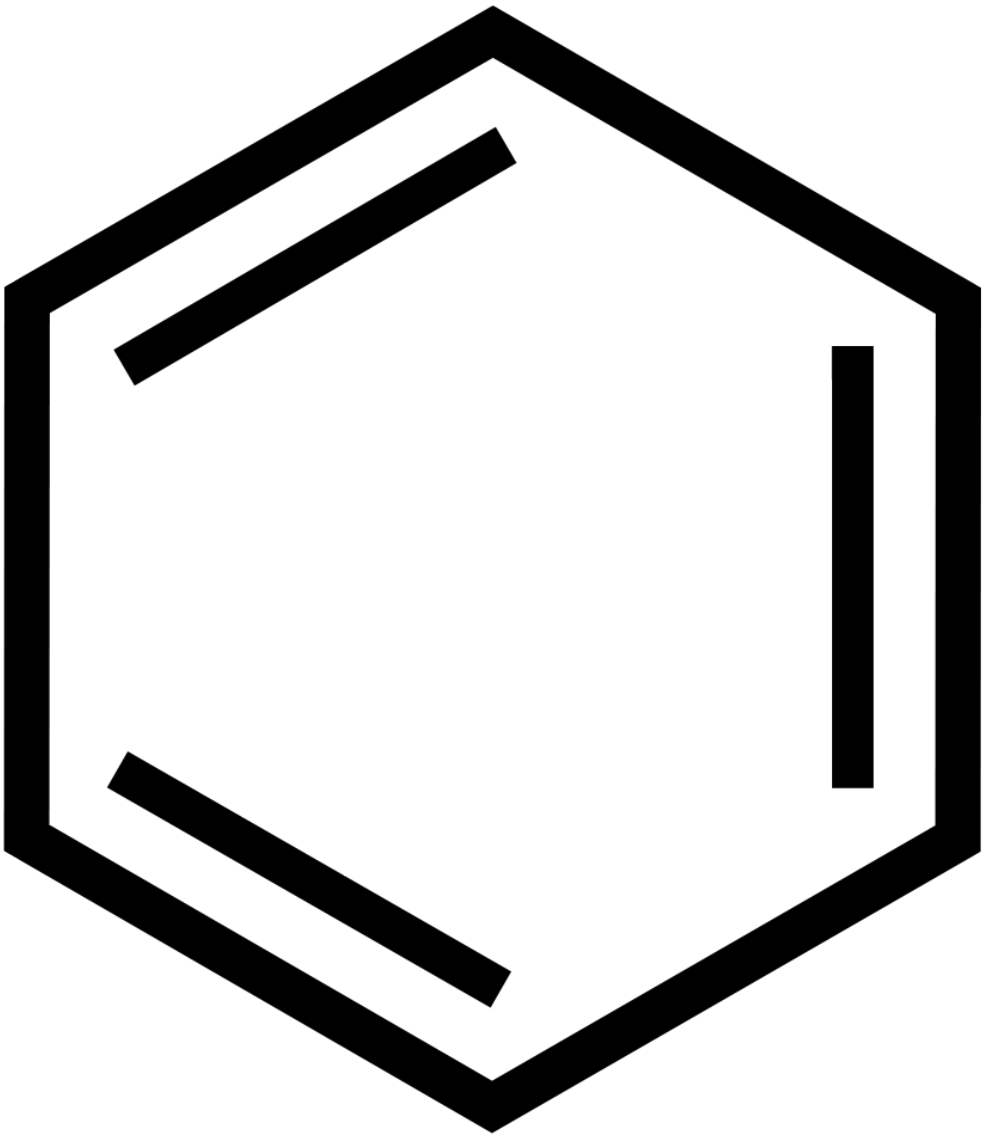

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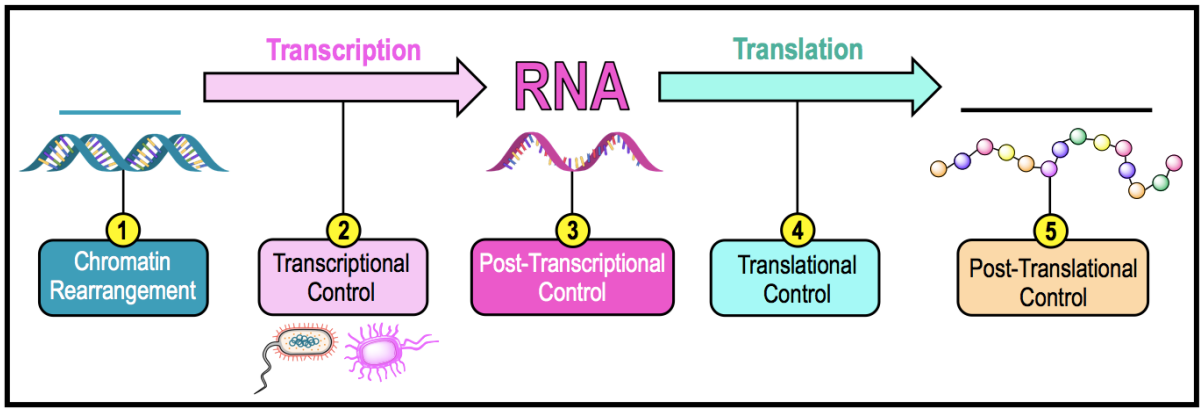
CONCEPT: INTRODUCTION TO REGULATION OF GENE EXPRESSION

- Prokaryotic & eukaryotic cells both have the ability to *regulate* (or *control*) their **gene** _____.
- *Gene expression* can be controlled at any of _____ stages:
  1. _____ **Rearrangements:** regulates chromatin conformation & DNA's accessibility for transcription.
  2. _____ **Control:** regulates RNA polymerase binding to a promoter & initiation of transcription.
     - Most _____ gene regulation occurs via *transcriptional control*.
  3. _____**-Transcriptional Control:** regulates modifications to RNA *after* transcription.
  4. _____ **Control:** regulates initiation & elongation steps of translation.
  5. _____**-Translational Control:** regulates modifications to proteins *after* translation.

EXAMPLE: 5 Stages Regulating Gene Expression.

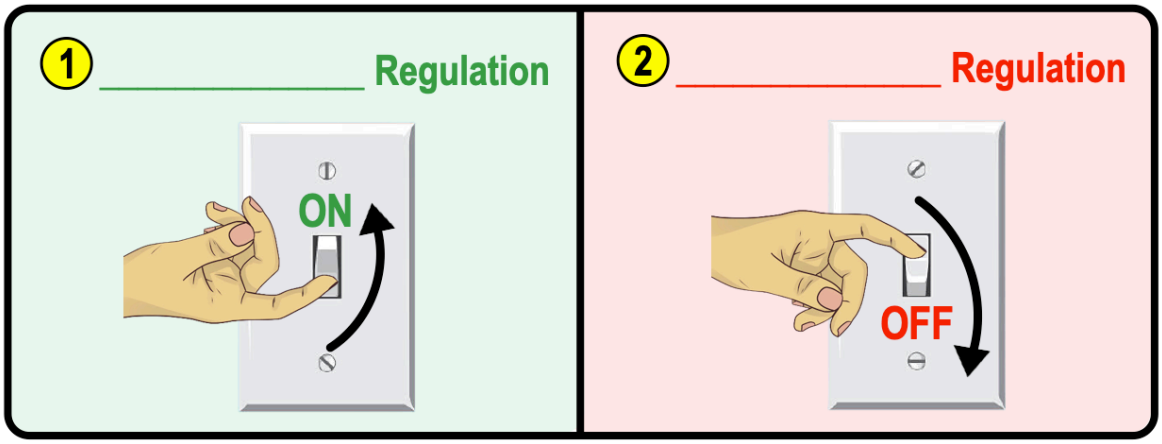


- _____ gene regulation can occur at any of these 5 stages.

Positive vs Negative Gene Regulation

- Cells regulate gene expression in ___ ways:
  1. **Positive Regulation:** *stimulates gene* expression by turning "_____" the gene.
  2. **Negative Regulation:** *prevents* gene expression by turning "_____" the gene.

EXAMPLE: Positive & Negative Regulation of a Gene Resembles a "Light Switch."



CONCEPT: INTRODUCTION TO REGULATION OF GENE EXPRESSION

PRACTICE: Post-translational control refers to:

a) Regulation of gene expression after transcription.
b) Regulation of gene expression after translation.
c) Control of epigenetic activation.
d) Period between transcription and translation.

PRACTICE: Which of the following is an example of positive regulation of gene expression?

a) Transcription is halted on a specific gene to limit the amount of protein being created by the gene's expression.
b) The protein that is translated is immediately degraded by the cell before it can serve its function.
c) Elongation of translation comes to a stop and the ribosome dissociates when a regulatory protein binds.
d) A protein binds to DNA and then stimulates the initiation of transcription of a specific gene.

PRACTICE: In prokaryotes, control of gene expression usually occurs at the

a) Splicing of pre-mRNA into mature mRNA.
b) Post-translational control level.
c) Transcriptional control level.
d) All of the above.

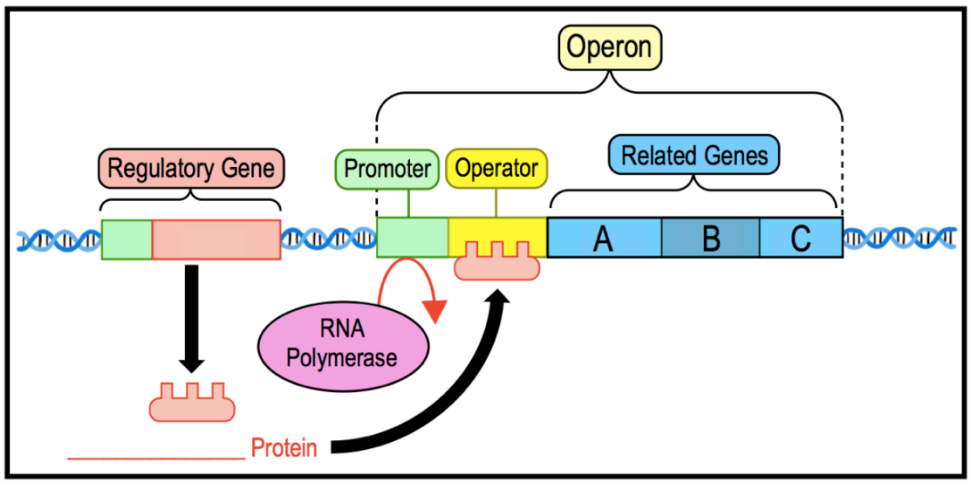
CONCEPT: PROKARYOTIC GENE REGULATION VIA OPERONS

- *Prokaryotes* must survive in environments that constantly _____ in the availability of nutrients.
  - □ Requires them to rapidly change their metabolic pathways by _____ expression of certain genes.
  - □ *Prokaryotes* commonly control expression of genes using _____.

Structure of an Operon

- _____: a set/group of prokaryotic genes of related function controlled by a *single* **promoter**.
- Transcription of the *operon* is regulated by the _____: region of DNA where *regulatory proteins* bind.
  - □ **Regulatory protein**: binds to the *operator* & _____ RNA polymerase binding to the promoter.
  - □ **Repressor**: regulatory protein that _____ RNA polymerase binding (*preventing* transcription).
  - □ **Activator**: regulatory protein that _____ RNA polymerase binding (*stimulating* transcription).

EXAMPLE: Structure of an Operon & Repressor Protein Binding.



PRACTICE: Altering patterns of gene expression in prokaryotes would likely increase a prokaryote's survival by _____.

a) Organizing gene expression, so that genes are expressed in a given order.
b) Allowing each gene to be expressed an equal number of times.
c) Allowing a prokaryote to adjust to changes in environmental conditions.
d) Allowing environmental changes to alter a prokaryote's genome.

PRACTICE: Which of the following is true about operons?

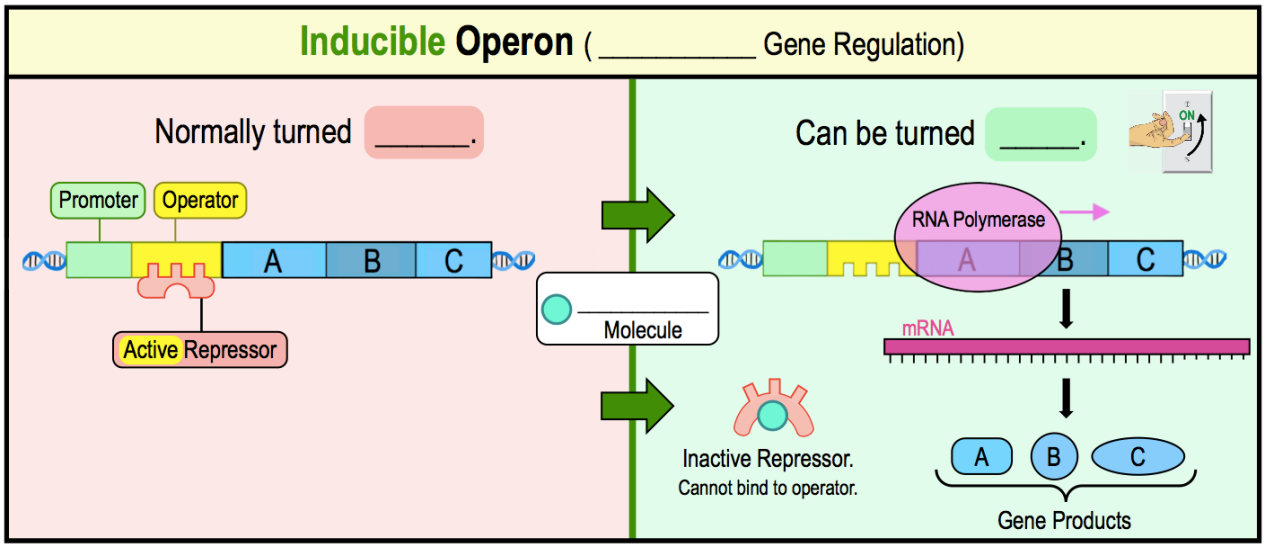
a) They allow the organism the opportunity to simultaneously regulate transcription of multiple genes.
b) They allow the organism the opportunity to regulate transcription of a single gene.
c) They allow many genes to be expressed at the same time, even those unrelated in function.
d) They significantly increase the rate of DNA replication, thereby make transcription more efficient.

CONCEPT: PROKARYOTIC GENE REGULATION VIA OPERONS

Inducible Operons

- _____ **Operon:** normally turned "_____" but can be turned "_____" (*induced*) in presence of **inducer**.
  - □ **Active** *represssor protein* represses transcription but can be inactivated by the _____ *molecule.*
  - □ In other words: the inducer inactivates the repressor protein, so transcription is turned _____.

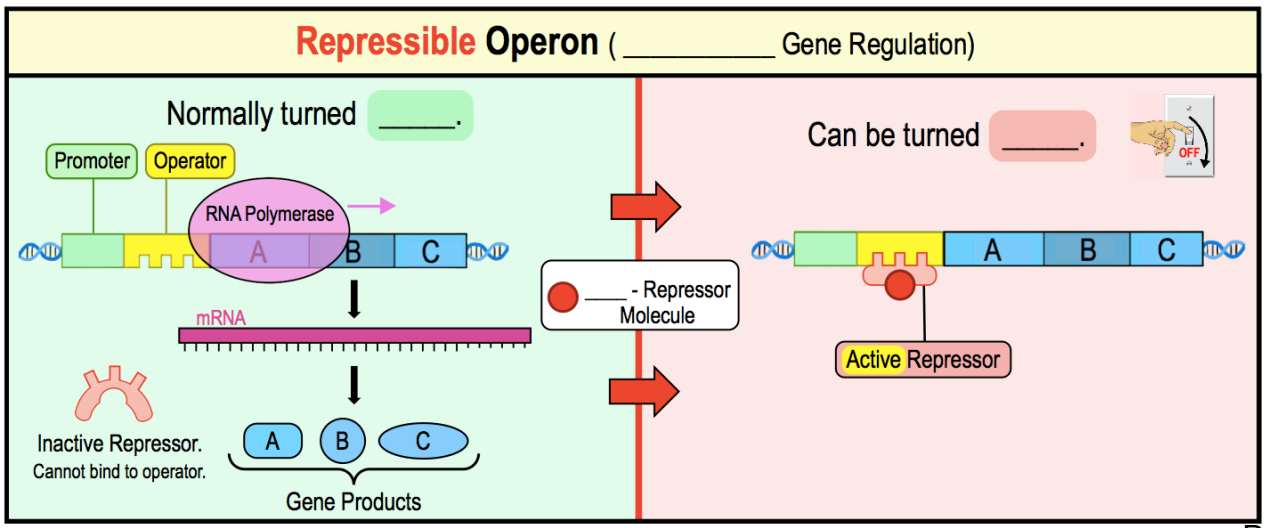
EXAMPLE: An inducible operon is turned on in the presence of an inducer molecule.



Repressible Operons

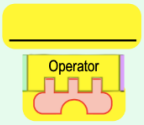
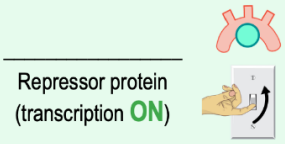
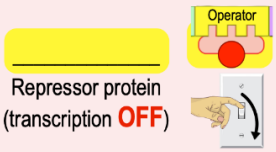
- _____ **Operon:** normally turned "_____" but can be turned "_____" (*repressed*) by **active** *repressor protein*.
  - □ Inactive *Repressor protein* can _____ repress transcription without a co-repressor.
  - □ _____***-repressor:*** small molecule that binds to the repressor forming an **active** *repressor protein*.
  - □ In other words, the *co-repressor* activates the *repressor protein*, so transcription is turned _____.

EXAMPLE: A repressible operon is turned off in the presence of a co-repressor molecule.



CONCEPT: PROKARYOTIC GENE REGULATION VIA OPERONS

Review of Inducible vs. Repressible Operons

Type:	Normally turned:	Can be turned:	Repressor protein normally:	Regulatory molecule:	Effect of regulatory molecule:	Example:
Inducible Operon						*lac* operon
Repressible Operon						*trp* operon

PRACTICE: Which of the following molecules is a protein that stops the transcription of a gene?

a) Operon.
b) Inducer.
c) Promoter.
d) Repressor.

PRACTICE: When this is present in the cell, it binds to the repressor and the repressor can no longer bind to the operator:

a) Operon.
b) Inducer.
c) Promoter.
d) Repressor.
e) Corepressor.

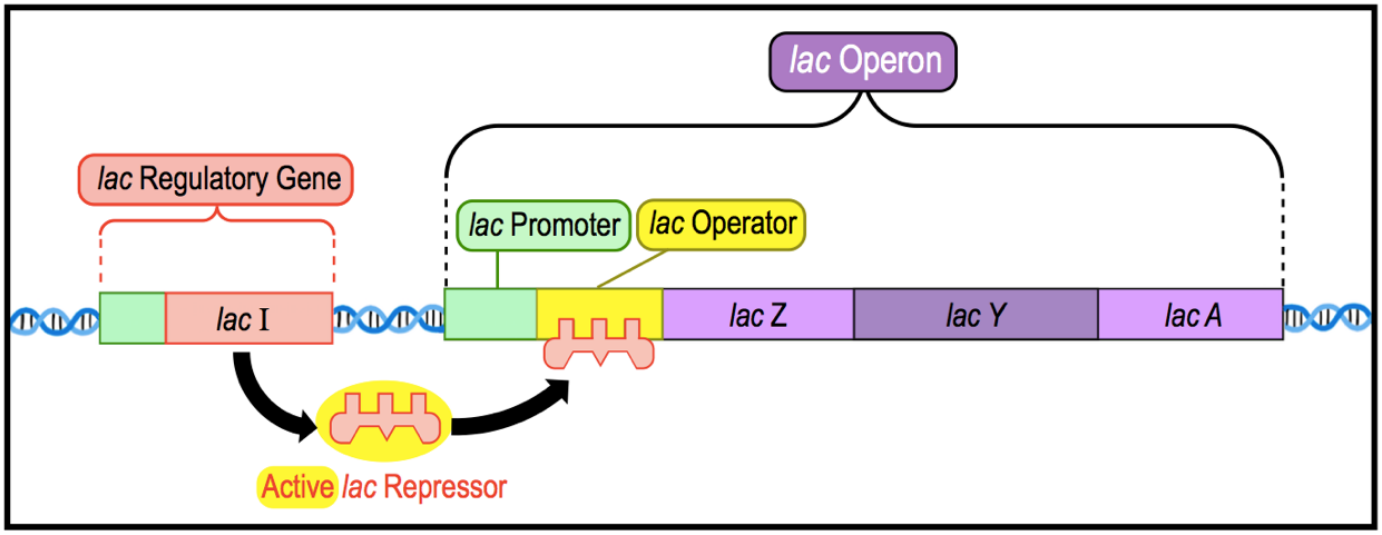
PRACTICE: Which of the following statements is FALSE?

a) An inducible operon is turned on by the presence of an inducer molecule.
b) An inactive repressor protein requires binding of a corepressor molecule to become active.
c) A repressible operon is turned on when the repressor protein is not bound to the corepressor molecule.
d) An active repressor protein is inactivated by the binding of an activator molecule.

CONCEPT: THE LAC OPERON

- _____ **Operon**: *inducible operon* with ____ genes encoding enzymes that metabolize lactose for energy:
  1) ***lac***____ 2) ***lac***____ 3) ***lac***____
  - □ Transcription & translation *require a lot of energy*, so cells only want to express lac operon genes when needed.
- The **active** *repressor protein* (_____) normally *represses* transcription when bound to *lac* _____.
  - □ Only in the presence of _____ (*& the absence of glucose*) is the lac operon transcribed.

EXAMPLE: The Lac Operon in E. coli contains a single promoter & 3 genes required for lactose metabolism.



PRACTICE: The protein that binds to the operator of the *lac* operon to prevent transcription is encoded by which gene?

a) *lac*I.
b) *lac*Y.
c) *lac*A.
d) *lac*Z.

PRACTICE: The *lac* operon is a(n) _____ operon that is typically _____.

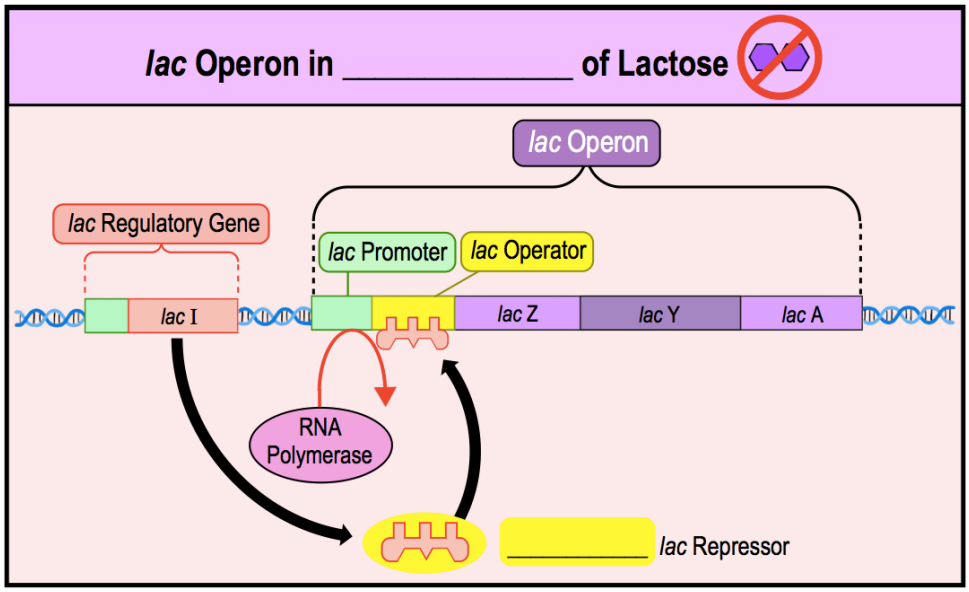
a) inducible; induced.
b) repressible; repressed.
c) inducible; repressed.
d) repressed; inducible.

CONCEPT: THE LAC OPERON

In the Absence of Lactose

- When **lactose** is not available to metabolize, _____ *represses* the expression of genes in the *lac* operon.
  - □ **LacI** binds to the *lac* operator & blocks *RNA polymerase* from initiating _____.

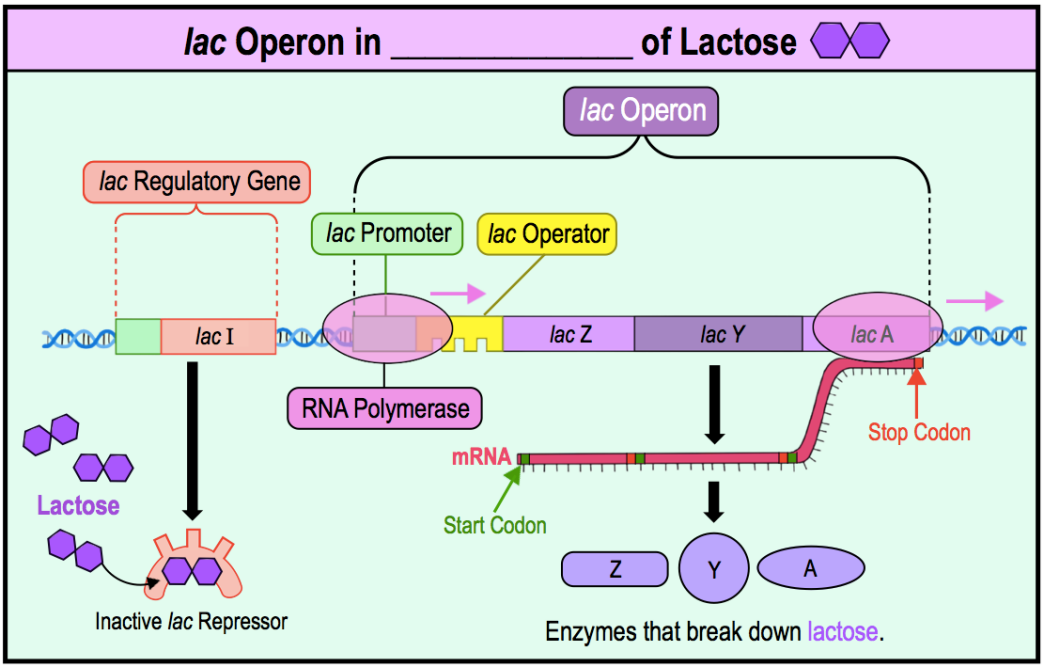
EXAMPLE: In Absence of Lactose, LacI is Active & Blocks Transcription.



In the Presence of Lactose

- When **lactose** is readily available to metabolize, it acts as an _____ *molecule* in the *lac* operon.
  - □ A derivative of lactose binds & _____ *LacI* so it *cannot* bind to the *operator*.
  - □ Allows *RNA polymerase* to initiate transcription of the *lac* operon.

EXAMPLE: In Presence of Lactose, LacI is Inactive, Allowing for Lac Operon Transcription.



CONCEPT: THE LAC OPERON

PRACTICE: In the *lac* operon, which of the following functions does the lactose molecule serve:

a) It is the corepressor molecule.

b) It is the repressor molecule.

c) It is the inducer molecule.

d) It serves no function in regulating the *lac* operon.

PRACTICE: If *E. coli* bacteria are grown in the presence of lactose:

a) The repressor will bind the operator allowing transcription of the lac operon genes.

b) The repressor will not bind the operator preventing transcription of the lac operon genes.

c) The repressor will not bind the operator allowing transcription of the lac operon genes.

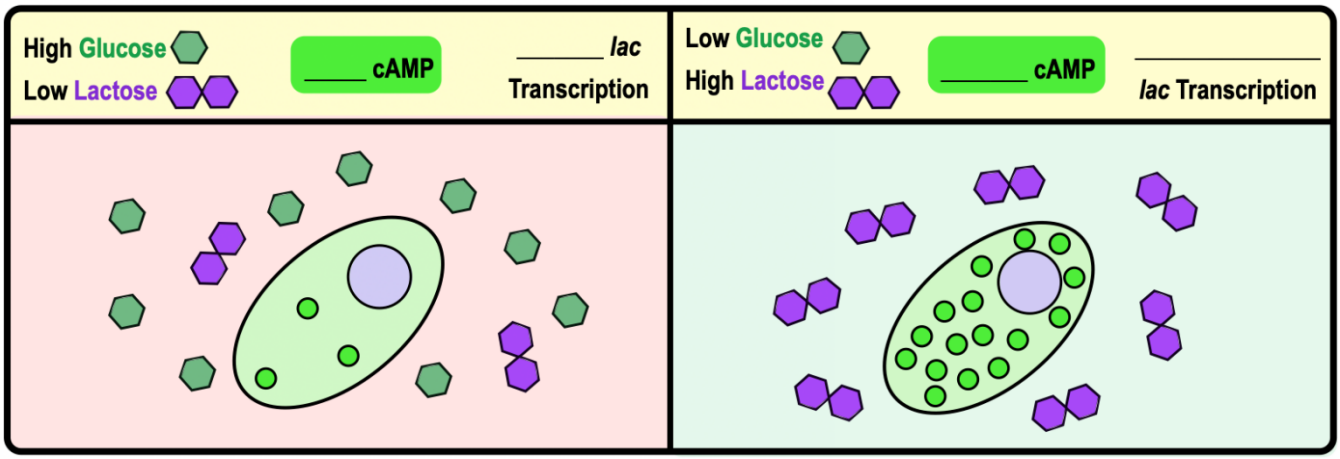
d) The repressor will bind the operator preventing transcription of the lac operon genes.

CONCEPT: GLUCOSE'S IMPACT ON LAC OPERON

Glucose Levels, cAMP, & the *lac* Operon

- In most prokaryotes, _____ is the preferred energy source even in the presence of **lactose**.
  - This means that if **glucose** is available, then the lac operon should be turned "_____."
- *Glucose levels* are linked to cellular levels of a molecule called **cyclic AMP** (_____).
  - When **glucose** is *low/absent* & *not* available for metabolism, cellular levels of cAMP _____.
  - *High* cellular *cAMP* levels _____ the *rate* of transcription of the *lac* operon.
  - *cAMP* levels do _____ affect *repressor protein's* activity & only increase transcription when **glucose** is absent.

EXAMPLE: Glucose Levels Control cAMP Levels in the Cell, Which Controls Rate of Lac Operon Transcription.



EXAMPLE: Complete the table below:

Environmental Levels		Cellular Levels			Expressed?
Glucose	Lactose	Glucose	cAMP	Lactose	*lac* Operon
HIGH	HIGH	HIGH	low	_____	_____
HIGH	low	_____	_____	low	_____
low	HIGH	low	_____	_____	_____
low	low	low	_____	low	_____

PRACTICE: How does extracellular glucose inhibit transcription of the lac operon?

a) By strengthening the binding of the repressor to the operator.

b) By weakening the binding of the repressor to the operator.

c) By inhibiting RNA polymerase from opening the strands of DNA to initiate transcription.

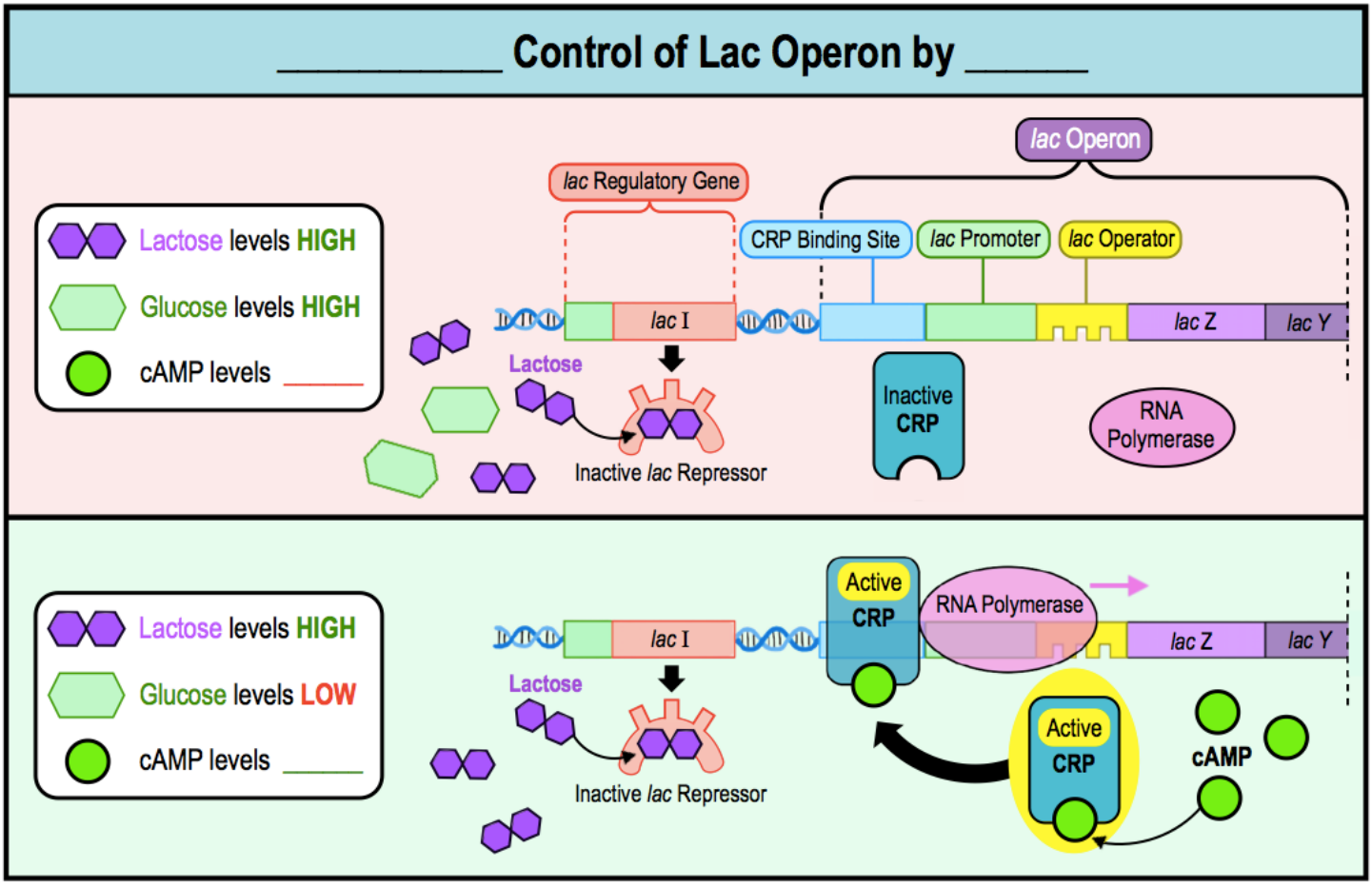
d) By reducing the levels of intracellular cAMP.

CONCEPT: GLUCOSE'S IMPACT ON LAC OPERON

Positive Control by cAMP & CRP

- **C**yclic AMP **R**eceptor **P**rotein (_____) is an _____ *protein* of the *lac* operon when bound to *cAMP.*
- Low Glucose levels =_____ cellular *cAMP* levels which binds to & activates CRP.
  - □ *Active CRP* binds to a region of DNA upstream of the *lac* _____ & recruits *RNA polymerase.*
  - □ _____ Glucose = _____ cAMP = _____ CRP = _____ Rate of Lac Operon Transcription.

EXAMPLE: cAMP & CRP Positively Control Expression of *lac* operon.



PRACTICE: When glucose is present:

a) cAMP is high, CRP binds to the activator binding site, and transcription of the *lac* operon is turned off.

b) cAMP is low, CRP binds to the site activator binding site, and transcription of the *lac* operon is turned on.

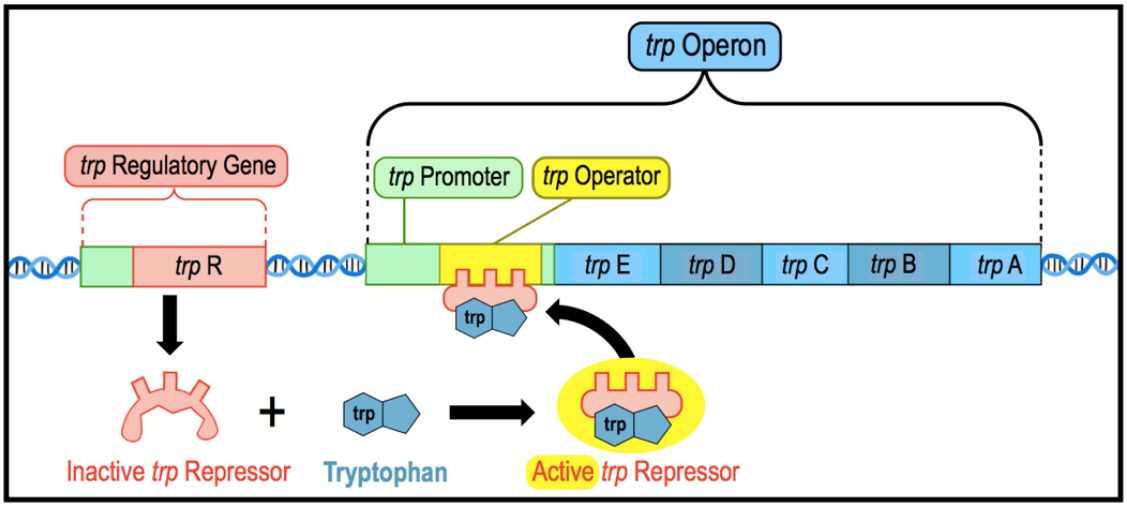
c) cAMP is high, CRP does not bind to the activator binding site, and transcription of the *lac* operon is turned on.

d) cAMP is low, CRP does not bind to the activator binding site, and transcription of the *lac* operon is turned off.

CONCEPT: THE TRP OPERON

- Tryptophan (_____) is an *amino acid* that can be *absorbed* from the environment or *synthesized* by the cell.
- _____ **Operon**: *repressible operon* with _____ genes encoding enzymes required for synthesizing Tryptophan.
- ***trp*____: encodes the *trp* _____ protein** which is expressed in the _____ form.
  - *Inactive TrpR* protein requires a _____ (usually Trp itself) in order to bind the operator.

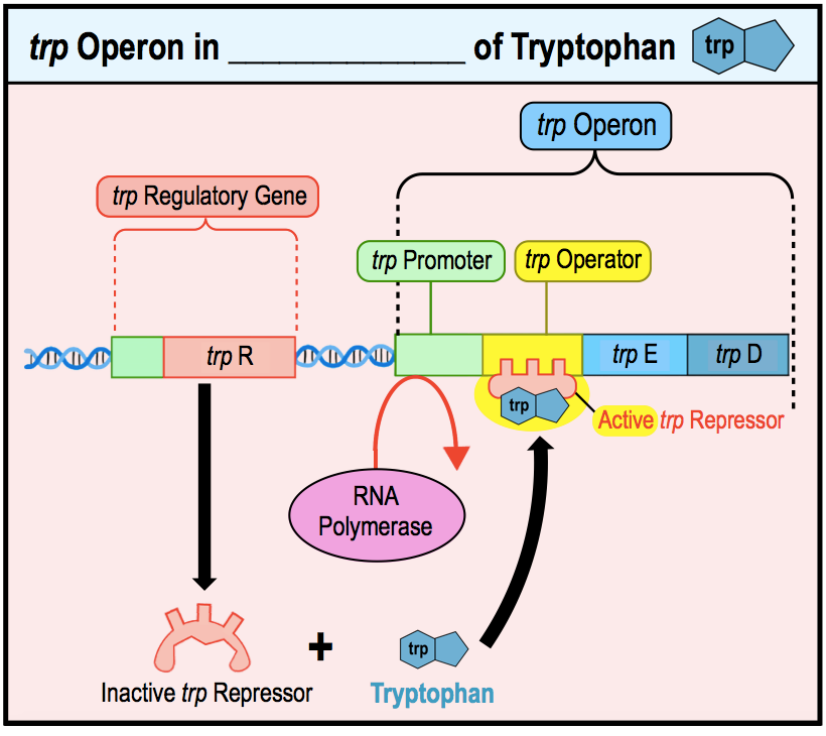
EXAMPLE: The *trp* operon contains 5 genes required for Tryptophan synthesis & is regulated by the *trp* repressor.



In the Presence of Tryptophan

- When Tryptophan is abundant, the cell does not need to synthesize its own & the *trp* operon is _____.
  - Tryptophan acts as a _____ that binds to & _____ the *trp* repressor protein.

EXAMPLE: Cellular Tryptophan co-represses the *trp* operon when it is readily abundant for the cell.

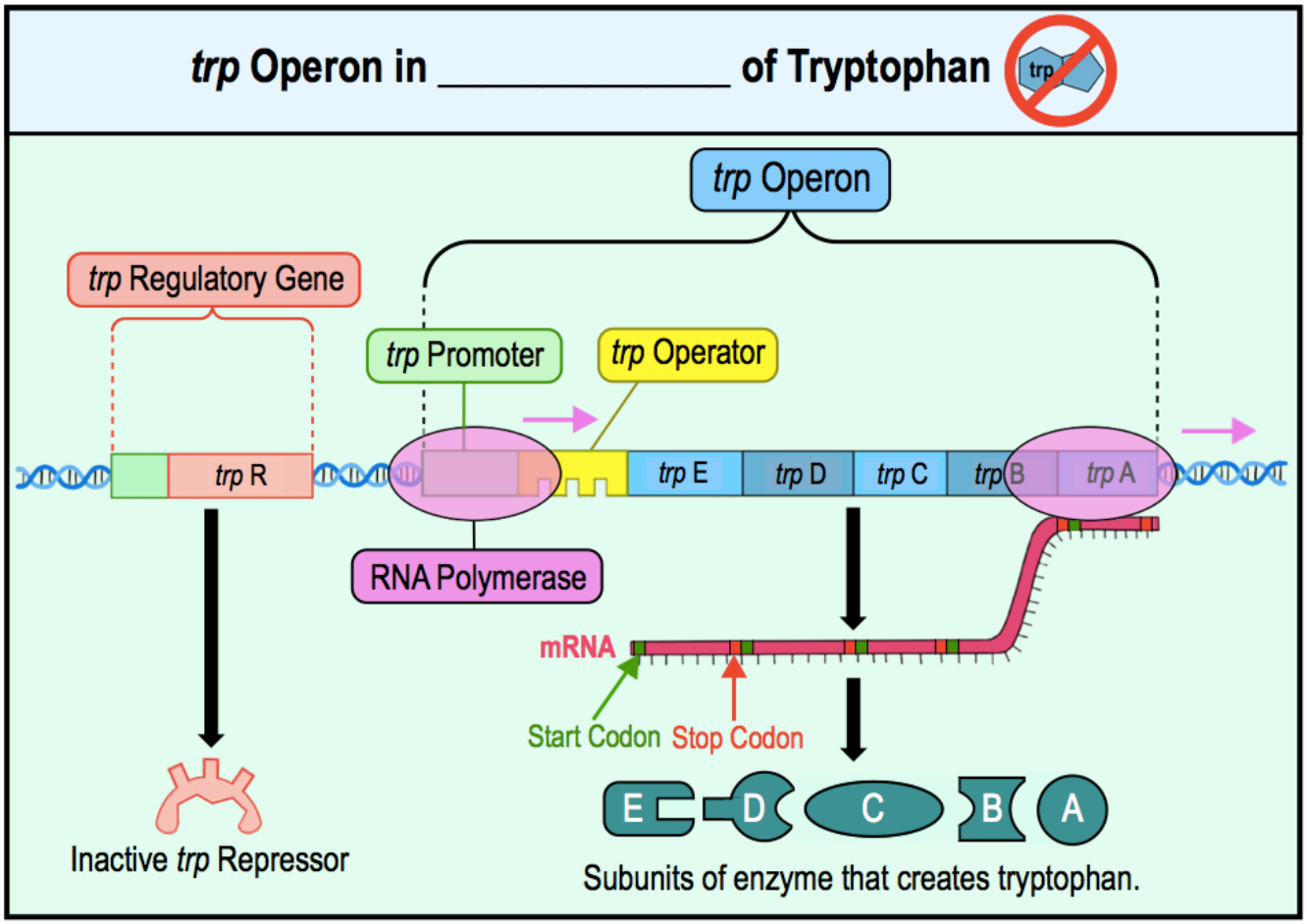


CONCEPT: THE TRP OPERON

In the Absence of Tryptophan

- When Tryptophan is *not* readily available the cell must _____ its own using enzymes from the *trp* operon.
  - When cellular Tryptophan levels are *low*, the *TrpR* remains _____, allowing for transcription.

EXAMPLE: Low cellular Tryptophan levels result in increased transcription of the *trp* operon.



PRACTICE: The trp operon consists of _____ genes that encode tryptophan biosynthesis enzymes.

a) One. b) Two. c) Three. d) Four. e) Five.

PRACTICE: Under what conditions does the trp repressor block transcription of the trp operon?

a) When the repressor binds to the inducer.
b) When the repressor binds to tryptophan.
c) When the repressor is not bound to tryptophan.
d) When the repressor is not bound to the operator.

CONCEPT: THE TRP OPERON

PRACTICE: If the *trp* regulatory gene mutates so that the repressor protein can no longer bind to tryptophan what will be the result?

a) The *trp* operon will not be expressed.
b) The *trp* operon will be continuously expressed.
c) The *trp* operon will be expressed in the presence of tryptophan only.
d) The *trp* operon will be expressed in the absence of tryptophan only.
e) There will be no effect on the *trp* operon.

PRACTICE: In the absence of tryptophan, _____:

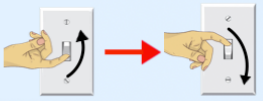
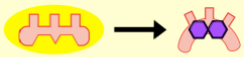
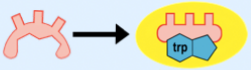
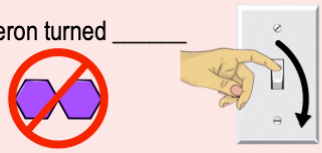
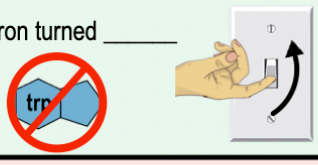
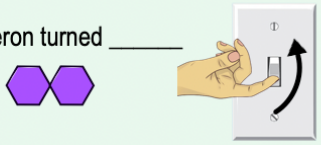
a) The inducer cannot bind to the operator, so *trp* operon transcription occurs.
b) The active repressor cannot bind to the operator, so *trp* operon transcription is reduced.
c) The inactive repressor cannot bind to the operator, so *trp* operon transcription occurs.
d) The repressor binds to the corepressor, and *trp* operon transcription occurs.
e) The active repressor binds to the operator, so *trp* operon transcription is repressed.

PRACTICE: Based on the information you know about the *trp* operon, is the creation of tryptophan expensive to the cell?

a) Yes, this is why tryptophan is the co-repressor of the *trp* operon.
b) No, this is why tryptophan is the inducer of the *trp* operon.
c) Yes, this is why tryptophan is the repressor of the *trp* operon.

CONCEPT: REVIEW OF LAC & TRP OPERONS

●Now let's review the *lac* and *trp* operons:

	***lac* Operon**	***trp* Operon**
Operon type	_____ 	_____ 
# of Genes	___	___
Function of operon genes	_____ Lactose	_____Tryptophan
Repressor gene	_____	_____
Regulatory molecule	 _____ (Inducer)	trp _____ (Corepressor)
Effect of regulatory molecule	_____ Repressor Protein 	_____ Repressor Protein 
Regulatory molecule Absent ✗	Operon turned _____ 	Operon turned _____ trp 
Regulatory molecule Present ✓	Operon turned _____ 	Operon turned _____ trp 

PRACTICE: Which of the following statements is FALSE?

a) The *lac* operon is an inducible operon that is normally turned off.
b) The *trp* operon is a repressible operon that is normally turned on.
c) Lactose is the inducer molecule for the *lac* operon.
d) Tryptophan is the activator molecule for the *trp* operon.
e) All of the above are true.

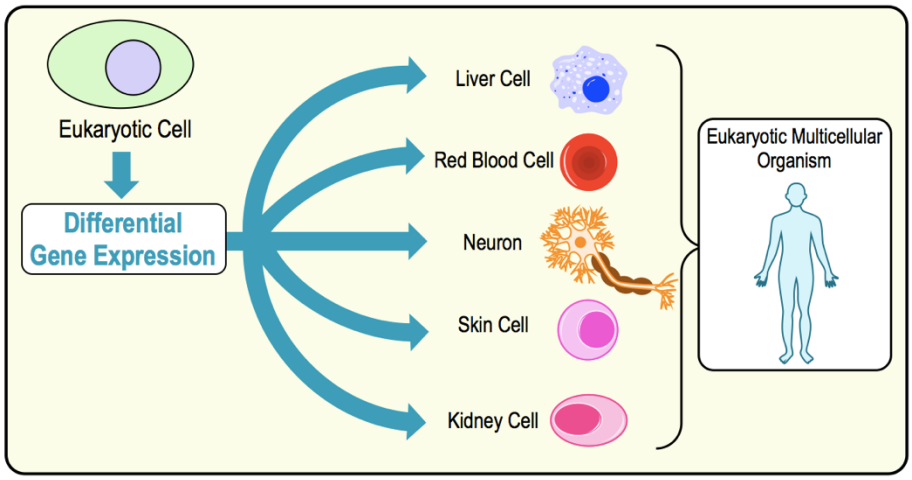
PRACTICE: Which of the following statements is TRUE?

a) Lac I is the inducer molecule for the *lac* operon.
b) Tryptophan is an inducer molecule for the *trp* operon.
c) In the presence of lactose, the *lac* operon is expressed.
d) In the presence of tryptophan, the *trp* operon is expressed.

CONCEPT: INTRODUCTION TO EUKARYOTIC GENE REGULATION

- Gene regulation in eukaryotes is extremely important to allow for _____ *gene expression*.
- **Differential Gene Expression**: process allowing multi-cellular organisms to express genes *differently* in *different* cells.
- *All* cells of a multi-cellular organism have the _____ genome/DNA, but a _____ proteome (set of proteins)

EXAMPLE: Liver cells and skin cells have the same DNA, but different genes are expressed.

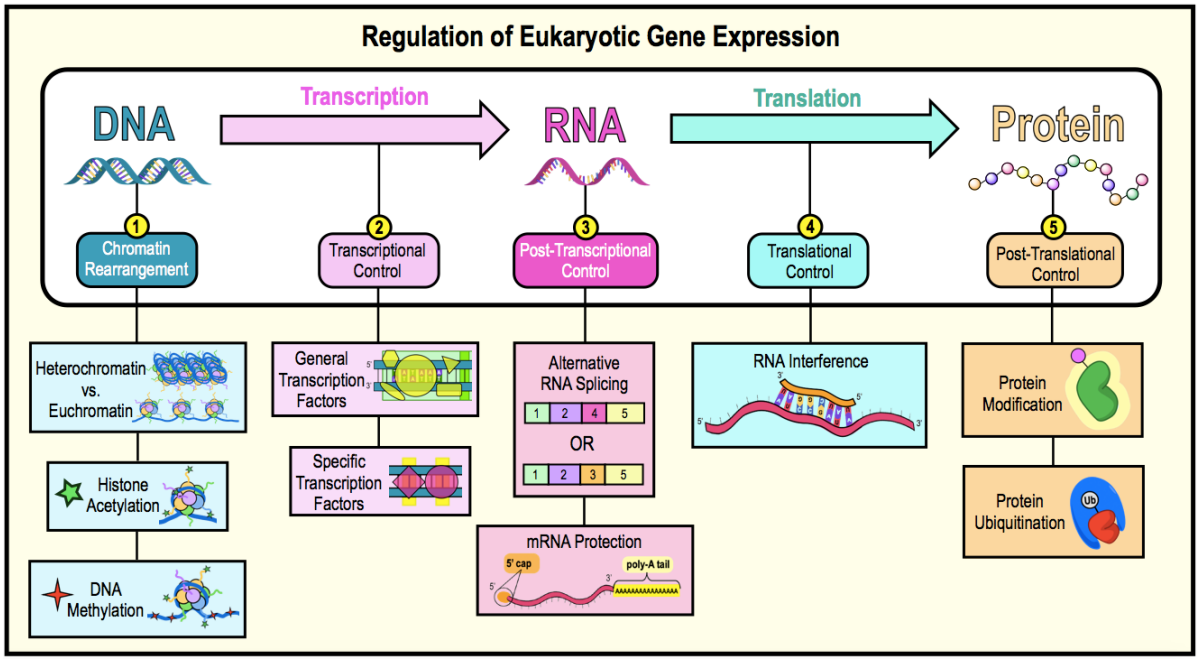


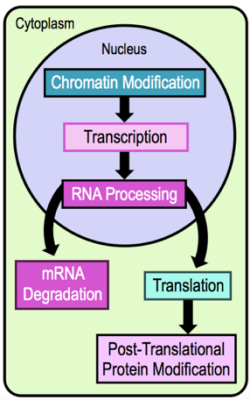
PRACTICE: The process of cellular differentiation is a direct result of:

a) Differential gene expression.
b) Mutations made in specific cells.
c) Different types of cell division.
d) Apoptosis.
e) Differences in cellular genomes.

Map of Eukaryotic Gene Regulation

- *Recall*: Eukaryotic gene regulation occurs at any of these _____ stages:

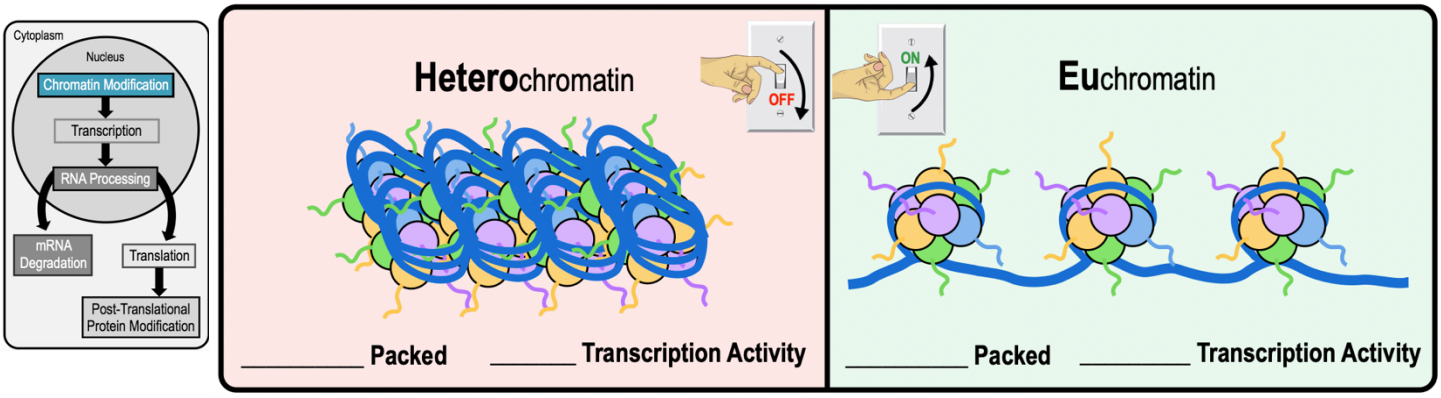




CONCEPT: EUKARYOTIC CHROMATIN MODIFICATIONS

- Eukaryotes can regulate gene expression by modifying the structure of their _____.
- *Recall: Chromatin* are _____ packed/coiled *nucleosomes* (DNA wrapped around units of ___ histone proteins).
  - Modifications to _____ *proteins* or _____ sequence are made to control transcription.
  - _____**chromatin:** *condensed* region of genome with *low* transcriptional activity.
  - _____**chromatin:** *lightly packed* region of genome with *high* transcriptional activity & histone/DNA modifications.

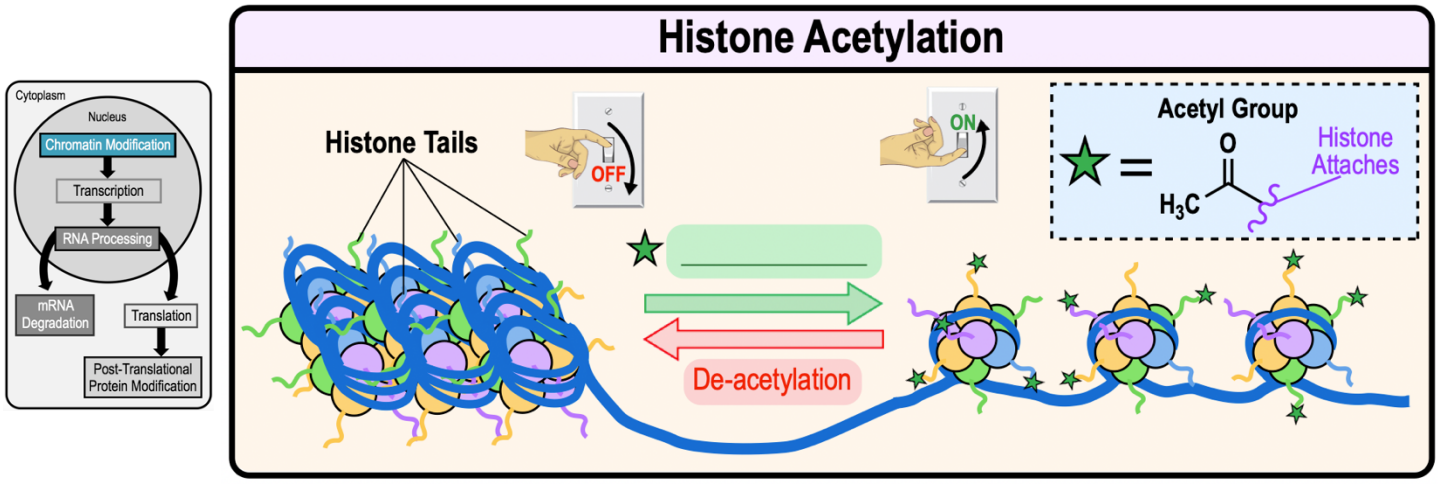
EXAMPLE: Heterochromatin vs. Euchromatin.



Histone Acetylation

- *Histone proteins* contain long polypeptide "_____" that can be chemically modified by cellular enzymes.
  - The most common modification is _____: addition of an *acetyl group*.
  - *Histone acetylation* _____ the chromatin structure, making the DNA accessible to *RNA polymerase*.

EXAMPLE: Histone Acetylation Loosens Chromatin Structure, Forming Euchromatin.



- Removal of acetyl groups (**de-acetylation**) results in _____ packing of the chromatin structure (heterochromatin).

CONCEPT: EUKARYOTIC CHROMATIN MODIFICATIONS

PRACTICE: Histone acetylation is associated with:

a) Activate transcription in that region, RNA Polymerase can easily interact with DNA.
b) Repressed transcription in that region, RNA Polymerase cannot easily interact with DNA.
c) Tightly-packed nucleosomes.
d) No change in chromatin structure or transcription rates.

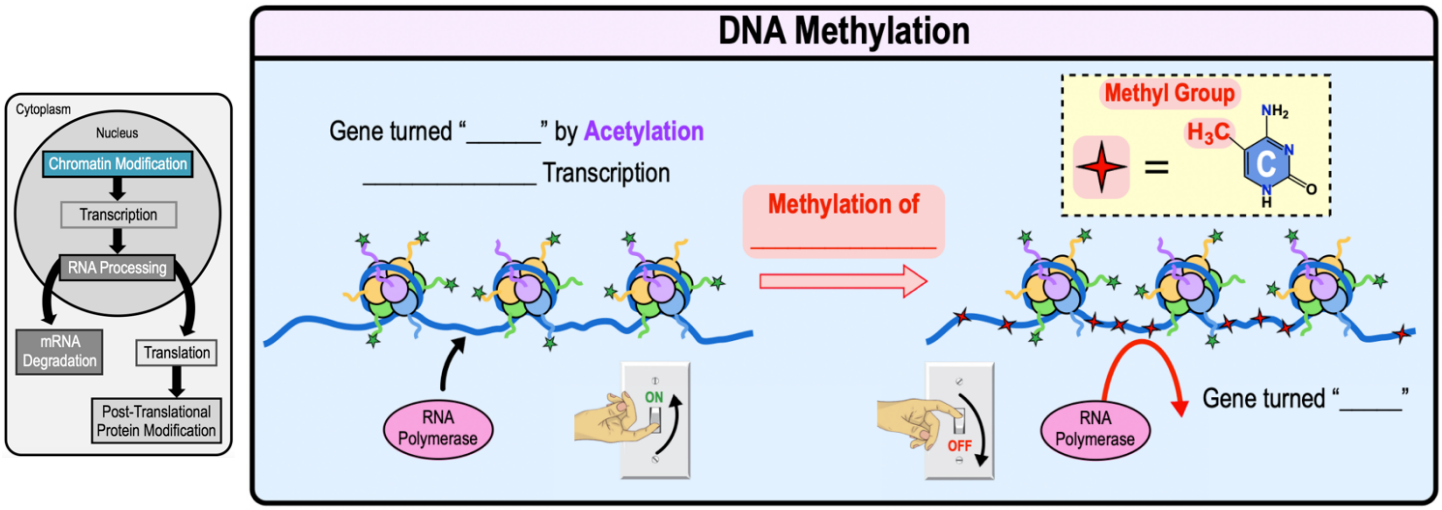
DNA Methylation

●In addition to histone modifications, the _____ sequence can also be chemically modified to regulate transcription.

□ Most common DNA modification is _____: addition of a *methyl group* to Cytosine (C) residues.

●*DNA Methylation* _____ transcription of by *blocking* RNA polymerase access to the promoter.

EXAMPLE: Methylation of Cytosine Nucleotides Blocks Transcription.



PRACTICE: Transcriptional repression by methylation of DNA involves the methylation of which nucleotide?

a) Adenine. b) Uracil. c) Cytosine. d) Thymine. e) Guanine.

PRACTICE: Which of the following causes transcription to be increased for a specific gene?

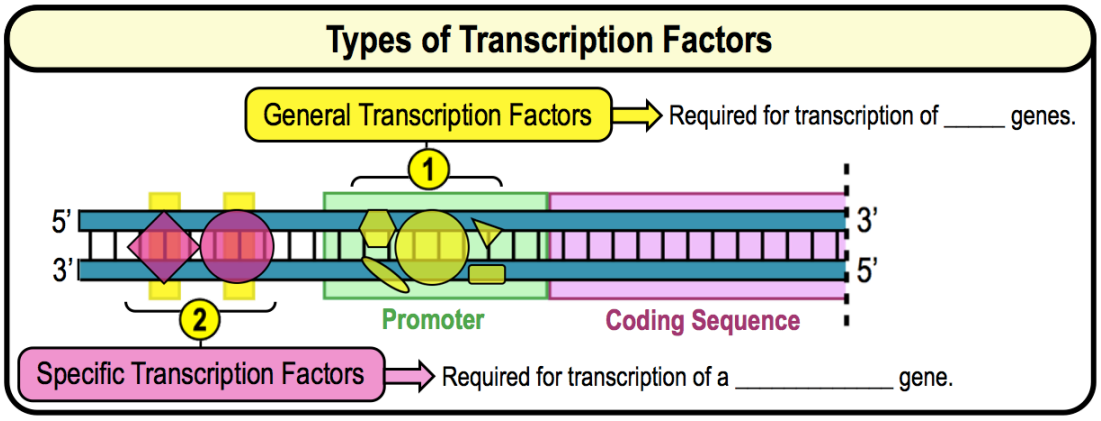
a) Histones in that region are deacetylated.
b) DNA is methylated in the regulatory region of the gene.
c) Histones in that region are acetylated.
d) The chromatin structure is tightly packed.
e) B and D.

CONCEPT: EUKARYOTIC TRANSCRIPTIONAL CONTROL

- Eukaryotes can also regulate gene expression by utilizing _____-binding proteins that bind to regulatory regions in a gene.

Introduction to Transcription Factors

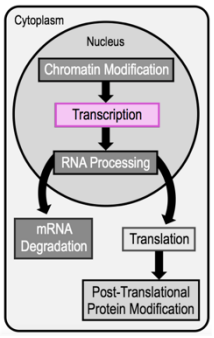
- *Recall*: transcription initiation in Eukaryotes requires a complex of *transcription factors* bound to the promoter sequence.
- _____ **Factors:** proteins that bind to specific DNA sequences & regulate transcription initiation.
- There are _____ types of transcription factors in Eukaryotes:
  1. _____ **transcription factors**
  2. _____ **transcription factors**

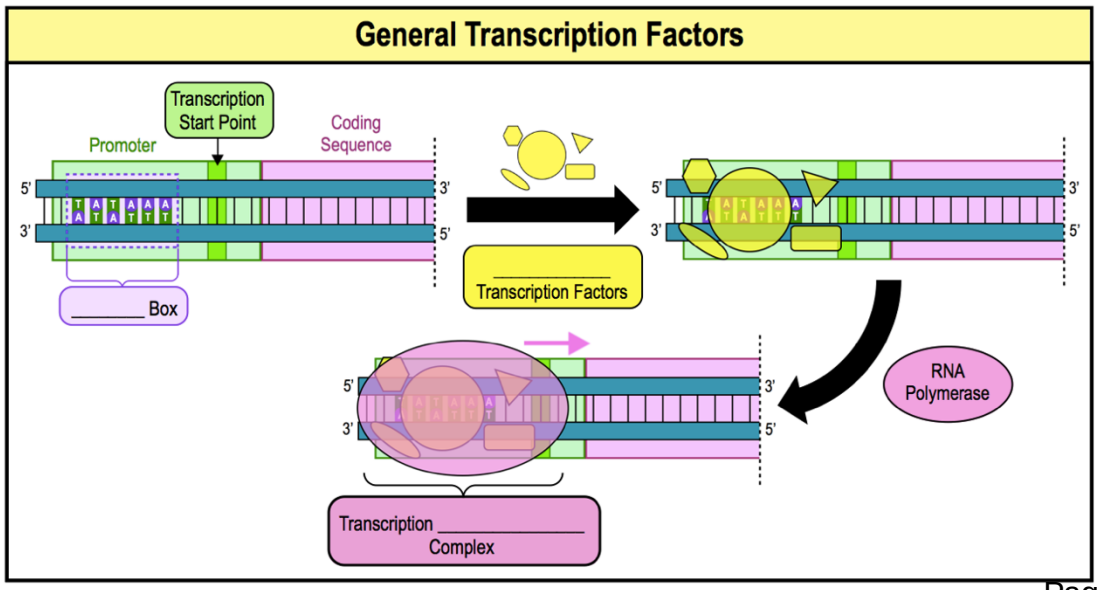


General Transcription Factors

- *Recall:* _____ *transcription factors:* required for the transcription of *every* gene in the genome.
  - □ Recruits RNA polymerase to the _____ region of a gene
- **Transcription Initiation complex (_____)**: the entire complex of all *general transcription factors* & *RNA polymerase*.
  - □ _____ **Box:** sequence of A T repeats located in the promoter that recruits the *TIC*.

EXAMPLE: General transcription factors bind the TATA box in the promoter & recruit RNA polymerase for transcription.



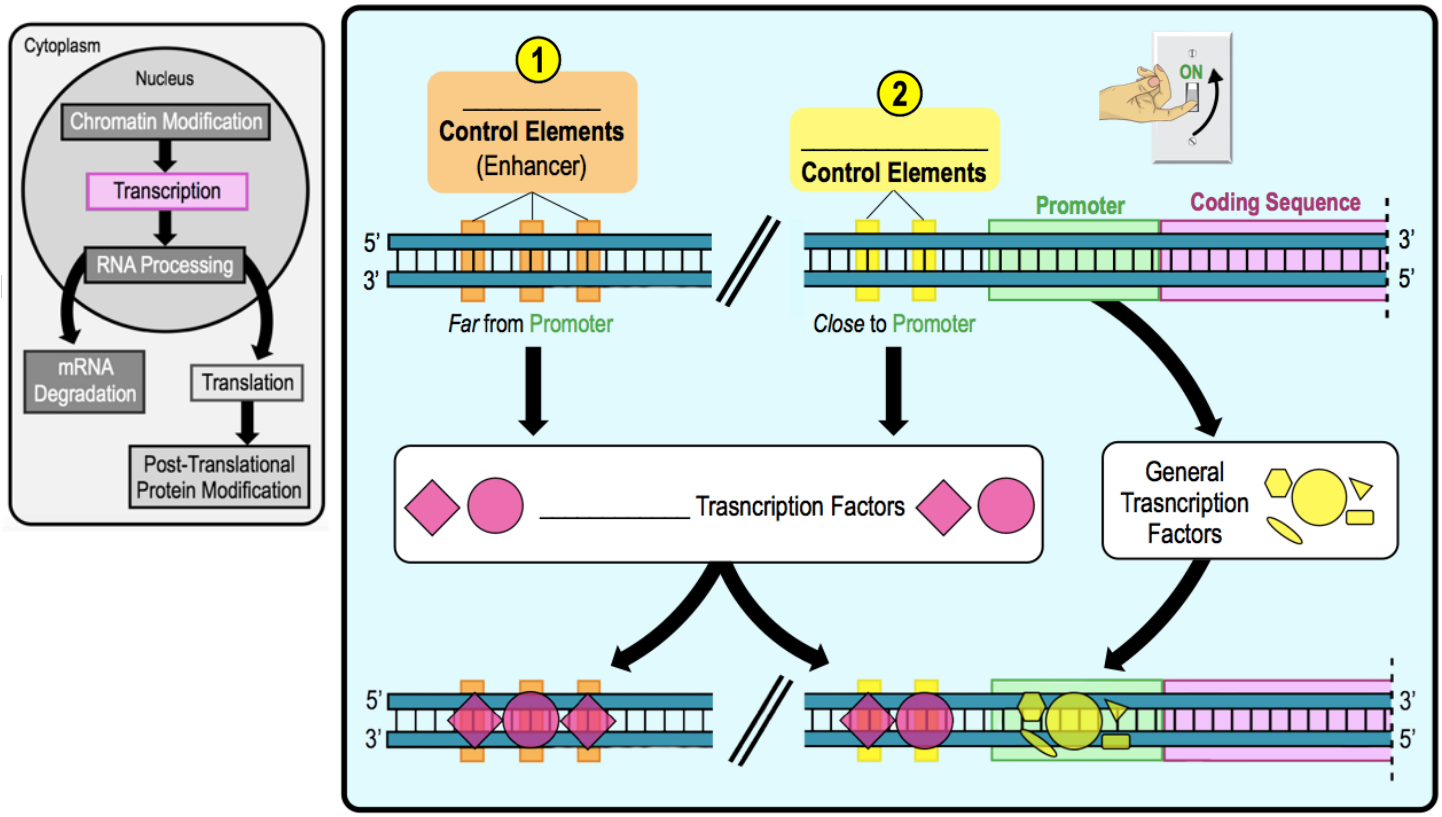


CONCEPT: EUKARYOTIC TRANSCRIPTIONAL CONTROL

Specific Transcription Factors

- *Recall:* _____ *transcription factors* are only required for increasing the transcription of a *specific* gene.
  - □ _____ **Elements:** regions of noncoding DNA where *specific* transcription factors bind.
    - (1) ***Distal* Control Elements:** located _____ (distant) from the promoter sequence.
      - □ _____**:** groups of *distal* control elements.
    - (2) ***Proximal* Control Elements:** located _____ to the promoter sequence.

EXAMPLE: Specific Transcription Factors can bind Distal or Proximal Control Elements.



PRACTICE: Regulatory segments of DNA that function to increase transcription levels in eukaryotes are called:

a) promoters.
b) silencers.
c) enhancers.
d) transcriptional start sites.
e) activators.

CONCEPT: EUKARYOTIC TRANSCRIPTIONAL CONTROL

PRACTICE: Which of the following statements correctly describes the primary difference between enhancers and proximal control elements?

a) Enhancers are transcription factors; proximal control elements are DNA sequences.
b) Enhancers increase transcription of specific genes; proximal control elements inhibit transcription of specific genes.
c) Enhancers are located thousands of nucleotides away from the promoter; proximal control elements are close to the promoter.
d) Enhancers are DNA sequences; proximal control elements are transcription factors.

PRACTICE: Which of the following is NOT true regarding the differences of transcription in eukaryotes and prokaryotes?

a) Eukaryotes use multiple transcription factors to help initiate transcription.
b) Most eukaryotes have regulatory sites that are close to their promoters.
c) Most prokaryotes transcribe multiple genes under the regulation of a single operon.
d) Prokaryotic transcription factors usually interact directly with RNA polymerase while eukaryotic transcription factors do not**.**

PRACTICE: Which of the following statements about transcription factors is **incorrect**:

a) The transcription initiation complex is composed of RNA polymerase, general and specific transcription factors.
b) General transcription factors help initiate transcription of all eukaryotic genes.
c) Specific transcription factors do not bind the promoter of a gene, but to control elements associated with the gene.
d) The transcription initiation complex associates with the TATA box of the promoter to begin transcription.

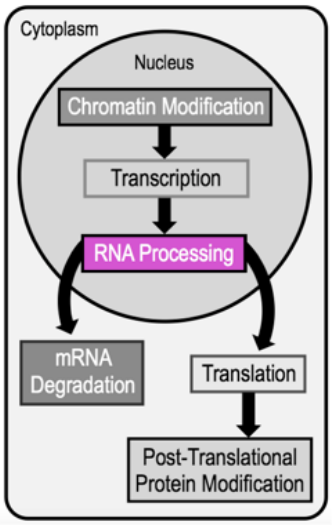
CONCEPT: EUKARYOTIC POST-TRANSCRIPTIONAL REGULATION

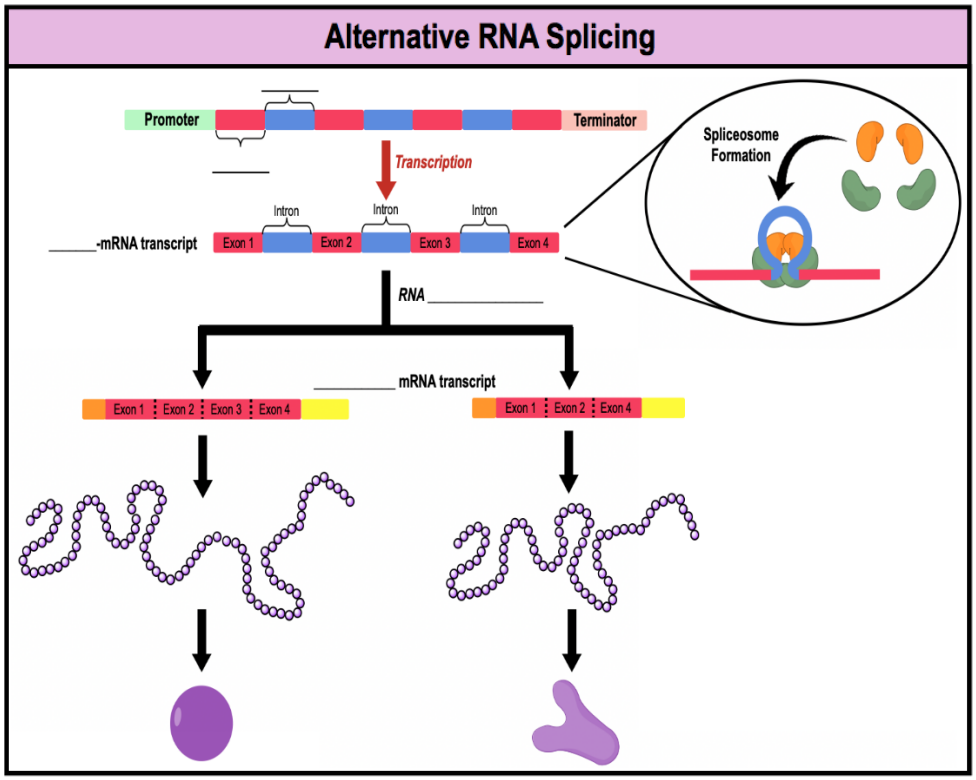
- Eukaryotes regulate gene expression at the post-transcriptional level in _____ ways:
  1. Alternative RNA _____ results in different protein products from the same mRNA transcript.
  2. RNA processing adds a 5' _____ & poly-_____ tail to mRNA for protection from RNA degrading enzymes.
  3. mRNA can be tagged for degradation or transcription is blocked by small noncoding _____ molecules.

1) Alternative RNA Splicing

- *Recall:* Eukaryotes require _____-transcriptional modifications like *RNA splicing* which can alter gene expression.
  - □ **Alternative splicing**: when different mRNA molecules are produced from the _____ premature RNA.
  - □ The _____: the RNA-protein complex that removes introns from premature RNA.

EXAMPLE: Alternative RNA splicing results in different protein products from the same premature RNA.





PRACTICE Alternative RNA splicing has been estimated to occur in more than 95% of multi-exon genes. Which of the following is **not** an evolutionary advantage of alternative RNA splicing?

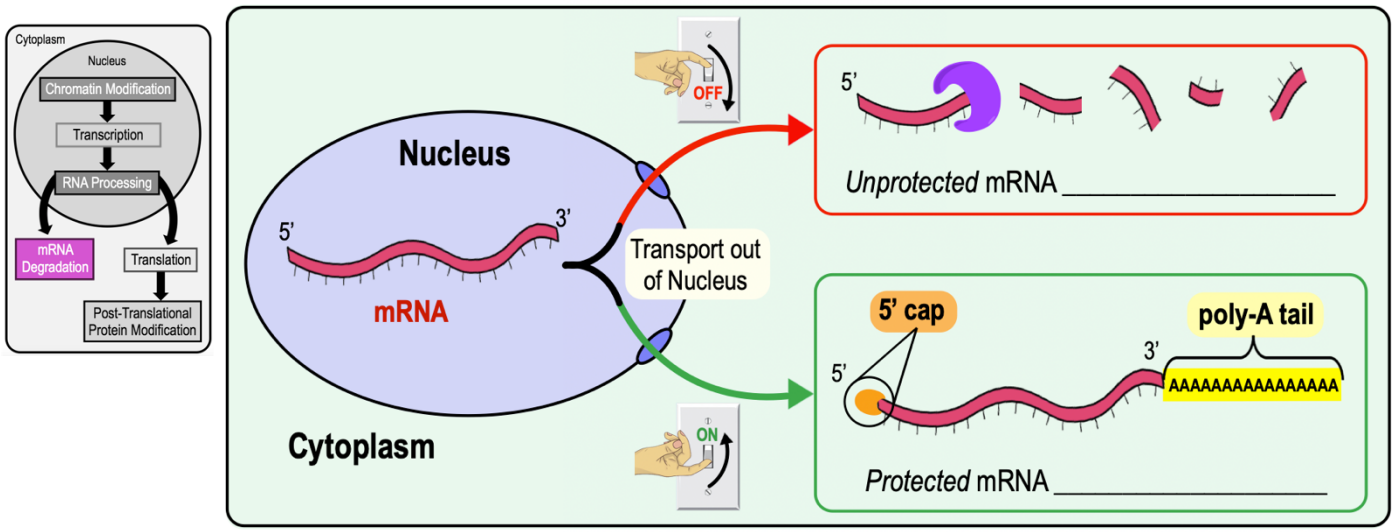
a) Alternative RNA splicing increases diversity without increasing genome size.
b) Different protein variants can be expressed by the same gene in different tissues.
c) Alternative RNA splicing creates shorter mRNA transcripts.
d) Different protein variants can be expressed by the same gene during different stages of development.

CONCEPT: EUKARYOTIC POST-TRANSCRIPTIONAL REGULATION

2) mRNA Protection in the Cytoplasm

- mRNA transcripts must be transported to the _____ where they can be translated by ribosomes.
  - The cytoplasm has many RNA degrading enzymes destroy *foreign* viral RNA molecules.
- The ____' cap & poly-A _____ of mRNA molecules _____ the mRNA from degradation by enzymes.

EXAMPLE: mRNA is protected from degradation by cytoplasmic enzymes with a 5' cap and poly-A tail.

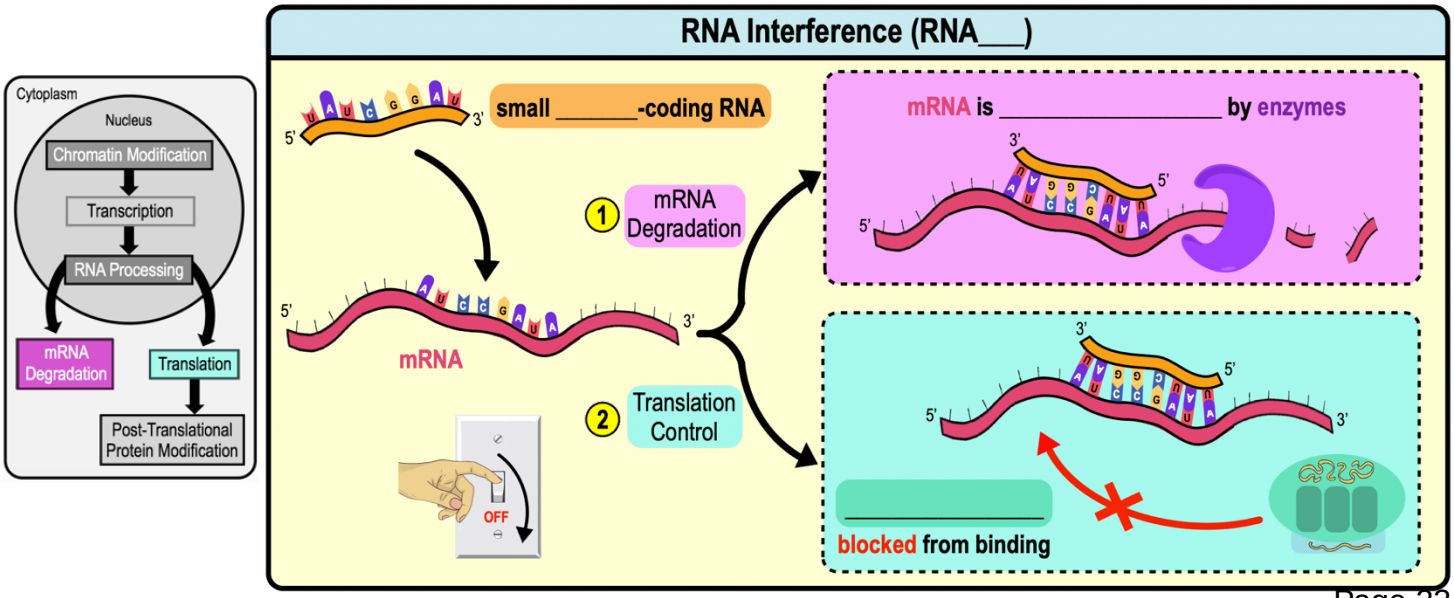


3) RNA Interference

- **RNA** _____ **(RNA__):** process of small noncoding RNAs blocking translation of target mRNA molecules.
  - **Small noncoding RNA:** short strands of RNA that have a *complementary sequence* to their mRNA target.
- There are _____ possible scenarios that turn gene expression **OFF**:

(1) mRNA is _____ OR (2) Ribosome is _____ from binding

EXAMPLE: RNA Interference can block ribosome binding or recruit cellular enzymes for mRNA degradation.



CONCEPT: EUKARYOTIC POST-TRANSCRIPTIONAL REGULATION

PRACTICE: Which of the following statements best describes the function of RNAi?

a) Small RNA molecules interfere with translation by targeting ribosomes for degradation.

b) Small DNA molecules interfere with mRNA molecules by blocking their ability to bind to a ribosome.

c) Small RNA molecules interfere with translation by targeting specific tRNA molecules

d) Small RNA molecules interfere with translation by blocking a target mRNA's ability to bind to a ribosome.

Types of Small Noncoding RNAs

●There are _____ classes of RNAs involved *in RNAi*:

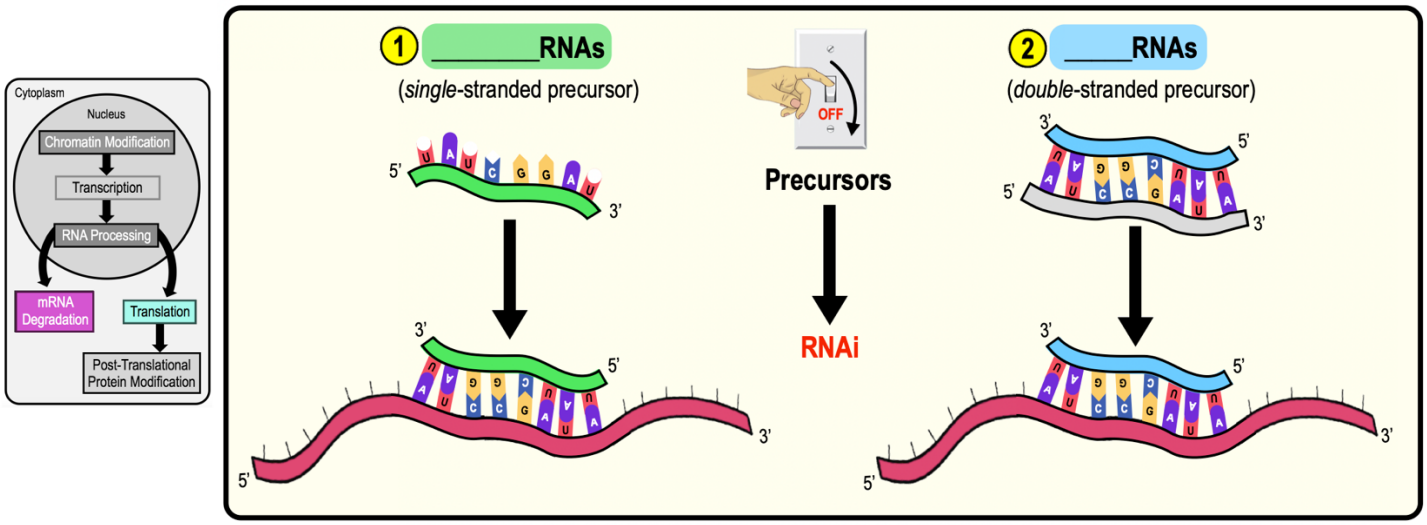
1 _____RNAs 2 small interfering RNAs (_____)

□ BOTH types bind to a target mRNA by complimentary base paring & turns _____ expression of that gene.

●The only difference between microRNAs & siRNAs is the structure of their precursor form:

□ *mircoRNAs* have a _____-stranded precursor & *siRNAs* have a _____-stranded precursor

EXAMPLE: RNA interference by two types of small noncoding RNAs (microRNAs & siRNAs).



PRACTICE: Which of the following best describes siRNA?

a) A short double-stranded RNA with one strand that can complimentarily bind to and inactivate an mRNA.

b) A single-stranded RNA with internal complementary base pairs that allow it to fold into a cloverleaf pattern.

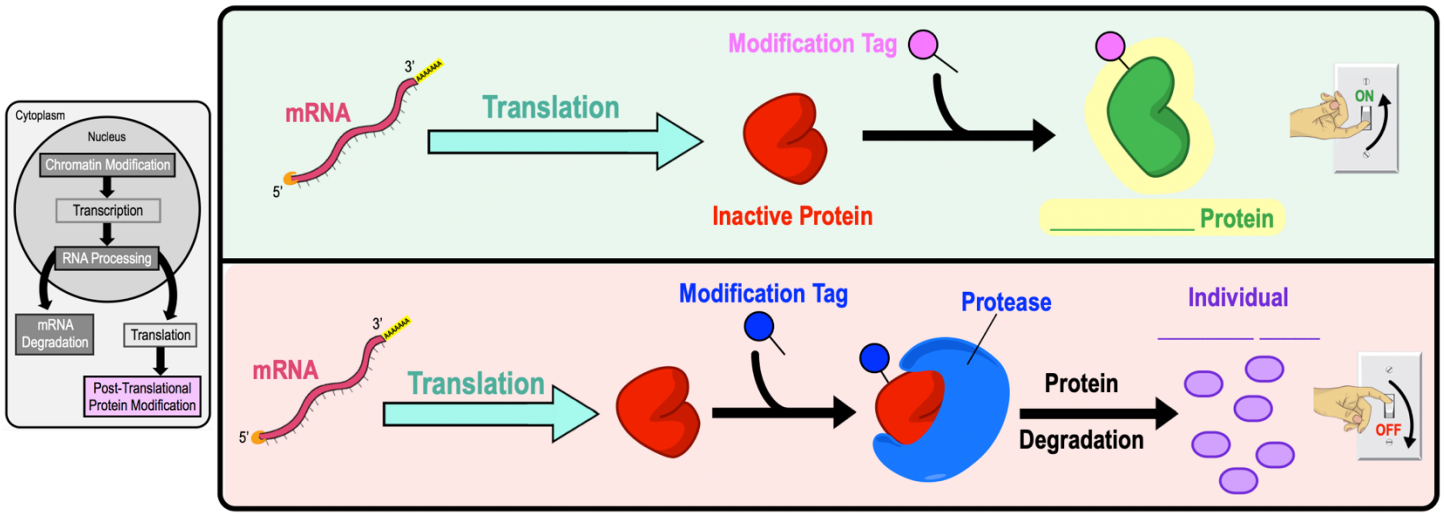
c) A portion of rRNA which is a component of the large and small ribosomal subunits.

d) A molecule, known as Dicer, that can degrade or cut RNA sequences.

CONCEPT: EUKARYOTIC POST-TRANSLATIONAL REGULATION

- Eukaryotes regulate expression at the post-_____ by controlling activity of the expressed protein.
  - □ *Recall: Post-translational modifications (PTMs)* are covalent modifications to proteins _____ translation.
- *PTMs* can activate/inactivate a protein or "_____" the protein for degradation by **Proteases.**
  - □ _____: enzymes that degrade proteins by breaking *polypeptide bonds* making single amino acids.

EXAMPLE: Protein activity can be controlled by post-translational modifications or degradation by proteases.



PRACTICE: Protein degradation is one strategy to control gene expression and is considered _____.

a) Transcriptional control.
b) Post-transcriptional control.
c) Translation initiation control.
d) Post-translational control.
e) Chromatin remodeling.

PRACTICE: Post-translational modifications of proteins can affect which of the following?

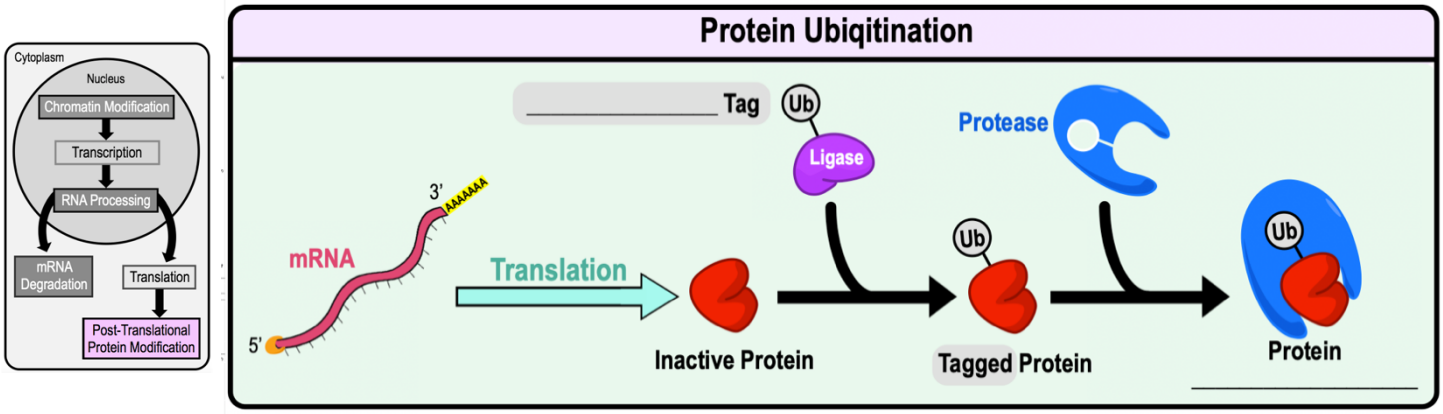
a) Protein function.
b) Protein location within the cell.
c) Protein activation or inactivation.
d) Protein degradation.
e) All of the above.

CONCEPT: EUKARYOTIC POST-TRANSLATIONAL REGULATION

Protein Ubiquitination

- Eukaryotes need a way to _____ which proteins in a cell are no longer needed & can removed.
- Cells utilize PTMs to "tag" specific proteins in a cell to be _____ by cellular *proteases*.
  - _____: small peptide used by Eukaryotic cells to mark proteins for degradation.
  - **Ubiquitin** _____: cellular enzyme that adds the *ubiquitin* peptide to the target protein.

EXAMPLE: Ubiquitin ligase adds a ubiquitin peptide to a mis-folded or non-functioning protein.



PRACTICE: A hormone signal reaches a cell and causes the cell to produce a large quantity of Protein X. After some time, the hormone signal disappears and the cell no longer needs a large quantity of Protein X. How will the cell remove the excess protein?

a) The repressor protein for the Protein X gene will stop the transcription of the gene.
b) The excess Protein X will be tagged with ubiquitin proteins and degraded over time.
c) The Protein X mRNA will be bound by a microRNA blocking its translation.
d) Over time the excess Protein X will diffuse out of the cell.