Hello Friends and welcome to

this presentation on Gene Expression and Regulation.

In this module we will be talking about: Gene Expression

and Regulation, Induction and

Repression and Catabolite Repression.

At the end of the presentation

you will be able to define terms like gene expression,

transcriptional level gene regulation, translational gene

regulation. You will be able to compare and contrast between

induction and repression.

And you will be able to explain catabolite

repression.

So let's begin with the Central

Dogma. According to the Central Dogma, DNA makes RNA and RNA

makes protein. So this happens by the process of transcription

and translation respectively.

This formation of protein from DNA is actually what is

gene expression.

Expression of the gene can be controlled. It can be controlled

by controlling m RNA synthesis.

Or it can be controlled by controlling the protein synthesis.

If control of gene expression is through mRNA synthesis control

it is referred to as transcriptional level of

control. And if the control

is with respect to protein synthesis, then the control

is said to be at the translational level.

Such a control of gene expression through

transcription and translation is referred to

as regulation of gene expression.

Though transcription and translation are similar in all

domains, Bacteria, Archaea and

Eukarya, Regulation of gene expression differs in each of

these. Today we will be concentrating only on the

bacterial regulatory processes and in particular regulation at

the transcriptional level.

So this regulation happens by induction of enzyme

synthesis and repression of enzyme synthesis.

In a cell or in a system, there are enzymes which catalyze

reactions that are needed by the cell all the time.

So these enzymes are functional all the time and they are

referred to as housekeeping

enzymes. For example, the enzymes of the glycolytic pathway. And the genes that code for such enzymes are continuously expressed. They have to be continuously expressed so such genes are called as constitutive genes. On the other hand, there are enzymes which are made only when needed. So the expression of these genes, the genes for these enzymes, is regulated. Their expression is regulated. Such enzymes could be inducible enzymes, or they could be repressible enzymes and the genes in turn are called as inducible genes and repressible genes. Let us take a look at inducible enzymes.

A very good example of an inducible enzyme is beta galactosidase. The levels of betagalactosidase are found to rise in the presence of effector molecules like lactose or allolactose. Now betagalactosidase is an enzyme which breaks down lactose to give you glucose and galactose. This enzyme is not produced until and unless the substrate that is lactose is present in the medium. When lactose is present in the medium, it is converted into its isomer allolactose. And this allolactose binds to the repressor, inactivates it, and thus induces the gene responsible for the production of betagalactosidase.

Therefore, allolactose is called the inducer and the

gene which gets triggered is called the inducible gene.

This is the process of

induction. So in induction the

enzymes are produced only when the substrate is present.

And the production of the enzyme requires the

presence of inducers.

Repressible enzymes, on the

other hand. A good example to study repressible enzymes is

biosynthesis of amino acids.

The enzymes responsible for the biosynthesis of

amino acids are said to be under repressible control.

Amino acids present in the

surroundings inhibit the enzyme responsible for its

own biosynthesis.

If you look at this illustration, suppose you have a

system where there is no amino acid in the medium,

then the genes for production of the enzyme for the biosynthesis

of the amino acid is expressed,

as, the repressor is inactive.

Once the enzyme is produced, the amino acid is produced.

So the levels of amino acid in the system increase.

The minute high levels of amino acid are present in the environment, the amino acid acts on the repressor and activates the repressor.

Once the repressor is active

it inhibits the transcription of those genes responsible for producing the enzyme.

Thus, the amino acid itself inhibits the enzyme for its own biosynthesis. It acts as a corepressor, along with the repressor. And the genes which are affected by such a repressor corepressor interaction are called repressible genes. And the phenomena is referred to as repression.

If you compare the two that is inducible enzymes

and repressible enzymes,

We notice that inducible enzymes are required only when the substrate is available. If you recall, we spoke about beta galactosidase which is made only when lactose is present in the medium. Again, it is made only when the inducer allolactose is present in the

medium. And such enzymes are usually seen in catabolic pathways. On the other hand,repressible enzymes are known to

be involved in biosynthetic pathways, and they are not

needed if the substance is already present in the medium.

as we said earlier, as in the case of amino acids.

Thus induction and repression both act to

regulate gene expression.

Besides these two, let us look at another

condition. Another phenomena that happens

in *E. coli.*

When *E. coli* are grown in a medium containing glucose and

lactose, it is observed that glucose is utilized first.

The enzymes for lactose breakdown are not produced

at all, until all the glucose is exhausted.

Which means that the expression of the genes coding for the

enzymes of lactose breakdown is repressed because of the

presence of glucose.

This phenomena was referred to as glucose effect because it was

felt that it was glucose in the medium that was bringing about

repression or inhibition of enzymes of lactose.

But later on it was found that there is another protein which

regulates enzymes of lactose

breakdown. This protein is the Catabolite Activator Protein

which is also called as the cyclic AMP Receptor Protein.

And this kind of a regulation is called as

catabolite repression.

To understand catabolite repression, let us take

a look at the catabolite activator protein.

So catabolite activator protein or CAP, as it is commonly called

or CRP, that is the cyclic AMP receptor protein, exists in two

states. An inactive state and the active state.

In the inactive form, CAP is unable to bind to the DNA, to the

CAP binding site.

It has to be activated to bind.

And to activate it, we require high levels of cyclic AMP in the

system. When cyclic AMP is present in high levels, it

is able to bind to CAP and activate it.

Active CAP, that is the cyclic AMPCAP complex is now able to

bind to the CAP binding site on the Lac operon.

It bends the DNA by almost 90

degrees and stimulates transcription of beta galactosidase

gene by triggering the binding of RNA polymerase.

Now since CAP requires cyclic AMP in high levels.

We notice that cyclic AMP itself is dependent on the

levels of adenylate cyclase.

And adenylate cyclase is said to be active in the system

only when the levels of glucose

are low. So when levels of glucose are low

adenylate cyclase is active;

and brings about the production of cyclic AMP.

So cyclic AMP levels rise.

And when cyclic AMP levels rise,it can activate CAP.

Therefore, the levels of glucose is inversely

proportional to the levels of cyclic AMP in a system.

Thus, presence or absence of glucose in the system

regulates CAP and finally the metabolism of lactose through

regulation of the gene for beta galactosidase.

If you talk about the presence of the sugar, glucose and

lactose. And the absence of the sugar glucose and the absence of the sugar lactose, we have four

different combinations possible. Let us take a look at only two.

When glucose is present and lactose is absent:

Now, since the glucose is

present Cyclic AMP levels will be low. We said when glucose is

in high concentration, cyclic AMP is low, therefore CAP is not activated and you will not have transcription of the structural genes. At the same time we said there is no lactose in the medium, so, no transcription. On the other hand when glucose is absent in the medium and lactose is present. So the absence of glucose results in high levels of cyclic AMP, which in turn activates CAP and results in stimulating the structural genes and expression of the operon.

At the same time, presence of lactose in the medium acts as an inducer and triggers the gene to produce the enzyme beta galactosidase, again resulting in high levels of gene expression.

Thus the Lac operon is regulated by two proteins:

CAP and the lac repressor.

To summarize therefore,

Gene expression is regulated at the level of transcription and translation.

Induction is seen in catabolic enzymes, while repression is seen in genes of biosynthetic pathways. And two regulatory proteins CAP and lac repressor exercise dual control in the regulation of lac genes.

Thank you.