Nanotechnology, IoT, Data Analytics, 100G+: 2050 and Beyond

Ali Shakouri,
Mary Jo & Robert Kirk Director
Birck Nanotechnology Center
9/27/2050

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REVOLUTIONARY FORCES

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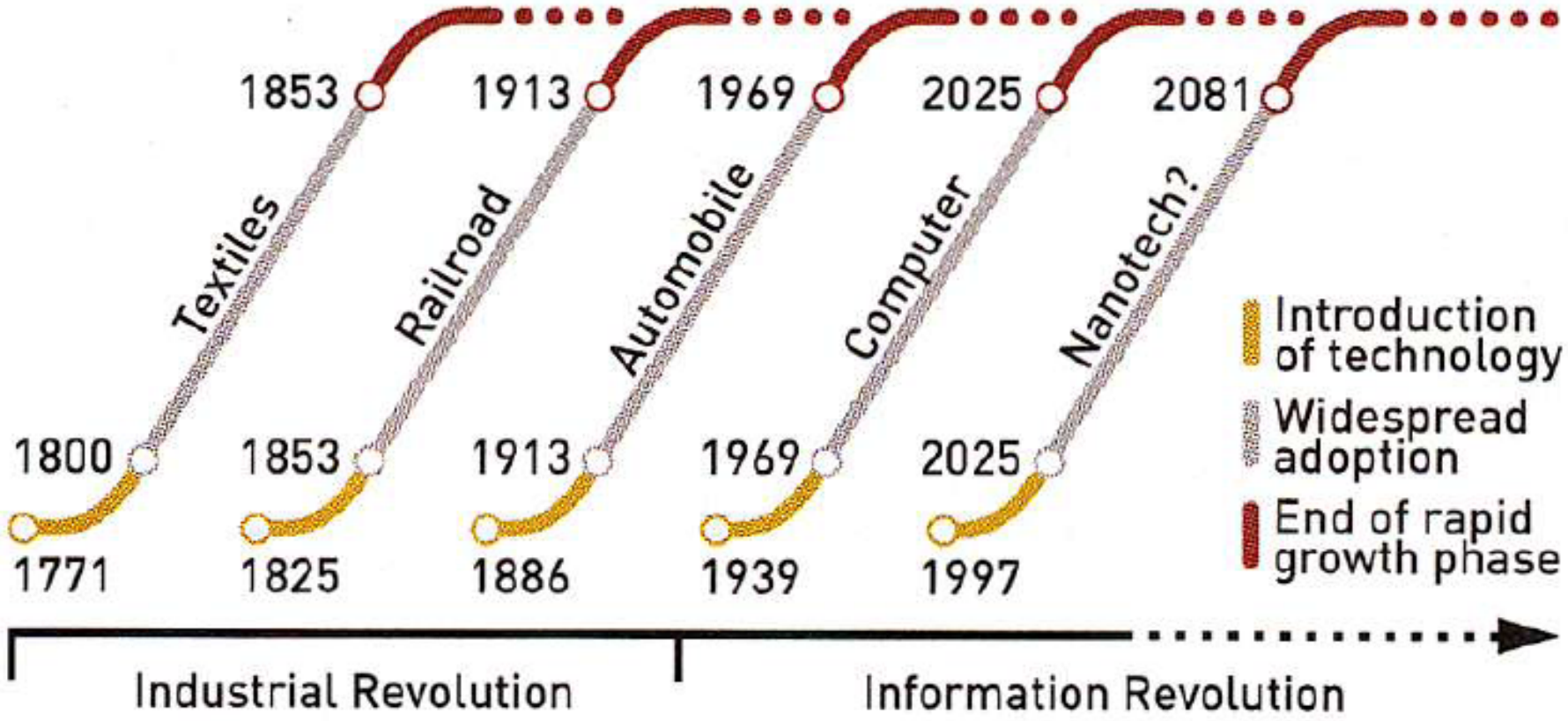
Basic advancements in science and technology come about twice a century and lead to massive wealth creation.



SOURCE: Norman Poire, Merrill Lynch

Red Herring, 2003

National Nanotechnology Initiative

Pres. Clinton, 2000

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Why Nanotechnology?

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- Miniaturization
  - Less material, faster
- Novel Properties
  - Quantum phenomena
- Bring Different Disciplines Together
  - Engineering, Physics, Chemistry, Biology,…

M.C. Roco, NSF, 11/05/02

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Birck Nanotechnology Center (est. 2005)

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- *A **multidisciplinary** center for **collaborative** research*
- ***55** faculty, **20** tech staff and **200+** students from 15 departments resident in the building (Eng., Science, Ag, Pharmacy, Vet Med,…)*

2025 Technologies

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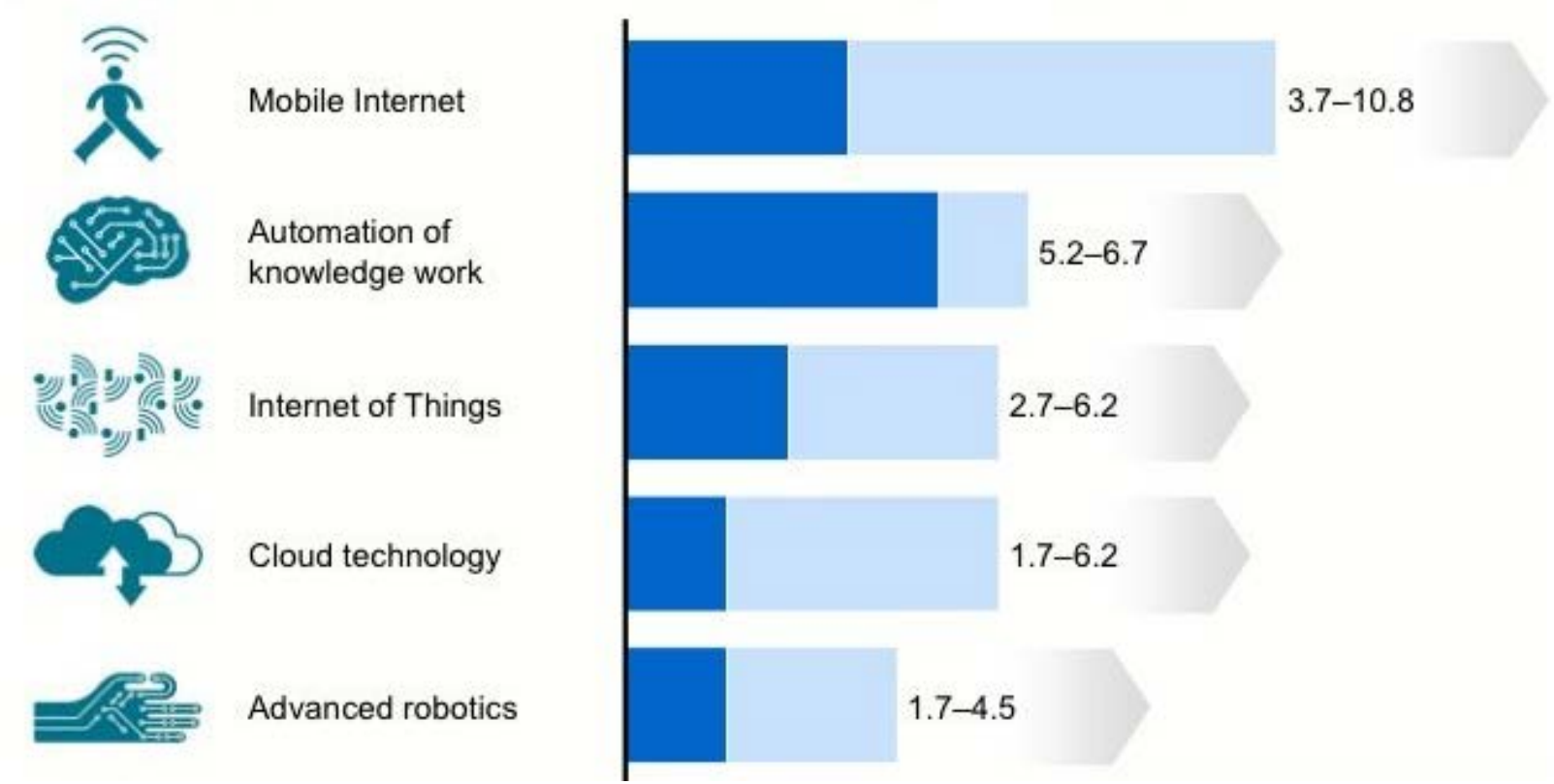
Deloitte
(Dec. 2015)

25 billion connected devices (enabled by IoT) will be in use by 2025

McKensie (2014)



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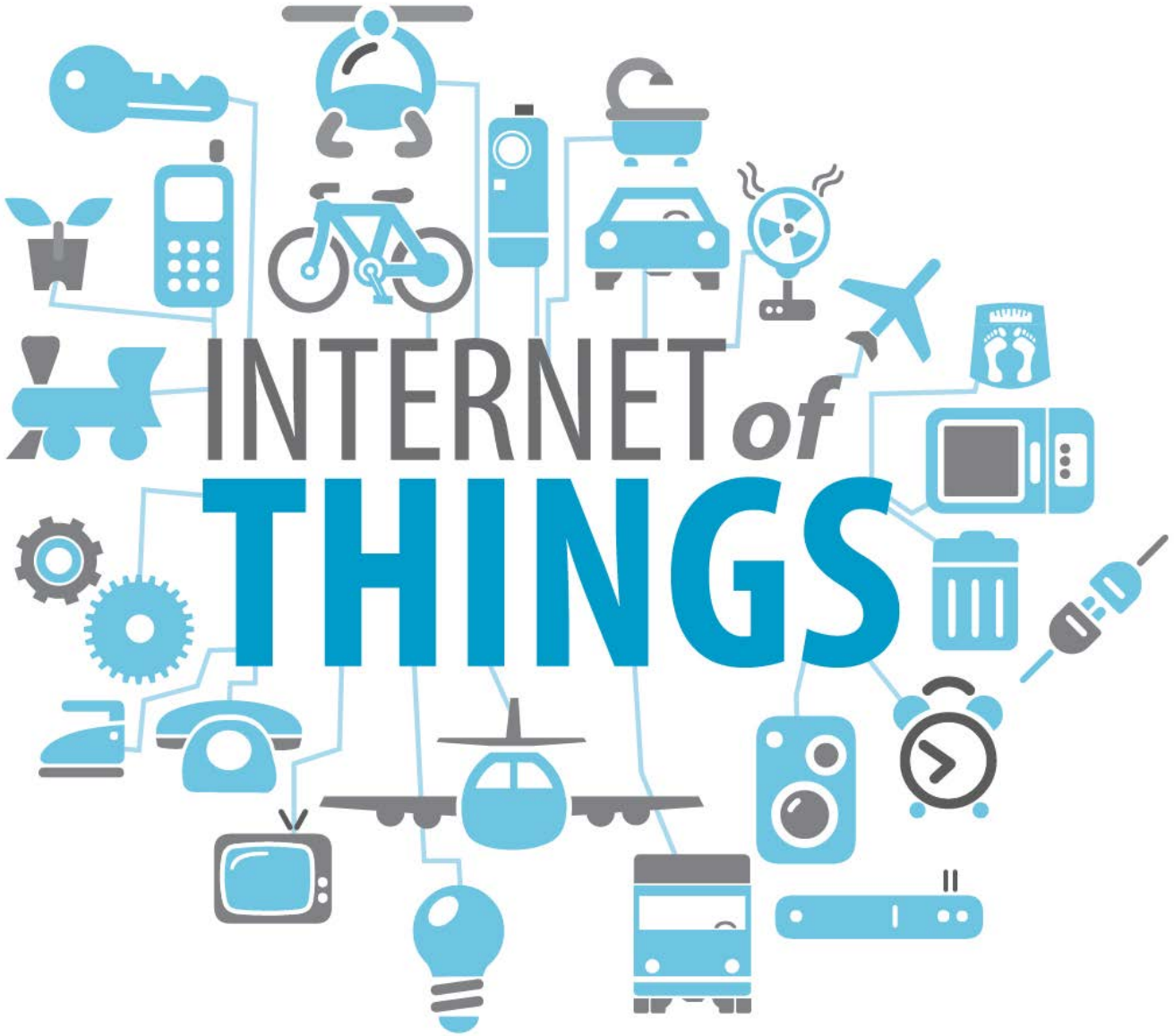
Internet of Thing (IoT)



Applications: *smart infrastructure/ buildings, digital ag, digital health, industry 4.0, smart food packaging, …*

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Making sense of the world around us?

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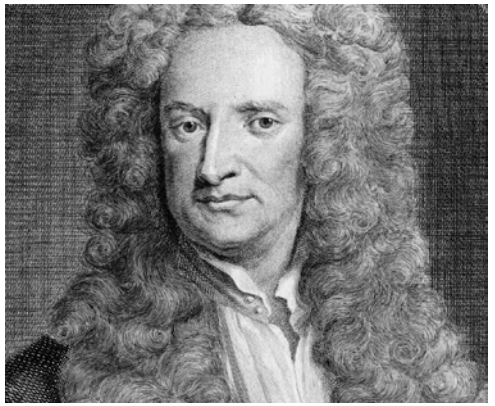
- 1600's Mechanics
  - Analytical equations: $F(x)=m\ d^2x/dt^2$

- 1900's Quantum Mechanics/ Relativity



- 1950's Computers
  - Solve equations numerically
- 2000's Machine Learning
  - Neural networks

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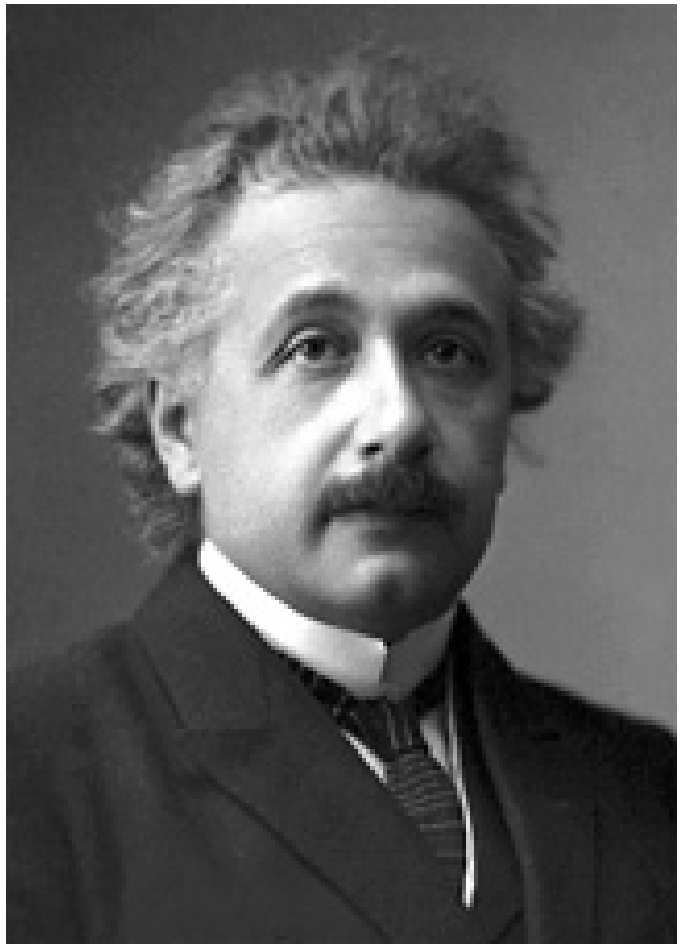
Data and observation



1920's

It is the theory which decides what can be observed.

Technology du Jour Phenomenon

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Disruptive and wasteful

***Transportation Energy 1978-2008**:*

1978	*Synfuels (oil shale, coal)*
1988	*Methanol*
1993	*Electricity (BEV)*
2003	*Hydrogen (fuel cells)*
2006	*Ethanol (Biofuels)*
2008	*Plug in hybrid*

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Global Megatrends (Discovery Park 2015)

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Climate Change? Global Warming?

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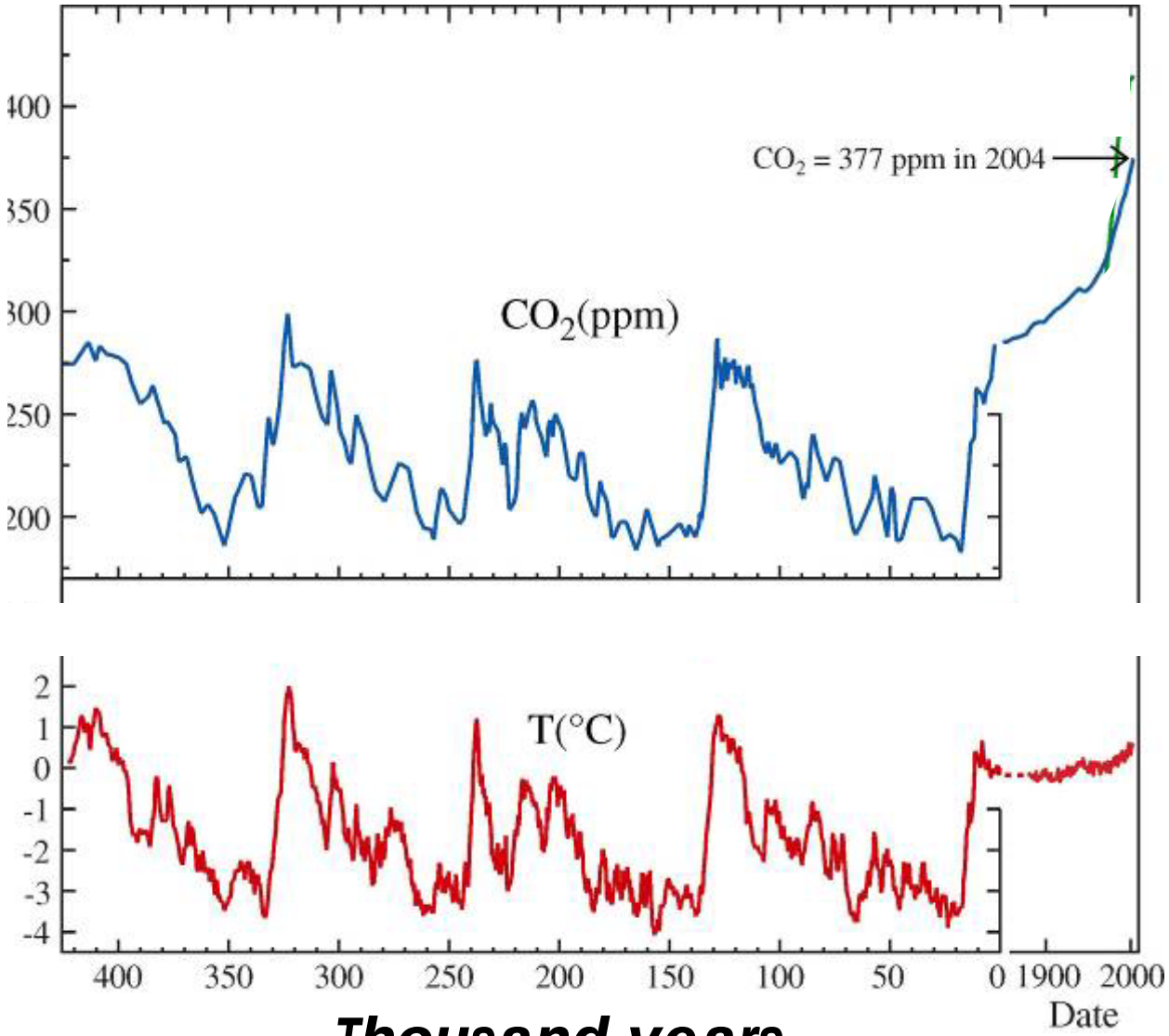
400,000 years of greenhouse-gas & temperature history based on bubbles trapped in Antarctic ice



Thousand years before 1850

Last time CO_2 >300 ppm was 25 million years ago.

*Source: Hansen, Clim. Change, **68**, 269, 2005.*

John P. Holdren, 2006

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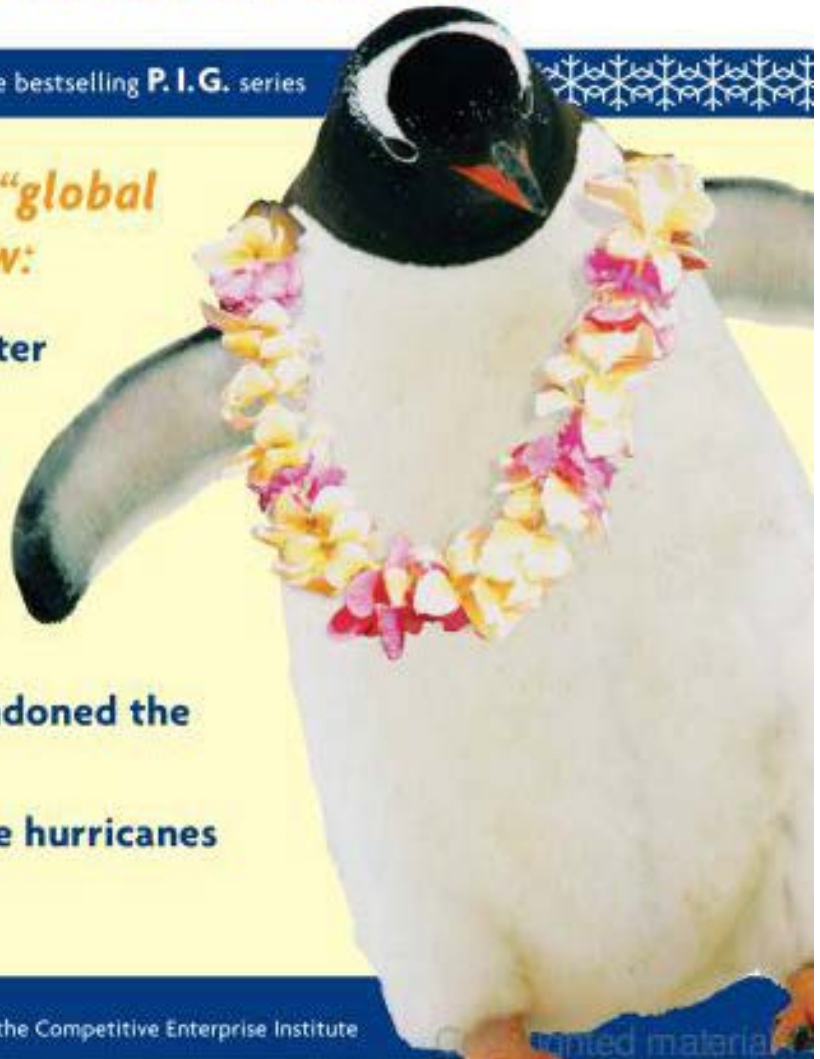
The Politically Incorrect Guide™ to GLOBAL WARMING and Environmentalism

A part of the bestselling P.I.G. series

You've heard plenty about "global warming." But did you know:

- The Earth has often been hotter than it is now
- Only a tiny portion of greenhouse gases are man-made
- Most of Antarctica is getting colder
- The media only recently abandoned the "global cooling" scare
- "Global warming" hasn't made hurricanes worse



Christopher C. Horner Senior Fellow at the Competitive Enterprise Institute

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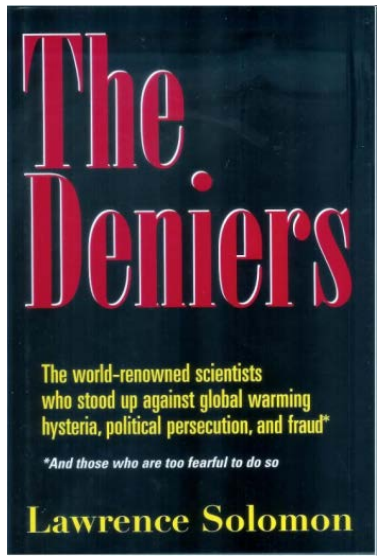

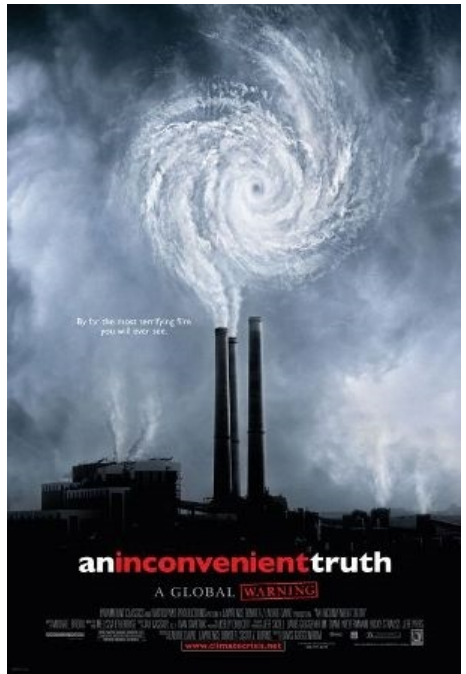

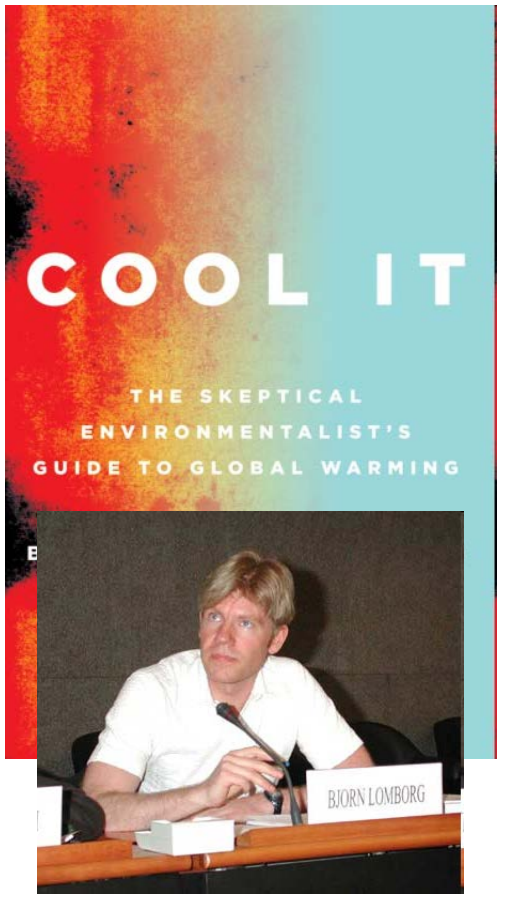

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Limits to Growth (Club of Rome)

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Estimated lifetimes[a] of selected resources at current world use rate

Resource	Meadows et al.,[b] 1972 (Static)	Meadows et al.,[b] 1972 (Exponential)	MMSD[c], 2002 USGS, 2005[d] (Static)
Aluminum	100	31	202[c], 16[d]
Chrome	420	95	48[d]
Cobalt	110	60	149[d]
Copper	36	21	28[c], 32[d]
Iron	240	93	132[c], 64[d]
Lead	26	21	21[c,d]
Mercury	13	13	69[d]
Nickel	150	53	41[c], 44[d]
Tin	17	15	37[c], 24[d]
Tungsten	40	28	48[d]
Zinc	23	18	25[c], 24[d]

ENERGY: Physical, Environmental, and Social Impact
(3rd ed.), Gordon J. Aubrecht

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World Marketed Energy Use 1990-2040

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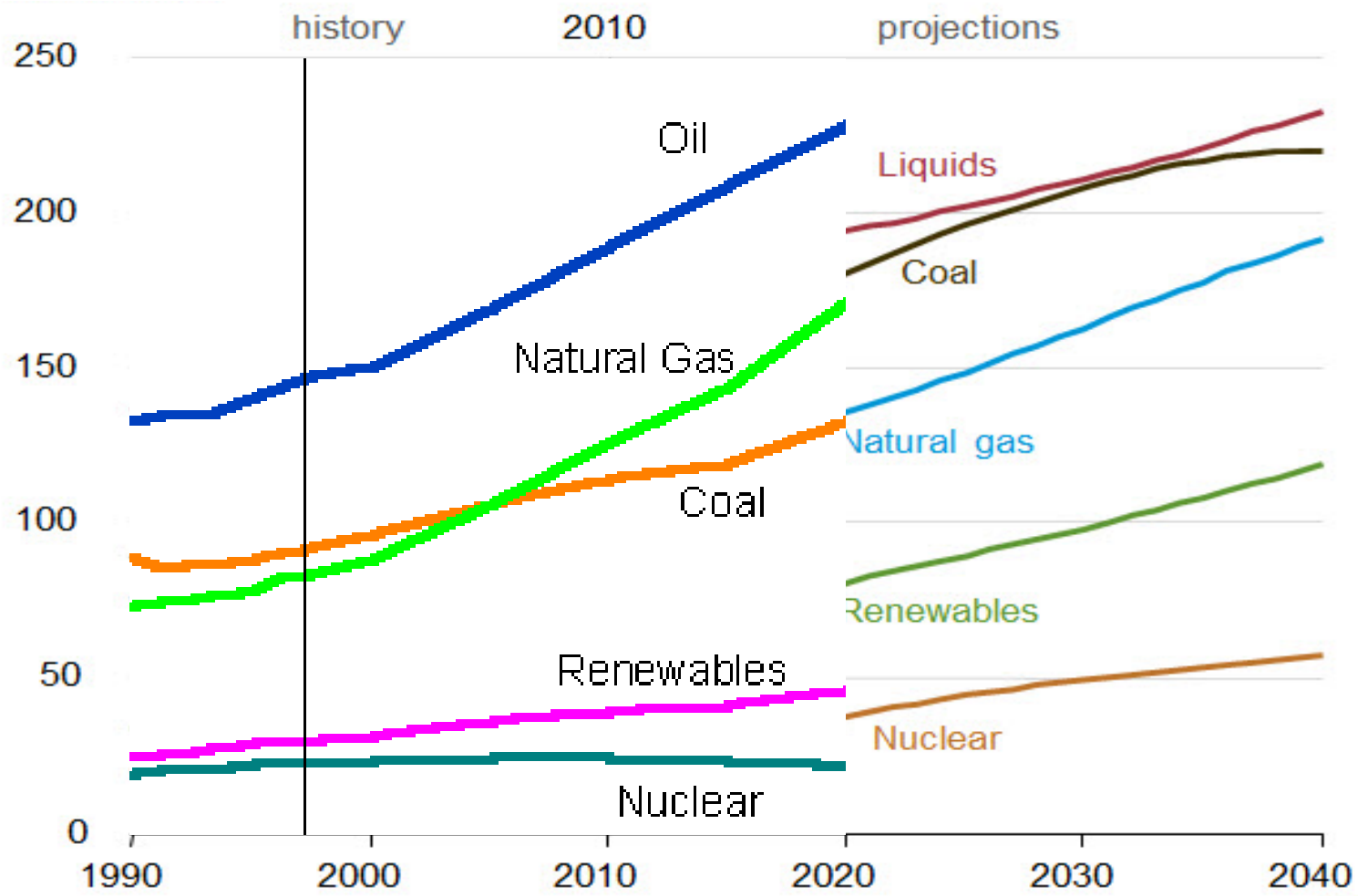
US Department of Energy;

Energy Information Administration (2013)

(2000)

1 Quad = 1.055 x 10^{18}J

13TW ***2050: 25-30TW***



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George Seurat

La Grande Jatte (Seine)

1889

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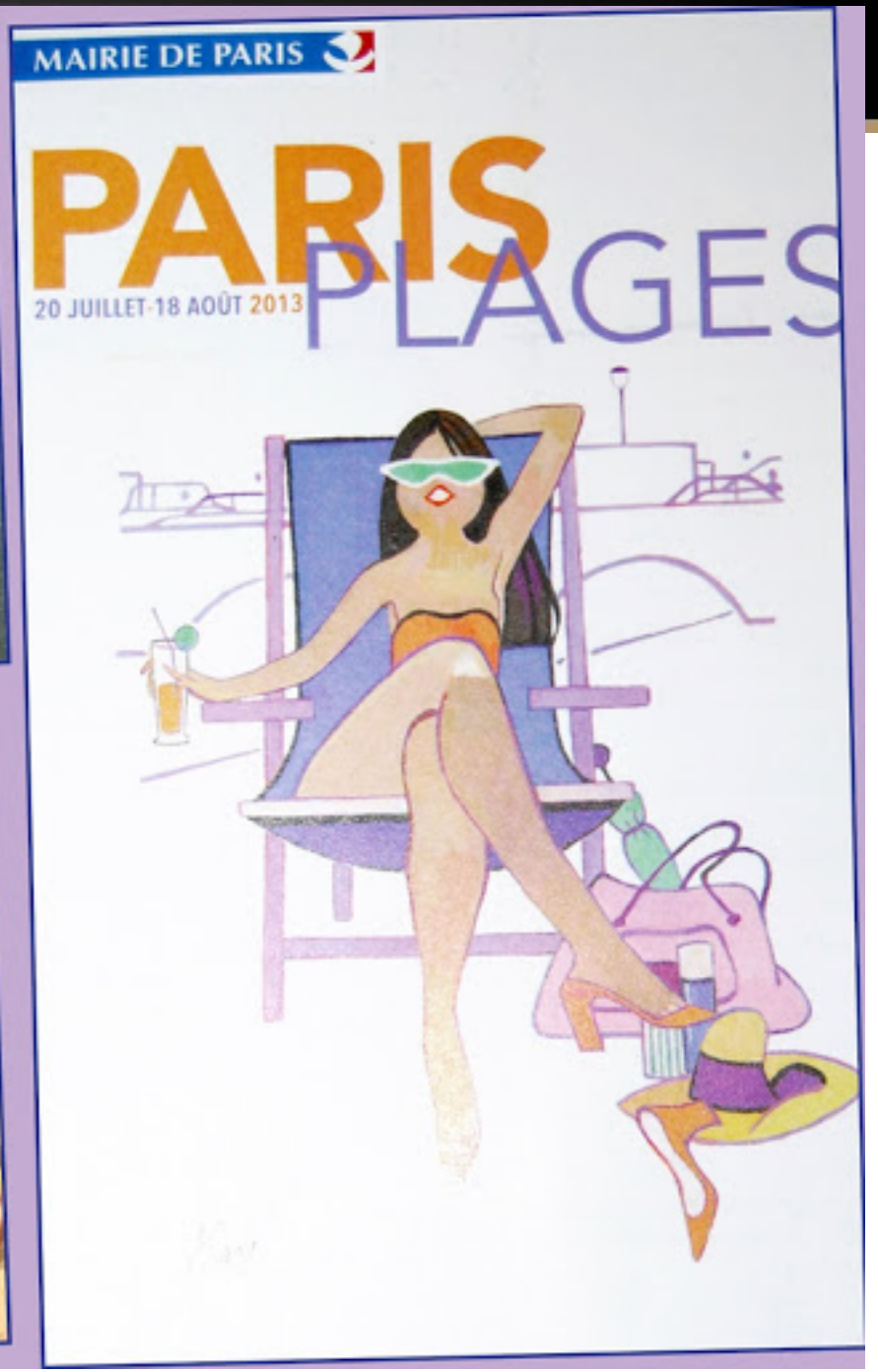

Paris Beach

2013

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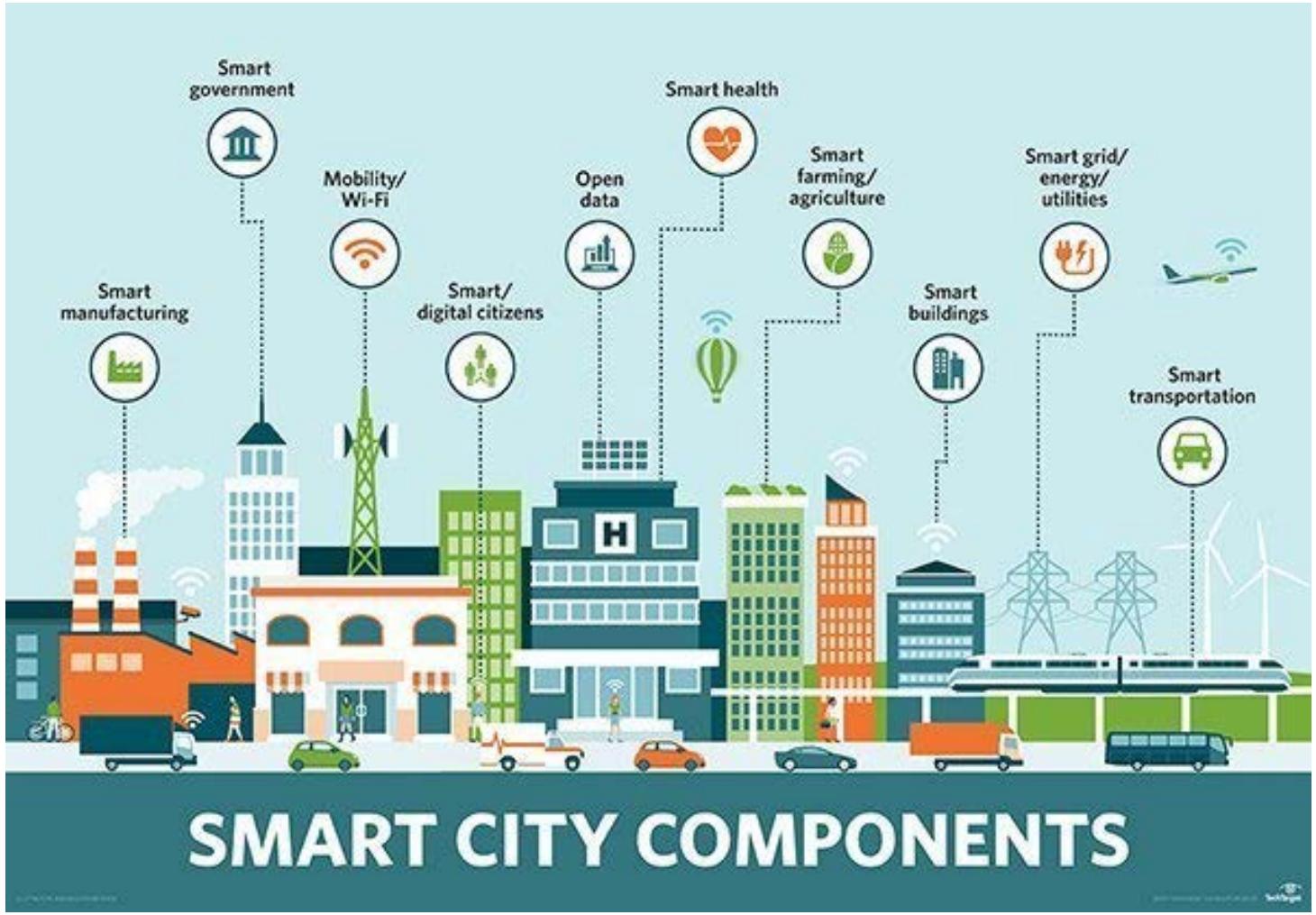
Future Smart Cities

Trend toward mega-cities



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Many SMART city initiatives in early 2000's aimed to mitigate deep problems in big cities! Solutions that only work when density of population is high.

- *Mid 2010's: Can we use IoT /connected communities to benefit from economy of scale without concentration/ traffic/ pollution?*

SMART Community in Discovery Park District

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400+ acre development
over 10 years,
$1B+ investment,
90,000 residents

150 1869 2019 YEARS OF GIANT LEAPS PURDUE UNIVERSITY

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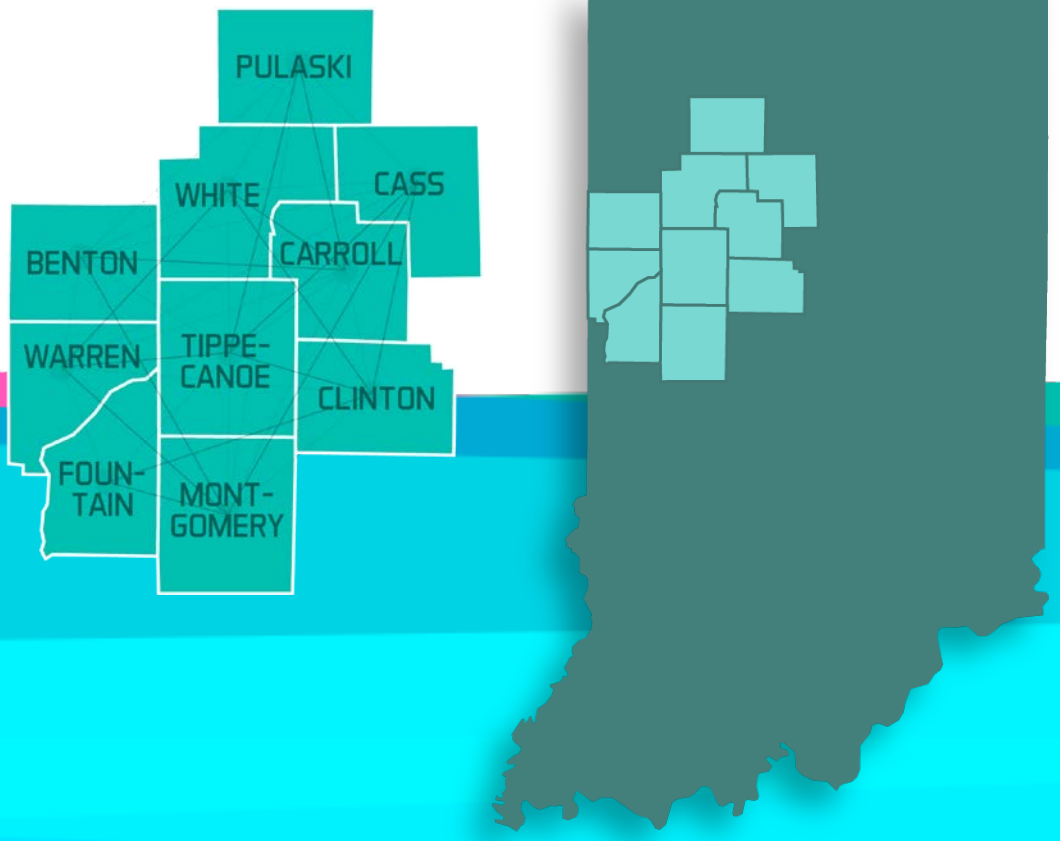
The Wabash Heartland Innovation Network

$38.9M, 2018-2022



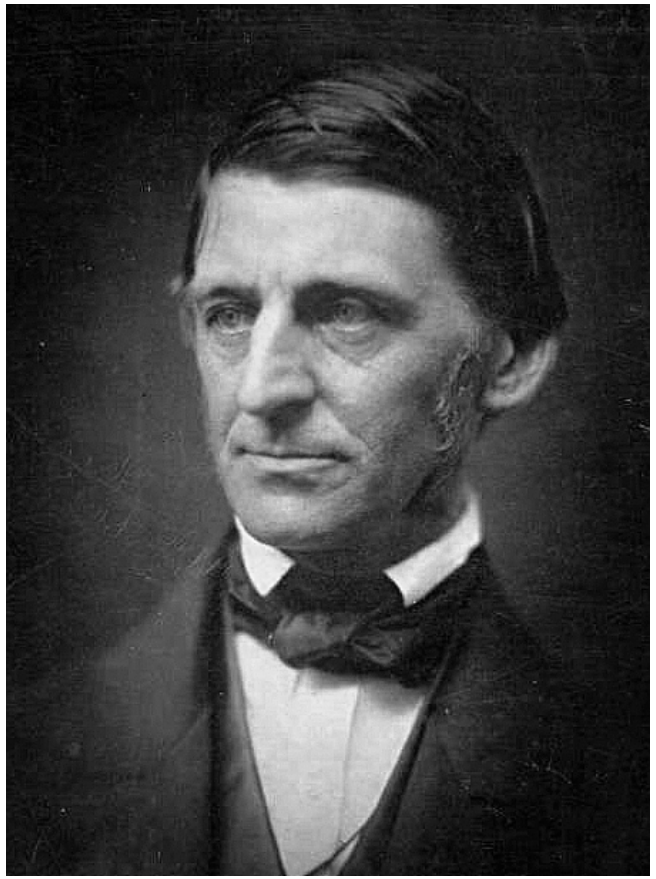
Create a living laboratory (community IoT testbed) in 10 counties:

- ***Population ~ 400,000***
- ***4000 farms***
- ***>250 small and medium manufacturers***

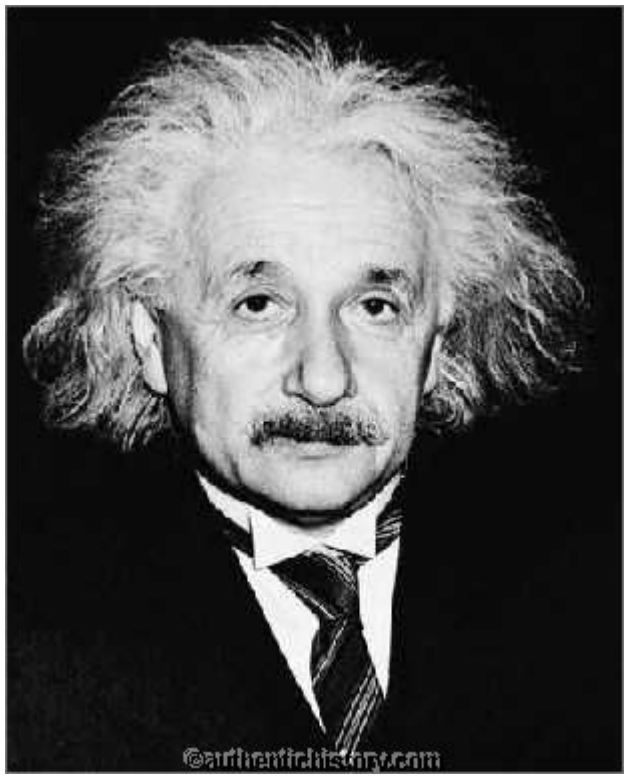
WHIN

Competition, Collaboration

There is no limit to what can be accomplished if it doesn't matter who gets the credit.



Ralph Waldo Emerson



1950's

A human being experiences himself separated from the rest — a kind of optical delusion of his consciousness.

This delusion is a kind of prison for us, restricting us to our personal desires and to affection for a few persons nearest to us.

Our task must be to free ourselves from this prison by widening our circle of compassion to embrace all living creatures and the whole of nature in its beauty.

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Background Slides

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A.N. Whitehead *(The Aims of Education; 1928)*

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- *Justification for a university: preserve the connection between knowledge and the zest of life, by uniting the young and the old in the imaginative consideration of learning.*
- *… This atmosphere of excitement, arising from imaginative consideration, transforms knowledge.*

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Some food for thought

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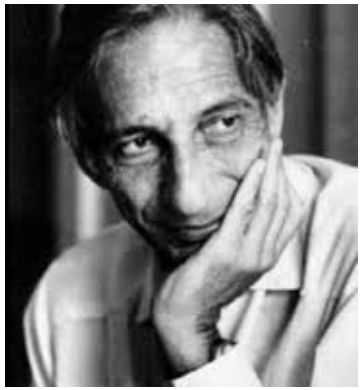
- **Russell Ackoff:** Idealized Design 2006: How Bell Labs Imagined — and Created — the Telephone System of the Future

- **Ivan Illich:** Deschooling Society 1972, Medical Nemesis 1975, …



- **Wendell Berry:** Unsettling of America 1972, The Art of Loading Brush 2017 (Letter to a Scientific Friend)

- **Christopher Alexander**: The Pattern Language 1977

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