The Genetics of Cancer [1]

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Key Messages:

- Genes are found in every cell of your body, controlling how each cell functions.
- Mutations (changes) in genes, either inherited from your mother and father or from damage that occurred during a person?s life, contribute to the growth and development of cancer.
- Many of the genes that contribute to the development of cancer fall into broad categories, but usually cancer is caused by multiple changes to several different genes.

About genes

Genes are made up of deoxyribonucleic acid (DNA) and are found in each cell in your body. Genes control how each 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 pairs, which means you have 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 (these are called the X and Y chromosomes). The other 22 chromosome pairs, called autosomes, determine your other physical features.

Genes control how your cells work by making proteins that have specific functions and act as messengers for the cell. Therefore, it is essential that each gene have the correct instructions or "code" for making its protein so that the protein can perform the correct function for the cell. All cancers begin when one or more genes in a cell are mutated (changed), creating an abnormal protein or no protein at all. The information provided by an abnormal protein is different from that of 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 and germline. Acquired mutations are the most common cause of cancer. These mutations occur from damage to genes during a person?s life, and they are not passed from parent to child. Tobacco use, exposure to ultraviolet (UV) radiation (such as sunlight or from tanning beds), viruses, and age can damage genes and cause these mutations. Cancer that occurs because of acquired mutations is called sporadic

cancer.

Less commonly, a mutation can be in every cell of a person?s body from birth. These mutations are typically passed from a parent to a child. This is called a germline mutation. Because this type of genetic change is in every cell of the body, including the reproductive sperm cells (in a boy?s body) and egg cells (in a girl?s body), it can be passed from generation to generation. Cancer caused by germline mutations is called inherited cancer, which 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 these changes. Depending on where in the gene the change occurs, a mutation may be beneficial, harmful, or make no difference at all. Therefore, the likelihood of one mutation leading to cancer is small. Usually, it takes multiple mutations over a lifetime to cause cancer. This is why cancer occurs more often in older people, for whom there have been 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 suppress (limit) cell growth by monitoring how quickly cells divide into new cells, repairing mismatched DNA (which is often a cause of mutations; see below), and controlling when a cell dies. When a tumor suppressor gene is mutated (from heredity or environmental factors), 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. *HER2* (a specialized protein that controls cancer growth and spread, found on some cancer cells, such as breast and ovarian cancer cells) and the *ras* family of genes (genes that make proteins involved in cell communication pathways, cell growth, and cell death) are common oncogenes. Mutations in these genes are almost always acquired (not inherited).
- DNA repair genes fix mistakes made when DNA is replicated (copied). If a person has error in a DNA repair gene, these mistakes are not corrected. Mistakes that aren?t fixed become mutations, which may eventually lead to cancer (especially 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. It is likely that multiple, different genes are involved in the development of cancer. There is also some evidence that genes interact with their environment, further complicating the role of genes in cancer.

In the future, doctors hope to learn more about the role of genetic changes in the development of cancer, which 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]

Explaining Cancer Genome Research [6]

Facts About Personalized Cancer Medicine [7]

Genetic Testing [8]

Hereditary Cancer-Related Syndromes [9]

Additional Resource

National Cancer Institute: Cancer Genetics [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
[6] http://www.cancer.net/node/24519
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[9] http://www.cancer.net/node/24905
[10] http://www.cancer.gov/cancertopics/genetics