Leadership of Technological Change

Ten Areas of Disruption, Strategic Opportunity, and Threat

MITRE

Apr 2013 ❖ McLean, VA

John Smart, President,
Acceleration Studies Foundation
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Theory of Change

What Drives Accelerating Change?

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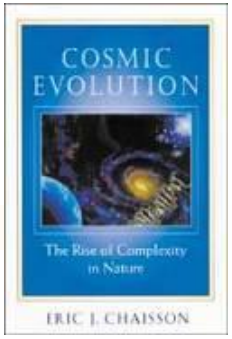
Are You Accelaware? The Most Complex Universal Systems Are Always Accelerating

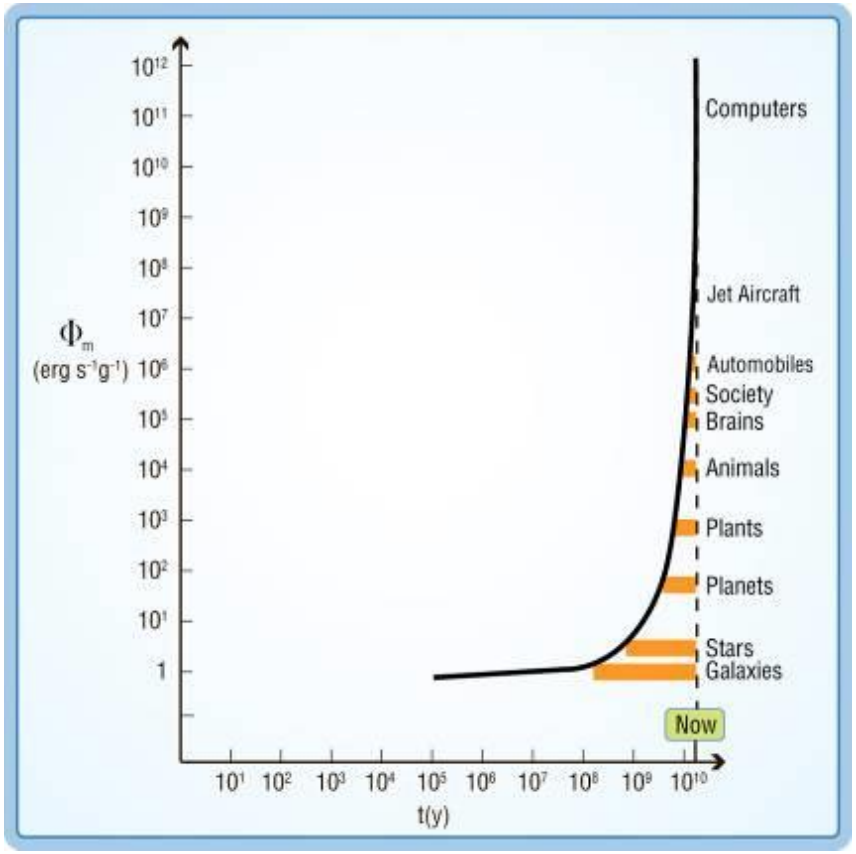
We don't know why yet. But one thing is clear: **Leading-edge systems are always more Space, Time, Energy, and Matter (STEM) dense and efficient over time**.



Cosmic Evolution, Chaisson, 2001

Free Energy Rate Density (Φ)

System	(ergs/sec/gm)
Global AI of the 21st C	10^12+
Pentium II of the 1990's	**10^11**
Intel 8080 of the 1970's	10^10
Modern Engines	10^5 to 10^8
Culture (human)	500,000 (10^5)
Brains (human)	**150,000** (**10^5**)
Animals (human body)	20,000 (10^4)
Plants and Ecosystems	**900** (**10^2**)
Planets (Early)	75
Stars	**2**
Galaxies	0.5



Free energy rate density growth in *hierarchically emergent* complex systems over universal time.

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Strategic Vision: What's Your Theory of Change? Of *Progress*?

Good theories of change include values, and an *idea of progress*.

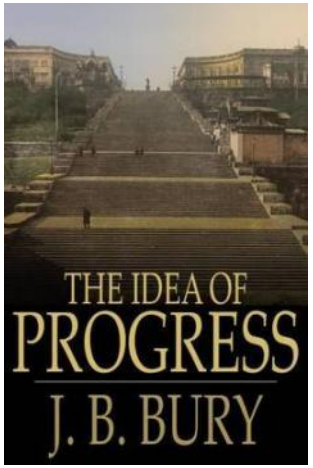
My bias: I'm in a group of scholars who study complex systems from

- **Evolutionary "evo" variation**,
- **Computational "compu" selection**, and
- **Developmental "devo" optimization** approaches.

More at:

Evo Devo Universe

EvoDevoUniverse.com



Bury, 1920

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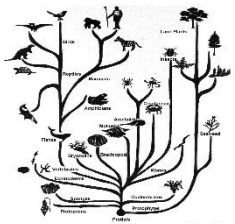
Evolution, Computation, and Development:
Three Drivers and Two Patterns Found in All Complex Systems

Utility

Computation

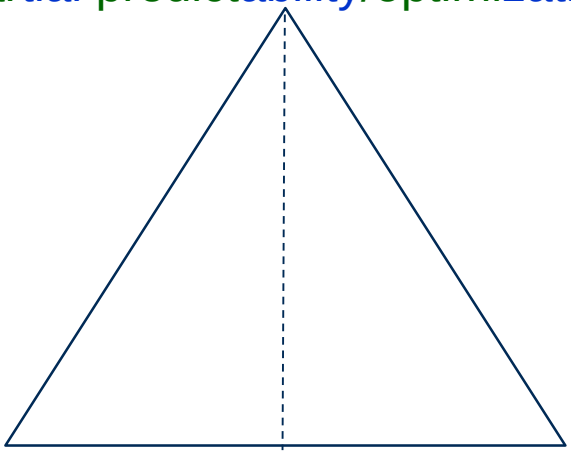
Adaptation/Selection

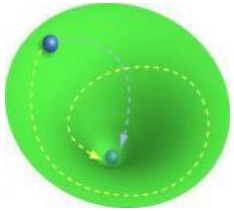
Partial predictability/optimization



"Trees"

Diversifying, Local





"Funnels"

Unifying, Universal

Chance

Evolution

Unpredictable/
Not optimized

Necessity

Development

Predictable/
Optimized

The Structure of Evolutionary Theory, Gould, 2002, p. 1052
The Plausibility of Life, Kirschner & Gerhart, 2005, p. 219
Evo Devo Universe?, Smart, 2008, p. 18
What Technology Wants, Kelly, 2010, p. 123

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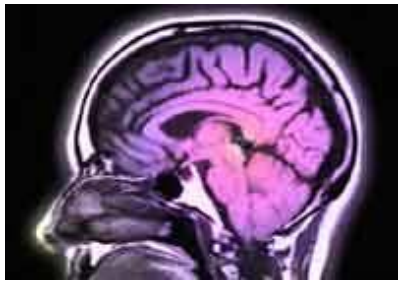
Evolution vs. Development: Understand it in Life, Understand it in Society

Two ‘genetically identical’ twins:



Almost all local features are unique.

Evo: Almost all *local* processes (thumbprints, brain wiring, learned ideas, behaviors) are **unpredictably unique** in each twin.

Devo: A few *systemic* processes are **predictably the same**.

Key Lessons:

- **Both evo** and **devo** processes at work in people, orgs, society, technology.
- **95%** of our genes are **evolutionary** (creative, unpredictable, bottom up).
- Only **5%** of them are **developmental** (constrained, predictable, top-down).

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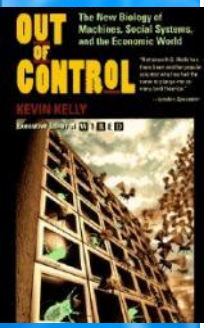
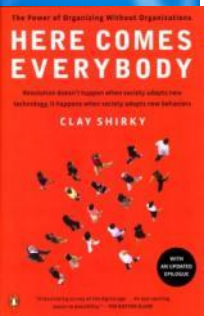
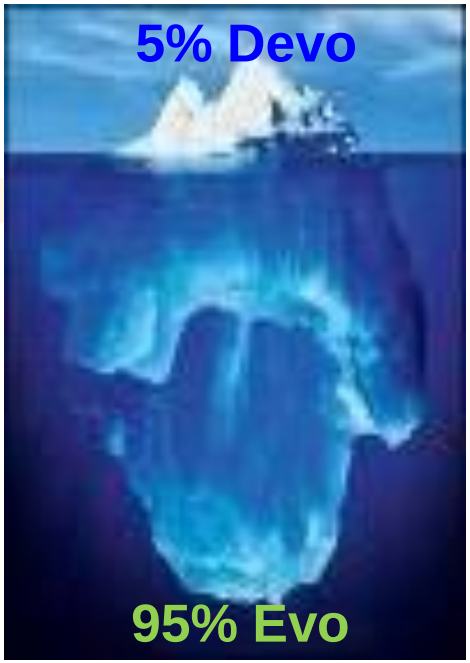




The "95/5%" Evo/Devo Ratio: *Most Change is Bottom-Up*



Roughly 20X More Change is Bottom-Up than Top-Down

Nearly all (perhaps **95%**) of the decisions and events that create or control complex systems appear to be bottom-up **evolutionary processes**.

Only a small critical subset (~**5%**) are top-down, hierarchical, **developmental processes**.

Planning and policy **leadership** often forgets this.

Examples:

- Almost all **genes** in an organism create evolutionary variety vs. a special subset *(3-5%)* that form the developmental toolkit.
- Almost all **thoughts** in an organism are unconscious, vs. ~5% conscious.
- Almost all **behaviors** of an indiv. are environmental reactions vs. plans.
- Almost all **decisions & actions** in an org. are "out of control" vs. planned.
- Almost all **social innovation** occurs in economic markets vs. by govt policy.
- Almost all **new IT prods & services** empower network nodes vs. hierarchies. (personal computers, email, web, smartphones, wearables)

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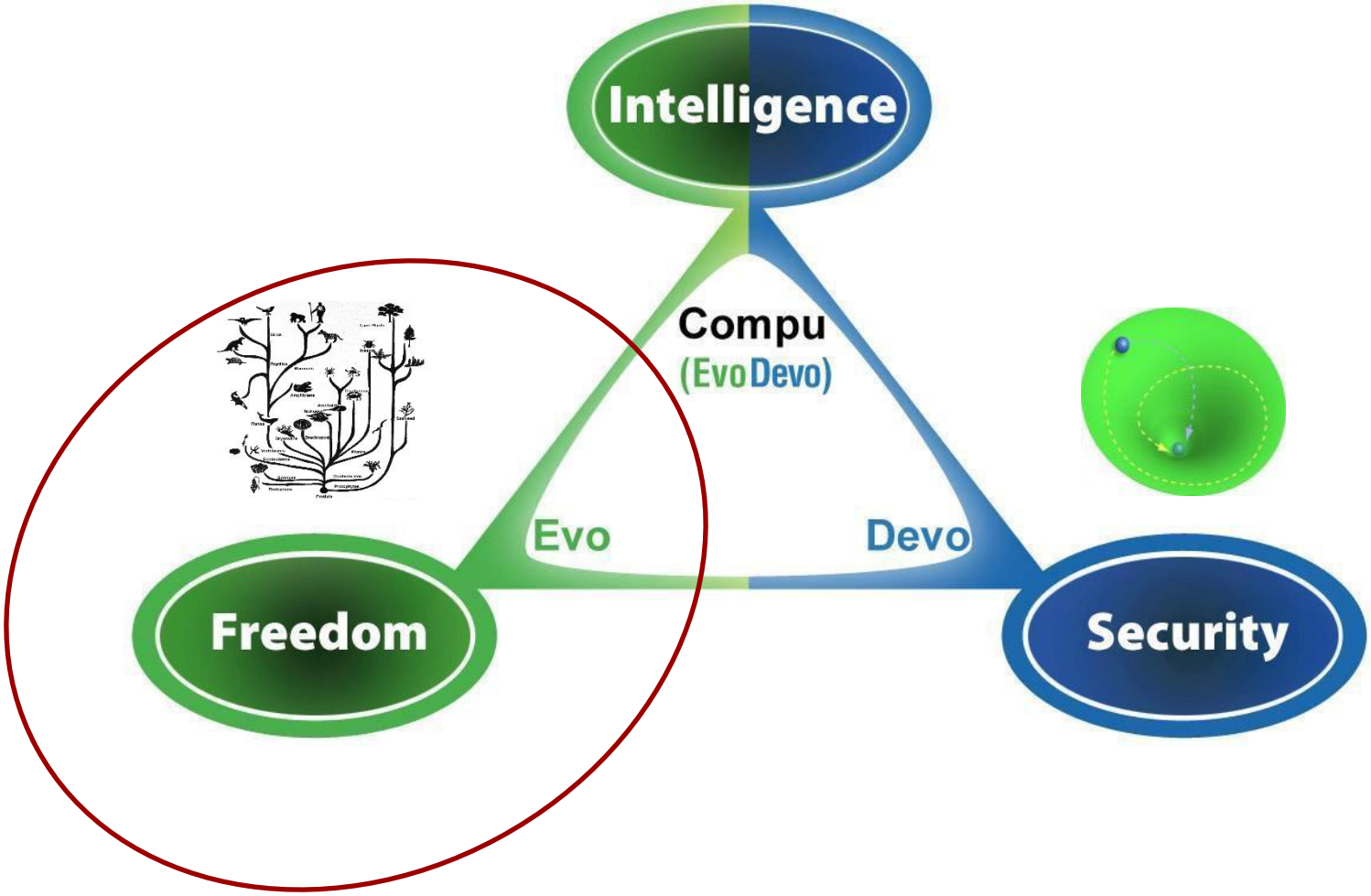
FIS Model: Freedom, Intelligence, and Security: Three Key Values of Social Progress



Underemployed in Defense Culture

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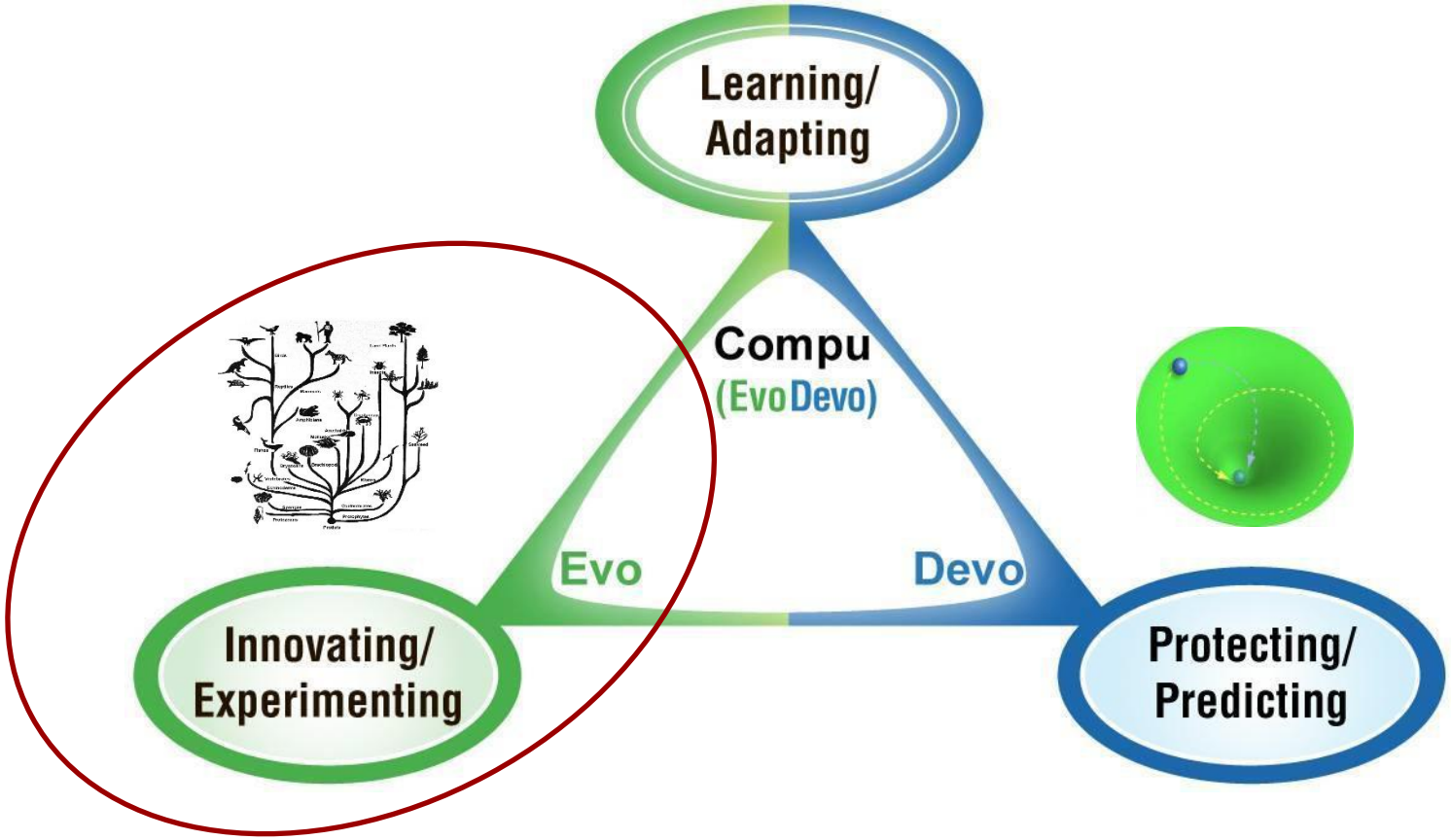
ILP Model: Innovation, Learning, and Protecting: Three Basic Leadership Challenges



Any system can be analyzed as either:

1. A **Learning ("Adaptive") System**
2. A **Innovating and Protecting ("Sustainable Innovation") System**
3. An **Innovating, Learning and Protecting ("ILP") System**

Evo Devo Universe?, Smart, 2008, p. 10

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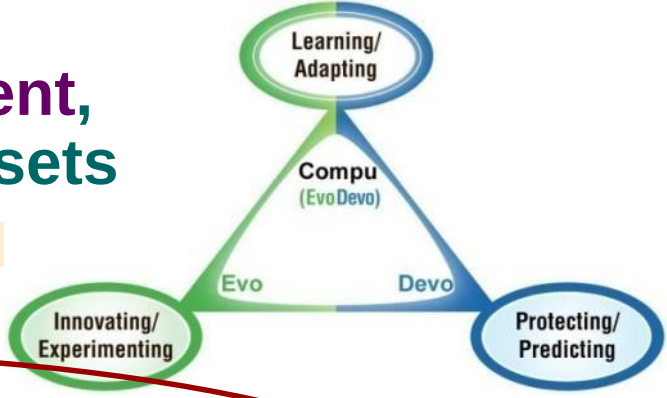
IMF Model: Innovation, Management, Foresight: Three Leadership Toolsets



INCUBATION
COMMERCIALIZATION
COST REDUCTION
SEED FUNDING
I.P.
COMPETITION
INNOVATION
FREEDOM
PLATFORMS
CREATIVITY
INCENTIVES
OUTSOURCING
CROWDSOURCING
R&D
DESIGN
& ENTREPRENEURSHIP
VENTURE CAPITAL
IDEATION
DIFFUSION
COMPETITIVE INTELLIGENCE
END USER INNOVATION

QUALITY IMPROVEMENT
H.R.
BRAND
MARKETING
BUSINESS INTELLIGENCE
ACCOUNTING
FINANCE
BENCHMARKING
REAL OPTIONS
ECONOMICS
COMPLIANCE
PLANNING
MANAGEMENT
EFFICIENCY
RESILIENCE
SOCIAL RESPONSIBILITY
& STRATEGY
GOVERNANCE
METRICS
ETHICS
SCALE
PERFORMANCE
ANALYTICS
BUSINESS MODEL

RISK MANAGEMENT
DELPHI GROUPS
SCENARIOS
ROADMAPPING
BLACK SWANS
VISIONING
HORIZON SCANNING
MODELS
TRENDSPOTTING
INVESTING
TECHNICAL INTELLIGENCE
LEARNING CURVES
CYCLES
SYSTEM CURVES
MINIATURIZATION
VIRTUALIZATION
BEHAVIORAL ANALYSIS
FORESIGHT
FORECASTING
& SECURITY
PREDICTION MARKETS
DEMOGRAPHICS

Emerging Tech MS Curriculum Framework, U. of Advancing Technology, Smart, 2011.

Nine Drivers Model:
Leadership Priorities Under Accelerating Change

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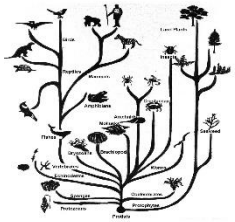
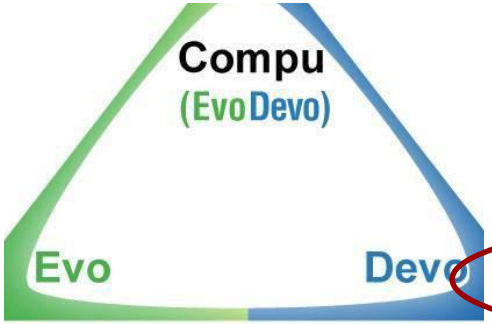
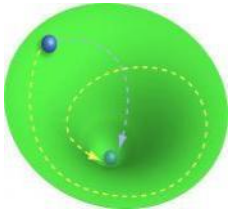
1. Intelligence, Virtualization, & Substitution
2. Social-Political Civics, Ethics, Norms, and Rules/Laws
3. Governance & Management







1. Information, Communication, & Specialization
2. Entrepreneurship & Freedom
3. Experimentation & Innovation

1. Miniaturization, Densification, & Efficiency
2. Security & Sustainability
3. Planning & Foresight

Evo Devo Universe?, Smart, 2008.

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Developmental Foresight

What Can We Anticipate?

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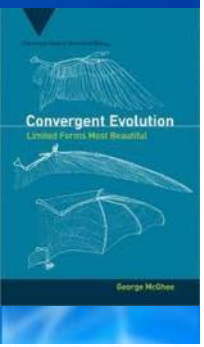
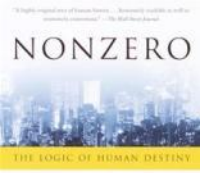
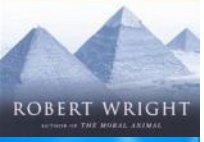
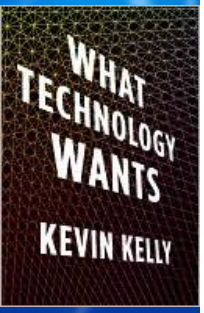
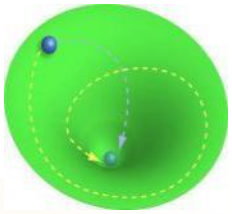








Funnels (Developmental Attractors)
Are the Fewest, and Hardest to See



In Chemistry:

- **Carbon ("organic") chemistry** (vs. silicon, boron, etc.) for life
- **Amino acids, purines, pyrimidines, pre-lipids** as cell precursors
- **RNA** as enzyme and code for protein architectures

In Biology:

- **Universal pattern modules** in multicellularity
- **Antifreeze molecules** in northern and southern polar fish
- **Eyes**, **body plans**, **limbs**, **joints**, **wings**, **fins**, **emotions**
- **Bilateral symmetry**, **binocular vision**, **tetrapod form**
- Placental vs. marsupial **mice, moles, rabbits, wolves, tigers,** etc.
- **Prehensile limbs**, **opposable thumbs**, **anthropoids**

In Society ("TINA Trends"):

- **Mimicry memetics (languages)** behavioral → gestural → oral → written
- **Moral codes, property, capitalism, rights, democracy, conflict control**

In Technology:

- **Neolithic tools** (**rock, club, spear**). Later: **lever, rope, wheel, pulley**
- **Metallurgy**, **chemistry**, **electronics**, **internal combustion engines**,
- **Math, science, computers, internet, cell phones… Next?**

Convergent Evolution, 2011; *Nonzero*, 2001; *What Technology Wants*, 2010

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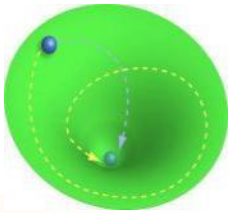
TINA Trends:
Irreversible Social, Political, and Tech Trends

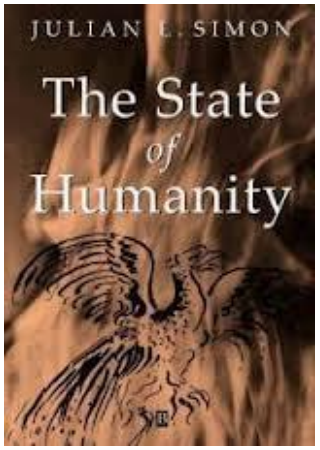


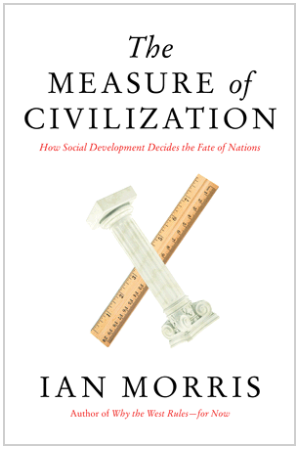
Pierre Wack, Shell Scenarios Group, 1970's:

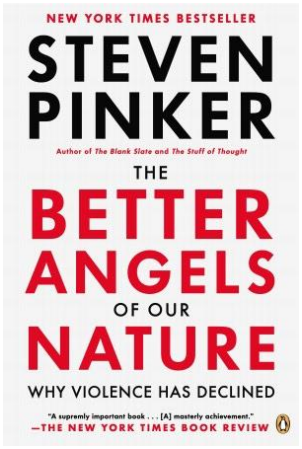
TINA = "There Is No Alternative"
(to the Trend Advancing, On Average)

Examples To Test:

- **Increasing Democratization, Global Interdependence**
- **Increasing Central Govt Rights/Powers vs. Indiv.**
- **Increasing Indiv. Rights (Women, Child, Relig, Minority, Gay)**
- **Increasing Total Information, Comp., Communication, Specialization**
- **Increasing Total Wealth, Social Safety Nets, Liesure Time**
- **Increasing National Energy Use/Capita (Saturating Indiv. Use/Capita)**
- **Decreasing Violence (Incr. Reg. of Violence and War Capacity)**







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Ten Areas of Technological Change

1. **Information Tech**
2. **Nanoscience and Nanotech**
3. **Resource** Tech
4. **Engineering** Tech
5. **Health** Tech
6. **Social** Tech
7. **Cognitive** Tech
8. **Economic** Tech
9. **Political** Tech
10. **Security** Tech

See Read Ahead for details.

LE Drones (Phantom Eye, Scan Eagle)
Disruptive Naval ISR Platforms

Unmanned Surface Vehicle (Piranha)
Naval ISR, Escort, Antipiracy Platform

Leadership of Technological Change (and 30 Books For Further Reading), Smart, 2012

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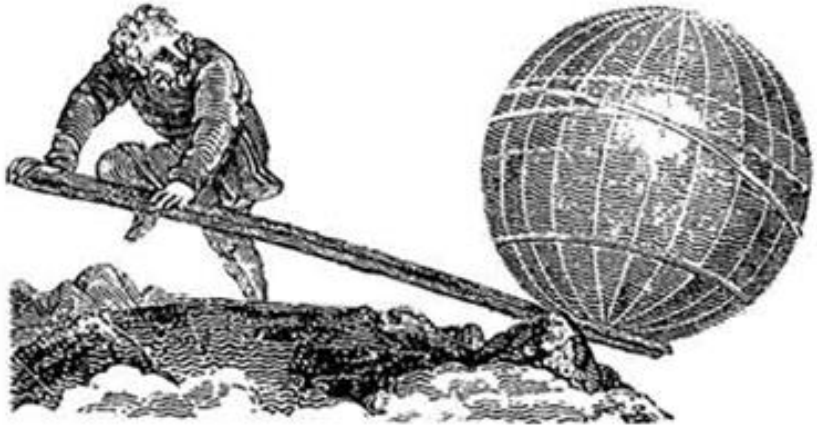
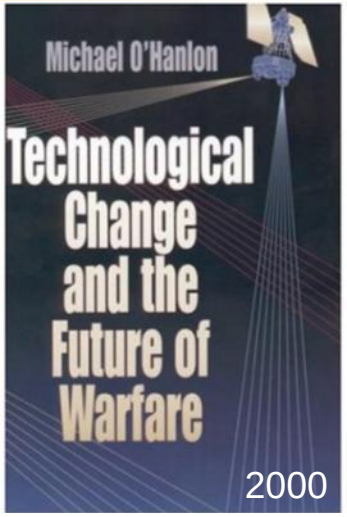
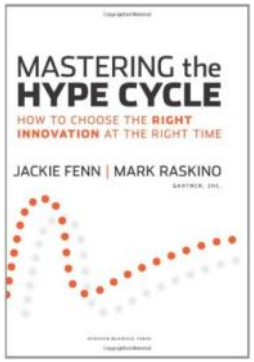
Leaders Must Use the Strongest Levers: Infotech and Nanotech



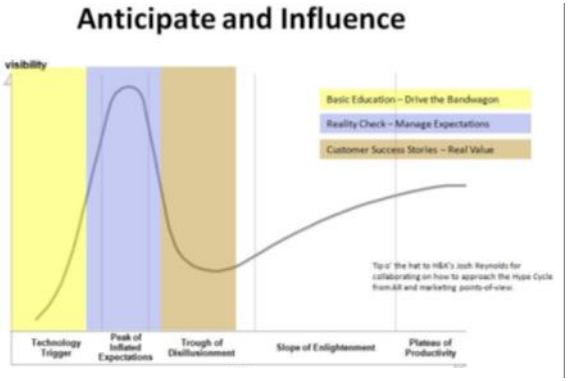
"Give me a lever long enough, a fulcrum, and place to stand and I will move the world."
- Archimedes, 250 BCE



"Only ICT (and Nano) are truly driving the RMA. The rest is always oversold."



Fenn&Raskino, 2008



Gartner Hype Cycle

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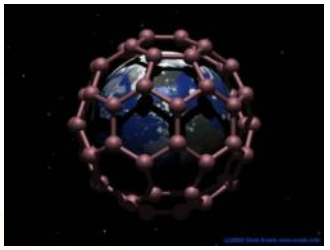
A "Race to Inner Space:" The Steering and Engine of Accelerating Change



Infotech/Simulation - *Virtual* Inner Space – "Steering System"

- **"As Intelligence Rises, Thinking Becomes More Adaptive Than Acting"**
- Adult humans no longer act in novel ways, they think in novel ways.
- Simulations allow "ephemeralization" (far less mass/energy per action)
- Rise of scientific simulations. NSF. IPCC. NASA Solar System Simulator
- Telepresence, telerobotics/haptics outcompetes traveling in person
- Google maps, sensors, geoweb, parallelized GPUs: visual cortex for the web.
- **Machine sim data doubles every 2 years. Human sims grow far slower.**

Nanoscience/Nanotech - *Physical* Inner Space – "Engine"

- **"There's Plenty of Performance at the Bottom."**
- Photonic crystal lasers 10^6 more E efficient than other microlasers
- Programmable synapses 10^6 faster, 10^3 less E/comp. than neurons
- Fission 1,000X more E/mass than chem. Fusion 1,000X more E than fission
- Fuel cells allow 100,000X more E/mass than chem. batteries (Dan Nocera)
- Synthetic catalysts increase reaction speeds and yields 10^3 to 10^6
- **Single step efficiency jumps in macro (human) space are always far less.**

Info: *Intelligence*, Fischler, 1987; *Simulation*, Ross, 2006; *Simulation-Based Engineering Science*, NSF, 2006.
Nano: *Engines of Creation*, Drexler, 1987; *Nanotechnology*, Ratner, 2002; *The Race to Inner Space*, Smart, 2012.

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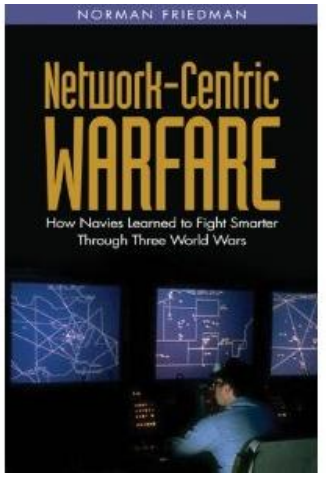
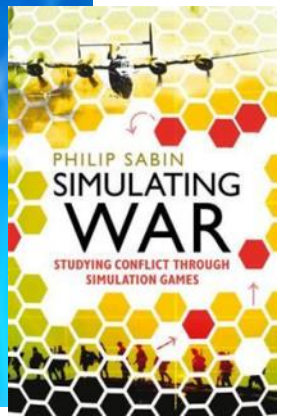
Security Technologies

- **ISR, Reciprocal Transparency, Collective Intelligence**
- **Immunity, Decentralization, and Resilience**
- **Physical Security, Stability, and Openness**
- **Cybersecurity and Simulations**
- **Machine Ethics and Autonomy**



Friedman, 2009
Shared Near-Realtime Picture
Navy does this very well.



Sabin, 2012
Global security games:
The future of defense

Cybersecurity
and Simulations

"Top Down" vs "Bottom Up" Transparency

Navy Issues:

Surveillance vs. Sousveillance. Centralized vs. Decentralized. Network-Centric, Map-Centric Security. Mothership vs. Swarm Networks, Tech Alliances, Tech Transfer. Counternarcotics. Piracy. Trafficking. Counterinsurgency. Failed States.

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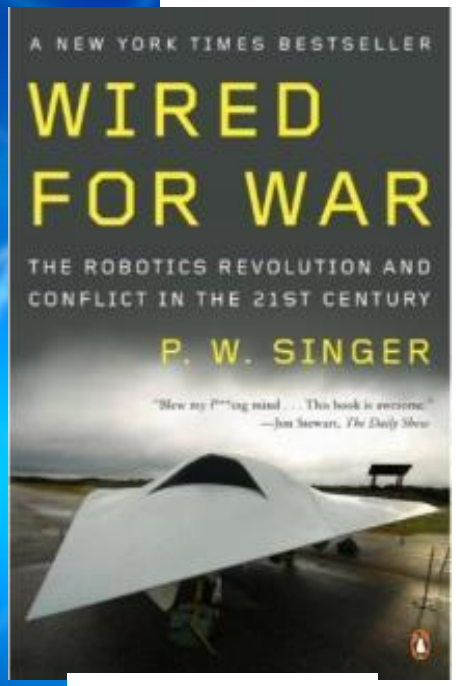
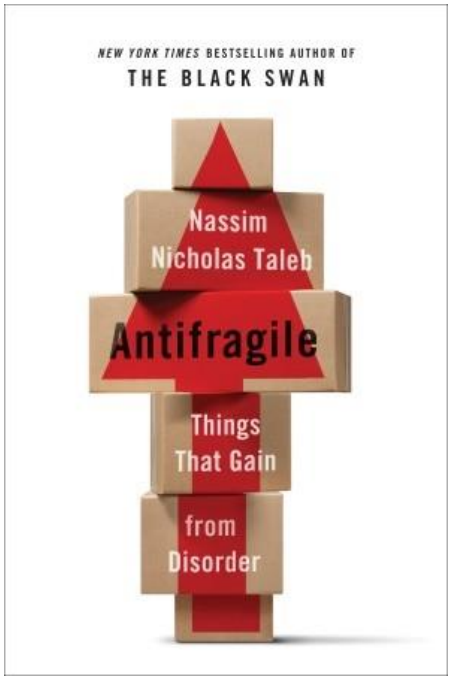
ISR, Automation, and Proportionate Response Are Keys to Healthy Immunity (Antifragility)



Singer, 2009

Thesis: ISR, Robotics/Automation, and PrecisionStrike and Defense are driving our current RMA:

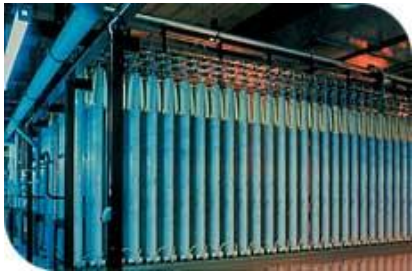
1. ICT Sensors, Nets, Sensemaking
2. Drone-aided Persistent ISR
3. Drone-aided Logistics
4. Precision Strike
5. Precision Defense
   (Active Protection Systems)



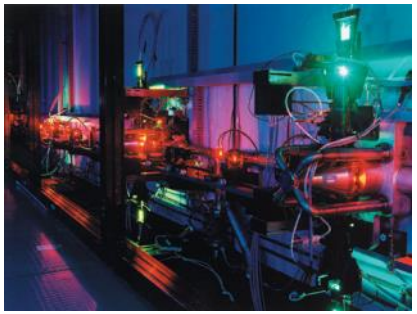
Taleb, 2012

Uranium^{235} Laser Enrichment: A Future Threat to Global Security

Gaseous Diffusion – 1940's-1970's
100's of acres, 1000's of people, man-years,
Enormous quantities of energy.



Ultracentrifuges – 1980's-2000's
Acres of land, hundreds of people, man-months,
50X less energy per mass of refined U^{235}
A.Q. Khan stole and proliferated this tech globally.



Laser Isotope Separation – 2010's-?
MLIS to AVLIS to SILEX, Australia, 2006.
75% less space, pipe to seawater, man-months,
"Considerably" less E than ultracent. Classified.
NRC OK's GE-Hitachi-Cameco plant for N. Carolina (Sep 2012).

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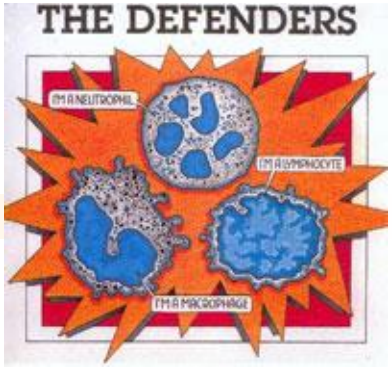
A Global Immune System Must Protect Privacy and End Anonymity



Minority Report, 2002

- A healthy living system is:
  - **Transparent** to a trusted immune system
  - **Compartmentalized** to everyone else.
- **No place** your immune cells can't go
- **Likewise, in late 21C society privacy, compartments, and secrets will abound, yet all comms and actors must, by then, be near fully immune-transparent.**
- **The alternative just doesn't work.**
- And since **information can asymmetrically protect itself** (it is always far easier to encrypt than decrypt):
  - All encryption must be breakable by trusted actors, w/ due process.
  - Good packet monitoring, channel sampling to find illicit activities.

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"Reciprocal Transparency" is a Positive-Sum, Win-Win Strategy in Modern Democracies

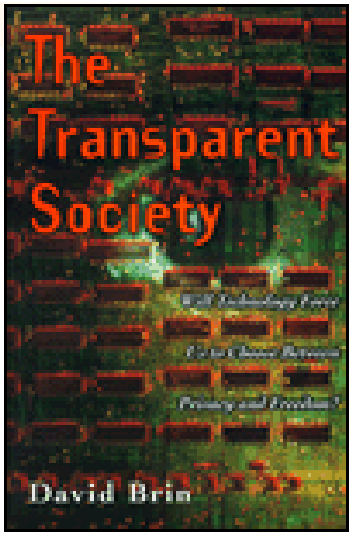
Surveillance (5% top-down tracking) vs.

Souveillance (95% bottom-up tracking)

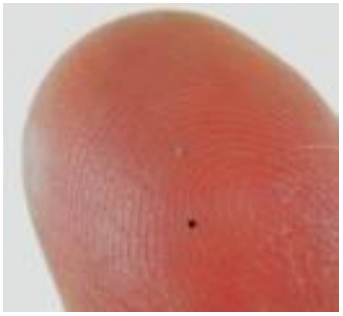
Ex: Lower Manhattan Security Initiative (2008):
- 3,000 new sec. cameras, 2/3 in private hands.

Ex: Cameras on Cops and in Cruisers (2003+)
- Sometimes at behest of officers (backup)
- Sometimes citizen initiatives (civil rights)

Moving to a '**Panopticon**', **all-watching-all, in public spaces**.



Brin, 1998



Hitachi's mu-chip: RFID for paper currency (2003)
Tracking illicit economies.

Google Glass

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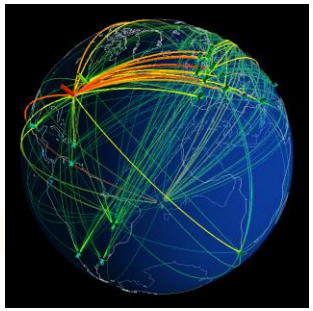
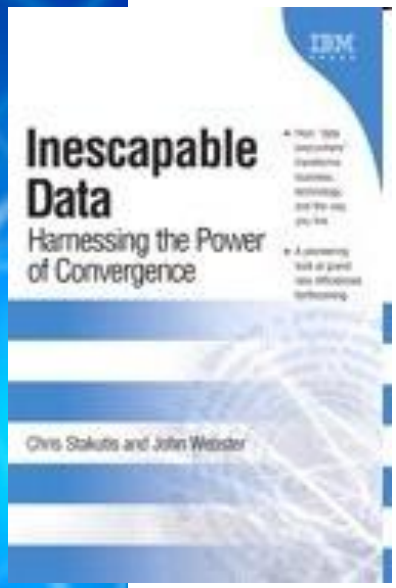
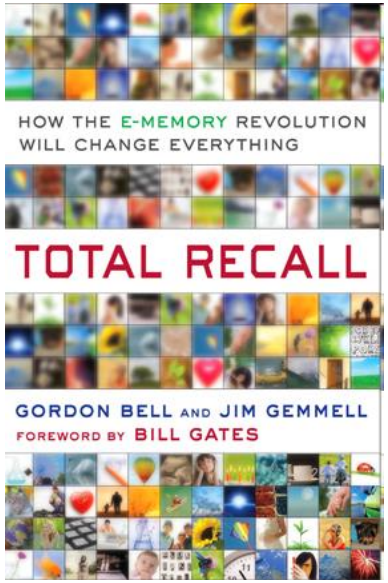
Global Digital Transparency: Result of a Networked Planet



Gmail (2004) preserves every email we've ever typed. Gmailers are **all bloggers who don't know it.**



Lifelogs, like Google Glass (2013) are systems for **auto-recording, archiving indexing, and searching our life experience, as it happens.**



Some of us will store everything we've ever **said**. Next, **seen**. This makes us all **networkable** in ways we never dreamed. Add **NLP**, **collaborative filtering**, and early **AI** to this, and all this **data** begins turning into **collective intelligence**.

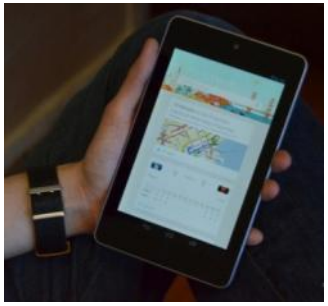
Your Digital Self – Circa 2020: Conversational Interface & Virtual Assistant

IBM Watson Jeopardy Challenge Feb 2011

Vlingo (Nuance) Virtual Assistant InCar Beta, Dec 2010

SpeakToIt Virtual Assistant, Feb 2012

Apple's Siri on iPhone 4S, May 2012



Google Now on Nexus 7, Jul 2012

Within 5 years the best systems will:

- **Read your lips & facial expressions**
- **Read the emotion in your voice**
- **Have a crude map of your interests**

The Conversational Interface: Our Next Great Leap Forward, John Smart, AccelerationWatch.com, 2003.

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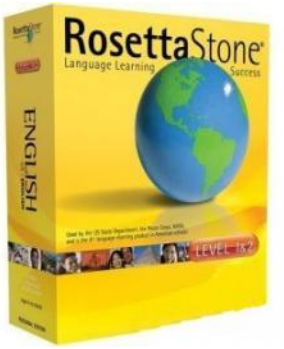
Global English – Circa 2020: Teacherless Education and the Wearable Web



$500

Open Learning and Teacherless Education: Coming soon to the Wearable Web!

- There are just **1.8 billion** English speakers today. **2 billion more kids** by 2040.
- How soon until **a free Global English** is more effective than Rosetta Stone?
- How soon till we have **one billion new English speakers** in the global workforce?
- 7B will use automatic lang translation. But **1B will learn English from the web**, as kids.
- Contextual, visual, conversational learning. Adaptive testing. Computer-rated skills.
- Open learning of all types will be **ranked by skill on LinkedIn**, other job networks.
- Your email, social networks, learning platforms will **build a statistical map of… you.**

One Tablet-Laptop Per Child
Asus Transformer Prime 2012

'Wrist PC' concept
Metaverse Roadmap, 2007

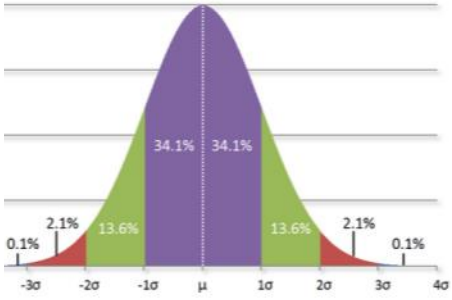
Google Now on Glass
Dev: Mar 2013

Free Courses,
Machine Learning Core

Group Behavior – Circa 2020: Symbiont Networks

When we have *affordable broadband*, we can expect:

- Symbionts – ~150 (Dunbar number) of our kid's most *cognitively diverse* friends telenetworked, *nearly 24/7*.
- A reputation and reciprocity system that keeps everyone contributing to the group (no free riders). Symbionts will *greatly outperform* unconnected individuals. 150 "lifelines" avail. for any situation.
- A powerful new platform for *learning* (educ.), *behavior modification* (juveniles, criminals, mentally ill) and *performance enhancement* (career).
  - *~1% of US society is in prison.* They should be *in* ***parole rehab. symbionts****.*
  - *~1% have major mental illness* (BPD II, schizophrenia). They should be *in* ***mental health rehab. symbionts****.*
- Major new subcultural diversity.



Why Symbionts Will Help Criminals and the Mentally Ill:
There are *50X More Normals* than Those Who Need Help.

Scott Page, *The Difference: How Cognitive Diversity Creates Better Groups, Firms, Schools, Societies*, Princeton, 2008.

Leadership Strategies

Innovation, Management, Foresight

Technology is Becoming Biological

Leader's Challenge:

Enabling Staff to do *Bottom-Up* Ideation, Intelligence, and Innovation.

***Theory:* Imagine More Bio-Inspired Machines**

***Training:* Know Your Current Platforms (ScanEagle)**

***Data Points:* Autonomous RC planes, Fowler flaps, bird behavior.**

Question: What would **landing like a bird** do for **small Naval UAVs**?

- How **feasible** is this? What are **TRLs** for gating tech?
- How to **quantify benefits vs. other real options**?
- Who can best **support** a study? Prototype?
- Who has the best **R&D competency** for this?
- How/where to best do **procurement** for this?

Quadcopters and Superior Urban OODA
Israel-Lebanon 2006
Need: Battery Depot Robotics

Boeing ScanEagle
Naval ISR Platform

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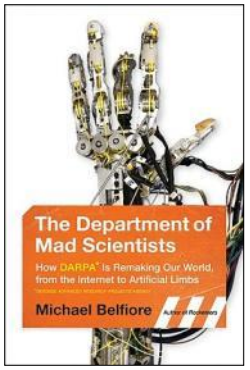
DARPA and Google: Client-Centric, Network-Centric Models for Tech Innovation and Intelligence

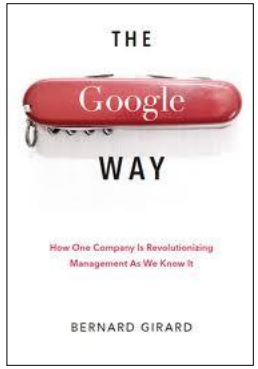
DARPA

- Orientation to Radical Innovation
- Decent Technical Intelligence
- Autonomy and Freedom
- Acceptance and Review of Failure
- Small and Flexible Units
- Flat (3 level) Organization
- Constant Talent Rotation (4-6 yr terms)



Google adds..

- Measurement Culture
- Feedback/Learning Culture
- Analysis/Intelligence Culture
- Client (End-User) Orientation
- Automation Orientation
- Network/Platform-Centric (Tools first)



Google's R&D budget is $6B for 2012, DARPA's is $3B.
Top 20 IT firms R&D budget >$30B. "It's a COTS World."

Knowledge Bases, Ideation, and Innovation Platforms Now *Critical*

Problem-Solving Marketplaces

http://usnwc.libguides.com

Popular Guides: RMA, Cyberwarfare, LOAC

intellipedia

Started in 2005.
3 clearance levels.

spigit

BRIGHTIDEA
THE POWER OF INNOVATION

Benefit-Cost Analysis to Relatively Rank Ideas

Those submitting ideas need:

1. **Leadership by Example**
2. ***Manager* Support** and **Incentive** (Institutional support can be nonexistent!)
3. **Facilitated Exercises, "Innovation Games,"** equivalent of Wargames.
4. **Benefit-Cost Analysis** at the end. Innovation is 95% bottom up.

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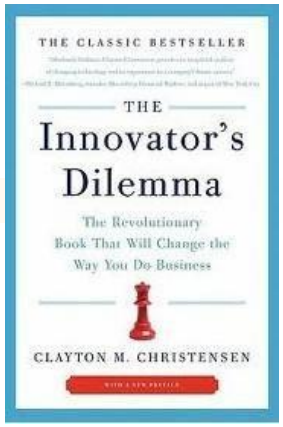
Innovation:
Procurement Strategies

Unpopular Truths:

- **Small firms** are much more **Innovative** than large firms.
- **DoD Acquisitions Programs** have been going **backwards** in **Speed to Capability** since 1950's.
- **Tech companies** and **asymmetric actors** have made **exponential gains** in Speed to Capability at same time.

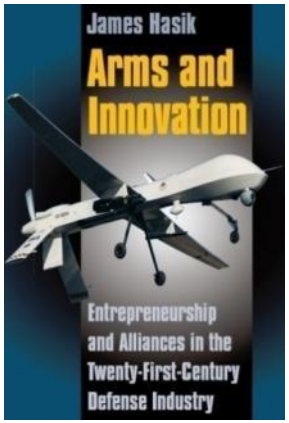


Small firms innovate best.

Lessons:

- **"Speed to Capability"** is the critical performance measure for all DoD procurement programs. Lower must die.
- Procurement must include **diversity** (small firms).
- Diversity needs **periodic culling** or it gets wasteful.
- DARPA, ONR, SPAWAR, NAVAIR, NAVSEA, etc. need their own competitions and innovation platforms.

Example: Predator MQ-1. First prototype developed on DARPA contract (1984) by Leading Systems Inc., Abraham Karen, Israeli Air Force chief designer and US immigrant. LSI went bankrupt 1990, bought by Gen. Atomics. LSI did all primary innov. Common story.



Just as true in the defense industry.

We Won't Get What We Don't Measure, Marv Langston, Former US Deputy Asst. Sec. of Defense, Dec 2012.

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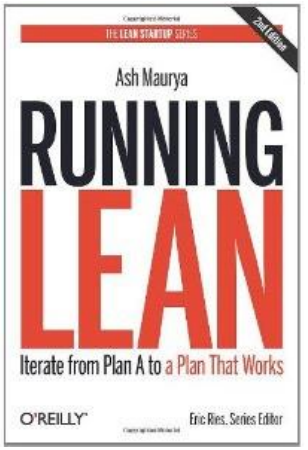
How Do You Build Your Best Small, Expert Teams? How Do You Keep Your Suppliers Competitive?

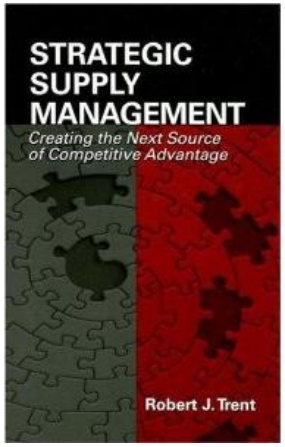


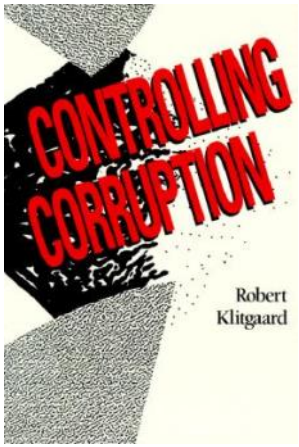
Small Teams can:

-- Rapidly innovate and adapt
-- Operate below the radar (stealth)
-- Have superior urgency and purpose
-- Ignore convention and pursue vision
-- Get hand-picked excellence and resources
-- Be expendable, experimental, exploratory

Supply Management Excellence:

-- Learn from Industry Benchmarks
-- Large and Small Suppliers
-- Suppliers Deliver Overlapping Functions
-- Performance-Based Budgets
-- End-Client Feedback Drives Metrics
-- Balance Supplier Pruning and Redundancy





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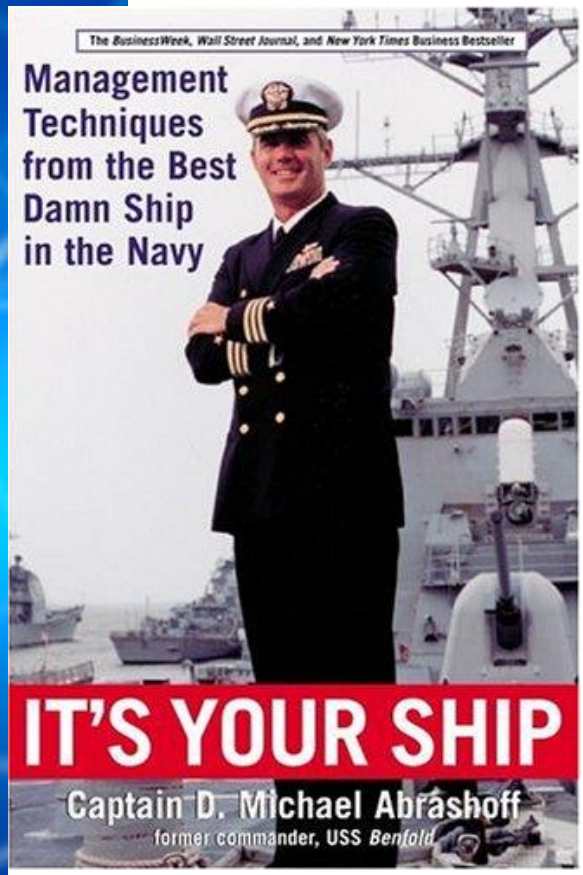
Management for Innovation: Visionary/Personality-Driven Style

"See the Ship Through the Eyes of Crew (Bottom-Up); Build Tools; Focus on Purpose; Communicate Constantly; Listen Aggressively"



Abrashoff, 2002, 200 pp.

USS Benfold Innovations (1997-1999):

- Exit interviews for all crew, Top Five Complaints DB
- Incoming interviews of all crew, New Ideas DB
- NewTalent and Training DB
- Gulf Ship Boarding DB
- After Action Reviews – Critiques from All Ranks
- Junior Officers Supervising Readiness Training
- SAT, Math, Eng, Navy Advancement Test Training
- Mentor-Based Disciplinary Rehabilitation
- Less Training w/ Hi Readiness Scores (Freedom)
- Better Shore Leave Incentives (Freedom)
- Better Food and Gear
- Crew-Created Fun (Movie Nights, Zodiac Races)

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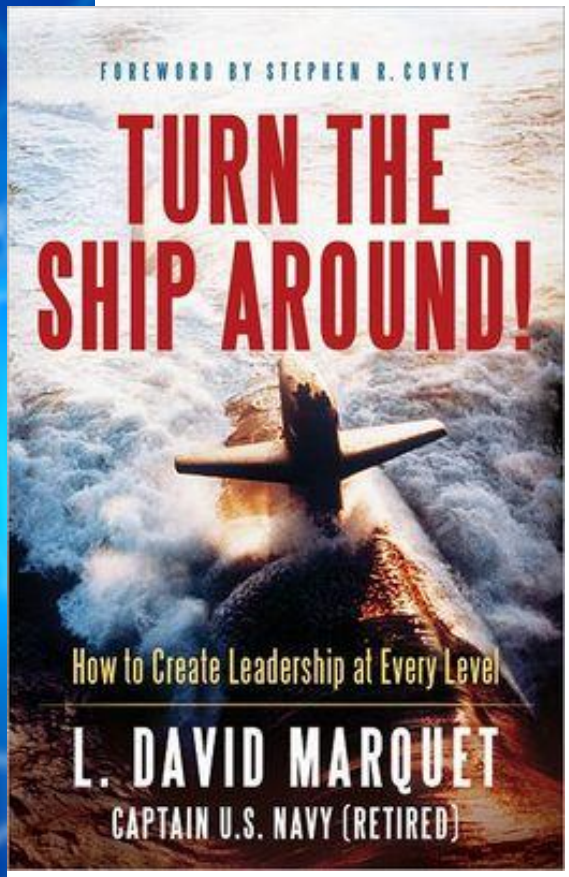
Management for Innovation: Servant Leader/Leader-Leader Style

"Give Away Control; Keep Responsibility; Create Self-Leaders"
"95% of Leadership is Bottom-Up"



Marquet, 2012, 217 pp.

USS Santa Fe Innovations (1999-2001):

- From Fleet Worst to First in:
  - Operational Performance
  - Sailor and Officer Retention
- Pushed decisionmaking (leaves, schedules, performance) down to Chiefs ("Chiefs in Charge")
- Eliminated top-down monitoring. Sought 20:1 ratio of bottom-up to top-down monitoring.
- Early, informal conversations ("Think out loud").
- Proactive conversations: "I Intend to…"
- Goal to minimize officer response to: "Very Well."
- Officers require their team to provide inputs.
- Reward creative solutions, rewrite the rules.

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Leading the Mgmt. of Accelerating Change: Unit and Project Reporting Priorities

Identify your current rate-limiting resources:

Personnel, Finances, Physical Assets, Risk Mgmt, Tech, Culture/Freedom, Incentives, Training, Community Partners…

What strategies will get best cost- or speed-to-capability incr. in resource Density, Efficiency, Virtualization, and Substitution?

1. Densification and Miniaturization
- How do I get denser and more ubiquitous communications networks?
- What can I learn from the biggest and densest (cities, orgs, depts) in my domain?
- What resources could use more densification or miniaturization? Faster access?

2. Efficiency (Learning Curves)
- What are our critical learning curves? Efficiency/Innovation thresholds?
- How do we get to scale in production (new applications, partnership, procurement process), and share our learning better, to ride faster down our learning curves?

3. Virtualization (Simulation)
- What can be automated or simulated? Where can information replace doing things?
- Can I get more and better virtual meetings? Better predictive security?

4. Substitution (People for Other People, Machines for People)
- Will upgrading, offshoring, temping, or privatizing grow resource density/efficiency?
- Where can computers or other people, do key jobs better, faster, smarter, cheaper?
- Do my managers identify and substitute those best at critical tasks?

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Innovation:
Million Veteran Program

Goal: Collect anonymous genetic, exposure, lifestyle and health data from **one million people with diseases**, over 5 years (2012+).
The MVP turns veterans into **early adopters** of genetic clinical research.

Trend Opp: Falling sequencing costs. Coup for DVA's innovation brand.

Q: What is the Navy equivalent?

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A Navy Brand Vision: "Open, Safe, Lawful, and Sustainable Seas, For All."

Vision: "Open Oceans" public GIS platform and Google Earth layer.

A Publicly-Endorsed, Navy-Run Sensor Grid and GIS platform.

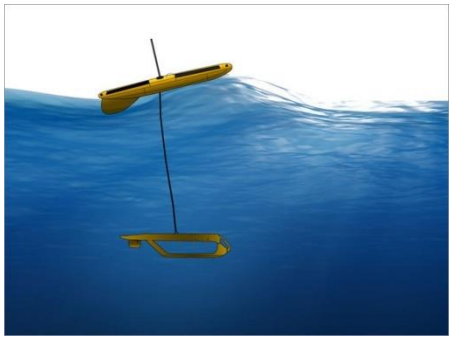
Sensors on partner coasts, commercial ships, offshore platforms, free-floating constellations. Fed with Navy, Intel, Global Partner and public data. Public and classified (open to security partners) versions.

Open
- Shipping and Defense Access Maps and Agreements

Safe
- Piracy Maps, Trafficking Maps, Humanitarian Relief Maps

Lawful
- Alliances and International Agreement Maps
- Disputed Territories and Disagreement Maps

Sustainable
- Fishing Maps/Sustainable Fishing Agreements
- Resource Maps/Sustainable Resource Agreements
- Pollution Maps/Remediation Agreements



Wave Glider: Wave-Powered UMV and Sensor Platform.

Analogy: Policing was once just:
1. Law Enforcement & Investigation

Then it also became:
2. Crime Prevention & Prediction
3. Public Safety & Homeland Security
4. Community Service

Developmental Futures:

Get **In Front** of the Parade, or Get **Driven into It** as it Grows – Our Choice.

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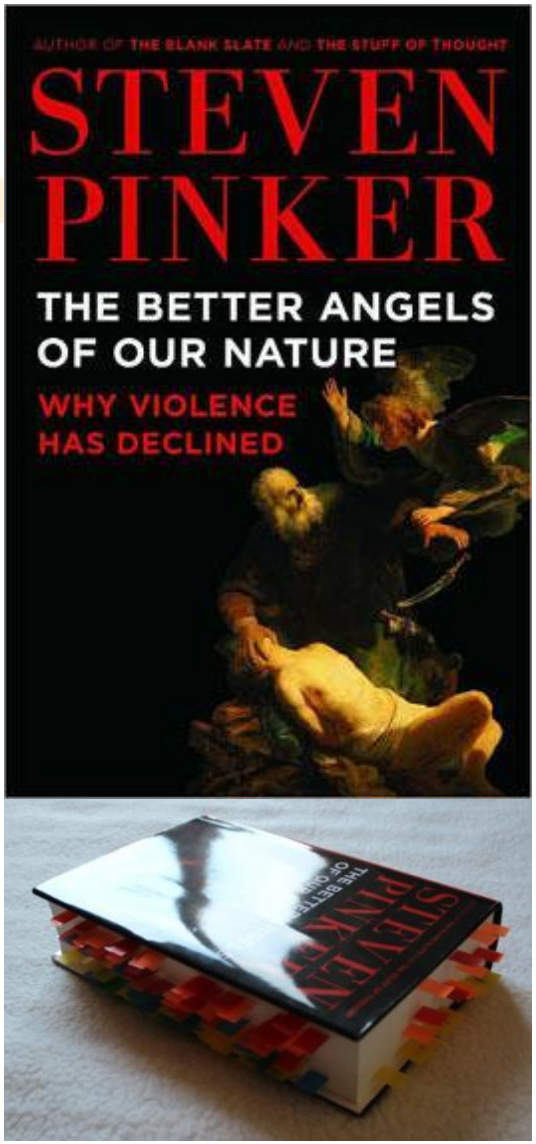
Declining Global Violence: A Most Interesting Trend

As the **social contract** improves, we're seeing a global populace with measurably greater:

- **Sci-Tech-orientation**
- **Progress-orientation**
- **Future-orientation**
- **Sustainability-orientation**
- **Truth and Justice-orientation**
- **Community-orientation**

Defense leadership can **measure and take reasonable credit for this developmental trend,** as it unfolds.



Pinker, 2011
Most Interesting Book Of The Decade

Technology Foresight and Forecasting

Key Elements

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Technology Forecasting: Key Elements and Best-In Class Examples

- **History, Bias & Deception.**
  Past Prediction-, Ontol-, Bias-Analysis., Cog. Div., Truth Incentives (Reference Class Forecasting)
- **Forecasting.**
  Analogy, Curves, TINA Trends, Cross-Impact, Morph. Anal., Relev. Trees. (Growth Theory, Good Judgment Project)
- **Intel, Sensemaking, & Foresight.**
  System & Human Intel, Scenarios, Arg. Maps, Delphi, Prediction Mkts (RAHS, Palantir, Recorded Future, Quid)
- **Decision Analysis.**
  Risk/Threat, Benefit Cost, Opportunity Assessment (Benefit-Cost Analysis, Real Options)
- **Strategic Planning.**
  Credibility, Stakeholders, Champions, Communication, Feedback/Iteration. (Roadmapping, Agile Planning)

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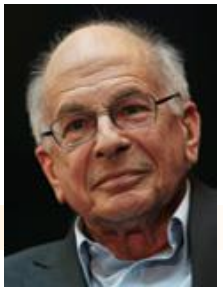
Reference Class Forecasting


Kahneman

Flyvbjerg

For any Big Forecasting Project:

- **Form a Reference Class** (Find Past Outcomes of a Type**)**
- **Get a Probability Distribution for the Reference Class**
- **Develop the Inside View** (Project Team's Forecast)
- **Adjust Inside View against Reference Class.**
- **Look for Bias or Deception Causing any Difference**
- **Bias Drops and Deception Grows as Cost and Pressure Increase**

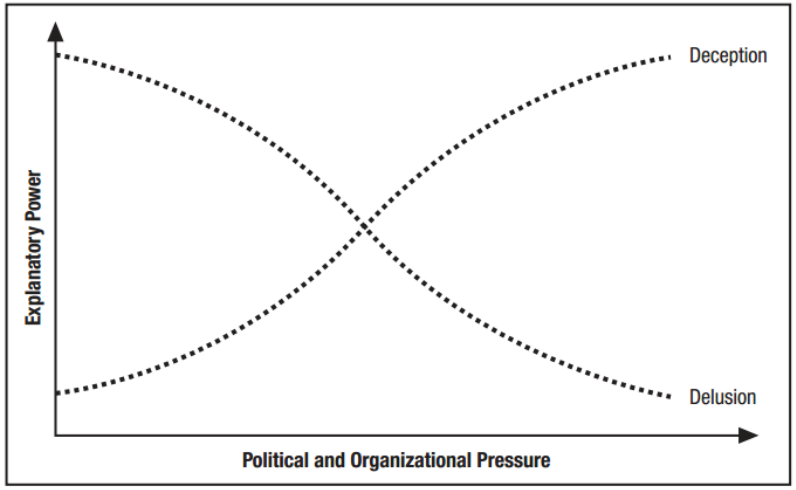


Figure 1: Explanatory power of optimism bias and strategic misrepresentation, respectively, in accounting for forecasting inaccuracy as function of political and organizational pressure

From Nobel Prize to Project Management: Getting Risks Right, Bern Flyvbjerg, *Proj, Mgmt J*, Aug 2006.

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Diagnosing and Countering Bias and Deception on Your Teams

- **Adversarial** Bias (Paid Experts)
- **Attentional** Bias (Selective Attention)
- **Audience** Bias (Marketable, Sensational Info)
- **Congruence and Confirmation** Bias (Self-Fulfilling)
- **Optimism** Bias (Costs/Risks are Discounted)
- **Overconfidence** Bias (Certainty over Uncertainty)
- **Negativity** Bias (Opportunities/Benefits are Discounted)
- **Recall/Priming** Bias (Selective Recall)
- **Response** Bias (Leading Opinion/Influence)
- **Safety/Conservatism** Bias (Fear of Failure/Criticism)
- **Omission** Bias (Harmful Action "Worse" than Do-Nothing)
- **Selection/Sampling** Bias (Echo Chamber)

Which are key org. pitfalls in your past forecasts?
Need to diagnose systemic B&D. Design solutions.

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Good Judgment Project

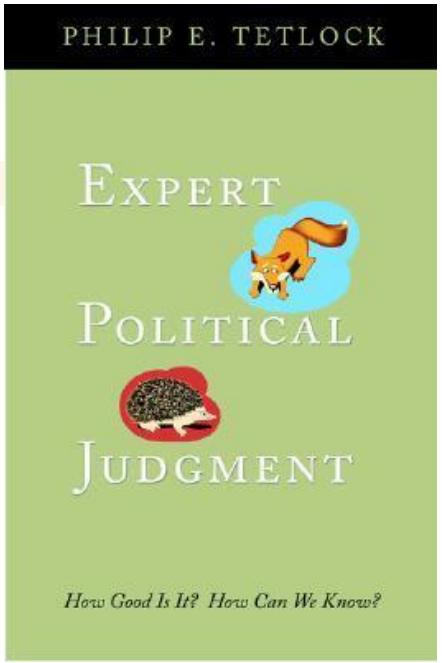
Philip Tetlock, UC Berkeley, U Penn, IARPA.

Started with 3,000 forecasters Year 1 (2011).

Second year, took top 60 performers and randomly assigned them into five teams of 12 each.

These “super forecasters” also delivered a far-above-average performance in Year 2.

Apparently, forecasting skill cannot only be taught, it can be replicated



Tetlock, 2006

The Good Judgment Project

http://www.nytimes.com/2013/03/22/opinion/brooks-forecasting-fox.html

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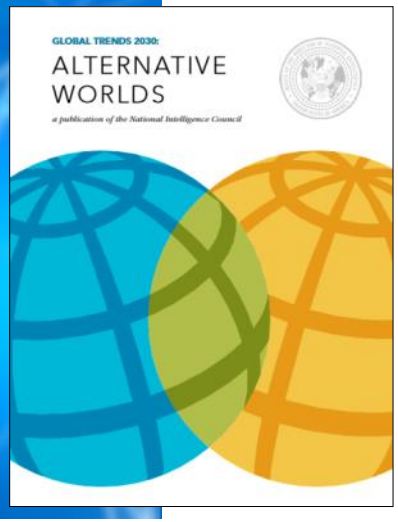
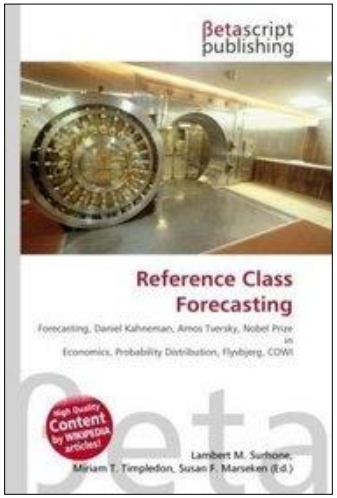
We are Good at Prediction, and Will Get Even Better Leaders Need to Do It More

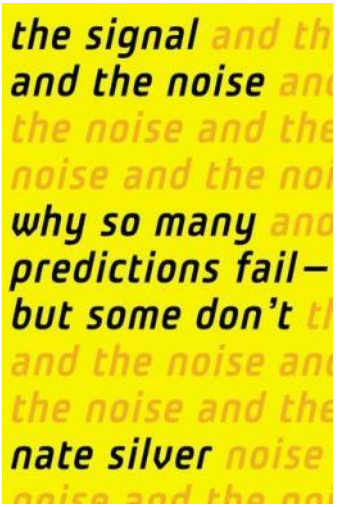
After convincing ourselves that *developmental futures are predictable*,
our next prediction problems are *deception*, *bias* and *understanding probability*.
Quantitative models help, but numeracy is no guarantee of accuracy.
We are biased to value confidence over uncertainty.
We need less confidence and more uncertainty for greater accuracy.



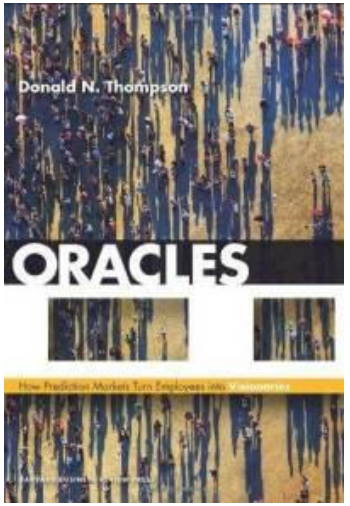
National Intell. Council, 2012
"We do not seek to predict the future – which would be an impossible feat."
Wrong!



Kahneman & Tversky, 2010
Forecasting Bias



Silver, 2012
Forecasting Uncertainty



Thompson, 2012
Prediction Platforms

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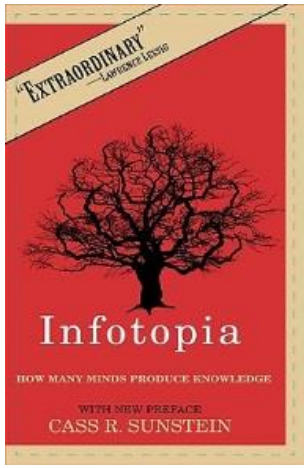
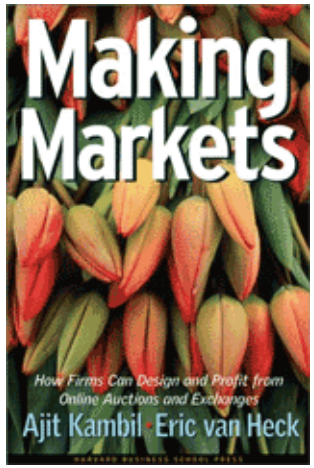
Prediction/Decision Markets

- Smart aggregation of opinions is the new frontier for prediction/ innovation/ decisionmaking. Google saw hidden opinion order in an apparently chaotic net. PageRank captured that order, created better search.
- Reduces bias. Michael Jensen, "Forecasting is paying people to lie."





Sample Internal Markets:

Eli Lilly. Drug efficacy and market size.
Siemens. Software project length.
Google. Over 200 markets (experimental)
Microsoft. Software development.

Requirements:

1. **Cognitive Diversity (for "Hard" Problems)**
2. **Freedom/Independence (Honesty)**
3. **Incentives**
4. **Aggregation Tools (still primitive)**

Real Money Markets:

intrade The Prediction Market

betfair

Reputation Points Markets:

HOLLYWOOD STOCK EXCHANGE

newsfutures PREDICTION MARKETS

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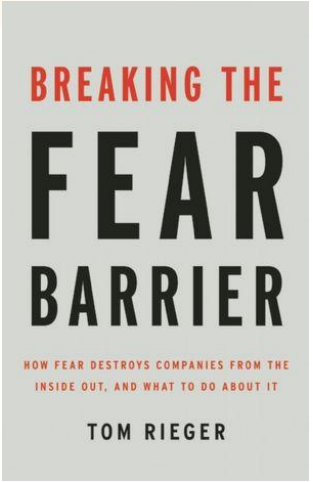
Defense Culture Bias Example: Safety/Conservatism (Fear of Failure/Criticism)

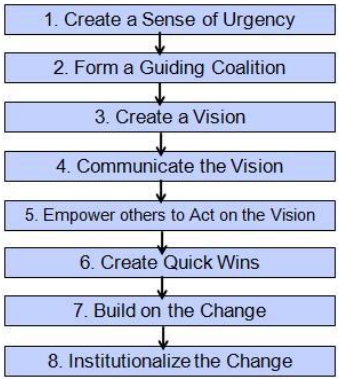
First, Diagnose It in Staff:

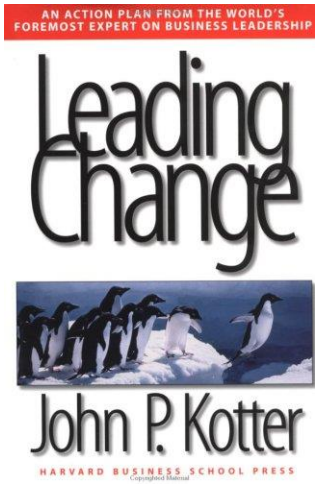
- *Breaking Fear Barrier,* Reiger, Gallup



If You Find It, Need Change Mgmt:

- Find Fearless Senior Champions
- Workshops/Retreats to Initiate Change
- Create Support Groups ("12 Step")
- Performance mgmt sys must regularly reassess for evidence of regression:





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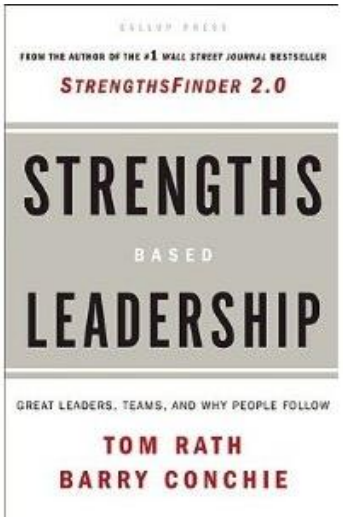
Cognitive Diversity: Combat Bias with Multibiasing, and Open Communication

"You can't get an unbiased education, so the next best thing is a multibiased one." – Buckminster Fuller

Build cognitively diverse, strengths diverse teams.
Measure for strengths diversity.

Page is Prof. of Complex Systems, U. Michigan



Rath is at Gallup

"Don't expect what you don't inspect." – Lou Gerstner

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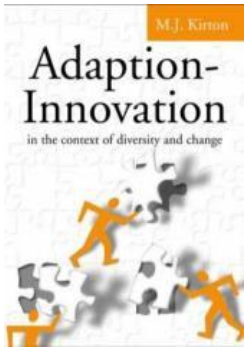
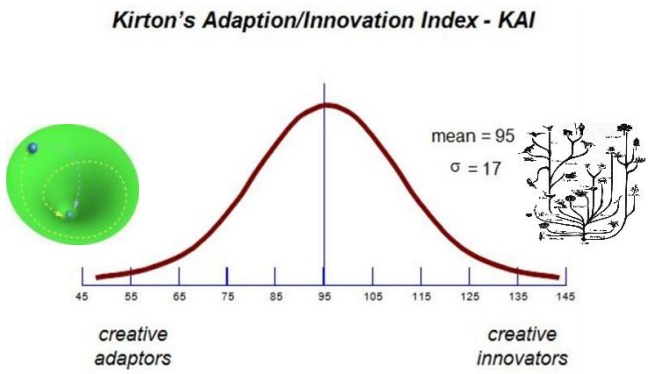
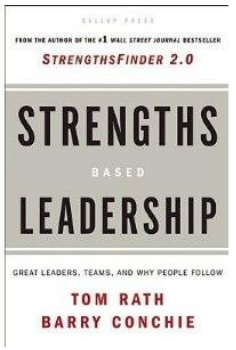
Good Self-Management Allows Great People Management

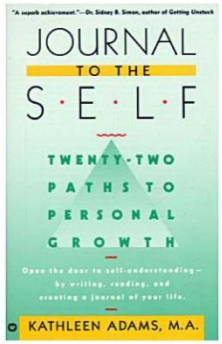
- **Self-Diagnosis comes before Self-Management**

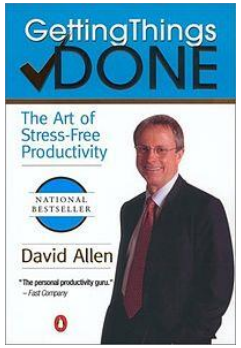


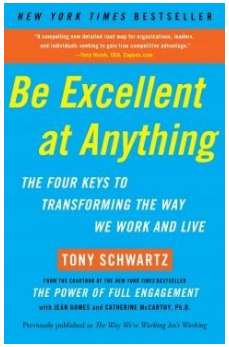


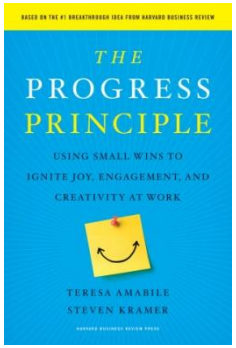


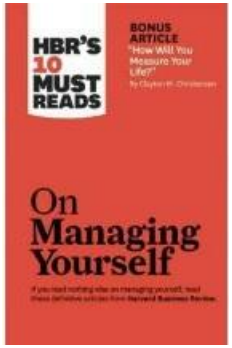
- **Self-Management improves People Management**

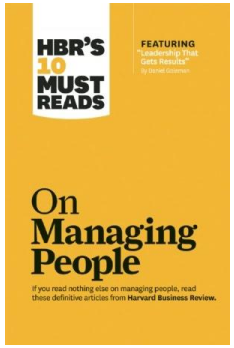












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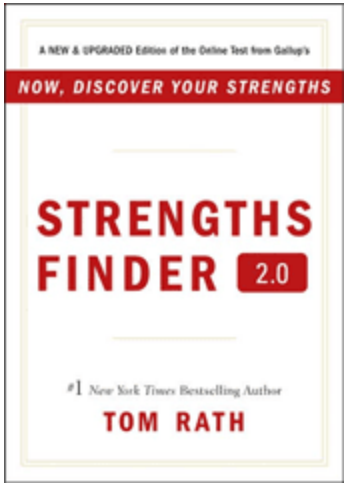
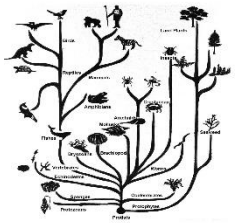
Psychological Foresight Tools: StrengthsFinder (and other Psych Testing Rubrics)

Peter Drucker: Individuals should discover and focus on building their best **strengths**, much more than fixing their weaknesses, to make their best and happiest contribution to the world.



Weaknesses in turn can be best managed by:

1. Being aware of strengths you don't have
2. Joining strengths-complementary teams
3. Allowing others to lead from their different strengths
4. Building situational intelligence (routines, tools, brief courses, etc.) to keep you from getting tripped up by your weaknesses.



Gallup's **StrengthsFinder** (& other psych profiling assessments like **MBTI**, **DiSC**, etc.) are **predictive futures tools**.

- Gallup lists **34 strengths**, large polling set
- How complete are they (strengths *and* weaknesses, integral)?

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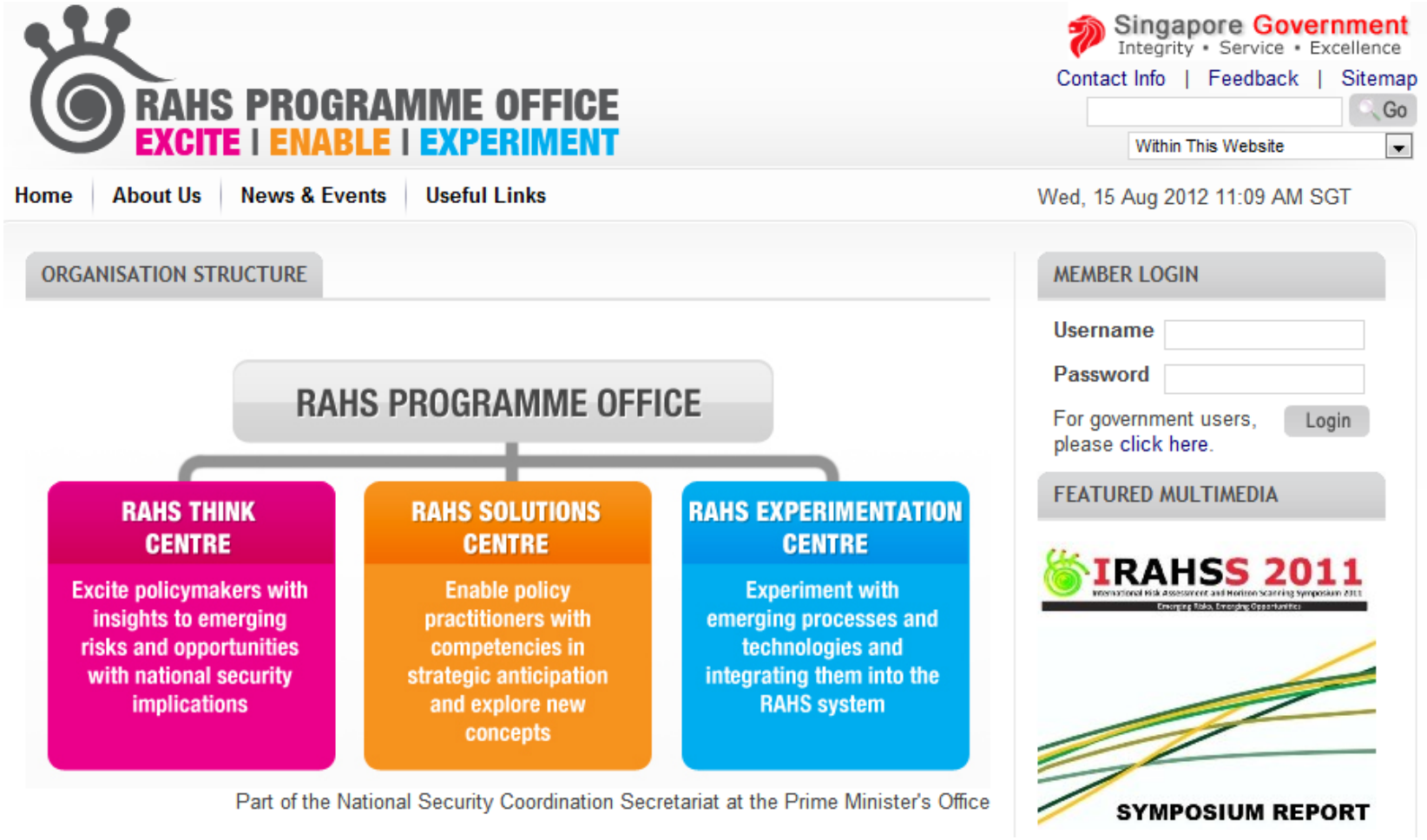
Singapore: World-Class National Security Risk Assessment and Horizon Scanning (RAHS)



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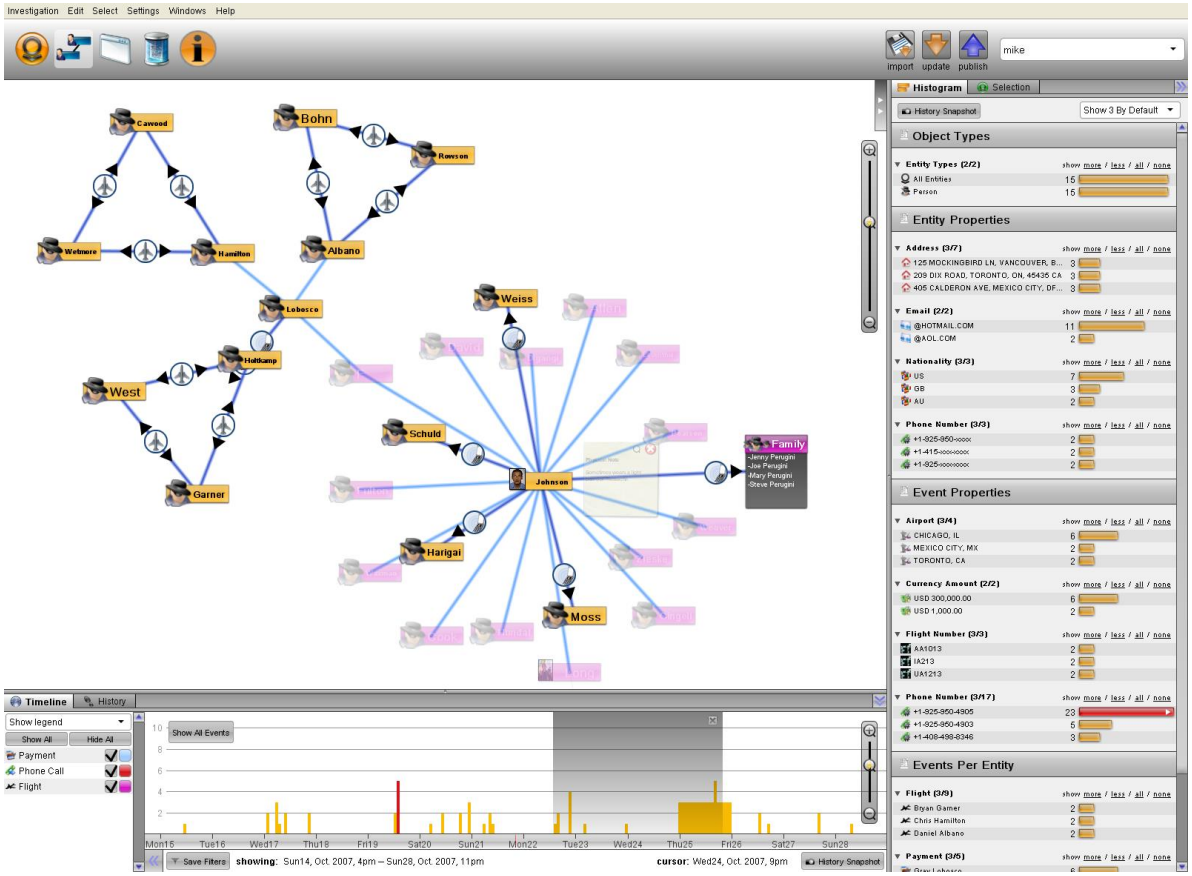
Palantir Technologies:
Web Intelligence and Predictive Analytics - Defense

Palantir Technologies

In-Q-Tel and Founders Fund are investors.



The War on Terror's Secret Weapon, *BusinessWeek*, Vance and Stone, Nov 22, 2011.

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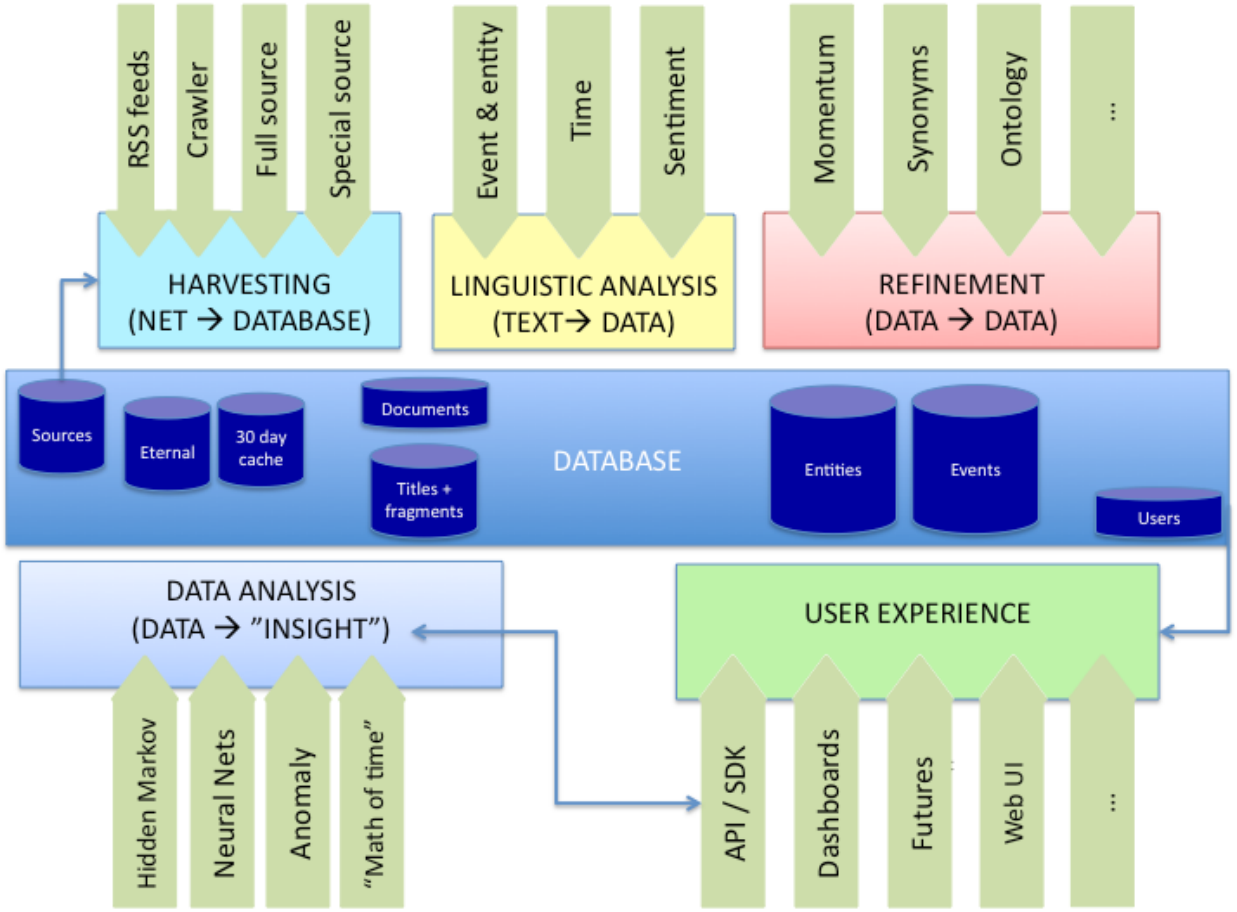
Recorded Future: Web Intelligence and Predictive Analytics - General

Google and In-Q-Tel are investors.

Recorded Future
UNLOCK THE PREDICTIVE POWER OF THE WEB



See the Future With a Search, *Tech Review*, Tom Simonite, Dec 2, 2010.

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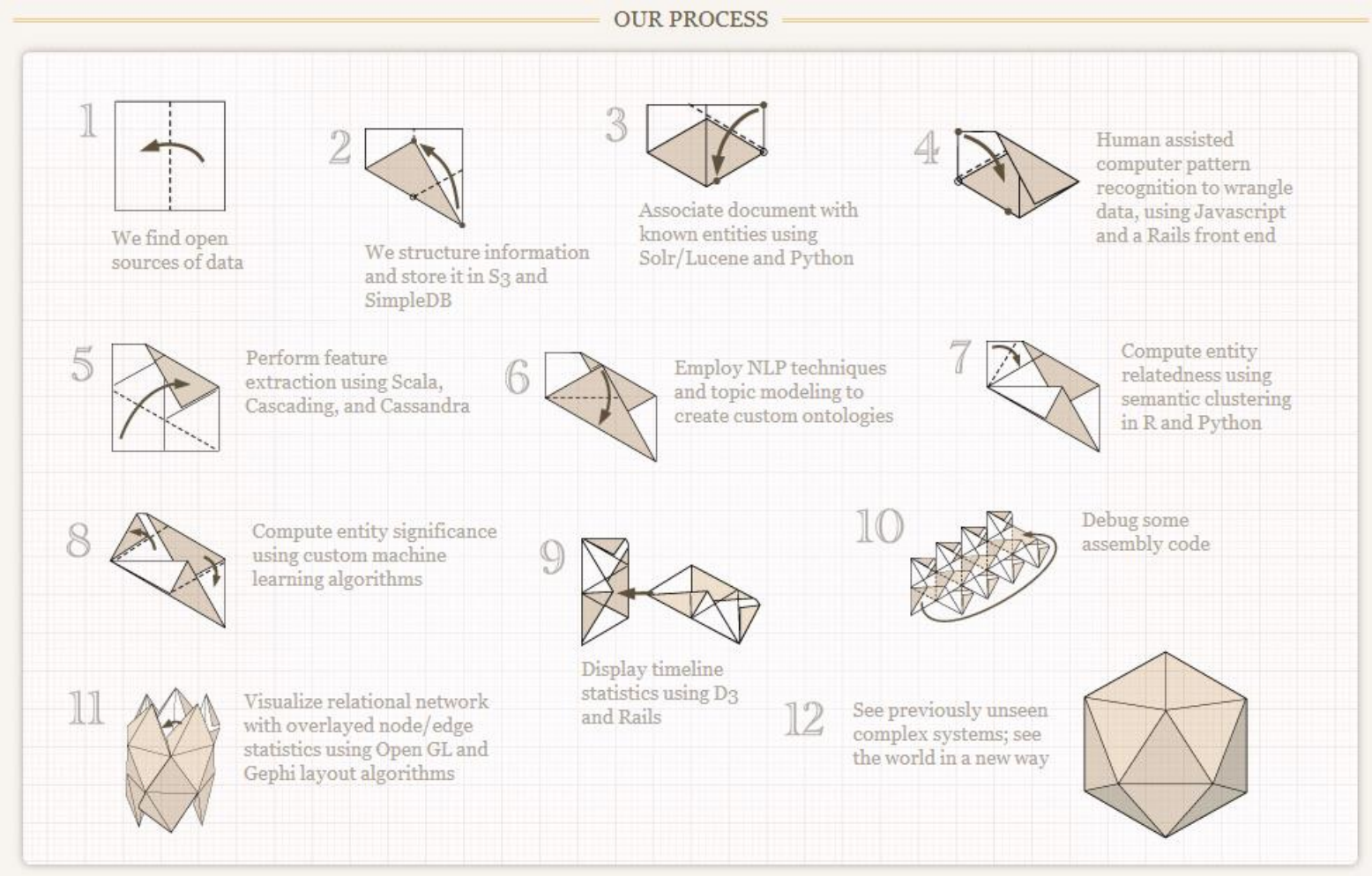
Quid:
Web Intelligence and Predictive Analytics - General

Quid™

Founders Fund are investors.



Growth Theory / Learning Curves

An Evo Devo Taxonomy

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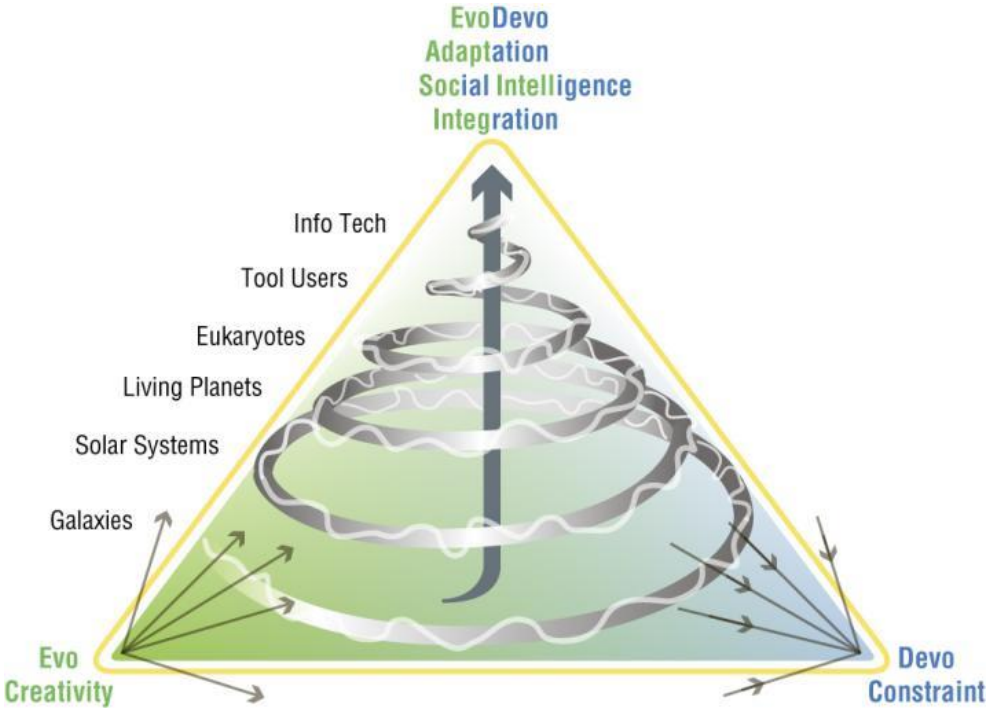
Learning Curves

1. Four Futures
2. Learning Curves I – "Evolutionary" (Seed/Diversity)
3. Learning Curves II – "Evo Devo" (Organism/Adaptation)
4. Learning Curves III –"Developmental"(Environment/Constraint)



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Dator's "Four Futures": Four Classic Growth Scenarios

Four Basic Stories/Components of Change

Perspectives in Cross-Cultural Psychology, Jim Dator, Academic Press, 1979

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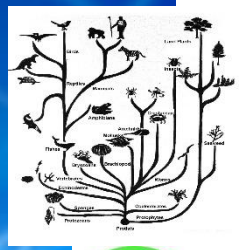
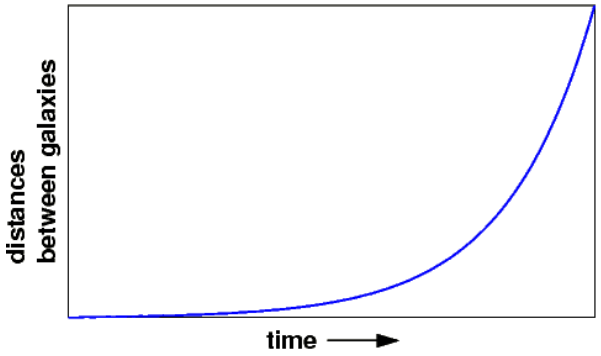
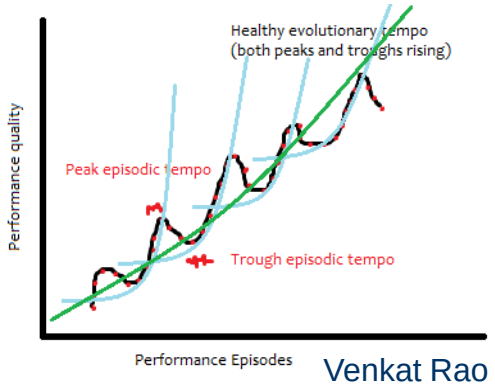
Learning Curves I – Free Growth ("Evolutionary")

Exponential

"Free/Uniform Motion" Growth (in Time via Replication/Iteration)



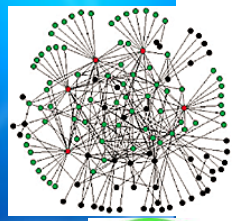


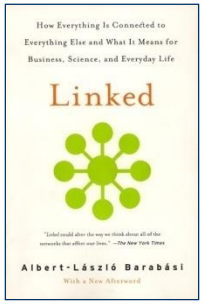


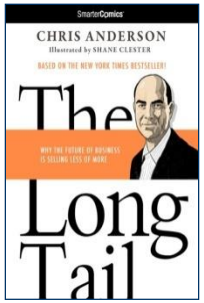
Venkat Rao

Spatial Power Law

"Free/Uniform Motion" Growth (in Space via Pref. Attachment Networks)







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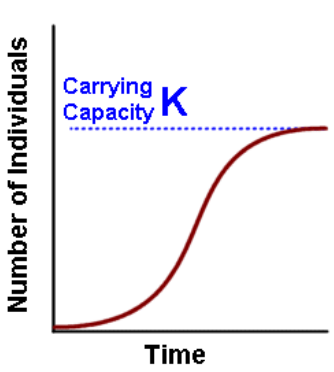
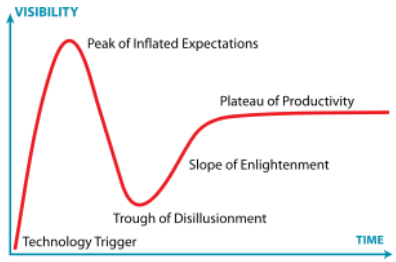
Learning Curves II - Self-Balancing ("Evo Devo")

"Self-Balancing" Growth

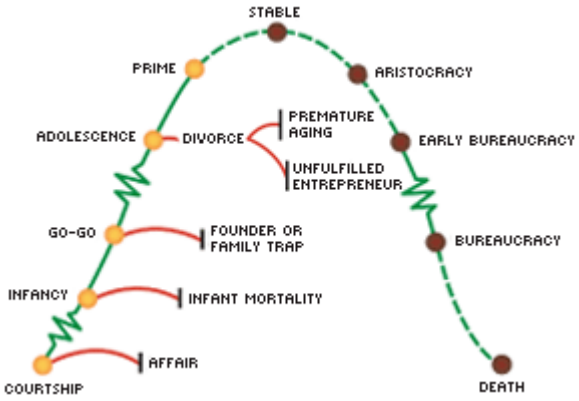
Logistic

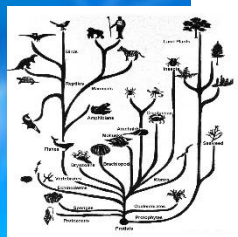


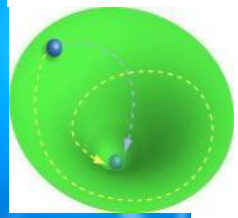
Hype Cycle



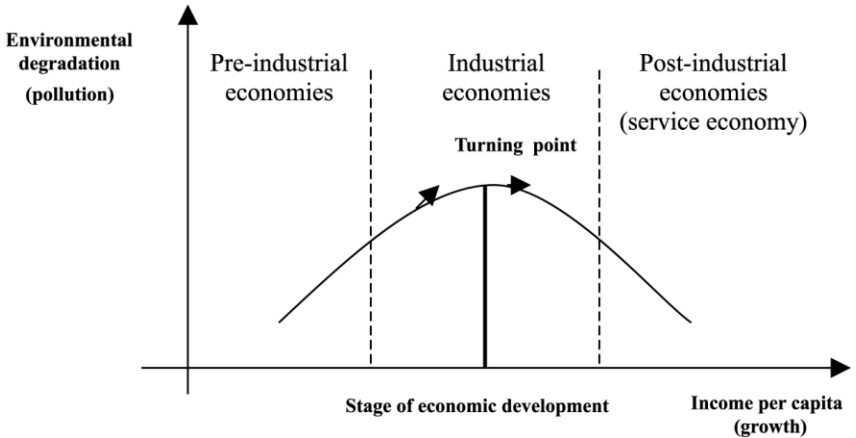
Life Cycle



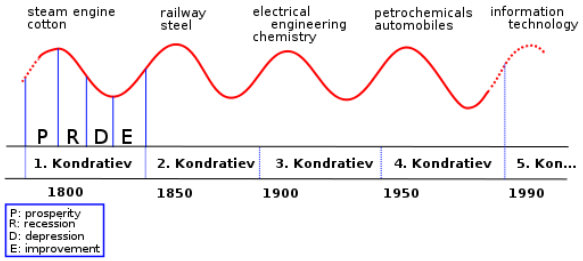




Kuznets



Cyclic (K-Wave)



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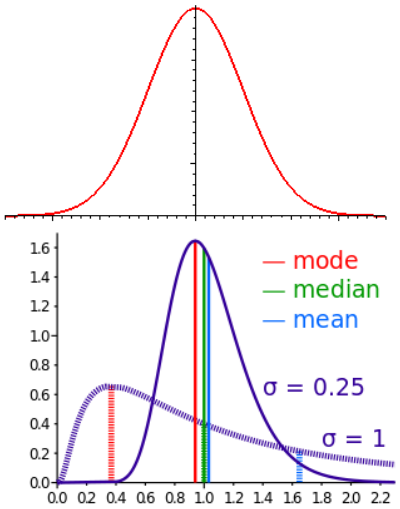
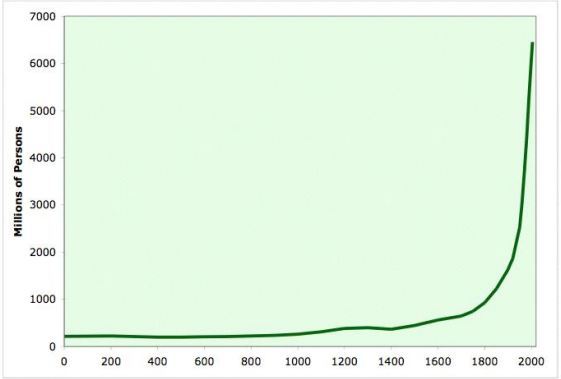
Learning Curves III – Environmentally-Driven ("Devo")

"Environmentally- and Framework-Driven" Growth

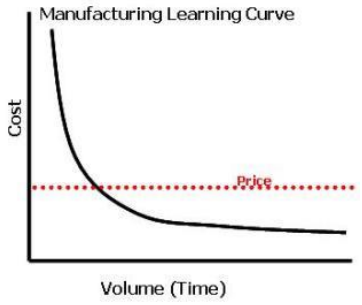
Normal & Log-Normal

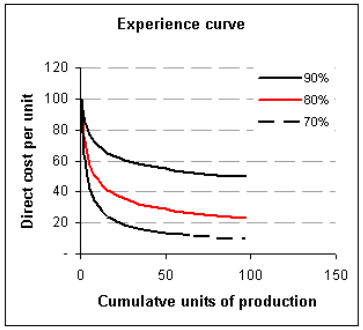


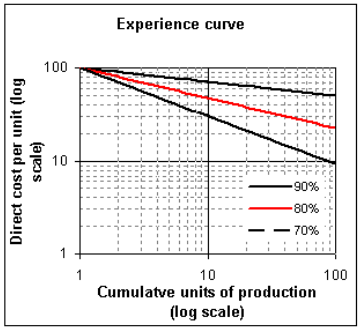
Hyperbolic/Superexponential



Temporal Power Law (Iteration)







Learning Curves

A Few Interesting Examples

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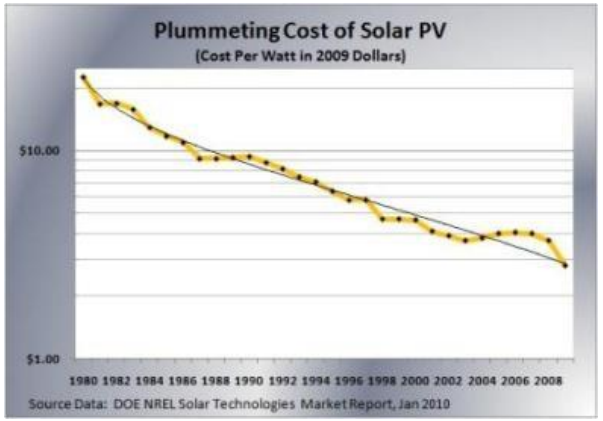
Accelerating Change: Consider What We've Seen in the Last Ten Years

Sci, Tech, Envir, Economic, Political, Social trends:

- Global CO2 emissions: 6%/yr
- Solar PV price-perf.: 7%/yr
  <10 yrs (2021) to outcompete coal*
- China's GDP: 9%/yr
- Online commerce: 14%/yr
- China's top cities GDP: 20%/yr.
- World's digital info: 36%/yr
- Facebook, 900M users: 200%/yr. G+ even faster.



Defense and Security:

- 2001 NYC, 02 Bali, 03 Istanbul, 04 Madrid, 05 London, 08 Mumbai
  What vulnerabilities will be probed next?
- Drones. Al-Qaeda used in 2001. Now $45B/yr, micro, DIY drones
  FAA banned urban use in 2007, ~300 exceptions (borders, law enf.)
- IEDs, DIY rocketry, Cruise missiles, AVLIS, Iran, Narcoterrorism.
- Smartphones, Sensors, Big Dog, Stuxnet, Data Mining, Palantir…

*Smaller, Cheaper, Faster, Ramez Naam, *Scientific American* Blog, 3.16.11

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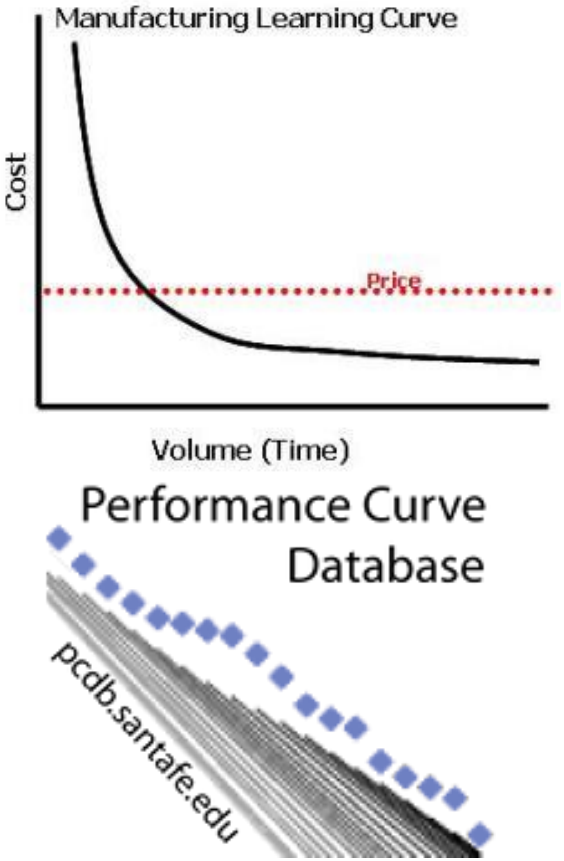
The Manufacturing Learning Curve: A Production Power Law Process



http://pcdb.santafe.edu

The price/performance ratio of **all productive processes** gets **'exponentially' better** with volume and S&T progress, different slopes for different tech:

- **Smartphone Use Growth (1 year doubling time)**
- **Computing Power (Moore's law, 1.5-2 years)**
- **Digital Disk Storage (Kryder's law, 2 years)**
- **Computer Graphics (polygon prod., 2 years)**
- **Wired Bandwidth (Nielsen's law, 2 years)**
- **Network Address Density (Poor's law, 2 years)**
- **Flat Panel Display Size (Nishimura's law, 2 years)**
- **Wireless Bandwidth (Cooper's law, 2.5 years)**
- **Computational Efficiency (Koomey's law, 2.5 years)**
- **Electronic Systems Linear Miniaturization (5.4 years)**
- **Algorithmic Efficiency (Ebrahimi's law, 5-6 years)**

Some learning curves drop *very slowly* (battery energy density grows just 2%/yr, 36 yr doubling) vs substitutes (capacitors).

Performances of critical learning curves are bottlenecks to economic and social innovations (solar PV efficiency, desalination, etc.).

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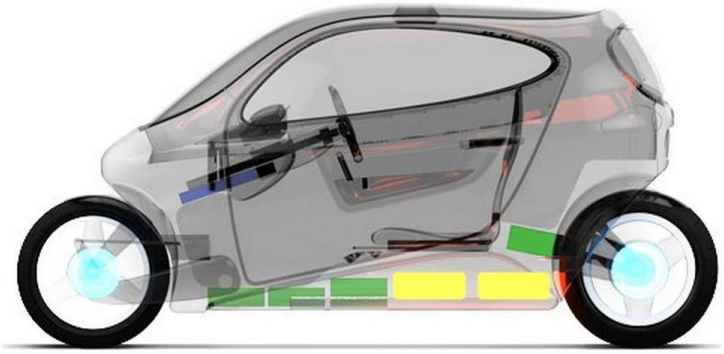
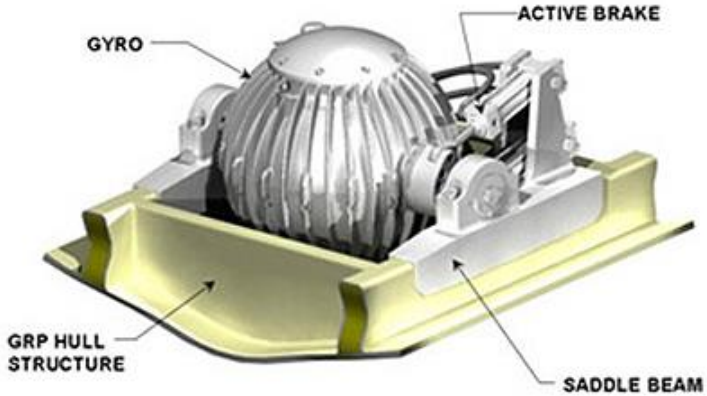
Gyro Learning Curves: Transportation and Sea Base Disruption?



Lit Motors C-1 – Two Indep. Gyros



Seakeeper – Yacht Gyros

Sea Bases, Folding Bridges, (Gyro) Hovercraft, Smart Cranes

Marine Corps Makes Strong Pitch for Sea Bases, *Nat'l Defense Mag*, Feb 2008

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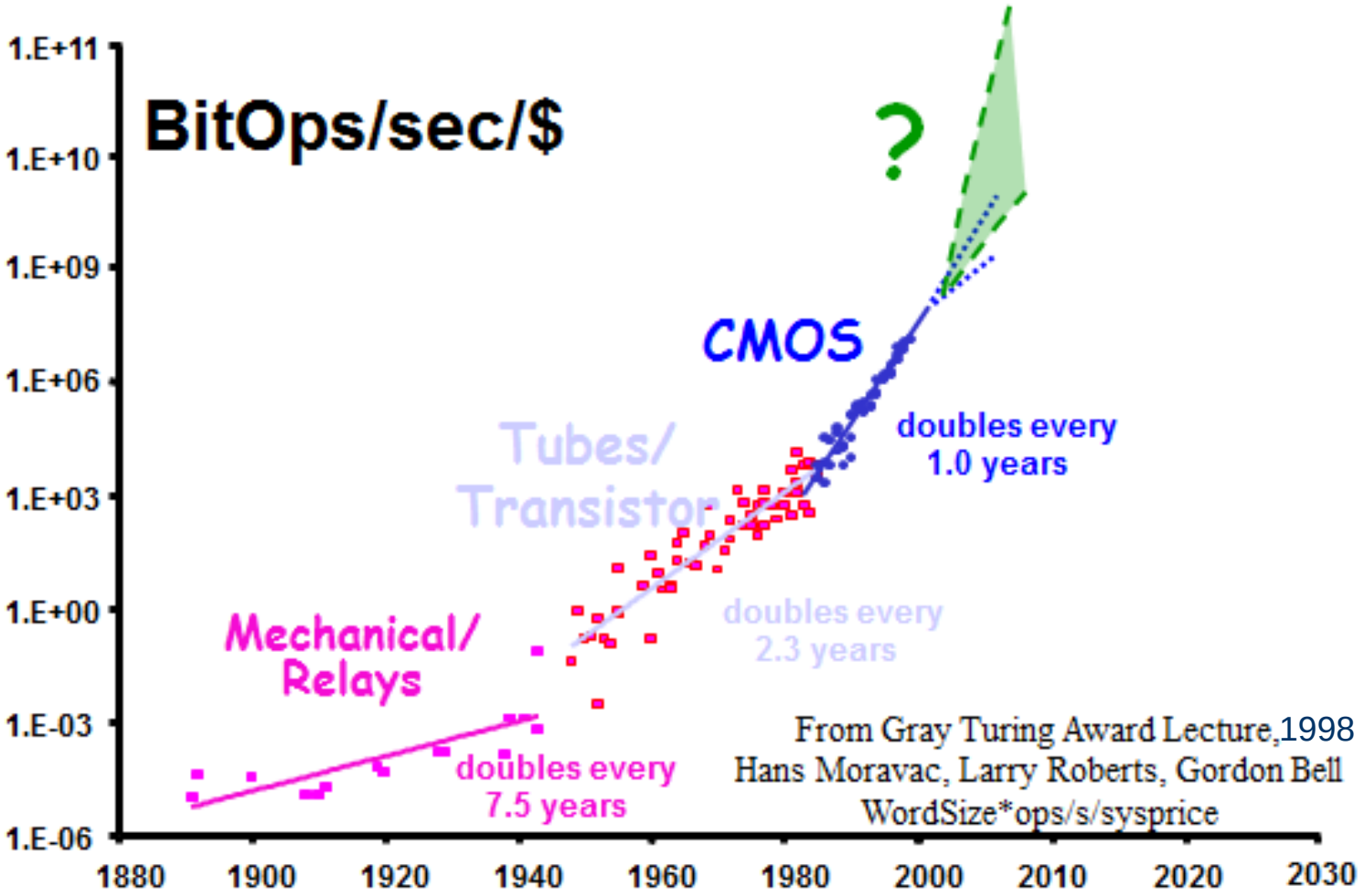
Moravec/Roberts/Bell: Computing Has Had Three Increasingly Rapid Learning Curve Paradigms

Will we see another shift? Or plateau?



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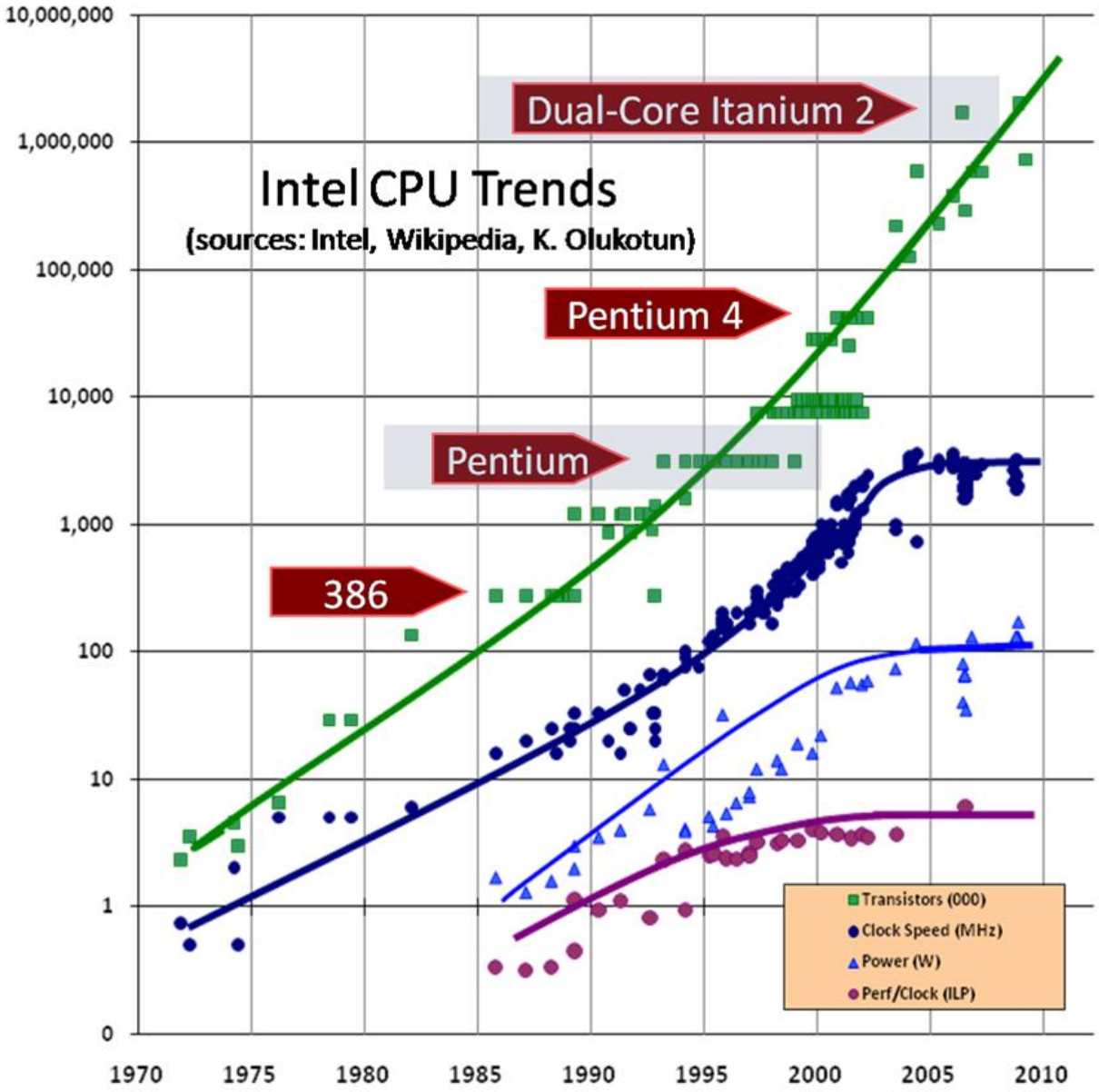
A Generalized Moore's Law Stopped in 2003: A Multicore Moore's Law Has Started



Transistor density keeps rising, **but**

- Clock speed
- Power
- Perf/Clock

Saturated in 2003.

Good News: This provides opportunity to create **more parallel, biologically-inspired hardware.** (eg, multicore processors, IBM's SyNAPSE Chip)

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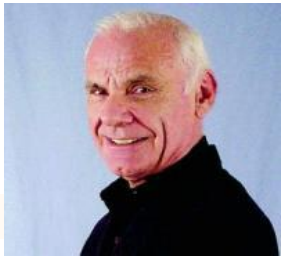
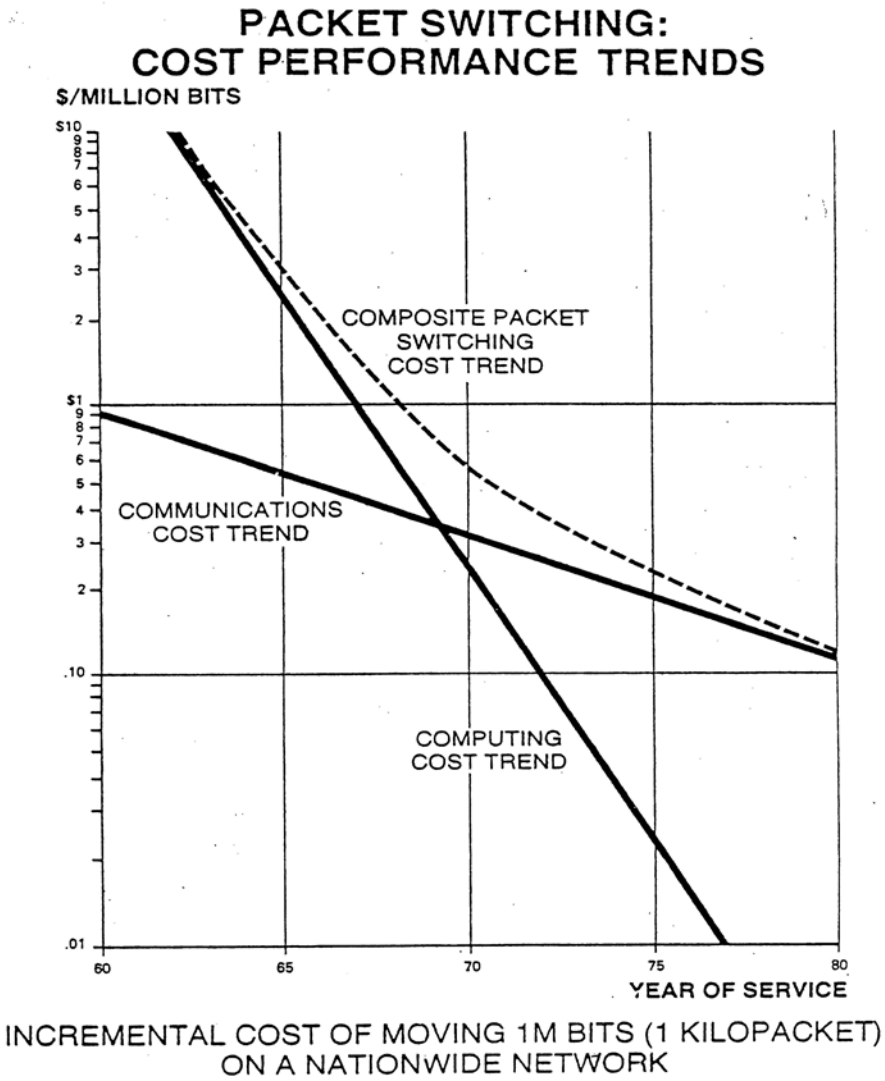
Roberts Law: The Moore's Law for the Internet





INCREMENTAL COST OF MOVING 1M BITS (1 KILOPACKET) ON A NATIONWIDE NETWORK

Roberts, 1971

- In early 1960's it was far too expensive to implement packet switching for networks
  - AT&T had built large circuit-switched networks
  - Computation cost of packet switching very expensive
- A few visionaries saw that Moore's law implied change
  - **Larry Roberts**, DARPA.
- Almost all then-current vested interests **resisted** change
  - AT&T, other non-DARPA-sponsored folks bet on existing circuit-switched net.
  - **ARPANET funded 1969**. Exponential disruption!

Ref: Pat Lincoln, SRI

Composite Learning Curve: Networking Costs

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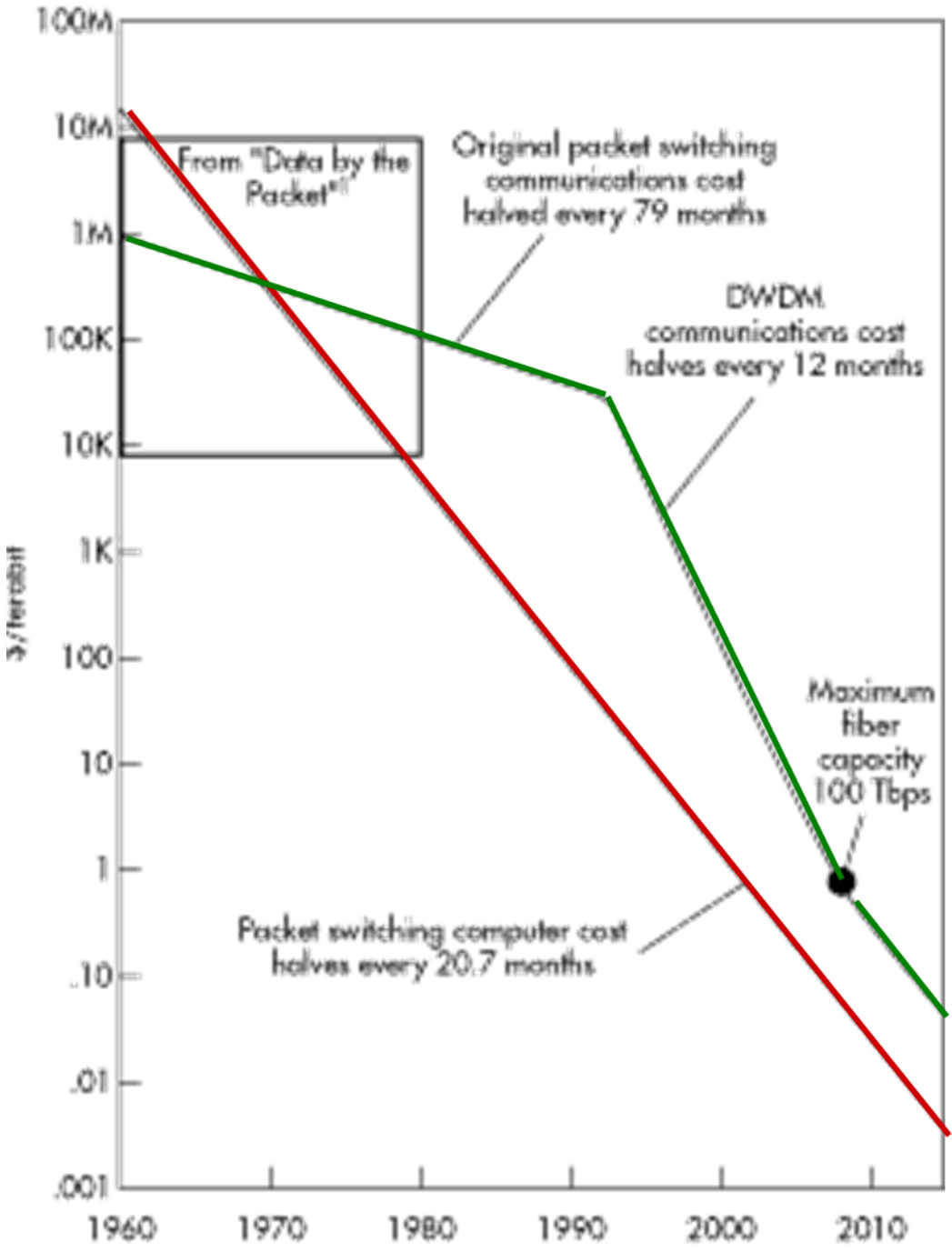
Total network hardware costs per switched terabit, broken here into:

- **Computer cost**
- **Communications cost**

Note the three packet switching communications tech paradigm shifts over fifty years, while network computer cost reduction stayed log-constant.



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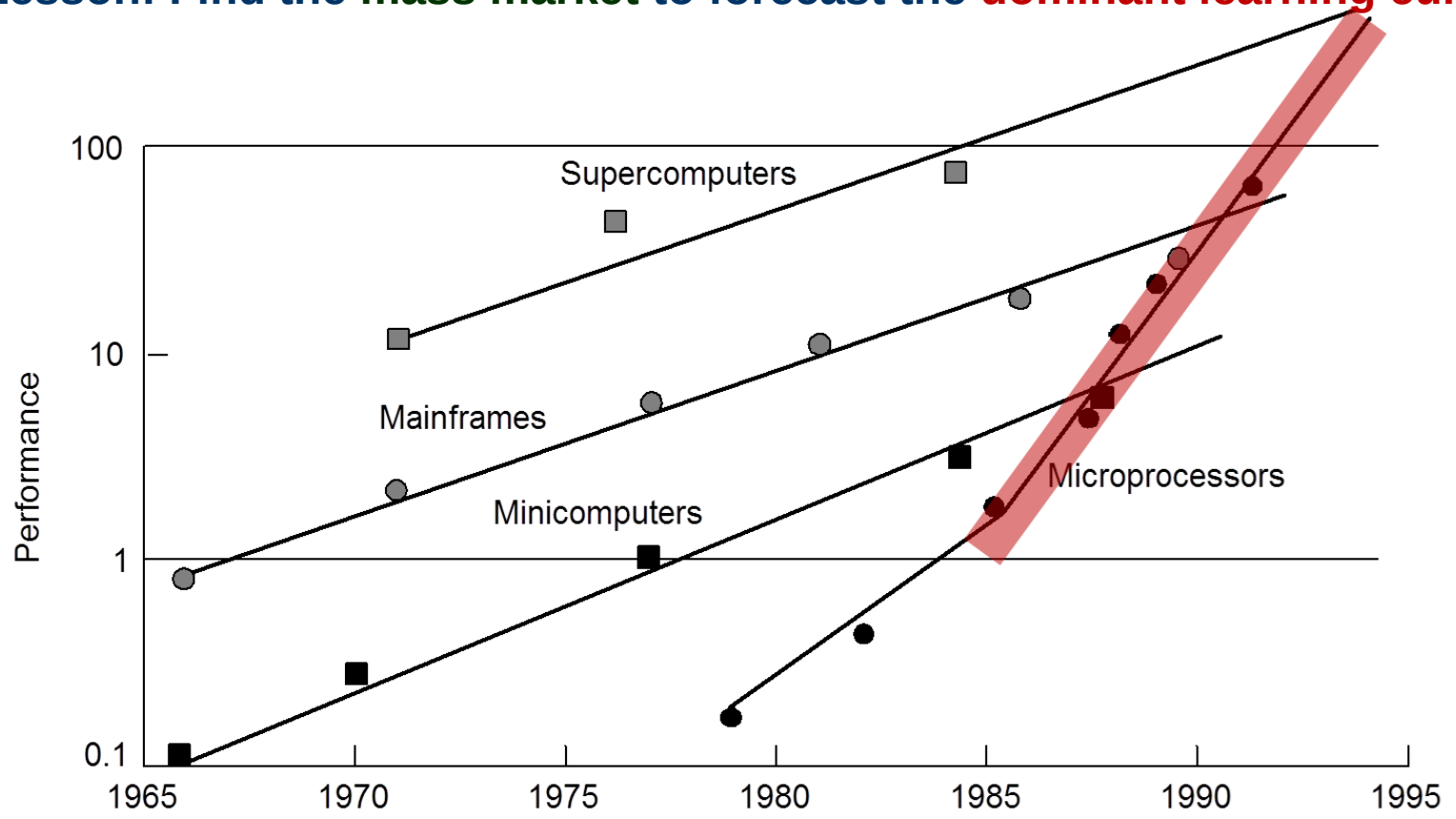
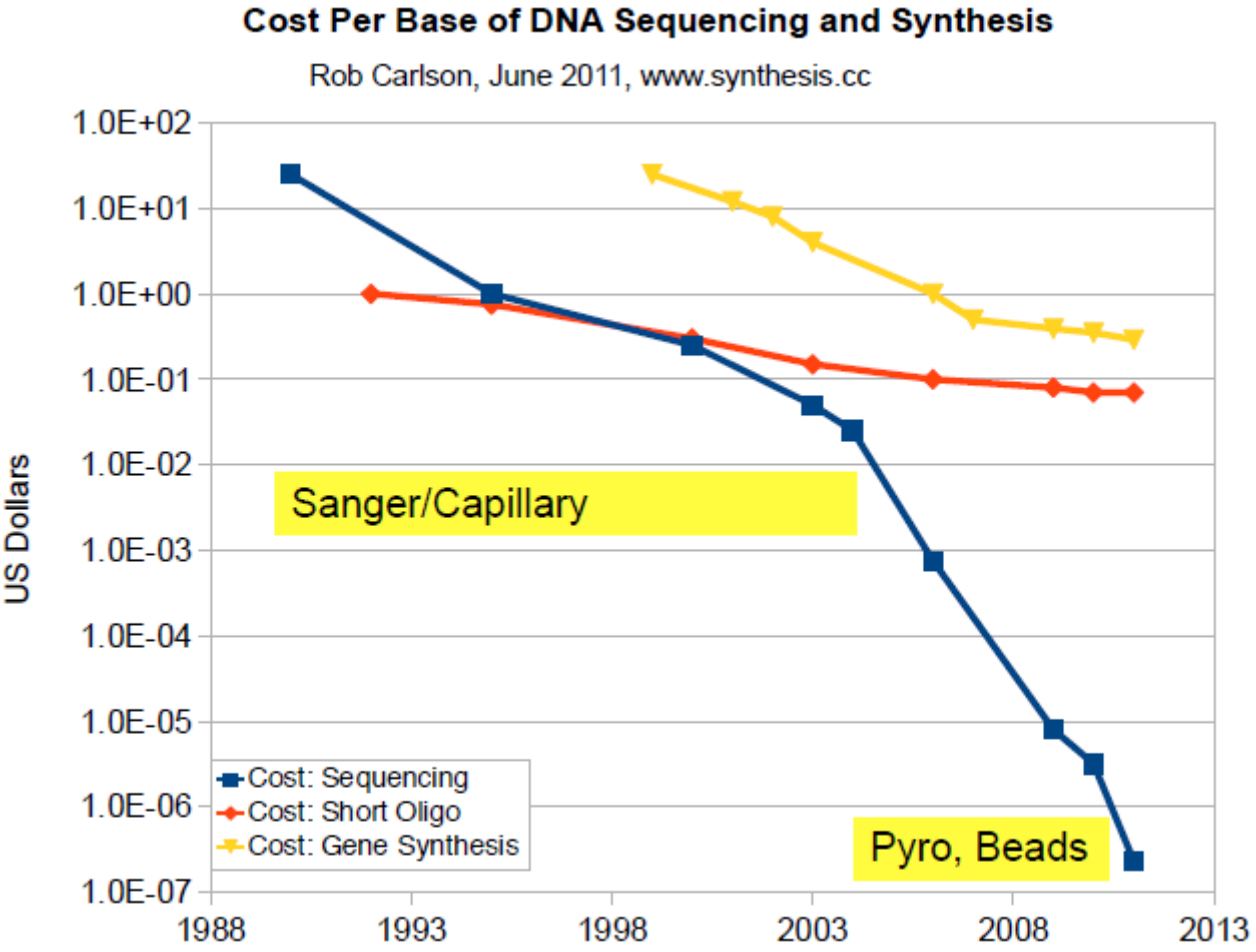
Attack of the Personal Computers: Superior Manufacturing Scale, Superior Learning

This again happened to PCs (Smartphones and Tablets) in the 2000's.
Embedded computing/sensing and virtualization are next (2020's).
Lesson: Find the mass market to forecast the dominant learning curve.



Eugene Brooks, Attack of the Killer Micros (talk), Supercomputing 1990

DNA Sequencing and Synthesis



Oxford Nanopore, 2011

- **Next sequencing paradigm?**
- **Touch DNA forensics will be enabled.**
- **Major transparency advance.**

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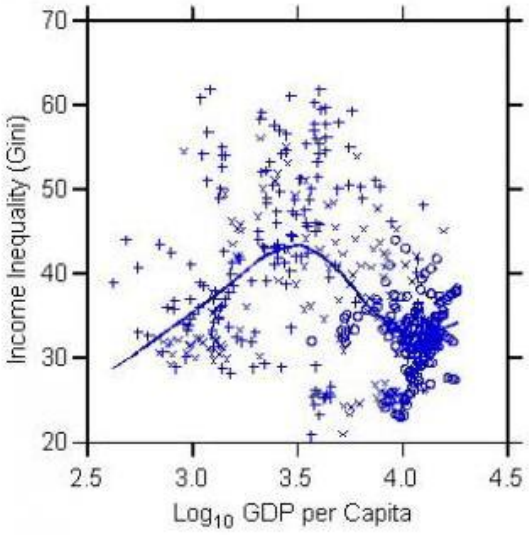
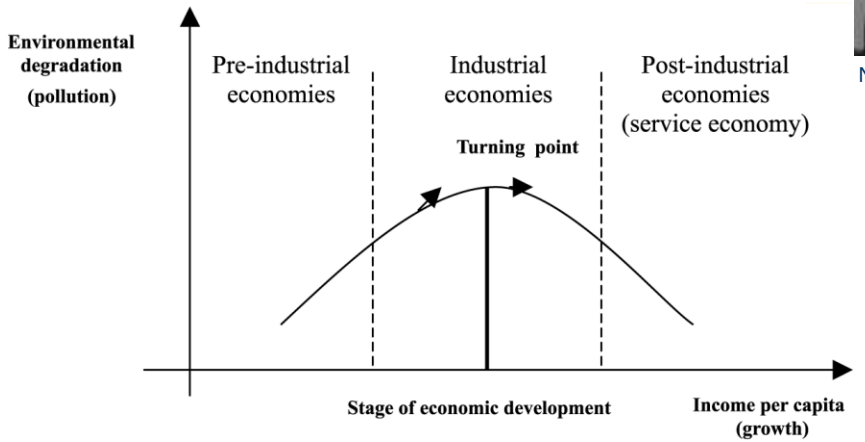
The Kuznets Curve: "Things Get Worse Before they Get Better"

Nobel-laureate Economist Simon Kuznets





Panayotou, T. 1993. "Empirical Tests and Policy Analysis of Environmental Degradation at Different Stages of Economic Development."

Kuznets' Inverted U Curve of Development

X Axis (indep. variable) growth → Y Axis (dependent variable) inverted U.

- **GDP/capita growth → Rich-poor divide**
- **City growth → pollution, deforestation, disease**
- **Industrialization → labor exploitation and job loss**
- **Calculator growth → innumeracy**
- **Video game growth → illiteracy and desocialization**
- **Social network growth → physical world alienation**

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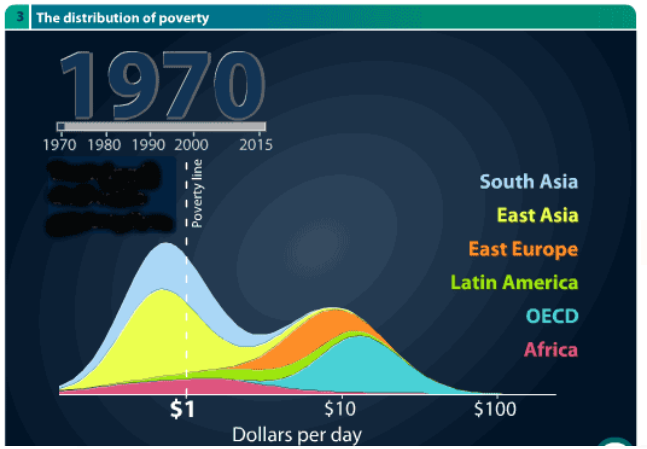
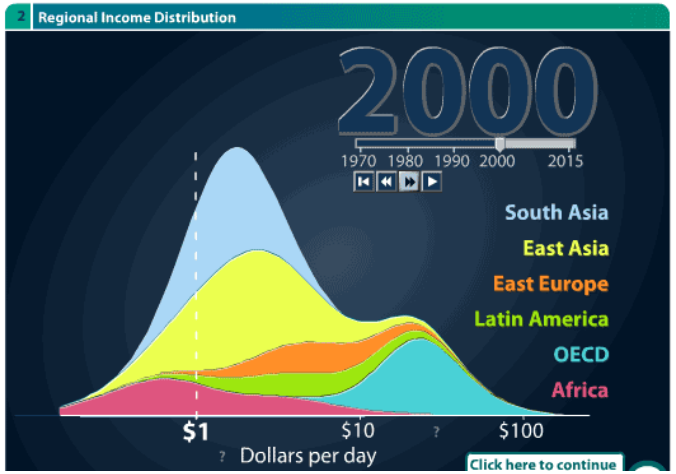
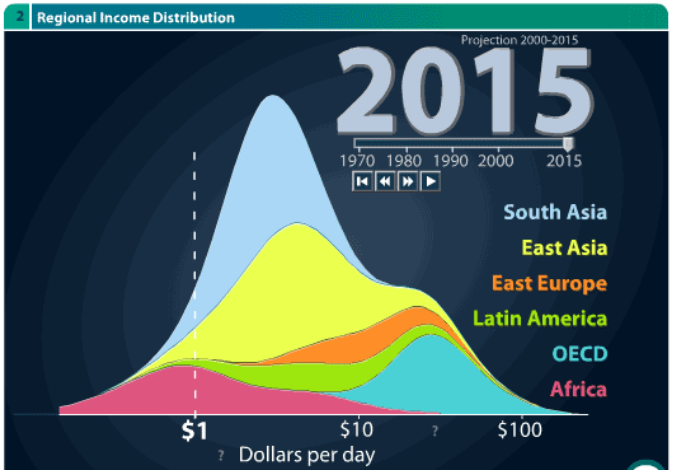
The Global Income Gap Is Steadily Closing

- Global individual income distribution is **log-normalizing**.
- A key social and technology trend.
- What is the **ideal range for asset and income multipliers** between richest and poorest in any nation?
- We will find this out, empirically, via **comparative political science** (ex: Germany vs. US)







Human Development Trends, Gapminder, 2005

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The Economic Kuznets Curve Has Happened Many Times: Technological Growth Creates New Inequalities, "U-Turns"

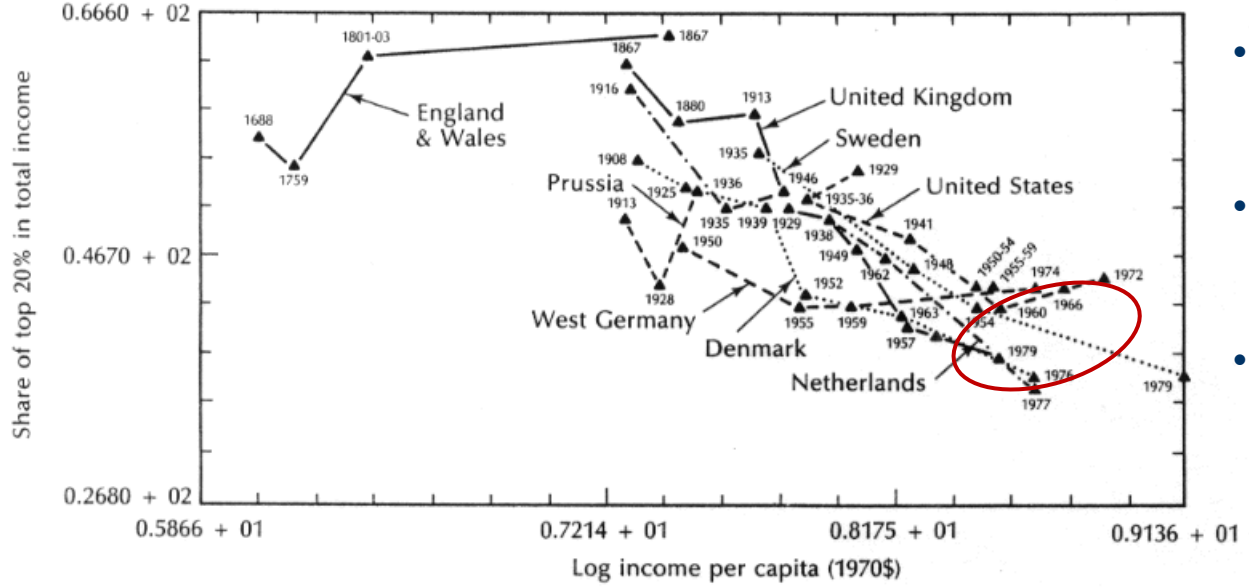
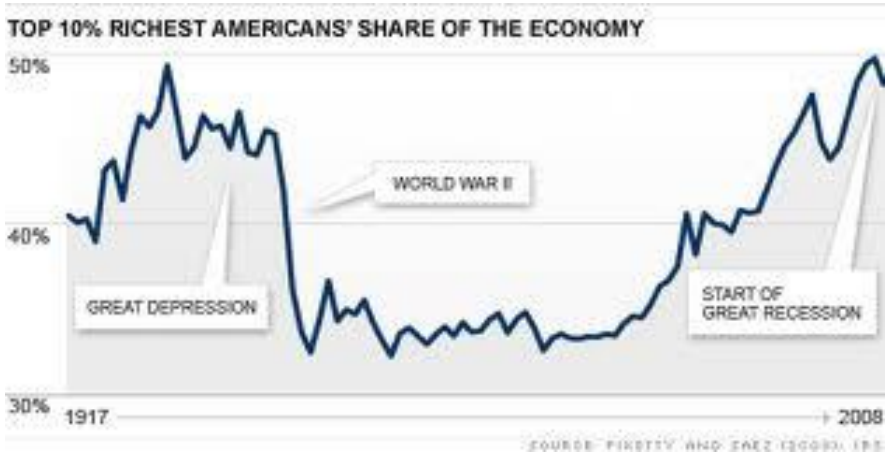
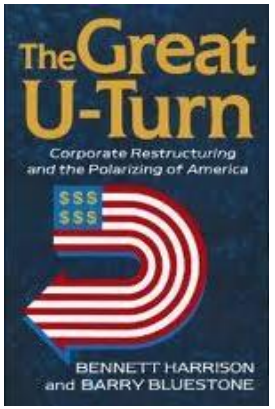


Figure 1.3 The Kuznets Curve: mostly the twentieth-century downswing.
Source: Lindert and Williamson (1985, Figure 2, p. 345)

- **UK: 1750-1800**, industrial revolution created inequalities, which flattened out by 1880's.
- **US: 1880-1929,** Wall St. trusts & automation created inequalities, which flattened out by 1940's.
- **US: 1960-2012,** globalization & automation created new income inequalities, which will flatten out again (in 2010's? 2020's?).





Harrison and Bluestone, The Great U-Turn, 1988.
Alderson and Nielsen, The Kuznets Curve and the Great U-Turn, 1997

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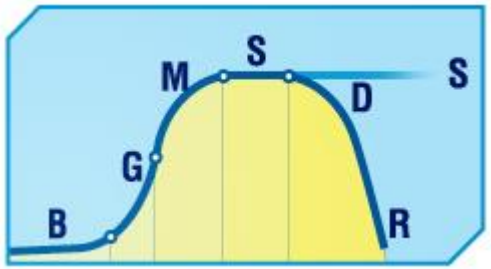
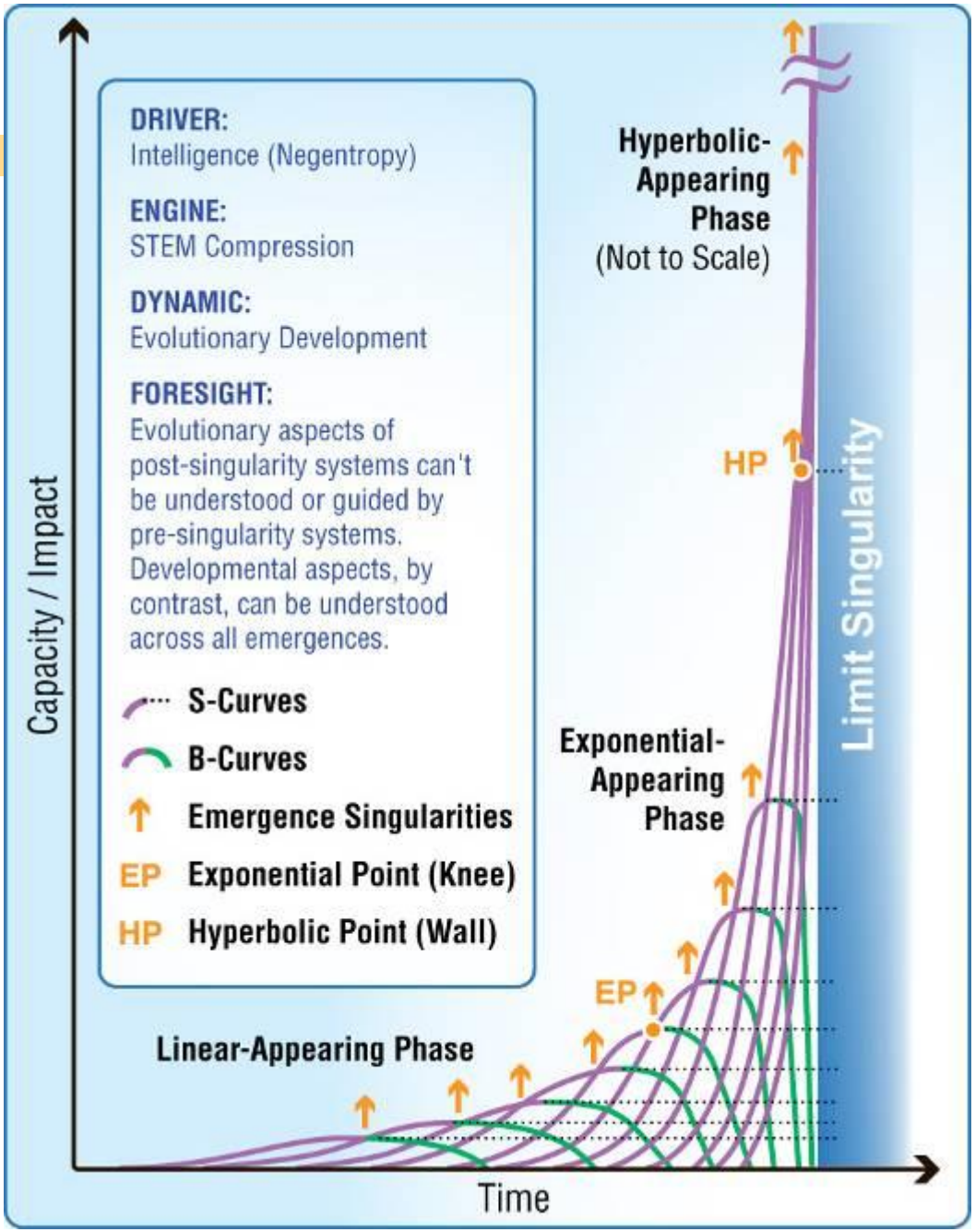
The J Curve



First-Order Logistic and Life Cycle Growth

Second-Order Superexponential Growth

Examples:
Sagan's Cosmic Calendar
Chaisson's Phi (FERD)
Global Economic Performance
Select Tech Performance Metrics



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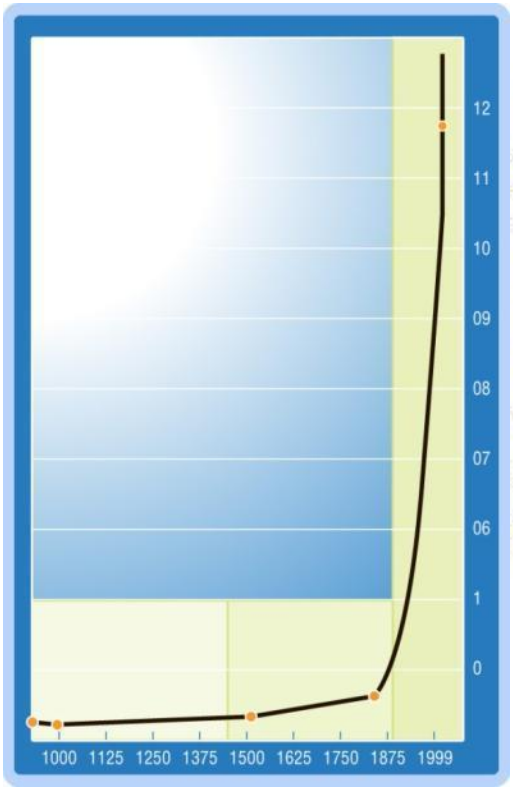
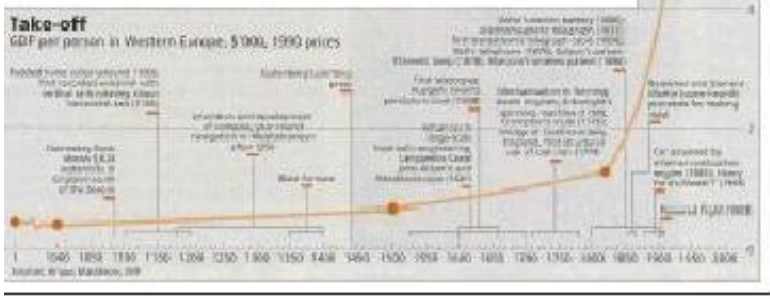
World Economic Performance is Superexponential

GDP per capita in West Europe, from 1000-1999 A.D.

- Curve is **smooth**, **superexponential** on a very long time scale.
- First, note the **"knee of the curve"** (state switch) in 1850, at the **Industrial Revolution**.
- Next, growth gets so fast it goes vertical **"wall of curve"** in 1950.
- Each new system **grows much faster** than its predecessor.
- **Superexponentiality can continue, as far as we can see**.





Contours of the World Economy 1-2030 AD, Angus Maddison, 2007

Discussion

What Do You Think?