Ambivalence in Teaching Publicly Controversial Science (what can college faculty do?)

Sarah Wise, Ph.D.
University of Colorado at Boulder
July 6, 2011
Thank you

• participating teachers and districts

• National Center for Science Education (NCSE), Colorado Science Educator’s Network (CSEN)

• U. of Colorado’s Cooperative Institute for Research in Environmental Science, (Education and Outreach Group):
  
  Susan Buhr  
  Susan Lynds  
  Lesley Smith  
  Ryan Vachon

  Sandra Laursen  
  Mark McCaffrey  
  Lornay Hansen
Talk outline

• science and public controversy

• methods: survey design

• evolution teaching practices

• climate change teaching practices
at the college level

• We can find out about our students’ thinking

• We can reexamine the focus of our classes

• We can get active locally – with colleagues and K-12
Talk outline

• science and public controversy

• methods: survey design

• evolution teaching practices

• climate change teaching practices
science and public controversy

• Scientific vs. public controversy
• Which topics inspire public controversy?
  – origin of life
  – human reproduction
  – human embryonic stem cells
  – endangered species
  – nuclear energy
  – evolution
  – climate change
two types of publicly controversial topics

<table>
<thead>
<tr>
<th>how to apply science</th>
<th>validity of the science</th>
</tr>
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<tbody>
<tr>
<td>– human reproduction</td>
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<td>– embryonic stem cells</td>
<td></td>
</tr>
<tr>
<td>– endangered species</td>
<td></td>
</tr>
<tr>
<td>– nuclear energy</td>
<td></td>
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<tr>
<td>– responding to climate change</td>
<td></td>
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<tr>
<td>– origin of life</td>
<td></td>
</tr>
<tr>
<td>– evolution</td>
<td></td>
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<tr>
<td>– human-caused climate change</td>
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Let’s pause to discuss:

- Which controversial topics have you taught? How did you approach teaching them?
- In general, do these categories require different instructional techniques or emphasis?

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<td>– nuclear energy</td>
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</tr>
<tr>
<td>– responding to climate change</td>
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evolution and climate change: common features

• call concepts of human/nature into question
• confusion about nature of science
• misconceptions
• misinformation

Understanding Evolution:
http://evolution.berkeley.edu/evosite
Understanding Science:
http://undsci.berkeley.edu/

evolution and climate change: key differences

- religious vs. political divide
- central to discipline vs. critical to decision-makers
- inclusion in education standards
- place in curriculum

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Miller et al. 2006

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BBC, 2007
does controversy affect instruction?

• marginalization, avoidance of evolution:
  – 16% of biology teachers do not present evolution (Oregon) (Trani, Amer. Biol. Teacher, 2004)
  – “pervasive reluctance of teachers to forthrightly explain evolutionary biology” – the “cautious 60%”
    - speciation, human evolution avoided (Berkman 2010)

• avoidance of climate change:
  – seems likely, but not documented
  – Do you know of examples?
unique study goals:

• describe climate change instruction; compare with evolution

• compare different science subjects, grade levels

• assess impact of community pressure

• identify relationships between instruction and specific teacher characteristics and experiences
Talk outline

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• climate change teaching practices
Teaching About Publicly Controversial Science Survey

- open to public school teachers in Colorado, Fall 2007
- parallel questions for evolution and climate change
- online only, “convenience sample”
  (if I had to do it again….)
- used “skip logic” to give different teachers different questions

www.surveymonkey.com
survey recruitment

• targeted recruitment district-by-district for statewide representation (n=107/178)

• offered “thank you” gift card incentive – to decrease self-selection bias
survey sample

- secondary teachers (n=628)

<table>
<thead>
<tr>
<th>life</th>
<th>Earth</th>
<th>all other</th>
<th>middle</th>
<th>high</th>
</tr>
</thead>
<tbody>
<tr>
<td>35%</td>
<td>29%</td>
<td>36%</td>
<td>46%</td>
<td>54%</td>
</tr>
</tbody>
</table>

- return rate: <30%
- not generalizable, but comparable

Proportions of teachers in Colorado and in sample, by Colorado region.
Talk outline

• science and public controversy

• methods: survey design

• evolution teaching practices
  – patterns
  – factors influencing patterns

• climate change teaching practices
How do teachers sampled view evolution?

Figure 3. Views of sampled life science teachers on statements related to evolution. Comparative data from the National Survey of High School Biology Teachers (Berkman et al., 2008).

Preliminary unpublished data. Please contact Sarah Wise at sarah.wise@colorado.edu if you are interested in sharing/reporting these data.

Sampled teachers’ views of evolution line up with peers nationwide, in between scientists and the public.
What should be taught in schools?

Preliminary unpublished data. Please contact Sarah Wise at sarah.wise@colorado.edu if you are interested in sharing/reporting these data.

* Question wording: About 65% of the U.S. population thinks that creationism and evolution should both be taught in schools, according to a recent CBS poll. Do you think Colorado teachers should discuss "both sides" of the public controversy in class?
Let’s discuss:
What are possible explanations for inconsistencies in these results?

“both sides”*

Preliminary unpublished data. Please contact Sarah Wise at sarah.wise@colorado.edu if you are interested in sharing/reporting these data.

* Question wording: About 65% of the U.S. population thinks that creationism and evolution should both be taught in schools, according to a recent CBS poll. Do you think Colorado teachers should discuss “both sides” of the public controversy in class?
How much time is spent on evolution concepts?

Nationwide, 17% of h.s. life science teachers do not “cover human evolution”. (Berkman et al. 2008)

Class hours allocated by sampled life science teachers (73%) to subtopics of evolution.

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Do teachers marginalize or avoid evolution?

Top 3 reasons for omitting evolution:
- it’s not in my curriculum/standards
- fear objections (30%)
- it’s too controversial (55%)

Nationwide, only 2% of h.s. life science teachers “exclude evolution entirely” (Berkman et al. 2008)

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A quick, non-scientific poll about your institution:

Is an evolution course required for biology majors?

Is an evolution course required for preservice teachers?
Let’s discuss:

Do intro biology and geology students have the opportunity to “master” these ideas at your institution? What about biology majors? Preservice teachers?

-- natural selection
-- macroevolution
-- speciation
-- human evolution
-- other topics?

What are the consequences, when students aren’t challenged to address these topics?
Talk outline

• science and public controversy

• methods: survey design

• evolution teaching practices
  – patterns
  – factors influencing patterns

• climate change teaching practices
Does community pressure affect teaching?

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"It makes me want to find a way to present both sides."
-- Broomfield, CO

"I start to feel that it is impossible to teach about evolution - which is an absolute shame."
-- Centennial, CO

"I am afraid to discuss evolution for fear of being sued or fired. I teach the concepts without the vocabulary."
-- Centennial, CO

"I left the school due to non-support of the admin."
-- Aurora, CO

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Does community pressure affect teaching?

**encouragement has more impact**

…and many teachers resist discouragement!

Preliminary unpublished data. Please contact Sarah Wise at sarah.wise@colorado.edu if you are interested in sharing/reporting these data.
Who applies pressure about evolution to teachers?

“teach it”

“avoid it”

Community sectors applying pressure to life science teachers about evolution. Some teachers chose more than one sector; proportions of total responses shown.

Preliminary unpublished data. Please contact Sarah Wise at sarah.wise@colorado.edu if you are interested in sharing/reporting these data.
What is the basis of teachers’ knowledge?

Proportions of life science teachers reporting engagement with various modes of learning about evolution (or no learning).

Preliminary unpublished data. Please contact Sarah Wise at sarah.wise@colorado.edu if you are interested in sharing/reporting these data.
Which factors affect evolution instruction?

Statistical testing using logistic regression

- Which factors are significantly associated with teachers who teach evolution *formally*?
  
  Where they live in Colorado?  
  The district or school they are in?  
  The kinds of community pressure they have received?  
  How much they have learned?  
  Gender, religion, or political affiliation?

- Significant relationships have less than 5% (p<.05) likelihood of occurring by chance.

- Regression identifies significant factors while *controlling for* other variables

  Evolution dataset = Earth + Biology teachers = 351 responses, 25 variables
### Which factors affect *formal* evolution instruction?

<table>
<thead>
<tr>
<th></th>
<th>no trend</th>
<th>trend present</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>district^/school</strong></td>
<td>most regions of Colorado urban/ rural/ suburban</td>
<td>north eastern Colorado</td>
</tr>
<tr>
<td></td>
<td>% free/reduced lunch</td>
<td>higher revenue per pupil *</td>
</tr>
<tr>
<td></td>
<td>district size</td>
<td></td>
</tr>
<tr>
<td></td>
<td>school size</td>
<td></td>
</tr>
<tr>
<td><strong>teacher</strong></td>
<td>gender</td>
<td>middle vs. high school **</td>
</tr>
<tr>
<td></td>
<td># years teaching</td>
<td></td>
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<td></td>
<td># subjects taught</td>
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<td></td>
<td>religion</td>
<td></td>
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<td></td>
<td>political affiliation</td>
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<tr>
<td><strong>experience</strong></td>
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<td></td>
<td></td>
<td>more scientific views of evolution *^</td>
</tr>
<tr>
<td></td>
<td></td>
<td>more evolution learning experiences **^</td>
</tr>
<tr>
<td></td>
<td></td>
<td>more encouragement *</td>
</tr>
<tr>
<td></td>
<td></td>
<td>more discouragement</td>
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^ = trend seen in National study

* = p < .05

red = less likely

** = p < .01

blue = more likely

*^ = trend seen in National study

** = p < .01

= more likely

= less likely

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Let’s discuss:

What do these regressions tell us about the problem of ambivalence in evolution education (if anything)?

Which questions need further study?
Let’s discuss:

Given K-12 trends, can any changes be made at the college level to help shift the “status quo” with respect to public understanding of evolution?
Discuss:

7th inning stretch
Add video clip of ken miller?
Talk outline

- science and public controversy
- methods: survey design
- evolution teaching practices
- climate change teaching practices
How do teachers sampled view climate change?

Percent of sampled Earth science teacher agreement with statements about global warming. International Panel on Climate Change (IPCC, 2007) reports reflect agreement with these statements.

How do teachers sampled view climate change?

Figure 3. % of Earth science teacher agreement with statements about global warming. IPCC reports reflect disagreement with these statements.

How does instruction around evolution and climate change compare?

<table>
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<th>climate change (all Earth science)</th>
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<td>98%</td>
<td>99%</td>
</tr>
<tr>
<td>teach &quot;both sides&quot;?</td>
<td>43%</td>
<td>86%</td>
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“teach both sides?” = “About 20% of the U.S. population does not think that recent global warming is caused primarily by human activity, according to a recent poll by TIME. In general, do you think Colorado teachers should discuss "both sides" of this public controversy with students?”
What are teachers’ reasons for “teaching both sides”? (more on handout)

“This issue about human cause is still being peer reviewed and tested. Thus it is an important topic for showing the science process in action.” Jamestown, CO

“I feel it's important for students to be given unbiased information and allow the students to make their own personal decisions.” Jamestown, CO

“Even though I believe that it is entirely caused by human factors, there are those who disagree, including some parents. I feel teaching multiple sides will lead to better debate/ discussion of the topic.” Colorado Springs, CO

“I think teachers should address the controversy (not teach the controversy) and teach the science. Let the individual decide what to believe.” Silverthorne, CO

“There is no other side supported by scientists at this time, when there is we should teach it.” Wellington, CO

“Present “both sides” as science”

“Leave scientific validity unclear”

“Emphasize views of scientific community”
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“Do you teach about climate change formally?”

Figure 6. Proportions of middle level and high school science teachers teaching formal lessons about climate change. Significant differences exist between middle and high school science teachers (*, t=-4.25, p<.01; **, t=-1.89, p<.05)

“How much time do you spend on these concepts?”

Amount of class time reported by Earth science teacher participants as devoted to the topics of climate (light blue) and global warming (dark blue). GHG = greenhouse gases.

How does instruction around evolution and climate change compare?

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</thead>
<tbody>
<tr>
<td>teach informally?</td>
<td>17%</td>
<td>27%</td>
</tr>
<tr>
<td>avoid discussion?</td>
<td>9%</td>
<td>8%</td>
</tr>
<tr>
<td>reason avoided?</td>
<td>controversy (30-50%)</td>
<td>not in curriculum (60%)</td>
</tr>
<tr>
<td>pressure to avoid it?</td>
<td>36%</td>
<td>13%</td>
</tr>
<tr>
<td>pressure hinders teaching?</td>
<td>6%</td>
<td>4%</td>
</tr>
<tr>
<td>pressure to teach it?</td>
<td>36%</td>
<td>31%</td>
</tr>
<tr>
<td>pressure enhances teaching?</td>
<td>18%</td>
<td>17%</td>
</tr>
</tbody>
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maybe curriculum/standards issues mattered more for climate change (in 2007)
Which factors affect formal climate change instruction?

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  Climate change dataset = Earth + other science teachers  
  = 292 responses, 25 variables
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<td></td>
</tr>
<tr>
<td>teacher</td>
<td>gender(^\land)</td>
<td>main subject: Earth vs. other science **</td>
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<tr>
<td></td>
<td># years teaching(^\land)</td>
<td>life science: middle vs. high school **(^\land)</td>
</tr>
<tr>
<td></td>
<td># subjects taught(^\land)</td>
<td>democrat vs. other political affiliation</td>
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<tr>
<td></td>
<td>religion(^\land)</td>
<td></td>
</tr>
<tr>
<td>experience</td>
<td></td>
<td>more scientific views of GW **(^\land)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>more GW learning experiences **(^\land)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>more encouragement **(^\land)</td>
</tr>
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<td></td>
<td></td>
<td>more discouragement (^\land)</td>
</tr>
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\(^\land\) = same finding as in Evolution sample

\(\ast = p < .05\) red = less likely

\(\ast\ast = p < .01\) blue = more likely

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major findings

• both evolution and climate change instruction appear to be impacted by public controversy

• overemphasis on “both sides” weakens instruction, particularly at middle level

• avoidance linked strongly to experience

• a potentially powerful “encouragement effect”

implication

• climate change has a chance of becoming “the next evolution” – but this is preventable
Let’s discuss:

Where does ambivalence around teaching publicly controversial topics come from?
Where does ambivalence come from?

This study highlights *proximate* factors:

• Leadership vacuum – lack of emphasis in standards, which vary state-by-state

• Teachers’ lack of professional development on these topics → biology and education faculty – a tradition of dismissing the problem as non-academic (Alters 2005, Berkman 2010)

• Mistaken application of journalistic/ethical code to “be fair”, “present both sides”
  • counterpoint: science operates like a jury, on a “preponderance of evidence”

• Avoidance of controversy – and why not?
Where does ambivalence come from?

At the root:

- Historically strong U.S. tradition of anti-intellectualism
  - Wm. Jennings Bryan: the majority must be defended against “irresponsible oligarchy of self-styled intellectuals”
  - the myth of the classless society
  - rational thought is “cold and amoral”
  - recommended reading: “Denying Evolution” (Pigliucci 2002)
  - Postmodernism / relativism

- Wedding group-identity with anti-science stance within the political right

- Increasingly heightened sensitivity to crossing parents
Summing up the cultural factors producing ambivalence: Colbert Report

Stephen Colbert and Benard-Henri Levy
Jan 12, 2011

start after camera view switches ~1:00

Stephen Colbert and Ken Miller
June 16, 2008
Jan 12, 2006

“welfare queens”

“Steve Martin Theory of Evolution”
at the college level

• We can find out about our students’ thinking:
  – Clicker Question: In high school, what did your science teachers emphasize about whether human activity causes climate change (CC)
  – Concept Inventories and Surveys (handout)

• We can reexamine the focus of our classes
  • Just the facts? or also How do we know what we know?
  • Do we distinguish between public controversy and science?
  • What if we viewed all students as prospective teachers?

• We can get active locally
  • Talk to and lead our colleagues
  • Contribute to K-12 dialogue: letters, conferences messages: “educate, don’t debate”, “teach the science first”
  • Analyze, comment on science standards/curriculum
  • Organize teacher workshops focused on misconceptions
Handouts
Figure 1. Continuum of secondary science teacher responses to the question “About 20% of the US population does not think that recent global warming is caused primarily by human activity, according to a recent poll by TIME. In general, do you think Colorado teachers should discuss “both sides” of this public controversy with students? (Explain why and how).

<table>
<thead>
<tr>
<th>Reasonings Promoting 'Both Sides' as Valid Science</th>
<th>Reasonings Leaving Validity of Each Side Unclear</th>
<th>Reasonings Promoting Validity of Human-Caused Climate Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discussing both sides allows students to see scientific evidence supporting both sides of this issue. This is an important skill in science, and all classes really.</td>
<td>Part of teaching is allowing students to make an argument for what they believe... Teachers could present both sides by having the students have a debate, using primary sources and summarizing what they say... analyzing [TV] programs, etc...</td>
<td>It is always important to show a balanced view of topics. Even if you have an opinion it is important to let the kids decide what they think and draw conclusions from the evidence.</td>
</tr>
<tr>
<td>You cannot be a fair teacher by teaching only one theory about a controversial topic.</td>
<td>It is always important to show a balanced view of topics. Even if you have an opinion it is important to let the kids decide what they think and draw conclusions from the evidence.</td>
<td>I think it should be discussed because students have preconceived ideas not based on fact. I think it is important to show them the research and look at opinions out there...I think they will see that the research points to human causes.</td>
</tr>
<tr>
<td>A teacher's personal opinion should never be taught exclusively. Global warming caused by human activity is a theory...Students should have enough information presented to them that would show doubt on 'both sides'.</td>
<td>Again, in order to not be biased, one must present varying views on such controversial topics.</td>
<td>Students need to know the facts behind the issues. Introducing the confusion and argument that is unfounded only serves to confuse students who are not critical thinkers, thus introducing misconceptions.</td>
</tr>
<tr>
<td>Students should have facts in order to develop their own thinking. If only presented with one side of an issue, then they are not given the tools to develop their own thinking. That is our primary job.</td>
<td>As with all topics, if students are not informed... myths become truth.</td>
<td>I think that the focus should be on the scientific consensus. Addressing the fact that most people do not understand the science... is worthwhile.</td>
</tr>
<tr>
<td>Teachers should always mention other sides of an issue, if for no other reason, just to acknowledge that they exist.</td>
<td>I think it should be discussed because students have preconceived ideas not based on fact. I think it is important to show them the research and look at opinions out there...I think they will see that the research points to human causes.</td>
<td>Students should...adress their understanding, then challenge it using scientific data.</td>
</tr>
</tbody>
</table>

Sample Items: Conceptual Inventory of Natural Selection (CINS)*

The Canary Islands are seven islands just west of the African continent. The islands gradually became colonized with life plants, lizards, birds, etc. Three different species of lizards found on the islands are similar to one species found on the African continent (Thomas & Brown, 1969). Because of this scientists assume that the lizards traveled from Africa to the Canary Islands by floating on tree trunks washed out to sea.

Choose the one answer that best reflects how an evolutionary biologist would answer.

15. What do you think happens among the lizards of a certain species when the food supply is limited?
   a. The lizards cooperate to find food and share what they find.
   b. The lizards fight for the available food and the strongest lizards kill the weaker ones.
   c. Genetic changes that would allow lizards to eat new food sources are likely to be induced.
   d. The lizards are successful in the competition for food are likely to die of starvation and malnutrition.

16. A well-established population of lizards is made up of hundreds of individual lizards. On an island, all lizards in a lizard population are likely to .
   a. be indistinguishable, since there is a lot of interbreeding in isolated populations.
   b. be the same in the male but display differences in their external features.
   c. be similar, yet have some significant differences in their internal and external features.
   d. be the same on the outside but display differences in their internal features.

18. Fitness is a term often used by biologists to explain the evolutionary success of certain organisms. Below are descriptions of four fictional female lizards. Which lizard might a biologist consider to be the “most fit”?

<table>
<thead>
<tr>
<th>Lizard</th>
<th>Body length</th>
<th>Comparing surviving to adulthood</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20 cm</td>
<td>19</td>
</tr>
<tr>
<td>B</td>
<td>15 cm</td>
<td>23</td>
</tr>
<tr>
<td>C</td>
<td>16 cm</td>
<td>22</td>
</tr>
<tr>
<td>D</td>
<td>15 cm</td>
<td>25</td>
</tr>
</tbody>
</table>

* Lizard A is very healthy, strong, and clever.
* Lizard B has mated with many lizards.
* Lizard C is dark-colored and very quick.
* Lizard D has the largest territory of all the lizards.

20. What could cause one species to change into three species over time?
   a. Groups of lizards encountered different lizard environments so the lizards needed to become new species with different traits in order to survive.
   b. Groups of lizards must have been geographically isolated from each other and random genetic changes must have accumulated in these lizard populations over time.
   c. There may be minor variations, but all lizards are essentially alike and all are members of a single species.
   d. In order to survive, different groups of lizards needed to adapt to different islands, and so all organisms in each group gradually evolved to become new lizard species.

Sample items: Greenhouse Effect Concept Inventory (GECI)**

4) Which of the following is a primary characteristic of greenhouse gases?
   a. They can destroy certain molecules in the atmosphere.
   b. They bend and magnify sunlight entering the atmosphere.
   c. They can trap certain molecules in the atmosphere.
   d. They can bounce around more in the atmosphere.
   e. They are transparent to some forms of energy but not all.

5) The greenhouse effect is a very _____ process probably caused by _____
   a. recent; burning of fossil fuels, industry, agriculture, and other human activities.
   b. old; plants that increase humidity and create conditions similar to those in a greenhouse found at a plant nursery.
   c. recent; depletion of the ozone layer which allows more ultraviolet sunlight to reach the Earth’s surface.
   d. old; interactions between naturally occurring gases and various forms of energy in the atmosphere.
   e. recent; natural processes including volcanic emission and changes in solar activity.

8) Which one of the following is not a greenhouse gas?
   a. carbon dioxide (CO2)
   b. water vapor (H2O)
   c. methane (CH4)
   d. oxygen (O2)
   e. ozone (O3)

9) Which of the following best describes the relationship between the greenhouse effect and global warming?
   a. The greenhouse effect and global warming are the same thing.
   b. An increase in the greenhouse effect may be causing global warming.
   c. Global warming may be causing an increase in the greenhouse effect.
   d. The greenhouse effect and global warming are likely unrelated.
   e. There is no definite proof that either the greenhouse effect or global warming exist.

2. Keller, J. 2010. Portion of unpublished doctoral dissertation. To obtain, contact Dr. Keller at: jmkeller@calpoly.edu
Sample Items: Measuring Acceptance of the Theory of Evolution (MATE)

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Undecided</td>
<td>Disagree</td>
<td>Strongly Disagree</td>
</tr>
</tbody>
</table>

1. Organisms existing today are the result of evolutionary processes that have occurred over millions of years.
2. The theory of evolution is incapable of being scientifically tested.
3. Modern humans are the product of evolutionary processes which have occurred over millions of years.

Sample Items: Global Warming’s 6 America’s survey (multiple choices found in report)

- How certain are you about whether global warming is occurring?
- What is global warming caused mostly by?
- Could you easily change your mind about global warming?
- Is there disagreement among scientists about whether global warming is happening?
- How worried are you about global warming?
- How much do you think global warming will harm people in the United States? When?
- Do you think humans can reduce global warming? Will they?

Sample Items: Biology Colorado Learning and Attitudes about Science Survey (Bio-CLASS)

15. To learn biology, I only need to memorize facts and definitions.

16. Reasoning skills used to understand biology can be helpful to my everyday life.

17. It is a valuable use of my time to study the fundamental experiments behind biological ideas.

   Students can quiz themselves at: http://apps.facebook.com/climatesurvey