Worcester Polytechnic Institute

Education through Visualization

Designing a Year 12 Chemistry Educational Program

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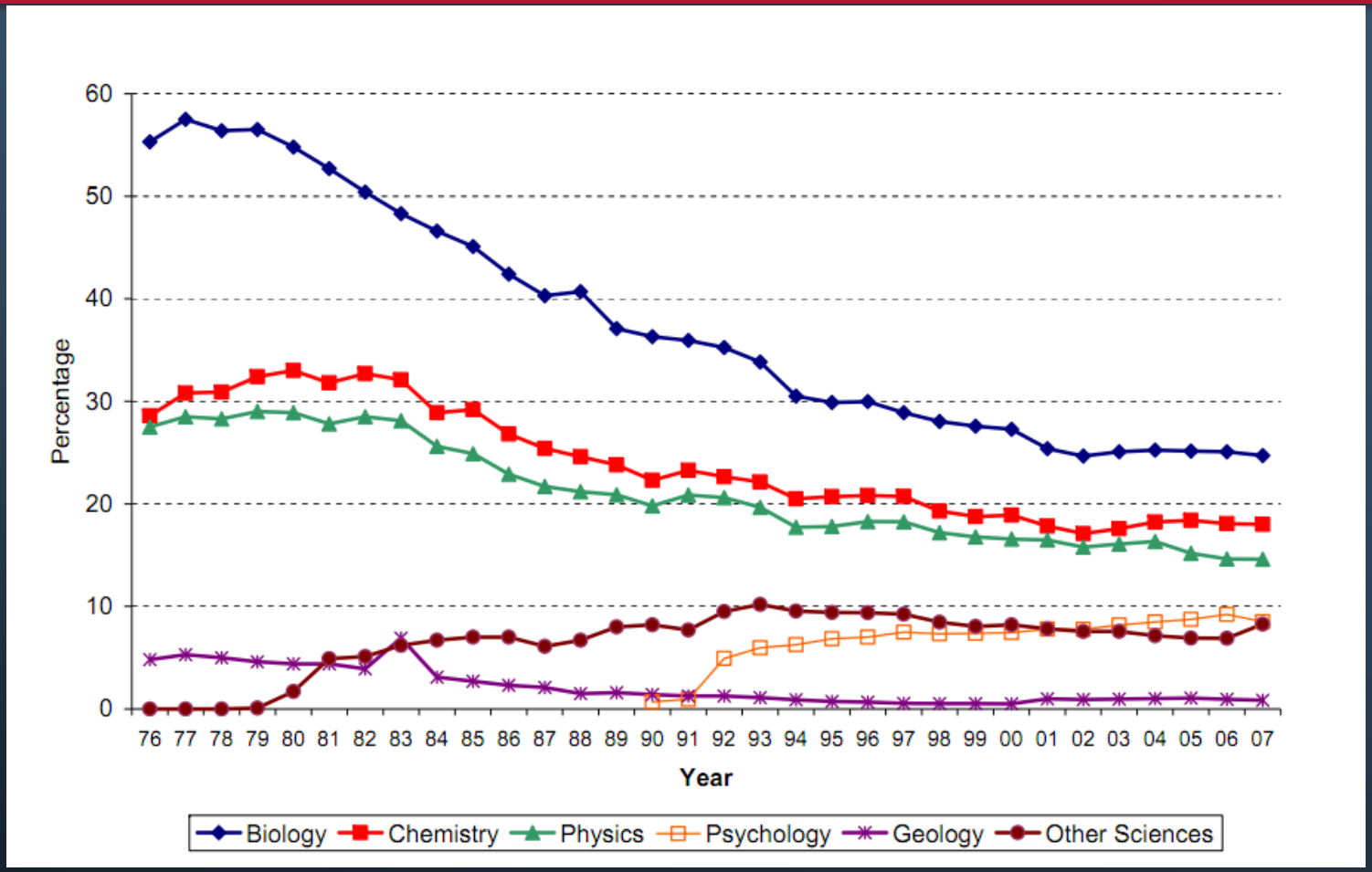
Worcester Polytechnic Institute

A Decline in STEM

- Globally, 40% of STEM students will not complete their major[1]
  - Low participation in University STEM majors has downsized the departments
- Enrolment of year 12 students in Australia in STEM courses has halved since 1976 [2]

1.Gregson, R. (2007) Motivating science students to select science as a field to study and as a career. *Discover Science*
2. Dekkers, J., & De Laeter, J. (2001). Enrolment trends in school science education in Australia. *International Journal of Science Education, 23*(5), 487-500

Decline in Year 12 Science Enrolment



Year 12 science participation as a percentage of the Year 12 cohort

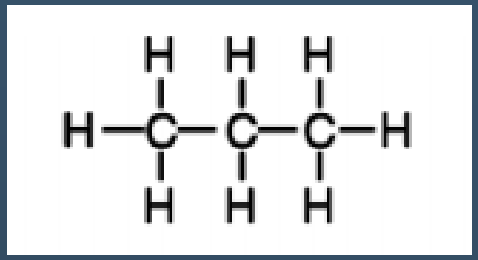
1. Ainley, J., Kos, J. & Nicholas, M. (2008). *Participating in science, mathematics and technology in australian education.* Retrieved 2/5, 2012, from http://research.acer.edu.au/acer_monographs/4

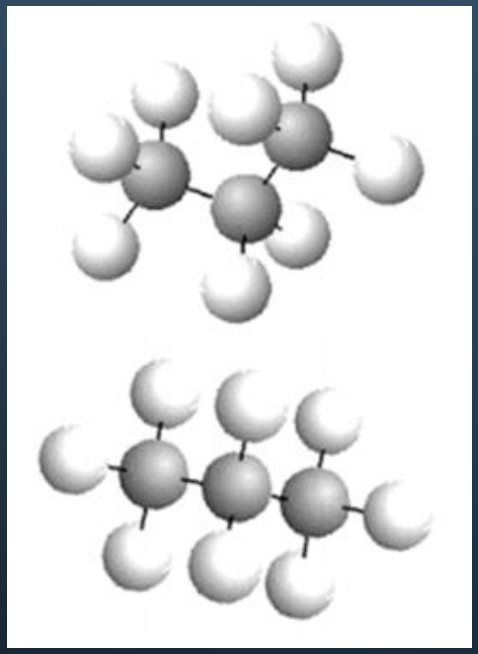
Bio-Chemistry is Very Complex

- In part this decline is a result of material complexity.
- Concepts like DNA were only recently introduced into chemistry education

Visuals and Learning

- In a 2000 case study with simple 3D images, the students improved their test scores by 85%.

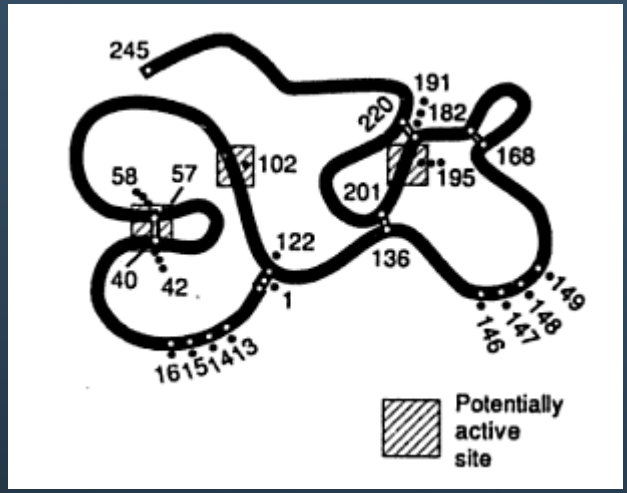




Wu, H. K., J. S. Krajcik, and E. Soloway. "Promoting Understanding of Chemical Representations: Students' use of a Visualization Tool in the Classroom." Journal of Research in Science Teaching 38.7 (2001): 821-42. Web.

The Current Issue

"The chymotrypsin molecule has a chain length of 246 amino acids. The active site of chymotrypsin is identical to that of trypsin. It is believed that the conversion of inactive precursor zymogen forms of both trypsin and chymotrypsin to active forms involves, essentially, a change in the conformational state of enzyme protein so as to expose the catalytic site of the enzymes."[1]



1. Talwar, G. P., & Srivastava, L. M. (2003). ***Textbook of biochemistry and human biology*** (3rd ed.). New Delhi: New Delhi : Prentice-Hall of India.

- CSIRO Education
  - Education centres across the country
- Provides dozens of educational programs for all ages

Photos Courtesy of www.csiro.au

Our Project

- Creating the foundations for a new year 12 educational chemistry program
  - Focusing on the visualization of 3D biomolecules
- Effects
  - Help students visualize abstract and microscopic concepts
  - Biochemistry will be more accessible and more tangible

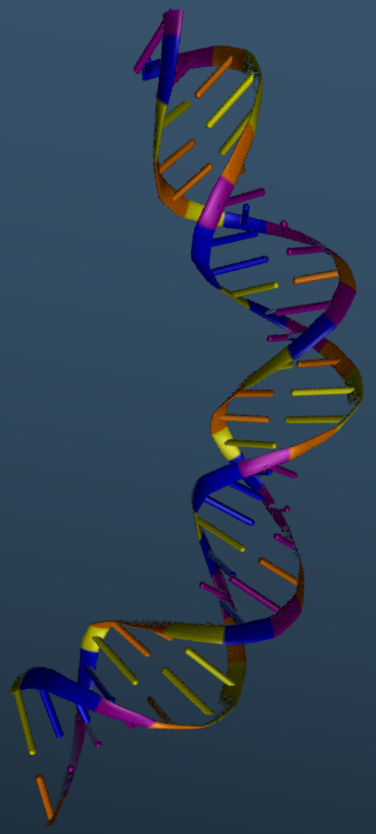
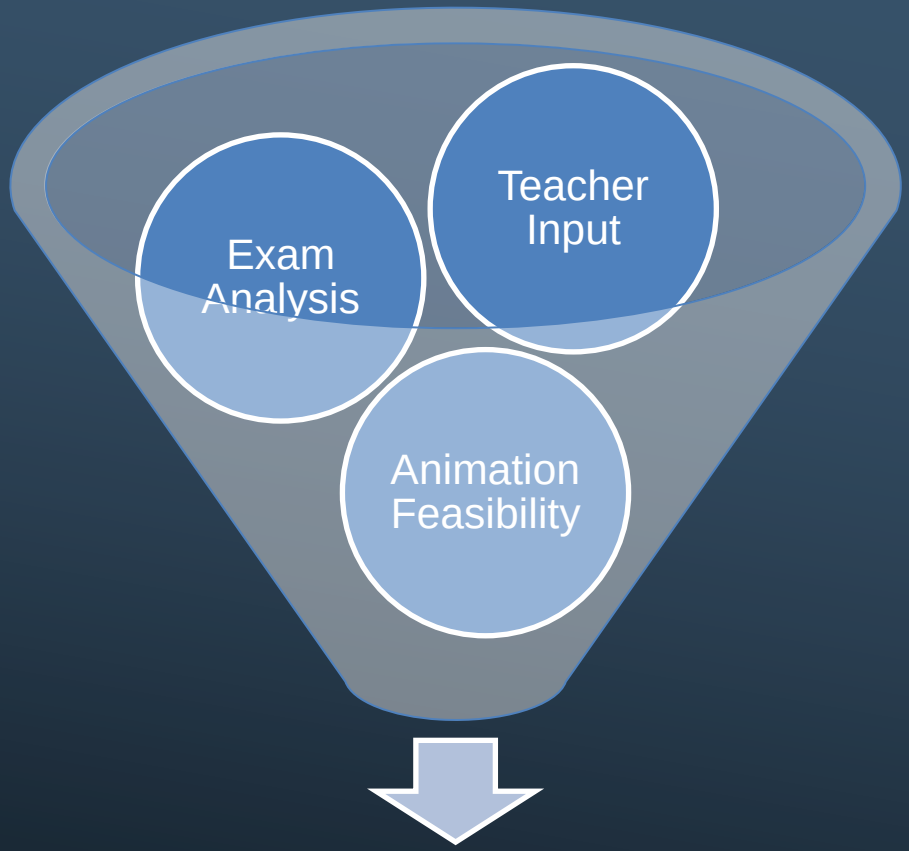


Image courtesy of Humphrey, W., Dalke, A. and Schulten, K., ``VMD - Visual Molecular Dynamics" *J. Molec. Graphics* **1996**, *14.1*, 33-38.

Objectives

- Identify the concepts of VCE Chemistry that are difficult to visualize using standard teaching techniques.
- Determine logistical program requirements.
- Determine the suitability of Visual Molecular Dynamics (VMD) for generating educational animations.

Distinguishing Chemistry Concepts



Determine Program Constraints

Features and Limitations of VMD

- Interview Dr. Mike Kuiper
  - Computational Molecular Scientist
- Investigate other animations created with VMD
- Determine how VMD will affect and restrict our animation storyboards

Findings

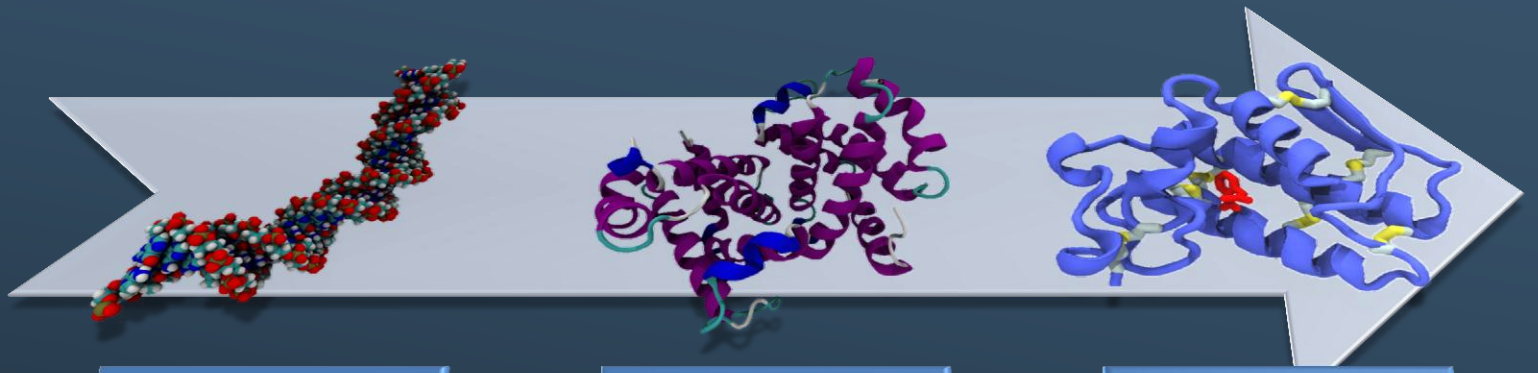
- Determined valuable information for creating a new educational program
  - Metrics – cost, size, and time
  - Science content to focus on
  - Specific abilities of VMD Software
  - Additional content and recommendations

Position in Curriculum

Introduction → Mid-Term → **Conclusion**

- Teachers prefer a conclusion
  - Opportunity for VCE Exam review
- Greatly influences subject matter
  - Less time reviewing
  - More real-world examples
  - Opportunity for Career Relevance

Content Narrative



DNA

- *Genetic Storage*
- *Codes for proteins*

Proteins

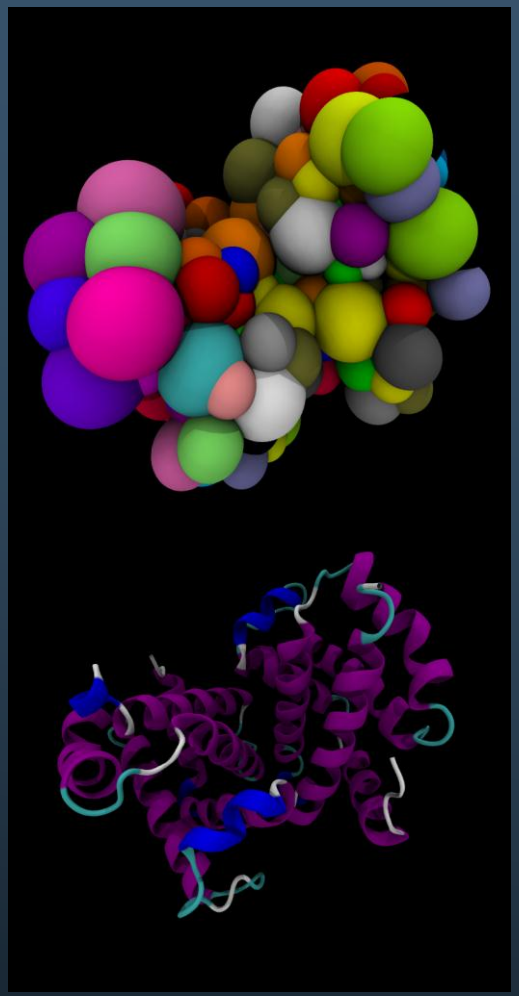
- Metabolic Machines
- Enzyme Action

Drug Design

- Protein Analysis

Molecular Modeling

- Utilize VMD to generate animations
  - Detailed 3D representation of any protein
  - Realistically simulates motion.



Going Beyond Videos

- Supporting activities:
  - 3D models
  - Kinetic activities
  - Worksheets

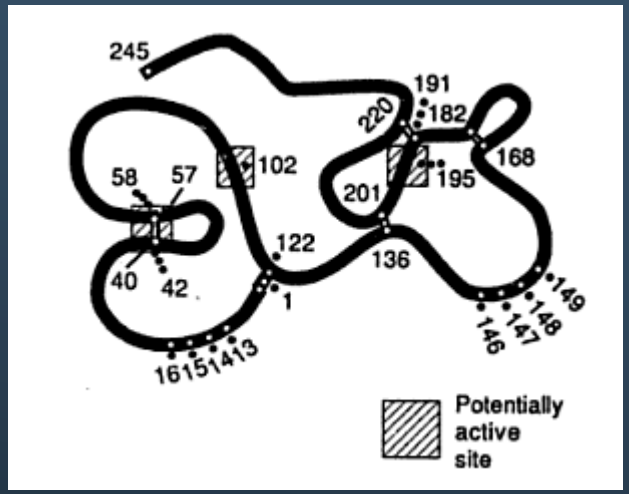
Flaten, J. (Photographer). (2012). *http://www.life123.com/hobbies/scale-models-and-model-making/science-models/how-to-make-a-dna-model.shtml*. [Web Photo]. Retrieved from http://www.life123.com/hobbies/scale-models-and-model-making/science-models/how-to-make-a-dna-model.shtml

Recap

- Program Recommendations:
  - Metrics: 1 Hour – 15-30 Students - Conclusion
  - Content: DNA – Proteins – Drug Design
  - Animation: VMD – Full featured
  - Augment program with additional activities

Recall

"The chymotrypsin molecule has a chain length of 246 amino acids. The active site of chymotrypsin is identical to that of trypsin. It is believed that the conversion of inactive precursor zymogen forms of both trypsin and chymotrypsin to active forms involves, essentially, a change in the conformational state of enzyme protein so as to expose the catalytic site of the enzymes."[1]



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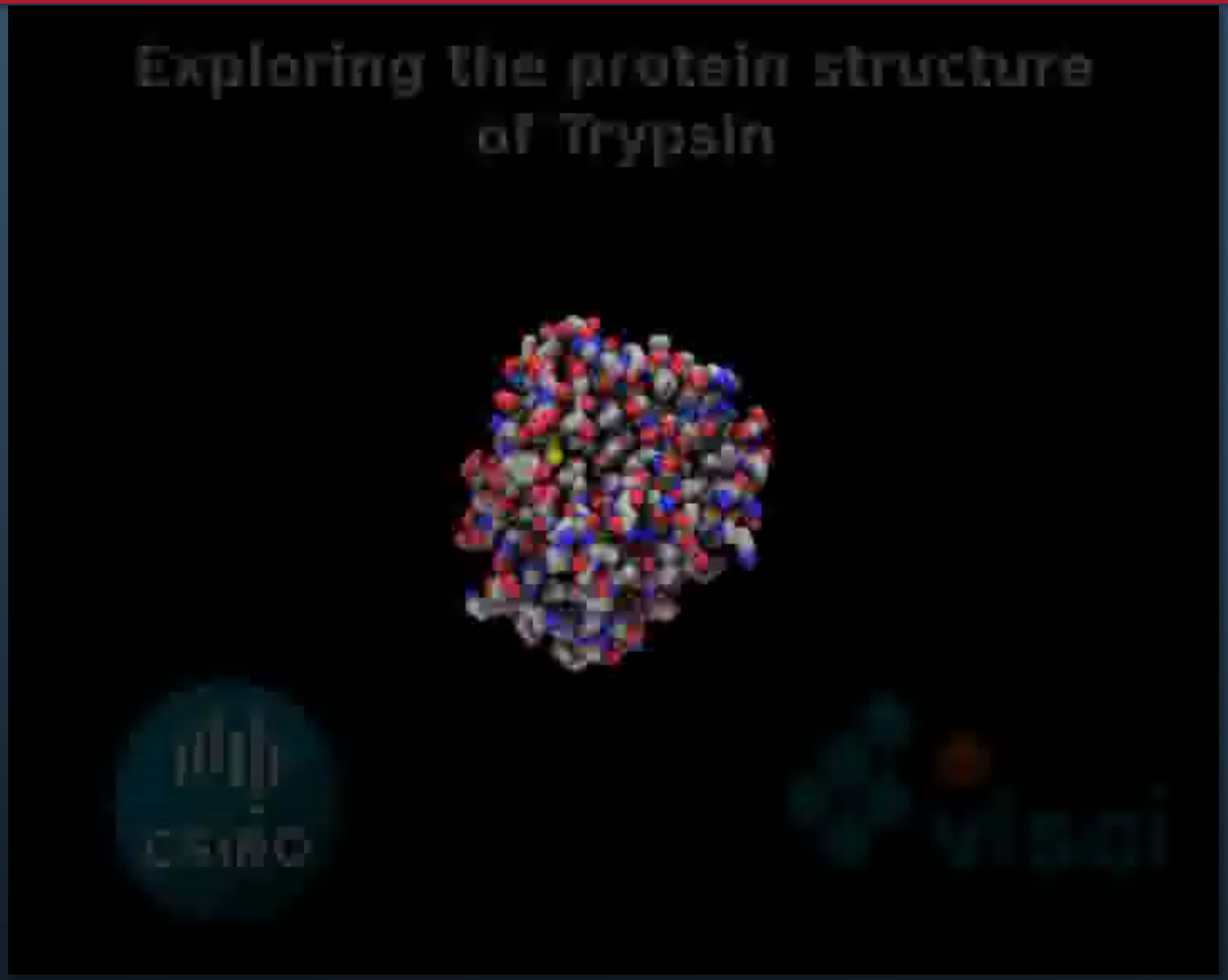
Trypsin in Action

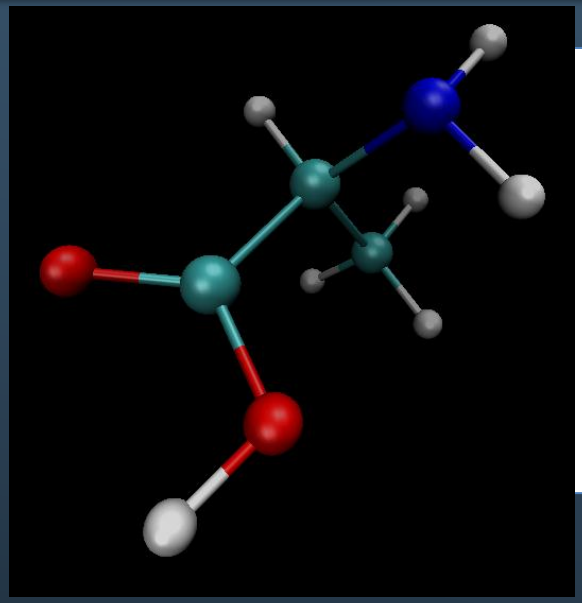


Questions?

Program Metrics

- Cost should be 20 to 30 dollars per student
  - CSIRO does this every day
  - Continue to find RMIT-Style sponsors
- Program should hold 15-30 students
  - Accommodates double classes
- Program Duration: Approx. 1 hour

VCE Exam Questions



Question 6

Alanine, lysine and aspartic acid are amino acids.

Which of these will react with 1.0 M HCl(aq)?

A. lysine only

B. alanine and lysine only

C. aspartic acid and lysine only

D. alanine, aspartic acid and lysine

The tertiary structure of a protein is maintained by interactions between the side chains of amino acid residues. One such interaction is between cysteine residues.

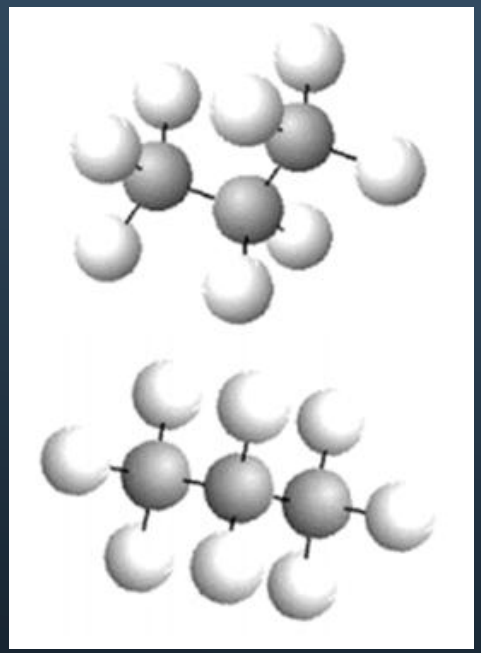
d. In the space below, sketch a covalent link that can form between the side chains of two cysteine residues. Only the relevant atoms that form the link need to be shown.

1.Question 6 is from the 2011 VCE Exam. The other question is

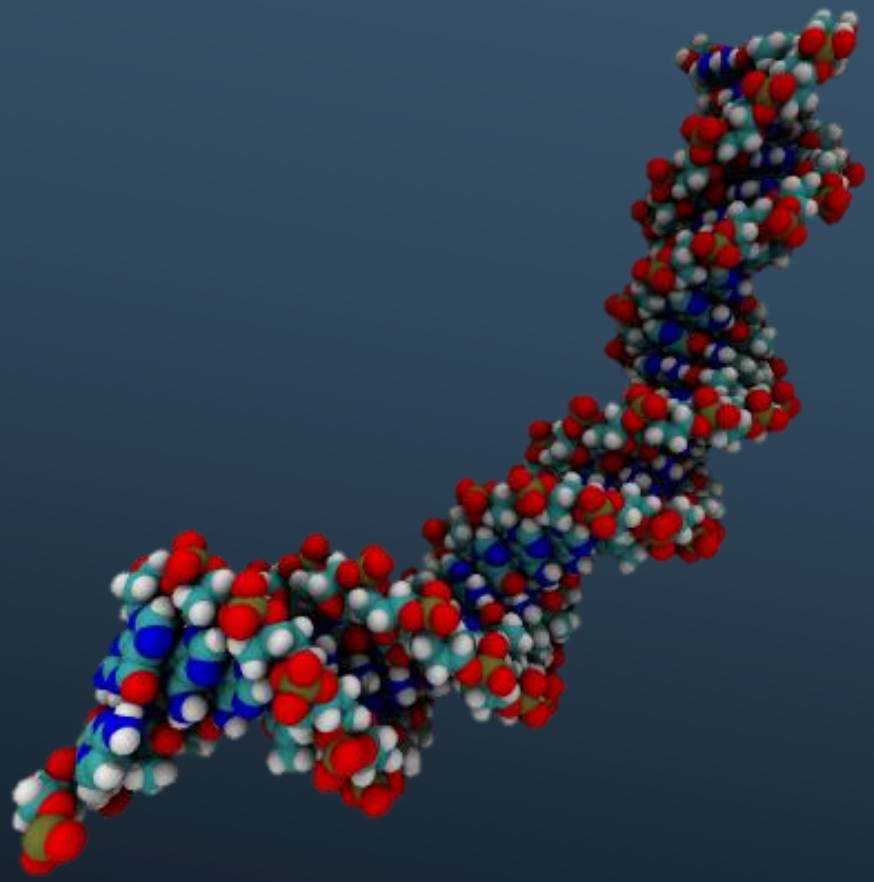
VCE Explained

- VCE – Victorian Certificate of Education
- Students in year 12 VCE Chemistry take two exams, until next year.
- Similar to Advanced Placement (AP) in US

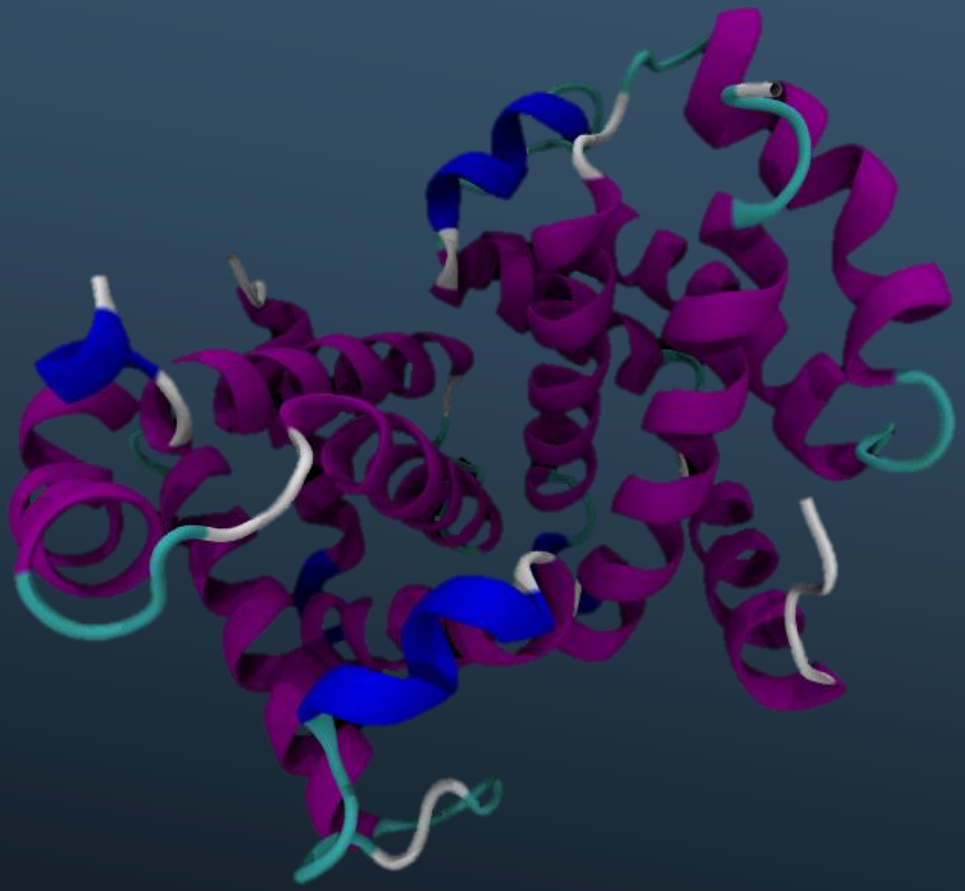
Additional Comparison



DNA Segment



Hemoglobin Tertiary Structure



Aspirin Binding Site