

## 7.016 Recitation 9 – Fall 2018

(**Note:** The recitation summary should NOT be regarded as the substitute for lectures)  
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### Summary of Lectures 11 (10/1), 12 (10/5) and 13 (10/10):

**Cell and its organelles:** The cell is the smallest unit that displays the properties of life. All living cells have a plasma membrane, an internal region called cytoplasm and a region where DNA is concentrated. The plasma membrane is selectively permeable and is composed of a lipid bilayer (predominantly phospholipids) with proteins embedded in it.

**Scale of cells and subcellular structures:** Living things can either be unicellular or multi-cellular and can be of different shapes and sizes.

#### **Useful links:**

Cell Size and Scale: <https://learn.genetics.utah.edu/content/cells/scale/>

Inner Life of the Cell (Full Version – Narrated): <https://www.youtube.com/watch?v=FzcTgrxMzZk>

**Organelles:** Eukaryotic cells have a nucleus and other organelles. Most organelles are membrane bound (with some exceptions such as ribosomes), they create physically distinct regions within the cell and have specific functions.

Organelles	Description
Nucleus	A membrane-bound compartment that separates the DNA, the hereditary material from the cytoplasm. Pores across the nuclear membrane help control the passage of many substances between the nucleus and the cytoplasm.
Endoplasmic reticulum (ER)	A membrane bound region where polypeptide chains are processed (Rough ER, studded with ribosomes) and lipids are assembled (Smooth ER, is not studded with ribosomes)
Mitochondria	The power- house of energy and the site of aerobic respiration and oxidative phosphorylation. Unlike any other organelle the mitochondria have their own DNA, ribosomes and proteins and is said to have originated per the endosymbiotic theory. <b>Endosymbiosis</b> explains the origin of mitochondria and their double membranes. This concept postulates that mitochondria are the result of years of evolution initiated by the endocytosis of bacteria, which were not digested; they became symbiotic instead.
Nucleolus	Localized in the nucleus. It is a site where the ribosomes and tRNA are synthesized
Ribosomes	Small, Non-membranous organelles that are not surrounded by membrane and are involved in the synthesis of proteins and are comprised of RNA and proteins
Lysosomes	They contain enzymes that are involved in digesting cell's own toxic material and have acidic pH
Cytoskeleton	A dynamic network of fibers that maintain cell shape and motility and play important roles in intracellular transport and cell division.
Extracellular matrix (ECM)	Filamentous structure that is present between cells, provides them with anchorage and is involved in intercellular communication
Golgi Body	Tubular structures in cell where the newly translated proteins are modified

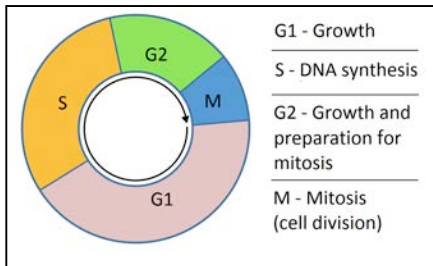
It is important to note that ions and other molecules can move across the cell membrane by the processes such as exocytosis and endocytosis.

### Common genetic terms:

Some commonly used terms in genetics along with their definition are given below.

Terms	Definitions
Gene	(Abstractly) a fundamental unit of inheritance; (chemically) a sequence of DNA that encodes an RNA or protein.
Allele	Different forms or variants of a gene
Genotype	Set of alleles; genetic make-up
Phenotype	Physical appearance, trait or characteristic imparted by the genotype
Homozygous	Presence of identical alleles at one loci between homologous chromosomes
Heterozygous	Presence of different alleles at one loci between homologous chromosomes
Pure- or true- breeding	Contains homozygous alleles at the gene of interest
Trait	One or more detectable variants in a genetic character
Dominant	Phenotype that is expressed in a heterozygote
Recessive	Phenotype that is NOT expressed in heterozygote

**Cell cycle:** The cell cycle is the process by which one cell becomes two identical cells. The cell cycle is the chain of events that occur in a dividing cell. Cells preparing to undergo cell division must first copy each of their double-stranded DNA molecules (or chromosomes) by DNA replication. The duplicated homologs remain attached to each other by cohesin protein. The cell cycle consists of four stages – G1, S (DNA synthesis/ replication), G2, and M (mitosis). G1 phase is when the cells are preparing to replicate their DNA, which occurs in S phase. G2 is when cells are preparing to divide, which occurs in M phase. Of these, the G1 phase shows variable length in different cell types.



Hartwell & Nurse received the Nobel Prize in 2001 for their contribution. Please see the link below.

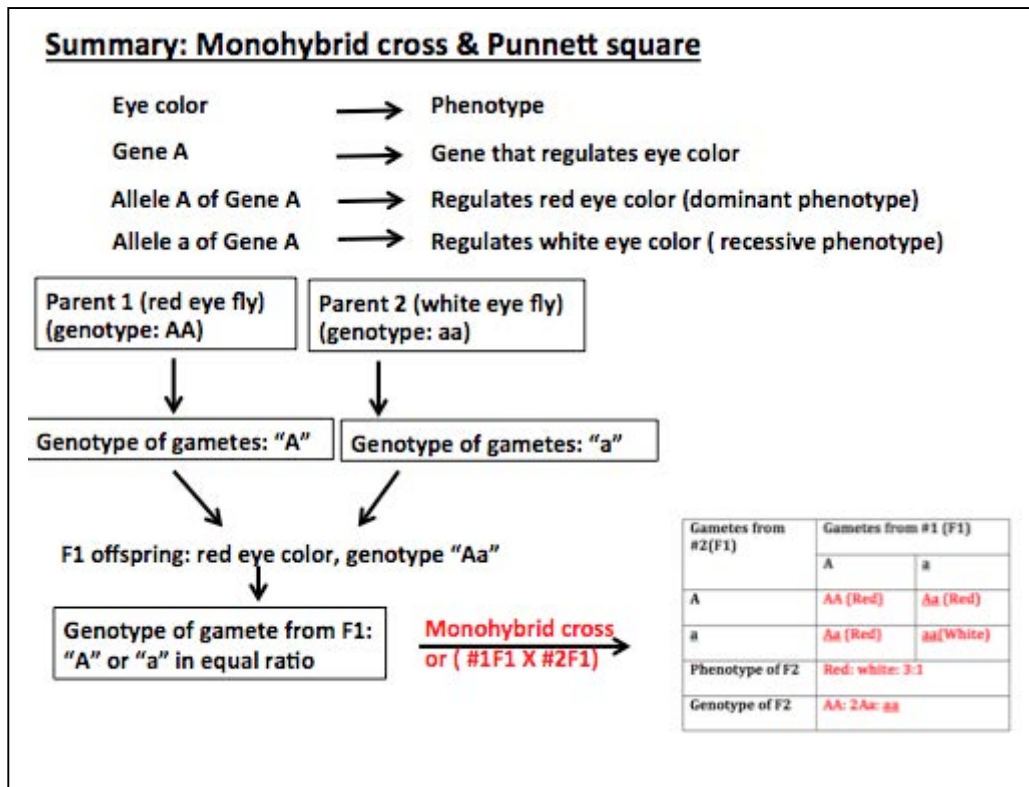
**Link:** [http://www.nobelprize.org/nobel\\_prizes/medicine/laureates/2001/illpres/index.html](http://www.nobelprize.org/nobel_prizes/medicine/laureates/2001/illpres/index.html)

**Cell division:** Mitosis is the division of a diploid somatic cell ( $2n$ ) to form two daughter cells ( $2n$ ) that are similar to the parental somatic cell. Meiosis has two divisions; **meiosis-I** looks different from mitosis, but **meiosis-II** looks similar to mitosis. In Meiosis I a parent cell ( $2n$ ) duplicates its genome ( $4n$ ) and then divides to form two daughter cells ( $2n$ ), this involves the separation of duplicated homologs. In meiosis II, each daughter cell ( $2n$ ) divides to form two daughter cells ( $n$ ), this involves the separation of chromatids. So the end result of meiosis is the production of four haploid gamete cells/ reproductive cells such as eggs or sperm, each of which has half the number of chromosomes ( $n$ ) as a diploid somatic cell ( $2n$ ).

**Link:** <http://www.pbs.org/wgbh/nova/body/how-cells-divide.html>

**Non-disjunction and its effect:** It is important to note that failure of separation of duplicated chromosomes (non-disjunction) during cell division may result in daughter cells with abnormal number of chromosomes. If non-disjunction occurs during mitosis, it results in both daughter cells having an abnormal number of chromosomes ( $n+1$  for one daughter cell and  $n-1$  for the other), which may be transferred to subsequent daughter cells and can result in diseases such as cancer. However non-disjunction in mitosis is never passed on to the offspring of the next generation. In comparison, non-disjunction either during meiosis -I or meiosis-II can result in gametes with abnormal number of chromosomes and is the cause of genetic disorders such as Down's syndrome, Edwards syndrome, Turner's syndrome, Klinefelter's syndrome etc.

**Mendel's laws; Monohybrid cross:** Here you cross/ mate two true-breeding (i.e. homozygous for the alleles of a gene(s)) organisms that differ by a single characteristic that is regulated by one gene, such as plants that produce round versus wrinkled seeds. The two organisms you cross are called the P or  $F_0$  (parental) generation. One such cross is outline below:



**Mendel's laws; Dihybrid cross:** A dihybrid cross is when you cross/ mate two true-breeding organisms that differ by two characteristics each being controlled by a single gene, such as pea plants that produce round versus wrinkled seeds (controlled by Gene R, that can exist as allele R or r) and green or yellow peas (regulated by Gene Y that exists as allele Y or allele y). For example, a cross between two pea plant P1 (genotype: RRYy) and P2 (genotype: rryy) can result in F1 offspring (genotype: RrYy), which are heterozygous for the alleles of both genes and which display the dominant phenotypes (in this case round and green). If you cross two F1 organisms together (RrYy x RrYy), you create the F2 generation with the phenotypes: Round/ Yellow (9): Round/ Green (3): Wrinkled/Yellow (3): wrinkled/ Green (1). The ratios of different genotypes and phenotypes within the F2 generation can be derived either by using the probability rule or by using a Punnett Square.

**Test cross:** This is used to determine whether an individual showing a dominant trait is homozygous (genotype AA) or heterozygous (genotype: Aa) for the allele(s) of a gene(s). The individual in question is crossed with an individual that is homozygous (genotype: aa) for the recessive trait- this is easy to identify, because all individuals with the recessive phenotype are homozygous for that trait. If the

individual in question is homozygous then all the offspring resulting from the test cross will be heterozygous and will exhibit the dominant trait. In comparison, if the individual in question is heterozygous, then the back cross will produce offspring showing the dominant trait and offspring showing the recessive trait in the ratio of 1:1.

**Questions:**

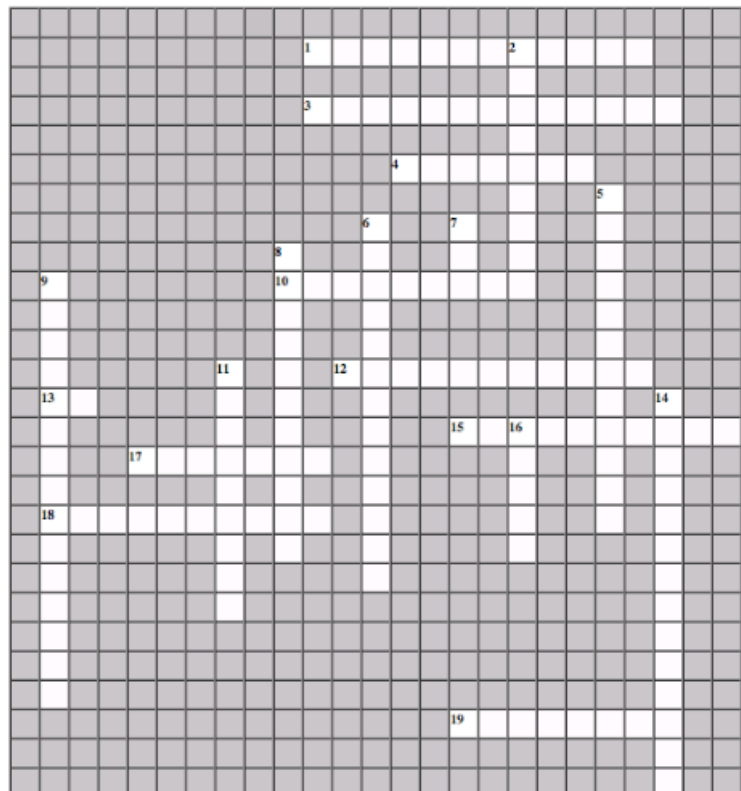
1. Complete the crossword puzzle by using the following keywords: *Cell junctions, extracellular matrix (ECM), nucleus, chromosomes, mitochondria, organelles, cytoskeleton, flagella, phospholipids, cytosol, genes, plasma membrane, endoplasmic reticulum (ER), lysosomes, prokaryotes, Eukaryotes, nucleolus, ribosomes, Nuclear membrane*

**Down**

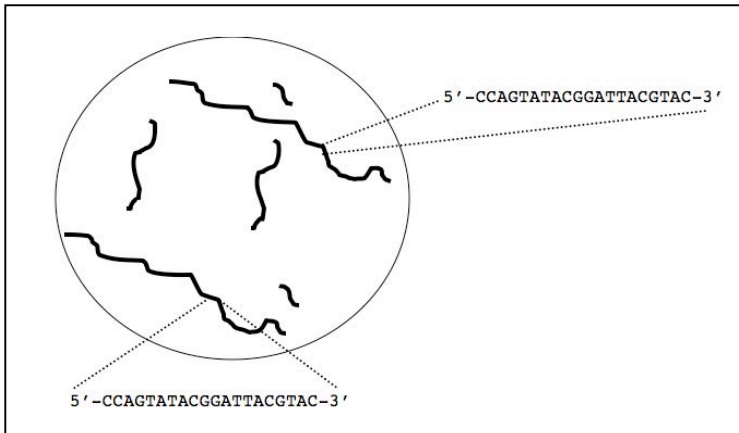
- 2. A component of the cell that is involved in the synthesis of ribosomes.
- 5. A dynamic network of fibers that maintain cell shape and motility and play important roles in intracellular transport and cell division.
- 6. Membrane lipids that possess a hydrophobic head and a hydrophilic tail.
- 7. Filamentous structure that is present between cells, provides them with anchorage and is involved in intercellular communication. (*Note: Use the abbreviation*).
- 8. Organisms that do not contain a nucleus.
- 9. Location of proteins that form a channel to export mRNA from the nucleus into the cytosol.
- 11. Locations of the enzymes that digest the toxic substances produced within a cell.
- 14. Location of a protein that transports water in and out of the cells.
- 16. Discrete units of hereditary information.

**Across**

- 1. An organelle in a eukaryotic cell that is involved in the synthesis of ATP.
- 3. Cell structures comprised of proteins that are involved in cell-cell adhesion.
- 4. Part of eukaryotic cell where DNA is synthesized and stored.
- 10. The assemblies of rRNA and proteins that play a major role in protein synthesis.
- 12. The assemblies of DNA and proteins that carry hereditary information.
- 13. One location of protein synthesis in a cell. (*Note: Use the abbreviation*).
- 15. Membrane enclosed sacs in eukaryotic cells that have diverse functions.
- 17. Location of an enzyme that initiates the breakdown of glucose.
- 18. Organisms whose cells are nucleated.
- 19. Cellular appendages that propel the movement of sperms.



2. Pictured below is the nucleus from a skin cell taken from a mouse (named Mouse #1), with the chromosomes shown in bold.



a) Is the cell **haploid** or **diploid**?

b) The sequence of one locus of gene in longest chromosome is highlighted in the schematic.

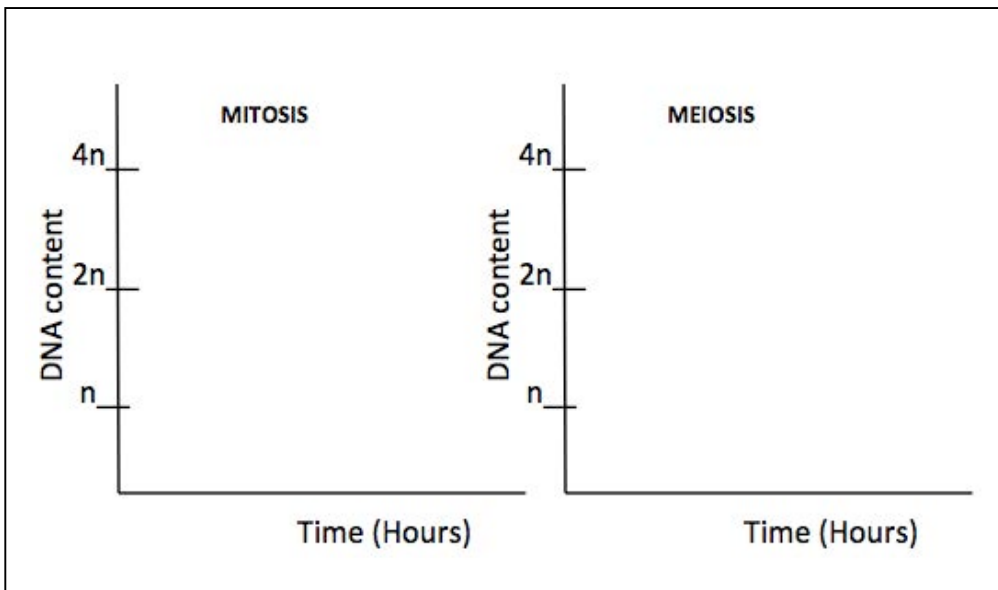
i. Is Mouse #1 homozygous or heterozygous for this gene?

ii. When you zoom in on the same locus on the long chromosome in a cell from Mouse #2 you find that its two homologous chromosomes have the sequences 1 and 2 below. How might we write the genotypes of Mouse #1 and Mouse #2, if Sequence #1 encodes a functional protein but Sequence #2 encodes an inactive, nonfunctional protein? (**Note:** Use the upper case or lowercase A while writing the genotypes).

Sequence 1: 5'-----GAGTA-----3'

Sequence 2: 5'-----GATTA-----3'

3. In a diploid cell ( $2n$ ), that is undergoing cell division, draw a graph showing the variation in the DNA content ( $n$  = haploid) against time for both mitosis and meiosis.



4. Tomato plants can be **tall** or **short** and have **notched** or **smooth** leaves. You cross a tall, smooth leafed plant with a short, notched leafed plant. All of the progeny are **tall**, and **notched** leafed.

a) Which traits are dominant and which are recessive?

b) What are the genotypes of the two **true-breeding** parents? Use the letters *H* or *h* to represent the alleles of the height gene and the letters *S* or *s* to represent the alleles of the leaf gene. In each case, use the uppercase letter for the allele associated with the dominant phenotype and the lower case letter for the allele associated with the recessive phenotype. Assume that the genes assort per Mendel's laws.

Tall & smooth: \_\_\_\_\_ Short and notched; \_\_\_\_\_

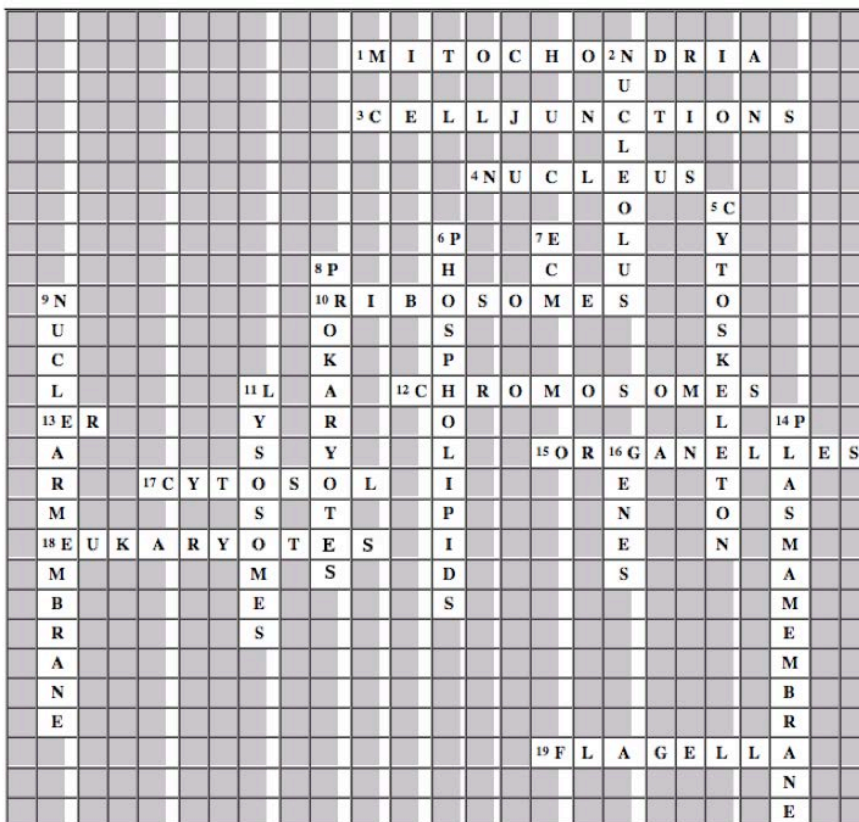
c) Two tall, notched F1 plants were crossed (self cross) to get 1600 F2 plants

- i. What ratio of phenotype do you expect in the F2 generation?
- ii. If you get 400 plants in F2, how many of these will be homozygous recessive for both traits?

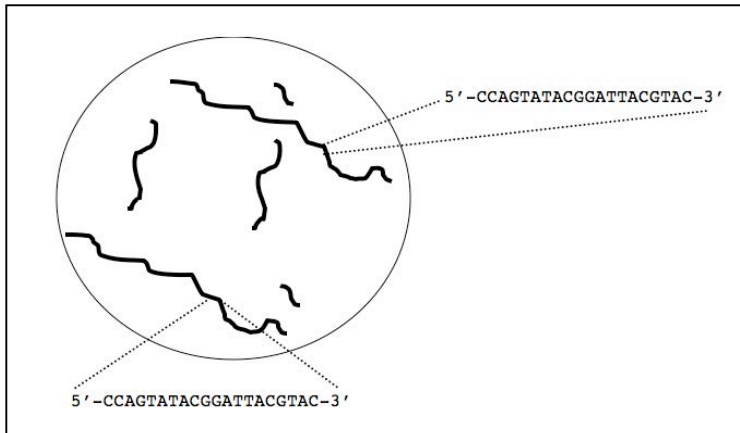
5. Design a mating experiment that can help you test whether a plant having red Petals (dominant trait over white petals) is homozygous or heterozygous for the alleles of Gene A.

**Solutions to Questions:**

1. The crossword puzzle



2. Pictured below is the nucleus from a skin cell taken from a mouse (named Mouse #1), with the chromosomes shown in bold.



a) Is the cell haploid or diploid? *Diploid*

b) The sequence of one locus of gene in longest chromosome is highlighted in the schematic.

- i. Is Mouse #1 homozygous or heterozygous for this gene?  
*Homozygous since the two sequences are identical*

iii. When you zoom in on the same locus on the long chromosome in a cell from Mouse #2 you find that its two homologous chromosomes have the sequences 1 and 2 below. How might we write the genotypes of Mouse #1 and Mouse #2, if Sequence #1 encodes a functional protein but Sequence #2 encodes an inactive, nonfunctional protein? (**Note:** Use the upper case or lowercase A while writing the genotypes).

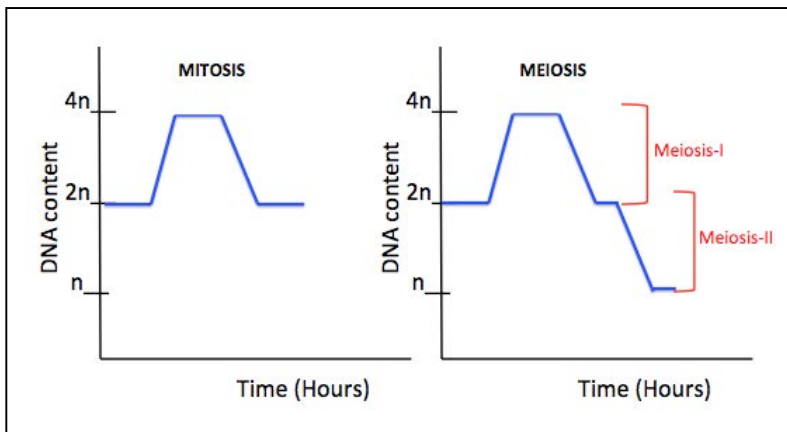
Sequence 1: 5'-----GAGTA-----3'

Sequence 2: 5'-----GATTA-----3'

Mouse1: *AA*

Mouse 2: *Aa*

3. In a diploid cell ( $2n$ ), that is undergoing cell division, draw a graph showing the variation in the DNA content ( $n$  = haploid) against time for both mitosis and meiosis.



4. Tomato plants can be **tall** or **short** and have **notched** or **smooth** leaves. You cross a tall, smooth leafed plant with a short, notched leafed plant. All of the progeny are **tall**, and **notched** leafed.

a) Which traits are dominant and which are recessive? *Tall & notched*

b) What are the genotypes of the two **true-breeding** parents? Use the letters *H* or *h* to represent the alleles of the height gene and the letters *S* or *s* to represent the alleles of the leaf gene. In each case, use the uppercase letter for the allele associated with the dominant phenotype and the lower case letter for the allele associated with the recessive phenotype. Assume that genes assort per Mendel's laws.

Tall & smooth: *HHss*

Short and notched; *hhSS*

c) Two tall, notched F1 plants were crossed (self cross) to get 1600 F2 plants

i. What ratio of phenotype do you expect in the F2 generation?

*Tall and notched: Tall and smooth: short & notched: short & smooth = 9: 3: 3: 1*

ii. If you get 400 plants in F2, how many of these will be homozygous recessive for both traits?

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5. Design a mating experiment that can help you test whether a plant having red Petals (dominant trait over white petals) is homozygous or heterozygous for the alleles of Gene A.

*You would do a test cross. If you get red: white petals plants in the ratio of 1: 1, then the test plant is heterozygous (Genotype Aa) for the gene regulating petal color. However, if you get only red petals plants then the test plant is homozygous for the above trait (genotype AA).*



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