SECTION I

MCQs:

1. The sigma factor is involved in which cellular process?

A. Transcription
B. Translation
C. Replication
D. Cell division

Ans:A

2. Which of the following statements best describes the Central Dogma of Molecular Biology?

A. DNA is directly translated into proteins.
B. RNA is transcribed into DNA during protein synthesis.
C. Information flows from proteins to RNA and then to DNA.
D. Genetic information flows from DNA to RNA to proteins.

Ans:D

3. Where is the Shine-Dalgarno sequence typically found in relation to the start codon in prokaryotic mRNA?

A. Upstream (5') of the start codon.
B. Downstream (3') of the start codon.
C. Directly overlapping with the start codon.
D. Internal, within the coding sequence.

Ans: A

4. What is the mRNA produced from the template sequence 5'-ATG TAC CGC CTA TCG-3'?

A. 5'-CGA UAG GCG GUA GCT-3'
B. 5'-AUG UAC CGC GUA GCU-3'
C. 5'-UAC AUG GCG CAU CGA-3'
D. 5'-UAC ATG GCG CAU CGA-3'

Ans:A

5. Which of the following statements best describes a frameshift mutation?

A. A mutation that substitutes one nucleotide for another, leading to a change in a single amino acid.
B. A mutation that involves the insertion or deletion of nucleotides, causing a shift in the reading frame during translation.

C. A mutation that occurs in the promoter region, affecting the initiation of transcription.
D. A mutation that results in the formation of abnormal protein aggregates.

Ans: B

6. What are riboswitches?

A. Enzymes involved in RNA processing.
B. Sequences of DNA that regulate gene expression.
C. RNA sequences that can directly bind small molecules and regulate gene expression.
D. Proteins responsible for splicing introns during transcription.

Ans: C

7. What is the role of transcriptional factors in gene expression?

A. Discrete regulation
B. Promoting the initiation of translation
C. Global regulation
D. Mediates RNA splicing

Ans: A

8. Choose the correct statement:

A. Introns Are coding Regions in mRNA.
B. tRNA Carries Genetic Information from DNA to the Ribosomes.
C. Transcription occurs in the presence of RNA polymerase
D. Translation occurs during DNA replication

Ans: C

Paragraph:

Enzyme cooperativity refers to the phenomenon where the activity of one enzyme molecule influences the activity of neighbouring enzyme molecules within the same complex. This interaction can be categorised into two main types: positive cooperativity and negative cooperativity.
Enzymes exhibiting positive cooperativity show increased substrate binding affinity as more substrate molecules bind to the enzyme. On the other hand, negative cooperativity involves a decrease in substrate binding affinity as more substrate molecules bind to the enzyme.

1. Given the binding of transcriptional factors to DNA exhibits positive cooperativity, choose the graph that best describes the relation between transcription factor concentration and binding. (Graphs to be drawn for options below)

A. Sigmoid Curve
B. Linear

C. Parabolic
D. Hyperbolic

Ans: A

2. When choosing the parts of a genetic circuit, its dynamic characteristics are an important consideration. How should the cooperativity of system being designed be to allow it to rapidly react to changes in the environment/substrate concentration?

A. Positive
B. Negative
C. Zero
D. Cooperativity has no effect

Ans: A

SECTION II

1) **Which of the following are true:**

    a) **The chassis can be a living organism (also called in vivo implementation), or it can be abiotic, providing only the necessary biochemical components for in vitro transcription and translation.**
    b) **it is assumed that parts and devices cannot be exchanged without affecting the behaviour of other system components .**
    c) **The strength of repressor or activator binding is influenced by the DNA sequence of the operator. This can be manipulated to tune the level of repression or activation and, thus, the strength of the promoter.**
    d) **Terminators are placed past the 5' end of a protein coding sequence**
        A. a,c
        B. c
        C. a,b,c
        D. a,b,c,d

    Ans: A

2) **Considering a case where there is a mutation in the terminator sequence, which of the following functions will be affected by it?**
        A. Termination of translation
        B. Termination of transcription
        C. Nothing will really be affected since the Stop codon will end the translation anyway
        D. Both A and B

    Ans: B

3) **Which of the following can influence the level of protein synthesis?**
    i.Changing the DNA sequence of Ribosome Binding sites.
    ii.Changing the DNA sequence of Operator.
    iii.Changing the DNA sequence of Promoter.
    iv.Changing the DNA sequence of Terminator.
        A. i,ii,iii,iv
        B.i.iii,iv
        C. i,iii
        D.i,ii,iii

    Ans: D

4) **What is the RBS called in prokaryotes and eukaryotes respectively?**

A. Kozak Consensus Sequence and Shine Dalgarno Sequence
B. Shine Dalgarno Sequence and Shine Dalgarno Sequence
C. Shine Dalgarno Sequence and Kozak Consensus Sequence
D. Kozak Consensus Sequence and Kozak Consensus Sequence

Ans: C

5) What does the AHL signal molecule bind to?

A. Receptor proteins
B. Promoter region
C. Transcription factors
D. Ribosome binding site

Ans: C

6) A promoter function is affected by

A. Promoter sequence
B. DNA sequence upstream to it
C. DNA sequence downstream to it
D. All of the above

Ans: D

7) Match the following:

Part	**Function**
1. Promoter	a. Initiate translation
2. Ribosome binding site	b. Encode for a protein
3. Operator	c. Initiate transcription
4. Protein coding sequence	d. Regulate transcription

A. 1-a 2-b 3-d 4-c
B. 1-c 2-a 3-d 4-b
C. 1-c 2-d 3-a 4-b
D. 1-a 2-c 3-d 4-b

Ans: B

8) **Genes from which of the following organisms can be used in light control devices?**
    A. *Saccharomyces cerevisiae*, also known as Baker's yeast
    B. Mammalian cells
    C. E. coli
    D. Cyanobacteria

    Ans: D

9) **The equations which govern the behaviour of predator-prey relations are used in —-?**
    A. Lottka-Volterra oscillators
    B. Repressilators
    C. Toggle switch
    D. Kill switch

    Ans: A

10) **What is GFP?**
    A. Enzyme
    B. Reporter gene
    C. Receptor protein
    D. Structural Protein

    Ans: B

11) **Which of the following uses coupling of protein generators?**
    A. Counter
    B. Edge detector
    C. Repressilator
    D. Both a and c

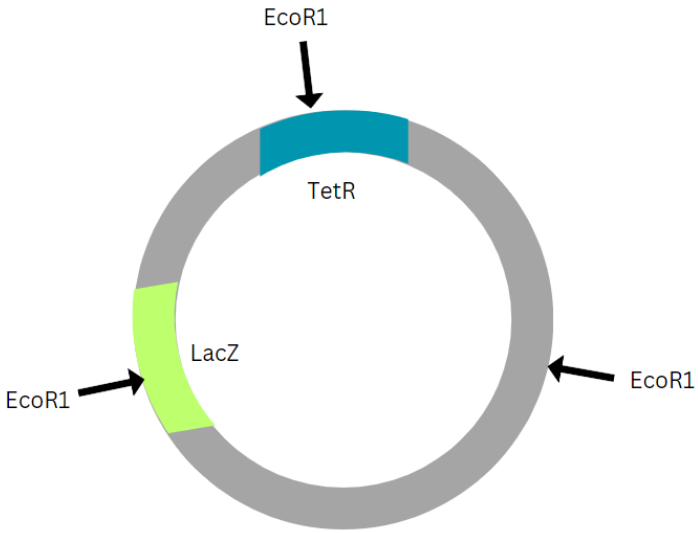
    Ans: D

Analytical:

1. **Which one of the following mRNA sequences will not give a valid amino acid sequence?**
    A. 5'AUGUAUUGUCAUGCCUAG3'
    B. 3'AGUGAAUGCGUAGCGA5'
    C. 5'AUGAGCUCCGAGUAA3'
    D. 3'AUGUGCUACGCAUAG5'

    Ans: D

2. **Reporters include enzymes which catalyse a reaction leading to a coloured or fluorescent product. One classic example is the enzyme β-galactosidase (also known as LacZ) which is the enzyme utilised in blue–white screening schemes for cloning. LacZ naturally catalyses the degradation of lactose into glucose plus galactose, but also hydrolyses galactose residues from a variety of chemical substrates. X-gal is used in blue-white screening for clones with recombinant DNA. β-galactosidase hydrolyes X-gal, forming a blue pigment in non-recombinant colonies. IPTG induces lacZ gene expression.**
The following vector is chosen for transformation into *E. coli*. It has 3 restriction sites for the restriction enzyme EcoR1 as shown in the figure below:



Hitesh, a clumsy student was given the task of culturing the transformed *E. coli* on tetracycline and X-gal + IPTG plates. He didn't follow the instructions carefully and ended up creating 3 different kinds of plates as shown below. He forgot to label the plates and hence needs your help in figuring out plate composition based on possible observations. He knows that exactly one insertion has happened.

Plate compostion	Possible observations
1.Tetracycline + X-gal and IPTG	a.Blue colonies only
2.Tetracycline	b.White colonies only
3. X-gal and IPTG	c.Both blue and white colonies
	d.No colonies

A. 1-ac 2-abcd 3-abc

B. 1-abcd 2-bc 3-abc

C. 1-abd 2-bd 3-ab

D. 1.abcd 2-bd 3-abc

Ans: D

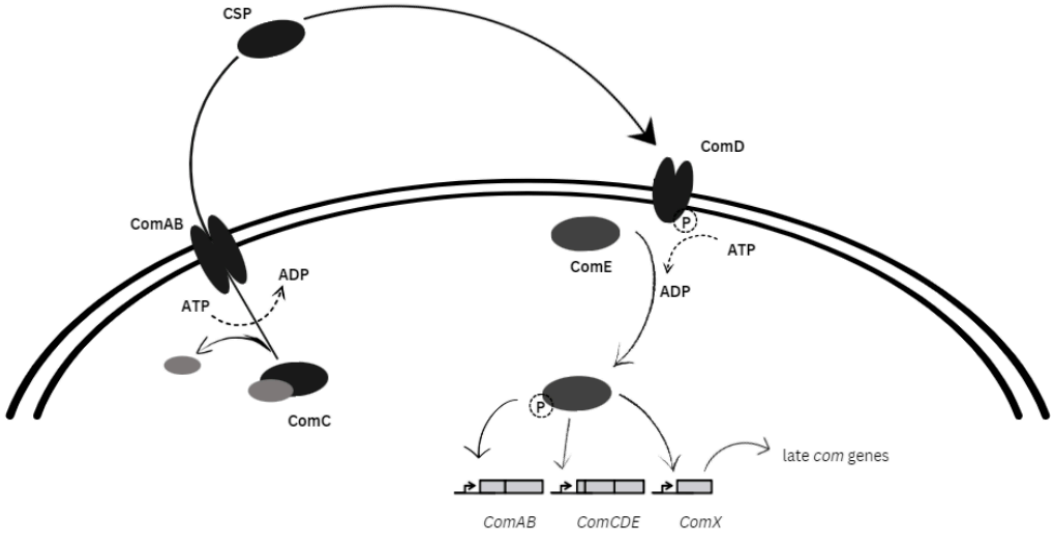
3. **This time Hitesh knows that he has cultured the transformed bacteria on Tetracycline + X-gal and IPTG plates, however, he doesn't know how many insertions have taken place. Match the following possible observations with the number of insertions.**

Number of insertions	**Possible observations**
1.Zero	**a.Blue colonies only**
2. Two	**b.White colonies only**
3.Three	**c.Both blue and white colonies**
	d.No colonies

A. 1-a 2-abd 3-d
B. 1-c 2-abd 3-b
C. 1-a 2-bd 3-d
D. 1-c 2-bd 3-d

Ans: C

4. **Competence refers to a bacterium's ability to uptake and incorporate exogenous DNA into its genome through genetic transformation. In naturally competent S. pneumoniae competence is not a constitutive property but is induced through a quorum-sensing mechanism in the presence of streptococcal donor DNA in the environment. A critical component of this process is Competence Stimulating Peptide (CSP), a self-induced signal that operates in a quorum-dependent manner as shown in the figure below**



Mutation in which of the genes in a particular bacteria will not lead to its incompetence?

A. ComAB
B. ComCDE
C. ComX
D. None of the above

Ans: A

5. Biosensors are analytical devices that detect biological molecules and convert their presence into measurable signals. Below is a biosensor devised to detect the presence of arabinose in the surroundings, with a list of the components used to build the genetic circuit.

	araC-p BAD	**Inducible promoter Positively regulated by arabinose Initiates transcription of reporter gene**
	constit utive promot er	**Always remains on Initiates transcription of araC gene**
	araC gene	**Regulator gene Codes for araC protein - regulatory protein- binds with arabinose to regulate araC-pBAD promoter**
	GFP	**Reporter gene**

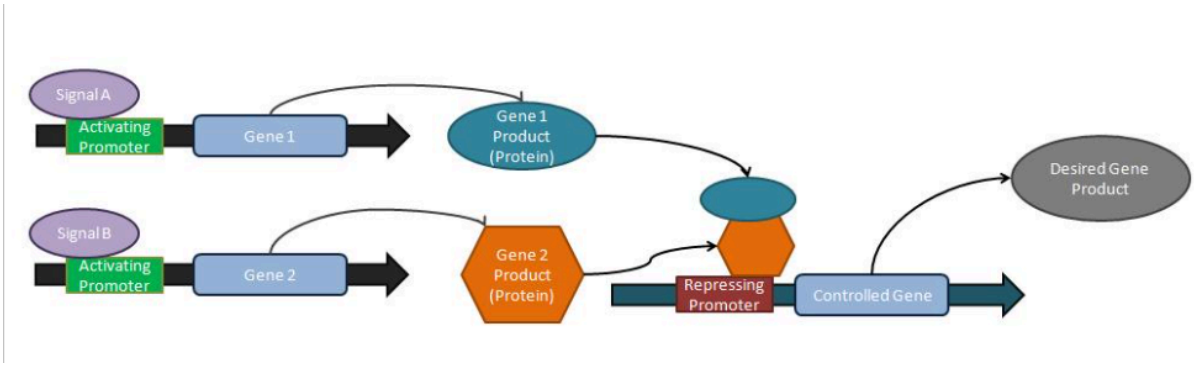
		Codes for green fluorescent protein

Match the components a,b,c,d with their position in the genetic circuit.

A. 1-a, 2-c, 3-b, 4-d
B. 1-b, 2-c, 3-a, 4-d
C. 1-a, 2-d, 3-b, 4-c
D. 1-c, 2-d, 3-b, 4-a

Ans: B

6. Identify which logic gate is being represented by the following schematic figure:



A. AND
B. NAND
C. OR
D. NOR

Correct answer: B

7. In the above scenario, if there is a mutation in Gene1 how would it affect the output product and logic gate?

A. It will now behave like a NOR gate.
B. It will not give any output.
C. It will give the same output regardless of input.
D. It will behave like an AND gate.

Correct answer: C

SECTION III

1) Why are designed systems preferred to non designed systems?

i. They are more reliable
ii. They are more specific and can be optimised
iii. They are cheaper to produce

A) Only i
B) Both ii and iii
C) Only i and ii
D) All of the above

Ans: D

2) Why is personalised medicine not suitable for synthetic biology devices?

A) Synthetic biology is not advanced enough for medicine
B) Synthetic biology cannot be used as each person will require a different device
C) Synthetic biology is not safe for medicinal purposes
D) Synthetic biology is only suitable for small scale purposes

Ans: B

3) Which of the following organisms are best suited for fermentation chambers?

A) Thermophilic
B) Thermophobic
C) Lyophilic
D) Lyophobic

Ans: A

4) Which of the following are necessary criteria for the application of Synthetic Biology?

A) Large and homogeneous application area
B) Constrained application to prevent contamination
C) Both A and B
D) None of the above

Ans: C

5) Which of the following statements are false?

A) Kill switches or fail safe mechanisms are vital to prevent consequences of accidental contamination
B) Synthetic biology are developed to be used not only in a laboratory environment, but also in industries
C) Insulin can be produced using synthetic devices

D) Blood glucose sensors can be used to sense not only glucose, but other molecules as well

Ans: D

6) What is the primary goal of bioremediation?

A) Accelerating chemical degradation through physical processes
B) Enhancing soil fertility through synthetic fertilisers
C) Harnessing biological organisms to mitigate and degrade pollutants
D) Implementing mechanical filtration to remove contaminants

Ans: C

7) What is not a potential frontier in synthetic biology?

A) Developing crops resistant to drought, high salinity, and high metal exposure for high-yield production of safe produce

B) Engineering microbial commensal organisms in farmland soil to reduce nutrient availability and cycling

C) Creating genetically modified crops with extended technology beyond current varieties

D) Both A and B

Ans: B

Analytical

i) Microbes, with their inherent functions like receptors and environmental sensing, can be repurposed for discerning health and disease states. *E. coli*, engineered to detect and eliminate cancer cells, uses invasin from Yersinia pseudotuberculosis controlled by various sensors. Cancer cell specificity is achieved through sensors, such as the *Vibrio fisheri* quorum-sensing circuit or hypoxia-responsive and arabinose-responsive promoters. Engineered bacteria successfully invaded cancer-derived cell lines, showcasing reprogrammed bacterial functions for therapeutics.

1) How is cancer cell specificity achieved in the engineered *E. coli*?

A) Through synthesising therapeutic proteins
B) By using invasin from Yersinia pseudotuberculosis
C) Via the *Vibrio fisheri* quorum-sensing circuit
D) By producing specific chemicals

Ans: C

2) Which statement accurately describes the role of the hypoxia-responsive promoter in the research?

A) It induces invasin expression in the absence of tumour cell environments.
B) It controls invasion by *E. coli* through external, researcher-inducible control.
C) It regulates invasin expression only in the presence of hypoxic conditions in tumours.
D) It enhances the environmental sensing capabilities of E. coli.

Ans: C

ii) Researchers have explored unconventional methods to program pattern formations, drawing inspiration from lithographic and printing techniques rather than developmental patterns. A notable achievement in synthetic biology involved constructing a bacterial strain capable of sensing red light and regulating gene expression. By incorporating a chimeric two-component photorhodopsin system from the cyanobacteria Synechocystis into E. coli, the engineered bacteria formed a photographic film. Projecting an image onto this bacterial lawn enabled the recording of a high-definition two-dimensional chemical image at resolutions up to 100 megapixels per square inch.

The potential applications of controlling pattern formation in living cells extend to constructing intricate biomaterial patterns, tissue engineering, and parallel biological computation. Synthetic biologists have further advanced this work, enabling massively parallel 'edge detection' of projected images. This involves cells communicating to distinguish and outline boundaries between regions sensing light and dark.

1) What is the primary achievement in synthetic biology mentioned in the passage?

A) Constructing a bacterial strain for biomaterial patterns
B) Projecting images onto bacterial lawns
C) Engineering a two-component photorhodopsin system
D) Initiating work as part of an international collaboration

Ans: B

2) How do synthetic biologists extend the capabilities of the engineered bacteria for 'edge detection'?

A) Sensing red light
B) Communicating to discriminate boundaries
C) Recording chemical images
D) Incorporating cyanobacteria into E. coli

Ans: B

SECTION IV

1. What is a major challenge in the field of synthetic biology regarding safety knowledge transfer?
a) Lack of regulatory guidance
b) Difficulty in synthesising DNA
c) Generational gap among practitioners
d) Overemphasis on microbiological safety

Ans: c) Generational gap among practitioners

2. Why is the entry of professionals from non-biological backgrounds into synthetic biology mentioned as a complicating factor?
a) They bring innovative perspectives
b) They lack experience in microbiological safety
c) They prioritise laboratory safety
d) They oppose regulatory guidance

Ans: b)They lack experience in microbiological safety

3. What is a concern associated with the release of synthesised organisms into the environment?
a) Their inability to survive outside the lab
b) Unexpected consequences on public health
c) Strict regulatory oversight
d) Limited interaction with naturally occurring substances

Ans: b) Unexpected consequences on public health

4. What distinguishes synthetic organisms from genetically modified organisms in terms of regulatory scrutiny?
a) Their use of synthetic DNA
b) Their bespoke functionality
c) Lack of unintended consequences
d) Exclusively laboratory-based existence

Ans: a) Their use of synthetic DNA

5. Why is there a need to consider the risks of synthetic organisms transferring genes into existing organisms?
a) To encourage genetic diversity

b) To alter the balance of the ecosystem
c) To prevent laboratory accidents
d) To enhance bespoke functionality

Ans: b) To alter the balance of the ecosystem

6. What is the primary concern regarding dual-use potential in synthetic biology?
a) Limited applications
b) Unintended consequences
c) Bioterrorism threat
d) Lack of public interest

Ans: c) Bioterrorism threat

7. Why do some experts caution against an excessive emphasis on bioterrorism in the synthetic biology debate?
a) Lack of tools and techniques
b) Narrowing the scope of the debate
c) Global cooperation
d) Overestimation of bioterrorism risks

Ans: b) Narrowing the scope of the debate

8. What is a key assumption in the debate on synthetic biology's security implications?
a) Amateur scientists can easily construct dangerous pathogens
b) Synthetic biology progress will be unlimited
c) State-level programs pose minimal threats
d) The field will eliminate all technical obstacles

Ans: c) State-level programs pose minimal threats

9. What is the potential emergence discussed in relation to synthetic biology?
a) Professional bio-weapon programs
b) A biohacker culture
c) Global cooperation in research
d) Bioterrorism alliances

Ans: b) A biohacker culture

10. Why is it crucial to involve diverse stakeholders in the public debate on synthetic biology?
a) To limit progress in the field
b) To ensure global domination
c) To explore and debate various perspectives

d) To create exclusive regulations

Ans: c) To explore and debate various perspectives