

Genetics 1 - Patterns of Inheritance

ENVS 10
Lecture 9

Book Chapter 9

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Heritable Variation and Patterns of Inheritance

- **Gregor Mendel**
 - Was the first person to analyze patterns of inheritance.
 - Deduced the fundamental principles of genetics.

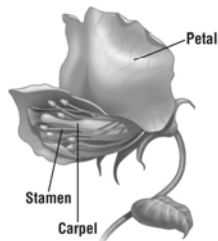


Figure 9.2

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In an Abbey Garden

- Mendel studied garden peas because
 - These plants are easily manipulated.
 - These plants can self-fertilize.

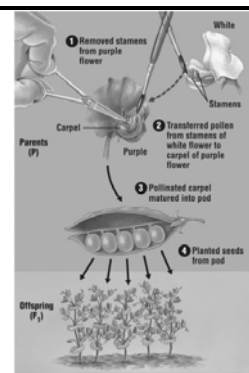


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Figure 9.3

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- Mendel created true-breeding varieties of plants (purebreds).
- Mendel then carried out some cross-fertilization: fertilization of one plant by pollen from a different plant.
 - He crossed two different true-breeding varieties.



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Figure 9.4

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Mendel's Law of Segregation

- Mendel performed many experiments in which he tracked the inheritance of characteristics that occur as two alternative traits.

- He tracked several characteristics in pea plants from which he formulated several hypotheses.

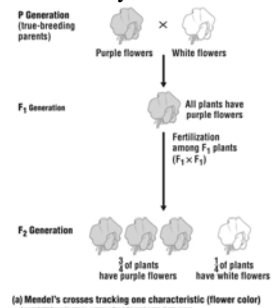
	Dominant	Recessive
Flower color	Purple	White
Flower position	Axial	Terminal
Seed color	Yellow	Green
Seed shape	Round	Wrinkled
Pod shape	Inflated	Constricted
Pod color	Green	Yellow
Stem length	Tall	Dwarf

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Figure 9.5

Monohybrid Crosses

- A monohybrid cross is a cross between parent plants that differ in only one characteristic.



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Figure 9.6a

- Mendel developed four hypotheses from the monohybrid cross:
 - There are alternative forms of genes (the units that determine heritable traits) called **alleles**.
 - Example: the gene for flower color in pea plants exists in one form for purple and another for white.

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- Mendel developed four hypotheses from the monohybrid cross:
 - For each characteristic, an organism inherits **two alleles**, one from each parent.
 - Alleles may be the same or different.
 - Organism that has two identical alleles for a gene is said to be **homozygous** for that gene.
 - Organism that has two different alleles for a gene is said to be **heterozygous** for that gene.

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- Mendel developed four hypotheses from the monohybrid cross:
 3. Alleles can be **dominant** or **recessive**.
 - If the two alleles of an inherited pair differ, then one determines that organism's appearance and is called the **dominant** allele (e.g., *P* - purple flower allele).
 - The other allele has no noticeable effect on the organism's appearance and is called **recessive** (e.g., *p* - white flower allele).

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- Mendel developed four hypotheses from the monohybrid cross:
 4. Gametes (egg and sperm) carry only one allele for each inherited characteristic.
 - This fourth hypothesis is known as Mendel's Law of Segregation.

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Mendel's Law of Segregation

- Mendel's law of segregation
 - *A sperm or egg carries only one allele for each inherited characteristic because the two members of an allele pair segregate (separate) from each other during the production of gametes (egg and sperm).*
 - *When sperm and egg unite at fertilization, each contributes its allele, restoring the paired condition in the offspring.*

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- Because an organism's appearance does not always reveal its genetic composition, geneticists distinguish between an organism's expressed physical traits and its genetic makeup:
 - **Phenotype**
 - An organism's expressed physical traits (e.g., purple or white flowers).
 - **Genotype**
 - An organism's genetic makeup (e.g., *PP*, *Pp*, *pp*).

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Genetic Alleles and Homologous Chromosomes

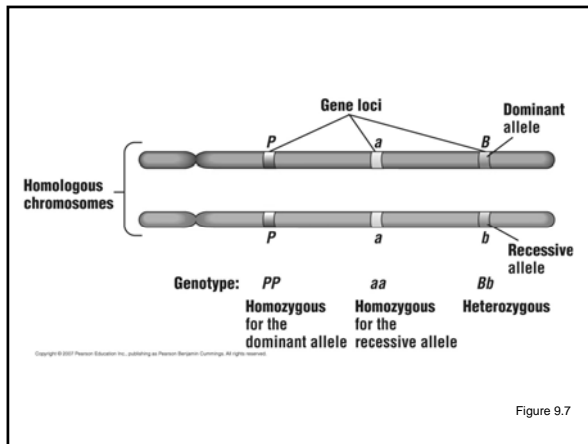
- **Chromosomes** - organized structures of DNA and associated proteins; they carry the genes with all of the inherited information.
- **Homologous chromosomes** are matching pairs of chromosomes that carry versions (alleles) of the same genes.
- One homologous chromosome is inherited from the organism's father, the other from the mother.

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Genetic Alleles and Homologous Chromosomes

- **Homologous chromosomes**
 - Have genes at specific *loci* (singular *locus*) – specific locations of genes along the chromosome.
- What is the connection, then, between Mendel's Law of Segregation and homologous chromosomes?
 - Alleles (alternative forms) of a gene reside at the same locus on homologous chromosomes.

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Mendel's Law of Independent Assortment

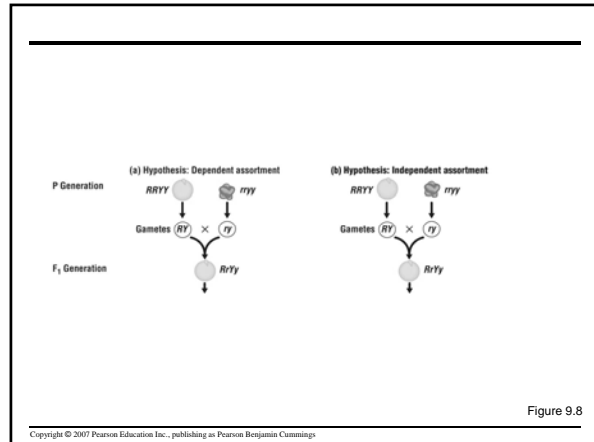
- Mendel then extended his experiments to look at crosses between parental varieties that differed in more than one characteristic:
 - Seed shape: round or wrinkled
 - Seed color: yellow or green
- Asked: Were the two characteristics transmitted as a package (dependent of the other) or were they inherited independently of each other?

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Mendel's Law of Independent Assortment

- Tested using a **dihybrid cross** - the mating of parental varieties differing in two characteristics.
- Mendel crossed homozygous plants having round yellow seeds (genotype $RRYY$) with plants have wrinkled green seeds ($rryy$).
- Result in the first generation was $RrYy$ (round and yellow seeds).

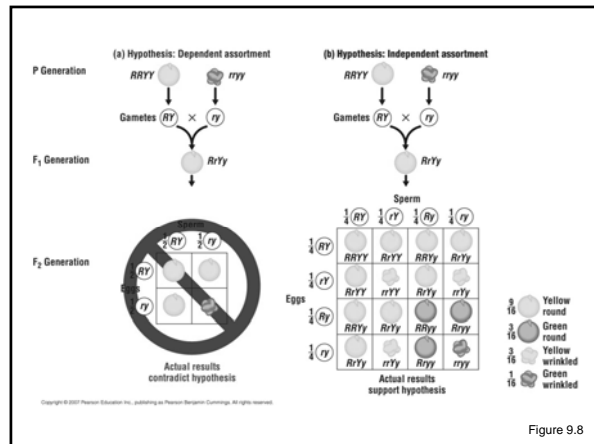
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Mendel's Law of Independent Assortment

- What happens, though, when one allows fertilization of the first generation ($RrYy$)?
- Two hypotheses are:
 - **Dependent assortment** – every plant in second generation will have seeds exactly like one of their parents.
 - **Independent assortment** – plants in second generation will have four different seed phenotypes (physical expressions) which include yellow round, yellow wrinkled, green round, green wrinkled.

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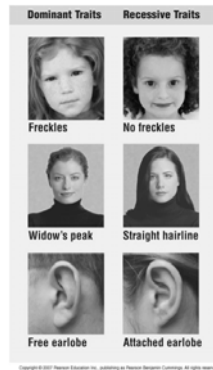
Mendel's Law of Independent Assortment

- Mendel found that four different phenotypes were produced - yellow round, green round, yellow wrinkled, green wrinkled.
- Mendel's **Law of Independent Assortment:**
- Results supported the hypothesis that *each pair of alleles sorts independently of the other pair of alleles during the formation of egg and sperm.*
- In other words, the inheritance of one characteristic has no effect on the inheritance of another.

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Family Pedigrees

- Mendel's principles apply to the inheritance of many human traits.



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Figure 9.12

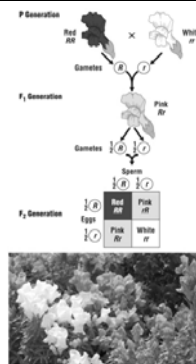
Variations On Mendel's Laws

- Some patterns of genetic inheritance are not explained by Mendel's laws.

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Incomplete Dominance in Plants and People

- In incomplete dominance, first generation hybrids have an appearance in between the phenotypes of the two parents.







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Figure 9.16

ABO Blood Type: An Example of Multiple Alleles and Codominance

- The ABO blood groups in humans are an example of multiple alleles.
- Three common alleles for the characteristics of ABO blood groups: I^A , I^B , i .
- The three alleles produce four phenotypes: A, B, O, AB.

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Genotype	Phenotype (Blood Type)	Red Blood Cells
$I^A I^A$ or $I^A i$	A	 Carbohydrate A
$I^B I^B$ or $I^B i$	B	 Carbohydrate B
$I^A I^B$	AB	
ii	O	

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Figure 9.18

- The immune system produces blood proteins called antibodies that can bind specifically to the blood cell carbohydrates we lack.
- If a donor's blood cells have a carbohydrate that is foreign to the recipient, then the recipient's antibodies will cause the blood cells to clump together.
 - Clumping (or clotting) can kill the recipient.

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Blood Group (Phenotype)	Antibodies Present in Blood	Reaction When Blood from Groups Below Is Mixed with Antibodies from Groups at Left			
		O	A	B	AB
O	Anti-A Anti-B				
A	Anti-B				
B	Anti-A				
AB	—				

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Figure 9.19

- Two of the human blood type alleles (I^A , I^B) exhibit **codominance** meaning that both alleles are expressed in heterozygous individuals ($I^A I^B$), who have type AB blood.
 - Both alleles are expressed in the phenotype.

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Polygenic Inheritance

- **Polygenic inheritance** is the additive effects of two or more genes on a single phenotypic characteristic.
- Example: skin color and height
- Assume that skin pigmentation in humans is controlled by three genes that are inherited separately.
- Dark skin allele is A , B , C contributes one “unit” of darkness and is incompletely dominant to the other alleles (a , b , c).

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Polygenic Inheritance

- Person who is $AABBCC$ would be very dark
- Person who is $aabbcc$ would be very light
- Person who is $AaBbCc$ would have skin of intermediate shade.
- Because the alleles have an additive effect, the genotype $AaBbCc$ would produce the same skin color as any other genotype with just three dark skin alleles such as $AABbcc$.

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The Role of Environment

- Many human characteristics result from a combination of heredity and environment.



Figure 9.22

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