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Course Code : BC302CR

UNIT – V

GENOME PROJECTS AND BIOETHICS

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HUMAN GENOME PROJECT
GENE BANK
GENETICALLY MODIFIED ORGANISM IN
DEVELOPMENT AND DEVELOPED COUNTRIER

HUMAN GENOME PROJECT

The **Human Genome Project (HGP)** was an international research initiative that aimed to map and understand all the genes of the human species.

Who

- U.S. Department of Energy (DOE)
- National Institutes of Health
- 18 countries

When

- Target; 13 years
- Started;1990
- Completed; 2006

METHODS

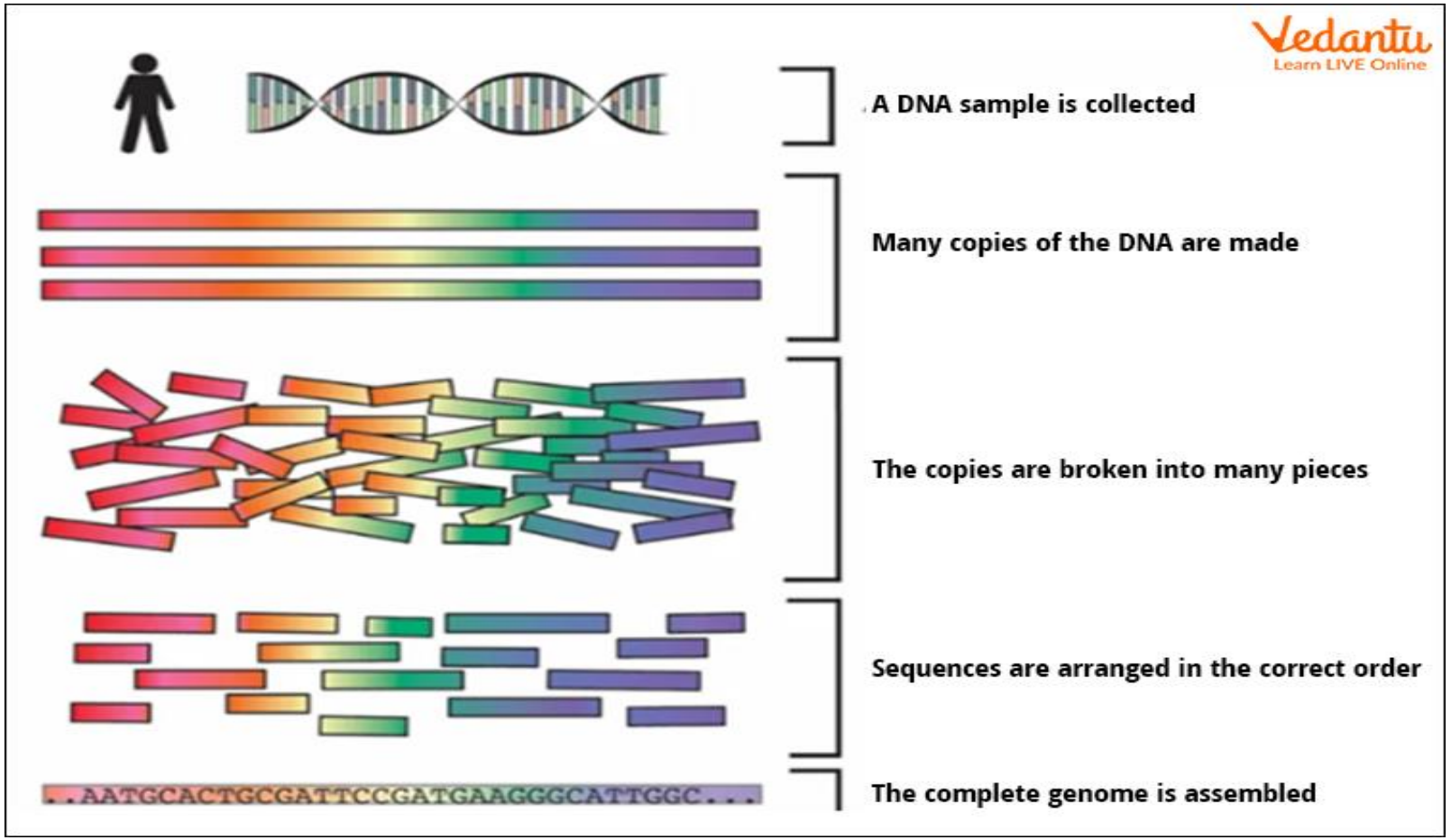
PROCEDURE

DNA Extraction

DNA Fragmentation

DNA Cloning

DNA Sequencing



GOALS OF THE HUMAN GENOME PROJECT

Mapping and Sequencing;

The primary goal was to determine the complete sequence of the 3 billion DNA base pairs that make up the human genome and identify all human genes (estimated to be between 20,000 and 25,000

Gene Function Identification:

The project sought to identify the function of various genes and how they relate to human traits and diseases.

Technological Development:

The project led to advances in DNA sequencing technologies and bioinformatics tools, which allowed scientists to store and analyze massive amounts of genetic data efficiently.

GENBANK

- GenBank is a publicly accessible database of nucleotide sequences and associated information, maintained by the National Center for Biotechnology Information (NCBI) in the United States. It is one of the most widely used repositories for genetic data worldwide. GenBank contains sequences submitted by individual researchers and institutions, as well as data collected from genome projects. The database includes DNA and RNA sequences from various organisms, including viruses, bacteria, plants, animals, and humans

ACCESSING GENBANK

- **Steps:**
- Go to the **NCBI homepage**: https://www.ncbi.nlm.nih.gov
- Navigate to the **GenBank** section by selecting "Nucleotide" from the search dropdown menu or directly via the **GenBank page**: https://www.ncbi.nlm.nih.gov/genbank/
- You can use the search bar to enter gene names, accession numbers, or keywords to find specific sequences.

GENETICALLY MODIFIED ORGANISM

- A **genetically modified organism (GMO)** is any organism—such as a plant, animal, or microorganism—whose genetic material has been altered using genetic engineering techniques.
- These modifications are made to give the organism new traits that are not naturally occurring in its species.
- Genetic modifications can be as simple as inserting a gene from one organism into another to give it a new characteristic, like disease resistance, or as complex as reconfiguring entire genetic pathways to produce new compounds.

KEY POINTS OF GMOS

- **Gene Transfer Across Species**: Genetic material from one species can be inserted into another. For example, a gene from a bacterium can be inserted into a plant to make it pest-resistant.
- **Desired Traits**: Common goals for GMOs include increased yield, pest and disease resistance, herbicide tolerance, and improved nutritional content.
- **Techniques Used**: The most common techniques for creating GMOs include **CRISPR gene editing**, **gene splicing**, and **recombinant DNA technology**.

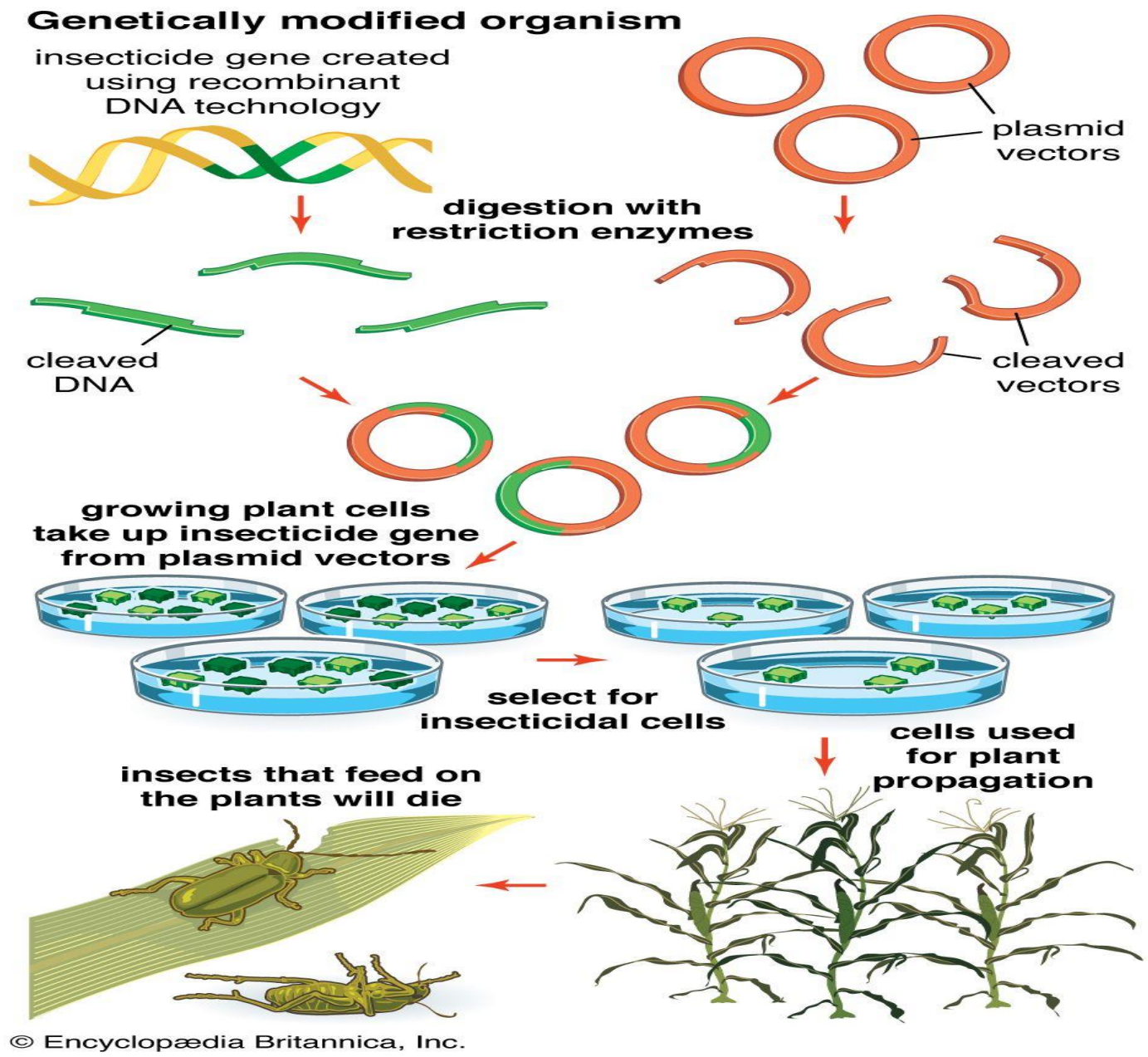
DIFFERENCE BETWEEN CIS & TRANSGENIC

CISGENIC

- A gene from a sexually compatible plant is introduced into the recipient plant. Cisgenic plants are less likely to have unintended consequences, such as harming the ecosystem or soil, or causing allergies. Cisgenic plants can also be created through conventional breeding or crossing.

TRANSGENIC

- A gene from a non-plant organism or a sexually incompatible plant is introduced into the recipient plant. Transgenic technology can improve the nutritional quality of animal products



PROCEDURE GENETICALLY MODIFIED ORGANISM

APPLICATIONS

- **Agricultural Products**
- **Bt Corn and Bt Cotton**: These crops contain genes from the bacterium *Bacillus thuringiensis* (Bt) that produce proteins toxic to specific insect pests, reducing the need for chemical pesticides.
- **Herbicide-Resistant Crops (e.g., Roundup Ready soybeans and corn)**: These are modified to withstand certain herbicides, allowing farmers to control weeds without harming the crop itself.
- **Golden Rice**: This rice variety is engineered to produce beta-carotene, a precursor to vitamin A, to combat vitamin A deficiency in regions where rice is a staple food.

PHARMACEUTICAL PRODUCTS

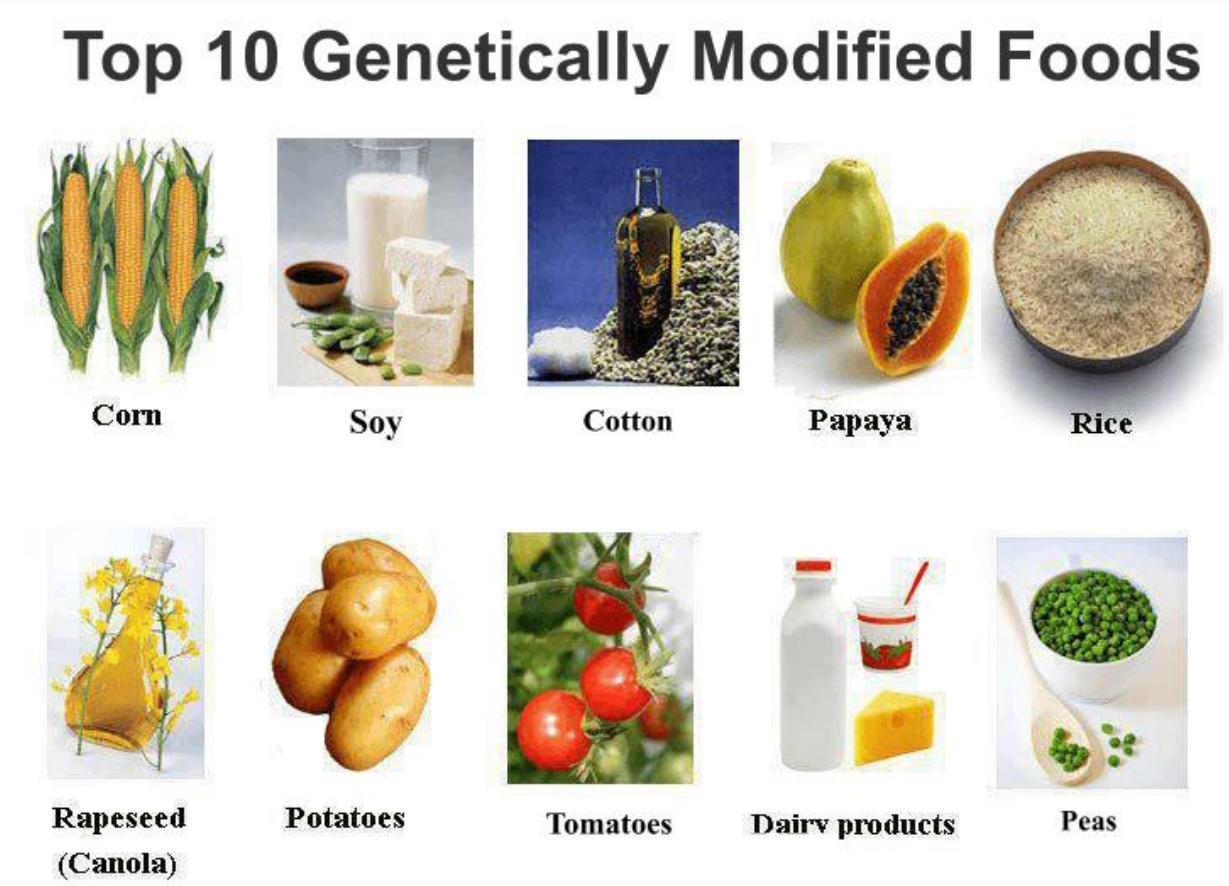
- **Insulin**: The first commercially available GM product, insulin is produced using genetically modified bacteria or yeast to treat diabetes. This GMO-derived insulin is identical to human insulin.
- **Human Growth Hormone (HGH)**: Genetically modified bacteria produce HGH, used to treat growth hormone deficiencies in children and adults.
- **Vaccines**: Certain vaccines, including some hepatitis B and COVID-19 vaccines, are made using GMOs. Modified yeast or other cells produce specific viral proteins to stimulate immunity.
- **Monoclonal Antibodies**: GM cell lines are used to produce monoclonal antibodies, which are key in treating diseases like cancer, autoimmune disorders, and viral infections.

RESEARCH AND MEDICAL MODELS

- **Transgenic Mice**: Mice genetically modified to express human genes are used to study diseases such as cancer, Alzheimer's, and diabetes. These models help scientists understand disease mechanisms and test treatments.
- **Gene Therapy Vectors**: Modified viruses, like adeno-associated viruses (AAV), are used in gene therapy to deliver therapeutic genes into patients with genetic disorders, offering potential cures or treatments for diseases like hemophilia and spinal muscular atrophy (SMA).

GENETICALLY MODIFIED FOODS (GMOS)

- **The most common genetically modified crops**
- Canola.
- Corn.
- Cotton.
- Papaya.
- Soy.
- Sugar beets.
- Yellow squash.
- Zucchini.



BIOETHICS

Bioethics : Laws and Regulations in Biotechnology ,patent laws ,copyrights and Intellectual property rights (IPR)

Definition of Bioethics

Bioethics is defined as the study of the ethical and moral implications of new biological discoveries and biomedical advances; mostly in the fields of genetic engineering and drug research.

LAWS IN BIOTECHNOLOGY

- The Indian biotechnology sector has observed a strident increase in R&D and its application in numerous sectors like agriculture, medicine, industries, and the environment.

- agricultural biotechnology sector, India has established a policy and a regulation system in the 1980s. Currently, the country is witnessing severe changes in all biotechnology sectors.

- Execution of the Rules for the Manufacture, Usage, Import, Export, and Storage of Hazardous Microorganisms/Genetically Engineered Organisms or Cells, 1989 under the Environment Protection Act, 1986 (EPA) was the very first enactment credited to agrarian biotechnology in India.

- The EPA (1986) and the Rules (1989) are still seen to control the pending parliamentary sanction of the Biotech Regulatory Authority of India (BRAI), India's Biotech Policy, and governing mechanisms. The growth of India's Biotech Policy can be characterized in three phases:

PATENT LAWS

What is a patent?

- A patent is an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem. To get a patent, technical information about the invention must be disclosed to the public in a patent application.

- The history of Patent law in India starts from 1911 when the Indian Patents and Designs Act, 1911 was enacted
- Act, 2005, wherein product patent was extended to all or any fields of technology including food, drugs, chemicals, and micro-organisms.
- 20 years in India

TYPES OF PATENT

Utility Patents

- It can also be obtained for new improvements to existing processes, compositions of matter, machines, and manufacturers

Design Patents

- This type of patent can only be obtained where the design is inseparable from the object. This type of patent only protects the object‘s appearance

Plant Patents

- Plant patents are often obtained to protect new and distinctive plants. In order to obtain this type of patent are the plant is should not a tuber propagated plant (i.e. an Irish potato)

COPYRIGHT

- Copyright is a form of IP that grants its owner the exclusive rights of publication/distribution, reproduction, adaptation, display, and performance of the copyrighted work for a limited time

- While it is easy to assume that copyrighted works and copyright law don't play a large role in biotechnology, copyright protection has long been a point of discussion for many in the industry. Specifically, the idea that DNA sequences may be copyrightable works of authorship has been considered.

- If a sequence of DNA is written by a scientist in a lab, isn't it similar in authorship as to a developer writing a line of code? Furthermore, the argument included that copyrighting

- biotechnology could be a way to protect work that

- doesn't qualify for patent protection.

- Copyright valid for 60 years after the author's death.

INTELLECTUAL PROPERTY RIGHTS

- Intellectual property rights are the rights given to persons over the creations of their minds
- Biotechnology intellectual property rights are the legal ownership of an interest in a patent, trademark or trade secret. This means that another company cannot use those assets without permission from the company established as the official owner
- It’s possible for IPRs to have meaningful impacts on both upstream and downstream aspects of biotechnology innovation. However, IPRs are most applicable to downstream aspects, such as, commercialization, manufacturing, and market access/shar
- example, patents, copyright and trademarks

BIOSAFETY-TYPES OF BIOSAFETY, ADVANTAGE AND DISADVANTAGE. ETHICS IN CLONING AND STEM CELL RESEARCH

BIOSAFETY

- Biosafety is the prevention of risk to human health and safety, and the conservation of the environment and the pathogen, as a result of the use for research and commerce of infectious or genetically modified organisms.
- Biosafety defines the containment conditions under which infectious agents can be safely manipulated.
  - **Primary containment** involves protecting personnel and the immediate lab environment from exposure (e.g., gloves, biosafety cabinets)
  - **Secondary containment** involves protecting the community and environment from exposure to hazardous agents (e.g., sealed lab environments, air filtration).

PHYSICAL AND BIOLOGICAL CONTAINMENTS.

PHYSICAL CONTAINMENTS

- The physical methods being adopted inside the laboratories to prevent escaping of GEOs to the environment are called physical containment.

It include;

1. Air filtration
2. Sterilization lights
3. Waste disposal
4. Protective handling

1.Air filtration

• The exhaust air from the laboratory is filtered through exhaust filters.

• It prevents the escaping of GEOs from the lab.

2.Sterilization lights

• Flurescent tube lights which emit UV light,are fitted in the laboratory to sterilize the work areas and exposed surfaces of the lab.

• This technique destroys microbial contaminent inside the lab.

3.Waste disposal

• All waste coming from the laboratory are sterilized by autoclaving or by incinerating them in an incinerator.

• This will prevent the escaping of contaminated wastes from the lab.

4.Protective handling

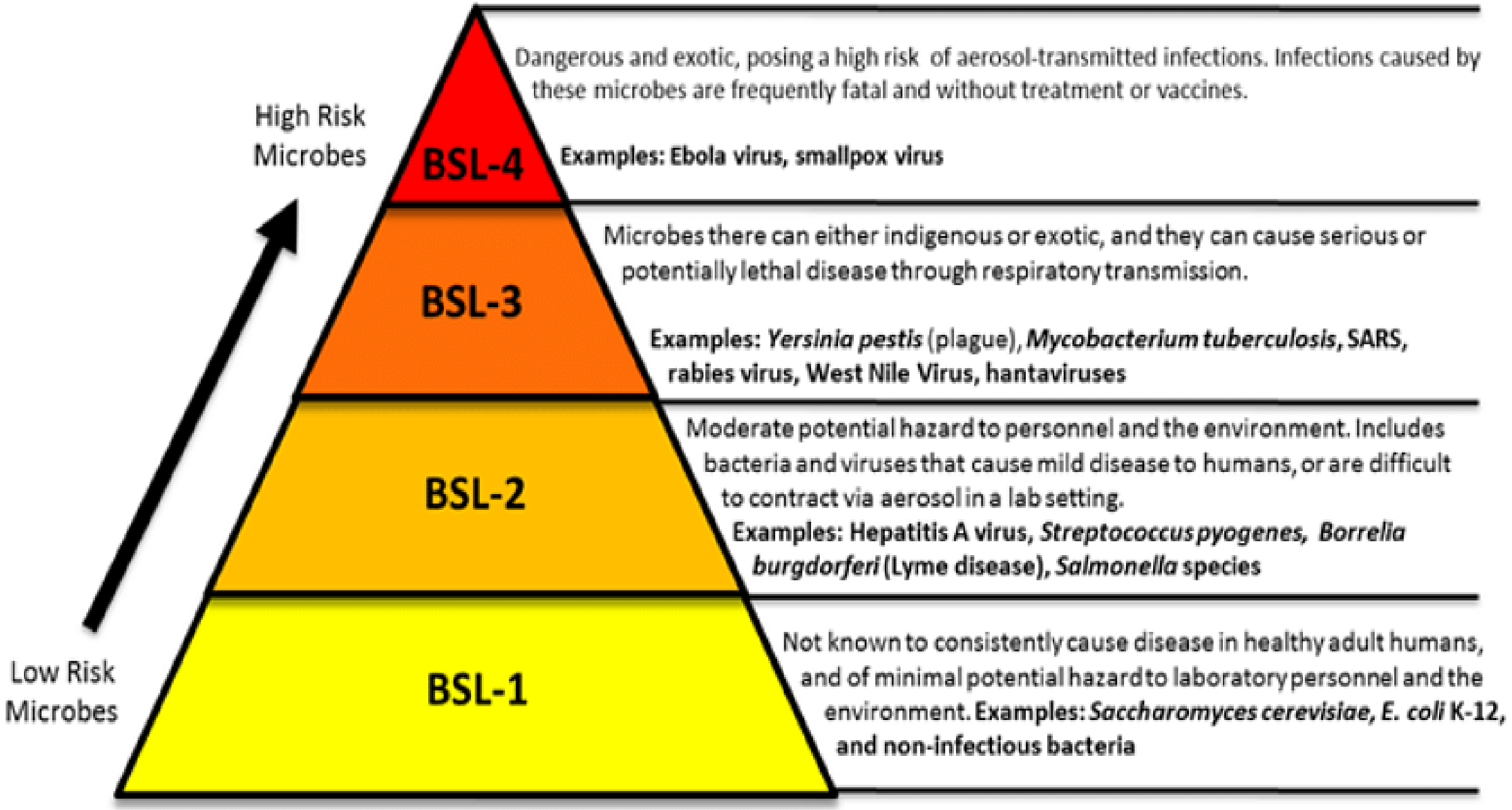
• Persons working in the laboratory must follow certain techniques to avoid contamination and to prevent escaping of microbes.

• The person must wear protective clothing before entering the work area,it should not be carried outside.

• Mouth pipetting should be avoided.

BIOLOGICAL CONTAINMENT

- The biological principles used in laboratories to prevent the escape of GEOs or microbes are called biological containment.
- Biological containment makes the organisms unable to survive in the outside environment.
- It prevents the spreading of vector DNAs to the organisms outside the laboratory by usual conjugation, transformation or transduction.
- Bacteria which cannot grow outside unless suitable nutrients have to be supplied are used for gene manipulations.
- Such bacteria are made by inducing gene mutation. This is a mutant bacterium that survive only in the culture.


High Risk Microbes
Low Risk Microbes
BSL-4
Dangerous and exotic, posing a high risk of aerosol-transmitted infections. Infections caused by these microbes are frequently fatal and without treatment or vaccines.
Examples: Ebola virus, smallpox virus
BSL-3
Microbes there can either indigenous or exotic, and they can cause serious or potentially lethal disease through respiratory transmission.
Examples: Yersinia pestis (plague), Mycobacterium tuberculosis, SARS, rabies virus, West Nile Virus, hantaviruses
BSL-2
Moderate potential hazard to personnel and the environment. Includes bacteria and viruses that cause mild disease to humans, or are difficult to contract via aerosol in a lab setting.
Examples: Hepatitis A virus, Streptococcus pyogenes, Borrelia burgdorferi (Lyme disease), Salmonella species
BSL-1
Not known to consistently cause disease in healthy adult humans, and of minimal potential hazard to laboratory personnel and the environment. Examples: Saccharomyces cerevisiae, E. coli K-12, and non-infectious bacteria

BIOSAFETY LEVELS

basic classes of laboratory risks from low to high

BSL-1 BSL-2 BSL-3 BSL-4

TYPES OF BIOSAFETY

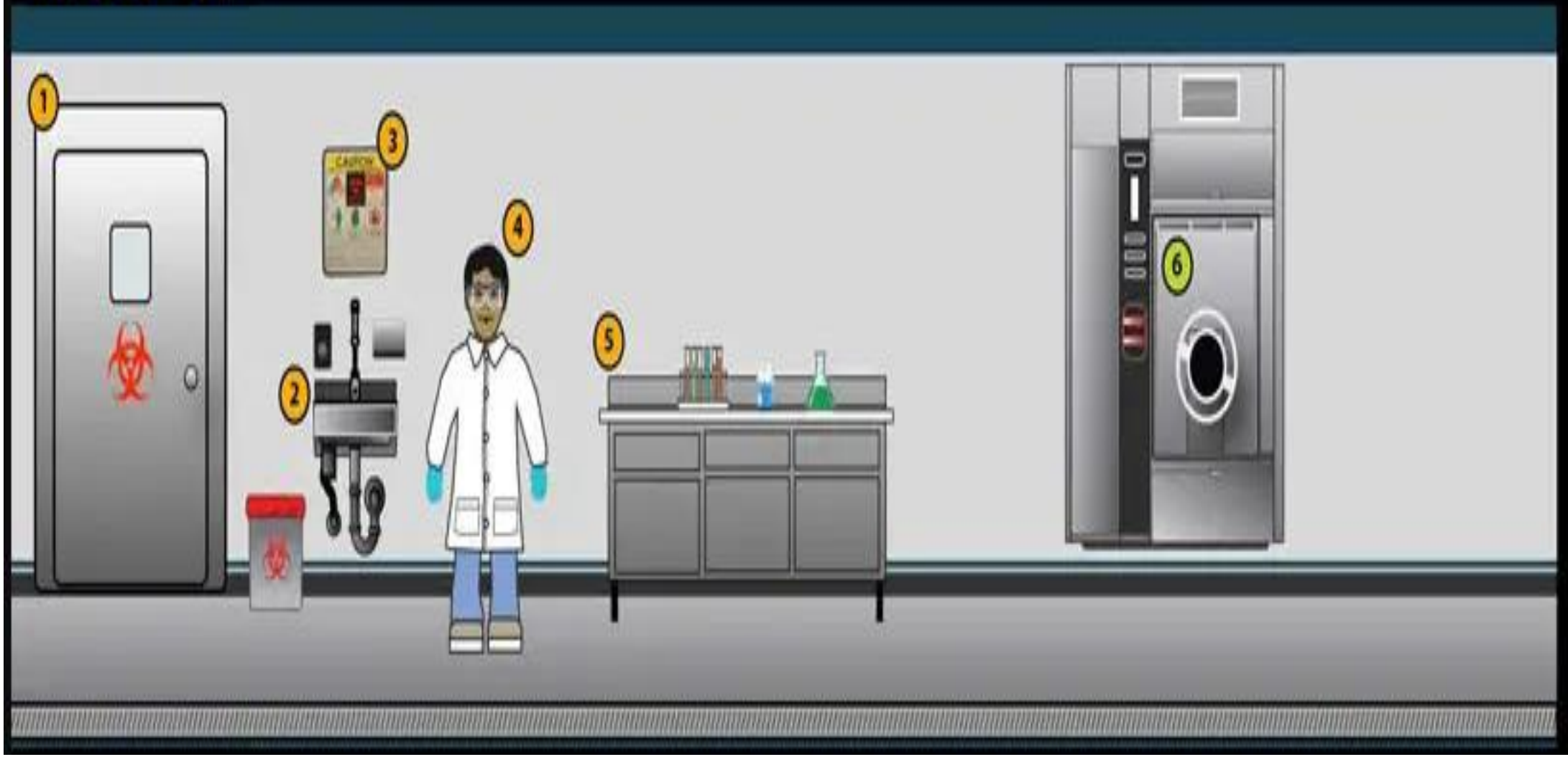
Biosafety Level 1

- The first level of Biosafety includes the least harmful agents. It is the lowest level of all the levels of Biosafety.
- They are so less toxic that they do not even need to be isolated from the building.
- For example, the non-pathogenic strain of *E.coli* is worked at the Biosafety level 1.

The biosafety level 1 practices are as mentioned below:

- Avoiding splashes and aerosols during the experiment
- Washing hands with soap
- Taking care of signs of biohazards
- Safe handling of sharp tools
- Mechanical pipetting
- Strict prohibition on drinking, smoking, and food in the laboratories
- Use of protective equipment such as gloves, goggles, lab coats, gowns while the experiment
- All the infectious experimental material should be decontaminated before being disposed of

BSL1



BSL1

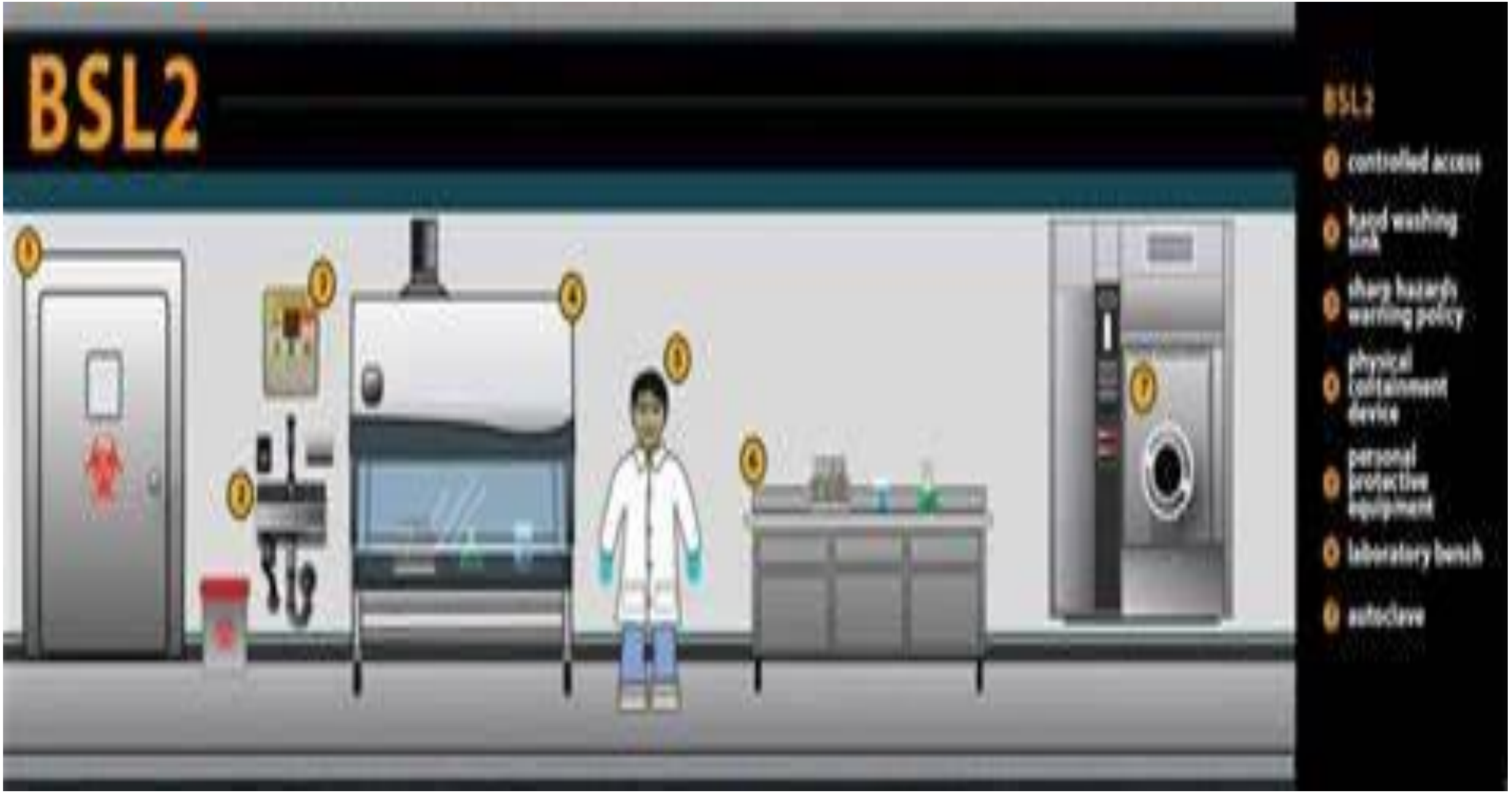
1. controlled access
2. hand washing sink
3. sharp hazards warning policy
4. personal protective equipment
5. laboratory bench
6. autoclave

Biosafety Level 2

- This level deals with the agents that cause human illness.
- For example., HIV, encephalitis virus, Staphylococcus aureus, and many more. Personnel working in these laboratories need greater attention to prevent injuries such as cuts, ingestions, etc.

The practices to be carried out in a Biosafety Level 2 laboratory are as follows:

- It would be best to use protective equipment such as goggles, glasses, face shields, etc.
- The procedures that can cause infections should be carried out in biological safety cabinets.
- The waste material should be decontaminated before disposal.
- An eyewash and a sink should always be available.
- Biohazard signs should be provided.

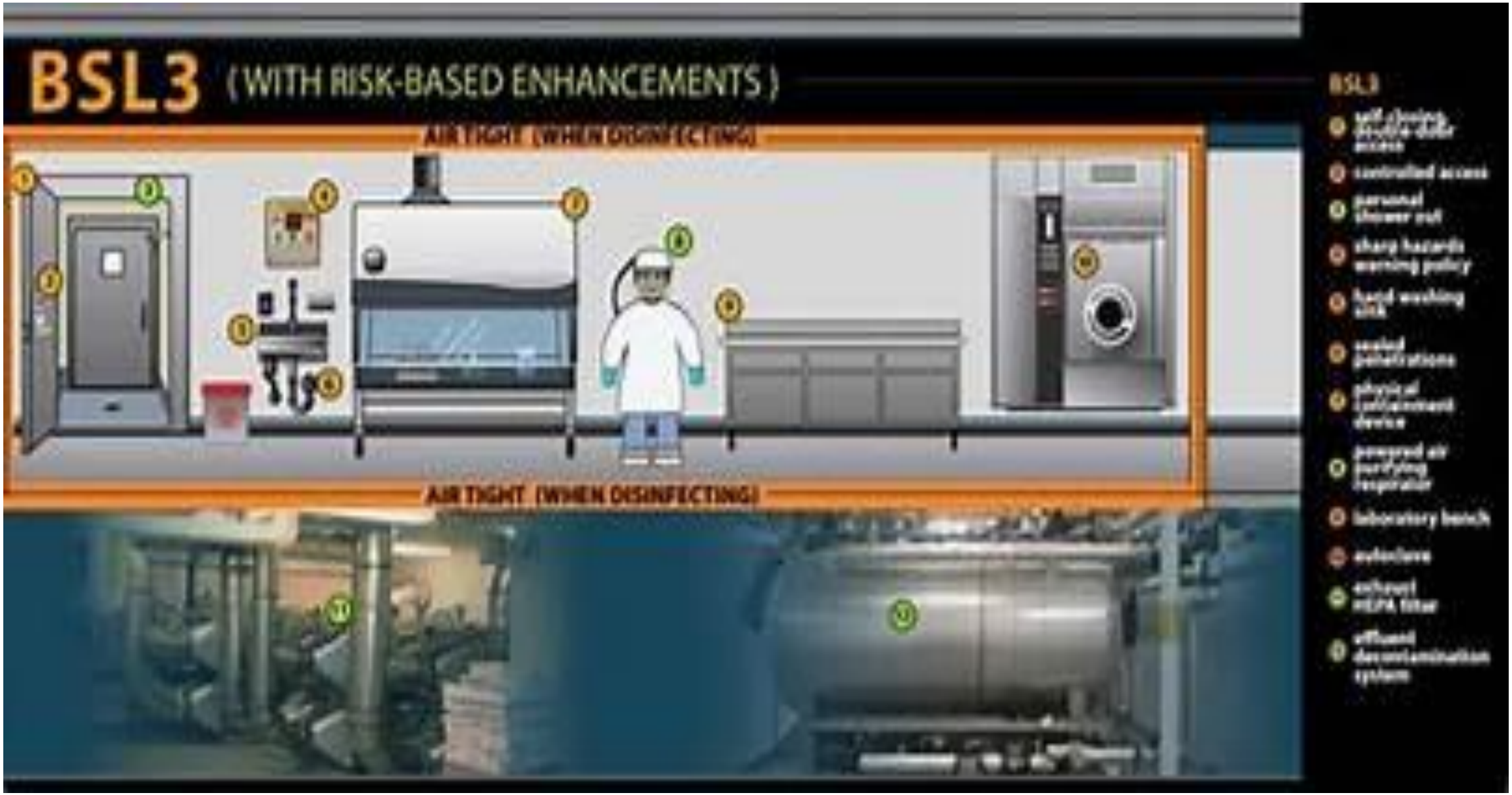

BSL2
BSL2
controlled access
hand washing sink
sharp hazards warning policy
physical containment device
personal protective equipment
laboratory bench
autoclave

Biosafety Level 3

- The Level 3 of Biosafety includes working on pathogenic microbes that inhalation can cause severe disease.
- For example., yellow fever virus, west nile virus, bacteria causing tuberculosis, etc.

The standard requirements in a Biosafety level 3 laboratory are:

- Protective equipment, including respirators, is a must.
- All the experiments should be carried out under proper biosafety cabinets.
- The lab door should have access away from the general building.
- The researchers should be kept under medical surveillance and pre-immunized against certain microbes they perform experiments on.


BSL3 (WITH RISK-BASED ENHANCEMENTS)
AIR TIGHT (WHEN DISINFECTING)
AIR TIGHT (WHEN DISINFECTING)
BSL3
controlled access
personal shower out
laboratory bench
autoclave

Biosafety Level 4

- The fourth level of Biosafety deals with hazardous and exotic microbes. Infections through these microbes cannot be treated or immunized and are usually fatal
- for example, Ebola and Marburg virus.

The standard requirements needed in a biosafety level 4 laboratory:

- The researchers need to change their clothes and shower while leaving.
- All the experiment materials should be carefully decontaminated.
- All the experiments should be carried out under class III safety cabinets.
- The laboratory is isolated from the main building and present in a separate building, and the entry to this zone is highly restricted.

What Viruses Are Considered Biosafety Level 4 (BSL-4)?

biorecovery
BIOHAZARD SPECIALISTS

Advantages of Biosafety :

1. **Protects people** from exposure to harmful biological agents.
2. **Prevents environmental contamination** by containing hazardous materials.
3. **Supports safe research** on dangerous pathogens.
4. **Ensures compliance** with health and safety regulations.
5. **Reduces cross-contamination** in lab experiments.

Disadvantages of Biosafety :

1. **High costs** for equipment, infrastructure, and training.
2. **Slows down research** due to strict safety protocols.
3. **Limited access** to certain pathogens and materials.
4. **Stress for workers** in high-containment labs.
5. **Challenges in waste disposal** of hazardous materials.

ETHICS IN CLONING

Ethical Issues of Human Cloning

History of Cloning:

Robert Briggs and Thomas J. King successfully cloned tadpoles by nuclear transfer.

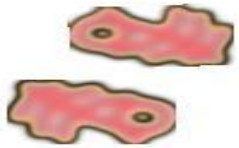
The world's first ever successful animal cloning experiment.

1952

Robert Briggs and Thomas J. King successfully cloned tadpoles by nuclear transfer.

The world's first ever cloned mammal.

1996



South Korean scientists create several cloned human embryos which they only allowed to develop for a short while – just long enough to extract embryonic stem cells which could be used in the treatment of disease. .

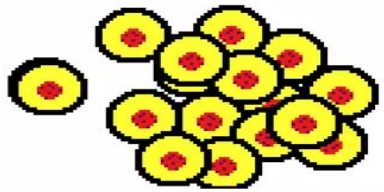
The world's first ever cloned human embryo.

2004

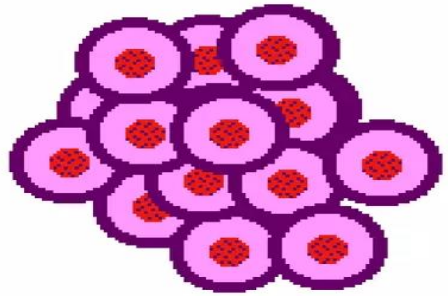
What is Cloning?

- The production of genetically identical organisms via “somatic cell nuclear transfer”
- Somatic cell nuclear transfer refers to the process of removing the nucleus of a somatic cell of an organism and transferring it into an oocyte from which the nucleus has been removed.

Organism to be cloned



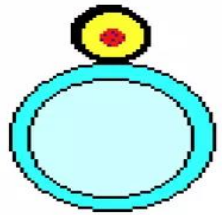
Developed differentiated cells taken from the organism. They have been starved of nutrients so that they don't begin to copy their chromosomes. The copy their chromosomes right before the cells reproduce themselves. Two copies of chromosomes can cause defects in the organism.



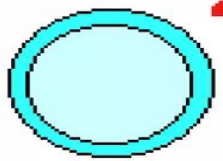
Begins to develop as an embryo

Implanted into a ewe

Clone is born

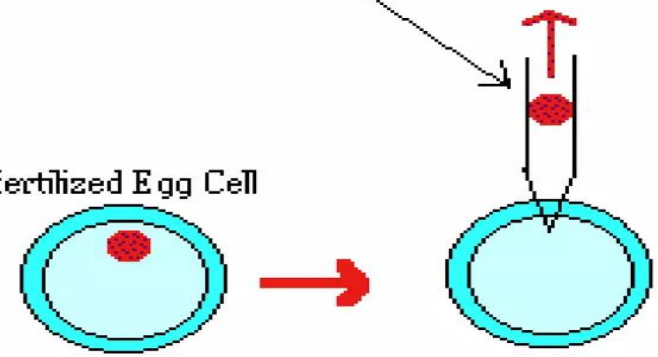


Egg cell and cell to be cloned, are fused together



Egg Cell with no Nucleus

A glass pipette smaller in diameter than hair



Untertilized Egg Cell

Nucleus removed from egg cell

Ethics in Cloning

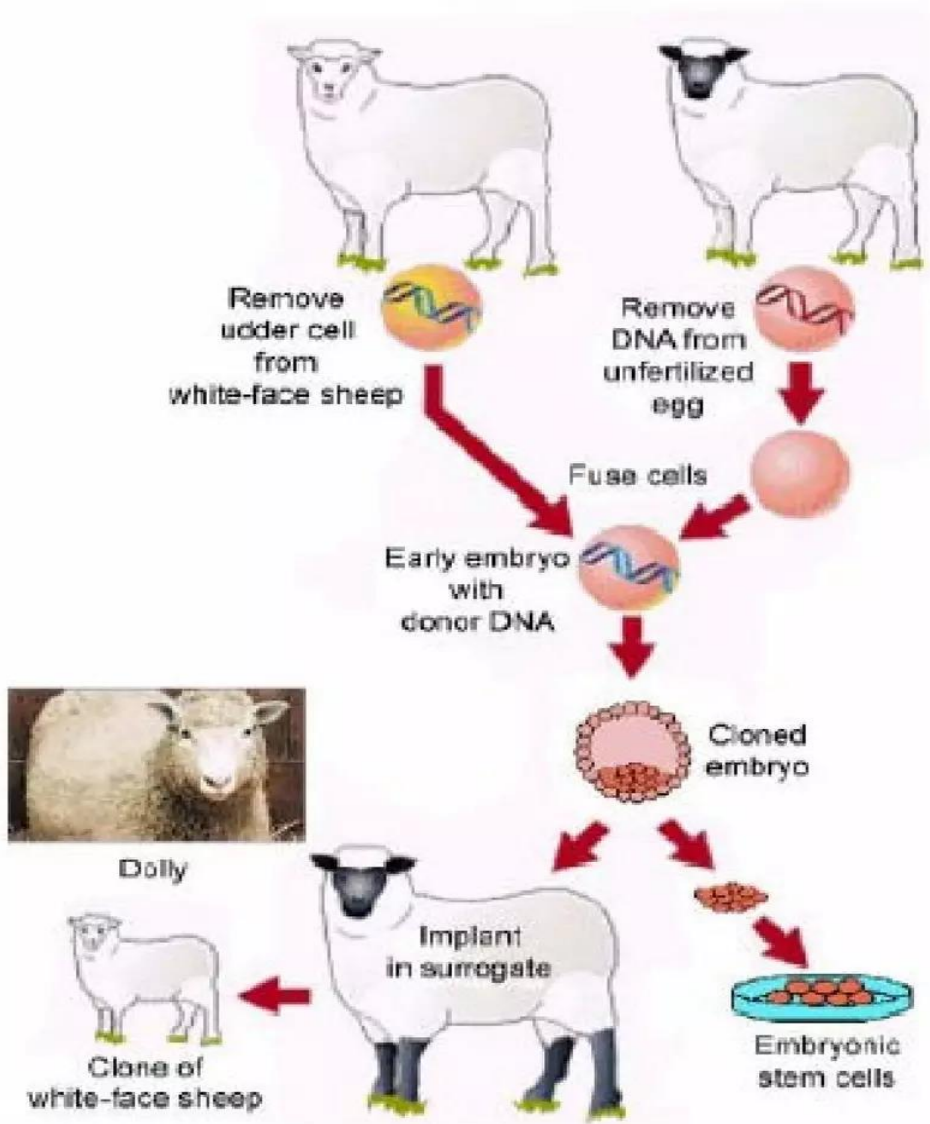
- Cloning, particularly human cloning, raises numerous ethical concerns that revolve around the potential consequences, risks, and moral values associated with creating genetically identical organisms.
- Cloning can be broadly divided into **reproductive cloning** (producing a living organism) and **therapeutic cloning** (creating embryos for medical research).

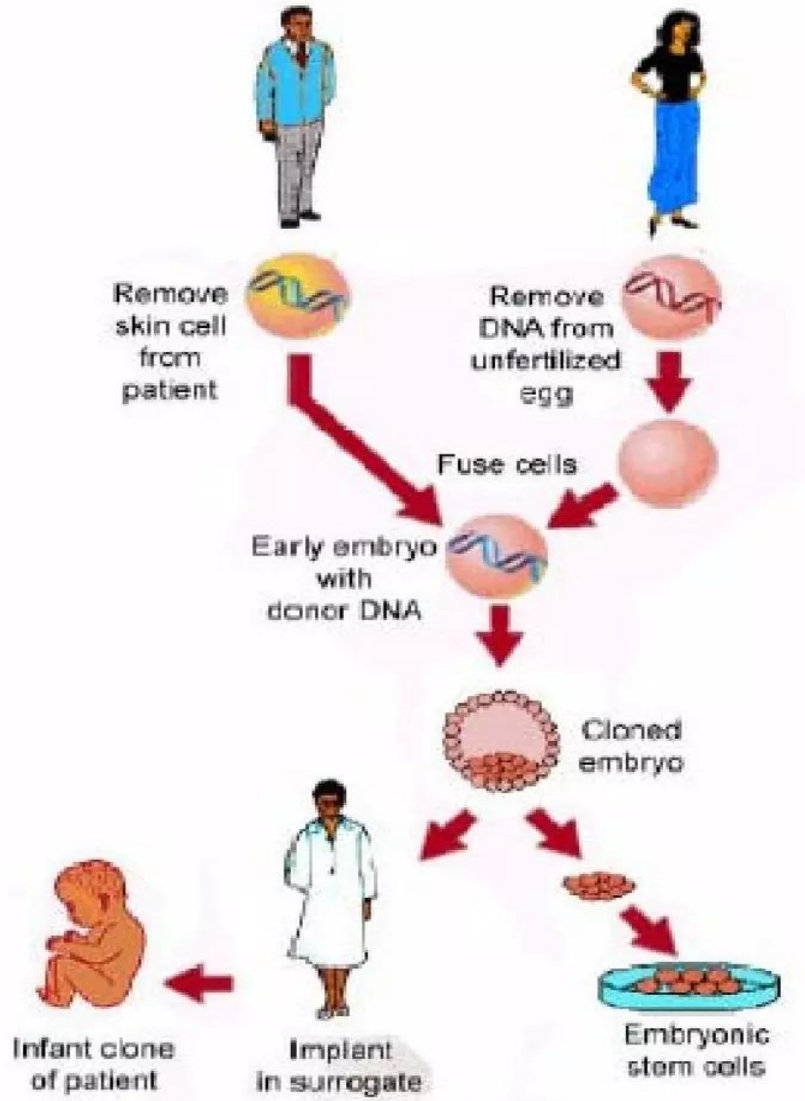
Reproductive cloning

- It could undermine human dignity by treating individuals as products designed for specific purposes.
- There are concerns that clones may be viewed as mere copies rather than unique individuals with their own identity and rights.
- For eg: cloned pigs, cats, dogs, mules.

Therapeutic cloning

- creating embryos for stem cell research
- It might lead to ethical issues regarding the destruction of embryos, as some consider it morally equivalent to ending a human life.
- For eg: human cloning


Remove udder cell from white-face sheep
Remove DNA from unfertilized egg
Fuse cells
Early embryo with donor DNA
Cloned embryo
Dolly
Implant in surrogate
Clone of white-face sheep
Embryonic stem cells


Remove skin cell from patient
Remove DNA from unfertilized egg
Fuse cells
Early embryo with donor DNA
Cloned embryo
Infant clone of patient
Implant in surrogate
Embryonic stem cells

Risks and Safety:

- Cloning technology is still imperfect and comes with high risks of malformations, premature aging, and health issues.
- In animal cloning, there have been high failure rates and significant suffering due to complications, raising concerns about whether such risks are ethical to impose on potential human clones.

Advantages of Ethical Cloning :

1. Medical advancements through stem cell therapy.
2. Infertility solutions for couples.
3. Organ and tissue regeneration with reduced rejection.
4. Conservation of endangered species.
5. Scientific research benefits for genetic and disease understanding.

Disadvantages of Ethical Cloning :

1. Embryo destruction in therapeutic cloning.
2. Reduced genetic diversity.
3. Identity and individuality issues for clones.
4. Risk of exploitation and commodification of life.
5. High failure rates and health risks in clones.
6. Potential for misuse in creating "designer babies

STEM CELL RESEARCH

- Stem cell research is a scientific field focused on studying stem cells, their potential uses, and their ability to differentiate into various types of cells.
- Stem cells are unique because they have the ability to develop into many different types of cells in the body, offering immense potential for understanding and treating various medical conditions.

Stem Cell Characteristics

- Blank cells' (unspecialized)
- Capable of dividing and renewing themselves for long periods of time (proliferation and renewal)
- Have the potential to give rise to specialized cell types (differentiation)

Types of Stem Cells:

1. **Embryonic Stem Cells (ESCs):**

   Found in early embryos and can become any type of cell in the body.

   They are very versatile but their use raises ethical concerns since they involve destroying embryos.

2. **Adult Stem Cells (ASCs):**

   Found in adult tissues (like bone marrow or skin).

   They can only develop into a limited range of cells.

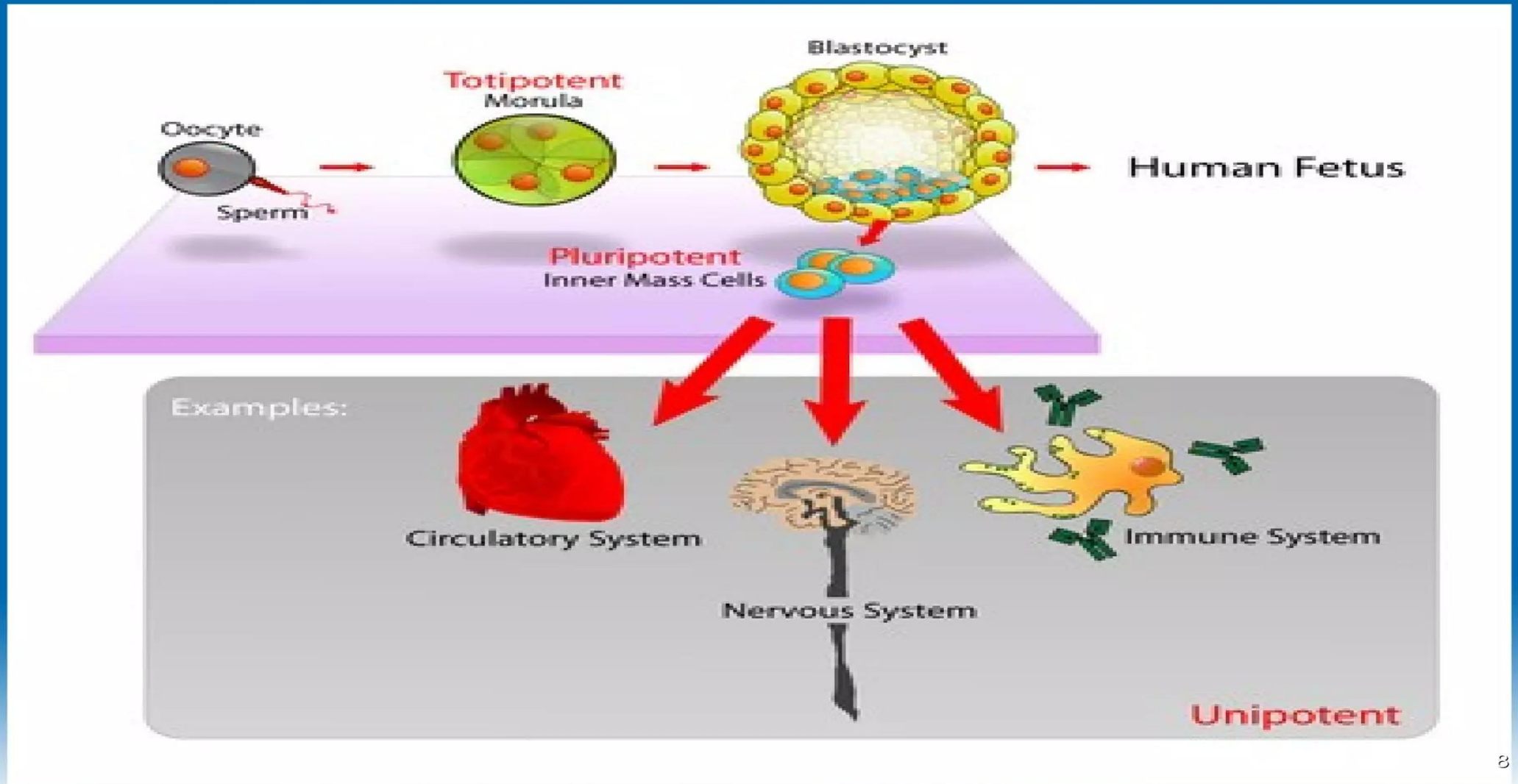
   They are less controversial because they don’t involve embryos.

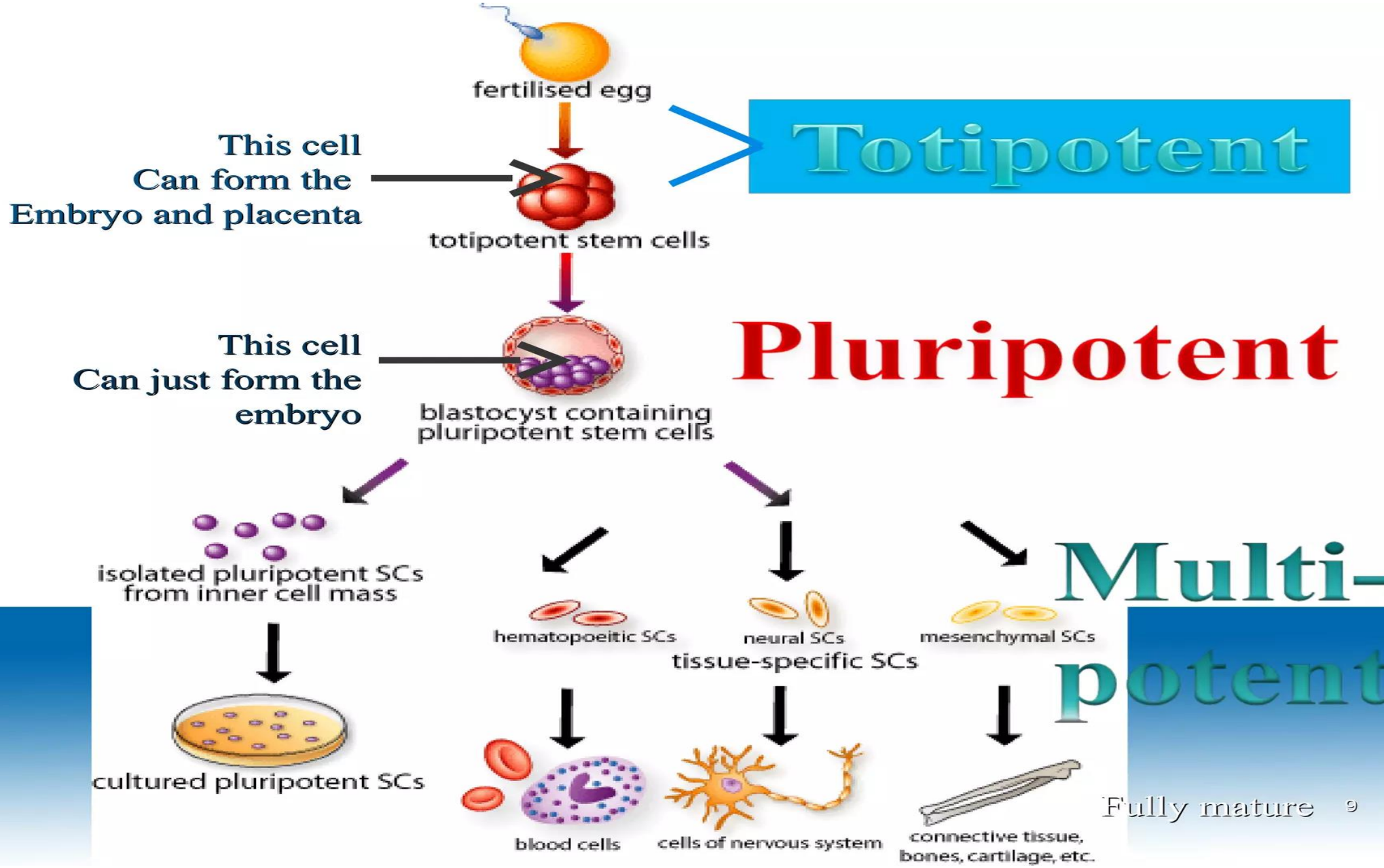
3. **Induced Pluripotent Stem Cells (iPSCs):**

   Created by reprogramming adult cells (like skin cells) to behave like embryonic stem cells.

   They can become any type of cell and do not involve embryos, making them a more ethical option.

Stem Cell Differentiation



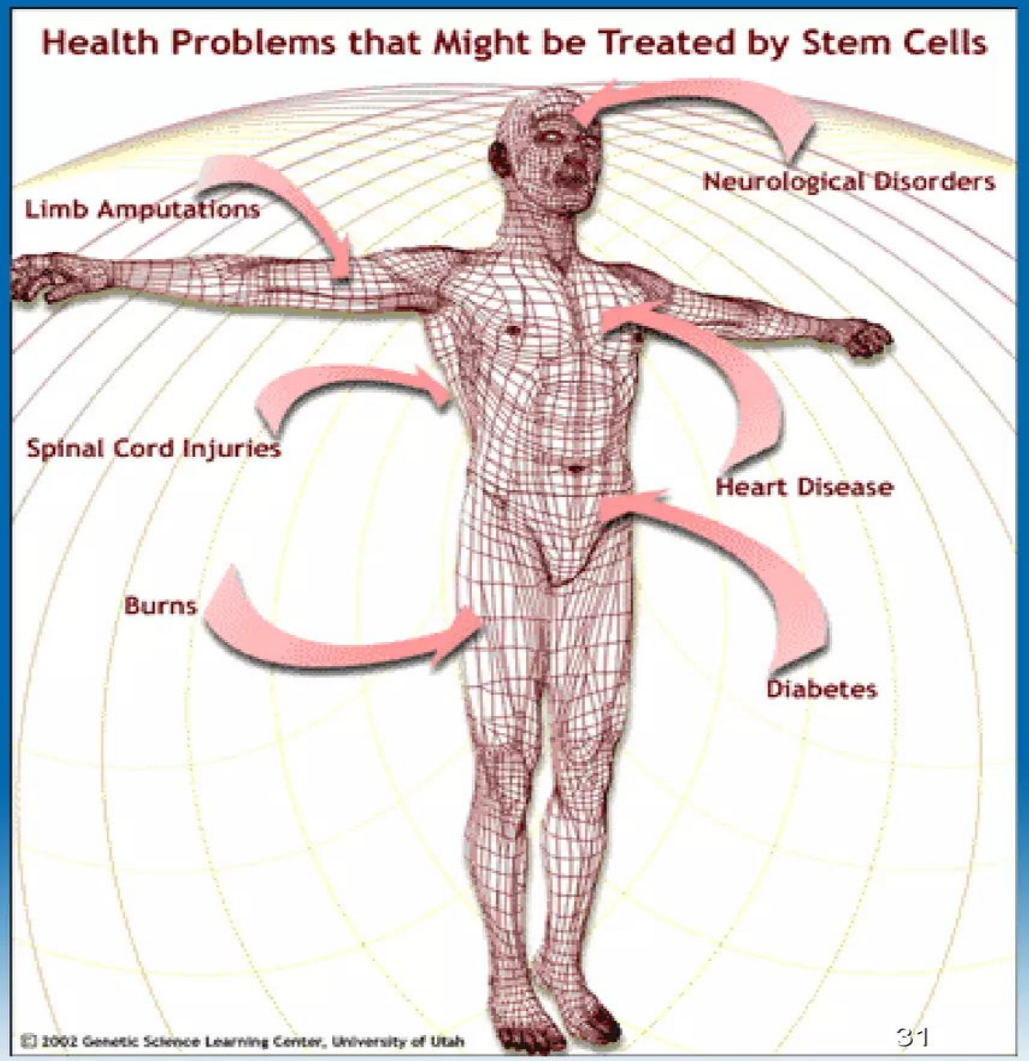

fertilised egg
This cell
Can form the
Embryo and placenta
totipotent stem cells
Totipotent
This cell
Can just form the
embryo
blastocyst containing
pluripotent stem cells
Pluripotent
isolated pluripotent SCs
from inner cell mass
cultured pluripotent SCs
hematopoeitic SCs
neural SCs
mesenchymal SCs
tissue-specific SCs
Multi-
potent
blood cells
cells of nervous system
connective tissue,
bones, cartilage, etc.
Fully mature

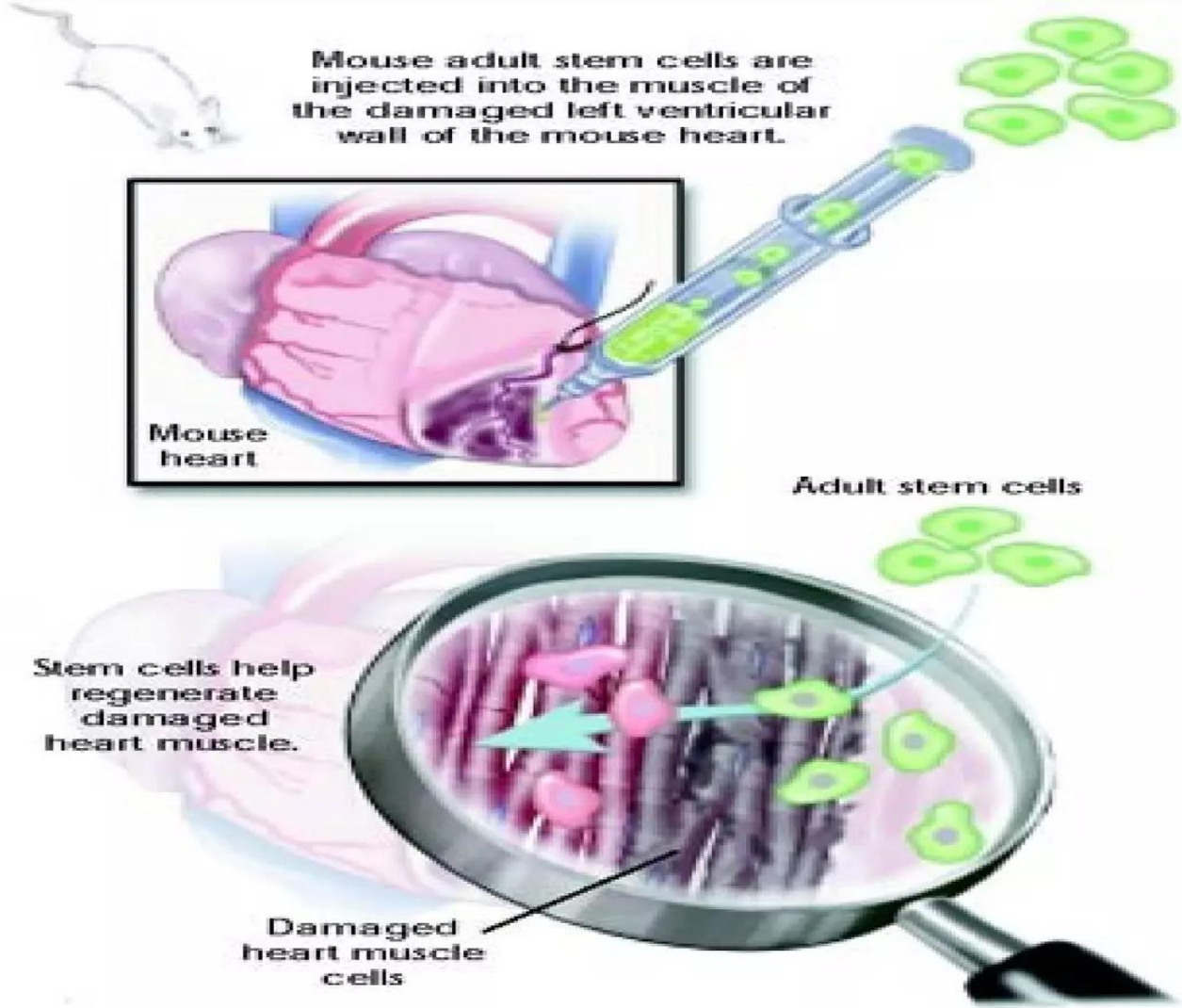
POTENTIAL APPLICATIONS OF STEM CELL RESEARCH:

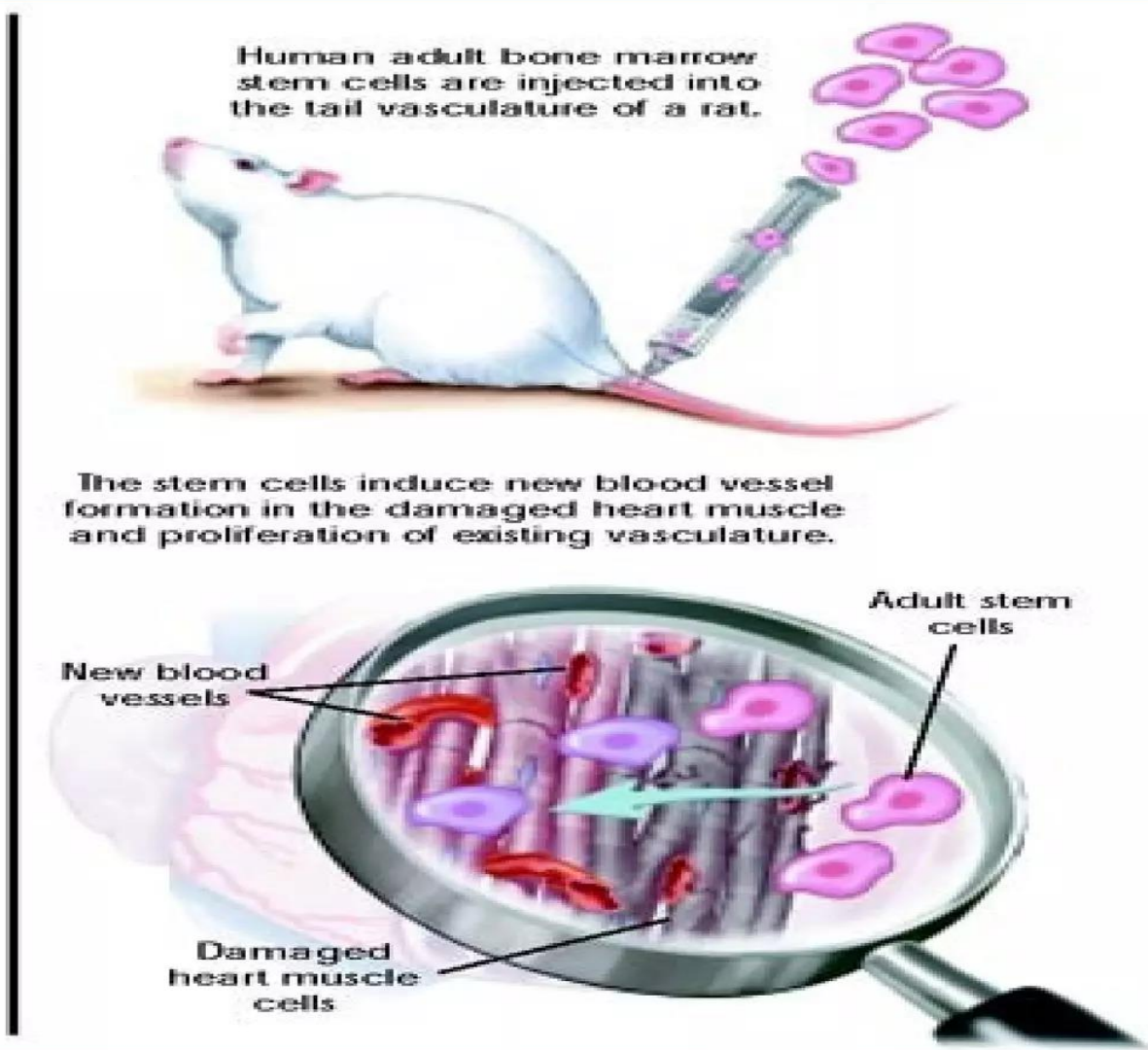
1. **Regenerative Medicine:**
    1. Stem cells can potentially regenerate damaged tissues or organs, offering treatments for conditions like spinal cord injuries, heart disease, diabetes, and neurodegenerative diseases (e.g., Parkinson's, Alzheimer's).
    2. For example, stem cells could be used to replace damaged neurons in Parkinson's patients or produce new heart muscle tissue after a heart attack.
2. **Drug Testing and Development:**
    1. Stem cells can be used to create specific types of human cells for drug testing, allowing scientists to study how new drugs interact with human tissue without testing on animals or humans first.
    2. This helps in developing safer, more effective treatments and understanding drug toxicity.
3. **Study of Disease Mechanisms:**
    1. Stem cells can be used to model diseases in the lab, allowing researchers to study how diseases like cancer, genetic disorders, or neurodegenerative diseases develop and progress.
    2. This helps in identifying potential therapeutic targets and understanding the underlying biology of diseases.
4. **Tissue and Organ Transplantation:**
    1. Stem cell research could eventually lead to the ability to grow organs in the lab for transplantation, eliminating the need for donor organs and reducing the risk of rejection, as the cells would be genetically identical to the patient's.
5. **Treatment of Blood Disorders:**
    1. Bone marrow transplants are a form of adult stem cell therapy used to treat blood disorders such as

Applications

- Disease
  - Diabetes, Spinal cord injury, Parkinson's disease, heart disease
- Genetic based Disease
  - Cystic fibrosis, Huntington's




Mouse adult stem cells are injected into the muscle of the damaged left ventricular wall of the mouse heart.
Mouse heart
Adult stem cells
Stem cells help regenerate damaged heart muscle.
Damaged heart muscle cells


Human adult bone marrow stem cells are injected into the tail vasculature of a rat.
The stem cells induce new blood vessel formation in the damaged heart muscle and proliferation of existing vasculature.
Adult stem cells
New blood vessels
Damaged heart muscle cells

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THANK YOU