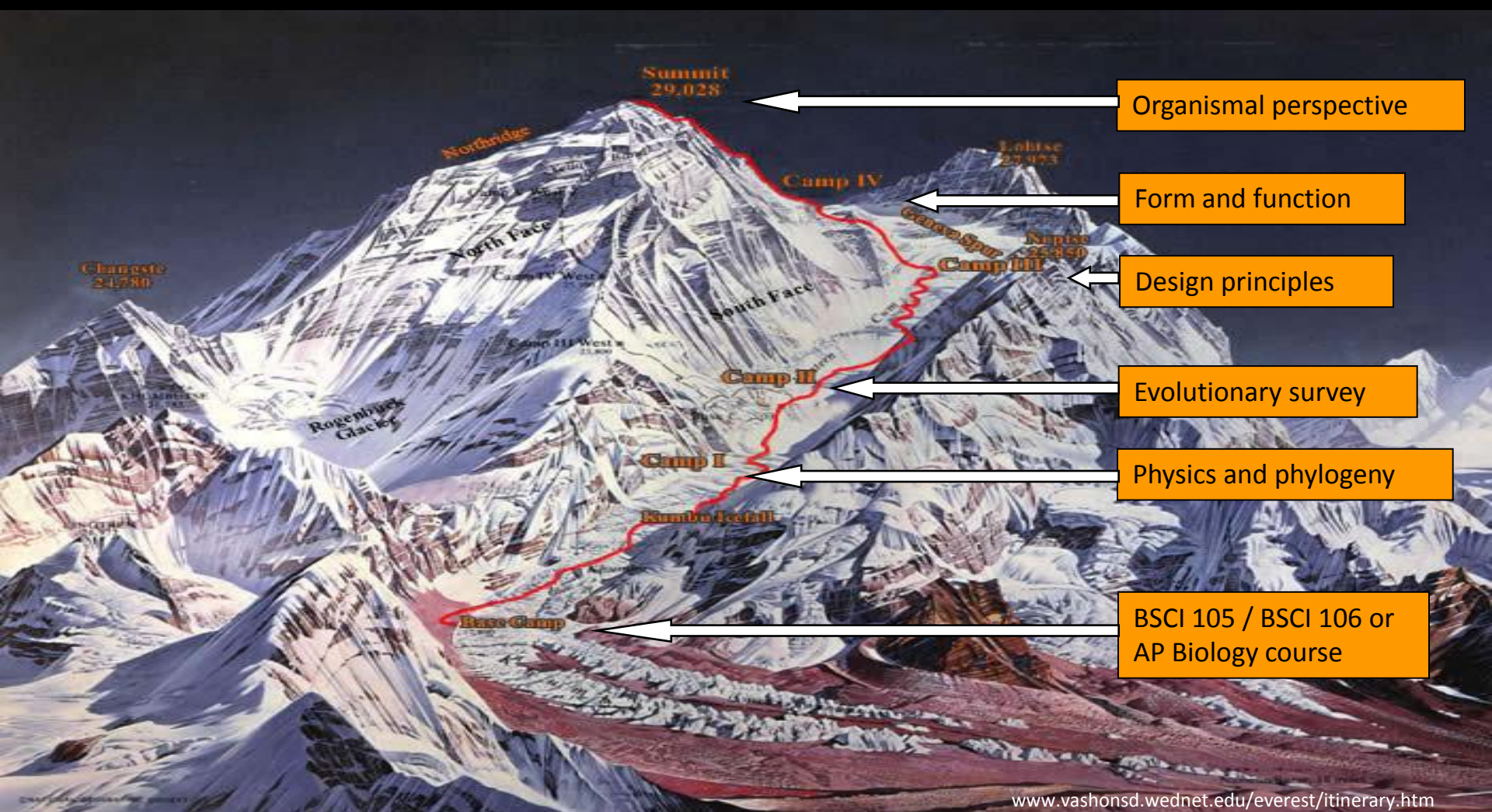


Use of mathematics and physics across disciplines



Jessica Watkins
Biology Education Research Group



Organismal perspective

Form and function

Design principles

Evolutionary survey

Physics and phylogeny

BSCI 105 / BSCI 106 or AP Biology course

www.vashonsd.wednet.edu/everest/itinerary.htm

**coherence of *epistemology*,
not just content**

Physics and Biology in IPLS courses

A cheetah is one of the fastest animals, but it can only maintain its high speed for a short time. The pronghorn can continue to run at a steady pace of 80 km/hr for a long time.



- a) What is the cheetah's average acceleration, $\langle a \rangle$, and its average speed, $\langle v \rangle$?
- b) How far away from the cheetah do the pronghorn have to be if they are to be safe?

Physics and Biology in IPLS courses

**in physics, knowledge consists of formulas
(rather than concepts expressible by formulas)**

concepts are cues for deciding which equation to use

Hammer, 1994

Redish, 1998

Calculating

**Understanding biological
phenomena**

How do the biology instructors ask students to use math & physics?

**Synthesizing
experimental data**

**Knowing physical
principles**

How much time does it take for a molecule to diffuse from the gametophyte to the top of a sporophyte 2.5 cm in height?

Understanding biological phenomena

How do the biology instructors ask students to use math & physics?

Synthesizing experimental data

Knowing physical principles

Calculating

Understanding biological
phenomena

How do the biology instructors ask students to use math & physics?

Plot the data and describe the curve seen in your graph. Relate that curve to Fick's First Law.

Knowing physical
principles

Calculating

Understanding biological
phenomena

How do the biology instructors ask students to use math & physics?

Synthesizing
experimental data

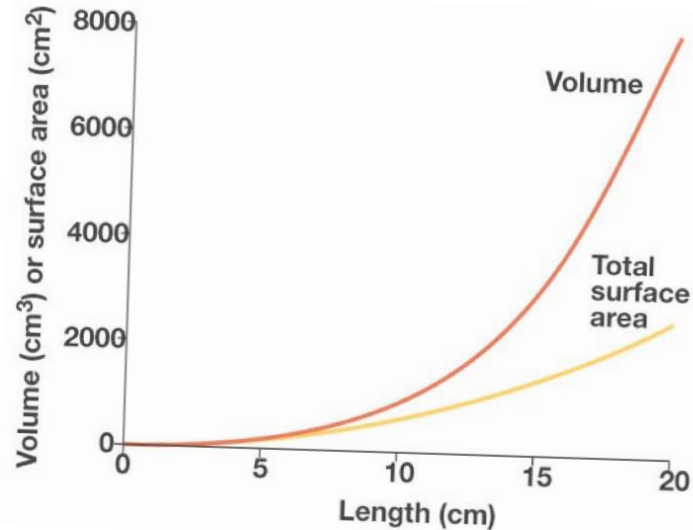
**What is the Second Law of
Thermodynamics?**

Understanding biological phenomena

$$\text{time to diffuse : } t = x^2 / 2D$$

- a) How much time would it take for a glucose molecule to diffuse to the center of an embryo?
- b) How much time would it take for glucose to diffuse from the top of the plant to its base?
- c) Evaluate the strengths and weaknesses of this statement:
Multicellular organisms do not use diffusion to move molecules.

Understanding biological phenomena



- In the graph, sketch the relationship between volume vs. length and surface area vs. length.
- Why would small organisms be unlikely to need surface elaborations such as gills to meet their gas exchange needs?

**Understanding biological
phenomena**

How do the students respond to these uses in biology?



**equation not that useful:
“concept put in terms of letters”**

biology is supposed to be something else

“unappealing”



Interviewer: So you like the GAEs.

**mathematics helps her
understand the world**

“mindboggling”



Larry: there's like Fick's Law is like, this um equation where it's like um. I can't remember exactly what it is, but it's like, it's like uh. There's a diffusion constant and there's area.

**describes the concept without
using the equation**

“mathy, mathy terms”

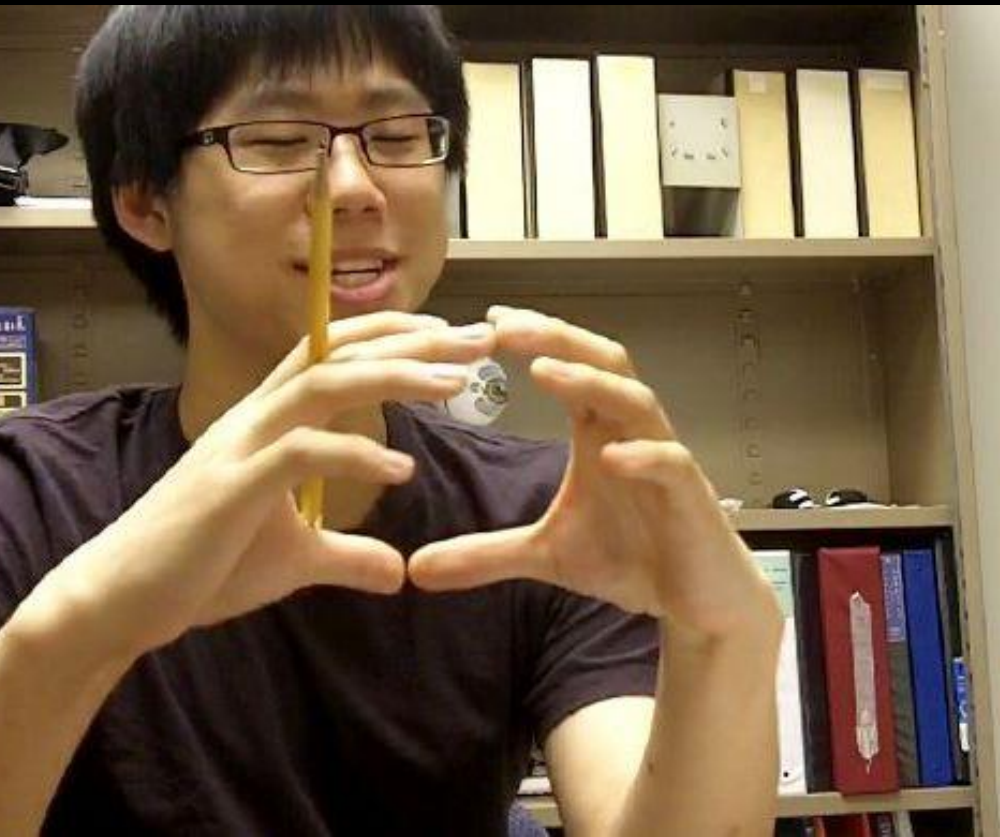


Larry: Um. So, um, the volume of flow... this is like one of the things I had trouble on the test. I don't completely understand it, but it's like, like the rate of like, flow through the body is like the change in pre..the pressure gradient, which is like how like, how the change in pressure, and then like times like the radius to the fourth power over some, like some, a couple constants and stuff like that. Constants and um..

**variables and proportionalities
essential to explain the relationship**

**related to physical and biological
understanding**

importance of course context
variability in how students talk/use math
intellectual resources for math reasoning



We want to build on what students are doing in their biology courses

Compare an artery with five centimeters radius, which is, pretty big. Ridiculous actually.

There's a mathematical relationship... and that was really helpful to just my general understanding of the world. It was, like, mindboggling.



**coherence of *epistemology*,
not just content**

Teaching

biologically authentic examples

how biologists use math and physics

Teaching

biologically authentic examples
how biologists use math and physics

Research

understanding epistemological differences
how do student interact with this
epistemology?

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