Lecture Note: Gene and Cell Therapy

Target Audience: B.Tech I Semester (Introductory Biotechnology Course, 2 Credits)

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1. Introduction to Gene and Cell Therapy

Gene and cell therapy are advanced biotechnological approaches used to treat, prevent, or cure diseases by modifying or replacing defective cells or genes in a patient.

- **Gene Therapy**: The delivery of genetic material (DNA or RNA) into a patient's cells to correct or replace faulty genes responsible for disease.
- **Cell Therapy**: The use of living cells to restore the function of damaged tissues or organs.

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2. Basics of Gene Therapy

Types of Gene Therapy:

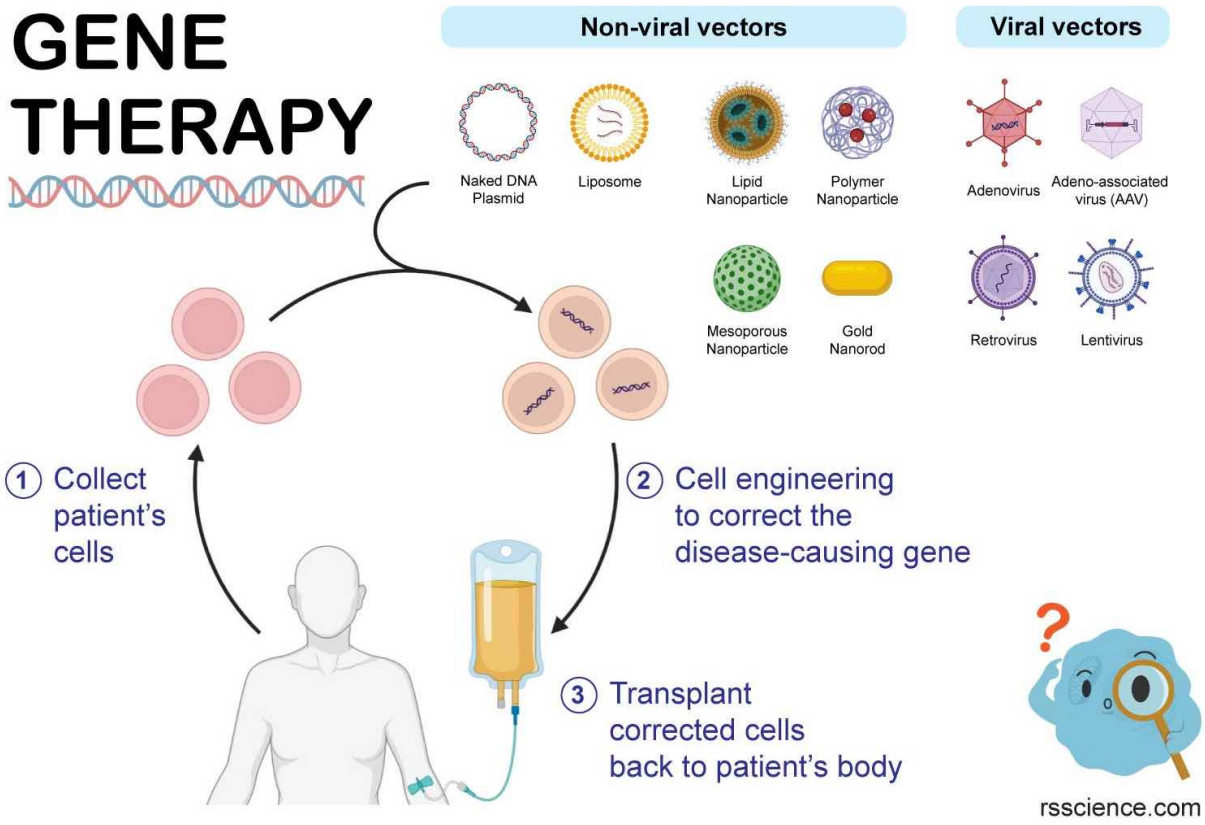
1. **Somatic Gene Therapy**:
    - Targets non-reproductive (somatic) cells.
    - Changes are not passed to offspring.
    - Example: Treating cystic fibrosis by delivering a functional CFTR gene.
2. **Germline Gene Therapy** (Experimental):
    - Targets reproductive cells (sperm, eggs).
    - Changes are inheritable.
    - **Not approved for use in humans due to ethical concerns.**

Mechanisms of Gene Therapy:

- **Gene Addition**: Adding a functional gene to replace a missing or faulty one.
- **Gene Editing**: Using tools like CRISPR-Cas9 to directly modify the faulty gene.
- **Gene Silencing**: Using RNA interference (RNAi) to silence harmful genes.

Example of Gene Therapy:

- **Spinal Muscular Atrophy (SMA)**: Treated with the gene therapy drug **Zolgensma**, which delivers a functional copy of the SMN1 gene using a viral vector.


GENE THERAPY
Non-viral vectors
Viral vectors
Naked DNA Plasmid
Liposome
Lipid Nanoparticle
Polymer Nanoparticle
Adenovirus
Adeno-associated virus (AAV)
Mesoporous Nanoparticle
Gold Nanorod
Retrovirus
Lentivirus
1 Collect patient's cells
2 Cell engineering to correct the disease-causing gene
3 Transplant corrected cells back to patient's body
rsscience.com

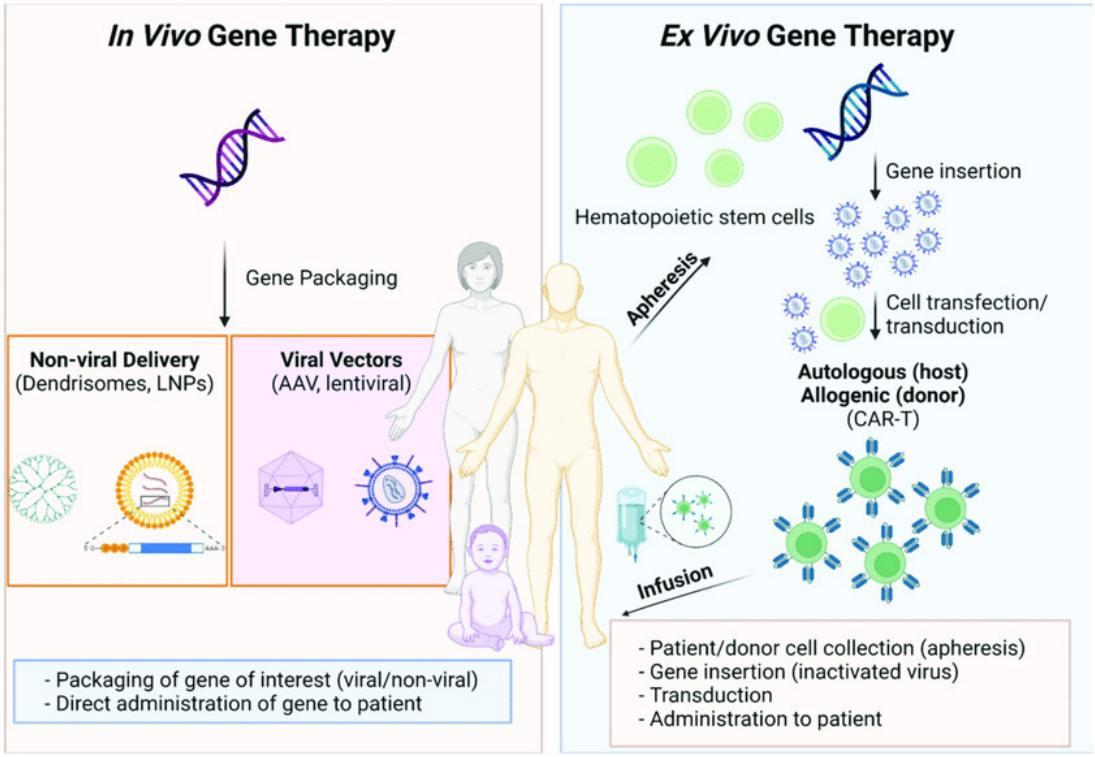


Fig. 1. Gene therapy

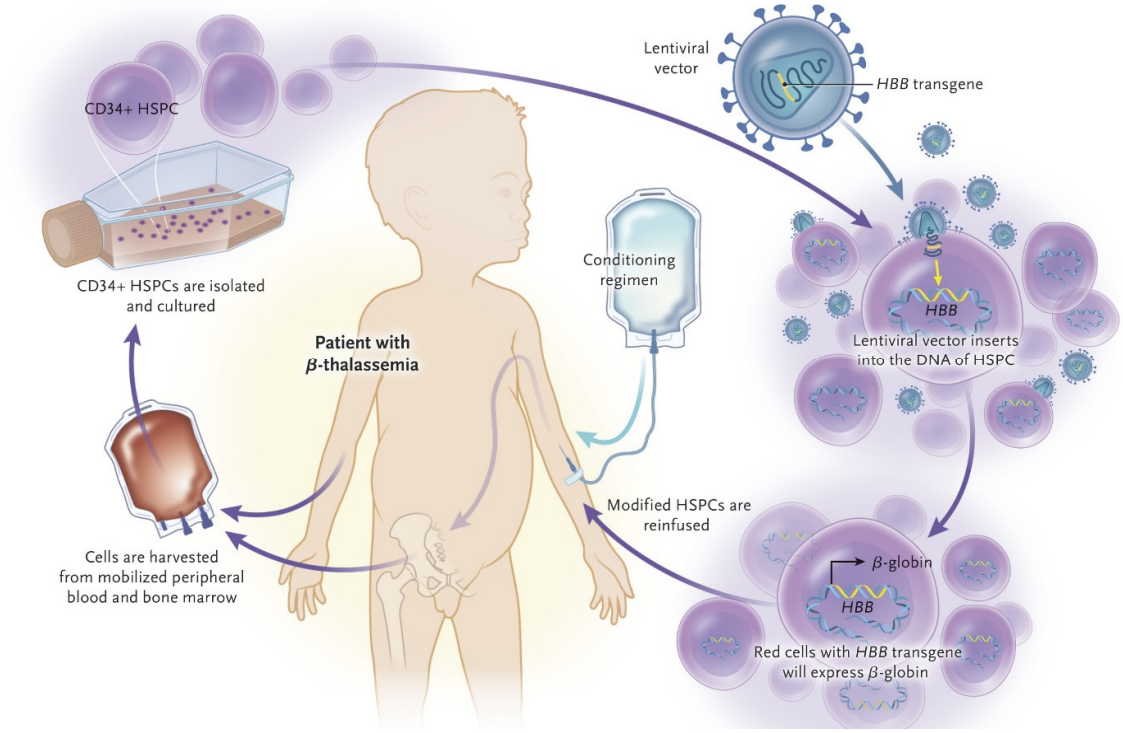


Fig. 1. Gene therapy for Beta Chain-Thalassimea

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3. Basics of Cell Therapy

Key Concepts in Cell Therapy:

- **Stem Cells**: Special cells with the ability to develop into different cell types (e.g., muscle, nerve, or blood cells).
- **Differentiated Cells**: Mature cells, like immune cells, used directly for therapeutic purposes.

Types of Cell Therapy:

1. **Autologous Cell Therapy**:
    - Uses the patient's own cells (e.g., bone marrow transplants).
2. **Allogeneic Cell Therapy**:
    - Uses donor cells that match the patient's immune profile.

Applications of Cell Therapy:

- **CAR-T Cell Therapy**: Engineering a patient's immune cells (T-cells) to fight cancer.
- **Stem Cell Therapy**: Using stem cells to treat conditions like Parkinson's disease or spinal cord injuries.

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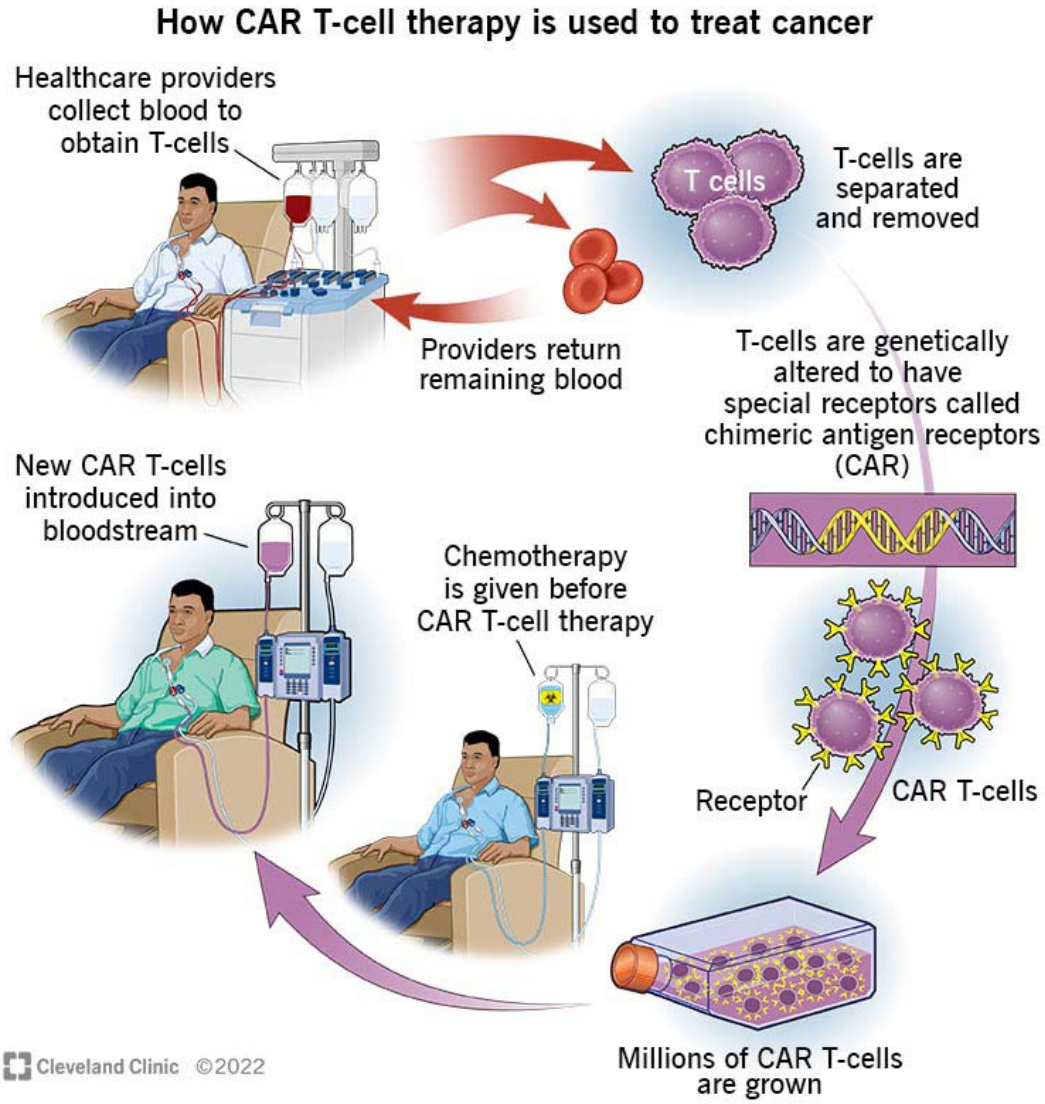
4. Examples of Gene and Cell Therapy

Therapy Type	Disease/Condition Treated	How It Works	Example
Gene Therapy	Hemophilia	Delivers a functional copy of a clotting factor gene using a viral vector.	**Hemgenix** (for Hemophilia B)
	Cystic Fibrosis	Adds a healthy CFTR gene to repair defective chloride channels in lung cells.	Clinical trials ongoing
	Leber's Congenital Amaurosis (LCA)	Corrects a faulty RPE65 gene to restore vision.	**Luxturna**

Therapy Type	Disease/Condition Treated	How It Works	Example
Cell Therapy	Blood Cancers (Leukemia, Lymphoma)	CAR-T cells target and destroy cancer cells.	**Kymriah** or **Yescarta**
	Type 1 Diabetes	Stem cells differentiate into insulin-producing pancreatic cells.	Research trials ongoing
	Spinal Cord Injuries	Stem cells regenerate damaged nerve tissues.	Experimental therapies



Key Challenges and Ethical Considerations

- **Gene Therapy**:
  - High cost of treatment (e.g., Zolgensma costs ~$2.1 million).
  - Delivery challenges (e.g., ensuring vectors reach target cells).
  - Ethical concerns over germline editing.
- **Cell Therapy**:
  - Immune rejection of donor cells in allogeneic therapies.
  - Scalability and cost of stem cell production.
  - Safety concerns over tumor formation from stem cells.

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6. Future Prospects

- **Personalized Medicine**: Tailoring therapies based on a patient's genetic profile.
- **Advances in CRISPR**: Safer and more efficient gene-editing tools for therapy.
- **Regenerative Medicine**: Using stem cells to grow entire organs for transplantation.

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7. Conclusion

Gene and cell therapy are transforming medicine by offering curative treatments for diseases previously considered untreatable. While challenges remain, continued research and technological advances are paving the way for widespread applications.

Discussion Questions for Students

1. How does gene therapy differ from traditional drug-based treatments?
2. Discuss the role of CRISPR-Cas9 in modern gene therapy.
3. What are the ethical considerations of using stem cells in cell therapy?