Chapter 14
The Human Genome
Human Chromosomes – Pieces of DNA that are found within the nucleus of a human cell.

Biologists take chromosomes in their condensed form during mitosis, cut them out and organize them in pairs.

This produces a product called a karyotype.
Karyotypes

- An arrangement of homologous chromosomes that can identify gender and abnormalities.
Human Chromosomes

- Humans have 46 total chromosomes.
- 23 pairs to be exact.
- 1 pair of sex chromosomes
- Females have two X chromosomes, and males have an X and a Y.
- 22 pairs of autosomes.
- 46,XX = Female
- 46,XY = Male
How is sex determined in humans?
The presence of a Y chromosome determines the sex of an individual.
Females always provide an X chromosome.
Males can provide an X or a Y.
Draw a punnett square to represent this relationship.
Pedigree Charts

- Shows a genetic relationship within a family.
- A circle represents a female, and a square represents a male.
- Shaded represents the expression of a trait while not shaded represents the absence of a trait.
- A horizontal line connecting a male and a female represents a marriage.
- A vertical line and bracket connect parents to their children.
Human Genes

- The human genome – our complete set of genetic information which includes tens of thousands of genes.
Blood Group Genes

- Blood Type is determined by two separate genes. The ABO gene and the Rh gene.
- Rh is determined by a single gene with two alleles: positive and negative.
- The positive allele is dominant and the negative is recessive.
- Rh stands for Rhesus which is the type of monkey it was discovered in.
The ABO blood group is determined by one gene that has three alleles.

\( I^A \) and \( I^B \) are codominant and \( i \) is recessive.

Draw a punnett square for parents \( AB^- \) and \( A^+ \) (both the A and the + are heterozygous)
ABO Blood Groups

1. 4 Types of blood groups.
   1. A, B, AB & O
   2. Antigens – molecules that can be recognized by the immune system.
   3. Presence or absence of the A & B antigens produce the four blood types.
   4. Type A - has red blood cells that carry antigen A.
   5. Type B – has red blood cells that carry antigen B.
6. Type AB – has both antigens
7. Type O – has neither antigen.
8. Blood types are important in blood transfusion.
9. ABO blood groups are determined by a single gene with three alleles: $I^A$, $I^B$, & $i$
<table>
<thead>
<tr>
<th>Phenotype (Blood Group)</th>
<th>Genotypes</th>
<th>RBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>O</td>
<td>ii</td>
<td><img src="image1" alt="Red Blood Cell" /></td>
</tr>
<tr>
<td>A</td>
<td>$I^A I^A$ or $I^A i$</td>
<td><img src="image2" alt="Star Blood Cell" /></td>
</tr>
<tr>
<td>B</td>
<td>$I^B I^B$ or $I^B i$</td>
<td><img src="image3" alt="Crowd Blood Cell" /></td>
</tr>
<tr>
<td>AB</td>
<td>$I^A I^B$</td>
<td><img src="image4" alt="Star Blood Cell" /></td>
</tr>
</tbody>
</table>
C. Rh Blood Groups

1. Rh antigen – another antigen found in blood.
2. Named after rhesus monkey which it was first discovered in.
3. People with Rh antigen are Rh⁺
4. People without antigen are Rh⁻
5. Blood types are typically listed as a combined symbol. Ex O⁻
Recessive Alleles

- Many human genes have become known through the study of genetic disorders.
- Some are caused by recessive alleles, some by dominant alleles, and some by codominant alleles.
Some Autosomal Disorders in Humans

- **Albinism** – Rec.: Lack of pigment in skin, hair, and eyes.
- **Cystic Fibrosis** – Rec.: Excess mucus in the lungs, digestive tract, liver; increased susceptibility to infection.
- **Phenylketonuria (PKU)** – Rec.: Accumulation of phenylalanine in tissues; lack of normal skin pigment; mental retardation.
- Achondroplasia – Dom.: Dwarfism (one form).
- Huntington’s Disease – Dom.: Mental deterioration and uncontrollable movements; symptoms usually appear in middle age.
- Sickle cell disease – CoDom.: Misshapen, or sickled, red blood cells; damage to many tissues.
II. Huntington Disease

A. What is it?

1. Produced by a single dominant allele.
2. People show no symptoms until 30’s – 40’s.
3. Gradual damage to their nervous system.
4. Causes loss of muscle control and mental function.
5. Gene is located in chromosome 4.
There are approximately 30,000 known cases of Huntington's disease in the United States. That means about 150,000 Americans have the potential to inherit Huntington's disease from a parent. Huntington's disease is a dominant inherited disease. That means that a person only needs to inherit one copy of a mutated gene to get HD. Therefore, people who have Huntington's disease have a fifty percent chance of passing Huntington's disease on to their children.
III. Sickle Cell Anemia

A. What is it?
   1. Red blood cells that are in the shape of sickles.

B. Cause
   1. A change in a polypeptide found in hemoglobin.
   2. Hemoglobin – protein that carries O$_2$
   3. Person is deprived of O$_2$
   4. Cells become more rigid and stick in capillaries.
Sickle Cells in the Vessels
These stretched, or "sickled," cells are no longer flexible and jam up in small vessels plugging them. This causes pain and damage to the areas behind the plug that cannot receive oxygen and nutrients from the blood.
C. Genetics of Sickle Cell Anemia

1. The allele for normal hemoglobin $H^A$ is codominant with the sickle cell allele $H^S$

2. $H^A H^S$ sickle cell carriers, suffers some effects.

3. $H^S H^S$ sickle cell sufferers

4. Sickle cell is the result of a single nucleotide substitution which codes for the wrong a.a.

D. Distribution of Sickle Cell Anemia

1. In the US, African people are most common to carry trait.
Every human diploid cell has more than 6,000,000,000 base pairs packed into 46 chromosomes.

A large portion of that DNA either doesn’t do anything, or we haven’t figured out what it does yet.

Only about 2% of your DNA is believed to exist as functioning genes.
Each Chromosome has hundreds if not thousands of genes located on it as well as sections that contain no known genes.
Sex-Linked Genes

- Any gene located on one of the sex chromosomes is said to be sex-linked.
- Why is this important?
- X chromosomes carry many genes while the Y chromosome only carries a few.
- It only takes one recessive sex-linked gene in a male to express that gene, while a female requires that a recessive allele is in both X chromosomes.
What do females do with the extra X chromosome?

They become Barr bodies – inactivated chromosome.
II. Sex-Linked Genetic Disorders

A. Sex-Linked

1. Genes that are carried on either the X or Y chromosomes
2. the small Y chromosome carries few genes
3. the larger X chromosome carries many genes that are vital to proper growth and development
Sex-linked disorders

- Colorblindness. 1 out of 10 men, 1 out of 100 women.
- Hemophilia – inability to make a blood clotting protein. 1/10,000 men.
B. Colorblindness

1. a recessive disorder in which a person cannot distinguish between certain colors

2. most is caused by sex-linked genes located in the X chromosome

3. most common type is red-green colorblindness
Pseudoisochromatic Plate Test

- Persons with normal color vision can discern these patterns but those with color defects cannot.
C. Hemophilia

1. recessive allele on the X chromosome
2. also called “bleeders disease”
3. these people are missing the AHF necessary for normal blood clotting
4. affects 1 in 10,000 males and 1 in 100,000,000 females
5. people can bleed to death from minor cuts
6. can be treated
D. Muscular Dystrophy (MD)

1. inherited disease that results in the progressive wasting away of skeletal muscle.
2. no cure yet
3. gene found on X chromosome
Chromosomal Disorders

- Sometimes problems occur during meiosis.
- The most common problem is a nondisjunction disorder.
- Nondisjunction is the failure of chromosomes to separate properly during meiosis.
Down Syndrome

- Trisomy 21 – an individual has three copies of the 21st chromosome.
- 1/800 babies in the US.
- Mild to severe mental retardation.
- Scientists aren’t sure why an extra copy of a chromosome causes so much trouble.
- Growth failure
- Mental retardation
- Flat back of head
- Abnormal ears
- Many "loops" on finger tips
- Palm crease
- Special skin ridge patterns
- Unilateral or bilateral absence of one rib
- Intestinal blockage
- Umbilical hernia
- Abnormal pelvis
- Diminished muscle tone

- Broad flat face
- Slanting eyes
- Epicanthic eyefold
- Short nose
- Short and broad hands
- Small and arched palate
- Big, wrinkled tongue
- Dental anomalies
- Congenital heart disease
- Enlarged colon
- Big toes widely spaced
A. The Human XY System.

1. Nondisjunction – the failure of chromosomes to separate properly during one of the stages of meiosis

2. produces gametes that contain either 2 sex chromosomes or no sex chromosomes
NONDISJUNCTION

1. Meiosis I starts normally. Tetrad line up in middle of cell.
2. Then one set of homologs does not separate (= nondisjunction).
3. Meiosis II occurs normally.
4. All gametes have an abnormal number of chromosomes—either one too many or one too few.
B. Nondisjunction Disorders
   1. 1 in 1000 births is involved in nondisjunction
   2. most abnormalities are Turner’s and Klinefelter’s Syndrome

C. Turner Syndrome
   1. people are female in appearance but sex organs do not develop at puberty
   2. they are sterile
   3. abbreviated 45X or 45XO
   4. frequency is 1 in 2000 live female births
Short stature
Low hairline
Shield-shaped thorax
Widely spaced nipples
Shortened metacarpal IV
Small finger nails
Brown spots (nevi)

Characteristic facial features
Fold of skin
Constriction of aorta
Poor breast development
Elbow deformity
Rudimentary ovaries
Gonadal streak (underdeveloped gonadal structures)
No menstruation
D. Klinefelter’s Syndrome
  1. male in appearance
  2. they are sterile
  3. abbreviation is 47XXY

E. Things we learn from these abnormalities
  1. X chromosome is essential for survival
  2. sex seems to be determined by the presence or absence of Y chromosome and not by # of X chromosome.

    Ex.) we have seen people with 48XXXXY and 49XXXXXY who are male in appearance

There are no known cases of a child being born with only a Y chromosome.
Sex-Influenced Traits

1. Some traits seem to be sex-linked but are not
2. ex) male pattern baldness
3. This is a sex-influenced trait- a trait that is caused by a gene whose expression differs in males and females
4. Males with heterozygous Bb will be bald where female will not be
5. We think it has something to do with male hormones
   - Some men have areas on the scalp that are very sensitive to the male sex hormones that circulate in men's blood.
   - These hormones, that makes the hair follicles from which hair grows, tends to shrink → cannot produce hair
Gene Interactions

Dominance

- When a dominant allele is present, the dominant allele is seen.

Question: What causes dominance?

Answer: Dominant alleles code for a polypeptide (string of a.a.) that works whereas the recessive allele codes for a polypeptide that does not work.
B. Incomplete Dominance

1. Joseph Kolreuter crossed white carnations (rr) with red carnations (RR).

2. The offspring were pink!!

3. This is an example of incomplete dominance.

4. The dominant allele, R, is not completely dominant over the recessive allele.
C. Codominance

1. A condition in which both alleles of a gene are expressed.

2. Alleles are written with subscripts ($B_1$ and $B_2$) or superscripts ($R^1$ and $R^2$).

3. Ex/ cattle – red hair ($H^R$) is codominant with white hair ($H^W$).

4. Cattle with $H^R H^W$ are called roan, and have a spotted coat.
D. Polygenic Inheritance

1. Traits that are controlled by two or more genes.

2. Ex/ shape of your nose, color and markings on an animal's coat.
Why is it difficult to study human genetics?

1. We only produce a few offspring.
2. Contain nearly 100,000 genes.
3. Cannot be used in test crosses.
4. Humans live many years.
B. Gametes

1. Reproductive cells; contain a single copy of each gene.

C. Zygote

1. Form when sperm and egg meet – fertilized egg.
II. Human Traits

A. Environmental Factors

1. Factors that influence traits; nongenetic
2. Ex: Nutrition & Exercise.
3. Ex: Increased height has been seen in countries with good nutrition.
IV. Polygenic Traits

A. Definition

1. Human traits that are controlled by a number of genes.
2. Height, body weight, skin color.
3. Skin color has at least four genes that control it. Creates a wide variety of color.
4. Dark skin – high amount of melanin.
5. Light skin – low amount of melanin.
II. Prenatal Diagnosis

A. Amniocentesis

1. The removal of a small amount of fluid from the sac surrounding the embryo.
2. Used to detect genetic disorders.
3. A Karyotype can be prepared from this to examine all of the chromosomes.
B. Chorionic Villus Biopsy

1. When a sample of embryonic cells are removed directly from the membrane surrounding the embryo.

2. Get results faster from this test.
- Human Genome Project
- Genetic Testing
- Gene Therapy