University of Jordan
Faculty of Medicine

Medical Committee
The University of Jordan

Introduction to

Microbiology

Title :

Bacterial genetics

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: 8

○ Slides
○ Handout
● Sheet

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Bacterial genetics

Genetics is a part of the clinical medicine and it's used in the molecular technique in order to:

1.dignose infectious agent .

2. Treat certain genetic disorder even malignancy.

Example:

it's very difficult to distinguish between upper respiratory tract infection caused by viruses or bacteria due to the fact that both of them have the same clinical features.

*this is a problem especially to pediatrician.

*A simple test has been discovered and this test might be applied to infant.

It's about taking a blood sample from people who suffer from upper respiratory tract infection and they can distinguish between the viral and bacterial infectious according to the change in specific antigen in the blood stream.

*The growth of all bacterial cells is metabolic activity.

*Any part of bacterial cells is controlled by the presence of genes within the bacterial chromosome. Therefore the structure of the DNA is considered an important structure within any bacterial cell because it carries all necessary genes

for metabolic activity and the production of any proteins or enzymes in the bacterial cells.

*The bacterial genome is composed of a double helix DNA usually in a circular form (highly coiled) , and the DNA structure have all the necessary genes that can be used for the growth of the bacterial cell.

Types of genes

1. Expressed genes : Genes that can be expressed , and they're responsible for the phenotype growth of the bacteria and its characteristics can be observed whether in (vivo or vitro) in relation to infection.
as example : A, if the bacteria becomes resistant to the ampicillin due to a change in the genotype in the (expressed genes)
B, If the cell is non-motile then it becomes motile then these also are important in relation to what express genes.
C. If bacteria cells produced an end product then it also can be recognized.
2. Genes that cannot be expressed

*genotype: summary of all potential genes which found on the bacterial cell (all properties which found in the gene but it's not necessary for these properties to be expressed).

*Number of genes in most of bacterial cells range between 1000-4000 genes.

* some of exceptions like Chlamydia (1-500 genes)

*DNA in bacterial cells is a double helix, one copy is called template , and this template will be used to produce complimentary copy of DNA (transcription ,translation) then at the end it will produce an important proteins , enzymes ,,,, etc.

So genes are a segment of DNA that might be short or long and each one of these genes can be responsible for production of an end specific product (polypeptide , amino acids ,,,) , but generally more than one gene contribute in forming an enzyme (not only one).

Example: 15 genes contribute in forming the flagella.

This means that the number of genes depend on the end product.

According to the similarities between bacterial cells we can classify them to families (large group) – genus – species -- strains . (these similarities might be in relation to cell wall , presence of capsule or genetic background).

*The difference between two types of strain or two types of

genus or strains,,,, might be in a few number of genes in the bacterial chromosome and this means that some of the properties and characteristics will be different.
like (the presence of flagella ,the presence of capsule or the fermentation of lactose)
* the strains considered as a base of heredity or what we call clone.

*One clone will be dominant and the production of end products (express the true gene)

* Remember: not all genes will be expressed, (E.coli has 3000 genes, but less than 200 genes will be translated and sometimes under certain condition 300 will be translated.)
* This is important to recognize the evolution of bacterial cells , and that gene which will be expressed is responsible of all biological characteristics of the bacterial cells.

* phenotype is less understandable than the genotype due to the rapid changing of the phenotype in the bacterial cells.
(bacterial cells could convert and be resistant to some kinds of antibiotics or become toxic where before wasn't)

Bioengineering

* we can see the major shape of the genotype when we are at the beginning of culturing .

* any later change in the shape is a change in the phenotype.

example to illustrate : originally the genotype of the bacterial cell is not toxic but it becomes toxic during maturation.

*and this is used for genetic manipulations (pick up some genes and make new strains that might give us better end products such as (steric acid , lactic acid ,,,)

1. There are some segments of the bacterial cells that cannot be changed.
2. We can use these segments to identify a specific bacterial cell.

such as 16SRNA which help us to recognize staph

We use it to see if there are pathogens in urine.

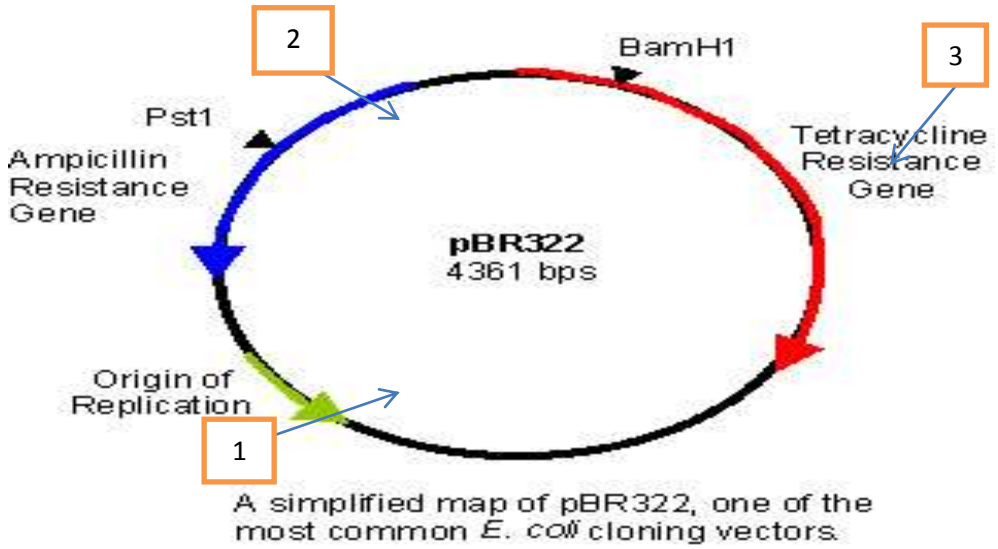
PLASMID

in addition to the bacterial chromosome there's something called plasmid.

**plasmid is a smaller segment of DNA found as extracellular extrachromosomal within the cytoplasm.

Due to fact that plasmid is a double helical structure within the cytoplasm it can't be eliminated from the bacterial cell (endonucleases can't cut double helix DNA while it's in a circular shape) so it's stable and small in size (100-200 genes only)

*more than one plasmid can be found in the bacterial cells … that depends on the type of the bacterial cell.



A simplified map of pBR322, one of the most common *E. coli* cloning vectors

(The next part depends on these figure)

(Arrow 1) indicates the Origin of replication :

here begins the replication of the plasmid if there's an importance to make a new one (as an example: to donate some DNA segments)

so it opens the double helix structure and starts

unwinding to release one copy of plasmid which can later produce a complimentary copy (within the same cell or another cells) with the same genes in a short period

*Structure of plasmid : 1. There is a main structure for the plasmid which is the circle in the figure above (without the arrows).
2. There are some addition structures represented by the arrows.
(Arrow 2): is the number of genes recombined with the main structure , it stands for production of Beta lactamase (ampicillin resistance enzyme) and can be inhereted thus resistant will be inhereted too .
*the plasmid might contain one or more resistant genes. (in the figure above we see 2 resistant genes) ,, it depends on the site of the plasmid.

Types of plasmid :

1. Conjugative Plasmid :

* It can be transmitted by presence of small segment of DNA which is responsible for production of what we called (Pilus)

* So … Pilus : Two black structure and allow of one copy of these plasmid to be transferred to a new bacterial cell . Therefore , for any bacterial culture you have to imagine that there's what we called (F+ Cells , F- Cells)

((F)) Stands For ((Fertility))

*Fertility : To donate small segment of DNA in a form of plasmid.

*So F+ Cells can donate a plasmid , and F- Cells having a lack of plasmid in their cytoplasm .

*In another way , The cells that donate a plasmid called (Donor Cells) , and the cells that accept these plasmid called (Recipient Cells) .

2. NonConjugative Plasmid

*It cannot be transmitted because one of these two reasons :

A- It doesn't have the mechanism of transmission.

B- It doesn't have the enzymes responsible for transmission .

If there's one conjugative plasmid and other nonconjugative within the same bacterial cell , then the non conjugative can cooperated with conjugative and transmitted together .

*The plasmid is found in the gram negative bacteria more than the gram positive bacteria .. and the transformation of the plasma can't easily happen form a negative bacteria to a positive one .

*So, keep in mind that there's a narrow host range of transformation so there's plasmid for E Coli and other or Salmonella .. etc . And these can help in differentiation of plasmid and understanding the method of transformation between cells

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Changes In The Bacterial Cells

There's always a changes in the arrangement of the nucleotides bases in the genes of the DNA within the bacterial cell .

Nice information to know : Our human body is always in mutations but if it reaches a certain level it will cause al malignancy

But the bacteria will not suffer from malignancy is will suffer from changes (maybe we could recognized the changes in more than 2 years) during replication .

* These mutation can occur mostly spontaneously at a low frequency of 10^-3 to 10^-10 per bacterial cell .

In the laboratory we can make some changes on the bacterial cell but not on the major properties such as the presence of the capsule or the response of the cell wall to the gram stain , but we can control other things like (controlling of the resistance of the bacterial cells to a certain enzymes).

Mechanism of gene transfer

Some of bacterial cells die during culturing , so it will release all of the components in there cytoplasm including the chromosome , at these time other bacterial cells (that have the ability to replicate) absorb the chromosome that's released by the dead cell . They absorb it using their cell wall and cytoplasmic membrane , these chromosome will inter the cytoplasm , therefore , if there chromosome has insertion sequence , then they can incorporated within the bacterial chromosome.

Insertion sequence : the chromosome that come from outside the cell should be ready to inter the bacterial chromosome in SPECIFIC sites , there must be certain compatibility

Importance of transformation

There's a bacteria called (streptococcus pneumoniae) -which is not associated with diseases under normal condition – some of them are capsulated other are not , sometimes we can convert the noncapsulated bacterial cells to capsulated and therefore increasing the pathogenecity .

1-To control the end product of a bacterial cell

2-To control the resistance of a bacterial cell to a certain antibody.

We can increase the concentration of the calcium in the bacterial cell which will increase the size of the cell and therefore increase the capability to enter more segments and cause more changes for the cell.

Transformation of plasmid

When the plasmid released from a cell and become ready to inter another cell it's converted by an enzymes to linear shape , and after entering the cytoplasm (and because the linear shaped DNA can't survive in the bacterial cells) it will back to the circular shape to avoid the cutting of the segments.

Then the plasmid will transport it's features to the host bacterial cell and it will be inherited to the next generation (the majority of our intestinal bacteria changes in these method),

- **Transposome**

During the replication of the bacterial chromosome , sometimes a small segment of DNA can be separated from the double helix DNA (but as we know the linear can't survive in the bacterial cell) so , if these segmental DNA have at there ending an (insertion sequences) it can easily combine with another DNA (Bacterial chromosome or plasmid). These Segment Called Transposome.

These small segment has a gene responsible for production of an enzyme called (transposase) induce the integration of the

segment (which called transposome) to the bacterial chromosome or the plasmid .

The importance of these process :

The scientists found that the bacterial cells once expressed to a pressure of an antibiotic they might lose these small segment (transeposome) and these small segment later are usually stands for production of certain enzymes against one or more antibodies .

Integrons :

They Are smaller than the transposone and linear , and they are responsible for antibiotic resistance (transfer resistance markers) They carry what we called R-gene cassettes .

Insertion sequences (IS):

are small segment of DNA units that can insert themselves into Plasmid/ Integrons.. and later attached to Chromosome.. Both are not capable of autonomous replication.

To Be Happy .. You Must Be Your Own Sunshine

Sorry for any mistake =D