

# Collaboratively Designed Tools to Evaluate Student Visual Literacy: The BioMolViz Library and Framework



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Swati Agrawal

Shane Austin

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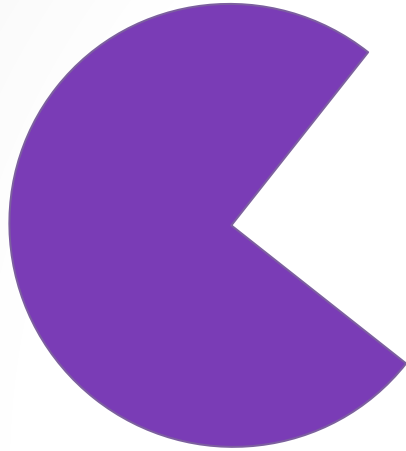
Didem Vardar-Ulu



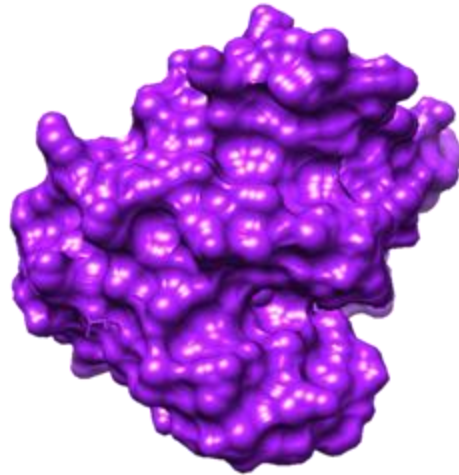
This material is based upon work supported  
by the National Science Foundation

IUSE:1712268 and  
RCN-UBE: 1920270

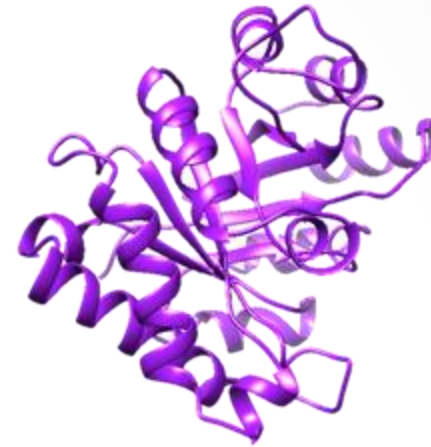
# Visual Representations



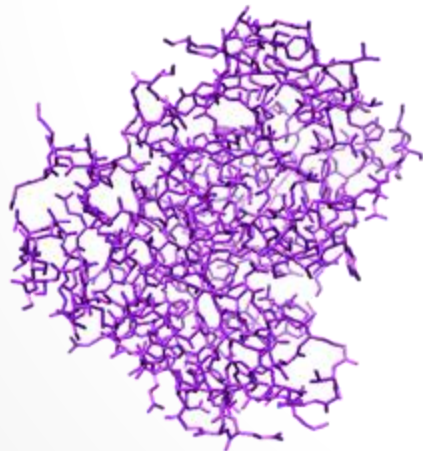
**“Pac-person”**



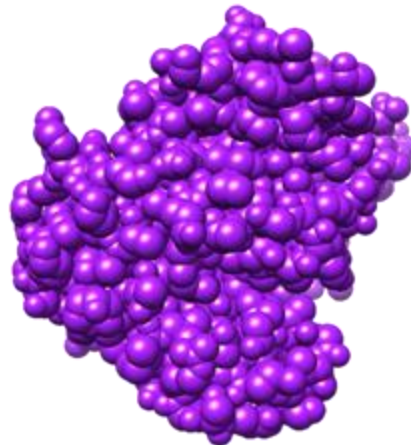
**Surface**



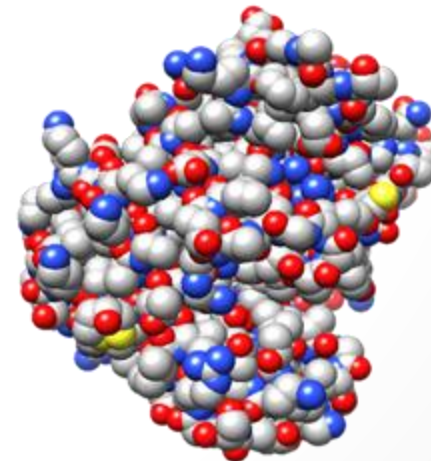
**Ribbon**



**Stick**

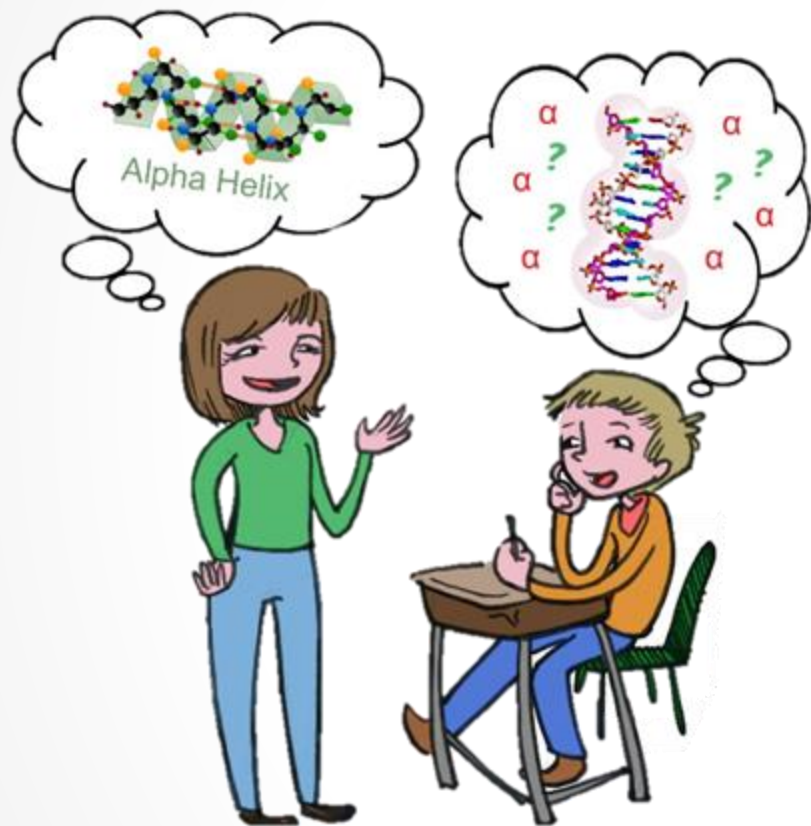


**Spacefilling**



**There's color, too!**

# Challenges in Teaching Biomolecular Visualization



Do our students see what we think they see?

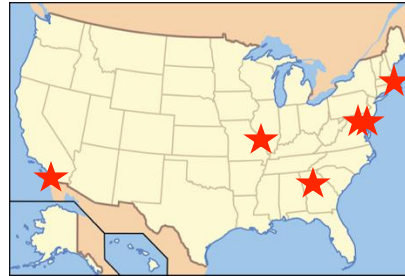
- Cognitive overload



# Building an RCN-UBE Community

## Assessment Writing Workshops (2018–2024)

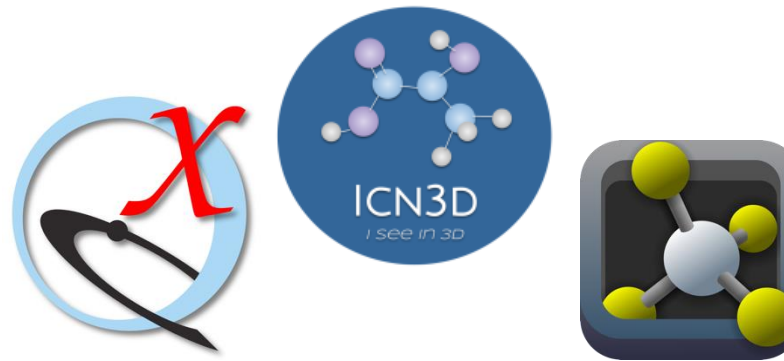
- >180 participants
- Six in-person, six online



Procko, K. et. Al (2021). *Biochem. Mol. Bio. Educ.* 49(2), 278-286.

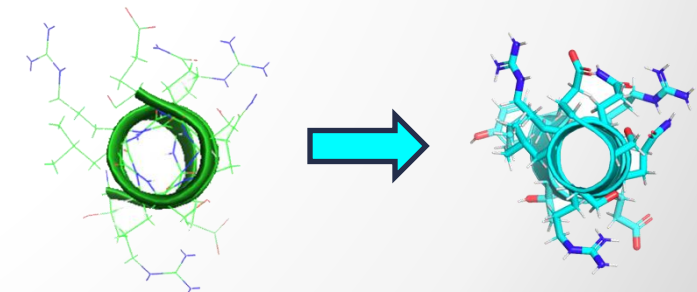
## Other Professional Development Training (2022–2023)

- Program training (iCn3D, PyMOL, ChimeraX) workshops
- Open Educational Resource assessment workshop



Procko, K. et al. (2021). *JoVE* (178), e63170.

## Assessment Working Group (2021–present)

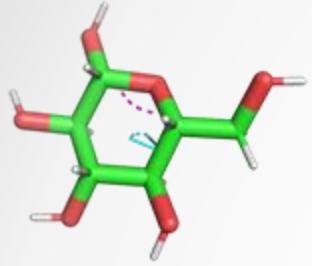


# The BioMolViz Framework

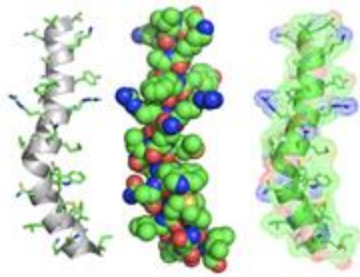


A Tool for Backward Design

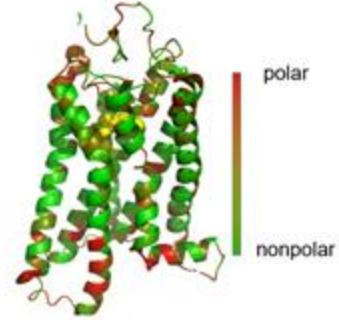
### Atomic Geometry (AG)



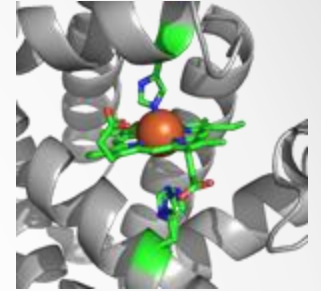
### Alternate Renderings (AR)



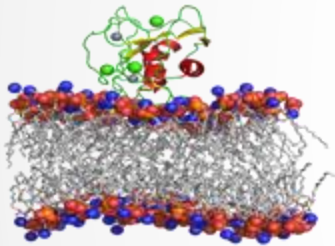
### Construction and Annotation (CA)



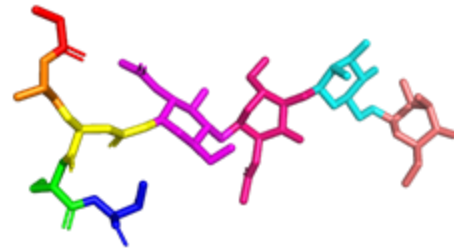
### Ligands and Modifications (LM)



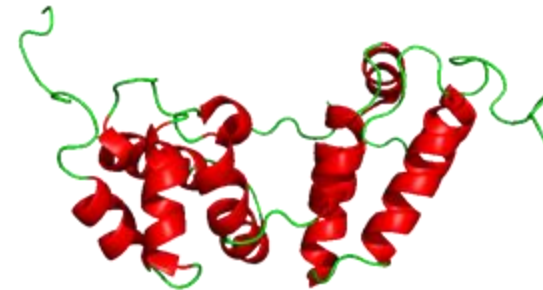
### Macromolecular Assemblies (MA)



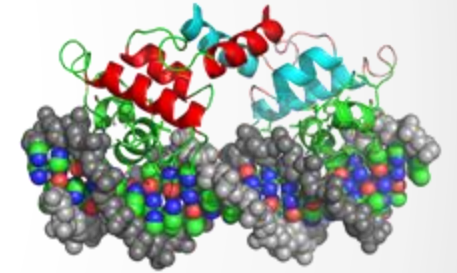
### Macromolecular Building Blocks (MB)



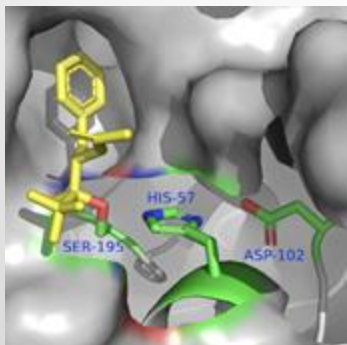
### Molecular Dynamics (MD)



### Molecular Interactions (MI)



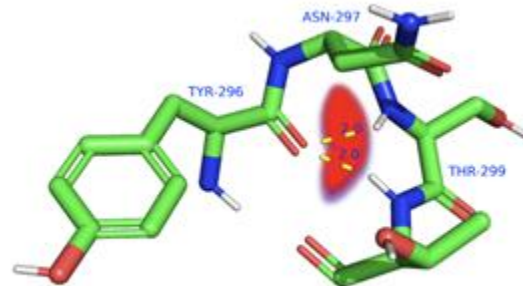
### Structure-Function Relationship (SF)



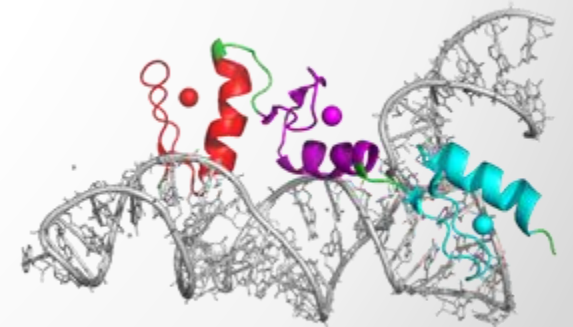
### Symmetry/Asymmetry Recognition (SA)



### Structural Model Skepticism (SK)



### Topology and Connectivity (TC)



+ Ligands and Modifications (LM) [HG]

+ Macromolecular Assemblies (MA)

- Macromolecular Building Blocks (MB) [MR]

**Recognition of native amino acids, nucleotides, sugars, and other biomonomer units/building blocks. Understanding of their physical and chemical properties, particularly regarding functional groups.**

*Note that this theme was formerly called Monomer Recognition (MR).*



- MB1. Students can identify individual building blocks of biological polymers.

**MB1.01** Given a rendered structure of a biological polymer, students will be able to identify the ends of a biological polymer. (Novice, Amateur, Expert)

**MB1.02** Given a rendered structure, students can divide the polymer into its individual building blocks. (Novice)

# The Biomolecular Visualization Framework

Dries, D. R. et. al *Biochem. Mol. Bio. Educ.* 45(1), 69-75.

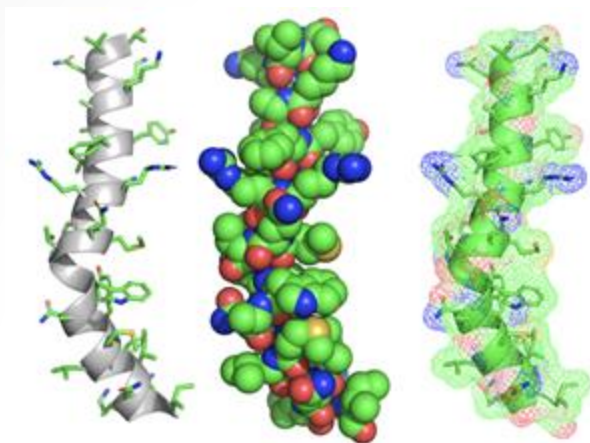
Themes

Learning Goals

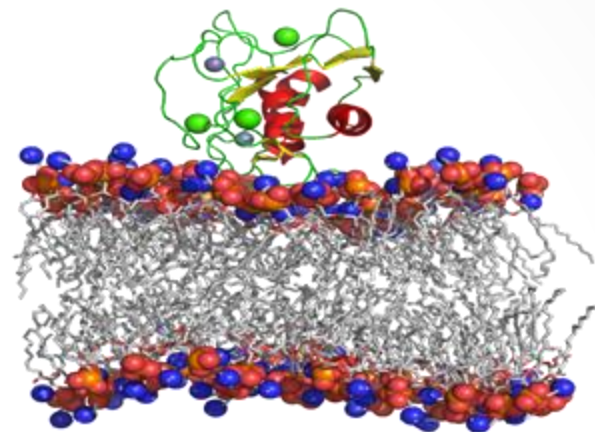
Learning Objectives

[biomolviz.org/framework](http://biomolviz.org/framework)

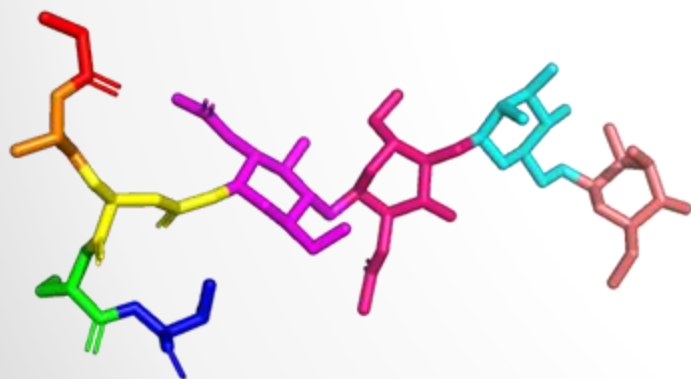
Alternate  
Renderings (AR)



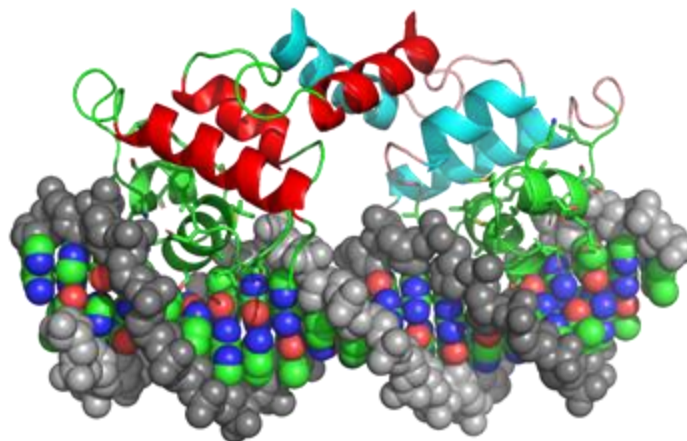
Macromolecular  
Assemblies (MA)



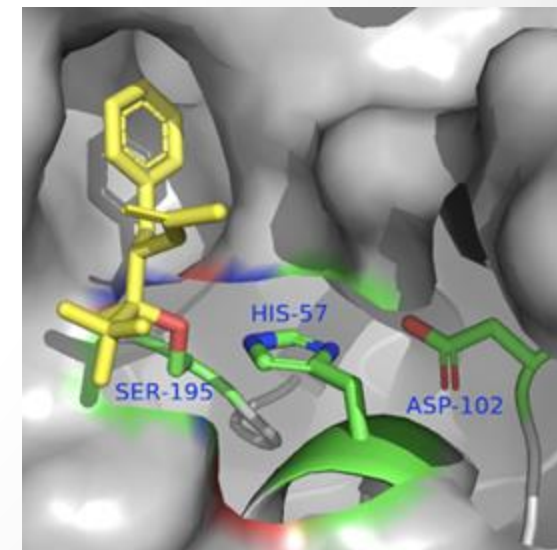
Macromolecular  
Building Blocks (MB)



Molecular  
Interactions (MI)



Structure-Function  
Relationship (SF)



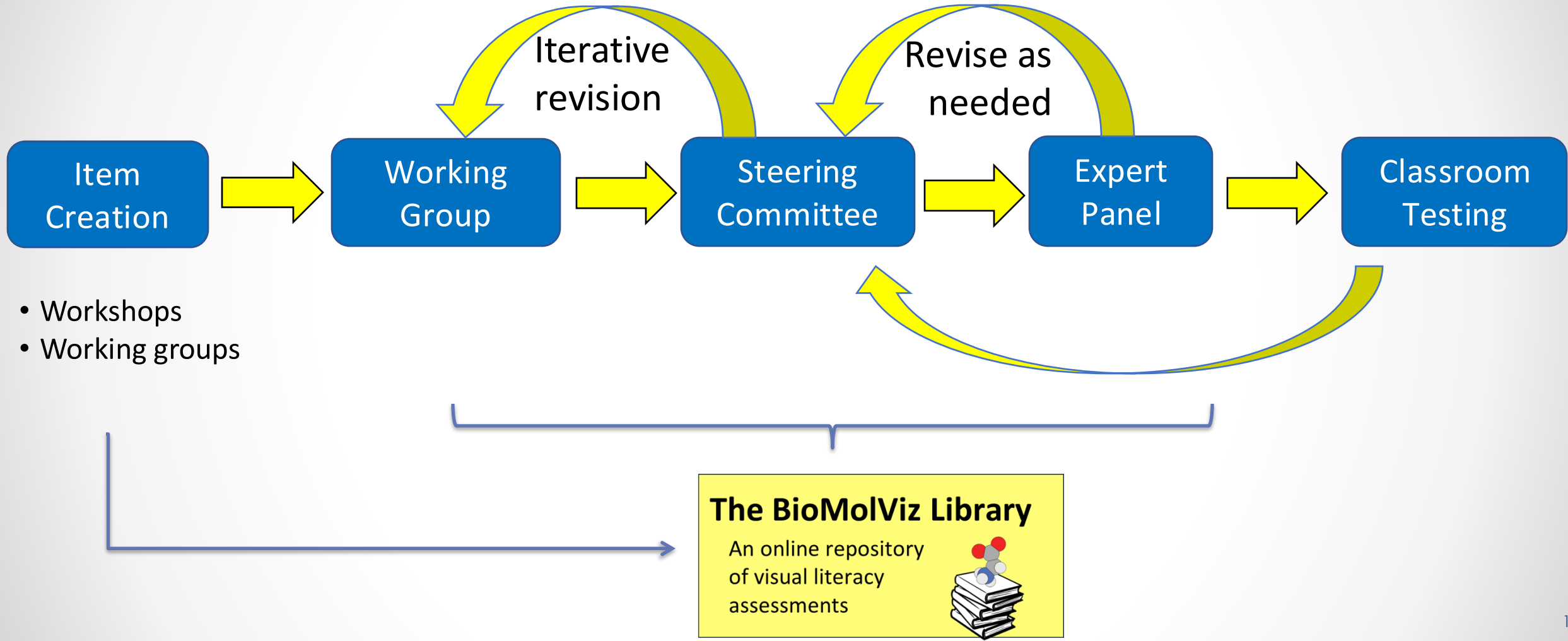
[biomolviz.org/framework](http://biomolviz.org/framework)

# BioMolViz Assessments

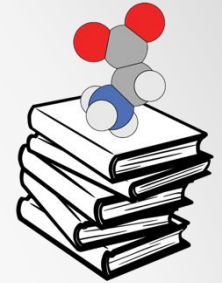


Our Validation Process

# An Iterative Process for Assessment Validation



# The BioMolViz Library



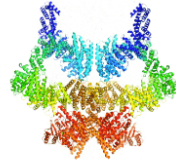
Welcome to the BioMolViz Library! We're a group of educators, assessment experts, and biomolecular visualization enthusiasts who are passionate about promoting visual literacy in the biochemistry and molecular biology community. We have developed a Biomolecular Visualization Framework that outlines 12 key themes in visual literacy and provides learning goals and objectives ([biomolviz.org/framework/](https://biomolviz.org/framework/)).

Our current project, funded by the NSF, focuses on using the Framework to design effective biomolecular visualization assessments for instructors to use in their classrooms. We offer workshops where instructors can work together to write and review assessments, which are then evaluated by an expert panel and field tested in classrooms at various institutions.

The BioMolViz Library is where you can find these assessments at various stages of the review and validation process. We invite you to browse our library and use our assessments to evaluate the visual literacy of your students. Thank you for visiting!

To reference the BioMolViz Library, please use this citation:  
Beckham, J., Acevedo, R., Dries, D.R., Engelman, S., Franzen, M.A., Jakubowski, H., Mertz, P., Novak, W.R., Roberts, R., Roca, A.I., Procko, K.\* *The BioMolViz Library: An Assessment Repository to Evaluate Biomolecular Visual Literacy Through the BioMolViz Framework*. 2023. [library.biomolviz.org](https://library.biomolviz.org) (<https://doi.org/10.15781/6mcy-8m69>)  
\*The University of Texas at Austin, [info@biomolviz.org](mailto:info@biomolviz.org)

*This material is based upon work supported by the National Science Foundation (NSF) under grants RCN-UBE #1920270 and NSF-IUSE #1712268. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.*  
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Dashboard

### Assessment Search

Keyword Search:  
keyword, PDB ID, assessment ID

Filter by BioMolViz Framework:

Theme: AR - Alternate Renderings - Rendering of a m... Goal: -- Objective: --

Other filters:

|   |   |   |  |
|---|---|---|--|
| Question Format:                                  | Level of Expertise:                         | Molecule Type:                          | Modeling Program:                      |
| <input type="checkbox"/> Label Structure          | <input checked="" type="checkbox"/> Novice  | <input type="checkbox"/> Carbohydrate   | <input type="checkbox"/> None          |
| <input type="checkbox"/> Render Structure         | <input checked="" type="checkbox"/> Amateur | <input type="checkbox"/> Lipid          | <input type="checkbox"/> Any           |
| <input type="checkbox"/> Multiple Choice (or T/F) | <input type="checkbox"/> Expert             | <input type="checkbox"/> Nucleic Acid   | <input type="checkbox"/> Browser-based |
| <input type="checkbox"/> Multiple Select/Answer   |   | <input type="checkbox"/> Protein        | <input type="checkbox"/> Chimera       |
| <input type="checkbox"/> Short Answer             |   | <input type="checkbox"/> Small Molecule | <input type="checkbox"/> iCn3D         |
|   |   |   | <input type="checkbox"/> Jmol          |
|   |   |   | <input type="checkbox"/> Pymol         |

## Let's check out the BioMolViz Library

**Email:** your registration email for this conference

**Password:** RSBMB

9 assessments found.

Assessment ID: 10000  
Status: Expert Panel Reviewed

Different representations of molecules are used to illustrate different features. All of these images (A-E) are different representations (renderings) of B-DNA. The B-DNA backbone structure follows a right-handed direction. Select all of the images where this characteristic of B-DNA can be seen from the rendering.

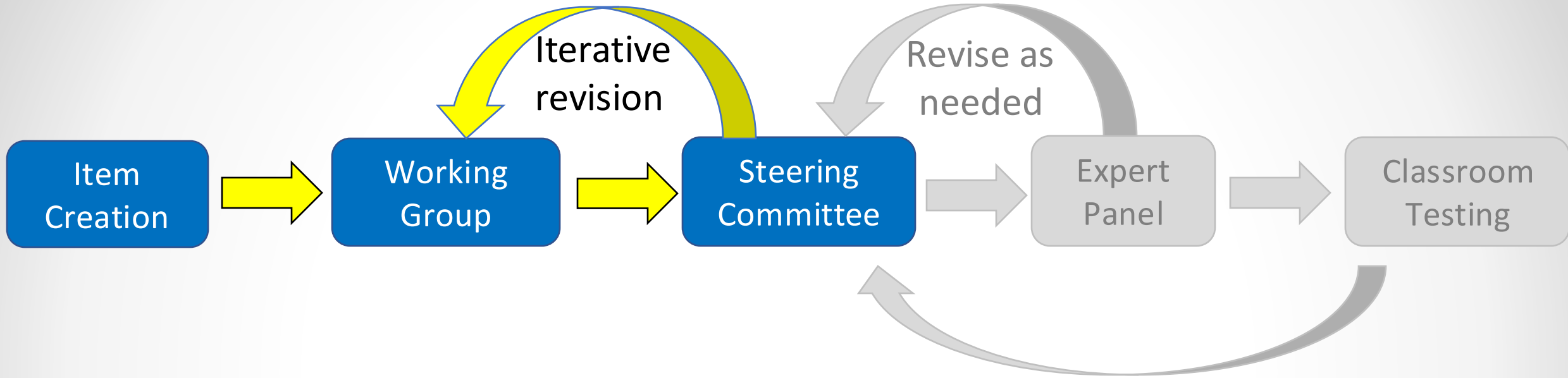
Assessment ID: 10015  
Status: Expert Panel Reviewed

Five segments of  $\alpha$ -helices (alpha helices) are shown in standard CPK colors with cyan carbons. By examining the side chains, which helix corresponds to the amino acid sequence: Glu-Ser-Ser-Leu-Gln-Gln-Arg-Arg-Arg-Glu-Thr ?

Assessment ID: 10017  
Status: Expert Panel Reviewed

Consider a beta strand that contains six amino acids. The "barrier" represents the backbone of the protein and the circles represent the amino acid side chains. Which of the images best represents the orientation of the amino acid side chains of a typical beta strand?

• <https://library.biomolviz.org/>



...

## Item Creation & Revision Process

# Item Creation and Revision

“I have not worked a day at BioMolViz — I have fun making the assessments with my friends every week.”

-Roderico Acevedo,  
Westfield State University

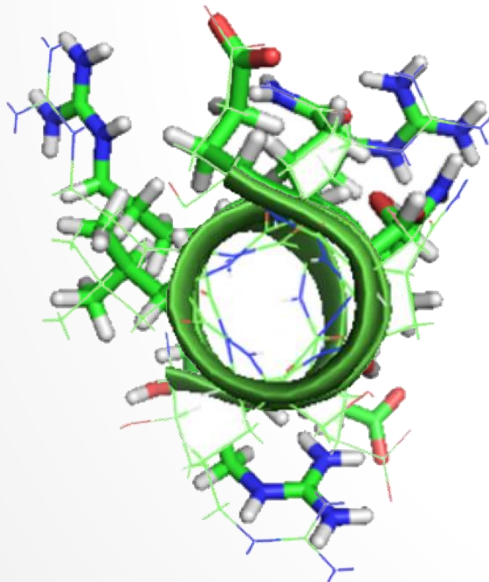


# Item Creation and Revision

## Workshop Product

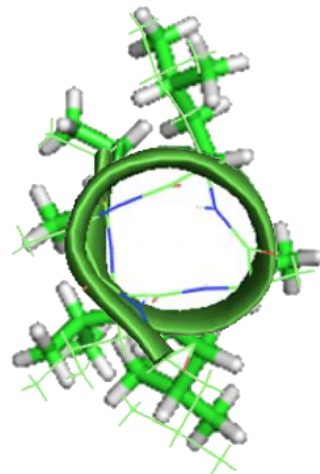
Which of the following images depicts an amphipathic alpha helix, viewed down the helix axis? Explain your answer.

**A**



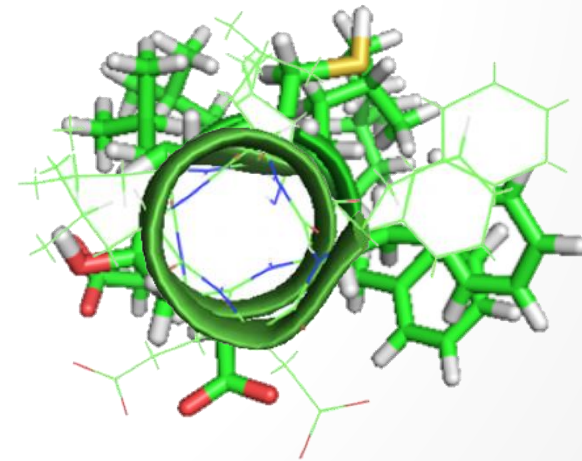
**PDB ID: 2P81**

**B**



**PDB ID: 2LCN**

**C**



**PDB ID: 2MJ2**

# Item Creation and Revision

## Testing for Colorblindness

*Trichromatic view:*  Normal

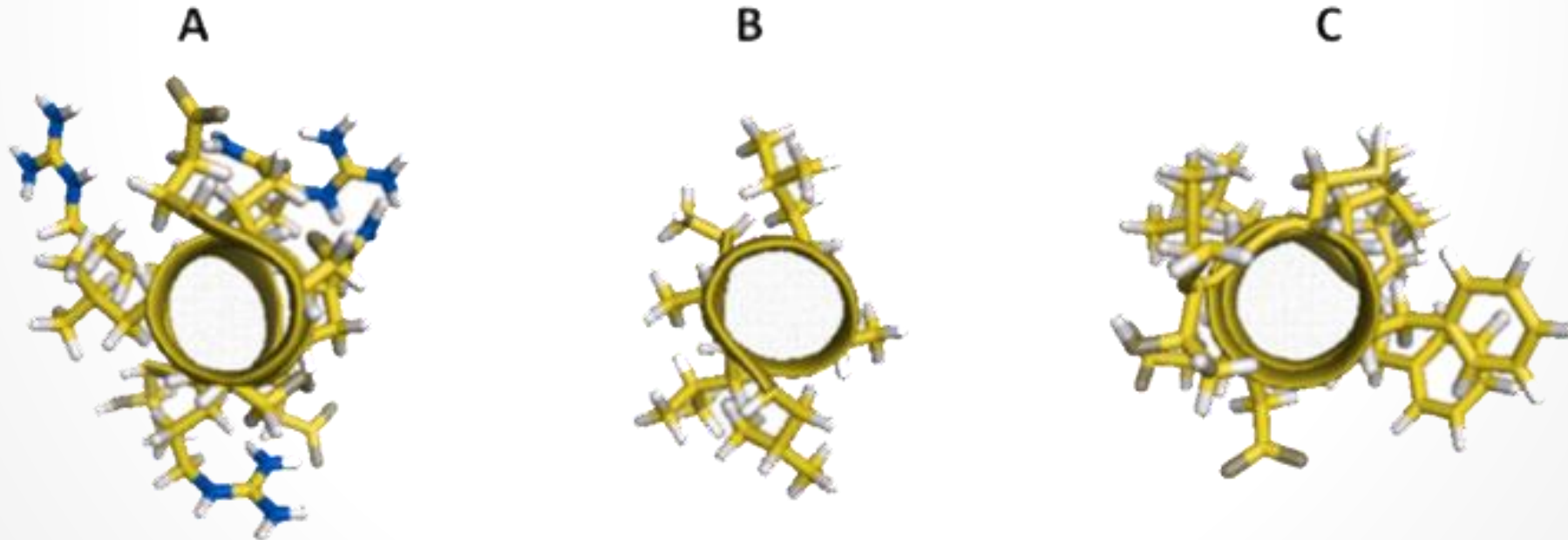
*Anomalous Trichromacy:*  Red-Weak/Protanomaly  
 Green-Weak/Deuteranomaly  
 Blue-Weak/Tritanomaly

*Dichromatic view:*  Red-Blind/Protanopia  
 Green-Blind/Deuteranopia  
 Blue-Blind/Tritanopia

*Monochromatic view:*  Monochromacy/Achromatopsia  
 Blue Cone Monochromacy

Use lens to compare with normal view:  No Lens  Normal Lens  Inverse Lens

[Reset View](#) [Open simulated image in new window](#)



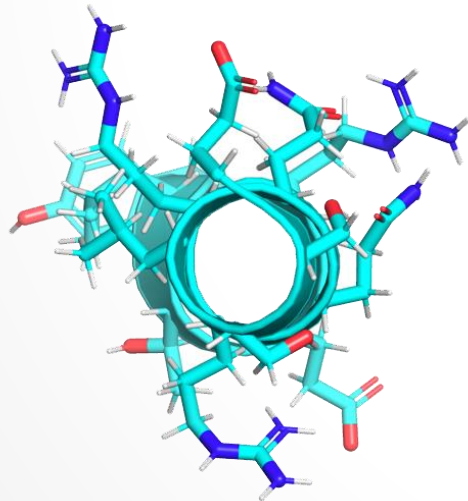
# Item Creation and Revision

Working Group: Colorblindness and Wording Revision

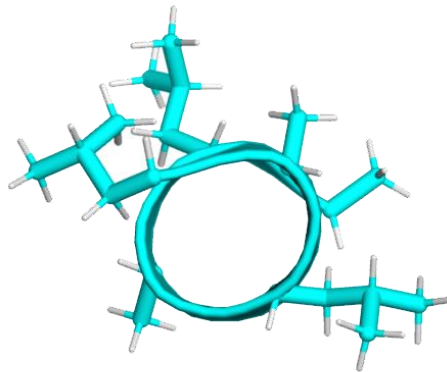
~~Which of the following images depicts an amphipathic alpha helix, viewed down the helix axis? Explain your answer.~~

Three  $\alpha$ -helices are shown, viewed down the helix axis. Which image depicts an amphipathic  $\alpha$ -helix? Explain your answer; include a definition of amphipathicity and how you used the images to identify the helix.

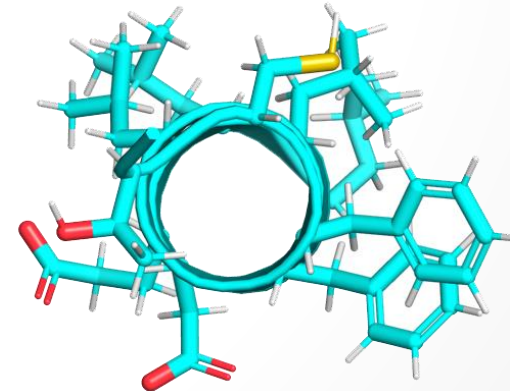
**A**

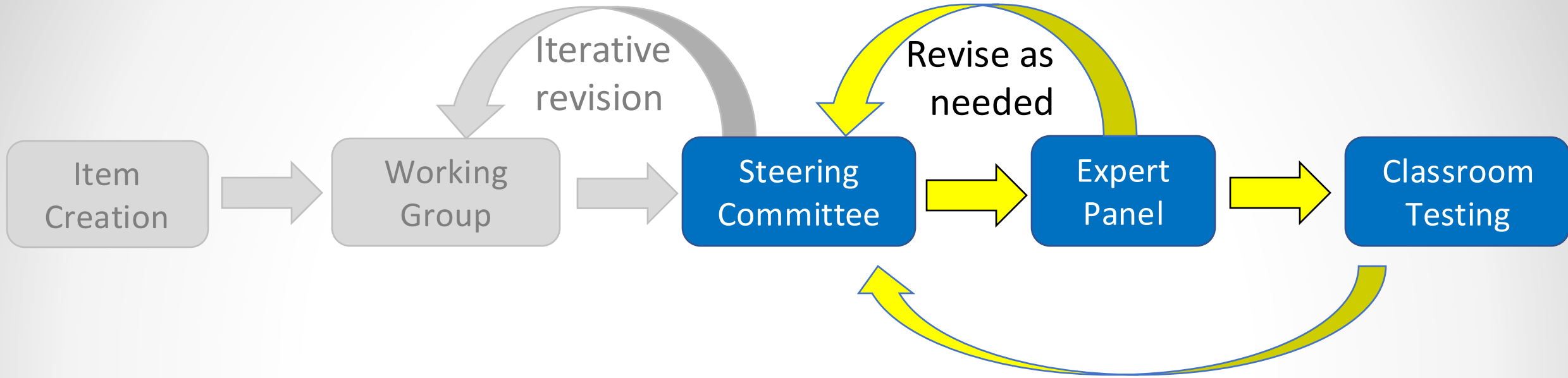


**B**



**C**



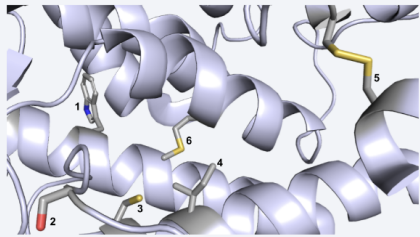


...

# Assessment Validation

# Rating for Assessment #10011

- **Learner Level:** Amateur
- **Primary Learning Objective:** Students can identify physical/chemical properties of individual building blocks/functional groups in different local environments. (Amateur)



[\(see full-size image\)](#)

The image shown displays amino acid side chains (shown as sticks) labeled with numbers.

From the options given below, Identify the labels representing two amino acids that can act as nucleophiles in enzyme active sites.

- A. label 2 and label 3
- B. label 1 and label 4
- C. label 2 and label 6
- D. label 1 and label 5
- E. label 3 and label 6

[Click here to reveal answer.](#)

# Expert Panel Review

To what extent is this item...

|  | 1. Not at all         | 2. Somewhat           | 3. Mostly             | 4. Very               |
|--|-----------------------|-----------------------|-----------------------|-----------------------|
| <b>RELEVANT</b> to the Primary Learning Objective? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <b>APPROPRIATE</b> for the learner level?          | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| <b>CLEAR</b> and/or unambiguous?                   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Your feedback/suggestions, if any:

# Classroom Testing Overview

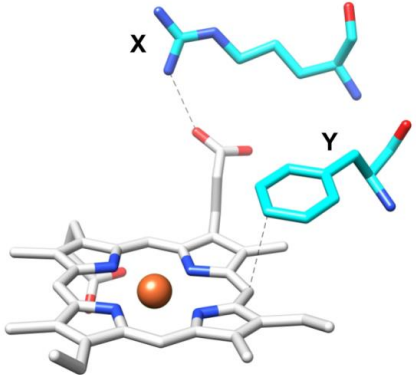
| Identifier | # of Questions | # of Responses |
|------------|----------------|----------------|
| Sets A–C   | 6              | 50–131         |
| Set D      | 16             | 441            |
| Set E      | 15             | 364            |

Beckham, J. T. et. al (2024). *Education Sciences*, 14(1), 94.

- **Multiple Choice** and **Multiple Select** Questions
- Examined student performance
- Analyzed answer choice selection

TEXAS  
The University of Texas at Austin

Survey Completion 0% 100%



In the diagram shown, there are two amino acids labeled X and Y that interact with the heme prosthetic group of myoglobin. Dashed lines represent specific interactions. Amino acid X interacts with the heme prosthetic group with a \_\_\_\_\_ interaction and Amino acid Y interacts with the heme prosthetic group with a \_\_\_\_\_ interaction. Identify the correct choice.

polar; salt bridge

salt bridge; polar

nonpolar, polar

nonpolar, salt bridge

salt bridge, nonpolar

# Example A: Expert Panel Review

**Learner Level:** Amateur

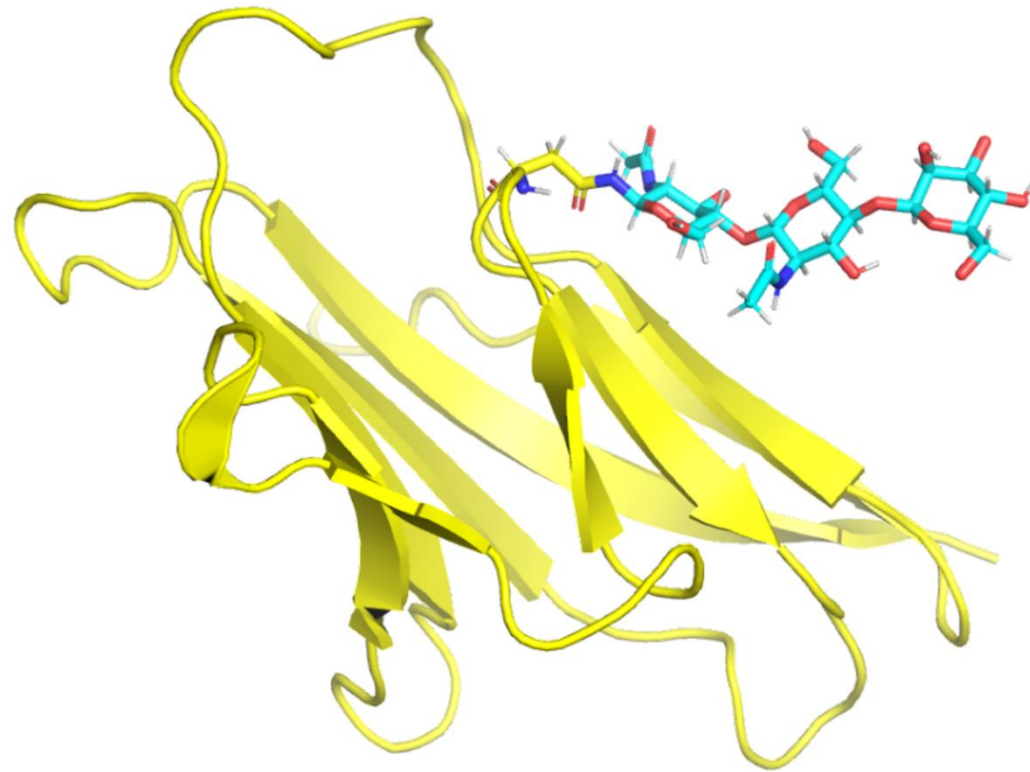
**Primary Learning Objective:**

MA1.01 Students can identify individual structures in a macromolecular assembly.

What type of biomolecule is depicted in the structure shown?

1. Lipoprotein
2. Nucleoprotein
3. Glycoprotein
4. Glycolipoprotein
5. Phospholipid

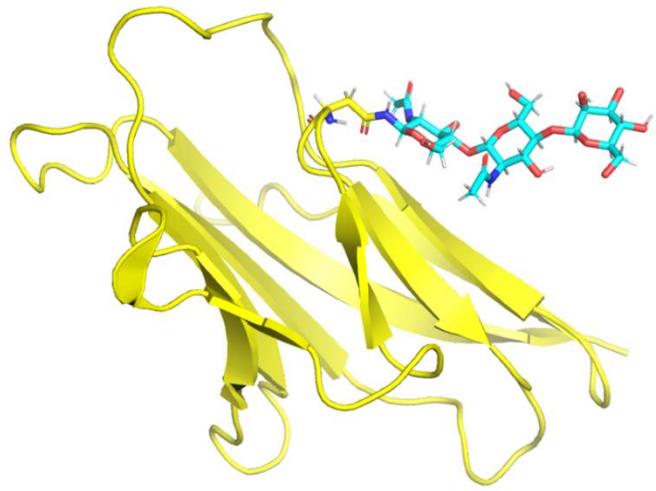
Answer C



**Relevant** to the learning objective?

**Appropriate** for learner level?

**Clear** and unambiguous?

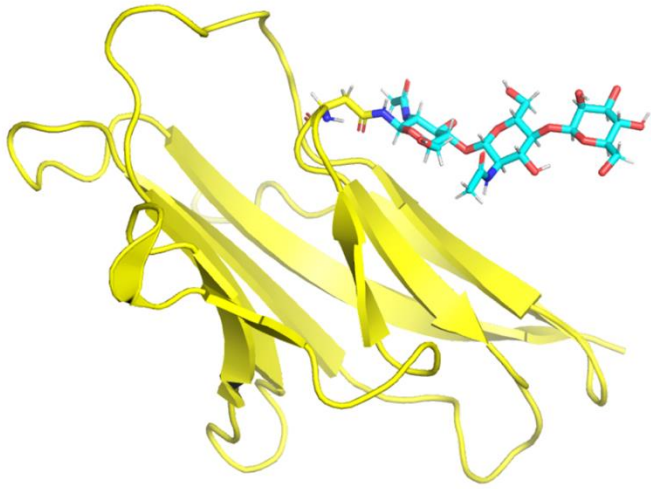


## Example A: Expert Panel Ratings

|                                       |     |  |
|---------------------------------------|-----|--|
| <b>RELEVANT TO LEARNING OBJECTIVE</b> | 4.0 | <b>Excellent;<br/>no improvements needed</b> |
| <b>APPROPRIATE FOR LEARNER LEVEL</b>  | 4.0 | <b>Excellent;<br/>no improvements needed</b> |
| <b>CLEAR &amp; UNAMBIGUOUS</b>        | 3.8 | <b>Excellent;<br/>no improvements needed</b> |

This assessment passed expert panel review - no revisions needed.

# Example A: Classroom Testing



What type of biomolecule is depicted in the structure shown?

1. Lipoprotein
2. Nucleoprotein
3. Glycoprotein
4. Glycolipoprotein
5. **Phospholipid**  
→ Phosphoprotein

| Library ID # | n  | % Correct | Response Options (correct answers are highlighted in green) |     |     |     |    |
|--------------|----|-----------|---|-----|-----|-----|----|
|              |    |           | a   | b   | c   | d   | e  |
| 10001        | 50 | 50%       | 10%   | 22% | 50% | 18% | 0% |

| Library ID # | n   | % Correct | Response Options (correct answers are highlighted in green) |    |     |    |     |
|--------------|-----|-----------|---|----|-----|----|-----|
|              |     |           | a   | b  | c   | d  | e   |
| 10001        | 441 | 60%       | 14%   | 8% | 60% | 9% | 10% |

**Learner Level:** Amateur

**Primary Learning Objective:**

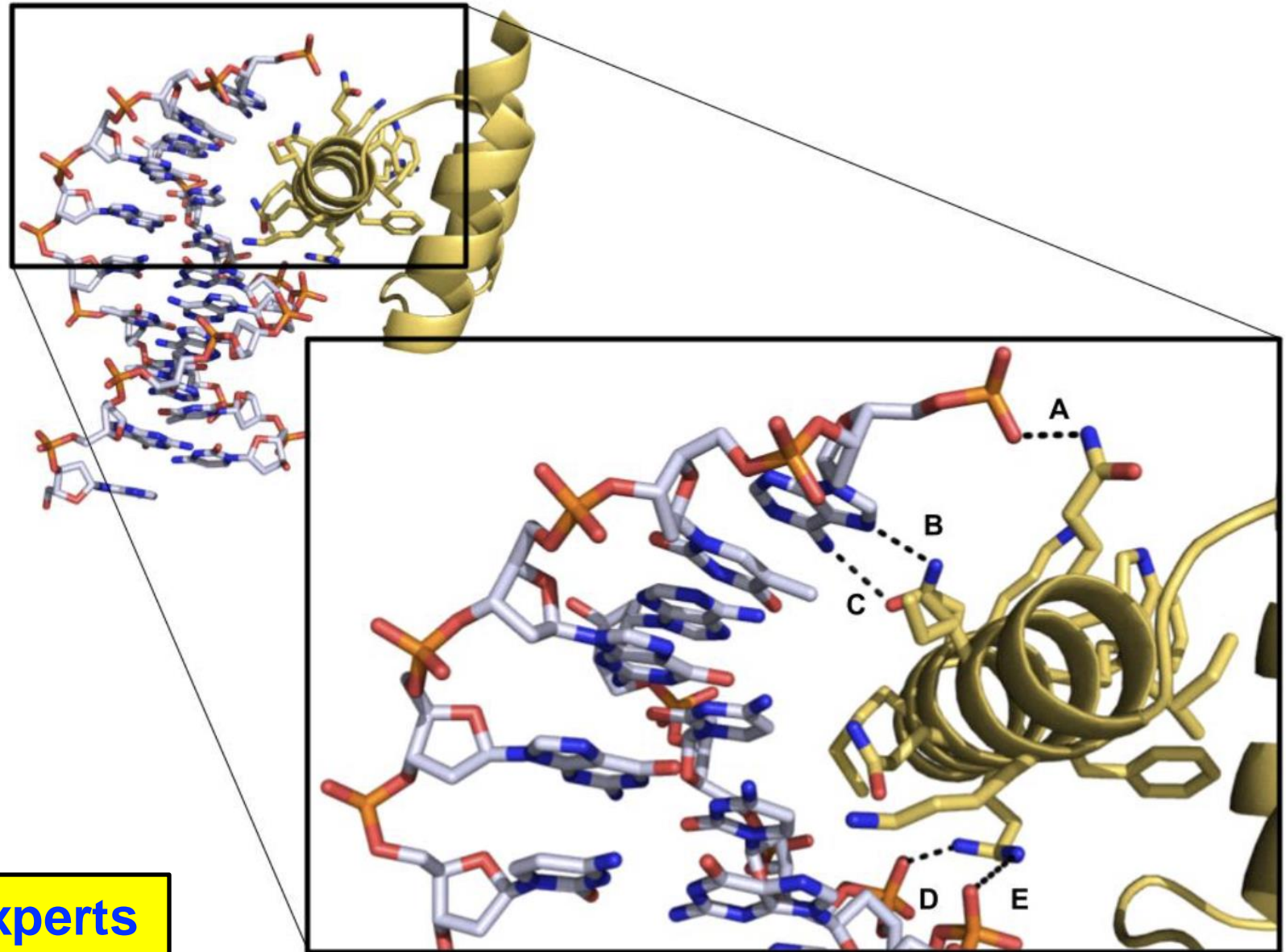
SF2.03 Students can identify functionally relevant features of a macromolecule.

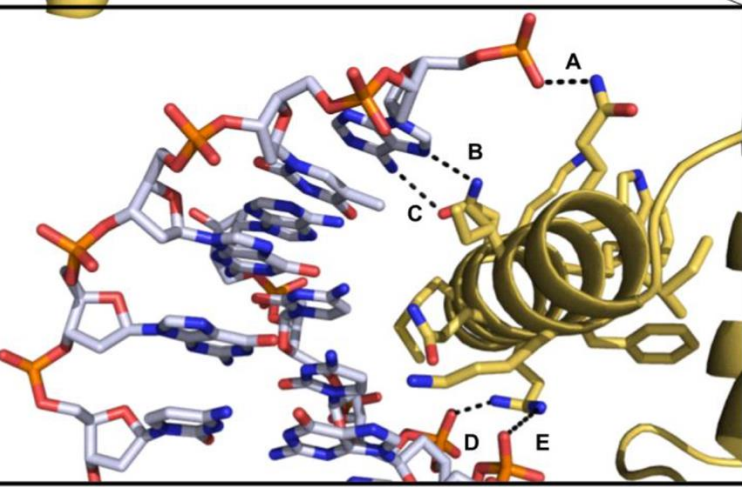
A transcription factor is shown bound to a DNA helix. Hydrogen bonds are shown as labeled dashed lines. From the depicted hydrogen bonds, select all that are due to DNA sequence-specific interactions with the protein.

Answers B & C

**Now, you will be the experts**

## Example B: Expert Panel Rating

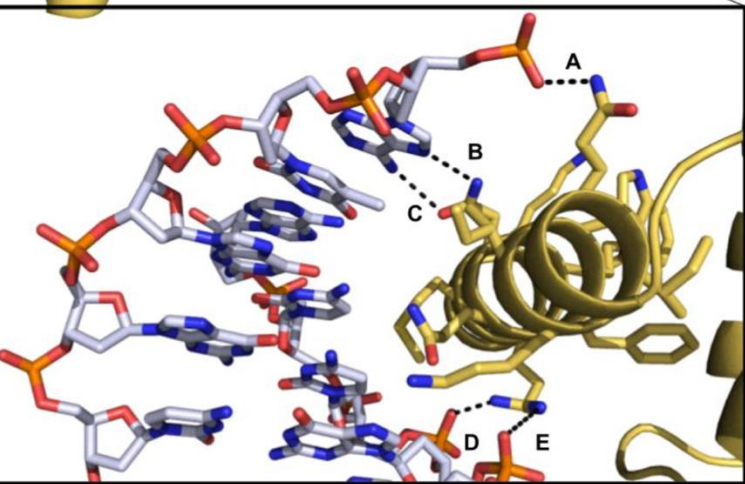




## Example B: Expert Panel Ratings

|                                       |     |  |
|---------------------------------------|-----|--|
| <b>RELEVANT TO LEARNING OBJECTIVE</b> | 4.0 | <b>Excellent;<br/>No improvements needed</b> |
| <b>APPROPRIATE FOR LEARNER LEVEL</b>  | 4.0 | <b>Excellent;<br/>No improvements needed</b> |
| <b>CLEAR &amp; UNAMBIGUOUS</b>        | 2.8 | <b>Major modifications needed</b>            |

Revisions are needed to improve clarity



## Example B: Expert Panel Comments

Bond E is hard to see clearly. Can you move... or make the inset the whole image?

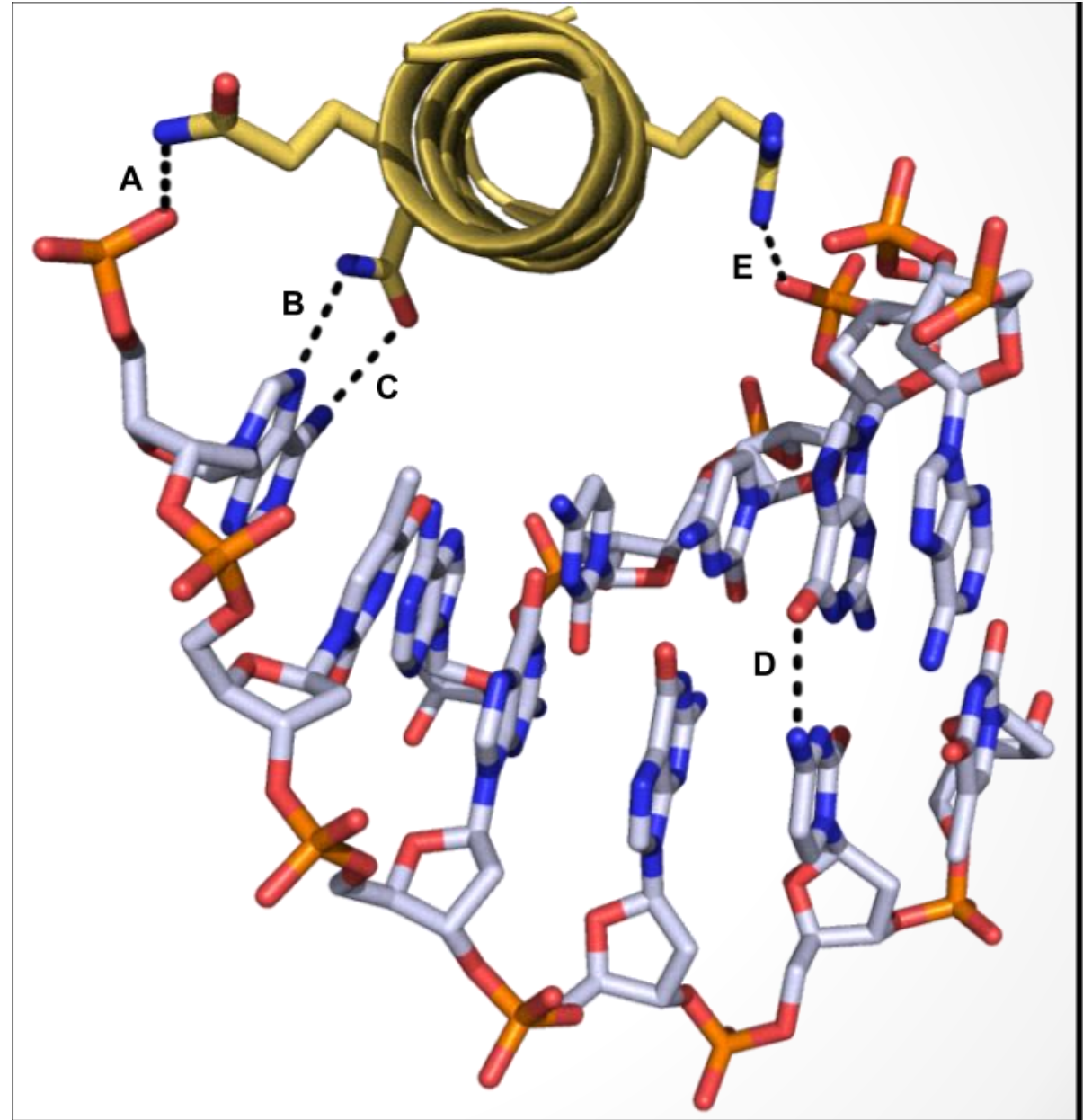
I really love this question. Only critique is that some of these interactions are not H-bonds, some are ion-dipole. So suggest replacing the words "hydrogen bonds" with "non-covalent interactions (like ionic, ion-dipole, H-bonds, etc.)"

1. "sequence-specific" might be taken also as depending on the protein sequence...
2. Protein atoms involved in B and C are behind, so it is not easy to ascertain if they belong to backbone or sidechain. ...
3. The DNA part in E is cropped too close to the image border; from the colours one can assume it is a phosphate, but more of it should be visible to avoid confusion.

# Example B: Steering Committee Revision

A part of a transcription factor (yellow) is shown bound to DNA. Five noncovalent interactions are shown as labeled dashed lines. From the depicted noncovalent interactions, select all that are due to DNA sequence-specific interactions with the protein.

Answers B & C



# Example B: Classroom Testing

| Item #       | % Correct (Mean) | Level of Difficulty                  |
|--------------|------------------|--------------------------------------|
| <b>10051</b> | <b>40%</b>       | <b>Ideal/Desirable/<br/>Moderate</b> |

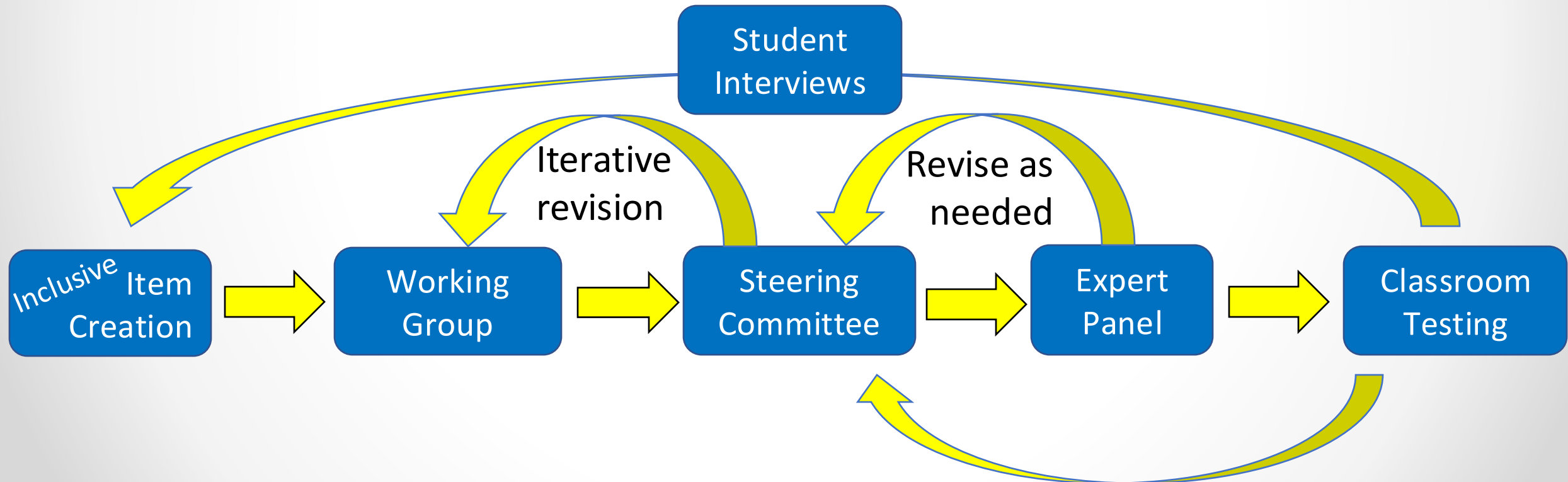
Difficulty

Discrimination

| Index       | Evaluation  |
|-------------|-------------|
| <b>0.39</b> | <b>Good</b> |

# Current Work

- Analyze classroom testing results – identify problematic questions
- Conducting student interviews
  - Improve questions
  - Understand performance differences



# Stay Connected with BioMolviz

- Check out our website for resources
- Email KP about joining a working group or online workshop
- Email us for a link to join our Slack community

Sign up for our  
newsletter:



<https://biomolviz.org/contact/>