Homework

- Read the “Law of Segregation” section in chapter 11
  - Objective #’s 2-3

© 2014 Pearson Education, Inc.

CAMPBELL BIOLOGY IN FOCUS

Urry • Cain • Wasserman • Minorsky • Jackson • Reece

11

Mendel and the Gene Idea

Lecture Presentations by
Kathleen Fitzpatrick and Nicole Tunbridge

© 2014 Pearson Education, Inc.

Objective: You will be able to explain how a Punnett square is used to determine heredity.

- **Do Now:**
  - Take out your meiosis drawings

© 2014 Pearson Education, Inc.

Some genetic vocabulary

- **Character:** a heritable feature, such as flower color
  - **Genes** code for characters

- **Trait:** a variant of a character, such as purple or white flowers
  - **Alleles** code for the alternative traits

Turn to a partner and come up with 3 genes for human characteristics

Provide 2 alleles for each

© 2014 Pearson Education, Inc.

The BIG Overview

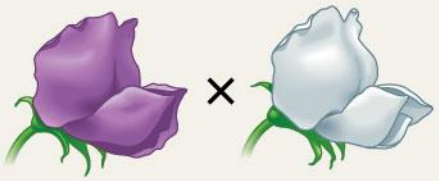
- Genetics and heredity
- Mendel discovered genes
- Gene-Chromosome theory
- Mitosis/meiosis
- Free-write on how all of these terms fit together

© 2014 Pearson Education, Inc.

Figure 14.3-1

EXPERIMENT

P Generation
(true-breeding parents)

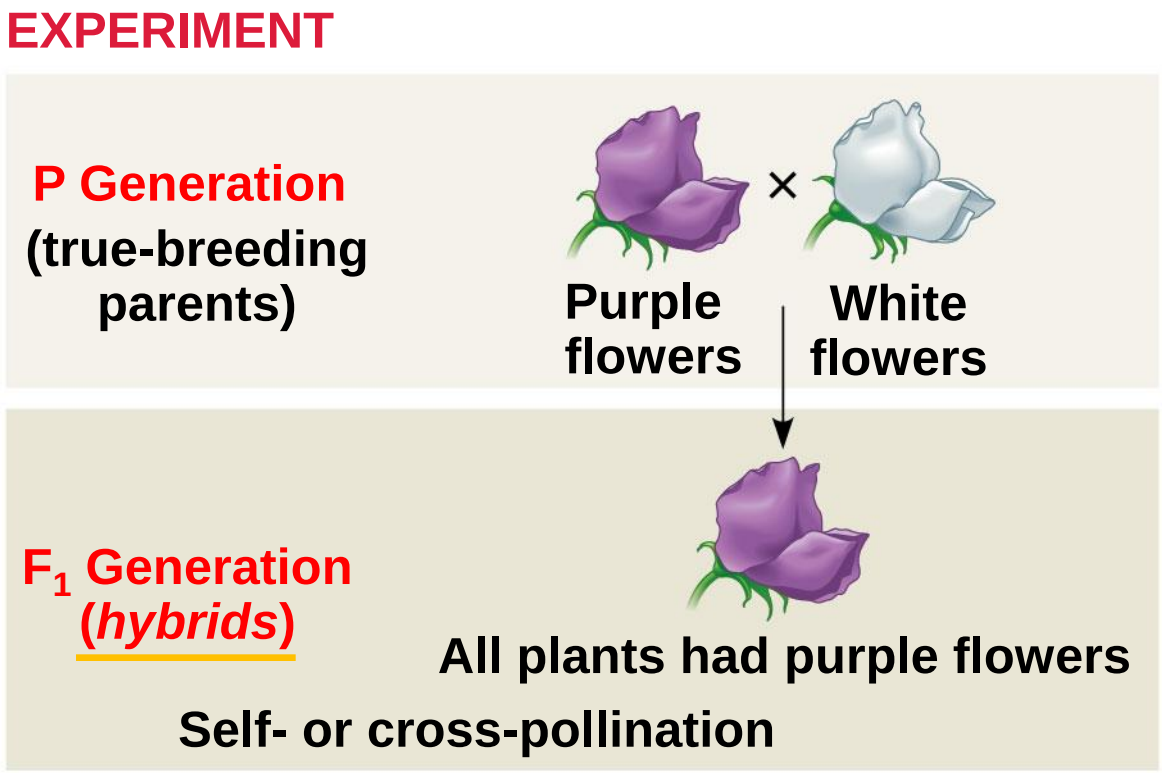


Purple flowers × **White flowers**

© 2011 Pearson Education, Inc.

© 2014 Pearson Education, Inc.

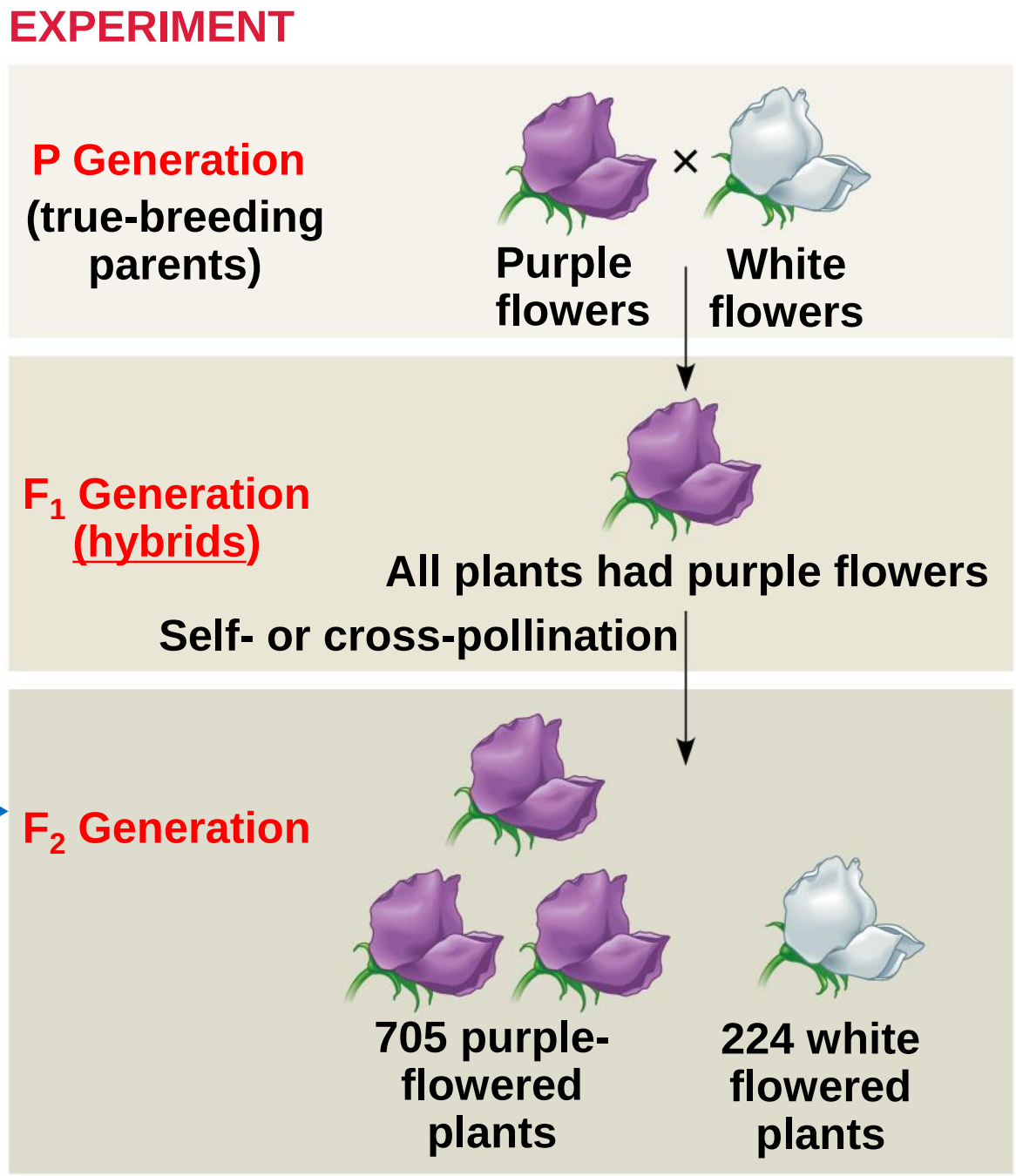
Figure 14.3-2



Why were they all purple?

© 2011 Pearson Education, Inc.
© 2014 Pearson Education, Inc.

Figure 14.3-3



How did the white reappear?

© 2011 Pearson Education, Inc.

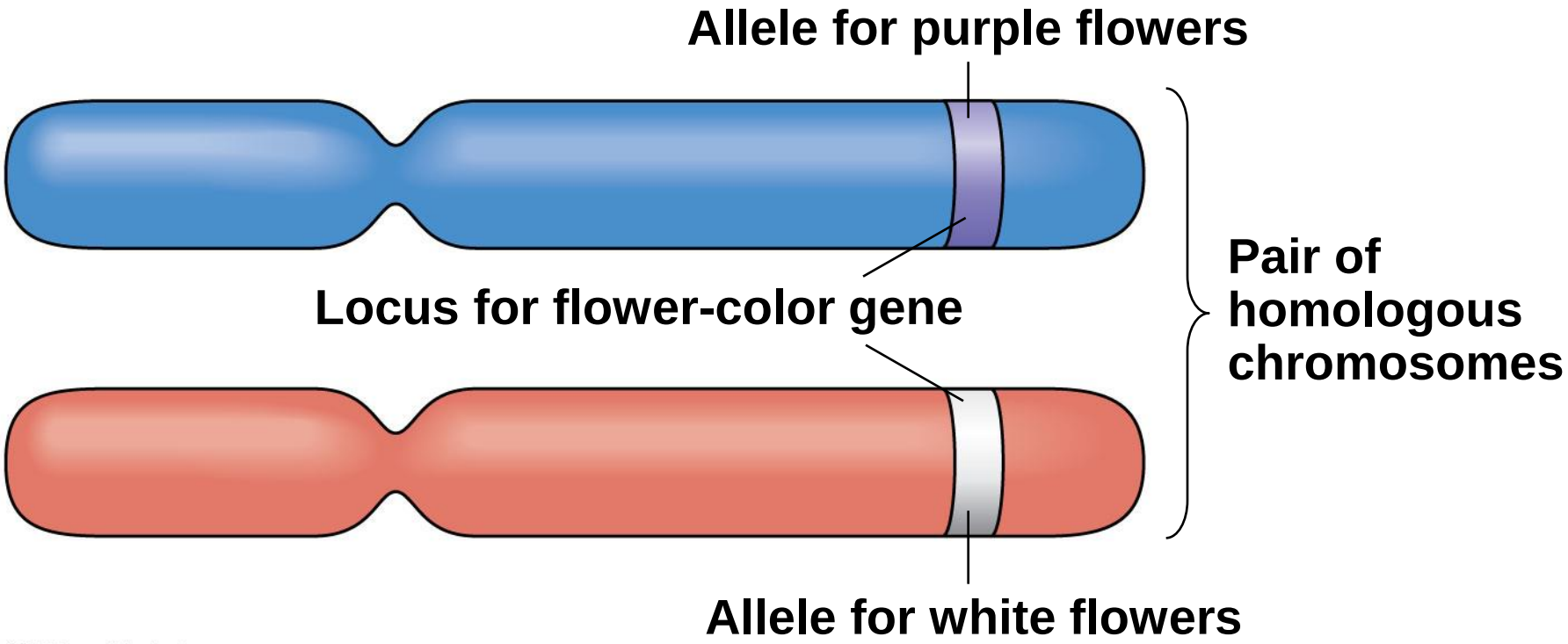
© 2014 Pearson Education, Inc.

Mendel's Model to Explain the 3:1 ratio

1. Alternative versions of a genes, called **alleles**, accounts for each character (color in this case)
    - We now know that these genes and their alleles are found on chromosomes

© 2014 Pearson Education, Inc.

Figure 14.4

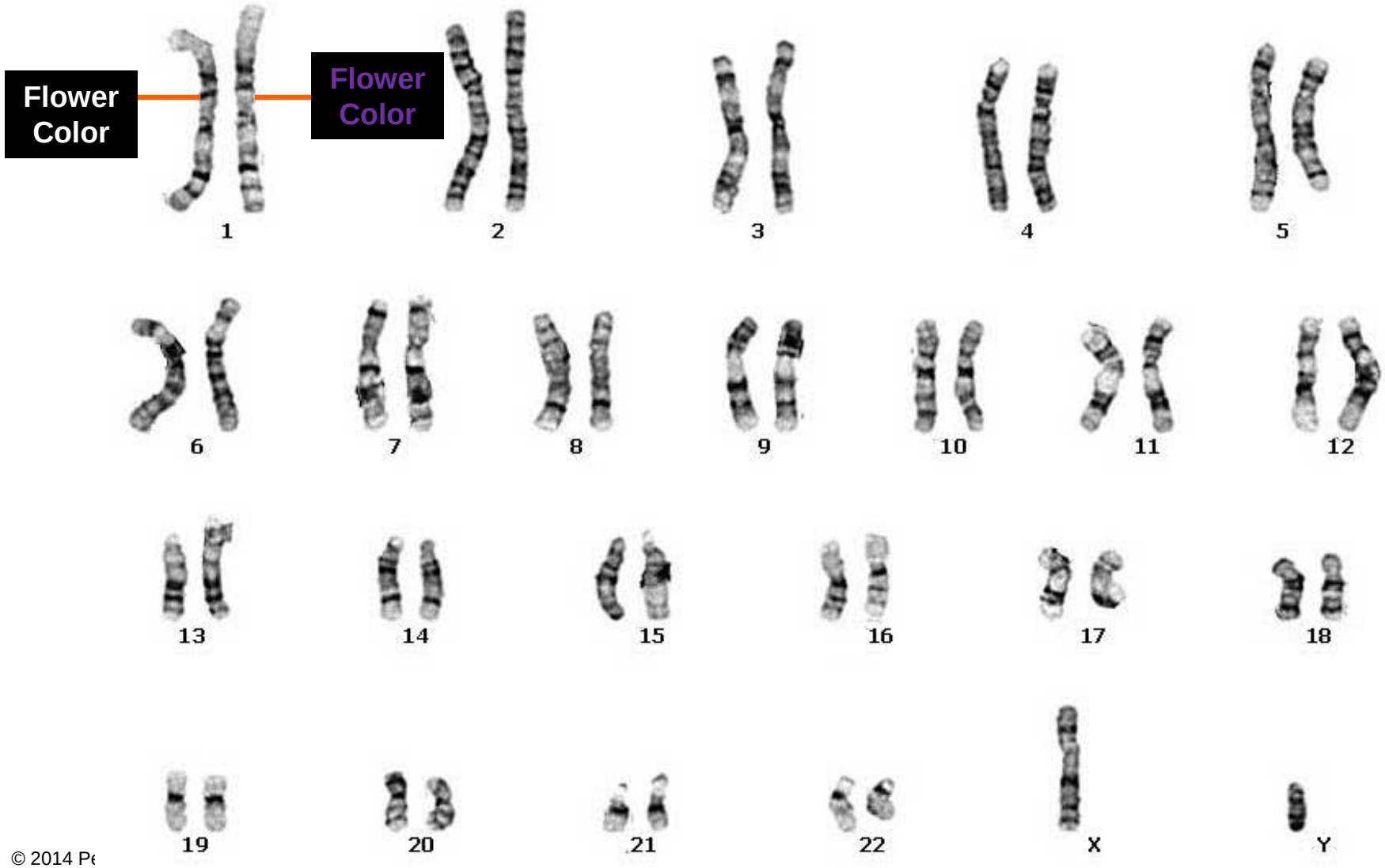


© 2011 Pearson Education, Inc.

© 2014 Pearson Education, Inc.

True-breeding versus non-true-breeding

Homozygous versus Heterozygous



© 2014 Pe

Mendel's Model to Explain the 3:1 ratio in F_2

1. Alternative versions of a genes, called **alleles**, accounts for each character (color in this case)
   - We now know that these genes and their alleles are found on chromosomes

2. An organism inherits two copies (2 alleles), 1 from each parent

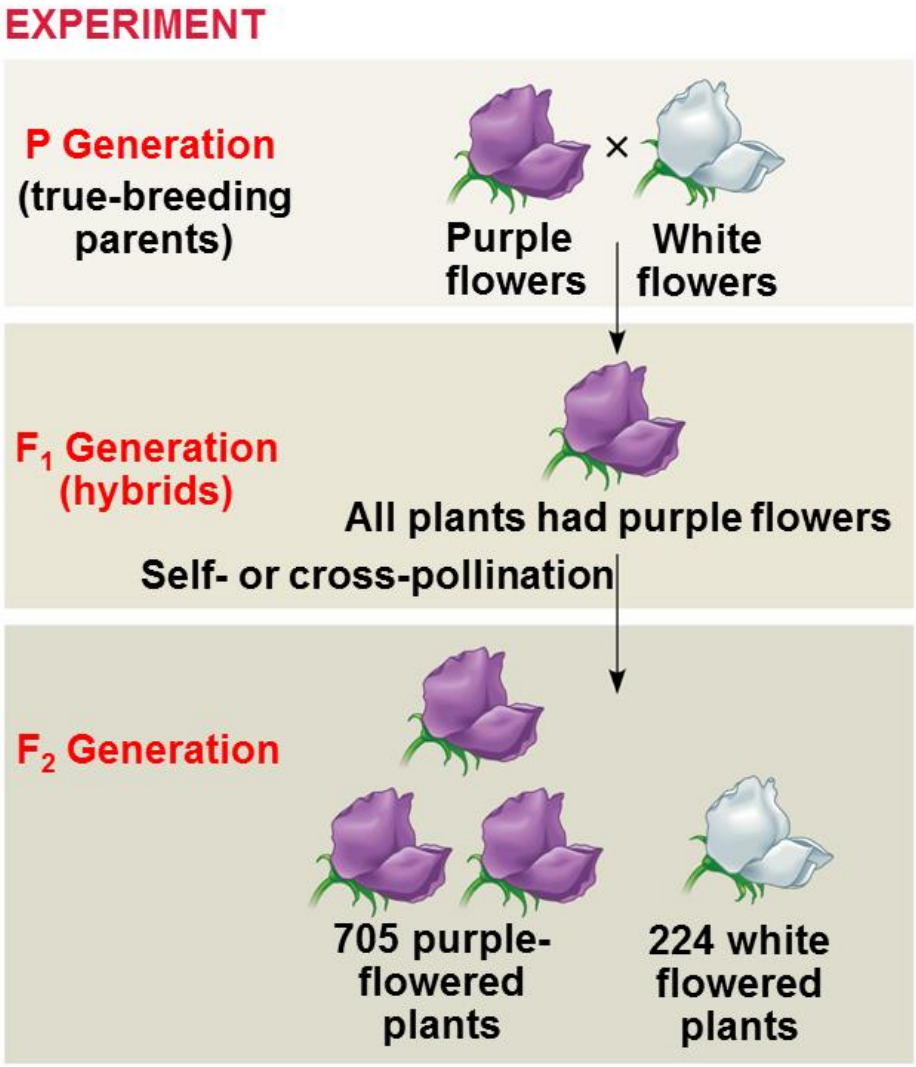
3. If an organism has two different alleles, the dominant allele will appear

4. The two alleles segregate from each other during gamete formation and *end up in different gametes*
   - ***This is called the Law of Segregation***

Does this model explain the 3:1 ratio in the F_2 generation?

© 2014 Pearson Education, Inc.

Punnett Squares and Lettering System



© 2011 Pearson Education, Inc.

© 2014 Pearson Education, Inc.

Table 11.1 The Results of Mendel's F_1 Crosses for Seven Characters in Pea Plants

Character	Dominant Trait	×	Recessive Trait	F_2 Generation Dominant: Recessive	Ratio
Flower color	Purple	×	White	705:224	3.15:1
Seed color	Yellow	×	Green	6,022:2,001	3.01:1
Seed shape	Round	×	Wrinkled	5,474:1,850	2.96:1
Pod shape	Inflated	×	Constricted	882:299	2.95:1
Pod color	Green	×	Yellow	428:152	2.82:1
Flower position	Axial	×	Terminal	651:207	3.14:1
Stem length	Tall	×	Dwarf	787:277	2.84:1

Phenotype
vs.
Genotype

Mate a pea plant that is heterozygous for pod shape with a plant that is homozygous recessive

Mate a pea plant that is axial for flower position with one that is terminal.

What do you need to know?

© 2014 Pearson Education, Inc.

Objective: You will be able to use your knowledge of genetics to solve problems using pedigree charts.

Do Now:

- In pea plants, purple flower color is dominant to white.
- If you had a plant with purple flowers, how could you determine if it was homozygous purple or heterozygous purple?

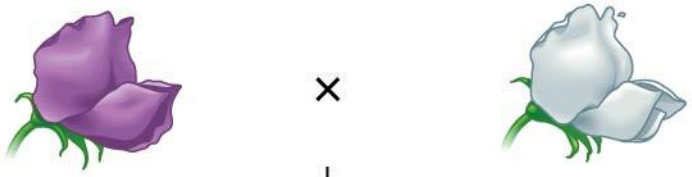
Show your work

© 2014 Pearson Education, Inc.

Figure 11.7

Technique

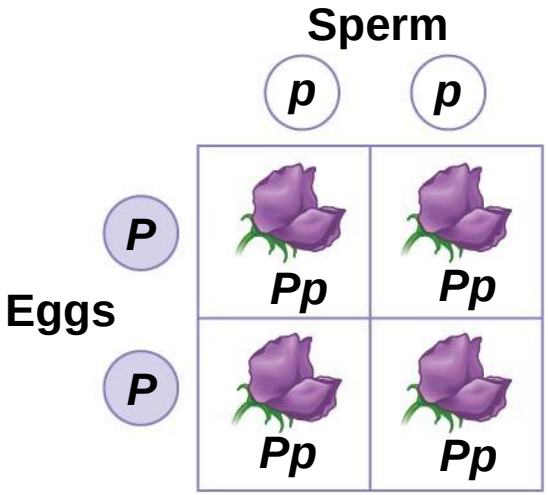
The Testcross



Dominant phenotype, unknown genotype: *PP* or *Pp*? × **Recessive phenotype, known genotype: *pp***

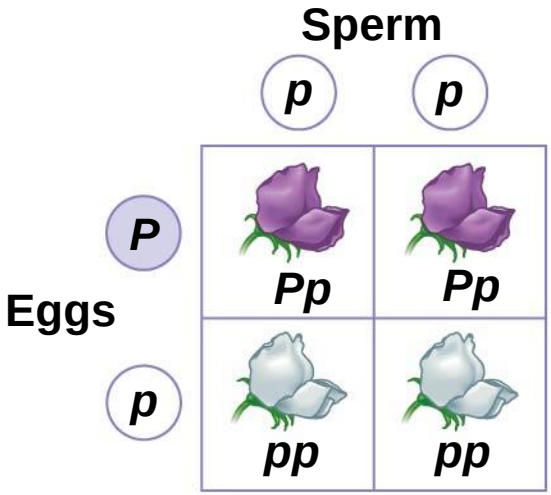
Predictions

If purple-flowered parent is *PP*



or

If purple-flowered parent is *Pp*



Results

All offspring purple

or

½ offspring purple and ½ offspring white

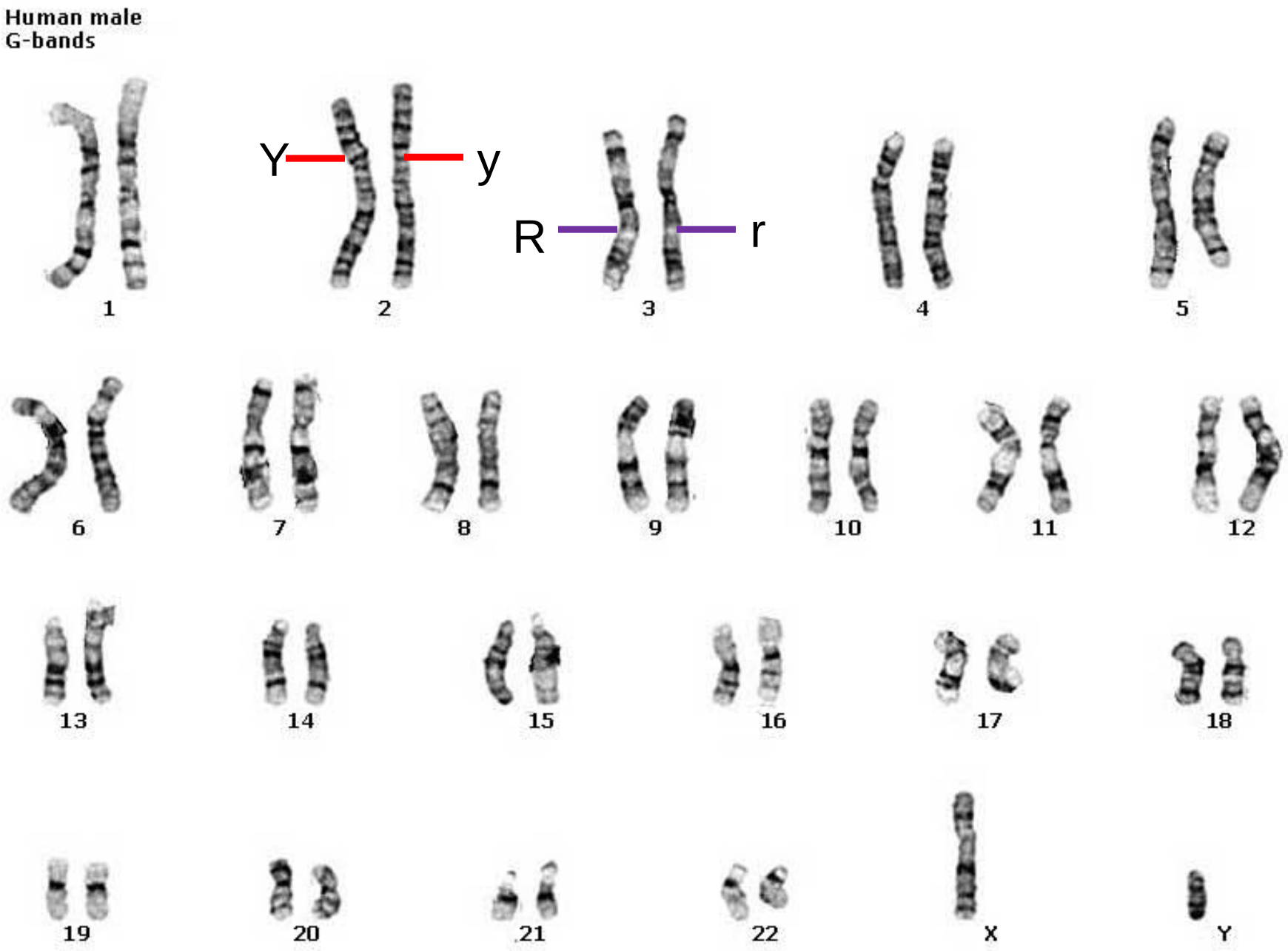
© 2014 Pearson Education, Inc.

- Take out the basic genetics worksheet from last night. Compare your answers to a neighbor.

- Monohybrid crosses
  - Pp x Pp **OR** Yy x Yy **OR** Rr x Rr
  - What phenotype ratio will you *always* get?
  - Demonstrates the **<u>Law of Segregation</u>**

© 2014 Pearson Education, Inc.

Figure 13.x5 Human male karyotype shown by bright field G-banding of chromosomes

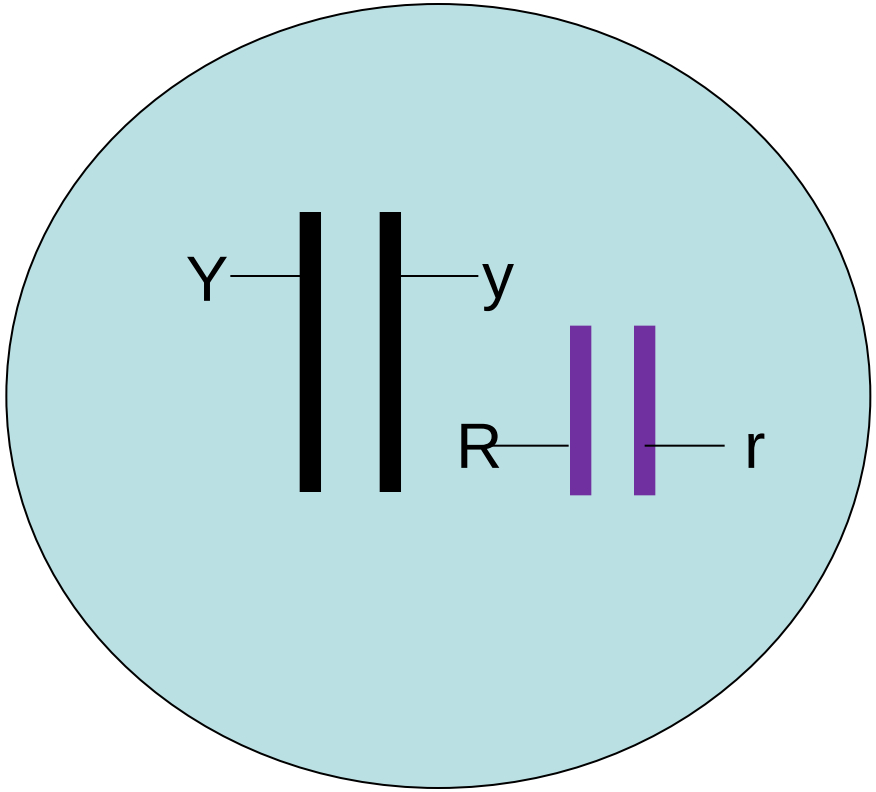


©

Meiosis and Segregation

- Compare the chromosomes with “Y” and “y”
- Compare the chromosomes with the “Y’s with those with the “R’s”

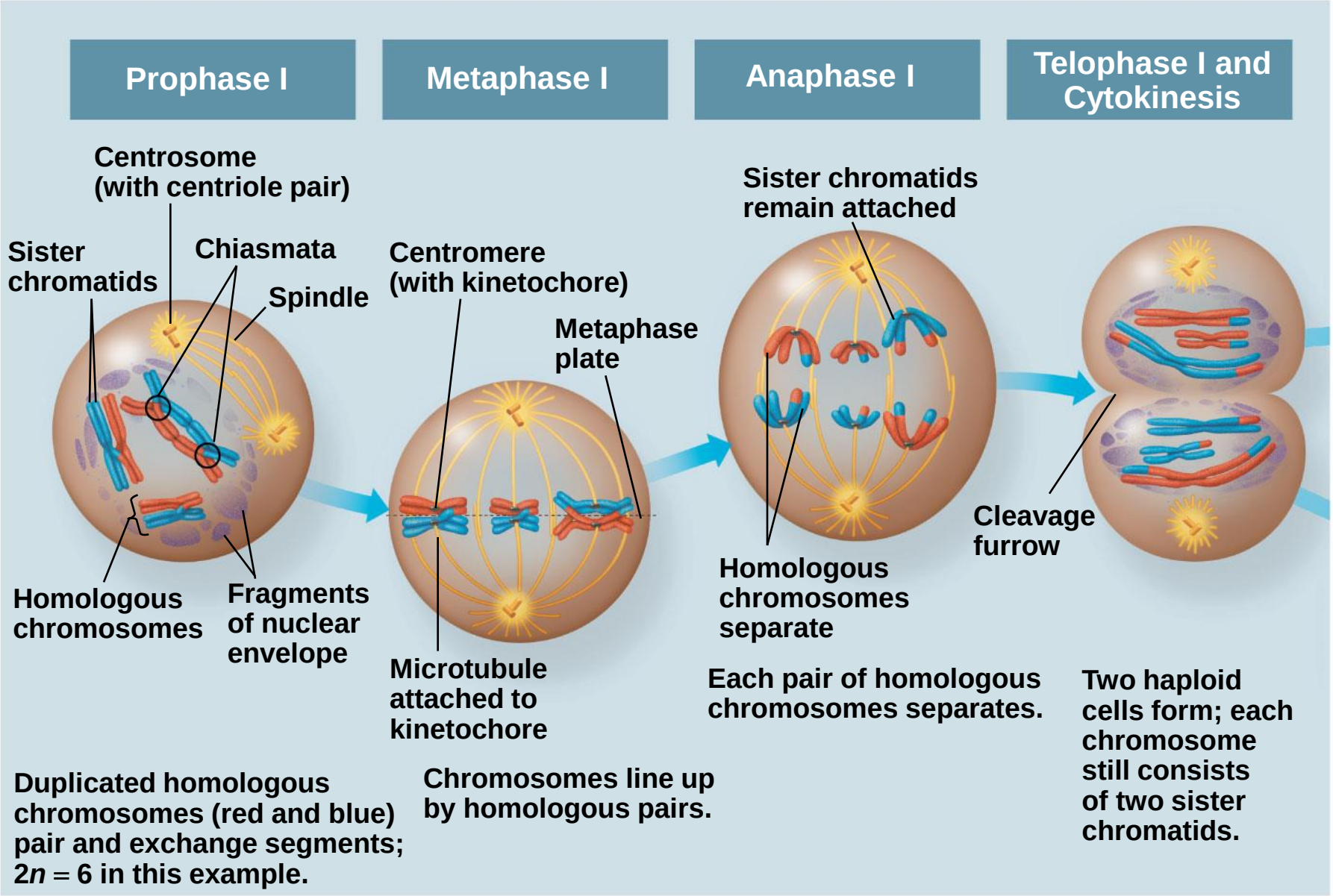
When the “Y” and the “y” separate when you make gametes, it causes the law of segregation to occur.



- Think back to Meiosis. When does the chromosome with the “**Y**” separate from the chromosome with “**y**”?

© 2014 Pearson Education, Inc.

Figure 13.8a



© 2011 Pearson Education, Inc.

© 2014 Pearson Education, Inc.

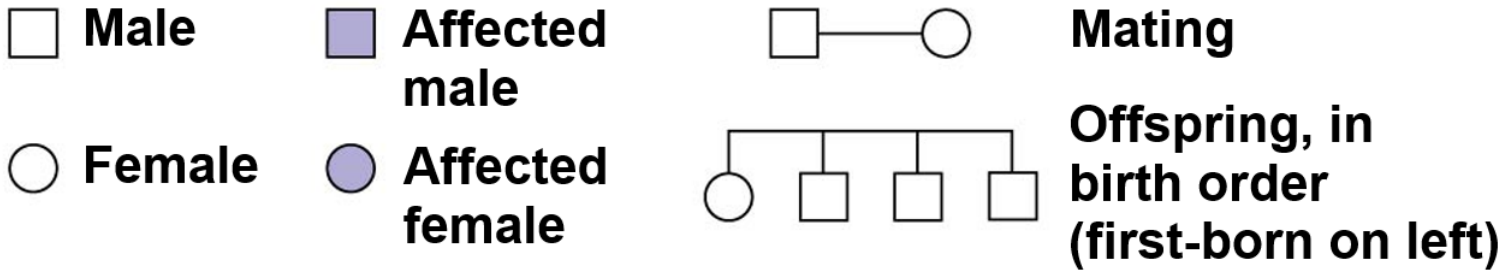
Pedigree Charts

- Help track a gene/alleles through generations
- Can determine:
  - Dominant/recessive alleles
  - a persons probable genotype

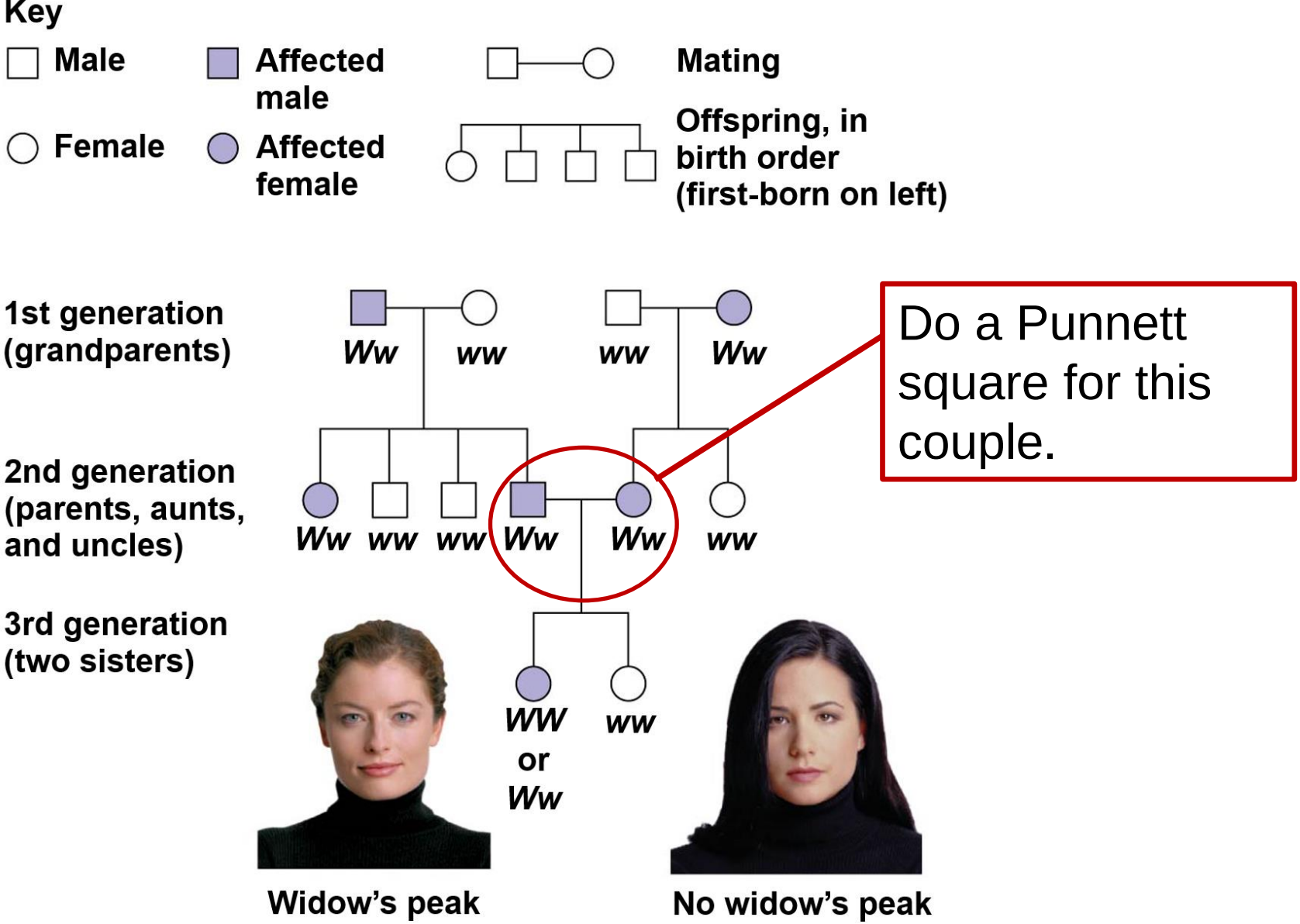
© 2014 Pearson Education, Inc.

la

Key



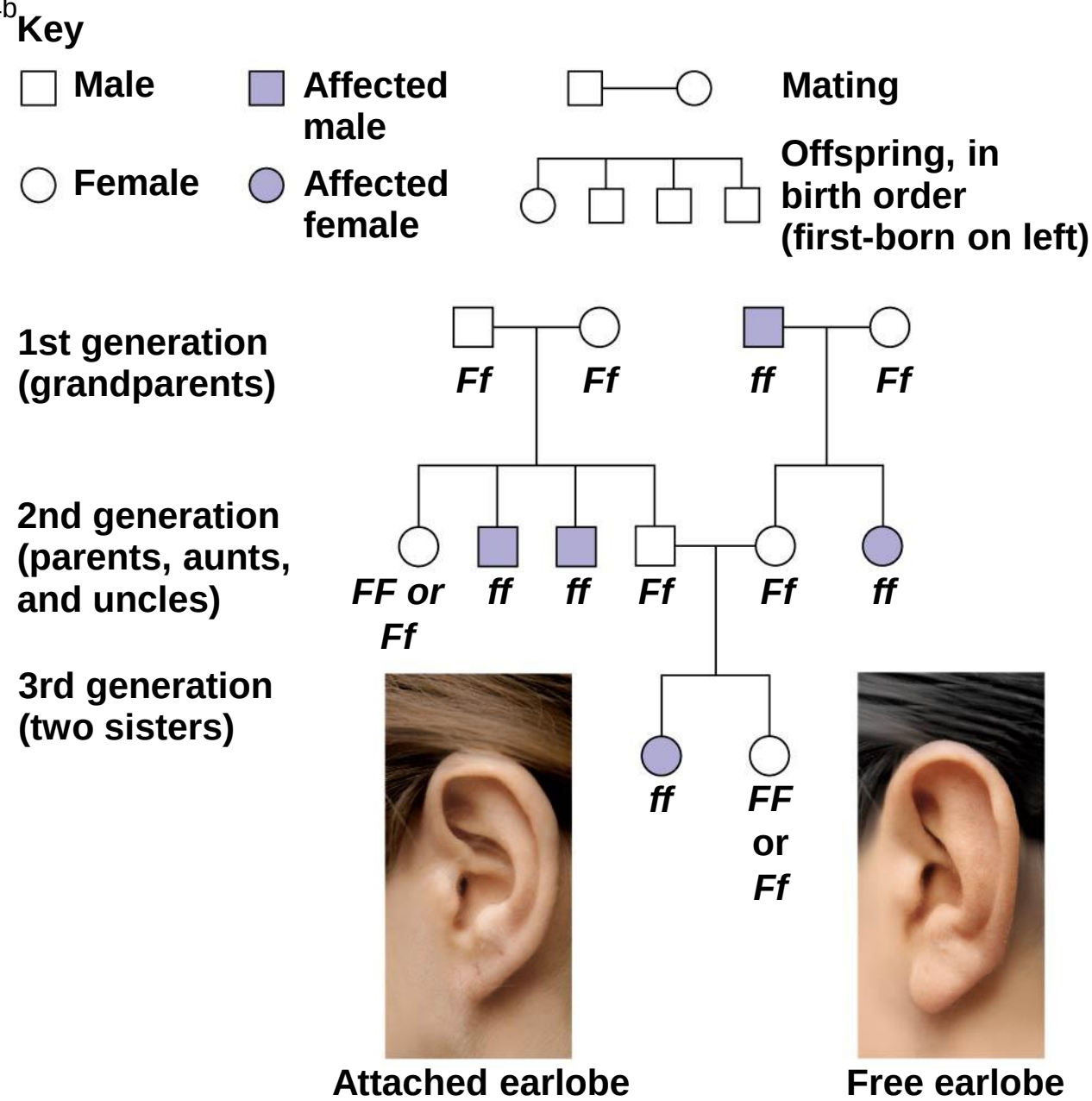
© 2014 Pearson Education, Inc.



(a) Is a widow's peak a dominant or recessive trait?

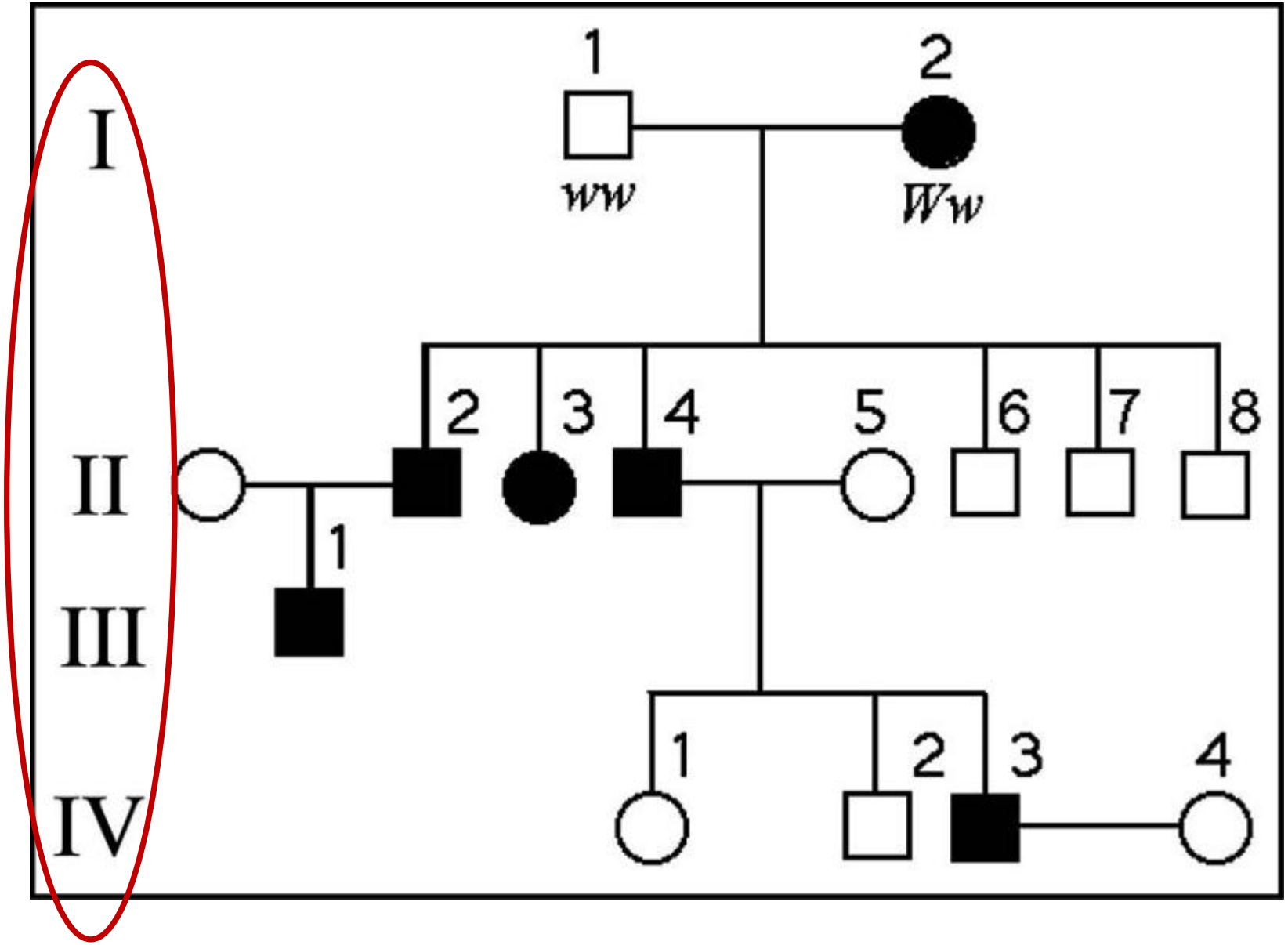
© 2014 Pearson Education, Inc.

Figure 11.14b



(b) Is an attached earlobe a dominant or recessive trait?

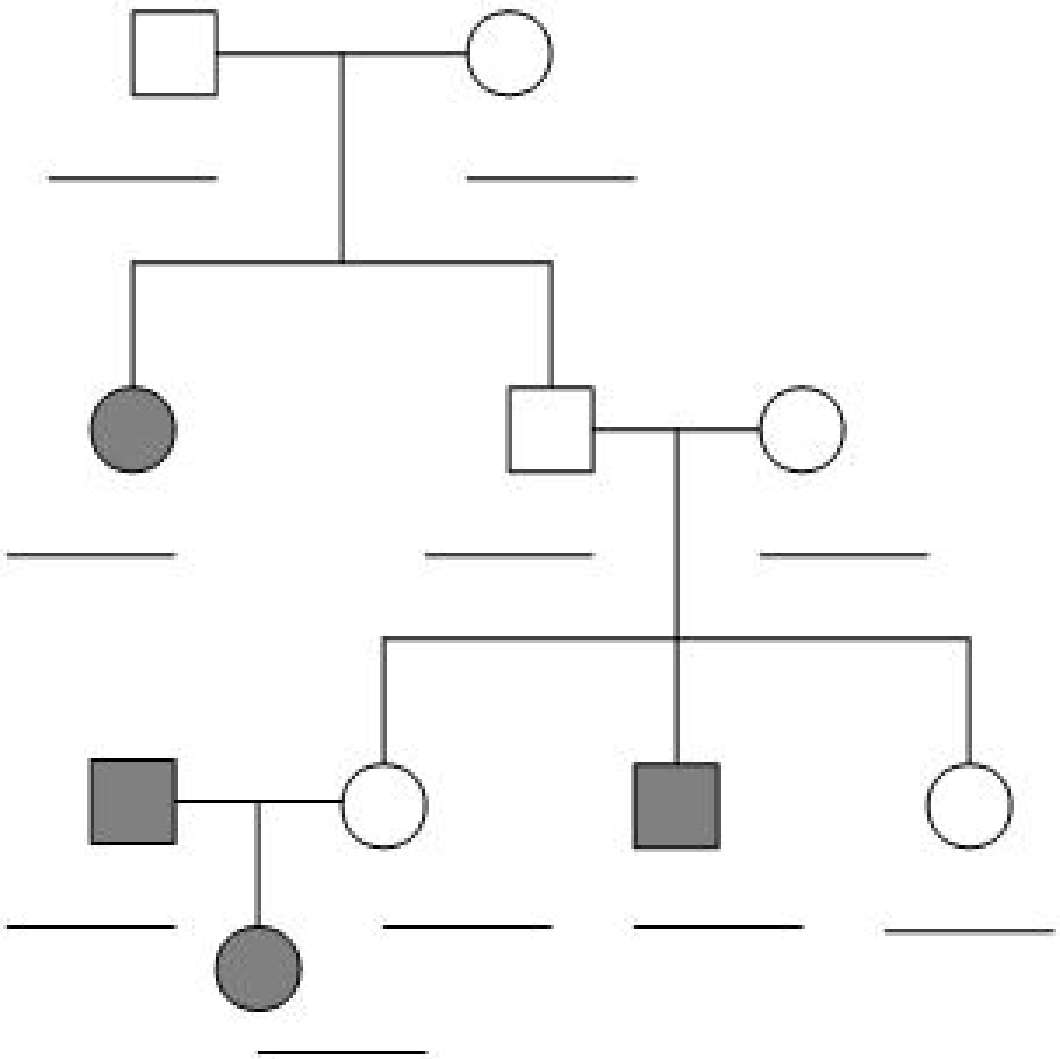
© 2014 Pearson Education, Inc.



© 2014 Pearson Education, Inc.

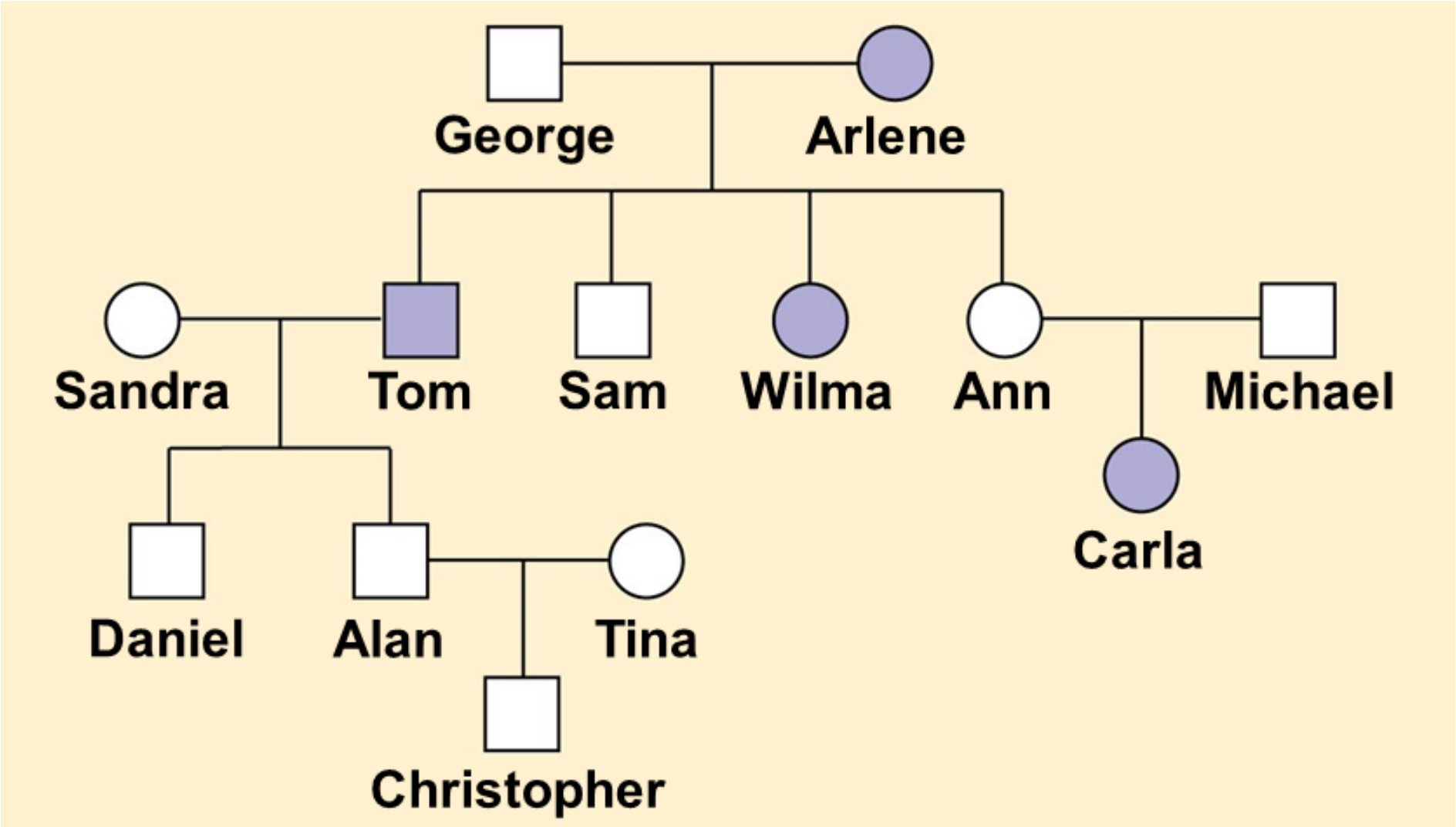
- **What would you look for in a pedigree chart to determine if a trait was dominant and not recessive?**

- **Does this trace a dominant or recessive trait?**



© 2014 Pearson Education, Inc.

- **Does this trace a dominant or recessive trait?**
- **What evidence do you have to support your answer?**



© 2014 Pearson Education, Inc.

Paired Work

- Work on the Pedigree chart activity

© 2014 Pearson Education, Inc.

Objective: You will be able to compare and contrast the law of segregation and the law of independent assortment

- **Do Now:**

© 2014 Pearson Education, Inc.

The Law of Independent Assortment

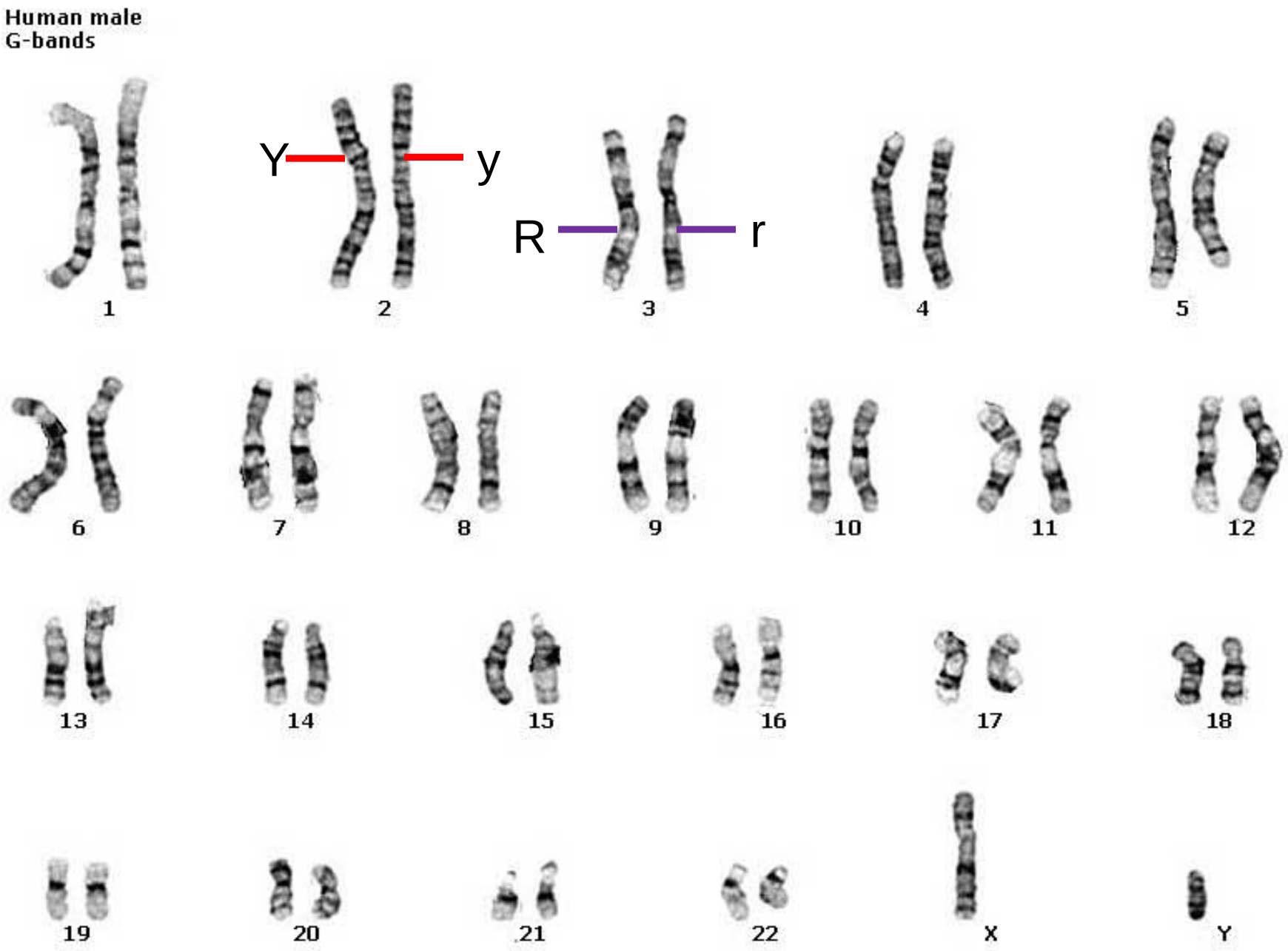
- Non-homologous chromosomes separate independently of each other during gamete formation.
- In pea plants round is dominant to wrinkled and yellow pea color is dominant to green

YyRr x YyRr

  - **This is a dihybrid cross**
  - Write down each different sex cell formed by the first parent
  - Make a Punnett square
  - Find the Phenotype ratio

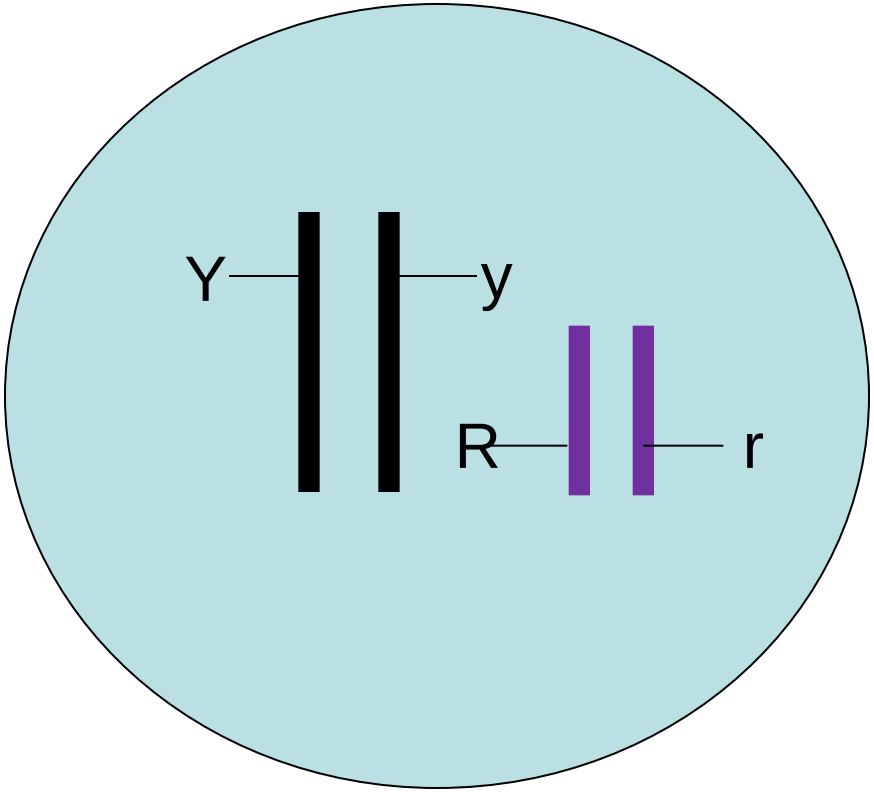
© 2011 Pearson Education, Inc.

Figure 13.x5 Human male karyotype shown by bright field G-banding of chromosomes



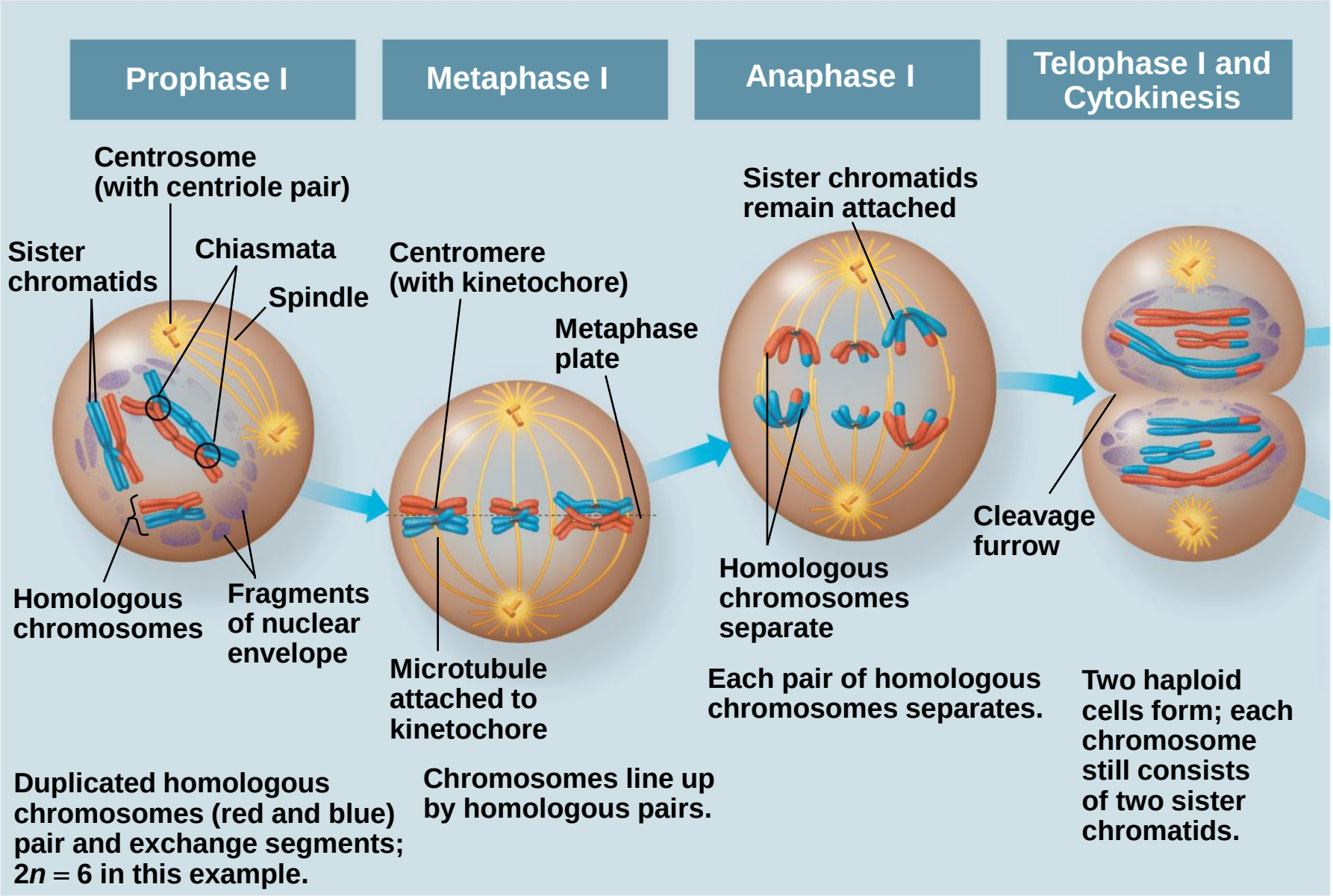
©

Meiosis and Independent Assortment



© 2014 Pearson Education, Inc.

Figure 13.8a



© 2011 Pearson Education, Inc.

© 2014 Pearson Education, Inc.

Paired Work

- Work with a partner to differentiate between the laws of segregation and independent assortment

- Begin working on the independent assortment worksheet

© 2014 Pearson Education, Inc.

Objective: You will be able to use math to solve complex genetics problems.

Do Now:

- Take out the independent assortment sheet and compare with a partner.

- List the different sex cells that can be created with the following individual (AABbccDd)
  - What is the probability that the sex cell will have:
    - At least the “B”
    - At least “B” and “D”
    - “AbcD”

© 2014 Pearson Education, Inc.

Important Ratios to Know

- 1:1
- 3:1
- 4:0
- 1:2:1
- 9:3:3:1

For each ratio, write the parent genotypes that would produce that ratio

© 2014 Pearson Education, Inc.

A new way to solve genetic problems

- Turn to page 234 and try question 5(a).

- Work with a partner to complete the following problems in this order:
  - 5 (b-d)
  - 8
  - 7
  - 11

© 2014 Pearson Education, Inc.

- Find the <u>expected</u> phenotype ratios for:
  - TT x tt
  - Tt x Tt
  - Tt x tt
  - TTYY x ttyy
  - TtYy x TtYy
  - TtYy x ttyy

  - For each expected ratio above, determine the approximate number of each phenotype if 800 individuals were produced.

© 2014 Pearson Education, Inc.

Objective: You will be able to use the chi square test to determine if there are significant differences between expected and observed results.

Do Now:

© 2014 Pearson Education, Inc.

Take out the "expected" results from yesterday

- TT x tt – 426 total offspring produced (426 tall)
- Tt x Tt - 406 total offspring produced (312 tall, 94 dwarf)
- Tt x tt - 420 total offspring produced (208 Tall, 212 dwarf)
- TTYY x ttyy - 401 total offspring produced (401 Tall and yellow)

- TtYy x TtYy - 241 total offspring produced (139 tall and yellow, 40 tall and green, 46 short and yellow, 16 short and green)

- TtYy x ttyy- 441 total offspring produced (109 tall and yellow, 135 tall and green, 96 short and yellow, 101 short and green)

- Are the observed results (in purple) close to the ratios that you expected? Show your work!
- When is it too far off? That why we use the chi square test!

© 2014 Pearson Education, Inc.

A poker-dealing machine is supposed to deal cards at random, as if from an infinite deck.

In a test, you counted 1600 cards. What would be your expected values for each suit?

You observed the following:

Spades	**404**
Hearts	**420**
Diamonds	**400**
Clubs	**376**

- Are these discrepancies too much to be random? Or are they in the realm of probability?

- Scientists use chi-square as a statistical method that assesses the <u>goodness of fit</u> between observed values and those expected.

© 2014 Pearson Education, Inc.

$$X^2 = \sum \frac{(o - e)^2}{e}$$

Spades	$(404 - 400)^2/400 =$	0.04
Hearts	$(420-400)^2/400 =$	1.0
Diamonds	$(400-400)^2/400 =$	0.0
Clubs	$(376-400)^2/400 =$	1.44

$$X^2 = 2.48$$

So…are these discrepancies too much to be random? Or are they in the realm of probability?

© 2014 Pearson Education, Inc.

Percentage Points of the Chi-Square Distribution

Degrees of Freedom	Probability of a larger value of x^2								
	0.99	0.95	0.90	0.75	0.50	0.25	0.10	0.05	0.01
1	0.000	0.004	0.016	0.102	0.455	1.32	2.71	3.84	6.63
2	0.020	0.103	0.211	0.575	1.386	2.77	4.61	5.99	9.21
3	0.115	0.352	0.584	1.212	2.366	4.11	6.25	7.81	11.34
4	0.297	0.711	1.064	1.923	3.357	5.39	7.78	9.49	13.28
5	0.554	1.145	1.610	2.675	4.351	6.63	9.24	11.07	15.09
6	0.872	1.635	2.204	3.455	5.348	7.84	10.64	12.59	16.81
7	1.239	2.167	2.833	4.255	6.346	9.04	12.02	14.07	18.48
8	1.647	2.733	3.490	5.071	7.344	10.22	13.36	15.51	20.09
9	2.088	3.325	4.168	5.899	8.343	11.39	14.68	16.92	21.67
10	2.558	3.940	4.865	6.737	9.342	12.55	15.99	18.31	23.21
11	3.053	4.575	5.578	7.584	10.341	13.70	17.28	19.68	24.72
12	3.571	5.226	6.304	8.438	11.340	14.85	18.55	21.03	26.22
13	4.107	5.892	7.042	9.299	12.340	15.98	19.81	22.36	27.69
14	4.660	6.571	7.790	10.165	13.339	17.12	21.06	23.68	29.14
15	5.229	7.261	8.547	11.037	14.339	18.25	22.31	25.00	30.58
16	5.812	7.962	9.312	11.912	15.338	19.37	23.54	26.30	32.00
17	6.408	8.672	10.085	12.792	16.338	20.49	24.77	27.59	33.41
18	7.015	9.390	10.865	13.675	17.338	21.60	25.99	28.87	34.80
19	7.633	10.117	11.651	14.562	18.338	22.72	27.20	30.14	36.19
20	8.260	10.851	12.443	15.452	19.337	23.83	28.41	31.41	37.57
22	9.542	12.338	14.041	17.240	21.337	26.04	30.81	33.92	40.29
24	10.856	13.848	15.659	19.037	23.337	28.24	33.20	36.42	42.98
26	12.198	15.379	17.292	20.843	25.336	30.43	35.56	38.89	45.64
28	13.565	16.928	18.939	22.657	27.336	32.62	37.92	41.34	48.28
30	14.953	18.493	20.599	24.478	29.336	34.80	40.26	43.77	50.89
40	22.164	26.509	29.051	33.660	39.335	45.62	51.80	55.76	63.69
50	27.707	34.764	37.689	42.942	49.335	56.33	63.17	67.50	76.15
60	37.485	43.188	46.459	52.294	59.335	66.98	74.40	79.08	88.38

© 2014 Pea

Take out the "expected" results from yesterday

- TT x tt – 426 total offspring produced (426 tall)
- Tt x Tt - 406 total offspring produced (312 tall, 94 dwarf)
- Tt x tt - 420 total offspring produced (208 Tall, 212 dwarf)
- TTYY x ttyy - 401 total offspring produced (401 Tall and yellow)

- TtYy x TtYy - 241 total offspring produced (139 tall and yellow, 40 tall and green, 46 short and yellow, 16 short and green)

- TtYy x ttyy- 390 total offspring produced (109 tall and yellow, 135 tall and green, 96 short and yellow, 50 short and green)

– Fill out the chi square sheets starting with the Tt x Tt cross and determine the X^2 value

© 2014 Pearson Education, Inc.

- Complete the Chi Square practice sheet
  - Questions 1-4 only

© 2014 Pearson Education, Inc.

Hypothesis

- *Null hypothesis*

- *Alternative hypothesis*

© 2014 Pearson Education, Inc.

Complete questions 1, 2 and 3 on the Mendelian Class Quiz

You will need the chi square table and your blank practice sheets

- Complete questions 6, 7 and 8 on Mendelian genetics from the AP Classroom site.

© 2014 Pearson Education, Inc.

Objective: You will be able to apply mathematical routines to determine patterns of inheritance involving gene linkage.

Do Now:

© 2014 Pearson Education, Inc.

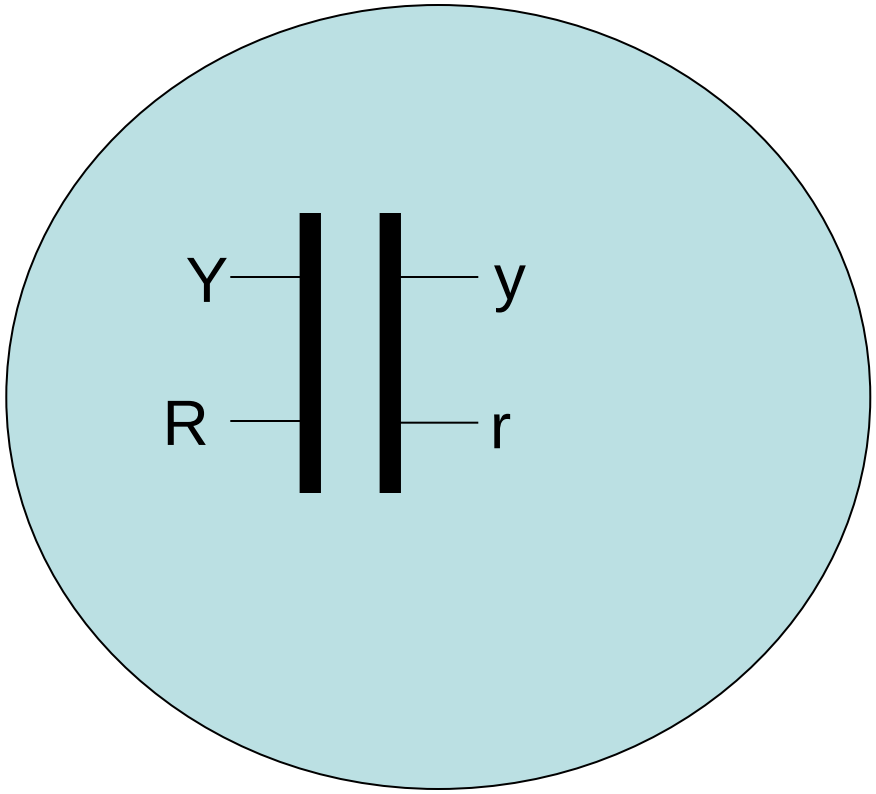
Gene Linkage

- Genes that are adjacent and close to each other on the <u>same chromosome</u> tend to move as a unit.

© 2014 Pearson Education, Inc.

Gene Linkage

- A cell in G_1
- How is this different from independent assortment?



So how would you know if genes are unlinked or linked?

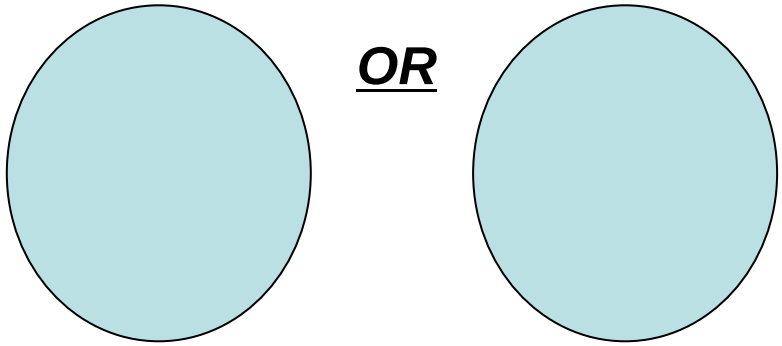
Perform a test cross!

© 2014 Pearson Education, Inc.

Are these two genes linked?

Mate: YyRr x yyrr ← Test cross

Start by drawing the chromosomes and their genes for the highlighted individual above



OR

Unlinked

Linked

- If they <u>are linked</u>, what should be the F_1 ratio?
- If they are <u>not</u> linked what should be the F_1 ratio?

© 2014 Pearson Education, Inc.

The actual ratios from this cross was:

- 456 Yellow and Round
- 439 Green and Wrinkled
- 38 Yellow and Wrinkled
- 27 Green and Round

- So? Are the genes for pea color and pea shape located on the same chromosome and therefore linked?

- So…why did we get some that were yellow/wrinkled and some that were green/round?

- What percentage of the offspring were a result of crossing over?
  - This is called the <u>recombination frequency</u>

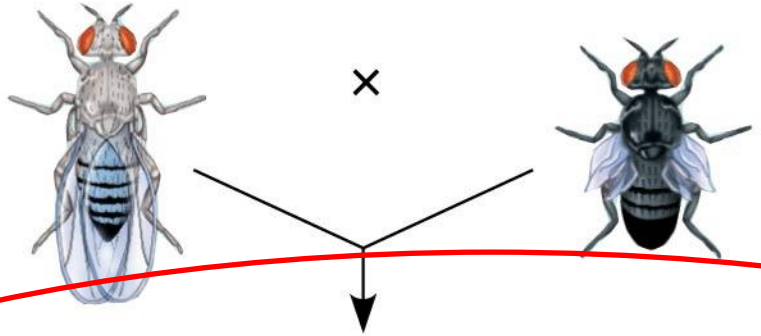
© 2014 Pearson Education, Inc.

Experiment

P Generation (homozygous)

Wild type (gray body, normal wings)

b^+ b^+ vg^+ vg^+



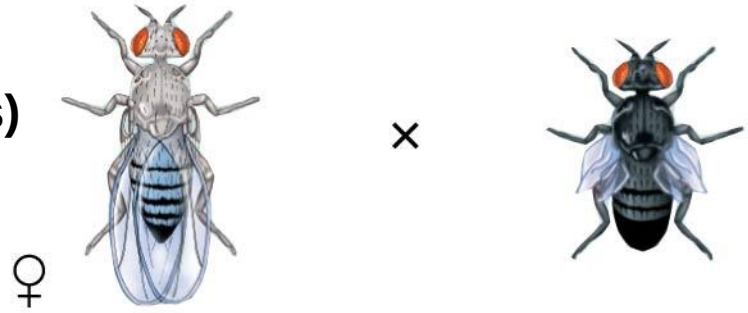
Double mutant (black body, vestigial wings)

b b vg vg

F_1 dihybrid testcross

Wild-type F_1 dihybrid (gray body, normal wings)

b^+ b vg^+ vg



Homozygous recessive (black body, vestigial wings)

b b vg vg

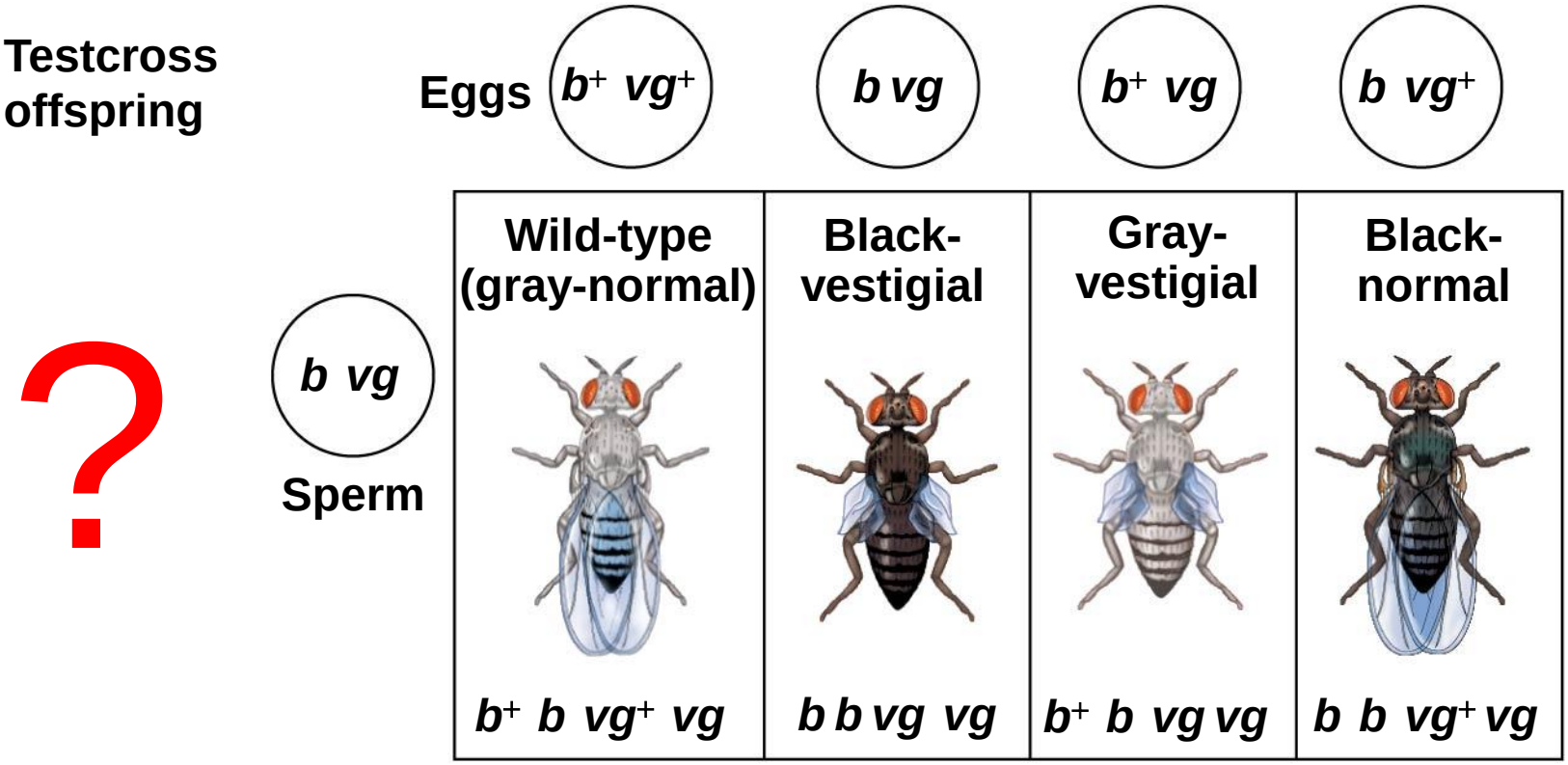
If the two genes are on the same chromosome (linked), what is the expected F1 ratio

© 2014 Pearson Education, Inc.

Figure 12.9b

Experiment

Testcross offspring



PREDICTED RATIOS

Genes on different chromosomes:	1	:	1	:	1	:	1
Genes on same chromosome:	1	:	1	:	0	:	0
Results	965	:	944	:	206	:	185

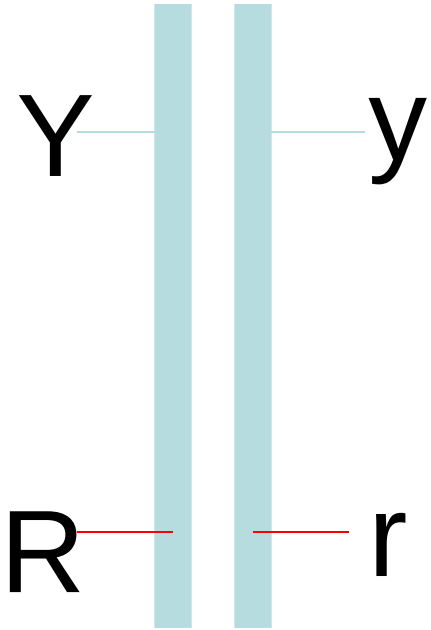
© 2014 Pearson Education, Inc.

Gene Linkage

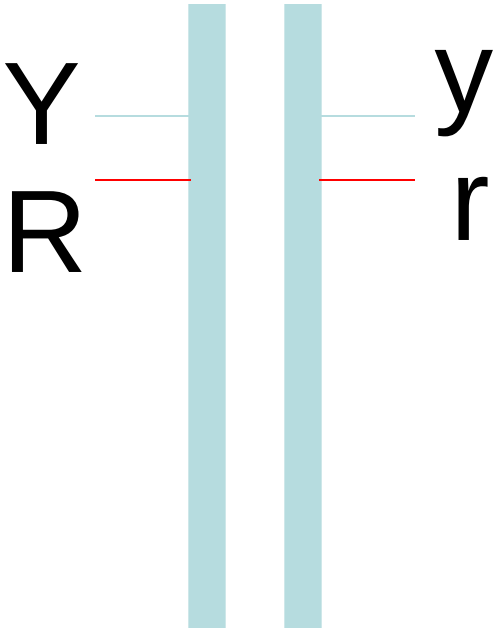
- The probability that they will cross over is a function of the distance between them.

© 2014 Pearson Education, Inc.

Which would show more crossing over?



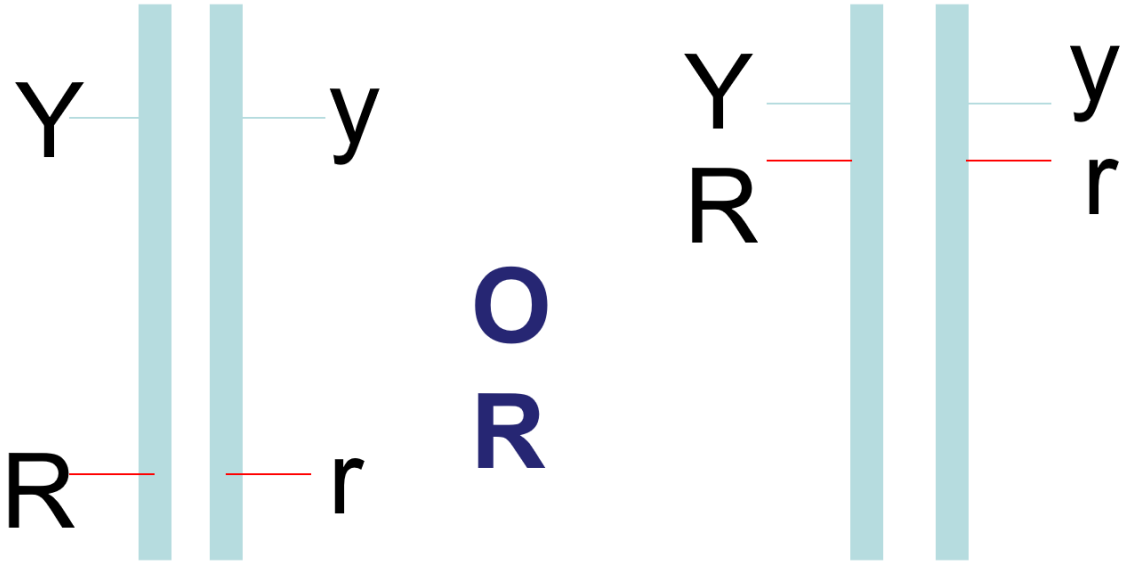
OR



© 2014 Pearson Education, Inc.

- The **recombination frequency** is the percentage of the offspring that were a result of crossing over

- Which scenario would produce offspring with the highest recombination frequency?



© 2014 Pearson Education, Inc.

- When posing questions involving two genes, they may say "…assume no autosomal linkage."

© 2014 Pearson Education, Inc.

Complete questions 4, 5, 6 and 7 on the Mendelian Class Quiz

- Complete question 1 and 5 on Mendelian genetics from the AP Classroom site.
    - #1 is an essay that also requires graphing
- Complete questions #4 and #6 from the non-Mendelian question set

© 2014 Pearson Education, Inc.

Objective: You will be able to solve problems involving sex-linked traits.

- **Do Now:**
  - Take out your Chromebook and go to question #1 from the AP classroom

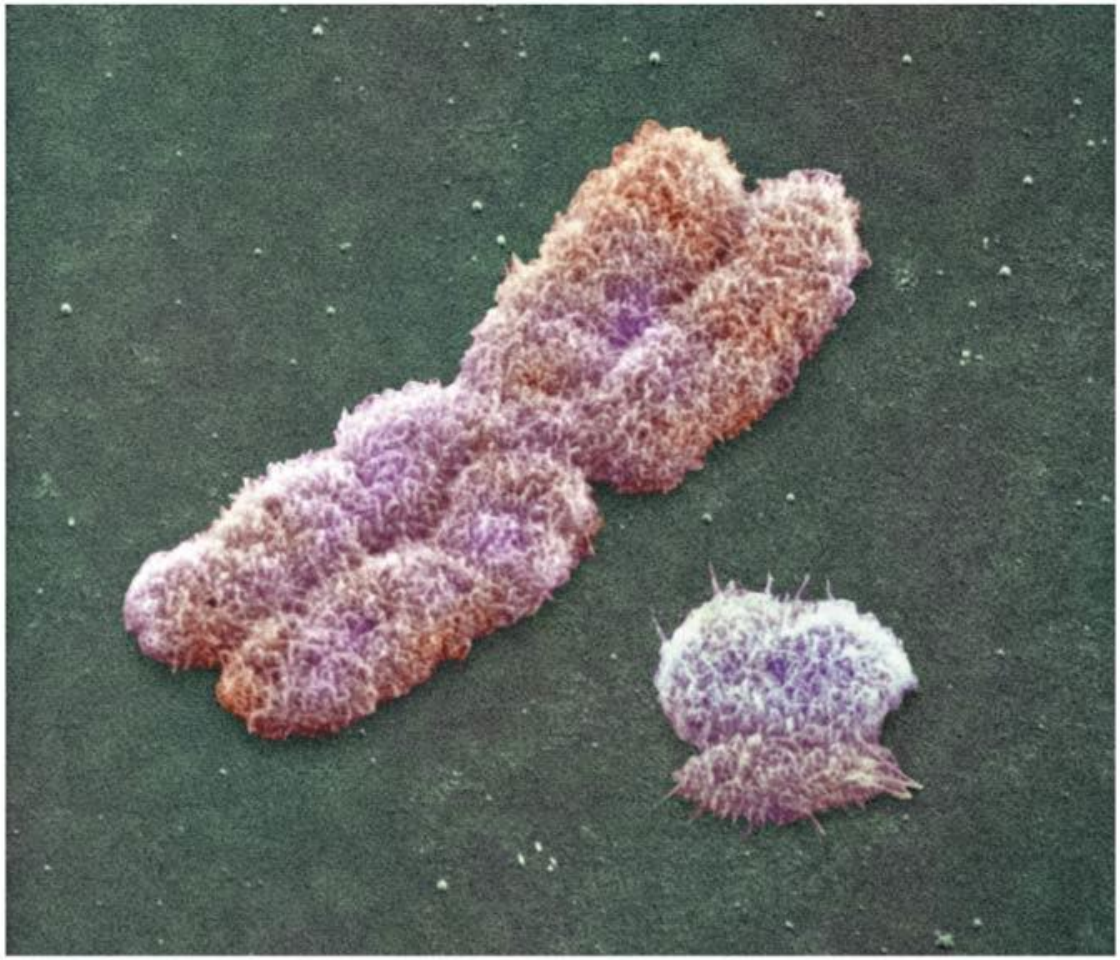
© 2014 Pearson Education, Inc.

- Draw a Punnett square that proves which gender is responsible for the sex of the child.

- List two examples of sex linked-traits in humans

© 2014 Pearson Education, Inc.

Sex-linked genes exhibit unique patterns of inheritance



© 2014 Pearson Education, Inc.

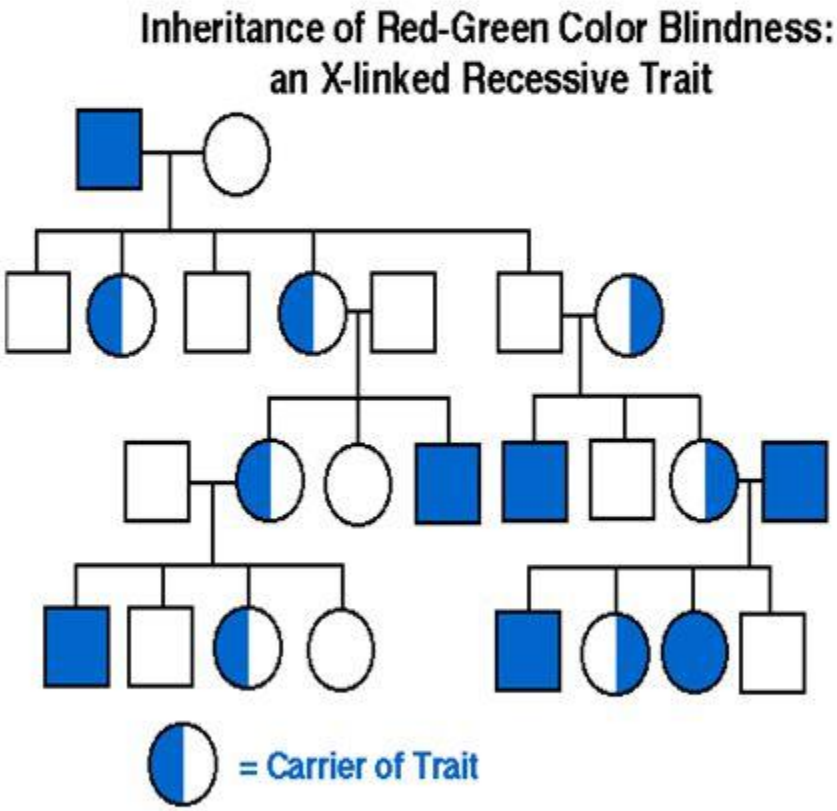
- Punnett Squares and sex-linkage

© 2014 Pearson Education, Inc.

- If a disorder were caused by a dominant X-linked trait, how would the inheritance pattern differ from what we see for recessive X-linked disorders?
  - There will be NO carriers if it is dominant

© 2014 Pearson Education, Inc.

Pedigree of a Sex-linked Trait



- Colorblindness is sex-linked.
- Blue box is colorblind
- White box is normal vision with two normal genes.
- Half blue/half white is a carrier with normal vision, but one abnormal gene.

- Provide an example of what you would look for in a pedigree to determine if a trait is a sex-linked trait instead of an autosomal trait.
  - Females can be carriers but males cannot

© 2014 Pearson Education, Inc.

It’s for the birds!

ZZ x ZW

© 2014 Pearson Education, Inc.

- Complete the Chi Square <u>practice sheet</u>
  - Questions 6 and 7

© 2014 Pearson Education, Inc.

Complete questions 8 and 9 on the Mendelian Class Quiz

- Complete question 3 on Mendelian genetics from the AP Classroom site.
- Complete question 7 from the non-Mendelian question set

© 2014 Pearson Education, Inc.

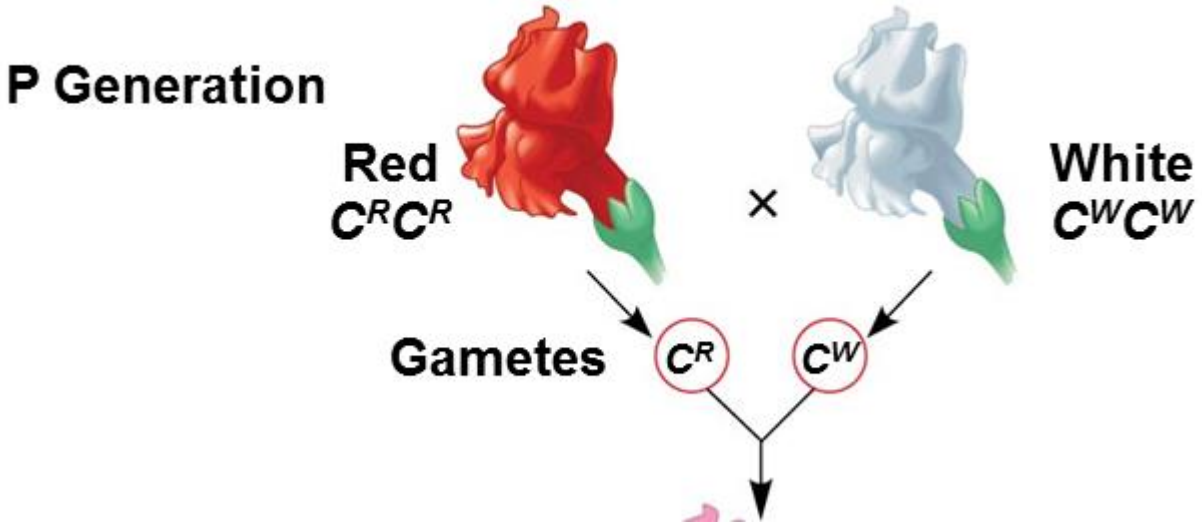
Complete the Pedigrees of Lactose Intolerance

© 2014 Pearson Education, Inc.

Objective: You will be able to solve problems involving incomplete dominance, codominance and multiple alleles.

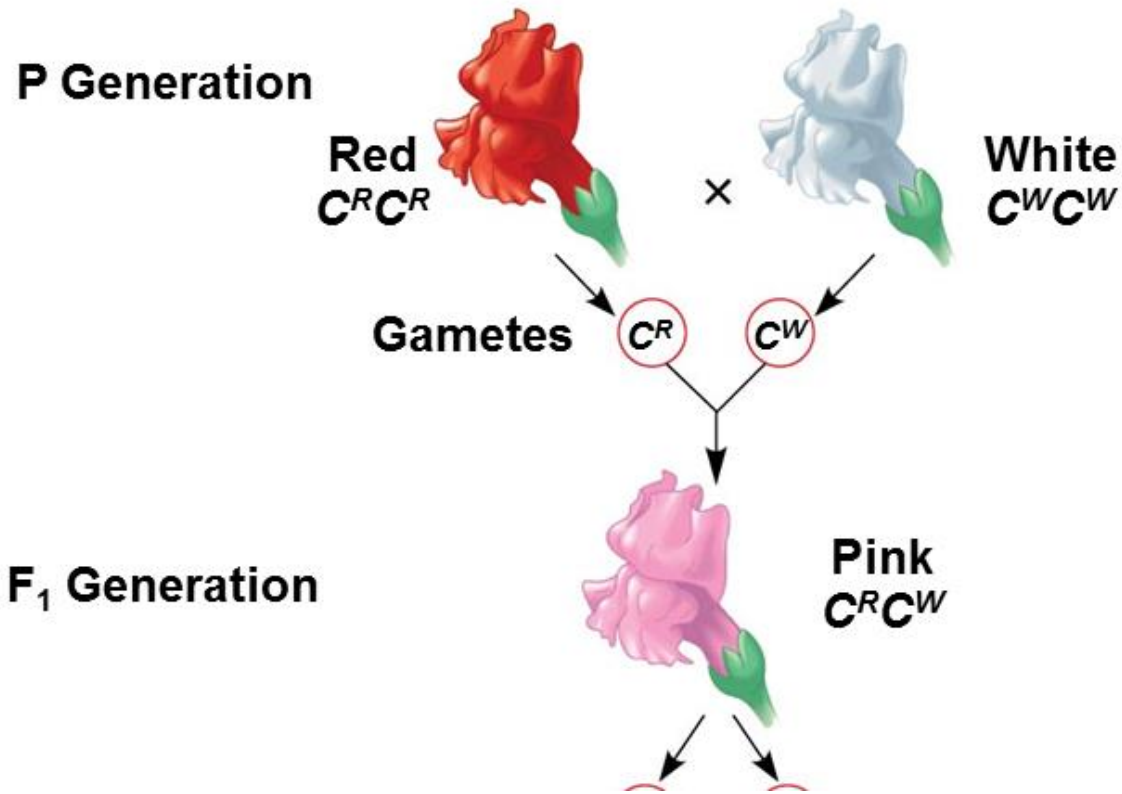
- **Do Now:**

© 2014 Pearson Education, Inc.



© 2014 Pearson Education, Inc.

Figure 11.10-3



What about the F_2 generation?

© 2014 Pearson Education, Inc.

Roan Cattle

This is called <u>codominance</u>

© 2014 Pearson Education, Inc.

Multiple Alleles

Figure 11.11

(a) The three alleles for the ABO blood groups and their carbohydrates

Allele	I^A	I^B	i
Carbohydrate	A △	B ○	none

(b) Blood group genotypes and phenotypes

Genotype	I^AI^A or I^Ai	I^BI^B or I^Bi	I^AI^B	ii
Red blood cell appearance				
Phenotype (blood group)	A	B	AB	O

© 2014 Pearson Education, Inc.

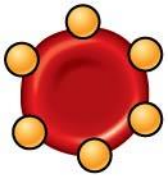
© 2014 Pearson Education, Inc.

Figure 11.11

(a) The three alleles for the ABO blood groups and their carbohydrates

Allele	I^A	I^B	i
Carbohydrate	A	B	none

(b) Blood group genotypes and phenotypes

Genotype	I^AI^A or I^Ai	I^BI^B or I^Bi	I^AI^B	ii
Red blood cell appearance				
Phenotype (blood group)	A	B	AB	O

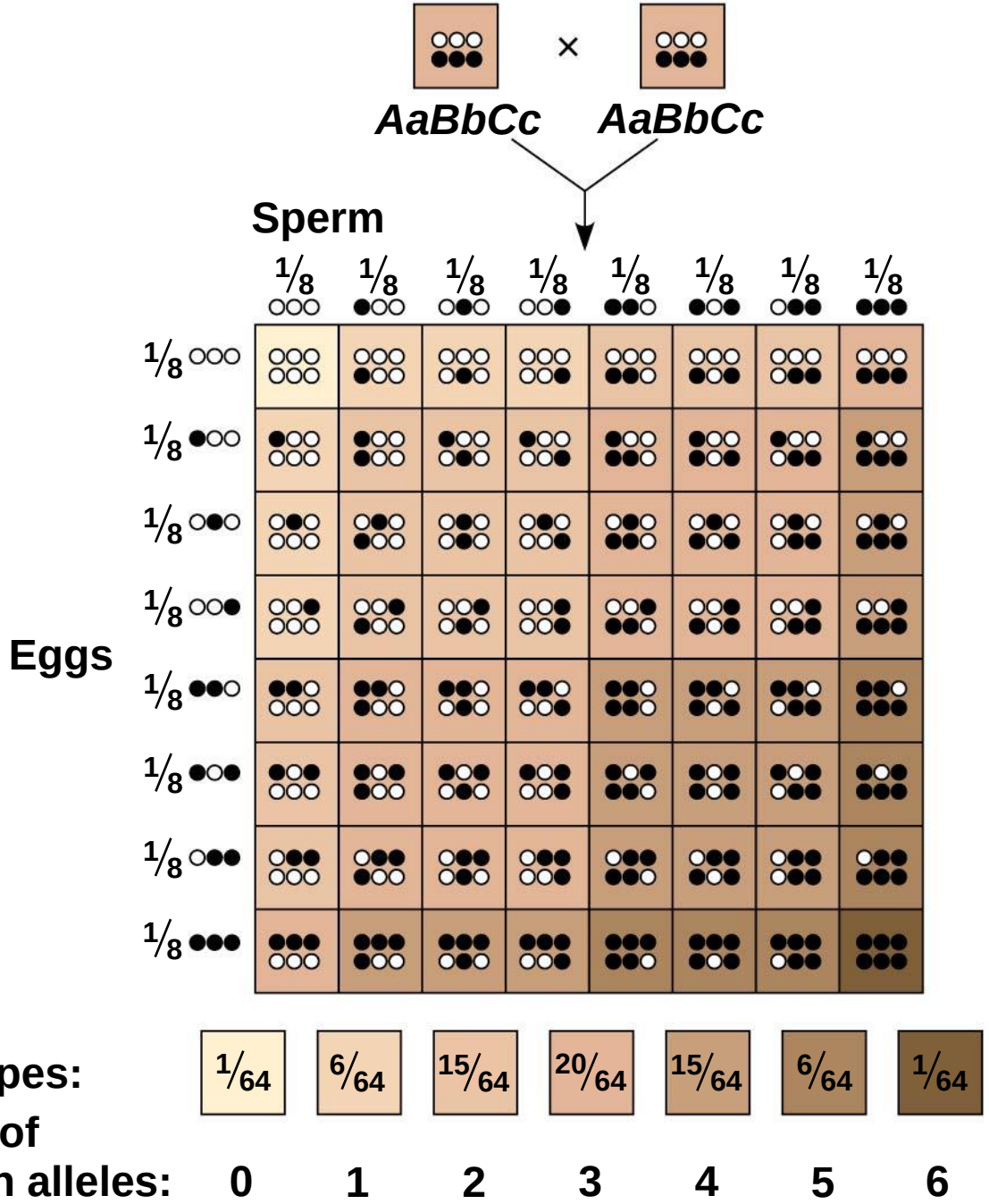
© 2014 Pearson Education, Inc.

Polygenic Inheritance

- **Quantitative characters** are those that vary in the population along a continuum
- Quantitative variation usually indicates **polygenic inheritance**, an additive effect of two or more genes on a single phenotype
- Skin color in humans is an example of polygenic inheritance

© 2014 Pearson Education, Inc.

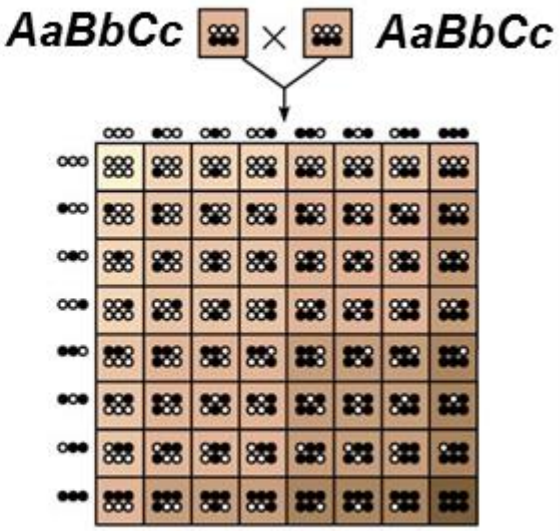
Figure 11.13



© 2014 Pearson Education, Inc.

Relationship among alleles of a single gene	Description	Example
Complete dominance of one allele	Heterozygous phenotype same as that of homozygous dominant	*PP* *Pp*
Incomplete dominance of either allele	Heterozygous phenotype intermediate between the two homozygous phenotypes	C^RC^R C^RC^W C^WC^W
Codominance	Both phenotypes expressed in heterozygotes	I^AI^B
Multiple alleles	In the whole population, some genes have more than two alleles	ABO blood group alleles I^A, I^B, i

© 2014 Pearson Education, Inc.

Polygenic inheritance	**A single phenotypic character is affected by two or more genes**	

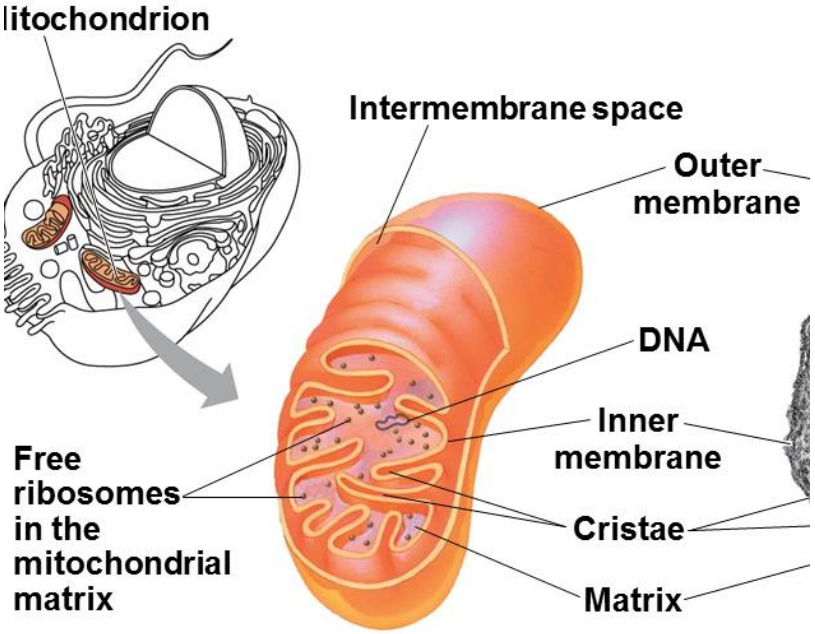
© 2014 Pearson Education, Inc.

Some traits result from non<u>nuclear</u> inheritance

- Chloroplasts and mitochondria are randomly assorted to gametes and daughter cells; thus, traits determined by chloroplast and mitochondrial DNA do not follow simple Mendelian rules.

- In animals, mitochondrial DNA is <u>transmitted by the egg</u> and not by the sperm; as such, mitochondrial-determined traits are <u>maternally</u> inherited.

<u>mtDNA Video</u>



© 2014 Pearson Education, Inc.

Nature and Nurture: The Environmental Impact on Phenotype

© 2011 Pearson Education, Inc.

© 2011 Pearson Education, Inc.

Objective: You will be able to pose questions about ethical, social or medical issues surrounding human genetic disorders.

Do Now:

- Compile of list of human disorders that are linked to genetics

© 2014 Pearson Education, Inc.

Certain human genetic disorders can be attributed to the inheritance of single gene traits or specific chromosomal changes, such as nondisjunction.

Examples:

- Sickle cell anemia (rec.)
- Tay-Sachs disease(rec.)
- Huntington's disease (dom.)
- X-linked color blindness(rec.)

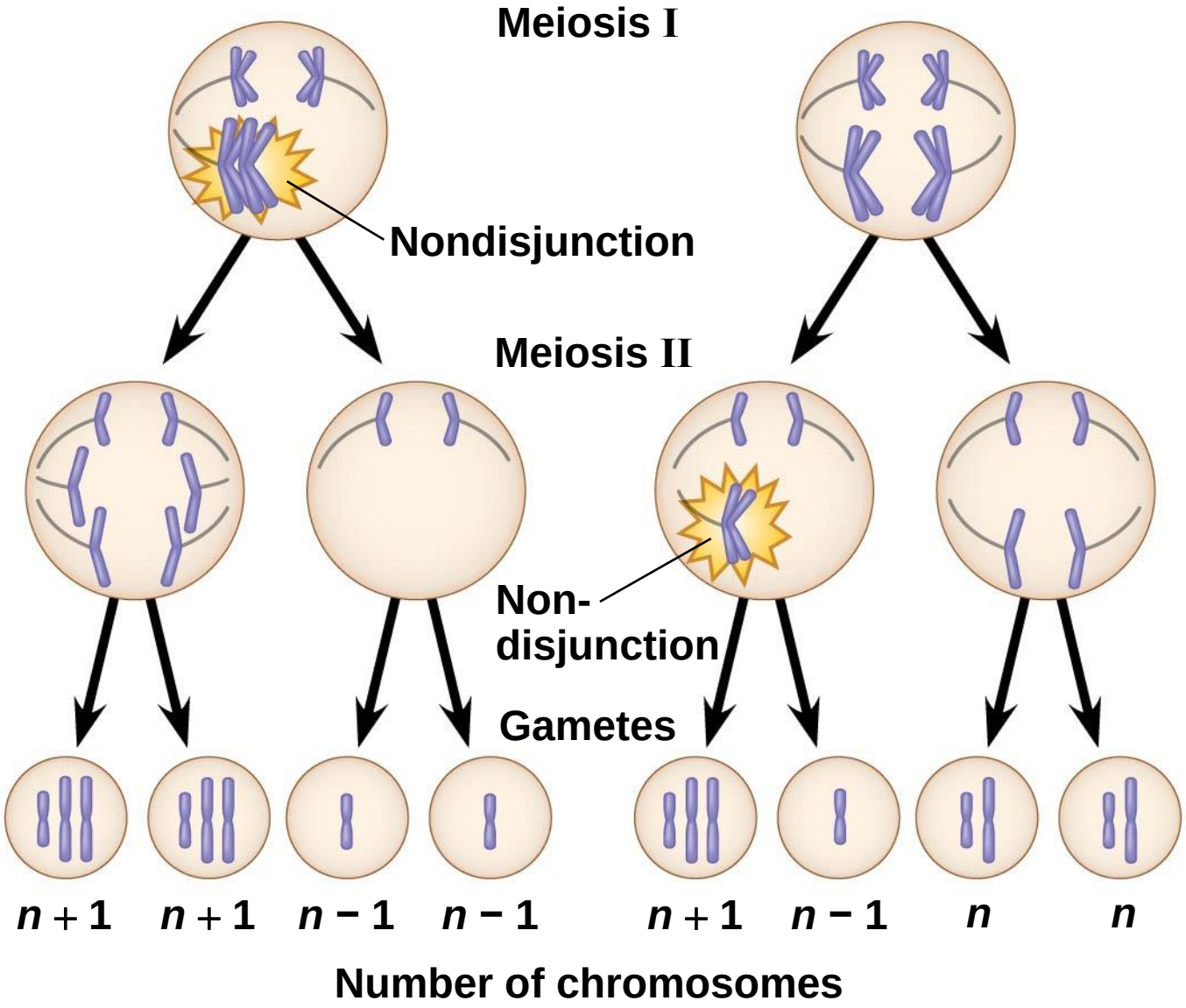
Single gene traits

- Trisomy 21/Down syndrome
- Klinefelter's syndrome

Nondisjunction

© 2014 Pearson Education, Inc.

Figure 12.13-3



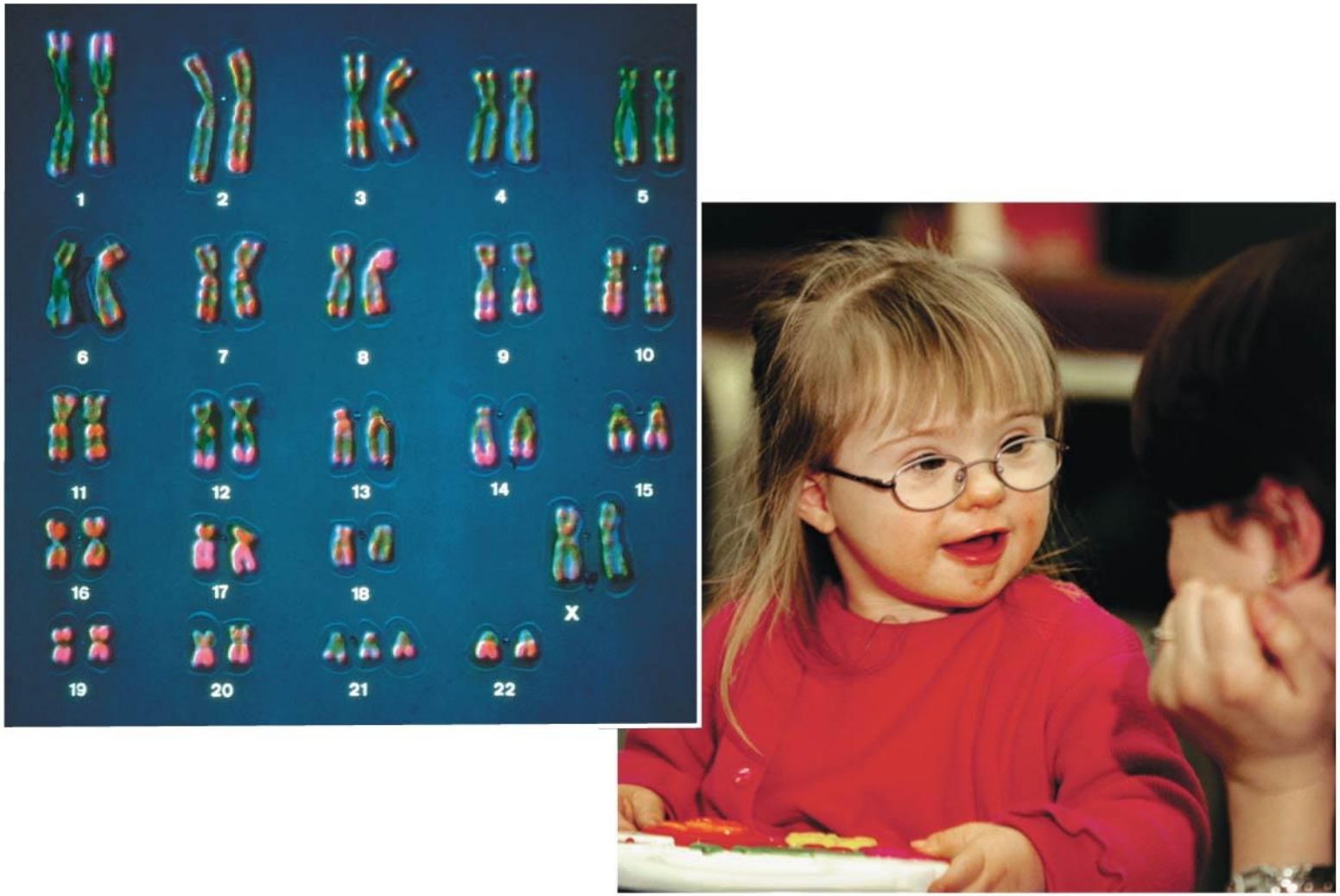
(a) Nondisjunction of homologous chromosomes in meiosis I

(b) Nondisjunction of sister chromatids in meiosis II

© 2014 Pearson Education, Inc.

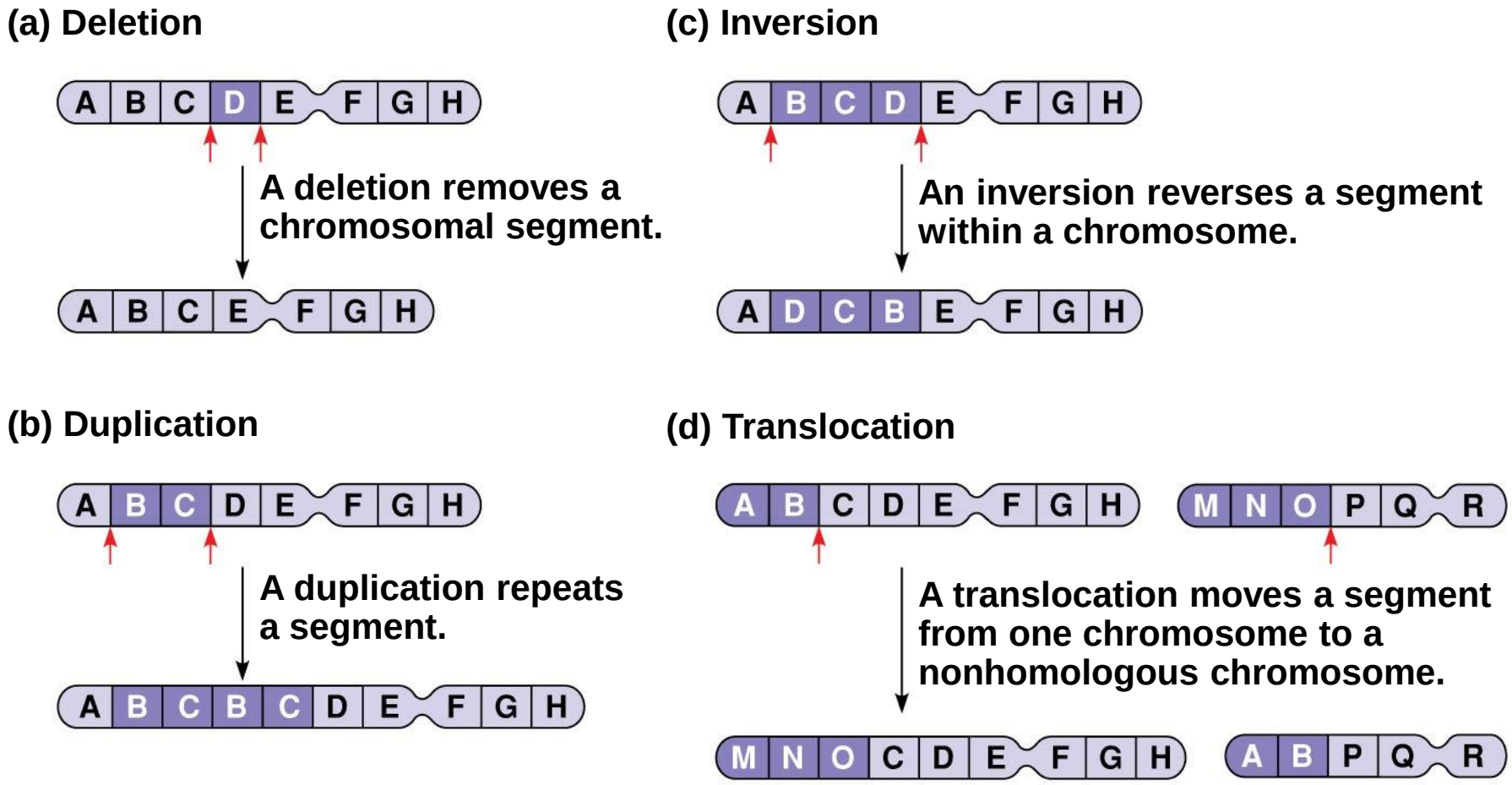
Figure 12.15

Trisomy 22/Down Syndrome



© 2014 Pearson Education, Inc.

Figure 12.14



© 2014 Pearson Education, Inc.

Many ethical, social and medical issues surround human genetic disorders.

Examples

- Reproductive issues
- Civic issues such as:
  - Ownership of genetic information
  - Privacy

Work with a partner to pose FIVE questions about ethical, social or medical issues surrounding human genetic disorders.

© 2014 Pearson Education, Inc.