TRESTLE Scholars Fall 2016
Final Report

Group Details:

Name: "Designing and facilitating group worthy activities"
Facilitator: Jenny Knight, MCDB
Group Members: Alex Jahn (ATOC), Becca Ciancanelli (SASC), Derek Brown (ATOC), Abbie Liel (CEAE), Nicole Lovenduski (ATOC), Julie Lundquist (ATOC), Melissa Nigro (ATOC), Cheryl Pinzone (EBIO).

Group structure: The group met every other week for 90 minutes. Participants read a relevant article in advance of the scheduled meeting. Each meeting spent 45 minutes discussing the article and relevant ideas, often with a short activity. Additionally, each participant signed up to lead the group through, and get feedback on, a group activity for their class. The second 45 minutes of the meeting was spent on this activity.

Meeting schedule:

TOPIC	PARTICIPANT ACTIVITY
8/23: Introductions, Personal and Group Goals, decisions about what we want to discuss, ice-breaker activities.	
9/6: How to establish, organize and manage groups in different settings	**Nikki:** Residence time and Talking climate
9/20: Different kinds of activities for group work; what works and why	**Alex:** CO2 and sea ice activity
10/4: Assessing effectiveness of group work	**Melissa:** Impact of phase changes on the temperature of the atmosphere
10/25: Implementation and Facilitation (clickers)	**Cheryl:** Cell cycle, Meiosis, Ploidy
11/1: Techniques for increasing buy-in and engagement	**Abbie**: Central limit theorem
11/15: Techniques for increasing buy-in and engagement	**Becca:** Metacognition activities
11/29: Group work in small vs. large classes (design and facilitation ideas)	**Julie**
12/6: Wrap up: reflect on individual goals, process of the FLC, what have you learned	

Reflections from Group Members

We found that discussing the concept of group work with each other was really useful. Our facilitator, Jenny Knight, provided us with useful readings to prepare us for each of our meetings. Jenny's expert knowledge on education research allowed her to locate readings that were both relevant and concise, which was extremely useful in our preparation. Occasionally, she also prepared summaries of various articles which facilitated discussions. By reading literature beforehand, we had time to ponder the concepts and prepare for the group discussion. The archive of these readings also provides a useful resource to refer back to when we attempt to implement these group activities in our classrooms.

Group discussions in our meetings allowed us to talk about teaching on a regular basis, especially across disciplines, which made us more intentional in our own teaching efforts. Through the organic nature of our conversations, people shared useful information about their own classes, providing everyone with tips and ideas that could be incorporated into their own teaching practices. We also felt that hearing about how other people implemented active learning activities and group work into their classes gave us the courage to try new teaching techniques. All in all, the frequent group discussions throughout the semester inspired and encouraged innovation in our individual classrooms, and made us more mindful of our pedagogical practices. It was also exciting to have a community for teaching, like we have communities for research.

We discussed many topics throughout the semester, but the two topics that resonated the most were the discussions on how groups should be formed, and the barriers and potential solutions to group work. Hearing from others about the strategies they employed when faced with these barriers was very useful. We debated how to encourage disengaged students and strategies to avoid having only one member of the group do most of the work. We also discussed the use of clickers many times, given that some of us teach large lectures and some of us teach small lectures. Hearing feedback from others about strategies that have been successful seemed to inspire many of us to try new techniques.

During our meetings, we took turns presenting active learning activities that we have used or plan to use in our own classes. During this time, the presenter would introduce the activity to the remaining members of the group, given us context in terms of what content had just been covered in class and the learning objectives involved in the activity. The group members then worked through the activity, and they provided the presenter with feedback and ideas on how to improve the activity. This type of exercise was an extremely valuable use of our time. As the presenter, it gave us feedback on areas where students might get lost, misinterpret the concept, need a visual, etc. As a member of the group, it allowed us to see what others were doing in their classrooms and helped us to identify ways to improve student learning in a group setting. In addition, actually doing the activities as part of the group was very helpful not only for remembering what it feels like to be a student, but also to remember how to appropriately scaffold the activity to support learning in a new area.

As was highlighted by sharing our active learning activities with the group, we feel that getting good constructive feedback on our teaching is extremely important. In future TRESTLE groups, it might be useful to have group members or the facilitator attend our lectures and provide feedback on the use and implementation of active learning activities in the classroom. Similar to our practice of sharing active learning activities with the group, this would benefit both the reviewer and the reviewee. Receiving honest teaching feedback that is not tied to promotion and tenure, but really targeted at providing constructive feedback to improve our teaching techniques, would be extremely valuable.

These informal active learning critiques would undoubtedly improve student engagement in our classrooms. In addition, the skills gained here will be ultimately disseminated throughout the larger teaching community via discourse in peer course reviews and faculty meetups. We feel that this is a wonderful ‘grassroots’ aspect of the TRESTLE small group teaching meetups.

In the future, it would be useful to discuss ways to develop group activities that make the best use of teaching and learning assistants in the classroom. Oftentimes, we develop activities with the students in mind, with little regard for how TAs and LAs will help to facilitate or implement these activities. Given the emphasis of the LA program on “learning how to teach”, discussions centered around their involvement in teaching would be useful.

We also discussed whether, in the future, TRESTLE could be a voice on campus to encourage more active learning facilities, as classrooms are largely designed for traditional lectures. Until more classrooms are adapted for active learning, it would also be beneficial to discuss how to implement active learning activities in sub-ideal large classroom environments, e.g., engaging people in the classroom balconies (and back rows).

The entire group expressed that a TRESTLE scholar’s group devoted to assessment would be valuable and likely well-attended. This group could focus on writing rubrics, and similar to this semester’s sharing of activities, group members could share their rubrics for various activities, to allow members to learn from each other and get feedback on their rubrics. When complemented with curated reading on the subject and guided discussions, this group would be very valuable. Other aspects to cover in such an assessment-focused scholar group would be to discuss how to write better multiple choice questions and how to best assess group projects. The FTEP workshops on these topic are helpful, but they don’t offer enough time to actually design a rubric or multiple choice exams, reflect on them, try it out, and get feedback. And finally, discussing how metacognition activities tied to assessment strategies can be used to enhance student learning would be useful.

Participant developed activities and reflections

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Alex Jahn

Alexandra Jahn – Arctic and Antarctic sea ice

Original Arctic and Antarctic sea ice activity

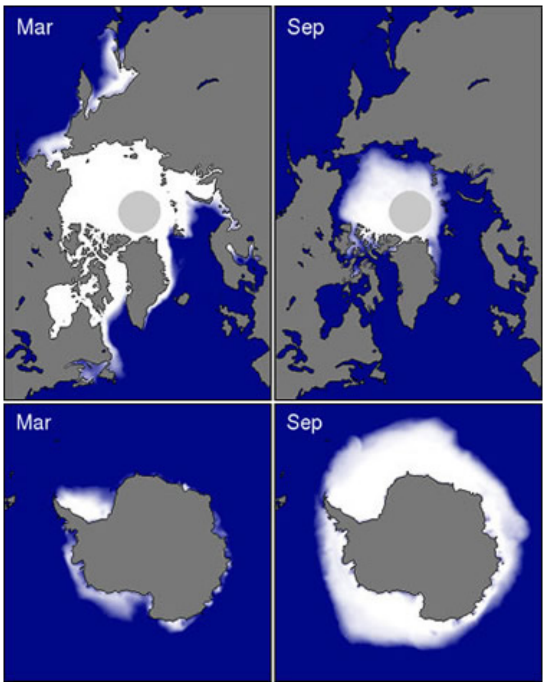


Figure 1: Arctic (top) and Antarctic (bottom) sea ice cover. White is ice covered, blue is ocean, grey is land.

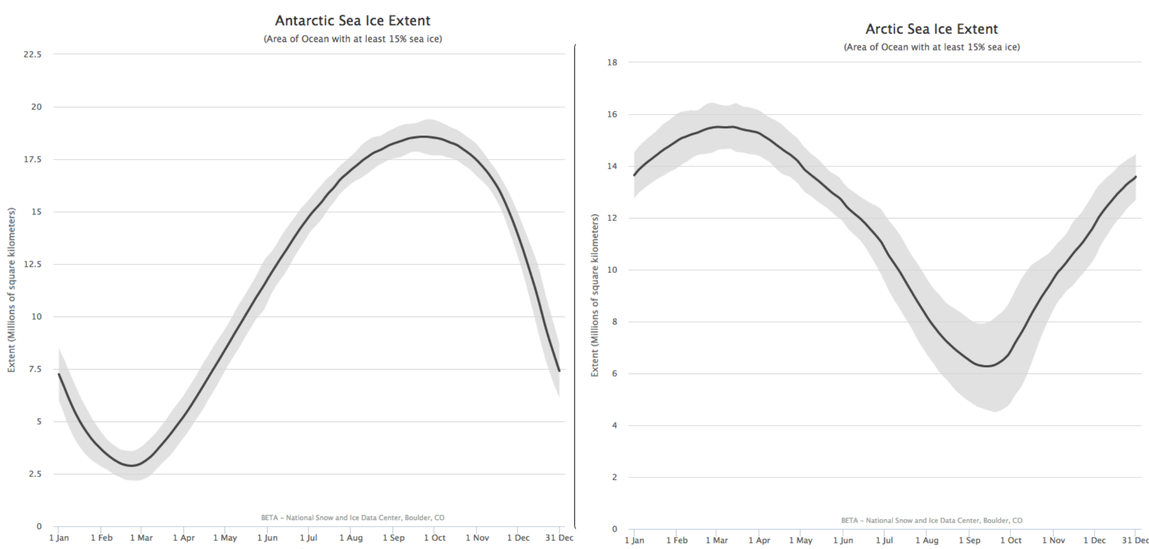


Figure 2: Seasonal cycle of the Arctic (left) and Antarctic (right) sea ice extent

In groups of 5, analyze the graphs and summarize what you see in each of them in one sentence. Come up with possible reasons why the Arctic and Antarctic sea ice cover looks different in the graphs.

1. Summaries:
    A. Figure1:

    B. Figure 2:

2. What are the differences between Arctic and Antarctic sea ice as shown in Figure 1 and 2? List at least 2 differences.
    A.

    B.

3. Come up with at least one possible reason why you see the differences listed in 2.

Revised Arctic and Antarctic sea ice activity

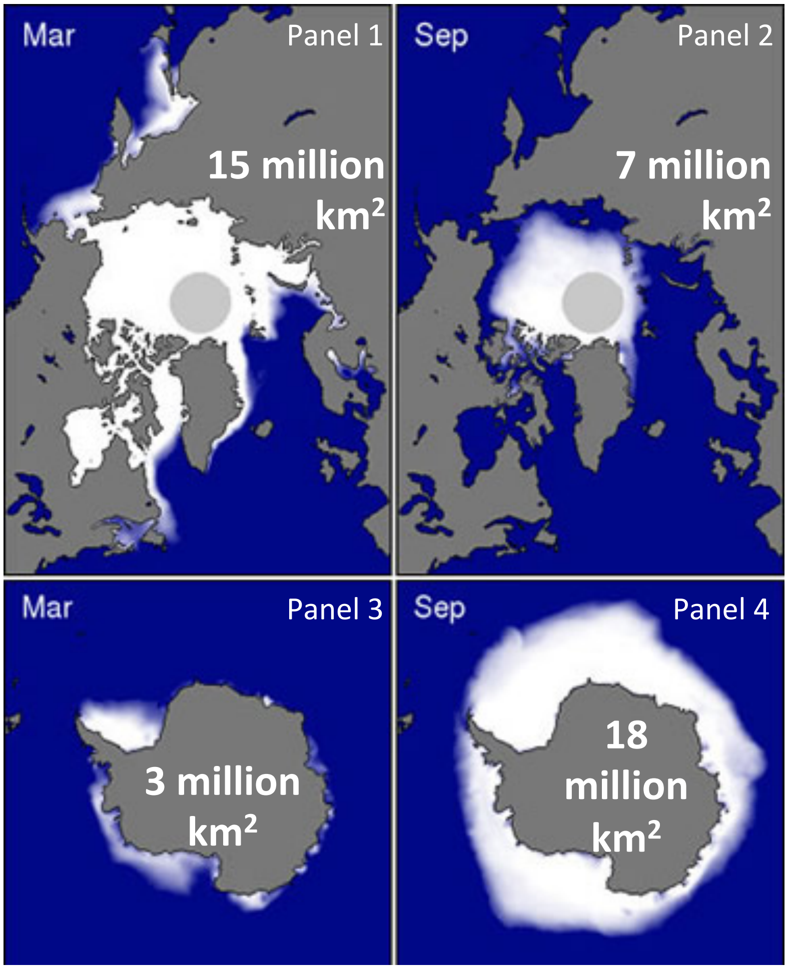


Figure 3: Climatological average Arctic (panel 1 & 2) and Antarctic (panel 3 & 4) sea ice cover in March and September. White areas are ice covered, blue areas are ocean, dark grey areas are land. The light grey circle around the North Pole in the Arctic plots shows the satellite coverage gap around the poles. Aircraft and ground observations show that this area is filled with ice in all months of the year. In white text over the continents, the average areal sea ice extent cover (in million km^2) that corresponds to these images is shown for each panel.

Q1: In groups of 4, summarize what you see in the four panels of Figure 1.

- Panel 1:

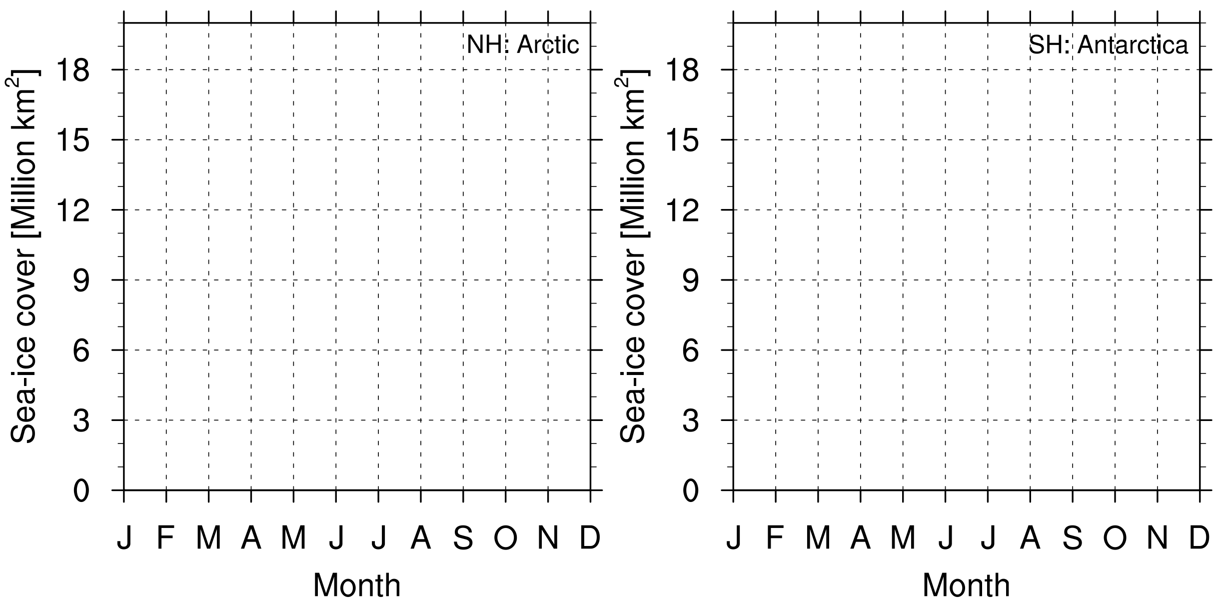
- Panel 2:

- Panel 3:

- Panel 4:

Q2a: Mark the amount of sea ice cover in March and September given in white text in each panel in Figure 1 in the blank chart provided below, for the Arctic (left blank plot) and Antarctic (right blank plot).

Q2b: Assuming these are the maximum and minimum seasonal sea ice cover values, connect the points in each graph with each other with curved lines, drawing the seasonal cycle of sea ice cover in the Arctic and Antarctic regions.



Q3: What are the differences between Arctic and Antarctic sea ice cover as shown in the graph above? List the 2 main differences.

A. ______________________________

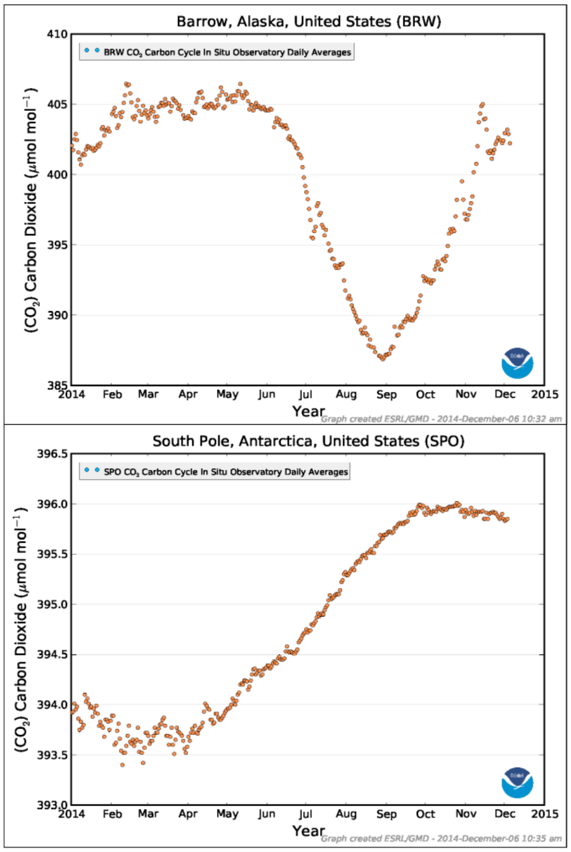
B. ______________________________

Q4: Hypothesize at least one possible reason why you see the two differences in Arctic and Antarctic sea ice cover that you listed in Q3.

A. ______________________________

B. ______________________________

Original CO_2 activity



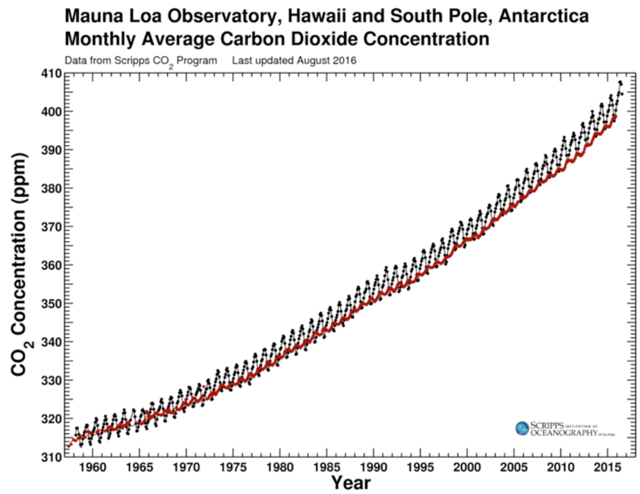


Figure 4: Observed Atmospheric CO2 concentration over time, from Mauna Loa (Hawaii, black) and South Pole (Antarctica, red)

Figure 1: Seasonal cycle of CO2 at Barrow, Alaska, and South Pole, Antarctica

In groups of 5, analyze the provided graphs and write short answers to the following questions:

1. Describe what you see in Figure 1. In particular, describe how the seasonal evolution of CO_2 is different in Barrow, Alaska, from the South Pole, Antarctica, and what they have in common.

2. Hypothesize why you see the differences described in 1)

3. Describe what you see in Figure 2. In particular, describe the change over time at the two stations, and how they differ from each other as well as what they have in common.

4. Hypothesize why you see the differences and commonalities described in 3)

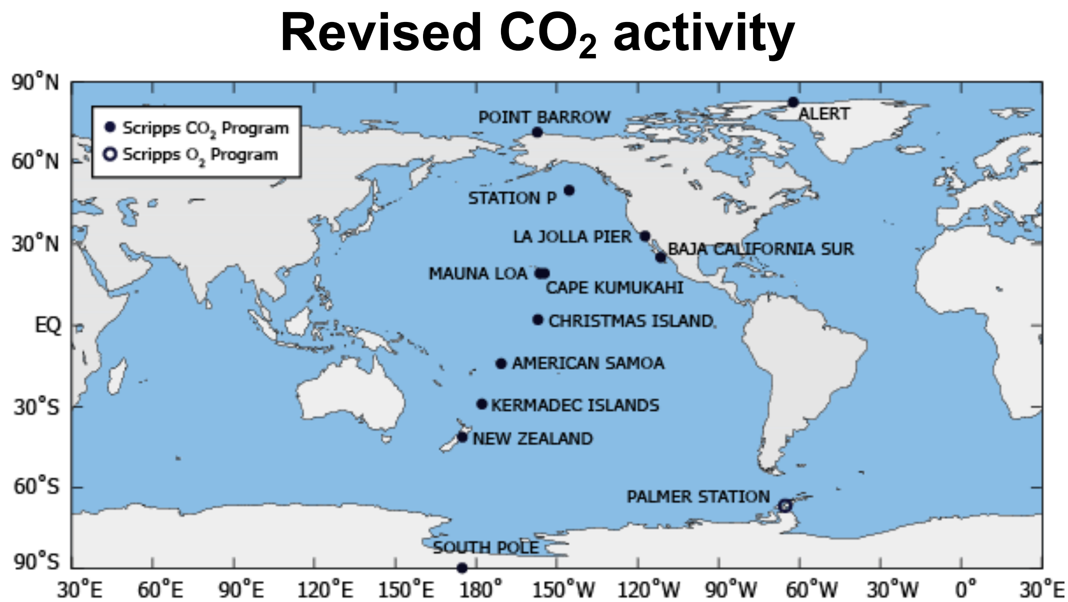


Figure 5: Stations where Atmospheric CO2 concentrations are measured continuously worldwide.

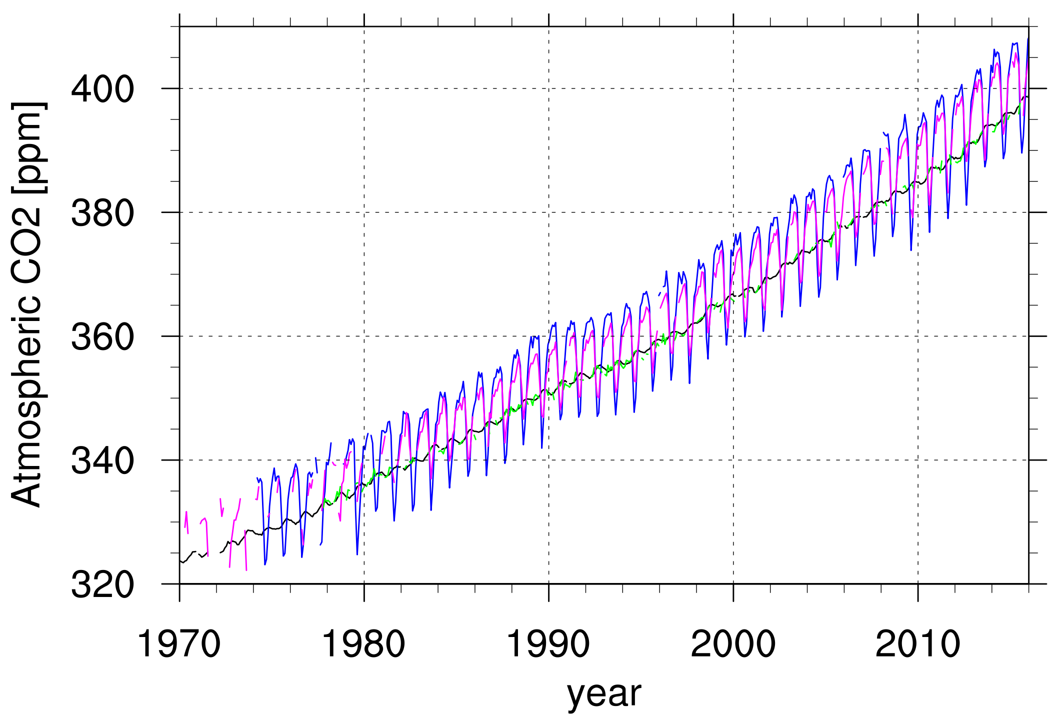


Figure 6: Observed atmospheric CO2 concentration in ppm at four different stations over time.

Blue: Point Barrow, Alaska; Pink: La Jolla Pier, California; Green: New Zealand; Black: South Pole

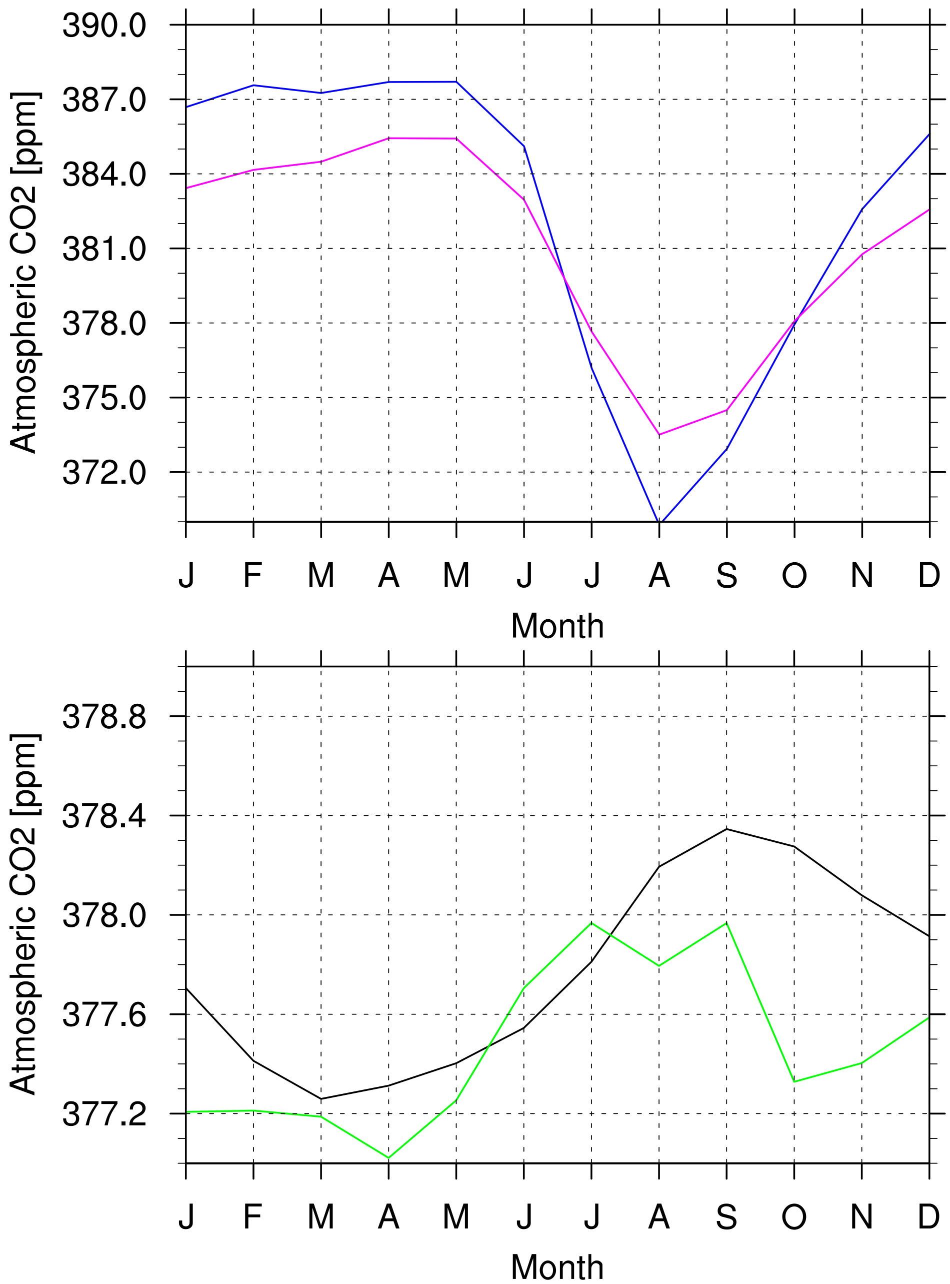


Figure 7 Observed seasonal cycle of Atmospheric CO2, averaged over the period 1996-2015, at different stations. Note the different scale of the y-axis on the two seasonal cycle plots.

Blue: Point Barrow, Alaska; Pink: La Jolla Pier, California; Green: New Zealand; Black: South Pole

In groups of 4, write short answers to the following questions using the provided graphs:

5. Circle the four stations that are plotted in Figure 2 on the map in Figure 1.

6. Describe what you see in Figure 2. In particular, describe the <u>change over time</u> at the four different stations, and <u>how they differ from each other</u> as well as <u>what they have in common.</u>

7. Describe what you see in Figure 3. In particular, describe the <u>differences and commonalities</u> between the two stations in the first panel (Point Barrow, Alaska, and La Jolla Pier, CA) compared to the two stations in the second panel (South Pole, Antarctica and New Zealand).

8. Hypothesize why you see the commonalities between stations you described in 2.

9. Hypothesize why you see the differences between stations you described in 3.

Alex Jahn – Reflection

Reflection on class activities reviewed in TRESTLE meeting

I designed two activities for use in a non-science major introduction to climate change class for freshmen (ATOC1060). One was focused on the seasonal cycle of sea ice in the two polar regions, with the goal of having students recognize that 1) the sea ice cover changes with the seasons and 2) that seasons are opposite on the two hemispheres. The second activity focused on the seasonal versus long term changes of atmospheric CO2, with the goal of the students recognizing that CO2 changes on seasonal and multi-year time scales, leading the discussion in class of the different reasons why CO2 changes on these timescales (seasonal plant respiration versus anthropogenic CO2 emissions, with respiration stronger on the NH than the SH, as there is more land and more plants on the NH), and how it is corrected with temperature on the long timescale but not the seasonal time scale. I also gathered feedback on how to best involve graduate students in deriving equations in the physical oceanography class I am teaching this semester.

Sea ice activity

The main feedback for this activity was to restructure the activity so that the students actually draw the seasonal cycle of the sea ice cover, based on the satellite images, rather than giving them the seasonal cycle graphs. Thinking about how to implement that change, I concluded that this activity would either need to be qualitative, as they can't read of the numbers of area coverage from the images, or better, I would need to provide sea ice area in the images, so they can plot the 4 points shown in the graphs and draw lines around that. I decided to provide them with the numbers in the images so they can plot actual "data", and can see difference sin the sea ice area between the two polar regions quantitatively. Another main point was to add the learning objective to the activity. Other feedback for the activity was to revise question 1, as it asked for too much and had overlap with Question 3. I changed this accordingly. Also, the feedback alerted me to the fact that I need to explain why there is a grey circle in the white sea ice cover in the Arctic (satellite data gap around the North Pole).

The feedback was very useful and easy to implement and I think it made the activity much stronger and useful. I have revised the activity accordingly and the original and revised activity are included. I will try it in the spring 2017 ATOC1060 class in the recitations.

CO2 activity

The main feedback for this activity was to re-draw the graphs, to ensure that the sites for the seasonal versus long term changes were the same and to remove "wiggles" from the seasonal cycle (caused by forest fires) by showing the climatological seasonal cycle, to remove detractors. The other feedback was that it might be too much to expect students to come up with the different reasons for the two changes, plant respiration versus anthropogenic CO2 emissions. I have revised the activity, by replotting the CO2 data and revising the questions. As the students will do this activity in recitations, I hope that with the LA and TAs help they will be able to contrast that all stations have a common increase in time in common, due to CO_2 emissions, but that they differ in their season cycle. Whether they will be able to come up with the correct hypothesis for the cause of the seasonal cycle remains to be seen, and I will adapt the activity based on feedback once I try it this semester in ATOC1060 in the recitations.

Deriving equations in graduate classes

In my graduate level Physical Oceanography class, I have to derive a lot of equations, and I wanted to see if my current way of doing it could be improved. Currently, I derived a lot of equations on PowerPoint slides, step by step. But sometimes I ask students to do steps on the three in-class white board, working in groups, giving them instructions on the technique they should use. This has worked quite well so far, but I wanted to see what else I could do. The feedback that the TRESTLE members provided was that this is a good way to do it. In addition, they shared the suggestion to show students steps 1 and 4 of a derivation, and have them fill-in (back-generate, knowing the solution in step 4) steps 2-3 in groups. The other idea was to do a jigsaw, where groups of students work on different parts of the problem, and to bring them back together afterwards to share their solution with members of a different group. I haven't tried these suggestions yet, but will consider them for next fall. I have found that just by telling students that next it will be their turn to do this derivation, they pay more attention and ask more questions about the derivations I do, as they know it might be their turn next.

Abbie Liel

Liel – Fatigue Failure activity

This activity is intended for the first class period. In the first part of the class, students will break paperclips by bending them back and forth, counting how many times they have to bend their paperclip to break it (i.e. cycles until fatigue failure is reached). These examples are intended to illustrate the concepts of randomness (aleatory) and epistemic uncertainties. Then, we will do this example.

………

First, answer these two questions on your own in about 3 minutes:

1. What is your best estimate of the surface area of the inside of this classroom in ft^2?

2. What is your upper bound estimate? Here, think of the upper bound as the largest value you could reasonably estimate with the available information. What is your lower bound estimate?

Next, compare your answers with the members of your group.

3. Do you agree? Why or why not?

4. What steps would you take to improve your estimate and reach consensus among your group?

5. What are the differences between this example and the previous example (breaking of paper clips)?

Liel – Central Limit activity

Before this time, we will have introduced a number of probability models, including the normal (Gaussian) distribution, and discussed how to solve problems with these distributions.

OBJECTIVE:

……

The Central Limit Theorem

1. Roll your dice once.
   a. Describe the random variable.

   b. What are the possible outcomes of the random variable?

   c. What do you expect the probability mass function (PMF) for X to look like? Sketch below. Be sure to label your axes.

   d. What probability model can be used to represent this random variable?

   e. Work with your group to plot the PMF of X for your dice rolls in the spreadsheet provided. Be sure that as a group you have 20 data points with each dice roll recorded as a separate entry.

2. Roll your dice four times and add the results. This random variable is Z.
   a. Work with your group to plot the PMF of Z for your dice rolls in the spreadsheet provided. So that you have enough data points, each member of your group should obtain three results (i.e. roll it four times, sum the results, and then repeat this process twice), and record it as a separate entry.

   b. What probability model appears to be appropriate for this data set?

3. The Central Limit Theorem states that the distribution of a random variable X = X1 +X2 +… Xn, which is the sum of underlying random variables X1, X2 …, Xn, will be normally distributed as the number of variables in the sum becomes large.

   a. In our experiment, what is the distribution of X1, X2, etc.? What is the distribution of X? Does the distribution of X appear to depends on the distribution of X1, etc?

   b. With your group, come up with at least two examples of random variables that can be assumed to be normally distributed on the basis of the Central Limit Theorem. Hint: We are looking for a variable that is inherently the sum of other random variables.

   c. With your group, what is an example of a random variable of interest in civil engineering that can be considered as a sum of random variables, and is therefore known to be normally distributed? Explain.

Abbie Liel – Reflection

I presented two activities for our required undergraduate probability and statistics course in civil engineering. This course enrolls juniors, and there are typically about 100 students in the course.

The first activity is designed for the first day of class and intends to introduce students to the idea of epistemic, as opposed to aleatory or randomness, sources of uncertainty. The questions posed in my initial draft were:

> "First, answer these two questions on your own in about 3 minutes:
> 1. What is your best estimate of the surface area of the inside of this classroom in ft^2?
> 2. What is your upper bound estimate? What is your lower bound estimate?
>
> Next, compare your answers with the members of your group.
> 3. Do you agree? Why or why not?
> 4. What steps would you take to improve your estimate and reach consensus among your group?"

Feedback from the TRESTLE group indicated that the overall idea was working, but the group made some suggestions on details. On question 2 (above), there was some debate about what was meant by upper bound and lower bound. The group also thought an additional question was needed at the end to sum up the differences between an earlier example in the same class (focusing on randomness) and this example (focusing on epistemic uncertainties).

The revised set of questions now reads:

> "First, answer these two questions on your own in about 3 minutes:
> 1. What is your best estimate of the surface area of the inside of this classroom in ft^2?
> 2. What is your upper bound estimate? Here, think of the upper bound as the largest value you could reasonably estimate with the available information. What is your lower bound estimate?
>
> Next, compare your answers with the members of your group.
> 3. Do you agree? Why or why not?
> 4. What steps would you take to improve your estimate and reach consensus among your group?
> 5. What are the differences between this example and the previous example (breaking of paper clips)? <To be asked in a clicker question: Can our uncertainty in the number of cycles required to break a paper clip be reduced by more careful measurement?>"

The second example was intended for a class on the normal (Gaussian) distribution and, specifically, to illustrate the concept of the central limit theory (CLT). The CLT states that a sum of n random variables will be normally distributed under many conditions as n becomes large. There is no requirement on the distribution of the underlying random variables, i.e. they can be non-normal.

This activity involves rolling a dice. In the first round, each participant rolls the dice once, and records their result. When combined with the results of their group, the results show that the dice rolls are approximately uniformly distributed: 1 is equally likely as 2 or 3, etc. Given the small group size 3-4, the worksheet suggests that each individually roll the dice 3-4 times to get more than 10 data points. In the second round, each participant rolls the dice twice, and adds their two dice rolls before recording their result. In the third round, each participant rolls the dice four times, adding the outcome from all four dice rolls and recording the result. When combined with the dice rolls from other group members, the participants can observe that the distribution is much closer to normally distributed than uniformly distributed, i.e. the Central Limit Theorem is at work.

The TRESTLE group made a number of suggestions for this activity. First, the group suggested a number of editorial changes. In addition, the TRESTLE group suggested that there weren't enough data points in each round (e.g. part 1e) so the the activity now asks each group to come up with 20 data points for each round. There was some discussion in the group about how many rounds are needed. In general, the team felt that the second round was probably not needed.

The group also thought that the link from the example from the dice rolling part of the activity to other examples, and particularly civil engineering examples, needed more work. There is now a question about examples of the central limit theorem in everyday life that tries to lead the participants to thinking about civil engineering distributions.

Becca Ciancanelli

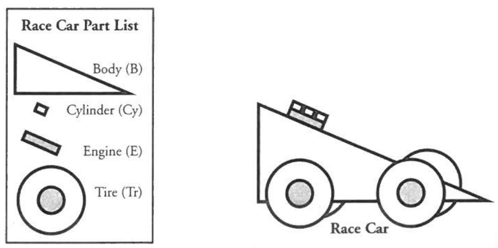
Ciancanelli – Reagents activity

Limiting and Excess Reagents

Learning objectives

You should be able to explain the difference between a limiting reactant and an excess reagent.
You should be able to describe how to determine the amount of product formed based on the amount of reactants.

Model 1 – Assembling a Race Car



1. How many of each part are needed to construct one complete race car?

2. How many of each part would be needed to construct 3 complete race cars?

3. Assuming that you have 15 cylinders and an unlimited supply of the remaining parts, how many complete race cars can you make?

4. How many of each remaining part would you need, for question #3?

5. Count the number of each Race Car part in your packet.

6. Build as many cars as you can. How many can you make?

7. What do you have leftover?

8. What parts are limiting how many cars that you can make?

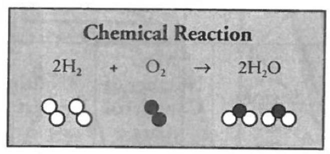
9. Complete the chart below. The first line shows the work that you just did! Get initials from another group's spokesperson when you are done.

Container	Bodies	Cylinders	Tires	Engines	Max number of completed cars	Limiting part
A	3	10	9	2	2	Engines
B	50	12	50	5		
C	16	16	16	16		
D	4	9	16	6		
E	20	36	40	24		

Initials __________

Model 2 – Assembling water molecules

$2 H_2 + O_2 \rightarrow 2H_2O$



10. Using the images for hydrogen and oxygen molecules in Model 2, draw a representation of the chemical reaction shown for the formation of water.

11. How many water molecules are produced if one molecule of oxygen completely reacts?

12. How many hydrogen molecules are needed to react with one molecule of oxygen?

13. Look at the parts that you were given. Build oxygen and hydrogen molecules. How many do you have?

14. Now take those apart and build water molecules. How many do you have?

15. Which reactant limited the production of water molecules?

16. How many molecules did not react?

17. Complete the chart below. The first line shows the work that you just did, except using mole ratios instead of molecule ratios! Get initials from a facilitator you are done.

Container	Moles of hydrogen	Moles of oxygen	Max. Moles of water produced	Limiting Reactant	Excess Reactant
Q	7	3	6	O_2	1 mol H_2
R	8	3			
S	10	5			
T	5	5			
U	8	6			

Initials _________

Ciancanelli – Activity Reflection

I brought an activity to share with the faculty scholars group that was designed for a small chemistry lecture course. The course is Introductory Chemistry, CHEM 1021, and the lecture is reserved for students in the Student Academic Success Center programs. These students are low income, first generation and/or underrepresented students at CU. There are 20 students in the course this semester, and they participate in group activities twice a week

The activity that I shared involved discussion regarding limiting reagents in chemical reactions. I explained to the group that students often struggle with this concept, so they can easily memorize how to solve the problems. I had designed an activity that involved hands-on manipulation of car parts (and how the parts can limit how many cars that you can make) and model kits (how the number of reactant molecules can limit how many product molecules that you can make), hoping that they would transfer the knowledge from one activity to another. After the students played with the physical manipulatives, they were asked to complete a chart shown below:

Container	Bodies	Cylinders	Tires	Engines	Max number of completed cars	Limiting part
A	3	10	9	2		
B	50	12	50	5		
C	16	16	16	16		
D	4	9	16	6		
E	20	36	40	24		

The group enjoyed the hands-on part of the activity but they did not think that transfer would happen, since the ratio of car parts to assembled car wasn't very similar to the ratio of reactant molecules to product molecules. They also noticed that there were multiple limiting reagents in the car part activity which may be confusing to students. A suggestion was made that I could create a physical analogy that had the same ratios and would therefore seem more similar to the chemical reaction activity. Lastly, they did not believe that completing the charts would be as helpful as having the students reflect more on the concepts involved.

Modifications will be made to this activity next year in the following ways:

- I plan to take out the car part analogy and replace it with something that has the same ratio as the chemical reaction. Stephanie suggested using the sandwich analogy from the PhET simulation.
- I will remove the charts from the activity and add in critical thinking questions such as having the students describe what is happening in the chemical reaction in terms of bonds breaking and bonds being made.
- I will finish the activity with having the students design their own questions regarding a new reaction.

Cheryl Pinzone

Pinzone – Meiosis activity

Week 9 - Meiosis - In-class **Name:__________________**

1. What is the difference between a genotype and a phenotype?

2. What are the differences between alleles, genes, chromosomes, and genomes?

3. What is the overall purpose of meiosis?

4. In what types of organism(s) does meiosis occur? What type of cell division occurs in bacteria?

5. What are two hypotheses for why sexual reproduction exists (vs. asexual reproduction)?

Week 9 - Meiosis - In-class 2 **Name:__________________**

____

____

Have you ever seen someone with more than 5 fingers or toes? Polydactyly is a disorder that causes extra appendages during development. It is cause by a dominant autosomal gene, and affects 1 in 500 people in the United States.

Hemophilia is a genetic disorder where the body has a decreased ability to make blood clots. The inability to stop bleeding is caused by an X-linked recessive gene. It affects about 1 in 5,000 people.

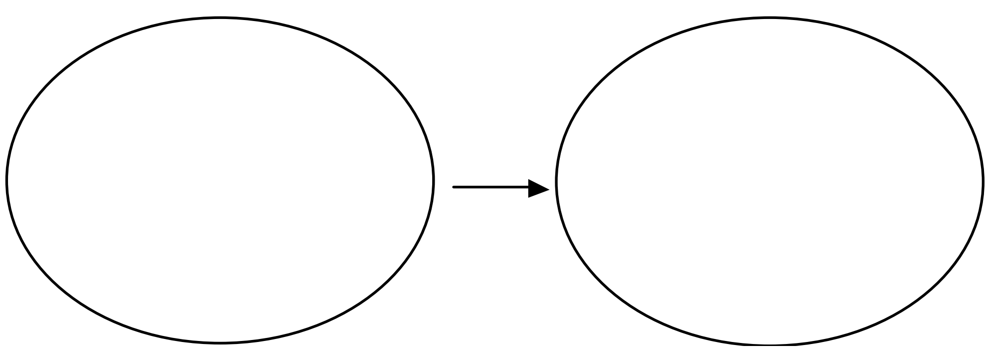
Sally wants to have a baby, but she is concerned about the chances of whether it will be healthy. She has 6 toes, and both her mother was a hemophilia carrier and her father had hemophilia (but Sally does not have the disease).

1. What is Sally's genotype for these two disease loci?

2. Draw Sally's parental body cells in the Growth stages 1 and 2.

- ✓ **Label the homologs (maternal or paternal) for the autosomal chromosomes and sex chromosomes, and draw the alleles for the disease loci on these chromosomes.**

Parental Cell G1 Phase **S Phase** **Parental Cell G2 Phase**

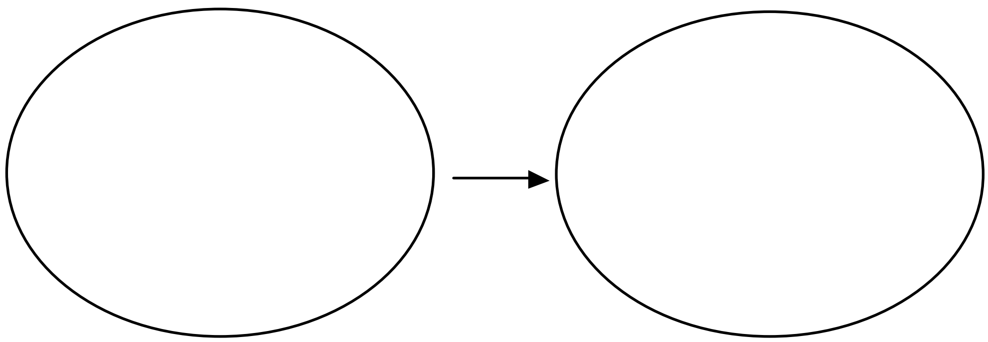


2. Draw the stages of meiosis that Sally's cells went under to create her eggs.

- ✓ **For each cell, label at least one structure that is important at that stage.**

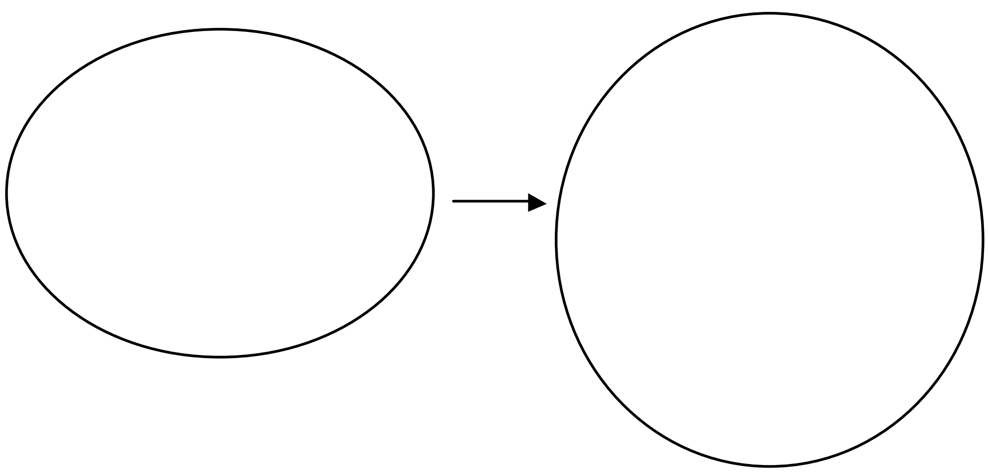
A. ***Meiosis I***

Early Prophase I **Late Prophase I**

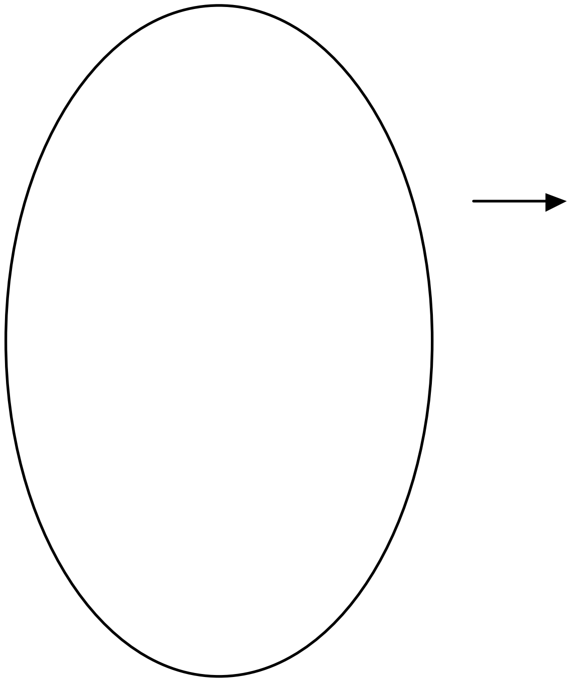


B.

Metaphase I **Anaphase I**

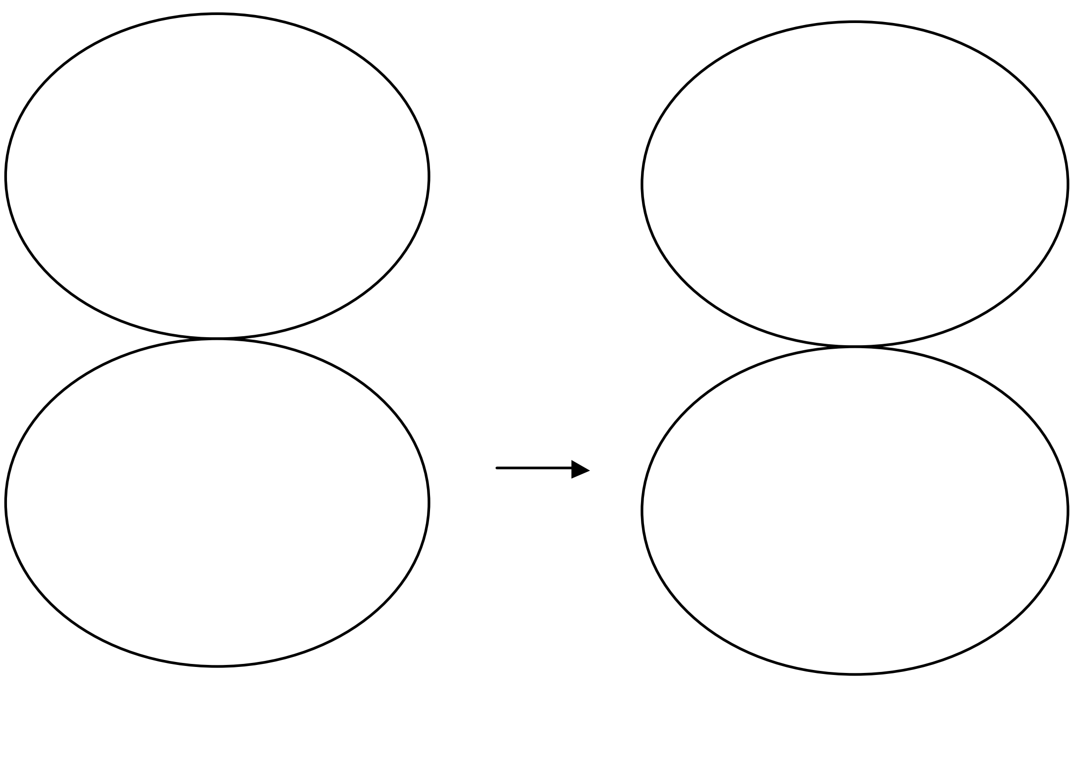


C. **Telophase I** **Cytokinesis completion**

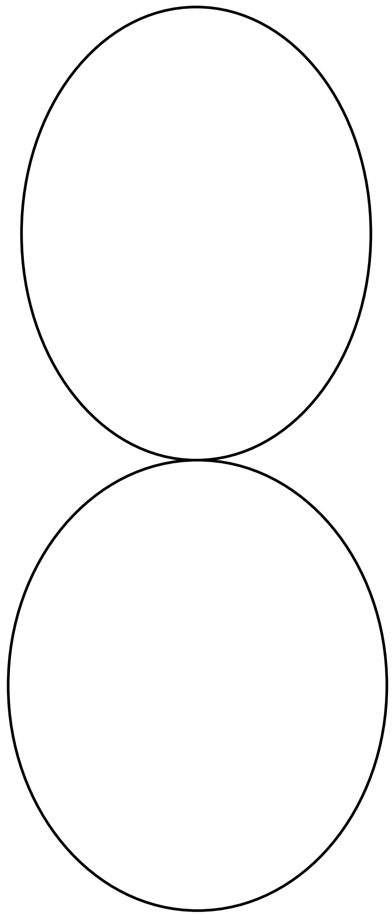


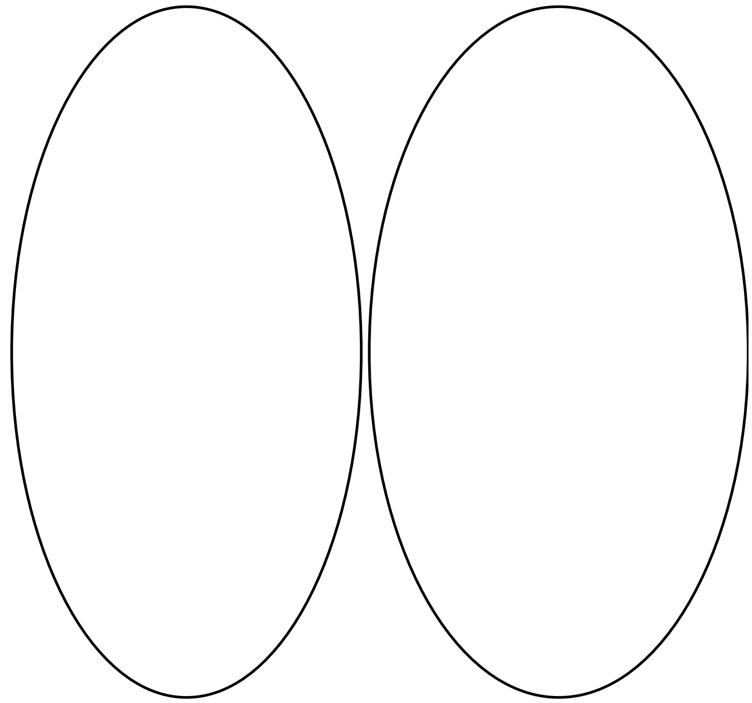
D. ***Meiosis II***

Prophase II **Metaphase II**



E. **Anaphase II** **Telophase II**





F. Draw the products of cytokinesis from Meiosis II below:

3. If she has a child with a normal (non-polydactyl, non-hemophilic/non-carrier) male, what are the chances she will have a healthy/normal child?

Derek Brown

Derek Brown – Paleoclimate activity

Here is one (compressed) original in-class activity that I used in this class this semester. They had roughly 30 minutes to complete this exercise.

ATOC 3600: Principles of Climate

Exercise 3 – Paleoclimate Reconstruction

We know the isotopic composition for the present day water cycle and Antarctica snow. Here, you will calculate the isotopic composition for Antarctic conditions that are 10ºC colder than today. Using this calculated difference, we can then estimate the temperature of Antarctica during the Last Glacial Maximum. (**NOTE: Keep at least 4 significant figures in calculations…such as the entered values in the table do**)

Isotopes 101: Let's consider normal water➔ H_2O and deuterium➔ HDO. The deuterium has a hydrogen atom with an extra neutron. This makes HDO a bit heavier than normal H_2O, which makes it a bit harder to evaporate/sublimate HDO vs. H_2O and also makes it a bit easier to condense/deposit HDO vs. H_2O. Thus, one gets fractionations (changes in the ratios of heavy to light water) when going from liquid or snow to vapor or vice versa. We use the variable *R* to represent the ratio of HDO molecules to H_2O molecules in air, water, or snow. R=[HDO]/[H_2O]

1) Compute the isotopic ratio of vapor over the subtropical ocean assuming an isotopic fractionation of α = 1.016 occurs during oceanic evaporation. Do not worry about the '$*10^{-3}$' unit in the table, but understand that these ratios are very small in reality. Use the following fractionation equation, and also fill in table below.2pts

$$R_{sub\_vapor} = R_{ocean} / \alpha$$

2) Let's assume this vapor rises to some height in the subtropics, becomes saturated, and then heads towards cold Antarctica, which is going to force more and more water to condense out en route. If the saturated air over the subtropical ocean has an air temperature of 15°C and the moisture in this air is continually forced to condense en route to Antarctica (at -35°C), one can compute the fraction of water that remains once it arrives in Antarctica. Since the saturation vapor pressure is 18 hPa at 15°C and 1.2 hPa at -35°C, the fraction *F* = 1.2 hPa/18 hPa = 0.067 gives you the fraction of vapor remaining. If we repeat this experiment but we now assume Antarctica is 10ºC colder (subtropical temps stay the same),

what fraction of vapor remains now? (Saturation vapor pressure is 0.56 hPa at -45°C.) (show your work and fill in table below…2pts)

F=____________________

3) Calculate the isotopic ratio of the water vapor arriving in Antarctica. Again, α = 1.016 (Calculate exponent first, raise *F* to exponent, *then* multiply by *R)* Show your work and fill in table…2pts). R_{ant_vapor}. will be the ratio of the Antarctic vapor.

$$R_{ant\_vapor} = R_{sub\_vapor} F^{(\alpha-1)}$$

4) Calculate the isotopic ratio of the Antarctic snow that forms from this vapor. Hint: one may rearrange the equation from (1) to get the appropriate fractionation you'd see going from vapor to snow (roughly the same as going from vapor to liquid). Remember that the HDO is easier to condense than the H_2O…so your R_{snow} should be higher than the R_{ant_vapor} from which it formed. (Show your work and fill in table…2pts).

5) Convert the answer from (4) into a "delta" value in units of *permil* (parts per thousand). Essentially this will give you the level of isotopic depletion in Antarctic snow compared to some standard (i.e., the average isotopic ratio in seawater). Your number should come out negative (depleted). 2pts

$$\delta = \left[\frac{R_{snow}}{R_{ocean}} - 1\right] * 1000$$

(**Make sure to fill in the table with your values!)**

	R_{ocean} (*10^{-3})	R_{sub_vapor} (*10^{-3})	F	R_{ant_vapor} (*10^{-3})	R_{snow} (*10^{-3})	δ_{snow} (permil)
Today's Climate	2.005	1.973	0.067	1.890	1.920	-42.3
10ºC colder	2.005					

6) You can now view from the table the change in isotopic composition (Δδ) expected if the Antarctic temperature was 10ºC colder than today (ΔT=-10ºC). Use this to calculate the change in Antarctic temperature expected for a 1 permil change in isotopic composition of snow. (Be careful with signs, and make sure your sign aligns with what you generally know about how this process works)

ΔT/Δδ = °C/permil (2pts)

7) The δ of snow during the Last Glacial Maximum (LGM) seen in Antarctic ice cores ➔ $\Delta\delta$ = 6.7 permil ***lower*** than today. How many degrees Celsius *colder* was it during the LGM when compared with today?

ΔT= ____________°C (2pts)

Derek Brown – Reflection

I did not share an activity with the TRESTLE group this semester, however I learned quite a few things from participating in the evolution of other's exercises at our meetings. Since I run ATOC's weather laboratory, I have plenty of experience designing and implementing hands-on activities for small groups (up to 24 students) with a 2 hour window. What I struggle with most, however, is designing and implementing creative and engaging classroom activities for my larger classes of 40 (Desert Meteorology & Weather and Climate Analysis), 100 (1000 level climate and 3000 climate), and 300 students (1000 level weather) with shorter 1 hour windows and with limited in-class help. Here I will focus on applying what I have learned to an exercise that I use in my mid-level climate course of 100 students. In reality, I'd expect 75 students to show up any given day when there is a low-stakes (worth ~1% of their final grade) in-class exercise happening. Many of the choices below represent a balance between what is optimal given the tenets of TRESTLE and what is possible given the large class size, single TA, and general time constraints.

You can see that this exercise is mostly a plug and chug situation, with some explanations about how heavy isotopes of hydrogen are preferentially removed from the subtropics to the poles during condensation en route. The overall point to the exercise is recognizing that there is simply more condensation that occurs from the subtropics to the poles on a cold polar year, and thus more heavy isotopes are removed from the moisture along the way. Thus, cold polar year have less heavy isotopes to fall into the polar snowpack, and this is how scientists infer ancient polar temperatures from the isotopic composition of each layer within the ice cores.

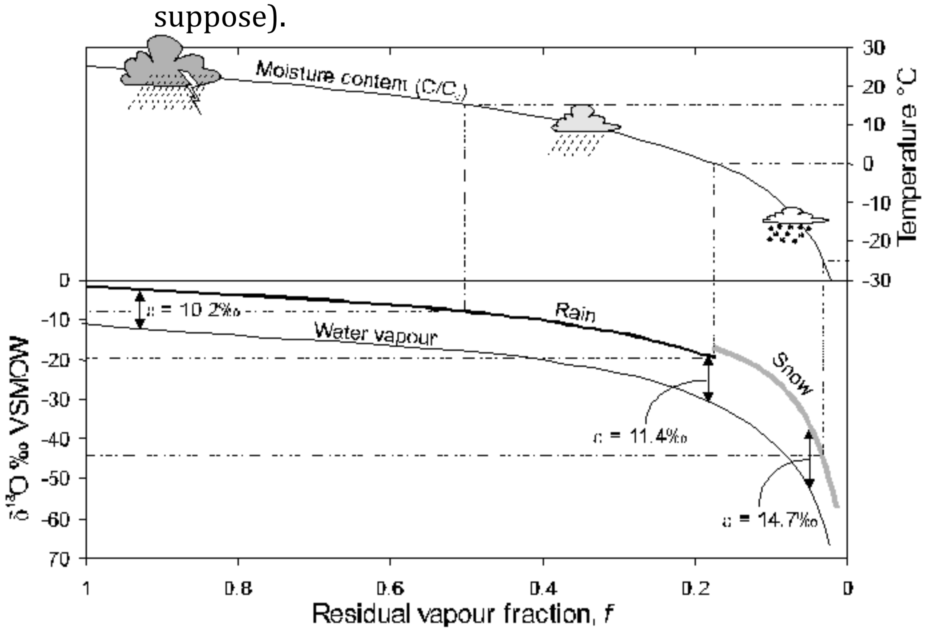
That general point is made currently in lecture, but I propose to expand this activity to teach that somewhat simple point using a hands-on component. I can thus cut some lecture time out. I would like to retain the quantitative component at the end, which shows pretty well what a change in isotopic composition means for a change in temperature (i.e., the precise calibration).

Below are some TRESTLE ideas and my proposed solutions for this exercise.

- Group choice
    - TRESTLE input: We have learned generally that a group should not be larger than say 5 people. We've also learned that group dynamics work best when the instructor chooses the group (or at least when the groups aren't formed simply from close friends) and when those students have distinct roles.
    - My solution: Use D2L groups to randomly select groups and have emails sent with group number, roles, and seating chart. This saves critical in-class time for the exercise. My roles for this particular exercise would be something like 'Demo. Expert(2)', 'Equation solver (1)', 'Graphical Interpreter(1)', & 'Synthesizer(1)'. This will leave me with 15 groups of 5, for me and one TA to handle. *Note that I'm considering requesting 2 LAs for this course should it become a permanent rotation on my schedule.*
- Hands-on
    - TRESTLE input: We have learned that students generally benefit from having a hands-on experience. They retain more of what they have learned this way. All of the activities presented at our meetings had a hands-on component, whether is was marked marbles, Styrofoam balls, student drawings, or whatnot.
    - My solution: Use bags of marbles (a mix of white & black) to illustrate both fractional decreases in moisture amounts via condensation effects, as well as isotopic fractionation effects en route to the poles. I would choose to combine these concepts with the hands on demo. Simply introduce the concept that each marble represents a gas-phase water molecule, with the white marbles being 'normal' water (H_2O^{16}) and black marbles being 'heavy' water (either HDO or H_2O^{18}). You start off in the subtropics with some set ratio of black to white marbles (representing airborne moisture). As your bag travels poleward, it encounters cold temperatures that force the gas to condense into liquid (i.e., rain-out into the sea). For every condensation step on a normal year (perhaps there are 2 steps from subtropics to poles on normal year), you lose three gas-phase molecules (two blacks and one white). On a cold year, you have more steps (3 or 4), since cold air can't 'hold' as much vapor, which means you lose more marbles in general en route and specifically you lose a higher percentage of black marbles (the heavy isotope). Your ratio of what's left in the bag vs. what you started with is your fraction of vapor left. Your ratio of black to white marbles at the end is your isotopic ratio of Antarctic vapor (which the snow will be formed from…involving one more arbitrary fractionation) . The ratio of black to white marbles you lost into the ocean is important, since you'll find more black marbles were dumped into the ocean on a cold year, which means the

biology picks this up and we can infer temps in marine organic sediments this way as well. You could also start from a very large bag of marbles (representing the ocean and its 'delta' value) that the students choose from to start their demo. You can then ask questions about isotopic effects on the ocean's delta regional delta values from oceanic evaporation, etc. In general, the hands on component could be done in a variety of ways, but time constraints might make the simplest scenario attractive (simply lose more black marbles than whites along subtropical to polar path). Luckily, we have 2 demo. experts per group for this task.

- Graphical analysis
  - TRESTLE input: Using, or creating, graphs is one type of hands-on activity and can increase student engagement Most of the activities presented in our meetings involved using graphical analysis to some degree.
  - My solution: ATOC coursework is loaded with graphs, thus its important that the students work with them as much as possible. In problem 3, I present an equation for Rayleigh distillation but the student don't have a sense of where it comes from exactly, its limits, or what this equation would look like on a graph. The precise derivation of this is a little sticky for this level and given the time constraint here, and I'd have to give that some more thought before I could represent it easily. Essentially, the loss of more black marbles vs. white from A to B on cold years was Rayleigh distillation anyways. I could, however, add a graph of what Rayleigh distillation looks like here, and ask some simple interpretation questions. An example is below from U of Ottawa. There are many questions to ask here, and a challenge would be resolve this obvious exponential relationship with the linear relationship that the simple marble experiment showed (simply modify the marble experiment I suppose).



  - I would likely create a similar, yet more simple, graph for analysis and have the student plot some of their table values along the graph. I'd aim to bring this whole thing back to the exponential relationship of saturation vapor pressure and temperature (something called the Clausius-Clapeyron relationship). This would be an important tie to humidity work that we do earlier in the semester. A broader question here is "since the ratio change is far more sensitive near the poles than in the subtropics (see graph), what are the ice cores really telling us about past temperatures?". This of course ties with the original assumption with the marbles…that we assume we start with the same ratio in the subtropics in both the cold and warm scenarios. The action happens in the poles. The 'Graphical Interpreter' would be responsible for this section (on in charge at least). The 'Equation Solver' would be responsible for the formation of relevant equations in the exercise (perhaps they form a delta value given some conceptual ideas of what that is, and rearrange the other simple equations to solve some problems).

- Learning Goals
    - TRESTLE input: We've learned that in-class activities are useful and engaging, but they are even better if they serve to fill one of your original learning goals. In other words, just having students be active isn't enough. They hopefully will be learning critical thinking techniques by engaging in said activity
    - My solution: There are a variety of closing questions that I could ask from this exercise that would give them some ideas of the uncertainties involved in these polar calibrations. One common one that I talk about in class is Antarctic vs. Greenland ice cores. We assumed in our activity that the source of vapor (the subtropics) was constant. But how would our results change if the source vapor changed year to year….some years local with less condensation history and some years remote with more condensation history? The answer is that this would also change the ice core's ratios and therefore our perceived ancient temps. We could go on to describe the periodic glacial advances in N America, and how they build mtns of ice that deflect vapor from Greenland. The students can then think of how these ice mtns may have influenced Greenland's source vapor and ice cores. The 'Synthesizer' group member would articulate this part.

- Conclusion
    - TRESTLE has given me an opportunity to have a real good think about how I can do better in my classroom. Watching the evolution of my peer's exercises has given me insight into how I can improve this exercise and all my exercises in general. It has clearly been a positive experience for me.

Nicole Lovenduski

Lovenduski – Residence time activity

ATOC 1060
Week 7 Recitation Worksheet
Residence Time

Part 1: Get into small groups and do the "residence time" experiment with a bag of marbles. Don't peek into your bag! Each bag contains marbles of two different colors. Each marble has a unique identifier, usually a letter or number (for example, one red marble marked "B", one white marble marked "F", one white marble marked "D", etc.)

- Nominate 1 person to be in charge of the marble bag. This is the only person in your group who is allowed to look inside the bag.
- Nominate 1 person to record on paper which marbles are pulled out of the bag at every turn.
- The rest of the group members will decide when they're ready to make a prediction and then guess at the concentration of colors in the bag.

Running the experiment:

- The goal of the experiment is to correctly guess how many of each color marble is in your bag (for example: 3 red marbles and 3 blue marbles) by collecting information on the probability.
- The person in charge of the marble bag looks inside and pulls out two marbles: one marble from each color.
- The recorder writes down information about each colored marble (for example, the identifying letter)
- The person in charge of the marble bag puts the two marbles back into the bag, shakes it up, reaches inside and pulls out two marbles: one marble from each color.
- The recorder writes down the information, and the process repeats until the group is ready to make a prediction.

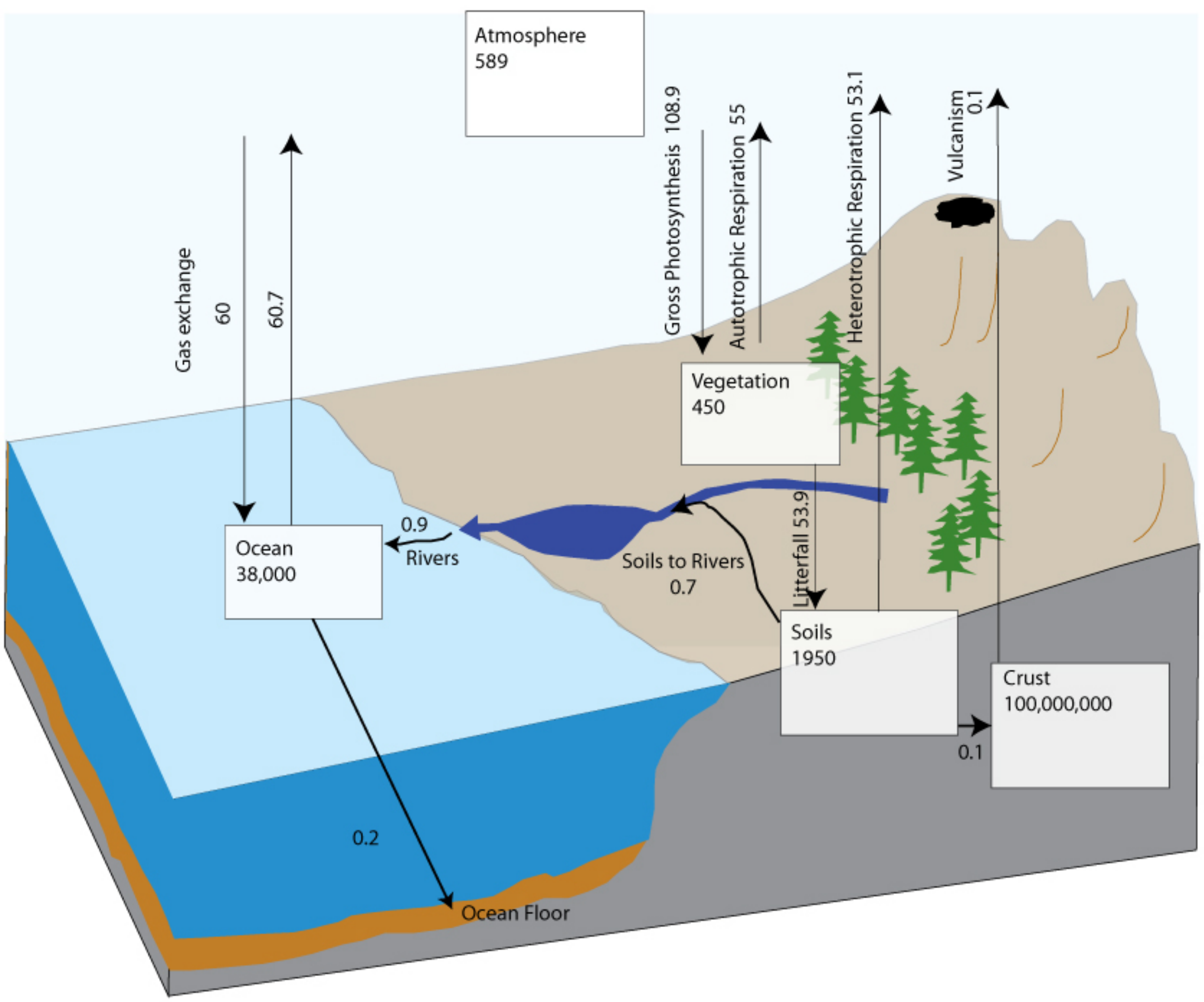
1) From your selections, what do you think the ratio of the two colors is in your bag?
2) Look into your bag – was your prediction correct?
3) If the bag represents the reservoir, was the reservoir in steady state with respect to the two different colors of marbles?
4) The average length of time that a marble of one color spends in the bag is equivalent to the residence time of that color in the bag. How does this relate to the concentration?

Part 2: CU Boulder student statistics: Consider that CU Boulder admitted 6,208 undergraduate students in 2015. 3,290 of these admitted students were in-state students. Assume that the number of undergraduate students (as well as the number of in-state undergraduate students) is in steady state.

5) If the total number of undergraduate students at CU Boulder is 25,864, what is the residence time of a typical undergraduate student?
6) If the total number of in-state undergraduate students at CU Boulder is 15,746, what is the residence time of a typical in-state undergraduate student?
7) What is the residence time of a typical out-of-state undergraduate student at CU Boulder? Compare your answer with part (6). Why do you think they are different?

Part 3: Consider the global carbon cycle before humans perturbed it in the Figure below. Reservoirs (boxes) have units of Petagrams of Carbon (1 Pg = 1×10^{15} g); fluxes between reservoirs (arrows) have units of Pg C / yr.

8) Are all five reservoirs of carbon in steady state? How do you know?
9) Calculate the residence time of carbon in each of the 5 reservoirs. Based on your calculation, where would you want to store carbon so as to most effectively prevent it from reaching the atmosphere for long periods of time?



Lovenduski – Talking Climate activity

ATOC 1060
Week 12 Recitation
Talking Climate

We've all talked to someone about global warming before, and some of us have had debates with people who don't think global warming is real or that it's caused by humans. Now that we've been presented with key pieces of scientific evidence on global warming, your task today is to refute or support the claims made by people about global warming. The next time you get in a taxi and your taxi driver says "I don't believe that global warming stuff because…." – you'll know exactly how to respond!

Get into small groups and await your "talking climate cards" from the instructor. For each card, nominate 1 person to read the card to the group and write down your group's reply. Nominate 1 person to get their laptop/tablet/phone out and help search for evidence (you may find that the lecture notes and the skepticalscience website are good resources for this activity). Nominate 1 person to orally deliver your reply to the instructor when time is up. Other group members are expected to engage in the discussion and contribute to the group reply. Please switch/rotate roles for each card.

For each card, focus your discussion on the scientific evidence that is available to support or refute the claim.

Text on the cards:

I read a news article that said Antarctic sea ice is growing. So I guess global warming isn't happening, after all.

I lived through the dust bowl and I remember that 1934 was the hottest, driest year on record.

I know the globe is warming, but I doubt that the warming is caused by humans.

I heard on the news that global warming is just natural cycles.

Scientists barely agree on global warming, so I doubt it's happening.

It was really cold in Baltimore this winter, so I doubt global warming is happening.

Global warming is caused by sunspots.

Climate models are completely unreliable.

If they can't forecast the weather for tomorrow, how can they predict how warm the globe will get?

Climate change isn't necessarily a bad thing. Plants are growing better than ever in Canada.

I heard that the Earth was even warmer during the medieval period.

If global warming is happening, why hasn't the Earth warmed since 1998?

The temperature record is biased because of the urban heat island effect.

Climate has changed before, you know.

Animals and plants can easily adapt to global warming.

Lovenduski – Reflection

I presented two activities for the ATOC 1000-level introduction to climate class. This class enrolls mostly non-science majors in a lecture setting, and this semester, my section had an associated recitation (max 25 students) attached to lecture (max 100 students) each week.

The first recitation activity was designed for Week 7 of class, when the lecture material introduces chemicals in reservoirs (e.g., carbon in the atmosphere) and describes the concept of "steady-state": when the concentration of the chemical in a reservoir does not change with time. In lecture, we further discuss how the residence time (average time that a molecule of chemical substance spends in a reservoir) is proportional to its concentration. In years past, students struggled to understand this relationship, and so I designed an activity that I hoped would improve their understanding. The final, revised version of the activity is attached below. The first iteration was improved by trial and discussion with the TRESTLE group in several ways:

1. At first, I used rounded marbles marked with markers, but during the TRESTLE trial, I learned that the marbles easily rolled off the tables and were lost, and that the marker rubbed off on everyone's hands. The final classroom activity had flat marbles that were marked with purple nail polish instead.
2. At first, I did not have explicit directions for the activity at the beginning of the worksheet, and the TRESTLE trial revealed that most people weren't listening to the orally-delivered instructions and needed to see them written on the worksheet.

3. The first iteration of the worksheet had only one follow-up question based on the marble activity, but the TRESTLE trial revealed that this question needed to be broken down into several smaller questions, to ensure that students grasped each concept in turn.
4. At first, the University of Colorado student residence time activity labeled students as "residents" or "non-residents" – The TRESTLE trial revealed this was confusing with the word "residence time", so the final version called students "in-state" and "out-of-state".

The second recitation activity was designed for Week 12 of the semester, when the lecture material describes the evidence for, and causes of, global warming. In lecture, students are presented with four key pieces of scientific evidence to support the idea that the globe is warming: global temperature increases, declining Arctic sea ice extent, land ice sheets losing mass, and sea level rise. They also see graphs showing the changing isotopic composition of carbon dioxide in the atmosphere -- scientific evidence to support the idea that the warming is caused by humans. The goal of this recitation activity is to give students practice talking to people about global warming, while using key pieces of scientific evidence to refute or support their claims. The final, revised activity is attached below. The first iteration was improved by trial and discussion with the TRESTLE group in several ways:

1. At first, students were presented with the talking climate cards and instructions were delivered orally. The TRESTLE trial revealed that I needed to write explicit instructions on the worksheet.
2. At first, students did not have specific roles in the group, but the TRESTLE group suggested that assigning roles would lead to more productive group discussion.
3. At first, the instructions were not specific about providing scientific evidence, and the TRESTLE group mentioned that the group discussion could easily get off track if not scientifically focused.
4. At first, some of the talking climate cards had statements that some in the TRESTLE group thought were too controversial (e.g. "Do you believe in global warming?"), and so these were removed from the cards and replaced with other statements.

Julie Lundquist

Lundquist Coriolis activity

You spin me right round, baby, right round
or
Why does the Coriolis force work the way it does?

In this group activity, we will work with a model of the Earth to evaluate velocities on our rotating planet and explore how changes in latitude affect the speed and direction of parcels moving in our atmosphere. This activity builds on an introduction that has distinguished between an inertial reference frame and a rotating reference frame. Students should have their own copy of this worksheet, but the team will work together with one Styrofoam ball.

1. Sketch an image of Earth as seen from the side, using a solid line to show the equator (latitude = 0 deg) and dotted lines to show lines of constant longitude (such as the International Date Line or the Prime Meridian). Compare your figure with those of your team.

2. After your team has agreed on latitude and longitude, on your team's Styrofoam ball, draw an equator (solid line), and eight other equally spaced lines of constant longitude (dotted lines).

3. Mark some "special" spots on your Styrofoam ball, such as Boulder (40 deg N latitude), somewhere with a latitude of 5 deg N, and somewhere with a latitude of 85 deg N. It's helpful if you mark all these points as having the same longitude. (FYI, Boulder's longitude is 105 deg W.) Mark the 5 deg N point as "A", the Boulder point "B", the 85 deg N point as "C".

4. Put a skewer on the south pole of your Earth so that you can rotate it on its skewer axis. Designate one team member as the "Sun", and then rotate your Earth so that the Sun "comes up" in New York before it comes up in Boulder and then Los Angeles (as it does in real life). What direction must the Earth be rotating on its axis (clockwise or counterclockwise) as you look down on the North Pole from "outer space", which we will call **the inertial reference frame**? Can your team agree on the answer?

5. We will consider how the velocities of points on the Earth vary with latitude due just to the Earth's rotation. Recall that **velocity is equal to distance divided by time**. With one team member rotating your earth one-quarter day (one quarter of the way around), have another team member hold markers to draw lines at 5 deg N (A), Boulder (B), and 85 deg N (C) showing how much distance is "covered" in six hours.
a. Are the distances the same at each of these three locations?
b. Why?
c. Given the relation between velocity, distance, and time, which of your three points (A, B, or C), is moving with the greatest tangential velocity from the perspective of your team in space (in the **inertial reference frame** outside of the Earth's rotating reference frame)?

6. Now imagine throwing a paper airplane from south to north starting at point A and moving to point B. Remember the paper airplane must conserve its velocity with respect to the **inertial reference** frame.
a. Is its east-west velocity faster at point A or at point B?
b. When the paper airplane has moved to point B, will the east-west component of the plane's motion (conserved from point A) be faster than the ground beneath it, slower than the ground beneath it, or at the same speed as the ground beneath it? Can your team agree on an answer?
c. If you were in the "cockpit" of the airplane, would you be moving towards your right or towards your left (as you were flying north from the equator)? How does this compare with the rotation of the Earth?

7. Now imagine your paper airplane is flying **south** from the equator towards the South Pole. It still must conserve its velocity with respect to the inertial reference frame. You might find it helpful to draw lines at 5 deg S, 40 deg S, and 85 deg S just as you did in the Northern Hemisphere.

a. Is its east-west velocity faster at 5 deg S, 40 deg S, or 85 deg S?

b. When the paper airplane has moved from 5 deg S to 40 deg S, will the east-west component of the plane's motion be faster than the ground beneath it, slower than the ground beneath it, or at the same speed as the ground beneath it? Can your team agree on an answer?

c. If you were in the "cockpit" of the airplane, would you be moving towards your right or towards your left (as you were flying **south** from the equator)? How does this compare with the rotation of the Earth as seen from the South Pole?

8. This apparent motion (as seen from the perspective of someone in the rotating reference frame on Earth or in the paper airplane) can be attributed to the "Coriolis force", an apparent force that results from the conservation of angular momentum in the **inertial** reference frame. From your answers to 7b and 8b above, how would you summarize the effects of the Coriolis force?

Lundquist reflection

I designed an active learning group project/worksheet to discuss with the TRESTLE group, focusing on a concept (angular momentum and the resulting Coriolis force) that is fundamental to all classes I teach, from a large 300-student introductory weather course, to a small upper-division undergraduate course, to a small first-year graduate course. I initially intended the activity for the small twenty-student graduate class I am currently teaching, but I realized through the design process that I could (should!) apply this activity to the undergraduate courses. With some modifications, it can apply to all of these courses. For the large undergraduate course, it may be best as an activity led by a Learning Assistant in a twenty-student recitation session. Materials are consumed by the project, so it is not inexpensive.

The concept of conservation of angular momentum is easily memorized and the "rule" that flow turns to the right in the Northern Hemisphere and to the left in the Southern Hemisphere is easily regurgitated, but a deeper intuitive and physical understanding of the process is of course more desirable. This hands-on activity is meant to help students develop that intuitive understanding of how objects at different latitudes on our rotating planet move at different speeds with our planet. I would follow the activity with a video from NOVA that addresses the same concept, using a demonstration involving a paper airplane similar to the one discussed in this activity.

The peer review of this activity was very helpful. I had inadvertently used some language ("lines of constant longitude") that borders on jargon for some student groups, and my peers made helpful suggestions, like "International Date Line", to help jog students' memories of the difference between latitude and longitude. They also identified problems in my guidance, like telling students when to label points, that I should just provide the equation relating distance, rate, and time, etc. I really appreciated the feedback about how helpful it was to play with a tactile object (the Earth as a small Styrofoam ball) and whether or not skewers (for the axis of rotation) were helpful (yes). We also had a fun discussion about how this activity could be extended for graduate students, which was great as my current graduate students were the ones I had in mind when starting to design this project initially!

Melissa Nigro

Melissa Nigro – latent heat activity

ORIGINAL

ATOC 1050-001 Learning Session #1 Worksheet Name:__________________

Phase Changes and Latent Heat

***The following is adapted from the "How can freezing make something warmer?" exercise from Little Shop of Physics at Colorado State University ***

Theory

You know that an ice cube will cool your drink. When the ice cube melts, it absorbs heat energy from its surroundings. Water molecules frozen in the form of ice are tightly bound. Water molecules in the form of liquid aren't. So to turn a solid into a liquid means breaking bonds, and that takes energy. As the ice melts, it cools off its surroundings.

Now, think about freezing. When you make ice cubes, you put liquid water in the freezer. The freezer cools the water, taking energy out. When water melts, it takes in energy; when it freezes, it must give off energy.

This taking in and giving off of energy is a very important process for the earth. Ice can melt in one place (taking in heat) flow to another place and freeze there (giving off heat). Not only has water moved from one place to another, so has the heat energy.

Doing the Experiment

SAFETY NOTICE: The contents of the packet aren't toxic; this is food-grade sodium acetate. But when the packet freezes, it will get hot. If it is hot enough to become uncomfortable, please set the package down. Additionally, it is a good idea to wash your hands after handling the packets. Please do not touch your eyes until after you have washed your hands.

1. Break into groups of 5 or 6 people. Each group should receive a heat package.
2. Observe the package.
    a. What phase is the substance inside the packet?

    b. Does it feel hot, cold, or room temperature?

3. Pop the disk inside the packet and observe what happens over the next few minutes.
    a. Did a phase change take place? If so, what is the phase of the substance inside the packet?

    b. Did the packet feel hot, cold, or room temperature after you popped the disk?

4. How would you relate this process to water in the atmosphere? What would be the beginning phase of the water? The ending phase of the water? And would this warm or cool the atmosphere?

Latent Heat

Phase changes of water (conversions between ice, liquid water, and water vapor) occur constantly in Earth's atmosphere. Heat is either released into the atmosphere (heating the air) or extracted from the atmosphere (cooling the air) during phase changes. In the exercises below insert the appropriate letters to indicate the correct phase change and whether the atmosphere would be heated or cooled as a result of the phase change.

	V (vapor) L (liquid) I (ice)		V (vapor) L (liquid) I (ice)		H (heating) C (cooling)	
1. During *evaporation:*	____________	converts to	____________	which leads to	____________	of the air.
2. During *melting:*	____________	converts to	____________	which leads to	____________	of the air.
3. During *condensation:*	____________	converts to	____________	which leads to	____________	of the air.
4. During *deposition:*	____________	converts to	____________	which leads to	____________	of the air.
5. During *sublimation:*	____________	converts to	____________	which leads to	____________	of the air.
6. During *freezing:*	____________	converts to	____________	which leads to	____________	of the air.

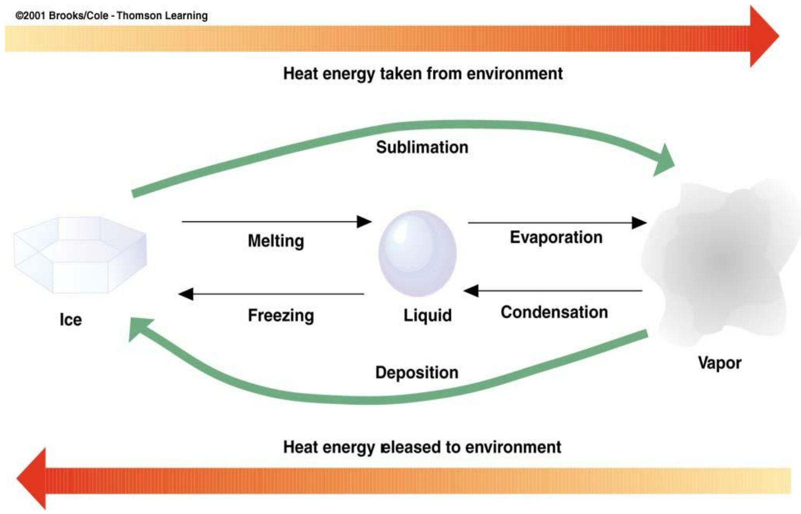
7. Which of the six processes listed above releases the largest amount of heat to the atmosphere?

8. Which of the six processes extracts the most heat from the atmosphere?

9. What types of particles are clouds composed of?

10. What phase changes can occur during cloud formation?

11. During cloud formation, do changes of phase warm or cool the surrounding atmosphere? Why?


©2001 Brooks/Cole - Thomson Learning
Heat energy taken from environment
Sublimation
Melting
Evaporation
Ice
Freezing
Liquid
Condensation
Vapor
Deposition
Heat energy released to environment

REVISED

ATOC 1050-001 Learning Session #1 Worksheet Name:__________________

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Theory

You know that an ice cube will cool your drink. When the ice cube melts, it absorbs heat energy from its surroundings. Water molecules frozen in the form of ice are tightly bound. Water molecules in the form of liquid aren't. So to turn a solid into a liquid means breaking bonds, and that takes energy. As the ice melts, it cools off its surroundings.

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Doing the Experiment

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1. Break into groups of 5 or 6 people. Each group should receive a heat package.
2. Observe the package.
    a. What phase is the substance inside the packet?

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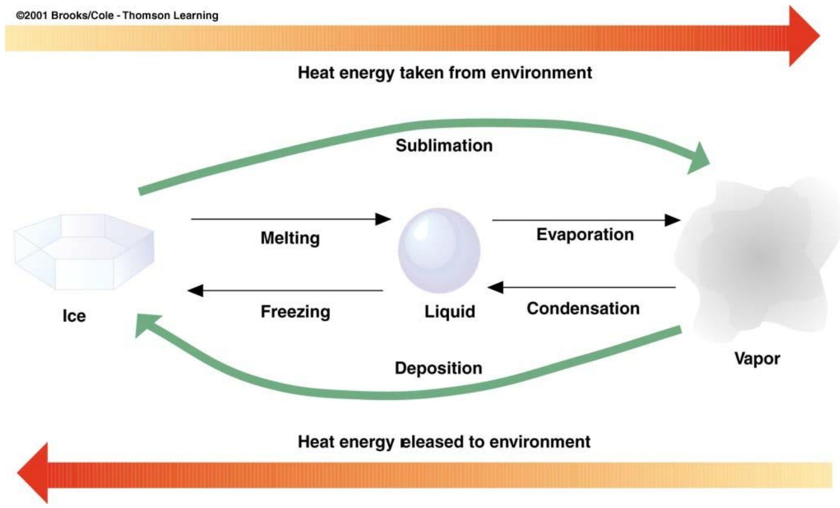
3. Pop the disk inside the packet and observe what happens over the next few minutes.
    a. Did a phase change take place? If so, what is the phase of the substance inside the packet?

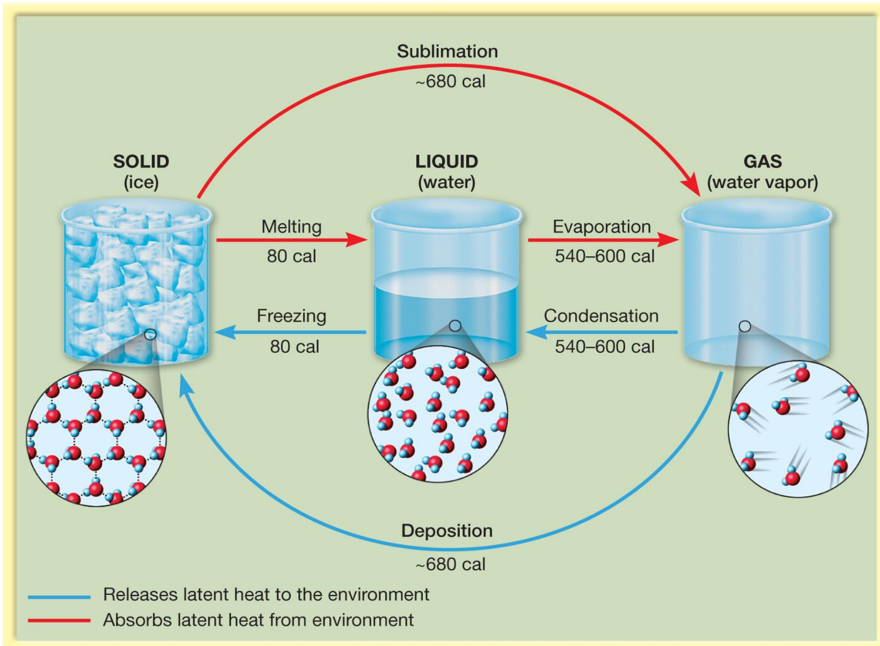


b. If a phase change took place, circle the phase change on the diagram above.

c. Did the packet release heat or absorb heat from the environment? Did this warm or cool the atmosphere in the classroom?

4. Using the information provided at the beginning of this worksheet, how would you relate this process to water in the atmosphere? What would be the beginning phase of the water? The ending phase of the water? And would this warm or cool the atmosphere?

5. These packets are reusable. I have to boil them to return them to a liquid phase. Is this consistent with what we have talked about?



Use the diagram above and the knowledge you have gained through this exercise to determine if each phase change warms or cools the environment. Label the diagram with your answers.

Latent Heat

Phase changes of water (conversions between ice, liquid water, and water vapor) occur constantly in Earth's atmosphere. Heat is either released into the atmosphere (heating the air) or extracted from the atmosphere (cooling the air) during phase changes. In the exercises below insert the appropriate letters to indicate the correct phase change and whether the atmosphere would be heated or cooled as a result of the phase change.

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10. What phase changes can occur during cloud formation?

11. During cloud formation, do changes of phase warm or cool the surrounding atmosphere? Why?

Melissa Nigro – Reflection

I designed an active learning activity to discuss with the TRESTLE group. The activity was designed for an 18-student Learning Session that is led by a Learning Assistant. The Learning Session is part of a large-lecture non-science major introductory Weather and the Atmosphere class. The activity uses sodium acetate heat packets to demonstrate how phase changes in the atmosphere can either warm or cool the atmosphere. This is a concept that students often struggle with and the intent is to provide them with a hands on activity to help them better understand the concept.

The original and revised activities are included above. The feedback from the TRESTLE group was very helpful. The group members identified ways to incorporate diagrams into the worksheet to better illustrate what was happening in the experiment. In question 3, a diagram was added for students to circle the phase change that takes place in the experiment. Question 3c was added to make sure the students are able to connect the temperature change of the heat packet with the impact the phase change had on the temperature of the atmosphere in the classroom. The TRESTLE group also suggest the addition of question 5, which asks the students to think about what happens when the phase change goes in reverse. Lastly, the final diagram of the worksheet was moved to page 2 and the students are asked to indicate if each phase change warms or cools the atmosphere. This is important, because the ability to identify if a given phase change warms or cools the atmosphere is the main goal of this exercise.