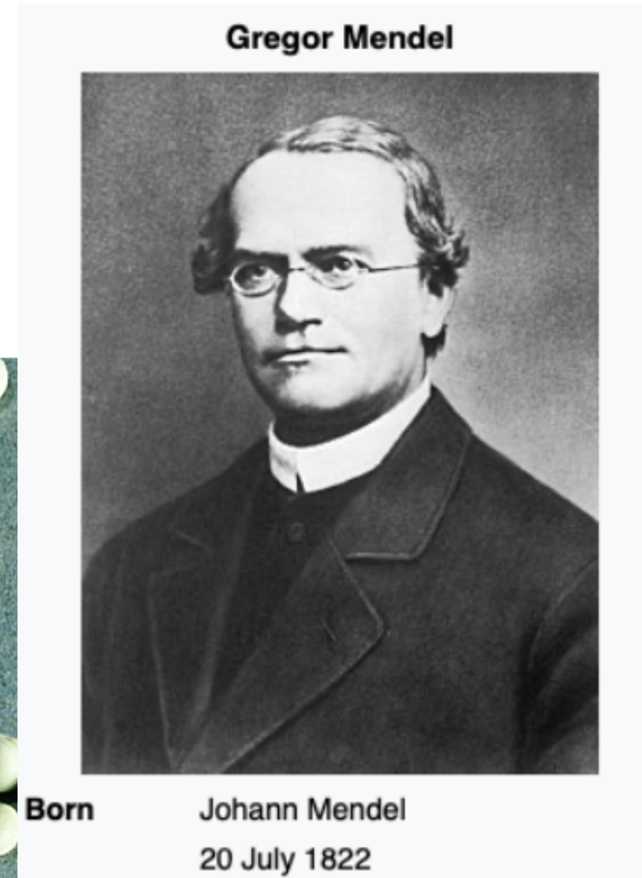
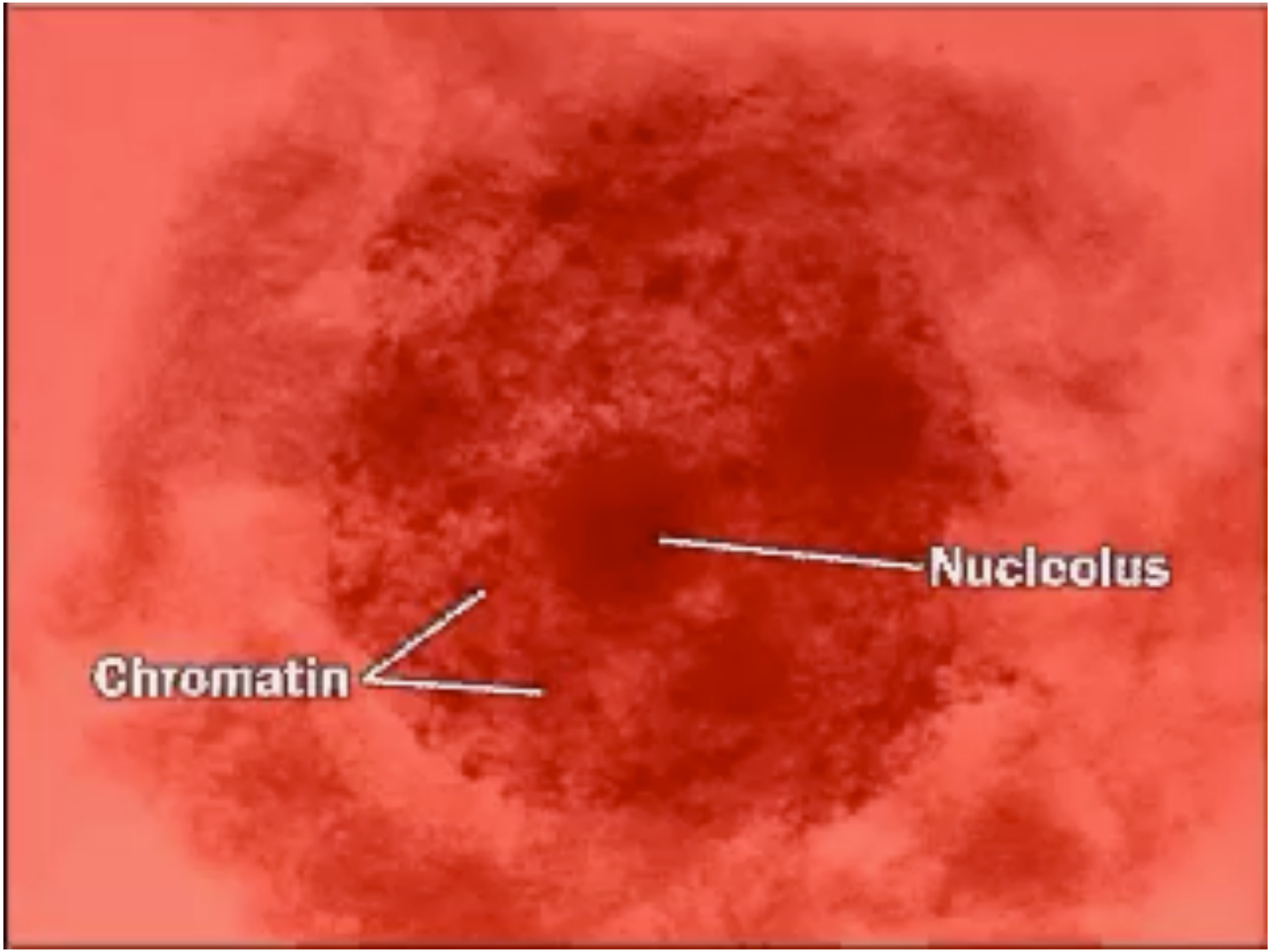
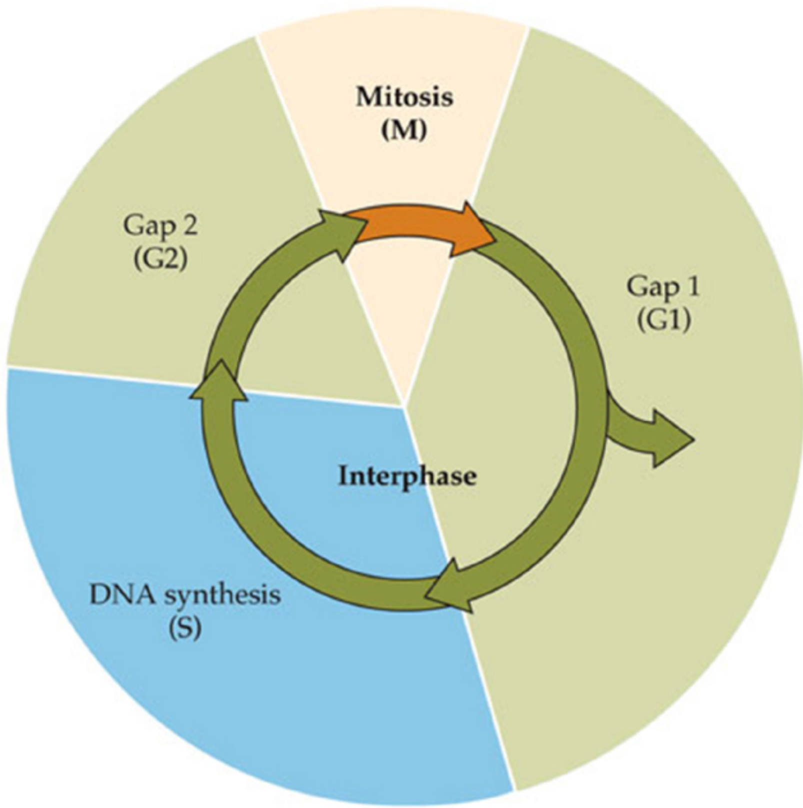
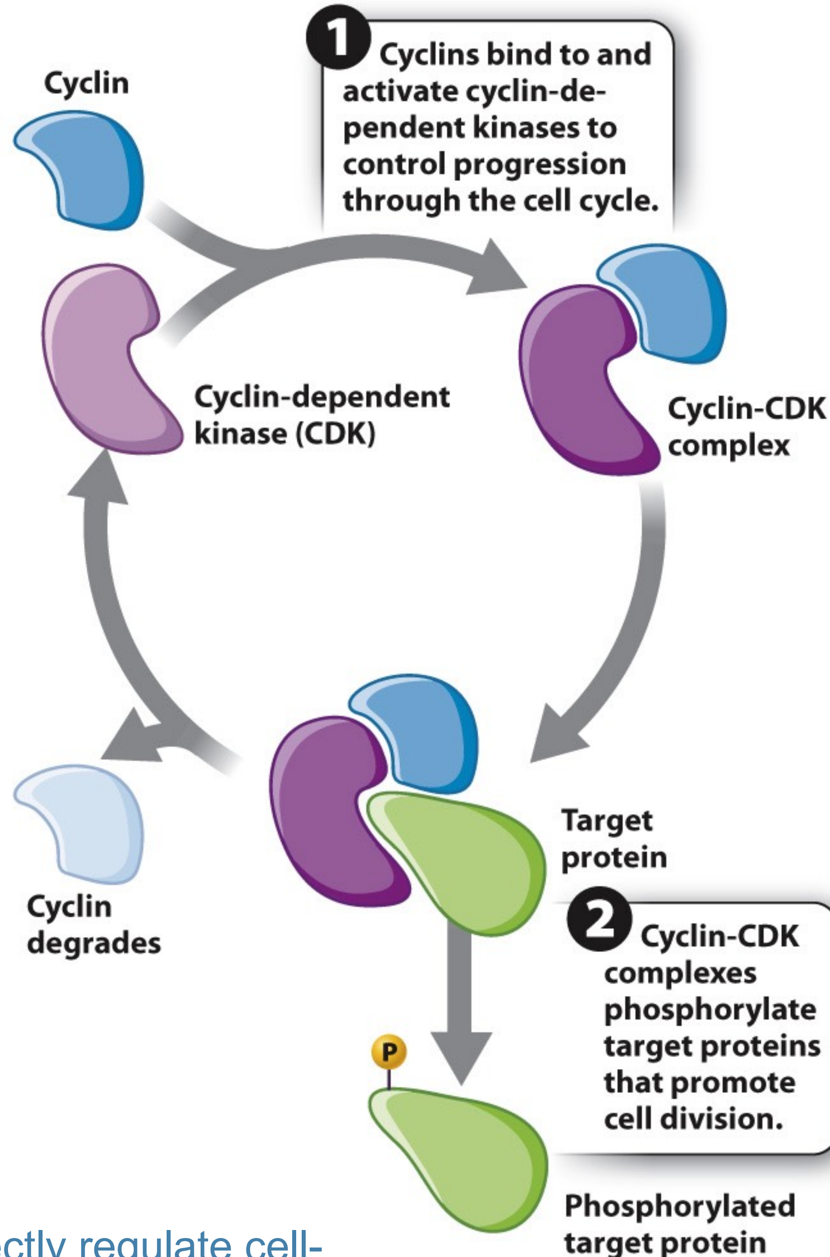
BIOL2107, Fall ’23

Lecture 11



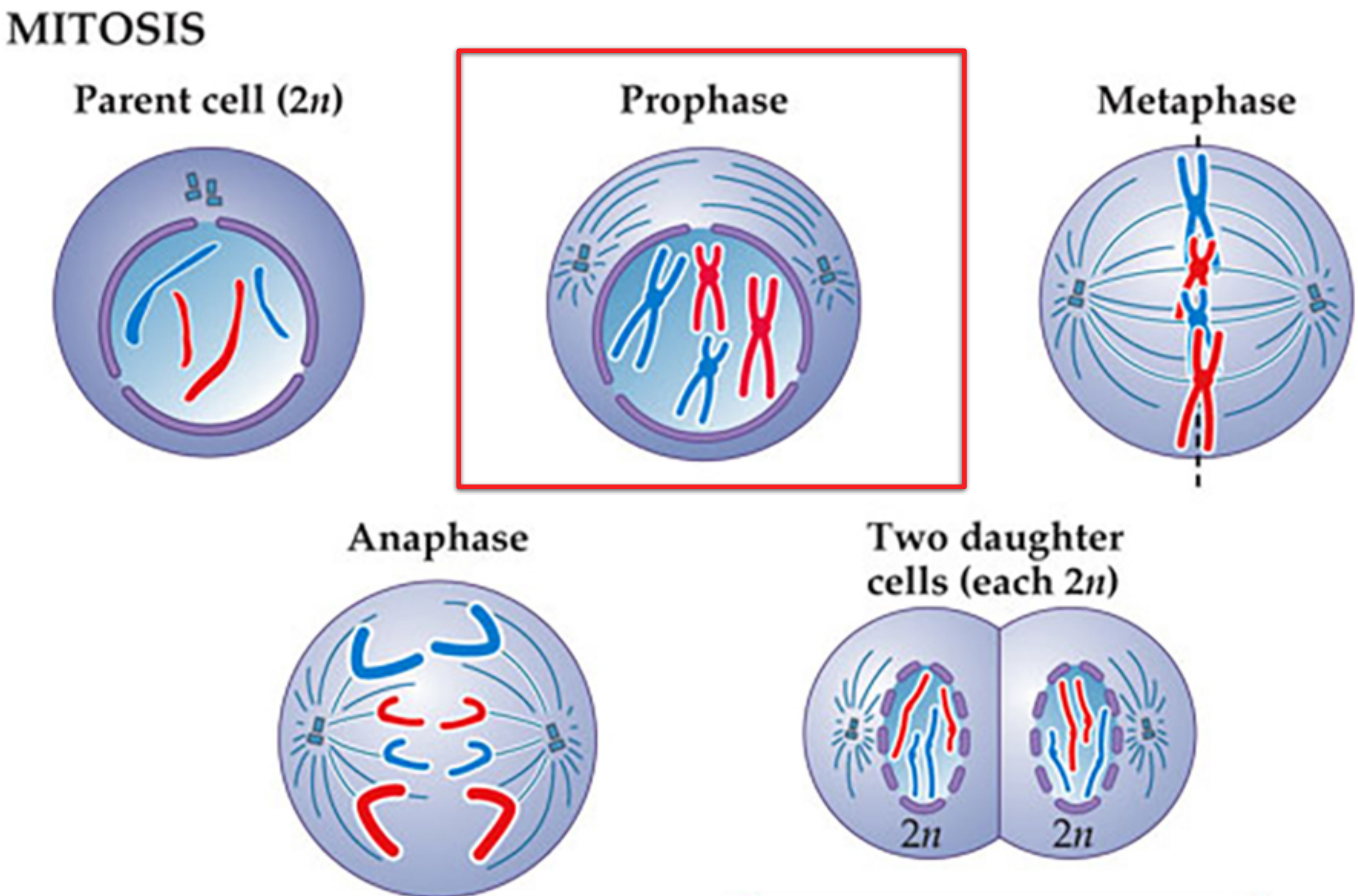

Nucleolus
Chromatin





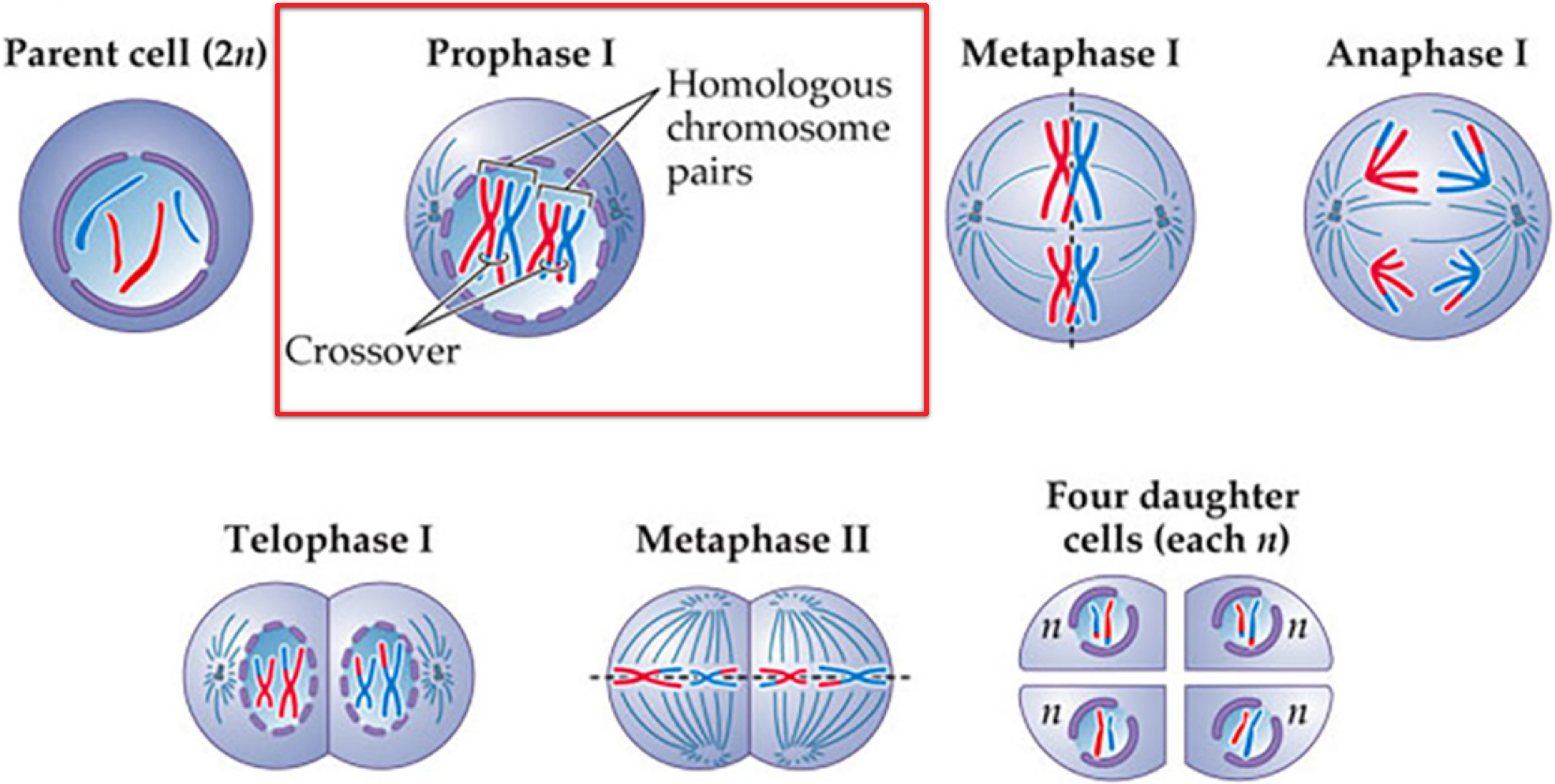
In human cells, there are **20 CDK**s and **29 cyclins**.

CDK1, CDK2, CDK3, CDK4, CDK6, and CDK7 directly regulate cell-cycle transitions and cell division, whereas CDK7–11 mediate gene transcription.



Mitosis is a mechanism for constancy: The parent nucleus produces two identical daughter nuclei.

MEIOSIS



Meiosis is a mechanism for diversity: The parent nucleus produces four different haploid daughter nuclei.

MEIOSIS

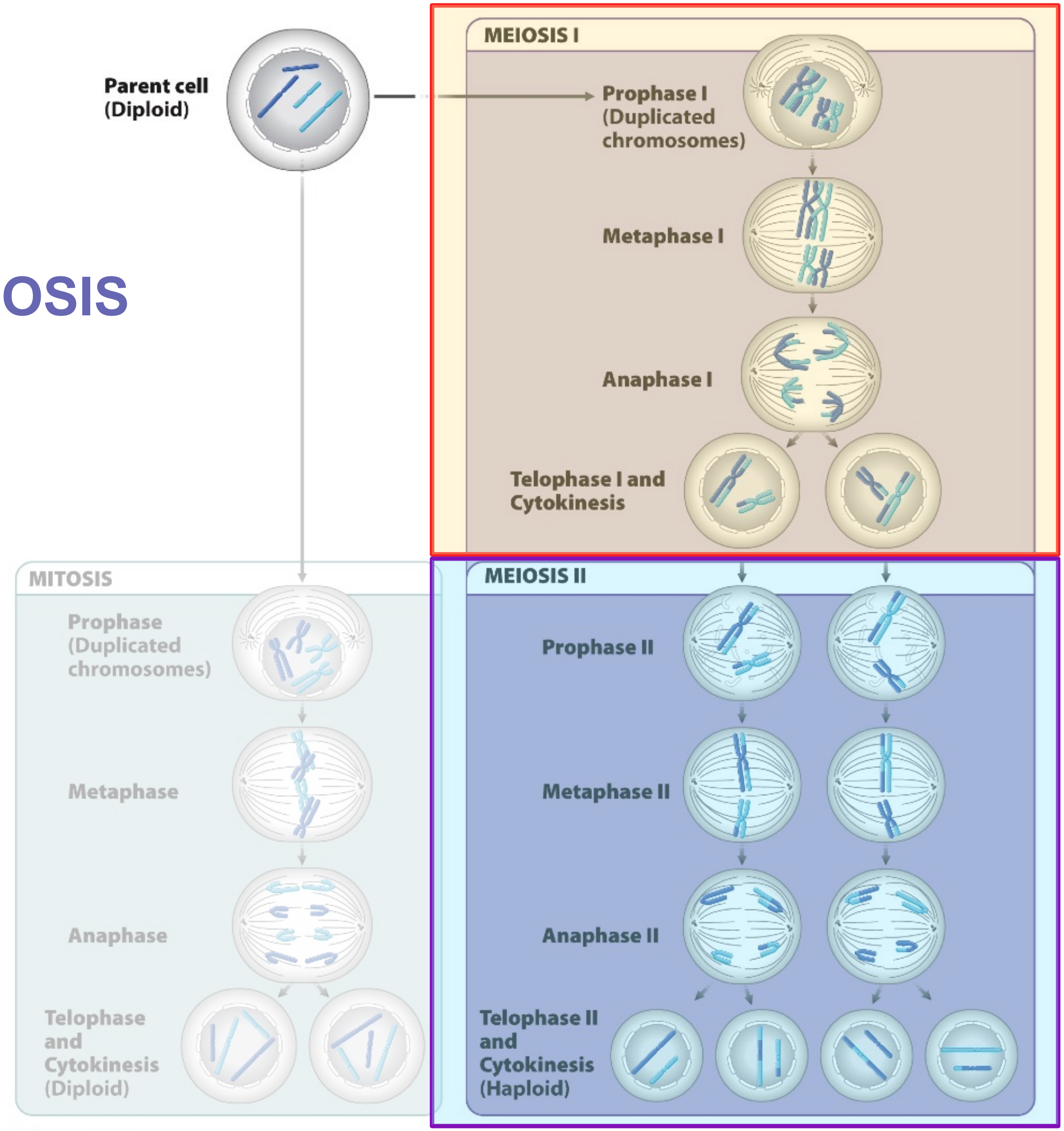
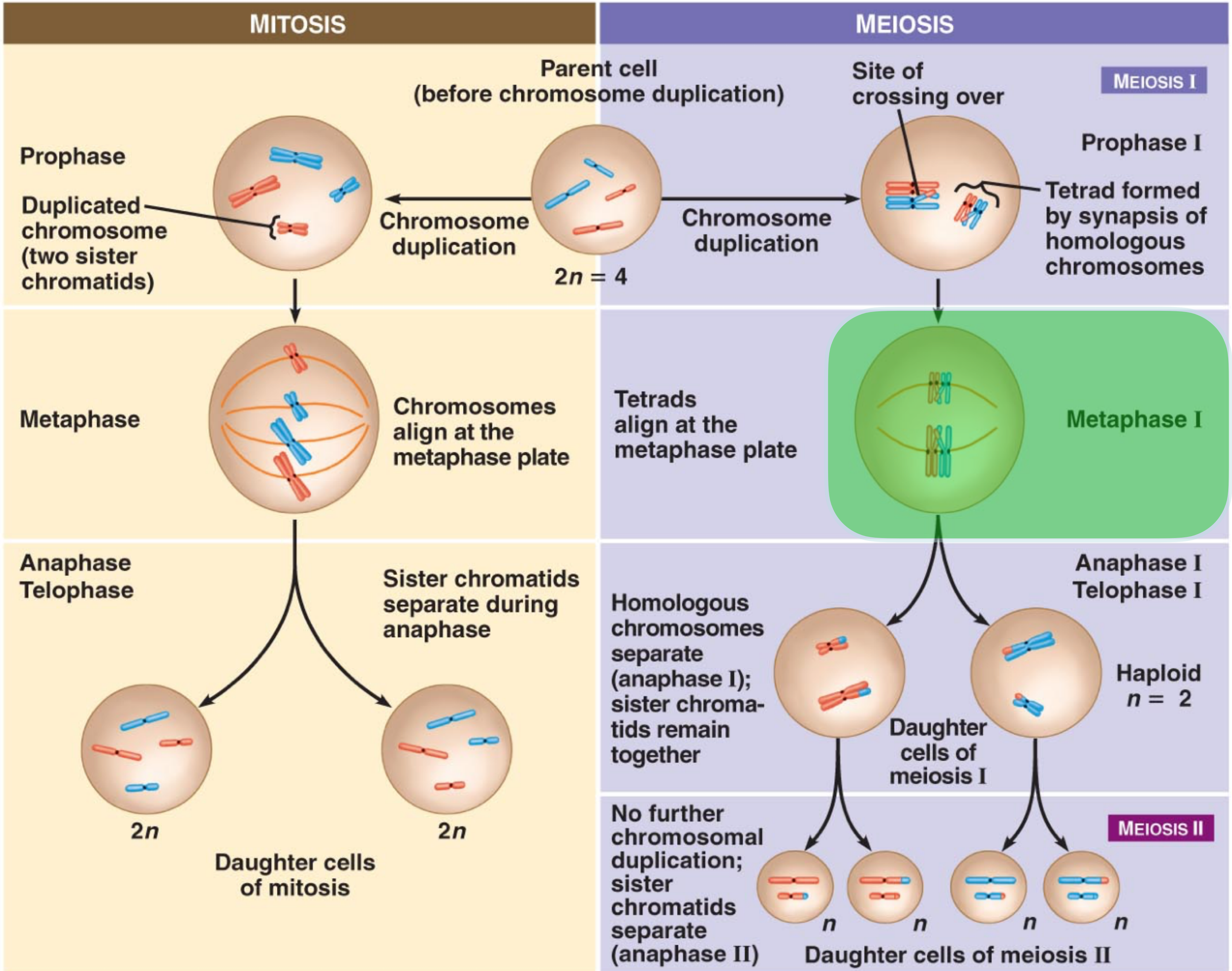
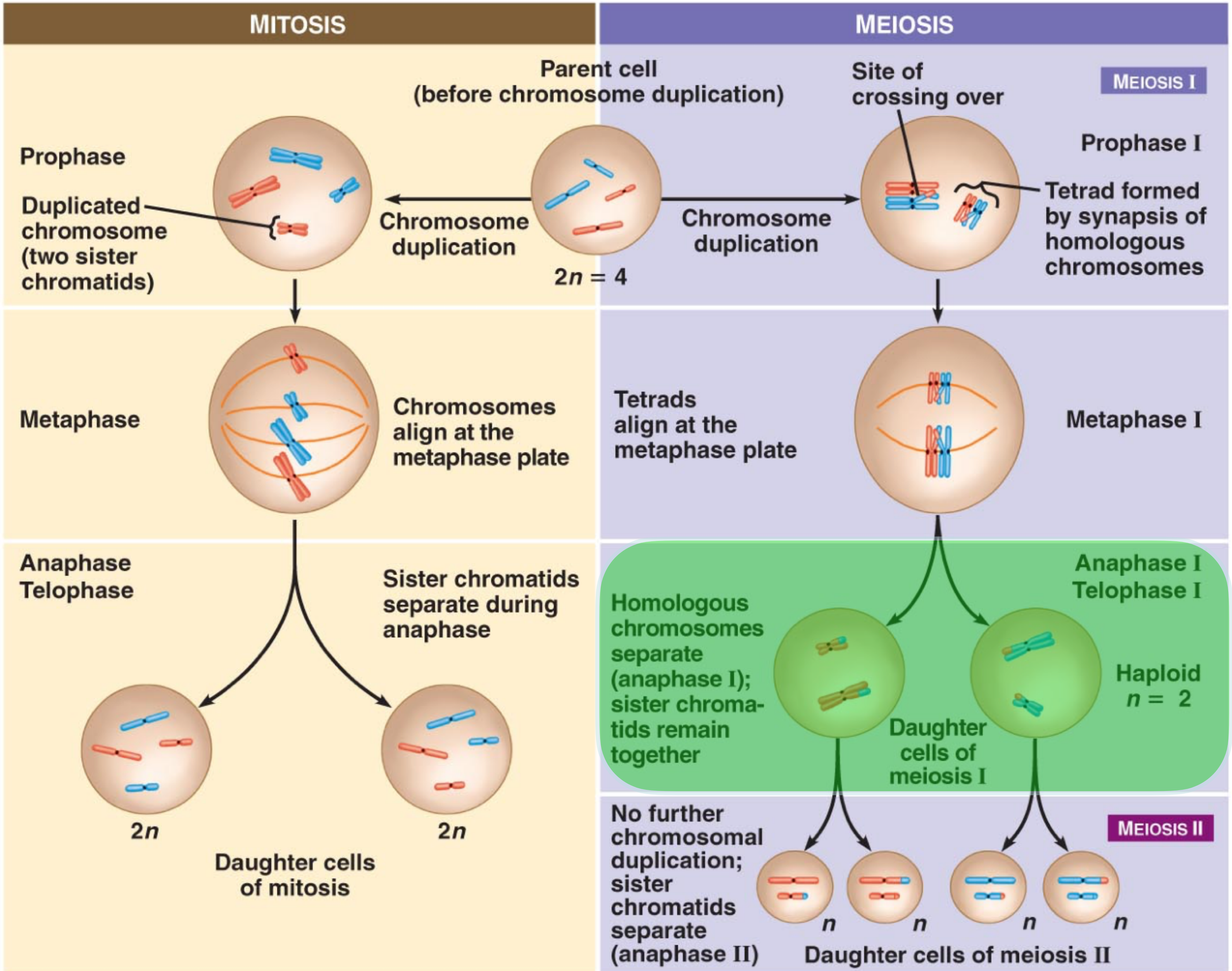
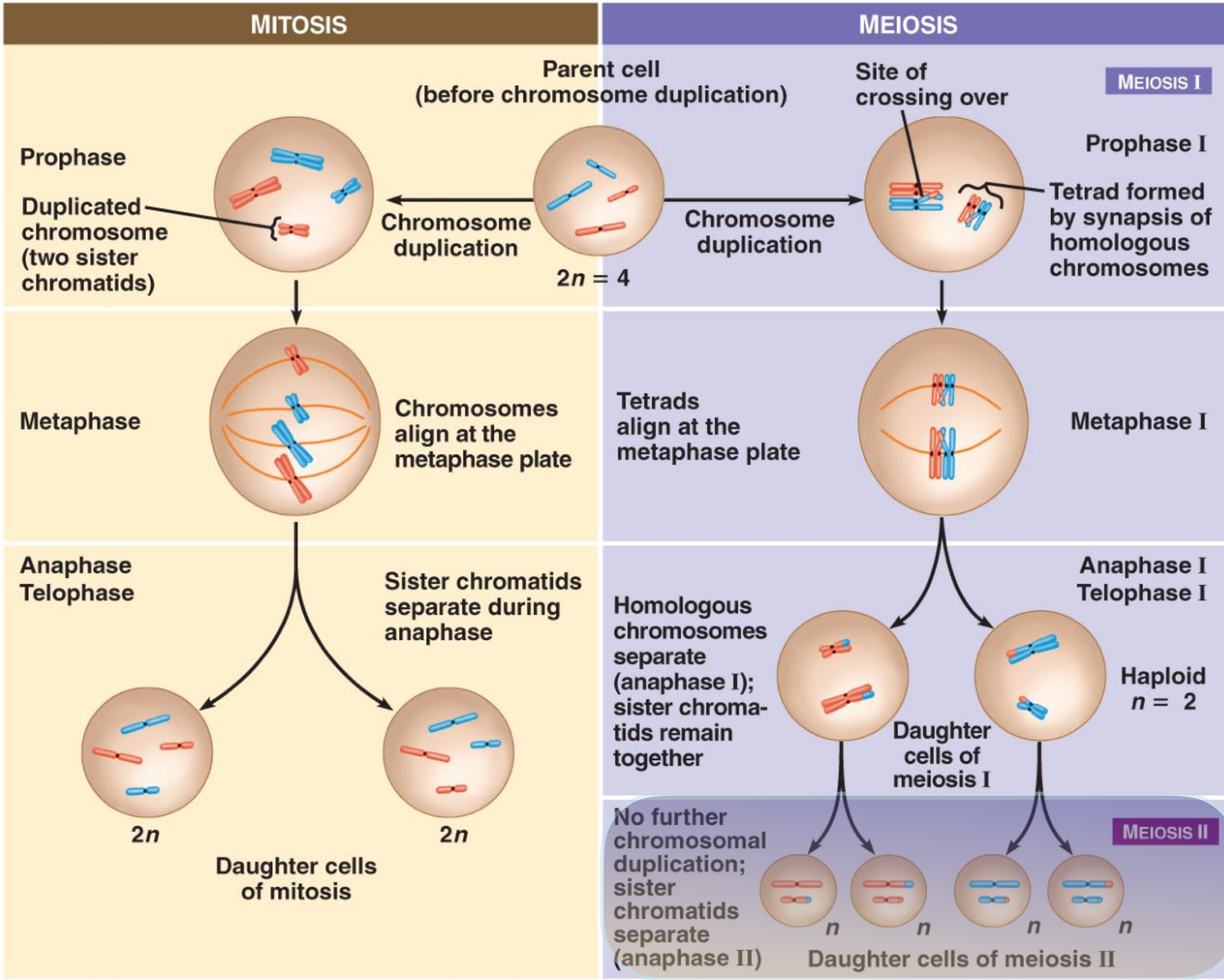


Figure 11.12
Biology: How Life Works, Second Edition


MITOSIS
MEIOSIS
Parent cell
(before chromosome duplication)
Site of
crossing over
MEIOSIS I
Prophase
Duplicated
chromosome
(two sister
chromatids)
Chromosome
duplication
Chromosome
duplication
2n = 4
Prophase I
Tetrad formed
by synapsis of
homologous
chromosomes
Metaphase
Chromosomes
align at the
metaphase plate
Tetrads
align at the
metaphase plate
Metaphase I
Anaphase
Telophase
Sister chromatids
separate during
anaphase
Homologous
chromosomes
separate
(anaphase I);
sister chroma-
tids remain
together
Anaphase I
Telophase I
Daughter
cells of
meiosis I
Haploid
n = 2
2n
2n
Daughter cells
of mitosis
No further
chromosomal
duplication;
sister
chromatids
separate
(anaphase II)
MEIOSIS II
n
n
n
n
Daughter cells of meiosis II


MITOSIS
MEIOSIS
Parent cell
(before chromosome duplication)
Site of
crossing over
MEIOSIS I
Prophase
Duplicated
chromosome
(two sister
chromatids)
Chromosome
duplication
Chromosome
duplication
$2n = 4$
Prophase I
Tetrad formed
by synapsis of
homologous
chromosomes
Metaphase
Chromosomes
align at the
metaphase plate
Tetrads
align at the
metaphase plate
Metaphase I
Anaphase
Telophase
Sister chromatids
separate during
anaphase
Anaphase I
Telophase I
Homologous
chromosomes
separate
(anaphase I);
sister chroma-
tids remain
together
Haploid
$n = 2$
Daughter
cells of
meiosis I
$2n$
$2n$
Daughter cells
of mitosis
MEIOSIS II
No further
chromosomal
duplication;
sister
chromatids
separate
(anaphase II)
n
n
n
n
Daughter cells of meiosis II


MITOSIS
MEIOSIS
Parent cell
(before chromosome duplication)
Site of
crossing over
MEIOSIS I
Prophase
Duplicated
chromosome
(two sister
chromatids)
Chromosome
duplication
Chromosome
duplication
2n = 4
Prophase I
Tetrad formed
by synapsis of
homologous
chromosomes
Metaphase
Chromosomes
align at the
metaphase plate
Tetrads
align at the
metaphase plate
Metaphase I
Anaphase
Telophase
Sister chromatids
separate during
anaphase
Homologous
chromosomes
separate
(anaphase I);
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tids remain
together
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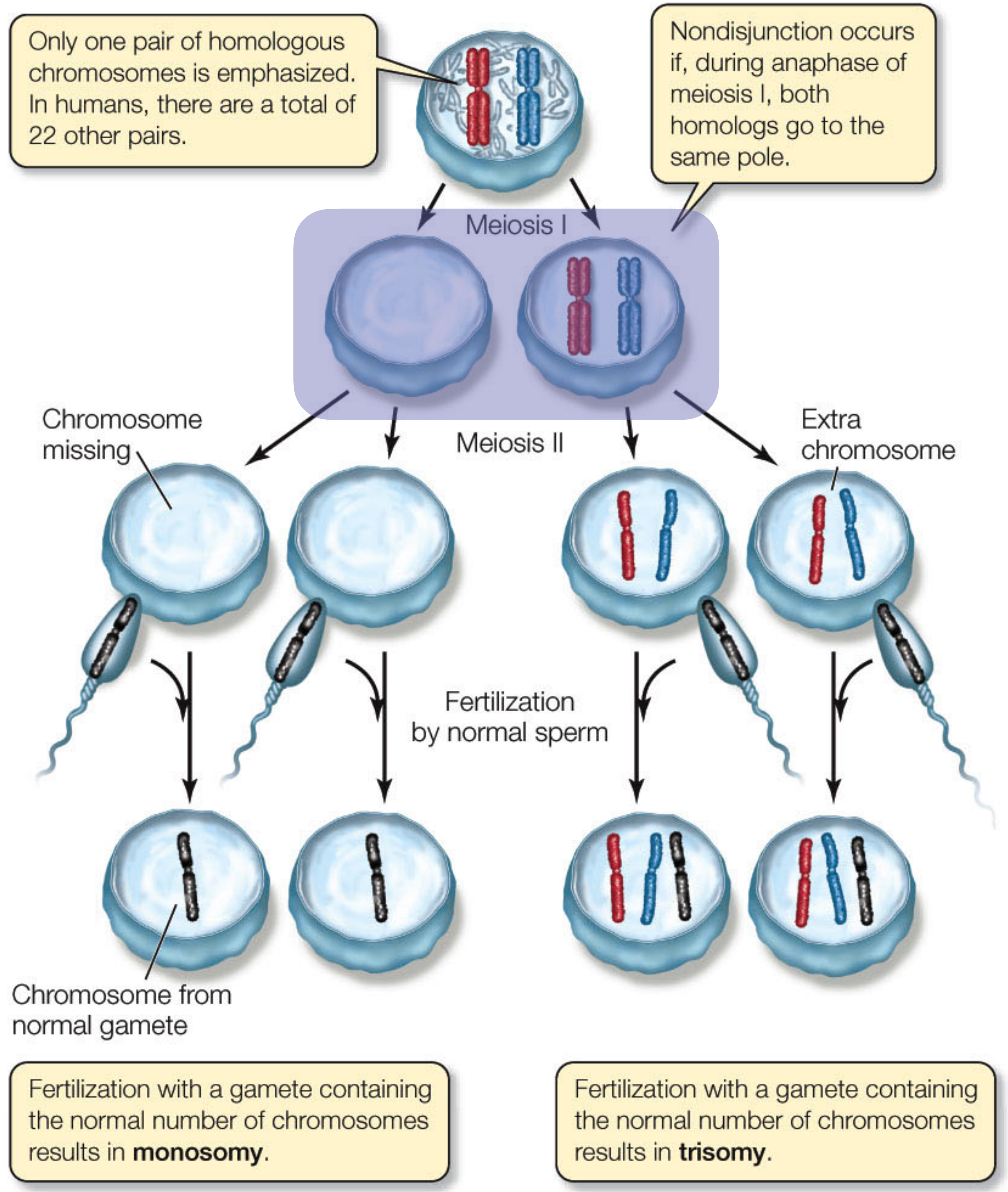
Haploid
n = 2
Daughter
cells of
meiosis I
2n
2n
Daughter cells
of mitosis
No further
chromosomal
duplication;
sister
chromatids
separate
(anaphase II)
MEIOSIS II
n
n
n
n
Daughter cells of meiosis II

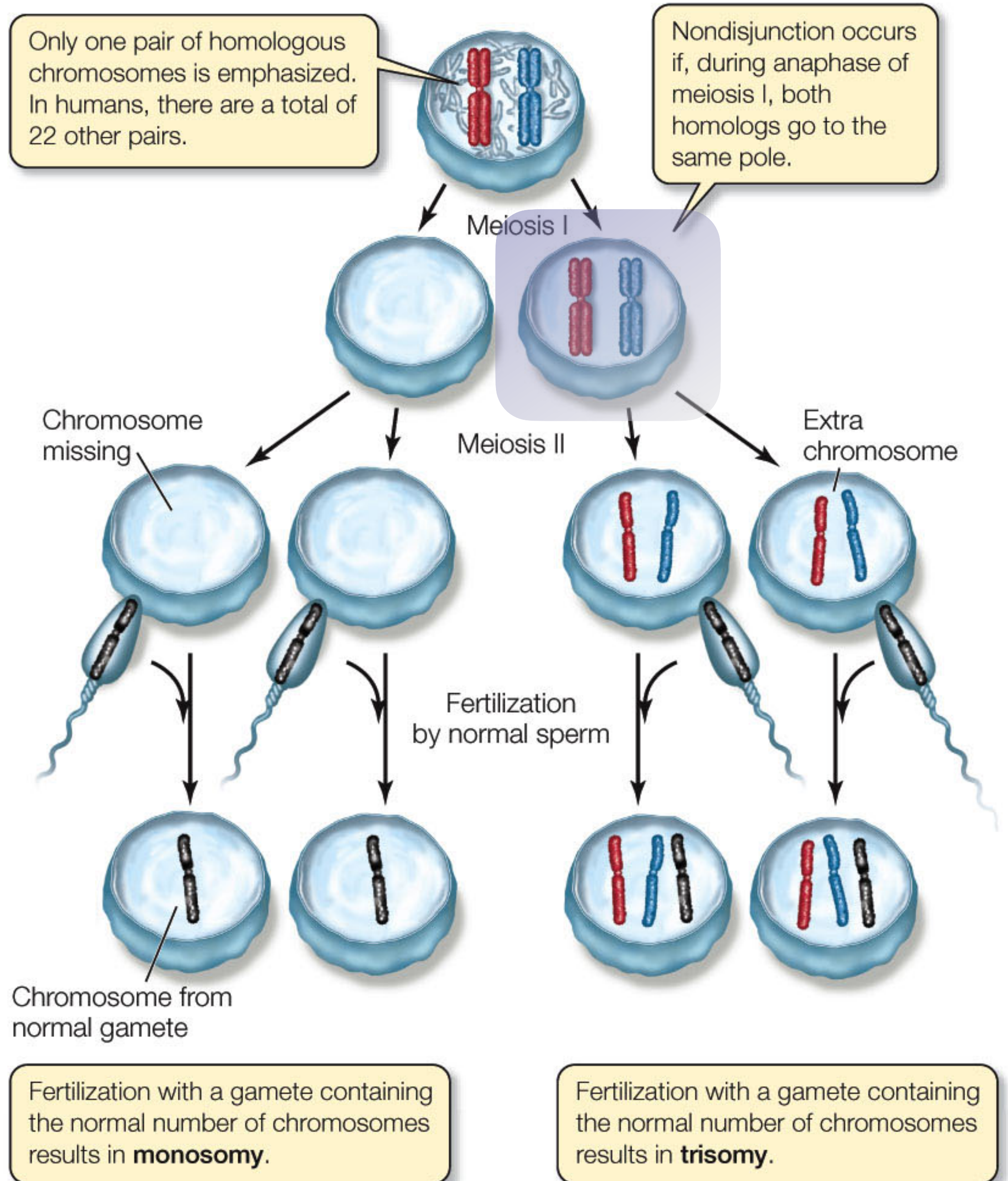
TABLE 11.1 Comparison of Mitosis and Meiosis.

	MITOSIS	MEIOSIS
Function	Asexual reproduction in unicellular eukaryotes Development in multicellular eukaryotes Tissue regeneration and repair in multicellular eukaryotes	Sexual reproduction Production of gametes and spores
Organisms	All eukaryotes	Most eukaryotes
Number of rounds of DNA synthesis	1	1
Number of cell divisions	1	2
Number of daughter cells	2	4
Chromosome complement of daughter cell compared with parent cell	Same	Half
Pairing of homologous chromosomes	No	Meiosis I—Yes Meiosis II—No
Crossing over	No	Meiosis I—Yes Meiosis II—No
Separation of homologous chromosomes	No	Meiosis I—Yes Meiosis II—No
Centromere splitting	Yes	Meiosis I—No Meiosis II—Yes
Separation of sister chromatids	Yes	Meiosis I—No Meiosis II—Yes

Table 11.1
Biology: How Life Works, Second Edition



Only one pair of homologous chromosomes is emphasized. In humans, there are a total of 22 other pairs.
Nondisjunction occurs if, during anaphase of meiosis I, both homologs go to the same pole.
Meiosis I
Chromosome missing
Meiosis II
Extra chromosome
Fertilization by normal sperm
Chromosome from normal gamete
Fertilization with a gamete containing the normal number of chromosomes results in **monosomy**.
Fertilization with a gamete containing the normal number of chromosomes results in **trisomy**.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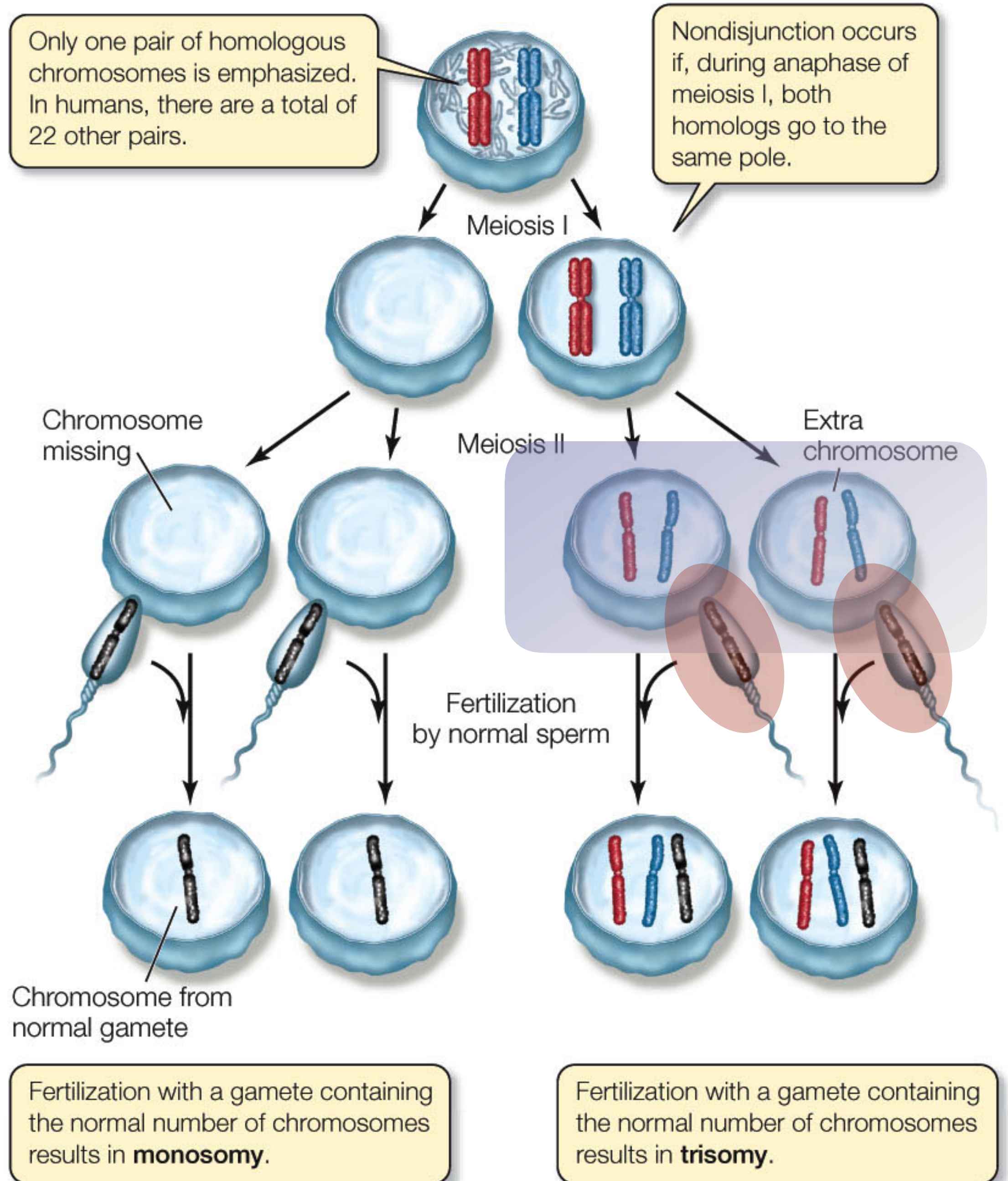

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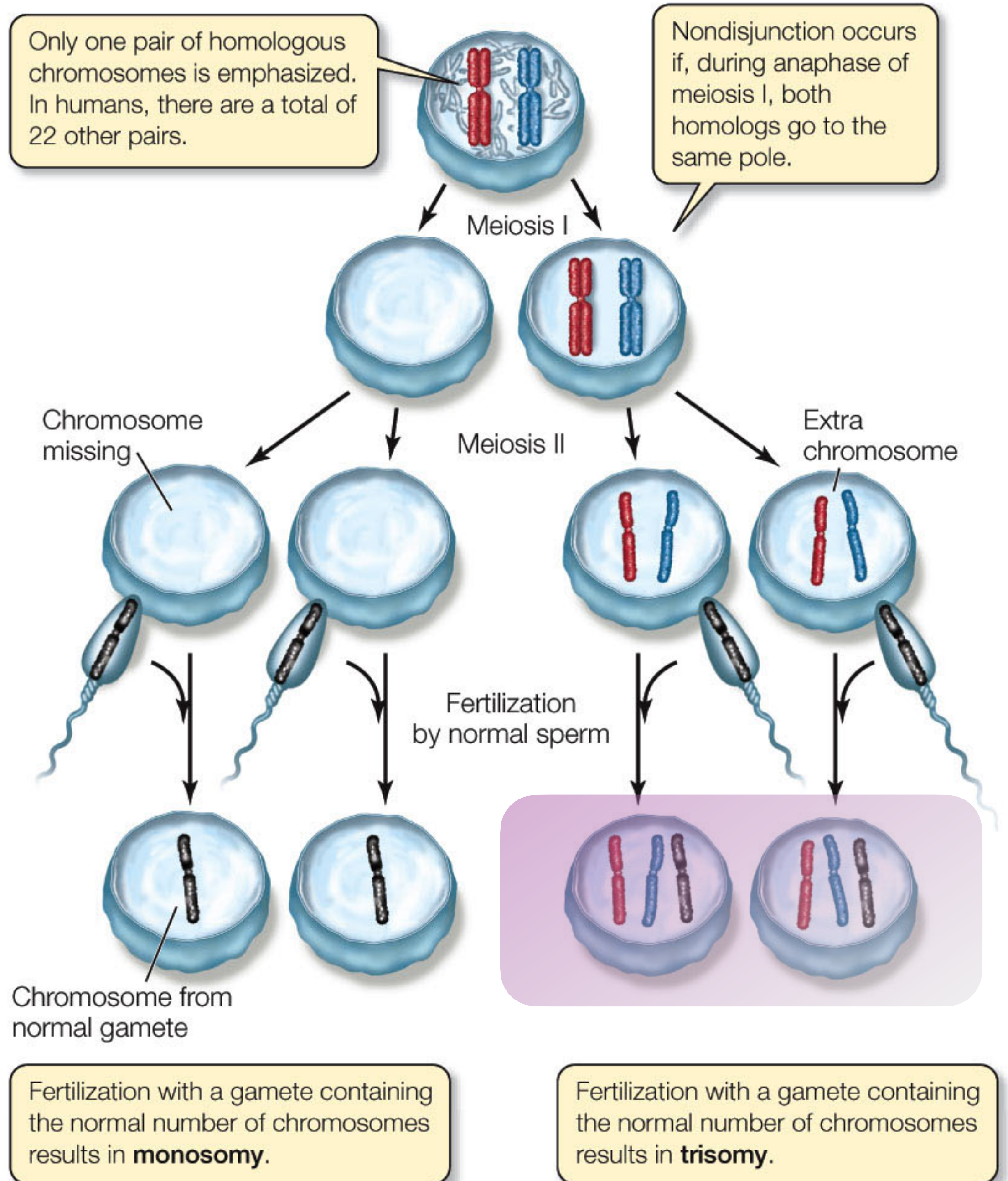

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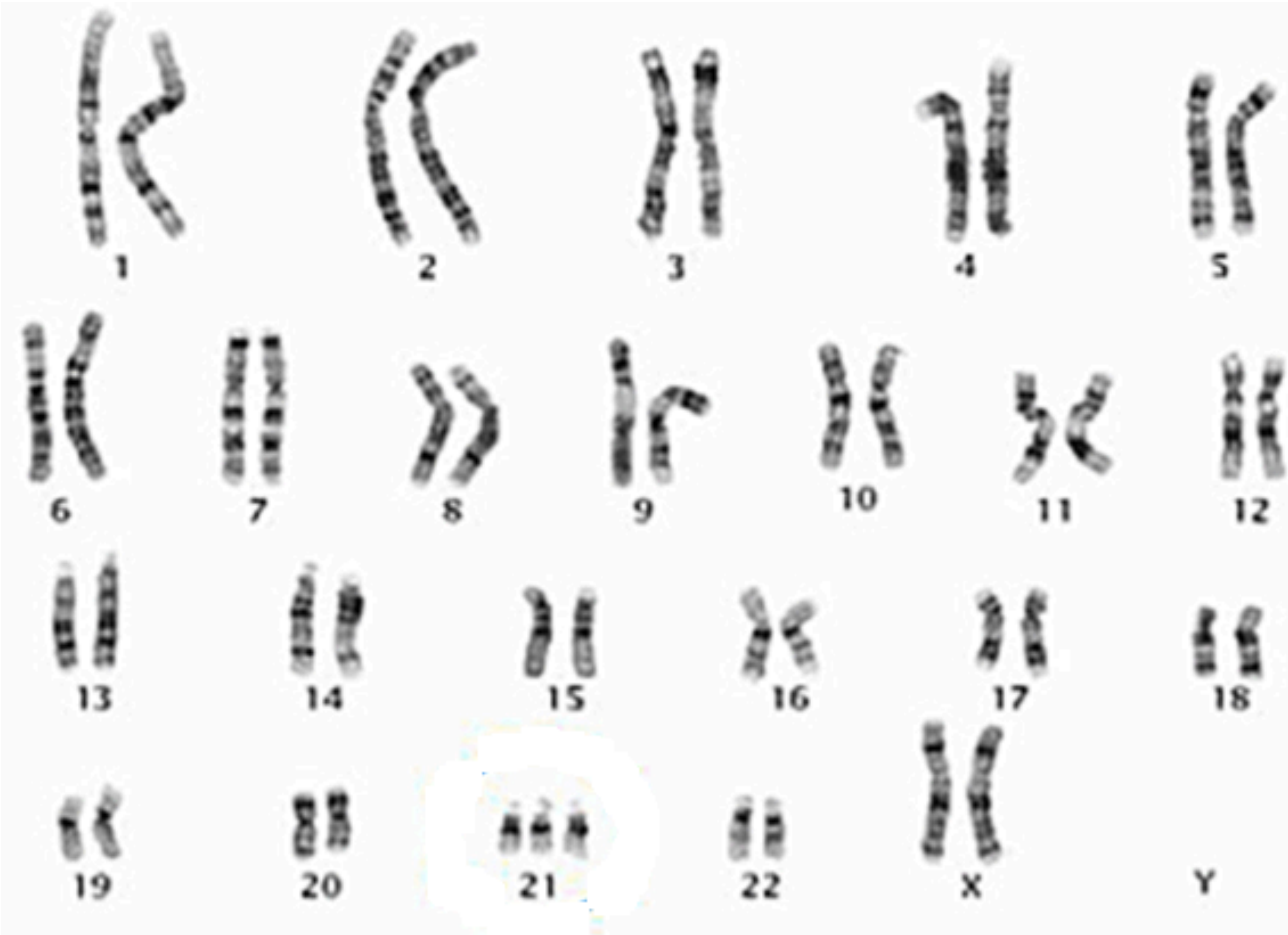
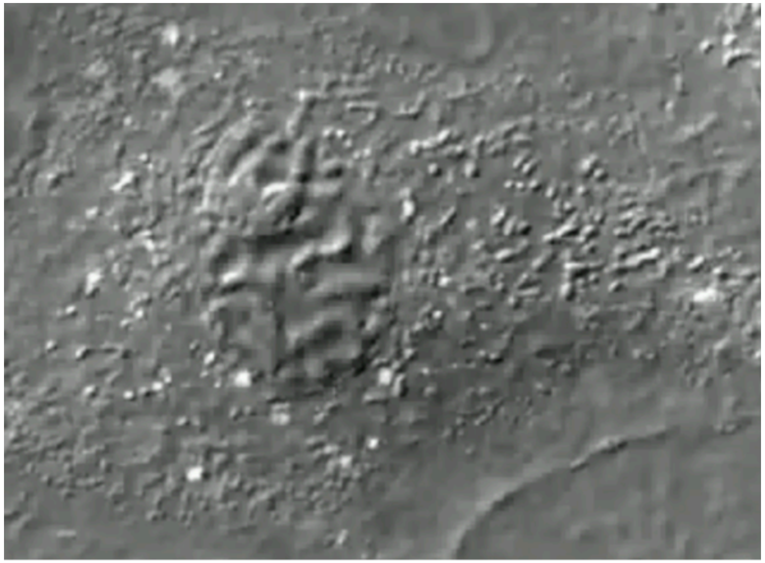

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
X
Y



Sutton & Boveri 1900’s

Gregor Mendel

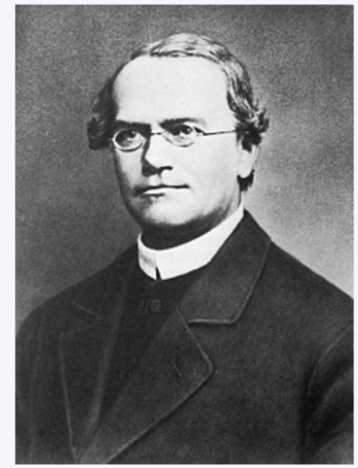
From Wikipedia, the free encyclopedia

Gregor Johann Mendel (Czech: *Řehoř Jan Mendel*;[1] 20 July 1822[2] – 6 January 1884) (English: /ˈmɛndəl/) was a scientist, Augustinian friar and abbot of St. Thomas' Abbey in Brno, Margraviate of Moravia. Mendel was born in a German-speaking family[3] in the Silesian part of the Austrian Empire (today's Czech Republic) and gained posthumous recognition as the founder of the modern science of genetics. Though farmers had known for millennia that crossbreeding of animals and plants could favor certain desirable traits, Mendel's pea plant experiments conducted between 1856 and 1863 established many of the rules of heredity, now referred to as the laws of Mendelian inheritance.[4]

Mendel worked with seven characteristics of pea plants: plant height, pod shape and color, seed shape and color, and flower position and color. Taking seed color as an example, Mendel showed that when a true-breeding yellow pea and a true-breeding green pea were cross-bred their offspring always produced yellow seeds. However, in the next generation, the green peas reappeared at a ratio of 1 green to 3 yellow. To explain this phenomenon, Mendel coined the terms "recessive" and "dominant" in reference to certain traits. (In the preceding example, the green trait, which seems to have vanished in the first filial generation, is recessive and the yellow is dominant.) He published his work in 1866, demonstrating the actions of invisible "factors"—now called genes—in predictably determining the traits of an organism.

The profound significance of Mendel's work was not recognized until the turn of the 20th century (more than three decades later) with the rediscovery of his laws.[5] Erich von Tschermak, Hugo de Vries, Carl Correns and William Jasper Spillman independently verified several of Mendel's experimental findings, ushering in the modern age of genetics.[4]

Gregor Mendel



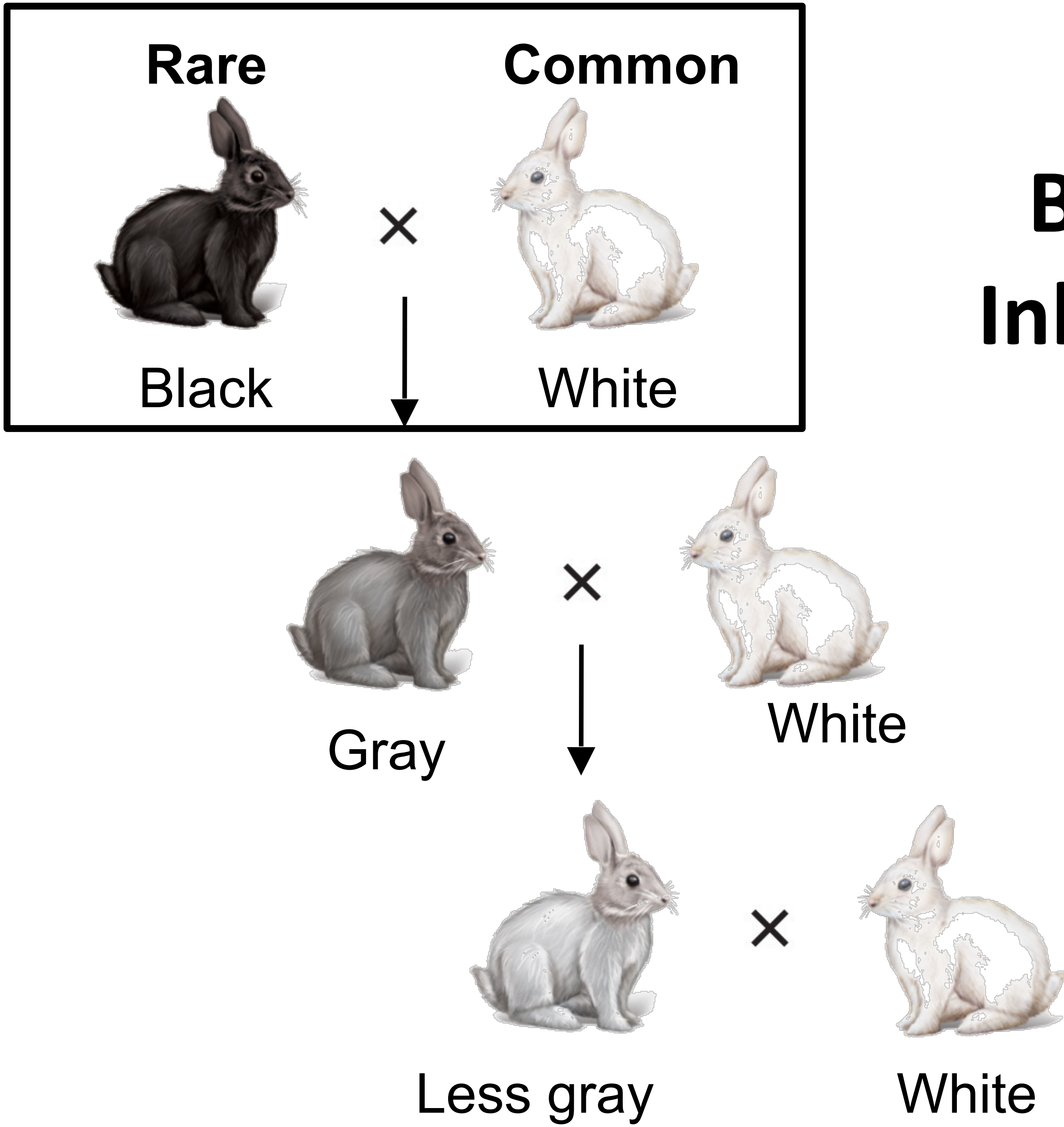
Born	Johann Mendel 20 July 1822 Heinzendorf bei Odrau, Silesia, Austrian Empire (now Hynčice, Czech Republic)
Died	6 January 1884 (aged 61) Brünn, Moravia, Austria-Hungary (now Brno, Czech Republic)
Nationality	Austrian
Alma mater	University of Olomouc University of Vienna
Known for	Creating the science of genetics
Scientific career	
Fields	Genetics
Institutions	St Thomas's Abbey

Contents [hide]

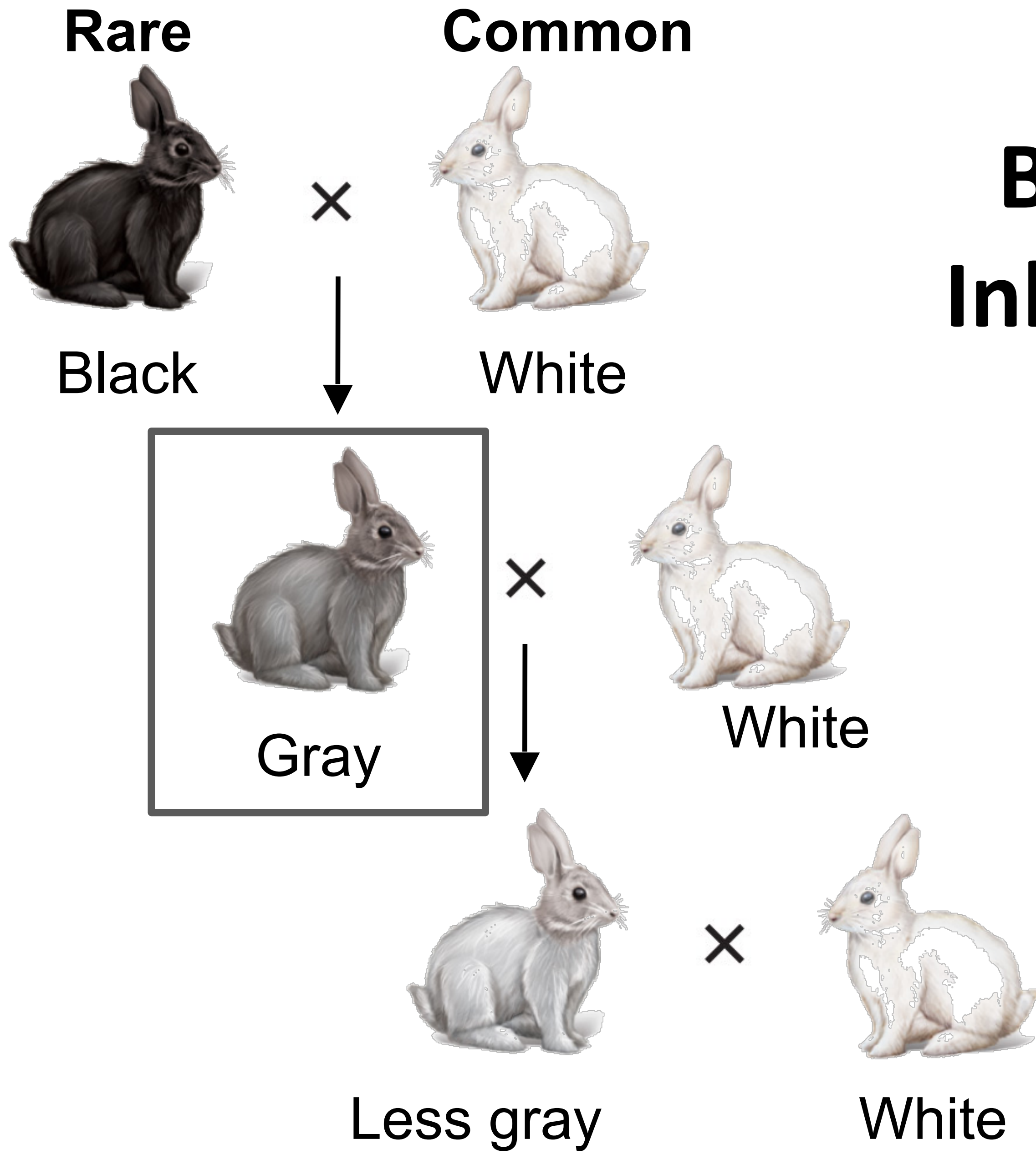
Life and career

Mendel was born into a German-speaking family in Hynčice (*Heinzendorf bei Odrau* in German), at the Moravian-Silesian border, Austrian Empire (now a part of the Czech Republic).[3] He was the son of Anton and Rosine (Schwirtlich) Mendel and had one older sister, Veronika,

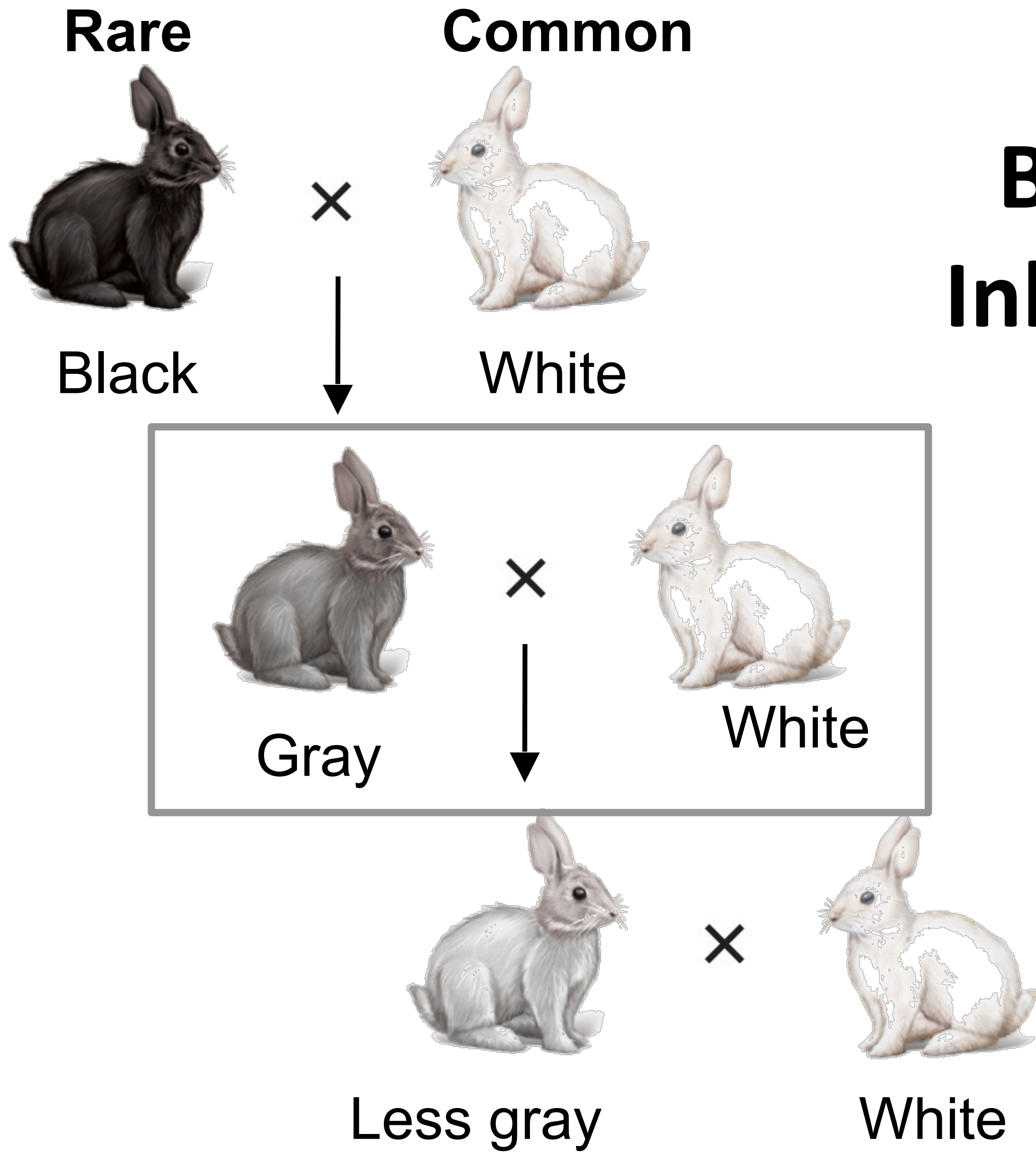
Blending Inheritance



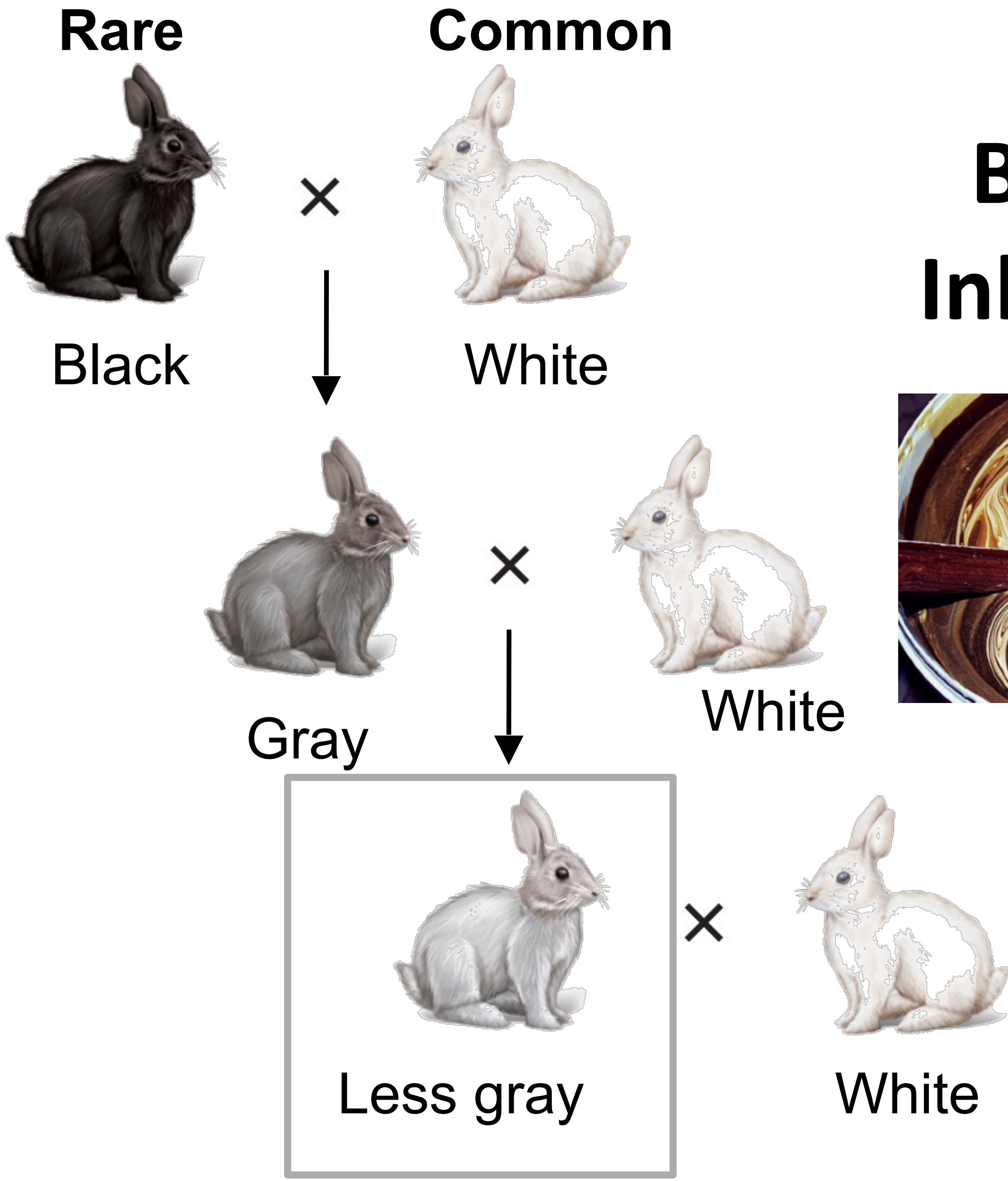
Blending Inheritance



Blending Inheritance



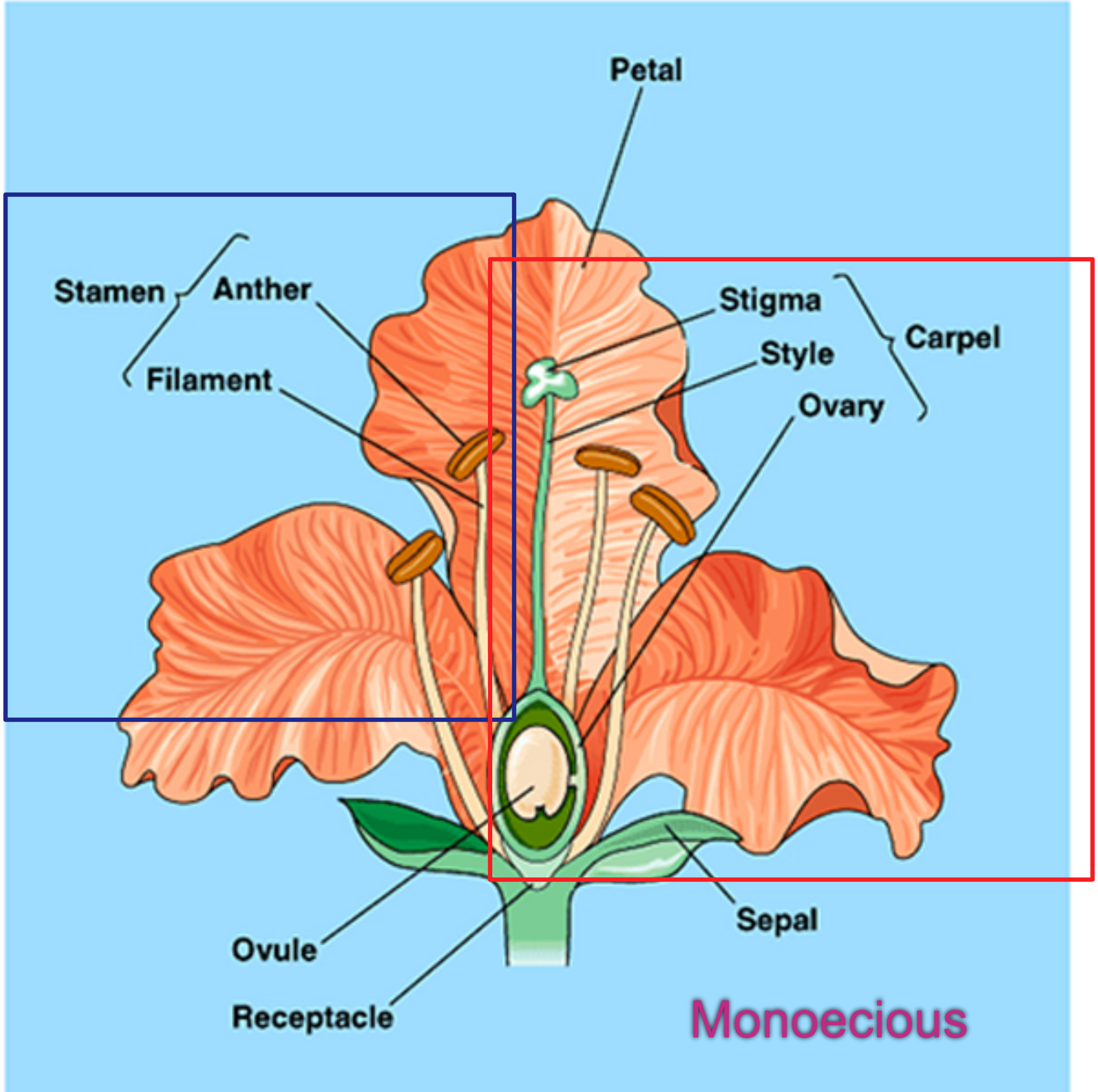
Blending Inheritance

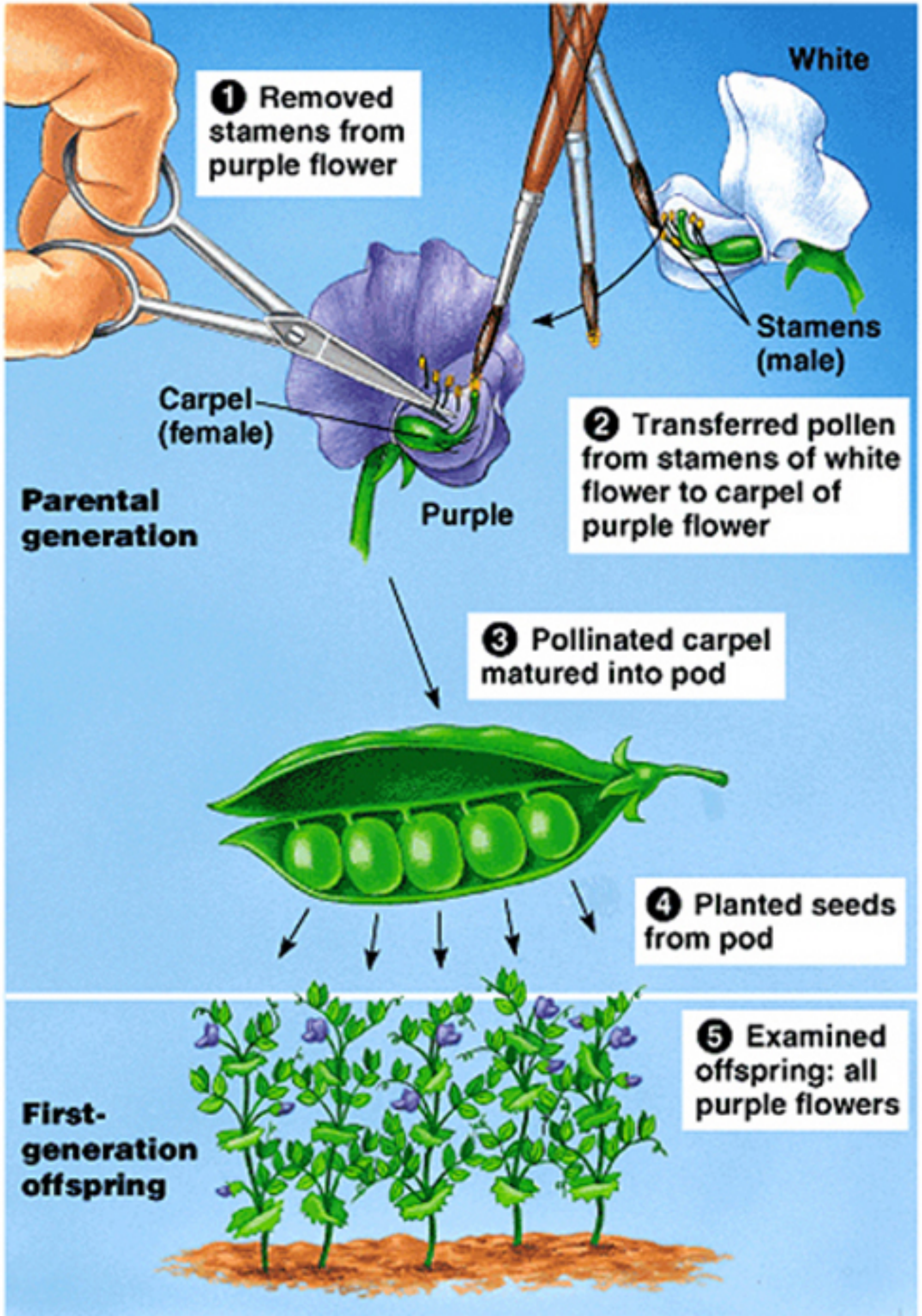


Gregor Mendel

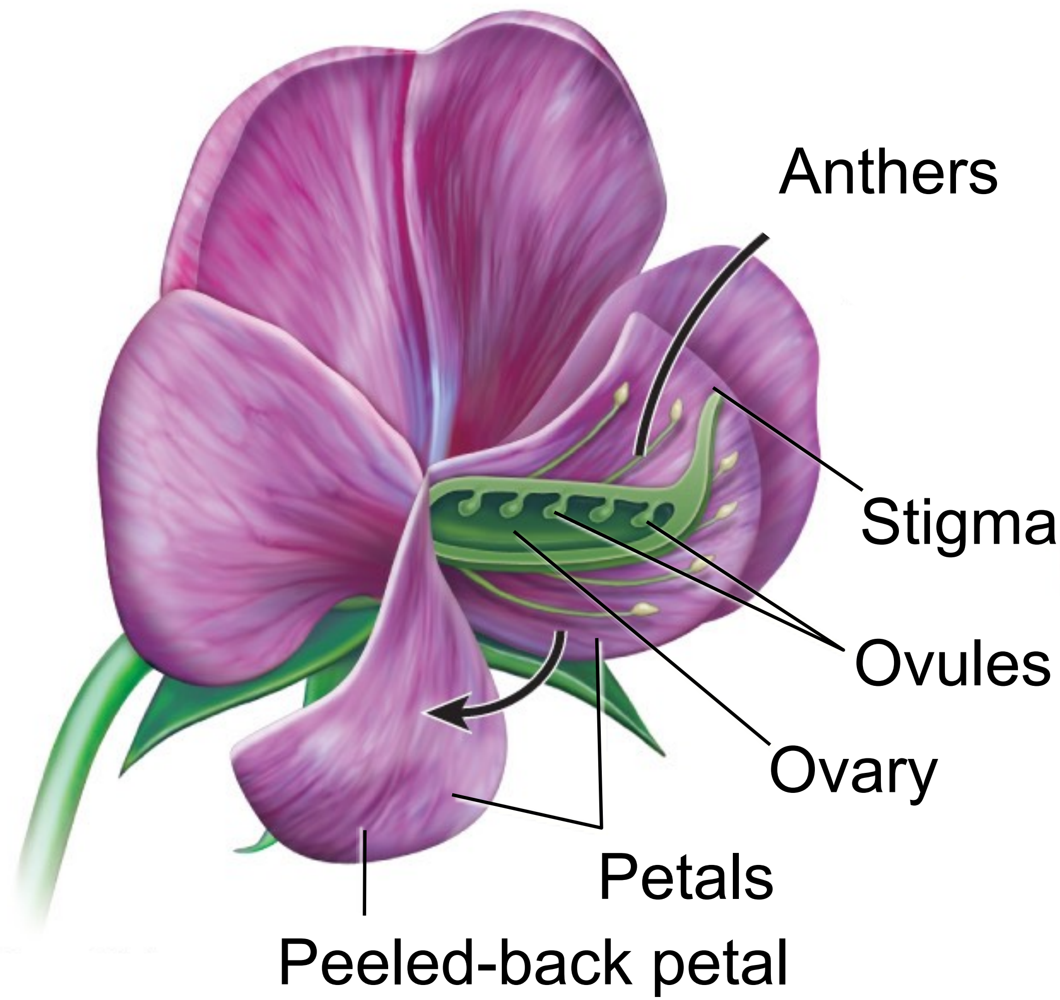
Born Johann Mendel

20 July 1822


Petal
Stamen
Anther
Filament
Stigma
Style
Carpel
Ovary
Ovule
Receptacle
Sepal
Monoecious


1 Removed stamens from purple flower
White
Stamens (male)
Carpel (female)
2 Transferred pollen from stamens of white flower to carpel of purple flower
Parental generation
Purple
3 Pollinated carpel matured into pod
4 Planted seeds from pod
5 Examined offspring: all purple flowers
First-generation offspring

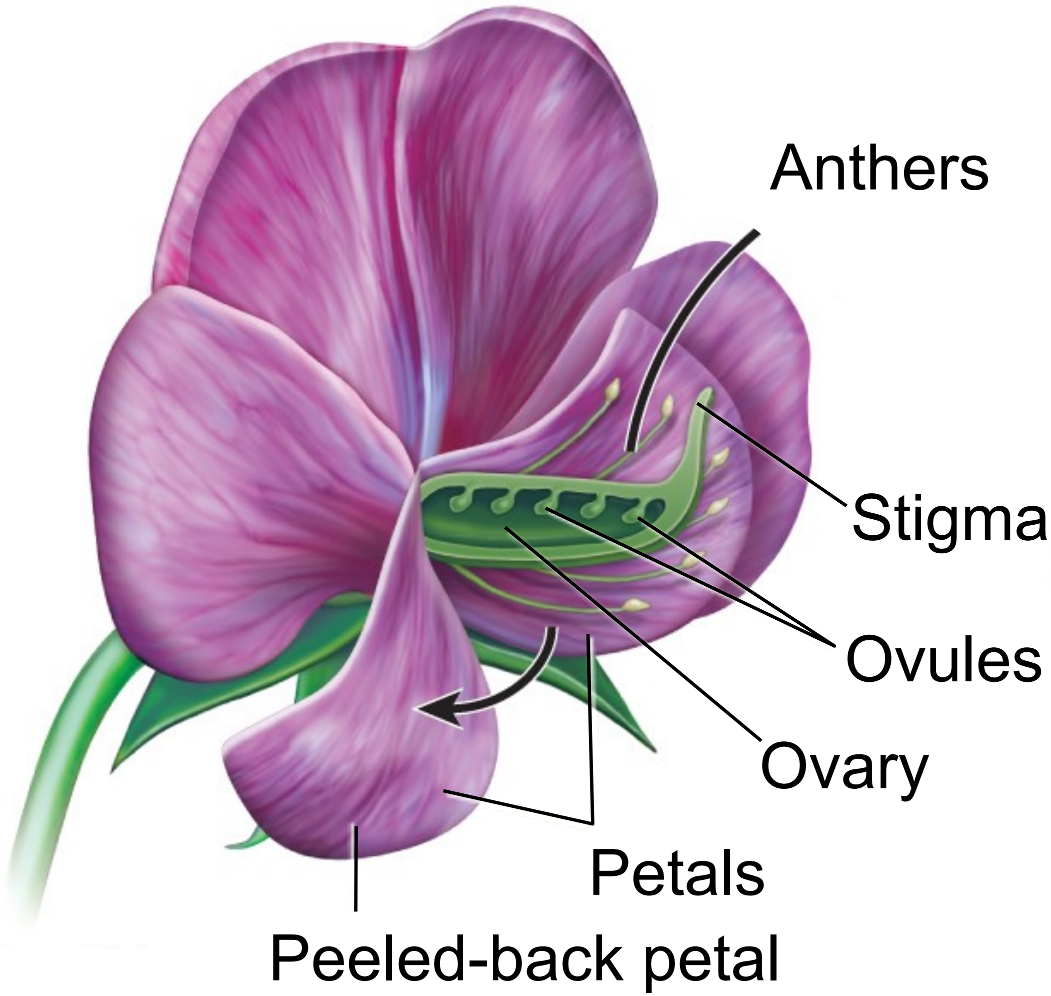
Pea Plant Crossing



1

In crossing peas, the anthers of the female parent are first exposed and then cut off to prevent self-fertilization.

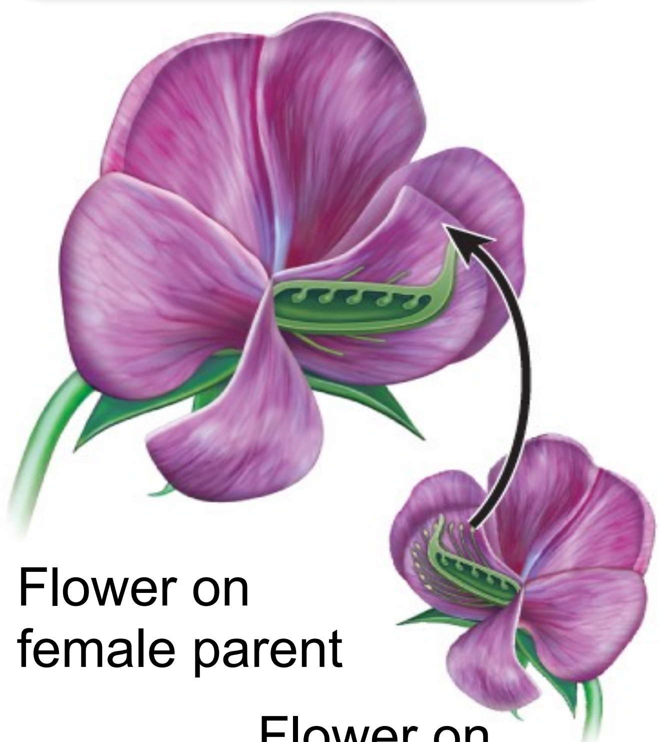
Pea Plant Crossing



Pea Plant Crossing

2

Mature pollen is collected from another flower and deposited on the stigma of the female parent.



Pea Plant Crossing

2

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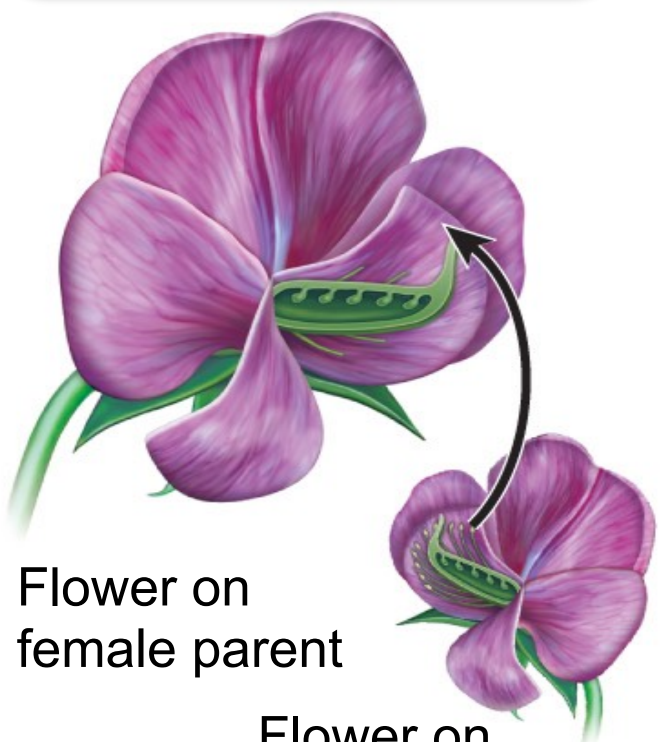
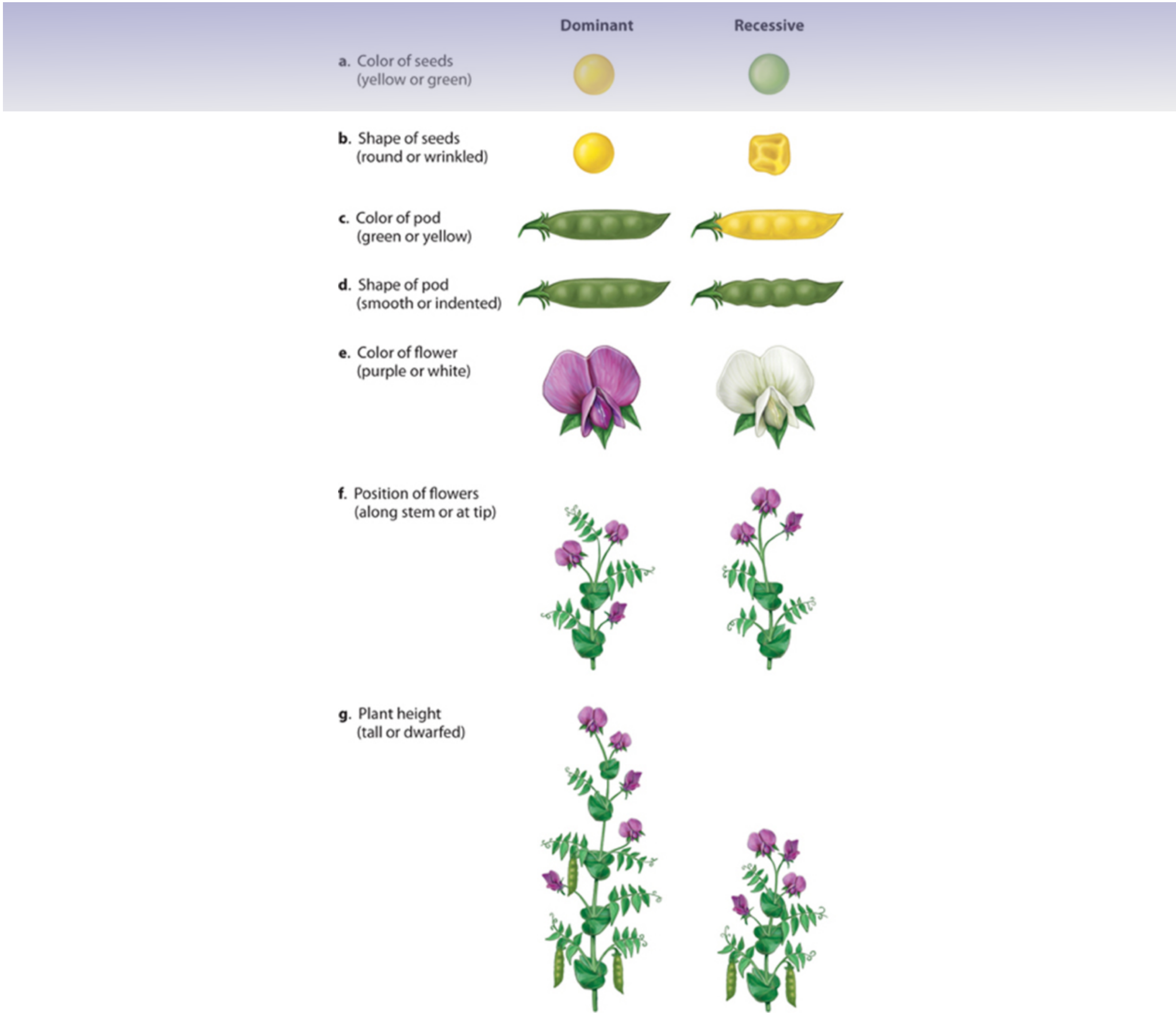
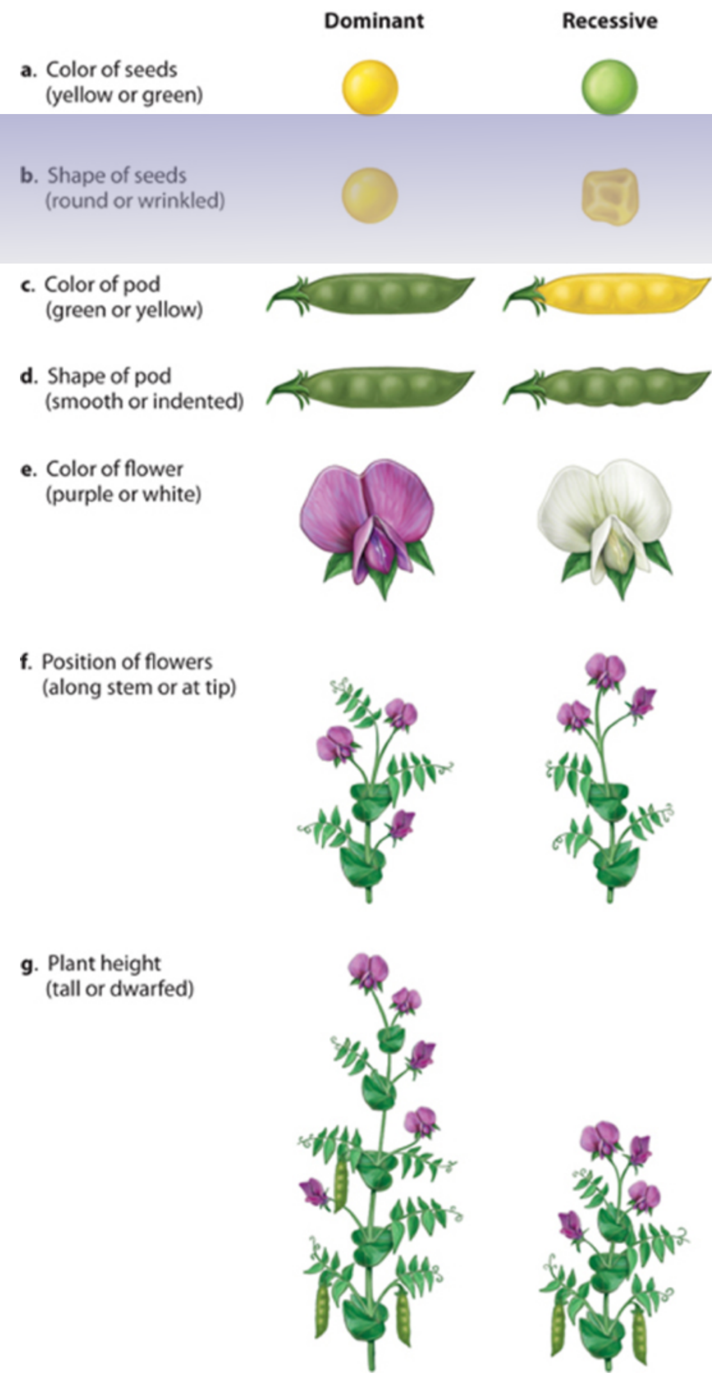



Dominant
Recessive
a. Color of seeds (yellow or green)
b. Shape of seeds (round or wrinkled)
c. Color of pod (green or yellow)
d. Shape of pod (smooth or indented)
e. Color of flower (purple or white)
f. Position of flowers (along stem or at tip)
g. Plant height (tall or dwarfed)



Dominant
Recessive
a. Color of seeds (yellow or green)
b. Shape of seeds (round or wrinkled)
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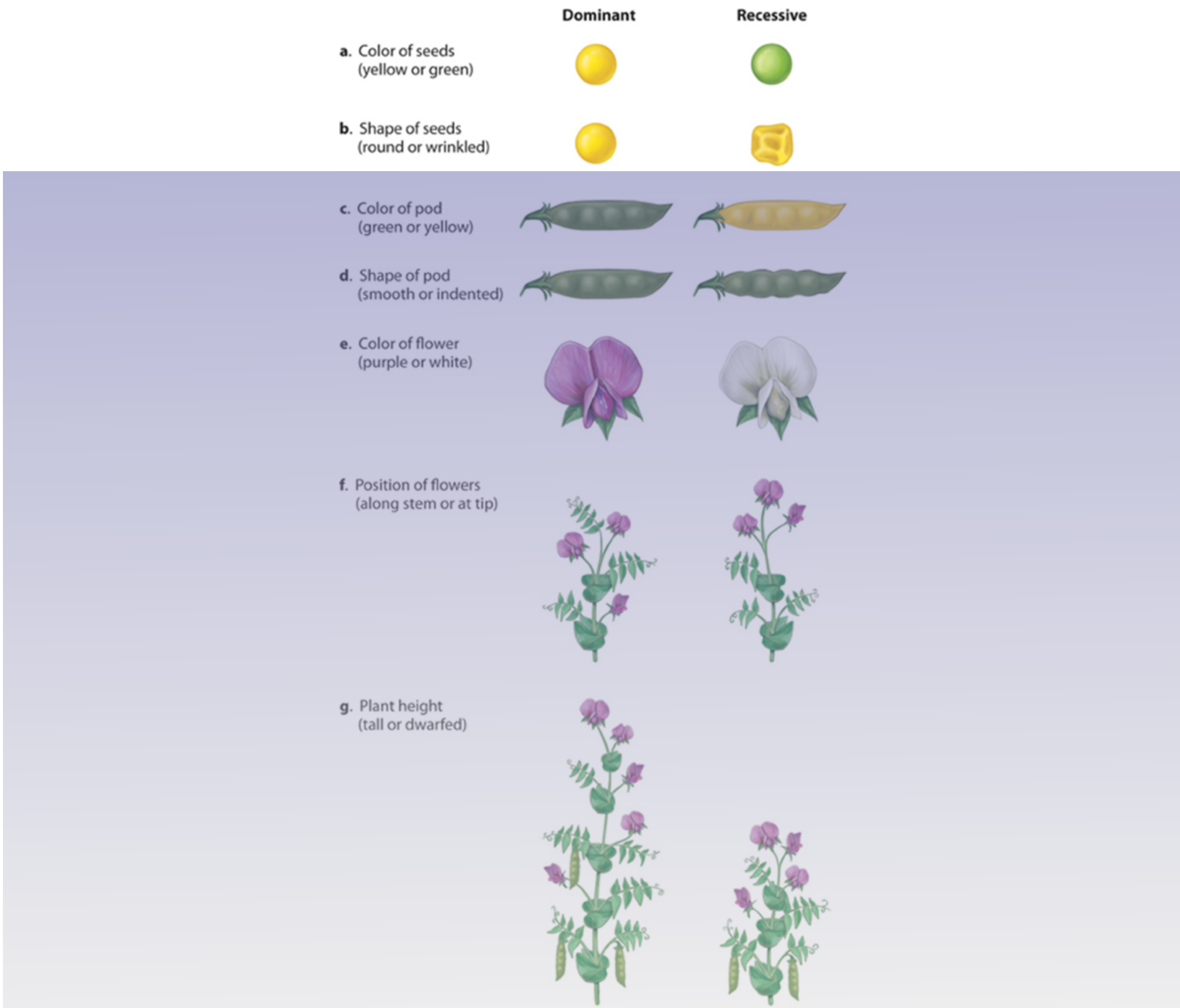
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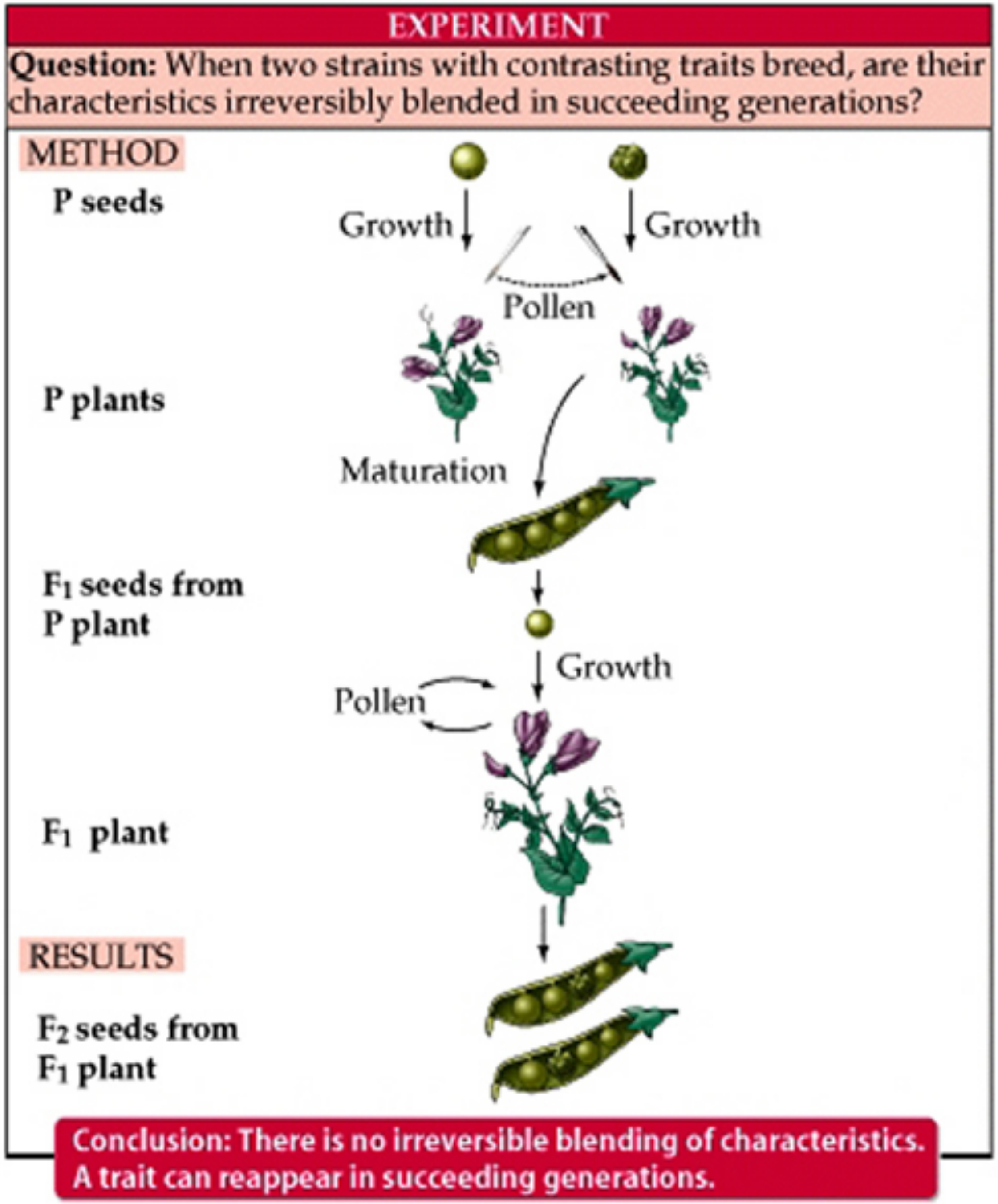
g. Plant height (tall or dwarfed)


EXPERIMENT
Question: When two strains with contrasting traits breed, are their characteristics irreversibly blended in succeeding generations?
METHOD
P seeds
Growth
Growth
Pollen
P plants
Maturation
F1 seeds from P plant
Growth
Pollen
F1 plant
RESULTS
F2 seeds from F1 plant
Conclusion: There is no irreversible blending of characteristics. A trait can reappear in succeeding generations.

Gregor Mendel's hypotheses:

1. Hereditary determinants are of a particulate nature. Each genetic trait is governed by **unit factors** , which "hang around" in pairs (or **gene pairs)** within individual organisms.

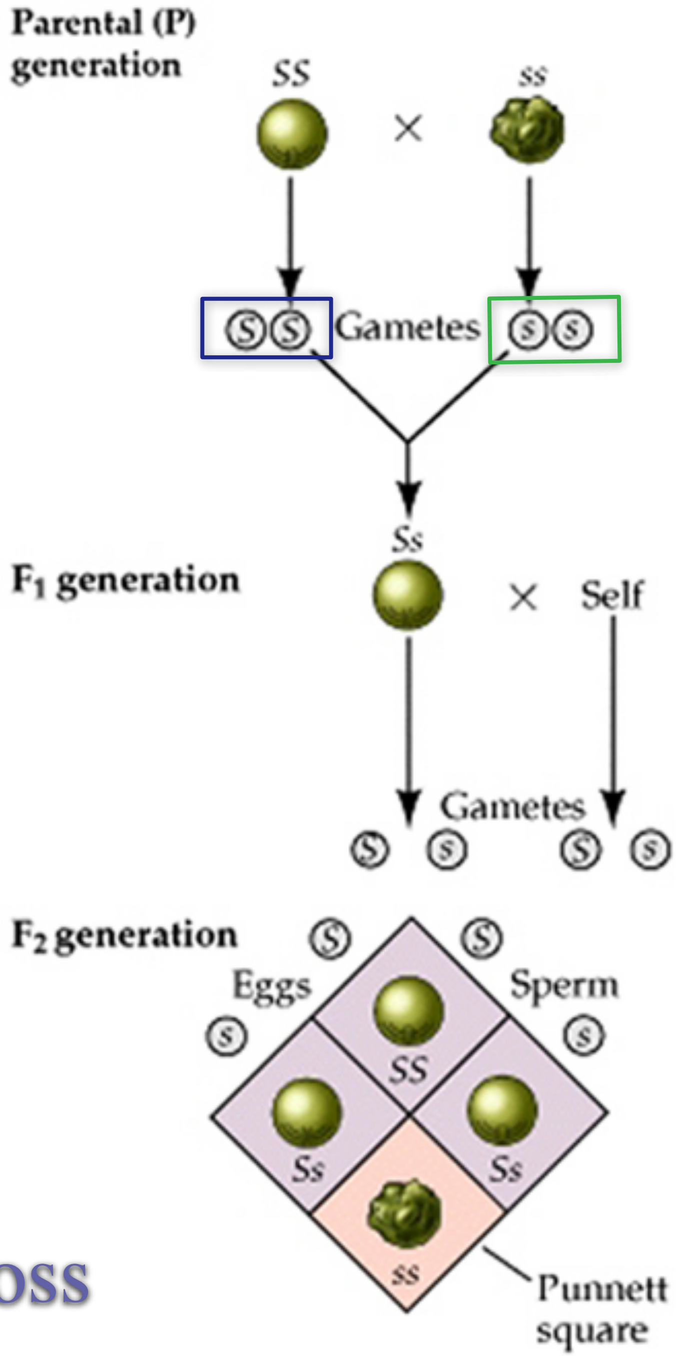
2. When two different unit factors governing the same phenotypical trait occur in the same organism, one of the factors is **dominant** over the other one, which is called the **recessive** trait.

3. During the formation of gametes the "paired" unit factors separate or **segregate randomly** so that each gamete receives either **one or the other** of the two traits, but **only one**.

4. The union of one gamete from each parent to form a resultant zygote **is random** with respect to that particular characteristic.

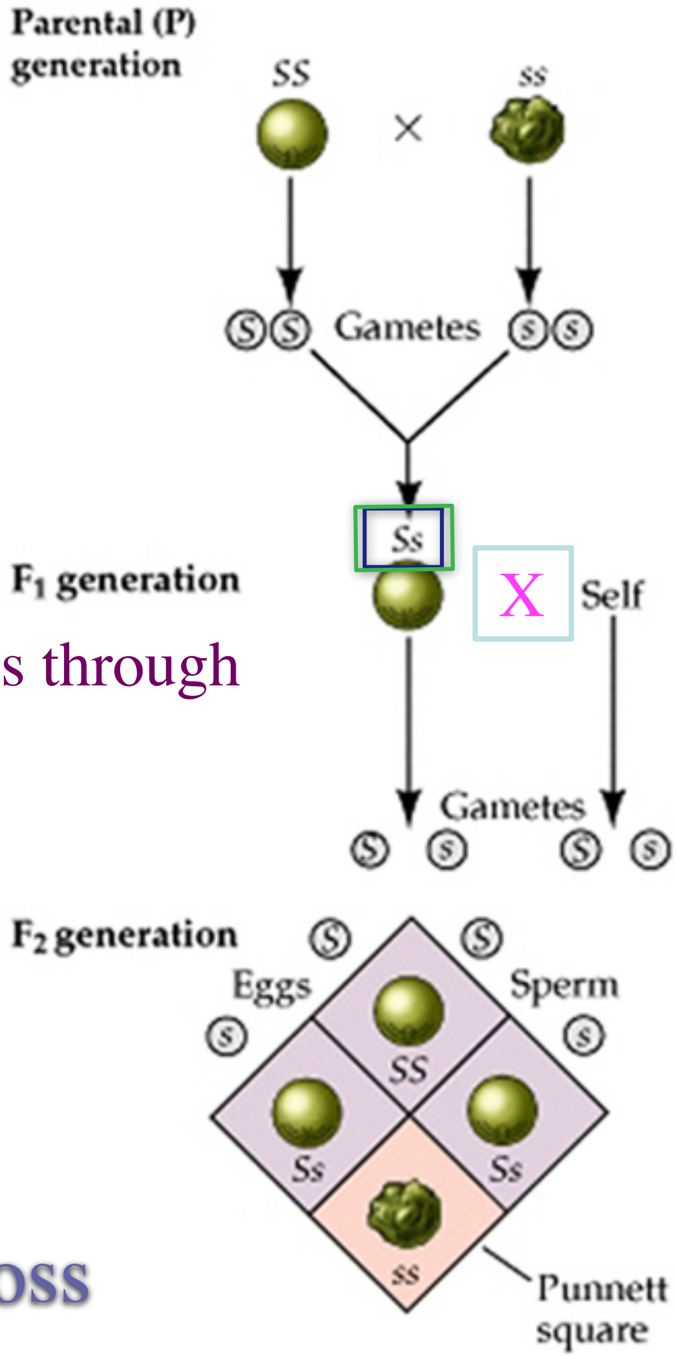
5. During production of gametes, only one of the "pair members" for a given character passes to the gamete.

6. When fertilization occurs, the zygote gets **one from each parent**, thus restoring the pair.

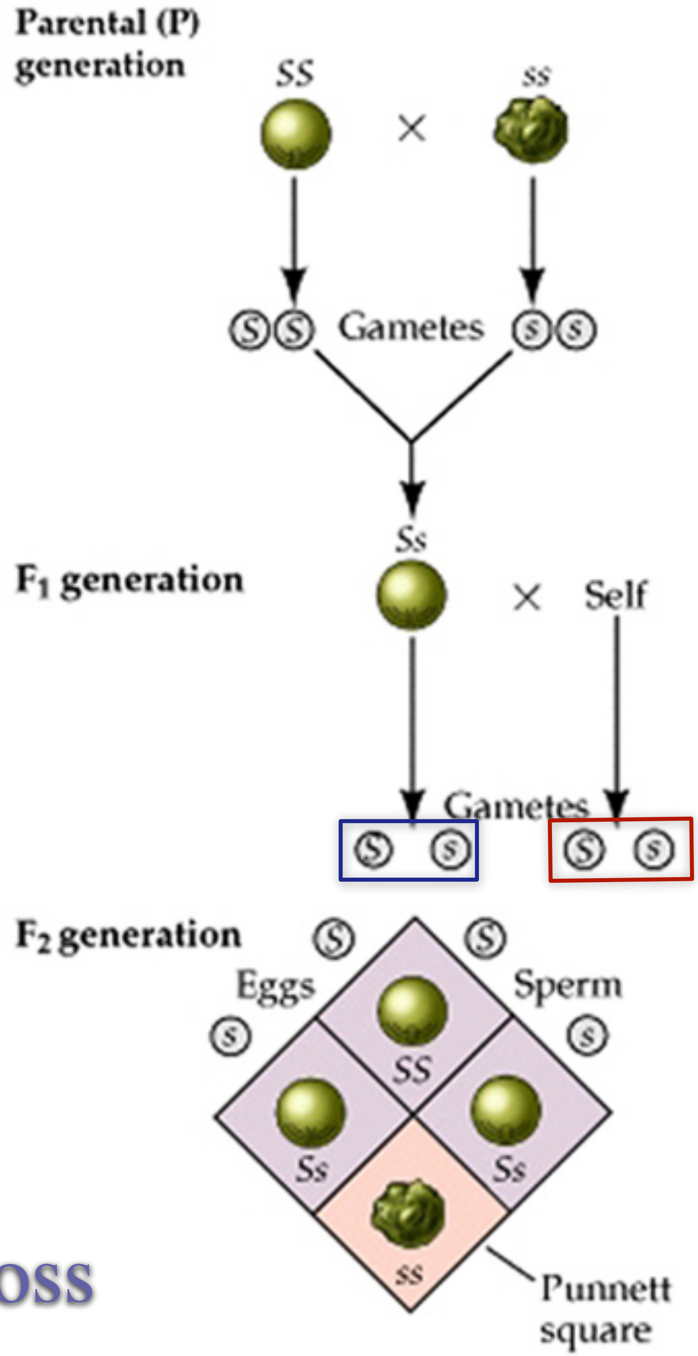


Monohybrid Cross

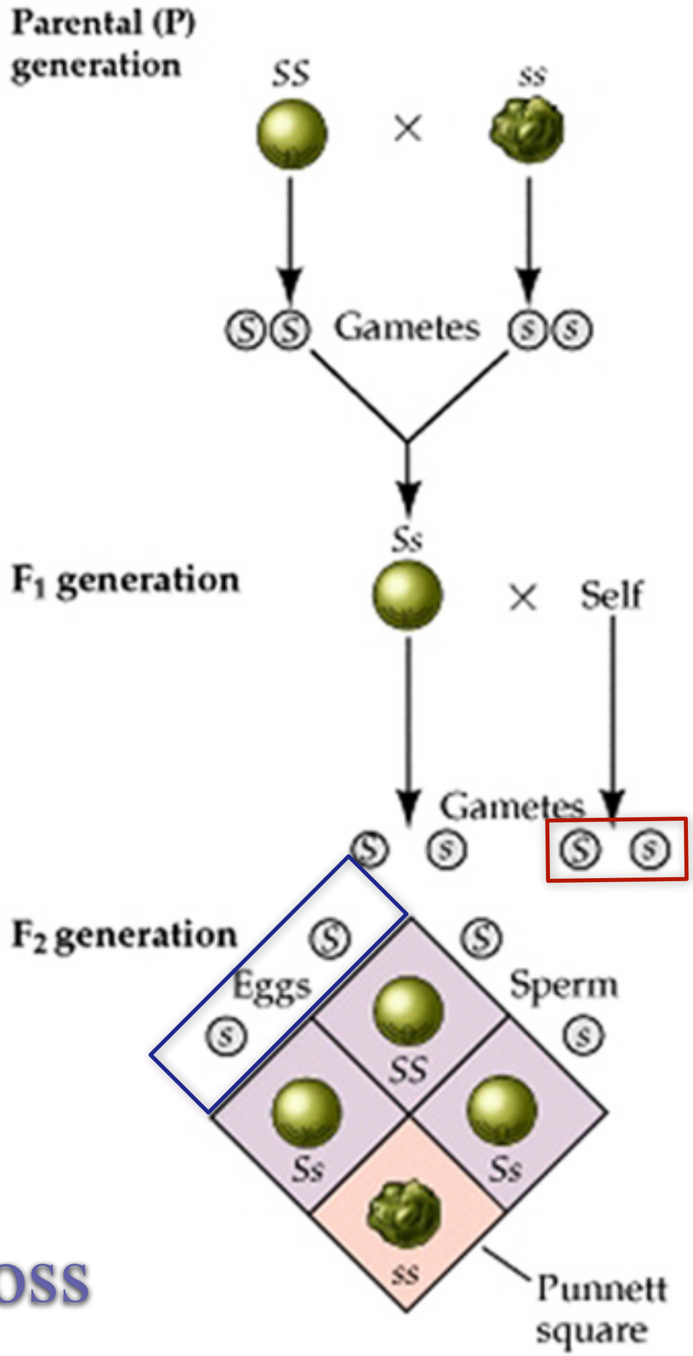
ALWAYS
Dominant trait shows through



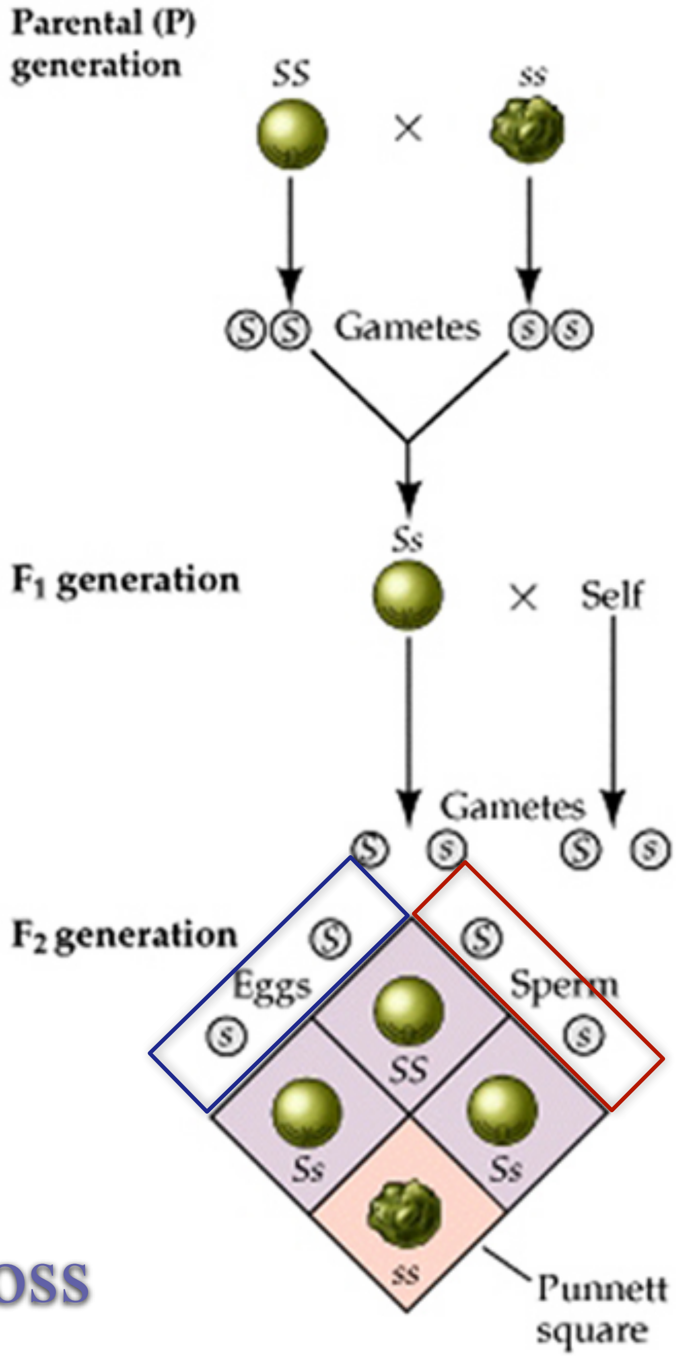
Monohybrid Cross



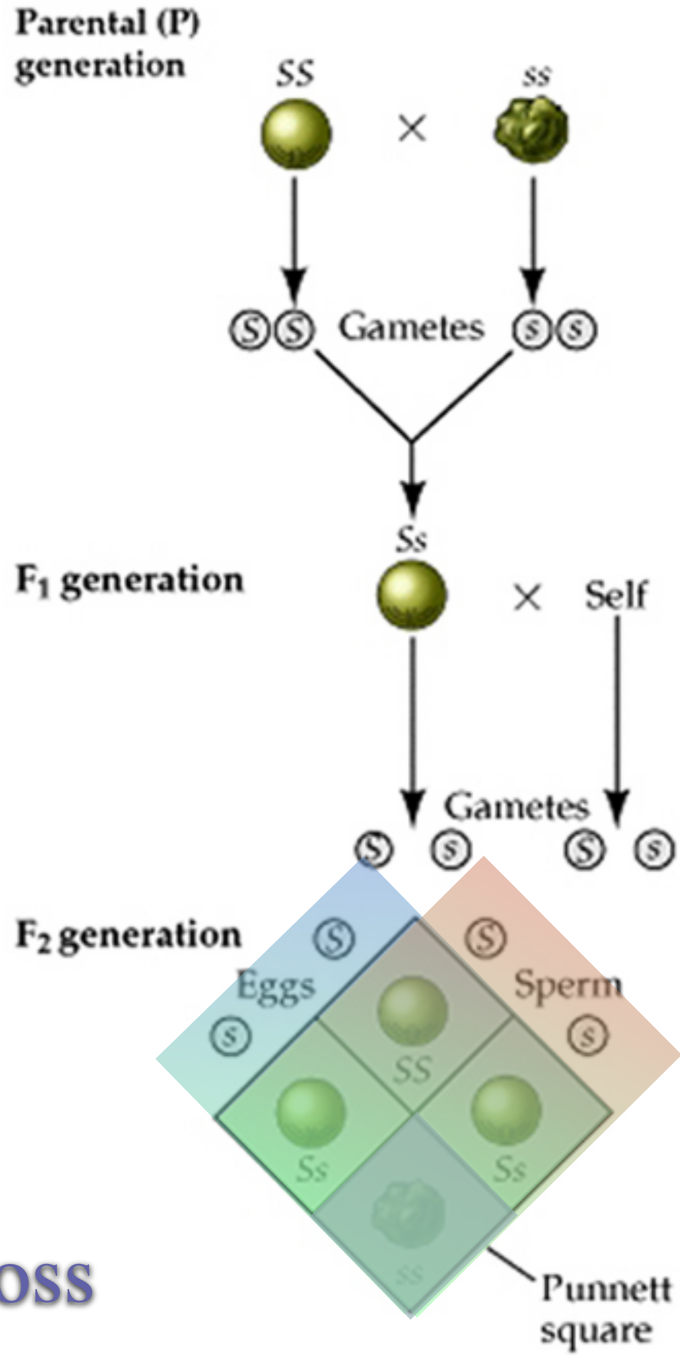
Monohybrid Cross



Monohybrid Cross

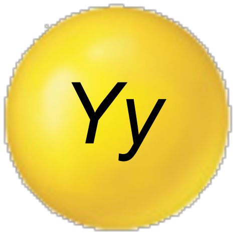


Monohybrid Cross



Monohybrid Cross

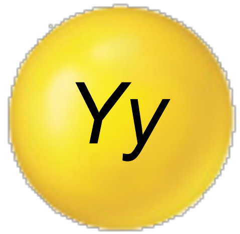
Homozygous DOMINANT



Heterozygous

Homozygous recessive

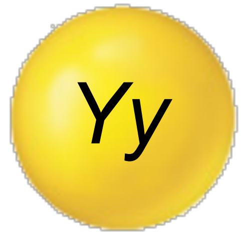
Homozygous
DOMINANT



Heterozygous

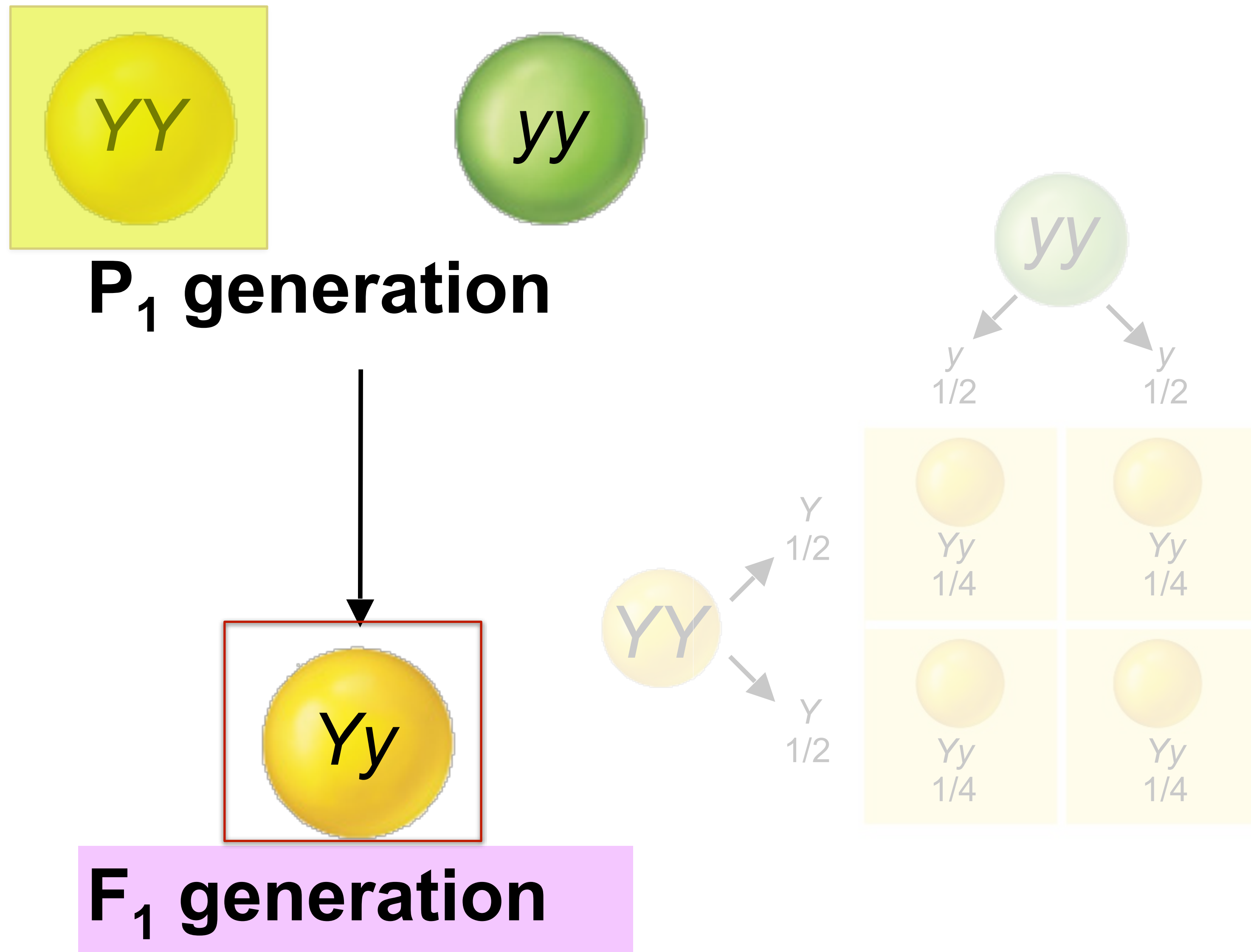
Homozygous
recessive

Homozygous DOMINANT

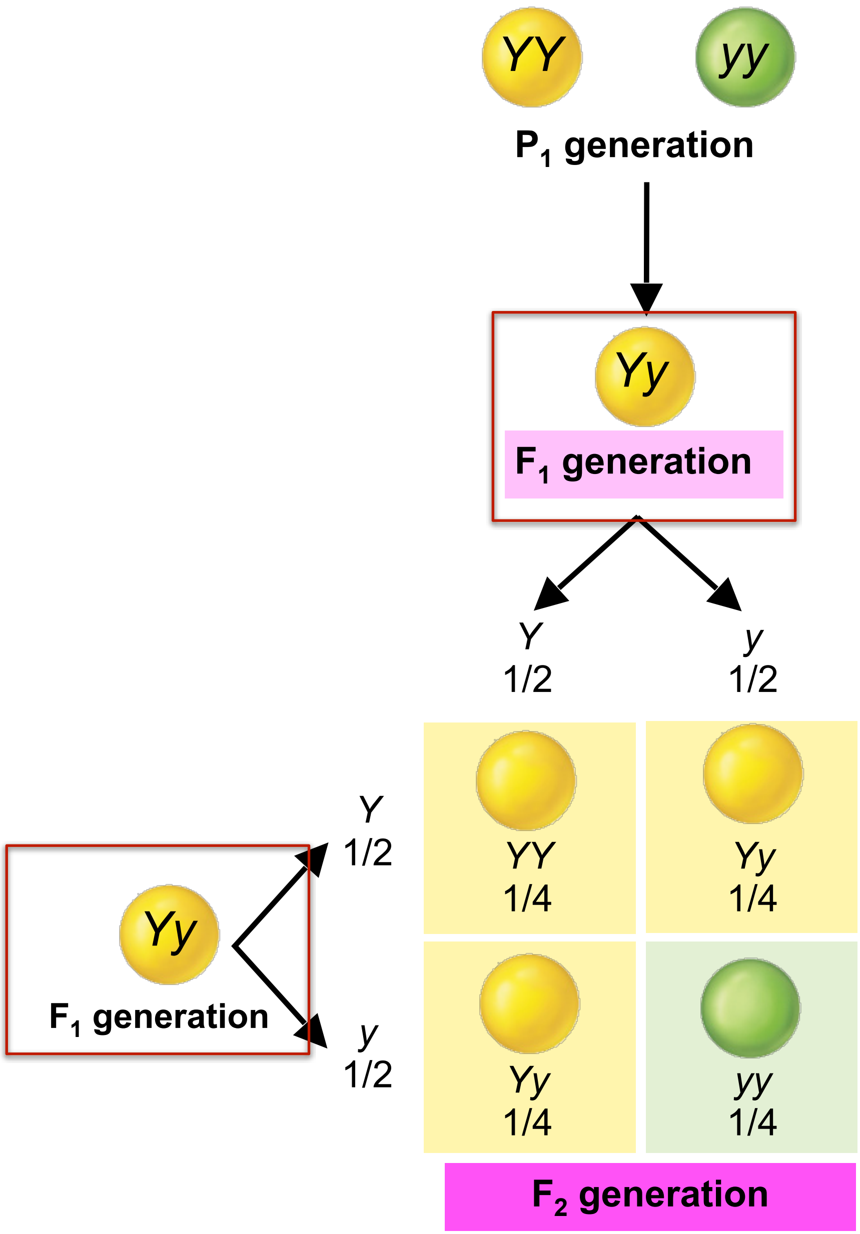


Heterozygous

Homozygous recessive


YY
yy
P_1 generation
Yy
F_1 generation
yy
y
1/2
y
1/2
YY
Y
1/2
Y
1/2
Yy
1/4
Yy
1/4
Yy
1/4
Yy
1/4

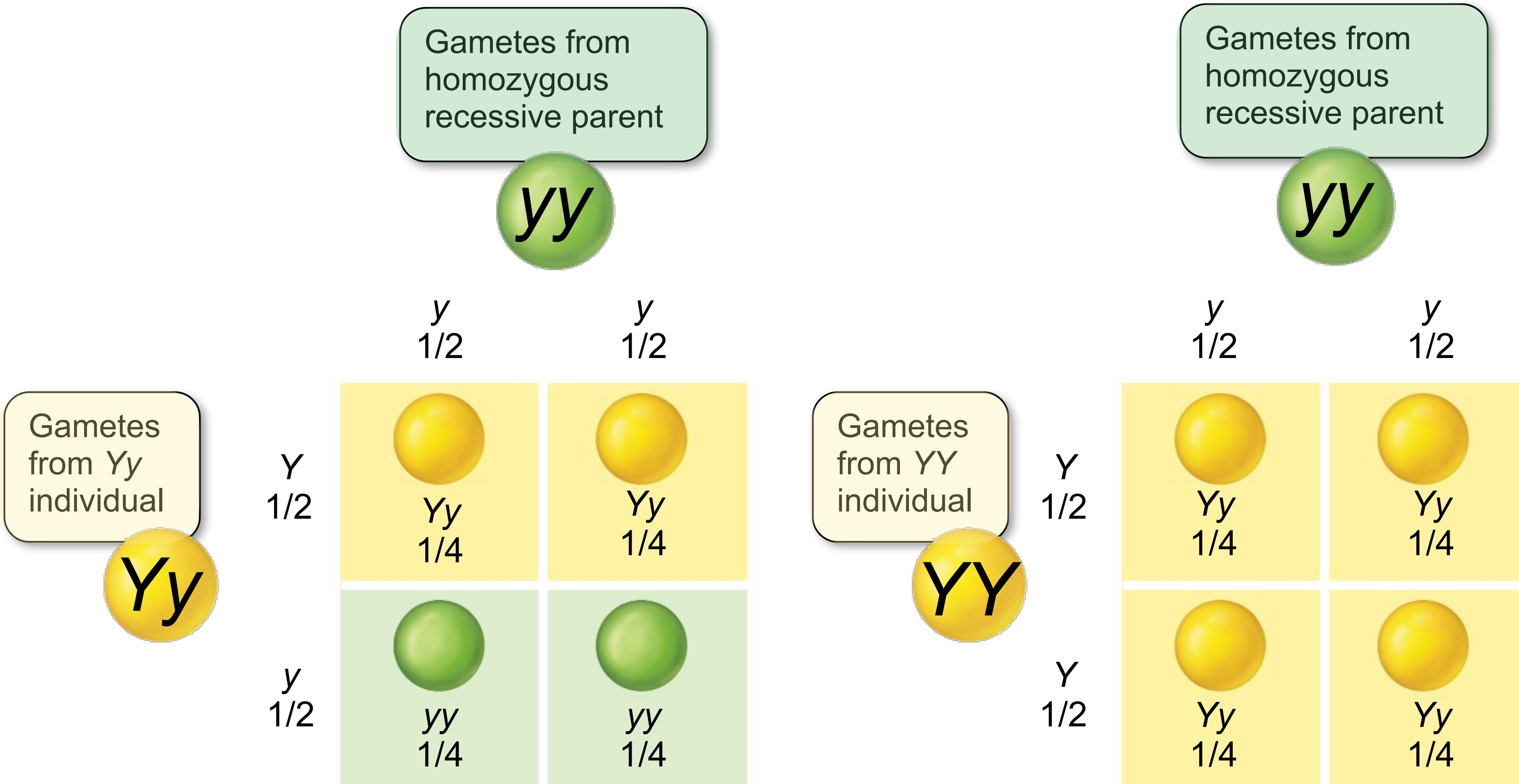
The Principle of Segregation



Expected ratio of *YY* : *Yy* : *yy* genotypes is 1 : 2 : 1

Expected ratio of dominant:recessive phenotypes is 3 : 1

Testcross



Heterozygous &
Homozygous recessive
genotypes 1:1.

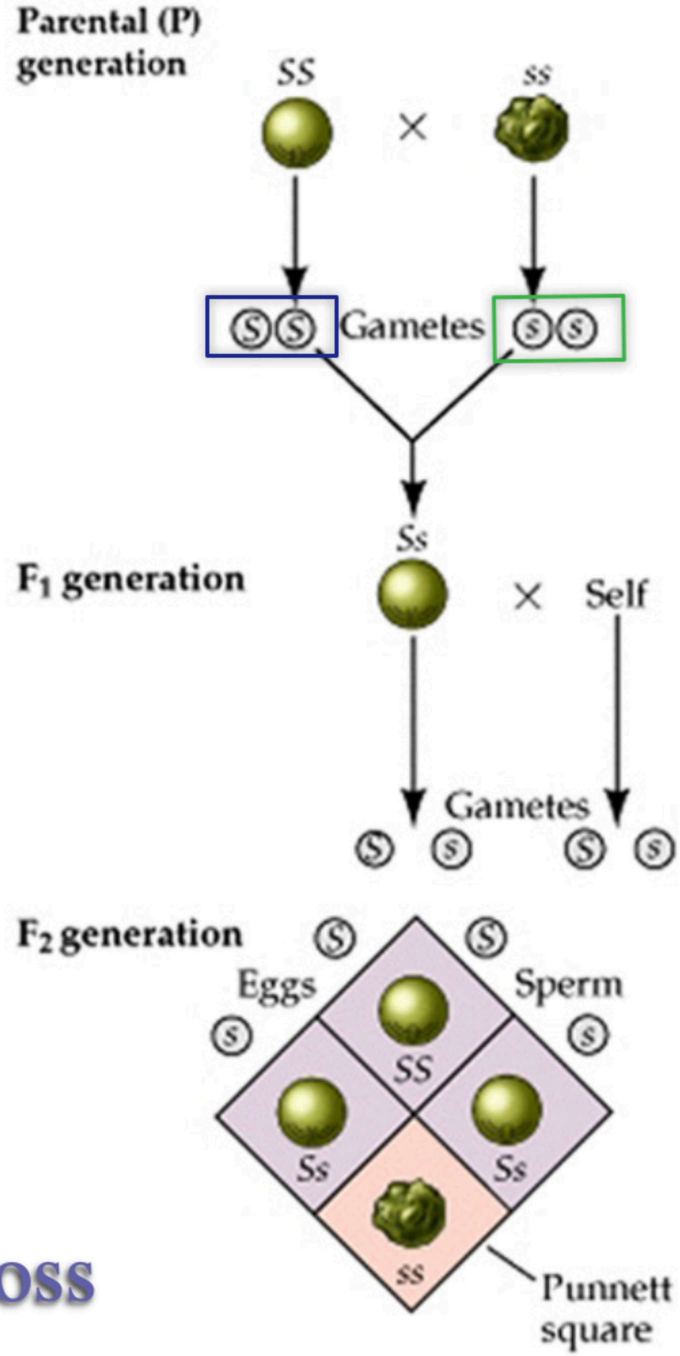
ALL Heterozygous
genotypes

Mendel's 1st law- the law of segregation

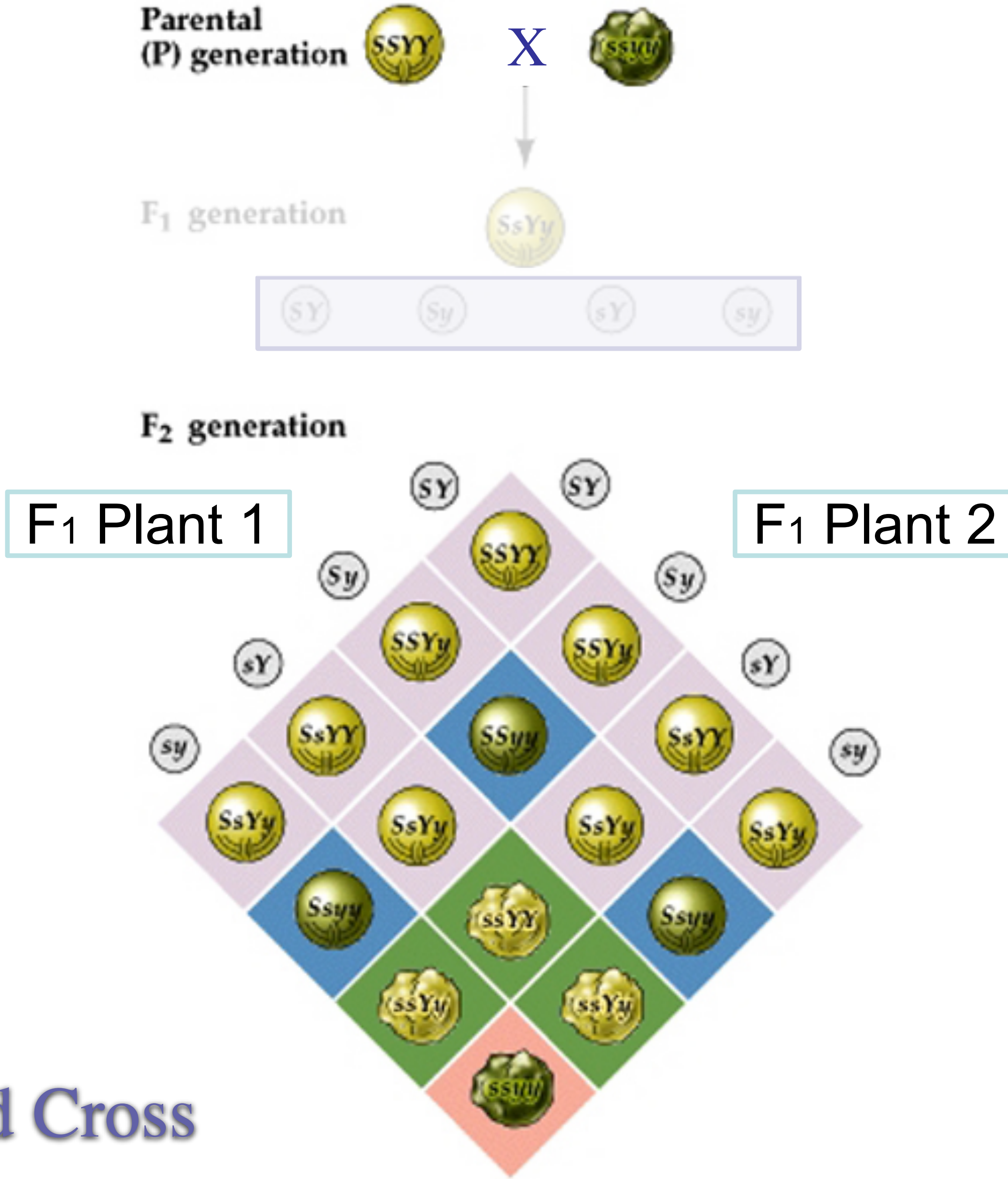
Mendel's First Law: Two members of a gene pair segregate from each other into the gametes, whereby one half of the gametes carries one of the traits, the other half carries the other.

Mendel's 2nd law- the law of random/independent assortment

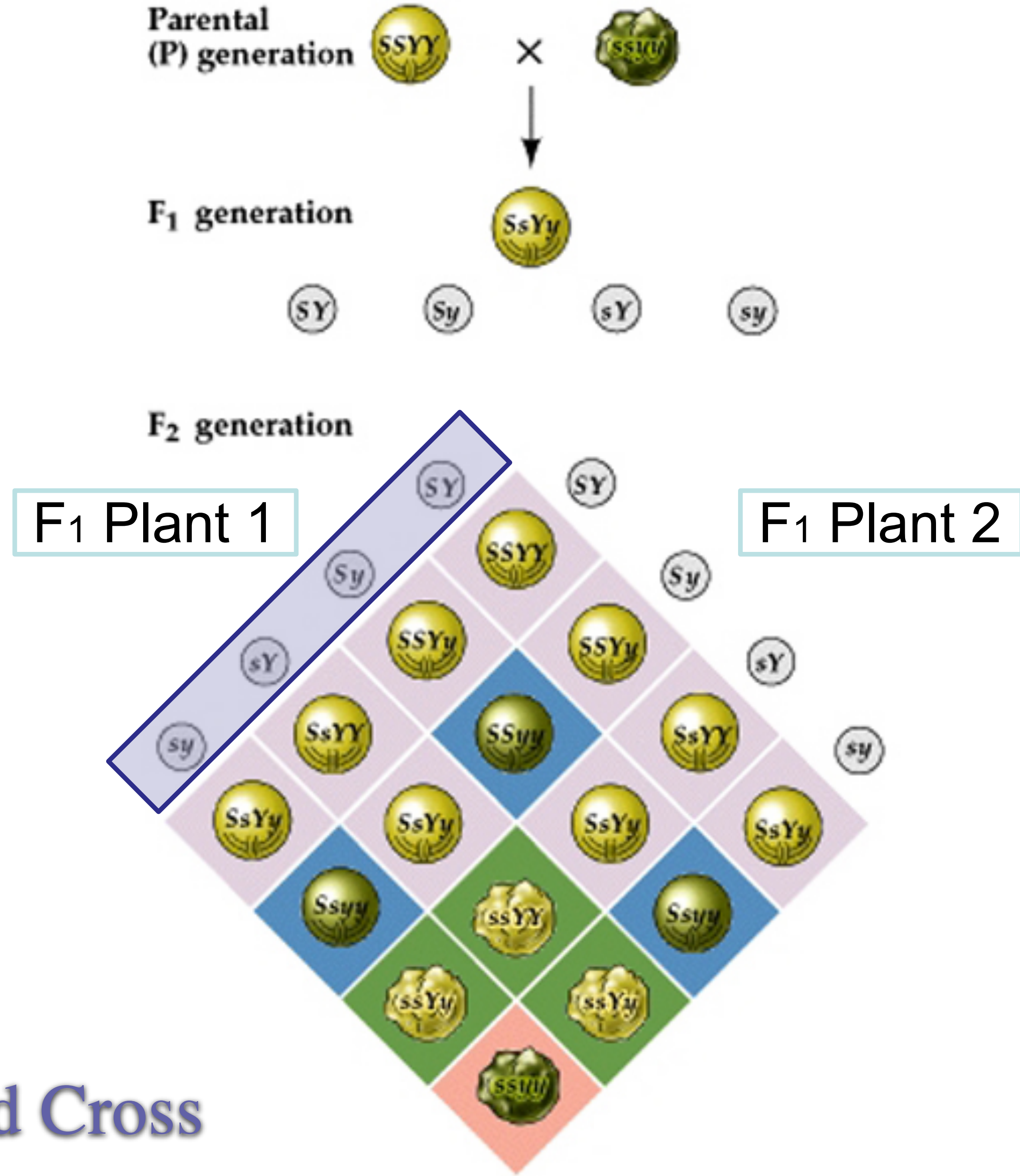
Mendel's Second Law: During gamete formation the segregation of one gene pair is independent of all other gene pairs



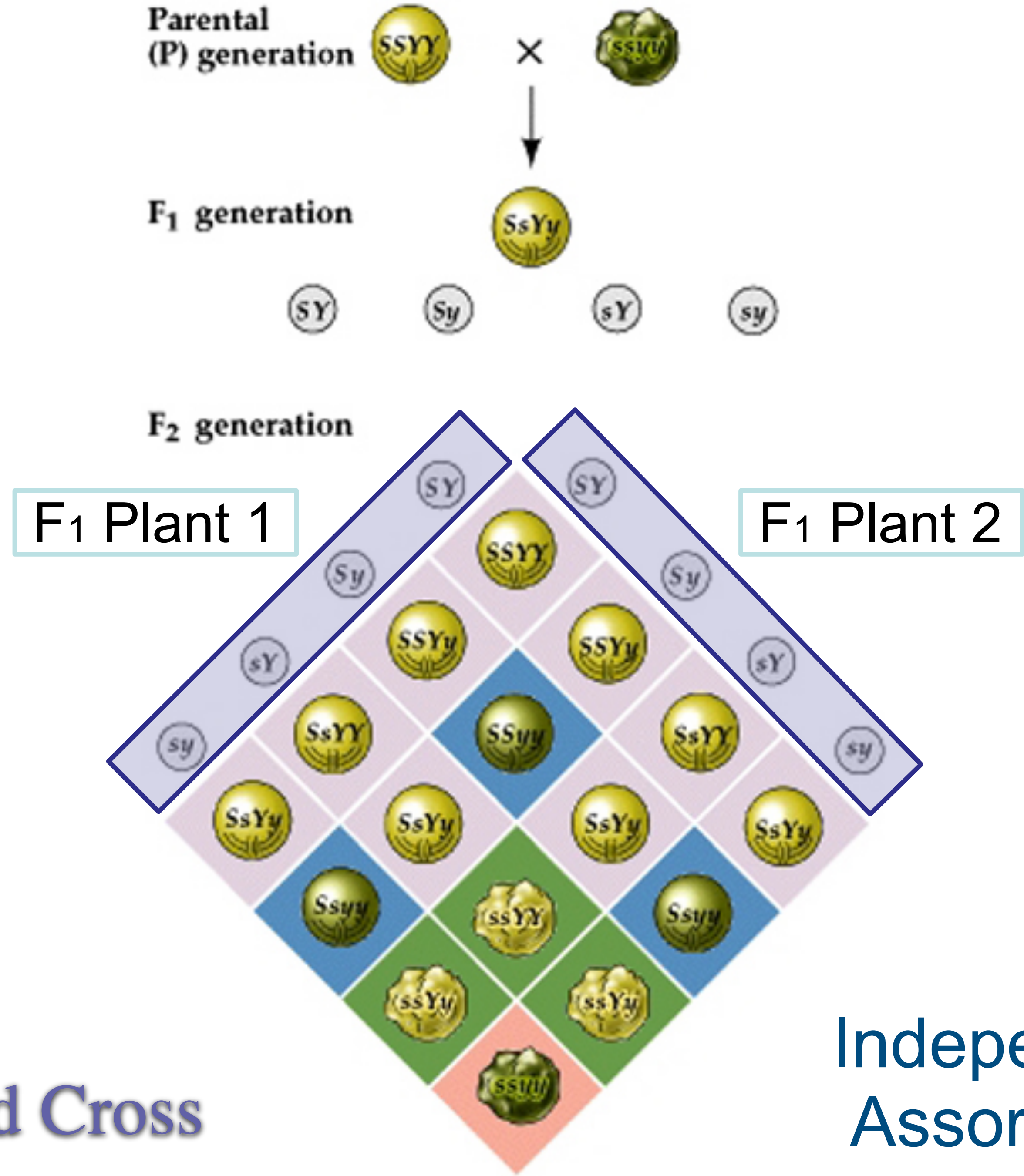
Monohybrid Cross



Dihybrid Cross



Dihybrid Cross



Dihybrid Cross

Independent Assortment

Independent Assortment

Ovule gametes \ Pollen gametes	*Y S* 1/4	*Y s* 1/4	*y S* 1/4	*y s* 1/4
Y S 1/4	*YY SS* 1/16	*YY Ss* 1/16	*Yy SS* 1/16	*Yy Ss* 1/16
Y s 1/4	*YY Ss* 1/16	*YY* ***ss*** 1/16	*Yy Ss* 1/16	*Yy* ***ss*** 1/16
y S 1/4	*Yy SS* 1/16	*Yy Ss* 1/16	***yy*** *SS* 1/16	***yy*** *Ss* 1/16
y s 1/4	*Yy Ss* 1/16	*Yy* ***ss*** 1/16	***yy*** *Ss* 1/16	***yy ss*** 1/16

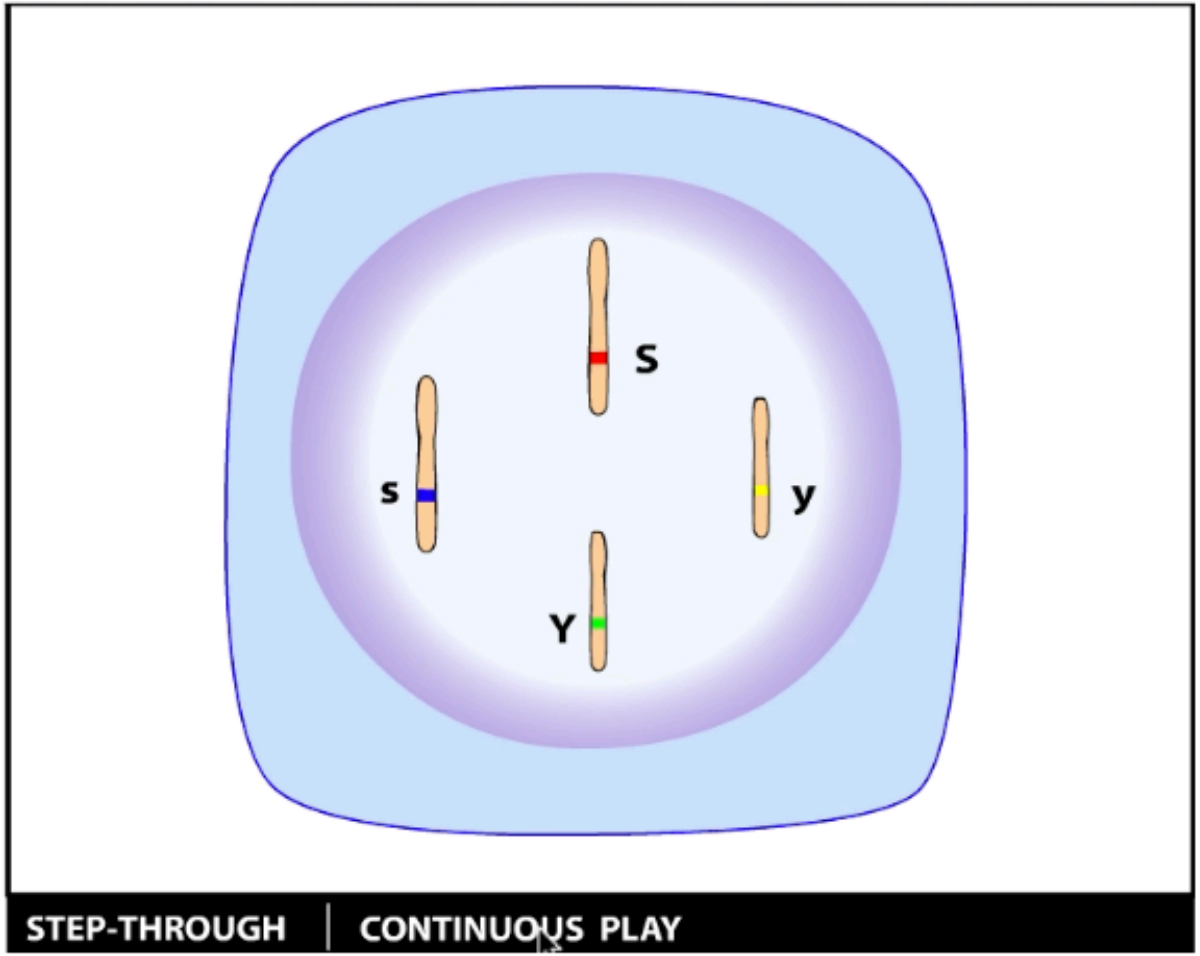
There are **9 possible genotypes** and 4 possible phenotypes. The ratio of phenotypes is **9:3:3:1**.

	RYS	RYs	RyS	Rys	rYS	rYs	ryS	rys
RYS	RRYYSS	RRYYSs	RRYySS	RRYySs	RrYYSS	RrYYSs	RrYySS	RrYySs
RYs	RRYYSs	RRYYss	RRYycSs	RRYyss	RrYYSs	RrYYss	RrYySs	RrYyss
RyS	RRYySS	RRYySs	RRyySS	RRyySs	RrYySS	RrYySs	RryySS	RryySs
Rys	RRYySs	RRYyss	RRyySs	RRyyss	RrYySs	RrYyss	RryySs	Rryyss
rYS	RrYYSS	RrYYSs	RrYySs	RrYySs	rrYYSS	rrYYSs	rrYySS	rrYySs
rYs	RrYYSs	RrYYss	RrYySs	RrYyss	rrYYSs	rrYYss	rrYySs	rrYyss
ryS	RrYYSS	RrYySs	RryySS	RryySs	rrYySS	rrYySs	rryySS	rryySs
rys	RrYySs	RrYyss	RryySs	Rryyss	rrYySs	rrYyss	rryySs	rryyss

Phenotypic ratio:

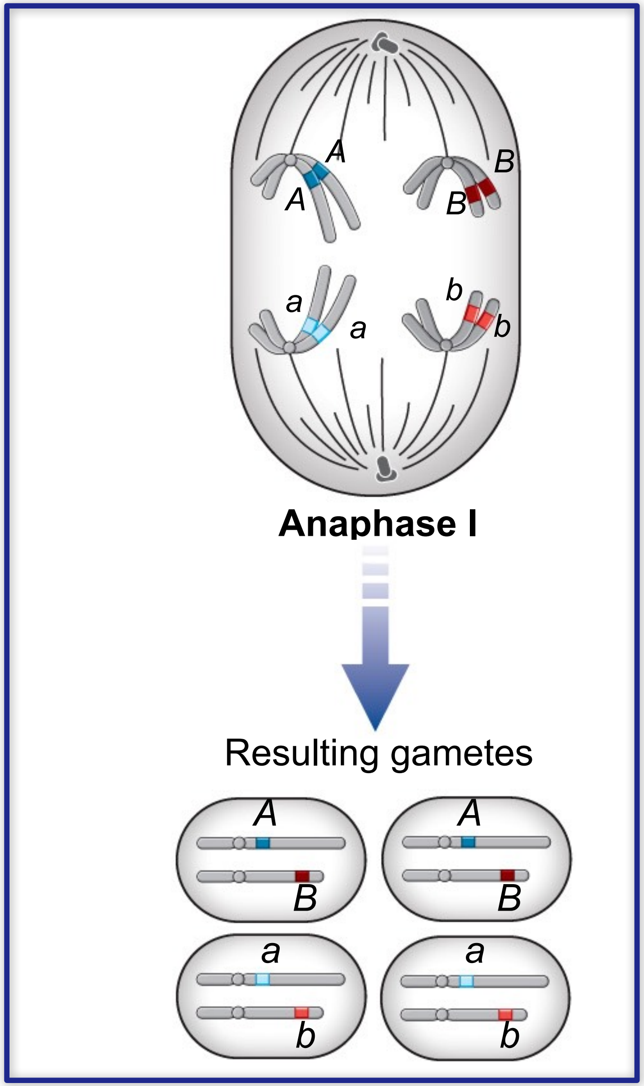
27: round, yellow, smooth pod
9: round, yellow, constricted pod
9: round, green, smooth pod
3: round, green, constricted pod
9: wrinkled, yellow, smooth pod
3: wrinkled, yellow, constricted pod
3: wrinkled, green, smooth pod
1: wrinkled, green, constricted pod

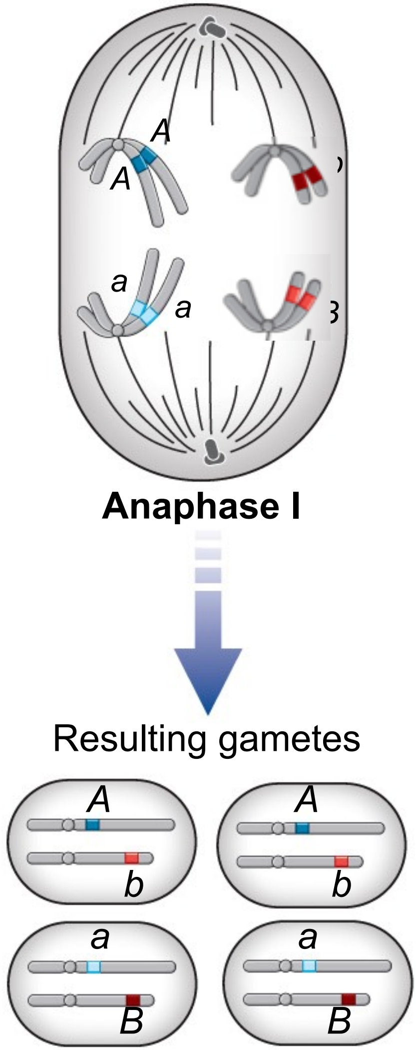
Trihybrid Cross


S
s
y
Y
STEP-THROUGH
CONTINUOUS PLAY

Independent Assortment

Independent assortment of genes in different chromosomes reflects the fact that non homologous chromosomes can orient in either of two ways that are equally likely.





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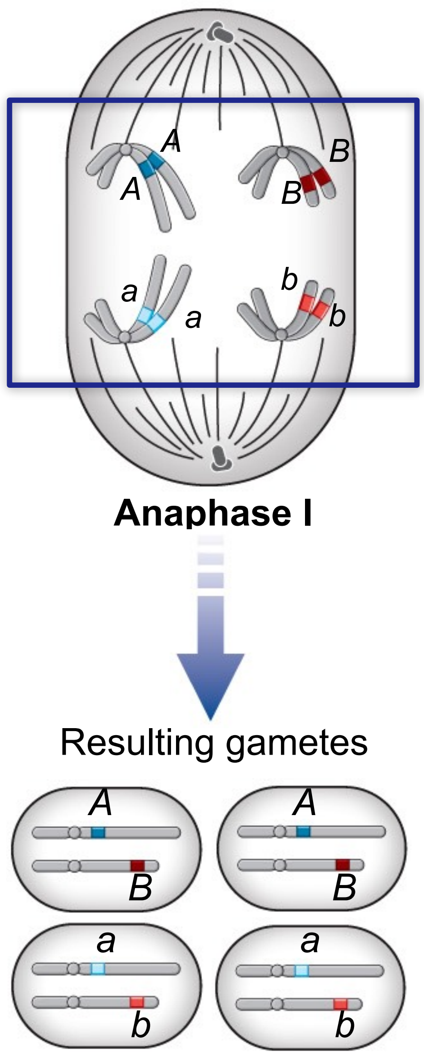

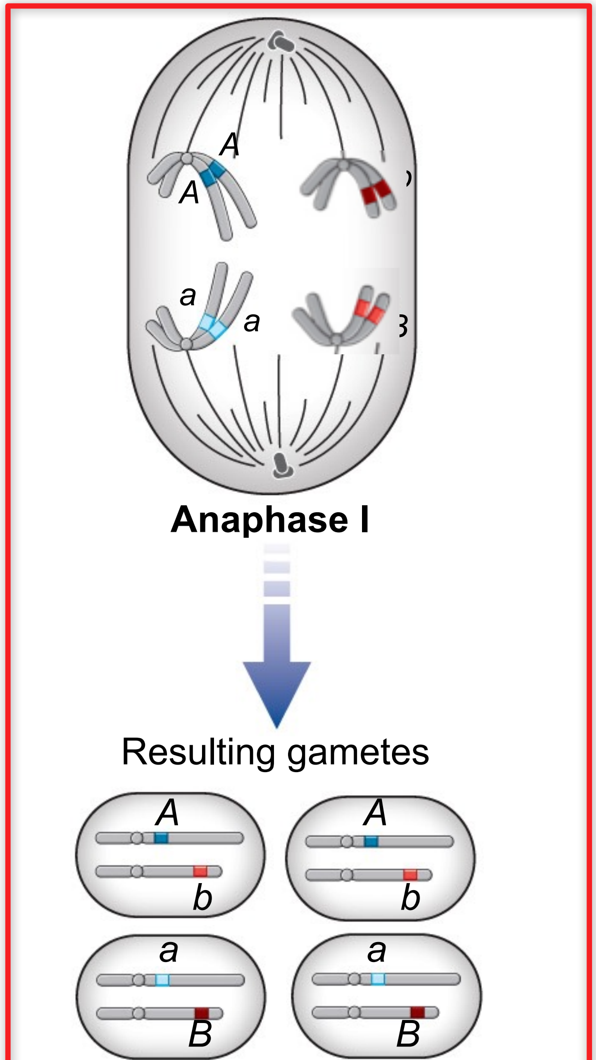

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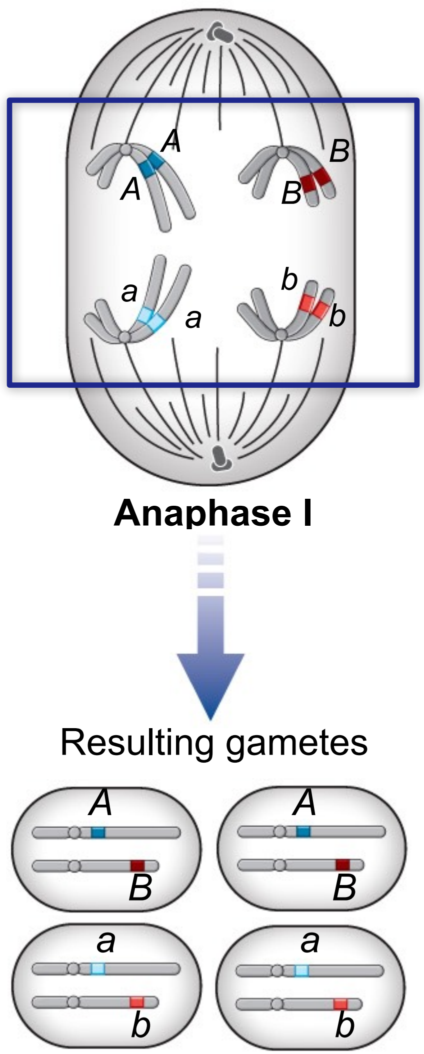

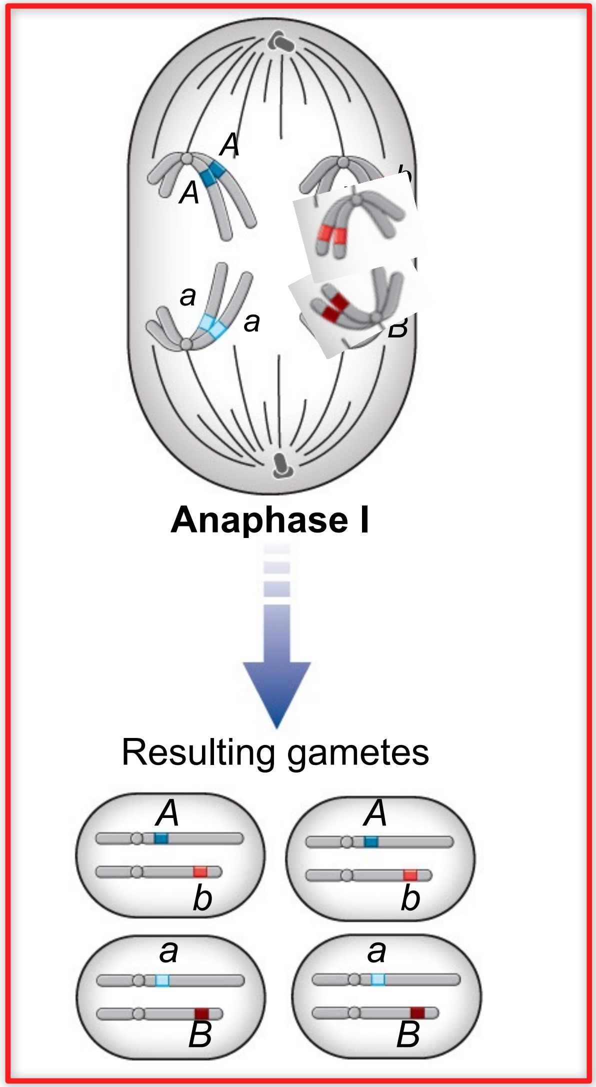

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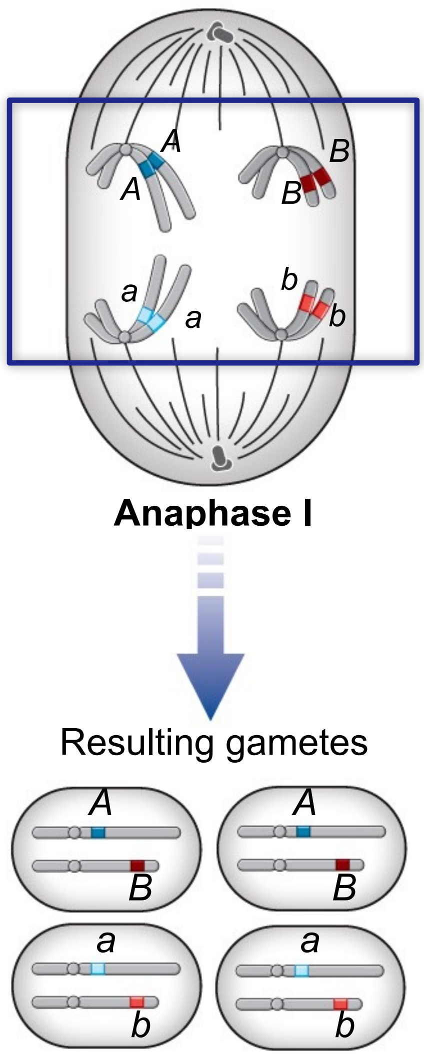

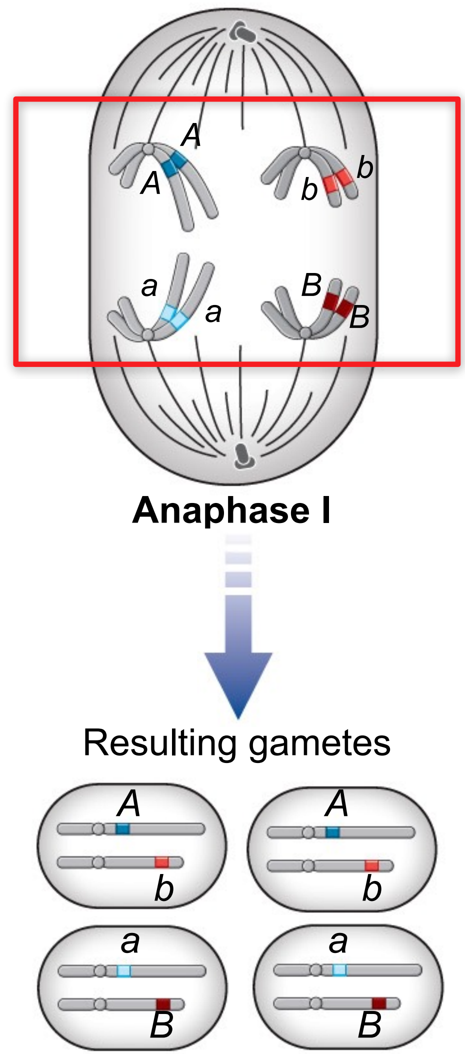

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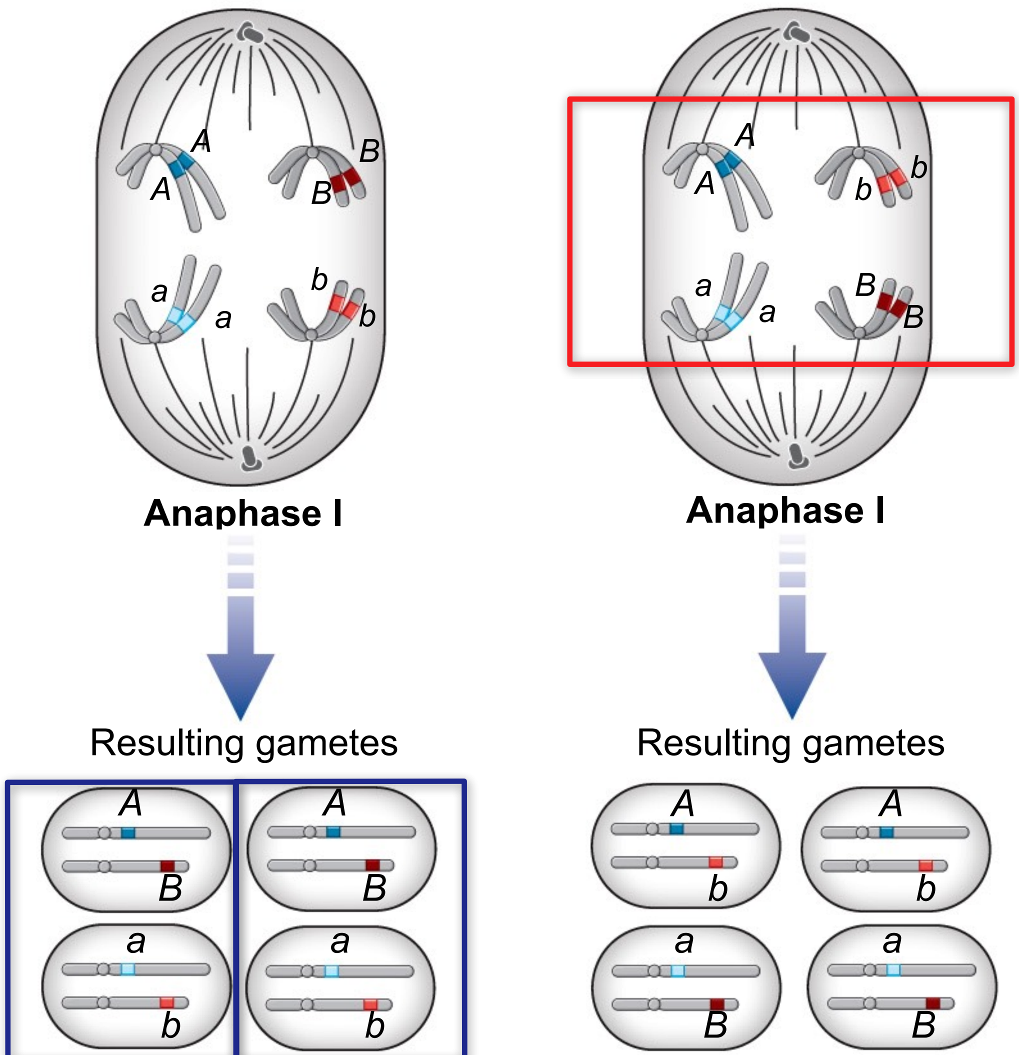

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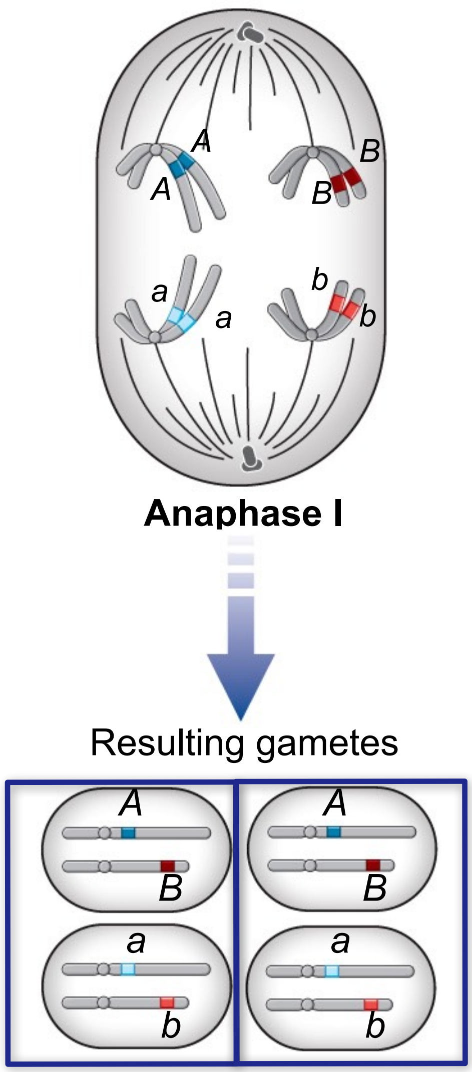
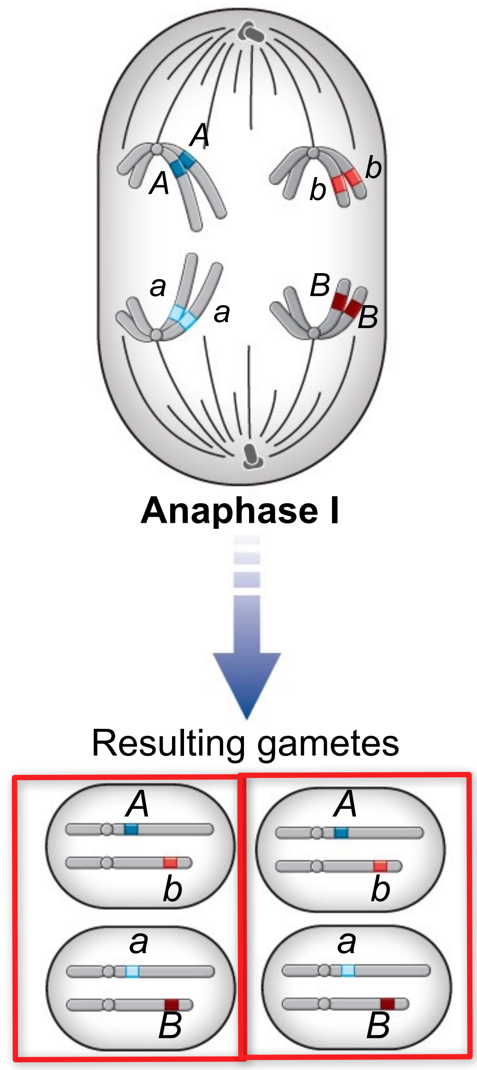
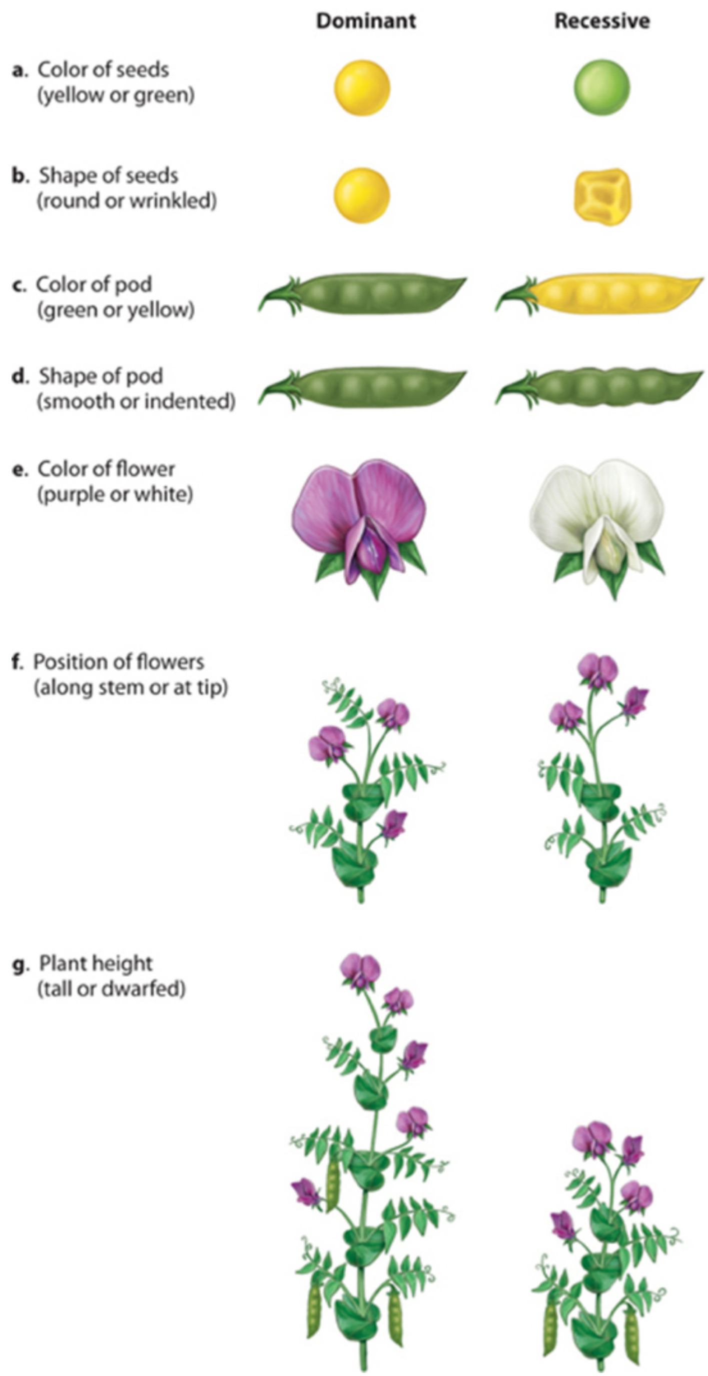
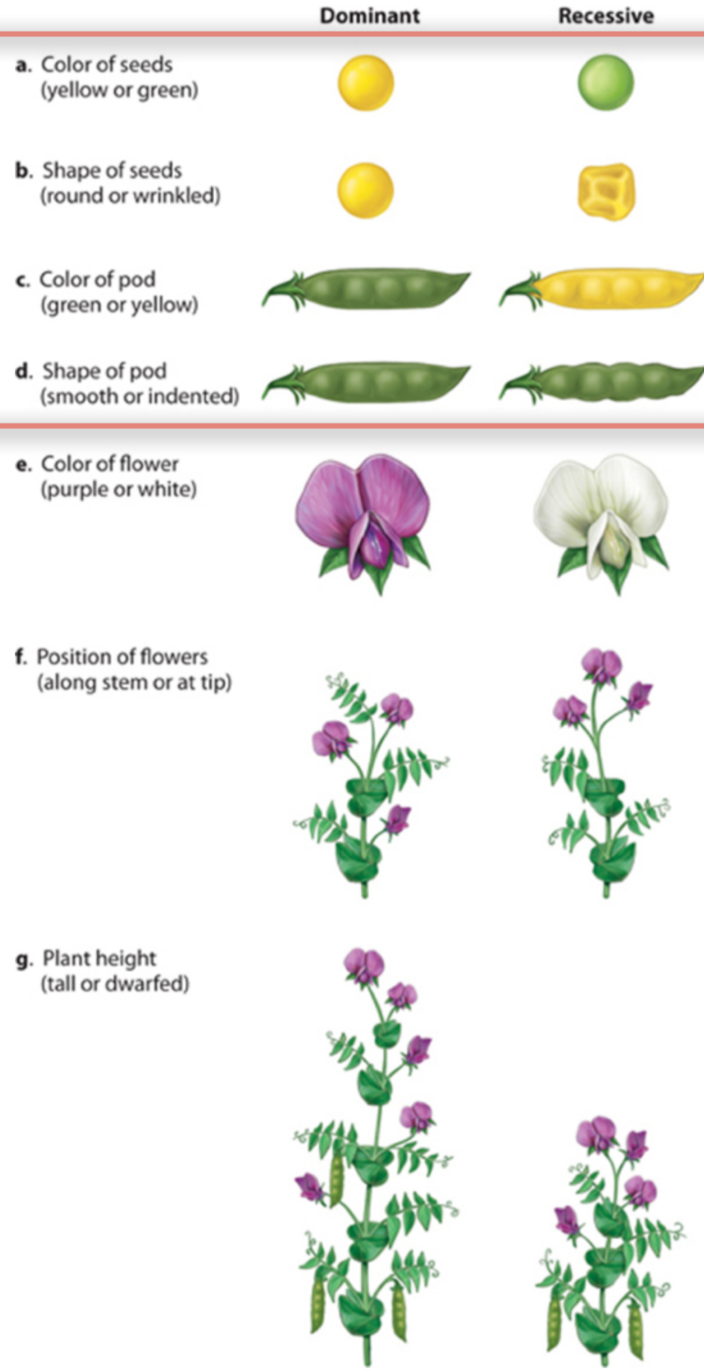





Dominant
Recessive
a. Color of seeds
(yellow or green)
b. Shape of seeds
(round or wrinkled)
c. Color of pod
(green or yellow)
d. Shape of pod
(smooth or indented)
e. Color of flower
(purple or white)
f. Position of flowers
(along stem or at tip)
g. Plant height
(tall or dwarfed)



chromosome 1

chromosome 7

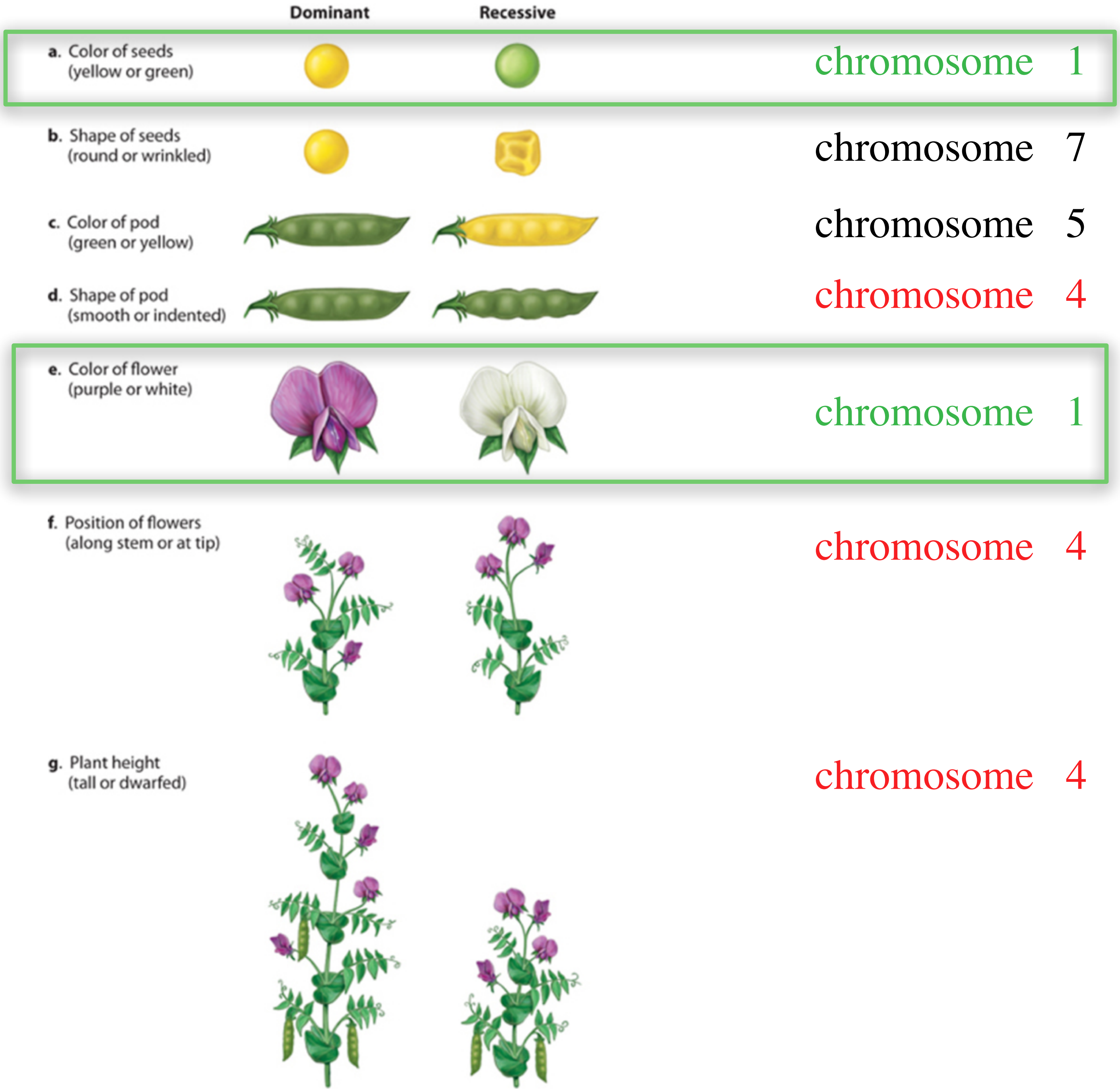
chromosome 5

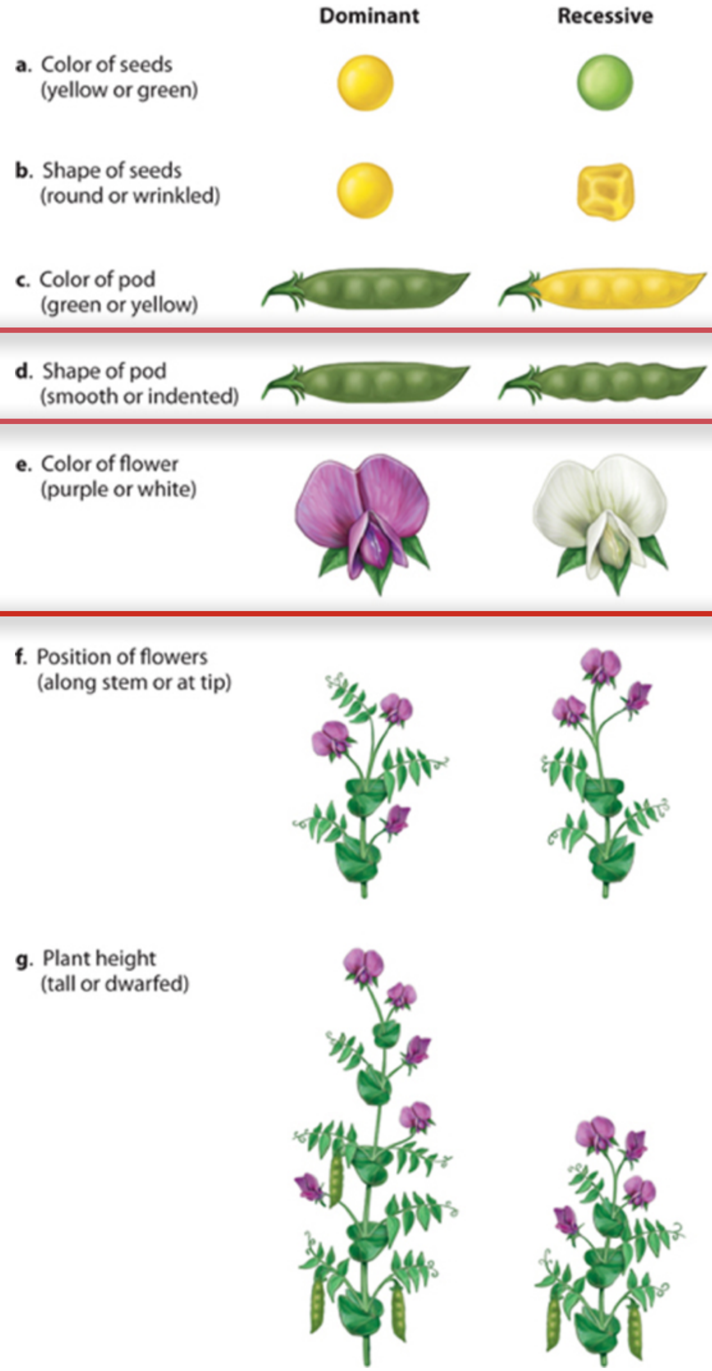
chromosome 4

chromosome 1

chromosome 4

chromosome 4


Dominant
Recessive
a. Color of seeds (yellow or green)
chromosome 1
b. Shape of seeds (round or wrinkled)
chromosome 7
c. Color of pod (green or yellow)
chromosome 5
d. Shape of pod (smooth or indented)
chromosome 4
e. Color of flower (purple or white)
chromosome 1
f. Position of flowers (along stem or at tip)
chromosome 4
g. Plant height (tall or dwarfed)
chromosome 4



chromosome 1

chromosome 7

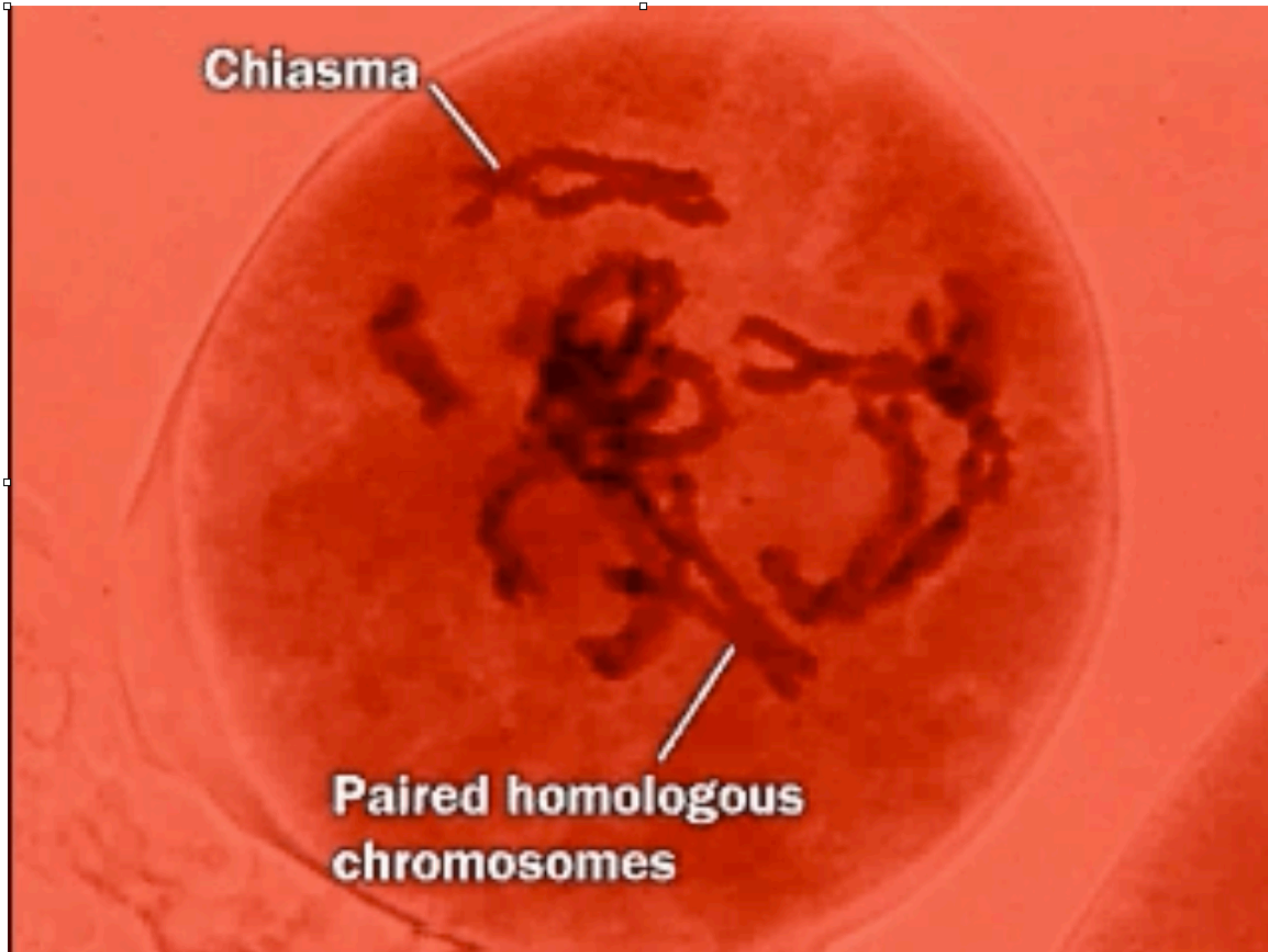
chromosome 5

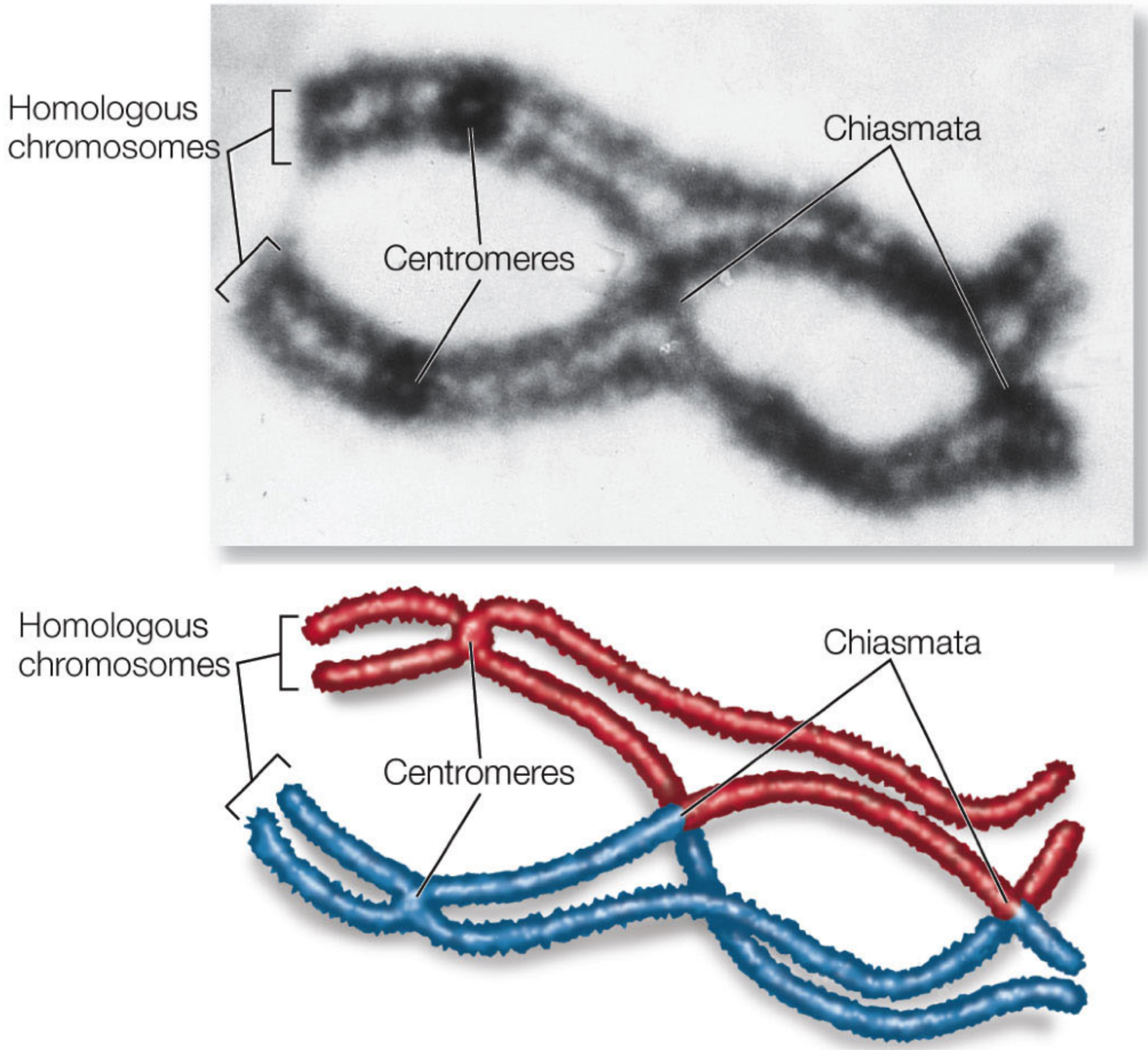
chromosome 4

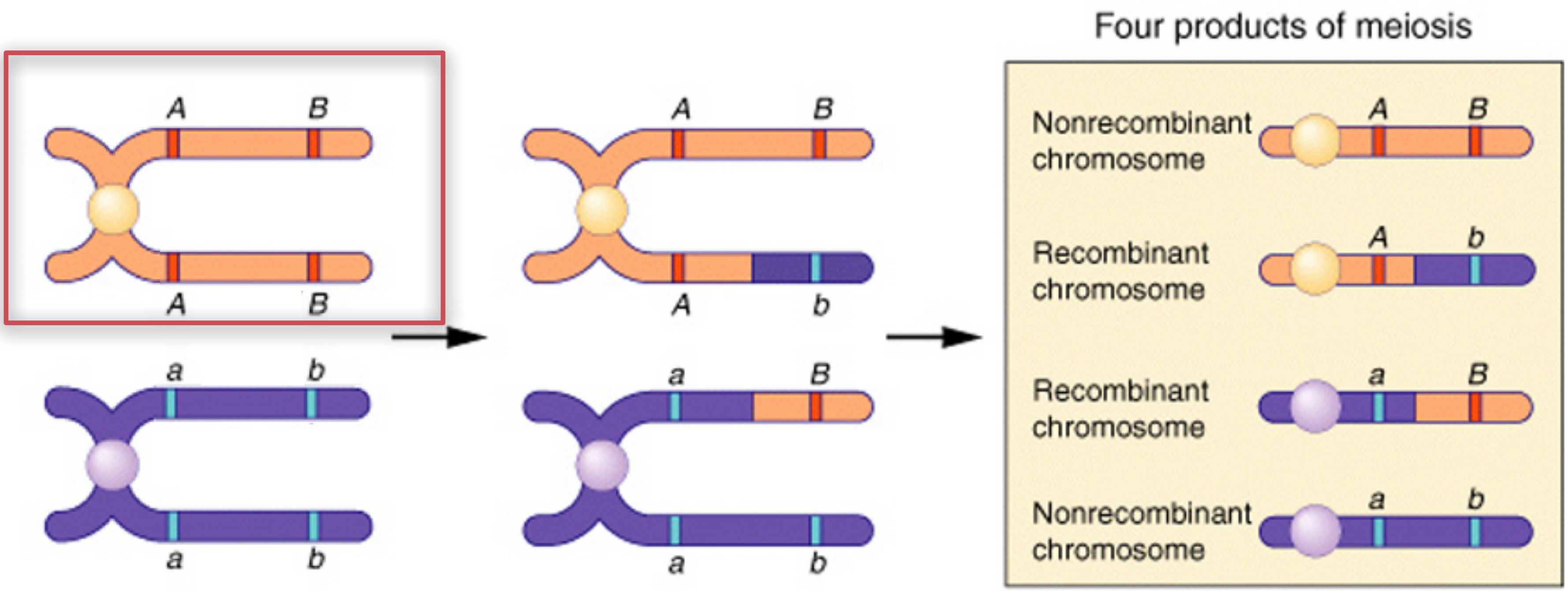
chromosome 1

chromosome 4

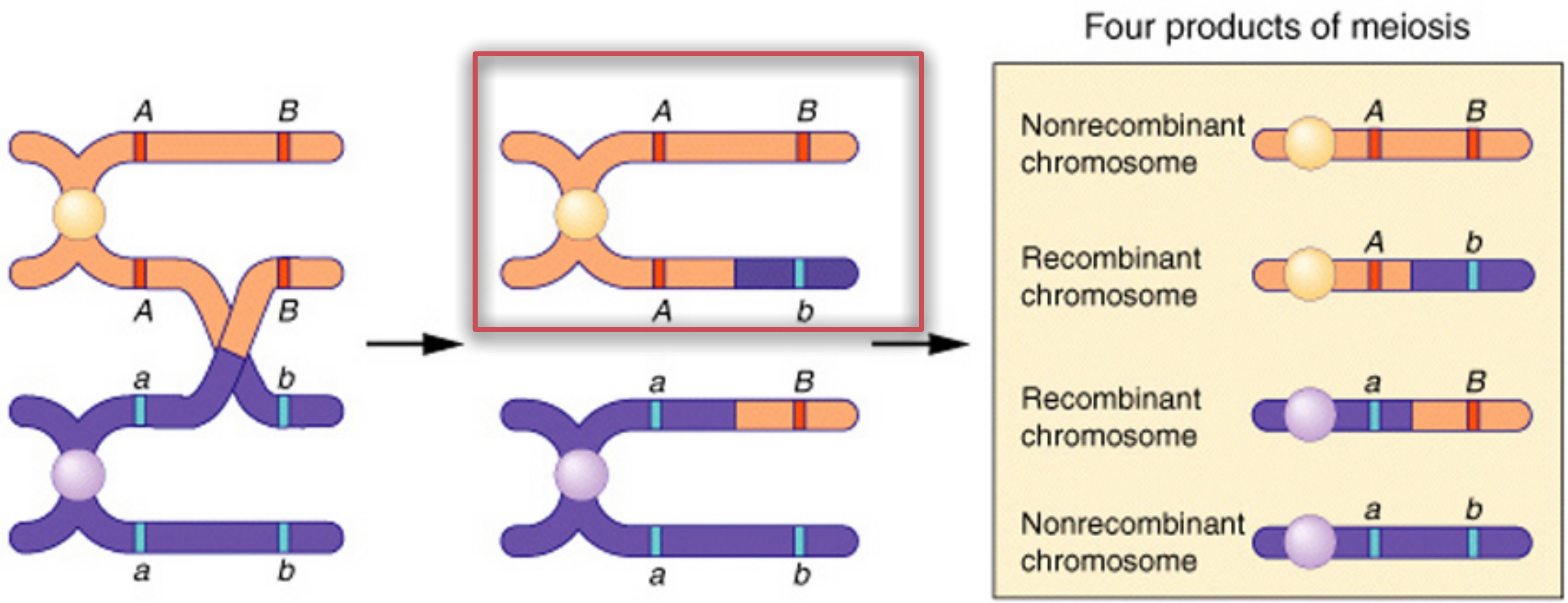
chromosome 4


Chiasma
Paired homologous
chromosomes

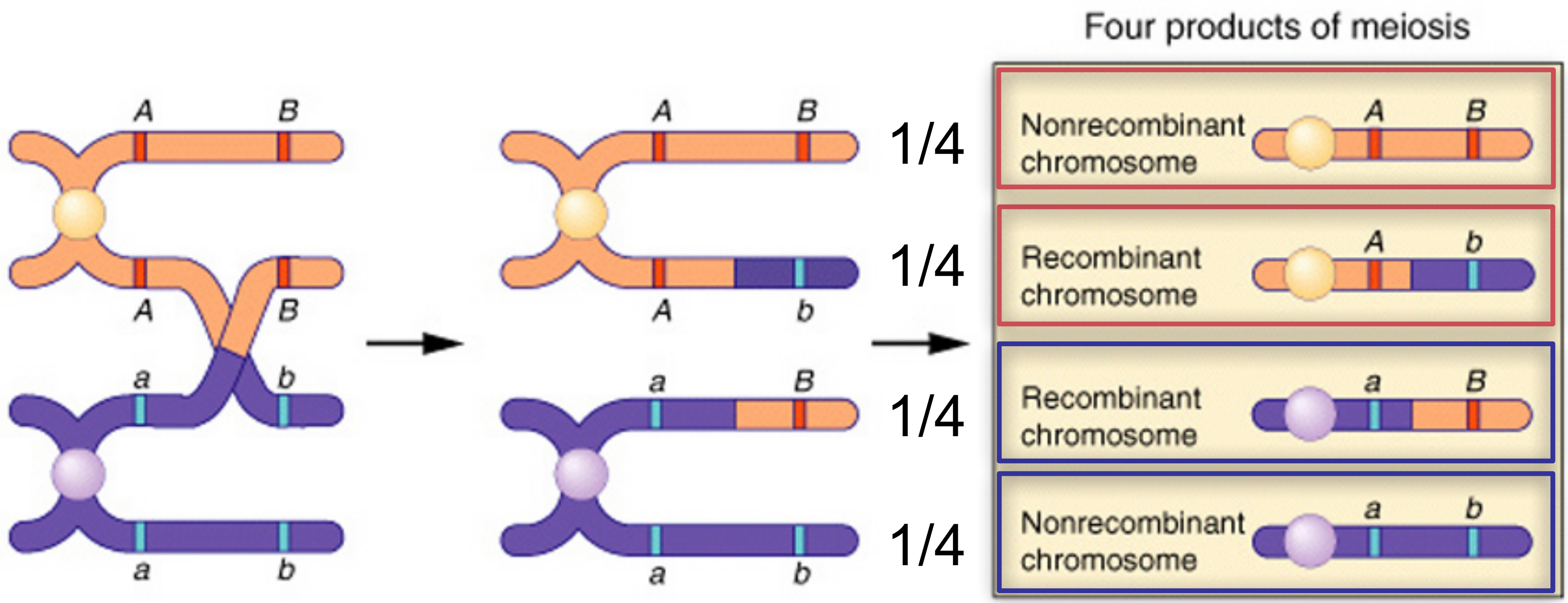

Homologous chromosomes
Centromeres
Chiasmata
Homologous chromosomes
Centromeres
Chiasmata



Four products of meiosis
A
B
A
B
a
b
a
b
A
B
A
b
a
B
a
b
Nonrecombinant chromosome
A
B
Recombinant chromosome
A
b
Recombinant chromosome
a
B
Nonrecombinant chromosome
a
b



A
B
A
B
a
b
a
b
A
B
A
b
a
B
a
b
Four products of meiosis
Nonrecombinant chromosome
A
B
Recombinant chromosome
A
b
Recombinant chromosome
a
B
Nonrecombinant chromosome
a
b



Full agreement with Mendel's 2nd law

Hybrid Vigor or “heterosis”

Extensions to Mendelian Genetics

Incomplete dominance

Codominance

Multiple Alleles

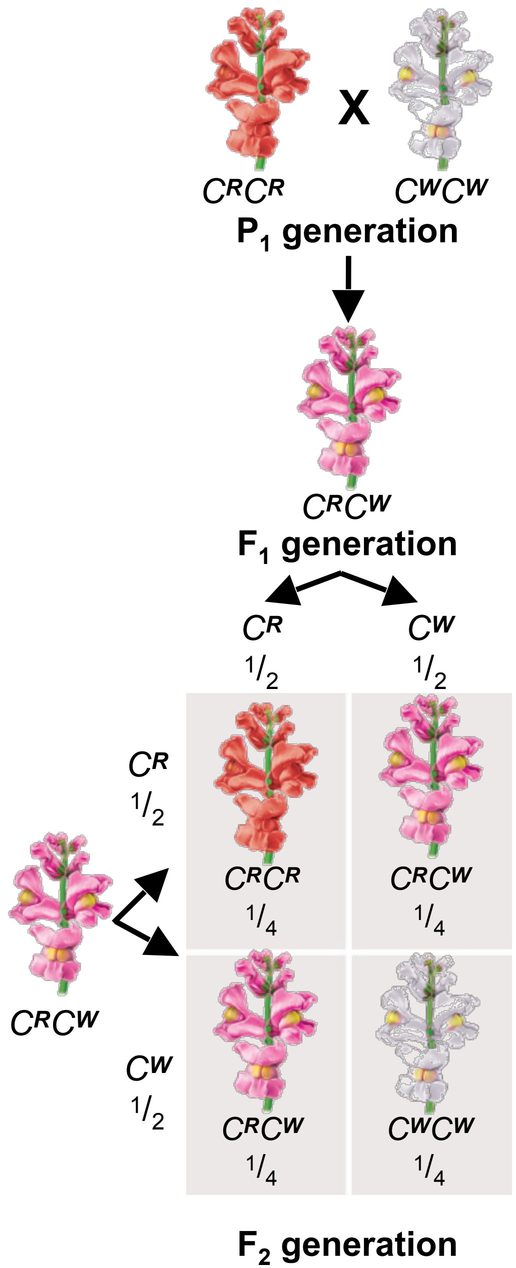
Incomplete dominance

	Red	Pink	White
Phenotype	Red	Pink	White
Genotype	RR	Rr	rr

Incomplete Dominance

	Phenotype	Genotype	Amount of gene product
	Red	*WW*	$2x$
	Pink	*Ww*	x
	White	*ww*	0

Incomplete Dominance



The phenotype of the heterozygous C^RC^W plant is intermediate, an example of incomplete dominance.

The result of segregation can be observed directly, because the ratio of red:pink:white phenotypes is **1 : 2 : 1**, which reflects the ratio of C^RC^R:C^RC^W:C^WC^W genotypes.

Extensions to Mendelian Genetics

Incomplete dominance

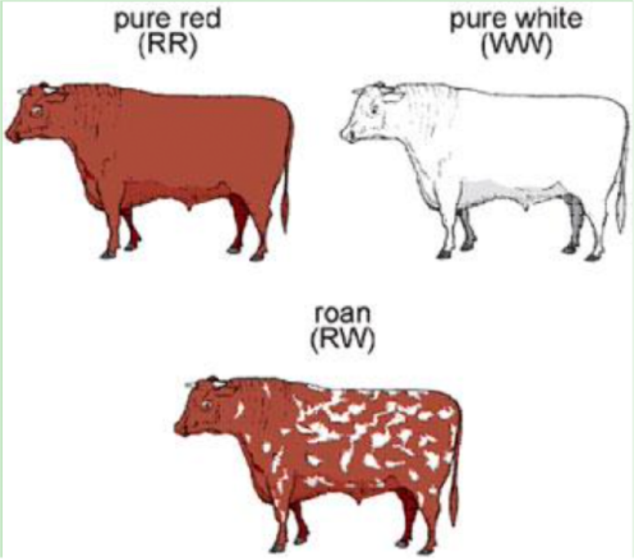
Codominance

Multiple Alleles

Codominance

Phenotype	Red	**Red/white**	White
Genotype	RR	**Rr**	rr

Codominance



Camelias & Cows

Hh x hh

Parent with Huntington’s

	H	h
h	Hh	hh
h	Hh	hh

Parent with Huntington’s

Parent with Huntington’s		H	h
	H	HH	Hh
	h	Hh	hh

Hh x hh

Parent with Huntington's

	H	h
h	Hh	hh
h	Hh	hh

Parent with Huntington's

Parent with Huntington's

	H	h
H	HH	Hh
h	Hh	hh

Hh x hh

	Parent with Huntington's: H	Parent with Huntington's: h
h	Hh	hh
h	Hh	hh

Parent with Huntington's	Parent with Huntington's: H	Parent with Huntington's: h
H	HH	Hh
h	Hh	hh

Hh x hh

		Parent with Huntington's	
		H	h
Normal Parent	h	Hh	hh
	h	Hh	hh

		Parent with Huntington's	
		H	h
Parent with Huntington's	H	HH	Hh
	h	Hh	hh

Hh x hh

		Parent with Huntington's	
		H	h
Normal Parent	h	Hh	hh
	h	Hh	hh

Hh x Hh

		Parent with Huntington's	
		H	h
Parent with Huntington's	H	HH	Hh
	h	Hh	hh

Hh x hh

		Parent with Huntington's	
		H	h
Normal Parent	h	Hh	hh
	h	Hh	hh

Hh x Hh

		Parent with Huntington's	
		H	h
Parent with Huntington's	H		Hh
	h	Hh	hh

	Genotype	Phenotype
 Albino	cc	White hairs over the entire body
 Himalayan	c^hc^h	Black hairs on the extremities; white hairs everywhere else
 Chinchilla	$c^{ch}c^{ch}$	White hair with black tips on the body
 Wild-type	c^+c^+	Colored hairs over the entire body

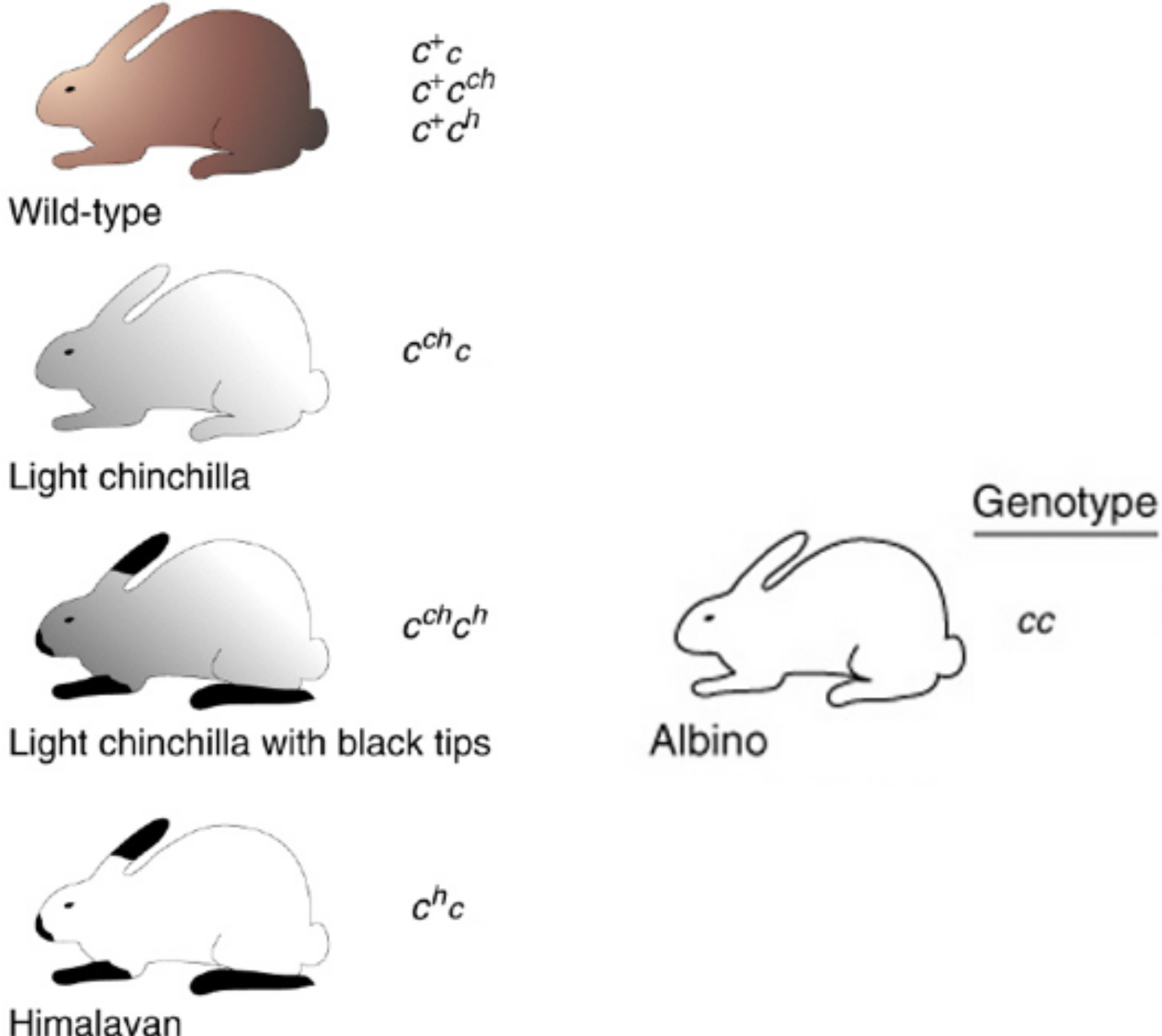


Figure 4.4 Phenotypes of different combinations of c alleles in rabbits. The alleles form a series, with the wild-type allele, c^+, dominant over all the other alleles and the null allele, c (albino), recessive to all the other alleles: one hypomorphic allele, c^{ch} (chinchilla), is partially dominant over the other, c^h (himalayan).

Some of the differences are:

S.N.	Characteristics	Antigen	Antibody
1	Molecule Type	Usually, proteins may also be polysaccharides, lipids or nucleic acids.	Proteins
2	Definition	These are substances that provoke an immune response.	These are Glycoproteins that are secreted by immune cells (plasma cells) in response to a foreign substance (antigen).
3	Effect	Cause disease or allergic reactions.	Protect the system by lysis of antigenic material.
4	Origin	Within the body or externally.	Within the body.

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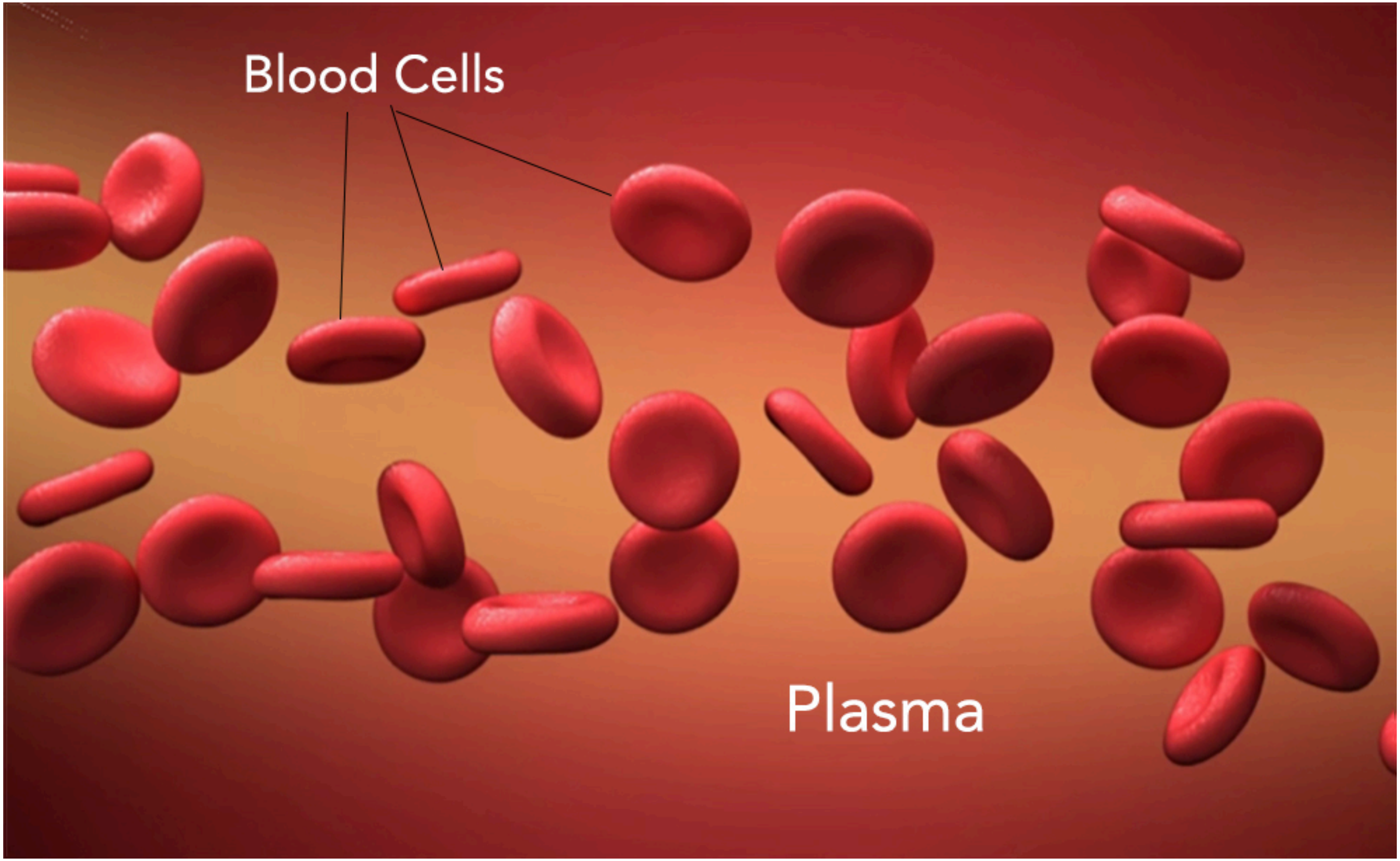
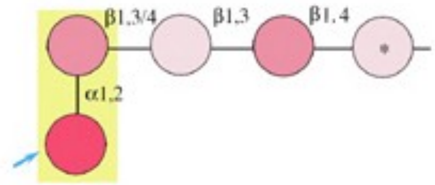
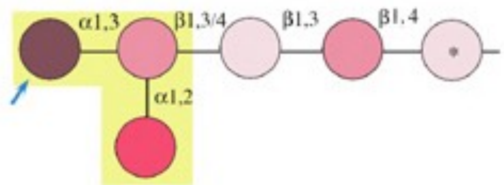

Blood Cells
Plasma

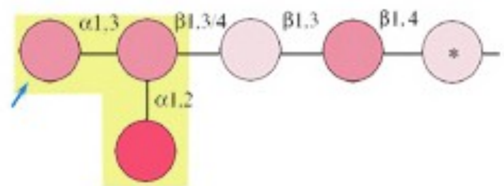
H - antigen =

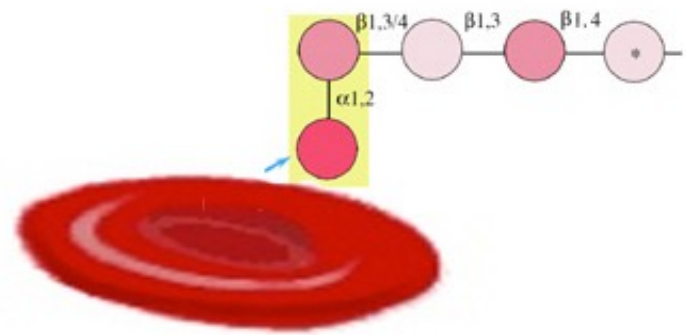


A - antigen =



B - antigen =





An example of "co-dominant" alleles in humans

The ABO Blood Group System

Antigens: molecules, usually on the outside of a cell, that provoke an immune response

Genetics of the ABO System

A person with at least one A gene will produce the A protein

Type A

A person with at least one B gene will produce the B protein

Type B

A person with one A gene and one B gene will produce both proteins

Type AB

A person with neither A nor B gene will not produce either protein

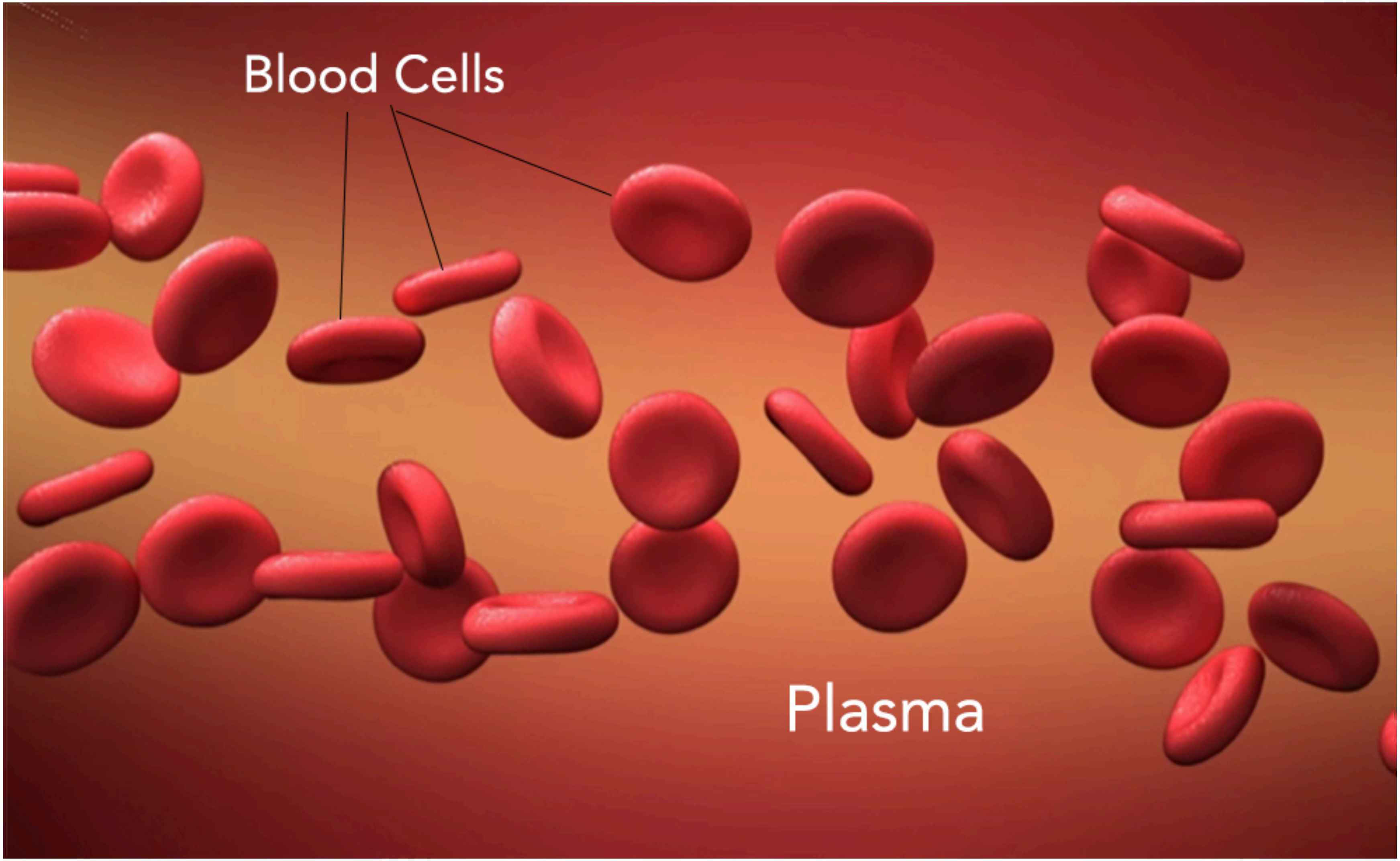
Type O

		Potential Donors			
Blood Type	**Antibodies Produced**				
A		+	-	-	+
B		-	+	-	+
AB	None	+	+	+	+
O	 	-	-	-	+

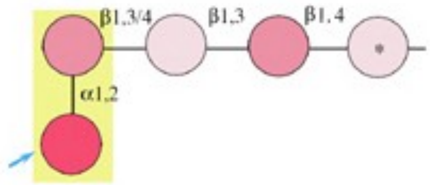
RECIPIENT

DONOR

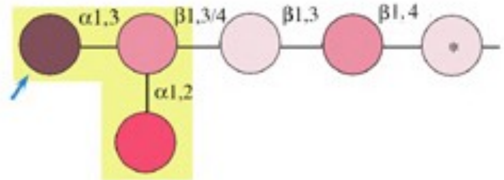
Alleles & Antibodies	O anti-A anti-B	A anti-B	B anti-A	AB None
O	None	None	None	None
A	Clump	None	Clump	None
B	Clump	Clump	None	None
AB	Clump	Clump	Clump	None


Blood Cells
Plasma

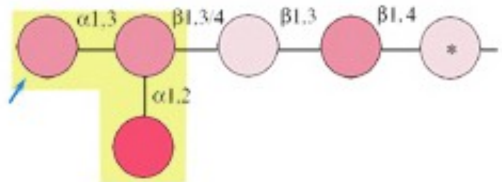
H - antigen =

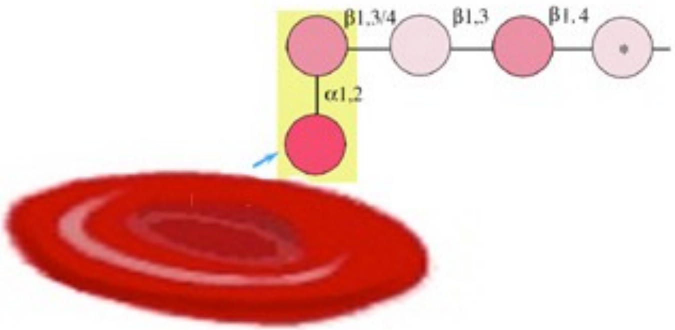


A - antigen =



B - antigen =





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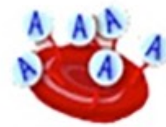
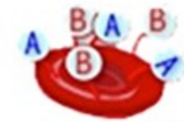
Type O

Blood Type	Antibodies Produced	Potential Donors			
					
A		+	-	-	+
B		-	+	-	+
AB	None	+	+	+	+
O	 	-	-	-	+

RECIPIENT

DONOR

Alleles & Antibodies	O anti-A anti-B	A anti-B	B anti-A	AB None
O	None	None	None	None
A	Clump	None	Clump	None
B	Clump	Clump	None	None
AB	Clump	Clump	Clump	None

(A) Black labrador (*B_E_*)   (B) Chocolate labrador (*bbE_*)   (C) Yellow labrador (*_ _ee*)

Some of the differences are:

S.N.	Characteristics	Antigen	Antibody
1	Molecule Type	Usually, proteins may also be polysaccharides, lipids or nucleic acids.	Proteins
2	Definition	These are substances that provoke an immune response.	These are Glycoproteins that are secreted by immune cells (plasma cells) in response to a foreign substance (antigen).
3	Effect	Cause disease or allergic reactions.	Protect the system by lysis of antigenic material.
4	Origin	Within the body or externally.	Within the body.

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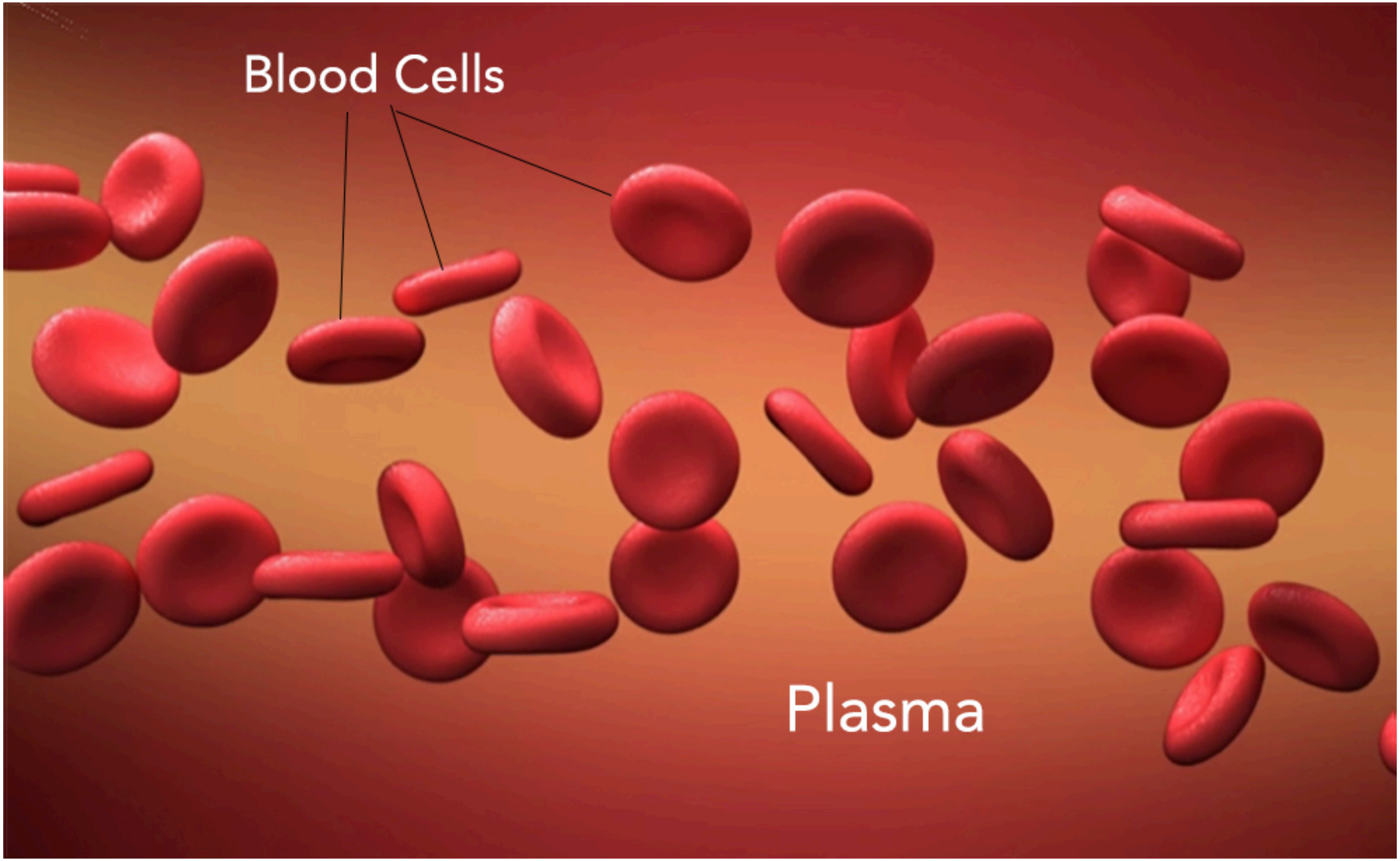
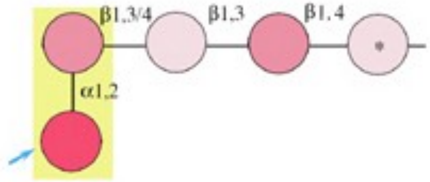
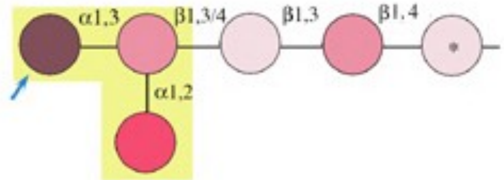

Blood Cells
Plasma

H - antigen =



A - antigen =



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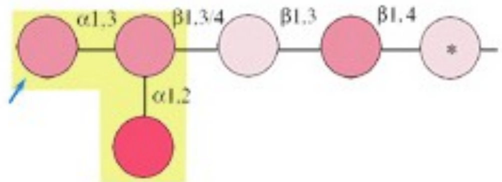
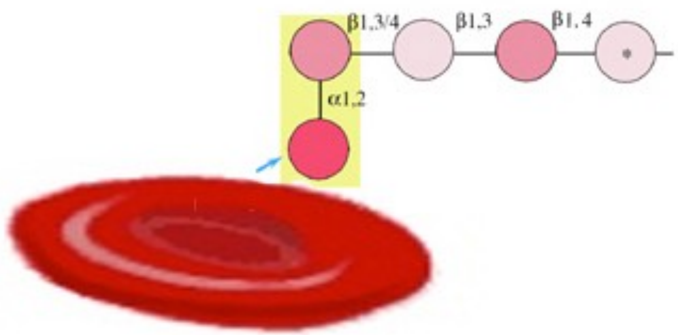




An example of “co-dominant” alleles
in humans

The
ABO Blood Group System

Antigens: molecules, usually on the outside of a cell, that provoke an immune response

Genetics of the ABO System

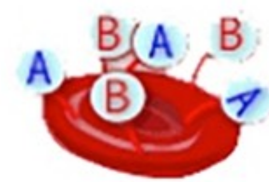
A person with at least one A gene will produce the A protein

Type A

A person with at least one B gene will produce the B protein

Type B

A person with one A gene and one B gene will produce both proteins



Type AB

A person with neither A nor B gene will not produce either protein

Type O

Blood Type	Antibodies Produced	Potential Donors			
					
A		+	-	-	+
B		-	+	-	+
AB	None	+	+	+	+
O	 	-	-	-	+

RECIPIENT

DONOR

Alleles & Antibodies	O anti-A anti-B	A anti-B	B anti-A	AB None
O	None	None	None	None
A	Clump	None	Clump	None
B	Clump	Clump	None	None
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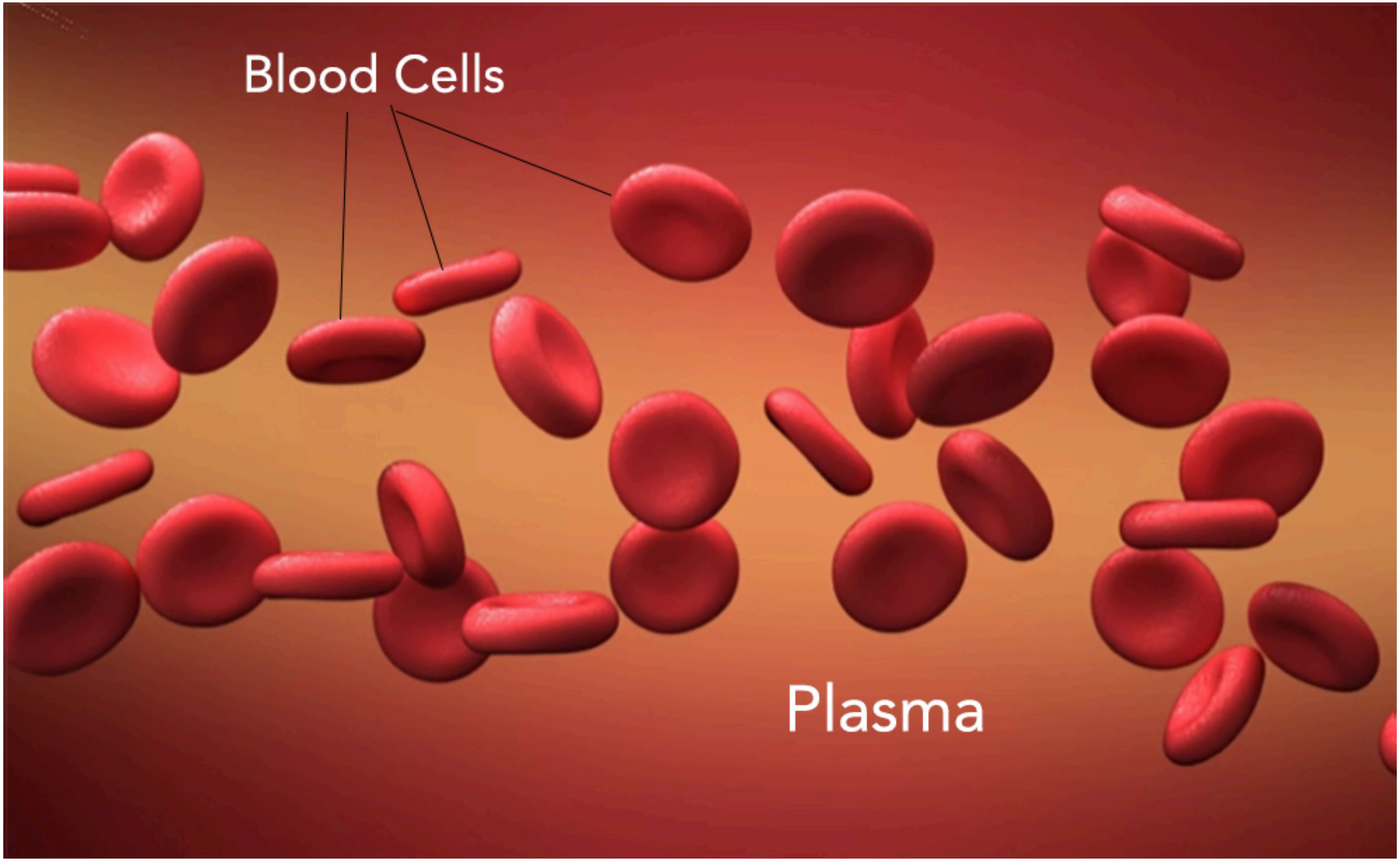
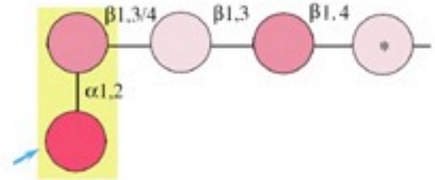
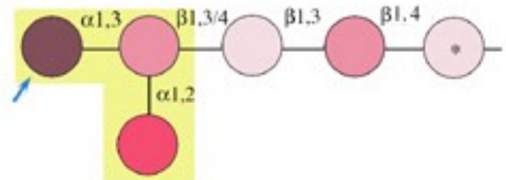

Blood Cells
Plasma

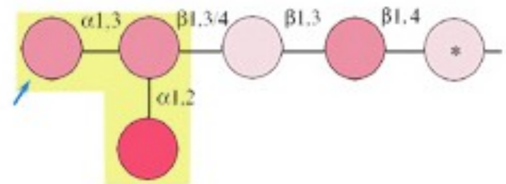
H - antigen =

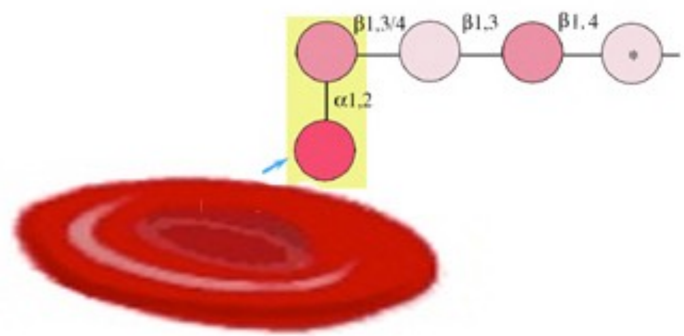


A - antigen =



B - antigen =





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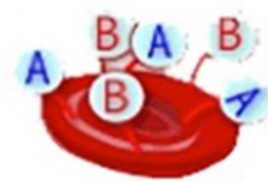


Type AB

A person with neither A nor B gene will not produce either protein

Type O

		Potential Donors			
Blood Type	**Antibodies Produced**				
A		+	-	-	+
B		-	+	-	+
AB	None	+	+	+	+
O	 	-	-	-	+

RECIPIENT

DONOR

Alleles & Antibodies	O anti-A anti-B	A anti-B	B anti-A	AB None
O	None	None	None	None
A	Clump	None	Clump	None
B	Clump	Clump	None	None
AB	Clump	Clump	Clump	None

Hh x hh

Parent with Huntington's

	H	h
h	Hh	hh
h	Hh	hh

Parent with Huntington's

Parent with Huntington's		H	h
	H	HH	Hh
	h	Hh	hh

Hh x hh

	Parent with Huntington's H	Parent with Huntington's h
h	Hh	hh
h	Hh	hh

Parent with Huntington's	Parent with Huntington's H	Parent with Huntington's h
H	HH	Hh
h	Hh	hh

Hh x hh

	Parent with Huntington's	
	H	h
h	Hh	hh
h	Hh	hh

		Parent with Huntington's	
		H	h
Parent with Huntington's	H	HH	Hh
	h	Hh	hh

Hh x hh

		Parent with Huntington's	
		H	h
Normal Parent	h	Hh	hh
	h	Hh	hh

		Parent with Huntington's	
		H	h
Parent with Huntington's	H	HH	Hh
	h	Hh	hh

Hh x hh

		Parent with Huntington's	
		H	h
Normal Parent	h	Hh	hh
	h	Hh	hh

Hh x Hh

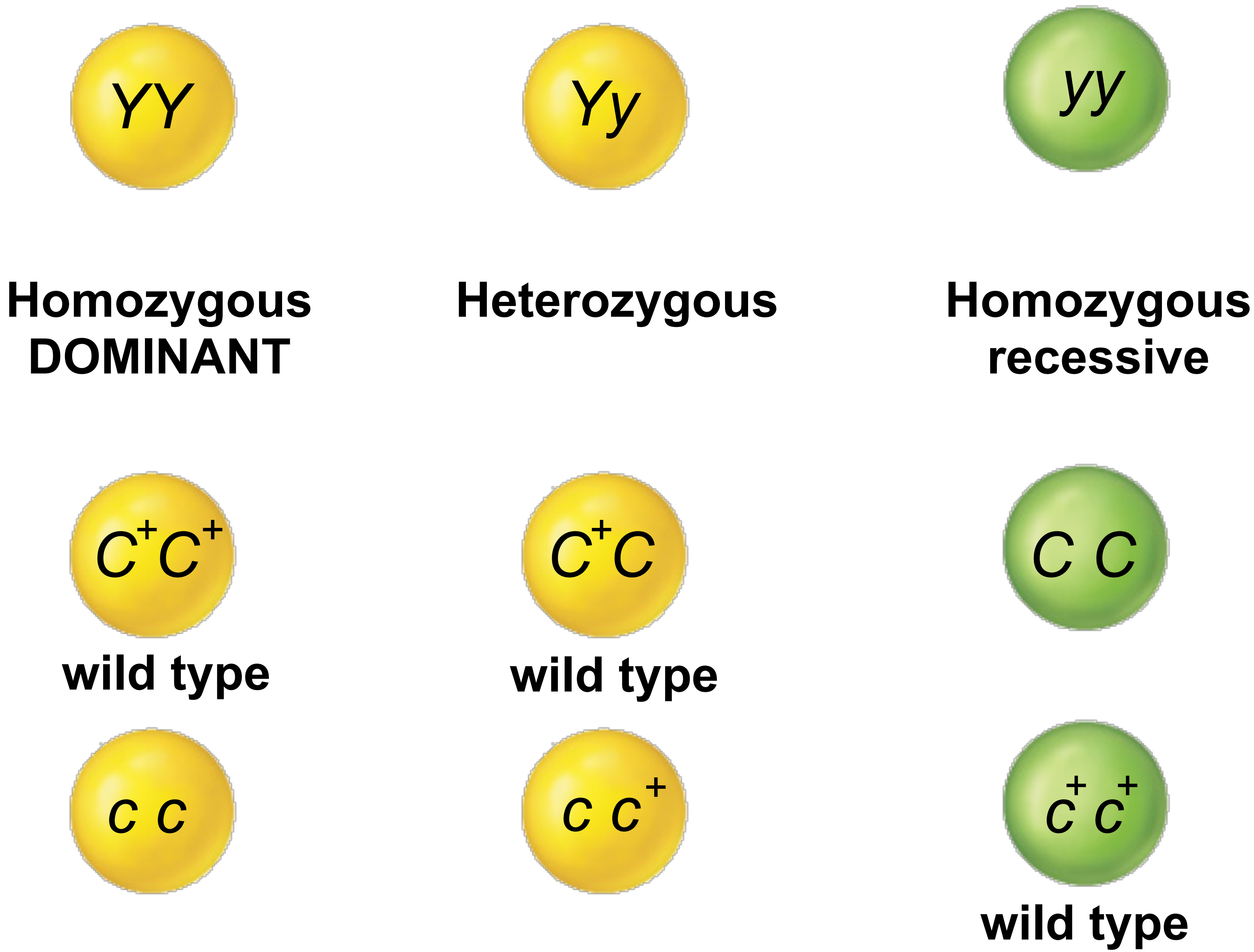
		Parent with Huntington's	
		H	h
Parent with Huntington's	H	HH	Hh
	h	Hh	hh

Hh x hh

		Parent with Huntington's	
		H	h
Normal Parent	h	Hh	hh
	h	Hh	hh

Hh x Hh

		Parent with Huntington's	
		H	h
Parent with Huntington's	H		Hh
	h	Hh	hh



YY
Yy
yy
Homozygous DOMINANT
Heterozygous
Homozygous recessive
C+C+
wild type
C+C
wild type
C C
c c
c c+
c+c+
wild type

	Genotype	Phenotype
 Albino	cc	White hairs over the entire body
 Himalayan	$c^h c^h$	Black hairs on the extremities; white hairs everywhere else
 Chinchilla	$c^{ch} c^{ch}$	White hair with black tips on the body
 Wild-type	$c^+ c^+$	Colored hairs over the entire body

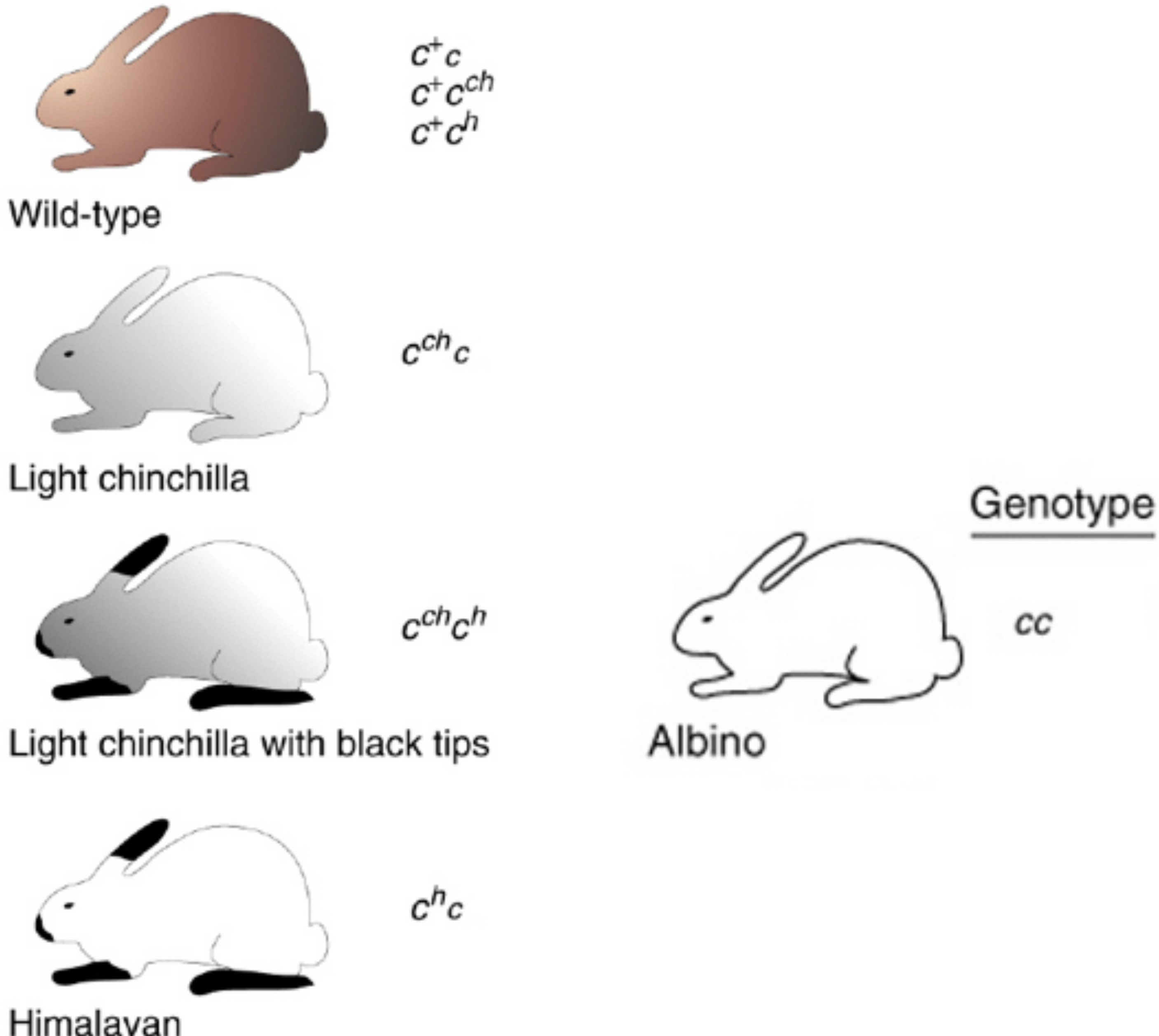


Figure 4.4 Phenotypes of different combinations of c alleles in rabbits. The alleles form a series, with the wild-type allele, c^+, dominant over all the other alleles and the null allele, c (albino), recessive to all the other alleles; one hypomorphic allele, c^{ch} (chinchilla), is partially dominant over the other, c^h (himalayan).