TET 103: CHILD DEVELOPMENT (0–3 YEARS)

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Lecture 4: Chromosomes and Genes

Objectives

- At the end of this lecture the learner should be able to:
  a) Define Chromosome and Gene
  b) Highlight functions of DNA
  c) Explain Mitosis
  d) Describe genetic inheritance
  e) Explain sex determination in organisms

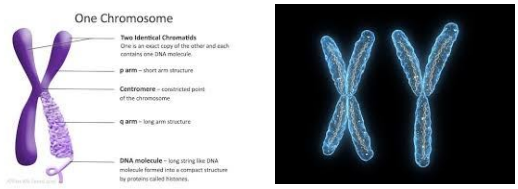
What are Chromosomes?

- Human life starts with a single fertilized cell called zygote.
- The zygote is a result of the single sperm cell penetrating the single ovum cell.
- The nucleus of the sperm cell contains 23 chromosomes and that of the ovum also contains 23 chromosomes.
- The resulting zygote is therefore made up of 46 chromosomes or 23 pairs of chromosomes, half from each parent, the number required for a normal human being.

What is a chromosome?

- Chromosomes are thread-like structures located inside the nucleus of animal and plant cells. Each chromosome is made of protein and a single molecule of deoxyribonucleic acid (DNA).
- Passed from parents to offspring, DNA contains the specific instructions that make each type of living creature unique.
- The term chromosome comes from the Greek words for color (chroma) and body (soma). Scientists gave this name to chromosomes because they are cell structures, or bodies, that are strongly stained by some colorful dyes used in research.

What are Chromosomes?



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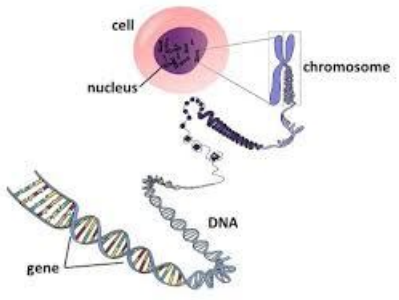


What are genes?

- These are complex molecules that carry within their structures the traits of parents and transmit them to their offspring.
- The genes carry the blue prints of the common characteristics shared by all human beings (e.g. two legs, ears, eyes, nose, mouth, arms, etc) and also determine our individual differences.
- They determine the specific ways in which human beings differ from other species in such aspects as size, shape, behavior and aging and they also determine the unique qualities that set us apart from other people.

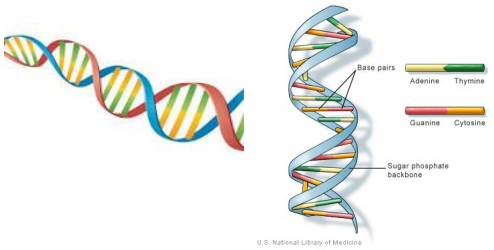
What are genes?

- Genes are composed of DeoxyriboNucleus Acid (DNA) - sometimes called the substance of life.

What DNA?

- DNA - is a ladder - like molecule that stores genetic information in cells and transmits it during reproduction.
- DNA molecule is composed of carbon, hydrogen, nitrogen and phosphorus atoms which contain the genetic code or blue print to regulate the functioning and development of the organism.

What DNA?



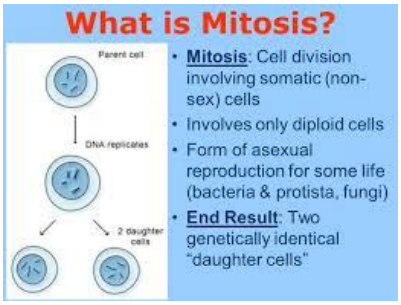
Functions of DNA

- DNA contains elaborate information needed to perform all activities of living matter.
- Directs the formation of chains of proteins which in turn form two new tissues and organs.
- Regulates other genes
- Control the operation activities of enzymes crucial in body processes.
- A unique feature about DNA is that it duplicates itself. This special ability makes it possible for the one fertilized cell (zygote) to develop into a complex human being composed of many cells through a process of cell duplication called mitosis.

Mitosis

- A type of cell division that results in two daughter cells each having the same number and kind of chromosomes as the parent nucleus, typical of ordinary tissue growth.
- The daughter cells each contain the usual 46 chromosomes.
- The major purpose of **mitosis** is for growth and to replace worn out cells.

Mitosis



Mitosis

- At the level of chromosomes, during mitosis, each chromosome copies itself.
- As a result each new body cell (daughter cell) contains the same number of chromosomes, 46 or (23 pairs) and the identical genetics information.
- The first 22 pairs of chromosomes - called **autosomes** contain genes that determine a variety of physical and mental traits.

Mitosis

- The 23rd pair contains the sex chromosome also called **gametes**.
- Gametes are unique in that they contain only 23 chromosomes, half as many as regular body cells.
- They are formed through a process of cell division called **meiosis** which halves the number of chromosomes normally present in body cells.

The Sex Chromosomes (Gametes)

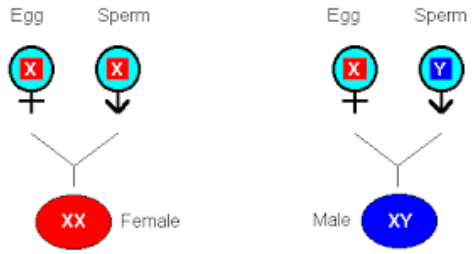
- The sex chromosomes (gametes) have two X chromosomes in a normal female (XX) and an X and Y chromosomes in a normal male (XY).
- The sex chromosomes contain genes that determine the development of primary and secondary sex characteristics and various other sex - linked traits.

The Sex Chromosomes (Gametes)

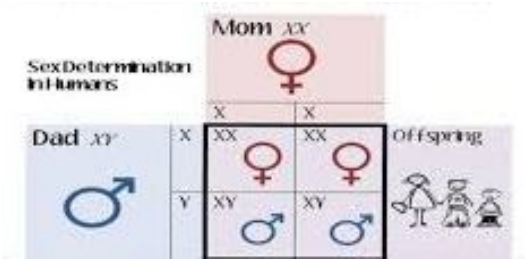
- When fertilization of the ovum occurs, the sex of the resulting organism is determined by the sperm.
- The pairing of the two X chromosomes (one from female and the other from male) will give rise to a female child.
- On the other hand, the pairing of X from female and Y from male will produce a male child.
- The X chromosome is relatively long while the Y chromosome is short and carries very little genetic material.

The Sex Chromosomes (Gametes)

The Sex Chromosomes (Gametes)



The Sex Chromosomes (Gametes)



GENETIC INHERITANCE

- All the tens of thousands of genes in an individual occur in the pairs of chromosomes e.g. 22 pairs of autosomes except 23rd pair which is the sex chromosome (gametes).
- Each form of the pair of genes is called an **allele** and it occurs at the same place on the autosomes.
- An **Allele** - is a pair of genes found on corresponding chromosomes that affect the same trait.
- It is an alternate form of a gene - typically a gene has two allele, one inherited from the mother and the other from the father.

GENETIC INHERITANCE

- The child's genetic make-up (genotype) is determined by how the allele combine
- If the genes, or the alleles from both parents are alike, the child is said to be homozygous (e.g. mother black and father black - child black - the child therefore displays the same inherited trait of both parents
- If the two alleles are different, then the child **is heterozygous** (father white (w) and mother black (b) and the traits that will appear in the child will depend on the relationship between the alleles.

GENETIC INHERITANCE

- In heterozygous pairing only one allele affects the child's characteristics and this is called the **dominant gene**
- The second allele that has no effect is called **recessive gene** it is also inherited by the offspring.
- Heterozygous individuals with one recessive allele can pass that trait on to their children
- They are therefore called **carriers of the trait** (Gene carrier)

GENETIC INHERITANCE

EXAMPLE

- Hair color is an example of dominant/recessive gene inheritance
- If the allele for dark hair is dominant - represented by DD - while the one for blond hair is recessive - represented by (bb), children who inherit either a **homozygous pair** of dominant alleles DD or a **heterozygous** pair Db will be dark haired even though their genetic make up is different.
- Blond hair can only result from having two recessive alleles of blond (bb).

GENETIC INHERITANCE

- Heterozygous individual(Db) with only one recessive allele (b) can pass that trait to their children
- They are therefore called carriers of the trait
- In dominant - recessive inheritance, if we know the genetic makeup of the parents, (Genotype), we can predict the percentage of children who are likely to display a certain trait or those who will be carriers of it.

GENETIC INHERITANCE

- Most traits, including colour of eyes do not usually result from a single gene pair but from a combination of many gene pairs with or without dominance - that interact in a number of ways
- For example, for the characteristics of height, several genes or gene pairs seem to combine with others in an additive fashion to create larger or smaller people with larger or smaller limbs and other body parts
- Gene pairs may also interact in such a way that one gene pair either allows or inhibits the expression of another gene pair.

GENETIC INHERITANCE

- A system of various types of interaction among genes and gene pairs is called a **polygenic system of inheritance**
- Such systems frequently give rise to phenotypes that differ markedly from those of either parent
- Phenotype refers to the observable physical properties of an organism; these include the organism's appearance, development, and behavior.
- An organism's **phenotype** is determined by its genotype, which is the set of genes the organism carries, as well as by environmental influences upon these genes.

Genotype Crossing/Matching

- **Allele**: Different versions of the same trait represented by letters
- most living thing gets one set of chromosomes from biological mother and one set from biological father (this does not include cloning)
- 2 alleles for each trait
- **Phenotype**: what an organism looks like - what you see
- **Genotype**: the genes that make up the genetics
- **Dominant trait**: a trait that shows up no matter what it is paired with
- **Recessive trait**: a trait that is masked or hidden unless it is paired with another recessive trait

- Genes are represented by letters
  - 2 different types of the same gene: one is dominant and one is recessive
  - An example of this is: T is a gene for tall and t is a gene for short
- The two versions of the same gene are called alleles
- Dominant genes will always prevent the recessive gene from working
  - 2 dominant alleles for tallness: TT then he will be tall
  - 1 dominant and 1 recessive allele for tallness: Tt then he will be tall
  - 2 recessive alleles for short: tt then he will be short

Homozygous vs. Heterozygous

- **Homozygous: pair of genes controlling the characteristic has identical alleles, TT or tt**
  Heterozygous: pair of genes controlling the characteristic are different alleles, Tt
- **Punnett Squares/Genetic Crosses:**
  - When working on genetic crosses the **capital letter represents the dominant allele** and the **small letter represents the recessive allele**

Using the Punnett Squares to Predict Genotypes

- The **Punnett square** is a **square** diagram that is used to predict the genotypes of a particular cross or breeding experiment.
- It is named after Reginald C. **Punnett**, who devised the approach.

Using the Punnett Squares to Cross Genotypes

- **STEPS:**

1. determine the genotypes of the parent organisms
2. write down your "cross" (mating)
3. draw a p-square
4. "split" the letters of the genotype for each parent & put them "outside" the punnett-square
5. determine the possible genotypes of the offspring by filling in the punnett-square
6. summarize results (genotypes & phenotypes of offspring)

Using the Punnett Squares to Cross Genotypes

Step #1: *Determine the genotypes of the parent organisms*.

Sometimes this is done for you, "Cross two organism with the following genotype: Tt & tt", it's all right there in the question already.

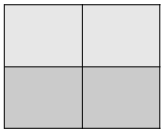
Sometimes you need to use key words from the questions to figure out the genotypes of the parents. "Cross a short pea plant with one that is heterozygous for tallness."

Genotypes: short pea plant (tt) x heterozygous tall pea plant (Tt)

Using the Punnett Squares to Cross Genotypes

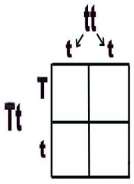
Step 2: W*rite down your "cross" (mating).* Write the genotypes of the parents in the form of letters (ex: Tt x tt)

Step #3: *Draw a Punnett-square*.



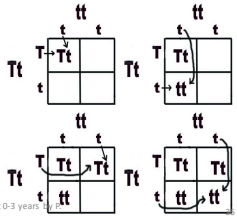
Using the Punnett Squares

- **Step #4: *"Split" the letters of the genotype for each parent & put them "outside" the punnett-square*.**
  - **Use these parental genotypes: Tt x tt.**
  - **Take the genotype letters of one pa them and put them on the left, out of the punnett-square.**
  - **Now take the two letters of the sec parent's genotype, split them up, them above each of the two colur punnett-square**



Using the Punnett Squares

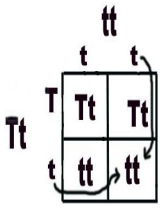
- **Step #5: *Determine the possible genotype of the offspring by filling in the punnett-square*.**
- **To determine the outcome, fill-in the the boxes of the punnett-sq this be taking a letter from the left & n with a letter from the to**



Using the Punnett Squares

Step 6: **summarize results (genotypes & phenotypes of offspring).**

Phenotypes of Offspring:
2 heterozygous tall
2 short
Genotypes of Offspring:
2 Tt
2 tt
Ratio and Percentage:
Percent of tall offspring 2/4 or 50%
Percent of short offspring 2/4 or 50%



Practice

Predict the genotype and phenotype of the following:

A species of flamingo's has been discovered that have 2 different colored feathers, orange or blue.

A is a dominant trait **a** is a recessive trait

A represents red **a** represents blue

AA and Aa are red **aa is** blue

A homozygous red bird (AA) is crossed with a homozygous blue bird (aa).

Practice

A is a dominant trait a is a recessive trait

A represents red a represents blue

AA and Aa are red aa is blue

A heterozygous red bird is crossed with a heterozygous red bird. (remember step 2!)

Assignment

a) Define the following
   i. Chromosome
   ii. Gene
   iii. Alleles
b) Explain the functions of DNA
c) Explain Mitosis process
d) Describe genetic inheritance
e) Explain how sex of a child is determined in human beings

….END…