GENETICS

This is the story of Gregor Mendel – the Father of Modern Genetics

www2.edc.org/.../Mendel/mendelInstructions.html

Cute site to virtually experiment with peas like Mendel

Genetics is the study of heredity.

Heredity is the passing of traits from parents to their young.

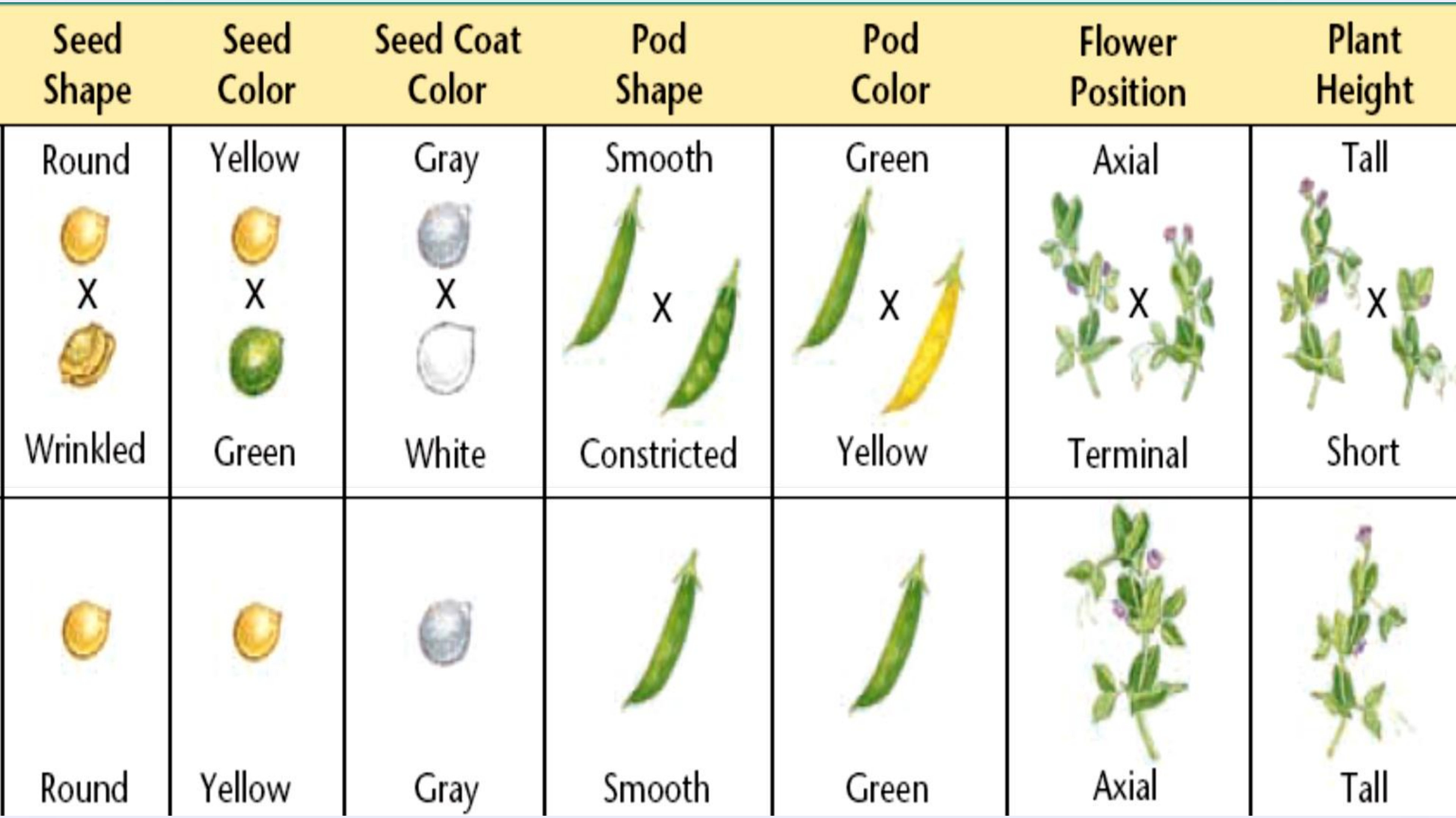
A **trait** is a characteristic that a living thing can pass on to its young.

It (genetics) explains how certain characteristics are passed on from parents to children.

Mendel worked exclusively with true-breeder pea plants. This means…

True-breeding or purebred – belonging to a group of organisms that can produce offspring having only one form of a trait in each generation.

Cross pollination produced seeds that are the offspring of two different plants and Mendel was able to cross plants with different characteristics.



The F1 generation of peas, because they had the genes (or alleles) for two different traits,were called

Hybrids

In other words,

These offspring were **heterozygous**.

Heterozygous – organisms resulting from a cross between dissimilar parents

Because the parental generation (the P generation) were the products of two parents with the same traits (or alleles), the P generation was

HOMOZYGOUS

Homozygous – Organism that has two (2) identical alleles for a particular trait

Refresher:

An **ALLELE** – one of a number of different forms of the SAME GENE for a specific trait

A **GENE** – a segment of DNA that codes for a particular protein (hence a trait or characteristic). it is the basic unit of heredity.

The Law 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 have that form.

Dominant: form of a gene (allele) that is expressed even if present with the contrasting recessive allele. They overpower the expression of the other form of the allele.

Always use an **uppercase** letter to represent the dominant allele.

An organism with a **recessive** allele for a particular form of a trait will have that form only when the dominant allele for the trait is not present

Recessive – Description of a form of a gene (allele) that is only expressed in the homozygous state.

Always use a **lower case** letter to represent the recessive allele.

In Mendel's experiments, the allele for tall plants was dominant and the allele for short plants was recessive. In his first experiments, Mendel looked at only one trait at a time.

Phenotype

Physical characteristics of an organism.

What the organism physically looks like

How the genes are expressed.

Ex.: Pea plants with Tt are always Tall – look at them – they are tall. You can SEE the trait.

Genotype

What the genes look like – the genetic makeup of an organism.

Ex.: a heterozygous tall pea plant would have the genes (alleles) T and t (Tt)

A homozygous tall pea plant would have the alleles T and T (TT)

Whenever Mendel performed a cross with pea plants, he carefully counted the offspring. Every time Mendel repeated a particular cross, he obtained similar results. For example, **whenever Mendel crossed two plants that were hybrid for stem height (*Tt*), about three fourths of the resulting plants were tall and about one fourth were short**. Mendel realized that the **principles of probability** could be used to explain the results of genetic crosses

Probability - the likelihood that a particular event will occur

Ex.: flipping a coin

2 possible outcomes

1 in 2 chance it will be heads (or 50% chance)

1 in 2 chance it will be tails (or 50% chance)

Flip a coin three times in a row, what is the probability that it will land heads up?

Because each coin flip is an independent event, the probability of each coin's landing heads up is 1/2

Therefore, the probability of flipping three heads in a row is:

$$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \frac{1}{8}.$$

The principles of probability can be used to predict the outcomes of genetic crosses.

•The initial cross always begins with pure breeding parents of contrasting traits. This is known as the Parental or P generation. And we always study one trait at a time.

A simple way to represent a cross is to set up a **Punnett square**.

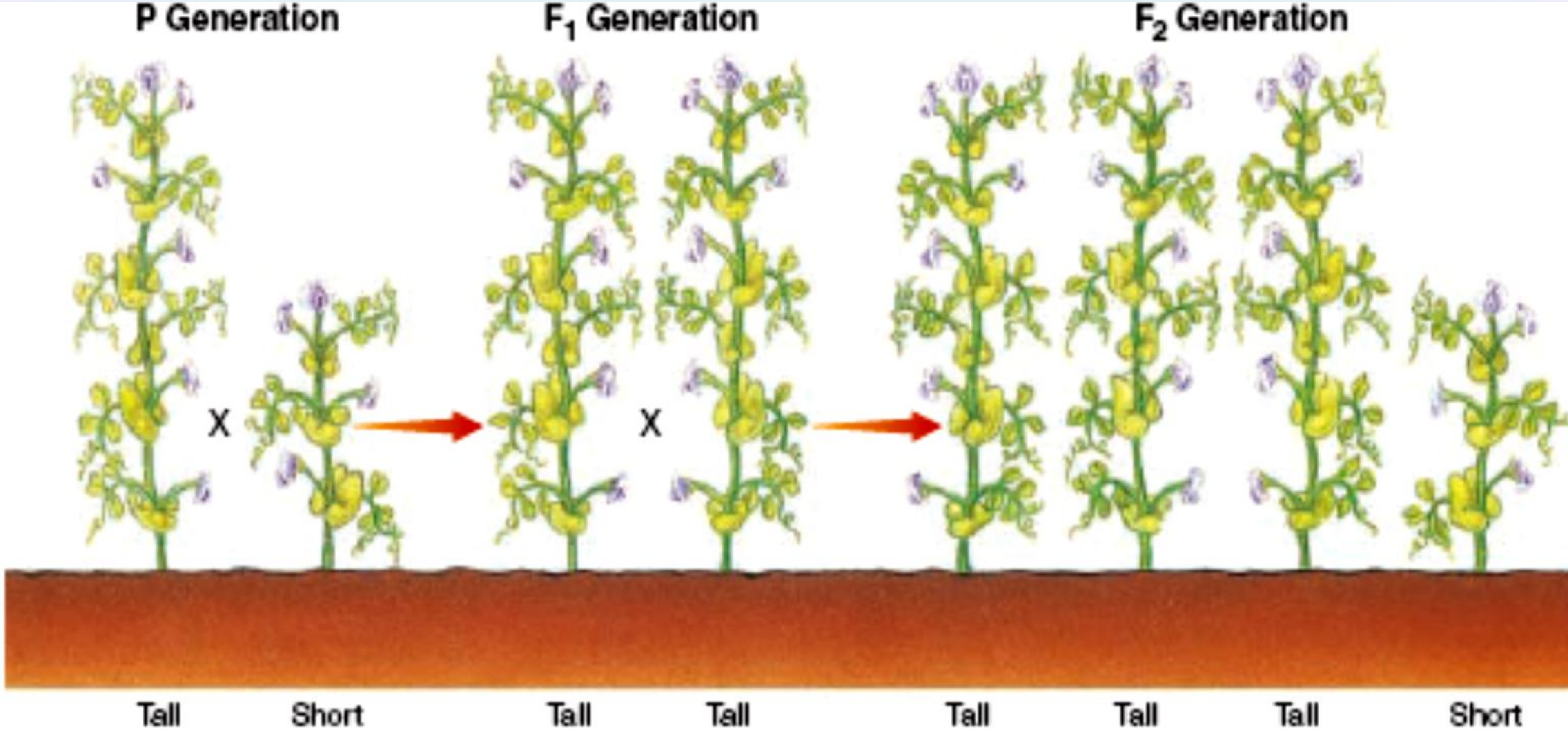
It is a chart showing the possible combinations of genes in the offspring of a cross or the probability that a certain trait will appear in the next generation.

P generation

	T	T
t	T t	T t
t	T t	T t

F1 generation

	T	t
T	T T	T t
t	T t	t t


P Generation
F_1 Generation
F_2 Generation
X
X
Tall
Short
Tall
Tall
Tall
Tall
Tall
Short

One of the offspring was a short pea plant!!!!

The short pea trait reappeared in the F2 generation.

How did that happen???

Once again, the alleles separated and recombined to produce a new combination

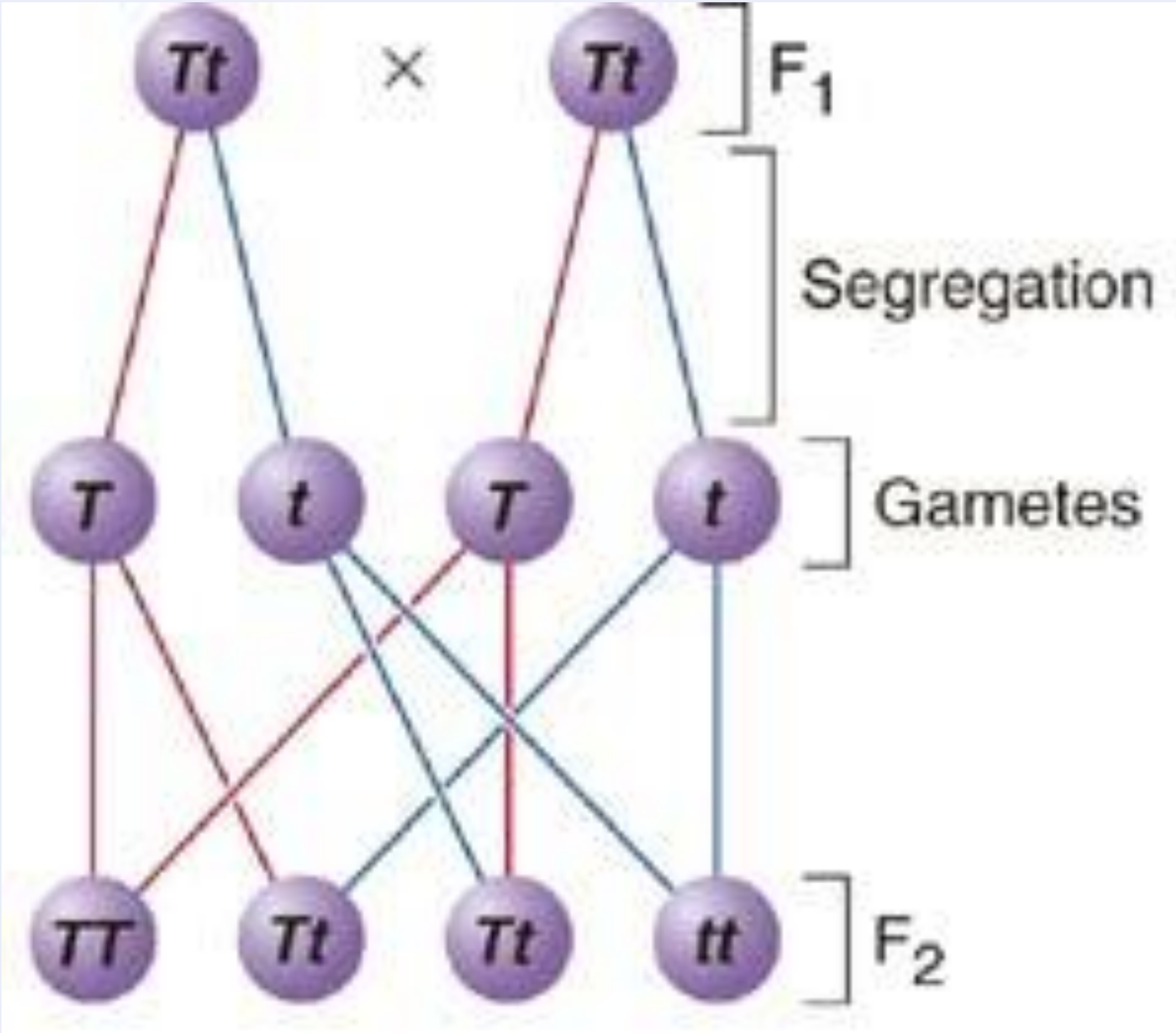
The cross resulted in one pair of recessive alleles, tt.

Although all of the F1 plants appeared to be tall, the alleles separated and recombined during the cross.

This is an example of the **LAW OF SEGREGATION**.

Segregation – the separation; in genetics, the separation of alleles during gamete formation.

When each F_1 plant flowers, the two alleles are segregated from each other so that each gamete carries only a single copy of each gene. Therefore, each F_1 plant produces two types of gametes—those with the allele for tallness and those with the allele for shortness


Tt
×
Tt
F1
Segregation
T
t
T
t
Gametes
TT
Tt
Tt
tt
F2

FYI's

The calico cat

3 main colors – black, orange and white.

White is due to a single gene difference.

The black and orange are due to X chromosome inactivation part of the X chromosomes are inactivated).

Hairy ear rims.

Caused by an allele of a Y-linked gene.

Did alleles segregate independently.
Does the segregation of one pair of alleles affect the segregation of another pair of alleles?
For example, does the gene that determines whether a seed is round or wrinkled in shape have anything to do with the gene for seed color?
Must a round seed also be yellow?

To answer his questions, Mendel crossed purebred plants that produced Round Yellow Seeds with purebred plants that produced Wrinkled Green Seeds

The 2-Factor Cross: F1 Generation (two traits)

Round yellow seeds	RRYY
Wrinkled green seeds	rryy

An RY gamete and an ry gamete combine to form a fertilized egg with a genotype RrYy

rryy

RRYY

	ry	ry	ry	ry
RY	RrYy	RrYy	RrYy	RrYy
RY	RrYy	RrYy	RrYy	RrYy
RY	RrYy	RrYy	RrYy	RrYy
RY	RrYy	RrYy	RrYy	RrYy

Only one kind of plant will show up in the F1 generation – heterozygous or hybrid for both traits.

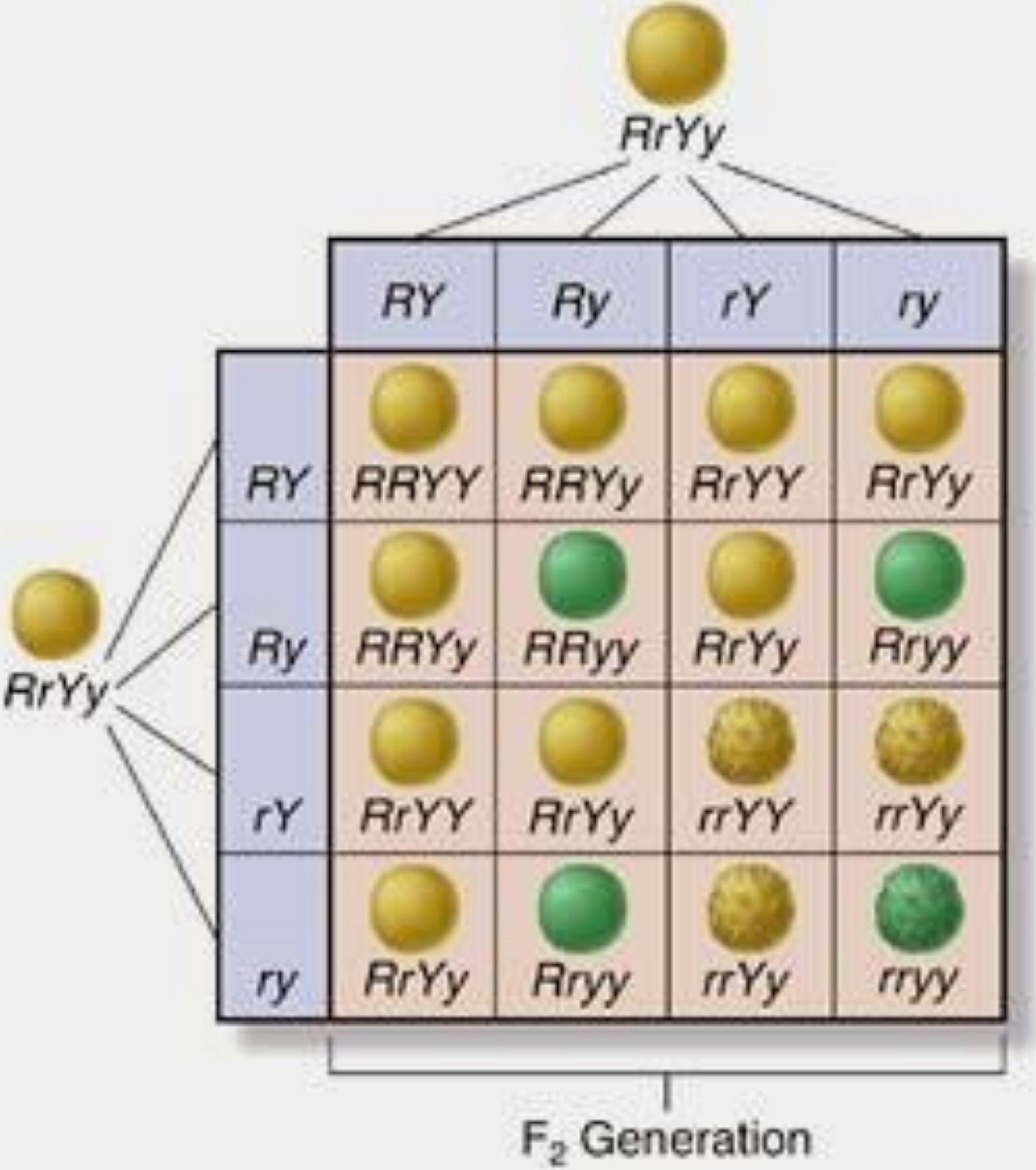
The phenotype of the F1 ge3neration will be all round and yellow.

Round and Yell are both dominant

Cross the F1 plants wit each other. What will happen?

If the genes for seed shape and color are connected in some way, then the dominant R and Y alleles and the recessive r and y alleles will be segregated as MATCHED sets into the gametes.

If the genes are NOT connected, then they should segregate independently or undergo INDEPENDENT ASSORTMENT.


RrYy
RY
Ry
rY
ry
RrYy
RY
RRYY
RRYy
RrYY
RrYy
Ry
RRYy
RRyy
RrYy
Rryy
rY
RrYY
RrYy
rrYY
rrYy
ry
RrYy
Rryy
rrYy
rryy
F_2 Generation

Mendel's 3rd law

The Law of Independent Assortment

states:

Genes for different traits can segregate independently during the formation of gametes

Through his work with peas, Mendel came up with three principles:

- The Law of Dominance
- The Law of Segregation
- The Law of Independent Assortment

A Summary of Mendel's Principles

- The inheritance of biological characteristics is determined by individual units known as genes. In organisms that reproduce sexually, genes are passed from parents to their offspring.
- In cases in which two or more forms of the gene for a single trait exist, some forms of the gene may be dominant and others may be recessive.
- In most sexually reproducing organisms, each adult has two copies of each gene—one from each parent. These genes are segregated from each other when gametes are formed.
- The alleles for different genes usually segregate independently of one another.

Some alleles are neither dominant nor recessive, and many traits are controlled by multiple alleles or multiple genes.

Co Dominance

Sometimes you'll see an **equal expression of both alleles**

Ex.: roan coat in cattle

If one parent has a red coat, RR, and the other parent has a white coat, WW, the offspring will have a roan coat. RW

BOTH ALLELES ARE EXPRESSED.

Multiple Alleles

Sometimes the expression of a trait involves more than two alleles

Ex.: two genes are involved in the expression of AB blood group

A combination of genes determine the different blood types (A, B, AB, O)

In the case of the AB blood type, BOTH A and B are expressed.

Coat Color in Rabbits Coat color in rabbits is determined by a single gene that has at least four different alleles. Different combinations of alleles result in the four colors you see here. **Interpreting Graphics** *What allele combinations can a chinchilla rabbit have?*

Full color: CC, Cc^{ch}, Cc^{h}, or Cc

Chinchilla: $c^{ch}c^{h}$, $c^{ch}c^{ch}$, or $c^{ch}c$

Himalayan: $c^{h}c$ or $c^{h}c^{h}$

Albino: cc

Key

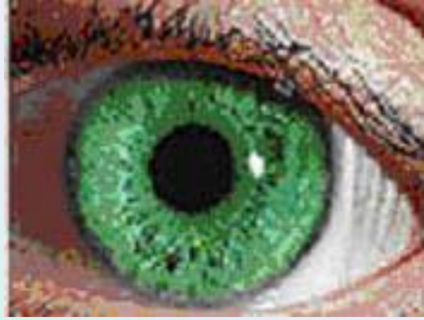
C = full color; dominant to all other alleles

c^{ch} = chinchilla; partial defect in pigmentation; dominant to c^{h} and c alleles

c^{h} = Himalayan; color in certain parts of body; dominant to c allele

c = albino; no color; recessive to all other alleles

GREEN EYES



Eye color comes from a combination of two black and yellow pigments called melanin in the iris of the eye. If you have no melanin in the front part of your iris, you have blue eyes. An increasing proportion of the yellow melanin, in combination with the black melanin, results in shades of colors between brown and blue, including green and hazel.

Generally, brown eye genes are dominant over green eye genes which are both dominant over blue eye genes. However, because many genes are required to make each of the yellow and black pigments, there is a way called genetic compensation to get brown or green eyes from blue-eyed parents.

Coat color inheritance in Labrador retrievers.

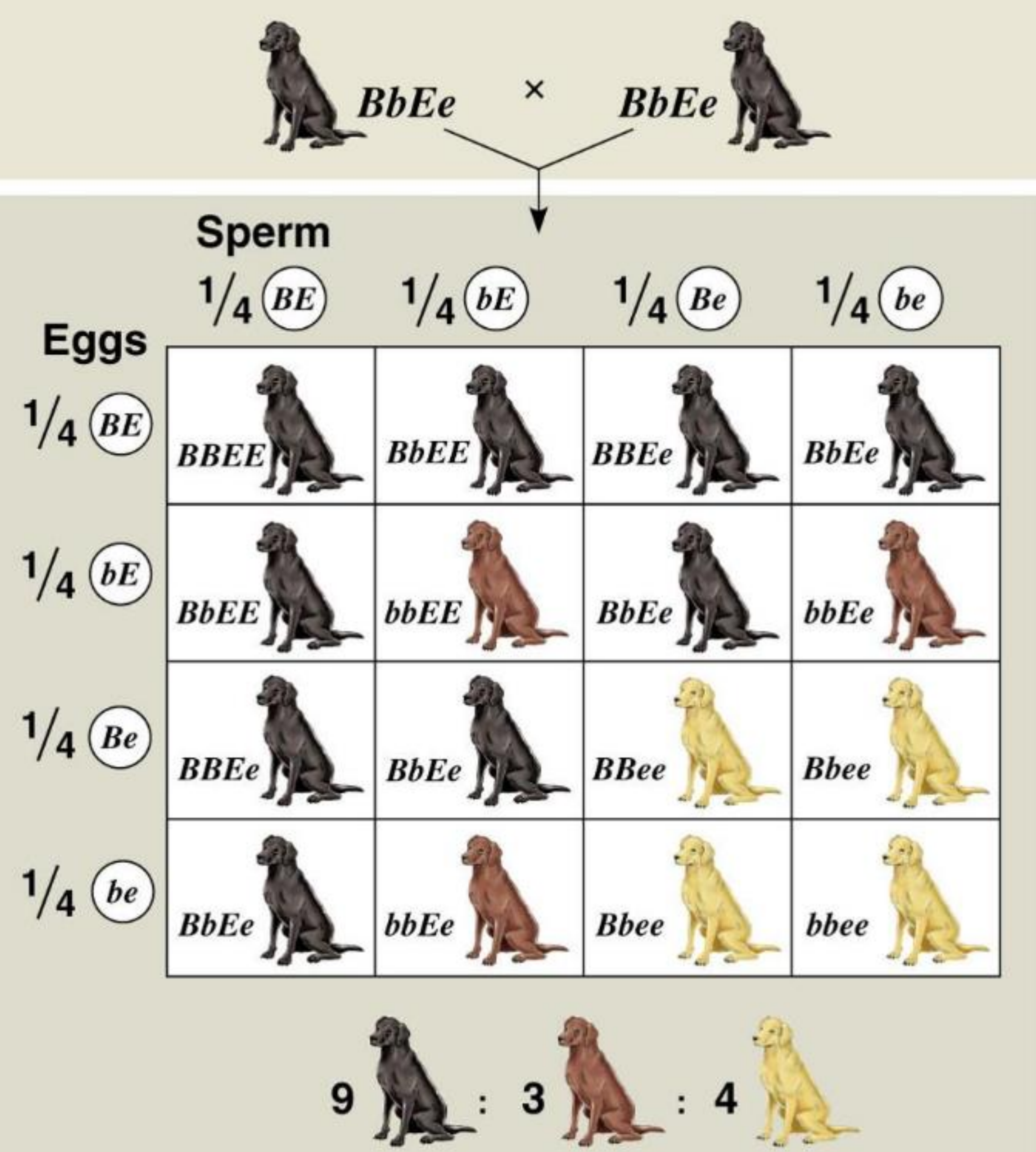
2 alleles b and B, of a pigment gene, determine black and brown respectively.

At a separate gene, E allows color deposition in the coat, and ee prevents deposition, resulting in a gold phenotype

This is a case of recessive epistasis (canceling out genes).

Thurs there are three homozygous genotypes: BBEE, BbEE, Bbee or bbee.

The ability to make black pigment, as witnessed by a black nose on a gold retriever, but not to deposit this pigment on the hairs is probably BBee.



BbEe
×
BbEe
Sperm
1/4 BE
1/4 bE
1/4 Be
1/4 be
Eggs
1/4 BE
1/4 bE
1/4 Be
1/4 be
BBEE
BbEE
BBEe
BbEe
BbEE
bbEE
BbEe
bbEe
BBEe
BbEe
BBee
Bbee
BbEe
bbEe
Bbee
bbee
9 : 3 : 4

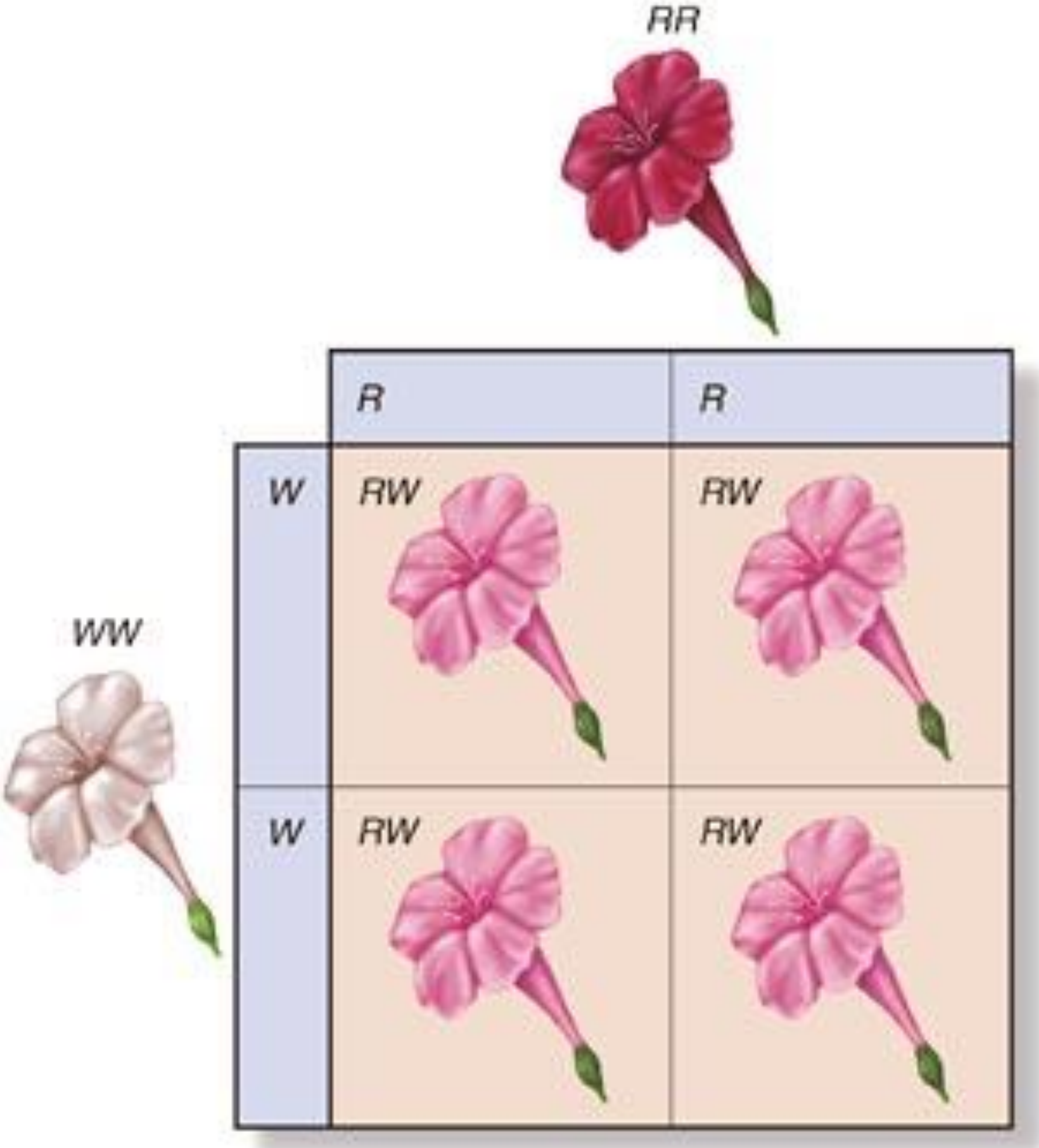
Intermediate Inheritance or Incomplete Dominance

Not all patterns of inheritance obey the principles of Mendelian genetics.

In fact, many traits occur due to a combined expression of alleles.

Ex.: Crossing pure red (RR) and pure white (WW) Japanese four-’clocks results in flowers that are all pink (RW)

To know if something is dominant, co dominant or incomplete dominance, you must look at the phenotype.


RR
R
R
W
W
RW
RW
RW
RW
WW