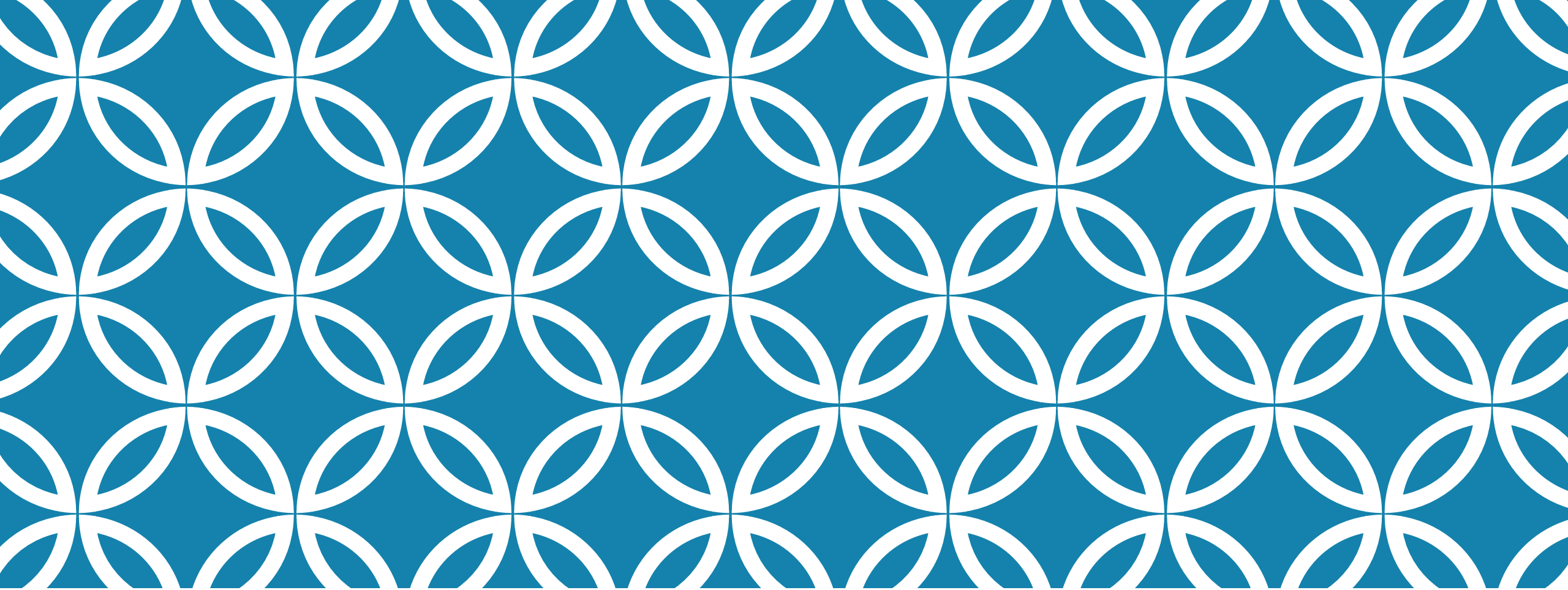


CHAPTER 3.4

Inheritance

JOHANN GREGOR MENDEL

Austrian monk & father of modern genetics.

planted **1000s of seeds per trial** & carried out many trials

His work published 1865 → was ignored for 30 years

MENDEL'S EXPERIMENT

	Flower Color	Plant Height	Seed Color	Seed Shape	Pod Color	Pod Shape
Dominant Trait	 purple: 705	 tall: 787	 green: 6022	 round: 5474	 green: 428	 inflated: 882
Recessive Trait	 white: 224	 short: 257	 yellow: 2001	 wrinkled: 1850	 yellow: 152	 flat: 299
Ratio	3.15 : 1	3.06 : 1	3.01 : 1	2.96 : 1	2.82 : 1	2.95 : 1

MENDEL'S CONCLUSIONS

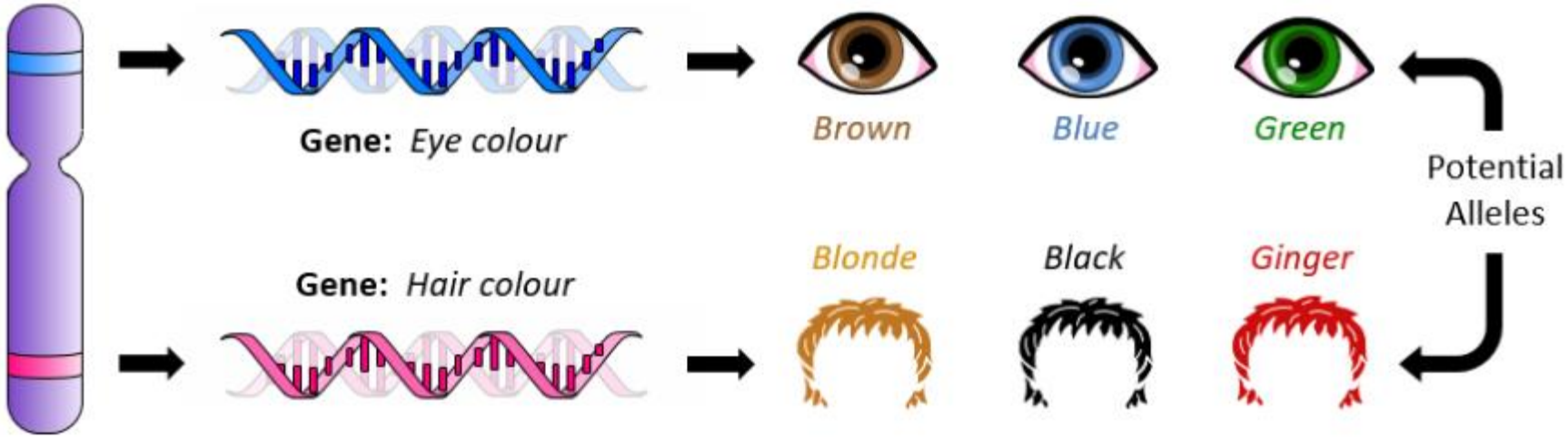
Mendel's Conclusions	Current Understanding
Organisms have inheritable factors	
There are versions of each factor	
Parents pass on only one version	
Parents contribute equally to inheritance	
Only one version of a factor is expressed	

MENDEL'S CONCLUSIONS

Mendel's Conclusions	Current Understanding
Organisms have inheritable factors	These factors are called *genes*
There are versions of each factor	Genes have alternative *alleles*
Parents pass on only one version	Gametes (sex cells) are *haploid*
Parents contribute equally to inheritance	Offspring body cells are *diploid*
Only one version of a factor is expressed	*Dominant* versus *recessive* alleles

MECHANISMS OF INHERITANCE

GENES VS ALLELES



DIPLOID VS HAPLOID

Genes are located at specific positions on chromosomes (=**locus**)

Offspring inherit chromosomes from **both** parents → chromosome pairs

- only one chromosome of each homologous pair gets passed on to offspring

Consequence:

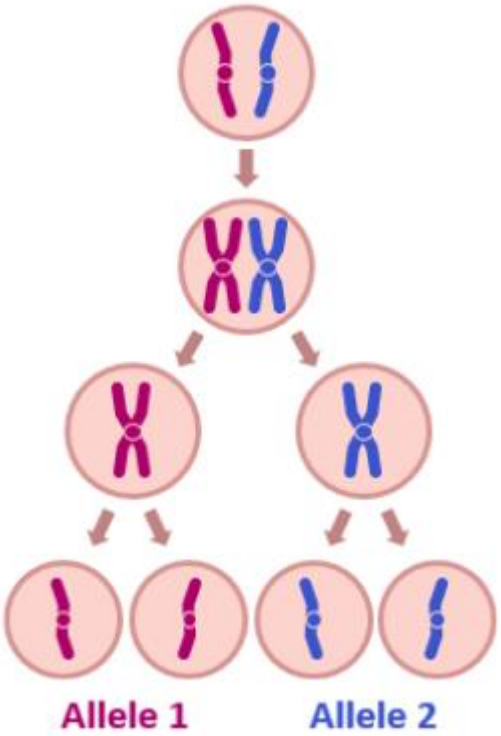
- body cells = **diploid** (*two alleles per gene*)
- sex cells = **haploid** (*one allele per gene*)

ALLELE SEGREGATION IN GAMETES

Haploid gametes – because of meiosis

Meiosis separates chromosome (and allele) pairs into separate gametes

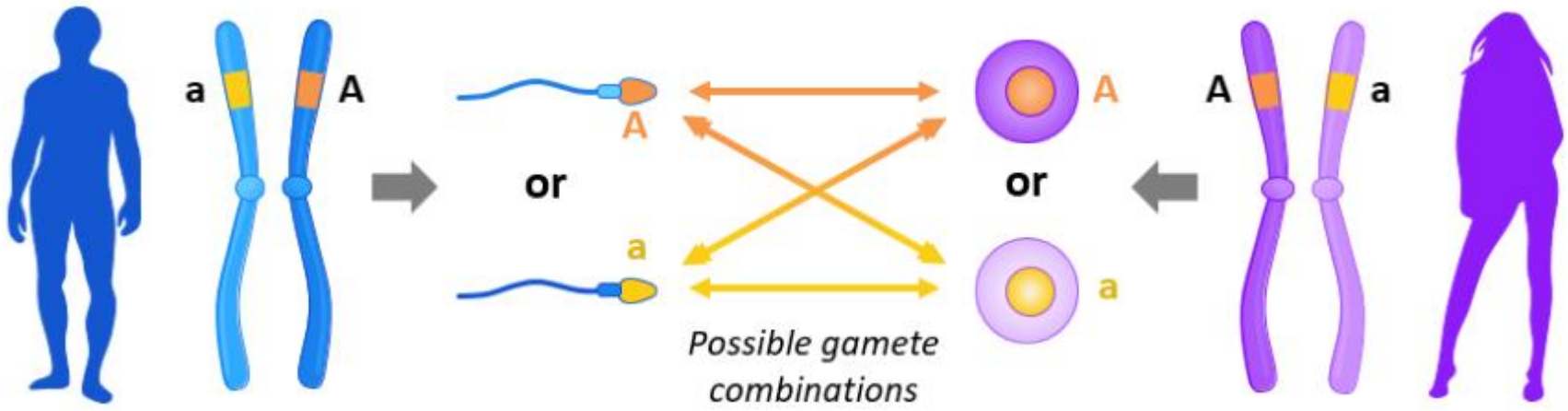
Segregation = random → independent inheritance patterns



SEXUAL REPRODUCTION

Fusion of gametes → diploid zygote

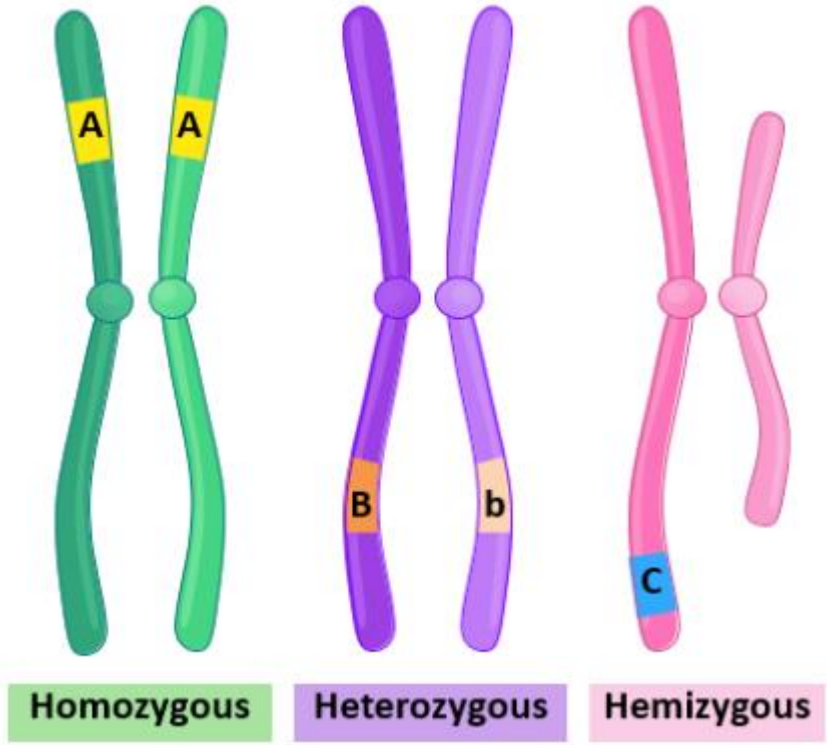
- two copies of every chromosome, two alleles for each gene
- allele combination → random probability



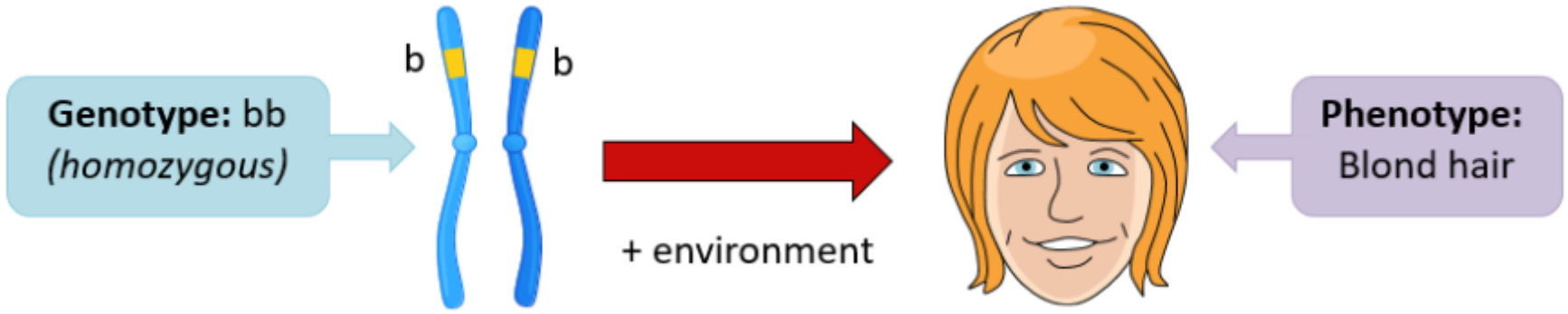
TYPE OF ZYGOSITY

3 possible allele combinations:

- **Homozygous:** Alleles are the same
- **Heterozygous:** Alleles are different
- **Hemizygous:** There is only one allele

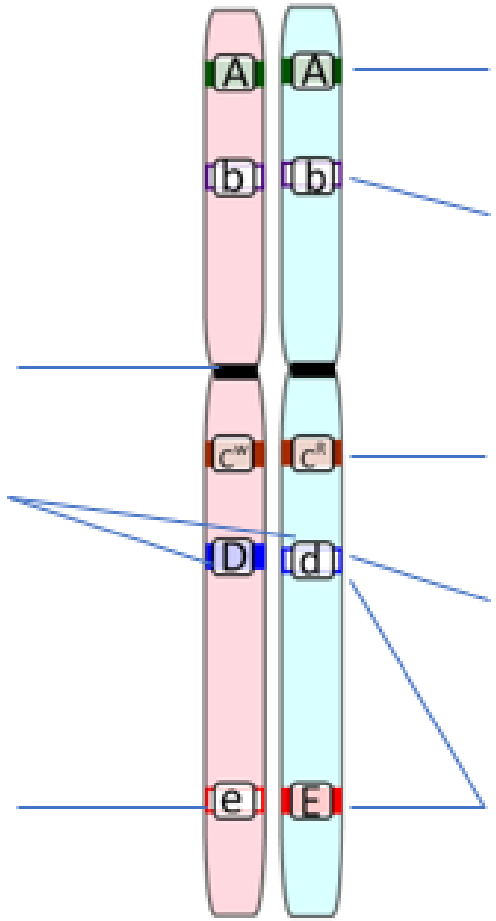


GENOTYPE VS PHENOTYPE



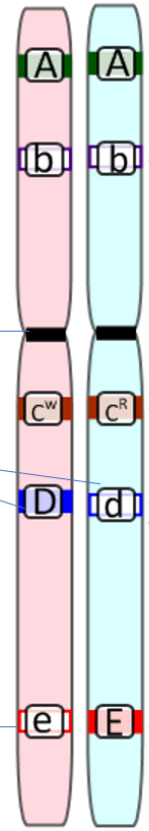
EXERCISE:

This image shows a pair of homologous chromosomes.
Name and annotate the labeled features.



EXERCISE

This image shows a pair of homologous chromosomes.
Name and annotate the labeled features.



Genotype
*The **combination of alleles** of a gene carried by an organism*

Phenotype
*The **expression of alleles** of a gene carried by an organism*

Centromere
Joins chromatids in cell division

Alleles
***Different versions** of a gene*
Dominant alleles = capital letter
Recessive alleles = lower-case letter

Carrier
*Heterozygous carrier of a **recessive disease-causing** allele*

Homozygous dominant
Having two copies of the same dominant allele

Homozygous recessive
Having two copies of the same recessive allele. Recessive alleles are only expressed when homozygous.

Codominant
Pairs of alleles which are both expressed when present.

Heterozygous
Having two different alleles. The dominant allele is expressed.

Gene loci
Specific positions of genes on a chromosome

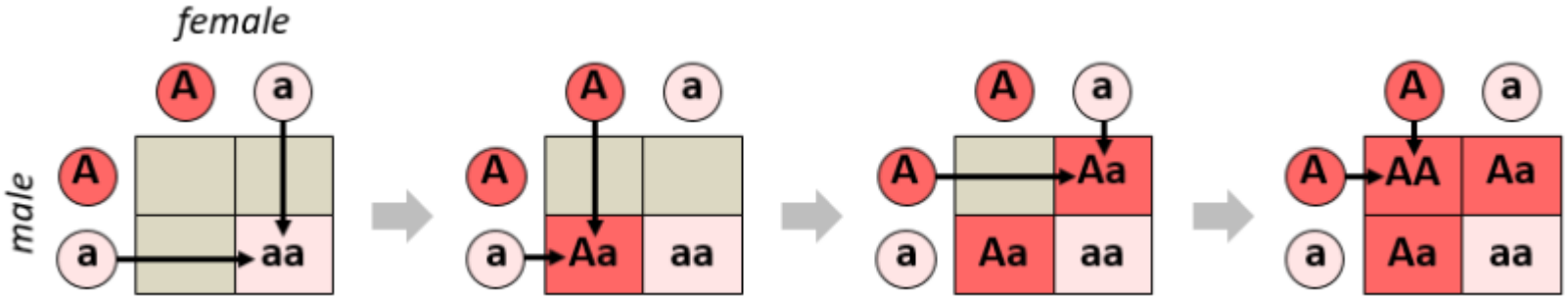
HOW TO WORK WITH PUNNET GRIDS

1.) Designate characters to represent alleles (e.g. ***A*** = *dark red;* ***a*** = *light red*)

2.) Write the genotype and phenotype of the parents (e.g. *dark red cross:* ***Aa x Aa***)

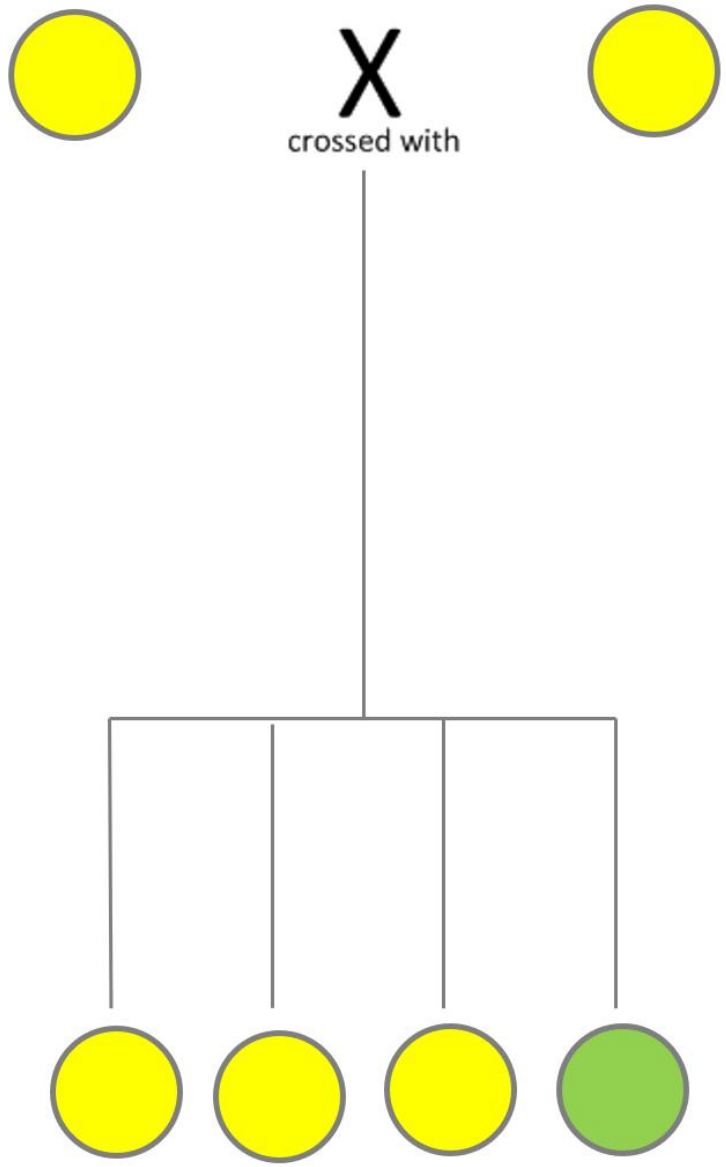
3.) Use a grid to work out gamete combinations (*see below*)

4.) Write the genotype and phenotype ratios of offspring (*3 dark red : 1 light red*)



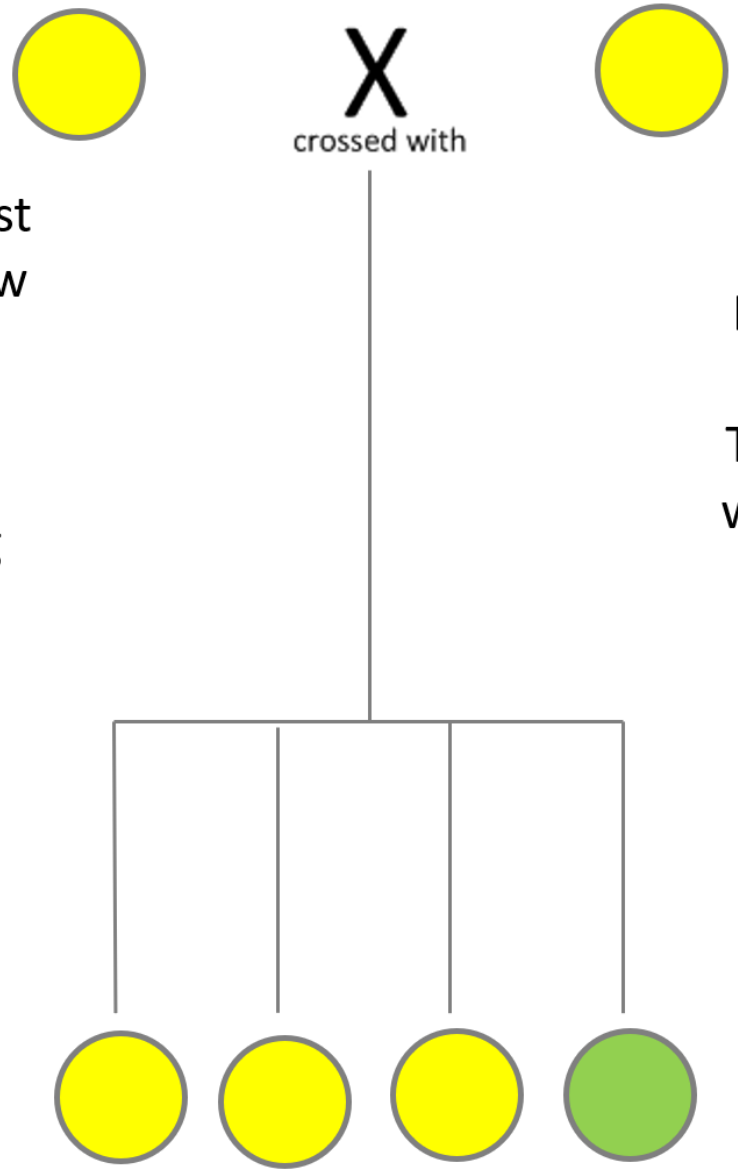
Explain this

Mendel crossed some yellow peas with some yellow peas. Most offspring were yellow but some were green!



Segregation

"alleles of each gene separate into different gametes when the individual produces gametes"



The yellow parent peas must be **heterozygous**. The yellow phenotype is expressed.

Through meiosis and fertilisation, some offspring peas are **homozygous recessive** – they express a green colour.

Mendel did not know about DNA, chromosomes or meiosis.

Through his experiments he did work out that 'heritable factors' (*genes*) were passed on and that these could have different versions (alleles).

TASK:

Calculate Genotype and Phenotype ratios from different F1 generations:

Key to alleles:
Y = yellow
y = green

- ♂ Yy X ♀ Yy
- ♂ yy X ♀ yy
- ♂ yy X ♀ Yy
- ♂ YY X ♀ Yy

SEGREGATION

Key to alleles:
Y = yellow
y = green

F_0

Genotype: ♀ **Y y** X crossed with ♂ **Y y**

Gametes: **Y or y** **Y or y**

Punnet Grid:

gametes		♂
♀		

Simplified notation of using upper case for dominant and lower case for recessive is acceptable in the case of two alleles without co-dominance.

F_1

Genotypes:

Phenotypes:

Phenotype ratio:

MONOHYBRID CROSS

Crossing a single trait.

F_0

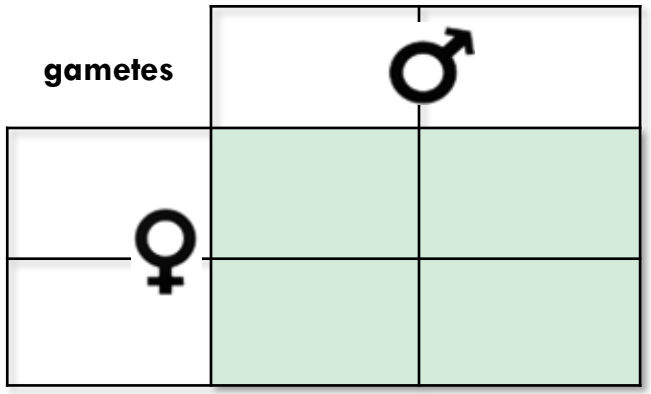
crossed with

Key to alleles:
Y = yellow
y = green

Genotype: **Y y** X **Y y**

Gametes: **Y or y** X **Y or y**

Punnet Grid:



F_1

Genotypes:

Phenotypes:

MONOHYBRID CROSS

Crossing a single trait.

F_0

Key to alleles:
Y = yellow
y = green

Genotype: **Y y** X **Y y**

Gametes: **Y or y** **Y or y**

Punnet Grid:

gametes	Y ♂	y
Y ♀	YY	Yy
y	Yy	yy

F_1

Genotypes:

Phenotypes:

Phenotype ratio:

MONOHYBRID CROSS

Crossing a single trait.

F_0

Key to alleles:
Y = yellow
y = green

Genotype: **Y y** × **Y y**

Gametes: **Y or y** × **Y or y**

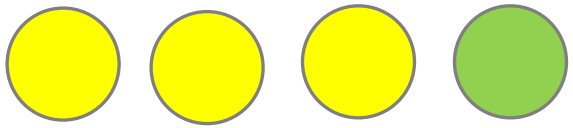
Punnet Grid:

gametes	**Y** ♂	**y**
Y ♀	YY	Yy
y	Yy	yy

F_1

Genotypes: YY, Yy, Yy, yy

Phenotypes:



Phenotype ratio: **3 : 1**

MONOHYBRID CROSS

F_0

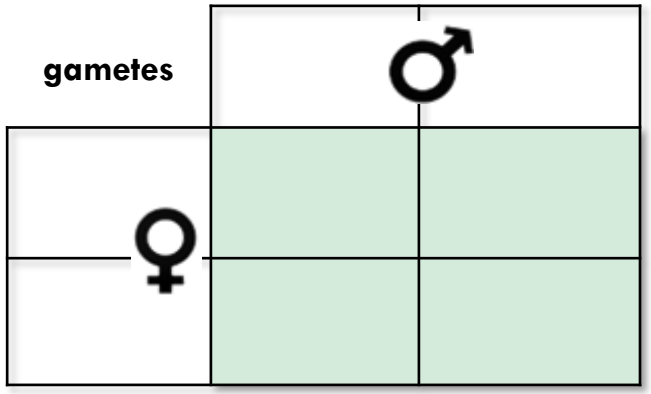
Phenotype: ♀ ◯ X crossed with ◯ ♂

Genotype:

Homozygous recessive *Homozygous recessive*

Key to alleles:
Y = yellow
y = green

Punnet Grid:



F_1

Genotypes:

Phenotypes: ◯ ◯ ◯ ◯

Phenotype ratio:

MONOHYBRID CROSS

F_0

Phenotype: ♀  X crossed with  ♂

Genotype: **y y** X crossed with **y y**

Homozygous recessive X crossed with *Homozygous recessive*

Key to alleles:
Y = yellow
y = green

Punnet Grid:

gametes	y ♂	y
y ♀	yy	yy
y	yy	yy

F_1

Genotypes: yy yy yy yy

Phenotypes: 

Phenotype ratio: **All green**

MONOHYBRID CROSS

F_0

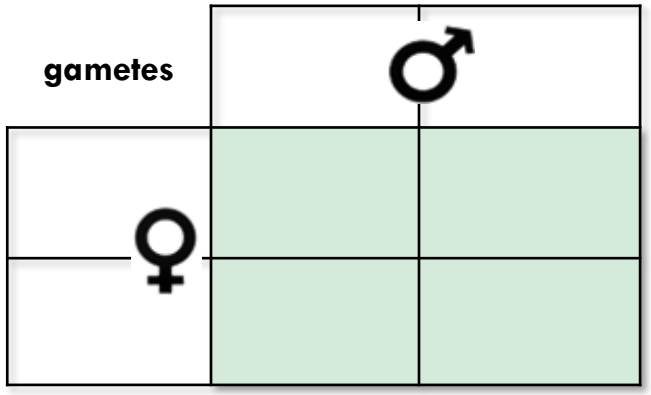
Phenotype: ♀ ◯ X crossed with ◯ ♂

Genotype:

Homozygous recessive *Heterozygous*

Key to alleles:
Y = yellow
y = green

Punnet Grid:



F_1

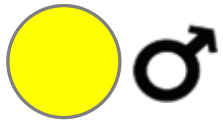
Genotypes:

Phenotypes: ◯ ◯ ◯ ◯

Phenotype ratio:

MONOHYBRID CROSS

F_0

Phenotype: ♀  X crossed with  ♂

Genotype: **y y** X **Y y**

Homozygous recessive X *Heterozygous*

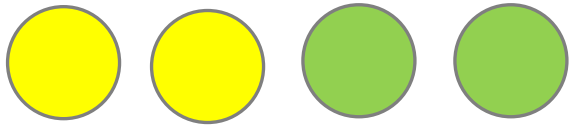
Key to alleles:
Y = yellow
y = green

Punnet Grid:

gametes	**Y** ♂	**y**
y ♀	Yy	yy
y	Yy	yy

F_1

Genotypes: Yy Yy yy yy

Phenotypes: 

Phenotype ratio: **1 : 1**

MONOHYBRID CROSS

F_0

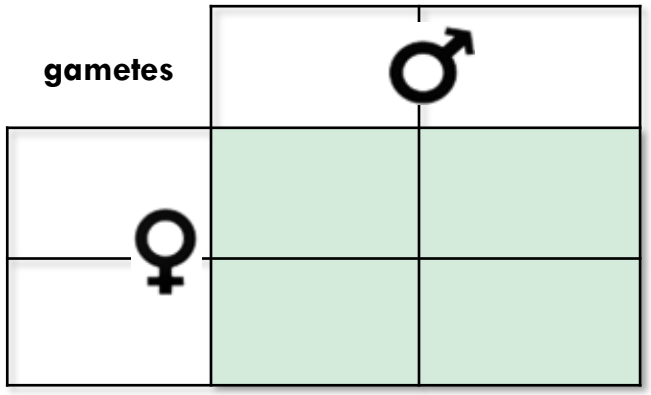
Phenotype: ♀ ○ X crossed with ○ ♂

Genotype:

Homozygous dominant *Heterozygous*

Key to alleles:
Y = yellow
y = green

Punnet Grid:



F_1

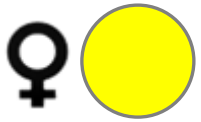
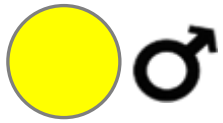
Genotypes:

Phenotypes: ○ ○ ○ ○

Phenotype ratio:

MONOHYBRID CROSS

F_0

Phenotype:  X crossed with 

Genotype: **Y Y** **Y y**

Homozygous dominant *Heterozygous*

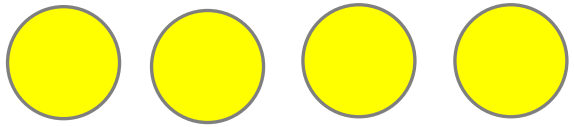
Key to alleles:
Y = yellow
y = green

Punnet Grid:

gametes	**Y** ♂	**y**
Y ♀	YY	Yy
Y	YY	Yy

F_1

Genotypes: YY YY Yy Yy

Phenotypes: 

Phenotype ratio: **All yellow**

HOW CAN WE FIND OUT THE GENOTYPE?

Phenotype: ♀ 

Genotype: **R ?**

unknown

Key to alleles:
R = Red flower
r = white

TEST CROSS

*Used to **determine the genotype** of an **unknown** individual.*
*The unknown is crossed with a known **homozygous recessive**.*

F_0

Phenotype: ♀  X crossed with  ♂

Genotype: **R ?** **r r**

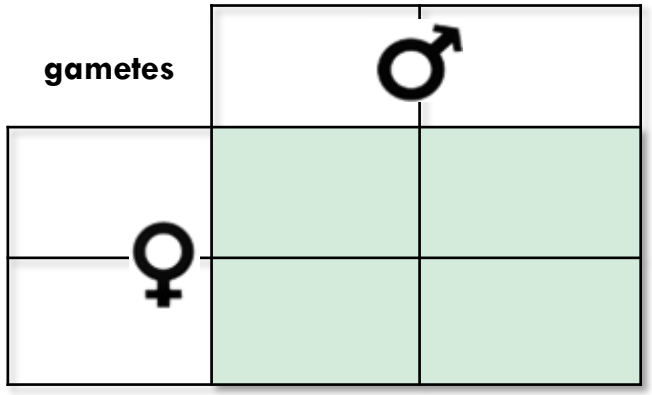
unknown *Homozygous recessive*

Key to alleles:
R = Red flower
r = white

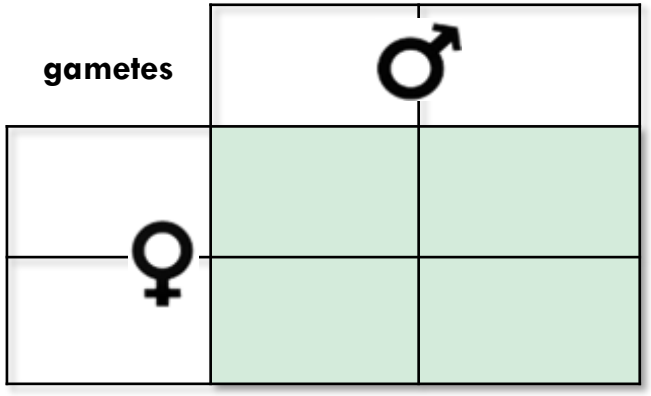
Possible outcomes:

F_1 Phenotypes:

Unknown parent = RR



Unknown parent = Rr



TEST CROSS

*Used to **determine the genotype** of an **unknown** individual.*
*The unknown is crossed with a known **homozygous recessive**.*

F_0

Phenotype: ♀  X crossed with  ♂

Genotype: **R ?** **r r**

unknown *Homozygous recessive*

Key to alleles:
R = Red flower
r = white

Possible outcomes:

F_1 Phenotypes: **All red**

Unknown parent = RR

gametes	r ♂	r
R ♀	Rr	Rr
R	Rr	Rr

Some white, some red

Unknown parent = Rr

gametes	r ♂	r
R ♀	Rr	Rr
r	rr	rr

MENDELIAN LAWS

Law of Dominance and Uniformity

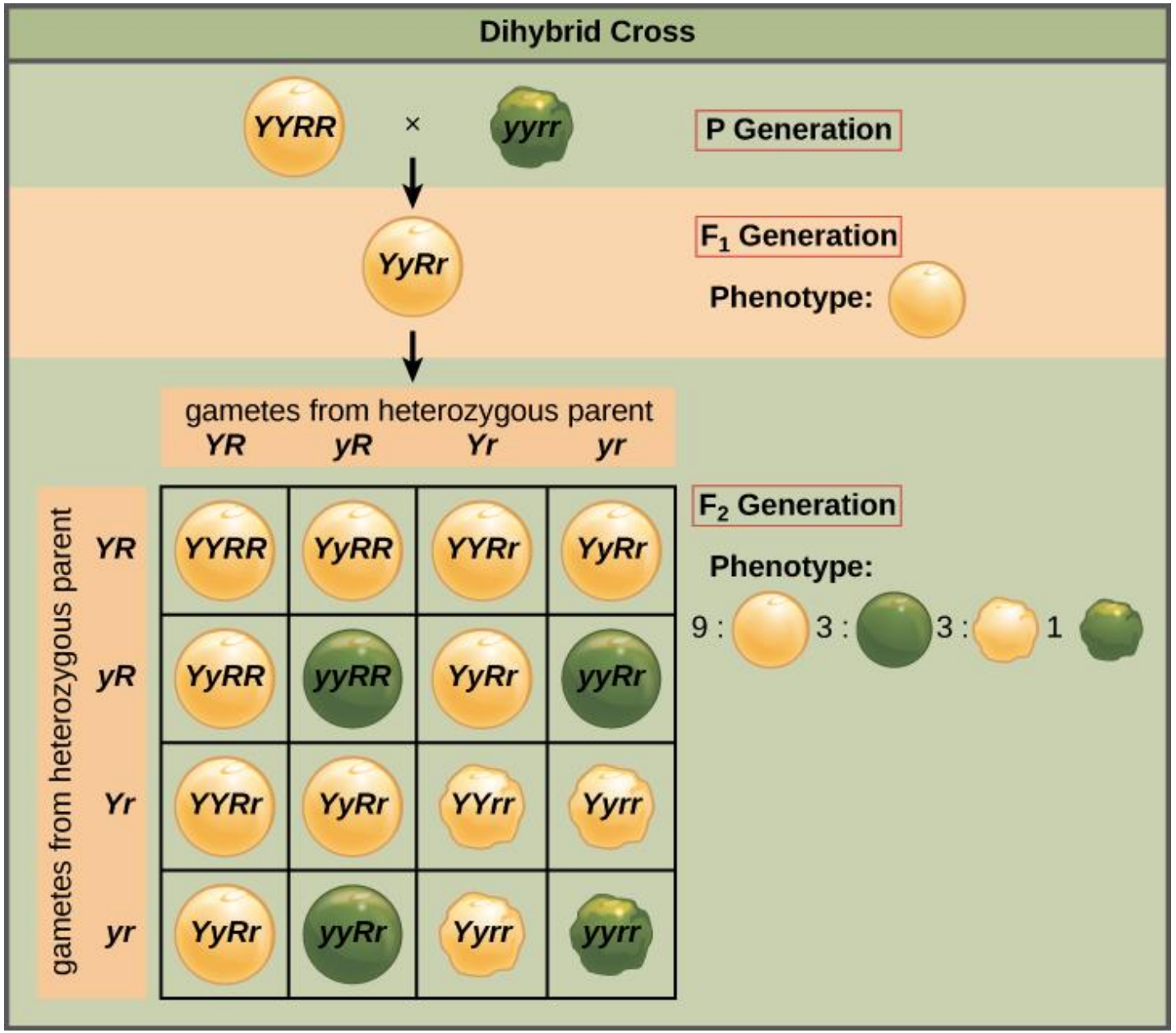
- Homozygous red X homozygous white

Law of Segregation of Genes

- Heterozygous x heterozygous

Law of independent Assortment

- Two features


Dihybrid Cross
YYRR
×
yyrr
P Generation
YyRr
F1 Generation
Phenotype:
gametes from heterozygous parent
YR yR Yr yr
gametes from heterozygous parent
YR
yR
Yr
yr
YYRR YyRR YYRr YyRr
YyRR yyRR YyRr yyRr
YYRr YyRr YYrr Yyrr
YyRr yyRr Yyrr yyrr
F2 Generation
Phenotype:
9 : 3 : 3 : 1

ANALYZING GENETIC CROSSES

IB Companion p. 176/177