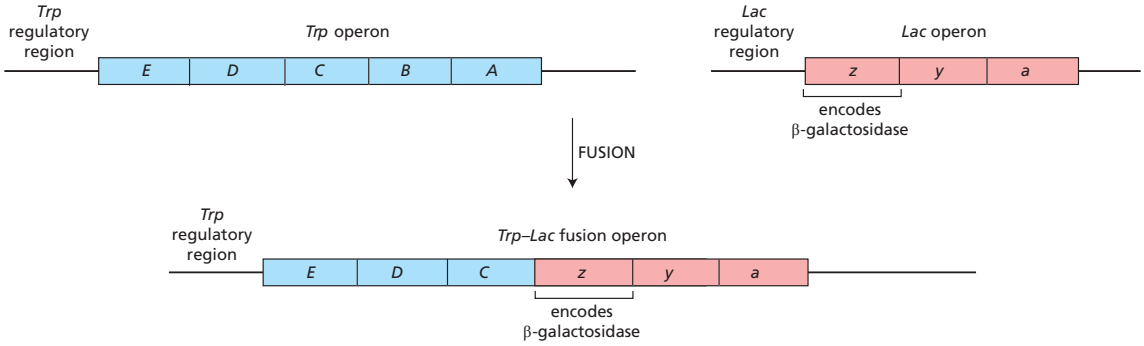
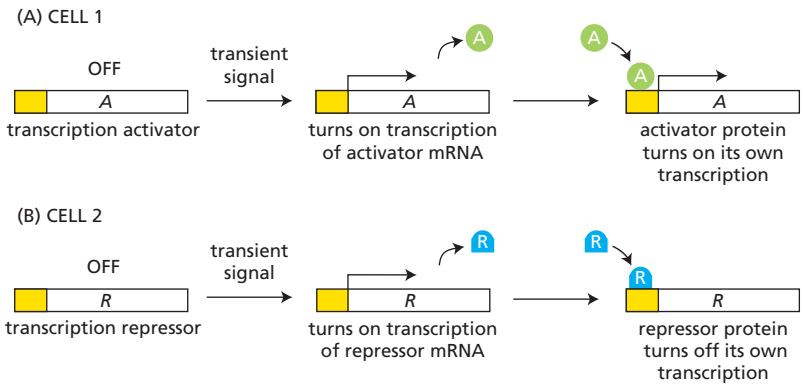
1. Imagine that you have created a fusion between the *Trp* operon, which encodes the enzymes for tryptophan biosynthesis, and the *Lac* operon, which encodes the enzymes necessary for lactose utiliza- tion (Figure below). Under which set of conditions will β-galactosidase be expressed in the strain that carries the fused operon?

1. Only when lactose and glucose are both absent.
2. Only when lactose and glucose are both present.
3. Only when lactose is absent and glucose is present.
4. Only when lactose is present and glucose is absent.
5. Only when tryptophan is absent.
6. Only when tryptophan is present.



In the fused operon, the genes in the *Lac* operon have come under control of the regulatory region of the *Trp* operon. Thus, expression of β-galactosidase, the product of the *LacZ* gene, will be regulated by the tryptophan repressor. Because the tryptophan repressor requires tryptophan in order to bind to its regulatory region and shut of the operon, expression of β-galactosidase (and the other genes in the fused operon) will occur only when tryptophan is absent from the medium (condition E).

Imagine the two situations shown in the figure below. In cell 1, a transient signal induces the synthesis of protein A, which is a transcription activa- tor that turns on many genes including its own. In cell 2, a transient signal induces the synthesis of protein R, which is a transcription repressor that turns of many genes including its own. In which, if either, of these situations will the descendants of the original cell "remember" that the progenitor cell had experienced the transient signal? Explain your reasoning.



The induction of a transcription activator that stimulates its own synthesis creates a positive feedback loop that can, depending on the stability of protein A, its ainity for its *cis*-regulatory sequence, and other parameters, lead to cell memory. The continued self-stimulated synthesis of activator A can, in principle, last for many cell generations, serving as a constant reminder of an event in the distant past. By contrast, the induction of a transcription repressor that inhibits its own synthesis creates a negative feedback loop that guarantees a transient response to the transient stimulus. Because repressor R shuts of its own synthesis, the cell will quickly return to the state that existed before the transient signal.

Multiple Choice Questions

1. What percentage of genes are estimated to be imprinted?

a) 100%
b) 50%
c) 5%
d) <1%

d) is correct. See slide 10.

2. Which of the following statements are CORRECT:

a) Both imprinting and X-inactivation lead to monoallelic gene expression
b) The Y chromosome contains more genes than the X one.
c) Hypermethylation of CpG islands is a characteristic of the inactive X-chromosome.
d) Xist silences genes and itself too.

a) is correct. (slide 16)

3. Epigenetic inheritance refers to:

a) Inheritance of mitochondrial DNA
b) Mutations in DNA that are passed to offspring
c) Changes in gene expression that are heritable with changes to the DNA sequence
d) Modifications of histone proteins that can be passed to future generations

d) is correct.

4. Which of the following statements are INCORRECT for transcription attenuation:

a) Riboswitches are part of the transcription attenuation mechanisms
b) Transcription attenuation is definitive
c) Transcription attenuation only occurs in eukaryotes
d) Anti-terminator blocks the RNA polymerase and thus the transcription stops.

b), c), d) are false.

5. What is one the important consequences of alternative splicing?

a) Reducing the number of proteins produced by an organism
b) Complete elimination of introns from messenger RNA
c) Increasing polypeptide chains diversity from a limited number of genes
d) Creation of new DNA sequences

c) is correct.

6. Which of the following statements are TRUE about mRNA transport?

a) The specific locations for the mRNA are usually quite distant from where the protein is needed.
b) mRNA never comes out of the nucleus unspliced.
c) rRNA is involved in carrying genetic information from the nucleus to the cytoplasm.
d) mRNA transport can be coupled with translation

d) is correct. a) is false because many mRNAs are directed to specific intracellular locations close to sites where the protein is needed (slide 35). HIV perturbs the RNA transport and thus allows the unspliced mRNAs to go into the cytosol (slide 34). It is not rRNA but mRNA that is involved.

7. Which of the following is CORRECT:

a) lncRNAs are usually shorter than a thousand nucleotides in humans
b) piRNAs inhibit the transposon activity
c) a miRNA regulates one specific mRNA.
d) lncRNAs serve as guide RNAs.

b) and d) are correct. lncRNAs are bigger than 5000 nt in the human genome (slide 50). A single miRNA can regulate a whole set of different mRNAs (slide 44).

<u>True or False</u>

1. All genes are inactive on the inactivated X-chromosome.
   FALSE, 10% escape the X-chromosome inactivation. (slide 19)

2. A black, orange and white cat is most probably a female.
   TRUE

3. CG islands are thought to have arisen during evolution because they were associated with portions of the genome that remained unmethylated in the germ line.
   FALSE, DNA methylation occurs on the cytosine, largely in sequence CG. (slide 7)

4. When a riboswitch is bound by its specific small molecule such as guanine, it induces a conformational change which allows the elongating RNA polymerase to transcribe the following gene.
   FALSE, it forces the RNA polymerase to terminate transcription. (slide 27)

5. Argonaute is a protein part of the RISC complex which holds the 5' region of the miRNA so that it is optimally positioned for the base-pairing to another RNA molecule.
   TRUE (slide 45)

6. If the RNA editing happens outside of the coding region, nothing will be affected.
   FALSE, it may affect splicing, transport of mRNA, efficiency of translation, etc. (slide 32)

7. The dynamic interaction between stress granules and P-bodies is thought to play a crucial role in mRNA triage, where transcripts can be sorted for storage, degradation, or return to translation, depending on the cellular needs and stress conditions.
   TRUE (slide 42)