Concept Inventories/Conceptual Assessments in Biology (CABs): An annotated list (Jan. 12, 2012.)[1]

Compiled by Kathleen M. Fisher and Kathy S. Williams for CAB III meeting participants
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Assessments by topics and references. Legend: Topic of assessment – capitalized; Assessment name italicized and underlined, followed in parentheses by assessment abbreviation, number of items, item characteristics, and notation of whether items are presented in references. Item characteristics: MC = multiple choice, TF = true/false, diagram = diagrams used in items, scenario = scenarios used in items. All are one-tiered items unless noted.

1) NATURAL SELECTION

Conceptual Inventory of Natural Selection (CINS) (20 MC items, scenarios)
ITEMS PROVIDED

Anderson DL, Fisher, KM, Norman JG. 2002. Development and validation of the conceptual inventory of natural selection. *Journal of Research in Science Teaching* **39**: 952-978.

Anderson DL. 2003. Natural selection theory in non-majors' Biology: instruction, assessment, and conceptual difficulty. Thesis (Ph.D.) University of California, San Diego and San Diego State University, San Diego, CA.

2) MACROEVOLUTION

Measure of Understanding of Macroevolution (MUM) (28 items: 27 MC items, plus one open-ended item, diagrams)
ITEMS PROVIDED

Nadelson LS, Southerland SA. 2010. Development and preliminary evaluation of the Measure of Understanding of Macroevolution: Introducing the MUM. *The Journal of Experimental Education* **78**: 151–190.

3) EVOLUTIONARY RELATIONSHIPS

Basic Tree Thinking Assessment (two tests, 10 MC items each, diagrams)
ITEMS PROVIDED

Baum DA, Smith SD, Donovan SSS. 2005. The tree-thinking challenge. *Science* **310**: 979-980.

4) GENETICS LITERACY

Genetics Literacy Assessment Instrument (GLAI) (31 MC items)
FOUR ITEMS PROVIDED in Bowling et al. Genetics 2008; ALL in Moskalik 2007)

Bowling BV, Acra EE, Wang L, Myers MF, Dean GE, Markle GC, Moskalik CL, Huether CA. 2008. Development and evaluation of a genetics literacy assessment instrument for undergraduates. *Genetics* **178**: 15-22.

Bowling BV, Huether CA, Wang L, Myers MF, Markle GC, Dean GE, Acra EE, Wray FP, Jacob, GA. 2008. Genetic literacy of undergraduate non-science majors and the impact of introductory biology and genetics courses. *BioScience* **58:** 654-660.

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[1] Please cite as: Fisher, K.M. and K.S. Williams. 2011. Concept Inventories and Conceptual Assessments in Biology (CABs): An annotated list. http://www.sci.sdsu.edu/CRMSE/files/Concept_Inventories_in_Biology_20110325.pdf

Moskalik, CL. 2007. I. Impact of a Genetics Education Workshop on Faculty Participants II. Investigations of Undergraduate Genetic Literacy. Thesis (M.S.), University of Cincinnati, Cincinnati OH, Arts and Sciences: Biological Sciences, 2007. (available at *http://etd.ohiolink.edu/view.cgi/MOSKALIK%20CHRISTINE.pdf?ucin1195583851 and http://rave.ohiolink.edu/etdc/view?acc_num=ucin1195583851* accessed March 20 2011)

[Note: Instrument appears in the document above. The instrument was called Genetics Literacy Concept Inventory (GLCI) in the thesis and is called Genetics Literacy Assessment Instrument (GLAI) in most places in the BioScience paper, and always GLAI in the Genetics paper. Items appearing in Bowling, Acra, et al. 2008, match those in Moskalik 2007.]

5) GENETICS

Genetics Concept Assessment (GCA) (25 MC items, diagrams)
ITEMS NOT PROVIDED

Smith MK, Wood WB, Knight JK. 2008. The genetics concept assessment: A new concept inventory for gauging student understanding of genetics. *CBE Life Sci Edu* **7**, 422-430.

additional future tests to be posted online at www.colorado.edu/sei/departments/mcdb_assessment.htm

6) GENETICS

Genetics Literacy (13 two-tiered MC items, diagrams)
SOME ITEMS PROVIDED

Tsui CY, Treagust D. 2009. Evaluating secondary students' scientific reasoning in genetics using a two-tier diagnostic instrument. *International Journal of Science Education* **32**: 1073-1098.

7) INTRODUCTORY BIOLOGY

Biology Concept Inventory (BCI) (30 MC items)
ITEMS PROVIDED ON-LINE at http://bioliteracy.colorado.edu/

Klymkowsky MW, Garvin-Doxas K, Zeilik M. 2003. Bioliteracy and teaching efficacy: What biologists can learn from physicists. *Cell Biol Educ* **2**: 155-161.

Garvin-Doxas K, Klymkowsky MW, Elrod S, 2007. Building, using, and maximizing the impact of concept inventories in the biology education: a meeting report. *CBE- Life Science Education* **6:** 277-282.

Klymkowsky M.W., K. Garvin-Doxas. 2008. Recognizing students' misconceptions through Ed's tools and the Biology Concept Inventory. PloS Biology 6: e3. doi:10.1371/journal.pbio.0060003.

Garvin-Doxas K, Klymkowsky MW. 2008. Understanding randomness and its impact on student learning: Lessons learned from building the Biology Concept Inventory (BCI). *CBE-Life Sciences Education* **7:** 227–233.

8) ANIMAL DEVELOPMENT

Developmental Biology Content Survey (15 MC items)
ITEMS PROVIDED

Knight JK, Wood WB. 2005. Teaching more by lecturing less. *Cell Biology Education* **4**: 298-310.

9) PLANT GROWTH AND DEVELOPMENT

Flowering Plant Growth and Development (13 two-tiered MC items)
ITEMS PROVIDED

Lin SW. 2004. Development and application of a two-tier diagnostic test for high school students' understanding of flowering plant growth and development. *International Journal of Science and Mathematics Education,* **2**: 175–199.

10) TRANSPORT IN PLANTS AND CIRCULATION IN HUMANS

Internal Transport in Plants and the Human Circulatory Systems (28 two-tiered MC items)
ITEMS NOT PROVIDED

Wang JR. 2004. Development and validation of a two-tier instrument to examine understanding of internal transport in plants and the human circulatory system. *International Journal of Science and Mathematics Education* **2**: 131–157.

11) HOST-PATHOGEN INTERACTIONS

Host-Pathogen Interactions (HPI) (17 [18 noted in 2009 paper] two-tiered MC items)
ITEMS NOT PROVIDED

Marbach-Ad G, Briken V, El-Sayed NM, Frauwirth K, Fredericksen B, Hutcheson S, Gao L-Y, Joseph SW, Lee V, McIver KS, Mosser D, Quimby BB, Shields P, Song W, Stein DC, Yuan RT, Smith AC. 2009. Assessing student understanding of host pathogen interactions using a concept inventory. *Journal of Microbiology Education* **10**: 43-50.

Marbach-Ad G, McAdams KC, Benson S, Briken V, Cathcart L, Chase M, El-Sayed NM, Frauwirth K, Fredericksen B, Joseph SW, Lee V, McIver KS, Mosser D, Quimby BB, Shields P, Song W, Stein DC, Stewart R, Thompson KV, Smith AC. 2010. A model for using a concept inventory as a tool for students' assessment and faculty professional development. *CBE Life Sci Educ*, **9:** 408-416.

12) OSMOSIS AND DIFFUSION

Diffusion and Osmosis Diagnostic Test (DODT) ((12 two-tiered MC items, diagrams)
ITEMS PROVIDED

Odom AL, Barrow LH. 1995. The development and application of a two-tiered diagnostic test measuring college biology students' understanding of diffusion and osmosis following a course of instruction. *Journal of Research in Science Teaching* **32**: 45-61.

Odom, A. L. 1995. Secondary and college biology students' misconceptions about diffusion and osmosis. *American Biology Teacher* **57:** 409–415.

Fisher, K.M., K.S. Williams, J. Lineback. 2011. Osmosis and diffusion conceptual assessment. CBE—Life Sciences Education, Winter 2011. 10 (4): 418-29.

13) INTRODUCTORY MOLECULAR AND CELL BIOLOGY

Introductory Molecular and Cell Biology Assessment (IMCA) (24 MC items, diagrams)
ITEMS PROVIDED

Shi J, Wood WB, Martin JM, Guild NA, Vicens Q, Knight JK. 2010. Diagnostic assessment for introductory molecular and cell biology. *CBE-Life Sciences Education* **9:** 453-461.

14) MOLECULAR LIFE SCIENCES

Molecular Life Sciences (MLS) Concept Inventory (26 MC items in trial reported in Wright and Hamilton 2008; 96 MC items addressing 10 "big ideas" in 6 modules on-line at www.lifescinventory.edu.au , diagrams, scenarios)
ITEMS AVAILABLE WITH REGISTRATION ON-LINE at www.lifescinventory.edu.au

Howitt S, Anderson T, M, Hamilton S, Wright T. 2008. A concept inventory for molecular life sciences: How will it help your teaching practice? *Australian Biochemist* **39**: 14-17.

Wright T, Hamilton S. 2008. Assessing student understanding in the molecular life sciences using a concept inventory. In: Duff A, Green M, Quinn D, ATN Assessment Conference Proceedings. Australian Technology Network (ATN) Assessment Conference: Engaging Students in Assessment, Adelaide, South Australia, (pp 216-224). 20-21 Nov., 2008.

15) BREATHING AND RESPIRATION

Breathing and Respiration (12 two-tiered MC items)
ITEMS PROVIDED

Mann M, Treagust DF. 1998. A pencil and paper instrument to diagnose students' conceptions of breathing, gas exchange and respiration. *Australian Science Teachers Journal* **44**: 55–59.

16) PHOTOSYNTHESIS AND RESPIRATION

Photosynthesis and Respiration (13 two-tiered MC items, plus open ended)
ITEMS NOT PROVIDED

Haslam F, Treagust DF. 1987. Diagnosing secondary students' misconceptions of photosynthesis and respiration in plants using a two-tier multiple choice instrument, *Journal of Biological Education* **21**: 203–211.

(Covalent Bonding and Photosynthesis test development)
ITEMS NOT PROVIDED

Treagust D. 1986. Evaluating students' misconceptions by means of diagnostic multiple choice items. *Journal of Research in Science Education* **16**: 199-207.

17) ENERGY AND MATTER (total of 16 Diagnostic Question Clusters of 6-8 items each; some items appear in more than one DQC)

Diagnostic Question Clusters on Energy and Matter (DQCs)
(five groups of MC, TF, and open-ended items on different aspects of metabolism in photosynthesizing and respiring organisms; diagrams, scenarios)
ITEMS PROVIDED

Wilson CD, Anderson CW, Heidemann M, Merrill JE, Merritt BW, Richmond G, Sibley DF, Parker JM. 2007. Assessing students' ability to trace matter in dynamic systems in cell biology. *CBE Life Sciences Education* **5:** 323-331.

Hartley LM, Wilke BJ, Schramm JW, D'Avanzo C, Anderson CW. 2011. College students' understanding of the carbon cycle: contrasting principle-based and informal reasoning. BioScience 61: 65-75.

Thinking like a Biologist: Using diagnostic questions to help students to reason with biological principles (16 DQC sets of ~7 items each, MC, TF, open-ended)
ITEMS PROVIDED ON-LINE at www.biodqc.org

D'Avanzo C, Anderson CW, Griffith A, Merrill J. 2011. Thinking like a biologist. Using diagnostic questions to help students reason with biological principles. (accessed 30 January 2011; www.biodqc.org).

[The site at http://www.biodqc.org/ has Diagnostic Question Clusters (DQC's) organized by three ecological topics (Carbon Cycling, Energy Flow in Ecosystems, Climate Change), and by three biological processes (Photosynthesis, Biosynthesis, Cellular Respiration) - with two DQCs each; plus one each DQC under topics Gasoline, Biofuels, Carbon in Nature, and Carbon Balance. Some items appear in more than one DQC.]

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