1.2 Human Energy Systems Storyline Reading: Learning from the Work of an Atmospheric Chemist

Purpose for reading: *As you read this text, work to make sense of the roles you will take on during this unit and how those roles relate to the work scientists do.*

In this unit, you are learning about how human activities influence the climate of our planet. Some human activities produce gases that contribute to air pollution and warming in the atmosphere. But how do we know that? Here, you will meet a real atmospheric chemist. As a scientist she is a questioner, investigator, and explainer—roles you will take on later in this unit to find patterns in and connections between long-term trends in Earth systems.

Figure 1: Me, very excited for the arrival of a new part for the instrument I used for my research.

As a scientist, I work to understand the air we breathe. My name is Dr. Timia Crisp (Figure 1), and I received my Ph.D. in Chemistry from the University of California, San Diego. But my story starts before my Ph.D., as a student at the University of California, Los Angeles. There, I learned how human activities can affect our environment and our health. I remember sitting in a class learning about how exposure to certain chemicals in our environment can make us sick. This worried me! I thought we should take care of our planet and make sure that the chemicals we produce do not harm our environment or people. When I asked, “What can we do to prevent this?” my professor answered, “We need more people trained in chemistry doing research and communicating their results to policymakers who create environmental laws and regulations.” That was the day I decided I would be *that* chemist.

I decided to go to graduate school to do research so that we can better understand the air we breathe. I also wanted to communicate the importance of understanding air quality and our changing climate to our community and to policymakers.

Atmospheric chemists like me investigate the composition of the atmosphere – including the air we breathe. Many of the gases in the air we breathe are inert – inert gases do not easily react with other chemicals. Less than one percent of the air we breathe (in the layer of the atmosphere known as the troposphere) plays an active role in pollution and warming of the atmosphere. This means that less than 1% of the air we breathe is responsible for the things we worry about like smog and warming of the planet. Some of the gases in the troposphere that are of interest to scientists are present in very low concentrations, it’s like trying to find one person in a country of a billion people, when that person is moving *and* changing their appearance! This makes gases difficult to measure and study, yet they are important for understanding the air we breathe!

I am a questioner. I specifically looked at gases that contain chlorine. Chlorine gases can form through reactions between particles from the ocean (like the mist that you feel when waves crash) and industrial air pollution. Some come directly from industrial sources. Through additional reactions, chlorine gases form chlorine radicals (also gases). Chlorine radicals react extremely fast and can remove greenhouse gases and other pollutants from the atmosphere—kind of like a natural air scrubber. Each type of greenhouse gas and pollutant has a different lifetime, or the amount of time it stays in the atmosphere, which can range from days to years. Therefore, a gas's lifetime depends on these removal processes, like reactions with chlorine radicals.

I wanted to understand a gas's potential impact on climate and as a pollutant. In my work, I asked a few questions: how can we measure chlorine gases that form chlorine radicals, even though they are present in such low concentrations and react so quickly? How much of these gases is present in the troposphere, and where are they coming from? How do chlorine gases affect our air quality?

I am an investigator. I started my investigation like many scientists do – by reading about what other scientists had done before me. It turned out that no one had successfully measured chlorine radicals directly from the air in real time. I wondered if we could design an instrument to quickly measure (in seconds or less) the concentration of chlorine gases (called precursor gases) that lead to chlorine radicals, and then calculate the chlorine radicals that are produced. Existing instruments typically needed 30 minutes to measure the precursor gases—much too slow to understand fast-reacting chlorine radicals. So, I worked with my advisor to design, build, and test an instrument for measuring precursor gases with the hopes that we could use that information to understand chlorine radicals (Figures 1 and 2).

Figure 2: The instrument taking measurements of chlorine gases in coastal California on board the research vessel.

As with any new scientific instrument, I had to test it to determine how well it actually measures gas concentrations. First, I did a lot of tests in the laboratory because there I could test the instrument's ability to measure gases when I already knew their concentration. That way I was able to assess whether our instrument was measuring the gases accurately and precisely. After a few adjustments, the instrument demonstrated the accuracy and precision we needed, so it was time to take it out of the laboratory and into the real world!

That summer, I took my instrument on a research vessel– a large former Navy ship that was remodeled to take scientists and their instruments out into the ocean to investigate research questions (Figure 3). The vessel sailed up the coast of California from San Diego to San Francisco. This was ideal because it allowed me to investigate how sea spray from the ocean interacts with air pollution to produce those precursor gases that lead to chlorine radicals. On board, I also got to work with other scientists from across the country who were also studying gases (and particles) in the atmosphere, which helped me connect my work to the bigger picture of atmospheric chemistry research. The instrument I built performed well. It measured precursor gases in almost real time, allowing me to see changes in concentration every half-second!

Figure 3: The research vessel where our newly developed instrument took her maiden voyage.

After my time on the vessel, I analyzed my data and used mathematical calculations to understand how many chlorine radicals were present and how the precursor gases affected those levels. From my research we learned that precursor gases in that region contributed to significant levels of chlorine radicals, which impact the lifetime of greenhouse gases. This project expanded scientists' current understanding of chlorine, but also led me to ask other questions, such as how many of the precursor gases were from industrial plants vs. reactions in the air with sea spray particles. Understanding this question could help scientists get a better sense of what is having the biggest influence on chlorine radical production.

I am an explainer. While I worked on my research, I also worked with our local San Diego community to explain how we were measuring gases. I also wrote reports, which were reviewed by other scientists who gave me even more new questions and ideas. Communicating science to people in different fields and with different expertise is a very important role for scientists, especially when that science helps us understand how human activity affects people's health. The skills I learned communicating science to other people who may not have studied science helps me to talk with policymakers about how science helps our lives every day.

When you have enough evidence, you'll take on the role of explainer to put together the evidence and tell a scientific story. The Explanation Tools will help you figure out how to put the pieces together to tell a single story. Toward the end of the unit, you'll explain why the Earth is warming. Your peers will read and critique your explanations, providing feedback to help you improve your explanations.

At the end of the unit, you'll be able to answer some of your initial questions about why Arctic sea ice is melting. While your answers will be based on evidence and tell a scientific story, there will still be more to investigate and understand. Likewise, you'll be able to apply what you learn about Arctic sea ice and other systems to other science units as you continue to ask scientific questions to deepen your understanding as well as the understanding of your peers about the world around you.