Genetics (BTBio 211)

Lec. 1

Dr. Rehab M. Hafez

Biotechnology Students (BTBIO 211)
For 2nd level/ 3rd Semester
Genetics (Part 1)

قسم النبـــات و الميكروبيولوجى

WEEKS	DATE	CONTENTS	
		Lecture	Lab
5	Sa 8/11- Wed 12/11	GENETIC TRANSMISSION & MENDELIAN GENETICS	------------------------
6	Sa 15/11- Wed 19/11	MIDTERM (Dr. Magda's part)	
7	Sa 22/11- Wed 26/11	TRANSMISSION AND INHERITANCE OF CHROMOSOMES (Quiz on Lecture 1)	MENDELIAN PROBLEMS
8	Sa 29/11- Wed 3/11	LINKAGE AND MAPPING (Quiz on Lecture 2)	MITOSIS AND MIEOSIS & FEULGIN SQUASH TECHNIQUE
9	Sa 6/11- Wed 10/11	EXTENSIONS OF MENDEL'S LAWS (Quiz on Lecture 3)	LINKAGE AND MAPPING PROBLEMS
10	Sa 13/11- Wed 17/11	MIDTERM (on lectures 1, 2, 3)	PRACTICAL EXAM

N.B. There is an assignment every week in lecture.

SCHEDULE (2014-2015)

6-5	5-4	4-3	3-2	2-1	1-12	12-11	11-10	10-9	9-8	الايام
	BTBIO 211 lab.			Students follow-up			MIC 312 lab.			السبت
	BTBIO 211 lab.			Students follow-up						الاحد
BTBIO 211 lect.										
BTBIO 211 lect.				Students follow-up						الاثنين
										الثلاثاء
	BTBIO 211 lab.			Students follow-up			B 252 Lab			الاربعاء
				MIC 411 Lab.			B252 Lect.			الخميس

GENETICS: PART I

Course Syllabus:

1. Genetic Transmissions. (Sun 9/11, Mon 10/11)
2. Mendelian Genetics. (Sun 9/11, Mon 10/11)
3. Transmission and inheritance of chromosomes. (Sun 23/11, Mon 24/11)
4. Linkage and Mapping. (Sun 30/11, Mon 1/12)
5. Extensions of Mendel's laws. (Sun 7/12, Mon 8/12)

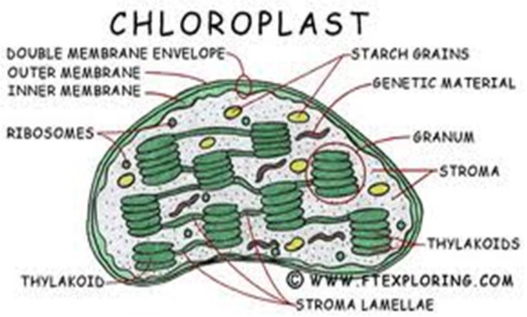
1. GENETICS TRANSMISSION

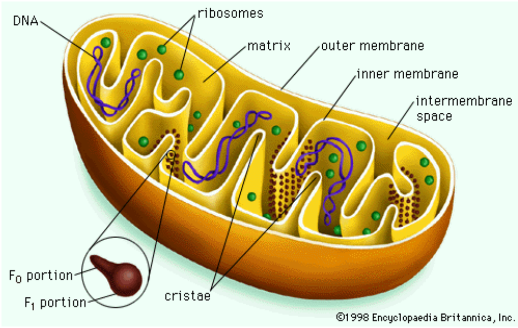
Genetics

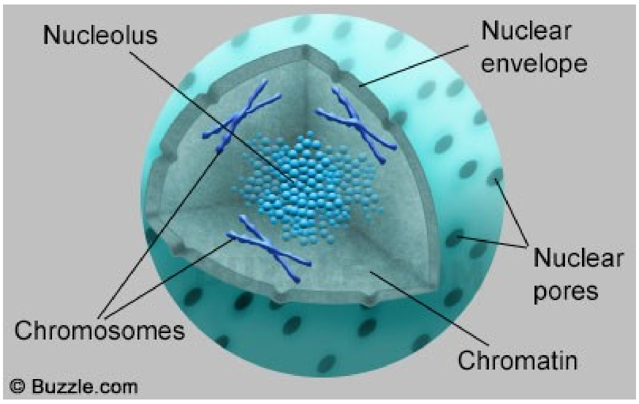
It is the science that seeks to understand, explain and ultimately exploit the phenomenon of heredity (i.e. transmission of biological characteristics, its mechanism and its variation).

Genetic material

The genetic material of a cell can be a gene, a part of a gene, a group of genes, a DNA molecule, a fragment of DNA, a group of DNA molecules, or the entire genome of an organism or even RNA in certain viruses. They are found in the nucleus, cytoplasm, mitochondria and plastids (for algae and plant), which play a fundamental role in determining the structure and nature of cell substances, and capable of self-propagating and variation.







Heredity – the passing on of characteristics from parents to offspring.

Breeding- is the reproduction producing of offspring, usually animals or plants.

Traits – characteristics that are inherited.

Hybrid – offspring of parents that have different traits.

Genetic transmission (genetic transfer, GT) is almost synonymous with heredity, which study of how genetic information from genes are transmitted from cell to cell and generation to generation (from parent to offspring), how they recombine and segregate, with the goal of explaining the numerical proportions of the progeny in cross.

There are two types of genetic transmission:

1. **Vertical gene transmission** (VGT) is the transmission of genes from one generation of species (the parental or ancestor generation) to the next generation of the same species (offspring) via sexual or asexual reproduction (figure below).

   DNA encodes all the information necessary to make an organism.

   DNA → RNA → Protein

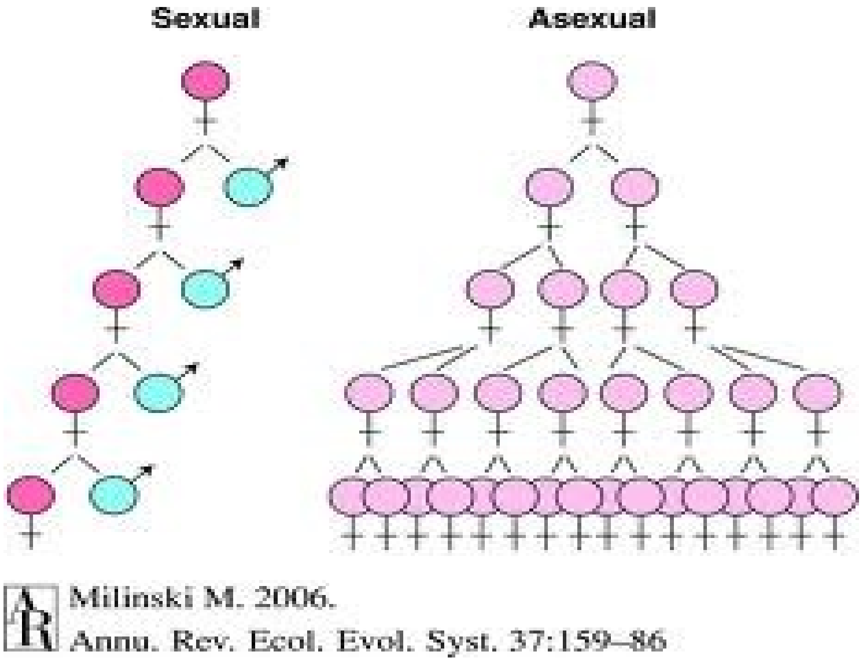
   Every organism's DNA is made of the same basic parts, arranged in different orders.

There are two ways for vertical gene transfer:

Sexual reproduction is a biological process by which organisms create descendants that have a combination of genetic material contributed from two (usually) different members of the species using meiosis. Sexually reproducing organisms have different sets of genes (2 or more) for every trait or character (called alleles). Offspring inherit one allele for each trait from each parent, thereby ensuring that offspring have a combination of the parents' genes. Most animals (including humans) and plants reproduce sexually.

Asexually reproducing organisms creates descendants that have a copy of the same genetic material using mitosis. Bacteria divide asexually via binary fission; viruses take control of host cells to produce more viruses; Hydras (invertebrates of the order *Hydroidea*) and yeasts are able to reproduce by budding. Other ways of asexual reproduction include parthenogenesis, fragmentation and spore formation.

Both these mechanisms (sexual and asexual rep.) involve duplication of DNA, which then gets passed to offspring. RNA is a key component in the duplication of DNA.

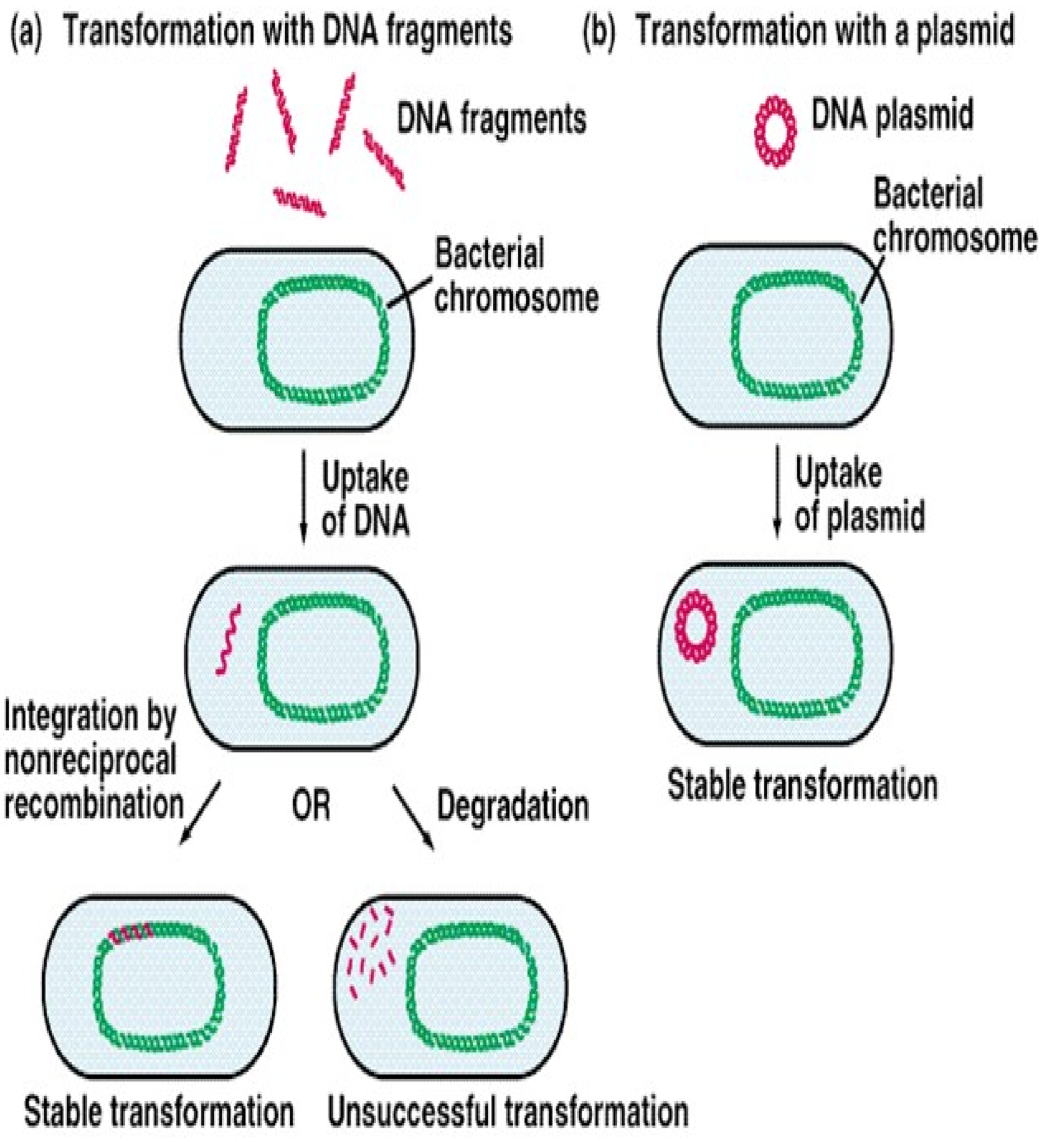


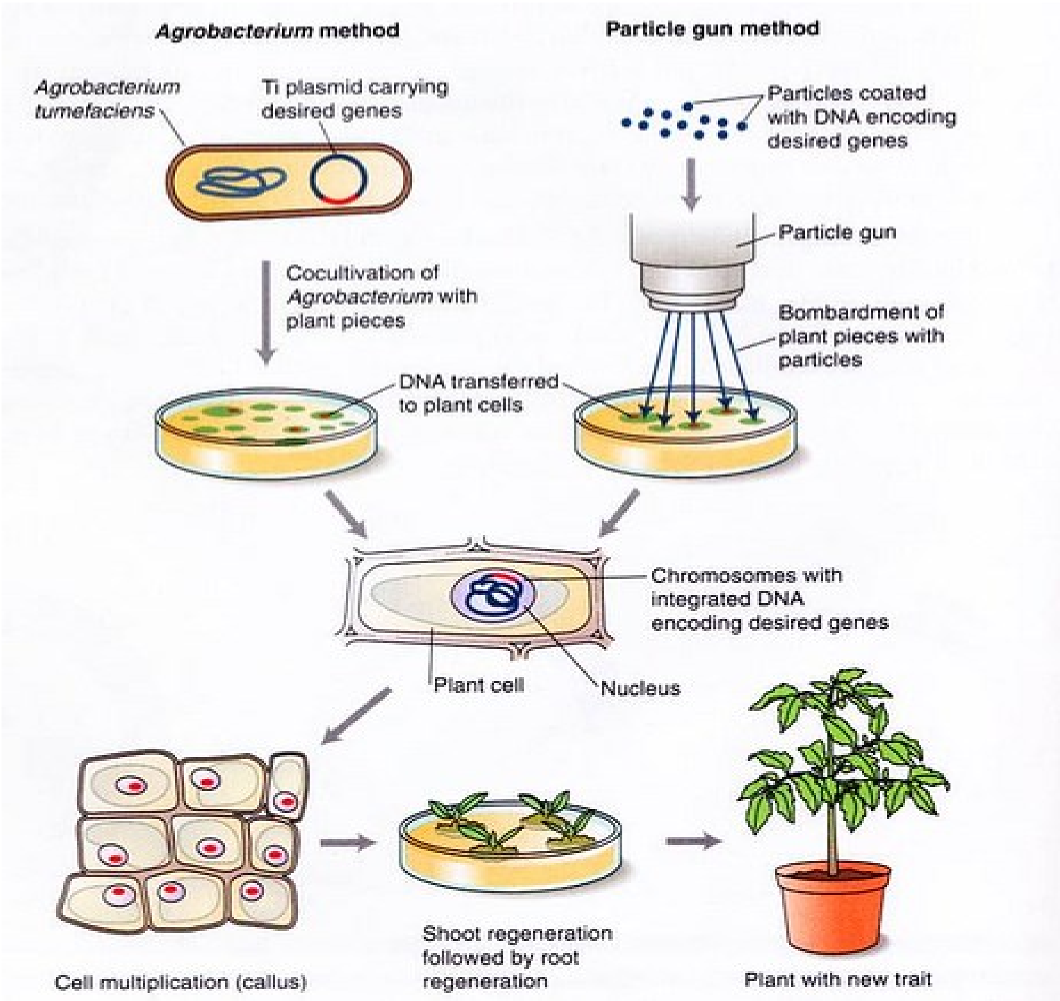
2. **Horizontal gene transmission** (**HGT**) refers to the transfer of genes between organisms, from one species to another species, in a manner other than traditional reproduction. It is also termed lateral gene transfer.

   HGT has been shown to be an important mechanism that drives evolution of many organisms due to the incorporation of genetic material from an organism to another one without being the offspring of that organism.

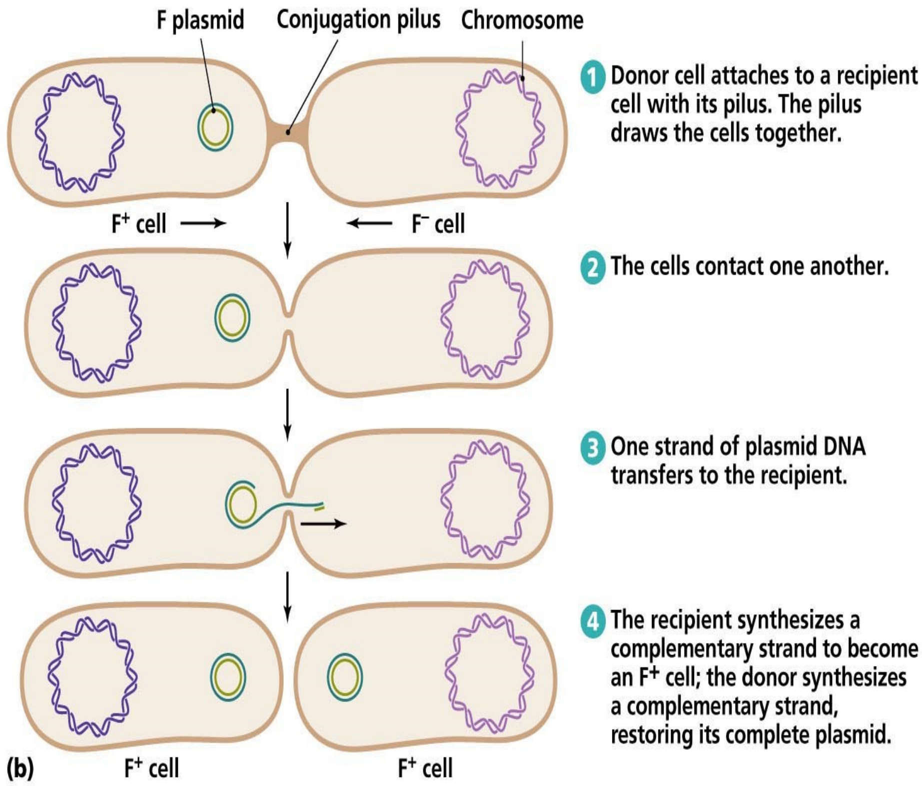
There are three main mechanisms for horizontal gene transfer:

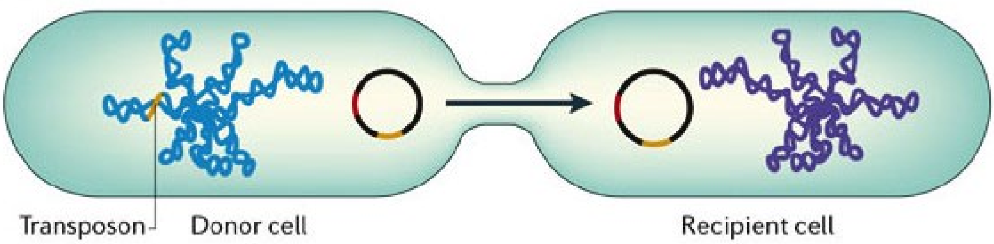
a. **Transformation**, the genetic alteration of a cell resulting from the introduction, uptake and expression of foreign genetic material in form of fragment (DNA or RNA) or plastids either naturally or artificially (figure below). Artificial transformation happens in laboratories to insert novel genes into bacteria, plant, animal, stem cell, insect, … for research experiments or for industrial or medical applications through molecular biology and biotechnology. Transformation of tomato, potato, canola, … with *Agrobacterium tumefaciens* or by gene gun (biolistic) for fungal or salt tolerance (figure below).

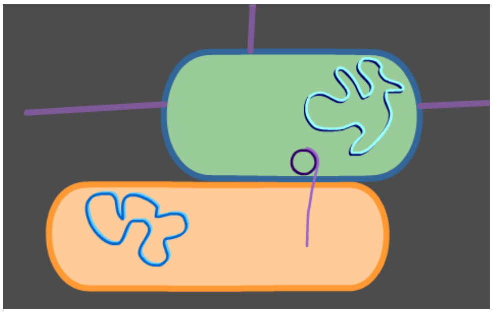


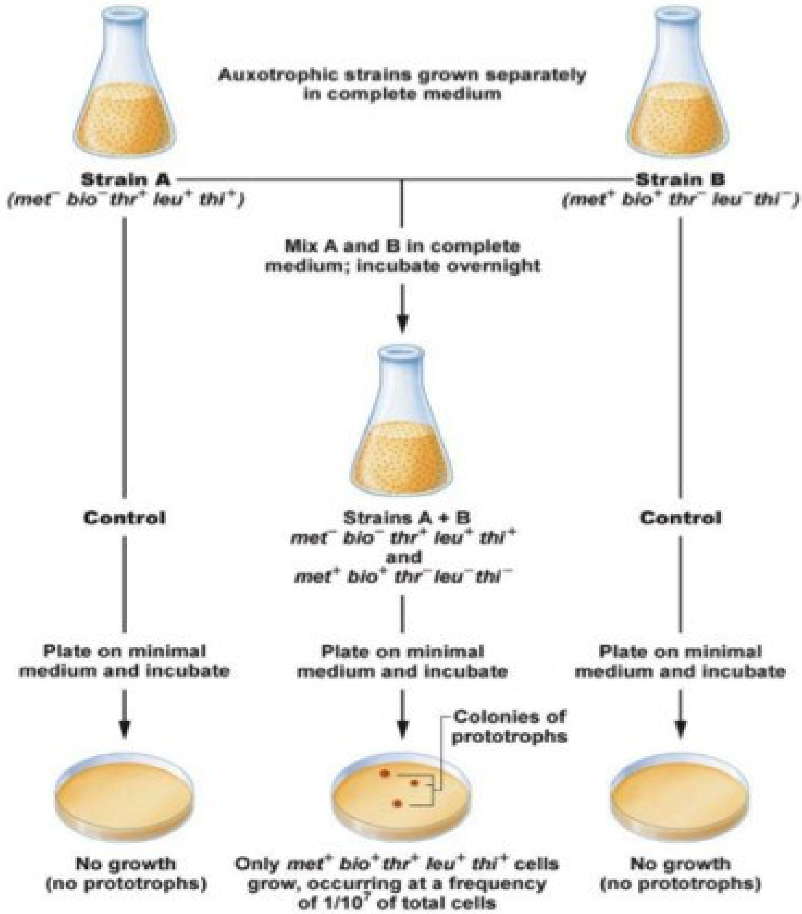


b. Conjugation, a process in which a cell transfers genetic material to another cell by cell-to-cell contact or by a bridge-like connection between two cells (figures below). During conjugation the donor cell provides a conjugative or mobilizable genetic element that is most often a plasmid or transposon (jumping gene). Most conjugative plasmids have systems ensuring that the recipient cell does not already contain a similar element. The genetic information transferred is often beneficial to the recipient. Benefits may include antibiotic resistance, xenobiotic tolerance or the ability to use new metabolites (figure below). This process is common in bacteria.


F plasmid
Conjugation pilus
Chromosome
1 Donor cell attaches to a recipient cell with its pilus. The pilus draws the cells together.
F+ cell
F− cell
2 The cells contact one another.
3 One strand of plasmid DNA transfers to the recipient.
4 The recipient synthesizes a complementary strand to become an F+ cell; the donor synthesizes a complementary strand, restoring its complete plasmid.
(b)
F+ cell
F+ cell


Transposon
Donor cell
Recipient cell

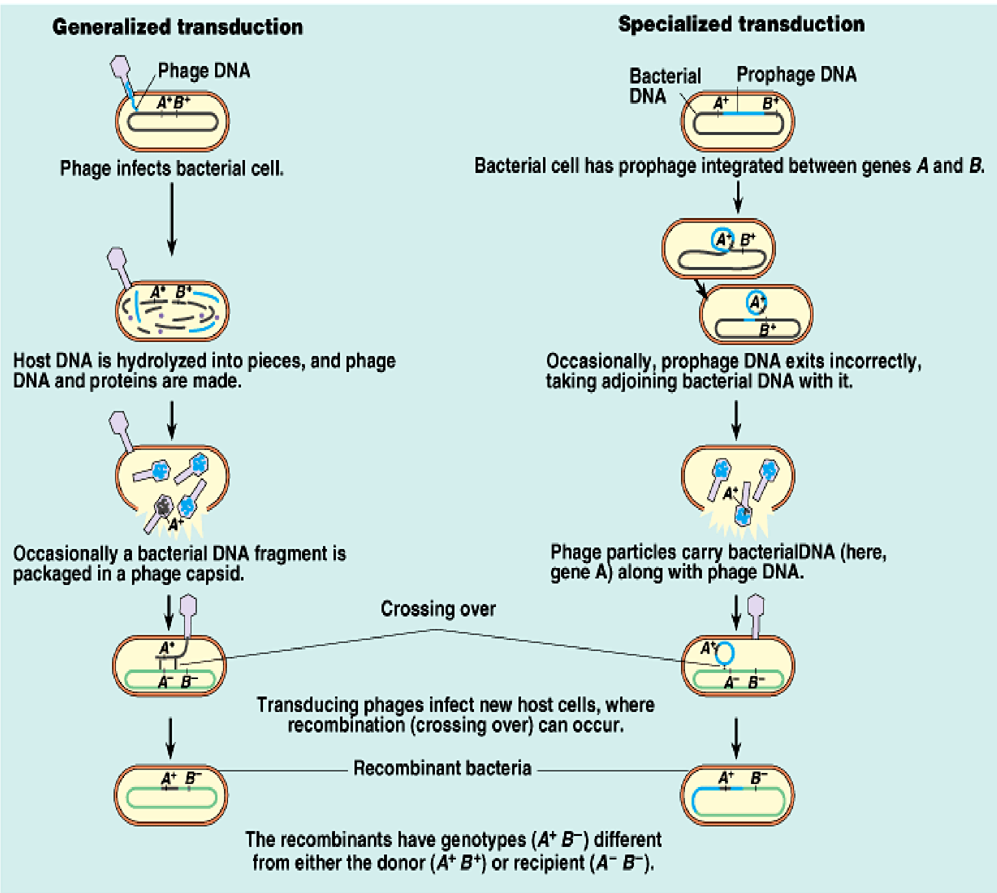




c. **Transduction** is a method in which bacterial DNA is moved from one bacterium to another by a virus. When the process whereby foreign DNA is introduced into another cell by bacteriophage is called **Generalized transduction (natural)**, while the process used a viral vector (prophage) is known as **Specialized transduction (artificial)**. Transduction does not require physical contact between the cell donating the DNA and the cell receiving the DNA (which occurs in conjugation). Phages also inject their DNA into host DNA so it's copied and passed on (figure below).

Transduction is a common tool used by molecular biologists to stably introduce a foreign gene into a host cell's genome. Transduction is especially important because it explains:

- mechanism by which antibiotic drugs become ineffective due to the transfer of antibiotic-resistance genes between bacteria, which is becoming a medical challenge to deal with. This is the most critical reason that antibiotics must not be consumed and administered to patients without appropriate prescription from a medical physician.
- the evolution of bacteria that can degrade novel compounds such as human-created pesticides, and in the evolution, maintenance, and transmission of virulence.



NOTE: Most thinking in genetics has focused upon vertical transfer, but there is a growing awareness that horizontal gene transfer is a highly significant phenomenon and among single-celled organisms perhaps the dominant form of genetic transfer.

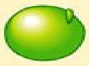
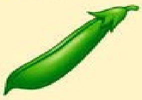
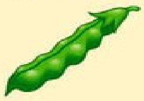
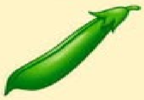
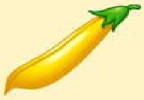
The genetic material is found primarily in the nucleus of the cell and that it is organized in the form of chromosomes. We will explore how the genetic material is inherited from generation to generation and the changes in the organization of the genetic material that occur between generations. This subdiscipline of genetics is called Transmission Genetics or Mendelian Genetics after Gregor Mendel who discovered the laws of inheritance with his experiments on garden peas.

2. GENETICS TRANSMISSION: HERITAGE FROM MENDEL

Mendel's Crossing Experiments with Peas

In 1865, the Austrian monk Gregor Mendel began his series of crossing experiments with garden peas. By any standard, Mendel was a very gifted scientist who appreciated the importance of carefully designing and interpreting his experiments. Mendel sought to understand the patterns of inheritance of seven different characters in peas (table below) by crossing plants with identifiably different **phenotypes** of a particular character, and then following the presence or absence of the character in successive generations. The traits Mendel studied were morphological attributes of the seed, pod, flower and stem (table below).

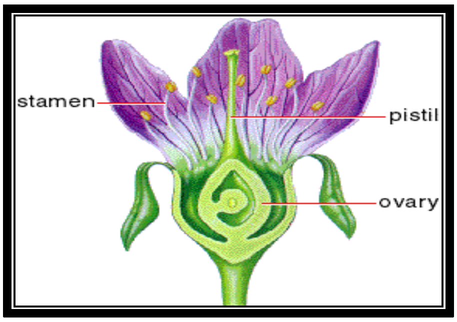
Table. Seven Pea-Plant characters studied by Mendel

Character	Dominant Trait	×	Recessive Trait
Flower color	Purple 	×	White 
Flower position	Axial 	×	Terminal 
Seed color	Yellow 	×	Green 
Seed shape	Round 	×	Wrinkled 
Pod shape	Inflated 	×	Constricted 
Pod color	Green 	×	Yellow 
Stem length	Tall 	×	Dwarf 

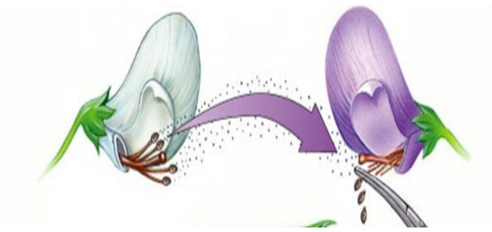
The types of crosses Mendel made are still widely used in genetics today. Unfortunately, Mendel’s discoveries were largely ignored during his lifetime, and it was not until 1900 that his work was rediscovered by three European scientists, Hugo de Vries, Carl Correns, and Erich von Tschermak and its importance finally appreciated. Mendel's findings allowed other scientists to predict the expression of traits on the basis of mathematical probabilities.

Why peas?

- Can be grown in a small area
- Produce lots of offspring
- Available in many varieties with distinct heritable features with different variations: flower color, seed color, seed shape, etc.
- Produce pure plants when allowed to self-pollinate (*Self-fertilization* can occur in the same flower) for several generations



- Can be artificially cross-pollinated (*Cross-fertilization* can occur between different flowers)



- Mendel had strict control over which plants mated with which:
  1. Peas contain both gametes (♀/♂) in the same flower
  2. Pollen contains sperm produced by the stamen (♂)
  3. Ovary contains eggs inside the flower (♀)
  4. Pollen carries sperm to the eggs for fertilization

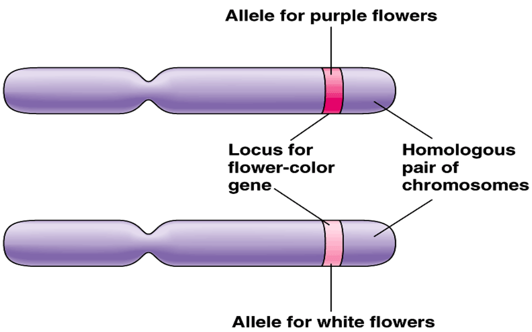
MENDELIAN TERMS

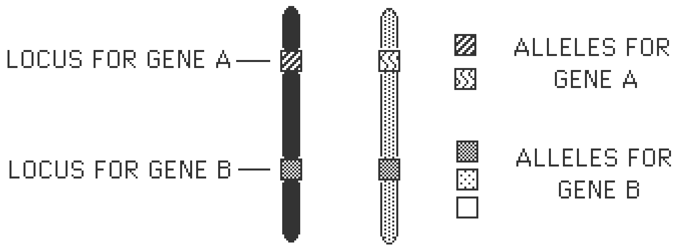
Gene: A part of the genetic material that carries information about a specific character. Genes are found on chromosomes and each gene has a designated place on every chromosome, called a locus. Each gene is signed by at least 2 alleles.

Character: Heritable feature that varies among individuals (eg. flower color).

Trait: A variant for character, such as white or purple colors for flowers.

Alleles- alternative form or version of a single gene passed from generation to generation. Each allele is at specific locus responsible for a trait of the character which the gene controls (photo below). They are referred to by letters (capital and small).



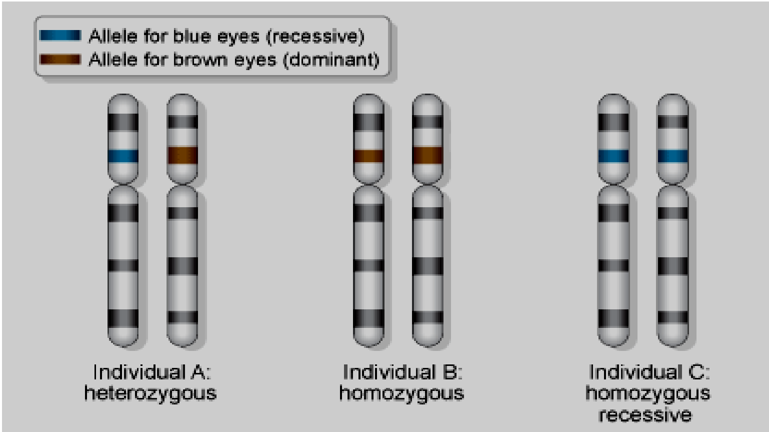


Phenotype – the way an organism looks and behaves (tall or short or color,…)

Genotype – it is the genetic make-up and can give the information about the gene combination an organism contains either homozygous or heterozygous alleles (TT, Tt, tt)

Homozygous: The individual is called homozygous for certain character If the two alleles controlling such character are similar (TT or tt).

Heterozygous: The individual is called heterozygous for certain character If the two alleles controlling such character are Different (Tt).



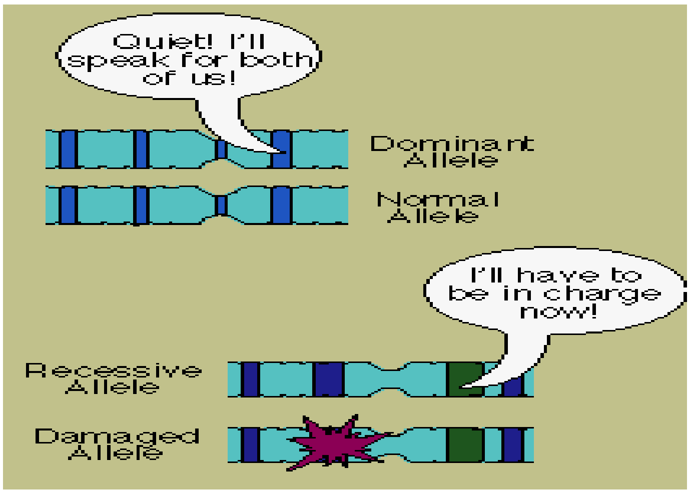
purple	PP	homozygous dominant

purple	P*p*	heterozygous

Dominant and Recessive in genetics is a relationship between alleles of a single gene. In heterozygous individual one allele is expressed (the trait it controlled appears) and the other allele is not expressed or masked (the trait it controlled does not appear). The expressed allele and its trait are dominant (sign by capital letter), while the not expressed or masked allele and its trait is recessive (sign by small letter).

Dominant gene that produces the same phenotype in the organism whether or not its allele identical.

Recessive gene is an allele that causes a phenotype (visible or detectable characteristic) that is only seen in a homozygous genotype (an organism that has two copies of the same allele) and never in a heterozygous genotype.



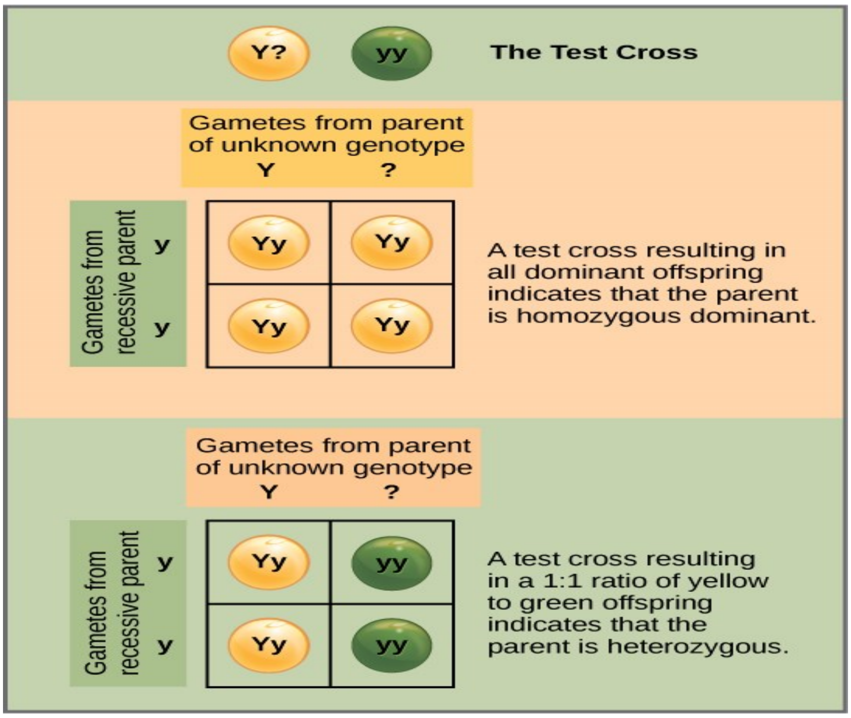
Genetic cross -breeding or mating of two different individuals resulting in offspring that carries a portion of the genetic material of both the parent individuals.

Monohybrid crosses – the two parents differ by a single trait (eg. height).

Dihybrid cross – the two parents differ by two different traits (eg. height and color).

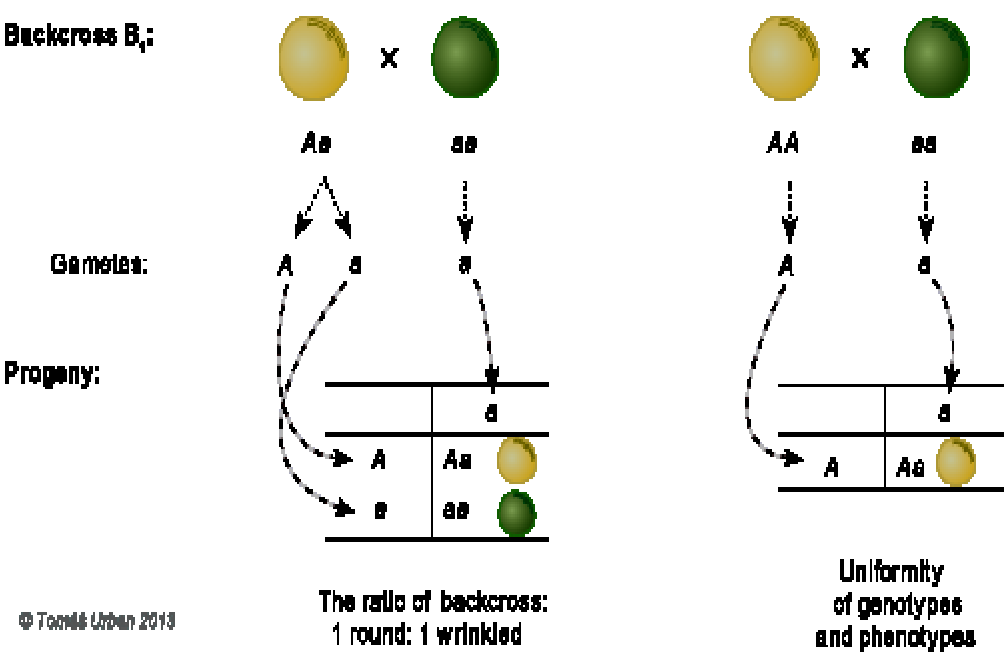
Trihybrid cross- the two parents differ by three different traits (eg. Shape and color of pea seeds and the shape of the pod).

Test cross- is used to determine the unknown genotype of a particular phenotype. If an organism has the dominant phenotype, you can't be sure whether it is homozygous dominant or heterozygous. By crossing it with a homozygous recessive individual (tester), you can infer the genotype by observing the offspring.



Backcross: The process of crossing a hybrid with its parent or with another individual with genotype similar to its parent.

Backcross of monohybrids (evidence of heterozygous genotypes) and cross of homozygous forms



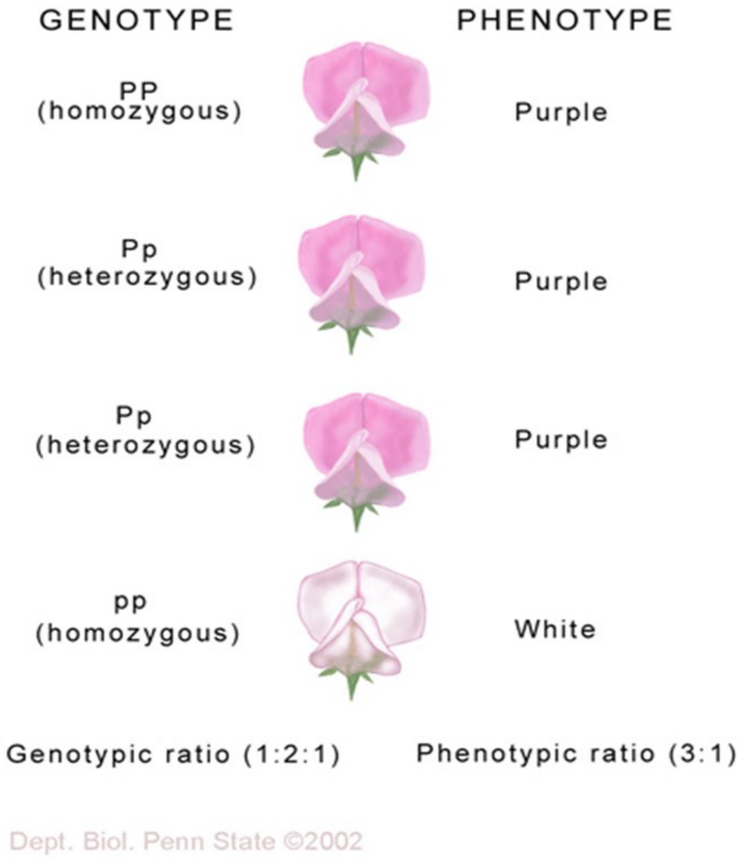
P_1 generation – "parent" - the original true-breeding parents (♀/♂)

F_1 generation – "filial" (or son or daughter) offspring of the parent plants

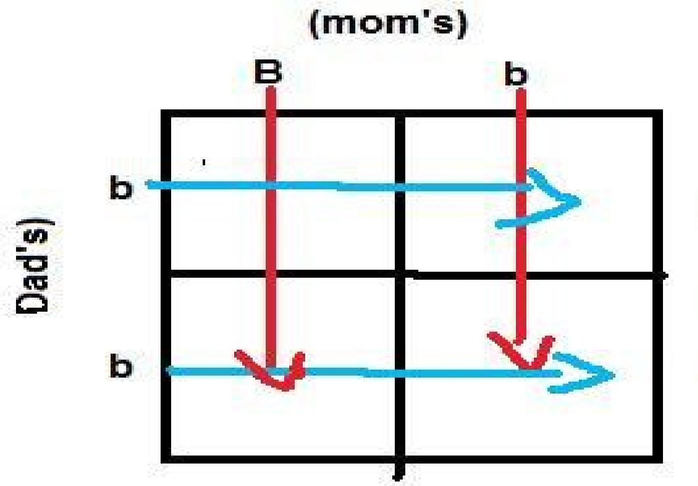
F_2 generation or "second filial generation" (or granddaughter or grandson)

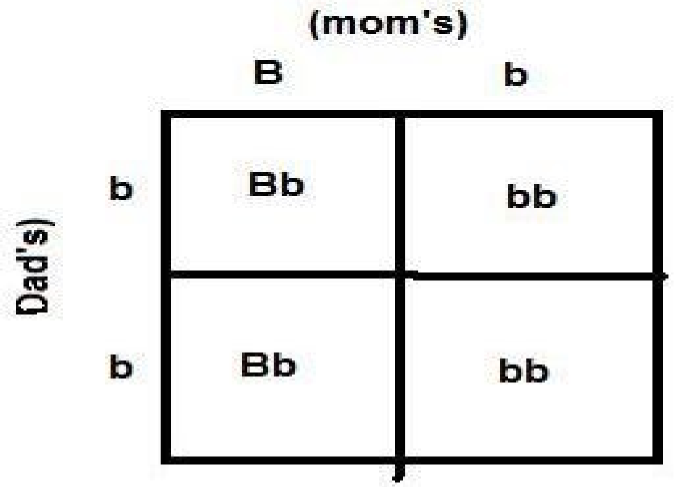
Phenotypic ratio- a ratio that shows the different outcomes after a cross based on physical appearance alone.

Genotypic ratio is the proportion of genotypes found in individuals after a cross.



Punnett Squares - a shorthand way of finding the expected proportions of possible genotypes in the offspring of a cross invented by an English biologist Reginald Punnett (1905).





MENDEL RULE AND LAWS

In Mendelian inheritance, the character is controlled by one gene only (**monogenic traits)** and inherited in a simple fashion through the nucleus as follows. Mendel believed that all units of inheritance are passed on to offspring unchanged.

Rule of Dominance

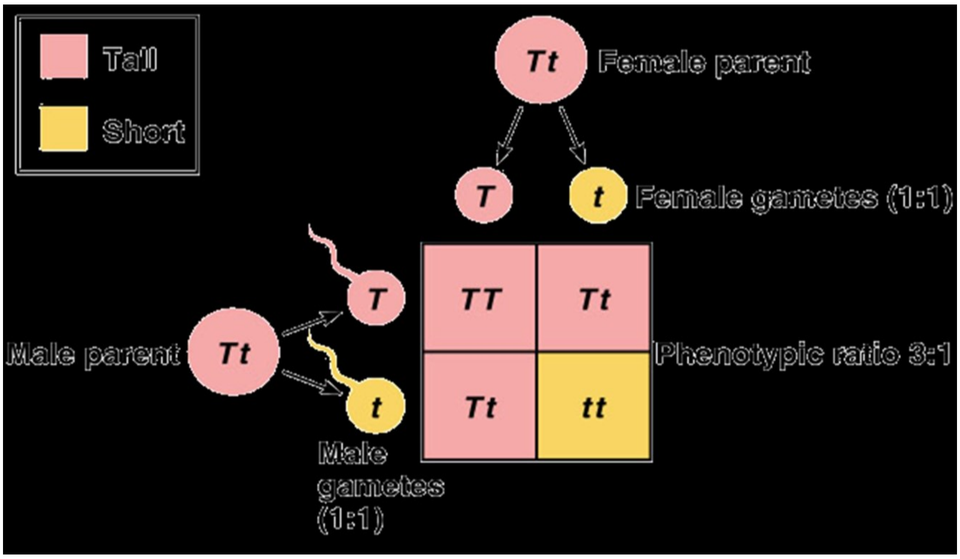
Complete dominance occurs when only one allele (**dominant**) accounts for the phenotypic expression in heterozygotes. In heterozygotes, the unexpressed allele is called **recessive**.

Dominant character is sign either by 2 capital letters (eg TT for homozygous tallness) or 1 capital and one small letter (eg Tt for heterozygous tallness) and recessive character appear when signed by 2 small letters (eg tt for homozygous shortness).

For example (figure below):

Pea plants have 2 genes that control each trait located on the chromosomes.

Pea plants (P generation) that have at least 1 allele for tallness (TT or Tt) are tall because the allele for tallness is dominant over the allele for shortness. The only way a plant can be short is if both height alleles are for a short plant (tt). Dominant trait appears in the F_1 generation, while recessive trait disappears in the F_1 generation. The 2 alleles are located on different copies of a chromosome – one copy inherited from the female parent and one from the male parent.



NOTE: According to Mendel laws, (♀A x ♂B) and (♀B x ♂A) should give same results depending only on dominance.

Student Assignment: bring several human facial characters showing the dominant and receive phenotype, as well as the homozygous and heterozygous (print it out).

Symbolism for Dominant and Recessive alleles

According to Mendel: Alphabetical letters were used to symbolize the different alleles so, capital letter for dominant and small letter for recessive.

Example A (dominant purple color) & a (white recessive color) for Pea flower's color.

According to Bateson: The capital letter was derived from the name of the dominant and so, its small letter will represent the recessive.

Example P (dominant purple color) & p (recessive white color) of Pea flower.

According to Wild type System: The word wild type means the dominant natural population (or most common) so, the allele of the recessive will be signed with the letter of its name and that of wild type will be signed + alone or the letter of the recessive with + as superscript. Example + or s^+ (dominant tall plant) and s (recessive short plant)

MENDEL'S FIRST LAW (LAW OF SEGREGATION)

Law 1. states that every individual possesses a pair of alleles for any particular **trait** (assuming diploidy). Each parent passes a randomly selected copy (allele) of only one of these to its offspring. Interactions between alleles at a single locus influence how the offspring expresses that trait according to dominant and recessive rule (previously explained).

Monohybrid Cross

The first crosses Mendel made were between inbred lines of peas that were true **breeding** for opposite types of a character, for example, tall x dwarf, yellow x green seed, round x wrinkled seed coat, etc. These are called **monohybrid crosses** because the peas were inbred lines that differed for a single character (Figure below). In the progeny from the hybrid cross, called the **F1 generation**, he observed that all offspring were always just one of the two alternate types.

Example (1) tall x dwarf plants

Never were both types observed or were offspring of some intermediate type. Mendel then self-pollinated some F1 offspring to create an **F2 generation**, whose plants segregated for both characters found in the inbred parents (Figure below). It was at this point that Mendel was at his scientific best. Not only did he observe the character types in the offspring, but he also counted them and calculated ratios of each type. In the F2 for all seven of the characters he was studying, he observed approximately three times as many plants of one character type as the other. Furthermore, the type observed in the F1 was the one in greater number in the F2.

Mendel interpreted the results of his monohybrid crossing experiments to develop his first three laws of inheritance. He surmised that there must be one factor for tall and one factor for dwarf, and that these factors are somehow paired (**Law 1**). Later this became the basis of the concept of pairs of **homologous chromosomes** with the gene determining a particular character located at the same position (*i.e.* locus) in each homologue. A locus can have different forms of the gene, which are called **alleles**. For example, in Mendel's peas there was one allele coding for tall plants (*D*) and one allele coding for short plants (*d*) and these alleles segregated among the offspring. Plants that have the same allele at a locus on each of the homologous chromosomes are homozygous (*e.g. DD* and *dd*), whereas those with a different allele on each homologous chromosome are heterozygous (*e.g. Dd*).

Mendel further hypothesized that one unit factor (*i.e.* allele) is **dominant** to the other **recessive** factor (*i.e.* the dominant allele masks the effect of the recessive allele), based on the phenotypes he found in the F1 and F2 (**Law 1**). For example, the allele for tall (*D*) is dominant and the allele for dwarf (*d*) is recessive. This leads to the important distinction between genotype and phenotype. The three possible genotypes are *DD*, *Dd*, and *dd*, although with *D* being dominant to *d*, there are only two phenotypes. The *DD* and *Dd* genotypes are both tall phenotypes and the *dd* genotype is the dwarf phenotype.

A simple method to interpret the results of the monohybrid cross is through the **Punnett Square**, named after its inventor Reginald Punnett (Figure below). It can be seen that when a heterozygous F1 is mated to itself (or crossed to an identical F1), three genotypes (*DD*, *Dd* and *dd*) are found in the 1:2:1 ratio (**genotypic ratio**), respectively. However, only two phenotypes are found, tall and dwarf, in the ratio of 3:1 (**phenotypic ratio**), respectively. Finally, Mendel proposed that the 3:1 ratio observed in the progeny of selfed F1 plants is expected if the *D* and *d* alleles are transmitted from each parent to the offspring at random. The frequencies of the offspring genotypes are the products of the frequencies of the alleles transmitted from each parent. The frequency of the *DD* genotype is 1/4, the frequency of the heterozygous *Dd* class is 1/2, and the frequency of *dd* is 1/4. Because *D* is dominant to *d* and therefore, *DD* and *Dd* have the same phenotype, the expected proportion of tall offspring is 3/4 and the dwarf offspring is 1/4 (or a 3:1 ratio). Mendel confirmed the expectations of random segregation with another type of cross, called a **test cross**. Here he crossed a *Dd* plant with a *dd* plant and found that approximately half of the offspring were tall and half were dwarf.

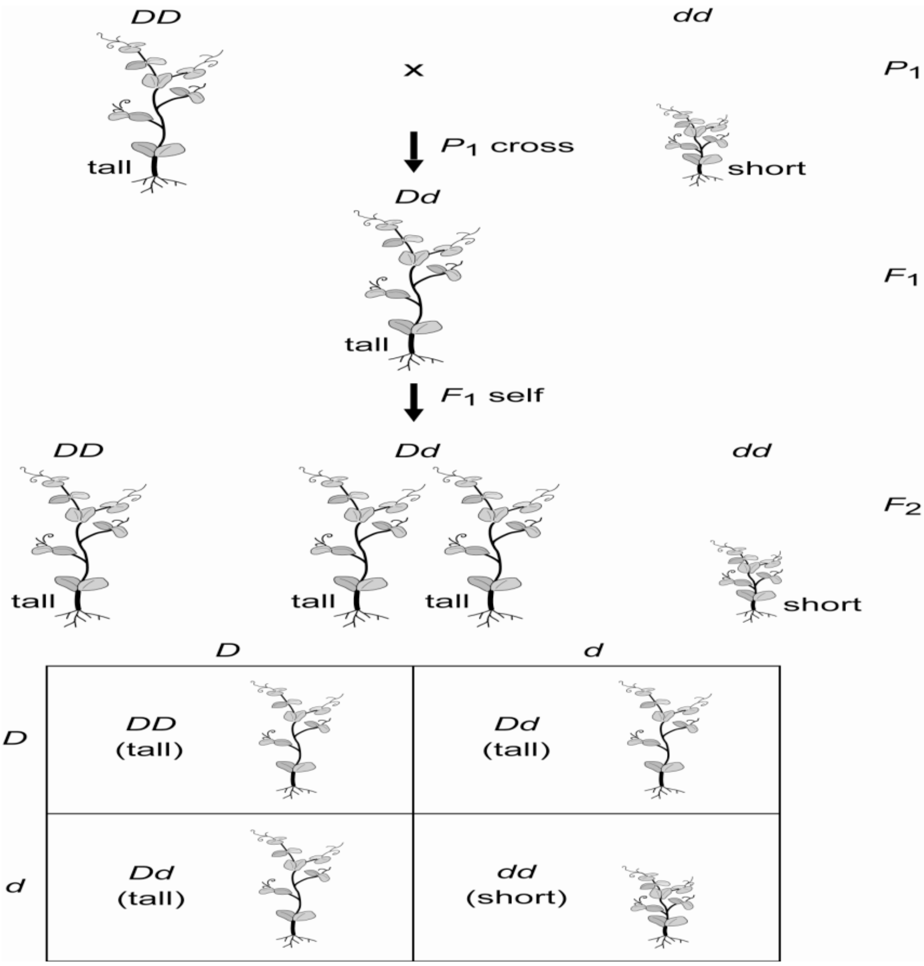
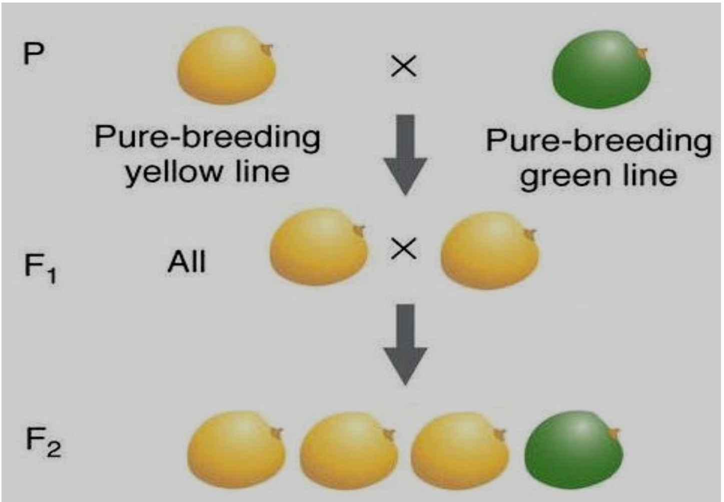


Fig. Mendel’s monohybrid crosses with peas (tall x dwarf plant).

Example (2) yellow x green seed

Mendel grew seeds from a cross between green-seed and yellow-seed plants (figure below). All of the offspring in F1 generation had yellow seeds. Mendel allowed the plants in F1 generation to self pollinate. ¾ of the plants had yellow seeds and ¼ had green forming **phenotypic ratio** of 3:1 (3 yellow to 1 green) and genotypic ratio 1 (homozygous dominant) : 2 (heterozygous) : 1 (homozygous receissive).



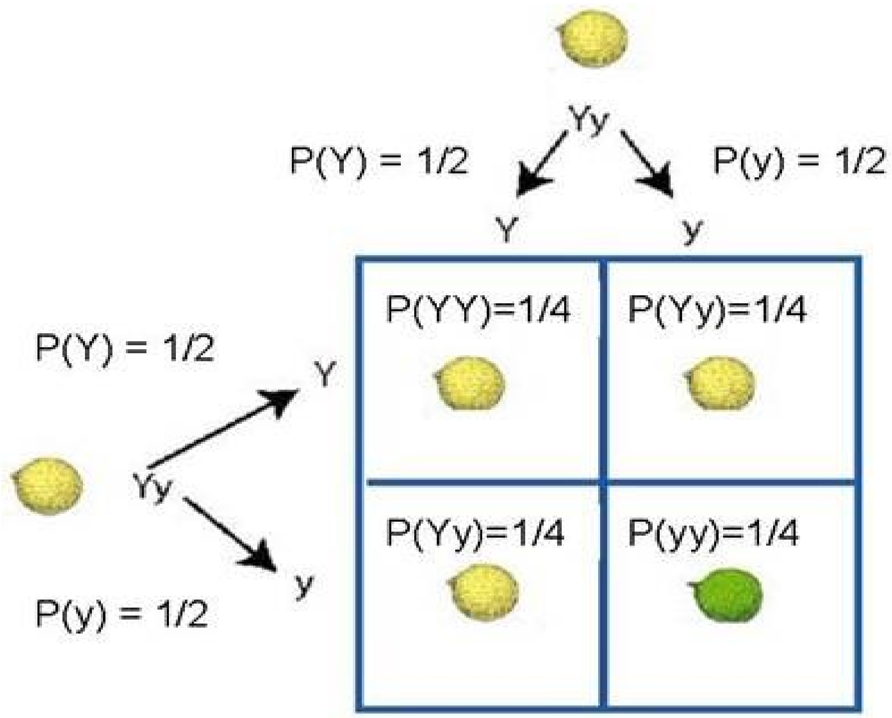


Fig. Mendel's monohybrid crosses with peas (yellow x green seeds).

NOTE: Traits come in alternative versions. For each trait, an organism inherits 2 alleles, 1 from each parent. Eg: purple vs. white flower color, purple-flower allele & white-flower allele are two DNA variations at flower-color locus i.e. different versions of gene at same location on homologous chromosomes.

Modern molecular study's findings that different alleles vary in the sequence of nucleotides at the specific locus of a gene some difference in sequence of A, T, C, G, so differ in their functional proteins.

Lecture activity: Punnett square of the some monohybrid cross (students solving and open discussion).

MENDEL'S SECOND LAW (LAW OF INDEPENDENT ASSORTMENT**)**

Law 2. states that different separate genes for different separate traits are passed independently of one another from parents to offspring during gamete formation. That is, the biological selection of a particular gene in the gene pair for one trait to be passed to the offspring has nothing to do with the selection of the gene for any other trait.

Dihybrid Cross

A second type of experiment Mendel performed was the **dihybrid cross**, which was an extension of the monohybrid cross to two characters (figure below). Mendel crossed a yellow and round seeded type to a green and wrinkled seeded type. The F1 offspring were all yellow and round and the alternate types of each character were found in 3:1 ratios in the F2, as observed in monohybrid crosses involving the same traits.

Mendel also counted the two-character phenotypes and these were in a 9:3:3:1 ratio in the F2. This is the expected ratio of two-character phenotypes given that both pairs of traits segregate randomly and completely independently of one another (**Law 2**). Under independent assortment, the expected frequency of any two-character phenotype is the product of the frequencies of each component character. Therefore, the frequency of yellow round offspring is 9/16 and the frequency of yellow wrinkled is 3/16. In this case, the genes controlling color and smoothness of seed coat reside on different chromosomes. The Punnett square shows the offspring resulting from selfing the F1. There are nine possible genotypes (**genotypic ratio** 1:2:2:4:1:2:1:2:1) but only four phenotypes (yellow and round, yellow and wrinkled, green and round, green and wrinkled) which segregate in a 9:3:3:1 ratio (**phenotypic ratio**).

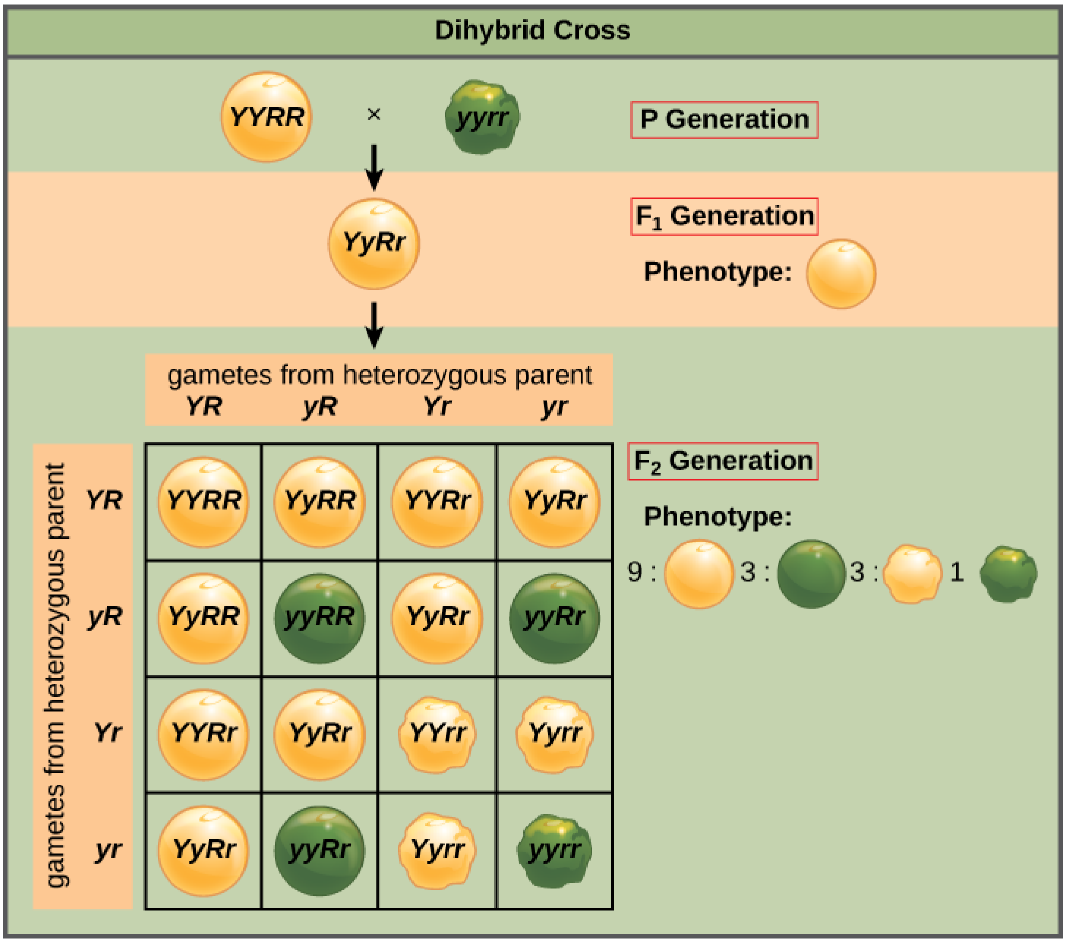


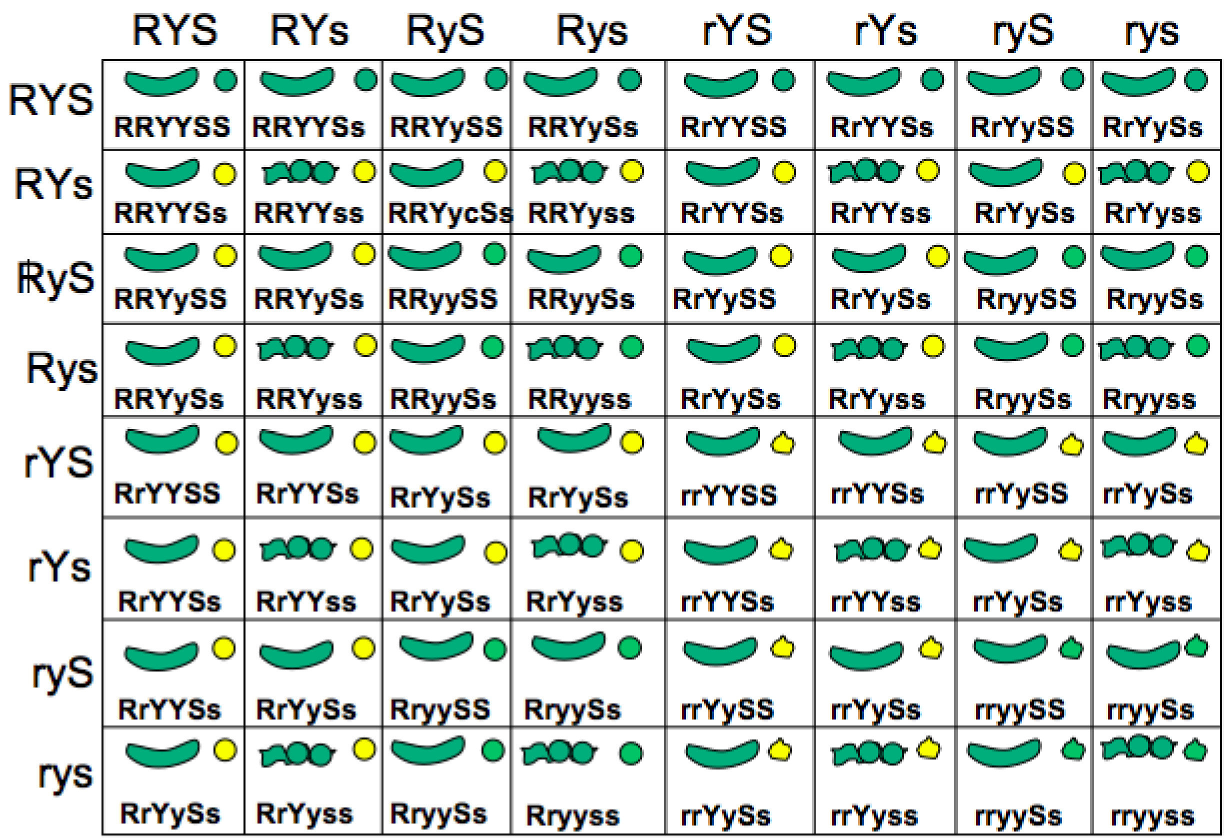
Fig. Mendel's dihybrid crosses with peas (yellow and round x green and wrinkled seeded type).

Lecture activity: Punnett square of the some dihybrid cross (students solving and open discussion).

Trihybrid Cross

A trihybrid cross is between two individuals that are heterozygous for three different traits: pea shape and pea color and then a new trait: pod shape. The same rules as before apply for shape and color (round is completely dominant to wrinkled, and green is completely dominant to yellow). Pea pod shape follows similar rules, with smooth pods being completely dominant to constricted pods. Therefore, homozygous-dominant and heterozygous individuals will have smooth pods, while homozygous-recessive individuals will have constricted pea pods.

RrYyCc x RrYyCc is a trihybrid cross, the shape of the pea is controlled by one set of alleles, where round is completely dominant to wrinkled (RR and Rr = round, rr = wrinkled). The second set of alleles is the color of the peas. Green is dominant to yellow (YY and Yy = green, yy = yellow). The third set of alleles is the shape of the pea pod. Smooth is completely dominant to constricted (CC and Cc = smooth, cc = constricted). The gametes for each parent in a trihybrid cross would be RYC, RYc, RyC, Ryc, rYC, rYc, ryC, ryc, with one-eighth of a chance for any of them. The **64 offspring** show a **phenotypic ratio** of 27:9:9:9:3:3:3:1 and a **genotypic ratio** of 1:2:1:2:4:2:1:2:1:2:4:2:4:8:4:2:4:2:1:2:1:2:4:2:1:2:1 .



Example of Trihybrid Punnett

How to know the number of gametes and the number of offspring in a cross?

\# gametes (♀ or ♂) = $2^{\#characters}$

Total # offspring = # ♂ gametes X # ♀gametes

<u>In Monohybrid:</u> # gametes (♀ or ♂) = 2^1 =2

Total # offspring = 2 X 2 = 4

<u>In Dihybrid:</u> # gametes (♀ or ♂) = 2^2 =4

Total # offspring = 4 X 4 = 16

<u>In Trihybrid:</u> # gametes (♀ or ♂) = 2^3 =8

Total # offspring = 8 X 8 = 16

Lecture activity: Punnett square of the some trihybrid cross (students solving and open discussion).

Animation:

Mendel

https://www.youtube.com/watch?v=3CQqFpKiRhw

http://www.youtube.com/watch?v=Mehz7tCxjSE

https://www.youtube.com/watch?v=GRDKoxNc3MI

For more reading: (in Botany and Microbiology Departmet Library)

1. Study guide and problems workbook: Principles of genetics, Peter Snustad, Simmons and Price (eds), 2^{nd} edition, 2000.
2. Introduction to genetic analysis, Griffiths, Wessler, Lewontin and Carroll, 9^{th} edition, 2008.
3. Concepts of Genetics, William S. Klug, Michael R. Cummings, Charlotte A. Spencer and Michael A. Palladino, 10^{th} edition, 2012, Pearson Education Inc. (also present online)