Overcoming entropy

C. Armanda Roco

Published online: 12 October 2017
© Springer International Publishing AG 2017

“Thermodynamics tells us that soils exist precariously—like people. But experience tells us that both soils and people are wonderfully resistant to degradation in spite of unfavorable thermodynamic odds.”

—Soil Physical Chemistry, Second Edition Pg 180 by
Donald L. Sparks, 1986.

Earth is approximately 4.5 billion years old. Recently, controversial evidence has suggested that Earth was home to microbial life during its smoldering infancy, around 3.95 billion years ago (Tashiro et al. 2017). Microbes have altered the chemical speciation of nearly all elements on the planet we call home. The foundation of biogeochemical cycling by these tiny beings has allowed the proliferation and the persistence of life through extreme environmental pressures. However, these omnipresent and seemingly ‘invisible’ microbes have gotten a bad rap. One could argue they are responsible for more human deaths than any other known cause, but without them we wouldn’t be here in the first place. The mutualistic relationship of beneficial microbes on and inside us assist with digestion, immune responses, and underpin the trophic design of ecosystems worldwide. Microbes are dominant facilitators of global nutrient cycling, play a major role in global greenhouse gas release, soil fertility, and the

health of our ecosystems. Global environmental change brings into question how some of the smallest biological drivers will ultimately influence global patterns. Will the changing environment exist precariously? Or will it be resistant to degradation? Much remains unclear (Graham et al. 2016). This is why I became a microbiologist.

Recent Pew Research Center studies show that Americans are largely skeptical of the scientific community’s grasp of the causes of climate change, with only 27% of Americans believing that almost all climate scientists agree human behavior is mostly responsible for climate change (Pew Research Center 2016). To battle these facts many scientists have started to take science communication more seriously. Explaining science in a passionate way, we hope to somehow inspire others to care. However, a number of studies have shown that explaining the real science better may actually have the opposite effect of what we scientists are trying to achieve. People with the highest scientific literacy have been shown to not be the most concerned about climate change (Kahan et al. 2012). The “backfire effect”, where corrections can actually increase misperceptions, may arise when

C. A. Roco (✉)
Department of Microbiology, Oregon State University,
Corvallis, OR, USA
e-mail: armanda.roco@oregonstate.edu

presenting facts that conflict with an individual's world view or identity (Nyhan and Reifler 2010). So, what to do? Scientists need to think a little more strategically about how we communicate our science. With political polarization at an all-time high (Pew Research Center 2017a), it is crucial to find common ground with the community and individuals we are targeting. Appealing to one's emotions or, as Stephen Colbert would put it, the 'truthiness' (The Colbert Report) of a subject, could help to convey why a specific scientific fact should matter. How will climate change affect us directly? How will it affect things we commonly see in our everyday lives? In a recent talk I saw by Dr. Katharine Hayhoe at Oregon State University, she aptly asks the audience of a few hundred, mainly academics, how many have seen a polar bear out in the wild. Four, including herself, raised their hands. Polar bears sitting on a broken sheet of ice have been the iconic image of climate change. No matter how much it pulls at our heart strings, how applicable is that to most Americans daily lives? Appealing to one's values can be a much more effective tool to instill change (Myers et al. 2012; Hayhoe 2016). Maybe a new mascot for climate change is needed.

More than 75% of coral reefs are predicted to experience an annual severe bleaching event by 2070 even if countries meet their pledges to reduce greenhouse emissions under the Paris Agreement (van Hooijdonk et al. 2016). Only 26 of 150 glaciers remain at Glacier National Park in Montana (USGS 2017). As an avid scuba diver and mountaineer, the rapid decline of these habitats is hard to comprehend. My love for the natural world inspired me to go to graduate school to learn and try to understand a little better how microbes in soil can affect our environment. Now, as a postdoc, I have begun to rethink what I want my scientific impact to be. I strive to learn, share through publications to my fellow colleagues, and to gain a credible reputation. However, this past year has increasingly made me stop and critically evaluate how my science can be measured in a more holistic manner. How can I begin to make a difference to my fellow citizens? Sharing my passion about why I care about science, about how much our natural wonders mean to me, and how I want to understand biological systems so that we can better protect them for the future is in the forefront of my mind. With this, I have taken more time to engage with my community. I have

gone to local schools and museums in an attempt to communicate to younger generations why I care about science, and hopefully inspire them to care too. It is reported that only 18% of Americans engage with science through hobbies, interests and activities at home (Pew Research Center 2017b). This is what motivates me to go out and engage with American citizens to critically evaluate how biology plays into the larger picture of our lives and enable them to make informed decisions in their communities. After one of my in-class activities exploring pond water microbes, a 5th grade girl came up to me enthusiastically exclaiming "I hope I get a microscope for my birthday this year!" We are currently facing a historic turning point, where entropy seems to be winning. Despite the unfavorable thermodynamic odds we are up against, we are also in exciting times. Humanity is in its height of technological advancements (Roser and Ritchie 2017), making us better equipped than ever to make a change. Now is the time for us, scientists and citizens alike, to strategically and critically evaluate how to work together toward a common goal.

References

- Graham EB et al (2016) Microbes as engines of ecosystem function: when does community structure enhance predictions of ecosystem processes? *Front Microbiol* 7:214
- Hayhoe K (2016) Why climate change should matter to you. <https://www.ecowatch.com/hayhoe-climate-change-2117925528.html>
- Kahan DM et al (2012) The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nat Clim Change* 2:732–735
- Myers TA, Nisbet MC, Maibach EW, Leiserowitz AA (2012) A public health frame arouses hopeful emotions about climate change. *Clim Change* 113:1105–1112
- Nyhan B, Reifler J (2010) When corrections fail: the persistence of political misperceptions. *Political Behav* 32:303–330
- Pew Research Center (2016) Many Americans are skeptical about scientific research on climate and GM foods. <http://www.pewresearch.org/fact-tank/2016/12/05/many-americans-are-skeptical-about-scientific-research-on-climate-and-gm-foods>
- Pew Research Center (2017a) The partisan divide on political values grows even wider. <http://www.peoplepress.org/2017/10/05/the-partisan-divide-on-political-values-grows-even-wider/>
- Pew Research Center (2017b) Science News and Information Today. <http://www.journalism.org/2017/09/20/science-news-and-information-today/>

- Roser M, Ritchie H (2017) Technological Progress. Published online at OurWorldInData.org. Retrieved from: <https://ourworldindata.org/technological-progress/>
- Tashiro T et al (2017) Early trace of life from 3.95 Ga sedimentary rocks in Labrador, Canada. *Nature* 549:516–518
- The Colbert Report: Videos: The Word-Truthiness <http://www.cc.com/video-clips/63ite2/the-colbert-report-the-word-truthiness>. Accessed 17 oct 2005
- USGS (2017) Glaciers rapidly shrinking and disappearing: 50 years of glacier change in Montana. <https://www.usgs.gov/news/glaciers-rapidly-shrinking-and-disappearing-50-years-glacier-change-montana>
- van Hooidonk R et al (2016) Local-scale projections of coral reef futures and implications of the Paris Agreement. *Sci Rep* 6:39666