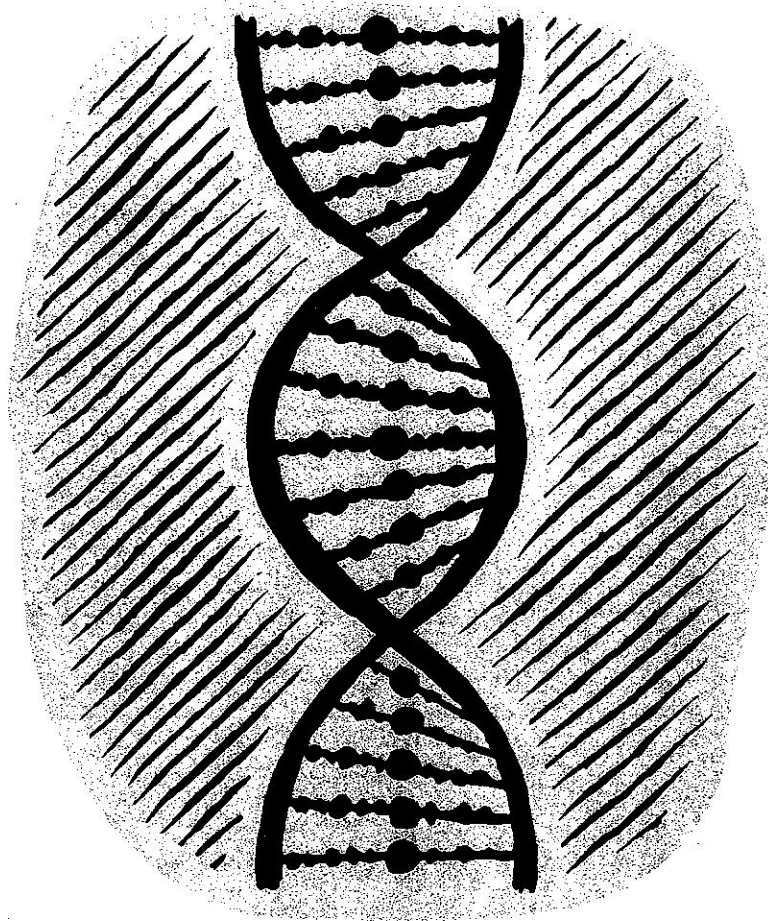


Protein Synthesis



Teacher Manual

Protein Synthesis Teacher Manual

Thank you for the purchase of the Protein Synthesis Manipulative Kit. This kit was designed and developed for use in the science classroom by a science teacher. All of us are aware that abstract concepts can be difficult for our students. I'm confident that this product can make it easier for you to teach, and for your students to learn protein synthesis.

In this manual, I will give you some ideas on how to get started using your new kit. The included CD will also be useful for this purpose. I'm sure, that in time you will discover a host of new applications and situations in which it can be used.

Placement of Magnets

Locate the box of magnets in your kit. Attach them to the back of your manipulatives according to Appendix D. Clean and dry the surface of the magnet and application site before application of glue. Epoxy, hot glue or a good plastic glue will work.

Teacher Kit Transcription

The Teacher Demonstration Kit begins with a double stranded DNA Model. Consisting of:

- A 3'-5' DNA strand (sense strand)
- A linear 5'-3' DNA strand (anti-sense) and
- DNA in the double helix that your students are probably most familiar with. The helix is included to prevent the misconception that the entire strand of DNA uncoils and is transcribed.

1. Arrange these three manipulatives on the board

2. Point out the features of the model.

- Backbone (phosphates-Yellow) (DeoxyRibose sugar-Black)
- Nucleotide bases
- Area of hydrogen bonding

3. Introduce the RNA polymerase enzyme manipulative. Use the enzyme to simulate the breaking of the hydrogen bonds between the DNA nucleotides as you physically separate the two complementary DNA strands.
4. Ask students to identify the RNA nucleotides complementary to each of the bases on the now single stranded 3'-5' DNA "sense strand".
5. Bond the requested RNA nucleotides to their complementary DNA nucleotides.
 - You have enough RNA nucleotides to build a complete mRNA
6. Introduce the complete mRNA manipulative. This comes in two pieces which are hinged together to allow for shipping.
7. Compare this mRNA to the one you just produced in (step 5). Verify for students that the RNA base sequence is the same in both.
8. Remove the individual RNA nucleotides from the board and bring back together the two complementary DNA strands.
9. Move the mRNA out of the nucleus through a nuclear pore and into the cytoplasm. Use tape or draw a line on your board to represent the nuclear membrane. A gap in the line will represent the opening of the nuclear pore.
 - Let students know that what has just taken place is transcription. The "blueprint" encoded in DNA has been transcribed into the message of mRNA. Stress that the entire process takes place in the nucleus of eukaryotes.
 - When teaching advanced students this is a good time to discuss mRNA processing with subsequent splicing of introns and exons.
 - This is also a good time to bring out an overhead or model of a eukaryote cell in cross section. Point out the nuclear membrane, nuclear pore, rough endoplasmic reticulum and the ribosomes. This will give students a visual picture of where cellular protein synthesis events are taking place.

Teacher Kit Translation

10. Now point out the features of the mRNA manipulative.

- Point out the change in color of the sugar in the “backbone” to indicate the change from deoxyribose to ribose sugar.
- Point out the codons, artificially grouped in three’s for emphasis.

11. Attach the ribosome manipulative to the board.

- Inquire what the ribosome is made of: Ans: RNA-protein complex and
- consists of a large and small subunit.
- Inquire about the two sites that will be occupied by t-RNA: The “P” site (on the left) and “A” site (on the right).
- How deep you want to go into the origin and structure of ribosomes will depend on the level of your students.

12. Simulate the mRNA initiator codon (A-U-G) entering the “P” site of the ribosome with the second codon (A-U-C) occupying the “A” site.

- Now that you have the initiator codon in the “P” site of the ribosome, inquire what the anti-codon complementary to the codon on the mRNA would be.

13. Place the transfer RNA with the (U-A-C) anti-codon on the board.

- Now is a good time to discuss structure and function of tRNA, codons and anti-codons.
- Provide students with a copy of the Genetic Code Table included in Appendix A at the end of this manual. This table provides the amino acids specified by each codon sequence on mRNA. Ask them to specify the amino acid that should be attached to this (U-A-C) tRNA

14. Attach the Methionine (MET) amino acid to the first t-RNA

15. Move the Methionine tRNA to the “P ” site on the ribosome. Line up the complementary anti-codon with the codon on the mRNA.

- Inquire what the tRNA anti-codon complementary to the mRNA codon now occupying the “A” site on the ribosome would be?

16. Place the tRNA with the (U-A-G) anti-codon on the board

- Using their table (Appendix A) have students identify the amino acid to be attached to this t-RNA

17. Attach the Isoleucine (Ile) amino acid to the second t-RNA

18. Move the Isoleucine tRNA to the “A” site on the ribosome. Line up the complementary anti-codon with the codon on the mRNA.

19. Insert the peptide bond manipulative between the Methionine and Isoleucine amino acids

- Depending on the level of students you are instructing, this may be a good time to teach peptide bonding between amino acids.

20. Shift the ribosome one reading frame to the right so the Isoleucine codon is now in the “P” site of the ribosome.

21. Move the Methionine t-RNA to the bottom of the board to simulate return to the cytoplasm for the purpose of obtaining another amino acid.

- Ask students what the anti-codon complementary to the codon (C-A-G) now in the “A” site on the mRNA would be?

22. Place the tRNA with the (G-U-C) anti-codon on the board

- Using their table (Appendix A) have students identify the amino acid to be attached to this t-RNA.

23. Attach the Glutamine (Gln) amino acid to the third t-RNA

24. Move the Glutamine tRNA to the “A ” site on the ribosome. Line up the complementary anti-codon with the codon on the mRNA.

25. Insert the model representing the peptide bond between the Isoleucine and Glutamine amino acids.

26. Shift the ribosome one frame to the right so the Glutamine is now in the “P” site.

27. Move the isoleucine t-RNA back into the cytoplasm.

- Ask students what the anti-codon complementary to the codon (G-U-A) now in the “A” site on the ribosome would be?

28. Place the tRNA with the (C-A-U) anti-codon on the board.

- Using their table (Appendix A) have students identify the amino acid to be attached to this t-RNA

29. Attach the Valine (Val) amino acid to the last t-RNA

30. Move the Valine tRNA to the “A ” site on the ribosome. Line up the complementary anti-codon with the codon on the mRNA.

31. Insert the model representing the peptide bond between the Glutamine and Valine amino acids.

32. Move the Glutamine t-RNA back into the cytoplasm.

33. Shift the ribosome one frame to the right so the Valine is now in the “P” site and the stop or termination codon is in the “A” site. This codon signals release of the ribosome and release of the newly formed polypeptide.

- Check student understanding. Call for student volunteers to explain the process using the manipulatives. Use good questioning techniques to check for misconceptions.

Student Kit

The student kit is designed to provide students the opportunity to practice the concepts introduced with the teacher demonstration manipulatives. It is also designed to allow the teacher an opportunity to assess student learning in an efficient manner. You will quickly discover individual student misunderstandings and be able to pinpoint where remedial help is required.

NOTE: Be sure that you provide **erasable** markers for students to write codes on the student manipulatives. If proper markers are used the manipulatives can be erased and should last indefinitely. If replacement parts are required contact United Scientific.

The student set consists of:

- DNA “sense strands” with pre-printed DNA base sequences. There are four different sequences. Each sequence is labeled 1-4 at the top of each strand. There are five copies of each of the four sequences for a total of twenty strands. Each of the four pre-printed DNA base sequences will produce a unique 5 amino acid sequence. The correct amino acid sequence for each of the four pre-printed DNA base sequences can be found in Appendix B of this manual. Use this key to quickly check the final step of a student’s work. If the students amino acid sequence does not match your key, check that the student has written the correct codons and anti-codons.
- Blank DNA strands upon which students code the bases complementary to the bases on the above “sense strand”
- Blank messenger RNA strands upon which the student writes the codons derived from the DNA “sense strand”
- Blank transfer RNA’s upon which the student writes the anti-codons complementary to the mRNA codons
- Blank polypeptide chain upon which the student codes the amino acid sequence. If correct this code will correspond to the teacher key in Appendix B. The three letter abbreviations for the amino acids can be found in Appendix C and should be copied for student use.