The Universities’ Role in Fostering Innovation and Societal Change
- The Viewpoint of Academia -

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The Fourth Industrial Revolution

We stand on the brink of a technological revolution that will fundamentally alter the way we live, work, and relate to one another. In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before.


We are witnessing profound shifts across all industries.

- The emergence of new business models
- The destruction of current jobs
- The reshaping of production, consumption and transportation systems

Jaap Bloem et al. “The Fourth Industrial Revolution Things to Tighten the Link Between IT and OT”
Industrie 4.0

Horizontal and Vertical value chain integration

Horizontal value chain

Supplier

Networking of suppliers

Cooperation partners

Company

Networking of customers

Planning

Purchasing

Manufacturing

Logistics

Customer

Vertical value chain

Company

Sales

Product development (R & D)

Planning

Purchasing

Manufacturing

Logistics

Service

IT, shared service

Finance, tax and legal

Volkmar Koch et al. “Industry 4.0: Opportunities and Challenges of the Industrial Internet”

Information transparency actualizes a highly effective business management and an authentic product lifecycle management
Japanese Core Competence

- Advanced research, Ability to develop new products
  - especially in Automation Engineering, Implementation of best practices in manufacturing operation
  - World leader in major fields such as automotive and electronics industries

- Usage data of enormous amount of products

- High quality manpower

- Advanced skills, artisanship
Japanese Universities are expected to undertake cutting-edge R&D before commercialization in order to realize Society 5.0, utilizing Japan’s superiority in Industry 4.0.
Universities’ Challenge 1 - Academia-industry cooperation for innovation

“Joint Research Chair” system originated by Osaka University (since 2006)

Joint Research Chair

Osaka University
provides researchers, premises, facilities etc.

Industry etc.
provides funds, researchers, research materials etc.

Joint Research Chair / Joint Research Division

- Duration: 2 to 10 years
- Fully devoted to joint research
- Arrangement with emphasis on use of intellectual properties
- Jointly operated by sponsoring corporations and Osaka University

- Reflect social demands
- Enhance university’s research function
- Financial independence - leading to medium or long term continuity

U of Tokyo, Kyoto U, Nagoya U, etc. followed Osaka U

Staff
At least one Professor or Associate Professor plus,
one researcher of occupational level between Associate Professor and Associate Professor

Corporate researcher
Postdoctoral Fellow, Graduate Student
Concurrent Professor, Associate Professor etc.
Administrative staff

Screening

Source: Office for University-Industry Collaboration, Osaka University
Comprehensive Collaboration Agreement between the Center for iPSCell Research and Application (CiRA), Kyoto University and Takeda Pharmaceutical Co., Ltd. (from April 2015)
- Takeda will provide research facilities and collaborative funding of 20 billion yen as well as more than 12 billion yen worth of research support (facility, equipment, Takeda researchers and various research services) over a 10-year period
- Around 10 projects on iPSCell technology applications will be pursued concurrently
- About 100 researchers engaged in joint research, with each contributing about 50 researchers

Comprehensive Collaboration Agreement between the Osaka University Immunology Frontier Research Center (IFReC) and Chugai Pharmaceutical Co., Ltd. (from April 2017)
- Total of 10 billion yen contribution over 10 years to IFReC to support IFReC basic research
- IFReC is going to disclose its research results to Chugai twice a year
- ”Collaboration Promotion Laboratory” will be set up at IFReC to pursue 5 to 10 projects concurrently
Universities’ Challenge 2 – COI STREAM

Three Visions of COI STREAM

**Vision 1**
Secure sustainability as a country advanced in its aging population and declining birth rate
- Smart Life Care, Ageless Society
  - Key concepts: Function, Medical health, Mental health, Motivation, Sports, Food, Time
  - Realization of happiness

**Vision 2**
Create a living environment with a high quality of life as a prosperous and reputable country
- Smart Japan
  - Key concepts: Function, B) Evolutionary thinking, Active thinking, Sensibility, Six senses
  - Innovative thinking method

**Vision 3**
Establish a sustainable society with vitality: Active Sustainability
- Key concepts: Function, Personalization, Resonance, Sustainability
  - Development of a durable town for centuries

**Backcasting**
Identify multi and/or interdisciplinary R&D challenges

**Research Promotion Institution**
Act as a research headquarters, create a strategic management plan
- Project Leader (from industry)
  - Supervise the overall management of COI sites and their R&D activities.
- Research Leader (from academia)
  - Responsible for the day-to-day operation of the headquarters of COI sites and support of R&D strategy planning.

**Under One Roof**
The activities of COI Sites are managed thorough resources from industry as well as support from MEXT/JST.

http://www.jst.go.jp/coi/etc/pamphlet2016.2EN.pdf
Kanazawa’s Challenge 1: Atomic Force Microscope (AFM)

**Operation principles**

- **Cantilever (silicon)**
- **Interaction force**
- **Path of the probe**

**Merits**

- Molecular resolution in liquid
- Can observe insulating objects
- Label-free
- Measure mechanical properties

**Problems**

- Imaging speed: ~1 min/frame → difficult to observe dynamic behavior
- Resolution: ~1 nm → impossible to observe atomic resolution

Development of High-speed AFM

Prof. Toshio ANDO

High-speed AFM

Imaging speed

Original: 1 min/frame  
High-speed: 0.1 sec/frame

- Increase imaging speed by 600 times
- Visualize molecular dynamics

Ex. Myosin V

Electron Microscope

Fluorescence Microscope

cannot observe movement


cannot observe molecular structure

Kodera et al, Nature 468 (2010) 72

CAN observe molecular structural changes!
Kanazawa’s Challenge 1: Elucidating Molecular Dynamics by High-speed AFM

Rotation propagation of structural change of axle-less $F_1$-ATPase

Continuous movement and "traffic jam" phenomenon of cellulase

Experiment

Simulation


Igarashi et al. Science 333 (2011) 1279
Early detection

Support of the early detection with the medical equipment

Maladjustment in a school and the society

Prevalence of the autism spectrum disorder is around 1% LANCET 2006

STOP !!

Early intervention

Prevent maladjustment! Develop their ability!

Kanazawa’s Challenge 2: Benefit from early diagnosis of ASD

Kanazawa University
Child custom-sized whole head magnetoencephalography (MEG) for young children with autism

2008 Child custom-sized whole head MEG
(2008 in Macquarie University)
(2009 in Kanazawa University)
(2015 in Beijing Language and Culture University)

Only three MEG systems in the world

Merits
Easy!
Non-stressful!
Beside their parents!
Real brain activity
Higher temporal resolution
Higher space resolution
Bambi Plan since 2009

To date, more than 200 typically developing children and more than 100 children with autism spectrum disorder participated this plan, and we investigated the brain functions and the psychological features.
Kanazawa’s Challenge 3: Construction of next-generation infrastructure systems using innovative materials

1- Development of Innovative materials (upstream)
- Development of highly functional thermoplastic resins (high modulus, long term durability, self-healing, flame retardant and other properties), and bio-based materials
- Biomass → Ionic liquid → Highly functional wood-based structural materials
- Innovative biorefining processes (direct use of polymers)

4- Development of recycling technologies (downstream)
- Establish reuse technologies and recycling systems capable of handling high volumes at low cost
- High volume, low-cost construction members
- Carbon fiber

2- Development of innovative manufacturing processes (mid-stream)
- Integration technologies
- Highly shapeable materials
- Continuous molding processes and manufacturing technologies
- Molding machines and construction technologies
- Innovative manufacturing technologies and structuring processes

3- Development of applications (downstream)
- Implementation in society
- Aiming to implement in society various public infrastructure (roads, tunnels, bridges, high-rise buildings and other infrastructure where maintenance costs can be reduced), building and house infrastructure (infrastructure that enables flexible design and is easy to relocate) and offshore structure (sailing vessels, offshore wind power generation, deep ocean drilling and other infrastructure not possible with existing materials)
- Tunnels/railroad, bridges, Ocean drilling
Kanazawa’s Challenge 3: Development of Carbon Fiber Reinforced Plastic Derived from Plant Biomass

Biomacromolecules in biomass
- Oil plant biomass
- Microalgae biomass
- Lignocellulosic biomass

Platform chemicals
- Glycerol
- Glucose
- Xylose
- Lignin monomer

Resin & Fiber
- Carbon fiber
- Acrylonitrile
- Carbon fiber reinforced plastic (CFRP)

Carbon

Thermosetting and thermoplastic resin
- Cellulose acetate butyrate
- Lignin acetate

Lignocellulosic composite
Development of Carbon Fiber Reinforced Plastic (CFRP) based on Cellulose acetate butyrate (thermoplastic resin)

\[ R = \text{CH}_3\text{CO-} \]
\[ \text{CH}_3\text{CH}_2\text{CH}_2\text{CO-} \]
Cellulose acetate butyrate

Thermoplastic resin

Carbon fiber

Film

Carbon fiber reinforced plastic (CFRP)
Autonomous driving at Expressway

- Road condition at express way
  - Simple and maintained condition
  - Lane marker detection and tracking
- Examples of national projects
  - CHAUFFEUR (EU)
  - PATH (USA)
  - SARTRE (EU)
  - Energy-ITS (JAPAN)
- Subject
  - Safety and comfortability
  - Traffic capacity and freight efficiency
Autonomous driving on all road

• Road condition at general road
  – Complicated and without maintenance
  – Digital map

• Subject
  – Traditional vehicle
    • Same as highway
  – New style vehicle
    • Public transportation
    • Ride sharing

• Japan
  – Aged and depopulated area
  – Lack of public transportation system
Autonomous driving at Suzu city

• Aged society (As of Dec. 2014)
  – Population 15,948
  – Rate of aging 44.2%

• Transportation
  – From urban
    • 3 Hours (Bus from Kanazawa city)
  – In the city
    • Bus, Taxi

• Autonomous vehicle
  – For public transportation system
Tasks to be resolved in Japan

Lack of company/human resource that is able to connect each potential technology to business

Lack of company/human resource that is able to develop a comprehensive plan by going beyond the boundaries of individual industry/company, and propose as a project

Lack of company/human resource that is able to overview the entire value chains not only in the industrial world but in society, and create a new value

Those are the types of desired human resources that universities should develop and train
The Universities’ Role in Fostering Innovation and Societal Change

“The Fourth Industrial Revolution”, “Industry 4.0”, “Industrial Internet”, “IoT”, “Big data”. . .those keywords superficially mean promotion of streamlining or prediction of problems or customer’s needs.

However, the true essence of the matter is to create new value in things, services and the whole system including them.

Cutting-edge R&D is one of important roles expected of universities, but another significant role is to develop human resources...
-who can see things from various aspects such as what role universities are expected to play now and from now on and how next society will become in the future, and contribute to create new value
-who can consider one’s own role based on those perspectives