



Successful research driven projects in the science classroom

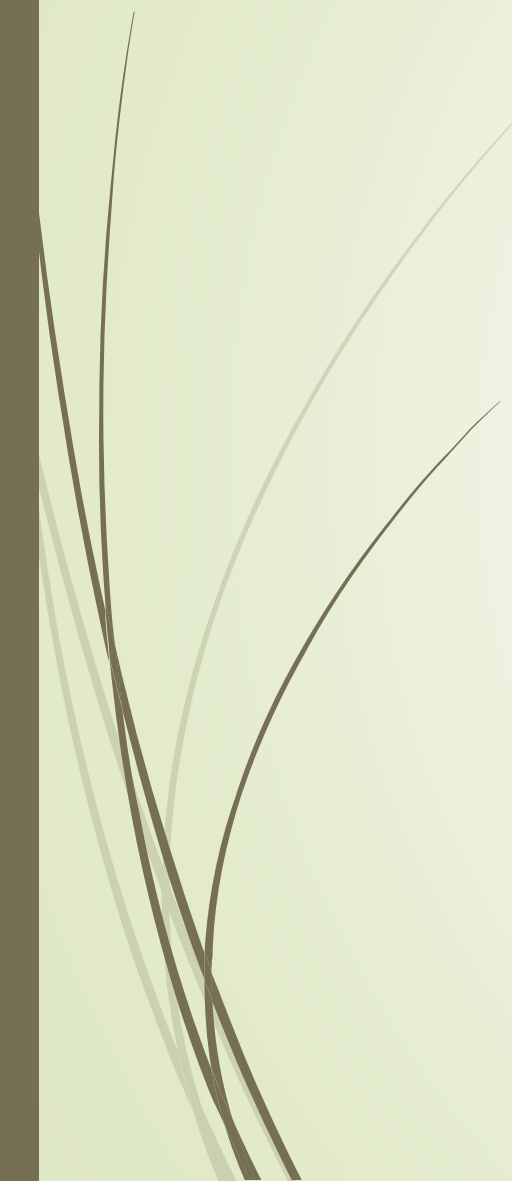
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Illinois Math and Science Academy

Japan Super Science Fair Teacher Presentation 2022



Illinois Math and Science Academy (IMSA)

- Residential academy for gifted students
 - One hour west of Chicago, Illinois
 - Approximately 650 students 10th-12th grade
 - Approximately 50% female and 50% male
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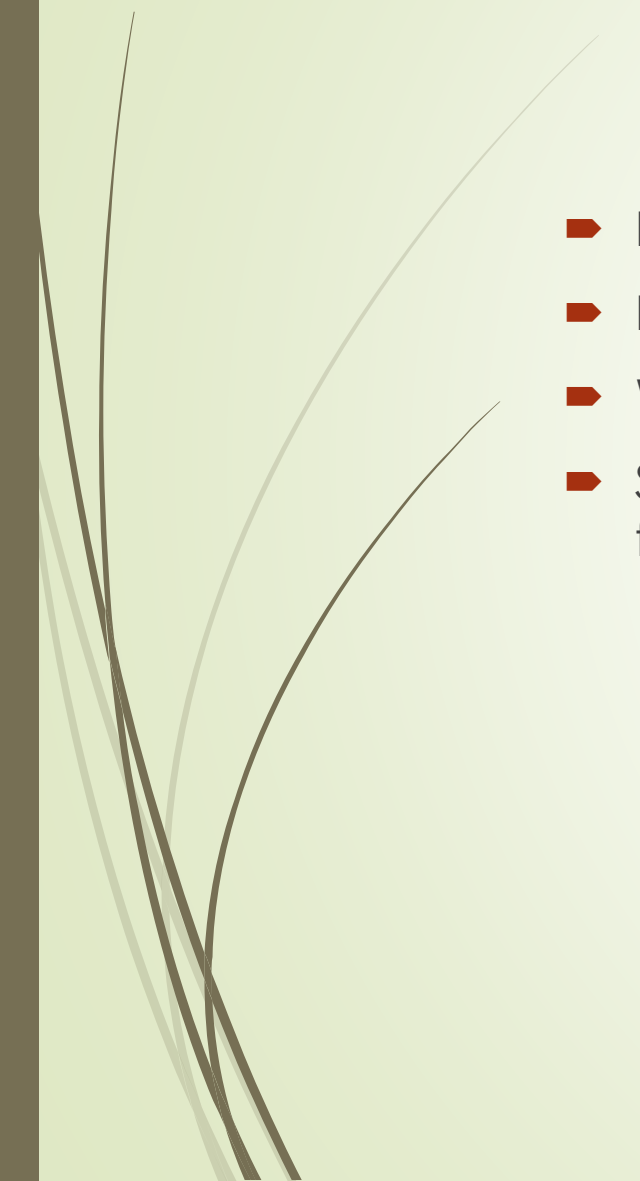


Types of Student Research Projects

- ▶ Research in the classroom
- ▶ Research outside the classroom
 - ▶ Research on-campus
 - ▶ Research off-campus



Research in the Classroom

- ▶ Pathophysiology is a Biology elective
 - ▶ Emphasis is on biological systems modeling
 - ▶ Ways to model through different means
 - ▶ Students are encouraged to model situations using what they have learned from other classes
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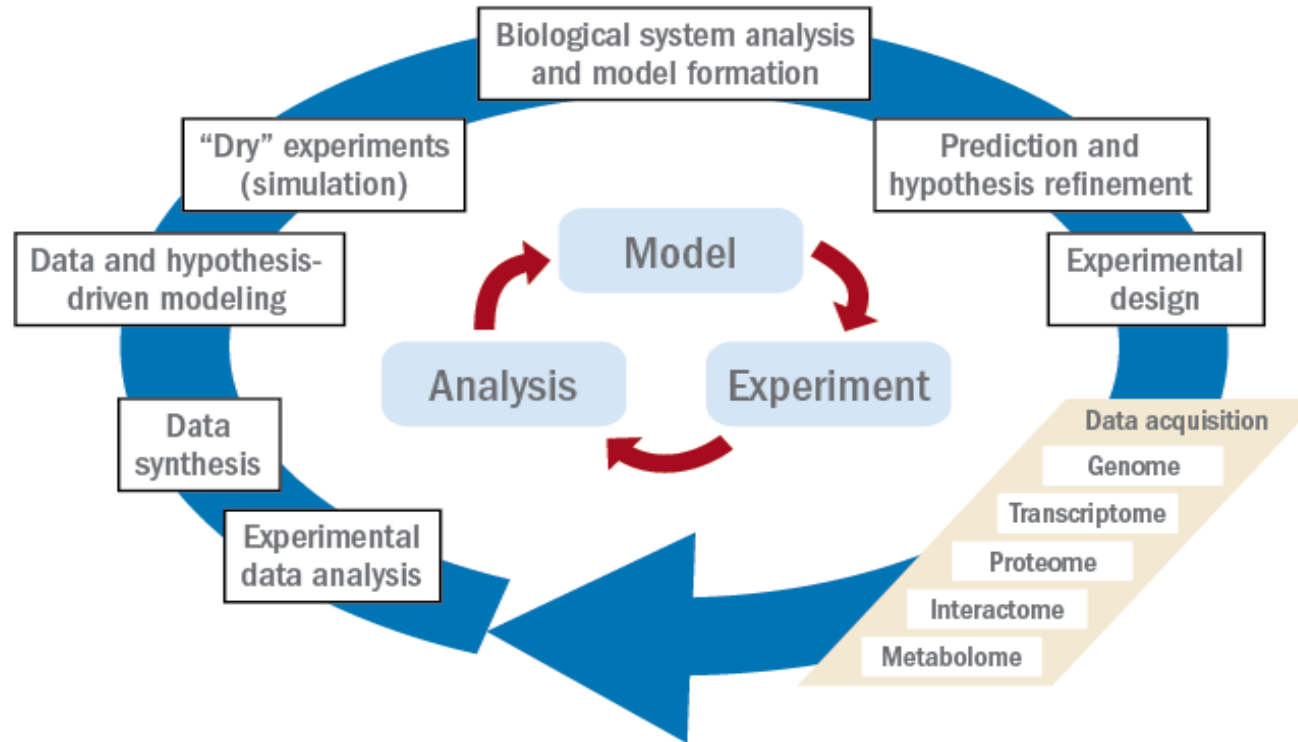


Student Success in Pathophysiology

- ▶ Research on modeling
 - ▶ Model biological systems
 - ▶ Discuss and integrate into real life examples
 - ▶ Use math, computer science, etc to model
 - ▶ 3-D modeling
 - ▶ Graphic novel (comic) modeling

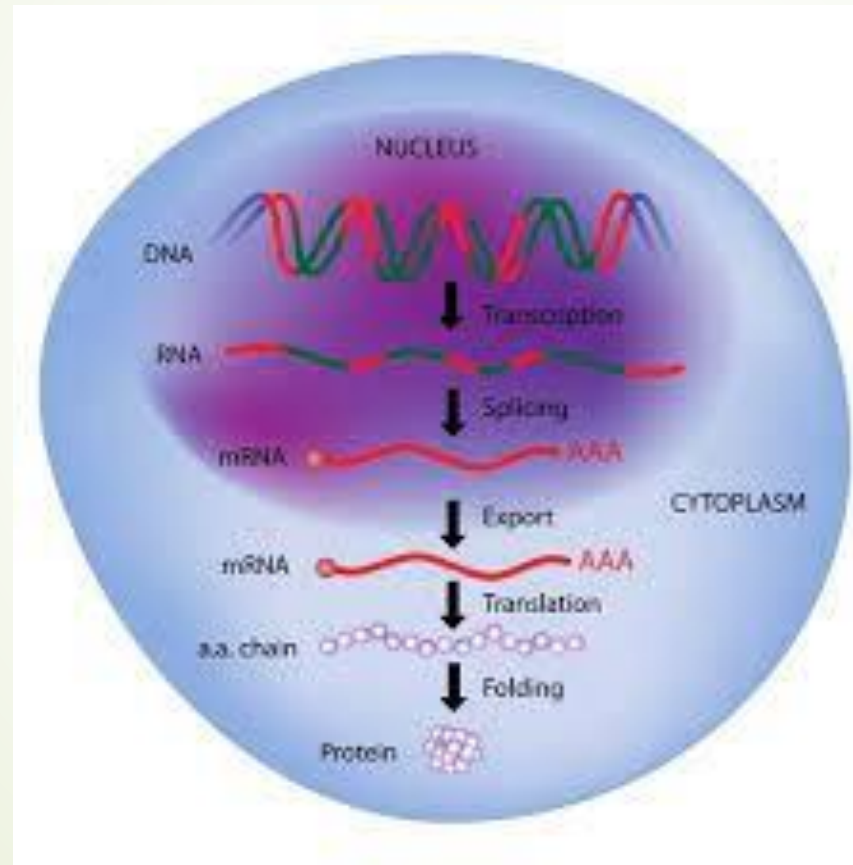
Modeling Concepts in Biological Systems

The process of systems biology research



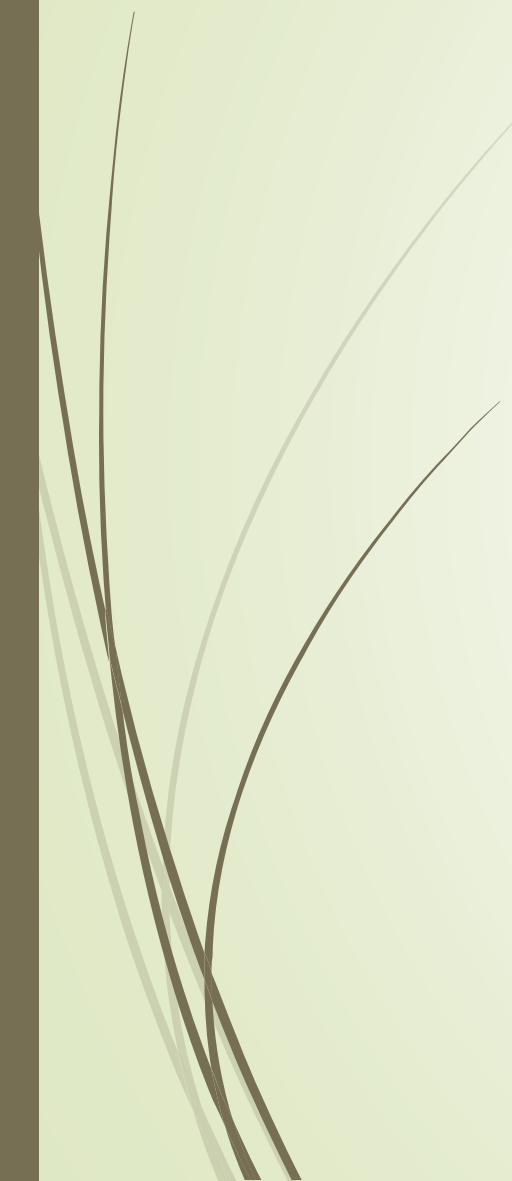
Source: Agilent Technologies

What is Transcription?





Transcription Modeling Project

- ▶ Students were asked to model transcription
 - ▶ Incorporate previous learning
 - ▶ Demonstrate clear understanding
 - ▶ Discuss procedure with other students
- 

Student Transcription Model #1

```
There's no promoter so the RNA Polymerase can't bind!  
Please choose an index from 0-4 for the promoter:  
2  
Great the promoter is at position: 2  
Press 1 to remove the repressor blocking transcription. Press 0 to keep repressor.  
1  
Press 1 to add activator to increase transcription. Press 0 to not add activator.  
1  
Press 1 to add another activator to further increase transcription. Press 2 to not add activator.  
0  
Here is your DNA:  
TCACAATTGTGTGGGATTGACGACAG  
AGTGTTAACACACCCTAACTGCTGTC  
Press Enter to allow the method RNA Polymerase to synthesize an RNA string from the DNA  
  
Here's your mRNA Strand that was transcribed 5 times:  
UCUUAAGAGAGGGUAAGUCGUC
```

Student Transcription model #2

Inverting a Matrix

$$\begin{bmatrix} 6 & -7 \\ -2 & 4 \end{bmatrix}$$

Student Transcription Model #2 (continued)

Substitution Matrices

Rectangular Snip

- Sequence Alignment is a way of translating DNA sequences into easily understandable matrices where similar DNA sequences are aligned on top of each other, this can be used to see regions that are similar because of functional, structural, or evolutionary relationships between the two
- Used to record the rate at which a nucleotide sequence would mutate over a long period of time
- Identity matrix can be used to see the relationship between two closely related DNA sequences but fails at recognizing relationships between more distantly related strands
- PAM was developed to be better at recognizing the differences between closely related proteins
- Blosum Developed because PAM was bad at calculating evolutionary divergent nucleotide sequences
 - The problem with the identity and the PAM matrix was that they approximated small changes over small time scales which was very difficult to work with when presented with a longer period of time



3-D Modeling Projects

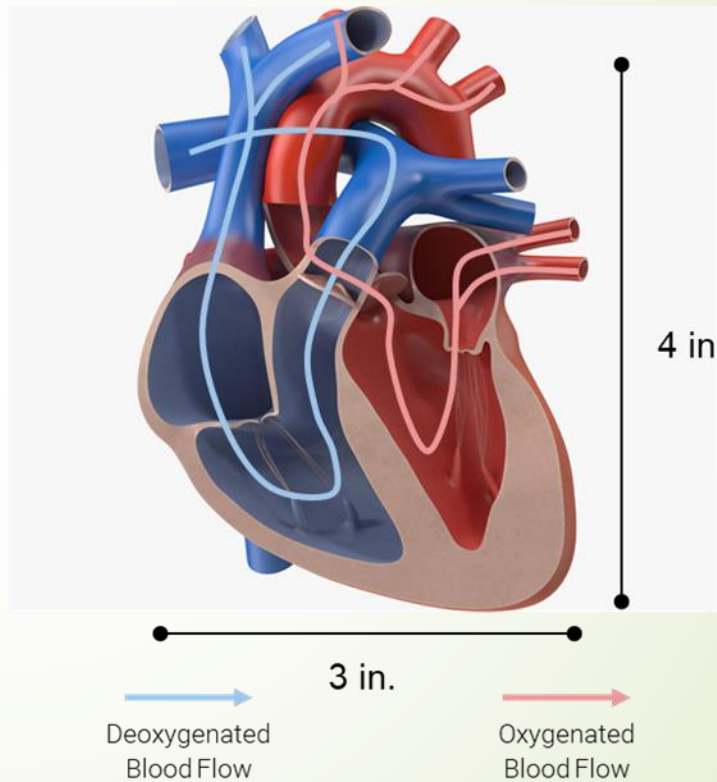
- ▶ Heart Model Project

- ▶ Students were asked to make a 3-D model of a human heart
- ▶ They were required to mark all the parts and the coronary circulation
- ▶ They could make the heart “work” for extra credit
- ▶ Students were given 2-3 weeks to complete this project outside of class with a partner
- ▶ A heart model proposal was first submitted for teacher approval after which they began building the heart

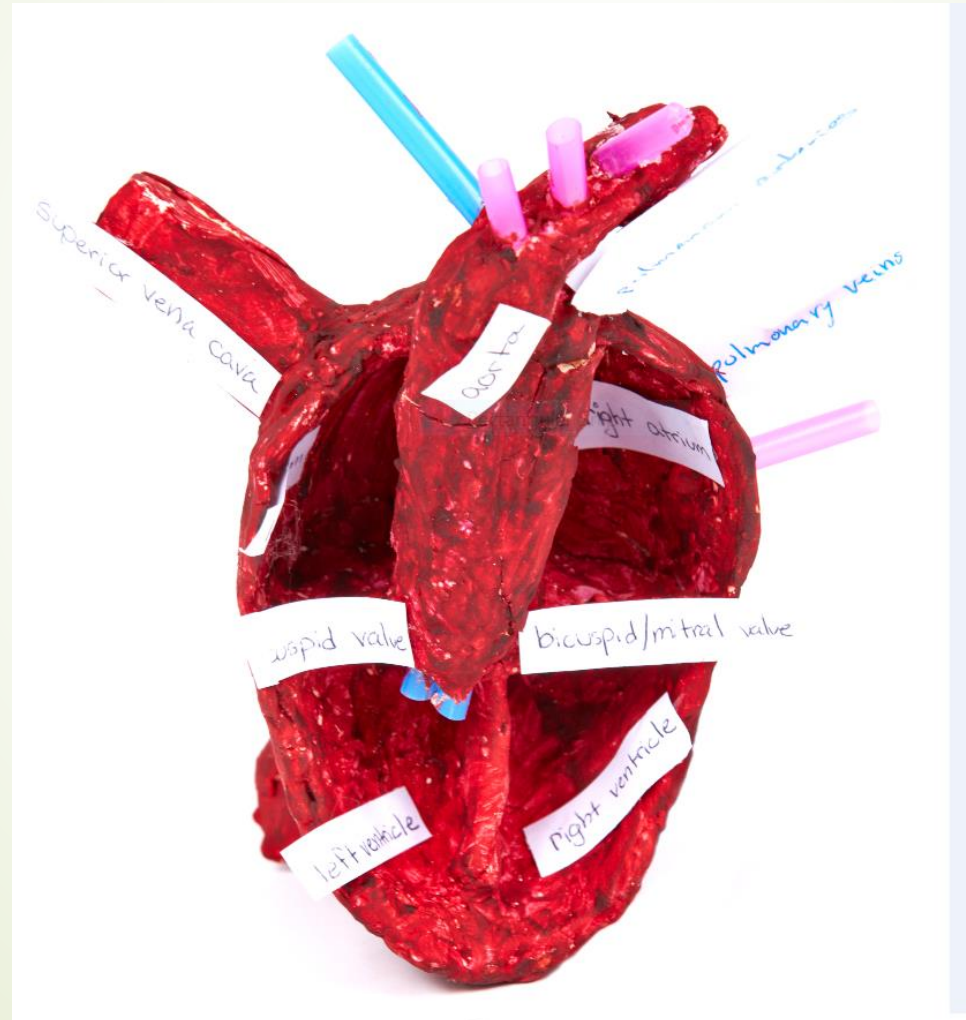
Excerpt from a Student Heart Model Blueprint

Components

6.5" x 3/16"
Airline Tubing for
Veins
4" x 3/16" Airline
Tubing for Arteries
3" x 1/2" Plastic
Tubing for Aorta
2 Pounds of
Modeling Clay for
Heart Tissue
Blue and Red
Paint for Labeling



Example of a Student Heart Model

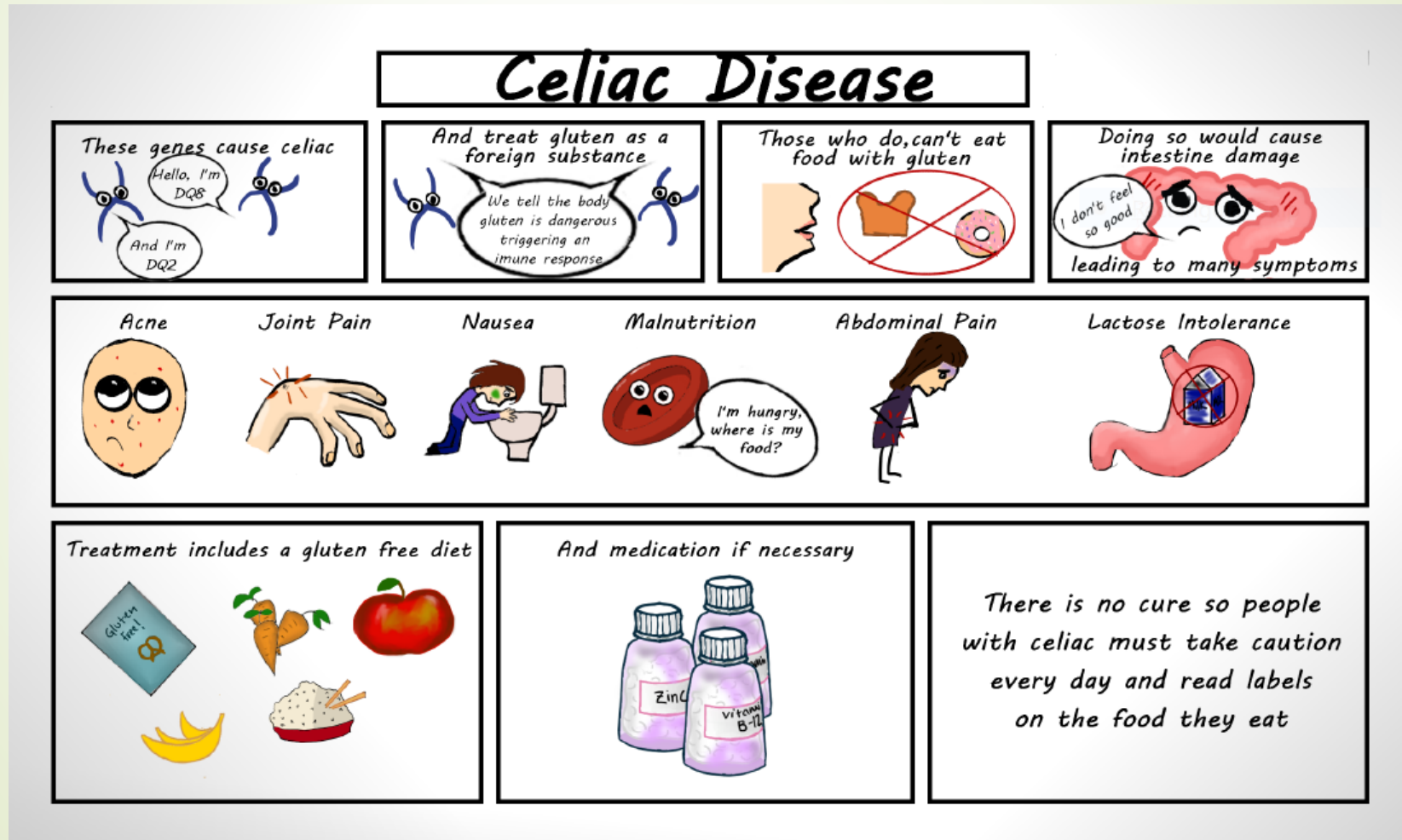





Graphic Novel Modeling

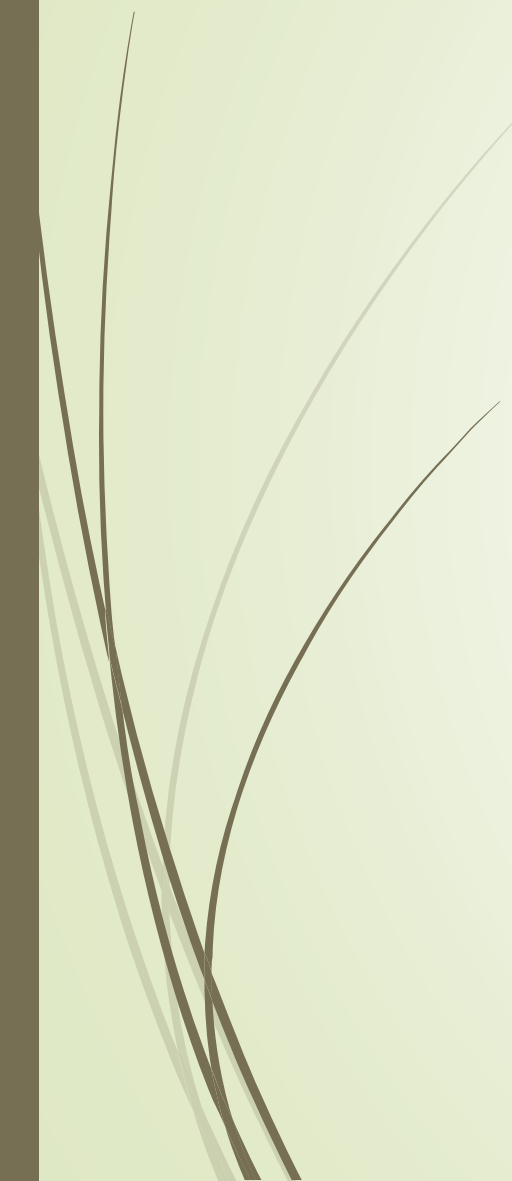
- ▶ Students were asked to make a comic strip demonstrating
 - ▶ Their understanding of homeostasis in their chosen system
 - ▶ Explain the inputs and outputs of the system and how they changed during disease
 - ▶ Identify treatments that would correct the disrupted homeostasis
 - ▶ Explain their progress to their classmates

Student Graphic Novel Example






Student Success (Outcomes) in the Classroom

- ▶ Students feel a sense of belonging by completing research projects
 - ▶ They integrate knowledge from previously learned sources
 - ▶ Students are able to integrate new knowledge into their projects
 - ▶ The stress of written exams is removed
 - ▶ Students get to develop their collaboration and leadership skills
 - ▶ Students make conclusions based on evidence
- 



Research outside the classroom

- ▶ Conducted through the Student Inquiry and Research Program
- ▶ Open to 11th-12th grade students
- ▶ 2021-2022:
 - ▶ Off campus projects: 72 students
 - ▶ On campus projects: 127 students
 - ▶ On campus courses (4)
 - ▶ On campus individual projects
- ▶ 2022-2023:
 - ▶ “Off campus” projects: 96 students
 - ▶ “On campus” projects: 68 students
 - ▶ On campus courses (2)
 - ▶ On campus individual projects



Where our students do off-campus research

- ▶ Northwestern University Feinberg Medical School
- ▶ Northwestern University
- ▶ University of Chicago
- ▶ University of Illinois at Chicago
- ▶ University of Illinois Urbana-Champaign
- ▶ Fermi National Accelerator Laboratory
- ▶ Argonne National Laboratory
- ▶ Washington University, St. Louis
- ▶ Northern Illinois University
- ▶ Loyola University



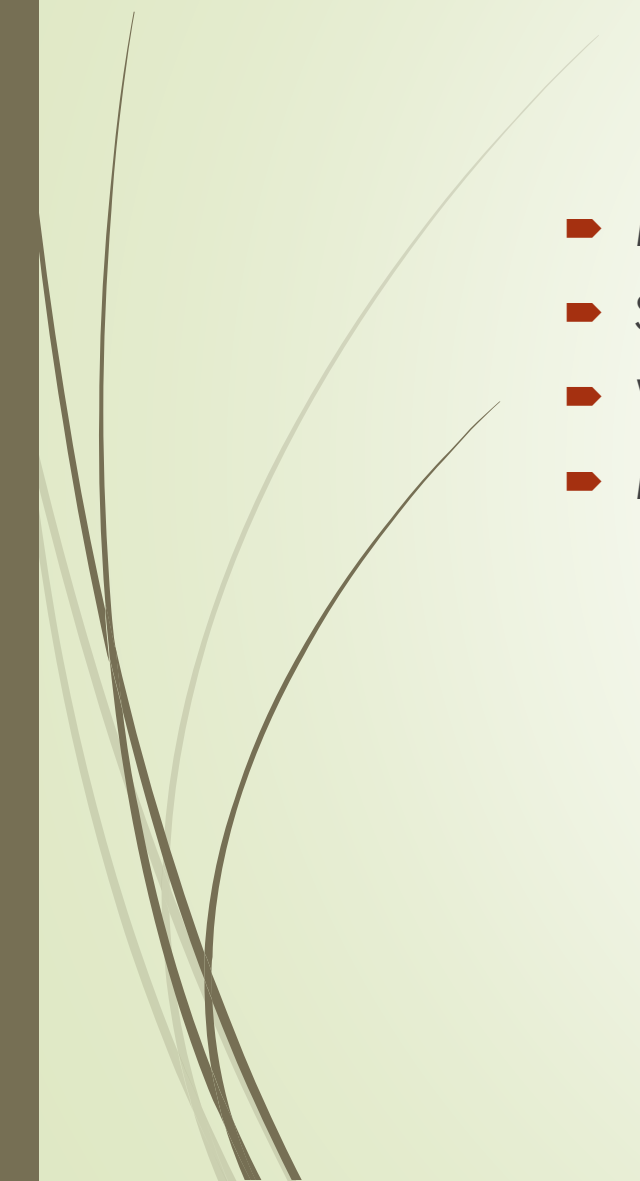
Research On-Campus

- ▶ 4 on campus SIR courses in 2021-22
 - ▶ Molecular Modeling
 - ▶ Particle Physics
 - ▶ Drug Discovery
 - ▶ Econometric Analysis

- ▶ 2 on campus SIR courses in 2022-23
 - ▶ Particle Physics
 - ▶ Drug Discovery



What Students do on campus

- Meet advisors on Wednesdays
 - Spend time working on their projects in the lab
 - Write down their observations and gather data
 - Make conclusions based on evidence
- 



Presentation of SIR Results

- Communication of research is critical!
- IMSAloquium (April 19, 2023)
 - All SIR students give oral presentation of results
 - Abstracts are in IMSA Digital Commons
https://digitalcommons.imsa.edu/sir_presentations/
- JSSF
- ISSF
- Publications in peer-reviewed journals



Student Success (Outcomes) Outside the Classroom

- ▶ Students feel a sense of accomplishment for working with mentors both off campus and on campus, over and beyond their classroom responsibilities
- ▶ Students learn advanced concepts by hands on experiences by devoting a day per week to these projects
- ▶ Students are able to apply what they learn from their research into their academic learning
- ▶ Students develop leadership and collaboration skills and a sense of passion for learning and making conclusions in a scientific manner

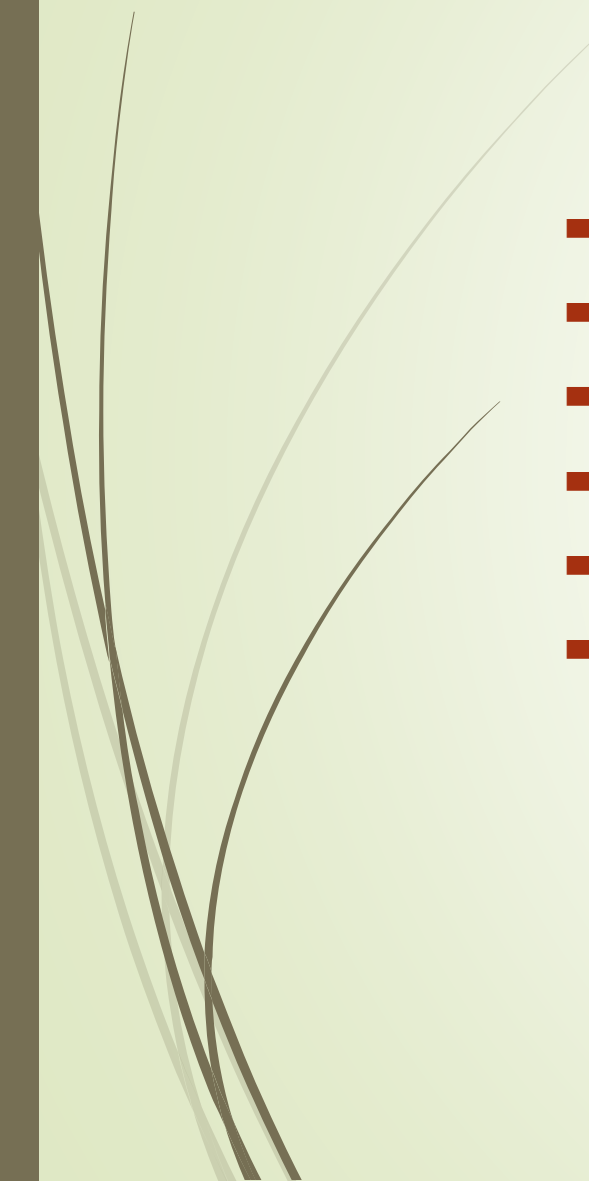


Collaboration Projects

- ▶ IMSA-Ritsumeikan Collaboration 2021-22
 - ▶ Cultural exchange
 - ▶ GMO presentation and discussion
 - ▶ My students really loved the experience and are asking for more this year!
 - ▶ Students learn how the same topic is considered in different ways in other countries
 - ▶ Time difference ensured that only the students that were interested participated in the collaboration



Benefits to students

- Global connections
 - Cultural exchange
 - Broader perspectives
 - In depth learning
 - Integration into real life
 - Students take responsibility for their own learning
- 

Thank you for listening!



Any Questions?

