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A Review on Cancer Disease

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Abstract: *Cancer is a group of diseases characterized by the uncontrolled growth and spread of abnormal cells in the body. It can occur in almost any part of the body and may lead to the formation of tumors or disrupt normal organ functions. Cancer develops due to genetic mutations and environmental factors such as smoking, diet, and exposure to harmful chemicals. Early detection through screenings and advances in treatment options, including surgery, chemotherapy, radiation, and immunotherapy, have improved patient outcomes. Despite these advances, cancer remains a leading cause of death globally. Ongoing research is essential for developing more effective treatments and preventive strategies.*

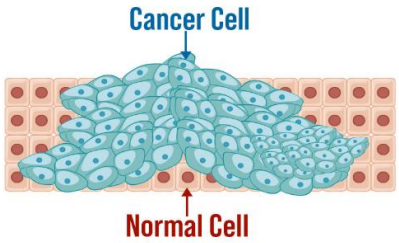
Keywords: Cancer Disease, Types, Stages, Treatment

I. INTRODUCTION

Cancer is a multifactorial, heterogeneous and chronic disease. Basically, cancer itself is a group of diseases, because of its frequency, reciprocal influences-even minor influence may lead to a major impact. Epidemiological studies clearly indicate that risk for several types of cancer (including pancreas cancer, liver cancer, breast cancer, urinary tract (colorectal) cancer is too high for mortality and morbidity. Obesity, hyperglycemia, and increased oxidative stress may also contribute to increased cancer risk. Despite many decades of basic research and clinical research and trials of promising new therapies, new drugs, new treatments, cancer is the main cause of morbidity and mortality. In conclusion cancer is a complex disease which is gaining more of its popularity in humans and so, it needs more clinical attention and better designed treatments, studies and drugs.

Health is "a condition of total physical, mental, and social well-being and not only the absence of disease or disability," according to the World Health Organization. Over time, several definitions have been employed for various objectives. Healthy behaviors can be encouraged, such as regular exercise and getting enough sleep, while unhealthy behaviors, such as smoking or high levels of stress, can be reduced or avoided. Some factors that affect health are caused by personal decisions, such as whether to engage in a high-risk habit, while others are the result of structural factors, such as how society is structured and how easy or difficult it is for individuals to get essential healthcare services. Others, including hereditary illnesses, are independent of individual and community preferences.

Cancer is a condition when a few of the body's cells grow out of control and spread to other bodily regions. Since the human body contains billions of cells, cancer can develop practically everywhere. Human cells often divide (via a



process known as cell growth and multiplication) to create new cells as the body requires them. New cells replace old ones when they die as a result of aging or damage. Occasionally, this systematic process fails, causing damaged or aberrant cells to proliferate when they shouldn't. Tumors, which are tissue masses, can develop from these cells. Tumors may or may not be malignant (benign). Cancerous tumors can move to distant parts of the body to produce new tumors, invade neighbouring tissues, or both (a process called metastasis). Malignant tumors are another name for cancerous tumors. Malignancies of the blood, including leukaemia's, seldom develop solid tumors although many other

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cancers do. Noncancerous tumors do not penetrate or spread to neighbouring tissues. Benign tumors typically don't come back after removal, however malignant tumors can. However, benign tumors can occasionally grow to be quite enormous. Some, like benign brain tumors, can have grave side effects or even be fatal.

Problems: Globally, about 9.6 million in 2018 deaths were estimated in cancer, which represents the cancer is the second leading cause of deaths.

The most common cancers are:

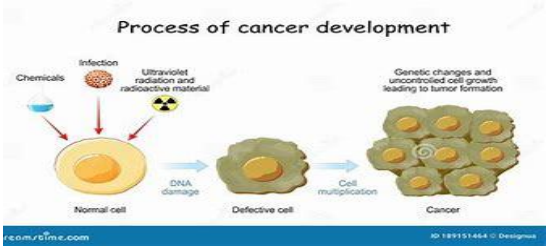
- Lung (2.09 million cases)
- Breast (2.09 million cases)
- Colorectal (1.80 million cases)
- Prostate (1.28 million cases)
- Skin cancer (non-melanoma) (1.04 million cases)
- Stomach (1.03 million cases)

The most common causes of cancer death are cancers of:

- Lung (1.76 million deaths)
- Colorectal (862 000 deaths)
- Stomach (783 000 deaths)
- Liver (782 000 deaths)
- Breast (627 000 deaths)

How Does Cancer Develop?

Cancer develops through a series of changes in the genes that regulate normal cell growth and function. These genetic changes can result in the uncontrolled growth of abnormal cells, which is the hallmark of cancer.



Let's break down how cancer develops step-by-step:

1. Normal Cell Division and Growth

In a healthy body, cells follow a well-regulated process of growth, division, and death. Cells grow and divide to form new cells when the body needs them (for example, to heal wounds or replace dead cells). When cells become damaged or old, they undergo **apoptosis** (programmed cell death), allowing the body to remove the unwanted or damaged cells.

This process is tightly controlled by a set of genes known as **oncogenes** (which promote cell division) and **tumor suppressor genes** (which prevent excessive cell division). When these genes are functioning correctly, cells grow and divide only when needed, and old or damaged cells die.

2. Genetic Mutations and DNA Damage

Cancer starts when the DNA of a single cell becomes damaged and undergoes mutations. These mutations can be caused by various factors, including:

- **Environmental factors**: Exposure to carcinogens (cancer-causing substances) such as tobacco smoke, UV radiation from the sun, asbestos, or certain chemicals can damage DNA.

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- **Lifestyle factors**: Smoking, poor diet, excessive alcohol consumption, and lack of physical activity can also increase the risk of mutations.
- **Inherited mutations**: Some people inherit mutated genes from their parents that predispose them to certain types of cancer. For example, mutations in the **BRCA1** and **BRCA2** genes increase the risk of breast and ovarian cancer.
- **Spontaneous mutations**: Sometimes, DNA errors occur randomly during normal cell division, leading to mutations without any external causes.

These mutations alter the genetic instructions within the cell, disrupting the balance between cell growth and cell death. The cell may start to grow uncontrollably and become cancerous.

3. Oncogenes and Tumor Suppressor Genes

In the process of cancer development, two main categories of genes are usually involved:

- **Oncogenes**: These are mutated or overactive versions of **proto-oncogenes** (normal genes that promote cell division). When oncogenes are activated or overexpressed, they can drive cells to divide uncontrollably. This leads to excessive cell growth and tumor formation.
- **Example**: Mutations in the **RAS** gene can cause uncontrolled cell division, which is commonly seen in cancers such as lung, pancreatic, and colon cancer.
- **Tumor Suppressor Genes**: These genes normally act as brakes on cell division. They prevent cells from growing too quickly or from surviving when they should die. When tumor suppressor genes are inactivated or deleted, the brakes on cell division are removed, and cells can continue to divide uncontrollably.
- **Example**: The **p53** gene is a well-known tumor suppressor gene. It helps control the cell cycle and trigger apoptosis when DNA damage is detected. Mutations in the p53 gene can lead to the survival of abnormal cells that would normally be eliminated.

4. Loss of Cell Cycle Control

A key feature of cancer cells is the loss of normal **cell cycle control**. The cell cycle is the process by which a cell grows and divides. The cell cycle is regulated by a series of checkpoints that ensure the cell divides only when it is ready and that the genetic material is intact.

In cancer cells:

- **Checkpoint failures**: The normal checkpoints that detect DNA damage or errors during replication are bypassed. This allows cells with damaged DNA to continue dividing and proliferating.
- **Continual growth signals**: Cancer cells can acquire mutations that allow them to ignore signals that normally stop growth, leading to continuous cell division.

5. Evading Apoptosis (Cell Death)

Normally, when a cell's DNA is severely damaged or it becomes dysfunctional, the cell undergoes **apoptosis** (programmed cell death) to prevent it from becoming cancerous. However, cancer cells often develop the ability to evade apoptosis, allowing them to survive despite having DNA damage.

This can happen through mutations in genes that regulate cell death, such as **p53**. When apoptosis is avoided, abnormal cells can accumulate and divide, leading to tumor growth.

6. Angiogenesis (Formation of New Blood Vessels)

As cancerous cells continue to grow and multiply, they need nutrients and oxygen to survive. To meet these needs, cancer cells can stimulate the formation of new blood vessels, a process known as **angiogenesis**. This allows the tumor to grow larger and also provides a pathway for the cancer cells to spread to other parts of the body.

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7. Invasion and Metastasis

One of the most dangerous characteristics of cancer is its ability to **invade surrounding tissues** and **metastasize** (spread to other parts of the body). Cancer cells can invade nearby tissues and then enter the bloodstream or lymphatic system. These circulating cancer cells can travel to distant organs, such as the lungs, liver, bones, or brain, where they can form secondary tumors.

This process is driven by mutations that allow cancer cells to alter their structure and behavior to become more mobile, invade surrounding tissues, and resist the body's immune system.

8. Tumor Microenvironment

The tumor microenvironment plays a critical role in cancer development. It consists of not just the cancer cells but also other cells, blood vessels, immune cells, and extracellular components surrounding the tumor. Tumors can influence their microenvironment by secreting signaling molecules that:

- Promote angiogenesis.
- Suppress the immune system's ability to attack cancer cells.
- Stimulate cell growth and survival.

A **favourable tumor microenvironment** promotes cancer growth and metastasis, making it harder for the body to fight the disease.

9. The Multi-Step Process of Cancer Development

Cancer typically doesn't develop from a single mutation. It usually requires multiple mutations that accumulate over time, and the progression from normal cells to cancerous cells happens in stages:

- **Initiation**: A normal cell undergoes a mutation that can lead to uncontrolled growth.
- **Promotion**: Additional mutations or changes in the microenvironment promote the growth of the abnormal cells.
- **Progression**: The tumor becomes more aggressive, gains the ability to invade surrounding tissues, and may metastasize to other organs.

This multi-step process explains why cancer often develops slowly over many years, and why it may take time for symptoms to appear.

Properties of Cancerous cells

Cancerous cells have several distinct properties that distinguish them from normal, healthy cells. These properties enable cancer cells to grow uncontrollably, evade the immune system, and spread to other parts of the body (metastasis). Below are the key **properties of cancerous cells**:

1. Uncontrolled Cell Growth

Cancerous cells lose the normal regulatory mechanisms that control cell growth and division. While normal cells follow a controlled cell cycle, cancer cells divide uncontrollably. This uncontrolled division results from mutations in genes that regulate the cell cycle, such as **oncogenes** (which promote growth) or **tumor suppressor genes** (which inhibit growth).

- **Oncogenes**: Mutated or overactive versions of normal genes (proto-oncogenes) that push cells to divide continuously.
- **Loss of Tumor Suppressors**: Genes such as **p53**, which normally inhibit cell division in response to damage, may be inactivated in cancer cells.

2. Resistance to Apoptosis (Programmed Cell Death)

Cancer cells can evade apoptosis (the programmed death of damaged or abnormal cells), which allows them to survive despite being damaged or dysfunctional. This evasion of cell death mechanisms enables cancer cells to accumulate mutations and continue proliferating.

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- **Inactivation of p53**: One of the most common alterations in cancer cells is the loss of **p53**, a tumor suppressor gene that normally triggers apoptosis when DNA damage occurs.

3. Sustained Angiogenesis (Blood Vessel Formation)

Cancer cells can stimulate the growth of new blood vessels (angiogenesis) to supply the tumor with oxygen and nutrients, which are necessary for continued growth and survival. Without this ability to grow blood vessels, tumors cannot increase beyond a certain size.

- **Vascular Endothelial Growth Factor (VEGF)**: Cancer cells often secrete VEGF and other factors to promote angiogenesis, which helps tumors grow larger and survive in low-oxygen environments (hypoxia).

4. Unlimited Replicative Potential

Normal cells have a limit to how many times they can divide, known as the **Hayflick limit**. However, cancer cells can avoid this limit by maintaining or activating an enzyme called **telomerase**, which rebuilds the telomeres (the protective caps at the end of chromosomes) during cell division.

- **Telomerase Activation**: In most normal cells, telomeres shorten with each division, leading to cell death or senescence. Cancer cells, by maintaining telomere length, can continue to divide indefinitely.

5. Tissue Invasion and Metastasis

One of the most dangerous properties of cancer cells is their ability to invade surrounding tissues and spread to distant organs (metastasis). Cancer cells acquire the ability to degrade the extracellular matrix (ECM) that normally holds cells together and allows them to migrate and invade new areas.

- **Matrix Metalloproteinases (MMPs)**: Cancer cells produce enzymes like MMPs that break down the ECM, allowing the cells to move and invade other tissues.
- **Ability to Enter Blood and Lymphatic Systems**: Once cancer cells invade the surrounding tissue, they can enter the bloodstream or lymphatic system, spreading the cancer to other organs.

6. Deregulated Energy Metabolism (Warburg Effect)

Cancer cells often exhibit a unique metabolism known as the **Warburg effect**. Under normal conditions, cells produce energy (ATP) primarily through oxidative phosphorylation in the mitochondria. However, cancer cells tend to rely on **aerobic glycolysis** (producing energy through glycolysis even in the presence of oxygen) to fuel their rapid growth.

- **Increased Glycolysis**: Even in oxygen-rich environments, cancer cells preferentially use glycolysis for energy production, which supports their fast growth and provides intermediates for biosynthesis (e.g., building blocks for cell division).

7. Immune Evasion

Cancer cells can evade detection and destruction by the body's immune system. They often do this by:

- **Suppressing immune cell activity**: Tumors can secrete immune-suppressive factors like **TGF-beta** or **IL-10** to inhibit immune responses.
- **Loss of Tumor Antigens**: Some cancer cells may lose or downregulate surface molecules (tumor antigens) that the immune system recognizes, making it harder for immune cells to detect and attack the tumor.
- **Immune Checkpoint Activation**: Cancer cells may also hijack immune checkpoint pathways like **PD-1/PD-L1** to turn off immune responses that would normally target and destroy the tumor.

8. Avoiding Growth Suppressors

Cancer cells bypass signals that would normally stop cell division or promote cell death. For example, tumor suppressor genes like **p53**, **RB**, and **APC** are frequently mutated or inactivated in cancer, preventing the normal growth control mechanisms from functioning.

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- **Loss of p53**: This allows cancer cells to continue dividing even if they have damaged DNA or other abnormalities.
- **Inactivation of RB**: Inactivating the **retinoblastoma (RB)** protein removes a major checkpoint that normally prevents cells from entering the S-phase of the cell cycle.

9. Genomic Instability and Mutation

Cancer cells tend to have an abnormally high rate of mutations and genetic instability. This leads to a constant accumulation of mutations, some of which may provide a survival advantage to the tumor cells. This increased genetic instability is one of the key factors that drive cancer progression and resistance to therapy.

- **Chromosomal Instability**: Cancer cells often have abnormal chromosome numbers (aneuploidy) and may have rearranged chromosomes that contribute to the genetic diversity of the tumor.

10. Altered Cell Communication

Cancer cells alter how they interact with their surrounding environment, including other cells in the tissue and the extracellular matrix (ECM). They can change the way they respond to growth signals and secrete signaling molecules that promote their own growth and survival.

- **Autocrine Signaling**: Some cancer cells produce growth factors and other signaling molecules that act on themselves, stimulating their own growth.
- **Paracrine Signaling**: Cancer cells may also stimulate nearby stromal cells (e.g., fibroblasts, endothelial cells) to promote tumor growth and metastasis.

Causes of Cancer

Cancer can be caused by a variety of factors, ranging from genetic predispositions to environmental exposures. The development of cancer is typically a multifactorial process, meaning it results from a combination of genetic mutations, lifestyle choices, and environmental influences. Below are the **primary causes of cancer**:

1. Genetic Factors

Some cancers are caused by inherited mutations in certain genes. These mutations may be passed down from one generation to the next, increasing the likelihood of developing cancer. Inherited genetic mutations are responsible for approximately 5-10% of all cancers.

- **Inherited Mutations in Tumor Suppressor Genes**: Tumor suppressor genes, such as **BRCA1** and **BRCA2**, help control cell growth and repair DNA damage. Mutations in these genes increase the risk of certain cancers, particularly breast, ovarian, and prostate cancer.
- **BRCA1/BRCA2 Mutations**: Individuals with inherited mutations in these genes have a higher risk of developing breast and ovarian cancers.
- **Lynch Syndrome**: Caused by inherited mutations in genes involved in DNA repair, such as **MLH1**, **MSH2**, and **PMS2**, leading to an increased risk of colorectal and other cancers.
- **Inherited Cancer Syndromes**: Certain inherited conditions, such as **Familial Adenomatous Polyposis (FAP)**, **Li-Fraumeni syndrome**, and **Retinoblastoma** predispose individuals to higher cancer risks due to mutations in specific genes involved in regulating cell growth or repairing DNA.

2. Environmental Exposures

Environmental factors are a significant cause of cancer. These include exposure to carcinogens, which are substances known to increase the risk of cancer by causing genetic mutations or other cellular damage.

Carcinogens

Carcinogens are substances or environmental factors that promote cancer development. They can cause DNA damage directly or disrupt normal cellular processes, leading to cancer.

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- **Tobacco Smoke**: Smoking is the leading cause of cancer, particularly lung cancer. It contains over 70 carcinogens that can damage DNA and lead to mutations in cells of the lungs, mouth, throat, bladder, pancreas, kidney, and more.
- **Radiation**: Exposure to ionizing radiation (such as X-rays, radon gas, and radiation therapy) can damage DNA and increase the risk of developing cancers like leukemia, thyroid cancer, and breast cancer. **Ultraviolet (UV) radiation** from the sun can also cause skin cancers, including melanoma, basal cell carcinoma, and squamous cell carcinoma.
- **Chemicals**: Exposure to certain industrial chemicals, like **asbestos**, **benzene**, **formaldehyde**, and certain pesticides, increases the risk of cancers like mesothelioma, leukemia, and bladder cancer.
- **Pollution**: Air pollution, including exposure to fine particulate matter (PM2.5) and other pollutants, has been linked to increased risks of lung cancer, as well as other cancers.
- **Viruses and Bacteria**: Some viruses and bacteria are known to increase the risk of cancer by causing long-term infections or changes in the DNA of cells.
    - **Human Papillomavirus (HPV)**: HPV infections are linked to cervical, anal, and oropharyngeal cancers.
    - **Hepatitis B and C viruses**: These viruses increase the risk of liver cancer by causing chronic liver inflammation.
    - **Helicobacter pylori**: A bacterium that can cause stomach ulcers and is associated with stomach cancer.

3. Lifestyle Factors

Lifestyle choices have a significant impact on cancer risk. Many cancers are preventable by adopting a healthy lifestyle.

- **Diet and Nutrition**: A diet high in processed foods, red meat, and low in fruits, vegetables, and whole grains may increase cancer risk. For example, diets high in fat and low in fiber have been linked to colorectal cancer.
- **Obesity**: Obesity is a well-established risk factor for various cancers, including breast (post-menopausal), colorectal, endometrial, kidney, and esophageal cancers. Obesity leads to chronic inflammation and hormonal changes that can promote cancer development.
- **Physical Inactivity**: Lack of exercise increases the risk of developing several types of cancer, including colorectal, breast, and endometrial cancers. Regular physical activity helps maintain a healthy weight and reduce inflammation.
- **Alcohol Consumption**: Drinking alcohol increases the risk of several cancers, including mouth, throat, liver, breast, and colorectal cancers. Alcohol can damage DNA and interfere with the body's ability to repair DNA.
- **Smoking and Tobacco Use**: Tobacco use is the leading cause of preventable cancer and cancer-related deaths. It is strongly linked to cancers of the lung, mouth, throat, esophagus, and pancreas, among others.
- **Sun Exposure and Tanning Beds**: Overexposure to UV rays from the sun or tanning beds increases the risk of skin cancer, including melanoma, basal cell carcinoma, and squamous cell carcinoma.

4. Age and Gender

- **Age**: The risk of developing cancer increases with age, as genetic mutations accumulate over time. Most cancers are diagnosed in individuals over the age of 50, though some cancers, such as leukemia or testicular cancer, are more common in younger people.
- **Gender**: Certain cancers are more common in one gender than the other due to biological and hormonal differences. For example, **breast cancer** is more common in women, while **prostate cancer** primarily affects men.

5. Hormonal Factors

Hormones play a significant role in some types of cancer, especially cancers of the reproductive organs.

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- **Estrogen**: Prolonged exposure to estrogen has been linked to an increased risk of breast and endometrial cancer. Women who begin menstruation early or experience menopause late may have a higher lifetime exposure to estrogen.
- **Testosterone**: High levels of testosterone in men have been associated with an increased risk of prostate cancer.
- **Hormone Replacement Therapy (HRT)**: Long-term use of combined estrogen and progesterone therapy in postmenopausal women has been linked to an increased risk of breast cancer and endometrial cancer.

6. Immune System and Chronic Inflammation

A weakened immune system, whether due to **genetic factors** or as a result of conditions like **HIV/AIDS**, can make the body more susceptible to developing cancer. Infections from certain viruses (e.g., HIV, Epstein-Barr virus) can impair immune function and increase the risk of some cancers, like Kaposi sarcoma and lymphoma.

- **Chronic Inflammation**: Long-term inflammation in the body can damage DNA, promote mutations, and lead to cancer development. Conditions like **Crohn's disease** or **ulcerative colitis**, which cause chronic inflammation in the intestines, increase the risk of colorectal cancer.

7. Pre-existing Health Conditions

Certain pre-existing conditions can increase the risk of developing cancer:

- **Chronic infections**: Chronic viral or bacterial infections can lead to cancer. For example, **hepatitis B or C** infections increase the risk of liver cancer, and **HPV** can lead to cervical cancer.
- **Chronic conditions**: Diseases like **Crohn's disease**, **ulcerative colitis**, and **chronic pancreatitis** are associated with a higher risk of developing certain cancers, such as colorectal and pancreatic cancer.

8. Random DNA Mutations

In some cases, cancer arises due to **spontaneous mutations** that occur in the DNA during the normal process of cell division. These mutations are random and not caused by environmental factors or inherited genes. This is often the case in cancers like **leukemia**, **lung cancer**, and others.

Types of Genes that Cause Cancer

Cancer is primarily caused by genetic mutations that disrupt the normal regulation of cell growth and division. These mutations can occur in different types of genes that regulate key cellular processes, including cell division, DNA repair, and cell death. The three main types of genes that are involved in the development of cancer are:

1. Proto-Oncogenes

Proto-oncogenes are normal genes that play a crucial role in regulating cell growth, differentiation, and survival. However, when these genes are mutated or overexpressed, they can become **oncogenes**—genes that drive uncontrolled cell division and contribute to the development of cancer.

- **Function**: Proto-oncogenes encode proteins involved in various processes such as signal transduction, cell cycle regulation, and cell survival. When they become oncogenes, they lead to excessive or unregulated cell division.

Examples of Proto-Oncogenes:

- **RAS**: A family of genes that code for small proteins involved in transmitting signals within cells, which regulate cell growth. Mutations in **KRAS** or **NRAS** can lead to uncontrolled cell growth and are common in cancers such as lung, colorectal, and pancreatic cancer.
- **HER2 (ERBB2)**: This gene encodes a receptor involved in cell signaling. In many cases of breast cancer, **HER2** is overexpressed, leading to aggressive tumor growth.

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- **MYC**: A gene that encodes a transcription factor involved in cell cycle progression and apoptosis. MYC amplification is observed in various cancers, including **lymphomas** and **leukemias**.

BCR-ABL: This gene fusion results from a translocation between chromosomes 9 and 22, producing a hybrid protein that causes chronic myelogenous leukemia (CML).

2. Tumor Suppressor Genes

Tumor suppressor genes are genes that normally inhibit cell division, promote DNA repair, or trigger apoptosis (programmed cell death) when cells are damaged. When tumor suppressor genes are mutated or inactivated, their ability to regulate cell growth and repair is lost, leading to uncontrolled cell division and the potential for cancer.

- **Function**: Tumor suppressor genes help maintain cellular homeostasis by preventing the formation of tumors. Their inactivation is a critical step in cancer development.

Examples of Tumor Suppressor Genes:

- **TP53 (p53)**: Known as the "guardian of the genome," **p53** plays a key role in detecting DNA damage and initiating cell cycle arrest or apoptosis. Mutations in **TP53** are the most common genetic alterations found in human cancers and are associated with a wide range of cancers, including **lung, colon, breast**, and **head and neck cancers**.
- **RB (Retinoblastoma Protein)**: **RB** is involved in controlling the cell cycle by preventing cells from progressing from the G1 phase to the S phase. Mutations in **RB** can lead to unregulated cell division. This gene is frequently mutated in cancers like **retinoblastoma**, **osteosarcoma**, and **bladder cancer**.
- **BRCA1 and BRCA2**: These genes are involved in the repair of DNA damage, specifically double-strand breaks. Mutations in **BRCA1** and **BRCA2** significantly increase the risk of **breast cancer**, **ovarian cancer**, and **prostate cancer**.

PTEN: This gene encodes a phosphatase that helps regulate cell growth and survival by antagonizing the **PI3K-AKT** signaling pathway. Loss of **PTEN** function can contribute to several cancers, including **breast cancer**, **endometrial cancer**, and **prostate cancer**.

3. DNA Repair Genes

DNA repair genes are responsible for identifying and correcting errors that occur during DNA replication. When these genes are mutated, the cell's ability to repair damaged DNA is compromised, leading to the accumulation of mutations that can drive cancer.

- **Function**: DNA repair genes maintain the integrity of the genome. When these genes are defective, cells accumulate mutations at a higher rate, which increases the risk of cancer.

Examples of DNA Repair Genes:

- **MLH1, MSH2, MSH6**: These genes are involved in the **mismatch repair** (MMR) pathway, which fixes errors that occur during DNA replication. Mutations in these genes are associated with **Lynch syndrome**, which increases the risk of colorectal, endometrial, and other cancers.
- **ATM (Ataxia Telangiectasia Mutated)**: **ATM** is involved in detecting DNA damage and activating DNA repair mechanisms. Mutations in **ATM** are associated with **ataxia telangiectasia**, a condition that increases the risk of developing cancers, including **leukemia** and **lymphoma**.
- **FANC** Genes: The **Fanconi anemia (FANC)** pathway is involved in repairing DNA interstrand crosslinks. Mutations in any of the **FANC** genes increase the risk of **acute myelogenous leukemia (AML)** and **solid tumors**.

XPA, XPC, and other NER (Nucleotide Excision Repair) genes: These genes are involved in repairing damage caused by UV light. Defects in these genes can lead to **xeroderma pigmentosum**, a condition that increases the risk of **skin cancer** due to impaired DNA repair from UV exposure.

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Types of cancer

Cancer is a group of diseases characterized by the uncontrolled growth and spread of abnormal cells. There are more than 100 different types of cancer, each named based on the organ or type of cell where it originates.

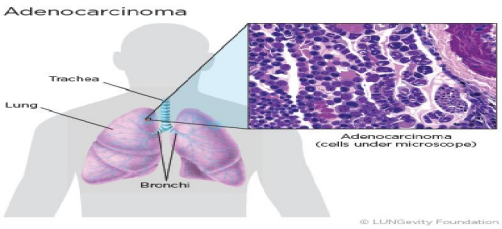
Below are the main types of cancer, categorized by the tissues or organs where they develop:

1. Carcinoma

Carcinomas are cancers that begin in the **epithelial cells**, which are the cells that line the inner and outer surfaces of the body. These are the most common types of cancer.

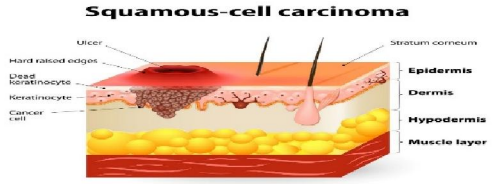
Adenocarcinoma: A type of carcinoma that originates in glandular tissues or cells that secrete fluids. Common examples include:

- **Breast cancer**
- **Lung cancer**
- **Pancreatic cancer**
- **Colon cancer**

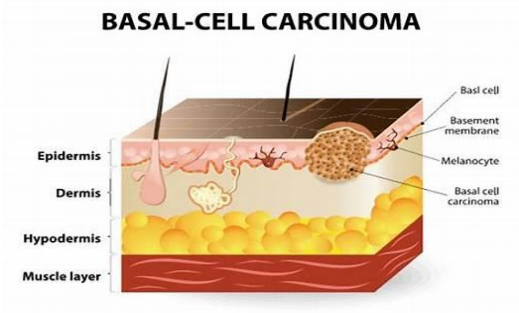


Squamous Cell Carcinoma: This type begins in the squamous cells, which are flat cells found on the skin and mucous membranes. Examples include:

- **Skin cancer**
- **Lung cancer**
- **Esophageal cancer**



Basal Cell Carcinoma: A type of skin cancer that begins in the basal cells of the epidermis. It is the most common type of skin cancer but rarely metastasizes.



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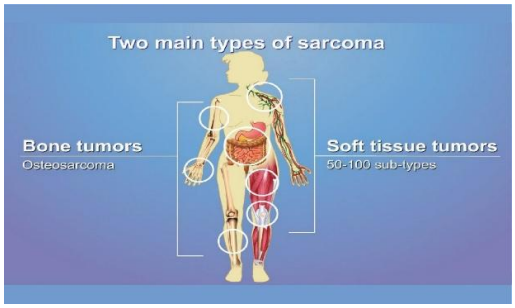
2. Sarcoma

Sarcomas are cancers that begin in the **connective tissues**, such as bones, cartilage, fat, and muscle.

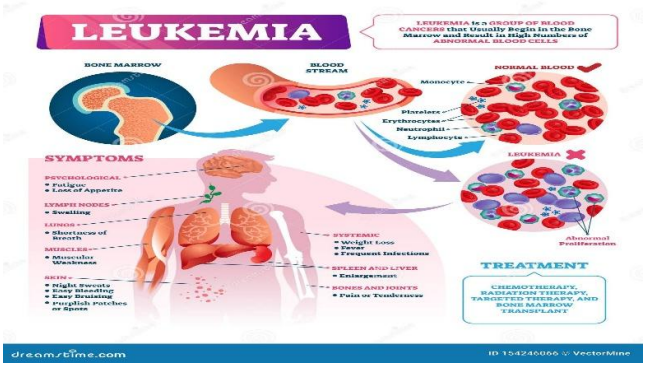
- **Osteosarcoma**: A type of bone cancer that most often affects the long bones, such as the arms and legs.
- **Liposarcoma**: A cancer that originates in fat tissue.
- **Leiomyosarcoma**: A cancer of smooth muscle tissue, which can occur in organs like the uterus or digestive tract.
- **Rhabdomyosarcoma**: A cancer that affects striated muscle tissue, commonly found in children.



3. Leukemia

Leukemia is a cancer of the **blood** or **bone marrow**, characterized by the rapid production of abnormal white blood cells. These cancers can be either **acute** (fast-growing) or **chronic** (slow-growing).

- **Acute Lymphoblastic Leukemia (ALL)**: A type of leukemia that affects lymphoid cells, common in children.
- **Acute Myeloid Leukemia (AML)**: Affects myeloid cells and is more common in adults.
- **Chronic Lymphocytic Leukemia (CLL)**: A slow-growing leukemia that primarily affects older adults.
- **Chronic Myeloid Leukemia (CML)**: A type of leukemia characterized by the overproduction of white blood cells and is often linked to genetic changes.



4. Lymphoma

Lymphomas are cancers that develop in the **lymphatic system**, which includes the lymph nodes, spleen, and bone marrow. These cancers involve the abnormal growth of **lymphocytes**, a type of white blood cell.

- **Hodgkin Lymphoma**: A cancer that is characterized by the presence of **Reed-Sternberg cells**. It is more common in younger adults and adolescents.
- **Non-Hodgkin Lymphoma**: A diverse group of lymphomas that can develop from B cells or T cells. It includes several subtypes like **diffuse large B-cell lymphoma** and **follicular lymphoma**.

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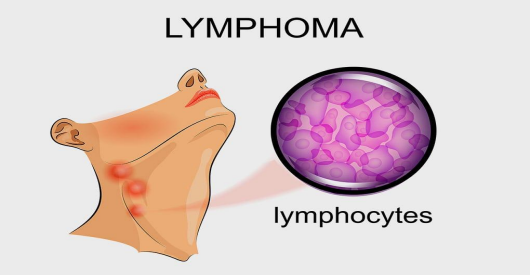
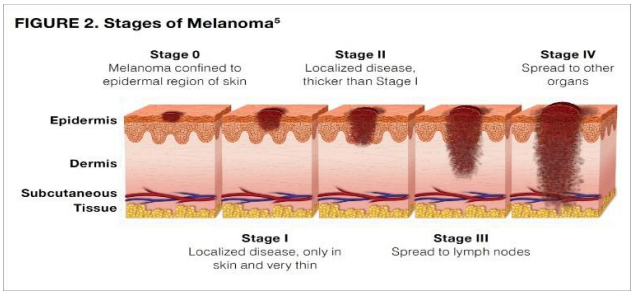


5. Melanoma

Melanoma is a type of cancer that originates in the **melanocytes**, the pigment-producing cells in the skin. It is a more aggressive form of skin cancer that can spread to other parts of the body if not detected early.

- **Cutaneous Melanoma**: The most common type of melanoma, found on the skin.
- **Mucosal Melanoma**: A rarer form of melanoma that occurs in mucous membranes such as in the mouth, gastrointestinal tract, or genitals.
- **Ocular Melanoma**: A type of melanoma that affects the eye.



6. Brain and Spinal Cord Cancers (CNS Cancers)

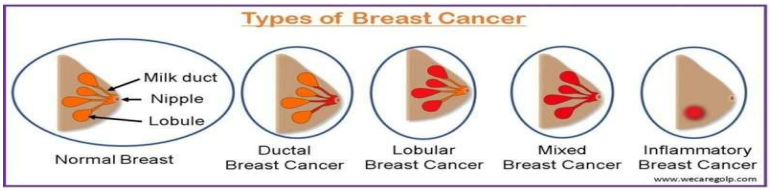
Cancers of the **central nervous system (CNS)**, which includes the brain and spinal cord, can occur in various tissues within these organs.

- **Gliomas**: Cancers that originate in the glial cells (the supportive cells in the brain). The most common type is **glioblastoma**.
- **Meningioma**: A tumor that forms in the meninges, the protective layers surrounding the brain and spinal cord. It is typically benign but can be malignant in some cases.
- **Medulloblastoma**: A type of brain cancer that often occurs in children and starts in the cerebellum.

7. Breast Cancer

Breast cancer originates in the **cells of the breast tissue**. It is the most common cancer in women, although men can also develop it. It can be categorized based on the type of tissue involved, including:

- **Ductal carcinoma**: Originates in the milk ducts.
- **Lobular carcinoma**: Begins in the milk-producing lobules.



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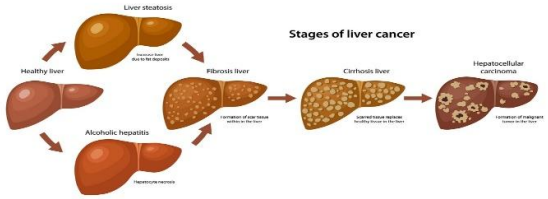
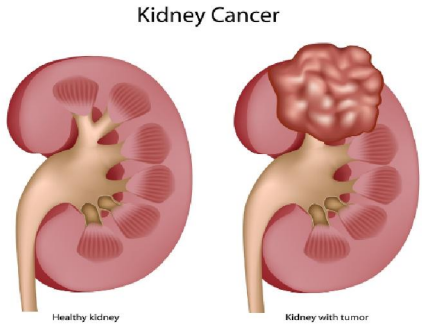
8. Liver Cancer

Liver cancer typically starts in the **hepatocytes**, the cells of the liver. The most common type is **hepatocellular carcinoma (HCC)**. It can develop in people with chronic liver diseases such as cirrhosis or hepatitis B and C infections.



9. Kidney Cancer

Kidney cancer originates in the **kidneys**, and the most common type is **renal cell carcinoma (RCC)**. Other forms include **Wilms' tumor**, which typically occurs in children.



10. Colon and Rectal Cancer (Colorectal Cancer)

Colorectal cancer is a cancer that begins in the **colon** or **rectum**, part of the large intestine. It typically begins as **polyps** that develop in the lining of the colon and may become cancerous over time. It is one of the most common cancers in both men and women.

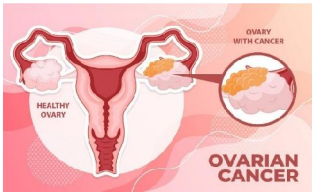
11. Pancreatic Cancer

Pancreatic cancer originates in the **pancreas**, an organ located behind the stomach that helps regulate blood sugar levels and produces enzymes for digestion. The most common form is **adenocarcinoma**, which develops in the exocrine cells of the pancreas.

12. Ovarian Cancer

Ovarian cancer starts in the **ovaries**, which produce eggs in females. It often goes undetected until it is in advanced stages, making it a leading cause of cancer-related deaths in women. It can be categorized into three types:

- **Epithelial ovarian cancer**: The most common type, originating in the outer layer of the ovary.
- **Germ cell tumors**: Develop from the cells that produce eggs.
- **Stromal cell tumors**: Begin in the supportive tissue of the ovaries.



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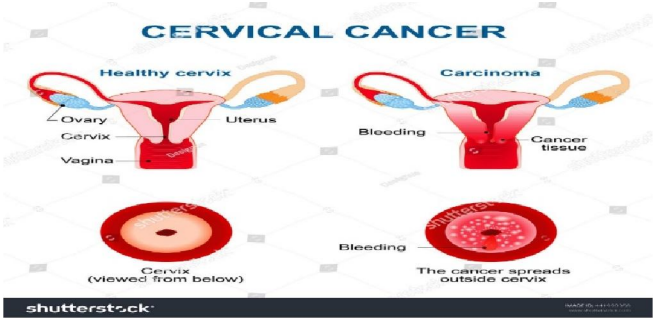
13. Cervical Cancer

Cervical cancer originates in the **cervix**, the lower part of the uterus. It is usually caused by persistent infection with **high-risk types of human papillomavirus (HPV)**. The most common type is **squamous cell carcinoma**.

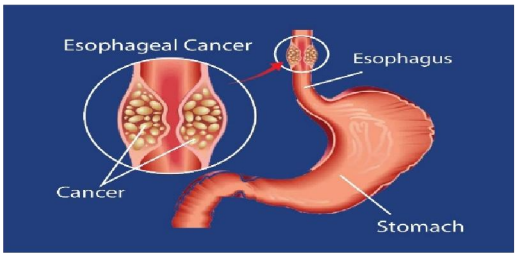


14. Esophageal Cancer

Esophageal cancer occurs in the **esophagus**, the tube that connects the mouth to the stomach. The two most common types are:

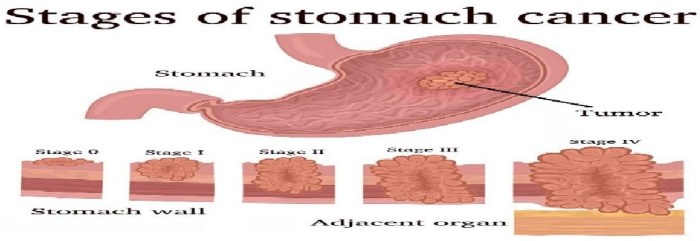
Adenocarcinoma: Often found in the lower part of the esophagus and is associated with acid reflux.

Squamous cell carcinoma: More common in the upper or middle part of the esophagus.



15. Stomach Cancer (Gastric Cancer)

Stomach cancer, or **gastric cancer**, occurs in the **lining of the stomach**. It is often diagnosed at later stages and may present with vague symptoms like indigestion and weight loss.



Stage of Cancer

Cancer staging refers to the process of determining the extent to which cancer has spread in the body. Staging helps doctors assess the severity of cancer, plan the most effective treatment, and predict the patient's prognosis (outlook). The **stage** of cancer is typically described by a number or a combination of numbers (such as 0 to 4), and it can involve several factors, including tumor size, lymph node involvement, and whether cancer has metastasized (spread to other parts of the body).

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Common Staging System: The TNM System

The most widely used system for cancer staging is the **TNM system**, developed by the **American Joint Committee on Cancer (AJCC)** and the **Union for International Cancer Control (UICC)**. It uses three key components to describe the extent of cancer:

T (Tumor): Describes the size and extent of the primary tumor.

- **TX**: Primary tumor cannot be assessed.
- **T0**: No evidence of primary tumor.
- **T1–T4**: Indicates the size of the tumor and its extent. The higher the number, the larger or more extensive the tumor.

N (Lymph Node): Describes the extent of regional lymph node involvement (whether cancer has spread to nearby lymph nodes).

- **NX**: Regional lymph nodes cannot be assessed.
- **N0**: No regional lymph node involvement.
- **N1–N3**: Indicates the extent of lymph node involvement. The higher the number, the more lymph nodes are involved and the larger the size of the affected nodes.

M (Metastasis): Describes whether cancer has spread to distant parts of the body.

- **MX**: Distant metastasis cannot be assessed.
- **M0**: No distant metastasis.
- **M1**: Distant metastasis is present.

The stage of cancer is typically a combination of these T, N, and M categories. For example, a cancer diagnosis might be described as **T2 N1 M0**, which means the tumor is of a certain size (T2), there is regional lymph node involvement (N1), but there is no distant spread (M0).

Stages of Cancer (0 to IV)

The **overall cancer stage** is determined by the combination of T, N, and M classifications. The stages are generally numbered from **0 to IV**, with **Stage 0** representing early-stage, localized cancer, and **Stage IV** indicating advanced cancer that has spread to distant parts of the body.

1. Stage 0: Carcinoma in Situ (CIS)

- **Description**: This is the earliest stage of cancer, often referred to as "in situ" cancer, meaning that the cancer cells are confined to the layer of tissue where they originated and have not spread to nearby tissues. **Stage 0** cancers are localized and have not invaded surrounding tissues.
- **Example**: **Cervical carcinoma in situ** or **ductal carcinoma in situ (DCIS)** of the breast.
- **Treatment**: Often curable with surgery or localized treatments.

2. Stage I: Localized Cancer

- **Description**: The tumor is relatively small and has not spread to nearby lymph nodes or other distant parts of the body. Stage I cancer is still confined to the organ of origin.
- **Example**: Early-stage **breast cancer** where the tumor is confined to the breast.
- **Treatment**: Often treated with surgery, radiation, or localized treatments such as chemotherapy.

3. Stage II: Early Locally Advanced Cancer

- **Description**: The tumor may have grown larger or spread to nearby tissues or lymph nodes but is still confined to the region of origin and has not spread to distant parts of the body.
- **Example**: **Stage II breast cancer** might involve a larger tumor or spread to nearby lymph nodes but has not metastasized.
- **Treatment**: Usually involves surgery, possibly combined with chemotherapy, radiation, or hormone therapy depending on the cancer type.

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4. Stage III: Locally Advanced Cancer

- **Description**: Cancer has spread to surrounding tissues and/or lymph nodes near the primary tumor but has not spread to distant parts of the body. The cancer is considered more advanced, but it is still confined to the region.
- **Example**: **Stage III lung cancer** may involve extensive lymph node involvement.
- **Treatment**: Treatment often includes a combination of surgery, chemotherapy, radiation therapy, and sometimes immunotherapy or targeted therapy, depending on the cancer.

5. Stage IV: Metastatic Cancer (Advanced Cancer)

- **Description**: Stage IV is the most advanced stage of cancer, indicating that cancer has spread to distant organs or tissues beyond the primary site. This stage is also known as metastatic cancer.
- **Example**: **Stage IV colon cancer** has spread to the liver or lungs.
- **Treatment**: While Stage IV cancer is not curable in most cases, treatment may focus on slowing the progression of the disease, relieving symptoms, and extending life. Treatment can involve chemotherapy, targeted therapy, immunotherapy, radiation, and sometimes surgery.

Staging Considerations for Specific Cancers

- **Breast Cancer**: In breast cancer, staging considers tumor size, lymph node involvement, and whether cancer has spread to other organs. For example, **Stage II** may involve a tumor of 2 to 5 cm in size and may have spread to some nearby lymph nodes but not distant organs. **Stage IV** refers to cancer that has spread to distant organs like the bones, liver, or lungs.
- **Lung Cancer**: Lung cancer is staged using a combination of the **TNM system** and a specialized system, including whether cancer is limited to one side of the chest or has spread. **Small cell lung cancer** and **non-small cell lung cancer** are staged differently.
- **Prostate Cancer**: Prostate cancer staging focuses on whether the tumor is confined to the prostate, whether nearby lymph nodes are involved, and whether cancer has spread to other organs. Early-stage prostate cancer (Stage I and II) is localized, while Stage IV prostate cancer has metastasized to distant areas.

Additional Considerations in Staging:

- **Grade of Cancer**: In addition to stage, doctors also consider the **grade** of cancer, which refers to how abnormal the cancer cells look under a microscope. A higher grade often suggests a more aggressive and fast-growing cancer.
- **Cancer Classification (Histopathology)**: This refers to the specific type of cancer cells and tissue involved, which also influences staging and treatment options.

Stage	Description	Characteristics
Stage 0	Carcinoma in Situ	Early stage, localized, confined to the layer of origin.
Stage I	Localized	Small tumor, no lymph node involvement or distant spread.
Stage II	Early Locally Advanced	Tumor may be larger or involve nearby lymph nodes but has not spread distantly.

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Stage III	Locally Advanced	Cancer has spread to nearby tissues and/or lymph nodes but not distant parts.
Stage IV	Metastatic (Advanced)	Cancer has spread to distant parts of the body, often affecting multiple organs.

Treatments for Cancer

Cancer treatment depends on the type, stage, and location of cancer, as well as the patient's overall health and preferences. Treatment may be curative, aimed at removing or destroying cancer cells, or palliative, focusing on reducing symptoms and improving quality of life. Several types of cancer treatments can be used alone or in combination. Here are the primary treatment options for cancer:

1. Surgery

Surgery is one of the oldest and most common treatments for cancer. It involves physically removing the tumor or the affected part of the organ.

- **Goal**: The goal of surgery is to remove the tumor completely or as much of it as possible, while trying to preserve normal tissue and organ function.
- **Indications**: Surgery is often used in early-stage cancers that are confined to one area, such as **breast cancer**, **colon cancer**, **lung cancer**, and **skin cancers**. It is also used for diagnostic purposes (e.g., biopsy), staging, or symptom relief (e.g., to remove an obstruction caused by the tumor).

Types:

- **Excisional surgery**: The tumor and some surrounding healthy tissue are removed.
- **Laparoscopic (minimally invasive) surgery**: Smaller incisions are made, often leading to shorter recovery times.
- **Radical surgery**: More extensive surgery to remove the entire organ or part of it, such as in cases of **prostate cancer** or **bladder cancer**.

2. Chemotherapy

Chemotherapy involves the use of drugs to destroy cancer cells by interfering with their ability to divide and grow. Chemotherapy is often used to treat cancers that have spread to other parts of the body (metastasized).

- **Goal**: To kill rapidly dividing cancer cells, shrink tumors, and sometimes make surgery or radiation therapy more effective.
- **Indications**: Chemotherapy is commonly used for cancers like **leukemia**, **lymphoma**, **breast cancer**, **ovarian cancer**, and **colon cancer**. It can be used before surgery to shrink tumors (neoadjuvant therapy), after surgery to kill any remaining cancer cells (adjuvant therapy), or to treat metastatic cancer.
- **Side Effects**: Chemotherapy drugs also affect normal cells, especially those that divide rapidly, such as cells in the bone marrow, digestive tract, and hair follicles. This leads to common side effects like hair loss, nausea, fatigue, and increased risk of infection.

3. Radiation Therapy

Radiation therapy (or radiotherapy) uses high-energy radiation to kill or damage cancer cells, which prevents them from growing and dividing.

- **Goal**: To target and destroy cancer cells while minimizing damage to surrounding healthy tissue. It can be used alone or in combination with other treatments such as surgery or chemotherapy.

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- **Indications**: Radiation is often used for cancers in localized areas, such as **prostate cancer**, **lung cancer**, **head and neck cancer**, and **brain tumors**. It can be used to shrink tumors before surgery or to kill any remaining cancer cells afterward.

Types:

- **External beam radiation**: A machine directs radiation at the tumor from outside the body.
- **Internal radiation (Brachytherapy)**: A radioactive source is placed inside or very close to the tumor, as in the case of **prostate cancer** or **cervical cancer**.
- **Systemic radiation**: Radioactive substances are introduced into the body (e.g., **radioactive iodine** for **thyroid cancer**).
- **Side Effects**: Radiation therapy can cause fatigue, skin changes, nausea, and tissue damage. The side effects depend on the area being treated.

4. Immunotherapy

Immunotherapy uses the body's immune system to fight cancer. This treatment works by enhancing the natural ability of the immune system to recognize and destroy cancer cells.

- **Goal**: To stimulate or enhance the body's immune response to cancer cells, making the immune system more effective at targeting tumors.
- **Indications**: Immunotherapy is used for cancers like **melanoma**, **lung cancer**, **bladder cancer**, **leukemia**, and **lymphoma**. It is particularly useful for cancers that have spread or recurred after other treatments.
- **Types**:
- **Checkpoint inhibitors**: These drugs block proteins that inhibit immune responses, allowing immune cells to attack cancer cells. Examples include **pembrolizumab** (Keytruda) and **nivolumab** (Opdivo).
- **CAR-T cell therapy**: T cells are extracted from the patient's blood, modified to recognize cancer cells more effectively, and then reintroduced into the body. This is used for some blood cancers like **leukemia** and **lymphoma**.
- **Monoclonal antibodies**: These lab-made molecules can target specific cancer cell markers and stimulate the immune system to attack cancer cells. Examples include **rituximab** (Rituxan) and **trastuzumab** (Herceptin).
- **Side Effects**: Immunotherapy can lead to side effects such as flu-like symptoms, fatigue, skin rash, or inflammation in various organs (autoimmune side effects).

5. Targeted Therapy

Targeted therapy involves drugs or other substances that specifically target cancer cells while sparing normal cells. These therapies work by interfering with specific molecules involved in cancer cell growth.

- **Goal**: To target cancer cells more precisely by interfering with their ability to grow and divide. Targeted therapies can block signals that tumors need to grow or stop the blood vessels that supply tumors.
- **Indications**: Targeted therapies are used for cancers like **breast cancer** (e.g., HER2-positive breast cancer), **lung cancer**, **leukemia**, and **melanoma**.

Types:

- **Small molecule inhibitors**: These drugs block specific enzymes or proteins that cancer cells need to survive, such as **imatinib** (Gleevec) for **chronic myelogenous leukemia** (CML).
- **Monoclonal antibodies**: These antibodies are designed to bind to specific targets on cancer cells and prevent them from growing. Examples include **trastuzumab** (Herceptin) for HER2-positive breast cancer and **rituximab** (Rituxan) for **non-Hodgkin lymphoma**.
- **Side Effects**: Side effects vary depending on the targeted therapy but can include skin problems, liver damage, diarrhea, and changes in blood counts.

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6. Hormone Therapy

Hormone therapy works by blocking or reducing the levels of hormones in the body that fuel certain cancers, such as breast and prostate cancer.

- **Goal**: To stop or slow the growth of cancers that are hormone-dependent (e.g., breast and prostate cancer).
- **Indications**: Hormone therapy is most often used for **hormone-sensitive cancers**, including **breast cancer** (estrogen receptor-positive) and **prostate cancer** (testosterone-dependent).

Types:

- **Aromatase inhibitors**: Block the production of estrogen (used for estrogen receptor-positive breast cancer).
- **Anti-androgens**: Block the action of testosterone in prostate cancer.
- **Oophorectomy**: Removal of ovaries to stop estrogen production in women with breast cancer.
- **Side Effects**: Hormone therapy can cause hot flashes, mood changes, fatigue, sexual dysfunction, and bone thinning.

7. Stem Cell Transplant (Bone Marrow Transplant)

A stem cell transplant involves replacing damaged or destroyed bone marrow with healthy stem cells. This is often used after high-dose chemotherapy or radiation therapy for cancers that affect the bone marrow, such as **leukemia** and **lymphoma**.

- **Goal**: To restore the body's ability to produce healthy blood cells after cancer treatment.
- **Indications**: Often used in cases of **leukemia**, **lymphoma**, **multiple myeloma**, and some solid tumors.
- **Types**:
- **Autologous transplant**: The patient's own stem cells are used.
- **Allogeneic transplant**: Stem cells are taken from a donor.
- **Side Effects**: Infections, graft-versus-host disease (in allogeneic transplants), and organ damage.

8. Palliative Care

Palliative care focuses on improving the quality of life for patients with advanced or terminal cancer. It aims to manage symptoms, control pain, and address psychological, social, and spiritual needs.

- **Goal**: To provide comfort and alleviate symptoms, rather than attempting to cure the disease.
- **Indications**: Often used in the later stages of cancer or for patients who are not responding to curative treatments.
- **Treatments**: Pain relief (opioids, non-steroidal anti-inflammatory drugs), anti-nausea medications, psychological support, and physical therapy.

II. CONCLUSION

Cancer is a complex and challenging disease that arises from the uncontrolled growth of abnormal cells in the body. It can occur in nearly any organ or tissue, leading to a variety of symptoms and complications. Early detection, advances in treatment options like surgery, chemotherapy, radiation therapy, immunotherapy, and personalized medicine, as well as lifestyle changes, have significantly improved survival rates. However, cancer remains a major global health issue, and ongoing research is essential to find more effective treatments and ultimately a cure. Early prevention, awareness, and regular screenings play a crucial role in improving outcomes and reducing the impact of cancer on individuals and communities.

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