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| --- | --- | --- |
| |  |  | | --- | --- | | |  | | --- | | *Human Perspectives ATAR Units 3 & 4* | | |

Answers: Chapter 7 The body can protect itself from infection

Questions 7.1

RECALL KNOWLEDGE

**1** Define ‘pathogen’.

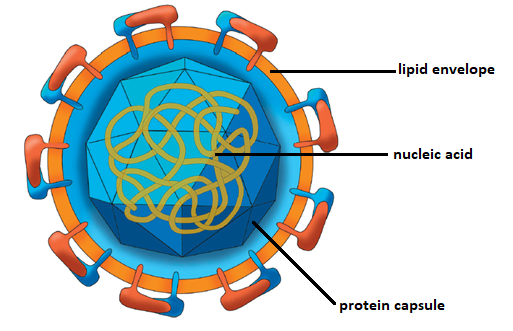
*Answer:* A disease causing organism.

**2** List the ways that a pathogen can pass from an infected person to someone else.

*Answer:* Transfer by contact, ingestion, transfer of body fluids, infection by droplets, airborne transmission, transmission by vectors

**3** The diagram below is of the zika virus. Label the nucleic acid, protein capsule and lipid envelope.

*Answer:*



**4** Describe the structure of a typical bacterium.

*Answer:* Bacterium are unicellular and lack a nucleus, their DNA is either free floating in the cytoplasm or in circular plasmids. Bacteria are microscopic and can be classified according to shape.

**5** List the different shapes of bacteria.

*Answer:* Cocci – round, Bacilli – rod, Spirilla – spiral, Vibrio – curved rod/comma shape.

**6** List three vectors of pathogens and the diseases that they transmit.

*Answer:* Mosquito – malaria or dengue fever, Tsetse fly – trypanosomiasis (African sleeping sickness), Ticks – Lyme disease, Fleas from rats and mice – bubonic plague.

APPLY KNOWLEDGE

**7** During the COVID-19 pandemic, people were advised to wash their hands with soap to break down the coronavirus’s protein coat. Explain how this would be effective in preventing the transmission of the virus.

*Answer:* The soap dissolves the oily surface membrane/fatty membrane, so the virus is destroyed. If the virus is unable to reproduce it cannot be transmitted.

**8** There is some debate as to whether viruses are living things. Discuss your views on this idea.

*Answer:* Student responses will vary as this is an opinion question. To be determined living, many scientists believe that all eight characteristics of life must be fulfilled. Viruses are not able to reproduce without the use of a host cell, nor are they made of cells which are two characteristics of life.

**9** It is easier to stop the transmission of pathogens that are transferred by body fluids than those that are transferred by moisture. Explain the reason for this observation.

*Answer:* Transmission by body fluids can be prevented using a condom or dental dam during sexual intercourse. Not sharing needles with anyone will prevent the spreading of pathogens from the bloodstream. Transmission by moisture is harder to prevent as droplets containing the pathogenic organism may be inhaled or may settle on food or utensils to later be ingested with food.

Questions 7.2

RECALL KNOWLEDGE

**1** Define ‘non-specific defences’.

*Answer:* non-specific defences work against all pathogens, they form the body’s first line of defence.

**2** Explain why the skin is such an effective external defence to infection.

*Answer:* The skin is very good at stopping the entry of micro-organisms provided it is not broken or has abrasions. There are many bacteria on the surface of the skin, making it difficult for pathogenic bacteria to become established. The skin also secretes sebum, an oily secretion that has the ability to kill some pathogenic bacteria. Sweat, containing salts and fatty acids, to prevent the growth of many micro-organisms.

**3** Describe the role of cilia in the external defence mechanisms.

*Answer:* Cilia are tiny hair-like projections from cells that are capable of a beating motion. The beating motion moves mucus containing trapped particles and micro-organisms towards the throat where it may be coughed up or swallowed.

**4** List the parts of the body that use acids to protect against disease.

*Answer:* Stomach, vagina, urine and sweat.

**5** List five protective reflexes that protect against disease or injury.

*Answer:* Sneezing, coughing, vomiting, diarrhoea, gag reflex, blinking.

**6** Name three cells that are phagocytes in tissue.

*Answer:* Monocytes, macrophages and neutrophils.

**7** Draw a series of diagrams to show phagocytosis.

*Answer:* Refer to Figure 7.10 on page 163 of the student book to show phagocytosis.

**8** List the signs of inflammation.

*Answer:* Redness, swelling, heat and pain.

**9** Which cells release heparin and histamine following tissue damage?

*Answer:* Mast cells release heparin and histamine following tissue damage.

**10** Define ‘fever’ and ‘pyrogen’, and explain their relationship.

*Answer:* Fever is an elevation of body temperature. Pyrogens are chemicals released by white blood cells released during inflammation that act on the hypothalamus to re-set the body’s thermostat. For a fever to occur, the pyrogens must be released so that the hypothalamus can raise the set point for temperature higher than normal.

**11** Name one pyrogen.

*Answer:* Interleukin 1.

**12** What is the benefit of fever during an infection?

*Answer:* Elevated body temperature inhibit the growth of some bacteria and viruses. Heat speeds up the rate of chemical reactions which may increase the rate of cell repair. A fever may inhibit viral reproduction by allowing interferons to operate more quickly.

**13** Describe how lymph nodes provide non-specific defence against disease.

*Answer:* Lymph nodes occur at intervals along the lymphatic vessels. Each node contains lymphoid tissue, cells that are criss-crossed by a network of fibres. Lymph enters the lymph nodes and is filtered, with large particles, such as bacteria, getting trapped in the meshwork of fibres. Macrophages ingest and destroy these particles by phagocytosis. Lymph nodes form a part of the non-specific defence as they are not specific to types of pathogens that are filtered out of the lymph.

APPLY KNOWLEDGE

**14** Explain why it is common to cough after being in a dusty environment.

*Answer:* Being in a dusty environment will result in particles being inhaled and stuck to the mucus membranes of the lower respiratory tract. Coughing will force air from the lungs to try and remove the irritant.

**15** Explain why the incidence of urinary tract infections is higher in females than in males.

*Answer:* The incidence is higher in females due to the shorter length of the urethra. It is more likely that pathogens will enter the urethra and cause a urinary tract infection.

**16** Suggest what nephritis is.

*Answer:* Nephritis is inflammation of the nephrons.

**17** Compare and contrast macrophages and neutrophils.

*Answer:* Compare: Macrophages and neutrophils are both white blood cells. They are involved in non-specific defence and destroy pathogens by phagocytosis.

Contrast: Macrophages remove microbes and dying cells, neutrophils are important in killing pathogens inside cells.

**18** Explain how histamine causes swelling during inflammation.

*Answer:* Histamine is released by mast cells and causes an increase blood flow through the area. Histamine also causes the walls of the blood capillaries to become more permeable so more fluid will escape from the capillaries and move into the tissue causing swelling.

**19** When people are sick, they often feel cold even though their body temperature may be above normal. Explain why this happens.

*Answer:* During a fever the hypothalamus raises the set point of the body’s thermostat higher. As the set point is higher than normal the person will feel cold. In addition they will undergo vasoconstriction to conserve heat loss and will shiver to produce heat.

**20** During the COVID-19 pandemic, it was compulsory in many places to wear a mask when in public. Explain how a mask could reduce the transmission of the virus.

*Answer:* COVID-19 is transmitted through droplets. Wearing a mask will prevent the spread of droplets that may contain the virus, it may also reduce the inhalation of infected droplets to an uninfected person.

**21** Traditionally, it was common practice to cover your mouth with your hand when coughing. Recently, it is recommended that you cough into your elbow or shoulder. Explain why this method could be more beneficial in preventing the transmission of disease.

*Answer:* Coughing or sneezing into the elbow or shoulder will prevent the transmission of viral droplets onto the hands which are more likely to touch another surface and transmit the infection further.

Questions 7.3

RECALL KNOWLEDGE

**1** Define ‘specific defences’.

*Answer:* Specific defences are those directed towards a particular pathogen.

**2** Name the two types of lymphocytes, and state where each is produced and becomes mature.

*Answer:* B-lymphocytes – produced in the bone marrow and matured in the bone marrow.

T-lymphocytes – produced in the bone marrow and matured in the thymus.

**3** Which type of lymphocyte is responsible for cell-mediated immunity?

*Answer:* T-lymphocytes are responsible for cell-mediated immunity.

**4** Define ‘antigen’ and describe its role in specific defences.

*Answer:* An antigen is any substance capable of producing a specific immune response. Non-self antigens are foreign compounds that trigger an immune response.

**5** Describe the structure of an antibody.

*Answer:* An antibody is a Y-shaped specialised protein produced by plasma cells. Antibodies have a complimentary shape to a specific antigen allowing the two molecules to fit together like a lock and key.

**6** Describe the series of events that occur during antibody-mediated immunity.

*Answer:* An antigen presenting cell presents the antigen to the specific B-cells in lymphoid tissue. The B-cells are sensitised, enlarged and divide to form a clone. The majority of the clone form plasma cells which secrete specific antibodies capable of attaching to the active site of the antigen. The remainder of the clone become memory cells.

**7** List the ways that an antigen–antibody complex stops an infection.

*Answer:* The antigen-antibody complex can

* Inactivate foreign enzymes or toxins by combining them or inhibiting their reaction with other cells or compounds.
* Bind to the surface of viruses and prevent them entering cells.
* Coat bacteria so that they are more easily consumed by phagocytes.
* Cause particles such as bacteria, viruses of foreign blood cells to clump together, a process known as agglutination.
* Dissolve organisms.
* React with soluble substances to make them insoluble and thus more easily consumed by phagocytes.

**8** Describe the function of helper T-cells, killer T-cells and suppressor T-cells.

*Answer:*

|  |  |
| --- | --- |
| **T-cell types** | **Function** |
| Helper T-cells | They bind to the antigen on antigen-presenting cells. They secrete a substance that enhances macrophage activity, attracts more macrophages and that sensitises more lymphocytes. |
| Killer T-cells | Migrate to the site of the infection and deal with the invading antigen. They attach to the invading cells and secrete a chemical that will destroy the antigen, and then go in search of more antigens. |
| Suppressor T-cells | They release substances that inhibit T- and B-cell activity to slow down the immune response. |

**9** Describe how immunity can be classified based on the method of gaining:

**a** antibodies

*Answer:* Passive immunity – receiving antibodies produced by someone else.

**b** immunity.

*Answer:* Active immunity – producing antibodies and memory cells in response to exposure to an antigen.

APPLY KNOWLEDGE

**10** Draw a flow chart to show how the immune response is a homeostatic response.

*Answer:*

**11** People whose blood type is A have the A antigen on their red blood cells.

**a** Explain why they may contain B antibodies in the plasma.

*Answer:* B antibodies are in the blood stream so that if a B-antigen enters the bloodstream from a non-matched blood transfusion, the B antibodies will attach to the B antigen and cause agglutination.

**b** Suggest what might happen if they are given red bloods cells of blood type B or AB.

*Answer:* The B antibody will attach to the active site on the B antigen on the red blood cells and cause agglutination.

**c** Explain why red blood cells of blood type O are safe to receive.

*Answer:* O type blood cells do not have an antigen on the surface of the membrane. As such there is no opportunity for an antigen-antibody complex to form.

**d** Explain why, if a plasma transfer is needed, the preferred type is A and not O.

*Answer:* Plasma contains anti-A and anti-B antibodies depending upon the blood group. Patients should only receive plasma that does not contain an antibody which could attack the antigens present on their own red blood cells. Group A recipients have A antigen on their red blood cells, so they cannot receive group O or group B plasma as the anti-A will attack their red blood cells.

**12** Why is the secondary response quicker and longer lasting than the primary response?

*Answer:* Second or subsequent exposures to the same antigen results in a quicker and longer lasting response due to the action of memory cells. The plasma cells are able to form very quickly, with antibody levels in the blood plasma rising rapidly to a higher level that lasts longer.

**13** Even though we consider the cell-mediated and humoral responses separately, there is some overlap. Discuss this overlap.

*Answer:* When an antigen-presenting cell presents the antigen to helper T-cells they release cytokines. These cytokines cause the helper T-cells to clone themselves and to release different cytokines which activate the B-cells.

**14** For each situation below, state whether the humoral response or cell-mediated response would be more important.

**a** A heart transplant

*Answer:* Cell-mediated response

**b** A viral infection

*Answer:* Cell-mediated response

**c** A blood transfusion

*Answer:* Humoral response

**d** Tetanus toxins

*Answer:* Humoral response

**e** A bacterial skin infection

*Answer:* Humoral response

**f** A fungal infection.

*Answer:* Cell-mediated response

**15** Explain why vaccination leads to an active, artificial immunity, while breast milk produces a passive, natural immunity in a baby.

*Answer:* A vaccination results in the ability to manufacture antibodies resulting from being given an injection of the antigens associated with a disease. Passive natural immunity through breastmilk provides the baby antibodies produced by the mother.

Questions 7.4

RECALL KNOWLEDGE

**1** Define ‘vaccination’.

*Answer:* A vaccination is the artificial introduction of antigens of pathogenic organisms.

**2** List the ways that vaccines have traditionally been made.

*Answer:* Live attenuated vaccines, inactivated vaccines, toxoid vaccines and sub-unit vaccines.

**3** Why are infants not vaccinated against most diseases until at least two months of age?

*Answer:* Infants have natural passive immunity from their mother, where antibodies have passed through the placenta and breastmilk. If a newborn is given a vaccine, the antibodies from the mother’s antibodies will eliminate the antigens in the vaccine.

**4** Define ‘herd immunity’ and describe what is needed to achieve it.

*Answer:* Herd immunity is a type of group immunity that occurs when such a high proportion of people in a population are immunised that those who are not immune are protected. To achieve herd immunity large scale vaccination programs need to be completed.

**5** List some of the reasons that people may choose not to be vaccinated.

*Answer:*

* Health issues: Allergic reactions, use of preservatives
* Social concerns: ethical concerns with the use of animals to produce vaccines, ethical concerns with the use of human tissue to produce vaccines, ethical concerns with informed consent, ethical concerns with testing on animals, concerns about promoting sexual activity in teenagers, availability
* Cultural factors: Religious beliefs
* Economic factors: cost of vaccine, commercialisation and availability

**6** Penicillin is an antibiotic.

**a** Define ‘antibiotic’.

*Answer:* Antibiotics are drugs that are used to fight infections of micro-organisms, particularly bacteria.

**b** List two other antibiotics.

*Answer:* Streptomycin, erythromycin, neomycin, tetracycline, vancomycin, cephalosporin.

**c** Would penicillin be effective in treating an infection caused by the influenza virus? Explain.

*Answer:* No, antibiotics can only be used to fight bacterial infections. Antibiotics act to change the structure of the bacterial cell wall, disrupting the action of essential enzymes or to stop the reproduction of bacterial cells.

**7** Define ‘antiviral drug’ and identify an infection that is able to be treated with antiviral drugs.

*Answer:* Antiviral drugs are used specifically for treating viral infections. Most antiviral drugs that are available now target HIV, herpes, hepatitis B and C and influenza A and B.

APPLY KNOWLEDGE

**8** A person whose immune system is compromised is unable to be vaccinated. Explain why this is so, and why herd immunity plays a vital role in this person’s health.

*Answer:* People with a compromised immune system who are given certain vaccines, in particular live attenuated vaccines, might make them very ill due to the underlying problems with their immune response. Herd immunity is vital for the protection of these people because if most of the population is immunized, there can be no transmission of the pathogen. The individuals who cannot be immunised are protected by the larger group.

**9** Explain how it is possible to introduce a virus or bacteria in a vaccine without producing the associated disease.

*Answer:* A vaccine may contain either a dead pathogen, a sub-unit of the protein coat of a virus, or a pathogen that has been attenuated. These vaccine types will not result in the person getting the disease or the symptoms associated with the disease. They will produce an immune response and memory cells for the person being vaccinated.

**10** Which antibiotic is more important – broad-spectrum or narrow-spectrum? Justify your answer.

*Answer:* Both types of antibiotic are important as both provide an opportunity to fight a bacterial infection. Students should consider both types and justify their decision. For example: Narrow spectrum antibiotics are only effective against specific types of bacteria. This is better than broad spectrum antibiotics which affect a wide range of bacteria and whose use has contributed to antibiotic resistant bacteria.

**11** ‘Golden staph’ is a common name for the bacteria *Staphylococcus aureus* that can be resistant to most commonly used antibiotics. Explain why this bacteria is such a problem.

*Answer:* Staph infections, caused by the staphylococcus bacteria, usually result in minor skin infections. However, staph infections can turn deadly if the bacteria invade the bloodstream, joints, bones, lungs or heart. Treatment usually involves antibiotics and drainage of the infected area, however some staph infections no longer respond to common antibiotics. Different antibiotics and stronger antibiotics have to be used to treat staph infections, however if these antibiotics are mismanaged then the staph bacteria will become resistant to those as well.

**12** Explain why antiviral drugs are harder to develop than antibiotics.

*Answer:* Antivirals are harder to develop than antibiotics because antivirals can damage host cells where viruses reside and replicate. This can cause further damage to the individual without potentially removing the virus. Another difficulty is viral variation, viruses containing either DNA or RNA which makes it virtually impossible to create a broad spectrum anti-viral drug that will work across different virus types.

**13** Use a table to compare and contrast bacteria and viruses in terms of:

**a** their size

**b** their structure

**c** whether they are living or non-living

**d** how they replicate

**e** how they affect the body

**f** treatment.

*Answer:*

|  |  |  |
| --- | --- | --- |
| **Characteristic** | **Bacteria** | **Virus** |
| Size | 0.5–2.0 micrometres diameter and 1–10 micrometres in length. Can be seen with a light microscope. | 20 – 750 nanometres. They can only be seen with an electron microscope. |
| Structure | Unicellular with a cell wall. Genetic material found free in the cytoplasm or in circular plasmids. | All contain either DNA or RNA, but not both. The genetic material is found within a protein coat and some viruses have an external lipid envelope. |
| Living or non-living | Living | Non-living |
| How they replicate | Binary fission / asexual reproduction | Using host cells to create new viruses – lytic cycle |
| How they affect the body | Bacteria affect the body differently depending on the species. Either they produce toxins or an allergic response. | Symptoms shown in viral infections depend on the cell or tissue type they invade. |
| Treatment | Antibiotics | Antivirals |

Chapter 7 activities

ACTIVITY 7.1 Investigating the effectiveness of hand washing

**Planning your investigation**

**1** What will be your independent variable? You may wish to test different types of soap, different methods of hand washing, different lengths of time of hand washing, antiseptic solution vs antiseptic wipes, natural soaps vs synthetic soaps, or another factor.

*Answer:* Responses will vary depending on what the students decide to test.

**2** What will be your dependent variable?

*Answer:* Number of bacterial colonies growing on the culture plate

**3** What variables will you need to control? How will you do this?

*Answer:*

|  |  |
| --- | --- |
| **Variable** | **How it can be controlled** |
| Same hands touching the plate | Identification of the hand being used |
| Same agar | Agar made in one batch |
| Same temperature of environment for incubation | Same incubator used for incubation |
| Same soap/ antiseptic used for each trial | Only one soap/antiseptic available for testing |
| Hands washed for same length of time | Timing the hand washing |
| Hands equally dirty each time | Exposure to an ‘unclean’ surface for a predetermined time. |
| Same temperature of water for washing | Thermometer used to control temperature |
| All plates incubated for same length of time | Timed incubation, same incubator used for all plates |
| Fingers pressed onto agar with same pressure and for same length of time for each trial | Timing, same person pressing the finger on the agar. |

**4** Draw up a suitable table in which to record your results.

*Answer:* Responses will vary depending on what the students decide to test.

ACTIVITY 7.2 Investigating infectious disease transmission

**Discussion**

**1** If the class were divided into three groups of 10 at the start of this procedure and allowed to exchange only within their group, what would the transmission of the disease look like?

*Answer:* Two groups would be unaffected, and the third would have up to eight infections after three exchanges.

**2** Did you know which vials were infected during the procedure?

*Answer:* No

**3** Do you believe that an individual who does not show any signs of a disease can transmit it to others?

*Answer:* Yes, as they may be asymptomatic.

**4** What is the importance of identifying patient zero in epidemics?

*Answer:* Identifying patient zero during an epidemic is critical to determining how the outbreak began. Studying patient zero, helps epidemiologists and health experts understand the source of the disease, model its progress and prevent another outbreak from jumping from animals to humans.

**5** How does this simulation differ from the spread of disease in the real world, such as the spread of COVID-19? Explain.

*Answer:* Real-world infections are spread more sporadically than in the simulation, as real pathogens will not necessarily be transmitted in every interaction between individuals. Interaction rates are also slower and more erratic. Furthermore, real infectious diseases, such as COVID-19 typically require a longer incubation period in a host before the host can transmit the disease to another. In real epidemics, vaccines, hygiene practices and the body’s natural defences can aid in preventing the transmission of disease.

**6** List the appropriate measures that individuals should take to limit the spread of diseases.

*Answer:* Student answers may include:

• Wash and dry your hands regularly and well

• Self-isolate if you are unwell

• Cover coughs and sneezes

• Clean surfaces regularly

• Immunise against infectious diseases

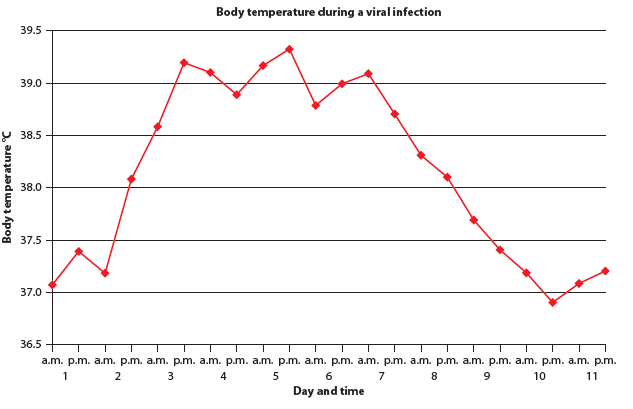
• Wear a mask when infected and isolation is not possible

ACTIVITY 7.3 Plotting a fever

**What to do**

**1** Plot the data on a graph. Refer to Chapter 1 to review how to draw a graph correctly.

*Answer:*



**2** Describe what happened to the patient’s temperature over the 11-day period covered by the data.

*Answer:* Temperature was normal on day 1; began to rise in the afternoon of day 2; remained abnormally high for days 3 to 7; declined on day 8; and was back to normal on day 9.

**3** Calculate the patient’s average temperature from 8 a.m. on day 3 to 8 p.m. on day 8.

*Answer:* 38.8 °C

**4** During a fever, the body’s ‘thermostat’ is set to a higher level. Explain how your graph illustrates this characteristic of a fever.

*Answer:* Once the fever set in at the end of day 2, body temperature remained fairly constantly around 39°C, until it went down on day 10.

ACTIVITY 7.4 Investigating the testing of animals in the manufacture of vaccines

After listening to the opinions expressed during the discussions, prepare a list of arguments for and against the use of animals for the manufacture and testing of vaccines.

*Answer:*

Some points that students may make include the following:

**For**

• Testing of some sort is necessary before a trial in humans, and animals are the only alternative.

• It is not necessary to get informed consent from animals.

• It is safer to test on animals first before trialling on humans.

• It is easier to test large numbers of animals than humans.

• It is easier to provide controlled conditions for a trial with animals than with humans.

• Genome of animals may be manipulated so that genetic effects on results are reduced or eliminated.

**Against**

• Researchers are unable to predict the effect a trial may have on the animal.

• Animals may suffer as a result of the trial.

• Animal physiology is different from that of humans, so trial results may not be transferrable to humans.

• Researchers are likely to take less care with animals than with human subjects.

• Animals are unable to communicate their opinions about the testing.

ACTIVITY 7.5 Investigating antibiotic resistance

**Discussion**

**1** Explain the function of the control plate in the experiment. How could a control plate be helpful in the event there is no growth on the experiment plate?

*Answer:* If there is no growth on the experiment plate, it may mean either that the bacteria did not grow at all, or that the antibiotics worked extremely well. Growth, or lack thereof, on the control plate should be able to answer that question.

**2** What were four variables that you kept constant in this experiment? How did you control them?

*Answer:* Variables that were kept constant throughout the experiment include, temperature of incubation, time of exposure to antibiotics, number of bacterial colonies, size and placement of antibiotic discs. Furthermore, students may refer to temperature, time of exposure and number of bacterial colonies are controlled by testing all antibiotics on the same plate.

Student answers regarding how these variables were kept constant will vary.

**3** Why is it important to pool data from the class results and find the average zone of inhibition for each antibiotic?

*Answer:* Living specimens do not always behave in exactly the same way, so averaging the class results should allow for this variation.

**4** What is a zone of inhibition? How were they created in your experiment?

*Answer:* The area in a bacterial lawn in which an antibiotic has not allowed a susceptible species to grow.

Each disc is impregnated with a different antibiotic, which diffuses into the agar in a concentration gradient, most concentrated near the disc and reducing as it gets further away. The clear circle around a disc denotes a concentration of that antibiotic high enough to inhibit the growth of the bacteria in that area.

**5** Which antibiotic had the greatest zone of inhibition? Explain why this might be.

*Answer:* Penicillin and tetracycline are likely to produce the greatest zone of inhibition in the *S. epidermidis* test as *S. epidermidis* is most susceptible to these antibiotics. In the *E. coli* test, ampicillin and chloramphenicol are likely to produce the greatest zones of inhibition *as E. coli* is most susceptible to these antibiotics. Be aware that individual results may vary.

**6** Did your individual results differ from the class results? If so, suggest possible reasons.

*Answer:* Student answers will vary. If the lawn is still damp when the Mastring is added, the antibiotic may diffuse further than expected. This could either make the zone larger by spreading the antibiotic further or make it smaller by reducing the concentration near the disc to too-dilute a level.

**7** Which antibiotic would be most suitable to treat an infection by *Staphylococcus epidermidis*?

*Answer:* Responses may vary but will probably include penicillin and/or tetracycline.

**8** Which antibiotic would you use if you were unsure of the pathogen in an infection? Explain your answer.

*Answer:* Student answers will vary. However, students may suggest the antibiotic with the greatest zone on inhibition on average between the *E. coli* and *S. epidermidis* tests.

**9** Did your results show any signs of antibiotic resistance?

*Answer:* *E. coli* was shown to be resistant to penicillin.

*Answer:* *S. epidermidis* was shown to be resistant to sulphatriad.

**10** Discuss the effects that antibiotic resistance has on medical treatment.

*Answer:* As a result of antibiotic resistance, antibiotic medicines are not able to fight certain bacteria as effectively as they once did, and medical professionals have been forced to find alternative solutions when treating patients with disease. Additionally, to slow the progress of antibiotic resistance, medical professionals have become more careful in prescribing antibiotics, opting for lower doses or alternative solutions where possible.

**11** Why have antibiotics become a less effective treatment for infection in recent years?

*Answer:* Antibiotics have become less effective in recent years as overuse has led to antibiotic resistance. Antibiotics resistance results from certain bacteria evolving to become resistant to the antibiotics that have been used to fight them. As a result, antibiotic medicines are not able to fight certain bacteria as effectively.

Chapter 7 Review questions

Recall

**1** Define ‘communicable disease’ and name five examples.

*Answer:* A communicable disease is one that can be passed from one person to another – caused by foreign organisms invading the body. Examples include influenza, AIDS, hepatitis, chickenpox and rubella (refer to Table 7.1 on page 158 of the student book for more).

**2** List the external defences that prevent the entry of pathogenic organisms into the body.

*Answer:* The body’s external defences include:

• cerumen, which inhibits bacterial growth in the outer ear

• the skin that forms an impervious barrier on the outside of the body

• tears, which contain the enzyme lysozyme. They cleanse the eyes and inhibit bacterial growth

• mucous membranes that line body cavities that open to the exterior

• mucus which is produced in the trachea and bronchi to trap micro-organisms

• acid in the stomach kills many micro-organisms

• acidic secretions in the vagina inhibit growth of pathogens

• mucus secreted at the anus traps micro-organisms

• urine which flushes the urethra

• the mouth cavity with a mucous membrane that is cleansed by saliva

• hairs and mucus in the nasal cavity trap micro-organisms.

**3 a** How do protective reflexes help to defend the body from infection by pathogenic organisms?

*Answer:* Protective reflexes are automatic, involuntary responses to a stimulus and are able to defend the body from infection by removing the pathogenic organism before it has a chance to cause an infection.

**b** List four reflexes that help to protect against infection.

*Answer:* Four reflexes that help to protect against infection include the following:

• Sneezing: When the walls of the nasal cavity are stimulated by such things as noxious fumes or dust particles, the forceful expulsion of the air from the lungs carries mucus, foreign particles and irritating gases out through nose

• Coughing: Irritation to the bronchi and bronchioles results in the forceful expulsion of air from the lungs, which carries with it any mucus and foreign matter up to the throat and mouth.

• Vomiting: Contraction of the muscles of the abdomen and diaphragm as a result of the presence of bacterial toxins, stretching of the stomach, or psychological factors, results in the expulsion of the stomach contents.

• Diarrhoea: Contraction of the muscles of the walls of the small and large intestine as a result of irritation by bacteria, viruses or protozoans results in the removal of the irritant so quickly that water has little time to be absorbed.

**4** In the inflammatory response, describe the role of:

**a** mast cells

*Answer:* Mast cells stimulate and coordinate inflammation by releasing histamine, heparin and other substances into the tissues.

**b** histamine

*Answer:* Histamine increases blood flow through the area and causes the walls of the blood capillaries to become more permeable, so that fluid is filtered from the blood.

**c** heparin

*Answer:* Heparin is released from the mast cells to prevent clotting in the immediate area of the injury.

**d** phagocytes.

*Answer:* Phagocytes such as macrophages and leucocytes are attracted by the chemicals released from the mast cells. They consume micro-organisms and cell debris at the site of the infection.

**5** How is fever during the course of an infection thought to be beneficial?

*Answer:* The beneficial effects of fever result from the elevated body temperature that inhibits the growth of some bacteria and viruses. In addition, heat increases the rate of chemical reactions, which may assist body cells to repair themselves more quickly during an infection.

**6** Why is the immune response said to be a specific response?

*Answer:* The immune response is said to be a specific response since it is directed towards a particular pathogen. As such it is one of the body’s specific defences. For example, if you get infected (or vaccinated) with chickenpox virus the body will make antibodies to combat that virus. Those antibodies are only effective against chickenpox virus and will not work against any other virus or bacterium. Thus the antibodies are specific for that pathogen.

**7 a** What is an antigen?

*Answer:* An antigen is any substance that is capable of causing a specific immune response.

**b** Explain the difference between self-antigens and non-self antigens.

*Answer:* Large molecules produced in a person’s own body are called self-antigens because they do not cause an immune response. Compounds that do trigger an immune response are non-self-antigens. The immune system becomes programmed to distinguish between self-antigens and non-self-antigens before birth. From then on, it normally only attacks non-self-antigens.

**8** List the ways in which the antigen–antibody complex helps to overcome the effects of invading micro-organisms.

*Answer:* All antibodies combine with the antigen for which they are specific to form an antigen–antibody complex. The response that then occurs varies according to the particular antigen and antibody.

Antibodies may:

• combine with foreign enzymes or bacterial toxins, or inactivate them by inhibiting reaction with other cells or compounds

• bind to the surface of viruses and prevent the viruses from entering cells

• coat bacteria so that the bacteria are more easily consumed by phagocytes

• cause particles such as bacteria, viruses or foreign blood cells to clump together – a process known as agglutination

• dissolve organisms

• react with soluble substances to make them insoluble and thus more easily consumed by phagocytes.

**9** List the ways in which killer T-cells and helper T-cells can deal with an invading antigen.

*Answer:* Killer T-cells migrate to the site of infection and deal with the invading antigen. They attach themselves to the invading cells and secrete a substance that will destroy the antigen, and then go off in search of more antigens.

Helper T-cells play an important role in both humoral and cellular immunity. They secrete a number of substances that:

• cause lymphocytes at the infection site to become sensitised, thus intensifying the response

• attract macrophages to the place of infection so that the macrophages can destroy the antigens by phagocytosis

• intensify the phagocytic activity of macrophages.

**10 a** How can passive immunity be gained artificially?

*Answer:* Passive immunity is when a person is given antibodies produced by someone else. The individual’s body plays no part in the production of antibodies. It can be gained artificially when a person is injected with antibodies to combat a particular infection. This is often done when a person is exposed to pathogens that cause serious diseases, such as tetanus, diphtheria and rabies. Antibodies are given so that immunity is established immediately.

**b** How can active immunity be acquired naturally?

*Answer:* Active immunity results when the body is exposed to a foreign antigen and manufactures antibodies in response to that antigen. Such immunity lasts for many years, often for life, and can be gained naturally from an infection of the disease-causing organism.

**11 a** What is a vaccine?

*Answer:* A vaccine is the antigen preparation used in artificial immunisation. The antigen is strong enough to provoke an immune response but does not produce symptoms of the disease.

**b** Describe three ways in which older types of vaccines are produced.

*Answer:* One type contains living attenuated micro-organisms – micro-organisms of reduced virulence – that is, micro-organisms with a reduced ability to produce disease symptoms, so that the immunised person does not contract the disease but does manufacture antibodies against the antigen.

A second type of vaccine contains dead micro-organisms.

The third type of vaccine is made from toxins. In cases where bacteria produce their effects in humans by liberating toxins, it is not necessary to use living or dead bacteria for immunisation; inactivated toxins (toxoids) can be used instead.

**c** What new methods are being trialled to produce vaccines?

*Answer:* Recombinant DNA technology is being used to modify the characteristics of a micro-organism by changing the DNA in the micro-organisms cell, making the pathogen less virulent. Another way is to insert certain DNA sequences from the pathogen into harmless bacterial cells. The DNA sequences will cause the production of antigens that are characteristic of the pathogen. Vaccination with the harmless bacterium will result in immunity against the pathogen.

**d** List the risks associated with the use of vaccines.

*Answer:* The main risk associated with the manufacture of vaccines is that new vaccines have to be trialled. The vaccine may not work and the trial subjects may suffer from the disease. There may be unacceptable side effects caused by the new vaccine.

One of the main risks of vaccination is an allergic reaction. This may occur not so much from the vaccine itself, but from a reaction to the medium in which the vaccine was cultured. In the manufacture of vaccines, certain chemicals are used as preservatives. Preservatives used include formaldehyde, phenol (carbolic acid), aluminium phosphate, alum and acetone. Individuals concerned about vaccination claim that these preservatives are able to affect the nervous system and can lead to other health issues.

**12** Explain the difference between:

**a** an antibiotic and an antiviral

*Answer:* The term antibiotic is used to refer to drugs that fight infections caused by bacteria. Antivirals are drugs that specifically treat viral infections.

**b** a bactericidal and a bacteriostatic antibiotic

*Answer:* Bactericidal antibiotics kill bacteria (by changing the structure of the cell wall or cell membrane, or by disrupting the action of essential enzymes). Bacteriostatic antibiotics do not kill the bacteria but stop them from reproducing (usually by disrupting protein synthesis).

**c** a broad-spectrum and a narrow-spectrum antibiotic.

*Answer:* Broad-spectrum antibiotics are effective against a wide range of different bacteria (for example, those that cause a chest infection). Narrow-spectrum antibiotics only affect specific types of bacteria.

Explain

**13** Explain the difference between:

**a** a pathogen and a vector

*Answer:* Pathogens are disease-causing organisms such as certain bacteria and viruses, whereas vectors are intermediate hosts of the pathogen, such as mosquitoes or fleas, which spread the pathogen from person to person.

**b** RNA viruses and DNA viruses

*Answer:* RNA viruses contain only ribonucleic acid (RNA); whereas DNA viruses contain only deoxyribonucleic acid (DNA).

**c** bacteria and bacteriophages.

*Answer:* Bacteria are very small single-celled organisms. They can be seen only with a microscope and some are pathogens.

Bacteriophages are viruses that multiply in bacterial cells, causing the death of the bacterium.

**14** Explain the importance of phagocytes in defence against disease.

*Answer:* Phagocytes ingest debris and micro-organisms before they have a chance to cause symptoms of disease.

**15** Explain what causes the four signs of inflammation.

*Answer:* Inflammation is characterised by:

• redness

• swelling

• heat

• pain.

Histamine increases blood flow through the area and causes the walls of the blood capillaries to become more permeable, so that fluid is filtered from the blood. It is the increased blood flow that causes the heat and the redness. The escape of fluid from the blood into the tissues causes the swelling. The abnormal conditions in the tissue stimulate pain receptors so that the person feels pain in the inflamed area.

**16** Explain the difference between:

**a** natural and artificial immunity

*Answer:* Immunity is resistance to infection by invading micro-organisms. Natural immunity occurs without any human intervention; artificial immunity results from giving people an antibody or an antigen.

**b** active and passive immunity.

*Answer:* Active immunity occurs when a person makes their own antibodies after being infected with a pathogen or after receiving a vaccine, whereas passive immunity occurs when a person receives ready-made antibodies.

**17** Why is the secondary immune response so much faster than the primary response?

*Answer:* Some B and T-cells of the original clones that are produced in the primary immune response remain in the lymphoid tissue as memory cells, which can recognise the original invading antigen. If infection with the same antigen should reoccur, these memory cells can initiate a much faster and more intense secondary immune response to the second and subsequent infections, because they recognise the antigen more quickly and thus produce more antibodies at a much faster rate.

**18** Why is it rare to get a disease such as measles or chickenpox more than once?

*Answer:* It is rare to get diseases such as measles or chickenpox more than once because of active immunity. Active immunity results when the body is exposed to a foreign antigen, such as the microorganisms that cause measles and chickenpox, and manufactures antibodies in response to that antigen. This type of immunity is prolonged because, although the amount of the antibody produced gradually decreases, the ‘memory’ of that antigen persists through the memory cells once the antigen has been dealt with. Should a subsequent infection involving the same antigen occur, the appropriate antibodies can be produced very quickly before the infection can produce any disease symptoms. Such immunity lasts for many years, often for life.

**19** Explain how T-cells are able to produce immunity.

*Answer:* T-cells are responsible for cellular immunity. When a foreign antigen is presented to a particular type of T-cell, they become sensitised, enlarge and divide to produce a clone of identical T-cells. Some of these T-cells remain in the lymphoid tissue as memory cells in the event of second and subsequent infections. The clone of T-cells differentiate into killer T-cells, helper T-cells and suppressor T-cells which act to destroy the antigen.

Apply

**20 a** Bacteria were first detected in 1683, but viruses were not detected until 1938. Suggest why this happened.

*Answer:* Viruses are much smaller than bacteria and can only be seen using an electron microscope. The first electron microscope was invented in 1931, but viruses were not identified until 1938.

**b** List four differences between bacteria and viruses.

*Answer:* Differences between viruses and bacteria include the following:

• Bacteria are living things; viruses are difficult to classify and there is debate about whether they should be seen as living or non-living because they do not have all the characteristics of a living organism.

• Bacteria are large enough to be seen with a light microscope; viruses are much smaller and can only be seen with an electron microscope.

• Bacteria have cell walls; viruses do not.

• Bacteria can live independently; viruses need host cells to survive and reproduce.

• Bacteria contain both RNA and DNA; viruses have only DNA or RNA, not both.

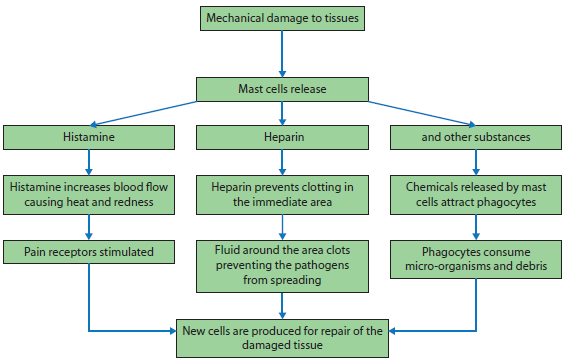
• Viruses have a protein coat and lipoprotein envelope; bacteria have a cell wall and cell membrane.

**21** Explain how coughing into your elbow can help reduce the spread of disease.

*Answer:* Coughing into your elbow will catch the droplets and will stop them getting onto your hands to prevent further contamination.

**22** Draw a flow chart showing the events that occur in an inflammatory response.

*Answer:*



**23** Explain why someone with an infected toe may develop a lump in the groin.

*Answer:* Bacteria and cell debris from the infected toe enter the lymph system. There are large numbers of lymph nodes in the groin and those nodes filter and destroy bacteria and other debris in the lymph coming from the toe. Micro-organisms are attacked by macrophages and there is an increased production of lymphocytes to assist with the destruction. The increased activity causes the groin lymph nodes to become swollen and painful.

**24** During a fever, people often have severe chills and can shiver uncontrollably even though their temperature is above normal. Explain how this is thought to come about.

*Answer:* During a fever the body’s thermostat seems to be set at a higher temperature. The person feels cold and may shiver because the body temperature is lower than the body’s set point for temperature. The shivering and vasoconstriction in the skin rapidly drive the body temperature up to the new elevated set point.

**25** Compare and contrast antigens and antibodies.

*Answer:*

Compare: Both antigens and antibodies are involved in the body’s antibody-mediated immune response. Both are required to produce the antigen-antibody complex.

Contrast: Antigens are molecules capable of stimulating an immune response, they are usually proteins but may be polysaccharides, lipids or nucleic acids. Antibodies are Y-shaped proteins produced by B-cell in response to exposure to antigens. Antigens originate wither within the body or externally whereas antibodies only originate within the body.

**26** Draw a flow chart to show how cell-mediated immunity is activated.

*Answer:*

**27** Typhoid is caused by a bacillus. To make a positive diagnosis of typhoid, a sample of the patient’s blood is taken and mixed with typhoid bacilli. If the bacilli agglutinate, the patient has typhoid.

**a** Why is this a positive diagnosis for the disease?

*Answer:* It is a positive diagnosis because it means that the patient has been exposed to the disease and has produced antibodies to the antigen. When the blood that contains the antibodies is mixed with the typhoid bacilli, the antibodies react with it, resulting in agglutination.

**b** Could the person be suffering from some other disease?

*Answer:* No, it is very unlikely because antibodies are highly specific for the antigen, in this case, typhoid bacilli, that they were produced to combat.

**28** A person was prescribed an antibiotic for a bacterial infection of the throat. While taking the antibiotic tablets, the patient developed a bacterial infection in their big toe. Explain why the antibiotics that the patient was taking for the sore throat did not prevent the growth of bacteria in the toe.

*Answer:* The bacterium causing the toe infection would have been a different type from the one that was causing the throat infection. Many antibiotics are specific; that is, they will only kill certain types of bacteria (narrow-spectrum antibiotics). The bacteria in the toe were not affected by the antibiotic used to treat the sore throat.

Extend

**29** During the COVID-19 pandemic in 2020, there was debate about the effectiveness of the general public wearing masks. Discuss both sides of this debate.

*Answer:*

For mask wearing: Masks can help prevent the spread of COVID-19 as people may be either pre-symptomatic or asymptomatic to COVID-19. There has been a lot of asymptomatic infection, so if everyone wears a mask more people are protected. Viral loads peak in the days before symptoms appearing and even just speaking provides enough force to expel virus-carrying droplets. There is data comparing COVID-19 growth rate before and after mask mandates in certain areas of the world. It shows that mask mandates slowed the daily growth rate and reduced the spread over time.

Against mask wearing: If physical distancing measures are adhered to, along with regular hand washing and washing of surfaces, there should be limited spread. Some masks containing one-way valves do not stop the dispersal of viral-infected droplets, in which case they are not useful in slowing the spread of the disease. COVID-19 can be contracted through the eyes as well, which are not protected by mouth and nose masks. There is some (small) studies being done suggesting that mask wearers become more complacent with handwashing and physical distancing. Mask wearers are more likely to touch their face, particularly if the mask is ill-fitting, increasing the risk of contamination from surfaces to yourself, or vice versa.

**30** The Russian composer Tchaikovsky died of cholera during an epidemic in Moscow in 1893. It is believed that Tchaikovsky drank unboiled water during the epidemic, some think in a deliberate attempt to commit suicide. Why would drinking unboiled water increase the risk of cholera infection?

*Answer:* Cholera is transmitted by the ingestion of water contaminated with faeces or through ingesting fruit and vegetables watered with, or washed with, contaminated water. Bacteria, such as those that causes cholera, can live in moist surroundings at a variety of temperatures, but cannot survive temperatures of 100°C – that is, the temperature at which water boils. Thus, there is more chance of getting infected by the disease with unboiled water.

**31** The body’s immune system does not normally react against its own antigens – the body is said to have tolerance for its own antigens. However, sometimes this tolerance breaks down. Conduct research to find out:

**a** what autoimmune diseases are

*Answer:* An autoimmune disease is a condition in which your immune system mistakenly attacks your body’s healthy tissues and organs. In an autoimmune disease the immune system is unable to tell the difference between your own cells and foreign cells. Autoantibodies are released to attack healthy own cells. An autoimmune disease may be specific to one organ, for example Type 1 diabetes damages the pancreas, whereas systemic lupus erythematosus affects the whole body.

**b** what causes these diseases

*Answer:* Many autoimmune diseases are idiopathic, meaning doctors are unsure what causes them, others have an increased prevalence in certain ethnic groups, or may occur in families and be linked genetically. A study conducted in 2015 focused on the theory of the hygiene hypothesis. As children are not as exposed to pathogens now as they were in the past, the lack of exposure may make the immune system prone to react to harmless or self-substances. Environmental factor such as infection, stress, medication diet or ultraviolet radiation may trigger the symptoms of an autoimmune disease.

**c** how autoimmune diseases are treated.

*Answer:* Treatment depends on the autoimmune disease. As there are more than 100 different types of autoimmune diseases, there is no one treatment. A table is included below for some common autoimmune diseases.

|  |  |  |
| --- | --- | --- |
| **Autoimmune disease** | **Description** | **Treatment** |
| Coeliac disease | The immune system reacts to gluten and damages and destroys the villi of the small intestine. | Dietary changes to remove all gluten. |
| Lupus | Inflammation caused by lupus can affect many body systems including joints, skin, kidneys, blood cells, brain, heart and lungs. | Treatment depends on signs and symptoms. Some anti-inflammatory medications may be prescribed or corticosteroids. Immunosuppressants may be prescribed in severe cases. |
| Rheumatoid arthritis | Damage to the bone and cartilage resulting swollen and stiff joints. | Some anti-inflammatory medications may be prescribed or corticosteroids. |
| Graves’ disease | On overactive thyroid gland, causing anxiety, heart palpitations, weight loss and bulging eyes | Surgery to remove all or part of the thyroid gland. Consumption of radioactive iodine to kill of thyroid cells. |
| Multiple sclerosis | Damage to the nervous system causing muscle weakness and poor coordination, sight problems and potentially cognitive difficulties. | Treatment usually focuses on recovery from attacks and to slow the progression of the disease. Corticosteroids may be prescribed to reduce nerve inflammation. Plasma exchange ay be used if your symptoms are new, sever and have not responded to steroids. |
| Type 1 diabetes | The beta cells in the pancreas are destroyed, so the sufferer in unable to produce any insulin. Results in thirst, hunger and frequent urination | Daily injection of insulin to help lower blood glucose levels. A change in diet to reduce consumption of glucose. |

**32** Investigate and report on the issues surrounding the use of vaccines to protect against human papilloma virus (HPV). Ensure that you provide a balanced discussion of both sides of the subject.

*Answer:* Students should present a report outlining the advantages of vaccination against the human papilloma virus as well as presenting the ethical concerns many parents have about having their child immunised. As HPV is a sexually transmitted virus that causes genital warts and cervical cancer, the most effective way for the vaccine to be used is with girls who have yet to become sexually active. Many parents and health professionals believe that girls of this age, around eleven or twelve, are too young to be discussing such matters, while others are concerned that immunising young women with the vaccine may encourage sexual activity.

**33** Reye’s syndrome (pronounced ‘rise’) is a serious disorder that sometimes occurs in children after a viral infection such as chickenpox or the flu. It was first recognised as a distinct disorder in 1963 by R Douglas Reye, an Australian pathologist. Reye’s syndrome mainly affects children between the ages of 4 and 16 years, and statistics show that it can be triggered by the use of drugs that reduce fever, such as aspirin. Use the Internet to research Reye’s syndrome, including its:

**a** causes

*Answer:* The cause of Reye’s syndrome is unknown, but it typically follows a viral illness such as an upper respiratory tract infection, chickenpox, influenza or gastroenteritis, and is associated with aspirin use during the illness. Any young child who has recently suffered a previous viral infection, such as the flu or chickenpox, should be monitored closely.

**b** signs and symptoms

*Answer:* Signs and symptoms of Reye’s syndrome include:

• recent upper respiratory infection or chickenpox

• nausea and vomiting

• aggressive or irritable behaviour

• lethargy

• confusion

• rash on palms of hands and feet

• loss of consciousness or coma may develop

• seizures

• unusual placement of arms and legs (decerebrate posture), where the arms are extended straight and turned towards the body, the legs are held straight, and the toes are pointed downward.

**c** long-term consequences

*Answer:* How well a person recovers depends on the severity of any coma, as well as other factors. The average death rate for patients with Reye’s syndrome is a little over 30%. However, the outcome for those who survive an acute episode is good. Possible complications are permanent brain damage and coma.

**d** frequency

*Answer:* Reye’s syndrome is rare, occurring almost exclusively in children aged under 18 years. There are estimated to be 0.03–1 cases per 100 000 people aged less than 18 years.

Most cases occur between 5 and 14 years of age, with males and females affected at the same frequency. The incidence of Reye’s syndrome has decreased dramatically in recent years, possibly due in part to the decreased use of aspirin in children.

**e** prevention.

*Answer:* Never give a child aspirin unless specifically told to do so by a doctor.

When a child must take aspirin, care must be taken to reduce the child’s risk of catching a viral illness such as the flu and chickenpox. Aspirin should be avoided for several weeks after receiving a varicella (chickenpox) vaccine.