A common misconception arises from news stories suggesting we are experiencing a cancer "epidemic." This only appears to be the case because the number of new cancer cases reported is rising as the population is both expanding and aging. Older people are more likely to develop cancer; however, this trend is offset by new births, which are also increasing, and cancer is rare among the young. So as more and more members of a 75-million-strong "baby-boomer" cohort begin shifting en masse to older, more cancer-prone ages, the number of new cancer cases is expected to increase in the next several decades. But since the birth rate is also expected to increase, the cancer rate may either stay the same or, perhaps, decline.
Cancer is not considered an inherited illness because most cases of cancer, perhaps 80 to 90 percent, occur in people with no family history of the disease. However, a person's chances of developing cancer can be influenced by the inheritance of certain kinds of genetic alterations. These alterations tend to increase an individual's susceptibility to developing cancer in the future. For example, about 5 percent of breast cancers are thought to be due to inheritance of particular form(s) of a "breast cancer susceptibility gene."

Is cancer considered an inherited illness?

How can genetic alterations increase the probability of contracting cancer?
Inherited mutations can influence a person's risk of developing many types of cancer in addition to breast cancer. For example, certain inherited mutations have been described that increase a person's risk of developing colon, kidney, bone, skin or other specific forms of cancer. But these hereditary conditions are thought to be involved in only 10 percent or fewer of all cancer cases.

What is the percentage of the above types of cancer that may involve a genetic influence?

Cancer can originate almost anywhere in the body. Carcinomas, the most common types of cancer, arise from the cells that cover external and internal body surfaces. Lung, breast, and colon are the most frequent cancers of this type in the United States. Sarcomas are cancers arising from cells found in the supporting tissues of the body such as bone, cartilage, fat, connective tissue, and muscle. Lymphomas are cancers that arise in the lymph nodes and tissues of the body’s immune system. Leukemias are cancers of the immature blood cells that grow in the bone marrow and tend to accumulate in large numbers in the bloodstream.
Where do Carcinomas originate in the body?

Where do sarcomas originate in the body?

Where do lymphomas originate in the body?

Where do leukemias originate in the body?

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Scientists use a variety of technical names to distinguish the many different types of carcinomas, sarcomas, lymphomas, and leukemias. In general, these names are created by using different Latin prefixes that stand for the location where the cancer began its unchecked growth. For example, the prefix "osteo" means bone,
so a cancer arising in bone is called an osteosarcoma. Similarly, the prefix "adeno" means gland, so a cancer of gland cells is called adenocarcinoma--for example, a breast adenocarcinoma.

Cancer is caused by Mutations in DNA

What is the Structure of DNA?

Genes reside within chromosomes, the large DNA molecules, which are composed of two chemical strands twisted around each other to form a "double helix." Each strand is constructed from millions of chemical building blocks called "bases." DNA contains only four different bases: adenine, thymine, cytosine, and guanine (abbreviated A, T, G, and C), but they can be arranged in any sequence. The sequential order of the bases in any given gene determines the message the gene contains, just as the letters of the alphabet can be combined in different ways to form distinct words and sentences.
From what you have already learned about mitosis when do the chromosomes become present in a cell?

From what you have already learned about protein synthesis is one side of the helix or both sides of a helix read when a protein needs to get made?

Where do genes reside?
Genes can be mutated in several different ways. The simplest type of mutation involves a change in a single base along the base sequence of a particular gene—much like a typographical error in a word that has been misspelled. In other cases, one or more bases may be added or deleted. And sometimes, large segments of a DNA molecule are accidentally repeated, deleted, or moved.

In what 3 general ways can DNA be mutated?

In which part of mitosis would this happen?
Mutations of DNA Cause Abnormal Growth in Cells

To illustrate what is meant by normal growth control, consider the skin. The thin outermost layer of normal skin, called the epidermis, is roughly a dozen cells thick. Cells in the bottom row of this layer, called the basal layer, divide just fast enough to replenish cells that are continually being shed from the surface of the skin. Each time one of these basal cells divides, it produces two cells. One remains in the basal layer and retains the capacity to divide. The other migrates out of the basal layer and loses the capacity to divide. The number of dividing cells in the basal layer, therefore, stays the same.

How does the number of cells in the basal base stay the same when normal growth is occurring?
Proto-oncogenes - the Normal Genes

Oncogenes are related to normal genes called proto-oncogenes that encode components of the cell's normal growth-control pathway. Some of these components are growth factors, receptors, signaling enzymes, and transcription factors. Growth factors bind to receptors on the cell surface, which activate signaling enzymes inside the cell that, in turn, activate special proteins called transcription factors inside the cell's nucleus. The activated transcription factors "turn on" the genes required for cell growth and proliferation.

What is the name of the normal genes related to oncogenes?

What type of cellular pathways do these normal genes control?

What do transcription factors do in the cell?
Oncogenes

One group of genes implicated in the development of cancer are damaged genes, called "oncogenes." Oncogenes are genes whose PRESENCE in certain forms and/or overactivity can stimulate the development of cancer. When oncogenes arise in normal cells, they can contribute to the development of cancer by instructing cells to make proteins that stimulate excessive cell growth and division.

What is an oncogene?

How are oncogenes and protein synthesis related to one another?
What is the other group of genes implicated in causing cancer?

How can a tumor suppressor gene be “lost”?
Tumor suppressor genes are a family of normal genes that instruct cells to produce proteins that restrain cell growth and division. Since tumor suppressor genes code for proteins that slow down cell growth and division, the loss of such proteins allows a cell to grow and divide in an uncontrolled fashion. Tumor suppressor genes are like the brake pedal of an automobile. The loss of a tumor suppressor gene function is like having a brake pedal that does not function properly, thereby allowing the cell to grow and divide continually.

What do tumor suppressor genes tell the body to produce?

One particular tumor suppressor gene codes for a protein called "p53" that can trigger cell suicide (apoptosis). In cells that have undergone DNA damage, the p53 protein acts like a brake pedal to halt cell growth and division. If the damage cannot be repaired, the p53 protein eventually initiates cell suicide, thereby preventing the genetically damaged cell from growing out of control.
What is the name of the tumor suppression gene that triggers cell suicide?

When does the p53 tell the cell to commit suicide?

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DNA Repair Genes

A third type of genes implicated in cancer are called "DNA repair genes." DNA repair genes code for proteins whose normal function is to correct errors that arise when cells duplicate their DNA prior to cell division. Mutations in DNA repair genes can lead to a failure in repair, which in turn allows subsequent
mutations to accumulate. People with a condition called xeroderma pigmentosum have an inherited defect in a DNA repair gene. As a result, they cannot effectively repair the DNA damage that normally occurs when skin cells are exposed to sunlight, and so they exhibit an abnormally high incidence of skin cancer. Certain forms of hereditary colon cancer also involve defects in DNA repair.

What are DNA repair genes?

From what you have learned about mitosis in what phase of mitosis would this problem occur?
Cancer may begin because of the accumulation of mutations involving oncogenes, tumor suppressor genes, and DNA repair genes. For example, colon cancer can begin with a defect in a tumor suppressor gene that allows excessive cell proliferation. The proliferating cells then tend to acquire additional mutations involving DNA repair genes, other tumor suppressor genes, and many other growth-related genes. Over time, the accumulated damage can yield a highly malignant, metastatic tumor. In other words, creating a cancer cell requires that the brakes on cell growth (tumor suppressor genes) be released at the same time that the accelerators for cell growth (oncogenes) are being activated.

Is cancer usually due to only one mutation?
While the prime suspects for cancer-linked mutations are the oncogenes, tumor suppressor genes, and DNA repair genes, cancer conspires even beyond these. Mutations also are seen in the genes that activate and deactivate carcinogens, and in those that govern the cell cycle, cell senescence (or "aging"), cell suicide (apoptosis), cell signaling, and cell differentiation. And still other mutations develop that enable cancer to invade and metastasize to other parts of the body.

Are the three major mutations you have just learned about the only kind of mutations that cause cancer?
How Tumors Grow

Cancer arises from a loss of normal growth control. In normal tissues, the rates of new cell growth and old cell death are kept in balance. In cancer, this balance is disrupted. This disruption can result from uncontrolled cell growth or loss of a cell's ability to undergo cell suicide by a process called "apoptosis." Apoptosis, or "cell suicide," is the mechanism by which old or damaged cells normally self-destruct.

What keeps cell growth normal?

How does cancer disrupt normal growth of cells?
**What is cell suicide?**

During the development of skin cancer, the normal balance between cell division and cell loss is disrupted. The basal cells now divide faster than is needed to replenish the cells being shed from the surface of the skin. Each time one of these basal cells divides, the two newly formed cells will often retain the capacity to divide, thereby leading to an increase in the total number of dividing cells.

![The Beginning of Cancerous Growth](image)

**What is the name of the process that is not shutting down after normal cell division?**

This gradual increase in the number of dividing cells creates a growing mass of tissue called a "tumor" or "neoplasm." If the rate of cell division is relatively rapid, and no "suicide" signals are in place to trigger cell death, the tumor will grow quickly in size; if the cells divide more slowly, tumor growth will be slower. But regardless of the growth rate, tumors ultimately increase in size because new cells are being produced in greater numbers than needed. As more and more of these dividing cells accumulate, the normal organization of the tissue gradually becomes disrupted.
What is a tumor?

Cancers are capable of spreading throughout the body by two mechanisms: invasion and metastasis. Invasion refers to the direct migration and penetration by cancer cells into neighboring tissues. Metastasis refers to the ability of cancer cells to penetrate into lymphatic and blood vessels, circulate through the bloodstream, and then invade normal tissues elsewhere in the body.

What are the two mechanisms that spread cancer? Explain how they differ?
Depending on whether or not they can spread by invasion and metastasis, tumors are classified as being either benign or malignant. Benign tumors are tumors that cannot spread by invasion or metastasis; hence, they only grow locally. Malignant tumors are tumors that are capable of spreading by invasion and metastasis. By definition, the term "cancer" applies only to malignant tumors.

What is the difference between a malignant tumor and a benign tumor?

Which one is considered cancer and why?
Cancer Prevention

As the single largest cause of cancer death, the use of tobacco products is implicated in roughly one out of every three cancer deaths. Cigarette smoking is responsible for nearly all cases of lung cancer, and has also been implicated in cancer of the mouth, larynx, esophagus, stomach, pancreas, kidney, and bladder. Pipe smoke, cigars, and smokeless tobacco are risky as well. Avoiding tobacco is therefore the single most effective lifestyle decision any person can make in attempting to prevent cancer.
What is the number of deaths caused by cancer that can be attributed to smoking?

While some sunlight is good for health, skin cancer caused by excessive exposure to sunlight is not among the sun's benefits. Because some types of skin cancer are easy to cure, the danger posed by too much sunlight is perhaps not taken seriously enough. It is important to remember that a more serious form of skin cancer, called melanoma, is also associated with excessive sun exposure. Melanomas are potentially lethal tumors. Risk of melanoma and other forms of skin cancer can be significantly reduced by avoiding excessive exposure to the sun, using sunscreen lotions, and wearing protective clothing to shield the skin from ultraviolet radiation.
What is the name of the most serious skin cancer?

Drinking excessive amounts of alcohol is linked to an increased risk for several kinds of cancer, especially those of the mouth, throat, and esophagus. The combination of alcohol and tobacco appears to be especially dangerous. For example, in heavy smokers or heavy drinkers, the risk of developing cancer of the esophagus is roughly 6 times greater than that for nonsmokers/nondrinkers. But in people who both smoke and drink, the cancer risk is more than 40 times greater than that for nonsmokers/nondrinkers. Clearly the combination of alcohol and tobacco is riskier than would be expected by just adding the effects of the two together.
What is the most dangerous combination of lifestyle choices that cause cancer?

Studies suggest that differences in diet may also play a role in determining cancer risk. Unlike clear-cut cancer risk factors such as tobacco, sunlight, and alcohol, dietary components that influence cancer risk have been difficult to determine. Limiting fat consumption and calorie intake appears to be one possible strategy to decrease risk for some cancers, because people who consume large amounts of meat, which is rich in fat, and large numbers of calories exhibit an increased cancer risk, especially for colon cancer.
What are the top two countries that show a correlation between meat consumption and colon cancer?

In contrast to factors such as fat and calories, which appear to increase cancer risk, other dietary components may decrease cancer risk. The most compelling evidence has been obtained for fruits and vegetables, whose consumption has been strongly correlated with a reduction in cancer risk. Although the exact chemical components in these foods that are responsible for a protective effect are yet to be identified, eating five to nine servings of fruits and vegetables each day is recommended by many groups.
What groups of foods show dramatic evidence in reducing cancer rates?

Actions can also be taken to avoid exposure to the small number of viruses that have been implicated in human cancers. A good example is the human papillomavirus (HPV). Of the more than 100 types of HPVs, over 30 types can be passed from one person to another through sexual contact. Among these, there are 13 high-risk types recognized as the major cause of cervical cancer. Having many sexual partners is a risk factor for infection with these high-risk HPVs, which can, in turn, increase the chance that mild cervical abnormalities will progress to more severe ones or to cervical cancer.
What is HPV?

The fact that several environmental chemicals can cause cancer has fostered the idea that industrial pollution is a frequent cause of cancer. However, the frequency of most human cancers (adjusted for age) has remained relatively constant over the past half-century, in spite of increasing industrial pollution. So, in spite of evidence that industrial chemicals can cause cancer in people who work with them or in people who live nearby, industrial pollution does not appear to be a major cause of most cancers in the population at large.
Industrial Pollution

Incidence of Most Cancers

Year

1930  1950  1970  1990

NATIONAL CANCER INSTITUTE