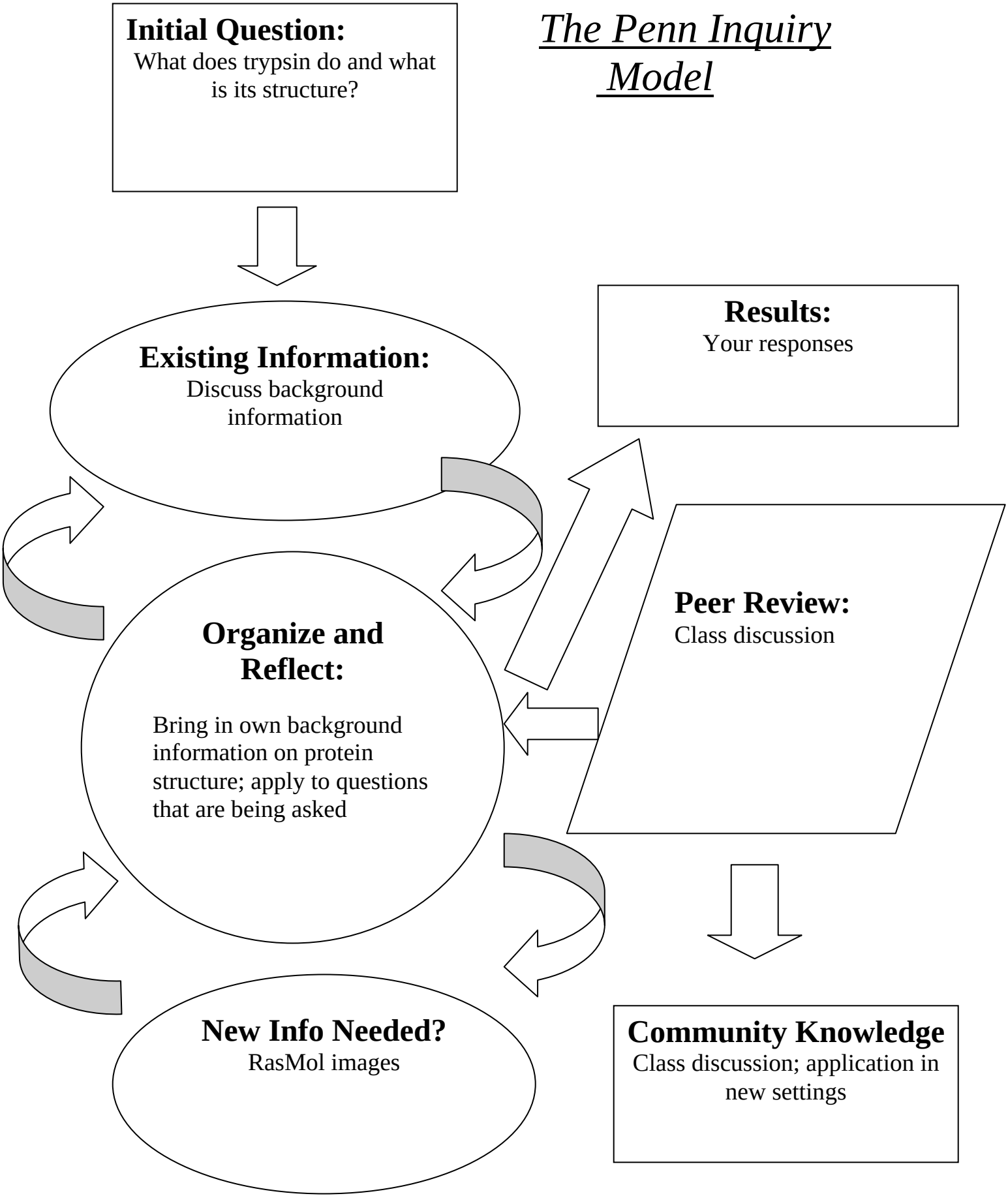
The Penn Inquiry Model



Jennifer Tareila
August 8, 2004
Lesson Plan: Pet Enzyme (Trypsin)

Title: Trypsin Lesson Plan
Audience: 11th and 12th grade Human Biology (some previous chemistry; all have had biology)
Goals: To introduce trypsin, a digestive enzyme, in the context of protein structures
Student Objectives:

At the end of the lesson, students will be able to:

1. Identify the structure of trypsin in the context of general protein structure.
2. Illustrate real life examples of protein structures
3. Use Ras-Mol
4. Identify the reactions catalyzed by trypsin

Purpose: To use trypsin as a model protein in regards to structure; identify the reaction(s) catalyzed by trypsin.

Materials/ Resources:

Computer with Internet access; handout
Printer
Colored pencils/ markers/ crayons
Web link to protein data bank

Prior preparation: verification of web addresses; copies for students of handout questions, protein structure lesson, preview of RasMol program,

Time required: One class period (48 minutes)

Procedure: Student groups are to answer the questions on the handout using the web pages provided, then discuss questions as a class.

Assessment: Quiz

Name: _____ Date: _____

Partner:_____

Web resources:

http://bioinformatics.weizmann.ac.il/hyd-bin/plot_hydroph.pl

RCSB Protein Data Bank
http://www.rcsb.org/pdb/cgi/explore.cgi?job=chains&pdbId=1A0J&page=0&pid=25048 1091560047. Protein ID 1AOJ
Go to the address and search for the protein by its ID; select the first response by selectring explore; download the rasmol file and open it on the desktop. Take a few moments to explore what you can do in rasmol. You can always go back to the original. Print a copy of the ribbon form in monochrome to color as you go along.

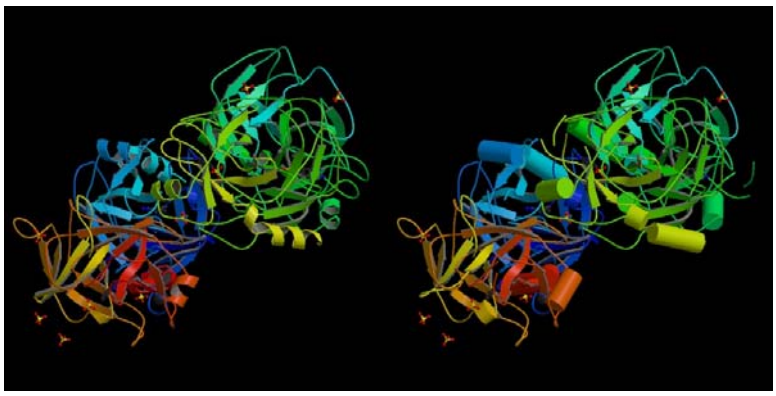
(Links may also be found on the class webpage or on my hotlist in the "Teacher Hotlist" folder on the shared drive of the server.)

Directions: Use the web sites above to answer the following questions on a separate sheet of paper.
Questions:
1. How many chains are present in trypsin?
2. In each chain, identify and color red the helices.
3. In each chain, identify and color blue the pleated sheets.
4. Explain why pleated sheets and helices form.(go back to class notes if you need to!)
5. What is a hydropathicity plot is and why it is significant.
6. Describe any tertiary structure.
7. Describe any quaternary structure.
8. Given that trypsin cleaves proteins at Arg and Lys, what peptide piece would be created from the following protein sequence being cleaved by it?

Met-Arg-Lys-Gly-Glu-Try-Asn-His-Pro-Arg-Cys- Asp- Ala-Gly-Arg-His-Cys-Lys-Trp-Lys-Ser-Glu-Asn-Leu-Ile-Arg-Thr-Tyr

Jennifer Tareila

Pet Enzyme Project/ Lesson Plan on Trypsin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What reaction(s) is specifically catalyzed by your enzyme?

Trypsin cleaves proteins at Arg or Lys by cutting at the carboxy terminus at these amino acids; in addition it activates other proteases like trypsinogin, chymotrypsinogin, elastase, and procarboxypeptidase. If there are 30 Arg and Lys residues present, there will be 31 peptide fragments created.

$H3N^+$- Asp- Ala-Gly-Arg-His-Cys-Lys-Trp-Lys-Ser-Glu-Asn-Leu-Ile-Arg-Thr-Tyr-C

$H3N^+$- Asp-Ala-Gly-Arg-C + $H3N^+$- His-Cys-Lys-C + $H3N^+$- Trp-Lys-C

+ $H3N^+$- Ser-Glu-Asn-Leu-Ile-Arg-C + $H3N^+$- Thr-Tyr-C

(1, 2, 3)

What is its Primary structure?

Chain 1A0J:A

Sequence

```
   1 IVGGYECRKN SASYQASLQS GYHFCGGSLI SSTWVVSAAH CYKSRIQVRL

  51 GEHNIAVNEG TEQFIDSVKV IMHPSYNSRN LDNDIMLIKL SKPASLNSYV

 101 STVALPSSCA SSGTRCLVSG WGNLSGSSSN YPDTLRCLDL PILSSSSCNS

 151 AYPGQITSNM FCAGFMEGGK DSCQGDSGGP VVCNGQLQGV VSWGYGCAQR

 201 NKPGVYTKVC NYRSWISSTM SSN
```

Chain 1A0J:B

Sequence

```
   1 IVGGYECRKN SASYQASLQS GYHFCGGSLI SSTWVVSAAH CYKSRIQVRL

  51 GEHNIAVNEG TEQFIDSVKV IMHPSYNSRN LDNDIMLIKL SKPASLNSYV

 101 STVALPSSCA SSGTRCLVSG WGNLSGSSSN YPDTLRCLDL PILSSSSCNS

 151 AYPGQITSNM FCAGFMEGGK DSCQGDSGGP VVCNGQLQGV VSWGYGCAQR

 201 NKPGVYTKVC NYRSWISSTM SSN
```

Chain 1A0J:C

Sequence

```
   1 IVGGYECRKN SASYQASLQS GYHFCGGSLI SSTWVVSAAH CYKSRIQVRL

  51 GEHNIAVNEG TEQFIDSVKV IMHPSYNSRN LDNDIMLIKL SKPASLNSYV

 101 STVALPSSCA SSGTRCLVSG WGNLSGSSSN YPDTLRCLDL PILSSSSCNS

 151 AYPGQITSNM FCAGFMEGGK DSCQGDSGGP VVCNGQLQGV VSWGYGCAQR

 201 NKPGVYTKVC NYRSWISSTM SSN
```

Chain 1A0J:D

Sequence

```
   1 IVGGYECRKN SASYQASLQS GYHFCGGSLI SSTWVVSAAH CYKSRIQVRL

  51 GEHNIAVNEG TEQFIDSVKV IMHPSYNSRN LDNDIMLIKL SKPASLNSYV

 101 STVALPSSCA SSGTRCLVSG WGNLSGSSSN YPDTLRCLDL PILSSSSCNS

 151 AYPGQITSNM FCAGFMEGGK DSCQGDSGGP VVCNGQLQGV VSWGYGCAQR

201 NKPGVYTKVC NYRSWISSTM SSN
```

(5)

What is its Secondary structure?

The secondary structure of trypsin has three helices (per chain); one large, one intermediate size, and one small. It contains two large regions of beta sheets. The center is mainly hydrophobic, with the exterior being mostly hydrophilic.


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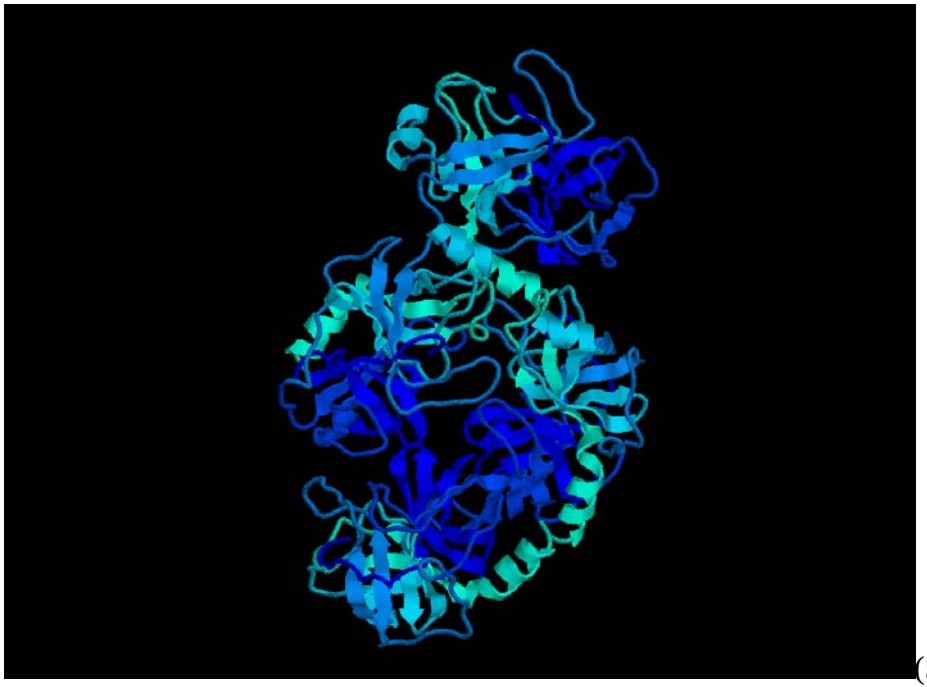
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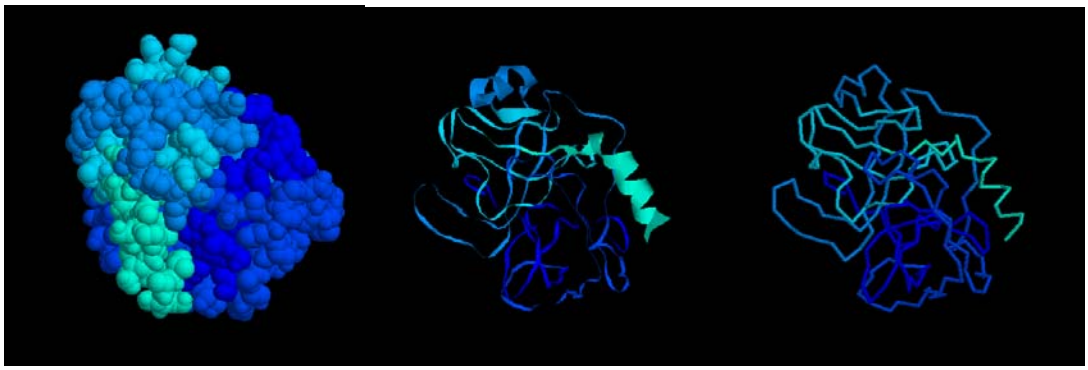
Views from each chain:

(5)



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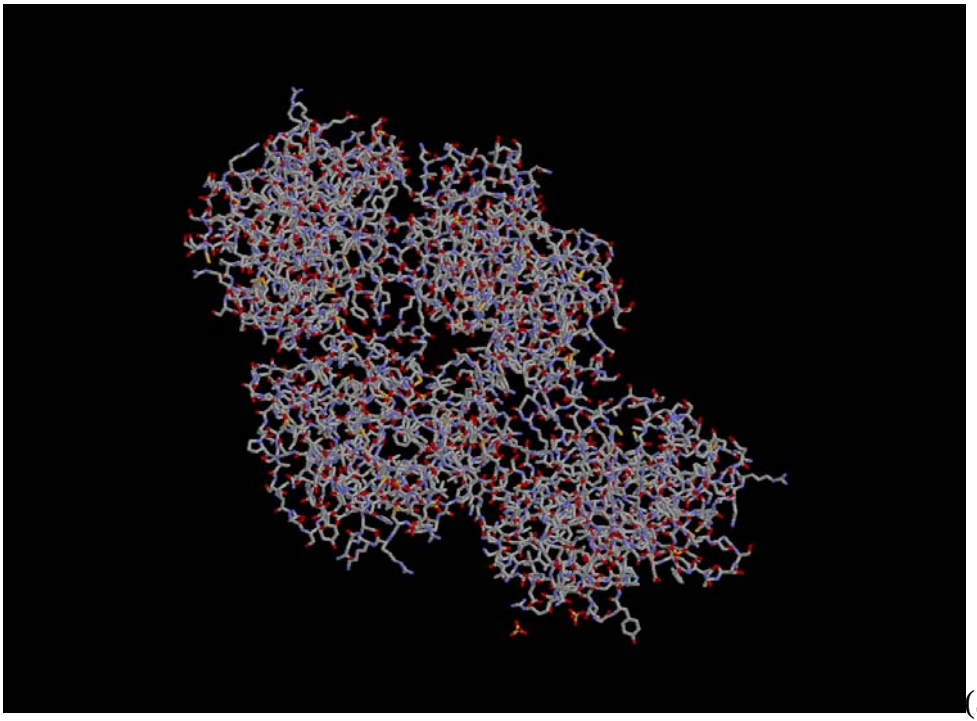
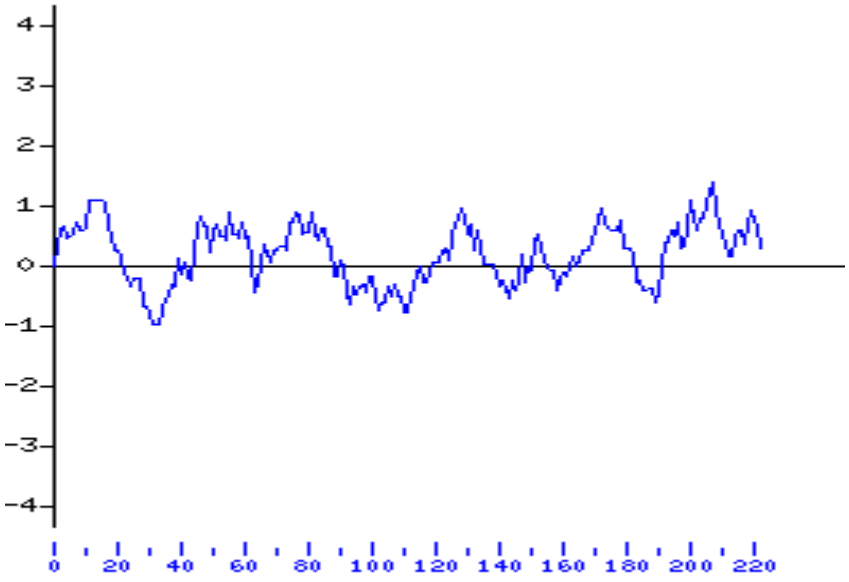


(5)

What is the Hydropathicity Plot for your enzyme?



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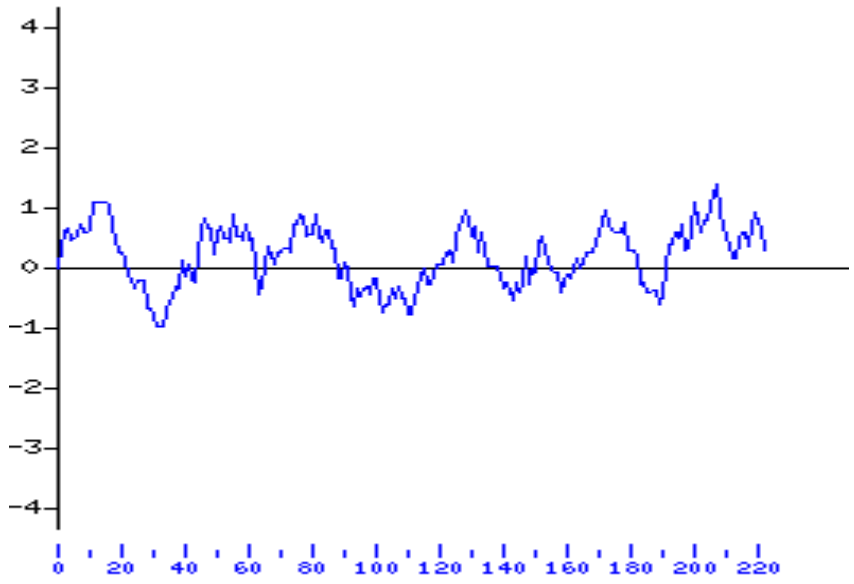
Chain A



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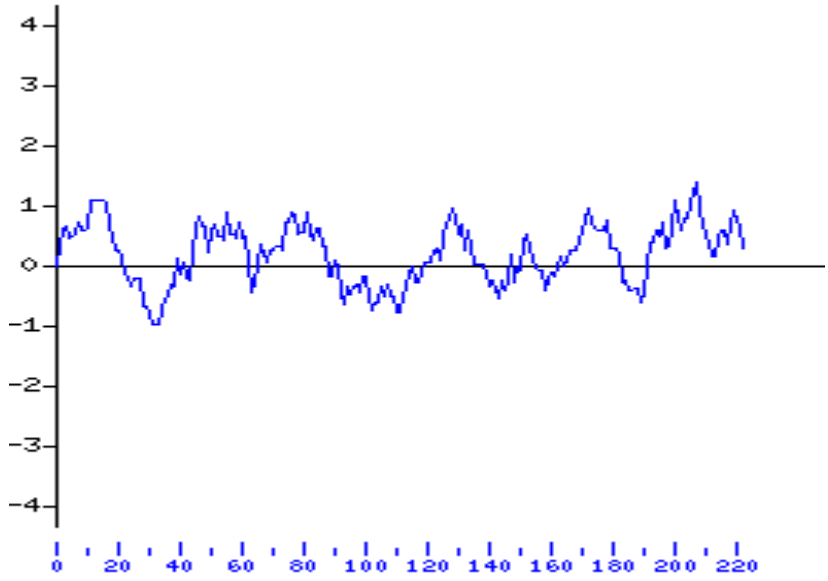
Chain B



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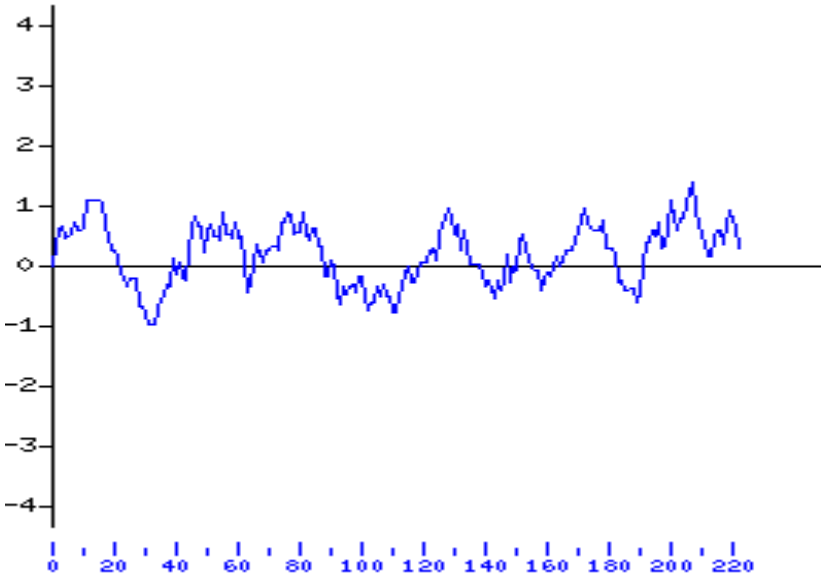
Chain C



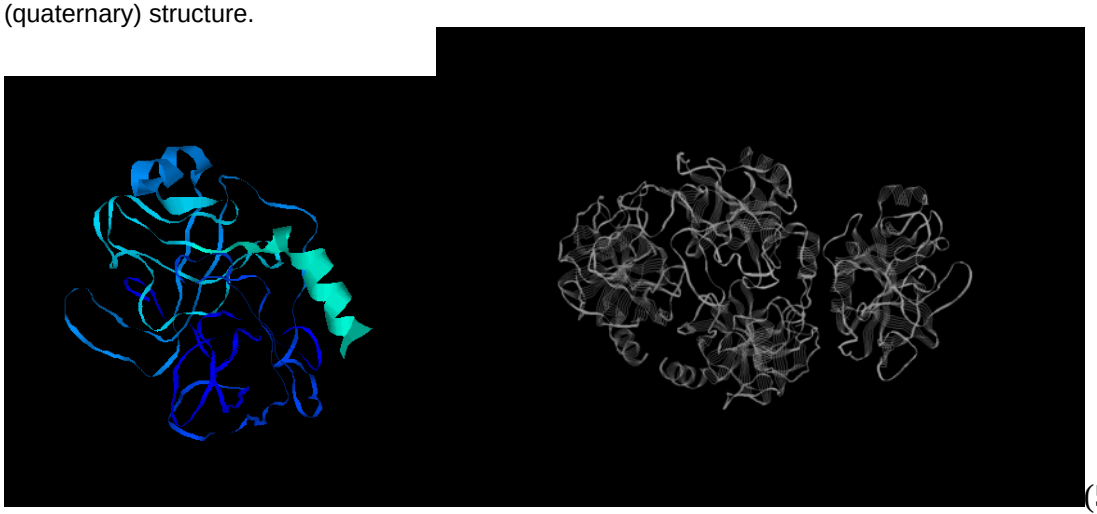
(4)

Chain D

Hydrophathicity plots indicate the interactions with water of an amino acid sequence, giving an overall view of the nature of the protein. As a result, one can also see the regions of amino acid sequence with respect to the nature of the amino acids and correlate it to the location on the completed protein; and therefore correlate the secondary structure to the sequence and location (inner or outer) region of the complete, folded protein. Trypsin has 7 hydrophobic regions (above the origin above), and 6 hydrophilic regions.

What is its Tertiary, and, if it has any, its Quaternary structure?

The individual chains can be seen below; it is easier to see the regions when in the final protein form (quaternary) structure.



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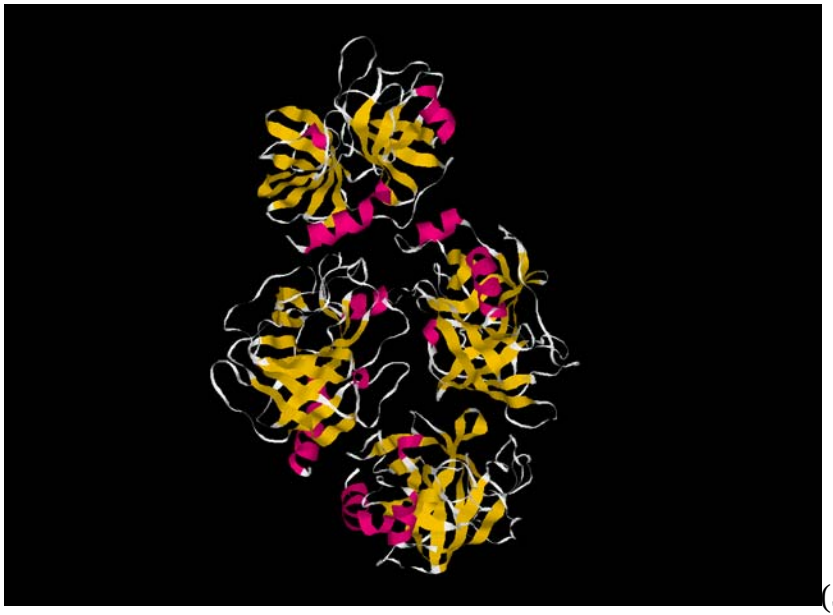
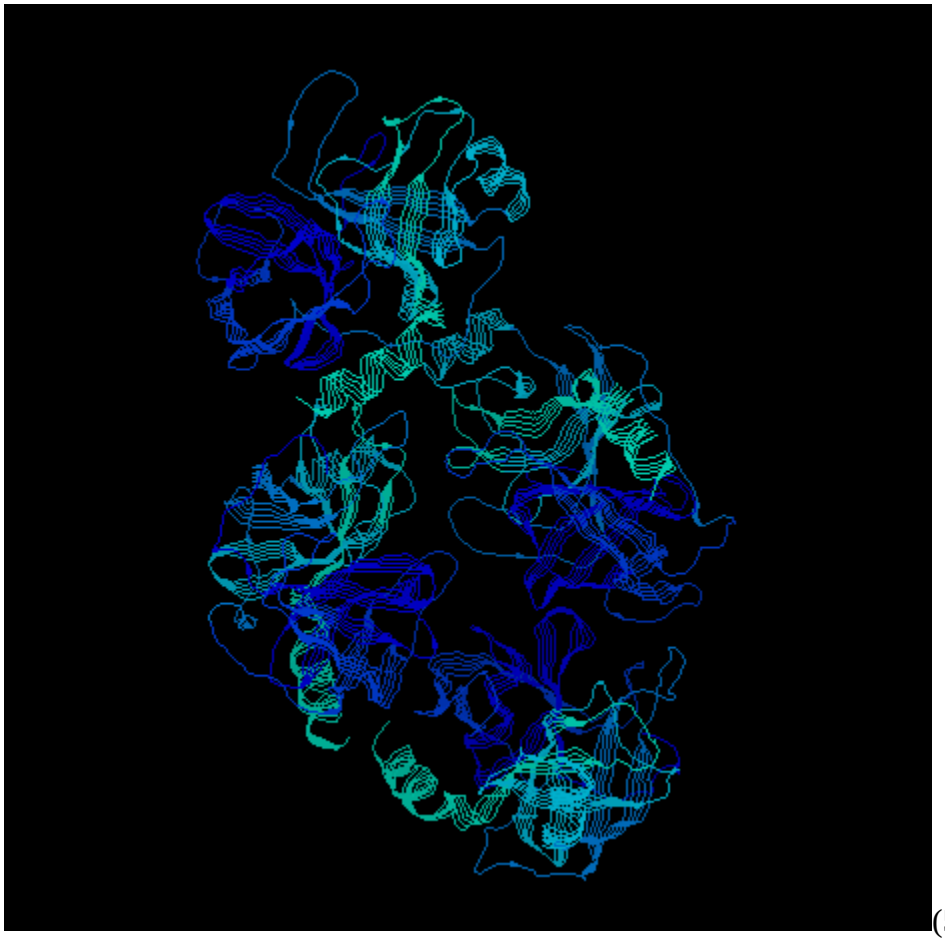
 (5)

It can be seen in the above diagrams that the beta sheets are folded in the interior, and the helices are located on the exterior of the tertiary structure.

It does have quaternary structure; there are four very similar chains present (as can be seen from looking at the primary structures).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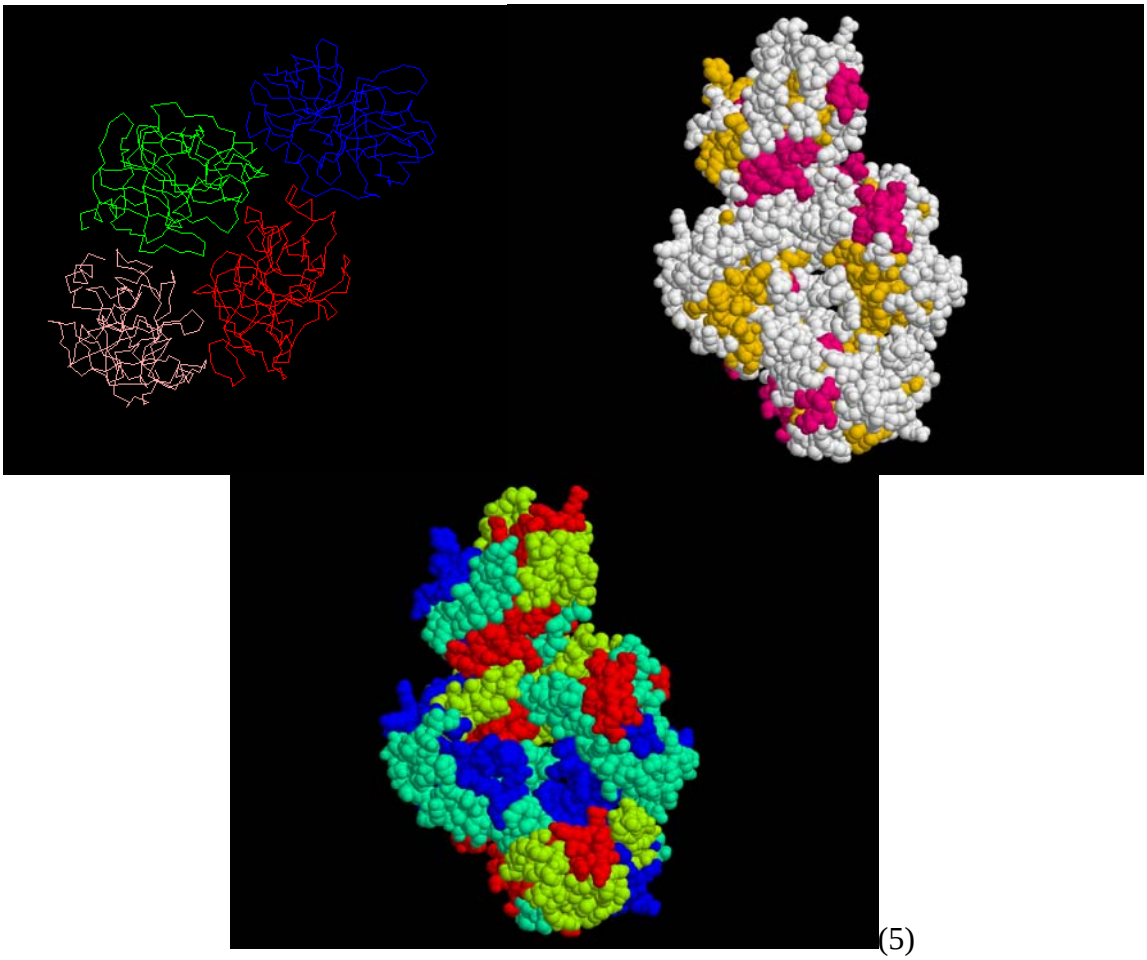 (5)

Are there any ligands present? If so, what are their structures? How many are present? Where are they located?

No ligands present.

Finally, because this is a topic you have investigated for presentation in your Lesson Plan, what are the references and sources for all of your information?

1. Bio220 Exam with posted answers available at http://www.muhlenberg.edu/depts/biology/courses/bio220/keyex1.html Accessed August 8, 2004

2. Chemistry 3560 lectures notes, accessed online at http://www.chembio.uoguelph.ca/educmat/chm356/3560L11.pdf on August 8, 2004.

3. Garrett, Reginald; Grisham, Charles. Principles of Biochemistry with a Human Focus. Brooks/Cole Thomson Leanring, USA. 1997. p 96.

4. Hydrophobicity plot from Plot the Hydropathic of a protein.
http://bioinformatics.weizmann.ac.il/hyd-bin/plot_hydroph.pl
accessed August 2, 2004

5. RCSB Protein Data Bank
http://www.rcsb.org/pdb/cgi/explore.cgi?job=chains&pdbId=1A0J&page=0&pid=250481091560047. Protein ID 1AOJ Accessed August 3, 20024 (all images)