Notes: Mendelian Genetics

Heredity is passing characteristics from one generation to the next.

Genetics is the study of **heredity.**

Who was Gregor Mendel?

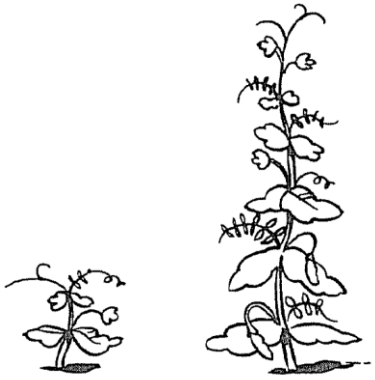
- **Gregor Mendel** is the "**Father of Modern Genetics**." He was an Austrian monk who studied heredity in **pea plants**. His work was published in 1865.
- He described **"factors"** that were passed between generations of plants.
- We now know the factors are **genes**: **chemical factors that determine characteristics**.

Mendel observed **true-breeding** pea plants produced **genetically identical** offspring.

ex. **Tall** plants produced **tall** offspring, short produced short.

True-breeding plants **self-pollinate**. (have both male and female parts)

Mendel's Peas



- Mendel studied seven different traits in pea plants.
  - **-Traits** are inherited characteristics that **vary** from individual to individual.
    - Each trait each had **two different forms or alleles.**
    - Pea plant height can be either tall (T) OR short (t).

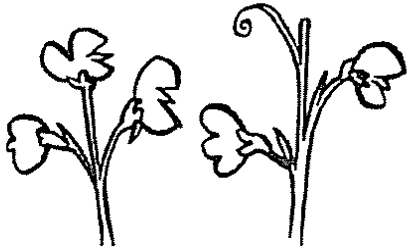
THESE ARE THE **SEVEN TRAITS** THAT MENDEL CHOSE FOR HIS STUDIES ON HEREDITY IN PEA PLANTS, AND THE TWO PHENOTYPES IN WHICH EACH MIGHT BE EXPRESSED:

1 HEIGHT:

TALL OR SHORT

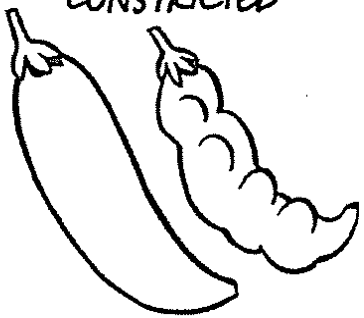
2 FLOWER LOCATION:

TIP OF STEM OR ALONG THE STEM



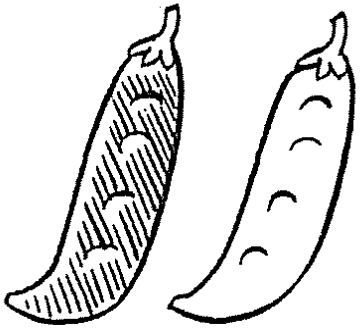
3 POD SHAPE:

INFLATED OR CONSTRICTED



4 POD COLOR:

GREEN OR YELLOW

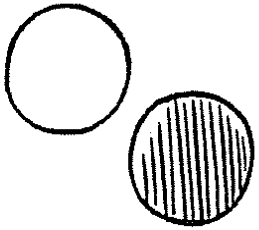


5 SEED SHAPE:

ROUND OR WRINKLED

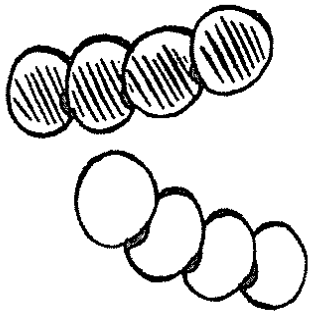
6 SEED COLOR:

YELLOW OR GREEN



7 SEED COAT COLOR:

GRAY OR WHITE



Mendel's Peas

- **Homozygous** means to have **2 identical** alleles for a trait.
  Ex. TT or tt True-breeding pea plants are homozygous.

- **Heterozygous** means to have **2 different** alleles for a trait.
  Ex. Tt Hybrid plants are heterozygous.

Generations of Pea Plants

P = **Parent generation** = your parents

F1 = **First generation** offspring. = you

Produces **hybrids** = crosses between parents with different traits (Tall x short) (TT x tt)

F2 = **Second generation** offspring. = your kids

Formed from hybrid x hybrid. **(Tt x Tt)** (F1 x F1)

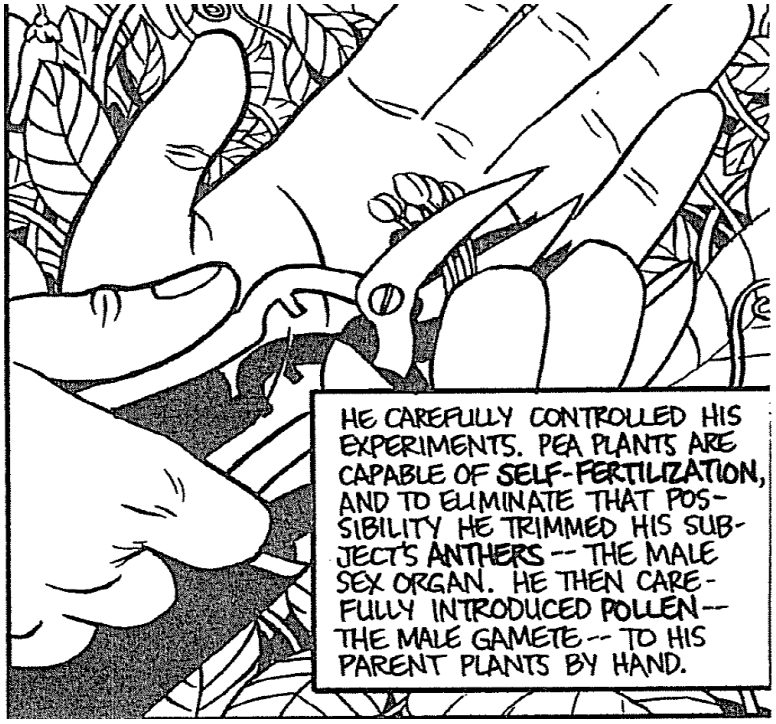
Mendel's Experiment: TT x tt

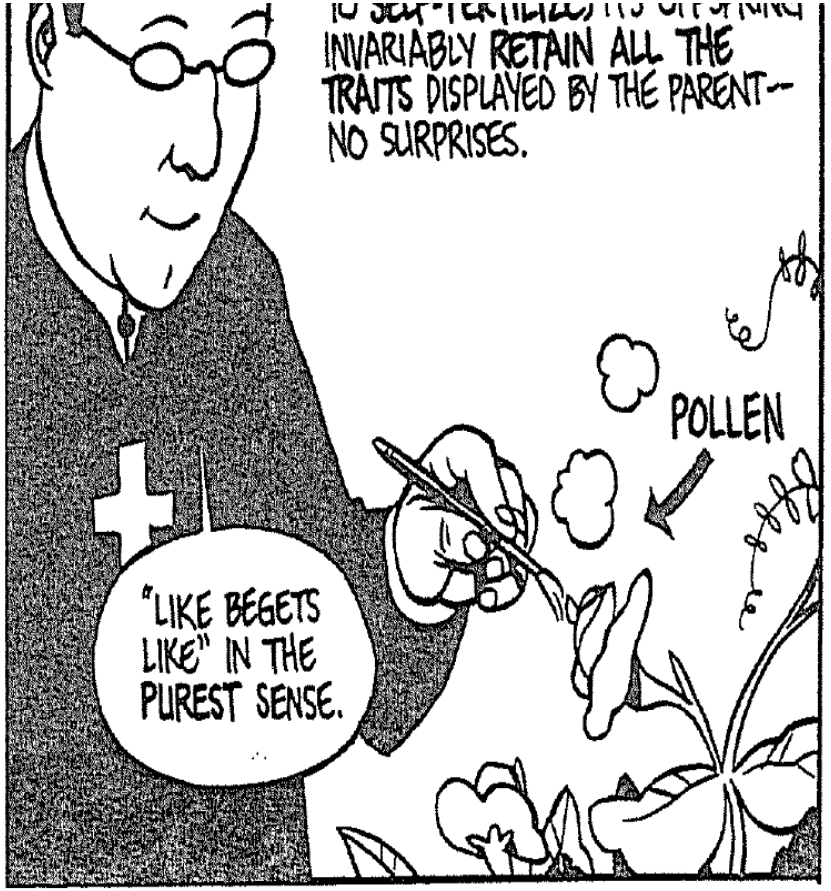
Question: True-breeding tall x true breeding short? (P generation)

Hypothesis: Mendel expected **medium-sized** plants in F1 generation.

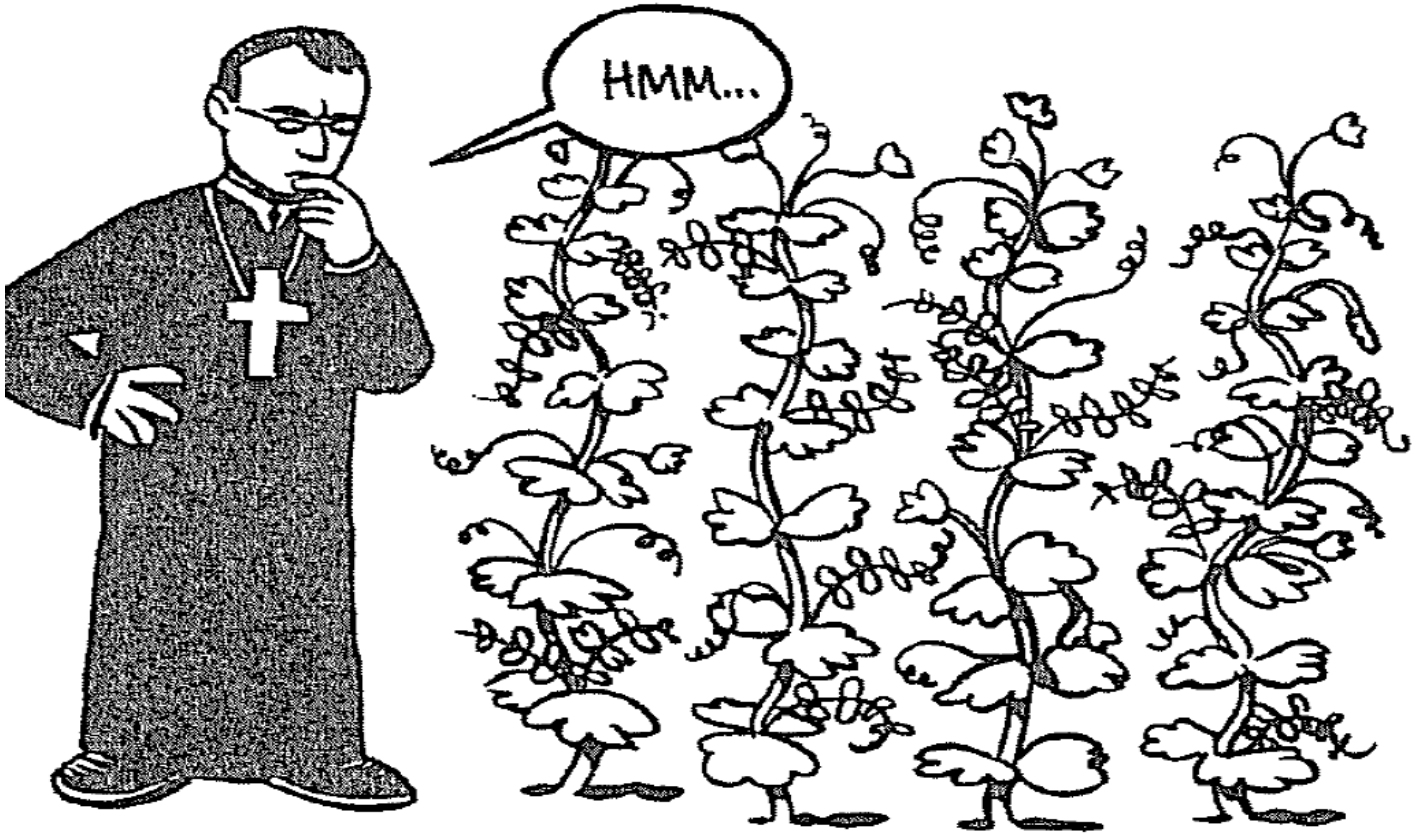
Method: He **cross-pollinated** plants, taking pollen from one flower onto another.

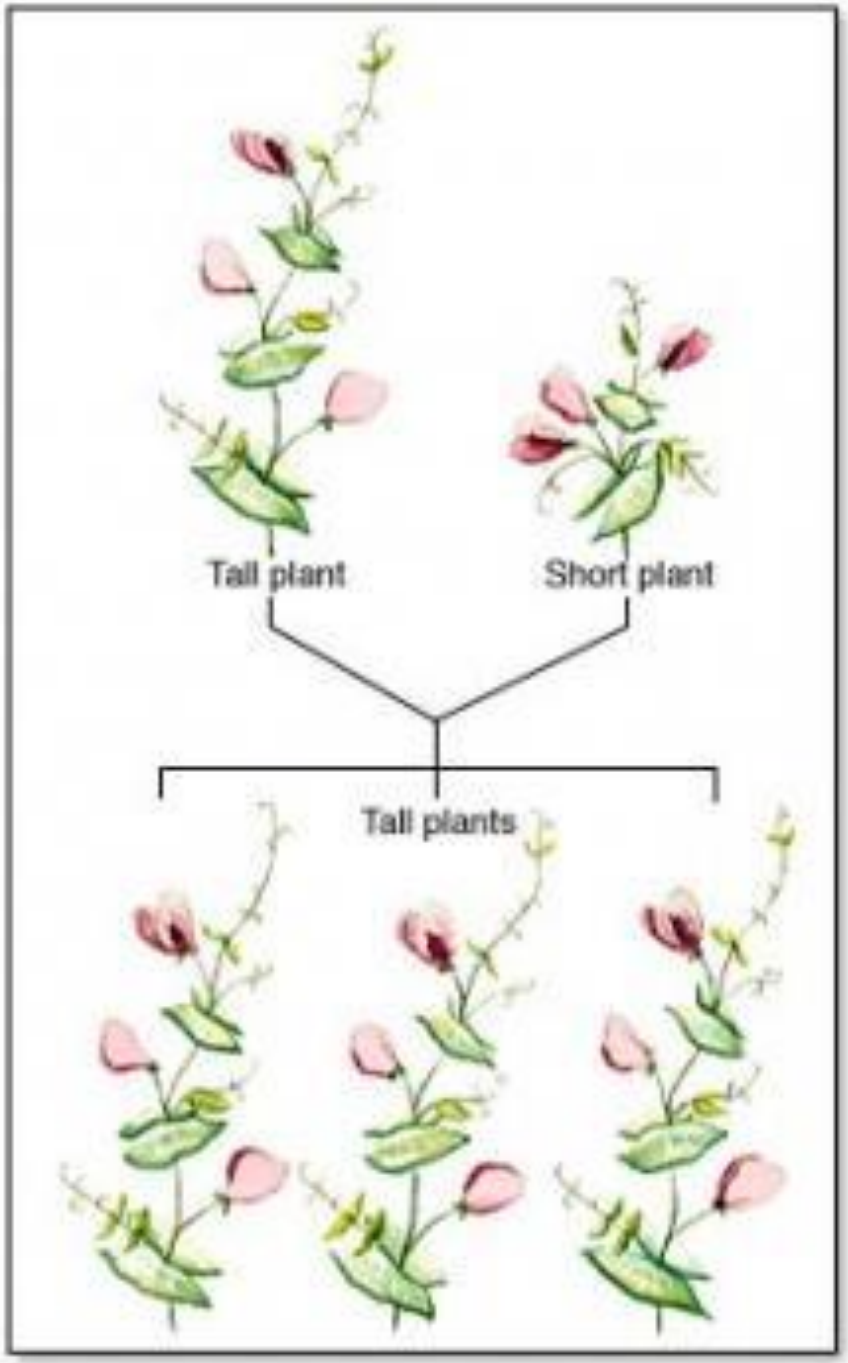
Results: F1 generation = hybrid generation
- All plants were **TALL**, not medium as expected.


HE CAREFULLY CONTROLLED HIS EXPERIMENTS. PEA PLANTS ARE CAPABLE OF SELF-FERTILIZATION, AND TO ELIMINATE THAT POSSIBILITY HE TRIMMED HIS SUBJECT'S ANTHERS -- THE MALE SEX ORGAN. HE THEN CAREFULLY INTRODUCED POLLEN -- THE MALE GAMETE -- TO HIS PARENT PLANTS BY HAND.


INVARIABLY RETAIN ALL THE TRAITS DISPLAYED BY THE PARENT-- NO SURPRISES.
POLLEN
"LIKE BEGETS LIKE" IN THE PUREST SENSE.

HIS RESULTS OF THESE **MONOHYBRID CROSSES** WERE EXTREMELY CONSISTENT. IN THIS CASE, THE TALL CROSSED WITH THE SHORT ALWAYS PRODUCED **TALL** OFFSPRING PLANTS.




Tall plant
Short plant
Tall plants

Mendel's Experiment:

TT x tt

Genotypic ratio (genetic makeup):
0TT: 4 Tt : 0 tt

Phenotype (physical appearance):
4 Tall : 0 short

	T	T
t	**Tt**	**Tt**
t	**Tt**	**Tt**

Conclusion: **Principle of Dominance:** some alleles are dominant and others are recessive

Principle of Dominance

Dominant traits are expressed if only one allele is present. (capital letter, first letter of trait ex. **Tall= T)**

Ex - Tall allele **(T)** is dominant and short allele is recessive **(t)**

F1 generation = All plants were tall even though Tt

both **TT and Tt** plants are Tall

WHILE 75% OF THE OFFSPRING OF THE F_1 GENERATION SHOWED THE TALL TRAIT...

...25% CAME UP SHORT!

Principle of Dominance

Recessive traits are expressed when the dominant allele **not present.** Two alleles are needed for the recessive trait to be expressed. (lower case letter)

Ex from pea plants- short allele is recessive (t)

Only tt plants are short.

Principle of Dominance

The Principle of Dominance explains why genotype differs from phenotype.

Genotypes for plant height are **TT, Tt, tt.** Genotypes can be heterozygous or homozygous.

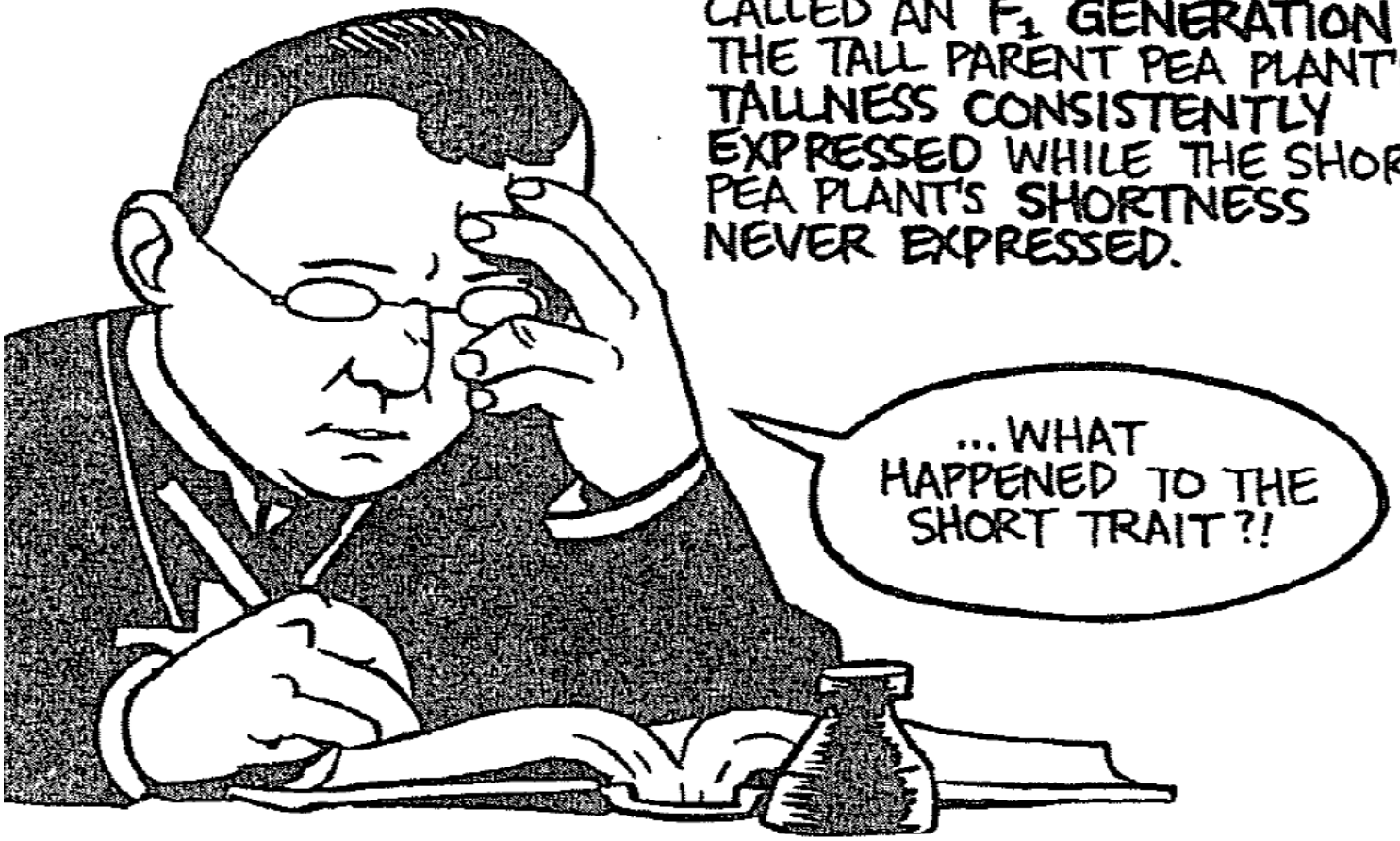
Phenotypes for plant height are **tall or short.**

TT and Tt genotypes both expressed the **tall** phenotype because the T is dominant to t.

Only the tt genotype expressed the **short** phenotype.

THAT WAS AN IMPORTANT OBSERVATION: UP UNTIL THEN, THE ACCEPTED THEORY HELD THAT INHERITED TRAITS WERE A **BLEND** OF BOTH PARENTS' TRAITS. THERE WAS CLEARLY **NO** BLENDING OF HEIGHT TRAITS IN THE PEA PLANTS.

WHAT MENDEL **DID** SEE WAS THAT IN THE OFFSPRING — CALLED AN **F_1 GENERATION** -- THE TALL PARENT PEA PLANT'S **TALLNESS CONSISTENTLY EXPRESSED** WHILE THE SHORT PEA PLANT'S **SHORTNESS NEVER EXPRESSED.**



Mendel's Experiment: Tt x Tt

Question: Have the recessive alleles disappeared?

Hypothesis: The F2 generation will be all tall plants.

Method: **F1 x F1** Tt x Tt = Mendel allowed the hybrids to self-pollinate

	T	t
T	**TT**	**Tt**
t	**Tt**	**tt**

Mendel's Experiment: Tt x Tt

Result: F2 Generation

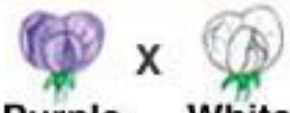
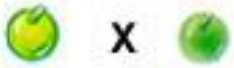
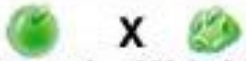
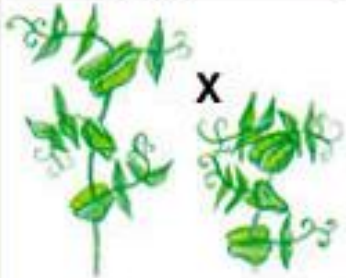
genotypic ratio:
1 TT : 2 Tt : 1 tt

phenotypic ratio:
3 tall: 1 short

	T	t
T	**TT**	**Tt**
t	**Tt**	**tt**

- The recessive alleles **reappeared** and were expressed.

Mendel's Experiment Results

Trait	Dominant vs. recessive	F_2 generation Dominant form	F_2 generation Recessive form	Ratio
Flower color	 Purple X White	705	224	3.15:1
Seed color	 Yellow X Green	6022	2001	3.01:1
Seed shape	 Round X Wrinkled	5474	1850	2.96:1
Pod color	 Green X Yellow	428	152	2.82:1
Pod shape	 Round X Constricted	882	299	2.95:1
Flower position	 Axial X Top	651	207	3.14:1
Plant height	 Tall X Dwarf	787	277	2.84:1

Mendel's Experiment: Tt x Tt

Conclusion:

Principle of Segregation: 2 alleles for a trait **separate** during **meiosis.** Each gamete receives only one allele.
-The alleles are on separate **homologous chromosomes.**

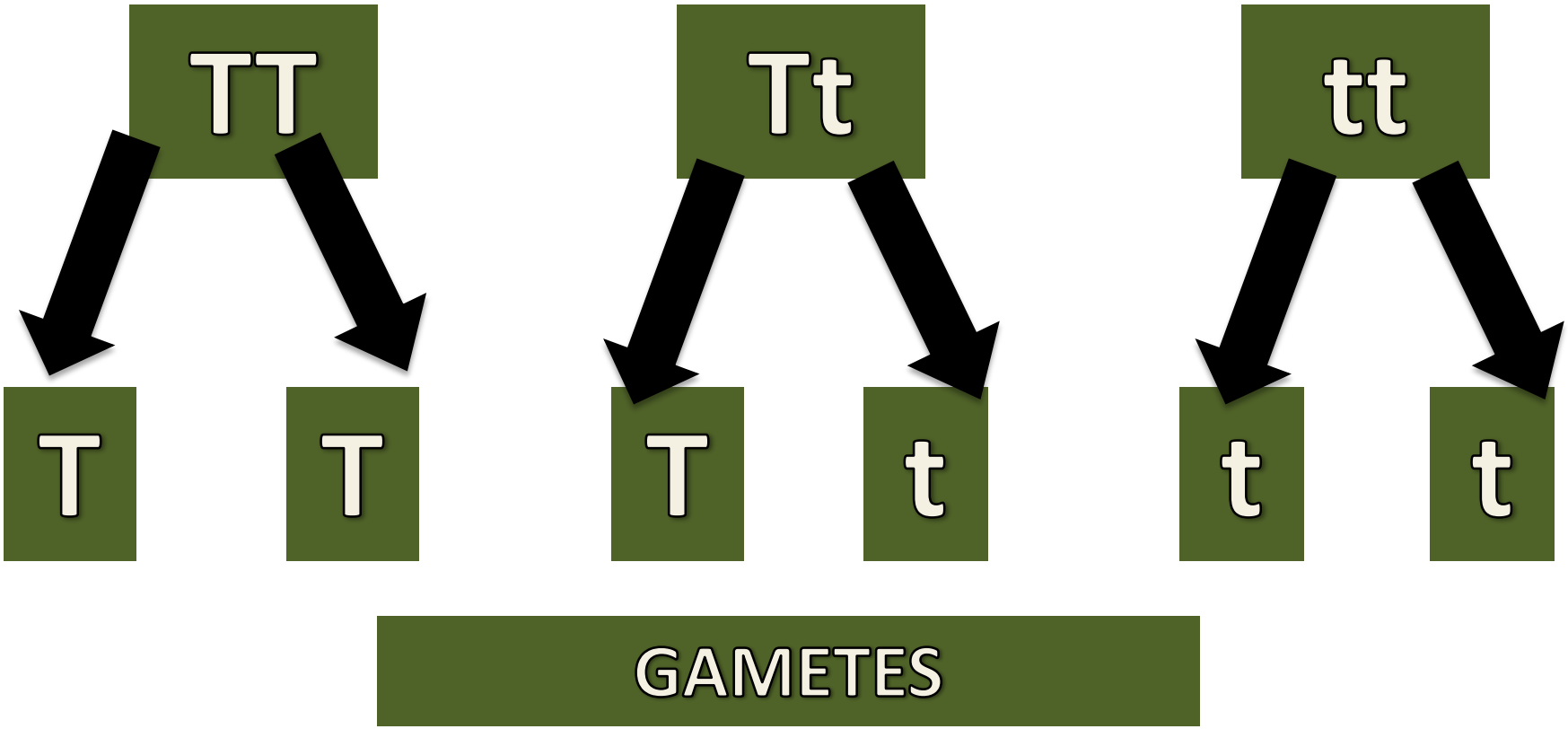
T and t separated (segregated) during meiosis, and each gamete received only T or t.

Principle of Segregation

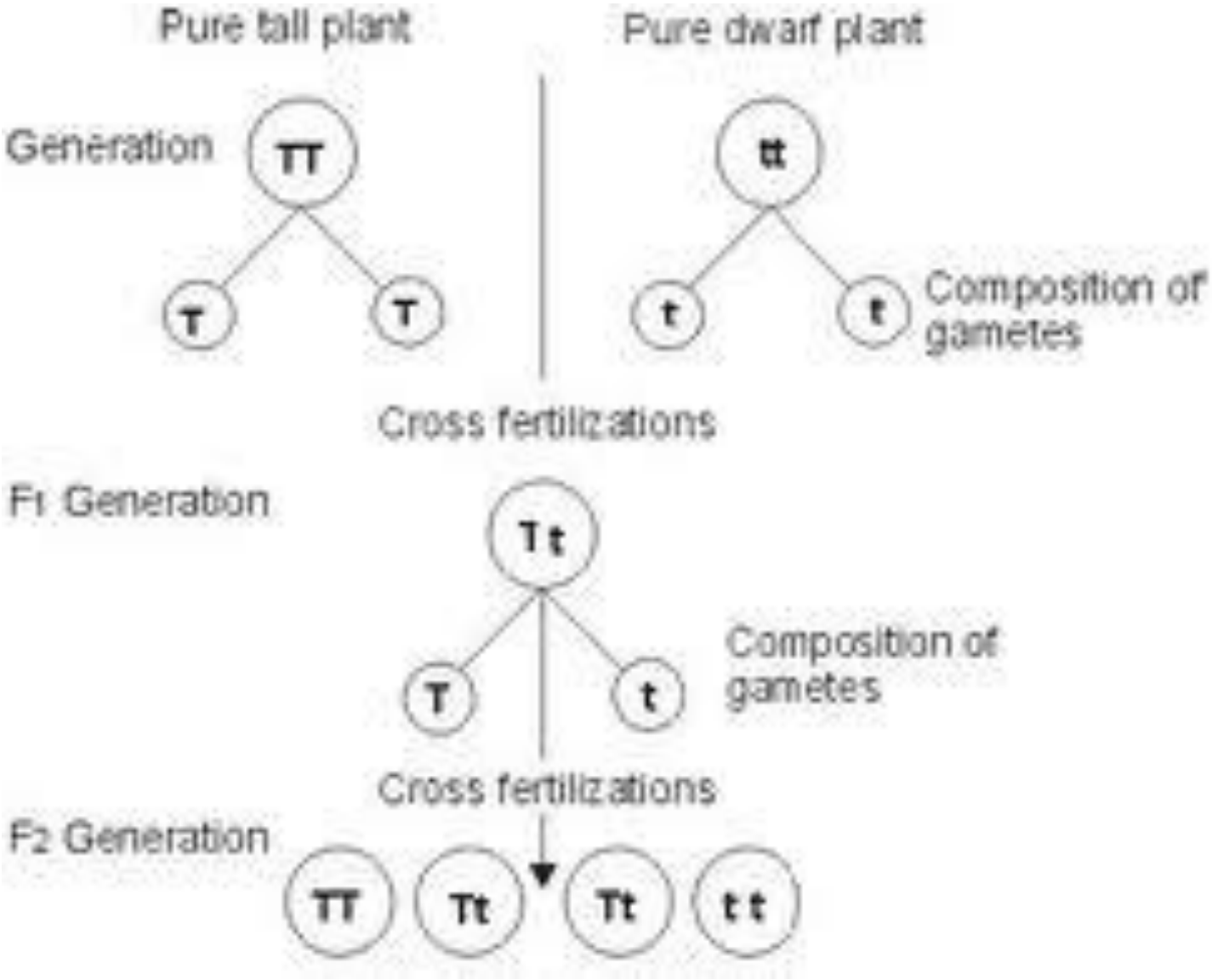
During fertilization, a “t” gamete fertilized a “t” gamete 1/4 of the time, resulting in tt short plants.

This accounts for **new combinations of alleles** that were not present in either parent.

Principle of Segregation



Principle of Segregation



Punnett Squares

- A **Punnett square** is a diagram that **predicts outcomes** of genetic crosses.
- use dominance to determine phenotype from genotype

- Ex. #1 *In humans, having **dimples is dominant** to not having dimples. Predict the genotypic and phenotypic ratios of a cross between a man heterozygous for dimples and a woman without dimples.*

D = dimples
d = no dimples

Equation: **Dd x dd**

•Genotypic ratio:
0DD: 2 Dd: 2 dd

•Phenotypic ratio:
2 dimples: 2 no dimples

	D	d
d	**Dd**	**dd**
d	**Dd**	**dd**

Link: Mendel Rap

- Lryics:
- The answer's in my garden where I've planted different peas
- And sprinkled pollen as I pleased then counted out the progeny.
- What did you discover in your garden with your peas?
- About those factors we can't see but which explain our family trees?
- Here's the news. They come in two's. They separate. It's up to fate. If an egg or a sperm has a trait that will dominate.
- And when they join together, my forecasting's most impressive. Bet you, three times out of four I'm right unless they're both recessive.
- But where these hidden factors are well that I cannot fathom.