Genetics: Mendelian Genetics

Patterns of Inheritance

Outline

1. Key concepts
2. A few terms
3. Mendel's Experimental Approach
4. Monohybrid
5. Dihybrid
6. Incomplete dominance
7. Polygenic inheritance

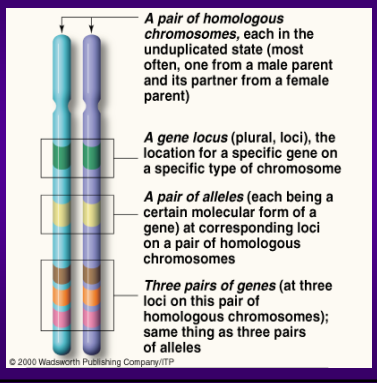
Key Concepts:

1. Genes are units of information about inherited traits
2. Each gene has a particular location on a particular chromosome
3. During meiosis, paired genes are moved apart
4. Gregor Mendel found evidence for gene segregation

Key Concepts:

5. **Homologous chromosomes are independently distributed and assorted during meiosis**
6. **Not all traits are clearly dominant or recessive but can be partially dominant or codominant**
7. **Environmental factors can induce variations in traits**

A Few Genetics Terms



A Few Genetics Terms

Gene – function unit codes some trait.

Alleles - one of alternative forms of a particular gene

True-breeding - produce offspring consistently identical to the parent with respect to certain defined characters after generations

Homozygous – carrying two copies of the same allele of a given gene (= True breeding)

Heterozygous - carrying two different alleles of a given gene

A Few Genetics Terms

Dominant - allele that expresses itself

Recessive - an allele that is masked

Genotype - an organism's allelic (genetic) makeup

Phenotype - the outward appearance or expression of an organism

Generations

- P - parental generation
- F_1 - offspring of the parental generation
- F_2 - offspring of the F1

Gregor Mendel

Father of Genetics – Gregor Mendel

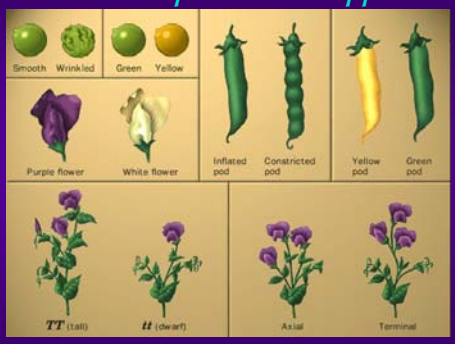
Mendel was an Austrian monk with an interest in botany. He attended the University of Vienna for 2 years, where he studied botany and mathematics, among other subjects. He did some wonderful experiments, which were the foundation for the modern science of genetics.

Mendel's Experimental Approach

Mendel chose to study peas because:

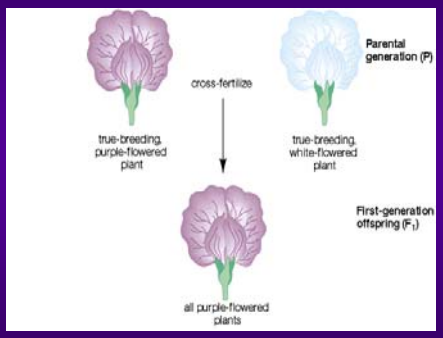
- They were small, easy, and inexpensive
- They had a short generation time
- Many varieties of pure lines available which were "true-breeding"
- He could obtain large numbers for mathematical analysis of the data

Mendel's Experimental Approach

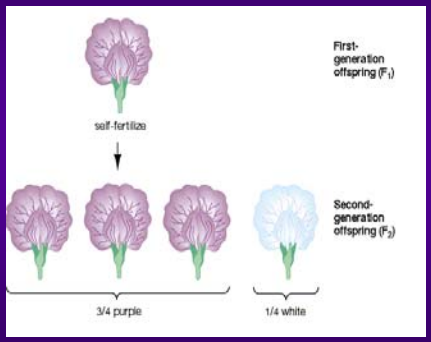


Mendel studied seven traits, one at a time

Mendel's Monohybrid Cross



Mendel's Monohybrid Cross



Mendel's Monohybrid Cross

P: Purple flowered X White flowered

F1: All purple flowered

Dominant form appears in F1

Recessive form does not appear in F1

F1: Purple X Purple

F2: ¾ purple flowered; ¼ white flowered

If: P = purple flowered and p = white flowered

PP- Dominant homozygous;

Pp- heterozygous; pp-Recessive homozygous

P: PP X pp

F1: Pp, then Pp X Pp

F2: ¼ PP, 2/4 Pp, ¼ pp

Mendel's Monohybrid Cross

[Punnett Square] = a way to predict the genotypes and phenotypes of offspring in specific crosses

F2 generation:

¼ purple flowered – Homozygous (PP)

2/4 purple flowered – Heterozygous (Pp)

¼ white flowered – Homozygous (pp)

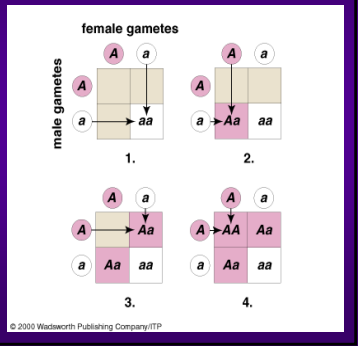
phenotypic ratio: purple flowered : white flowered = 3:1

genotypic ratio: PP:Pp:pp = 1:2:1

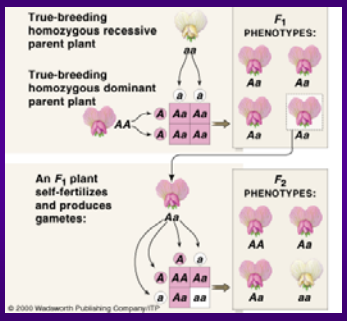
Probability and Punnett Squares

A possibility of gene combinations of next generation from

TEST CROSSES



Mendel's Monohybrid Cross



Dominant-to-Recessive ratio in F_2 plants is 3:1

Results from Mendel's Monohybrid Cross

Pea Plant

Trait Studied	Dominant Form	Recessive Form	F_2 Dominant-to-Recessive Ratio
SEED SHAPE	5,474 round	1,850 wrinkled	2.96:1
SEED COLOR	6,022 yellow	2,001 green	3.01:1
POD SHAPE	882 inflated	299 wrinkled	2.95:1
POD COLOR	428 green	152 yellow	2.82:1

Trait Studied	Dominant Form	Recessive Form	F_2 Dominant-to-Recessive Ratio
FLOWER COLOR	705 purple	224 white	3.15:1
FLOWER POSITION	651 along stem	207 at tip	3.14:1
STEM LENGTH	787 tall	277 dwarf	2.84:1

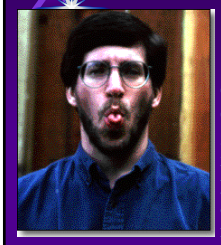
Mendel's First Law

The results from Mendel's monohybrid crosses became the basis of a theory (Law) of **segregation**, which we state here in modern terms:

Each gamete receives only one of each parent's pair of genes for each trait.

When a sperm fertilizes an egg, the resulting offspring receives one allele from the father and one from the mother

Independent assortment



Some people can roll their tongues, other cannot. Some people have attached earlobes, others have free earlobes. The genes that influence these traits are inherited independently. As a result, some people who can roll their tongues also have attached earlobes, while other tongue rollers have detached earlobes.

Independent assortment was first described in the mid-nineteenth century by Gregor Mendel, who was studying inherited traits in garden pea plants. Mendel noted that traits such as flower color and plant height seemed to be inherited independently. To better understand this variation, Mendel carried out a series of dihybrid crosses such as that shown on the following page.

Mendel's Dihybrid Cross

P: Smooth (S) & Yellow seeded (Y)
wrinkled (s) & green seeded (y)
(both true-breeding)

P: SSYY X ssyy

F1: All Smooth & Yellow seeded

F1: SsYy

[Punnett Square]

F2 expected genotypic ratio:

1/16 SSYY, 2/16 SSYy, 2/16SsYY, 4/16 SsYy
1/16 SSyy, 2/16 Ssyy
1/16 ssYY, 2/16 ssYy
1/16 ssyy

Mendel's Dihybrid Cross

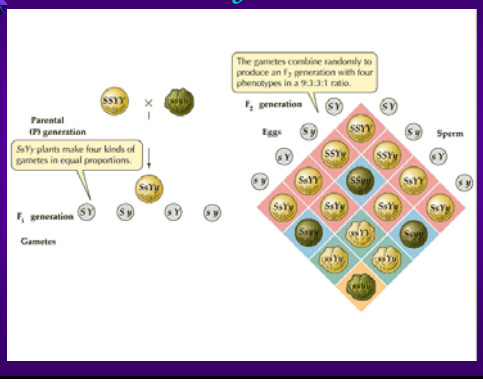
F2 phenotypic ratio:

9/16 (S-Y-) Smooth & Yellow seeded
3/16 (S-yy) Smooth & green seeded
3/16 (ssY-) wrinkled & Yellow seeded
1/16 (ssyy) wrinkled & green seeded

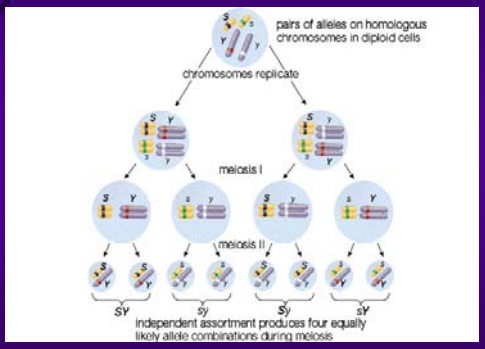
Mendel's results (total plants 556):

S&Y=315, S&g=108,w&Y=101, w&g=32
556 x 9/16 = 312.8;
556 x 3/16 = 104.2;
556 x 1/16 = 34.8

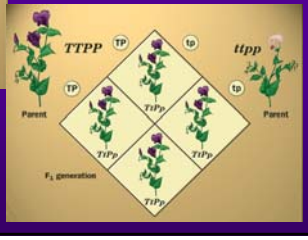
Mendel's Dihybrid Cross



Mendel's Dihybrid Cross



Mendel's Dihybrid Cross



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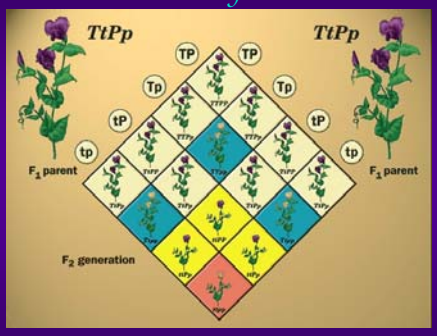


Phenotypic ratio in F_2 plants is 9:3:3:1

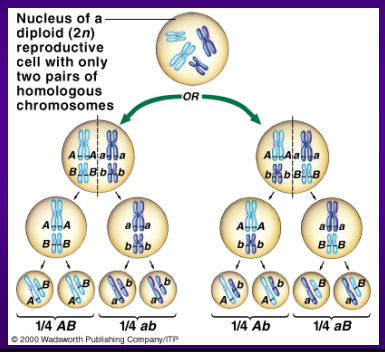
Mendel's Second Law

Mendel's dihybrid crosses all showed the same phenotypic ratio of about 9:3:3:1.

On the basis of such observations, Mendel formulated a theory (law) of **Independent assortment**:

The alleles for one trait may distributed to the gametes independently of the alleles for the other traits.

Independent Assortment



Incomplete dominance

Incomplete dominance – heterozygous phenotype is intermediate between two parents

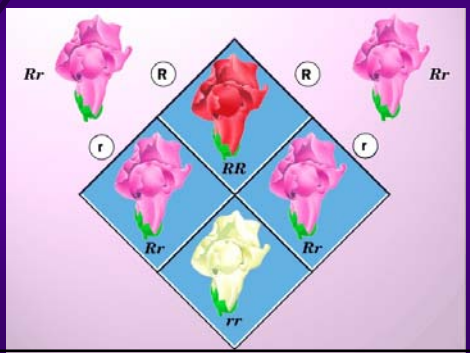
for example, snapdragons:

P: Red x White (RR x R′R′)

F1:Pink (RR′)

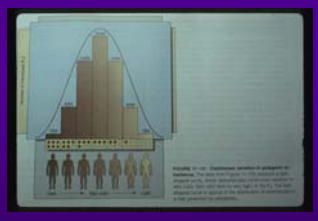
F2: ¼ Red(RR), 2/4 Pink(RR′), ¼ White(R′R′)

Incomplete dominance



Polygenic inheritance

Polygenic inheritance – when alleles at more than one locus contribute to the same trait

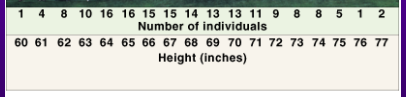


for example:

(1) **skin color**

(2) **human height**

Polygenic inheritance



In Conclusion

1. *A gene is a unit of information about a heritable trait*
2. *Mendel provided evidence of dominant and recessive genes*
3. *Monohybrid crosses are crosses between two individuals that are homozygous for different versions of a trait*
4. *Crosses from F_1 result in F_2 offspring with phenotypes having a 3:1 ratio*

In Conclusion

5. *Dihybrid crosses result in 9:3:3:1 phenotypic ratio*
6. *Theory of Independent Assortment states that gene pairs independently sort out into different gametes regardless of other gene pairs of other chromosomes*