

Genome Science as a scaffold for teaching literacy in biology with artificial intelligence

Steve Briggs

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Careers for UCSD Biology graduates

- Biotechnology
- Science
- Medicine
- Agriculture
- Conservation
- Education

Doing, regulating, or facilitating

Research Responsibilities

- BS
 - Ability to learn and perform sophisticated technical tasks
 - Ability to interpret and report results
 - Ability to read, understand, and explain the research literature (and patent literature)
 - Ability to contribute to a team of associates
- PhD
 - Ability to identify research goals that will enable the achievement of the sponsor's goals
 - Ability to develop and implement a research strategy to achieve the research goals
 - Ability to develop tasks for associates that will collectively accomplish the research goals
 - Ability to lead a team of associates and contribute to teams of peers and organizational leaders

Students must be able to use AI to assist in understanding and explaining research articles, especially in genome science

Genome Science

- Genome science is:
 - The study of genome structure and function
 - The use of genome technologies/resources to advance understanding of the natural world and to serve society*
 - An overlap of technologies from biology, chemistry, and computer science
- Typical topics
 - Genome expression (chromatin; enhancers; conformation; chemical modifications of DNA/RNA/proteins)
 - Evolution (human and microbial)
 - Development (stem cells; organoids)
 - Immunology (adaptive; innate; auto)
 - Disease (cancer; heart; dementia)
 - Ageing (causes; interventions)
 - Microbiome (e.g., gut-brain axis)
 - New technologies (e.g., single cell modalities)

*medicine, agriculture, forensics (criminal and IP), genealogy

Biology Literacy

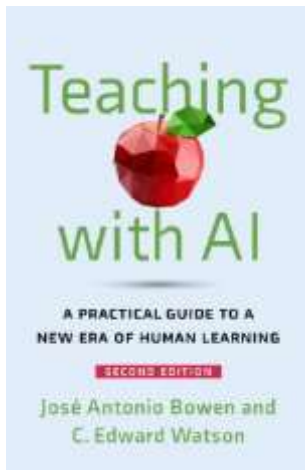
- Literacy is the ability to read, understand, and explain written works
- The language of Biology is comprised of figures, images, and tables
- This language is translated (interpreted) by an author to produce a narrative
 - Most students can only read the translation
- Literacy enables graduates to continuously acquire new knowledge and skills, in an ever-changing knowledge and technology landscape
- The process of explaining results verbally and in documents deepens understanding, develops communication skills, and instills confidence
- Reading research articles causes collateral learning of essential subjects that students were either not exposed to or they failed to incorporate it into their working knowledge

docendo disco, scribendo cogito = I learn by teaching, think by writing
- Seneca the Younger (c. 4 BC – 65 AD)

If you can't explain it, you don't understand it.

Teaching with AI

- LLMs enable on-camera, real-time feedback to enhance verbal presentation accuracy and effectiveness
- LLMs enable skilled users to produce analyses of higher quality in less time
 - Biologists will continue to analyze articles and deliver verbal reports
 - But they will write prompts instead of text!



Both communication activities will compel biologists to partner with AI in the same creative process that we use for writing:
Conception > articulation > reflection > revision

I think by prompting – Seneca the *Much* Younger

Course overview

- BIMM172 is designed to convey current knowledge regarding the acquisition and use of genome-wide information to understand biology
 - No subject is more central to understanding life than genome science
 - By reading the literature, providing verbal explanations, and answering quiz questions each student will learn how the genome is characterized and exploited using a combination of technologies from biology, chemistry, and computerscience
 - The utility of genomics as an organizing principle for biology and to aid in practical advances will be explored
- Most students in the class are seniors
 - They will be working in the biotechnology industry or on an advanced degree within the next few months
 - Their ability to verbally present scientific results in group meetings and to report their results in writing will be crucial to their success
 - Similarly, it will be necessary for them to analyze research publications that are relevant to their work
- Learning objectives
 - Skills: ability to read and explain a contemporary research article in genome science and understand the strategy and conclusions; determine whether the conclusions are based on correlative evidence that infers causality or direct evidence that proves causality; ability to explain to an audience how a figure was produced and what it means; ability to answer in writing questions that probe the methods and conclusions of an article
 - Knowledge: familiarity with topics of contemporary genome science such as models of 2D and 3D genome structure; omic profiling and single-cell multi-modal analysis; forward and reverse genome-wide genetic studies with natural variation and CRISPR; synthetic lethals in cancer therapy; protein interaction maps and imaging; and molecular interactions between the microbiome and hosts
- Eleven articles in the field of Genome Science that were published within the preceding 12 months will be studied
- Preparation for verbal and written assessments will be assisted by AI
- The instructor will occasionally give short lectures to provide background information
- Grading
 - Students will provide verbal explanations of a figure when randomly called upon in class or in discussion session. Each contribution is worth up to 2 points for a complete and accurate explanation or 1 point for a partially complete and accurate explanation
 - There will be a weekly in-class quiz
- Verbal in-person explanations: 40 points
- Quizzes: 50 points
- Final exam: 10 points
- Total: 100 points

Assignments/Assessments

- Verbal explanation of two figures/panels each week
 - Practice and coaching on-camera with AI
 - In class; student chosen randomly to present
 - Or by Zoom, recorded during discussion session
 - Each student will be in their own breakout room
 - Upload your video file to Canvas (maximum of 5 minutes)
 - Upload a PDF of the complete prompt-and-response chat record of your interactions with AI
 - Evaluation criteria:
 - Accuracy and completeness
 - Professional demeanor and confidence
- One in-class quiz per week (Scantron)
 - No electronics allowed; paper copy of notes and article are OK
- Final exam
 - Verbal explanation of all figures from article 11a

How to explain figures

- The use of notes is encouraged. It is best to prepare notes for the entire article before class and then refine your notes based on discussions within your group
- We will divide into groups to discuss the next figure/panel of the article to be addressed. Members will briefly explain their current understanding to each other
- The instructor will select a student at random to present the figure/panel
- The student will speak in a professional, confident manner, and describe the figure/panel (basically, read all the labels; tell us what kind of graph we are looking at)
- Then the student will provide an interpretation of the data
 - How were the data generated?
 - Are the data random? If not, what patterns do you see?
 - What are the controls; what are the tests; how do they differ?
 - What conclusions can YOU draw from the data? Do your conclusions agree with the authors?
 - How important is this figure/panel for the article as a whole?
 - Are there additional questions we should answer regarding this figure/panel?
- Prompts for the student to use with AI while trying to understand the figures:
 - In the article titled, XXX, I have questions regarding Figure YYY. What kind of display is this?
 - How were the data generated?
 - Are the data random? If not, what patterns do you see?
 - What are the controls; what are the tests; how do they differ?
 - What conclusions can YOU draw from the data? Do your conclusions agree with the authors?
 - How important is Figure YYY for the article as a whole?
 - Are there additional questions we should answer regarding Figure YYY?

End

It's not about being smarter than AI,
It's about using AI to make you smarter than you were!