

Cell Division Going Wrong: Cancer

Uncontrolled cell division is called cancer. Understanding how cells reproduce is an essential component of understanding cancer.

Cancer: a broad group of diseases that result in uncontrolled cell division.

Cancer results from a change occurs in the cell, affecting the DNA that controls the cell cycle, thus preventing the cells from staying in interphase for the normal length of time. Hence, the cell and all its daughter cells continue to undergo cell division uncontrollably.

When a cell's DNA is changed, it is known as a **mutation**.
(A change in the usual order of a gene's A, C, T and G building blocks is called a mutation.)

Apoptosis is the normal death of a cell that is no longer useful or is not functioning normally. Death of cells allows space for new healthy cells to grow.

A **cancer cell** is a cell with abnormal genetic material that divides uncontrollably and can spread to other body parts.

Cancer cells are irregular in shape with less cytoplasm than normal cells. They have thicker chromosomes, less cytoplasm, and do not fit together as well as normal cells.

Many cancer cells have been found to make an enzyme called 'telomerase', which signals they do not have to stop dividing. Thus, they keep reproducing, even if their DNA has been mutated.

Normal cells usually live for ~ 50 – 60 cell divisions, cancer cells can seem to be "immortal" because they do not stop dividing.

A normal cell will undergo apoptosis if it is damaged genetically, whereas a cancer cell will continue to divide.

Normal cells stick together to form masses of cells as appropriate, however cancer cells do not stick to other cells, they behave independently.

Cell Growth Rates and Cancer

A cancer cell continues to divide despite messages from the nucleus or surrounding cells to stop growing and undergoing cell division. This uncontrolled growth and cell division results in creating a rapidly growing mass of cells that form a lump or tumour.

Tumours reduce the effectiveness of other body tissues.

Tumour: a mass of cells that continue to grow and divide without any obvious function in the body; i.e. an abnormal clump or group of cells.

Example a lung tumour takes up space in the lung that should be filled with normal cells performing normal lung functions. Also abnormal cells use up nutrients that are required by normal cells.

If the cells of the lump, i.e. the tumour have no effect on the surrounding tissues, then this is called a benign tumour.

Benign tumour: a tumour that does not affect surrounding tissues.

However, if this mass of cells interferes with the functioning of the surrounding cells, such as in the production of enzymes and hormones, then this tumour is known as a **malignant tumour**, it is a cancerous tumour.

Sometimes, the mass of cancer cells breaks away from the original, i.e. the primary tumour and moves to a different part of the body —continuing to grow and divide uncontrollably creating a new secondary tumour. This process of cancer cells breaking away from the primary tumour and establishing another secondary tumour is known as **metastasis**.

Causes of Cancer

1. A random change in the DNA, i.e. mutation
2. Carcinogens: environmental factors, e.g. X-rays, UV rays from tanning beds and sunlight, tobacco smoke, asbestos
3. Viral infections, .e.g. human papilloma virus (HPV), hepatitis B
4. Certain chemicals in plastics, many organic solvents
5. Some cancer causing mutations are genetic, i.e. hereditary, i.e. the DNA passed from one generation to the next may contain information that leads to disease, (e.g. breast cancers and colon cancers)

Carcinogen: any environmental factor that causes cancer.

Mutagens: are chemicals or other forces that cause mutations in the DNA.

Carcinogens are often linked to a higher rate of cancer in humans. They are useful in predicting higher probabilities of incidence of cancer, but carcinogens have different effects on different people.

Cancer is a complex disease, and its causes are varied, and how and what causes mutations are unknown.

Cancer Screening

Cancer screening means checking for cancer even if there are no symptoms.

Many early stages of cancers have no noticeable symptoms. However, many screening tests are available to diagnose cancer early and improve treatment success rates.

Methods of screening:

Medical check-up, specialist appointments, self-examination, for women a regular Pap test, blood test called the PSA: screen for prostate cancer for men, blood test for colon cancer, skin test by doctor or dermatologist to look at moles, new growth and sores (ABCD of moles: asymmetry, border, colour, and diameter).

Reducing Your Cancer Risk

The risk of cancer can be reduced by making lifestyle decisions to reduce the intake of carcinogens, eating healthy foods, and performing regular self-screenings to detect cancer in its early stages.

Diagnosing Cancer

Various imaging technologies can be used to identify abnormalities and diagnose cancer.

Imaging techniques: Endoscopy, X-ray, Ultrasound, CT scanning (or CAT scan), MRI

Summary of different imaging technologies:

Technology	What it does	Used for viewing (for example)
X-ray	forms image of body tissues	breast
ultrasound	sound waves form visual image	heart, liver, soft tissue
endoscopy	fibre-optic cable enters body	digestive system
CT scan	multiple X-rays from different angles gives 3-D images	liver
MRI	magnetic 3-D image, higher resolution than CT	brain

Examining Cells

If any of the medical tests or images show abnormalities, the next step is to examine a sample of the suspected cancer cells under a microscope.

This can be done by a blood test, (e.g. for leukemia), or removing a sample of the tumour cells surgically and examining under a microscope, known as “taking a biopsy”.

Treatment for Cancer

The main purpose of cancer treatment is to slow down the growth of the tumours or to destroy as many cancer cells as possible.

There are three main methods of treating cancer:

1. **Surgery:** involves cutting out the cancerous tissue. Surgery works well in cases where the cancerous tissue is well defined. When the cancerous tissue is diffuse, it is not possible to remove it without harming the patient.
2. **Chemotherapy:** employs drugs to kill cancer cells or stop them from growing, and reduces the size of the tumour.
3. **Radiation therapy:** uses high energy radiation to kill cells and reduces the size of the tumour; and leave surrounding healthy tissue intact.

Chemotherapy and radiation can both eliminate more diffuse cancers. However both of these methods can cause damage to healthy tissue.

All three of these methods can fail to remove all cancerous tissue.

The new method in fighting cancer is **biophotonics**: the technology of using beams of light energy to diagnose, monitor, and treat living cells and organisms, it has fewer side effects than conventional radiation treatment, as it can more accurately target the cancerous tissue.

Comparison of Healthy cells with Cancer Cell

	Rate of cell division	Level of specialization	Length of mitosis	Appearance of cell	Ability to move
Healthy cells	low	high	long cycle	regular	do not usually migrate
Cancer cells	high	none	short cycle	irregular, odd shaped	able to migrate

Assignment: Cell Division Going Wrong: Cancer

1. Give two examples in your body where you would find cells that live for a short time. Explain why.
2. Describe three conditions during the cell cycle that determine whether the cycle will be allowed to continue.
3. Some treatments for cancer involve the use of drugs that specifically attack cells that are actively dividing. Why is this treatment effective for fighting cancerous cells?
4. A drug used in chemotherapy results in chromosomes to move incorrectly during mitosis. As a result the daughter cells have either too much or too little genetic information. Explain why this drug causes the cancer cells to die.
5. Sunscreens protect your skin by blocking types of ultraviolet radiation. Explain why the population is encouraged to use sunscreens.
6. Three samples of cells from three different patients were unlabelled. One sample was from an 80-year old man, one was from a 10-year old boy, and one was from a person with skin cancer. Explain how you could determine which sample belonged to which patient.
7. Complete the following statements:
 - a. The only way to confirm cancer is by _____.
 - b. Taking a _____ is a technique in which part of a tumour is removed surgically to look at _____ under a microscope.
 - c. Cancer is a group of diseases that result from _____.
 - d. Some cancer cells are able to move to new areas of the body in a process called _____.
 - e. _____ and _____ minimize the risk of cancer.
 - f. The process in which cancer cells break away from the original (primary) tumour and move to a different part of the body is called _____.
 - g. Tumours that are found to be cancerous are called _____.
 - h. Random changes in the DNA that may lead to cancer cells are called _____.
 - i. _____ uses beams of light to detect and treat cancer and has fewer side effects than conventional radiation treatment, as it can more accurately target the cancerous tissue.
8. Explain why an X-ray may represent an increased danger to a fetus.
9. Explain why being unusually tired is one of the symptoms that someone with cancer might have.
10. Predisposition to cancer can be passed on genetically. Why do you suppose this is true?
11. How would the cell cycle of a cancer cell be different from that of a normal cell?
12. What are some features of cancer cells that make them dangerous?
13. Why are skin cells so susceptible to cancer?
14. Some antibiotics interfere with a bacterial cell's ability to copy DNA.
 - a. How would this type of antibiotic be able to stop a bacterial infection?
 - b. These antibiotics do not have any effect on the DNA replication of human cells. Why is this important?
15. Explain the connection between mitosis and cancer.
16. Explain why cancer is rare even though mutations happen constantly in cells.
17. Draw and label a diagram of the cell cycle of a cancerous cell.
18. Compare and contrast the terms *mutation* and *mutagen*.
19. Why is radiation considered to be a mutagen and carcinogenic?
20. Explain why biophotonics is a preferred technique for cancer treatment.