A collection of papers, books, and book chapters that inspired my talk given at Evolution, 2021. (❗ indicates slide citation)

Evolution-Centered Teaching of Biological Sciences

Using the unifying framework for all biology to inform biology education practices.

Araújo, L. A. L. (2020). The centrality of evolution in biology teaching: Towards a pluralistic perspective. *Journal of Biological Education*, 1–12. https://doi.org/10.1080/00219266.2020.1757486

Burke da Silva, K. (2012). Evolution-centered teaching of biology. *Annual Review of Genomics and Human Genetics*, *13*, 363–380.

Catley, K. M. (2006). Darwin's missing link — a novel paradigm for evolution education. *Science Education*, *90*(5), 767–783.

Cummins, C. L., Demastes, S. S., & Hafner, M. S. (1994). Evolution: Biological education's under-researched unifying theme. *Journal of Research in Science Teaching*, *31*(5), 445–448.

❗ Dobzhansky, T. (1973). Nothing in biology makes sense except in the light of evolution. *The American Biology Teacher*, *35*(3), 125–129.

Glass, B. (1967). The centrality of evolution in biology teaching. *The American Biology Teacher*, *29*(9), 705–715.

Hanisch, S. & Eirdosh, D. (2020). Educational potential of teaching evolution as an interdisciplinary science. *Evolution: Education and Outreach*, *13*(25), 1–26.

Nehm, R. H., Poole, T. M., Lyford, M. E., Hoskins, S. G., Carruth, L., Ewers, B. E., & Colberg, P. J. (2009). Does the segregation of evolution in biology textbooks and introductory courses reinforce students' faulty mental models of biology and evolution? *Evolution: Education and Outreach*, *2*(3), 527.

Scott, E. C. (2010). Dobzhansky was right: Let's tell the students. *Bioessays*, *32*(5), 372–374.

Zook, D. (1995). Confronting the evolution education abyss. *Journal of Research in Science Teaching*, *32*(10), 1111–1120.

Toward an Epistemology of Evolution

A smattering of topics centered around biology knowledge and acquisition of knowledge: what threshold concepts are needed to understand natural selection?, conceptual change and misconception theory, the importance of narrative for understanding, and lessons from physics education research.

Bruner, J. S. (2009). *Actual minds, possible worlds*. Harvard University Press.

Carey, S. (1995). On the origin of causal understanding. In *Causal cognition: A multidisciplinary debate* (pp. 268–308).

Catley, K., Lehrer, R., & Reiser, B. (2005). Tracing a prospective learning progression for developing understanding of evolution. *Paper Commissioned by the National Academies Committee on Test Design for K-12 Science Achievement*, 67.

❗ Coffey, J.E., Hammer, D., Levin, D. M., & Grant, T. (2011). The missing disciplinary substance of formative assessment. *Journal of Research in Science Teaching*, *48*(10), 1109-1136.

diSessa, A. A. (1993). Toward an epistemology of physics. *Cognition and Instruction*, *10*(2-3), 105–225.

Evans, E. M. (2008). Conceptual change and evolutionary biology: A developmental analysis. *International Handbook of Research on Conceptual Change*, 263–294.

Göransson, A., Orraryd, D., Fiedler, D., & Tibell, L. A. (2020). Conceptual characterization of threshold concepts in student explanations of evolution by natural selection and effects of item context. *CBE — Life Sciences Education*, *19*(1), ar1.

Hammer, D. (1994). Epistemological beliefs in introductory physics. *Cognition and Instruction*, *12*(2), 151–183.

❗ Heath, C., & Heath, D. (2007). *Made to Stick: Why some ideas survive and others die.* Random House.

❗ Lemke, J. L. (1990). *Talking Science: Language, learning, and values.* Ablex Publishing Corporation, New Jersey.

Nehm, R. H. (2018). Evolution. In *Teaching Biology in Schools: Global Research, Issues, and Trends* (pp. 164–177). Routledge.

Smith, J. P., Disessa, A. A., & Roschelle, J. (1994). Misconceptions reconceived: A constructivist analysis of knowledge in transition. *The Journal of the Learning Sciences*, *3*(2), 115–163.

Student Explanations of Complex Biological Phenomena

Schemas, p-prims and beyond: how do students construct explanations about biology and where are they going wrong?

❗ Chi, M. T., Roscoe, R. D., Slotta, J. D., Roy, M., & Chase, C. C. (2012). Misconceived causal explanations for emergent processes. *Cognitive Science*, *36*(1), 1–61.

❗ Coley, J. D., & Tanner, K. (2015). Relations between intuitive biological thinking and biological misconceptions in biology majors and nonmajors. *CBELife Sciences Education*, *14*(1), ar8.

Demastes, S. S., Good, R. G., & Peebles, P. (1996). Patterns of conceptual change in evolution. *Journal of Research in Science Teaching*, *33*(4), 407–431.

Ferrari, M., & Chi, M. T. (1998). The nature of naïve explanations of natural selection. *International Journal of Science Education*, *20*(10), 1231–1256.

❗ Gouvea, J. S. & Smith, M. R. (2018). Challenging cognitive construals: A dynamic alternative to stable misconceptions. *CBE — Life Sciences Education*, *17*(2), 1–19.

Greene Jr, E. D. (1990). The logic of university students' misunderstanding of natural selection. *Journal of Research in Science Teaching*, *27*(9), 875–885.

❗ Jolfaee, S., Zazkis, R., & Sinclair, N. (2014). "It is very, very random because it doesn't happen very often": Examining learners' discourse on randomness. In *Probabilistic thinking* (pp. 397–416). Springer.

Nehm, R. H., & Reilly, L. (2007). Biology majors' knowledge and misconceptions of natural selection. *BioScience*, *57*(3), 263–272.

Nehm, R. H., & Schonfeld, I. S. (2008). Measuring knowledge of natural selection: A comparison of the CINS, an open-response instrument, and an oral interview. *Journal of Research in Science Teaching*, *45*(10), 1131–1160.

Schank, R. C., & Abelson, R. P. (1977). *Scripts, plans, goals, and understanding: An inquiry into human knowledge structures.* Psychology Press.

Scott, E. E., Anderson, C. W., Mashood, K., Matz, R. L., Underwood, S. M., & Sawtelle, V. (2018). Developing an analytical framework to characterize student reasoning about complex processes. *CBE — Life Sciences Education*, *17*(3), ar49.

Southerland, S. A., Abrams, E., Cummins, C. L., & Anzelmo, J. (2001). Understanding students' explanations of biological phenomena: Conceptual frameworks or p-prims? *Science Education*, *85*(4), 328–348.

Speth, E. B., Shaw, N., Momsen, J., Reinagel, A., Le, P., Taqieddin, R., & Long, T. (2014). Introductory biology students' conceptual models and explanations of the origin of variation. *CBE — Life Sciences Education*, *13*(3), 529–539.

The Dual Causality of Biological Sciences

Proximate and ultimate causality is unique in biological sciences and requires understanding evolutionary principles – especially distinguishing a pattern from its generating process.

Abrams, E., & Southerland, S. (2001). The how's and why's of biological change: How learners neglect physical mechanisms in their search for meaning. *International Journal of Science Education*, *23*(12), 1271–1281.

Bock, W. J. (2017). Dual causality and the autonomy of biology. *Acta Biotheoretica*, *65*(1), 63–79.

Chapleau, F., Johansen, P. H., & Williamson, M. (1988). The distinction between pattern and process in evolutionary biology: The use and abuse of the term 'strategy'. *Oikos*, *53*(1), 136–138.

❗ Cummins, C., & Remsen Jr, J. (1992). The importance of distinguishing ultimate from proximate causation in the teaching and learning of biology. *History and Philosophy of Science in Science Education: Proceedings of the Second International Conference for History and Philosophy of Science in Science Teaching*, *1*, 201–210.

Dewsbury, D. A. (1999). The proximate and the ultimate: Past, present, and future. *Behavioural Processes*, *46*(3), 189–199.

❗ Mayr, E. (1961). Cause and effect in biology. *Science*, *134*(3489), 1501–1506.

Biology is booooring!

Away from the rote memorization of facts in early postsecondary biology courses, and issues of motivation & value: why should students care?

❗ Brophy, J. (1999). Toward a model of the value aspects of motivation in education: Developing appreciation for particular learning domains and activities. *Educational Psychologist*, *34*(2), 75–85.

Mervis, J. (2009). Universities begin to rethink first-year biology courses. *American Association for the Advancement of Science*.

❗ Momsen, J. L., Long, T. M., Wyse, S. A., & Ebert-May, D. (2010). Just the facts? Introductory undergraduate biology courses focus on low-level cognitive skills. *CBE — Life Sciences Education*, *9*(4), 435–440.

Tinbergen Framework

Framework for analysis of behavioral adaptations and an application to education.

❗ Nesse, R. M. (2013). Tinbergen's four questions, organized: A response to Bateson and Laland. *Trends in Ecology & Evolution*, *28*(12), 681–682.

O'Brien, D. T., & Gallup, A. C. (2011). Using Tinbergen's four questions (plus one) to facilitate evolution education for human-oriented disciplines. *Evolution: Education and Outreach*, *4*(1), 107.

Tinbergen, N. (1963). On aims and methods of ethology. *Zeitschrift Für Tierpsychologie*, *20*(4), 410–433.