ULTIMATE KCET

CRASH COURSE 2026

Botany | Lecture - 01

Molecular basis of Inheritance

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Topics to be covered

1. SYNOPSIS - up to transcription
2. PYQs
3.
4.

Structure of Polynucleotide Chain

- **Bonds to Remember (NEET Favorite):**
  - **N-glycosidic linkage:** Base to Sugar. (1C)
  - **Phosphodiester bond:** Connects two nucleotides (3' - 5').
  - **Hydrogen Bonds:** Between bases (A=T has 2, G≡C has 3).

For example, a bacteriophage known as [redacted] ×174 has 5386 nucleotides, Bacteriophage lambda has 48502 base pairs (bp), Escherichia coli has 4.6×10^6 bp, and haploid content of human DNA is 3.3×10^9 bp. $2n = 6.6 \times 10^9$ bp

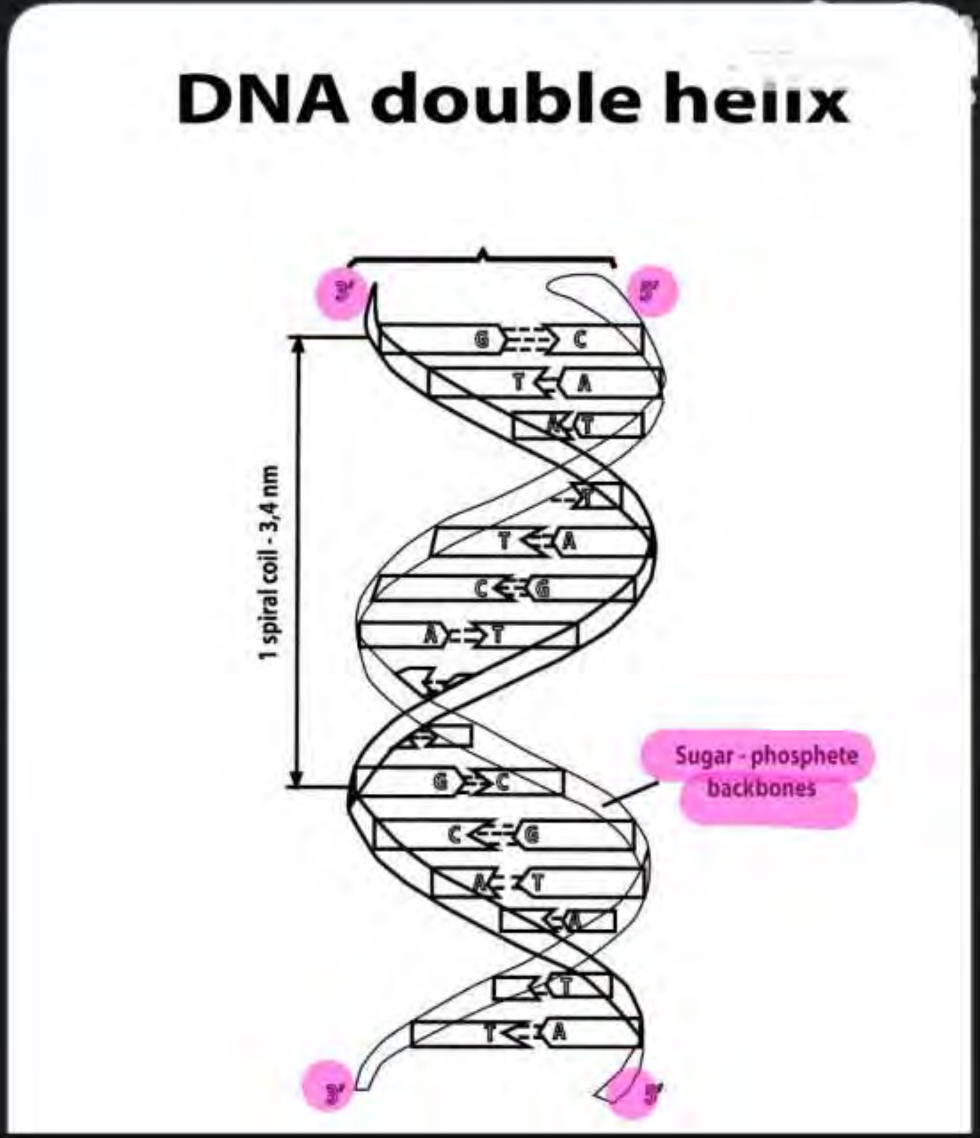
nucleotide

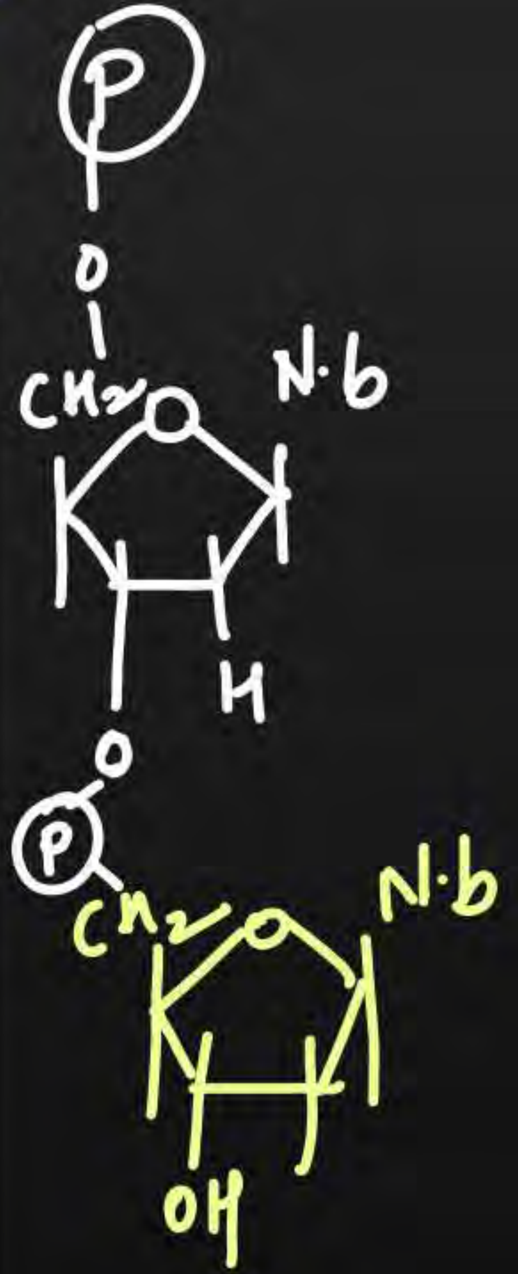
The Components: Pentose Sugar + Nitrogenous Base + Phosphate group.

purine pairs with pyrimidine

- **Chargaff's Rule:** For double-stranded DNA,

amt. $[A+G] = [T+C]$ or $\frac{A+G}{T+C} = 1.$





Structure of Polynucleotide Chain

Franklin, Wilkins
Watson & Crick.

X-ray
Crystallography

salient features of the Double-helix structure of DNA are as follows:

(i) It is made of two polynucleotide chains, where the backbone is constituted by sugar-phosphate, and the bases project inside.

(ii) The two chains have anti-parallel polarity. It means, if one chain has the polarity 5' 3', the other has 3' 5'.

(iii) The bases in two strands are paired through hydrogen bond (H-bonds) forming base pairs (bp). Adenine forms two hydrogen bonds with Thymine from opposite strand and vice-versa. Similarly, Guanine is bonded with Cytosine with three H-bonds. As a result, always a purine comes opposite to a pyrimidine. This generates approximately uniform distance between the two strands of the helix

34Å (iv) The two chains are coiled in a right-handed fashion. The pitch of the helix is 3.4 nm (a nanometre is one billionth of a metre, that is 10-9 m) and there are roughly 10 bp in each turn. Consequently, the distance between a bp in a helix is approximately 0.34 nm.

3.4Å

(v) The plane of one base pair stacks over the other in double helix.

This, in addition to H-bonds, confers stability of the helical structure

[redacted]: Packaging of DNA Helix

2m

- **The Problem:** 2.2 meters of DNA must fit into a $6\mu m$ nucleus.
- **The Solution: Nucleosomes.**
  - **Histone Octamer:** 2 copies each of H2A, H2B, H3, and H4.
  - **Charge:** DNA is negative (phosphate); Histones are positive (rich in Lysine and Arginine).
  - **H1 Histone:** Acts as a "linker" or "plug."

nucleosome?

- **Chromatin:** "Beads-on-a-string" structure.
  - **Euchromatin:** Loosely packed, transcriptionally active.
  - **Heterochromatin:** Densely packed, inactive.

200bp?

1 not part of octamer

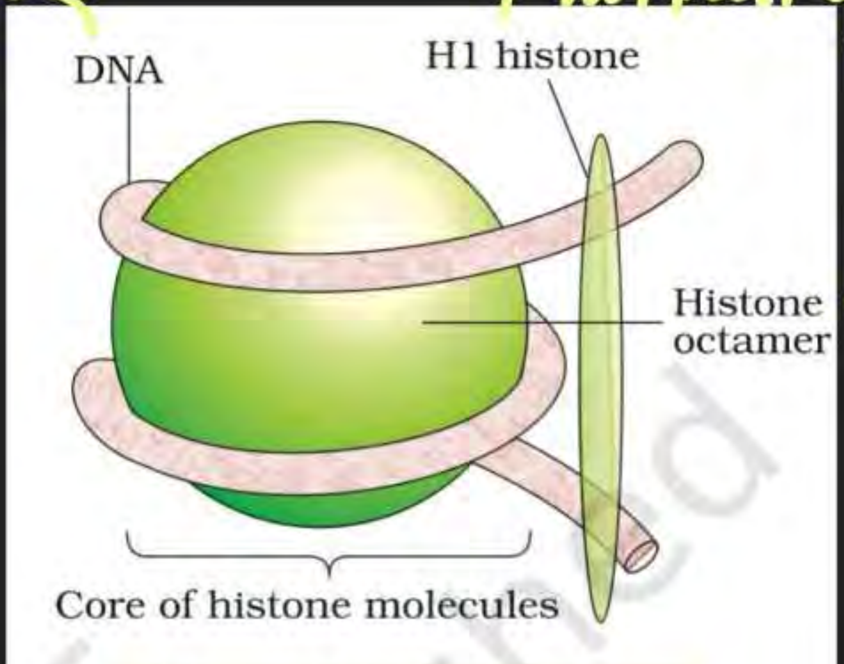


Figure 5.4a Nucleosome

2x H_2A
2x H_2B
2x H_3
2x H_4

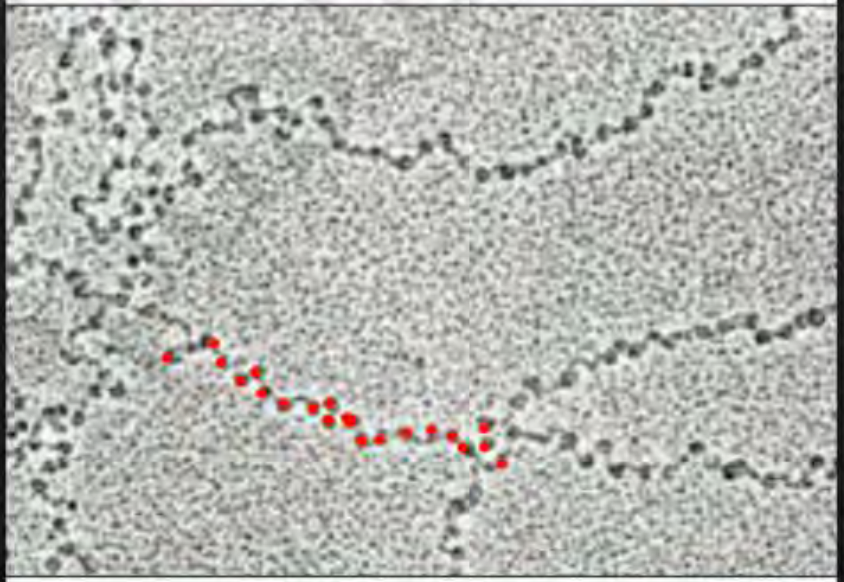


Figure 5.4b EM picture - 'Beads-on-String'

pro-region
{
nucleoid.

Length of DNA / RNA = no. of bps × dist. b/w two bps

OR

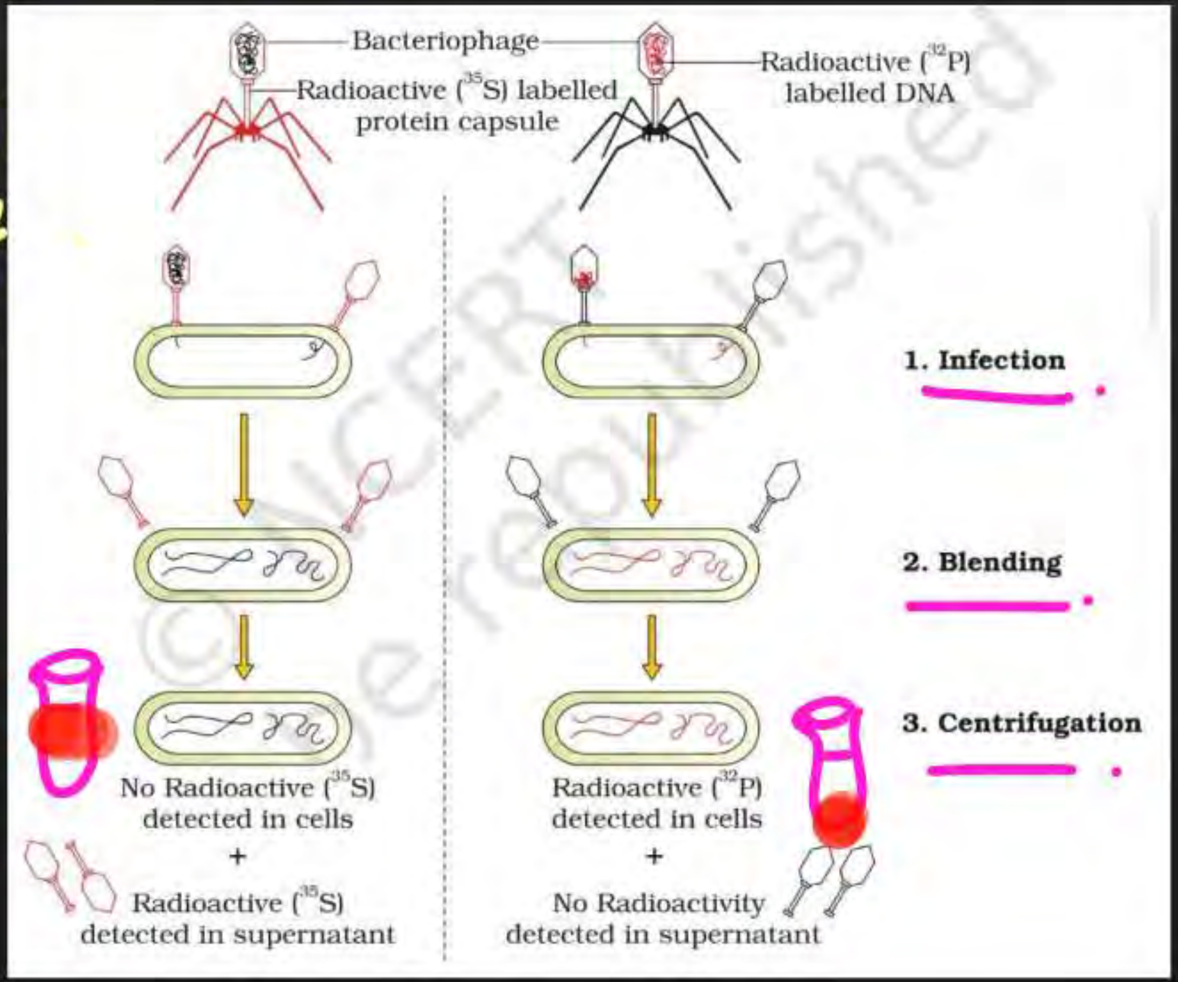
Length of nucleicacids = no. of bps × 0.34×10^{-9}

Slide 4: Search for Genetic Material (The Experiments)

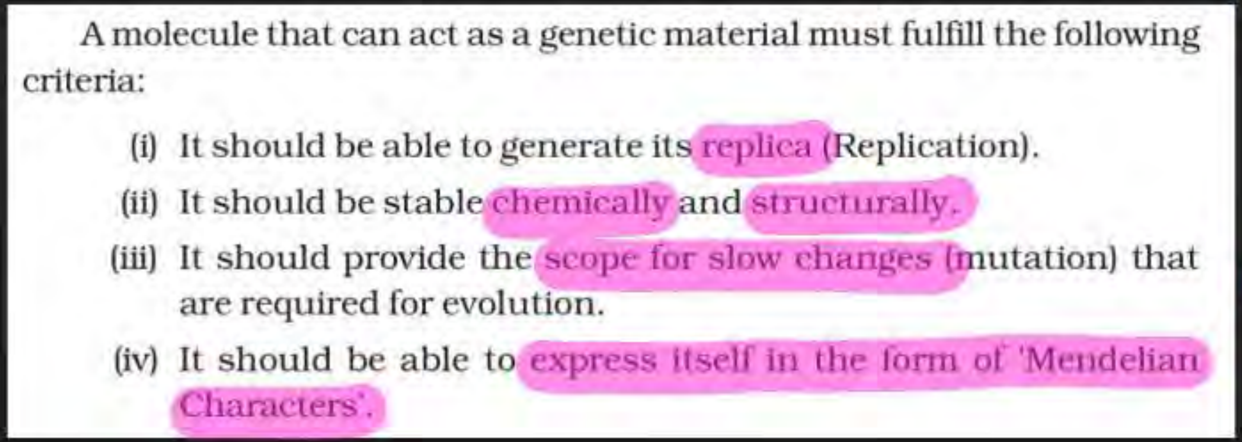
→ heat killed S + live R → mice → dies

heat killed S + R strain
+ DNase → mice → lives

- Griffith (1928): Transforming Principle (S-strain and R-strain Streptococcus). → Avery, Mcleod McCarty
  - **Avery, MacLeod, McCarty:** Proved the "principle" was DNA using DNase, RNase, and Proteases.
- **Hershey and Chase (1952):** Unequivocal proof using Bacteriophages. (viruses)
  - ^{32}P labeled **DNA**.
  - ^{35}S labeled **Protein**.
  - **Result:** Radioactivity found in the cell (pellet) only with ^{32}P.



RNA v/s DNA



A molecule that can act as a genetic material must fulfill the following criteria:

- (i) It should be able to generate its replica (Replication).
- (ii) It should be stable chemically and structurally.
- (iii) It should provide the scope for slow changes (mutation) that are required for evolution.
- (iv) It should be able to express itself in the form of 'Mendelian Characters'.

DNA → RNA → protein

DNA is Stable

- DNA that the two strands being complementary if separated by heating come together, when appropriate conditions are provided. Further, 2'-OH group present at every nucleotide in RNA is a reactive group and makes RNA labile and easily degradable. RNA is also now known to be catalytic, hence reactive.

- Therefore, DNA chemically is less reactive and structurally more stable when compared to RNA. Therefore, among the two nucleic acids, the DNA is a better genetic material.

- In fact, the presence of thymine at the place of uracil also confers additional stability to DNA. Both DNA and RNA are able to mutate. In fact, RNA being unstable,mutate at a faster rate. Consequently, viruses having RNA genome and having shorter life span mutate and evolve faster.

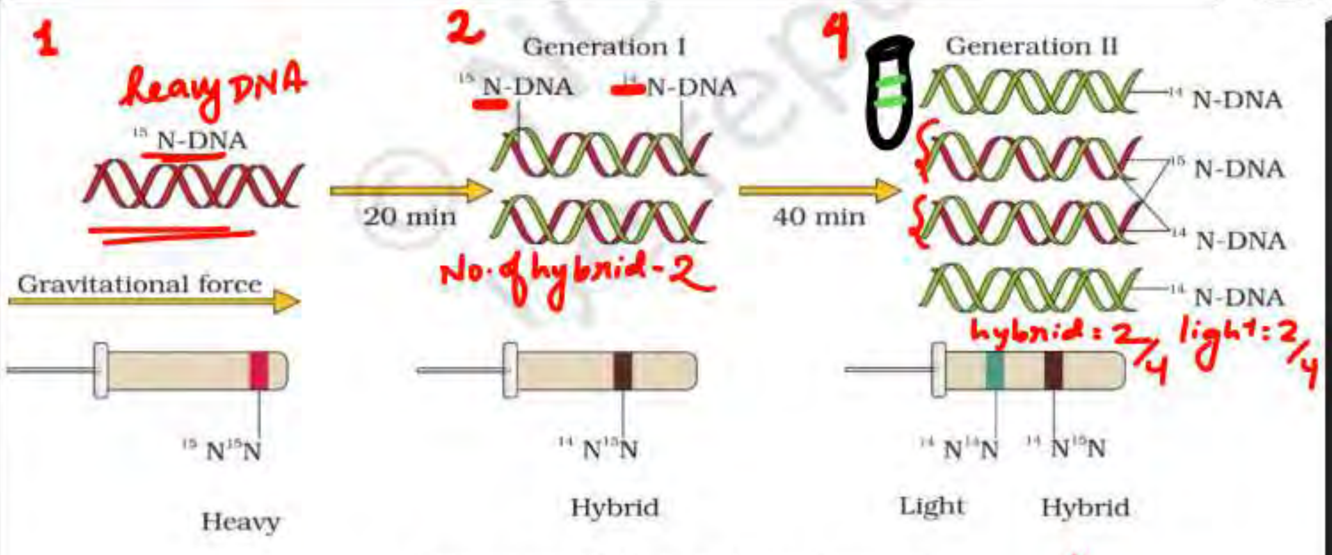
- RNA can directly code for the synthesis of proteins, hence can easily express the characters. DNA, however, is dependent on RNA for synthesis of proteins. The protein synthesising machinery has evolved around RNA. The above discussion indicate that both RNA and DNA can function as genetic material, but DNA being more stable is preferred for storage of genetic information. For the transmission of genetic information, RNA is better.

RNA was the first genetic material. There is now enough evidence to suggest that essential life processes (such as metabolism, translation, splicing, etc.), evolved around RNA. RNA used to act as a genetic material as well as a catalyst (there are some important biochemical reactions in living systems that are catalysed by RNA catalysts and not by protein enzymes). But, RNA being a catalyst was reactive and hence unstable. Therefore, DNA has evolved from RNA with chemical modifications that make it more stable. DNA being double stranded and having complementary strand further resists changes by evolving a process of repair.

[redacted]C: DNA Replication

→ eu - nucleus
→ pro - cytoplasm.

- Scheme: Semi-conservative (Watson & Crick).
- **Experimental Proof: Meselson and Stahl (1958)** using $E.coli$ and heavy nitrogen (^{15}N).
  - Centrifugation: CsCl density gradient.
- **The Machinery:**
  - **Helicase:** Unwinds the DNA.
  - **DNA Polymerase:** Synthesizes DNA in 5' → 3' direction only.
  - **Leading Strand:** Continuous synthesis.
  - **Lagging Strand:** Discontinuous (Okazaki fragments), joined by **DNA Ligase**.



(Separation of DNA by Centrifugation)

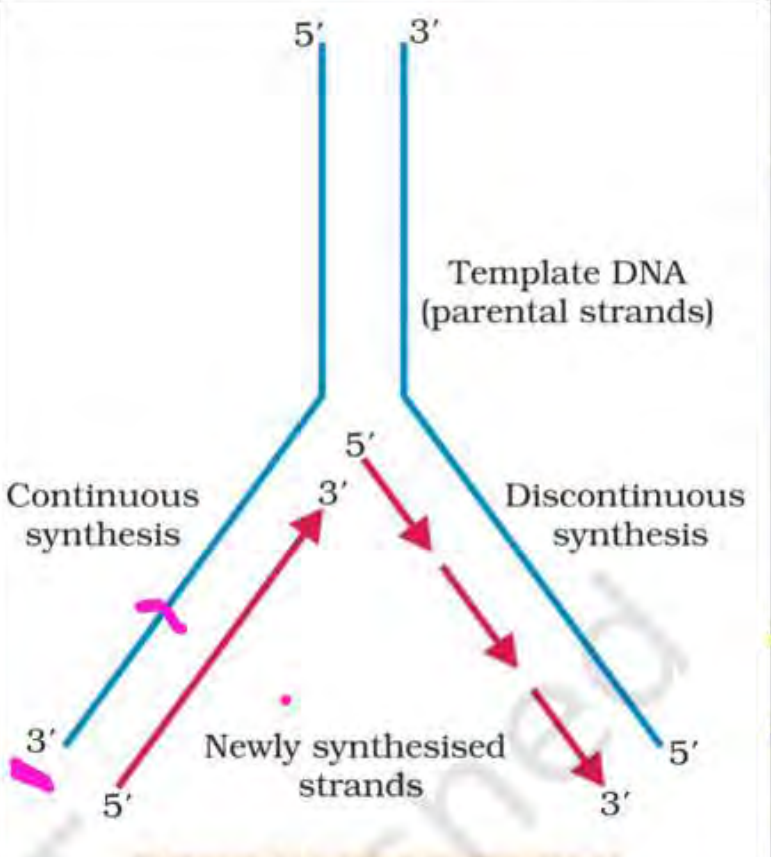
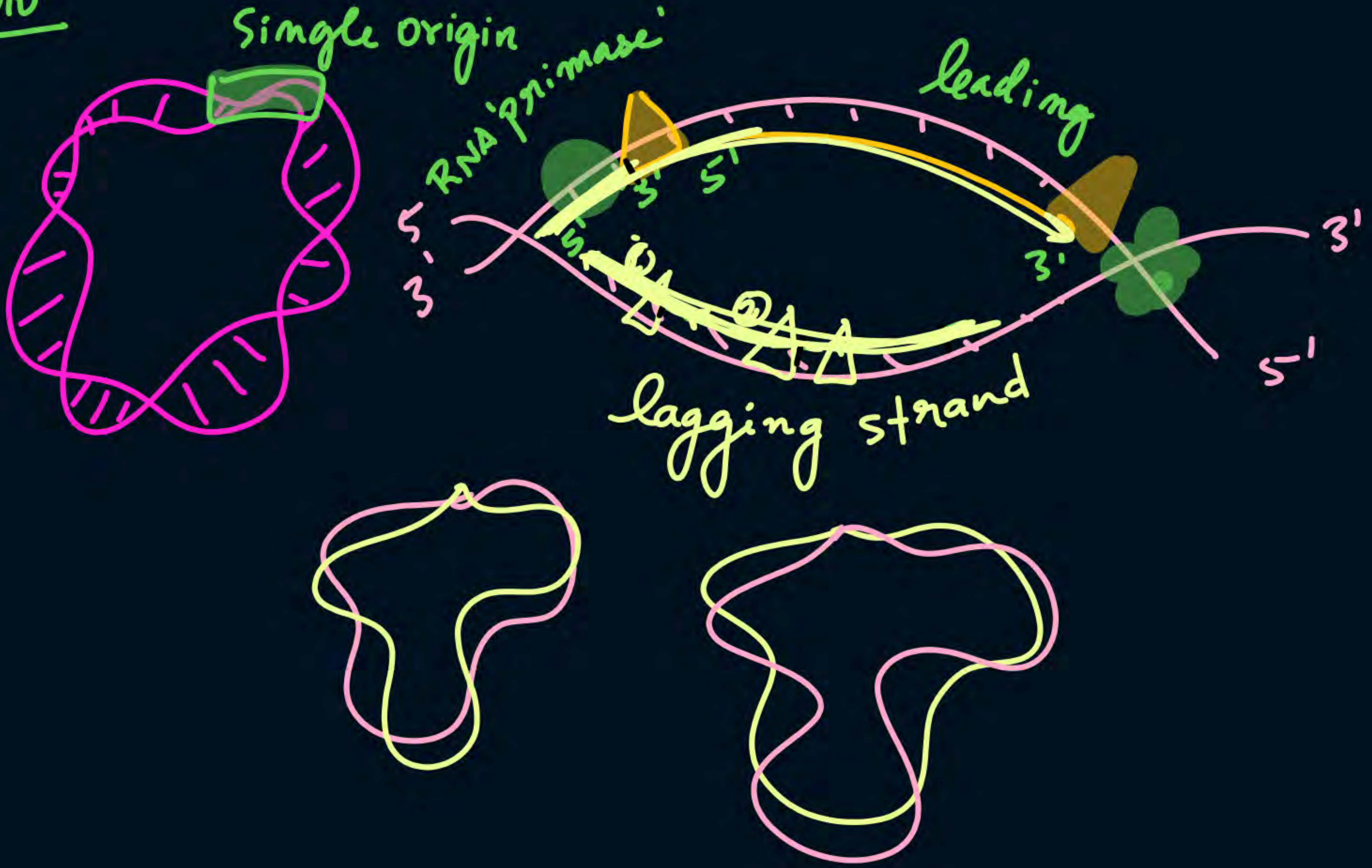


Figure 5.8 Replicating Fork

60 mins.
Total helix = 8
heavy = 0/8
hybrid = 2/8
light = 6/8

80 mins
Total helix = 16
heavy = 0/16
hybrid = 2/16
light = 14/16

प्रो

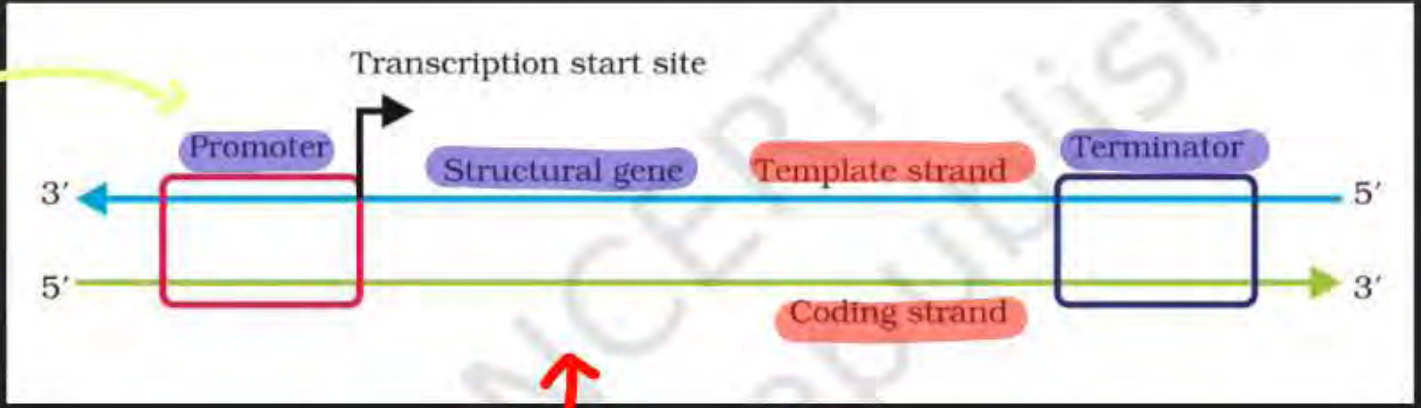

Single origin
RNA 'primase'
leading
5'
3'
3'
5'
5'
3'
3'
5'
lagging strand

Slide 6: Transcription (The Central Dogma)

eu-nucleus; pro. cytoplasm.

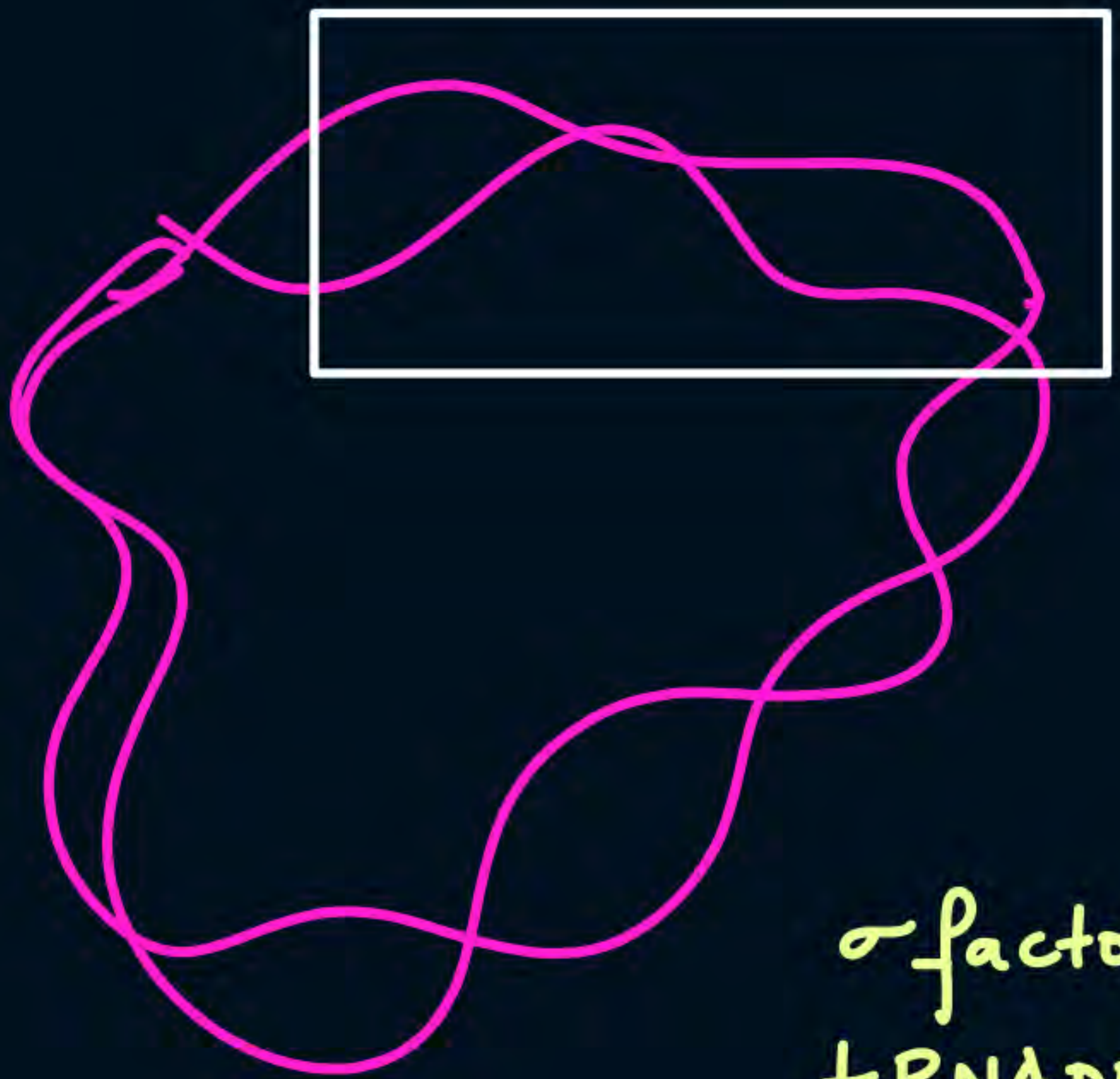
- **Transcription Unit:** Promoter, Structural Gene, Terminator.
- **Strands:**
    - **Template Strand:** 3' → 5' (Read by RNA Pol).
    - **Coding Strand:** 5' → 3' (Matches the mRNA sequence except T is replaced by U).
- **Post-Transcriptional Modifications (Eukaryotes):**
    1. **Splicing:** Removal of Introns (non-coding), joining of Exons.
    2. **Capping:** Methyl guanosine triphosphate at 5' end.
    3. **Tailing:** Adenylate residues (Poly-A tail) at 3' end.

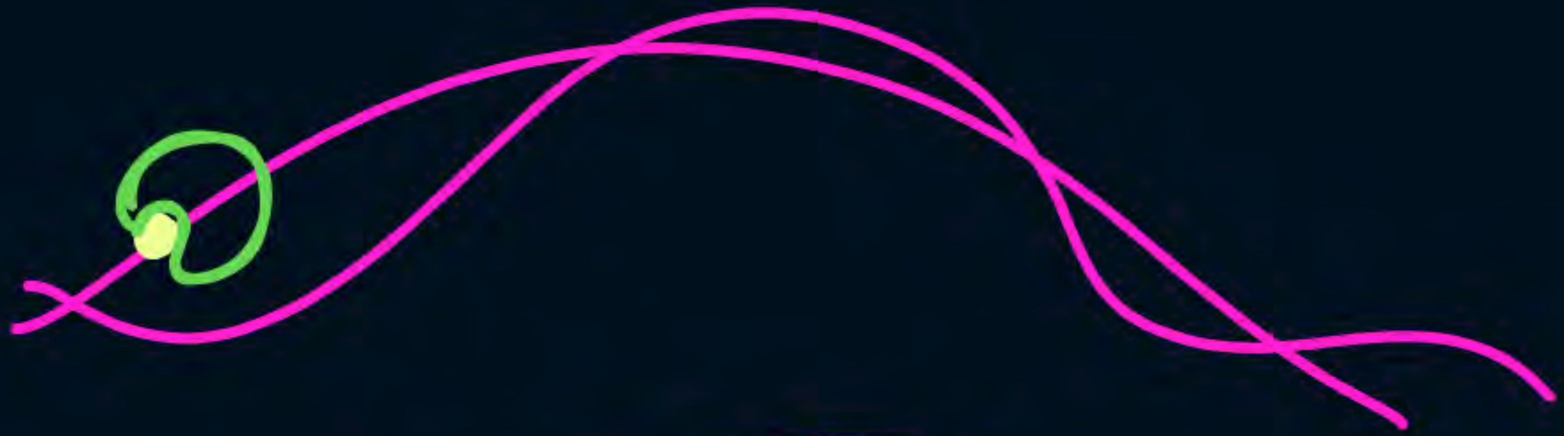
RNA pol



promoter: 5' (upstream) of coding

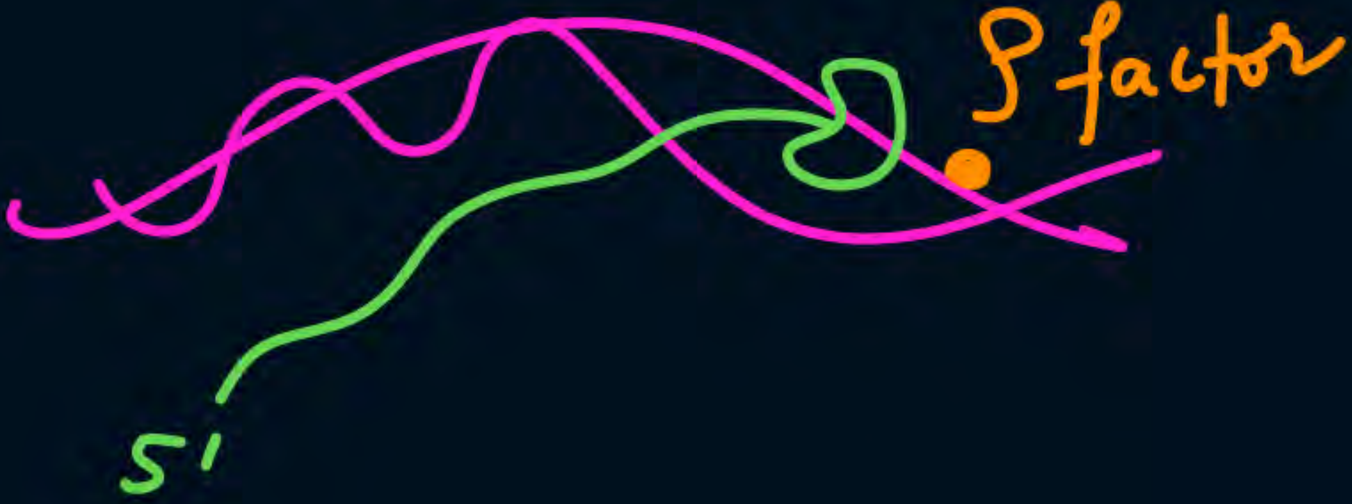
Terminator. 3' (downstream) of coding.





σ factor
+ RNA pol = holoenzyme

active



Pro Transcription

- Single RNA pol
- cytoplasm

Eu Transcript^n.

- RNA pol I - 18s rRNA, 28s rRNA
  5.8s rRNA
  RNA pol II - mRNA/hnRNA/
  RNA pol III - tRNA
  snRNA
  5S rRNA
- nucleus.

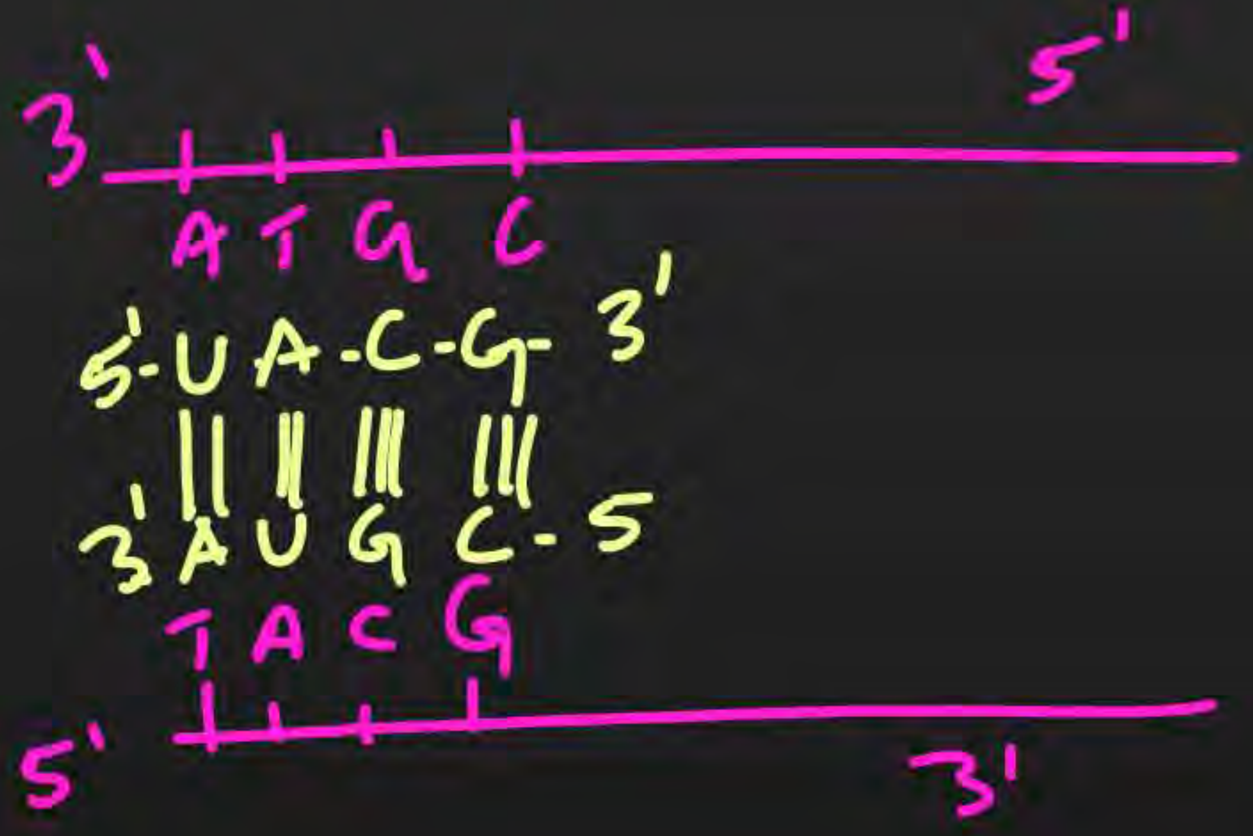
1° transcript

1. Prevention of Coding Conflicts

- If **both strands** acted as templates → would produce **RNA molecules with different sequences**
- **Complementarity ≠ Identical sequences**
- Result: One DNA segment would code for **two different proteins**
- This would **complicate the genetic information transfer machinery**

2. Prevention of Double-Stranded RNA Formation

- If two RNA molecules were produced **simultaneously** from both strands:
  - They would be **complementary to each other**
  - Would form **double-stranded RNA (dsRNA)**
- **Problem with dsRNA:**
  - Prevents RNA from being **translated into protein**
  - Makes transcription a **futile exercise**



Question

The sequence of events mentioned below are symbolised by alphabets. Choose the correct answer where the alphabets are matched with the processes.

Reverse Central Dogma
Retroviruses

$$\text{RNA} \xrightarrow{Ⓐ} \text{DNA} \xrightarrow{Ⓑ} \text{DNA} \xrightarrow{Ⓒ} \overset{\text{rRNA}}{\underset{\text{tRNA}}{m\text{RNA}}} \xrightarrow{Ⓓ} \text{Polypeptide}$$

A A= Replication, B= Transformation, C= Transcription, D= Translation

[✓ **B** A= Reverse transcription, B= Replication, C = Transcription, D= Translation]

C A= Replication, B= Transcription, C = Translation, D= Transduction

D A= Reverse transcription, B= Translation, C= Transcription, D= Replication

Question

When DNA replication starts

- **A** the phosphodiester bonds between the adjacent nucleotides break. ✗
- **B** the bonds between the nitrogen base and deoxyribose sugar break. ✗
- **C** the leading strand produces Okazaki fragments. ✗
- **D** the hydrogen bonds between the nucleotides of two strands break ✓ → DNA helicase

Question

Ribose sugar is present in

- A RNA polymerase and ATP
- B RNA and ATP deoxyribose
- C RNA polymerase, RNA and ATP
- [✓ D] RNA only

Question

Compare the statements A and B .

Statement A : RNA produced during transcription in eukaryotic cells cannot be straight away used in ~~photosynthesis~~. translation. ✓

Statement B : RNA splicing phenomena helps in the removal of exons. ✗

Choose the correct description.

A Both the statements A and B are wrong.

B Both the statements A and B are correct.

C Statement A is correct and B is wrong. ✓

D Statement A is wrong and B is correct.

Question

Tem. strand

$3'$ AAA TGC GCG ATA $5'$ is the sequence of nucleotides on a gene; after transcription the *m* RNA formed against it and the sequence of bases in the corresponding binding anticodons will be

↳ on tRNA

Coding strand = mRNA
'T' U
$5' \rightarrow 3'$ $5' \rightarrow 3'$

✓ ✓

A $5'$ UUU ACG CGC UAU $3'$ and $3'$ AAA-UGC-GCG-AUA $5'$

$3'$ AAA UGC GCG AUA $5'$

B $5'$ UAU CGC GCA UUU $3'$ and $3'$ AUA-GCG-CGU-AAA $5'$

C $5'$ UUU ACC TUG UAU $3'$ and $3'$ AAA-UGG-UAC-AUA $5'$

D $5'$ UAU GUT CCA UUU $3'$ and $3'$ AUA-CAU-GGU-AAA $5'$

Question

The most unstable RNA is

- A messenger RNA
- B soluble RNA
- C ribosomal RNA - ribosome - Catalytic
- D heterogeneous nuclear RNA.

Question

Read the statements A and B and select the correct option.

Statement A: Synthesis of m RNA takes place in $5' - 3'$ direction. ✓

Statement B : Reading of m RNA is always in 3'-5' direction. ✗

↳ by ribosome during translat^{n}.

A Both the statements are incorrect

B Statement A is incorrect, B is correct

[✓ **C**] Statement B is incorrect, A is correct

D Both the statements A and B are correct

Question

The sequence of nitrogenous bases in one strand of DNA are 3′ TAC GCG ACG 5′. The complementary DNA strand should have

5′ ATG CGCTGC 3′

- **A** 5′ AUG CGC TGC 3′ ✗
- **B** 3′ ATG CGC TGC 5′
- **C** 5′ UAC GCG ACG 3′ ✗
- **D** 5′ ATG CGC TGC 3′ ✓

Question

The result of which of the following reaction experiments carried out by Avery et. al. on Streptococcus pneumoniae has proved conclusively that DNA is the genetic material?

- A Live 'R' strain + DNA from ' S ' strain + RNAase
- B [✓ Live 'R' strain + DNA from 'S' strain + DNAase] ⇒ mice → lives
- C Live 'R' strain + Denatured DNA of 'S' strain + protease
- D Heat killed 'R' strain + DNA from 'S' strain + DNAase

Question

RNA polymerase-I transcribes eukaryotic ribosome which does not consist of

- A 5.8 SrRNA
- B 28 SrRNA
- C 18 SrRNA
- D 5$SrRNA$ ✓ - III

Question

In a 3.2 Kbp long piece of DNA, 820 adenine bases were found. What would be the number of cytosine bases?

- **A** 780 ✓
- **B** 1560
- **C** 740
- **D** 1480

1K = 1000

3200 bp

820 A = 820 T

C = ?

A+T = 1640

$$\begin{array}{r} 3200 \\ -1640 \\ \hline 1560 \end{array}$$

$1560/2 = 780$

780 G ≡ 780 C

Question

E. coli bacteria grew in 15NH4Cl medium for several generations are allowed to grow in "NH4Cl medium. After 2 generations, the bacteria are isolated from the medium and DNA of bacteria centrifuged in CsCl. The result of the density gradient of DNA is

40 mins.

A only hybrid DNA - after 1st generation

B both hybrid and heavy DNA

C both heavy and light DNA

[✓ **D**] both hybrid and light DNA

Thank

You