

# **UC Office of the President**

## **Bending the Curve: Climate Change Solutions**

### **Digital Textbook**

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CLIMATE CHANGE SOLUTIONS

LEARNING COMPANION

# BENDING THE CURVE

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## How to use the learning companion

*Bending the Curve: Climate Change Solutions* brings together leading experts from diverse areas of academia and research to address the multidimensional aspect of climate change. Given the interdisciplinary nature of this book, there will inevitably be concepts and details that are new and possibly challenging to any reader. The companion booklet provides reflective questions which can help organize your learning and help you apply what you read. No single technology or action will solve the problem of climate change. However, public communication and education can help promote a broad culture of climate action. Using the questions in this booklet can help you take action, and to collaborate with others as a learning community, focused on climate change solutions.

*Bending the Curve: Climate Change Solutions* is written for a broad audience. It can be used by instructors and students as a resource for classroom instruction and learning. It can be used by leaders and advocates as a resource for scientific data and broad understanding. It can be used by individuals who are already climate change solution champions interested in expanding their learning. It can be used by those who are new to the idea of identifying climate change solutions.

For Students/Learners: The *Bending the Curve: Climate Change Solutions* book provides engaging learning for students at all levels. The companion booklet helps you manage your own learning by providing review questions which allow you to check your own learning after reading each chapter. Review questions are presented in multiple-choice format and are designed to help you gauge how well you have grasped key concepts and information. Discussion questions are open-ended and designed to help you apply what you read to the world around you.

These questions are designed to promote deeper learning through conversation with your fellow students, or others outside the classroom.

For Instructors Facilitating a Class or Seminar: The *Bending the Curve: Climate Change Solutions* book covers a wide range of topics and disciplines of study. The contents of the companion booklet can help you facilitate learning at all levels, and in a variety of contexts. This resource provides you with questions which can guide classroom interaction and activity in subject areas like physical and atmospheric science, government and policy, economics, social communication and movements, transportation, and technology (and more). Discussion questions can be used to initiate dialogue between learners, or activities which apply ideas to familiar contexts.

For Readers Beyond the Classroom: You can use the review questions for each chapter to check your understanding of key concepts, and main points. You can use discussion questions to engage others in public communication about climate change solutions. We recognize that your own learning is a social process and that it is important to seek opportunities to discuss concepts in this book with others. This can help build community and support your own learning and growth. The discussion questions can be placed in a context relevant to you and your community, your social networks, and your world view. These questions can be a starting point for discussions that help create meaning through sharing of ideas.

This companion booklet uses two types of questions for each chapter. **Review Questions:** These questions can be used to test the reader's understanding of the chapter content and to ensure familiarity with key points, facts, and concepts. This also provides an opportunity to identify areas the reader may be unclear on, and to revisit the section for greater understanding.

**Discussion Questions:** These questions can be used to inspire deeper thinking, by connecting broad concepts of the chapter to real-world application. These questions may stimulate discussions in your classroom,

through your personal and professional contacts, or in almost any other social context.

Each author has developed the discussion questions in a way that promotes your own reflection and deeper thinking. Some of the discussion questions will include an answer (or example from the chapter author). Other discussion questions are left open-ended, allowing each reader to consider the question in the context of their own experience, feelings, attitudes and beliefs about the subject.

# Chapter 1: Climate Change

## Review Questions

1. Why is the current era called the Anthropocene?
  - a. Because humans are inhabiting the planet
  - b. Humans are changing only the climate
  - c. Humans have become a geologic force impacting every aspect of the planet's environment as well as its natural resources

**Answer:** C

2. How do some pollutant gases warm the planet?
  - a. By trapping the sun's heat
  - b. By trapping the infrared heat from the surface and atmosphere
  - c. By trapping the heat from the ozone layer

**Answer:** B

3. What are the major pollutant gases generated from human activities that are warming the planet?
  - a. Nitrogen and Oxygen
  - b. Carbon Dioxide, Water Vapor and Methane
  - c. Carbon Dioxide, Methane, Nitrous Oxide and CFCs

**Answer:** C (Note: Answer B also lists the major greenhouse warming gases but water vapor is natural. The question is asking for pollutant gases.)

4. Once emitted, how long does CO<sub>2</sub> stay in the atmosphere?
  - a. Decade to centuries to thousands of Years
  - b. One Year
  - c. 10 Years

**Answer:** A (Note: About 50% of what we emit today is taken by the

ocean and the land in less than a decade; The remaining 50% stays in the air for a century; and about 20% for thousands of years.)

5. What are the major natural factors that cause climate change?
  - a. Fires & volcanoes
  - b. Variations in ocean circulation
  - c. Variations in solar output & volcanoes
  - d. All of the above

**Answer:** D

6. How much have natural factors contributed to the observed warming?
  - a. About 20%
  - b. 100%
  - c. 0%

**Answer:** A

## Discussion Questions

1. How might the Great Acceleration have benefitted the natural world?
2. What are some super-pollutants that you might still see?
3. What are the 6 major human activities contributing to global warming?
4. How would you describe the difference between weather and climate and the role of both in climate change and global warming?
5. Climate change scientists have asserted for few decades without success, that climate change problem has to be solved before it is too late. Have they succeeded or failed? If your opinion is that they have failed to persuade the society, discuss why and what would you do differently?
6. The planet's climate has changed significantly in the past; why are the current and future changes cause of great concern and that we should try to solve this problem?



7. List the 6 major problems facing the world, ranking them by order of their importance. If climate change is NOT among the six, discuss what would it take to rank climate change among the top six.
8. Imagine you ran into your congressional representative, who is skeptical of climate change science; How will you use the knowledge gained in this lecture (along with the supporting materials) to persuade her otherwise? If you don't have good arguments to persuade her, what else would you want to know to develop a convincing case?

## Chapter 2: Humans, Nature, and the Quest for Climate Justice

### Review Questions

1. What is Terra Nullius?
  - a. A 17th century European explorer
  - b. Land that is empty or underutilized
  - c. Land that is too compromised, polluted or inaccessible to be useful to humans

**Answer:** B

2. “Adaptation” is:
  - a. the capacity to teach others how to reduce carbon emissions
  - b. the capacity to maintain one’s livelihood and health in face of changing environmental patterns.
  - c. the capacity to reduce carbon emissions

**Answer:** B

3. Which of the following statements are true?
  - a. Those who contribute least to greenhouse gas emissions are also least vulnerable to the negative impacts of climate change.
  - b. Those who contribute most to greenhouse gas emission bear primary responsibility for remediating the harms of climate change.
  - c. Both a and b are true

**Answer:** B

4. Climate Justice is concerned with remediating:
  - a. the intergenerational impacts of climate change
  - b. the intragenerational impacts of climate change
  - c. both

**Answer:** C

5. Major Climate Policy Frameworks:
- a. have been so successful that climate change is much less of a threat today
  - b. are well intended, but limited
  - c. are superior to other alternatives, especially those involving social movements

**Answer:** B

6. The Climate Justice Movement:
- a. is of marginal significance for achieving climate solutions
  - b. is a term that refers to the melting of glaciers
  - c. is important for addressing climate change

**Answer:** C

7. Social Inequality:
- a. is important but will have to be addressed after we solve the climate crisis
  - b. is a driving force behind the climate crisis
  - c. will be intensified if we increase regulatory oversight of the oil and coal industries

**Answer:** B

8. African Americans, Indigenous Peoples, and Women:
- a. are disproportionately impacted by climate change and many are leading the climate justice movement
  - b. are largely to blame for the climate crisis
  - c. tend to care much less about environmental and climate issues than other groups

**Answer:** A

9. Climate Justice:
- a. focuses on the root causes of the climate crisis
  - b. reveals that climate solutions require systemic transformation rather than modest reforms
  - c. underscores that pursuing solutions through the mechanisms that caused climate change makes little sense

- d. includes students working on fossil fuel divestment campaigns, urban gardening, and bikeable cities
- e. all of the above

**Answer:** E

## Discussion Questions

1. Describe both the religious and secular root of man's domain over nature.
2. What are some examples of disproportionate impacts of climate change on society?
3. What is climate justice? What responsibilities does it entail?
4. Why do the vulnerable lose more when disaster strikes?
5. How did Terra Nullis historically justify man's dominion over nature and how does it work in the world today?
6. Why is the suburbanization of cities problematic, from the perspective of climate change?
7. How is the responsibility to the natural world connected with the responsibility to other humans?
8. How can your generation be mobilized as agents of climate justice?
9. Give an example of climate change as a social justice issue from your experiences.
10. Drawing on the lessons of climate justice and injustice, how can we deepen and improve our responses to the challenges of climate change?
11. Why do you think government regulations have not achieved the desired goal of addressing climate change?
12. What would happen if we developed climate solutions without attention to social inequality? Draft a sample/mock piece of legislation that would be an example of a climate solution that ignores social inequality. Write down and discuss what you think the concerns

of climate justice movement organizations might be regarding this legislation. How would you respond to those concerns?

13. The Anthropocene is the name that scholars use to describe the current geological epoch, in which humans are the dominant influence on planet earth's climate and environment. Scholars have proposed other names as well, including the Capitalocene and the Wasteocene to reflect the view that this epoch is marked by the dominance of capitalism and the massive production of industrial and consumer waste, respectively. Consider the following: 1) answer the question—what do you think living in the Anthropocene, Capitalocene, or Wasteocene might mean for the future of humankind and ecosystem health? 2) Come up with your own term for a future geological epoch that you would like to live in, which would be characterized by climate justice, thriving democracies, and greater social equality. How might we work toward making that epoch become a reality?

# Chapter 3: Climate Change and Human Health

## Review Questions

1. All of the following can trigger asthma attacks and are projected to worsen with fossil fuel combustion and climate change, except:
  - a. Ozone (“smog”)
  - b. Ragweed pollen
  - c. Carbon dioxide
  - d. Particulate matter pollution

**Answer:** C – carbon dioxide levels are going up with climate change, but carbon dioxide itself is not linked to asthma or any other respiratory effects. All of the others listed are linked to respiratory symptoms.

2. Which of the following health effects can occur after flooding?
  - a. Injuries from falling or moving debris
  - b. Skin or gastrointestinal illnesses
  - c. Mental health problems
  - d. All of the above

**Answer:** D – floodwater can cause severe damage to structures, and more people are usually injured or killed from being struck by debris during the flood and clean-up than from drowning. Contamination of both floodwater and drinking water can occur, resulting in a spike of illnesses including skin infections and diarrhea. Depression, anxiety, post-traumatic stress disorder, and suicide rates increase after major flood events.

3. Heat waves have been linked to:
  - a. More emergency department visits in cooler coastal areas than in hot inland areas
  - b. Big increases in hospitalizations from asthma

- c. Decreases in violent crime rates
- d. Lower levels of ozone in the air

**Answer:** A – California’s cooler coastal areas have larger spikes in emergency department visits for heat-related illness, probably because people in the normally cooler areas are less acclimated to heat and are less likely to have air conditioning. There is no direct link between asthma and heat; asthma can be directly triggered by cold air but not by hot air. It’s true that if ozone concentrations rise during a heat wave (see below), that could trigger increased asthma exacerbations. Hospitalization data during heat waves generally show increased rates of cardiovascular and kidney-related hospitalizations, but not increases for asthma. Violent crime rates have been shown to increase during heat waves. Ozone is created more rapidly through photo-chemical oxidation as the temperature increases, so ozone concentrations tend to rise during heat waves.

4. Which of the following patterns of illness are predicted with climate change?
- a. Lyme disease will move south into the tropics
  - b. Dengue fever may move north into the southern half of the U.S.
  - c. Illnesses from toxic algae will be less frequent
  - d. California will be relatively unaffected by climate-related illnesses

**Answer:** B – The two mosquito vectors that carry Dengue fever have been introduced into the U.S. and are moving northward. In addition to affecting the Southeastern states and Texas, they have also been reported in Southern California. Although Dengue fever outbreaks have not yet occurred in the U.S., the stage may be set for an outbreak. Lyme disease is moving north into Canada. Harmful algal blooms (HABs) are becoming more and more frequent, and are resulting in illnesses ranging from shellfish poisoning to contamination of drinking water and poisonings of pets and livestock that drink from contaminated lakes and ponds. California will be affected by climate-related illness, although developing countries will be much more severely affected.

5. Which of the following strategies can help reduce vulnerability to climate change’s health effects?
- a. Plant trees to keep communities cooler

- b. Ensure access to medical care for everyone who needs it
- c. Foster strong communities where people know and help their neighbors
- d. All of the above

**Answer:** D – All of these strategies can help reduce vulnerability. Reducing heat in communities by increasing tree cover and decreasing impervious dark surfaces (e.g., roads, parking lots), can mitigate the urban heat island effect and reduce heat related illness. People who are most vulnerable are those with disabilities and underlying illnesses; for example, people with asthma, cardiovascular disease, diabetes, and kidney disease are the most vulnerable to heat. Good preventive medical care can help reduce vulnerability in these populations. Strong communities can save lives. Neighbors can help their vulnerable neighbors evacuate during fires and floods. They can check on elderly neighbors during heat waves, and communities can work together to ensure they are prepared in case of an emergency.

## Discussion Questions

1. What are two illnesses predicted with climate changes and what are the driving causes? How can we mitigate them?

**Answer:** The two mosquito vectors that carry Dengue fever have been introduced into the U.S. and are moving northward. In addition to affecting the Southeastern states and Texas, they have also been reported in Southern California. Although Dengue fever outbreaks have not yet occurred in the U.S., the stage may be set for an outbreak. Lyme disease is moving north into Canada. Harmful algal blooms (HABs) are becoming more and more frequent, and are resulting in illnesses ranging from shellfish poisoning to contamination of drinking water and poisonings of pets and livestock that drink from contaminated lakes and ponds. California will be affected by climate-related illness, although developing countries will be much more severely affected. For more information, go to the lecture Climate Change: Health Impacts, Module 3: Disease: The Coming Plagues?



2. Climate change worsens existing public health challenges. What is the general solution in one sentence in how public health can play a role?

**Answer:** The solution is to enhance our public health capacity to be prepared, while also bending the curve.

3. How is massive population displacement one of the most serious impacts of climate change?

**Answer:** When people are displaced, they face needs for safe food and water that often cannot be met. People with chronic diseases such as diabetes don't have their medications, mental health issues flare, acute illnesses are caused by contaminated water, and people who need care can't get it because hospitals and clinics are flooded or damaged. Finally, it can take years to clean up the contamination and repair the infrastructure enough for people to be able to return home, and in some cases they never can.

4. Which of the health issues discussed in the modules concerns you most directly? Are there other health threats that might be linked to climate change?

**Answer:** Not all climate-health threats are covered in these modules, and some are mentioned only briefly. Students could read more and identify other issues of concern. Students might also be motivated to learn more about specific health links. For example, a student who has asthma might be interested in learning more about the air pollution links, whereas a student whose family lives in Florida or Texas may want to focus on the health effects of hurricanes.

Possible additional areas to explore include: crop loss/hunger, loss of critical species such as pollinators, fisheries collapse, waterborne disease outbreaks, other vector-borne diseases, massive population displacement, conflict/war. Students could be asked to form pairs or groups and research any of these links, or those covered in the modules, and do a short presentation for the rest of the class.

5. What are the most significant climate vulnerabilities on your campus and in your community?

**Answer:** Students could research local vulnerability to sea level rise, riverine flooding, wildfire, air pollution, and other threats covered in the modules. There are California resources available that contain local information, including <http://cal-adapt.org/>, the Adaptation Planning Guide: <http://resources.ca.gov/climate/safeguarding/local-action/>, the CalBRACE project: <https://www.cdph.ca.gov/Programs/OHE/Pages/CC-Health-Vulnerability-Indicators.aspx>. The California Department of Public Health (CDPH) has also produced climate vulnerability reports for many counties on California: <https://www.cdph.ca.gov/Programs/OHE/Pages/ClimateHealthProfileReports.aspx>.

Challenge the students to identify the top 3 vulnerabilities that they would worry about on campus or in the local community. They could then discuss what strategies might work to reduce these vulnerabilities and enhance resilience.

6. What are the vulnerabilities in your community?

**Answer:** Students could choose different neighborhoods (with different socioeconomic or other characteristics) and do walk-throughs of those neighborhoods in pairs or small groups. They should develop and use checklists to identify factors that could increase vulnerability or resilience.

Students could document the number of trees per block, green spaces, and the estimated square meters of paved surface as an estimate of the urban heat island effect <https://www.epa.gov/heat-islands/learn-about-heat-islands>. They could look at the buildings to see if there are air conditioners, cool roofs, and other factors that could protect occupants against excessive heat. They could also evaluate vulnerability to fire and flood on the ground and on maps. Bike lanes and sidewalks could also be documented, as could demographics (i.e. elderly, young children, disabled, who might be more vulnerable). The groups could document their findings and present them in class.

7. What can you do to reduce climate vulnerability?

**Answer:** Students could brainstorm and make commitments of things that they will do to increase climate and health resilience in their family or community. Examples could include anything from checking on elderly relatives or neighbors during heat waves, to assembling an emergency kit for their home or their car, to educating their family or friends about links between climate change and health, to raising money for storm or wildfire victims or refugees. Other students may want to take various actions to reduce their own GHG footprint that are also health-protective (e.g. eating less meat, bicycling or walking more, etc.) The goal would be for each student to make a commitment to taking some action after this class.

8. How would you communicate to others the important links between climate change and our health?

**Answer:** Students could develop their own ways to transmit this information to various audiences. They would first pick an audience (e.g. the general public, policymakers, university officials, other students, etc.). Then they would develop materials to communicate the information to these audiences. Products could include short videos, mock news stories, an op-ed, tweets, Facebook posts, cartoons, collages, paintings, a rap, their own PowerPoint presentations, a factsheet, or whatever they want to create.

Notes to instructor: The goals of these exercises are generally to get the students to look around them and think about the place where they are living and how they can ultimately help make it better and more resilient for the benefit of everyone living there. The hope is to turn the students into informed observers who can identify vulnerabilities and think creatively about local solutions, whether in their home or their dormitory, or their community, and ultimately in other communities around the world.

# Chapter 4: Overview of the Ten Solutions for Bending the Curve

## Review Questions

1. Name the three classes of climate pollutants important for mitigation actions:
  - a. Greenhouse gases (GHGs)
  - b. Pollutant gases (e.g., carbon monoxide; nitrogen oxides) that lead to formation of ozone (a greenhouse gas)
  - c. Climate warming particles such as black carbon.

**Answer:**

2. How much time do we have before climate change can become dangerous?
  - a.
  - b. Not much; about 15 years
  - c. 50 Years
  - d. 100 years

**Answer:** A

3. Note: UNFCCC (see the Copenhagen accord) defines dangerous as when the warming exceeds 2C. In recent years, this threshold is shifting to 1.5C. We will take 1.5 C as the threshold for dangerous warming.
  - a. If society ignores the warnings by scientists, what is the projected warming by 2100?
  - b. 1-3 C
  - c. 4-6 C
  - d. cooling of 1-3 C

**Answer:** B

4. Note: There is a 50% probability of 4C warming and a 5% probability of 6C warming.
  - a. Select all of the sectors of direct relevance to society that will be impacted by climate change.
  - b. Housing
  - c. Education
  - d. Commerce
  - e. Technology
  - f. Religion

**Answer:** A, C, D, and E. Others include Employment, Recreation, and Government

5. True or false: The following is an inter-generational: Climate change can last for thousands of years and thus impact generations unborn who have very little or no role in climate pollution.

**Answer:** True

## Discussion Questions

1. Give two reasons why Societal transformation solutions should be ranked as high as #2 and #3. If you don't agree with this ranking, give two reasons why not.
2. There are no correct answers for this. The UC-fifty reasons are: Currently there is not much public support for the sort of drastic actions required to slow down climate change. The second reason is the lack of confidence and trust in science and scientific methods.
3. The Six Clusters & Ten Solutions lists can be a bit unwieldy. Can you think of a simpler way to organize the solutions? Are there major missing pieces?
4. How would you start implementing the 10 solutions? Perhaps you'd begin with solution #1 and go down the list or put into place a governance mechanism to implement the solutions?

5. Which living laboratory would you take advantage and why?
6. Mitigation vs Adaptation: Given the choice, would you rather mitigate and adapt at the same time; or adapt to climate change first and then mitigate later if necessary. Discuss the pros and cons of the two approaches.
7. Is climate change a solvable problem? Or is it like the nuclear threat or the population problem, both of which do not seem to have technical solutions.
8. Individual behavioral changes (e.g. riding a bus) to collective actions such as influencing your senator. Can the section come up with a list of actions and ranking of said actions?

## Chapter 5: Your Leadership: Social Movements and Social Solutions to Climate Change

### Review Questions

1. True/False: The right piece of technology will solve our climate problems.

**Answer:** False

2. What does it mean to think of climate change as a problem of power?
  - a. A. In problems of power, politicians are the ones who have to create the solution.
  - b. B. In problems of power, people who want the change the most don't have the resources they need to make the change they want.
  - c. C. In problems of power, the solutions require a fight, or conflict, to solve it.

**Answer:** B

3. True/False: Social movements only recruit people who support their cause to join them.

**Answer:** False

4. Fill in the blank: Social movements seek to make change by recruiting [blank] to take action.

**Answer:** ordinary people

5. True/False: To inspire people to take action, facts are more persuasive than stories.

**Answer:** False

6. True/False: In social movements, we should not have any hierarchy and allow everyone to work independently.

**Answer:** False

7. True/False: Research shows that movements that have more money or more people on their side tend to win.

**Answer:** False

## Discussion Questions

1. How is social movement leadership defined? Do you agree with this? Why or why not?
2. In social movements, what is perceived as success? How might this differ from technology's definition of success?
3. Section 6.1 argues that climate change is, in part, a problem of power. What are some organizational structures that you think might be part of the problem?
4. Some people may disagree with or feel uncomfortable with the characterization that climate change is, in part, a problem of power. How about you? Do you agree or disagree? Why do you think it might make some people feel uncomfortable?
5. Section 6.2 argues that social movements are complex constellations of players and arenas. Look at the list of players who are identified. Can you imagine what role each plays in social movements? Can you think of examples of each type of player in the climate movement?
6. Section 6.3 argues that leadership begins with accepting responsibility for engaging others. Do you accept the responsibility to engage others around climate solutions? Why or why not?
7. Sections 6.4 and 6.5 describe a set of leadership practices that movement leaders use to develop a movement. How comfortable are you engaging those practices? Which seem like they will be hard? Why?
8. Section 6.4 describes a set of leadership practices movement leaders



use to build power. Many of these are dependent on developing relationships with others. Why do movement leaders have to develop relationships with others? How comfortable are you doing so?

9. Make a list of particular players in the climate movement. What does that tell us about who is involved—or missing—from today's climate movement?
10. Consider mobilizing a local climate change solutions movement on campus (or within a department on campus) using your favorite (or most popular) social media. Develop a plan to identify and engage the players who could affect a social movement at this local level.
11. Your team has been asked to take responsibility for engaging other groups on campus for a climate change solutions awareness day. Your team will develop a plan to identify the key tasks and distribute them among members of your team. Each member will identify leadership practices they will use to ensure the climate change solutions awareness day is a success.

## Chapter 6: Social Transformation: Changing Attitudes, Norms, and Behaviors

### Review Questions

1. What does this chapter focus on?
  - a. Culture of collaboration
  - a. Culture of communication
  - a. Culture of challenge

**Answer:** C

2. Which is not a strategy mentioned in the lecture?
  - a. Bottom-up mobilization
  - b. Ethical destinies
  - c. Technology transfer

**Answer:** B

3. Which is part of the UCSD Community Stations Agenda? Choose all that apply.
  - a. Supporting community-based climate education for students
  - b. Increasing knowledge about climate change and environmental health in our partner communities
  - c. Stewarding high-impact climate interventions at neighborhood scale

**Answer:** A, B, and C

4. True or False: Bogota and Curitiba are cities that exemplify municipalities committed to equitable green urbanization.

**Answer:** True

## Discussion Questions

1. How have Latin American cities been so successful at tackling problems of climate change while reducing social disparity?
2. What are some of the social barriers of technology transfer?
3. What does it mean to take an “integral” approach to tackling climate change? What are the benefits and difficulties of such an approach?
4. Why have mayors been such successful agents of progressive climate action? Why have so many cities become important living laboratories?
5. Why are universities particularly well-suited to lead local climate action initiatives? What is your university doing? How can the UC San Diego Community Stations model be scaled?
6. Why is changing social attitudes and behavior essential to tackling climate change?

# Chapter 7: Communicating Climate Change Science

## Review Questions

1. What is not a rule of effective communication?
  - a. Simple messages
  - b. Repeated often
  - c. Trusted listeners

**Answer:** C, the third is trusted messengers

2. Which must you know for effective communication? Choose all that apply.
  - a. Your doubters
  - b. Your audience
  - c. Yourself
  - d. Your topic

**Answer:** B, C, and D

3. Which are techniques for effective communication? Choose all that apply.
  - a. Use stories and metaphors
  - b. Have a simple message
  - c. Use jargon
  - d. Emphasize solutions and optimism

**Answer:** A, B, and D

4. True or False: Communicating with the public requires leading with lots of background information.

**Answer:** False, start with the bottom line, introduce the “So What?”, and finish with supporting details.

## Discussion Questions

1. List at least four terms that have different meanings for scientists and the public, and provide a better choice for each of them. List at least four important scientific findings that illustrate our understanding of recently observed and predicted climate change.

**Answer:** Here is a partial list:

- a. We have measured the carbon dioxide content of the atmosphere and shown it is increasing.
  - b. We have proven that carbon dioxide and other gases, and particles, can trap heat and cause warming.
  - c. We have discovered that the warming observed in recent decades is due to human activities.
  - d. We have found that cumulative emissions of heat-trapping gases determine how much the world will warm.
  - e. We understand that reducing emissions of heat-trapping gases will limit the warming.
  - f. We find that natural climate change such as ice ages starting and ending did not cause the recent warming.
2. Explain for non-scientists at least four kinds of observational evidence that show that the global climate has recently experienced warming.

**Answer:** Here is a partial list:

- a. The atmosphere is warming.
- b. The ocean is warming.
- c. Sea level is rising.
- d. Ice sheets and glaciers are shrinking.
- e. Arctic sea ice extent is decreasing.
- f. More high temperature records are being set than low temperature records.
- g. The water vapor content of the atmosphere is increasing.

# Chapter 8: Religion, Ethics and Climate Change

## Review Questions

1. True/False: Instrumental valuation of nature is the value of nature to humans and is a commodity to be used for profit.

**Answer:** True.

2. Multiple Choice: Which is not considered a religious value or ethic?
  - a. Value of “creation”
  - b. Ethics of “stewardship” & “creation care”
  - c. Only on anthropocentrism
  - d. Value for future generations

**Answer:** C, rather it is beyond anthropocentrism.

3. True/False: 75% of the world's people are religious.

**Answer:** False. 85% of the world's people are religious.

## Discussion Questions

1. Of the religious leaders shared in the lecture, which would you like to have dinner with and why? What are two questions that would you like to ask them?
2. Consider your community. Which religion is most prevalent? How would you provide a climate message for this audience? Write a one paragraph pitch. If the opportunity is available, try presenting this pitch to one of your community members and engaging them in this conversation.
3. Discuss why Laudato Si was so influential and how next steps could be made after this document. What are 3 actions that the authors might want to continue? How about 3 actions by the readers?

4. Chose a climate crisis that is occurring today. How might these different religions respond to this? What are some differences and similarities?

## Chapter 9: Lessons from California

### Review Questions

1. True/False: The Los Angeles basin has met air quality standards for ozone, a component of smog, for many years.

**Answer:** False

2. About how much of California's electricity is produced by renewable sources like hydro, solar and wind?
  - a. 75%
  - b. 90%
  - c. 40%
  - d. 20%

**Answer:** C

3. Policy tools, like taxes or tradeable permits, generally have the following features:
  - a. Government specifies environmental quality goals, but not how the goals should be achieved.
  - b. Government specifies environmental quality goals and how the goals should be achieved.
  - c. Government dictates the technology that must be used for pollution control.
  - d. Government provides information so that consumers can make "greener" choices.

**Answer:** A

4. California's climate strategy includes which of the following elements?
  - a. Large-scale geoengineering projects to scrub CO<sub>2</sub> from the atmosphere.
  - b. Increases in nuclear power for electricity generation.



- c. Billions of dollars in urban mass transit projects.
- d. A doubling of energy efficiency in existing buildings throughout the state.

**Answer:** D

5. True/False: California is on track to meet its AB 32 goal for 2020.

**Answer:** True

6. True/False: Total greenhouse gases related to transportation emissions in California started to go down in 2008 and have never reversed course.

**Answer:** False

## Discussion Questions

1. How did the geography of the Los Angeles basin exacerbate the photochemical smog problem? How do you think geographic features of your hometown help or hinder air pollution control?
2. What do you think of the California Climate Strategy? Which do you think has the greatest impact on bending the curve?
3. Section 9.2 discusses the accomplishments and shortcomings of AB32. Discuss with your peers what you think of the Act – did it succeed or fail? Why or why not?
4. Section 9.4 discusses many of the energy efficiency and renewable power efforts implemented in California over the last 40-50 years. Are any of these familiar to you? For example, do you know if your appliances or car are relatively efficient or inefficient? How can you tell?
5. Check out the California Energy Commission and/or your local utility's websites on energy efficiency and renewable energy. Are energy audits available? Do they offer rebates for renewable energy equipment (like solar panels) or energy efficient appliances?
6. Section 9.1 introduces different kinds of policy tools. We encounter

many of these every day. Think of one policy using a command and control approach. How might the same thing be accomplished with a market incentive such as a tax or tradeable permit?

7. Ultimately, California's climate policy innovations will be most effective if they are widely adopted around the world. Give some thought to which approaches you think might be most promising in different parts of the US and in other countries.

# Chapter 10: The Paris Agreement and Its Implementation

## Review Questions

1. Which are six implementation challenges? Choose all that apply.
  - a. Making “Pledge and Review” work
  - b. Building a Verification System
  - c. Building a Following
  - d. Proper Leadership

**Answer:** A, B, and C. The six challenges are Making “Pledge and Review” work, Continued Implementation of National Policies, Carbon Embodied in International Trade, Leadership, Existing Policies Not on Track for 2 Degrees C, and Building a Verification System.

2. True or False: One striking thing about the Paris Agreement is that almost every country participated.

**Answer:** True

3. True or False: The US signed the Paris Agreement.

**Answer:** True

4. What was not a characteristic of the Paris Agreement?
  - a. Allows for flexible geometry
  - b. Less reliance on binding commitments
  - c. Clear cut and immediately deep
  - d. Universal participation

**Answer:** C; Paris had less reliance on binding commitments, “bottom up” pledges, allowed for flexible geometry, universal participation, and shallow coordination that allowed going deep later.

5. What is not a policy review mechanism?

- a. TWO Trade Policy Review Mechanism
- b. G5 Mutual Peer Review on Renewable Energy
- c. IMF Article IV reviews
- d. OECD policy review

**Answer:** B

## Discussion Questions

1. 1. Why is international cooperation needed?

**Answer:** The need for cooperation emerges, mainly, because the benefits from limiting climate warming are diffused across many countries. Even more importantly, the cost of efforts to control the pollutants that cause climate warming could be high and could affect the economic competitiveness of firms inside countries that adopt the strictest controls. Those firms will suffer if their competitors don't face similar costs. Knowing this, firms won't offer political support to governments that move too aggressively. Cooperation helps to level the playing field and build confidence in firms that all nations are doing their part.

2. 2. Why was there a declining impact of the Kyoto Protocol?

**Answer:** Kyoto created a very rigid framework, and creating circumstances for important countries they had no way to honor the treaty. That behavior was most notable for the US, which at the time was the world's biggest emitter. Without the US, the fraction of emissions covered under the Protocol declined. In addition, the Kyoto protocol only covered emissions from the industrialized nations, and starting in the 1990s (and especially in the 2000s), the emerging economies grew rapidly, led by China and now India. The countries that stayed inside the Kyoto Protocol—mainly Europe and Japan, and after 2012, not even Japan—were a declining fraction of global emissions.

3. 3. Why is the Paris agreement expected to be more effective than Kyoto?

**Answer:** Because the Paris agreement allows countries to set their own commitments, it is much more likely that countries will set their commitments at levels they are willing and able to honor. The “pledge and review” system in Paris also increases the likelihood that countries will provide useful information about which policies actually work (and which don’t), and that could help pave the way for more cooperation. In effect, this theory is based on the idea that one of the factors limiting deeper cooperation is information about how countries (and firms) can cooperate better. Eventually, this approach will need to be augmented by enforcement mechanisms—those will need to come in time, but right now it is most important to develop the systems and experience with at least shallow cooperation.

4. Which of the six implementation challenges do you think is the greatest challenge? Why?

**Answer:** There are many ways to answer this. I think the most important near-term challenges relate to getting the system for pledge and review operational. That means getting countries to volunteer themselves for peer review of their policies and pledges (“Nationally Determined Contributions”, or NDCs) under the Paris agreement. That will require better NDCs as well. Over the longer term, the bigger challenges relate to creating incentives for deeper cooperation—including addressing the trade effects when countries adopt different levels of cuts in emissions. Over the long term, as well, it will become crucial to begin to help countries adapt to the impacts of climate change.

5. Despite the much more flexible framework of the Paris Agreement why are many countries not honoring their pledges?

**Answer:** Countries adopt pledges for many reasons. Western democracies are often under lots of public pressure to demonstrate they are doing something about the problem. But action, nonetheless, is not free—and often it is not quite clear what to do. Thus, governments have been good at making pledges but the task of implementation is much harder to deliver.

# Chapter 11: Economics: Emissions, Impacts, and Policy

## Review Questions

1. Emissions in 2016 are \_\_\_% higher than in 1991.
  - a. 25
  - b. 35
  - c. 45
  - d. 55

**Answer:** D

2. Emissions will come from \_\_\_\_\_ countries.
  - a. Developed
  - b. Developing
  - c. Least Developed

**Answer:** B

3. True or False: 40% of housing stock in California are located in very high-risk fire areas.

**Answer:** True

4. True or false: most sectors are well studied and subsequently well prepared for climate change.

**Answer:** False, many sectors are understudied or even not studied. Refer to Module 2 for the full list.

5. How do we mainly regulate emissions through economics? Check all that apply.
  - a. Command and control
  - b. Incentive based regulation
  - c. Cash flow

**Answer:** A and B

## Discussion Questions

1. What is one way that markets fail?
2. Why do economists like incentive-based policies? What is needed in order to have a successful policy of any kind?
3. Choose a command and control regulation and an incentive-based regulation. How do the benefits and costs differ between the two methods?
4. What is lacking in how we evaluate policies? How would you improve them?

# Chapter 12: Cost Effective and Efficient Climate Policies

## Review Questions

1. 1. Which of the following carbon-saving activities are incentivized by California's cap-and-trade system?
  - a. a. Switching away from fossil fuels in electricity generation
  - b. b. Driving less
  - c. c. Installing insulation in attics
  - d. d. None of the above
  - e. e. All of the above

**Answer:** E

2. 2. Fuel economy standards have been estimated to be \_\_\_\_\_ times costlier per gallon saved than a gasoline tax.
  - a. a. 3 to 5
  - b. b. 10 to 20
  - c. c. Same cost
  - d. d. 30 to 50

**Answer:** A

3. 3. The Supreme Court case Massachusetts vs. EPA (2007) is one of the most important legal decisions regarding greenhouse gas regulation. What did the court rule?
  - a. a. That the EPA has the right to set limits on carbon dioxide and other greenhouse gases.
  - b. b. That Massachusetts has the right to regulate carbon dioxide and other greenhouse gases as long as the emissions occur within the state.
  - c. c. That Massachusetts can set nationwide limits on carbon dioxide and other greenhouse gases.



- d. d. That the EPA must set limits on carbon dioxide and other greenhouse gases.

**Answer:** D

- 4. 4. Which of the following is an example of a “double dividend” from consumer protection?
  - a. a. A policy that requires consumers to buy smaller vehicles, and the consumers save money since smaller vehicles are typically cheaper than larger ones.
  - b. b. A policy that requires households to add insulation, and it turns out that the energy savings are greater than the cost of the insulation.
  - c. c. Subsidies to solar power large enough to cause solar to be cheaper than buying electricity from the grid.
  - d. d. Subsidies to research and development that cause energy-saving light bulbs to be cheaper than standard incandescent light bulbs.

**Answer:** D

## Discussion Questions

- 1. Leakage through policy overlap (where multiple levels of government act simultaneously) is a particular worry with city level policies. Provide some examples of inefficient policy overlaps and how you might solve them.

**Example:** Suppose the state government mandates that 10,000 electric vehicles be sold in the next year. If a city government passes a policy to buy electric vehicles for its fleet this will reduce carbon emissions in that city, but since these vehicles will also count toward the 10,000 at the state level the city’s actions will result in no change at the state level.

- 2. Both California’s carbon cap-and-trade system and Australia’s (former) carbon tax exclude agriculture. Why do you think this is? Why does this imply a reduction in efficiency?

**Answer:** Any time a method of saving carbon (for example no-till agriculture) is excluded from a policy that policy becomes more expensive per ton of carbon saved (since it misses potentially low-cost carbon reduction opportunities in the uncovered sector). They may be excluded in these cases because emissions are hard to measure or for political reasons.

3. Think about the two basic ways to reduce emissions from cars: (i) more efficient cars, and (ii) fewer cars. Is one policy easier or more effective to implement than another? What politics are likely to enter the decision? Do gasoline taxes lead to one or both of these effects?

**Answer:** To the extent automobile production is politically important it will be far easier to implement efficiency improvements. Reducing the number of cars may be more effective, however. Gasoline taxes will, as is generally the case with price-based instruments, encourage all ways of reducing gasoline use and so will do both (i) and (ii) simultaneously.

# Chapter 13: Energy Technology Pathways

## Review Questions

1. What, in addition to energy storage, is required to manage and complement the limited capacity factor and dynamics (diurnal variation and intermittency) associated with renewable solar and wind power generation?
  - a. Non-combustion, clean, firm (24/7, load-following) power generation
  - b. Combustion peakers
  - c. Alternative fuels

**Answer:** A

2. Upon which fuel cell component does the type (PEMFC, PAFC, MCFC, SOFC) of fuel cells embody?
  - a. Temperature
  - b. Electrode
  - c. Electrolyte

**Answer:** C

3. In support of a 100% renewable future, what is the progression of fuels for fuel cells (electric power and vehicle power) from the fuels available today, to the renewable fuel projected to be abundant in the future?
  - a. a. Natural gas - biogas - hydrogen
  - b. b. Natural gas - biogas - renewable hydrogen
  - c. c. Natural gas - syngas - hydrogen

**Answer:** B

4. Identify two attributes of smart-grid technology

- a. Facilitate a 100% renewable grid, achieve environmental goals (GHG, urban air quality)
- b. Facilitate a 100% renewable grid, improve fuel economy
- c. Facilitate a 100% renewable grid, facilitate messaging

**Answer:** A

5. What are the three principal roles that renewable hydrogen portends?
- a. Capture of otherwise curtailed renewable power, subsequent utilization through fuel cells (electric power, vehicle power), and blimp buoyancy
  - b. Capture of otherwise curtailed renewable power, storage, and manufacturing
  - c. Capture of otherwise curtailed renewable power, storage, and subsequent utilization through fuel cells (electric power, vehicle power)

**Answer:** C

## Discussion Questions

1. What is the major technology do we have now that do you think was considered science fiction back in the 1950's?
2. If fuel cells are to be as ubiquitous as computers are today, what are positive and negative impacts?
3. What are examples of transportation merging with the electric grid? Map three in your community.
4. While the increasing deployment of solar and wind electric generation resources produce renewable power, what challenges accompanying the deployment? How can we mitigate them?
5. What are examples of technologies required to support a 100% renewable grid?

**Examples:** Electric battery storage, load-following clean, firm (24/7,

load-following) power generators (e.g., fuel cell technology), generation and utilization of hydrogen as a “battery” for massive energy storage and utilization to support FCEV fueling and FC generation of electric power on demand, and smart grid technology

# Chapter 14: Sustainable Transportation

## Review Questions

1. What is the best average speed to travel at to minimize your GHG emissions?
  - a. 10 mph
  - b. 15 mph
  - c. 50 mph
  - d. 90 mph

**Answer:** C

2. Which is not a main area of Intelligent Transportation System?
  - a. Vehicle-based ITS technology
  - b. Traffic system technology
  - c. Interstate network technology
  - d. Driver behavior technology
  - e. Answer: C. This does not exist
  - f. Which selection below represents one of the four different “levels” where automation can be applied to transportation?
  - g. Automated Powertrain in Management
  - h. Vehicle Dynamics
  - i. Traffic Dynamic Automation
  - j. Infrastructure Related Automation

**Answer:** C. The four levels are: Traffic Dynamic Automation; Traffic Flow Automation; Traffic Light Signal Optimization, and Cooperative Cruise Control.

3. What is a major transportation concern? Select all that apply.
  - a. Safety
  - b. Efficiency
  - c. Economics

d. Human population number

**Answer:** D. The last concern is energy, climate change, and environment.

## Discussion Questions

1. What is “induced travel demand” and how does it relate negatively towards GHG emissions?
2. Answer: “induced travel demand” is the effect when there is an attraction for an individual to travel more, thereby increasing the total number of miles traveled and increasing GHG emissions. These attractions included uncongested roadways, faster speeds, increased mobility, automated vehicles, etc. The increase in GHG emissions would be proportional to the amount of GHG emissions emitted now, unless the travel modes changes.
3. What are criteria pollutant emissions and how are they different from GHG emissions? Which do you think is most impactful to human health?
4. Answer: Criteria pollutant emissions: CO: carbon monoxide; HC: hydrocarbons; NOx: oxides of nitrogen; PM: particulate matter; GHG emissions: CO<sub>2</sub>: carbon dioxide; N<sub>2</sub>O: Nitrous Oxide; criteria pollutant emissions affect health, GHG emissions affect climate
5. What are the three main areas of Intelligent Transportation Systems and what are some examples from each?
6. Answer: Vehicle-based ITS technology: adaptive cruise control, lane keeping technology; forward collision avoidance; traffic system technology: highway ramp metering; traffic light synchronization; traffic speed harmonization; driver behavior technology: vehicle routing; electronic payment services
7. Go online and examine the Urban Mobility Scorecard website: <https://mobility.tamu.edu/ums/>. How has traffic congestion grown in your city? Is congestion getting better or worse? Why don't we simply build many more roads to mitigate traffic congestion?

8. If you had an automated vehicle in the future, would you use that vehicle more than you do now? Estimate how much your driving would change, and figure out how your GHG emissions would also change.



# Chapter 15: Technologies for Super Pollutants Mitigation

## Review Questions

1. Why are SLCPs called super pollutants?
  - a. They are more common than other pollutants
  - a. Per ton of emission, these are ten to thousand times more potent than a ton of CO<sub>2</sub> emission

**Answer:** B

2. If the entire world stops emitting black carbon today, how long will it take for the black carbon concentration in the atmosphere to reduce drastically (i.e., by more than 70%).
  - a. 25 years
  - b. 6 months
  - c. Several weeks

**Answer:** C

3. How does black carbon damage the health of people? Choose all that apply.
  - a. Leads to over 3 million mortalities every year
  - b. Second to their largest global warming agent
  - c. Melts sea ice and glaciers
  - d. Causes global dimming and decreases monsoon rainfall

**Answer:** all of the above

4. True or False: The bottom three billion people contributes 50% of carbon dioxide emissions.

**Answer:** False, they contribute only 5% of emissions

5. Where is the ozone layer?

- a. Troposphere
- b. Stratosphere
- c. Mesosphere

**Answer:** B. Stratosphere (beginning 6–10 miles up in the atmosphere and reaching nearly 31 miles up)

6. What does the ozone layer absorb?
- a. Green wavelength
  - b. Radiation
  - c. Ultraviolet

**Answer:** C. Ultraviolet (UV) rays [spell this out]

7. How soon after Molina and Rowland made their discovery about CFCs depleting the ozone did Ramanathan discover that CFCs were also greenhouse gases?
- a. One year
  - b. Five years
  - c. Ten years

**Answer:** A. One year (1975)

8. What health issues would not result from a depleted ozone layer?
- a. Skin cancer
  - b. Asthma
  - c. Eye damage
  - d. Cataracts
  - e. Immune suppression

**Answer:** B.; Only skin cancer, eye damage, cataracts, and immune suppression would result

9. When was the Montreal Protocol first adopted?
- a. 1977
  - b. 1987
  - c. 1997

**Answer:** B. 1987

10. How many parties signed the Montreal Protocol?
- a. 79
  - b. 97
  - c. 167
  - d. 197

**Answer:** D; 197 (This all 193 UN Members plus the Cook Islands, the European Union, Holy See, and Niue)

11. What is the most abundant HFC?
- a. HFC-23
  - b. HFC-134a
  - c. R410a

**Answer:** B HFC-134a

12. How much would the carbon budget be reduced if the growth of HFCs was not restricted by the Kigali Amendment?
- a. 10-30%
  - b. 30-60%
  - c. 60-90%

**Answer:** B. 30–60%

13. How much warming will be avoided by the Kigali Amendment?
- a. 0.5°C by 2100
  - b. 1.0°C by 2150
  - c. 0.5°C by 2150

**Answer:** A: Up to 0.5°C by 2100

## Discussion Questions

1. Find and share an article on a city mitigating SLCPs.
2. Name the three most important measures to reduce black carbon emission. Which might be the easiest to implement?
3. Name the five ways by which methane leads to warming. Which do you think is more critical, and why?

4. There is concern that targeting SLCPs could take attention away from CO2 emissions.
5. If you have the same concern, explain why policy makers have the inability to address more than one solution? What can be done to address this concern?
6. If you think this is a non-issue, discuss how you will persuade the policy maker. Explain the local benefits to the jurisdiction that mitigates SLCPs.
7. Methane is emitted by multiple sources. If your city does not have the funds to target all of them, what would be your top choice for mitigation? And why?
8. Consider the situation, where nations focus just on CO2 emissions, and the warming exceeds 2 C by 2050 and leads to dangerous tipping points with frequent extreme events such as heatwaves etc. What are the responses available to society?
9. Discuss this with the perspective of the wealthiest one billion who are responsible for most of the pollution; and the poorest 3 billion who had little to do with the pollution but can face existential threats. Prioritize them and list 3 most important actions you will recommend to each group.
10. Consider the topic above, and describe how faith leaders can help the disastrous situation. How will you use what you learned in this class to attempt societal transformation?
11. Consider the emissions of your local area, and describe the specific SLCPs mitigation measures your local area can take to contribute to the global mitigation actions.
12. What health issues result from a depleted ozone layer?
13. 10. How many amendments to the Montreal Protocol have there been so far? How many further adjustments? Why are amendments important?
14. What are some of the key reasons that make the Montreal Protocol so successful?

15. How many chemicals phased out so far? Emissions avoided between 1990 and 2010?
16. The Montreal Protocol is considered one of the first international treaties to reflect the precautionary approach to environmental issues, which urges policymakers to take action in the face of scientific uncertainty. Given the state of scientific knowledge at the time of the Protocol, how reasonable was it to take this approach? How does this compare to the progress with climate change under the UNFCCC?
17. One year following Mario Molina and Sherry Rowland's discovery that CFCs appeared to be destroying the protective stratospheric ozone shield, UCSD Professor V. Ramanathan found that CFCs were also powerful greenhouse gases. How did these discoveries influence the form of the Montreal Protocol?
18. Some of the companies that made CFCs attacked the credibility of the scientists, including Molina and Rowland, who found that their invitations to scientific conferences and talks drying up. Given the critical role the science played in the development of the Montreal Protocol, what are your thoughts on scientists as advocates for political change? Should there be any limitation to their involvement? Should scientists let their work speak for them? Should they have a place at the negotiation table and/or in front of legislative bodies?
19. How did consumer boycotts impact CFC phasedown and the subsequent national and international regulations? Could these sorts of actions be used for other climate issues? What sorts of boycotts could be useful for tackling climate issues? What other similar actions could be taken?
20. Health benefits from protecting the stratospheric ozone layer were helpful in encouraging policy and generating public acceptance. In what ways can health issues be incorporated to developing other climate policies? Are there other collateral benefits that could be emphasized for promoting climate protection?
21. The Montreal Protocol is a "start-and-strengthen" treaty. What are the benefits to structuring a treaty this way? Should other climate

- issues be handled in a similar fashion? How could other treaties be structured to mimic this successful aspect of the Montreal Protocol?
22. The Kigali Amendment to the Montreal Protocol to include HFCs under the Protocol took nearly a decade. What pieces of the puzzle were crucial to turning the tide for accepting phasing down these chemicals that did not destroy ozone under a treaty built specifically for protecting the stratospheric ozone layer?
  23. What are the practical reasons for considering energy efficiency adjustments while changing HFC refrigerants?
  24. The Montreal Protocol targeted a specific set of chemicals (known as fluorinated gases used primarily as refrigerants, to make insulating foams, and as solvents) whereas the climate problem incorporates a wider range of pollutants from a large number of different sectors, which makes the climate problem inherently more challenging than the ozone problem. In what ways can the lessons learned from the success of the Montreal Protocol be extended to other climate issues? Do you think climate policy would be more effective if it took a sectorial approach and developed other tailor-made treaties to address, for example, the steel industry, aluminum industry, cement industry?
  25. Media is instrumental for communicating and explaining climate issues. Many issues with the Montreal Protocol were handled in various op-eds and news articles that reached the general public as well as policymakers. Consider what media sources would be best for disseminating climate information? Are there media and communication avenues that are better for climate communication? Worse? What concerns or issues arise in covering these topics in the media and how can they be avoided?
  26. As the range of climate friendly alternatives to HFCs expanded, countries and their industries were more willing to agree to the Kigali Amendment. What alternatives exist for other climate pollutants? How can these be readily incorporated to enhance and speed up a global transition to a safer climate?

# Chapter 16: Enhancing Carbon Sinks in Natural and Working Lands

## Review Questions

1. Which of the following statements about soil carbon sequestration is true? Select all that apply.
  - a. It can eliminate the need for emissions reduction in other sectors
  - b. It can solve climate change by removing all the excess CO<sub>2</sub> from the atmosphere
  - c. It temporarily removes carbon from the atmosphere
  - d. It is an approach for climate change mitigation with many co-benefits.

**Answer:** C and D

2. How does carbon get into soils? Select all that apply.
  - a. From ozone in the atmosphere
  - b. From the deposition of waste products and the mortality of plants and animals
  - c. From organic amendments
  - d. From rainfall and snowmelt

**Answer:** B and C

3. Which of the following are true? Select all that apply.
  - a.  $\text{Photosynthesis} > \text{Microbial Respiration} = \text{Soil Carbon Sequestration}$
  - b.  $\text{Photosynthesis} < \text{Microbial Respiration} = \text{Soil Carbon Sequestration}$
  - c.  $\text{Global Soil Carbon Stock} > \text{Global Atmospheric Carbon Stock}$
  - d.  $\text{Global Soil Carbon Stock} < \text{Global Atmospheric Carbon Stock}$

**Answer:** A and C

4. True or False: California is the largest dairy producer in the US.

**Answer:** True

5. Livestock manure is a large source of \_\_\_\_\_, a potent greenhouse gas.

- a. Carbon dioxide
- b. Methane
- c. Nitrous oxide

**Answer:** Nitrous oxide

## Discussion Questions

1. How can land management contribute to climate change mitigation?

**Answer:** Plant and soil carbon sequestration are examples of land-based climate change mitigation approaches. Forests, because of their large woody biomass, have the potential to remove considerable carbon from the atmosphere. Soils are a large pool of carbon; because there are large areas of degraded soils, there is great potential to increase soil carbon storage through improved management for climate change mitigation.

2. Is emissions reduction alone sufficient to stop climate change? Why or why not?

**Answer:** the IPCC AR5 stated that emissions reduction alone is insufficient to reverse climate change and that it must be coupled with a sustained removal of CO<sub>2</sub> from the atmosphere in order to slow or reverse climate change.

3. What are some potential problems with forest carbon sequestration?

4. Find and share other examples of natural carbon sequestration.

5. We need to get carbon out of the atmosphere to slow climate change. Emissions reduction is essential, but not enough to Bend the Curve. How can you spread the word? How can you help people understand what is needed to slow climate change?



6. Soil is a great place to store excess carbon. How can you promote soil carbon sequestration?

**Example:** Use Google maps or Google Earth to determine the potential land areas within 50 miles that might be available for C sequestration projects. You can compare values with others.

7. Agriculture and forestry can be part of the solution. How can you change your eating and purchasing habits to contribute to this solution? How can you help spread the word on the potential for climate friendly agriculture and forestry? Small group or whole class discussions.
8. Scientists working with stakeholders can advance new strategies for carbon sequestration while supporting sustainable food production. What would be your dream team for carbon removal? Small group or whole class discussions.
9. How can you help move your ideas forward towards reality? This is a like a strategic planning session, with the goal of empowering students to translate their ideas into action. Open ended discussion with the whole class.

# Chapter 17: Sea Level Rise from Melting Ice

## Review Questions

1. True/False: Ice melt in Greenland is almost entirely due to melting of the ice/snow surface from warmer air temperature.

**Answer:** False, increase in glacier speed is equally if not more important.

2. True/False: We have not reached the point of no return in any part of Greenland or Antarctica.

**Answer:** False, we reached that point in Jakobhavn in Greenland and the Amundsen Sea in West Antarctica.

3. True/False: The melting of ice sheets is not clearly related to climate warming.

**Answer:** False. There are direct links in the Arctic and in the Antarctic to melting ice.

4. True/False: The impact of climate warming is nearly the same in the Arctic and the Antarctic.

**Answer:** False. In the Antarctic the wind regime is intensifying; in the Arctic, it is the opposite.

5. True/False: A warming at 1.5 degrees C above pre-industrial level is going to protect us from sea level rise from the ice sheets.

**Answer:** False. Sea level is likely to rise by 6-9 m with 1.5 degrees C above pre-industrial.

6. True/False: There are no solution readily implementable to transition to a carbon-free energy production. There is no solution to sequester carbon and return to pre-industrial GHG concentrations.

**Answer:** False. There is a technology mix available now to transition to a near carbon free energy production, and technologies exist for carbon sequestration but need to be improved.

## Discussion Questions

1. Greenland and Antarctica are some of the most important regions for sea level rise. What are two other places you think are critical contributors? (You may research articles that you think best describe the process and/or impacts of melting ice).
2. Engage in conversation with your community: about melting of ice in the polar regions. Ask them: 1) do you believe in climate warming? 2) if scientists tell you it is real, are you willing to trust their reporting? 3) What evidence would convince you that ice is melting at the poles? 4) do you think ice melting at the poles is something that will happen in the near future, is already happening, or is fake news; 5) do you know how much sea level is locked in the ice sheets? Greenland? Antarctica? 6) do you think scientists have a good idea of how fast ice is melting into the ocean? 7) Do you know what the projection for sea level rise is for the end of the century; 8) do you know whether sea level rise will keep happening for centuries? 9) do you know if there is anything we can do about this, and if someone knows what to do, would you be willing to listen and take action?
3. Consider the impact of sea level rise along coastal areas. Try to imagine the impact of a 1 m sea level rise versus a 10 m sea level rise. Go on the web and find resources that conducted simulations of coastal flooding. Discuss among yourselves what went into the model and what could be the shortcomings of these models.

## Chapter 18: Atmospheric Carbon Extraction: Scope, Available Technologies, and Pathways

### Review Questions

1. Multiple Choice: 1/5 annual production of oil is \_\_\_\_\_?
  - a. One gigaton
  - b. One megaton
  - c. One gigagram

**Answer:** A

2. True/False: We can put carbon dioxide back underground as a liquid.

**Answer:** True. There is unlimited capacity but it is expensive.

3. True/False: Carbon removal potential of a forest increases with time.

**Answer:** False. Carbon removal potential of a forest decreases with time.

4. True/False: The cost of electricity is no longer a barrier to industrial growth.

**Answer:** True.

5. Multiple choice: Transportation, refining, and oil production makes up \_\_\_% of California's greenhouse gas emissions in 2016?

- a. 32%
- b. 42%
- c. 52%

**Answer:** C.

6. Multiple choice: Which sector is the problem in California regarding carbon emissions?

- a. Agriculture
- b. Waste

- c. Transportation
- d. Housing

**Answer:** C.

7. Multiple answer: In order to achieve California 2045 and Paris Agreement Goals, what needs to occur?
  - a. Renewable electricity will be cheap.
  - b. Carbon economy will die.
  - c. Up to 20 billion tons per year of carbon dioxide must be removed from the atmosphere after 2050.
  - d. We will rely only on technology.

**Answer:** B and C

## Discussion Questions

1. Consider the different active carbon removal strategies in this lecture. Rank them in the order of efficacy in your opinion. Now rank them again in the order which you think is most likely to be implemented. Do these rankings match? Why or why not?
2. For each carbon removal strategy, consider stakeholders that would be for and against the strategy. What reasons do these entities have for promoting or discouraging these strategies? What compromises might need to take place?
3. Consider California's Low Carbon Fuel Standard. What are some benefits and challenges to this framework? Do you think that this framework is scalable, meaning that other states and countries can adopt it?
4. How can policy support technological development for negative carbon emissions?

# Chapter 19: Local Solutions

## Review Questions

1. What is necessary to maintain the health of plants, trees, and the ecosystems they support?
  - a. Clean water
  - b. Pure air
  - c. Fertilizers containing the correct balance of nutrients
  - d. A healthy living soil

**Answer:** D

2. How much food produced for human consumption is wasted due to the inefficiencies of the supply chain and the compilation of food waste?
  - a. exactly 50%
  - b. more than 66%
  - c. more than 33%
  - d. less than 10%

**Answer:** C

3. In what way(s) do/does composting improve the health of the environment?
  - a. Composting can improve planetary biomass production.
  - b. Composting acts as a carbon sink by sequestering carbon in soils and plants.
  - c. Composting rejuvenates the soil by providing it with organic matter that supports insects, annelids, and microorganisms vital to the continuation of biogeochemical cycles.
  - d. All of the above

**Answer:** D

4. \_\_\_\_\_ of carbon could be sequestered per year in agricultural soils.
- a. 500 million tons
  - b. 1.2 billion tons
  - c. 10 million tons
  - d. 9.8 billion tons

**Answer:** B

5. The products of anaerobic digestion can contribute to which environmental or industrial processes?
- a. Produces sludge that brings nutrients back to the soil as processed organic fertilizer
  - b. Produces biogas that can be used to generate electricity, provide natural gas for cooking, or processed for use in fuel cells
  - c. A and B
  - d. none of the above

**Answer:** C

6. What benefits do fruit trees bring?
- a. a. carbon sequestration
  - b. b. shade/cooling
  - c. c. food source
  - d. d. improves soil, water, and air quality
  - e. e. all of the above

**Answer:** E

7. What benefits do planting fruit trees for yourself and your local community bring?
- a. food security
  - b. more nutritious
  - c. more variety
  - d. control over fertilizer and pesticides
  - e. all of the above

**Answer:** E

8. What's the best way students can get involved with fruit trees?

- a. buy and plant one
- b. visit a local community garden/orchard
- c. read about them online
- d. cold-call experts over the phone
- e. all of the above

**Answer:** B

9. What is the most important thing to maintain for a healthy fruit tree/food forest?
- a. pure water
  - b. healthy soil
  - c. clean air
  - d. love
  - e. all of the above

**Answer:** B

## Discussion Questions

1. Global political, economic and ecological megatrends are giving rise to urban and rural development strategies referred to as localization (in part, as reactions against globalization)? Identify one or more of these global megatrends.
2. Around the world there is a rising level of interest in local and bioregional approaches to climate change mitigation and adaptation. Give an example that involves biota (e.g., trees, vegetation) and/or soil.
  - a.
3. According to an estimate shared during this lecture, how many billion tons of CO<sub>2</sub> do experts say we will need to pull out of the atmosphere by 2100 in order to avert major climate disruptions on a planetary scale?

**Answer:** Experts project that we need to sequester about 500 to 1000 billion tons of CO<sub>2</sub> (or about 150 to 300 billion tons of Carbon) by 2100.

4. Of the estimated 500 to 1000 billion tons of CO<sub>2</sub> (or about 150 to



300 billion tons of carbon) that we need to sequester by 2100, how much of this can be accomplished through ecosystem management and restoration?

5. Evaluate the strengths and limitations of local place-based efforts to address climate change (e.g., solutions focused on neighborhoods, cities and towns), as compared to solutions that are more national and global in scope (e.g., National Climate Plans, Paris Climate Accord)
6. What is green infrastructure? Identify examples of green infrastructure and indicate the degree to which you think these examples might improve climate change mitigation and/or adaptation.
7. Distinguish how a bioregional approach, including the design of local, place-based Natural and Managed Ecosystem Solutions, differs from, and can complement other types of solutions (e.g., Technology-Based Solutions).
8. When it comes to addressing climate change mitigation and adaptation, how important is local community knowledge? Can local community knowledge (e.g., from neighborhood residents, community-based organizations) help improve science-society relations and democratic public reasoning? How so?
9. Anaerobic digesters and compost bins can be used as methods of carbon sequestration and putting food waste back to the soil. In detail, compare and contrast these composting methods, describing how they each relate to food waste reduction, the continuation of healthy ecosystems, and production of goods that humans can use.
10. Describe how composting can lead to carbon sequestration. How does this improve soils and benefit environmental and human health?
11. Describe how different academic disciplines can still work on improving the health of the environment and soils. How does collaboration with different groups help accomplish common goals?
12. In the anaerobic digester module (module 5) the narrator discusses how she followed her passion of becoming an environmental engineer by joining organizations that were working on projects she

was interested in. Now it's your turn! Make a list of projects that you are interested in pursuing and why. Then, find organizations on your campus and elsewhere that work on these projects that you're interested in. How could you get involved?

13. Trees have a dynamic set of uses for the environment, people, and industry. What are some of the ways, in addition to climate, that trees help with?
14. Community gardens offer broad cross-collaborative opportunities in the planning, maintenance, and utilization of fruit trees and food forests. Brainstorm different ways academia can engage students to work interdisciplinary to address the importance of healthy fruit trees.
15. How can strategies and policy regarding food waste mitigation and climate action intersect with food forests?