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Medical Models for Helping Us Understand Global Environmental Threats

Keynote by Eric Chivian M.D. at the Rhode Island Land & Water Conservation Summit

Introduction

Thank you Senator Whitehouse for that wonderful introduction. I am very sorry that my parents are no longer around, for my father would have been very proud to hear it, and my mother would have believed every word. I also want to thank Rupert Friday for inviting me to give this keynote, and to all those who have been involved in helping put this important conference together.

Before beginning I want to ask everyone in the room to stand and join me in thanking you Senator Whitehouse for being the most powerful, best informed, most persistent, most compelling voice today in the United States Senate for protecting our small planet from the catastrophe of climate change.

I am delighted to be here this morning at this pivotal moment in human history, when we must figure out how best to address the unparalleled global environmental dangers we face, the greatest threat ever to humanity, at a time when the present Administration, and many, many Americans, seem unable or unwilling to understand what lies ahead if we continue our present course. I will try to shed some light on this dangerous disconnect, and will speak about some medical models that may be useful in helping people better understand these dangers.

But first, a story. It seems that when Donald Trump and Steve Bannon were visiting Alaska to meet with Sarah Palin about a possible job for her, she invited them to go bear hunting. So they drove to a nearby mountain, and waited with their rifles loaded. After a while a large brown bear came into view and Trump, Bannon, and Palin raised their guns, aimed, and fired. But all the triggers jammed. The bear heard the sound, and as it

started charging towards them, in a panic, in unison, Trump, Bannon, and Palin began to pray. They said "Dear Lord, we have always been your faithful servants, Dear Lord, Please, please, please make that bear a Christian." And just at that moment, the bear came to a sudden halt, and raised its huge paws to the sky and said "Dear Lord, I thank thee for the gift I am about to receive."
As you can probably tell, I am rooting for the bears, even though two black bear completely destroyed my orchard's beehives some years ago. I am rooting for them because they are truly remarkable creatures, extremely valuable to human medicine, as you will soon hear.

Since our Oxford University Press book
Slide 1— <u>Sustaining Life: How Human Health Depends on Biodiversity</u>
was published in 2008, I have spoken mainly about the book's subject, providing examples of how our health and lives are affected when we damage the living world. I will do some of this today, but because I am increasingly alarmed about how rapidly we are altering planetary systems and how relatively few people seem to fully recognize this, I have been spending a lot of my time these days lecturing on what you will hear today.

Slide 2—Nobel Peace Prize
In 1980, with three other Harvard faculty members, I started an organization called the International Physicians for the Prevention of Nuclear War, which eventually included some 80 national organizations of physicians around the world. In 1985, we won the Nobel Peace Prize. I'm that guy with the hair holding the prize. The most important contribution of the tens of thousands of physicians who were eventually part of this federation was to help people grasp what a nuclear war would really be like, so that they knew that these weapons were so catastrophically destructive that they could not be used in wartime, and so policy-makers and the public would do everything in their power to prevent a nuclear war from occurring.

We did this by translating the abstract, technical science of nuclear weapons explosions, that world class scientists had been talking about and warning about for decades, into the concrete, personal terms of human health, into everyday

language that people could relate to and understand—namely what would really happen to us in such a war. We talked about skull fractures instead of the force of the explosion, about 3rd degree burns instead of the temperatures in the fireball, and about radiation sickness instead of the amount of radiation in the fallout. And, as a result of these medical stories, I believe we helped make nuclear war more real for people, we made it harder for them to think about such wars in vague, abstract, technical terms, and in the process, I believe, we helped change public opinion and indeed maybe even public policy about the use of these weapons. That was why, in addition to our bringing physicians from the Soviet Union and the US and their allies together at the height of the cold war, we won the Nobel Peace Prize.

But, in contrast to nuclear weapons explosions, changes to the global environment like climate change and the loss of biological diversity are much harder to grasp. We have no Hiroshimas or Nagasakis to serve as models, as concrete examples of what will happen.

Global environmental changes, unlike explosions, can also be very hard to see—they often occur slowly or intermittently, sometime almost imperceptibly, and on global scales, and they can be obscured by normal fluctuations in things like temperatures or rainfall, which are changing naturally and often abruptly and with large swings all the time. Our brains are wired to see what is happening right in front of us right now—we don't do very well with seeing things that are not obvious, that happen incrementally, or that occur over large areas or in other parts of the world.

It is very hard, for example, for us to grasp the meaning of concepts like average global temperatures. When we hear scientists say that the surface of the planet has warmed on average by about 2.0 degrees Fahrenheit since 1880 or so, around the time the Industrial Revolution began and humanity started burning fossil fuels on a large scale, and when we hear leading scientists say they are beside themselves with worry that the Earth may warm by an additional 8 or more degrees by the end of this century, or some 10 degrees F. warming in all, if we do not change our ways, it is hard for many of us to be terribly concerned about this. After all, it was minus 13 degrees

F. in Petersham, Mass. where my heirloom fruit orchard is located a year ago on Feb. 15th, and two days later it jumped to 55 degrees F., an increase of 68 degrees in less than 48 hours. With such enormous temperature changes that we frequently experience even over short periods, many may ask "what's a measily10 degrees of warming by 2100?" But what we are talking here is global averages, a concept that it is very difficult to wrap one's mind around. Our experience with temperature is very much what is happening right here, right now. To help put into perspective what an average warming of the Earth's surface of 10 degrees F. really means, let us go back in time to the end of the last Ice Age, some 18,000 years ago. At that time, when the average temperatures of the Earth's surface were only about 10 degrees F. cooler than they are now, there was a layer of ice on top of where we are now sitting that was more than one mile thick and the Atlantic Ocean was about 400 feet lower than it is now. That is the scale of what a change in average global temperatures of 10 degrees is like.
All the changes we have already seen secondary to climate change—the dramatic increase in extreme weather events, the heat waves and droughts and fires, the enormous storms, the melting of ice all over the world, the dying of conifer forests in western states and in Canada, the bleaching and loss of coral reefs, the coastal flooding, the change in the range of disease vectors, the extinction of countless species that could not adapt, all these changes have occurred with an average warming of only around 2.0 degrees F., not over thousands of years, but only since about 1880. So when we are talking about a possible average warming totaling 10 degrees F. by 2100, if we don't reverse the course we are on, we are talking about a world I believe we would have trouble recognizing.

The task of grasping changes to the global environment is also made more difficult:

- **because there is such a fundamental misunderstanding that many, if not most, people have about the environment—believing that we human beings are somehow separate from it, that it exists outside of us. And so, as a result, many people are not terribly worried about our degrading the atmosphere, or the oceans, or soils, as if these changes will have little to no effect on them whatsoever, almost as if they were happening someplace other than where we all live.**

- **Understanding what is happening to the environment is also hard for many people, because scientists who describe this often speak in technical, jargon-filled language that most people cannot follow. I am sorry to say that scientists are mostly trained to talk only to one another, a problem, which is becoming more and more pronounced as science becomes more and more specialized.**
- **Moreover, scientists are always talking about probability, and will never say with certainty, for example, that we are causing North Atlantic hurricanes to become larger and more powerful with our ever-increasing use of fossil fuels, or Arctic Ice and Greenland to melt. Scientists are always hedging their bets, for that is the way of science, to provide the best and most probable explanation for a series of observations, until a better one comes along. The deniers, on the other hand, are often more convincing as they are always 100% certain.**

There are other reasons that we human beings have such a hard time grasping what we are doing to the environment

- **For one, the storms and floods, drought, fires, famine, extinctions, and epidemics associated with climate change are too frightening and overwhelming to most people for them to want to think about, and seem too large and difficult to solve, making them feel hopeless and helpless, feelings we all will do anything to avoid experiencing. Frankly, I too would rather have a glass of wine and watch Antiques Roadshow than think about Greenland melting.**
- **Many people also feel that changes to the environment are not worth worrying about, believing that if science got us into this mess, it can surely get us out—that we will invent or synthesize or engineer our way out of all of our difficulties. And while science has much to offer, we must be humble and fully aware of its limitations, especially in the face of understanding and in finding ways to alter highly complex systems.**
- **And, finally, there has been a widespread, sophisticated, and highly effective campaign, much as there was by the tobacco industry, to cast doubt on the science of global environmental change and to discredit the scientists, and here I am speaking for myself, and myself alone, not for the organizers of this conference or anyone or any group**

connected to it in any way. You need to know that I am increasingly outspoken these days, as I try to follow the advice of Ghandi as much as I can, who said that in life, "one must be truthful, peaceful, and fearless".

And this profoundly and dangerously ignorant campaign of disinformation has been funded by some corporations and individuals, and has been disseminated by many politicians, including our President, and the chairs of the House Science Committee and the Senate Environment and Public Works Committee, and the head of the EPA, and by right-wing think tanks like the Competitive Enterprise Institute, and by some media outlets like Fox News and the editorial pages of the Wall Street Journal, and talk show hosts like Rush Limbaugh, which tens of millions of people read, watch, and listen to. So it is not at all surprising that many people believe there is a significant debate going on in the scientific community, which there is not, about whether human activity is harming the global environment, and that many people don't know what or whom to believe. I'm afraid there is no other way to say this, but in my view, those who support this campaign while knowing full well the dangers involved are guilty of "crimes against humanity."

So that is my first point. That man-made changes to the global environment are too technical and complicated and abstract for most people to grasp, too frightening and unpleasant for them to want to think about, and that people are highly vulnerable to being lulled into believing that the changes we are experiencing are the result of natural cycles and are not worth worrying about. And so, as was true with the issue of nuclear war, we must help educate people about what is really happening to the environment in language they can relate to and understand, and there is no more compelling way to do this, in my view, than by talking about health. That is why I am here today.

Now, my 2nd point.
Let me give you a few examples of the value of using a medical model to help people understand the human consequences of altering the global environment.

Slide 3—Polar Bear and Cubs

Polar bears, these magnificent creatures, the Earth's largest land carnivores, evolved from brown bears around the same time as did our species, some 195,000 to 200,000 years ago. It is predicted that they will be extinct in the wild by the end of this century if not before,

Slide 4—Polar Bears and Melted Ice
Largely because of global warming and the melting of the Arctic ice sheet, as this leads to their inability to capture seals, their main food. Polar bears wait at thin areas of ice for seals, marine mammals like themselves, to come up for air. But if there are large areas of open water, which is increasingly becoming the case, the Arctic Ice sheet is at its lowest level since our species first walked on Earth [and could be completely free of ice, even with a total average warming of the Earth's surface of 3.6 degrees F. (or 2 degrees C.), the goal of the Paris Summit], then seals can allude capture. That is why polar bears are starving, having fewer cubs, and are threatened. Polar bears have become iconic figures in discussions about what we will lose if we don't reduce our reliance on fossil fuels—adorable polar bear cubs are on almost every environmental poster, and people are heartbroken by their expected loss. But polar bears' medical value is almost never mentioned. Let me tell you about this.

Slide 5—mother black bear and cubs
This shows a mother black bear and her cubs hibernating. Her glazed expression is the result of her having been put to sleep with an anesthetic dart. Like all bears that hibernate, polar bears are essentially immobile for 5-7 months or more, and yet they don't get osteoporosis, the loss of bone mass.

In each of us, there is a dynamic process going on where cells called osteoblasts are making new bone, and other cells called osteoclasts are resorbing bone, so that bone architecture is constantly being remodeled. Under conditions where there is no weight bearing, no muscles pulling on bone, the equilibrium shifts to one's bones become thinner and weaker. Every other mammal, including human beings, even other true hibernators like woodchucks and bats, lose bone mass during periods of prolonged immobility. We lose a third or more of our bone, for example, after 5 months of being bed ridden.

But hibernating bears do not. Osteoporosis is a huge public health problem for the elderly, and particularly for post-menopausal women, because of the role of estrogen. We can do many things to reduce our risk, like get enough Calcium and Vitamin D in our food and in supplements, stay active, and exercise regularly. We can also take medicines called bisphosphonates to reduce the amount of bone loss or to halt it, but we cannot put back new bone once it has been lost. Osteoporosis causes more than 70,000 deaths in the U.S. each year. We have the highest osteoporosis rates in the world. Hibernating bears have compounds in their blood streams that prevent osteoporosis, compounds that may someday allow us to effectively treat, and possibly even prevent, this largely untreatable disease.

Bears also don't eat, drink, urinate, or defecate for the months they are hibernating, and yet they don't become dehydrated, don't starve, and don't get sick from not urinating. If we don't urinate for a few days, we die. No-one fully understands how bears do this, but somehow they are able to recycle their urinary wastes, break them down, and turn them into proteins. More than 26 million Americans have chronic kidney disease, many of whom go on to kidney failure. There is no treatment other than dialysis or kidney transplantation for kidney failure, which kills more than 87,000 people each year in the U.S. alone. By studying hibernating bears, we may find ways of treating this dreaded condition.

Finally, Polar bears become massively obese on seal blubber prior to hibernating, but they don't develop Type II diabetes, as we tend to do when we become obese. This is also not well understood. Obesity-related Type II diabetes, which is essentially epidemic in the U.S., now causes ¼ of a million deaths each year. The U.S. has the highest obesity rates in the world today, with some three quarters of adults being either overweight or obese. It is estimated that cases of obesity-related Type II diabetes will double or triple in the U.S. by the year 2050, resulting in as many as 1/3rd of American adults having the disease.

With the loss of polar bears, which must be studied in the wild as bears don't hibernate in zoos, we may lose with them the secrets they hold that could allow us to treat, and perhaps even

prevent, three largely untreatable diseases—osteoporosis, kidney failure, and obesity-related type 2 diabetes—that together kill more than 400,000 Americans each year. That is what global warming and the melting of Arctic ice and the loss of polar bears in the wild really means for us.

Slide 6—Coral Bleaching—

- **Another example involves the loss of coral reefs, increasingly threatened in tropical regions the world over, both from ocean warming and acidification. New estimates are that a third of the world's reefs are in mortal peril, even the Great Barrier Reef. This is a photo of coral bleaching off the coast of Florida. Corals live within very narrow temperature ranges and when these temperatures are exceeded, even by a few degrees for a few days, they can become bleached by losing the microscopic algae that live within their tissues and that give corals their color. With the loss of the algae, the corals become vulnerable to infections and suffer high mortality, taking with them the enormous numbers of other organisms that live in the reefs. Coral reefs have been called "the rain forests of the seas."**

Slide 7—Conus bullatus—

- **This is a cone snail called *Conus bullatus*. Cone snails are a large group of predatory snails that mostly live in tropical coral reefs.**

Slide 8—Close up of cone snail harpoon.

They defend themselves and paralyze their prey for food—worms, small fish, and other mollusks---by firing a poison-coated harpoon at them. There are 700 known species and each one makes some 200 distinct toxins. Only 100 or so of the estimated 140,000 toxins have been studied in any detail, but even among this extremely small percentage of the total, they have been shown to target almost every known molecular receptor on our cells—from nerve cells to heart cells to those in other organ systems—that regulate the functioning of those cells. One of these toxins has been discovered to be a pain-killer, that is not only 1000 times more potent than morphine, but which does not cause addiction or tolerance (the condition where one has to keep giving larger and larger doses with continued use, as the

effectiveness lessens over time). Opiates like morphine are extremely effective pain-killers for acute pain, but because of tolerance, they are not for severe, chronic pain. The finding of a potent pain-killer from cone snails that does not cause tolerance is a watershed event in medicine. Some believe that cone snails may provide more leads to important medications for people than any other group of organisms in Nature. And yet, as I said, they live in coral reefs, which are threatened worldwide. That is what warming and acidification of the oceans and losing coral reefs really means for us.

Finally let me switch gears a bit and talk about another area of environmental change—deforestation, in this case complicated by climate change.

Slide 9—Map of Lyme Disease Cases

- **This is a map of the U.S. a few years ago showing cases of Lyme Disease. Note the concentration of cases in the Middle Atlantic states and southern New England, the upper Midwest, parts of California, and a smattering of cases in the south east and north western parts of the country.**

Slide 10—Blue States and Red States

- **You can see that the distribution of Lyme cases is surprisingly concentrated in the blue states during the 2004 Presidential election. This fact has caused some to conclude that Lyme disease may have a positive effect on portions of one's brain that are the seats of intelligence and judgment. In 2008, Obama and Biden captured former red states like Iowa, Ohio, Virginia, and others, leading some to suggest that we should be looking for Lyme disease in those states as well.**

This is all totally bogus. I just wanted to be sure you were paying attention.

Slide 11—Lyme tick

- **Lyme disease is the most common vector-borne disease in the U.S. today. Until just two years ago, it was estimated that there were only some 30,000 or so cases each year, but the Centers for Disease Control now says that this figure may be**

only 1/10th of the actual total, and new figures estimate that there are more than 300,000 cases in the U.S. each year. The reason these numbers are difficult to estimate is that a very large number of cases are missed. Lyme is often very hard to detect, as many of you may know. The early symptoms resemble a bad flu, the ticks are very small and hard to see and may not cause a local skin reaction, the classic bulls eye rash of Lyme, appears in only 75 to 80% of people, and the blood tests are often negative early on. If left untreated, Lyme can result in serious chronic health problems, with effects on joints, the nervous system, and the cardiovascular system. I suspect many people in this room have had Lyme or know of someone who has.

Now, it was noticed that in some parts of the country where there was little vertebrate diversity, there was more Lyme disease, and some elegant research demonstrated why this may be so. Lyme is a complex disease involving the infectious agent, a bacterium, a spirochete named *Borrelia burgdorferai*, the transmitter or vector of the bacterium, the black-legged tick in the Eastern U.S., also called the deer tick, shown in this slide, and hosts that support the proliferation of the pathogen and its passage to another host.

Slide 12—White-footed mouse

- **In the East, the most important host is the white-footed mouse. Humans are an incompetent host. In fact we are dead-end hosts, that is, we can get Lyme disease, but we do not pass it onto other organisms when ticks bite us and then bite other animals. It turns out that ticks are omnivorous feeders and they bite almost any vertebrate that crosses their path in search of a blood meal. They will bite us, our dogs and cats, other rodents like chipmunks or squirrels, birds, even reptiles. Many of the animals ticks bite, like us, are incompetent or dead-end hosts. So if there is a lot of vertebrate diversity, then there are a lot of animals around for ticks to bite that do not pass on the Lyme infection. The result is that Lyme bacteria become diluted in hosts that do not pass it on, and therefore it is less likely for ticks to become infected in these areas, and for them to pass the disease onto people.**

There is another mechanism that keeps infection rates lower for us when there is greater vertebrate diversity, and that is

there are more animals competing with white-footed mice for food, like other rodents, and there are more animals that eat white-footed mice, like foxes and hawks and weasels and bobcats, which eat mice like Godiva chocolates, all of which results in reduced white footed mouse populations, and a lower chance for people in these forests to become infected with Lyme. The diversity of vertebrates serves as protection for our getting a serious infectious disease.

Slide 13—Forest Fragmentation in Bear Lake Maine

- **The fragmentation of forests in the U.S. is one of the main reasons for losing vertebrate diversity, which then increases our risk of getting Lyme, particularly for those living at forest edges. This is a photo of forest fragmentation around Bear Lake, in Maine with clear-cut patches from several acres to tens of acres. Such deforestation, now happening all over New England not only threatens countless species like woodpeckers and owls and forest floor organisms like salamanders, it also leads to an increased risk of Lyme disease.**

Slide 14—Lyme Spreading in Maine

- **This slide shows a 10 fold increase of Lyme cases in Maine from 2004 to 2009, a result, it is believed, of both increasing forest fragmentation and warmer winters, the latter allowing ticks to survive in areas where they had previously died from the cold. You can see that Lyme cases are moving from warmer southern coastal regions, both northward and inland. [tell about moose cubs?]**

The Medical Model--Evidence and Proof

I want to start winding up my talk by looking at the role of evidence and "proof" in medicine and how important they are as models for helping people understand the need for action when the risks are great. This is my 3rd and last point.

In making a medical diagnosis, a physician relies on genetics, the present and past history, a physical exam, lab tests, and imaging studies like x-rays, cat scans and MRIs. Unlike in science where one tries to prove a hypothesis, in medicine, it is rarely possible to have enough evidence to establish a proof, before one has to act. Decisions are made based on an accumulated

body of evidence, and the urgency of making them is based on the degree of risk involved. The greater the risk, the less evidence one relies on before making a decision. This is what is called the "precautionary principle". In medicine, it is not an abstract scientific idea, it is something medical professionals must deal with everyday. Let me give you an example.

If a child less than one month old shows up at the hospital with a fever of more than 100.4 degrees F., or 38 degrees Celsius, he or she is immediately put on two broad spectrum antibiotics after blood, urine, and cerebrospinal fluid (the fluid that bathes the brain and spinal cord) are drawn for bacterial cultures. One doesn't wait until the cultures come back two days later before starting treatment, one can't afford to wait, for in that time, a bacterial infection could spread rapidly through the infant's body and kill it. More than 90% of fevers in infants are, in fact, caused by viruses, not bacteria, and are not treatable by antibiotics, and only a small fraction of those that are caused by bacteria go on to cause serious problems or death. But the risk of not starting antibiotics immediately on all of the infants with high fevers is much too great, for by not doing so, one takes the risk that one or more of them, perhaps one out of a hundred, perhaps one out of a thousand, will become dangerously ill and may die. That is a risk no pediatrician is willing to take.

This is the model we need to use for making decisions about reducing greenhouse gas emissions and for addressing other assaults to the global environment. The risks of inaction and delay are so enormous, so potentially catastrophic for the planet, not just for now, but for hundreds and thousands, and in the case of the melting of Greenland and the Antarctic and the acidification of the oceans, perhaps for tens of thousands of years to come, that to wait to act until we have absolute proof, absolute certainty of what will happen, is to take a risk with the physical, chemical, and biological systems of the planet, to do, in essence, a global experiment with our own health and our lives, to take a risk that no member of congress, no president, that no-one should ever be willing to take. This is the lesson of medicine.

Conclusion

Slide 15—Voyager I pale blue dot

I want to end my talk with this next image that was taken by the Voyager I Spacecraft. Voyager I, launched in 1977 with computers that had one-240,000th the memory of a low-end I-phone today, left our Solar System in 2014 after 37 years in space, having travelled for 11.7 billions miles, equivalent to 125 trips between the Earth and the Sun. At the suggestion of Carl Sagan, on Feb. 14th, 1990, when the spacecraft was over 4 billion miles from the Earth, NASA directed Voyager to turn around and photograph the planets of the Solar System. One image showed the Earth, what Sagan called "the pale blue dot", here enlarged.

I want to read what Carl Sagan, whom I was lucky enough to know and to have considered a friend, what Carl, who died tragically at a very young age, said about that pale blue dot.

"Look at that dot. That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives. The aggregate of our joy and suffering, thousands of confident religions, ideologies, and economic doctrines, every hunter and forager, hero and coward, every creator and destroyer of civilization, every king and peasant, young couple in love, mother and father, hopeful child, inventor and explorer, every teacher of morals, corrupt politician, and "superstar", every "supreme leader" every saint and sinner in the history of our species lived there—on a mote of dust suspended in a sunbeam.

The earth is a very small stage in a vast cosmic arena. Think of the rivers of blood spilled by all those generals and emperors so that, in glory and triumph, they could become the momentary masters of a fraction of a dot. Think of the endless cruelties visited by the inhabitants of one corner of this pixel on the scarcely distinguishable inhabitants of some other corner, how frequent their misunderstandings, how eager they are to kill one another, how fervent their hatreds. Our posturings, our imagined self-importance, the delusion that we have some privileged position in the Universe, are challenged by this point of pale light. Our planet is a lonely speck in the great enveloping cosmic dark. In our obscurity, in all this vastness, there is no hint that help will come from elsewhere to save us from ourselves.

The Earth is the only world known so far to harbor life. There is nowhere else, at least in the near future, to which our species could migrate. Visit, yes. Settle, not yet. Like it or not, for the moment the Earth is where we make our stand.

It has been said that astronomy is a humbling and character-building experience. There is perhaps no better demonstration of the folly of human conceits than this distant image of our tiny world. To me, it underscores our responsibility to deal more kindly with one another, and to preserve and cherish the pale blue dot, the only home we've ever known."

My wife and I live in Boston's Fenway Studios, a national historic landmark, two blocks from the Boston Red Sox's Fenway Park, built for artists as live-work space—she is a print-maker, painter, and art professor. We live in the studio that was first occupied in 1905 by painter and teacher Philip Leslie Hale, grand nephew of Edward Everett, a governor of Mass., U.S. Senator, Secretary of State, and a great orator who had the highly unfortunate role of being the warm-up act for Abraham Lincoln at the dedication of the Gettysburg National Cemetery in 1863, speaking for a full 2 hours, followed by Lincoln's 2 minute Gettysburg Address.

Philip Hale's father, Edward Everett Hale was a polymath author, editor, historian, abolitionist, and Chaplain of the U.S. Senate. He is known for a quote that I believe summarizes what each of us goes through in our work to protect the environment, what each of us feels on some level whenever we try to do anything that is larger than ourselves. So I want to honor Edward Everett Hale's memory by repeating what he said---

"I am only one, but I am one. I cannot do everything, but I can do something. And because I cannot do everything, I will not refuse to do the something that I can do. What I can do, I should do. And what I should do, by the Grace of God, I will do."

So I want to leave you with these thoughts. I believe we are all incredibly lucky to be alive at this moment in history, for the changes to the environment I have spoken about are caused by our own behavior, and we have the ability, our generation, especially those of us in the richest, most powerful nation on

the planet, especially those of us in this room, who are among the most privileged and influential members of our society, we have the ability, and the responsibility, to help turn them around. It is up to us. Who will do it if we do not?

And so I urge all of you to learn as much as you can about what human beings are doing to the global environment, to use all of your enormous creativity and intelligence and energy and resources, to join us at Harvard and in other academic institutions and environmental and land and water conservation groups in the U.S. and around the world, to speak out, to become more involved, to be fearless in combating the appalling ignorance and greed and corruption that underlie the destruction of our common home, to do everything in your power to preserve our wondrous living world, our pale blue dot, this indescribably beautiful and precious gift we have all been given.

Thank you