

Medical Biotechnology 2026

Biological therapies

Lecture 1-2nd

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Definition, History, Main fields



Main therapeutic fields in human medicine

- Surgical treatments
- Conservative therapies
 - drug-based therapies
 - biological therapies
- Radiotherapies
- Physiotherapies
- Balneotherapy
- Psychotherapy

Definition of the biological therapy

Biological therapies use substances derived from living organisms to treat disease. These agents may be **naturally occurring in the body** or **produced using biotechnology**.

They can act by:

- **stimulating or suppressing the immune system**, helping the body fight cancer, infections, autoimmune and inflammatory diseases
- **targeting specific cancer cells**, inhibiting their growth or inducing cell death

Major types of biological therapies:

- **Immunotherapy**
(e.g. vaccines, cytokines, monoclonal antibodies)
- **Gene therapy**
- **Targeted therapies**
- **Biological response modifier therapies (BRMs)**

Main branches in biological therapies

Biological therapies can be broadly classified into three main categories:

- 1. Therapies based on biological substances:** Derived from living organisms or their products: vaccines, immunoglobulins (IVIg), antitoxins
- 2. Engineered biological molecules:** Genetically engineered or recombinant biomolecules: monoclonal antibodies, gene therapies, biologics
- 3. Therapies using living organisms:** Intact biological agents applied therapeutically: oncolytic viruses, zoo-therapy (maggots, leeches, honey bee-derived products)

Monoclonal antibody therapy

Derived



History

Biological therapies have evolved through key milestones over more than two centuries:

1796 – Vaccination

Edward Jenner introduces vaccination, laying the foundation of immunotherapy

Late 19th century – Vaccines and immunoglobulin therapy

Louis Pasteur establishes active and passive immunization

Early 20th century – Tumor immunotherapy

William Coley pioneers immune-based cancer treatment

(Coley's toxins)

1907 – The “magic bullet” concept

Paul Ehrlich formulates the idea of targeted therapy

Late 20th century – Modern cancer vaccines and gene therapy

Steven Rosenberg and others translate immunology into clinical oncology



Main classes of biological therapies

- **Based on academic research, and validated in evidence based experimental and clinical studies** (E.g. therapeutic monoclonal antibodies, recombinant hormones and cytokines)
- **Partially based on academic research but not validated by large scale evidence based studies** (E.g. tumor vaccines)
- **Based on empiric observations, not validated by evidence based studies** (E.g. maggot therapy, some procedures of complementary medicine)
- **Based on theories never approved by the academic research** (methods of natural and alternative medicine)

Main forms of biological therapies

Vaccines

Healthy Gene

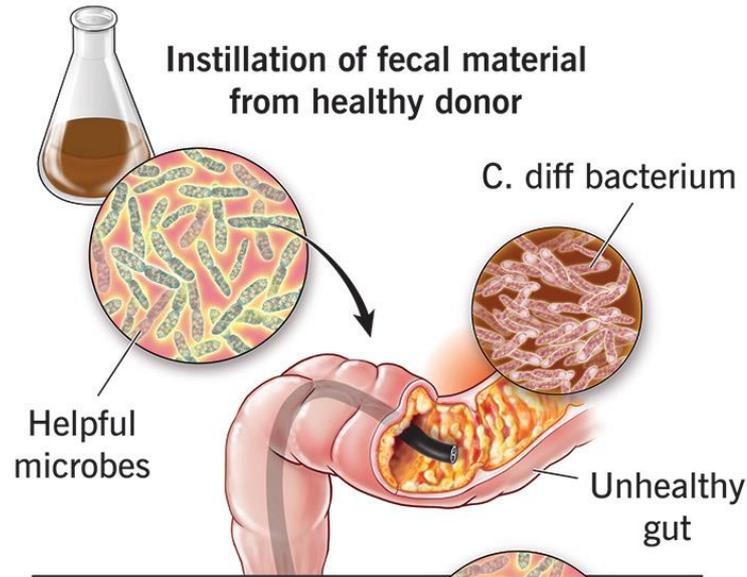
HOW DID THEY MAKE

fermentation tank

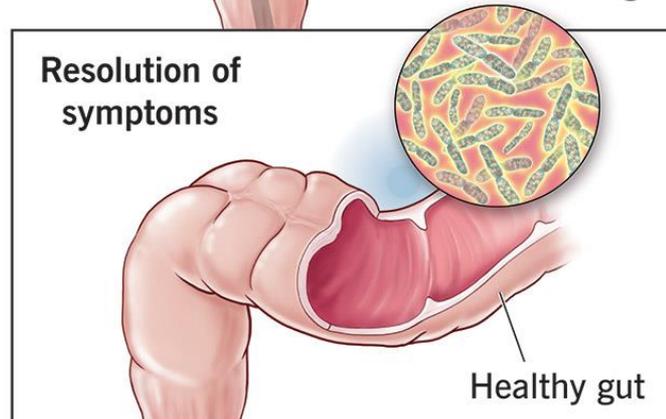


Fecal transplant

Instillation of fecal material from healthy donor



Resolution of symptoms



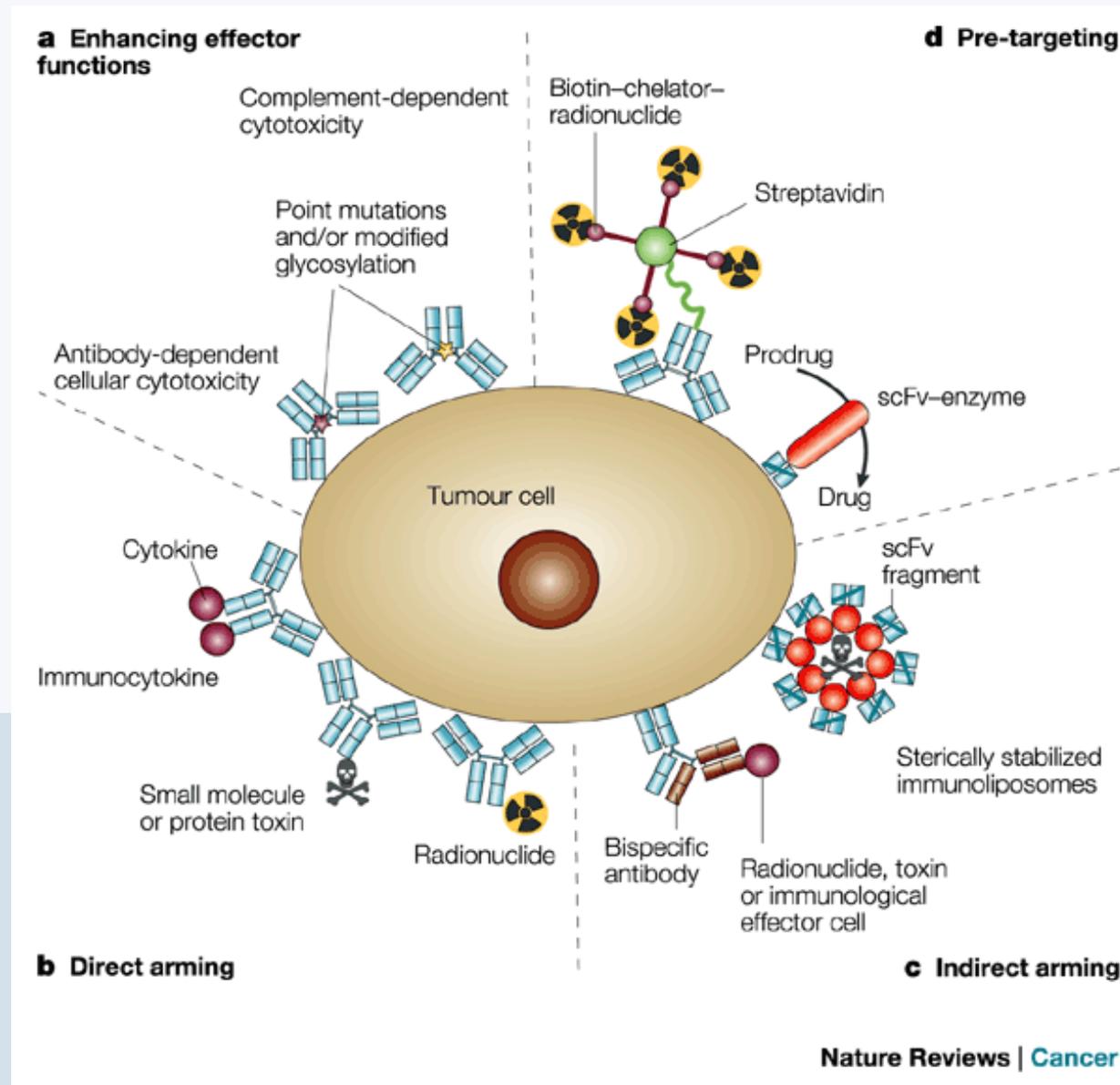
Biotherapy of autoimmune diseases

- Biologic therapies in which **molecules involved in the pathomechanisms are targeted**
- Provide an **alternative to the existing treatment** methods of disease-modifying anti-rheumatic drugs and other immunosuppressive medications
- **Intravenous administration**, the high costs of these drugs, and the adverse events associated with them, prevent their wide use as first-line medications.

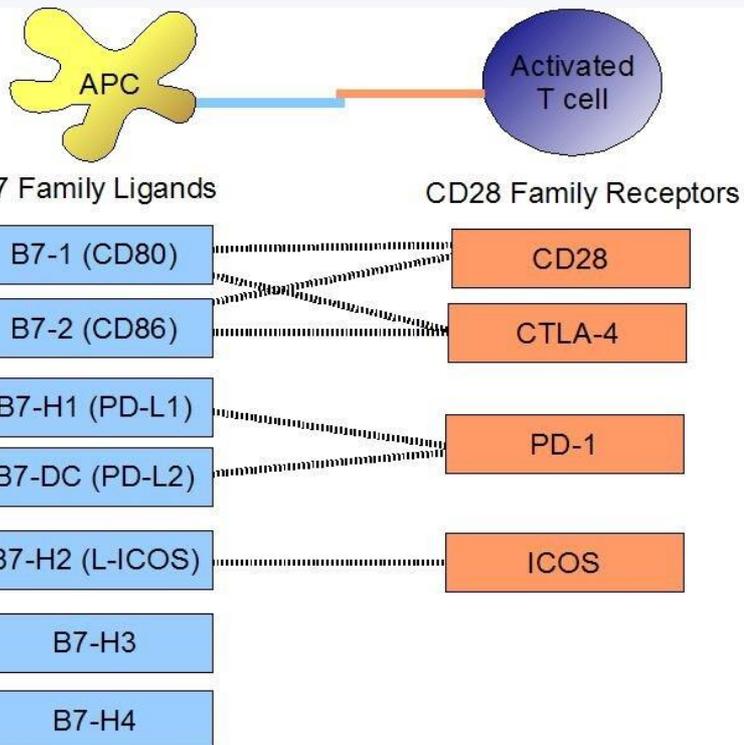
Immune based biological therapies of cancer

- **Direct immunotherapy** uses a **variety of methods and drugs to manipulate the immune system** to create a **hostile environment** for the cancer in the body.
- In **indirect biological therapy** the biologically derived **agents are either used to modify the relationship between tumor and host**, (E.g. check point inhibitors) Common biological agents include interferons, monoclonal antibodies, interleukins, growth factors, and tumor vaccines.
- **Cytotoxic therapy** involves **changing the cancer cells' biology** so that they become weak and die.
- **Stem cell or bone marrow transplantation** is often used to replace stem cells destroyed by high doses of chemotherapy and/or radiation therapy, or to directly attack the malignancy.

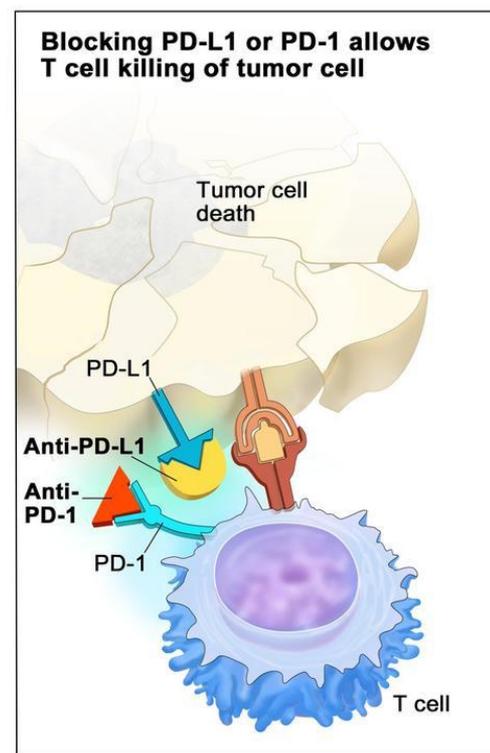
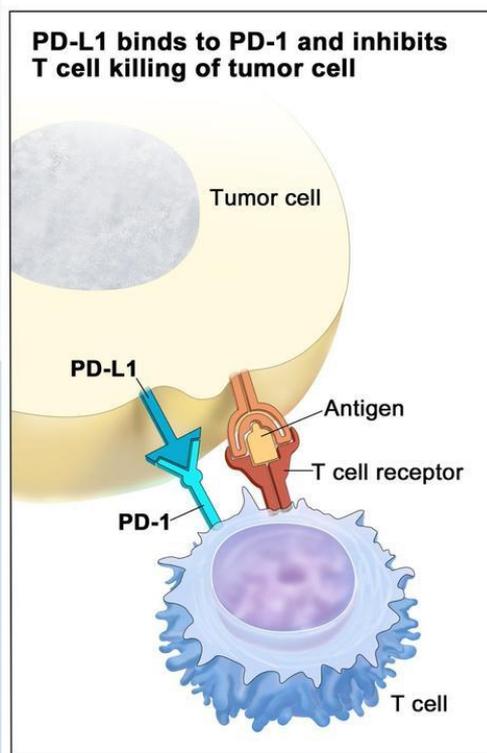
Monoclonal antibodies for therapeutic use



Checkpoint inhibitors

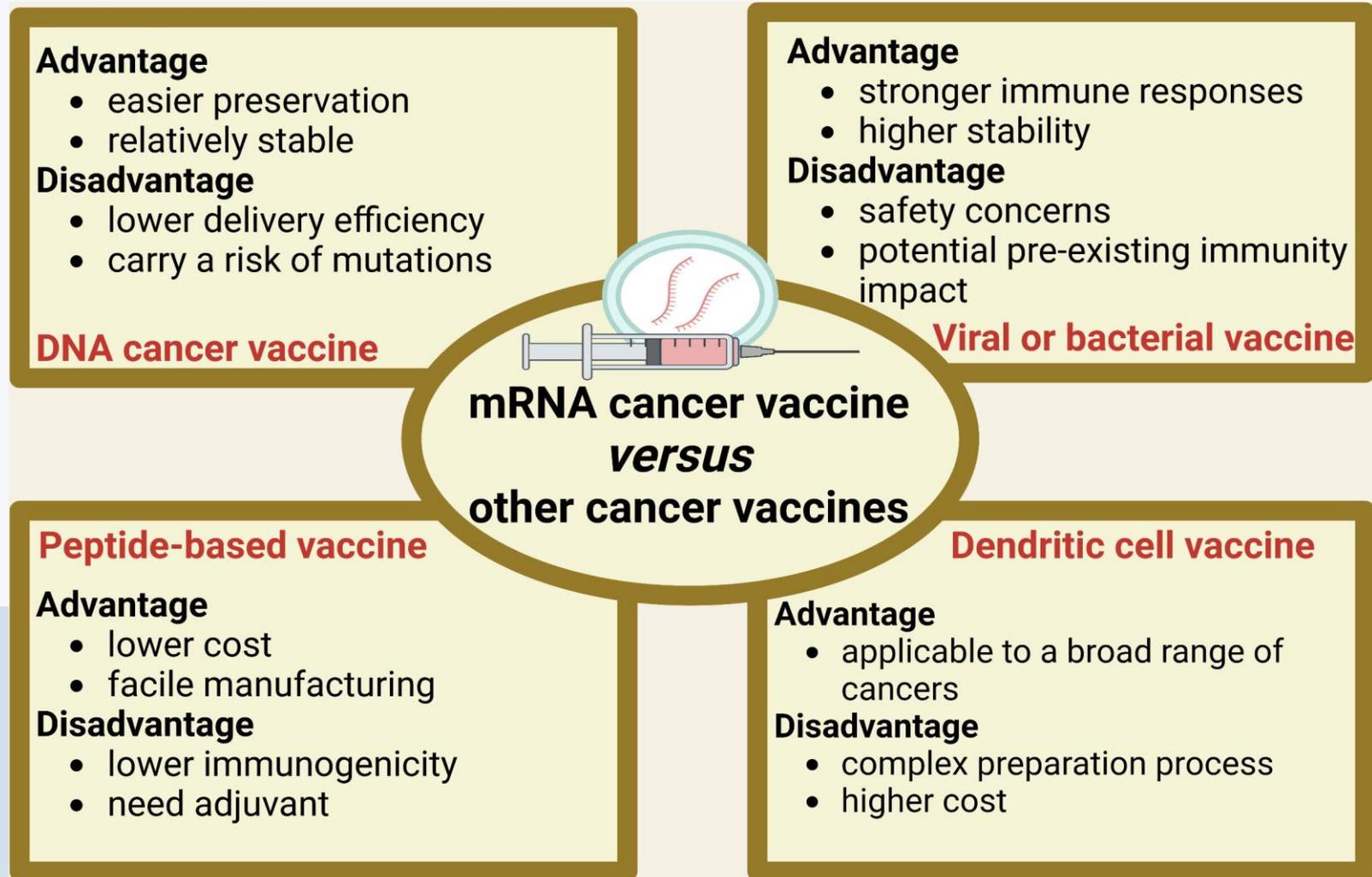


- Blocking of CTLA-4, PD-1 and PD-L1 using monoclonal antibodies is able to delete the T cell inhibition induced by cancer cells
- Blocking the T cell blockade = T cell activation



<https://youtu.be/GIUu239FWMg?si=DI8u9Ek7PEUjusY2>

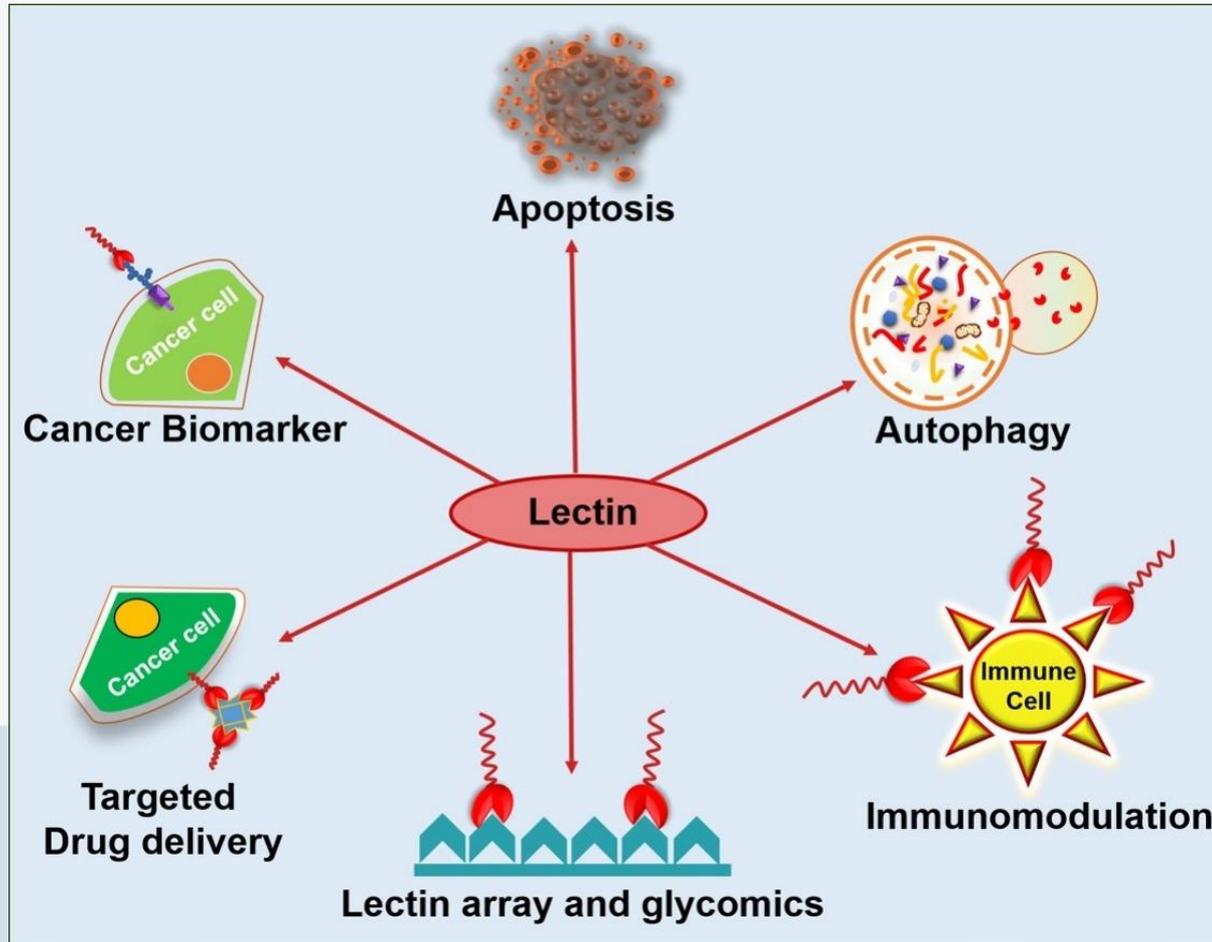
Cancer vaccines



Techniques for modification of immune response

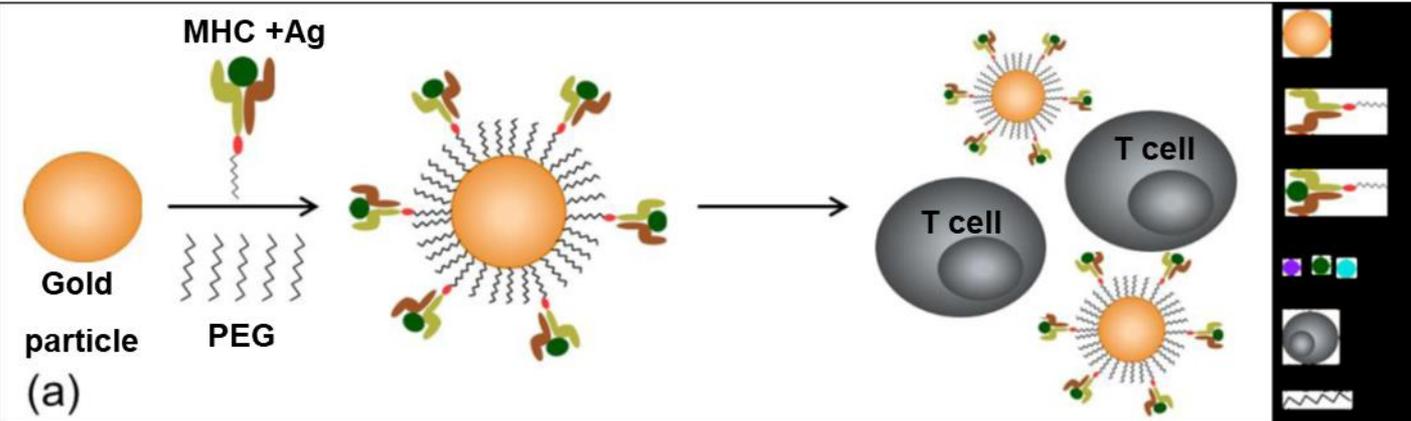
- Phytotherapy with plant lectins
- Application of arteficial nanoparticles
- Virus therapy against cancer

Plant lectins for biological therapy

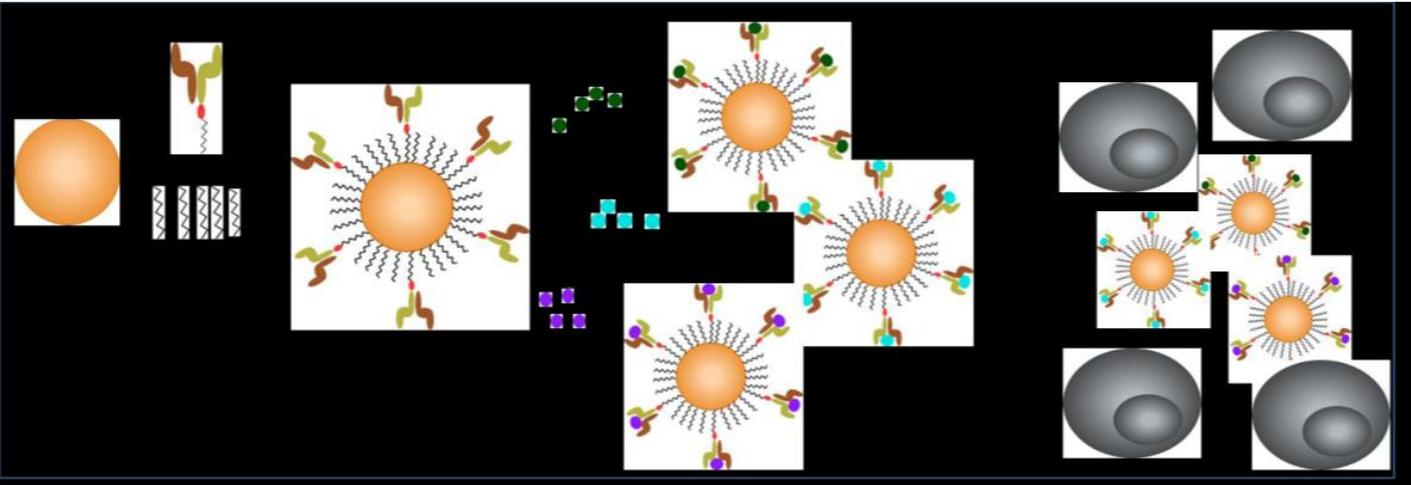


- potential cancer biomarkers
- recognize carbohydrates pattern on malignant tumor cells
- targeted drug delivery in cancer therapy
- induce cell death through apoptosis and autophagy
- modulate immune cells

Nanoparticles = smart delivery + immunomodulation



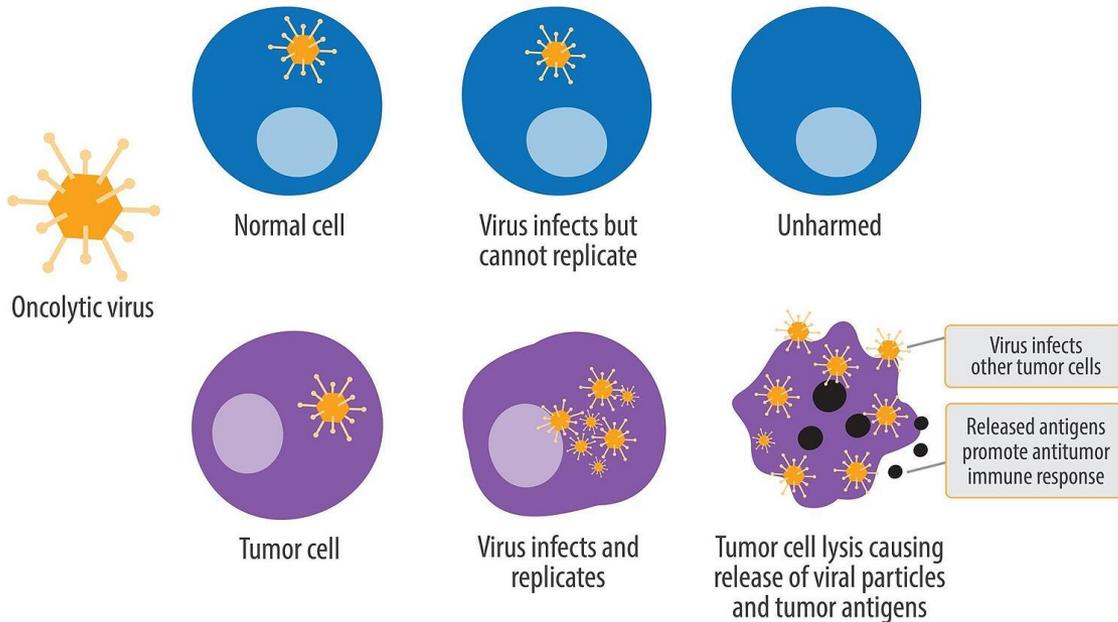
(a) Gold Nanoparticles are functionalized with PEG + MHC-peptide complexes. The functional NPs are designed to interact with T-Cells.



(b) NPs are functionalized with PEG+MHC complex, free of peptides. Various peptides are then loaded on the MHC NPs. The functional NPs are designed to interact with T-Cells

Oncolytic viruses

Antitumor Mechanisms of an Oncolytic Virus

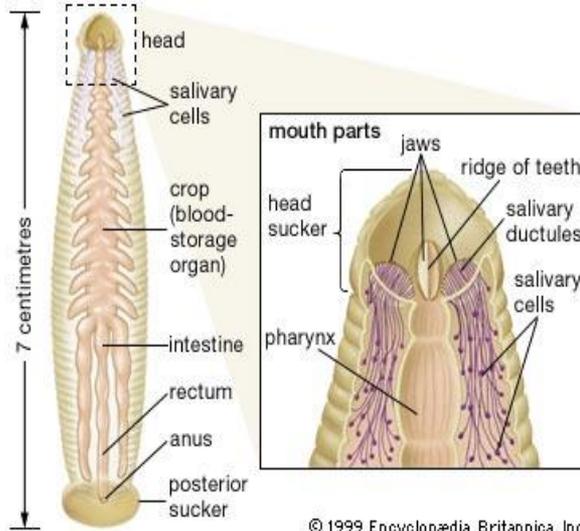
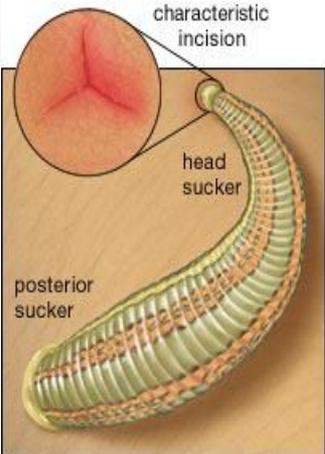


- Clinically validated cancer immunotherapies
- Dual mechanism: direct oncolysis + immune activation
- Convert immunologically “cold” tumors into “hot” tumors
- Most effective in combination with checkpoint inhibitors

*Harrington KJ et al.: **Clinical development of oncolytic viruses.** Lancet Oncol. 2019;20(8):e537–e548.*

Zoo-therapy

European medicinal leech (*Hirudo medicinalis*)



LEECH THERAPY (Hirudotherapy)



Produce

- Local anesthetic
- Local vasodilator
- Anticoagulant agents
- Platelet aggregation inhibitors

Treat

- Hypertension
- Varicose veins
- Hemorrhoids
- Skin problem
- Arthritis



Madam Fatimah undergoing leech therapy for her swollen foot at her flat in Sembawang recently. "Before this, my foot was like an elephant's," she said. ST PHOTO: TEH JOO LIN

The most common complication from leech treatment is prolonged bleeding, although allergic reactions and bacterial infections may also occur.

Fields of biotherapies will be discussed

Therapeutic monoclonal antibodies

Stem cell therapy and transplantation

General conditions of protein therapies

Vaccination (preventive and curative vaccines)

Recombinant protein therapeutics

In vitro tumor vaccines

Tumor gene therapy

Tissue engineering

Nanoparticles with biological functions

Oncolytic viruses

Zoo-therapies