Ministry of Higher Education

& Scientific Research

Al Muthanna University

College of Veterinary Medicine

Division of Public Health

Subject: Genetics

Grade: 2

Lecture : 4

Genetic materials

The progeny of organism develops characters similar to that Organism. The resemblance of offspring to their parents depends on the precise transmission of principle component from one generation to the next.

It is well known fact that transmission of traits takes place from one generation to other. The off springs are similar to both the parents in some traits Greg or Johann Mendel (1866) on the basis of his hybridization experiments on Sweet pea gave the idea that transmission of traits over generations take place through Factor or Determiner or Gene which carries information for expression of trait or phenotype. Genes are present on the chromosomes which are distributed equally into the two daughter cells during cell division. The biochemical studies reveal that chromosomes are composed of proteins (60%) and DNA (40%)

What is the genetic material

The genetic material of a cell or an organism refers to those materials found in the nucleus, mitochondria and cytoplasm, which play a fundamental role in determining the structure and nature of cell substances, and capable of self-propagating and variation. Protein,RNA and DNA were thought as genetic material. But many experiments suggest DNA as genetic material rather than protein and RNA

Genetic material must be capable of

- Replication (Make its copy) : The genetic material must be capable of storing genetic information and transmitting this information faithfully from parents to progeny, generation after generation.
- Storage of information for expression of trait : The genetic material must control the development of phenotype of the organism, be it a virus, a bacterium, a plant or animal .That is, the genetic material must dictate the growth and differentiation of the organism from single celled zygote to the mature adult.
- Control expression of traits
- Change in controlled way (undergo mutation)
- Must be stable

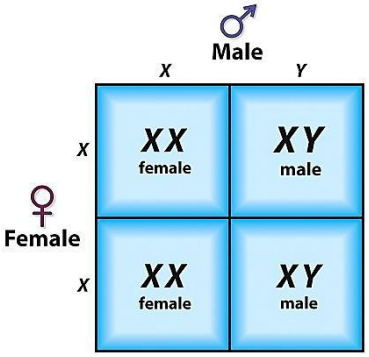
DNA , The Genetic material

• The first direct evidence showing that the genetic material is DNA rather than RNA or protein was published by O.T. Avery, Macleod and C.M. Mccarty in 1944.

• They demonstrated that the component of the cell responsible for the phenomenon of transformation in the bacterium *Diplococcus pneumoniae* is DNA.

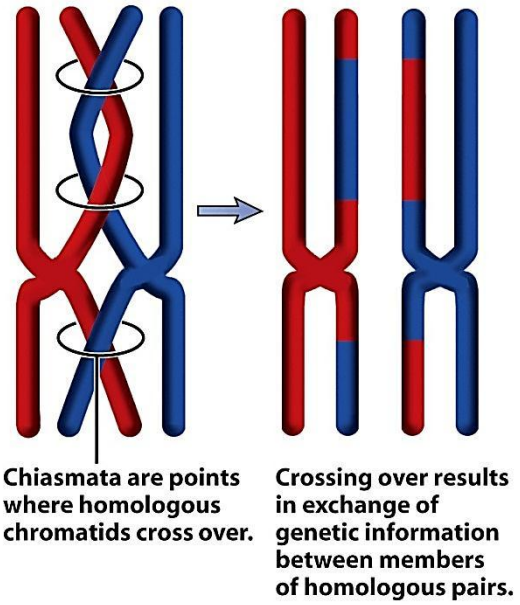
- Chromosomes are composed of two types of large organic molecules (macromolecules) called proteins and nucleic acids.
- The NA are of two types: DNA and RNA
- For many years there was considerable disagreement among scientists as to which of these macromolecules carries genetic information.
- During the 1940s and early 1950s, several elegant experiments were carried out that clearly shows that NA is genetic material rather than protein.

- More specifically these expt. shows that DNA is genetic material for all living organism except for RNA viruses.
- Chromosomes contain genes, Chromosomes follow law of independent assortment, not genes
- If two genes are on the same chromosome, the two genes are inherited together or are said to be linked or in linkage groups
- Sex linkage: (Sex chromosomes) Contain other genes aside from those to determine gender. Example: eye color and gender in fruit flies



Chromosomes Can Exchange Segments During Meiosis

- Crossing over
  - Exchange of genetic material between chromatids of homologous chromosomes. It is an important mechanism for creating new combinations of genes.
  - Disrupts linkage groups.



The Chemical Nature of the Gene

In 1860s: Frederich Meisner studied fundamental constituents of life, he Discovered unknown substance contains carbon, nitrogen, oxygen, and phosphorus. Found it came from nucleus of cell. He named it *nucelin*. His students renamed substance *nucleic acid* after finding it was acidic.

During 1881, the discovered nucleic acids were contained in chromatin

In 1928: Fred Griffiths, who was a medical officer for British Ministry of Health, Studied the bacteria *pneumococcus*, Two kinds were discovered

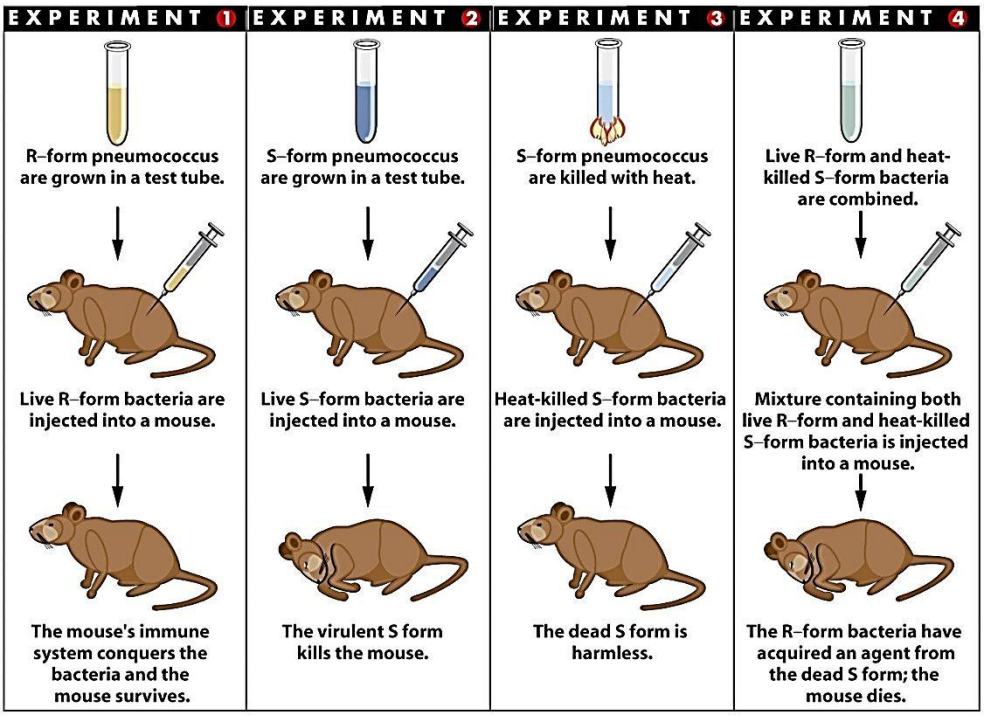
- Smooth: Virulent form that appears smooth and shiny when grown on agar plate
- Rough: harmless form that appears rough when grown on agar plate.

They were experimented by injecting the two types in mice.

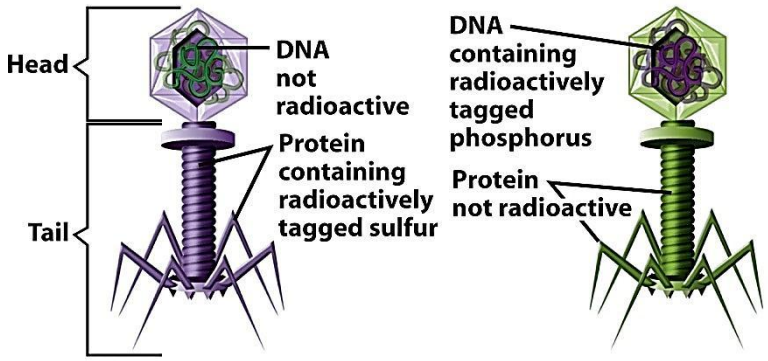
Griffiths identified the material as the transforming principle

Avery, MacLeod and McCartney studied the transforming principle for 20 years. They determined that the transforming agent was DNA.

The figure below showing the emerging traits of two different species for DNA exchanging

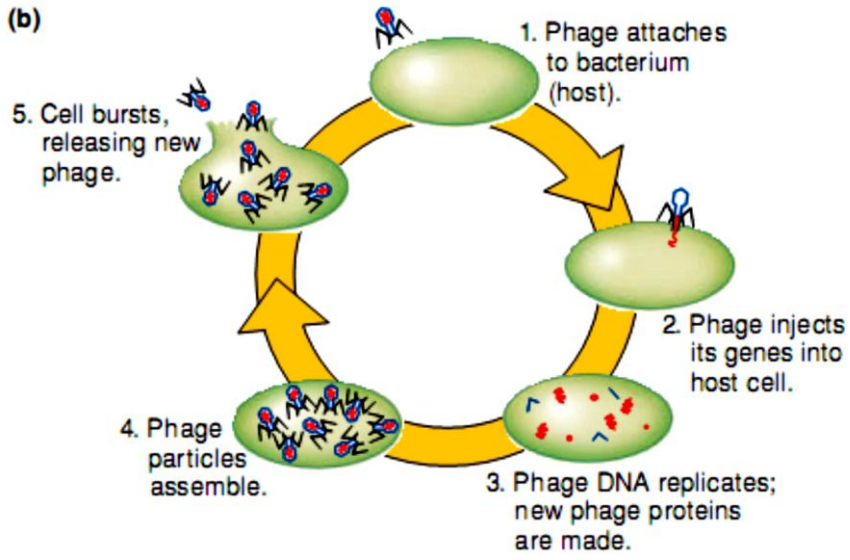


- Alfred Hershey and Martha Chase studied viruses that infect bacteria, Viruses are called bacteriophages, which are made of Protein coat and nucleic acid
- Viruses mix their genes with host genes
  - hijack cell machinery and use it to produces new viruses
  - Usually kills host cell
- Hershey and Chase labeled protein and DNA differently with isotopes, Variants of elements that share same chemical properties but differ in number of neutrons, he label DNA with ^{32}P and protein with ^{35}S



EVENTS WHICH TAKE PLACE IN LIFECYCLE OF BACTERIOPHAGE

- Attachment of Bacteriophage to receptor site on bacterial cell wall by its tail
- Bacterial cell wall dissolves at the point of contact
- Phage DNA enters into Bacterial cell, protein coat remains outside
- Phage DNA replicates forming many copies
- Assembly of phage DNA into new protein shells
- Lysis or breakdown of host cell and release of infective phage particle.



HERSHEY & CHASE (1952) EXPERIMENT WITH T2BACTERIOPHAGE

In culture I Bacteriophage was grown in medium containing Radioactive Phosphorus (32P)) To make DNA RadioactiveIn, culture II Bacteriophage was grown in medium containing radioactive Sulphur (35S) To make proteins Radioactive. Both kinds of Bacteriophage particles were allowed to infect Bacteria, The infected bacteria were observed for radioactivity. Radioactive Phosphorus was found with bacterial cells Radioactive. Sulphur was not traced in bacterial cells (Only in Ghosts) Bacteriophage progeny carried only radioactive phosphorus and not radioactive sulphur

INDIRECT EVIDENCES FOR DNA AS GENETIC MATERIAL

1. Presence of DNA regularly in nuclei of all types of cells

2. Equal amount of DNA is present in all cells of an organism

3. Amount of DNA is proportional to the diploidy of cell . Haploid cells have ½ the amount of DNA than diploid cell.

4. Nuclear Division occurs only after DNA duplication during S phase of Interphase

5.Vaiation in Diploid amount of DNA amongst different species

6. DNA has same physical and chemical properties in all organisms yet allow to produce great diversity of organisms

7. Indefinite number of combinations are possible with four bases A T G C

8. Of all macromolecules DNA is metabolically most stable. In prokaryotes DNA is not linked with proteins still characters are inherited

The Structure and Function of Genes

• The complete set of instructions for making anorganism is called its genome. It contains themaster blueprint for all cellular structures andactivities for the lifetime of the cell or organism.

• The genome consists of tightly coiled threads of deoxyribonucleic acid (DNA) and associated protein molecules, organized into structures calledchromosomes.

• For each organism, the components of these slender threads encode all the information necessary for building and maintaining life, from simple bacteria to remarkably complex human beings.

An organism has some form of nucleic acid which is the chemical carrier of its genetic information.

• There are two types of nucleic acids, *deoxyribonucleic acid* (DNA) and *ribonucleic acid* (RNA) which code for all the information that determines the nature of the organism's cells.

• DNA codes for all the instructions needed for the cell to perform different functions. Human DNA contains enough information to produce about 100,000 **proteins**

THE STRUCTURE OF NUCLEIC ACID CHAINS

• To form polynucleotides of either DNA or RNA , nucleotides are linked together by covalent bond between the phosphate groups. These phosphate linkage are called phosphodiester bonds.

• Nucleotides are joined together in DNA and RNA by ***phosphodiester bonds*** between the phosphate component of one nucleotide and the hydroxyl component in the sugar molecule of the next nucleotide.

• An ester bond is a bond which occurs between a Carbon atom and an Oxygen atom.

• More and more nucleotides can be added on by the same process of forming ester bonds until an immense chain is formed.

• But no matter how long a polynucleotide chain is, one end of the nucleic acid

molecule always has a free -OH group on the sugar at the Carbon known as C3'

(called the ***3' end***) and the other end of the molecule always has a phosphate group at C5' (the ***5' end***).

SOME ORGANISMS HAVE RNA AS GENETICMATERIAL

Some Viruses have RNA as Genetic Material RNA Virus (Ribo Virus) may have ssRNA or dsRNA enveloped by Protein Coat Notable human diseases caused by RNA viruses include SARS, Influenza ,Hepatitis C, Measels, Mumps and Rabies Rous Sarcoma Virus (causing cancer) and HIV (causing AIDS) both are Retrovirus using Reverse Transcription for DNA synthesis in host cell

EVIDENCE IN FAVOUR OF RNA ASGENETIC MATERIALA

- Gierer and G Schramm (1956) when inoculated tobacco plants with Purified RNA isolated from TMV
- Leisons appeared on leaves of healthy plant
- H Fraenkel Conrat and B Singer (1957) separated RNA from protein of TMV in first step .In second step reconstituted virus with protein from mutant strain of TMV
- Inoculated Hybrid TMV into healthy tobacco plant
- Tobacco Mosaic disease appeared TMV progeny isolated from diseased plant showed parental RNA only but not parental proteins, This provided evidence that RNA carries information for assembly of Virus particles and not proteins RNA thus is the Genetic Material in TMV

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