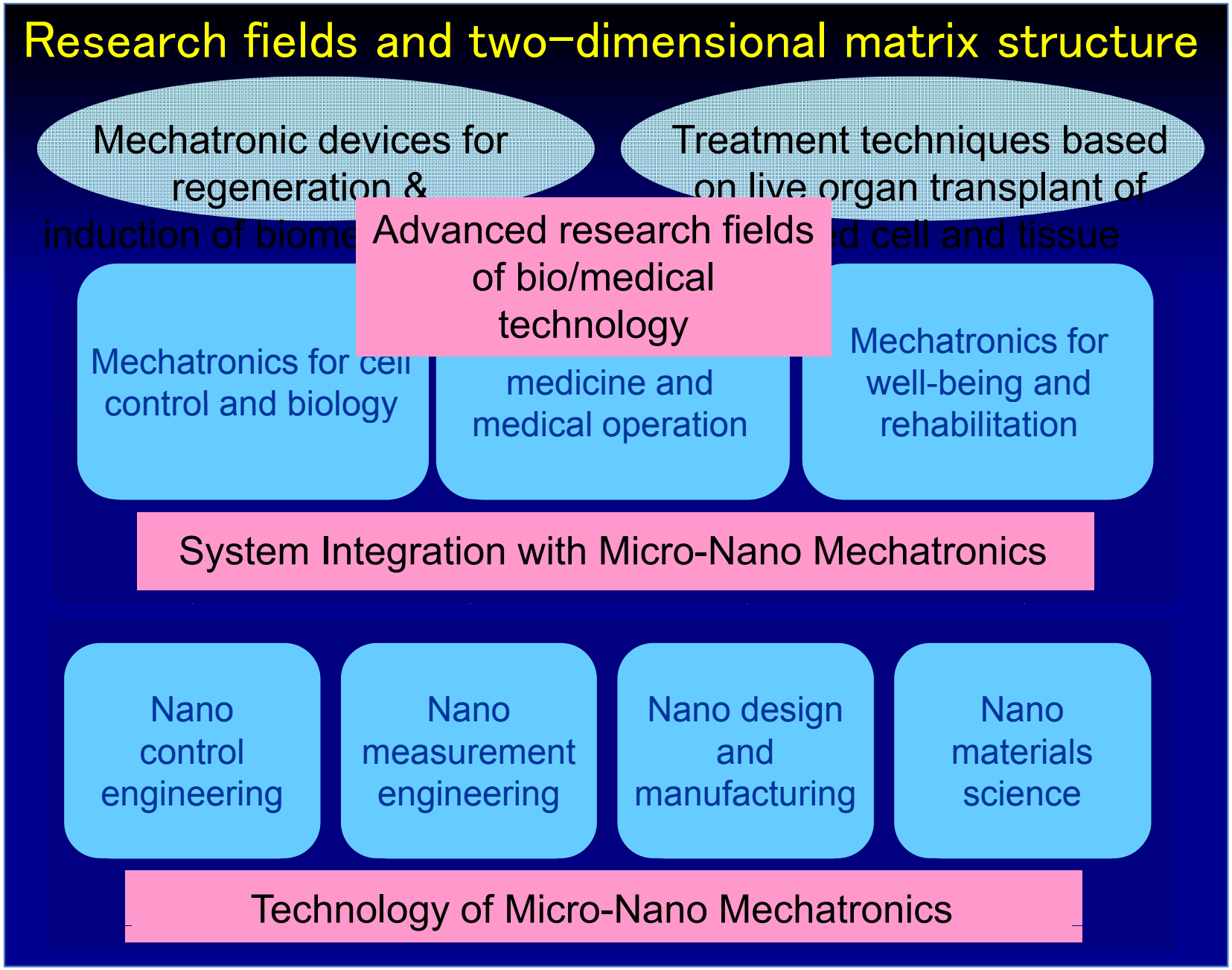
Basic 1
Introduction of Micro-Nano Mechatronics

Prof. T. Fukuda
Dept. of Micro/Nano Systems Engineering
Nagoya University

COE for Education and Research of Micro-Nano Mechatronics



Mechatronics and Robotics *in Macro-Micro-Nano World*

- Macro Scale
  - Robotics and Mechatronics
  - System Design, Sensor and Actuator, Assembly and Control
  - Design Goal and Knowledge , Design Principle

- Micro Scale
  - Micro Machine, Micro Mechatronics, Micro Fabrication and Assembly
  - Micro Bio Technology, Wet Mechatronics, Micro Total Analysis System
  - Micro Medical Engineering, Regenerative Medical Engineering
  - MEMS, Micro Electro Mechanical Systems

- Nano Scale
  - Nano Mechatronics, Nano Devices, Nano Fabrication and Assembly
  - Nano Biotechnology, System Cell Engineering, Single Molecular Observation, DNA Analysis and Synthesis
  - NEMS, Nano Electro Mechanical Systems, Nano/Micro Engineered and Molecular System

Sensor Technology

- Only those who have cutting edge type of sensor technology can survive in the world.
- Dry technology to Wet technology
  - Human applications
  - Bio sensors
  - Nano bio technology
  - Hybrid sensor and acuator
  - Plant based sensor technology

Actuator Driven System Design

- Electric Motor + gears
- Hydraulic actuator
- Neumatic actuator
- Ultra Sonic motor
- PZT & PLZT actuator, Pb free actuator(2006-)
- SMA actuator
- GMA actuator
- Hydrogen Alloy Actuator
- Polymer actuator
- Bio actuator
- Others + Energy sources
- Sensor & communication built-in type of actuator

Nanomanipulation System

Microscope

TEM/SEM (3D Manipulation)

STM/AFM/SNOM (2D Manipulation)

Fabrication

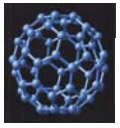
Super-molecule,
Self-assembly…
(Bottom-Up)

MEMS,
Lithography…
(Top-Down)

Atomic scale | Nano scale | Micro to Macro scale

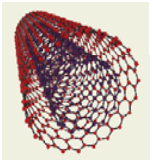
1Å 1nm 10nm 100nm 1μm

Atom



C_{60}

DNA



CNT

TEM: Transmission Electron Microscope
SEM: Scanning Electron Microscope
STM: Scanning Tunneling Microscope
AFM: Atomic Force Microscope

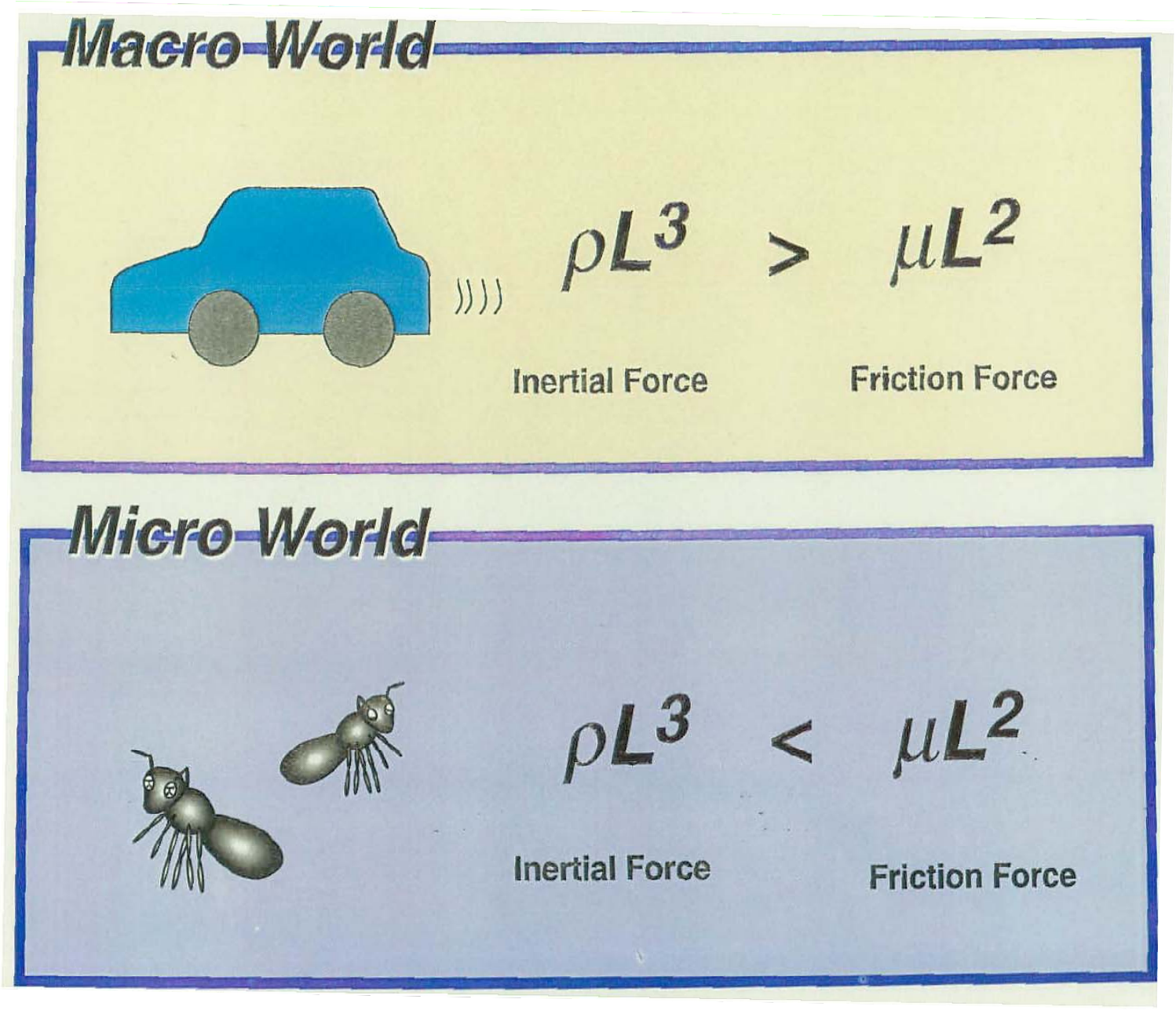
T. Fukuda al. IEEE Nanotechnology Magazine, Vol. 2 Issue 2, pp. 18-31 2008.

Micro/Nano Environment -Scaling law-

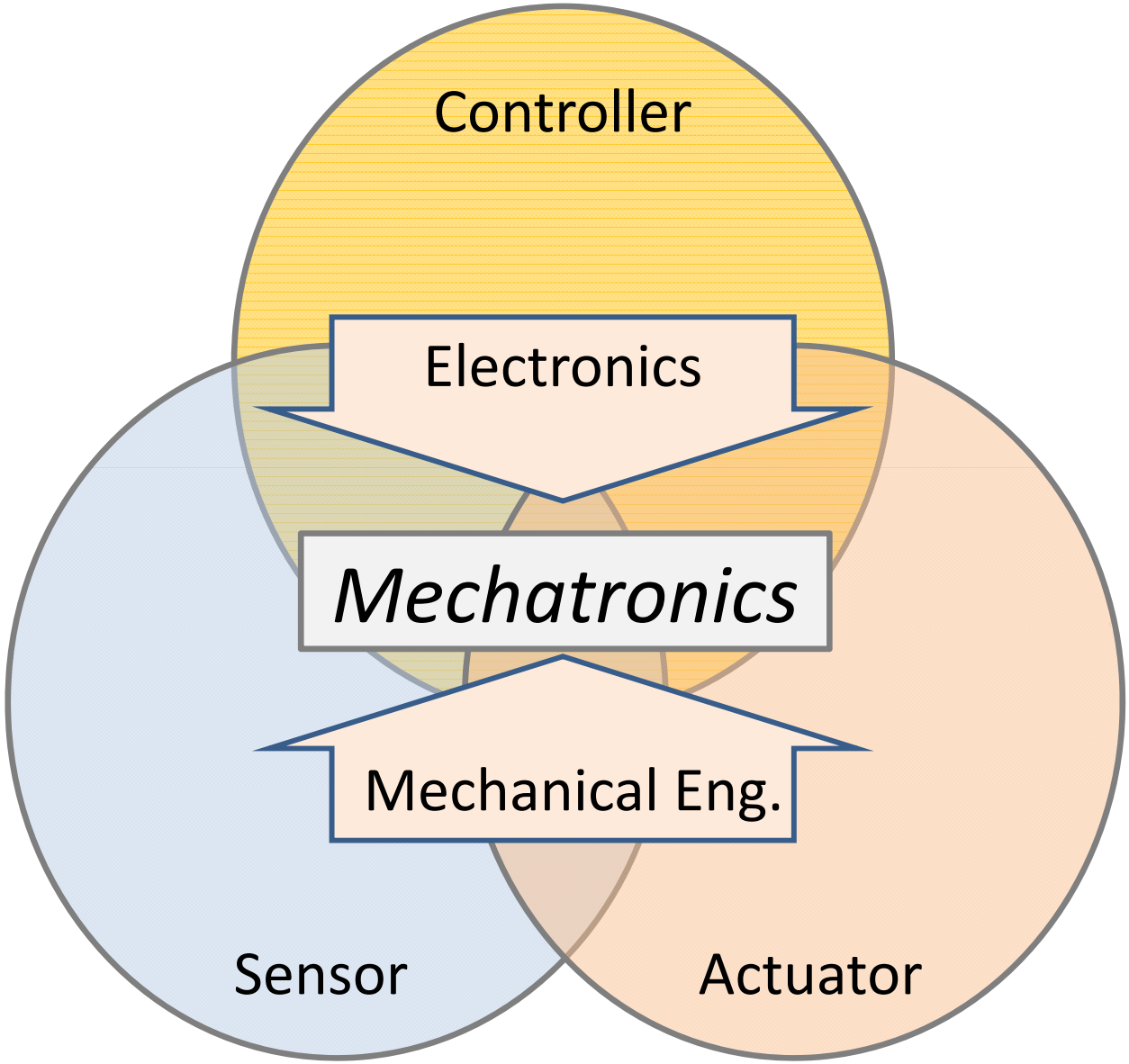
Physical Parameters	Symbols	Equations	Size Effects
Length	L	L	L
Area	S	$\propto L^2$	L^2
Volume	V	$\propto L^3$	L^3
Mass	m	ρV	L^3
Pressure	f_p	SP	L^2
Gravity	f_g	mg	L^3
Inertia Force	f_i	md^2x/dt^2	L^4
Viscous (Kinetic Friction) Force	f_f	$uS/d \cdot dx/dt$	L^2
Elastic Force	f_e	$eS?L/L$	L^2
Spring Constant	K	$2UV/(?L)^2$	L
Resonant Frequency	ω	$\sqrt{K/m}$	L^{-1}
Moment of inertia	I	$\alpha m r_I^2$	L^5
Deflection	D	M/K	L^2
Reynolds number	R_e	f_i/f_f	L^2
Electrostatic Force	F_e	$\varepsilon SE^2/2$	L^2
van der Waals Force	F_{vdw}	$F_{vdw} = \frac{Hd}{12z^2}$	L
Dielectric Force	F_d	$2\pi L^3 \varepsilon_1 \frac{\varepsilon_2 - \varepsilon_1}{\varepsilon_2 + 2\varepsilon_1} \nabla(E^2)$	L^3

ρ: density, P: pressure, g: Acceleration of gravity, x: displacement, t: time, U: unit volume elongation energy, d: density, e: Young's modulus, a: constant, r_I: radius of body of rotation, ε: dielectric constant, E: electric field, d: conversed radius, C: constant of the atom-atom potential.

Micro/Nano Environment –Inertial and Friction Forces-



Mechatronics

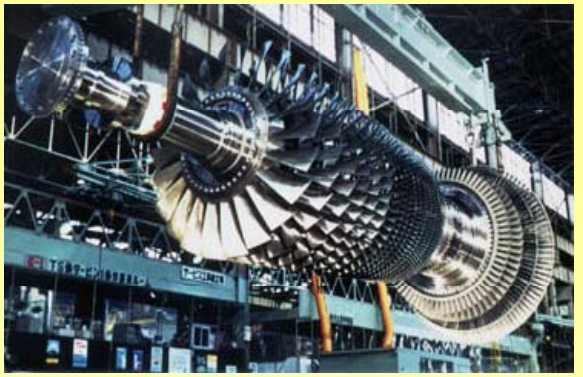


•Mechatronics was born in Japan in 1969.

•Industrial robots by replacing the hydraulic actuator with the electric motors.

•Synergetic integration of the Mechanical and Electrical engineering with computer technology.

T. Fukuda et al., IEEE Industrial Electronics Magazine, Vol. 4,pp. 13-22, 2010.



Sensor

Actuator

Material Technology

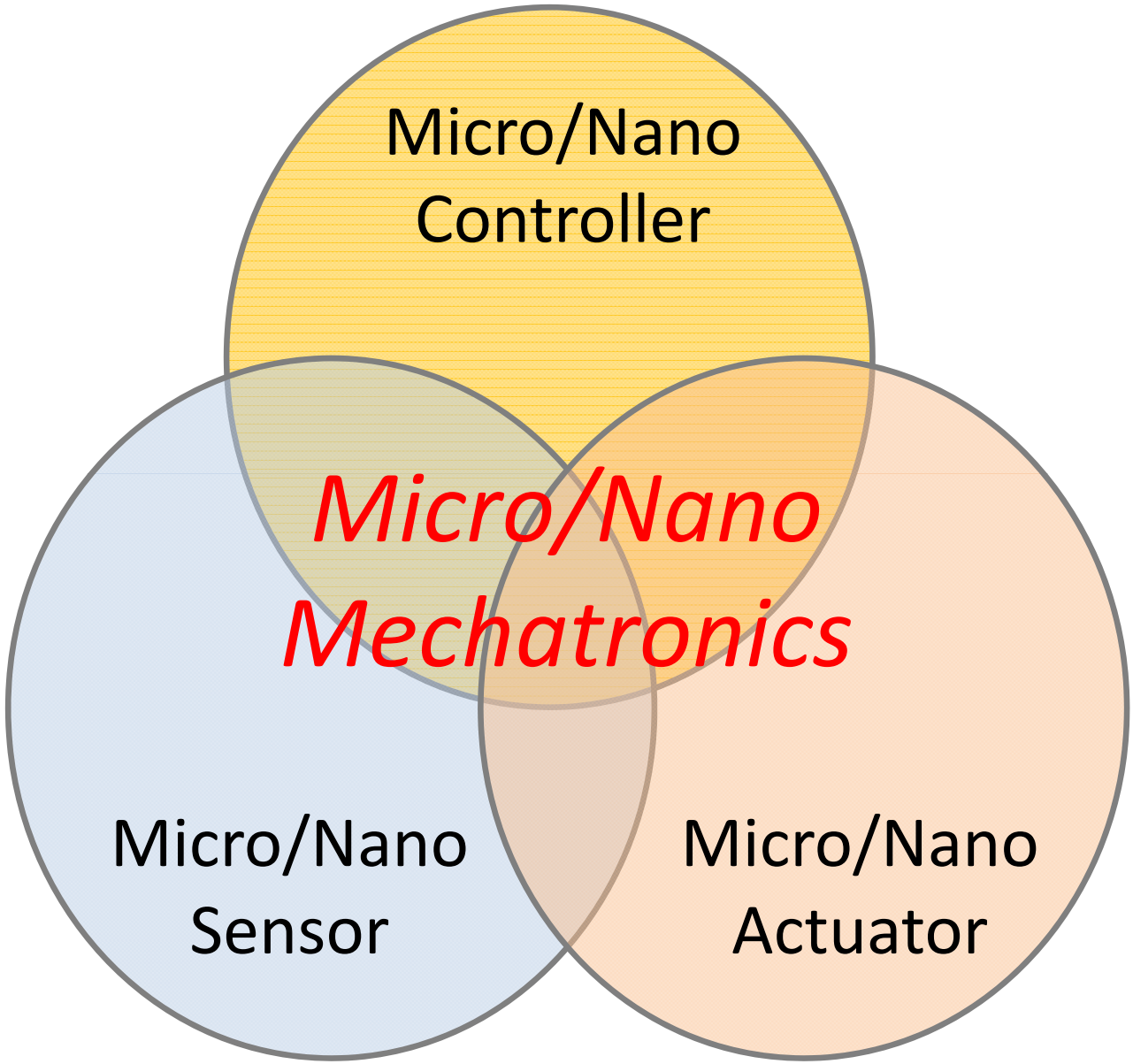
Mechatronics

Control Technology

Computer

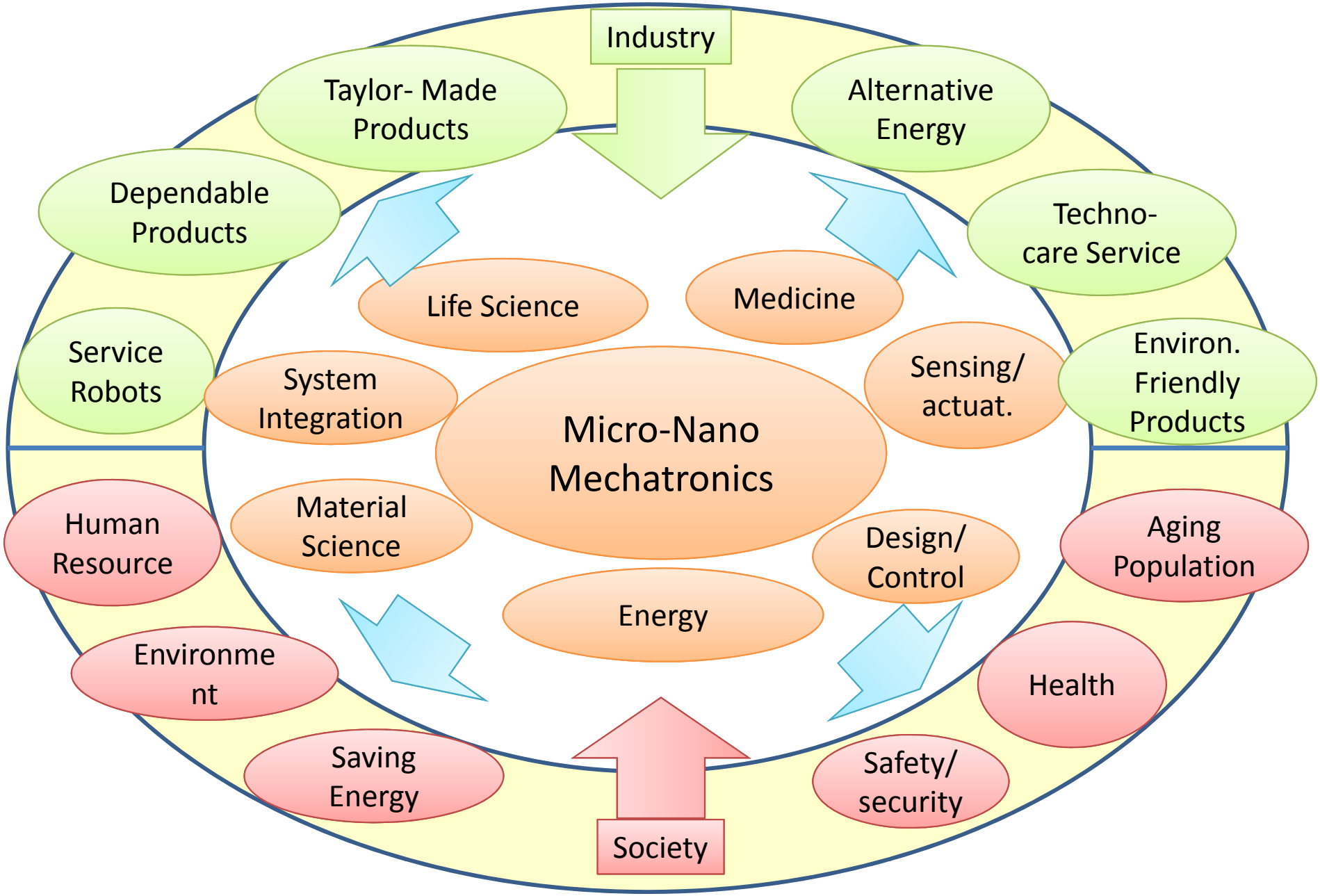
System Integration

Micro-Nanomechatronics

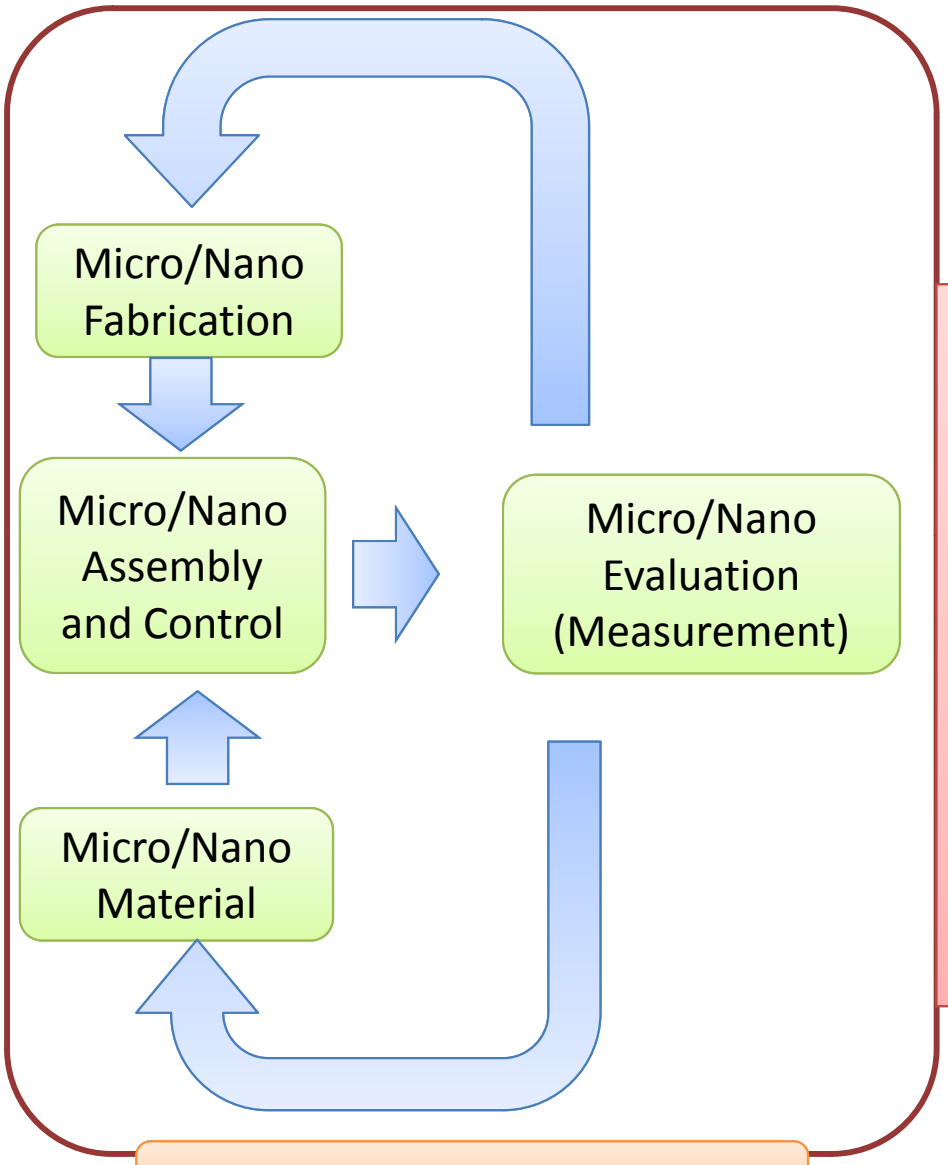


T. Fukuda et al., IEEE Industrial Electronics Magazine, Vol. 4,pp. 13-22, 2010.

Micro-Nano Mechatronics



Micro-Nano Mechatronics for Industry



Various Applications in Industry

- •Automobiles
- •Computer peripheries
- •Amusements
- •Printers
- •Cameras
- •Robotics and automation
- •Environmental monitoring
- •Biological/medical treatments
- •Energy resource

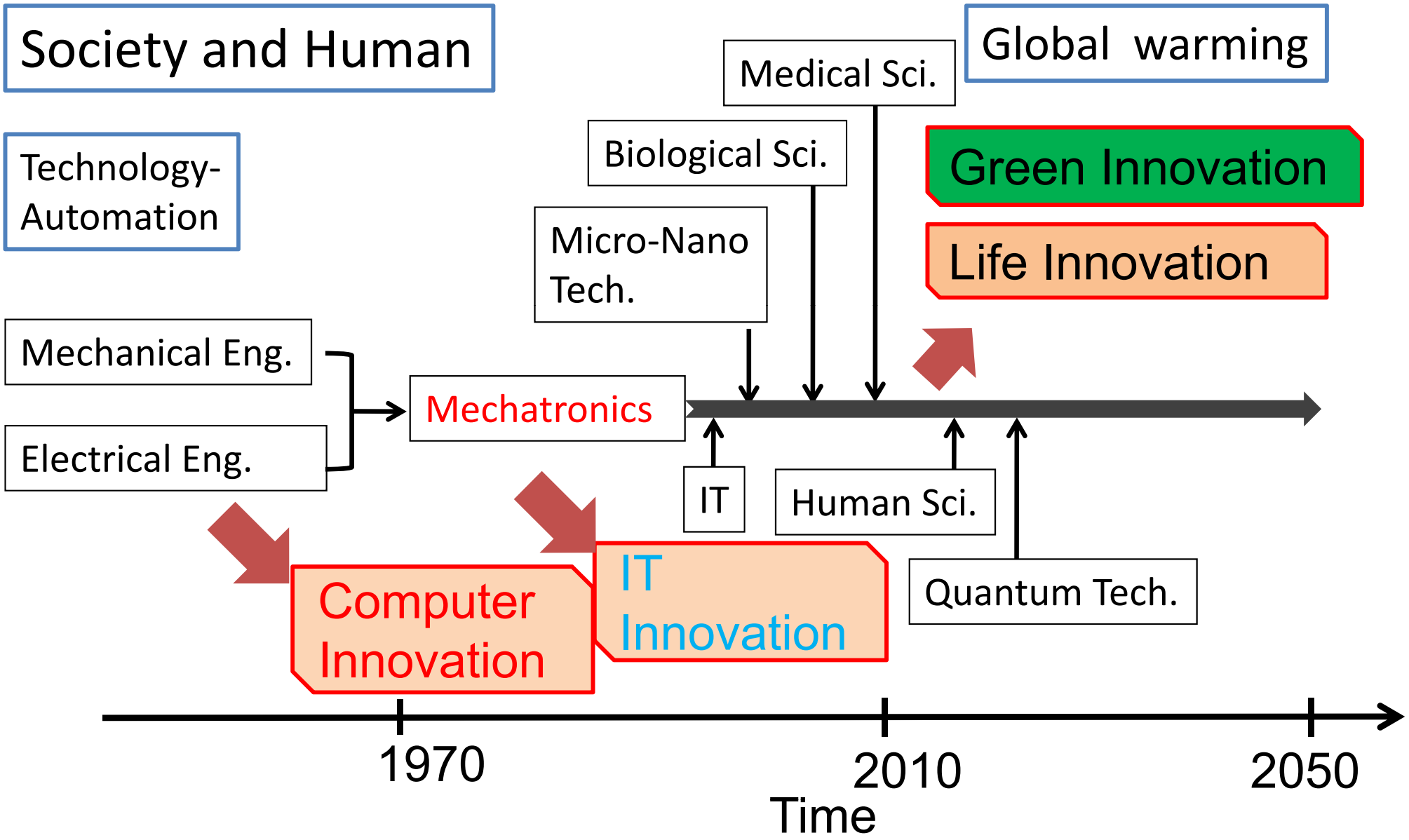
To make

- •High-efficiency
- •High-integration
- •High-functionality
- •Low-energy consumption
- •Low-cost
- •Miniaturization
- •etc.

T. Fukuda et al., IEEE Industrial Electronics Magazine, Vol. 4,pp. 13-22, 2010.

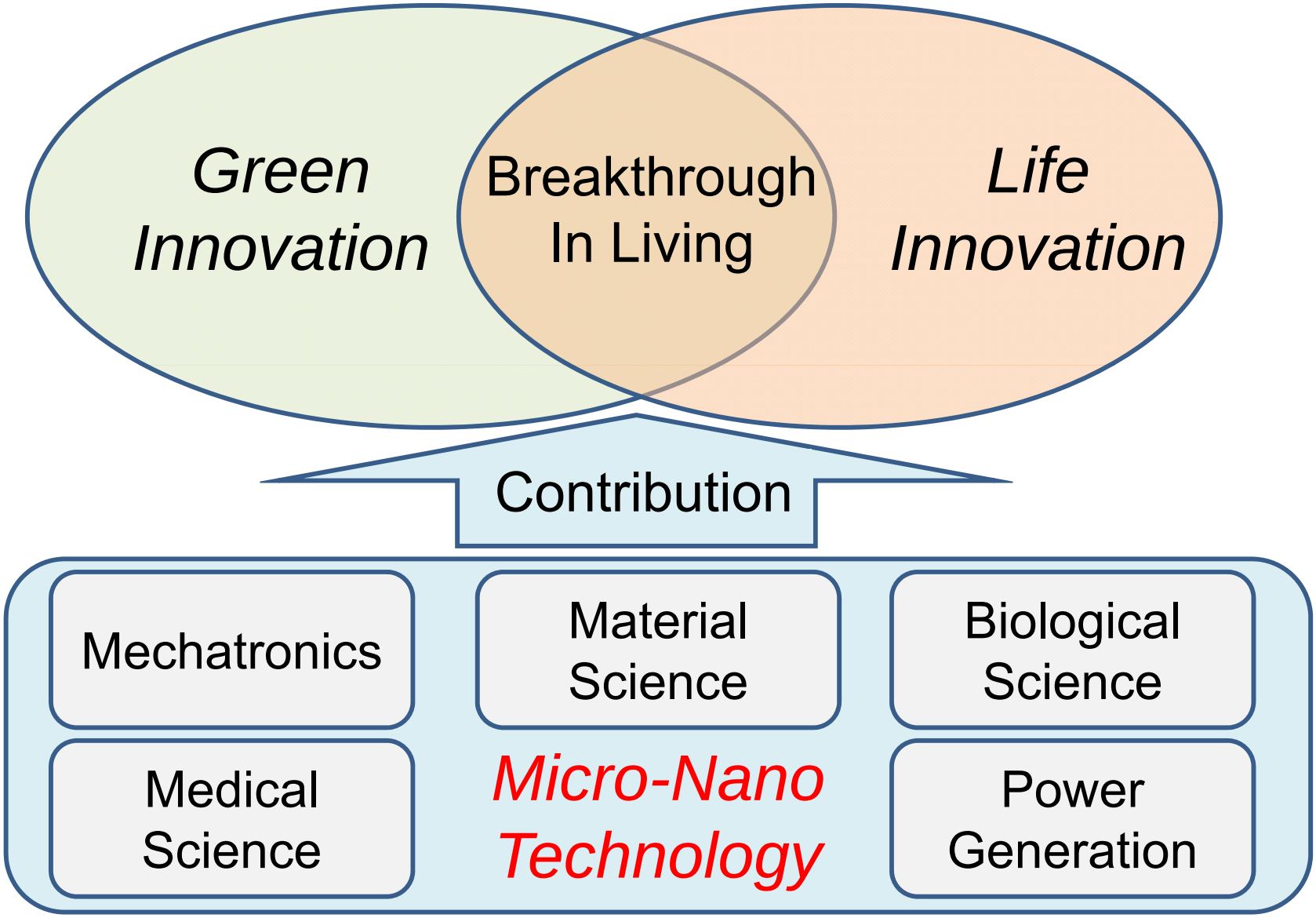
Mechatronics in History and Future Direction

Mechatronics is important technology for Green and Life Innovations.



Mechatronics based on Micro/Nano Technologies

Global and social issues for Green and Life innovations based on micro-nano technologies



T. Fukuda et al., IEEE Industrial Electronics Magazine, Vol. 4,pp. 13-22, 2010.

Challenge for Green Innovation

By Micro-Nano mechatronics and robotics in Green Innovation

Green innovation	Technological Challenges
Natural Resources	Micro/nano devices for Discovery of oil resource, Management of water resources, Prevention of forest destruction, etc.
Environmental Pollution	Monitor, control and management of Environment, Distributed sensing & control, Pollution control, Green vehicle, etc.
Energy Development	Energy saving, harvesting and alternatives , Energy grid and management, Power control and green electronics, etc.
Food and Agriculture	Safety, testing and tracing, Efficient harvesting, nutritious products, genetically-modified products, etc.

T. Fukuda et al., IEEE Industrial Electronics Magazine, Vol. 4,pp. 13-22, 2010.

Challenges for Life Innovation

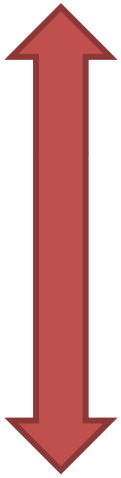
By Micro and nano mechatronics and robotics in Life Innovation

Life innovation	Technological Challenges
Medicine for life	Inspection and diagnosis , Re-generative medicine, Gene therapy and life science, monitoring diseases, Neuro Science, In-situ diagnostics, Cell diagnosis and surgery, New drug and medicine, DDS, Minimally invasive surgery, Rehabilitation, Techno-care, Wearable robots, Cyborg, QoL, etc.
Biology – Analysis and Synthesis	Sensing , manipulation and automation, New species, DNA diagnosis & manipulation, Cell screening, transport, cultivation, and function and differentiation control, Artificial cell, Life in chip, Cloning of stem cells, etc.

T. Fukuda et al., IEEE Industrial Electronics Magazine, Vol. 4,pp. 13-22, 2010.

Category of Nanotechnology

	Category	Basics	Components	Applications
Inorganic (Dry)	Mechanical	Nanocarbon, Battery,…	Fuel Cells, Micro-Nano Actuators, Inkjet System…	MEMS, Photonic Devices, Storage,…
	Electrical	Photonic Crystals,…	Semi-conductor Devices,…	IC, Memory, Molecular Computing, …
Organic (Wet)	Biology/Medical	Biomaterials, Artificial Cells,…	Bio-sensors, Bio-catalyst,	Bio-chips, DNA Computing,…



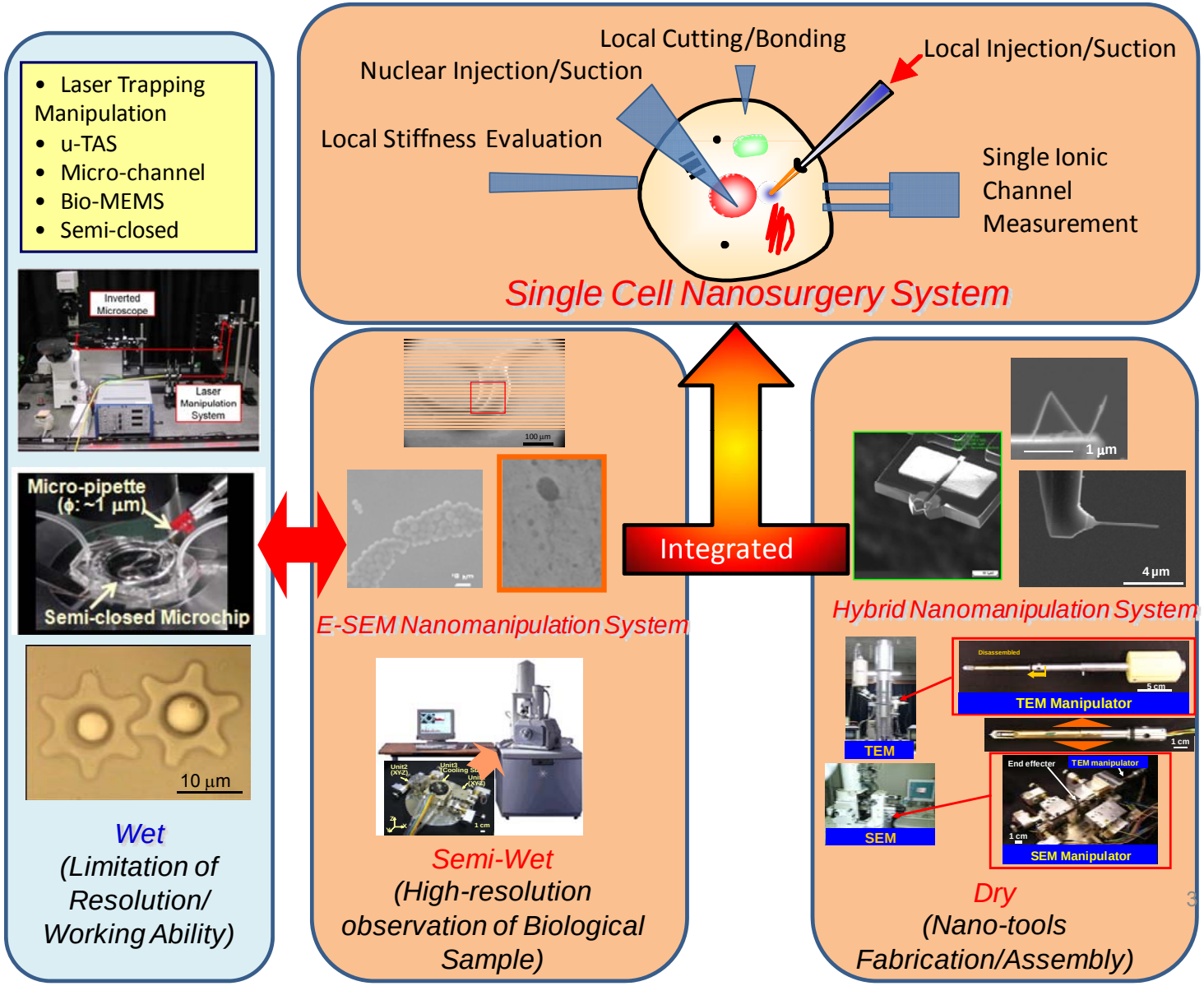
T. Fukuda et al., IEEE Industrial Electronics Magazine, Vol. 4,pp. 13-22, 2010.

Micro-Nano Mechatronics Technology in Industry

Application Fields	Important Technology	Examples
Automobiles	Si etching, Micromachining, Ceramics processing, Metal coating, Photolithography…	Temperature sensor, Gas sensor (O_2, NO_X), Knock sensor, Pressure meter(Fuel), Acceleration meter (Air-bag), Yaw rate sensor, …
Computer peripheries	Photolithography, Precision machining, Micromachining, Nano-imprinting…	CPU, Hard disk drive, Memory device, Electric circuits, …
Printers	Micromachining, Ceramics processing…	Ink-jet head, Ink solution delivery line, Surface potential sensor,
Cameras	Micromachining, Ceramics processing…	Photo-sensitive elements, Lens, Lens actuator, Shutter, …
Amusements	Photolithography, Micromachining…	Acceleration meter (Gravity/Angle sensor), Display, Touch panel (Display), Wireless communicator, …
Robotics and Automation	Photolithography, Precision machining, Micromachining, …	Force sensor, Pressure sensor, Displacement sensor, Gyro sensor, IR sensor, Switch, …
Environmental monitoring	Photolithography, Micromachining, Database…	Temperature sensor, Humility sensor, Solar irradiation sensor, CO_2 sensor, …
Energy resource	DNA delivery, Micro/Nano materials, …	Transgenic plants, Energy conversion system (Solar panel)…
Biological/medical treatments	Pharmacy, Cell analysis, Cell treatments, …	Single cell injection, Nuclear transplantation, Tissue engineering, Regeneration medicine, Surgical system, Surgical simulator …

T. Fukuda et al., IEEE Industrial Electronics Magazine, Vol. 4,pp. 13-22, 2010.

Single Cell Nanosurgery System based on Single Cell Analysis

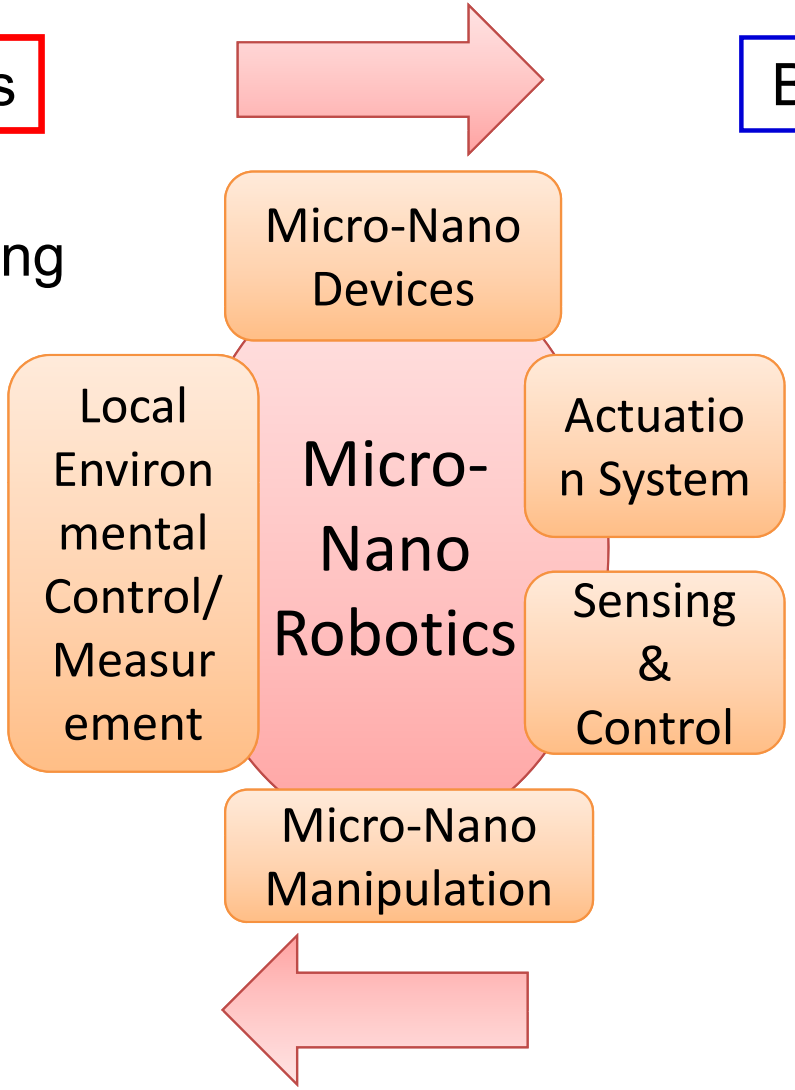


T. Fukuda et al., IEEE Industrial Electronics Magazine, Vol. 4,pp. 13-22, 2010.

Medical/Biological Applications based on Micro-Nanorobotics

Medical Applications

- Regeneration Engineering
- Blood Vessel Simulator
- Tissue Engineering
- Functional Catheter
- Biodegradable Scaffold
- Drug Delivery System

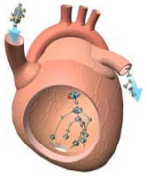


Biological Applications

- Single Cell Analysis
- Cell Separation
- Cell Harvesting
- Cell Injection
- Gene Manipulation
- Spheroid Construction

The challenging research is
"In vitro" Realization of Real Biological Model in "In vivo" Environment

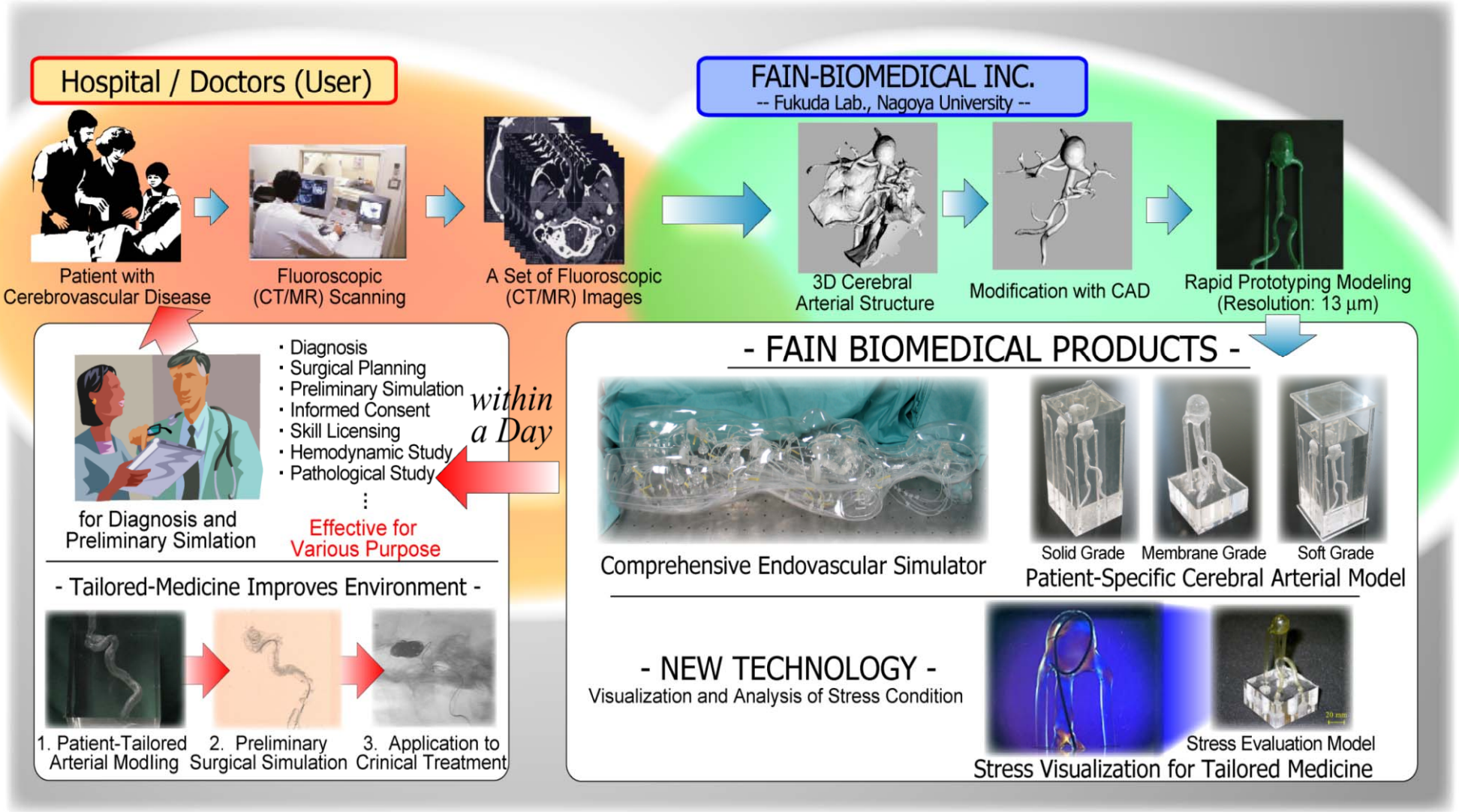
The EVE project



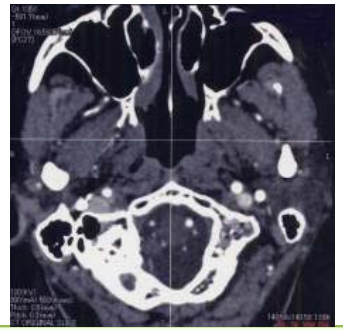
Nagoya University
Micro-Nano Systems Department
Fukuda Laboratory

Challenging the Frontier of the Surgical Simulation since 1989

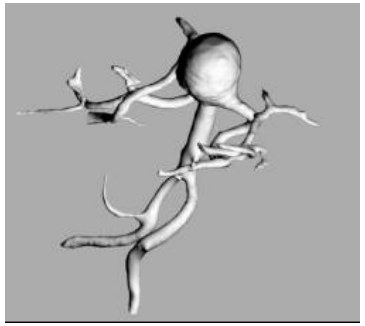
Established "FAIN BIOMEDICAL Co. Ltd." (Date of Establishment :2005/05/09)



Tailor-made Regeneration Medicine -3D Cell Block for Blood Vessels-

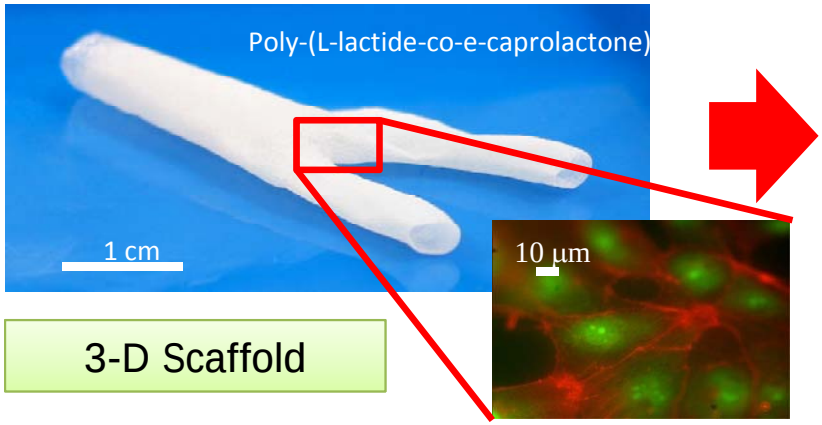


Patient' Information (CT/MRI) Image

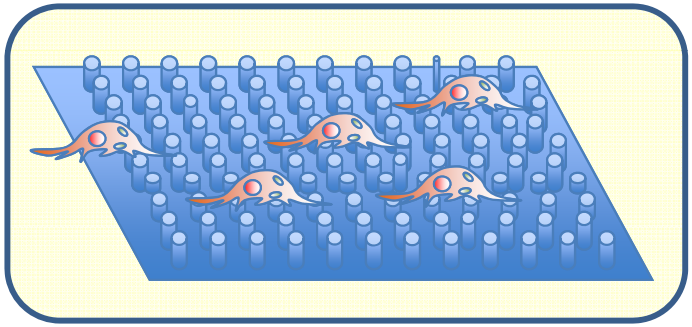


3-D Vascular Reconstruction

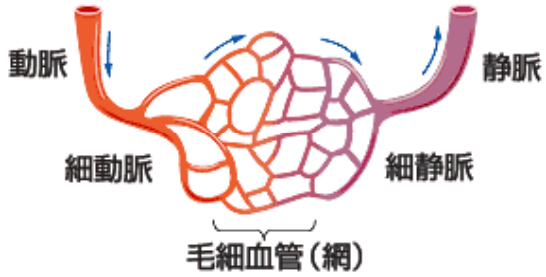
3-D Modeling (Resolution: 13μm)



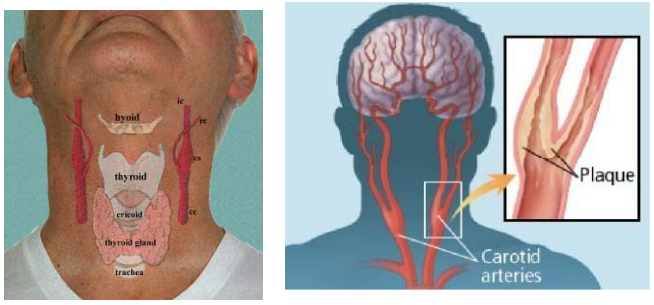
3-D Scaffold



Cell Culturing System

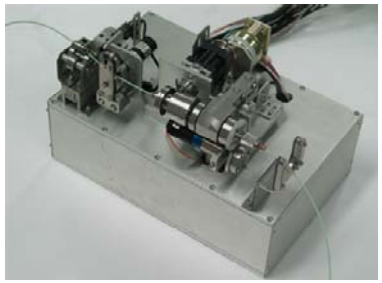


3D Cell Block for Blood Vessels

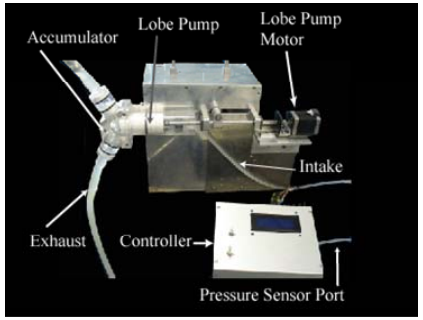


3D Cell Block for Blood Vessels

Blood Vessel Simulator and Surgical Operation System

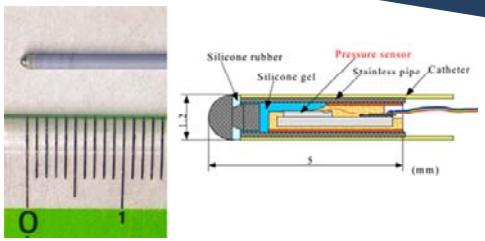


Linear Stepping Mechanism (LSM) for catheter control (2003)

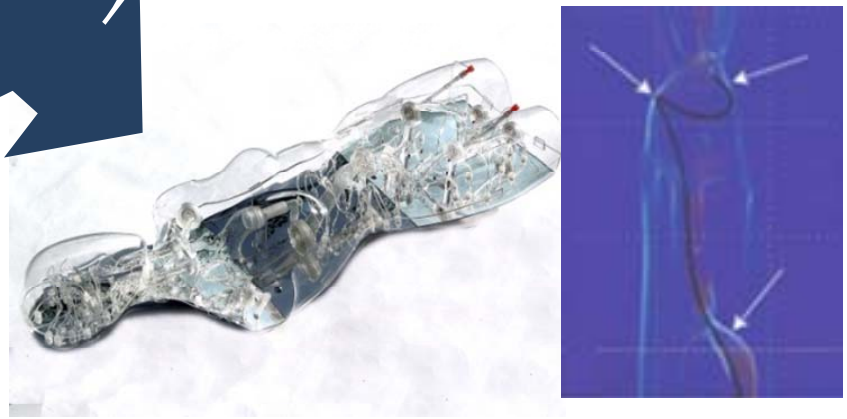


Human Blood Pressure Simulation (2008)

Blood vessel simulator and surgical operation system



Catheter with Micro Force Sensor (1997)



Endovascular Evaluator and Photoelastic Effect of Arterial Models (2005-)

T. Fukuda et al., IEEE Industrial Electronics Magazine, Vol. 4,pp. 13-22, 2010.

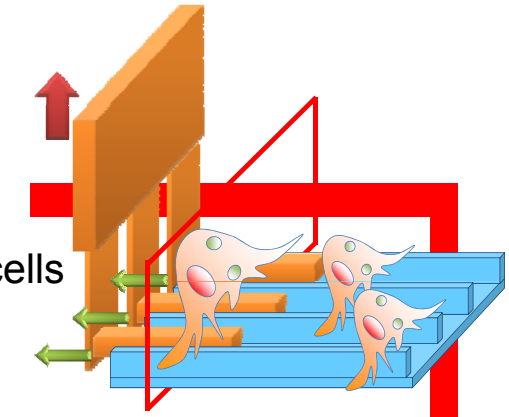
“In vitro” Realization of “In vivo” Environment ~Blood vessel~

Micro-Nano Sensing

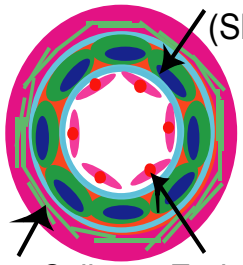
Blood VesselSignificant Improvement of Regeneration Engineering/Biology

•Evaluation of clinical condition of blood vessel (Therapeutic evaluation)

•Interaction measurement between multi-cells



Smooth Muscle Cell (SMC)

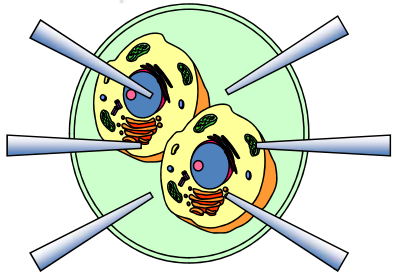


Fibro Cell

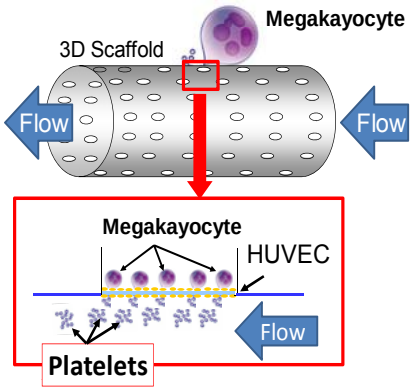
Endothelial Cell

•Realization of vessel structure

Local measurement of In vivo environment by micro-nano sensors



• 3D scaffold
• cyclic culturing



“In vitro” realization of “In vivo” environment under microscopes

T. Fukuda et al., IEEE Industrial Electronics Magazine, Vol. 4,pp. 13-22, 2010.

Purpose

- Development of young researchers for untrodden field challenge type
- The international research leader's promotion that used overseas collaborations
- Promotion of original high level micro nano mechatoronics research
- New functional materials, up-to-date mechatoronics uniting, and creation of the next generation medical treatment

View after five years

A Production of leader for next generation

B Leading-edge research and Information sending

C International micro nano mechatoronics interaction

Past achievements (2008-)

A. Leadership training

- Arrangement of curriculum
- Development of Young Researchers

B. Transmission of research information

- Information sending to the world
- Collaboration network between members
- External evaluation by International advisory board
- Data pool and hub function for international micro Nano mechatoronics interaction

C. COE for Education and Research

- Achievements of leading-edge research
- Establishment of “Center for Micro-nano Mechatronics”
- Activities with UCLA

Organization

Basic research

Nano control engineering




T. Fukuda G. Obinata F. Arai C.-M. Ho

UCLA

Nano measurement engineering




T. Niimi K. Fukuzawa Y. Ju I. Naruse

Nano design and manufacturing




K. Sato E. Shamoto N. Umehara A. Sasoh

Nano materials science



O. Takai N. Ono M. Okido

Applied research

Advanced bio/medical technology



M. Ueda K. Isobe J. Usukura

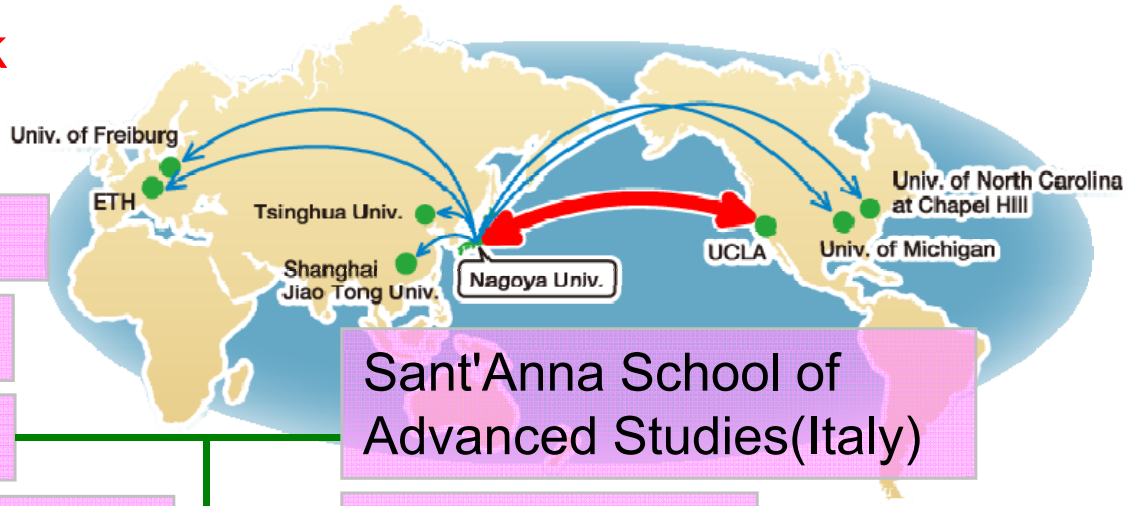
School of medicine

Achievement of internationalism

Progressing of international network

Nagoya University

- UCLA(USA)
- Univ. of Freiburg(Germany)
- Newcastle University(UK)
- Waseda University(Japan)
- Shanghai Jiao Tong Univ. (China)
- Tsinghua University (China)
- Seoul National Univ. (Korea)
- Pusan National Univ. (Korea)
- Sant'Anna School of Advanced Studies(Italy)
- KIST(Korea)
- Tsukuba University(Japan)




3rd Nagoya University-UCLA International Symposium
2008 Dec. 8 - 9 at Nagoya University

International hub formation

- International conferences (2008-2009 8 times)
  Overseas researcher　Total 211 people
- GCOE seminar by foreign famous researcher（2008-2009 55 times）

GCOE Curriculum

To cultivate basic skills

Super Doctor Course

D3

D2

D1

M2

M1

Systematic Process

【Systematic Technology : Applied】

Engineering Based Medicine

Interdisciplinary field

Interdisciplinary Study

【Expertise : Advanced 】

【Expertise : Basic 】

Lectures in English

Integrated/International Education

【Communication skills: Advanced】

UCLA staying

Lab Visiting and Presentation

International Engineering Ethic Seminar

Academic-Industrial Collaboration Seminar

【Communication skills : Basic 】

Communication in English

Japanese Culture and Technology Seminar

Increased New Lectures

Practical Studies Leadership

【Solving problems】

International collaboration by students

International Workshop

Project Simulation Seminar

【Project Research】

【Research/Experience】
M.S. Degree Thesis

Venture business theories

Medicine and Technology Seminar

Development of Young Researchers

1. Super Doctoral Course
   - Concentrated and shortened curriculum for Ph.D. candidates


培養液の蒸発抑制
長時間の研究作業向け
名大が機器
細胞採取など操作性も維持

2. Planning International Workshop
   - Planning and Organizing Students' Workshop
   - Training of leader ship

3. GCOE Seminar
   - The top-level researcher in the world
   - Chance to touch the leading edge of research
   - Holding 55 times in two years
   - Participation 1500 people

Development of Young Researchers #1
"Super Doctoral Course"

Unified Masters & Doctoral Programs

>> Concentrated and shortened curriculum for Ph.D. candidates

Variety of Experience Learning to Train World-class Leader

>> Encouraging overseas training

Selection by Application Documents and Interviews

>> 6 students/year

Financial Support from the 1st Grade of Master's Course

Worldwide Activity


培養液の蒸発抑制

長時間の研究作業向け

名大が機器

細胞採取や操作性も維持

Nikkan Kogyo Shimbun Newspaper
1st, Feb. 2010

2009 IEEE Young Award

Long-term Overseas Assignment at UCLA

Development of Young Researchers #2
- Planning and Organizing Students' Workshop -0

Experience-based Education

- Planning, Coordination and Operations
- International communication

58 participants (10 students from abroad)

Development of Young Researchers #2
- Symposium of Young Researchers -

On-the-job Training of Management

- Organized by Postdoc and Research Assistant
- Financial support for research

Invited Lecture: *Prof. George Kollias*

μ-Mech GEAR
GLOBAL COE PROGRAM

The Second Symposium of Young Researchers

-System Integration and its Application to Medical Technology-

General Information

Date: March 26 (Fri), 2010
Venue: Venture Business Laboratory, Nagoya University
Language: English

Program

Opening Remarks 13:00-13:10

Technical Sessions

	Room A	*Room B*
13:20-14:20	Robot Control	Numerical Analysis
14:40-15:40	Regenerative Medicine	Micro-nano Material
16:00-17:00	Fundamental Medicine	Surface Science

Keynote 17:20-18:20

A mesenchymal master switch to explain pathogenesis of joint/gut axis diseases

Professor George Kollias
President and Scientific Director,
Biomedical Sciences Research Center "Alexander Fleming", Greece

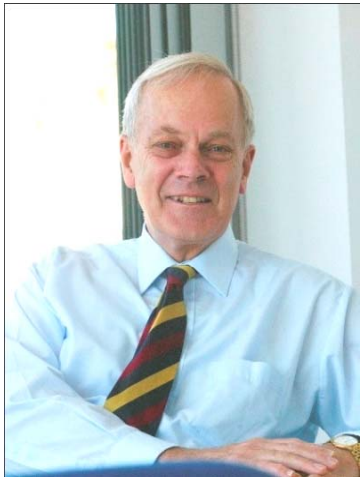
Closing Remarks 18:20-18:30

Symposium Fee FREE

Contact Information Micro/Nano Global COE Office
Tel: +81-52-788-6041 E-mail: gcoe_office@mech.nagoya-u.ac.jp

Development of Young Researchers #3
- GCOE Seminar -

- The top-level researcher gave a special seminar
- Holding 55 times in two years
- Participation 1500 people
- Chance to touch the leading edge of research



2009.3.19

Prof. Brian D O Anderson
The Australian National University
Former President of Australian Academy of Science

2010.3.25

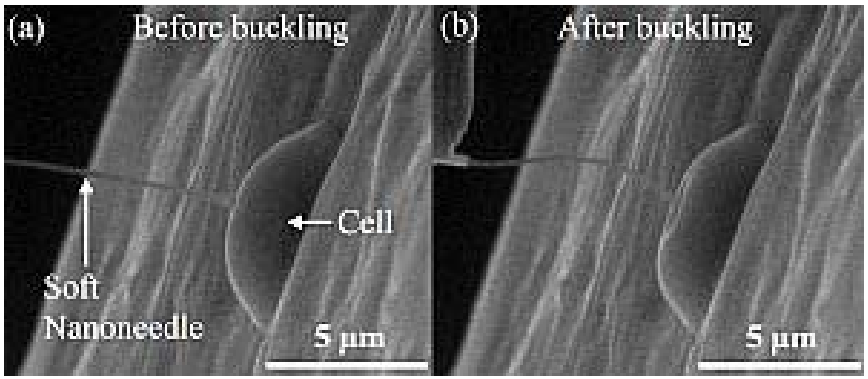
Prof. George Kollias
Biomedical Sciences Research Center
“Alexander Fleming”
President and Scientific Director

2010.3.20

Prof. Ning Xi
IEEE Nanotech. Council president

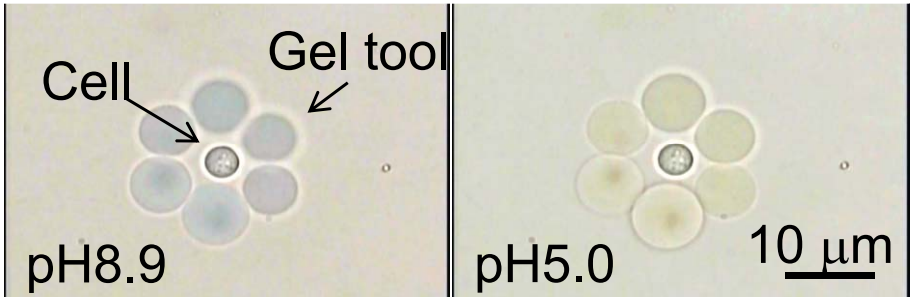
Research achievements (1)

Nano control engineering



Prof. Fukuda：Mechanical characteristics measurement of cells by nano needle

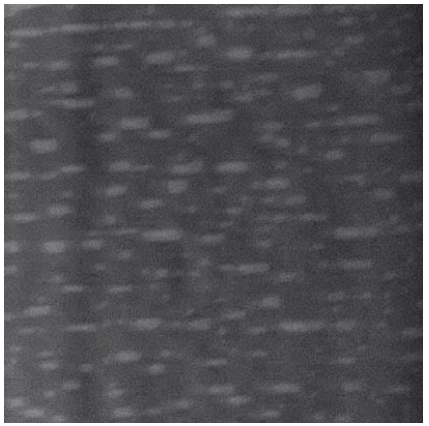
2010 IEEE Robotics and Automation Technical Field Award (The second Japanese awardee)



Prof. Arai： On-chip cell manipulation and measurement

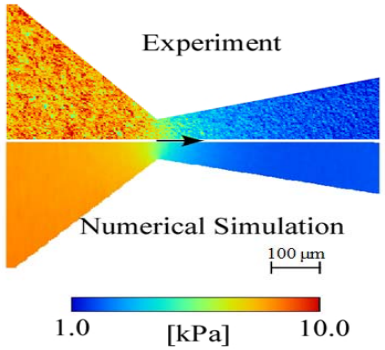
IEEE ICRA2008 Best Automation Award

Nano measurement engineering



Prof. Fukuzawa： Motion Picture Imaging of a Nanometer-Thick Liquid Film Dewetting by Ellipsometric Microscopy

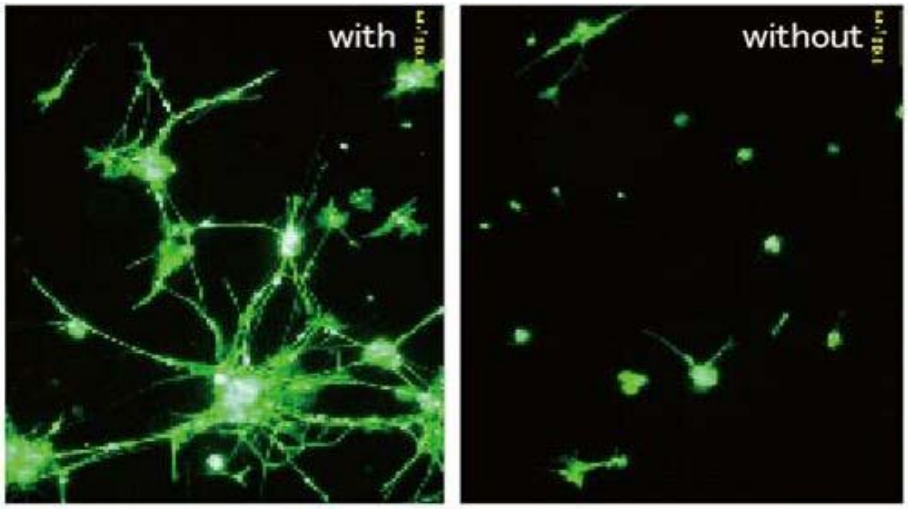
Storage Research Consortium Paper Award 2008

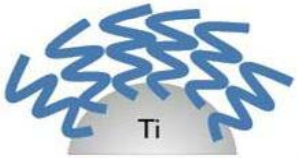


Prof. Niimi： Pressure distribution measurement of micro-nozzle by pressure sensitive molecular film, World first

Research achievements (2)

Nano materials science



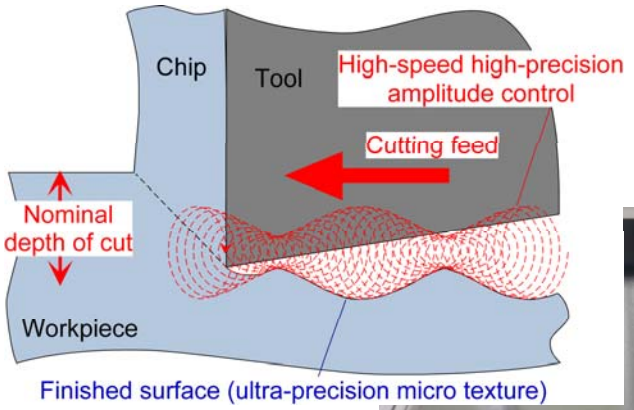


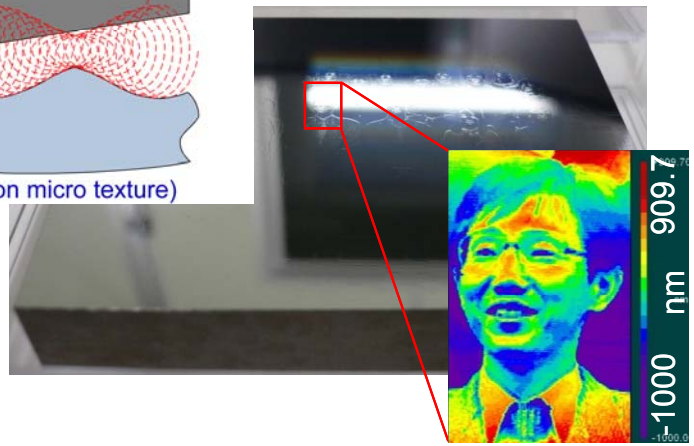
Cultured Dorsal Root Ganglion cells on the Ti disks covered (left) and not covered with (right) polyelectrolyte brush

Prof. Takai：Accomplishment of surface modification for high-biocompatibility, World first

Young researchers got the 14 awards after GCOE started.

Nano design and manufacturing





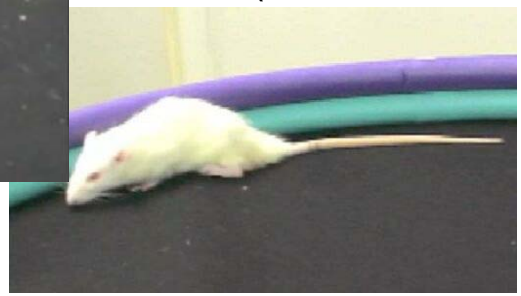
Prof. Tsujimoto：Ultraprecision micro machining by controlling Amplitude in elliptical vibration cutting

Commercial viability from Taga Electric Co., Ltd.

Research achievements (3)

Bio-medical application

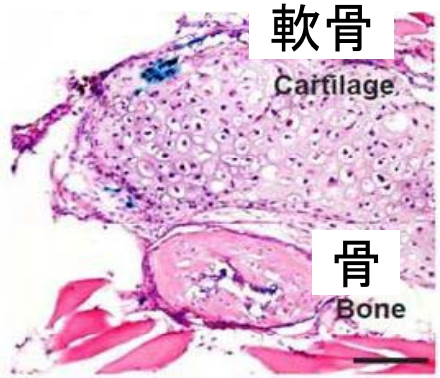
Reproduction of the ability to walk
(歩行能力の再生)

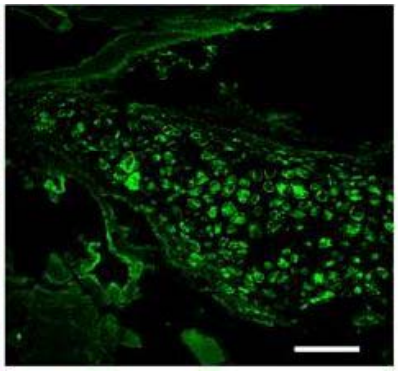


Spinal cord damaged rat
(脊髄損傷ラット)

Prof. Ueda：he succeeded in the reproduction of the nerve tissue by the dental pulp stem cell.
The Japanese Society for Regenerative Medicine, 2010

The world‘s first achievement



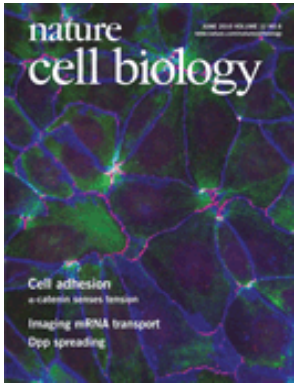


Prof. Isobe：he succeeded in the differentiation of the embryonic stem cell into the bone, the cartilage, and the muscle without serum

The world‘s first achievement

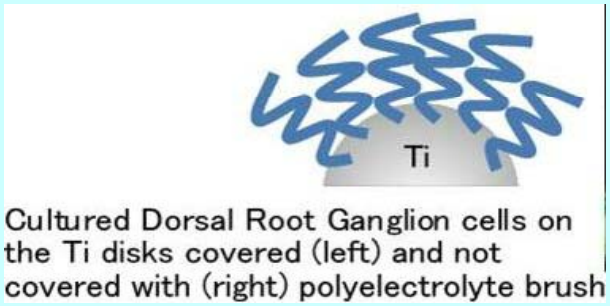
Journal papers

Nature Neuro Science,
Nature cell biology,
Lab on a Chip,
Physical review B,
Applied Physics Letter,
Tissue Engineering,
日本機械学会論文集
計測自動制御学会論文集
etc.



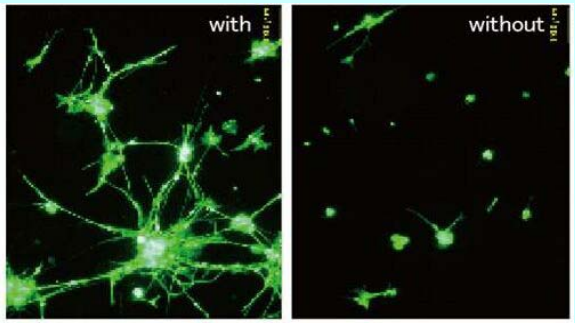
Generation of new idea and principle

New function emergence, new principle generation and new concept proposal without instrument performance



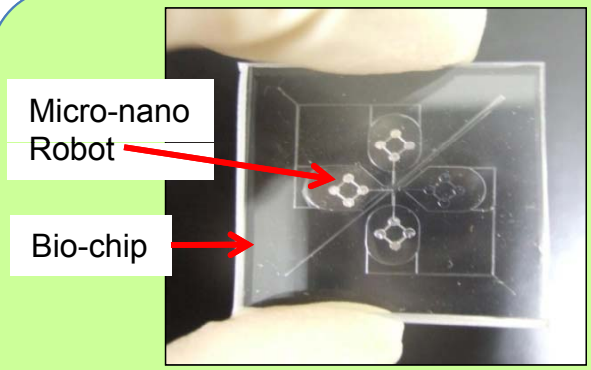
Cultured Dorsal Root Ganglion cells on the Ti disks covered (left) and not covered with (right) polyelectrolyte brush

Surface modification for high-biocompatibility



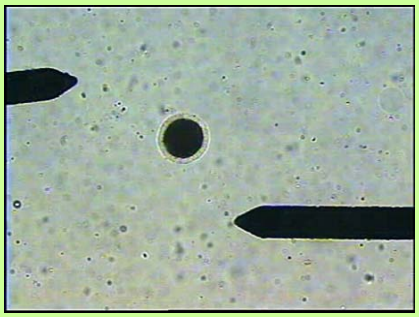
Prof. Takai

Young researchers got 14 awards



Robot-on-a-chip

(Cell manipulation, separation, cutting, measurement, etc.)

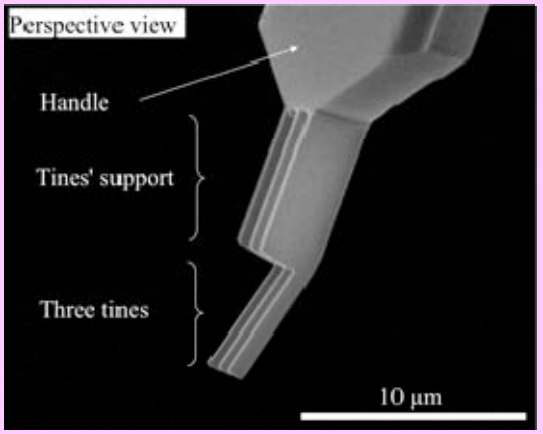


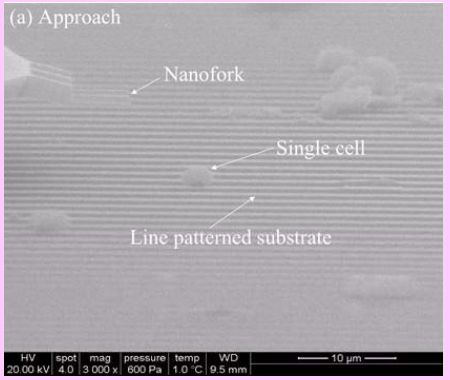
Manipulation of ovum 100μm

Prof. Arai

Awards (last 3 years)

Domestic: 14, International: 4



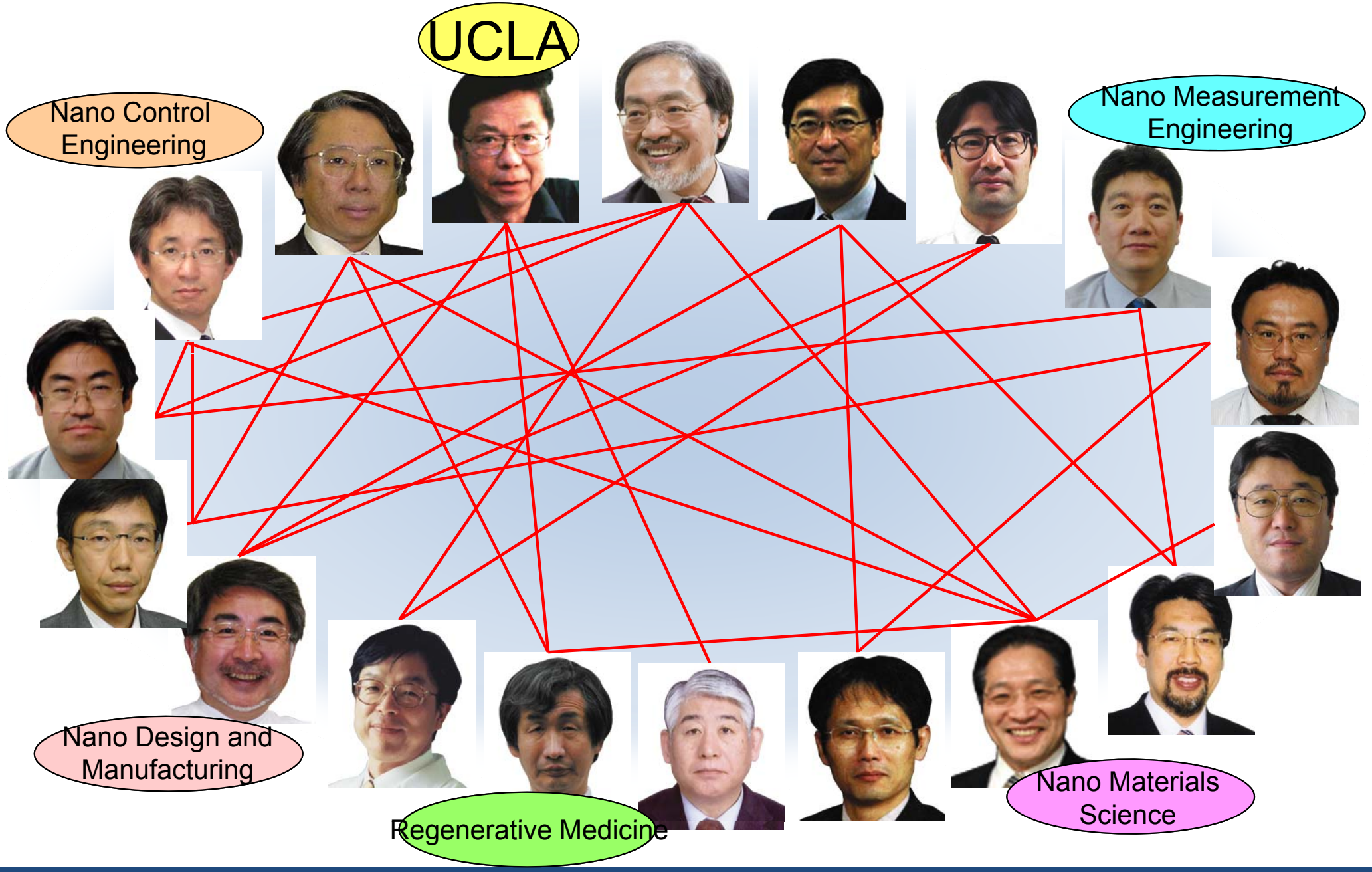


Prof. Fukuda

2010 IEEE Robotics and Automation Technical Field Award

(The second Japanese awardee)

Collaboration network between members



Transmission of research information

In cooperation with the university

1. Transmission of research information on「Nagoya University Research」, which is tie-upped by「Nature Asia」

2. Special article about GCOE was published in「Nature」

Vol.461(7265), 2009/10/8

2009, Oct, 8th
Volume 461
Number 7265

Advanced and Practical Research and Development for Micro-nano Mechatronics

Establishment of *"Center for Micro-nano Mechatronics"* (Oct., 2009)

Collaboration among 4 Core Technologies

1. Nano Control Engineering
2. Nano Metrology
3. Nano Manufacturing
4. Nano Material Science

Interdisciplinary Framework

Bio & Medical Applications

New Device, Method and System for

1. Transplantation of Cultured Cells and Tissues
2. Regeneration and Differentiation of Tissues

Opening of Micro-Nanomechatronics Research Center Building

2009/11/18

http://www.mech.nagoya-u.ac.jp/cmm/index_e.html

Purpose of "Center for Micro-Nanomechatronics"

Purpose

To promote

- Ultra high precision mechatronics technology
- Information technology
- Bio-medical technology
- Energy/Environmental technology

Basic Research

(1) Nano control engineering (*Control in nano-region*)
(2) Nano measurement engineering (*Measurement in nano-region*)
(3) Nano design and manufacturing (*Design and production in nano-region*)
(4) Nano materials science

Advanced Research

- Innovative research field of micro-nano mechatronics, such as medical engineering
- Collaborative researches between industry and center

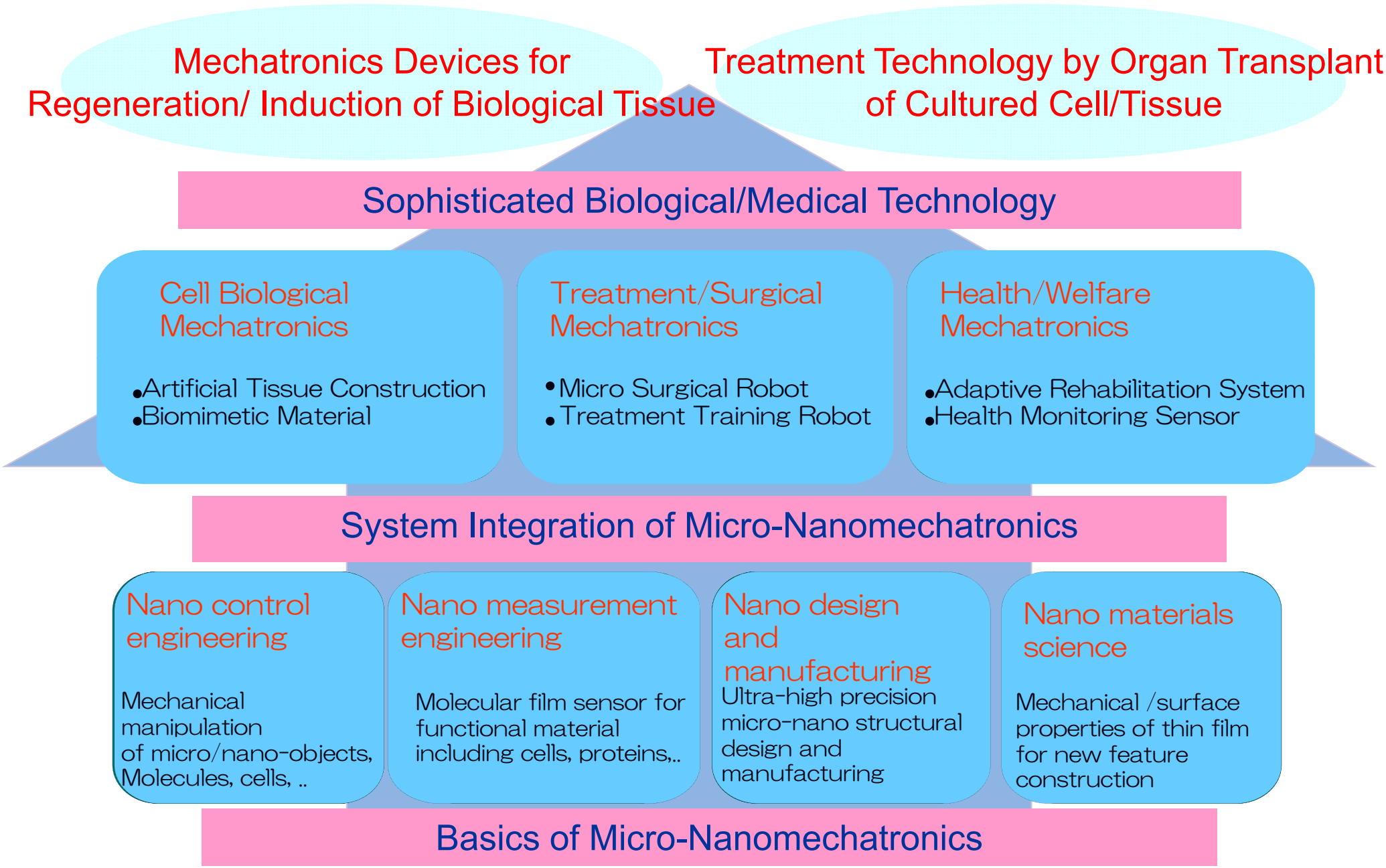
Members of "Center for Micro-Nanomechatronics"

Director: Toshio Fukuda

Field	Members	Affiliation	Position	Technical Field
Nano Control Engineering	Toshio Fukuda	Micro-Nano Systems Engineering	Professor	Micro-Nano Systems Engineering
	Goro Obinata	EcoTopia Science Institute	Professor	Biological Systems Control
	Koji Ikuta	Micro-Nano Systems Engineering	Professor	Biomedical Micro Machine
	Masahiro Nakajima	Center for Micro-nano Mechatronics	Assistant Professor	Engineering Micro-Nano Systems Engineering
Nano Measurement Engineering	Kenji Fukuzawa	Micro-Nano Systems Engineering	Professor	Micro-Nano Surface Engineering
	Tomohide Niimi	Micro-Nano Systems Engineering	Professor	Micro Thermo-Fluid Engineering
	Yang Ju	Mechanical Engineering Science	Professor	Nano Measurement Engineering
	Akihiro Sasoh	Aerospace Engineering	Professor	Fluid Engineering
	Jiro Usukura	EcoTopia Science Institute	Professor	Celllular Biology
Nano Design and Manufacturing	Eiji Shamoto	Mechanical Engineering Science	Professor	Ultraprecision Engineering
	Kazuo Sato	Micro-Nano Systems Engineering	Professor	Micro Mechanical Engineering,
	Ichiro Naruse	Mechanical Engineering Science	Professor	Thermo-Fluid Engineering
	Mitsuhiro Shikida	Center for Micro-nano Mechatronics	Associate Professor	Micro Mechanical Engineering
Nano Materials Science	Osamu Takai	Materials Science and Engineering	Professor	Nano Materials
	Masazumi Okido		Professor	Surface Engineering
	Nobutada Ohno	Materials Science and Engineering	Professor	Solid Mechanics
	Noritsugu Umehara	Computational Science and Engineering	Professor	Surface Engineering
		Mechanical Engineering Science		

Organization of “Center for Micro-Nanomechatronics” (Members)

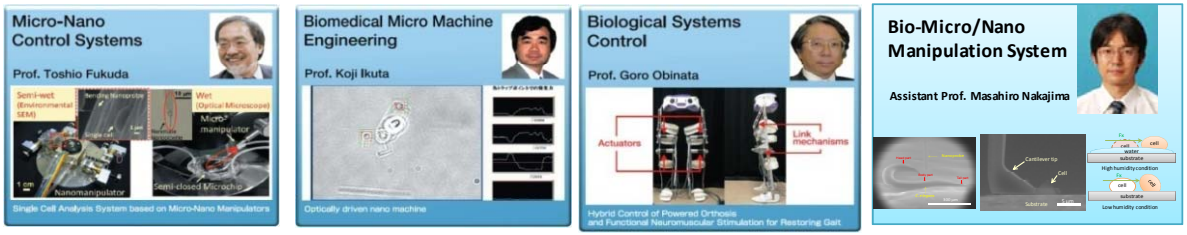
Research Diagram



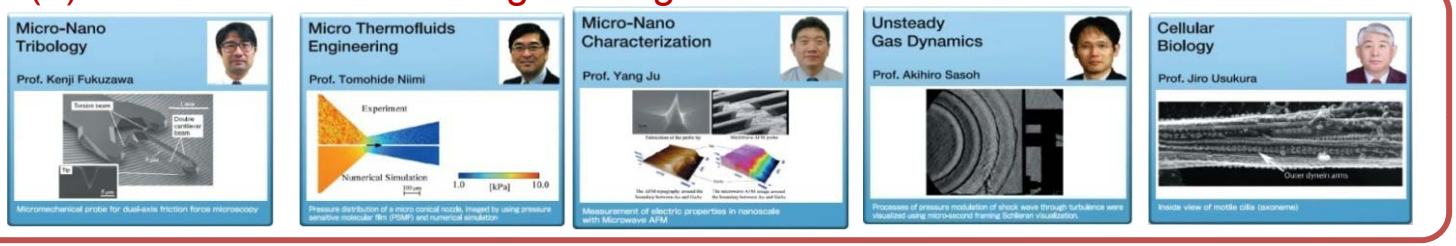
Research Works –Center for Micro-Nanomechatronics –

Members and Research of "Center for Micro-Nanomechatronics"

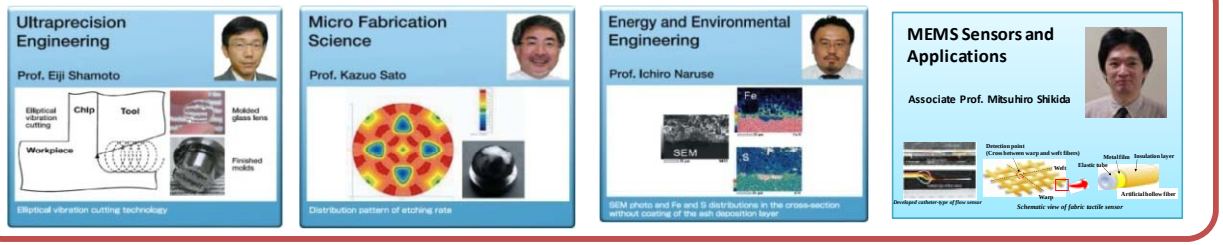
(1) Nano control engineering



(2) Nano measurement engineering



(3) Nano design and manufacturing



(4) Nano materials science

Micro-Nano Imaging/Measurement/Fabrication Instruments

Micro-Nano Imaging/Measurement Instruments

Transmission Electron Microscope (TEM)

Scanning Electron Microscope (SEM)

Confocal Microscope

Zygo (Interferometer)

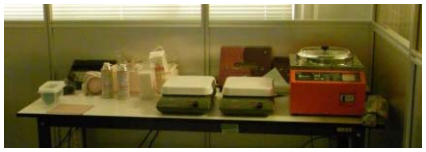
3-D Laser Microscope

Lumino Imaging Analyzer

Atomic Force Microscope (AFM)

Thick Film Step Height Measurement Machine

Micro-Nano Fabrication Instruments



m-TAS Fabrication System

Nano-imprinting System

Chemical Fume Hood

3-D Printing System

Focus Ion Beam (FIB) System

Sputtering Machine

Parylene Coating System

COE for Education and Research of Micro-Nano Mechatronics
Nagoya University Global COE Program

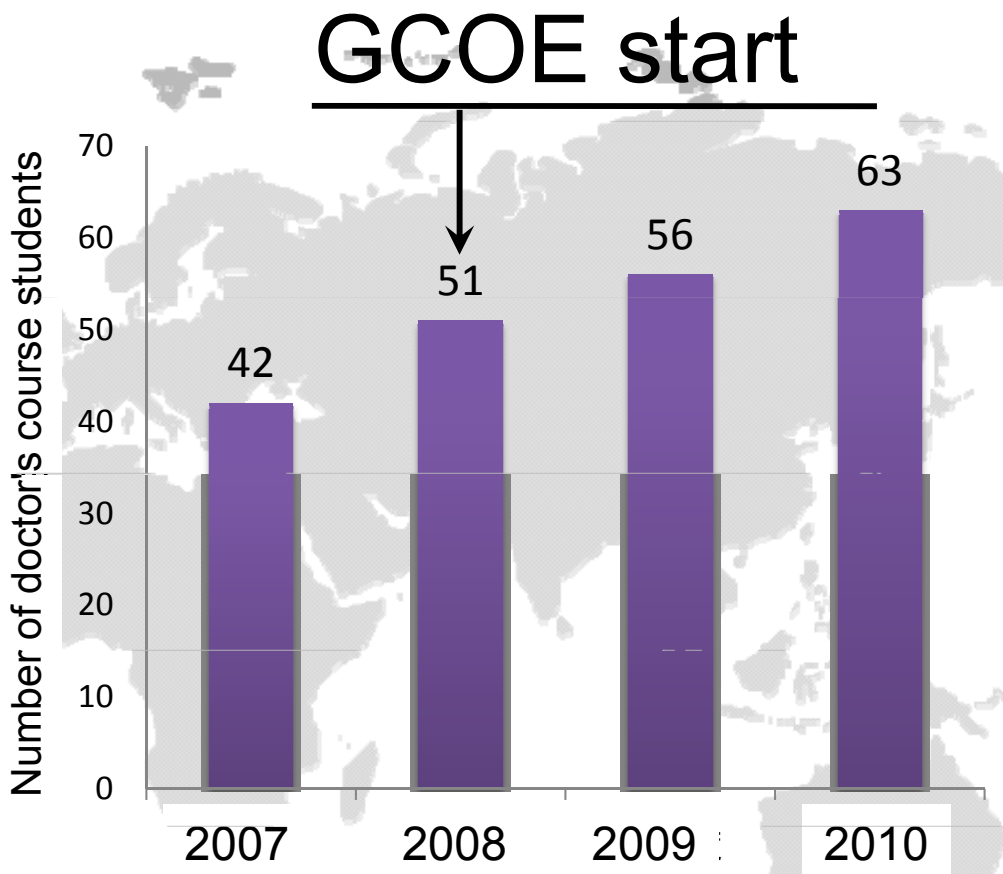
Center For Micro-nano Mechatronics
School of Engineering, Nagoya University

Activities with UCLA

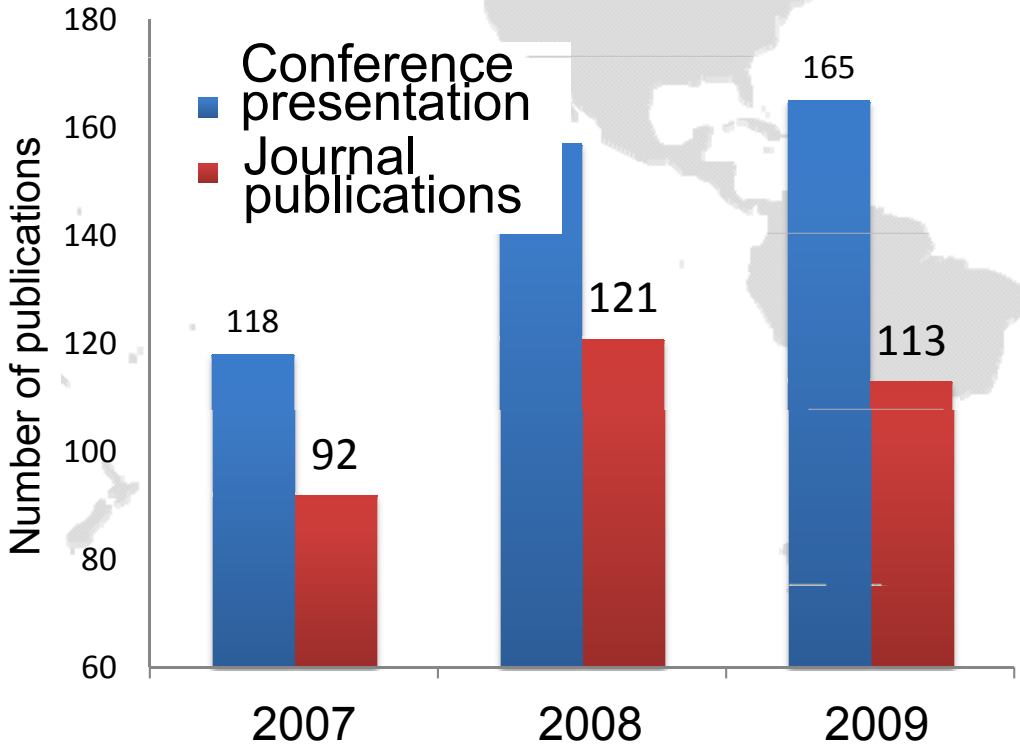
- Long-term visit and training at UCLA (annual)
  - For a year by 2 Ph.D. students
- Lab tours (Planned by students) (annual)
- Workshops (annual)
  - Exchange and discussion about the newest researches

Dean Nagoya Univ. Prof. Onogi Dean UCLA Prof. Ho

An increase in number of doctor's course students and academic conference presentation



Number of student's academic conference presentation and journal publications



Assessment of HRD

HRD: Human Resource Development

① Assessments at the end of a fiscal year

- Working papers
- Journal papers, International Conf.
- Credit earning (GCOE curriculum)

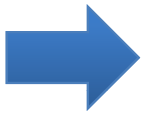
② Report presentations of foreign trainings

③ Third party advisors joined in young researcher workshops

Influence the grant

Motivation for study and research activities

Based on these assessments and advisories



Self and continuous improvements by students

Case example 1 : Trained

Example of a student A

Difficulty of answering the questions in English at the beginning

Get Incentive for study abroad after joining the lab tours in UCLA

Experience as a committee of a GCOE workshop

Email ar

conversations in English

Now he is well-trained and working in UCLA for a year

Case exampel 2: Global activity

（In the case of Student B）

She had…

- Experiences in a Immunology school and in a hospital as a medical doctor.
- Fundamental research skills in medical biology.

↓

Her strong incentive of a global activities in medical field was promoted by a GCOE foreign training program.

↓

- Based on her skills in medical biology and UCLA's technology in bio-MEMS,

She carried out functional analyses of cells and animal experiments.

- She gave a talk about her work in an international conference.

↓

"NIH Nanomedicine Development Centers
4th Annual Awardee Meeting "April 5-8, 2010

She has expanded her research field.

Development of leaders

GCOE human resource development system

Next generation research/ development leaders

Internationalization program

Practical human resource development program

Research support depend on research performance (Budget)

Rich inter-nationality

Expertise in micro-nano mechatronics

Power of research and execution

Career path

Academia

Research institute

Industry

Ex.

T. Ando
Associate Prof.
(Ritumeikan Univ.)

H. Zhang
Associate Prof.
(Nagoya Univ.)

H. Kimura
(Toyota Central R&D Labs., Inc.)

S. Ikeda
President
(University venture)

Field of Performance for Alumni

Field	5 years later	10 years later	20 years later
Academia Research institute	Open new Scientific Field and Interdisciplinary Field	Worldwide Opinion leader	Systematize the Scientific Field
Industry	Creation of New Businesses Venture Company	Commercialization and Global Expansion	Buildup the industrial infrastructure Worldwide Social Action

EVE
Endo Vascular Evaluator
FAIN-Biomedical Inc.

PARO
Most Therapeutic Robot Intelligent System Co.,Ltd.

Future Outlooks

2008 2010 2013

leadership training

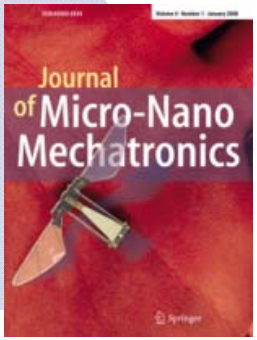
- Doctor Course Students
  51 -> 56 -> 63

Produce Many Human Resources

Research and Release

- Conferences of Micro-Nano Mechatronics
- Nature Web, GCOE HP

Journal Publication



Center for Education and Research

- Center For Micro-Nano Mechatronics

New Department for Advanced Studies

Summary

μMech-GCOE shall cultivate courageous intellectuals endowed with micro-nano technology and worldwide view.