scare story.

The media reported on controversial research speculating that MMR could cause autism, a behavioural disorder causing learning and communication difficulties.
Controversial data

How was the research presented?

Would you worry if your child was due to be vaccinated?

Year:
- 1971
- 1973
- 1975
- 1977
- 1979
- 1981
- 1983
- 1985
- 1987
- 1989
- 1991

Cases of autism in California:
- 0
- 100
- 200
- 300
- 400
- 500
- 600

MMR vaccine introduced
More evidence

More detailed research carried out in Japan showed no link between the MMR jab and autism.

Why are the results different? Who is right?
Reassessing the evidence

Independent expert scientists re-examined the original research and found no evidence of a link between the MMR vaccine and autism.

The original research failed to account for population growth or the fact that autism has become better understood by doctors and is now diagnosed more frequently.

However, many parents still distrust the MMR jab, preferring that their children receive single vaccinations or even no vaccination.

If 95% of children had the MMR jab the diseases could be wiped out in the UK. This is called herd immunity.
What are the benefits and risks of vaccination?

**Benefits**

**Risks**
MRSA bacteria are resistant to many antibiotics and can cause serious infections when they infect wounds. These wounds can now be treated with wound dressings that are coated with a **bacteriophage**.

A bacteriophage is a virus that naturally infects bacteria, but which is harmless to humans.

The bacteriophage reproduces inside the bacterial cells, killing them and preventing infection.
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Glossary (1/2)

- **antibiotic** – A drug that can destroy or prevent the growth of bacteria.

- **antibody** – A Y-shaped protein produced by the body that binds to antigens.

- **antigen** – A substance on pathogens that stimulates the production of antibodies.

- **B-lymphocyte** – A white blood cell that produces antibodies.

- **immunization** – The process of protecting against infection by using a vaccine.

- **immune response** – The body’s defence against foreign material such as pathogens.
• **immunity** – The ability to fight infection by pathogens. It can be active or passive.

• **pathogen** – A disease-causing micro-organism.

• **phagocytosis** – The process where a type of white blood cell called a macrophage ingests and destroys a pathogen.

• **T-lymphocyte** – A type of white blood cell that recognises and destroys pathogens, and co-ordinates the immune response.

• **tuberculosis** – A serious bacterial disease that mainly affects the respiratory system.

• **vaccine** – A small amount of dead or weakened pathogen that stimulates antibody production.
Anagrams

How quickly can you unscramble anagrams of words about infections and immunity?

start
Multiple-choice quiz

How healthy is your knowledge of infections and immunity?

Pathogenz Deliveryz