College of Pharmacy
Fifth Stage

Pharmaceutical Biotechnology

Dr. Maytham Ahmed

Lectutre 1
Introduction to Pharmaceutical Biotechnology

Introduction to Pharmaceutical Biotechnology

Pharmaceutical Biotechnology

- **Pharmaceutical biotechnology** consist of the combination of two branches which are “pharmaceutical science” and “biotechnology”.
- **Pharmaceutical science:** can simply be define as the branch of science that deals with the formulation and dispensing of drugs.
- **Biotechnology:** can simply be define as the application of biological system, living organisms, or their derivatives in making or modifying products or processes for specific use. Thus biotechnology is the technology based on biology.

- **Pharmaceutical Biotechnology:** can simply be defined as the science that covers all technologies required for the production, manufacturing and registration of biological drugs.
- **Biological drugs** (also known as biotherapeutics or biopharmaceuticals) are made from proteins and other substances which occur in nature. They are produced by a biological rather than chemical process – for example they can be created inside living cells.

- Biopharmaceuticals are **primarily proteins**, but therapeutic **DNA** or **RNA based molecules** (think about gene therapy products, DNA vaccines, and RNA interference-based products) may soon become part of our therapeutic arsenal.

- One example is **mRNA vaccine** used against covid-19. This vaccine uses mRNA that directs cells to produce virus protein which will activate the human immune system to produce antibody against that virus.

Development of Biotechnology

- **It started in the early 1890 with “serum therapy” for the treatment of diphtheria and tetanus.**
- **1953: Discovering the double helical structure of DNA.**
- **1971: Restriction enzymes discovered.**
- **1975: Production of monoclonal antibodies by hybridoma technology**
- **1982: Recombinant human insulin approved by the FDA.**

Gene Expression

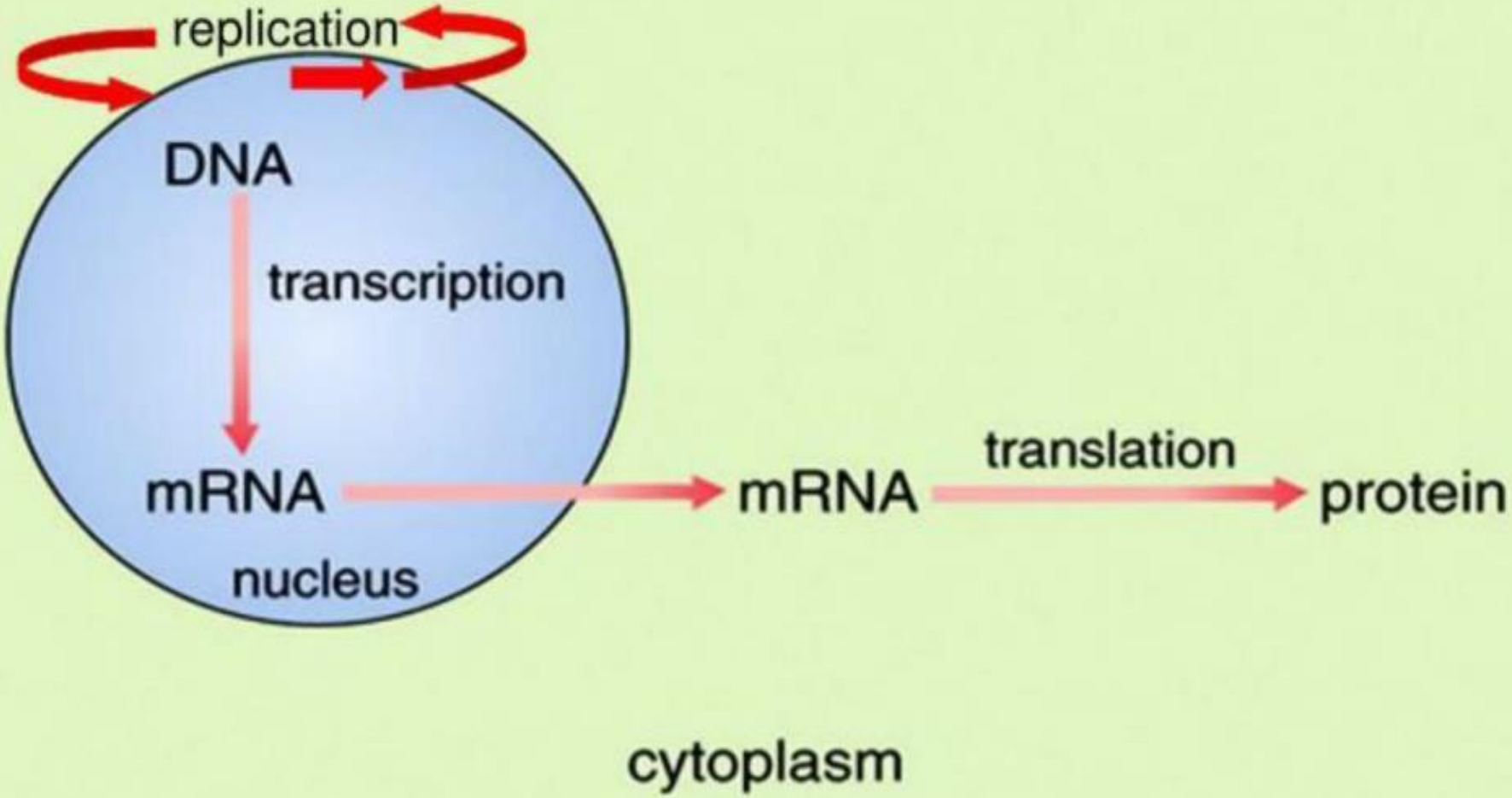
Genetic information, chemically determined by DNA structure, that is transferred during cell division to daughter cells by (DNA replication)

expressed by transcription (conversion of DNA into RNA)

followed by translation (conversion of RNA into protein)

Series of events DNA ⟶ RNA ⟶ Protein

The Central Dogma of Life.



Chromosomes

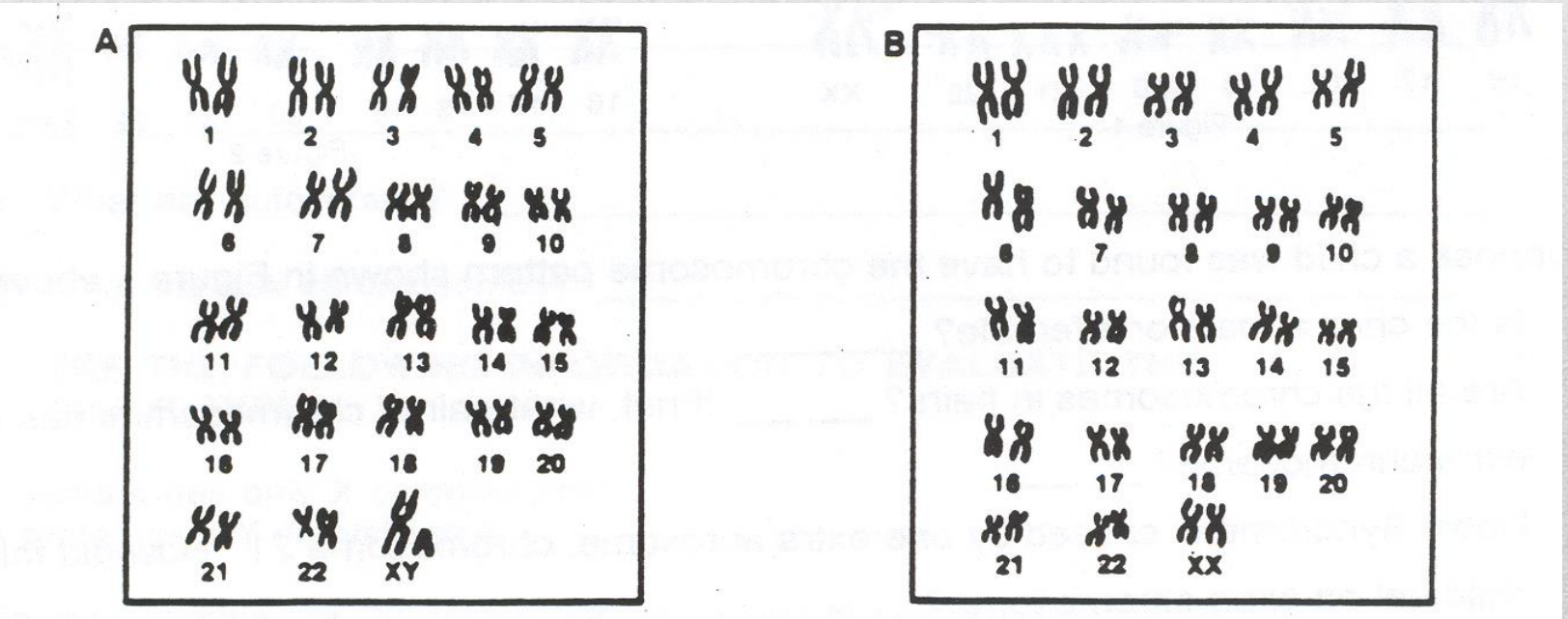
- Chromosomes are the form DNA.
- Humans have 46 chromosomes.
- One set of 23 chromosomes from mom.
- One set of 23 chromosomes from dad.

Types of Chromosomes:

1. Autosomes: Body chromosomes or non sex chromosomes (humans have 44 or 22 pairs)

2. Sex Chromosomes: 23rd pair for humans

The sex chromosomes of a male are **XY**.
The sex chromosomes of a female are **XX**.



Gene

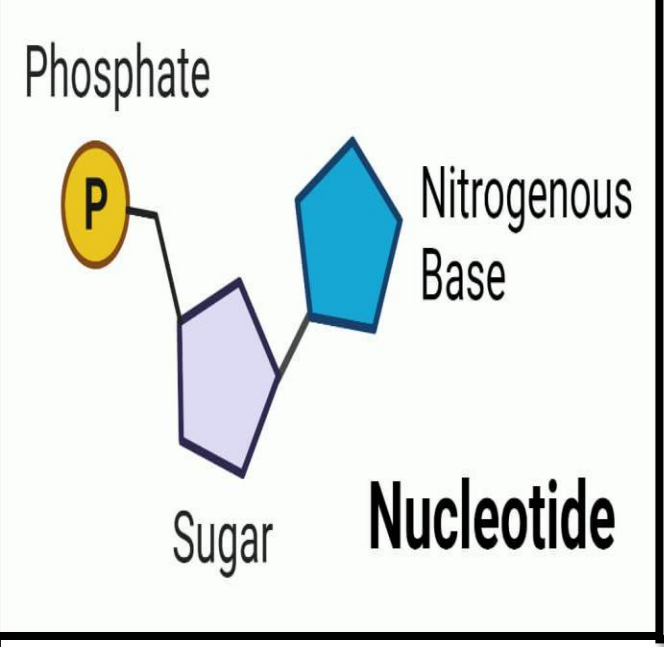
- Genes are pieces of DNA, and most genes contain the information for making a specific protein.
- A single molecule of DNA has thousands of genes.

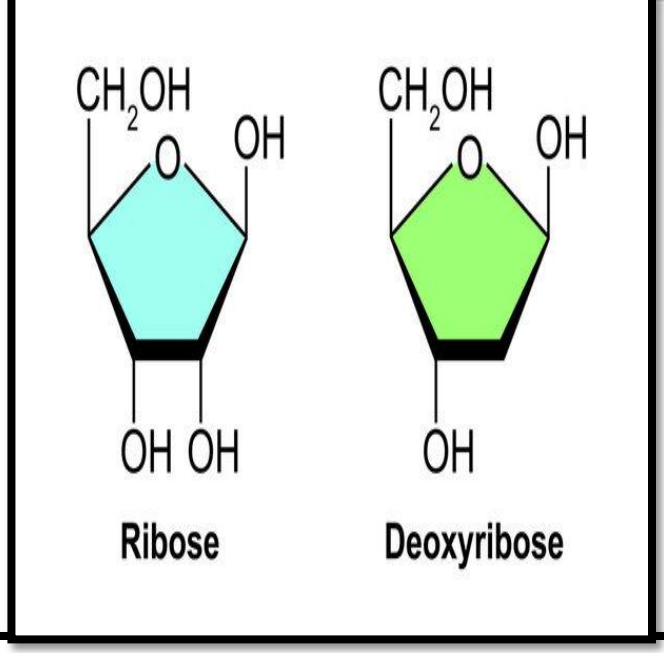
DNA (Deoxyribonucleic acid)

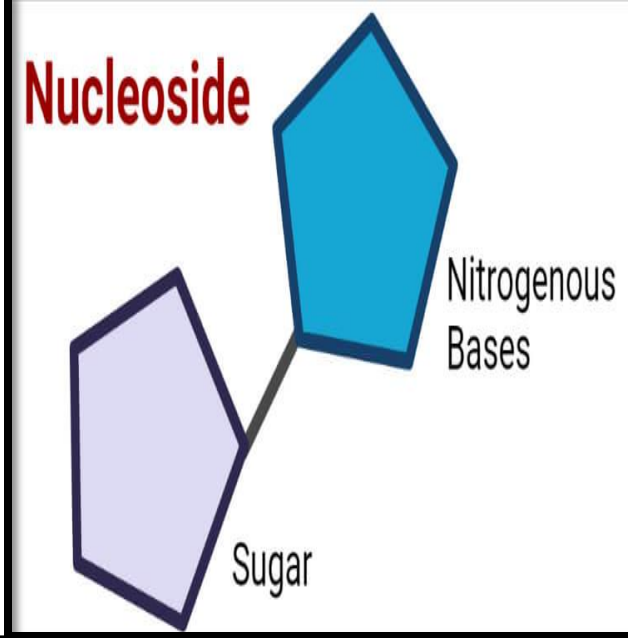
DNA is a double stranded structure takes the shape of a **double helix** (like a ladder that has been twisted).

It consists of a **deoxy ribose** sugar that attached to a **phosphate** backbone and a pairs of nitrogen bases of (Thymine and Adenine and (Guanin and Cytosine).

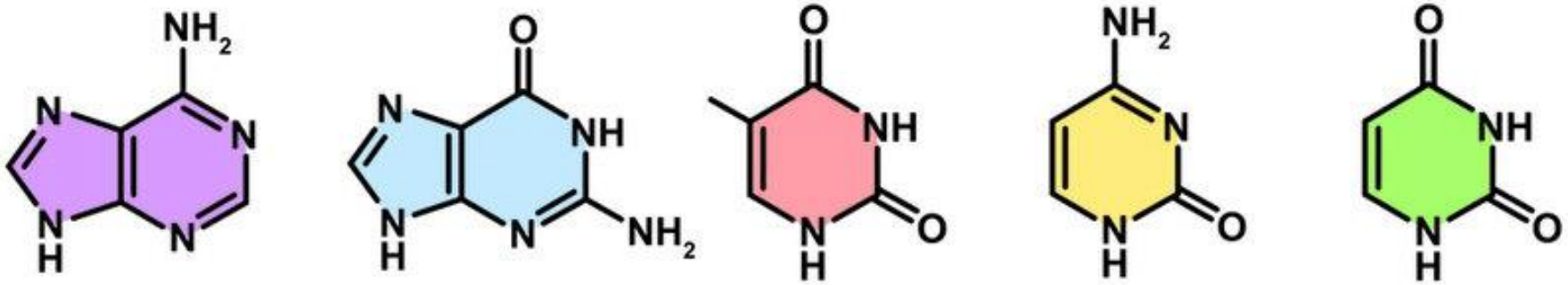
- The structure of the DNA is **antiparallel** in which the second strands is parallel to the first one but are **oriented is opposite directions**.
- Each strand of DNA is read in a specific **direction** from its **5′** (five prime) end to its 3′ (three prime) end.
- The 5' and 3' designations refer to the number of carbon atom in a deoxyribose sugar molecule to which a phosphate group bonds.
- **DNA sequences** in these databases are always given from the **5′ end to the 3′** end.
- Protein sequences is given from the **amino- to the carboxy**-terminal end.



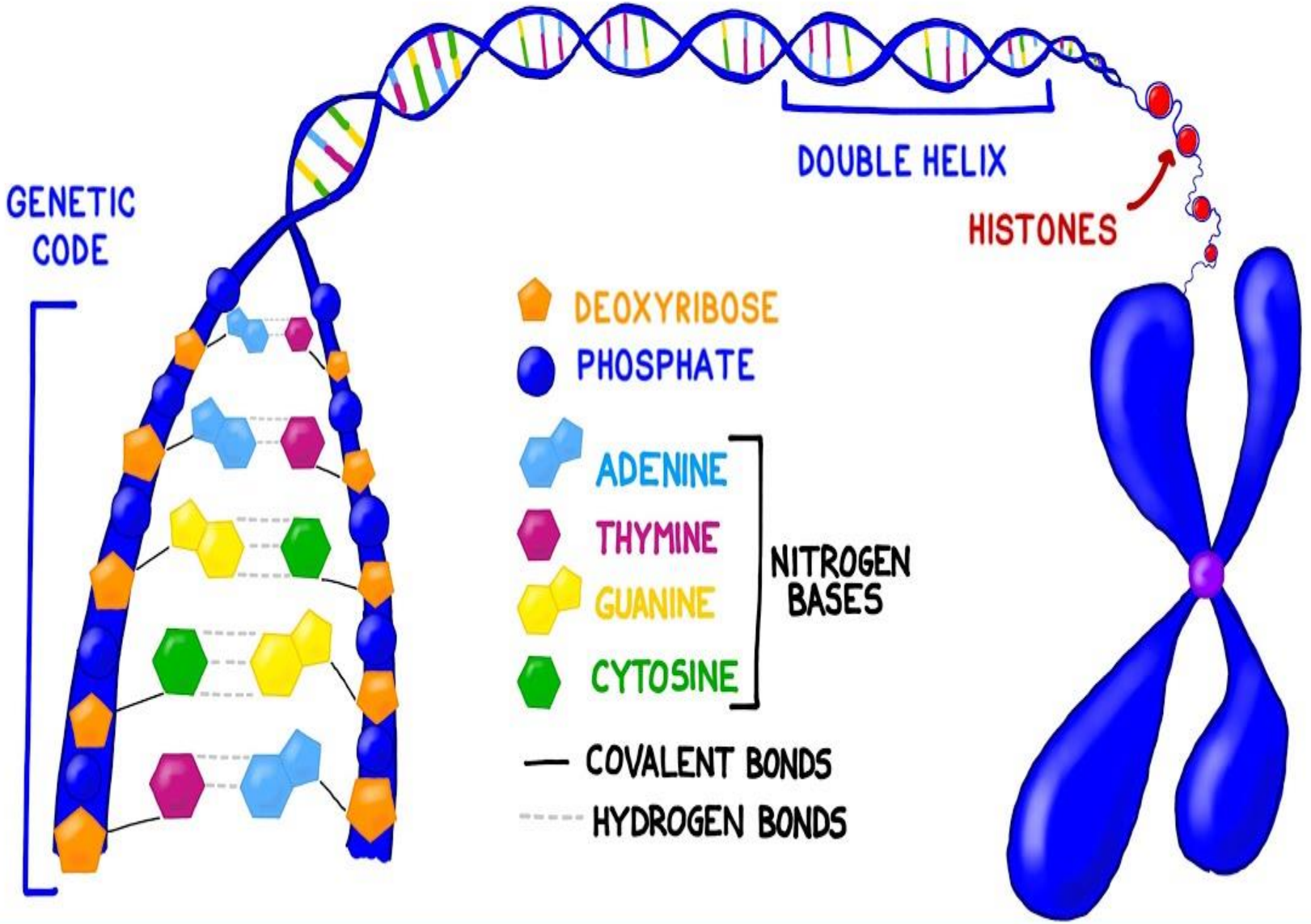




Nitrogenous Base



WHAT IS DNA?

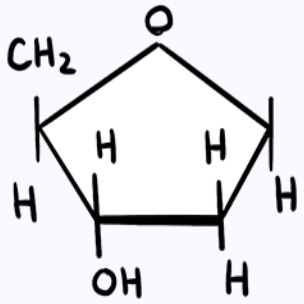

DOUBLE HELIX
HISTONES
GENETIC CODE
DEOXYRIBOSE
PHOSPHATE
ADENINE
THYMINE
GUANINE
CYTOSINE
NITROGEN BASES
COVALENT BONDS
HYDROGEN BONDS

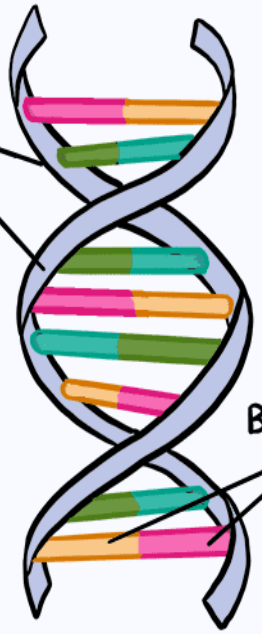
DNA vs. RNA

DEOXYRIBONUCLEIC ACID

DOUBLE-STRANDED
SUGAR* PHOSPHATE

* DEOXYRIBOSE



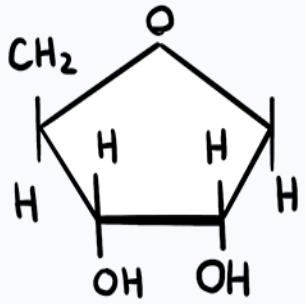


BASE PAIR

RIBONUCLEIC ACID

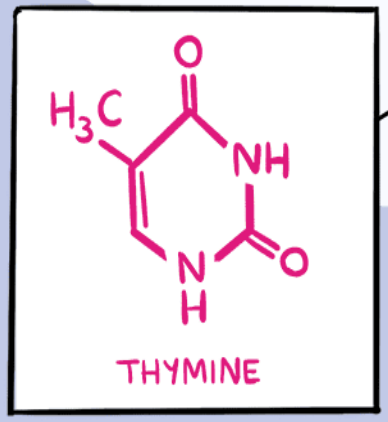
USUALLY SINGLE-STRANDED
SUGAR* PHOSPHATE

* RIBOSE

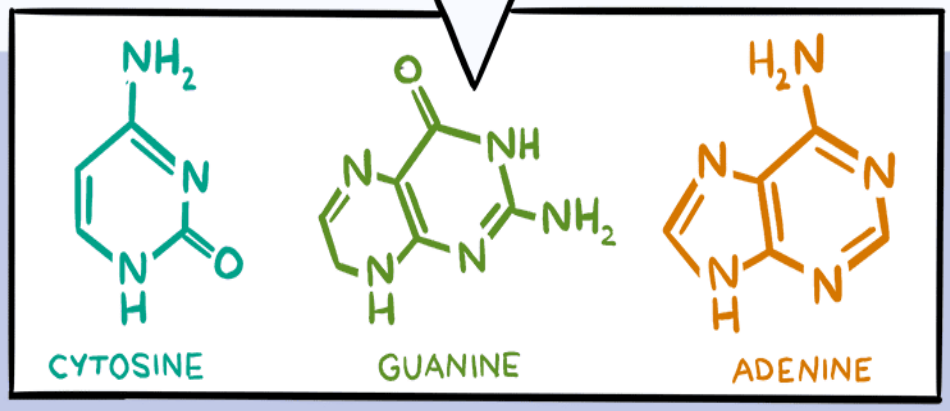


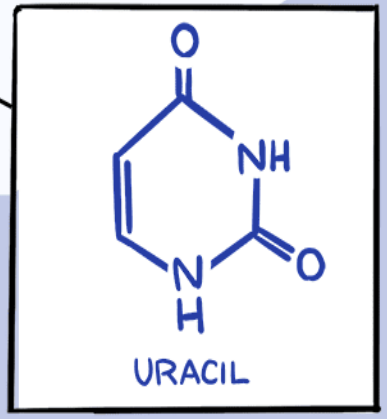
SINGLE
NUCLEOBASE

NUCLEOBASES



THYMINE

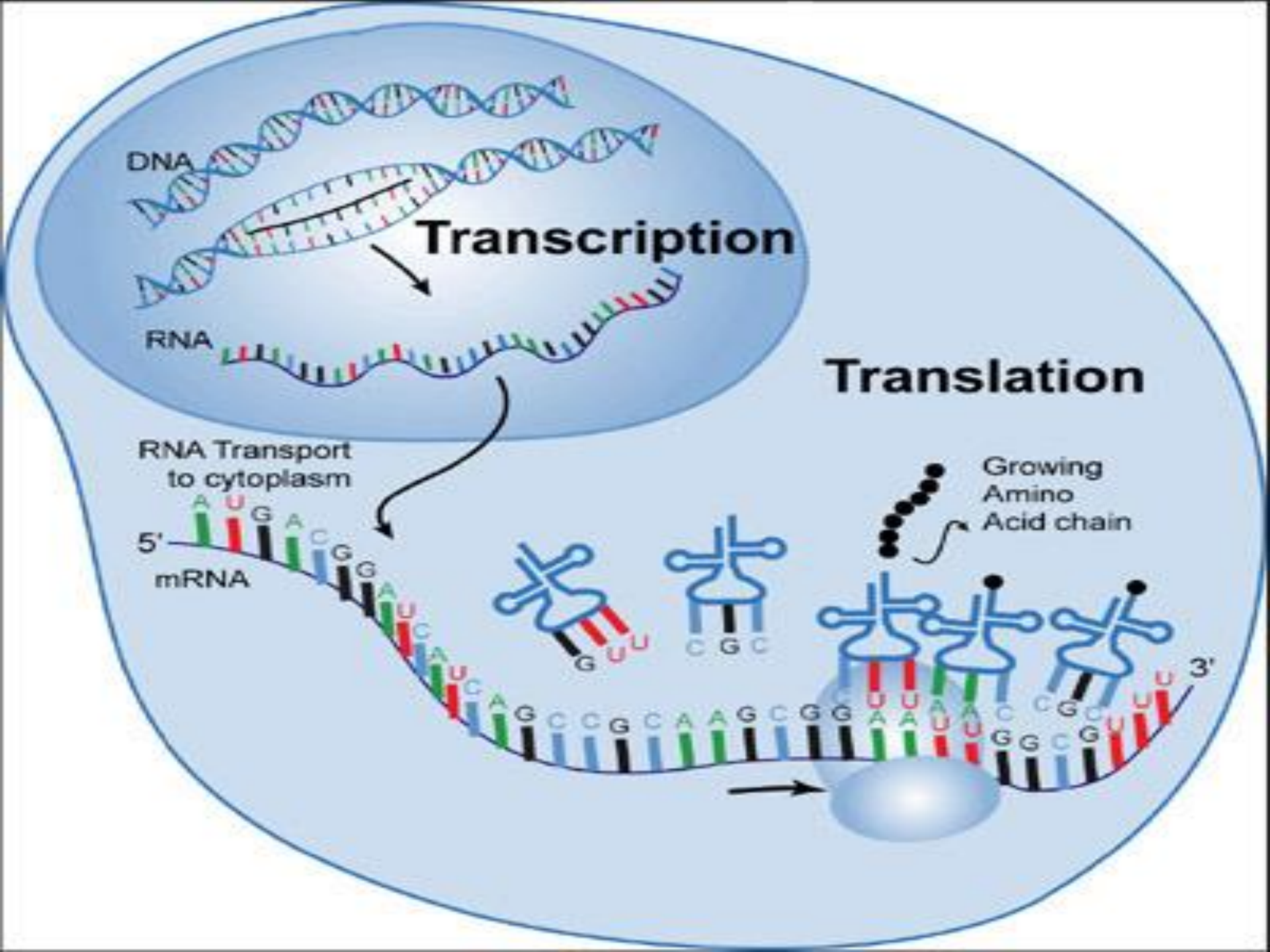




ThoughtCo.

Transcription and Translation

- DNA in nucleus control protein synthesis by process of transcription and translation.
- DNA double helix unwind and allow encoding of messenger RNA (mRNA) which transfer the information to ribosome in the cytoplasm (**transcription**).
- The ribosomal RNA (rRNA) in the ribosome translates (read) the codes in mRNA and transfer RNA (tRNA) help in transferring amino acids corresponding the code and amino acid chain starts growing which will them form a protein (**translation**).


DNA
Transcription
RNA
Translation
RNA Transport
to cytoplasm
5'
mRNA
Growing
Amino
Acid chain
3'

How Are Biotechnology Medicines Made?

- The manufacturing process consists of the following four main steps:

1. Producing the **master cell** line containing the **gene that makes** the desired protein.
2. **Growing** large numbers of cells that produce the protein.
3. **Isolating** and purifying the protein.
4. **Preparing** the biologic for use by patients.

- Some biologics can be made using common **bacteria**, such as E coli.
- Others require **cell lines** taken from mammals, such as **hamsters**. This is **because** many proteins have structural features that only mammalian cells can create.

Genetic Engineering

Genetic Engineering is the production of new genes and alteration of genomes by substituting or adding new genetic material. It is based on scientific **tools**, developed in recent decades, that enable researchers to:

1. **Identify** the gene that produces the protein of interest.
2. **Cut the DNA** sequence that contains the gene from a sample of DNA.
3. Place the gene **into a vector**, such as a **plasmid** or bacteriophage.
4. Use the vector to **carry the gene** into the DNA of the host cells, such as Escherichia coli (E coli) or mammalian cells grown in culture.
5. **Induce** the cells to activate the gene and produce the desired protein.
6. **Extract** and purify the protein for therapeutic use.

When segments of DNA are cut and pasted together to form new sequences, the result is known as **recombinant DNA**.

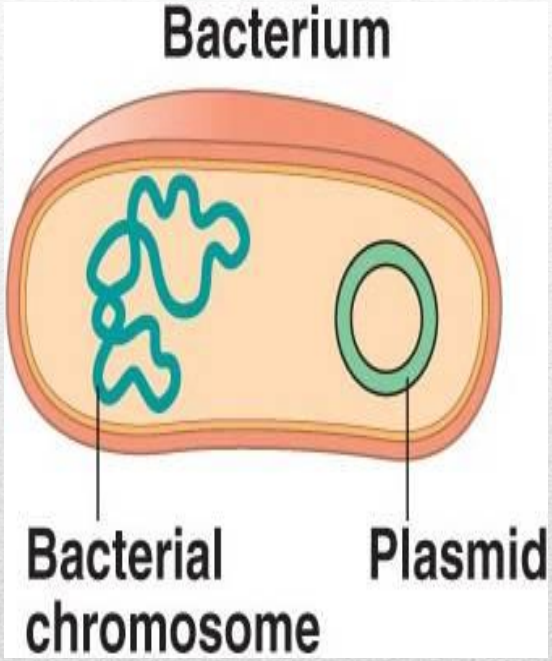
When recombinant DNA is inserted into cells, the **cells use** this modified blueprint and **their own** cellular machinery to make the **protein encoded** by the recombinant DNA.

This has resulted in important new types of therapies, such as therapeutic proteins.

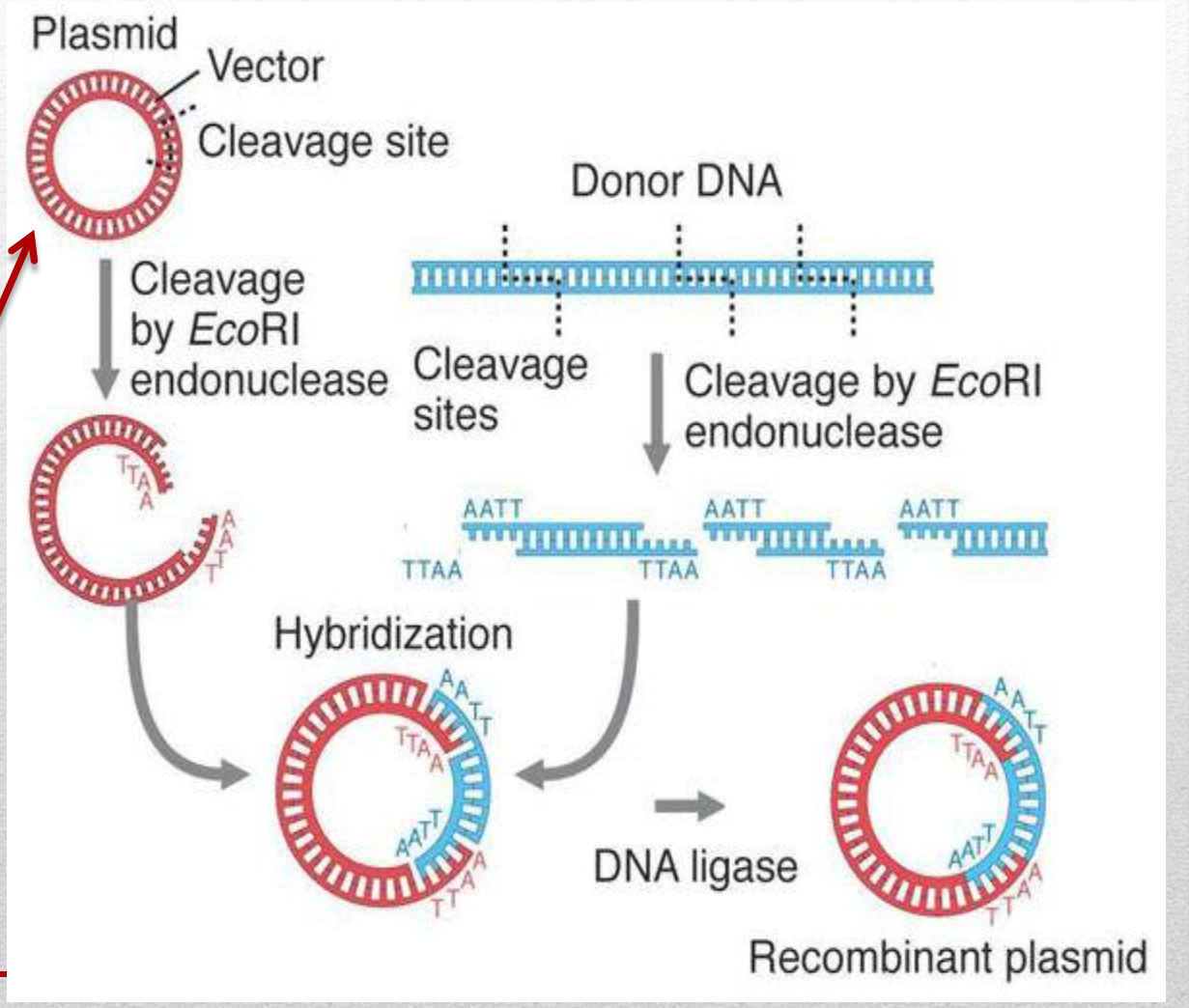
Therapeutic proteins are used to replace or augment a patient's naturally occurring proteins, especially when levels of the natural protein are low or absent due to disease.

Cells that have recombinant DNA are known as genetically modified or transgenic cells.

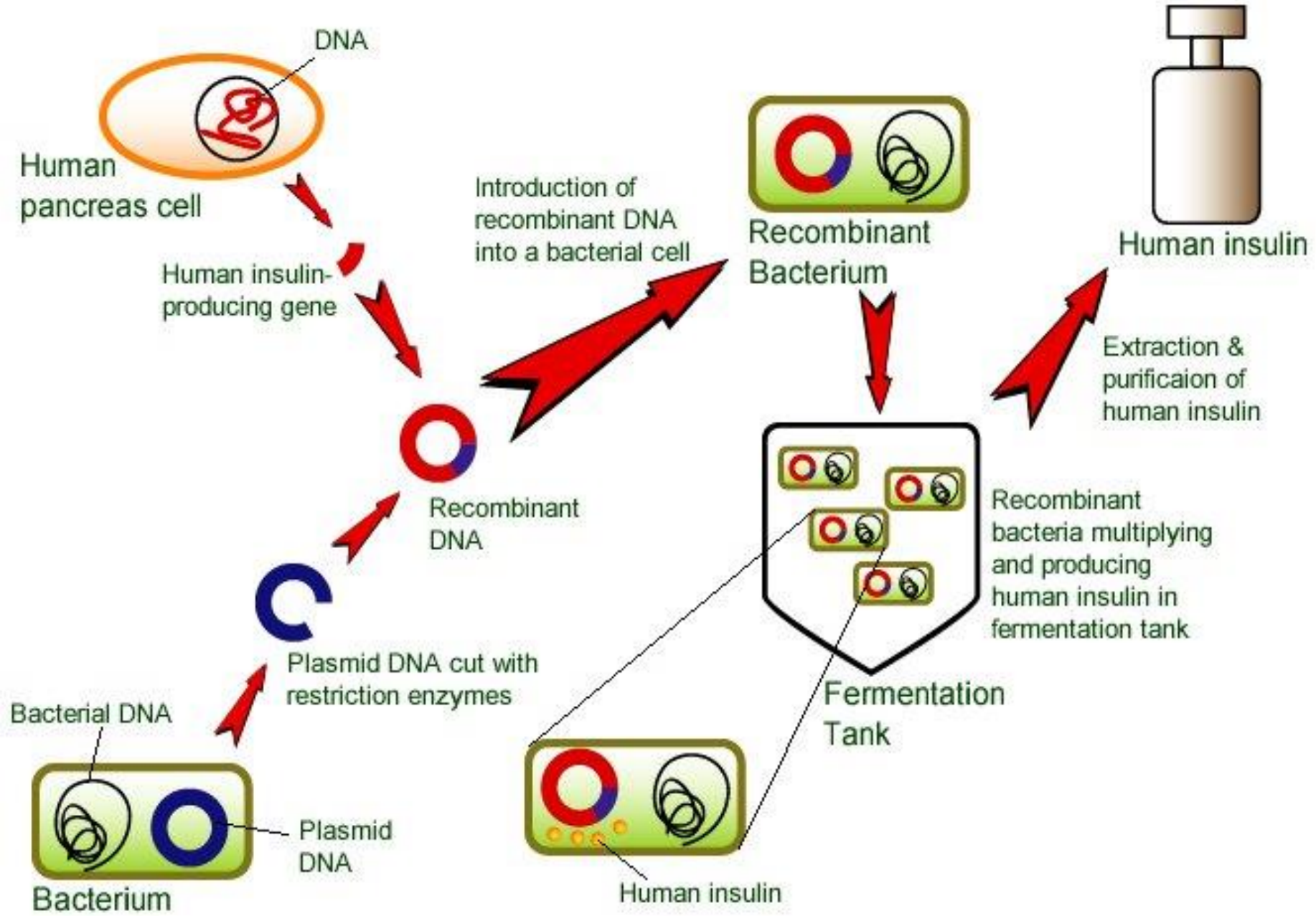
Recombinant DNA



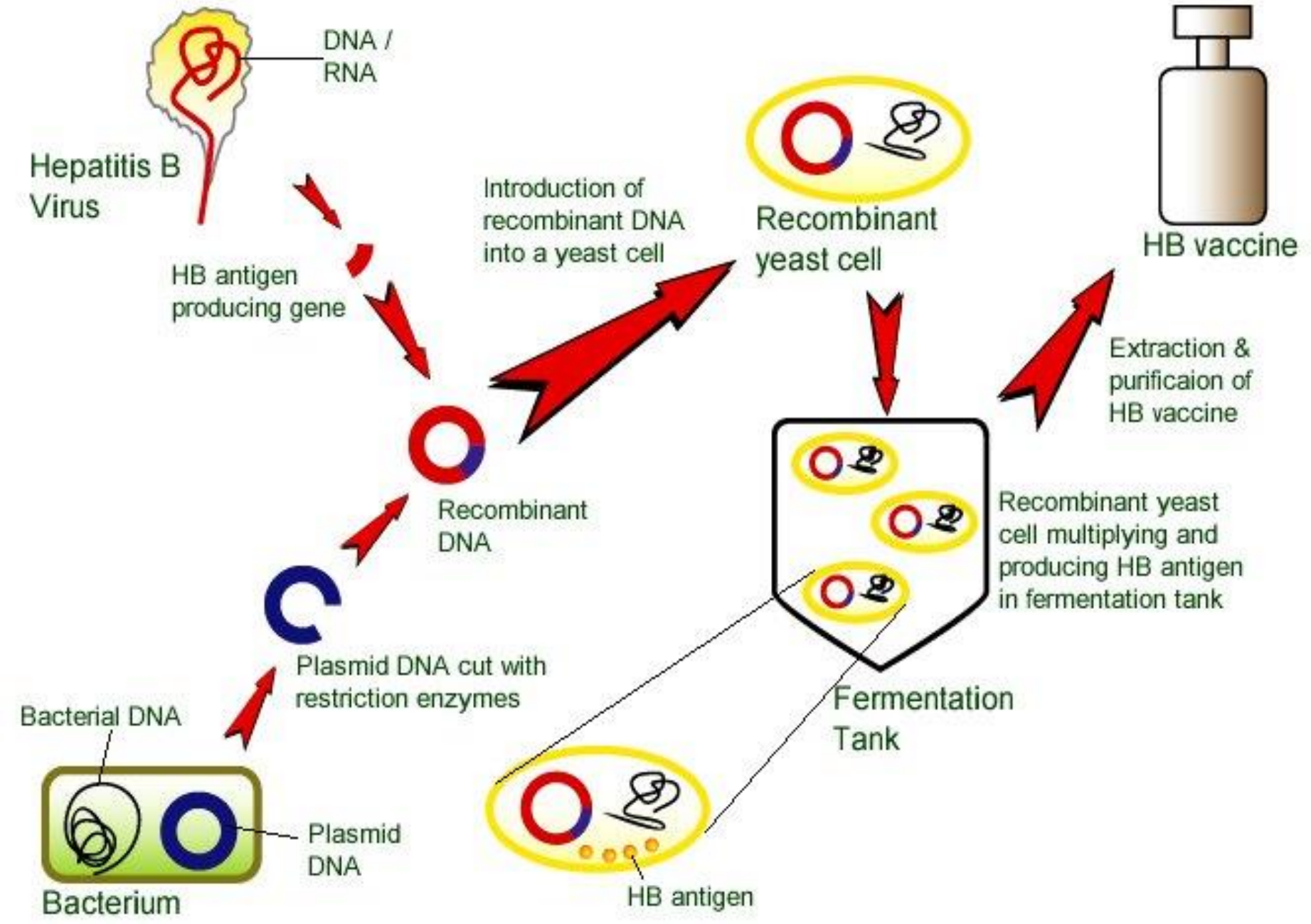
Plasmid or Vector



Human Insulin Production



Production of Recombinant HB Vaccine



Monoclonal antibodies are a specific **class of therapeutic proteins** designed to target foreign invaders (or cancer cells) by the immune system.

Vaccines stimulate the immune system to provide protection, mainly against viruses. Traditional vaccines use weakened or killed viruses to prime the body to attack the real virus. Biotechnology can create recombinant vaccines based on viral genes.

Most common Biopharmaceuticals

- **Hormones** (insulin, glucagon, growth hormone, gonadotrophins).
- **Monoclonal** antibodies (mAbs) (**Humira®** (adalimumab) , **Ritoxan®** (Rituximab), **Avastin®** (bevacizumab), **Actemra®** (tocilizumab).
- **Blood factors** (Factor VIII and Factor IX).
- **Thrombolytic** agents (tissue plasminogen activator) (Activase® Alteplase)
- **Hematopoietic** growth factors (Erythropoietin, colony stimulating factors)
- **Interferons** (Interferons-α, -β, -γ)
- **Interleukin**-based products (Interleukin-2)
- **Vaccines** (Hepatitis B surface antigen)
- Additional products (tumor necrosis factor)


Thank You