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Chemistry, Science, and Our Sustainable Future

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Chemistry has been in the media limelight much as of late, but often for the wrong reasons: harmful substances in food and everyday products, toxic waste-dumps, etc. It is all too easy to develop the perception that "chemistry pollutes." And, at a time when humanity confronts the unprecedented challenge of climate change, science has often been associated with the darker sides of human development.

How did this come about? And how can chemistry—and science in general—begin to play a different role in our sustainable development? Before we answer, let us first retrace the story of human development, and the part that science has played.

Before and After the Industrial Revolution

For most of history, humans depended almost entirely on solar energy and took only from the cycles of nature. Mankind thus had a negligible footprint on its environment. Two developments changed all that. The first was the industrial revolution, which kicked off in Europe and then America, rolling out ever more spectacular inventions from the steam engine to the harvester. Second was fossil energy, which rose to become roughly 90% of global energy use.

Scientists, notably chemists, were at the very center of it all. They made enormous strides in understanding the chemical combustion of fossil fuels. And this at once simple yet hugely complex process turned these ancient organic matters into jaw-dropping productivity, becoming a cornerstone of modern civilization.

The 20th Century: Arrival of Mass Production and Consumption

Developments truly broke loose in the 20th century. Henry Ford's Model T ushered in mass-production in 1908. Then after World War II, high-tech yet low-cost production arrived, boosted by the rise of Japan and the Asian Tigers. Other emerging economies soon followed, and population in the industrialized world quickly exceeded 2.5 billion (and counting).

Chemistry and material sciences were again of immense importance. The fruits of their innovation pervade every aspect of our lives, from energy and health to food, clothing, and transportation. While human welfare improved as never before, so did our ability to buy and consume. Cars, televisions, personal computers, cell phones and more were no longer the sole preserves of the rich. Technology was democratizing. But it was also individualizing. Everyone now aspires to personal copies of gadgets, and switch to the latest versions constantly. Ever-expanding markets and consumption have become cornerstones of our economic paradigm.

Our Impact on Nature

However, this progress has required a sharp rise in resource exploitation and waste production. The impact on nature has been astounding. According to the Global Footprint Network, the world now consumes resources that would take 1.5 earths to produce. If we all lived like the Americans, we would need 5.4 earths.[1] Most other global assessments tell similar tales of an overexploited planet.[2]

Then there is climate change, the goliath of all impacts. Things are much worse than we imagined even just a few years ago. A 2009 update to the famous "burning ember diagram" in the third Intergovernmental Panel on Climate Change assessment found that two Kelvin temperature rise above preindustrial levels may no longer keep us from severe risks.[3] One of these risks—extreme weather—has been simply horrific. Within the past year alone, floods put 20% of Pakistan underwater and deluged an area of Australia the size of France and Germany combined. Weeks later, Australians were bracing for a maximum category-five cyclone the size of Italy.

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Changing Course

Our current way of development is not viable. Changing course drastically within this decade is the only chance we have. But how can we do so? Here are a few principles to help guide us:

1. Finding an alternative way of development: First, *everyone* must accept this cold, hard truth: the path by which Europe and the U.S.A. attained their riches is not to be emulated. They got rich by over-consuming and over-exploiting the environment. Calling them "developed" implies that they have reached some sort of desired stage. In truth, any society that develops by destroying the very natural basis of that development is "over-developed," and should be seen as such. The developing and emerging countries (or "not-yet-over-developed" countries to be more correct) simply cannot copy this. Surely they have a right to development, but it must be "development" of a very different kind.
2. Going back to the sun: We must re-establish the central role of the sun in human development. It is estimated that the solar energy Earth receives in one hour equals the entire global annual energy consumption. We simply must dedicate much more R&D and deployment resources toward this area.
3. Science and technology for community: Evidently, ever-growing population and individual consumption equal ecological disaster. So we have to begin building technology and infrastructure to benefit groups rather than individuals. Recent examples include various transportation-sharing and goods-swapping arrangements. Whatever the specifics, the key is to make sharing collective benefits more attractive than consuming alone—thereby reducing our ruinous extraction of natural resources.
4. Tapping into our cultures and traditions: We must tap into the wisdoms of our forbearers. They lived for thousands of years in relative harmony with their environment. Surely there must be wisdoms in their ways of life. For instance, skyscrapers may be symbols of modernity, but they are often far less energy-efficient than traditional buildings in local climes. In today's milieu, where "hardware" approaches maturity, "software" has risen to the forefront. As we continue to innovate in hardware technologies, we cannot forget about the soft—our wisdoms of how to live. The good news is, all countries have rich cultures and traditions, and all can do better than to blindly follow the developed world.

The Role of Science

What is the role of science in all this? As an integral player in human development, science must help drive us toward a different future. A good start would be to follow the four principles outlined above. But science itself must undergo transformations to keep up with today's challenges.

Science must help drive us towards a different future.

First, science must become far more global, where today it is still largely national. Second, it must get better at integrating all disciplines and knowledge systems. Third, it has to inspire and involve young researchers, especially those in the developing world. Fourth, it needs to define a closer, more constructive relationship with the rest of society.

Let your imagination flourish for a moment: what if we could create a global scientific organization able to do all of the above, while wielding a mere 1% of the global defense budget? That would be roughly $10 billion! Imagine the impact it could make. This is an ambitious vision, to be sure. Some may even dismiss it out of hand. But it is surely worth striving for, and the magnitude of today's global challenges may demand no less.

Conclusions

Humanity has come a long way. In less than 300 years, a mostly rural world based on sunshine and biomass has metamorphosed into a planet criss-crossed by mammoth ships, planes, and communication signals at light-speed. Billions now possess technologies that not even the royals of earlier centuries could dream of. But smartphones or not, we are still a part of nature. And when we destroy our natural foundation for the sake of development, we have by definition over-developed.

We have to find another way. The emerging countries have to do better than to follow the road that America and Europe traveled to prosperity. Their right to prosperity may be undeniable, but it must be prosperity of a very different kind, and differently attained.

Science remains an indispensable force in human development. But it must transform itself along with the human enterprise: more focused on shared global problems; better at integrating diverse disciplines and knowledge systems; and more effective at working together with the rest of society. In short, it must embody the necessary transition.

Humanity has never faced a challenge of this nature and magnitude before. Can we defy the odds? The jury is still out. But we have no choice. Fail, and we will likely have to wave goodbye, leaving nothing but faint traces of our spectacular and ingenious, but ultimately temporary, development feats.

[1] The Global Footprint Network: http://www.footprintnetwork.org/en/index.php/GFN/.

[2] Consult, for instance, the *Millennium Ecosystem Assessment*, the *Living Planet Report* of the WWF, and many other assessments on the state of our forests, fisheries, coral reefs, etc.

[3] J. B. Smith, S. H. Schneider, M. Oppenheimer, G. W. Yohe, W. Hare, M. D. Mastrandrea, A. Patwardhan, I. Burton, J. Corfee-Morlot, C. H. D. Magadza, H.-M. Füssel, A. B. Pittock, A. Rahman, A. Suarez, J.-P. van Ypersele, *Proc. Natl Acad. Sci. USA* **2009**, *106*, 4133–4137.