Reaction: Thinking-Species Chemistry and the World's Problems

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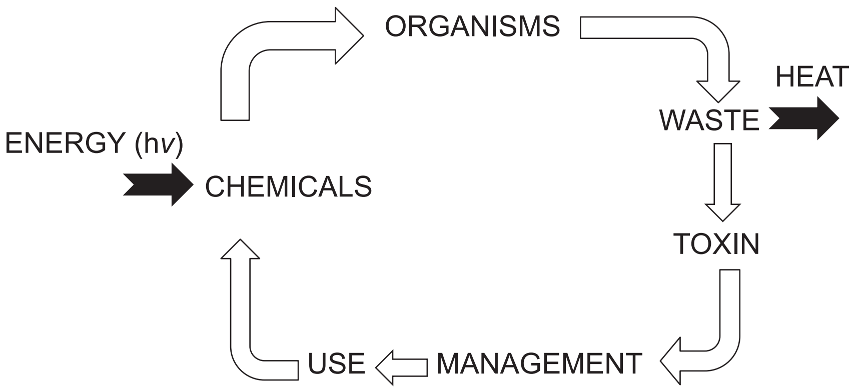

Figure 1. Illustration of the Chemical Feedback during Evolution
Adapted from Figure 4.2 from Williams and Rickaby.[2]

can only be understood backward, but it must be lived forward[3]), although history has demonstrated some well-publicized successes: the recognition and reparation of the ozone hole through elimination of chlorofluorocarbons[4] and the phasing out of tetraethyl lead as an anti-knocking agent in the internal combustion engine. A strong dialog between chemists who invent and (geo)chemists who monitor and measure the environment should speed up our reaction rate to poisoning crises.

An effort to more closely match thinking-species chemical rates with Earth's chemical rates might also resolve some environmental conflict. In the quest for progress via the growing demand for resources, many Earth processes have been accelerated to unprecedented levels, e.g., the accumulation of mercury and dimethylmercury in the food chain, the accumulation of CO_2 in the atmosphere, and eutrophication in coastal areas. One solution could be to slow down chemical progress toward sustainable rates. We might be forced to this scenario through limitation of one or other resource, such as energy, phosphorus,[5] or lithium. That is, unless the thinking chemist can find chemical substitutes or efficient recycling options for all such limitations. Alternatively, the thinking chemist might consider how best to accelerate the kinetics of many of Earth's regulatory feedbacks. Given that man's chemical operations have already taken place at a global scale, global-scale catalysis of, e.g., weathering rates to sequester CO_2, might be justifiable.

Although we have no natural predator in the classic sense, society's adaptability is slowed by our own and by the generation time of our comfort support system. By contrast, microbes are fleet of foot in adaptive terms. Novel chemistries could be our only line of defense to prevent man from being outcompeted by drug-resistant superbugs.

The kinetics of the Anthropocene dictates that it can represent only a transient step in evolution for the Earth system. Undoubtedly, the ecosystem will slowly try to attain a new balance in unanticipated ways and through exploitation of new chemical opportunities. Society might hang in the balance, but the shape and form of any future population will depend to some degree on this fragile symbiosis between the thinking chemist and the planet.

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CATALYSIS

Reaction: Thinking-Species Chemistry and the World's Problems

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Sijbren Otto received his PhD in 1998 from the University of Groningen under the supervision of Jan Engberts and was a postdoc with Steve Regen at Lehigh University and Jeremy Sanders at the University of Cambridge, where he also started his independent career in 2001. In 2009 he returned to the University of Groningen, where he is currently a professor of systems chemistry.

The preceding assay by Jean-Francois Lutz makes a very valid point: humankind, like other life forms on our planet, should not be considered separate from the planet but rather an integral part of it, connected through many interactions and governed by many of the same laws of biology. In fact, mankind does not differ from other species in that it alters its environment. This has happened before and on a devastating scale. Think only of the great oxygenation event: the buildup of oxygen in the atmosphere.[1] This oxygen is a waste product of photosynthetic organisms and toxic to many of the then-living organisms, which consequently became extinct or were at least forced to retreat into the remaining anoxic environments. At the same time, the event opened up opportunities for other new forms of life that were able to make good use of reactions with oxygen as an energy source, including eventually us humans.

But of course, although the impact of mankind on our planet's chemistry might not be so significant in comparison with other events in the history of Earth, we certainly should not marginalize the effects of, for example, the emission of greenhouse gases. The resulting global warming is a threat to human society and also endangers other species. Another major impact of chemistry on the planet and on humankind has been produced by the Haber Bosch process—the fixation of nitrogen from the air into ammonia, which can then be used as fertilizer.[2] Except for some exotic species, most life forms do not have the ability to utilize dinitrogen from the atmosphere but instead readily incorporate ammonia in their metabolism. Thus, the Haber-Bosch process can be considered an extension of metabolism and has resulted in a dramatic increase in agricultural production. Humankind has responded like any other life form does to an increase in resources: by rapidly increasing its population, thereby encroaching into the habitats of the fellow inhabitants of our planet. In nature, such population growth will continue until the maximum population size that can be sustained has been reached. If mankind were to follow this law of biology, then this would have a massive impact on the planet.

Fortunately, there are signs that mankind is starting to deviate from the laws followed by most life forms. Increasing reproduction further is thoroughly possible, certainly in the developed world. But with increased welfare, it seems that humans are opting for a different path (or am I too optimistic here?). With anticonception (another product of chemistry), we have decoupled sex from reproduction. With our desire (combined with societal pressure) to provide our children with a good position in life, we limit how many children we get. In the developed world, we could raise more children, but we choose not to. So we are breaking free from the "laws" of nature by rational thought. And this is a blessing: given the substantial ecological footprint that comes with welfare, the human population should not increase much further.

When it comes to the chemistry of our planet, a similar breaking free is desirable. Prior to thinking-species chemistry, chemistry took its course dictated by circumstances. But now, we can predict, design, anticipate, test, regulate, and keep in check the forces of economy that are not necessarily benevolent—all because we can think.

So what does it mean to be a chemist in the Anthropocene? It means taking responsibility—so much is clear to everyone. And this is where it becomes difficult. It seems already hard enough to act responsibly toward our own species, let alone act responsibly toward the many other inhabitants of our planet. It is also not like nature to do so. Survival of the fittest unfortunately also means death to the competitors—something already seen at the level of self-replicating molecules and traceable all the way down to the math of exponential growth. If two exponentially growing systems compete for a common resource, after a while there will be only one left.[3] So far this has been us, thanks largely to our ability to create. And we can do a lot to make sure it stays that way. We should even be able to manage doing so without inflicting too much damage on our fellow creatures, provided we use our ability to think to keep the cruel laws of nature in check. So, thinking-species chemistry is not the threat; rather, it is part of the solution.

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