

A close-up photograph of a light green grasshopper clinging vertically to a thin, textured plant stem. The background is a soft-focus green, suggesting a natural outdoor setting.

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Chapter 9

Patterns of Inheritance

PowerPoint Lectures

Campbell Biology: Concepts & Connections, 8th Edition, Global Edition

REECE • TAYLOR • SIMON • DICKEY • HOGAN

Lecture by Edward J. Zalisko

Introduction

- Dogs are one of man's longest genetic experiments.
 - Over thousands of years, humans have chosen and mated dogs with specific traits.
 - The result has been an incredibly diverse array of dogs with distinct
 - body types and
 - behavioral traits.



<http://www.akc.org/expert-advice/lifestyle/did-you-know/what-are-breed-groups/>

Introduction

- The people of Tibet live and work at altitudes above 13,000 feet, where the amount of oxygen that reaches the blood is 40% less than at sea level.
- What makes the Tibetan people so able to tolerate their harsh surroundings?
- Over the last several thousand years, the Tibetan population has accumulated several dozen **genetic mutations** that affect their **circulatory and respiratory systems**.



Are humans evolving?

Inuit people (Eskimos), few plants, traditional diet consists of food obtained by hunting large land mammals

Largely carnivorous, high in protein, very high in fat

100% Inuit people carry variances in a group of genes for fat-digesting enzymes (25% Chinese, 2% Europeans)

Slow down the body's natural production of omega-3 and omega-6 fats

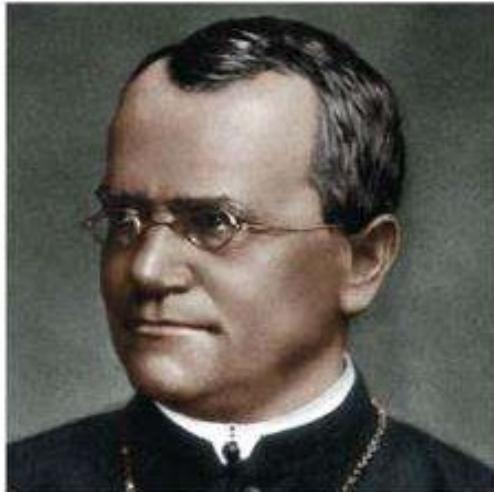
(<https://www.npr.org/sections/thesalt/2015/09/17/441169188/the-secret-to-the-inuit-high-fat-diet-may-be-good-genes>)

Body fat distribution: more brown fat for cold adaption

(<https://www.nytimes.com/2016/12/23/science/inuit-greenland-denisovans.html>)

Reduce the health risks associated with a high-fat diet

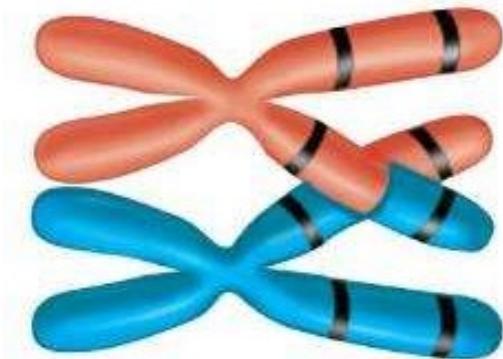
Chapter 9: Big Ideas



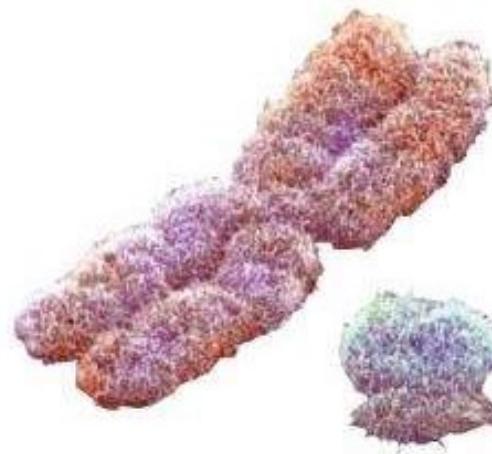
Mendel's Laws
9.1-9.10



**Variations on
Mendel's Laws 9.11-9.15**

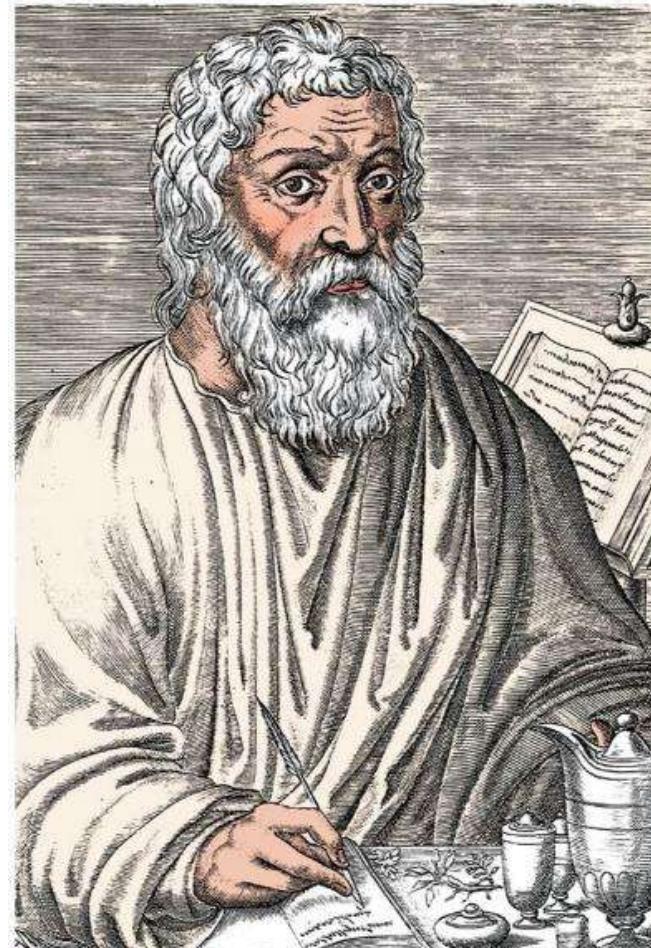


**The Chromosomal Basis
of Inheritance 9.16-9.19**



**Sex Chromosomes and
Sex-Linked Genes 9.20-9.23**

MENDEL'S LAWS



Hippocrates

9.1 The science of genetics has ancient roots

- **Pangenesis**, proposed around 400 BC by Hippocrates, was an early explanation for inheritance that suggested that
 - particles called **pangenes** came from all parts of the organism to be incorporated into eggs or sperm and
 - characteristics acquired during the **parents' lifetime** could be transferred to the offspring.
- Hippocrates's idea is incorrect in several respects.
 - The reproductive cells are not composed of particles from somatic (body) cells.
 - Changes in somatic cells do not influence eggs and sperm.
- Aristotle rejected pangenesis and argued that instead of particles, the ***potential*** to produce the traits was inherited.

9.1 The science of genetics has ancient roots

- The idea that hereditary materials mix in forming offspring, called the **blending hypothesis**, was
 - suggested in the 19th century by scientists studying plants but
 - later rejected because it did not explain how traits that **disappear** in one generation can **reappear** in later generations.

9.2 Experimental genetics began in an abbey garden

- **Heredity** is the transmission of **traits** from one generation to the next.What we observe & Why we observe
- **Genetics** is the **scientific study** of heredity.
- Gregor Mendel
 - began the field of genetics in the 1860s,
 - deduced the principles of genetics by **breeding** garden peas, and
 - relied upon a background of mathematics, physics, and chemistry.
- In 1866, Mendel
 - correctly argued that parents pass on to their offspring discrete “heritable factors” and
 - stressed that the **heritable factors** (today called genes), retain their **individuality** generation after generation.

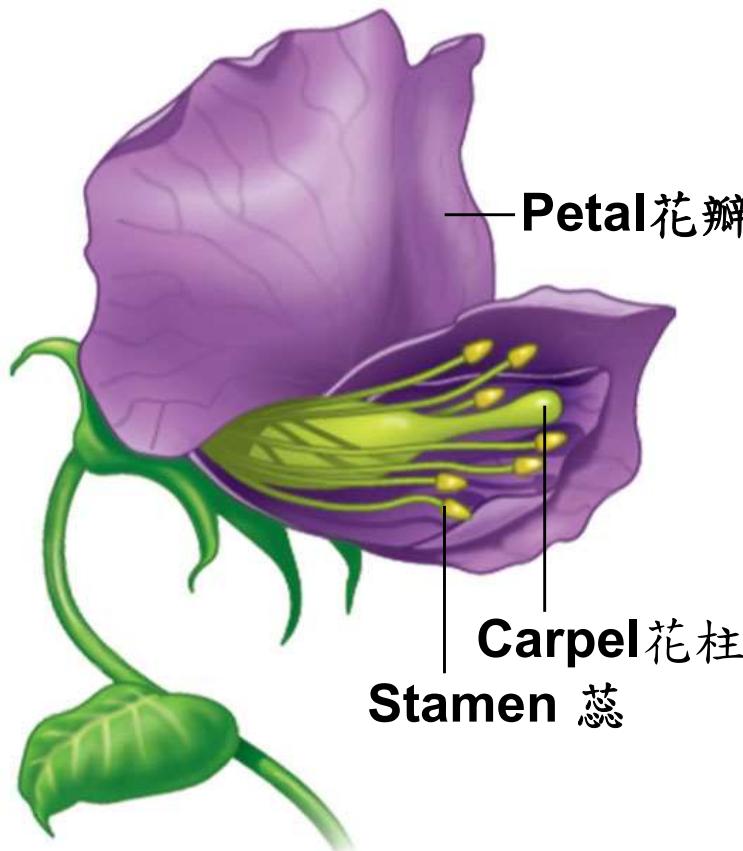
9.2 Experimental genetics began in an abbey garden

- In 1866, Mendel
 - correctly argued that parents pass on to their offspring discrete “heritable factors” and
 - stressed that the heritable factors (today called genes) **retain** their **individuality** generation after generation.
- A heritable feature that varies among **individuals**, such as flower color, is called a **character**. 性状
- Each **variant** for a character, such as purple or white flowers, is a **trait**. 特徵

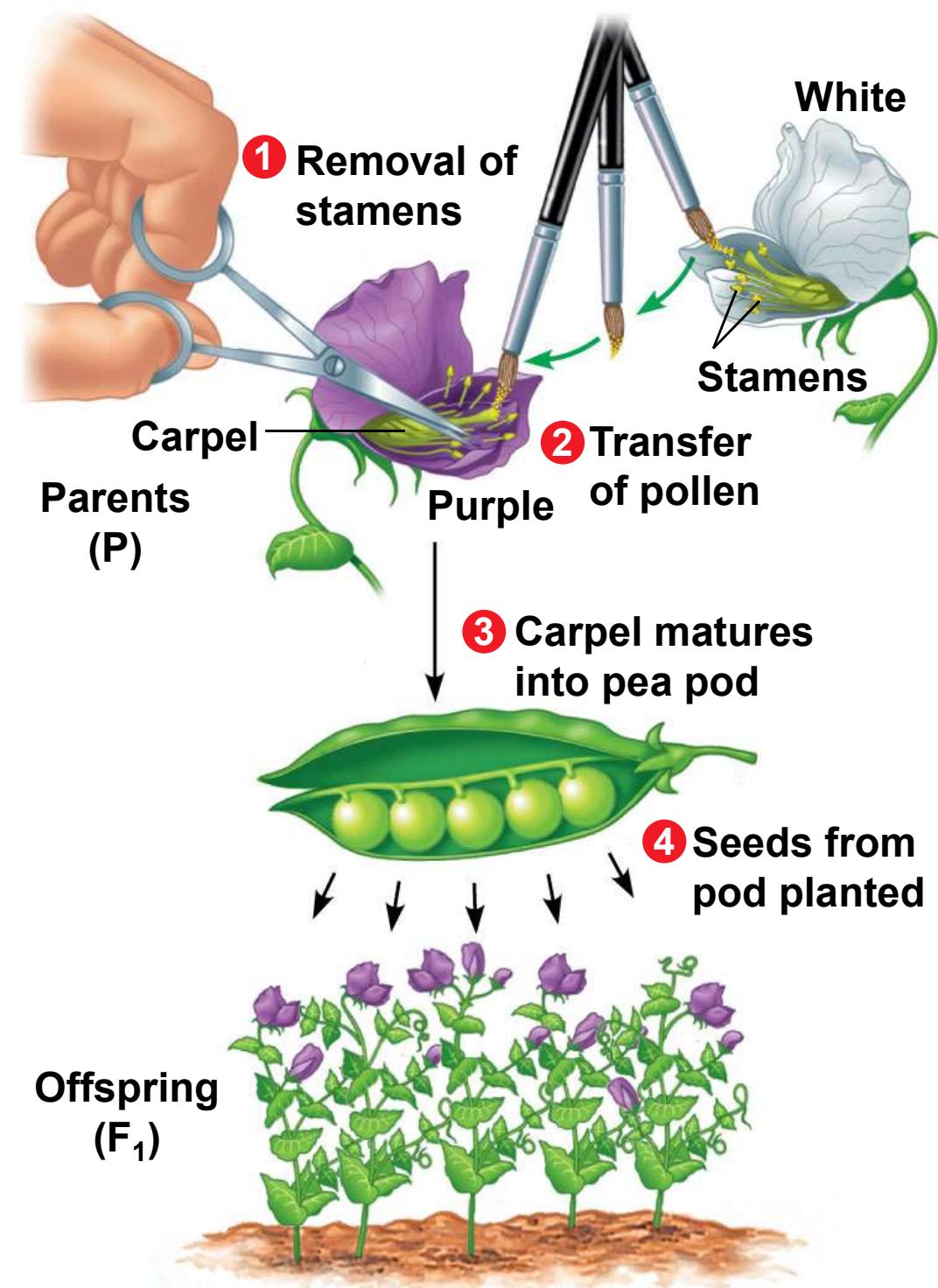
9.2 Experimental genetics began in an abbey garden

- Perhaps the most important advantage of pea plants as an experimental model was that Mendel could **strictly control matings.**
 - The petals of the pea flower almost completely enclose the reproductive organs: the stamens and carpel.
 - Consequently, pea plants usually are able to **self-fertilize** in nature.
- **True-breeding** varieties result when **self-fertilization** produces offspring all **identical** to the parent. 純種
- The offspring of two different varieties are **hybrids**. 混種
- The cross-fertilization is a hybridization, or genetic **cross**. 雜交
- True-breeding parental plants are the **P generation**. 親代
- Hybrid offspring are the **F₁ generation**. 子代
- A cross of F₁ plants produces an **F₂ generation**.

Figure 9.2C_s3



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Figure 9.2D

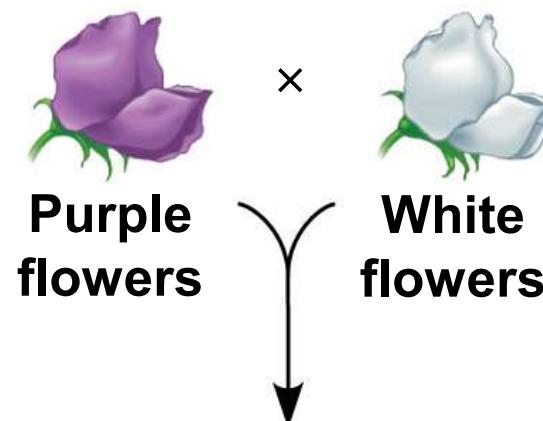
Character	Traits	
	Dominant	Recessive
Flower color		
	Purple	White
Flower position		
	Axial	Terminal
Seed color		
	Yellow	Green
Seed shape		
	Round	Wrinkled
Pod shape		
	Inflated	Constricted
Pod color		
	Green	Yellow
Stem length		
	Tall	Dwarf

9.3 Mendel's law of segregation describes the inheritance of a single character 分離律

- A cross between two individuals differing in a **single character** is a **monohybrid cross**.
- Mendel performed a monohybrid cross between a plant with purple flowers and a plant with white flowers.
 - The F_1 generation produced all plants with purple flowers.
 - A cross of F_1 plants with each other produced an F_2 generation with $\frac{3}{4}$ purple and $\frac{1}{4}$ white flowers.

The Experiment

P generation
(true-breeding parents)



monohybrid cross

F₁ generation

1. White disappear in F₁
2. $\frac{1}{4}$ white in F₂

An illustration of a single purple flower, positioned above the text "All plants have purple flowers".

All plants have
purple flowers

Fertilization
among F₁ plants
(F₁ × F₁)

F₂ generation



$\frac{3}{4}$ of plants
have purple flowers $\frac{1}{4}$ of plants
have white flowers

9.3 Mendel's law of segregation describes the inheritance of a single character

- The all-purple F₁ generation did not produce light purple flowers, as predicted by the blending hypothesis.
- Mendel needed to explain why
 - white color seemed to **disappear** in the F₁ generation and
 - white color **reappeared** in one quarter of the F₂ offspring.
- Mendel observed the same patterns of inheritance for six other pea plant characters.

9.3 Mendel's law of segregation describes the inheritance of a single character

- Mendel developed four hypotheses, described below using modern terminology. 等位基因
 1. **Alleles** are alternative versions of genes that account for variations in inherited characters.
 2. For **each characteristic**, an organism **inherits two alleles**, one from each parent. The alleles can be the same or different.
 - A **homozygous** genotype has identical alleles.
 - A **heterozygous** genotype has two different alleles.

9.3 Mendel's law of segregation describes the inheritance of a single character

3. If the alleles of an inherited pair **differ**, then one determines the organism's appearance and is called the **dominant** allele. The other has no noticeable effect on the organism's appearance and is called the **recessive** allele.

表現型

- The **phenotype** is the appearance or expression of a trait.
The **genotype** is the genetic makeup of a trait. 基因型
- The same phenotype may be determined by more than one genotype.

4. A sperm or egg carries only one allele for each inherited character because allele pairs separate (segregate) from each other during the production of gametes. This statement is called **the law of segregation**.

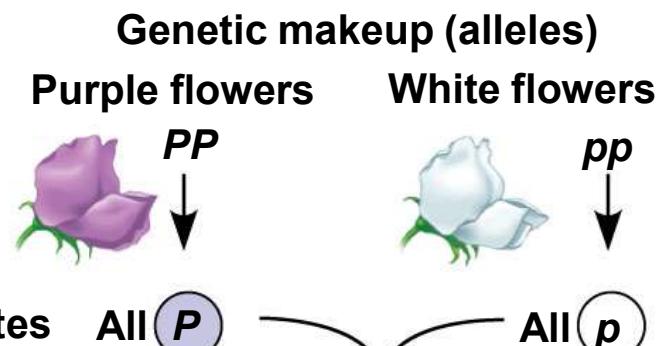
The fusion of gametes at fertilization creates allele pairs once again.

- Mendel's hypotheses also explain the 3:1 ratio in the F_2 generation.

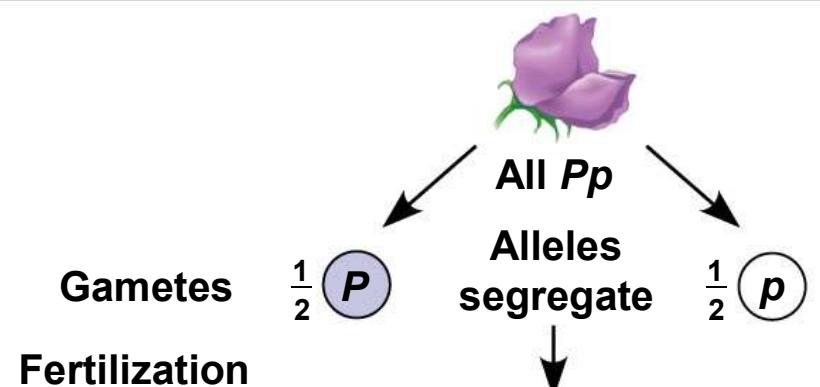
- The F_1 hybrids all have a Pp genotype.
- A **Punnett square** shows the four possible combinations of alleles that could occur when these gametes combine.

The Explanation

P generation



F_1 generation (hybrids)

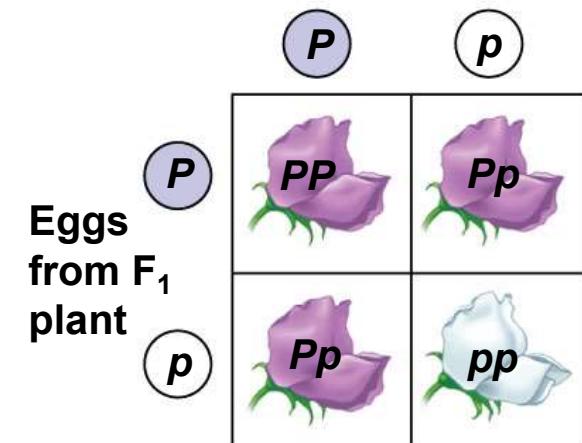


F_2 generation

Phenotypic ratio
3 purple : 1 white

Genotypic ratio
1 PP : 2 Pp : 1 pp

Sperm from F_1 plant

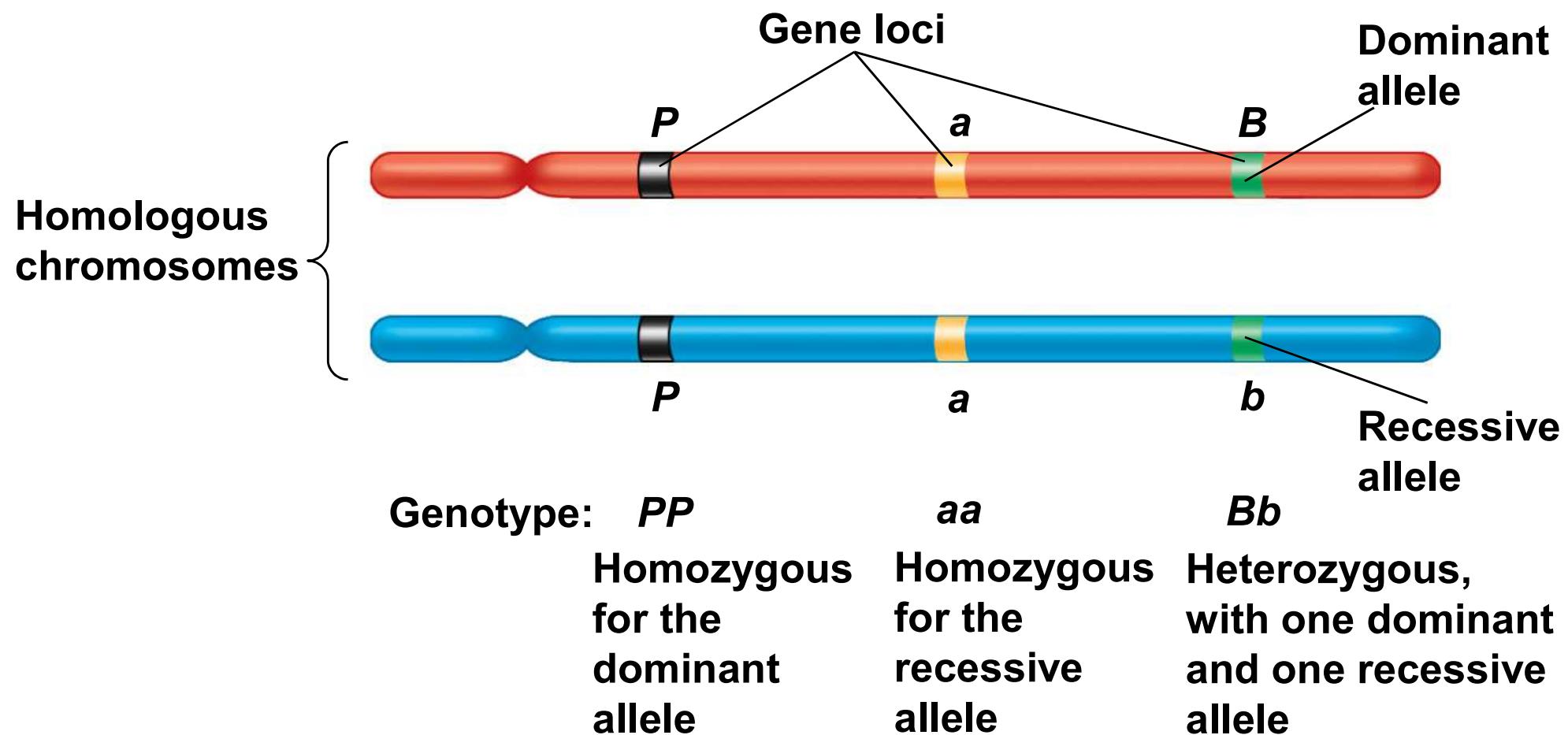


9.4 Homologous chromosomes bear the alleles for each character

- A **locus** (plural, *loci*) is the specific location of a gene along a chromosome. 基因座
- For a pair of homologous chromosomes, alleles of a **gene** reside at the same locus.
 - Homozygous individuals have the same allele on both homologues (chromosomes).
 - Heterozygous individuals have a different allele on each homologue (chromosome).

Allele vs. Gene

Figure 9.4



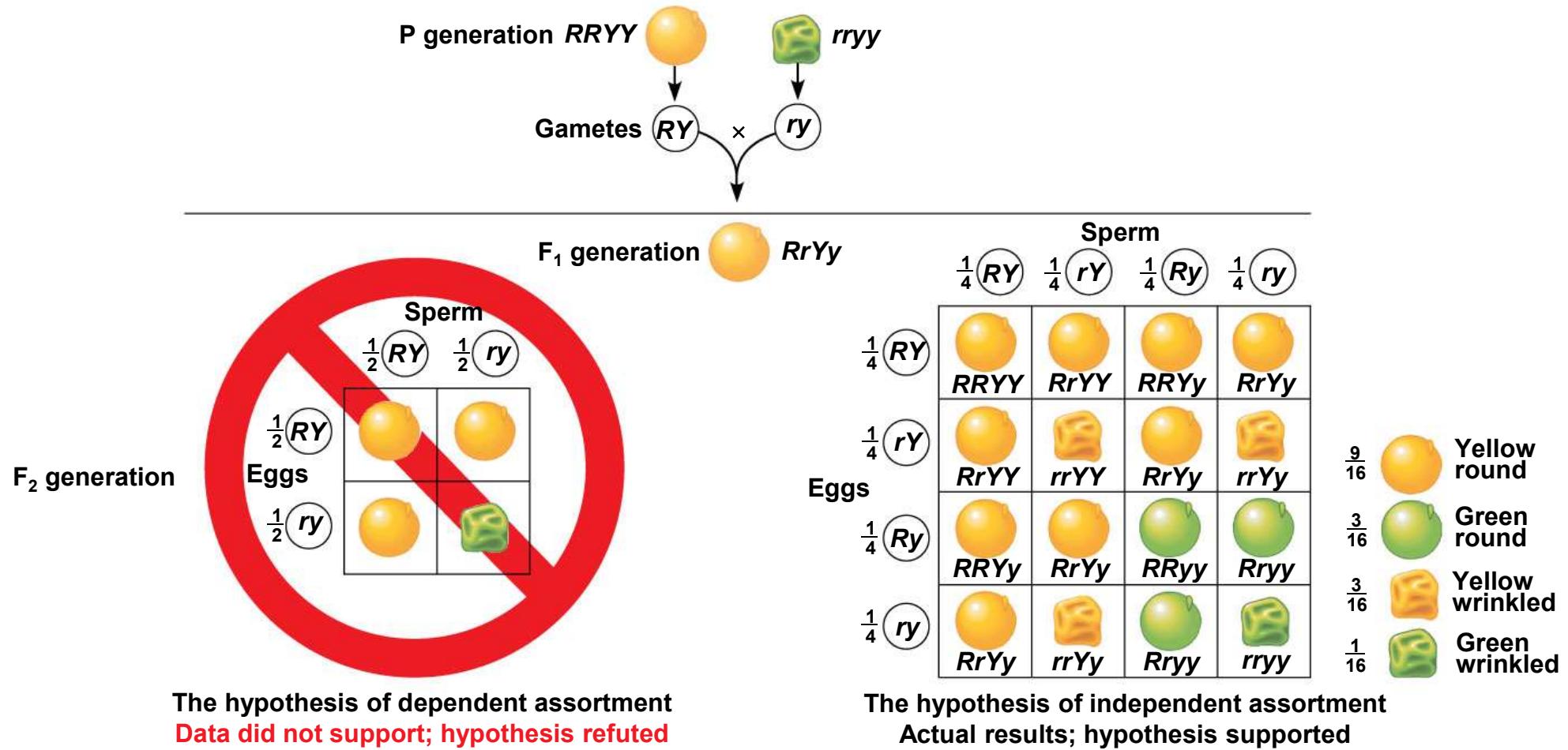
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9.5 The law of independent assortment is revealed by tracking two characters at once

獨立分配律

- A **dihybrid cross** is a mating of parental varieties that differ in two characters.
- Mendel performed the following dihybrid cross with the following results:
 - P generation: round yellow seeds × wrinkled green seeds
 - F₁ generation: all plants with round yellow seeds
 - F₂ generation:
 - 9/16 had round yellow seeds
 - 3/16 had wrinkled yellow seeds
 - 3/16 had round green seeds
 - 1/16 had wrinkled green seeds

Figure 9.5A



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9.5 The law of independent assortment is revealed by tracking two characters at once

- Mendel needed to explain why the F_2 offspring
 - had new nonparental combinations of traits and
 - a 9:3:3:1 phenotypic ratio.
- Mendel
 - suggested that the inheritance of one character has **no effect on the inheritance of another**,
 - suggested that the dihybrid cross is the equivalent to two monohybrid crosses, and
 - called this the **law of independent assortment**.
- The following figure demonstrates the law of independent assortment as it applies to two characters in Labrador retrievers:
 - black versus chocolate color,
 - normal vision versus progressive retinal atrophy.

Figure 9.5B

				
Phenotypes	Black coat, normal vision	Black coat, blind (PRA)	Chocolate coat, normal vision	Chocolate coat, blind (PRA)
Genotypes	$B_N_\!$	$B_nn\!\!$	$bbN_\!$	$bbnn\!\!$
Mating of double heterozygotes (black coat, normal vision)				
				
Phenotypic ratio of the offspring	9 Black coat, normal vision	3 Black coat, blind (PRA)	3 Chocolate coat, normal vision	1 Chocolate coat, blind (PRA)

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PRA: progressive retinal atrophy
慢性視網膜退化



9.6 Geneticists can use the testcross to determine unknown genotypes

- A **testcross** is the mating between an individual of unknown genotype and a homozygous recessive individual.
- A testcross can show whether the **unknown genotype** includes a **recessive** allele.
- Mendel used testcrosses to verify that he had **true-breeding** genotypes.
- The following figure demonstrates how a testcross can be performed to determine the genotype of a Lab with normal eyes.

What is the genotype of the black dog?

Testcross



×



Genotypes

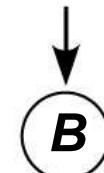
$B_?$

bb

Two possibilities for the black dog:

Gametes

BB



b

Bb

or

Bb



b

Bb bb

Offspring

All black

1 black : 1 chocolate

9.7 Mendel's laws reflect the rules of probability

- Using his strong background in mathematics, Mendel knew that the rules of mathematical probability affected
 - the segregation of allele pairs during gamete formation and
 - the re-forming of pairs at fertilization.
- The probability scale ranges from 0 to 1. An event that is
 - certain has a probability of 1 and
 - certain *not* to occur has a probability of 0.
- Using his strong background in mathematics, Mendel knew that the rules of mathematical probability affected
 - the **segregation** of allele pairs during **gamete formation** and
 - the re-forming of pairs at fertilization.
- The probability scale ranges from 0 to 1. An event that is
 - certain has a probability of 1 and
 - certain *not* to occur has a probability of 0.

Figure 9.7

F₁ genotypes

Bb female



Formation
of eggs

Bb male



Formation
of sperm



Sperm

F₂ genotypes



Eggs



$(\frac{1}{2} \times \frac{1}{2})$	
	$\frac{1}{4}$
	$\frac{1}{4}$
	$\frac{1}{4}$
	$\frac{1}{4}$

9.8 Genetic traits in humans can be tracked through family pedigrees

- In a simple dominant-recessive inheritance of dominant allele A and recessive allele a ,
 - a recessive phenotype always results from a homozygous recessive genotype (aa) but
 - a dominant phenotype can result from either
 - the homozygous dominant genotype (AA) or
 - a heterozygous genotype (Aa).
- Wild-type traits**, those prevailing in nature, are **not necessarily** specified by dominant alleles.

Dominant Traits



Freckles

Recessive Traits



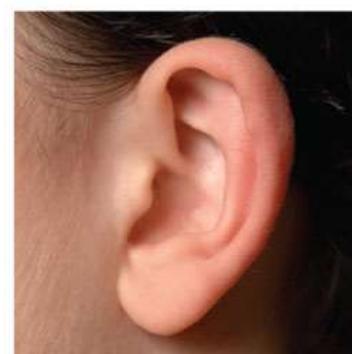
No freckles



Widow's peak



Straight hairline



Free earlobe



Attached earlobe

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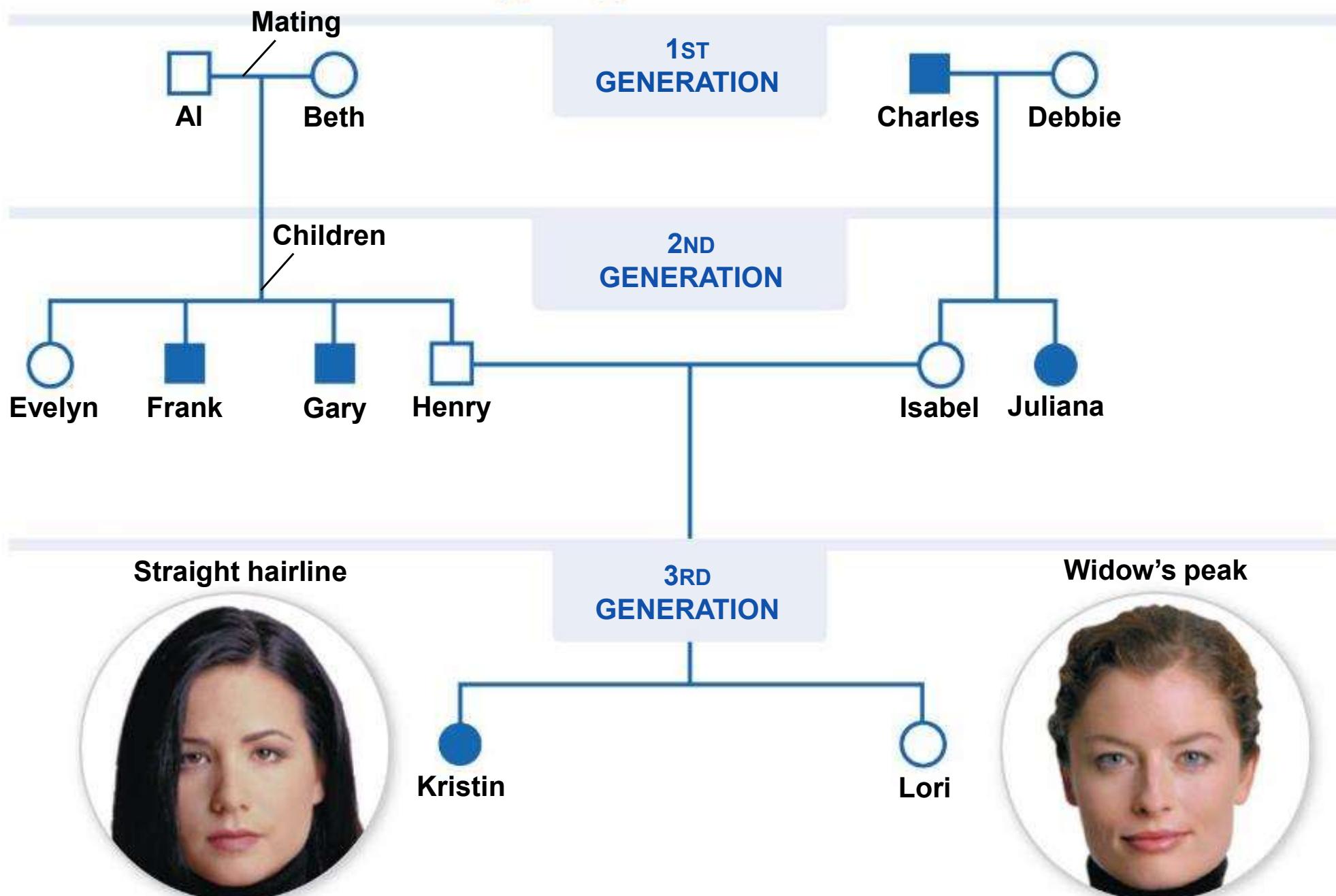
- The inheritance of human traits follows Mendel's laws.
- A **pedigree** 譜系
 - shows the inheritance of a trait in a family through multiple generations,
 - demonstrates dominant or recessive inheritance, and
 - can also be used to deduce genotypes of family members.

KEY Female Male



Widow's peak hairline trait
Straight hairline trait

H: widow's peak allele
h: straight allele

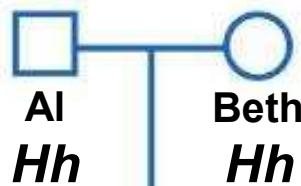


KEY Female Male

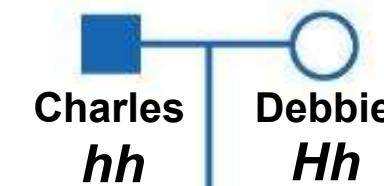


Widow's peak hairline trait
Straight hairline trait

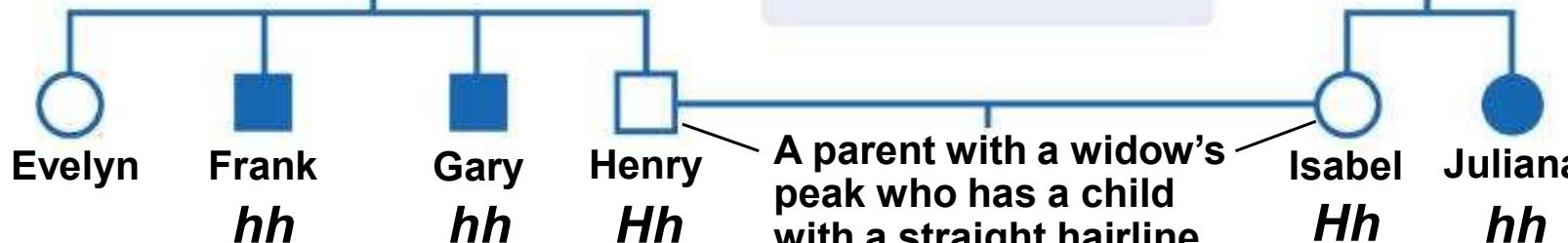
H: widow's peak allele
h: straight allele



1ST GENERATION



2ND GENERATION



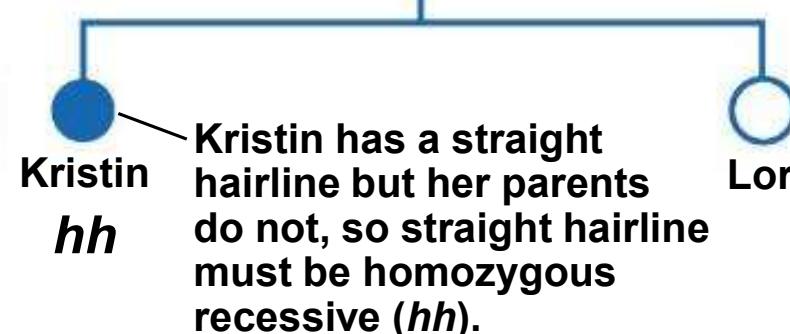
Straight hairline



Widow's peak



3RD GENERATION

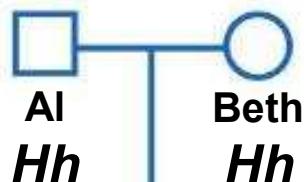


KEY Female Male



Widow's peak hairline trait
Straight hairline trait

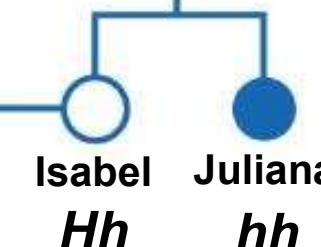
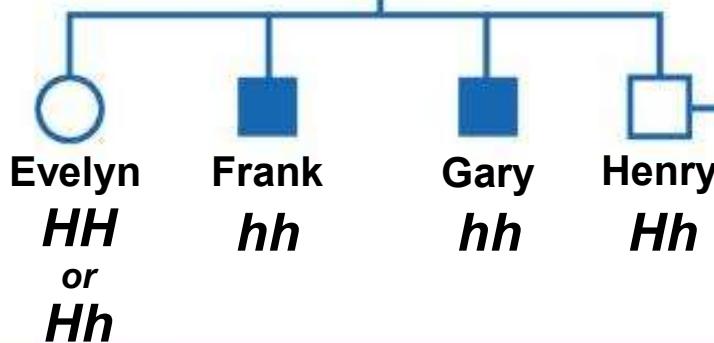
H : widow's peak allele
 h : straight allele



1ST GENERATION



2ND GENERATION



3RD GENERATION

Straight hairline



Kristin
 hh

Not all genotypes can be determined. Lori could be HH or Hh and there is no way to know (unless she has some children and the pedigree is extended).

Widow's peak



Lori
 HH or Hh

9.9 Many inherited disorders in humans are controlled by a single gene

- Because a trait is dominant does not mean that it is
 - “normal” or
 - more common than a recessive trait.
- Wild-type traits** are
 - those **most often seen** in nature and
 - not** necessarily specified by **dominant** alleles.

Dominant Traits

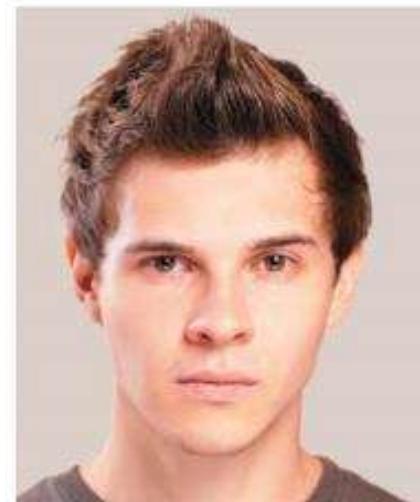


Recessive Traits



Freckles

No freckles



Key



Wild-type (more common) trait



Mutant (less common) trait

Normal pigmentation

Albinism

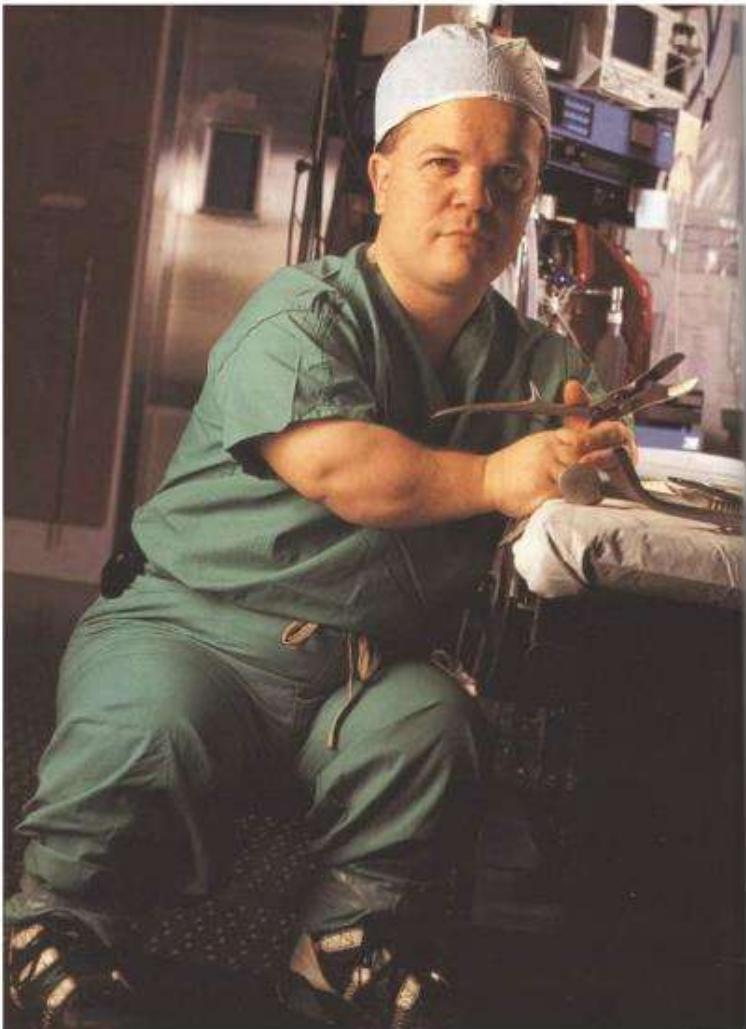
9.9 Many inherited traits in humans are controlled by a single gene

- The genetic disorders listed in Table 9.9 are known to be inherited as dominant or recessive traits controlled by a single gene.
- These human disorders therefore show simple inheritance patterns like the traits Mendel studied in pea plants.
- The genes discussed in this module are all located on autosomes.

TABLE 9.9 | SOME AUTOSOMAL DISORDERS IN HUMANS

Disorder	Major Symptoms	Incidence	Comments
Recessive Disorders			
Albinism	Lack of pigment in the skin, hair, and eyes	1/22,000	Prone to skin cancer
Cystic fibrosis	Excess mucus in the lungs, digestive tract, liver; increased susceptibility to infections; death in early childhood unless treated	1/2,500 Caucasians	See Module 9.9
Phenylketonuria (PKU)	Accumulation of phenylalanine in blood; lack of normal skin pigment; developmental disabilities	1/10,000 in United States and Europe	See Module 9.10
Sickle-cell disease	Sickled red blood cells; damage to many tissues	1/400 African Americans	See Module 9.13
Tay-Sachs disease	Lipid accumulation in brain cells; mental deficiency; blindness; death in childhood	1/3,600 Jews from central Europe	See Module 4.10
Dominant Disorders			
Achondroplasia	Dwarfism	1/25,000	See Module 9.9
Huntington's disease	Developmental disabilities and uncontrollable movements; strikes in middle age	1/25,000	See Module 9.9
Hypercholesterolemia	Excess cholesterol in the blood; heart disease	1/500 are heterozygous	See Module 9.11

- Thousands of human genetic disorders—ranging in severity from relatively mild, such as albinism, to invariably fatal, such as cystic fibrosis—are inherited as recessive traits.
- Most people who have recessive disorders are born to normal parents who
 - are both heterozygotes, **carriers** of the recessive allele for the disorder, but
 - are phenotypically normal.
- The most common lethal genetic disease in the United States is cystic fibrosis (CF). The CF allele is
 - recessive and
 - carried by about 1 in 31 Americans.
- Cystic fibrosis is
 - characterized by an excessive secretion of very thick mucus from the lungs and other organs and
 - most common in Caucasians.



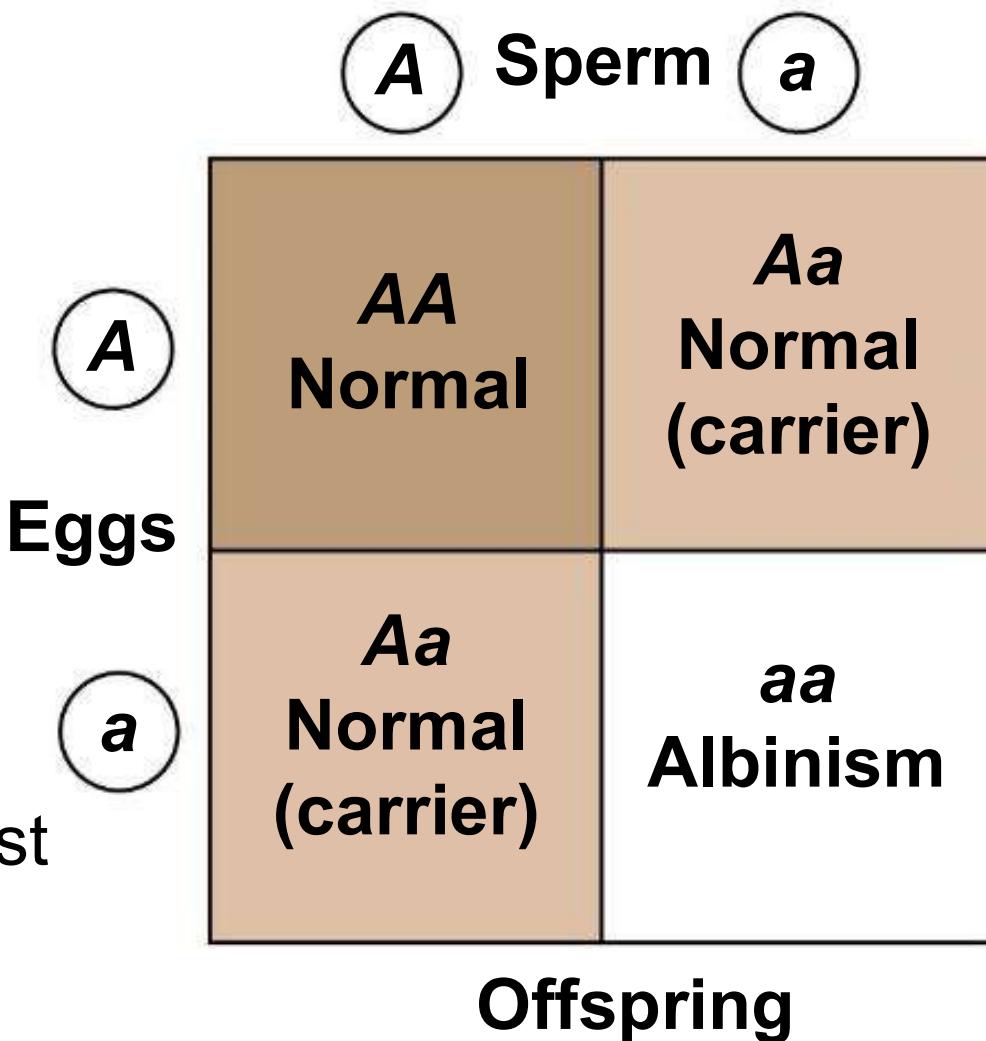
Dr. Michael C. Ain, a specialist
in the repair of bone defects

Parents

Normal Normal

Aa Aa

x



9.9 Many inherited traits in humans are controlled by a single gene

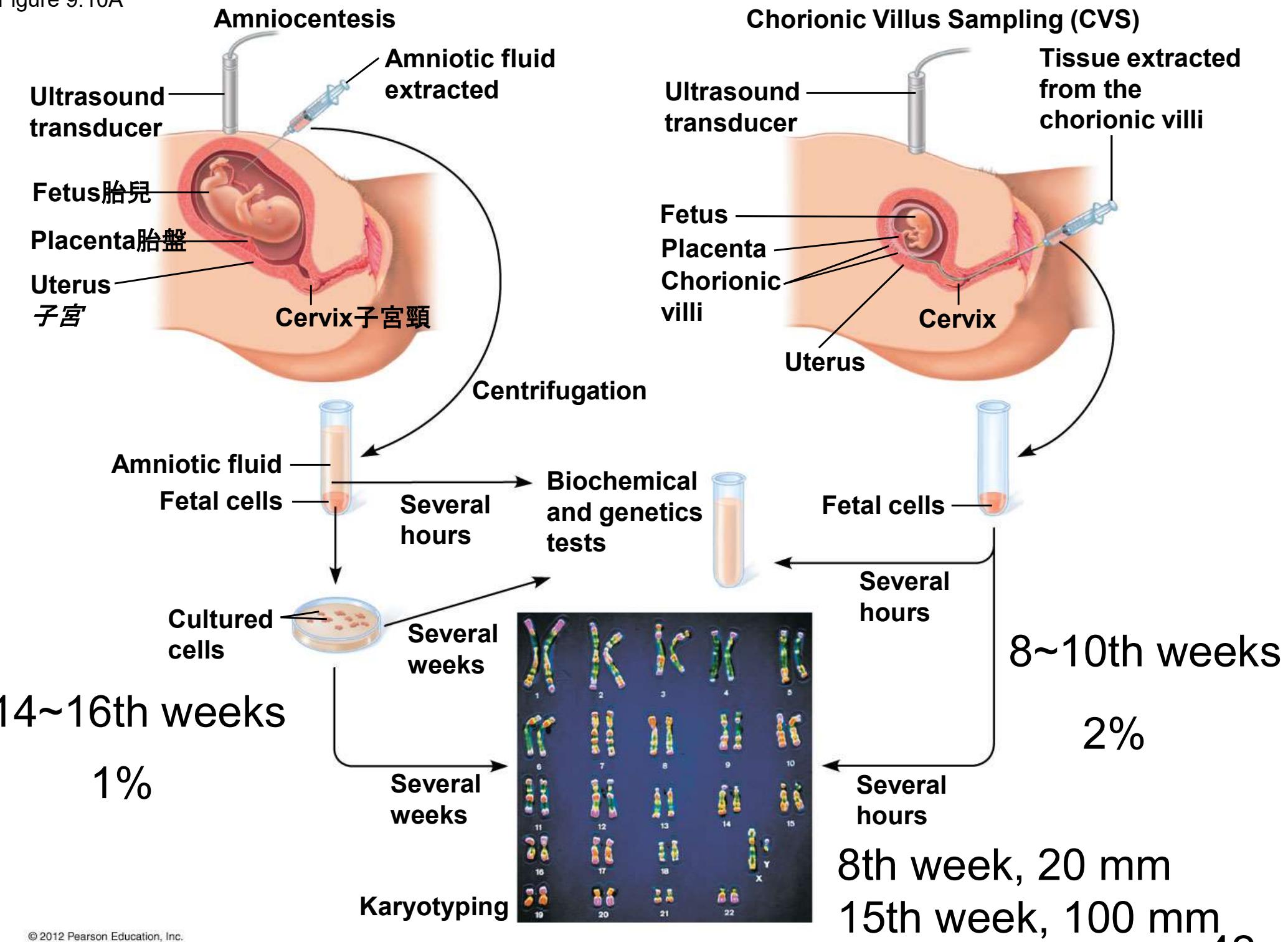
- Dominant human disorders include
 - **Huntington's disease**, a degenerative disorder of the nervous system and
 - achondroplasia, a form of dwarfism in which
 - the head and torso of the body develop normally but
 - the arms and legs are short.
- Until relatively recently, the onset of symptoms was the only way to know if a person had inherited the Huntington's allele.
- A **genetic test** is now available that can detect the presence of the Huntington's allele in an individual's genome.
- This is one of several genetic tests currently available.

9.10 New technologies can provide insight into one's genetic legacy

- Several technologies can be used for detecting genetic conditions in a fetus. 羊膜穿刺術
 - **Amniocentesis** extracts samples of amniotic fluid containing fetal cells and permits
 - karyotyping to detect chromosomal abnormalities such as Down syndrome and
 - biochemical tests on cultured fetal cells to detect other conditions, such as Tay-Sachs disease. 細毛篩檢
 - **Chorionic villus sampling** removes a sample of chorionic villus tissue from the placenta and permits similar karyotyping and biochemical tests.

Tay-Sachs disease: progressive deterioration of nerve cells and of mental and physical abilities that begins around six months of age. Hexosaminidase A

Figure 9.10A



民法第九百八十三條

與左列親屬，不得結婚：

一、直系血親及直系姻親。

二、旁系血親在六親等以內者。但因收養而成立之四親等及六親等旁系血親，輩分相同者，不在此限。

三、旁系姻親在五親等以內，輩分不相同者。

前項直系姻親結婚之限制，於姻親關係消滅後，亦適用之。

第一項直系血親及直系姻親結婚之限制，於因收養而成立之直系親屬間，在收養關係終止後，亦適用之。

74年修正以前，堂表兄妹（四親等）可以結婚。

最新文章: 0~9 : A : B : C : D : E : F : G : H : I : J : K : L : M : N : O : P : Q : R : S : T : U : V : W : X : Y : Z



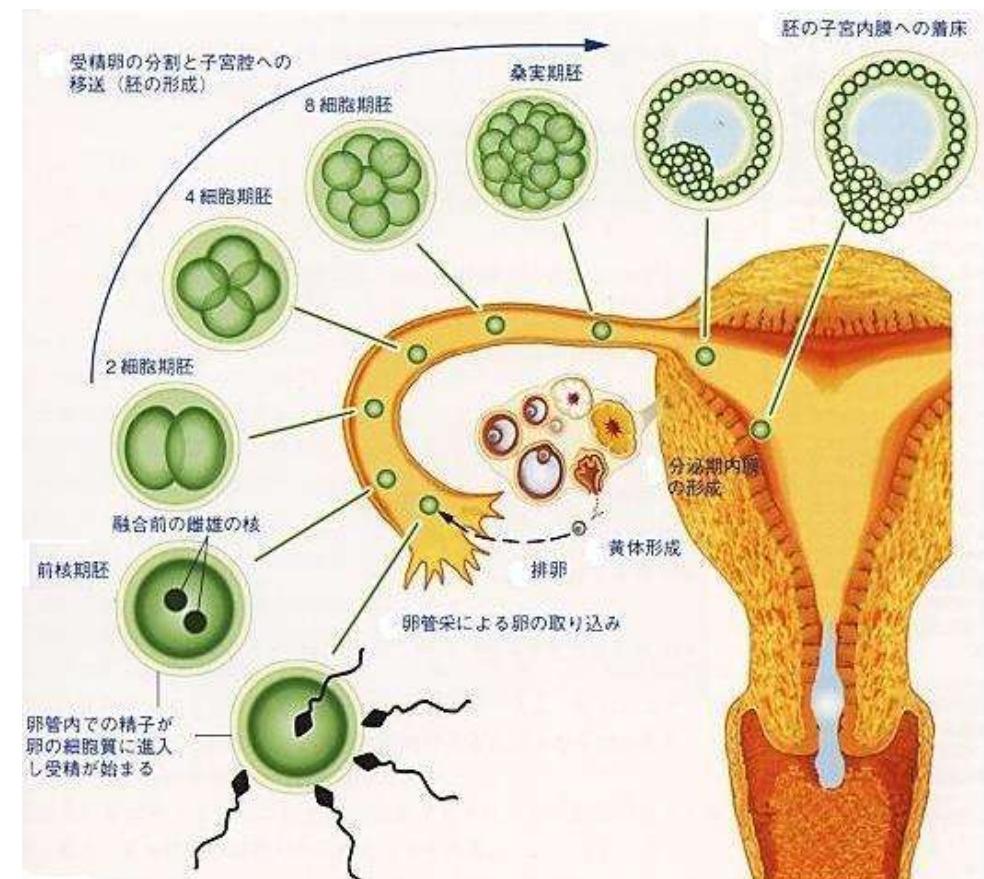
疾病介紹

PGD 胚胎著床前遺傳診斷 (Preimplantation Genetic Diagnosis)

高基因危險群

結合試管生殖技術及人工受孕，在受精卵變為8個細胞時，取出一顆進行基因檢測。

基因檢測晶片



jijimouse.pixnet.net

9.10 New technologies can provide insight into one's genetic legacy

- Blood tests on the mother at 15–20 weeks of pregnancy can help identify fetuses at risk for certain birth defects.
- Fetal imaging enables a physician to examine a fetus directly for anatomical deformities. The most common procedure is **ultrasound imaging**, using sound waves to produce a picture of the fetus.
- Newborn screening can detect diseases that can be prevented by special care and precautions.

9.10 New technologies can provide insight into one's genetic legacy

- New technologies raise **ethical considerations** that include
 - the confidentiality and potential use of results of genetic testing,
 - time and financial costs, and
 - determining what, if anything, should be done as a result of the testing.

非侵入性產前染色體篩檢

Non-Invasive Fetal Trisomy test; NIFTY/Non-Invasive Prenatal Test; NIPT



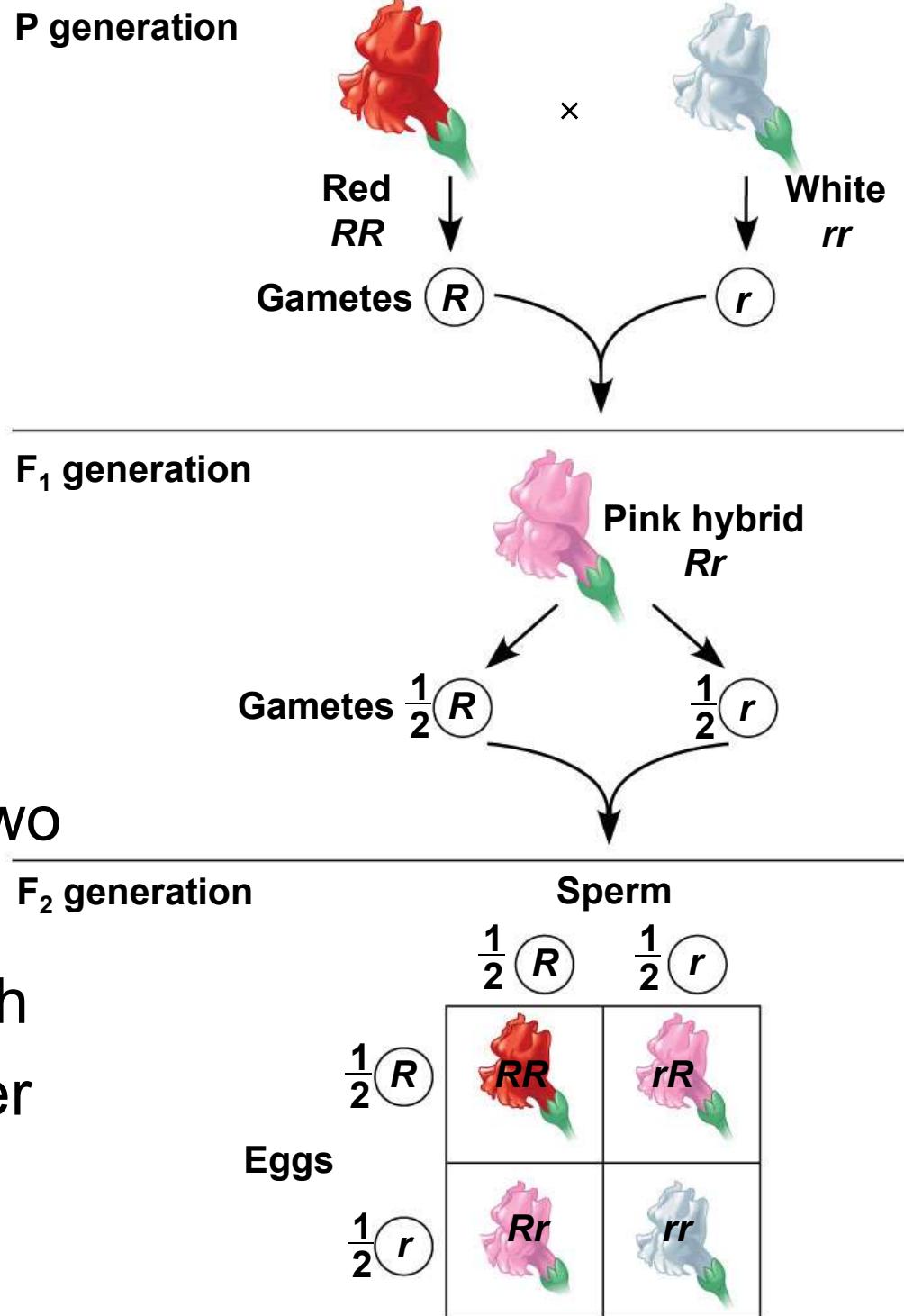
母親血漿含有胎兒的DNA片段，稱為「懸浮DNA」，再加上父親的DNA，在拼湊重建胎兒完整基因圖譜的同時，還可辨認胎兒的自發性基因突變。
18.5周、~2萬

VARIATIONS ON MENDEL'S LAWS

9.11 Incomplete dominance results in intermediate phenotypes

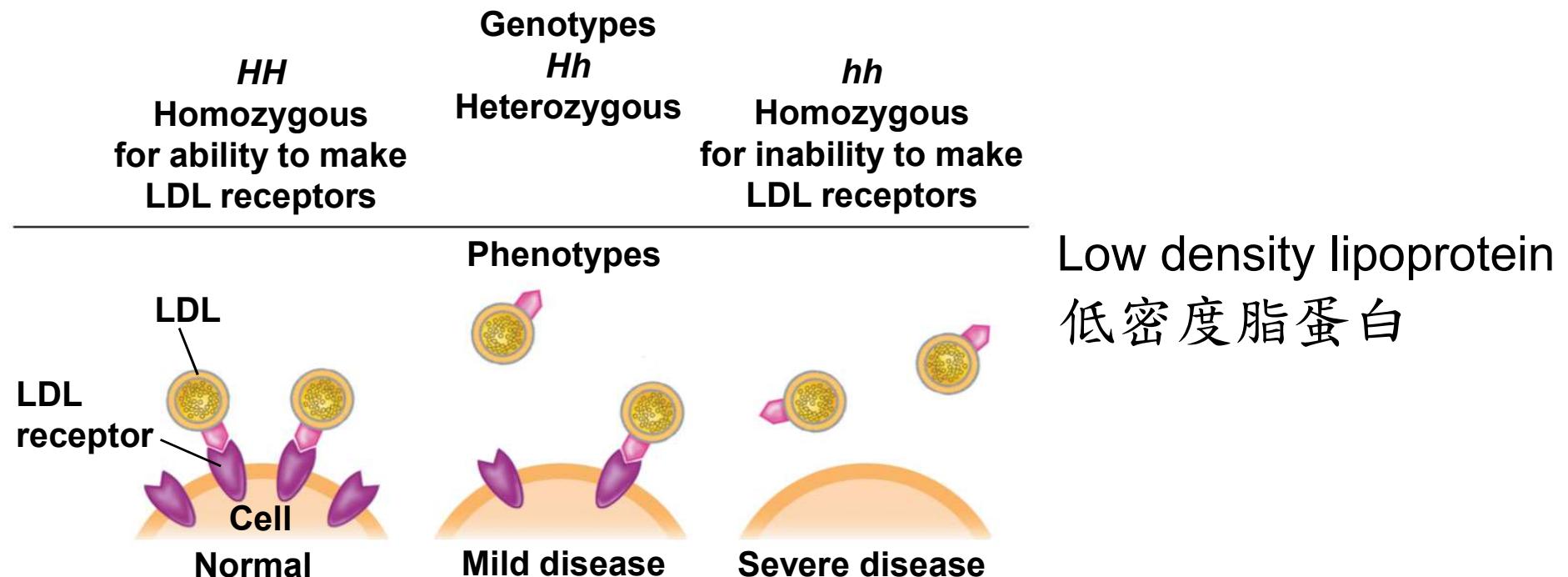
- Mendel's pea crosses always looked **like one of** the parental varieties, called **complete dominance**.

- For some characters, the appearance of F_1 hybrids falls **between** the phenotypes of the two parental varieties. This is called **incomplete dominance**, in which
 - neither allele is dominant over the other and
 - expression of both alleles occurs.**



9.11 Incomplete dominance results in intermediate phenotypes

- Incomplete dominance does not support the blending hypothesis because the original parental phenotypes **reappear** in the F_2 generation.
- One example of incomplete dominance in humans is **hypercholesterolemia**, in which 高膽固醇血症
 - dangerously high levels of cholesterol occur in the blood and
 - heterozygotes have intermediately high cholesterol levels.



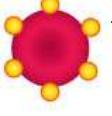
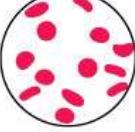
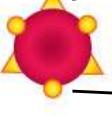
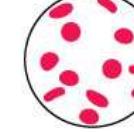
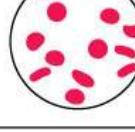
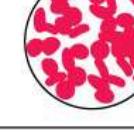
9.12 Many genes have more than two alleles in the population

- Although an individual can at most carry two different alleles for a particular gene, more than two alleles often exist in the wider population.
- Human ABO blood group phenotypes involve three alleles for a single gene.
- The four human blood groups, A, B, AB, and O, result from combinations of these three alleles.
- The A and B alleles are both expressed in heterozygous individuals, a condition known as codominance.

Incomplete: no clear-cut dominant or recessive

Codominance: both express “dominantly”

9.12 Many genes have more than two alleles in the population

Blood Group (Phenotype)	Genotypes	Carbohydrates Present on Red Blood Cells	Antibodies Present in Blood	Reaction When Blood from Groups Below Is Mixed with Antibodies from Groups at Left			
				O	A	B	AB
A 26%	$I^A I^A$ or $I^A i$	 - Carbohydrate A	Anti-B				
B 24%	$I^B I^B$ or $I^B i$	 - Carbohydrate B	Anti-A				
AB 6%	$I^A I^B$	 - Carbohydrate A and Carbohydrate B	None				
O 44%	ii	 Neither	Anti-A Anti-B				



No reaction



Clumping reaction

- In codominance,

- neither allele is dominant over the other and
- expression of **both** alleles is observed **as a distinct phenotype** in the heterozygous individual. (*vs. combined/blended phenotype*)
- AB blood type is an example of codominance.

RH陽性約99.7%，RH陰性0.3%。(白種人15%)

9.13 A single gene may affect many phenotypic characters

- **Pleiotropy** occurs when one gene influences multiple **characteristics**.

镰刀型紅血球疾病

- Sickle-cell disease is a human example of pleiotropy. This disease (usually homozygous)
 - affects the type of hemoglobin produced and the shape of red blood cells and
 - causes anemia and organ damage.
 - Sickle-cell and nonsickle alleles are **codominant**.
 - Carriers of sickle-cell disease are resistant to **malaria**.

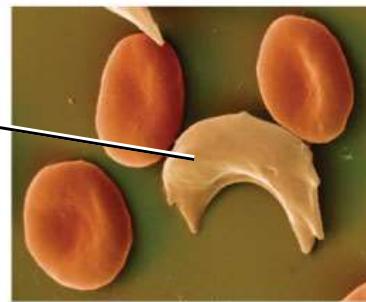
瘧疾

An individual homozygous for the sickle-cell allele

Produces sickle-cell (abnormal) hemoglobin

The abnormal hemoglobin crystallizes,
causing red blood cells to become sickle-shaped

Sickled cell



The multiple effects of sickled cells

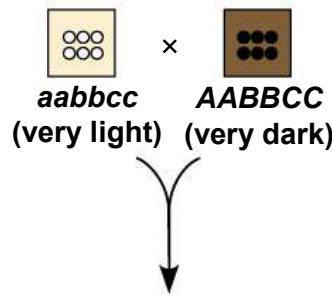
Damage to organs

- Kidney failure
- Heart failure
- Spleen damage
- Brain damage (impaired mental function, paralysis)

Other effects

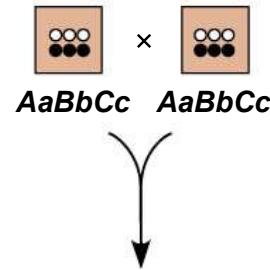
- Pain and fever
- Joint problems
- Physical weakness
- Anemia
- Pneumonia and other infections

P generation

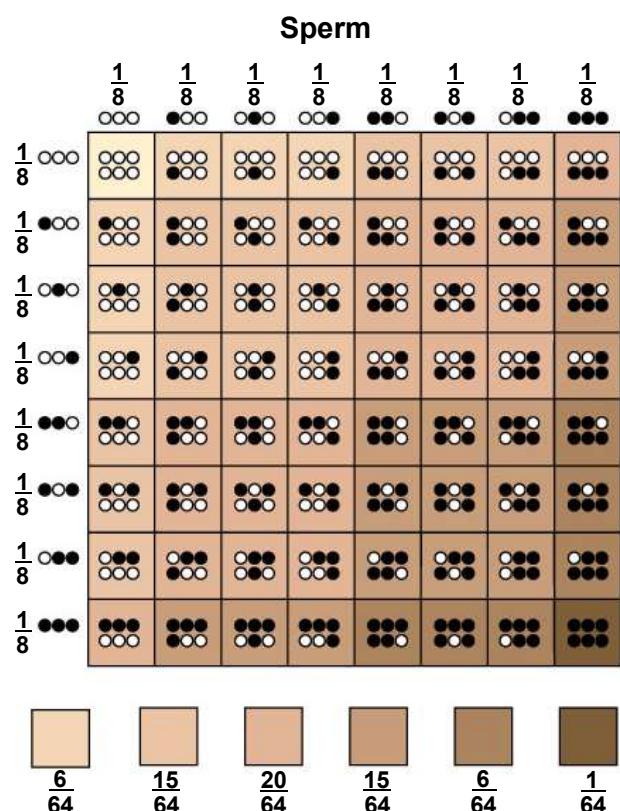


9.14 A single character may be influenced by many genes

F₁ generation

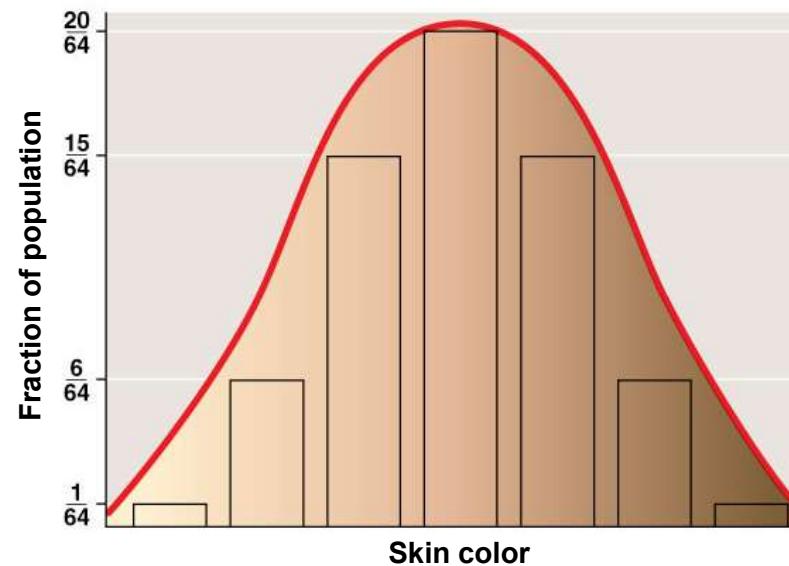


F₂ generation



- Many characteristics result from **polygenic inheritance**, in which a **single phenotypic character** results from the **additive effects** of two or more genes.

- Human skin color is an example of polygenic inheritance.



9.15 The environment affects many characters

- Many characters result from a combination of heredity and the environment. For example,
 - skin color is affected by exposure to sunlight,
 - heart disease and cancer are influenced by genes and the environment.
 - identical twins show some differences: **genetics and environment**.
- Only genetic influences are inherited.





Can gut microbes and genes do the job of weight loss surgery?

Medical Xpress - 17 小時前

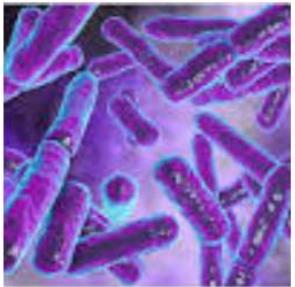
Mice that have undergone weight loss surgery experience a change in the composition of their gut bacteria and the functioning of their genes, ...



The Bacteria You've Never Heard Of That Promotes Weight Loss

mindbodygreen.com - 2019年3月30日

Some of these gut bacteria, like Lactobacillus and Bifidobacterium, we've ... For certain people—like those with high body weight, body mass ...



Gut bacteria and pregnancy

News-Medical.net - 21 小時前

The researchers explain that it is as if the gut bacteria can sense the fact ... pregnancy allow for adjustments in maternal metabolism and weight ...

Intestinal Bacteria Can Sense Pregnancy And Help In The ...

Tech Times - 2019年4月16日

[查看全部](#)



17 questions about gut health, answered by an expert

Telegraph.co.uk - 15 小時前

"The gut contains a community of 100 trillion microbes that are crucial for our health, metabolism, weight control and immune system," says ...

THE CHROMOSOMAL BASIS OF INHERITANCE

9.16 Chromosome behavior accounts for Mendel's laws

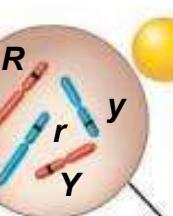
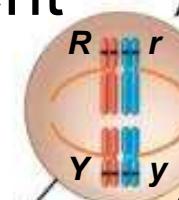
- The chromosome theory of inheritance states that
 - genes occupy specific loci (positions) on chromosomes and
 - chromosomes undergo **segregation** and **independent assortment** during meiosis.
- Mendel's laws correlate with chromosome separation in meiosis.
 - The law of segregation
 - states that pairs of **alleles separate from each other** during gamete formation via meiosis and
 - depends on separation of homologous chromosomes in **anaphase I**.
 - The law of independent assortment
 - states that each pair of alleles sorts independently of other pairs of alleles during gamete formation and
 - depends on alternative orientations of chromosomes in **metaphase I**.

Orientation of homologous pairs: law of independent assortment

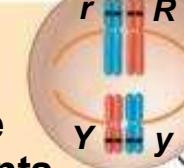
Separation of homologs: law of segregation

F₁ generation

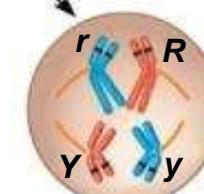
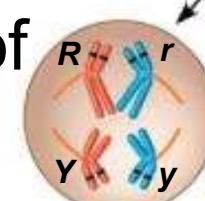
All yellow round seeds
(RrYy)



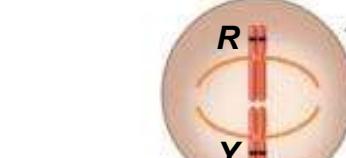
Two equally probable arrangements of chromosomes at metaphase I



Anaphase I



Metaphase II



Gametes



$\frac{1}{4}$

RY

RY

$\frac{1}{4}$

ry

ry

$\frac{1}{4}$

rY

rY

$\frac{1}{4}$

Ry

Ry

Fertilization among the F₁ plants

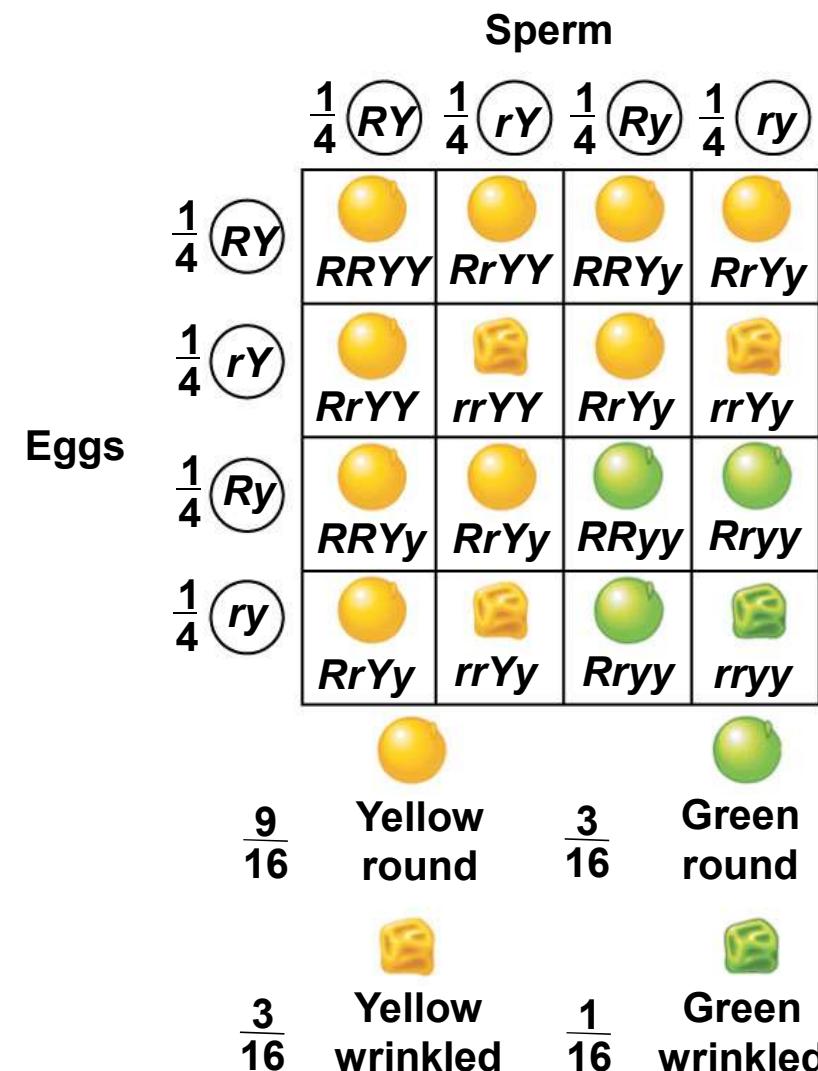
F₂ generation

9 yellow round : 3 yellow wrinkled : 3 green round : 1 green wrinkled

Meiosis I

Meiosis II

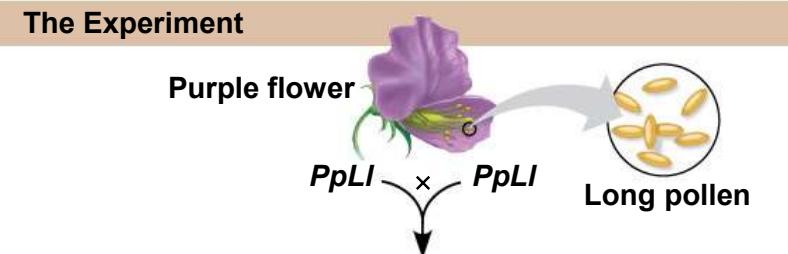
Figure 9.16_4



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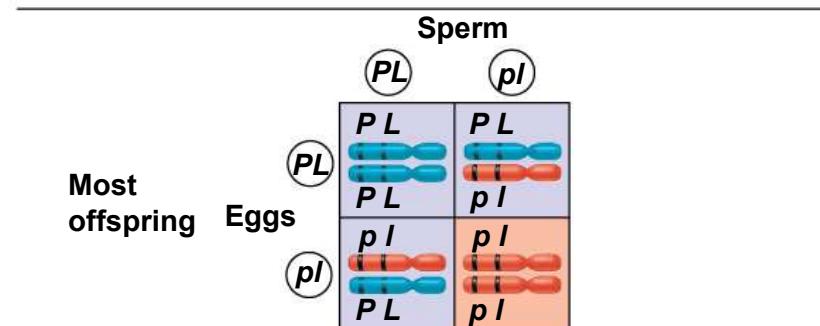
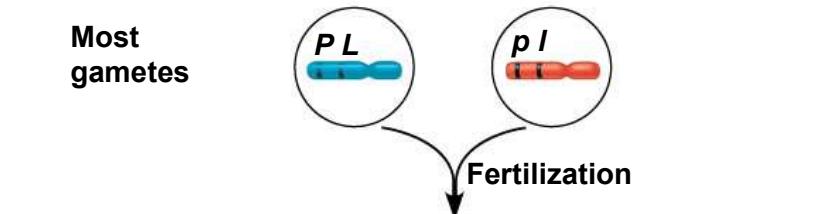
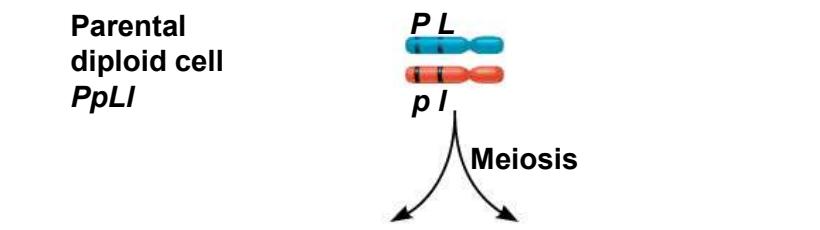
9.17 Genes on the same chromosome tend to be inherited together

- Bateson and Punnett studied plants that did not show a 9:3:3:1 ratio in the F₂ generation. What they found was an example of **linked genes**, which
 - are located close together on the same chromosome and
 - tend to be inherited together.



Phenotypes	Observed offspring	Prediction (9:3:3:1)
Purple long	284	215
Purple round	21	71
Red long	21	71
Red round	55	24

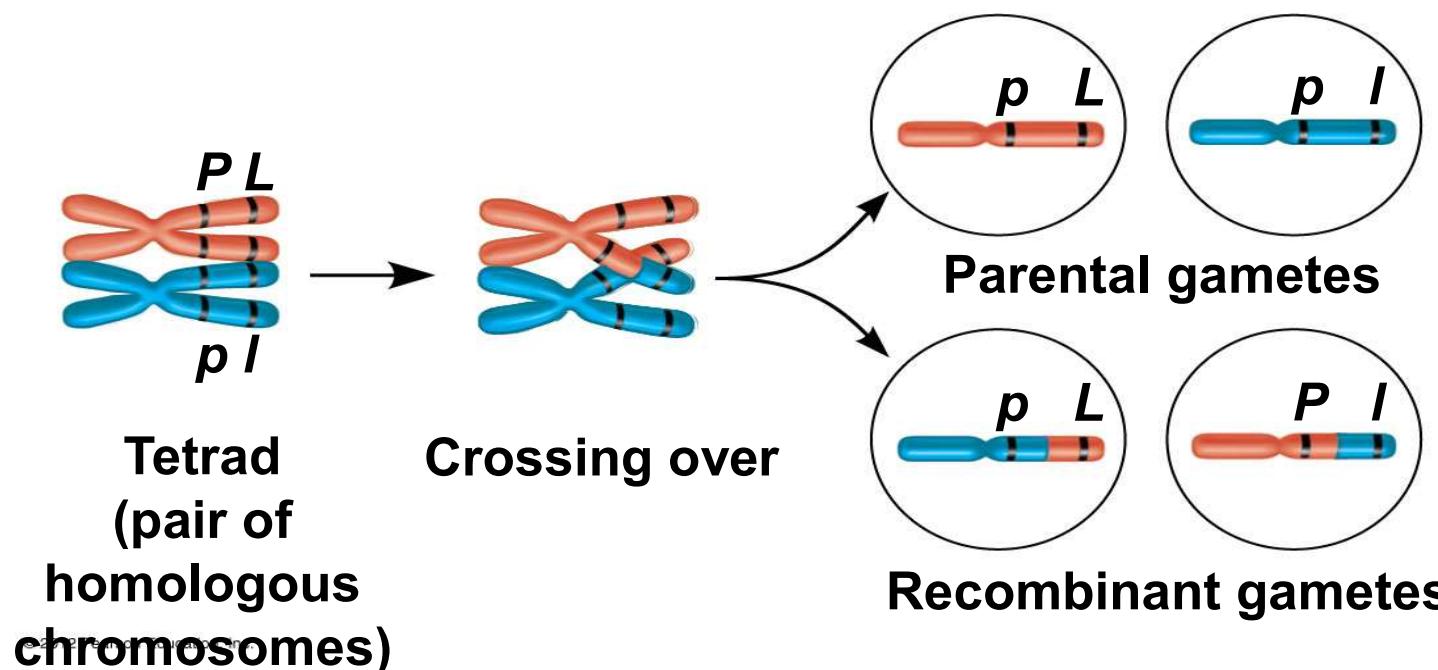
The Explanation: Linked Genes



3 purple long : 1 red round
Not accounted for: purple round and red long

9.18 Crossing over produces new combinations of alleles

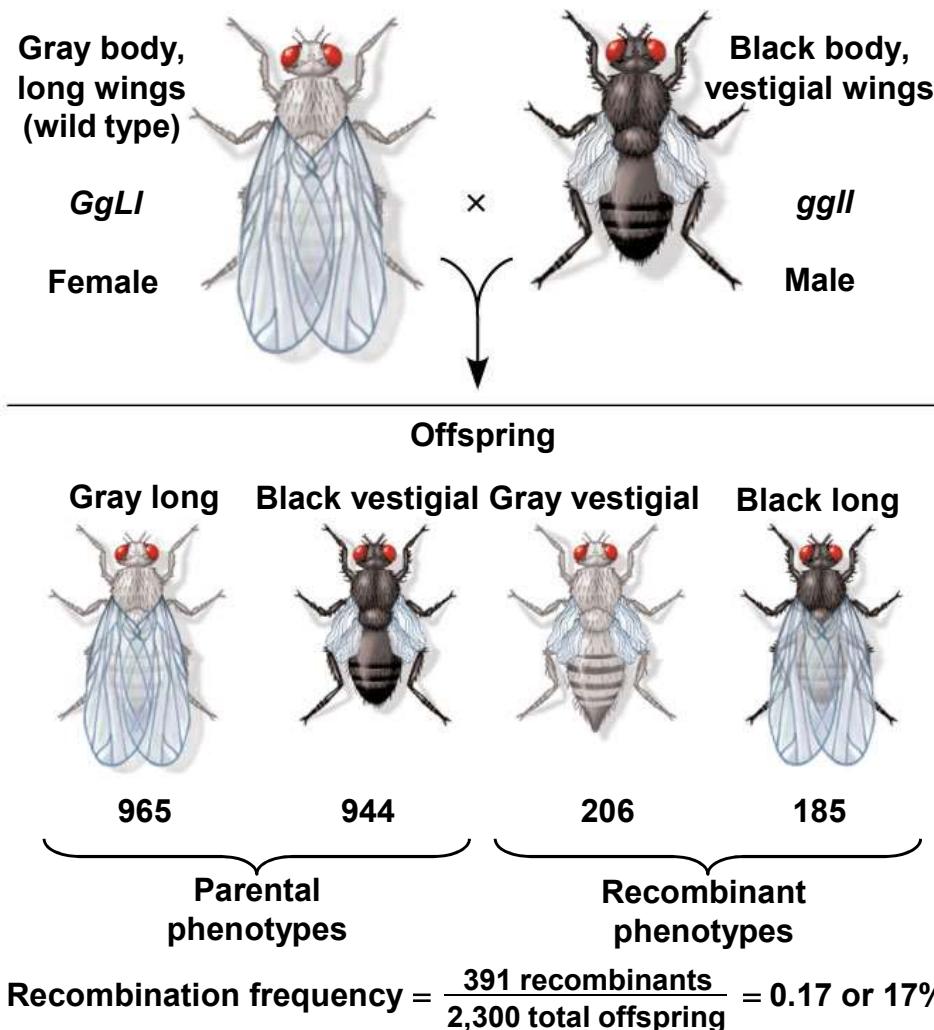
- Crossing over between homologous chromosomes produces new combinations of alleles in gametes.
- Linked alleles can be separated by crossing over, forming recombinant gametes.
- The percentage of recombinants is the **recombination frequency**.



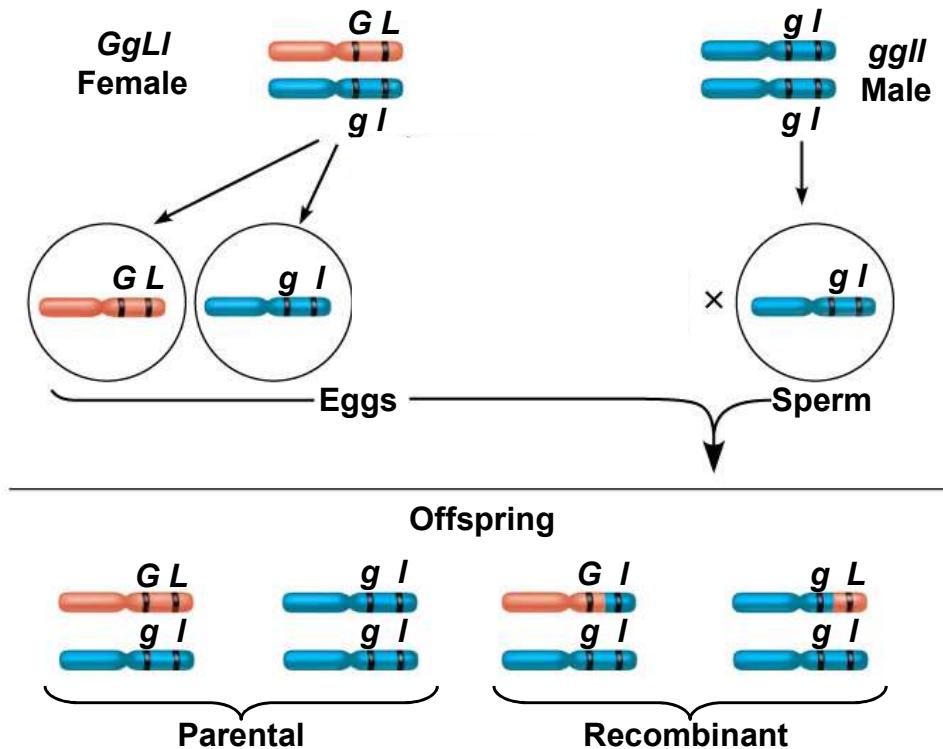
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Figure 9.18C

The Experiment

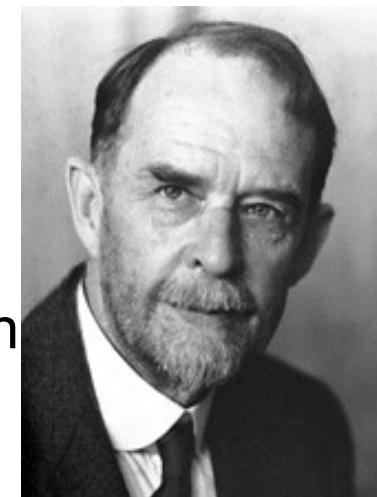


The Explanation



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Thomas Hunt Morgan
1866-1945
1933 Nobel Prize



http://nobelprize.org/nobel_prizes/medicine/laureates/1933/morgan-bio.html

9.19 Geneticists use crossover data to map genes

- When examining recombinant frequency, Alfred H. Sturtevant, one of Morgan's students, found that the greater the **distance** between two genes on a chromosome, the more points there are between them where crossing over can occur.
- Recombination frequencies can thus be used to **map** the relative position of genes on chromosomes.

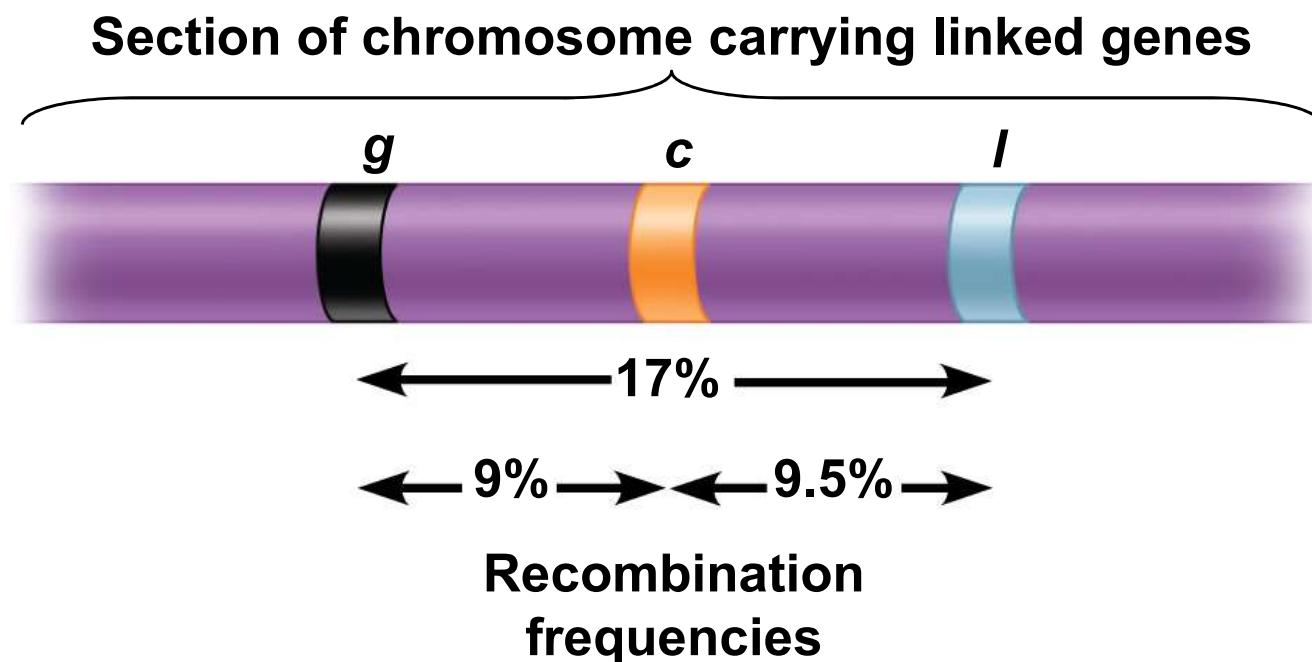
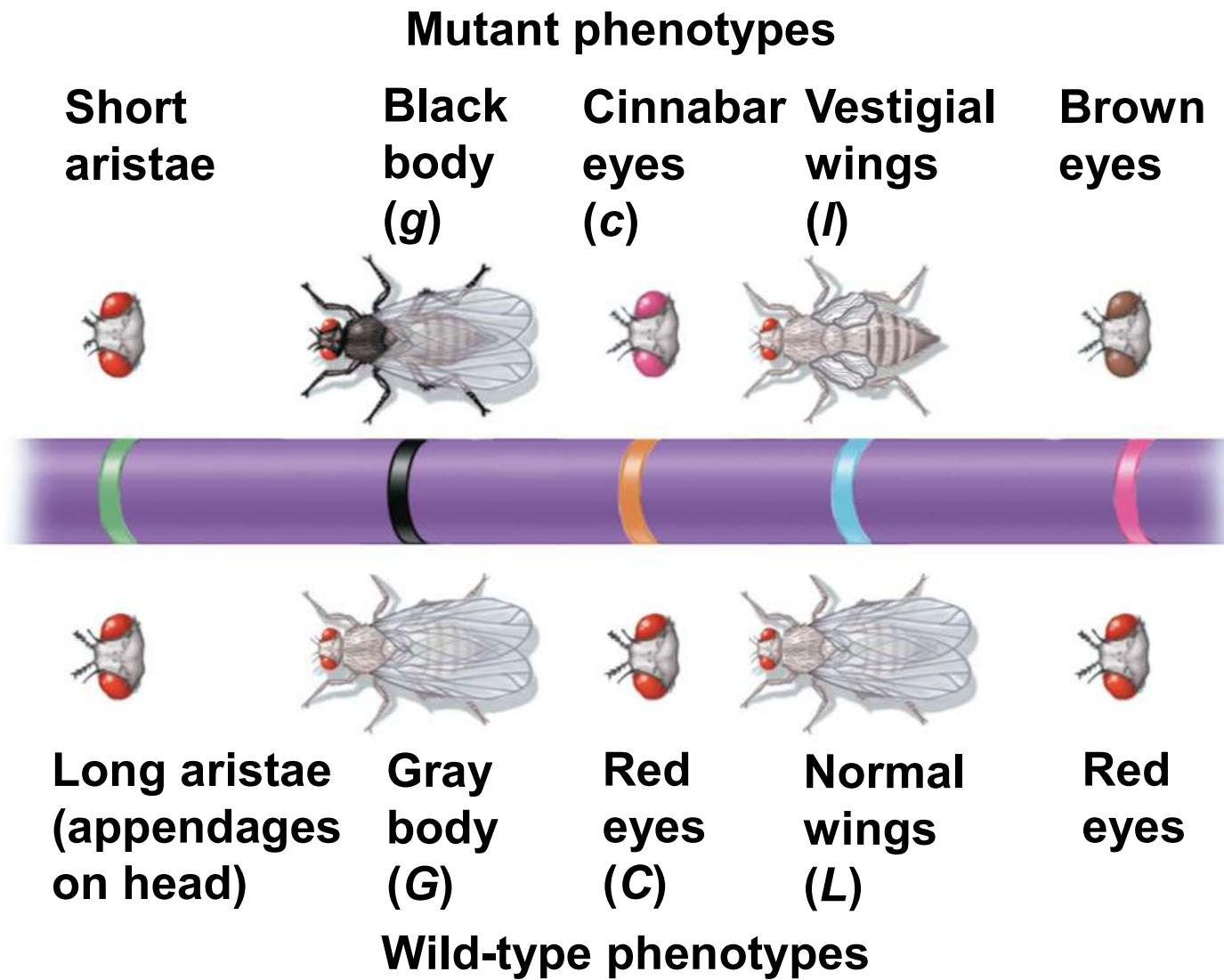


Figure 9.19B

Such a diagram of relative gene locations is called a **linkage map**.



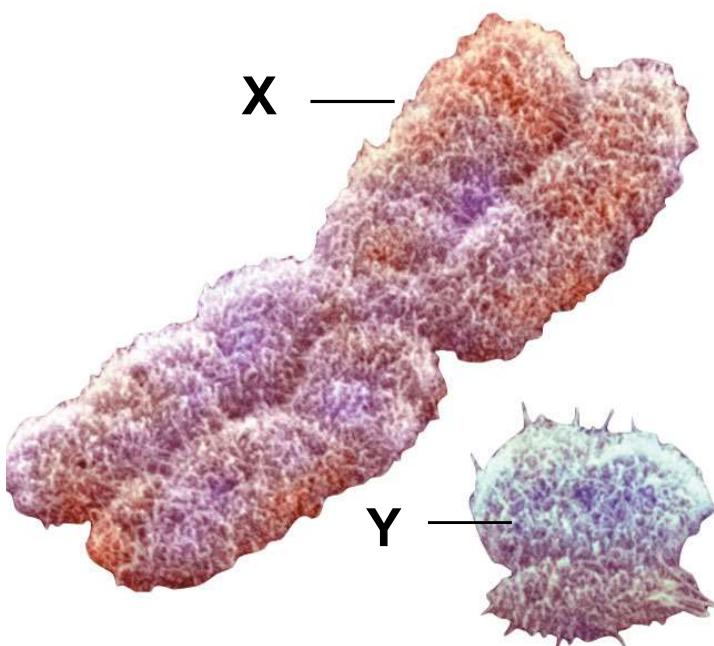
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SEX CHROMOSOMES AND SEX-LINKED GENES

9.20 Chromosomes determine sex in many species

- Many animals have a pair of **sex chromosomes**, designated X and Y, that determine an individual's sex.
- Among humans and other mammals,
 - individuals with one X chromosome and one Y chromosome are males, and
 - XX individuals are females.
- In addition, human males and females both have 44 autosomes (nonsex chromosomes).
- In mammals (including humans),
 - the Y chromosome has a crucial gene, *SRY*, for the development of testes, and
 - an **absence** of the *SRY* gene directs ovaries to develop.
sex-determining region of Y-chromosome

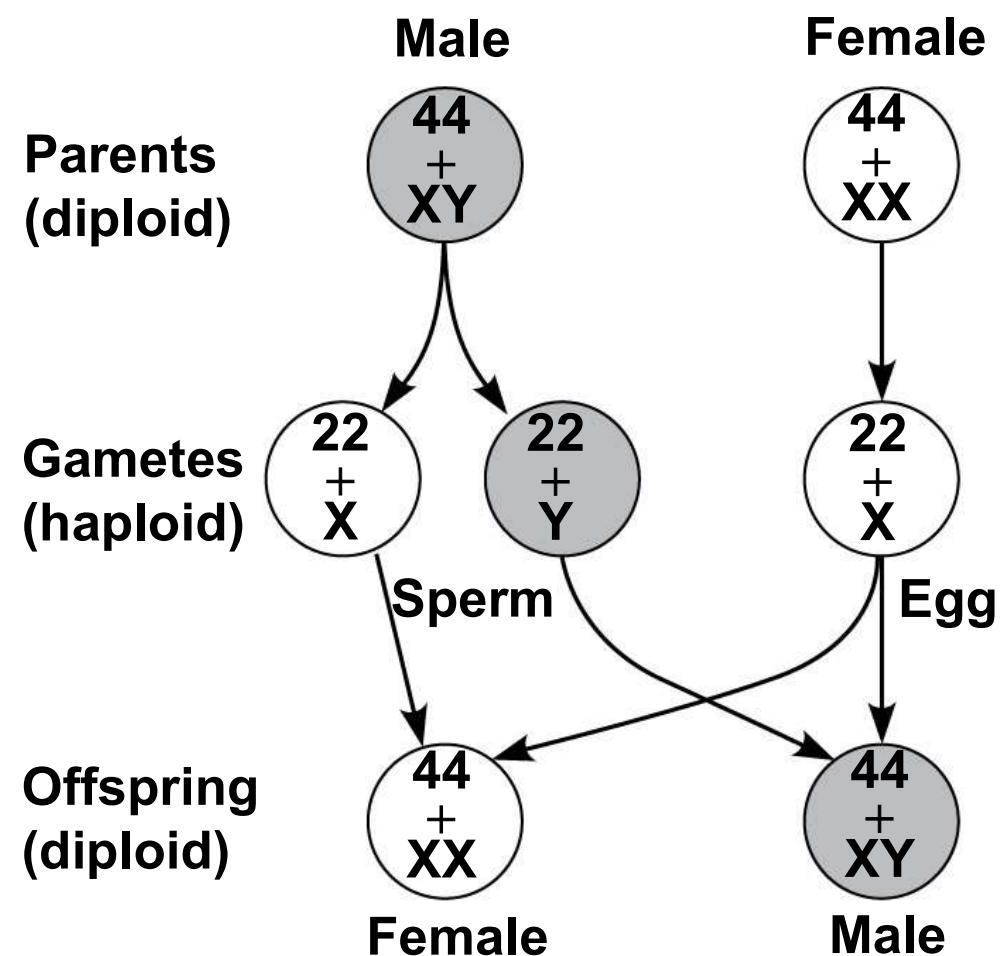
Figure 9.20B



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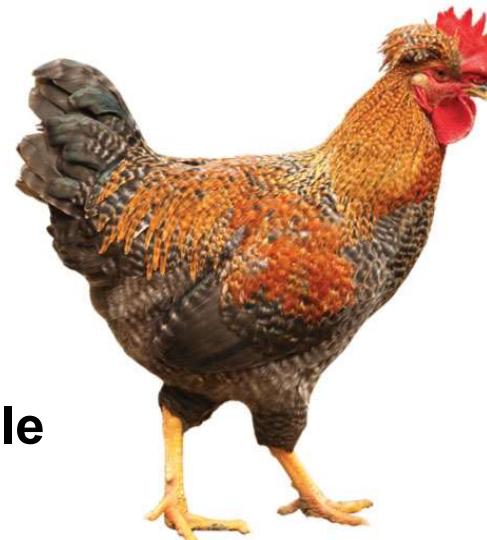
9.20 Chromosomes determine sex in many species

- Grasshoppers, roaches, and some other insects have an X-O system, in which
 - O stands for the **absence** of a sex chromosome,
 - females are XX, and
 - males are XO.
- In certain fishes, butterflies, and birds,
 - the sex chromosomes are Z and W,
 - males are ZZ, and
 - females are ZW.



Male
 $22 + X$

Female
 $22 + XX$



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Male
 $76 + ZZ$

Female
 $76 + ZW$

9.20 Chromosomes determine sex in many species

- Some organisms **lack sex chromosomes** altogether.
- In bees, sex is determined by chromosome number.
 - Females develop from fertilized eggs and thus are diploid.
 - Males develop from unfertilized eggs. Males are thus
 - fatherless and
 - haploid.



Male

16

Female

32

TABLE 9.20 THREE SYSTEMS OF SEX DETERMINATION

Genetic Makeup

System	Example Organism	Males	Females
X-O		22 + X	22 + XX
Z-W		76 + ZZ	76 + ZW
Chromosome number		16	32

9.20 Chromosomes determine sex in many species

- In some animals, environmental temperature determines the sex.
 - For some species of reptiles, the temperature at which the eggs are incubated during a specific period of development determines whether the embryo will develop into a male or female.
 - Global climate change may therefore impact the sex ratio of such species.

熱帶小丑魚：群體內的首領為雌性，其他則變為雄性。

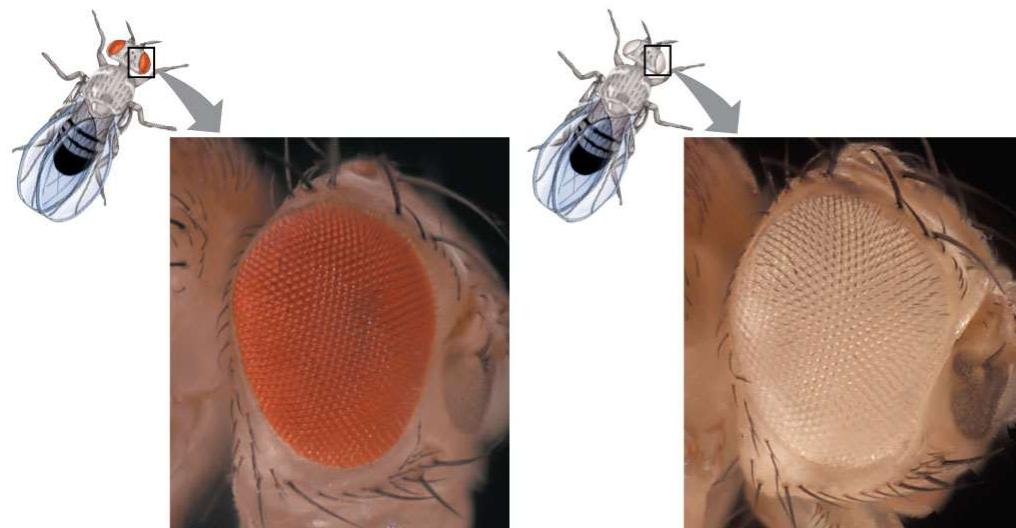
龜：孵卵時的溫度（綠蠵龜：同一卵窩中產生雄雌各半時的溫度，通常介於 $28.0\sim30.3^{\circ}\text{C}$ 之間。當性別決定期時的溫度高於中樞溫度時，孵出的均為雌龜；而當溫度低於中樞溫度時，均為雄龜）

人？

9.21 Sex-linked genes exhibit a unique pattern of inheritance

- **Sex-linked genes** are located on either of the sex chromosomes.
- The X chromosome carries many genes unrelated to sex.
- The inheritance of white eye color in the fruit fly illustrates an X-linked recessive trait.

Figure 9.21A

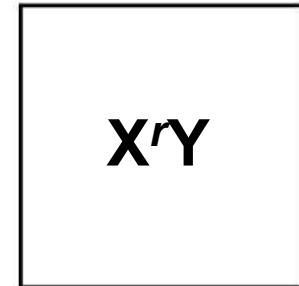


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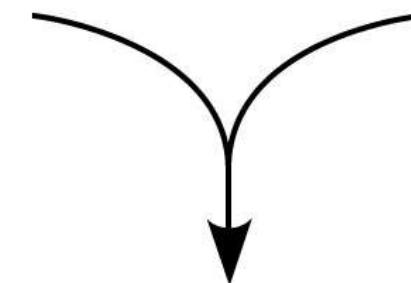
Female



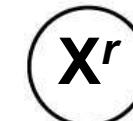
Male



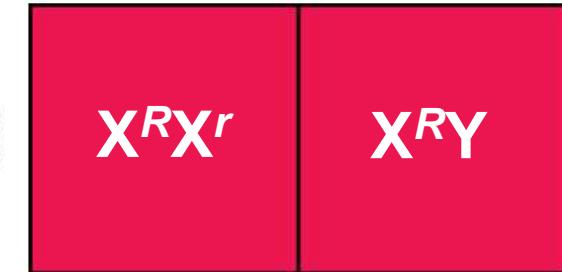
\times



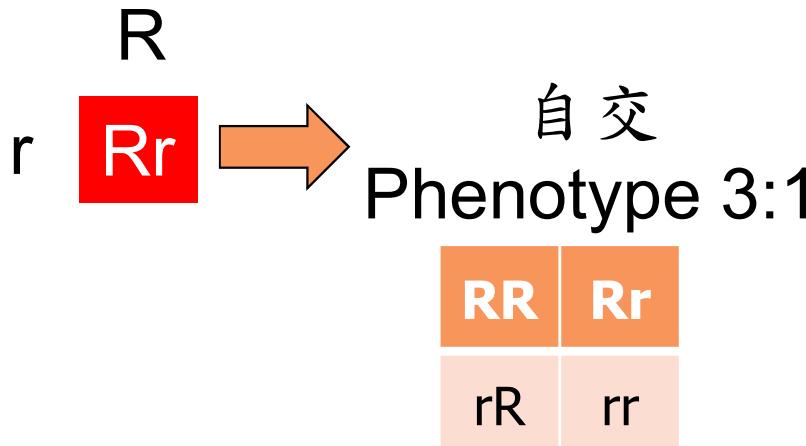
Sperm



Eggs



果蠅：共4對染色體



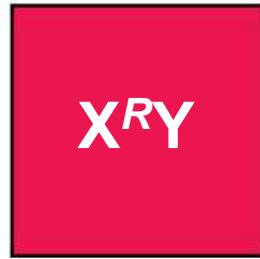
***R* = red-eye allele**
***r* = white-eye allele**

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Female



Male

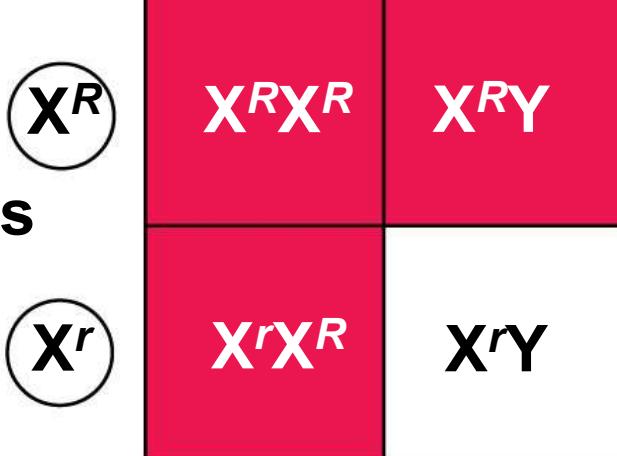


×

Sperm



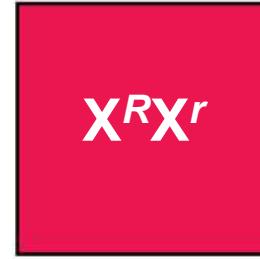
Eggs



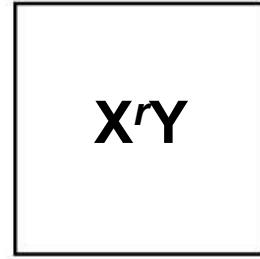
R = red-eye allele
 r = white-eye allele

3:1 but
All male

Female



Male

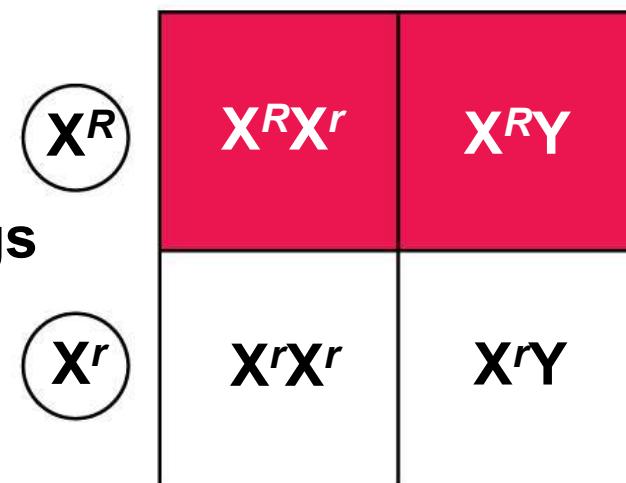


×

Sperm



Eggs



R = red-eye allele
 r = white-eye allele

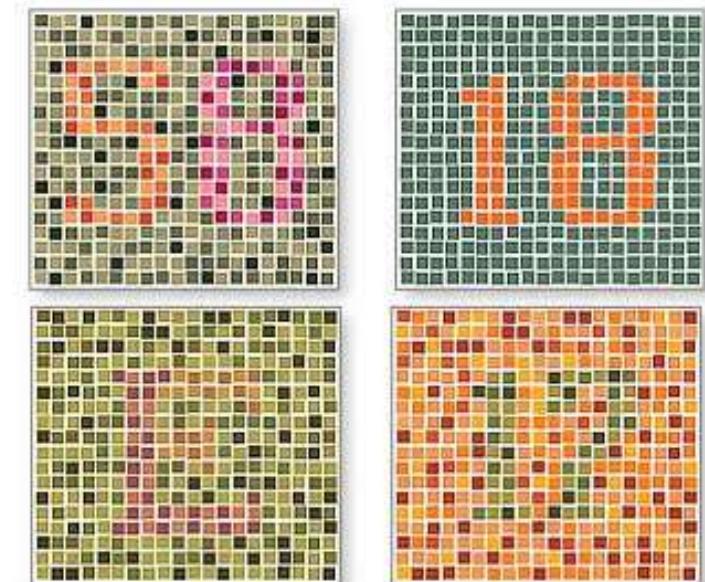
phenotype
1:1

9.22 Human sex-linked disorders affect mostly males

- Most sex-linked human disorders are
 - due to **recessive** alleles and
 - seen **mostly in males.**
- A male receiving a single X-linked recessive allele from his mother will have the disorder.
- A female must receive the allele from both parents to be affected.

9.22 Human sex-linked disorders affect mostly males

- Recessive and sex-linked human disorders include
 - **hemophilia**, characterized by excessive bleeding because hemophiliacs lack one or more of the proteins required for blood clotting, 血友病
 - **red-green color blindness**, a malfunction of light-sensitive cells in the eyes, and
 - **Duchenne muscular dystrophy** 萎縮, a condition characterized by a progressive weakening of the muscles and loss of coordination.



Various tests for color blindness

ADAM.

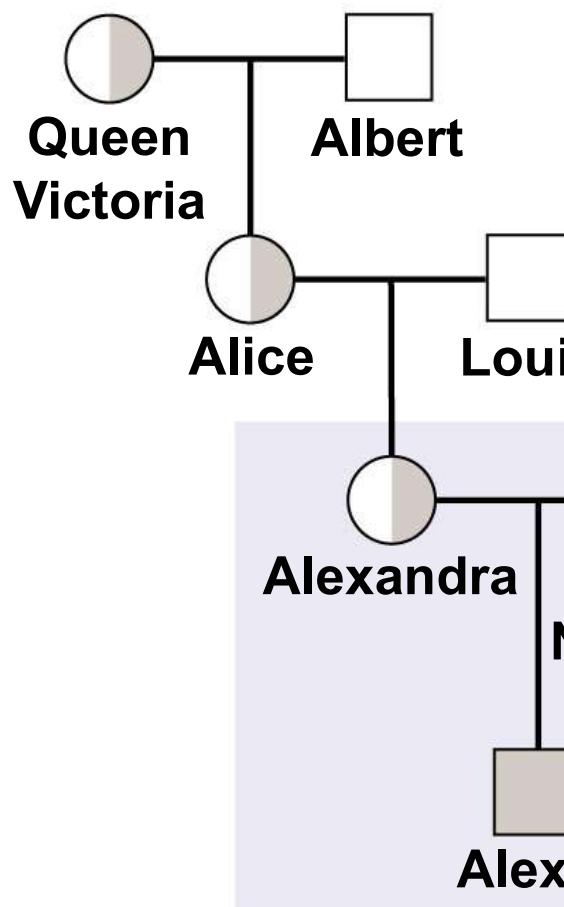


Figure 9.22

Female	Male
	Hemophilia
	Carrier
	Normal

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DNA testing ends mystery surrounding Czar Nicholas II children
With bone fragment analysis, scientists put to rest the rumors that two children might have escaped the royal family's murder during the Russian Revolution.

March 11, 2009 | Thomas H. Maugh II

<http://articles.latimes.com/2009/mar/11/science/sci-romanov11>

Newly analyzed DNA evidence from a second, nearby grave discovered in 2007 proves that the bones are those of two Romanov children, ending the mystery once and for all.

9.23 The Y chromosome provides clues about human male evolution

- In 2003, geneticists discovered that about 8% of males currently living in **central Asia** have Y chromosomes of striking genetic similarity.
- Further analysis traced their **common genetic heritage** to a single man living about 1,000 years ago.
- In combination with historical records, the data led to the speculation that the Mongolian ruler Genghis Kahn may be responsible for the spread of the telltale chromosome to nearly 16 million men living today

9.23 The Y chromosome provides clues about human male evolution

- The Y chromosome provides clues about human male evolution because
 - Y chromosomes are passed intact from father to son and
 - mutations in Y chromosomes can reveal data about recent shared ancestry.



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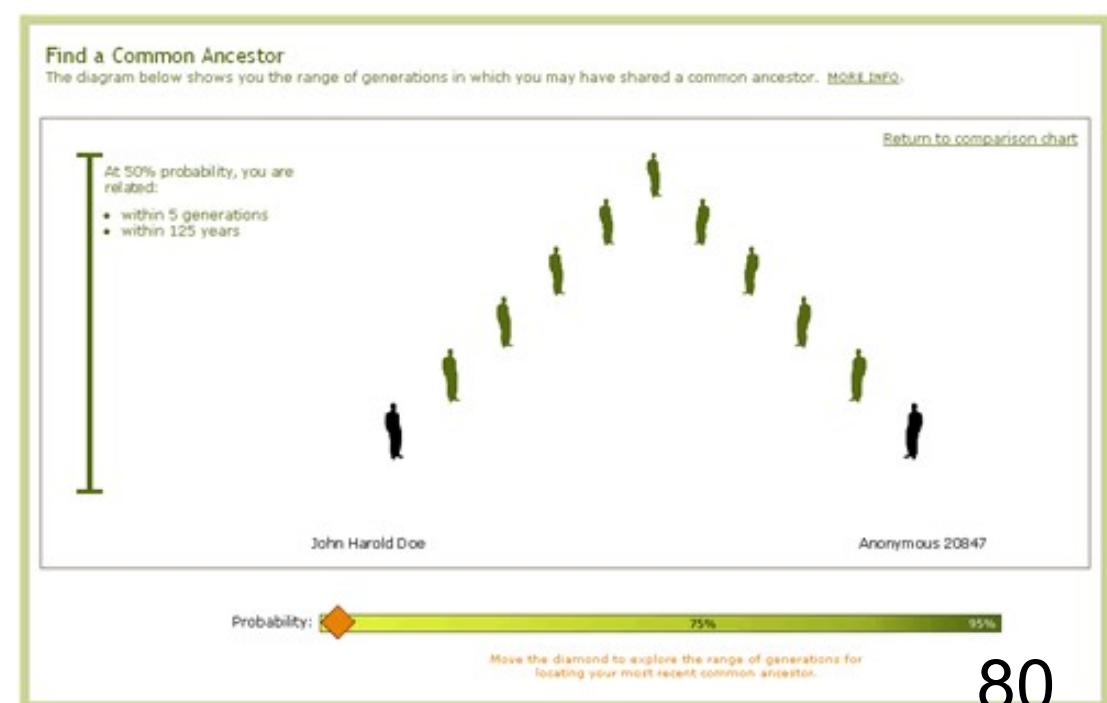
鄭和船隊與非洲？

<http://dna.ancestry.com/>

Paternal: Y chromosome

Maternal: mitochondria chromosome

臺灣有類似的公司嗎？

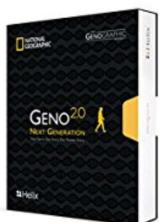


Amazon National DNA Day sale!

4/25, human genome project 2003 completion and 1953 DNA double helix

DNA Day Deals

Available



DEAL OF THE DAY

\$68.95
Price: \$99.00 (30% off)

Ends in 3:19:22

[Save on AncestryDNA](#)

Sold by AncestryDNA Official and Fulfilled by Amazon.

★★★★★ 3042

DEAL OF THE DAY

\$70.00
List: \$99.95 (30% off)

Ends in 3:24:21

[National Geographic DNA Test Kit](#)

Ships from and sold by Amazon.com.

★★★★★ 4

\$139.00
Price: \$199.00 (30% off)

[Save 30% On 23andMe Health + Ancestry Service DNA Test](#)

Sold by 23andMe, Inc and Fulfilled by Amazon.

★★★★★ 1190

\$68.00
List: \$75.00 (9% off)

[Celebrating DNA Day](#)

Ships from and sold by Amazon.com.

★★★★★ 465

\$14.50 - \$24.50
List: \$29.00 - \$49.00 (50% o

[Big Savings on Orig3n Mini E Test Kits](#)

★★★★★ 119

Family Tree DNA Genetic Ancestry Test Kit - Worlds First Genetic Genealogy Company - History Unearthed Daily [Family Tree DNA](#)

★★★★★ 104 customer reviews | 43 answered questions

List Price: \$79.00

Price: **\$69.99**

You Save: \$9.01 (11%)

In Stock. Sold by GVB C available.

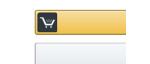
3 Styles: Test Kit - 1pk



This item does not ship to other sellers who may ship

Deliver to Taiwan

Qty: 1



THE TWO-WAY

In Hunt For Golden State Killer, Investigators Uploaded His DNA To Genealogy Site

April 27, 2018 • After failing to find a match within criminal databases, law enforcement uploaded the killer's DNA profile to a no-frills website used to trace ancestry. The tactic has spurred privacy concerns.

<https://www.npr.org/sections/science/>



Rich Pedroncelli/AP

You should now be able to

1. Describe the theory of pangenesis and the blending hypothesis. Explain why both ideas are now rejected.
2. Define and distinguish between true-breeding organisms, hybrids, the P generation, the F₁ generation, and the F₂ generation.
3. Define and distinguish between the following pairs of terms: homozygous and heterozygous; dominant allele and recessive allele; genotype and phenotype. Also, define a monohybrid cross and a Punnett square.
4. Explain how Mendel's law of segregation describes the inheritance of a single characteristic.
5. Describe the genetic relationships between homologous chromosomes.
6. Explain how Mendel's law of independent assortment applies to a dihybrid cross.
7. Explain how and when the rule of multiplication and the rule of addition can be used to determine the probability of an event.
8. Explain how family pedigrees can help determine the inheritance of many human traits.
9. Explain how recessive and dominant disorders are inherited. Provide examples of each.

10. Compare the health risks, advantages, and disadvantages of the following forms of fetal testing: amniocentesis, chorionic villus sampling, and ultrasound imaging.
11. Describe the inheritance patterns of incomplete dominance, multiple alleles, codominance, pleiotropy, and polygenic inheritance.
12. Explain how the sickle-cell allele can be adaptive.
13. Explain why human skin coloration is not sufficiently explained by polygenic inheritance.
14. Define the chromosome theory of inheritance. Explain the chromosomal basis of the laws of segregation and independent assortment.
15. Explain how linked genes are inherited differently from nonlinked genes.
16. Describe T. H. Morgan's studies of crossing over in fruit flies. Explain how Sturtevant created linkage maps.
17. Explain how sex is genetically determined in humans and the significance of the SRY gene.
18. Describe patterns of sex-linked inheritance and examples of sex-linked disorders.
19. Explain how the Y chromosome can be used to trace human ancestry.