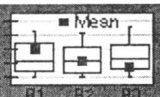

Go to this page in the current issue

One Enzyme Fits All

by Malcolm Campbell

(Posted February 5, 1999 · Issue 47)

Abstract

Most teaching labs seem to have been designed in a vacuum. To unify teaching labs, choose one model enzyme for students to study in depth in all its biological contexts, from enzymology to genetics to ecology.

Can you guess what amylase, acid phosphatase, and *Drosophila* eye color have in common? You probably can't unless you teach biology. The answer is that all three are used in teaching labs. Since the very first such labs were created, students have had to perform experiments on "model" systems that were totally unrelated to each other. Although many educators are trying to revise the biology curriculum, little of that attention has been focused on the laboratory curriculum. Typically, each lab course is designed in a vacuum, with little concern for the content in other lab courses.

The IDH enzyme gives our lab courses greater context.

At Davidson College, we have initiated a coordinated effort to unify our laboratory curriculum; our efforts have been recognized as exceptional by the National Science Foundation, which recently awarded us an Instrumentation and Laboratory Improvement grant. We chose a model enzyme, isocitrate dehydrogenase (IDH), to be used in as many laboratory courses as possible (figure 1). We have developed laboratory modules in introductory biology, molecular biology, and biochemistry, which are all freely available from our IDH Web page; protocols for genetics and developmental biology are under way.

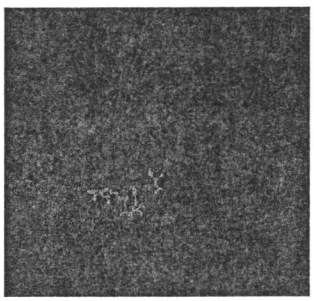

Figure 1

There are three IDH genes in most eukaryotes. The most familiar one is an NAD^+-dependent enzyme located in mitochondria. A second form found in the mitochondria is dependent on $NADP^+$ rather than NAD^+ [1]. We use the third form, which is very abundant, $NADP^+$ dependent, located in the cytoplasm, and involved in lipid synthesis. The atomic structure has been determined for IDH from several species and with different other molecules bound. One can locate files on our IDH Web site, viewable with freeware such as RasMol, Chime, or Cn3D; you can find your own RasMol images through the National Center for Biotechnology Information Structure Group. These files of X-ray crystallography data allow students to interactively view the enzyme bound to its substrate (isocitrate), its coenzyme ($NADP^+$), and its cofactor (Mg^{2+})

67&’065#4’ +0641&7%’861 &74+0) 6*’+4
(+456+0641&7%614%1745’ 10 %’.. #0& /1.’%7.#4
*+); *’; 2’4(14/ # 5’4+’5 1(6*4’’
’:2’4+/’065 6*#6+0641&7%’6*’/ 61
52’%6412*161/’64+% /’6*1&5 #0& ’0<;/’
-+0’6+%5 14 6*’+46*+4&#$ 6*’; 2’4(14/ #0
’:2’4+/’06 1(6*’+4190 &’5+)0 61 6’56 #
;216’5+5 1(6*’+4%*115+0) 4#&+6+10#..;
567&’065 914-’& 9+6* 6;415+0#5’ 2’41:+&#5’ 14 #%+&2*152*#6#5’ *’5’ ’0<;/’5 #4’
705#6+5(#%614; (14 691 /#+0 4’#5105 *’; 75’ 61:+%4’#)’065 #5 # 2#46 1(6*’ ’0<;/’
#55#; & 6*’; #4’ 016 &+5%755’&+0 .’%674’ $’%#75’ 6*’; #4’ 016 /#+0564’#/ 2416’+05 0
%1064#56 #%6+8+6%#0$’ /’#574’& 52’%6412*161/’64+%#..; $; &’6’4/+0+0) 6*’
%10%’064#6+101(6*’ 241&7%6 $; .+)*6 #$51426+10 #6 0/ 746*’4/14’ +5
2#46 1(# /’6#$1.+% 2#6*9#; 6*#6+5&+5%755’&+0 /156 +0641&7%614%1745’5

’ 9#06 567&’065 61 $’0’(+6 +0722’4 .’8’. %1745’5 (41/ 9*#6 6*’; .’#40 &74+0) +0641&7%614;
.#$5 0*+1%*’/+5648 .#$ 567&’065 274+(; #0& %*#4#%6’4+<’ *’ ’0<;/’ +5’#5; 61
24’2#4’ (41/ #./156 #0; #0+/#. 14 2.#06 5174%’ 5&7&’065%#0%1/2#4’ 52’%+(+%#6+8+6+’5
1(&+((’4’06 52’%+’5 14 1(6+557’5(41/ 6*’ 5#/’ 52’%+’5 *’; %#0’:#/+0’ *1.1’0<;/’ #0&
57$70+6 5+<’5 14 9*’6*’4 6*’+4+51.#6’&’0<;/’ %#0 76+.+<’ #0& 14 0
/1.’%7.#4 $+1.1); .#$ 567&’065 56#46$; 76+.+<+0);’#56)’01/’ &#6#(41/ 6*’ ’%#+ (
’01/’ #6#$#5’ *’; 5’#4%* 6*’ &#6#$#5’ (14 6*’)’0’ &’5+)0 21.;/’4#5’ %*#+0
4’#%6+1024+/’45 #0& #/2.+(; %.10’ #0& ’:24’55 6*’ ;’#56 !)’0’ +0 $#%6’4+# *’
4’%1/$+0#06 2416’+0 +5(70%6+10#.#0& *#5 # 5*146 ’2+612’ 6#) #66#%*’&51 6*#6+6%#0$’
&’6’%6’&10 #0 +//701$.16 +0#..; 567&’065%#075’ 6*’+4%.10’& ;’#56)’0’ #5 # 241$’ 10 #
176*’40 $.16 9+6* +51.#6’&(41/ # 9+&’ 4#0)’ 1(52’%+’5

’ #4%&’8’.12+0) #)’0’6+%5 .#$ /1&7.’ +09*+%*
567&’065 9+.. 75’ 07.. #..’.’5 1(61 ’:#/+0’
+0*’4+6#0%’2#66’405 +0 ’%(%& ” *+5%#0$’
%1/$+0’& 9+6* ’0<;/’ #55#;5 #0& .+0-#)’ #0#.;5+5 61
2418+&’ #0 +08’56+)#614; .#$ /1&7.’ 67&’0656#-+0) #
%1745’ +0&’8’.12/’06 9+.. ’:#/+0’ 6*’ 6+/’ #0&
.1%#6+101(!)’0’ ’:24’55+10 +0/1&’. ’/$4;15
57%* #5 %*+%-’0 (+5* 0+%5914/5 #0& 5’# 74%*+05
’%#75’ ’0<;/’ #%6+8+6%#0 &’6’%6’&
%1.14+/’64+%#..; 567&’0659+.. $’ #$.’ 61 8+57#.+<’ #
241%’55 6*#6+5014/#..; &+5%755’&876 016 5’’0
&+4’%6.;)’0’ 4’)7.#6+10 1(9*’0 #0& 9*’4’ ! +5’:24’55’& 6*’4 %1745’5 %17.& $’
#((’%6’& #5 9’.. %1.1); 567&’065%17.& &’6’4/+0’ 6*’ +51<;/’)’016;2’5 1(# 2127.#6+10
75+0) 56#4%*)’. ’.’%6412*14’5+5 *15’ 567&;+0) 2*;5+1.1); %17.& ’:2.14’ 6*’ ’((’%65
&+((’4’06 +51<;/’5 /+)*6 *#8’ 10 (70%6+10#66*’ 6+557’14 14)#0+5/ .’8’. 67&’0651(
+//701.1); %17.& 241&7%’ #06+$1&+’5#)#+056 #0& 6*15’ 567&;+0) %’.. $+1.1); %17.&
75’ +//701.1)+% 14 %’064+(7)#6+10/’6*1&5 61 &’6’4/+0’ 6*’ 57$%’..7.#4 .1%#.+<#6+101(
’.. $+1.1); 567&’065%17.& 75’ &+((’4’06 5+)0#. 2’26+&’5 61 6#4)’6 6*’ 5#/’ ’0<;/’ 61
&+((’4’06 14)#0’..’5 *’ 10.; .+/+6#6+10 +56*’ +/#)+0#6+10 1(6*’ (#%7.6;

16* 567&’065#0& (#%7.6; $’0’(+6 (41/ 75+0) # 5+0).’ ’0<;/’ +0&+((’4’06 %1745’5 67&’065
.’#40 6*#66*’ 5’2#4#6+105 $’69’’0 .#$14#614; %1745’5 #4’ #46+(+%+$170&#4+’5 6*#6&1 016
4’(.’%6 6*’ %106+077/ 1($+1.1); *’4’ +5# 4’9#4& (14 .’#40+0) #$176 #0 ’0<;/’ %18’4’& +0
6*’+4(+456#$14#614; %1745’ #0& #0 +0%’06+8’(14 %#0;+0) 18’4 .’#40’& +0(14/#6+10 (41/ 10’
.#$ 61 16*’45 #%7.6; /’/$’45 $’0’(+6 9*’0 6*’; %1..#$14#6’ 10 6*’ &’8’.12/’06 1(0’9 .#$5
5’0+14 /’/$’45 $4+0) ;’#45 1(’:2’4+’0%’ 9+6* &+((’4’06 14)#0+5/5 9*+.’ ,70+14 /’/$’45
$4+0) 0’9’4 /’6*1&5 51 6*’; %#0$’ ’37#. 2#460’45 14-+0) 9+6* %1..’#)7’5 10 # %1//10
)1#. +5#)11& 9#; 61)’0’4#6’ 4’0’9’& ’06*75+#5/ #0& 61 (156’4 6’#/914- #0& /767#.
4’52’%6#/10) 6*’ (#%7.6; 5 0’9 .#$14#614; /1&7.’5 #4’ &’8’.12’& 6*’ 6’#/ %#0 27$.+5* +65
4’57.65 +0# 2’’4 4’8+’9’& 6’#%*+0) ,1740#. 57%* #5 /’4+%#0 +1.1); ’#%*’4 +15%’0’
"17...#. 1(1..’)’ +1.1); ’#%*+0) +1%*’/+%#. &7%#6+1014 .17/#. 1(1..’)’ %+’0%’
’#%*+0) *’0 567&’0655’’ # %1*’5+8’ (#%7.6; 6*’; 8+’9 6*’ %744+%7.7/ #5 /14’ %1*’5+8’
611

05*146 #&126+0) # /1&’. ’0<;/’ 57%* #5 24’5’065 # 9+0 9+0 .’#40+0) ’08+410/’06
74 .#$ 24161%1.5 #4’ #.. (4’’.; #8#+.#$.’ (41/ 6*’ *1/’ 2#)’ ’9 $#5’&
24161%1.5 9+.. $’ &’8’.12’& 18’4 6*’ 0’:6 (’9 ;’#45 #5 /14’ %1745’5 #0& (#%7.6; ’/$4#%’ #
70+(+’& .#$14#614; %744+%7.7/

*” %”# #& ””($ ((() $) &’% ((%% %”% -) + (%$
%”” (# $*# ’%*(&’ ($)) %$(%*) $ ($
”) ’$) + ’ %&) %$ $ (,’) $ %)%) $/ %
) ’ ””” ’ ”+ $ ’’& * $())*) %$

$ ’ ’ ””. ($ ””*()’)%’ &%() # ! ’ ’)%%$ () $ & $) ’
, % ””*()’) (’ *” ’”- %’ ” * ’ $ *$ -
” ’ & %%!(”” ’ $,)) (# $

#0&

’0<;/

722’4 .’8’. .#$

Endlinks

Association for Biology Laboratory Education - provides links to interesting and innovative laboratory exercises, conferences, workshops, and related Internet resources.

Biolab Home Page - an unmoderated email list for discussion of issues and information related to teaching college biology laboratories.

Beyond Bio101: The Transformation of Undergraduate Biology Education - a report from the Howard Hughes Medical Institute describing remarkable changes taking place in how American college students learn biology.

CSU Bioweb - California State University's site consolidates biological science teaching and research resources.

NABT Online Resources - the National Association of Biology Teachers collection of links for biology teachers.

Federal Resources for Educational Excellence - provides access to hundreds of free teaching and learning resources throughout the federal government.

Model Systems - an HMS *Beagle* Cutting Edge Dialogue.

Tell us what you think.

Previous Adapt or Die Articles

- Meet the Press: But on Your Own Terms
  by Chris Edwards
  (Posted January 22, 1999 · Issue 46)
- Innovation: Making Ideas Work for Themselves
  by J. James Cotter
  (Posted January 8, 1999 · Issue 45)
- Going for a Spin? Points To Consider Before Commercializing Your Research
  by Chris Edwards
  (Posted December 11, 1998 · Issue 44)
- Out of the Lab and into the Kitchen
  by Allison Mack
  (Posted November 27, 1998 · Issue 43)
- Surviving Conferences
  by Sarah Bellum
  (Posted November 13, 1998 · Issue 42)
- Blockbusting II: Tips for Preventing and Breaking Writer's Block
  by Chris Edwards
  (Posted October 30, 1998 · Issue 41)

more