



University  
of Victoria

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## Our Travels Through Techno-Social Space-Time: Envisioning Incoming Waves of Technological Innovation

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University of Michigan, Ann Arbor

How can we visualize our life-journeys through an ever-more rapidly-changing techno-social landscape? How did the processes of social-change begin speeding-up in the first place? Where are we headed as we enter the looming techno-social age? These questions are on ever-more minds all around the world. For insights we reflect on, then follow, evidence and words of wisdom from the past.



[UVIC Transgender Archives](#)



This slideshow with embedded links is posted online for later study & reference:

[http://ai.eecs.umich.edu/people/conway/Memoirs/Talks/UVIC/Techno\\_Social\\_Talk.pptx](http://ai.eecs.umich.edu/people/conway/Memoirs/Talks/UVIC/Techno_Social_Talk.pptx)

[http://ai.eecs.umich.edu/people/conway/Memoirs/Talks/UVIC/Techno\\_Social\\_Talk.pdf](http://ai.eecs.umich.edu/people/conway/Memoirs/Talks/UVIC/Techno_Social_Talk.pdf)

[UVIC Engineering & Computer Science](#)



Let's begin by visualizing some past waves of techno-social change . . .



Dropping-back-in just before them, then coming forward through time . . .

And as we travel through space-time . . . be sure to keep these words in mind:



[Link](#)

*“The farther backward you can look, the farther forward you can see.”*

– [Winston Churchill](#)



We begin during the [Renaissance](#) in the 1400s, a time of transformational cultural advances . . .

Just look at the mechanization of astronomical calculations by the [Prague Astronomical Clock](#), c. 1410

It's a stunning confluence of the highly advanced Mathematics, Science, Engineering, Architecture and Art at That Time . . .

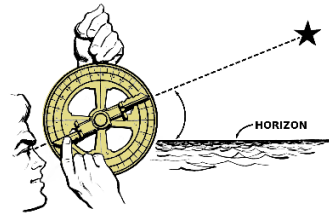


Photo by Hector Zenil ([www.hectorzenil.net](http://www.hectorzenil.net))

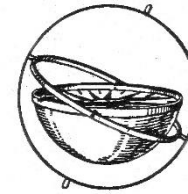


By the late 1400's advances in shipbuilding, navigation & mapping reached a 'tipping point' . . .

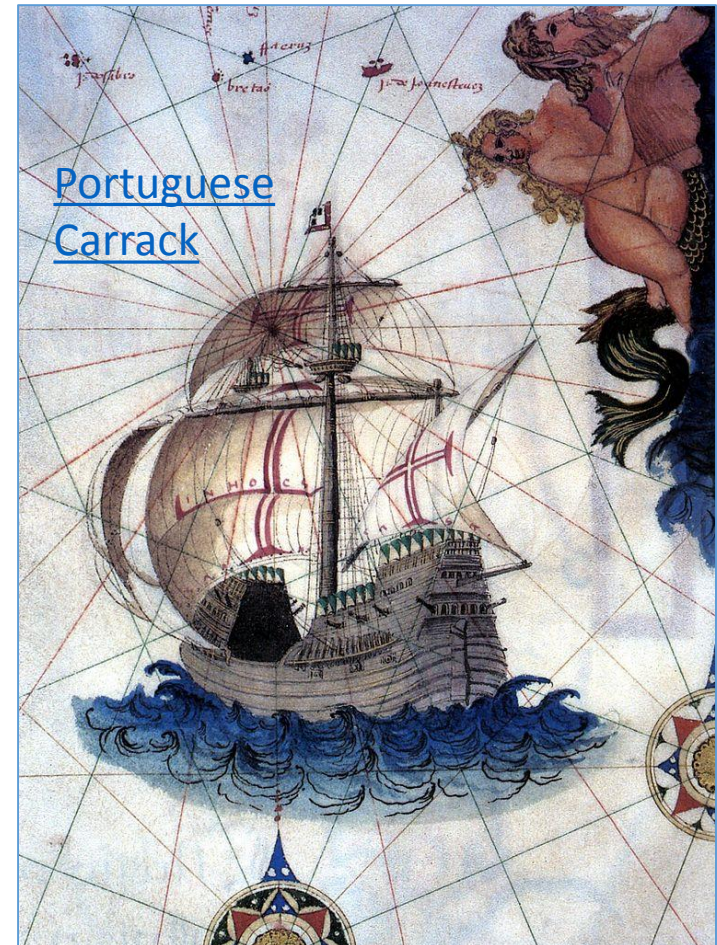
Triggering the Age of Discovery by enabling explorations across the open seas . . .



Mariner's Astrolabe

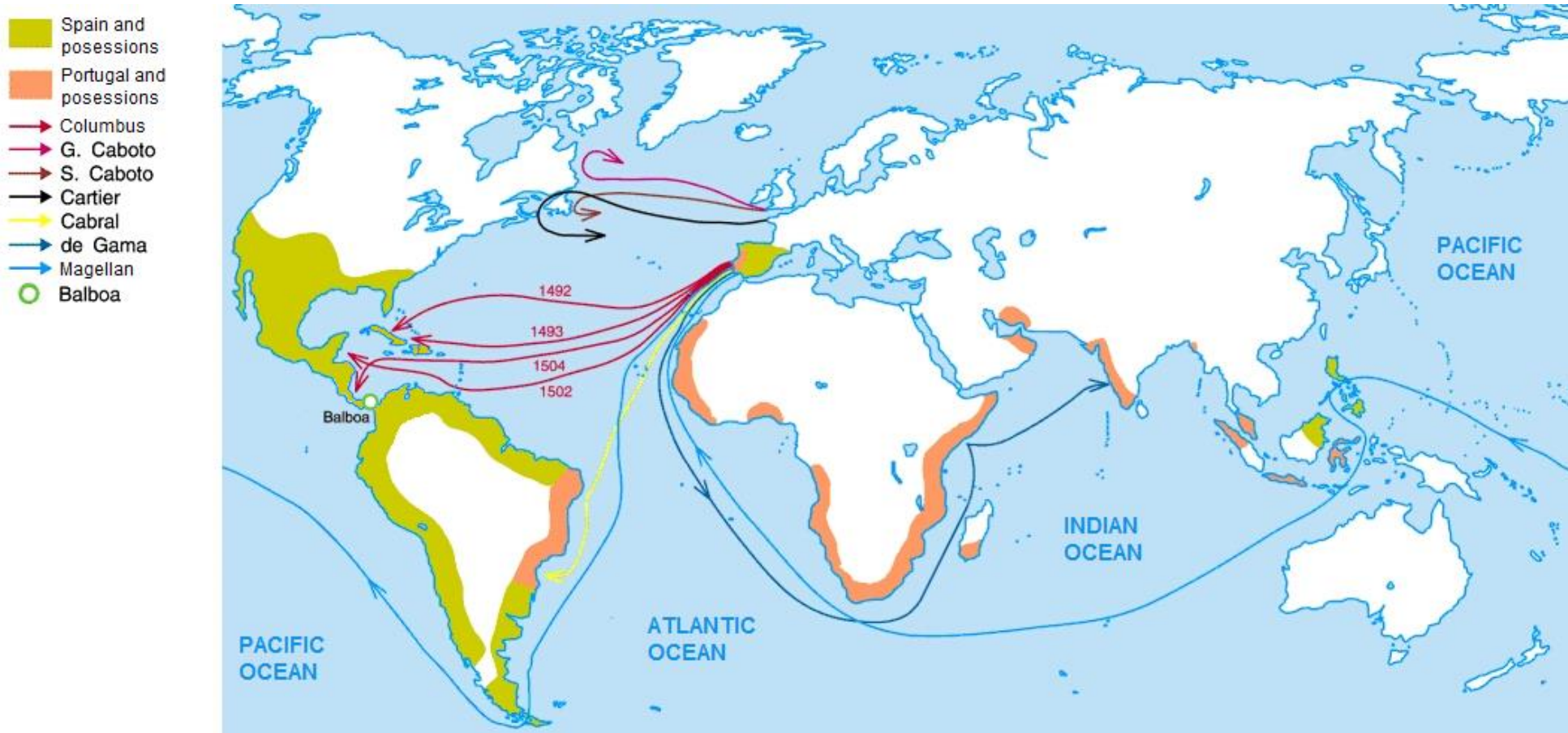


Gimbal Compass





Thus it begins: Charting the Early Voyages during the Age of Discovery, c.1492-1522 . . .



[Wiki Commons](#)

As mass-communication by [printing](#) spread in the late 1400s, it enabled adventurers to ever-more quickly propagate news of what they'd found and where they'd found it . . . dramatically escalating the exploration rate . . .

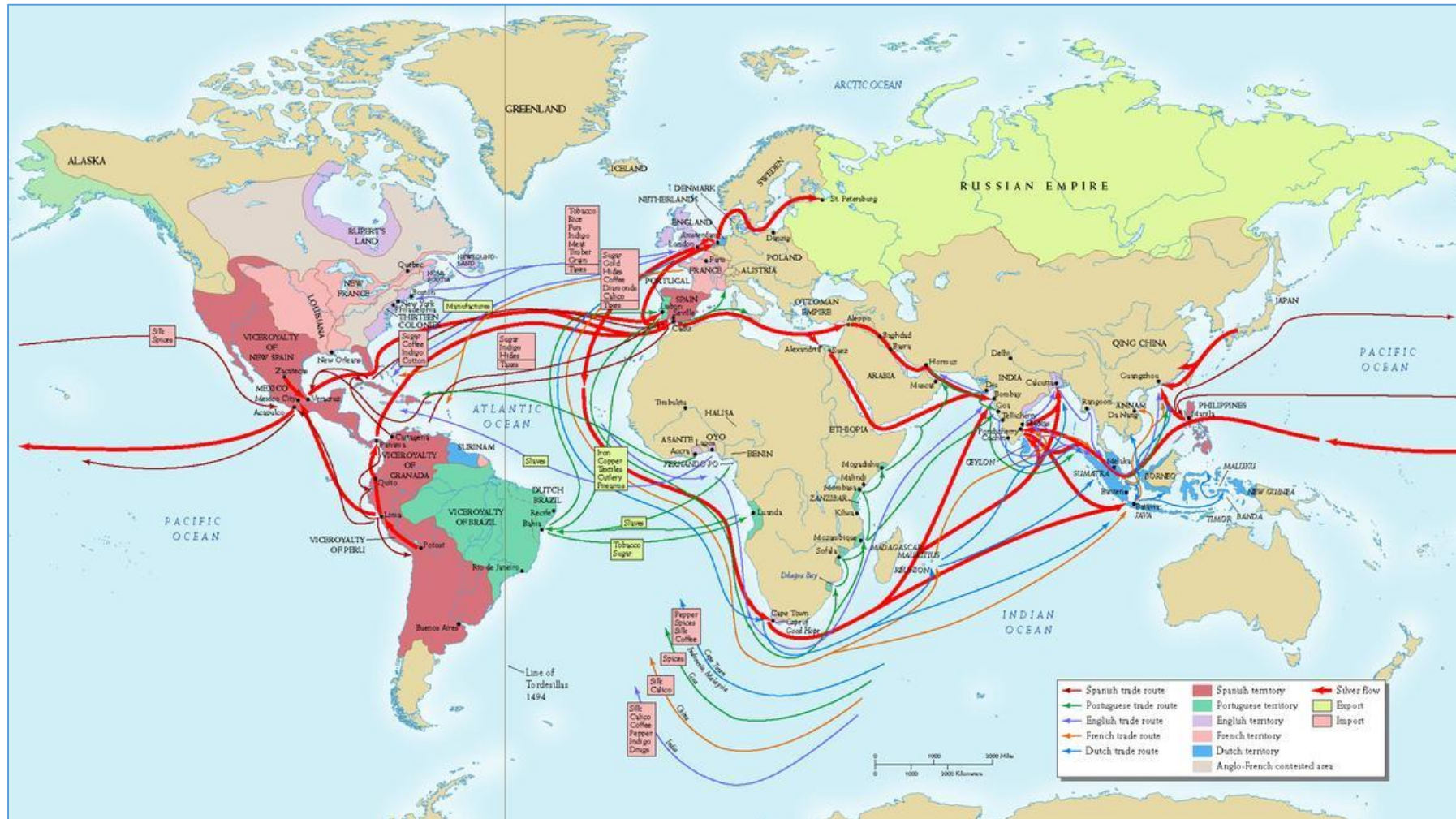
Replica Gutenberg Press at the [Featherbed Alley Printshop](#) Museum:



[Link](#); Attribution: [Aodhdubh](#) at [English Wikipedia](#)



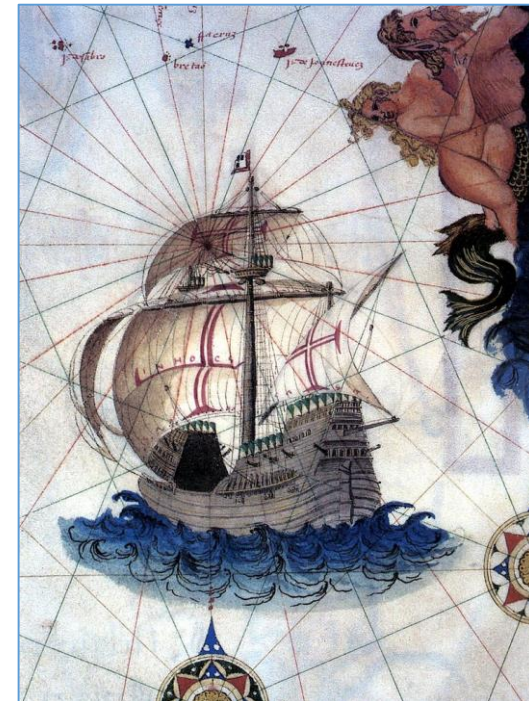
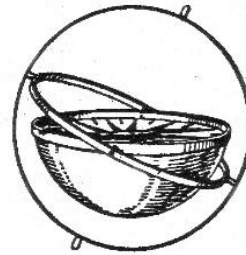
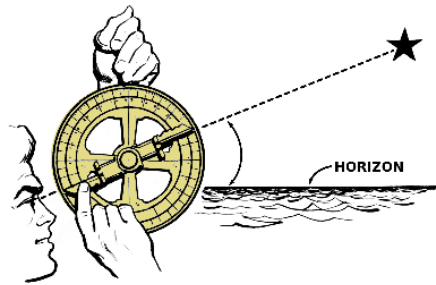
By the early 1700's, exponentiation had generated a massive global trading system . . .



Source

Now, what' happening here?  
Just exponentiation of THINGS?  
Is that all this is?

Or also exponentiation and diffusion of key clusters of innovative IDEAS thru the minds of ever more people?  
**IDEAS on how to MAKE and USE things . . .**



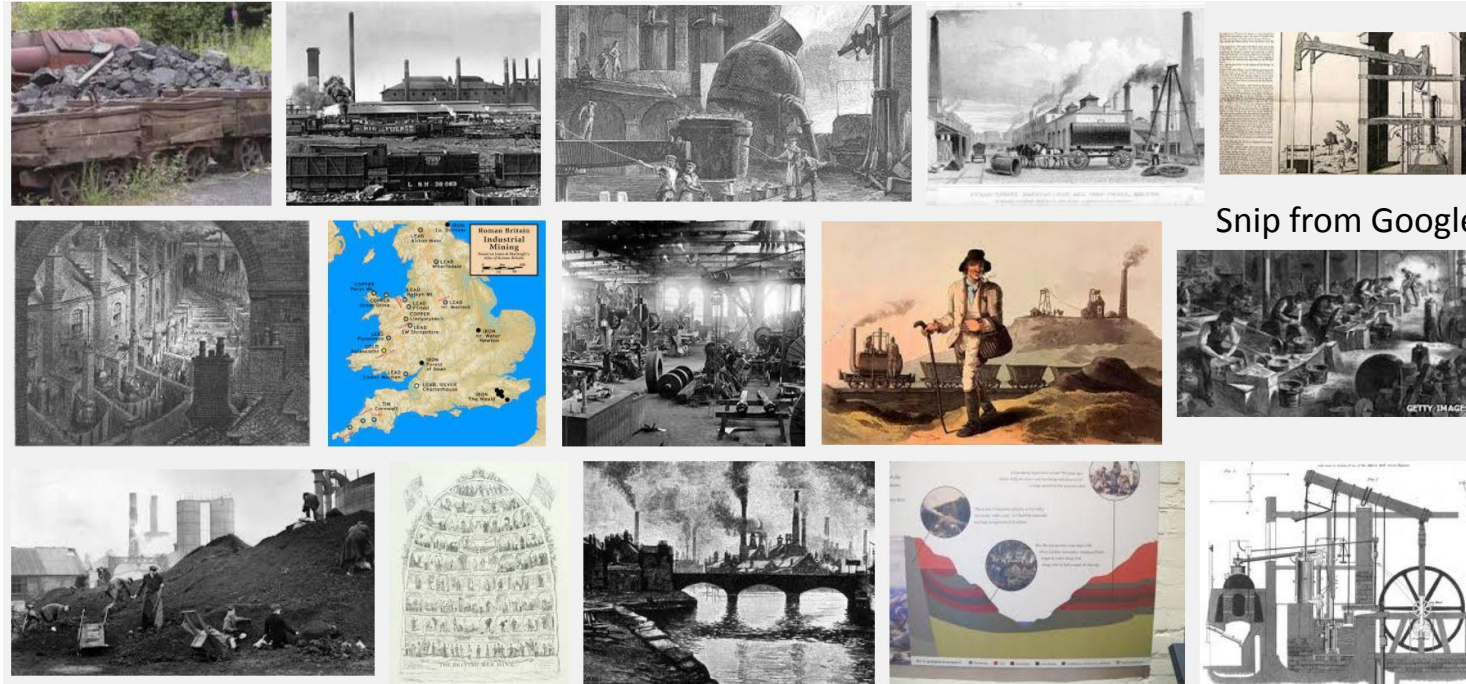


By the mid-1700's, the stage was set for yet another tremendous [disruptive wave](#) of innovation . . .  
and so began the [industrial revolution](#) (~1760) . . .





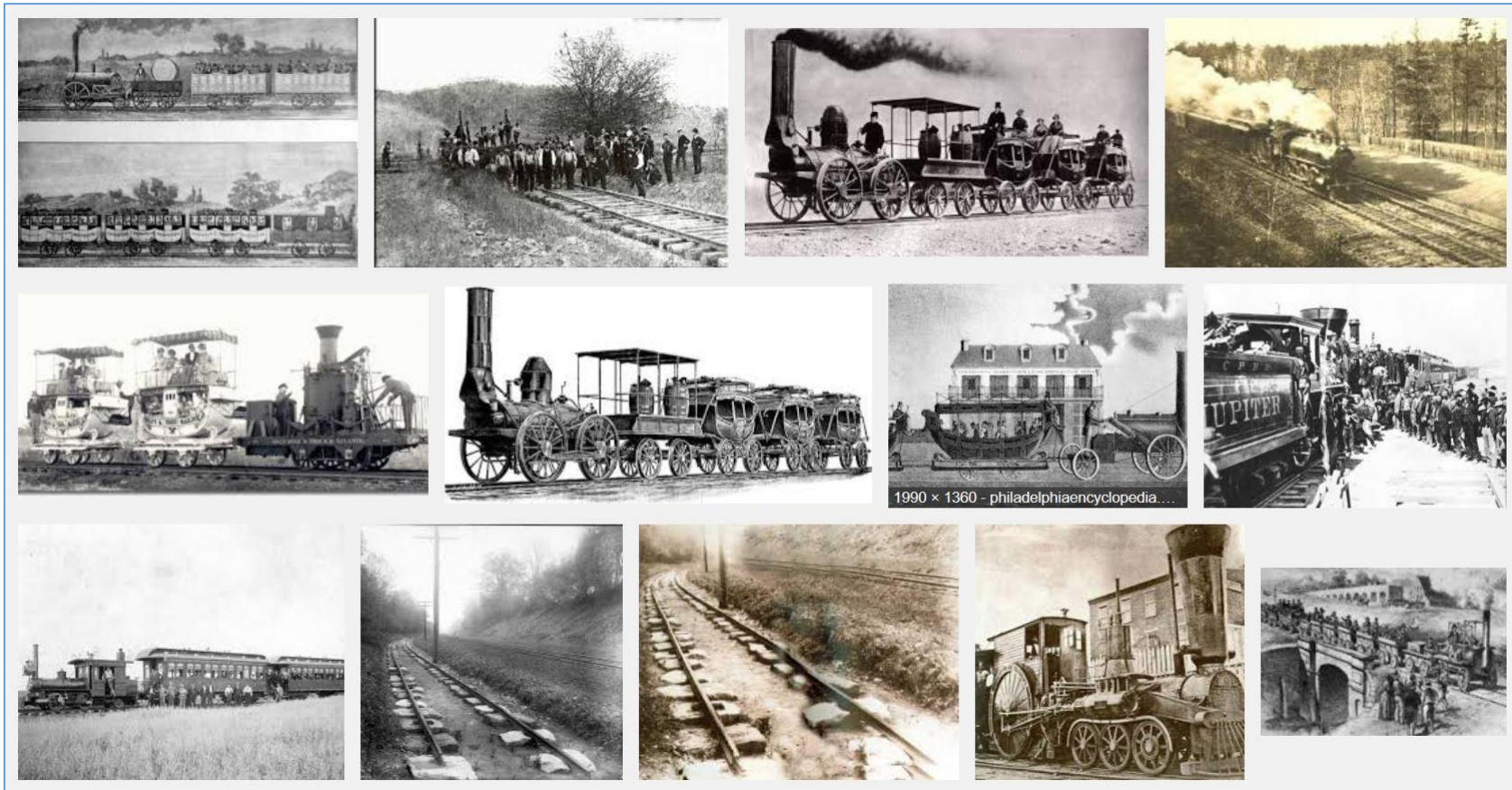
During the Industrial Revolution the mining/processing of coal and iron-ore was greatly amplified by steam-power . . .



Snip from Google Images

Some of the [resulting iron was used](#) to make more steam engines, and this positive feedback fueled an [iterative expansion-process](#) . . .

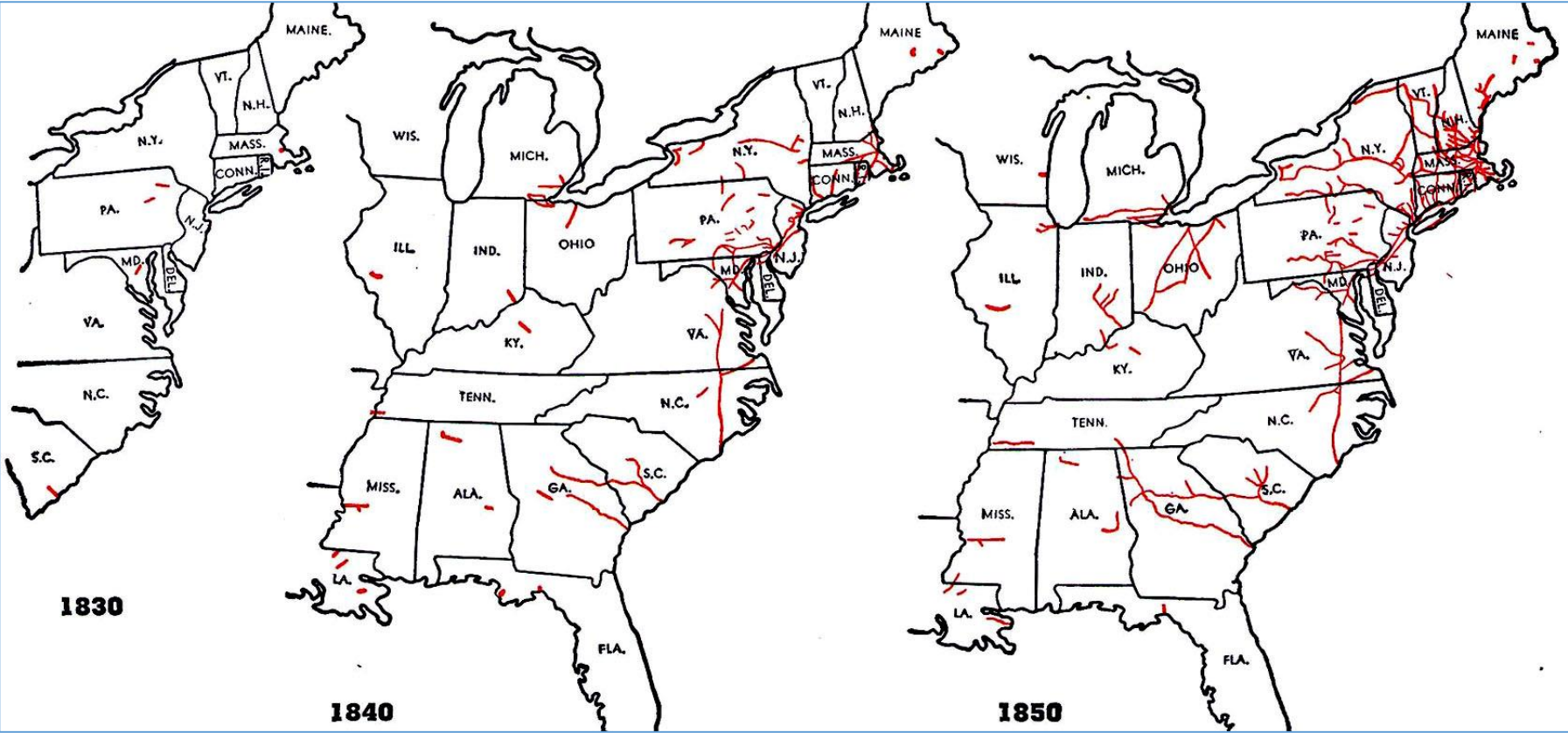
By the 1830's, steam-powered railroads began interconnecting mines to iron-works and rail-makers, enabling ever more rapid expansion of the railroads . . .



Snip from Google Images



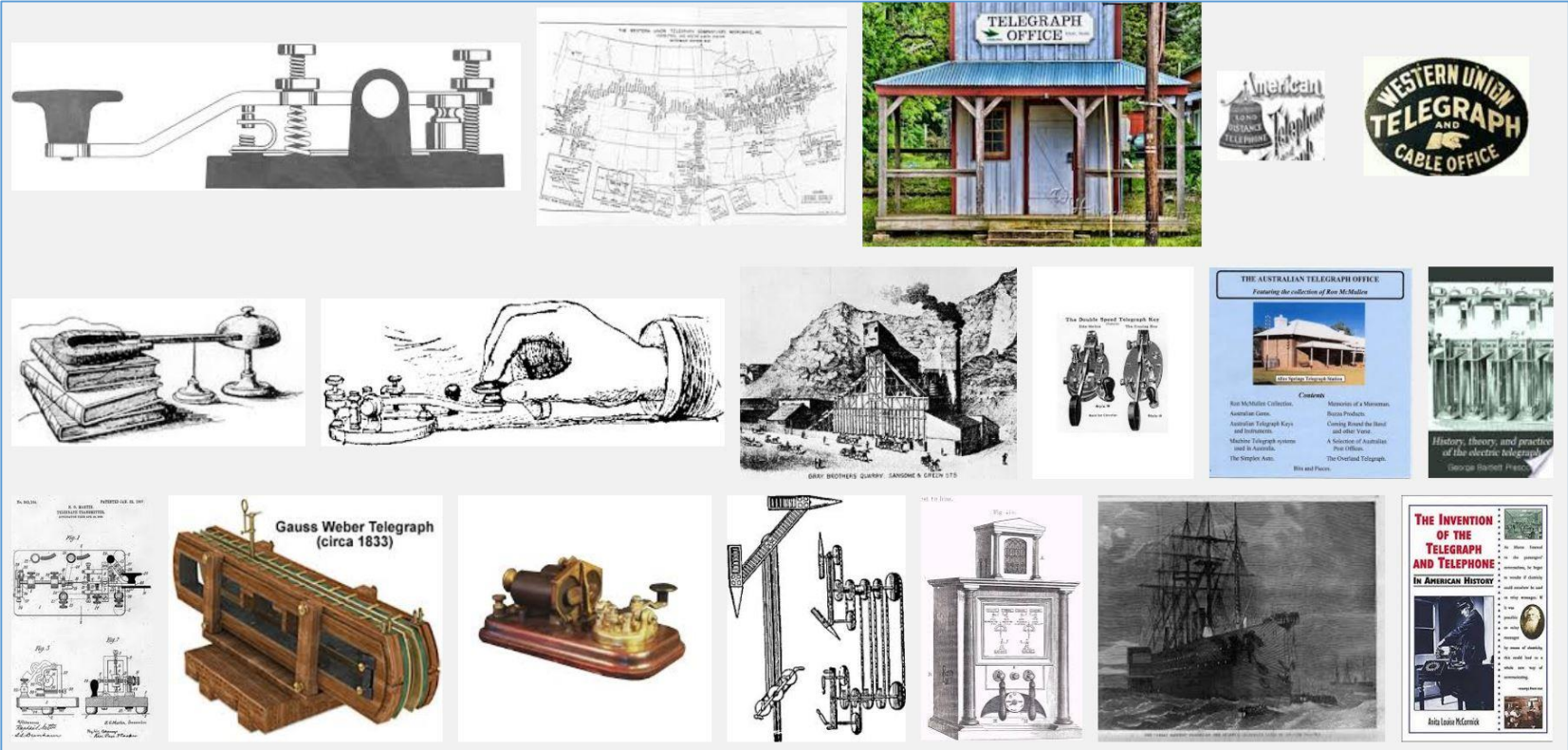
These maps show the rapid early-spread of railroading in the United States. . .



[http://www.cpr.org/Museum/RR\\_Development.html#2](http://www.cpr.org/Museum/RR_Development.html#2)

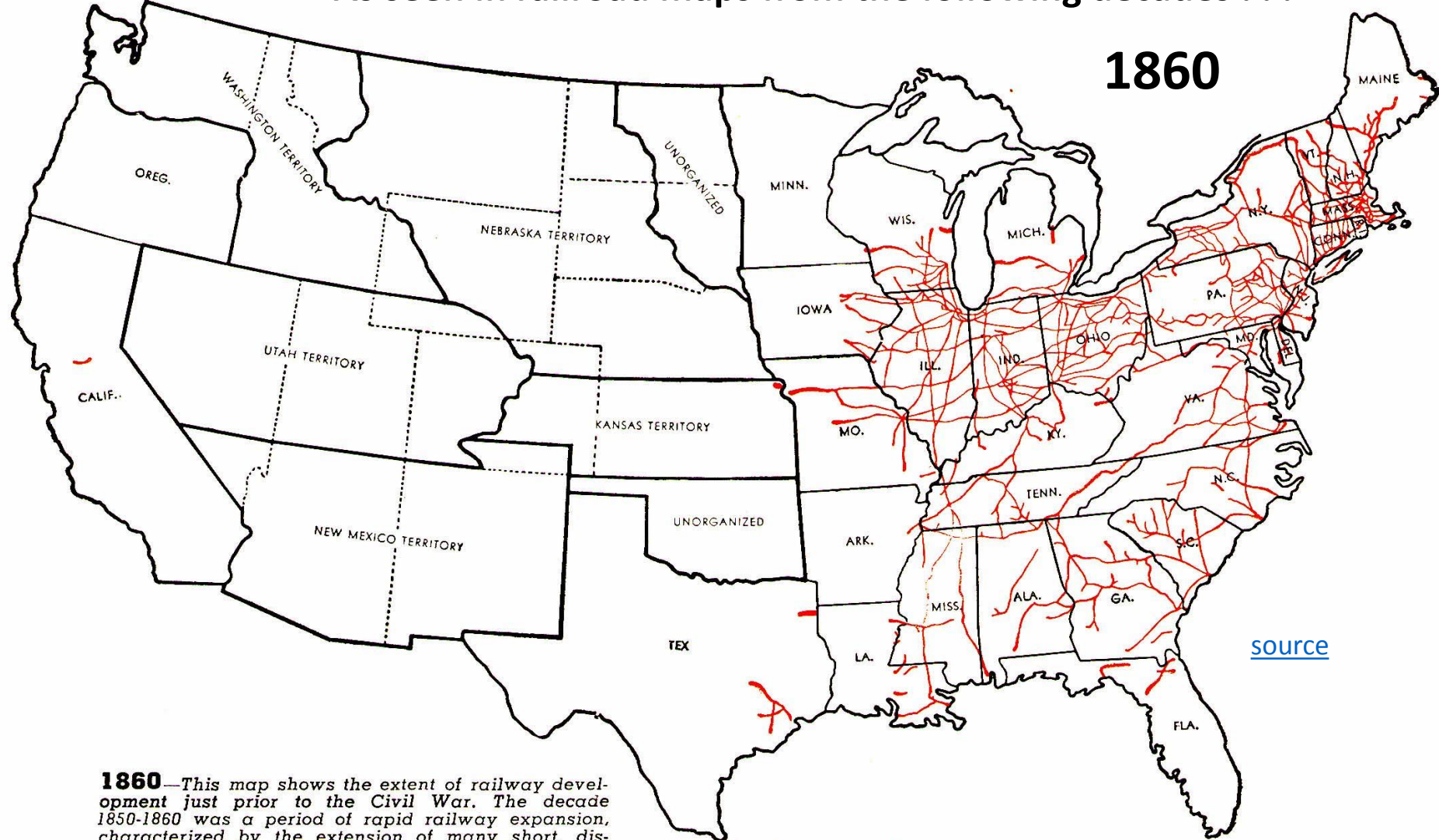


The expansion was accelerated by the rapid-spread of *telegraphy* in the 1850s, an effect analogous to that of *printing* during the age of discovery . . .



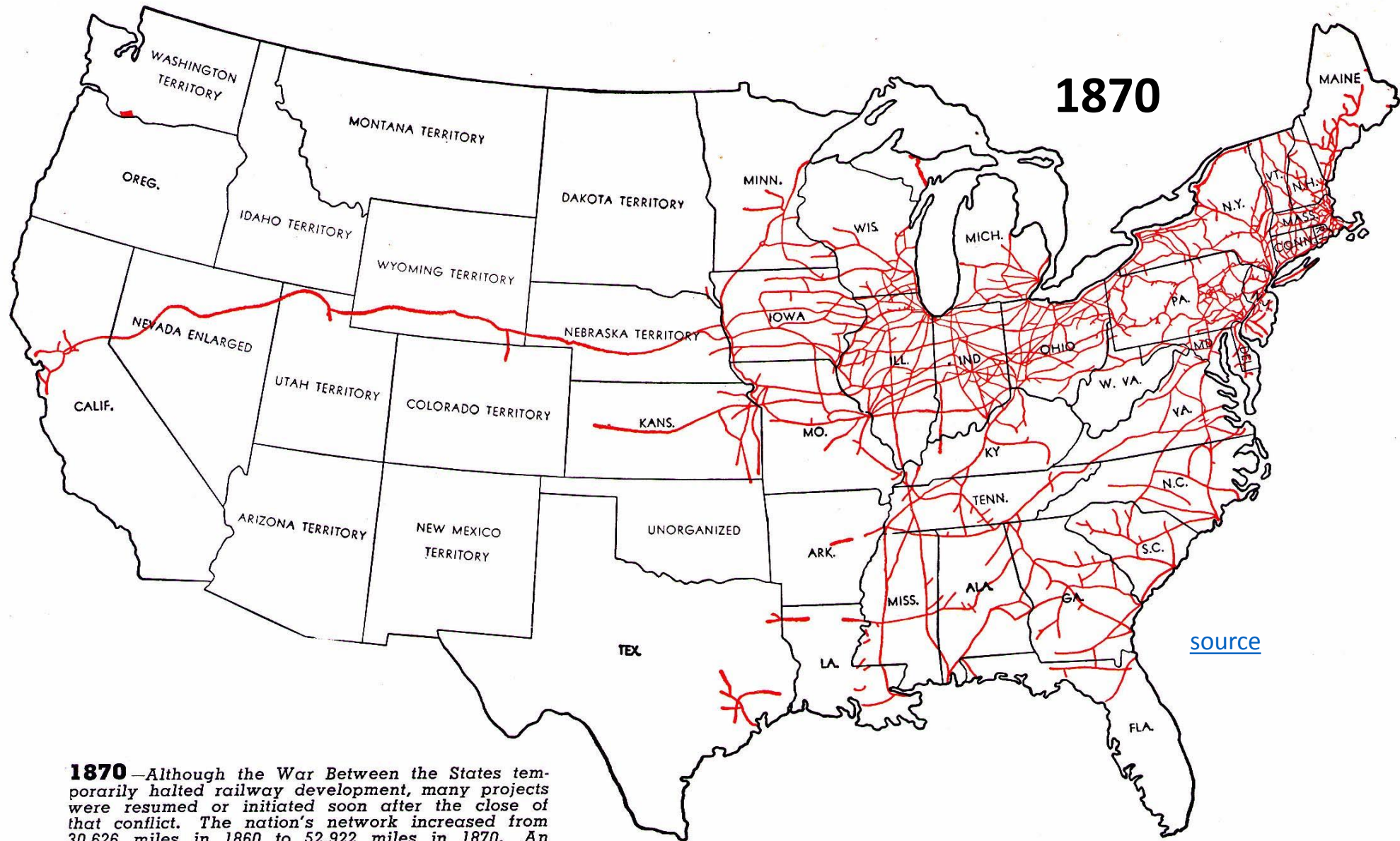
(Snip from Google Images)

As seen in railroad maps from the following decades . . .



**1860**—This map shows the extent of railway development just prior to the Civil War. The decade 1850-1860 was a period of rapid railway expansion, characterized by the extension of many short, disjointed lines into important rail routes. This decade marked the beginning of railway development in the region west of the Mississippi River. By 1860, the "Iron Horse" had penetrated westward to the Missouri River and was beginning to make itself felt in Iowa, Arkansas, Texas, and California.



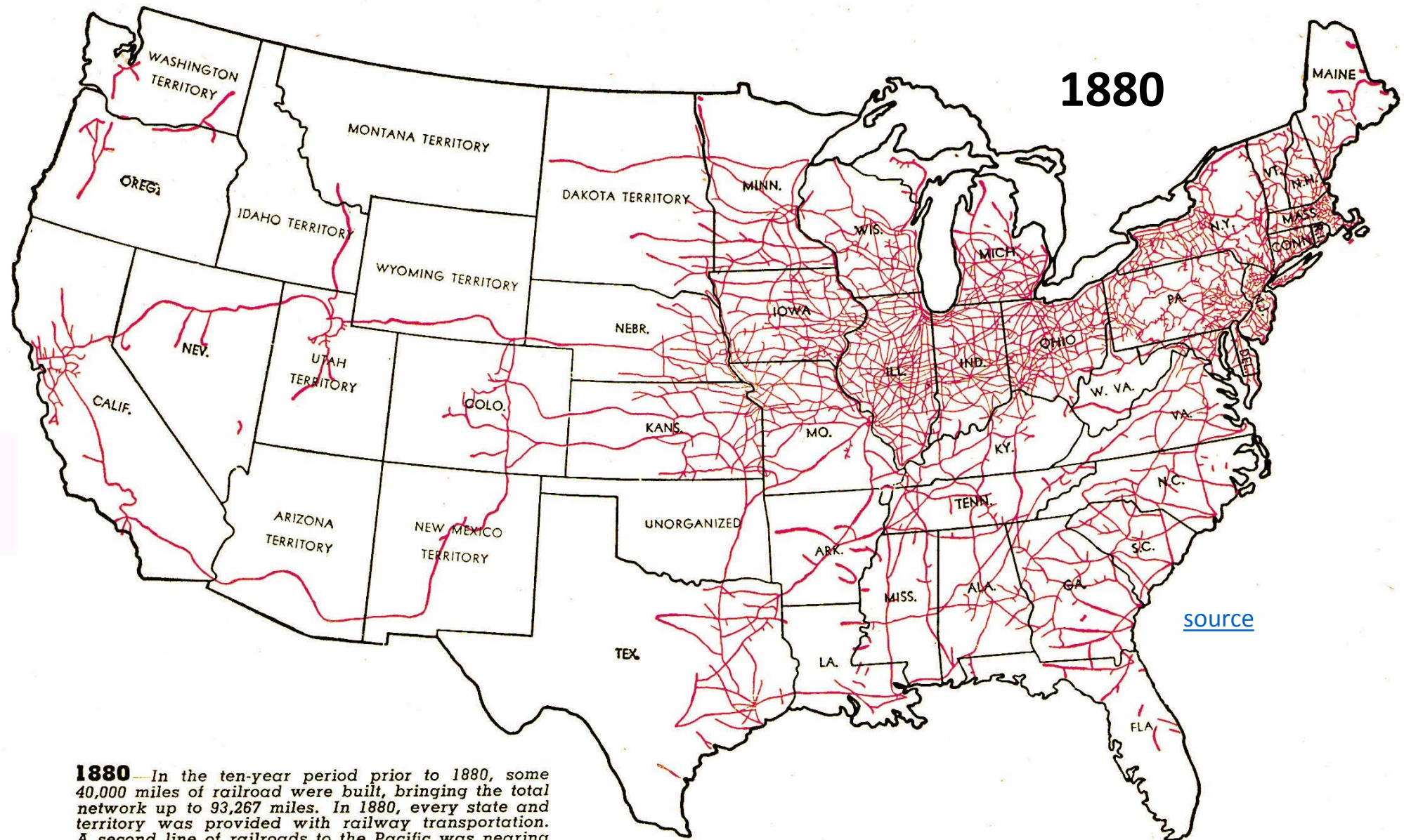


1870

[source](#)

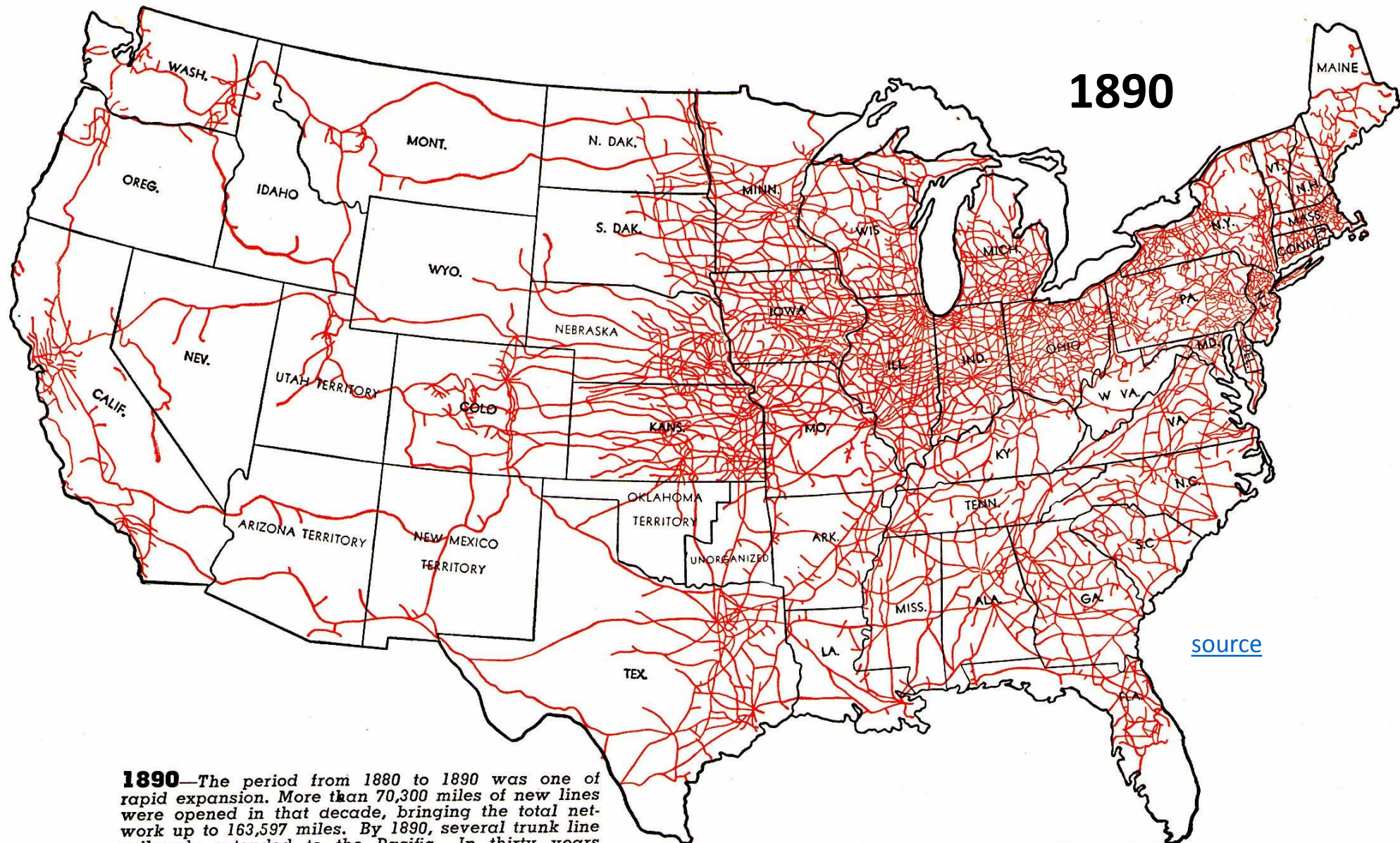
**1870**—Although the War Between the States temporarily halted railway development, many projects were resumed or initiated soon after the close of that conflict. The nation's network increased from 30,626 miles in 1860 to 52,922 miles in 1870. An outstanding development of the decade was the construction of the first railroad to the Pacific Ocean, making it possible for the first time to travel all the way across the country by rail. Railway development in the Mississippi and Missouri valleys was especially notable during this period.





**1880**—In the ten-year period prior to 1880, some 40,000 miles of railroad were built, bringing the total network up to 93,267 miles. In 1880, every state and territory was provided with railway transportation. A second line of railroads to the Pacific was nearing completion, and other transcontinental railroads were under construction. Railway development was exerting a powerful influence upon immigration and agricultural and industrial growth throughout the country.



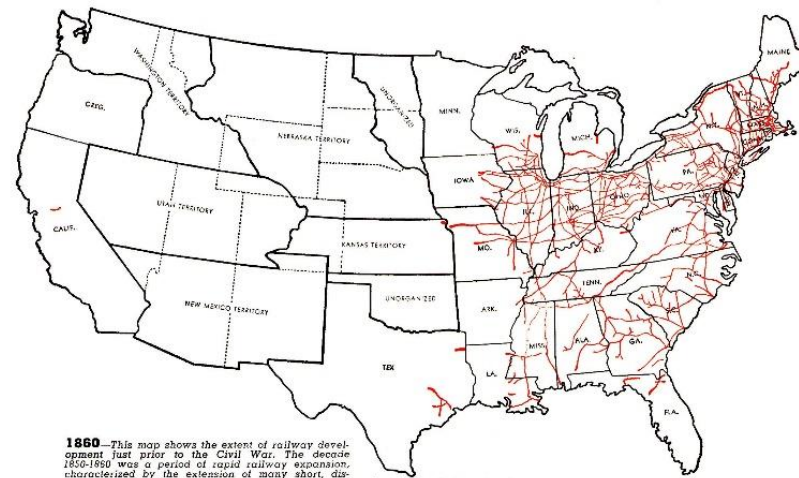
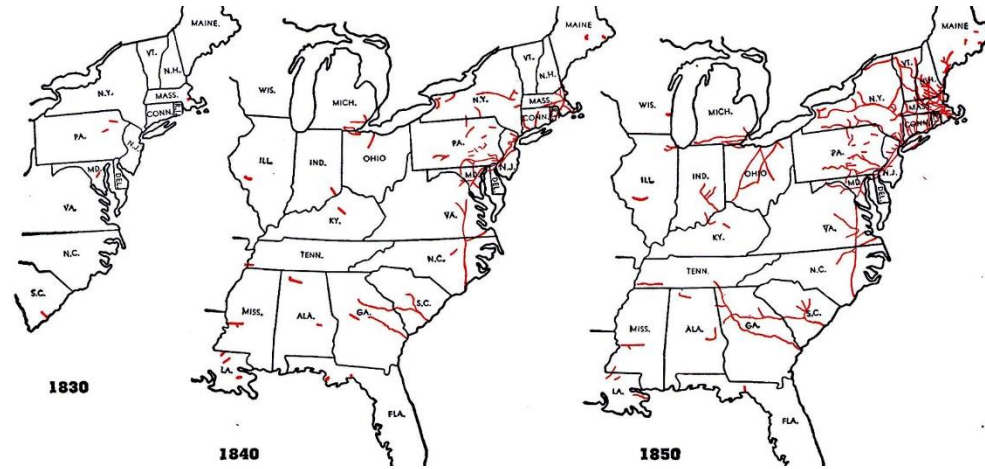
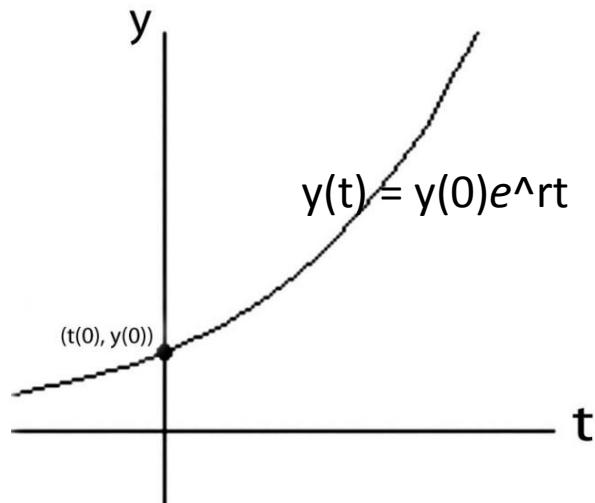


**1890**—The period from 1880 to 1890 was one of rapid expansion. More than 70,300 miles of new lines were opened in that decade, bringing the total network up to 163,597 miles. By 1890, several trunk line railroads extended to the Pacific. In thirty years from 1860 to 1890, the total mileage of the region west of the Mississippi River increased from 2,175 to 72,389, and the population of that area increased fourfold.



Like compound interest, the early social-diffusion rate of such clusters of technological ideas is proportional to what has materially accumulated at any given point in time . . .

(I.e., it's an exponential function):

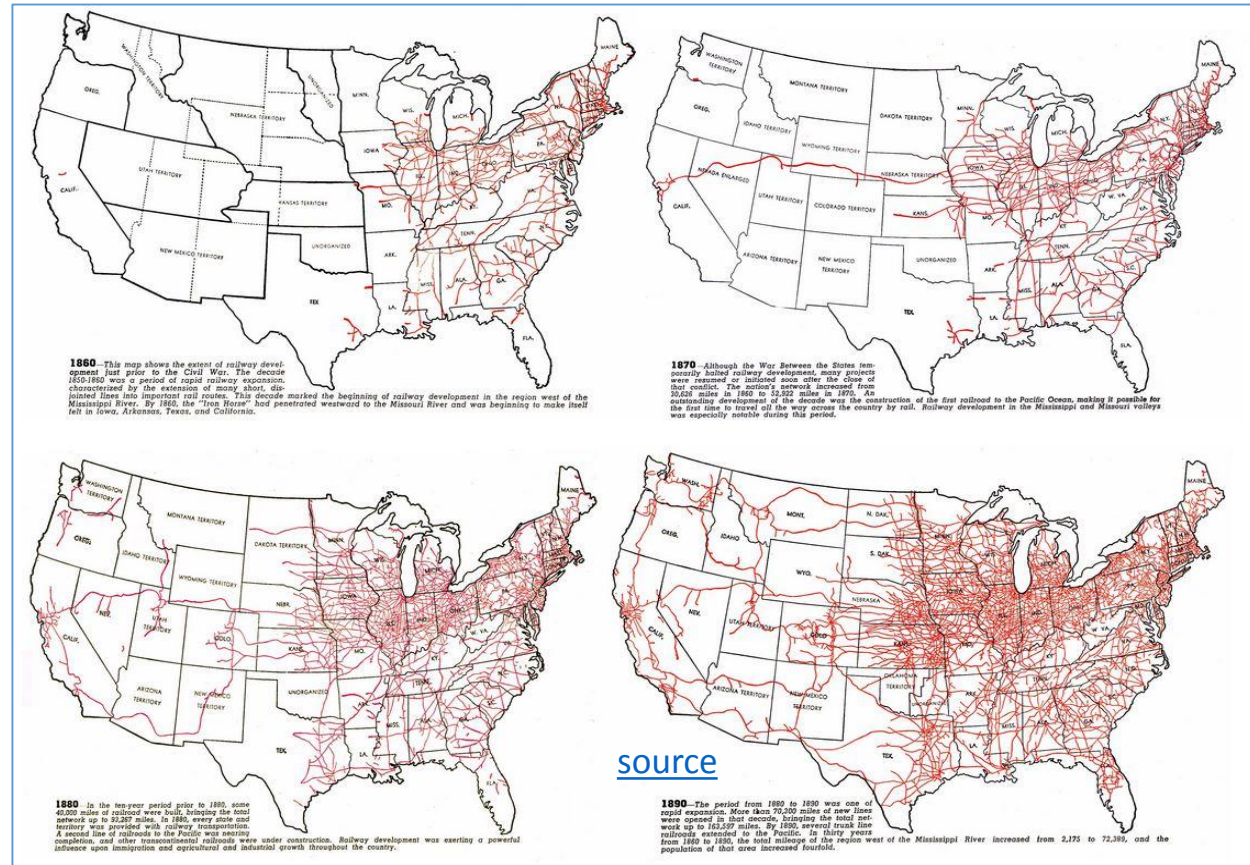
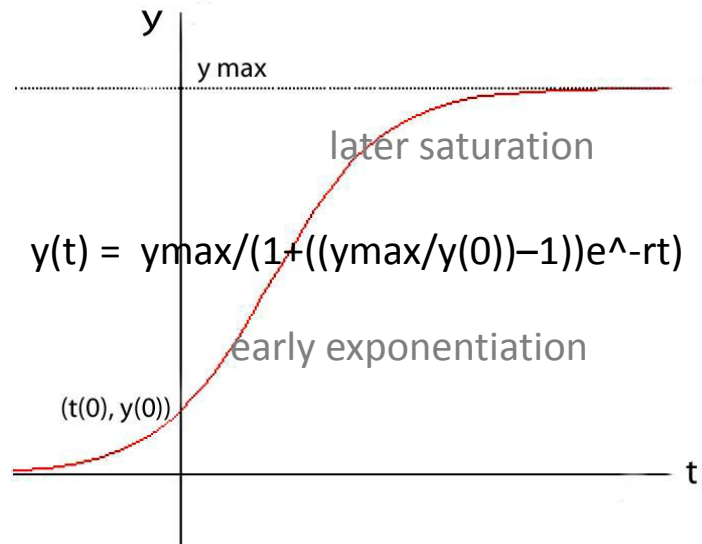


**1860**—This map shows the extent of railway development just prior to the Civil War. The decade 1850-1860 was a period of rapid railway expansion, characterized by the extension of many short, disjointed lines into important rail routes. This decade marked the beginning of railway development in the region west of the Mississippi River. By 1860, the "Iron Horse" had penetrated westward to the Missouri River and was beginning to make itself felt in Iowa, Arkansas, Texas, and California.

[source](#)

But as the opportunity-space fills, [diffusion of those technological ideas](#) slows as that cluster nears its materially-expressed expansion limits . . .

(I.e., it becomes a [logistic function](#)):



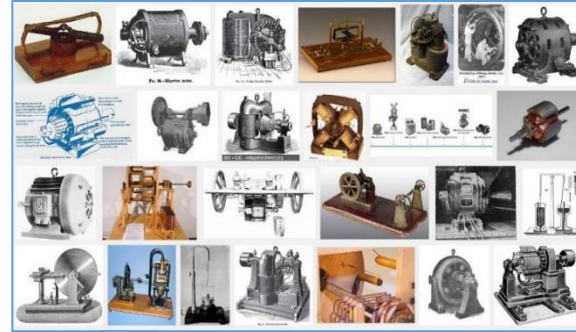


As a result of a widespread harnessing of electricity in the 1890's, innovative technology clusters lurched out into wild dimensions . . . as electric generators and motors were embedded into new industrial and transportation systems:

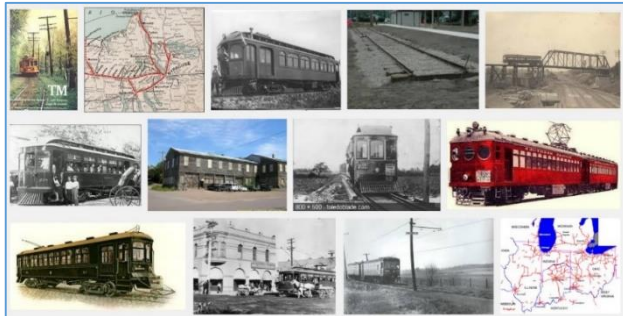
### Electrical Generators



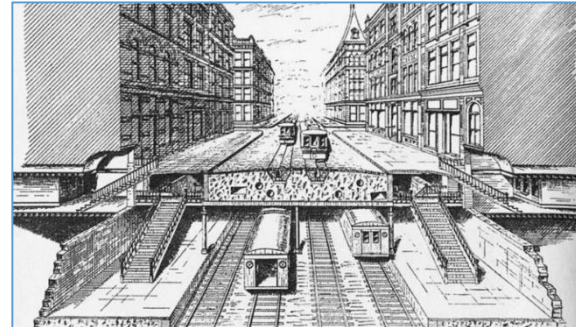
### Electrical Motors



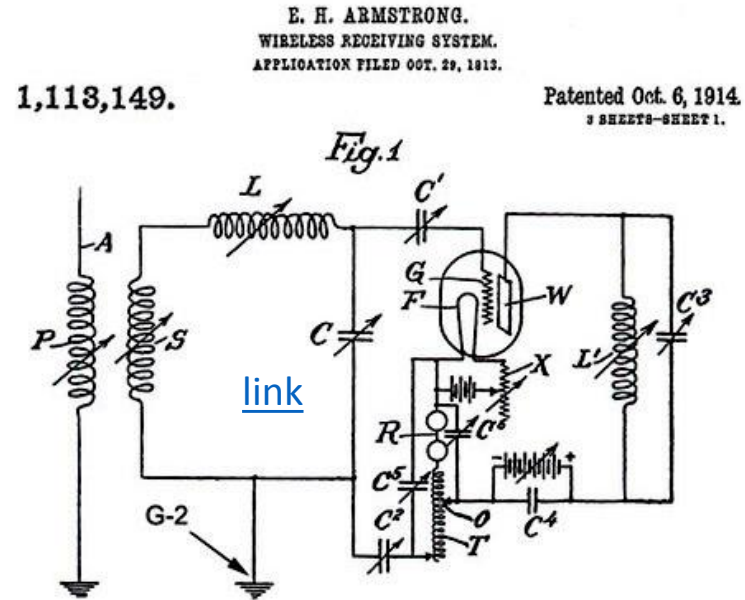
### Interurban rail



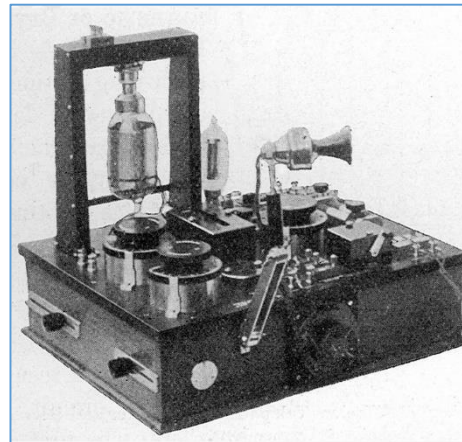
### Subways [Planning the IRT, 1891](#)



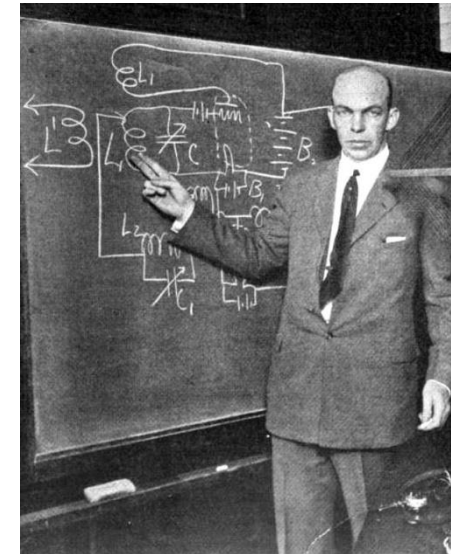
The rapidly diffusing electrification then co-evolved with rapidly-diffusing electric rail, subway, telephone and lighting systems, then with the new 'wireless' radio communication systems . . .



WWI military radio receiver



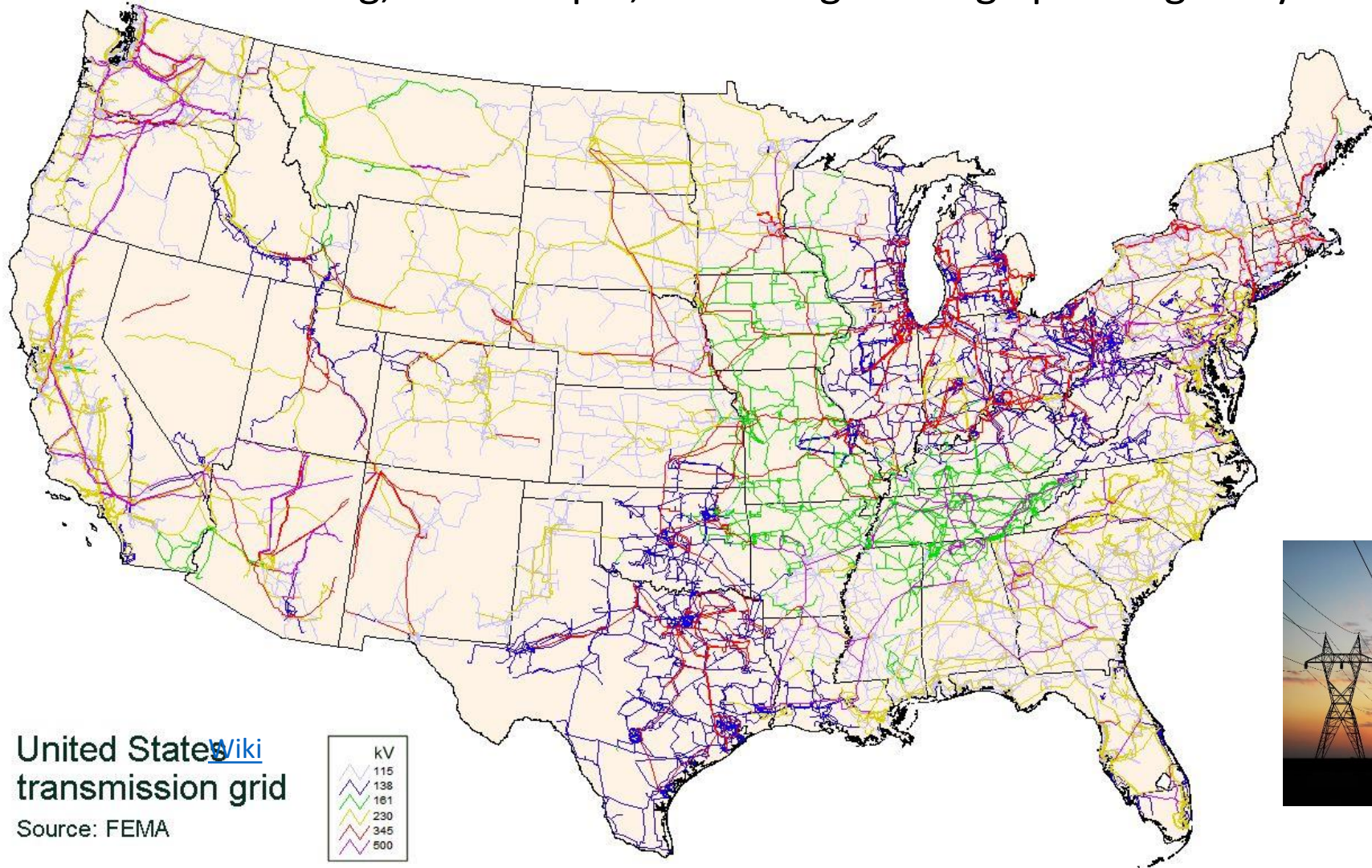
Armstrong at Columbia 1922



Back then, Edison, Westinghouse, Tesla, Steinmetz, Bell, Marconi and Armstrong became household names for their seminal ideas behind these wild technologies.



Leading, for example, to this high-voltage power grid by 2008!



United States [wiki](#)  
transmission grid

Source: FEMA



The dramatic results of the exponentiation of electrification are easily [seen from space](#) today . . .



Think how many minds the foundational ideas of [Faraday](#), [Maxwell](#), [Hertz](#), [Steinmetz](#), [Marconi](#), [Armstrong](#), . . . have cycled through to make this happen!



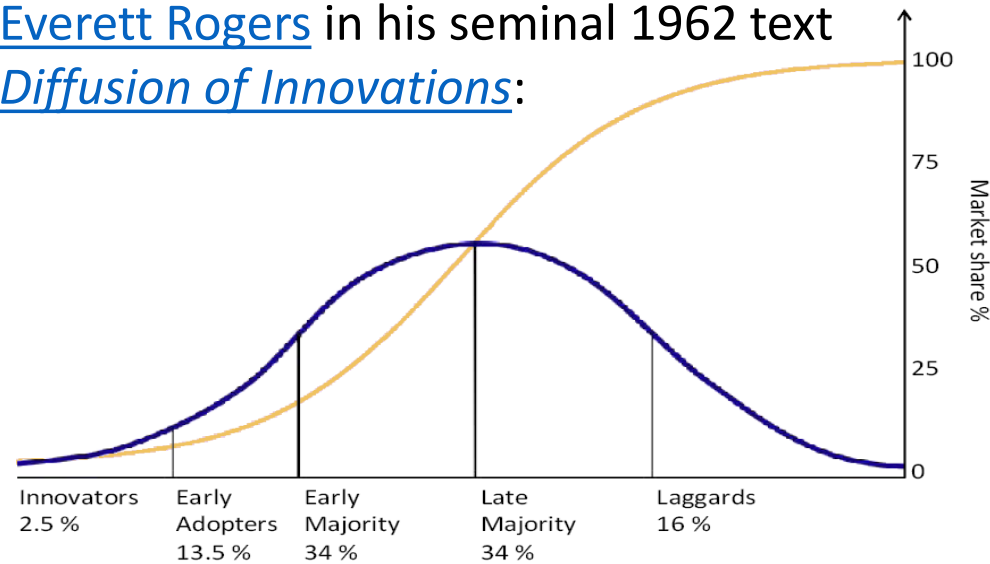
Let's now look at a wave of innovation that [I surfed](#) back in the 1970's:



The revolution in VLSI (Very Large Scale Integrated) microchip design . . .

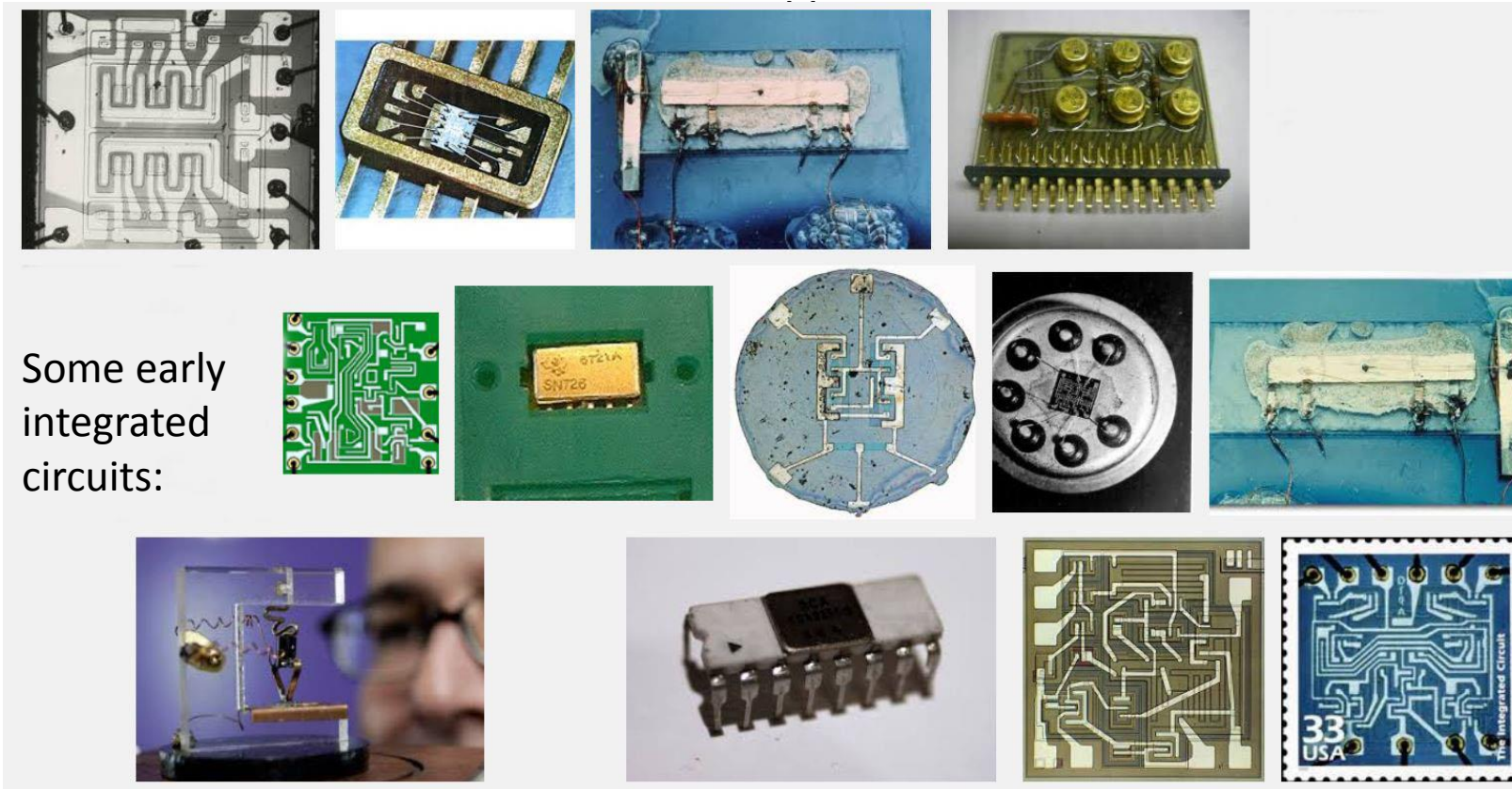
While doing this let's consciously notice how "the flow of ideas" expands as a function of the increasing connectivity and bandwidth . . . and the decreasing time-delays . . . in techno-social communication.

We'll also think along lines explored by [Everett Rogers](#) in his seminal 1962 text [Diffusion of Innovations](#):





The stage was set by the emergence of integrated circuit technology in the 1960's, enabling modest numbers of transistors and wiring to be 'printed' onto chips of silicon.



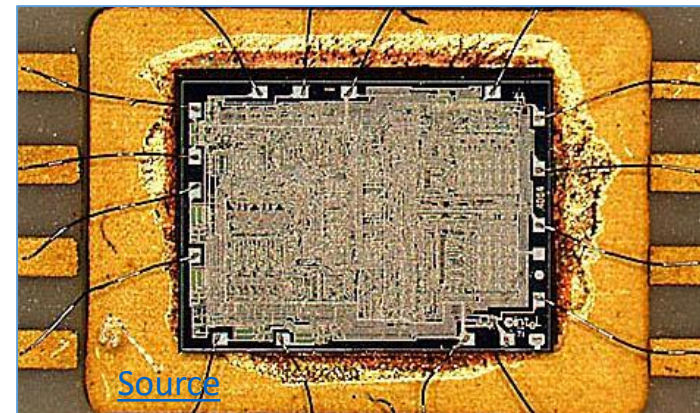
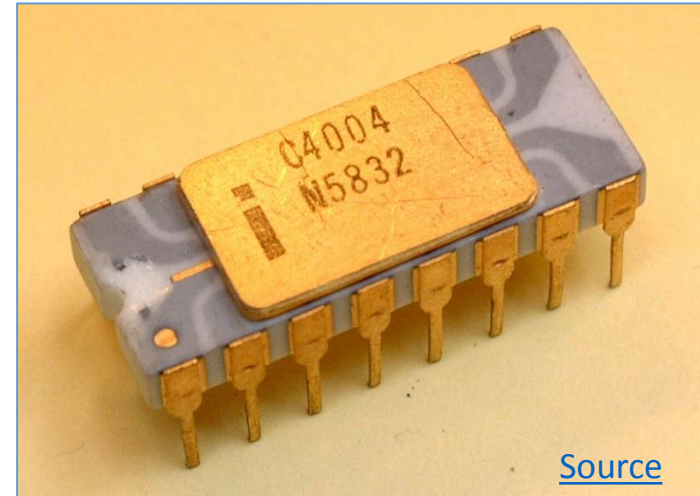
Some early  
integrated  
circuits:

Snip from Goggle images

Rapid advances in lithography enabled ever-finer features to be printed, ever-increasing the numbers of transistors printable on single chips.

**By 1971, a watershed was crossed** with the introduction of the [Intel 4004](#), the first single-chip “[microprocessor](#)”: a “computer processor on a chip” . . .

It contained [2300 transistors](#) . . .



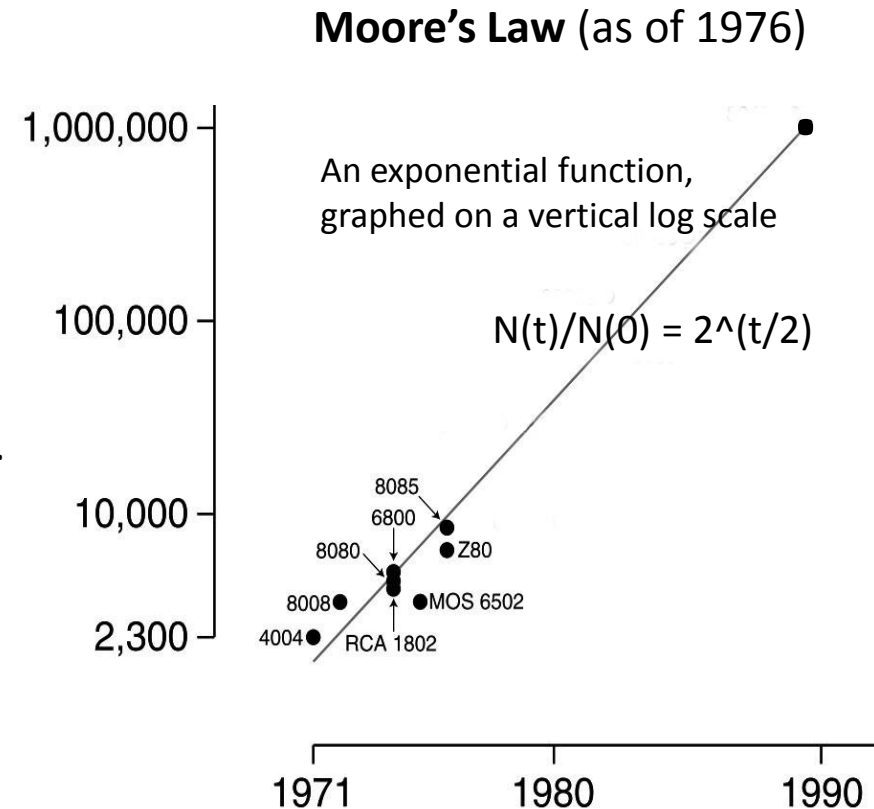


[Gordon Moore](#) at Intel observed that the number of transistors reliably printable on commercial chips was roughly doubling every two years . . .

[Carver Mead](#) named this “[Moore’s Law](#)” (clever career move, eh?) and his student [Bruce Hoeneisen](#) showed there were no physical limits to densities up to several million transistors/cm<sup>2</sup>.

Looking ahead it was conceivable that by ~1990 an entire “supercomputer” could be printed on a single chip . . .

**In 1976 this set-off a push at Xerox PARC and Caltech to explore how to enable such complex chips to be designed.**



The stage was further set by seminal innovations in personal computing & networking:

Innovation of the interactive-display, mouse-controlled “[personal computer](#)”, the “[Ethernet](#)” local-area network, and the “[laser printer](#)” (at Xerox PARC) . . .

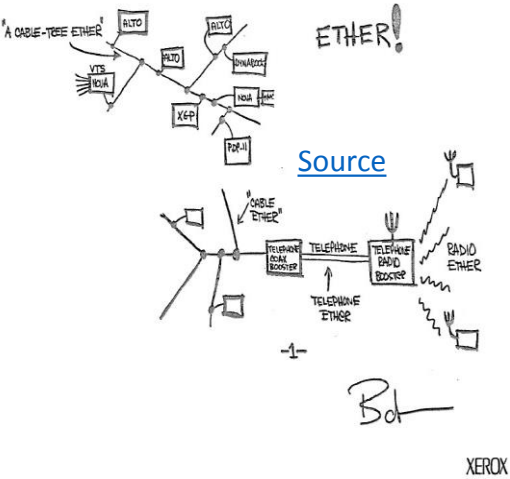
And the Dept. of Defense’s “Arpanet” (the early internet, at DARPA) . . .

[Xerox Alto, 1973](#)

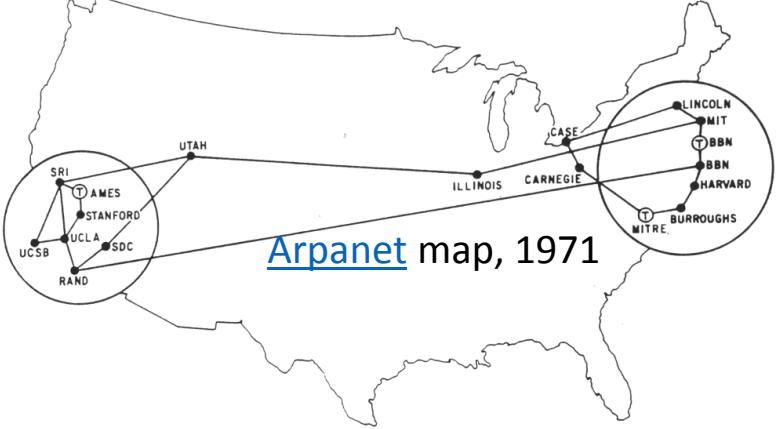
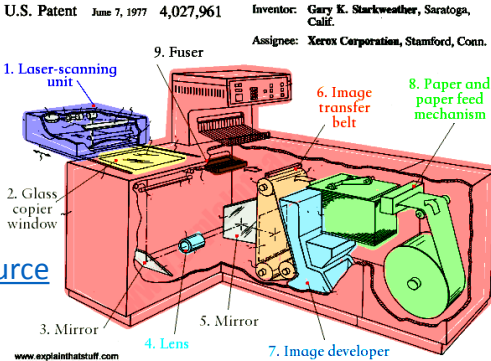


[Wiki commons](#)

[Metcalf’s original Ethernet sketch, 1973](#)



[Laser printer, 1971](#)



[Arpanet map, 1971](#)



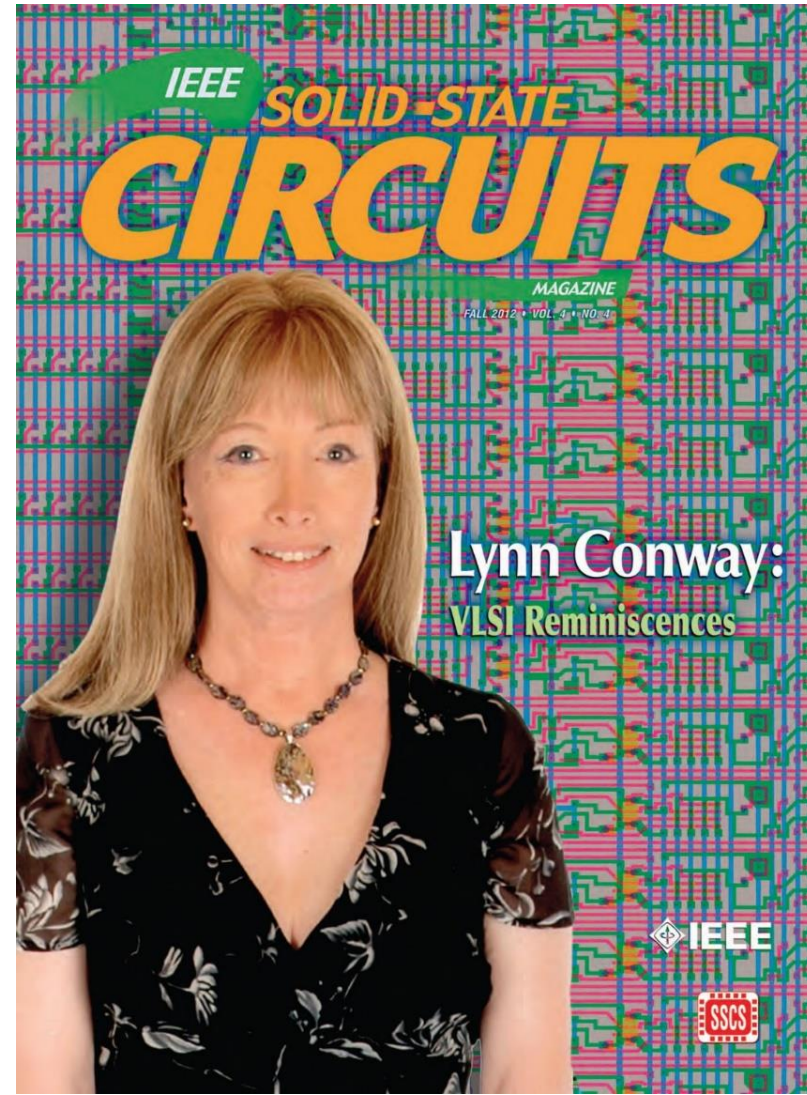
The story of what happened over the next four years is quite a saga . . .

You'll find insights into that saga in my "Reminiscences of the VLSI Revolution" in Fall 2012 [IEEE Solid State Circuits Magazine](#)

That was the very [first time I'd stepped forward](#) to [tell the story](#) . . .

Till then, [since I didn't look like an engineer](#), Silicon Valley [had no clue what I'd done](#) back during [the 1970's!](#) (and still doesn't!)

For now we'll just hit some highlights . . .



A sudden disruptive breakout was triggered by a cluster of abstract innovations, primarily at PARC . . .

Included was a set of scalable VLSI chip-layout digital design rules, as ratioed (dimensionless) inequality equations (Conway, Xerox PARC) . . .

These enabled digital chip designs to be numerically encoded, scaled, and reused as Moore's law rapidly advanced . . .

They also enabled subsystem designs to be scaled and open-source shared . . .

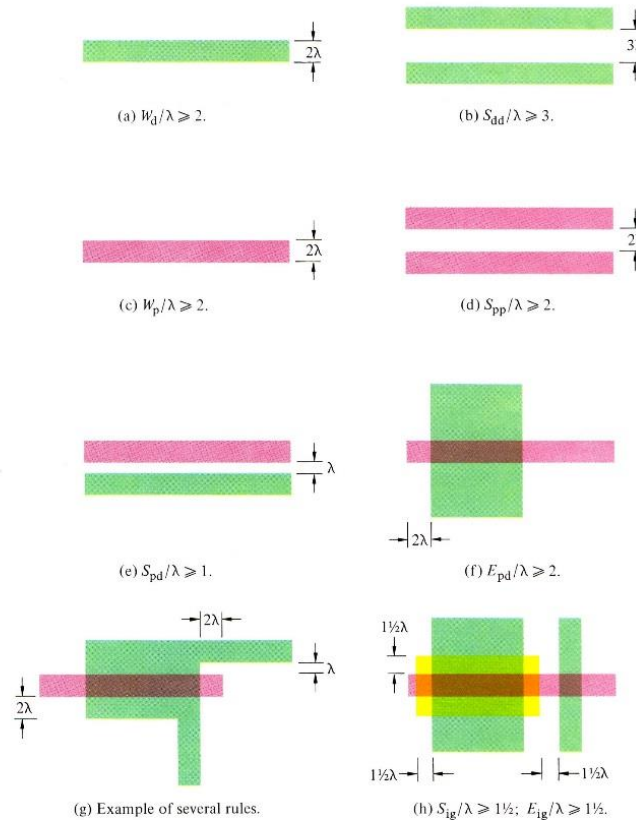


PLATE 2 nMOS design rules

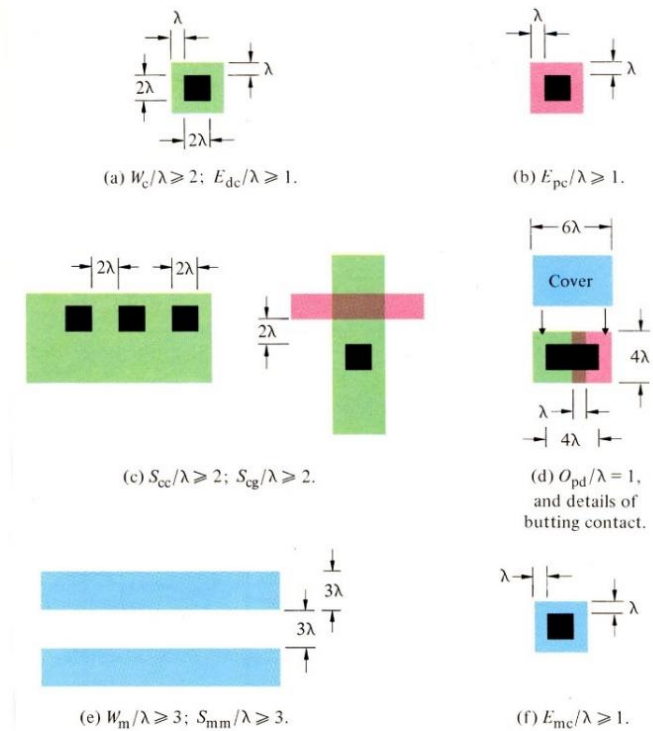


PLATE 3 nMOS design rules (continued)

[Link](#)



## The driving meta-architectural idea:

As chip lithography scales-down according to Moore's Law, and ever-more ever-faster transistors can be printed on individual chips as time passes, we can imagine launching the following "techno-social scripted-process":

### STEP (i):

**Use design tools on current computers to Design chip-sets for more powerful computers.**

**Print the more powerful chip-sets using foundries' next-denser fabrication processes.**

**Use some of those chip-sets to Update current computer-design computers & design tools.**

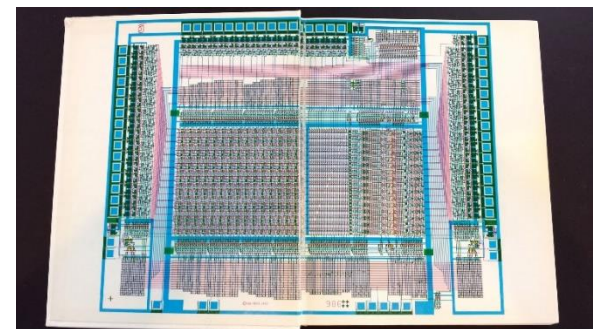
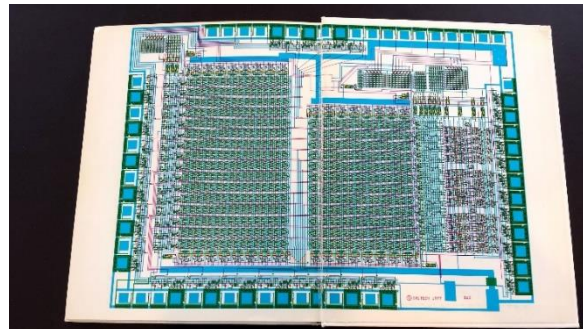
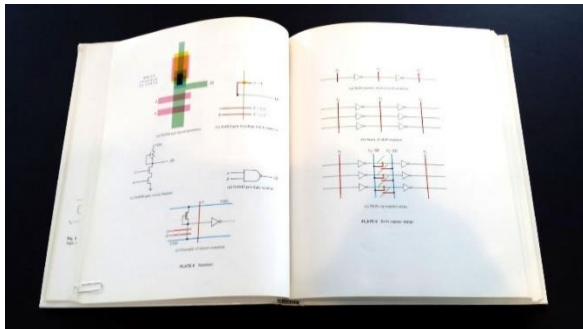
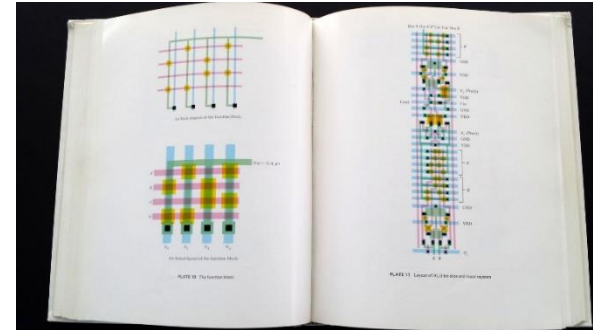
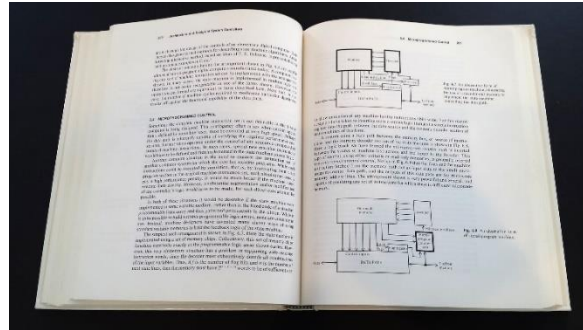
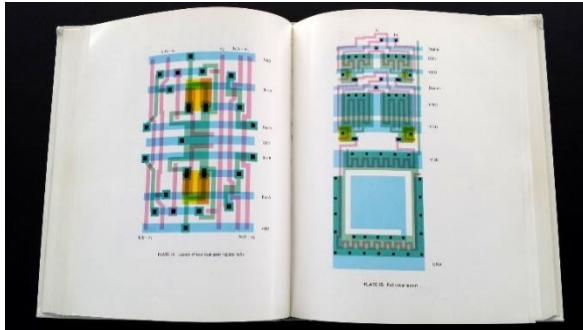
### REPEAT (as STEP (i+1))

If ever-more engineers and design-tool builders did this (on an expanding number of increasingly powerful computers), [the iterating techno-social expansion-process](#) could exploratorily and innovatively-generate ever-more, ever-more-powerful, digital systems . . .

I.e., that techno-social process could [exponentiate!](#) (until Moore's Law saturates . . .)

But there's a big problem: **Where will all these engineers/programmers come from, and how will they learn to do all this?**

To cope with this, I began documenting the new system of simplified, restructured chip design methods in [an evolving computer-edited book](#) . . .



[Link](#)

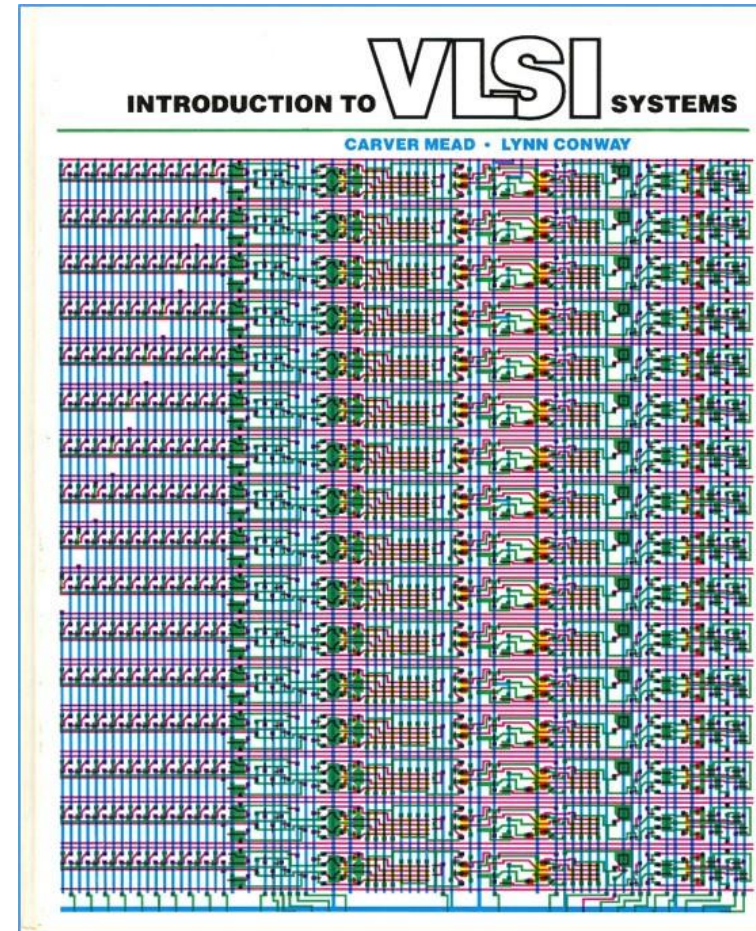


Thus using our [Alto](#) computers not only to mechanize the generation of chip-designs, but also to mechanize the evolution of the design-knowledge-book itself . . .

That [computer-edited evolving book](#), printed on laser printers at PARC, became [the draft](#) of the seminal textbook . . .

[\*Introduction to VLSI Systems\*](#)  
by Mead and Conway, 1980.

(later called "[the book that changed everything](#)" . . . )



[Following the “script” Charles Steinmetz used to propagate](#) his revolutionary AC electricity methods at Union College in 1912, I introduced the new methods in a special [VLSI design course at MIT in 1978](#).



## THE M.I.T. 1978 VLSI SYSTEM DESIGN COURSE

by Lynn Conway

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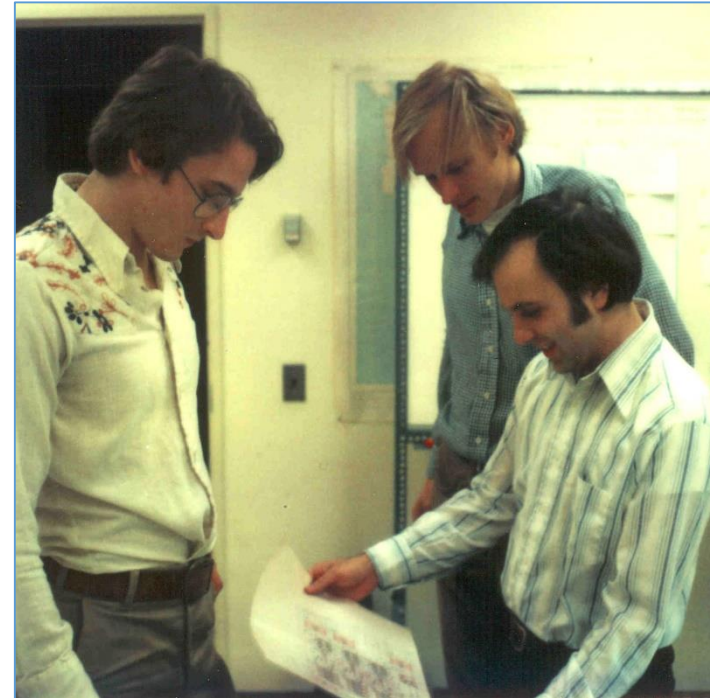
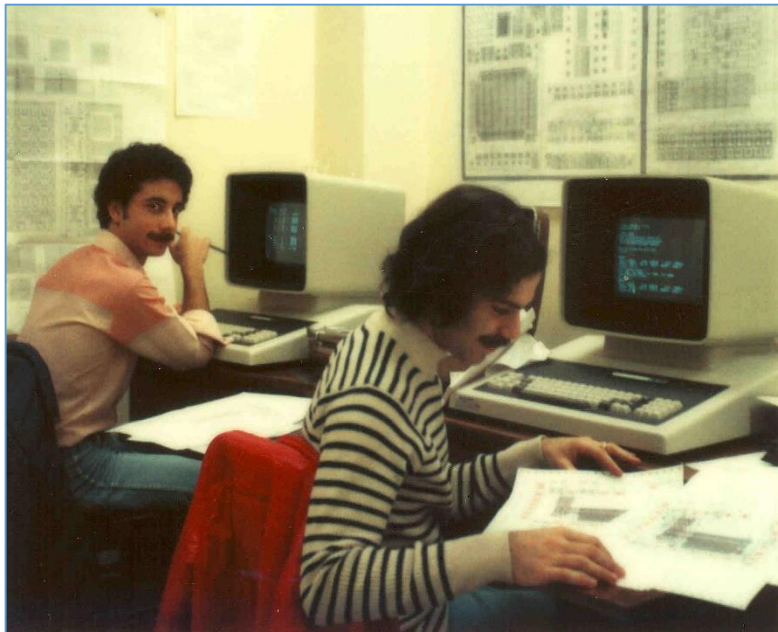
[Update: 11-14-07]

This course was an important milestone in the development, demonstration and evaluation of the Mead-Conway structured VLSI design methods. Lynn Conway conceptualized and planned the course during the late spring and summer of '78, and taught the course while serving as Visiting Associate Professor of EECS at MIT in the fall of '78 and early '79.

[Link](#)  
[Link](#)  
[Link](#)



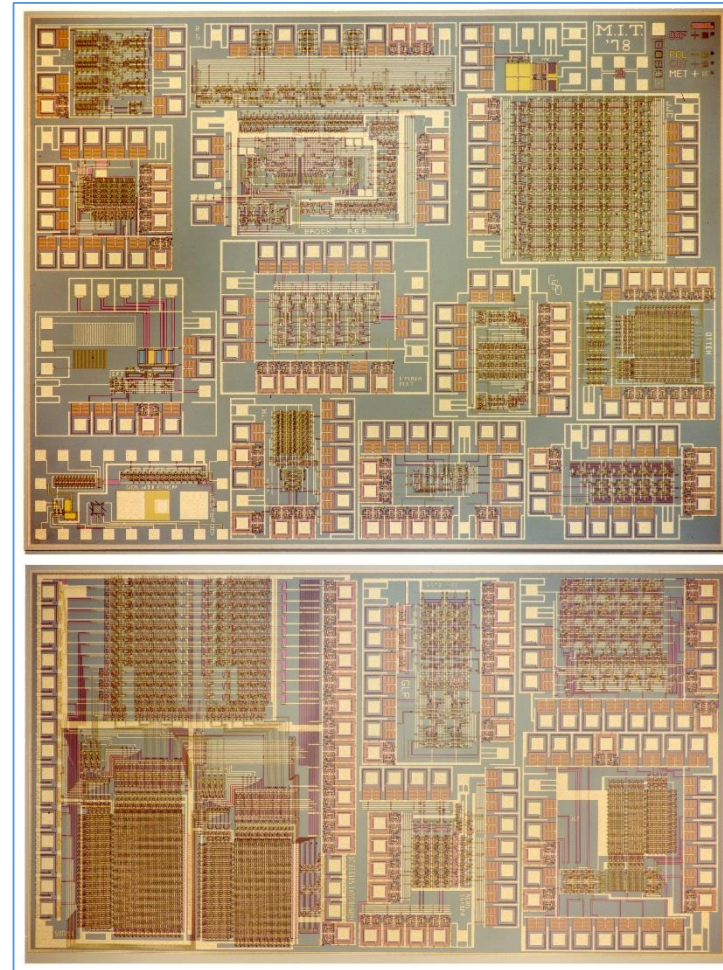
The students learned to design chips in the 1st half of the course, then did project-chip designs in the 2<sup>nd</sup> half. These were [fabricated in Pat Castro's lab at HP](#) shortly after the course.



There were many amazing results including a complete Lisp microprocessor design by [Guy Steele](#) . . .

[Map and photomicrograph](#)  
of the 19 student projects on  
the MIT'78 'MultiProject' Chip

19. Runchan Yang	18. Richard Stern	4. Mike Coln	MIT Test	Align
5. Steve Frank	2. Andy Boughton J. Dean Brock Randy Bryant Clement Leung	3. Jim Cherry		
1. Sandra Azoury N. Lynn Bowen Jorge Rubenstein	13. Ernesto Perea	11. Craig Olson	12. Dave Otten	
7. Nelson Goldikener Scott Westbrook	8. Tak Hiratsuka	9. Siu Ho Lam	10. Dave Levitt	
17. Guy Steele	14. Gerald Roylance	15. Dave Shaver		
	16. Alan Snyder	6. Jim Frankel		



For more about the [MIT'78 course](#), see [Lynn's "MIT Reminiscences"](#)



**The MIT'78 course stunned various top folks across Silicon Valley . . .**

Chip design till then had been a mystery, only grasped by a few computer engineers working for chip manufacturers . . and who thus had access to the “printing plants” . . .

**Many other top research universities wanted to offer an “MIT-like” course. But how?**

After intensive pondering, I grasped [the answer](#): Rerun the MIT'78 course at a dozen research universities . . . using my MIT lecture notes to keep everything in sync.

**But how to “print” all the student project chips?**

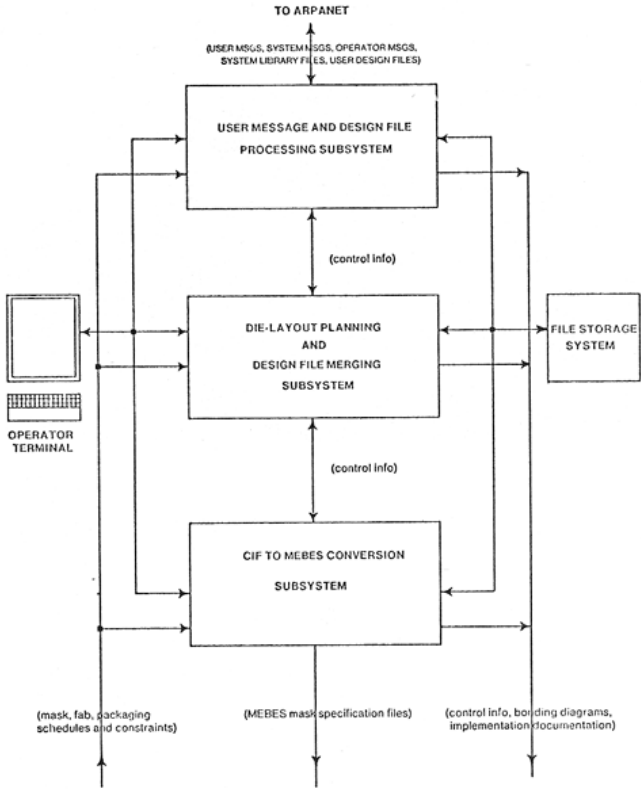
I suddenly [envisioned the idea of](#) (what's now called) an “e-commerce” system enabling student design files to be remotely submitted via the Arpanet to a “server” at PARC .

That server would run software to pack designs into multi-project chips (like composing the print-files for a magazine, using remotely-submitted articles) . . .

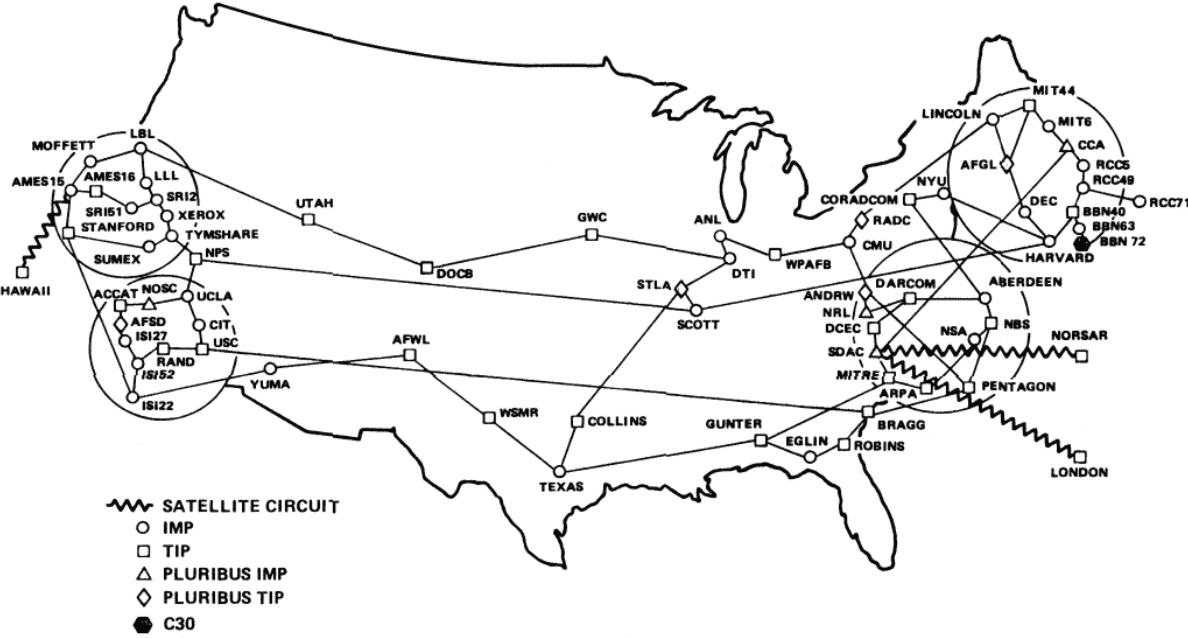
We'd then “print” the MPC's again at HP ([where Pat Castro had prototyped the first “silicon foundry”](#)), and quickly return the chips to students.

In the fall of 1979, I orchestrated a huge “happening” ([MPC79](#))\* . . . It involved 129 budding VLSI designers taking Mead-Conway courses at 12 research universities...

MPC79 e-commerce-system ARPANET interface:



ARPANET GEOGRAPHIC MAP, OCTOBER 1980



[\\*The MPC Adventures: Experiences with the Generation of VLSI Design and Implementation Methodologies, L. Conway, Xerox PARC, 1981 \(PDF\)](#)



[MPC79](#) not only provided a large-scale “demonstration-operation-validation” of the design methods, design courses, design tools and e-commerce digital-prototyping technology ... it also triggered ‘cyclic gain’ in, and exponentiation of, the budding VLSI-design-ecosystem...

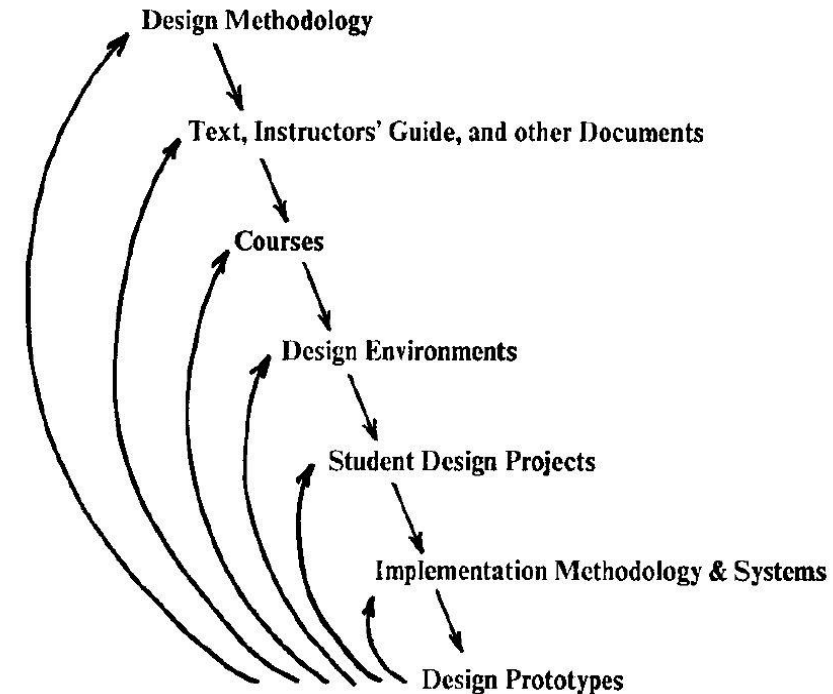
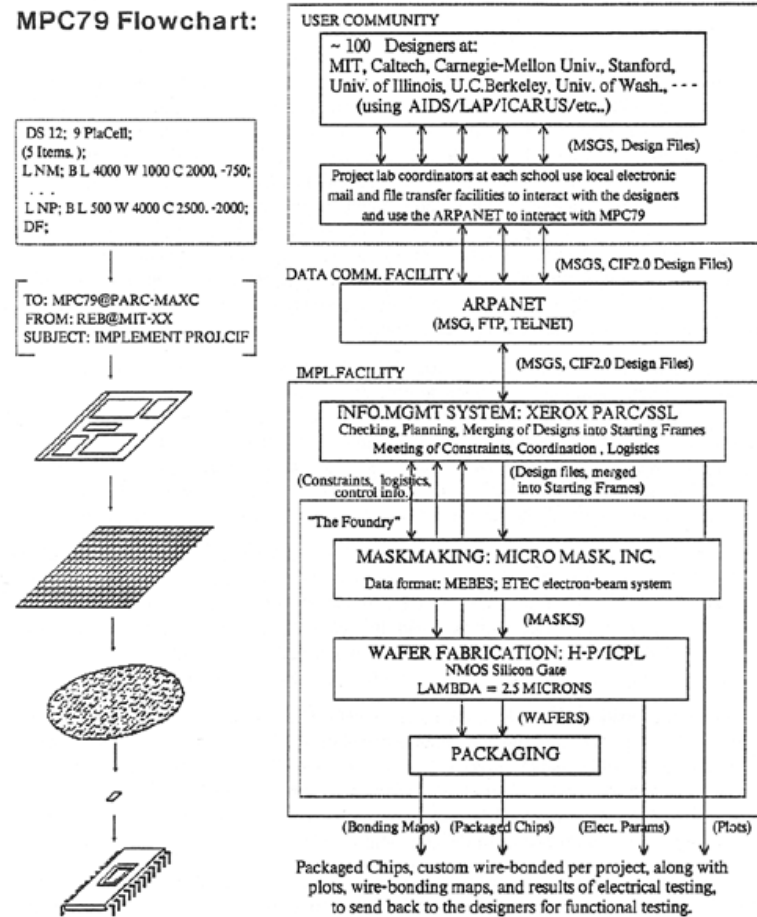


Figure 8. The Joint Evolution of the Multi-Level Cluster of Systems

[The MPC Adventures](#), L.ynn Conway, Xerox PARC, 1981.

Visualizing how [techno-social-system dynamics triggered an exponentiation](#) of the new VLSI chip design-and-making ecosystem via the emergent internet-communication technology . . .

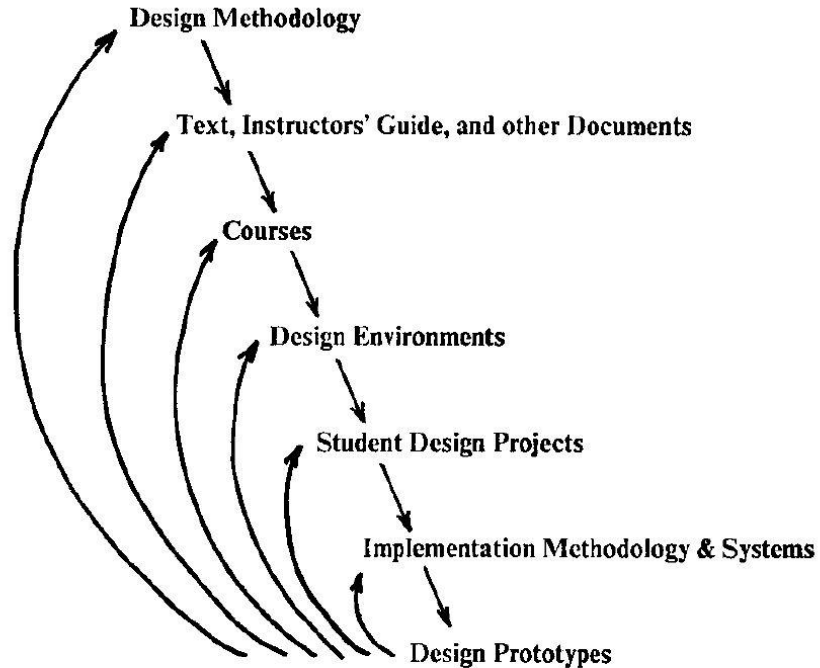
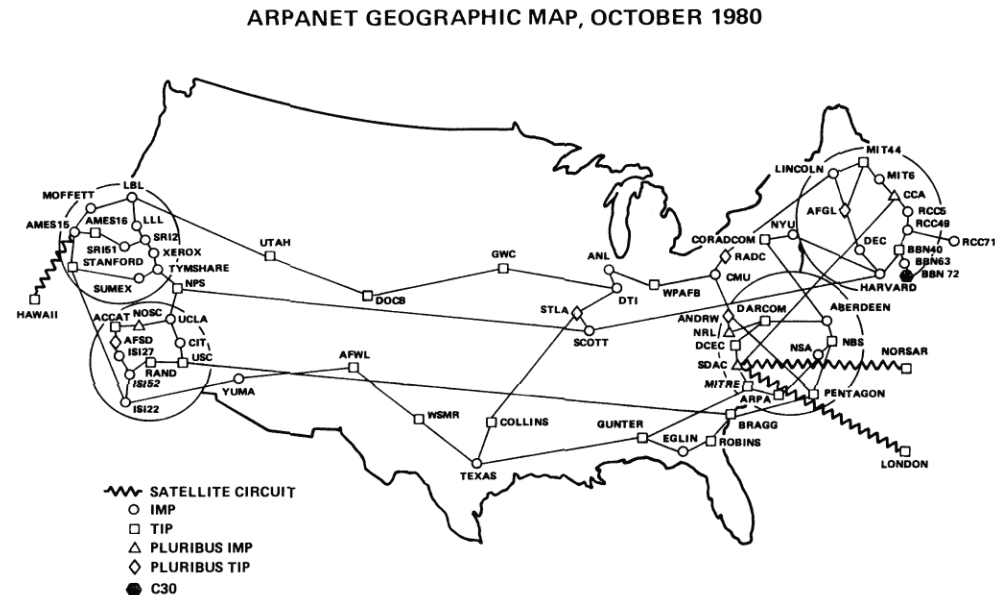


Figure 8. The Joint Evolution of the Multi-Level Cluster of Systems  
[The MPC Adventures](#)\* (LC, 1981, p. 16)



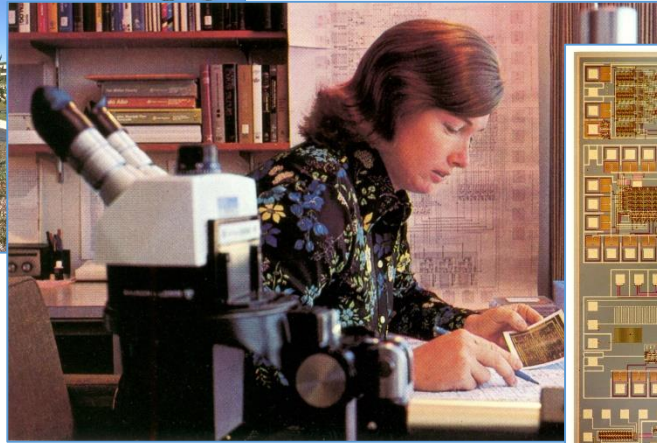
By 1982-83, Mead-Conway VLSI design courses were being offered [at 113 universities all around the world](#)

\*An early exploration of [emergent techno-social-system dynamics](#) by doing what decades later is becoming known as [“social physics”](#)

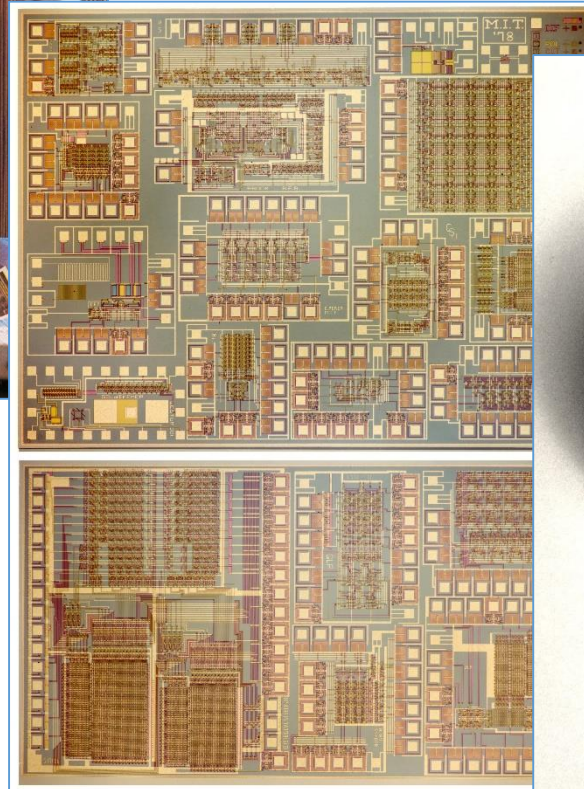
1976



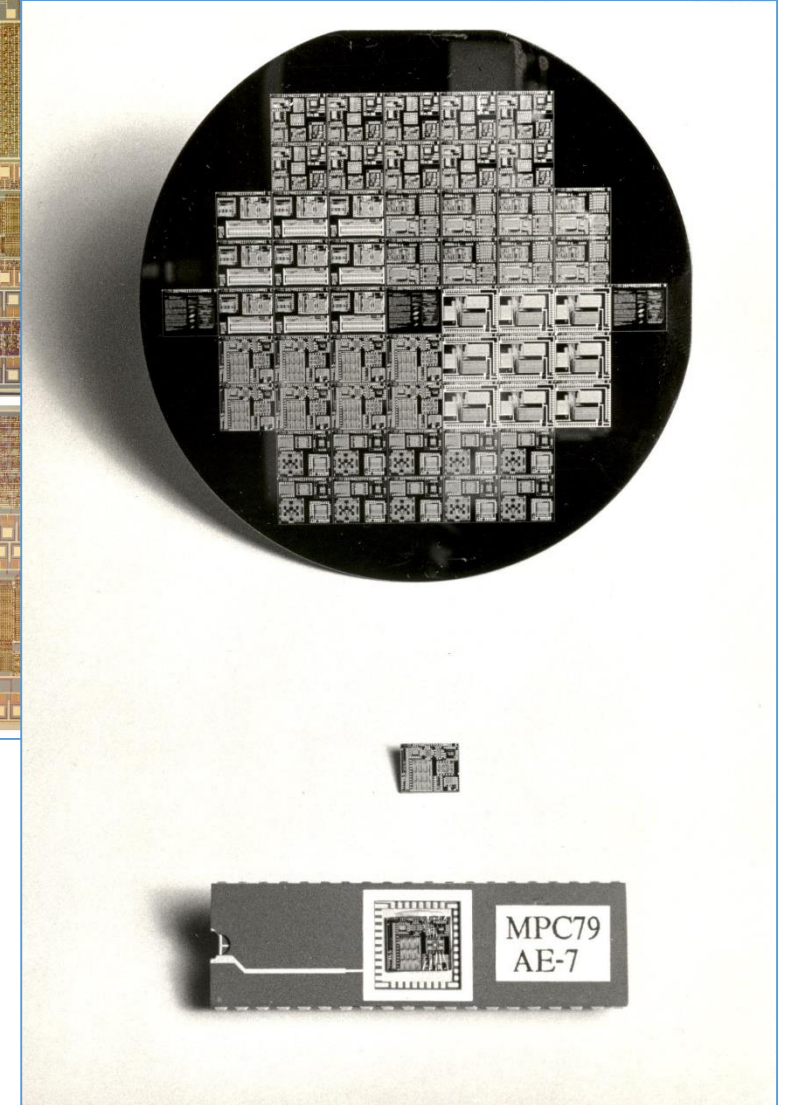
1977



1978



1979



Envisioning the exponentiating wave of VLSI innovation . . .

'76: How to cope with VLSI complexity?

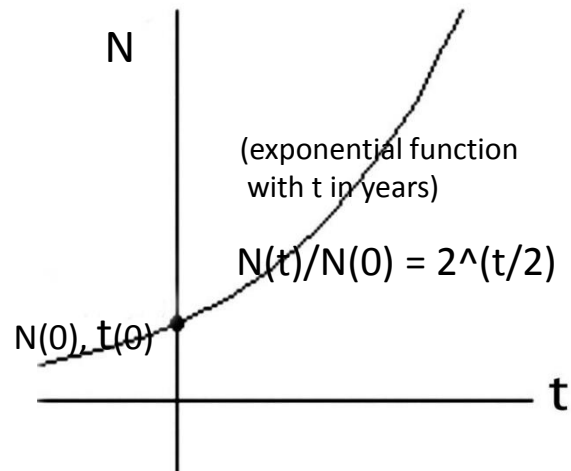
'77: Inventing scalable VLSI design rules.

'78: Launching the VLSI methods at MIT!

'79: Launching the VLSI courses via MPC79!!

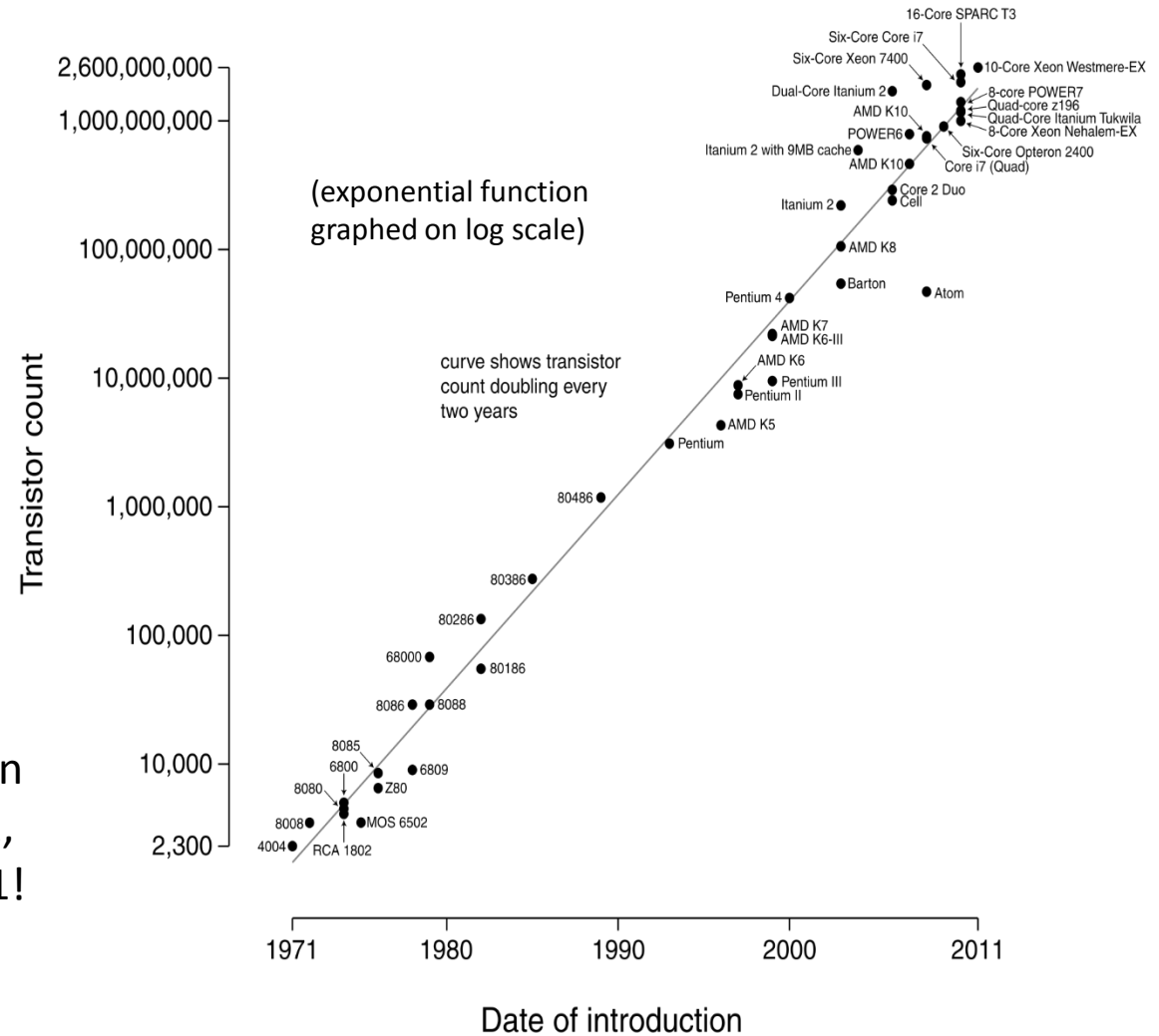


Over the past 40 years or so, [Moore's Law](#) stayed on track all the way:



Starting with [several thousand](#) in 1971, the number of transistors on a chip passed one million by 1991, and passed [several billion](#) by 2011!

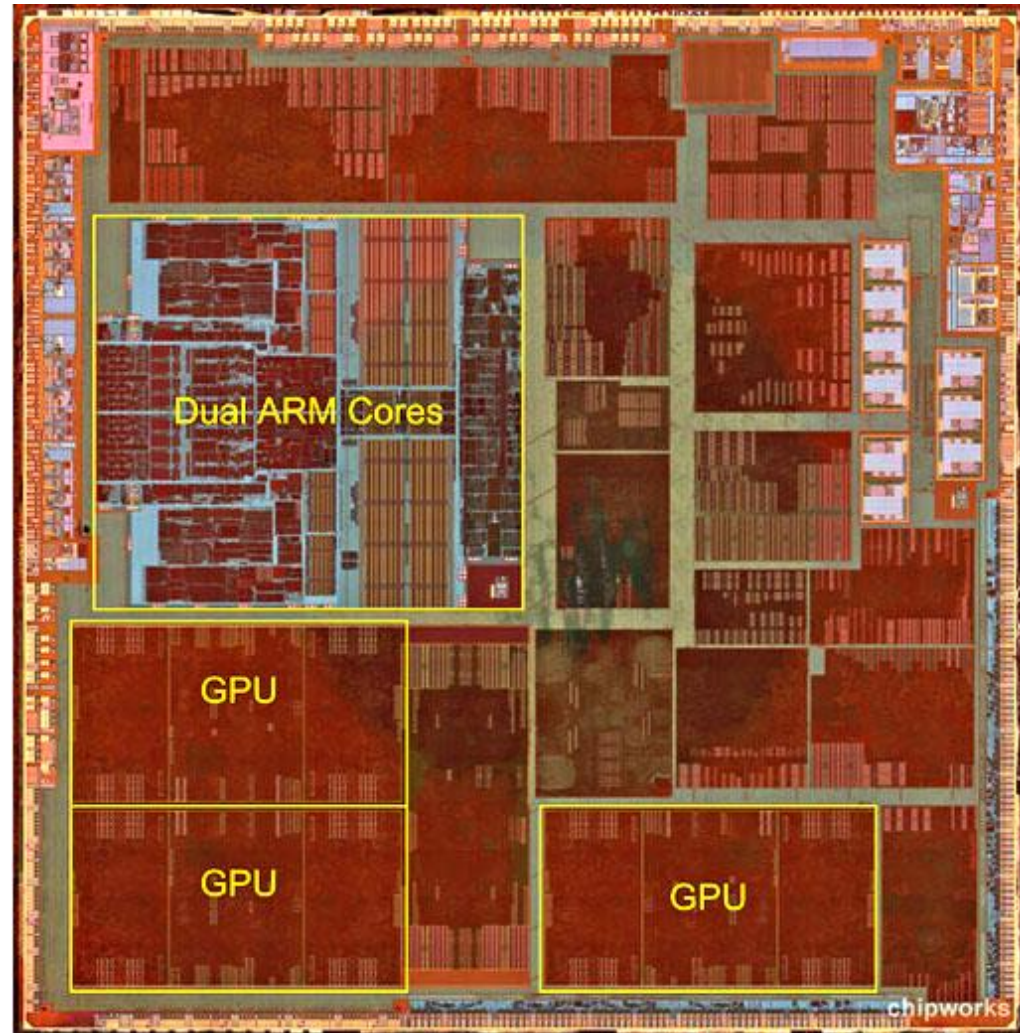
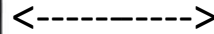
## Microprocessor Transistor Counts 1971-2011 & Moore's Law



For example, this [iPhone 5 'A6' chip](#) contains several billion transistors!

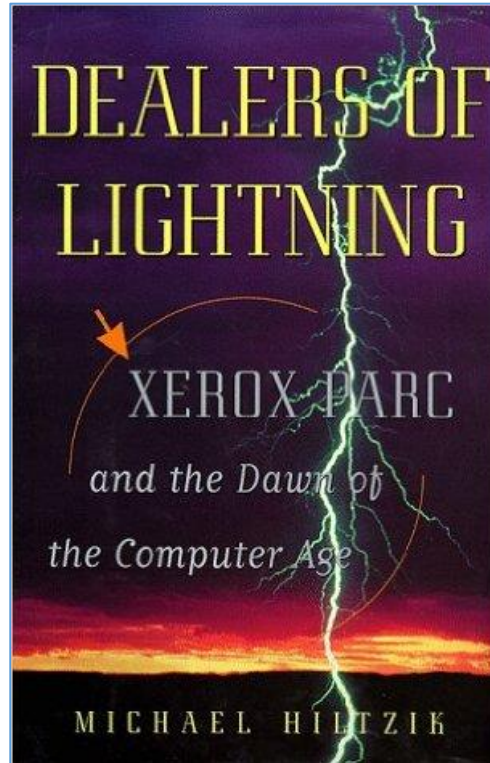


[Source](#)

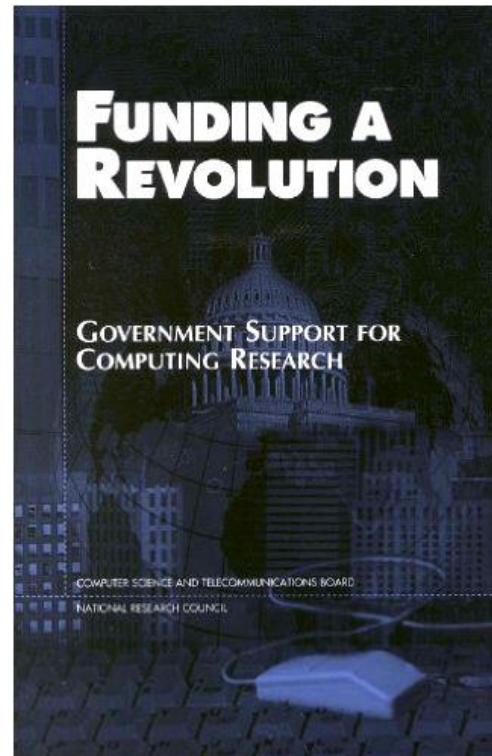


[Source](#)

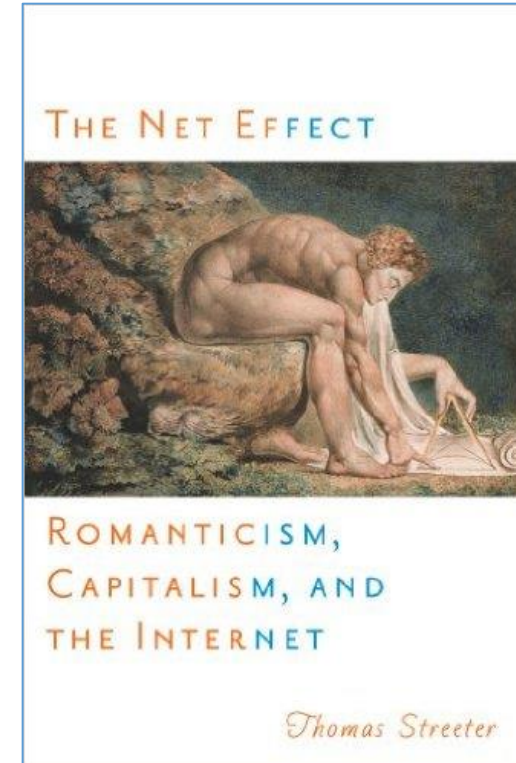
For more about PARC and the amazing things done there, see [Michael Hiltzik's \*Dealers of Lightning\*](#):



For insights into the role of gov't in VLSI's emergence, see [this book from the NRC](#):

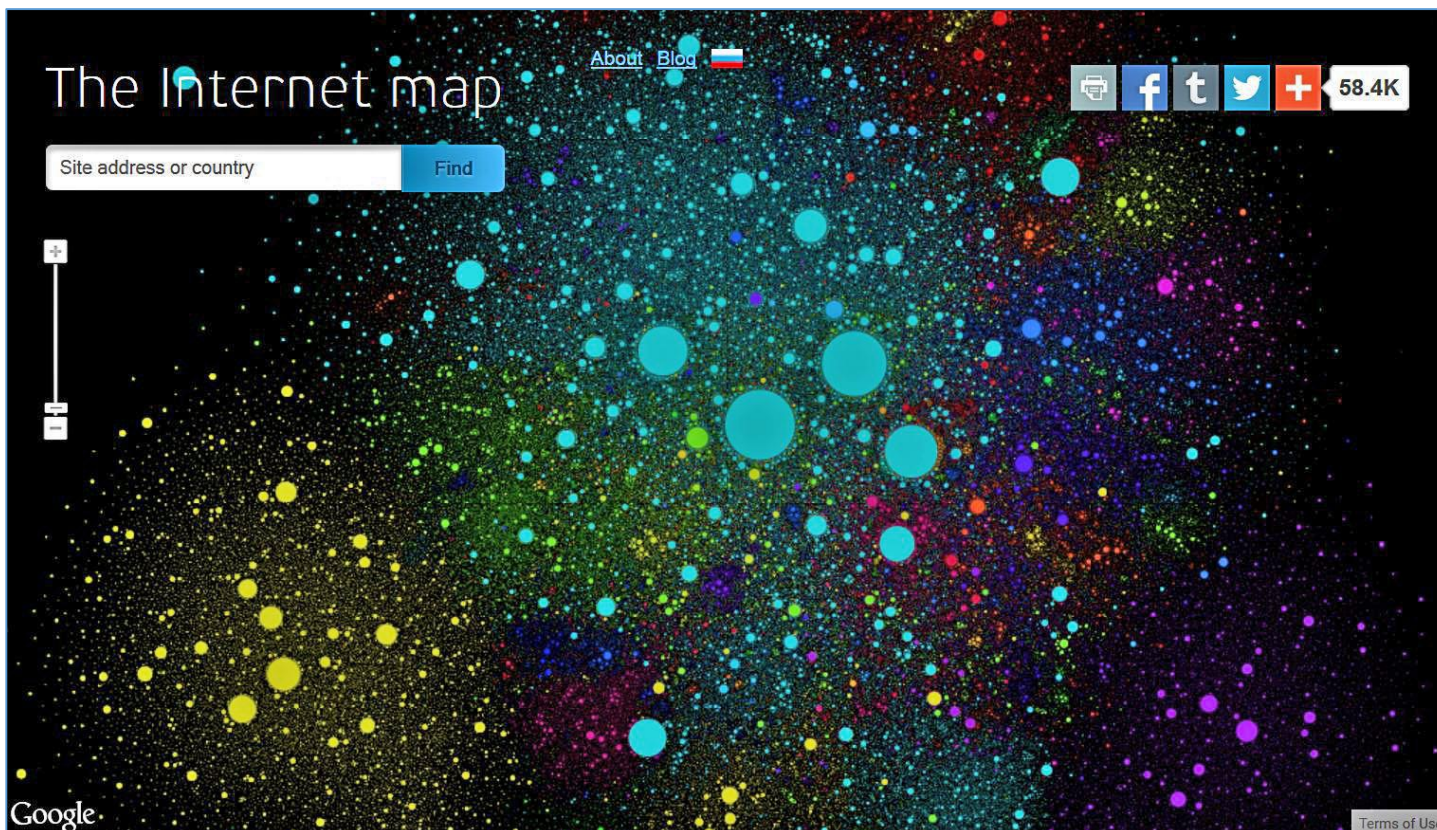


For a wider sociological perspective on the internet's emergence, see [Thomas Streeter's \*The Net Effect\*](#)

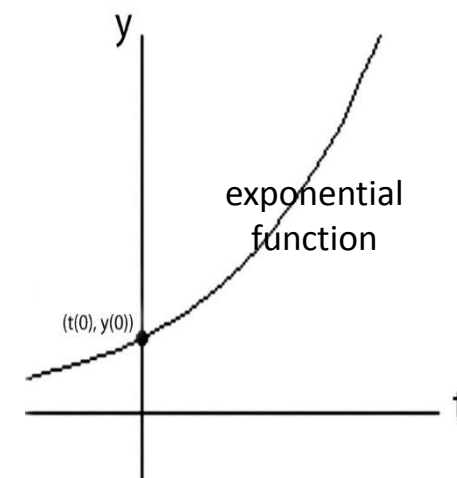




VLSI chips also empower the vast internet infrastructure, which also continues to expand exponentially . . .



Interactive Zoom-in  
[Internet Map](#), 2015



[Link](#)

And with the internet connecting ever-more people and chip-empowered things, just imagine what's going on out there now . . . all around the world!



[NASA](#): Earth from space at night

**Setting the stage for what's coming next . . . !**

"What's past is prologue" – William Shakespeare



It's now time to look forward, into the future . . . !



As we turn 180° and look ahead . . . we can glimpse another huge incoming wave of innovation . . . It's out there now, just beyond the social-time-horizon . . .





One thing for sure: This is the “Big One”! . . .



[URL](#)

But why is it starting now?

Until now microchip systems have been deeply embedded, **out-of-sight and out-of-mind** inside “things” like . . .

### Smartphones



### Wearables



### Autos

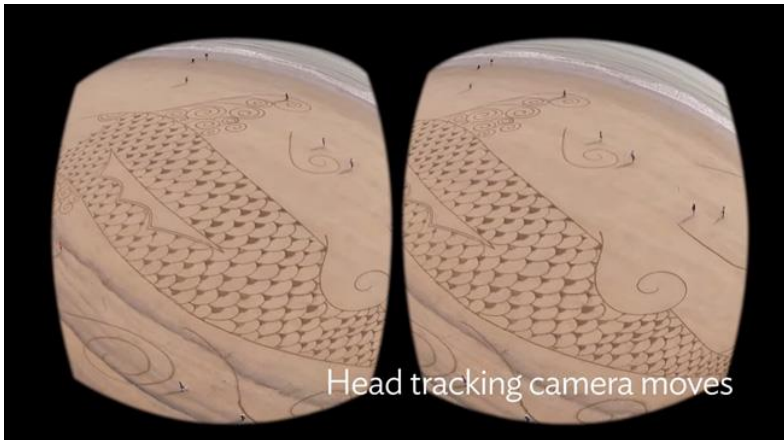


### Drones





Thus few folks visualize the “ideas in motion” behind effects like the astonishing ‘out-of-body’ experiences while flying a Parrot Bebop using an Oculus Rift . . .



[www.youtube.com/watch?v=lo6V0NR7DN0](http://www.youtube.com/watch?v=lo6V0NR7DN0)



[www.youtube.com/watch?v=6ZdSMAG90Rs](http://www.youtube.com/watch?v=6ZdSMAG90Rs)

Thus that “idea invisibility” is changing as teardowns of drones, smartphones and wearables make socially-visible the microsystem “hardware apps” within . . .

Namely, tiny modular micro-hardware versions of up-till-now “big things” like video-cameras, GPS units and inertial-measurement-units (IMU’s).

Including micro-electro-mechanical systems designed on computers and “printed” on “[MEMS chips](#)” in “foundries.”

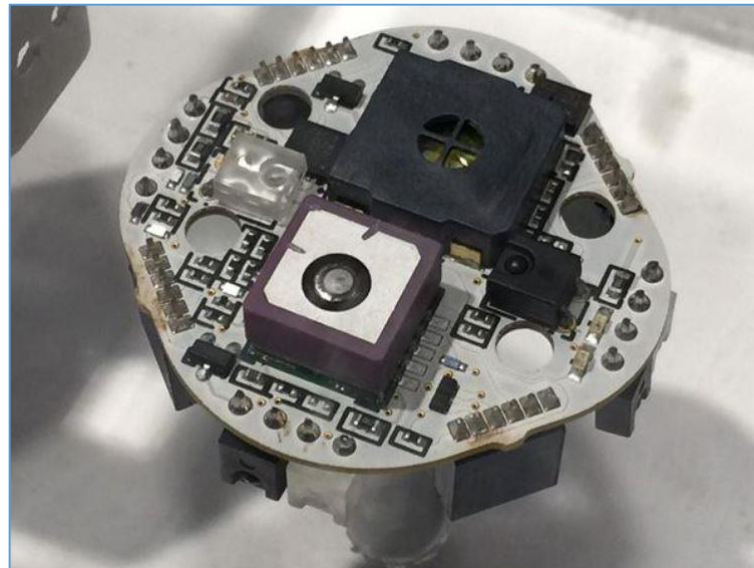
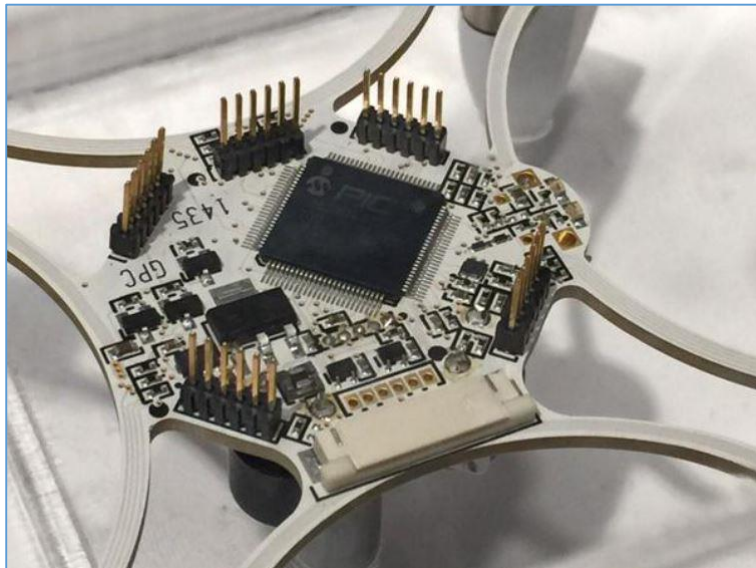
### [Oculus Rift Teardown](#)



Then too, imagine the impact on tomorrow's children when they start taking apart old nanodrones!

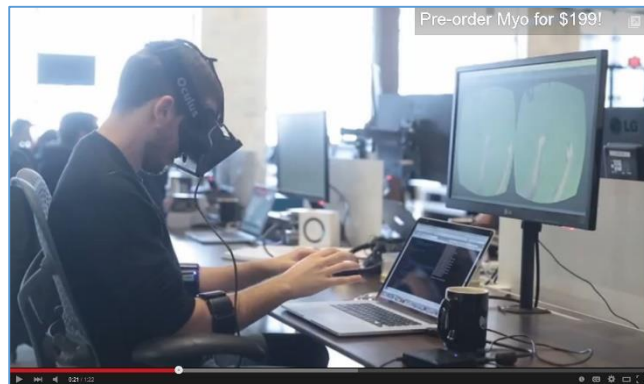


Imagine the wild things **they** might figure out how to do in time!





Further “ideas-in-things” in the coming wave of innovation are hinted-at by the [Myo gesture control armbands](#) from mechatronics engineers at [Thalmic Labs](#) (Kitchener, Ont.)



[VIDEO](#) [VIDEO](#) [VIDEO](#) [VIDEO](#)!

## **So, what's happening here?**

Instead of printing billions of transistors on single “large” smartphone chips.

We can print millions of transistors onto thousands of tiny but powerful chips.

[ you can do a lot with a million transistors! ]

And embed lots of tiny micro-control-processors . . . and MEMS micro-mechanisms . . . into almost everything.

Putting them where they measure, process and transmit local physical-data such as position, acceleration, temperature, pressure, etc.

Embedded-clusters of tiny-chips could animate and interactively-control lots of macro-things . . . such as robots, drones, mobility-aids and health-systems.

**These aren't frivolous play-things . . . they instead illuminate a vast frontier for human empowerment and amplification . . .**

Consider a patient confined to a hospital even now:

She can now explore the world beyond her window, using her smartphone to control a basic drone and see what's out there . . .

Now imagine joining a group "drone-tour" of some remote exotic place, right from your own individual homes . . .

With each your drones remotely "carrying your eyes", in the form of fisheye lens microcams (as in the [Parrot Bebob](#)) . . .

Which you look through using your [Oculus Rift](#) over the internet!



This embedded-microsystems revolution is getting up a big head of steam in emerging techno-social innovation centers all around the world ...

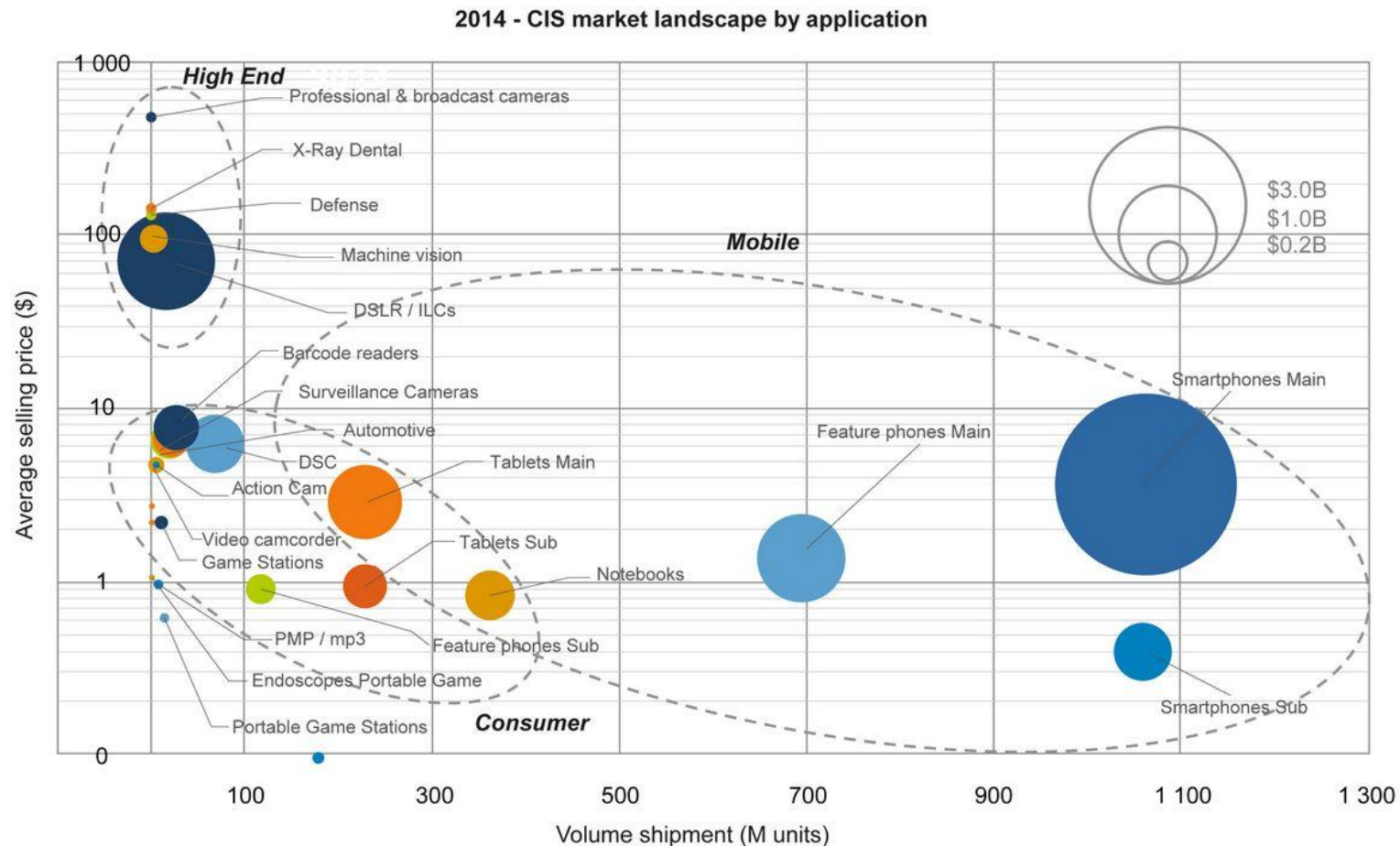


**But how on earth can we visualize and follow what's going on?**

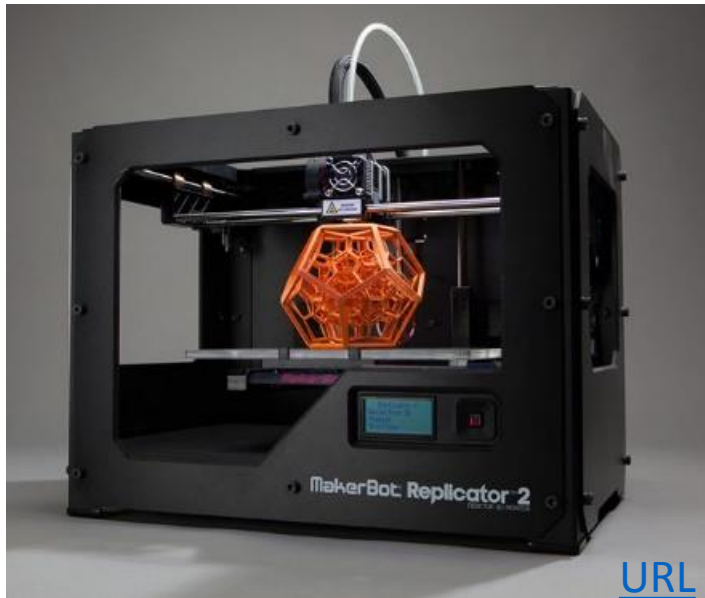
We can zoom-in on evolving fine-details in specific micro-technology areas by using tech-mappings like this for [microcamera image sensors](#) . . .

## 2014 CMOS image sensor market landscape

(Source: Status of the CMOS Image Sensor Industry report, Yole Développement, January 2015) [Source](#)



We can also follow, even participate in tech such as “[consumer 3D Printing](#),” enabling us to rapidly “make” all kinds of “things” from digital design specs created on personal computers . . .



3D printed  
prosthetic  
hand

Once perfected, such digital design files can be shared electronically with and/or marketed to users of 3D printers anywhere . . .



Even better, what about making 3D printers that print 3D printers!  
That's the UK's [Adrian Bowyer's](#) vision for the [global RepRap Project](#):

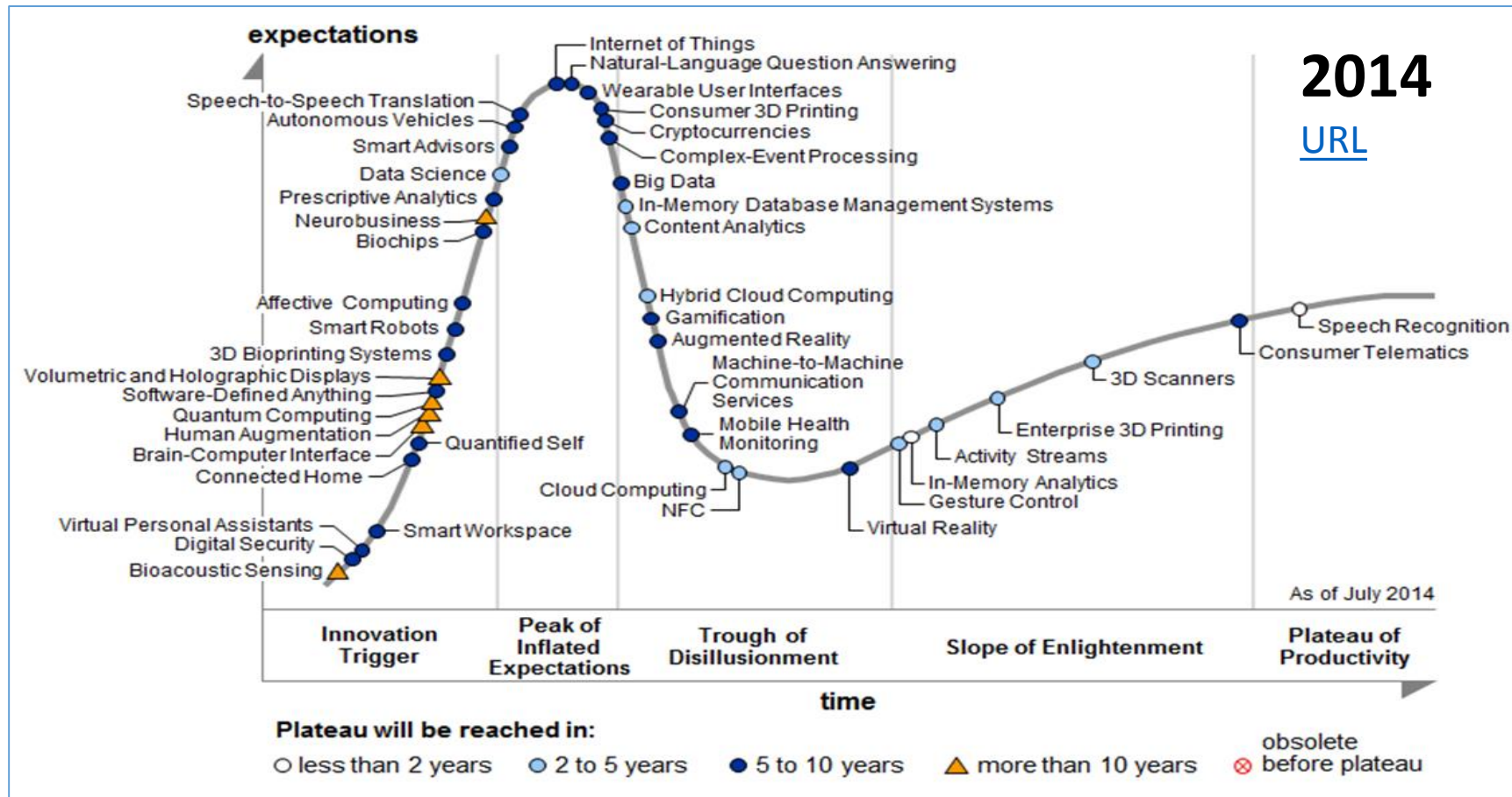
For more about RepRap  
and the philosophy behind it,  
watch this remarkable video:  
[“A machine that builds itself?”](#)



Just as some iron was fed-back to make more steam engines to help make more iron to further empower the industrial revolution . . .

Such systemic [positive feedback](#) can provide large “gain” in the emergent 3D-printing technology-generation ecosystem.

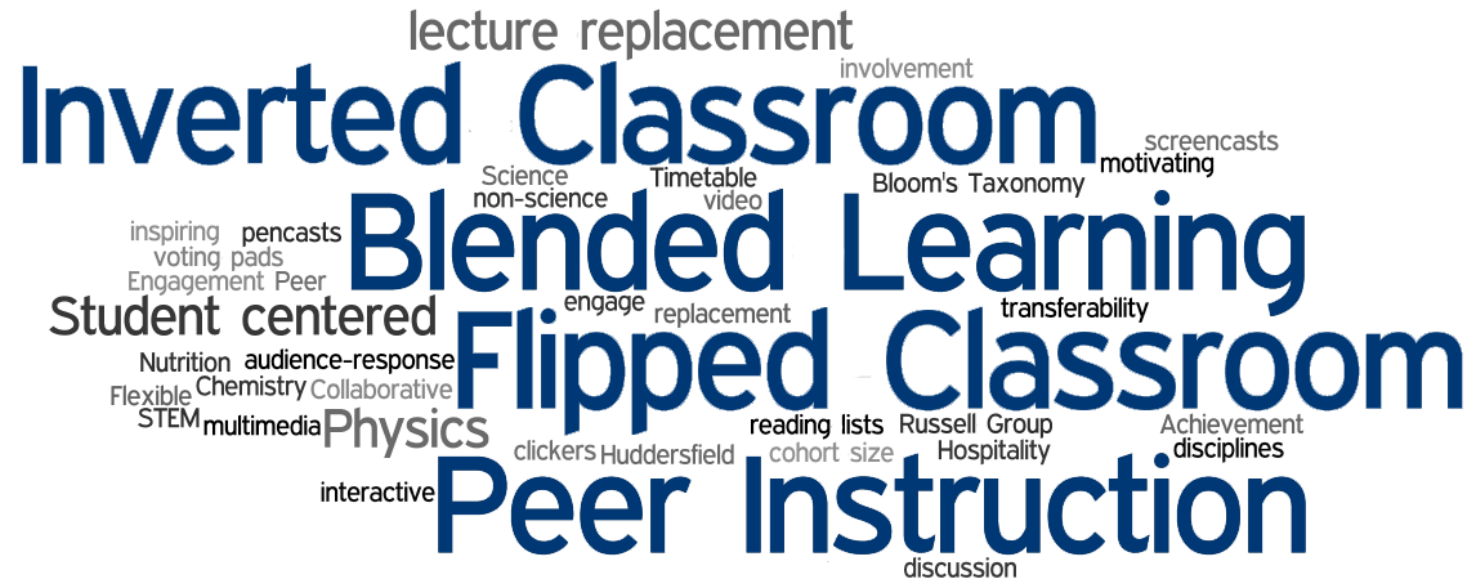
For the bigger picture we can zoom-out and follow paths of emerging application-clusters along [Gartner “Hype Cycle” infographs](#) that frame the overall technology-wave . . .



Thereby gaining the [venture capital community](#)'s perspective on it all . . .

But where will all the young innovators come from?  
And how can they learn to surf on this vast incoming wave?

Fortunately, a wave of change is also sweeping through STEM education, just in time!





Many incoming students also have gained hands-on team-experiences at . . .

LEGO Camps



Maker Faires



FAB Labs



Robot Competitions



They'll also gain emerging knowledge, just-in-time as needed, using rapidly evolving internet-based learning-resources . . .



[Image source](#)



The innovative embedding of ever-tiner micro-hardware apps will quickly spread . . .

And begin enhancing the functionality of just about everything:



<http://blogs.jabil.com/2014/08/13/internet-of-things-infographic/>



But how will we cope with the 'complexity' of the emerging techno-social ecosystem?



[From: The Age of Opportunity: Harnessing Complexity To Solve Big World Problems](#)  
[by Frank Spencer, kedgefutures.com](#)

We'll exploit rapidly-evolving new techno-social-coordination methods, such as [collaborative learning](#), [crowdsourcing](#), [crowdfunding](#), [IP brokering](#), [agile design](#) [rapid-digital-prototyping](#) and more . . .

Enabling everyone from [engaged-users](#) to [innovators](#) to [makers](#) to scale up their levels of participation and impact.



Only now, instead of just exploring how to make ever-bigger things that go ever-further, ever-faster . . . such as erecting skyscrapers that poke into the clouds, and shooting ever-bigger stuff out into “outer space” . . .

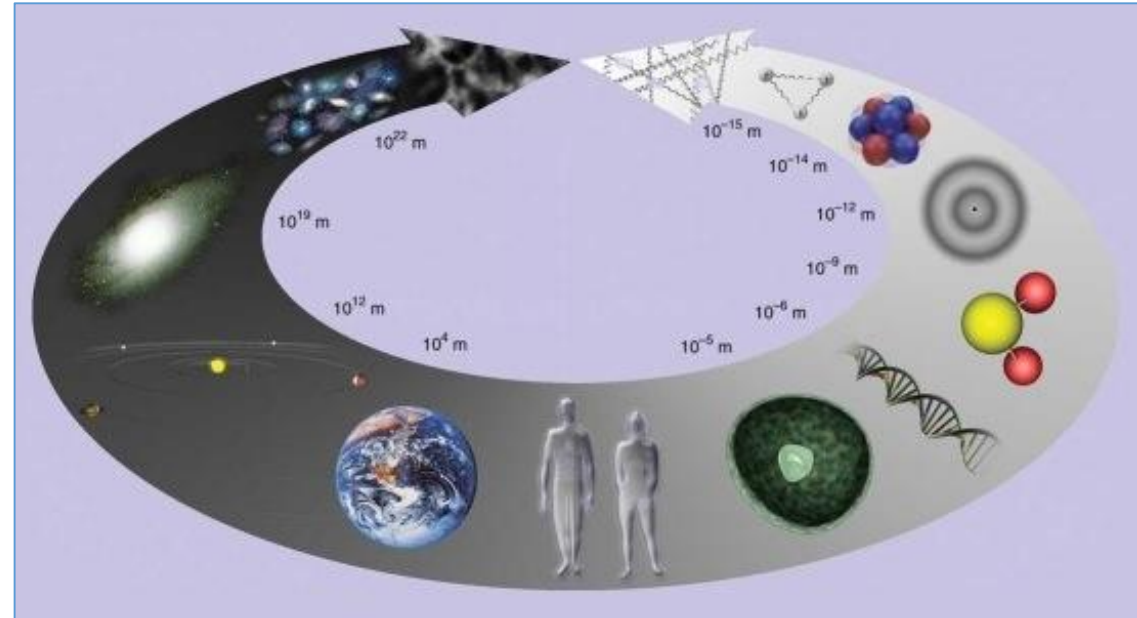




We'll increasingly invert our spherical-perspective by  $180^\circ$  and peer down into the “inner spaces” of the micro/bio/nano/pico worlds . . .



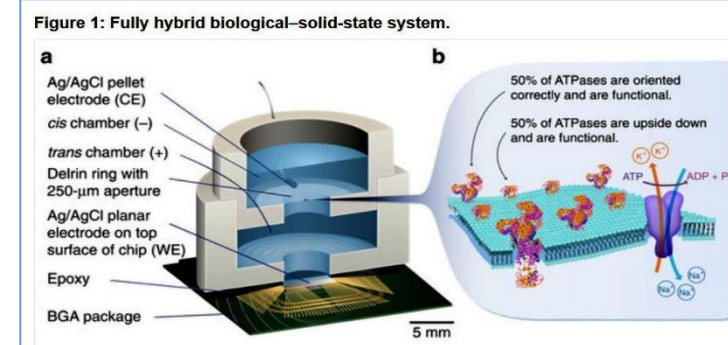
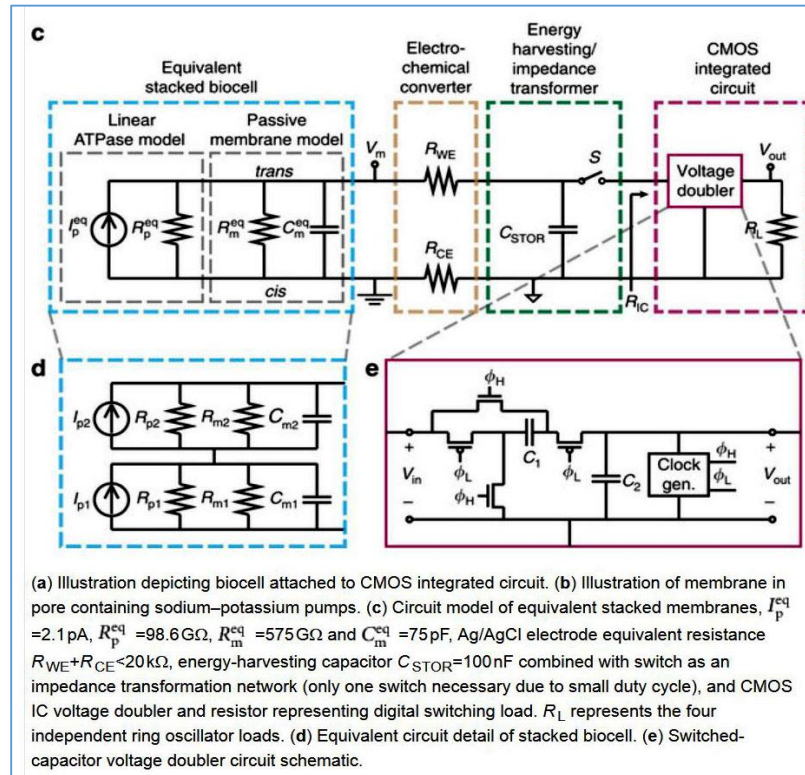
[Randy Scott Slavin](#)



[nupex.eu](http://nupex.eu)

As we explore how to make, share and exploit vast-exponentiations of ever-tinier, ever-more humanly-empowering “micro/bio/nano things” . . .

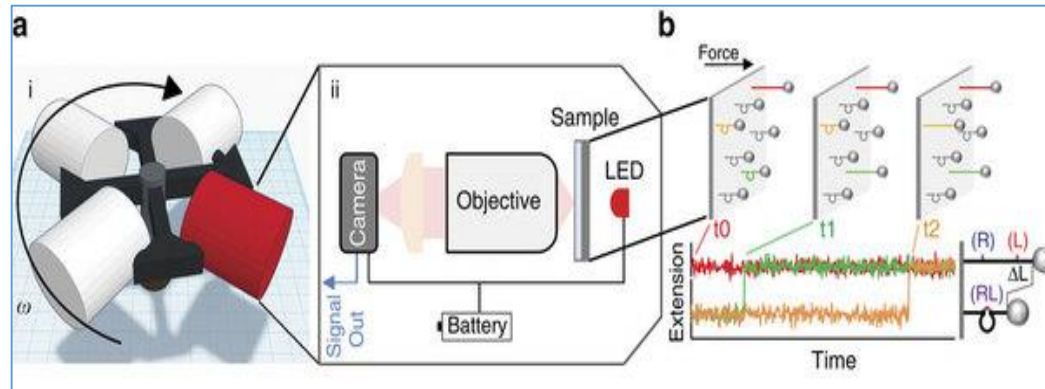
Study, for example, the [first fully-hybrid biological solid-state system](#) created by [Ken Shepard's team](#) at Columbia University's [Bioelectronics Systems Lab](#) ([video](#)):



By powering [CMOS](#) microcircuitry using [ATP](#) in an in-vitro electrogenic ion pump, this work opens a path to powering tiny nano-chips embedded inside living cells!

And as researchers zoom ever-further into the micro-biological, molecular and atomic levels . . .

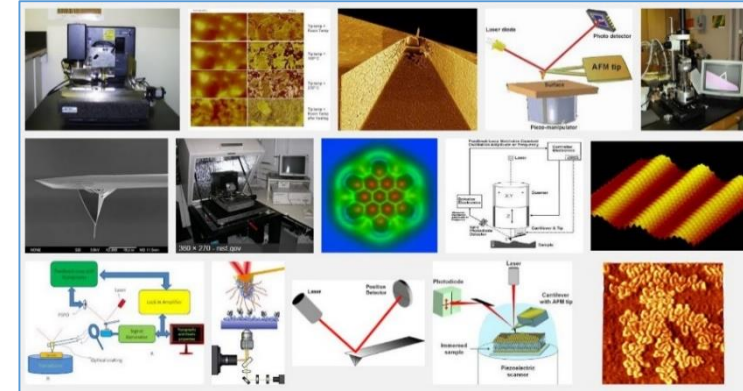
### Multiplexed Centrifuge Force Microscopy (CFM)



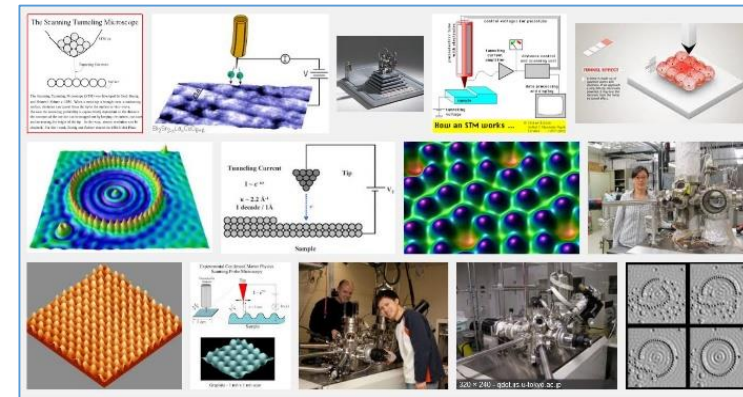
Democratizing high-throughput single molecular-pairs' force analyses using integrated DNA nanoswitches multiplexed into miniature benchtop CFMs. [Just announced on 3/17/16 by Harvard Wyss Institute.](#)

Their findings will help other adventurers better gear-up for explorations in places & frontier-fields such as . . .

### Scanning Tunneling Microscopy (STM)



### Atomic Force Microscopy (AFM)





Multi-physics EDA Augmented Reality Teleautonomous Systems

Photonics Wyss Institute Bio-Electronics Exploratory robotics

Hyperscaling Model-Based Design Biologically Inspired Engineering

Draper Lab

MIT Nano

Brain Science

Nano Technology

Multiengineering

Machine Vision

Social Physics

DARPA Microsystems

Machine Hearing

Research Universities

Meta^2Mathematics

Augmented Kinesthetics

Techno-Social Dynamics

Google ATAP

Ecological Algorithms

UPS Synthetic Biology

Meta Architecture

RI School of Design

Memetic Generators

Microsoft Research

Data Science

Genetic Algorithms

Metamaterials

Self Assembling Systems

Biosocial Learning

Facebook

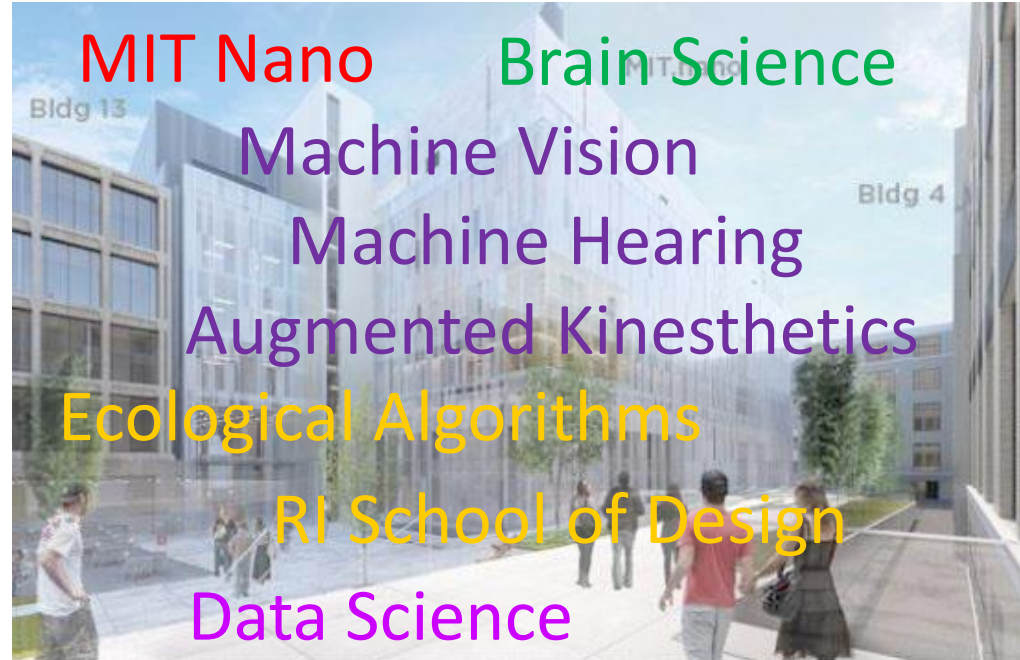
Techno-Social Exploration-Infrastructure

Amazon

AI & Machine Learning

STEM + ARTS = STEAM

Molecular Machines



Thus it begins, as such knowledge rapidly spreads, all around the world . . .





Before long, adventurers everywhere will be “surfing” somewhere on these waves . . .!



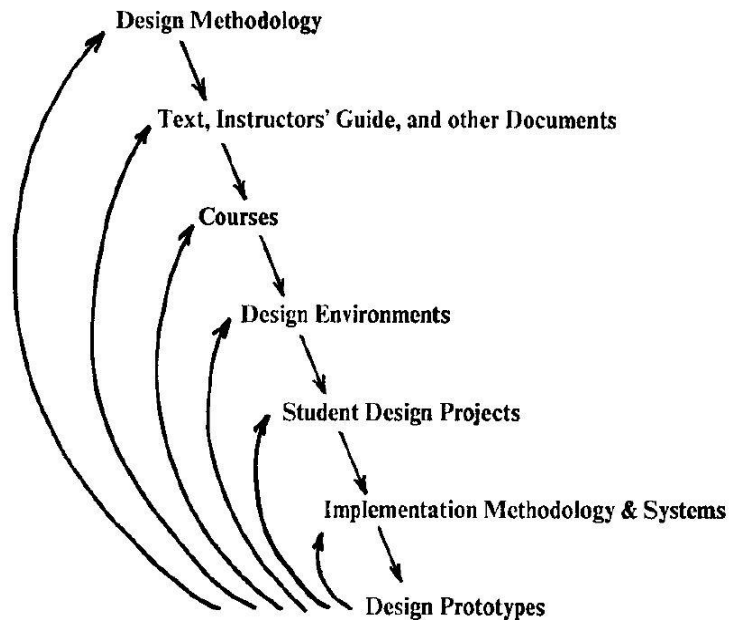


But how on earth will humanity ever grasp and knowingly guide what's happening in such massive techno-social waves?



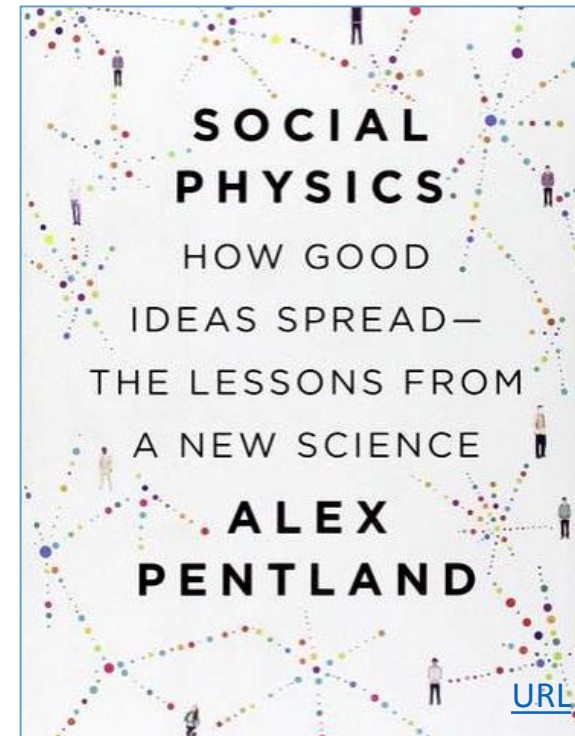
We'll evolve techno-social methods that help us meaningfully reflect-back-on and knowingly peer-ahead-into such evolving labyrinths, using methods and projections akin to today's weather models . . .

To envision the masses of ideas now cycling in techno-social motion, recall how we diagrammed the [nested-social-evolutionary-processes](#) of the VLSI revolution. Only now, vastly more such processes are running in parallel and cross-fertilizing. And [new science](#) is beginning to explore and map-out what's happening . . .

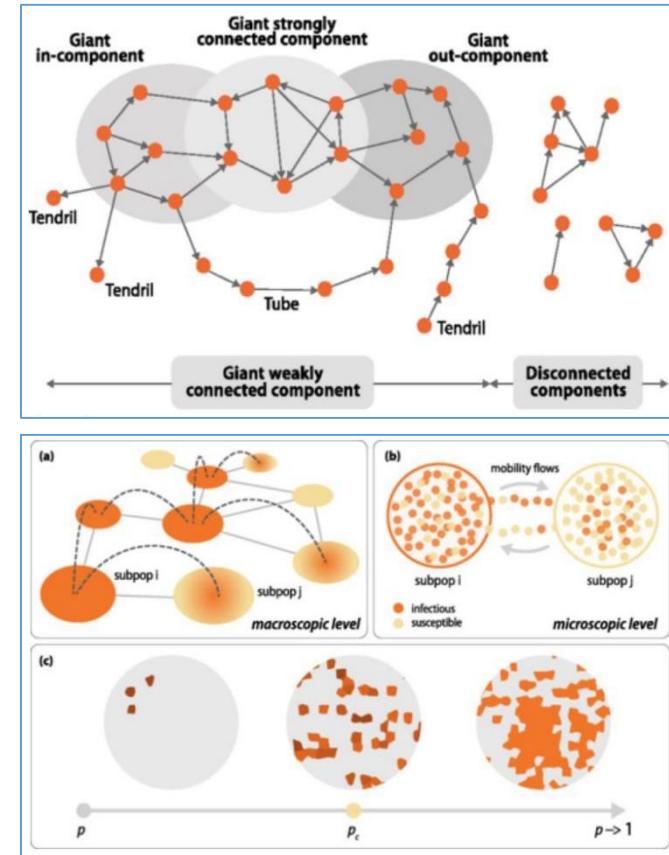
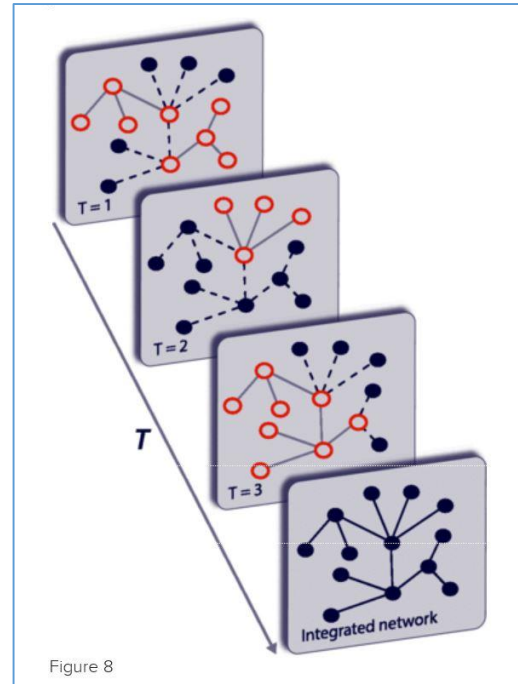
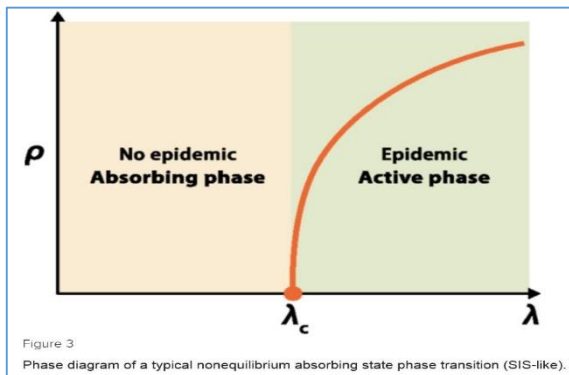
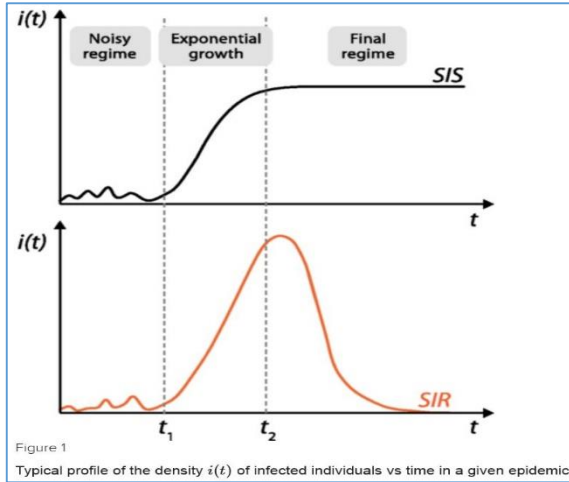


[The MPC Adventures](#) (p. 16) Xerox PARC 1981.

Figure 8. The Joint Evolution of the Multi-Level Cluster of Systems



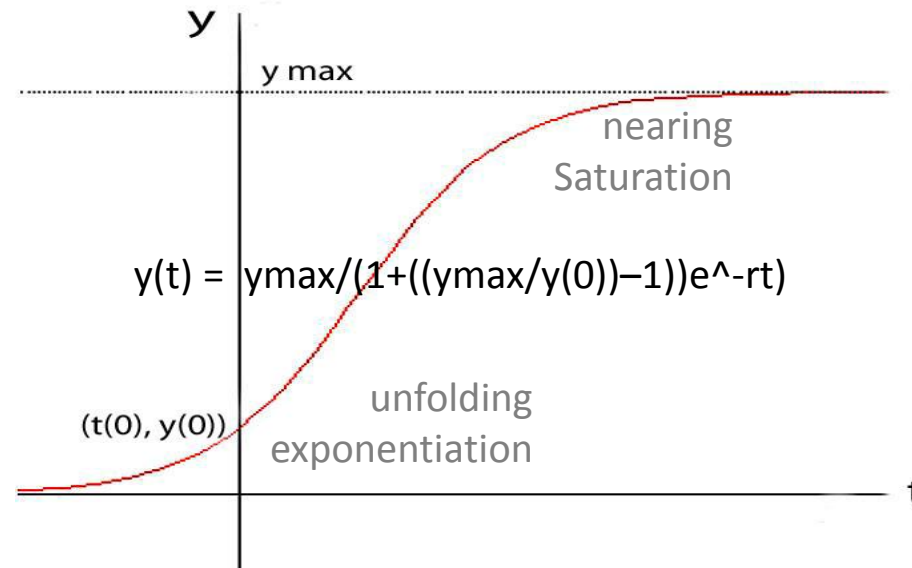
[Epidemic Processes](#) are already providing mathematical frameworks for partly-modeling techno-social dynamical-systems:



From: [“Epidemic processes in complex networks”](#) by Pastor-Satorras, et al, *Rev. Mod. Phys.* 87, 925 – 8/31/15  
See also recent work in [CNNs](#), [LVars](#) (L. Kuper), etc.



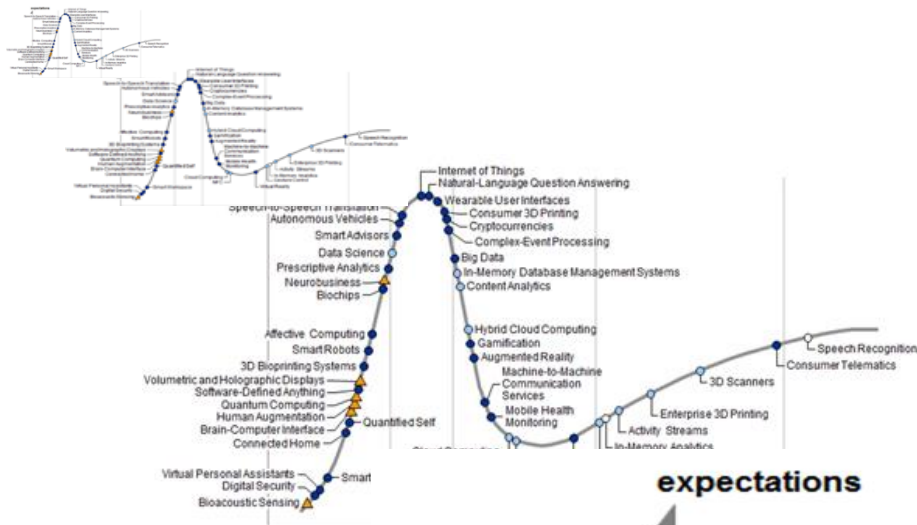
Note that the big incoming wave is way more than a few nested logistic ‘epidemic’ processes where each looks something like this:



And even in this simple case, each 2D slice hides tons of what “composes the wave”\*

\*For more insight into this all this, see Van Quine’s discussion of “the river” in [From A Logical Point of View, Ch.IV.](#)

Let’s re-slice and zoom into our incoming wave in 4D<sup>+</sup> to gain a better perspective



## Meta-ethnomethodology:

Envisioning the incoming wave of innovation as a time-series of “GHC profiles” (i.e., 2D+ slices thru the 3D+ wave at increments in time) . . .

Is this a Traveling Wave?  
A Standing Wave? Or What?

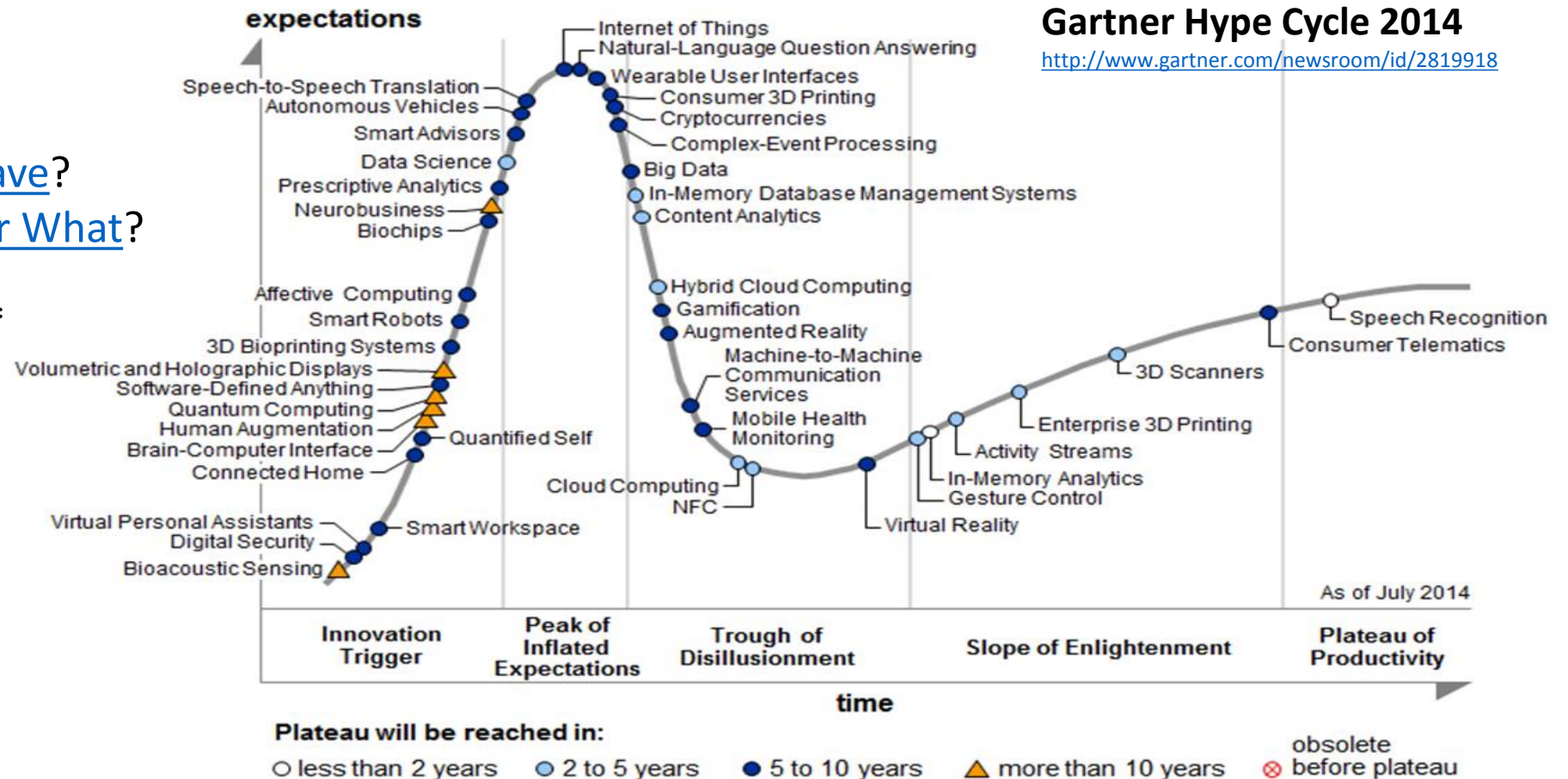
This stunning video\*

hints at ways to think about what it all means . . .

\*"Water," by Morgan Maasen  
<http://vimeo.com/90429499>

## Gartner Hype Cycle 2014

<http://www.gartner.com/newsroom/id/2819918>



**Looking back**, these processes seem remarkably similar to the explorations of the [alchemists](#), i.e., the labyrinths of emergent techno-social processes that gradually “self-abstracted” into the later sciences of [chemistry](#) and [materials](#).

Ex: See the work at Columbia and Princeton on [reenacting](#) the unfolding of medieval European alchemy via [hands-on, techno-social reverse-engineering](#) of what happened back then:

[The Making and Knowing Project](#) by [Pamela Smith](#), Columbia ([video](#)).

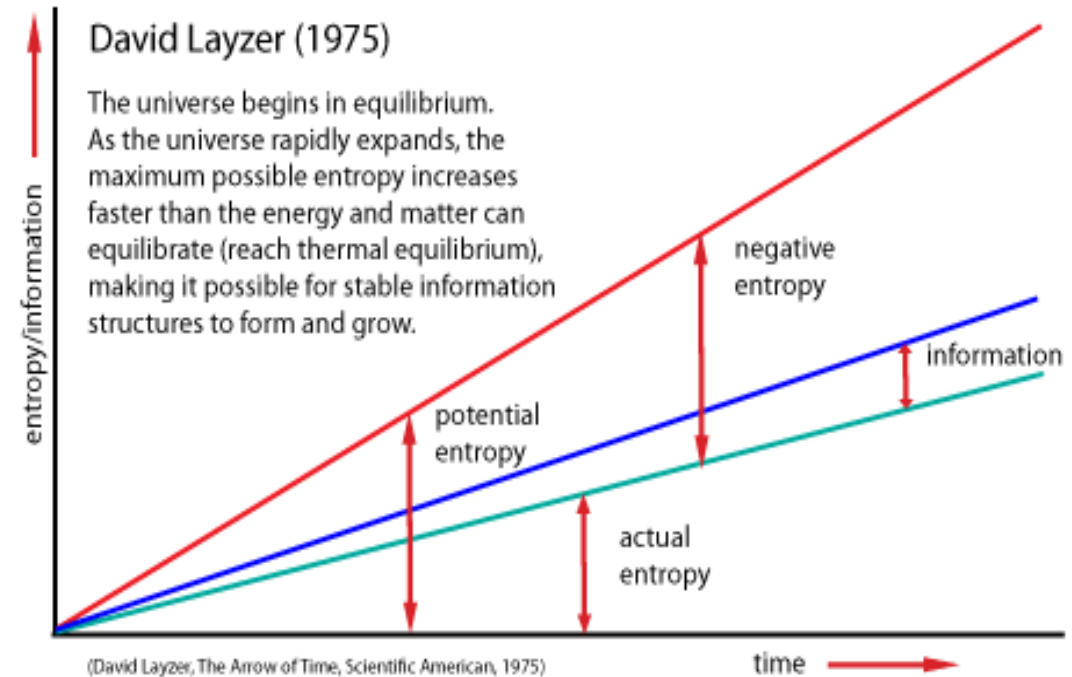


[Decoding Alchemy freshman seminar](#) by [Jennifer Rampling](#), Princeton.

Also see [Scientiae](#) and the [Society for the History of Alchemy and Chemistry \(SHAC\)](#)

**Looking forward**, are there limits to what it's possible to create? Doesn't the [2nd Law of Thermodynamics](#) say everything's “running down” as entropy inexorably increases? (as popularized by [Arthur Eddington](#) in [1927](#))

But [that's not so](#) given emerging insights re [the physics of time](#)!

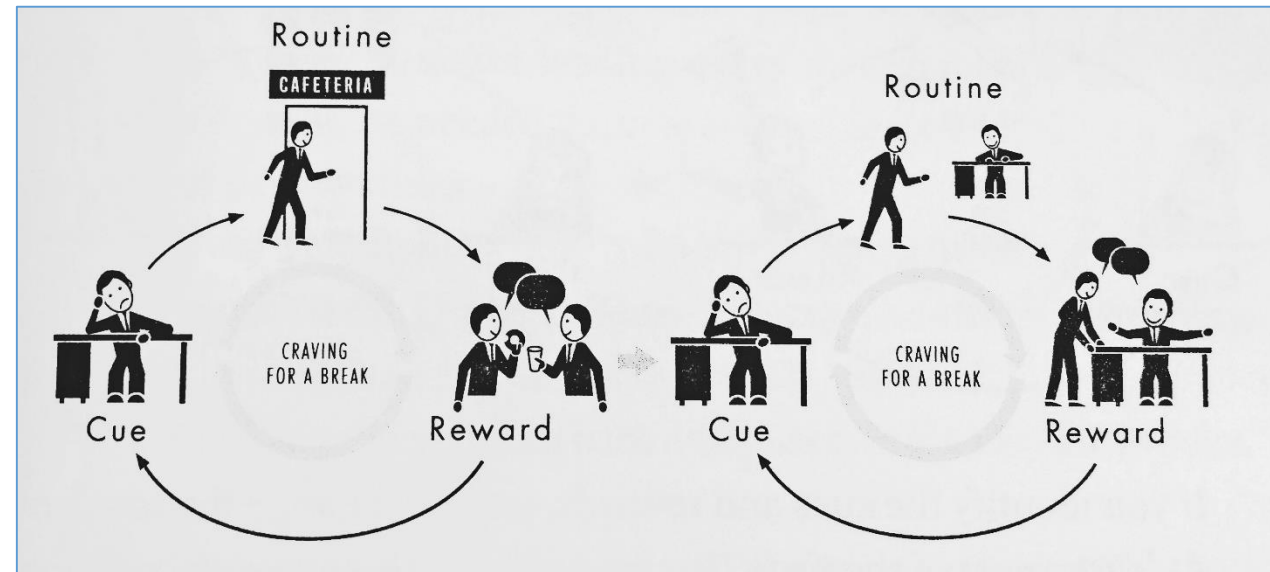
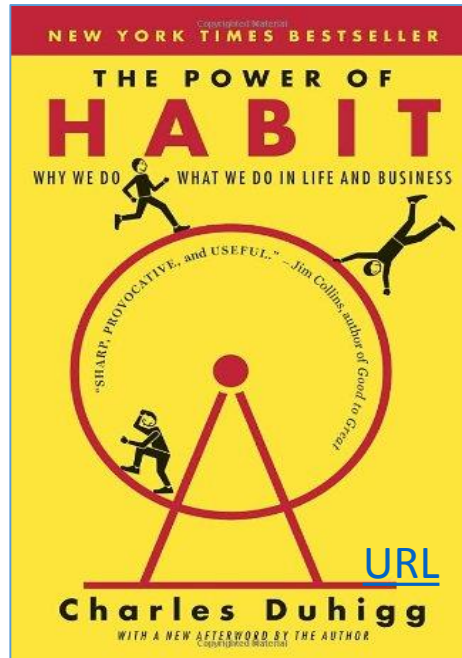




Meanwhile, as bandwidths, connectivity & latencies improve, escalating rates of techno-social change will challenge existing cultural patterns, because of the massive accumulation of social habits:

What's the new game?  
Who gets to play?  
What rules do we play by?  
Where can we turn for guidance?

**Especially, how do we drop old habits?**



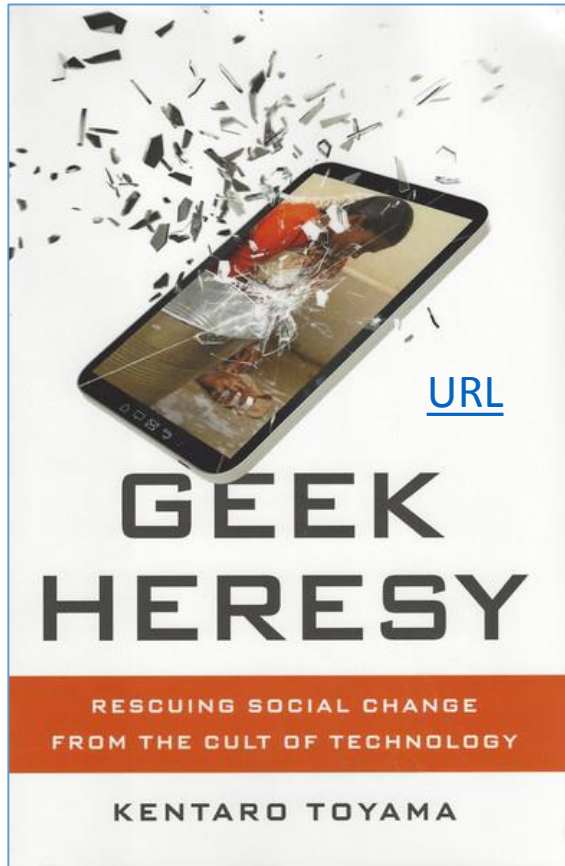
**Then too, “How can we ever adjust and keep up?”**  
Hasn't the train already left the station for many folks?

Words to ponder:

***"In a world of change, the learners shall inherit the earth, while the learned shall find themselves perfectly suited for a world that no longer exists"*** – [Eric Hoffer](#)

Meantime, something awesome has begun:

***"As the rate of techno-social change increases, we'll all live far further into the unfolding techno-social future than we ever dared dream"*** – [Lynn Conway](#)

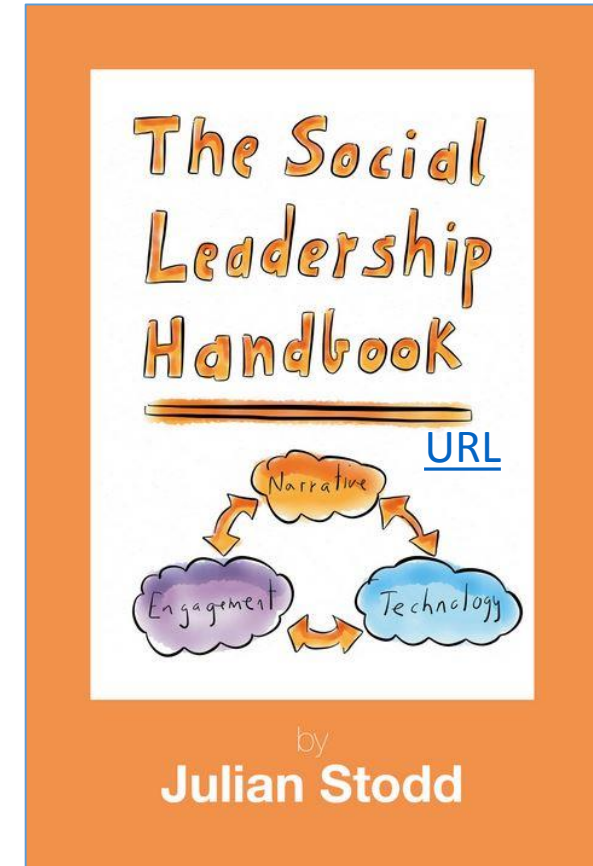


[Kentaro Toyama, 2015](#)

And, a word of caution!  
Do avoid becoming distracted by all the rapidly-emerging “things.”

As [Kentaro Toyama](#) says in [Geek Heresy](#), “technology alone won’t change the world” . . . We must instead rescue “Social Change from the Cult of Technology”!

One key will be the evolution of empowering “social-teaming” and “social leadership” for the incoming “[Social Age](#)”, as discussed by [Julian Stodd](#) . . .



[Julian Stodd, 2014](#)





There are also deep concerns about Data and Memory . . .

As in [Juan Benet's](#) discussion of [IPFS and the Permanent Web](#) as a way to ensure the Web's survival.



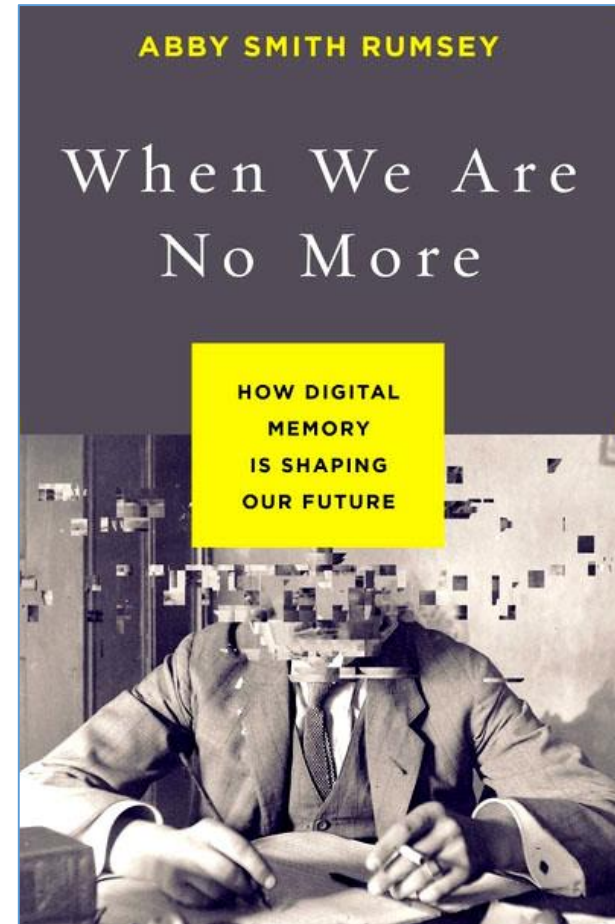
But then see [“DNA Data Storage Safe for Centuries”](#), NYT 12-3-15

And then explore historian [Abby Rumsey's](#) breathtaking book:

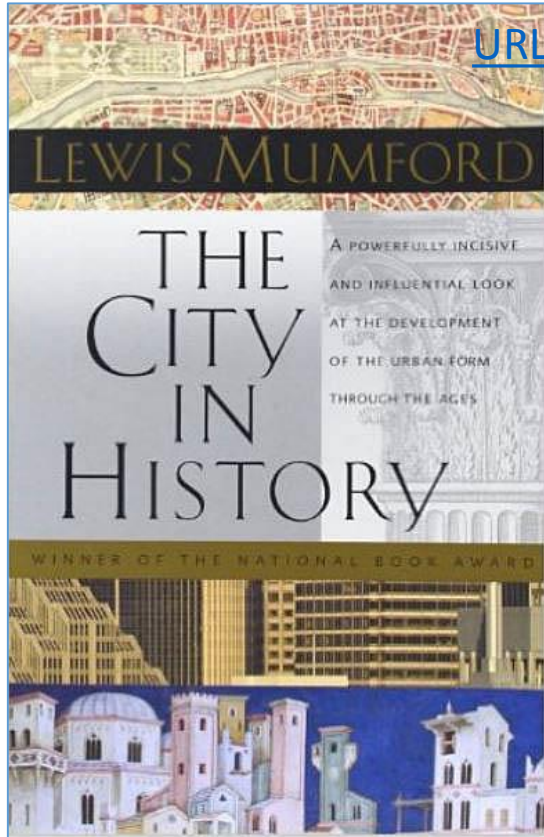
*“A call to consciousness, [When We Are No More](#) explains why data storage is not memory; why forgetting is the first step towards remembering; and above all, why memory is about the future, not the past. “*



[Juan Benet, 2015](#)



[Abby Smith Rumsey, 2016](#)

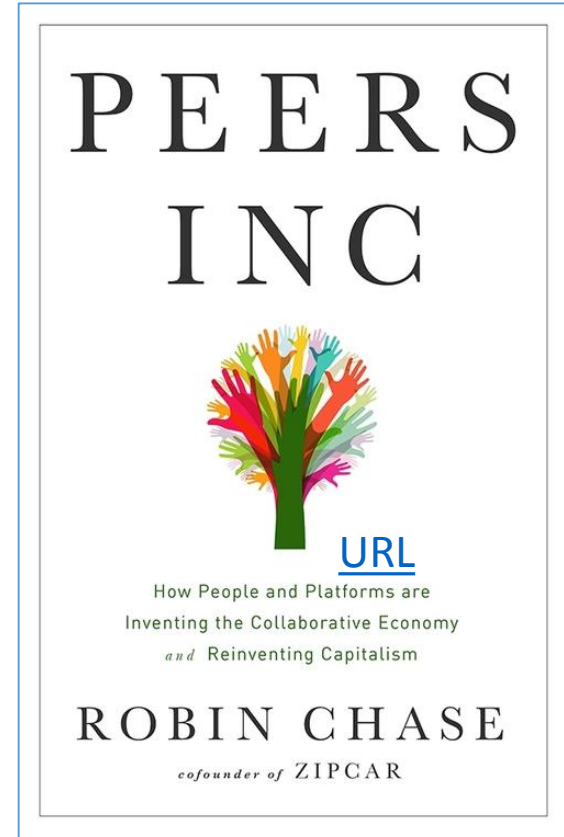


[Lewis Mumford, 1961](#)

Again, this isn't about things. It's about the escalating rate of generation + diffusion of ever-better ideas on how to make and use things!

This is triggering huge re-alignments in [political economy](#), including the role of [The City in History](#).

And to [the emergence](#) of “cooperative capitalism”, as discussed by [Robin Chase](#) of [ZipCar](#) fame in [Peers Inc](#)



[Robin Chase, 2015](#)

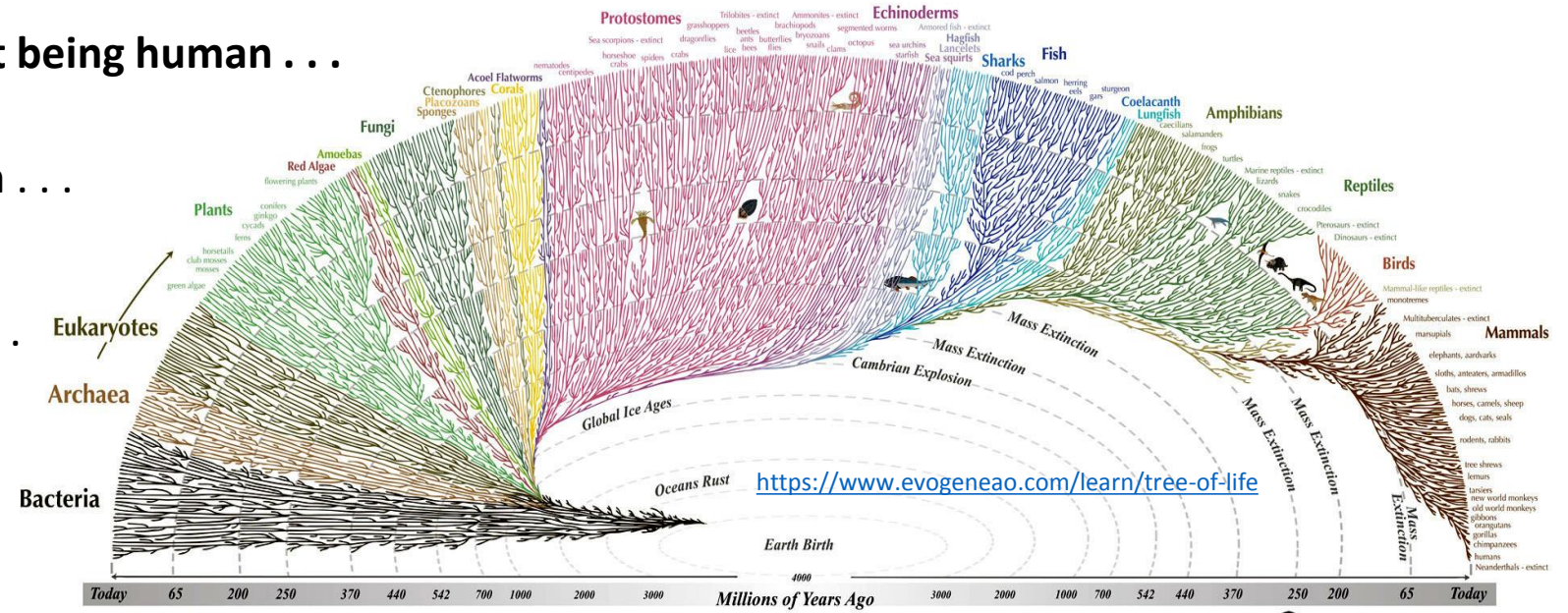



Most of all, it's about being human . . .

Where we came from . . .

What we're doing . . .

Where we're going . . .



All the major and many of the minor living branches of life are shown on this diagram, but only a few of those that have gone extinct are shown. Example: Dinosaurs - extinct 





# How Can We Best Enter, Explore and Unfold These Possible Futures?

By Building On and Sharing:

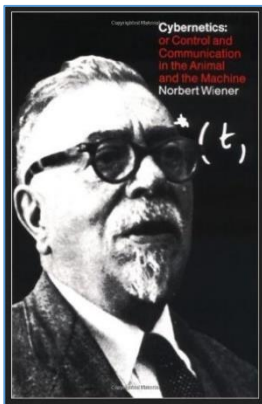
Models and Visualizations of Unfolding Techno-Social Dynamical Systems

Always Rethinking Foundations and Boundary-Conditions in:

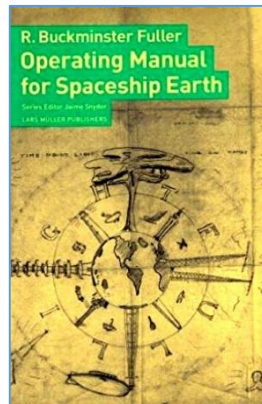
Mathematics, Statistics, Space-Time, Entropy, Complexity, Evolution . . .

While “On-the-Move” Living, Training, Participating and Adventuring In:

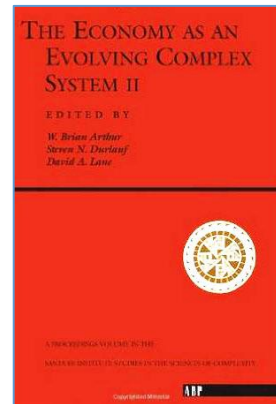
Creative-Explorations and Mappings, Social-Learning, Political Economics . . .



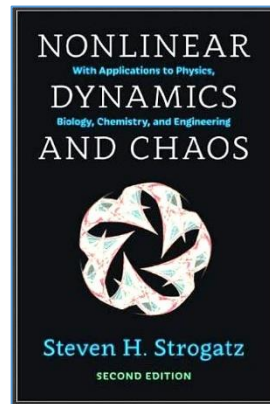
[N. Wiener '61](#)



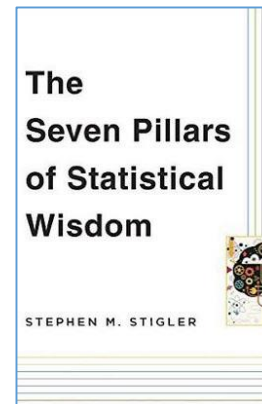
[R. B. Fuller '68](#)



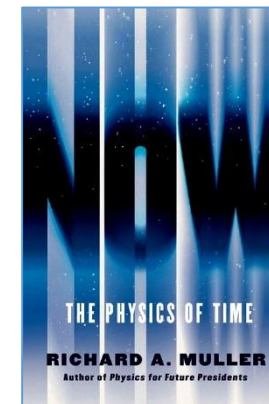
[W. B. Arthur, Ed '97](#)



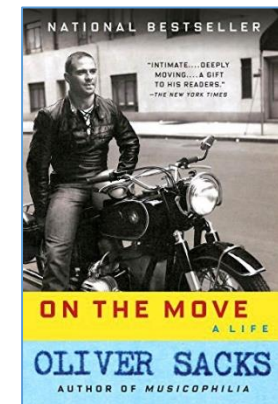
[S. H. Strogatz '14](#)



[S. M. Stigler '16](#)



[R. A. Muller '16](#)



[Oliver Sachs '15](#)

## **In Conclusion: A Conjecture about Possible Futures** (& alt. measures to GDP):

By cooperatively creating and sharing of ideas for doing ever-more with ever-less, the incoming wave of techno-social innovation now has the stunning potential of:

- (1) Sustainably providing **ever-increasing** infrastructural functionality and life experiential-amplification per person,
- (2) While consuming **ever-decreasing** energy and material resources per person
- (3) Thus beginning the **reigning-in** of our unsustainable over-use of planet earth
- (4) While simultaneously **opening-up** unprecedented explorations of the greatest evolutionary frontier . . . the frontier of **what it's possible to do!**

**Thus we begin another Renaissance, as we enter the Techno-Social Age.**

Finally, a personal perspective on “Our Travels Through Time” . . .



“If you want to change the future, start living as if you’re already there!”

– Lynn Conway



# END

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