SI Biology - Full Discipline Demo

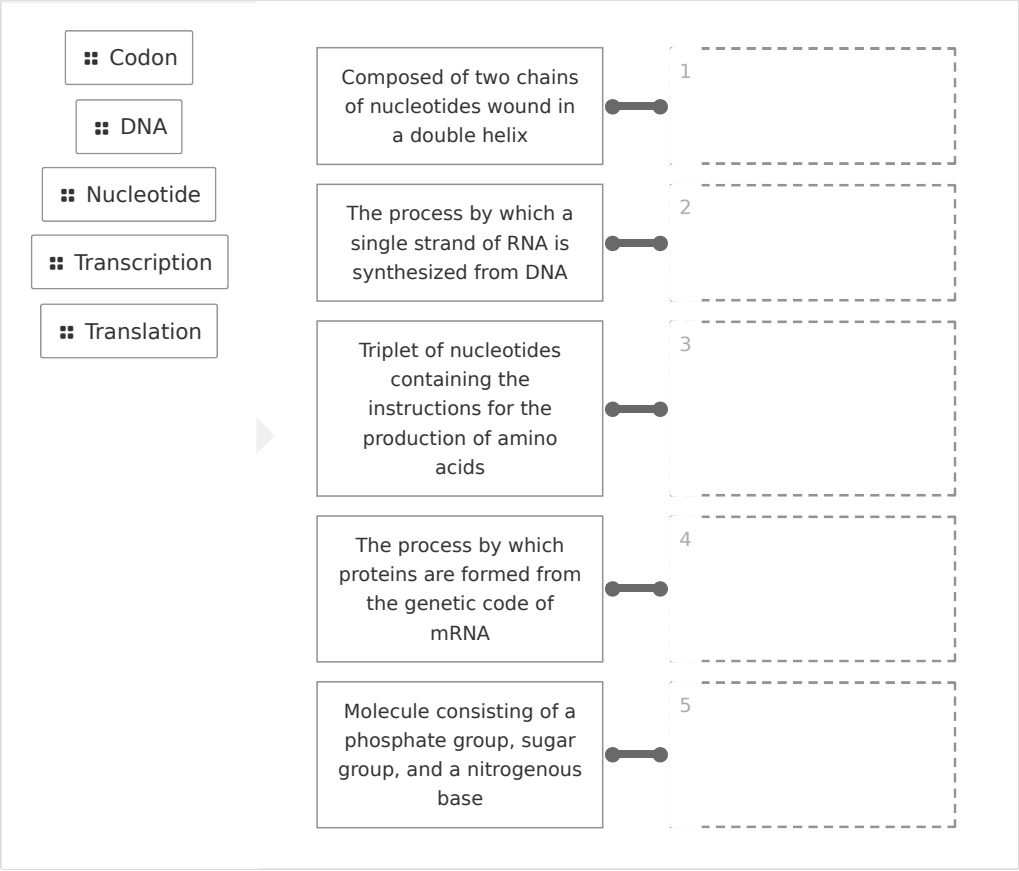
DNA, RNA, and Protein Synthesis

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Biology - Full Discipline Demo
Course	SI Biology - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

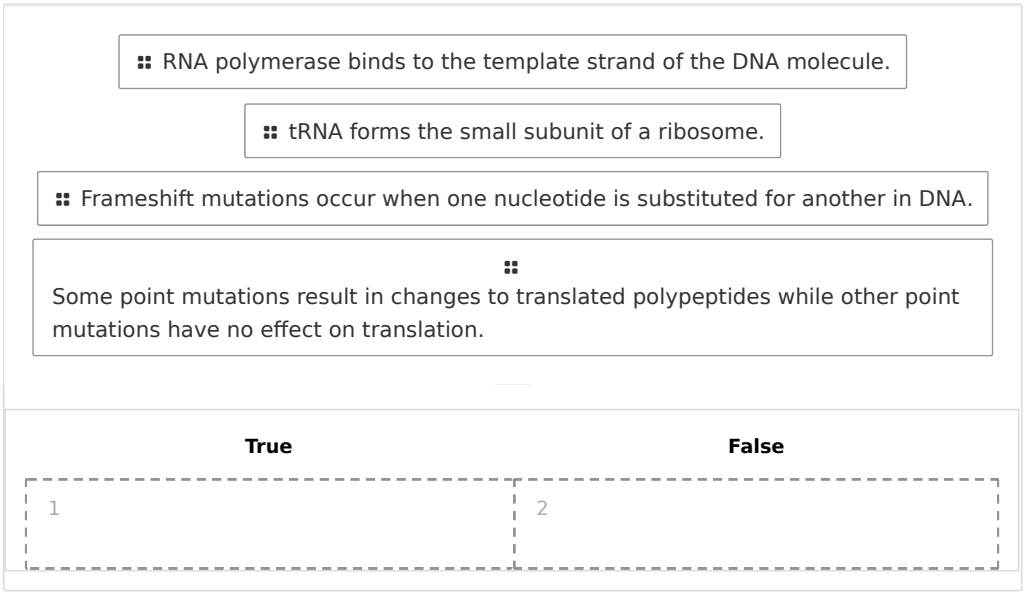
Match each term with the best description.



Correct answers:

1 DNA 2 Transcription 3 Codon 4 Translation 5 Nucleotide

Identify each statement as true or false



Correct answers:

1 RNA polymerase binds to the template strand of the DNA molecule.

Some point mutations result in changes to translated polypeptides while other point mutations have no effect on translation.

2 tRNA forms the small subunit of a ribosome.

Frameshift mutations occur when one nucleotide is substituted for another in DNA.

Exploration

Four _____ form the structure of DNA.

- amino acids
- nucleotides ✔
- proteins
- carbohydrates

Thymine is replaced with _____ in RNA.

- adenine
- cytosine
- uracil ✔
- guanine

A complete ribosome is formed during the _____ step of translation.

- elongation
- initiation ✔
- maximization
- termination

A stop codon codes for the amino acid proline.

- True
- False ✔

Frameshift mutations result when one or more nucleotides are added or removed from DNA.

- True ✔
- False

Exercise 1

What is the relationship between codons, amino acids, and proteins? Include the definitions of each term and reference your results Data Table 1 in your explanation.

The genetic code is composed of codons, triplets of nucleotides that contain instructions for the production of amino acids. Amino acids are organic compounds composed of an amino group

(NH_2), a central carbon, a carboxylic acid (CO_2H) and a functional group (R). Proteins are composed of long, folded polypeptide chains of amino acids. The code provided in Data Table 1 consisted of 12 codons that coded for 11 amino acids plus a stop codon. After translation, the resulting polypeptide chain, containing 11 amino acids would then undergo reactions and folding to form a protein.

Describe the three steps of transcription. Reference the example provided in Data Table 1 in your answer.

Initiation begins when the enzyme RNA polymerase binds to a location on the DNA template strand called the promoter. RNA polymerase then separates the two strands of DNA by breaking the hydrogen bonds between the base pairs. During elongation, RNA polymerase travels downstream (3’ to 5’) along the DNA template strand adding free nucleotides to the 3’ end of the growing RNA molecule. Termination occurs when the RNA polymerase reaches a stop codon. Transcription ends and the new mRNA molecule detaches from the DNA. Transcription creates an mRNA copy of the DNA coding strand with uracil replacing thymine in the newly constructed mRNA. This is demonstrated in Data Table 1 as the recorded mRNA is identical the coding DNA strand except for the 10 T nucleotides being replaced by 10 U nucleotides.

Describe the three steps of translation. Reference the example in Data Table 1 in your answer.

During initiation, the small subunit of a ribosome charged with a tRNA, and the amino acid methionine (Met) attaches to mRNA and scans for the start codon AUG (which codes for the amino acid methionine). Once the start codon is encountered, a large subunit joins the small subunit to form a complete ribosome. As a result of the initiation process, the methionine tRNA becomes positioned in the ribosomal P site. Elongation begins as a new tRNA plus amino acid enters the empty A site of the ribosome. If the anticodon matches the mRNA codon, the amino acid in the P site then forms a peptide bond with the amino acid in the A site, releasing the amino acid from the tRNA in the P site and moving the empty tRNA into the E site. Simultaneously, the tRNA in the A site, holding the two peptide-bonded amino acids, then moves into the P site, signaling the next tRNA to bind to the mRNA in the A site. Elongation continues until the stop codon (UAA, UAG, or UGA) is encountered on the mRNA strand. During termination, the stop codon signals the release of the polypeptide chain from the ribosome. The two ribosome subunits and the mRNA then dissociate from one another, completing the translation process. The polypeptide chain then undergoes a series of steps including post-translational modifications and folding to become a protein. Translation is illustrated in the results in Data Table 1 as the polypeptide chain consists of 11 amino acids that were formed from the mRNA strand which contained both the start codon, AUG, and stop codon UAA.

Data Table 1: Protein Synthesis

(SAMPLE ANSWER BELOW)

DNA Coding strand (5' to 3')	|ATG|ACC|AAC|AAG|CGC|AGT|CGA|TGT|TAT|TTC|CTC|TAA|
DNA Template strand (3' to 5')	|TAC|TGG|TTG|TTC|GCG|TCA|GCT|ACA|ATA|AAG|GAG|ATT|
mRNA Strand (5' to 3')	|AUG|ACC|AAC|AAG|CGC|AGU|CGA|UGU|UAU|UUC|CUC|UAA|
Amino acids coded for by mRNA	met|thr|asn|lys|arg|ser|arg|cys|tyr|phe|leu

Exercise 2

What effect did the point mutation have on the sequenced polypeptide in this exercise? Reference your results recorded in Data Table 2 in your explanation.

0 Word(s)

What effect did the frameshift mutation have on the sequenced polypeptide in this exercise? Reference your results recorded in Data Table 2 in your explanation.

0 / 10000 Word Limit

DataTable 2: Mutations

(SAMPLE ANSWER BELOW)

mRNA strand	|AUG|GAG|GUC|UUU|AAG|AGA|CAU|UUA|GAU|UAG|
Translated polypeptide chain	|Met|Glu|Val|Phe|Lys|Arg|His|Leu|Asp|
mRNA point mutation	|AUG|GAG|CUC|UUU|AAG|AGA|CAU|UUA|GAU|UAG|
Translated point mutation polypeptide	|Met|Glu|Leu|Phe|Lys|Arg|His|Leu|Asp|
mRNA frameshift mutation	|AUG|GAG|UCU|UUA|AGA|GAC|AUU|UAG|AUU|AG
Translated frameshift mutation polypeptide	|Met|Glu|Ser|Leu|Arg|Asp|Ile|

Competency Review

In DNA, adenine always pairs with thymine and cytosine always pairs with guanine.

- True ✔
- False

A _____ is a triplet of nucleotides that forms the genetic code for all organisms.

- polypeptide
- nitrogenous base
- codon ✔
- ribosome

Transcription creates an mRNA copy of the DNA _____ strand with uracil replacing thymine in the newly constructed mRNA.

- coding ✔
- template
- initiation
- termination

The _____ contains three binding locations where amino acids are connected to form a polypeptide chain during translation.

- small ribosomal subunit
- promoter
- large ribosomal subunit ✔
- start codon

The _____ signals the release of the polypeptide chain from the ribosome during the termination phase of translation.

- promoter
- start codon
- initiator
- stop codon ✔

_____ mutations result when one nucleotide is substituted for another in DNA.

- Polymerase
- Point ✔
- Frameshift
- Elongation

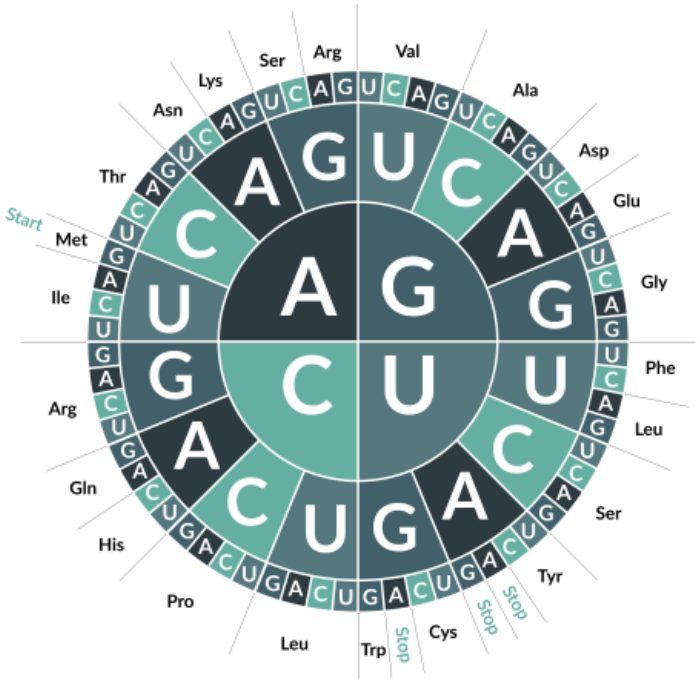
The template DNA sequence below would be transcribed to 5' _____ 3' mRNA sequence.

3' TAC TGG TTG TTC 5'

- GUU CUU CCU GAU
- ATG ACC AAC AAG
- GAA CAA CCA GTA
- AUG ACC AAC AAG ✔

The mRNA strand below codes for ____ amino acids.

5' AUG ACC AAC UAA 3'



- two
- three ✔
- four
- five

The sequence below is an example of a frameshift mutation of sequence AUG GAG GUC UAG.

AUG GAG GGU CUA G

- True ✔
- False

Extension Questions

Sickle cell anemia is a genetic disease resulting from a copying error for the DNA sequence that codes for Beta-hemoglobin, the molecule that assists red blood cells with transporting oxygen. The mutated mRNA sequence has the nucleotide uracil instead of adenine in the seventh codon as illustrated in the sequence below. Apply your knowledge of transcription, translation, and mutations to answer the following questions:

a. Is sickle cell anemia created by a point or frameshift mutation?

b. What are the coding and template strands of DNA that correspond to the provided mRNA sequence?

5' AUG GUG CAC CUG ACU CCU GUG GAG AAG 3'

(SAMPLE ANSWER BELOW)

a. The disease is caused by a point mutation because a single nucleotide is substituted within a codon.

b. Corresponding coding DNA sequence 5' ATG GTG CAC CTG ACT CCT GTG GAG AAG 3'. Corresponding template DNA sequence 3' TAC CAC GTG GAC TGA GGA CAC CTC TTC 5'