

S1 Table. Summary of concept inventory test sizes and question sources.

Course Level	Number of Students	Lower or Upper Division	Total No. of Questions	No. Home-made questions	No. Validated Questions	No. Modified Validated Questions	Question sources
100	1160	L	8	1	6	1	1
100	1900	L	23	4	3	16	2-7
200	1209	L	9	4	4	1	1, 8, 9
200	551	L	10	6	3	1	1, 10, 11
200	497	L	14	3	6	5	2, 6, 12
200	277	L	17	7	4	6	8, 10, 13-15
300	120	U	8	0	8	0	7
300	238	U	10	4	6	0	16,17
300	219	U	12	5	5	2	2,11,12
300	227	U	6	6	0	0	none
300	73	U	8	5	2	1	9, 11
400	19	U	12	4	6	1	11
400	12	U	8	5	2	1	9, 11
400	35	U	20	11	5	4	2, 6, 11, 12

References

1. Shi J, Wood W, Martin J, Guild N, Vicens Q, Knight JK. A diagnostic assessment for introductory molecular biology. *Cell Biol Educ.* 2010;9: 453–461. doi:10.1187/cbe.10
2. Smith MK, Wood WB, Knight JK. The Genetics Concept Assessment: a new concept inventory for gauging student understanding of genetics. *CBE Life Sci Educ.* 2008;7: 422–430. doi:10.1187/cbe.08
3. Abraham JK, Perez KE, Price RM. The dominance concept inventory: A tool for assessing undergraduate student alternative conceptions about dominance in mendelian and population genetics. *CBE Life Sci Educ.* 2014;13: 349–358. doi:10.1187/cbe.13-08-0160
4. Price RM, Andrews TC, McElhinny TL, Mead LS, Abraham JK, Thanukos A, et al. The genetic drift inventory: A tool for measuring what advanced undergraduates have mastered about genetic drift. *CBE Life Sci Educ.* 2014;13: 65–75. doi:10.1187/cbe.13-08-0159
5. Baum DA. The Tree-Thinking Challenge. *Science.* 2005;310: 979–980. doi:10.1126/science.1117727
6. Kalas P, O’Neill A, Pollock C, Birol G. Development of a meiosis concept inventory. *CBE Life Sci Educ.* 2013;12: 655–664. doi:10.1187/cbe.12-10-0174

7. Hansen M. Population Dynamics Concept Inventory [Internet]. 2013. Available: <http://q4b.biology.ubc.ca/concept-inventories/population-dynamics/>
8. Klymkowsky MW, Underwood SM, Garvin-Doxas RK. Biological Concepts Instrument (BCI): A diagnostic tool for revealing student thinking. arXiv:10124501. 2010; doi:abs/1012.4501
9. Deane T, Nomme K, Jeffery E, Pollock C, Birol G. Development of the biological experimental design concept inventory (BEDCI). *CBE Life Sci Educ*. 2014;13: 540–551. doi:10.1187/cbe.13-11-0218
10. Maskiewicz AC, Griscom HP, Welch NT. Using targeted active-learning exercises and diagnostic question clusters to improve students' understanding of carbon cycling in ecosystems. *CBE Life Sci Educ*.
11. Couch BA, Wood WB, Knight JK. The molecular biology capstone assessment: A concept assessment for upper-division molecular biology students. *CBE Life Sci Educ*. 2015;14: 1–11. doi:10.1187/cbe.14-04-0071
12. Taylor J, Oh-McGinnis R, Chowrira S, Smith K. Transcription and Translation Concept Inventory [Internet]. 2013. Available: <http://q4b.biology.ubc.ca/concept-inventories/transcription-and-translation/>
13. Michael JA, Wenderoth MP, Modell HI, Cliff W, Horwitz B, McHale P, et al. Undergraduates' understanding of cardiovascular phenomena. *Adv Physiol Educ*. 2002;26: 72–84. doi:10.1152/advan.00002.2002
14. Michael JA, Richardson D, Rovick A, Modell H, Bruce D, Horwitz B, et al. Undergraduate students' misconceptions about respiratory physiology. *Adv Physiol Educ*. 1999;22: S127–S135. Available: <http://advan.physiology.org/content/277/6/S127>
15. Fisher KM, Williams KS, Lineback JE. Osmosis and diffusion conceptual assessment. *CBE Life Sci Educ*. 2011;10: 418–429. doi:10.1187/cbe.11-04-0038
16. Knudson D, Noffal G, Bauer J, McGinnis P, Bird M, Chow J, et al. Development and evaluation of a biomechanics concept inventory. *Sports Biomech*. 2003;2: 267–77. doi:10.1080/14763140308522823
17. Martin J, Mitchell J, Newell T. Development of a concept inventory for fluid mechanics. *33rd Annu Front Educ 2003 FIE 2003*. 2003;1: 23–28. doi:10.1109/FIE.2003.1263340