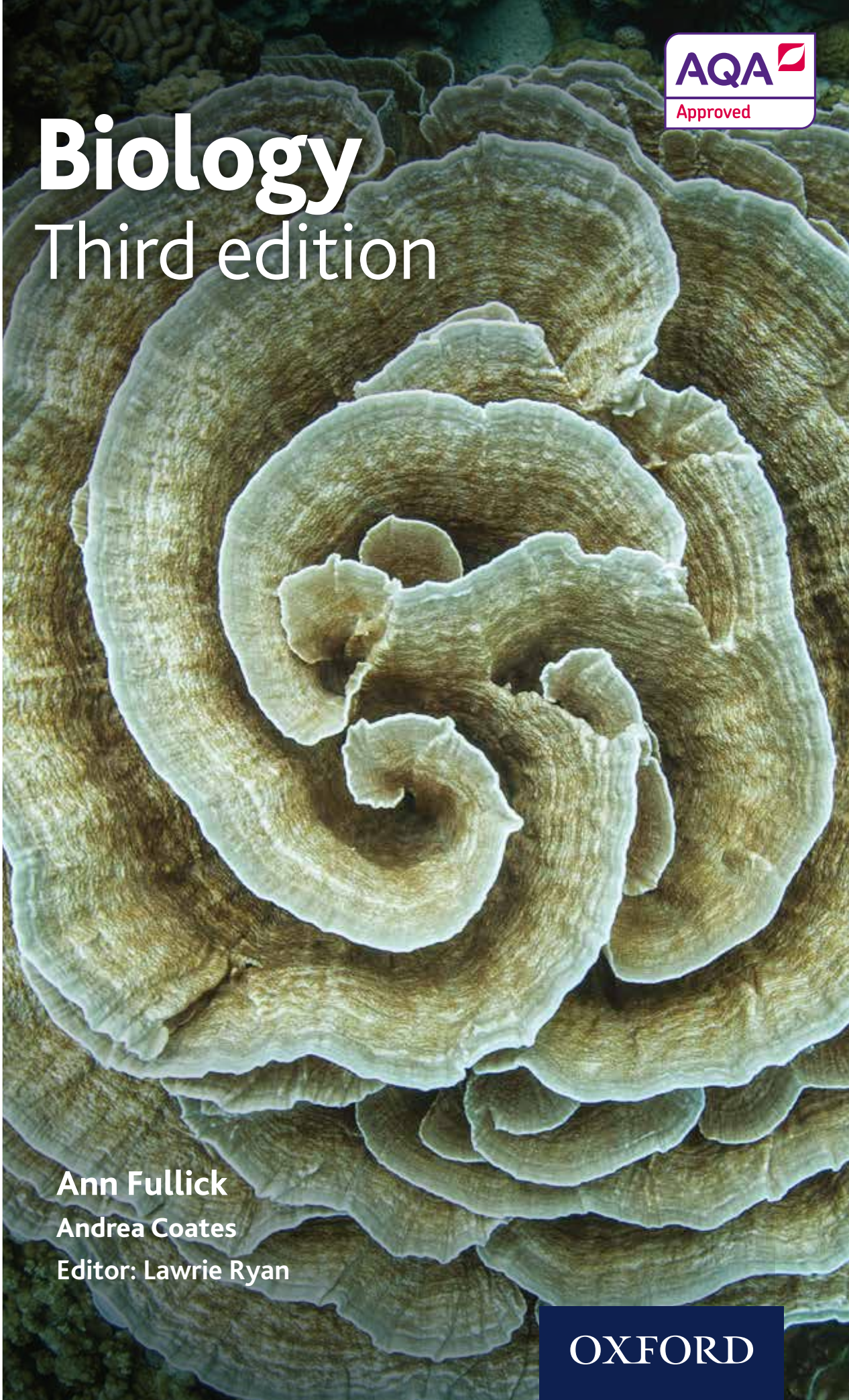
AQA

GCSE

Biology

Third edition



AQA Approved

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OXFORD

2 Disease and bioenergetics

Communicable diseases are caused by pathogens – microorganisms that can be spread from one organism to another. In this section you will learn how we defend ourselves from the pathogens that attack us, and how our lifestyles affect our risk of developing non-communicable diseases such as heart disease and cancer.

You will also learn about photosynthesis in plants – the process where they use light to make sugar from carbon dioxide and water. You will also look at respiration – all living organisms use respiration to transfer the energy they need to carry out the reactions required for life.

Key questions

- What are communicable diseases and how can we prevent them?
- How can your lifestyle affect your risk of developing many non-communicable diseases?
- How do plants use the glucose they make during photosynthesis?
- What is the difference between aerobic and anaerobic respiration?

Making connections

- You will learn about genetic diseases, which are not infectious but can be passed from parents to their offspring, in **B13 Reproduction**
- You will discover the importance of photosynthesis in feeding relationships and ecological communities in **B16 Adaptations, interdependence, and competition** and **B17 Organising an ecosystem**.
- You will find out how pollution of a waterway by fertilisers or sewage can make it impossible for water animals to respire in **B18 Biodiversity and ecosystems**.

I already know...	I will learn...
The consequences of imbalances in the diet.	More about the impact of obesity on human health.
The importance of bacteria in the human digestive system.	The role of bacteria and other pathogens in human and plant diseases, and how to calculate the effect of antibacterial chemicals by measuring the area of zones of inhibition.
The impact of exercise and smoking on the human gas exchange system.	How exercise and smoking can affect the health of other systems of the body.
The effects of recreational drugs on behaviour, health, and life processes.	How to interpret data to understand the effect of lifestyle factors including diet, alcohol, and smoking on the incidence of non-communicable diseases at local, national, and global levels.
The basic principles of photosynthesis.	How to measure and calculate the rate of photosynthesis, and how different factors affect the rate of photosynthesis.
The differences between aerobic and anaerobic respiration.	How an oxygen debt builds up during anaerobic respiration in your muscles.

Required Practicals

Practical		Topic
2	Investigating the effects of antiseptics and antibiotics	B5.4
6	Light intensity and the rate of photosynthesis	B8.2

B 5 Communicable diseases

5.1 Health and disease

Learning objectives

After this topic, you should know:

- what health is
- the different causes of ill health
- how different types of disease interact.

Synoptic links

Find out more about diseases in Chapter B6 and Chapter B7.

Synoptic links

You will learn more about cancer in Topic B7.2.

Synoptic link

For more help in interpreting correlations, looks at Maths skills MS2g.

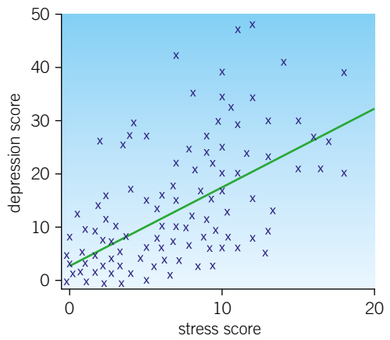


Figure 1 *Scatter graphs can show a correlation between stress and depression*

Your health is a state of physical and mental well-being, not just an absence of disease. It is at least partly based on individual perceptions. A cold or headache that might make you feel ill enough to stay in bed on a school day might be less likely to be a problem if you are on holiday.

What makes us ill?

Communicable (infectious) diseases (e.g., tuberculosis and flu) are caused by **pathogens** such as bacteria and viruses that can be passed from one person to another. **Non-communicable diseases** cannot be transmitted from one person to another (e.g., heart disease and arthritis). Both communicable and non-communicable diseases are major causes of ill health, but other factors can also affect health. Here are three examples:

- Diet – if you do not get enough to eat, or the right nutrients, you may suffer from diseases ranging from starvation to anaemia or rickets. Too much food, or the wrong type of food, can lead to problems such as obesity, some cancers, or type 2 diabetes.
- Stress – a certain level of stress is inevitable in everyone's life and is probably needed for our bodies to function properly. However, scientists are increasingly linking too much stress to an increased risk of developing a wide range of health problems. These include heart disease, certain cancers, and mental health problems.
- Life situations – these include:
  - the part of the world where you live
  - your gender
  - your financial status
  - your ethnic group
  - the levels of free health care provided where you live
  - how many children you have
  - local sewage and rubbish disposal.

People often have little or no control over their life situation, especially as children or young people. Yet such factors have a big effect on health and well-being and are responsible for many causes of ill health around the world. These include communicable diseases such as diarrhoeal diseases and malaria, through to non-communicable diseases such as heart disease and cancer.

How health problems interact

In the next three chapters you will be looking at different types of diseases in isolation. It is important to remember that in the real world, different diseases and health conditions happen at the same time. They interact and often one problem makes another worse. Here are a number of examples – you will learn more about the details of many of these conditions in later chapters.

- Viruses living in cells can trigger changes that lead to cancers – for example, the human papilloma virus can cause cervical cancer.
- The immune system of your body helps you destroy pathogens and get better. If there are defects in your immune system, it may not work effectively. This may be a result of your genetic makeup, poor nutrition, or infections such as HIV/AIDS. This means you will be more likely to suffer from other communicable diseases (Figure 2).
- Immune reactions initially caused by a pathogen, even something like the common cold, can trigger allergies to factors in the environment. These allergies may cause skin rashes, hives, or asthma.
- Physical and mental health are often closely linked. Severe physical ill health can lead to depression and other mental illness.
- Malnutrition is often linked to health problems including deficiency diseases, a weakened immune system, obesity, cardiovascular diseases, type 2 diabetes, and cancer.

The interaction between different factors, including lifestyle, environment, and pathogens, is an important principle to remember as you look at different types of disease.

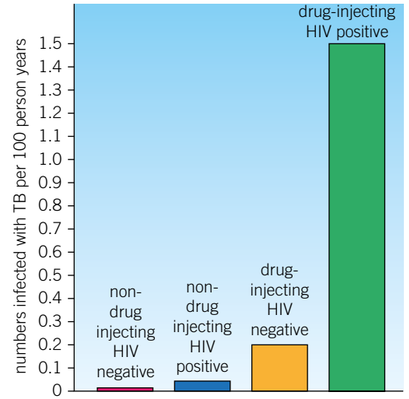


Figure 2 *Data collected in the Netherlands looks at the interaction between a number of health problems including HIV status and drug use in the incidence of tuberculosis (TB) in Amsterdam*

1 Define what is meant by good health. [1 mark]

2 **a** State three different factors that can cause ill health. [3 marks]
b Give an example of ill health that each factor can produce. [3 marks]

3 **a** What health interactions does the data in Figure 2 cover? [2 marks]
b What effect does injecting drugs have on your chances of becoming infected with tuberculosis (TB)? [1 mark]
c Which group has the greatest chance of getting TB? [1 mark]
d How much more likely is it for an injecting drug user who is HIV positive to get tuberculosis than for an injecting drug user who is HIV negative.
Give your answer to the nearest whole number. [2 marks]

4 Explain how the interactions between different types of disease can affect the prevalence of a disease around the World. [6 marks]

Key points

- Health is a state of physical and mental well-being.
- Diseases, both communicable and non-communicable, are major causes of ill health.
- Other factors including diet, stress, and life situations may have a profound effect on both mental and physical health.
- Different types of diseases may and often do interact.

B5.2 Pathogens and disease

Learning objectives

After this topic, you should know:

- what pathogens are
- how they cause disease
- how pathogens are spread.

Figure 1 *Many bacteria are very useful to humans but some, such as this strain of* E. coli, *are pathogens and cause disease*

Synoptic link

Remind yourself about the structure of bacteria by looking back to Topic B1.3.

Communicable diseases, also known as infectious diseases, are found all over the world. **Microorganisms** that cause disease are called pathogens. Pathogens may be bacteria, viruses, protists, or fungi, and they infect animals and plants, causing a wide range of diseases.

Communicable diseases are caused either directly by a pathogen or by a toxin made by a pathogen. The pathogen can be passed from one infected individual to another individual who does not have the disease. Some communicable diseases are fairly mild, such as the common cold and tonsillitis. Others are known killers, such as tetanus, influenza, and HIV/AIDS.

Sometimes communicable diseases can be passed between different species of organisms. For example, infected animals such as dogs or bats can pass rabies on to people. Tuberculosis can be passed from badgers to cows, and from cows to people.

What are the differences between bacteria and viruses?

Bacteria and viruses cause the majority of communicable diseases in people. In plants, viruses and fungi are the most common pathogens.

Bacteria are single-celled living organisms that are much smaller than animal and plant cells. Bacteria are used to make food such as yogurt and cheese, to treat sewage, and to make medicines. Bacteria are important both in the environment, as decomposers, and in your body. Scientists estimate that most people have between 1 and 2 kg of bacteria in their guts, and they are rapidly discovering that these bacteria have a major effect on our health and well-being.

Pathogenic bacteria are the minority – but they are significant because of the major effects they can have on individuals and society.

Viruses are even smaller than bacteria. They usually have regular shapes. Viruses cause diseases in every type of living organism.

How pathogens cause disease

Once bacteria and viruses are inside your body, they may reproduce rapidly.

- Bacteria divide rapidly by splitting in two (called binary fission). They may produce toxins (poisons) that affect your body and make you feel ill. Sometimes they directly damage your cells.
- Viruses take over the cells of your body. They live and reproduce inside the cells, damaging and destroying them.

Common disease symptoms are a high temperature, headaches, and rashes. These are caused by the way your body responds to the cell damage and toxins produced by the pathogens.

How pathogens are spread

The more pathogens that get into your body, the more likely it is that you will develop an infectious disease. There are a number of ways in which pathogens spread from one individual to another.

- By air (including droplet infection). Many pathogens including bacteria, viruses, and fungal spores (that cause plant diseases) are carried and spread from one organism to another in the air. In human diseases, droplet infection is common. When you are ill, you expel tiny droplets full of pathogens from your breathing system when you cough, sneeze, or talk (Figure 2). Other people breathe in the droplets, along with the pathogens they contain, so they pick up the infection. Examples include flu (influenza), tuberculosis, and the common cold.
- Direct contact. Some diseases are spread by direct contact of an infected organism with a healthy one. This is common in plant diseases, where a tiny piece of infected plant material left in a field can infect an entire new crop. In people, diseases including sexually transmitted infections, such as syphilis and chlamydia, are spread by direct contact of the skin. Pathogens such as HIV/AIDS or hepatitis enter the body through direct sexual contact, cuts, scratches, and needle punctures that give access to the blood. Animals can act as vectors of both plant and animal diseases by carrying a pathogen between infected and uninfected individuals.
- By water. Fungal spores carried in splashes of water often spread plant diseases. For humans, eating raw, undercooked, or contaminated food, or drinking water containing sewage can spread diseases such as diarrhoeal diseases, cholera, or salmonellosis. The pathogen enters your body through your digestive system.

Lifestyle factors often affect the spread of disease. For example, when people live in crowded conditions with no sewage system, infectious diseases can spread very rapidly.

Figure 2 *Droplets carrying millions of pathogens fly out of your mouth and nose at up to 100 miles an hour when you sneeze*

Synoptic link

For more information on bacteria that are resistant to antibiotics, see Topic B15.8.

1 **a** What causes infectious diseases? [1 mark]
b How do pathogens make you ill? [2 marks]

2 **a** Give two ways in which diseases are spread from one person to another. [2 marks]
b Give two ways in which diseases are spread from one plant to another. [2 marks]
c For each method given in part **a** and part **b**, explain how the pathogens are passed from one organism to the other. [4 marks]

3 Describe and explain the main differences between bacteria and viruses, and how they cause disease. [6 marks]

Key points

- Communicable diseases are caused by microorganisms called pathogens, which include bacteria, viruses, fungi, and protists.
- Bacteria and viruses reproduce rapidly inside your body. Bacteria can produce toxins that make you feel ill.
- Viruses live and reproduce inside your cells, causing cell damage.
- Pathogens can be spread by direct contact, by air, or by water.

B5.3 Growing bacteria in the lab

Learning objectives

After this topic, you should know:

- that bacteria multiply by simple cell division
- how to grow an uncontaminated culture of bacteria in the lab
- how uncontaminated cultures are used
- why bacteria are cultured at lower temperatures in schools than in industry.

Synoptic links

You learnt about mitosis, the process behind binary fission in Topic B2.1.

Figure 1 *When working with the most dangerous pathogens, scientists need to be very careful. Sensible safety precautions are always needed when working with microorganisms*

Study tip

It is important to sterilise solutions and equipment to kill the bacteria already on them. Otherwise they would grow and contaminate the culture to be studied.

To find out more about microorganisms, scientists need to culture them. This means they are grown in very large numbers so that scientists can see all of the bacteria (the colony) as a whole. Scientists can find out what nutrients they need to grow and investigate which chemicals are best at killing them. Bacteria are the most commonly cultured microorganisms. They divide rapidly and easily by simple cell division (**binary fission**).

Growing microorganisms in the lab

To culture (grow) microorganisms, you must provide them with everything they need. This means giving them a liquid or gel containing nutrients – a **culture medium**. This contains carbohydrate as an energy source, various minerals, a nitrogen source so they can make proteins, and sometimes other chemicals. Most microorganisms also need warmth and oxygen to grow.

Hot **agar gel** is poured into a Petri dish. It is then left to cool and set, before you add the microorganisms. You can also culture microorganisms in a flask of sterile nutrient broth solution.

You need uncontaminated cultures of microorganisms to investigate the effects of chemicals such as disinfectants and antibiotics. Contamination can come from your skin, the air, the soil, or the water around you. It is important to avoid any unnecessary contamination. You must take great care when you are culturing microorganisms. The bacteria you want to grow may be harmless. However, there is always the risk that a **mutation** (a change in the DNA) will take place and produce a new and dangerous pathogen.

Growing useful organisms

You can prepare an uncontaminated culture of microorganisms in the laboratory on sterile agar plates by following a number of steps.

Step 1:

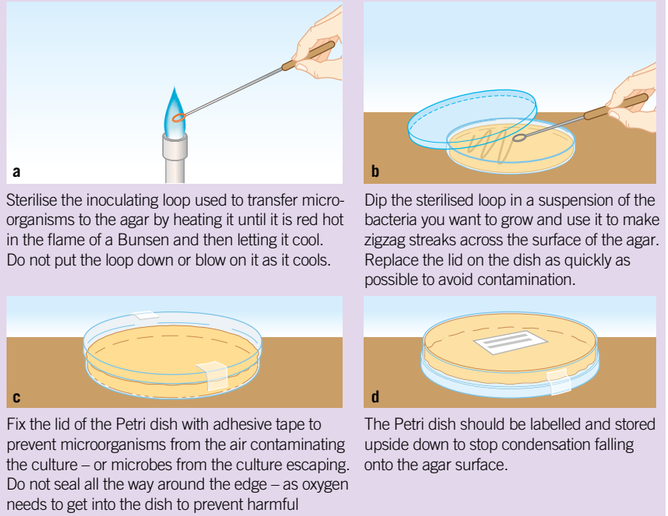
The Petri dishes on which you will grow your microorganisms must be sterilised before use. The nutrient agar must also be sterilised to kill off any unwanted microorganisms. Glass dishes can be sterilised by heating. A special oven called an autoclave is often used. It sterilises using steam at high pressure. Plastic Petri dishes are often bought ready-sterilised. UV light or gamma radiation is used to kill the bacteria.

Step 2:

The next step is to **inoculate** the sterile agar with the microorganisms you want to grow (Figure 2).

Step 3:

Once you have inoculated your plates, the secured Petri dishes need to be incubated (kept warm) for several days so the microorganisms can grow (Figure 3). Petri dishes should be stored upside down so condensation does not fall from the lid onto the agar surface.



a Sterilise the inoculating loop used to transfer microorganisms to the agar by heating it until it is red hot in the flame of a Bunsen and then letting it cool. Do not put the loop down or blow on it as it cools.

b Dip the sterilised loop in a suspension of the bacteria you want to grow and use it to make zigzag streaks across the surface of the agar. Replace the lid on the dish as quickly as possible to avoid contamination.

c Fix the lid of the Petri dish with adhesive tape to prevent microorganisms from the air contaminating the culture – or microbes from the culture escaping. Do not seal all the way around the edge – as oxygen needs to get into the dish to prevent harmful anaerobic bacteria from growing.

d The Petri dish should be labelled and stored upside down to stop condensation falling onto the agar surface.

Figure 2 *Culturing microorganisms safely in the laboratory*

In school and college laboratories, the maximum temperature at which cultures are incubated is 25 °C. You are surrounded by disease-causing bacteria all the time. If you cultured bacteria at 37 °C (human body temperature), there would be a high risk of growing some dangerous pathogens. If you use a lower temperature, you reduce the likelihood of growing pathogens that might be harmful to people. In industrial conditions, bacterial cultures are often grown at higher temperatures to enable the microorganisms to grow more rapidly – for example, insulin-producing genetically modified (GM) bacteria. A hospital lab also incubates human pathogens at 37 °C, so that they grow as fast as possible and are identified sooner.

1 **a** Why do scientists culture microorganisms in the laboratory? [2 marks]

b Explain why agar gel is important in setting up bacterial cultures. [2 marks]

2 **a** Suggest why bacteria are grown at 25 °C or below in the school lab when this is not their optimum temperature for growth. [1 mark]

b Explain why Petri dishes are not opened before incubation once they have been inoculated and sealed. [2 marks]

c Explain why bacteria are often cultured at much higher temperatures in industrial plants and hospital laboratories. [3 marks]

3 When you set up a culture of bacteria in a Petri dish you give the bacteria everything they need to grow as fast as possible. However, these ideal conditions do not last forever. Suggest what might limit the growth of the bacteria in a culture on a Petri dish. [6 marks]

Figure 3 *The colonies of microorganisms that grew from a sneeze*

Key points

- An uncontaminated culture of microorganisms can be grown using sterilised Petri dishes and agar. You sterilise the inoculating loop before use and fix the lid of the Petri dish to prevent unwanted microorganisms getting in.
- Uncontaminated cultures of microorganisms are needed for investigating the action of disinfectants and antibiotics.
- Cultures should be incubated at a maximum temperature of 25 °C in schools and colleges to reduce the likelihood of pathogens growing that might be harmful to humans.