SAY IT WITH DNA: Protein Synthesis Activity

by Larry Flammer

SYNOPSIS

This activity uses the metaphor of decoding a secret message for the Protein Synthesis process. Students teach themselves the sequence of DNA-Translation (DNA-mRNA-tRNA protein), and practice with DNA codes which translate into amino acid sequences spelling out meaningful sentences in English! This activity provides practice in base-pair matching and following the sequence as performed by cells. Further practice is provided by requesting students to create new DNA messages which can be "decoded biologically" by others.

CONCEPTS

1. DNA is the central repository of information (in molecular code form) which controls life via protein synthesis.
2. DNA makes RNA makes Protein ("The Central Dogma"), or, more precisely
3. DNA makes mRNA, which is read by ribosomes to position tRNA carrying amino acids into a particular sequence forming a particular protein, which in turn (at least as an enzyme) enables (or inhibits) a particular biochemical reaction.
4. DNA bases match (pair) in specific ways: A with T, C with G, (A with U in RNA)

ASSESSABLE OBJECTIVES

1. Recognize DNA as a central repository of information (in code form) which controls life via protein synthesis.
2. Know the "Central Dogma": DNA makes → RNA makes → Protein
3. Know that certain DNA bases match: A & T, C & G, (and A & U in RNA)

MATERIALS

Handouts
TIME: one 45 minute period

STUDENT HANDOUTS

☐ **Say It With DNA: Protein Synthesis Worksheet – Practice Pays Student Handout** (directions, tutorial, sample message, tRNA dictrionary)
☐ **SAY IT WITH DNA - DNA-Decoding Practice Sheet**
☐ **SAY IT WITH DNA Protein Synthesis Practice Sheet**
☐ **SAY IT WITH DNA MESSAGES 1-30 (**3 pages, 30 to choose from; laminate, cut into strips and place in a baggie or in plastic sleeve)
☐ **SAY IT WITH DNA: Message Maker - Student Handout**

TEACHING STRATEGY

1. This activity provides a logical activity to use following your Protein Synthesis reading assignment.
2. Be sure that students understand the **significance** of controlling protein production, namely the "One Gene - One Enzyme" concept: each step of a biochemical series of reactions requires a unique enzyme which in turn is the product of one gene. If the gene is there, the enzyme can be produced,

and that step of the series can proceed; if the gene is not there (or has mutated), the enzyme may not be produced, and that step may not proceed. This is to some extent a simplification of reality, but should be recognized as a fairly good generalization for understanding how DNA (genes) can control life processes.

3. The one-letter symbols for the amino acids are the standard symbols assigned in molecular biology.

PROCEDURE
1. Hand out the **Say It With DNA: Protein Synthesis Worksheet – Practice Pays Student Handout** to every student.
2. Have students read the Worksheet and finish the partially solved message. You may use the **SAY IT WITH DNA – DNA Decoding Practice Sheet** as additional practice problems in class or for students to complete as homework.
3. Hand out the **SAY IT WITH DNA Protein Synthesis Practice Sheet.**
4. Assign each student one of the practice messages. Have them decode the message making sure to show each step in the "Decoding a DNA Message" section of their practice sheet. They can do more, if interested and have the time. To check for accuracy of the decoded messages, use the **SAY IT WITH DNA MESSAGES 1-30 KEY.**
5. Optional: Students can do additional messages for homework.
6. Hand out the **SAY IT WITH DNA: Message Maker - Student Handout**. Have each student create at least one good message in the "Creating a DNA Message" section of their practice sheet using these instructions. This could be done for homework.
8. An optional follow-up activity would be to collect all of the newly made messages and re-distribute them among the class the following day for the students to decode.
9. Ask students to do the **Quick Check** measure of their understanding of the functional roles for the real "players" involved in protein synthesis in the cell. (Alternatively, have them do just one of the analogies here, and use the other for assessment, OR, use the Quick Check for assessment only. You could also enlarge the table, place it on an overhead transparency, and do the Quick Check with the entire class in dialogue/recitation mode.

ASSESSMENT
1. Along with your unit test on the DNA unit, include the "practical" test supplement, requiring students to decipher a short DNA message during a test. Provide the **Test Supplement** (including tRNA Dictinary), the special answer sheet, and a unique word for each student (on little slips of paper, which you can prepare from the sample sentences provided, or use the 33 3-letter **test words** provided (along with a **test key** for you to use in grading the test.). Insist that each step be shown and the molecules involved be labeled (DNA, mRNA, tRNA, "protein" (as the "meaningful amino acid sequence"). Include completeness and accuracy in showing these steps and labels in your grading.
2. In addition, you may want to use the "**Quick Check**" here as a measure of understanding of the actual roles for the real "players" in protein synthesis in the cell.

EXTENSIONS AND VARIATIONS
1. Students can use the DNA Message Maker to create the DNA sequence which would code for their initials or 3-letter name or nickname, then use that code to build DNA jewelry (earrings, etc.) in the **Genetic Jewels** activity (not included with this lesson document). They would have to be sure that the base letters (beads) for the code runs end to end along one strand, and the complementary base letters (beads) run along the connected strand. Such items would have even greater meaning and be uniquely personal, contributing to their retention of understanding.

2. As a special project, a student (or team) could build a large DNA demo model in which the base sequence codes for the name or initials of the school, or the school mascot. Flat rectangular sheets of Styrofoam could serve as the base-pair steps; flat pentagonal pieces as deoxyribose sugars, and flat round pieces as the phosphate groups. If interested in trying this, contact the webmaster on this site for templates and other details.

ATTRIBUTIONS
Larry Flammer, idea developed in 1963 and used in Biology classes ever since, as the finale to a series of Do-It-Yourself DNA Kits (1. DNA Structure & Sub Structure, 2. DNA Replication, and 3. Protein Synthesis, all involving manipulation of cutouts, and resulting in the spelling out of a little 3-letter word (meaningful amino acid sequence).

SAY IT WITH DNA: Protein Synthesis Worksheet: Practice Pays

Student Handout

Having studied the process by which DNA directs the synthesis of proteins, you should be ready to decode some DNA "secret" messages. To do this, you must follow the procedure of protein synthesis as this is taking place right now in your cells; no short cuts! Practice these steps by following and finishing the **partially solved message** below.

STEP 1: "Build" the mRNA molecule, matching the RNA nucleotides to the DNA nucleotides properly, letter by letter. (For purposes of simplicity, it will be assumed that this mRNA is bacterial; there are no introns to cut out!)

STEP 2: Figure out the tRNA triplets (codons) that would fit the mRNA triplets (letter by letter).

STEP 3: Look up each tRNA codon in the **tRNA Dictionary** (below), and find the corresponding symbol and amino acid abbreviation for that codon. Record that one-letter symbol (and its amino acid) below each codon. "Spc" = "space". If you have done this correctly, the symbols should spell out a meaningful message in English.

Remember, C always pairs with G, G always pairs with C, A pairs with T or T pairs with A (in DNA). In RNA, C always pairs with G, G always pairs with C, A pairs with U or U pairs with A. Clues: C & G are curved letters; A & T are angular; U is used in RNA in place of T.

When you finish the sample message below, decode the special message assigned to you (from the DNA Messages 1-30). Be sure to show the details of your solution on the student answer sheet provided, and hand it in.

Be sure to show the details of your solution on the **Practice Sheet** provided, and hand it in. In your DNA exam, you will be expected to do this from memory (provided with the tRNA Dictionary).

PARTIALLY SOLVED MESSAGE

GIVEN: DNA code message --> GAA TAG AAA CTT ACT TAG AGC ATT CCT GCC CTT CGA TGC ATC

SOLUTION (steps 1-4)

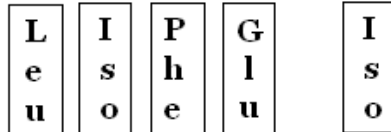1**. mRNA** (built to match the DNA message, letter for letter---------------→ CUU AUC UUU GAA UGA AUC UCG ... ...

2**. tRNA** (determined by matching letters (bases) with those in mRNA)-------→ GAA UAG AAA CUU ACU UAG ... ...

3. **Amino acids** carried by each tRNA (according to dictionary, below)-----------→

L e u	I s o	P h e	G l u	I s o

4. **Symbols** of amino acids:--→   L   I   F   E   –   I . . . .

DICTIONARY OF tRNA CODONS & THEIR AMINO ACIDS (SYMBOLS & ABBREVIATIONS)

tRNA	sym	AA	tRNA	sym	AA	tRNA	sym	AA	tRNA	sym	AA
AAA	F	Phe	CAA	V	Val	GAA	L	Leu	UAA	I	Iso
AAC	L	Leu	CAC	V	Val	GAC	L	Leu	UAC	M	Met
AAG	F	Phe	CAG	V	Val	GAG	L	Leu	UAG	I	Iso
AAU	L	Leu	CAU	V	Val	GAU	L	Leu	UAU	I	Iso
ACA	C	Cys	CCA	G	Gly	GCA	R	Arg	UCA	S	Ser
ACC	W	Trp	CCC	G	Gly	GCC	R	Arg	UCC	R	Arg
ACG	C	Cys	CCG	G	Gly	GCG	R	Arg	UCG	S	Ser
ACU	-	spc	CCU	G	Gly	GCU	R	Arg	UCU	R	Arg
AGA	S	Ser	CGA	A	Ala	GGA	P	Pro	UGA	T	Thr
AGC	S	Ser	CGC	A	Ala	GGC	P	Pro	UGC	T	Thr
AGG	S	Ser	CGG	A	Ala	GGG	P	Pro	UGG	T	Thr
AGU	S	Ser	CGU	A	Ala	GGU	P	Pro	UGU	T	Thr
AUA	Y	Tyr	CUA	D	Asp	GUA	H	His	UUA	N	Asn
AUC	-	spc	CUC	E	Glu	GUC	Q	Glu	UUC	K	Lys
AUG	Y	Tyr	CUG	D	Asp	GUG	H	His	UUG	N	Asn
AUU	-	spc	CUU	E	Glu	GUU	Q	Glu	UUU	K	Lys

SAY IT WITH DNA – DNA Decoding Practice Sheet

1. CGTCCACTT

2. CGATCTTAC

3. CGTTCGGTA

4. CTCCTTAAC

5. ACACGATGT

6. ACGCGTTGC

7. ACACGATCT

8. ACGCGTGGG

9. CTACGACTG

10. CTCCGAGCA

11. CTTCCACCT

12. CCACGAGAT

13. CTTGAATAC

14. CTCATGCTT

15. AAACGATGA

16. AAGTATGCA

17. GTACGTTGC

18. GTGCGATAC

19. GTACGTATG

20. GTGCTTTTA

21. TAATTGTTC

22. AACTAGGGT

23. GACCTTCCT

24. TACCGTTTA

25. GGACGATTG

26. GGTCGTACC

27. GGACTCCGA

28. AGTCGTGGA

29. TCGTTCTAA

30. GCACGTTGA

31. TCTCGACCA

32. TGTCGTGCA

33. TGCCGATTA

SAY IT WITH DNA – DNA Decoding Practice Sheet
KEY

1. CGTCCACTT
   AGE

2. CGATCTTAC
   ARM

3. CGTTCGGTA
   ASH

4. CTCCTTAAC
   EEL

5. ACACGATGT
   CAT

6. ACGCGTTGC
   CAN

7. ACACGATCT
   CAR

8. ACGCGTGGG
   CAP

9. CTACGACTG
   DAD

10. CTCCGAGCA
    EAR

11. CTTCCACCT
    EGG

12. CCACGAGAT
    GAL

13. CTTGAATAC
    ELM

14. CTCATGCTT
    EYE

15. AAACGATGA
    FAT

16. AAGTATGCA
    FIR

17. GTACGTTGC
    HAT

18. GTGCGATAC
    HAM

19. GTACGTATG
    HAY

20. GTGCTTTTA
    HEN

21. TAATTGTTC
    INK

22. AACTAGGGT
    LIP

23. GACCTTCCT
    LEG

24. TACCGTTTA
    MAN

25. GGACGATTG
    PAN

26. GGTCGTACC
    PAW

27. GGACTCCGA
    PEA

28. AGTCGTGGA
    SAP

29. TCGTTCTAA
    SKI

30. GCACGTTGA
    RAT

31. TCTCGACCA
    RAG

32. TGTCGTGCA
    TAR

33. TGCCGATTA
    TAN

SAY IT WITH DNA MESSAGES 1-30

1. CCT CTT TGC ACT CGG ATC GTA CGC TAT TCT ATG ATT ACA CGG TTG
   CGA TCC ATA ATC

2. AGA TAC TAG GAC CTT ACT CGA TTG CTG ATT GCG CGA CTA TAA
   CGG TGC CTC ACT CGG ATT AAC TAG TGC TGA AAT CTT ATT ACG
   GTA CTT CTC GCC ATC

3. TCC CTT GGG GAA TAT ACA CGC TGG CTT ACT CGA ATT TGA CTC CGT
   ACG GTA CTC GCC ATC

4. AGA ACA TAA CTC TTA ACA CTC TAA AGA CCA GCA CTC CGA TGA

5. TAA ACT CGG TAC ATT CTA GCT TAG CAC TAA TTA CCC ATC

6. TAC CGT TTC CTT ATT GAT CGC GCC CCA CTC ATT CTT CGG TCT AGG
   ATC

7. CTA GCC CTC CGT TAC TAG TTA CCT ACT TAT TCA ATT TTG TAA ACG
   CTC ATC CGA ACC CGC TTT TAA TTG CCC ACT TAG TCG ATT ACC CGT
   TTA TGT TAA TTA CCT ATC

8. ACC GTG ATA ACT CGT GCT CTT ATT ACC CTC ACT AAT CTC CGG TCC
   TTA TAT TTG CCT ATT TGC GTA TAG TCG ATC

9. TAC CGA TTT CTT ACT AGT GGC TCC TAT TTA CCT ATA ATT ACA GTG
   TAA ACG TTC CTC TTA TCA ATC

10. CTA TTA CGA ACT TAG AGC ATT GAA TAG AAA CTT ATC

SAY IT WITH DNA MESSAGES 1-30

(Cut into strips and give one message to each student)

11. CTC CAC GTG AGA ATT CAC CGA GCA TCA TAG TGG ATG ATT AGA

    ACC TAT TAC TAC TAT TTG CCT ATC

12. ACC GTG ATA ACT CGA GCA CTC ATT GGC AAC CGC TTA TGT AGC

    ATT CCT TCT CTC CTT TTG ATC

13. ACG GCT CTC CGT TGT CTC ACT CGA TTG ATT CTC ATG CTT ATC

14. CTG CTT AGT TAT CCA TTG ACT CGA ATT GTG CGC TTG CTG ATC

15. ACA GCC CTT CGC TGC CTC ACT CGA ATT AAA TAT TTG CCA CTC

    GCT ATC

16. AAA TAT TTA CTA ACT TGG GTA CTT ATT AGC CTC ACG GCG CTT TGT

    ATT TAC CTC AGA AGC CGA CCA CTC ATC

17. CTT CGA TGA ATT CCA GCC CTC CTT TTG ATC CTT CCA CCT AGC ATC

    CGA TTG CTA ACT GTA CGC ATC

18. AGT TAC TAA GAA CTT ACT TAG TGT TCA ATC GTA CTT CGA GAG TGG

    GTA ATG

19. ACC CGA TGG CTC TCT ATC TAT AGC ATT ACA AAC CTC CGA GCG

20. ACG CTT GAA AAT AGG ACT CGA TCT CTC ATC CCG TCC CTG CGC

    TGC ATT TGT GTA TAG TTA CCC AGG

21. GAA CTC CGA TCT TTG TAT CCG ACT CTA TTA CGG ATC TAA AGC ATT

    CCT TCC CTT CGT TGT

SAY IT WITH DNA MESSAGES 1-30

22. TAC ATA ACT TAC TAG TTA CTA ATC TAT AGA ATT TAC CGA CCC TTG TAT AAA TAG ACG CTT TTA TGC ATC

23. TAA ACT GTG CGA CAC CTC ATT CGT ATC CTA GCG CTT CGT TAC ATC

24. AGA CGG CAA CTC ATT TGG GTG CTT ACT TGT TCT CTT CTC AGT ATC

25. CCG GCA CTC CTT CTA ATT GCT CTT TAG CCA TTA AGT ACT TAA TTG ATC ACC CGA AAT GAG ATT AGG TGT TCC CTC CTT TGC ATC

26. GAT TAA AAA CTC ACT TAG AGC ATT AGT GGG CTT ACA TAA CGG GAA ATC

27. ACC GTA ATG ATT TAG AGG ATC CTG TTA CGA ACT TTG CTC ACA CTT AGC AGT CGG TCC ATA ATC

28. GTA CGA GGA GGA ATG ATC CAA CGA AAC CTC TTA TGA TAA TTA CTC AGG ATC CTA CGA ATA ATC

29. AAT CTC CGA GCT TTG TAG TTA CCC ATT TAG AGT ATC TAG TTG TGT CTC GCT CTC AGG TGC TAT TTG CCT ACT

30. CGA ACT AGA TAA CCC TTA TAG AAA TAT ACA CGC TTG TGA AAC ATA ATC CGG CTG CAA CGT TTA ACA CTC CTA ATT AGG ACA TAA CTC TTG ACA CTT ACT TAG AGA ACT CTC CGC TCA TAG GAG ATA ATT TAC TAA AGA TGA CGG TTT CTT TTG ACT CGA AGC ATT TAC CGC CCC TAG ATC

1. CCT CTT TGC ACT CGG ATC GTA CGC TAT TCT ATG ATT ACA CGG TTG CGA TCC ATA ATC
Get a hairy canary   (A. Mulder)

2. AGA TAC TAG GAC CTT ACT CGA TTG CTG ATT GCG CGA CTA TAA CGG TGC CTC ACT CGG ATT AAC TAG
        TGC TGA AAT CTT ATT ACG GTA CTT CTC GCC ATC
Smile and radiate a little cheer   (A. Mulder)

3. TCC CTT GGG GAA TAT ACA CGC TGG CTT ACT CGA ATT TGA CTC CGT ACG GTA CTC GCC ATC
Replicate a teacher   (J. Shepherd)

4. AGA ACA TAA CTC TTA ACA CTC TAA AGA CCA GCA CTC CGA TGA
Science is Great   (H. Bazan)

5. TAA ACT CGG TAC ATT CTA GCT TAG CAC TAA TTA CCC ATC
I am driving   (T. Nguyen)

6. TAC CGT TTC CTT ATT GAT CGC GCC CCA CTC ATT CTT CGG TCT AGG ATC
Make large ears   (J.G. Oliva)

7. CTA GCC CTC CGT TAC TAG TTA CCT ACT TAT TCA ATT TTG TAA ACG CTC ATC CGA ACC CGC TTT TAA
        TTG CCC ACT TAG TCG ATT ACC CGT TTA TGT TAA TTA CCT ATC
Dreaming is nice. Awaking is wanting (K. Vo)

8. ACC GTG ATA ACT CGT GCT CTT ATT ACC CTC ACT AAT CTC CGG TCC TTA TAT TTG CCT ATT TGC GTA
        TAG TCG ATC
Why are we learning this   (J. Mi1i)

9. TAC CGA TTT CTT ACT AGT GGC TCC TAT TTA CCT ATA ATT ACA GTG TAA ACG TTC CTC TTA TCA ATC
Make springy chickens(D. D. Ho)

10. CTA TTA CGA ACT TAG AGC ATT GAA TAG AAA CTT ATC
DNA is life   (P. Labrador)

11. CTC CAC GTG AGA ATT CAC CGA GCA TCA TAG TGG ATG ATT AGA ACC TAT TAC TAC TAT TTG CCT ATC
EVHS Varsity Swimming   (A. Valdez-Lanam)

12. ACC GTG ATA ACT CGA GCA CTC ATT GGC AAC CGC TTA TGT AGC ATT CCT TCT CTC CTT TTG ATC
Why are plants green   (A. Valdez-Lanam)

13. ACG GCT CTC CGT TGT CTC ACT CGA TTG ATT CTC ATG CTT ATC
Create an eye   (C. Smith)

14. CTG CTT AGT TAT CCA TTG ACT CGA ATT GTG CGC TTG CTG ATC
Design a hand   (D. Smith)

15. ACA GCC CTT CGC TGC CTC ACT CGA ATT AAA TAT TTG CCA CTC GCT ATC
Create a finger   (C. Smith)

16. AAA TAT TTA CTA ACT TGG GTA CTT ATT AGC CTC ACG GCG CTT TGT ATT TAC CTC AGA AGC CGA CCA
        CTC ATC
Find the secret message   (J. Thailer)

17. CTT CGA TGA ATT CCA GCC CTC CTT TTG ATC CTT CCA CCT AGC ATC CGA TTG CTA ACT GTA CGC TAM
Eat green eggs and ham   (H. Thompson)

18. AGT TAC TAA GAA CTT ACT TAG TGT TCA ATC GTA CTT CGA GAG TGG GTA ATG
Smile it's healthy   (H. Thompson)

19. ACC CGA TGG CTC TCT ATC TAT AGC ATT ACA AAC CTC CGA GCG
Water is clear   (J Blaskey)

20. ACG CTT GAA AAT AGG ACT CGA TCT CTC ATC CCG TCC CTG CGC TGC ATT TGT GTA TAG TTA CCC AGG
Cells are great things   (A. Skinner)

21. GAA CTC CGA TCT TTG TAT CCG ACT CTA TTA CGG ATC TAA AGC ATT CCT TCC CTT CGT TGT
Learning DNA is great (A. Skinner)

22. TAC ATA ACT TAC TAG TTA CTA ATC TAT AGA ATT TAC CGA CCC TTG TAT AAA TAG ACG CTT TTA TGC
         ATC
My mind is magnificent

23. TAA ACT GTG CGA CAC CTC ATT CGT ATC CTA GCG CTT CGT TAC ATC
I have a dream

24. AGA CGG CAA CTC ATT TGG GTG CTT ACT TGT TCT CTT CTC AGT ATC
Save the trees

25. CCG GCA CTC CTT CTA ATT GCT CTT TAG CCA TTA AGT ACT TAA TTG ATC ACC CGA AAT GAG ATT AGG
         TGT TCC CTC CTT TGC ATC
Greed reigns in Wall Street

26. GAT TAA AAA CTC ACT TAG AGC ATT AGT GGG CTT ACA TAA CGG GAA ATC
Life is special

27. ACC GTA ATG ATT TAG AGG ATC CTG TTA CGA ACT TTG CTC ACA CTT AGC AGT CGG TCC ATA ATC
Why is DNA necessary

28. GTA CGA GGA GGA ATG ATC CAA CGA AAC CTC TTA TGA TAA TTA CTC AGG ATC CTA CGA ATA ATC
Happy Valentines Day

29. AAT CTC CGA GCT TTG TAG TTA CCC ATT TAG AGT ATC TAG TTG TGT CTC GCT CTC AGG TGC TAT TTG
         CCT ACT
Learning is interesting

30. CGA ACT AGA TAA CCC TTA TAG AAA TAT ACA CGC TTG TGA AAC ATA ATC CGG CTG CAA CGT TTA ACA
         CTC CTA ATT AGG ACA TAA CTC TTG ACA CTT ACT TAG AGA ACT CTC CGC TCA TAG GAG ATA ATT
         TAC TAA AGA TGA CGG TTT CTT TTG ACT CGA AGC ATT TAC CGC CCC TAG ATC
A significantly advanced science is easily mistaken as magic

SAY IT WITH DNA: Message Maker

Student Handout

Since you will be expected to decipher a DNA message in the unit exam, it would be wise to get as much practice as possible. If you can have fun in the process, so much the better! You are to think up at least one good (clever? funny?) message that can be written using only the 20 symbols representing the 20 amino acids. Those 20 amino acids are represented by a universal single letter code, using all the letters in the English alphabet except B, J, O, U, X, and Z. This means, of course, that your message cannot have any B, J, O, U, X, or Z letters in it! A little restrictive, you see, so you will need to be a bit creative. After you have created your message (in English) on scratch paper, carefully print its DNA code along the length of a full separate sheet of notebook paper, held horizontally, using DNA triplets ONLY.

Try to keep it to one long row; make the letters clear. Include each row of mRNA, tRNA, amino acid sequence, and the English translation. **CAUTION:** obscene or derogatory messages are not acceptable, so use good judgment.

You will quickly notice that there is more than one codon for nearly every amino acid. Make a point of using different codons whenever you can for the same (amino acid) letter-symbol, especially when they occur side by side in succession.

Use the DNA-Amino Acid Dictionary below to help make your messages. You will need the tRNA Dictionary on your Protein Synthesis Worksheet for solving the messages.

"DNA - AMINO ACID DICTIONARY"
DNA Codons and the Amino Acids (symbols and abbreviations) for which they code.

DNA codon	AA sym	AA abr	DNA codon	AA sym	AA abr	DNA codon	AA sym	AA abr	DNA codon	AA sym	AA abr
CGA	A	ala	GTA	H	his	GGA	P	pro	TCA	S	ser
CGC	A	ala	GTG	H	his	GGC	P	pro	TCG	S	ser
CGG	A	ala	TAA	I	iso	GGG	P	pro	TGA	T	thr
CGT	A	ala	TAG	I	iso	GGT	P	pro	TGC	T	thr
ACA	C	cys	TAT	I	iso	GTC	Q	glu	TGG	T	thr
ACG	C	cys	TTC	K	lys	GTT	Q	glu	TGT	T	thr
CTA	D	asp	TTT	K	lys	GCA	R	arg	CAA	V	val
CTG	D	asp	AAC	L	leu	GCC	R	arg	CAC	V	val
CTC	E	glu	AAT	L	leu	GCG	R	arg	CAG	V	val
CTT	E	glu	GAA	L	leu	GCT	R	arg	CAT	V	val
AAA	F	phe	GAC	L	leu	TCC	R	arg	ACC	W	trp
AAG	F	phe	GAG	L	leu	TCT	R	arg	ATA	Y	tyr
CCA	G	gly	GAT	L	leu	AGA	S	ser	ATG	Y	tyr
CCC	G	gly	TAC	M	met	AGC	S	ser	ACT	-	space
CCG	G	gly	TTA	N	asn	AGG	S	ser	ATC	-	space
CCT	G	gly	TTG	N	asn	AGT	S	ser	ATT	-	space

Letters NOT available: B J O U X Z

SAY IT WITH DNA Protein Synthesis Practice Sheet

DECODING A DNA MESSAGE

Number of DNA Message Assigned: #_____ (carefully copy below the DNA message assigned):
Practice DNA message:

_____

mRNA:

_____

tRNA:

_____

AMINO ACID SEQUENCE (three-letter abbreviations are okay):

_____

Decoded Message (English word or words):

_____

CREATING A DNA MESSAGE

Practice DNA message:

_____

mRNA:

_____

tRNA:

_____

AMINO ACID SEQUENCE (three-letter abbreviations are okay):

_____

Decoded Message (English word or words):

_____

Test Supplement

You will be given a short DNA message or word to decode just as you did earlier with some practice messages. It is important that you SHOW HOW your cells do this, step by step. Show this on the special Message Sheet given you to do this.(16 points)

FIRST: Put your name, seat number, date, and period at top of page.
SECOND: copy the **number** of your message and the DNA message itself in the spaces so designated.
THIRD: decode the message, showing each step completely, just as it happens in your cells; be sure to label each step with the type of molecule involved in that step. NO SHORT CUTS! Use the dictionary provided below to determine which amino acids correspond with their respective t-RNA codes.
FOURTH: Take the letter-symbol of each amino acid used, arranged in its proper position, and print these letters on the "Decoded Message" line. They should spell out one or more short words.

DICTIONARY OF tRNA CODONS & THEIR AMINO ACIDS (SYMBOLS & ABBREVIATIONS)

tRNA	sym	AA	tRNA	sym	AA	tRNA	sym	AA	tRNA	sym	AA
AAA	F	Phe	CAA	V	Val	GAA	L	Leu	UAA	I	Iso
AAC	L	Leu	CAC	V	Val	GAC	L	Leu	UAC	M	Met
AAG	F	Phe	CAG	V	Val	GAG	L	Leu	UAG	I	Iso
AAU	L	Leu	CAU	V	Val	GAU	L	Leu	UAU	I	Iso
ACA	C	Cys	CCA	G	Gly	GCA	R	Arg	UCA	S	Ser
ACC	W	Trp	CCC	G	Gly	GCC	R	Arg	UCC	R	Arg
ACG	C	Cys	CCG	G	Gly	GCG	R	Arg	UCG	S	Ser
ACU	-	spc	CCU	G	Gly	GCU	R	Arg	UCU	R	Arg
AGA	S	Ser	CGA	A	Ala	GGA	P	Pro	UGA	T	Thr
AGC	S	Ser	CGC	A	Ala	GGC	P	Pro	UGC	T	Thr
AGG	S	Ser	CGG	A	Ala	GGG	P	Pro	UGG	T	Thr
AGU	S	Ser	CGU	A	Ala	GGU	P	Pro	UGU	T	Thr
AUA	Y	Tyr	CUA	D	Asp	GUA	H	His	UUA	N	Asn
AUC	-	spc	CUC	E	Glu	GUC	Q	Glu	UUC	K	Lys
AUG	Y	Tyr	CUG	D	Asp	GUG	H	His	UUG	N	Asn
AUU	-	spc	CUU	E	Glu	GUU	Q	Glu	UUU	K	Lys