Chapter 15: Genetic Engineering

Class	Biology

TABLE OF CONTENTS

15.1 — Selective Breeding

Selective Breeding

Selective Breeding: animals with wanted characteristics forced to produce offspring

- Takes advantage of genetic variation → Passes on wanted traits

Hybridization

Hybridization: crossing dissimilar individuals to bring together the best of both organisms

- Luther Burbank → Over 800 varieties of plants
- **Hybrids:** the individuals produced through *hybridization*

Inbreeding

Inbreeding: the continued breeding of individuals with similar characteristics

- Ensures desired characteristics are preserved
- Mostly genetically-similar

Increasing Variation

Breeders can *introduce mutations* → source of biological diversity

- **Biotechnology:** application of a technological process, invention, or method to living organisms

    - More variation than nature can provide

Bacterial Mutations

Mutations: heritable changes in DNA

- Chemicals or radiation can increase mutation rate
    - Most are harmful
    - Some can be desired by breeders

Polyploid Plants

Polyploid → more chromosomes than regular

- Larger and stronger plants

15.2 — Recombinant DNA

Copying DNA

> Previously, the only way to edit genes was to induce mutations.

- Now, genetic engineers can add certain genes to meet specific needs in organisms

Extracted DNA → cut into **restriction fragments** (uses *restriction enzymes*)

- Separated using **gel electrophoresis**
- Millions of restriction fragments to find one gene

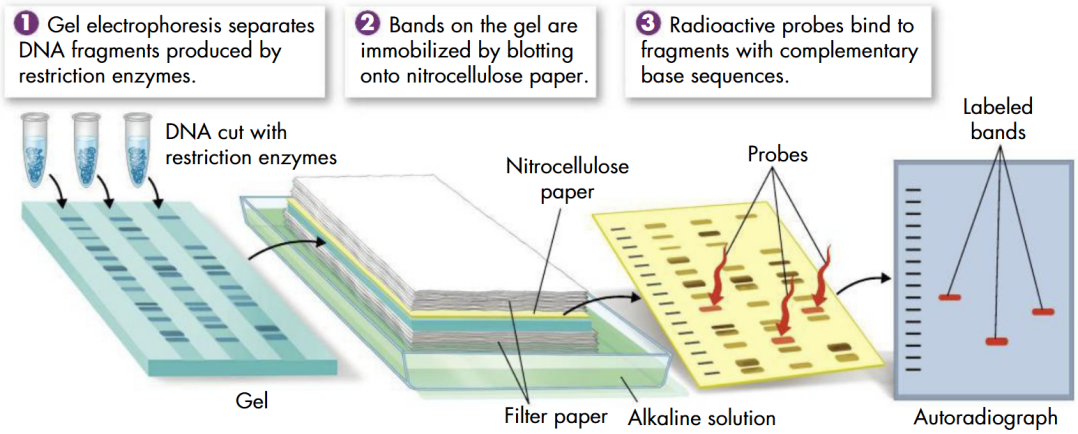
Finding Genes

Douglas Prasher searched for a gene in jellyfish (**Green Fluorescent Protein - GFP**)

- Visual marker of when proteins are made

Studied amino acid sequence → Found probably mRNA base sequences → Used complementary bases to “attract” mRNA to match his prediction → Found the perfect sequence from the jellyfish

- **Southern blotting** → uses gel to find where the gene is



Polymerase Chain Reaction

Polymerase Chain Reaction (PCR): technique to make copies of a gene once it is found

- Original piece of DNA → add *primers*
    - **Primers:** short pieces of DNA added to the beginning and end of the original strand
        - Prepare the DNA to be copied

1. Heat a piece of DNA (separates its strands)
2. Primers bind to the strands as it cools
3. DNA polymerase copies the region between the primers
    - Templates to make more copies

Changing DNA

Combining DNA Fragments

> Scientists can make custom DNA molecules in labs.

- Insert them and their genes into living cells

DNA Synthesizers → produce short fragments of DNA

- Allow you to add DNA from other organisms and attach it to DNA of another orgniasm
    - **Recombinant DNA Technology:** joining together DNA from multiple sources (can change the genetic makeup of an organism)
- Any pair of complementary bases tends to bond despite which organism it comes from

Plasmids & Genetic Markers

Many cells with recombinant DNA didn't copy the added DNA.

- Scientists join recombinant DNA with another piece containing a "start" signal
    - Recombinant DNA is copied as well

Bacteria contain their chromosomes and **plasmids** (small circular DNA molecules).

- Joining recombinant DNA with the plasmid allows for better replication

Genetic Marker: a gene that makes it possible to distinguish bacteria that carry the plasmid from those that don't

- Transformed bacteria will survive an antibiotic

Transgenic Organisms

Transgenic → containing genes from other species

- Produced by insertion of recombinant DNA into the genome of a host organism
- Genetic engineers can produce transgenic organisms

Transgenic Plants

Agrobacterium → produces tumors in plants

- Changed to produce desired traits in plants

DNA can be injected into cells.

Transgenic Animals

DNA can be injected into the nucleus of egg cells.

- Existing genes can also be eliminated

Specific genes in different organisms can be understood.

Cloning

Clone: a member of a population of genetically-identical cells produced from a single cell

- Uses a single cell from an adult organism to grow a new individual

15.3 — Applications of Genetic Engineering

Agriculture & Industry

Genetic modification → better, cheaper, and more nutritious food

- Less harmful manufacture

Genetically-Modified (GM) Crops

- Large percent of modern society (food)

Bt toxin → harmless to humans and animals (kills insects)

- Remove the need for pesticides
- Higher yields

Genetically-Modified (GM) Animals

> Transgenic animals are becoming more important nowadays.

- Genes are put into different animals to specialize
  - GM animals can be cloned

Health and Medicine

Recombinant DNA-technology → useful for disease prevention and treatment

- Golden rice → beta-carotene with more vitamins
- Transgenic animals can be used as test subjects to simulate genetic disorders in humans
- Can be used to create essential proteins

Gene Therapy: the process of changing a gene to treat a medical disease or disorder

- Absent/faulty genes and replaced with new, working ones

1. Create a harmless virus
2. Inject the correct DNA into the virus
3. Infect the patient's cells with the virus
   - Virus will put healthy gene into the cell

Genetic Testing

Find differences in normal or disease-causing genes.

- Scanned using specific tests

Examining Active Genes

All cells in the human body have the same genetic material.

- Not all genes are active/inactive in each cell

DNA Microarray technology → study many genes at once to understand their activity levels

- Glass slide/silicon chip where spots of DNA are attached
    - Each spot has different DNA fragments

mRNA of different colors (normal or disease-causing) will show complementary DNA (**cDNA**) and show the results in the gene.

- More active color in the gene will show

Personal Identification

> Except for *identical twins*, no two humans share the same genome.

- **DNA fingerprinting** → used to identify individuals
    - Analyzes sections of DNA that vary between individuals

1. Restriction enzymes cut a small sample of human DNA
2. Gel electrophoresis separates the fragments by size
3. DNA probe finds the highly variable regions(sized DNA bands)
    - Pattern can be distinguished from other people

Forensic Science

Forensics: the scientific study of crime scene evidence

- DNA fingerprinting helped to solve crimes and convict criminals
- Used in wildlife conservation as well

Establishing Relationships

- Solves paterity disputes

Ancestry can be traced using **Y chromsomes** (come from the father with little changes) and **mitochondrial DNA / mtDNA** (come from the mother with little changes).

15.4 — Ethics & Impacts of Biotechnology

Profits and Privacy

Patent: a legal tool that gives an individual or a company the exclusive right to profit from its innovation

- Private biotechnology and pharmaceutical companies use patents to protect their discoveries and innovations

Patenting Life

Molecules, DNA sequences, and chromosomes can be patented.

- Leads to ethical questions on privacy about genetic information

Genetic Ownership

Some soldiers are identified when they die.

- Biotechnology → no more unknown soldiers
    - U.S. military now takes DNA from each soldier when they begin service

U.S. Congress → *Genetic Information Nondiscrimination Act* (2008)

- Protects Americans from discrimination based on genetic information
- Hopefully leads to more effective uses of genetic information

Safety of Transgenics

Pros of GM Foods

- Higher yields (reduce land and energy needed)
  - Lowered cost of food
- Less insecticide required
  - Lessens environmental damage
- Better or safer than others

Cons of GM Foods

- Unintended consequences on agriculture
  - Insect resistance (harmful to beneficial insects)

> Currently, GM and non-GM foods are treated the same.

Ethics of the New Biology

Biotechnology allows us to learn more about ourselves.

- People need to use the ability to change life responsibly