Office Hours this week

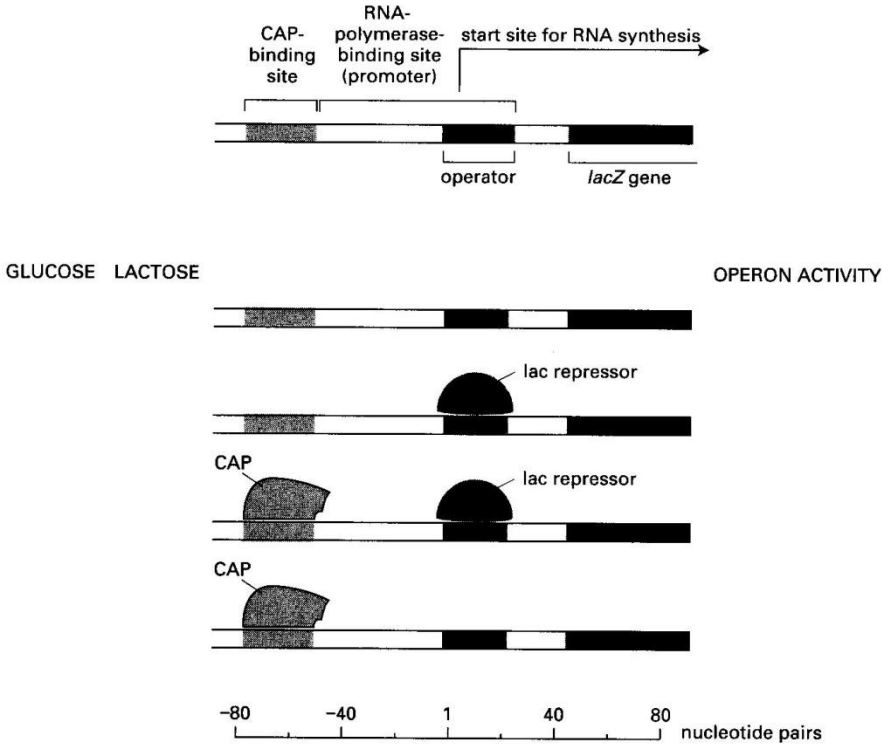
- Today: 2:00 – 3:30 PM
- Tomorrow 9:00 -10:30 AM (by appoint.)

- After tomorrow AM: only reachable by email.

Format Final Exam

- 25 MCQs Total of 40 marks
- 9 Questions: Total of 60 marks

1: In the following figure which shows the regulatory region of the lactose operon, you see the different possible occupancy status for the CAP and repressor binding sites. Associate each of these situations with presence or absence of glucose and lactose in the growth media and say if the operon will be active (ON) or inactive (OFF).



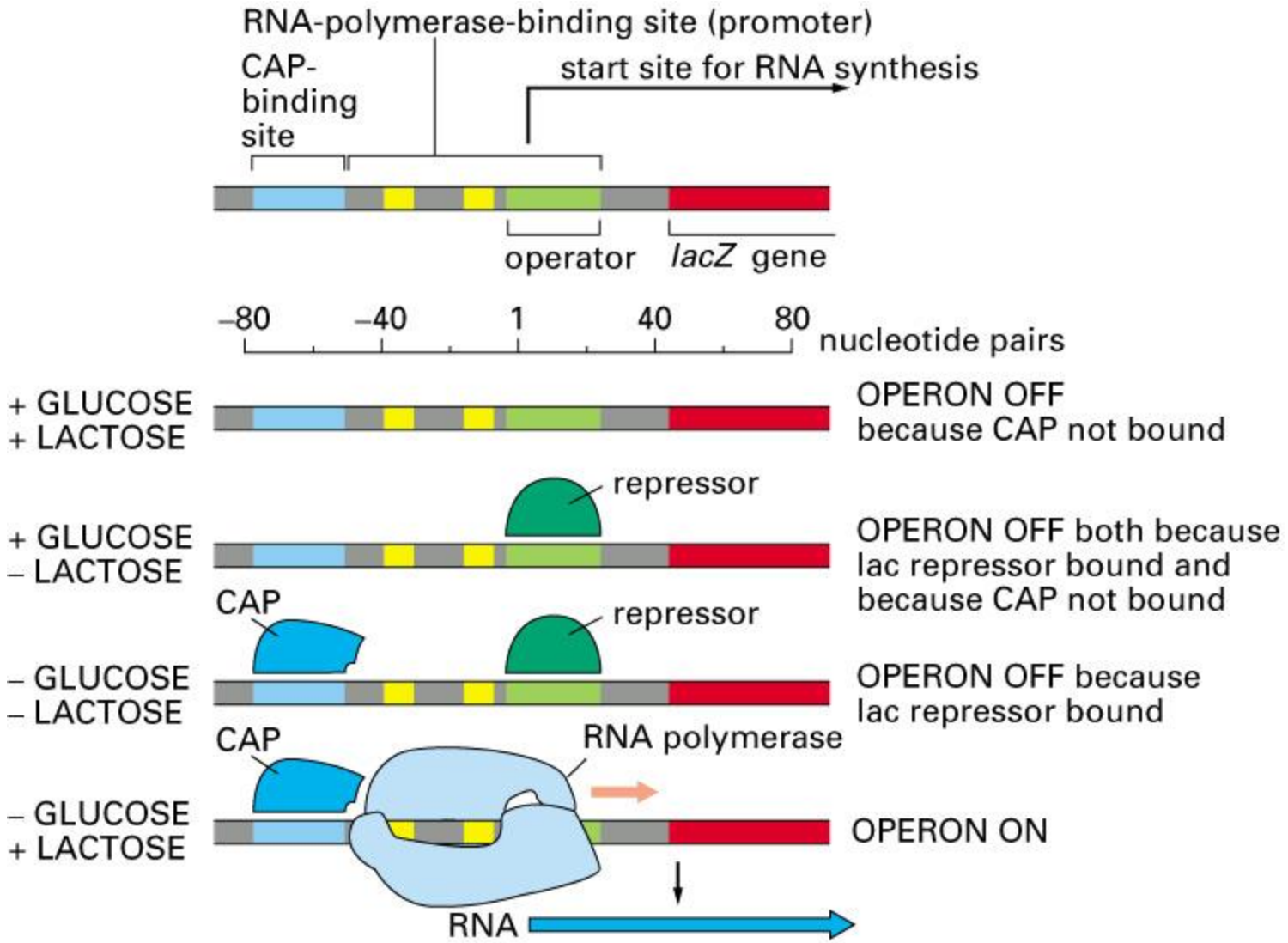


Figure 7–38. Molecular Biology of the Cell, 4th Edition.

2. Imagine you have created a fusion between the regulatory regions of the tryptophan operon and the coding region of the lactose operon. Under which circumstances do you expect to see expression of the β-galactosidase gene ?

A) Only when glucose and lactose are absent?

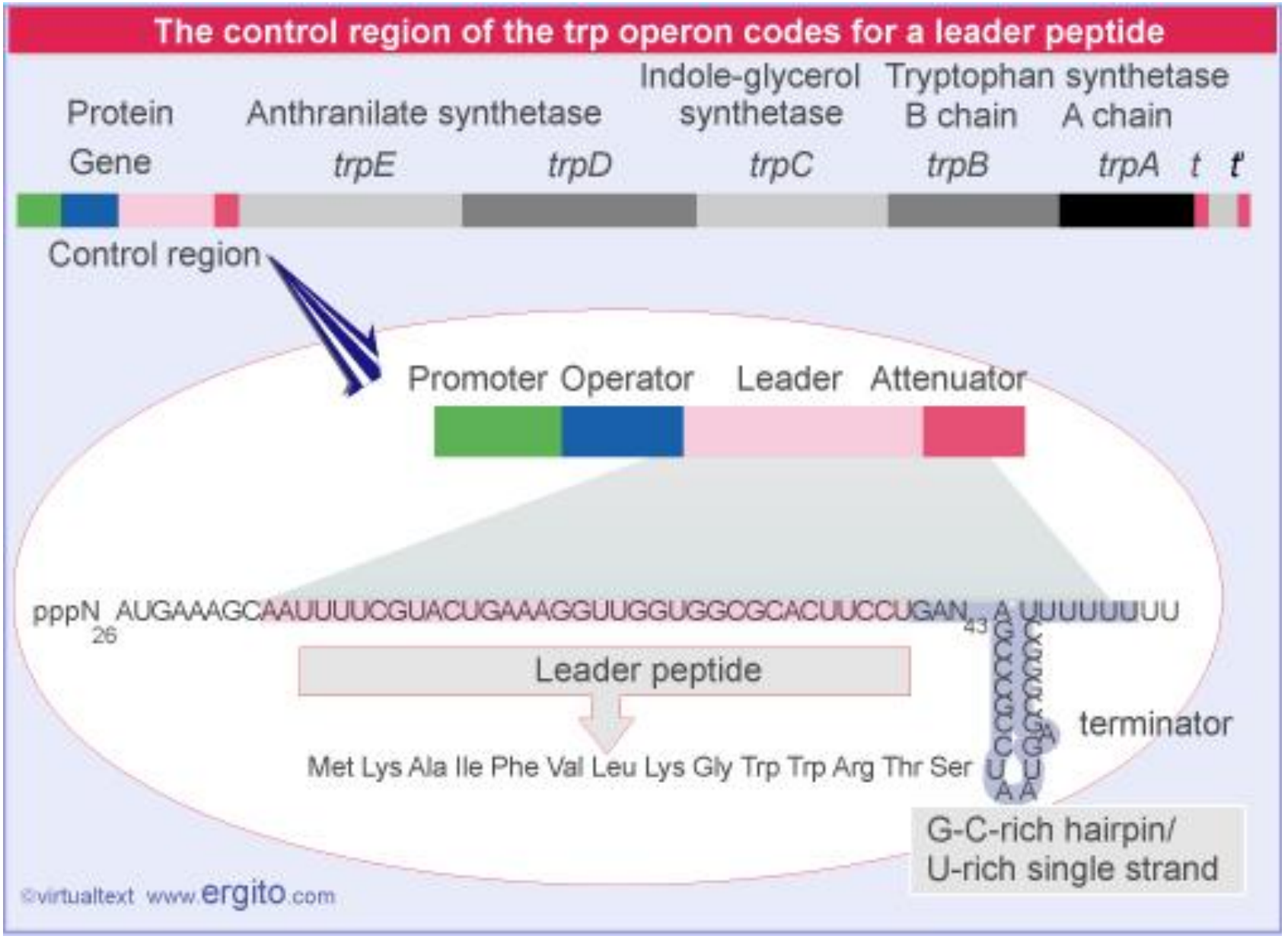
B) Only when glucose and lactose are present?

C) Only when glucose is present and lactose is absent ?

D) Only when lactose is present and glucose is absent ?

E) Only when tryptophan is absent ?

F) Only when tryptophan is present ?


The control region of the trp operon codes for a leader peptide
Protein
Gene
Anthranilate synthetase
trpE
trpD
Indole-glycerol
synthetase
trpC
Tryptophan synthetase
B chain
trpB
A chain
trpA
t
t'
Control region
Promoter
Operator
Leader
Attenuator
pppN
26
AUGAAAGCAAUUUUCGUACUGAAAGGUUGGUGGCGCACUUCCUGAN
43
A UUUUUUUU
Leader peptide
Met Lys Ala Ile Phe Val Leu Lys Gly Trp Trp Arg Thr Ser
terminator
G-C-rich hairpin/
U-rich single strand
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2. Imagine you have created a fusion between the regulatory regions of the tryptophan operon and the coding region of the lactose operon. Under which circumstances do you expect to see expression of the β-galactosidase gene ?

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C) Only when glucose is present and lactose is absent ?

D) Only when lactose is present and glucose is absent ?

E) Only when tryptophan is absent ?

F) Only when tryptophan is présent ?

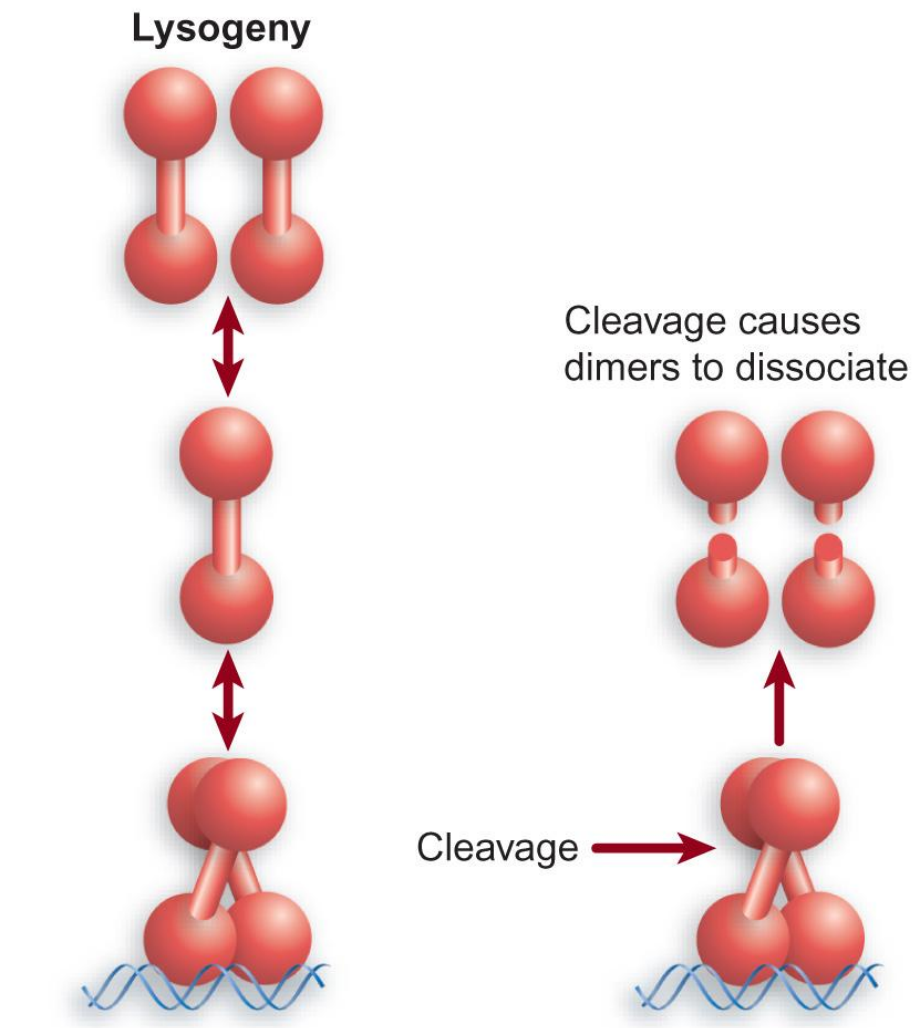
3- Bacteriophage lambda can use the lytic pathway or the lysogeny pathway. You saw the respective roles of the cro and cI proteins. When a bacteria where the phage is currently in the lysogeny state is briefly exposed to UV, the cI protein is degraded.

a) What will happen ?

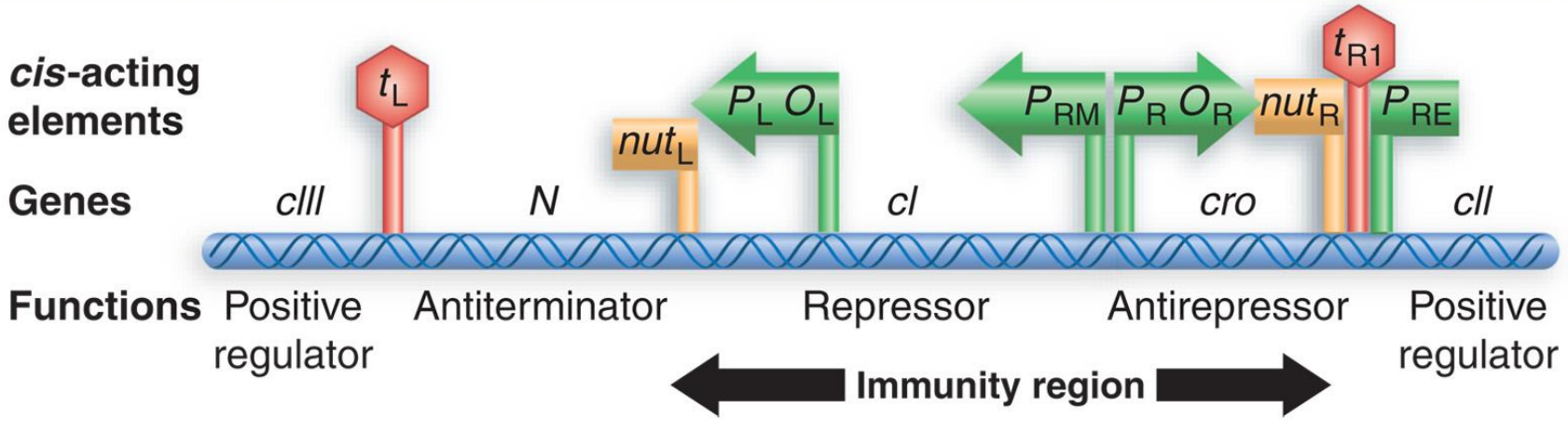
b) Is this change irreversible ?

c) How can this change be beneficial to the virus ?

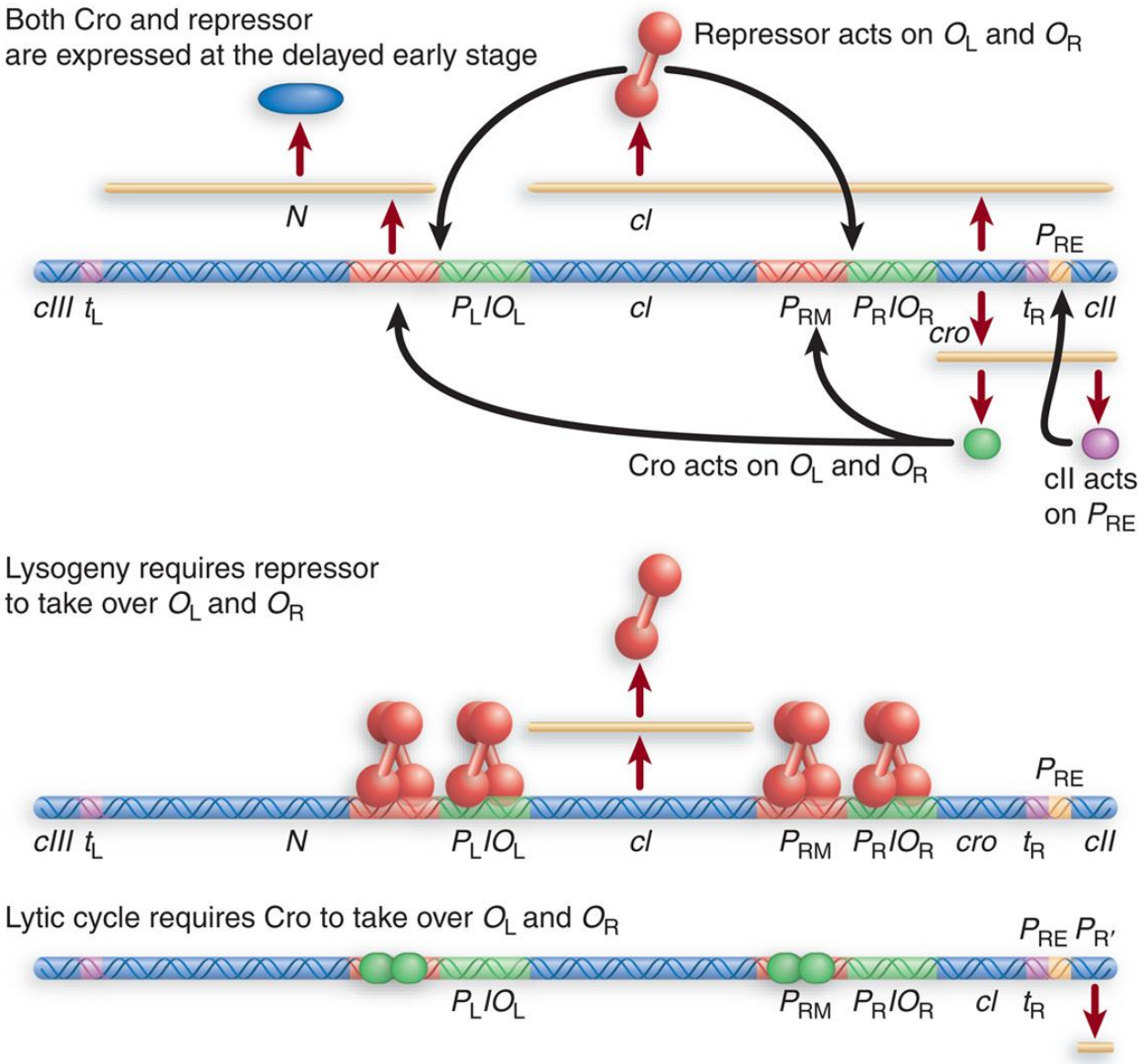
Repressor cleavage induces lytic cycle



Lambda has a compact regulatory region



Repressor determines lysogeny, and Cro determines the lytic cycle

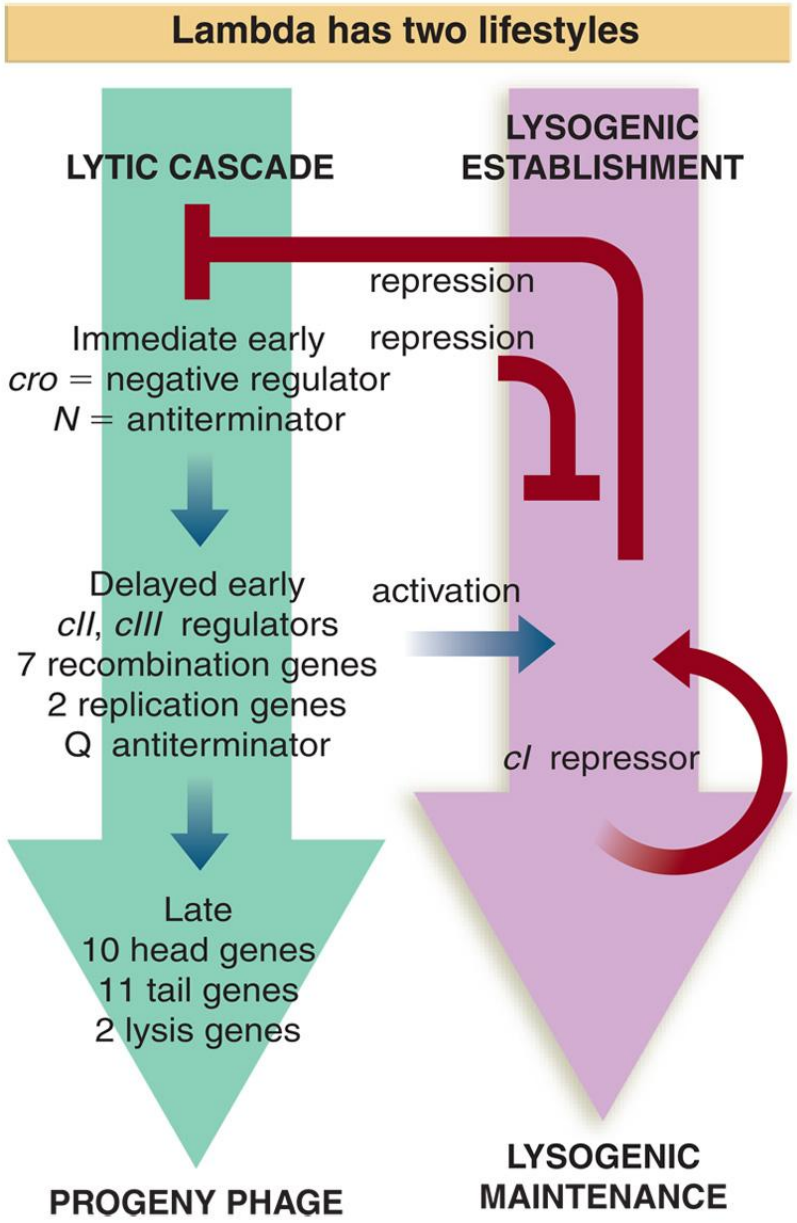


4. **In their studies of lambda bacteriophage, Jacob and Wollman transferred a fragment of bacterial chromosome in another bacterial cell. They observed that when the transferred DNA contained the lambda under lysogeny form (prophage), and that the recipient bacteria did not contain the lambda phage, lysis was taking place. They wanted to name this phenomenon "erotic induction" but had to change the name for "zygotic induction" (true story!) before they could publish it. What can you do, this was fifty years ago. The following table shows the results**

Receiving bacteria	lambda-	lambda+
Donnor DNA		
Lambda-	**no lysis**	**no lysis**
Lambda+	**lysis (λ is made)**	**no lysis**

a) Explain these results basing yourself on your knowledge of the phage repressor (cI).

b) Imagine a situation where, instead of having a repressor, the prophage would prevent lysis by producing an activator regulatory protein that would control the expression of an anti-lysis protein. How would the above results be affected? Explain your answer.



Receiving bacteria:

Lambda (-) : no cI repressor

Lambda (+): cI repressor present

Donnor DNA:
Lambda (-)
Lambda (+)

5. Suggest a mechanism by which protein-protein interactions that are too weak to cause formation of a multi-protein complex in solution can still lead to formation of such a complex on DNA ?

Synergy involving rDBPs, co-activators, and co-repressors

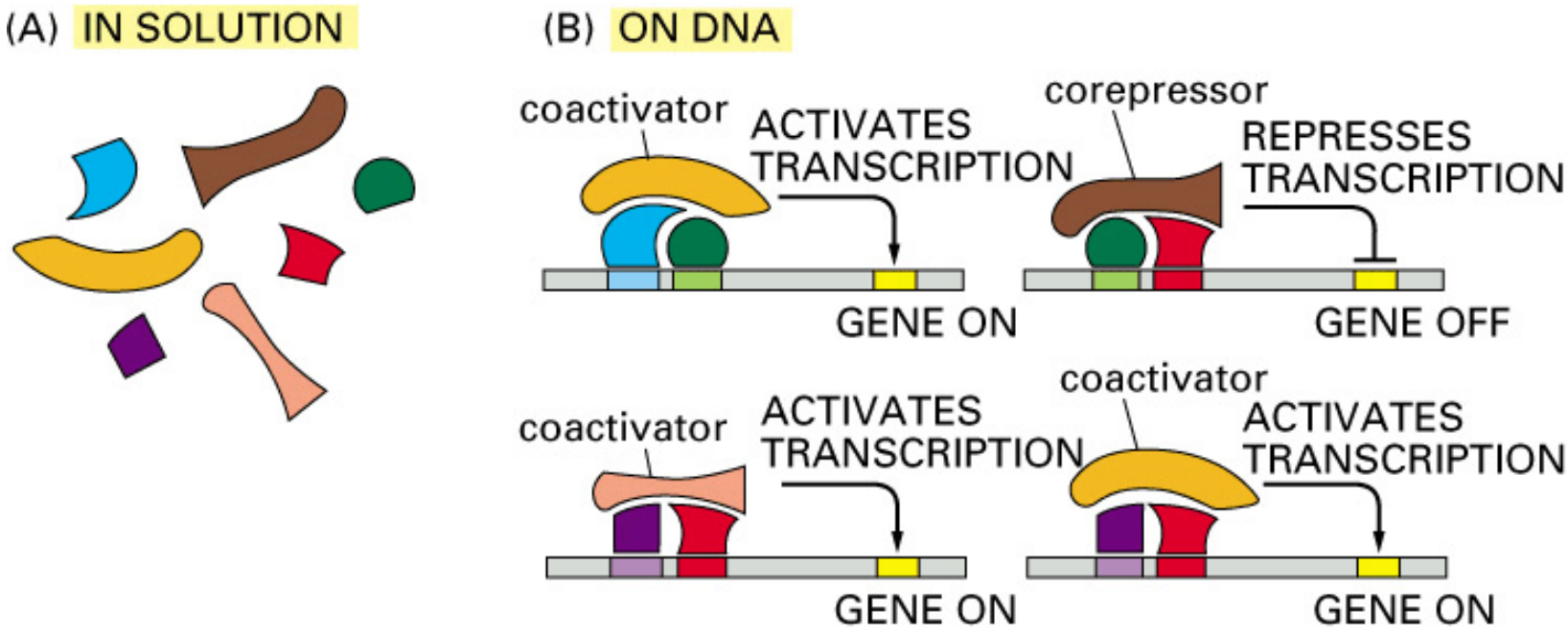


Figure 7–50. Molecular Biology of the Cell, 4th Edition.

6- Imagine the following two situations. In type I cell, a transient signal leads to synthesis of protein A, a transcriptional activator for several target genes including itself. In type II cells, a transient signal leads to synthesis of a repressor protein that represses transcription of several target genes including itself. Is one of the two cell types susceptible to generate daughter cells that « remember » that their mother cells and gone through the initial signal? Justify your answer.

Example of positive feedback

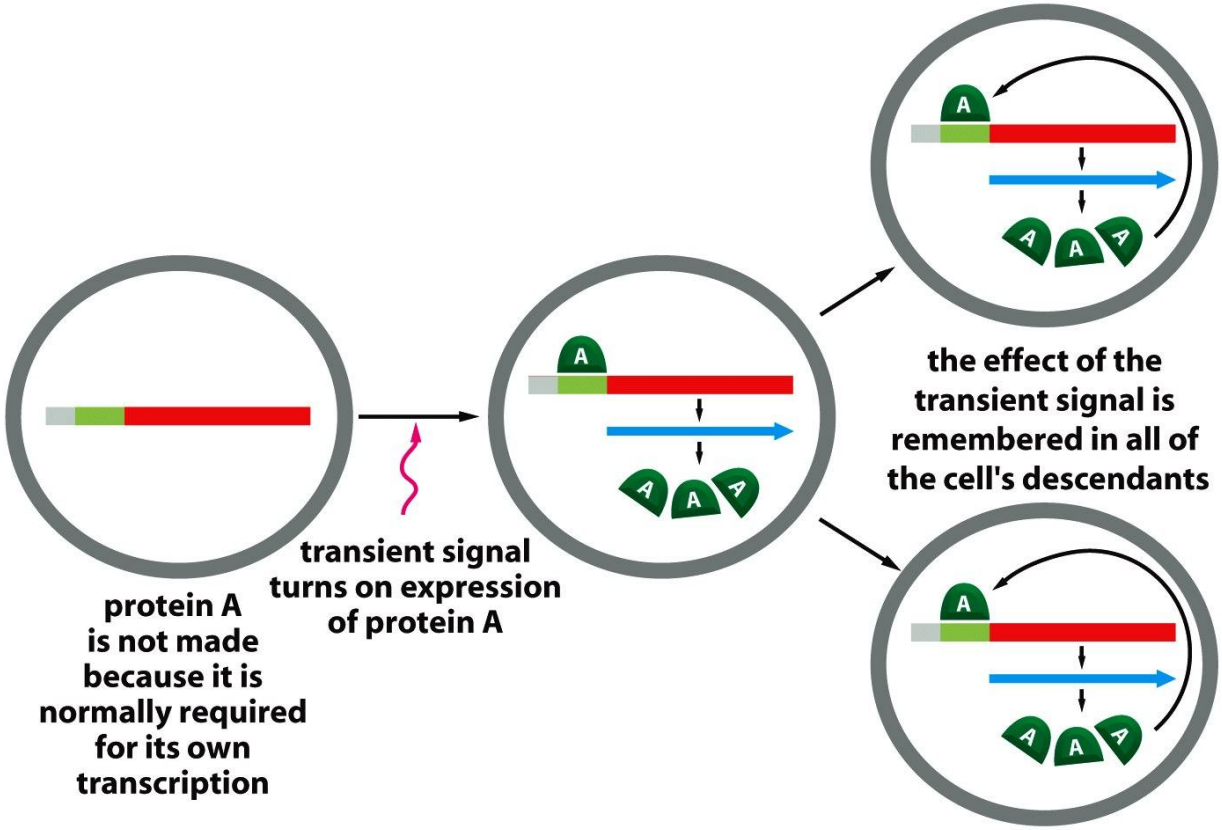


Figure 7-68 Molecular Biology of the Cell 5/e (© Garland Science 2008)

Cytosine methylation and transcriptional activity.

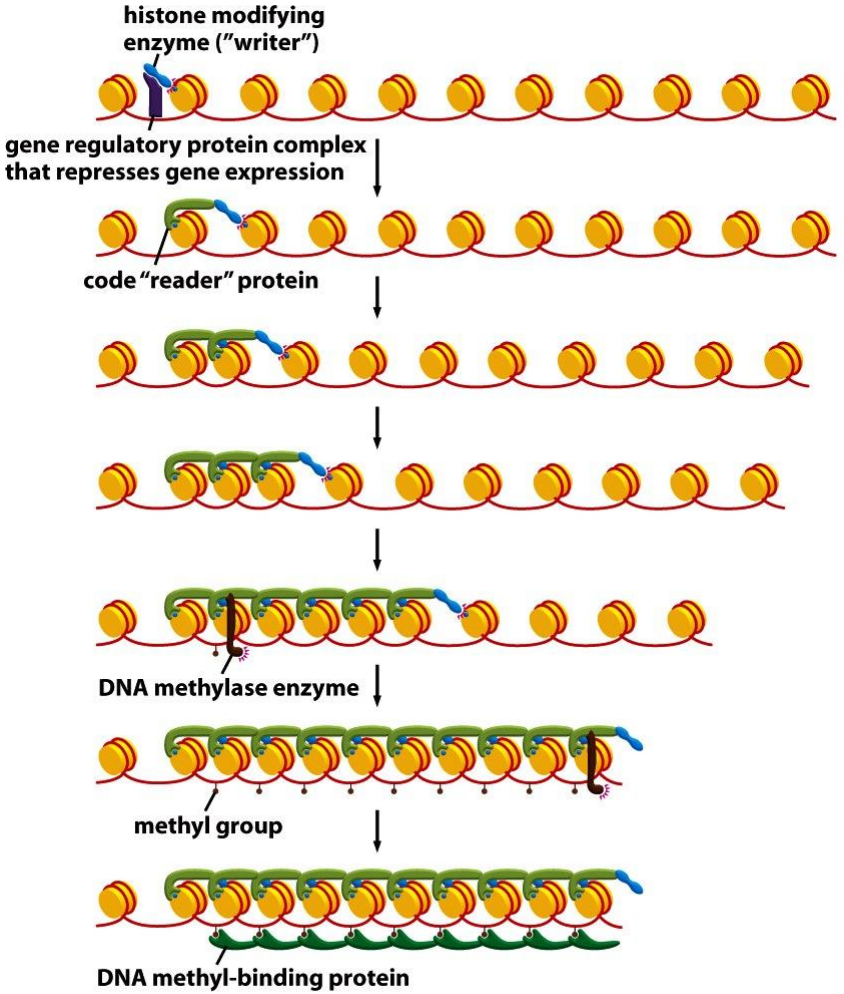
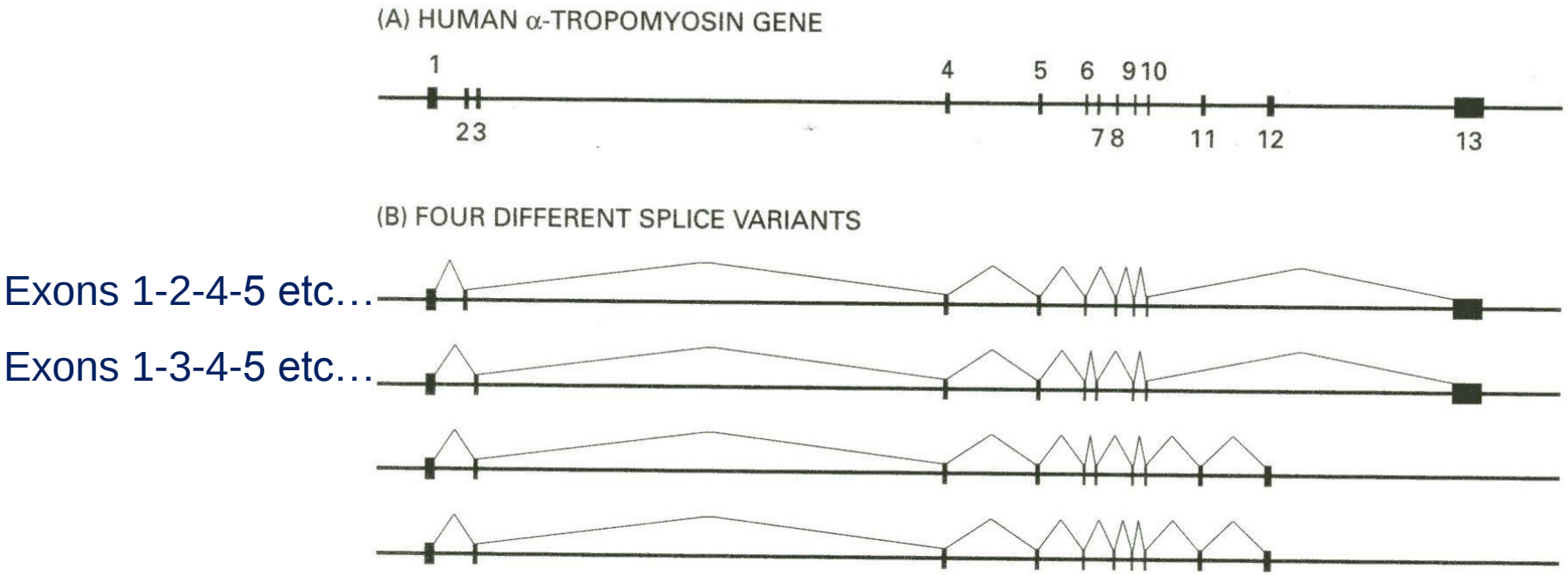


Figure 7-81 Molecular Biology of the Cell 5/e (© Garland Science 2008)

7. The human alpha-tropomyosin gene is subject to alternative splicing and produces mRNAs in different cell types. As shown in the figure below, exon 1 is used in all cases and the same applies to exons 4, 5, 6, 9, and 10. However, exons 2 and 3 are used alternatively (either one or the other) and the same applies for exons 7 and 8. Which of the following statements applies to exons 2 and 3? Is it also true for exons 7 and 8?



A) Exons 2 and 3 must have the same number of nucleotides.
B) Exons 2 and 3 must have nucleotide numbers that are multiple of 3.
C) Exons 2 and 3 must have a number of nucleotide which, once divided by three, give the same remainder (i.e. 0, 1 or 2).

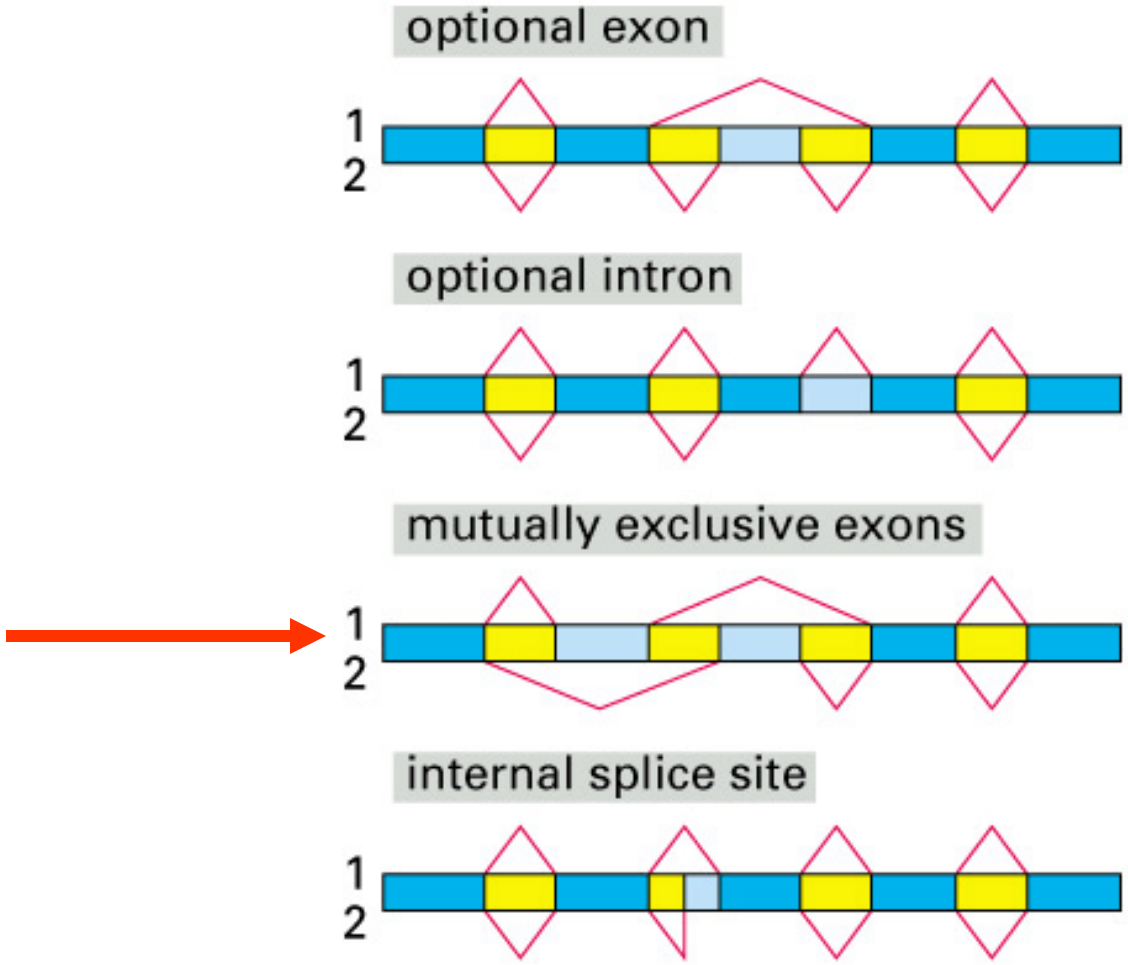
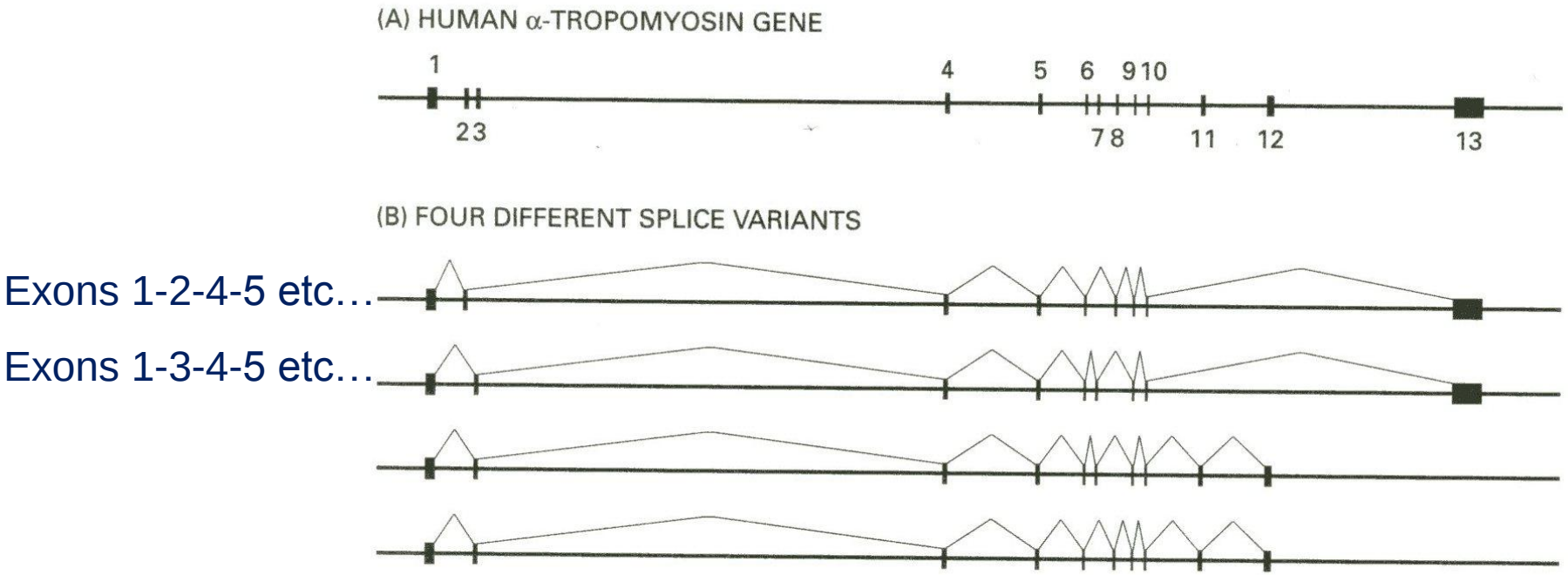


Figure 7–88. Molecular Biology of the Cell, 4th Edition.



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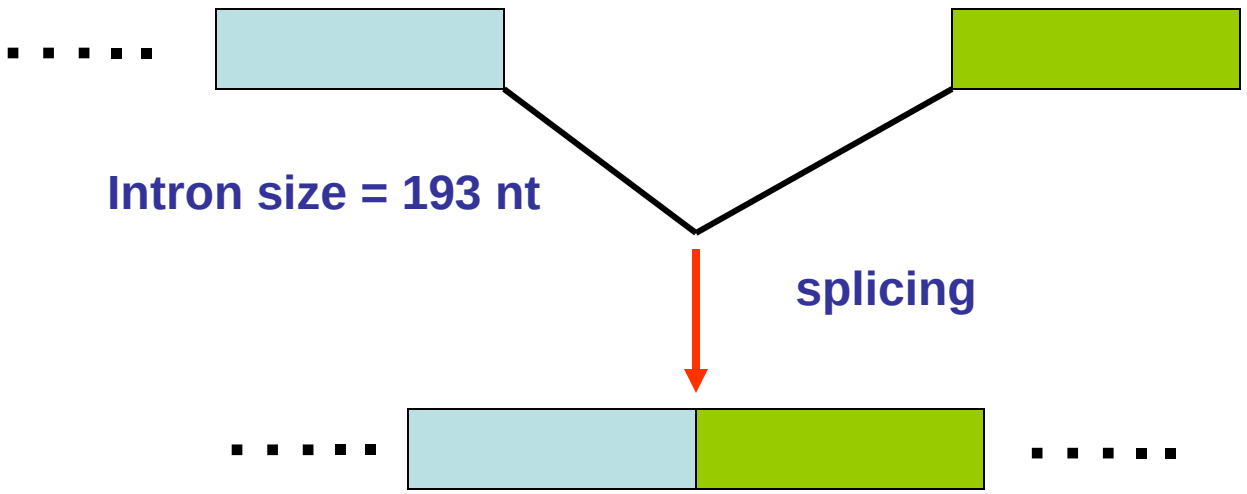
Answer: The only thing that matters is keeping the same reading frame. You do not need to have the same number of nucleotides to achieve this and you do not need to have an exon whose size is a multiple of 3. For example, if exon 2 has 13 nucleotides and exon 3 has16 nucleotides, their mutually exclusive use would result in 1-2-4 and 1-3-4 splicing that keep the same reading frame.

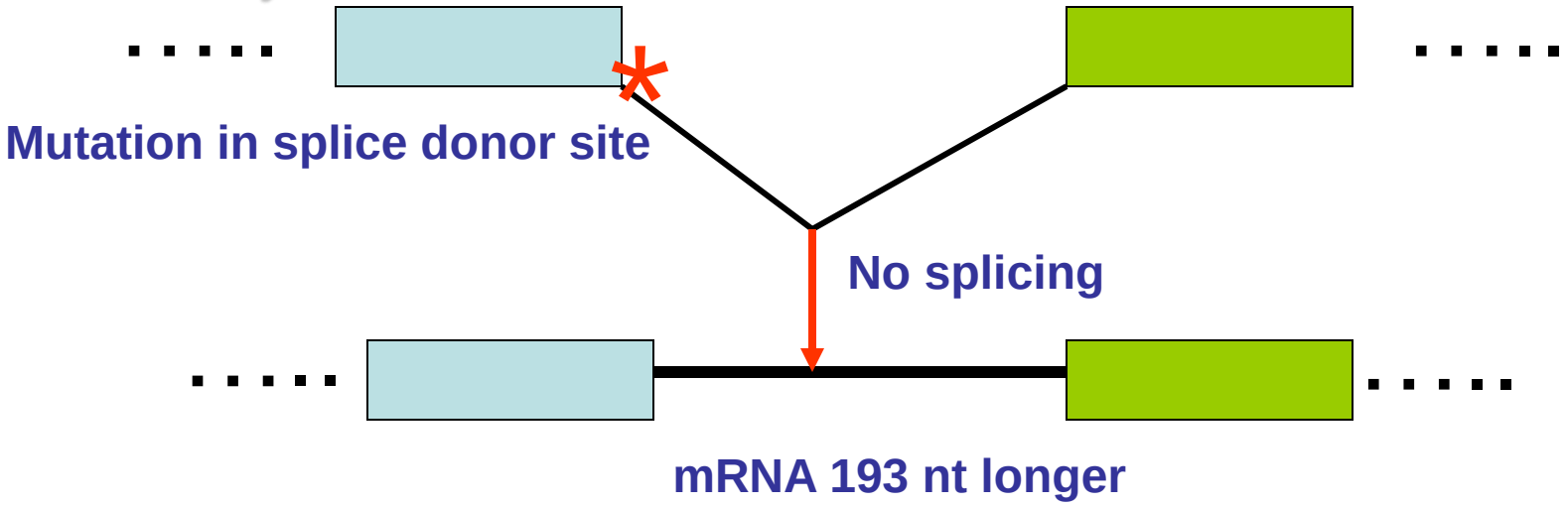
8. **« Memorizin » is a hypothetical protein involved in memory which allows students to memorize even the most trivial details during exam season. Protein activity is undetectable people with a bad memory. DNA was isolated from a family with several individuals suffering from bad memory and its analysis showed a single nucleotide substitution compared to DNA from people with a normal memory. There were no deletions or insertions. Sequence analysis algorithms suggest that this substitution should result in the synthesis of a mature mRNA that is 193 nucleotides (nt) longer in individuals affected with a bad memory compared to normal individuals.**

a) Suggest a mechanism that can explain how a single substitution can result in a mRNA that is 193 nt longer

Normal memory



Bad memory



b) Supposing that the 193 nt insertion falls within the protein coding sequence of the mRNA, mention two possible impacts on the synthesized protein?

c) Name one mechanism that could alleviate one of the problems mentioned in b) and explain the absence of protein activity in people with bad memory

b) Supposing that the 193 nt insertion falls within the protein coding sequence of the mRNA, mention two possible impacts on the synthesized protein?

Answer: 1) Abnormal protein sequence: 193 is not a multiple of three so this will change the reading frame. In addition to the abnormal amino acids introduced by the insertion, all amino acids in the downstream exons will be abnormal. 2) Truncated protein. There could be in-frame stop codons in the 193 nt insertion or in the downstream exons.

c) Name one mechanism that could alleviate one of the problems mentioned in b) and explain the absence of protein activity in people with bad memory

Non-sense-mediated mRNA decay

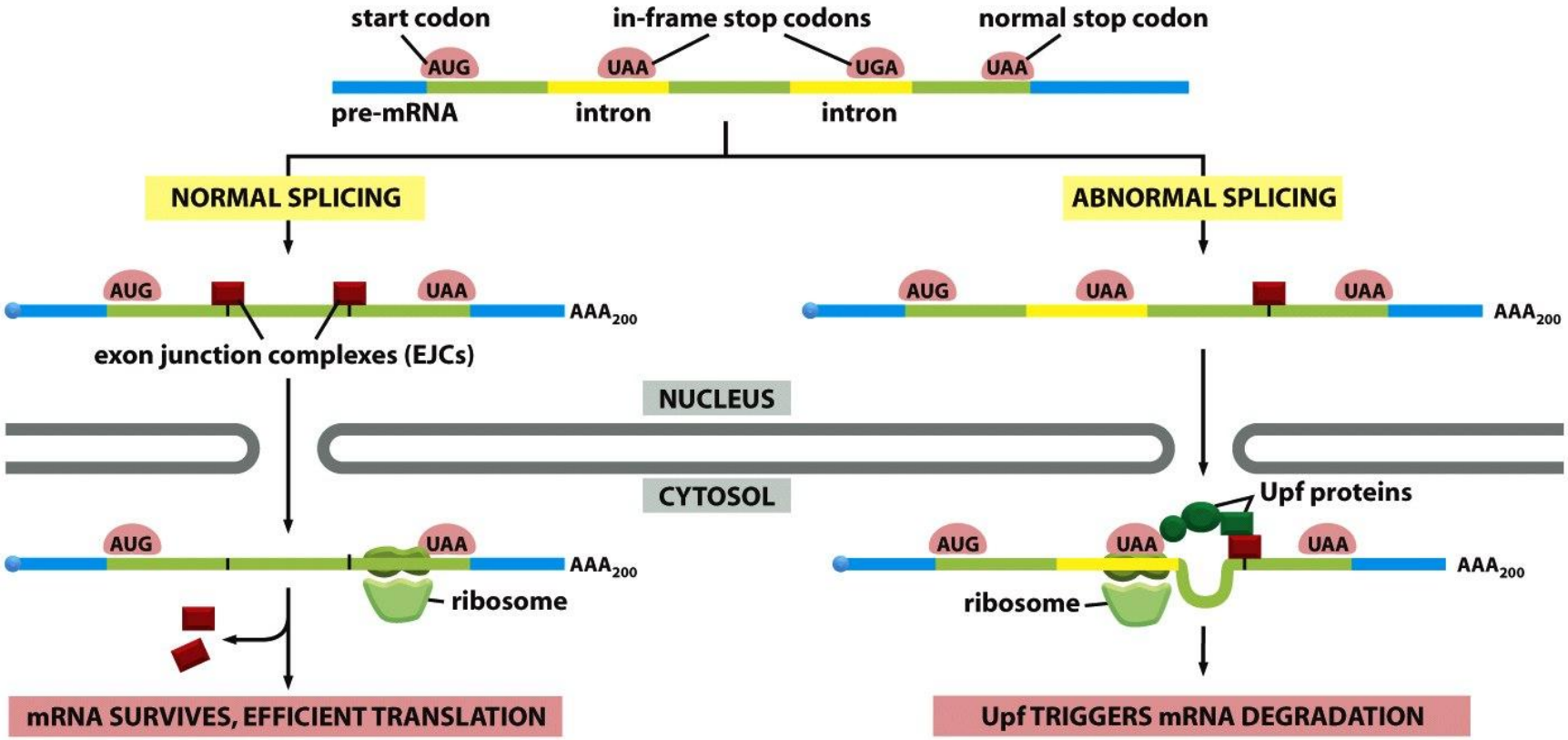


Figure 6-80 Molecular Biology of the Cell 5/e (© Garland Science 2008)

9- The Vg1 gene codes for a protein that plays an important role during early embryonic development. The Vg1 mRNA and the Vg1 protein are localized to the vegetal pole of the *Xenopus* oocyte and this localization is important for Vg1 function. One way to ensure localization is to prevent translation before localization is complete. It was previously shown that a sequence rich in U and A is located in the 3'UTR and is essential for translation control. However, if you insert an internal ribosomal entry site (IRES) upstream of the Vg1 initiator AUG, inhibition of translation is no longer possible. Suggest a mechanism to explain how translational control of Vg1 mRNA takes place.

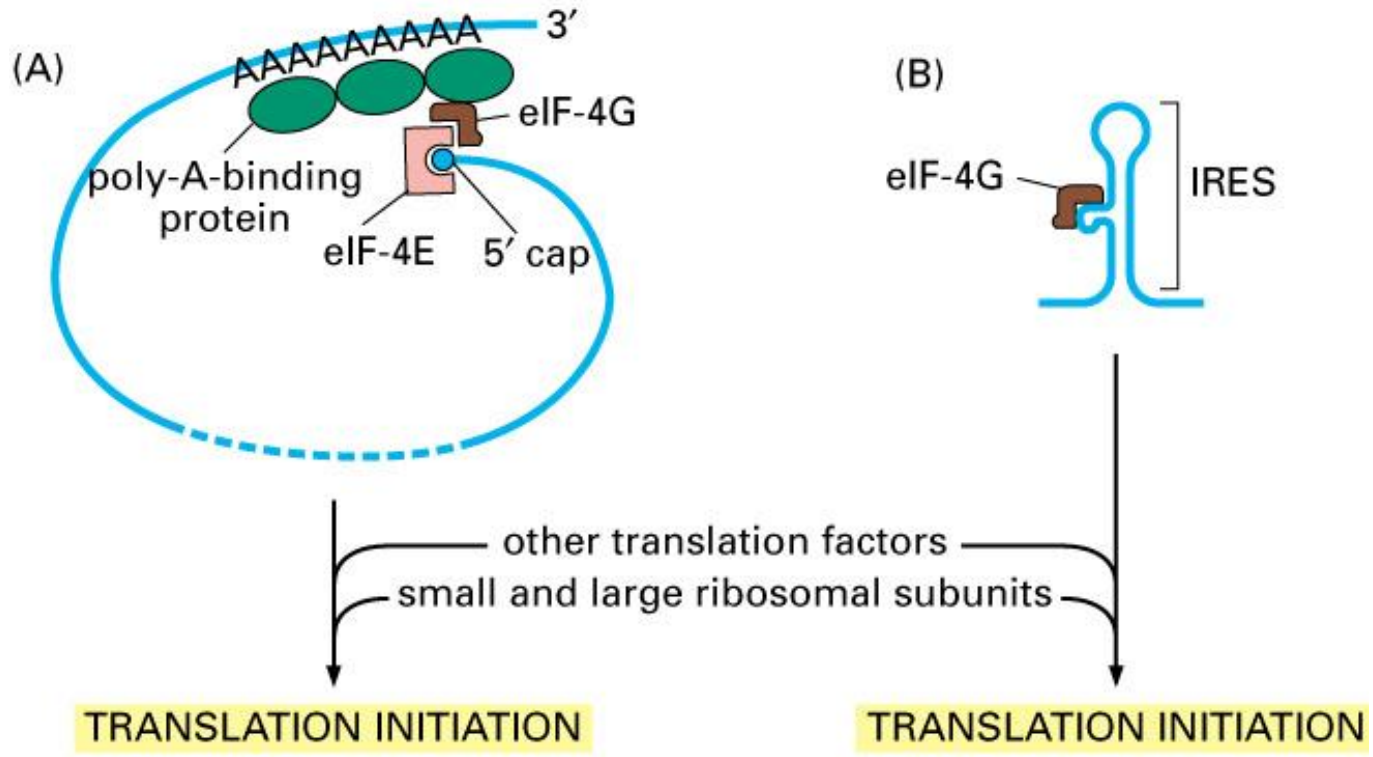


Figure 7–102. Molecular Biology of the Cell, 4th Edition.

Different translation factors are involved in initiation of translation from a regular AUG and from an IRES.

The localized translation of Vg1 might involve interaction between factors binding to 3'UTR and those binding to the cap (e.g. eiF4E, normal eiF4G). The IRES might bypass this control mechanism.