Cancer Biology

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1. Introduction to Cancer

Cancer is a generic name for a group of over a hundred diseases characterized by the **uncontrolled and abnormal growth and division of cells**. In a healthy body, cell growth, division, and death are tightly regulated processes. Cancer occurs when this balance is lost, leading to the formation of a mass of abnormal cells called a **tumor** (neoplasm).

Characteristics of cancer

- **Uncontrolled proliferation:** Cancer cells divide continuously without regulation.
- **Lack of differentiation:** They can revert to a less specialized state and don't function like normal cells.
- **Tumor formation:** Uncontrolled cell growth creates a mass of abnormal cells called a tumor.
- **Metastasis:** Malignant cells can break away from the original tumor, travel through the bloodstream or lymphatic system, and form new tumors in other parts of the body.
- **Loss of contact inhibition:** Cancer cells do not stop dividing when they come into contact with other cells, unlike normal cells.

Causes of cancer

- **DNA mutations:** Mutations in DNA can lead to the development of cancer.
- **Carcinogens:** Various agents, including physical, chemical, and biological factors, can cause these mutations.
    - **Physical:** Ionizing radiation (X-rays, gamma rays).
    - **Chemical:** Tobacco smoke.
    - **Biological:** Viruses (viral oncogenes), proto-oncogenes, and cellular oncogenes.
- **Lifestyle:** Habits like smoking, excessive sun exposure, and an unhealthy diet can increase cancer risk.

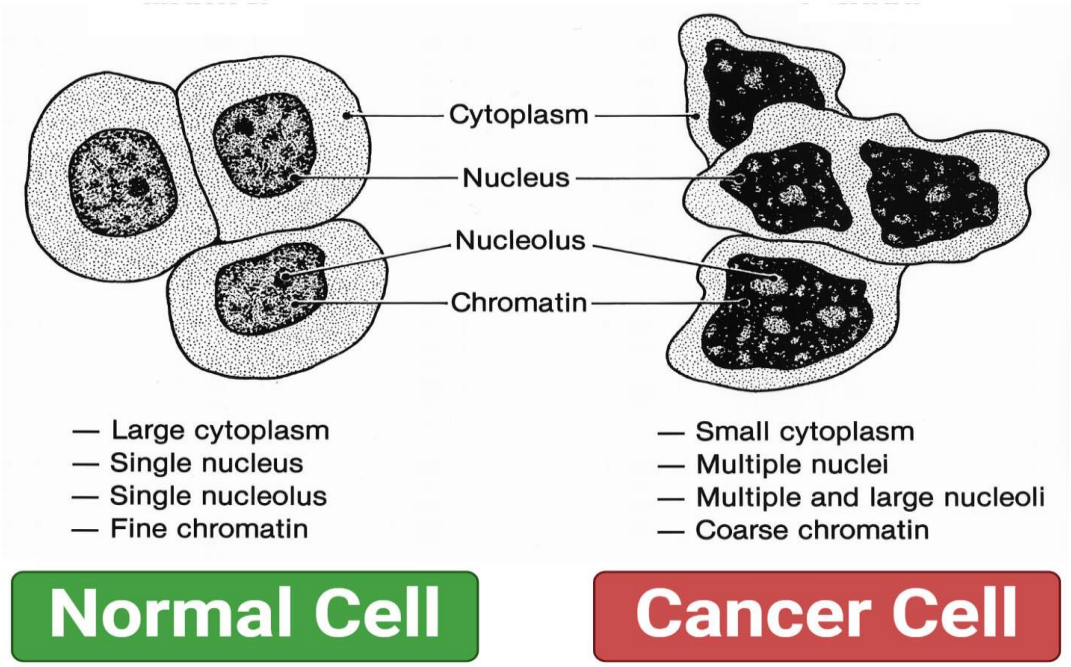
Types of cancer

- Cancer is not a single disease but a large class of diseases, with over 100 distinct types.
- **Benign tumor:** A non-cancerous growth that does not invade nearby tissues or spread to other parts of the body.

- **Malignant tumor:** A cancerous growth that can invade surrounding tissues and metastasize.

The primary characteristic that distinguishes malignant (cancerous) tumors from benign (non-cancerous) ones are the abilities to:

- **Invade** adjacent tissues and destroy them.
- **Metastasize**: spread to distant parts of the body through the bloodstream or lymphatic system to form secondary tumors.



2. Differences Between Normal and Cancer Cells

Feature	Normal Cells	Cancer Cells
Growth	Controlled and density-dependent (stop dividing when they touch others).	Uncontrolled (loss of contact inhibition), grow aggressively.
Shape/Appearance	Uniform in size and shape with well-organized interiors.	Irregular/misshapen, with disorganized internal structures.
Nucleus	Spheroid, smooth appearance, evenly distributed chromatin.	Irregular shape, often enlarged, with coarse chromatin clumps and prominent/multiple nucleoli.
Lifespan	Finite lifespan (undergo apoptosis - programmed cell death).	Potentially immortal (evade apoptosis), can divide indefinitely.
Blood Supply	Stimulate angiogenesis only when needed (e.g., wound healing).	Secrete chemical signals to induce continuous angiogenesis (new blood vessel growth) to ensure nutrient supply.

3. Classification of Cancer

Cancers are broadly classified based on the type of tissue from which they originate:

- **Carcinomas**: Most common type, arising from epithelial cells (tissues that line internal and external body surfaces, e.g., skin, lung, breast, colon cancer).
- **Sarcomas**: Arise from connective tissues such as bone, muscle, fat, and cartilage.
- **Leukemias**: Cancers of the blood-forming tissues (bone marrow, spleen, lymph nodes), resulting in the overproduction of abnormal white blood cells.
- **Lymphomas**: Arise from the cells of the immune system (lymphocytes).
- **Myelomas**: Affect plasma cells found in the bone marrow.

4. The Molecular Basis of Cancer

Cancer is fundamentally a **genetic disease**, caused by the accumulation of mutations in a cell's DNA. These mutations affect key genes that regulate cell growth and division:

- **Proto-oncogenes**: These genes normally promote cell growth and division (like a cell's "accelerator" pedal). Mutations can turn them into **oncogenes**, which are hyperactive and cause uncontrolled growth.
- **Tumor Suppressor Genes**: These genes normally inhibit cell growth or induce apoptosis (act as the cell's "brakes"). Mutations in these genes release the brakes, leading to unchecked proliferation.
- **DNA Repair Genes**: Mutations in these genes compromise the cell's ability to fix DNA damage, leading to a higher accumulation of further mutations.

5. Cancer Development and Progression (Carcinogenesis)

Carcinogenesis is a multi-stage process involving multiple "hits" or mutations over time.

Flow Chart of Cancer Development

A simplified flow chart of cancer development is as follows:

Normal Cell
↓
Initiation
(First mutation due to carcinogen exposure or error)
↓
Promotion
(Accumulation of further mutations, possibly due to continuous exposure to promoting agents)
↓
Conversion / Dysplasia
(Pre-cancerous abnormal growth)
↓

Malignant Conversion
(Cells acquire invasive properties)
↓
Tumor Progression
(Further growth, angiogenesis, and potential to metastasize)
↓
Metastasis
(Cancer cells spread to distant sites via blood/lymph)
↓
Secondary Tumors

6. Causes and Risk Factors (Etiology)

The etiology of cancer is multi-factorial. Causes can be:

- **Genetic/Inherited** (5-10%): Born with a predisposition (e.g., BRCA1/BRCA2 genes for breast cancer).
- **Acquired/Environmental** (majority): Caused by carcinogens.
    - **Chemicals**: Tobacco smoke, asbestos, alcohol.
    - **Radiation**: UV light, X-rays, ionizing radiation.
    - **Biological Agents**: Viruses (HPV, Hepatitis B/C), some bacteria.
    - **Lifestyle**: Diet, obesity, age.

7. Diagnosis and Treatment

Diagnosis often involves physical exams, imaging techniques (X-rays, CT, MRI scans), blood tests, and a **biopsy** (tissue sample for microscopic examination).
Treatment typically involves a combination of methods, depending on the cancer type and stage:

- **Surgery**: Removal of the primary tumor (effective if cancer is localized).
- **Radiation Therapy**: Uses high-energy rays to kill cancer cells and shrink tumors.
- **Chemotherapy**: Uses drugs that interfere with cell division to target rapidly dividing cancer cells.
- **Targeted Therapy & Immunotherapy**: Newer approaches that target specific molecular changes in cancer cells or boost the body's own immune system to fight cancer.