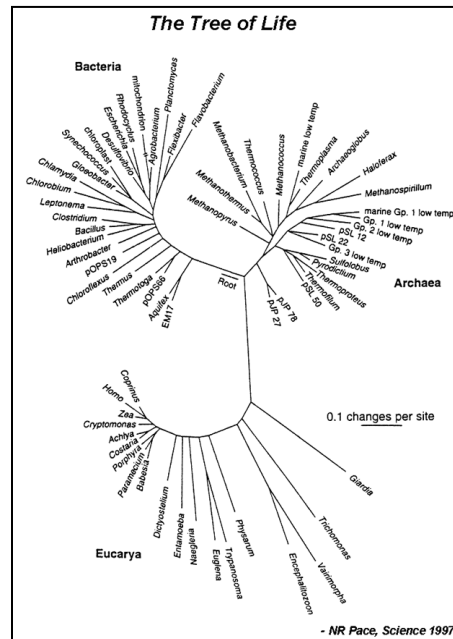


Ambivalence in Teaching Publicly Controversial Science (what can college faculty do?)



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



Teaching About
Publicly
Controversial
Science



Talk outline

- science and public controversy
- methods: survey design
- evolution teaching practices
- climate change teaching practices



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Science



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



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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

how to apply science

- human reproduction
- embryonic stem cells
- endangered species
- nuclear energy
- responding to climate change

validity of the science

- origin of life
- evolution
- human-caused climate change

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?

how to apply science

- human reproduction
- embryonic stem cells
- endangered species
- nuclear energy
- responding to climate change

validity of the science

- origin of life
- evolution
- human-caused climate change

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:

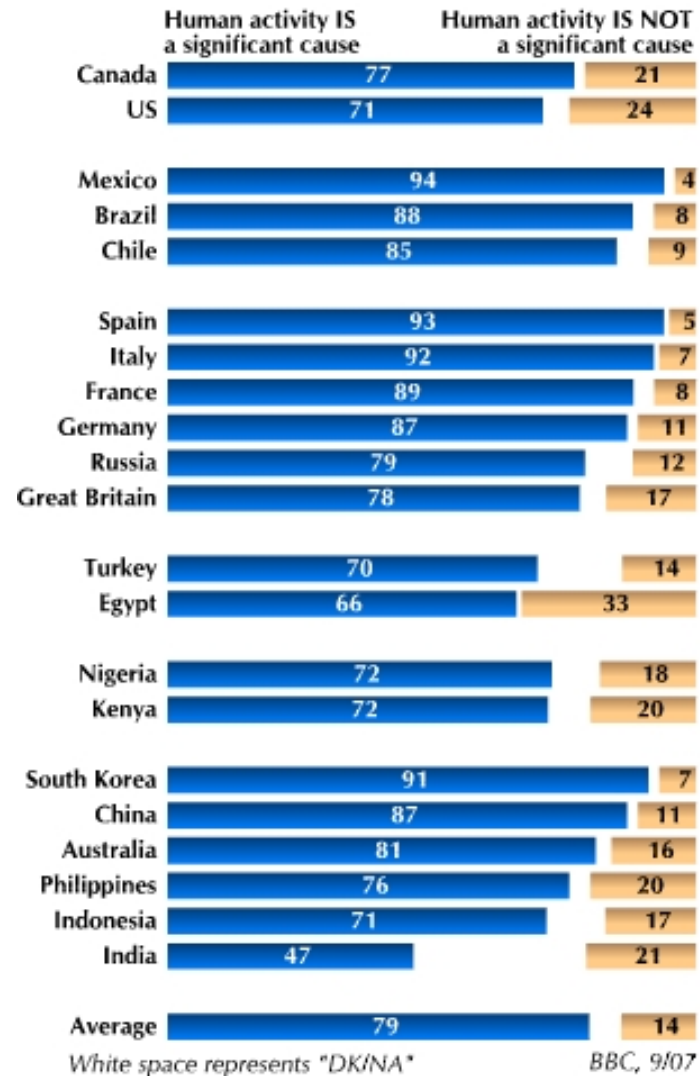
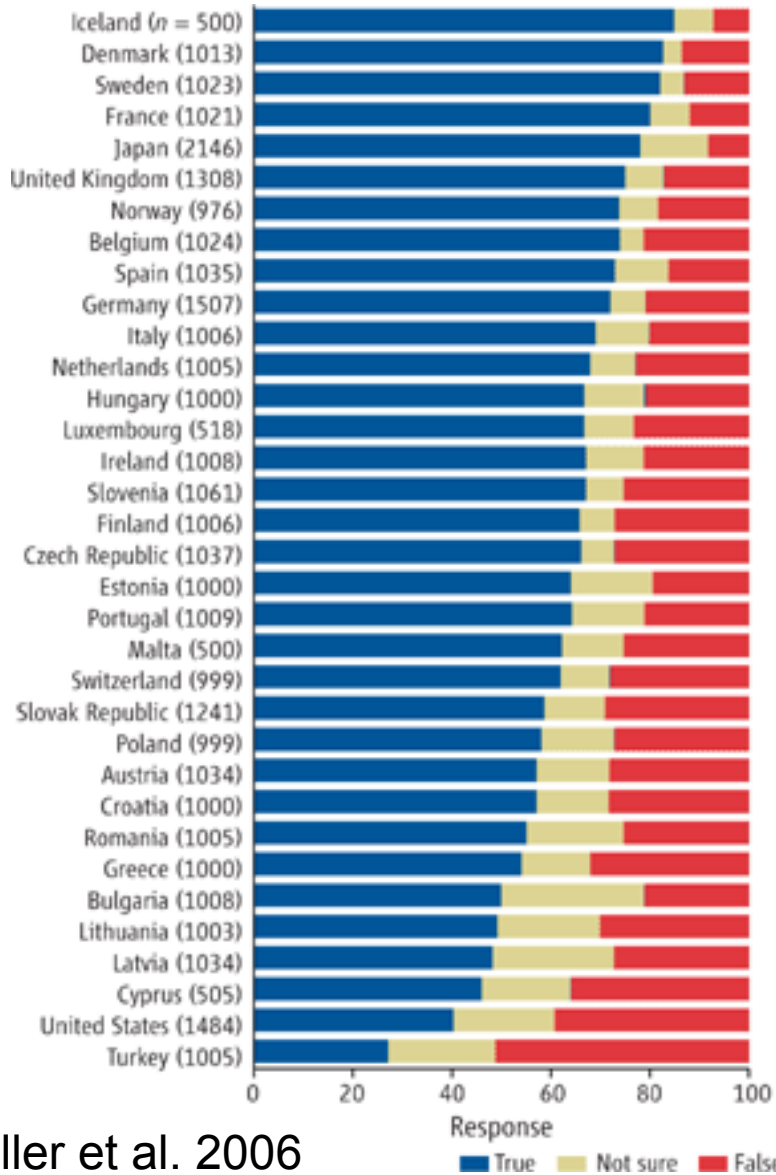
<http://undsci.berkeley.edu/>

Jensen and Finley 1996,
Fortner 2001, Cooper 2002,
Begley 2007

evolution and climate change: key differences

evolution

climate change



White space represents "DK/NA"

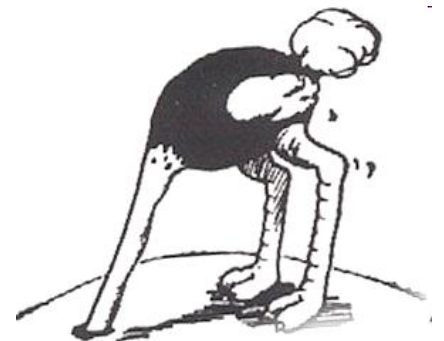
BBC, 9/07

Miller et al. 2006

BBC, 2007

does controversy affect instruction?

- marginalization, avoidance of evolution:
 - 43% of biology teachers do not consider evolution a unifying theme in biology (Moore, J. Biol. Educ., 2000)
 - 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

- science and public controversy
- methods: survey design
- evolution teaching practices
- climate change teaching practices



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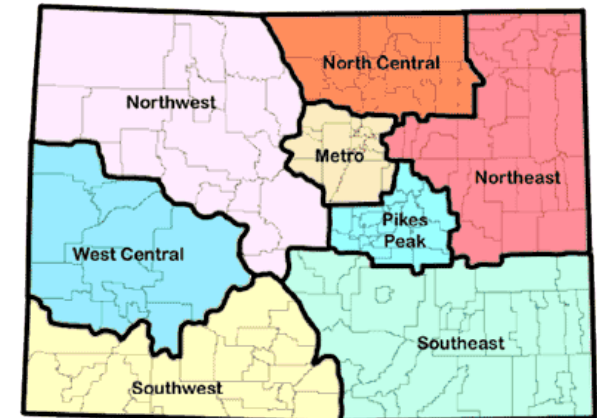
Teaching About Publicly Controversial Science Survey

- 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 a questions



survey recruitment

- targeted recruitment district-by-district for statewide representation (n=107/178)
- offered “thank you” gift card incentive – to decrease self-selection bias



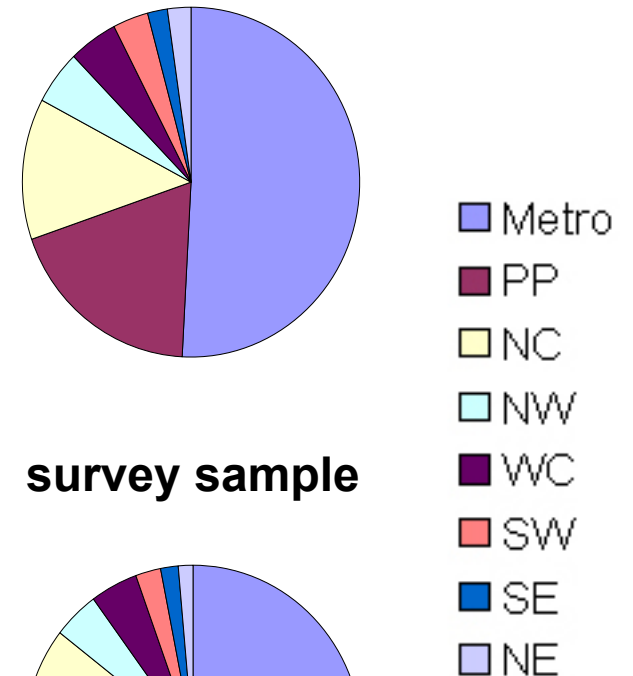
survey sample

- secondary teachers (n=628)

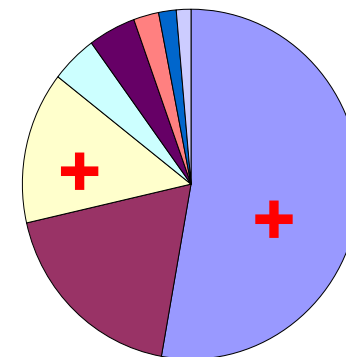
life	Earth	all other	middle	high
35%	29%	36%	46%	54%

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

CO teacher population
(CDE, 2006)



survey sample



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



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How do teachers sampled view evolution?

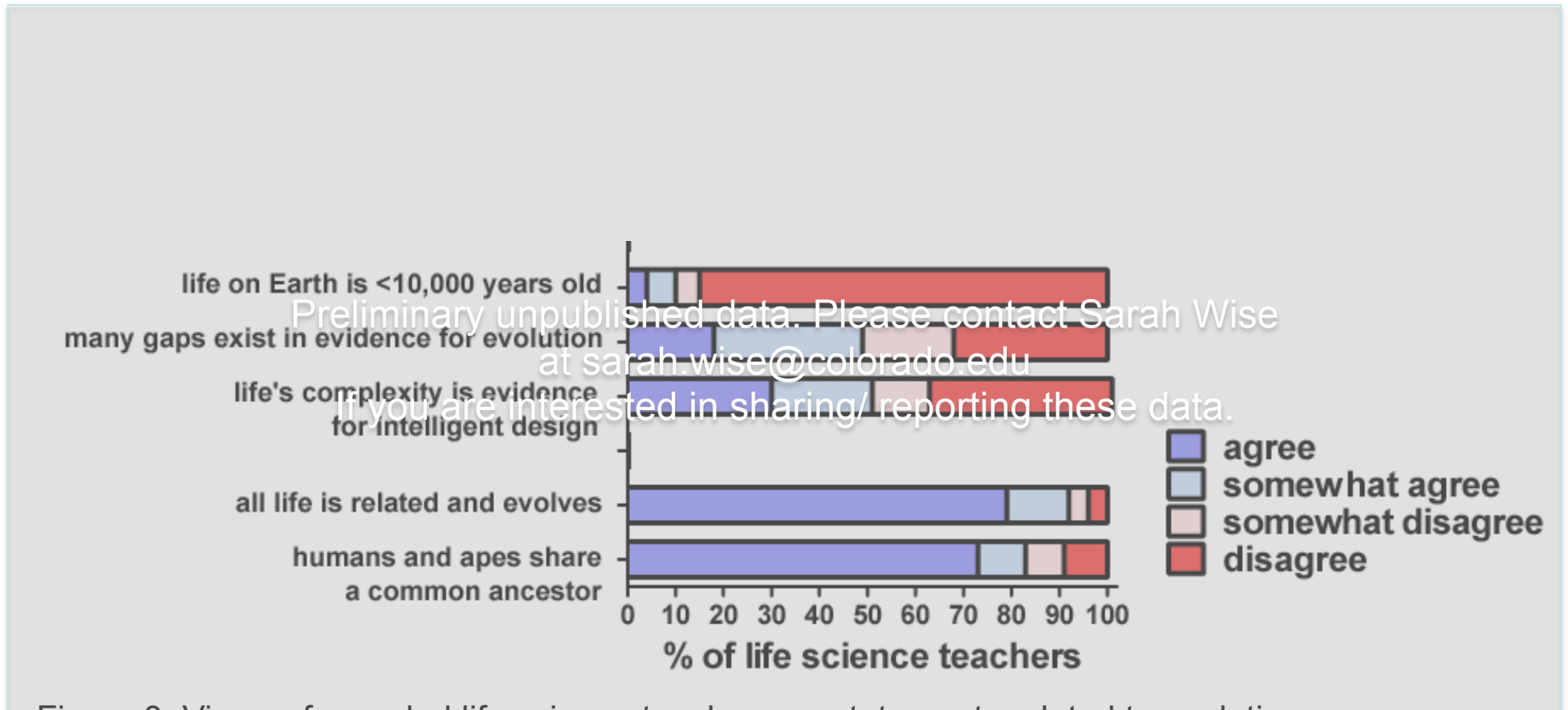
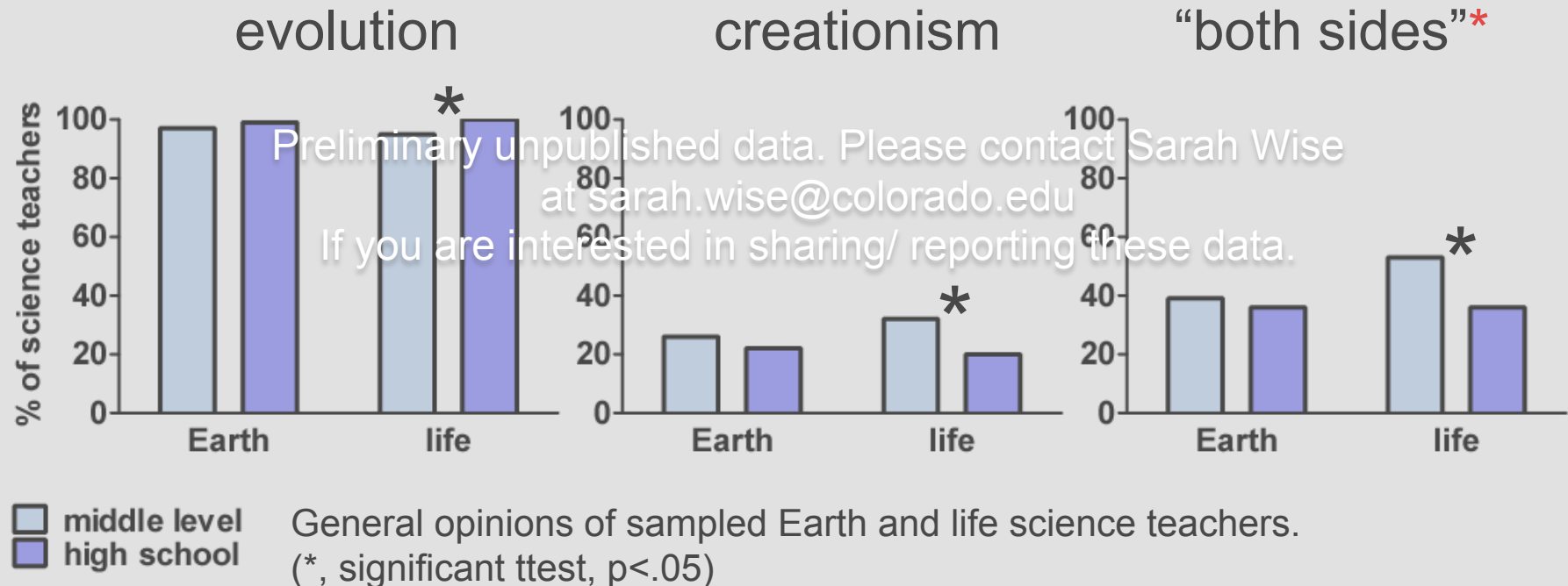


Figure 3. Views of sampled life science teachers on statements related to evolution. Comparative data from the National Survey of High School Biology Teachers (Berkman et al., 2008).

***sampled teachers' views of evolution
line up with peers nationwide, in
between scientists and the public***

What should be taught in schools?

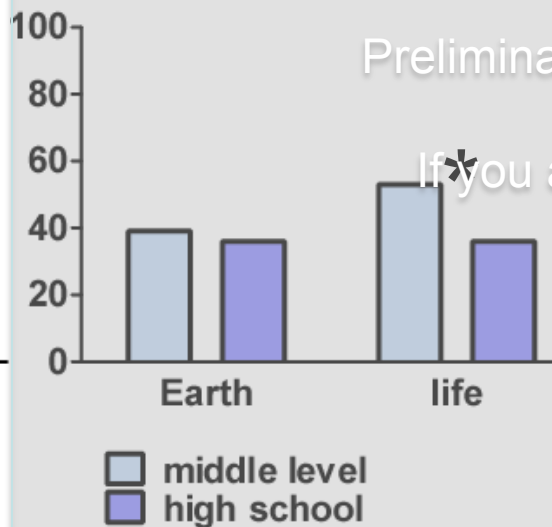


* Question wording: About 65% of the U.S. population thinks that creationism and evolution should both be taught in schools, according to a recent CBS poll. Do you think Colorado teachers should discuss “both sides” of the public controversy in class?

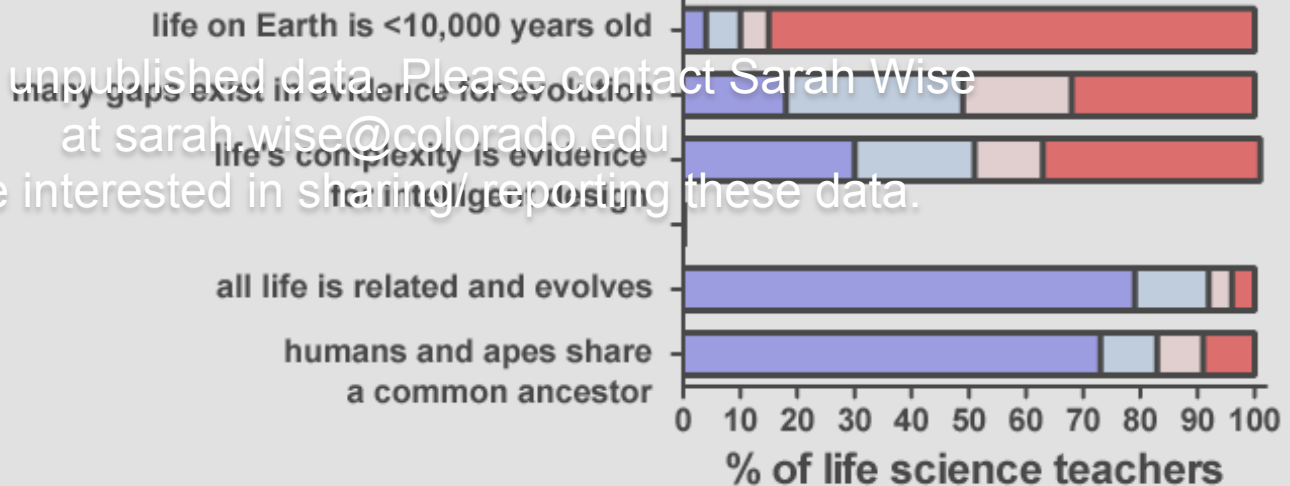
Let's discuss:

What are possible explanations for inconsistencies in these results?

“both sides”*

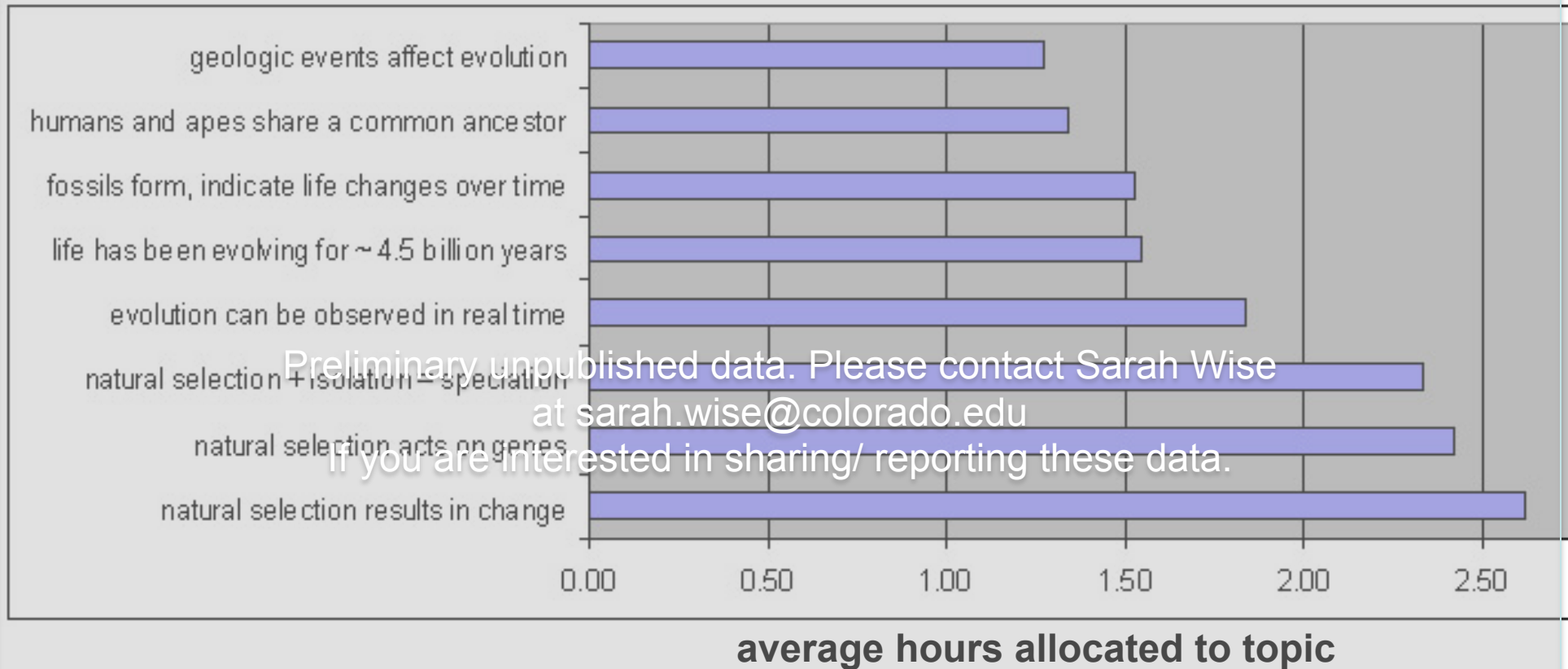


Preliminary unpublished data. Please contact Sarah Wise at sarah.wise@colorado.edu if you are interested in sharing/reporting these data.



* 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?

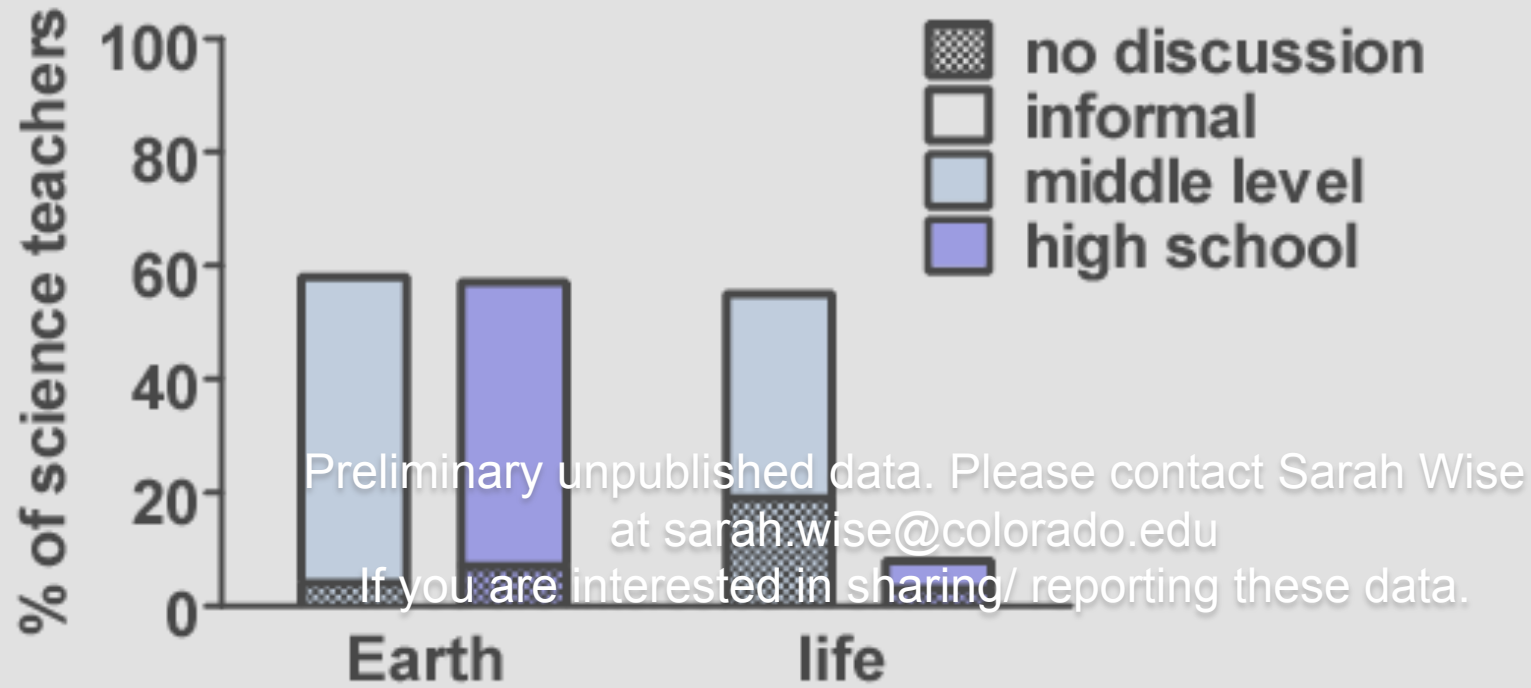


Class hours allocated by sampled life science teachers (73%) to subtopics of evolution.

Nationwide, 17% of h.s. life science teachers do not “cover human evolution”.

(Berkman et al. 2008)

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)

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

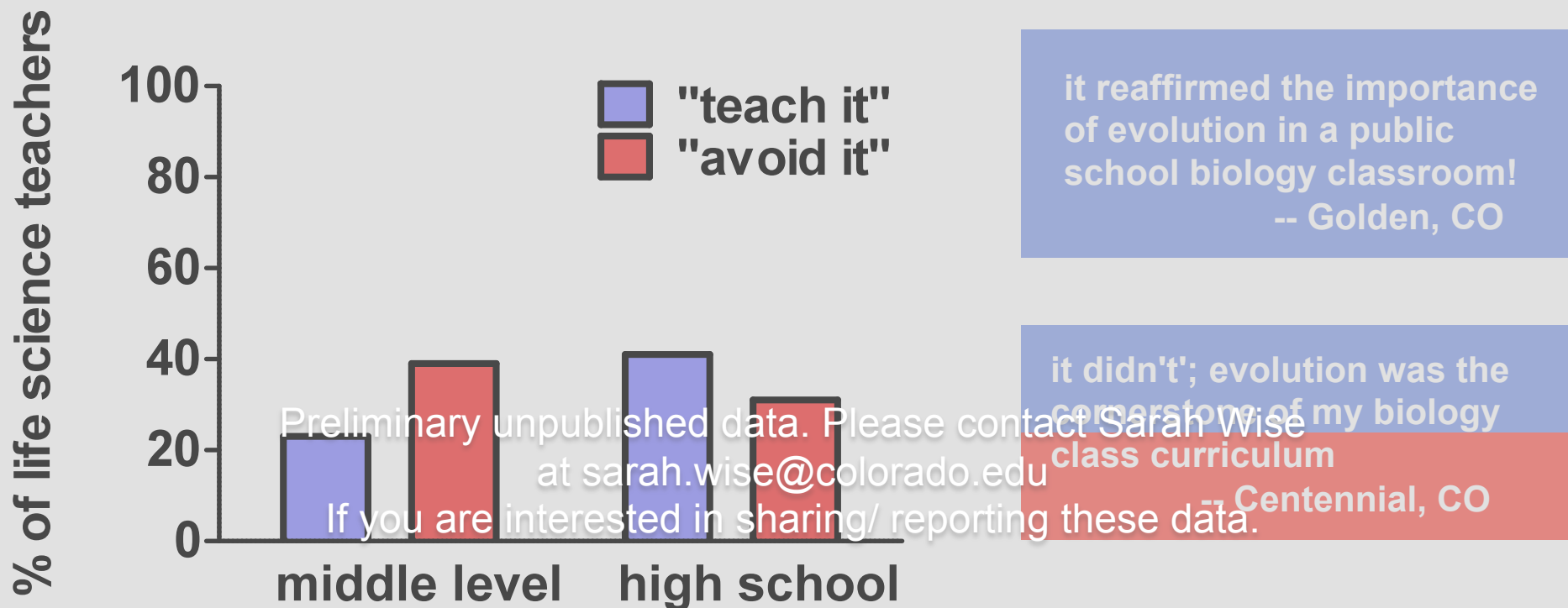
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Does community pressure affect teaching?



it reaffirmed the importance of evolution in a public school biology classroom!
-- Golden, CO

it didn't; evolution was the cornerstone of my biology class curriculum
-- Centennial, CO

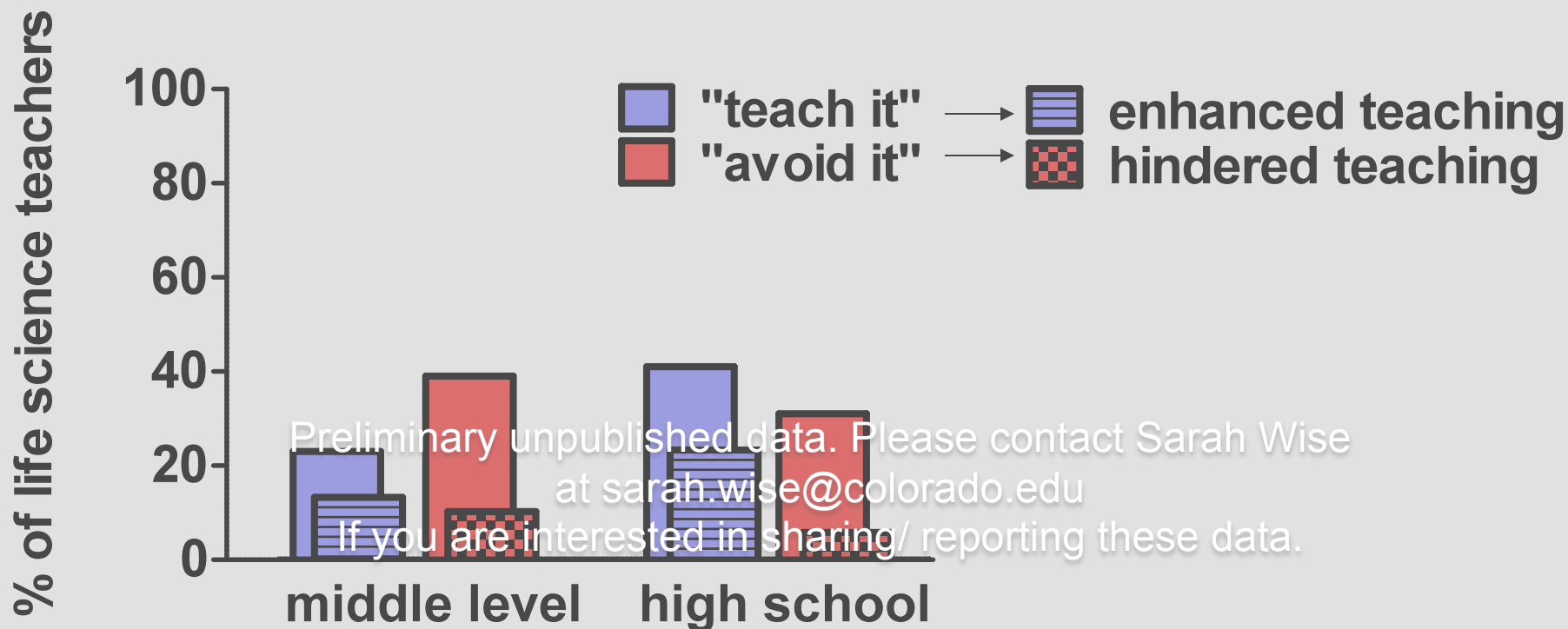
"It makes me want to find a way to present both sides."
-- Broomfield, CO

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

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

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

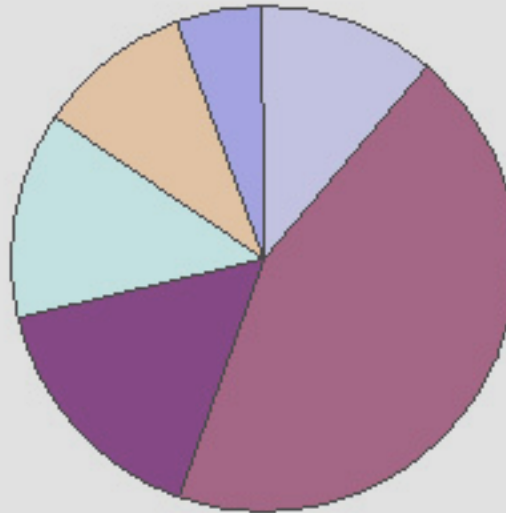
Does community pressure affect teaching?



*encouragement has more impact
...and many teachers resist discouragement!*

Who applies pressure about evolution to teachers?

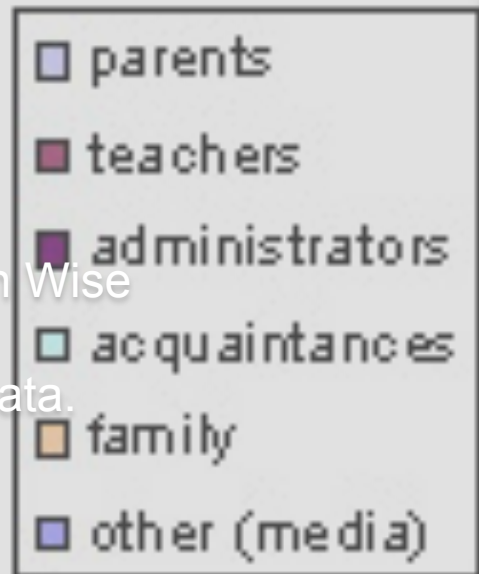
“teach it”



Preliminary unpublished data. Please contact Sarah Wise at sarah.wise@colorado.edu

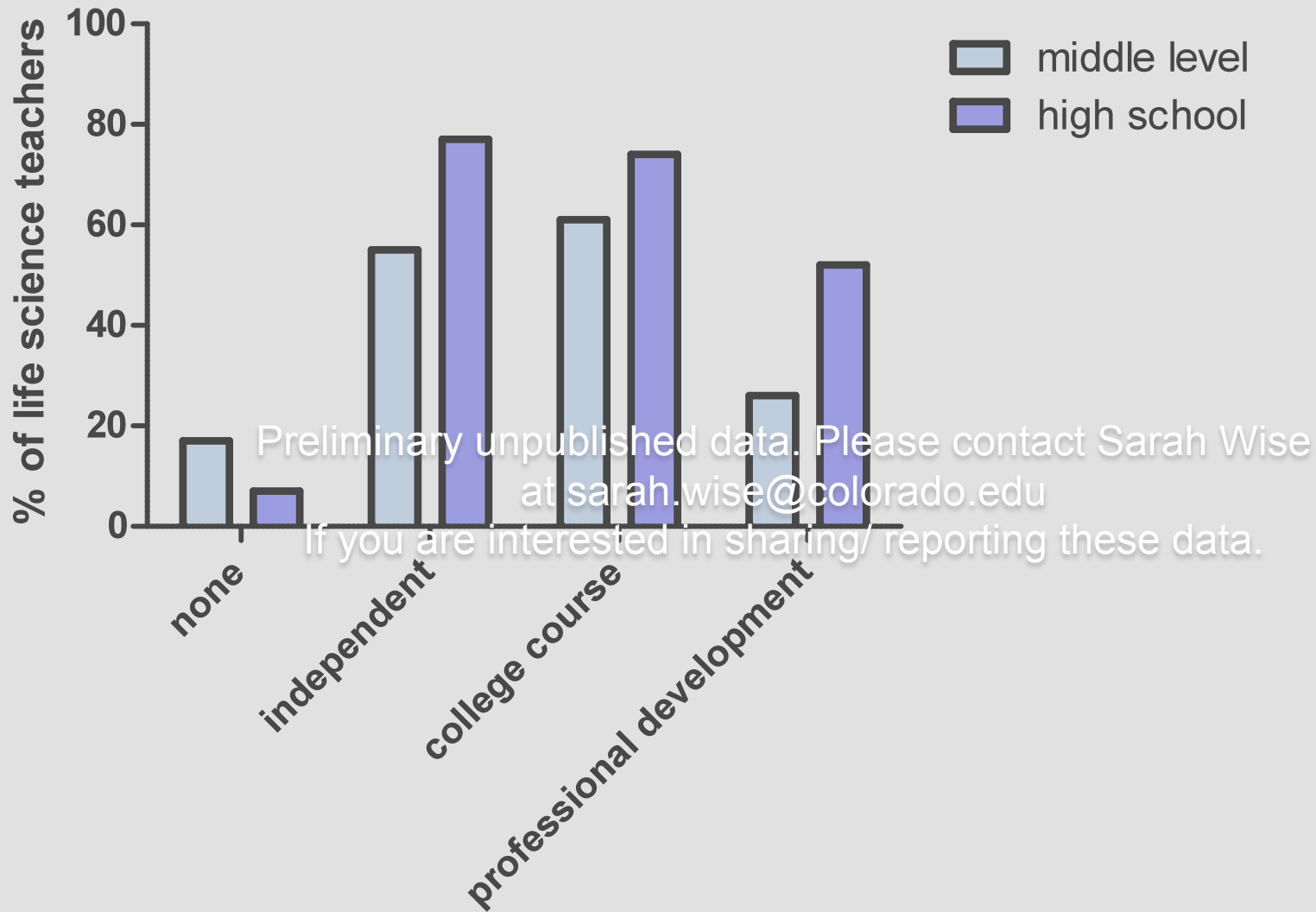
If you are interested in sharing/ reporting these data.

“avoid it”



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

What is the basis of teachers' knowledge?



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

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?

^ = trend seen in National study

* = $p < .05$

red = less likely

** = $p < .01$

blue = more likely

	no trend	trend present
district [^] / school	most regions of Colorado urban/ rural/ suburban % free/reduced lunch district size school size	north eastern Colorado higher revenue per pupil*
teacher	gender # years teaching # subjects taught religion political affiliation	middle vs. high school** main subject: Earth vs. life science**
experience		more scientific views of evolution* [^] more evolution learning experiences** [^] more encouragement* more discouragement

Preliminary unpublished data. Please contact Sarah Wise at sarah.wise@colorado.edu

If you are interested in sharing/ reporting these data

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

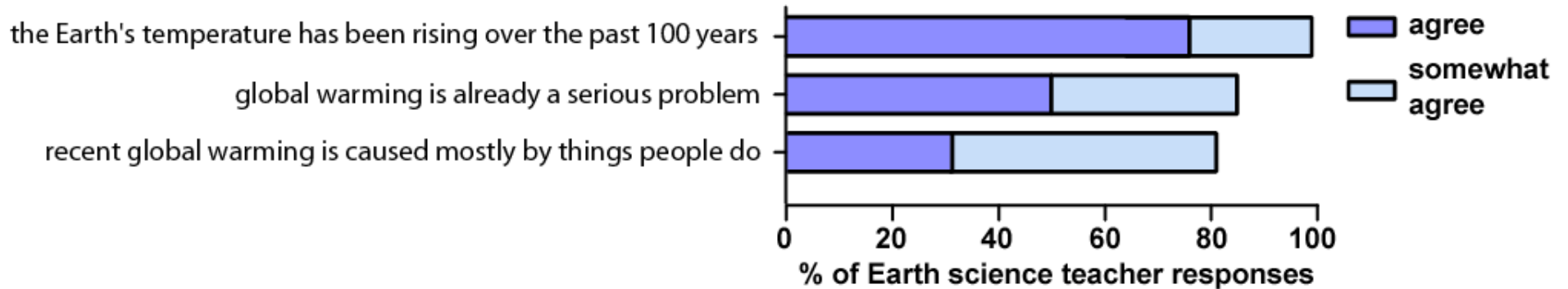
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How do teachers sampled view climate change?



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?

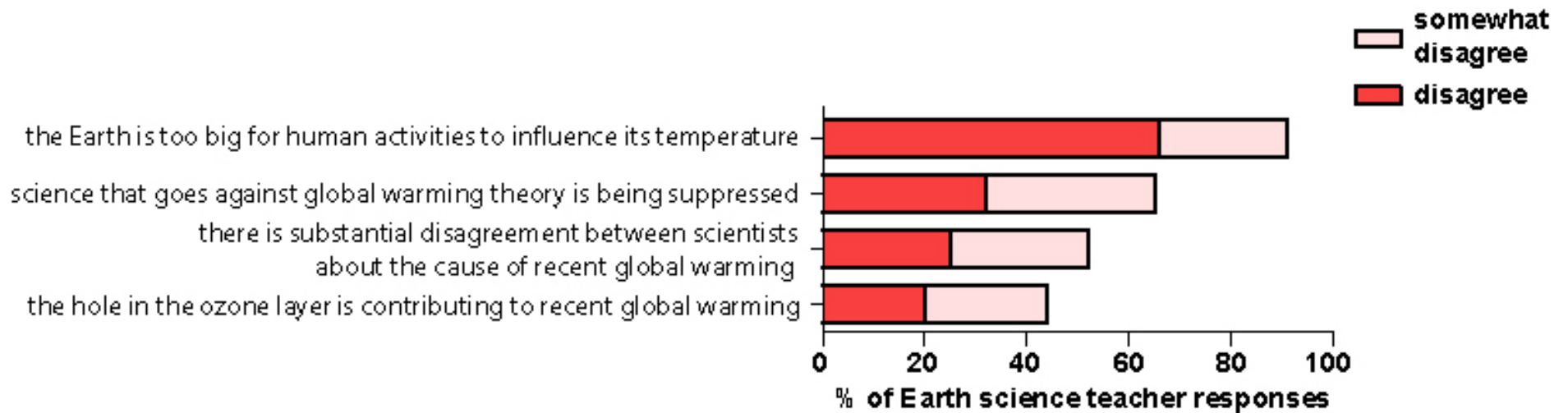


Figure 3. % of Earth science teacher agreement with statements about global warming. IPCC reports reflect **disagreement** with these statements.

How does instruction around evolution and climate change compare?

	evolution (all life science)	climate change (all Earth science)
support teaching the topic?	98%	99%
teach "both sides"?	43%	86%

Preliminary unpublished data. Please contact Sarah Wise
at sarah.wise@colorado.edu

If you are interested in sharing/ reporting these data.

“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."
Colorado Springs, CO

"I think there is conflicting evidence regarding global warming and both sides should be discussed so that students understand why there are two sides to this. This would be a great topic to have the students choose a side, research and debate." Parker, CO

**present
"both sides"
as science**

"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

**leave scientific
validity unclear**

"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

**emphasize
views of scientific
community**

How does instruction around evolution and climate change compare?

	evolution (all life science)	climate change (all Earth science)
support teaching the topic?	98%	99%
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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?”

“Do you teach about climate change formally?”

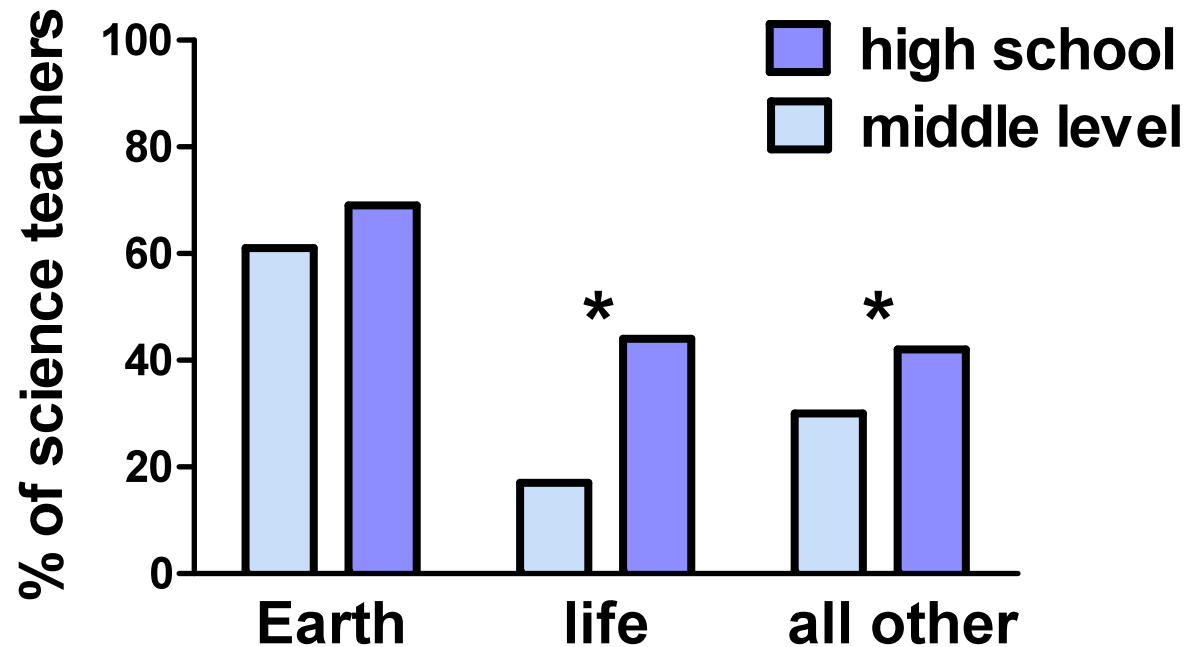
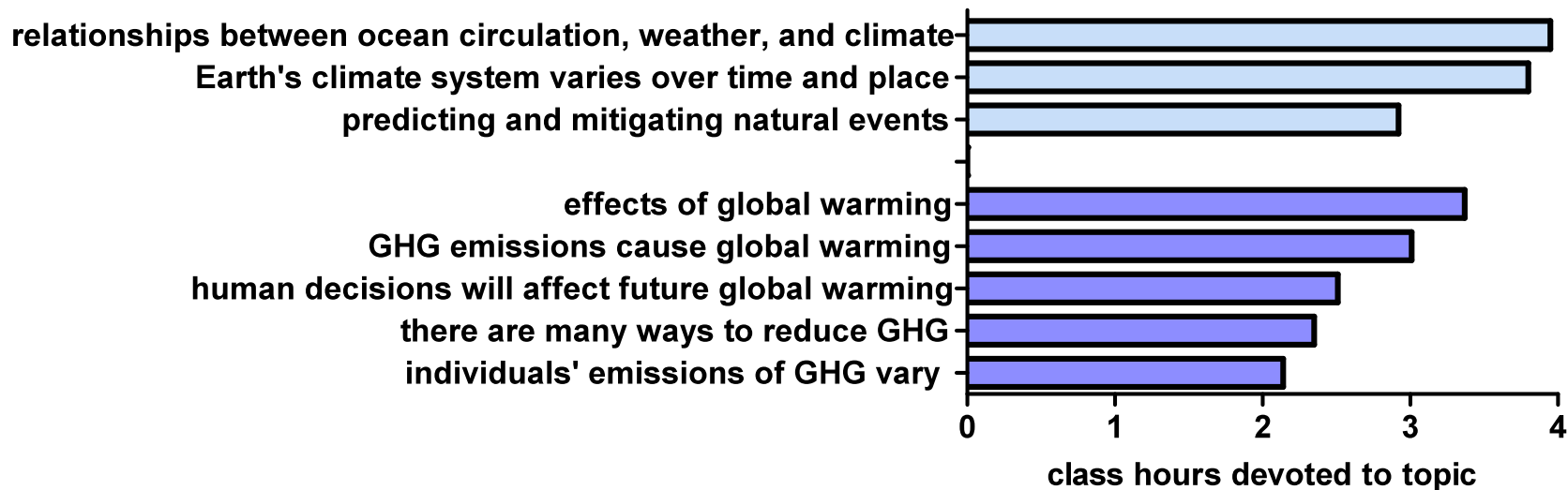


Figure 6. Proportions of middle level and high school science teachers teaching formal lessons about climate change. Significant differences exist between middle and high school science teachers (*, $t=-4.25$, $p<.01$; **, $t=-1.89$, $p<.05$)



“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?

	evolution (all life science)	climate change (all Earth science)
teach informally?	17%	27%
avoid discussion?	9%	8%
reason avoided?	controversy (30-50%)	not in curriculum (60%)
pressure to avoid it?	36%	13%
pressure hinders teaching?	6%	4%
pressure to teach it?	36%	31%
pressure enhances teaching?	18%	17%

Preliminary unpublished data. Please contact Sarah Wise at sarah.wise@colorado.edu

If you are interested in sharing/reporting these data.

maybe curriculum/standards issues mattered more for climate change (in 2007)

Which factors affect formal climate change 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

Climate change dataset = Earth + other science teachers
= 292 responses, 25 variables

Which factors affect formal climate change

instruction?

^ = same finding as in Evolution sample

* = $p < .05$

red = less likely

** = $p < .01$

blue = more likely

	no trend	trend present
district/ school [^]	any region of Colorado urban/ rural/ suburban % free/reduced lunch district size school size	higher revenue per pupil
teacher	gender [^] # years teaching [^] # subjects taught [^] religion [^]	main subject: Earth vs. other science ** life science: middle vs. high school ** [^] democrat vs. other political affiliation
experience		more scientific views of GW ** [^] more GW learning experiences ** [^] more encouragement * [^] more discouragement [^]

Preliminary unpublished data. Please contact Sarah Wise at sarah.wise@colorado.edu

If you are interested in sharing/ reporting these data.

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

<http://www.colbertnation.com/the-colbert-report-videos/370862/january-12-2011/bernard-henri-levy-pt--1>

start after camera view switches ~1:00

Stephen Colbert and Ken Miller

June 16, 2008

Jan 12, 2006

<http://www.colbertnation.com/the-colbert-report-videos/173859/june-16-2008/kenneth-miller>

“welfare queens”

<http://www.colbertnation.com/the-colbert-report-videos/181409/january-12-2006/kenneth-miller>

“Steve Martin Theory of Evolution”

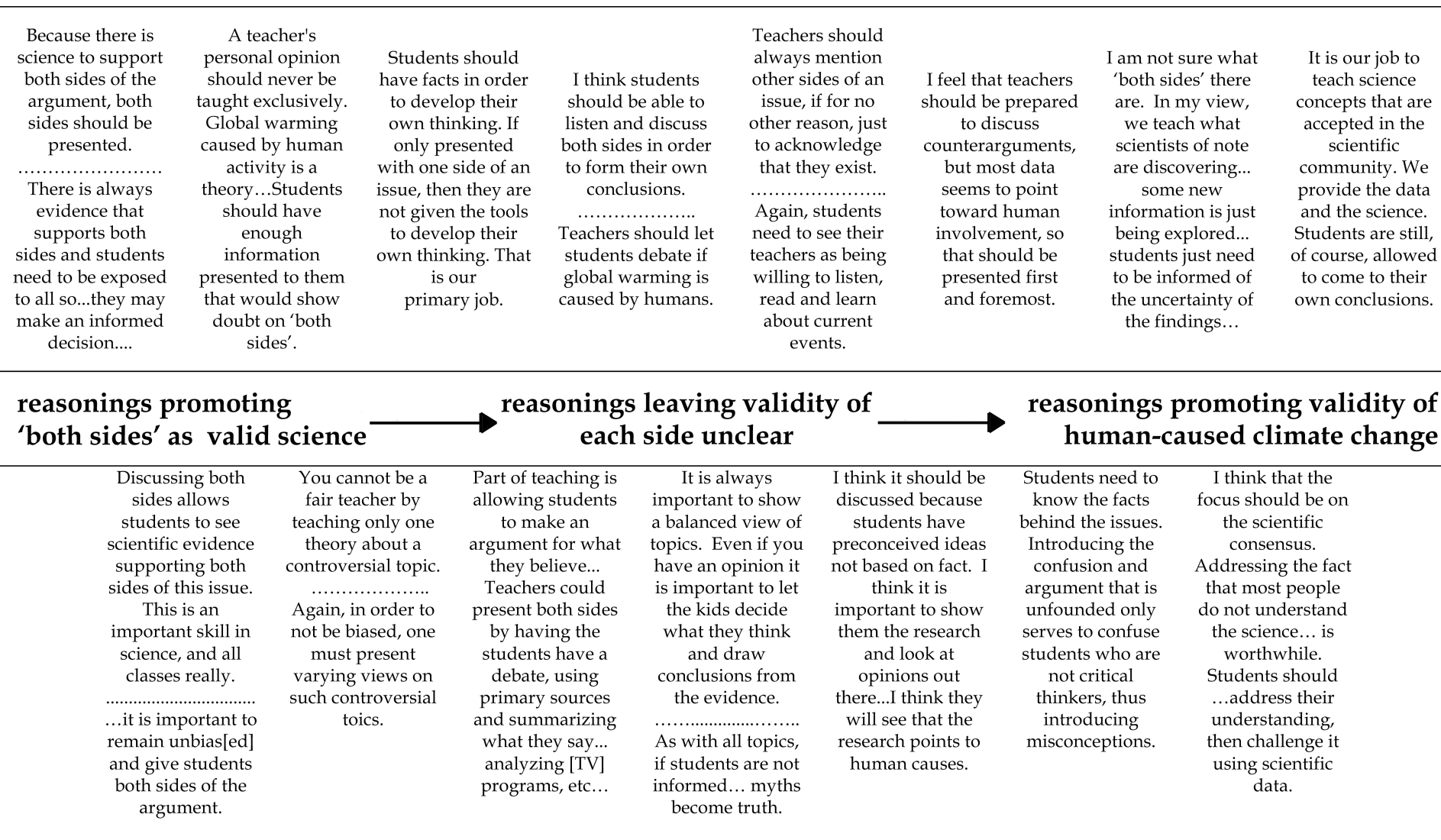
at the college level

- 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).



Sample Items: Conceptual Inventory of Natural Selection (CINS)¹

Canary Island Lizards



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 (Thorpe & Brown, 1989). 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?
- The lizards cooperate to find food and share what they find.
 - The lizards fight for the available food and the strongest lizards kill the weaker ones.
 - Genetic changes that would allow lizards to eat new food sources are likely to be induced.
 - The lizards least 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 . . .
- be indistinguishable, since there is a lot of interbreeding in isolated populations.
 - be the same on the inside but display differences in their external features.
 - be similar, yet have some significant differences in their internal and external features.
 - 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"?

	Lizard A	Lizard B	Lizard C	Lizard D
Body length	20 cm	12 cm	10 cm	15 cm
Offspring surviving to adulthood	19	28	22	26
Age at death	4 years	5 years	4 years	6 years
Comments	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

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

Sample items: Greenhouse Effect Concept Inventory (GECI)²

- 4) Which of the following is a primary characteristic of greenhouse gases?
- They can destroy certain molecules in the atmosphere.
 - They bend and magnify sunlight entering the atmosphere.
 - They can trap certain molecules in the atmosphere.
 - They can bounce around more in the atmosphere.
 - They are transparent to some forms of energy but not all.
- 5) The greenhouse effect is a very _____ process probably caused by _____.
- recent ; burning of fossil fuels, industry, agriculture, and other human activities.
 - old ; plants that increase humidity and create conditions similar to those in a greenhouse found at a plant nursery.
 - recent ; depletion of the ozone layer which allows more ultraviolet sunlight to reach the Earth's surface.
 - old ; interactions between naturally occurring gases and various forms of energy in the atmosphere.
 - recent ; natural processes including volcanic emission and changes in solar activity.
- 8) Which one of the following is not a greenhouse gas?
- carbon dioxide (CO₂)
 - water vapor (H₂O)
 - methane (CH₄)
 - oxygen (O₂)
 - ozone (O₃)
- 9) Which of the following best describes the relationship between the greenhouse effect and global warming?
- The greenhouse effect and global warming are the same thing.
 - An increase in the greenhouse effect may be causing global warming.
 - Global warming may be causing an increase in the greenhouse effect.
 - The greenhouse effect and global warming are likely unrelated.
 - There is no definite proof that either the greenhouse effect or global warming exist.

- Anderson, D. L, Fisher, K.M, and Norman, G.J. (2002). Journal of Research in Science Teaching. 29: 952-978. Downloadable .pdf found by internet search.
- 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)³






A	B	C	D	E
Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree

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)⁴

- 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?

Which of the following best represents your ideas about Earth's climate?

<p>Gradual</p>  <p>Earth's climate is slow to change. Global warming will gradually lead to dangerous effects.</p>	<p>Fragile</p>  <p>Earth's climate is delicately balanced. Small amounts of global warming will have abrupt and catastrophic effects.</p>
<p>Stable</p>  <p>Earth's climate is very stable. Global warming will have little to no effects.</p>	<p>Threshold</p>  <p>Earth's climate is stable within certain limits. If global warming is small, climate will return to a stable balance. If it is large, there will be dangerous effects.</p>
<p>Random</p>  <p>Earth's climate is random and unpredictable. We do not know what will happen.</p>	

Sample Items: Biology Colorado Learning and Attitudes about Science Survey (Bio-CLASS)⁵

15. To learn biology, I only need to memorize facts and definitions.
 Strongly Disagree 1 2 3 4 5 Strongly Agree
 not answered
16. Reasoning skills used to understand biology can be helpful to my everyday life.
 Strongly Disagree 1 2 3 4 5 Strongly Agree
 not answered
17. It is a valuable use of my time to study the fundamental experiments behind biological ideas.
 Strongly Disagree 1 2 3 4 5 Strongly Agree
 not answered

3. Rutledge, M.L. and Warden, M. 1999. School Science and Mathematics 99(1): 13-18. Survey available within publication. .

4. Leiserowitz, A.. Global Warming's 6 Americas 2007-2011. Reports containing survey questions at: <http://environment.yale.edu/climate/>
 Students can quiz themselves at: <http://apps.facebook.com/climatesurvey/>

5. Adams, W.K. et al. Multiple publications 2004-2009. Surveys and literature downloadable from: <http://www.colorado.edu/sei/class/>