In an upper-level biology course, students (n=76) completed the CINS and ORI:

- Two sections of learner-centered evolutionary biology course (Fall 2012, Spring 2014) taught by the same instructor
- Mean GPA = 3.26 ± 0.56 (SD)
- Students were assessed online pre, post instruction using CINS and ORI
- All assessments were graded
  - CINS features 10 key concepts of natural selection, we focused on 5 (see above)
  - CINS was not reliable
  - Pre-test reliability: 0.765
  - Post-test reliability: 0.694
  - ORI coded using modified Bishop and Anderson coding rubric², IRR = 87%
  - Alternative conceptions coded using Nehm Lab coding rubric³, IRR = 88%

Natural selection is a principle mechanism of evolution⁰
- A complete understanding of natural selection includes five key concepts
- Using these concepts of natural selection, the Concept Inventory of Natural Selection (CINS) and Bishop & Anderson Open Response Instrument² (ORI) assess student knowledge related to natural selection
- The CINS and ORI are documented as valid and reliable in introductory courses; their utility in upper division courses is unknown

What can upper-division biology instructors learn by using the CINS and ORI?
- Do the CINS and ORI capture change in upper division student understanding of natural selection?
- On the ORI, do students perform similarly across questions?
- Do the ORI prompts evoke more or different alternative conceptions?
- Students score high on the CINS and very low on the ORI
  - Students may be gaming the CINS
  - Key words are recognizable to upper division students
  - Distractions do not activate alternative conceptions
  - For both the CINS and ORI, the normalized change score was low (less than 0.40)
  - The CINS does not appear to capture upper-division student learning of evolution

Does assessment style matter?
- Students score high on the CINS and very low on the ORI
  - Students may be gaming the CINS
  - Key words are recognizable to upper division students
  - Distractions do not activate alternative conceptions
  - For both the CINS and ORI, the normalized change score was low (less than 0.40)
  - The CINS does not appear to capture upper-division student learning of evolution

How do students perform across questions within the ORI?
- Selection favored cheetahs that could run fast (V) and catch their prey to eat and survive (F), therefore they became more abundant in the population (P).
- CINS: 56.00% ± 32.89% 50.66% ± 30.36%
  - Students score significantly higher in V and F in the trait gain prompt
  - Students score significantly higher in V in the trait loss prompt

Do trait loss or trait gain evoke different alternative conceptions for students?
- CINS: 20% pre-test vs 34% post-test, F= 25.564, p=0.001
  - Students are more likely to discuss inheritance and fitness on the cheetah prompt than on the salamander prompt
  - For both prompts, students are unlikely to include origin of variation in their response (O)
  - The differences in student responses may be the result of prompt structure: trait gain versus trait loss

Recommendations for instructors
- Students score high on the CINS pre-test, making it less useful than the ORI in an upper-division course
- The ORI allows students to construct a response, providing a richer reflection of upper-division student understanding of natural selection
- We recommend instructors use both the cheetah and the salamander prompt to fully capture student understanding
- Further research should utilize larger populations of upper-division biology students to determine CINS reliability

Acknowledgments
NDU- DEU 1156974
There you go, Julia Bowman! and the Evolution students of NDSU: because to Race
if not, and the people who allowed me to focus ideas of them throughout this summary. Thank you to the OER faculty and students; [sign off our little bit too like the other articles, please cite as OER4895]