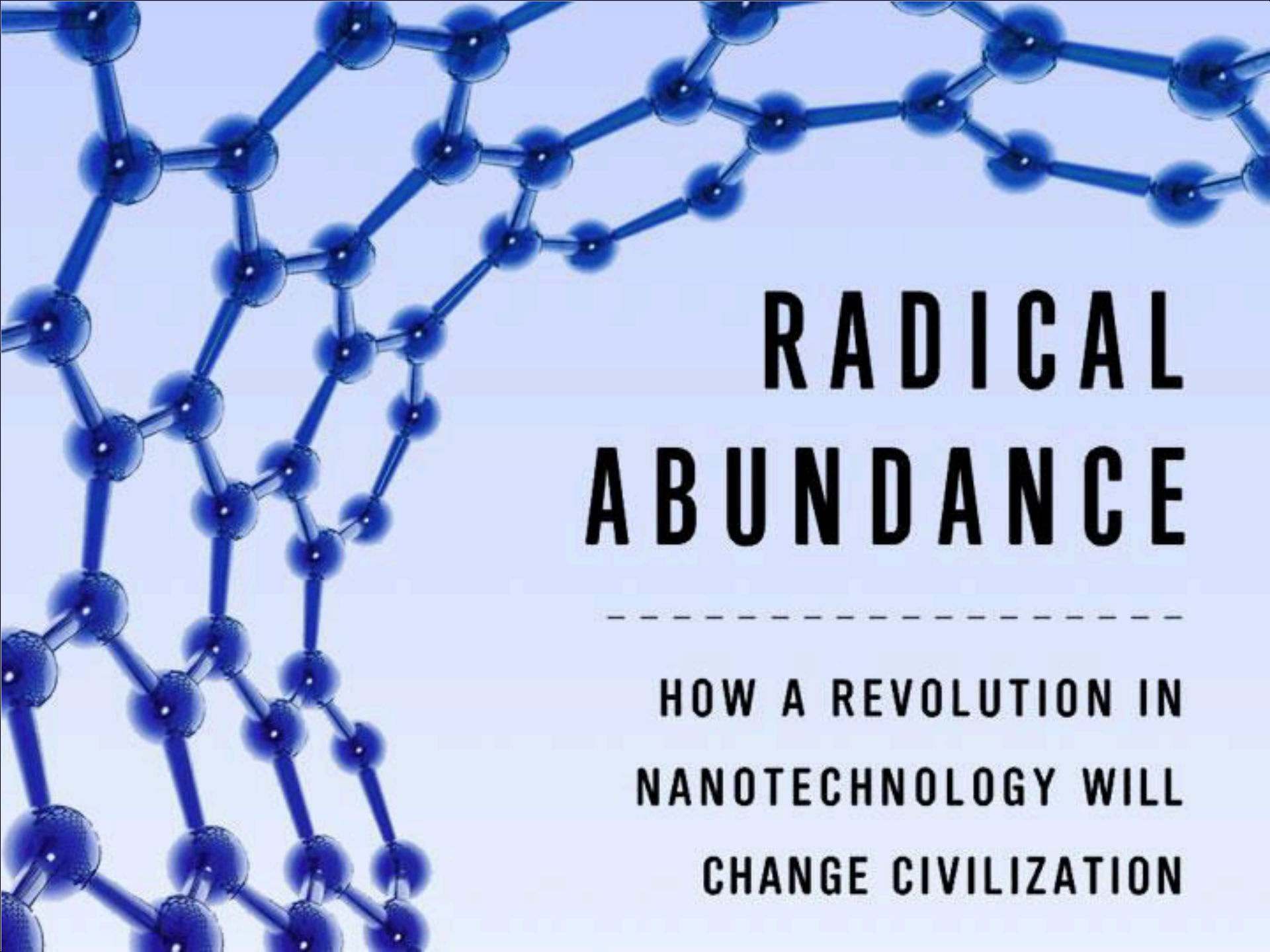


RADICAL ABUNDANCE

HOW A REVOLUTION IN NANOTECHNOLOGY WILL CHANGE CIVILIZATION

Different kinds of nanotechnology

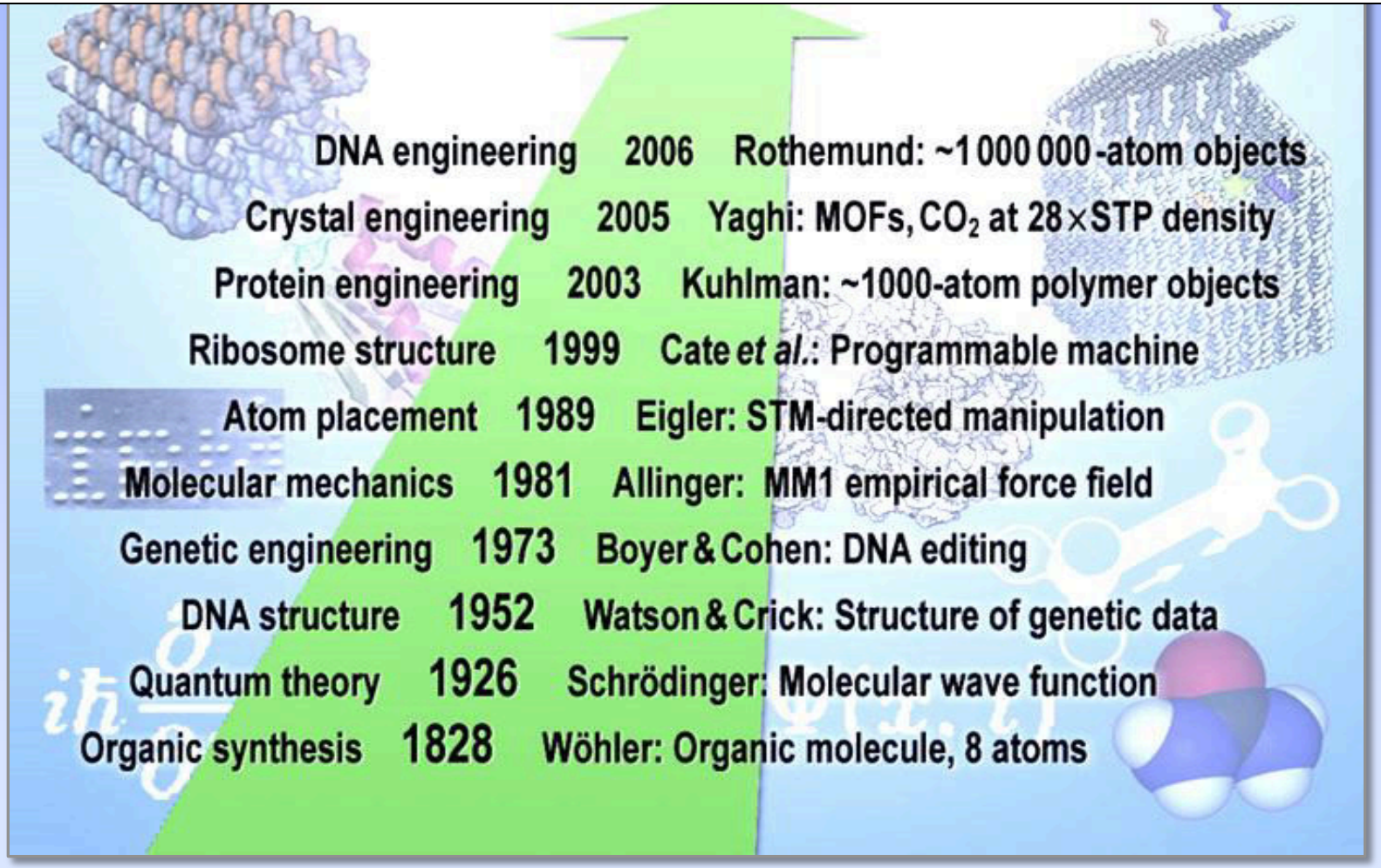
Materials and particles (SOCAR)

Electronic nanosystems (chips)

Mechanical nanosystems & APM

Progress in atomically precise *fabrication:*

Further on the road: Atomically Precise *Manufacturing*



Atomically Precise Manufacturing

How can we understand APM?

What will APM enable?

How can APM help solve global problems?

What are today's challenges?

Asking a different question about the future —

1) Predict specific scientific discoveries?

— *Unpredictable: future discoveries are unknown*

2) Predict specific technological developments?

— *Unpredictable: future inventions are unknown*

3) Predict specific winning technologies?

— *Unpredictable: future market outcomes are unknown*

Asking a different question about the future —

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— *Unpredictable: future inventions are unknown*

3) Predict specific winning technologies?

— *Unpredictable: future market outcomes are unknown*

4) Explore <u>timeless technological potential</u>?

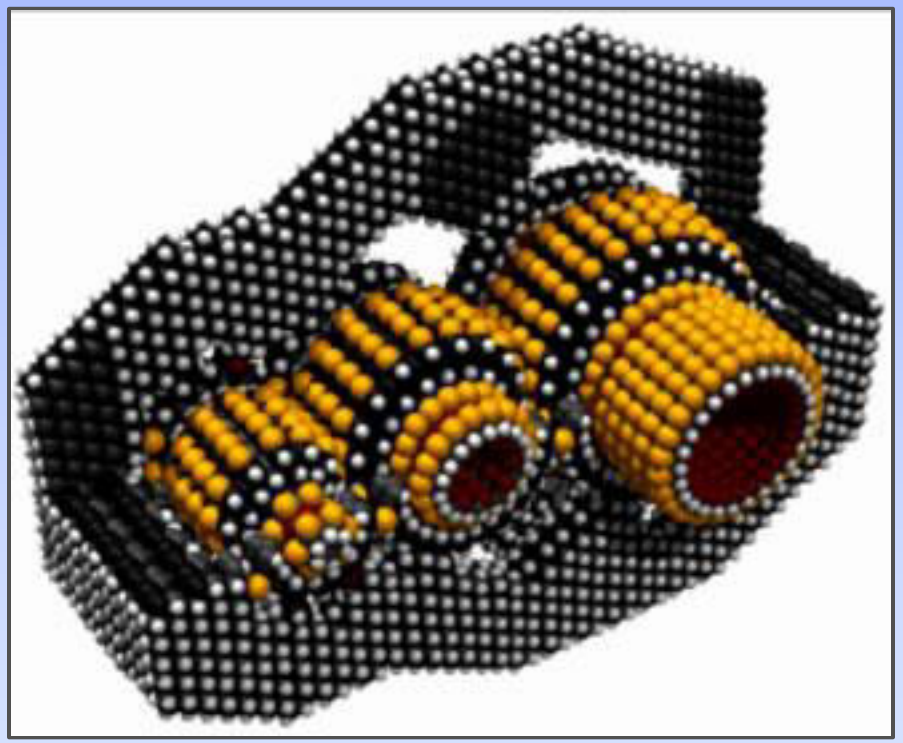
— Can find *reliable* answers to well-chosen questions:

apply textbook physics and engineering

principles (and then check the numbers)

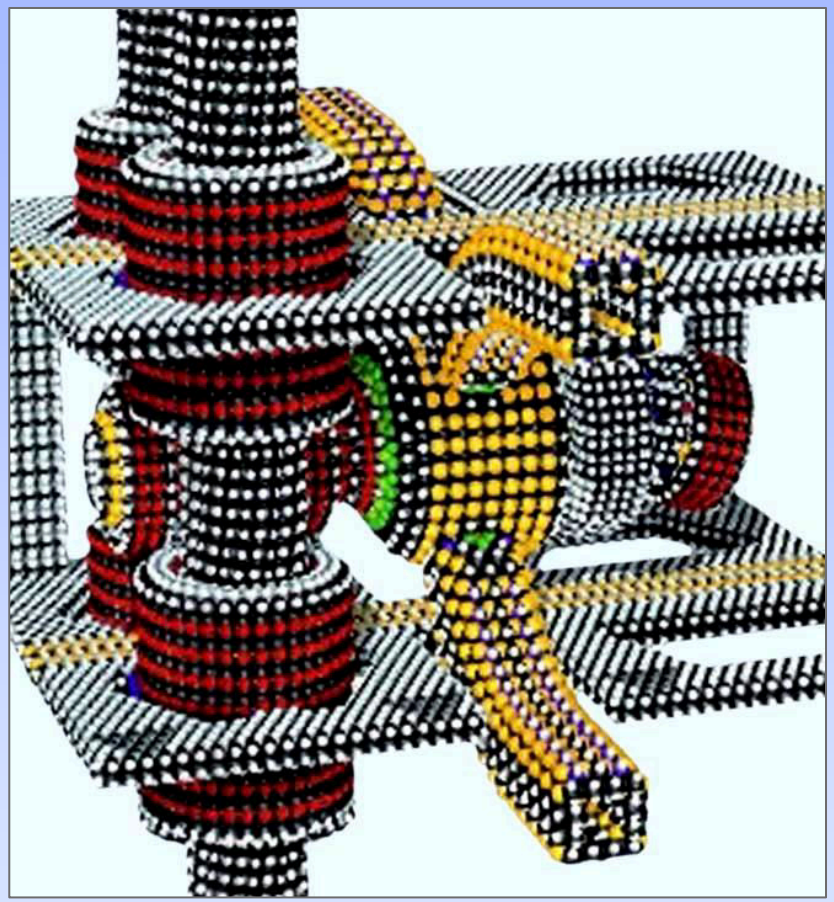
Exploring APM-level technologies:

Systems engineering and computational modeling



Modeling employs standard molecular-dynamics methods

Computational modeling and systems-level design



Machine components => APM

Factory-on-a-chip technologies

for general-purpose manufacturing

From simple substances to complex products

Atomically Precise Manufacturing

Precise:	controlled molecular encounters
Digital:	discrete, reliable operations
Fast:	millions of cycles per second
Clean:	control of all output materials
Efficient:	low resource consumption

- **Extremely high productivity**
- **Large scale, low cost**
- **Unprecedented products**

Millennium Project Global Challenges (8 of 14):

1. Enable sustainable global development while addressing global climate change
2. Ensure sufficient clean water
3. Balance population growth and resources
6. Ensure access to information technologies
7. Reduce the gap between rich and poor
8. Reduce the threat of emerging diseases
13. Meet growing energy demands
14. Accelerate technological breakthroughs

APM applications:

Energy: Solar photovoltaics, storage for base-load power, synthetic fuels (zero net carbon)

Transportation: Vehicles with high efficiency, high performance, and zero net carbon emissions

Clean water: Efficient purification/desalination, water-efficient enclosed agriculture

Information technologies: Extension of cost and performance trends far beyond current limits

Industrial production: Low scarce-resource demand, zero emissions, customized, decentralized

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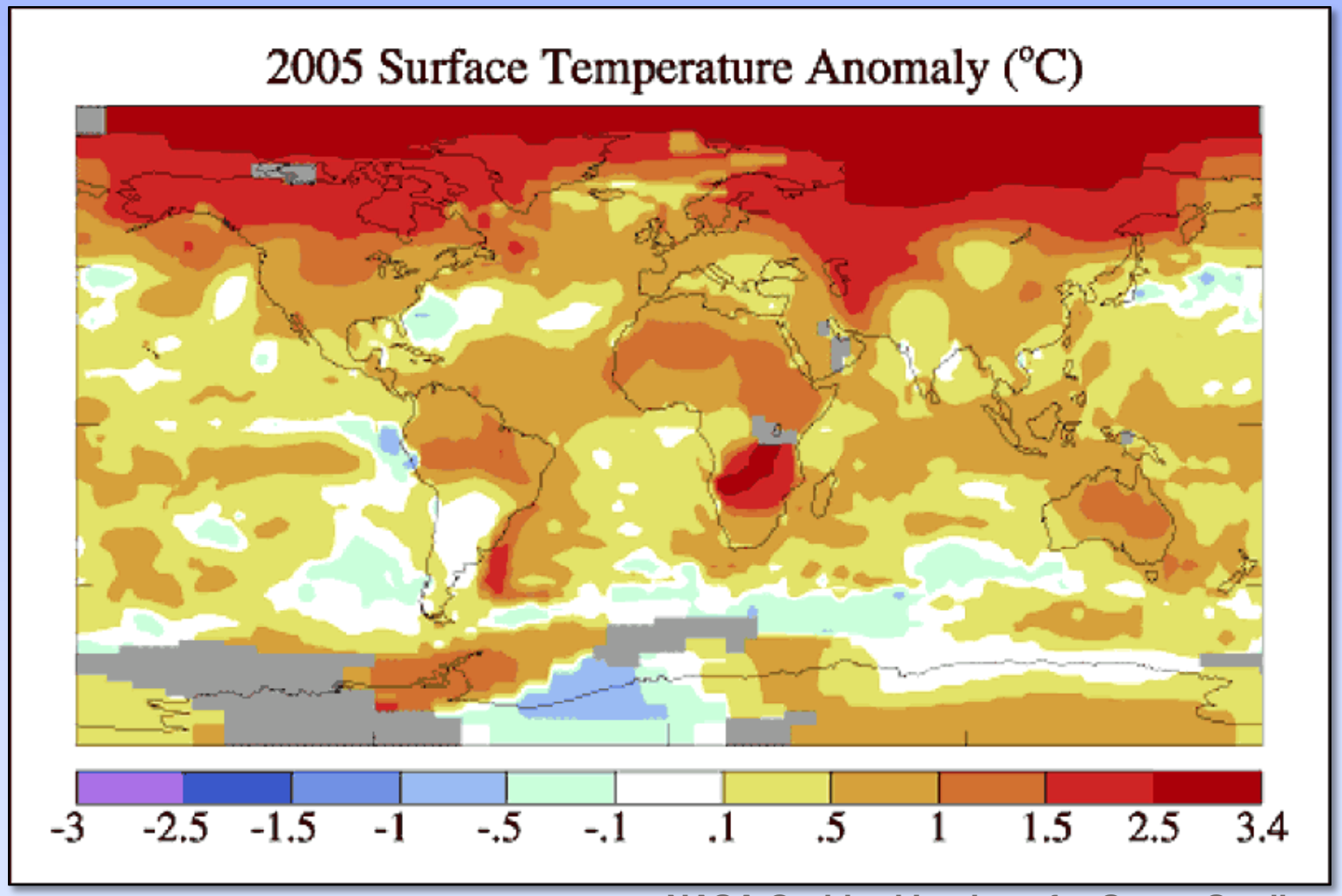
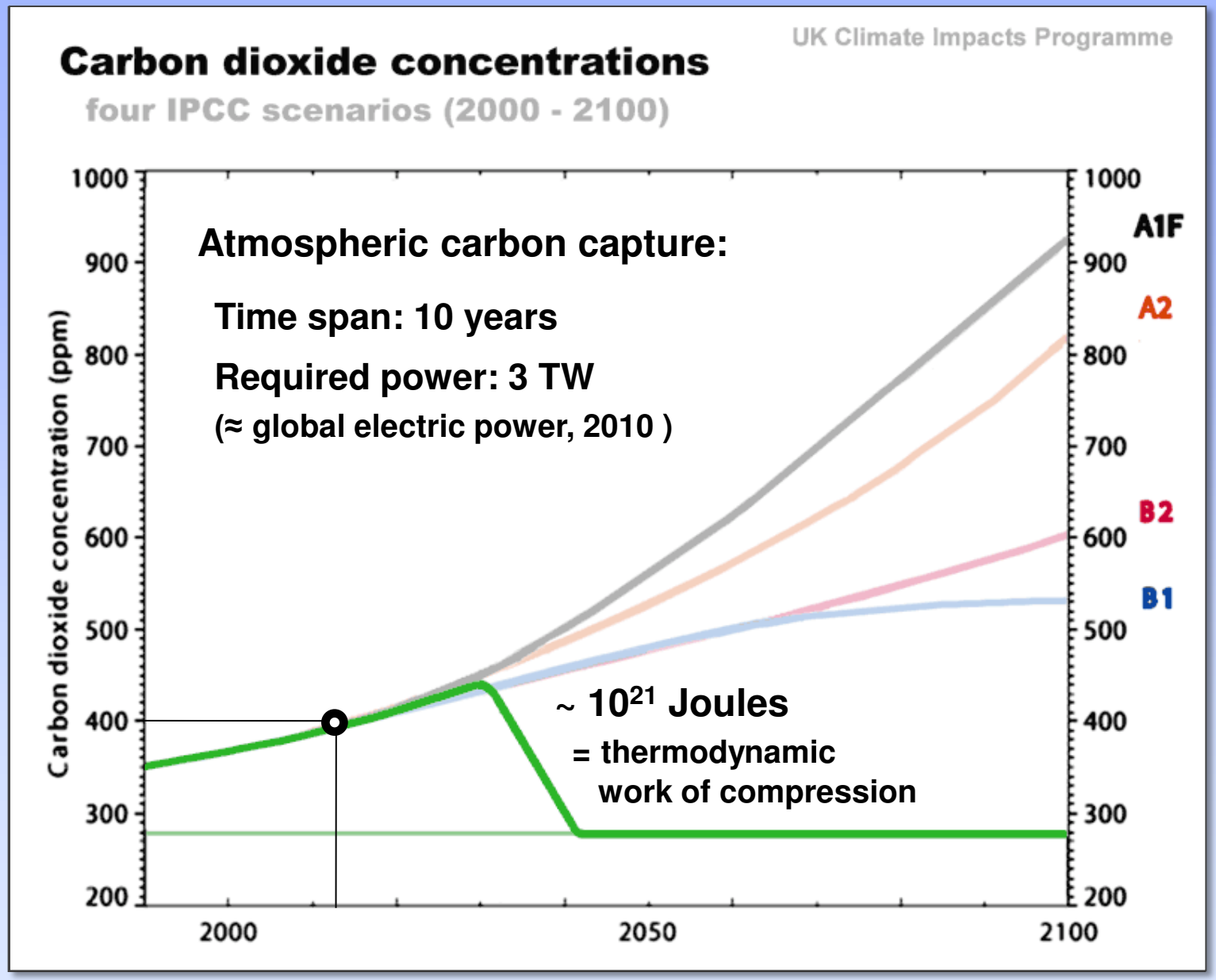
The trillion-ton greenhouse gas problem —



NASA Goddard Institute for Space Studies


Carbon dioxide concentrations
four IPCC scenarios (2000 - 2100)
UK Climate Impacts Programme
Atmospheric carbon capture:
Time span: 10 years
Required power: 3 TW
(≈ global electric power, 2010)
~ 10^21 Joules
= thermodynamic
work of compression
Carbon dioxide concentration (ppm)
1000
900
800
700
600
500
400
300
200
2000
2050
2100
A1F
A2
B2
B1

3 terawatts, equivalent solar array area:

APM, Azerbaijan, and the post-oil economy:

- **Will enable a decisive global shift to renewables**
- **Will reduce requirements for imports**
- **Will reduce requirements for exports**

APM, Azerbaijan, and the post-oil economy:

Will enable a decisive global shift to renewables

Will reduce requirements for imports

Will reduce requirements for exports

Will change the global situation:

- **Economic organization**
- **Environmental challenges**
- **Security concerns**

New challenges

New opportunities

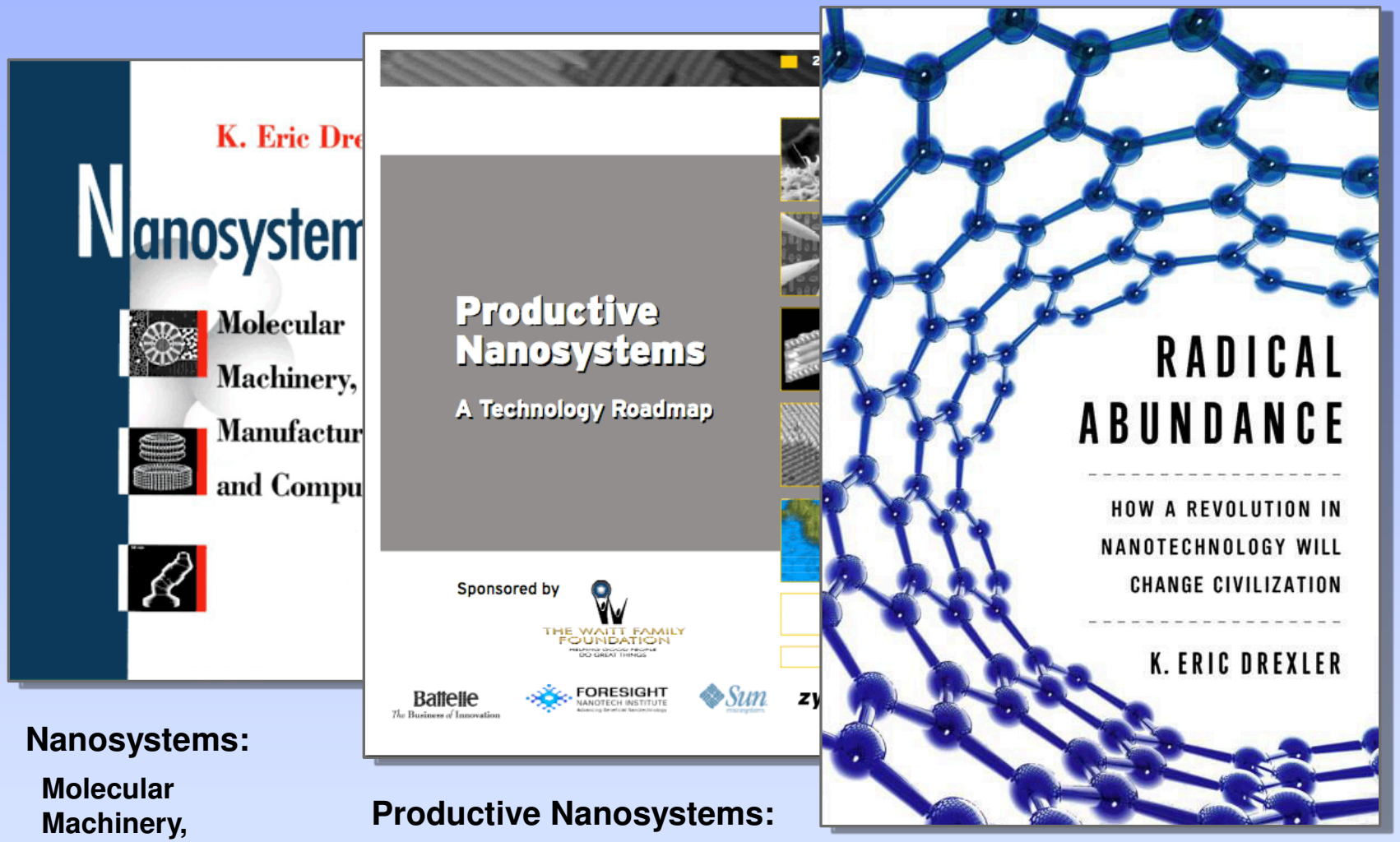
New questions

New challenges

New opportunities

New questions

A different *kind* of future



Nanosystems:

Molecular Machinery, Manufacturing, and Computation

Wiley/Interscience

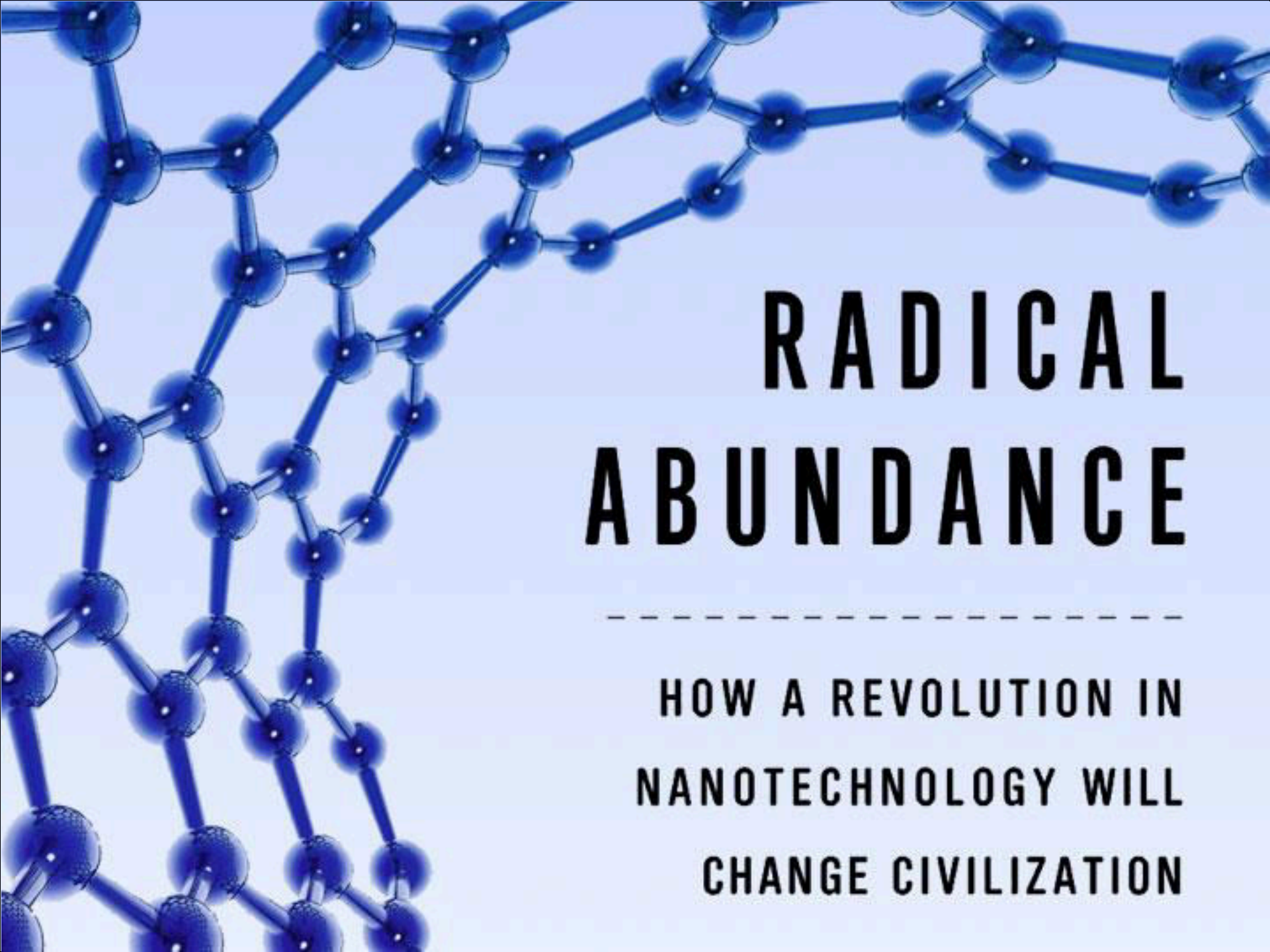
Productive Nanosystems:

A Technology Roadmap

Battelle / US National Labs (ProductiveNanosystems.com)

Radical Abundance

PublicAffairs / Perseus Books



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