***SPARKING INTEREST:***

***Popular Texts as Catalysts for Technoscientific Innovation***

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Good afternoon, ladies and gentlemen. I would synopsize our symposium to date as looking at scientific books from two viewpoints. The first is book *qua* book: its materiality (*e.g.* paper, ink, fonts, predecessors, context, content) – what it *is*. The second is book as catalyst: audience, influence, function, performativity, creation of meaning by author and reader – what it *does*. Today I shall speak to the second category, specifically the scientific book’s function in proposing new ideas that in time give rise to innovative technology.

If I would converse with you I must first define my terms. As I understand it, the phrase ‘scientific book’ includes mediaeval and early-modern codices such as *Principia*, as well as taxonomic and anatomical atlases that purport to organize life’s infinite instantiations (of flowers, tumors, embolisms *&c*) into some taxonomic ideal. In my own discipline of science and technology studies, Peter Galison has fruitfully illuminated this area under the rubric of Objectivity. Today, however, I propose to expand the concept of ‘scientific book’ from intra-élite texts *by* and *for* scientists, to texts written *about* science, for lay audiences. My timeframe is the twentieth century. As I see it, such texts could include -

1. Popularizations in daily papers and monthly magazines reporting on what Bruno Latour calls ‘technoscience’, from Mars rovers to gene therapy and the Higgs boson;
2. Commentary on world science and science policy;
3. Speculative-fiction radio scripts and screenplays for TV and motion pictures;
4. And finally, pulp sci-fi: ray guns, superluminal spacecraft, and little green men.

My thesis is that such popular science-*related* text – non-rigorous, non-peer-reviewed, non-*academic –* may over time prove as important in advancing technoscience as the formalized process propounded by Vannevar Bush 70 years ago, and now taken as canon. Bush posited a technoscientific conveyor belt in which initial theoretical hypothesis => experiment => research data => verification => proof of concept => scale-up => prototype => commercialization. Look closely at *how* Bush announced his stylized model, however, and you will see that it first appeared neither in scientific book nor learned journal, but in a short plain-language text submitted to the White House in July 1945 under the title *Science, the Endless Frontier.*

Technical ideas floating in a nebulous popular *zeitgeist* were characterized in 2009 by Sheila Jasanoff as ‘sociotechnical imaginaries’ or STIs. STIs, she said, exist “between imagination and action, between discourse and decision, and between inchoate public opinion and instrumental state policy.” In a moment I shall adduce specific examples of STIs; first, however, let me make a disclaimer. This paper comes nowhere near proof of thesis. Rather I examine five comparable case histories using a science writer’s intuition. I table no causation; only a handful of correlations that I find intriguing. Any general laws must wait upon further research. That said, at times I think I may have stubbed my toe on a new sub-discipline of scientific book studies – the investigation of trillion-dollar technoscientific ideas realized not through the standard Bush linearity of publication, peer response, and engineering application, but through *genius populi*. Now to details.

A science fiction story in the mid-1950s described a group of physicists shown film footage of an inventor apparently levitating without plausible explanation. The clip terminates with an accident that, the physicists are told, destroyed the device and its inventor. The physicists are tasked first with explaining, then with replicating, the technology they saw. They do so, avoiding despair of their goal by having witnessed its apparent achievement. They are then told that the film was a hoax; no antigravity existed until now. Here’s the moral: every innovation relies on faith in its possibility. *Velle est posse*; where there’s a will there’s a way.

Naïve? Grandiose? Perhaps not. On 2015 June 29 an unmanned Falcon 9 cargo rocket, launched from the Kennedy Space Center with supplies for the International Space Station, broke up soon after ignition. The core datum here is not the launch failure – hi-tech is born to trouble as the sparks fly upward – but that the Falcon 9 was built by a private firm, SpaceX, which still plans to upgrade its capsule to carry astronauts. Precisely this scenario – the private sector undertaking human spaceflight when public agencies have abdicated that role – was first propounded in the popular media over a century ago.

In 1901, H.G. Wells published *The First Men in the Moon*. In it a group of private citizens employs the antigravitic substance Cavorite to reach the Moon. Forty-six years after Wells, the American author Robert A. Heinlein published *Rocket Ship Galileo*, in which (again) a private consortium designs, builds, and operates a lunar craft. *Rocket Ship Galileo* not only owed a debt of gratitude to Wells; it continued an established tradition of stories for general-public audiences, especially adolescents. Heinlein’s youthful heroes exhibit not only Pluck, Grit, Fair Play, and Character, but more importantly an abiding faith in technology: their will always finds a way. Heinlein’s and Wells’s imaginary has now been realized in SpaceX, with follow-on innovations yet to come. Adolescents spellbound by this STI made it happen when they grew up.

My second example will be familiar to you, though blindingly fast technological evolution has already made it a curiosity. I refer to the flip phone, which my kids call a ‘geezerphone.’ Hello, President Reagan! While its design has been superseded by interactive touchscreens employing pressure-sensitive thin-films, two decades ago the geezerphone made ergonomic sense. Instead of leaving its interfaces exposed and vulnerable, its speaker and non-touch display screen fold over to protect both themselves and a lower module containing microphone and control buttons. The first flip phone to be marketed was the StarTac, whose name referenced an identical configuration (the ‘Starfleet Communicator’) widely known from a TV space opera. Unhappily for the StarTac’s manufacturer, all attempts to patent its invention were quashed by courts citing the principle of prior disclosure – a truth betrayed by the product’s very name. Sorry Motorola, the thing you’re claiming was actually beamed down to Earth by pop culture, two decades ago.

By contrast, my third example of a sociotechnical imaginary couched in popular text about science proved profitable in cash as well as *χύδοξ*. Arthur C. Clarke, who began his professional career as a WWII radar technician, in 1945 came across two forgotten papers on orbital mechanics that gave a theoretical basis for an artificial satellite in geosynchronous-equatorial Earth orbit. Such a device, with a periodicity of 24 hours, would seem to an Earthbound observer to hover at or near the same point in the sky. Clarke saw that such a satellite would in effect sit atop a radio mast 22,000 miles above the Earth’s surface, with uninterrupted line-of-sight to an entire hemisphere. He published his concept not in standard scientific books or learned journals, but in the popular magazine *Wireless World* -

- And twenty years later watched country after country realize his sociotechnical imaginary without giving him a dime. For by this time the Academy (indeed the entire global technoscientific establishment) had either forgotten, or else had never known, the conceptual origins of the communications satellite. As a Bell Laboratories scientist later remarked, in the mid-1950s geosynchronous wireless relay was well-known yet apocryphal – an 'idea in the air.’

Though Clarke never patented his concept, saying that patents were “a licence to be sued”, before his death the US National Aeronautics and Space Administration awarded him a substantial one-time payment – perhaps the only time a technical concept in the public domain has been assessed a monetary value. As scholarship has demonstrated, Clarke did not originate the idea; but by the time of the NASA award he had become so famous as a writer of sci-fi and science popularization that no one else alive was better placed to accept NASA’s largesse. By exhuming a moribund bit of astrophysics and inserting it into the popular imagination, Clarke had become Mr ComSat. Hence the NASA check was addressed to him.

If demotic concepts do spark technoscientific innovation, one would expect to find some popular imaginaries still *in utero*. I came across one of these three months ago, in an introduction to a new edition of Ray Bradbury’s *Martian Chronicles*. The intro was by astronaut Steve Hadfield, recently returned commander of the International Space Station, who describes a moment of revelation when an ISS colleague -

referred to an instruction from Mission Control as ‘Earth said’ . . . [S]he already saw herself and her crew as something apart from everyone else – no longer Earthlings . . . The crew [of a Mars expedition] will become ever more self-reliant, and at some point, will make a mental transition. Without even discussing it, inexorably, they will become . . . *Martians* . . . Sitting alone at his typewriter nearly seventy years ago, Ray Bradbury somehow saw all this coming.

To which I say, Of course he did! Along with Schiaparelli, Percival Lowell, Edgar Rice Burroughs, and H.G. (and Orson) Wells, Ray Bradbury was channelling an STI entrenched in the popular imagination by the popular media. As an aside, I hope that one day some of us here may see this particular imaginary made real.

Not every demotic idea is successful. Some promising starts prove final failures – technical imaginaries that society examines, weighs, and then rejects. For me, the paradigm of the failed imaginary is the molecular nanoassembler proposed by K. Eric Drexler. Thirty years ago in his popular-science book *Engines of Creation,* Drexler provided exhaustive plans for tiny tools, each of which contained only a few dozen atoms. These minuscule utensils would operate as bearings, motors, pincers, and other components of molecule-sized machines that assembled things atom by atom. Drexler had, it seemed, taken seriously Richard Feynman’s 1959 lecture *Room at the Bottom,* in which the famously puckish Dr Dick fantasized entire factories no bigger than enzymes.

This might have worked, had it been presented as an explicit STI. Some of Drexler’s simpler mechanisms have indeed been synthesized: ten years ago I was shown closed-ring molecules on the order of 10 nm *θ* that had been concatenated – linked into a chain – at a lab in Tsukuba, Japan. Publish a simple call to think out of the box, as Feynman did, and hard-headed engineers might have taken it seriously. Where Drexler erred was to offer speculative details as a done deal. These exact designs of nanoassembler, Drexler said, *must and shall* be achieved.

Well! maybe not. Response to Drexler from the mainstream technoscientific community was swift and cruel. The reputable critics, people who (unlike Drexler) really were involved in theory and experiment at the nanocosm, pointed out that you can’t just shrink a macro-world machine below invisibility and call it a day. Nanometre-scale conditions are vastly different from those we live with. Down in the nanocosm, matter can be wave and particle at once; water is more viscous than toothpaste; Brownian motion vibrates atoms at five million Hertz. My late colleague Richard Smalley, a Nobel laureate, said that operating a Drexlerian nanoassembler (even if one were possible, which it isn’t) would be like trying to put together a watch while wearing boxing gloves dipped in glue.

Drexler’s terminal failure was to position his STI as the means to a utopia in which nanoassemblers cruised human bloodstreams to kill cancer cells, repair age damage, and conquer death. The real τελóς of the Drexlerian STI, it turned out, was physical immortality, extending to the resurrection of corpses. This, society has correctly concluded, is a fool’s errand: it makes Drexlerians (including their leader) not scientists but devotees of a cult.

Of course it is logically rash to call any predictive STI impossible; one may be proven wrong at any time. But this particular sociotechnical imaginary is, I submit, not achievable. As Rick Smalley told me, “Real nanotechnology isn’t about waking up dear dead Auntie Flo from her long nap in the freezer.” And *Wired* magazine, itself no stranger to far-out imaginaries, recently called Drexler “the crazy uncle in the attic.”

Like the Academy, the δεμοζ exhibits a strong vector of self-correction, an arrow of truth; it is an affirmation of *Vox Americae* that its basic common sense has laughed the immortalizing nanoassembler out of court.

To conclude, I want to express a gratitude that is more than mere convention. Five years ago I retired as a science writer and with much trepidation re-entered the Academy as a lowly undergraduate. From that frail beginning I have met with nothing but kindness, helpfulness, and understanding. Professors, colleagues, and administrators have to a woman and man welcomed this dead white male into their midst without one whisper of ageism. Years have fallen from me; I have never felt so accepted, challenged, and charged with possibility. From my heart, then, *Mesdames et messieurs: Merci*. Thank you for hearing my very first paper.

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