Jesse H. Ausubel and H. Dale Langford, eds., *TECHNOLOGICAL TRAJECTORIES AND THE HUMAN ENVIRONMENT*. Washington, DC: National Academy Press, 1997. 198 pages, plus biographical data and index totaling 214 pp

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Worried about the future of the world? Concerned about overpopulation, hunger, pollution, global warming, clean energy, and humanity's place in the cosmos generally? Read this book. You'll feel a lot better as a result.

Blindly confident in the future? Ignorant of, and thus unconcerned about, questions regarding population, food, pollution, energy, or humanity's place in the cosmos? Read this book. You'll see there are plenty of reasons why you should be more informed and much more concerned.

This book, which first appeared in the Summer 1996 issue of Daedalus and is produced by the American National Academy of Engineering, intends to be a careful consideration of "long-term interactions between the environment and technological change" in order "to identify opportunities to embed industry and its products more intelligently within nature."

Some of you, reading those last-quoted words, might have been completely unmoved by them. Most (given the usual readers of this journal) probably registered agreement. And some few (also given the usual readers of this journal) might have felt your skin crawl: you mean to say that it is desirable to strive to "embed" more "industry" "within nature?"

All of the 14 authors or co-authors of the eleven essays in this collection clearly feel it is desirable, even necessary. It is what humans have always done, do now massively, and must (given the challenges) do even more massively but intelligently for the foreseeable future.

But none of the authors is a Pollyanna (or, being all male, an "Anna" of any sort). Nor are they Julian Simon (or Herman Kahn) clones in the way they write, though they are pretty much Herman Beings in the perspectives they present. They (some more than others) recognize the problematic character of humanity within nature. They (some more than others) recognize that most of the problems to which more technology is the answer are themselves the result of prior technologies. And they all (some more than others) recognize that the problems I listed above are real, urgent, potentially overwhelming. The future is not automatically going to turn out OK. There are many ways it could go wrong. But there also are many ways (none of which require improbable scientific or technological breakthroughs, they say) in which things can, should, and almost certainly will go right, if we let engineers alone to do their thing..

There are no viable solutions to our problems except as found in more, and more intelligently "embedded", technology.

Three of the essays (by Jesse Ausubel, Arnulf Grubler, and Klaus Michael Meyer-Abich) are essentially philosophical and reflective overall about humanity's role as a toolmaker and user. While all are to some extent "futuristic," one, by Chauncey Starr, bravely focuses primarily on the next two hundred years (hmmm. That title has a

familiar ring to it). The other seven articles (though also "philosophical" and futuristic to a degree) are mainly state-of-the-art reports, with reasonable projections, about the way technology has, is, can, should, and (if left alone) probably will continue to play a positive role in solving population (Robert Kates), food (Paul Waggoner), energy (Nebojsa Nakicenovic, Lee Schipper, Jesse Ausubel & Cesare Marchetti), materials (Iddo Wernick, Robert Herman, Shekhar Govind & Jesse Ausubel), and pollution (waste) problems (Robert Frosch)..

Though the volume is overwhelmingly devoted to the good things about technology, with seldom a discussion about how or why things might grow wrong, it is clear (especially in Starr's piece) that it is humans, and their crazy ideas--especially those of economists, policy-makers, and cultural leaders--who might prevent technology from doing the good things that only technology can do. Starr's very last sentence in the book is: "It seems that an optimistic sociologist and an optimistic economist are necessary to bolster my technological optimism for a globally happy future."

Similarly, in a piece provocatively titled, "How much land can be spared for nature?" Waggoner, starting from the well-known fact that farmers in some parts of the world are more productive than in others, argues that certain "master" farmers in all regions know how to produce food well above their national average. Waggoner then gives the example of certain American maize farmers who regularly produce above even the high American average. New technological breakthroughs thus are not required to increase global food output sufficiently to feed the ten billion people he believes may inhabit the Earth during the 21st Century. "Technology remains on a nearby shelf for farmers everywhere" (62) but "Technology left on the shelf butters no parsnips. Whether it will be employed depends on the profit the farmer foresees and the rules that discourage him." (63).

It is those darned economists and sociologists again!

Waggoner ends his essay with "a scenario for success" and a section on "surprises, bad and good" which might change that scenario. The successful scenario assumes a daily per capita diet of 3,000 calories, which can keep 10 billion people alive, if not fat and sassy. It would help a lot, Waggoner mentions frequently, if all people would become vegetarians, which he considers possible. "A diet requiring food and feed totaling 6,000 calories daily [which most people now seem to prefer, if given the chance] for ten billion people, however, would overwhelm the capability of present agriculture on present cropland." "Countering humanity's multiplying population and wealth to spare habitat for Nature requires never-ending research, encouraging incentives, and smart farmers", Waggoner concludes.

That phrase is typical of many throughout the book. The spirit is always upbeat and optimistic. Careful reading of the details reveals a lot of extremely heroic assumptions, actions, and good luck.

Still, the evidence here clearly shows that humanity can do it, with the aid of existing and reasonably-anticipated technology, if humanity wills to do it. The future need not be bleak. But it surely looks like there are more ways things could go wrong than right. There are, after all, more economists, sociologists (and lawyers), not to mention anti-technology humanists and religionists, than there are engineers (and scientists).

A similar grim optimism pervades Nakicenovic's essay, "Freeing energy from carbon." That task is necessary in order to reduce carbon in the atmosphere which is

the main contributor to greenhouse gases and possible global warming. Nakicenovic shows that all the historical record is towards decarbonization, and so are the feasible future projections. The obtainable goal is a carbon-free hydrogen/electric economy. But getting there seems to depend pretty heavily on at least a period of considerable reliance on nuclear fission which many people feel is too high a price to pay, not only because of its perceived present danger but also because of its irresponsibility to future generations who must care for our nuclear wastes for thousands of years.

"Elektron: Electrical systems in retrospect and prospect" is a fascinating history and future of electricity. After discussing a "six hundred year war for efficiency," Ausubel and Marchetti conclude with the estimation that "a new cycle formally beginning in 1995 started the game again, although the effects of the restart will not be particularly visible for a few years". Thus they have reasons for expressing optimism for the energy future as well.

Schipper looks at different energy usages required by different lifestyles, and the possibility of fitting the two together more efficiently in the future than at present. He notes that some measures of usage and efficiency are much more readily available than others and thus that there are a great many unpredictable variables involved in lifestyle changes and choices. While fundamentally optimistic, his article seems to reveal more clearly areas of ignorance and hence uncertainty than do some of the others in this volume.

Wernick, et al., in "Materialization and dematerialization," define dematerialization as "the absolute or relative reduction in the quantity of materials required to serve economic functions." They argue that dematerialization, like decarbonization, is a clear historical trend with an almost certain future trajectory, thus offering even more extravagant reasons for optimism in the future--less energy required, less extraction necessary, less pollution caused, cheaper products provided, everything as good as it can get. Moreover, if China and India (and the rest of the world) do succeed in their goal of "catching up" quickly to Western standards of living, it can only be sustained if dematerialization and decarbonization also quickly occur.

They conclude, "[S]ubstantial progress has been made over the past century in decoupling economic growth and well-being from increasing primary energy use through increased efficiency. Decoupling materials and affluence will be difficult--much harder than decoupling carbon and prosperity. Objects still confer status, and they take their revenge." (154).

Not necessarily. If we heed Schipper's discussion on lifestyle changes, and what Waggoner said about vegetarianism, is it too much to expect that, in this overall optimistic worldview, people can be persuaded that small is beautiful? Once upon a time, being fat was good. It meant you were rich. Now it means you are poor. Only rich people have time to be scrawny beanpoles, living forever instead of decently dying of a heart attack from overeating red meat. Surely, in a world were everyone can have everything, having nothing will be prestigious, and having everything be properly seen as thoughtless and greedy.

As interesting as the "substantive" essays are, I found the "philosophical" ones to be even more fascinating, though in fact timid when all was said and done. The main editor (and frequent co-author) Jesse Ausubel, opened the volume with an essay "The liberation of the environment". It is a commentary on the role of humans in environmental transformation, with the final punch line being, "We have liberated ourselves from the environment. Now it is time to liberate the environment itself."

The article by Meyer-Abich, "Humans in nature," strikes a similar theme, though he takes a more historical and indeed esthetic path to the present and future, relying splendidly on art, poetry and philosophy in addition to engineering (His critique of Bacon is especially good). And his punch line is "[T]he human challenge is to justify how we proceed to locate ourselves in an open cosmos, which centers neither on Earth nor on humanity but on its own nature, nature itself." "Apparently, we need the industrial economy to treat problems we would not have without the industrial economy. More generally, we will need science and technology to treat problems that we would not have without science and technology.; And we need to diffuse a new understanding of nature, including our own nature, in order to drive our science." (182).

Which brings me to my main concern about this volume. Technologies which are important for the future are very narrowly defined here. There is no mention of expert systems, artificial intelligence, robots, or any of the sciences and technologies of complexity and artificial life.

More importantly, except for a negative comment made in passing, all of the biological and life-science technologies are completely ignored.

While Meyer-Abich hints at an interest in the cosmos, there is no mention at all of space science and technology.

How it is possible to talk meaningfully and comprehensively about technology and the future without considering these in the same detail that energy, population, materials, and waste are considered is beyond my understanding. Of course, one book may not be able to do everything, but the book is less than 200 pages long and these technologies are bound to be at least, if not more, important for understanding the future.

Especially--and this is my main point--if we are to be interested in "liberating the environment" and focusing not on Earth or humanity but "on nature itself."

Artificial life, artificial intelligence, genetic engineering, molecular engineering (never once mentioned in the book) will (along with the population, energy and materials developments discussed in the volume) require an entirely artificial and wholly-managed environment if the ten billion (most certainly more!) people anticipated are to exist above a subsistence level on Earth during and after the 21st Century.

And I am convinced beyond a shadow of a doubt that if intelligent life continues to flourish on Earth at the end of the 21st Century, it will also exist on the Moon, Mars, and elsewhere in the solar system before and after that time.

And, once life leaves its apparent cradle, Earth, and takes its place among the myriad and diverse environments of space, there will be a burst of speciation and intelligences beyond anything we have known on Earth, or can successfuly now imagine.

That is the most important and optimistic thing one can anticipate in contemplating "technological trajectories and the human environment," though not in this otherwise challenging volume with that name.