MENDELIAN GENETICS

OVERVIEW

- Introduction to Genetics and heredity
- Gregor Mendel – a brief biography
- Genetic terminology
- Monohybrid crosses
- Dihybrid crosses

INTRODUCTION TO GENETICS

- **GENETICS** – branch of biology that deals with heredity and variation of organisms.

- **Chromosomes** carry the hereditary information (genes)
  - Arrangement of nucleotides in DNA
  - DNA → RNA → Proteins

GREGOR JOHANN MENDEL

- Austrian Monk, born in what is now Czech Republic in 1822
- Son of peasant farmer, studied Theology and was ordained priest Order St. Augustine.
- Went to the university of Vienna, where he studied botany and learned the Scientific Method
- Worked with pure lines of peas for eight years
- Prior to Mendel, heredity was regarded as a "blending" process and the offspring were essentially a "dilution"of the different parental characteristics.

Gregor Mendel

MENDEL PEA PLANTS

- Mendel looked at seven traits or characteristics of pea plants:

Trait	Stem length	Pod shape	Seed shape	Seed color	Flower position	Flower color	Pod color
Characteristics	 Tall	 Inflated	 Smooth	 Yellow	 Lateral	 Purple	 Green
	 Dwarf	 Constricted	 Wrinkled	 Green	 Terminal	 White	 Yellow

MENDEL'S WORK

- In 1866 he published *Experiments in Plant Hybridization*, (*Versuche über Pflanzen-Hybriden*) in which he established his three Principles of Inheritance
- He tried to repeat his work in another plant, but didn't work because the plant reproduced asexually!
- Work was largely ignored for 34 years, until 1900, when 3 independent botanists rediscovered Mendel's work.

MENDEL'S WORK

- Mendel was the first biologist to use Mathematics – to explain his results quantitatively.
- Mendel predicted

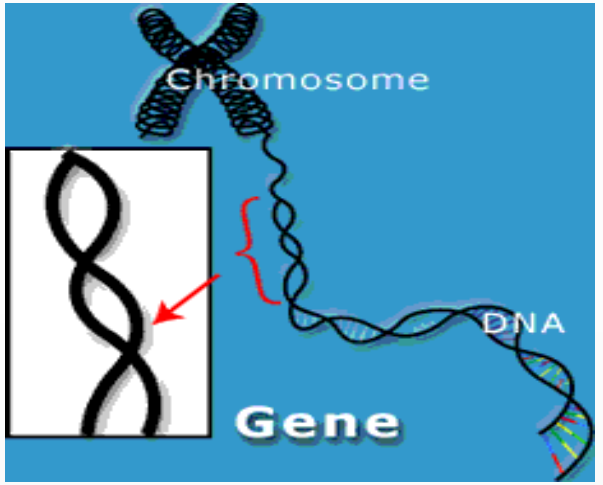
  The concept of genes

  That genes occur in pairs

  That one gene of each pair is present in the gametes

GENETICS TERMS YOU NEED TO KNOW

- **Gene** – a unit of heredity; a section of DNA sequence encoding a single protein
- **Genome** – the entire set of genes in an organism
- **Alleles** – two genes that occupy the same position on homologous chromosomes and that cover the same trait (like ‘flavors’ of a trait).
- **Locus** – a fixed location on a strand of DNA where a gene or one of its alleles is located.



GENETICS TERMS YOU NEED TO KNOW

- **Homozygous** – having identical genes (one from each parent) for a particular characteristic.
- **Heterozygous** – having two different genes for a particular characteristic.
- **Dominant** – the allele of a gene that masks or suppresses the expression of an alternate allele; the trait appears in the heterozygous condition.
- **Recessive** – an allele that is masked by a dominant allele; does not appear in the heterozygous condition, only in homozygous.

GENETICS TERMS YOU NEED TO KNOW

- **Genotype** – the genetic makeup of an organisms
- **Phenotype** – the physical appearance of an organism (Genotype + environment)
- **Monohybrid cross**: a genetic cross involving a single pair of genes (one trait); parents differ by a single trait.
- **P** = Parental generation
- $\mathbf{F_1}$ = First filial generation; offspring from a genetic cross.
- $\mathbf{F_2}$ = Second filial generation of a genetic cross

MONOHYBRID CROSS

- Parents differ by a single trait.
- Crossing two pea plants that differ in stem size, one tall one short

  T = allele for Tall

  t = allele for dwarf

  TT = homozygous tall plant

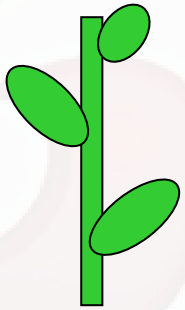
  t t = homozygous dwarf plant

T T × t t

Long or short stems

MONOHYBRID CROSS FOR STEM LENGTH

P = parentals
true breeding,
homozygous plants:



T T × *t t*

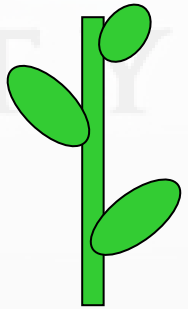
(tall) (dwarf)

↓

T *t*

(all tall plants)

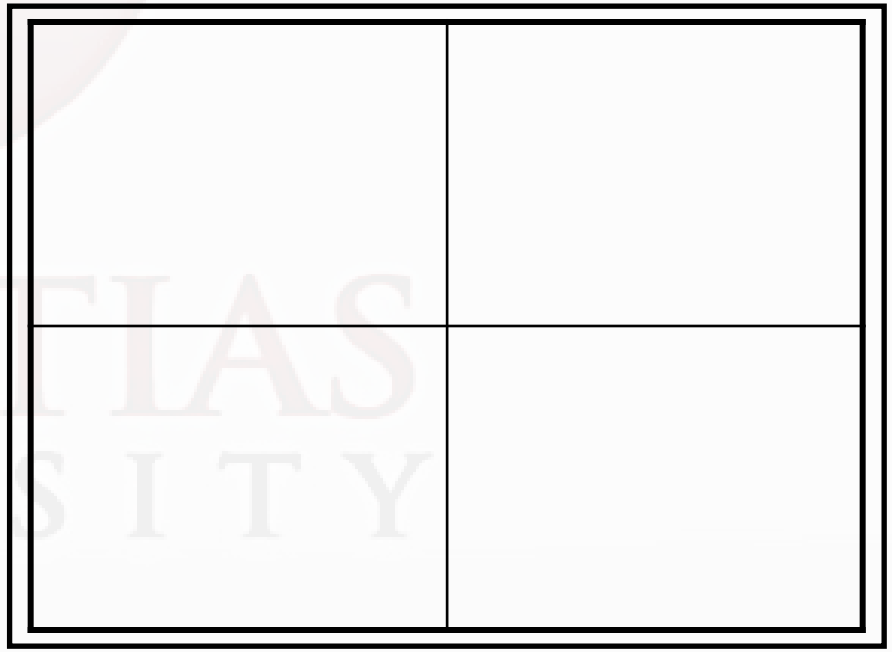
F_1 generation
is heterozygous:



PUNNETT SQUARE

- A useful tool to do genetic crosses
- For a monohybrid cross, you need a square divided by four….
- Looks like a window pane…

We use the Punnett square to predict the genotypes and phenotypes of the offspring.



USING A PUNNETT SQUARE

STEPS:

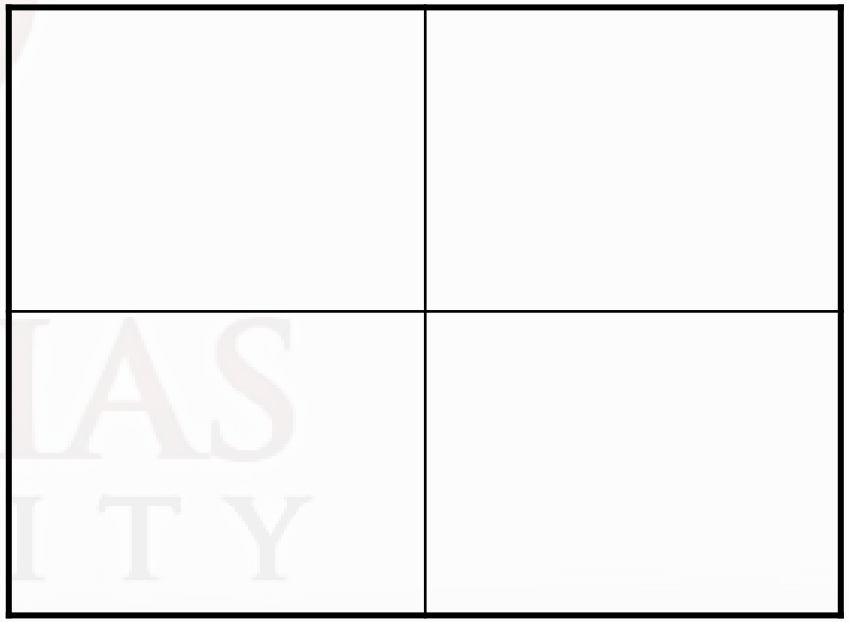
1. determine the genotypes of the parent organisms
2. write down your "cross" (mating)
3. draw a p-square

Parent genotypes:

TT and *t t*

Cross

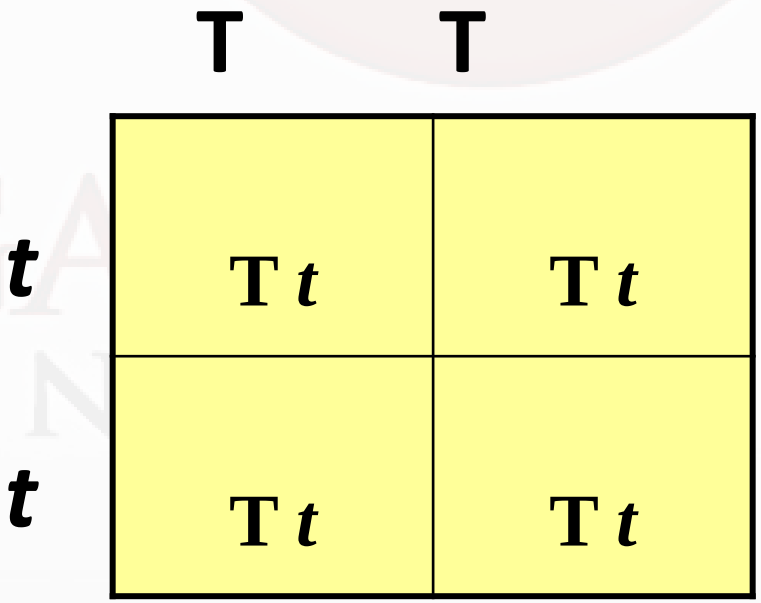
T T × ***t t***



PUNNETT SQUARE

4. **"split" the letters of the genotype for each parent & put them "outside" the p-square**
5. determine the possible genotypes of the offspring by filling in the p-square
6. summarize results (genotypes & phenotypes of offspring)

T T × ***t t***



Genotypes:
100% T t

Phenotypes:
100% Tall plants

MONOHYBRID CROSS: F2 GENERATION

- If you let the F1 generation self-fertilize, the next monohybrid cross would be:

T *t* × **T *t***

(tall) (tall)

	T	***t***
T	**T T**	**T *t***
t	**T *t***	***t t***

Genotypes:
1 TT= Tall
2 T*t* = Tall
1 *tt* = dwarf
Genotypic ratio= 1:2:1

Phenotype:
3 Tall
1 dwarf
Phenotypic ratio= 3:1

SECRET OF THE PUNNETT SQUARE

- Key to the Punnett Square:
- Determine the gametes of each parent…
- How? By “splitting” the genotypes of each parent:

If this is your cross

T T × *t t*

The gametes are:

Once you have the gametes…

T **T** × ***t*** ***t***

	t	***t***
T	**T *t***	**T *t***
T	**T *t***	**T *t***

MENDEL'S PRINCIPLES

- **1. Principle of Dominance**:

  One allele masked another, one allele was dominant over the other in the F_1 generation.

- **2. Principle of Segregation**:

  When gametes are formed, the pairs of hereditary factors (genes) become separated, so that each sex cell (egg/sperm) receives only one kind of gene.

DIHYBRID CROSSES

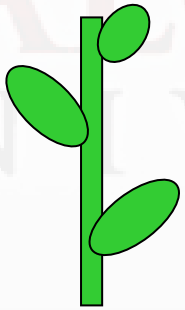
- Matings that involve parents that differ in **two** genes (two independent traits)

For example, flower color:

P = purple (dominant) 

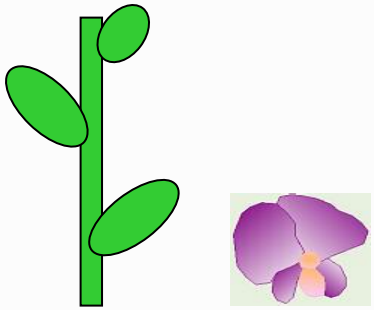
p = white (recessive) 

and stem length:

T = tall 

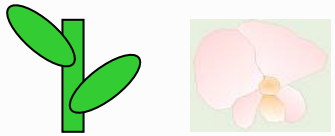
t = short 

DIHYBRID CROSSES : FLOWER COLOR AND STEM LENGTH



TT PP × *tt pp*

(tall, purple) (short, white)



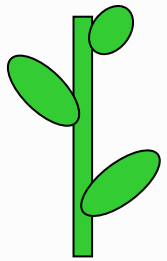
Possible Gametes for parents

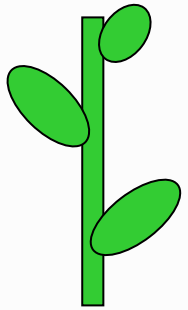
T P and *t p*

F1 Generation: All tall, purple flowers (T*t* P*p*)

	tp	*tp*	*tp*	*tp*
TP	T*t*P*p*	T*t*P*p*	T*t*P*p*	T*t*P*p*
TP	T*t*P*p*	T*t*P*p*	T*t*P*p*	T*t*P*p*
TP	T*t*P*p*	T*t*P*p*	T*t*P*p*	T*t*P*p*
TP	T*t*P*p*	T*t*P*p*	T*t*P*p*	T*t*P*p*

DIHYBRID CROSSES : 4 PHENOTYPES

9 Tall  purple 

3 Tall  white 

3 Short  purple 

1 Short  white 

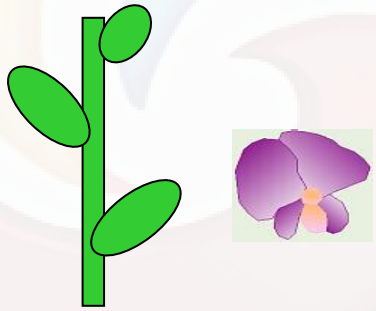
	TP	T*p*	*t*P	*tp*
TP	TTPP	TT*P*p	T*t*PP	T*t*P*p*
T*p*	TT*P*p	TT*pp*	T*t*P*p*	T*tpp*
*t*P	T*t*PP	T*t*P*p*	*tt*PP	*tt*P*p*
tp	T*t*P*p*	T*tpp*	*tt*P*p*	*ttpp*

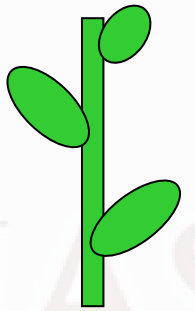
Phenotype Ratio = 9:3:3:1

DIHYBRID CROSSES : 9 GENOTYPES

Genotype ratios (9): Four Phenotypes:

1	TTPP	Tall, purple (9)
2	TTP*p*	
2	T*t*PP	
4	T*t*P*p*	
1	TT*pp*	Tall, white (3)
2	T*tpp*	
1	*tt*PP	Short, purple (3)
2	*tt*P*p*	
1	*ttpp*	Short, white (1)





PRINCIPLE OF INDEPENDENT ASSORTMENT

- Based on these results, Mendel postulated the **3. Principle of Independent Assortment**:

  "Members of one gene pair segregate independently from other gene pairs during gamete formation"

Genes get shuffled – these many combinations are one of the advantages of sexual reproduction

SUMMARY

- Chromosomes carry hereditary info (genes)
- Contribution of G J Mendel
- Monohybrid vs. Dihybrid crosses
- Mendel's Principles:
  - Dominance: one allele masks another
  - Segregation: genes become separated in gamete formation
  - Independent Assortment: Members of one gene pair segregate independently from other gene pairs during gamete formation

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