

**THE TREE OF LIFE: EXPLORING BIODIVERSITY
USING GENOMIC AND COMPUTATIONAL METHODS
July 15th – July 19th 2018**

Learning Activity

Title:

DNA, RNA and Protein Synthesis

Author:

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Abstract:

DNA is the carrier of the genetic information that determines everything about living organisms. Everyone's hair color, height, blood type and skin color are all determined by the DNA. To convert the information from the DNA to the characteristics in the genes, a process referred to in biology as the "central dogma" occurs. This process involves the transcribing of DNA into RNA, and then the translating of RNA into a protein.

DNA is made up of building blocks called nucleotides. The nucleotides are made of nitrogen bases called Adenine, Thymine, Cytosine, and Guanine, (A, T, C, G) whose arrangements will determine the types of genes found in living organisms. Translating the DNA sequences into an amino acid sequence which are the building blocks of proteins will determine the expression of a gene.

The activity in this lab involves a simplified way of transcribing DNA to RNA, and then translating RNA into a sentence that would represent an amino acid sequence that results in a protein. Following the simplified hands on activity, a computational method, BLAST, will be used to illustrate the process in a "real world" manner using a real DNA strand from a national database and translating it to a protein found in various animals. By observing similar animal species with this specific protein, and preparing a phylogenetic tree using these animals, one could identify the relatedness of different organisms in the Tree of Life.

Subject, Grade, Level:

High school, Grades 9 and 10, Honors Biology and Regular Biology

Learning Objectives:

At the end of this activity, students will be able to :

- Identify the role of DNA in heredity.
- Identify the chemical components of DNA.
- Summarize the events of DNA replication.
- Compare DNA replication in prokaryotes with that of eukaryotes.
- Contrast DNA and RNA.
- Explain the process of transcription.
- Identify the genetic code and explain how it is read.
- Summarize the process of translation.
- Describe the "central dogma" of molecular biology.
- Relate the central dogma to phylogeny.

NGSSS Benchmarks:

SC.912.N.1.1 SC.912.N.1.6
SC.912.L.14.3 SC.912.L.14.6 SC.912.L.15.15 SC.912.L.16.3
SC.912.L.16.4 SC.912.L.16.5 SC.912.L.16.8 SC.912.L.16.9
SC.912.L.18.1

Timeframe:

The bell ringer activities, lecture, class discussions and video clips should take 2 block periods, 180 minutes total.

This Transcription and Translation activity should take 1 block period, 90 minutes total.

List of materials:

1. 5 cards each with a DNA strand containing various lengths of nucleotides.
2. Transfer RNA cards each with different anticodons on one side and amino acids on the other. The amino acids are being represented by words that, when, translated will make sentences.
3. Data sheets for recording the transcribed RNA sequence from the DNA strand and the translated sentences.
4. Computer to do BLAST.
5. Instruction sheets to do BLAST.

Procedure and general instructions (for instructor).

1. Prepare 5 DNA strands with nitrogen bases that, when converted to RNA codons, will be a word. Remember to always begin the strand with the nitrogen bases that, when transcribed, will correspond to a START codon and end the strand with the nitrogen bases that, when transcribed, will correspond to a STOP codon.
(Appendix 1 has a copy of DNA strands. There are 15 strands on the sample sheet.)
Each group of 2 students could be given different sets of 5 DNA strands.
(Appendix 1 has an answer sheet for each DNA strand, this can be used for assessment of student results.)
2. Prepare cards, each with a transfer RNA that has an anticodon on one side and a word, representing the amino acid, on the other side. Remember to include cards with the anticodon for the START and STOP sequences.
(Appendix 2 has a copy of RNA cards with the anticodons and words, representing the amino acids.)
Lay the cards out so that the students can have access to them.
3. Have instructions on the lab sheet for transcribing from the DNA strands given, and translating from the tRNA cards.
4. After completing the hands-on lab, have the students retrieve a computer and write the website (<https://blast.ncbi.nlm.nih.gov>) on the board.
5. Demonstrate to the students how to retrieve and download 1 real DNA strand from the NCBI database, and following the directions on the site, transcribe it into an amino acid sequence, and then translate into a protein using BLAST.
6. After finding out the different organisms that share the protein sequence, they can make a phylogenetic tree.

Procedure and general instructions:

1. Students should be in groups of 2.
2. Retrieve a lab sheet and Data sheet from your teacher and read the instructions on the lab sheet.
3. Get a card with 5 DNA strands.
4. Write down the DNA stand on lines 1, 2, 3, 4, and 5 of the Data sheet.
5. Transcribe the DNA into RNA strands on lines 1a, 2a, 3a, 4a, and 5a.
6. Identify the codons, then place slashes between them for an easier translation process.
7. Record the anticodons immediately below on lines 1b, 2b, 3b, 4b, and 5b.
8. Go to the tRNA cards that were laid out by the teacher and locate the tRNA with anticodons that corresponds to the codons. Record the corresponding anticodons on lines 1b, 2b, 3b, 4b, and 5b.
9. Record the words, which are representing, the amino acids, on lines 1c, 2c, 3c, 4c, and 5c. The words will make sentences with the words START at the beginning of each sentence and STOP at the end.
10. Turn them in to the teacher.
11. Retrieve a computer and instructions for doing BLAST from the teacher.
12. Using the website follow the instructions to observe a real DNA sequence and translate it into a protein.
13. Observe the various species that share the same protein, then follow the instructions to make a Phylogenetic Tree with the information from BLAST.
14. Save the Phylogenetic Tree for another activity in the Evolution unit.

APPENDIX 1

1

ATGAAAAACAAGGTACACATCTAG

#2

ATGAAAAACAATTGCACGTAG

#3

ATGTAAACCACTACATAG

#4

ATGAGAAGTAGGAGAAGCATAATCTAG

#5

ATGATTCAACACATCCAGCCACATTAG

#6

ATGCCCCCGAGAAGCCCTTAG

#7

ATGCGACGCCGGCGTTAG

#8

ATGCTACTCATAGATCTGCTTTAG

#9

ATGTAAAGGGAAGACGAGTAG

#10

ATGCCCCCGGCAGCCGCGTAG

#11

ATGGCTCCGAGAGGAGGCAGAGGGTAG

#12

ATGAAAGGTAAGGTAGTCTAG

#13

ATGAAAGTGAAGGTTTAG

#14

ATGTAAAGGGAATACTATTCATAG

#15

ATGTAATCCTCGTCTCGGCGTTAG

#16

ATGATAGATCTGCTTCCGAGAAGCTAG

#17

ATGCCCCCGGAATGATGCTAG

#18

ATGTGGGTATGTCGGCGTTAG

#19

ATGTTACCGAGATTCTTGTTTTAG

#20

ATGTTATCCTCGTGGTTGTTTTAG

Protein Synthesis Lab

Sentence Key

1. Your mother wears a rubber band.
2. Your mother dresses you funny
3. We have dog breath.
4. The Beatles are the best rock band.
5. An old rubber band breaks when pulled.
6. Biology is the best subject.
7. Drink water every day.
8. I love rock and roll music.
9. We are all demented puppies.
10. Biology is so much fun.

11. Education is the door to the future.

12. Your father wears a dress.

13. Your brother wears nothing.

14. We are all in this together.

15. We must be informed every day.

16. Rock and Roll music is the best.

17. Biology is all around you.

18. Read a little every day.

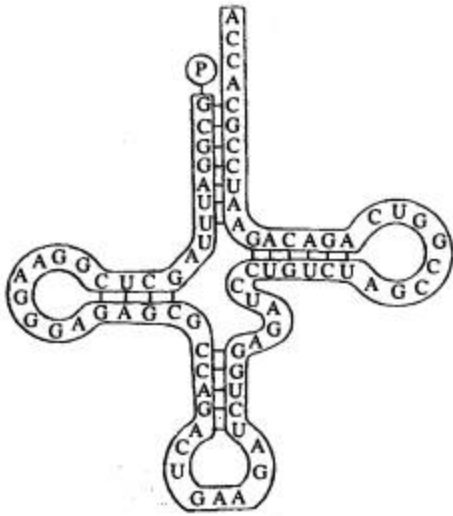
19. DNA is the code of life.

20. DNA must be read for life.

APPENDIX 2

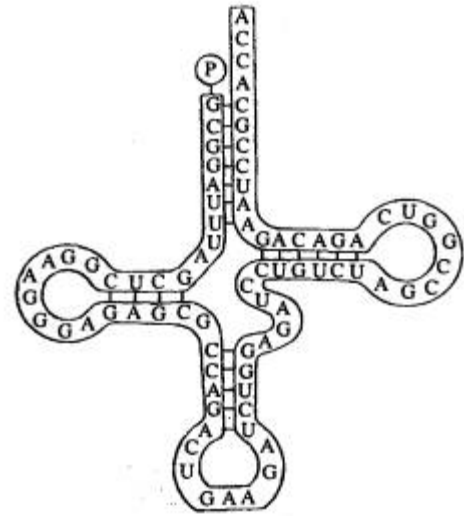
UAG

CCG



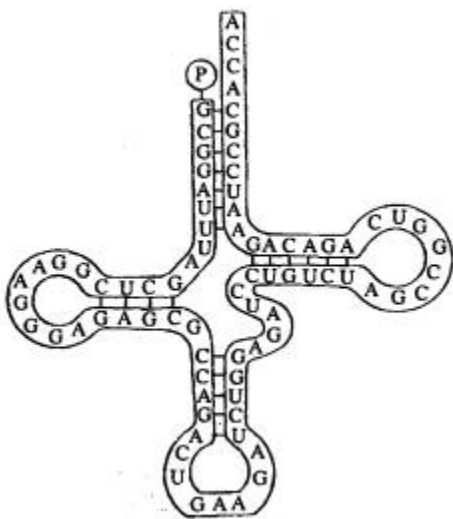
Stop

CGC



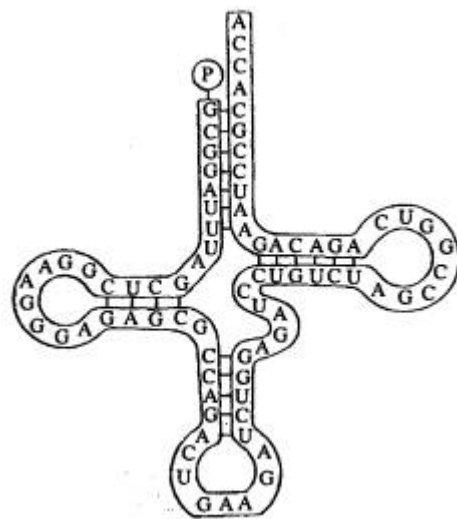
is

AUG



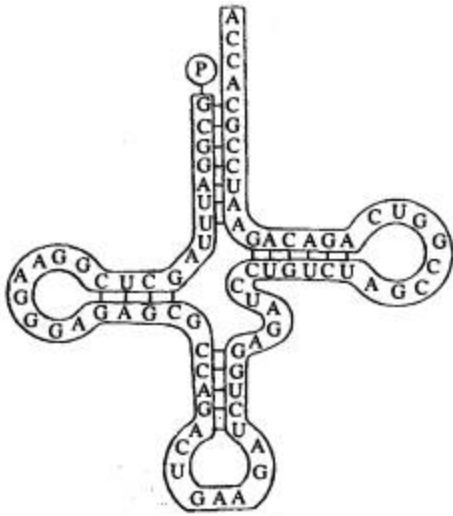
water

CCU



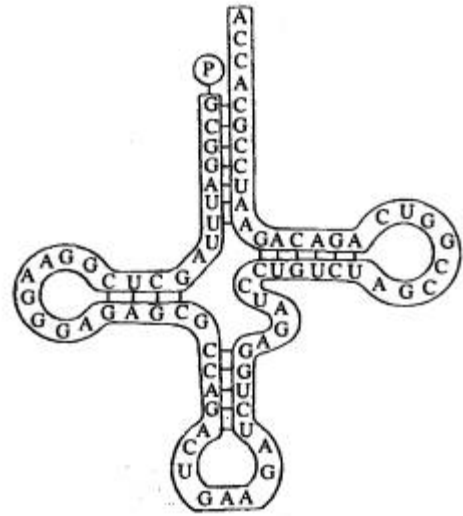
start

CGG



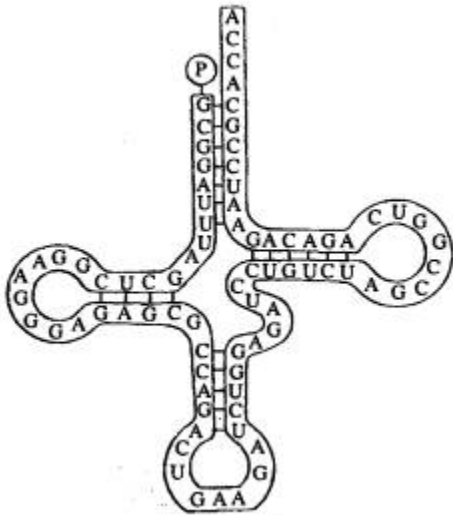
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AAA



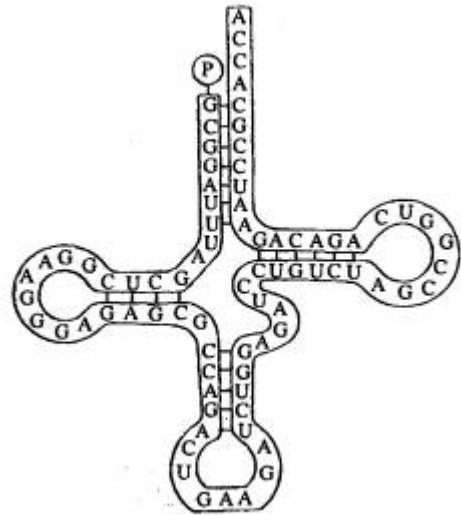
every

CGA



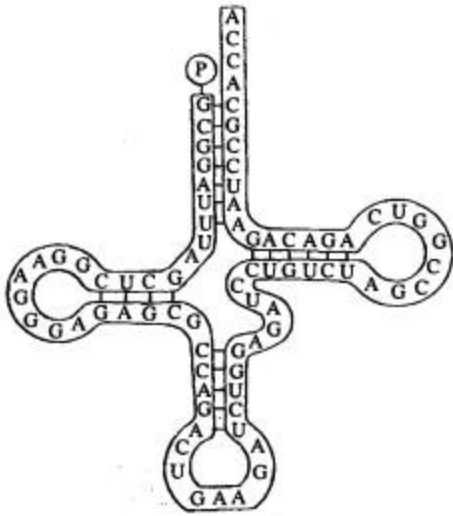
Your

CGU



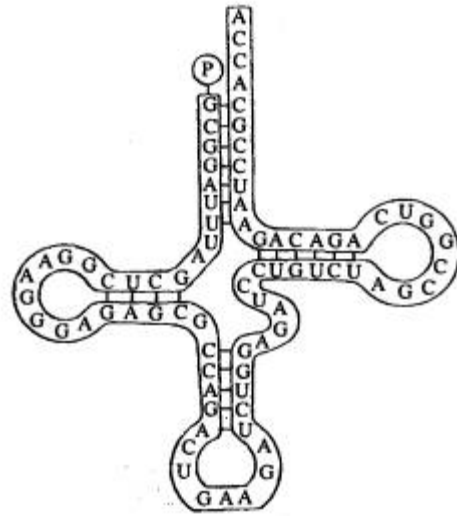
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AAC



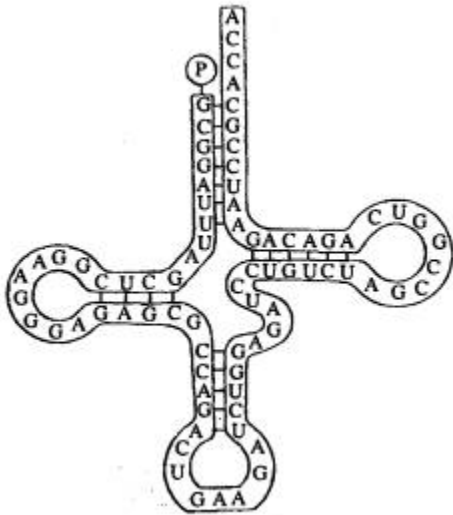
day

AAG



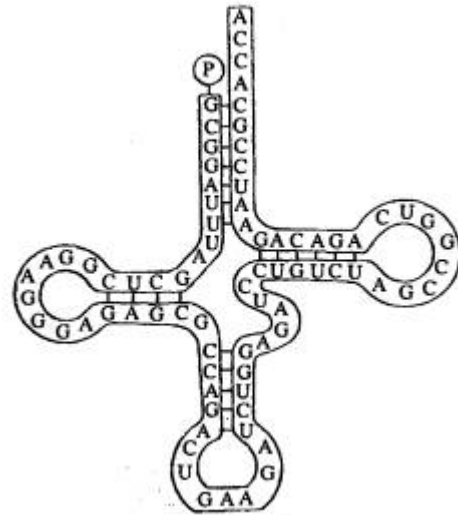
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AAU



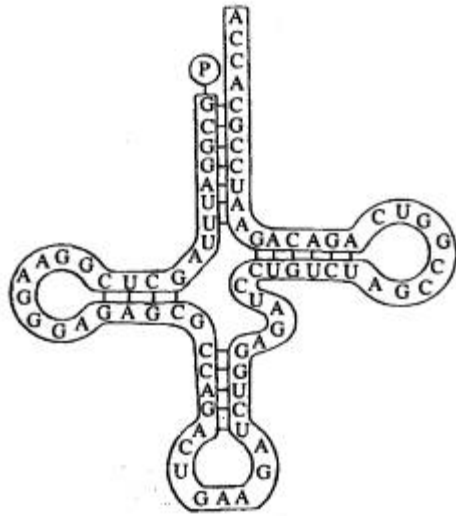
wears

ACG

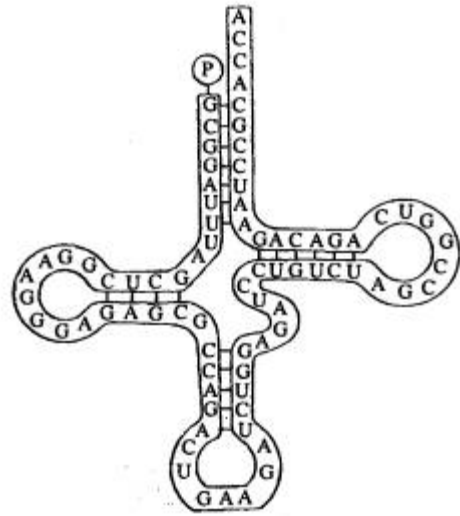


dresses

UUU



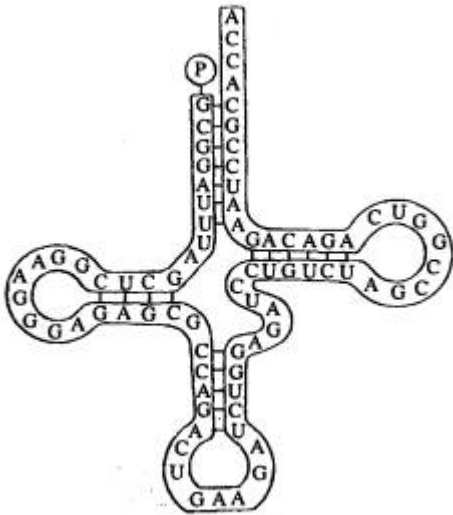
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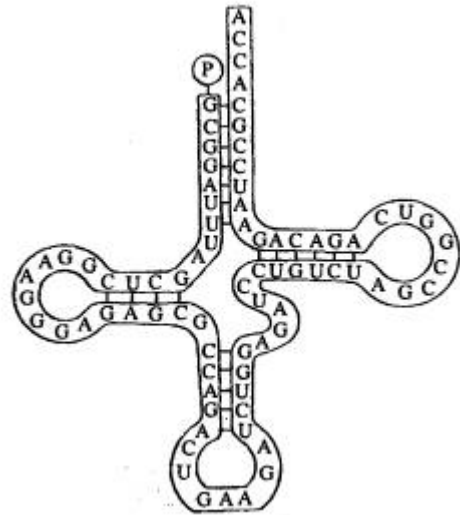
life

ACC

ACU

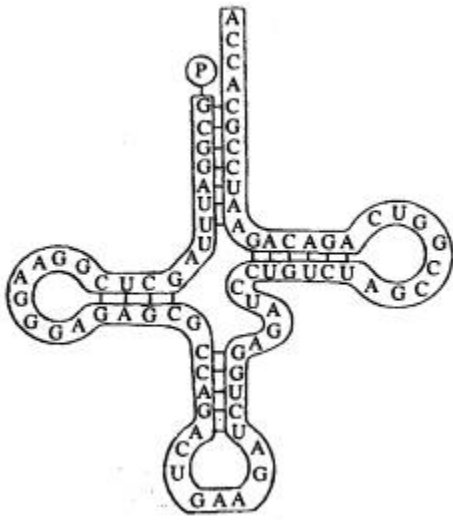


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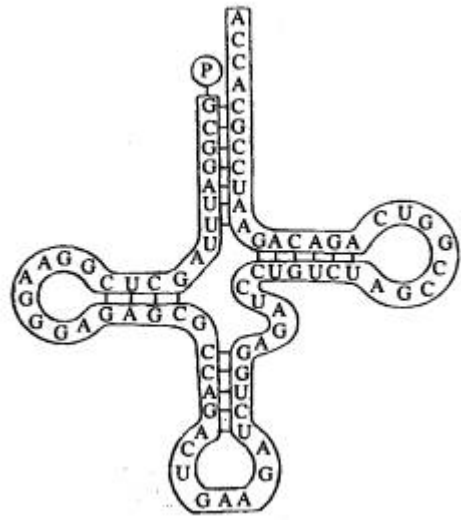
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ACA



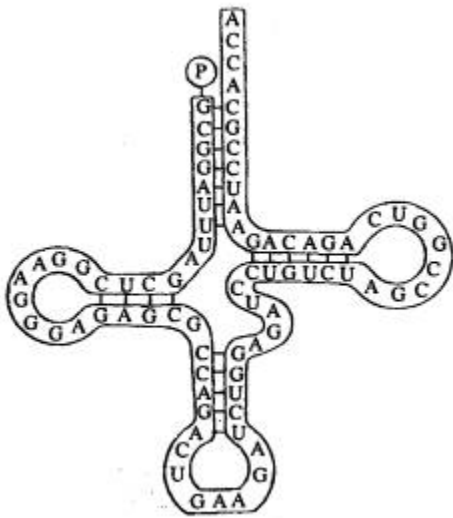
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AGA



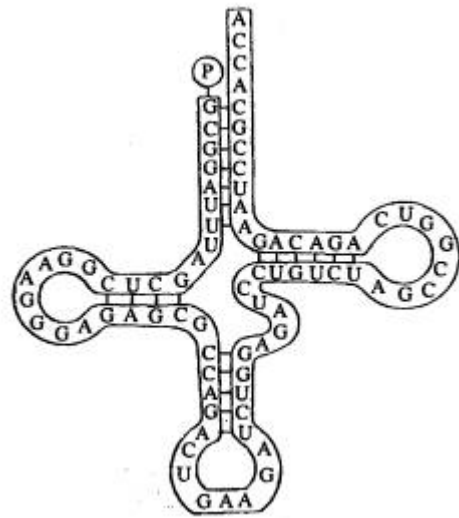
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AGG



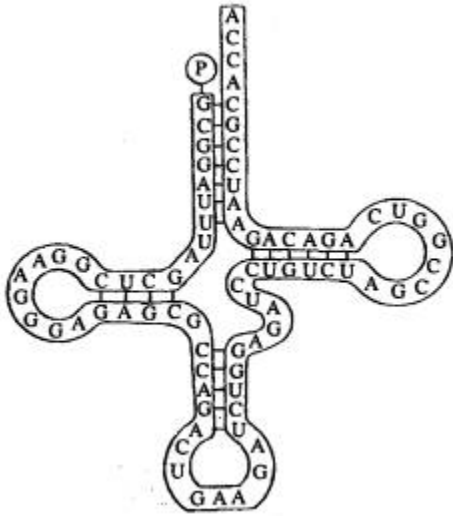
are

AGU



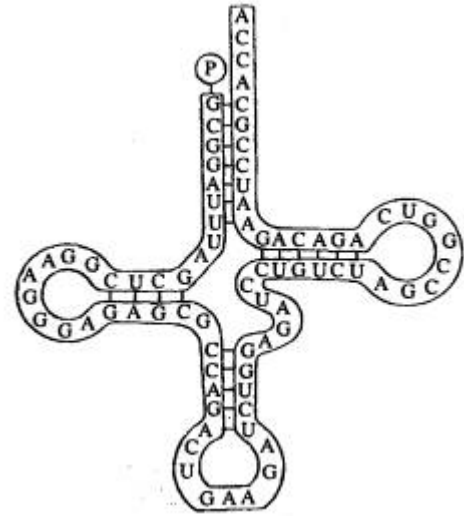
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AGC



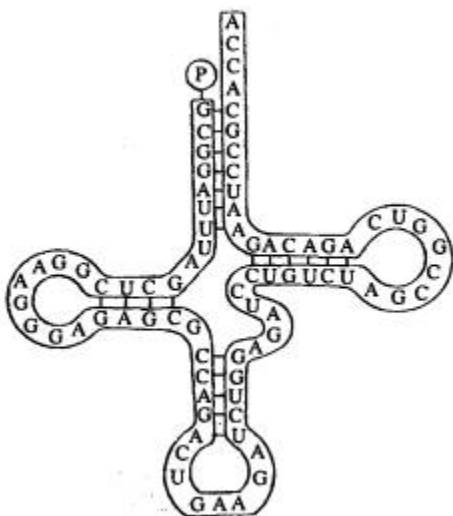
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AUA

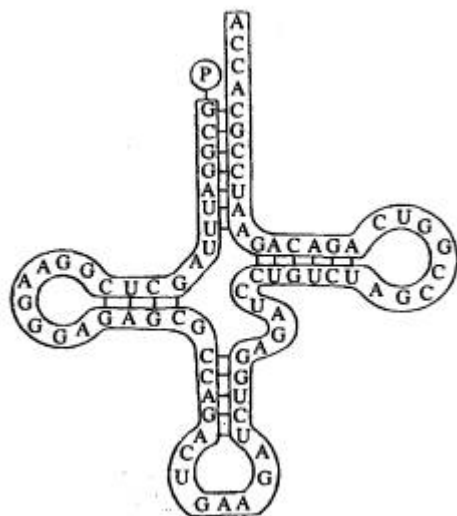


rock

AUC



AUU

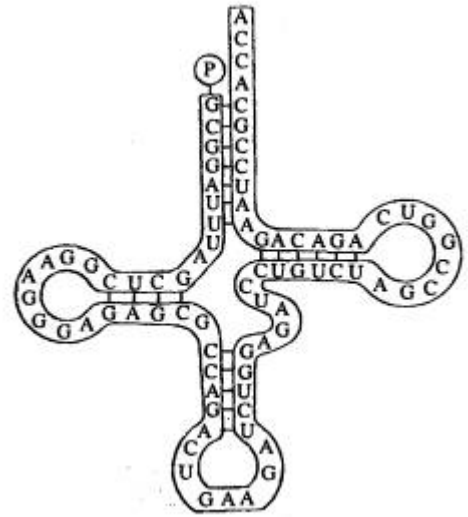
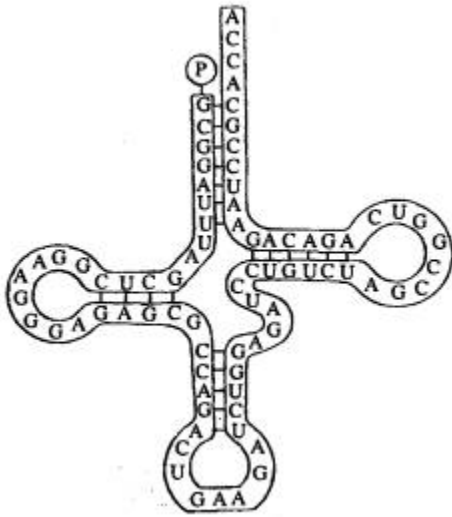


band

an

CAA

CAC

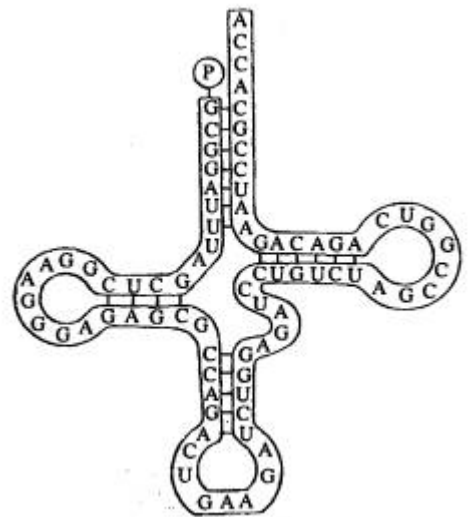
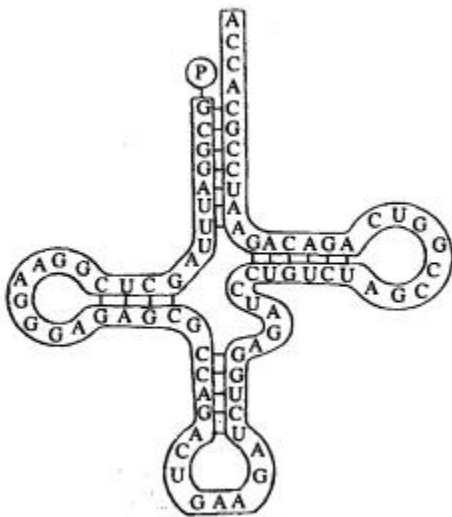


old

rubber

CAG

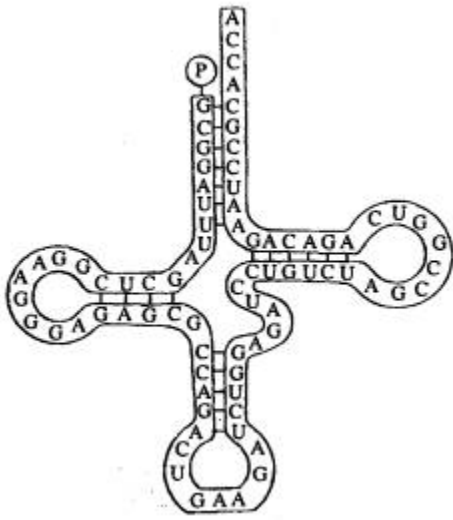
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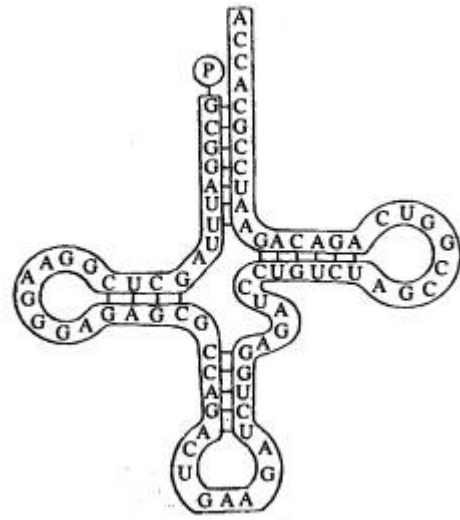
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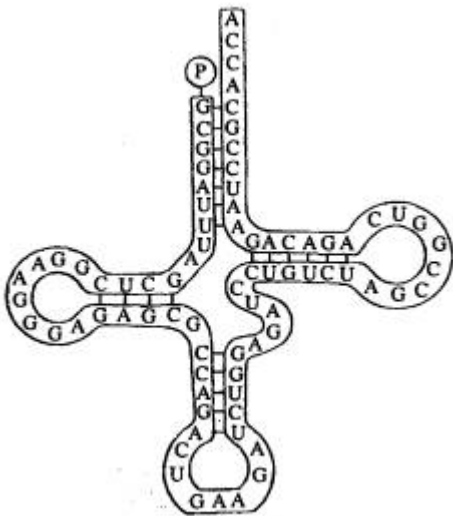
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CCC



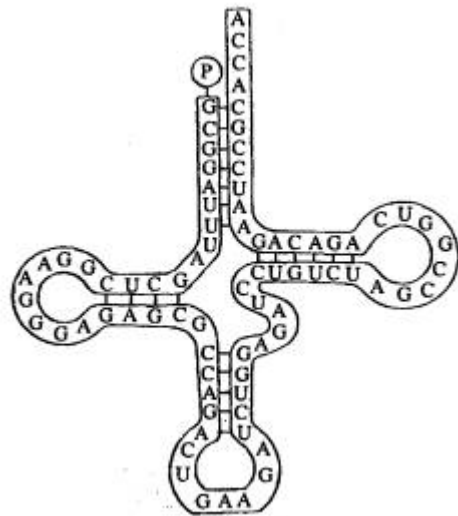
Biology

CUA



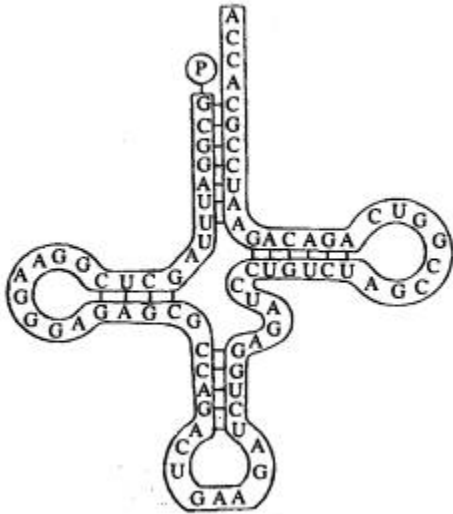
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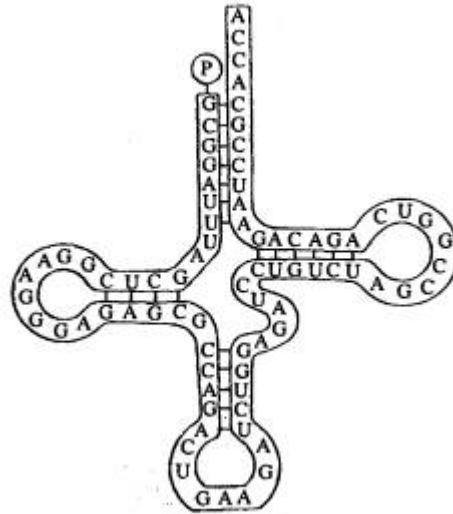
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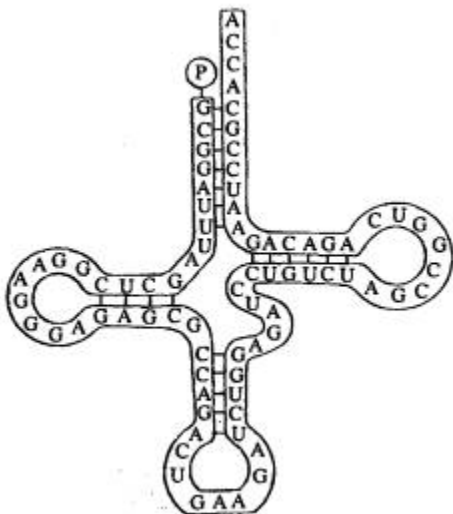
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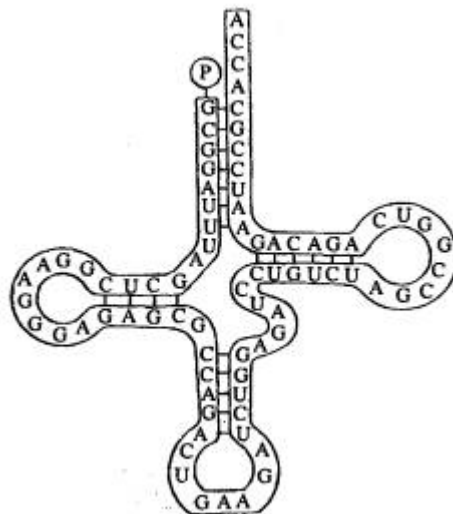
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GAA



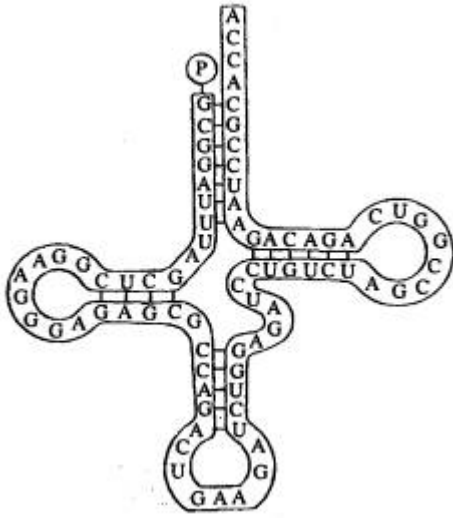
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GAC



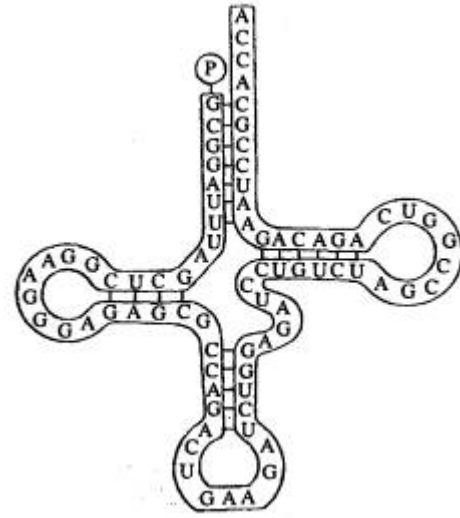
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GAG



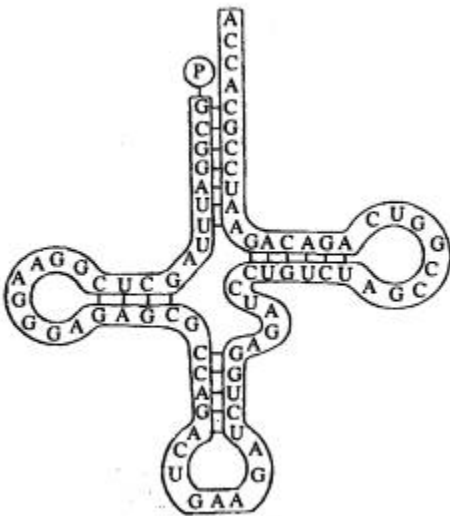
puppies

GAU



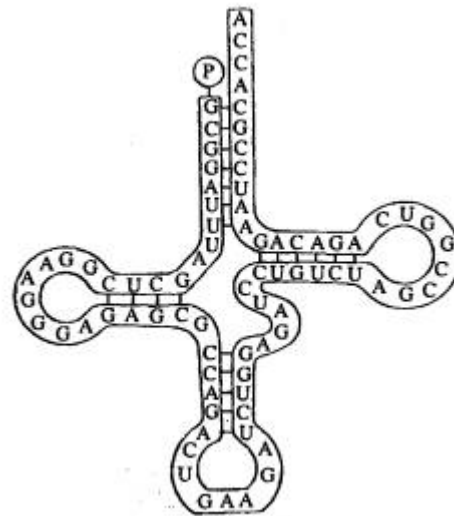
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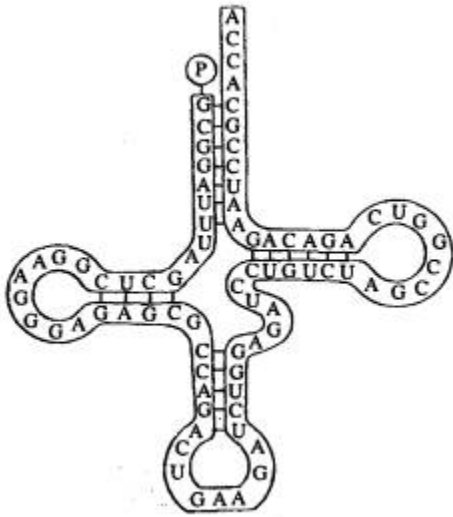
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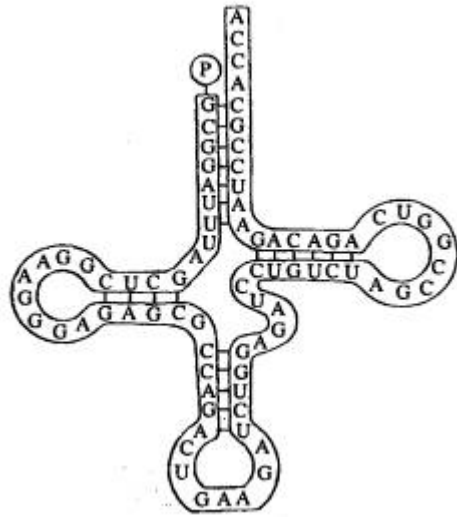
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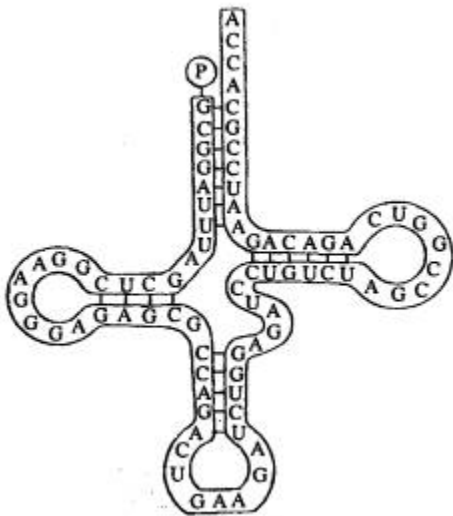
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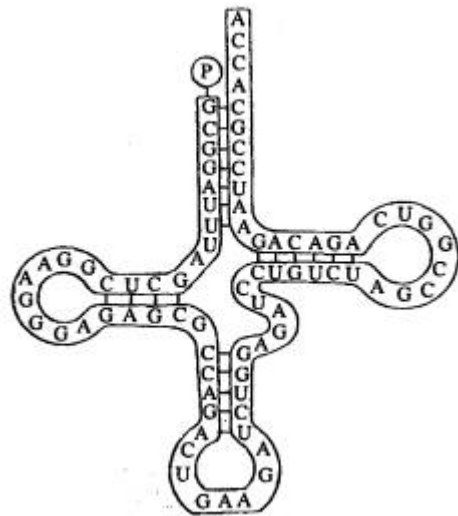
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GGA



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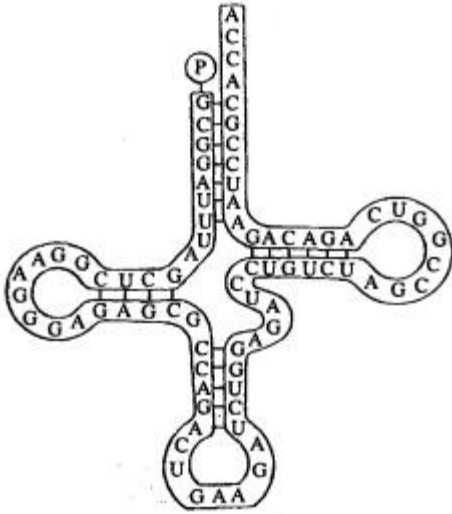
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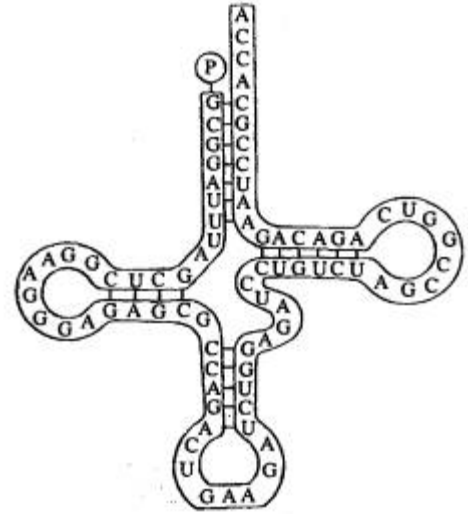
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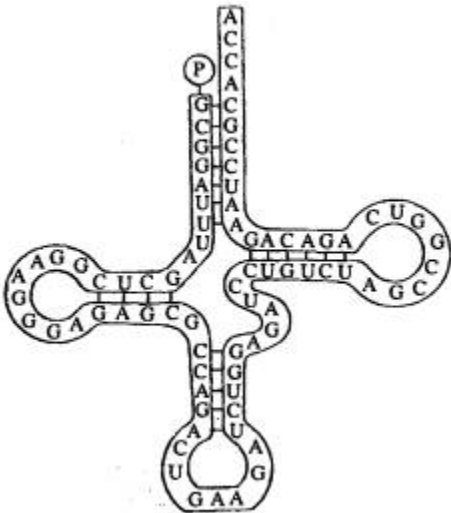
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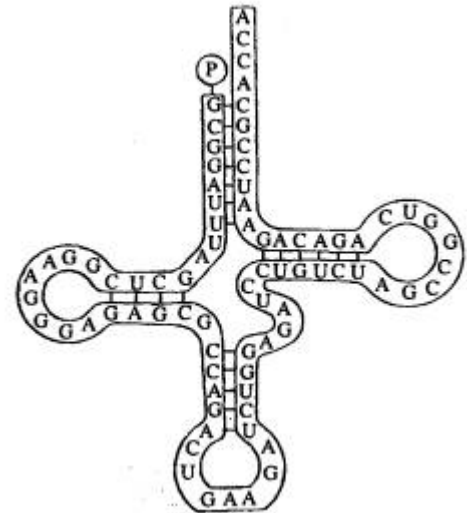
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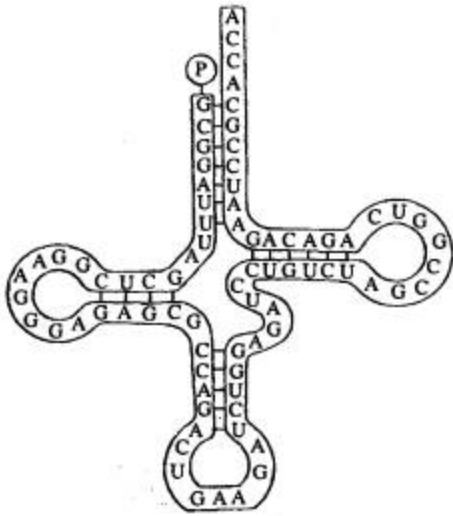
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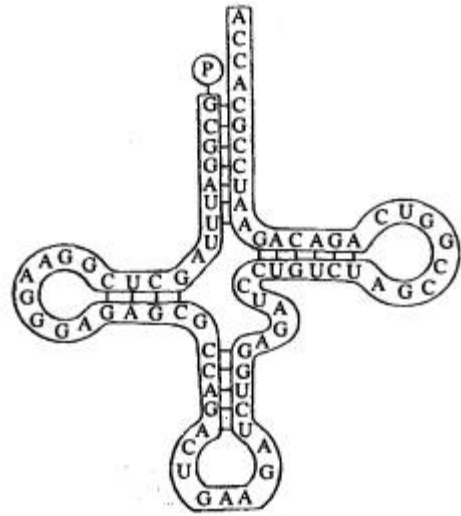
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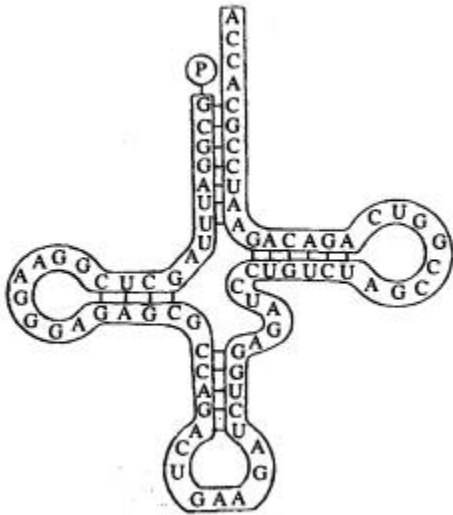
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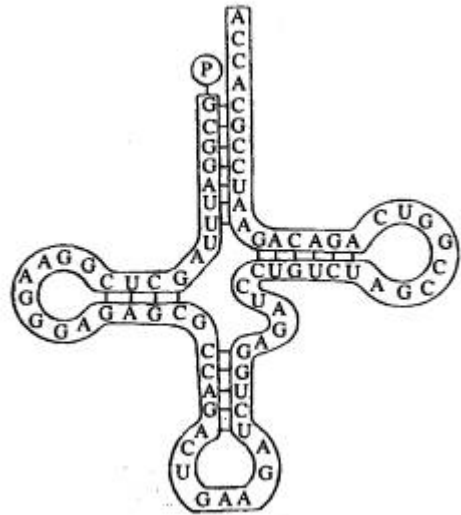
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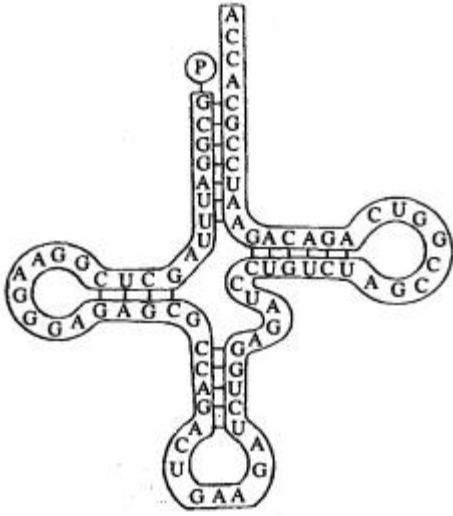
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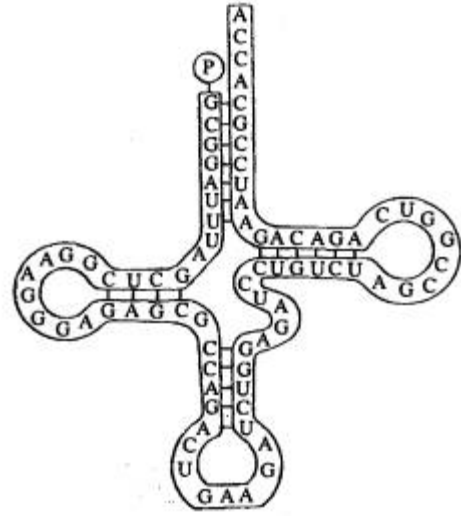
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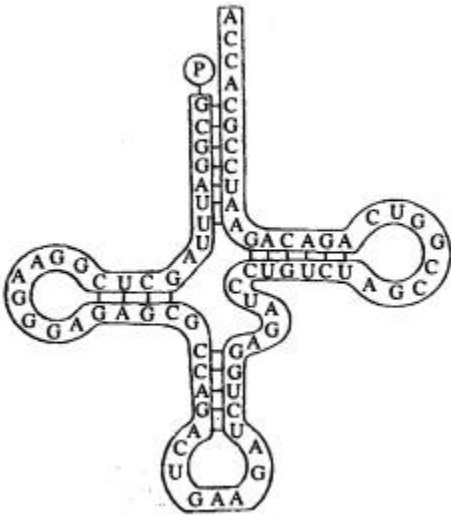
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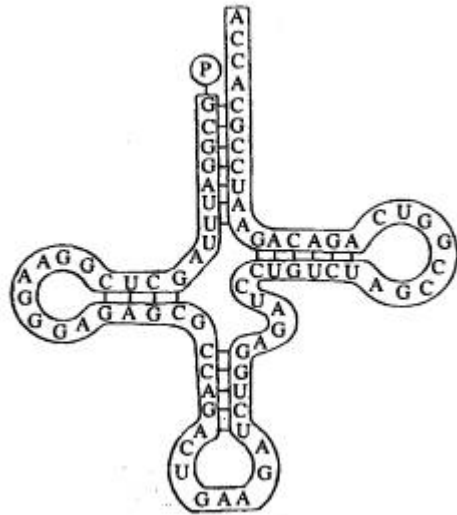
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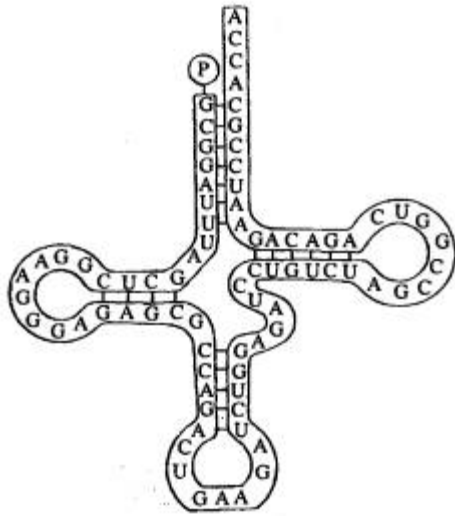
must

UCU



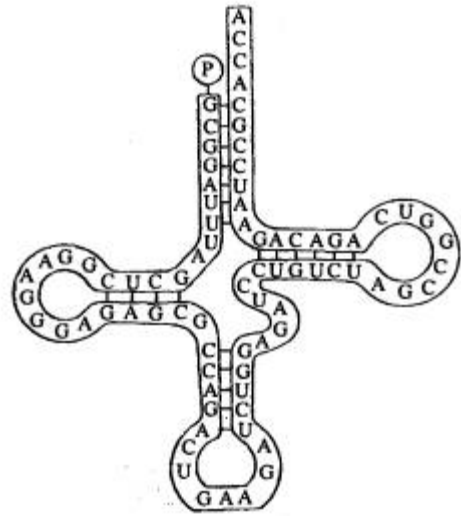
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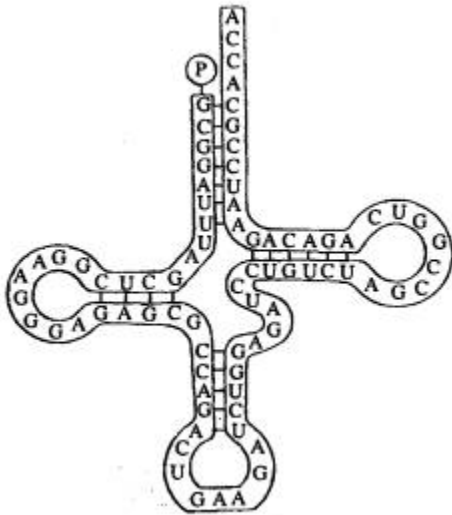
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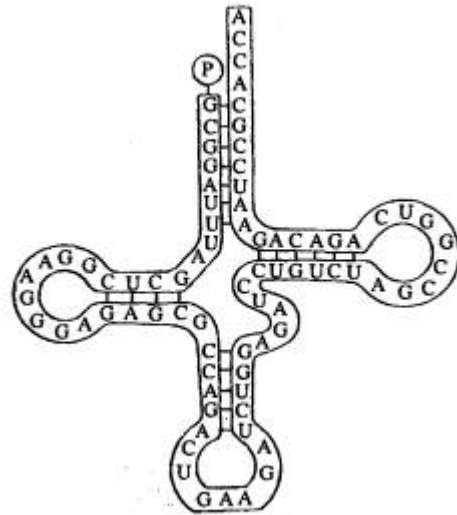
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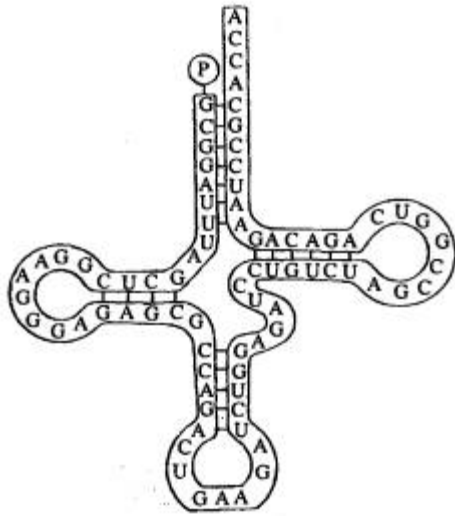
you

UGU

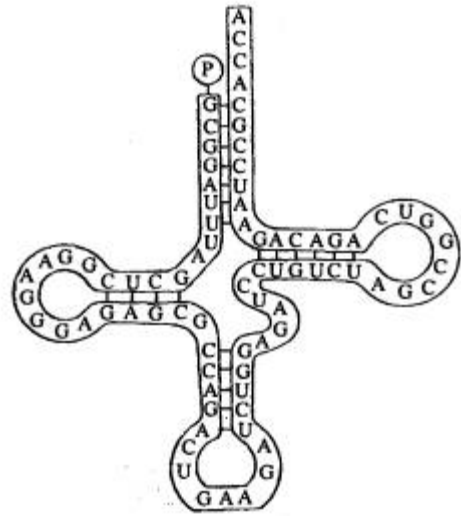


read

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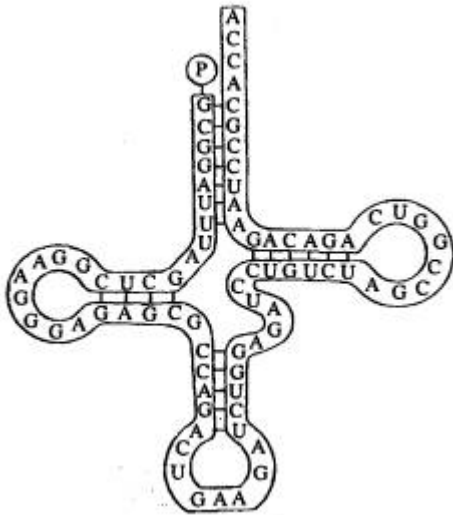
little



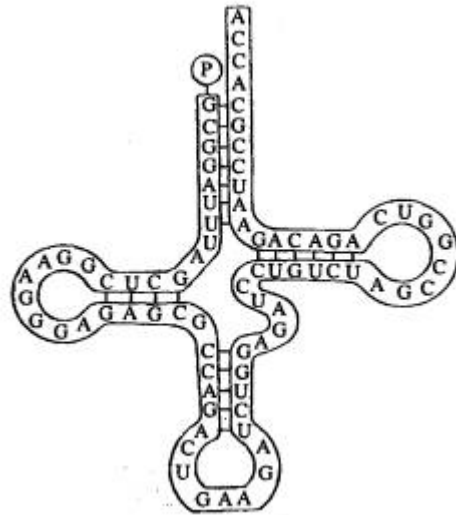
DNA

UUC

UUG



code



for

APPENDIX 3

DATA SHEET

NAME: _____ DATE: _____

Write the 5 different strands of DNA on the lines numbered 1 – 5.

On lines 1a, 2a, 3a, 4a, and 5a transcribe the DNA information immediately above it. This line represents the mRNA strand. Use lines to separate the codons along this strand.

On lines 1b, 2b, 3b, 4b, and 5b list the anticodons that correspond to the codons on the lines immediately above them.

On lines 1c, 2c, 3c, 4c, and 5c write the translated sentences from the tRNA cards that corresponds to the mRNA codons. A sentence should be made with the words START and STOP at the beginning and end of each sentence

1. _____

1a. _____

1b. _____

1c. _____

2. _____

2a. _____

2b. _____

2c. _____

3. _____

3a. _____

3b. _____

3c. _____

4. _____

4a. _____

4b. _____

4c. _____

5. _____

5a. _____

5b. _____

5c. _____