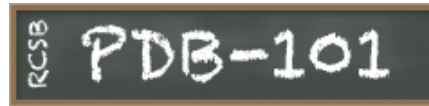


A "Box of Lessons"

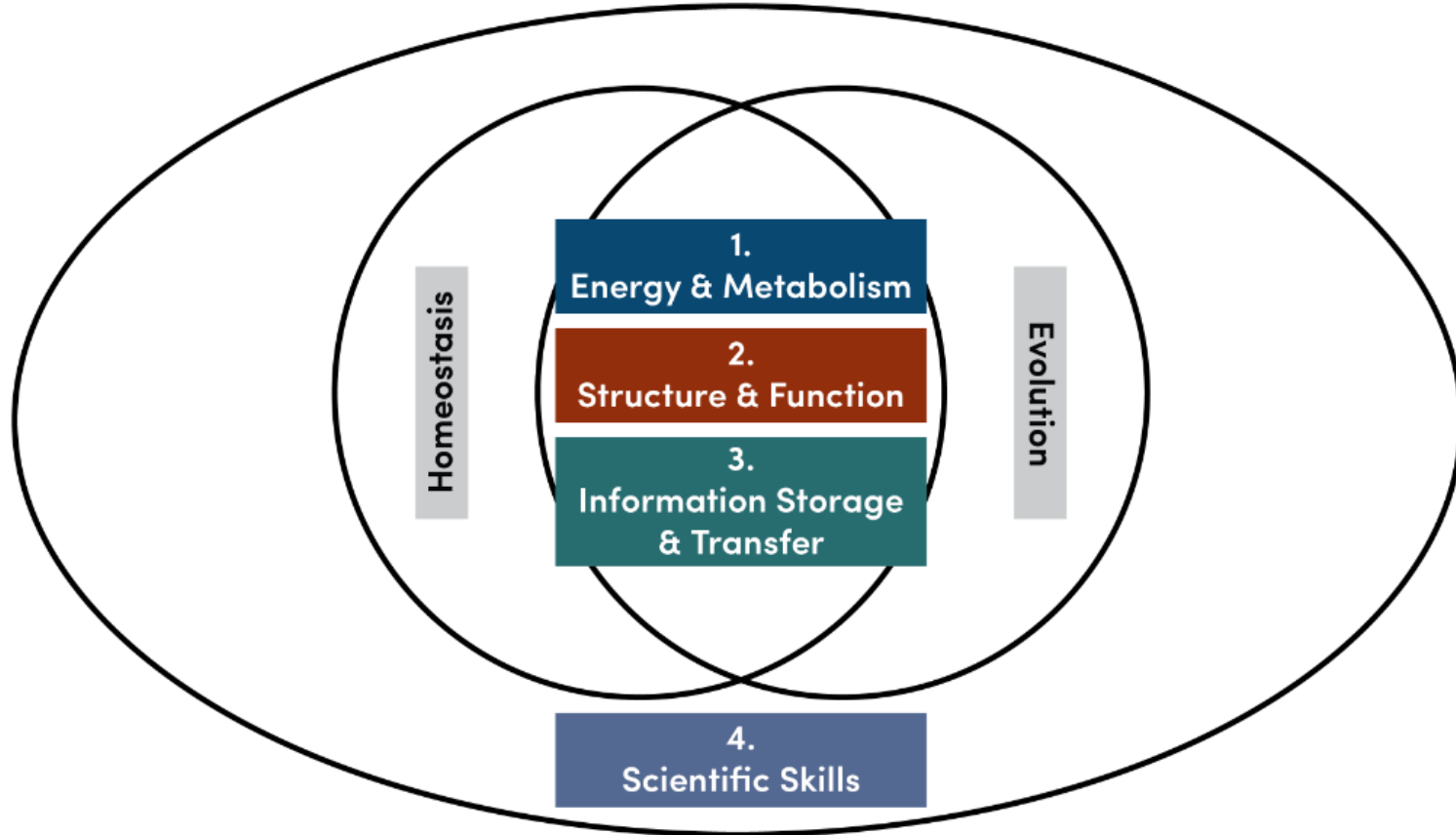
an OER for Exploring Biomolecular Structural Data to Learn Biology

Alexandra Pettit, Carleton University, Canada and *Shuchismita Dutta*, Rutgers University, USA



Do you have a learning outcome that addresses **structure and function** in a course you teach?

Foundational Concepts



About Us

The BOL project was a collaborative effort of members participating in the Molecular CaseNet Spring 2022 Faculty Mentoring Network.

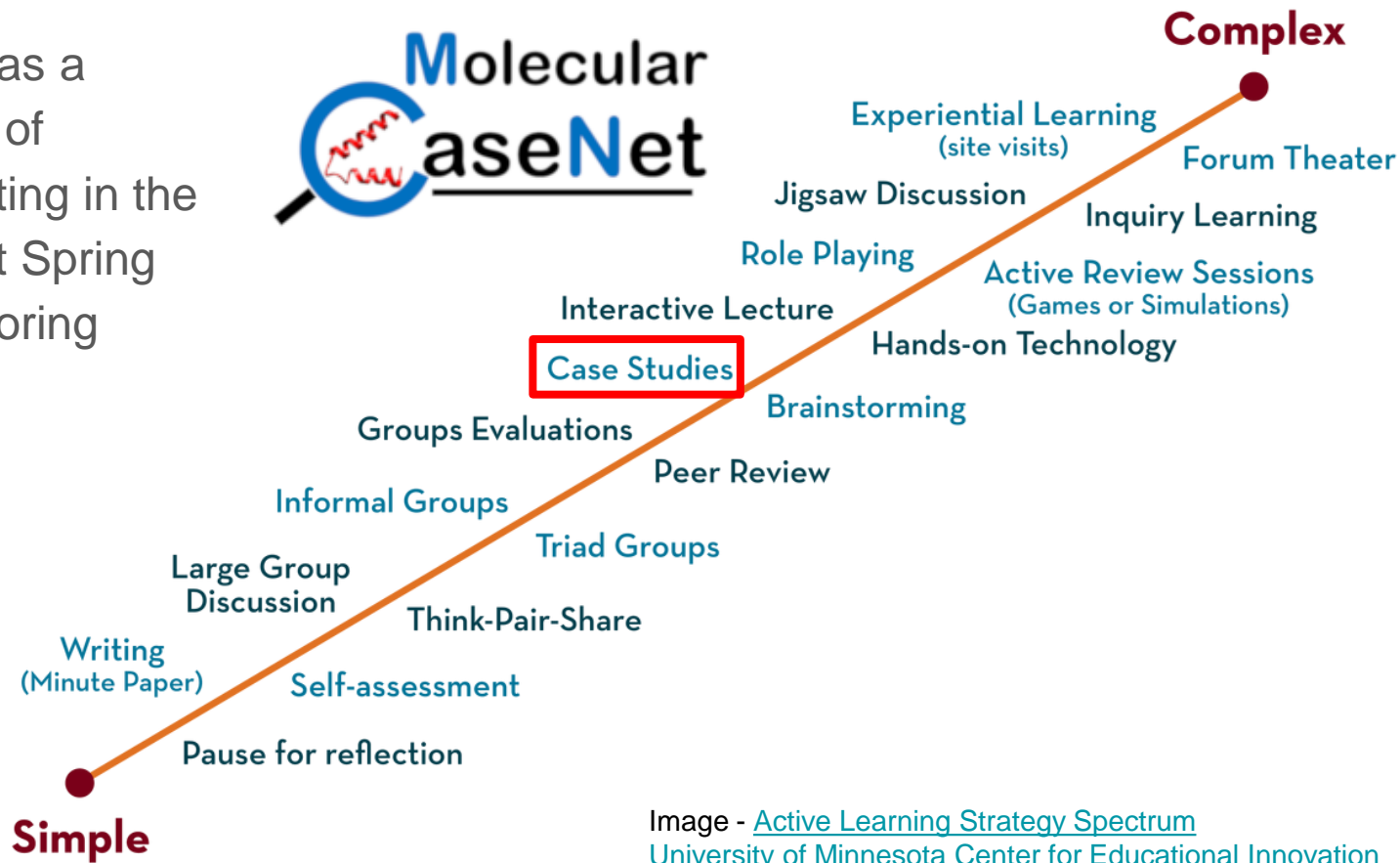
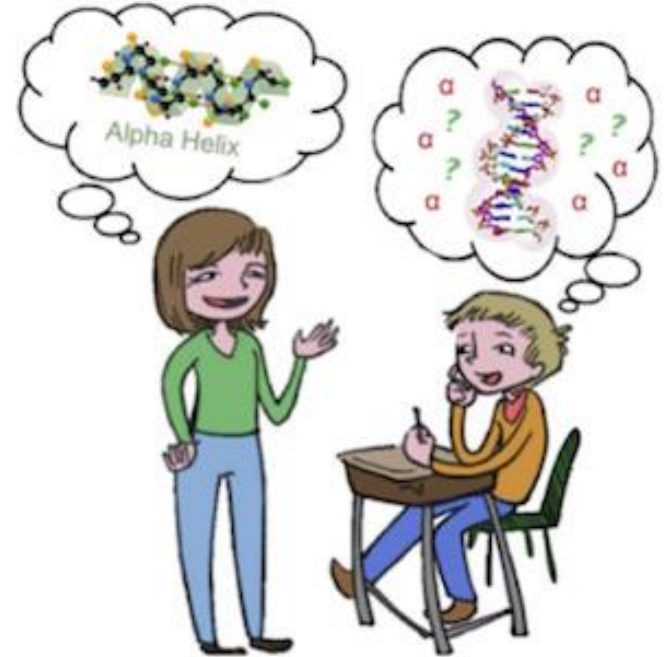
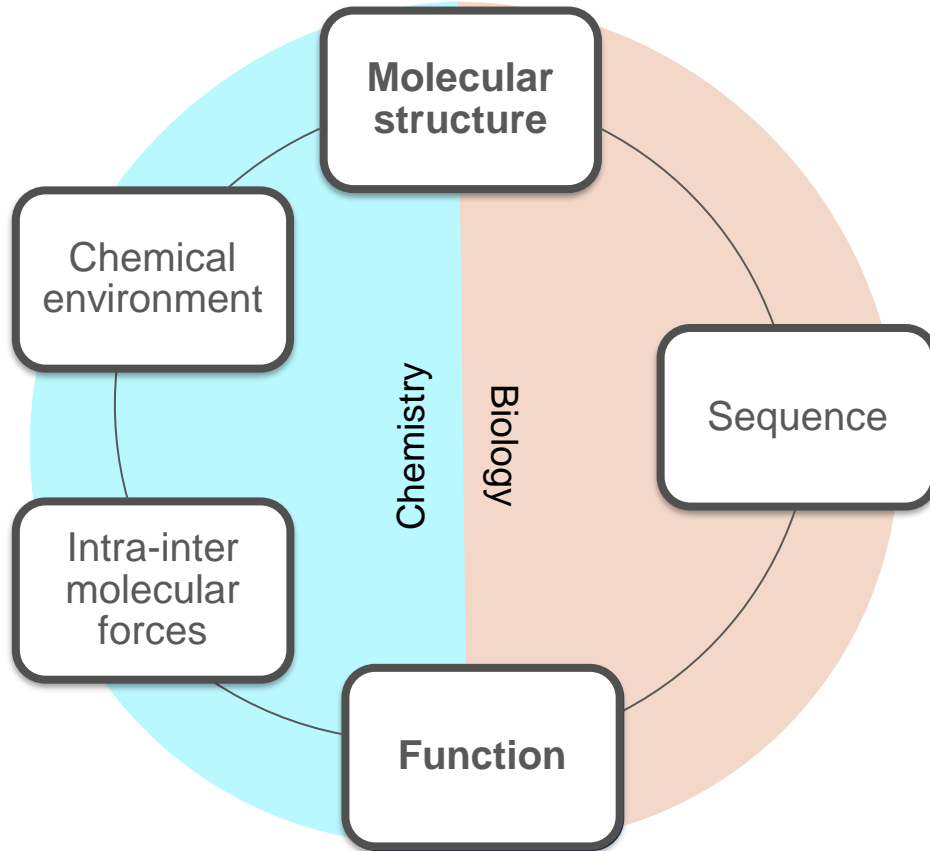


Image - [Active Learning Strategy Spectrum](#)
[University of Minnesota Center for Educational Innovation](#)

It is challenging to integrate these concepts!



Biomolecular Visualization Skills

Student-Instructor visual misunderstanding of protein vs DNA helix (Credit: A. Harvey)

Motivation for the “Box of Lessons”

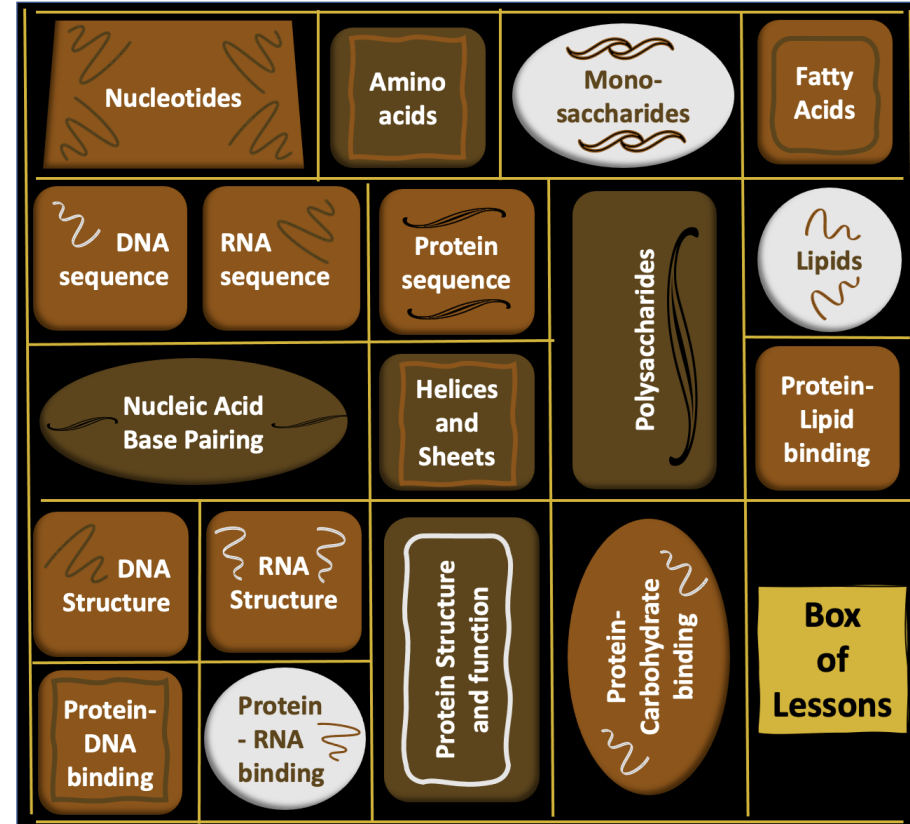
Active learning for bio/biochem using:

- Literature/data-based examples
- Open-access data resources

Free (OER) resource :

- Ready made
- Suits many curricula

Flexible, adaptable



Box of Lessons

[Biological Macromolecules](#) >[Proteins](#) >[Nucleic Acids](#) >[Carbohydrates](#) >[Lipids](#) >

Nucleic Acids



Learning Materials

- [DNA Conformations](#)
- [DNA Conformations: A-, B-, Z-DNA](#)

Activities

- [Exploring Nucleotides-Ex](#)
- [Base Pairing-Ex](#)
- [DNA Sequence and Structure-Ex](#)
- [RNA Sequence and Structure-Ex](#)
- [DNA Structure and Function-Ex](#)
- [RNA Structure and Function-Ex](#)
- [Protein-DNA Binding-Ex](#)
- [Protein-RNA Binding-Ex](#)

Activity Key & Teaching Notes

- [Exploring Nucleotides-key](#)
- [Base Pairing-key](#)
- [DNA Sequence and Structure-key](#)
- [RNA Sequence and Structure-key](#)
- [DNA Structure and Function-key](#)
- [RNA Structure and Function-key](#)
- [Protein-DNA Binding-key](#)
- [Protein-RNA Binding-key](#)

Includes a total of 21 ready-to-implement activities for students and 9 associated learning materials

What does an activity look like?

Base Pairing

Authors: Shuchismita Dutta, Rutgers University, NJ

Lesson Overview:

This lesson reviews base-pairing between nucleotides (seen in nucleic acids, DNA and RNA).

ASBMB Learning Objectives

(<https://www.asbmb.org/education/core-concept-teaching-strategies/foundational-concepts/structure-function>)

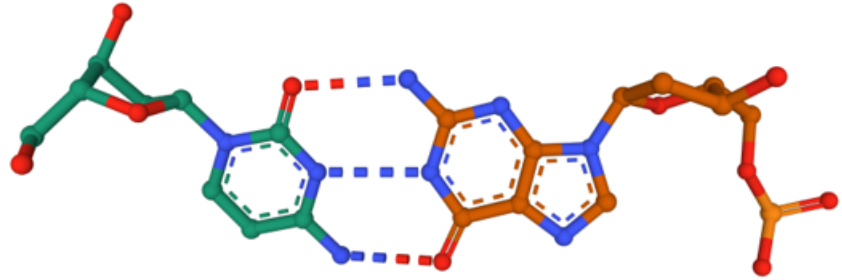
2. Structure is determined by several factors

- Students should be able to **recognize the repeating units in biological macromolecules** and be able to discuss the structural impacts of the covalent and noncovalent interactions involved (*Introductory*).
- Students should be able to discuss the **chemical and physical relationships** between **composition and structure** of macromolecules (*Introductory*).

What does an activity look like?

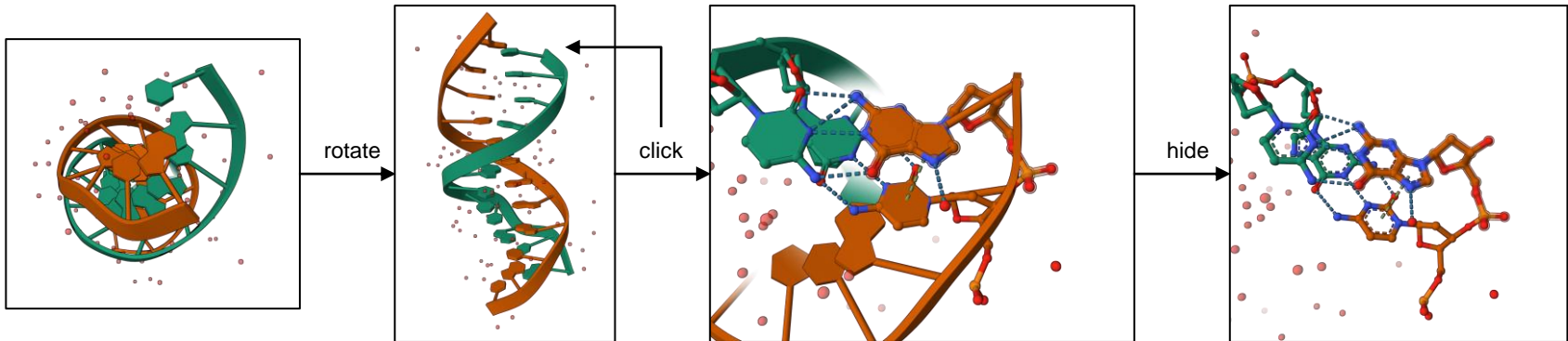
3. Examine the following figures and identify the base pairs shown. Feel free to consult the [nucleotide structures](#) to help with the identification. Complete the blanks in the sentences about the figure written below it. Follow the completed example.

a. Figure 1 (from PDB ID 1bna)



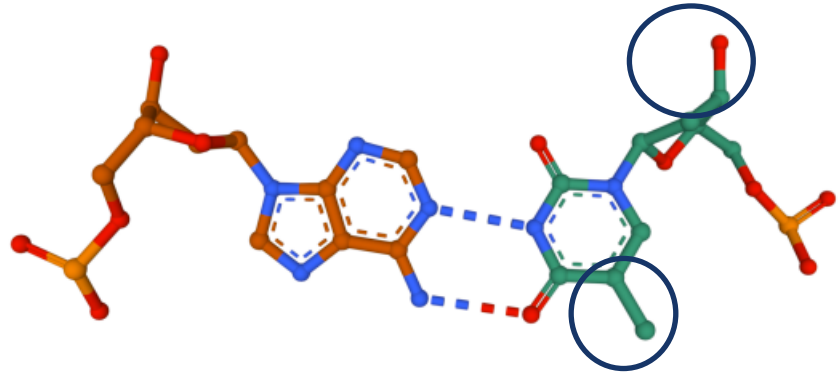
This base pair is between a C : G with 3 hydrogen bonds

An example is provided to get students started



What does an activity look like?

b. Figure 2 (from PDB ID 1bna)

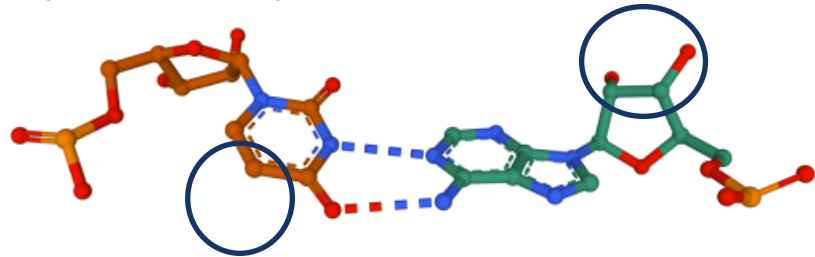


This base pair is between a A : T with 2 hydrogen bonds

Optional Q: Is this a Watson-Crick or Hoogsteen base pair?

Ans: Watson Crick base pair

c. Figure 3 (from PDB ID 1csl)



This base pair is between a U : A with 2 hydrogen bonds

Let's try a
question ...



Explore the base pairing interactions of the bases in the RNA structure, [PDB ID 1ETF](https://www.rcsb.org/entry/1ETF), and answer the following questions:

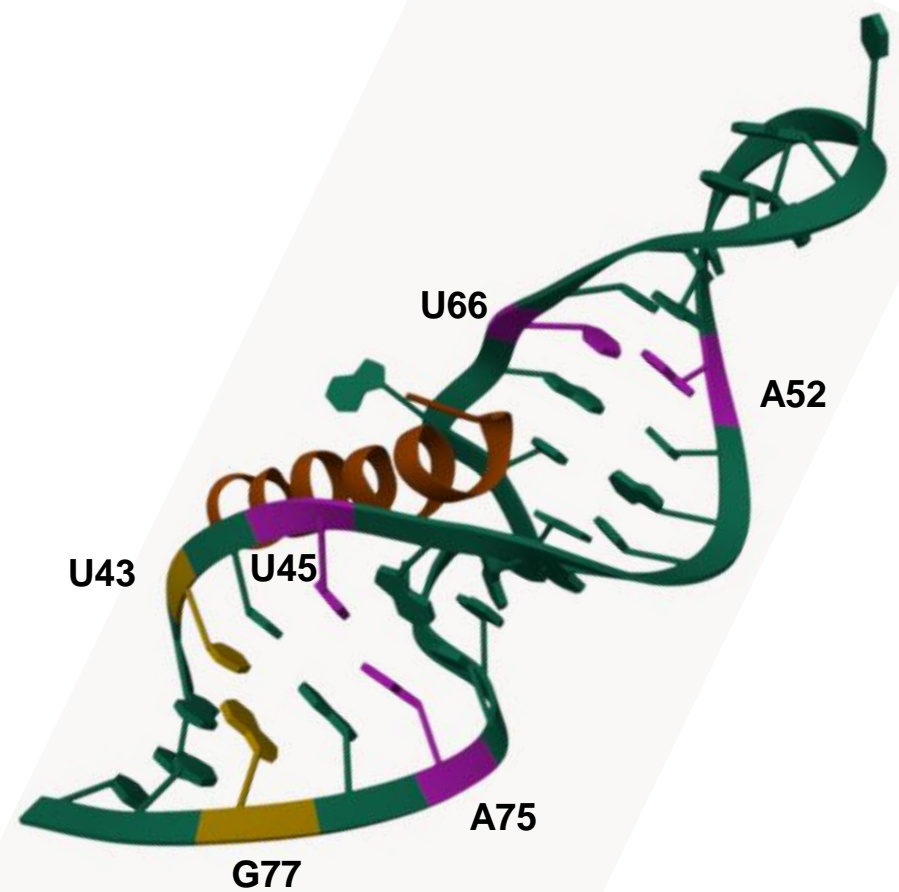
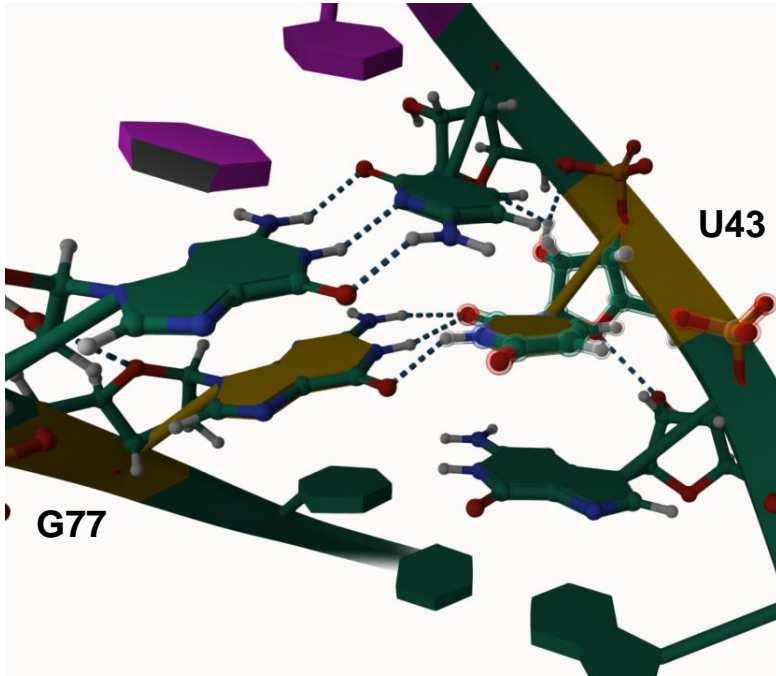
Hint: to explore the interactions of any specific nucleotide, click on it either in the 3D canvas or in the sequence panel

a) Examine the base pairing for nucleotide G77 in PDB entry 1etf. Which nucleotide does it base pair with?

Hint: identify the base that forms one or more hydrogen bonds with the base for G77

b) How many A:U (U:A) base pairs do you observe in this structure?

a) Examine the base pairing for nucleotide G77 in PDB entry 1etf. Which nucleotide does it base pair with?



b) How many A:U (U:A) base pairs do you observe in this structure?

The current “Box of Lessons” collection

All lessons have been
reviewed and pilot tested
by faculty

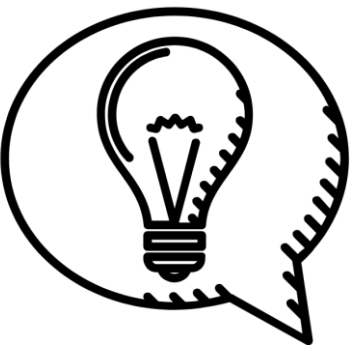
| Topic | Learning Materials | Activities |
|----------------------------------|--|---|
| Biological Macromolecules | <ul style="list-style-type: none">• Atoms, Bonds, and Molecules in the PDB• Water: Importance in Biology | <ul style="list-style-type: none">• Exploring Atoms and Biomolecules• Interrogating the PDB• Exploring waters in the PDB |
| Proteins | <ul style="list-style-type: none">• Amino Acids in the PDB• Exploring Levels of Protein Structure in the PDB• Handedness and Twist | <ul style="list-style-type: none">• Exploring Amino Acids• Protein Sequences• Helices and Sheet• Insulin Structure and Function• Hemoglobin Structure and Function |
| Nucleic Acids | <ul style="list-style-type: none">• Nucleotides in the PDB• DNA Conformations: A-, B-, Z-DNA | <ul style="list-style-type: none">• Exploring Nucleotides• Base Pairing• DNA Sequence and Structure• RNA Sequence and Structure• DNA Structure and Function• RNA Structure and Function• Protein-DNA Binding• Protein-RNA Binding |
| Carbohydrates | <ul style="list-style-type: none">• Saccharides in the PDB | <ul style="list-style-type: none">• Exploring Monosaccharides• Exploring Polysaccharides• Protein-Carbohydrate Binding |
| Lipids | <ul style="list-style-type: none">• Lipids in the PDB | <ul style="list-style-type: none">• Exploring Lipids• Protein-Lipid Binding |

Next Steps!

**Publish the BOL
Materials**
Projected - fall 2023

Examine the **student
experience** with these
materials and assess their
impact on learning!

I thought they were really cool. From the beginning, I never would've known what any of it meant, but I was impressed with how much I learned and applied to those assignments. Seeing the structures and researching everything has made a humongous difference on my life as a student. I feel a part of the science community even more, than I've ever felt before.



Could engaging your student in exploring biomolecular structural data enhance their learning experience in your course?

How could you use these resources to do so?

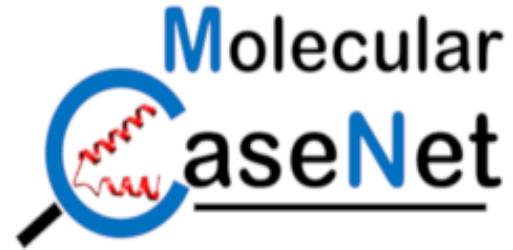
Are there other lessons you would like to see added to the collection?

Interested in exploring the BOL further?

Scan the QR code below and enter your contact info to receive a link to the beta website!



Want to learn more about Molecular Case Studies?



Visit Website:

<https://molecular-casenet.rcsb.org/>

Write to Shuchi Dutta at sdutta@rcsb.rutgers.edu

Acknowledgements

- Molecular Casenet is supported by the National Science Foundation - DBI 1827011; DBI 2018884
- All members of the Molecular CaseNet Spring 2022 QUBES FMN inspired and contributed towards the development of the “Box of Lesson”
 - Several members are still engaged in refining and evaluating the BOL
- The RCSB Protein Data Bank team works to bring data, tools, and resources to researchers, educators, students, and the curious public.

