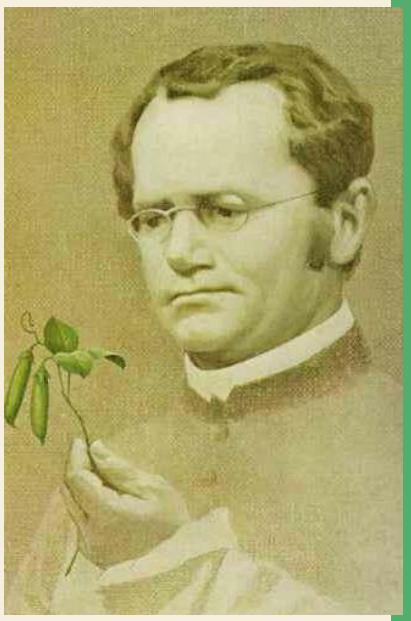
GENETICS

PREDICTING HEREDITY

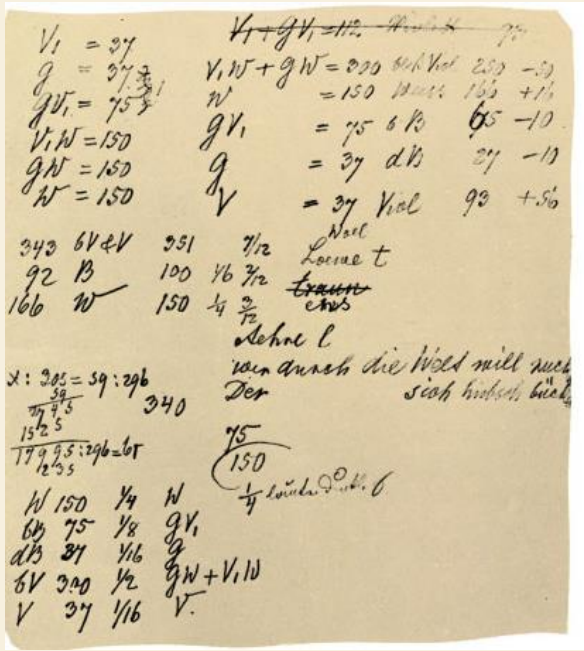
INTRODUCTION TO GENETICS

- Genetics is the scientific study of heredity
- Heredity is essentially the study of how traits are passed from parents to their offspring.

GREGOR MENDEL

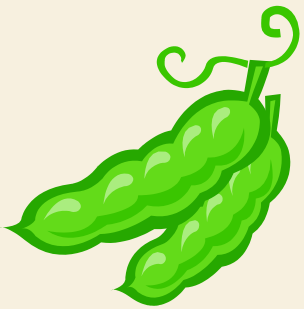


- Modern genetics began in the mid-1800s in an abbey garden, where a monk named Gregor Mendel documented inheritance in peas
  - used good experimental design
  - used mathematical analysis
    - collected data & counted them
  - excellent example of scientific method



GREGOR MENDEL & HIS PEAS

- Mendel used purebred *(organism with identical genes/alleles for a trait)* pea plants in a series of experiments in order to understand inheritance.



- The flowers of pea plants have both male and female parts & reproduce through **self-pollination** *(sperm in pollen fertilize the egg cells in the same flower).*

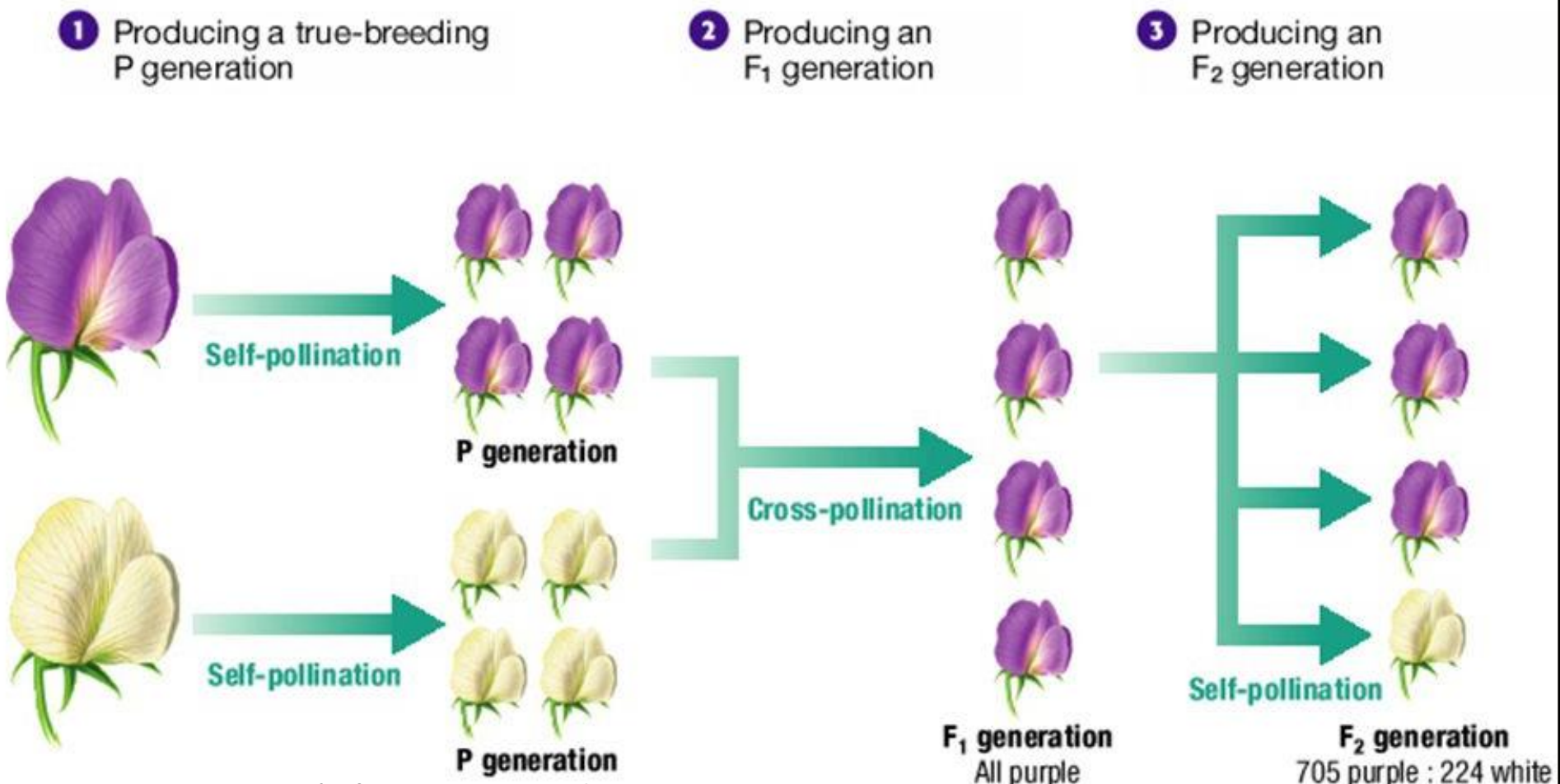
GREGOR MENDEL & HIS PEAS

- During self-pollination, the pollen from the **male** part of the flower fertilizes the **female** part of the flower.
  - Sexual or asexual reproduction?
- Seeds that come from a self-pollinated plant inherit all of their characteristics from just one parent, therefore, there is **no genetic diversity.**

GREGOR MENDEL & HIS PEAS

- In order to conduct his experiments, Mendel had to prevent the flowers from self-pollinating
  - Removed the male parts of the flower & dusted the plant with **pollen** from another plant.
- This process is called **cross-pollination.**
- Seeds that come from a cross-pollinated plant inherit a **combination** of characteristics from two **different** parents (just like you did).

THREE STEPS OF MENDEL'S EXPERIMENT



'P' = Parental Generation

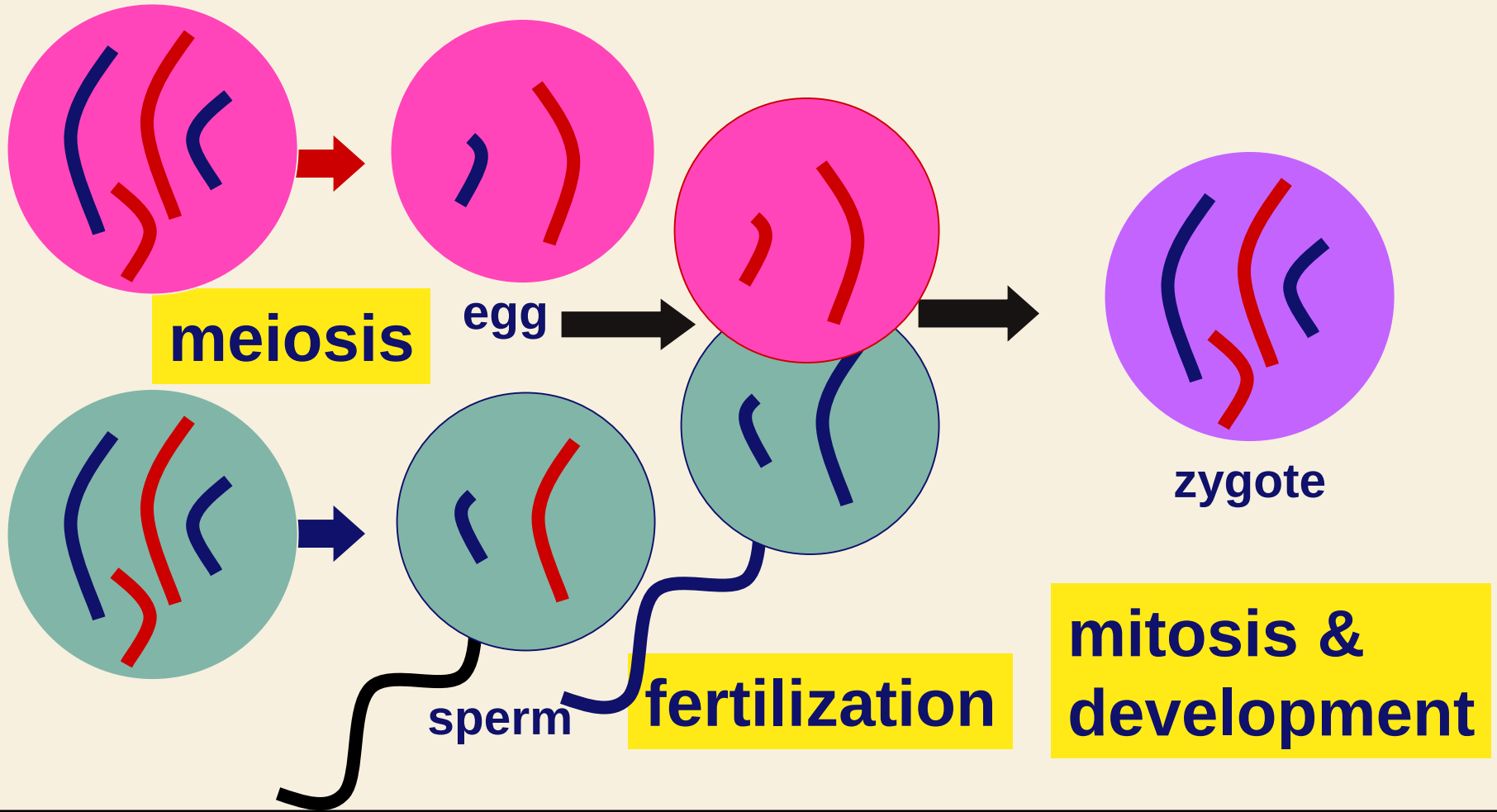
F_1 =The first offspring of parents

GENES AND DOMINANCE

- A **trait** is a very specific characteristic that varies from one individual to another
  - ex. Height, hair color, etc.
  - A trait is coded for by proteins
- The offspring of crosses between parents with different traits are called **hybrids**
  - ex. The child of one parent with curly hair and another with straight hair is a hybrid
- The chemical factors that determine traits are called **genes**
  - Different forms of genes are called **alleles**

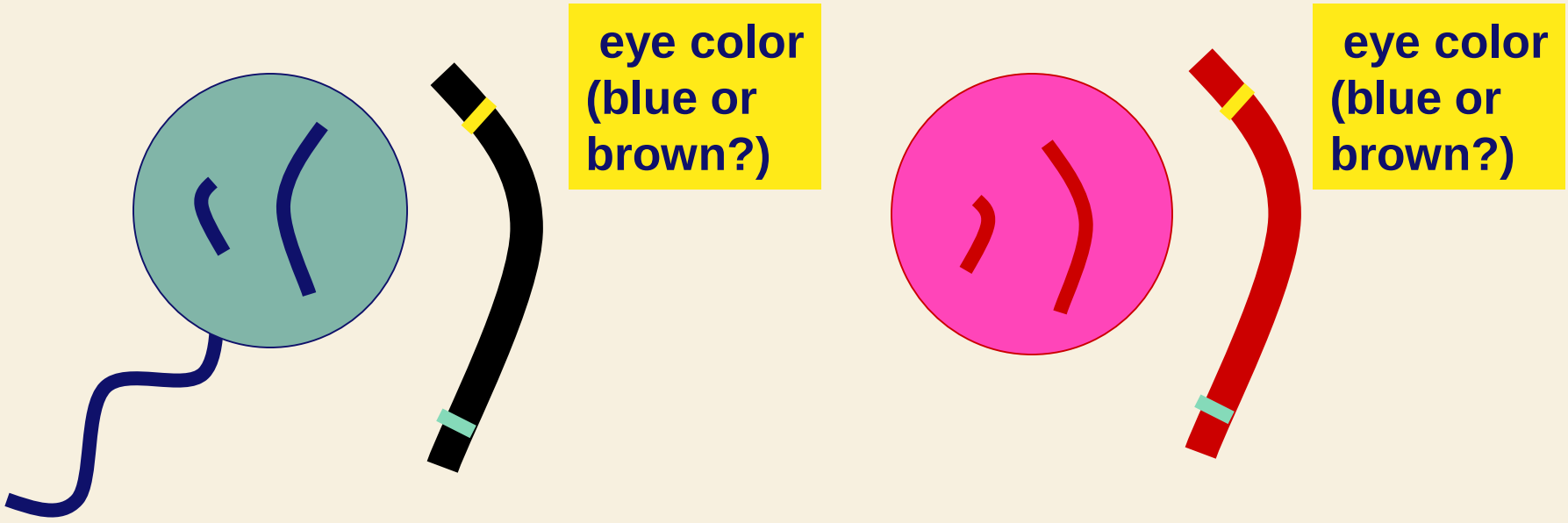
INHERITANCE OF CHROMOSOMES

Egg + sperm → zygote



INHERITANCE OF GENES

- Genes are on the chromosomes passed on from both parents
  - may be same information
  - may be different information



ALLELES

- Genes come in different versions which are referred to as **alleles**.

- ***Example***: *Hair color is a gene controlled by different alleles*
  - *Your mother may have black hair and your father blonde hair*
    - *you inherited only **one** of the alleles for this gene, so you have **either black or blonde hair**, not both.*

GENES AFFECT YOUR PHYSICAL APPEARANCE

P generation

bb  x  BB

 Bb

 Bb

 Bb

 Bb

F_1 generation

Where did the blue eyes go??

GENES AFFECT YOUR PHYSICAL APPEARANCE

P generation

bb  x  Bb

 Bb

 Bb

 bb

 bb

F_1 generation

Why did the blue eyes stay??

GENES AFFECT YOUR PHYSICAL APPEARANCE

P generation

Bb

x

Bb

BB or Bb

BB or Bb

BB or Bb

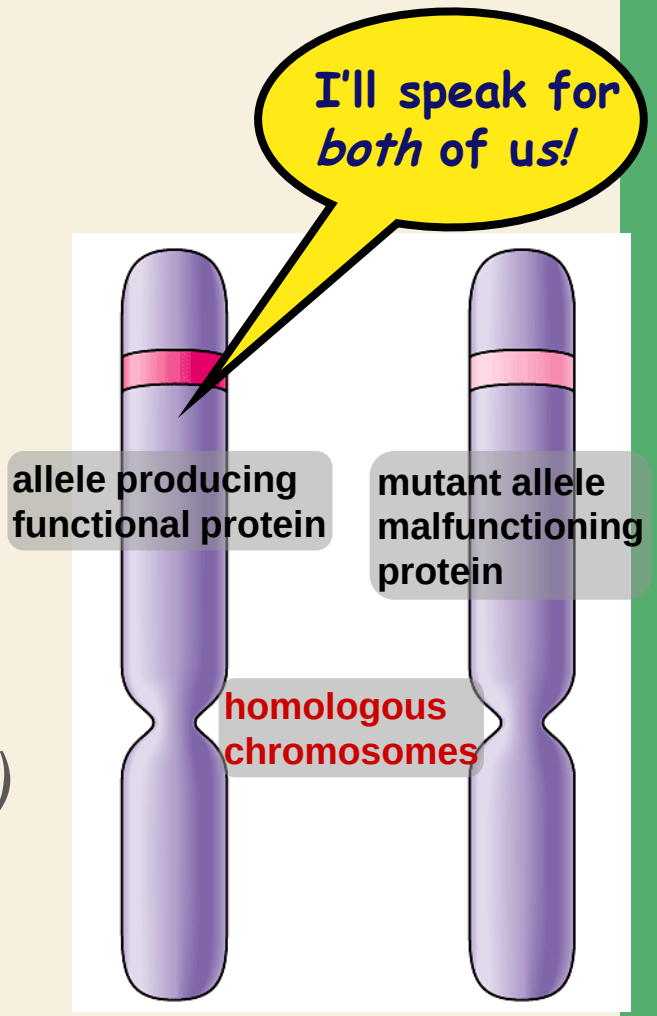
bb

F_1 generation

Where did the blue eyes come from??

MENDEL'S FINDINGS

- Some traits mask others
  - purple & white flower colors are separate traits that do not blend
    - purple x white ≠ light purple
    - purple masked white
  - dominant allele *(capital letters)*
    - functional protein
      - affects characteristic
    - **masks other alleles**
    - *Example: Brown eyes are usually dominant over blue eyes.*
  - recessive allele *(lowercase letters)*
    - **no noticeable effect**
    - allele makes a non-functioning protein

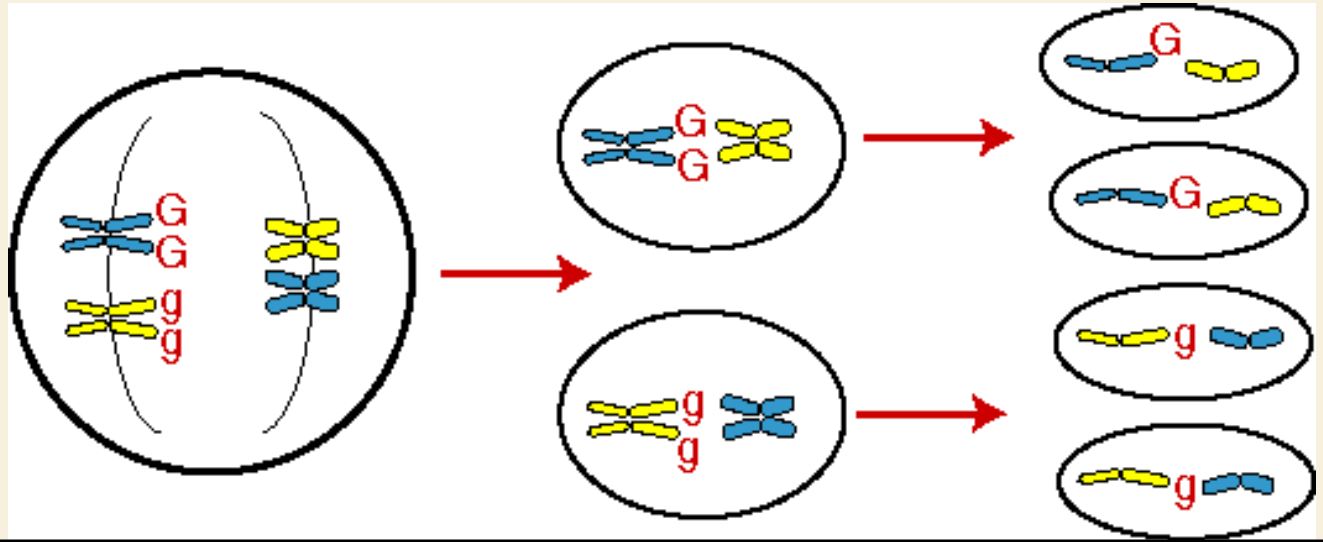


PRINCIPLE OF DOMINANCE

- ***The principle of dominance states that some alleles are dominant and others are recessive***
  - An organism with a dominant allele for a particular form of a trait will **ALWAYS** exhibit that form of the trait
  - An organism with a recessive allele for a particular form of a trait will exhibit that form only when the dominant allele for the trait is **absent**
  - **(DOMINANT) AA or Aa**
  - **(recessive) aa**

MENDEL'S FINDINGS

- **Law of Segregation:**
- Mendel concluded that alleles separate when gametes *(egg & sperm)* are formed.
- Each gamete carries only one copy of each **gene**.
  - Pulled apart and segregated during anaphase!!!



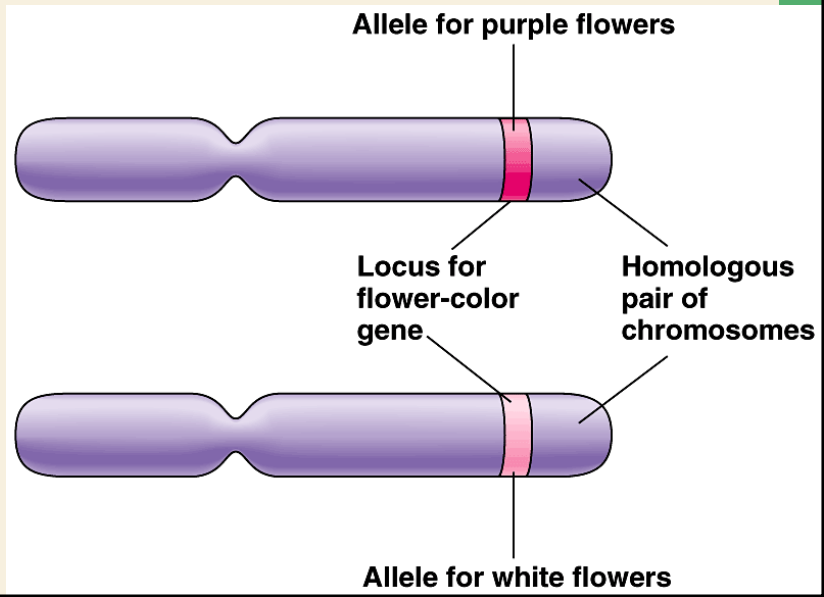
TRAITS ARE INHERITED AS SEPARATE UNITS

- For each trait, an organism inherits 2 copies of a gene, 1 from each parent
  - a diploid organism inherits 1 set of chromosomes from each parent
    - diploid = 2 sets of chromosomes (23 + 23)

1 from Mom

homologous chromosomes

1 from Dad



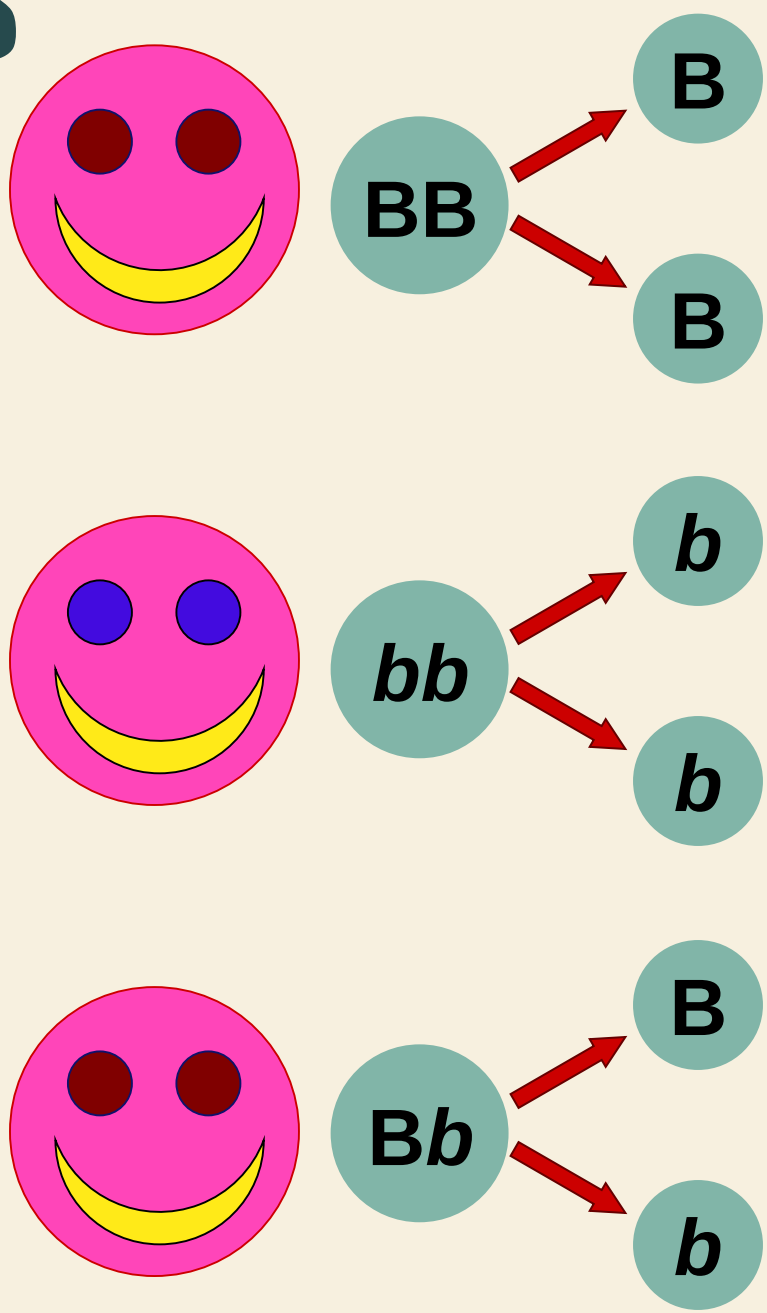
MAKING GAMETES

BB = brown eyes
B*b* = brown eyes
***bb* = blues eyes**

→ **brown** is **dominant** over **blue**

→ **blue** is **recessive** to **brown**

Remember meiosis!



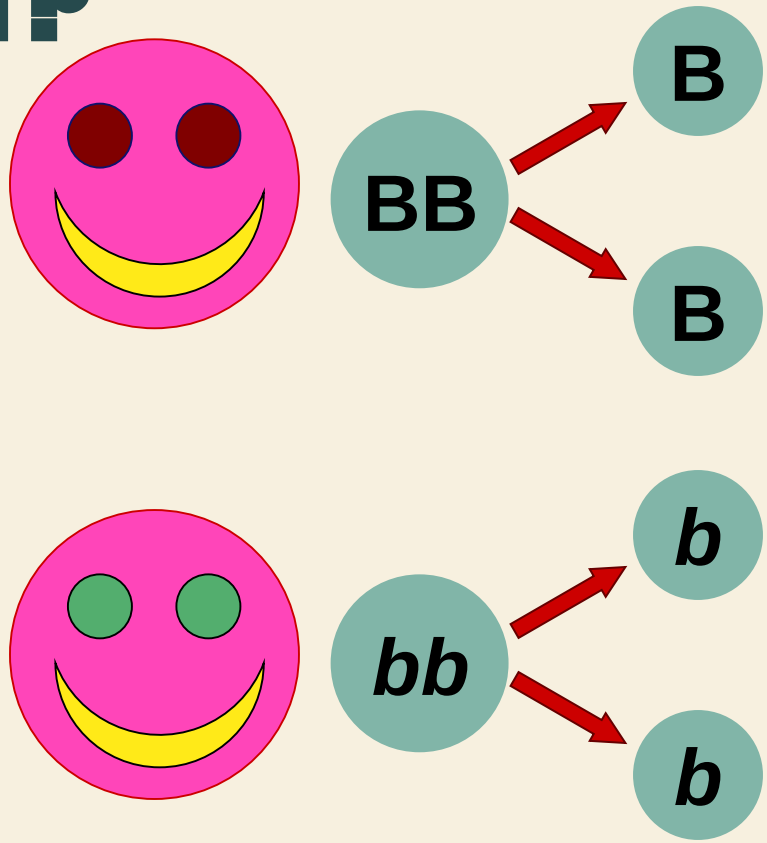
HOW DO WE SAY IT?

2 of the same alleles

Homozygous & Purebred

BB = brown eyes
***bb* = blues eyes**

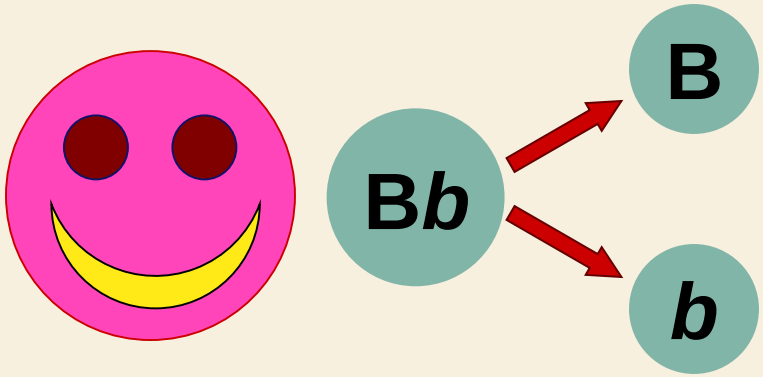
homozygous dominant
homozygous recessive



2 different alleles

Heterozygous & Hybrid

B*b* = brown eyes



GENOTYPE VS. PHENOTYPE

- A **genotype** is what we call the **genetic** make-up of an organism *(internal code for phenotype).*
- A person's **phenotype** is a **physical** description of their genotype *(outward appearance).*
  - *Example: B=black b=brown*
    - *Genotype = BB alleles for hair color*
    - *Phenotype = black hair*

USING PROBABILITY TO PREDICT TRAITS

- **Probability** refers to the likelihood that a particular event will occur
- Past outcomes do not affect the future ones
- ***The principles of probability can be used to predict the outcomes of genetic crosses***
- Ex. What is the probability that a single coin flip will come up heads?
  - a. 100 percent b. 75 percent
  - c. 50 percent d. 25 percent

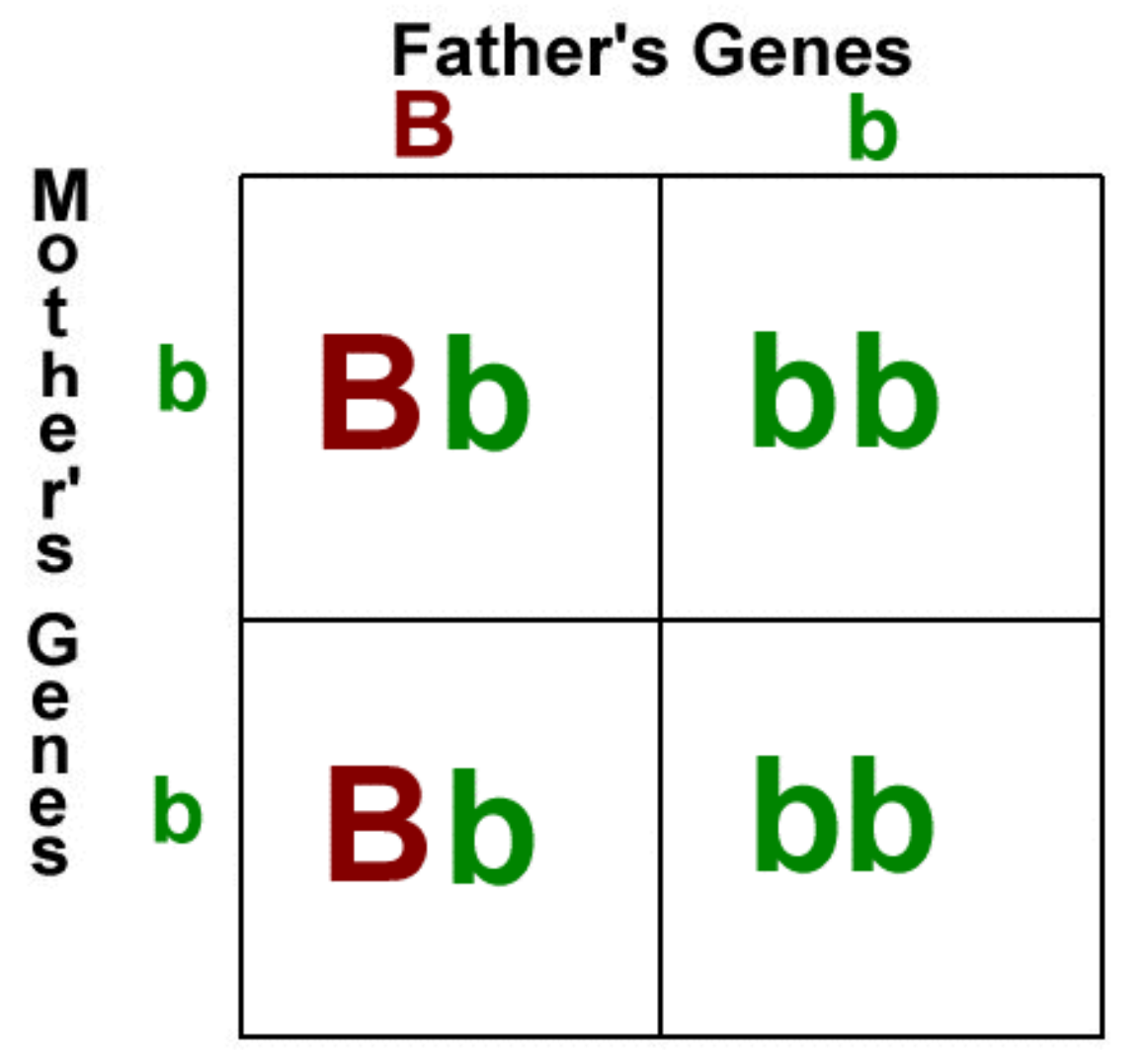
PROBABILITY

- Probability =

$$\frac{\text{\# of one possible outcome}}{\text{Total \# of all possible outcomes}}$$

- *Example: probability of getting tails when flipping a coin is ½ = .50, or 50%.*

A **Punnett Square** is a diagram showing the gene combinations that might result from a genetic cross



MONOHYBRID CROSSES

- A monohybrid cross is one that provides data about **1** set of traits.
- To complete the cross, each box of the Punnett square is filled with two letters: one from the left side of the square and one from the top.
- Note that the **dominant** trait is always written first & that the letters tell us the **genotypes** of the offspring.

MONOHYBRID CROSSES

- **Practice**: A cross between a homozygous dominant (TT) tall plant and a homozygous recessive (tt) short plant. (TT x tt)

MONOHYBRID CROSSES

- Example: A cross between two heterozygous (Tt) plants for the trait tallness. (Tt x Tt)

How many are:

____ homozygous dominant

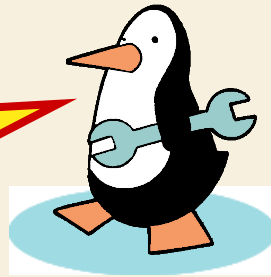
____ heterozygous

____ homozygous recessive for tallness

(___:___:___ ratio)

PUNNETT SQUARES

Phenotype & genotype can have different ratios!



1st generation (hybrids)

Pp x Pp

male / sperm

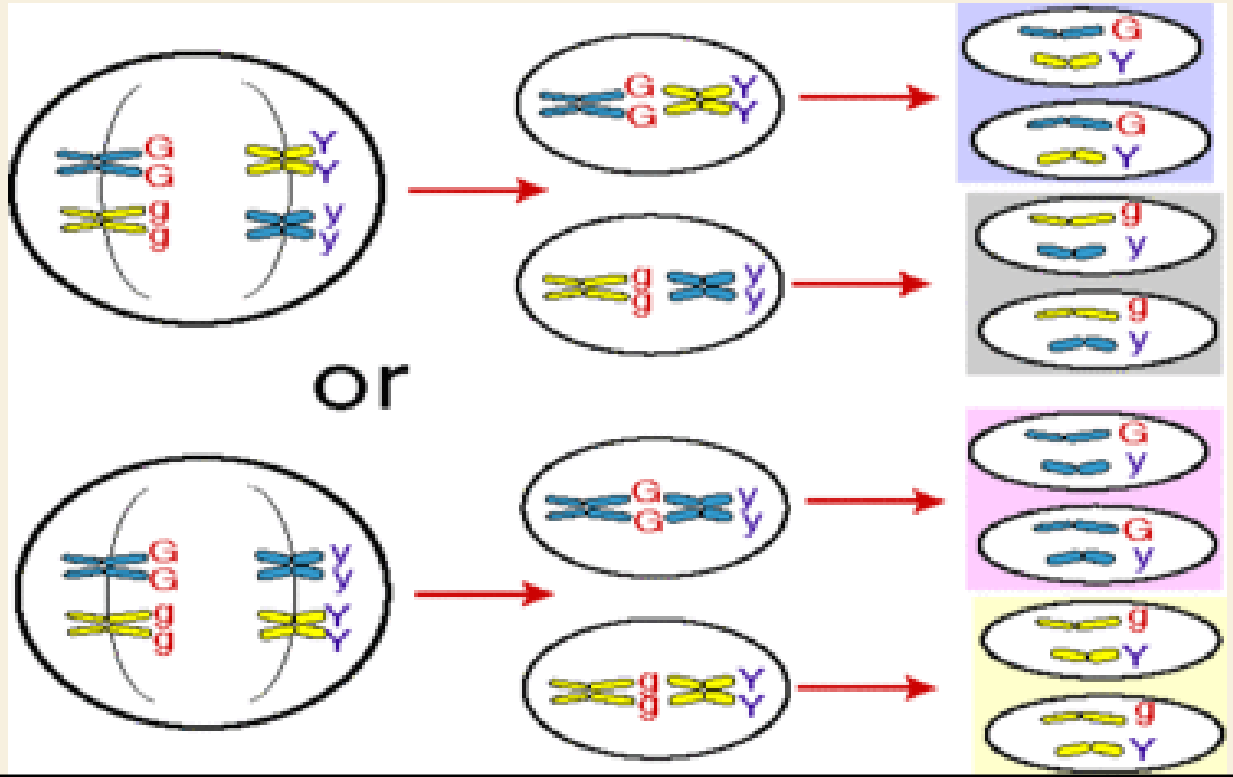
female / eggs	P	p
P	PP	Pp
p	Pp	pp

		% genotype	% phenotype
PP		25%	75%
Pp		50%	
Pp			
pp		25%	25%
		1:2:1	3:1

MENDEL'S FINDINGS

Law of Independent Assortment:

- Mendel found:
  - Genes that control one trait (like hair color) **do not** affect genes of another trait (like hair texture).
- Each gene sorts **independently** of all others during the formation of **gametes**



DIHYBRID CROSS

- A **dihybrid** cross is one that provides information about 2 sets of **contrasting** traits.
  - Ex. Fur color & coat texture
- In these crosses, alleles must be **sorted independently**, then listed for the Punnett square cross.

DIHYBRID CROSS PRACTICE

Fur Color:

B: Black

b: White

Coat Texture:

R: Rough

r: Smooth

In this example, we will cross a *heterozygous* individual with another *heterozygous* individual.

Their genotypes will be:

BbRr x BbRr

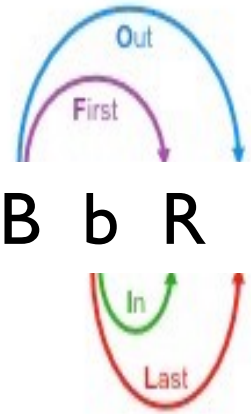
DIHYBRID CROSS - FOIL

- *First, you must find ALL possible gametes that can be made from each parent.*
  - *Remember, each gamete must have one B and one R.*

To find the alleles for each parent we use **FOIL**

Genotype B b R r

Foil Method: B b R r



F O I L

Gametes:

BR	Br	bR	br

GAMETE COMBINATIONS

BbRr x BbRr

Possible gametes:

BR

Br

bR

br

Next, arrange all possible gametes for one parent along the top of your Punnett Square, and all possible gametes for the other parent down the side of your Punnett Square…

BbRr x BbRr

Fill in the genotypes of the offspring.

Fur Color:
B: Black
b: White

Coat Texture:
R: Rough
r: Smooth

	BR	Br	bR	br
BR				
Br				
bR				
br				

DIHYBRID CROSS RESULTS

- How many of the offspring would have black, rough coat?
- How many of the offspring would have a black, smooth coat?
- How many of the offspring would have a white, rough coat?
- How many of the offspring would have a white, smooth coat?

Phenotypic Ratio

____:____

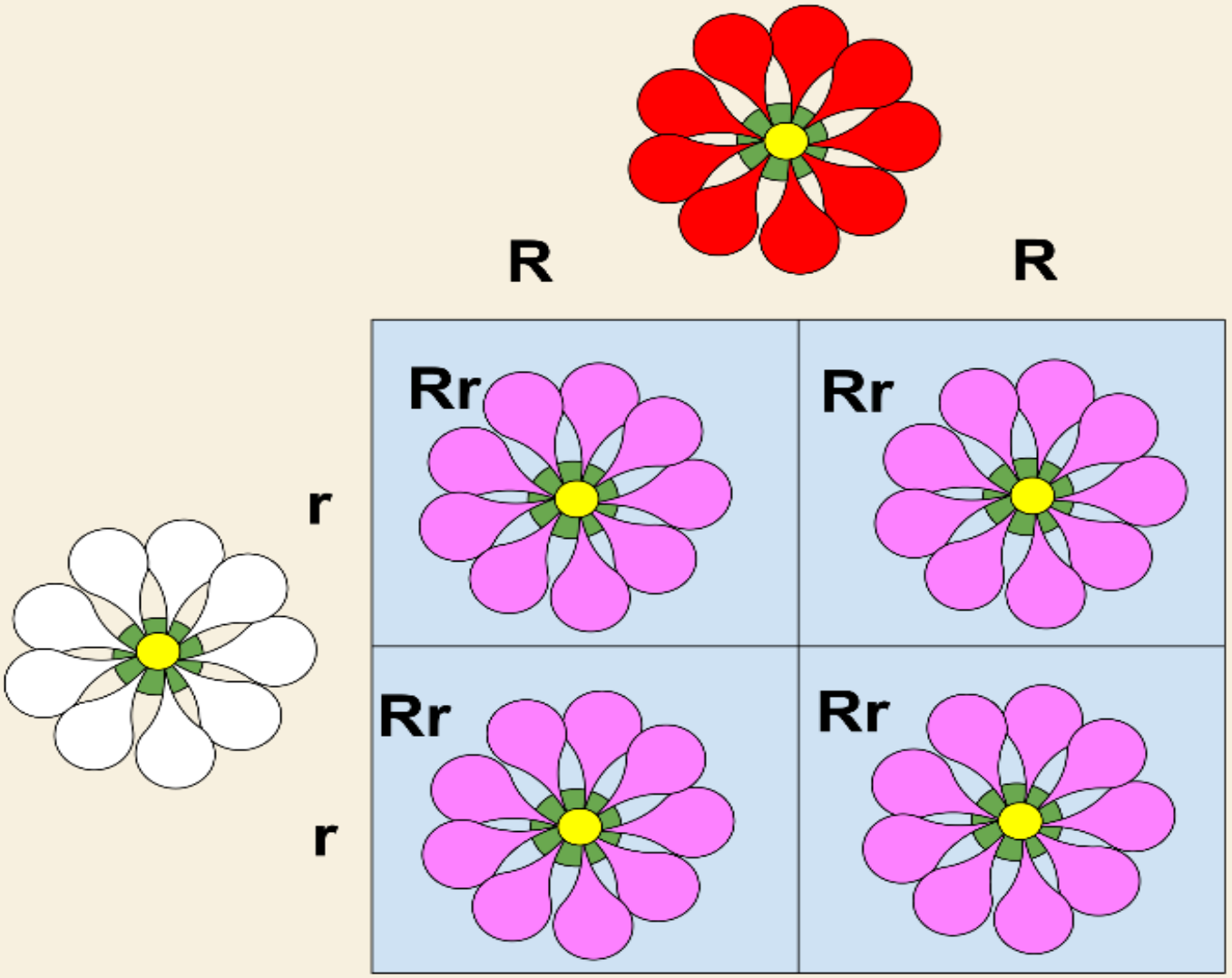
NON-MENDELIAN GENETICS

Some alleles are neither dominant nor recessive, and many traits are controlled by multiple alleles or multiple genes. Here are some exceptions to Mendel's principles:

Incomplete dominance:

- Occurs when one allele is not completely dominant over the other. The heterozygous phenotype is a "blended" version of the parents.
  - RR = red flowers -> RR
  - rr = white flowers -> WW
  - Rr = pink flowers -> RW

INCOMPLETE DOMINANCE



CODOMINANCE

- Occurs when both alleles contribute to the phenotype
  - The offspring of a black feathered chicken and a white feathered chicken would be both black and white feathered *(speckled)*

COMPLEX HEREDITY – MULTIPLE ALLELES & GENES

- Multiple alleles – Genes with more than 2 alleles.
  - –Blood types – **3 alleles** – A, B, O
  - –O is recessive

- Polygenic Inheritance –
  - –**2** or more **genes** controlling one trait
    - skin color, eye color, intelligence, height, weight

BLOOD TYPES

father \ mother	A	B	O
A	AA	AB	AO
B	BA	BB	BO
O	OA	OB	OO

alleles	blood type
A+A	A
A+O	A
A+B	AB
B+B	B
B+O	B
O+O	O

codominance

recessive

BLOOD TYPING PRACTICE

- Make a Punnett square to predict the potential genotypes of the offspring created by a father with the genotype **BO** and a mother with the genotype **AA**.

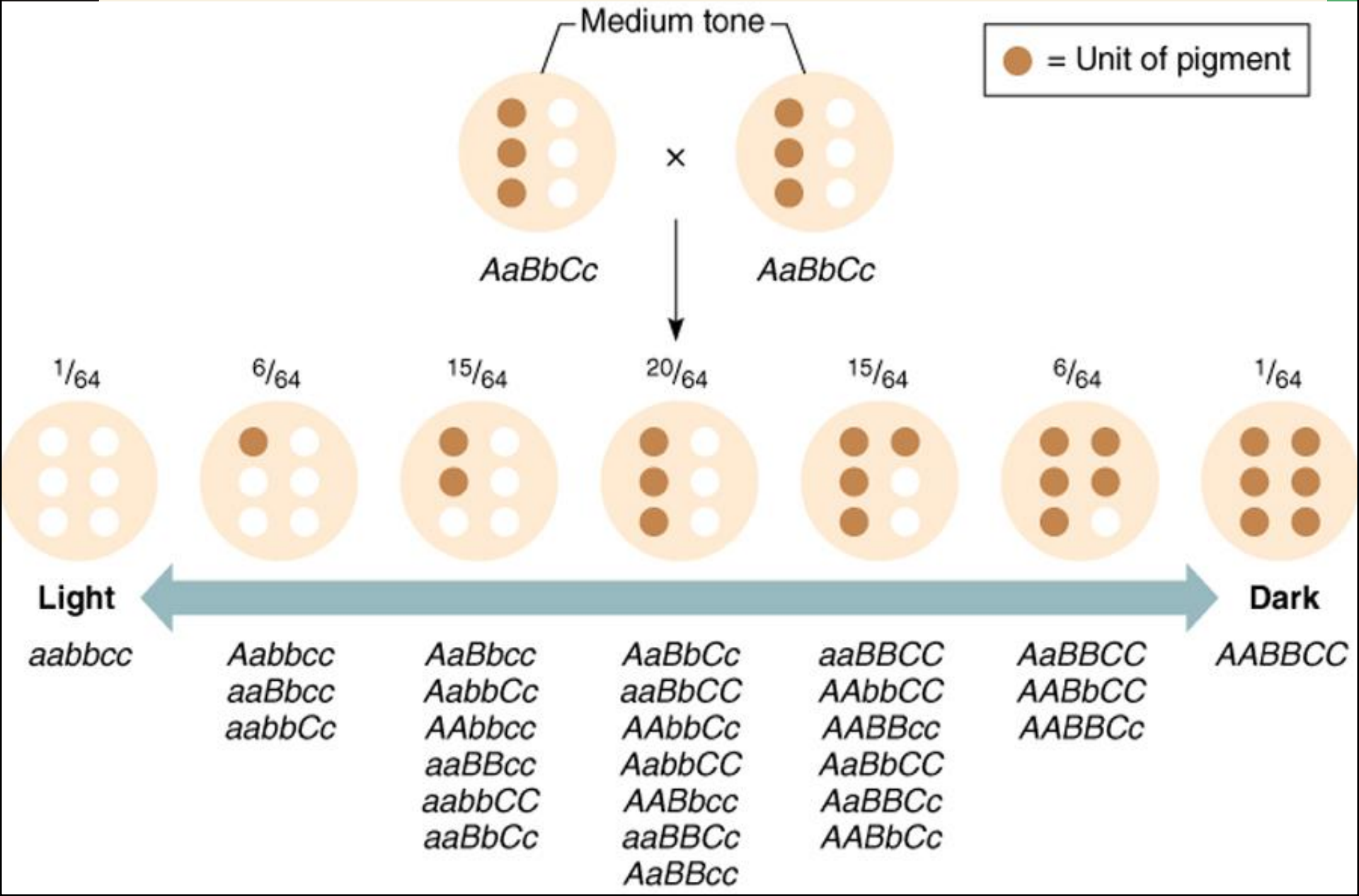
What is the ratio of blood types?

_____: _____

What is the probability they will have a baby with type A blood?

_____/_____ = _____ %

POLYGENIC INHERITANCE



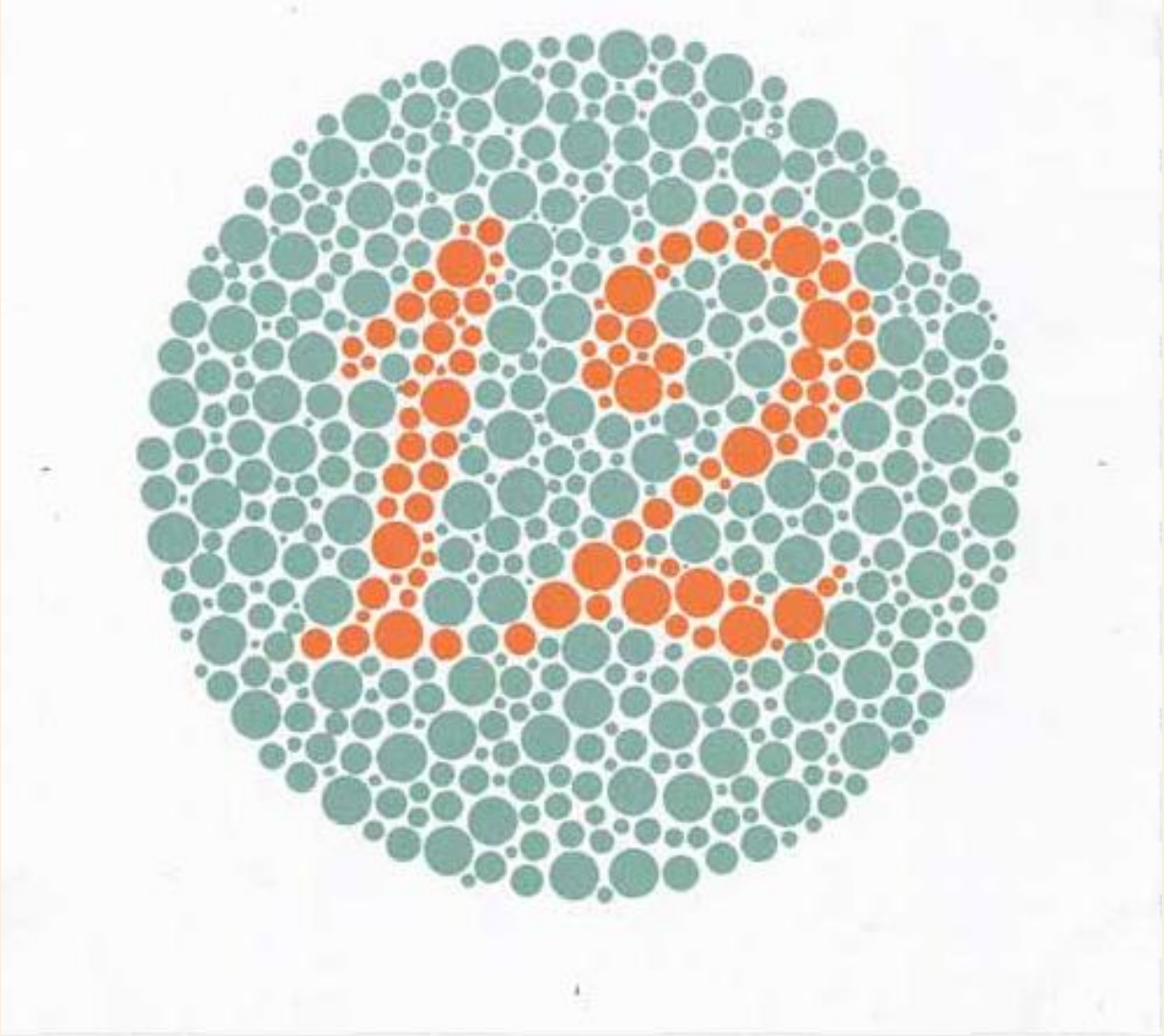
SEX-LINKED INHERITANCE

- Sex-linked traits are controlled by genes found on the X chromosome but NOT on the Y chromosome.
- Females = **XX** – carry 2 alleles for a sex-linked trait
- Males = **XY** – only carry 1 allele for a sex-linked trait, so it is more likely for them to get sex-linked traits or diseases

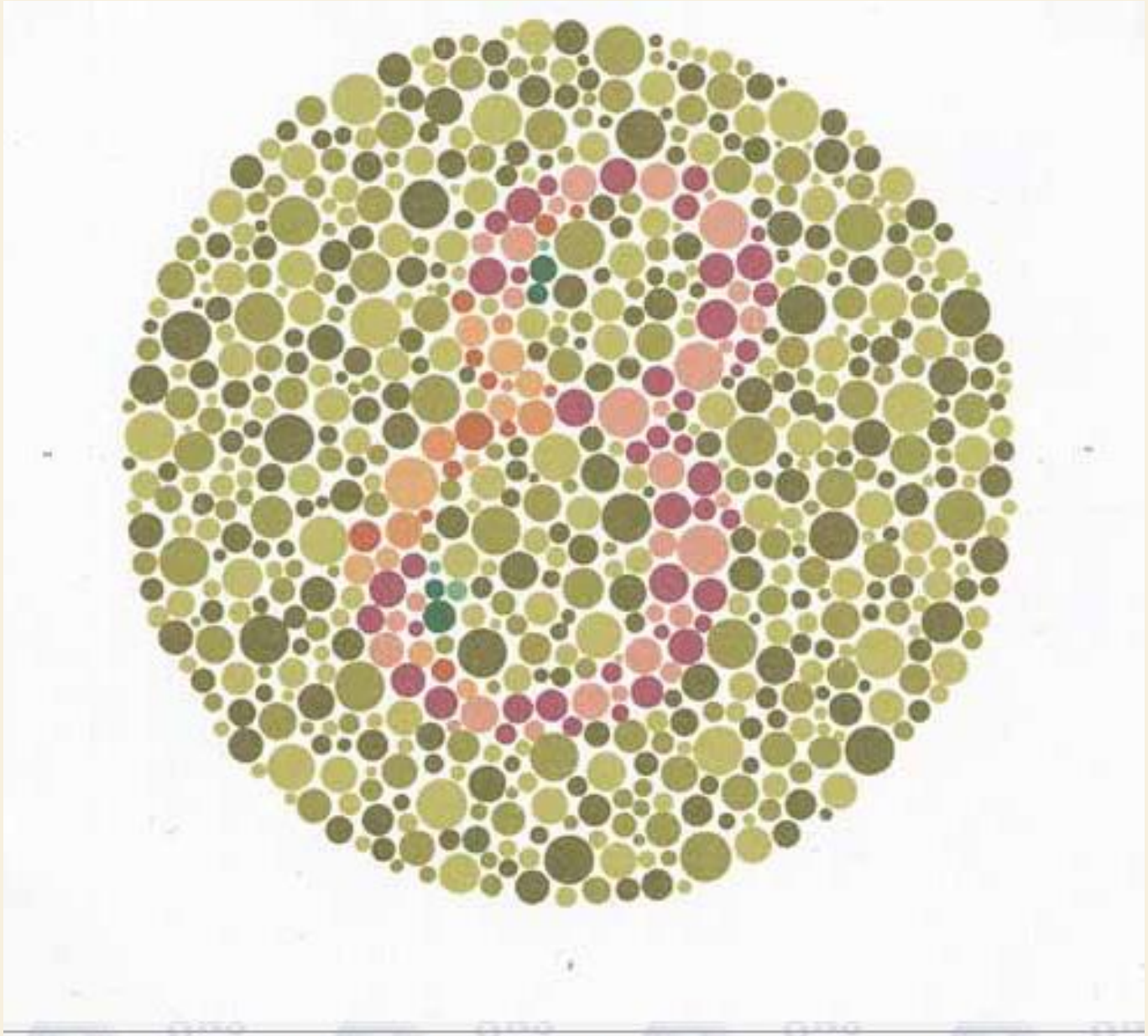
EXAMPLE: COLORBLINDNESS

- Colorblindness is a condition that affects a person's perception of colors.
- This leads to changes in color vision, that range from mild difficulty in recognizing shades, to total inability of detecting colors.

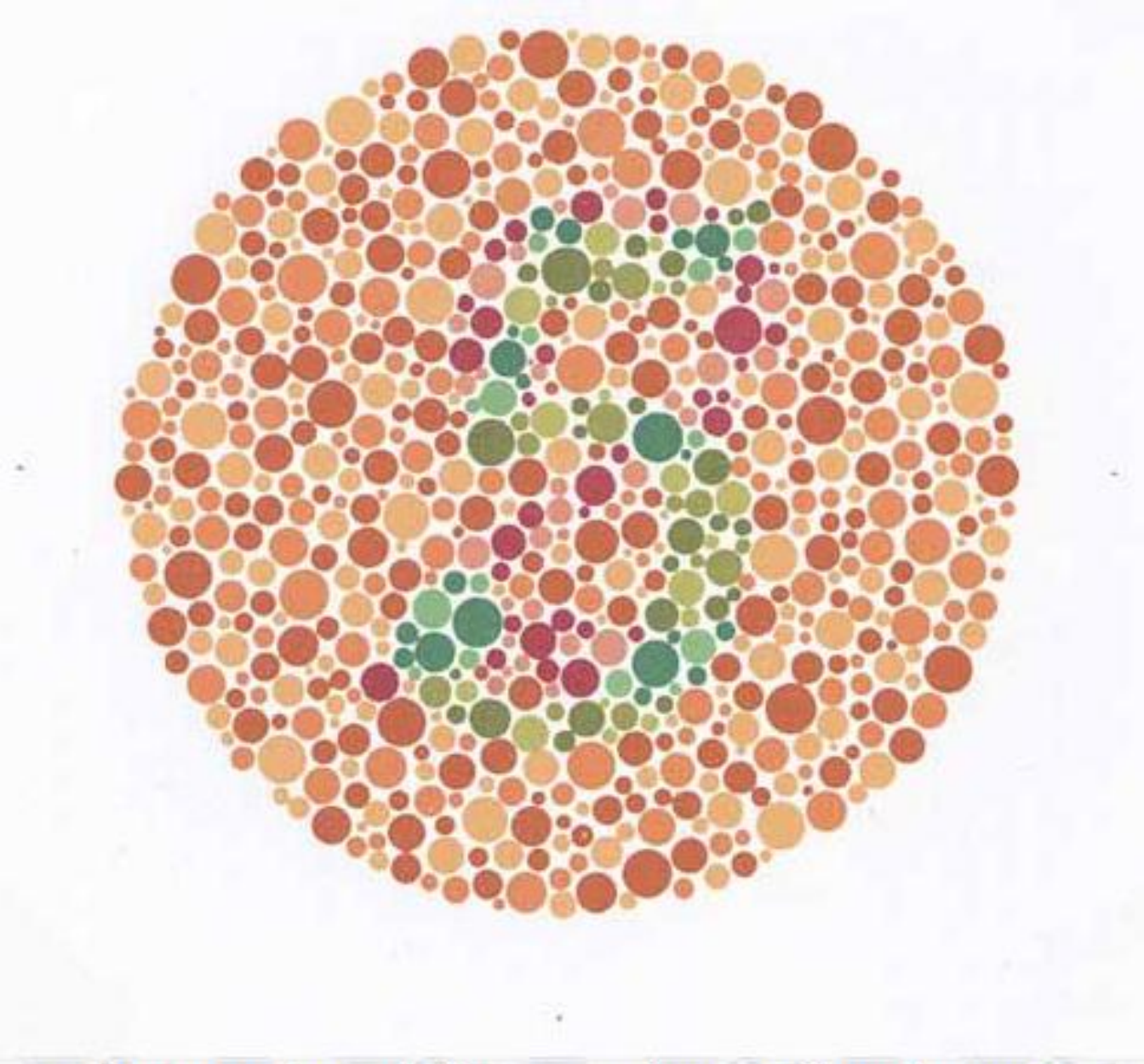
ARE YOU COLORBLIND?



Both the normal and those with all sort of color vision deficiencies read it as 12.



The normal read this as 8. Those with red-green deficiencies read this as 3. Those with total color blindness cannot read any numeral.



The normal read this as 5. Those with red-green deficiencies read this as 3. Those with total color blindness cannot read any numeral.

INHERITANCE OF COLORBLINDNESS

- N = Normal color perception (not colorblind)
- n = Colorblind
- Normal male: _____
- Male with colorblindness: _____
- Normal female (not a carrier for colorblindness – homozygous): _____
- Normal female (carrier for colorblindness – heterozygous): _____
- Female with colorblindness: _____

X^NX^N X X^NY

Chances of:

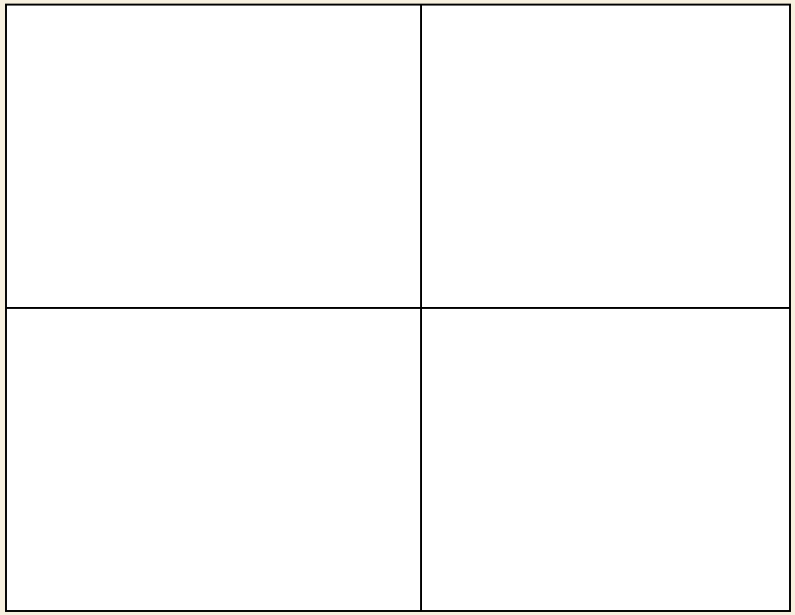
a. colorblind son?

_____

b. colorblind daughter? _____

c. daughter who is a carrier? _____

d. child who is not colorblind? _____



ENVIRONMENT EFFECT ON GENES

- Phenotype is controlled by both the environment & genes

Human skin color is influenced by both genetics & environmental conditions

Color of Hydrangea flowers is influenced by soil pH

Coat color in arctic fox influenced by heat sensitive alleles

(a)

(b)