Biology

Chapter 11 Notes: Genetics

Biology PRENTICE HALL — Section 11-1

Interest Grabber

Analyzing Inheritance

Offspring resemble their parents. Offspring inherit genes for characteristics from their parents. To learn about inheritance, scientists have experimented with breeding various plants and animals.

In each experiment shown in the table on the next slide, two pea plants with different characteristics were bred. Then, the offspring produced were bred to produce a second generation of offspring. Consider the data and answer the questions that follow.

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Interest Grabber *continued*

Parents	First Generation	Second Generation
Long stems × short stems	All long	787 long: 277 short
Red flowers × white flowers	All red	705 red: 224 white
Green pods × yellow pods	All green	428 green: 152 yellow
Round seeds × wrinkled seeds	All round	5474 round: 1850 wrinkled
Yellow seeds × green seeds	All yellow	6022 yellow: 2001 green

1. In the first generation of each experiment, how do the characteristics of the offspring compare to the parents' characteristics?

2. How do the characteristics of the second generation compare to the characteristics of the first generation?

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Biology PRENTICE HALL — Section 11-1

Section Outline

11–1 The Work of Gregor Mendel

A. Gregor Mendel's Peas
B. Genes and Dominance
C. Segregation
   1. The F_1 Cross
   2. Explaining the F_1 Cross

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Chapter 11 Notes:
Mendel and Heredity

- **Key Terms:**
- heredity
- genetics
- monohybrid cross
- true-breeding
- P generation
- F_1 generation
- F_2 generation
- alleles
- dominant
- recessive
- homozygous
- heterozygous
- genotype
- Gregor Johann Mendel
- phenotype
- law of segregation
- law of independent assortment
- Punnet square
- test cross
- probability
- pedigree
- sex-linked trait
- polygenic trait
- incomplete dominance
- codominance
- multiple alleles
- Sickle cell anemia
- Hemophilia
- Huntington's disease

Objective 1: Identify the investigator whose studies formed the basis of modern genetics

- **Heredity**--the passing of traits from parents to offspring
- **Genetics**--the branch of biology that studies heredity
- **Gregor Johann Mendel**
  - carried out experiments with pea plants
  - His experiments were unique because he used a quantitative approach
  - discovered patterns that formed the basis of genetics

Objective 2: List characteristics that make the garden pea a good subject for genetic study

- The pea has many traits that have two clearly different forms.
  - flower color is either purple or white
- Male and female reproductive parts are enclosed within the same flower.
  - Pea plants can self-pollinate or cross-pollinate.
  - Mendel prevented self-pollination by removing the male parts from some plants and the female parts from others.
- Garden pea is small, grows easily, matures quickly, and produces many offspring.

Objective 3: Summarize the three major steps of Mendel's experiments

- **Monohybrid cross**--a cross that involves *one* pair of contrasting traits
  - crossing a plant with purple flowers and one with white flowers
- **Step 1--**Mendel allowed each variety to self-pollinate for several generations
  - This ensured that each variety was **true – breeding**, which means Mendel knew that specific traits would always pass from parents to offspring.
  - True-breeding plants served as the parental generation

Mendel's three steps

- **Step 2**--He cross-pollinated two P generation plants that had contrasting forms of a trait
  - He called the offspring of the P generation the first filial generation, or **F_1 generation**
  - He recorded the number of F_1 plants expressing each trait

Mendel's three steps

- **Step 3**--Mendel allowed the F_1 generation to self-pollinate
  - the offspring of the F_1 generation was called the F_2 generation
  - recorded the number of offspring expressing each trait

Objective 4: Relate the ratios that Mendel observed in his crosses to his data

- When purple flowers were crossed with white flowers
  - all of the offspring in the F_1 had purple flowers
  - in the F_2, 705 had purple flowers and 224 had white flowers.
    - This is a ratio of 3:1
- Mendel found a 3:1 ratio in the F_2 for each of the seven traits he studied

You should now be able to:

- Evaluate how Mendel's studies contributed to the foundation of modern genetics.
- Describe why garden-pea plants are good subjects for genetic experiments.
- Summarize the design of Mendel's pea-plant studies.
- State the ratio Mendel obtained in each F_2 generation for each of the traits he studied.

Objective 5: Describe the four major hypotheses Mendel developed

- For each inherited trait, an individual has two copies of the gene--one from each parent.
- There are alternative versions of genes, called **alleles**

Mendel's hypotheses

- When two different alleles occur together, one of them may be completely expressed, the other may have no observable effect.
  - The expressed form of the trait is the **dominant** trait
  - The trait that is not expressed when the dominant one is present is **recessive**

Law (or Principle) of Dominance—One form of a hereditary trait, the **dominant** trait, prevents the recessive trait from showing up.

Mendel's hypotheses

- When gametes are formed, the alleles for each gene in an individual separate independently of one another.
  - Gametes carry only one allele for each inherited trait
  - During fertilization, each gamete contributes one allele

Objective 6: Describe the terms homozygous, heterozygous, genotype, and phenotype

- Dominant alleles are represented by writing the first letter of the *dominant trait* as a *capital letter*.
  - In pea plants, purple is a dominant trait and is written as *P*
- Recessive alleles are represented by writing the first letter of the *dominant trait* as a *lowercase letter*.
  - In pea plants, white is a recessive trait and is written as *p*

Mendel's findings in modern terms

- **Homozygous**--two alleles of a particular gene present in an individual are the same.
  - A pea plant that is homozygous recessive (pp) will have white flowers.
- **Heterozygous**--the alleles of a particular gene present in an individual are different.
  - A pea plant that is heterozygous (Pp) will have purple flowers

Mendel's findings in modern terms

- **Genotype**--the set of alleles that an individual has.
  - An individual's genetic make-up.
- **Phenotype**--the physical appearance of a trait.

Objective 7: Compare Mendel's two laws of heredity

- **Law of segregation**--states that the two alleles for a trait segregate (separate) when gametes are formed.
  - Describes the behavior of chromosomes during meiosis
    - homologous chromosomes separate
    - then chromatids are separated

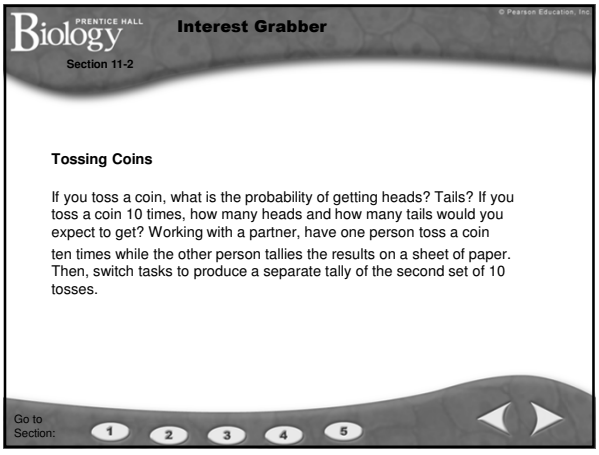
Laws of heredity

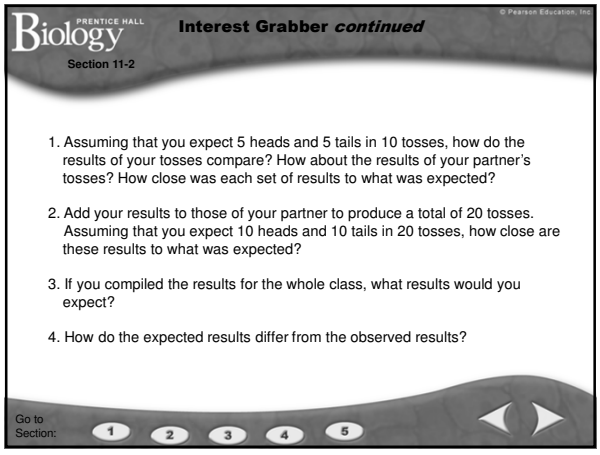
- **Law of independent assortment**--states that the alleles of different genes separate independently of one another during gamete formation.
  - Alleles for plant height separate independently of the alleles for flower color
  - Applies only to genes that are located on different chromosomes
  - or that are far apart on the same chromosome

You should now be able to:

- Differentiate between alleles and genes.
- Apply the terms *homozygous*, *heterozygous*, *dominant*, or *recessive* to describe a plant the genotype *Pp*.
- Identify the phenotype of a rabbit with the genotype *Bb*, where *B* = black coat and *b* = brown coat.
- Determine whether the rabbit in the above statement is heterozygous or homozygous.

Section 11-2 in text





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Section 11-2

Section Outline

11–2 Probability and Punnett Squares

A. Genetics and Probability
B. Punnett Squares
C. Probability and Segregation
D. Probabilities Predict Averages

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Objective 8: Predict the results of monohybrid genetic crosses by using Punnett squares

- **Punnett square**--a diagram used to predict the expected outcomes of a genetic cross.
  - considers all possible combinations of gametes in the cross
  - the possible gametes that one parent can produce are written along the top of a square
  - the possible gametes the other can produce are written along the left side

Monohybrid cross: homozygous plants

YY = yellow seeds
yy = green seeds

	Y	Y
y	Y y	Y y
y	Y y	Y y

The letters in the boxes indicate the possible genotypes of the offspring.

The offspring are all heterozygous and will have yellow seeds.

Monohybrid cross: heterozygous plants

Y = yellow seeds
yy = green seeds

	Y	y
Y	Y Y	Y y
y	Y y	y y

Predict the genotypes in this heterozygous cross.

One offspring is homozygous dominant (YY), another homozygous recessive (yy), and the remaining two are heterozygous (Yy). Three will have yellow seeds and one will have green seeds.

Monohybrid Crosses

Review :o)

Gregor Mendel

- A. First person to succeed in predicting how traits are transferred from one generation to the next.
- B. Studied pea plants because…
  - they're easy to grow
  - self-fertilizing
  - short generation time
- C. Considered the father of Genetics

Probability

- Branch of math that predicts the chances of event occurring.
- Probability= $\frac{\text{\# of events of choice}}{\text{\# of possible events}}$

Probability (cont.)

- 1st Principle of Probability
  - The outcome of a random event is not affected by the outcome of the previous events

Probability (cont.)

- What is the probability of tossing heads with a coin?
  - ½
- What is the probability of tossing heads a second time?
  - ½

What is the probability of flipping heads twice in a row?

- ½ X ½ = 1/4

Probability (cont.)

- 2nd Principle
  - Increasing the number of trials means you will be closer in agreement with the expected results.

P Generation

- Parent generation

F Generation

- The offspring generation

Punnett Square

- Shows the probability a trait will occur when 2 individuals mate

Mendel's Monohybrid Cross

- Parental (P) generation

GG x gg

g g

G

G

1st Filial (F_1) generation

Genotypic ratio 4/4 Gg

Phenotypic ratio 4/4 green pods

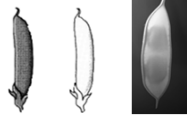
Key:

G – green pod (dominant)

g – yellow pod (recessive)

Homozygous – GG or gg

Heterozygous - Gg



Mendel (con.)

Gg x Gg (2 F_1 plants)

G g

G

g

2nd (F_2) Filial generation

Genotypic ratio ¼ GG : 2/4 Gg : ¼ gg

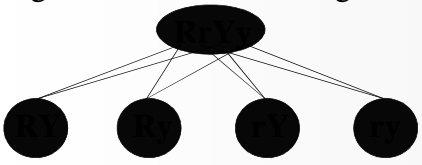
Phenotypic ratio ¾ green pods : ¼ yellow pods

Objective 8: Predict the results of dihybrid genetic crosses by using Punnett squares

- **Dihybrid cross**--a cross that involves *two* pairs of contrasting traits.
  - A cross between two plants that are heterozygous for seed shape (Rr) and seed color (Yy).
  - RrYy

Dihybrid crosses

- An individual with the genotype RrYy can generate four different gametes



Dihybrid crosses

Possible gametes from each parent

Objective 9: Apply a test cross to determine the genotype of an organism with a dominant phenotype

- **Test cross**--a cross in which an individual whose phenotype is dominant, but whose genotype is not known, is crossed with a homozygous recessive individual.

Test cross

- A plant with yellow seeds but unknown genotype (Y?) is crossed with a plant with green seeds (yy).
  - If all the offspring produce yellow seeds, the unknown plant must be YY.
  - If an offspring produces green seeds, the unknown plant must be Yy.

Objective 10: Predict the results of mono-hybrid genetic crosses by using probabilities.

You should now be able to:

- Predict the expected phenotypic and genotypic ratios among the offspring of two individuals who are heterozygous for freckles (Ff) by using a Punnett square.
- Summarize how a test cross can reveal the genotype of a pea plant with round seeds.
- Calculate the probability that an individual heterozygous for a cleft chin (Cc) and an individual homozygous for a non-cleft chin (cc) will produce offspring that are homozygous recessive for a non-cleft chin (cc).

Objective 12: Identify five factors that influence patterns of heredity.

- **Polygenic trait**--a trait influenced by several genes
  - eye color, height, weight, hair & skin color
  - the genes may be scattered along the same chromosome or located on different chromosomes

Intermediate traits

- **Incomplete dominance**--when an individual displays a trait that is intermediate between the two parents
  - If a snapdragon with red flowers is crossed with one with white flowers the offspring will have pink flowers.
  - In caucasians, the child of a straight-haired parent and a curly-haired parent will have wavy hair.

Codominance

- **Codominance**--when two dominant alleles are expressed at the same time.
  - Roan coats in horses (red and white hairs are present in equal numbers)

Multiple alleles

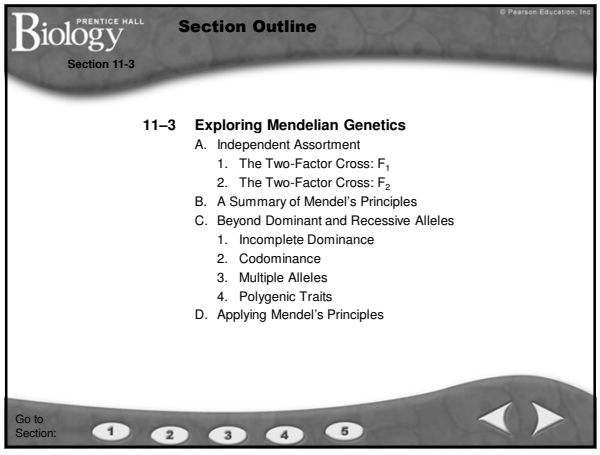
- **Multiple alleles**--genes with three or more alleles.
  - The ABO blood groups are determined by three alleles, I^A, I^B, and i.
  - I^A and I^B are both dominant over i
  - Neither I^A nor I^B is dominant over the other
  - Remember, individuals can have only *two* of the possible alleles for a gene

ABO blood groups

I^AI^A = A blood type
I^Ai = A blood type
I^AI^B = AB blood type
I^BI^B = B blood type
I^Bi = B blood type
ii = O blood type

Rh Factor

Genotypes	Phenotypes
++, + -	+
--	-



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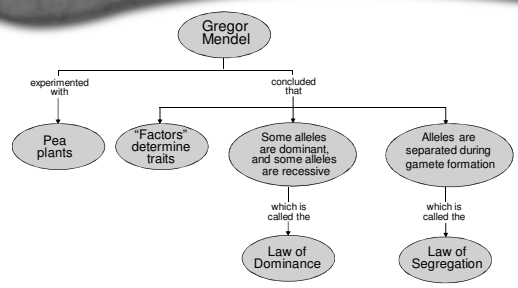
Concept Map

Section 11-3



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11-3 Independent Assortment

After showing that alleles segregate during the formation of gametes, Mendel wondered it they did so independently of each other?

- What does this mean?

Does the segregation of one pair of alleles affect the segregation of another pair of alleles.

- In other words…

Does the gene that determines whether a seed is round or wrinkled have anything do with the gene for whether the seed is green or yellow

1 2 3 4 5

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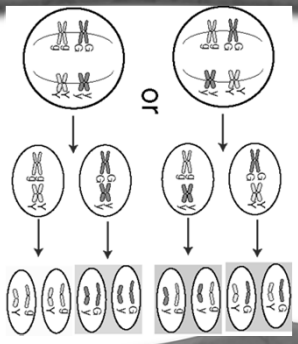
G = green eyes
g = blue eyes

Y = Yellow teeth
y = white teeth

Are green eyes and yellow teeth always inherited together?
NO
Independent Assortment



1 2 3 4 5

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What did Mendel do?

Crossed:

True breeding round and yellow seeds

RRYY

with:

True breeding wrinkled and green seeds

rryy

1 2 3 4 5

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What did the F1 generation look like?

All were Round and Yellow
Their genotype was RrYy (heterozygous for round and yellow)

1 2 3 4 5

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He then performed an F1 cross

Male x Female
RrYy x RrYy

What were the possible gametes?

Pollen
RY Ry rY ry

Egg
RY Ry rY ry

1 2 3 4 5

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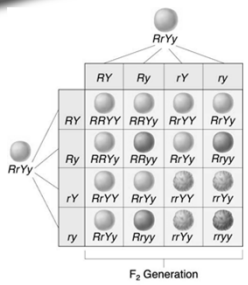
Section 11-3

Figure 11-10 Independent Assortment in Peas



F2 generation results:
9 round yellow
3 round green
3 wrinkled yellow
1 wrinkled green

Did the alleles assort independently? Yes

Go to Section: 1 2 3 4 5

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Beyond Dominant and Recessive Alleles

Incomplete Dominance – One allele is not completely dominant over another. The heterozygous phenotype is somewhere in between the two homozygous phenotypes. "Blend"

Example: Flower color in four o'clock plants
Humans -Wavy hair is "blend" between straight hair and curly hair

1 2 3 4 5

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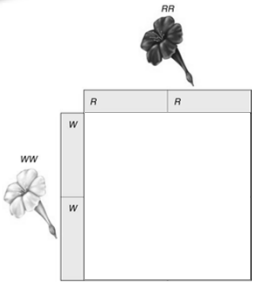
Section 11-3

Figure 11-11 Incomplete Dominance in Four O'Clock Flowers



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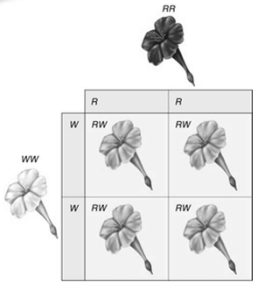
Section 11-3

Figure 11-11 Incomplete Dominance in Four O'Clock Flowers



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Beyond Dominant and Recessive Alleles

Co-dominance – Both alleles contribute to the phenotype of the organism.

Example: Roan coat colors in animals (mixture between white hairs and pigmented hairs.

1 2 3 4 5

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Co-dominance Problem

Exp. Genotype Frequencies
¼ RR
½ RW
¼ WW

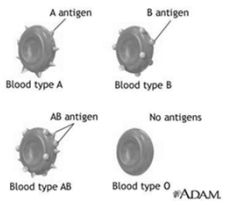
Exp. Phenotype Frequencies
¼ Red
½ Roan (codominance)
¼ White

1 2 3 4 5

Beyond Dominant and Recessive Alleles

Multiple Alleles – Genes having more than two alleles

Ex. Blood type in humans



Blood Type	Genotype		Can Receive Blood From:
A	$i^A i$ $i^A i^A$	AA AO	A or O
B	$i^B i$ $i^B i^B$	BB BO	B or O
AB	$i^A i^B$	AB	A, B, AB, O
O	ii	OO	O

Beyond Dominant and Recessive Alleles

Polygenic Traits – Two or more genes control a trait

Ex. Eye color, height, skin color http://www.athro.com/evo/inherit.html

Applying Mendel's Principles

Thomas Morgan Hunt – Looking for "Model Organism" for studying genetics in animals

Decided on Fruit Flies. Why?

- Small in size
- Easy to keep in laboratory
- Able to produce large numbers in a short amount of time
- Relatively small "genome"

Quiz over 11-3 on Thursday

Complete 11-3 Section Review for tomorrow

Interest Grabber

Section 11-4

How Many Chromosomes?

Normal human body cells each contain 46 chromosomes. The cell division process that body cells undergo is called mitosis and produces daughter cells that are virtually identical to the parent cell. Working with a partner, discuss and answer the questions that follow.

Interest Grabber *continued*

Section 11-4

1. How many chromosomes would a sperm or an egg contain if either one resulted from the process of mitosis?

2. If a sperm containing 46 chromosomes fused with an egg containing 46 chromosomes, how many chromosomes would the resulting fertilized egg contain? Do you think this would create any problems in the developing embryo?

3. In order to produce a fertilized egg with the appropriate number of chromosomes (46), how many chromosomes should each sperm and egg have?