

## Explanation of UIL Science District B20, Answer Choice (A)

The following sites will be helpful in this explanation:

[https://www.msi.umn.edu/~lifang/misc/genetic\\_code.html](https://www.msi.umn.edu/~lifang/misc/genetic_code.html)

[http://groups.molbiosci.northwestern.edu/holmgren/Glossary/Definitions/Def-C/coding\\_strand.html](http://groups.molbiosci.northwestern.edu/holmgren/Glossary/Definitions/Def-C/coding_strand.html)

The term “coding” in the question wording refers to the DNA strand that is the same sequence as the mRNA, except uracil replaces thymine. The reason it is the same sequence is because RNA polymerase uses the template strand (complement strand to the coding strand) in order to generate an RNA copy. Whenever nucleic acids are made, there are two rules that must be satisfied: 1) all nucleic acid is made in a 5'→3' direction relative to the newly synthesized strand; 2) double-stranded nucleic acid (i.e. DNA:DNA, RNA:RNA, and the DNA:RNA hybrid that would be found at the transcription bubble) must always be antiparallel.

**Answer (A) is the correct answer to B20. Here is the solution to the problem:**

1. The question wording gives a sequence and indicates it is a coding strand.

**5' –TACCATGTACAAAGTCCTTTAGCC– 3'**

We can create its complement, although this is not a requirement to answer the question if the reader remembers that the DNA coding strand and the mRNA transcript are the exact same sequence, except T's become U's (see below in summary). If the student does not remember this, then they can generate the complementary strand of DNA and then create the RNA complement of that derived strand.

2. Generating the complementary DNA sequence. Although it is unnecessary to generate this strand, it is not yet incorrect.

**3' –ATGGTACATGTTTCAGGAAATCGG– 5'**

This is the template strand, which is the strand that RNA polymerase uses to generate the mRNA. RNA polymerase synthesizes an mRNA that is complementary to the template strand. Using the template strand satisfies both rules. Messenger RNA is synthesized by RNA polymerase as the enzyme slides along 3'→5' on the template and plugging in complementary RNA nucleotides in a 5'→3' direction. Note the template runs 3'→5' and the new mRNA will be made and run 5'→3'. This makes the DNA:RNA hybrid antiparallel within the transcription bubble (the part of dsDNA that RNA polymerase opens up during transcription to read the template).

3. The result of RNA polymerase generating a complement in RNA format of the DNA template strand, in #2 from above, is the mRNA transcript:

**5' –UACCAUGUACAAAGUCCUUUAGCC– 3'**

Note that this mRNA transcript is both antiparallel and complementary to the DNA template strand.

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4. The small ribosomal subunit binds to the 5' end of mRNA and translocates until it finds the first AUG, where it is joined by the large subunit. On our mRNA, the first AUG is underlined. The ribosome reads the codons on the mRNA from 5' → 3' starting at the first AUG.

### In summary...

5' –TACCATGTACAAAGTCCTTTAGCC–3' (DNA Coding strand given in B20.)

3' –ATGGTACATGTTTCAGGAAATCGG–5' (Derived DNA template strand. Used by RNA polymerase to make mRNA.)

5' –UACCAUGUACAAAGUCCUUUAGCC–3' (mRNA that is both complementary and antiparallel to the template strand. The codon reading frame is highlighted. Note this mRNA is the same sequence as the DNA coding strand except U's replaced T's) (Correct protein sequence. Answer choice A.)

Met-Tyr-Lys-Val-Leu

### Concerning answer choice (C):

This was an excellent distractor. Many students only look for a TAC sequence and disregard the directionality of the nucleic acid, forget the use of directions in each process of protein synthesis, or miss the question's reference to coding strand. This strategy of finding a TAC only works if the strand given in the question is the template strand. The TAC in a template strand must be 3' –TAC–5' in order for RNA polymerase to build the mRNA correctly as 5' –AUG–3'. Additionally, students must remember that ribosomes read codons on mRNA 5' → 3'.

Students who chose C were probably doing this:

5' –TACCATGTACAAAGTCCTTTAGCC–3' (DNA Coding strand given in B20. Students who thought C was the answer were using this strand as the template strand.)

3' –AUGGUACAUGUUUCAGGAAUCCGG–5' (Building this mRNA strand would have required one of the nucleic acid synthesis rules to be broken; either mRNA be synthesized in a 3' → 5' direction, or not be antiparallel to what the students thought was the template.)

Met-Val-His...etc.

(Acquiring this incorrect protein sequence, which was answer (C) would have required the ribosome to move along the mRNA in a 3' → 5' direction; or students had incorrectly reversed the mRNA direction.)