This image is called the Blue Marble, and it was taken in 1972 during the Apollo 17 mission.

It has become a symbol not only of cool space travel, but the environmental movement back here on the ground. Think about it: when you're on the earth, it seems pretty dang big and solid.

But seen from far above, it's just a blue marble flecked with beautiful green. Inspiring, isolated, and not really all that big. And thanks to technologies like air travel and the Internet, and to a booming human population, it keeps feeling smaller.

And thanks to technologies… and a booming human population… it keeps losing those all-important green flecks. Today is the history of climate science, which leads to some dark questions about the future of life on earth. [Intro Music Plays] Scientists tend to be conservative—not politically conservative, but careful, resistant to big claims. So evidence for the possible end of the living world took a while to be seen as such.

One problem was the structure of modern science. Remember how those ancient Greek, Indian, and Chinese natural philosophers tended to study astronomy, math, the living world, and human society, all at once? By the 1900s, professional scientists had gone in the other direction, specialization.

Scientists tended to focus on learning about one specific thing, often practically oriented things. Another problem was actually epistemic: studying weather patterns in one region is useful, but how do you study global climate? How many local patterns add up to a global one?

And there are so many elements involved in the earth's systems—solar radiation, human activity, carbon, nitrogen, water, non-humans: how do you know which variables matter in answering any given question? Big Data suddenly becomes not a source of potential answers, but a serious problem. So how did we get here?

English inventor Guy Callendar correctly predicted rising atmospheric carbon dioxide concentration in 1938. He analyzed measurements of temperatures from the nineteenth century on, correlating them with measurements of carbon dioxide. He saw that temperature had increased and proposed that this was an effect of increasing CO2.

Most scientists were skeptical, but Callendar died convinced he was onto something. And his work influenced a small number of scientists. In 1957, Revelle published a paper with Hans Suess suggesting that human emissions of greenhouse gases like CO2 might create a "greenhouse effect"—these heat-trapping gases would be trapped in the atmosphere, not absorbed quickly enough by the oceans—which would cause global warming.

Revelle also convinced geochemist Charles Keeling to keep measuring atmospheric CO2 concentrations at Mauna Loa Observatory, starting in 1958. These measurements showed seasonal variation as well as a clear arc over time: the planet is warming, and CO2 is rising. This trend is called the Keeling Curve.

In 1988, the World Meteorological Organisation established the Intergovernmental Panel on Climate Change, or IPCC, which has become the premiere body for establishing just what is going on with the earth's climate. And in 1996, the governments of the world came together to ban chlorofluorocarbons or CFCs, a group of odorless chemicals that were used in hair sprays, refrigerators, and lots of other places… and that were causing a hole in the earth's protective ozone layer. By the 2000s, many scientists had overcome their conservatism to speak out about global shifts in climate which were affecting living systems of all sorts, agriculture, cities, and, well, everything.

In 2000, atmospheric chemist Paul Crutzen coined a term for these global shifts, and—however imperfect—it has stuck: the Anthropocene, or the "Age of Man." Some scholars have called into question naming this era after "the" human, as if all humans are equally to blame. Other contenders include Donna Haraway's the Chthulhucene, or Age of Science Fictional Badness; the Manthropocene, or Age of Dudes, which not so subtly hints at the gender bias in science; and, catching on with some historians, the Capitalocene, or Age of Political–Economics. This is a fight among historians over how to discuss longue durée history, or history across many millennia.

It's also a fight among geologists about where to place so-called "golden spikes"—moments that represent shifts in the very makeup of the earth, usually visible shifts in the fossil record. In fact, the Anthropocene is a political fight about the intersection of geological epochs and human history. The problem with the Anthropocene is there are so many good candidates for the golden spike of a human epoch.

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Bubble: First, there's the original fossil fuel—coal—which was mined extensively in certain regions starting in the late 1700s and ramping up seriously in the late 1800s—the Industrial Revolution. Second, there's radioactive material in the form of strontium-90, which could be traced all over the world soon after the Trinity atomic bomb test—the first of many such tests. So this date for the beginning of the Anthropocene would be the specific date of July 16, 1945—the day of the Trinity Test and the birth of the Cold War. Third, there's plastic, steel, and concrete—but especially plastic. Humans built stuff and even had plastic before World War Two, but development took off at an unprecedented pace around 1960. This "Great Acceleration" saw rapid, often exponential growth in human population, use of freshwater, ability to produce and move food, greenhouse gas emissions, temperature of the earth's surface, and consumption of natural resources of all kinds. The period of the Great Acceleration also gave rise to the first mega-cities, or urban areas with over ten million people. In reaction to massive urbanization, humans have also set aside more land as national parks or green-ways, creating a landscape dominated by industrial agriculture and cities but also sporting well-defined breaks of deep green. All of these changes can be seen in the earth's geological record, and they all symbolize how some humans have changed the physical world. But perhaps the best candidate is number four: chicken bones! With more than twenty-three billion alive at any time, chickens—whose bodies have been heavily designed by humans—are the most common terrestrial vertebrate species on the planet. Aliens visiting the ruins of earth could reasonably conclude from our fossil record that the only life-form that ever mattered on this planet was the chicken. Thanks, ThoughtBubble. But the Anthropocene is only one way of viewing geological change and human disruption of natural cycles. Also influential are the Planetary Boundaries—a set of nine specific ranges for natural processes within which humans can definitely live. These include measures such as climate change, ocean acidification, and ozone depletion, but also the genetic diversity of life on earth and how much land is converted to cropland. But we can't talk about climate disruption without mentioning the pushback. Even though the vast majority of scientists realized that humans have had a tremendous impact on the earth, politically conservative talk shows run stories about how there''s no consensus. So where did this idea come from? In 2010, geologist and historian of science Naomi Oreskes and NASA historian Erik Conway showed that fossil fuel companies had hired some of the same PR agents and strategists who had worked for the tobacco companies, decades earlier, to invent climate denial: that is, to create doubt about science that was not doubted by

scientists. Ultimately, climate science isn't just about long-term shifts in the movement of carbon, water, heat, and other natural phenomena. The big questions for scientists in the Capitalocene include epistemic, technical, and moral ones. Epistemic questions include how fast are humans, and especially humans working within capitalism changing which ecosystems, in what ways? For example, we know that many important pollinators such as honeybees, bumblebees, and butterflies are dying out. Which is real sad, but also potentially an enormous problem. And we have some ideas as to why. A major cause is off-target damage from pesticides—which, no surprise, they literally are made to kill bugs. But which pesticides affect which bugs in which ways? Are there are safe options? Can we test lots of ways of doing agriculture and see which is most bug-friendly? And which forms of agriculture are most likely to erode soil from the land, and which help build soil back up? Basically: what kinds of knowledge do we need to make today, in a connected, fragile, increasingly "disrupted" world? In terms of technical questions, earth scientists are increasingly being pushed from the role of description to recommending action. Some prominent scientists are calling for governments to seriously consider geoengineering, also known as climate engineering: the intentional, global-scale transformation of the environment to combat global warming and other disruptions. Some geoengineering would be relatively uncontroversial, like creating more forests. But other ideas have been hotly debated, like fertilizing the ocean with iron to accelerate the growth of algae, thus capturing more CO2 from the atmosphere. But perhaps the biggest shift in professional sciencing today is moral. Who should pay for solutions to global-scale problems such as sea-level rise and global warming? Everyone? Or only the people who most contributed to the problem? The Yellow Vest movement in France is a recent example of this conflict: people across the country were subject to a new tax on fuel, in order to help lower carbon emissions. But many of the working poor, especially in more rural areas, simply couldn't afford to pay more to get around, and riots broke out. And think about all of the scientists working on topics related to the environment but… maybe on the wrong side of history. What if you are a professional geologist, and Exxon, BP, or Shell hired you to find more fossil fuels to extract? Should you not do the science you've spent a decade getting really good at? I This isn't a portrait of doomsday, but a call to reflect on science's strengths… and its limits. Science alone can't answer tough questions about how humanity should address climate disruption, and who should pay for potential solutions. One thing is certain: whether we call it the Anthropocene, Capitalocene, or something else, the new era in which some humans have dragged the Blue Marble will forever change how we make and share knowledge and tools. Next time—we'll finish the series with a look at how science is gendered: not only how important women have been to the history of science, and how difficult it sometimes is to tell their stories. But also how our understandings of the natural world reflect our ideas about humanity. Crash Course History of Science is filmed in the Dr. Cheryll C. Kinney studio in Missoula, MT and it's made with the help of all these nice people and our animation team is Thought Cafe. Crash Course is a Complexly production. If you want to keep imagining the world more complexly with us you can check out some of our other shows like Animal Wonders, the Art Assignment, and Scishow Psych. And, if you would like to keep Crash Course free, for everyone, forever, you can support the series on Patreon A crowd funding platform that allows you to support the content you love. Thank you to all of our Patrons for their continued support.