

Driving to green with various approaches to sustainability

Recently I was walking along a golf course. A field with spaces of light green, medium green and dark green got me thinking. There are people who become quite obsessed with the game of golf. While I only play once or twice a year at most, I can appreciate why people love it. I have had many conversations with people who are passionate about the sport. One of my friends is extremely excited about driving the ball; he feels that the most important aspect is getting off a powerful drive. *"Move it down the fairway"* he will say. *"The further you go, the further you go!"* Another friend claims *"It is all in the mid game"*. She believes *"you must approach the green strategically"*. I have heard that it is critical to be able to get out of traps. I am told that the putting game is most important. There are so many ways to look at this game. I admire my friends' apparent mastery of the game and their self-confidence. But sometimes things get out of hand. I will watch my friends get angry with each other. They will argue that one view and perspective is more important and relevant than another view and perspective. I listen to them argue, and think to myself, *"Aren't they all correct? Why does one view have to be better than another? Don't you actually have to do all these things to be successful?"*

The various views of golf serve as a useful metaphor. The fields of chemistry and materials science have awoken to the realization that we must change the way we do things if we want to protect the future for our children and our children's children. Over the last several years, many views and perspectives have been presented on how to accomplish these goals. Limits to growth [1], biomimicry [2], the circular economy [3], cradle to cradle [4], natural capitalism [5], and green chemistry [6] are just some of the various descriptions of sustainability. And like my golf friends, my friends in the sustainability community will often argue over which approach is better, and which view falls short in their opinion.

Robust debate, passionate disagreement and free exchange of ideas are critical for us to learn from one another and build on various individual points of view. But synthesizing intellectual mechanisms for how different approaches can be mutually supportive will be far more useful than identifying processes to eliminate or ignore views that fall out of one narrow perspective. We humans come from a nearly infinite spectrum of backgrounds, points of views and life experiences. The approach that speaks to my heart and mind, will likely be different than the approach that speaks to someone else's heart and mind. This diversity is not only beautiful but an inherent powerful force that will help us all achieve the sustainable world we seek.

But there is something else that is important to understand. Let us go back to my golfing friends and imagine we assemble them all together. We will create a spreadsheet and measure their performance across all the various categories. Everyone will drive, we will measure the distance and the accuracy.

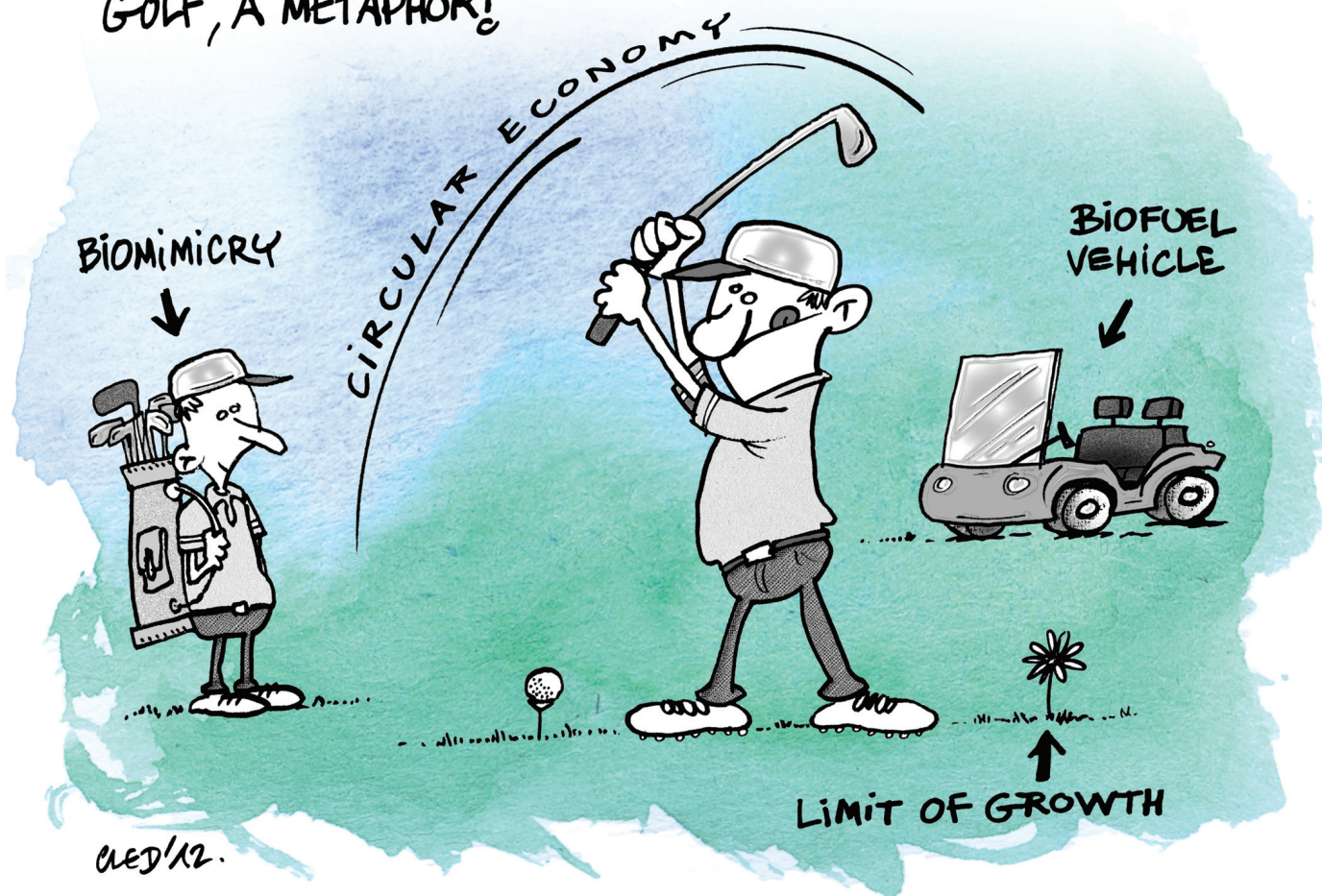
We will have people hit their balls from 100 yards, 150 yards, and other various distance and measure their distance and accuracy. Have them all get out of a sand trap and quantify their efficiency. Have them putt uphill, putt downhill, putt on level ground. We will fill up our spreadsheet with columns and rows of numbers. After analyzing this data, it is likely we will conclude that on different golf courses, different friends will excel. So, who's viewpoint is correct? It may very well be that on one certain golf course, the better driver is likely to win, and on another golf course the better putter is likely to win. While focusing on one specific golf course, we might be able to prioritize one approach over another, but integrated over the whole, our final analysis will be "all aspects are important".

This is likely the same for the various sustainability approaches. We may find that for the agriculture industry one set of metrics is more useful than another. For the electronics industry one approach is better than another. We will inevitably find that there is no silver bullet, no "one size fits all" that will serve all industry sectors, product categories, or subfields of chemistry. But again, integrated over the whole, we are likely to account for everything with the greatest diversity of approaches.

There is yet one more complexity we must acknowledge. So far, we have been discussing various ways to describe and measure people's success. Let us look at the golfing spreadsheet we just created. This is excellent data that describes and measures how our friends are playing golf today. We must ask ourselves a very difficult question. What if we want to improve our game? What if we want to do better? Does knowing all this information help us in any way? If we stare at this spreadsheet, if we sort the columns and perform mathematical calculations to combine various values, will we be able to improve? Sadly, perhaps heart wrenchingly, no. All this work, all the arguing and debating will not help us change our game. If we want to improve our game, surprisingly, we will have to identify an entirely different set of criteria. Things that do not fit so easily on a spreadsheet. How do we grip the club with our hands? How do we bend our knees? How do we place and move our feet? How do we position our back? These aspects are somewhat less intuitive. They can only be developed with the help of a good coach, a good trainer, a good teacher. Combined with a lot of hard work and practice, an individual's game will improve to a higher level. The next time the measurable attributes are recorded, the golfer that underwent this education and training will show that they will perform better on all the different golf courses.

We should take this to heart in our sustainability communities. With all the debate and discussion over the various ways to measure and characterize aspects of human health and environmental goals, the systems we codify and the metrics we define are at best only half the story. I can watch a golfer and understand the various aspects of the game, but that will

GOLF, A METAPHOR!



not make me a great golfer. Listing and describing illustrative examples of technologies invented and used to achieve sustainability goals will not give me the ability to create more sustainable technologies. There is a lot more to it than describing it.

Golf is a game. Sustainability, the future of human civilization and its relationship with the ecosphere is not a game. We need to do a better job changing the way we teach chemistry and materials science. Let's look at the curriculum we require our students to take, not just the electives. Let's ask ourselves difficult questions? Do we teach our students known mechanisms of biodegradation? Do we discuss the structural aspects of a molecule that makes it more bioavailable? If our students are working with an entirely new class of compounds, do we teach them what steps they should take to anticipate the potential toxicity? Every individual approach to sustainability is worthy. Every individual who has taken the time to craft a different way of describing a sustainable system and then had the courage to put that system out for public scrutiny deserves our deepest gratitude and support. And we should look at these approaches and ask ourselves the desperately needed next question: How can we translate these rules, systems, elements and principles into a pedagogy that will teach us not just WHAT to do, but HOW to do it? We have a lot to do, but much has already happened. The nonprofit organization Beyond Benign has a program called the green chemistry commitment [7]. Nearly 100 universities

world-wide have joined forces to share best practices, curricula and classroom tools to help provide the tools to develop the skills necessary to achieve the multifaceted sustainable worlds we all imagine.

[1] D.H. Meadows, D.L. Meadows, J. Randers, W.W. Behrens III, *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*, Universe Books, New York, 1972.

[2] J.M. Benyus, *Biomimicry: Innovations Inspired by Nature*, HarperCollins Publishers, New York, 1997.

[3] *Towards a Circular Economy: Business Rationale for an Accelerated Transition*, The Ellen MacArthur Foundation, 2015.

[4] W. McDonough, M. Braungart, *Cradle to Cradle: Remaking the Way We Make Things*, North Point Press, New York, 2002.

[5] P. Hawken, A.B. Lovins, L.H. Lovins, *Natural Capitalism: Creating the Next Industrial Revolution*, Little, Brown & Co, Boston, 1999.

[6] P.T. Anastas, J.C. Warner, *Green Chemistry: Theory and Practice*, Oxford University Press, London, 1998.

[7] www.beyondbenign.org

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