# From F=ma to Flying Squirrels: Curricular Change in an Introductory Physics Course

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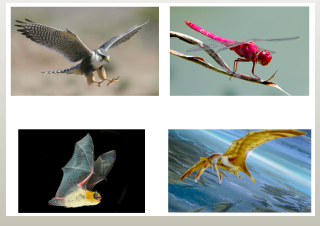
## Highlights

We measure the impact of changing the Lyman Briggs College introductory physics courses (LB 273/274, Physics I and II) from a standard calculus-based physics sequence into a more interdisciplinary effort focusing on physics as it applies to the life sciences (see examples below). Overall, the experiment was a success: student learning was maintained at a high level, and student enthusiasm about the subject and the course content, as well as ability to relate the material to their own majors and interests, increased substantially.

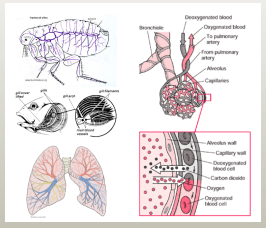
## Some life science-focused examples

### Scaling and flight



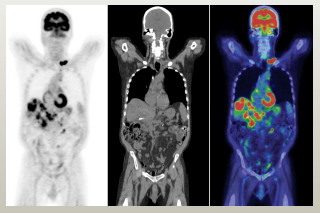
Scaling laws – for example, that the volume/mass of an object scales as its (size)$^3$, whereas the surface area of the creature and its wings scales as (size)$^2$ – result in convergent evolution in terms of physical processes such as flight.

### Diffusion and respiration



Diffusion – the spread of particles through random motion – is a physical process whose properties dictate the size of single-celled organisms as well as the respiratory and circulatory systems of multi-cellular creatures. The limitations of diffusion dictate the need for lungs or gills in large animals.

### Medical imaging



Medical diagnostic tools, including ultrasound, X-ray, fMRI, and PET imaging (shown above), utilize many concepts relating to waves, materials, radiation, and nuclear physics.

### Exam question

The peregrine falcon is one of the fastest animals on the planet, and hunts by diving from a great height and ramming into its prey (typically a smaller bird such as a pigeon or a dove). When diving, a peregrine falcon greatly reduces its cross-sectional area by tucking in most of its wing, making it almost teardrop-shaped ($C = 0.04$). Assuming that the falcon in question weighs 1 kg and has a cross-sectional area of 0.05 m$^2$ when her wings are tucked in, what is her terminal velocity if she is diving straight downward?

## Course details: LB 273/274 (Physics 1 and 2)

- Three lectures and one three-hour hands on session per week
- Lectures feature a wide range of interactive pedagogies
- Hands-on sessions focus on group problem solving, conceptual understanding, and laboratory activities
- LON-CAPA course management system used for pre-lecture reading assignments and post-lecture homework
- Life science-related examples were woven into all aspects of the course, with a great emphasis on the course pack, lectures, and homework.

## Assessing the curricular changes

- Force Concept Inventory (FCO), Maryland Physics Expectations Survey (MPEX) administered as pre- and post tests to compare to previous semesters of LB 273/4
- Standard end-of-semester student survey (written)
- 16 students interviewed in detail by a collaborator to explore student learning and feelings regarding the course and its life science focus.

## Quantitative outcomes

- Mean pre- and post-semester FCI scores were 42.3% and 61.6%, respectively (N=77). This corresponds to a normalized gain of $\langle g \rangle = 0.34$, comparable to other interactive-engagement courses of this sort and very good for the first semester using new curricular materials.
- Student SALG (Student Assessment of Learning Gains) and MPEX scores were substantially higher than in previous versions of the course.

## Student interviews and written feedback

**On the main themes from the class (chemistry major)**: "I guess my biggest takeaway is that physics really is applicable to everything. To be able to see it with biology and all of that, it was cool. Whenever I saw something I was like, 'Oh, physics explains that.' So that was cool to see. It also really helped to see how everything in physics is interconnected, and that hadn't been emphasized to me before. Seeing how everything built on it was cool."

**On how their thinking had changed (biochem major):** "In math, I usually just memorized the steps. In the physics problems here, it really was more understanding the concepts of what was going on… You'd have to know the concept, and you'd have to apply it once you had a thorough understanding."

**On its applicability to the life sciences (physiology major)**: "I'm really interested in physiology of human bodies, and the things we learned about tension and muscles and strain really tied in. It made my physiology classes make more sense."

## Holistic outcomes

The curricular change significantly increased my engagement in the course, as well as that of my students. The life science-focused examples were very interesting to me, and the change in ordering of materials was substantially more intuitive to the students. Overall, I feel the experiment was a great success, and I plan to use this curriculum again next year.

### Acknowledgments

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