Genome organisation of prokaryote

Eukaryotes – animal, Plant, Fungi, Protozoa

Prokaryotes – bacteria
Gram – negative – E.coli
+ Positive Bacillus subtilis
Cyano-bacteria (Anabaena)

Genome is complete set of genes of an organism (complete DNA sequence)

(1)

Genome of Prokaryotes :-

(1) an entire Prokaryotic genome is contained in a single circular DNA molecule

(2) Prokaryotes may also have independent smaller, circular & linear DNA molecule called Plasmid. The Plasmid gene coding for antibiotic resistance & ability to Utilize complex compound such as Toluene as a carbon source.

(3) Prokaryotes display a considerable diversity in genome organization.
eg. Unipartite genome to complex E.coli

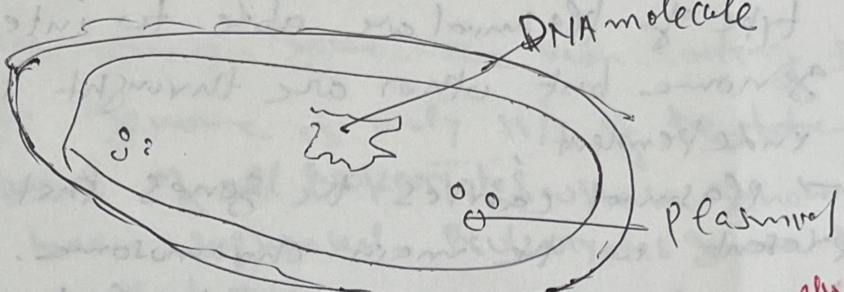
(4) Borrelia burgdorferi B-31 has a linear chromosome of 911 kb, having 853 gene. and also have 17 & 18 Linear & circular molecules
→ 533 kb – with atleast 430 genes.
Multipartite genome are known in many bacteria & archaea (extreme condition, spring condition) (bacterial less study)

(5) Prokaryotic genome is more compact than those of lower eukaryotes.
Some genes have no space between them eg – Thr A' & thr B' (Threonine) are separated by a single nucleotide & thr C' is found just after the last nucleotides of the thr B'. These three genes are an example of an operon

Operon: a group of genes involved in a single biochemical pathway & expressed in conjunction with one another.

(6) There are no Introns in the genes. ②

(7) There is no or low frequency of repetitive Sequence.



Prokaryotic bacteria

Bacillus Megaterium

Physical Structure of the Prokaryotic Genome

Most prokaryotic genome are less than 5Mb in size although a few are substantially larger than this. (B megaterium) has a huge genome of 30Mb. the genome is contained in a single circular DNA molecule localized with in the nucleoid

fig

DNA is very bigger than the size of cell for eg in E. Coli DNA size is 1.6 mm where as the size of bacteria is only 1.0 X 2.0 μm

for this there are several reasons

(1) DNA Super coiling < +ve supercoiling / -ve supercoiling during normal growth which is viewed & achived with the help of enzyme i.e DNA Gyrase & Topo-isomerase 1 & protein core

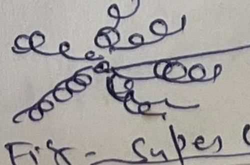


Fig = Super coiling

(2) Plasmid :- A plasmid is a small piece of DNA
→ often but not always circular that co-exist with the main chromosome in a bacterial cell. Some type of plasmid are able to integrate into many genome but other are thought to be permanently independent.

→ plasmid carries the genes that are usually not present in the main chromosome. but many cases these genes are not essential to the bacterium.

→ The plasmid are able to transfer from one cell to another & the same plasmid are some time found in the bacterial that along to different species.

→ The plasmid are independent identities & that is

~~most~~

The genetic organization of the prokaryotic genome

The bacterial genome have compact genetic organization with little space between gene. The non-coding DNA in the E. coli genome is only 11% of the total. E. coli is typical of all prokaryotes whose genome have so far been sequenced. Prokaryotes genome have many little wasted space.

(3) Operons are characteristic features of prokaryotic genome.

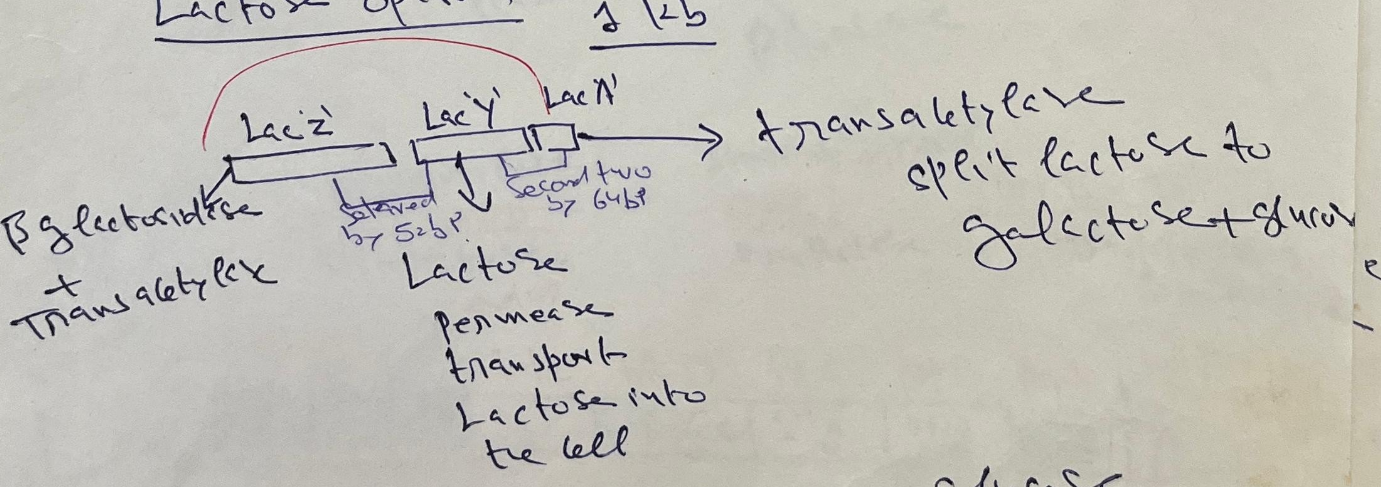
→ An operon is a group of genes that are located adjacent to one another in the genome with perhaps just one or two nucleotides between the end of one gene and the start of the next.

→ All the genes in an operon are expressed in a single unit. This type of arrangement is common in prokaryotic genome. eg Lactose operon of E. coli

→ This operon contain 3 genes involved in conversion of disaccharide sugar Lactose into its monosaccharide units - glucose & galactose

Lac

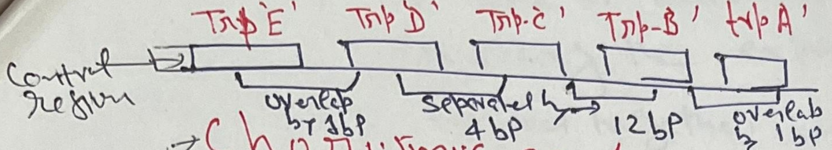
Lactose operon



Lactose → Galactose + Glucose

Trytophan operon

The trp operon consists of '5' structural genes arranged in a contiguous series, which code for the 3 enzymes that converts chorismic acid to Tryptophan



→ Chorismic acid → Tryptophan

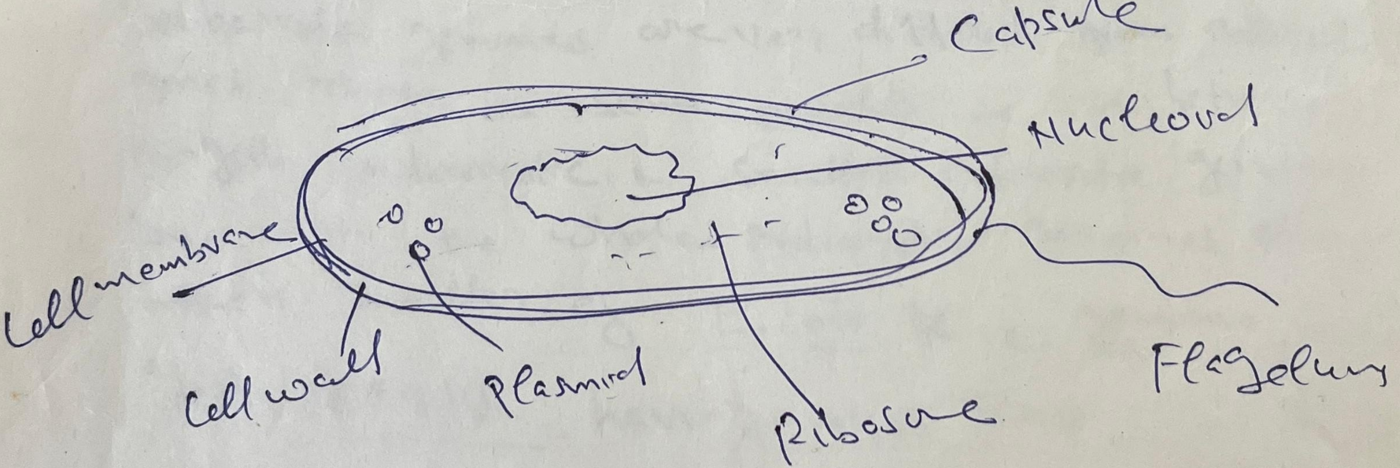
Chorismate → anthranilate → Phophoribosyl anthranilate ⟹ Indoleglycerol Phosphate → Indole → Tryptophan

Hr - 335 gre-g

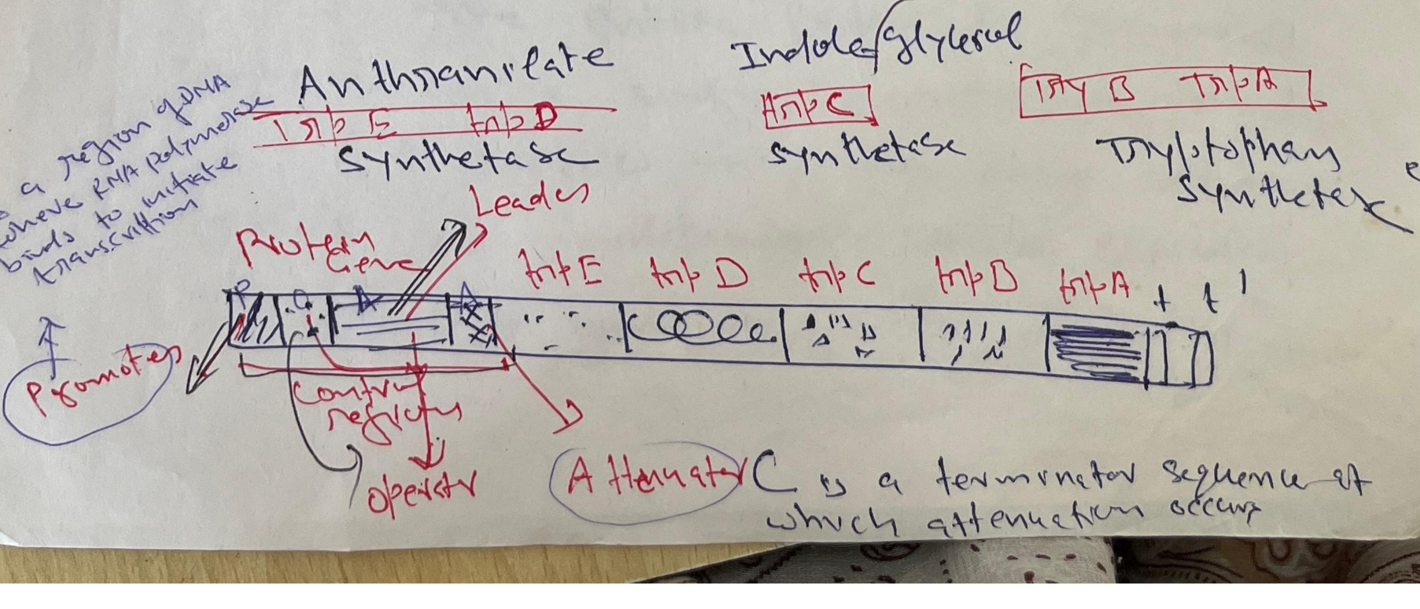
The Lactose operon!

3 genes are called Lac Z' Lac Y' & Lac A! The first two separated by 52bP & second two by 64bP.

→ All 3 genes are expressed together Lac Y' coding for the lactose permease with transport lactose into the cell & Lac Z' & Lac A' coding for enzymes that split lactose with its component systems - galactose & glucose.



Anthranilate	Indoleglycerol	
Trp E trp D	Trp C	Try B Trp A
Synthetase	synthetase	Tryptophan synthetase



C is a terminator sequence at which attenuation occurs

Tryptophan operon :

A bacterium is able to control its various biochemical activities by regulating the expression of groups of related genes. linked together in operon.

The tryptophan operon which contains five genes coding for enzyme involved in the multistep biochemical pathway that convert chorismic acid into amino acid tryptophan.

→ The genes in the tryptophan operon are close together. Trp 'E' & Trp 'D' overlap by 1bP as do trp 'B' & trp 'A', Trp 'D' & Trp 'C' are separated by 4 bP & Trp 'C' and Trp 'B' by 12 bP

Genomes of Prokaryotes

Prokaryotic genomes are very different from eukaryotic ones. There is some overlap in size between the largest prokaryotic & smallest eukaryotic genomes. but are the whole prokaryotic genomes are much smaller. eg. E. coli K 12 genome is just 4639 kb, having 4405 genes

The entire prokaryotic genome is contained in a single circular DNA molecules.

Prokaryotes may also have additional genes as independent smaller circular or linear DNA molecule called plasmid, Genome Organization :- "The genome organization is so Rigid that the overall result of selection pressure on DNA is visible in the genome text, which Differentiate the leading strand from the logging strand."

Genome Organization in Prokaryotes -

Most prokaryotic cells contain their genetic material in the form of a large single circular piece of double-stranded DNA, usually less than 5 Mbp long. In addition they may contain plasmid.

The protein-coding regions of bacterial genomes do not contain introns. In many prokaryotic genomes the protein-coding regions are partially organized into operons - "tendem genes transcribed into a single messenger RNA molecule under common transcription-al control." In bacteria, the genes of many operons code for protein with related functions. For instance, successive genes in the trp operon of E. coli for proteins that catalyse successive steps in the biosynthesis of tryptophan (~~form~~ In fig 1). In archaea, a metabolic relationship between genes in operons is less frequently observed.

Control region → | trp E | trp D | trp C | trp B | trp A |

Fig → The trp operon in E. coli begins with a control region containing promoter, operator and leader sequences. Five structural gene encode proteins that catalyse successive steps in the synthesis of the amino acid tryptophan from its precursor chorismate :-

Chorismate → anthranilate → Phosphoribosly anthranilate → indoleglycerol phosphate → Indol → ~~tryptophan~~

(1) (2) (3) (4) (5)

Most of the Prokaryotic genome are less than 5mb bi some cases it is more than or around 30 mb and the contained in the single circular molecule localized within the nucloides.

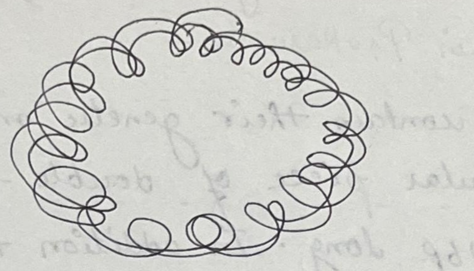


Fig - circular double stranded DNA

DNA is very bigger than the size of cell for eg in E.coli DNA size is 1.6 mm where as the size of bacteria is only 1.0 × 2.0 um.

For this there are several regsons -

1) DNA Supercoiling - The answer to this Question lies in DNA packaging. Most prokaryotes do not have histones (with the exception of those species in the domain Archaea. Thus, one way prokaryotes compress their DNA into smaller spaces is through supercoiling. Supercoiling is of 2 type
i) possitive Supercoiling and,
ii) Negative Supercoiling during normal growth which is viewed or achived with the help of enzyme i.e DNA gyrase & Topoisomerase I and protein core.

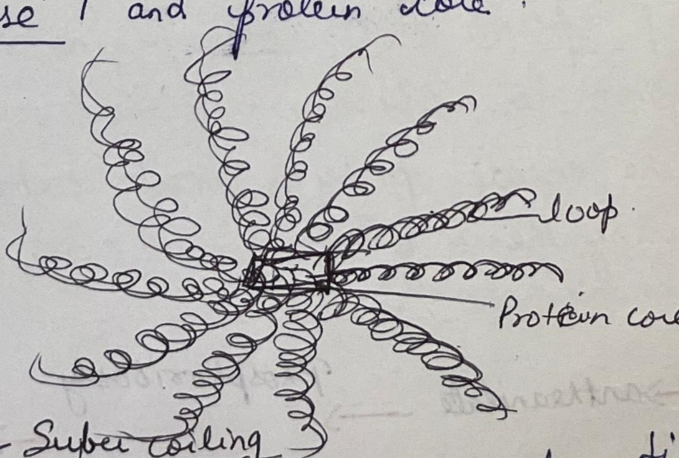
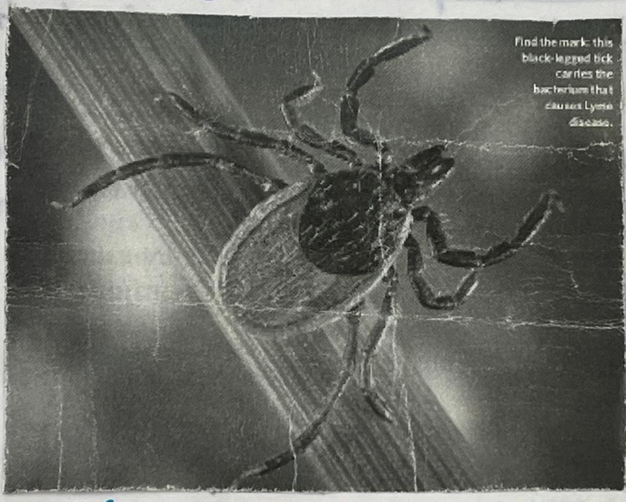


Fig - Super coiling

During the 1980s and 1990s, researchers discovered that multiple protein act together to fold and condense prokaryotic DNA.

studies have also shown that other protein, including integration factor (IHF), can bind to specific sequences within the genome and introduce additional bends (Rice et al., 1996) The folded DNA is the organised into a variety of conformation (Sinden & Pettijohn, 1981) that are supercoiled and wound around tetramers of the HU Protein;

On the prokaryotic genome has been condensed, DNA topoisomerase I, DNA gyrase, and other proteins help maintain the supercoils. One of these maintenance proteins, H-NS, plays an active role stimuli. Another maintainance protein, factor for inversion stimulation (FIS), is abundant during exponential growth and regulates the expression of more than 231 genes, including DNA topoisomerase I (Bradley et al 2007.)



Variation in Prokaryotic Genome Structure.

Fig → Deer tick (Ixodes sp.) transmits the bacteria (Borrelia sp.) that causes Lyme disease.

2) Plasmid – A plasmid is a small piece of DNA often but not always circular that co-exist with the main chromosome in a bacterial cell. Some type of plasmid are able to integrate into ~~many~~ main genome but other are thought to be paramanentelly independent. Plasmid carries the genes that are usually not present in the main chromosome. but many cases these genes are not essential to the bacterium. The plasmid are able to transfere from one cell to another and the same plasmid are some time found in the bacteria that along to different species. The plasmid are independent identies and that is most

cases the plasmid content of the prokaryotes are be included in the defination of genome.

3) Operon – It is characteristic feature of Prokaryotic genome due to the space constraints of packing so many essential genes onto a single chromosome, prokaryotes can be highly efficient in terms of genomic organization. Very little space is left between prokaryotic genes. As a result, non-coding seq. account for an average of 12% of the prokaryotic genome, as opposed to upwards of 98% of the genetic material in Eukaryotes (Ahnert et al, 2008) Furthermore, unlike eukaryotic chromosome, most prokaryotic genomes are organized into polycistronic operons, or clusters of more than one coding region attached to a single promoter, seperated by only a few base pair. The protein encoded by each operon often collaborate on a single task, such as the metabolism of a sugar into by-products that can be used for energy (Fig.-)

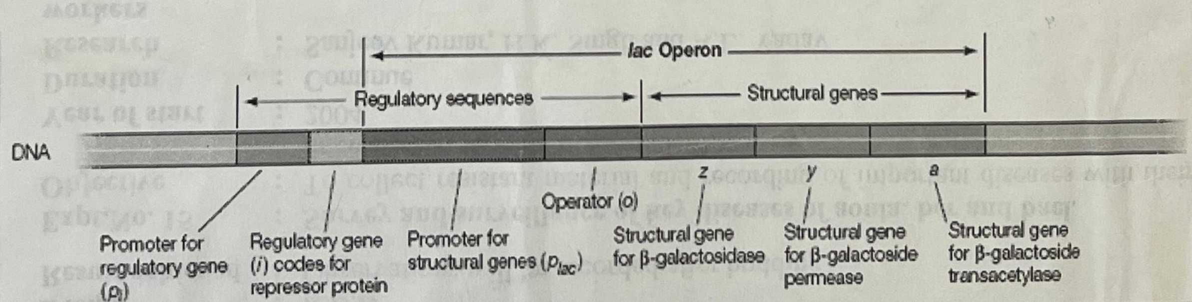


Figure 3: The lac operon of E. coli.
The lac operon of E. coli is a segment of DNA that includes a promoter, an operator, and the three structural genes that code for lactose-metabolizing enzymes.

often collaborate on a single task, such as the metabolism of a sugar into by-products that can be used for energy (Fig.)

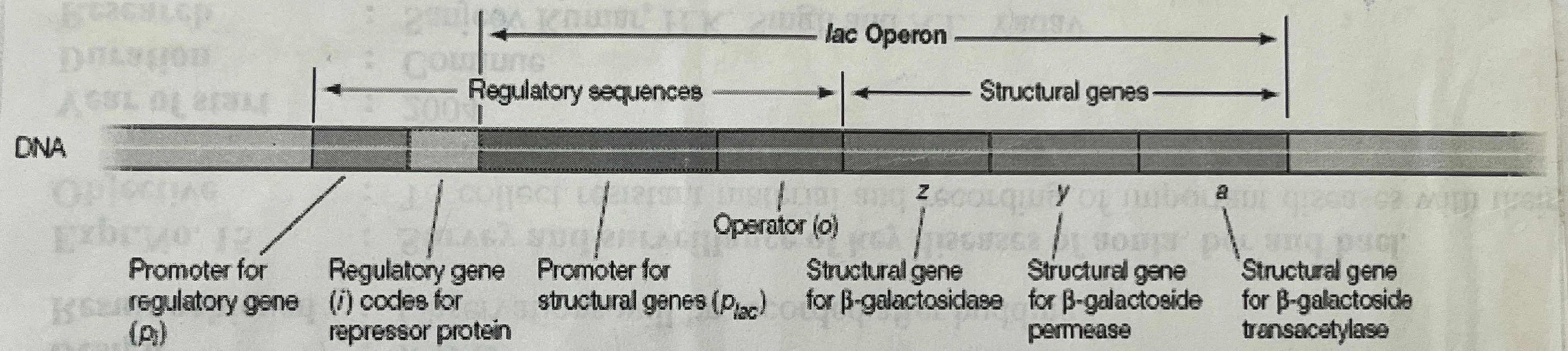


Figure 3: The lac operon of E. coli.

The lac operon of E. coli is a segment of DNA that includes a promoter, an operator, and the three structural genes that code for lactose-metabolizing enzymes.