HEALTH and DISEASE
The mould growing on the petri dish is Penicillium, from which the antibiotic penicillin is obtained. Penicillin, first used in 1943, revolutionised the treatment of disease.

Look to your health; and if you have it, praise God, and value it next to a good conscience; for health is the second blessing that we mortals are capable of; a blessing that money cannot buy.

Izaak Walton (1593–1683)

Soldiers have rarely won wars. They more often mop up after the barrage of epidemics. And typhus, with its brothers and sisters – plague, cholera, typhoid and dysentery – has decided more campaigns than Caesar, Hannibal, Napoleon and all the generals of history.

Hans Zinsser

This section of the book deals with a wide range of diseases, both infectious and non-infectious. You will learn that although some microorganisms cause disease, others are used in its treatment or as sources of beneficial products. You will also learn how the human body responds to disease, how your lifestyle can affect your chances of contracting a disease, and how diseases can be treated.
Infectious diseases

**What is health?**
Good health is more than just freedom from disease and infirmity. The term includes mental and social as well as physical well-being. A healthy person is able to use all of his or her mental, spiritual, and physical resources to maximise the chance of survival, to live a happy and fulfilling life, and to help dependants and society. Lifestyle can have a great effect on human health, particularly with regard to sexually transmitted diseases such as AIDS and non-infectious diseases such as diabetes (spread 8.3), cancer (spreads 16.5 and 16.6), and coronary heart disease (spreads 16.7 and 16.8). Changes in lifestyle, for example by drinking less alcohol, eating a more balanced diet, stopping smoking and taking more exercise, can reduce the risk of contracting these diseases.

**Types of disease**
A disease is often defined medically as any physical or mental disorder or malfunction with a characteristic set of signs and symptoms. This excludes disorders resulting from physical trauma (for example, a leg broken during a football match). Signs are indications of a disease that can be observed by a doctor. Symptoms are indications of disease perceived by a patient.

There are many different ways of classifying diseases. The classification system in table 2 places diseases into eight categories. Some authorities also include a ninth category, self-inflicted diseases, for diseases such as anorexia and alcoholism that appear to be self induced. Diseases may also be classified simply into single-factor diseases or multifactorial diseases, according to the number of causes:

- **Single-factor diseases** have a single cause and usually involve a specific organ or tissue.
- **Multifactorial diseases**, such as those of the heart and blood vessels, have many causes.

Another simple classification is as acute and chronic diseases:

- **Acute diseases** develop rapidly and usually last a short time.
- **Chronic diseases** are usually slow to develop and last a long time.

**Studying patterns of disease: epidemiology**
The study of patterns of disease and of the various factors that affect the spread of disease is called epidemiology.
Epidemiologists have been described as disease detectives. They try to discover the factors that cause a disease and to develop methods to prevent its spread. The main clues they use come from data about the number of people in a particular area (such as a city, a region of a country, or a whole country) affected by specific diseases, and the number who have died. The data are commonly expressed as incidence or morbidity rates, and mortality rates.

The **incidence** or **morbidity** rate is the number of new cases of a disease in a given population occurring during a specific period (a week, month, or year). It is calculated as:

\[
\text{Incidence or morbidity rate} = \frac{\text{number of new cases of a given disease}}{\text{number of individuals in the population}}
\]

To find how many cases of a disease are new, this calculation requires information about the **prevalence rate**. This is the total number of individuals infected in a population at any one time, no matter when the disease began. Information about prevalence rates is very useful in its own right.

The **mortality rate** of a disease may be estimated for a whole population irrespective of whether they have the disease or not:

\[
\text{Mortality rate} = \frac{\text{number of deaths due to a given disease}}{\text{number of individuals in the population}}
\]

Alternatively, it may be calculated using only those people who have the disease:

\[
\text{Mortality rate} = \frac{\text{number of deaths due to a given disease}}{\text{number of people with the same disease}}
\]

Epidemiological studies are used to identify whether a disease is endemic, epidemic, or pandemic:

- **An endemic** disease is always present in a population.
- **An epidemic** is a disease that spreads rapidly, suddenly, and unexpectedly to affect many people. The term does not include expected rises, for example, the increased incidence of influenza that happens every winter in temperate regions.
- **A pandemic** disease affects people over very large areas, such as a continent or even the whole world. AIDS and TB are pandemic at present.

Epidemiological information helps public health workers direct health care efforts effectively to control the spread of infectious diseases. For example, a sudden increase in the morbidity rate for a disease in a particular region may warn that immediate action is needed to prevent a future rise in the number of deaths from the disease. Effective and quick action may also prevent the disease spreading to other areas.

**Table 2 Classification of diseases into eight categories. Note that a disease may belong to more than one category: for example, sickle-cell anaemia is a non-infectious disease and an inherited disease.**

<table>
<thead>
<tr>
<th>Category</th>
<th>Examples</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infectious</td>
<td>Cholera; malaria</td>
<td>A disease caused by an invading organism or virus transmitted from person to person</td>
</tr>
<tr>
<td>disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-infectious</td>
<td>Stroke; sickle-cell anaemia</td>
<td>Any disease that cannot be transmitted from one person to another</td>
</tr>
<tr>
<td>disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inherited</td>
<td>Cystic fibrosis; sickle-cell anaemia; haemophilia</td>
<td>A disease caused by a genetic fault that may be passed from parents to children</td>
</tr>
<tr>
<td>disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degenerative</td>
<td>Arthritis</td>
<td>A gradual decline in function, often associated with ageing</td>
</tr>
<tr>
<td>disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social</td>
<td>Alcoholism</td>
<td>Drug dependence, often induced by social pressures and social behaviour</td>
</tr>
<tr>
<td>disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mental illness</td>
<td>Schizophrenia; anorexia</td>
<td>Disorder of the mind which may or may not have a physical or chemical cause</td>
</tr>
<tr>
<td>disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eating disorder</td>
<td>Anorexia; obesity</td>
<td>A disease caused by undereating or overeating</td>
</tr>
<tr>
<td>disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deficiency</td>
<td>Scurvy; rickets</td>
<td>A disease caused by a poor diet lacking one or more essential nutrients (spread 16.10)</td>
</tr>
<tr>
<td>disease</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Quick check**

1. Explain in what ways health is not just the absence of disease.
2. Which category of disease is transmitted from person to person?
3. Distinguish between morbidity and mortality.

**Food for thought**

Epidemiological studies have revealed great differences in the prevalence of certain diseases between economically well developed countries and countries that are less developed. Which categories of disease do you think are more prevalent in the well developed countries, and which in the less developed countries? Suggest reasons for these differences.
### Smallpox and AIDS

#### The eradication of smallpox

One of the great success stories of twentieth-century medicine has been the eradication of smallpox as a disease. Smallpox was a horrible disfiguring viral disease which, until the 1960s, affected more than 15 million people annually in 33 different countries. In 1956 the WHO launched a campaign to wipe it out. Large populations were vaccinated and people with the disease were isolated. Everyone within a certain area of an outbreak (a spontaneous occurrence of the disease) was vaccinated in a process called **ring vaccination**. In 1977, the last case of smallpox was reported in Somalia. At the time of writing the virus still exists locked up in laboratories in the USA and Russia.

Smallpox was an acute, highly infectious disease transmitted by direct contact. Obvious symptoms of the disease were red spots on the face, trunk, and extremities that changed to pea-sized blisters and became filled with pus (pustules) (figure 1). The pustules were so excruciatingly irritating that sufferers had to be prevented from tearing at their flesh. About 20–30 per cent of those with the disease died; many who recovered were blinded or permanently disfigured.

The eradication of smallpox was successful because:

- The smallpox virus is stable (see spread 17.1 for details of viruses). During the eradication programme it did not mutate, so the same vaccine could be used throughout the programme.
- The smallpox virus does not linger in the body after infection, nor does it infect other animals, so it cannot remain hidden anywhere.
- The living but non-virulent vaccine used was highly effective and easy to administer by a scratching technique (see spread 15.7 for an account of vaccination).
- It was easy to identify people with the disease, so isolation and ring vaccination were effective.

With the concerted efforts of many nations and a great deal of money, the fight against smallpox appears to have been won, but that against AIDS is still raging.

#### AIDS (acquired immune deficiency syndrome)

AIDS is characterised by a suppression of the immune system leading to the development of a number of rare infectious diseases. It is caused by a virus known as HIV (human immunodeficiency virus). The disease was first identified in Los Angeles in 1981, but probably originated in central Africa in the 1950s. It is believed that an HIV-related virus in African green monkeys somehow entered humans, mutated, and evolved into HIV. Since the discovery of the virus, HIV and AIDS have spread across the world to become a scourge of our times (figure 2). It is estimated that between 1990 and 2010, the number of people infected with HIV rose from 8 million to about 34 million. Since the beginning of the epidemic, about 30 million people have died from AIDS-related diseases.

HIV is transmitted mainly sexually: homosexually or heterosexually. The virus can pass from infected semen or vaginal fluids to the blood of the new host through damaged tissue in the rectum, vagina, or penis. It can also be transmitted via infected blood or blood products (for example, through transfusion of infected blood, or through contaminated needles used by drug takers), and from an infected mother to her child across the placenta or as a result of breast-feeding. In 2009, there were about 2.5 million children living with HIV/AIDS; most were infected from their mothers. Fortunately, HIV is a fragile virus and does not survive well outside the body. Therefore, ordinary social contact with HIV-positive people presents no risk of infection.
The action of HIV

HIV is potentially deadly because it attacks particular white blood cells (helper T cells) which are essential components of the body’s immune system (spread 15.5). HIV is a retrovirus which incorporates its genetic material into that of its host cell (spread 17.1). HIV may remain dormant in a cell, with its DNA being replicated each time the host cell divides. At this stage, a person with HIV may be symptomless. This condition may last for several or even many years. However, when active, HIV uses the host’s cellular machinery to manufacture new viruses. The new viruses burst out of the host cell and eventually kill it. Then they find new host cells to infect. When this happens, the body’s immune system is suppressed. The HIV patient develops full-blown AIDS and may succumb to a number of diseases (such as thrush, pneumonia, and a rare type of skin cancer called Kaposi’s sarcoma) that would normally be fought off by the immune system. Death may result from one of these opportunistic diseases (usually cancer or pneumonia) or from a pre-existing disease, such as tuberculosis. There is no known cure for AIDS: modern drugs slow its progress, but cannot stop it.

There are three main reasons why HIV is proving such a difficult enemy to defeat. First, it destroys helper T cells, the very cells that should be defending the body against it (figure 3). Secondly, HIV can remain hidden in cells for months or years. While inactive, it cannot be targeted and destroyed. Thirdly, HIV is extraordinarily variable. Cells in our defence system identify infective agents by the shapes of antigens on their protein coats. HIV escapes detection by frequently changing the shape of its antigens.

Although there is no known cure, antiretroviral therapy is bringing about a steady decline in the number of new infections and reducing significantly the number of AIDS-related deaths. Antiretroviral therapy is a special form of chemotherapy in which the patient takes a combination of two or more antiretroviral drugs, including reverse transcriptase inhibitors and protease inhibitors, designed to keep the amount of HIV in the body low.

Education programmes are also contributing to the decline by informing people about the risks of unprotected sex and the sharing of needles. People who have sex with different partners are told that using condoms reduces the risk of infection but does not eliminate it completely. Only abstinence or completely monogamous relationships between uninfected individuals are completely safe. Partners in a new relationship can check their HIV status by having a blood test. This usually involves screening the blood for particular antibodies. Those with the virus (who are HIV positive) should take great care not to spread the disease.

Q U I C K C H E C K

1. Explain what is meant by ring vaccination.
2. What is the difference between HIV and AIDS?
3. State the main ways in which HIV is transmitted.
4. List the reasons given in this spread why AIDS is more difficult to eradicate than smallpox.

Food for thought
The smallpox virus is not extinct: it still exists in laboratories. Suggest arguments in favour of:

a. retaining the virus
b. eliminating it altogether.
15.3

**OBJECTIVES**

By the end of this spread you should be able to describe the causes, mode of transmission, and control of:

- salmonellosis
- cholera
- tuberculosis (TB).

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**Fact of life**

Robert Koch (1843–1910), a German doctor, was the first to demonstrate the role of bacteria in disease when he infected healthy mice with anthrax by injecting them with material that contained the disease.

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**Bacterial diseases**

**Harmless and pathogenic bacteria**

The human body is home to many millions of bacteria. These bacteria may take nutrients from us and, when present in unusually large numbers, cause rashes and mild discomfort. However, they rarely do any significant damage; indeed, those in the large intestine benefit us by fermenting undigested foods and releasing vitamin K and biotin in the process. These harmless bacteria that normally live on and in us should not be confused with 'germs', those disease-causing (pathogenic) bacteria about which bleach manufacturers are forever warning us.

A bacterial disease is caused by entry of bacteria into a host which can grow and flourish there, causing harm to the host. Such an invasion activates the host's immune system (the biological defence mechanism). If the immune system is unsuccessful in fighting the infection, the host sickness and may die.

**Salmonellosis**

One of the most common routes of bacterial transmission is by eating food. Pathogenic bacteria belonging to the genus *Salmonella* enter via this route, causing a form of food poisoning called **salmonellosis**. The initial source of infection are *Salmonella* in the intestinal tracts of animals. The bacteria enter humans in contaminated food, such as meat and poultry and their products, raw eggs, and unpasteurised milk. Salmonellosis is an acute intestinal infection with an *incubation time* (the interval between exposure to infection and the appearance of the first symptoms) of between 8 and 48 hours. The symptoms are abdominal pain, cramps, diarrhoea, nausea, vomiting, and fever. The disease usually lasts 2–5 days, but may go on for several weeks.

There are many different types of *Salmonella*. *Salmonella typhi*, the bacterium that causes typhoid or enteric fever, produces an endotoxin (a toxin released only after the death of the bacterium). Some strains of *Salmonella enteritidis*, the species that commonly causes simple food poisoning, appear to irritate the gut simply by the large numbers of bacterial cells present. They produce large amounts of gas by fermenting glucose. At the height of infection, as many as one billion *Salmonella* bacteria may be found in each gram of faeces. Most patients with food poisoning recover with rehydration treatment using a salt/sugar solution. In some cases intravenous rehydration is required.

**Cholera**

Cholera is another water-borne and food-borne disease. Like salmonellosis, it is an intestinal infection. It is also treatable and avoidable, yet it kills over 100 000 people each year. The bacterium that causes the disease, *Vibrio cholerae* (figure 1), is prevalent in regions of the world where sanitation is poor, clean water is unavailable, or food is contaminated. Transmission is mainly by eating food or drinking water contaminated with faeces. The incubation period is short (1–5 days). The bacteria release an enterotoxin called choleraagen, a poison that affects the lining of the intestines specifically, causing vomiting and large quantities of watery diarrhoea (described graphically as ‘rice water’). A great deal of water may be lost from the body (10–15 dm³ per day in a very severe infection). This can quickly lead to severe dehydration and death if treatment is not given promptly: without treatment, over 50 per cent of cholera patients may die. However, effective treatment is cheap and simple. Those who are able to drink (80–90 per cent of patients) can be treated with a solution of salts and glucose, a process called oral rehydration therapy. Most of those too ill to drink recover if given an intravenous drip. In severe cases, an antibiotic such as tetracycline is often effective.
The prevention and control of both cholera and salmonellosis depend on:

- the supply of clean and safe drinking water (a number one priority)
- hygienic disposal of faeces
- hygienic handling and preparation of food (for example, correct refrigeration, cooking food, and eating food while it is still hot)
- preventing contamination from flies and other vectors.

Although these measures are usually simple to carry out in economically developed regions of the world, they are often difficult to achieve following natural disasters or in poor, overcrowded communities.

**Tuberculosis**

Tuberculosis (TB) is caused by an airborne bacterium, *Mycobacterium tuberculosis* (figure 2). Coughs, sneezes, and even speaking can spread the disease quickly from an infected person to another person, especially in areas of social deprivation and overcrowding. Currently, about one-third of the world's population is infected with TB. In 2010, 8.8 million people fell ill with TB and 1.4 million died from the disease. Over 95 per cent of deaths occurred in low- or middle-income countries. Since 1993, TB has been regarded by the WHO as a global emergency.

*M. tuberculosis* is a rod-shaped bacterium that is referred to as invasive because it enters and spreads through tissues, most commonly those of the lungs. An infection may result in an immediate disease, disease later in life, or no disease at all. The reason for the different outcomes is unclear, but it appears to depend on the state of a person's immunity. TB is an opportunistic infection, striking people with a depressed immunity (for example, it is the leading cause of death of HIV-positive people; see spread 15.2). A patient has small rounded lesions called tubercles, and suffers weight loss and muscle wasting (hence the common name of the disease in Victorian times, consumption).

In 1944, streptomycin was the first anti-TB drug to be used successfully to treat a TB patient. Until then, TB was called the 'White Plague' and, because it was untreatable, it was regarded by many as the most dreaded enemy of humankind. Although these first drugs were effective, they had to be taken for about 6 months. Many patients failed to complete their treatment properly, enabling drug-resistant TB strains to emerge. These strains have become more common. Multidrug-resistant TB (MDR-TB) is even resistant to isoniazid and rifampicin, two very powerful anti-TB drugs. While MDR-TB is generally treatable, it requires extensive chemotherapy (up to 2 years of treatment) which includes a cocktail of expensive anti-TB drugs that produce more side-effects. In 2006 extensively drug-resistant (XDR) TB began to appear. This is even more difficult to treat.

**Food for thought**

Despite an intense vaccination programme and the availability of antibacterial drugs, TB continues to pose serious health problems. In particular, there has been a recent increase of TB in the economically developed countries in western Europe and North America. Suggest reasons for this.

**Quick check**

1. What is the main way in which salmonellosis is spread?
2. a. What is an enterotoxin?
   b. Which of the following organisms produces an enterotoxin: *Salmonella*, *Vibrio cholerae*, *Mycobacterium tuberculosis*?
3. What makes tuberculosis highly infectious?