The Genetics of Cancer [1]

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About genes

Genes are found in the DNA in each cell that makes up your body. They control how the cell functions, including how quickly it grows, how often it divides, and how long it lives. Researchers estimate that there are 30,000 different genes in each cell.

Genes are located on 46 chromosomes, which are arranged in two sets of 23 chromosomes. You inherit one set of chromosomes from your mother and one set from your father. One chromosome in each set of 23 determines whether you are female or male. The other 22 chromosome pairs, called autosomes, determine your other physical characteristics.

Genes control how your cells work by making proteins that have specific functions and act as messengers for the cell. Therefore, each gene must have the correct instructions or "code" for making its protein. This is so the protein can perform the correct function for the cell. All cancers begin when one or more genes in a cell are mutated, or changed. This creates an abnormal protein or no protein at all. An abnormal protein provides different information than a normal protein, which can cause cells to multiply uncontrollably and become cancerous.

About genetic mutations

There are two basic types of genetic mutations:

- **Acquired mutations** are the most common cause of cancer. These occur from damage to genes during a person's life. They are not passed from parent to child. Factors such as

tobacco, ultraviolet (UV) radiation, viruses, and age cause these mutations. Cancer that occurs because of acquired mutations is called sporadic cancer.

- **Germline mutations**, which are less common, are passed directly from a parent to a child. In these situations, the mutation can be found in every cell of a person's body, including the reproductive sperm cells in a boy's body and egg cells in a girl's body. Because the mutation affects reproductive cells, it passes from generation to generation. Cancer caused by germline mutations is called inherited cancer, and it makes up about 5% to 10% of all cancers.

Mutations and cancer

Mutations happen often, and the human body is normally able to correct most of them. Depending on where in the gene the change occurs, a mutation may be beneficial, harmful, or make no difference at all. So, one mutation alone is unlikely to lead to cancer. Usually, it takes multiple mutations over a lifetime to cause cancer. This is why cancer occurs more often in older people who have had more opportunities for mutations to build up.

Types of genes linked to cancer

Many of the genes that contribute to the development of cancer fall into broad categories:

- Tumor suppressor genes are protective genes. Normally, they limit cell growth by monitoring how quickly cells divide into new cells, repairing mismatched DNA, and controlling when a cell dies. When a tumor suppressor gene is mutated, cells grow uncontrollably and may eventually form a mass called a tumor. *BRCA1*, *BRCA2*, and *p53* are examples of tumor suppressor genes. Germline mutations in *BRCA1* or *BRCA2* genes increase a woman's risk of developing hereditary breast or ovarian cancers [3]. The most commonly mutated gene in people who have cancer is *p53*. In fact, more than 50% of all cancers involve a missing or damaged *p53* gene. Most *p53* gene mutations are acquired mutations. Germline *p53* mutations are rare.

- Oncogenes turn a healthy cell into a cancerous cell. Mutations in these genes are not inherited. Two common oncogenes are:

    - *HER2*, which is a specialized protein that controls cancer growth and spread, and it is found on some cancer cells, such as breast and ovarian cancer cells

    - *T*he *ras* family of genes, which make proteins involved in cell communication pathways, cell growth, and cell death.

- DNA repair genes fix mistakes made when DNA is copied. But if a person has an error in a DNA repair gene, these mistakes are not corrected. And then they become mutations, which may eventually lead to cancer. This is especially true if the mutation occurs in a tumor suppressor gene or oncogene. Mutations in DNA repair genes can be inherited, such as with Lynch syndrome [4], or acquired.

Despite all that is known about the different ways cancer genes work, many cancers cannot be linked to a specific gene. Cancer likely involves multiple gene mutations. Some evidence also suggests that genes interact with their environment, further complicating genes' role in cancer.

Doctors hope to continue learning more about how genetic changes affect the development of cancer. This knowledge may lead to improvements in finding and treating cancer, as well as predicting a person's risk of cancer.

More Information

Understanding Cancer Risk [5]

Genetics [6]

What Is Personalized Cancer Medicine? [7]

Genetic Testing for Cancer Risk [8]

Hereditary Cancer-Related Syndromes [9]

Additional Resource

National Cancer Institute: The Genetics of Cancer [10]

Links
[1] http://www.cancer.net/navigating-cancer-care/cancer-basics/genetics/genetics-cancer
[2] http://www.cancer.net/about-us
[3] http://www.cancer.net/node/18922
[4] http://www.cancer.net/node/19223
[5] http://www.cancer.net/node/25007
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[10] http://www.cancer.gov/cancertopics/genetics