Cancer Genetics

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Summer Class

Lecture 9

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Outline

- What is Cancer
- What Is Cancer Genetics
- Type of Mutation
- Main concepts in cancer genetics
- Diagnostic and Clinical Implications

Objectives

- By the end of this lecture, students should be able to:
- Explain the genetic basis of Cancer Genetics

❑ What is Cancer?

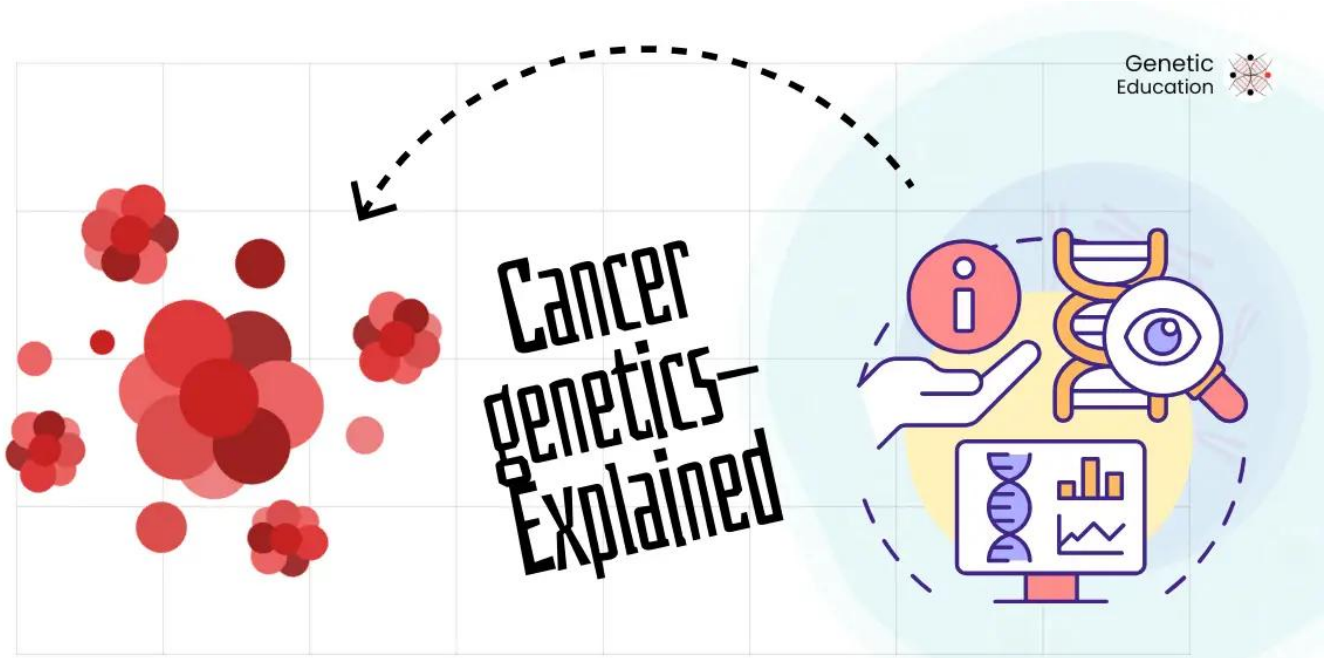
- Cancer is a disease characterized by **uncontrolled cell growth** due to **genetic alterations**.

- It is caused by mutations in genes that **regulate cell division**, **DNA repair**, and **apoptosis**.

- Cancer can be sporadic, familial, or inherited.

❑ What Is Cancer Genetics?

- Cancer genetics is the study of the **genetic changes** and mutations that lead to the development and progression of cancer.



❖ Type of Mutation:

- Mutations can also be classified according to where they occur in the body: germline mutations and somatic mutations.

i. **Germline:** Is a genetic change that occurs in a germ cell (egg or sperm).

✓ Can be inherited from a parent.

✓ Only one mutated copy of the gene is needed to increase risk.

✓ Example: An inherited pathogenic variant in BRCA1 or BRCA2

ii. Somatic mutation: Acquired during life; not inherited.

- A somatic mutation is a genetic change that occurs in a body cell (non-germ cell).

- Generally, cannot be passed to children.

- Example: acquired mutations in genes such as KRAS, BRAF, or TP53 can contribute to cancer.

❑ Why It Matters:

- Helps in understanding how cancer develops
- Aids in diagnosis, risk prediction, and targeted treatment
- Supports personalized medicine and genetic counseling

❑ Main concepts in cancer genetics:

- Oncogenes (genes that promote cancer when activated)
- Tumor suppressor genes (genes that prevent cancer when functional)
- Genetic predisposition (inherited risk factors)

What Are Oncogenes?

- Oncogenes are mutated or abnormally activated versions of normal genes called **proto-oncogenes**.
- These genes promote cell growth, division, and survival.
- When proto-oncogenes become oncogenes, they can cause uncontrolled cell proliferation, leading to cancer.

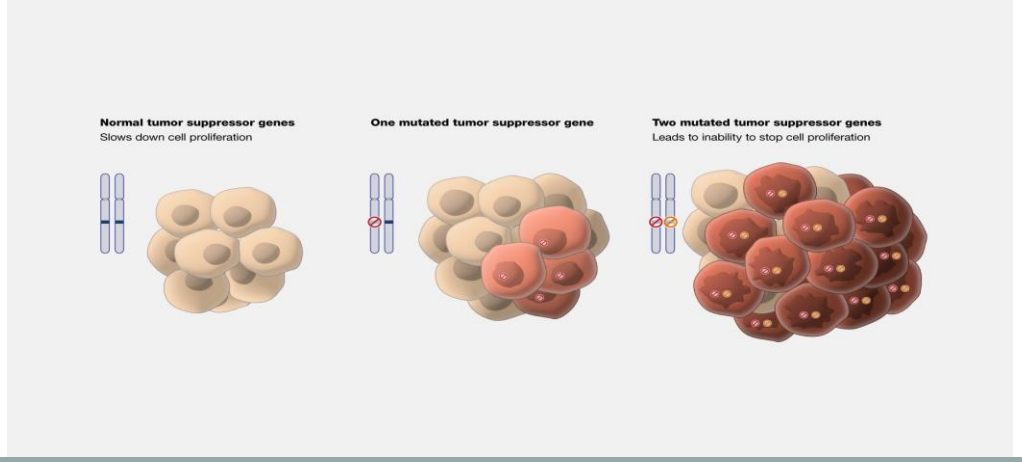
❑ How Proto-Oncogenes Become Oncogenes:

1. Point mutations (e.g., RAS gene)
2. Gene amplification (e.g., HER2 in breast cancer)
3. Chromosomal translocation (e.g., BCR-ABL in CML)
4. Insertion of viral DNA (e.g., HPV in cervical cancer)

❑ What Are Tumor Suppressor Genes?

- Are genes that protect cells from turning cancerous by controlling cell growth, repairing DNA damage, and triggering cell death.

- When these genes are mutated or inactivated, cells can grow out of control, contributing to cancer development.



❑ Main Functions:

1. Regulate the cell cycle (prevent uncontrolled cell division)

2. Repair DNA damage (maintain genetic stability)

3. Induce apoptosis (remove damaged or abnormal cells)

❑ Mutation Characteristics:

- Usually requires both copies of the gene to be inactivated (recessive effect).

- Based on the “two-hit hypothesis” both alleles must be "hit" for cancer to develop.

❑ What Is Cancer Genetic Predisposition?

- Refers to an increased risk of developing cancer due to inherited mutations in specific genes.

- These mutations are passed from parent to child and are present in every cell of the body from birth.

❑ Main Points:

1. Inherited Mutations: Unlike somatic mutations, predisposition is caused by mutations in genes like BRCA1, TP53, or APC that are inherited from a parent.

2. Increased Risk, Not Certainty: Having a genetic predisposition does not guarantee cancer.

3. Affected Genes: Most often involve:

- Tumor suppressor genes (e.g., BRCA1, BRCA2, TP53)
- DNA repair genes (e.g., MLH1, MSH2)

❖ Examples of Hereditary Cancer Syndromes:

Syndrome	Gene	Cancer Type
Hereditary Breast and Ovarian Cancer	BRCA1, BRCA2	Breast, ovarian
Lynch Syndrome (HNPCC)	MLH1, MSH2	Colorectal, endometrial
Li-Fraumeni Syndrome	TP53	Multiple early-onset cancers
Familial Adenomatous Polyposis (FAP)	APC	Colorectal cancer
Retinoblastoma	RB1	Eye cancer in children

❖ Diagnostic and Clinical Implications:

- Genetic Testing: BRCA1/2, TP53, APC, etc.
- Risk Assessment: Family history, gene panels
- Targeted Therapies: e.g., HER2 inhibitors, PARP inhibitors
- Surveillance and Prevention:

✓ Early screenings (e.g., colonoscopy)

✓ Preventive surgeries (e.g., mastectomy)

✓ Lifestyle and environmental control

References

1. Wallace DC. "Mitochondrial DNA mutations in disease and aging." Environmental and Molecular Mutagenesis, 2010.

2. DiMauro S, Schon EA. "Mitochondrial respiratory-chain diseases." The New England Journal of Medicine, 2003.

3. Vafai SB, Mootha VK. "Mitochondrial disorders as windows into an ancient organelle." Nature, 2012.

Thanks