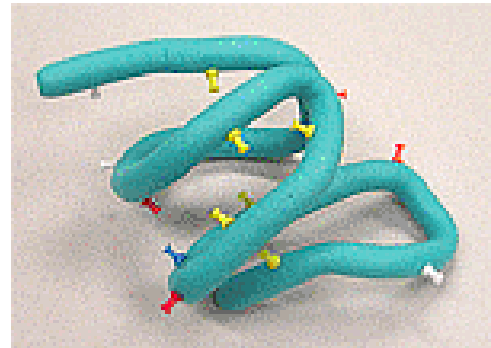
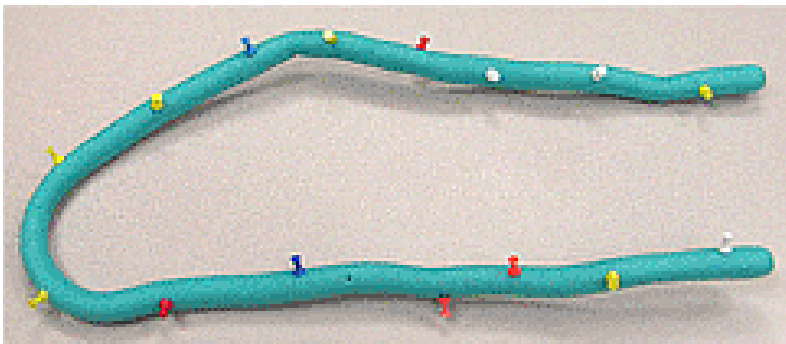


SMART TeamsExploring the
Molecular World

15 Tacks and a 4 Foot Toober Protein Folding Activity



Explore the forces that drive protein folding with 15 tacks and a 4 foot Toober. The color-coded tacks represent the sidechains of the following amino acids:

Blue tacks	(2)	basic amino acids (+)
Red tacks	(2)	acidic amino acids (-)
Yellow tacks	(6)	hydrophobic amino acids
White tacks	(3)	polar amino acids
Green tacks	(2)	cysteine amino acids
15 tacks		

Instructions:

1. Distribute the 15 tacks randomly but evenly along the toober. The tacked toober represents a protein made of 15 amino acids.
2. Fold your protein, following the laws of chemistry that drive protein folding. (These laws of chemistry are reviewed on the back of these instructions.)

Basic Laws of Chemistry that Drive Protein Folding

1. **Hydrophobic sidechains** (yellow tacks) will be buried on the inside of the globular protein, where they are hidden from polar water molecules.
2. **Charged sidechains** (blue and red tacks) will be on the surface of proteins where they often neutralize each other and form salt bridges.
3. **Polar sidechains** (white tacks) will be on the surface of the protein where they can hydrogen bond with water.
4. **Cysteine sidechains** (green tacks) often interact with each other to form covalent disulfide bonds that stabilize protein structure.

Teaching Tips:

Students should have no trouble folding their toober so that all of the yellow, hydrophobic tacks are clustered together in the central core of the folded structure.

However, it may be difficult to maintain this structure while **simultaneously**:

- Pairing blue and red tacks (positive and negative charges that neutralize each other),
- **And** pairing green tacks that form disulfide bonds,
- **And** keeping all of the polar white tacks on the surface of the protein.

After everyone has folded their toober as best they can, the teacher can point out:

- Every toober had a different random sequence of tacks (amino acids) and therefore each toober (protein) folded into a different structure.
- Some sequences of tacks were more easily folded into a reasonable structure than others. In fact, the ~25,000 proteins encoded by the human genome have been selected from an enormous number of possible amino acid sequences based on their ability to spontaneously fold into stable structures that simultaneously satisfy these basic laws of chemistry.

For more suggestions about how to teach concepts of molecular structure and function, visit the MSOE Center for BioMolecular Modeling website, <http://cbm.msOE.edu>.