


Changes to a Cell's DNA

The DNA that is found in almost every cell in your body forms your genetic code. It acts like the operating system of the cell, and it controls all your body's functions. What happens when the DNA is altered?

Mutations

In Section 2.3, you learned that the DNA in each gene provides the instructions to make a specific protein. The ribosomes in the cytoplasm assemble different amino acids in a specific order, according to the DNA's instructions. If the DNA in a gene has been changed in some way, the DNA's repair mechanism will often repair the damage. If the change in the DNA is not repaired, then the RNA molecule that is constructed will contain instructions that are altered. The altered instructions may direct the ribosomes to put the amino acids together in a different order, which will cause a change in the structure of the protein. For example, a change in the DNA in the hemoglobin genes may change the shape of the hemoglobin molecule. A change in the DNA, or the genetic code of a cell, is called a **mutation**. Mutations can be classified as beneficial, neutral (cause no effect), or harmful.

Genetic diseases are caused by harmful mutations. A harmful mutation in a gene's DNA causes changes in the protein that is produced, which in turn causes changes to how the body functions. For example, cystic fibrosis (CF) is a genetic disease that affects many parts of the body. A common symptom of CF is a buildup of thick mucus in the lungs (Figure 1). CF is caused by a mutation in a gene known as the CFTR gene. The normal CFTR gene codes for a protein that helps move certain chemicals into and out of the cell. When the gene has a mutation, the shape of the protein changes, and it no longer does its job properly. The change in the shape of the protein causes the many symptoms of CF. 

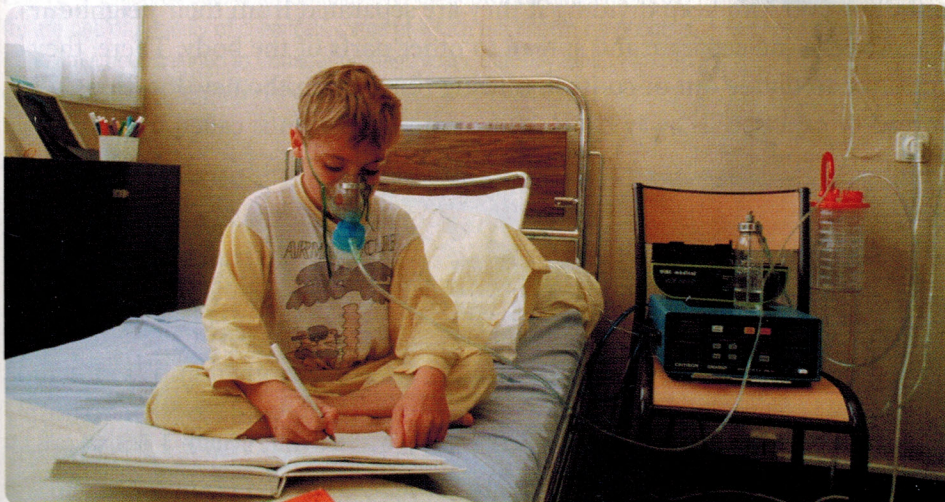


Figure 1 People with cystic fibrosis often get lung infections due to excess mucus in the lungs.

LEARNING TIP

Skim (read quickly) to get a general sense of Section 2.5. Examine the headings, and scan for words in bold. Ask yourself, "What information is important here?"

Did You KNOW?

A Beneficial Mutation

In Japan, a type of bacterium has been found that gets its nutrition from digesting nylon! This ability is caused by a beneficial mutation. Nylon was invented in 1935. Before that year, the mutation would not have been beneficial to the bacterium.

If you would like to learn more about mutations, go to

www.science.nelson.com 

LEARNING TIP

Make connections to your prior knowledge. Ask yourself, "What do I already know about cancer?" Consider the information you have learned in school, read on your own, or observed and experienced.



Figure 2 A wart is a benign tumour on the skin. Benign tumours usually cause no harm.

Did You Know?

Not Just Humans Get Cancer

Many other organisms besides humans can get cancer. Sunflowers and tomatoes often develop a type of cancer called a gall. This is a plant tumour caused by viruses, bacteria, fungi, or insects. There is evidence of cancerous tumours in dinosaur bones as well as in the cells of linen (made from the flax plant) found wrapped around ancient mummies.

Insulin is a protein that the body needs to control the amount of sugar in the blood. It is produced by special cells in the pancreas. In people that have diabetes, the cells that produce insulin have either stopped producing it or produce insulin that doesn't work. Why does this happen? The DNA in the cells that produce insulin has been altered, so the instructions for making insulin have been altered. As a result, the cells cannot produce insulin from the instructions, or the instructions produce insulin molecules that do not work.

Cancer

Harmful mutations may cause cancer. **Cancer** is a disease in which cells divide very rapidly and uncontrollably. A mutation in the genes that control the cell-division process in the cell cycle causes cell division to go out of control. Some types of cells have a shorter cell cycle than others. The length of the cell cycle is unique to each type of cell and is determined by the DNA. If a mutation happens in the DNA that controls the cell cycle in a bone cell, the bone cell starts to divide much more quickly than normal bone cells do. The mutation gets passed on to the daughter cells, since the DNA of the parent cell is duplicated in the daughter cells. So the daughter cells divide uncontrollably as well.

Characteristics of Cancer Cells

As the cancer cells keep dividing, they accumulate in abnormal masses called tumours. There are two types of tumours: benign and malignant. **Benign tumours** are masses of cells that grow but stay in one place and usually do not interfere with the normal functioning of the surrounding tissue or organ (Figure 2). Warts are benign tumours. Benign tumours can usually be removed by surgery. **Malignant tumours** invade the surrounding tissues and interfere with the normal functions of the tissues and organs.

Rapidly dividing cancer cells use up more nutrients than normal cells, but they do not carry out the functions of normal cells. Figure 3 shows normal cells and cancer cells. The cancer cells have highly visible enlarged nuclei because they are constantly dividing. Most normal cells stay in contact with neighbouring cells and cannot divide if they are separated from the neighbouring cells. Cancer cells, however, can keep dividing if they are separated from their neighbours. Cancer cells can separate and spread to other parts of the body. There, they continue to divide out of control, causing tumours in the new locations. The spread of cancer cells away from their original location is called **metastasis**.

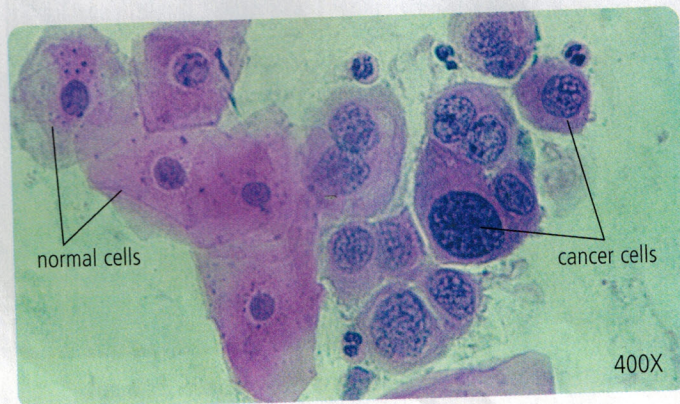


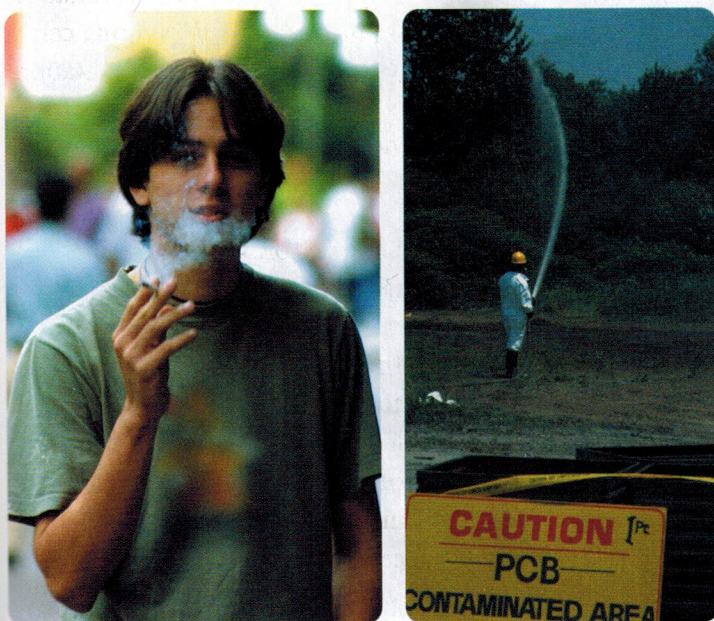
Figure 3 Normal cells, and cancer cells. Notice the enlarged nuclei in the cancer cells.

Causes of Cancer

Any substance that can cause cancer is called a **carcinogen**. Scientists have discovered many carcinogens such as asbestos, certain pesticides, X-rays, some viruses, and many of the chemicals found in tobacco (Figure 4(a)). The environment contains a variety of carcinogens, many of which are by-products of industrial processes (Figure 4(b)). Many carcinogens, however, remain unknown. Avoiding known carcinogens decreases the chances of developing cancer. By not smoking and avoiding second-hand smoke, people reduce their exposure to the carcinogenic chemicals in tobacco smoke. By reducing time spent in the sun and/or wearing sunscreen, people reduce their exposure to the carcinogenic ultraviolet rays found in sunlight. Figure 5 shows risk factors that are associated with cancer. As well as these risk factors, your own genetic makeup influences your chances of getting cancer.

LEARNING TIP

Look at Figure 5. How do the parts of the circle graph relate to each other? How does the legend help to explain the information in the graph?



(a)

(b)

Figure 4 Cigarette smoke (a) contains over 60 known carcinogens. PCBs (b) are one of a family of chemicals, some of which are known carcinogens. PCBs have been banned in Canada for many years, but they remain in the environment for a very long time.

Cancer Risk Factors

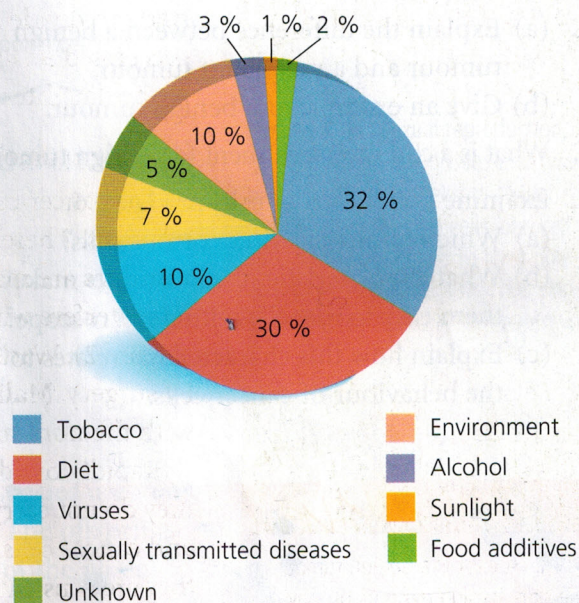


Figure 5 Estimates of risk factors are calculated in percentages.

Treating Cancer

Some cancers can be treated quite successfully if they are diagnosed early. Surgery can remove tumours before the cells metastasize. Radiation can be used to kill cancer cells by disrupting cell division in the rapidly dividing cancer cells. Chemotherapy involves using drugs to stop the cancer cells from dividing. Sometimes combinations of these treatments are used to treat a cancer patient. Unfortunately, chemotherapy and radiation also kill some fast-growing healthy cells, such as skin and hair cells, in addition to the cancer cells. This is why radiation therapy and chemotherapy can produce some unpleasant side effects, such as radiation burns, hair loss, nausea, and vomiting.

Did You KNOW?

Sunburns

After repeated sunburns, it can take 10 to 30 years for skin cancer to develop. Take a sun-sense quiz and find out more about cancer.

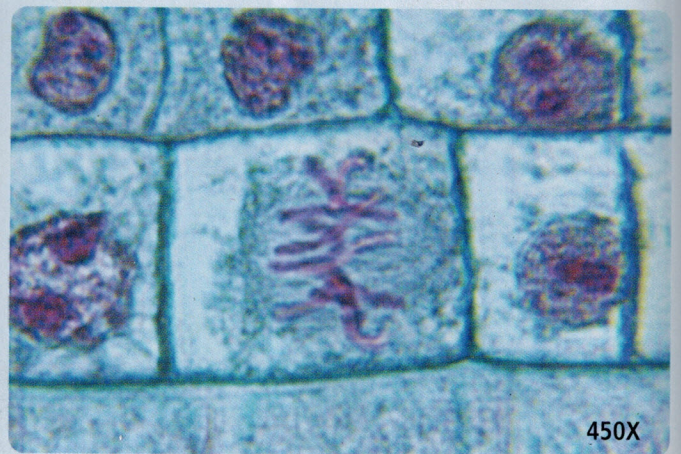
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1. What disease may result from a harmful mutation?
2. Which part of the cell does cancer affect?
3. Why do some normal cells have different lengths of cell cycles? Give two examples.
4. Describe two characteristics of cancer cells.
5. What characteristic of cancer cells allows cancer to spread to other areas of the body?
6. What is a carcinogen? Give two examples of known carcinogens.
7. Explain why not all mutations cause cancer.
8. (a) Explain the difference between a benign tumour and a malignant tumour.
(b) Give an example of a benign tumour.
9. What is a common treatment for benign tumours?
10. Examine the photos of cells in Figure 6.
 - (a) Which photo shows cancerous cells?
 - (b) What characteristic of cancer cells makes them easy to identify with a microscope?
 - (c) Explain how this characteristic relates to the behaviour of cancer cells.



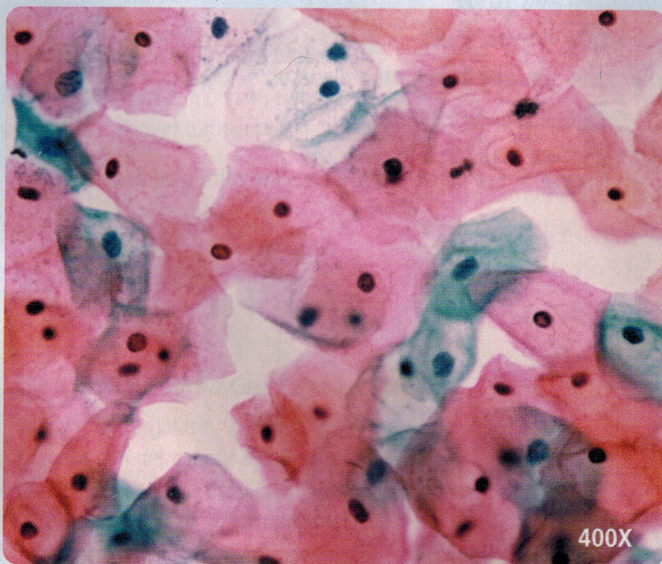
B



C

Figure 6

11. Why are cancers that metastasize more dangerous than cancers that do not?
12. Explain the differences between radiation and chemotherapy.
13. How does radiation affect cancer cells?
14. The percentage of people getting cancer is increasing. Considering the known causes, how can this increase be explained?
15. Explain why cancer treatment may cause burns and hair loss.



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