Molecular CaseNet:

Using a storytelling approach in exploring biomolecular structure–function relationships

Swati Agrawal, Ph.D.

University of Mary Washington
Fredericksburg, VA 22401

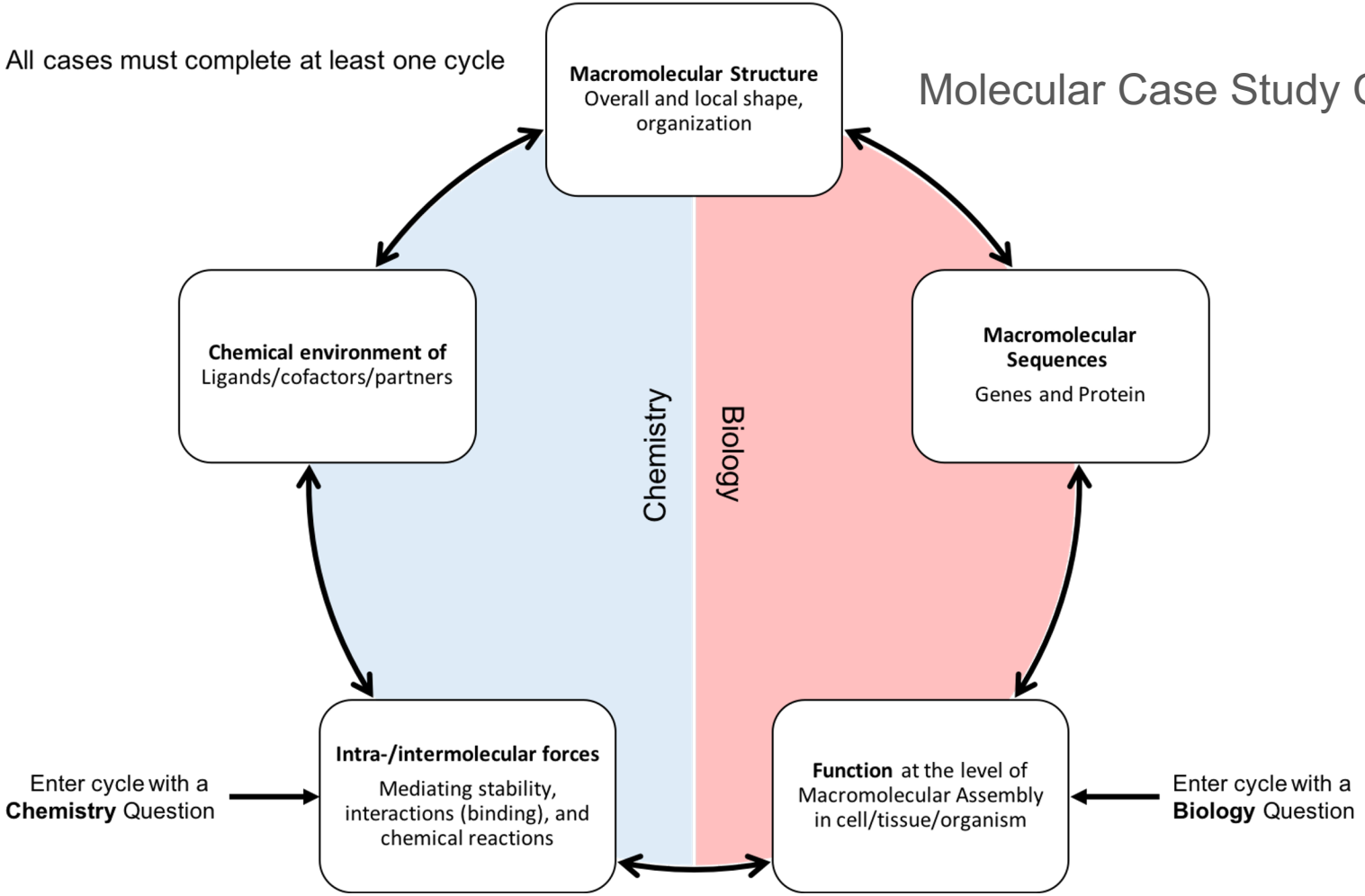
Overview

- The Molecular Case Study Cycle
- Using a published Molecular Case Study
- Connect with Molecular CaseNet to write your own case study

This project is supported by the National Science Foundation - DBI 1827011; DBI 2018884

Molecular Case Study Cycle

All cases must complete at least one cycle



Outline

- What is in a Molecular Case Study

Happy Blue Baby

Prior to case discussion (Homework): Read the news report (pdf) and answer the questions in the **Preparation** section

Resources to learn more:

The scientific article

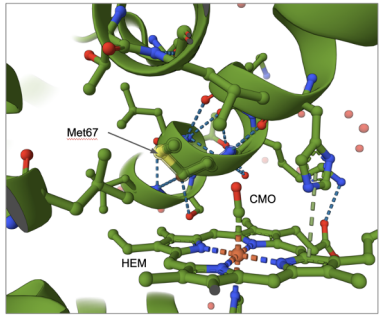
Question: What caused cyanosis in the happy blue baby?

Biology	*Getting to Structure*:	**Part 1**: Grandma provides a clue
	Molecular Exploration:	**Part 2**: Molecular Basis of Cyanosis
	Modeling:	**Part 3**: A Happy ending; **Part 4**: What causes the anemia?
	Assessment:	What if the mutation was present in adult hemoglobin?
Biochemistry	*Getting to Structure*:	**Part 1**: Grandma provides a clue
	Molecular Exploration:	**Part 2**: Molecular Basis of Cyanosis
	Modeling:	**Part 3**: A Happy ending; **Part 4**: What causes the anemia?; **Part 5**: Binding and Release
	Assessment:	What if the mutation was present in adult hemoglobin?

Happy Blue Baby

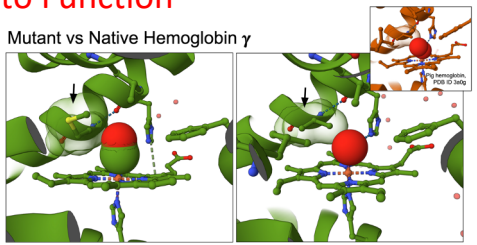
Exploring the Molecular Structure(s)

Examine the location and interactions of the mutation of Val67Met in HbF



Connecting Structure to Function

Mutant vs Native Hemoglobin γ



Macromolecular Structure
Overall and local shape, organization

Chemical environment of
Ligands/cofactors/partners

Macromolecular Sequences
Genes and Protein

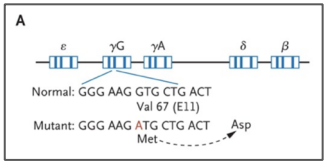
Intra-/intermolecular forces
Mediating stability, interactions (binding), and chemical reactions

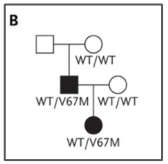
Function at the level of Macromolecular Assembly in cell/tissue/organism

Chemistry

Biology

Getting to the Structure





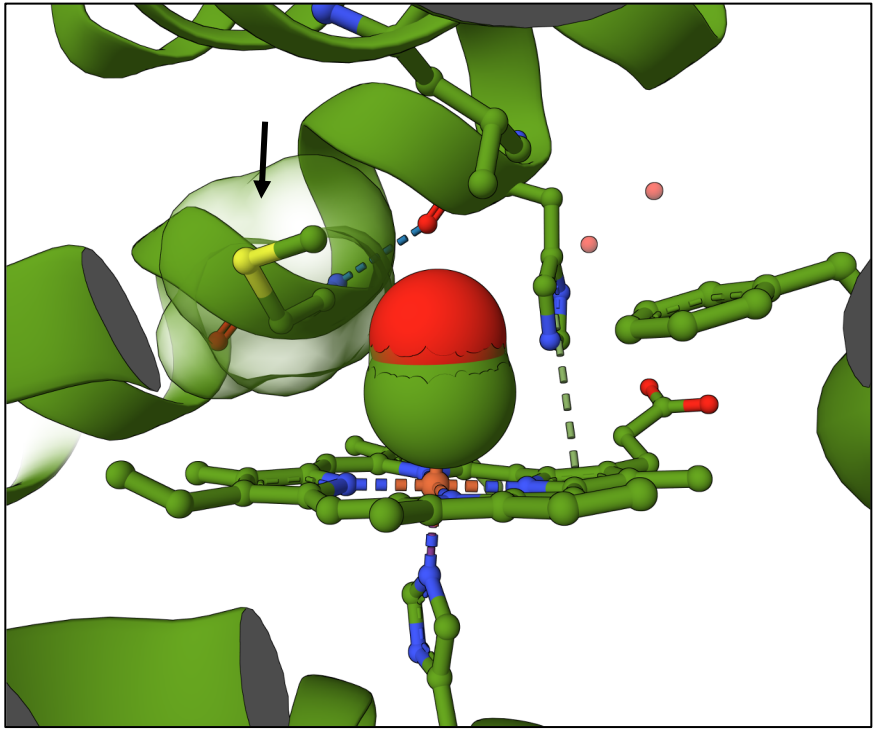
Mutation of Val67Met in HbF

Crowley et al., 2011, N Engl J Med., 365, 281

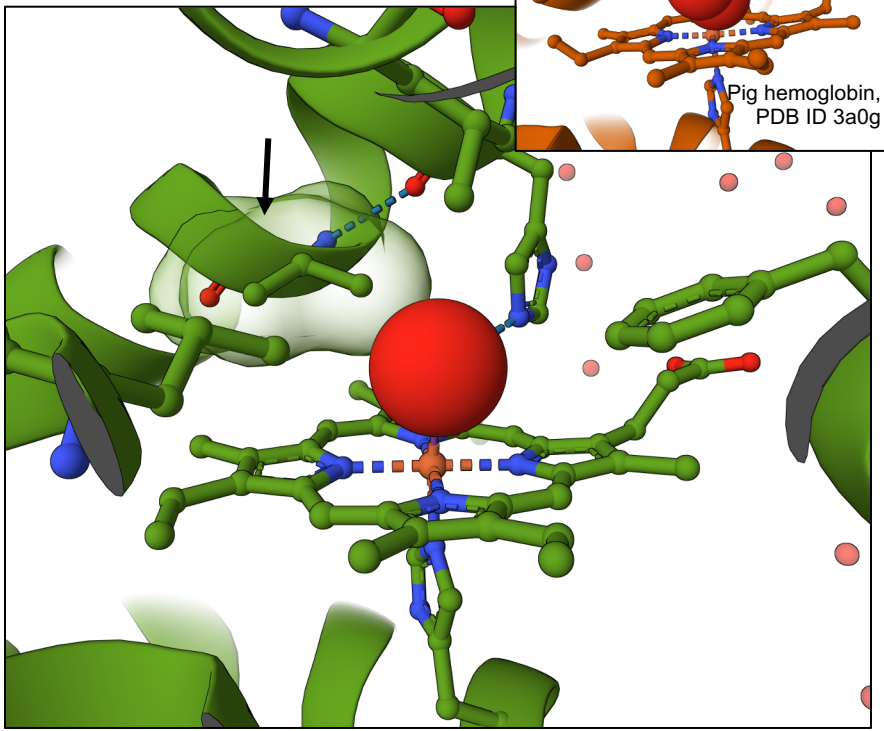
Presentation of Case context

Q. Why did the baby turn blue?

Mutant vs Native Hemoglobin γ



V67M in PDB ID 4mqk, chain B



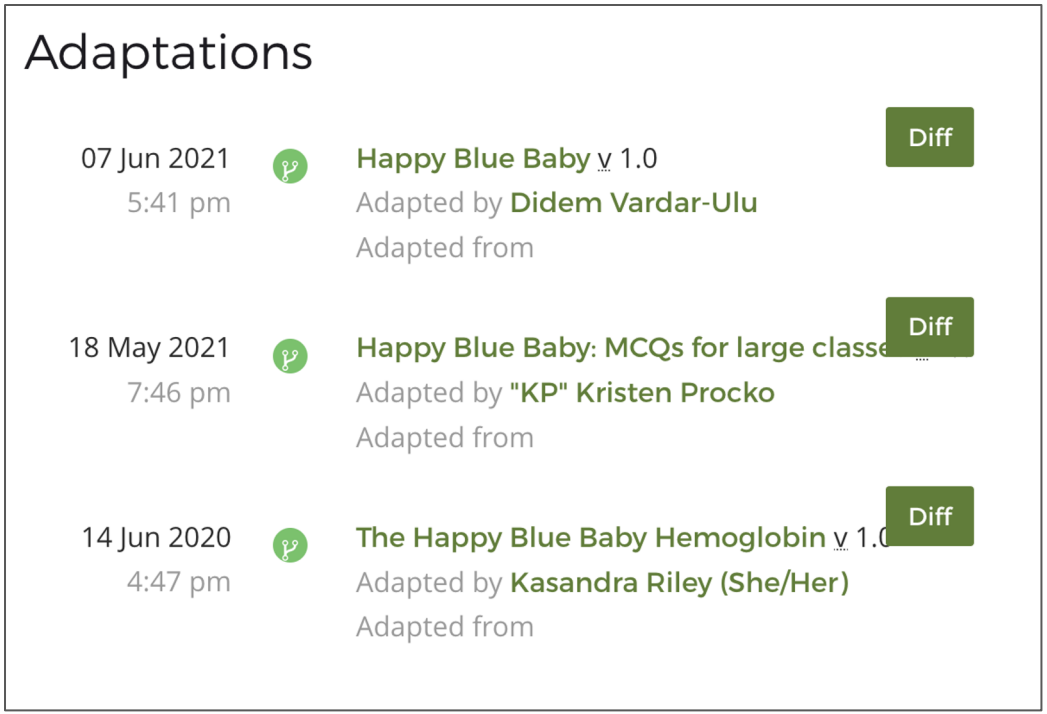
V67 in PDB ID 4mqj, chain B

Happy Ending

- When the mutant Fetal Hemoglobin γ changes to Adult Hemoglobin β → there is no mutation, hence cyanosis
  - Explore UniProt https://www.uniprot.org/uniprotkb/P69892

- Could the same mutation appear in Hemoglobin β?

Adaptations



How would you adapt this case?

Why should you join the MCN community?

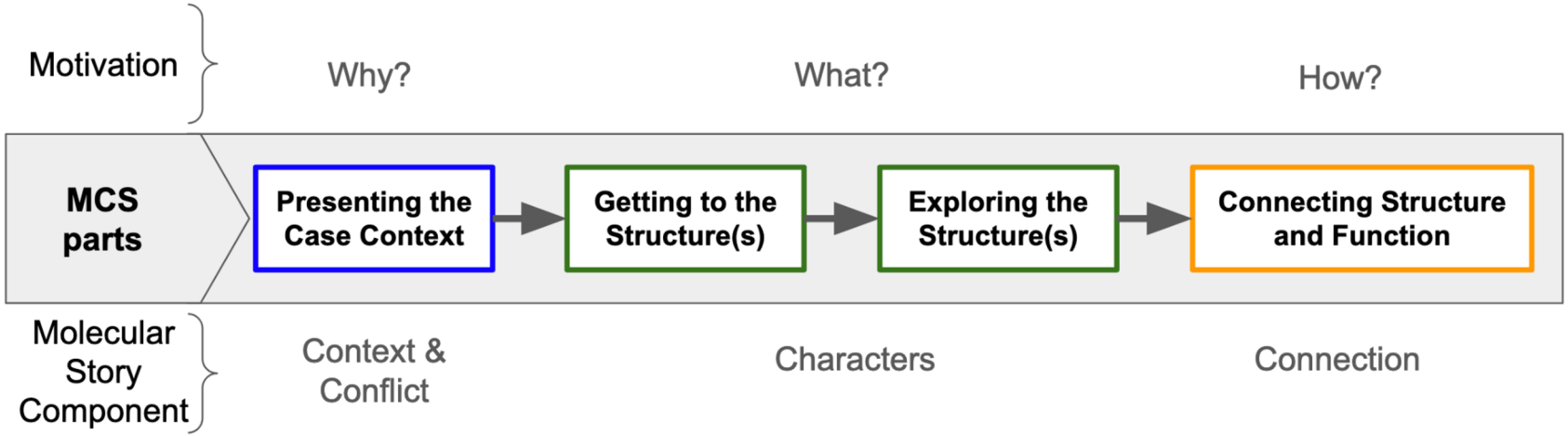
Educator Benefits:

- Free access to MCS (this is an OER)
- Opportunities to engage students in exploring molecular structures from the Protein Data Bank (PDB) and a variety of open access data resources
- Connect with a community of educators developing and using molecular case studies and participation in Professional Development

Student Benefits:

- Introduction to authentic data resources
- Opportunities to experience the scientific method (including the possibility to collaboratively author molecular case studies for submission to Molecular CaseNet)
- Engaging and real-world examples of concepts and skills learned in biology, chemistry, and other disciplines

Authoring a Molecular Case Study



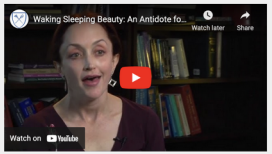
Variety of Molecular Case Studies available

Happy Blue Baby; doi:10.25334/2R67-W933;

Molecules explored: Hemoglobin, including structures of native, mutant, and variant proteins

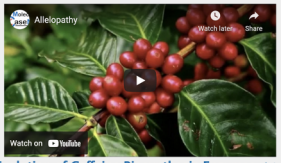
Nicholas' Story; doi:10.25334/H82J-3C28;

Molecules explored: Hemoglobin, including structures of native, mutant, and variant proteins; and complexes with drugs and gene therapy approaches



Waking up Anna; doi:10.25334/Y88F-9279;

Molecules explored: GABA-A receptor – a chloride ion channel

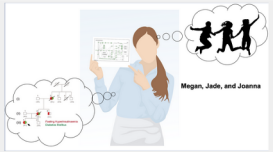


Evolution of Caffeine Biosynthesis Enzymes; doi: 10.25334/225Z-KR22;

Molecules explored:Caffeine biosynthesis methyltransferases and their evolutionary relationships

Piwi Matters; doi:10.25334/ZM3H-4149;

Molecules explored: Fruit fly Piwi protein structure, function, and design

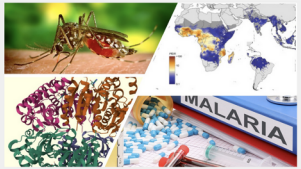


A Case of Severe Insulin Resistance; doi: 10.25334/DTTA-WW18;

Molecules explored: Akt-2 kinase protein and mutation in insulin signaling

COVID-19: Molecular Basis of Infection; doi: 10.25334/HQCA-QD59;

Molecules explored: SARS-Cov-2 and SARS-CoV Spike protein complexes with Angiotensin-converting enzyme 2 (ACE2)



Maria vs Malaria; doi:10.25334/RSGM-5K80

Molecules explored: Lactate Dehydrogenase (parasitic and human), in complex with the coenzyme NADH and a competitive inhibitor.

#	Case Study
1	Running Out of Time
2	Be careful what you eat: An analysis of enzymatic functional and structural effects due to α-amanitin toxicity
3	Why don't these antibiotics work? Selectivity vs Promiscuity In NDM-1
4	Meet Sam – the rapidly aging child
5	A Magical Trip into Protein Structure
6	Pandemics, Pitfalls, and Possibilities: A Study of HIV Protease Inhibitors and Drug Resistance
7	From Pandemic to Paxlovid
8	From Pandemic to Paxlovid (a variant)
9	Directed Evolution of I. sakaiensis PETase for plastic recycling
10	The Many Faces of Heme
11	Kristin's Story: Sentenced to a Restricted Diet? – Diagnosed at Birth with Phenylketonuria

Review Case and Learning Objectives

- ASBMB
  - Structure and Function
    - 3. Structure and function are related
    - 4. Macromolecular interactions
    - 7. The structure (and hence function) of macromolecules is governed by foundational principles of chemistry and physics
  - Scientific Skills
    - 2. Accessing, comprehending and communicating science
- (MSN) Systems in the Curriculum
  - Biochemistry
    - Impact of intramolecular interactions on protein structure, folding, influence on biological function
    - Intermolecular interactions of biopolymers and influence of polymer primary, secondary, and tertiary structure (DNA, RNA, proteins, etc.)
- NIBLSE
  - Find retrieve and organize various types of bioinformatics data
  - Explore and/or model biological interactions, networks, and data interactions using bioinformatics
- BioMolViz
  - Alternate Renderings
  - Ligands and modifications
  - Macromolecular assemblies
  - Molecular interactions
  - Structure Function Relationships
- BioCore
  - Information Flow
  - Structure and Function

A Collection of Goodies

What else would you like to see here?

Learn more about ...

- **Concepts**
  - Biological Macromolecules - e.g., Amino acids and other biomolecular building blocks, Proteins, covalent and non-covalent interactions
- **Tools for ...**
  - Molecular Visualization - e.g., Mol*, UCSF Chimera, iCn3D, JMol, PyMol
  - Exploring the Proteins Data Bank - What is in RCSB.org? How to use this data?
  - Exploring Bioinformatics Data Resources - Querying and integrating information from sequence, structure, and function data resources
- **Case Studies**
  - About Case Studies - General information
  - The Molecular Case Study Cycle - What all Molecular Case Studies must complete
  - Developing and Using Molecular Case Studies [**New Pipeline** - available now with documentation (March 2023)]

More resources on PDB-101

Box of lessons

How to connect with Molecular CaseNet?

- Join to use
  - published case studies or case studies for piloting at https://molecular-casenet.rcsb.org/
- Join the new Cohort in Fall 2024 (Sep./Oct.) to author your own molecular case study
  - Scan QR code to complete an interest form