SEMINAR 3

GENETIC ENGINEERING
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• History of Genetic Engineering
• Tools of Genetic Engineering
  • An Overview
  • Cloning
  • PCR
  • Vectors
  • DNA Sequencing
  • **CRISPR**
WHAT IS A MUTATION?

• **A mutation** is a permanent change to the sequence of DNA that can be passed to new cells.

• **Mutations** can be caused naturally or as the result of environmental factors.

• **DNA** is often damaged or changed temporarily, a mutation only occurs after that change has been made permanent.
Types of Mutations

Normal gene
AS THE MAN SAW THE DOG HIT THE CAN END ITIS

Point mutation
AS THE MAN SAW THE DOT HIT THE CAN END ITIS

Deletion
AS THE MAN SAW THE HIT THE CAN END ITIS

Insertion
AS THE MAN SAW THE FAT DOG HIT THE CAN END ITIS

Frame Shift
AS THE MAN SAW THE OGH ITT HEC ANE ND ITIS
CHROMOSOMAL MUTATIONS?

- Duplication
- Inversion
- Deletion
- Insertion
- Translocation
HOW DO MUTATIONS OCCUR

- UV light
- Radiation
- Chemical
- Error in DNA repair
- Error in transcription
- Error in replication
- Error in polymerisation

Induced vs spontaneous mutation
HOW DO MUTATIONS OCCUR

Type of Damage:
- Double-strand break
- Chemical bond between neighboring nucleotides
- Chemical modification of a nucleotide
- Chemical Linkage of Two Strands

Common Causes:
- Normal cellular activity
- Ionizing radiation (including X-rays)
- Chemotherapeutic drugs
- DNA repair of other types of damage
- Ultraviolet (UV) light
- Reactive oxygen species (ROS)
- Chemotherapeutic drugs
- Other cellular and environmental chemicals
- Normal modifications that regulate what genes are active
- Reactive oxygen species (ROS)
- Chemotherapeutic drugs
- Other cellular and environmental chemicals
A Definition:

The deliberate modification of the genetic information of an organism can be direct or random.
GENETIC ENGINEERING

• **Types of Genetic Engineering**
  • **Random Mutation and Selection**
  • **Transferring Genes from one Organism to Another**
  • **Editing a known Genome with Specific Changes**
  • **Removal of specific Genes**
Some History

THE DEVELOPMENT OF GENETIC ENGINEERING
History

For several thousands of years, human have performed selective breeding, this is the simplest form of genetic engineering.

The strongest livestock was used for breeding, seeds from the most productive plants were used for future crops, plants with desired characteristics were crossed.

Example: The *Brassicas* (Wild Mustard Family)
Examples of selective breeding

Brussels sprouts
Cabbage
Cauliflower
Broccoli
Kohlrabi
Selection for terminal bud
Selection for lateral buds
Selection for stem
Selection for leaves
Selection for flower clusters
Selection for stems and flowers

Brassica oleracea
(a common wild mustard)
History

The process of selective breeding can only select for traits that were present in previous generations.

The first efforts to introduce new genetic information was the process of mutation breeding.

In mutation breeding, chemicals or radiation are used to cause mutations in the DNA that can be passed to future generation.
History

Mutation breeding began in the 1920s and continues until today (although very sparingly used now)

Lewis John Stadler discovered reported in 1928 that X-ray radiation can cause mutations and that this could be used to induce new traits.

Over 3200 mutagenic plants have been released (both for agriculture and decorative purposes)
Induction of mutagenesis in parent populations by chemical or physical mutagens

$M_1$ populations

$M_2$ or higher populations after chimera dissolution

Phenotypic or genotypic evaluation of mutant populations

US Department of Nuclear Sciences
History

True genetic engineering began in the early 1970s

In 1972, Paul Berg created the first piece of recombinant DNA by combining DNA from a monkey SV40 virus and the lambda virus

(Recombinant DNA: artificially combined piece of DNA)

1973: Antibiotic-resistant genes cloned into E. coli
1974: Foreign DNA was added to a mouse embryo
History

- 1976-1980 – Human genes including insulin were transferred to and produced in *E. coli*

- 1983 – The first GMO organism was released – Strains of *Pseudomonas* bacteria that helped prevent ice formation were sprayed on crops

- 1986 – First GMO crop released, herbicide resistant tobacco plants in France
History

- 1997-2002: Fully sequenced genomes were published
- 2010: Craig Venter releases the first synthetic genome
- 2012: The CRISP/Cas9 is developed
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Genetic Engineering: An Overview

1. Isolate a piece of DNA of interest

2. Insert that piece of DNA into a **vector**

A vector is any molecule that can transport that DNA

3. Insert the vector into the new host organism
Genetic Engineering: Molecular Cloning

Molecular Cloning is the process of creating recombinant DNA molecules and inserting them into a new host organism.
Genetic Engineering: PCR

PCR Stands for the Polymerase Chain Reaction

PCR is used to make many copies of a desired piece of DNA

Only tiny amounts of starting DNA are required
Genetic Engineering: Vectors

Once a piece of desired DNA is produced (usually by PCR), it must be attached or inserted to a vector for transport into the new host organism.
Types of Vectors

1. Viruses
2. Plasmids
3. Loose DNA
4. Bacteria
5. Solid vector: i.e. gold bead
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Falling fast

In the first few years after the end of the Human Genome Project, the cost of genome sequencing roughly followed Moore’s law, which predicts exponential declines in computing costs. After 2007, sequencing costs dropped precipitously.
DNA Sequencing

DNA sequencing is the process of reading all of the letters in a piece of DNA.

Sequencing can range in coverage. More “reads” means higher accuracy in the sequence produced.

Sequencing involves reading short regions many times and overlapping those reads to determine the actual sequence.

Many samples can be read at once.
DNA Sequencing