Key Medical Terms Associated with the Cell and Cancer

**Apoptosis**: Programmed cell death; a normal type of cell death that removes unneeded cells during embryological development, regulates the number of cells in tissues, and eliminates many potentially dangerous cells such as cancer cells. During apoptosis, the DNA fragments, the nucleus condenses, mitochondria cease to function, and the cytoplasm shrinks, but the plasma membrane remains intact. Phagocytes engulf and digest the apoptotic cells, an inflammatory response does not occur.

**Biopsy**: The removal and microscopic examination of tissue from the living body for diagnosis.

**Progeny**: Offspring or descendants

**Progeria**: A disease characterized by normal development in the first year of life followed by rapid aging. It is caused by a genetic defect in which telomeres are considerably shorter than normal. Symptoms include dry wrinkled skin, total baldness, and birdlike facial features. Death usually occurs around age 13.

**Telomere**: A region of repetitive DNA at both ends of a chromosome that function like caps to protect against fraying, fusing with other chromosomes and prevent enzymes from mistaking the normal ends for broken DNA and doing damage by trying to “repair” the ends. Thus, the telomere regions deter the degradation of genes near the ends of chromosomes – like the plastic caps preserve the end of shoelaces. One theory of cell aging is the genetic theory, which suggests that cessation of mitosis and cell aging are “programmed into our genes”. One notion is that a telomere clock determines the number of times a cell can divide. During cell division, enzymes that duplicate DNA does not fully copy the telomeres, so the chromosome loses 50 to 100 base pairs in its telomeres each time the chromosome replicates. When telomeres reach a certain minimum length, it is thought that that the stop-division signal is given and the cell dies because of damage sustained in the course of aging. Telomere shortening/damage is thought to contribute to the decline of organ function and increased risk of disease with age. The telomeres are disposable buffers blocking the ends of the chromosomes and are consumed during cell division and replenished by an enzyme called telomerase. Telomeres have no genetic function; they are simply stretches of DNA - repeats of base pairs TTAGGG a thousand times or more, that protect the rest of the chromosome. If telomerase activity is high, telomere length is maintained, and cellular aging is delayed. Stem cells that can divide indefinitely
such as germinal stem cells (give rise to sperm), hematopoietic stem cells in the bone marrow (give rise to blood cells) and others – have high telomerase activity, which duplicate the telomere DNA. As a cell begins to become cancerous, it divides more often and its telomeres become very short. If its telomeres get too short, the cell may die. However, most cancer cells can escape this fate by up-regulating their production of telomerase, which can prevent telomeres from getting shorter and even elongate them.

**Tumor (Neoplasm) Information**

Neoplasia means “new growth,” and a neoplasm is commonly called a tumor. Tumors are of two types, benign and malignant. Malignant tumors (neoplasms) are referred to as cancer. Cancer is a group of diseases characterized by uncontrolled cell division and have the potential to metastasize. In metastasis, cancer cells break away from where they first formed (primary cancer), travel through the blood or lymph system, and form new tumors (metastatic tumors) in other parts of the body. The metastatic tumor is the same type of cancer as the primary tumor. Benign tumors are usually considered less serious because they rarely metastasize (spread) and are not life threatening unless they are found in certain locations, such as the brain, where they can cause pressure problems. An example of a benign tumor is a wart. Most benign tumors may be removed surgically if they interfere with normal body function or become disfiguring. The study of tumors is called oncology.

**Growth and Spread of Cancer:** Cells of malignant tumors duplicate rapidly and continuously. As malignant cells invade surrounding tissues, they often trigger angiogenesis, the growth of new networks of blood vessels. Proteins that stimulate angiogenesis in tumors are called tumor angiogenesis factors (TAFs). The formation of new blood vessels can occur either by overproduction of TAFs or by the lack of naturally occurring angiogenesis inhibitors. As the cancer grows, it begins to compete with normal tissues for space and nutrients. Eventually, the normal tissue decreases in size and dies. Some malignant cells may detach from the initial (primary) tumor and invade a body cavity or enter the blood or lymph, then circulate to and invade other body tissues, establishing secondary tumors. The pain associated with cancer develops when the tumor presses on nerves or blocks a passageway in an organ so that secretions build up pressure, or as a result of dying tissue or organs.

**Causes of Cancer:** Cancer cells develop from mutations in genes that produce proteins which regulate cell division. One cause is environmental agents: substances in the air we breathe, the water we drink, and the food we eat. A chemical agent or radiation that produces cancer is called a carcinogen. Carcinogens induce mutations, permanent changes in the DNA base sequence of a gene. Examples of carcinogens are hydrocarbons found in cigarette tar, radon gas from the earth, and ultraviolet (UV) radiation in sunlight. The gene alterations can be classified into 3 groups: proto-oncogenes, tumor suppressor genes, and DNA repair genes.
Proto-oncogenes: Intensive research efforts are now directed toward studying cancer-causing genes, or oncogenes. When inappropriately activated, these genes have the ability to transform a normal cell into a cancerous cell. Most oncogenes are derived from normal genes called proto-oncogenes that regulate growth and development. Proto-oncogenes in every cell carry out normal cellular functions until a malignant change occurs. The proto-oncogene undergoes some change in their DNA or a rearrangement of the chromosome so that the proto-oncogene are near genes that enhance their activity. These changes can cause the gene (1) to be expressed inappropriately, (2) to make its products in excessive amounts, or (3) to make its products at the wrong time. Some oncogenes cause excessive production of growth factors, chemicals that stimulate cell growth. Others may trigger changes in a cell-surface receptor, causing it to send signals as though it were being activated by a growth factor. As a result, the growth pattern of the cell becomes abnormal.

Tumor-suppressor genes: Damage to genes called tumor-suppressor genes, which produce proteins that normally inhibit cell division, causes some types of cancer. Loss or alteration of a tumor-suppressor gene called p53 on chromosome 17 is the most common genetic change leading to a wide variety of tumors, including breast and colon cancers. The normal p53 protein arrests cells in the G1 phase, which prevents cell division. Normal p53 protein also assists in repair of damaged DNA and induces apoptosis in the cells where DNA repair was not successful. For this reason, the p53 gene is nicknamed “the guardian angel of the genome”.

DNA Repair Genes code for proteins involved in DNA repair and maintenance of chromosome structure. Environmental factors, such as ionizing radiation, UV light, and carcinogenic chemicals, can damage DNA. Errors in DNA replication can also lead to mutations. Damage to DNA repair genes means their gene products are no longer made, preventing DNA repair and allowing further mutations to accumulate in the cell.

Many viruses infect humans but only a few viruses are known to promote human cancer. Viruses are tiny packages of nucleic acids, either RNA or DNA that can reproduce only while inside the cells they infect. Some viruses termed oncogenic viruses, cause cancer by stimulating abnormal proliferation of cells. For instance, certain strains of the human papilloma virus (HPV) cause the majority of all cervical cancers in women. The more virulent strains of the virus can produce a protein that causes proteasomes to destroy p53, a protein that normally suppresses unregulated cell division. In the absence of this suppressor protein, cells proliferate uncontrollably. Fortunately, if the immune system is properly activated it will attack and kill those cells infected with the virus.

Inflammation is a defensive response to tissue damage. It appears that inflammation contributes to various steps in the development of cancer. Some evidence suggests that chronic inflammation stimulates the proliferation of mutated cells and enhances their survival, promotes angiogenesis, and contributes to invasion and metastasis of cancer cells. There is a clear relationship between certain
chronic inflammatory conditions and the transformation of inflamed tissue to a malignant tissue. For example, chronic gastritis (inflammation of the stomach lining) and peptic ulcers may be causative factors in 60-90 percent of stomach cancers. Chronic hepatitis (inflammation of the liver) and cirrhosis of the liver are believed to be responsible for about 80 percent of liver cancers. Colorectal cancer is 10 times more likely to occur in patients with chronic inflammatory diseases of the colon, such as ulcerative colitis and Crohn’s disease. And the relationship between asbestosis and silicosis (two chronic lung inflammatory conditions) and lung cancer has long been recognized.

**Cellular Changes**

Cells have mechanisms by which they can adapt their growth and differentiation to altered conditions in the body. Some minor alterations, such as increases in breast and uterine tissue during pregnancy, are normal adaptations to change in the body. Tissues are frequently modified as a response to hormonal stimulation or environmental stimuli such as irritation. Frequently such changes are reversible after the stimulus is removed. However, disease may develop when cell structure and function change and homeostasis cannot be maintained as a result. When learning the following terms it is helpful to know that “plasia” is Latin indicating growth, development, or change.

- **Atrophy** refers to a *decrease in the size of cells*, resulting in a reduced tissue mass. Common causes include reduced use of the tissue, insufficient nutrition, decreased neurologic or hormonal stimulation, and aging. An example is the shrinkage of skeletal muscle that occurs when a limb is immobilized in a cast for several weeks.

- **Hypertrophy** refers to an *increase in the size of cells*, resulting in an enlarged tissue mass. This increase may be caused by additional work by the tissue, as demonstrated by an enlarged heart muscle resulting from increased demands. A common example of hypertrophy is the effect of consistent exercise on skeletal muscle, leading to an enlarged muscle mass.

- **Hyperplasia** refers to an *increase in the number of cells* resulting in an enlarged tissue mass. In some cases, hypertrophy and hyperplasia occur simultaneously, as in the uterine enlargement that occurs during pregnancy. **Hyperplasia may be a compensatory mechanism** to meet increased demands or enable certain organs to regenerate. For example, removal of part of the liver leads to hyperplasia of the remaining liver cells to compensate for the loss. Another example is a callus of the skin as there is hyperplasia of epidermal cells in response to mechanical stimulus. In certain pathologic situations there may be an increased risk of cancer when hyperplasia occurs.

- **Dysplasia** refers to abnormal changes in the size, shape, and organization of mature cells. Large nuclei are frequently present, and the rate of mitosis is increased. Dysplasia is related to hyperplasia and is often called **atypical hyperplasia**. This situation may result from chronic irritation/inflammation, infection, or it may be a precancerous change.
Dysplastic changes are often found in epithelial tissue of the cervix and respiratory tract, where they are associated with common neoplastic growths. Detection of dysplasia is the basis of routine screening tests for atypical cells such as the Pap smear (Papanicolaou test on cervical cells). **Note:** the term dysplasia does not indicate cancer and may not progress to cancer.

- **Metaplasia** is the reversible replacement of one mature cell type by a different mature cell type. Sometimes, metaplasia may be an adaptive mechanism that provides a more resistant tissue; for instance, when stratified squamous epithelium replaces ciliated columnar epithelium in the respiratory tracts of cigarette smokers. Although the new cells present a stronger barrier they do not secrete mucus or have cilia, causing loss of a vital protective mechanism. Bronchial metaplasia can be reversed if the inducing stimulus, usually cigarette smoking, is removed.

- **Neoplasia** means “new growth,” and a neoplasm is commonly called a tumor. **Tumors are of two types, benign and malignant.** Malignant neoplasms are referred to as **cancer.** Benign tumors are usually considered less serious because they do not spread and are not life threatening unless they are found in certain locations, such as the brain, where they can cause pressure problems.

**Necrosis:** A pathological type of cell death, resulting from tissue injury, in which many adjacent cells swell, burst, and spill their cytoplasm into the interstitial fluid; the cellular debris usually stimulates an inflammatory response, which does not occur in apoptosis

**Ischemia** is a decreased supply of oxygenated blood to a tissue or organ, due to circulatory obstruction