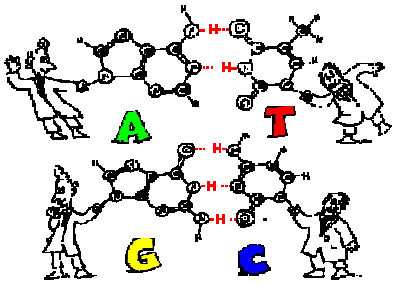
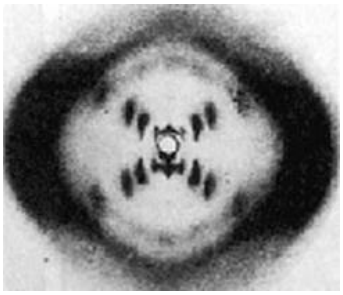
DNA – Deoxyribonucleic Acid

The History of DNA:

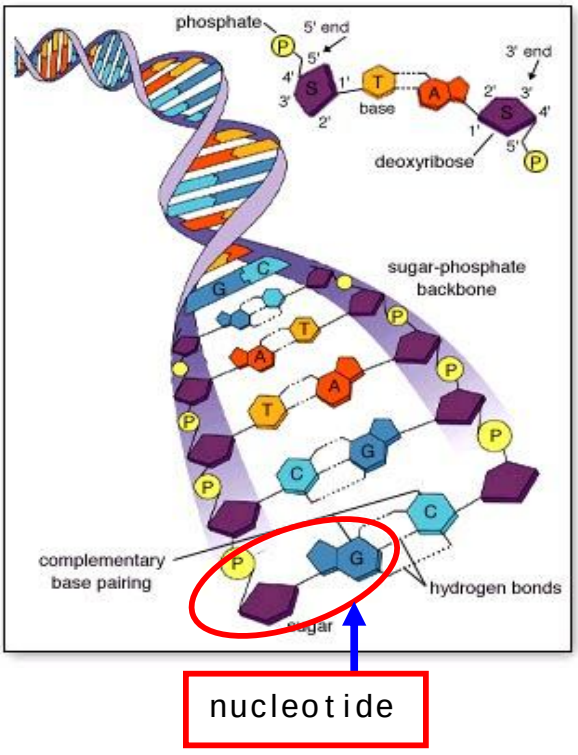


Chargaff analyzed the amounts of the four nucleotides found in DNA and noticed a pattern. The amount of A-T was the same & G-C was the same. From this, the **base-pair rule** was formed.



Rosalind **Franklin** and Wilkins spent time taking **X-ray diffraction** pictures of the DNA molecule in an attempt to determine the **shape of the DNA**.

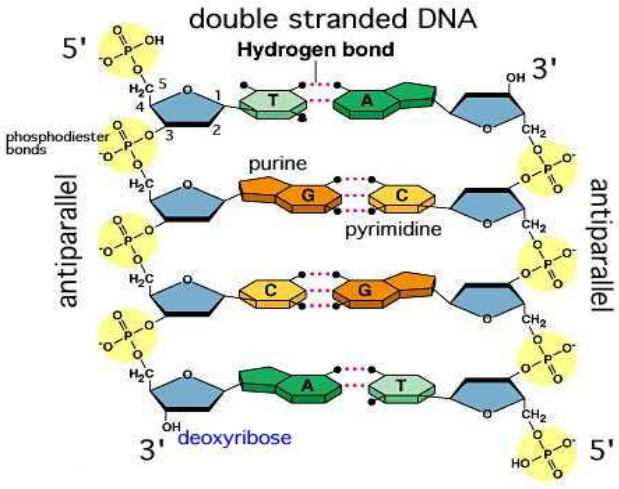
Watson and Crick are credited with finally piecing together all the information previously gathered on the molecule of DNA. They established the structure as a **double helix**. The sugar and phosphates make up the "backbone" of the DNA molecule.



DNA Structure:

DNA is composed of monomers called **nucleotides**. Each nucleotide consists of:

1. **a phosphate**
2. **a sugar (deoxyribose)**
3. **nitrogenous base (adenine, thymine, guanine, cytosine)**



DNA contains about 3 billion bases and about 20,000 genes (segments of DNA) on 23 pairs of chromosomes. Gene size varies:
1,000 bases to 1 million bases in humans

- Hydrogen bonds are found between the bases. G-C has 3 bonds and A-T has 2 bonds.
- There are two types of bases: pyrimidines (T & C) and purines (A & G).
- Each side has an opposite orientation. One side as a free sugar (the 3' end) the other side has a free phosphate (the 5' end). This arrangement is called: **ANTI-PARALLEL**
- **How the code works?** The sequence of bases forms your genetic code. Each individual has a unique sequence, but about 99.9% of your DNA is identical to one another.

DNA Semiconservative Replication:

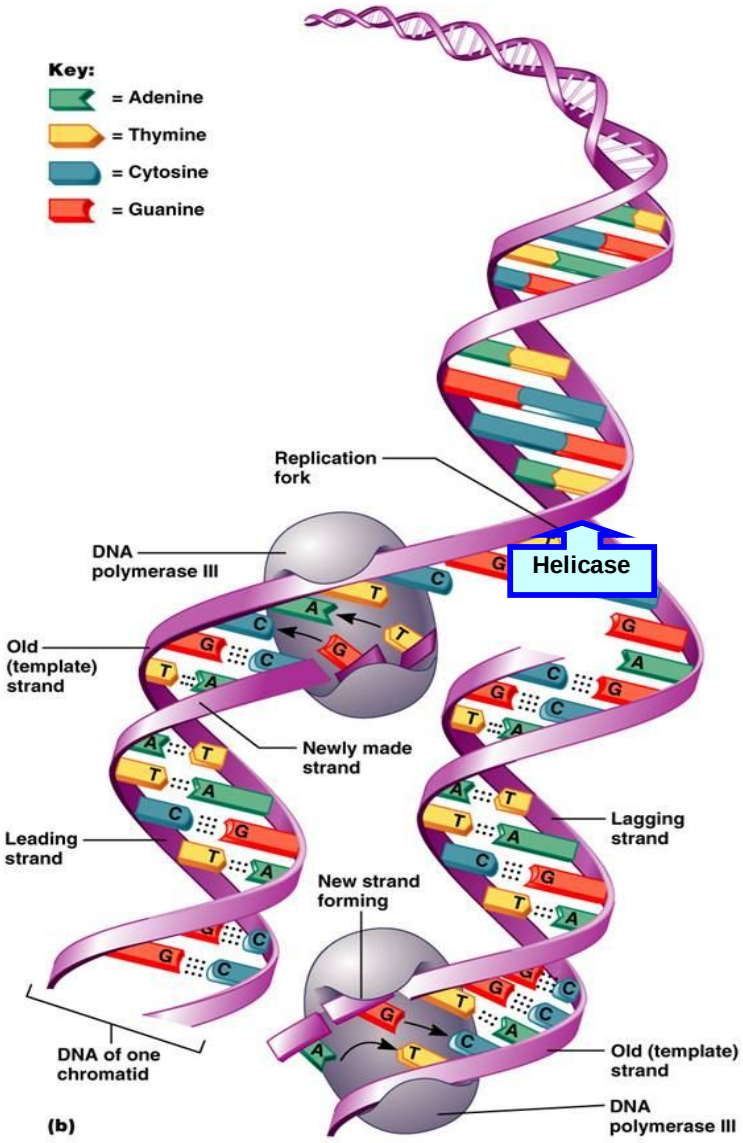
- Parental strands of DNA separate serving as templates and produce DNA molecules that have one old and one new strand. One at a time, nucleotides line up along the template strand according to the base-pairing rules. The nucleotides are linked to form new strands.

1. **DNA Helicase** unwinds and unzips the DNA strands at the replication fork.

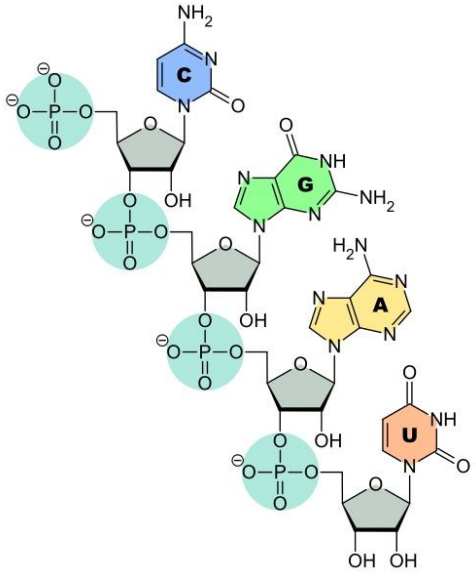
2. **DNA Polymerase** adds the complementary nucleotides to the original strand traveling in opposite directions.

3. Enzymes proofread DNA and repair mistakes to the 2 strands of DNA.

The rate of elongation is about 500 nucleotides per second in bacteria and 50 per second in human cells.



RNA – Ribonucleic Acid



RNA is composed of monomers called **nucleotides**. Each nucleotide consists of:

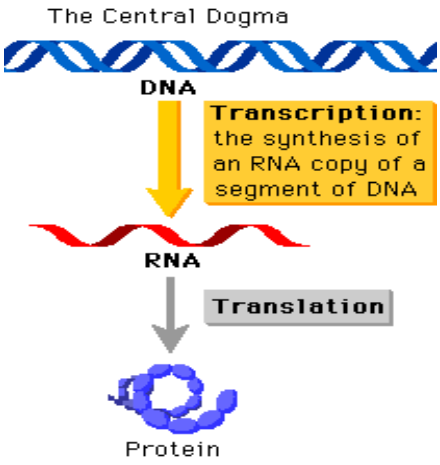
1. **a phosphate**
2. **a sugar (ribose)**
3. **nitrogenous base (adenine, uracil, guanine, cytosine)**

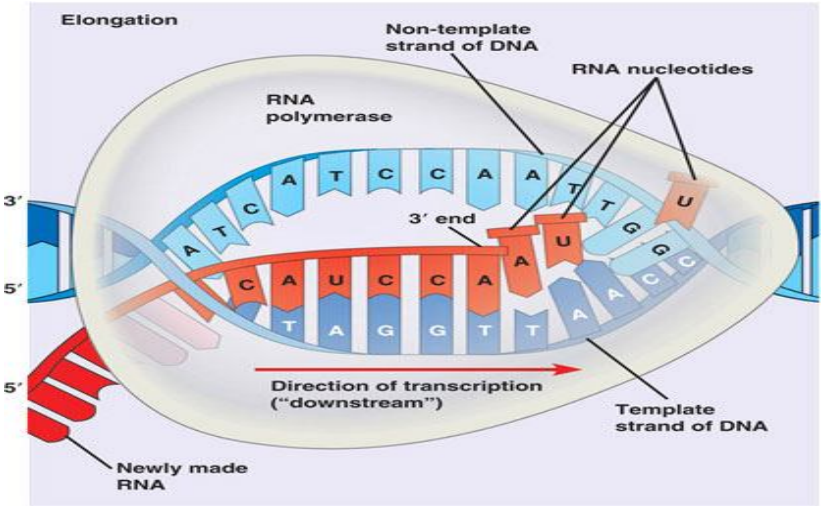
- RNA is single strand of nucleotides.
- RNA is a copy of DNA used for protein synthesis.
- There are 3 types of RNA: Messenger RNA (mRNA), Transfer RNA (tRNA), Ribosomal RNA (rRNA)

PROTEIN SYNTHESIS: DNA → mRNA → Protein

Step 1: Transcription – mRNA copies a segment of DNA.

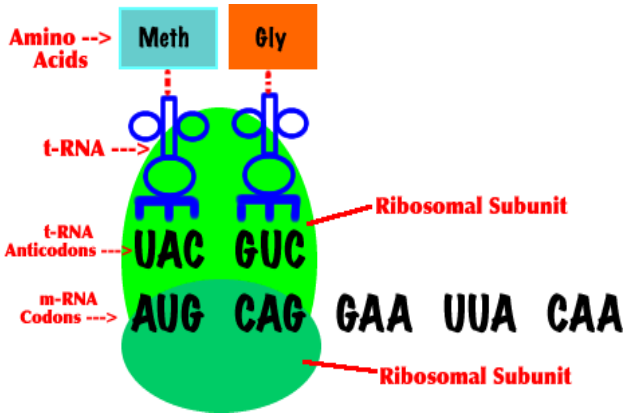
1. RNA polymerase attaches to DNA in the **nucleus** and initiates transcription at the promoter. A promoter is a sequence of DNA where enzyme attaches and initiates transcription.
2. RNA polymerase unwinds DNA and starts transcription. As it moves along the DNA strand from 3' to 5', complementary bases of RNA nucleotides are added.
3. When the RNA polymerase reaches a terminator sequence on the DNA, transcription stops. The mRNA strand disconnects from DNA.
4. Before leaving the nucleus, each new mRNA transcript undergoes modification. Introns, which are non-coding regions (junk DNA), are cut out of the mRNA strand. The strand is spliced back together leaving only exons. Exons are the coding regions (genes).
5. The mRNA strand leaves the nucleus and travels to the ribosome.



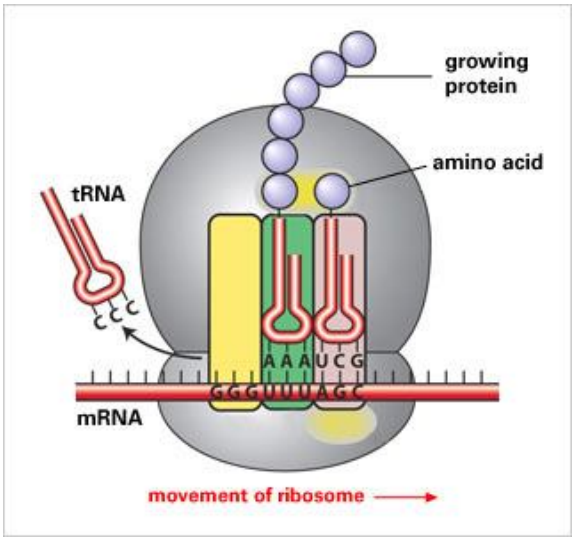


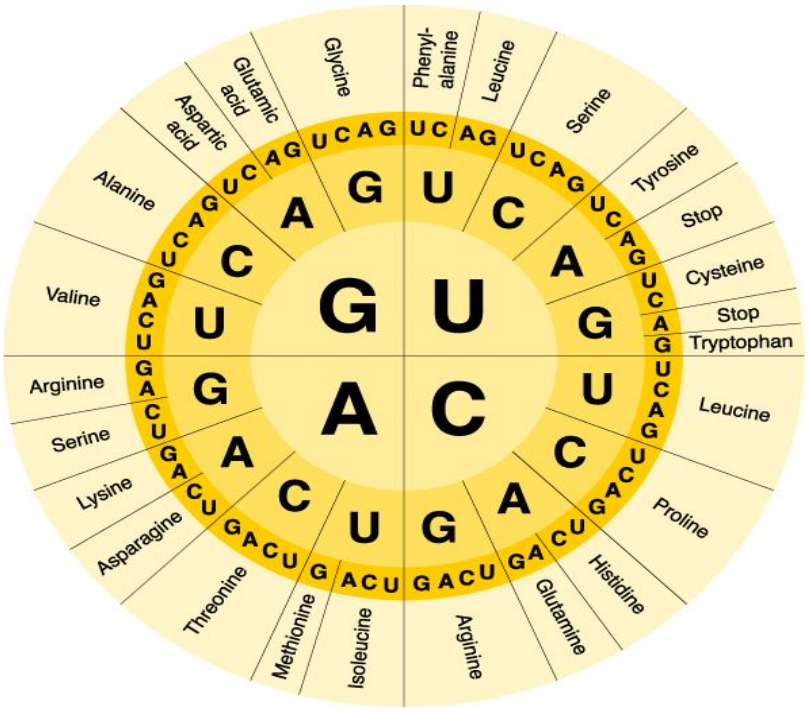
Step 2: Translation – information on the mRNA is used to make proteins

1. After leaving the nucleus, the mRNA enters the cytoplasm and attaches to a **ribosome**. The ribosome moves along the mRNA until it finds a **START CODON (AUG)** – (3 nitrogen bases on mRNA = codon).
2. tRNA binds to the mRNA strand at the start codon. tRNA transfers the amino acids to the ribosome. tRNA also carries the ANTICODON – (3 complementary nitrogen bases on tRNA = anticodon).
3. rRNA is found in ribosomes and helps in the attachment of tRNA to mRNA and in the assembly of proteins.



4. Another tRNA anticodon binds to the mRNA codon, and drops off the amino acid. The amino acids form a peptide bond and the tRNA detaches from mRNA.
5. The binding of tRNA and mRNA continue until the ribosome reaches a **STOP CODON**. The amino acid chain is released and folds to form a globular protein.

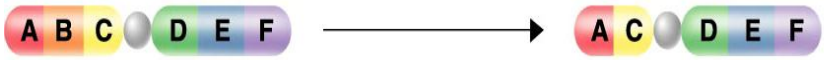




MUTATIONS

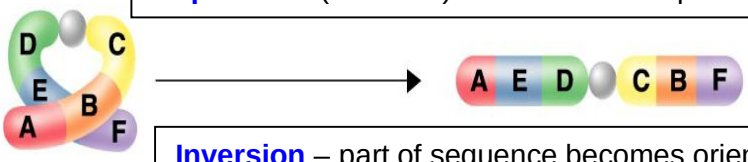
A **Mutation** occurs when a DNA sequence is damaged or changed which can alter the genetic message. Many mutations happen spontaneously when DNA is replicating. Some mutations can occur when DNA is exposed to **mutagenic factors** such as x-rays, UV radiation, and chemicals.

CHROMOSOMAL MUTATIONS: Changes in chromosome numbers or chromosomal arrangements affecting many genes. These mutations can lead to serious disorders, cancers or can be lethal.

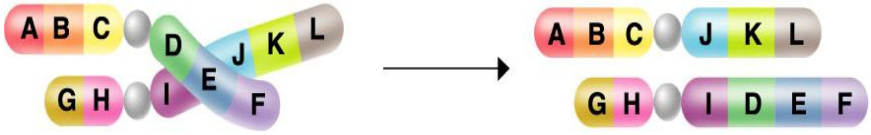


Deletion – loss of a segment

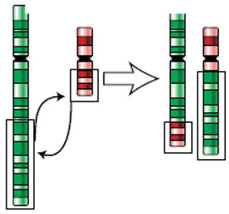
Duplication (Insertion) – sections are repeated



Inversion – part of sequence becomes oriented in reverse direction



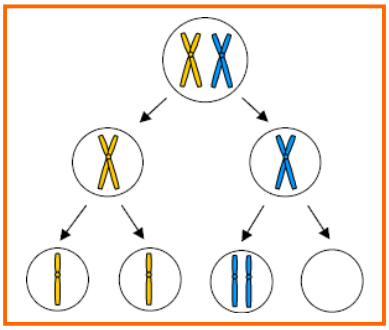
Translocation – broken part is attached on different chromosome



Changes in Chromosome Number?

- **Aneuploidy –** A chromosomal mutation occurs resulting in cells with one extra or one less chromosome
- **Polyploidy –** A chromosomal mutation occurs resulting in cells with three or more extra chromosomes

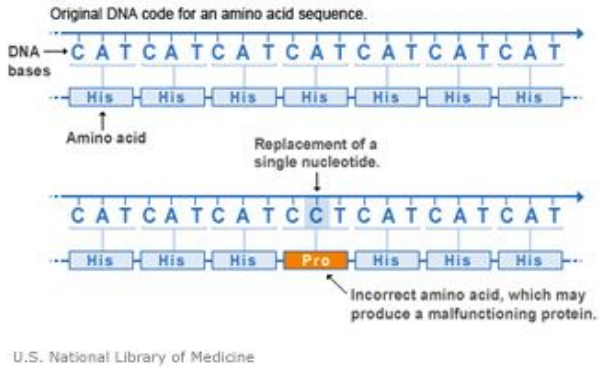
❖ **The chromosome numbers can change due to NONDISJUNCTION which occurs when homologous chromosomes do not separate properly during meiosis.**



Examples of Chromosomal Disorders:
Down Syndrome, Turners Syndrome, Klinefelters Syndrome, Progeria, Patau Syndrome, Edwards Syndrome, Cri-du-chat Syndrome

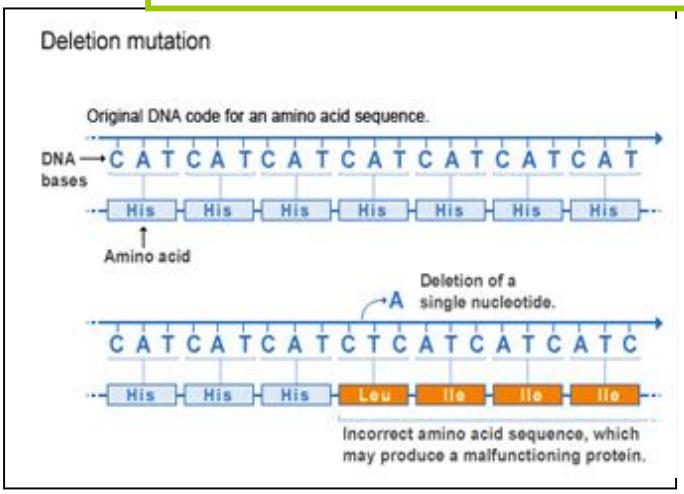
GENE MUTATIONS (aka. Point Mutations): Change in nucleotide sequence of DNA.

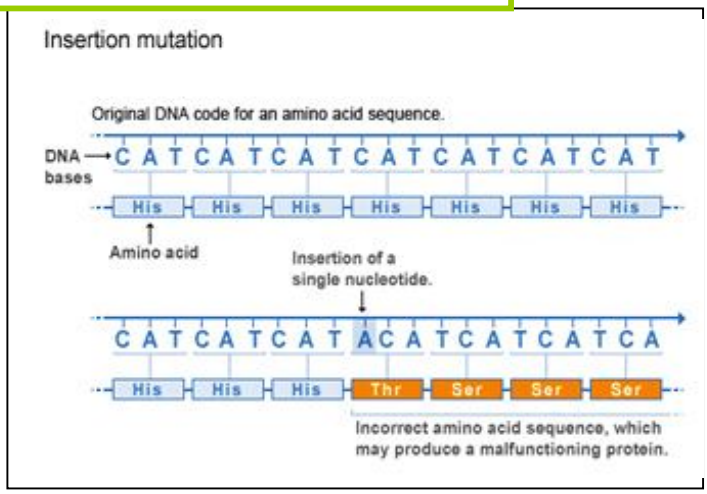
Substitution – replacement of one nucleotide with another nucleotide



- If a mutation occurs, then the DNA will be changed. This change will cause a change in mRNA when it is transcribed.
- The change in mRNA **may** cause a change in amino acids formed during translation. If a different amino acid is made then the protein shape will be different resulting in a nonfunctional protein.
- Mutations that occur in sex cells are passed on to the organism's offspring.

Frame Shift – insertion or deletion of nucleotides in a gene nucleotide





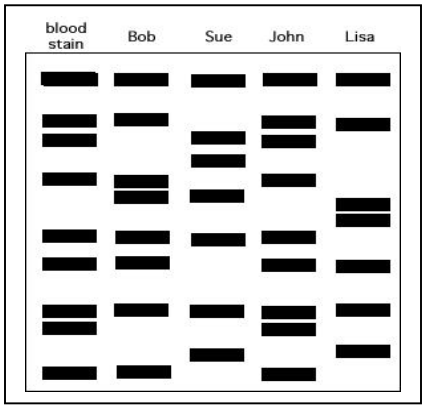
DNA TECHNOLOGY

Human Genome Project (1990-2003) – The projects purpose was to discover all the estimated 25,000 human genes and **map the 3 billion nucleotide sequences** of DNA in human chromosomes. Currently, scientists are using this information to identify where genes are located, control mechanisms of genes and the functions of genes.
http://www.ornl.gov/sci/techresources/Human_Genome/home.shtml

Gene Therapy – The transfer of normal or modified genes into a person's body cells to **correct a genetic defect** or boost resistance to disease -- possibly cure genetic disorders.

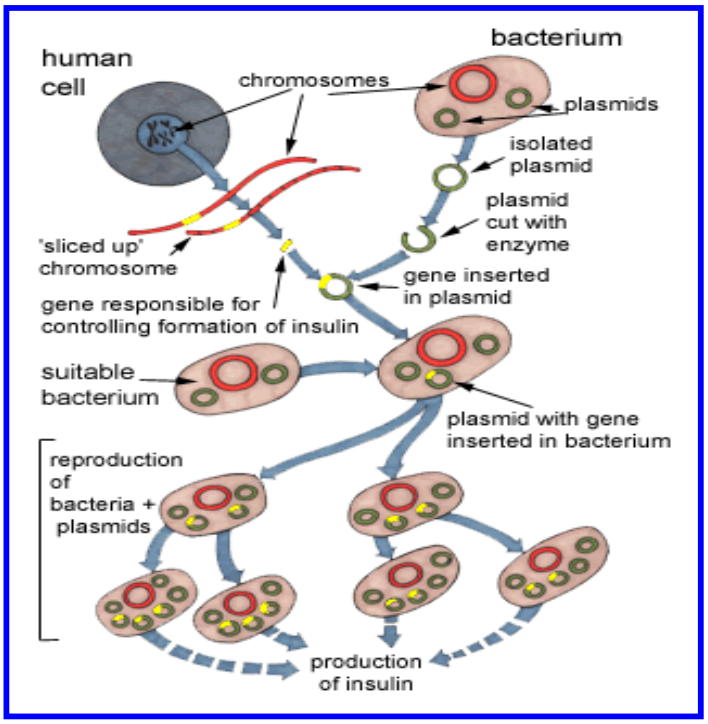
Cloning – The production of **identical copies** of DNA through some asexual method.

DNA Fingerprinting – Restriction enzymes and gel electrophoresis are used to **splice and separate DNA** fragments. This process produces a gel containing a banded pattern of DNA fragments that are used to compare individuals. This is used in forensics.



What if there's only a small sample of DNA found at the crime scene?
- Use **PCR** – polymerase chain reaction to replicate DNA fragments to rapidly amplify DNA samples.

Genetic Engineering – The process of changing the genetic makeup of an organism to introduce a desirable trait. Genes are transferred from one species into another species resulting in a **transgenic organism** that contains recombinant DNA. **Recombinant DNA** contains DNA spliced together from two different organisms. **Restriction enzymes** are used to splice DNA at specific base sequences into fragments.



- They cut, splice together, & insert the modified DNA molecules from different species into bacteria or another type of cell that rapidly replicates and divides.
- The cells copy the foreign DNA right along with their own DNA.
- An example of this is the gene for human insulin inserted into a bacterium. This is how human insulin is mass produced.

Benefits of Transgenic Organism –

Transgenic plants
- help farmers grow crops more efficiently and with less impact on the environment

Transgenic animals
- widely used in medical research – as sources of medically valued proteins or pharmacological
- food animals are being altered to be more nutritious, disease resistant or easier to raise