The Universities' Role in Fostering Innovation and Societal Change

- The Viewpoint of Academia -

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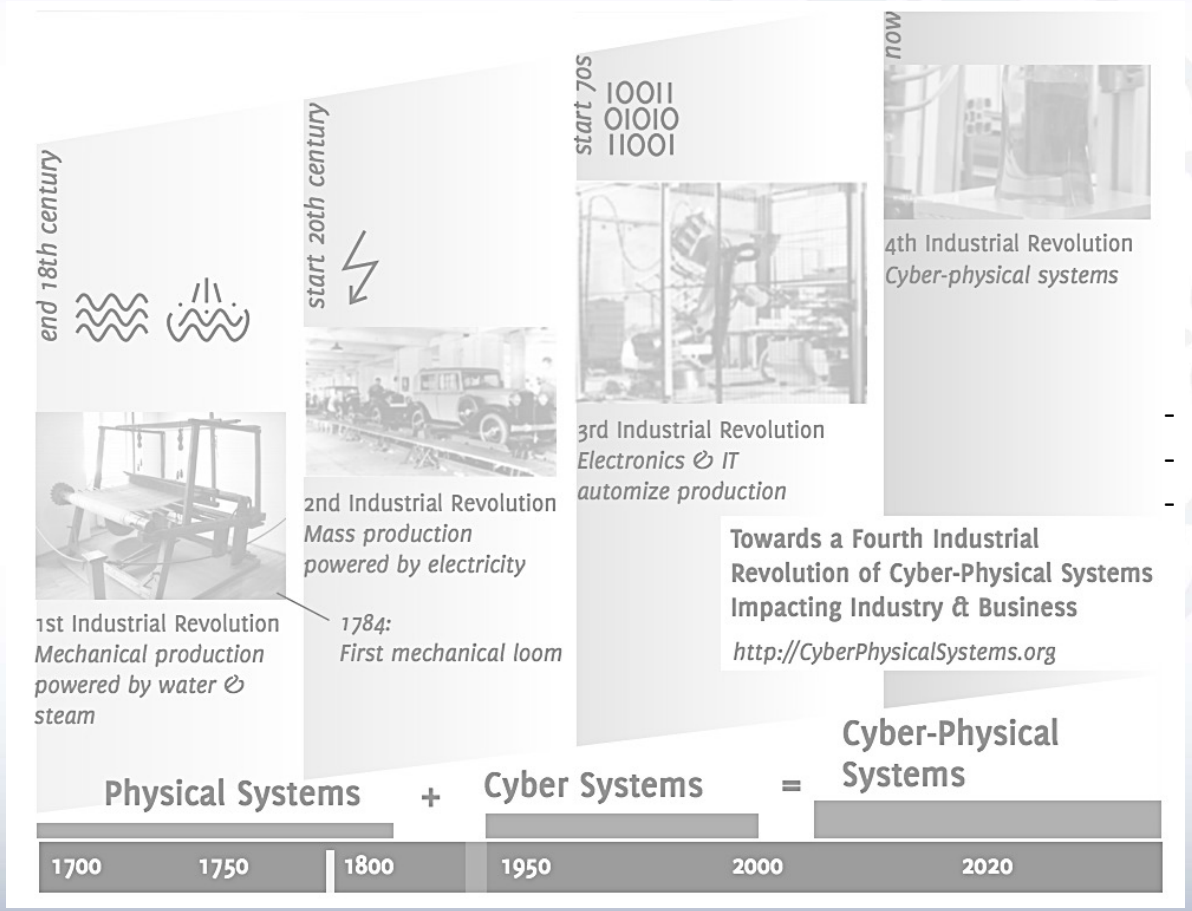
The Fourth Industrial Revolution

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.

By Klaus Schwab, https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/



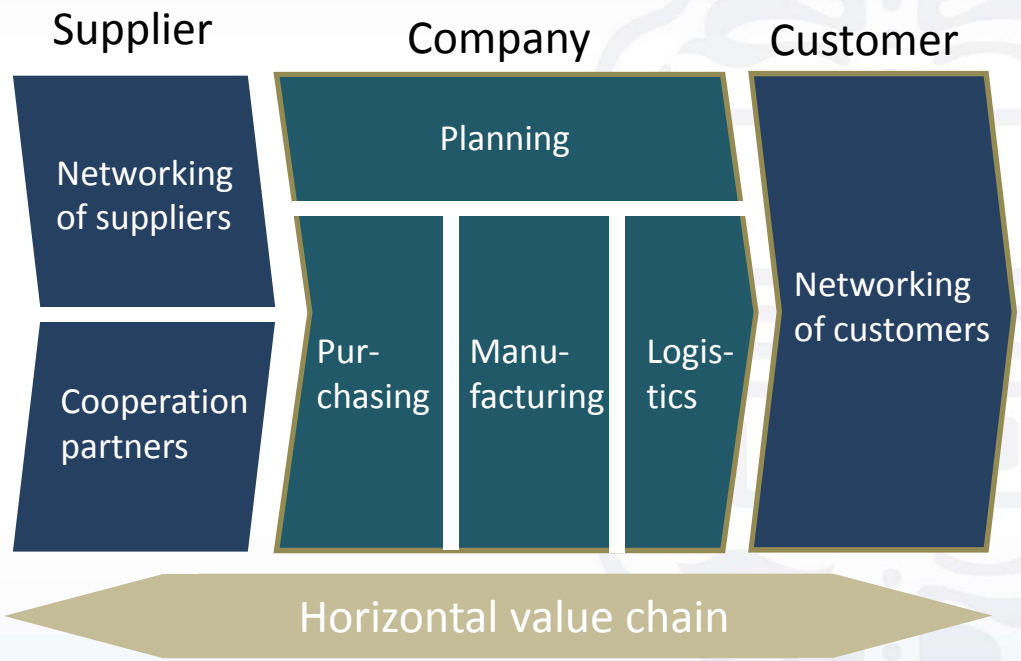
Jaap Bloem et al. "The Fourth Industrial Revolution Things to Tighten the Link Between IT and OT"

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

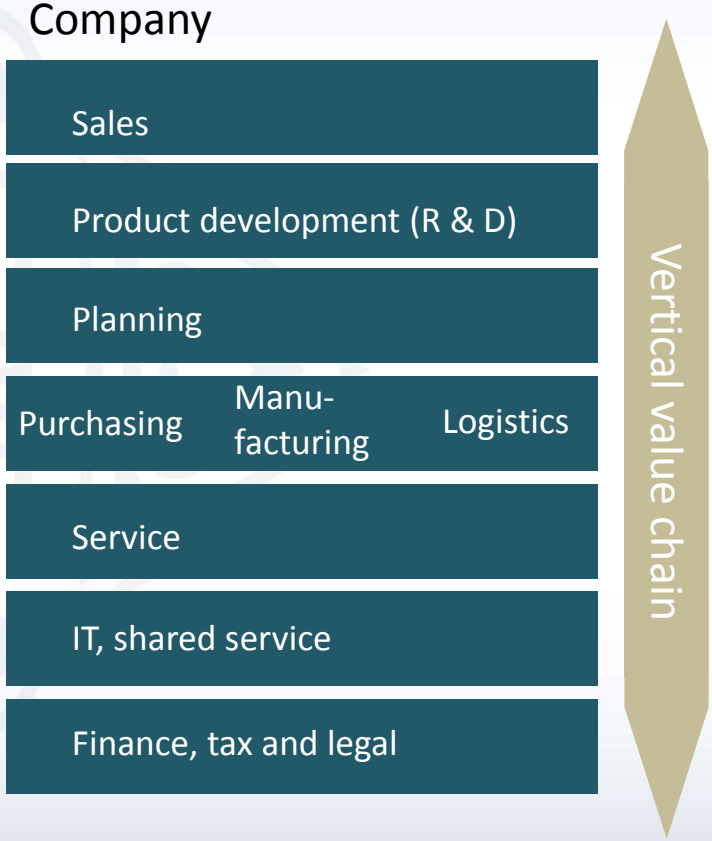
Horizontal and Vertical value chain integration

Horizontal value chain



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

Vertical value chain



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

Society 5.0

Society 1.0 Hunter–gatherer society

Society 2.0 Agricultural society

Society 3.0 Industrial society

Society 4.0 Information society

Society 5.0
Super Smart Society

The super smart society service platform

Standardization of Interfaces and data formats

Security advancement and use in society

Use of standard data

Consolidated development of ICT infrastructure

Reform of regulations and systems for new services

Human resource development

Optimizing the energy value chain
Building a global environment information platform
Maintenance and upgrade of an efficient and effective infrastructure
Attaining a resilient society against natural disasters
Intelligent transportation systems
New manufacturing systems
Integrated material development systems
Promoting integrated community care systems
Hospitality systems
Smart food chain systems
Smart production systems

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

週刊 経団連タイムス 2016年4月21日 No.3267, "Report on The 5th Science and Technology Basic Plan" Council for Science, Technology and Innovation Cabinet Office, Government of Japan (December 18, 2015)

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

- Osaka University
- Sponsoring corporations (temporary transfer)
- Other organizations

Screening

Staff

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

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

- 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

Source: Office for University-Industry Collaboration, Osaka University

●Comprehensive Collaboration Agreement between the Center for iPS Cell 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 iPS cell technology applications will be pursued concurrently

・About 100 researchers engaged in joint research, with each contributing about 50 researchers

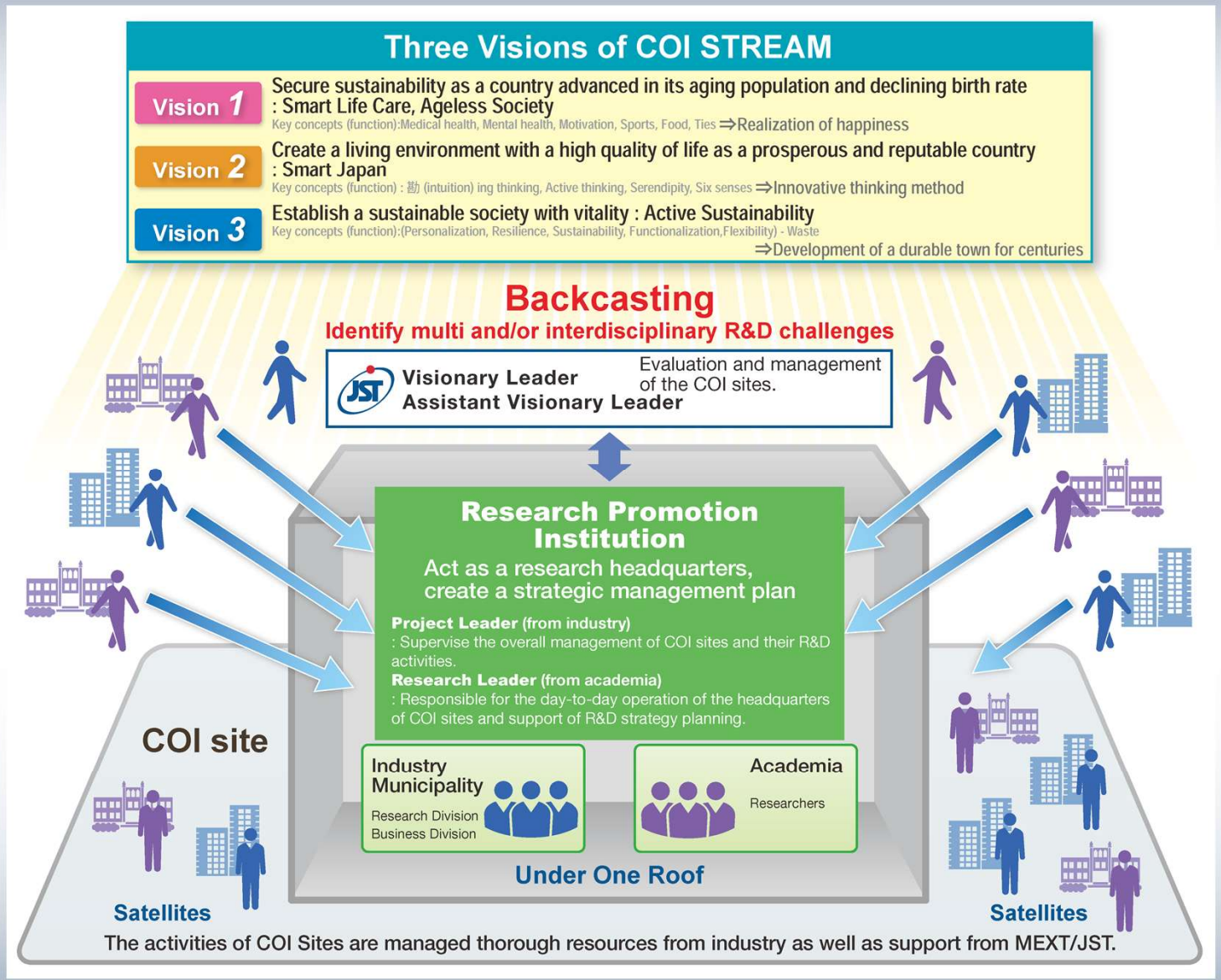
●Comprehensive Collaboration Agreement between the Osaka University Immunology Frontier Research Center (IFReC) and Chugai Pharmaceutical Co., Ltd.（from April 2017）

・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

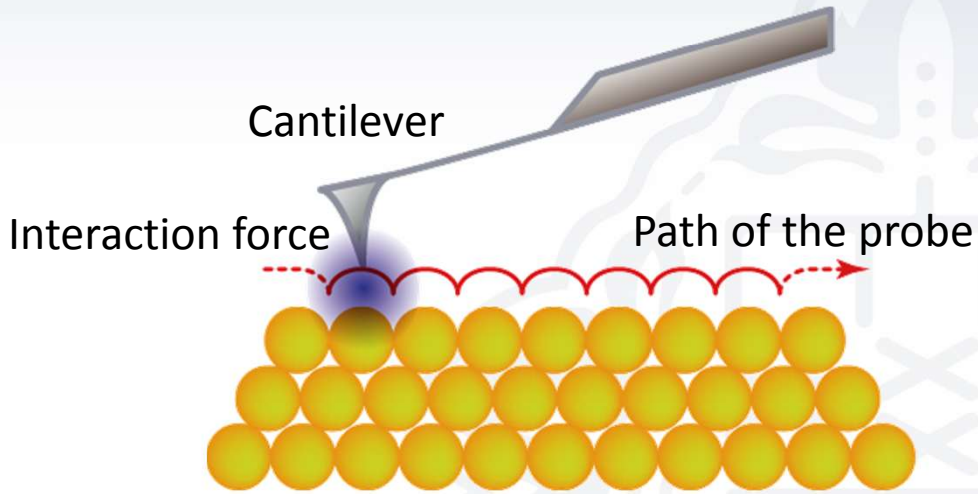


http://www.jst.go.jp/coi/etc/pamphlet2016.2EN.pdf

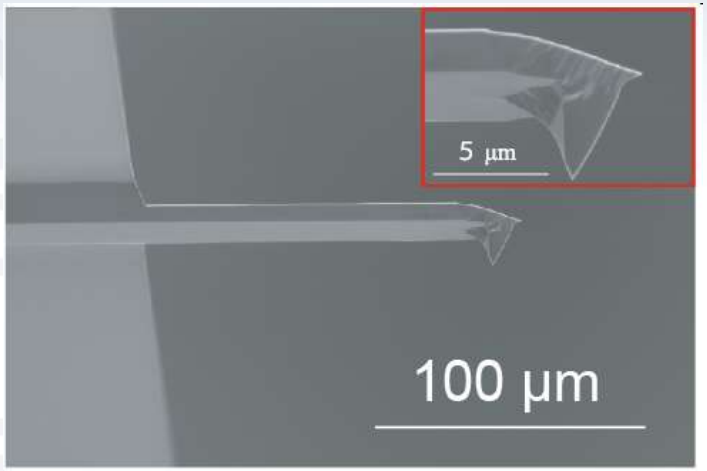
Kanazawa's Challenge 1: Atomic Force Microscope(AFM)

金沢大学 KANAZAWA UNIVERSITY

Operation principles

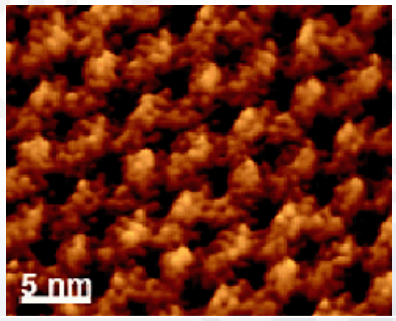


Cantilever (silicon)



Merits

-molecular resolution in liquid
-can observe insulating objects
-label-free
-measure mechanical properties



Engel et al. Nature 7 (2000) 715

Problems

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

Kanazawa's Challenge 1: High-speed Atomic Force Microscope(AFM)

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Development of High-speed AFM

Prof. Toshio ANDO

High-speed AFM

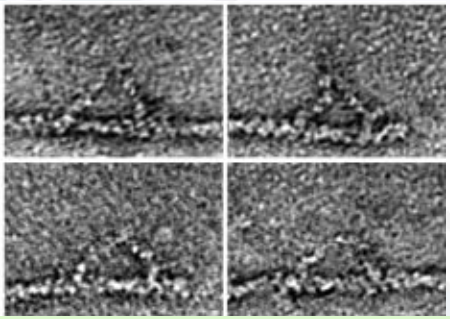
Imaging speed

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

-Increase imaging speed by **600 times**
-Visualize molecular dynamics

Ex. Myosin V

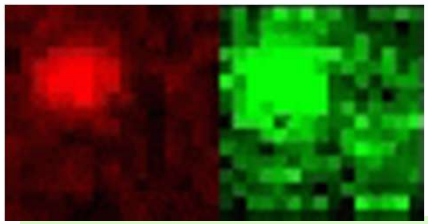
Electron Microscope



cannot observe movement

Walker et al, Nature (2000)

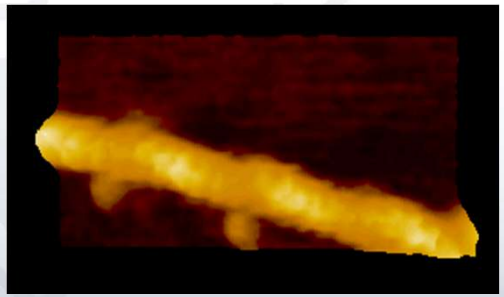
Fluorescence Microscope



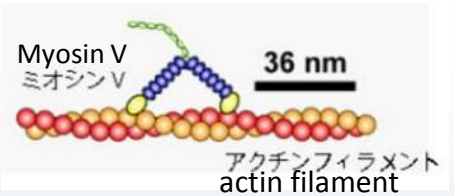
cannot observe molecular structure

Sakamoto et al, Nature (2008)

High-speed AFM



Kodera et al, Nature 4**68** (2010) 72

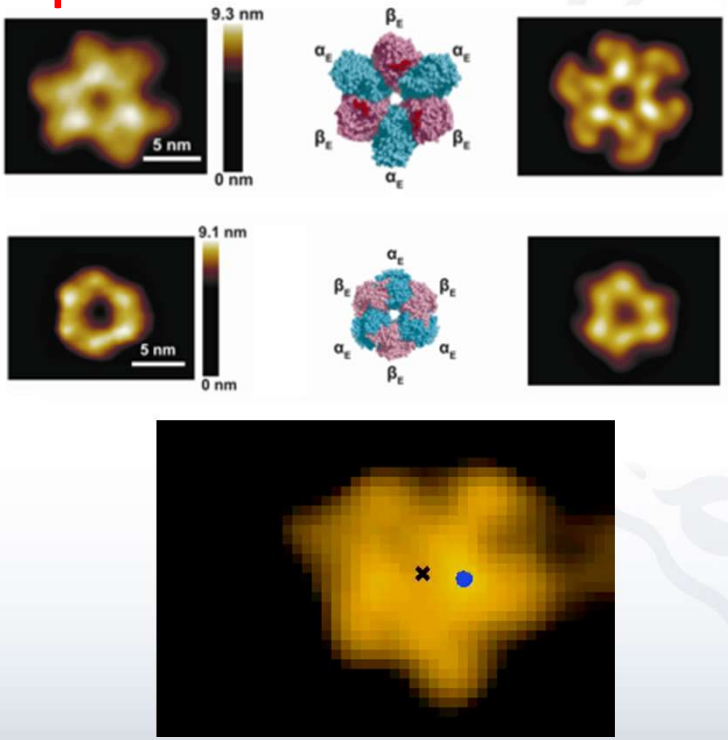


CAN observe **molecular structural changes !**

Kanazawa's Challenge 1: Elucidating Molecular Dynamics by High-speed AFM

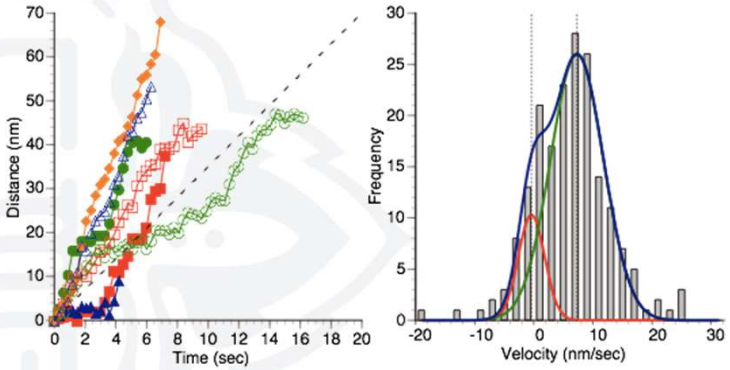
Rotation propagation of structural change of axle-less F_1-ATPase

Experiment **Simulation**



Uchihashi et al. Science 333 (2011) 755

continuous movement and "traffic jam" phenomenon of cellulase



Igarashi et al. Science 333 (2011) 1279

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

Prevalence of the autism spectrum disorder is around 1%

LANCET 2006

STOP !!

Maladjustment in a school and the society

1、障害と認識されていなかったため適切な療育を受けていなかったことが多い。
2、周囲が本人を追いつめ、結果的に攻撃的になるなどの「二次障害」に陥いることが問題。

Early detection

Support of the early detection with the medical equipment

Early intervention

Prevent maladjustment !
Develop their ability !

発達障害への早期介入は、大きなメリットをもたらす
NATURE CLINICAL PRACTICE 2008

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

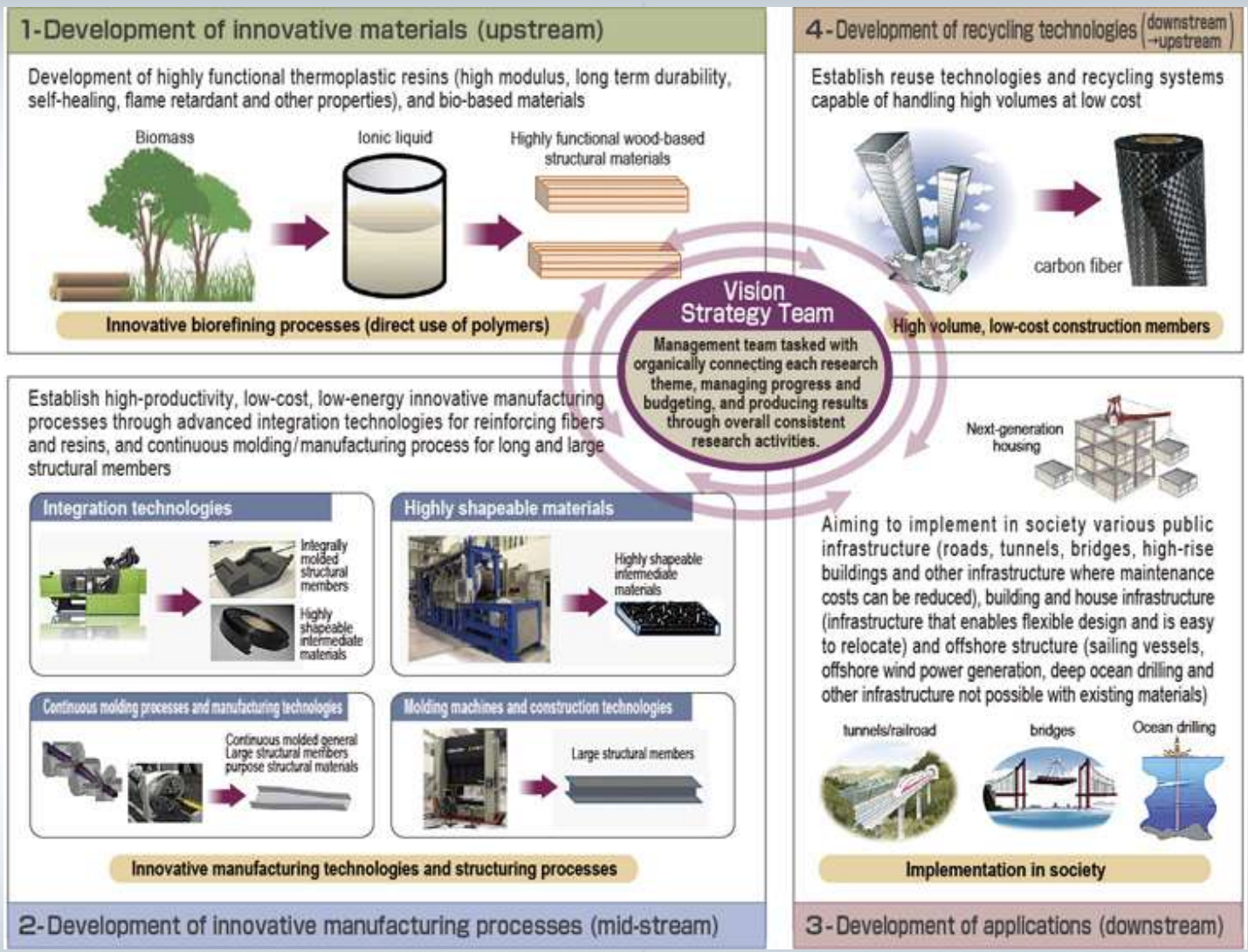
Merits

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



http://www.icc-kit.jp/coi/en/feature/02.html

Kanazawa's Challenge 3: Development of Carbon Fiber Reinforced Plastic Derived from Plant Biomass

COI STREAM

Biomacromolecules in biomass

Platform chemicals

Resin & Fiber

CO_2

Oil plant biomass

Plant oil

Microalgae biomass

Starch

Cellulose

Lignocellulosic biomass

Hemicellulose

Lignin

Glycerol

Glucose

Xylose

Lignin monomer

Epichlorohydrin

Glutamic acid

2,5-furan dicarboxyric acid

Vanillic acid

Syringic acid

Carbon fiber

Acrylonitrile

PAN -CF

Thermosetting and thermoplastic resin

Cellulose acetate butyrate

CMCAB

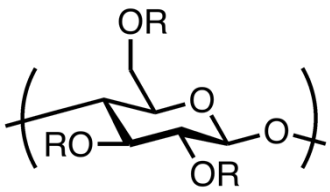
Lignin acetate

Carbon fiber reinforced plastic (CFRP)

Lignocellulosic composite

KANAZAWA UNIVERSITY

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



R= CH_3CO-

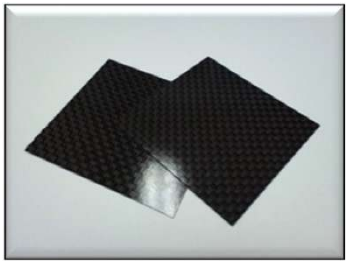
$CH_3CH_2CH_2CO$-

Cellulose acetate butyrate

Thermoplastic resin

Film

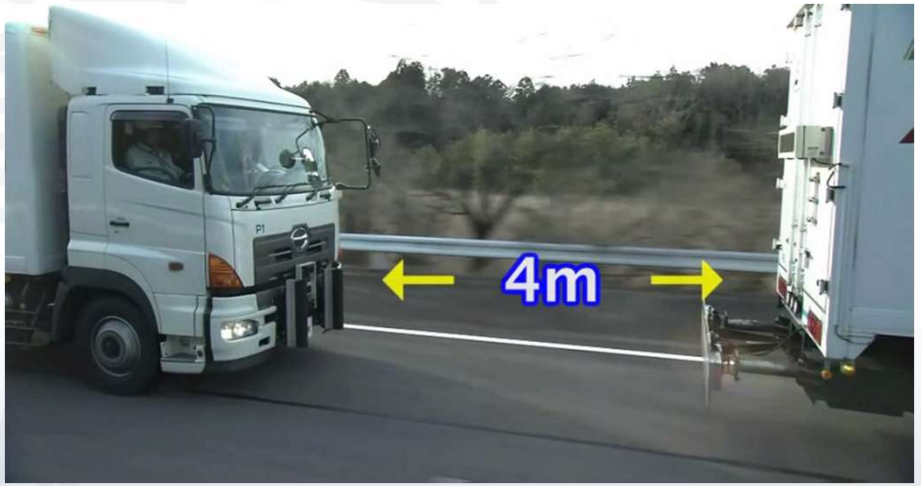
Carbon fiber



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



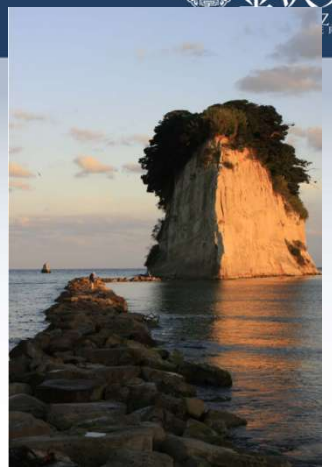
Energy-ITS

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

Public road experiment

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