Molecular Case Studies:
At the Interface of Biology and Chemistry

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Introduction

Structure-Function is a core concept in biology education.

Challenges for educators – how to:

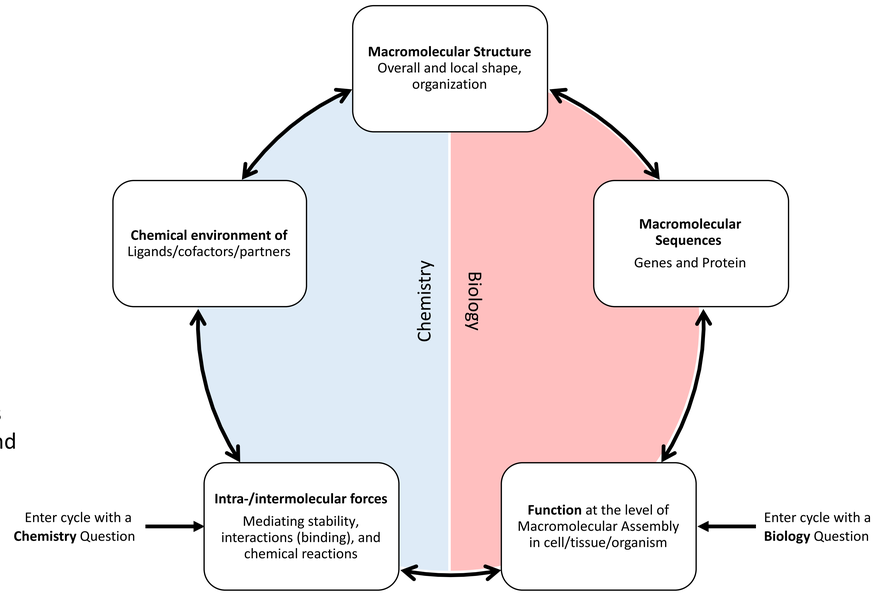
- identify examples to illustrate structure-function relationships?
- guide students to visualize relevant molecular structures that illustrate structure-function relationships?
- use data from various bioinformatics resources to facilitate a deeper understanding of biology?
- engage students in learning about structure-function relationships at the interface of biology and chemistry?

Possible solution – use a molecular case study. *Advantages* include:

- access ready to use examples illustrating structure-function relationships
- introduction to a real-world biology question
- modular and flexible design
- opportunity to engage students in exploring relevant molecular structures and learning structure-function relationships at the interface of biology and chemistry.

Components of a case

- *Introduction*: Engages student in a real-world problem
- *Getting to Structure*: Explores the case question; identifies relevant molecules to explore using bioinformatics and scientific literature.
- *Molecular Exploration*: Visualization and analysis using readymade virtual exhibits and/or web-based visualization tools.
- *Assessment*: Applying knowledge and skill to solve a new problem.



Molecular Case Study Cycle

Learning Objectives

Discipline specific:

- Cell Biology - explain how cellular structure impacts its function – e.g. communication of signals between outside and inside of cells.
- Biochemistry and Molecular Biology - describe how 3D structure of a protein impacts its function, including ability to interact with other molecules.

Competencies:

Apply the process of science; use modeling; interdisciplinary explorations (using data from various bioinformatics resources); communicate; understand the relationship between science and society

Examples of Molecular Case Studies

- **Nicholas' Story** – based on Sickle Cell Disease addresses
  - What causes SCD pain crisis?
  - How does the treatment w hydroxyurea work?
  - How can small molecule drugs and gene therapy help treat SCD?
- **Happy Blue Baby** – discusses a mutation in HbF
- **Waking Up Anna** – discusses GABA-A receptor agonist
- **Evolution of Caffeine** – explores Allelopathy, Convergent Evolution
  - Why do plants make caffeine?
  - How do plants make caffeine?
- **Piwi Matters** – discusses fruit fly egg production
- **A Case of Severe Insulin Resistance** – discusses Cell signaling

A Case of Severe Insulin Resistance

Introduction – the hook

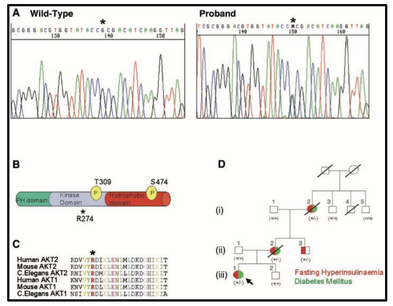
Jade and Megan have been best friends since second grade. While in school they spent a lot of time in each other's homes. Jade's older sister, Joanna, was their favorite go-to person – for help with school projects, personal advice, teenage troubles, and so much more. Currently the three of them live in different cities – Megan is in Boston College, majoring in Biochemistry, Jade is in Los Angeles studying to become a pianist, and Joanna is a nurse practitioner in Texas. A few years ago, Joanna got married and now lives with her husband and little baby girl. Last month, Jade called Megan on a Sunday and anxiously said – "Do you know Joanna is just 32 and she told me that she was recently diagnosed with Diabetes?" "She is not obese, you know, and is very particular about what she eats and stuff". Megan sensed that Jade was worried. She knew Jade's mom and grandma had been diagnosed with diabetes in their thirties too, so she wondered if Jade was worrying about developing diabetes herself. That day they talked on the phone for an hour about family history, food, obesity, and diabetes. By the time Jade hung up, Megan was seriously thinking about both Jade's chances of getting diabetes, and for than matter, Joanna's daughter's too.

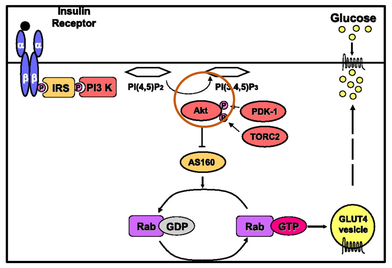
The next morning Megan started searching online to see if I could learn about diabetes running in families. She wanted to understand if diabetes could indeed be inherited. Searching through PubMed Megan read about Maturity Onset Diabetes of the Young (MODY) but brushed it aside because she believed that since Joanna is in the healthcare field, she must have thought about this and gotten tested. The other phrase that kept coming up in her exploration was insulin resistance. One particular paper that really caught her attention titled "A Family with Severe Insulin Resistance and Diabetes Due to a Mutation in AKT2". She became curious and opened the paper – the family tree shown in the paper seemed very much like Jade's family, so she wanted to learn more.

Let us join Megan in understanding what the paper described.

Getting to Structure

Identify mutation and role in signaling pathway

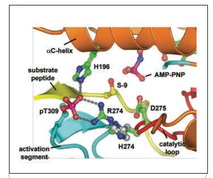




Dash et al., 2009, doi: 10.1073/pnas.0900909106.

Molecular Explorations

compare structures of active and inactive forms of Akt2



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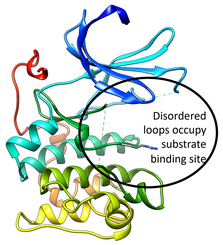
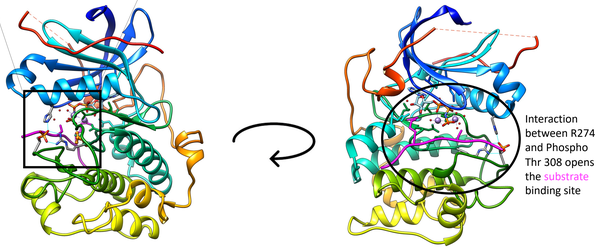
DOI: 10.1126/science.1096706



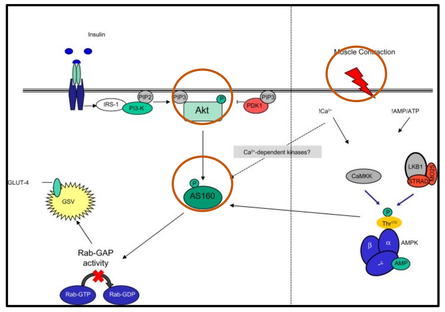
Inactive enzyme, PDB ID 1mrv, Huang et al., 2003)



Active Akt2 enzyme in complex with GSK3 peptide and an ATP analog, (PDB ID 1o6k, Yang et al., 2002)

Assessment

- how to bypass the block in signaling



Mackenzie and Elliot, 2014 10.2147/DMSO.S48260.

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An Invitation

Would you like to join Molecular CaseNet and collaborate with us?

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OR

Go to https://forms.gle/KwoEQ5xomdu6YB9cA