The BioIntelligence Age:
Healthcare after the Information Age

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US Army Medical Research and Materiel Command

Modeling and Simulation Emergency Response
NIST
March 4-6, 2003

Air Force 1 - refit Unofficial Administration request

Current Visions

"The Future is here …

. . . it's the Information Age"

Current Visions

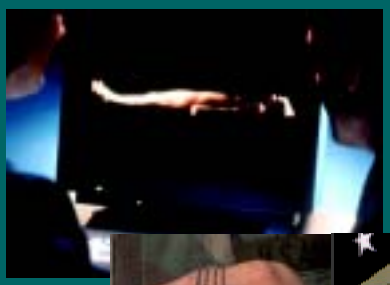
Today's technologies that
are recrafting how the
future of medicine will unfold

Fundamental Concepts

New technologies that are emerging
from Information Age discoveries
are changing our basic approach
in all areas of healthcare

Holomer

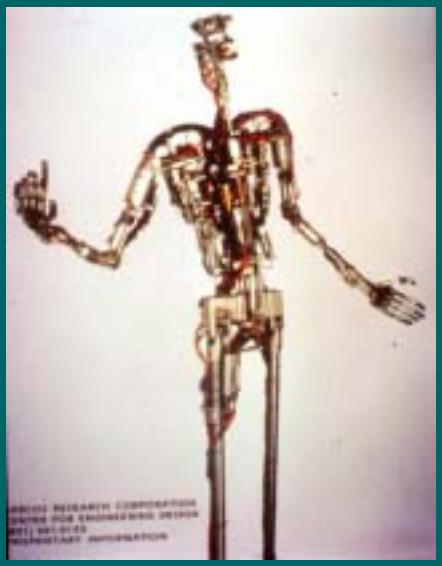
Total body-scan for sharing information



From visible human to virtual human

Satava March, 2002

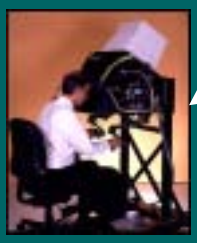
Healthcare Provider of the Future ??



Courtesy Steve Jacobsen, Sarcos, Inc, Salt Lake City, UT

Total Integration of Operative Care … Anywhere

Remote Surgery



Minimally Invasive Surgery

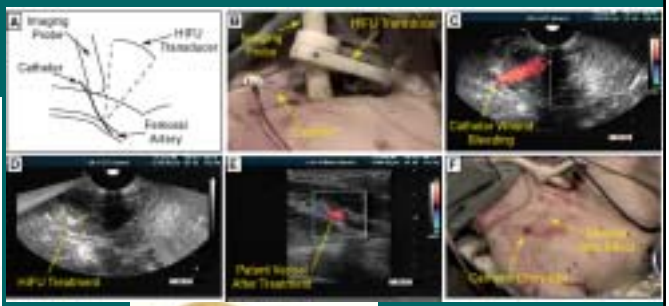
Pre-operative planning

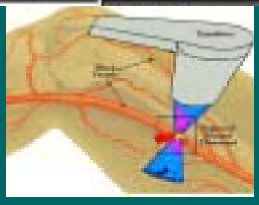
Intra-operative navigation

Simulation & Training

Joel Jensen,
SRI International, Menlo Park, CA

Point-of-care noninvasive therapy





HIFU

High Intensity
Focused Ultrasound
for
Non-invasive
Acoustic hemostasis

Courtesy Larry Crum, Univ Washinton Applied Physics Lab

The medic and physician …
are connected to their knowledge base

Point-of-care
ubiquitous knowledge

The medic and physician …
are connected to the patient

The LSTAT

- Defibrillator
- Ventilator
- Suction
- Monitoring
- Blood Chemistry Analysis
- 3-Channel Fluid/Drug Infusion
- Data Storage and Transmission
- On-board Battery
- On-board Oxygen
- Accepts Off-Board Power and Oxygen

Courtesy of Integrated Medical Systems, Signal Hill, CA

LSTAT Deployment to Kosovo - March 2000

212th MASH Deployed with LSTAT - Combat Support Hospital

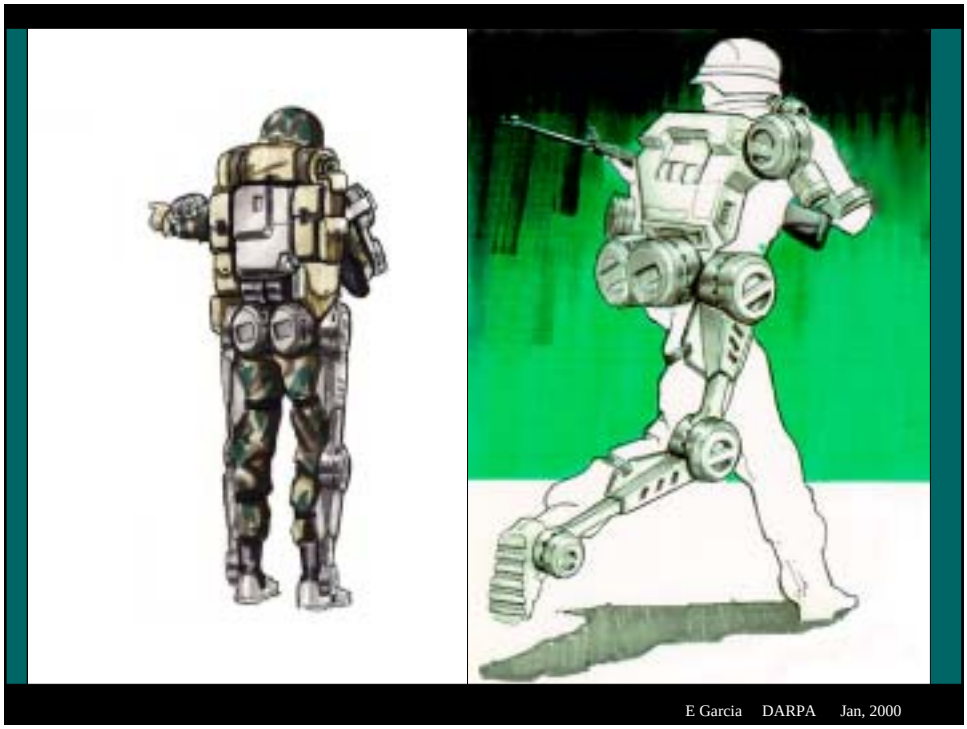
Courtesy of Integreated Medical Systems, Signal Hill, CA

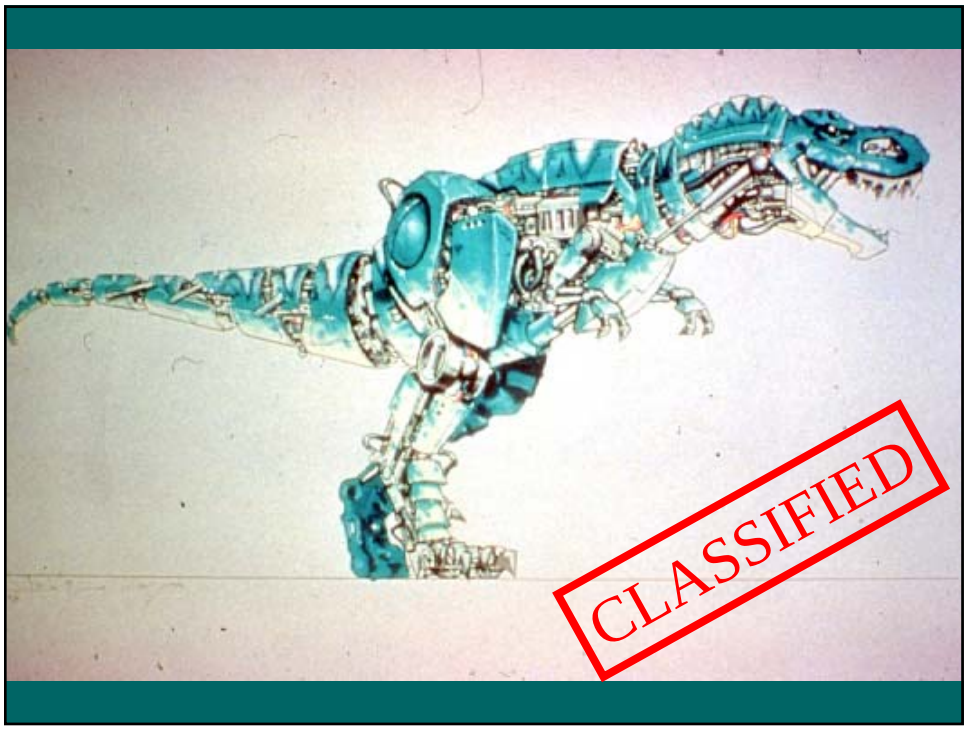
LSTAT in Battlefield Configuration

Courtesy Matt Hanson, Integrated Medical Systems, Signal Hill, CA

Objective Force Warrior
the soldier for Future Combat Systems
1st generation - 2015

Future Combat Systems - Soldier 2025 Courtesy Natick Labs, MA


E Garcia DARPA Jan, 2000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Disruptive Visions

"The Future is not what it used to be"

….Yogi Berra

The Information Age is NOT the Future

The Information Age is the Present ...

There is something else out there . . . . . .

SATAVA 7 July, 1999
DARPA

Creative Thinking

How can I think OUTSIDE of the box

When I don't know where the edges are?

OR

Am I still inside?

The Future of Science

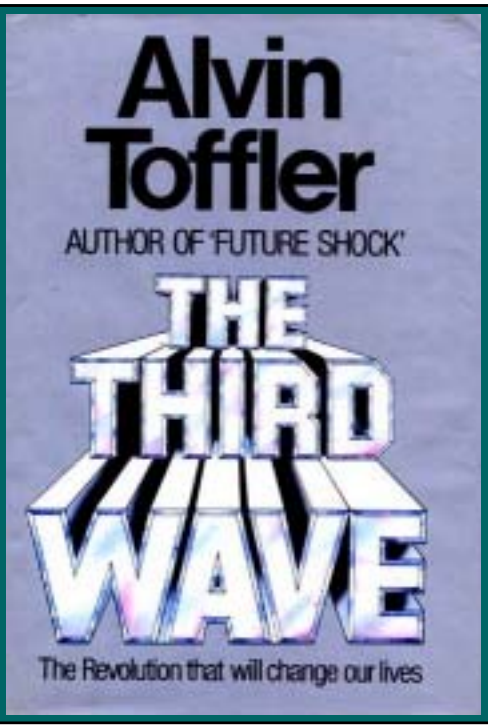
Is moving toward interdisciplinary fields

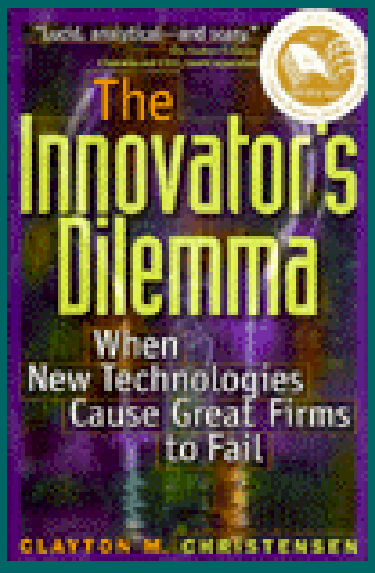
Must encompass all dimensions (or domains)

Must include time and information

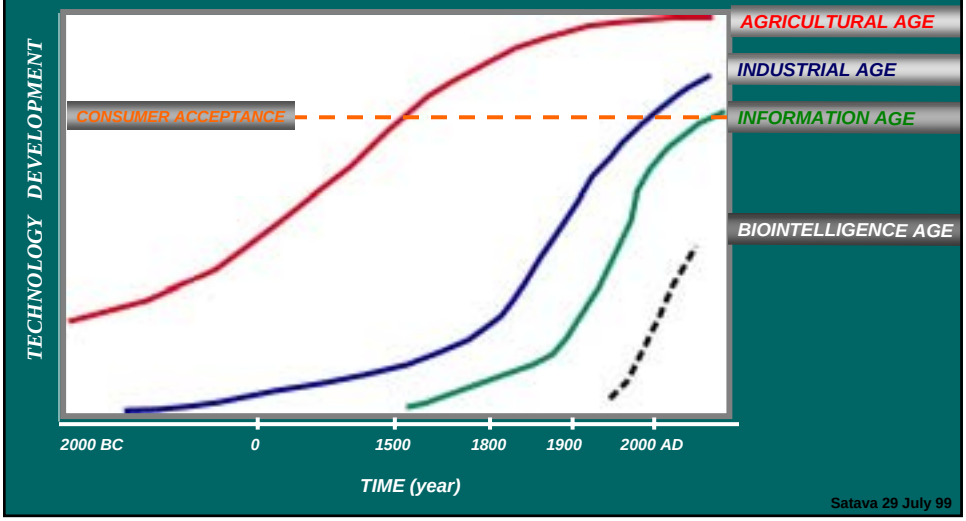
? BioIntelligence Age

SATAVA 7 July, 1999
DARPA


Alvin
Toffler
AUTHOR OF 'FUTURE SHOCK'
THE
THIRD
WAVE
The Revolution that will change our lives

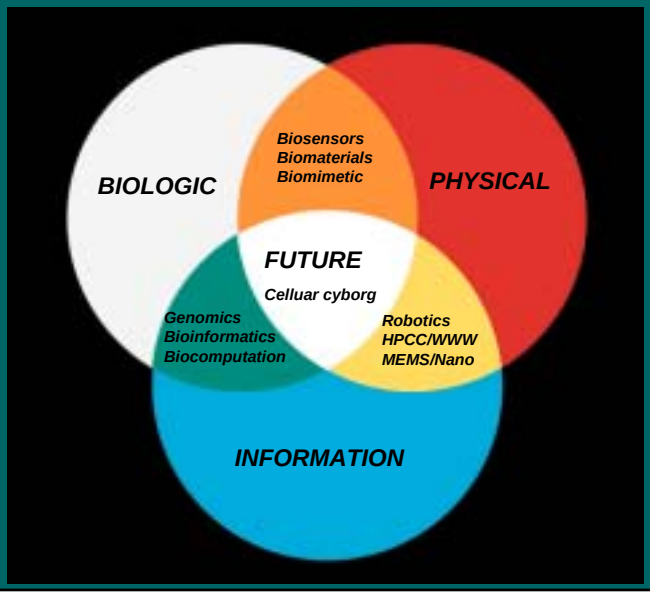

The
Innovator's
Dilemma
When
New Technologies
Cause Great Firms
to Fail
CLAYTON M. CHRISTENSEN

BIO INTELLIGENCE AGE



Satava 29 July 99

The BioIntelligence Age



Satava 2 Feb 1999

Global Concepts

?? BioIntelligence Age (what are the implications)

Understanding biologic processes is a cornerstone (4 1/2 Billion yrs)

The entire world is becoming "smarter" - embedded intelligence

Networking provides distributed intelligence (informatics, telecom)

The next wave will be Bio…..X
mimicking or incorporating biologic processes

Initiatives

DARPA	BioFocus 2000
NASA	BioAstronautics/Astrobiology
NSBRI	Human Systems Integration
NCI	Unconventional Projects
NSF	National Nanotechnology Initiative
DoE	Virtual Human Project
Stanford	Bio…X

Federal Investment in NanoTechnology

Table 1. Summary of Federal nanotechnology investment

FY 2002 Budget Request (in million of dollars)*

Department/Agency	FY00	FY01	FY02	FY03
Department of Defense	70	110	133.0	
Department of Energy	58	93	97.0	
Department of Justice	-	-	1.4	
Environ Protection Agency	-	-	5.0	
NASA	5	20	46.0	
NIH	32	39	45.0	
NIST	8	10	17.5	
National Science Found	97	150	174.0	.
Total	270	422	518.9	738

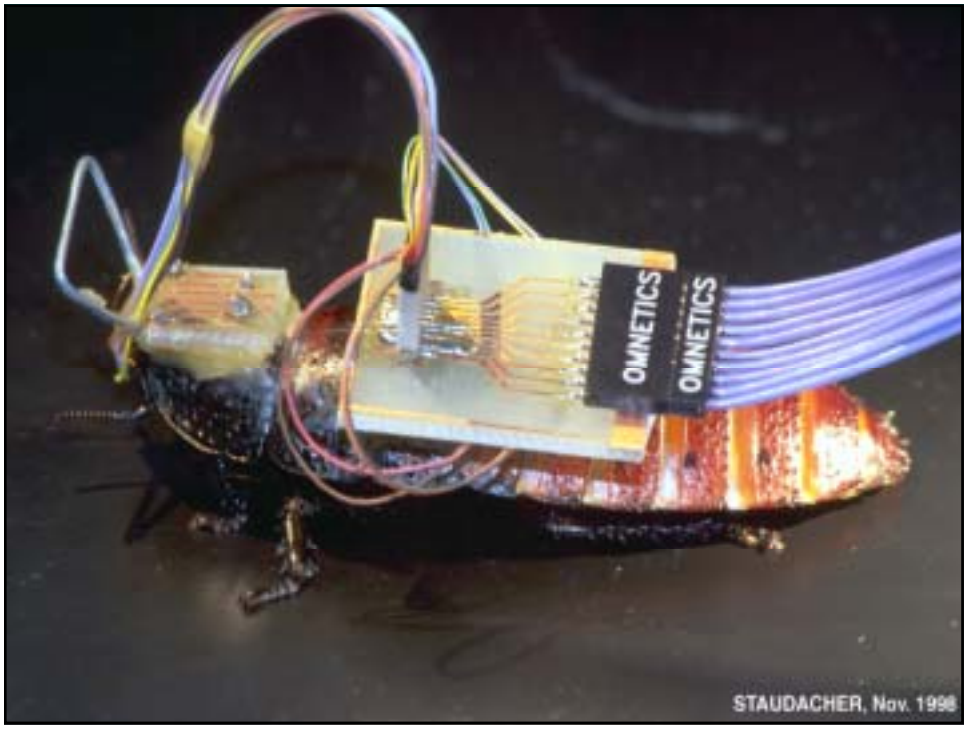
*Source: National Nanotechnology Investment in the FY 2002 Budget Request by the President

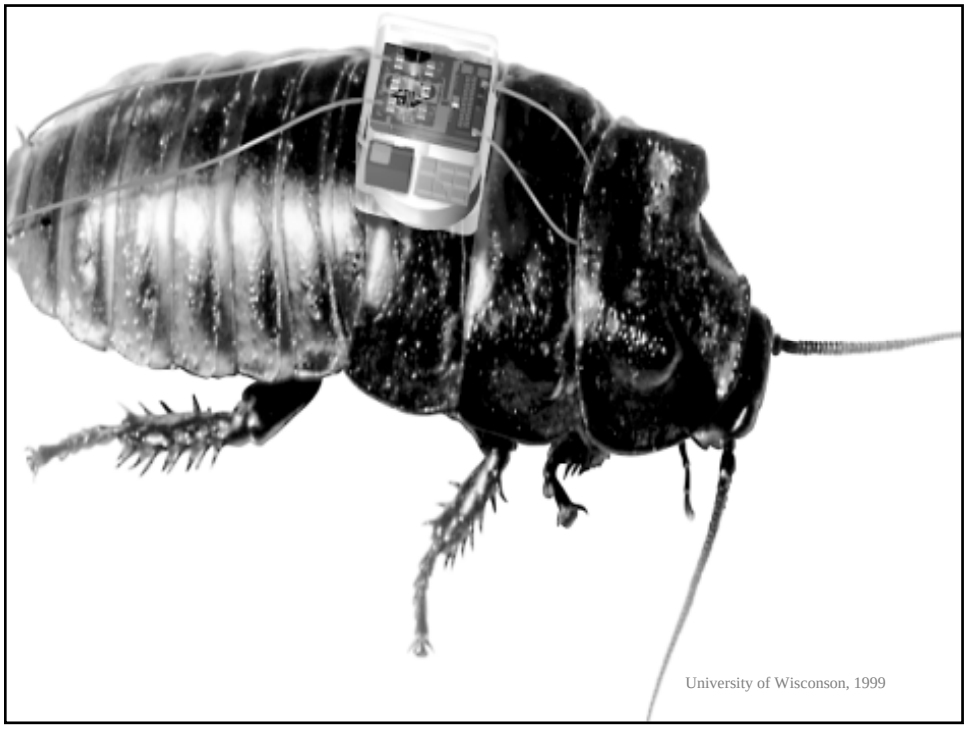
Disruptive Technologies

What are the technologies . . .

telemedicine must support?


University of Montana, 1999


OMNETICS
OMNETICS
STAUDACHER, Nov. 1998


University of Wisconson, 1999

Biomimetic Micro-robot

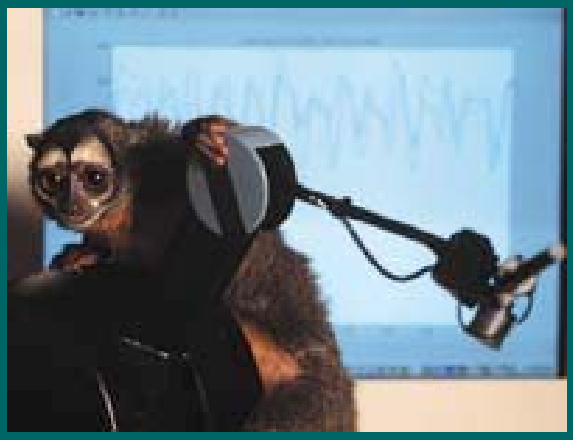
… controlled from a distance?

Courtesy Sandia National Labs

Capsule camera for gastrointestinal endoscopy

Courtesy Paul Swain, London, England

Thoughts into Action



Direct brain implant control of robot arm

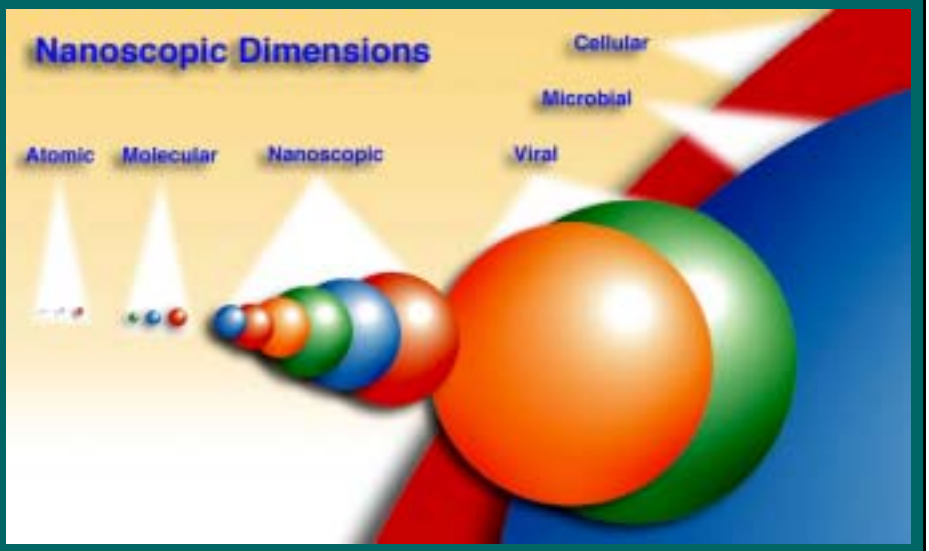
Duke University and MIT/Brown University

Satava January , 2003

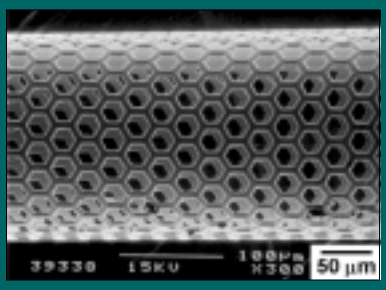
Way outside the Box

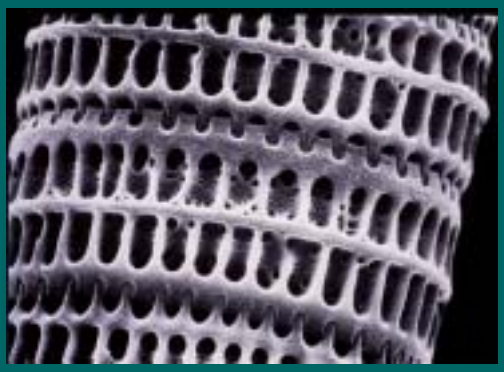
OR

Am I still inside?
And where is Healthcare?



Courtesy Dr. Ralph Merkel, Center for Biologic Nanotechnology, Univ Michigan, Ann Arbor, MI

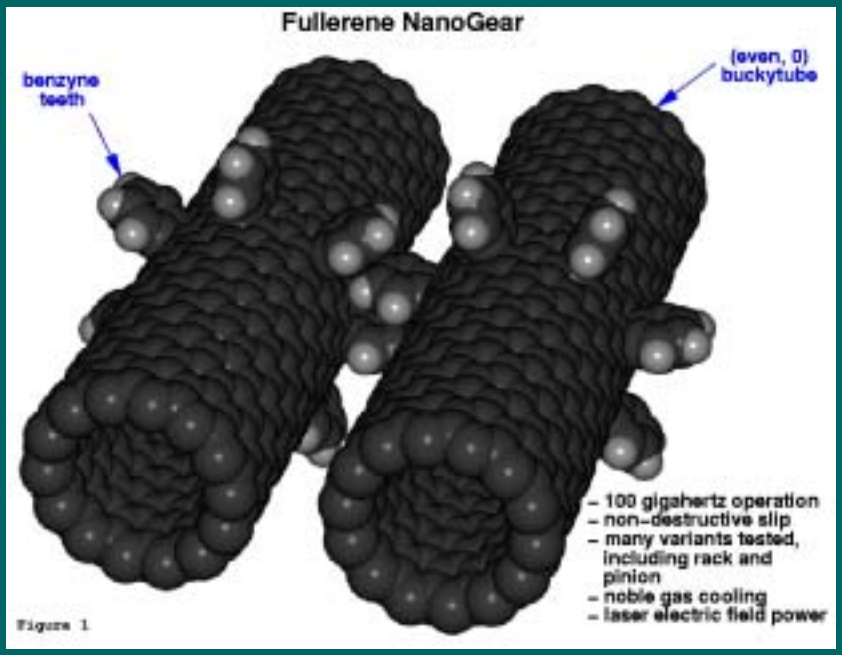




Spatial/temporal control of structure, function, morphology over multiple length scales

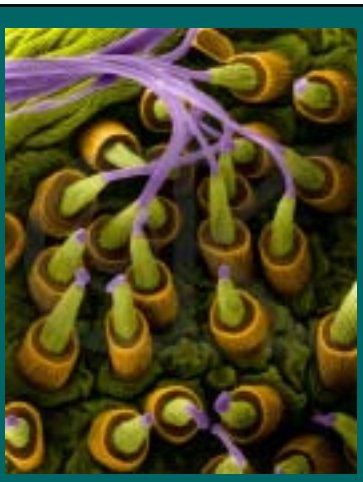
Eisenstadt DARPA Feb. 2000

Bacteria with flagella – Biology's nanomotor

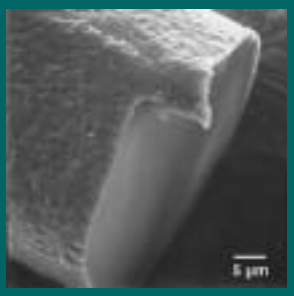


*Courtesy: Richard Smalley, Director, Center for Nanoscience Technology at RICE UNIVERSITY

Orb spider - web



Spinnerette of spider

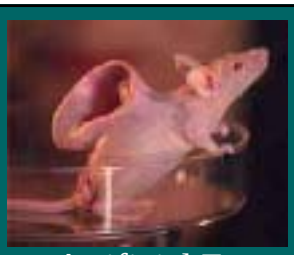


Cross section of synthetic fiber

Spider silk protein as biomaterial -BioSteel

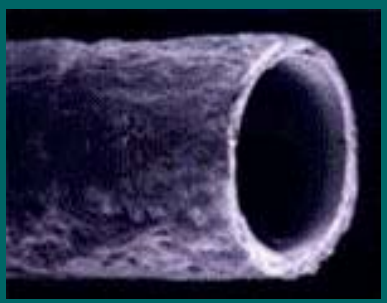
Nexia Biotechnologies, Montreal Canada

Tissue Engineering



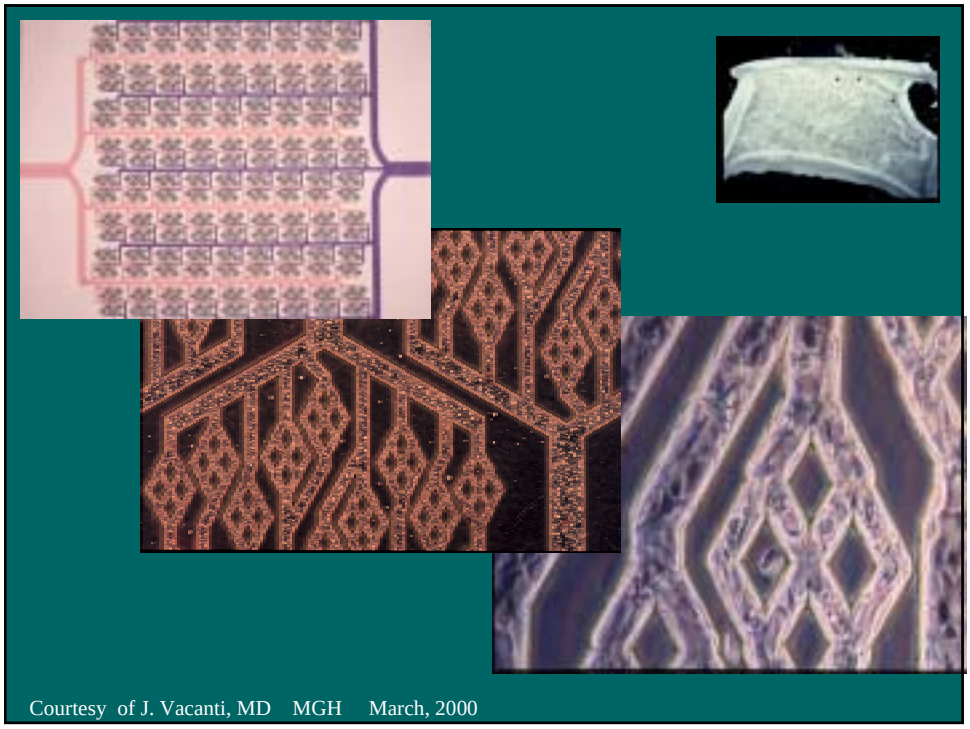
Artificial Ear

Liver Scaffolding



Artificial Blood Vessel

J. Vacanti, MD MGH March, 2000



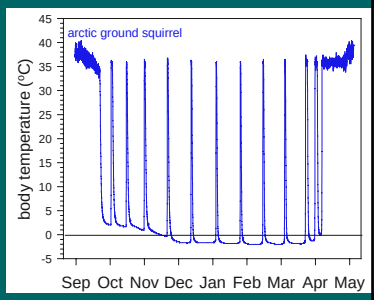
Courtesy of J. Vacanti, MD MGH March, 2000

Controlled Cellular Metabolism

Institute of Arctic Biology's

Toolik Field Station,

Alaska's North Slope



Brian M. Barnes, Institute of Arctic Biology , University of Alaska Fairbanks, 11/02

	active	hibernating
heart rate (beats/min)	300	3
resp. rate (breaths/min)	150	<1
body temp.	37°C	-2°C
gene function	ongoing	transcription and translation suppressed
metabolic rate ($mlO_2/g/h$)	0.5	0.01 (2%)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The Operating Room of the Future

Any sufficiently advanced technology

is indistinguishable from magic

- - Arthur C. Clarke

Technology is Neutral - it is neither good or evil

It is up to us to breathe the moral and ethical life into these technologies

And then apply them with empathy and compassion for each and every patient

The Miami Herald

INTERNATIONAL EDITION

SATURDAY, APRIL 6, 2002

Scientists weigh unconfirmed human cloning report

BY RICK WEISS
Washington Post Service

Scientists, ethicists and politicians around the world became caught up in a flurry of electronic chatter Friday triggered by an unconfirmed report that an Italian fertility doctor had helped a woman become pregnant with the world's first human clone.

The doctor, Severino Antinori, a renowned medical maverick and director of a human reproduction research center in

A woman who answered the telephone at Antinori's clinic Friday said the doctor was unavailable and would not be releasing any further information. "Science needs silence, or science will not get done," said the woman, who did not identify herself.

It's possible that the pregnancy claim, reportedly made Wednesday in veiled comments at a scientific meeting in the United Arab Emirates, amounts to nothing more than a publicity stunt — or that the

CNN news

Saturday, 28 December, 2002, 14:28 GMT

Demands grow for human clone ban

Advocates argue cloning can help infertile couples

There are growing demands for a ban on human cloning after claims that a girl born on Thursday is an exact genetic replica of her mother.

Clonaid scientist Brigitte Boisselier said four more clones will be born soon. French President Chirac has called on all countries to rally behind a Franco-German proposal for a global ban on human cloning which has been submitted to the United Nations.

US President George W Bush says the process is "deeply troubling".

Scientists remain sceptical of the success claimed by the Clonaid company, which is linked to a sect that believes aliens created humans by cloning 25,000 years ago.

But legislators in Britain and elsewhere say there has to be discussion and introduction of rules for the practice of scientific methods which could produce a cloned baby, even if Clonaid's claims are untrue.

"These technologies . . . are raising new moral and ethical morasses for us."

Dr Ian Gibson
British legislator

"The practice is contrary to human dignity and is criminal"

French President Jacques Chirac

Clonaid scientist Brigitte Boisselier said a baby girl - nicknamed Eve - was born in the US after the genetic material from a woman's skin cell was fused with one of her eggs.

Dr Boisselier said four other women were due to give birth to baby clones in the coming weeks - one in Europe, another in North America and two in Asia.

Gaak

Intelligent “Living Robot”

Uses genetic algorithms to “learn”

TECHNOLOGY NEWS

"Thinking" robot in escape bid

Scientists running a pioneering experiment with robots which think for themselves have caught one trying to flee the centre where it "lives".

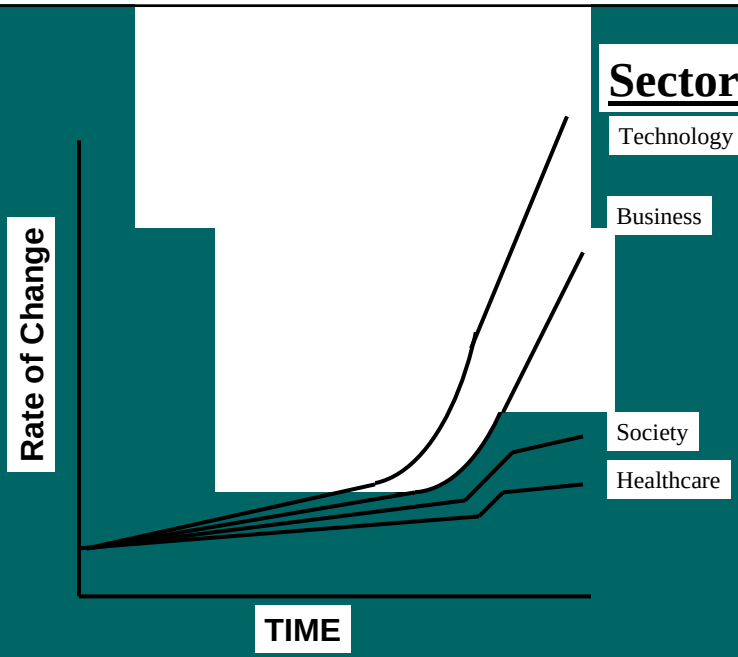
The small unit, called Gaak, is one of 12 taking part in a "survival of the fittest" test at the Magna science centre in Rotherham, South Yorkshire, which has been running since March.

Gaak made its bid for freedom after it had been taken out of the arena where hundreds of visitors watch the machines learning how to repair themselves after doing daily battle.

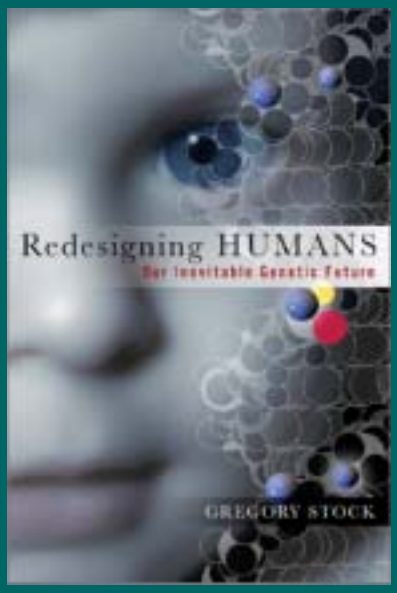
Professor Noel Sharkey said he turned his back on the drone, but when he returned 15 minutes later he found it had forced its way out of the small make-shift paddock it was being kept in.

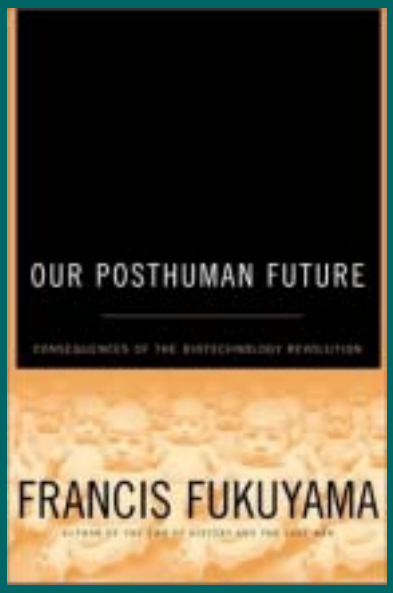
He later found it had travelled down an access slope, through the front door of the centre and was eventually discovered at the main entrance to the car park when a visitor nearly flattened it with his car.

Courtesy Professor Noel Sharkey, Sheffield Unversity, London



Differing responses to scientific discovery by various sectors





Moral and Ethical Issues

Raised by Technological Success

Should we do research in areas we may not be able to control?
(eg, genetics, cloning, nanobots, intelligent machines?)

Will prolonging life through technology result in more disease in the overall population

Can we change medicine from treatment to prevention of disease

In defeating diseases, will technology change a human into a combination of man and machine - what does it mean to be “human”

How will we decide who gets the technology, especially in 3rd World

Do Robots Dream?

Disruptive Visions

The Future will be here . . .

. . . sooner than you think