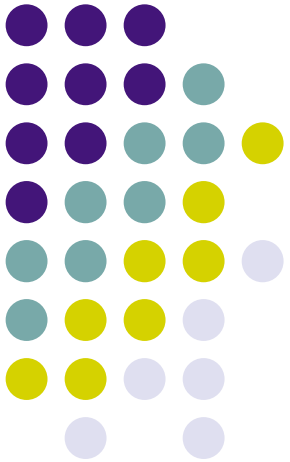
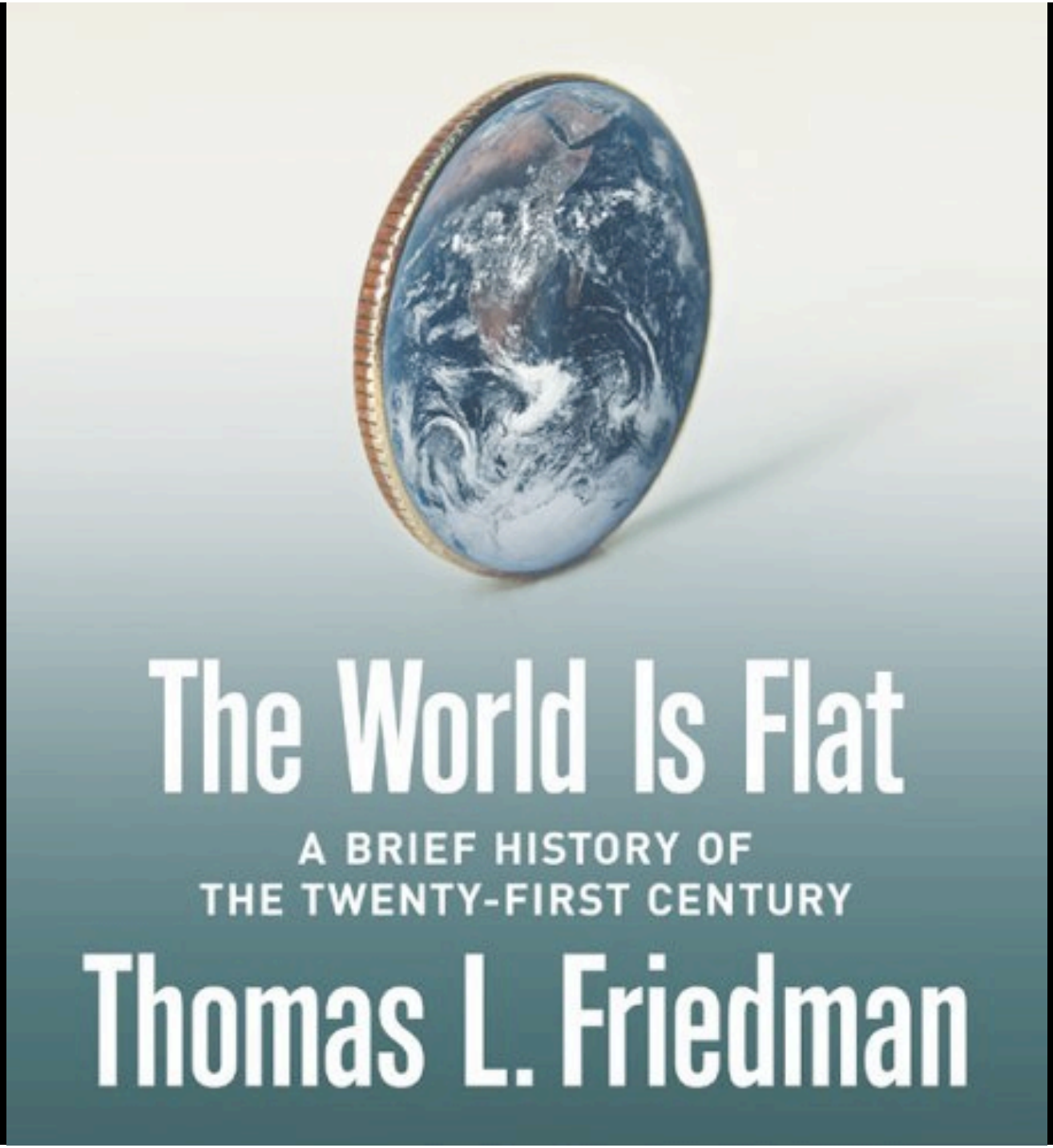
21st Century Engineering




The World Is Flat
A BRIEF HISTORY OF
THE TWENTY-FIRST CENTURY
Thomas L. Friedman

National Innovation
- NII Interim Report
- Background Documents
- Building Technical Talent

Regional Innovation

High Performance Computing

Global Initiatives

Competitiveness & Security

Benchmarking Competitiveness

World Class Workforce

Congressional Outreach

National Innovation

National Innovation Initiative

NII Working Group Web Portal

Vision

Innovation fosters the new ideas, technologies, and processes that lead to better jobs, higher wages and a higher standard of living. For advanced industrial nations no longer able to compete on cost, the capacity to innovate is the most critical element in sustaining competitiveness.

The United States stands apart from the rest of the world in its record of sustained innovation over decades, across industries, and through economic cycles. Why? What has made the United States an engine of innovation? A number of structural and economic advantages help explain this performance, including:

- Ready access to natural resources and labor
- The skills and work ethic of American workers
- Strong capital markets, a long tradition of the rule of law, a deep commitment to property rights, and a culture that encourages and rewards risk-takers
- A unique system of cooperation and collaboration among the federal government, national and military labs, private-sector R&D efforts, research universities and entrepreneurs

News

October 1, 2004
NII Co-Chairs Share Innovation Vision with BusinessWeek

September 30, 2004
Associated Press -- National Innovation Initiative heads expect recommendations to set agenda

September 30, 2004
Professional science master's can fill gaps in federal scientific workforce, Sloan's Teitelbaum says

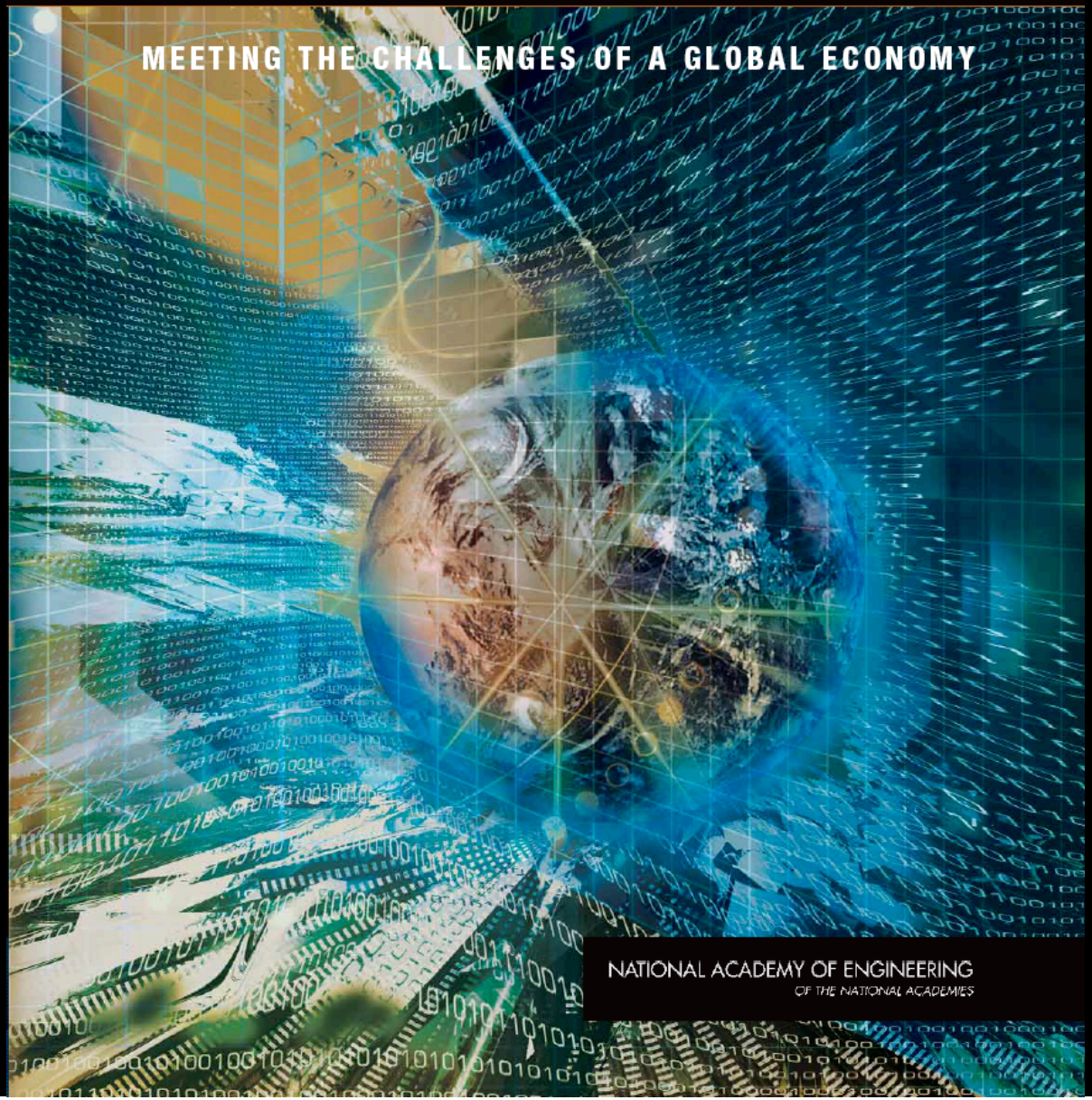
August 16, 2004
American Physical Society -- Workforce Issues Dominate Policy Briefing

July 30, 2004
California Computer News -- Innovate America...

July 22, 2004
Council On

ENGINEERING RESEARCH AND AMERICA'S FUTURE

MEETING THE CHALLENGES OF A GLOBAL ECONOMY



NATIONAL ACADEMY OF ENGINEERING
OF THE NATIONAL ACADEMIES

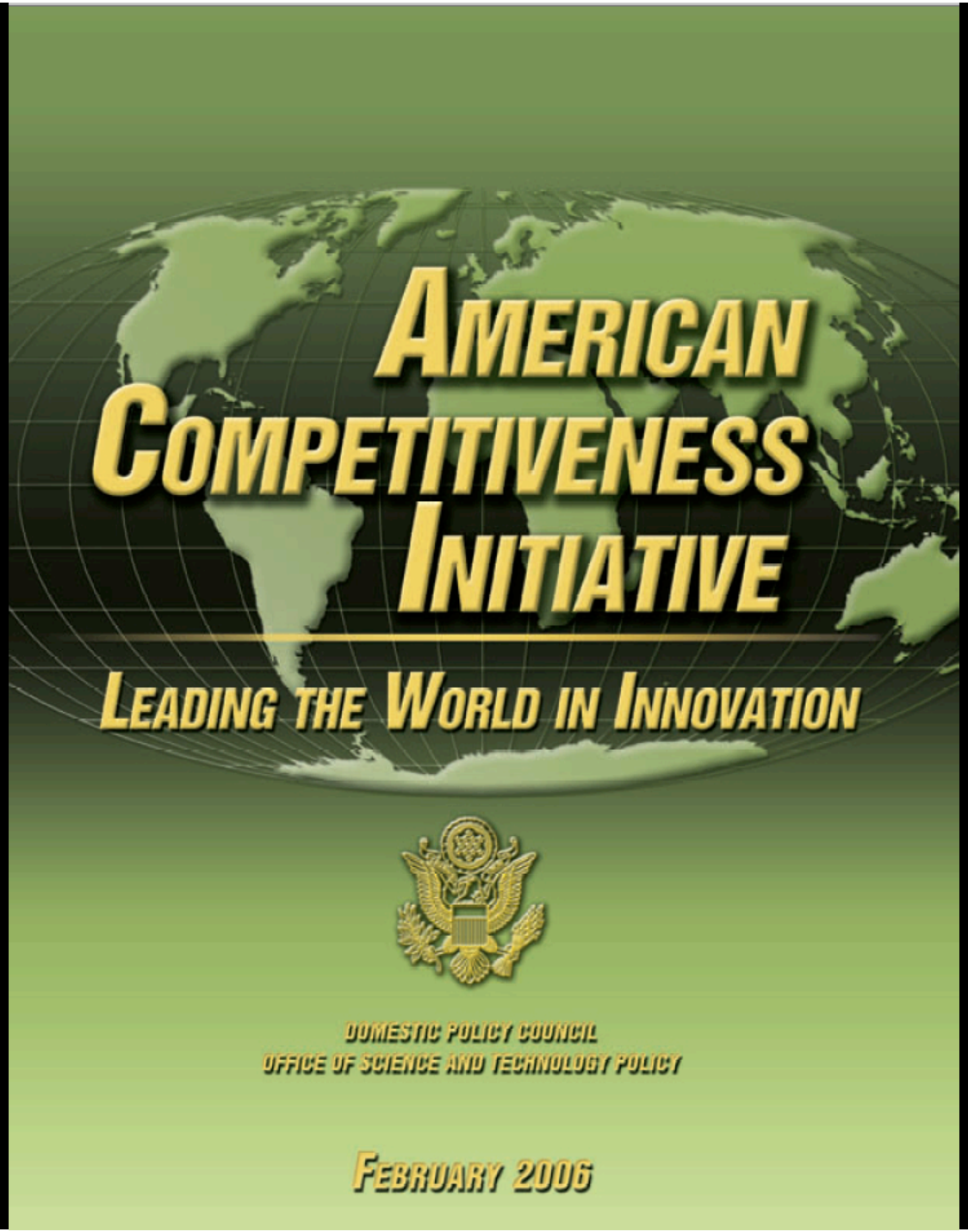
EXECUTIVE SUMMARY

Prepublication Copy

RISING ABOVE THE GATHERING STORM

Energizing and Employing America for a Brighter Economic Future

NATIONAL ACADEMY OF SCIENCES,
NATIONAL ACADEMY OF ENGINEERING, AND
INSTITUTE OF MEDICINE
OF THE NATIONAL ACADEMIES


AMERICAN COMPETITIVENESS INITIATIVE
LEADING THE WORLD IN INNOVATION
DOMESTIC POLICY COUNCIL
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
FEBRUARY 2006

[redacted]

109th CONGRESS
2d Session

S. 2197

To improve the global competitiveness of the United States in science and energy technology, to strengthen basic research programs at the Department of Energy, and to provide support for mathematics and science education at all levels through the resources available through the Department of Energy, including at the National Laboratories.

IN THE SENATE OF THE UNITED STATES

January 26, 2006

Mr. DOMENICI (for himself, Mr. BINGAMAN, Mr. ALEXANDER, Ms. MIKULSKI, Mr. LUGAR, Mr. DODD, Mr. HATCH, Mr. OBAMA, Mr. WARNER, Mr. LIEBERMAN, Mr. BOND, Mrs. MURRAY, Mr. BURNS, Mr. BAYH, Mr. CRAIG, Ms. CANTWELL, Mrs. HUTCHISON, Mr. MENENDEZ, Mr. DEWINE, Mr. KOHL, Mr. THOMAS, Mr. KERRY, Mr. SMITH, Mr. NELSON of Florida, Mr. VOINOVICH, Mr. LEAHY, Mr. ALLEN, Mr. AKAKA, Mr. TALENT, Mrs. CLINTON, Mr. CHAMBLISS, Ms. STABENOW, Mr. CORNYN, Mr. DAYTON, Mr. COLEMAN, Mr. SALAZAR, Mr. MARTINEZ, Mr. INOUYE, Mr. STEVENS, Mr. BIDEN, Mr. COCHRAN, Mr. HAGEL, Ms. MURKOWSKI, Mr. PRYOR, Ms. COLLINS, Mr. VITTER, and Ms. LANDRIEU) introduced the following bill; which was read twice and referred to the Committee on Energy and Natural Resources

---

A BILL

To improve the global competitiveness of the United States in science and energy technology, to strengthen basic research programs at the Department of Energy, and to provide support for mathematics and science education at all levels through the resources available through the Department of Energy, including at the National Laboratories.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

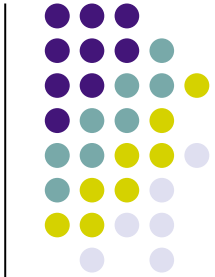
SECTION 1. SHORT TITLE.

This Act may be cited as the `Protecting America's Competitive Edge Through Energy Act of 2006' or the `PACE-Energy Act'.

SEC. 2. MATHEMATICS, SCIENCE, AND ENGINEERING EDUCATION AT THE DEPARTMENT OF ENERGY.

[redacted]

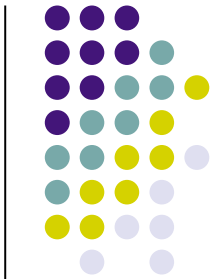
A quote …



“The problem with our time is that the future is not what it used to be…”

Paul Valery

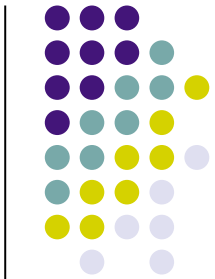
21st Century Challenges



- The Age of Knowledge
- Demographics
- Globalization
- Energy
- Global Sustainability
- Exponentiating Technologies
- The Singularity

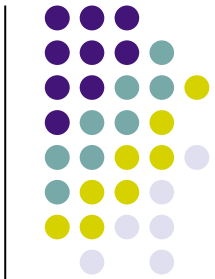

The Age of Knowledge

The Age of Knowledge



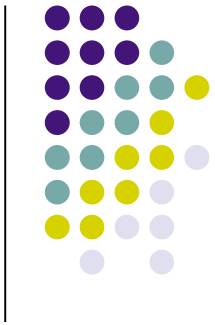
- Today we are evolving rapidly into a post-industrial, knowledge-based society, a shift in culture and technology as profound as the shift that took place a century ago when our agrarian societies evolved into industrial nations.
- Industrial production is steadily shifting from material- and labor-intensive products and processes to knowledge-intensive products and services.

The Age of Knowledge



- A radically new system for creating wealth has evolved that depends upon the creation and application of new knowledge.
- In this "Age of Knowledge", the key strategic resource necessary for economic prosperity and national security has become knowledge itself–educated people and their ideas.

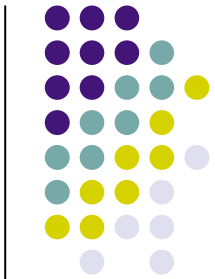
But…



- But unlike natural resources such as oil or iron that have driven earlier economic transformations, knowledge is inexhaustible. The more it is used, the more it multiplies and expands.
- But knowledge can be created, absorbed, and applied only by the educated mind.
- Hence the true wealth of nations in a global, knowledge-driven society has become human capital: educated people!


Demographics

Aging Populations



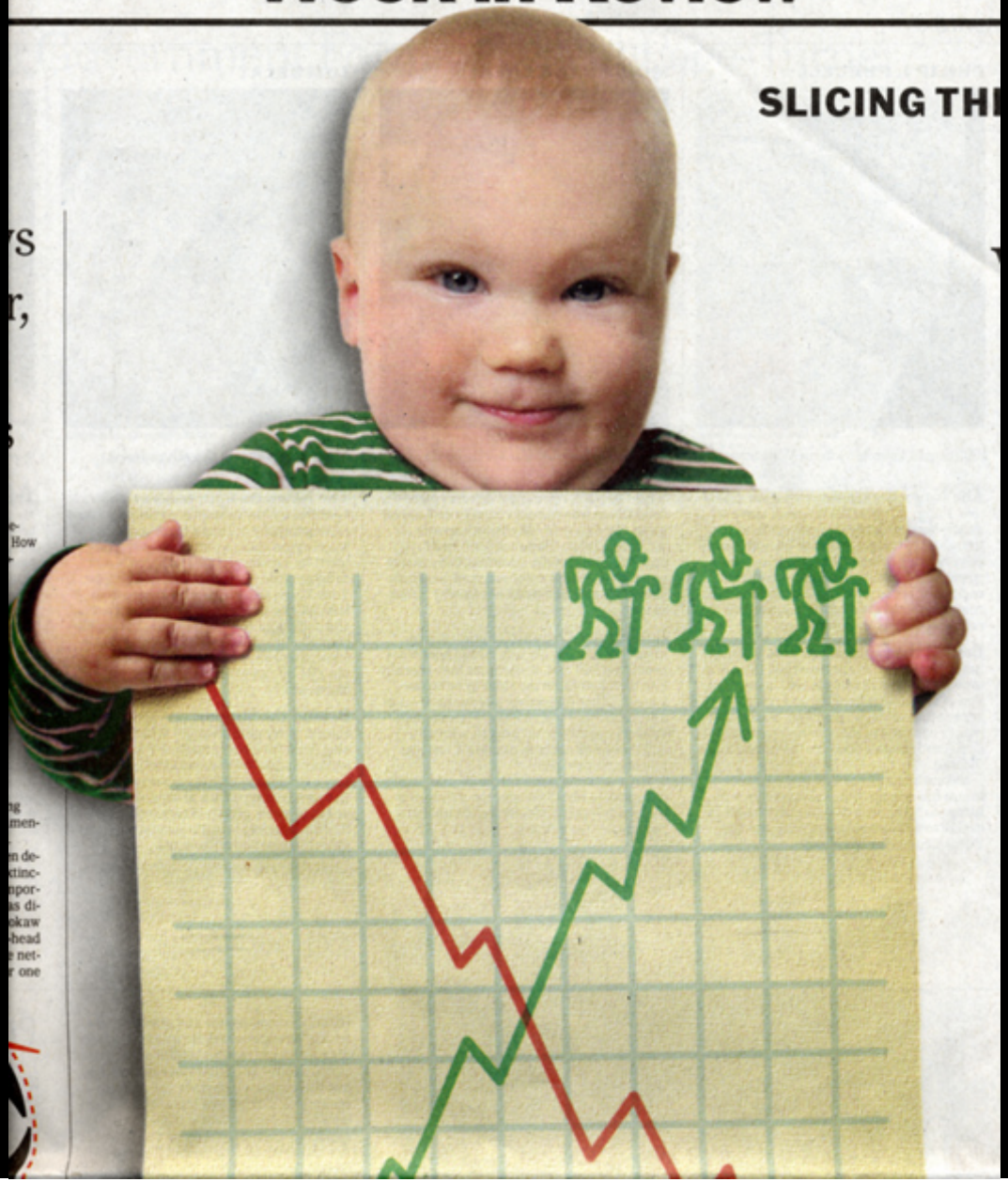
- Over the next decade the percentage of the population over the age of 60 will grow to v over 30% to 40% in the U.S., Europe, and parts of Asia.
- Half of the world's population lives in countries where fertility rates are not sufficient to replace their current populations.
- Aging populations and shrinking work forces will have an important impact, particularly in Europe, Russia, and some Asian nations such as Japan, South Korea, and Singapore.

Pages 11-13

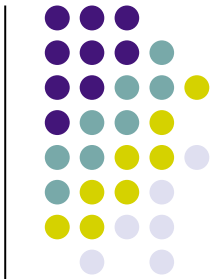
The New York Times

Week in Review

SLICING THI

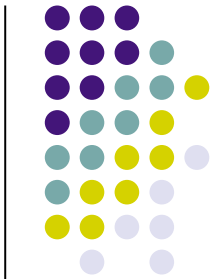


The United States



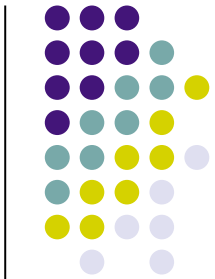
- The U.S. will be one of the few developed nations with a growing population, estimated to grow from 300 M to over 450 M by 2050 because of immigration from Latin America and Asia.
- However a growing population of aging voters will increasingly focus national priorities on the concerns of the elderly (e.g., health care, tax relief) rather than the needs of the young (e.g., education).

The United States (cont)



- Immigration will continue to diversify the American population with respect to race, ethnicity, and nationality, posing significant social and political challenges.
- Clearly the future of our nation depends on its capacity to draw strength from diversity, but political and economic barriers will continue to exist for many underrepresented populations.

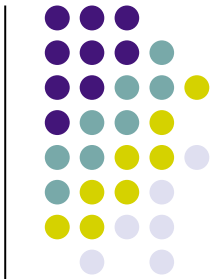
The Developing World



- Most population will occur in the developing world with high fertility rates–Africa, Latin America, Asia–where the average age is less than 20 (with over 2 B teenagers).
- Unless the world can provide this rapidly growing population with the education necessary to compete in and survive in a global economy, the resulting despair and hopelessness among the young will continue to feed the terrorism that so threatens our world today.

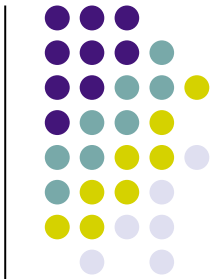

Globalization

Globalization



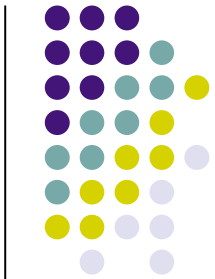
- "We see globalization–the growing interconnectedness reflected in the expanded flows of information, technology, capital, goods, services, and people throughout the world–as an overarching mega-trend, a force so ubiquitous that it will substantially shape all the other major trends in the world of 2020."
  - National Intelligence Council Project 2020

In 2020…



- China's GNP will exceed that of all individual western economic powers except for the U.S. India's GNP will be larger than European economies.
- Sheer size of China's and India's population (1.4 B and 1.3 B) along will make them powerful economies.
- The Asian mega-market–China, India, Russia, Korea, etc.–could become dominant–particular in human capital.

The Importance of Technology

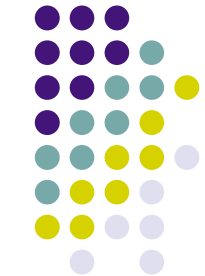


"The greatest benefits of globalization will accrue to countries and groups that can access and adopt new technologies. Indeed, a nation's level of technological achievement generally will be defined in terms of its investment in integration and applying the new, globally available technologies."

"China and India are well-positioned to become technology leaders, particularly in the next revolution of high technology involving the convergence of info-, bio-, and nano-technology."

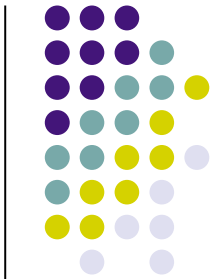

Dulux
KENWOOD
HTTP://DESK.XXINFO.HR.CN

An Example: "Off-Shoring"



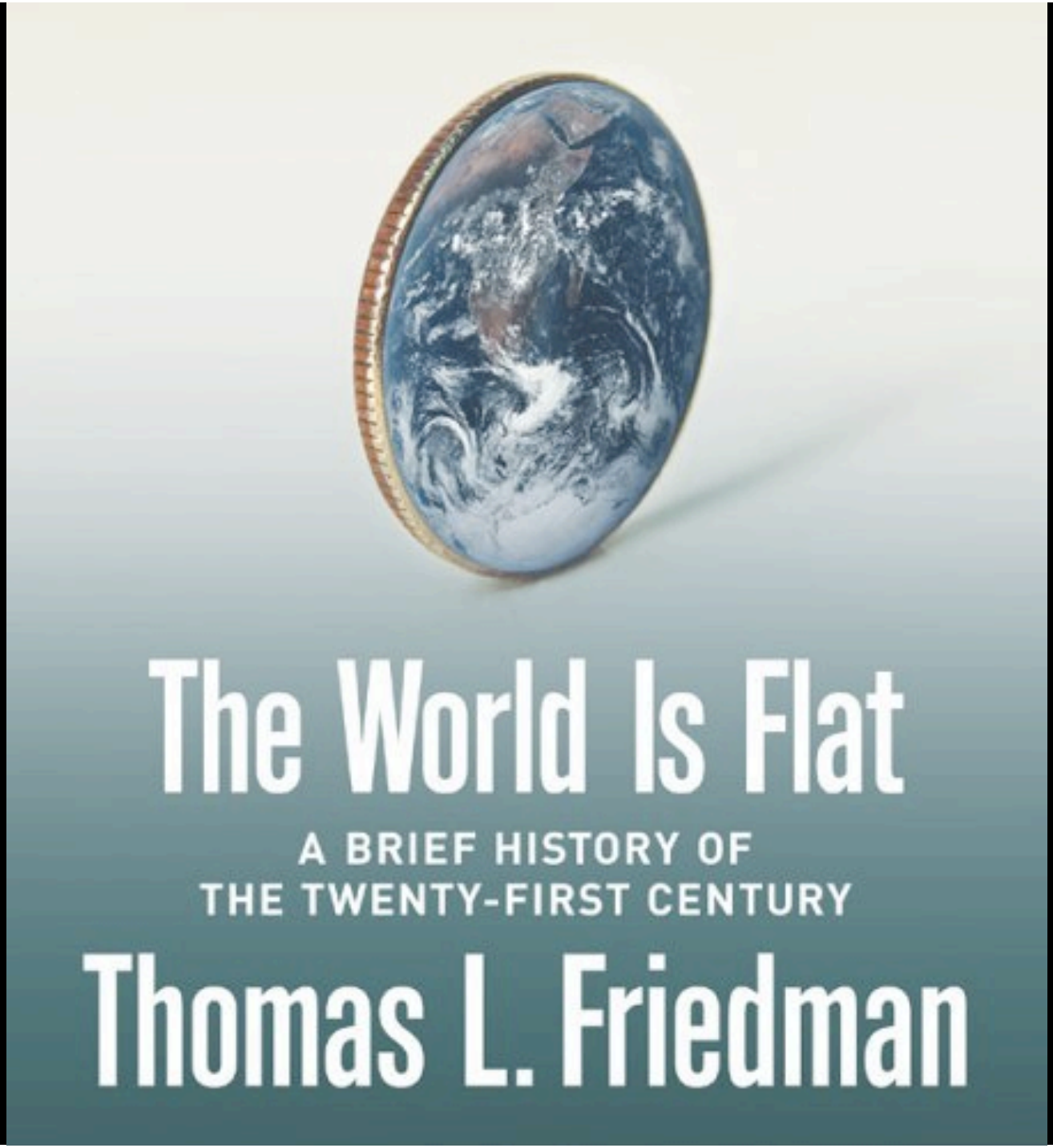
- U.S. has already lost most low skill, high pay jobs in manufacturing to Asia and Latin America ("out-sourcing"
- Today it is losing high tech jobs to India and China ("off-shoring")
- Tomorrow, the convergence of the gigantic source of human capital represented by India, China, and Russia threatens will have serious implications for sustaining our standard of living
- (We cannot maintain prosperity by just mowing each other's lawns…)

The Developed Nations



The transition to a global, knowledge-driven economy will not be painless, and it will hit the middle classes of the developed world in particular, bringing more rapid job turnover and requiring professional retooling. Outsourcing and off-shoring on a massive scale will be disruptive.

Example: Compensation levels in China and India for engineers are roughly one-fifth those in the U.S. How can American engineers produce FIVE TIMES the value-added necessary to be competitive in the global marketplace?


The World Is Flat
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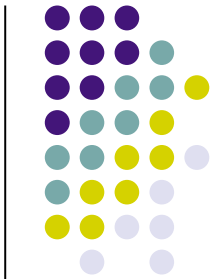
Tom Friedman



"The playing field is being leveled. Some three billion people who were out of the game have walked and often ran onto a level playing field, from China, India, Russia, and Central Europe, nations with rich educational heritages. It is this convergence of new players, on a new playing field, developing new processes for horizontal collaboration, that I believe is the most important force shaping global economics and politics in the early 21st century."


Energy

The Current Situation

Importance of energy:

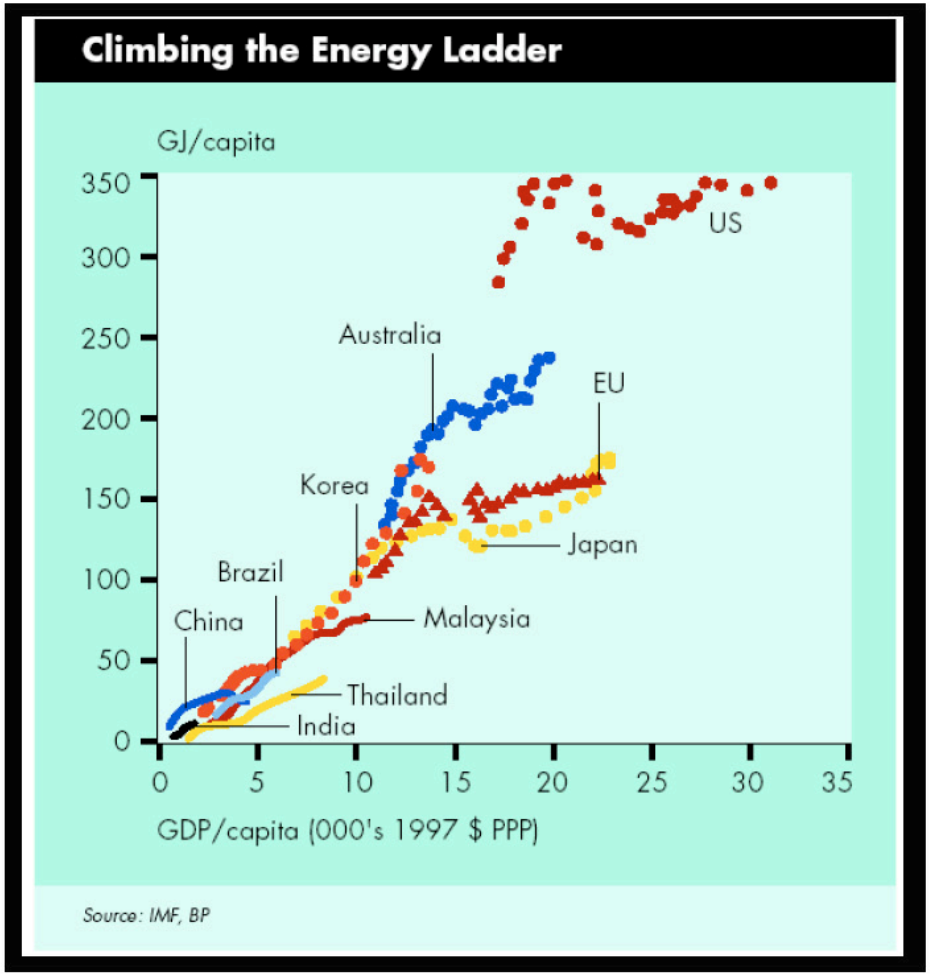
Energy costs typically absorb 7 to 10% of the cost of living (and are key factors in inflation and recession).

Energy is a major contributor to dangerous and complex environmental problems at every scale.

Energy issues can trigger issues in international security, from conflict over oil and gas reserves to nuclear weapons proliferation.

In 2000, more than 75% of world's energy was produced from fossil fuels.

Economic Prosperity Requires Reliable and Affordable Energy



Source: Royal Dutch Shell, "Exploring the Future – Energy Needs, Choices and Possibilities"

Sandia National Laboratories

Oil and gas

Exxon believes "that for the next 25 to 50 years, the oil available to the markets is for all intents and purposes infinite."

But scarcity is not the only reason why the world might move away from oil. The unnerving volatility of oil prices, together with growing concern about the environmental imapct of hydrocarbons, is already spurring the search for alternatives.

"The stone age did not end because the world ran out of stone, and the oil age will end long before the world runs out of oil!"

M. King Hubbert's Peak

- U.S. oil production peaked in the 1970s
  - **The imbalance between domestic production and consumption has led to our extreme dependence on Middle East oil**
- When will global oil production peak?
  - **Certainly some time during this century.**
  - **Within next few decades?**
  - **Within next decade?**
- Note the disruption that will occur when global consumption exceeds production!

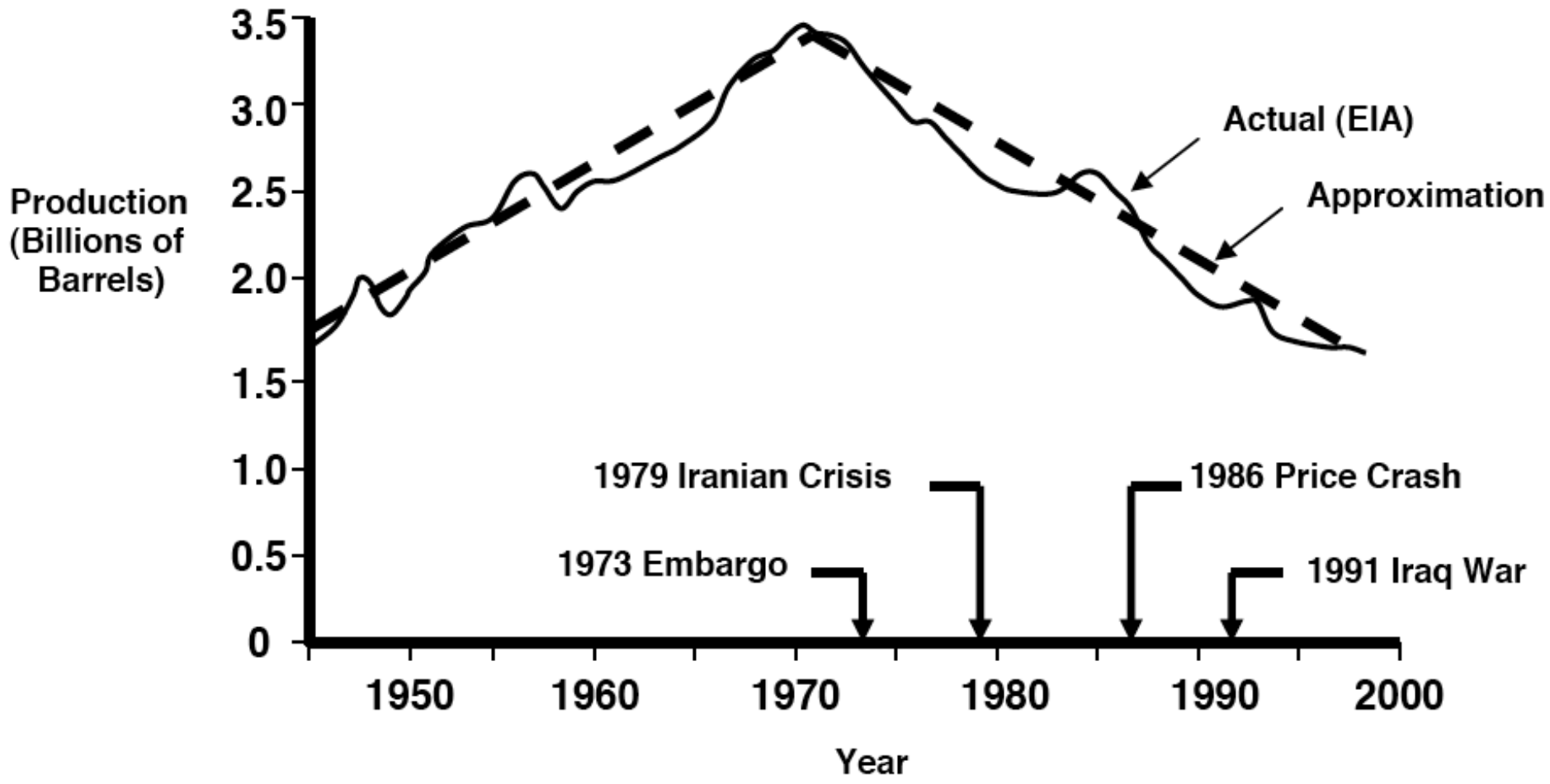


Figure II-2. U.S. Lower 48 Oil Production, 1945-2000

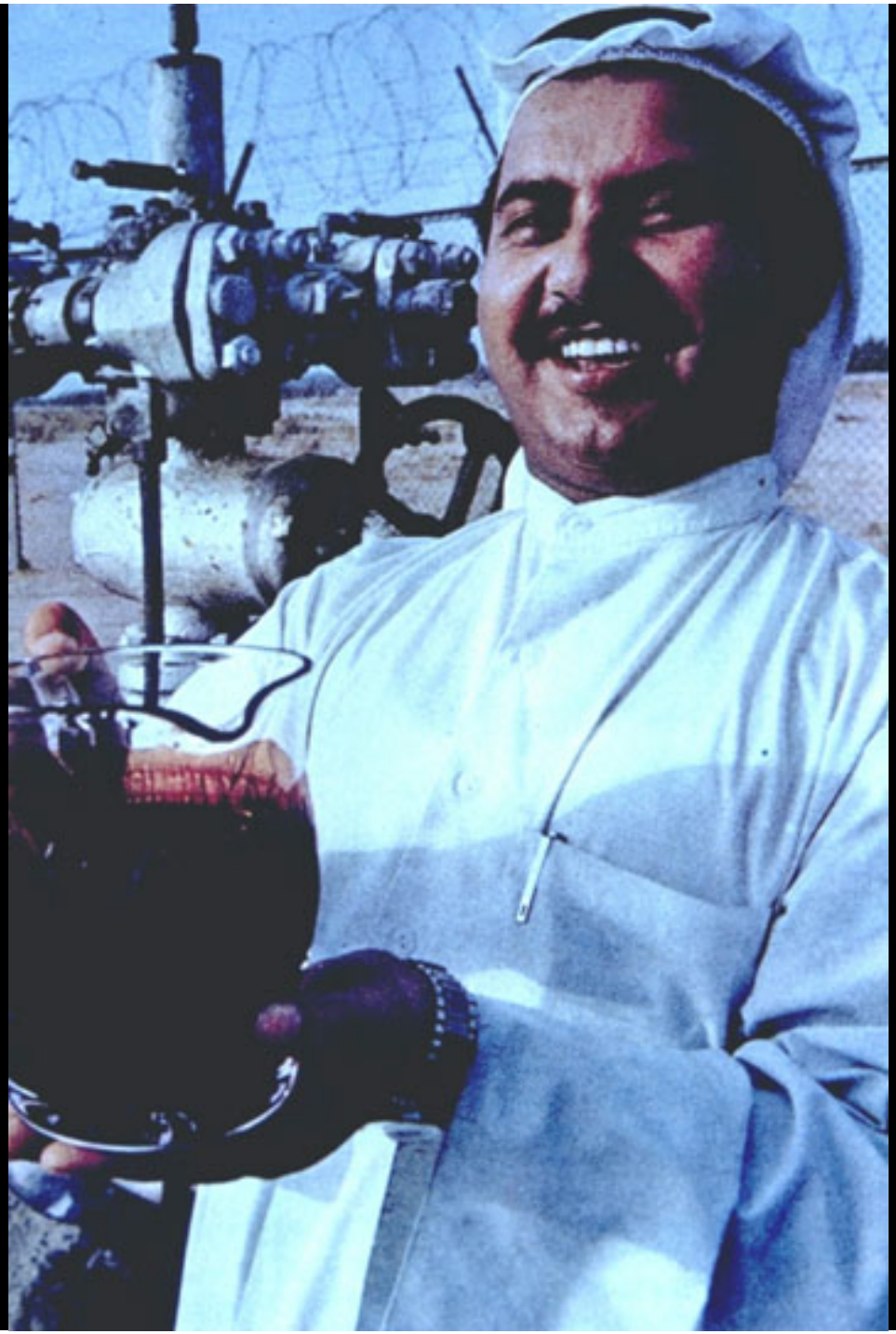


Table II-1. Projections of the Peaking of World Oil Production

Projected Date	Source of Projection	Background & Reference
2006-2007	Bakhitari, A.M.S.	Iranian Oil Executive[11]
2007-2009	Simmons, M.R.	Investment banker [12]
After 2007	Skrebowski, C.	Petroleum journal Editor [13]
Before 2009	Deffeyes, K.S.	Oil company geologist (ret.) [14]
Before 2010	Goodstein, D.	Vice Provost, Cal Tech [15]
Around 2010	Campbell, C.J.	Oil company geologist (ret.) [16]
After 2010	World Energy Council	World Non-Government Org.[17]
2010-2020	Laherrere, J.	Oil company geologist (ret.) [18]
2016	EIA nominal case	DOE analysis/ information[19]
After 2020	CERA	Energy consultants [20]
2025 or later	Shell	Major oil company [21]
No visible peak	Lynch, M.C.	Energy economist[22]

The World Energy Challenge …

A product of concurrent and connected trends

- **Oil will run out.**

World oil production will peak and then decline in the "near" future. Forcasted to occur sometime between 2015 and 2040.

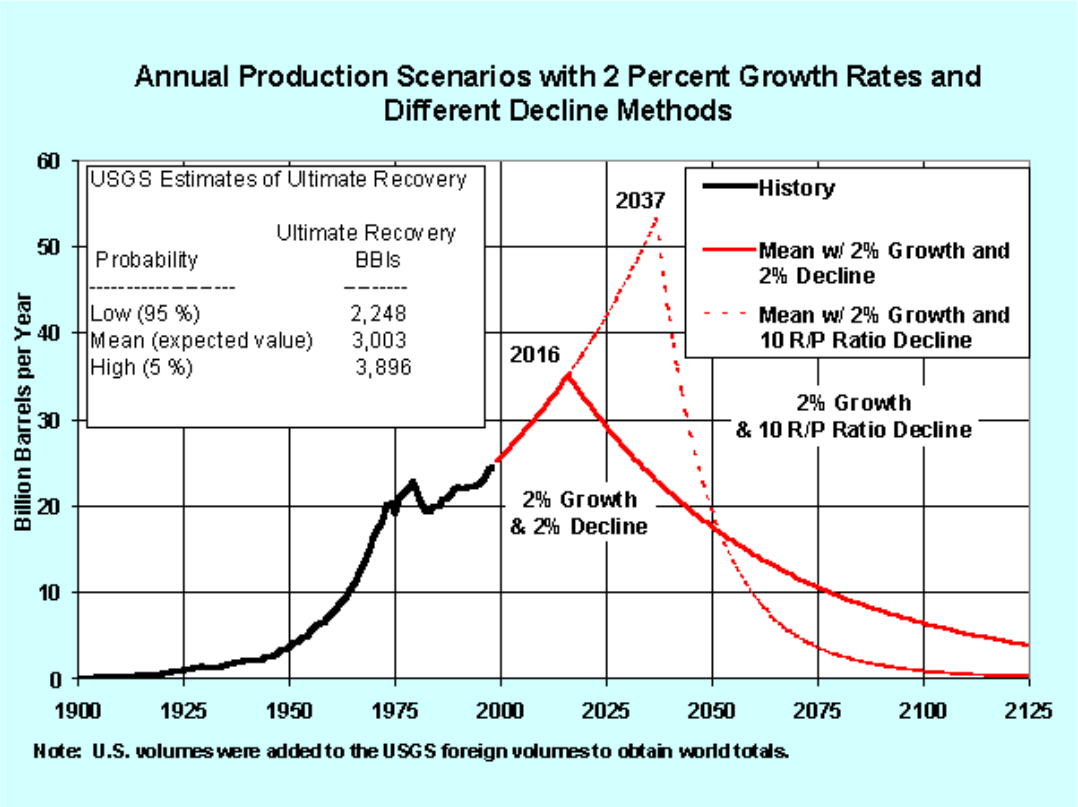
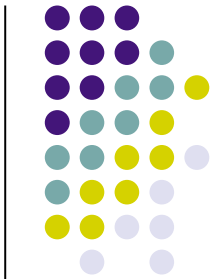


Figure A-1. Two EIA oil production scenarios based on expected ultimate world-recoverable oil of 3,003 billion barrels and a 2 percent annual world oil demand escalation

Ref: "Peaking of World Oil Production: Impacts, Mitigation, and Risk Management," Robert L. Hirsch, SAIC, Roger Bezdek, MISI, Robert Wendling, MISI, Feb, 2005, DOE-funded study.

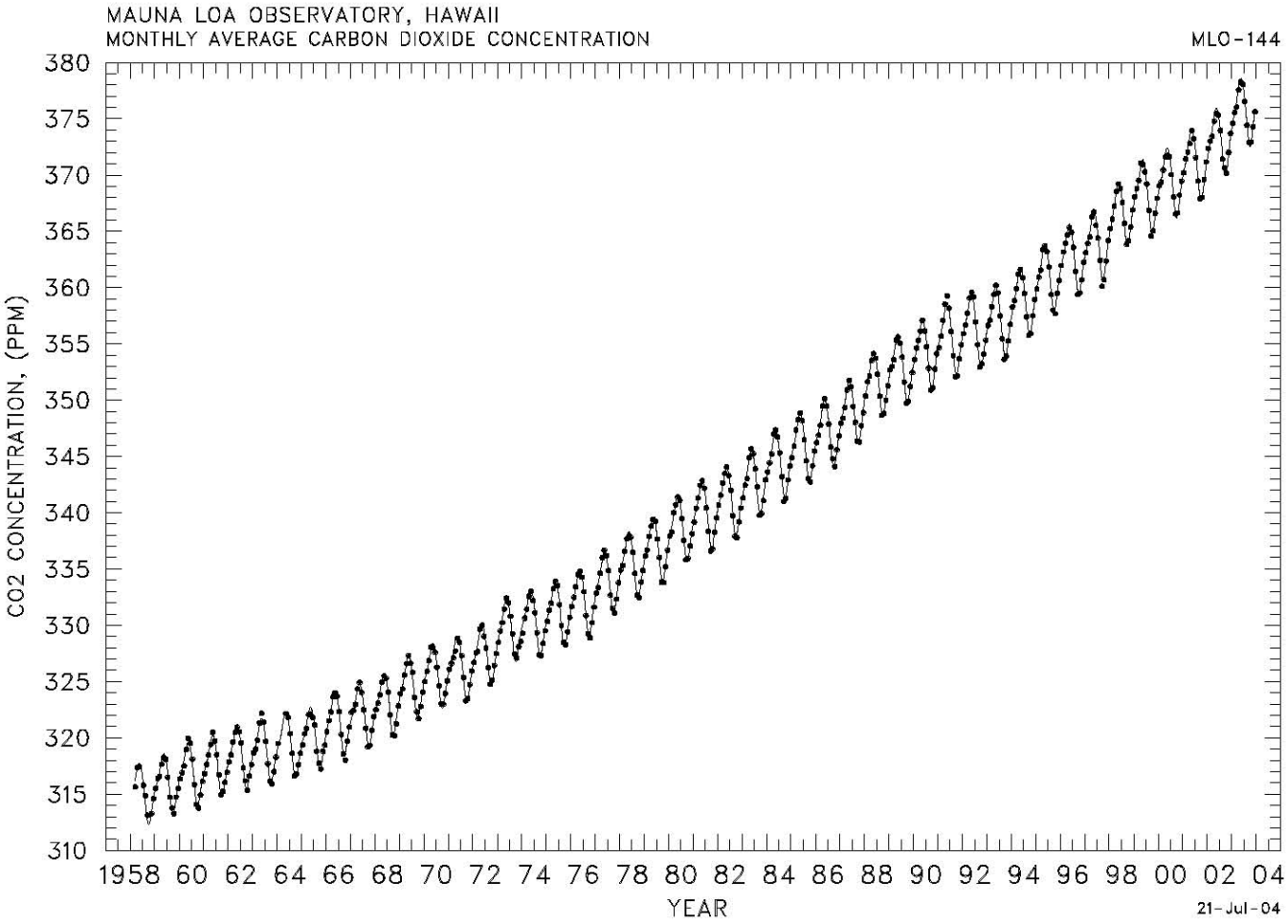

Global Sustainability

Global Climate Change

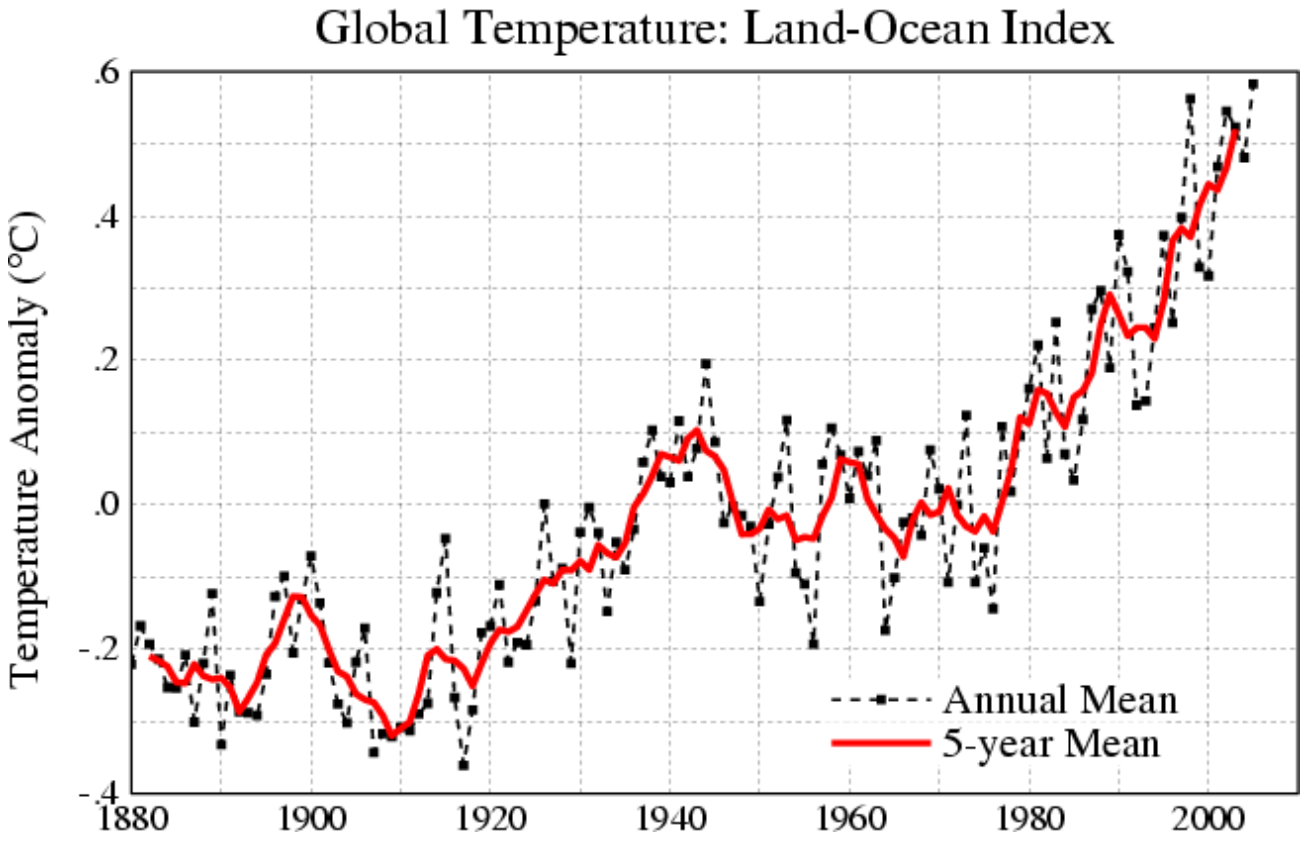


- There is compelling evidence that the growing population and invasive activities of humankind are now altering the fragile balance of our planet.
- The concerns are both multiplying in number and intensifying in severity: the destruction of forests, wetlands, and other natural habitats by human activities leading to the extinction of millions of biological species and the loss of biodiversity; the buildup of greenhouse gases such as carbon dioxide and their possible impact on global climates; the pollution of our air, water, and land.

Atmospheric CO_2 : 50-year history

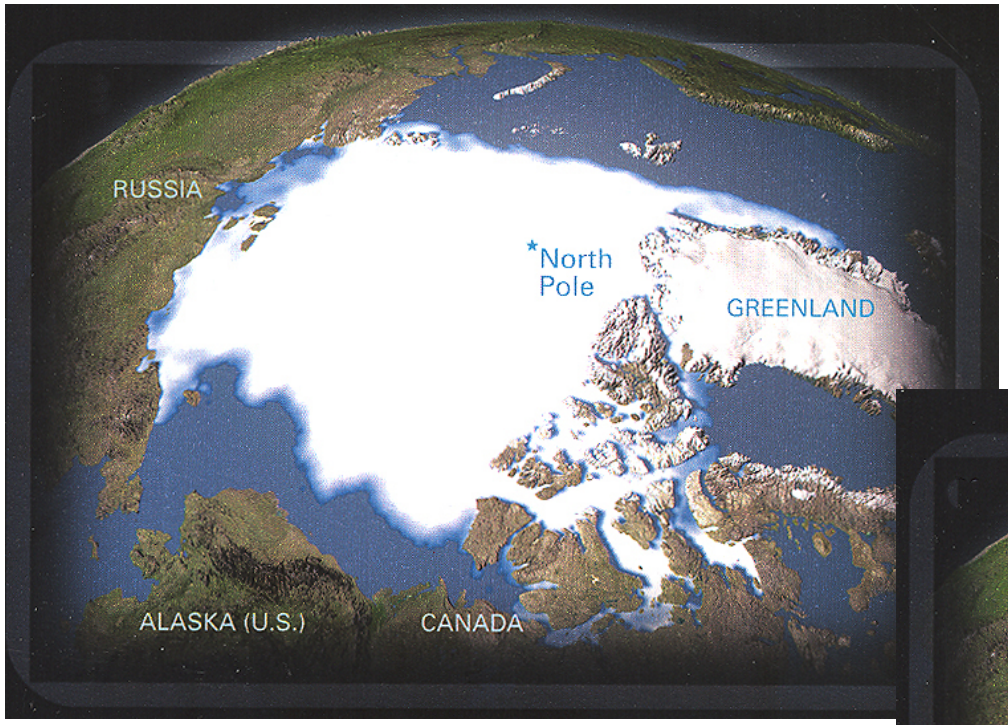


Source: Keeling and Whorf, data at cdiac.esd.ornl.gov/ndps/ndp001.html

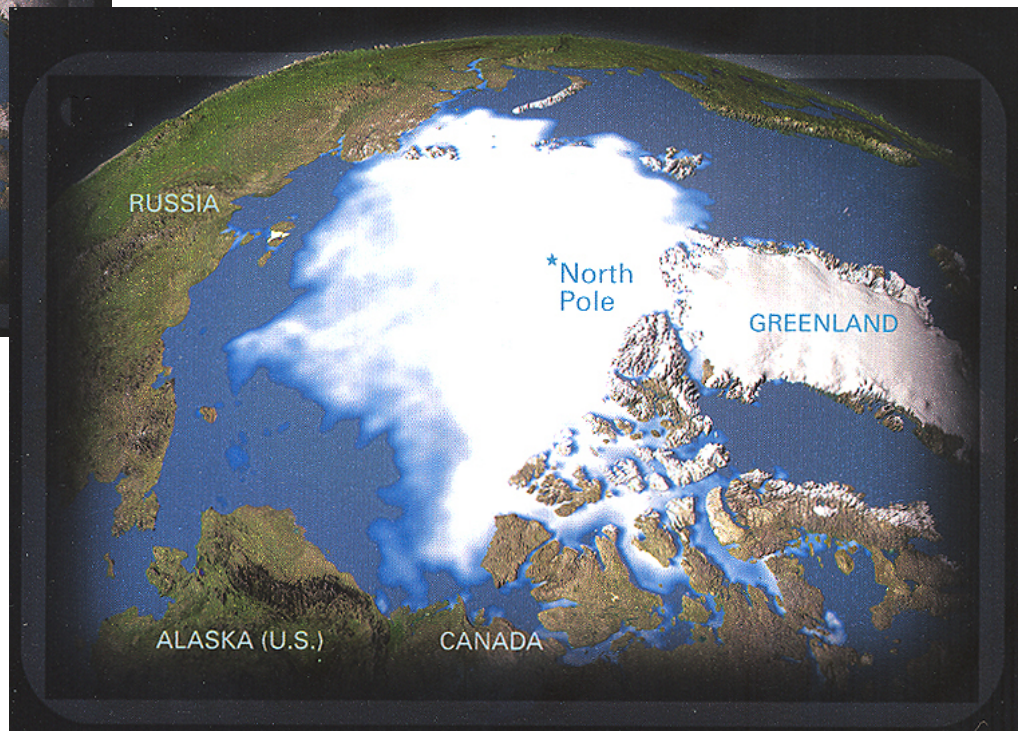


Source: NASA GISS, at data.giss.nasa.gov/gistemp/graphs/

Arctic Ice Cap Change

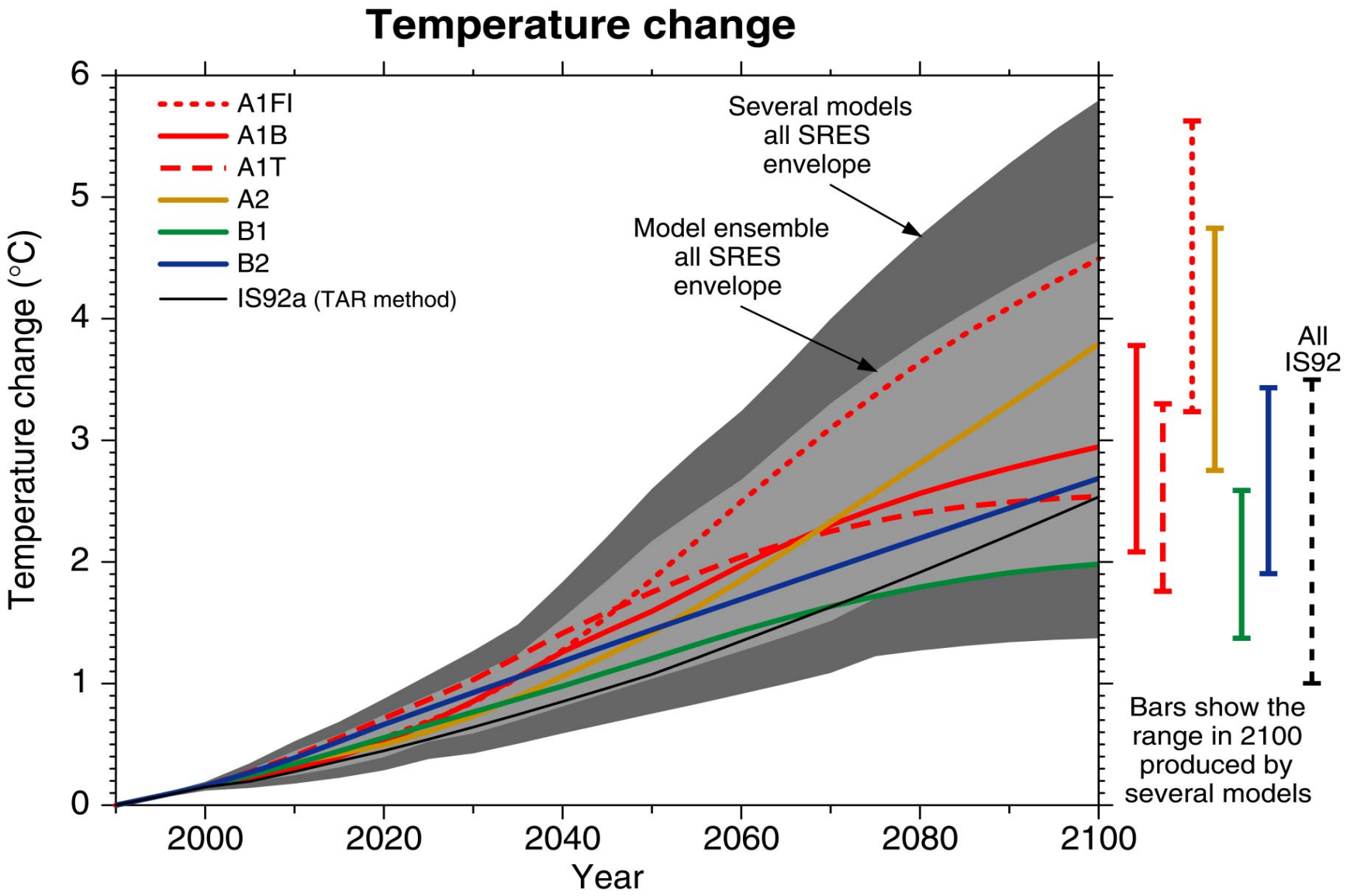


1979



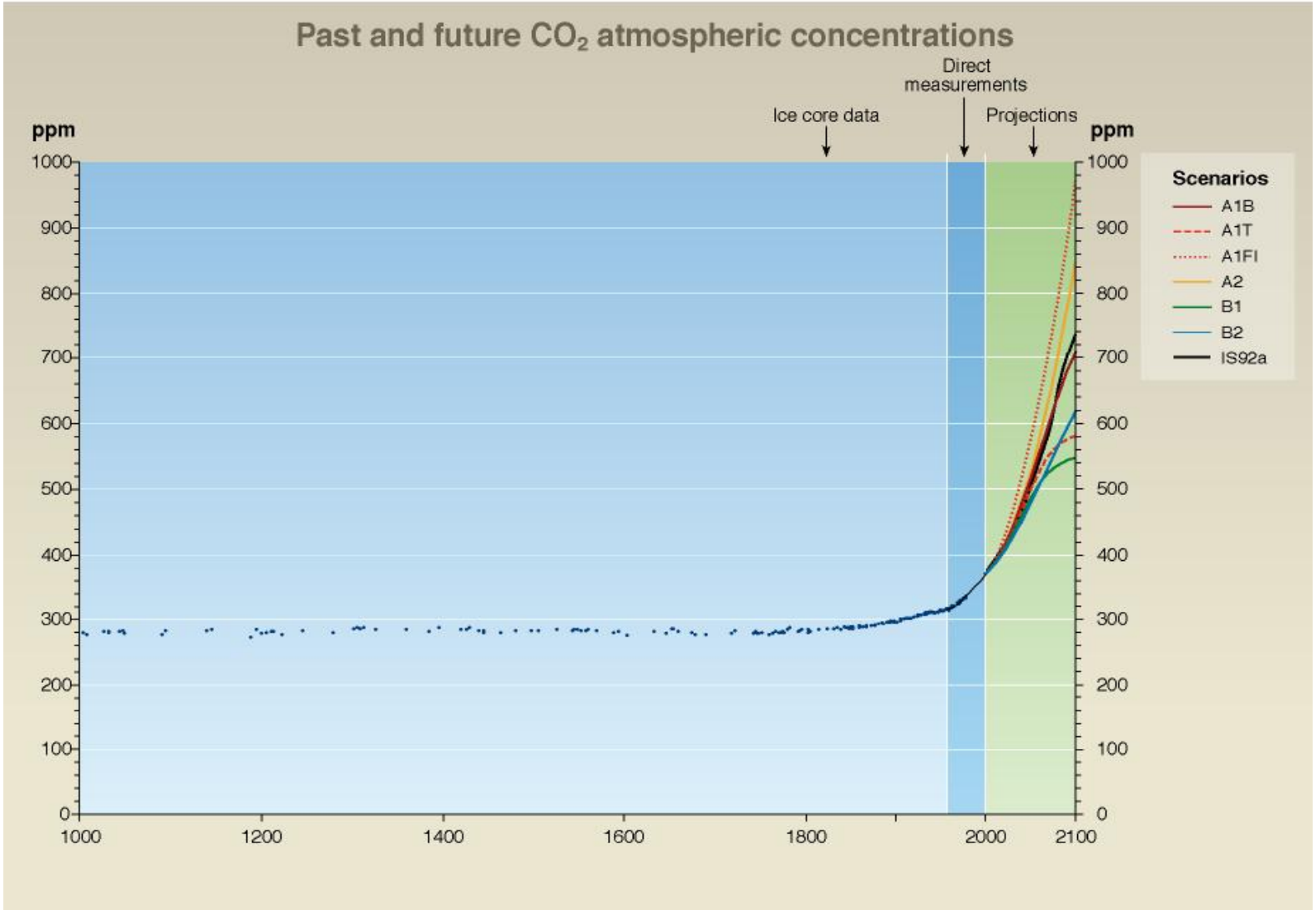
2003

Projected Global Warming Through 2100



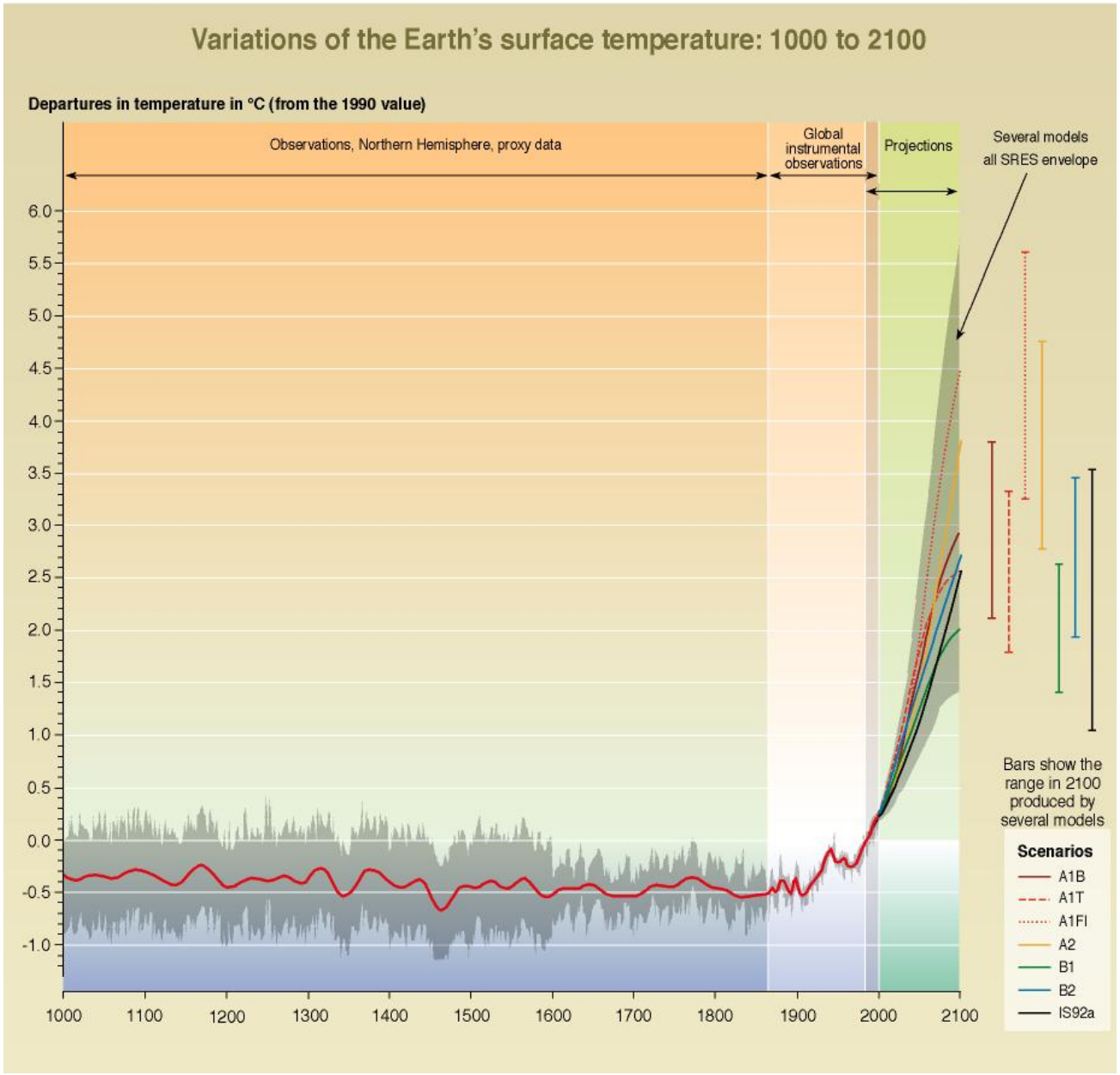
Atmospheric CO_2: 1,000-year history, 100-year projections

SPM - 10a



Projected Warming in the Context of 1,000 years of History

SPM - 10b

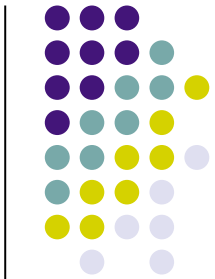


2100 Projection: 6-meter sea level rise

Florida; h < 6 m in green region

Composite satellite image taken by Landsat Thematic Mapper, 30-m resolution, supplied by the Earth Satellite Corporation.
Contour analysis courtesy of Stephen Leatherman.

What to do?



- It could well be that coming to grips with the impact of our species on our planet, learning to live in a sustainable fashion on Spaceship Earth, will become the greatest challenge of all to our generation. We must find new ways to provide for a human society that presently has outstripped the limits of global sustainability.
- This will be particularly difficult for the United States, a nation that has difficulty in looking more than a generation ahead, encumbered by a political process that generally functions on an election-by-election basis, as the current debate over global climate change makes all too apparent.

How serious is this?

"The global climate change caused by human activity and above all by fossil fuel combustion is both the most dangerous and the most intractable environmental problem that civilization faces.

It is the most dangerous because climate creates the envelope of environmental conditions within which all other processes that operative in support of human well-being have to be able to function.

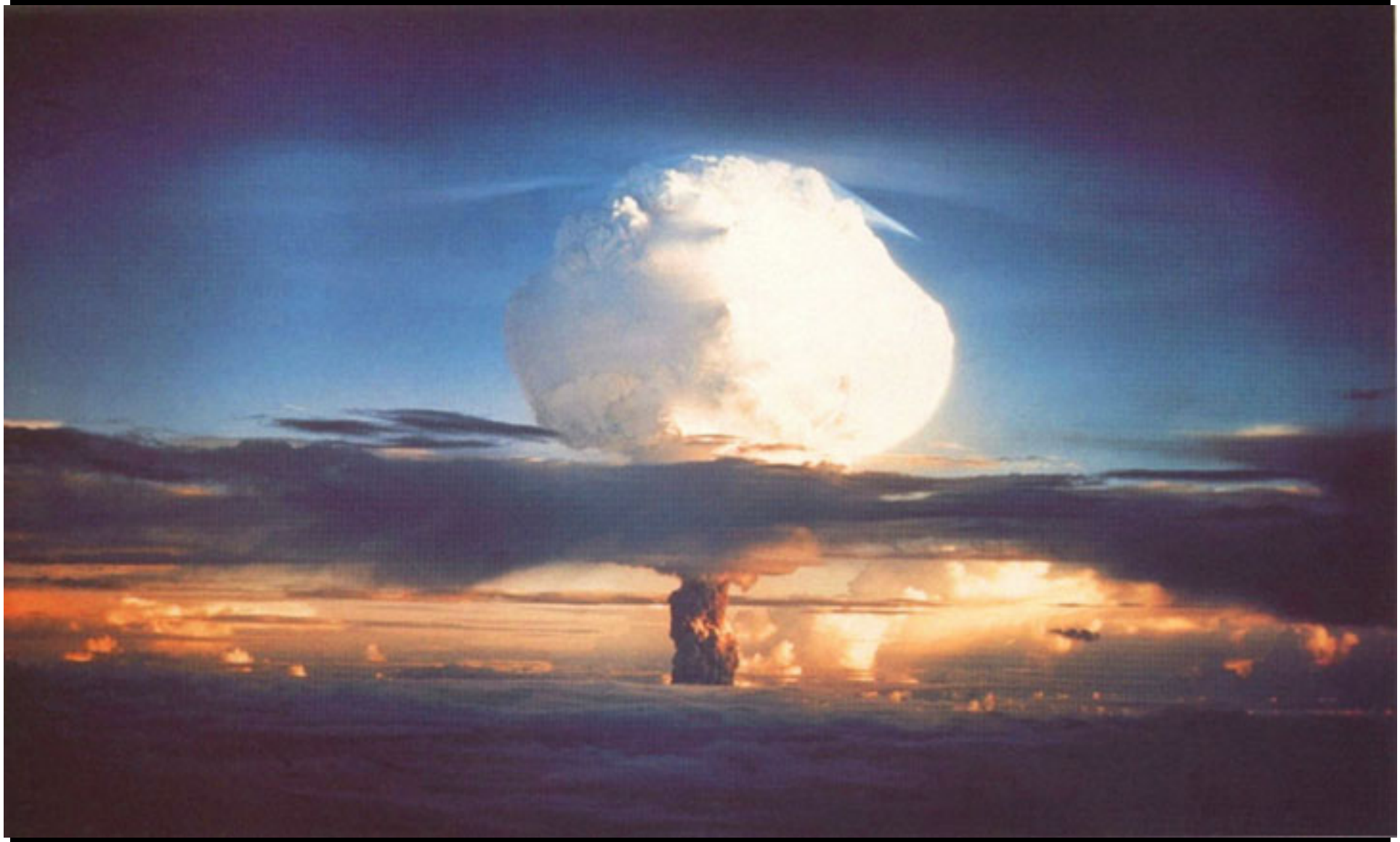
It is the most intractable of environmental problems because its fundamental changes are so deeply embedded in our way of life."

John Holdren


The Threats
of Today

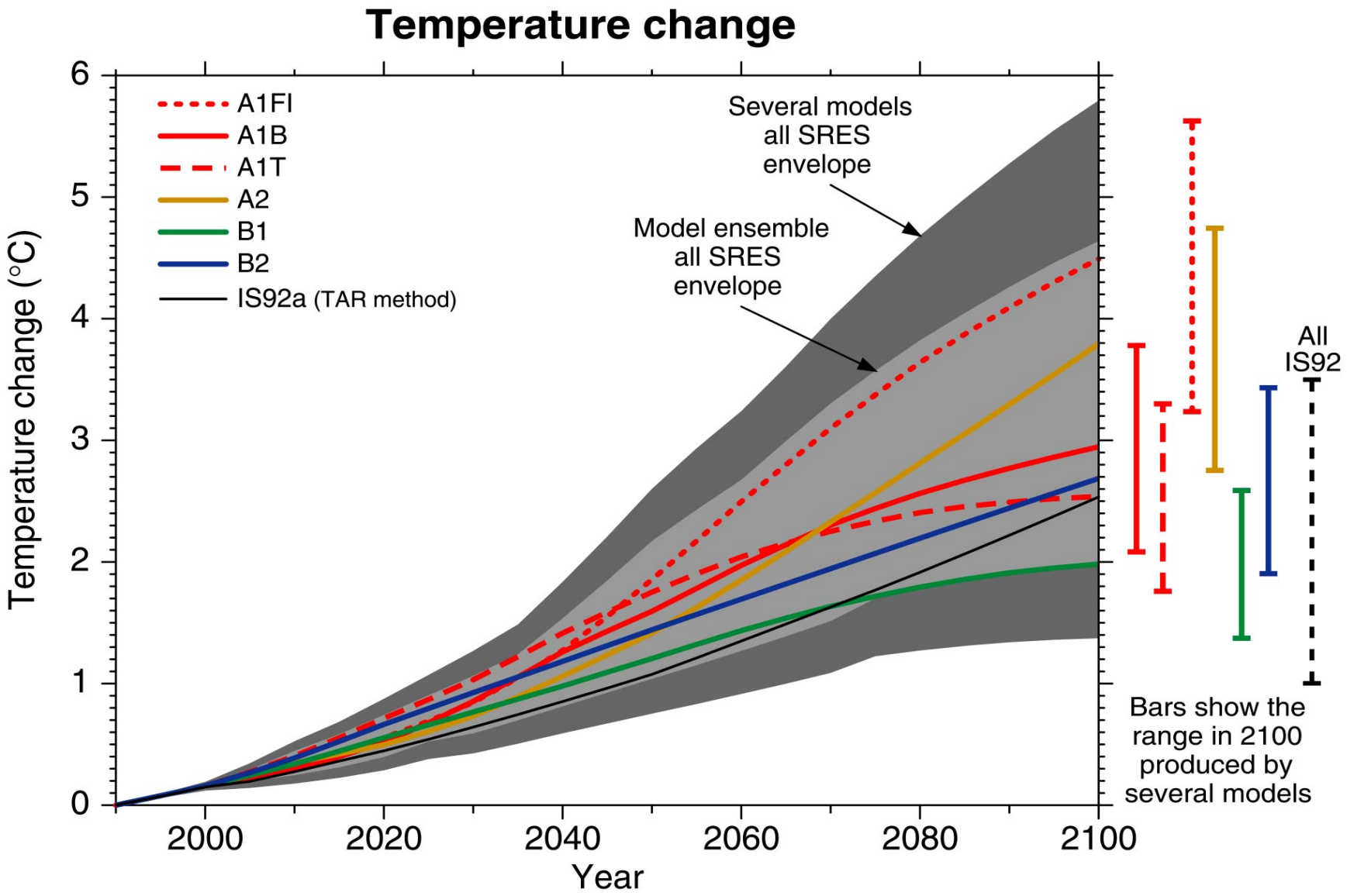

STRANGELOVE
OR
HOW I


GRAND
FORKS
22
26
25
24
21
27
28




FROM THE DIRECTOR OF INDEPENDENCE DAY
THE DAY AFTER TOMORROW
ENTER THE SITE
THE DAY AFTER TOMORROW
AVAILABLE ON DVD OCTOBER 12, 2004

Projected Global Warming Through 2100



2100 Projection: 6-meter sea level rise

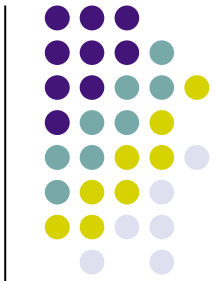
Florida; h < 6 m in green region

Composite satellite image taken by Landsat Thematic Mapper, 30-m resolution, supplied by the Earth Satellite Corporation.
Contour analysis courtesy of Stephen Leatherman.


The Challenges
of Tomorrow


Exponentiating Technologies

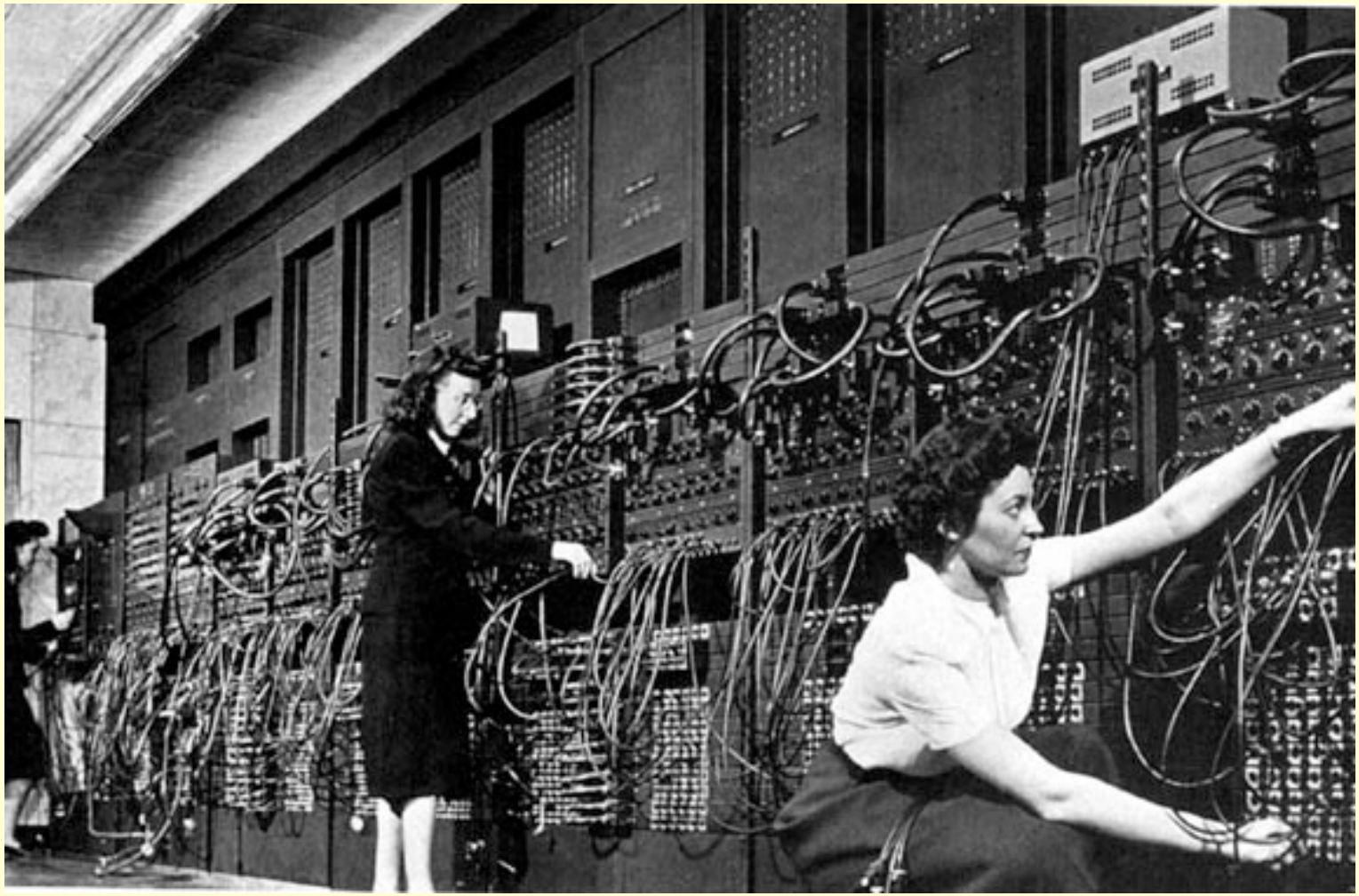
Exponentiating Technologies

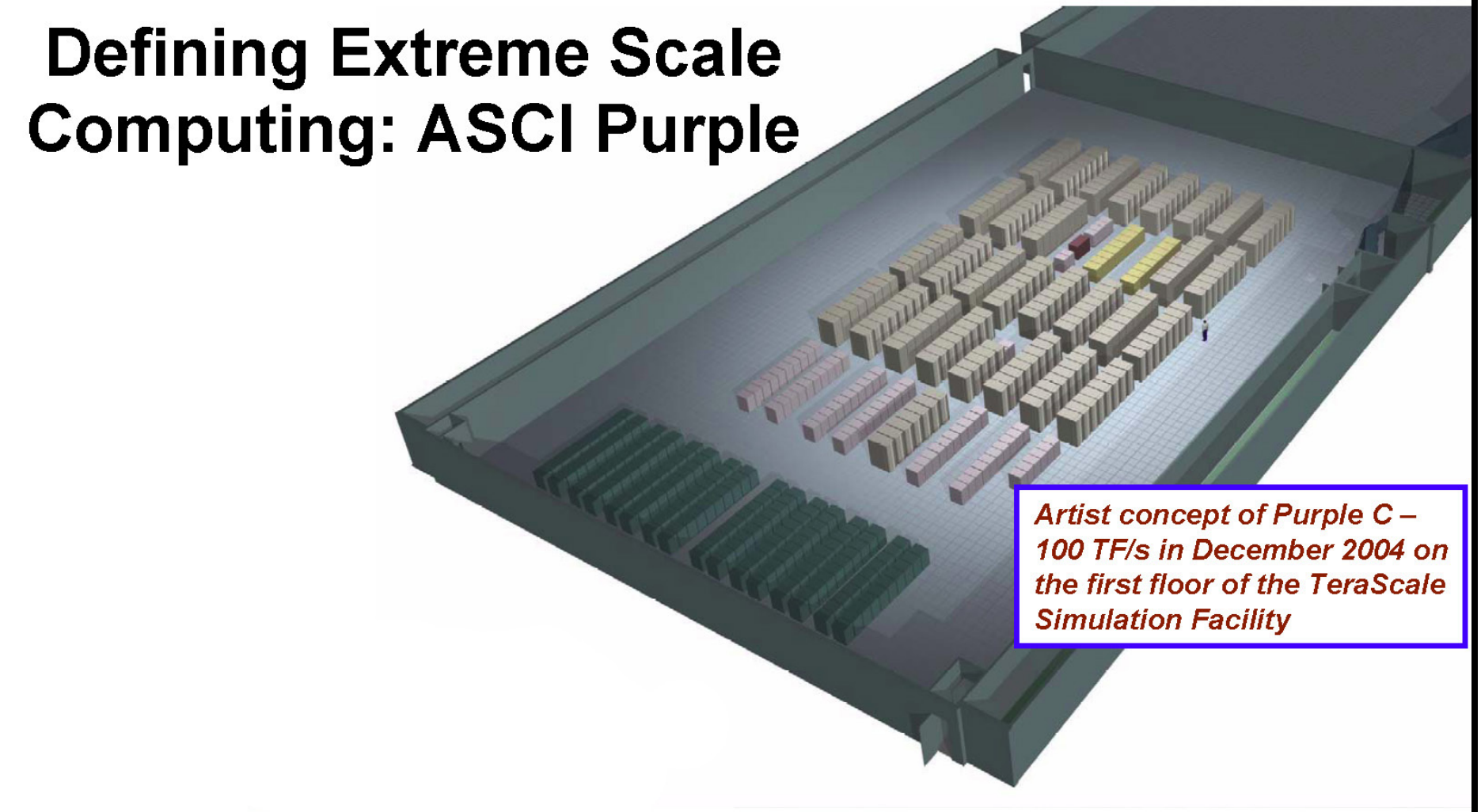


- The technologies driving such profound changes in our world, technologies such as information technology, biotechnology, and soon nanotechnology, are all characterized by exponential growth.
- When applied to computers, this remarkable property, known as Moore's Law, suggests that every 18 months computing power for a given price doubles. Other aspects such as memory, bandwidth, and miniaturization, are evolving even more rapidly, 100 or a 1,000 fold every decade.
- In fact, scientists and engineers today believe that the exponential evolution of these microscopic technologies is not only likely to continue for the foreseeable future, but the pace may be accelerating.


Information
Technology

From Eniac



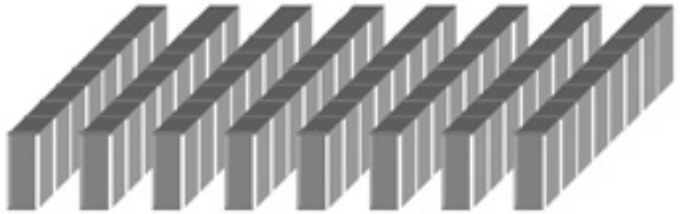


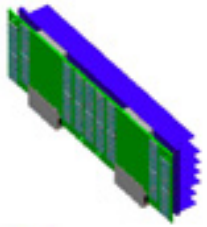
Defining Extreme Scale Computing: ASCI Purple

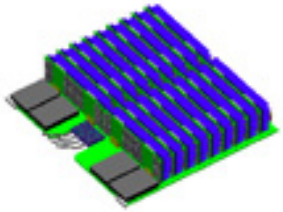
Artist concept of Purple C – 100 TF/s in December 2004 on the first floor of the TeraScale Simulation Facility

*Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

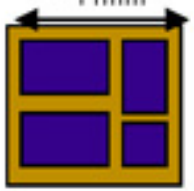
Building BlueGene/L







~11mm



Compute Chip

2 processors
2.8/5.6 GF/s
4 MiB* eDRAM

Compute Card
I/O Card

FRU (field replacable unit)
25mmx32mm
2 nodes (4 CPUs)
(2x1x1)
2.8/5.6 GF/s
256/512 MiB* DDR
15 W

Node Card

16 compute cards
0-2 I/O cards
32 nodes
(64 CPUs)
(4x4x2)
90/180 GF/s
8 GiB* DDR

Midplane

SU (scalable unit)
16 node boards
512 nodes
(1,024 CPUs)
(8x8x8)
1.4/2.9 TF/s
128 GiB* DDR
7-10 kW

Cabinet

2 midplanes
1024 nodes
(2,048 CPUs)
(8x8x16)
2.9/5.7 TF/s
256 GiB* DDR
15-20 kW

System

64 cabinets
65,536 nodes
(131,072 CPUs)
(32x32x64)
180/360 TF/s
16 TiB*
1.2 MW
2500 sq.ft.

(compare this with a 1988 Cray YMP/8 at 2.7 GF/s)

* http://physics.nist.gov/cuu/Units/binary.html

Curve 3

ASCI Purple (2004):

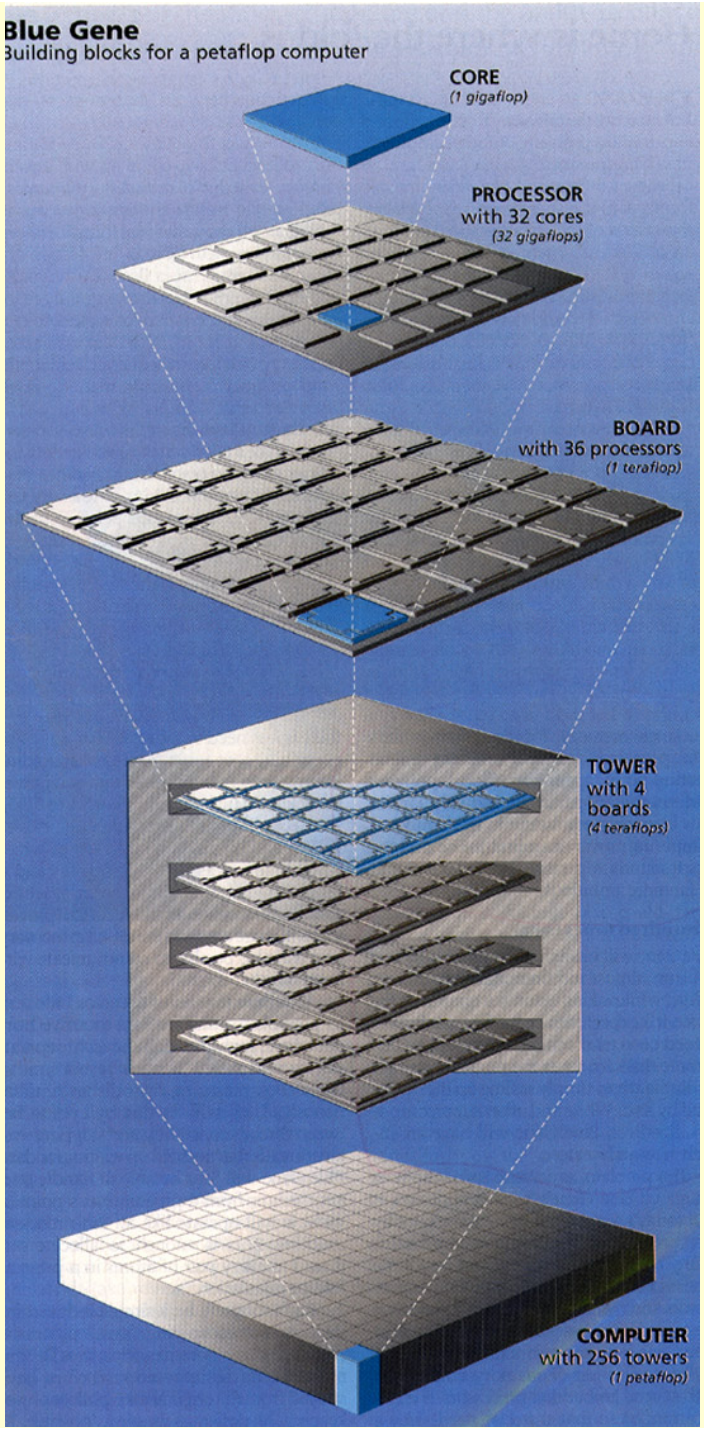
100 TeraFlops

IBM Blue Gene L (2004):

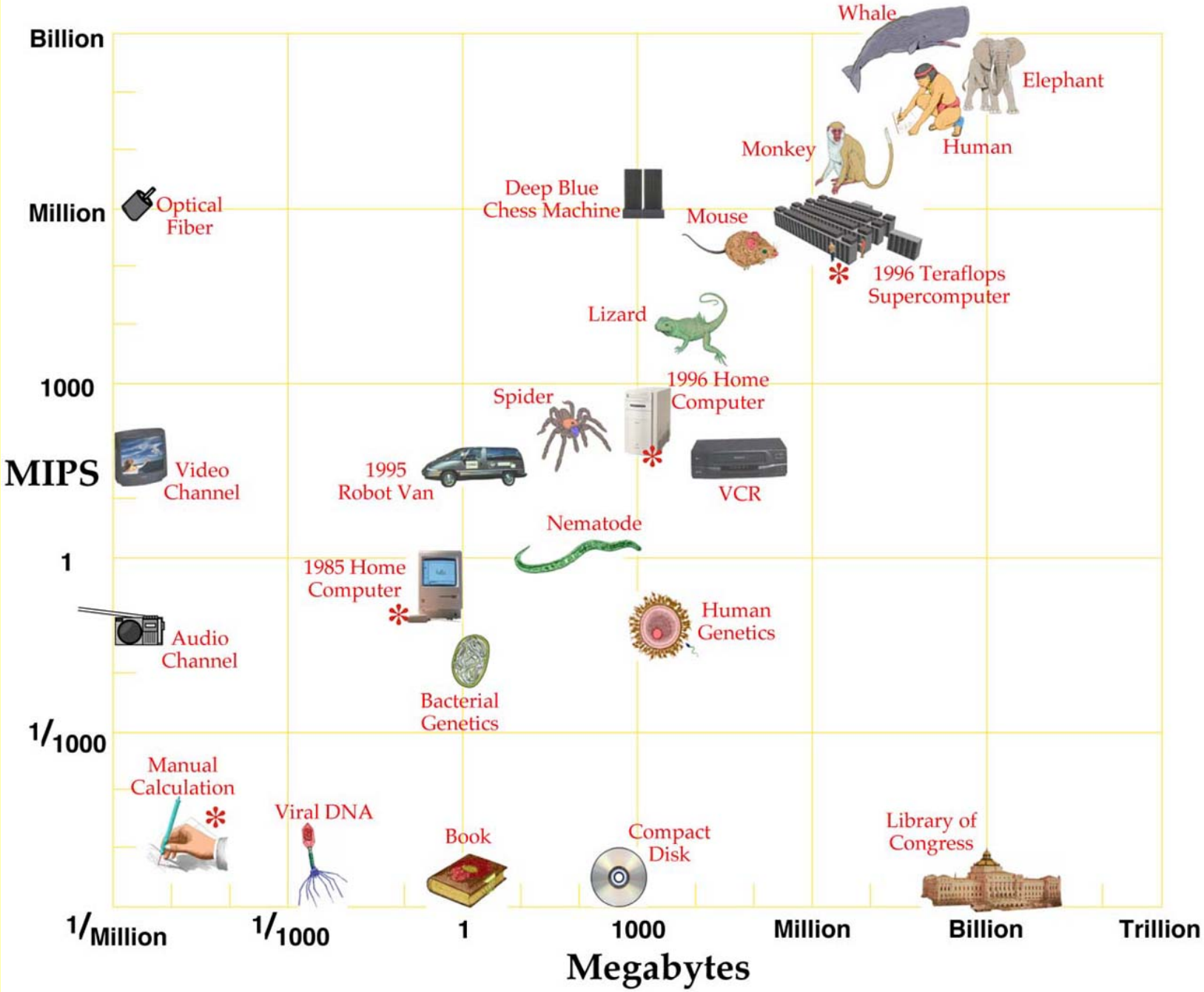
360 TeraFlops

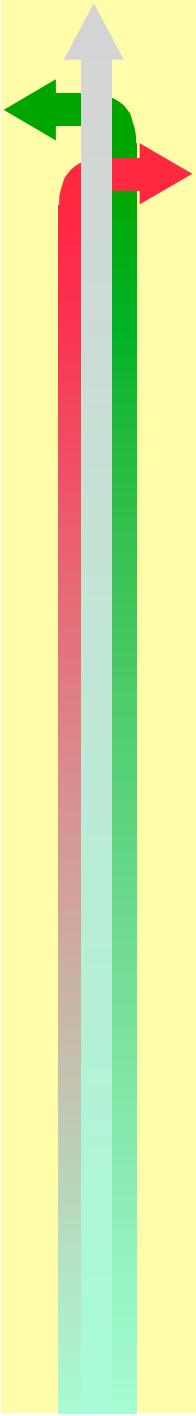
IBM Blue Gene P (2006):

“Several” PetaFlops



All Thinks, Great and Small



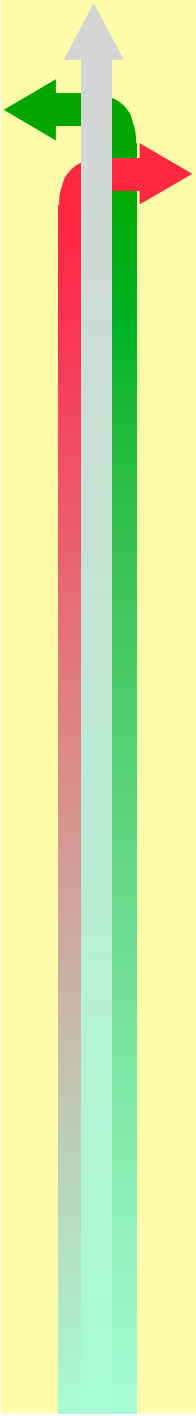


The Human Brain

The human brain has about 100 billion neurons.

It also has about one million billion connections, between neurons, each capable of a simultaneous calculation. This massively parallel form of computation is the key to image processing, but neutral circuitry is profoundly slow, only 200 calculations per second.

The memory capacity of the human brain is about 100 million synapse strengths, which amounts to about one million million bits.



Computer Evolution

By 2020 a $1,000 computer should have the capacity (both memory and processing speed) of a human brain.

By 2030, a $1,000 computer should be able to simulate the brainpower of a small village.

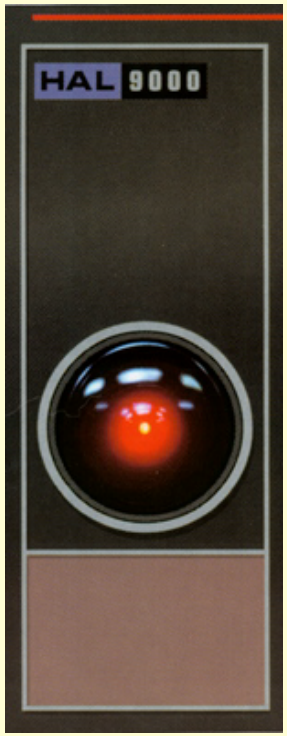
By 2050, a $1,000 computer will have the brainpower of the population of the United States.

By 2100, one penny's worth of computer will have a billion times greater computing capacity than all the humans on earth...

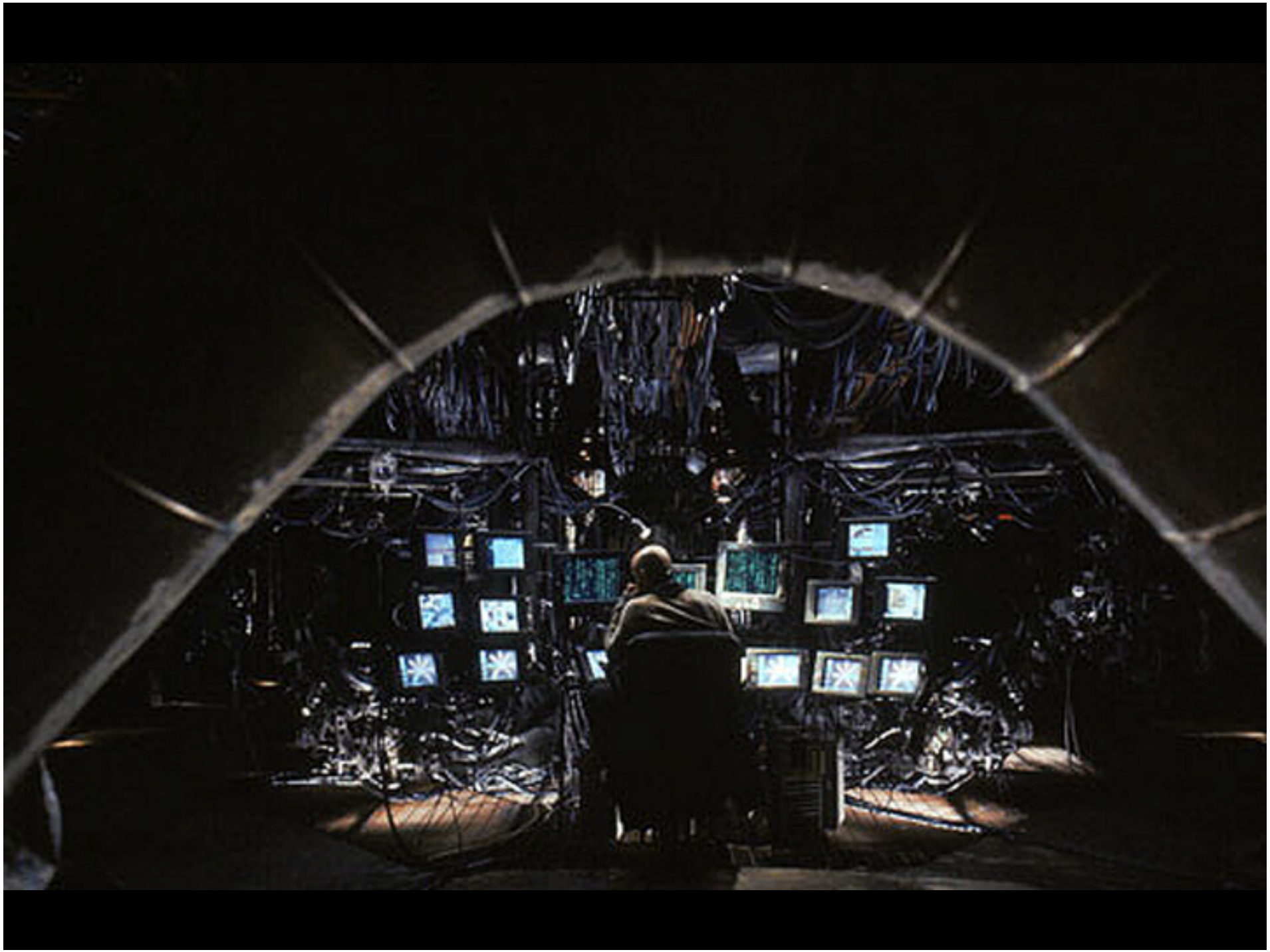
Evolution of the Net

- Already beyond human comprehension
- Incorporates ideas and mediates interactions among millions of people
- 200 million today; more than 1 billion in 2005
- Internet II, Project Abilene

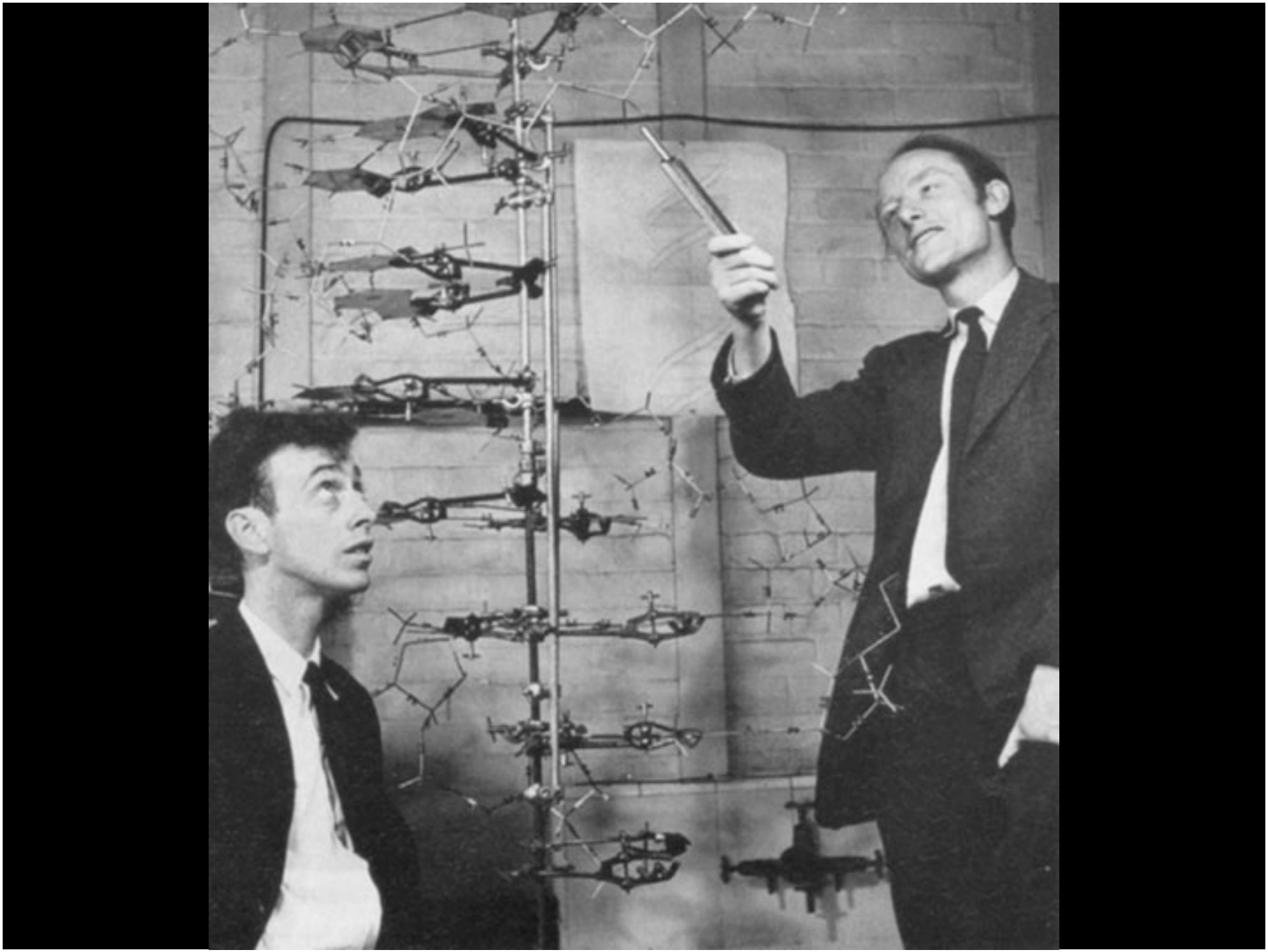
Some Other Possibilities

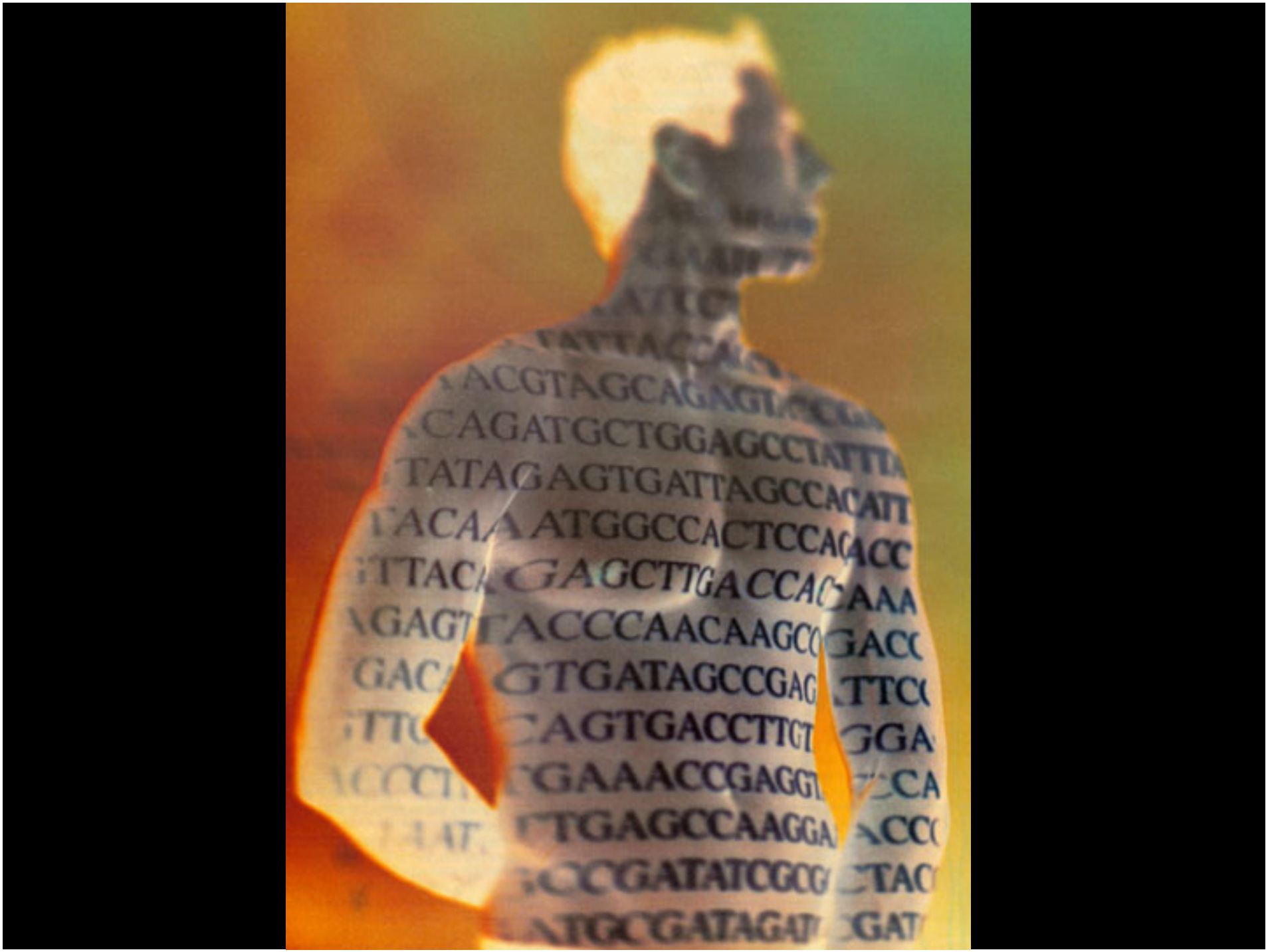


- **Ubiquitous computing?**
  - Computers disappear (just as electricity)
  - Calm technology, bodynets
- **Agents and avatars?**
  - Fusing together physical space and cyberspace
  - Plugging the nervous system into the Net
- **Emergent behavior?**
  - … Self organization
  - … Learning capacity
  - … Consciousness (HAL 9000)



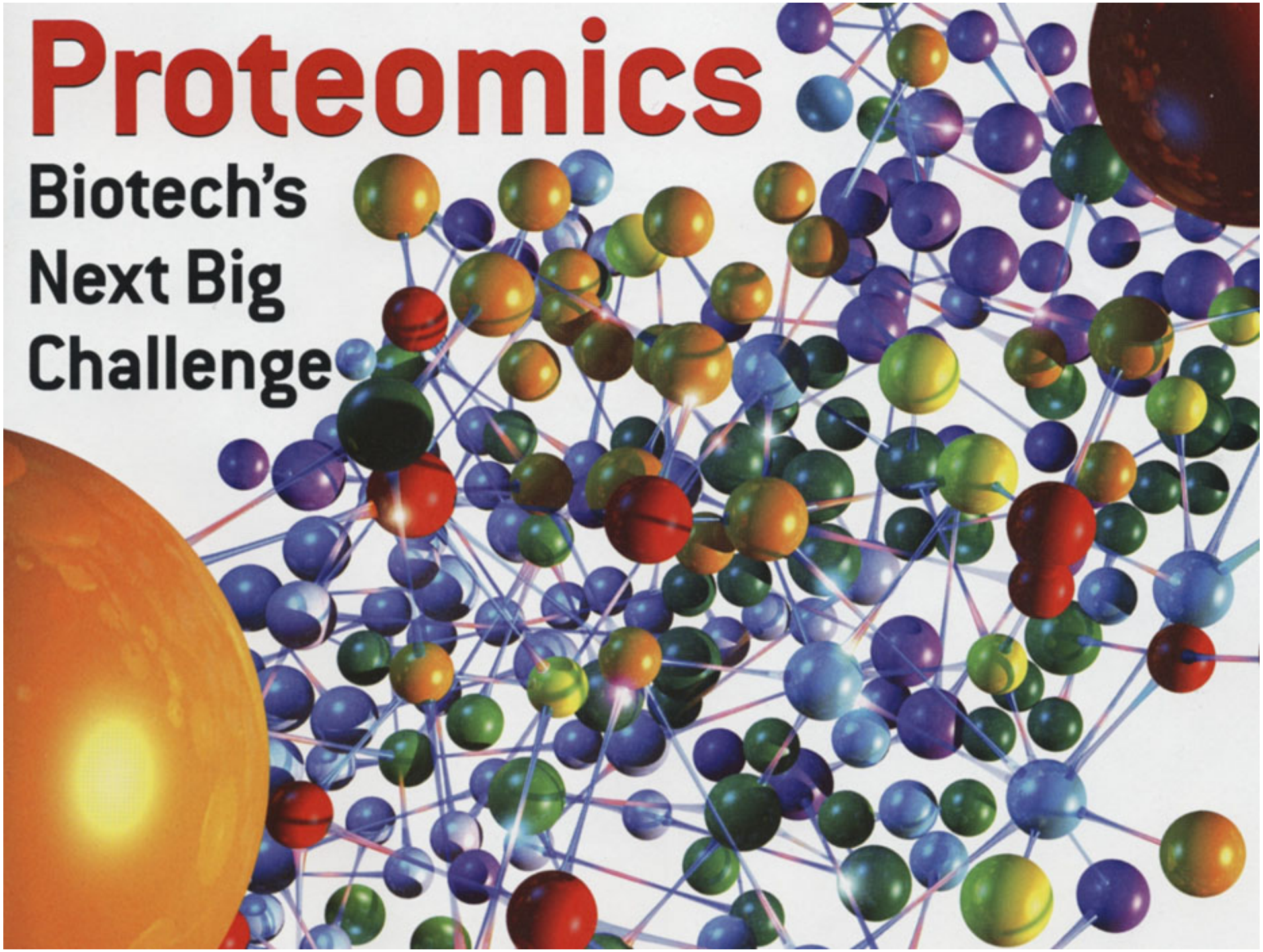

Biotechnology



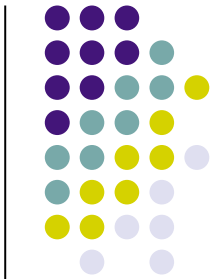

ACGTAGCAGAGT
CAGATGCTGGAGCCTATTT
TATAGAGTGATTAGCCACATT
ACAAATGGCCACTCCAGACC
TTACAGAGCTTGACCACGAAA
AGAGTTACCCCAACAAGCCGACC
GACAGTGATAGCCGAGTTTC
TTCCAGTGACCTTGTGGA
CCCTTGAAACCGAGGTCCA
TTGAGCCAAGGAACCC
CCGATATCGCCTAC
ATGCCGATAGATCGAT

Proteomics

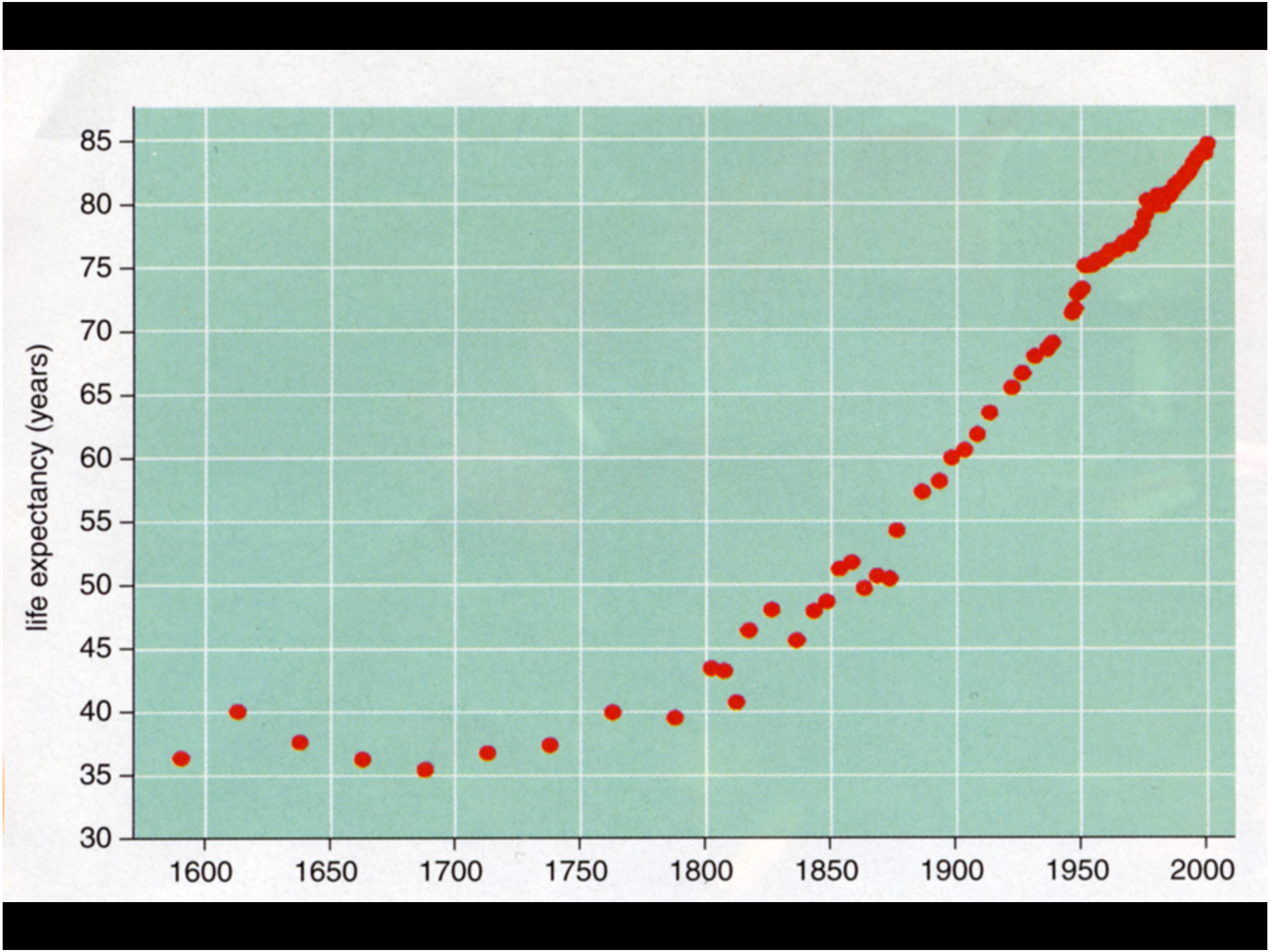
Biotech's Next Big Challenge



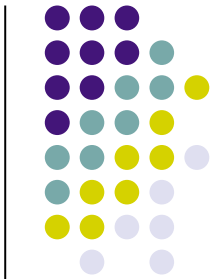
Over the next two decades



- Medicine will evolve from:
  - “reactive” medicine (curing disease)
  - “predictive” medicine (using genetic information to predict susceptability to particular diseases and adjusting lifestyles accordingly)
  - “preventive” medicine (using human gene therapy to correct genes)
- But what about aging? Survival beyond child-bearing and rearing age was not favored by natural selection…

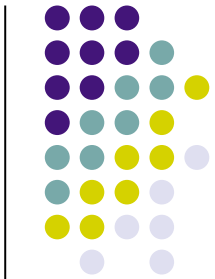

life expectancy (years)
85
80
75
70
65
60
55
50
45
40
35
30
1600
1650
1700
1750
1800
1850
1900
1950
2000

Changing the aging process



- Some experts believe that within 20 years, the life span will have increased by 10 years or more.
- Indeed, some believe that biotechnology will soon be adding more than a year to human life expectancy every year.
- Eventually, nanotechnology will allow us to repair at the microscopic level cell structure.
- “Life expectancy will be in the region of 5,000 years by the year 2100.” Aubrey de Grey (Cambridge)

One More Concern



Last month the United Nation's projected the Earth's population in the year 2050 as 9.1 billion, 50% larger than today.

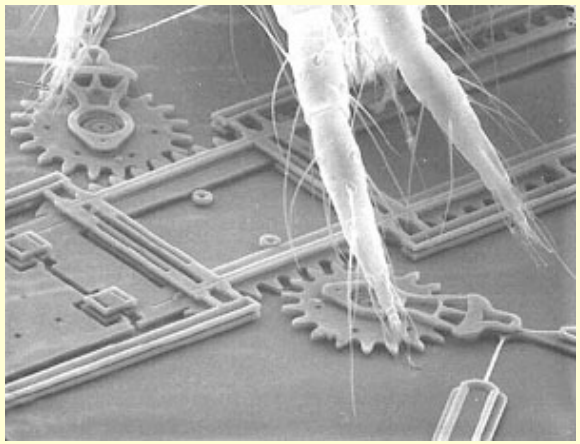
Can we sustain a population of that magnitude on Spaceship Earth?

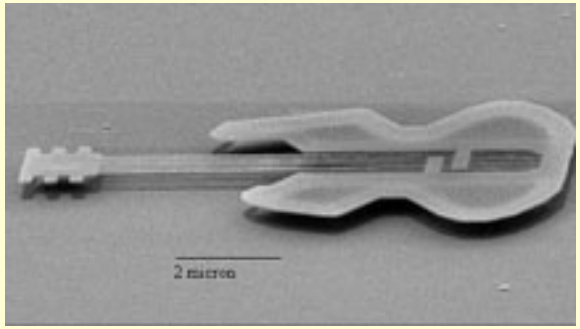

Nanotechnology

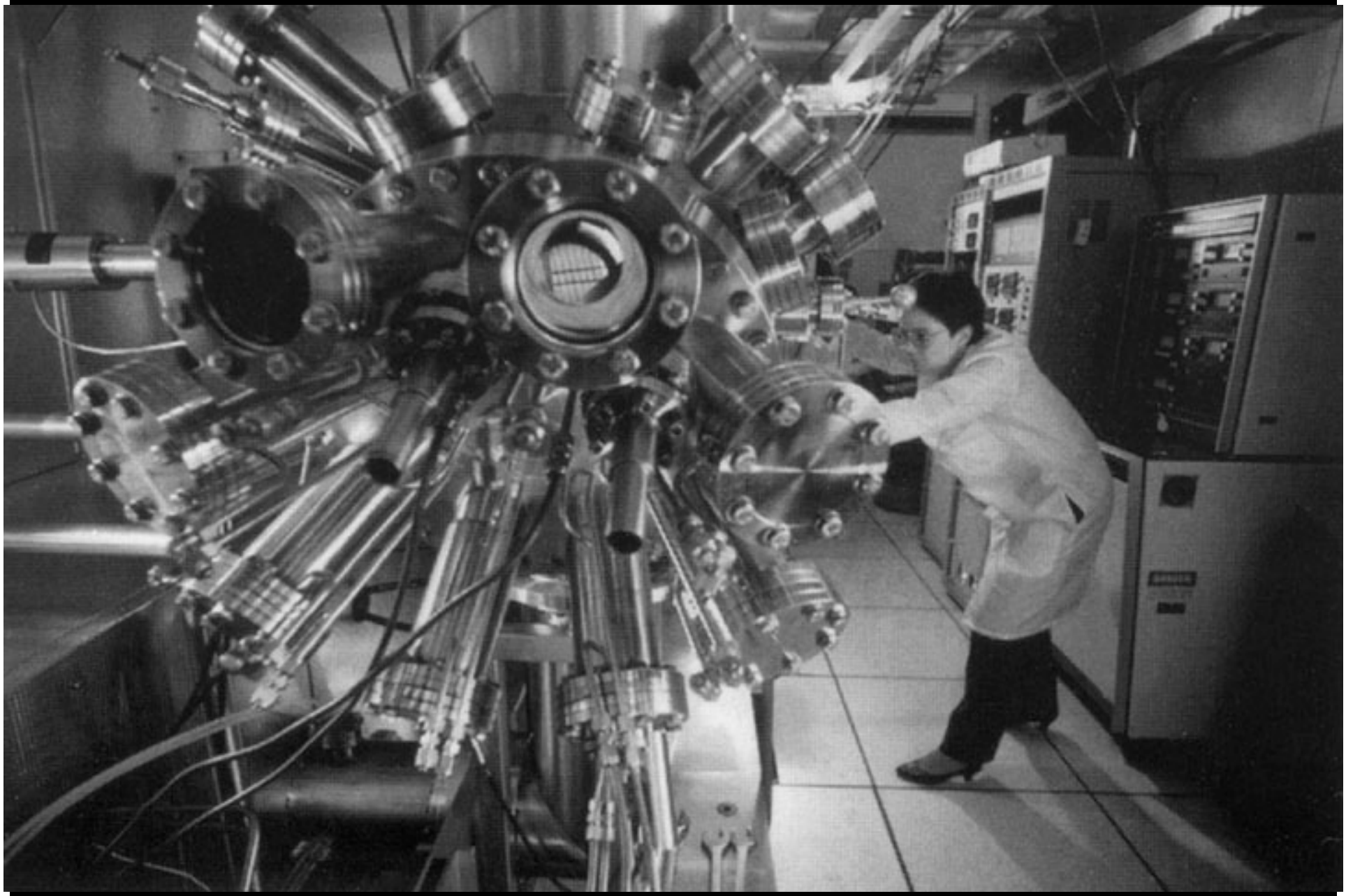
MEMS

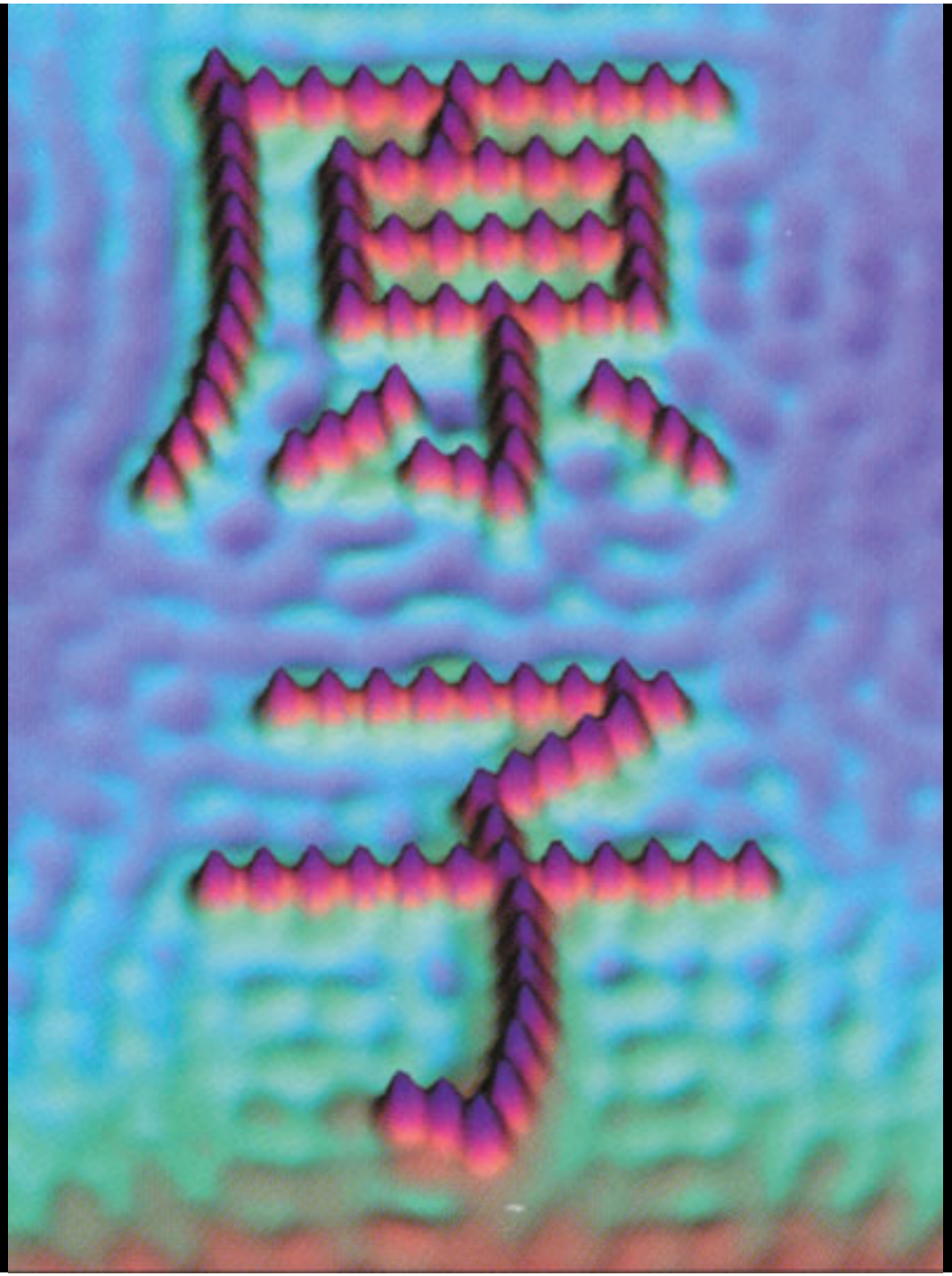
MEMS: Micro electromechanical machines

Engineers have developed the capacity to fabricate microscopic gears, machines, and motors out of silicon, much as they do electronic circuits. These are typically of submicron size.

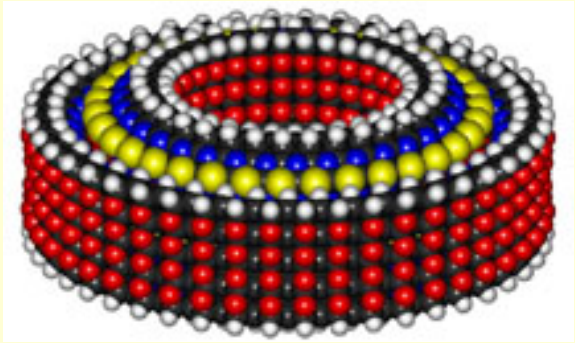




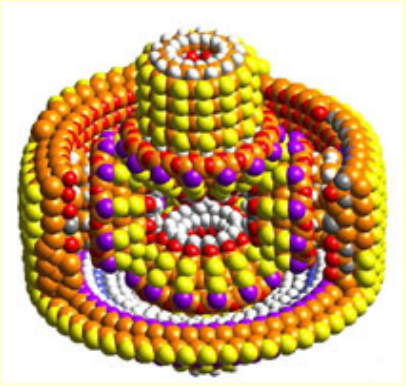




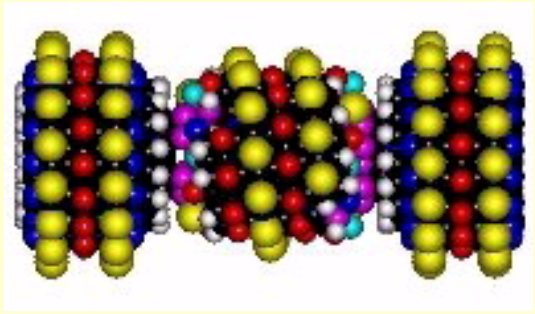
Molecular Nanomachines



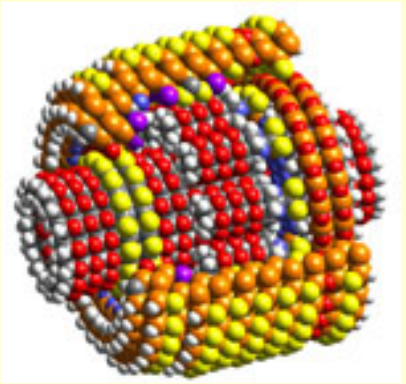
Bearing



A differential gear



Pump

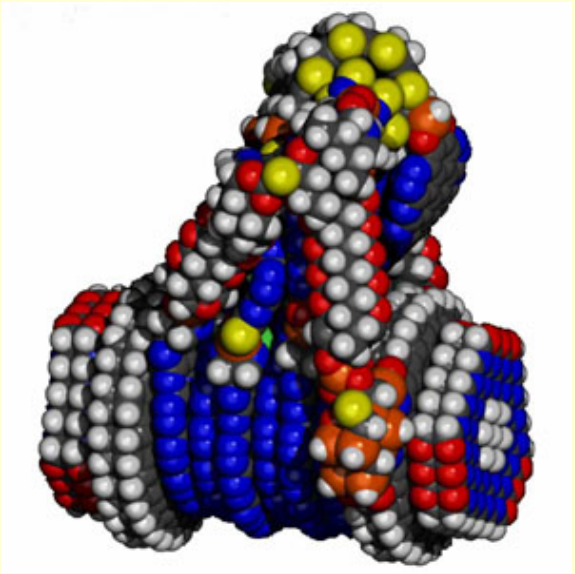


A planetary gear

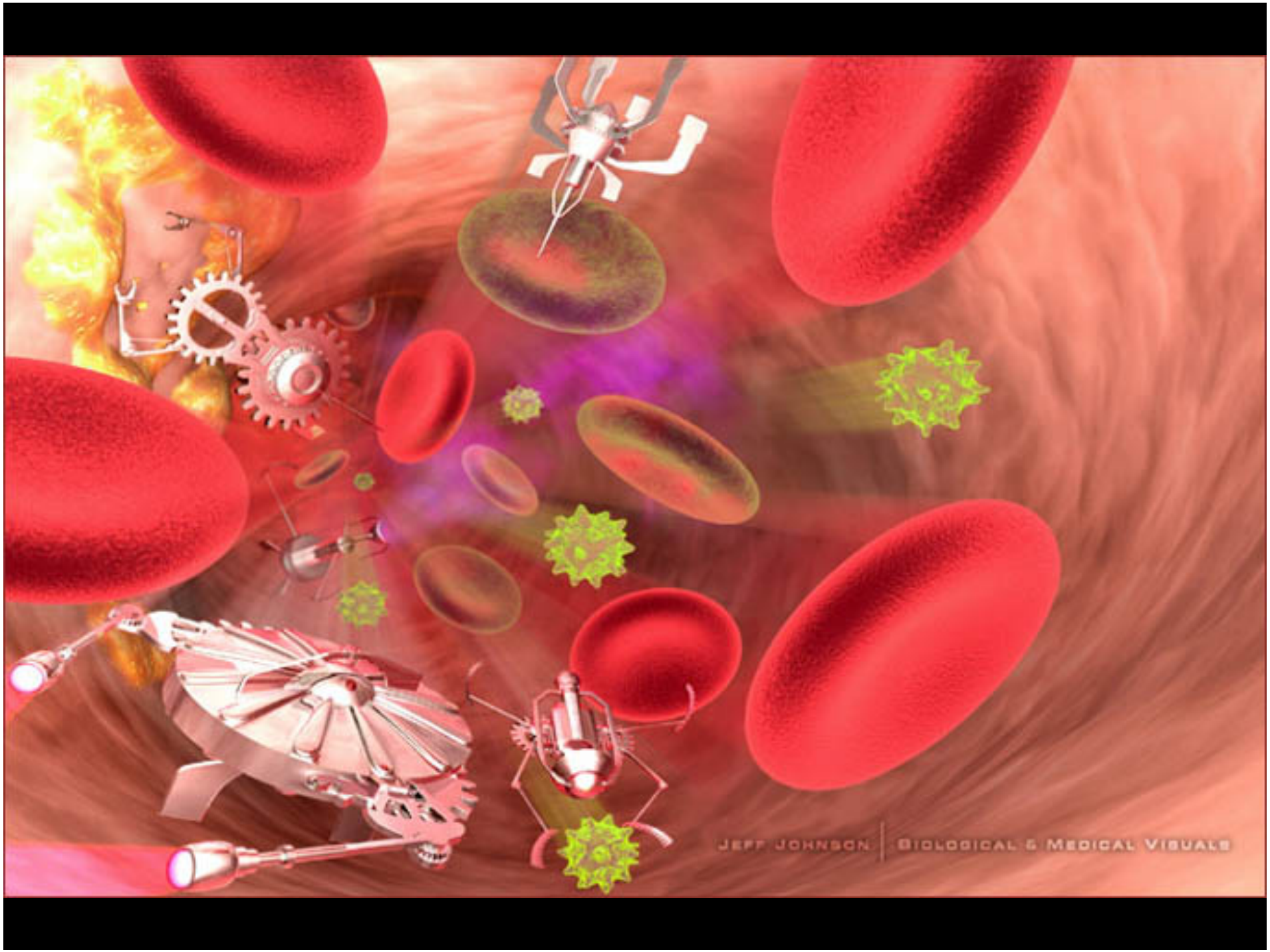
Nano Assemblers

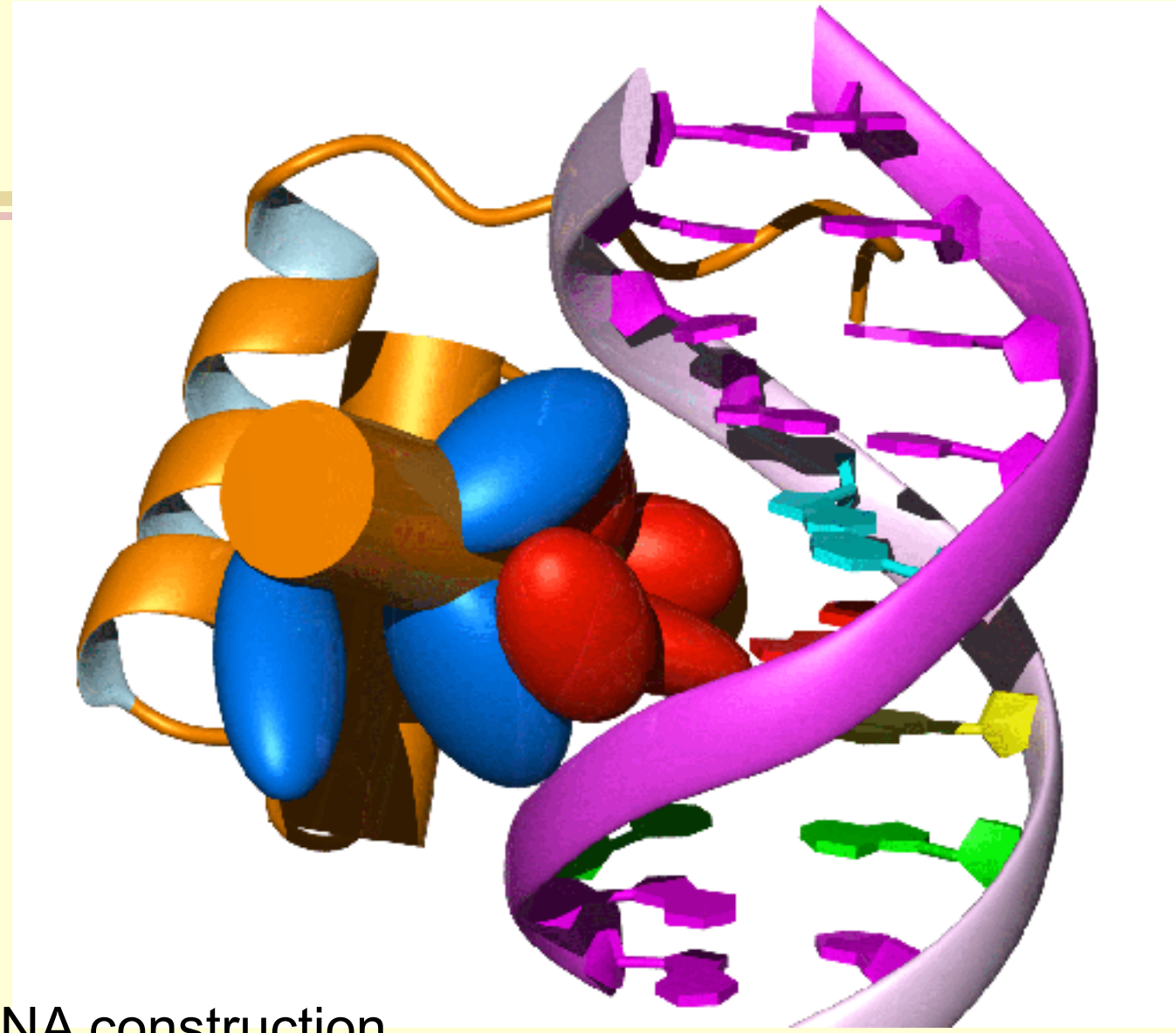
These second generation nanomachines will do all that protein machine can do and more. They will be able to bond atoms together in virtually any stable pattern, adding a few at a time to the surface of a workpiece until a complex structure is complete.

Think of such nanomachines as assemblers.



Nano Assembler
(Stewart Platform)

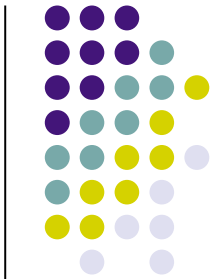

Jeff Johnson | Biological & Medical Visuals



DNA construction


The Convergence
of Info-Bio-Nano
and Disruptive
Technologies

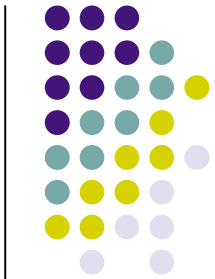
Disruptive Technologies



- Beyond this fact, there is another important characteristic of such technologies: they are disruptive! Their impact on social institutions such as corporations, governments, and learning institutions is profound, rapid, and quite unpredictable.
- As Clayton Christensen explains in *The Innovator's Dilemma*, while many of these new technologies are at first inadequate to displace today's technology in existing applications, they later explosively displace the application as they enable a new way of satisfying the underlying need. If change is gradual, there will be time to adapt gracefully, but that is not the history of disruptive technologies.

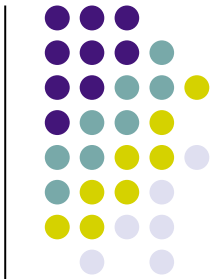

Technological Singularities

Technological Singularities

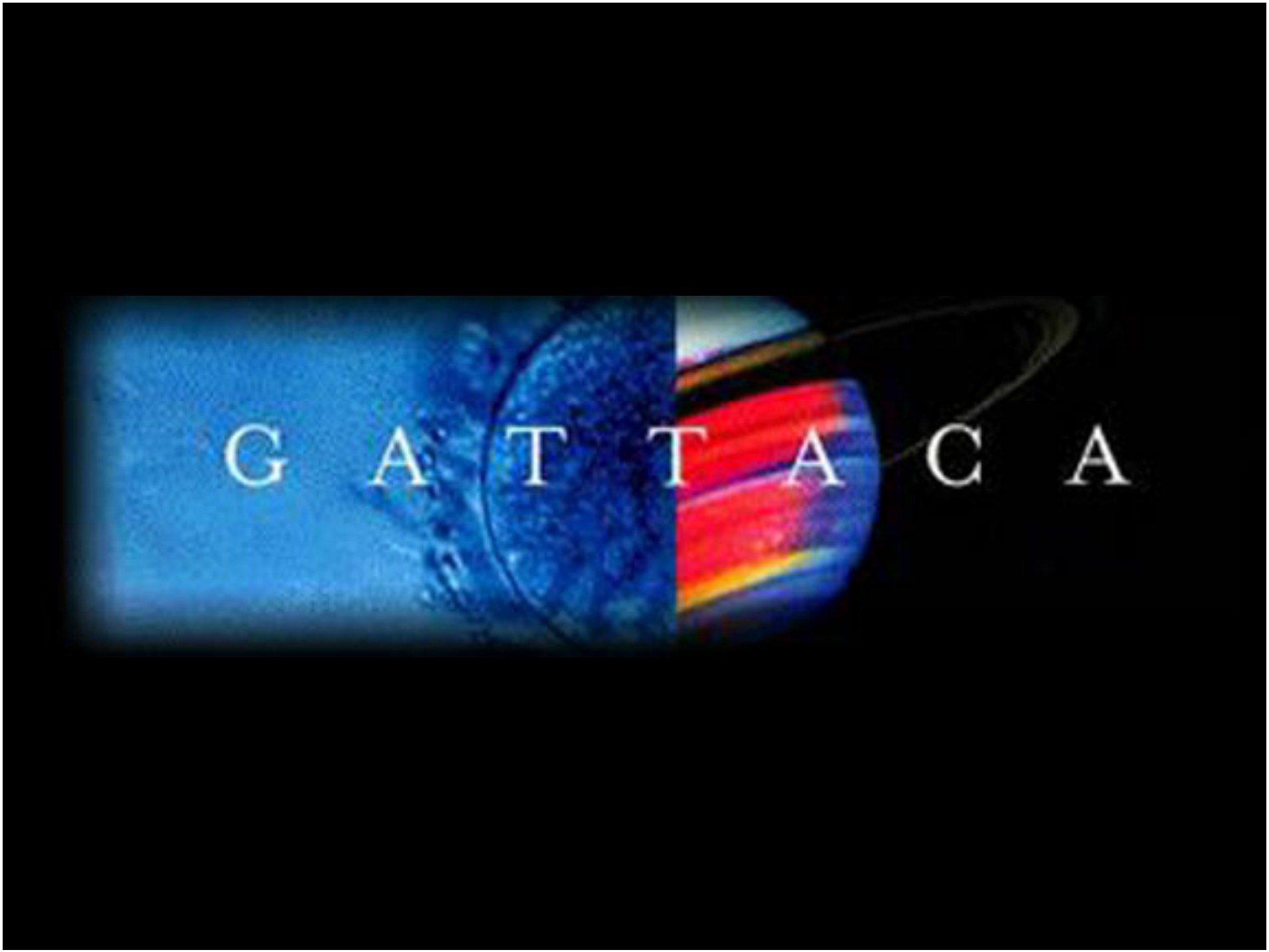


- The acceleration of technological progress has been the central feature of the past century and is likely to be even more so in the century ahead. John von Neumann once speculated that “the ever accelerating progress of technology and changes in the mode of human life gives the appearance of approaching some essential singularity in the history of the race beyond which human affairs, as we know them, could not continue.”
- Some futurists such as Ray Kurzweil and Werner Vinge have even argued that we are on the edge of change comparable to the rise of human life on Earth.

So what might happen?



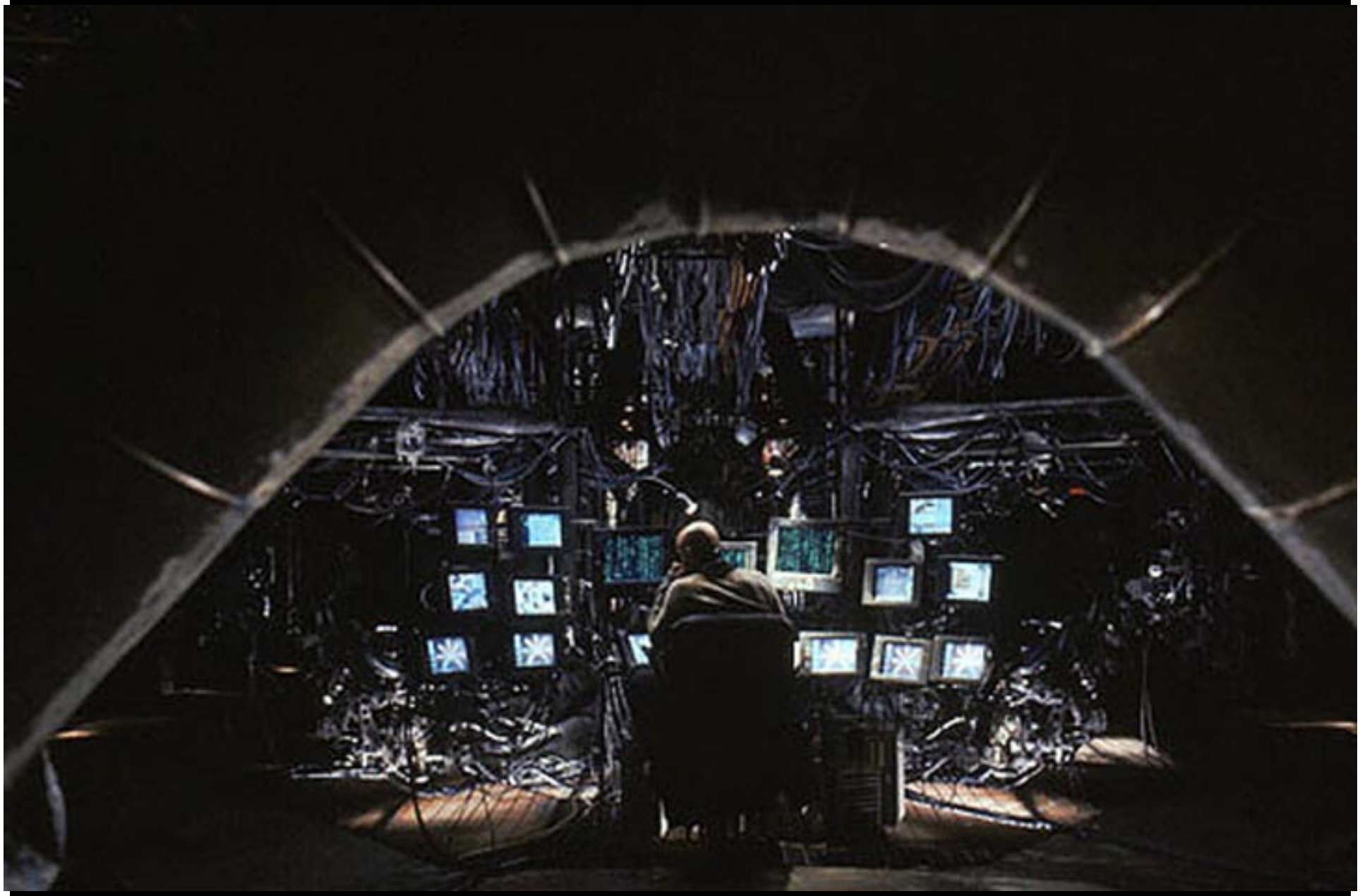
- The precise cause of this change is the imminent creation by technology of entities with greater than human intelligence. For example, as digital technology continues to increase in power a thousand-fold each decade, at some point computers (or large computer networks) might “awaken” with superhuman intelligence. Or biological science may provide the means to improve natural human intellect.
- When greater-than-human intelligence drives technological evolution, that progress will be much more rapid, including possibly the creation of still more intelligent entities, on a still shorter timescale.


G A T T A C A

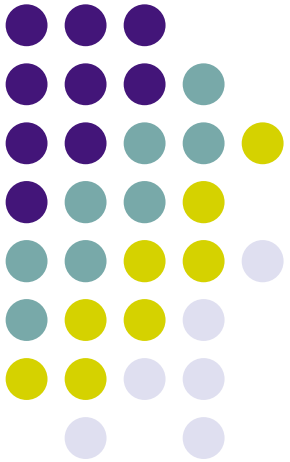

THE
TERMINATOR

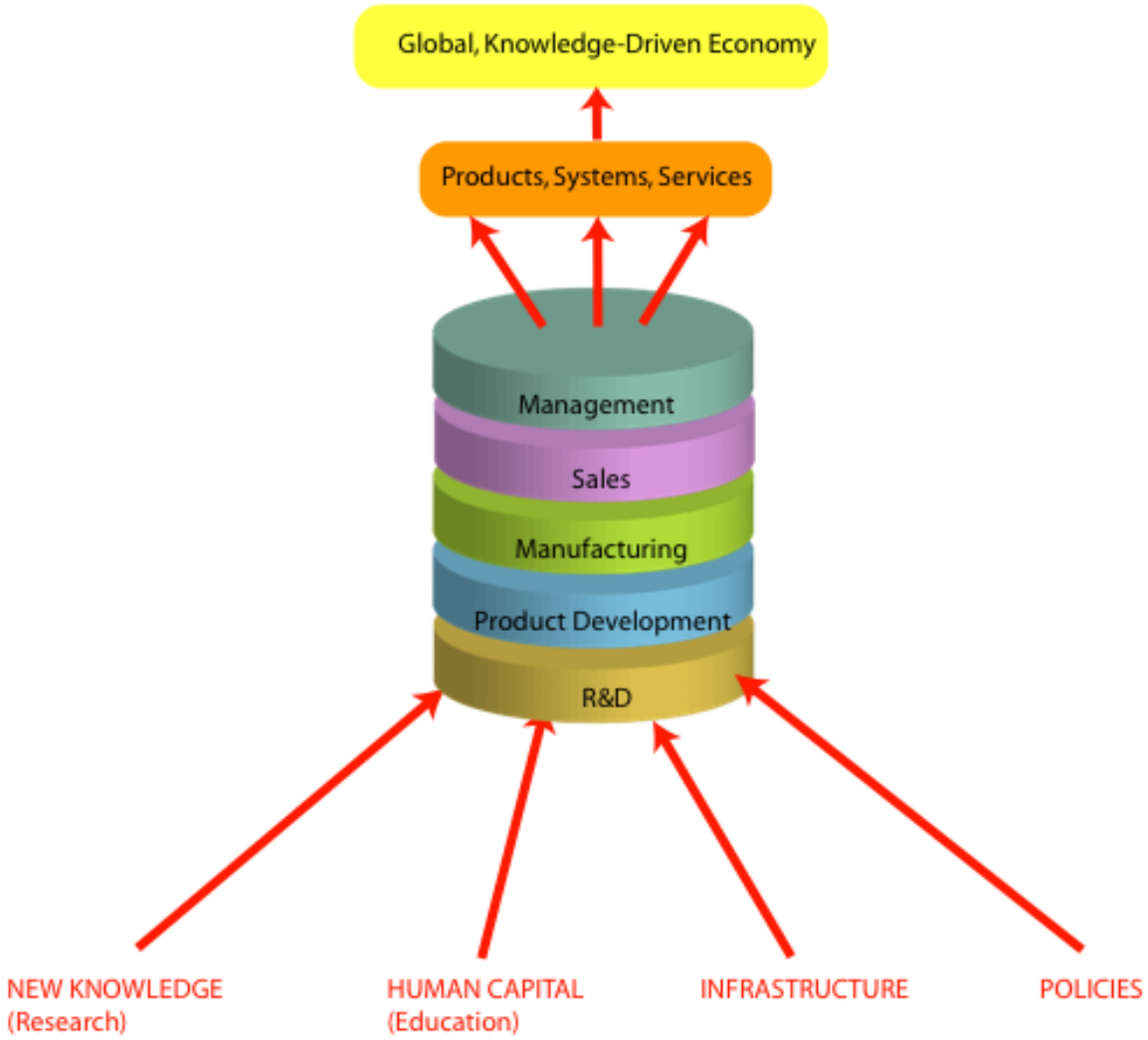

TERMINATOR 2
JUDGMENT DAY

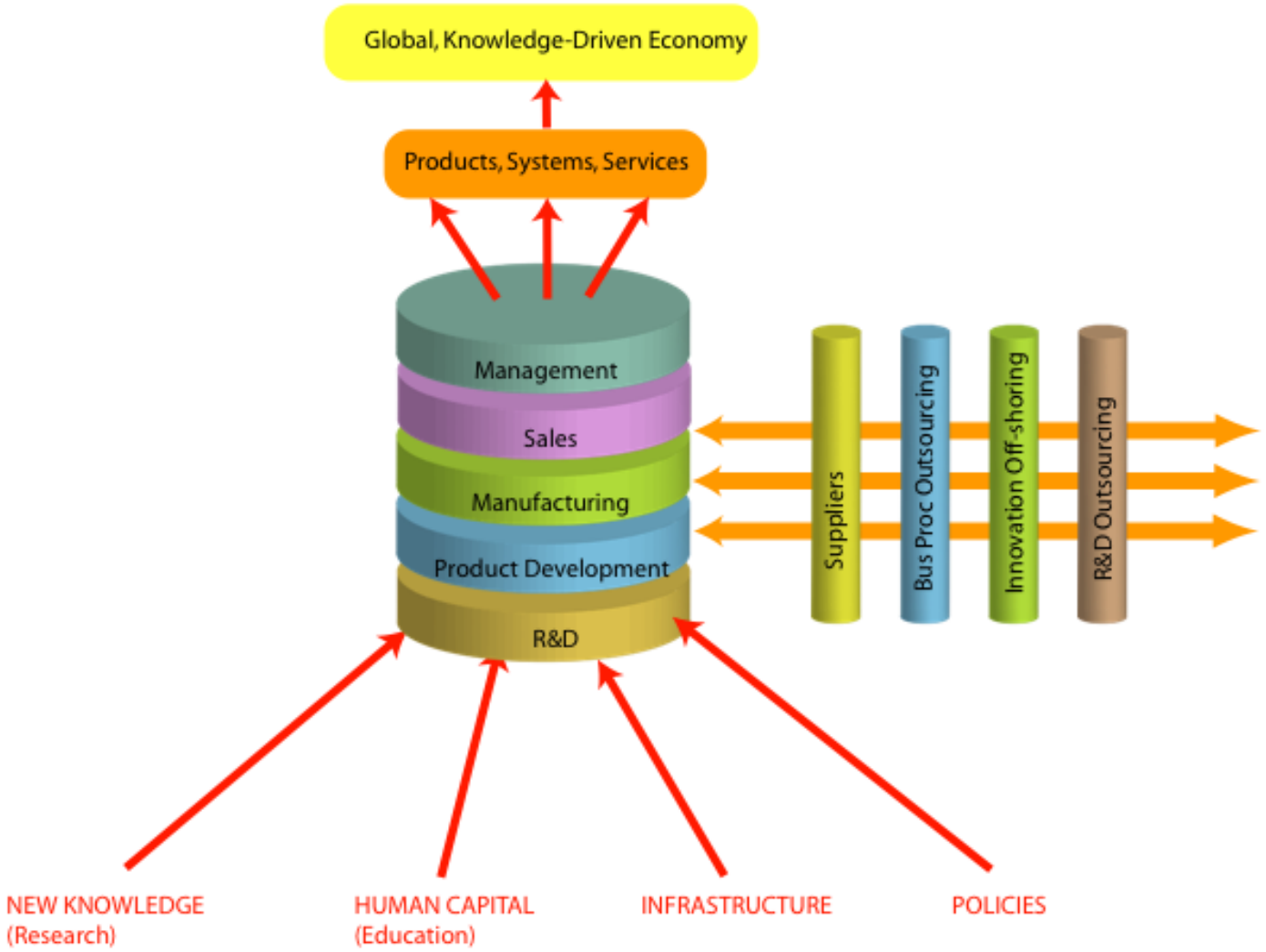

THE
MATRIX



The Way the World Works Today




Global, Knowledge-Driven Economy
Products, Systems, Services
Management
Sales
Manufacturing
Product Development
R&D
NEW KNOWLEDGE
(Research)
HUMAN CAPITAL
(Education)
INFRASTRUCTURE
POLICIES


Global, Knowledge-Driven Economy
Products, Systems, Services
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Product Development
R&D
Suppliers
Bus Proc Outsourcing
Innovation Off-shoring
R&D Outsourcing
NEW KNOWLEDGE
(Research)
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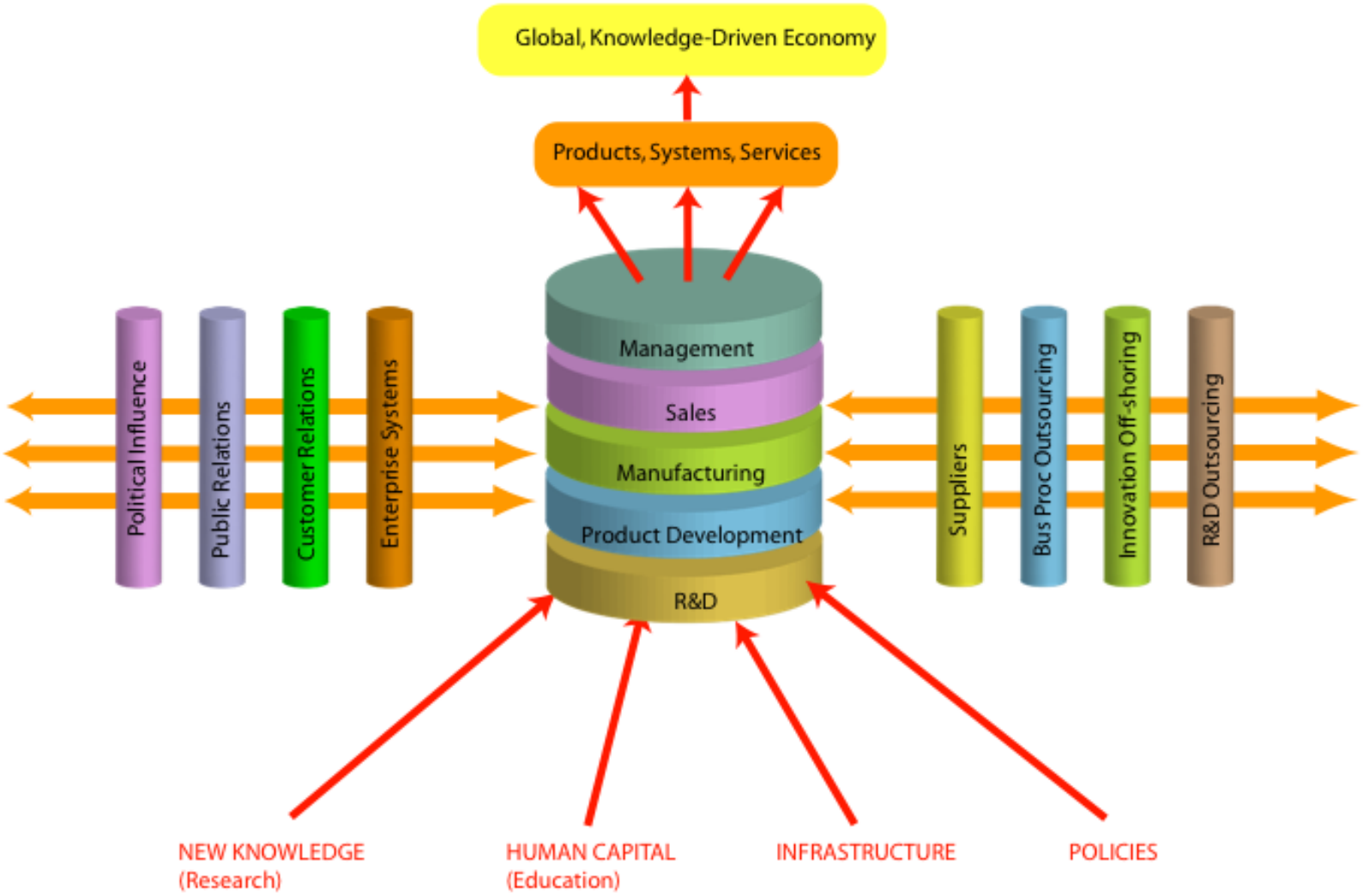
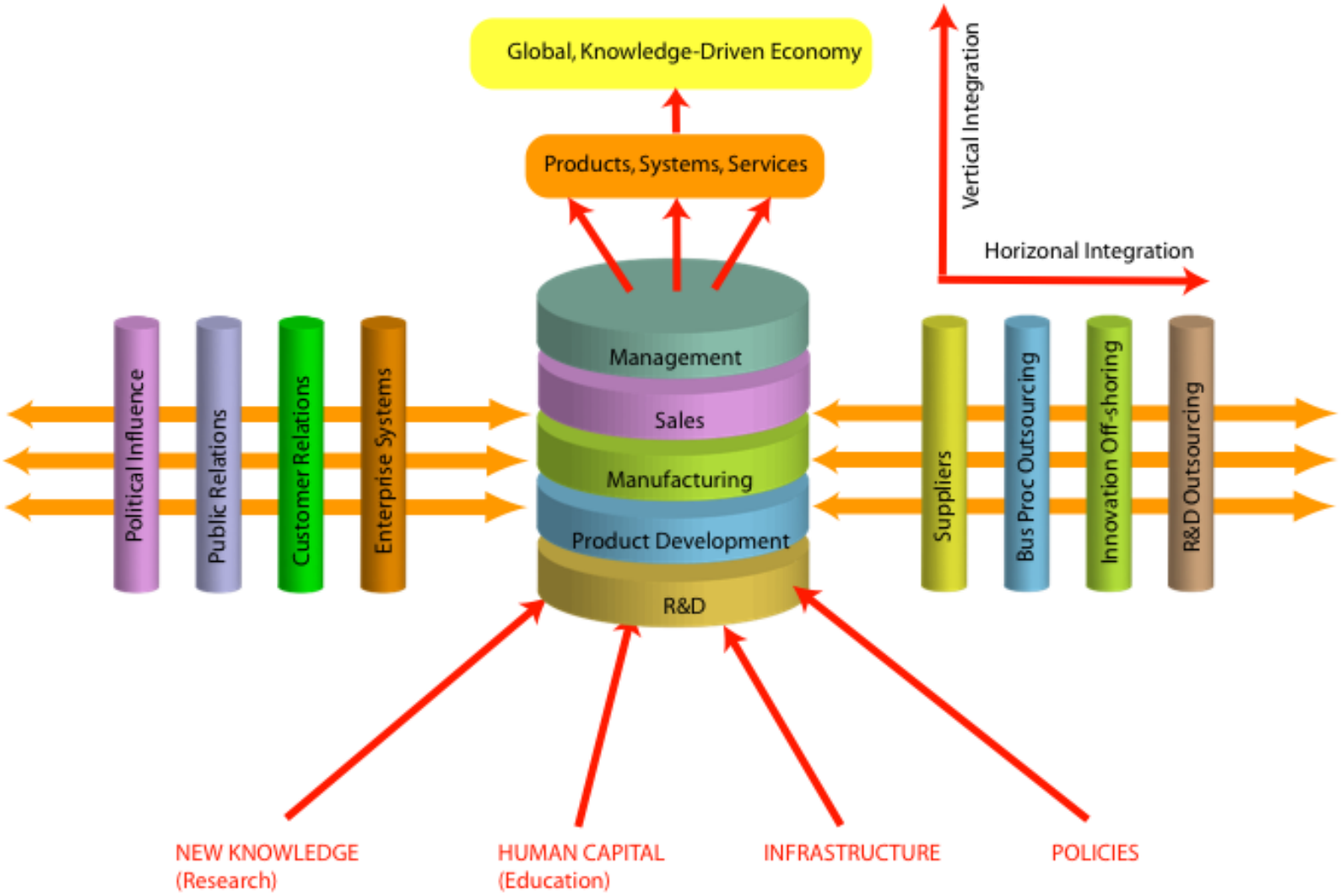
INFRASTRUCTURE
POLICIES


Global, Knowledge-Driven Economy
Products, Systems, Services
Management
Sales
Manufacturing
Product Development
R&D
Political Influence
Public Relations
Customer Relations
Enterprise Systems
Suppliers
Bus Proc Outsourcing
Innovation Off-shoring
R&D Outsourcing
NEW KNOWLEDGE
(Research)
HUMAN CAPITAL
(Education)
INFRASTRUCTURE
POLICIES


Global, Knowledge-Driven Economy
Products, Systems, Services
Vertical Integration
Horizonal Integration
Political Influence
Public Relations
Customer Relations
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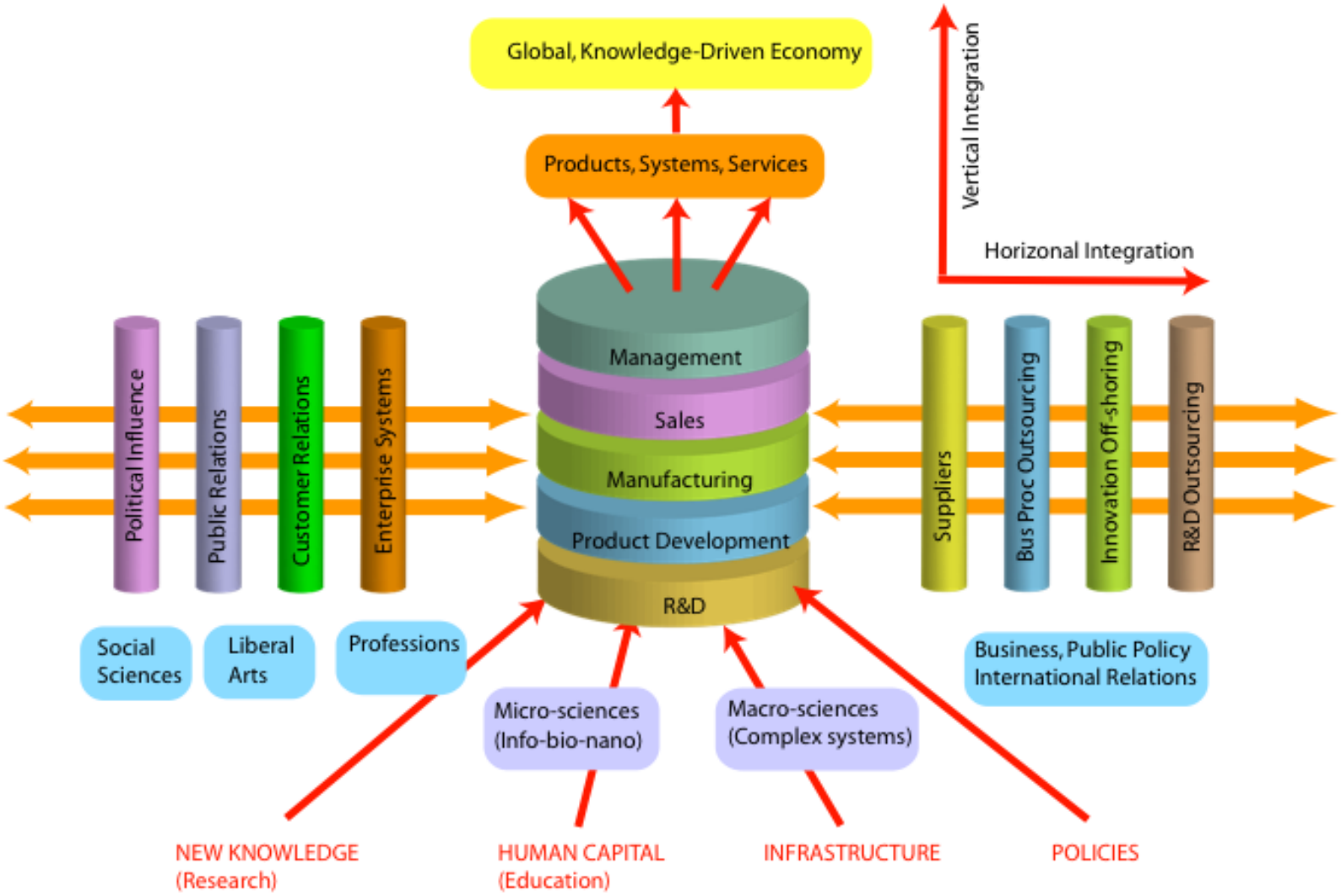
Global, Knowledge-Driven Economy
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Vertical Integration
Horizonal Integration
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Sales
Manufacturing
Product Development
R&D
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Public Relations
Customer Relations
Enterprise Systems
Suppliers
Bus Proc Outsourcing
Innovation Off-shoring
R&D Outsourcing
Social Sciences
Liberal Arts
Professions
Micro-sciences (Info-bio-nano)
Macro-sciences (Complex systems)
Business, Public Policy International Relations
NEW KNOWLEDGE (Research)
HUMAN CAPITAL (Education)
INFRASTRUCTURE
POLICIES


How Will the World Work
…Tomorrow?