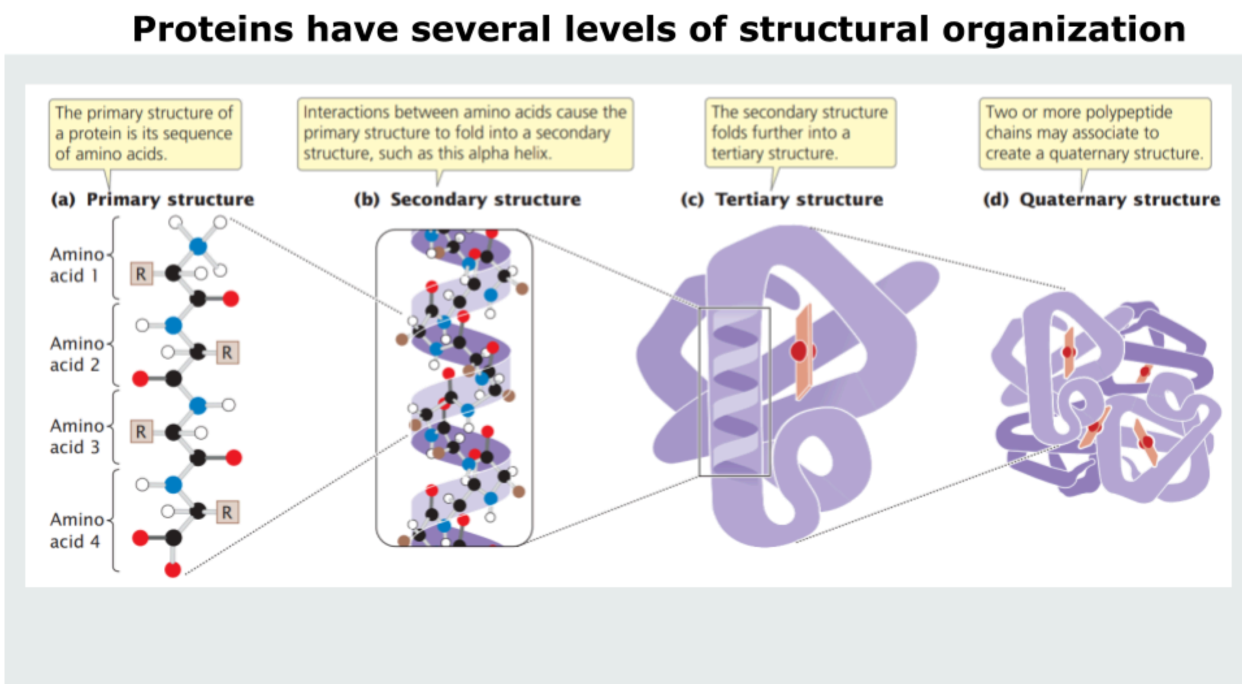
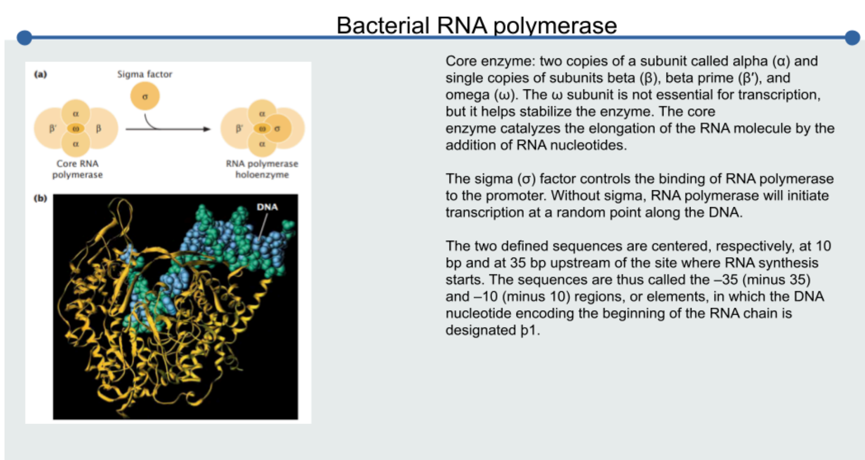
GMB Quiz 4 Rubrics

1. Describe the four levels of protein structure (primary, secondary, tertiary, and quaternary) and explain how each level contributes to the overall shape and function of a protein. Provide examples of the types of bonds or interactions that stabilize each structural level.



2. Explain the structure and function of bacterial RNA polymerase, including the roles of the core enzyme and the sigma (σ) factor in transcription. Describe how the −35 and −10 promoter regions facilitate the initiation of transcription. Compare and contrast the different types of eukaryotic RNA polymerases (I, II, III, IV, and V) in terms of their cellular presence and the types of RNA they transcribe. Discuss how the specialization of each RNA polymerase contributes to cellular function in eukaryotes.



Bacterial Transcription

Table 13.3 Eukaryotic RNA polymerases

Type	Present in	Transcribes
RNA polymerase I	All eukaryotes	Large rRNAs
RNA polymerase II	All eukaryotes	Pre-mRNA, some snRNAs, snoRNAs, some miRNAs
RNA polymerase III	All eukaryotes	tRNAs, small rRNAs, some snRNAs, some miRNAs
RNA polymerase IV	Plants	Some siRNAs
RNA polymerase V	Plants	RNA molecules taking part in heterochromatin formation

1. initiation, in which the transcription apparatus assembles on the promoter and begins the synthesis of RNA.

2. elongation, in which DNA is threaded through RNA polymerase, the polymerase unwinding the DNA and adding new nucleotides, one at a time, to the 3′ end of
the growing RNA strand

3. termination, the recognition of the end of the transcription unit and the separation of the RNA molecule from the DNA template

3. A strain of bacteria possesses a temperature-sensitive mutation in the gene that encodes the rho subunit of RNA polymerase. At high temperatures, the rho factor becomes nonfunctional. When these bacteria are exposed to elevated temperatures, which of the following effects would you expect to observe?

a. Transcription does not take place.
b. All RNA molecules are shorter than normal.
c. All RNA molecules are longer than normal.
d. Some RNA molecules are longer than normal.
e. RNA is copied from both DNA strands.
Explain your reasoning for accepting or rejecting each of the five options.

Ans: (a) No. Because the rho protein has a role in transcription termination, it should not affect transcription initiation or elongation. So you would expect to see transcription.

(b) No. Without the rho protein, transcription would be expected to continue past the normal termination site of rho-dependent terminators, producing some longer molecules than expected.

(c) No. Only RNA molecules produced from genes using rho-dependent termination should be longer. Genes that are terminated through rho-independent termination should remain unaffected.

(d) Yes. You would expect to see some RNA molecules that are longer than normal. Only genes that use rho-dependent termination would be expected to not terminate at the normal termination site, thus producing some RNA molecules that are longer than normal.

(e) No. RNA would be copied from only a single strand because the rho protein does not affect transcription initiation or elongation.

4. A series of auxotrophic mutants were isolated in Neurospora. Examination of fungi containing these mutations revealed that they grew on minimal medium to which various compounds (A, B, C, D) were added. Growth responses to each of the four compounds are presented in the following table:

Mutation number	Compound A	B	C	D
134	+	+	−	+
276	+	+	+	+
987	−	−	−	+
773	+	+	+	+
772	−	−	−	+
146	+	+	−	+
333	+	+	−	+
123	−	+	−	+

a. Determine the order of the compounds (A, B, C, and D) in a biochemical pathway.

b. Indicate which step in the pathway is affected by each of the mutations.

To the medium; so these mutations must affect a step before the production of all four compounds:

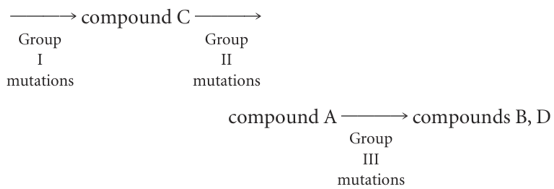
Ans: The underlying principle used to determine the order of the compounds in the pathway is as follows: if a compound is added after the block, it will allow the mutant to grow, whereas, if a compound is added before the block, it will have no effect. Applying this principle to the data in the table, we see that mutants in group I will grow if compound A, B, C, or D is added.

Mutation		Compound			
Group	Number	A	B	C	D
I	276	+	+	+	+
	773	+	+	+	+
II	134	+	+	−	+
	146	+	+	−	+
	333	+	+	−	+
III	123	−	+	−	+
IV	987	−	−	−	+
	772	−	−	−	+

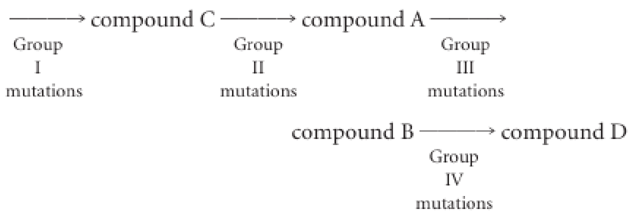
Group II mutants will grow if compound A, B, or D is added but not if compound C is added. Thus, compound C comes before A, B, and D; and group II mutations affect the conversion of compound C into one of the other compounds:

$$\xrightarrow[\substack{\text{Group}\\ \text{I}\\ \text{mutations}}]{} \text{compound C} \xrightarrow[\substack{\text{Group}\\ \text{II}\\ \text{mutations}}]{} \text{compounds A, B, D}$$

Group III mutants allow growth if compound B or D is added but not if compound A or C is added. Thus, group III mutations affect steps that follow the production of A and C. We have already determined that compound C precedes A in the pathway, and so A must be the next compound in the pathway:



Finally, mutants in group IV will grow if compound D is added but not if compound A, B, or C is added. Thus, compound D is the fourth compound in the pathway, and mutations in group IV block the conversion of B into D:



Order of the compounds in the pathway: C -> A -> B -> D

5. A researcher is studying the transfer of genes during bacterial conjugation using an Hfr strain (high-frequency recombination) and an F^- strain. The researcher notes the times at which various genes are transferred from the donor to the recipient during conjugation. Using this data, answer the following:

Gene	Transfer Time (minutes)
thr (threonine)	4
lac (lactose)	25
leu (leucine)	9
gal (galactose)	32
azi (azide resistance)	14
ton (tonicity)	18

a. Draw a genetic map indicating the relative positions of the genes based on their transfer times.

b. Explain how the transfer times reflect the order of gene transfer during conjugation.

c. If conjugation is interrupted after 15 minutes, which genes would you expect to find in the F^- recipient? Justify your answer.

d. What does the time gap between the transfer of genes indicate about the distance between them on the chromosome?

Ans:

a) A genetic map is a linear representation of gene positions based on their transfer times. The genes are transferred in the order of their transfer times. Here's the map in order:

thr (4 minutes)
leu (9 minutes)
azi (14 minutes)
ton (18 minutes)
lac (25 minutes)
gal (32 minutes)

This order reflects their positions along the chromosome during conjugation.

b) Explaining the transfer times
The order of gene transfer during conjugation reflects their positions on the chromosome. In Hfr conjugation, the DNA is transferred in a linear fashion, starting from the origin of transfer. Therefore, genes closer to the origin are transferred earlier, while genes further away take longer to transfer.

c) Genes expected after 15 minutes
If conjugation is interrupted after 15 minutes, only genes transferred within that time would be found in the F^- recipient. According to the map:

thr (4 minutes)
leu (9 minutes)
azi (14 minutes)
These genes would likely be transferred to the F^- strain within the first 15 minutes.

d) Time gap and gene distance
The time gap between the transfer of genes correlates with the physical distance between them on the chromosome. Larger gaps in transfer times indicate that the genes are further apart on the chromosome, while smaller gaps indicate closer proximity. This relationship allows researchers to map gene positions based on conjugation timing.