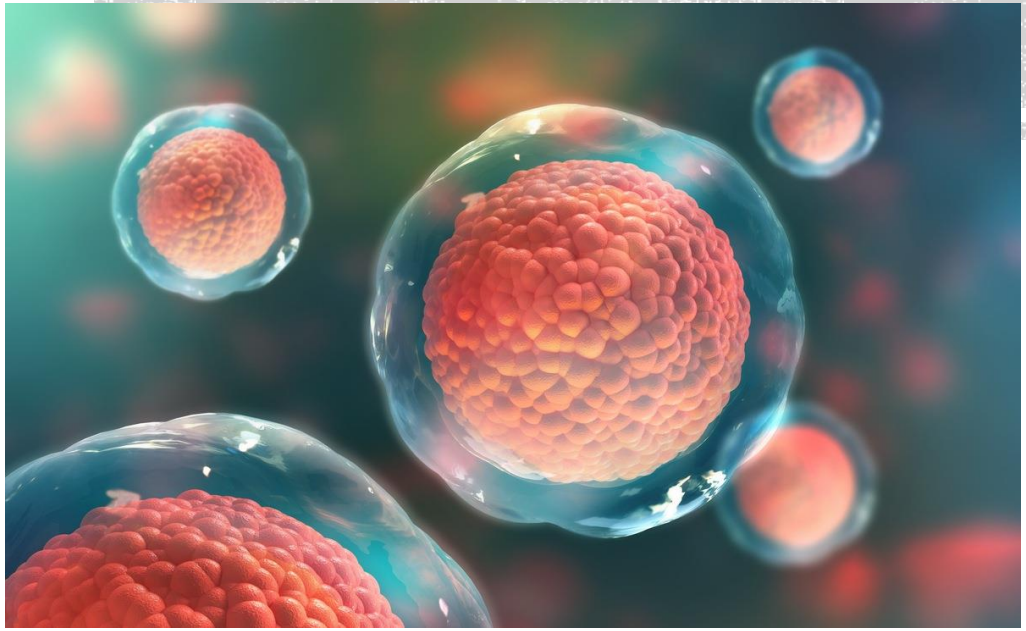
STEM CELLS AND TISSUE ENGINEERING



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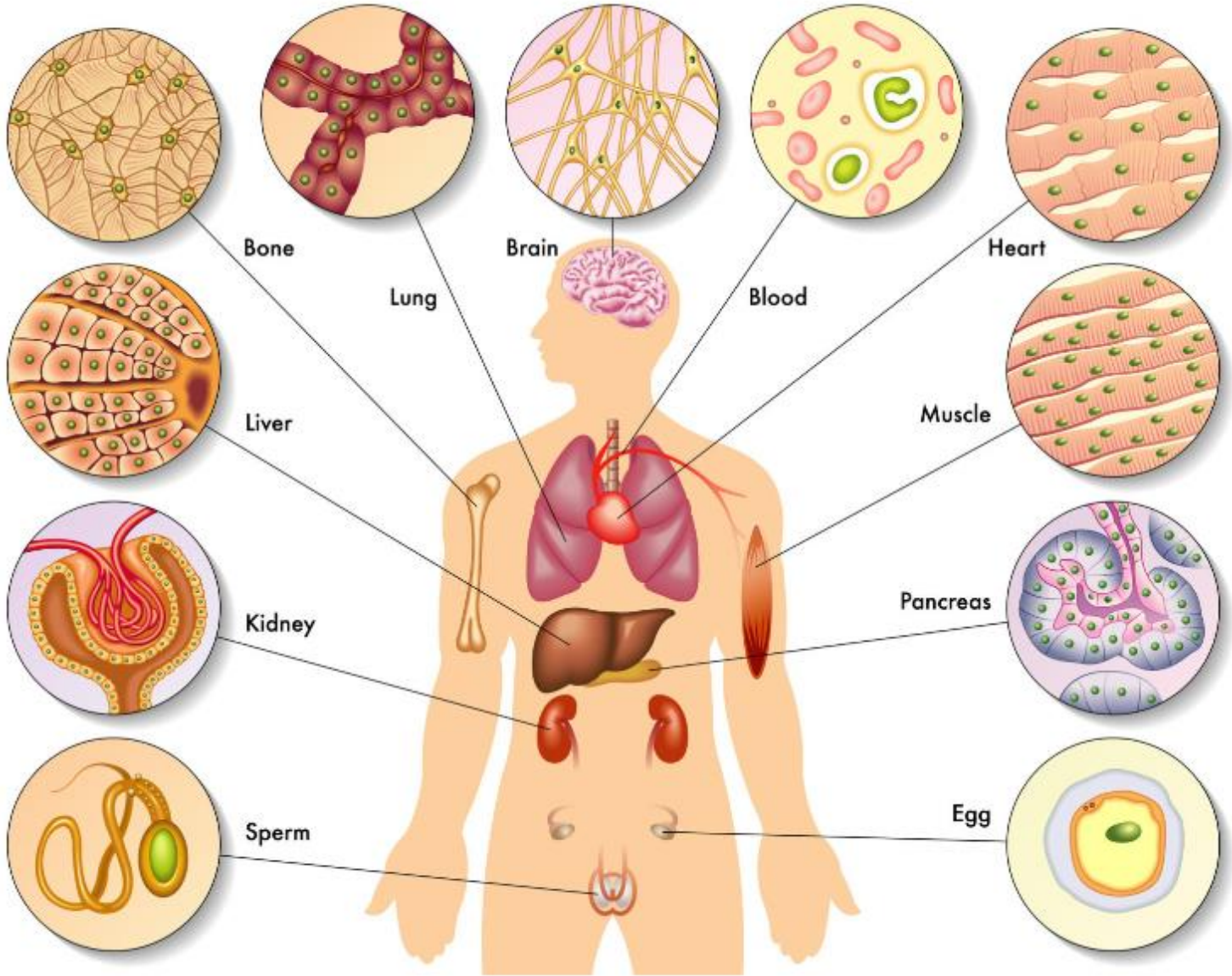
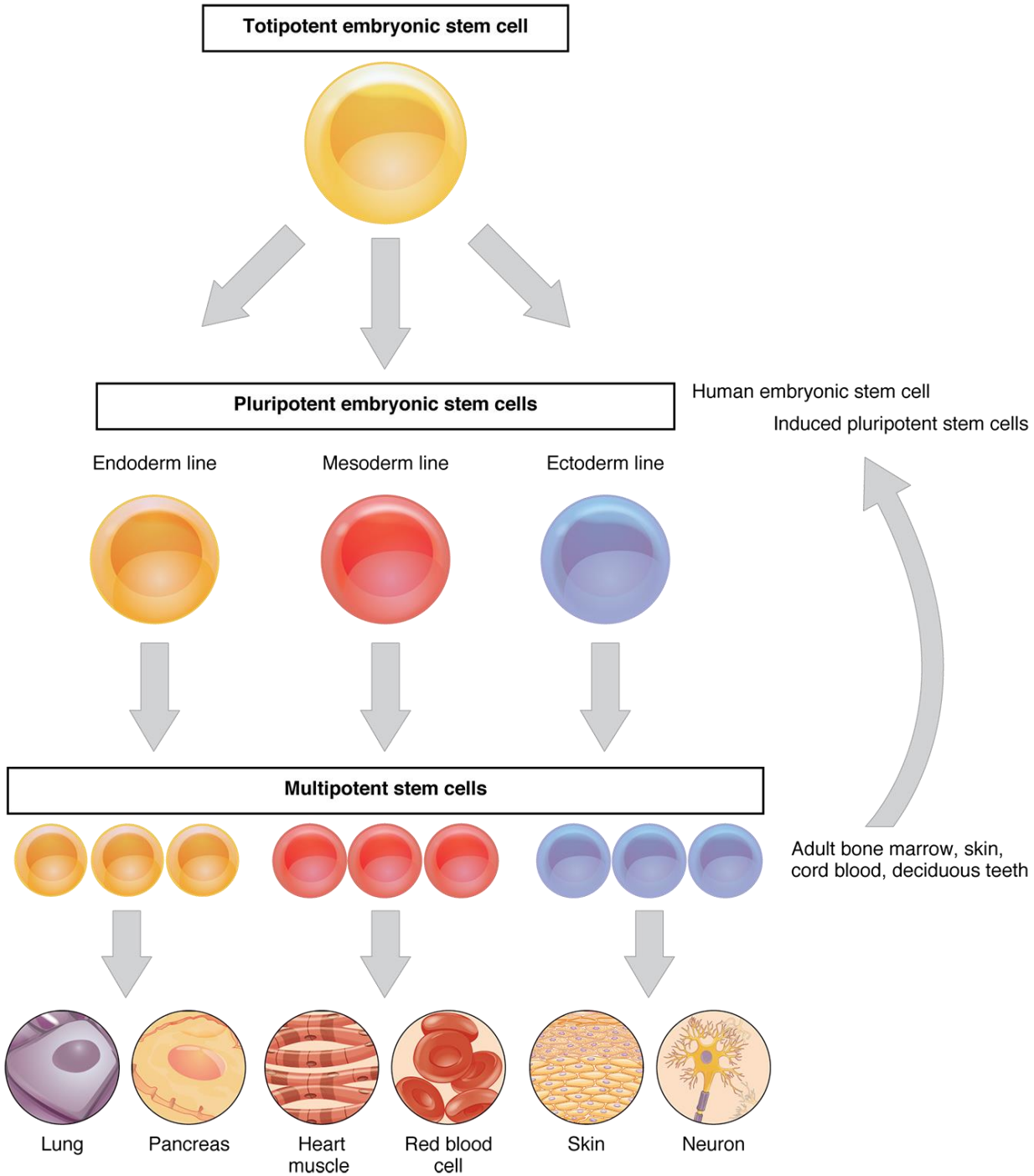
What Are Stem Cells?

Stem cells are undifferentiated cells with the capacity to both differentiate and multiply into the 200 cells types that form a human being.





Stem Cell Unique Properties:

1] Stem cells are **unspecialized**

One of the fundamental properties of stem cells is that it does not have any tissue specific structures that allow it to perform specialized function.

2] **Proliferation**

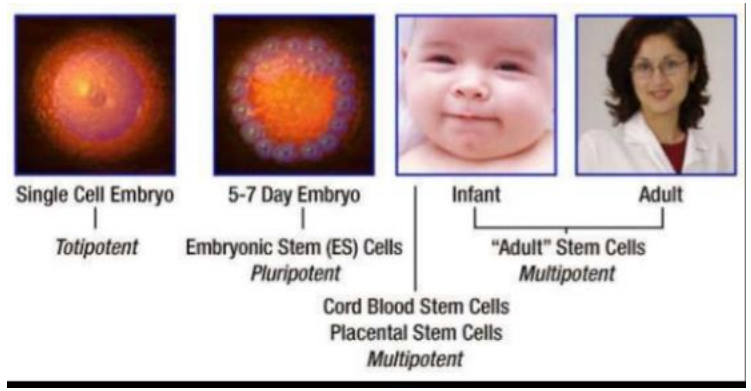
They are capable of dividing and renewing themselves for indefinite periods

3]**Differentiation**

They can give rise to specialized tissue. Under certain **physiological** and **experimental conditions** unspecialized cell can give rise to specialized cells such as including heart muscle cells, blood cells or nerve cells required to repair damaged or depleted adult cell population or tissue.

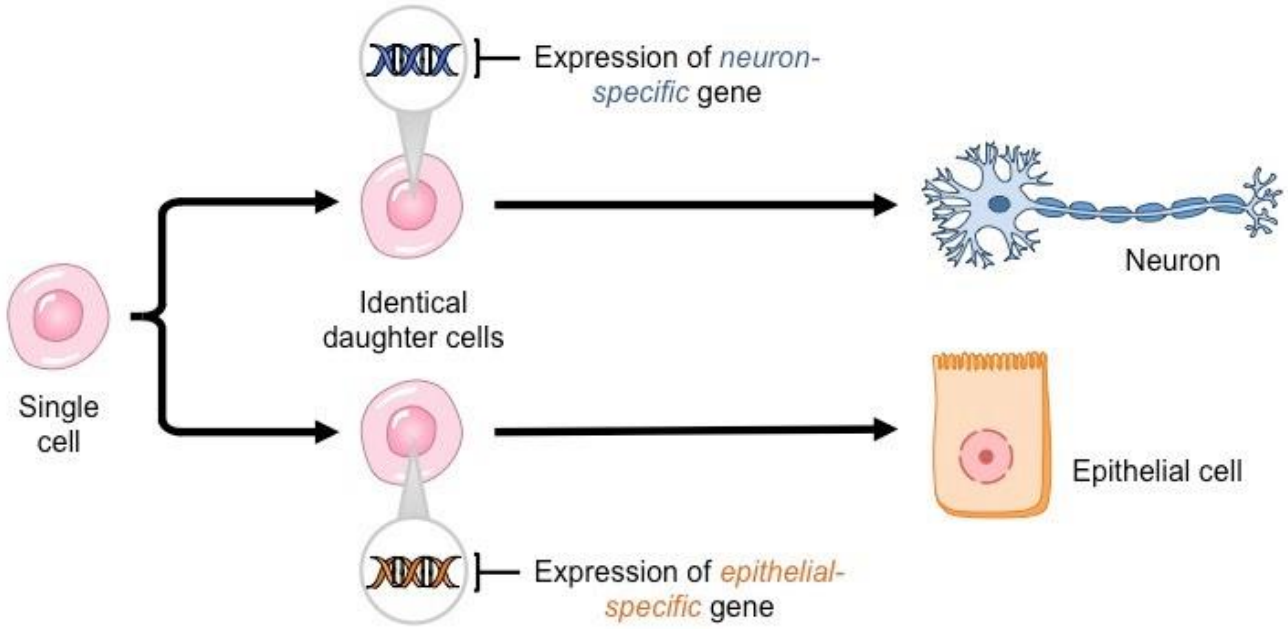
4]**Plasticity**

Stem cell from one tissue may be able to give rise to cell types of completely different tissue , a phenomenon known as plasticity. e.g. Blood cells becoming neuron, liver cells producing insulin and haematopoietic stem cells, developing into heart muscle.



DIFFERENTIATION

DIFFERENTIATED CELLS	UNDIFFERENTIATED CELLS
The cells in multicellular organisms modified to carry out a particular function, such as transporting a certain substance or executing a specific task	The cells capable of giving rise to indefinitely more cells of the same type, and from which certain other kinds of cell arise by differentiation
Specialized cells	Stem cells
Have a unique shape based on their function	Mainly rounded in shape and small in size due to their continuous cell proliferation process
Have distinct locations in the body based on their function	Occur in the embryo, fetus, and most organs of the body
Various types of cells perform distinct functions in the body	Responsible for replenishing old, injured or dead cells
Examples: Epithelial cells, skin fibroblasts, endothelial cells lining the blood vessels, smooth muscle cells, liver cells, nerve cells, human cardiac muscle cells, etc.	Examples: Cells in bone marrow, brain, blood, liver, skin, dental pulp, the eye, skeletal muscle, pancreas, gastrointestinal tract, etc.

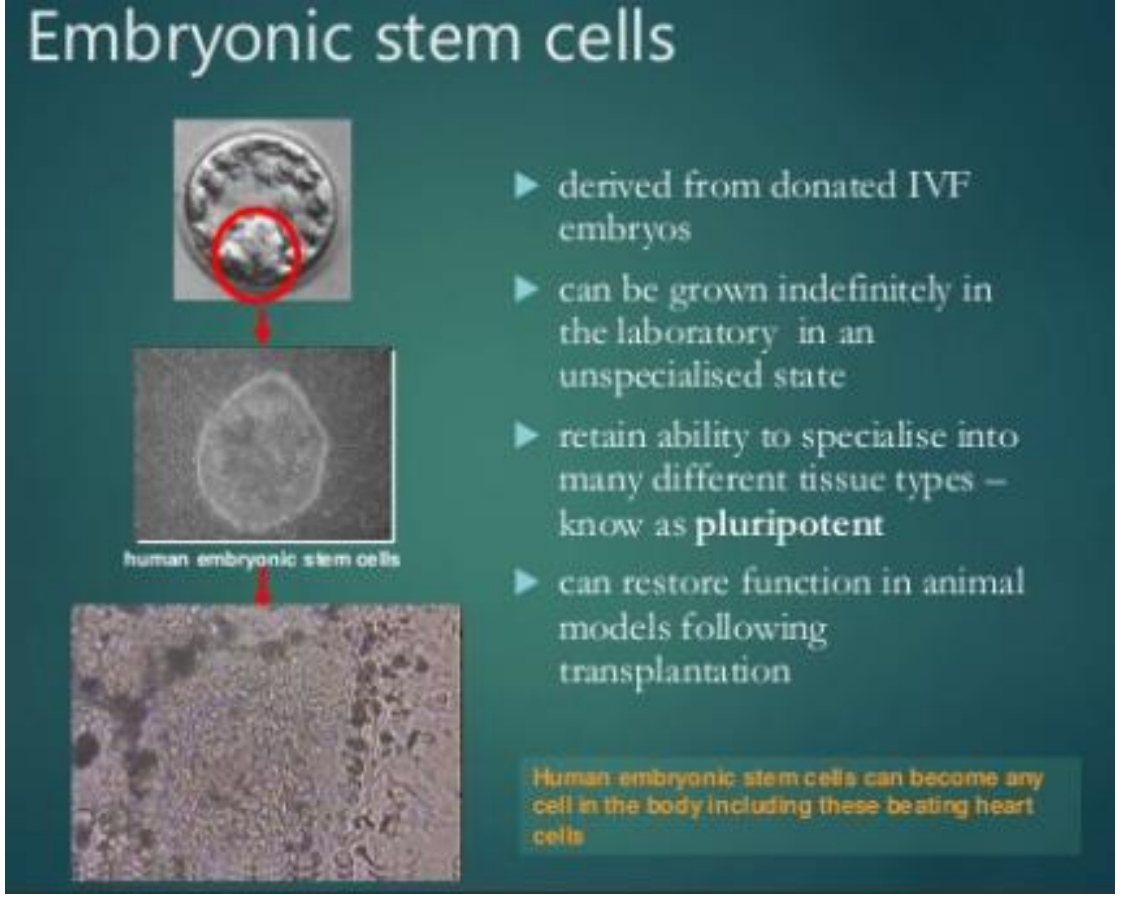


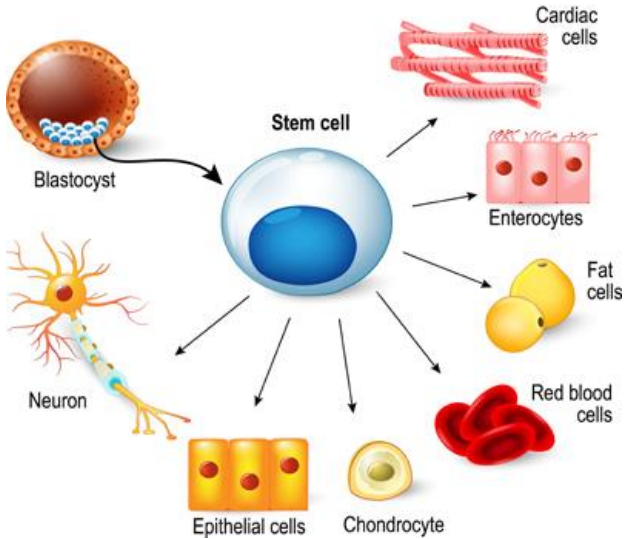
TYPES OF STEM CELLS

- **Embryonic stem cells**: Come from unused embryos from an in vitro fertilization procedure. They are donated to science. These embryonic stem cells are pluripotent. This means that they can turn into more than one type of cell.
- **Adult stem cells:**

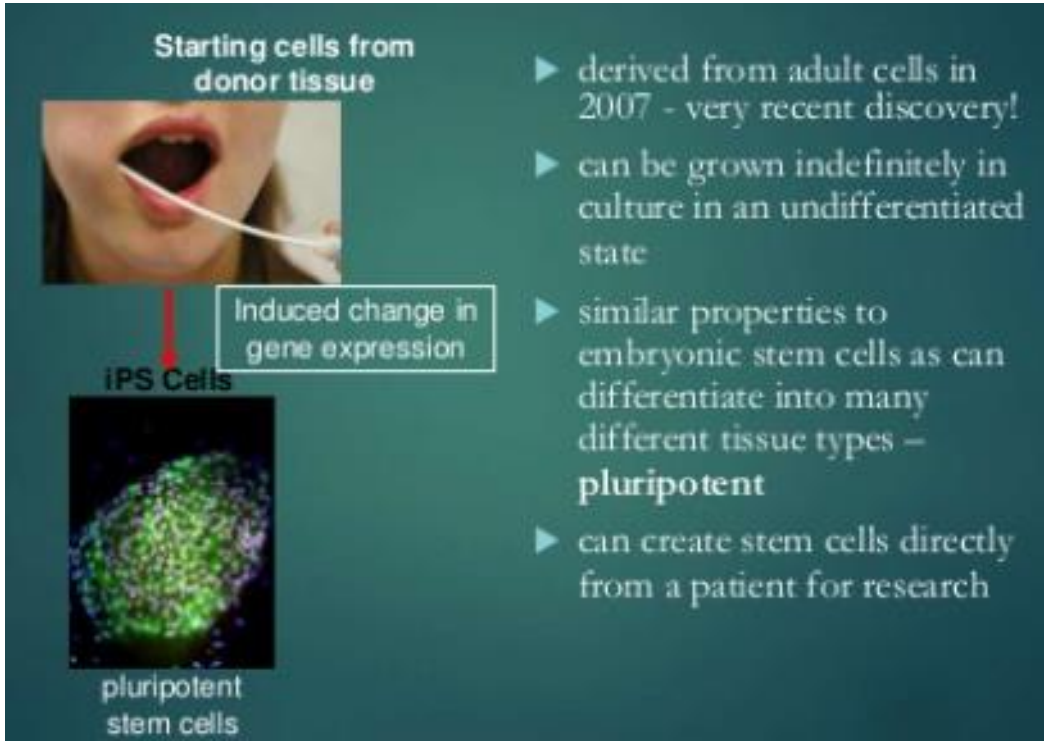
1. **From fully developed tissues** such as the brain, skin, and bone marrow. There are only small numbers of stem cells in these tissues. They are more likely to generate only certain types of cells. For example, a stem cell that comes from the liver will only make more liver cells.

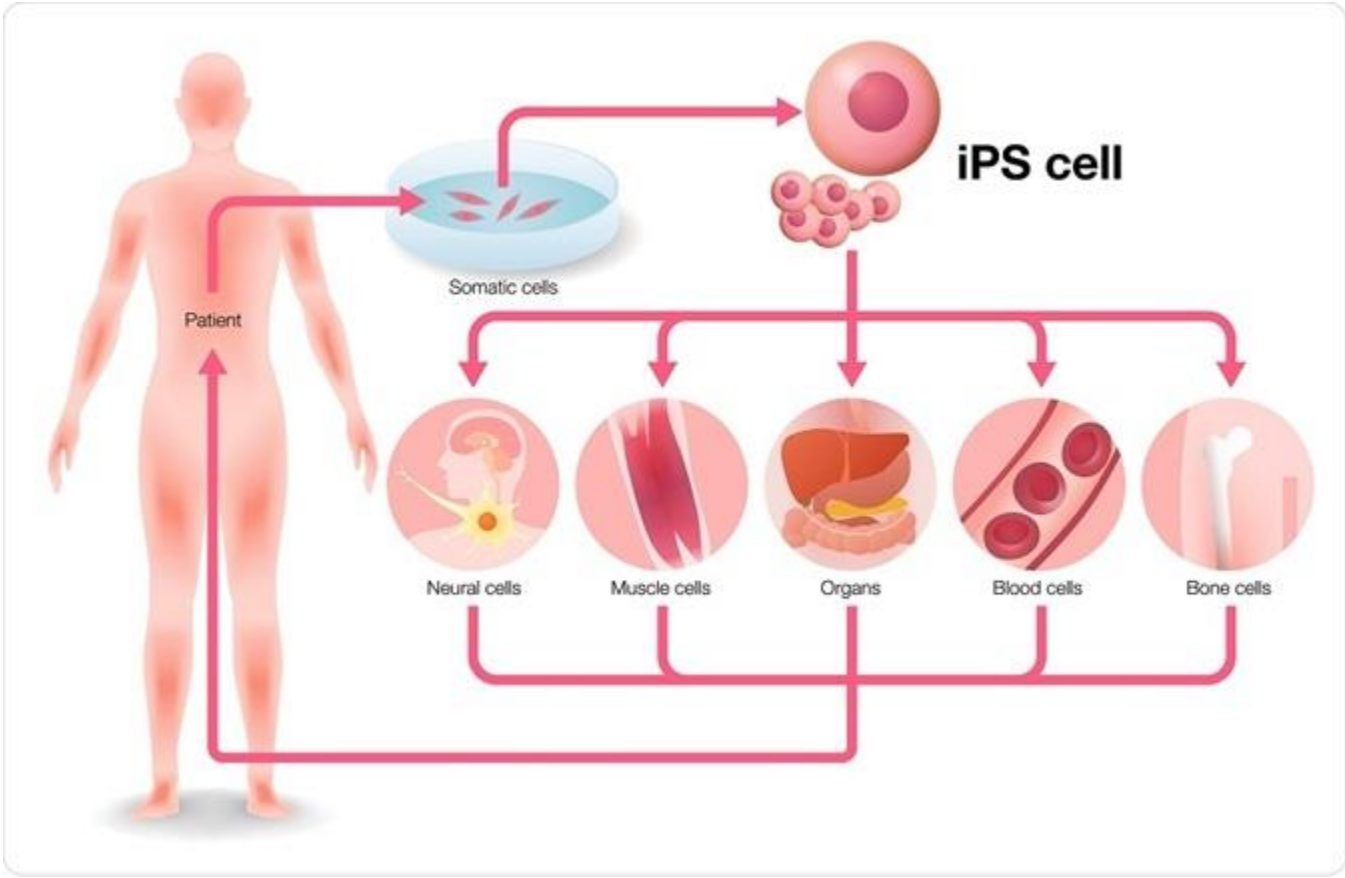
2. **Induced pluripotent stem cells** (iPSC)- These are adult stem cells that have been changed in a lab to be more like embryonic stem cells. Scientists first reported that human stem cells could be changed in this way in 2006. Induced pluripotent stem cells don't seem to be different from embryonic stem cells, but scientists have not yet found one that can develop every kind of cell and tissue.



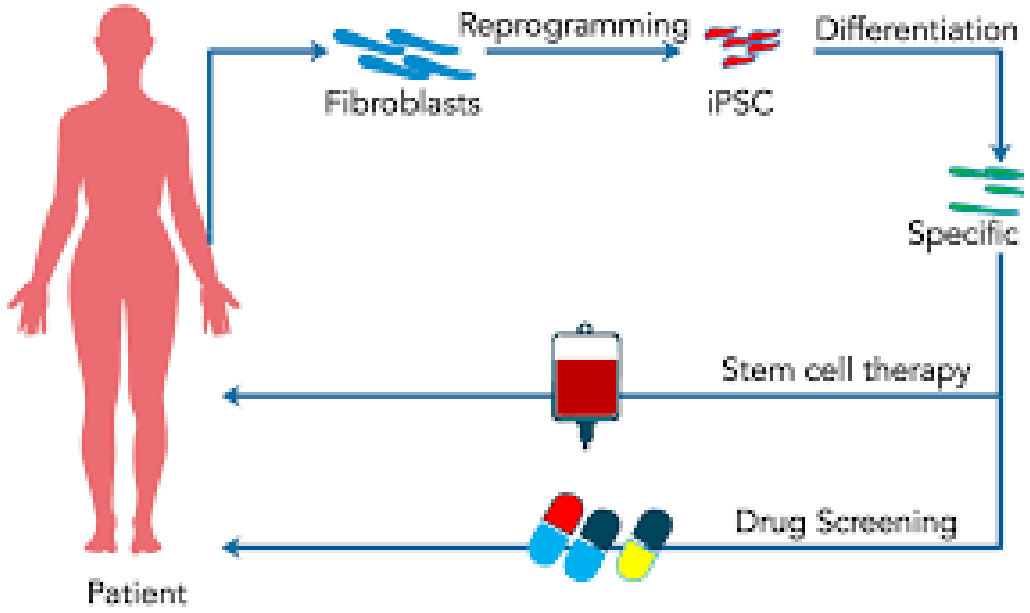


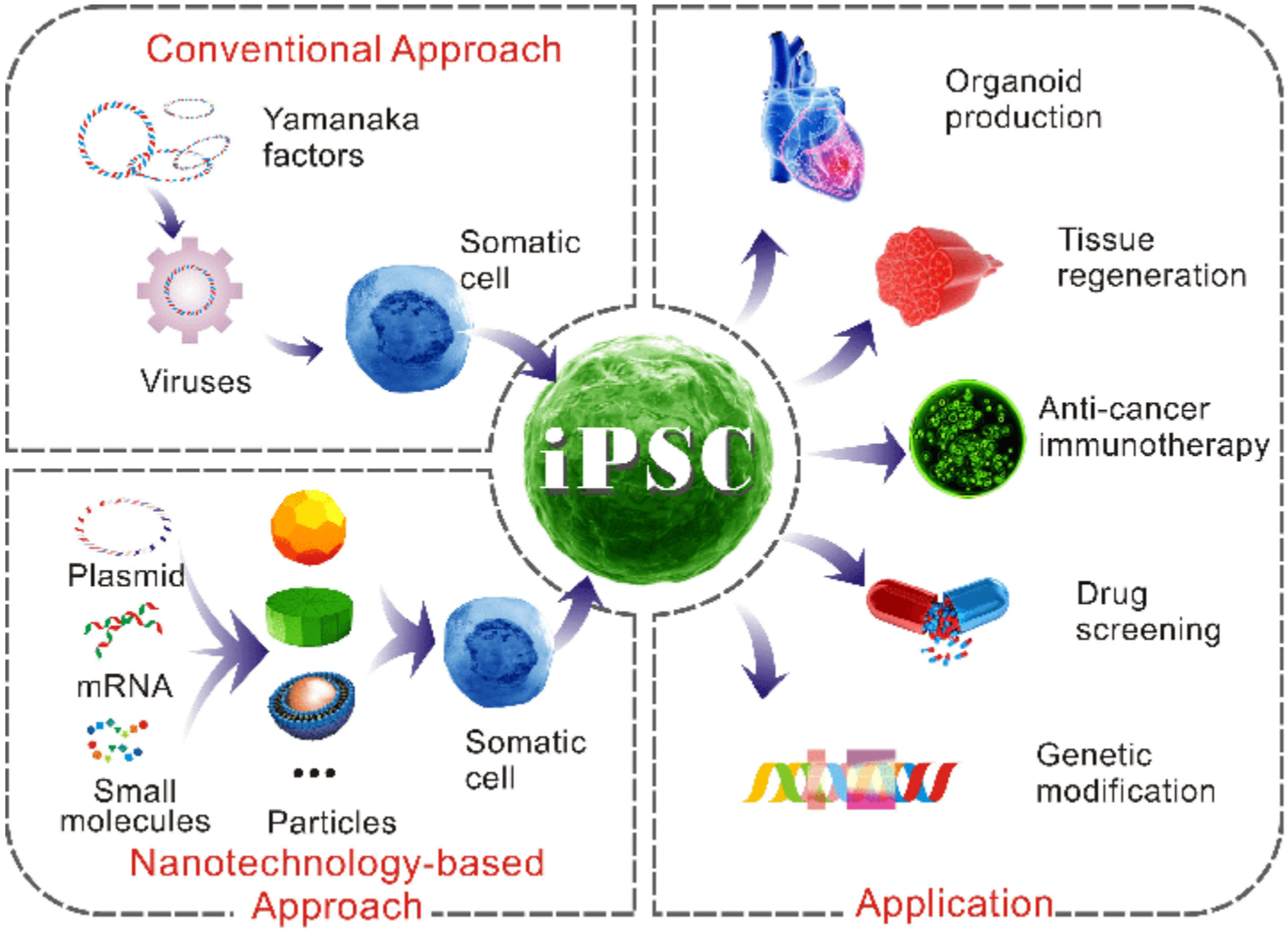
INDUCED PLURIPOTENT STEM CELLS





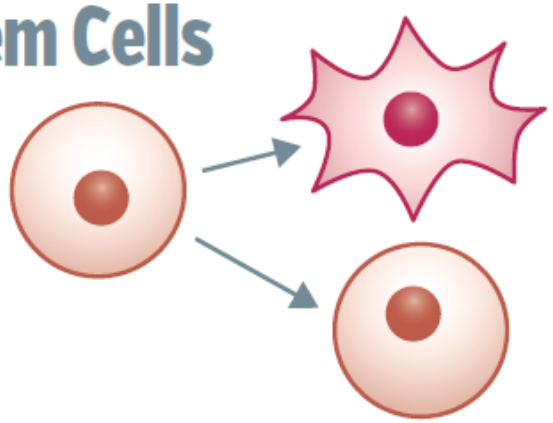
APPLICATIONS IPSC'S





Three Key Facts About Stem Cells

1. The defining characteristic of a stem cell is that it can self-renew or differentiate.
2. Stem cells enable the body to grow, repair and renew.
3. There are three types of stem cells:



Differentiation (Specializing)

Specialized cell
(e.g. muscle cell, nerve cell)

Self-Renewal (Copying)

Stem cell

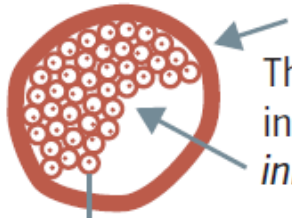
Tissue Stem Cells

In the fetus, baby and throughout life.

Found throughout the body, each type gives rise to at least one type of more specialized cell.

For example, blood stem cells are found in the bone marrow.

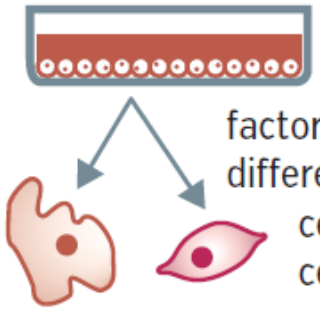
Embryonic Stem Cells



A *blastocyst*

The cells inside are the *inner cell mass.*

These cells, then grown in the lab, are called *embryonic stem cells.*



Varying factors are added to differentiate the ES cells into any cell type.

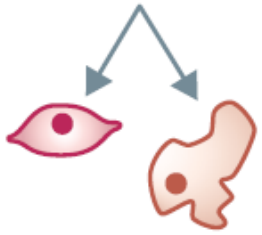
Induced Pluripotent Stem Cells (iPS)

Cell from the body

Genetically reprogrammed

Pluripotent cell ('embryonic-like')

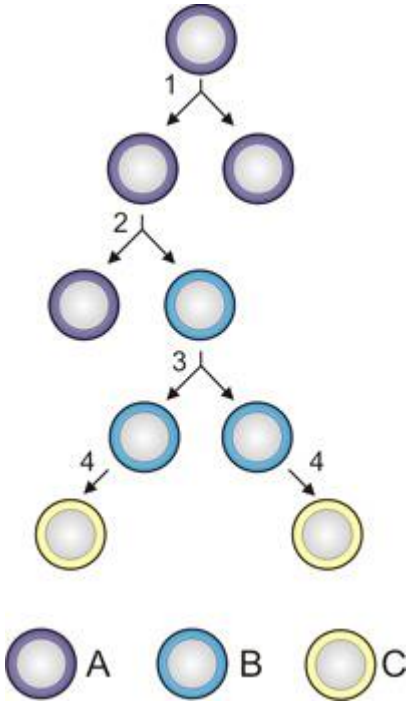
iPS cells are grown in the lab.



Varying factors are added to differentiate the iPS cells into any cell type.

Embryonic stem cells and iPS cells are *pluripotent;* they can generate all the specialized cells of the body.

Lineage!



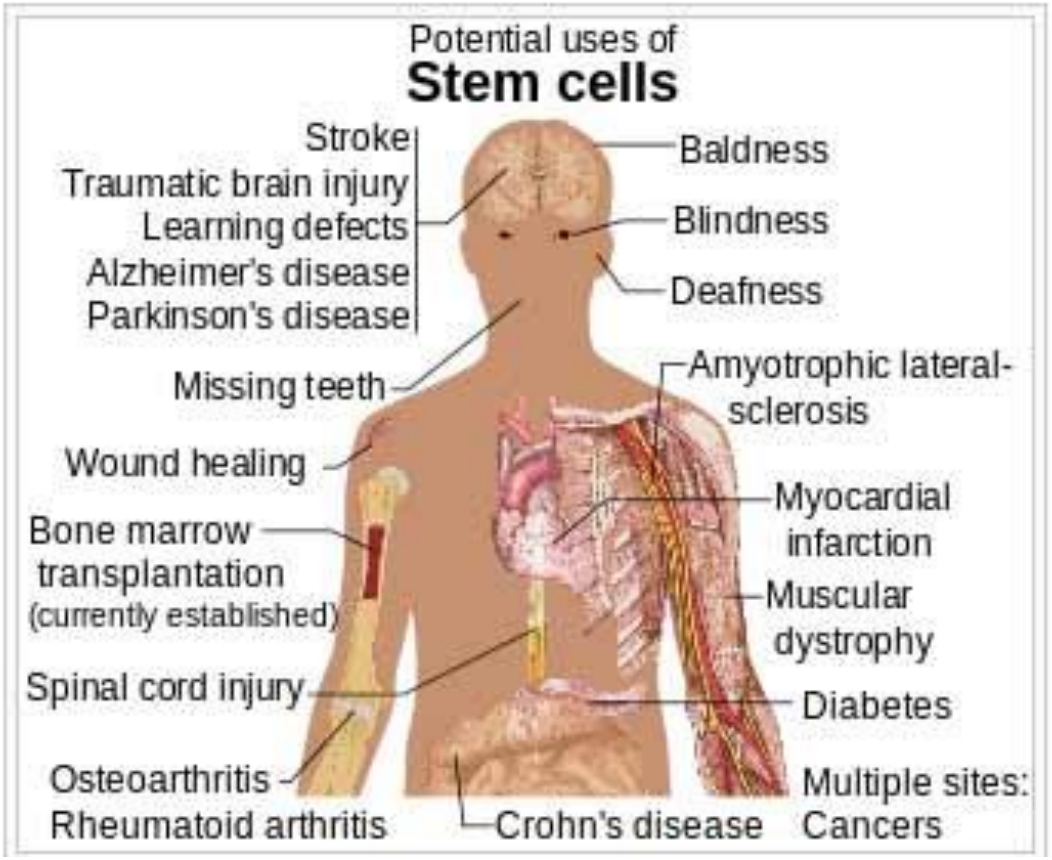
APPLICATIONS

Dental Applications

Pulpal regeneration
Craniofacial reconstruction
Engineering of new teeth

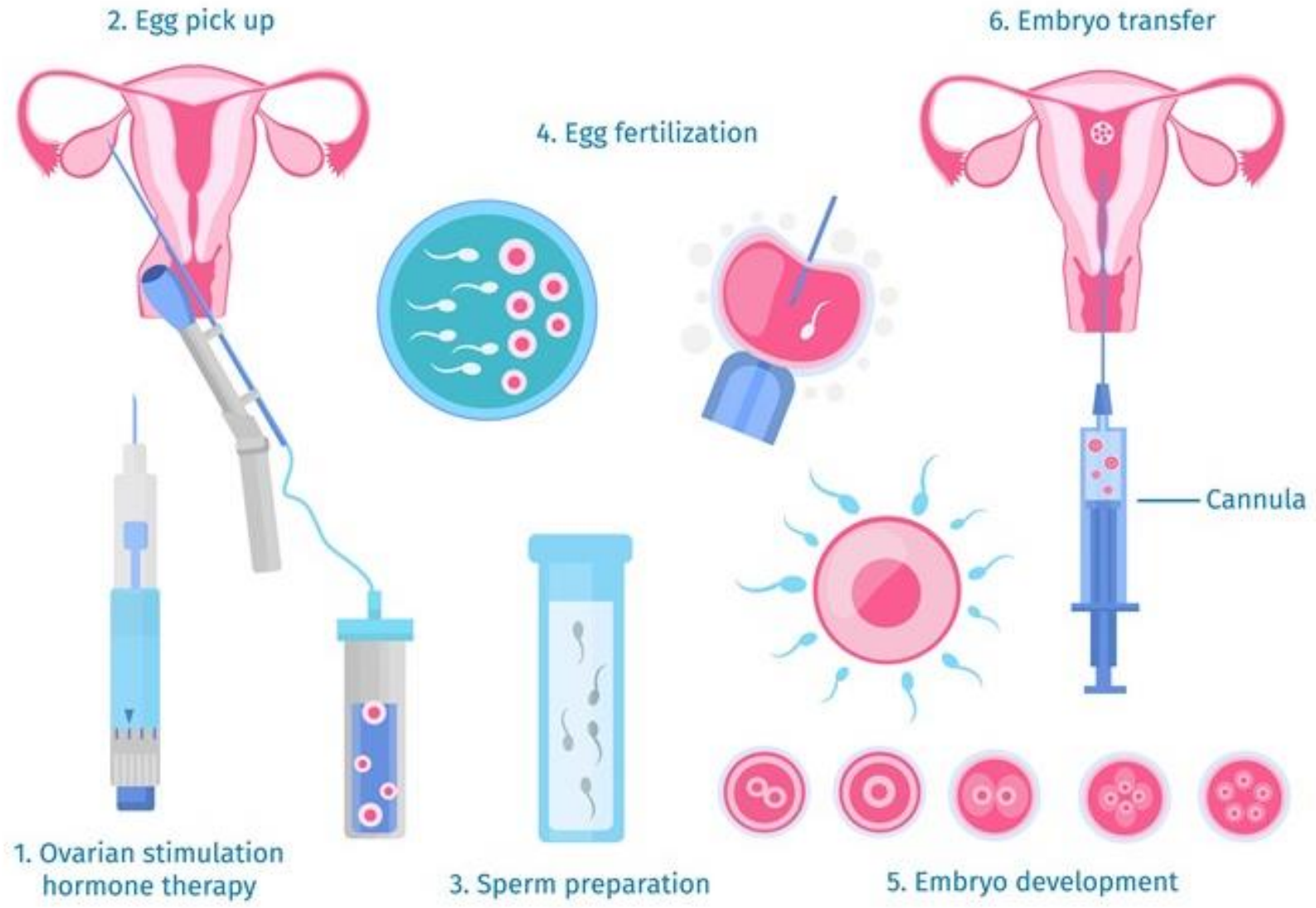
Medical Applications

Corneal repair
Lamellar bone generation
Treatment of liver disease
Cardiac repair following myocardial infarction
Treatment of muscular dystrophy
Treatment following a stroke
Spinal cord regeneration
Treatment of diabetes

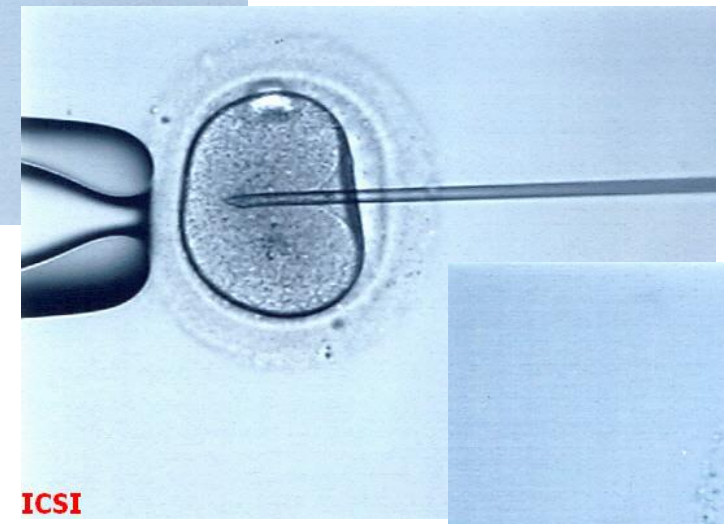


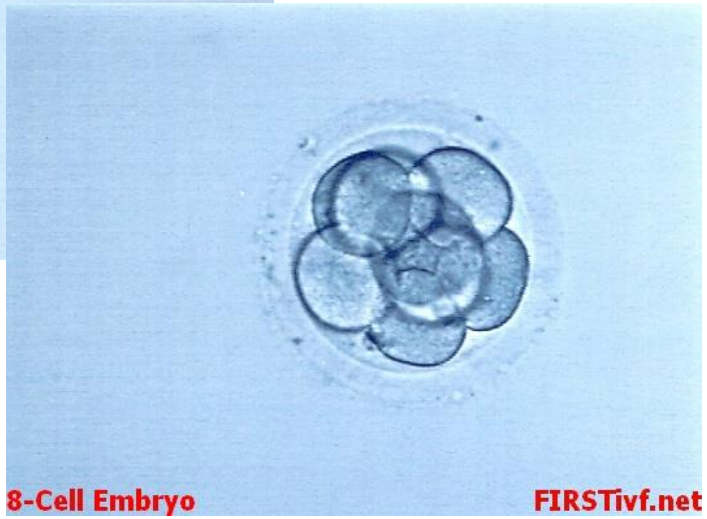
IN VITRO FERTILIZATION: STEPS

- Fertilization "in glass"
- Process of creating an embryo by artificially putting eggs and sperm together
- Alternative method of creating an embryo/ biological baby
- Referred to as "test tube babies"

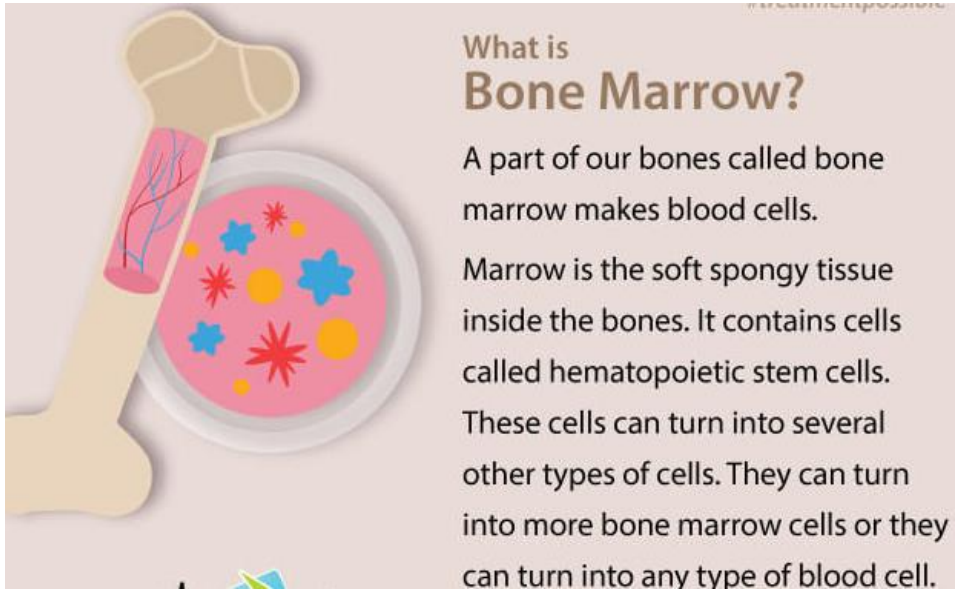


IN VITRO FERTILIZATION (IVF)



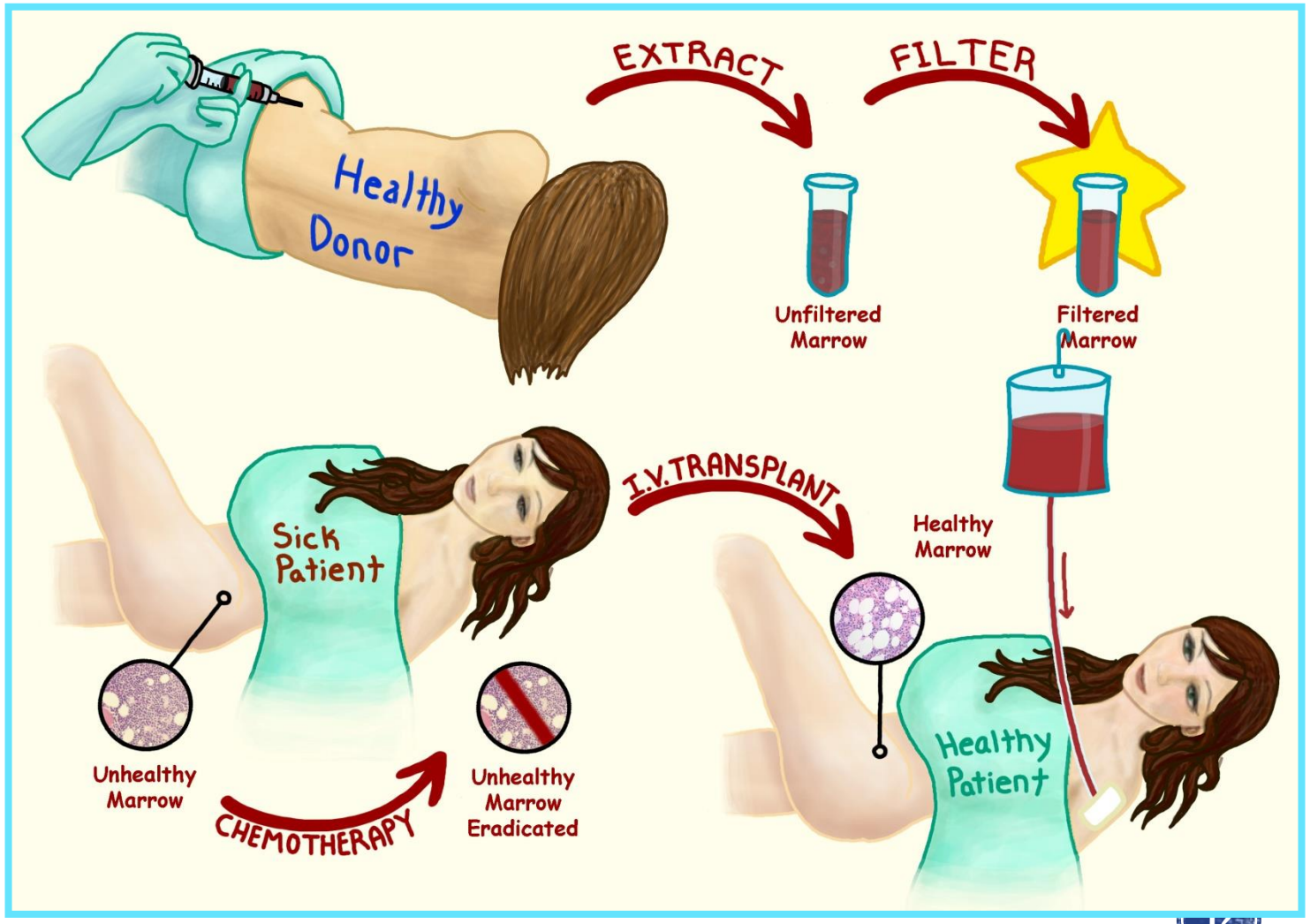


BONE MARROW TRANSPLANT



Used to recover patients with blood cancers:

- Leukemia
- Lymphoma



PLANT STEM CELLS- MERISTEMS

1. Cell division in plants only occurs in meristems

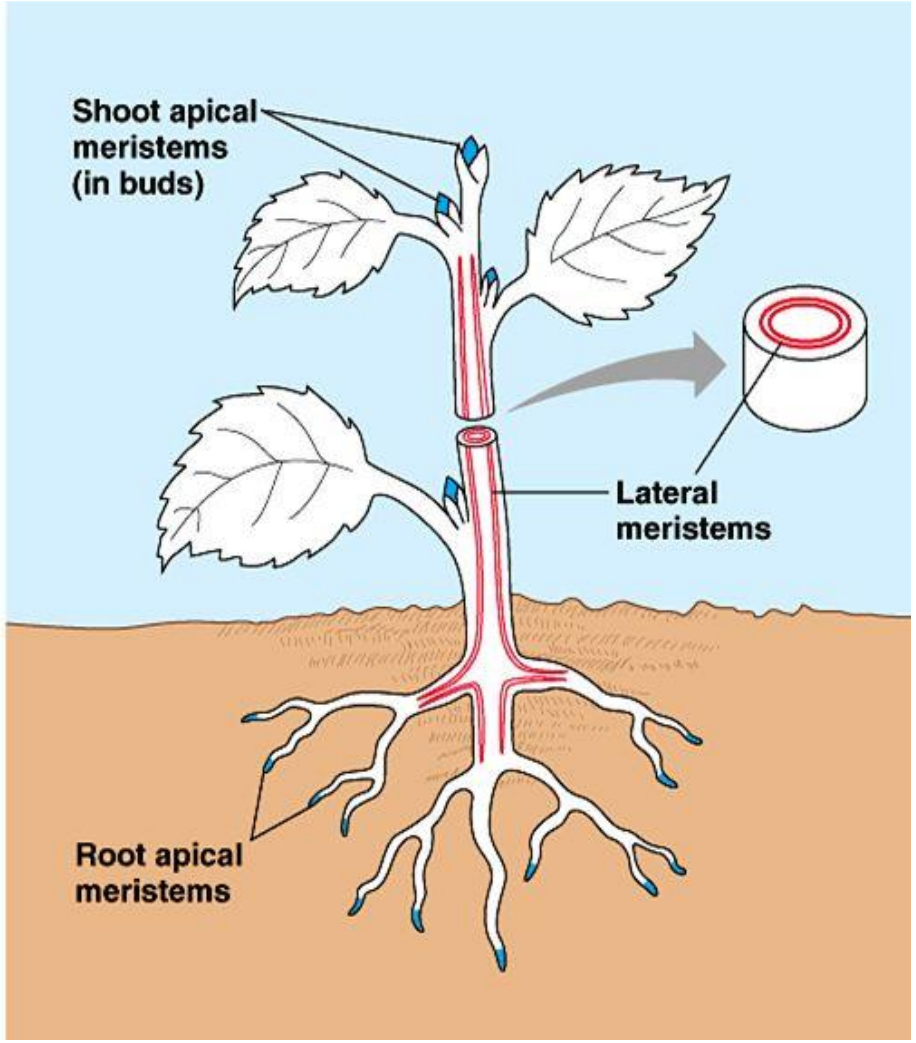
2. Stem cells found in the meristems have the potential to develop into any type of plant cell e.g. xylem, phloem, palisade mesophyll cells

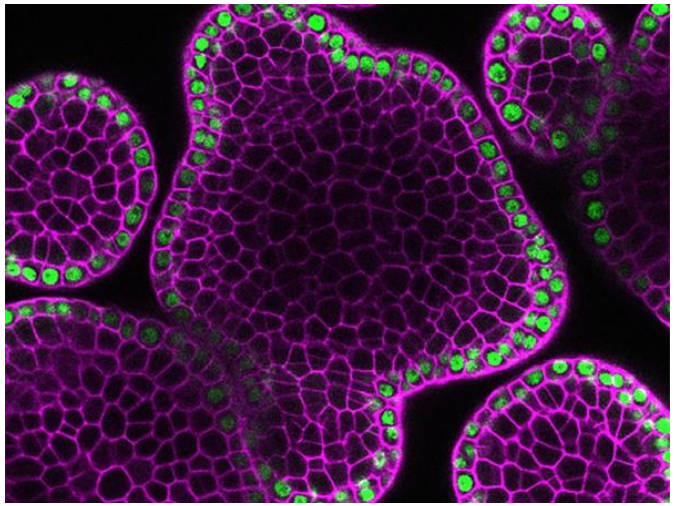
3. Apical meristems are found at the root and shoot tips.

Apical meristems increase the length of a plant.

4. Lateral meristems are made of cambium which is found in the vascular bundles between the xylem and phloem

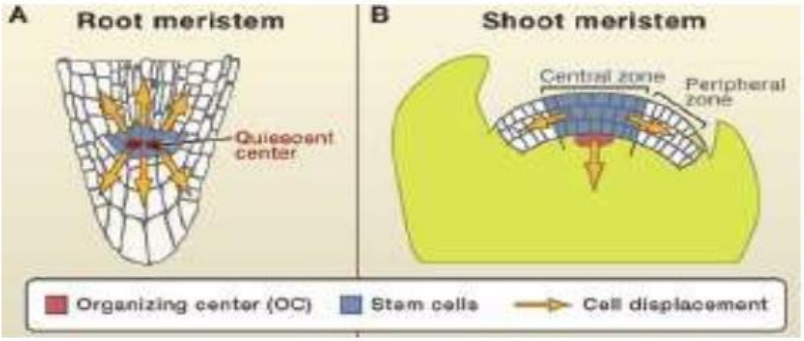
Lateral meristems increase in the girth (thickness) of the plant; this process leads to the formation of annual rings.





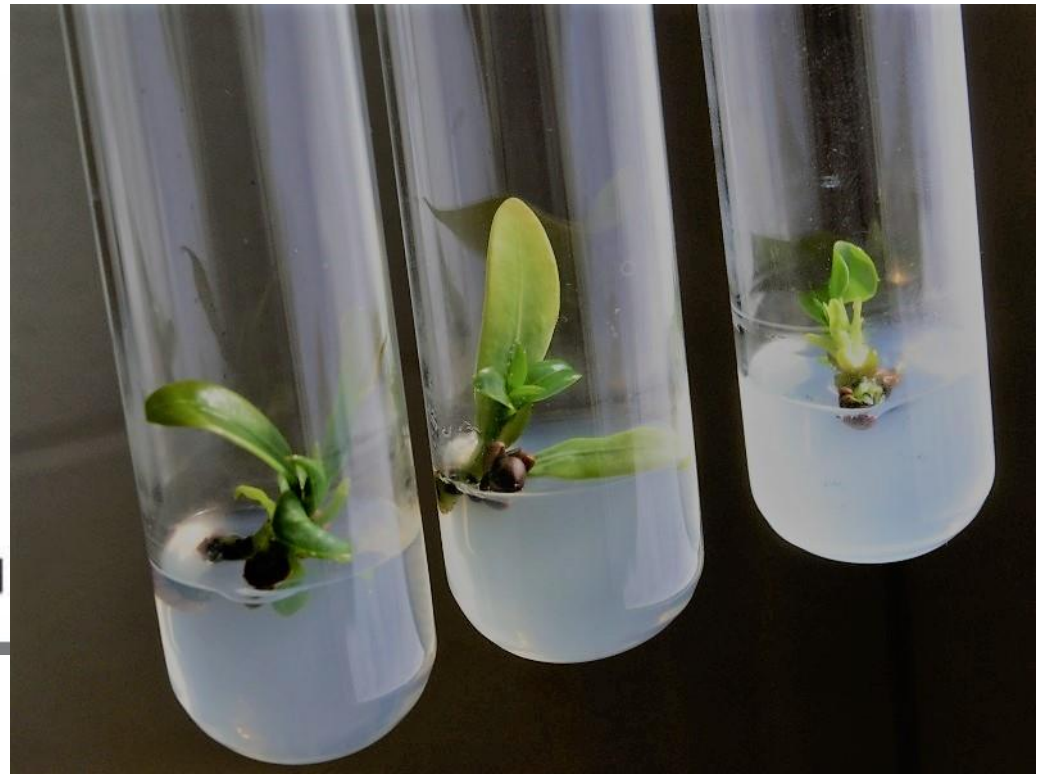
TYPES

1. **Shoot apical meristem**
2. **Root apical meristem**



APPLICATIONS: PLANT TISSUE CULTURE

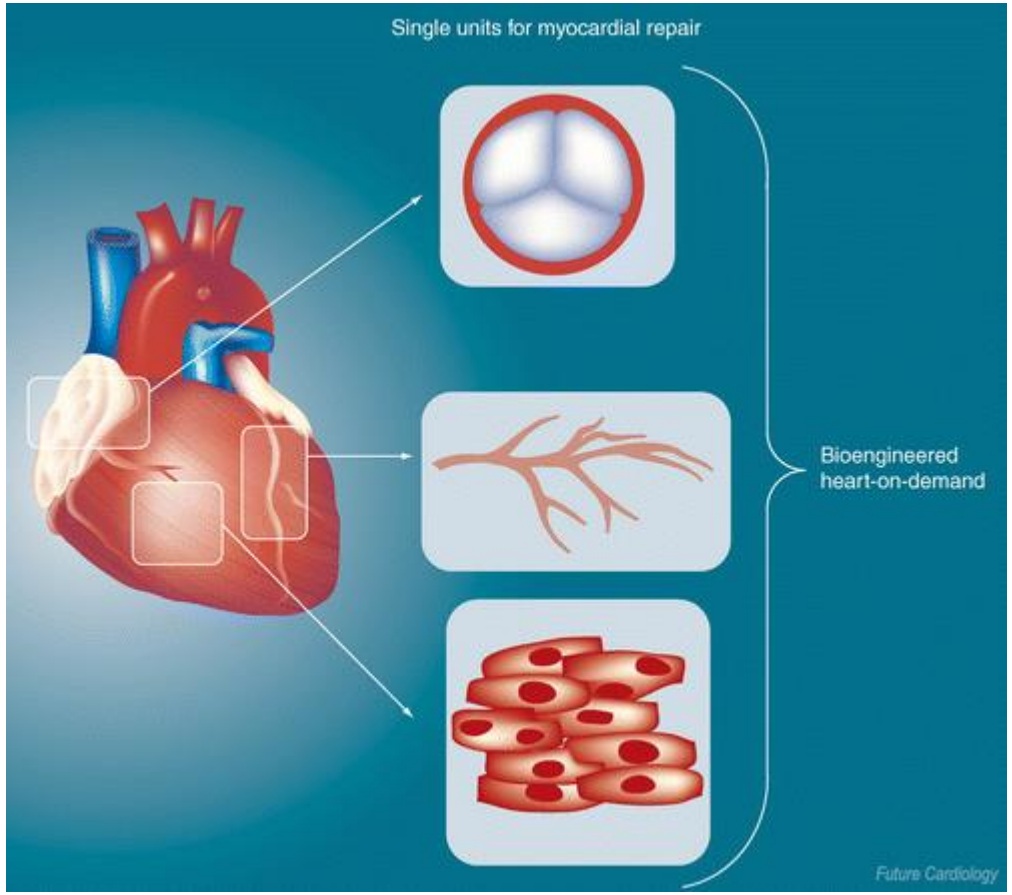
- The commercial production of plant
- To conserve rare and endangered plant species
- To screen cells rather than plant for advantages plant character, such as herbicide resistance
- Large scale growth of plant cells in liquid culture in bioreactor for production of valuable compound, like plant derived secondary metabolite, and recombinant proteins used as biopharmaceuticals
- To cross distantly related species by protoplast fusion and regeneration of the novel hybrid



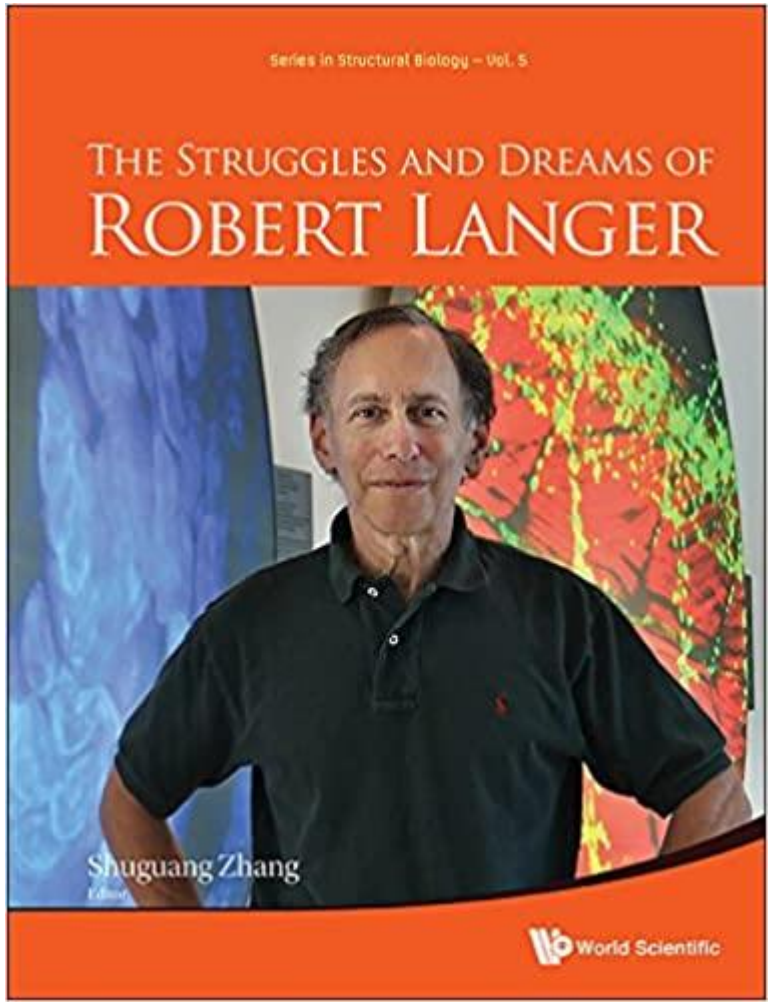
TISSUE ENGINEERING

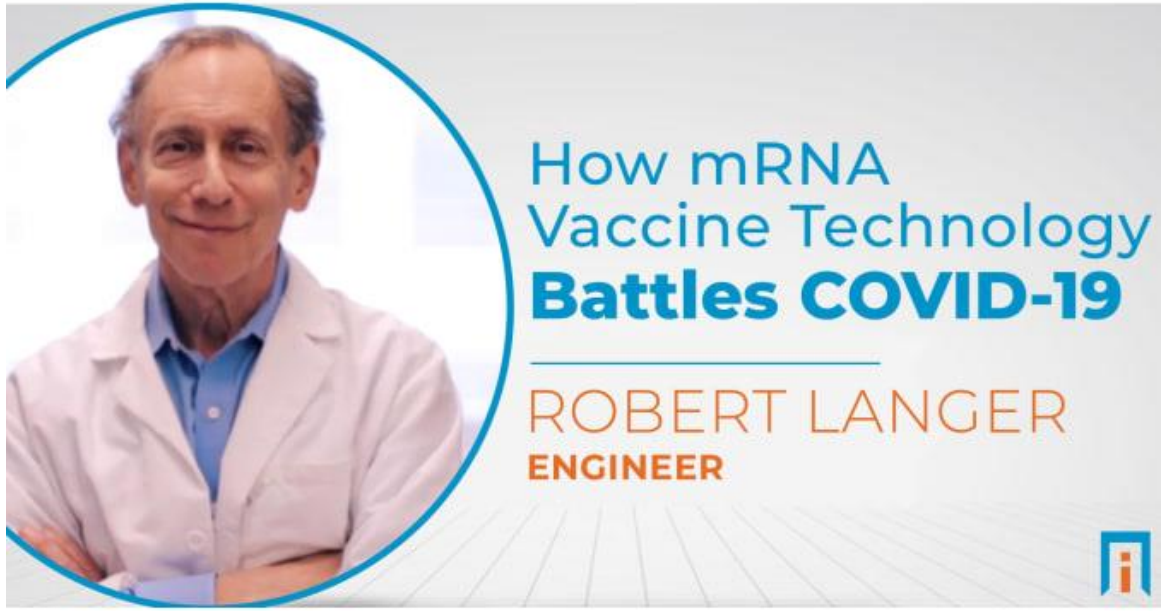
- **Tissue engineering** is the use of a combination of cells, engineering and materials methods, and suitable biochemical and physicochemical factors to improve or replace biological functions.
- The term has also been applied to efforts to perform specific biochemical functions using cells within an artificially-created support system (e.g. an artificial pancreas, or a bio artificial liver).

A commonly applied definition of tissue engineering, as stated by Langer and **Vacanti** is "An interdisciplinary field that applies the principles of engineering and life sciences toward the development of biological substitutes that restore, maintain, or improve [Biological tissue] function or a whole organ"



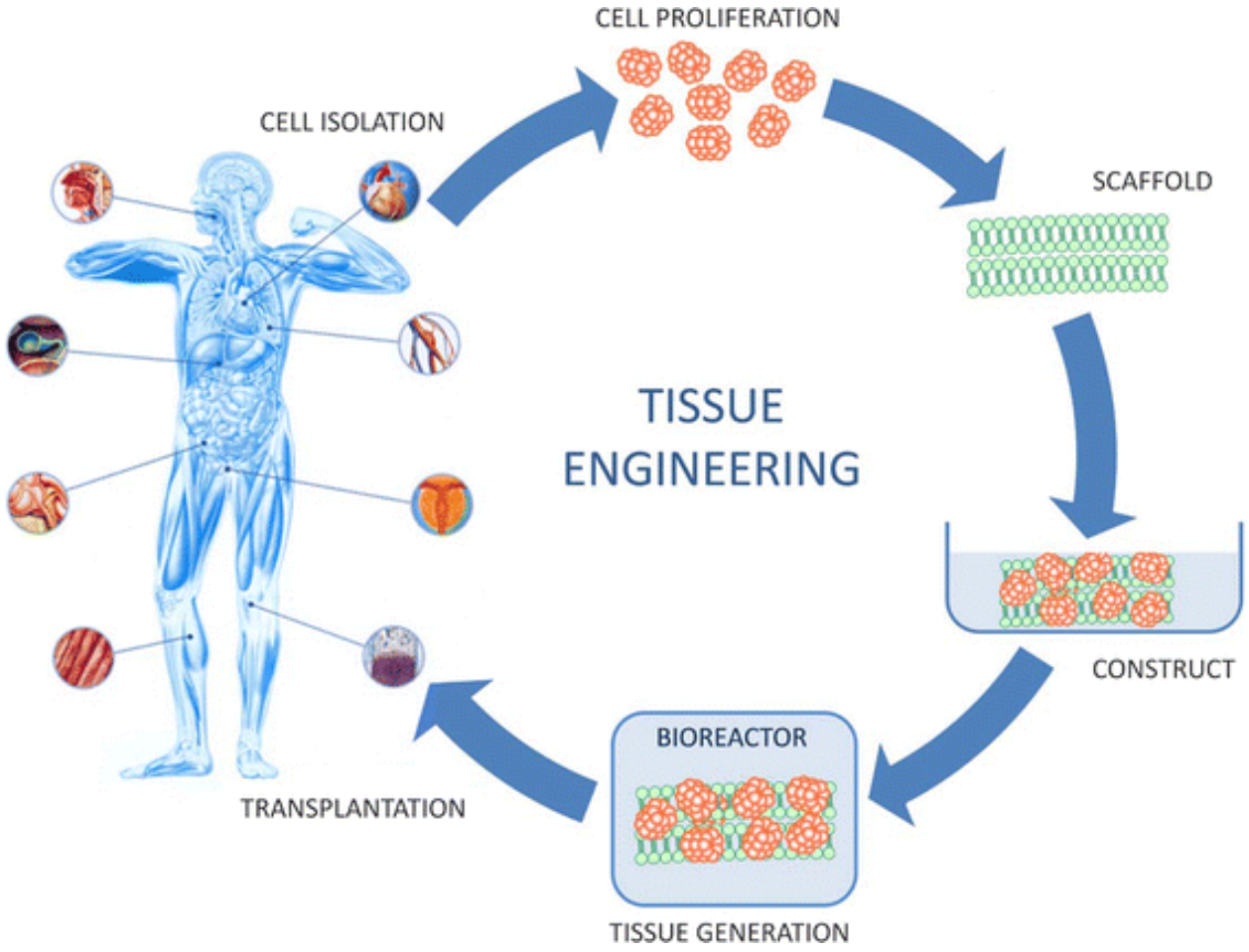
BOB LANGER!

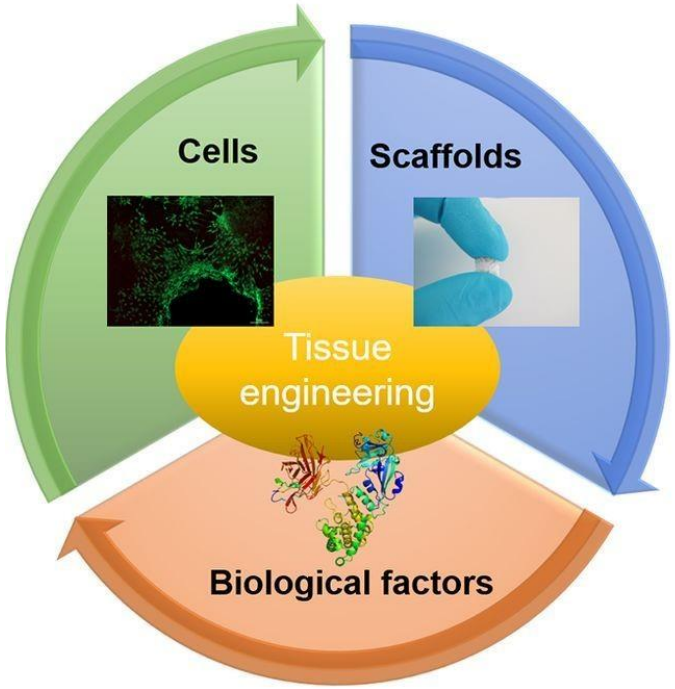


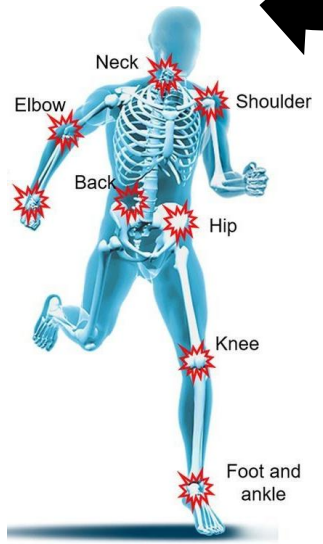


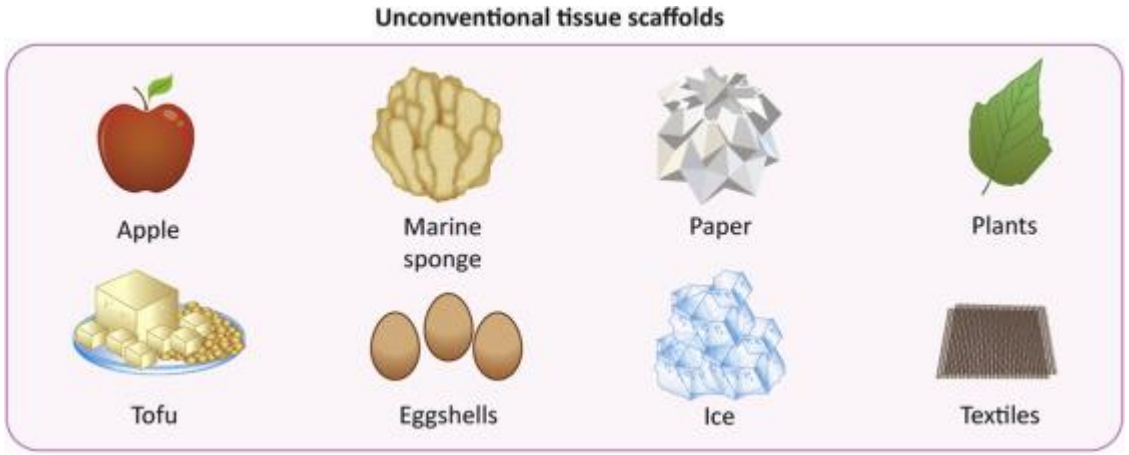
Chemical Engineer, MIT
1400 patents
Founder of over 40 companies

COMPONENTS


CELL PROLIFERATION
CELL ISOLATION
SCAFFOLD
TISSUE
ENGINEERING
CONSTRUCT
BIOREACTOR
TRANSPLANTATION
TISSUE GENERATION


Cells
Scaffolds
Tissue
engineering
Biological factors


Neck
Elbow
Shoulder
Back
Hip
Knee
Foot and
ankle

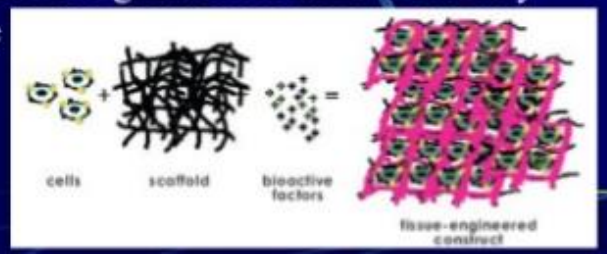


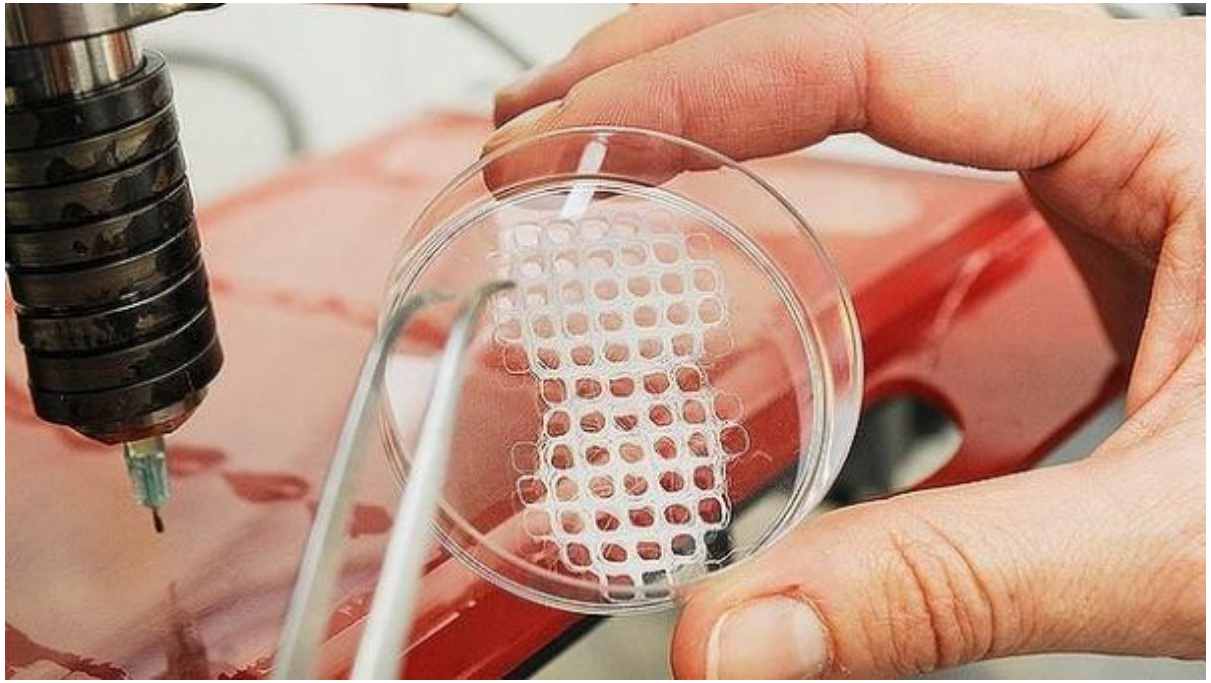
SCAFFOLDS

Cells are often implanted or 'seeded' into an artificial structure capable of supporting three-dimensional tissue formation. These structures, typically called scaffolds

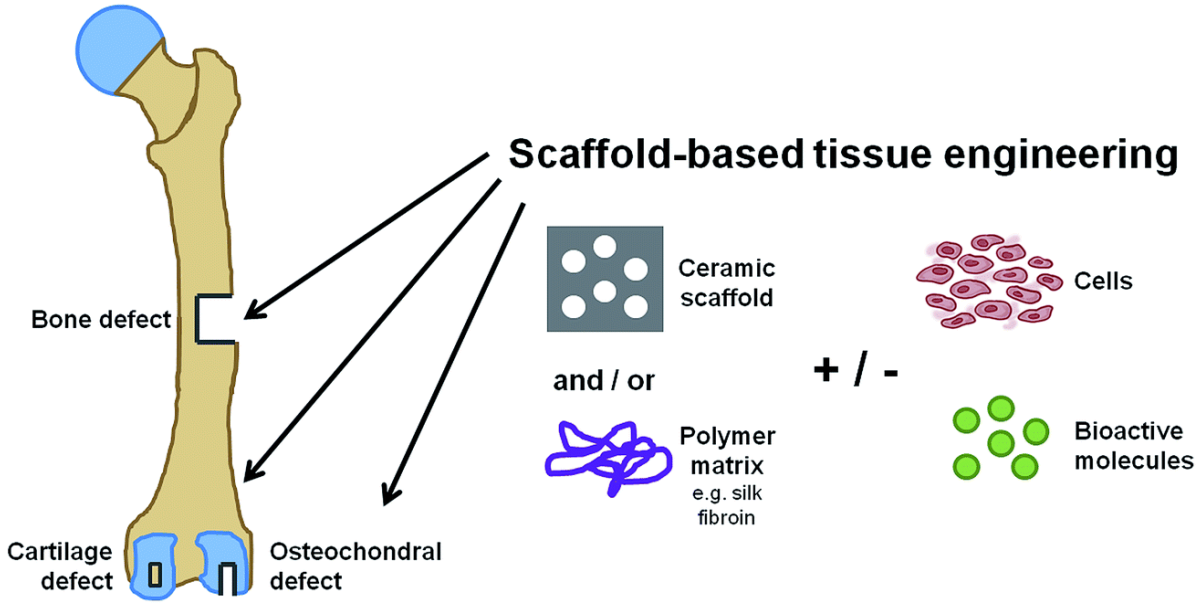
Scaffolds usually serve at least one of the following purposes:

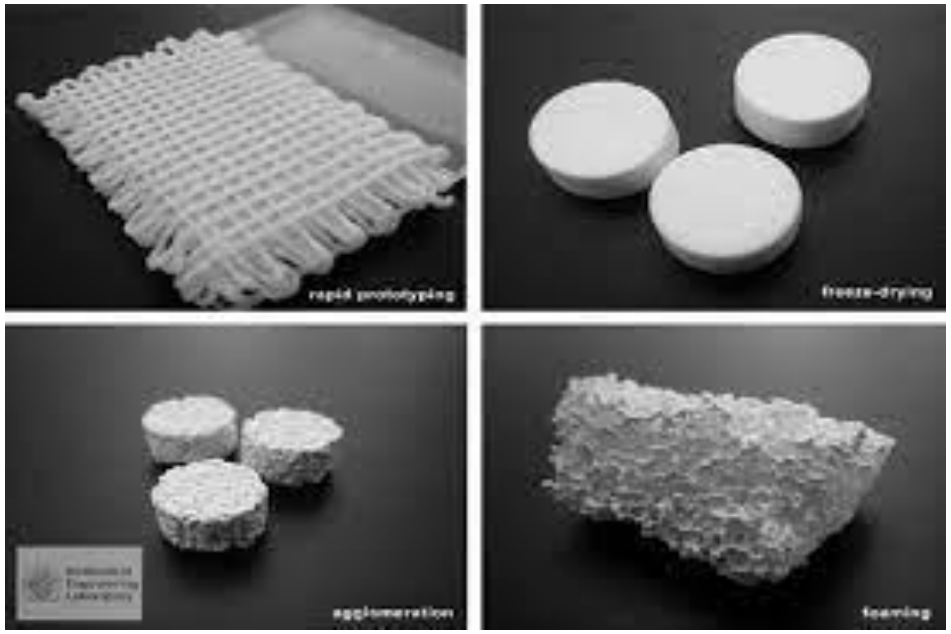
- Allow cell attachment and migration
- Deliver and retain cells and biochemical factors
- Enable diffusion of vital cell nutrients and expressed products
- Exert certain mechanical and biological influences to modify the behaviour of the cell phase





SCAFFOLDS





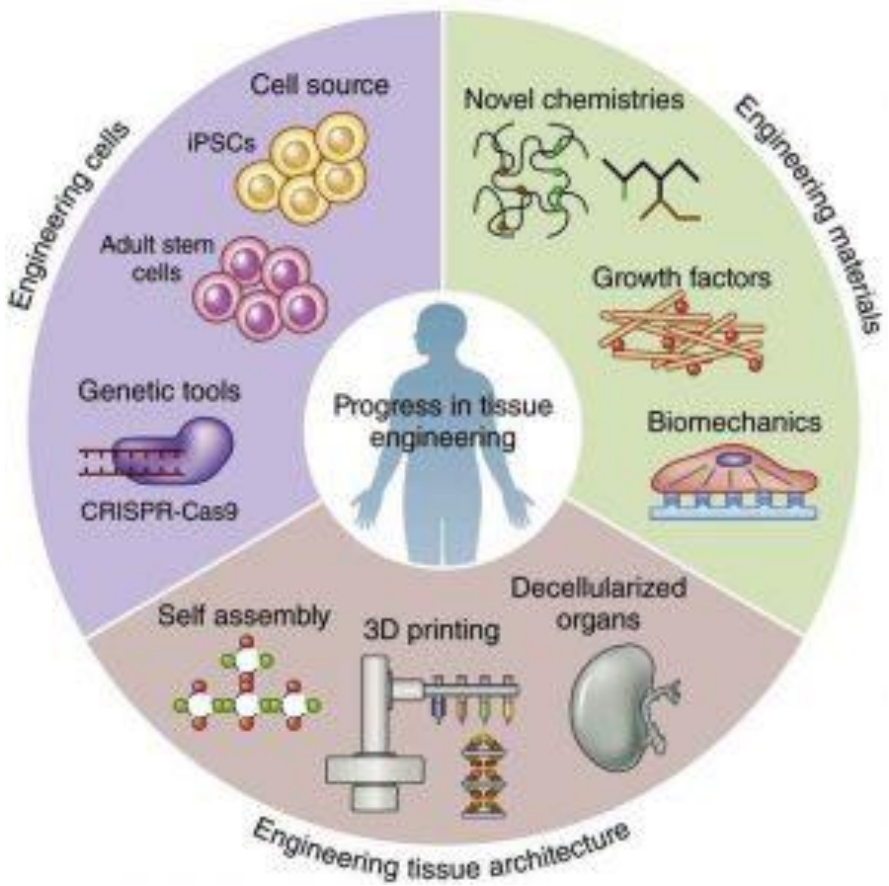
To achieve the goal of tissue reconstruction, scaffolds must meet some specific requirements. A high porosity and an adequate pore size are necessary to facilitate cell seeding and diffusion throughout the whole structure of both cells and nutrients. Biodegradability is often an essential factor since scaffolds should preferably be absorbed by the surrounding tissues without the necessity of a surgical removal.

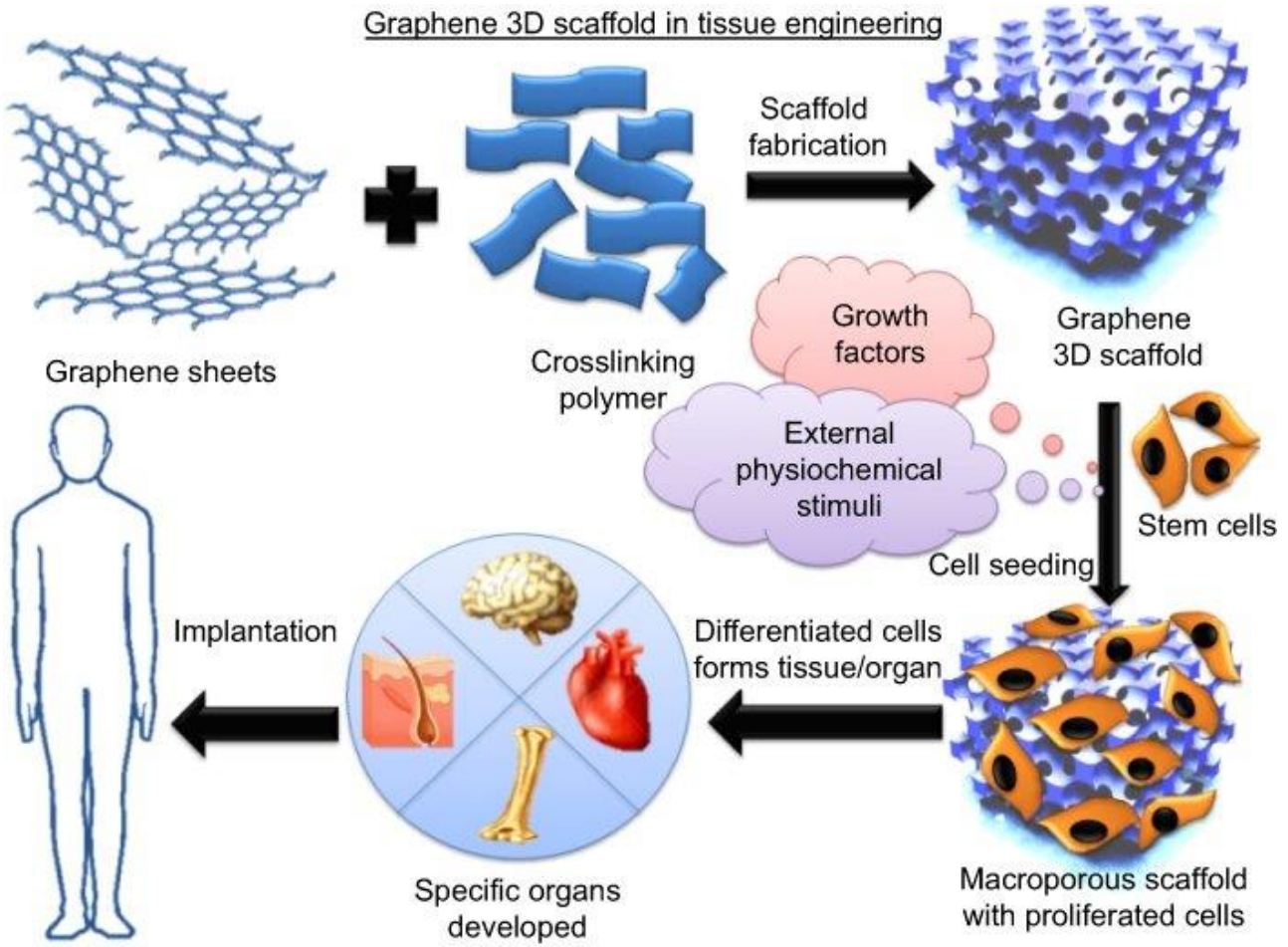
- New biomaterials have been engineered to have ideal properties and functional customization: injectability, synthetic manufacture, biocompatibility, non-immunogenicity, transparency, nano-scale fibers, low concentration, resorption rates, etc.

STEPS IN TISSUE ENGINEERING

(1)Start building material (e.g., extracellular matrix, biodegradable polymer).
(2) Shape it as needed.
(3) Seed it with living cells .
(4) Bathe it with growth factors.
(5) Cells multiply & fill up the scaffold & grow into three-dimensional tissue.
(6) Implanted in the body.
(7) Cells recreate their intended tissue functions.
(8) Blood vessels attach themselves to the new tissue.
(9) The scaffold dissolves.
(10) The newly grown tissue eventually blends in with its surroundings.

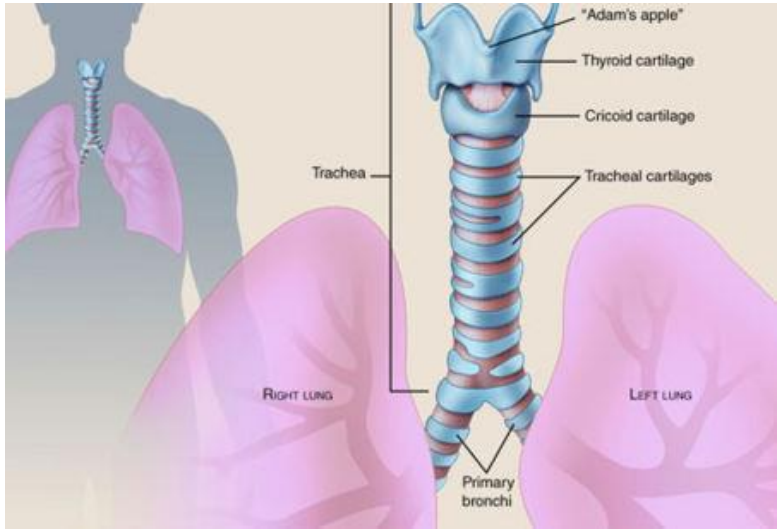
APPLICATIONS



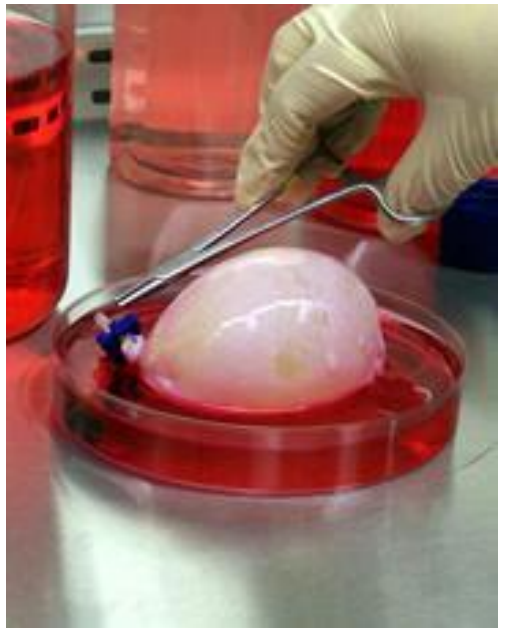


ARTIFICIAL ORGANS

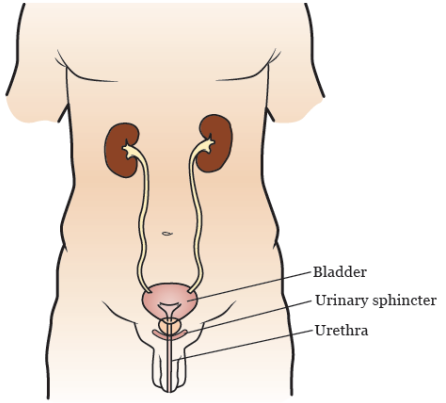
Trachea



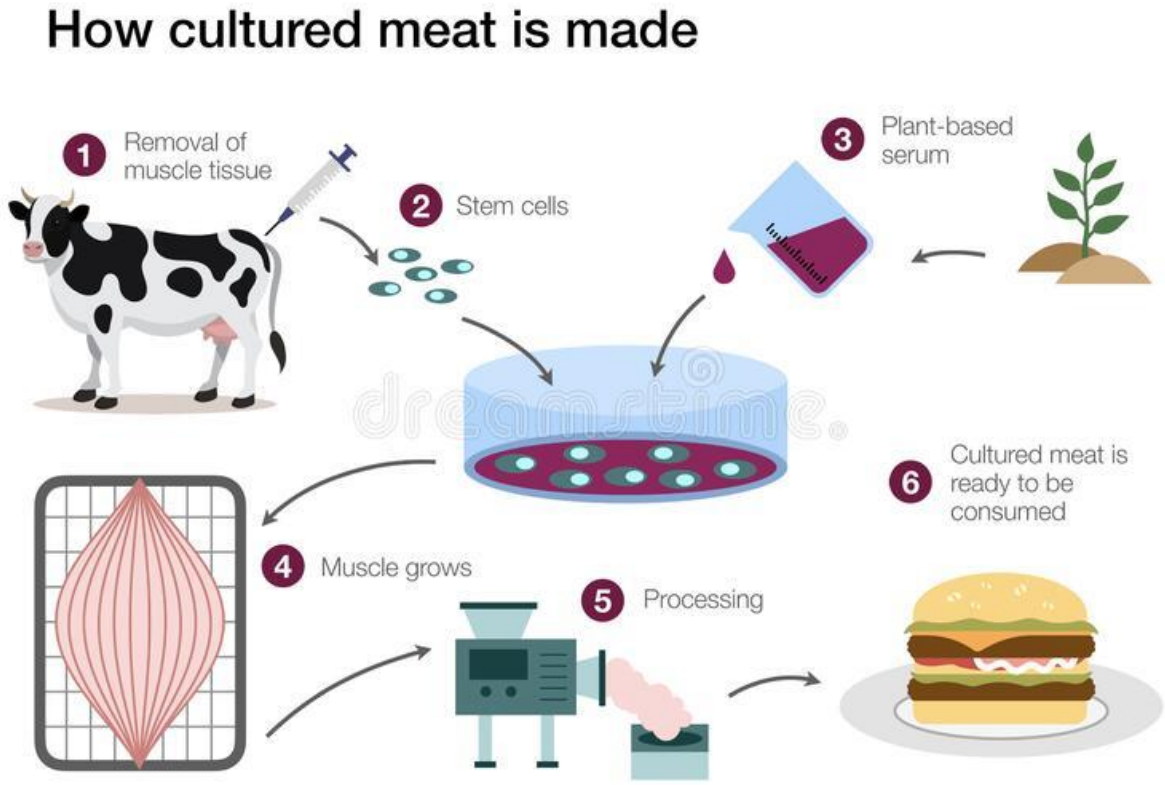
Heart Valve

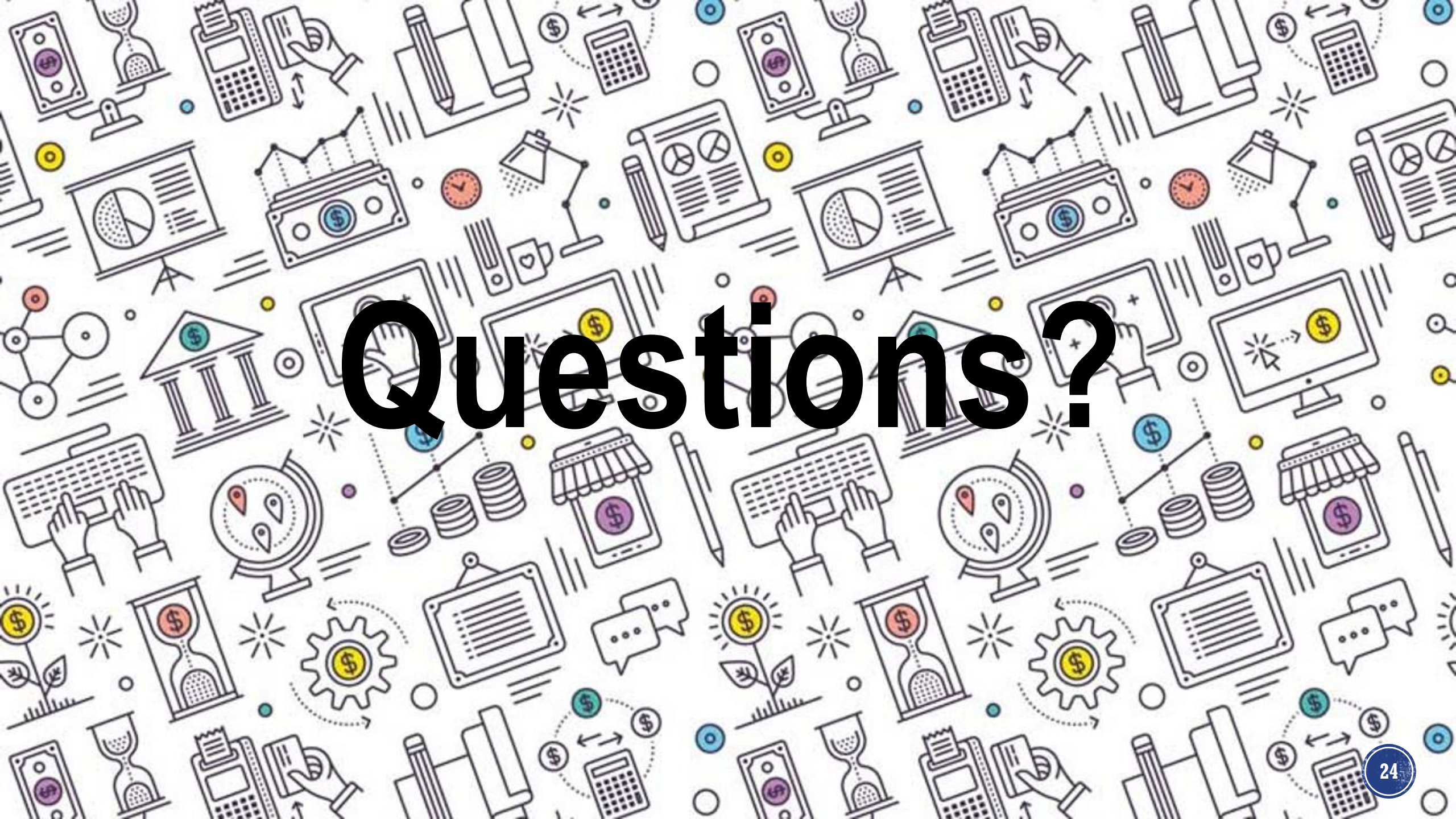


Bladder



- Help a person conquer a disease or illness
- Person will go through fewer surgeries
- No chance of rejection
- People would not have to wait for an organ donor
- People would not have to donate their organs after they die
- This technology could lead to even greater technologies in the future
- Permanent solution




Questions?