-Timing/coordination of specific events = necessary for normal development of organisms
- cell differentiation results from the expression of genes for tissue- specific proteins
- induction of transcription factors results in sequential gene expression. during development
- **Homeotic (HOX) genes** are involved in developmental patterns and sequences
- Embryonic induction in development results in the correct timing of events
-. **APOPTOSIS** (programmed cell death) plays a role in development/differentiation

- **MICRO RNA's**
- regulate genes/play role in development/ control of cellular functions
- Genetic mutations can result in abnormal development
- Environmental factors can influence gene expression
  EX: temperature and the availability of water determine seed germination in most plants.

PROKARYOTIC GENOME
• use substances/synthesize macromolecules just fast enough to meet needs
• If substance/enzyme needed, gene is transcribed.
• If substance/enzyme not needed, gene is turned off
• Allows for conservation of cell resources
• Controlling gene expression is one method of regulating metabolism

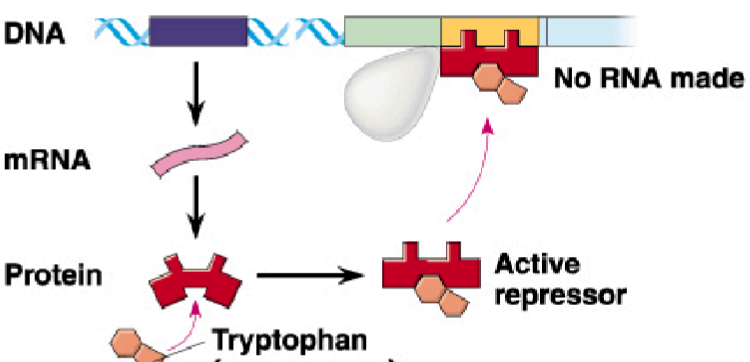
OPERON – Related genes grouped together with one promoter
• Allows for coordinated control of genes required for metabolism.
• One switch controls more than one gene
• Can be **inducible** or **repressible**.
• Not present in eukaryotes
Repressible and inducible enzymes = both examples of **NEGATIVE control** of a pathway
Activating the repressor proteins shuts off the pathway
POSITIVE control requires that an activator molecule switch on transcription

OPERATORS-
regions of DNA that control RNA access to promoter

REPRESSOR -
-regulatory protein binds to operator
- turns genes off (negative control mechanism)
- acts as a braking mechanism
- produced at a site away from the operon by regulatory gene.

Repressors alternate between active/inactive forms to control transcription.
• **Active form**- binds to operator/turns gene off
• **Inactive form**- conformation change prevents binding to operator
• Binding of **REPRESSOR** to **OPERATOR** prevents transcription -RNA polymerase not able to bind to promoter
~ **TURNS GENE OFF** -

Repressible Operons EX: trp operon	Inducible Operons EX: lac operon
Their genes are switched on until a specific metabolite activates the repressor.	Their genes are switched off until a specific metabolite inactivates the repressor.
Function in CATABOLIC pathways	
Enzyme synthesis is switched on by the nutrient the pathway uses	

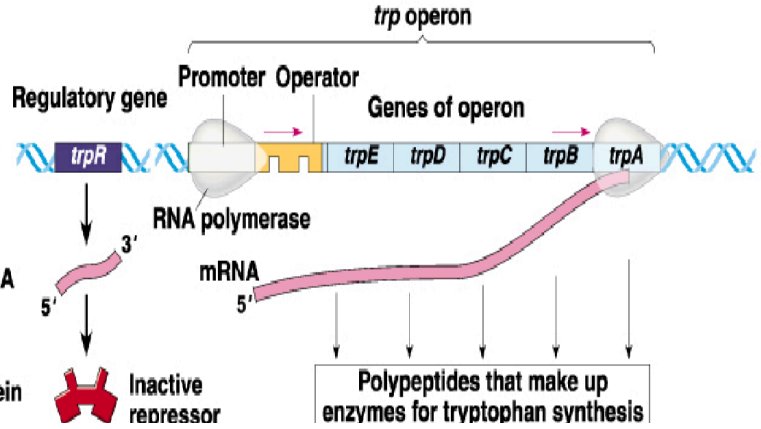


REPRESSIBLE: TRYPTOPHAN *trp* OPERON

Genes usually TURNED ON;
Repressor = INACTIVE;

Can be turned off
by activating repressor

Allows cell to use genes when tryptophan is needed and turn off genes when trp is plentiful



TRYPTOPHAN = corepressor
Presence of tryptophan activates repressor

If TRYPTOPHAN is present,
don't need to make more

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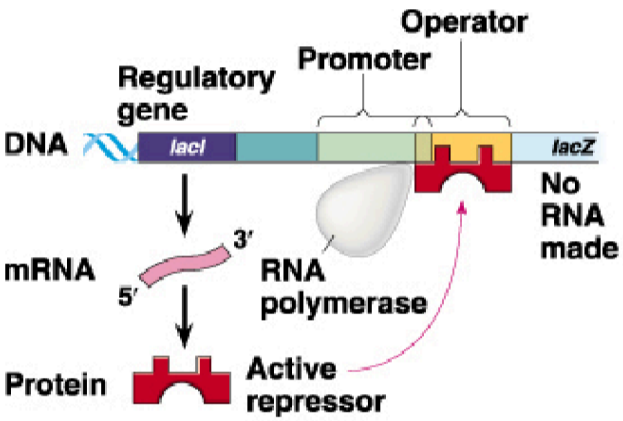
INDUCIBLE LACTOSE *lac* OPERON



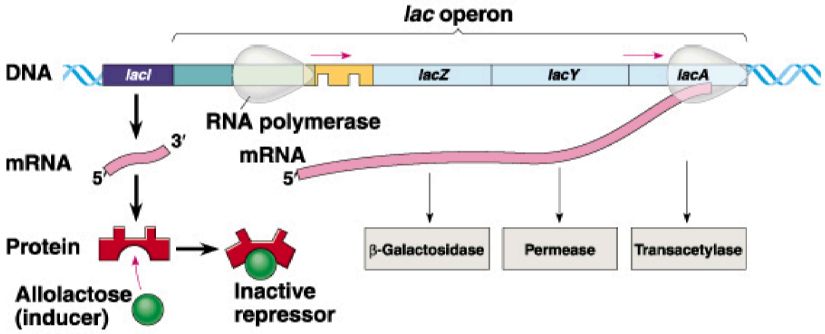
Genes usually TURNED OFF;
Repressor = ACTIVE; binds OPERATOR
Can be turned ON by deactivating repressor

Allows cell to turn on genes needed for lactose digestion when lactose is available

Keeps genes turned off unless needed

ALLOLACTOSE =inducer
presence inactivates repressor

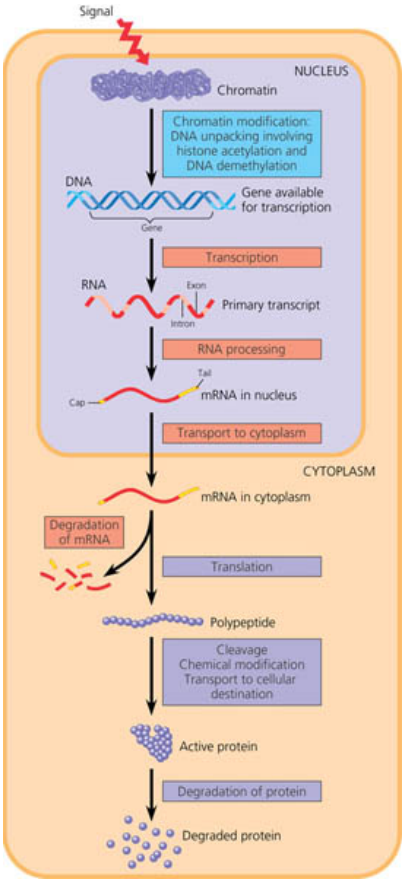
Cell only turns gene on when needed



EUKARYOTIC GENOME REGULATION
-genes NOT grouped into operons

CHROMOSOME STRUCTURE
DNA PACKING/CHEMICAL MODIFICATION
HISTONES wrap DNA into beadlike bundles = **NUCLEOSOMES**
Tight wrapping around **HISTONES** turns genes off
Addition of **ACETYL GROUPS** to histones loosens wrapping **HETEROCHROMATIN**-tightly packed
EUCHROMATIN-less tightly packed

DNA METHYLATION-adding ($-CH_3$) to cytosine blocks transcription
EX: Barr bodies, genomic imprinting (epigenetics)



TRANSCRIPTIONAL CONTROL
PROMOTER region at beginning of gene
binding of RNA polymerase/transcripton factors
controls speed of transcription

TATA BOX-helps position RNA Polymerase

ENHANCER sequences-upstream from gene
binding of proteins here speeds up transcription

POST TRANSCRIPTIONAL CONTROL
RNA PROCESSING
- Intron/exon editing
- Alternative RNA splicing
- 5' CAP & Poly-A tail

NUCLEAR TRANSPORT
-Control speed of exit out of nucleus

TRANSLATIONAL CONTROL
Regulatory proteins prevent ribosome binding to 5' end of mRNA
Change rate of mRNA digestion
Change rate of aminoacyl-tRNA synthetase recharging tRNA's

POST-TRANSLATIONAL CONTROL
RNAinterference (RNAi) – short RNA's bind mRNA
MICRO RNA (miRNA) - block reading of message by ribosomes
SMALL INTERFERING (siRNA) RNA's tag message for degradation
CLEAVAGE-Cutting polypeptide chain to produce functional protein
EX: proinsulin (1 chain) → insulin (2 chains)
CHEMICAL MODIFICATION-
Add sugars, phosphates, etc
TRANSPORT TAGS-
Identify cellular destination
UBIQUITIN=protein tag
identifies proteins for degradation
digested by **PROTEASOMES**