INTRODUCTION

The contamination of the environment with harmful substances is one of the major problems of modern life. The world of air and water and soil supports not only the hundreds of thousands of species of animals and plants, it supports man himself. In the past, we have often chosen to ignore this fact. Now we are receiving sharp reminders that our heedless and destructive acts enter into the vast cycles of the earth and in time return to bring hazard to ourselves.

RACHEL CARSON

THREE ICONIC BRIDGES in Pittsburgh mark great heroes who represent the city's ethos in art, sports, and innovation—artist Andy Warhol, baseball player Roberto Clemente, and the environmental philosopher Rachel Carson. Carson has been recognized as one of the most important thought leaders of the twentieth century.[1] Her eloquent exposition of the inner workings of the oceans that provide us with oxygen, nutrients, and water endeared her to millions. In a day when the written word was the most prominent

form of thought-provoking discourse, Carson's influence through her book *Silent Spring* reached the highest levels of government and evoked the concerns of millions of people who read and believed her words. In the fifty intervening years since *Silent Spring* was published, her call for precaution in protecting the living earth and the need to preserve the interconnected web of life, of which humans are but one part, has continued to strike against the mainstream approach of continued reliance on extractive industries. Carson's insistence on placing nature, rather than human convenience and profit, at the center of decisions about resource management assures her continued place as a revolutionary. Her environmental ethic, forged from growing up in Pittsburgh as her town shifted from agrarian to industrial, offers guidance in this new transition to a future based on preserving the natural world.

In the twenty-first century, the cumulative consequences of human behavior now threaten the viability of all life on earth. Earth bears the scars from 150 years of industrialization, which brought about economic progress without much regard for polluting the air, water, and land.[2] Today the long-term consequences have arrived in the form of climate change and global pollution. Climate change compromises the life support system of all oxygen-breathing, freshwater-dependent organisms, including humans, while global contamination from synthetic chemicals and their byproducts, especially those with endocrine-disrupting properties, threatens the health of creatures throughout the biosphere.[3] If the children of the twenty-first century are to have a viable future, human destruction of the interconnected web of life must stop. The window of opportunity to change direction may be very narrow, the remaining time to take a corrective course very brief.

To transition quickly from an economy that depends on fossil material—oil, gas, and coal; synthetic chemicals—to a system that operates on a renewable and sustainable base requires a commitment to preserving the living, natural world. The challenge of this transition is enormous because all aspects of modern civilization depend on fossil fuels. Transportation, power, heat, light, and machinery all operate on petroleum, coal, and natural gas. Industrialized food production depends on petrochemically derived fertilizers, herbicides, pesticides, and fossil-fuel-powered mechanization for cultivation, transportation, processing, and distribution. Construction materials, textiles, packaging, and consumer products come from plastics and synthetic materi-

als derived from fossil carbon sources. The entire economy runs on the infrastructure of extracting, transforming, and consuming fossil carbon, which compromises the viability of global living systems upon which future generations will depend. However, making a shift away from the fossil-fuel-based economy is critical for many reasons, including and especially climate change, wasteful and inefficient energy production processes, national security, and pollution and its effects on human and environmental health.

To set the discussion of climate change in context, it is important to recognize that the shape of the earth's orbit around the sun is the greatest long-term determinant of the earth's climate. As first described by the Serbian astrophysicist Milutin Milanković (1879–1958), the orbit of the Earth slowly shifts from an eccentric elliptical path to a nearly circular path over a period of 90,000-to-100,000-year cycles.[4] When the orbit is most elliptical, the winter period when the Earth is farthest from the sun lasts much longer than the summer period, allowing ice to accumulate progressively, forming the Ice Ages. When the orbit is more nearly circular, the climate is more temperate. Milanković also described the tilt of the Earth on its axis, creating the seasonal variations in the amount of solar exposure, and the "wobble" of the Earth's rotation on its axis. The current orbital configuration is closer to circular, Holocene epoch, and expected to last for approximately another ten thousand years before the elongated orbit ushers in the next major period of glaciation.[5]

Within the Holocene period—roughly aligned with the current orbital configuration and beginning approximately 11,700 years ago—the climate has been controlled by three major forces: the periodic oscillation of the sun's intensity, cycling over an eleven-year pattern of waxing and waning; the alternation of warming and cooling from El Niño and La Niña in the ocean heat sink in deep waters; and the periodic eruptions of volcanoes. These forces have shaped the variation in weather and the overall pattern of climate cycles for millennia, as documented by empirical data from ice cores and fossil sediments.[6] Over ten thousand years, the average period between glacial stages where ice covers the earth, the combined effect of all of these forces cycled the climate within a range of 12 degrees Celsius.[7] However, within the last hundred years, and most acutely in the last fifty years, a fourth influence on the climate has taken place: human activity.[8] Burning fossil fuels for energy is the most significant cause of climate change in modern times.

The steady, temperate climate with an oxygen-rich atmosphere that has characterized the Holocene epoch is shifting. Examined objectively, the evidence is alarming. The global carbon dioxide concentration has escalated sharply in the last fifty years from its preindustrial level of 278 parts per million (ppm) to over 400 ppm in September 2014, with an expected rate of rise of 1.8 ppm per year.[9] The atmospheric carbon dioxide concentration now is higher than has occurred at any time in the last fifteen million years, according to paleoclimatic and geologic evidence.[10] The science is unequivocal that humans are the cause of global warming, and major changes are already being observed: Global mean warming is 0.8°C above preindustrial levels; oceans have warmed by 0.09°C since the 1950s and are acidifying; and sea levels have risen by about 20 centimeters since preindustrial times and are now rising at 3.2 centimeters per decade. An exceptional number of extreme heat waves have occurred in the last decade, and major food-crop-growing areas are increasingly affected by drought.[11] In addition, the cycles from hot to cold are more severe, with lengthy drought cycles and winter arctic vortex conditions dipping far into the continental United States and lingering for days.[12]

Compared to the early industrial period, scientists now have a better understanding of the connections between fossil fuel combustion adding billions of pounds of carbon dioxide to the atmosphere and the changes in the composition of the air, in climate, and in the composition and chemistry of the waters of the ocean.[13] According to a 2011 report by the National Research Council,

> the scientific consensus shows conservatively that for every degree of warming, we will see the following impacts: 5–15 percent reductions in crop yields; 3–10 percent increases in rainfall in some regions contributing to flooding; 5–10 percent decreases in stream-flow in some river basins, including the Arkansas and the Rio Grande, contributing to scarcity of potable water; 200–400 percent increases in the area burned by wildfire in the US; 15 percent decreases in annual average Arctic sea ice, with 25 percent decreases in the yearly minimum extent in September.

Even if all carbon dioxide emissions stopped, the climate would continue to warm for several more centuries. Over thousands of years, this could unleash amplifying feedbacks leading to the disappearance of the polar ice sheets and

other dramatic changes. In the meantime, the risk of catastrophic wild cards "such as the potential large-scale release of methane from deep-sea sediments" or permafrost, is impossible to quantify.[14]

America has not yet seized climate change as a galvanizing issue for leadership. Political debate often touts the lack of certainty about the causes, permanent effects, or human contributions to climate change. The US military, however, recognizing its responsibilities for preparedness regardless of political consensus, has responded with precautionary planning. In his introduction to the Department of Defense's climate change analysis, the Climate Change Adaptation Roadmap, published in 2014, then-secretary of defense Chuck Hagel states, "Politics or ideology must not get in the way of sound planning. Our armed forces must prepare for a future with a wide spectrum of possible threats, weighing risks and probabilities to ensure that we will continue to keep our country secure."[15] Secretary Hagel notes, "The challenge of global climate change, while not new to history, is new to the modern world. Climate change does not directly cause conflict, but it can significantly add to the challenges of global instability, hunger, poverty and water shortages, pandemic disease, disputes over refugees and resources, more severe natural disasters—all place additional burdens on economies, societies and institutions around the world."[16]

Air pollution is another inevitable consequence of coal combustion in factories or power plants, oil refining and gasoline combustion in cars, or natural gas extraction. As the cumulative effects of fossil fuel combustion continue to increase, the health of people everywhere is showing the strain. In announcing new proposed regulations for reducing emissions from existing fossil-fueled electric generation units, EPA administrator Gina McCarthy said, "Rising temperatures bring more smog, more asthma, and longer allergy seasons. If your kid doesn't use an inhaler, consider yourself a lucky parent, because one in 10 children in the U.S. suffers from asthma. Carbon pollution from power plants comes packaged with other dangerous pollutants like particulate matter, nitrogen oxides, and sulfur dioxide, putting our families at even more risk."[17] In addition to carbon dioxide and the fine particulate matter, sulfur dioxide, and nitrogen oxides mentioned by McCarthy, the air we breathe is now also infused with volatile organic compounds, heavy metals, and radioactive materials released from the mineral deposits. A 2010 study by the Clean Air Task Force estimated that air pollution from coal-fired power plants accounts for more

than 13,000 premature deaths, 20,000 heart attacks, and 1.6 million lost workdays in the United States each year. The total monetary cost of these health impacts is over $100 billion annually.[18] The oldest 10 percent of coal-fired power plants, those operating for fifty years or more, contribute the most emissions, and cause the majority of the health and climate effects.[19] Another aspect of environmental pollution having a significant impact on human health is the production and use of synthetic chemicals and pharmaceuticals. For example, many synthetic chemicals affect the endocrine system, the internal communication system of all animals, including humans. Natural hormones within the body bind to a specific receptor to produce a specific response. The timing and duration of the hormone's presence can drastically change the effects. Some synthetic chemicals in common use today can act like hormones, in that they can bind to the hormonal receptor and block the normal hormone from acting, or they might mimic the natural hormone but cause an abnormal response.

As people accumulate exposure to these endocrine-disrupting contaminants, the normal endocrine system comes under stress. The chemical messengers that coordinate the functions of the brain, the immune system, and the endocrine system operate in the body at extremely low levels. Most natural hormones are active in blood concentrations of parts per trillion. That would be equivalent to a drop of dye in a train of railroad tankers ten miles long. Thus, even if such endocrine-disrupting chemicals appear in very low concentrations in our environment—parts per billion, for example—that is still much higher than the active level of natural hormones in the body. Numerous studies show that astoundingly small quantities of these hormonally active compounds can wreak all manner of biological havoc, particularly on those exposed in the womb.[20]

The rise of environmental awareness in the early 1970s sought to legislate air and water emissions, and limit the use of some kinds of chemicals, but this regulatory approach has allowed billions of pounds of toxic materials into the environment legally, without addressing the underlying problems. For example, approximately 3.89 billion pounds of toxic chemicals were released in the air or water or were disposed in landfills in 2014.[21] Even if emissions are controlled to a very low concentration, if the compound or its byproducts are taken into the food chain they can become concentrated. Consequently, very

low levels in water or soil can become more dangerous to tertiary consumers, such as people or eagles, at the top of long food chains.

PATHWAYS TO A SUSTAINABLE FUTURE—WHY PITTSBURGH?

The challenges manifest today present a daunting complex of causes and effects across all aspects of society, but an examination of the progress of a single important city may provide insight for a way forward.

Pittsburgh, Pennsylvania, sits at the confluence of the Allegheny and the Monongahela Rivers forming the Ohio, which flows into the Mississippi River and, ultimately, the Gulf of Mexico 1,981 miles away. An attractive center for civilization and trade among indigenous peoples who occupied the land for centuries before European colonists arrived, and contested by the French and the British for its strategic location, Pittsburgh played an important role in the formation of America as an independent nation. The two rivers funneled both travelers and materials into the growing city as it became a center for manufacturing, trade, and westward migration. In the late 1800s Pittsburgh led the Industrial Revolution in mobilizing and organizing both labor and industrial capacity.[22] During its peak, post–World War II Pittsburgh personified the hardworking toughness that won the war and built the industrial might of the country.

Pittsburgh's glass, metal, and chemical industries built the nation with a flourishing spirit of innovation, invention, and grit. And just as Pittsburgh was a leader in the rise of the industrial age, this city has taken a lead in the shift to the modern era of the electronic, high-tech-based industry of the future. The transition catalyzed by the collapse of the local steel industry in the late 1980s grew from the tremendous intellectual capital of Pittsburgh. The city's concentration of prominent universities attracts talent and resources, and with a strong collaborative spirit and leadership, the universities have made major contributions to innovation and problem solving both in industry and government. The people of Pittsburgh have pride, resilience, a strong work ethic, and a sense of place.

This is also a time of sharp division with the city and the surrounding areas with people's goals and expectations moving in different directions. Pittsburgh

stands at an intersection between the historic extractive and fossil-fuel-based industries and the potential for a renewable and sustainable future. The advance of the Marcellus and Utica shale gas discoveries draws a tremendous amount of resources and attention to the region. County, state, and federal laws and policies strongly support the shale gas industry. But between and under this surge of the newest fossil fuel development, a different path emerges within the interstices. Active struggle from differing perspectives and motives fuels the debate about how best to move forward, yet out of this struggle a new vision for Pittsburgh has emerged, one built on sustainability and resilience principles, respect for the diversity of cultures, and precaution in restoring and preserving the health of its natural environment.

Pathways to a Sustainable Future shows how Pittsburgh is addressing sustainability issues. The solutions are not necessarily found in technology alone; rather, the pathways forward are based on the ethical and moral basis for making choices about the future. The case studies presented here show the decision points scattered throughout the fabric of this community where individuals, companies, and institutions have made decisions to move in a new direction, not necessarily in the mainstream.

> *Those who contemplate the beauty of the Earth will find reserves of strength that will endure as long as life lasts. There is something infinitely healing in the repeated refrains of nature—the assurance that dawn comes after night, and spring after winter.*[23]
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> **RACHEL CARSON**

Pathways to a Sustainable Future travels in the direction Rachel Carson indicated—a path to where people live in harmony with nature's laws, as participants in thriving ecosystems. The first part addresses the essential connection between people and the earth, its living systems, and how people can reconnect with the natural world. The second addresses some sustainable directions to providing energy, food, and materials. It explores the policies embedded in the current system and some of the new directions to achieve change. The third

part examines the social and cultural impediments to change and the means to address them. This is a book of empowerment, inspired by Rachel Carson whose voice rose in challenge to a system that presented danger to living systems and moved thousands to respond. The situation facing humanity today calls for a unified response in defense of the earth, for the sake of all of its living creatures, including the children of the twenty-first century. The stories of Pittsburghers blazing new pathways share their struggles and their hopes for a sustainable future. It is time to act.