Cancer- Technical Extended Definition

Before we can discuss cancer as a biological term, we first have to start with the process of cell division. Each person is comprised of billions of cells. The two kinds of cells that each person posse are somatic cell and gamete cells. Somatic cells are the cells that you can find on your skin, inside your liver, on your lips, and basically any part of your body that does not deal with your reproduction cycle. The cells that are needed for reproduction are called gametes. These cells use a completely different process to replicate and produce new “daughter cells”, compared to somatic cells. For the purpose of this definition we will discuss how gene mutations that aid in the division of somatic cells contribute to cancer.

Chromosomes and DNA

Every cell in a human is considered a eukaryotic cell. This means that each of the cells contain inside itself a membrane bound nucleus. Cells without a membrane bound nucleus are considered prokaryotic cells, but we won’t be discussing those cells for the purpose of this extended technical definition. Inside of the membrane bound nucleus, normally called a nuclear envelope, of a eukaryotic cell you will most certainly find a considerable amount of deoxyribonucleic acid (DNA).

The structure of DNA contains four amino acids that are adenine (A), thymine (T), cytosine (C), and guanine (G). DNA is also held together with “backbone” made out of a sugar and phosphate groups. DNA is a very stable amino acid, and it takes time and effort to unwind the double helix structure. The different arrangements of A, T, C, and G is what makes every person physically and genetically unique. The DNA thread is said to be 3 billion miles long inside of each person.

Chromosomes are made up of very tightly coiled DNA. Inside of the membrane bound nucleus of a eukaryotic cell the DNA will normally be displayed in sets of chromosomes. A genetically normal human has 23 sets of chromosomes, making the total of 46 individual chromosomes. A mother will replicate and give 23 genetically similar chromosomes to her offspring through her egg, while the father will replicate and give the other 23 genetically similar chromosomes through his sperm.

Genes

Genes are DNA segments in the chromosome that determine every human characteristic. Some human characteristics are determined by several genes and others can be expressed with only one gene. Normally a person has about 25, 000 unique genes.

Cell Cycle

To understand how a cell can become a cancerous cell, a good comprehension of the cell cycle is needed. All cells are programmed with the ability to replicate its own DNA and divide to create new “daughter cells”. When somatic cells replicate and divide, the process is called mitosis. In gamete cells, this process is called meiosis I and meiosis II, but we won’t be going further into those cell cycles.

The first step of the mitosis cell cycle is called interphase. Interphase is the longest phase of the cell cycle. During this phase the DNA inside of the eukaryotic cell is starting to unwind and duplicate. The nuclear envelope of the cell is also beginning to expand to make room for the unwound and duplicated DNA. If you were to look at your skin cells through a microscope you will find that 90% of the cells are in this phase. In interphase, there are certain proteins that check for damaged DNA that will not allow the cell to continue to the next step if it is not corrected. If the damaged DNA is not repaired, the cell will “commit suicide”, termed apoptosis.

Prophase is the second phase of mitosis, which is basically just a continuation of interphase. The duplicated DNA is now binding back together to form chromosomes. Small structures in the middle of the chromosome, called centromeres, are beginning to form. The nuclear envelope is now almost completely gone. This phase is generally short.

Metaphase can be identified by the alignment of all of the chromosomes in the middle of the cell. By this point, the nuclear envelope is completely gone. All of the chromosomes are as tightly wound as they will be. The chromosomes are aligned on the central axis of the cell and are waiting for the spindle fibers to appropriately attach themselves to each centromere. The spindle fibers are created and found at the polar ends of the cell. The spindle fibers serve to only split the chromosome sets into chromatids, an individual side of a chromosome. There is another checkpoint during this phase that will not allow the cell to continue on its cycle if the spindle fibers are not all attached.

Anaphase is a short phase in which the spindle fibers pull the centromeres away from each other, separating a single chromatid to each of the polar ends. Essentially the chromosome that was a viewed as a set is now an individual chromatid. These chromatids will contribute to the new “daughter cells”.

Telophase finalizes the newly separated chromatids by creating a new nuclear membrane that will split up the original cell into two new “daughter cells”. A cleavage will form on the metaplate, the central axis, and split the cell. This phase has also a very short duration.

Cancer- Tumor Suppressor Genes

Now that we have explained the different steps of the cell cycle, we will discuss how an interference of the cell cycle will contribute to cancer.

During the explanation of the different cell cycle phases, there was a mention of checking or checkpoints. These checkpoints are controlled by different proteins and/or enzymes inside of a cell and are very specific in their task. Normally cancer starts when cell division and cell death balance is interrupted. When more cells are dividing then cells dying off, more and more cells are created. This cell mass is normally called a tumor. If tumors persist, they can disrupt the organization of normal tissue.

Cells will continue to divide if certain checkpoints are bypassed. There are some genes that help suppress tumors such as the retinoblastoma gene (Rb). Rb binds to several proteins in the cell that prevent the cell from activating and dividing. If a cell receives the signal that it should divide, it inactivates Rb. The problem arises when a person has Rb mutated where it can’t bind to proteins. This will cause the all of the person’s cells to continue dividing, since Rb will not put the brake on cell division.

Another tumor suppressor gene normally mentioned is the p53 gene. This gene helps in the prevention of cancer. If one person inherits an abnormal p53 gene, they will definitely be likely to develop some form of cancer. When p53 binds to DNA, during interphase, it stimulates another gene to interact with a protein that inhibits cell division when activated. If p53 does not bind properly to DNA, the stimulated protein will not be available to put the brakes on cell division. This will lead to the over production of cells, since they are bypassing the checkpoint and not stimulating the gene to stop cell division.

Cancer- Oncogene

Oncogenes are genes that carry the ability to provoke cancer. An oncogene is considered to be an altered or mutated form of DNA. These genes will then in turn “program” the cell to continue dividing. Normally these genes will play a huge role during the critical steps of the cell cycle. Proto- oncogenes are found naturally within many genomes in vertebrate species, but do not lead to cellular transformation. Though proto-oncogenes are not by themselves incredibly harmful, they can become deadly oncogenes.

Minor deletions of genes, insertion of genes, or addition of genes will drastically change the entire DNA code in a person. These changes will cause a proto-oncogene to transform into an oncogene. Different stimuli such as UV radiation, carcinogens, or other environmental events can lead to the transformation of oncogenes.

Many oncogenes can also be inherited. Breast cancer has been connected with the c-*ERBB2* (HER2) oncogene, meaning that is the c-*ERBB2* (HER2) oncogene is inherited by one parent there is a highly possible that the offspring will develop breast cancer. The oncogene RAS has been found in 20% of all human cancers, including pancreatic and colon.

Normally it is only through a thorough family history and genetic testing to know if these genes are present in a person’s DNA.

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