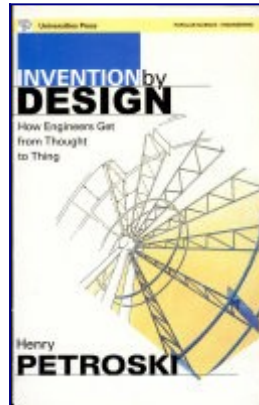


Society and Our Technology Built World

 Posted on 2 June 2011 by [cjf](#)

The interrelationships between society and technology run deep. We all partake and participate in



the unfolding technology evolution “discussion” that is our lives. The tools we use, try out, improvise, critique, and/or advocate are our minimal contributions to this discussion. The accidents of technological history set the context for the discussion. We are all technologists entangled in a technological world! Technology has been the main (perhaps the only?) means by which human progress has been achieved with tools like the pencil, slide fastener (or zipper), jet airplane, water systems, skyscrapers, bridges, and computers all dramatically changing society. Henry Petroski’s great short book “*Invention by Design: How Engineers Get from Thought to Thing*” explores the design and engineering arts in the full richness of their social context in nine intriguing case studies.

I first read *Invention by Design* in February 1999. Recently I was re-reading it when [Michael Tweed](#) of the [The Ben Franklin Thinking Society](#) invited me to lead the group’s *Science & Technology* meetup every month. That led to the [Discussion: Engineering Failures & Society on 8 May 2011](#). Here are some thoughts reflecting on Petroski’s book, the 8 May meetup, and further cogitating about the big picture of society and technology. Hopefully these notes and your feedback will help us better understand the technological world at the core of our ever changing civilization.

What is Technology?

Technology is the catch-all term used to describe objects and the networks, systems, and infrastructures in which they are embedded, as well as the patterns of use that we impose upon them and they upon us. Technology is clearly context-dependent and ever evolving. — Henry Petroski

Petroski’s definition suggests that civilization itself may be technology. So it would seem that [technology](#) embraces culture, values, psychology, history, and the multidimensional elements of the environment (materials science, biology, anthropology, geophysics, chemistry, etc.). Buckminster Fuller goes further:

[In its complexities of design integrity, the Universe is technology. The technology evolved by man is thus far amateurish compared to the elegance of nonhumanly contrived regeneration. Man does not spontaneously recognize technology other than his own, so he speaks of the rest as something he ignorantly calls nature. — Buckminster Fuller, Synergetics, 172.00-173.00](#)

By taking Petroski's "networks, systems, and infrastructures" to the next level of "design integrities" and identifying it as technology, Bucky leads us to the biggest of big pictures: Universe itself! As social creatures we often think of society as the big picture. I think his point is well made: technology is an inherent component of Universe itself. Human society is our storied Earth-developed technology. It seems likely that Human society will become the "brain" managing the regenerative ecological functions of [Gaia](#), the theory that Earth is "alive". If that happens, the storied technology of Earth would probably become even more [syntropic](#) and powerful than what life has achieved thus far. Regardless, society and the technology with which it is built are inextricably intertwined!

Design and Engineering in Society

Design and engineering are the arts of consciously working to evolve and develop our technological infrastructure to improve our worlds. Petroski emphasizes the role of society in the engineering process and vice versa in these illuminating quotes:

Engineering is a fundamental human process that has been practiced from the earliest days of civilization. ... We have to think and scheme about nature and existing artifacts and figure out how they can be altered and improved to better achieve objectives considered beneficial to humankind.

...

No engineering problem is ever completely solved to everyone's satisfaction. Engineering is the art of compromise, and there is always room for improvement in the real world. But engineering is also the art of the practical; engineers realize that they must at some point curtail design and begin to manufacture or build.

...

Because engineering is so inextricably involved with society and its goals, the practice of engineering is a very social endeavor

...

In fact, no artifact or system that any engineer designs or analyzes can function independent of a larger social system, and the best designers and analysts are those who are constantly aware of the interrelationships of all things.

...

Every engineering effort is shaped by, and in turn shapes, the culture, politics, and times in which it is embedded.

— Henry Petroski

It is noteworthy that Petroski includes compromise and politics in his conception of design and engineering initiatives. [Bucky Fuller](#) was avowedly apolitical and implied that good design innovations will be spontaneously adopted. Petroski's view seems more realistic: engineering is an ongoing process, never ending, always evolving; it is a discussion ... it is inherently political. I think Fuller's idealistic view is apt and important for visionaries whose work is so far ahead of its time that contemporary political forces would reject such new ideas (politics always lags significantly behind the initial vision for change). Still, it seems that most design or engineering projects that are actually implemented will be influenced by social forces with their concomitant political elements.

It is my feeling that too many engineers get so caught up in the practical and its political-economic forces that their work is stifled by slavery to the expedient. On the other hand, too many dreamers and visionaries, are so idealistic that they find it difficult to contribute to practical projects and are

relegated to the margins of social progress. Bucky was exceptional in that even though most of his ideas were too visionary and idealistic to be implemented in his lifetime, he managed to implement some substantial commissions.

It is also my feeling that present-day society is too focused on short term “return on investment” (1–5 years is typical with only a few industries investing more than 10 years out and almost no one investing 100 or 1000 years out). So we are currently making too little investment in the kind of technology that will be needed in just a few decades. The [Long Now Foundation](#) stands out as perhaps the only organized effort to envision Humanity’s 10 000 (10-illion) year plan. Academia also seems too short-term focused with their cut-throat “publish or perish” values and overly-specialized “departments”. Long range initiatives also deserve substantial investment!

The future belongs to those who believe in the beauty of their dreams. — Eleanor Roosevelt

How might such idealism be made more practical? I recommend one of [Ken Iverson](#)’s Nucor mottos: **“If it’s worth doing, it’s worth doing poorly.”** That is, if you identify something worth doing, start boldly working through its learning curve now. Do not worry that your first efforts might be “done poorly”: it’s worth doing, so get started! In short, do what Bucky did: boldly prototype solutions as stepping stones for the future.

Whatever you do will be insignificant, but it is very important that you do it. — Mahatma Gandhi

Not to dream boldly may turn out to be simply irresponsible. — George Leonard

Don’t undertake a project unless it is manifestly important and nearly impossible. — Edwin Land, Inventor

The Role of Failure

The best laid schemes o’ mice an’ men
Gang aft agley,
An’ lea’e us nought but grief an’ pain,
For promis’d joy!
— Robert Burns, “To a Mouse”



Petroski puts it more bluntly: “An idea that unifies all of engineering is the concept of failure.” *Failure criteria* are explicit ideas about how a system can fail to perform as intended. Preferably, the failure criteria are identified during the design process, but Petroski cites examples such as the explosions that destroyed [de Havilland’s Comets](#) where some failure criteria were only discovered after analysis. Petroski points out that failure can take nontechnical forms including environmental impact, aesthetics, and economic (including bankruptcy). In [Operating Manual for Spaceship Earth](#), Bucky blames over-specialization:

Of course, our failures are a consequence of many factors, but possibly one of the most important is the fact that society operates on the theory that specialization is the key to success, not realizing that specialization precludes comprehensive thinking.

A Case Study of Failure: The Aluminum Beverage Container

In Chapter 5 of “Invention by Design”, Petroski explores the role of failure with a case study of the Aluminum [Beverage Container](#). When the iron food container was first introduced instructions for how to open the containers with hammer and chisel were sometimes provided. Later



steel beverage containers required a [churchkey](#) which also needed instructions at first. The first Aluminum beverage containers needed churchkeys for opening. In 1962 Ermal Fraze invented the pull tab for opening aluminum cans. In 1976 Daniel Cudzik's patent introduced the stay-on-tab. Here is a listing of some of the failure criteria to which an aluminum beverage can is subject:

- Strength against bursting: the can is a pressure vessel
- Strength for storage and transport
- Lightweighting: strength with a minimal use of materials, e.g., aluminum vs. steel



- Pressure explosion upon opening the can
- Leaking from rivets, seams, or puncture of the thin wall
- Sitting flat on a surface given that the pressurized contents will tend to bow out the bottom of the can
- The tab may be too weak and fall off
- The tab's lever may be too weak to open the can
- The opening from the tab may be too small to allow air to enter to displace the contents
- The scoring of the metal may be inadequate making it hard to open or cause leaks



- The tab may become a projectile under pressure from the can
- Once opened, the can must maintain stability while being held and during the process of drinking from it
- Unless the culture is familiar with the mechanism of opening and using cans, instructions may be required
- Aesthetic concerns may block acceptance of some designs
- Environmental failure: litter of pull tabs, physical danger of small shards of aluminum from discarded tabs, danger of drinking pull tabs placed in the can itself
- Environmental failure: ease of recycling

As one can see from this seemingly simple example, there is tremendous complexity to take into account all the failure criteria! Diligent effort and years of continuous redesign and analysis are

needed to produce safer and more effective solutions for widely deployed technologies like the aluminum can. The inherent complexity means there are always opportunities for big improvements. Thinking this through, it becomes clear that these opportunities spur the incessant design evolution we all experience and sometimes struggle with as [future shock](#).

Failure is the Wellspring of Invention

The aluminum beverage can case study illustrates how failure leads to invention in that Frazee's pull-tab solved the problem of being thirsty without a churchkey. Then Cudzik's stay-on-tab solved the environmental hazard that was a side effect of Frazee's pull-tab. Modifying existing designs to overcome observed shortcomings drives innovation in the design and engineering arts. In short, failure is essential to progress ... it is, in fact, the wellspring of progress. Here are some inspirational quotes on failure:

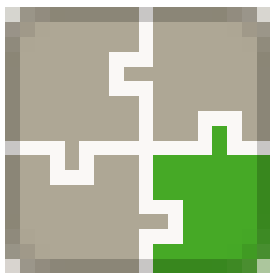
Everyone makes mistakes, even geniuses like Galileo. Engineers must always be alert for what they may be oversimplifying and overlooking or to what conclusions they may be jumping. Because errors in engineering can have disastrous consequences, it is especially important for engineers to be reflective and alert in their design and analysis.
— Henry Petroski

Mistakes aren't things to be discouraged. On the contrary, they should be cultivated and carefully investigated. —Jonah Lehrer

I only learn what to do when I have failures. — R. Buckminster Fuller

The way to succeed is to double your error rate. — Thomas J. Watson

The Risks of Safety



Thanks to [Brian B.](#), I learned about Edward Tenner's interesting work. Tenner wrote a piece in [The Atlantic](#) called [Technology's Disaster Clock](#) in which he cites his graduate teacher [William H. McNeill](#) who coined the *Law of the Conservation of Catastrophe*. The idea is that even if a new invention (including built technology as well as laws or regulations) resolves some acute safety issue, a chronic problem will develop as a side effect of the "solution". Although this "law" (like [Murphy's law](#)) is intentionally ironic, it points out that it is effectively impossible to achieve the perfection of any technology.

In the video Tenner cites other "risks of safety" including "normalization of deviance" (where people gradually adopt a culture of by-passing safety controls that initially were inviolable), "risk compensation" (where the adoption of safer procedures "encourages" the workers to take bigger



risks to “compensate” for their improved situation), and “practical drift” (where a safety feature is thoughtlessly required even when the “fix” is impractical; e.g., [the capsizing of the SS Eastland which killed 844 people due to instability from retrofitted lifeboats](#)). Tenner suggests that these risks can be mitigated by engaging engineers and designers in multidisciplinary teams whose many different perspectives can proactively identify some of the latent problems that are inevitable with each new push for better safety.

Security is mostly a superstition. It does not exist in nature ... Life is either a daring adventure or nothing.
— Helen Keller

Big Failures: Catastrophe and Disaster

Big failures seem to be in the news a lot lately: [the Fukushima Nuclear Accident](#), [Southwest’s failing jet fuselages](#), [BP’s Gulf Oil Spill](#), infrastructure failures from [Hurricane Katrina](#) and [the 2011 Joplin tornado](#), [the September 11 attacks](#), and the [global financial crisis of 2008-9](#). As suggested above, failure is normal and is indeed an essential element in all progress. What is the nature of catastrophic failure?

Big events happen less frequently than smaller scale events. It is an elementary observation that should inform our equanimity. Even if the impact is enormous and vigorous remediation is required, remember that big events are actually very rare. Long term, effort is best applied to find perspicacious solutions to provide wide-ranging improvements that would also mitigate the next disaster. Design work is filled with complex tradeoffs and insufficiently vetted, rushed “solutions” can cause more problems than the original disaster (witness the USA’s recent wars which have lost more lives, destroyed more capital equipment, and cost more money than the disaster on 9/11 that instigated them). Intelligent improvements to ameliorate the effects of another “big one” make sense, but efforts to “prevent” one “at all costs” can be a big waste of resources. [The wretched plan to irradiate airline passengers with “see-you-naked” scanners](#) is another example of over-reacting to unlikely risks such as IEDs (Improvised Explosive Devices) on planes [see this [cost-benefit analysis](#)].

[Nassim Nicholas Taleb](#) poignantly illustrates the problem of rare events with his [Black Swan Theory](#). The history of the term “black swan” is fascinating: in 16th century London the notion of a black swan was a statement of impossibility. Then in 1697, [Willem de Vlamingh](#) discovered flocks of them in Western Australia. So “black swan” is now a metaphor that assertions of “impossibility” based on prior experience can be untrustworthy. When there is almost no historical experience to guide us and complex decisions are necessary (Taleb’s so-called [Fourth Quadrant](#)), the future will be inherently unpredictable. In such situations it is unwise to delude oneself with traditional risk mitigation strategies (like [insurance](#), [six sigma](#), etc.). Taleb argues that “all small probabilities are incomputable” and are therefore meaningless. Attempts to compute them typically result in significant underestimates which can be enticingly deceptive and thus dangerous.

Another important thinker about [risk management](#) in society is [Charles Perrow](#). The second edition of his book “Normal Accidents” was published in 1999 and he has a 2010 book [The Next Catastrophe: Reducing Our Vulnerabilities to Natural, Industrial, and Terrorist Disasters](#). Here is a short review as I have not had a chance to read them:

“[Charles] Perrow is famous for his book Normal Accidents: Living With High-Risk Technologies, originally published in 1984. In it he argued that most major industrial disasters could be traced not to simple operator error but to the vulnerabilities of what he called complex, highly coupled systems, where each part depended on many others. He showed how small and apparently disconnected failures could cause such a system to fail catastrophically and unpredictably. So unpredictable are these systems that an effort to prevent one mode of failure may inadvertently create another one.”

— Kenneth R. Foster from the January 2008 issue of IEEE Spectrum

Preventing Catastrophe

Before a disaster, people tend to dismiss the possibility of black swans and their large impact. Even when someone raises the spectre of potential disaster, we tend to dismiss the concern noting that it has never happened before or we compute a meaningless astronomically low probability to boldly set ourselves up for infamy. Sometimes, we dismiss the concern because fixing it might cost too much. What is not often considered ahead of time is the fact that big unexpected failures often have extremely large impacts on psychology and society. These effects must be factored into planning! With Charles Perrow, Henry Petroski, Nassim Nicholas Taleb, and Edward Tenner ringing alarm bells alerting us to the nature of failure, perhaps we are now informed enough to build more robust systems in the future. Or will their message dissipate over time as the “normalization of deviance” suggests?

Beyond awareness, understanding and education, we have other tools to mitigate disasters. One trend that is helping is to include larger, more diverse teams in the design process. These more resourceful groups are more able to more completely identify the failure criteria and find better designs which can effectively balance tradeoffs. It could be that global Internet-connected communities working with open designs and discussions could take this notion of reliability from diversity to an even more effective scale. [Systems thinking](#), and comprehensive thinking approaches



like [synergetics](#) can also help us find better solutions. For example, a wind-shedding geometry like the [geodesic dome](#) could substantially reduce property damage from hurricanes and tornados. [Amory Lovins](#) et. al. at the [Rocky Mountain Institute](#) have an interesting [report entitled “Factor Ten Engineering Design Principles” on designing with whole-system thinking and integrative design](#). When failure criteria are addressed in the design phase and with a broad and creative approach, technology can more incisively meet society’s needs through effective design and engineering!

Fostering Technology to Build Society

We have seen that technology is inseparable from society. Indeed it may be that technology is the primary means by which life builds increasingly complex systems to perform its local [syntropic functions](#). If that is so, our role as individuals in the conversations to design and re-design technology are at the core of all social development. Failure is a focal point in developing technology: it is both inevitable and the impetus for our never ending quest to re-make the world to be better and better. In less than 250 pages Henry Petroski's *Invention by Design* helps clarify the nature of design and invention so that you can participate more effectively in the discussions and initiatives that improve society and our technology built world.

I look forward to reading your questions, thoughts and ideas in the comments.

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13 Responses to “Society and Our Technology Built World”

1. [Todd Walton](#) on 2 June 2011 at 1:48 pm



A wonderful and timely essay full of so many interconnected things to think about. I especially appreciate your inclusion of Buckminster Fuller in your discussion of technology and the importance of failures, which might also be called “helpful results along the design continuum.” Alas, the catastrophic failures of the nuclear

power plants at Fukushima are the result of greedy people ignoring thousands of lesser design failures that should have stopped them from building nuclear power plants in the first place.

[Reply](#)

2. **Doug** on 2 June 2011 at 4:33 pm

Again, this is an exploration that stimulates a desire to respond comprehensively, accompanied by a lack of time that inevitably brings on a failure to respond fully to the issues raised. Is that what I meant to say?

From one angle, for Bucky, there was no such thing as failure. If you pay proper attention to “failure” there is always an increase of knowledge. Failure is the shadow side lurking within any important goal. Failure only take on meaning within the context of a goal. Perhaps it’s not the failure that’s so valuable as the ability to give failure its proper attention. We turn from failure in shame. Toward the end of *Death of a Salesman*, Linda Loman says to her sons, “Attention must be paid.” She’s not really prescribing a “fix” but a quality of attention. During America’s rise in global affairs in the early 1950s, the most successful playwrights on Broadway were Poets of Failure... Tennessee Williams and Arthur Miller. Williams even wrote a short article about the Bitch Goddess Success.



The tragic hero takes on meaning because his excessive aspirations exceed capabilities, and inevitably trigger the “sacrifice.” The Greeks believed this doomed ambition was essential to society. The hero/heroine’s reach always exceeded the ability to grasp... but somehow society benefited from the aspiration. They also believed that a dramatization of this struggle could purge pity and fear and move us into a wonder that heals. Did Christianity redefine the tragic flaw into something more like sin?

Brecht’s *Galileo* strives to shuffle away from heroism and its destructive capabilities. He is upbraided with this statement from his sharpest disciple, “Sorry the the country that has no hero!” Galileo responds, “Sorry the country that needs a hero.” Is he sly? Is he a coward? This play, too, was written and rewritten in the shadows preceding and following the dropping of the atomic bomb. Since the renaissance, we’ve been wrestling endlessly with our various concepts of the hero. Do our heroes save us or destroy us?

[Reply](#)

3. **Dick Fischbeck** on 2 June 2011 at 6:13 pm

“Still, it seems that most design or engineering projects that are actually implemented will be influenced by social forces with their concomitant political elements.”



The ones that are ‘actually implemented’ are the ones that work in the sense of being economical, efficient and beneficial. I see politics as a case of the tail wagging the dog. I try to ignore it. I find no inspiration in it. Superfluous. Anachronistic. Sometimes even creepy.

Of course, maybe you mean by politics, decisions must be made or reversed.

[Reply](#)

4. [jeannie moberly](#) on 2 June 2011 at 8:13 pm



So we bumble along.

[Reply](#)

5. [Dick Fischbeck](#) on 5 June 2011 at 2:35 pm

Nature is at work everywhere. Nature is even working on supplying us with plenty, on FB and on voting, to name 3. How can this not be true? Where is nature not at work. I guess the questions are, how is nature using me. And what does nature want me to do.



“In its complexities of design integrity, the Universe is technology. The technology evolved by man is thus far amateurish compared to the elegance of nonhumanly contrived regeneration. Man does not spontaneously recognize technology other than his own, so he speaks of the rest as something he ignorantly calls nature.” — Buckminster Fuller, Synergetics, 172.00-173.00

[Reply](#)

6. [cjf](#) on 6 June 2011 at 6:02 pm

Doug, thanks for bringing out additional angles on “failure”. “Attention must be paid”: that is apt.

In our culture the idea of “failure” has a negative feeling to it, I tried to compensate by emphasizing its positive side. So much of our schooling involves punishment in the form of bad grades for “wrong” answers. It engenders a misplaced fear of failure. Effort must be applied to overcome this unfortunate tendency.



At least since [Hammurabi's Code](#), the Hebrew laws, Christianity and sin, and Islamic law, civilization has been immersed with God, Law, and the effort to sculpt society with rules. On the positive side, these rules provide guidance and codify learning from our ancestors. But some religious/government people get too carried away with their rules and they forget about the generative power of “the tragic flaw”. Is it possible to institutionalize *mistake mystique* to counter-balance the sometimes deleterious effects of *Law*?

Harvard has an interesting on-line course [The Heroic and the Anti-Heroic in Classical Greek Civilization](#) (I have not watched it). Given your references to heroism and the Greeks, you might find it interesting.

[Reply](#)

7. [cjf](#) on 6 June 2011 at 11:43 pm

Dick, I think of politics as the social effort involved in organizing groups of people. So politics is like social architecture. It is true that most politics is uninspiring, superfluous, anachronistic and sometimes even creepy. But that's just because we have such a crude culture of politics (winning is often considered more important than working toward common purpose; and worse, imposing our values upon others is frequently viewed as more important than compassionately tuning into the others' values and working to include them in the solution). Similar problems occur when working with bad tools ("this screwdriver stripped another screw"). That is, bad social engineering like bad technology leads to bad results.

I do like Bucky's apolitical view. Surprisingly, I find it is political: Bucky seems to be saying do not blindly rush to do the politically expedient thing; search for an even better design that will offend no one and will more significantly improve the system. He is saying take the long term view (which is typically considered impractical in too much of politics). This idealism has an important place (if all the actors abandon idealism and take the myopic view, we will only get the crudest of crude results).



I do not yet understand the subtleties of organizing groups of people while balancing the long and short term with failure criteria and analysis and mistake mystique. It often seems that politics is a complex muddle. But I think we need to muddle through and not completely disdain and ignore politics. Lest the short term and crude come to control our social systems without the influence of the perspective to strive for more comprehensive solutions (it may be that another angle on Bucky's apolitical view is that we have more influence as outside critics than as compromising deal-brokers). Fortunately, we have learned a lot about organizing people. We know that values, purpose, open mindedness, diversity and common ground are important. We have some democratic voting decision-making systems that strive to be somewhat inclusive. There is much more to learn.

[Reply](#)

8. **Russ Chu** on 7 June 2011 at 11:39 am

About our technology built world: It seems that the question could be – what is the difference between Universe or nature's way of building and human's way of building? Assuming that it is desirable to build more like nature.



Nature is self-assembling, it is synergistic, and evolving. All its parts are also evolving at the same time. Our world is within the Universe. Everything we build is based on euclidean geometry, and it is also evolving. The major difference is the self-assembly and its implications. Brian Arthur wrote a book "The Nature of Technology, what it is and how it evolves"

[Reply](#)

9. **Doug** on 9 June 2011 at 2:05 pm



Thanks for the course link. It looks interesting.

In the bible, there is a skepticism about the Law... and its stated as the need to

make sure the spirit of the law is not violated in applying the letter of the law.

It's a thread that goes through the whole history of Western law... and I suspect there is a version of it in most all cultures.

Mistake Mystique: I knew a music teacher who once told me, in Jazz, mistakes get repeated and they can become the pattern of a whole improvisation. She also said that even in top classical pianists, the players who all the time get every note right are not playing the music but the notes, and that there playing tends to be more mechanical than musical. In that context, she also said, "The wrong note in the right place is half wrong. The right note in the wrong place is all wrong." So... as ever... it's all in the timing.

[Reply](#)

10. [Dick Fischbeck](#) on 10 June 2011 at 7:13 pm



David Orr agrees with you, CJ, on 'politics are important.' He is speaking at the BFI Challenge award. You are in good company.

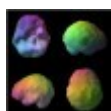
[Reply](#)

11. [Joshua pang](#) on 19 June 2011 at 6:31 pm

http://americansanskrit.com/read/a_techage.php

I love technology. Interesting no ray kurzweil name-drop.

Resonate @humanity=earth-brain #fun



Bonnie DeVarco in on global brain. Invisible architecture <3

Take care of your brain. I see hyperlinks as a afterimage re brain comprehension lags.

Happy to Universe Game w/ you.

Josh

[Reply](#)

12. [nick consoletti](#) on 20 June 2011 at 4:10 pm



i read through your post if i recall correctly jay baldwin once said good design (techology) comes from clear thinking. there is an evolution to design; it escapes me why we end up in the doldrums with hackneyed cliches, be it music, art, or what have you. jonas salk called it deevolution or anti evolution. i cannot remember the distinction. For my money i would refer people to henyr dreyfus's work one of them is "Design for People, or Victor Papanek's work in his last book "The Green Imperative" has challenged R Buckminster Fuller stance of being apolitical. At any rate Fuller used to always use that term Cosmic Evolution as

God articulate...

[Reply](#)

13. [David Calloway](#) on 27 June 2011 at 2:45 pm



Respond comprehensively, or not at all? Much to think about. Thanks for pointing me to this, CJ.

[Reply](#)

14.