

6. Nucleic acids and protein synthesis

1.

Which row is correct for the replication of a DNA molecule?

	direction of DNA synthesis	enzyme that adds complementary nucleotides to lagging strand
A	3' to 5'	DNA polymerase
B	3' to 5'	DNA ligase
C	5' to 3'	DNA polymerase
D	5' to 3'	DNA ligase

Ans: C

2.

Bacterial cells with DNA containing only the 'heavy' isotope of nitrogen (^{15}N) are allowed to reproduce for three generations in a culture medium containing the normal isotope of nitrogen (^{14}N).

Which percentage of the DNA molecules produced contain strands with the heavy isotope of nitrogen?

	first generation %	second generation %	third generation %
A	50	25	12.5
B	75	50	25
C	100	50	25
D	100	75	50

Ans: C

3.

A bacterial circular DNA molecule is 2 600 150 base pairs long. 26% of the bases are adenine.

How many cytosine bases would be in the DNA molecule?

A 624 036 **B** 676 039 **C** 1 248 072 **D** 1 352 078

Ans: C

on 1 strand = 2600150

both strands = 5200300

$$A = T = \frac{26}{100} \times 5200300 = 1352078$$

$$C = G = \frac{5200300 - 1352078 \times 2}{2} = 1248072$$

4.

Which statement describes the structure of ATP?

- A** It is a DNA nucleotide with two extra phosphates.
- B** It is a DNA nucleotide with three extra phosphates.
- C** It is an RNA nucleotide with two extra phosphates.
- D** It is an RNA nucleotide with three extra phosphates.

Ans: C

5.

Rifampicin is an antibiotic used to treat tuberculosis.

It works by inhibiting RNA polymerase in bacteria.

Which processes are directly inhibited by this antibiotic?

- 1 DNA replication
- 2 enzyme synthesis
- 3 ATP synthesis

- A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 only

Ans: D

6.

Which statement about the transcription and translation of a gene is correct?

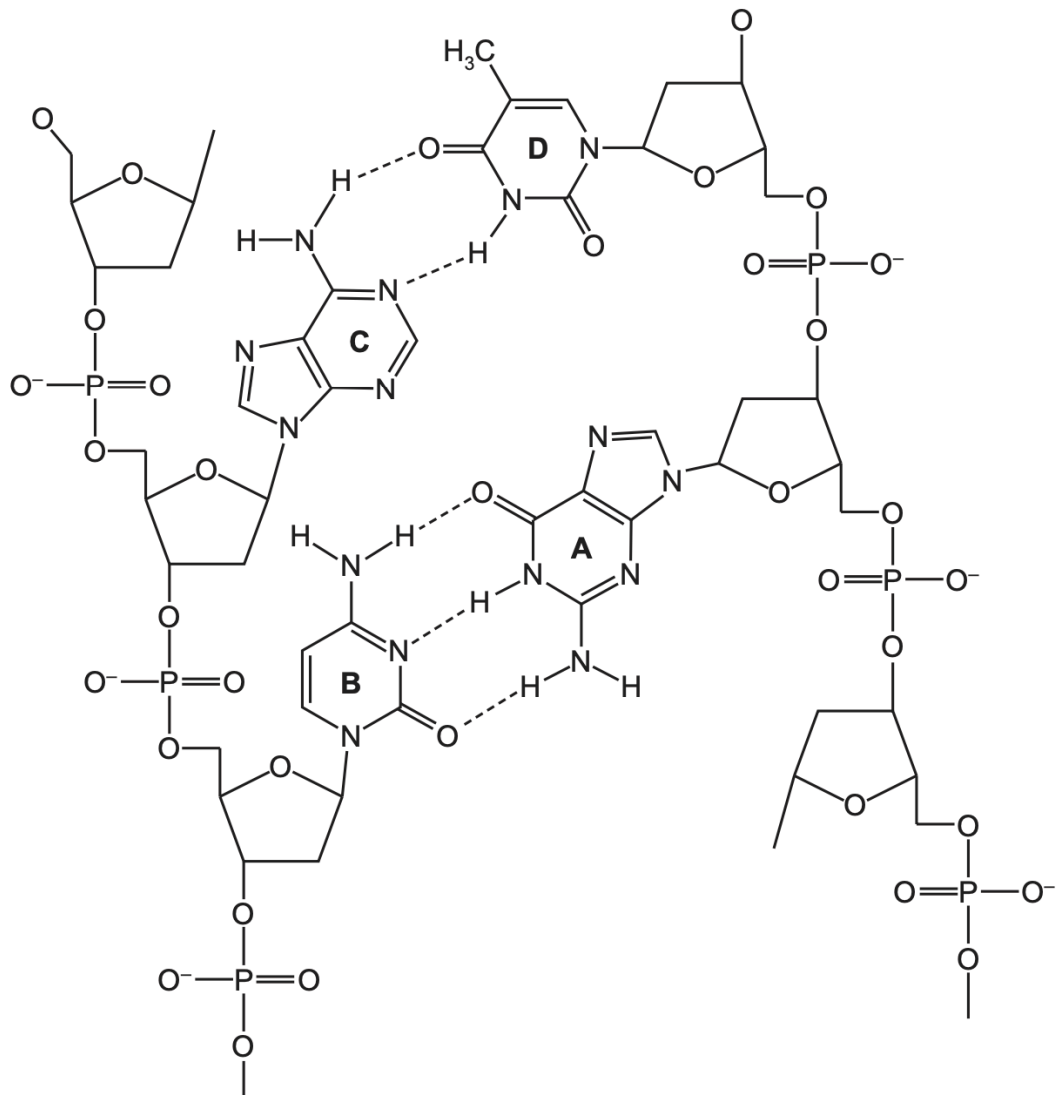
- A** The non-transcribed strand of DNA has a base sequence that is identical to the mRNA produced in transcription.
- B** The template strand of DNA has a base sequence that is identical to the mRNA produced in transcription.
- C** The non-transcribed strand of DNA has a base sequence that is complementary to the tRNA molecules required in translation.
- D** The template strand of DNA has a base sequence that is complementary to the tRNA molecules required in translation.

Ans: C

- A is false since DNA and mRNA coding cannot be identical due to U and T
- B is false since template strand is complementary to mRNA NOT identical
- D is false since template strand is complementary to mRNA, which is in turn complementary to tRNA
- C is true since non-transcribed strand is complementary to transcribed strand, which is complementary to mRNA, which is complementary to tRNA

7.

The diagram shows part of a DNA molecule.



Which label is correct?

- A** adenine
- B** guanine
- C** cytosine
- D** thymine

Ans: D

- C & D are A-T since 2 hydrogen bonds; A & B are C-G since 3 hydrogen bonds
- D and B are pyrimidines due to single ring; C and A are purines
- Hence A = guanine, B = cytosine, C = adenine, D = thymine

8.

The *Pdx1* protein is found in a wide range of animal species where it is regarded as essential for normal metabolism. In sand rats, the gene coding for the *Pdx1* protein has a much lower proportion of A and T nucleotides than *Pdx1* genes from other animals.

Finding the complete DNA sequence of the *Pdx1* gene in sand rats has been difficult. Sequencing involves splitting off nucleotides one at a time from single-stranded DNA.

What could account for the difficulty in finding the DNA sequence of the *Pdx1* gene in sand rats?

- 1 The *Pdx1* gene is present in only a small proportion of nuclei.
- 2 The *Pdx1* gene is transcribed in only some cells.
- 3 The strength of the hydrogen bonding between the two strands of the *Pdx1* gene is unusually high.

A 1, 2 and 3 **B** 1 only **C** 2 only **D** 3 only

Ans: D

9.

Different tissues in a plant were supplied with a radioactively labelled substance to identify which tissues were actively synthesising mRNA.

Which radioactively labelled substances would be suitable for this experiment?

- 1 adenine
- 2 uracil
- 3 inorganic phosphate
- 4 ribose

A 1, 2, 3 and 4
B 1, 2 and 3 only
C 2 and 4 only
D 4 only

Ans: C

10.

Which structures are involved in transcription only?

	DNA template strand	anticodons	RNA polymerase	
A	✓	✓	x	key ✓ = involved x = not involved
B	✓	x	✓	
C	x	✓	x	
D	x	x	✓	

Ans: B

11.

The table shows some mRNA codons that code for certain amino acids.

mRNA codon	amino acid
GCG, GCA, GCC, GCU	alanine
ACG, ACA, ACC, ACU	threonine
UGC, UGU	cysteine
UAC, UAU	tyrosine
CAG, CAA	glutamine
CGG, CGA, CGC, CGU	arginine

A DNA template strand has the base sequence shown.

ACAGTATTATTTGCAACG

What would the change in the amino acid be if the first base in the fifth DNA triplet was substituted for an A base?

- A** alanine to cysteine
- B** alanine to threonine
- C** arginine to cysteine
- D** arginine to threonine

Ans: C

- NOTE: The table gives mRNA codon while the base sequence is from DNA template strand!!
- These must be complementary
- Thus CGU becomes UGU

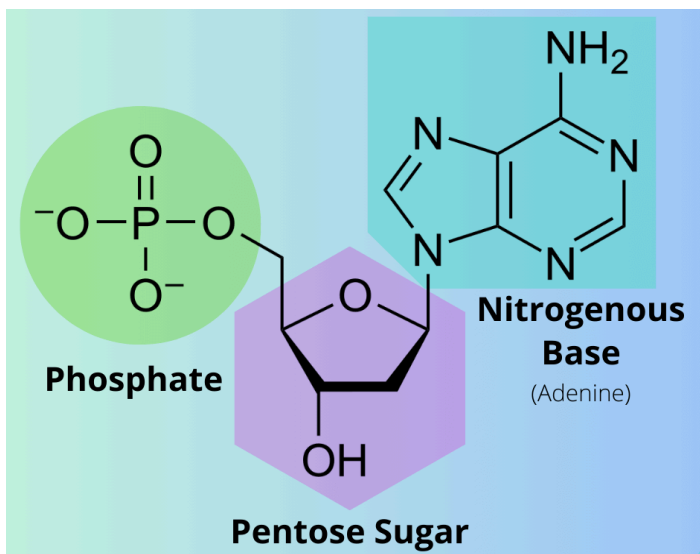
12.

Which statements are correct for **all** nucleotides?

- 1 The nitrogen-containing base is always attached to carbon atom 1 of the pentose.
- 2 The phosphate group is always attached to carbon atom 5 of the pentose.
- 3 A condensation reaction occurs to join the nitrogen-containing base to the pentose.
- 4 Nucleotides are linked together by condensation reactions between phosphate groups.

A 1, 2 and 3 **B** 1 and 2 only **C** 1, 3 and 4 **D** 2, 3 and 4

Ans: A



- Nitrogenous base is attached to 1st carbon (1')
- Phosphate is attached to 5th carbon (5')
- Nucleotides are linked together by phosphodiester linkage between 5' and 3' carbon atoms of pentose sugar.
- Nitrogen-containing base is joined to pentose by condensation reaction

13.

How many phosphodiester bonds are present in a circular DNA molecule of 2700 base pairs?

A 2699 **B** 2700 **C** 5398 **D** 5400

Ans: D

NOTE: in circular molecule, you don't need to subtract one bond!

14.

Which statements about complementary base pairing are correct?

- 1 Purines and pyrimidines are different sizes.
- 2 Complementary base pairing occurs during translation.
- 3 The base pairs are of different lengths.
- 4 Uracil forms two hydrogen bonds with adenine.

A 1, 2 and 3 **B** 1, 2 and 4 **C** 1, 3 and 4 **D** 2, 3 and 4

Ans: B

15.

During the mitotic cell cycle, the chromosomal DNA is replicated. The specific points in DNA molecules where replication is occurring are known as replication forks.

A typical human chromosome has about 150 million base pairs of DNA. It takes about 1 hour to replicate the DNA of a typical human chromosome.

The rate of replication using a single replication fork is approximately 50 base pairs per second.

Approximately how many replication forks must occur in a typical human chromosome during DNA replication?

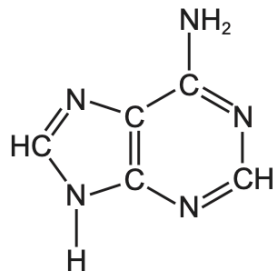
A 835 **B** 41 700 **C** 50 000 **D** 3 000 000

Ans: A

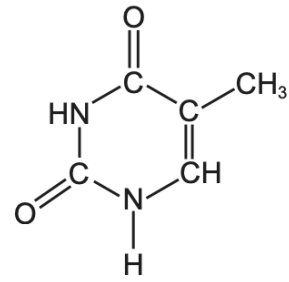
- 1 sec = 50 base pairs
- 3600 sec = 180000 base pairs
- Number of forks = $(150 \times 10^6) / 180000 = 833 = 835$

16.

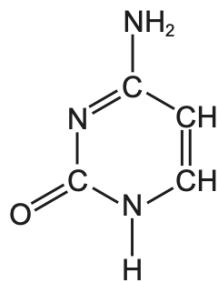
The diagrams show the chemical structure of four bases.



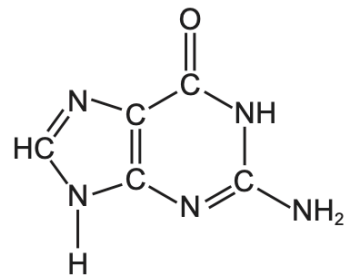
1



2



3



4

Which diagrams show thymine and cytosine?

- A** 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

Ans: C

17.

Which statements correctly describe the process of translation?

- 1 The nucleotide sequence on an mRNA molecule is used to produce a specific amino acid chain.
- 2 A section of DNA is copied into an mRNA molecule by RNA polymerase.
- 3 A polypeptide is produced because anticodons on tRNA molecules attach to mRNA codons through peptide bonds.

- A** 1 and 2 **B** 1 and 3 **C** 1 only **D** 2 and 3

Ans: C

Question asks for translation. Statement 2 applies to transcription!

18.

Which statements describe how a gene mutation can lead to the production of a non-functional protein?

- 1 During transcription, an incorrect nucleotide is added to a DNA molecule.
- 2 The mutated gene results in a new codon being transcribed.
- 3 The order of the bases in an anticodon on tRNA is altered during translation.

A 1, 2 and 3 **B** 1 and 2 only **C** 2 and 3 only **D** 2 only

Ans: D

- Mutations occur during DNA replication. Mutations DO NOT occur during transcription & translation!! Thus statement 1 and 3 are incorrect.
- A gene mutation changes codon sequence in mRNA, which may result in a non-functional protein.

19.

A polypeptide molecule contains the amino acid sequence:

glycine – leucine – lysine – valine.

The table shows DNA triplets for these amino acids.

glycine	leucine	lysine	valine
CCC	GAA	TTT	CAA

Which tRNA anticodons are needed for the synthesis of this polypeptide?

- A** CCC GAA TTT CAA
B CCC GAA UUU CAA
C GGG CUU AAA GUU
D GGG CUU UUU GUU

Ans: B

- DNA triplet → complementary → mRNA codon → complementary → tRNA anticodon
- Thus DNA triplet = tRNA anticodon

20.

XNA is a laboratory-made nucleic acid. XNA is made of nucleotides in which one component has been replaced by chemical X. The chemical X is organic but is **not** found in nature. The part of the molecule responsible for coding is **not** changed.

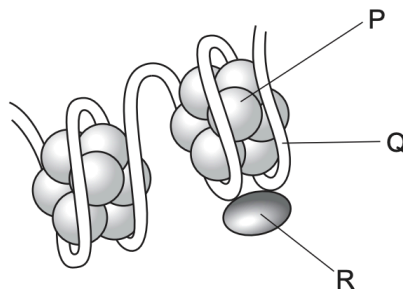
Which component of a DNA or RNA nucleotide has been replaced by the organic chemical X?

- A five-carbon sugar
- B phosphate group
- C purine base
- D pyrimidine base

Ans: A

21.

The diagram shows part of the organisation of a section of a DNA molecule and the associated histones, P and R, in prophase of mitosis.



Which statement about the features labelled P, Q and R during prophase of mitosis is correct?

- A The coiled DNA molecule forms Q and wraps around histone R to form small clusters held in place by histone P.
- B The groups of histones, P, and its associated DNA, Q, move closer together as the chromosome condenses around R.
- C The histones P and R are made of protein around which the DNA molecule, Q, is wrapped so that the DNA molecule can fit inside the nucleus.
- D The linked groups of histones P and R and the associated DNA, Q, form strands that fold and twist together to form a chromatid.

Ans: D

- Option A is reversed: it wraps around P and is held in place by R
- Option B: the chromatin as a whole condenses, the histones don't move together. They stay in position.
- Option C: DNA is not wrapped around R in this diagram

NOTE:

- DNA wrapped around histones = chromatin
- Chromatin condense to form chromatid = 1 part of chromosome

22.

One characteristic of DNA is that it is a universal genetic code.

What is meant by a universal genetic code?

- A** All living organisms use the same triplet code for amino acids.
- B** All DNA triplets code for a different amino acid.
- C** Not all DNA triplets code for an amino acid.
- D** All living organisms contain the same four nucleic acids.

Ans: A

23.

Which statement about mRNA is correct?

- A** It is a polymer made of nucleotides all joined with hydrogen bonds.
- B** Each nucleotide subunit contains the sugar ribose.
- C** It always has an equal proportion of adenine and uracil.
- D** The mRNA sequence is identical to the template strand of DNA.

Ans: B

NOTE: mRNA is single-stranded, so can't have same proportion of A and U