

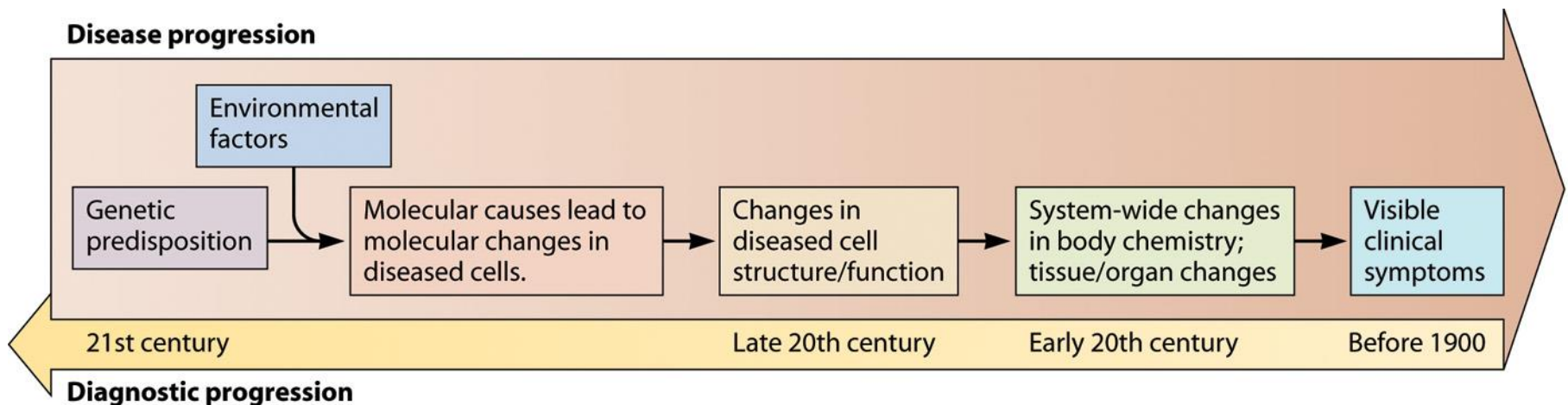
Chapter 19

Health Care Applications



Better Medical Technology

- More significant information for improving health
- Early and cheap diagnosis
- Identification of the cause, not a symptom
- Cure rather than management, disease prevention rather than treatment
- Fewer adverse side effects
- More efficacious and more affordable



Molecular Diagnostics

■ Diagnosis

■ Based on symptoms

- Different disease with same symptoms
- Maybe too late to cure

■ Visualization

- X-ray

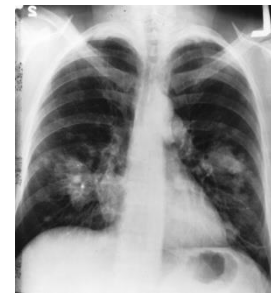
■ Chemical imbalance and blood disorders

■ Molecular diagnostics

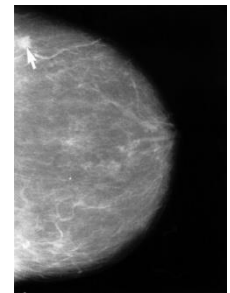
- Detection of a specific molecular event related to disease
- Less invasive: use urine, blood, or saliva



Disease diagnosis



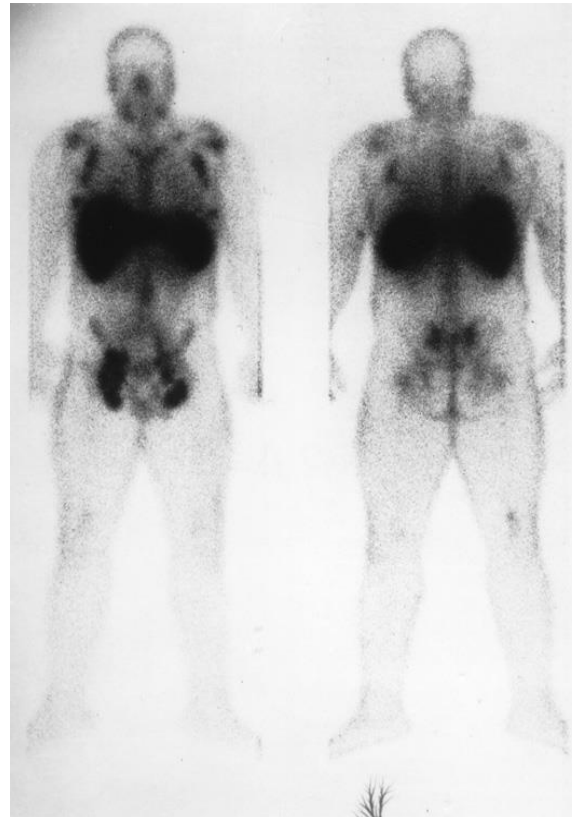
Lung cancer



Breast cancer

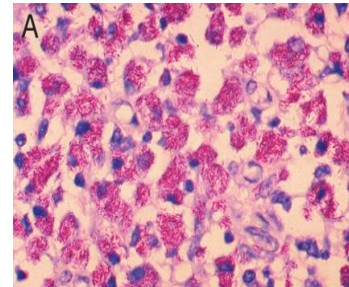
Monoclonal antibodies in cancer detection

- A radioactive isotope attached to monoclonal antibodies

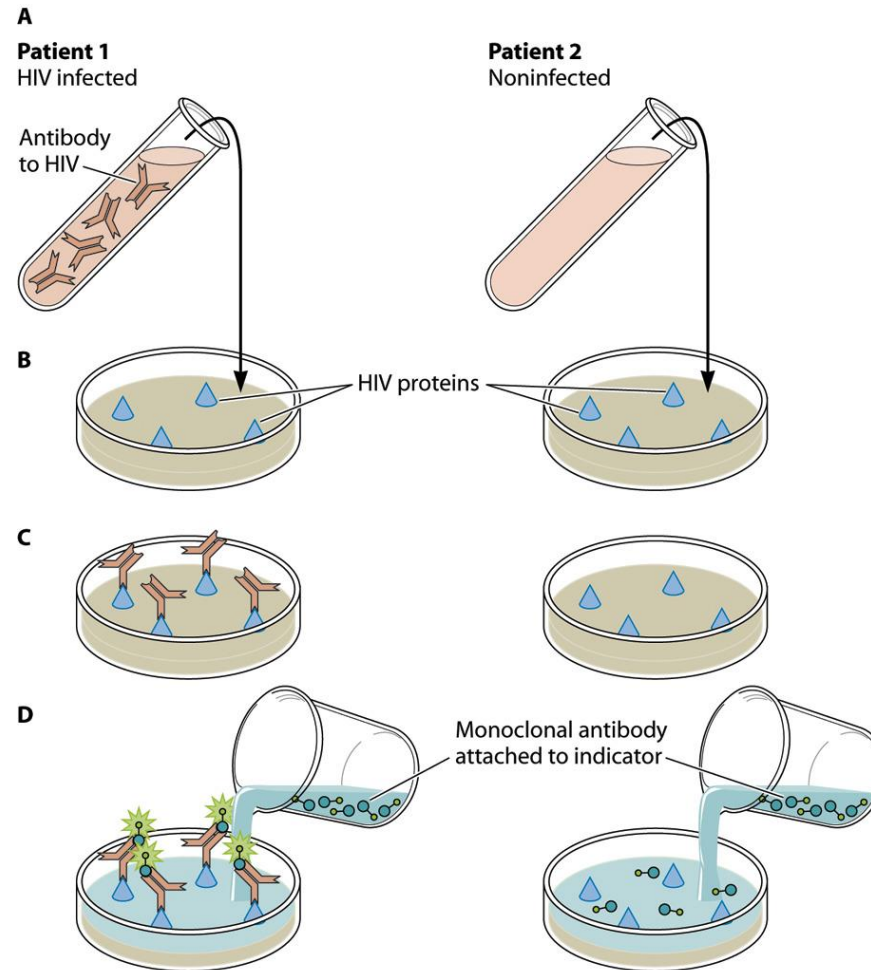


Early Diagnosis of Contagious Disease

- Monoclonal antibody-based diagnosis
 - Detection of pathogenic bacteria without culture
 - Diagnosis of HIV
 - AIDS-defining illnesses
 - Rare infectious diseases and uncommon cancers
 - Do not appear until 9 to 10 years after infection
 - Detection of HIV using antibody
 - HIV infection was identified as a cause of AIDS (1983)
 - Detection of HIV antibody generated in the patient 6 to 12 months after infection
 - Detection of HIV DNA by PCR

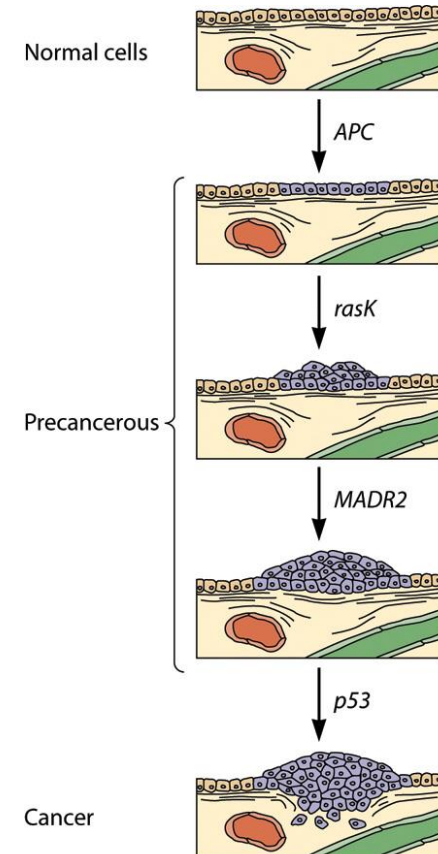


Detection of HIV



Other Diseases and Disorders

- Biomarkers
 - Molecular changes specific to the stages of disease progress
 - Provide targets for disease treatment
- For example, a number of mutations to become cancerous
- Identifying biomarkers and using them
 - Disease treatment
→ Disease prevention



Genetic Information for Familial Diseases

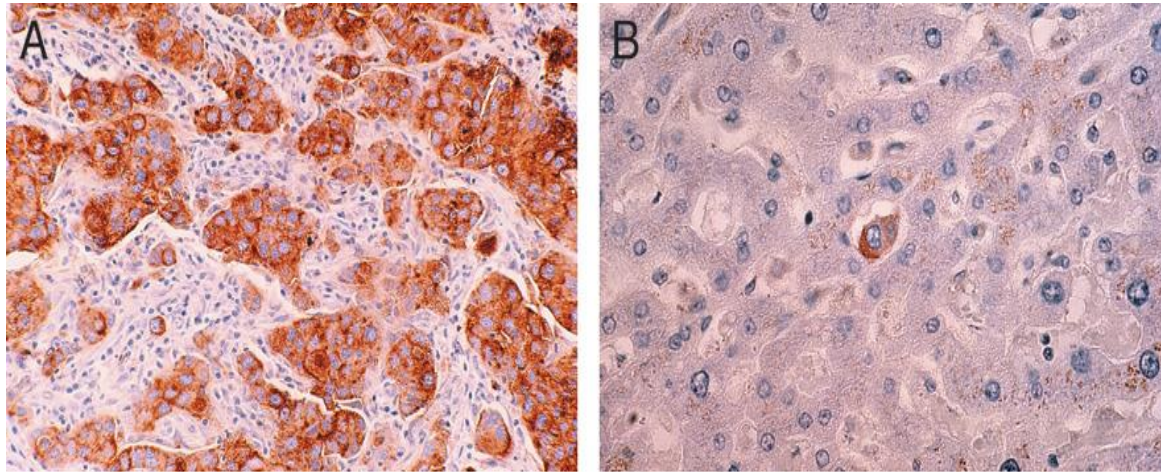
- Simple and complex genetic diseases
 - Simple genetic diseases
 - Caused by a single gene mutation
 - Multigenic disorder
 - Many genes contribute to the disorder
 - Multifactorial disorder
 - Genes and environmental factors interact and lead to the disorder
- Majority of mortal diseases are both multigenic and multifactorial.

Biotechnology Therapeutics

- Features of biotechnology-based therapeutics
 - Specificity
 - Specific inhibition of targets rather than general inhibition
 - Cancer-specific targeting
 - Biological therapeutics
 - Use natural products synthesized by plants, microbes, insects, and other animals
 - Search diverse ecosystems like sea
 - New production methods
 - Large-scale, economically feasible production
 - Recombinant DNA technology, cell culture, biomanufacturing technologies

Targeted Therapy with Monoclonal Antibodies

- Monoclonal antibodies can deliver chemotherapeutic toxins specifically to cancer cells.



- A. Cytoplasm of tumor cells in breast tissue is stained brown with a monoclonal antibody
- B. The same monoclonal antibody is able to locate a single breast cancer cell that has metastasized to the patient's liver.

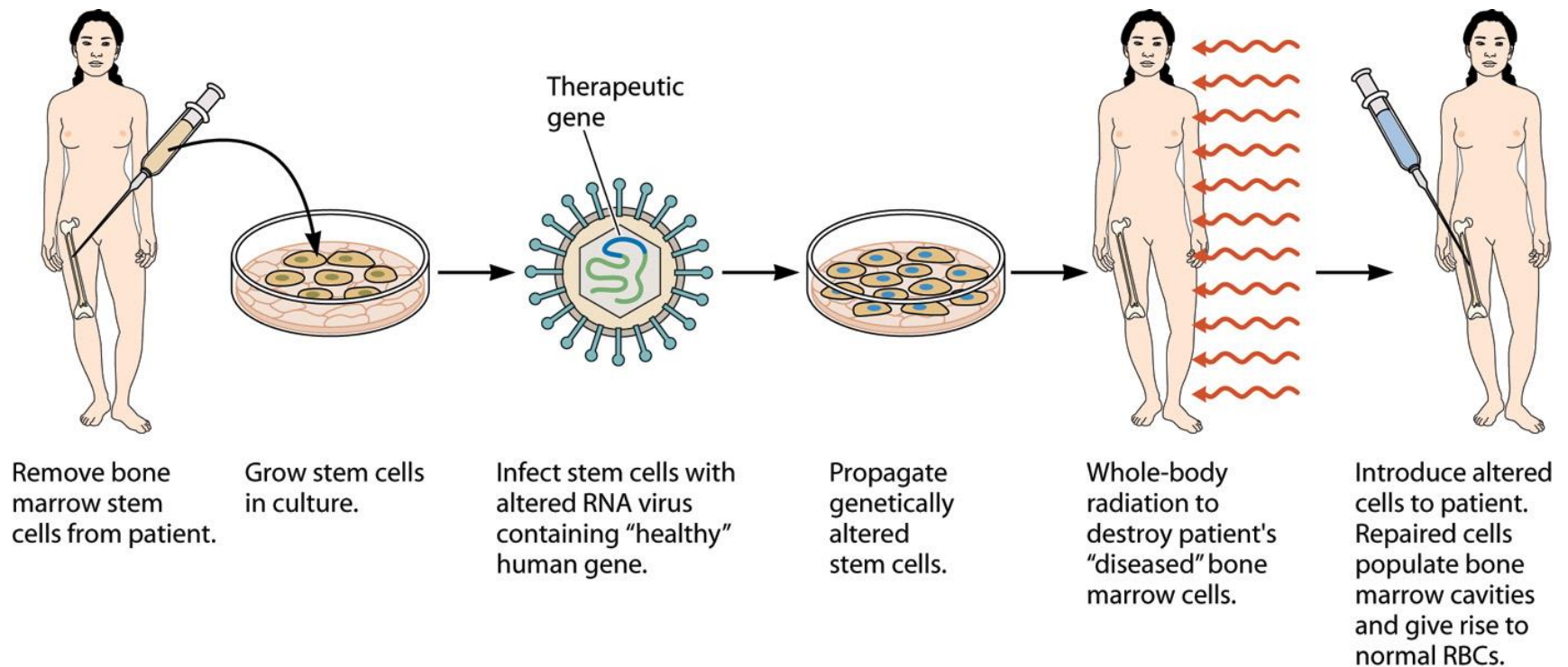
Biotechnology Therapeutics

- Use immune systems for treatments
 - Cytokines boosting immune response
 - Interleukin-2: cancer, AIDS
 - Interleukin-12: some infectious disease
 - Cancer vaccines
- Replacement of missing proteins with recombinant proteins
 - Insulin for diabetes
 - Glucocerebrosidase for Gaucher's disease
 - Hemophiliacs: missing components in the formation of a blood clot
 - Treatment of recombinant factor VIII (for hemophilia A) or factor IX (for hemophilia B)

Gene Therapy

- Administration of correct gene
- Applicable to some hereditary monogenic diseases
 - Hemophilia
 - Severe combined immunodeficiency disease (SCID); bubble boy disease
- Trial to transient gene therapy for non-hereditary disorders like cancer, infectious disease
- Still many technical barriers to overcome
 - e.g. gene delivery

Gene Therapy



Cell or Organ Transplantation

- Not enough supply of organ donations
 - In U.S. 60,000 people are on organ recipient list
 - 12 death/day while waiting
- Xenotransplantation
 - Organs from other animals like pig
 - Problems
 - Self protection mechanism of body
 - Risk of infectious viruses or retroviruses
 - Solutions
 - Genetic modification of the donor animals
 - Deletion of pig genes triggering the rejection
 - Adds genes of human membrane proteins
- Cell transplant therapy

Cell Transplant Therapy

- Bone marrow transfer
 - In some cases, the patient's own bone marrow cells are removed, grown in culture, and reimplanted after chemotherapy.
 - In the case of leukemia or other blood cell cancer, the transplanted bone marrow must come from a healthy donor who is genetically similar to the patient.
- Implantation of insulin-producing cells for diabetes
- Prevention of immune response
 - Monoclonal antibodies to various receptors on T cells, that recognize and reject foreign cells.
 - Cell encapsulation: prevent recognition by the immune system

Regenerative Medicine

- Use the body's natural healing processes to cure diseases
- Endogenous proteins promoting cell division and differentiation
 - Epidermal growth factor: wound healing
 - Fibroblast growth factor: healing ulcers, broken bones, growing new blood vessels
 - Transforming growth factor β : promote cell differentiation
 - Nerve growth factor: repair damage resulting from head and spinal cord injuries, degenerative neural diseases

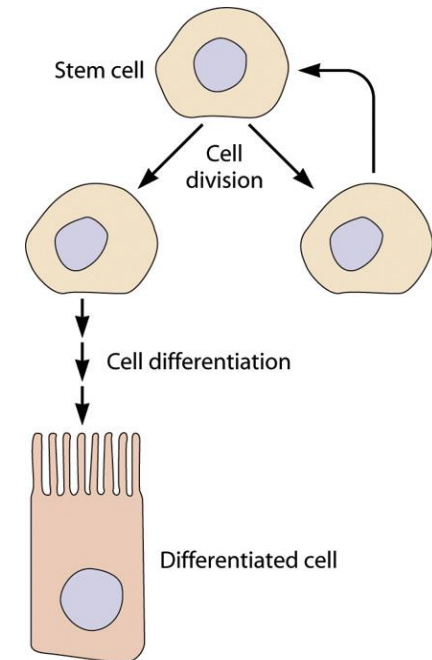
Stem Cells for Regenerative Medicine

■ Adult stem cells

- Partially differentiated progenitor cells
- Types of AS cells
 - Bone marrow AS cells → cells in blood and bone
 - Liver AS cells → liver cells: bile-secreting cells, glycogen storage cells

■ ES cells

- Pluripotent
- Isolation of human ES cells (1998)
 - From blastocysts or progenitor germ cells from aborted fetuses

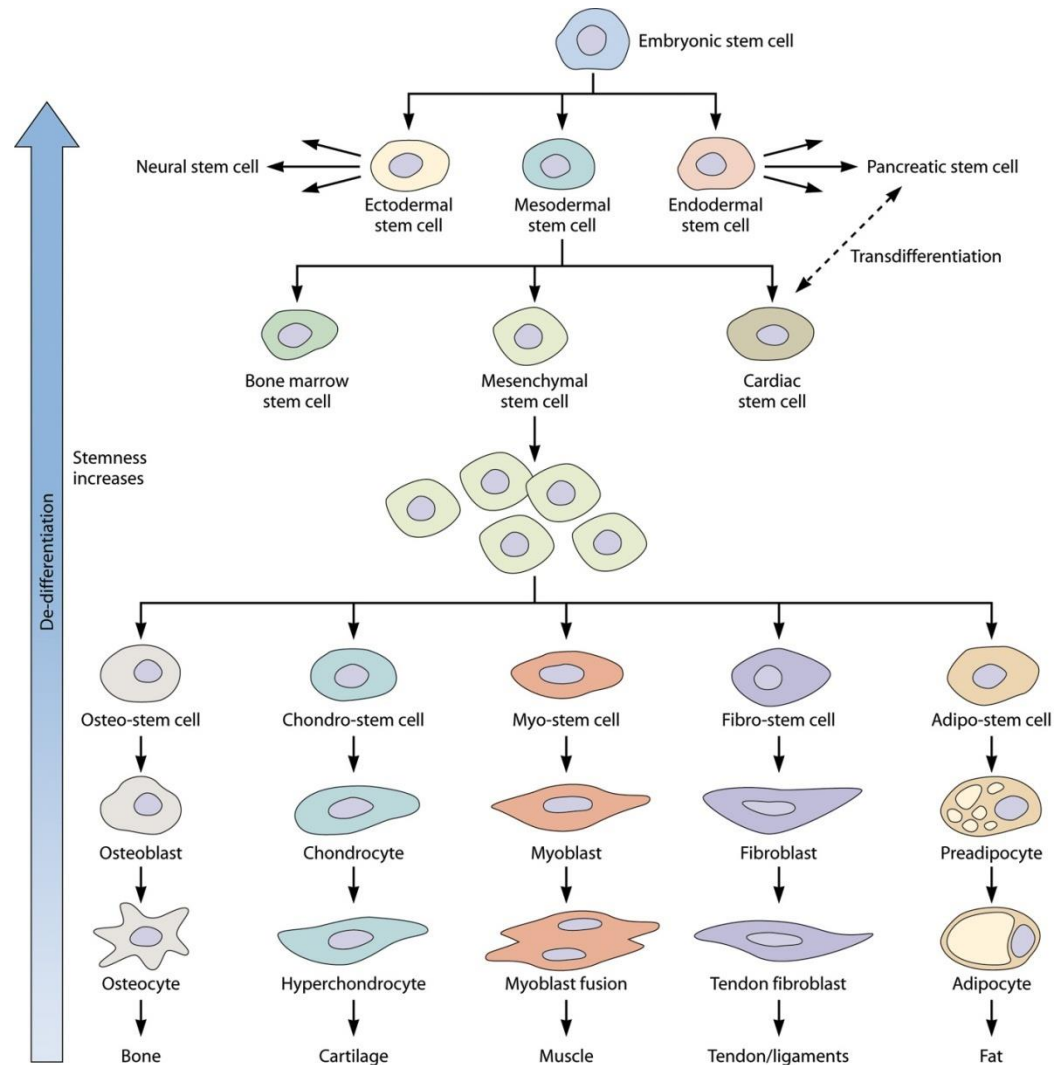


One stem cell and one differentiated cell after cell division to maintain a constant supply

Therapeutic Potential of Stem Cells

- Replacement of damaged cells with AS or ES cells
- Research on differentiation
 - Identification of proper growth factors, nutrients, and environmental factors for specific differentiation
 - Transdifferentiation
 - From one AS cell to another type of AS cell
- Research on dedifferentiation
 - Factors that reverse differentiation
 - Dolly: cloning from the fully differentiated somatic cell
 - Dedifferentiation can provide ES cells without using embryo, BUT... it is hard to study dedifferentiation without using ES cells

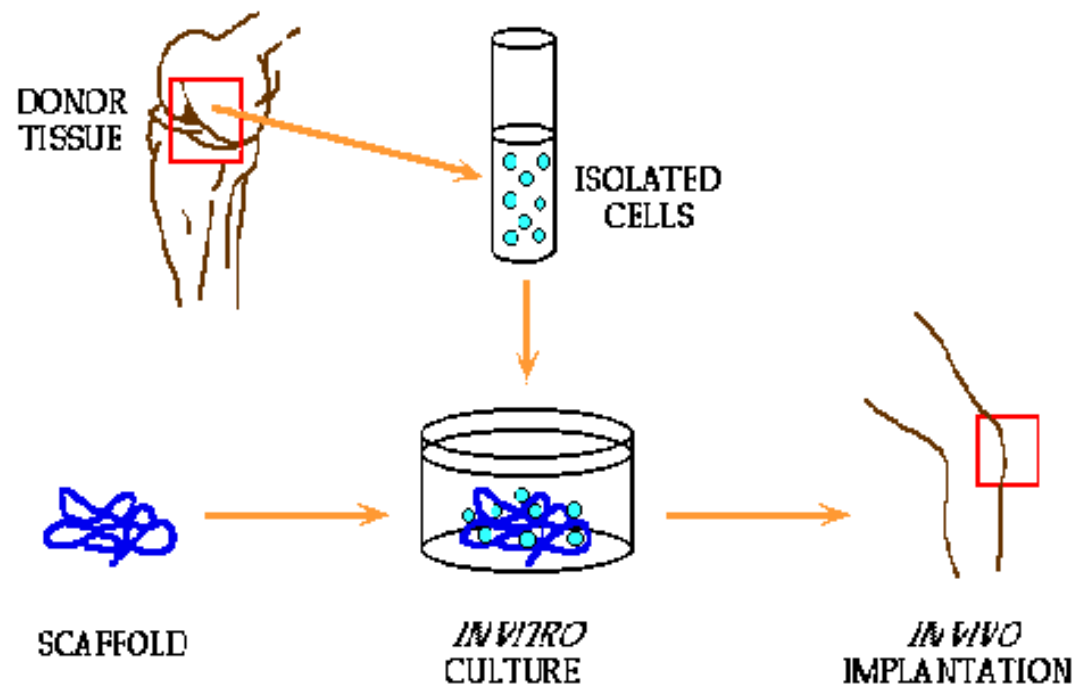
AS Cell De-differentiation



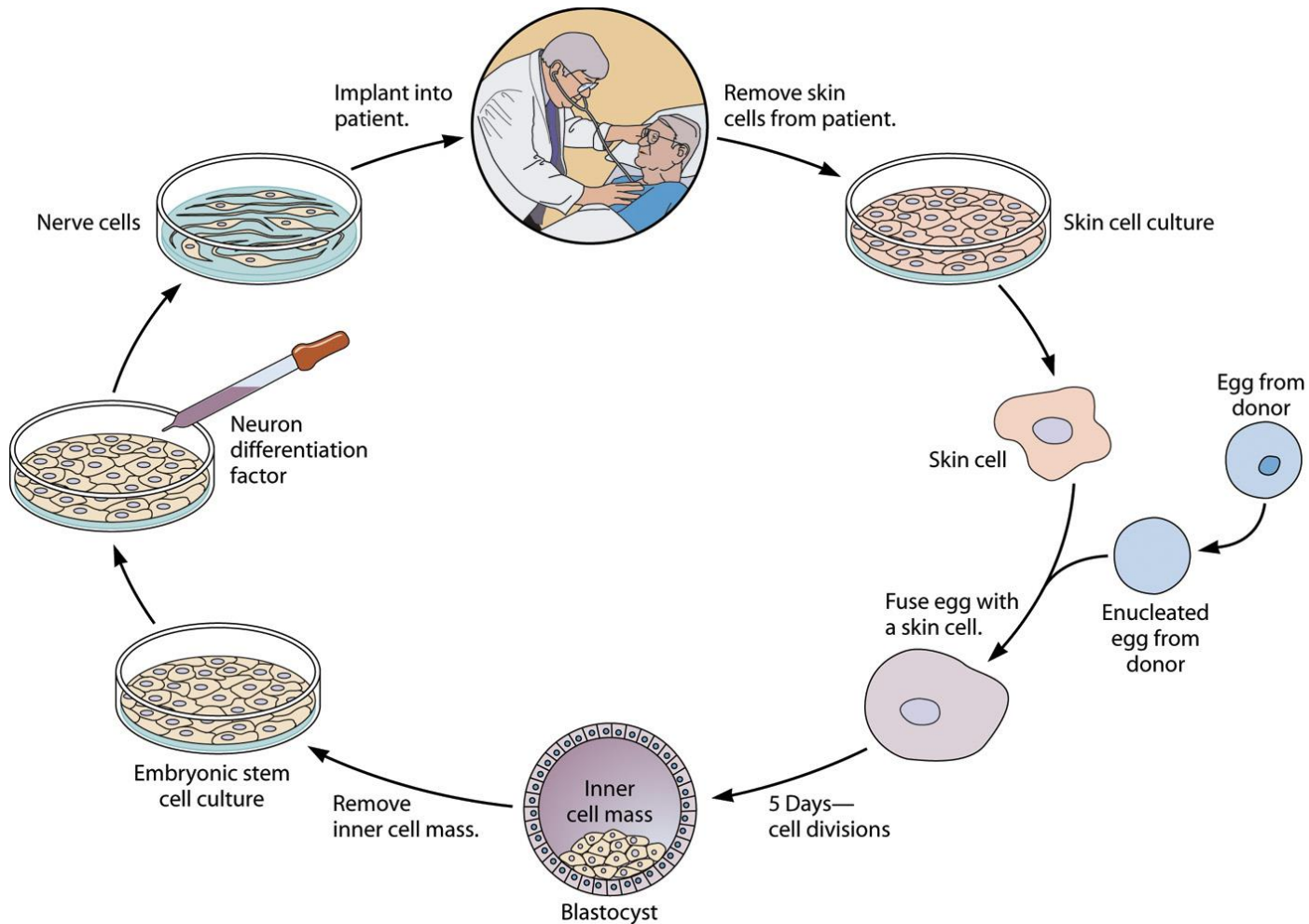
Tissue Engineering

- Generation of semisynthetic tissues and organs
 - Biocompatible scaffolding materials
 - Synthetic polymer or natural material (e.g. collagen)
 - Living cells grown in culture
 - Fully differentiated cells
- From simple tissues and organs (skin, cartilage, urinary bladders) to whole organs using stem cells

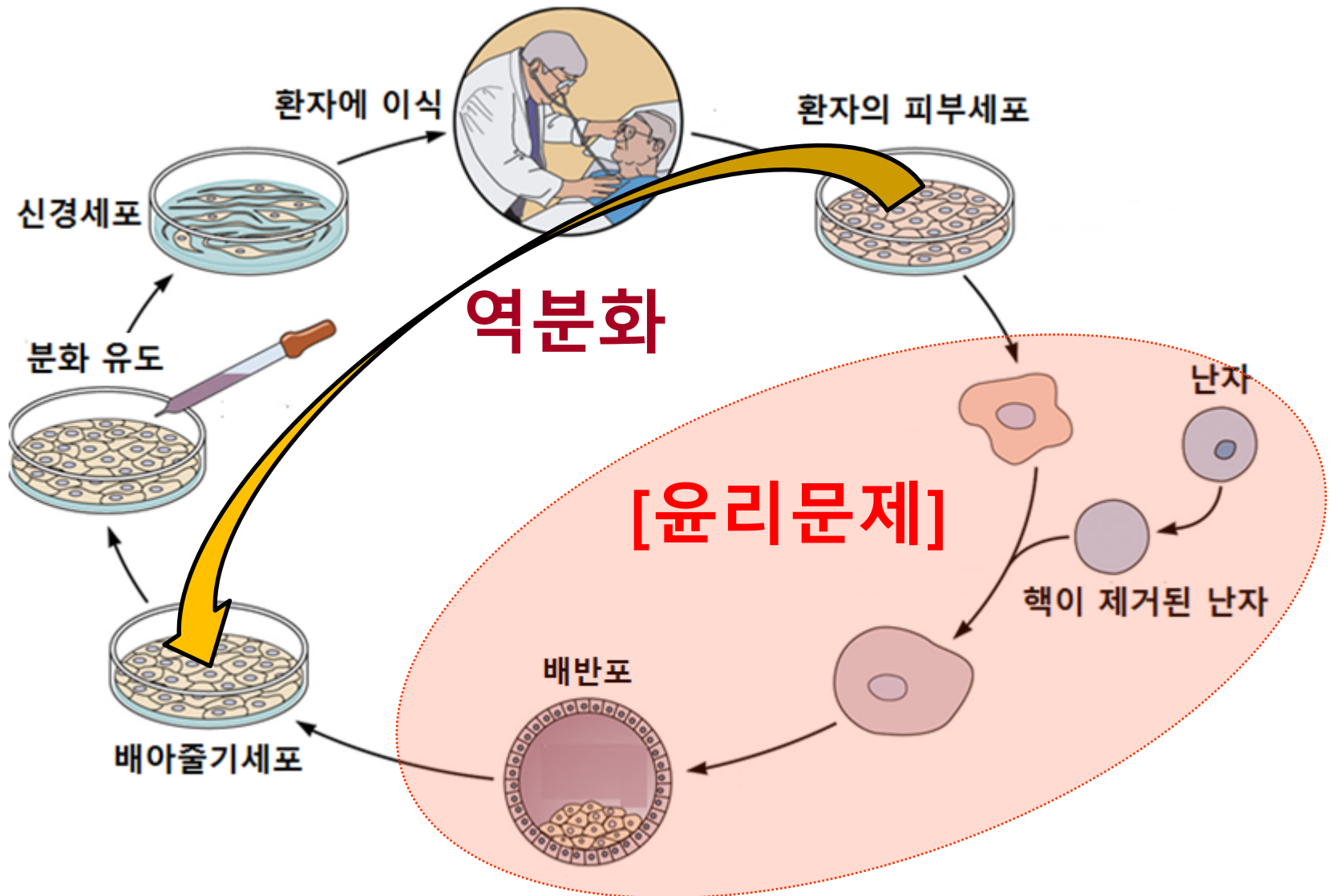
Tissue Engineering



Immune-Compatible Stem Cells



유도만능 줄기세포



Vaccines

■ Vaccines

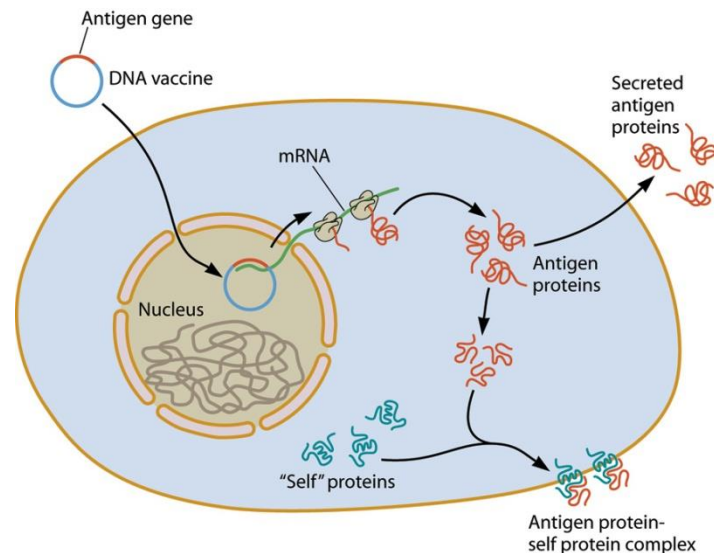
- harmless agents that elicit an immune response, thereby providing protective immunity against a potential pathogen

■ Types of vaccines

- Killed vaccines, attenuated vaccine
 - Potential problems
 - Side effects: allergic reactions, cause disease
 - Difficulty in mass production outside of the human body
 - Potential risk during human testing
- Subunit vaccines
 - Surface proteins of pathogen inducing immune response
 - Production using recombinant DNA technology
 - Vaccines for infectious virus (Hepatitis B), diabetes, cancer, chronic inflammatory disease etc.

DNA or Edible Vaccines

- DNA vaccines
 - Delivery of vector containing antigen gene



- Edible vaccines
 - Genetically modified animals or plants producing vaccines
 - Vaccines in milk
 - Vaccines in bananas or potatoes