

**Assessment of DU's Natural Science General Education Curriculum:
Student Understanding of Evolution
2009**

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A simple, standardized test of student understanding of concepts in basic science and, especially, evolution, was administered in two Core Curriculum courses in winter and spring of 2009. The test essentially evaluates the knowledge of evolution that students bring with them into Core after taking a year of natural science in the "NATS" curriculum. The test was modeled on those typically used to gain a basic understanding of a population's scientific literacy.

Knowledge of evolution is crucial for an educated, scientifically-literate citizenry for at least three reasons. First, evolution is critical to understanding the organic world around us; indeed, in 1973 the great geneticist Theodosius Dobzhansky asserted—in a subsequently widely quoted statement—that “nothing in biology makes sense except in the light of evolution.” Second, evolution is critical for understanding and contributing to often deeply divisive debates in the realm of American public culture; e.g., whether evolution or anti-evolutionary alternatives such as creationism or intelligent design should be taught in public school science class. Third, evolution as an integrative linchpin concept is gaining traction in many AHSS disciplines including anthropology, sociology, economics, literature, and art. We do not fulfill our educational responsibilities to our non-science majors by failing to give them an adequate understanding of evolution.

The winter course was open to the general student population. The spring course was for Honors students only. Test results for the spring course are presented below as a comparison with results from the winter course.

Core Course Test Results: “The Cultured Ape” (Winter 2009)

Test questions (see appendix) address what students should know by the time they take a Core course that lies at the intersection of science, social science, and humanities. Some test questions are modified from an introductory textbook in biological anthropology. Other questions were specifically developed for the test. Most of the questions are pretty straightforward. Others are more difficult, especially where they test the kind of nuanced understanding of science and evolution we try to teach in the NATS Foundations course “Origin and Evolution of Life” and in introductory anthropology courses. There was no attempt to produce “trick” questions.

Total number of students tested = 26. **The average grade on this test is 57.** The percent of correct answers for each question is as follows:

- | | |
|--|-----|
| 1. Definition of science as a process: | 73% |
| 2. Science offers provisional truth: | 23% |

3. Definition (selectionist) of Evolution:	19%
4. Definition of Evol Success:	50%
5. Picture of Evolution as a tree:	69%
6. Status of Evol as both fact and theory:	50%
7. Darwin as author of evolution:	100%
8. Darwin's century:	62%
9. Human and Chimp relationship:	92%
10. Time/Place of first Humans:	42%

Here are the results arranged from most correct to least correct:

7. Darwin as author of Evolution:	100%
9. Human and Chimp relationship:	92%
1. Definition of science as a process:	73%
5. Picture of Evolution as a tree:	69%
8. Darwin's century:	62%
4. Definition of Evol Success:	50%
6. Status of Evol as both fact and theory:	50%
10. Time/Place of first Humans:	42%
2. Science offers provisional truth:	23%
3. Definition (selectionist) of Evolution:	19%

Students were asked to indicate which NATS Foundations class they had taken. Here's the average grade by NATS class:

Origin and Evolution of Life:	75 (n=2)
Ecology for New Millennium:	70 (n=1)
Human Genetics (Honors):	70 (n=1)
Science and Contemporary Issues:	60 (n=3)
Dynamic Earth:	60 (n=2)
Technology 21:	48 (n=4)
Environmental Systems:	46 (n=3)
Molecules to Humankind:	30 (n=1)

Students who are science majors or who failed to provide the requested information about their Foundations course performed thusly:

Concepts in Biology:	90 (n=1)
Unknown:	80 (n=1)
Engineering	65 (n=2)
Molecular Biology:	60 (n=1)
Chemistry/Biochemistry:	50 (n=2)
Transfer from CU-Boulder:	40 (n=1)
Unknown:	40 (n=1)

Interpretation of these results

Although the sample size is small, there are patterns to suggest that the results are representative. The results certainly confirm impressions gathered (over 20 years of Core teaching) about the state of student knowledge when they enter Core after having taken the year-long Natural Science Foundations sequence.

Students do best on those questions which ask for easily memorizable answers (#s 7 and 9). Question #8 also has an easy answer, but the result is consistent with the common knowledge that students have as much trouble with time as they do with geography. Students know that Darwin is associated with the concept of evolution, but they're unsure about when he lived.

The other questions are a bit harder, but not so ambiguous that the results should be so poor.

Since NATS courses focus on defining science as a process, others can judge if the 73% correct answer to question #1 would be considered good or not.

A finding that emerged from the grading of question #2 indicates that 58% of the students see science as producing *relative* truth rather than *provisional* truth. This question may have been ambiguous to them. Some probably think that relative truth is equivalent to, or more secure than, provisional truth. Others might think that the humanists' notion of relative truth is shared by scientists. However, the distinction between relative and provisional truth is crucial and something that students should understand by the time they move from Foundations to Core, and certainly by the time they graduate from the university.

Scientifically-literate students might also be expected to understand the difference between transformationist, selectionist, progressivist, and "vitalist" conceptions of evolution. This is the subject of question #3. This might be the hardest and/or "trickiest" question in the bunch, but the distinctions are crucial and students should be doing much better than the 19% correct response rate.

Thus, the pattern in the Darwin questions suggest that students know him to be an evolutionist, that they are less sure about when he lived, and that they simply don't know what he's famous for *among scientists* (i.e., specifying the mechanism of evolutionary change). I suspect that this pattern accurately reflects the understanding that citizens have of Darwin in American society at large. This isn't good for society, and it's certainly not good for graduates of a natural science foundations curriculum.

Other observations that suggest the results of this test are meaningful:

It makes sense that the best performer on the test is the Biology major who is an alum of the "Concepts in Biology" course.

It makes sense that alums of the "Origin and Evolution of Life" course do next best, even though at a C average. It also makes sense that students taking "Ecology" and "Human

Genetics” score at least passing in their understanding of evolution. From there it appears to be all downhill in terms of the understandings of evolution that non-majors taking the other NATS Foundations classes have, and that they bring with them into Core.

It probably makes sense that the student transferring from CU-Boulder scored very low on the test, since they were likely taught in a class of thousands and probably by graduate students. Their 40% score on the test also reinforces the longstanding and widespread concern about what level of knowledge we’re approving as “foundational” when we accept transfer credits from other institutions.

Core Course Test Results: Science and Religion in Dialogue (Spring 2009)

An identical test was give in the Core course “Science and Religion in Dialogue” in Spring 2009. This is a writing intensive course for **Honors** students. Total number of students tested = 20. **The average grade is 61.** A comparison of results for the two Core courses follows.

The percent of correct answers for each question by class is as follows:

	<u>Cult Ape</u>	<u>Sci & Rel</u>
1. Definition of science as a process:	73%	95%
2. Science offers provisional truth:	23%	35%
3. Definition (selectionist) of Evolution:	19%	40%
4. Definition of Evol Success:	50%	70%
5. Picture of Evolution as a tree:	69%	75%
6. Status of Evol as both fact and theory:	50%	25%
7. Darwin as author of evolution:	100%	100%
8. Darwin’s century:	62%	55%
9. Human and Chimp relationship:	92%	85%
10. Time/Place of first Humans:	42%	30%

Summary Comments about Both Classes: Students know that Darwin’s the evolutionist. They are uncertain about what century he’s from. They get the human-chimp relationship, but they don’t know the human evolutionary time-place relationships. They seem to understand science as a process, but they’re very confused about the definition of evolution and whether it has status as *both* fact and theory (which may imply that they don’t understand the concept of “theory” as it’s used in science). More seriously, they also don’t seem to understand the concept of truth in science. The data suggest that students are primarily *relativists* as concerns truth, with a few *absolutists* thrown in for good measure. The “reflective judgment” theorists used to tell us that students come into university as primarily truth *dualists* and that we’d be lucky to turn them into relativists by the time they graduate (with the hope that they’ll cultivate a more nuanced, *contextualist* notion of truth in graduate school, or as they deal with the issues of everyday life). I have a suspicion (and these data may confirm it) that students are increasingly entering as relativists, and that they’re likely to stay relativists throughout college unless we do something a bit more intentional in the disciplines and, especially, in general education. Like, renewing the

commitment to a thoughtful, well-designed Core that has a robust, high-end interdisciplinary piece geared to challenging their provincial, relativized understandings of the world.

The average grade by NATS Foundations class taken:

	<u>Cult Ape</u>	<u>Sci & Rel</u>
Concepts in Biology:	90 (n=1)	56 (n=5)
Origin and Evolution of Life:	75 (n=2)	
Ecology for New Millennium	70 (n=1)	
Human Genetics (Honors)	70 (n=1)	73 (n=6)
Science and Contemporary Issues:	60 (n=3)	
Dynamic Earth	60 (n=2)	
Global Environmental Change (Honors)		60 (n=4)
Technology 21	48 (n=4)	
Environmental Systems	46 (n=3)	50 (n=1)
Molecules to Humankind	30 (n=1)	50 (n=1)

Comments: It appears that the high score of 90 on The Cultured Ape test is an outlier. The average score of 56 among Honors grads of “Concepts in Biology” brings those students back to the pack that’s performing at a “C” level (and generally much worse) on this particular test. The new data from the Honors “Global Environmental Change” sequence falls right in line with the other courses.

Thus, it seems that these data support the claim that our NATS Foundations sequence is doing poor work in creating the kind of broad scientific literacy that non-science majors (and Honors students) will need to effectively deal with the big policy issues of the day.

Conclusions

If evolution is one of the more important concepts that students should know in order to be scientifically literate (as well as understand American “culture wars” about evolution and be able participate, as citizens, in conversations about the content of public education) then **the assessment evidence suggests that we’re failing to impart an adequate understanding of evolution in NATS Foundations courses.** Students might be learning about science as a process, about the “scientific method”, and about concepts and facts that lie within a *specific* domain of science, but such knowledge does not necessarily constitute scientific literacy. To be counted as scientifically literate NATS graduates should understand as many concepts and methods as it takes to allow conversancy with *all five* of the following topics having contemporary societal import: (1) Evolution, (2) Climate Change, (3) Genes and behavior, (4) Biodiversity and extinction, and (5) Technology’s social causes and consequences.

This conclusion dovetails with James Trefil’s argument that to be scientifically-literate is to have knowledge of those “Great Ideas” of science that allow students to understand what they read about science in newspapers and magazines on the day that they graduate. This

Core test suggests that our NATS curriculum isn't producing this kind of literacy. **However we might also wonder whether the Foundations curricula in AHSS are doing any better within their domains.** Arguments asserting that General Education should teach "critical thinking", "ways of knowing", and knowledge as a "process" are sounding increasingly hackneyed. Equally hackneyed is the new argument being developed by the current General Education Review Committee that we need to replace Core with a single "Advanced Seminar" that teaches to a faculty member's "passion." We should be doing all of that, and certainly taking passion for granted in *everything* that we teach. If we're truly committed to a substantive, outcomes-based "Common Curriculum" (rather than to something that's "common" only by administrative assertion), then we should be attending to Great Ideas, and maybe even to a few Great Books. Minimally, there should be basic agreement about the substantive educational content of the curricula we teach and assess.

Appendix

Core Course Test: Scientific Literacy

Winter 2009

NATS Foundations Course Taken: _____

Please circle the correct answer:

1. Science is

- a. a way of collecting facts.
- b. a process of intellectual inquiry.
- c. a laboratory technique.
- d. a belief system.

2. Scientific work produces

- a. absolute truth
- b. relative truth
- c. doubt
- d. provisional truth
- e. uncertainty

3. Evolution is best defined by scientists as

- a. a process of transformation of one species into another.
- b. a process of selective elimination of individuals within a species.
- c. a process of progressive change of one species into another.
- d. a process driven by a species' will to survive.

4. Evolutionary success is best measured by

- a. the geographical distribution of an organism.
- b. size and strength of an organism.
- c. the reproductive ability of an organism.
- d. the physical and behavioral complexity of an organism.

5. The most accurate picture of evolution looks like a

- a. ladder.
- b. chain.
- c. tree.
- d. pyramid.

6. For scientists evolution is

- a. a fact
- b. a belief
- c. a theory
- d. a fact and a theory

7. The concept of evolution is most closely identified with the work of

- a. Newton
- b. Linnaeus
- c. Darwin
- d. Mendel

8. The century in which the person identified in Question #7 worked was the

- a. 19th
- b. 17th
- c. 18th
- d. 20th

9. According to evolutionists humans are most closely related both physically and behaviorally to the

- a. baboon
- b. chimpanzee
- c. monkey
- d. gorilla

10. According to evolutionists human-like organisms first appear when and where?

- a. 60 million years ago in Asia.
- b. 200,000 years ago in Africa.
- c. 40,000 years ago in Europe.
- d. 6 million years ago in Africa.
- e. 10,000 years ago in Eurasia (the Middle East).