Bacterial Genetics

Bacterial Genetics is the process of heredity and variation. It is the starting point from which all other cellular Pathways Functions, and structure originates.

the ability of a microorganism to maintain Viability, adapting multiply and cause disease is founded in genetics

the three major aspects of Microbial genetics that require discussion are:

1- the structure and organization of genetic material
2- Replication and Expression of genetic information
3- the mechanism by which genetic information is changed and exchanged among bacteria

* Gene: is the unit of heredity, it is a segment of DNA that carries its in formation Sequence and property.

* Phenotype in the collective structural and physiological properties of a cell or an organism (color of eye in human, resistance of antibiotics in bacteria.

*Genotypes :the alteration in the sequence of DNA within agene or in the organization of genes.

a change in genotype is the chemical basis for variation in phenotype.

The structure and organization of nucleic acids_ For all living cell, genetic informations resides in nucleic acids. They are stored as a sequence of bases in decoyribonucleic acid (DNA) and in ribonucleic acid (RNA)

Nucleotide structure and sequence :there are "Four common nucleotide bases in DNA they are

- two purines:
- A) Adenine
- (G) Guanine
- two Pyrimidines
- (C) Cytosine
- (T) Thymine

-DNA molecule also consists of deoxyribose sugar connected by phosphodiester bonds forming the (strand chain).the sugar, the phosphate and the base all together form a single unit referred to as a nucleotide

-The arrangement of bases along these strand is known as base sequence --the sequence provides information and determines the properties of the cell, it isKnown as the genetic code .

*** Deoxyribonucleic acid DNA**

Most DNA molecules are double stranded with complementary bases (A=T), (G≡C) paired by hydrogen bonding in the center of the molecule they are called Base paire the base pairs are stalked in the center of DNA double helix and they determine the genetic information the length of DNA molecule is expressed in thousands of base pairs or (kbp) Kilobase pair. eg. A small DNA virus may contain a singleDNA molecule of (5-Kbp) whereas the Single DNA molecule of the bacterium *E.coli* chromosomes is about (4000-Kbp)

-The DNA molecule is Folded and super coiled in the bacterial chromosome.

-Each base air is separated from the next by about (0.34 nm) or (3.4 x 10 mm) in *E.coli*

*** Ribonucleic acid RNA:**

most frequently occur in single-strand for the base uracil (U) have the same function as the base (T)thymine in DNA.,So

- the complementary bases that determine the structure of (RNA) are (A-U),(G-C)

-there are three major types of RNA:

1- messenger RNA(mRNA) : carry genetis messages

2- transfer RNA (tRNA), translator

3- ribosomal RNA (rRNA) the most general function of RNA is to communicate between DNA gene sequence and Ribosomes. this is done Primarily by (mRNA)from the DNA to ribosomes .the ribosomes that contain rRNA and protein translate this message in to the amino acid structure of proteins by the(tRNA)

- few RNA molecule have been found to function as enzymes

The Bacterial Genome:

the genome of an organism is defined as the totality of its genetic informations. For the bacteria, the genome consists of a Single chromosome, that carries all of the essential genes and one or more varieties of plasmid that generally caffy non essential genes.

* The chromosomes:

ALL of the essential genes and many non essential genes of the bacterium are carried on a single Long piece of circulars ,double Stranded DNA.this molecular structure is called the chromosome. most bacteria have chromosomes that contain 2000-4000 genes.

* Extra chromosomal elements

In addition to the chromosomes, many bacteria possess smaller, independently replicating (extra-chromosomal) nucleic acid molecules termed :

1-plasmids

2- Episomes

3-Transposons

4-Bacteriophages

1- plasmids: Bacteria contain small (DNA)circles "plasmids" ranging in size from 1.5 Kbp- 120kbp.

-plasmids replicate independently of the chromosome and can exist in the cell as one copy or many copies.

- Plasmids can carry genes for toxins and for Proteins that promotes transfer of the plasmid to other cells, but usually do not include genes that are essential for cell growth and replication. plasmids can be either:

(a) Transmissible: Transfere to another cell by conjugation eg. F Factor (sex Factor), R Factor (Drug Factor)

(b)-non-transmissible.

2- Transposons: these are mobile DNA sequences that can move between plmid and between plasmid and chromosoine.

- they are of two kinds:

(a)- Simple transposons - Carry only genetic information

(b)- Complex transposons: carry genes for specialized Functions

e.g. drug tesistance.

3) Episomes: Geneteic elements that can be integrated in the host cell chromosomes.

(4)- Bacteriophage.

***Gene Transfer**: Genes can be transferred from one bacterial cell to another by three distinct mechanisms

(1) conjugation; it is the process by which bacteria transfer genes from one cell to another brett-to cell contact.

-the donor (male) and recepient (female) cells must have the proper genetic constitution to adhere to each other, and form a cytoplasmic bridge between the cells through which DNA can pass.

-this process require the presence of hair-Like projections (sex pili) on donor cell with a specific receptor site on surface of resepient cell. This contact results in a stable cell pair and initiation of DNA transfer.

(2) Transcluction the transfer af genes from one cell to another (via a phage)Nector without cell-to-cell contact.

-phages that undergo this process are temperate phages which can transfer one portion of DNA from one bacterium to another. there are two-ways of transduction:

A- Generalized transductions: A randam fragment of bacterial DNA that is accidentally encapsulated in a phage instead of its DNA, this is transferred to another bacterium when this phage infects the new bacterium .(Transduction can transfer any bacterial genes).

B)- Specialized transduction: only certain bacterial genes Located on the proximitly to the phage are transduced. (Transduction of only certain group of genes)

(3) Transformation it is the transfer of genes from one cell to another

by means of naked DNA. the mechanism of DNA uptake includes the presence of specific receptors for DNA on the surface of recepient cell and their cell wall must contain Large Pores For the DNA to pass through

transformation process.:

a free double-stranded DNA enters the recepient cell. one of the two Strands is destroy by cell nucleases , the remaining single Strand invades

the resident chromosome Seeking a homologous sequence. if such Sequence is found, the invading Strand replaces one of the two resident Strands by a complex process(cut-and paste process).

Mutation: any change in the structure of genetic material or any change in the base sequence of DNA is called 'Mutation.

-some mutations are unstable (they revert back to their original state).

-Real mutations are those that are stable and can cause some changes in the characteistics of the oganism. Although all of the cells in a pure bacterial culture are derived from a single original cell, the culture typically contains rare cells that differ from the originating cell, this may occur after repeated cell divisions which may reaches to thousands. During such divisions, many different mutations will have occured affecting many genes of the cell. the final result is the presence of small proportions of variants (mutants).

***Genetic and Non-genetic Variations:**

the DNA is double helix with complementary nucleas Sequences in the two strands. At replication, the strands separate and a news complementary strands are formed on each of the originals, so that two identical double helices are produced, each with the some nucleotide sequence without same genetic information as the originals.

-Some times, alteration is nucleotide sequense occur during this process, this is called " Mutation", so, mutation is the commonest source of genetic Variation in bacteriche

The main distinction between genetic (genotypic) and non-genetic (phenotypic) Variasions is:

(a) the genotypic is heritable and maintained through changes in environmental conditions.

(b) the phenotypic is dependent on the inducing environmental conditions alteringe when these change.

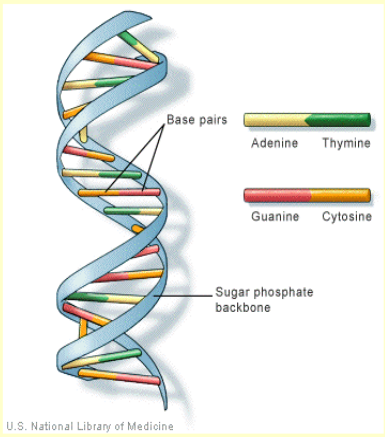
Lysogenic conversion:

Some bacterial Strains may get infected with temperate bacteriophage inducing new properties to the bacterial host, such properties are retained as long as the bacterium remains infected with the phage .(e.g - Toxigenicity acquirement in bacterias)

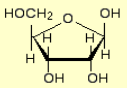
A quick look at the whole structure of DNA

These days, most people know about DNA as a complex molecule which carries the genetic code. Most will also have heard of the famous double helix.

I'm going to start with a diagram of the whole structure, and then take it apart to see how it all fits together. The diagram shows a tiny bit of a DNA double helix.



RIBOSE

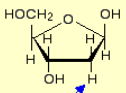


This diagram misses out the carbon atoms in the ring for clarity. Each of the four corners where there isn't an atom shown has a carbon atom.

The heavier lines are coming out of the screen or paper towards you. In other words, you are looking at the molecule from a bit above the plane of the ring.

So that's ribose. Deoxyribose, as the name might suggest, is ribose which has lost an oxygen atom - "de-oxy".

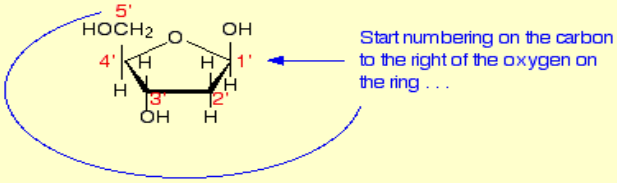
DEOXYRIBOSE



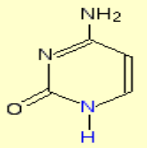
Deoxyribose has a hydrogen here rather than -OH.

The only other thing you need to know about deoxyribose (or ribose, for that matter) is how the carbon atoms in the ring are numbered.

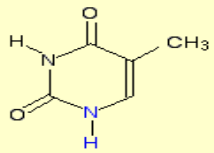
The carbon atom to the right of the oxygen as we have drawn the ring is given the number 1, and then you work around to the carbon on the CH_2OH side group which is number 5.



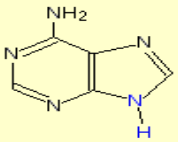
You will notice that each of the numbers has a small dash by it - 3' or 5', for example. If you just had ribose or deoxyribose on its own, that wouldn't be necessary, but in DNA and RNA these



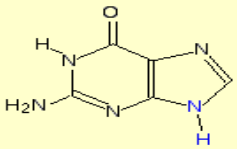
cytosine (C)



thymine (T)



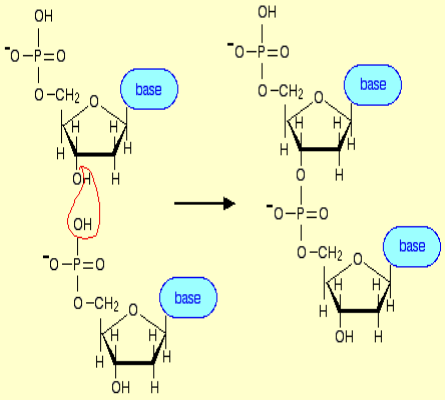
adenine (A)



guanine (G)

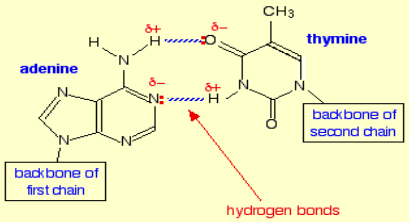
A DNA strand is simply a string of nucleotides joined together. I can show how this happens perfectly well by going back to a simpler diagram and not worrying about the structure of the bases.

The phosphate group on one nucleotide links to the 3' carbon atom on the sugar of another one. In the process, a molecule of water is lost - another condensation reaction.

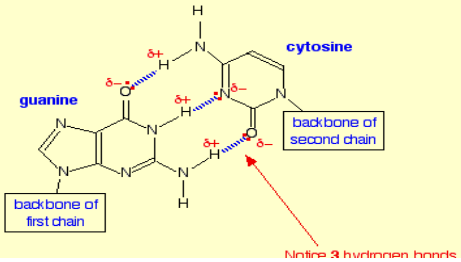


. . . and you can continue to add more nucleotides in the same way to build up the DNA chain.

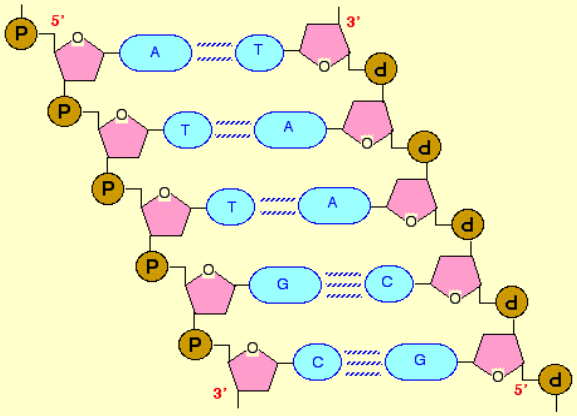
The A-T base pair:



The G-C base pair:



A final structure for DNA showing the important bits



Note: You might have noticed that I have shorten the chains by one base pair compared with the previous diagram. There isn't any sophisticated reason for this. The diagram just got a little bit too big for my normal page width, and it was a lot easier to just chop a bit off the bottom than rework all my previous diagrams to make them slightly smaller! This