# webZyme – Use It to Teach Kinetics (and more)

Bruce A. Palfey, Brian Haber, and Rebecca L. Fagan
Department of Biological Chemistry, University of Michigan Medical School, Ann Arbor, MI

Check it out!   http://tinyurl.com/webZyme Login as "FakeStudent" (password: "webzyme")   Use it in your class - brupalf@umich.edu

---

My experience teaching kinetics in a standard lecture class:

What I say in class   **What they hear**

Blah, blah, blah, blah, k, blah, blah, plot,...
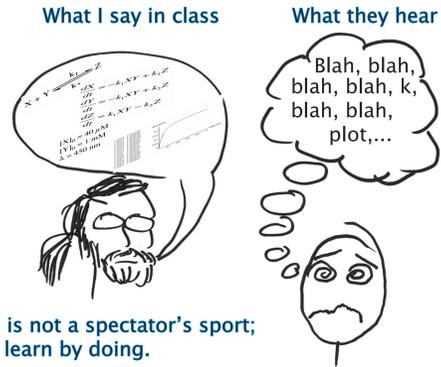
Kinetics is not a spectator's sport; need to learn by doing.

Our Solution: webZyme

- Instructors create "virtual enzymes" on a web-server.
- Students perform virtual experiments using their browser.
- Data are downloaded and analyzed independently of webZyme.
- Mechanism is a "black-box" to the student.
- Quality of the results depends on a student's experimental design; fosters the development of good judgement.
- Reactions defined with an intuitive syntax.
- Many types of experiments are possible.
- Allows model-building & hypothesis-testing.

$X + Y \underset{k_2}{\overset{k_1}{\rightleftharpoons}} Z$

$[X]_0 = 40\ \mu M$
$[Y]_0 = 1\ mM$
$\lambda = 450\ nm$

Professor → webZyme Server → Results for analysis → Student
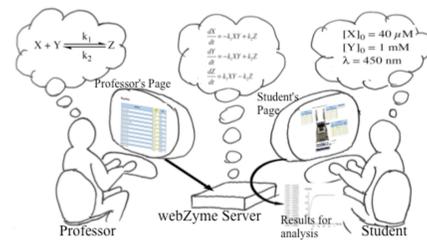
Current Capabilities

- Absorbance Stopped-Flow
- Fluorescence Stopped-Flow
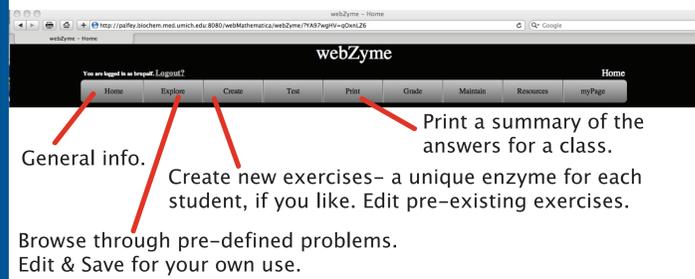- Quenching
- Steady-State Velocities

Unique Capabilities

- Calculates reactions between the contents of syringes in the virtual stopped-flow & quenching instruments prior to a shot.
- All data have experimental noise at a level controlled by the instructor.
- Nothing to install.
- Independent of platform & location.
- Works on my iPhone.
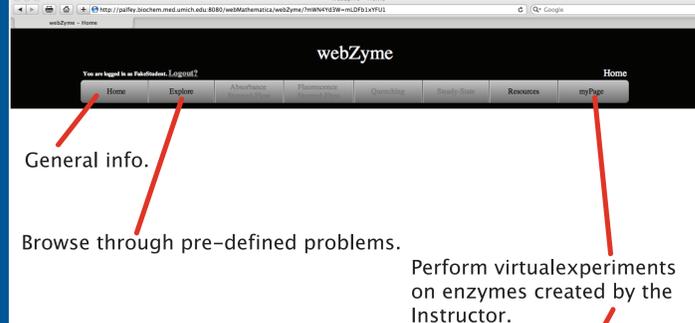- Easy to create unique enzymes for each student.

webZyme is **not**...

- ...a **curve-fitting program**.
- ...a **substitute for standard simulation programs** (e.g., KINSIM, Berkeley Madonna, Gepasi).
- ...**expensive**. Use webZyme on our server for free – just send Bruce an e-mail (brupalf@umich.edu).
- ...**finished**. Features are still being added, and bugs are still being found (and fixed).

Things Available to Instructors

General info.

Create new exercises– a unique enzyme for each student, if you like. Edit pre-existing exercises.

Browse through pre-defined problems. Edit & Save for your own use.

Print a summary of the answers for a class.

Things Available to Students

General info.

Browse through pre-defined problems.

Perform virtual experiments on enzymes created by the Instructor.
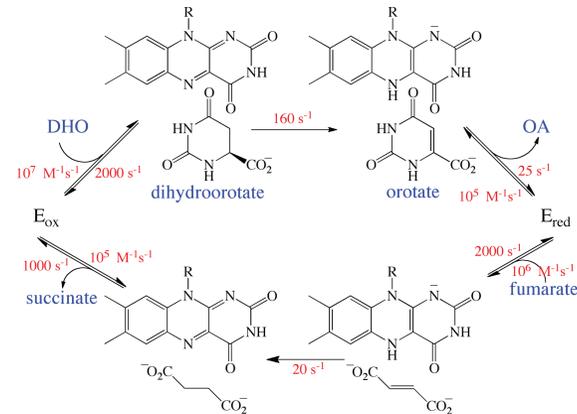
Experiments Allowed by Instructor

Ways to Use webZyme

- Introductory Courses
  - Have students perform a simple Michaelis–Menten analysis.
  - Project a demo for the class.

- Advanced Courses on Kinetics
  - Analyze "standard" kinetic systems, e.g., bimolecular reactions, two-step binding, bursts.
  - Determine spectra of intermediates.
  - Use several types of experiments to determine the mechanism of a student's personalized enzyme.

- Courses on Enzyme Mechanism
  - Bring the literature alive by having students do the experiments being studied in class.
  - Have students do experiments that have not been published.

- Lab Courses
  - Students can perform kinetics experiments at any level of sophistication at no cost.
  - Pre-lab webZyme exercises help prevent errors during lab.

- Research
  - Simulate experiments with distant colleagues in real time.

Complex Example: Dihydroorotate Dehydrogenase

Based on data from:
- Fagan, Jensen, Björnberg, & Palfey (2007) Biochemistry, **46**, 4028–4036
- Unpublished results

Instructor enters all reactions, rate constants, spectra, etc.

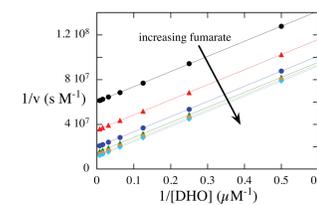| #	Reaction	kfwd	krev	
01	Eox+DHO<>RS	1E7	2000E0	Reset?
02	RS>CT	160E0	NA	Reset?
03	CT<>Ered+OA	25E0	1E5	Reset?

Students explore transient kinetics...

Reductive Half-Reaction

$E_{ox} + DHO \rightleftharpoons E_{ox}\cdot DHO$
$E_{red}\cdot OA \rightleftharpoons E_{red} + OA$

$k_{ox} = 185 \pm 3\ s^{-1}$
$K_d = 372 \pm 21\ \mu M$

Oxidative Half-Reaction

$E_{red} + Fumarate \rightleftharpoons E_{red}\cdot Fumarate$
$E_{ox}\cdot Succinate \rightleftharpoons E_{ox} + Succinate$

$k_{ox} = 20.3 \pm 0.1\ s^{-1}$
$K_d = 1.07 \pm 0.02\ mM$

Turnover: OA burst by quenching

E_{ox} DHO + Fumarate → [OA] (μM)
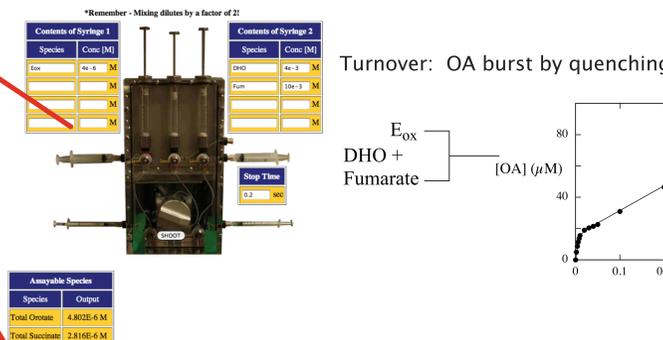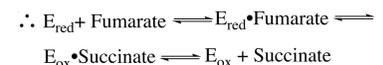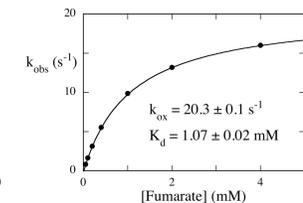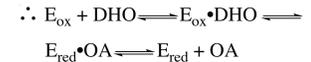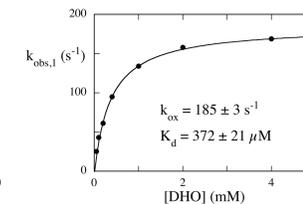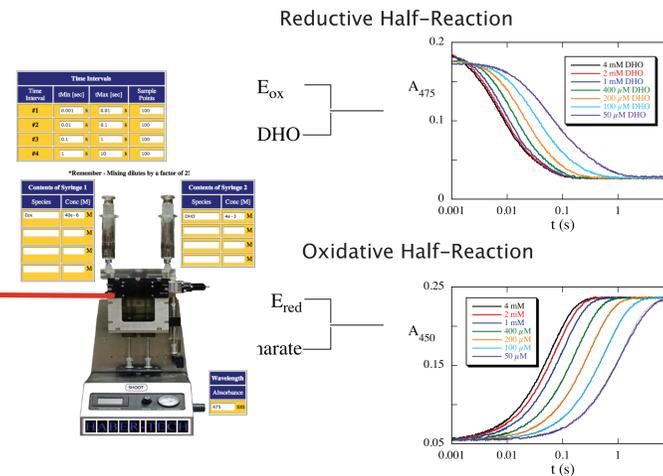
...and steady-state kinetics.

increasing fumarate

$\therefore$ **Ping-pong**

Conclusions

- Students can learn kinetics by doing.
- Exercises of arbitrary realism are easily created.
- webZyme helps the development of good judgement.
- It's free. You'd be nuts not to try it in your course.