

Introduction to Protein Structure Collection



Teaching Points

This collection is designed to introduce students to the concepts of protein structure and biochemistry. Different activities guide students from the basic building blocks of proteins, amino acids, through the different levels of protein structure. Using the MolyMod[®] models, students learn the different atomic components of an amino acid and how a peptide bond is formed through the loss of a water molecule. The Water Cup provides an overview of how water is essential for influencing protein folding. With this model collection, students can assemble an α -helix or anti-parallel β -sheet, compare the phi/psi angles of the two secondary structures, and explore the contribution of hydrogen bonding to the stability of secondary structure. Sidechains allow students to explore the different chemical properties of each group and how these properties help determine protein folding. Models of the α -helix and β -sheet, with and without sidechains, allow comparison of the features of the two secondary structures. Two protein models display tertiary protein structure. The β -globin protein consists predominantly of α -helices while the green fluorescent protein (GFP) consists predominantly of β -sheets. A flexible foam Toober[®] (made with wire in the center and 48" long) allows students to create their own protein structures while exploring basic protein-folding principles. The Amino Acid Starter Kit[®] incorporates foam amino acid residues on a Mini-Toober[®], providing a more advanced protein folding activity. This collection also includes a protein modeling activity that enables students to fold a Mini-Toober[®] to create a model of a zinc finger.

Models in this Collection

- Water Cup[®]
- Water Cup[®] CD
- MolyMod[®] models
- 15 Tacks and a 4 Foot Toober
- Amino Acid Starter Kit[®]

- Amino Acid Starter Kit[®] CD
- α -helix/ β -sheet construction kit
- α -helix backbone without sidechains
- α -helix backbone with sidechains
- β -sheet backbone without sidechains
- β -sheet backbone with sidechains
- β -globin protein
- Green fluorescent protein (GFP)
- Zinc finger folding activity

Model Details

- Water Cup[®]
 - 12 molecules of water with magnets to simulate hydrogen bonds
 - 1 sodium atom (blue) with magnets for interaction with water molecules
 - 1 chloride atom (green) with magnets for interaction with water molecules
 - 1 hydroxyl group with magnets for interaction with water molecules; combines with ethane core to form ethanol
 - 1 ethane core (2 grey carbon atoms, 5 white hydrogen atoms without magnets to simulate non-polar interactions with water molecules); used to make ethane or ethanol
 - 1 grey plug and white hydrogen cap without magnet; binds to ethane core to form ethane
- Water Kit[®] CD
 - Water Kit Basic Lesson Plans
 - Water Kit Constructivist Lab
 - Water Kit Flip Card
 - Ice and Snowflake Instructions
 - Project Wet and the Water Kit
 - Other Water Resources
- MolyMod[®] models for 2 amino acids
 - Individual atoms are represented by colored spheres
 - Red: oxygen
 - Black: carbon
 - Blue: nitrogen
 - White: hydrogen
 - Green: represents a generic sidechain
 - Covalent bonds are represented by thick gray bonds
 - Bonding of hydrogens represented by short white bonds
 - Kit contains 4 black, 4 red, 2 blue, 2 green, 8 white, 8 white bonds, 6 long grey bonds, 6 short grey bonds, 1 tan gripping tool
- 15 Tacks and a 4 Foot Toober[®]
 - 4 foot flexible foam toober[®] (wire in the center)
 - 15 colored pushpins (6 yellow, 3 white, 2 blue, 2 red, 2 green)
- Amino Acid Starter Kit[®]
 - 1 magnetic chemical properties circle
 - 1 laminated amino acid chart
 - 22 magnetic amino acid sidechains (1 of each amino acid, plus 1 additional cysteine and histidine)
 - 1 four-foot Mini-Toober[®]
 - 15 magnetic Mini-Toober[®] clips
 - 2 Mini-Toober[®] endcaps (1 each red and blue)

- CPK Coloring Dots
 - 6 Hydrogen Bond Connectors
- Amino Acid Starter Kit CD
 - Jmol tutorials
 - Images
 - PDF files with documentation
 - AASK Introduction and contents
 - AASK Standard Genetic Code
 - AASK Student Handout 1
 - AASK Student Handout 1 Key
 - AASK Student Handout 2
 - AASK Student Handout 2 Key
 - AASK Teacher Notes
 - AASK Toober Variations
 - AASK Toober Variations Key
 - Tertiary and Quaternary Protein Structure
- α -Helix β -Sheet Construction Kit
 - α -helix
 - Ball and stick format made as individual pieces that attach with magnets
 - Peptide backbone pieces (11)
 - May have green dot on alpha carbon
 - Metal hydrogen bonds with white hydrogen atoms (7)
 - Model made of plaster with the ZCorp printer
 - β -sheet
 - Ball and stick format made as individual pieces that attach with magnets
 - Anti-parallel β -sheet
 - Peptide backbone pieces (10)
 - May have green A (for antiparallel) or yellow dot on alpha carbon
 - Metal hydrogen bonds with white hydrogen atoms (4)
 - Model made of plaster with the ZCorp printer
 - Sidechains
 - Ball and stick format made as individual pieces that attach with magnets
 - 30 sidechains:
 - Four of glutamic acid
 - Three each of: leucine, serine, valine
 - Two each of: alanine, glycine
 - One each of: arginine, asparagine, aspartic acid, cysteine, glutamine, histidine, isoleucine, lysine, methionine, phenylalanine, threonine, tyrosine, tryptophan
 - Note that there is no sidechain for proline
- α -helix without sidechains
 - 17 amino acids without sidechains
 - Ball and stick format
 - Derived from Helix E of β -globin (amino acids 58-74)
 - Pitch is 3.6 amino acids per turn of helix
 - Hydrogen bonds (white) between nitrogen and carbonyl oxygen
 - CPK colors (carbon is gray, nitrogen is blue, oxygen is red)
 - Identical helix to the model α -helix with sidechains

- Model made of plaster with ZCorp printer
 - Based on PDB file 1AN3
- α -helix with sidechains
 - 17 amino acids with sidechains
 - Ball and stick format
 - Derived from Helix E of β -globin (amino acids 58-74)
 - Pitch is 3.6 amino acids per turn of helix
 - Hydrogen bonds (white) between nitrogen and carbonyl oxygen
 - Sidechains are CPK colors (carbon is gray, nitrogen is blue, oxygen is red, sulfur is orange)
 - Backbone atoms are colored green with the nitrogen colored blue (facilitates counting amino acids in the helix)
 - Amino acid sequence: NH₂ - Pro - Lys - Val - Lys - Ala - His - Gly - Lys - Lys - Val - Leu - Gly - Ala - Phe - Ser - Asp - Gly - CO₂H
 - Model made of plaster with ZCorp printer
 - Based on PDB file 1AN3
- β -sheet without sidechains
 - 30 amino acids without sidechains
 - Ball and stick format
 - Made from amino acids 14-32, 120-127 of GFP (the pattern of hydrogen bonds can be used to identify the location in the GFP model)
 - Hydrogen bonds (white) between nitrogen and carbonyl oxygen
 - Two strands are parallel
 - Two strands are anti-parallel
 - CPK colors (carbon is gray, nitrogen is blue, oxygen is red)
 - Identical backbone to β -sheet model with sidechains
 - Model made of plaster with ZCorp printer
 - Based on PDB file 1EMB
- β -sheet with sidechains
 - 30 amino acids with sidechains
 - Ball and stick format
 - Amino acid sequence:
 - NH₂ (120) - Val - Gln - Arg - Ile - Glu - Leu - Gly - CO₂H (127),
 - NH₂ (14) - Ile - Leu - Val - Glu - Leu - Asp - Gly - Asp - Val - Gln - Gly - His - Lys - Phe - Ser - Val - Ser - Gly - Glu - CO₂H (32)
 - Hydrogen bonds (white) between nitrogen and carbonyl oxygen
 - Two strands are parallel
 - Two strands are anti-parallel
 - Sidechains are CPK colors (carbon is gray, nitrogen is blue, oxygen is red)
 - Amino acid backbone atoms are colored green with the nitrogen colored blue (facilitates counting amino acids in the sheet)
 - Made from amino acids 14-32, 120-127 of GFP (the pattern of hydrogen bonds can be used to identify the location in the GFP model)
 - Model made of plaster with ZCorp printer
 - Based on PDB file 1EMB
- Green fluorescent protein, GFP
 - 1EMB pdb file
 - 236 amino acids
 - α -carbon backbone format
 - Chromophore, Ser 65, Tyr 66, Gly 67 green
 - Amino acid contacts with the chromophore, His 148, Gln 94, Arg 96, Glu 222, Thr 203, Ile 167

- β -sheets are colored yellow
 - α -helices are colored red
 - Model made of plaster with ZCorp printer
- β -globin
 - 1AN3 pdb file
 - Chain B
 - α -carbon backbone format
 - Protoporphorin IX ring containing iron (Fe)
 - His 63 and His 92 bind the protoporphorin ring
 - Glu 6 is the sidechain that is mutated to valine in sickle cell anemia
 - Model made of plaster with ZCorp printer
 - α -helices are colored red
- Zinc finger folding activity
 - 72 cm Mini-Toober ©
 - Zinc finger folding map
 - 7 amino acid sidechains: 2 histidine, 2 cysteine, 1 phenylalanine, 1 arginine, 1 leucine
 - 7 magnetic Mini-Toober© clips
 - 1 orange zinc atom with magnets
 - CPK Coloring Dots

Documentation included

- Teaching points and inventory
- How do the models fit back in the suitcase?
- Activity cards cover
- Activity cards
 - Quick reference card
 - Amino Acids are the Building Blocks of Proteins
 - Proteins Fold in Aqueous Environment
 - Secondary Structure
 - Linear Amino Acid Sequence Folds into Secondary Structure
 - The structure of Amino Acid Backbones in an α -Helix and β -Sheet
 - Building Secondary Structures
 - Amino Acid Sidechains have Different Chemical Characteristics
 - Modeling Helix A of β -Globin
 - Modeling a β -Sheet of Green Fluorescent Protein
 - Protein Tertiary and Quaternary Structure
 - Zinc Finger Folding Exercise
 - 15 Tacks and a 4 Foot Toober
 - Toober variations