

Road to 2030 Life Science

Kyosuke Nagata
the President of University of Tsukuba

From and to where science is coming and going?

Immanuel Kant : philosophy is involved in physics, ethics, and logic
as in philosophy in ancient Greece

Martin Heidegger: philosophy is for understanding of “being”
as essence but not existence

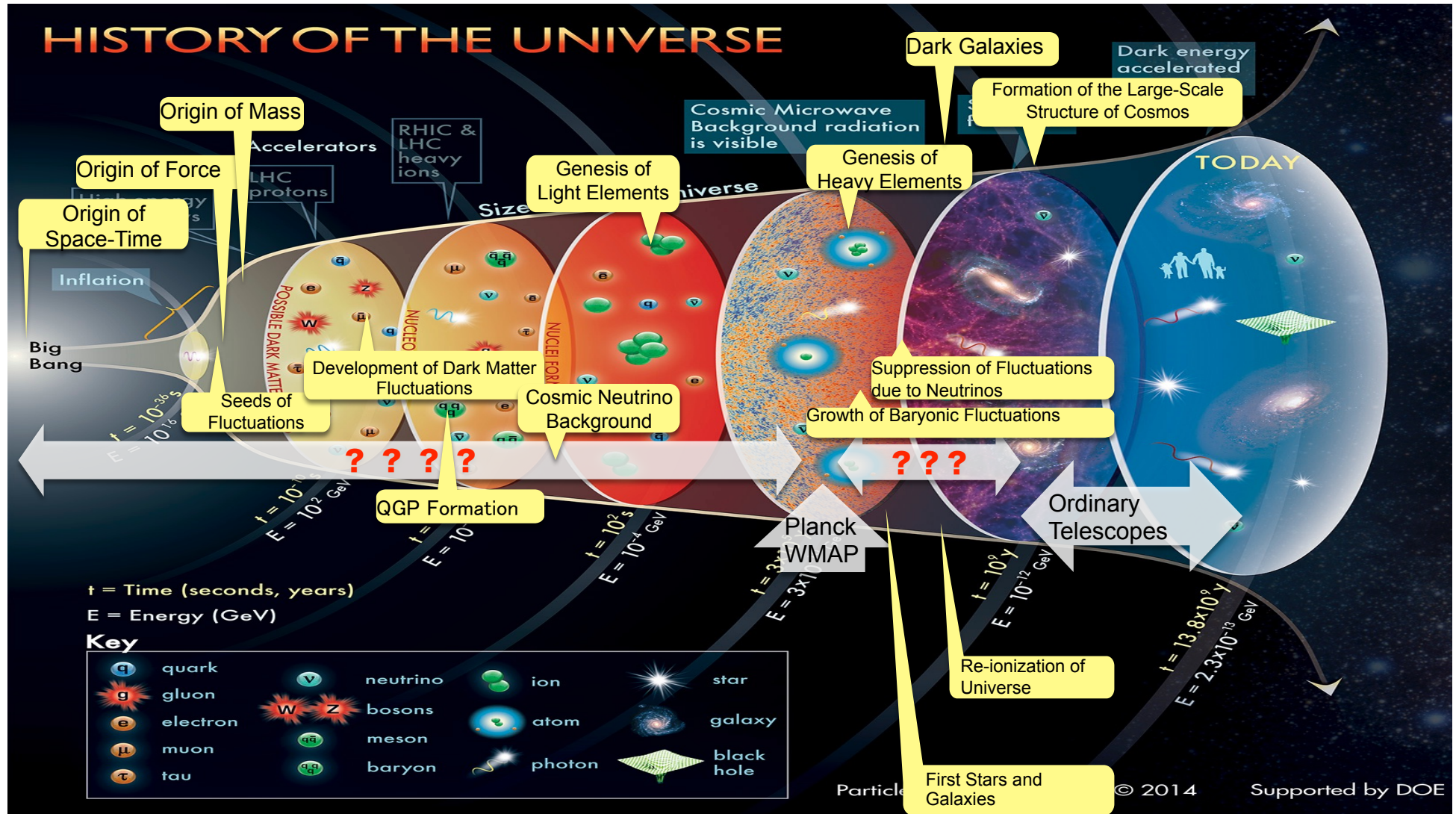
Propositions (neither sentence nor statement) **of natural science**

Origin of Universe

Origin of Life

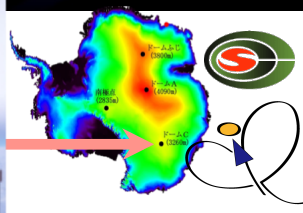
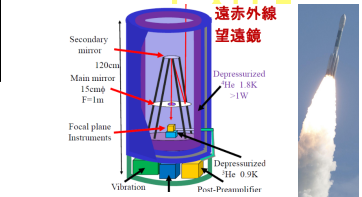
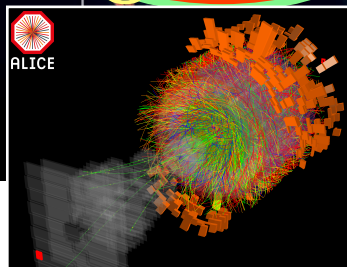
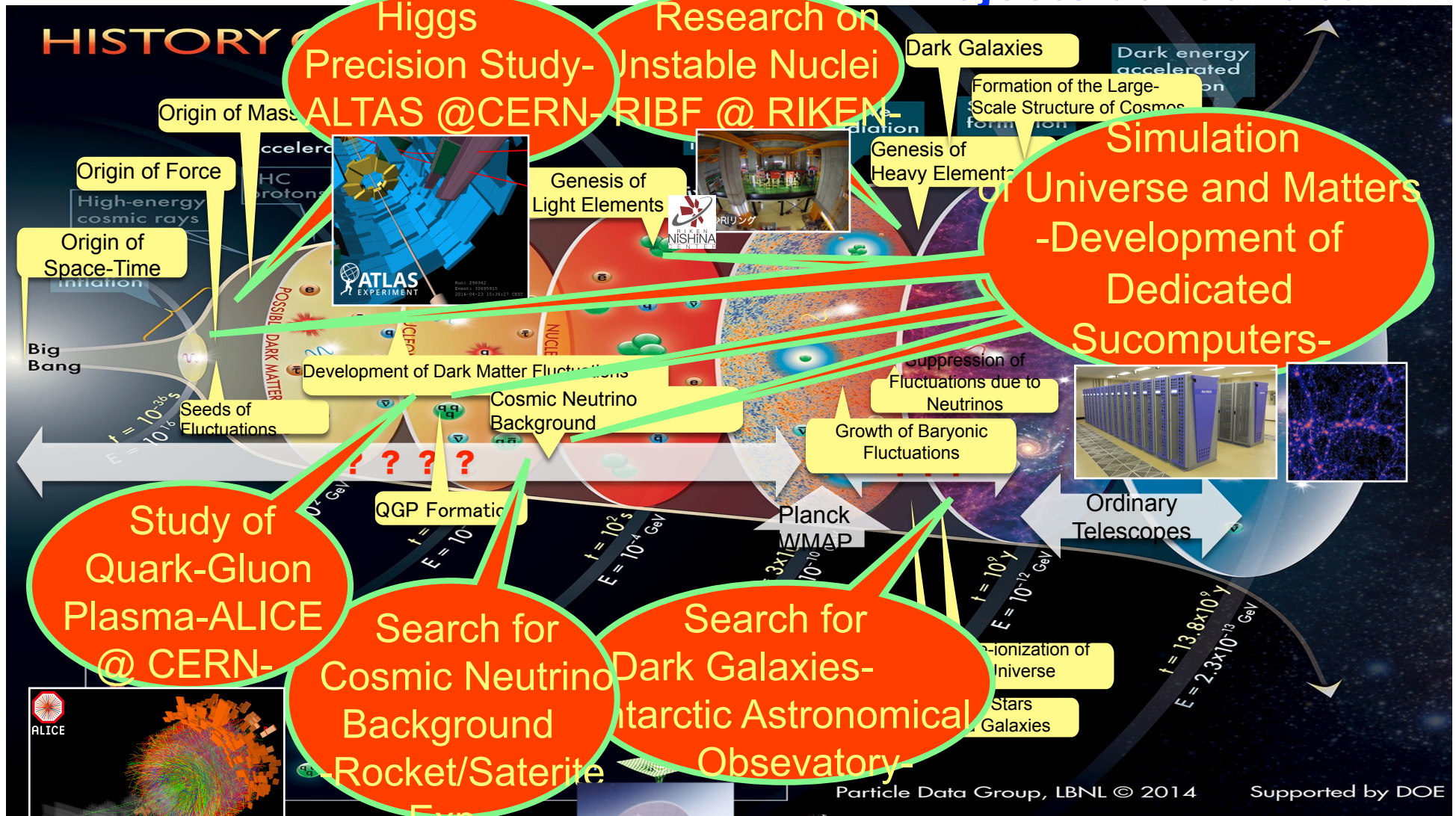
Cognition

Towards Clarification of the History of Universe



Towards Clarification of the History of Universe:

Projects at Tsukuba



University of Tsukuba
Center for Computational Sciences
 Center for Integrated Research
 in Fundamental Science and Engineering

What does Life Sciences* do

- **Challenge the fundamental question, the origin of life**
 - Biodiversity with evolution at the molecular level such as genomes, dynamics of functional molecules, etc.
- **Contribute to finding of practical solutions for a variety of problems**
 - Key societal needs: sustainable food production, ecosystem restoration, optimized biofuel production, and improvement of human health.
 - By integration with biology**, and closer collaboration with physical, computational, and earth scientists, mathematicians and engineers
 - Supported by leveraging resources across the national, private, and academic sectors

(Modified from A New Biology for the 21st Century (2009, The National Academy Press))

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** Biology (βίος (bios) + λόγος (logos)): started from Natural History including taxonomy and other fields to describe biological phenomena

Questions in fundamental biology to be solved

Bio-diversity research in genome- and post genome-project era
to understand “origin of life” and “evolution”

Life as complex system: from reductionism to reconstitution of life such as cell
through collaboration of organic chemistry, biophysics, biochemistry, etc

life/being in seas (eg. TARA Ocean Science)

Extraterrestrial life/being

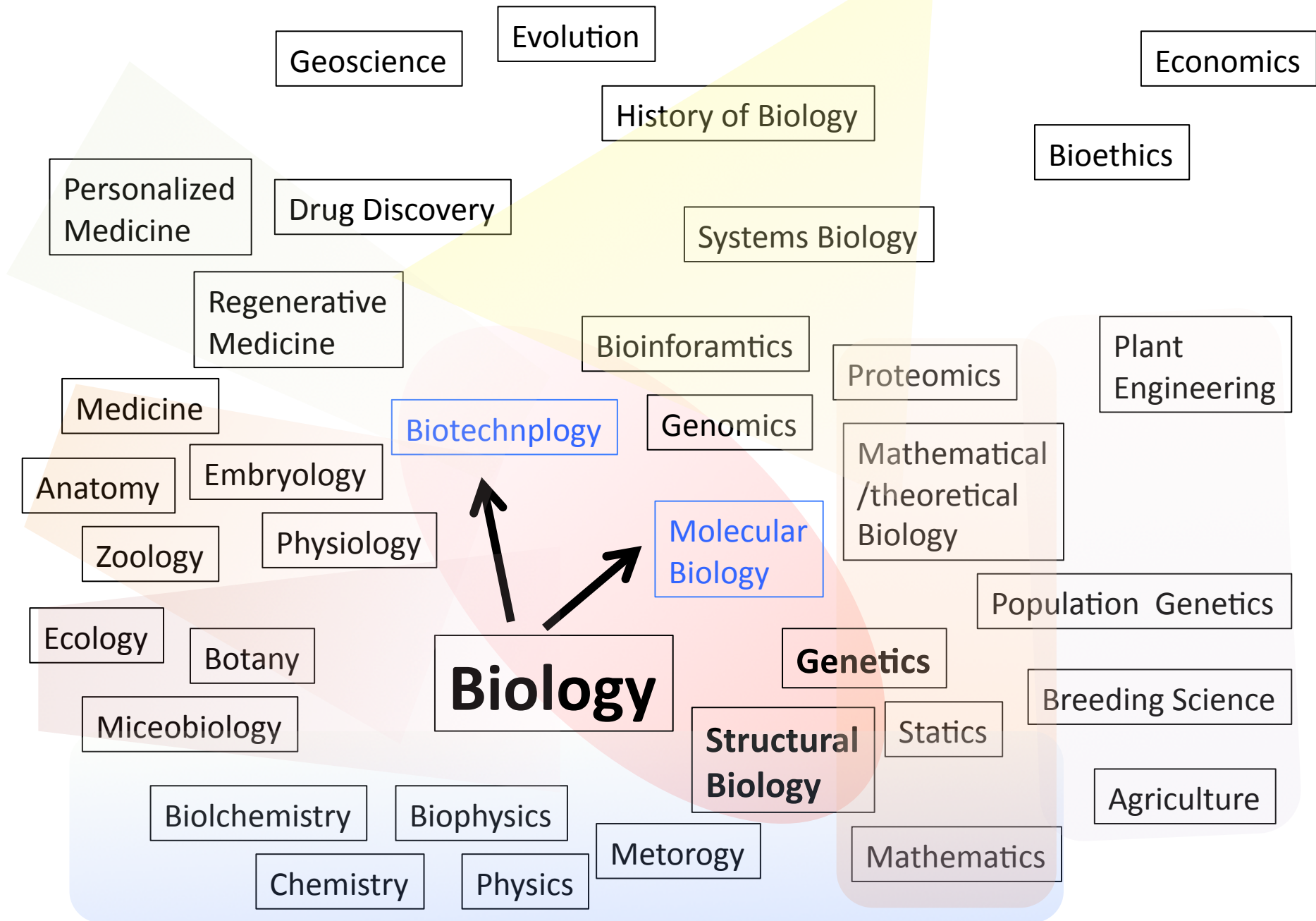
Process and Architecture of Spirit and Psychology of human being

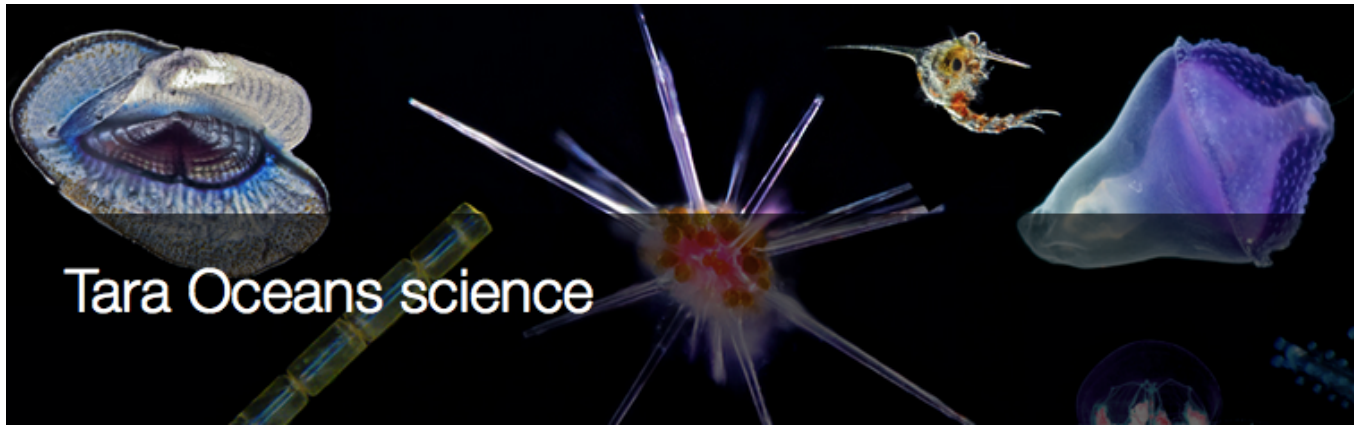
Spirit =, ≠, ≠ soul, heart, mind, concept, energy, etc

Psychology =, ≠, ≠ mental, Kansei, feeling, etc

Origin of Life

From & To Biology





Telling the story of life – its past and future

Life began in the ocean. It tells the story of how the most complex organisms evolved from primordial bacteria and it will tell us about the fate of the myriad organisms present today. As the oceans are the largest cohesive eco-system on earth the insights that researchers will be able to derive are crucial not only for the preservation of mankind but also of our planet.

(<http://www.embl.de/tara-oceans/start/>)



35000 samples were collected from all the world's oceans.



SHARE

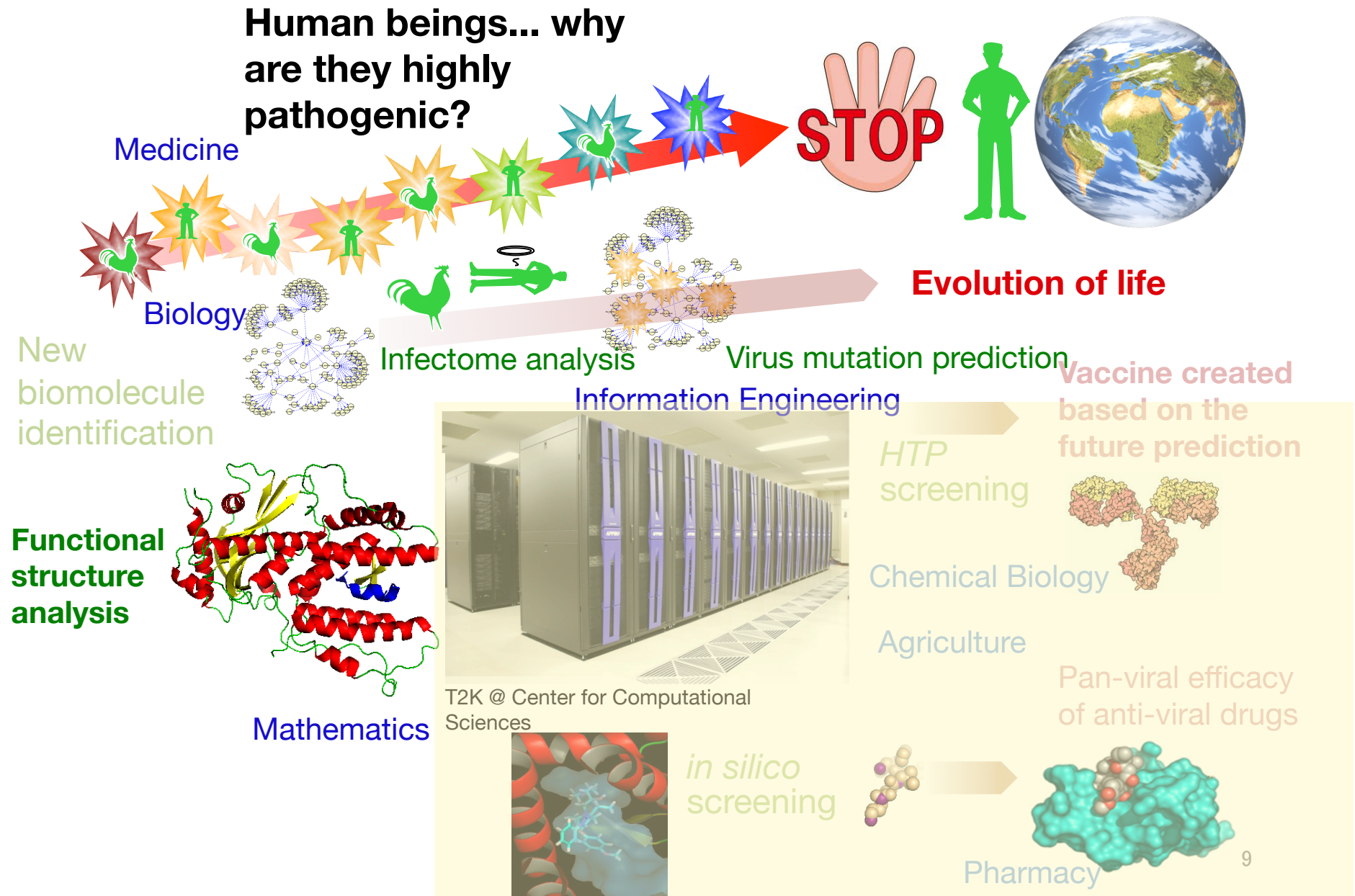
RESEARCH ARTICLE



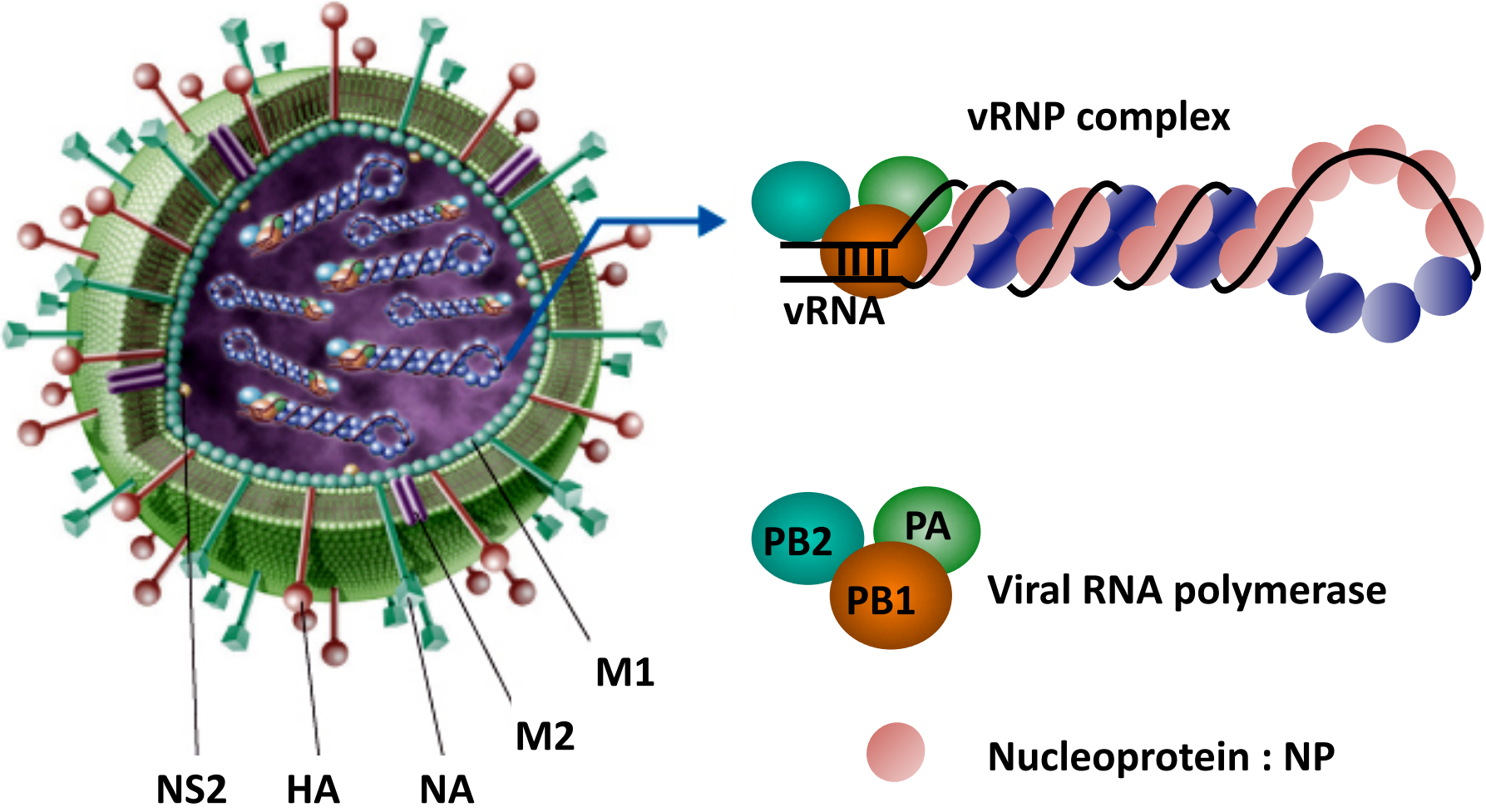
Structure and function of the global ocean microbiome

Science 22 May 2015:
Vol. 348, Issue 6237,
DOI: 10.1126/science.1261359

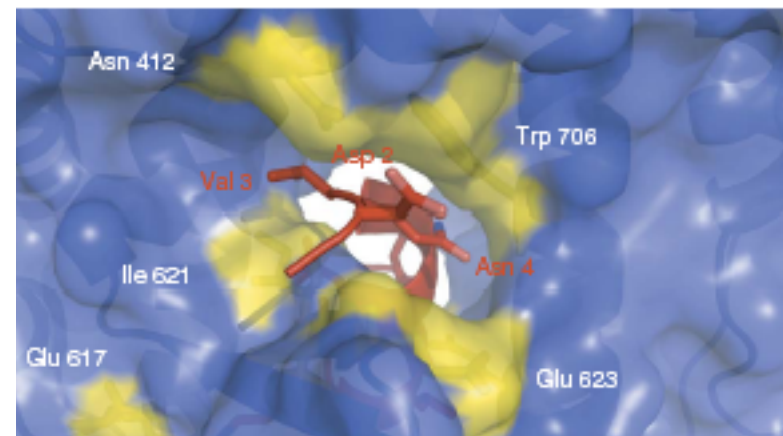
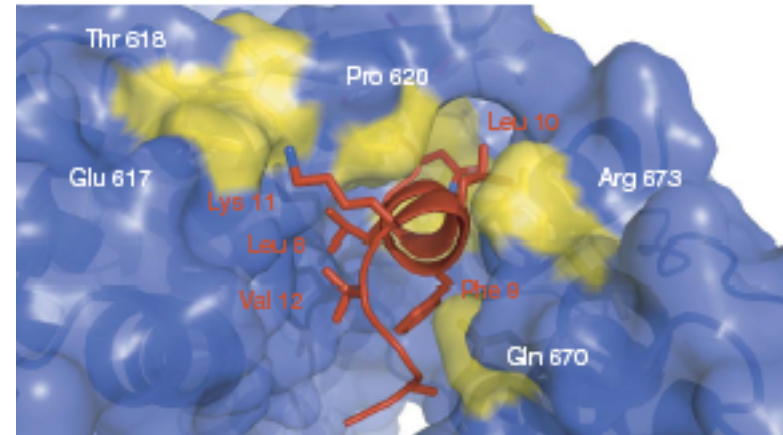
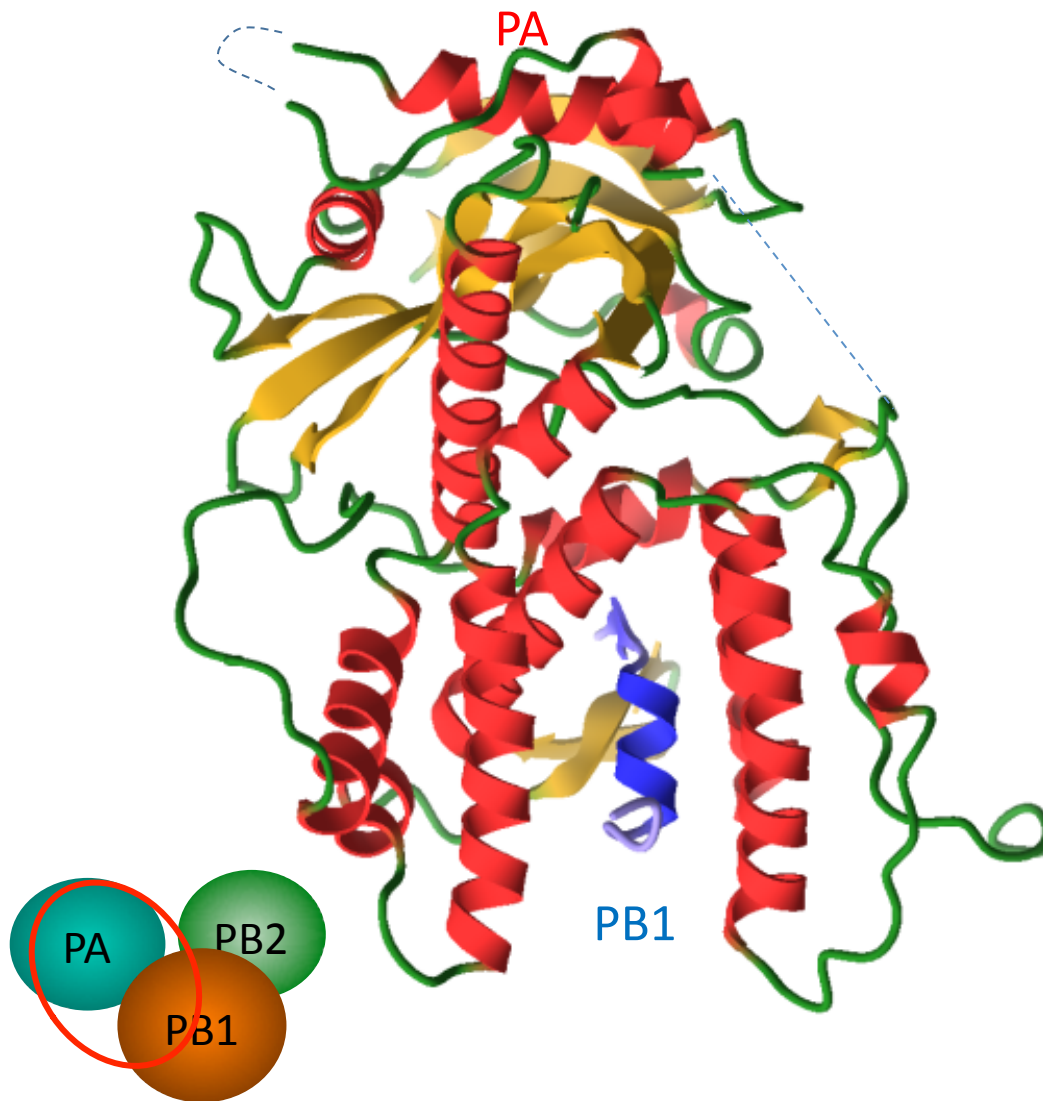
An example: recent studies on influenza virus



The Structure of Influenza vRNA-RNA Polymerase-NP (vRNP) Complexes



The crystal structure of PA-PB1 complex



Molecular surface representation showing the cleft into which PB1 binds.

Nature (2008) 454, 1127-1131

in collaboration with Dr. Park (Yokohama City University)

What is the current status ?

Initiated 20 years ago (in 1990s) → Now → Expected to bloom 15-20 years after

Synthetic biology: from reconstructed organic substances towards the life

TIGR (The Institute for Genomic Research) was founded in 1992.



Dr. Craig Venter



J. Craig Venter Institute was founded in 2006.

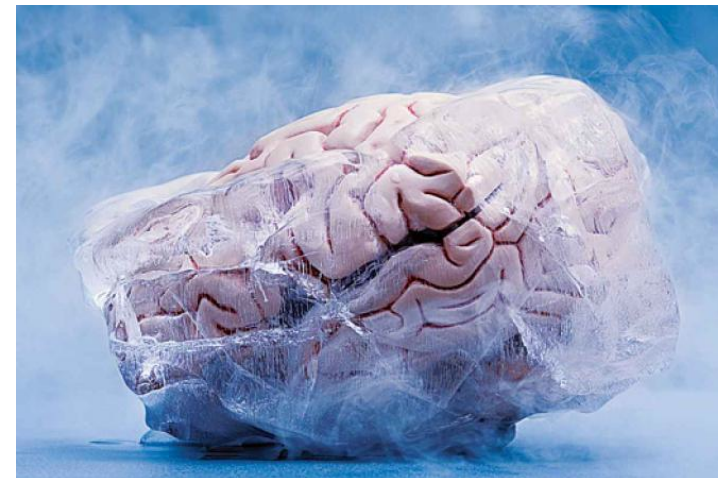


Cryobiology: from regenerative organ functions to the living organisms

21st Century Medicine was founded in 1993.



Dr. Greg Fahy



What does Life Science* do

To challenge the fundamental question, **the origin of life**

- biodiversity with evolution at the molecular level such as genomes, dynamics of functional molecules, etc.

To contribute to practical **solutions for a variety of problems**

- key societal needs: sustainable food production, ecosystem restoration, optimized biofuel production, and improvement in human health.
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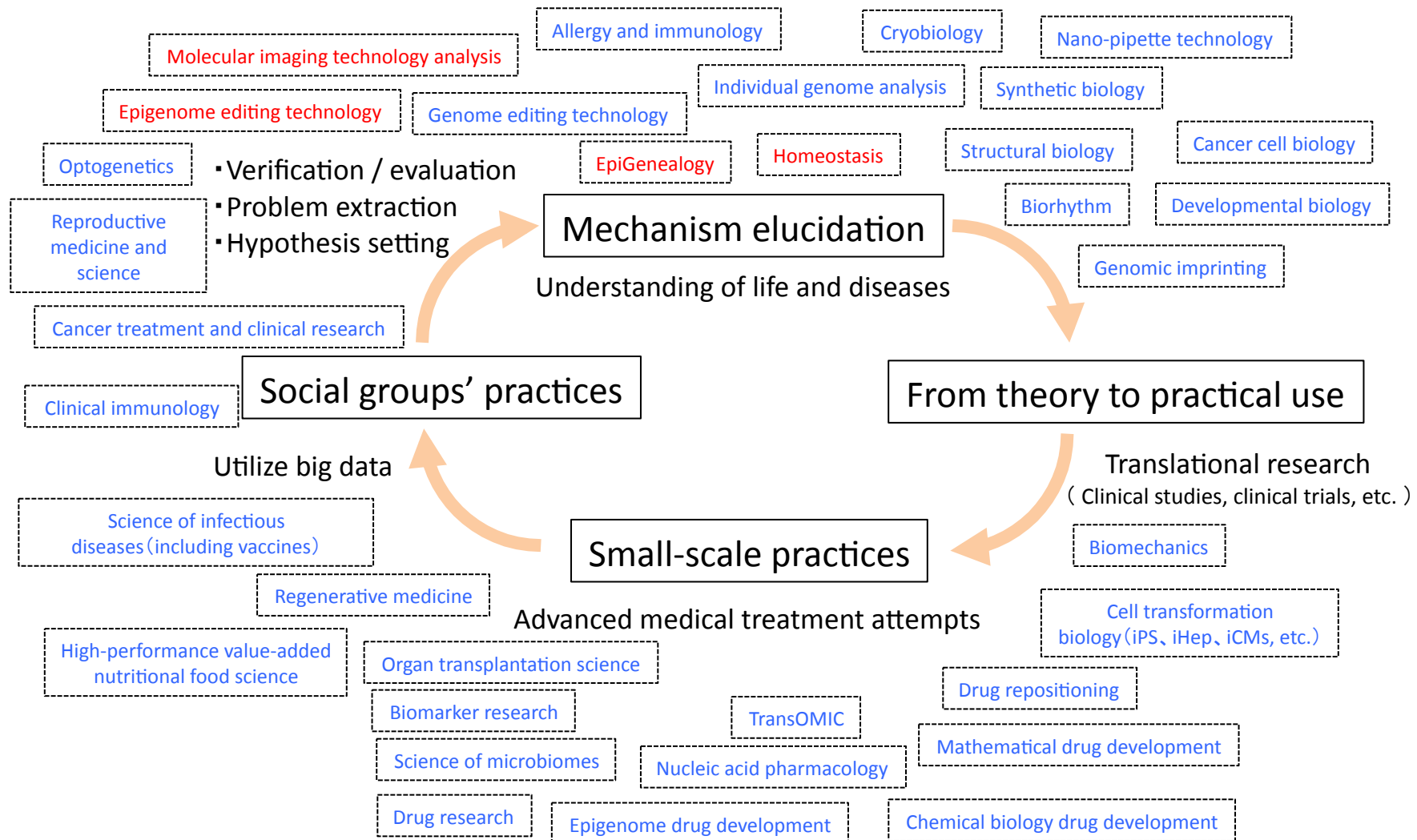
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Integrated research of life, health and medicine

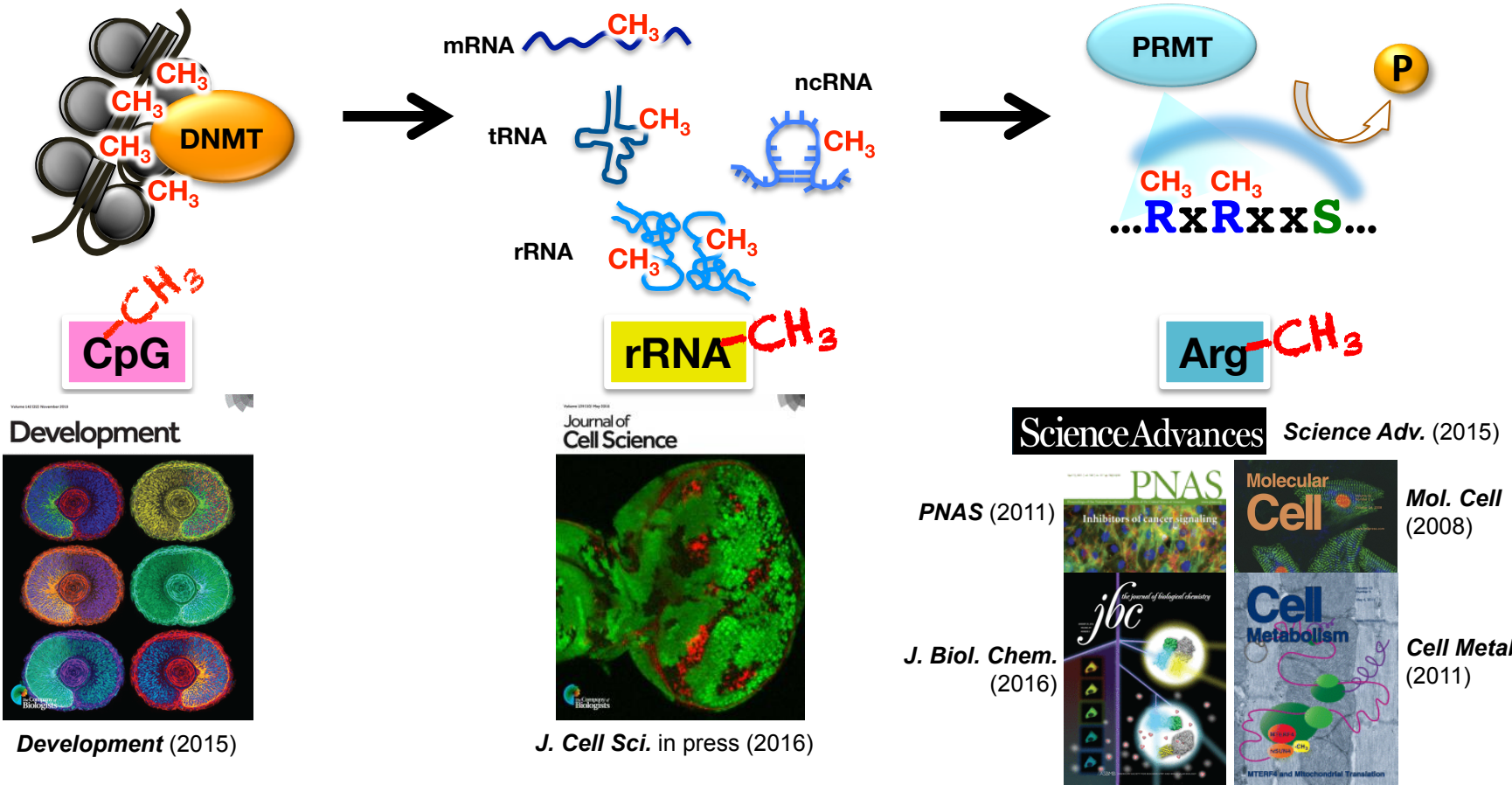


Trans-Methylation (-CH₃) in the Central Dogma

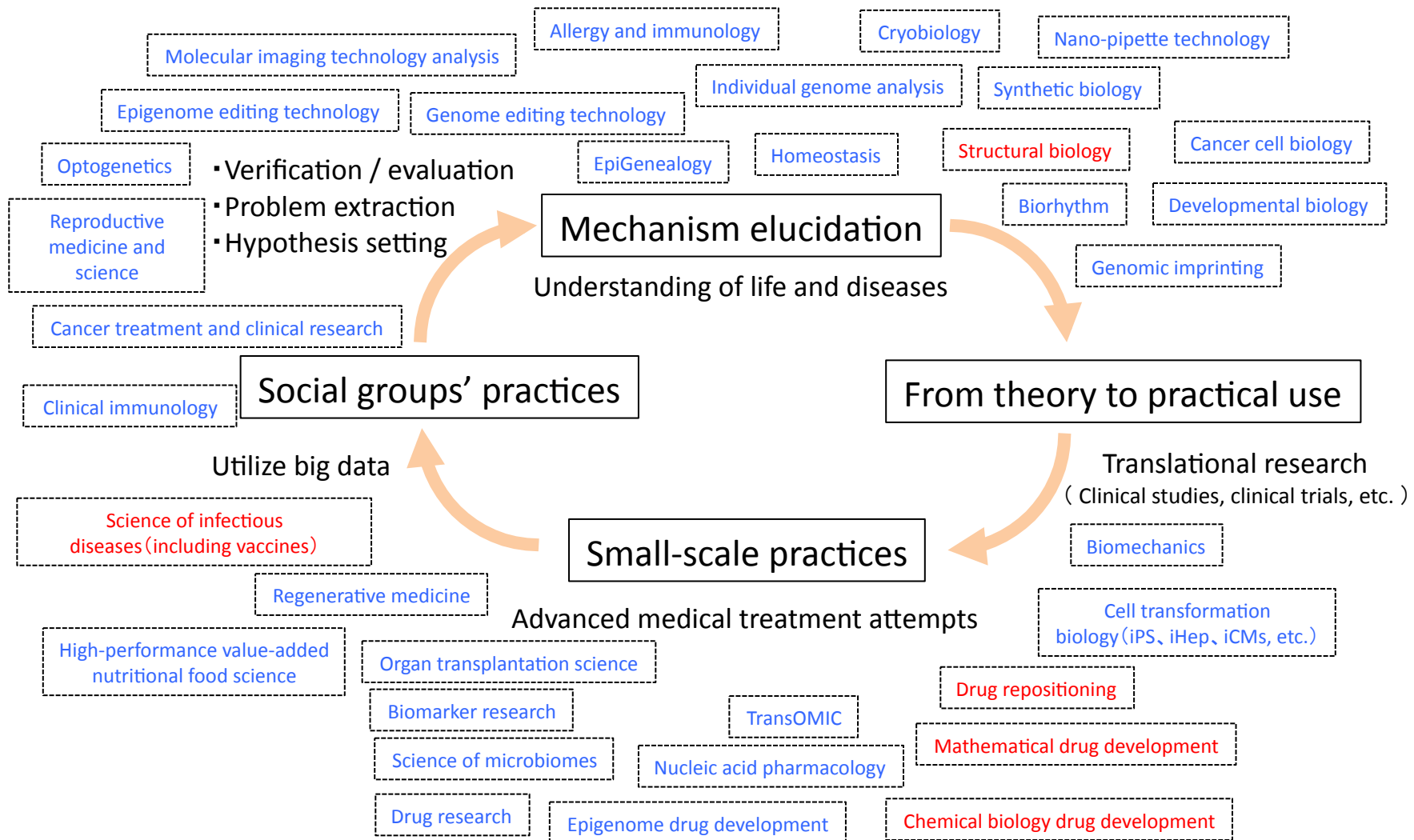


Professor
Akiyoshi Fukamizu

Trans-methylation is an essential modification of DNA, RNA, and histones and non-histone proteins, for controlling epigenome. **Fukamizu Lab.** in the Life Science Center, TARA, Univ. of Tsukuba focuses the research on exploring functional regulation of *trans*-methylation in response to nutritional conditions using model animals. These studies decipher an epigenome code and allow for understanding aging-associated biological processes to improve human health and diseases such as neurodegenerative and life style-related disorders.

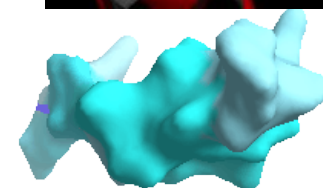
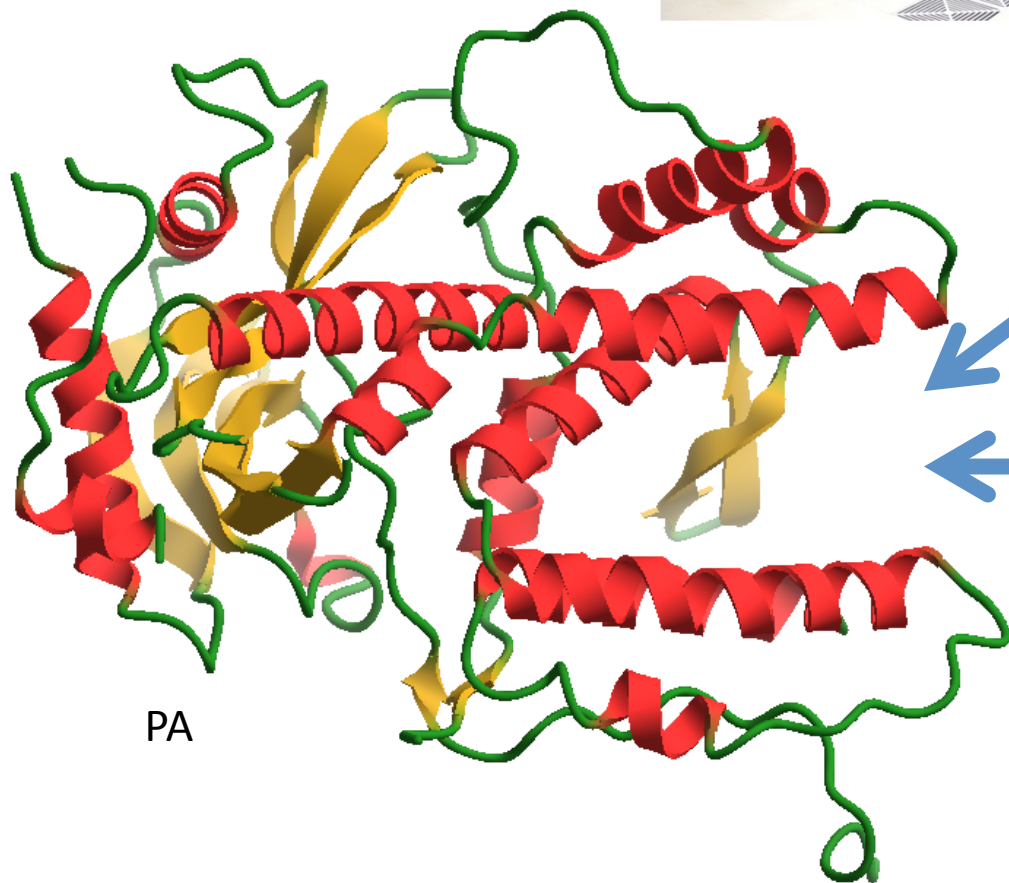
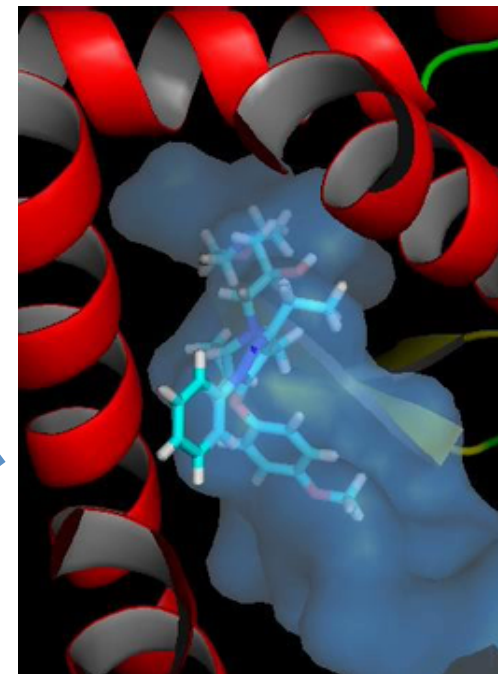


Integrated research of life, health and medicine



Compound screening by molecular dynamics calculation based on the crystal structure of PA-PB1 complex

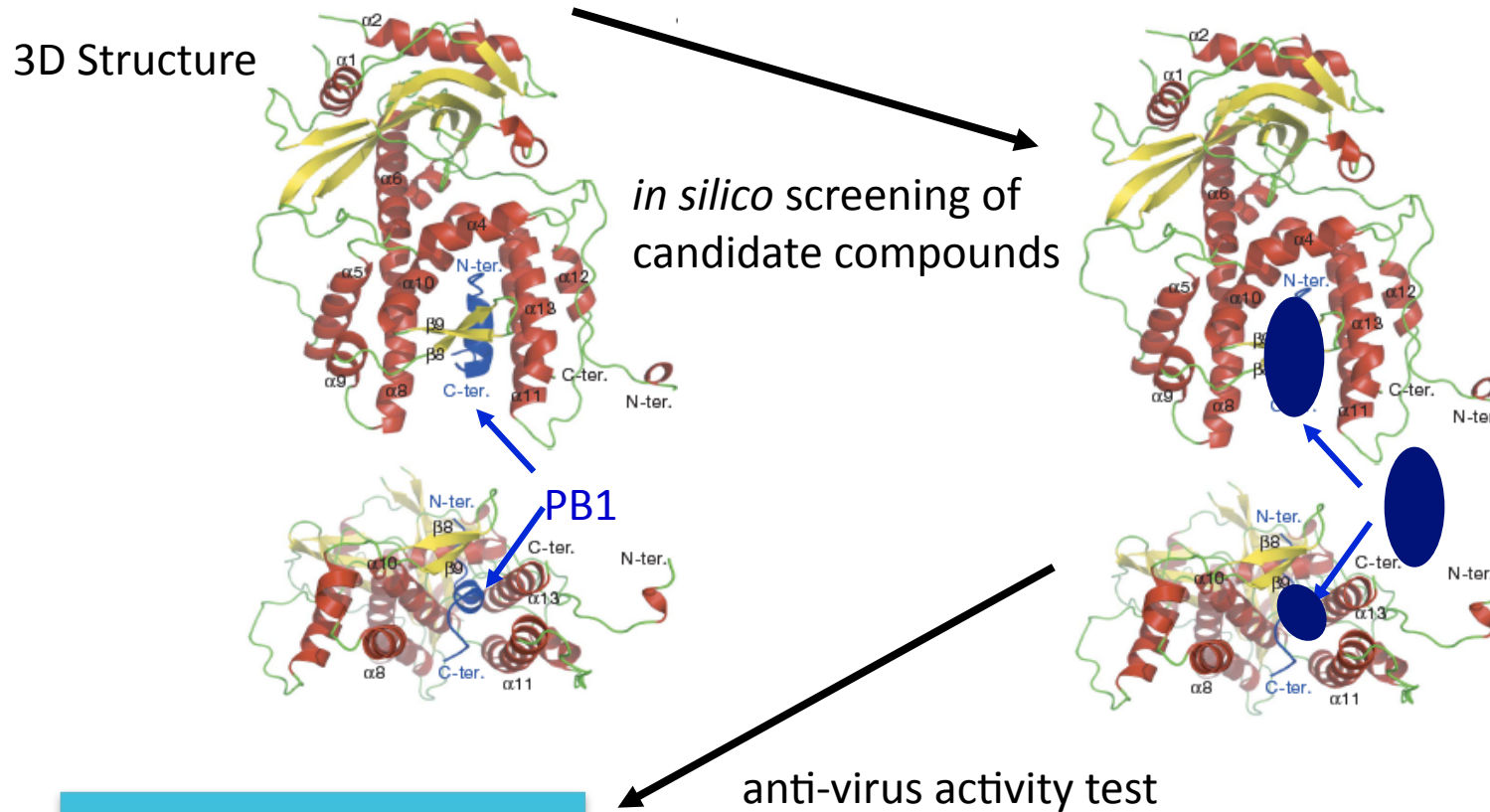
Mimicking the PB1 structure
important for
the interaction with PA



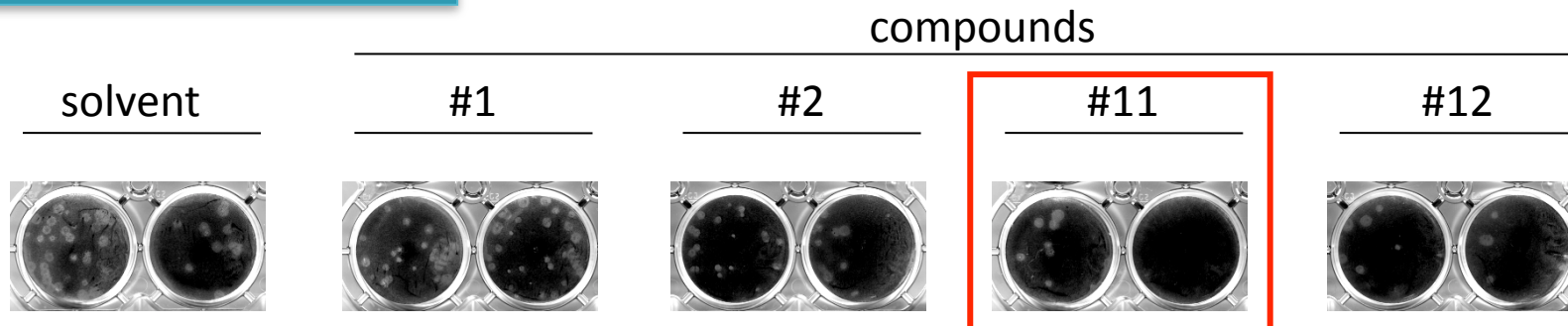
PB1

PA

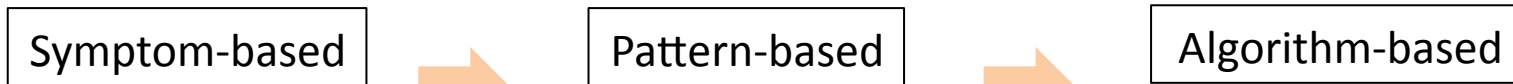
Drug candidate screening based on *in silico* search



Plaque assays



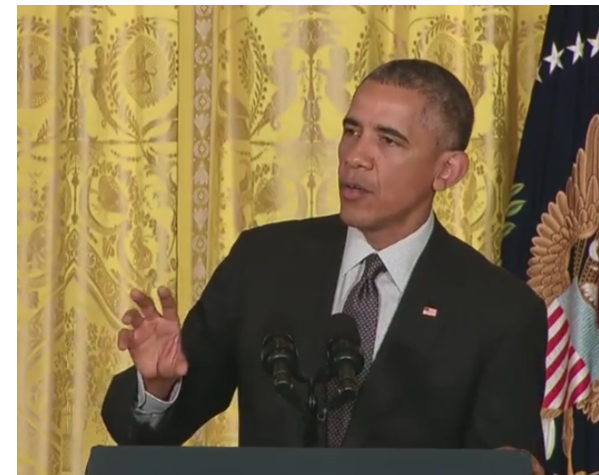
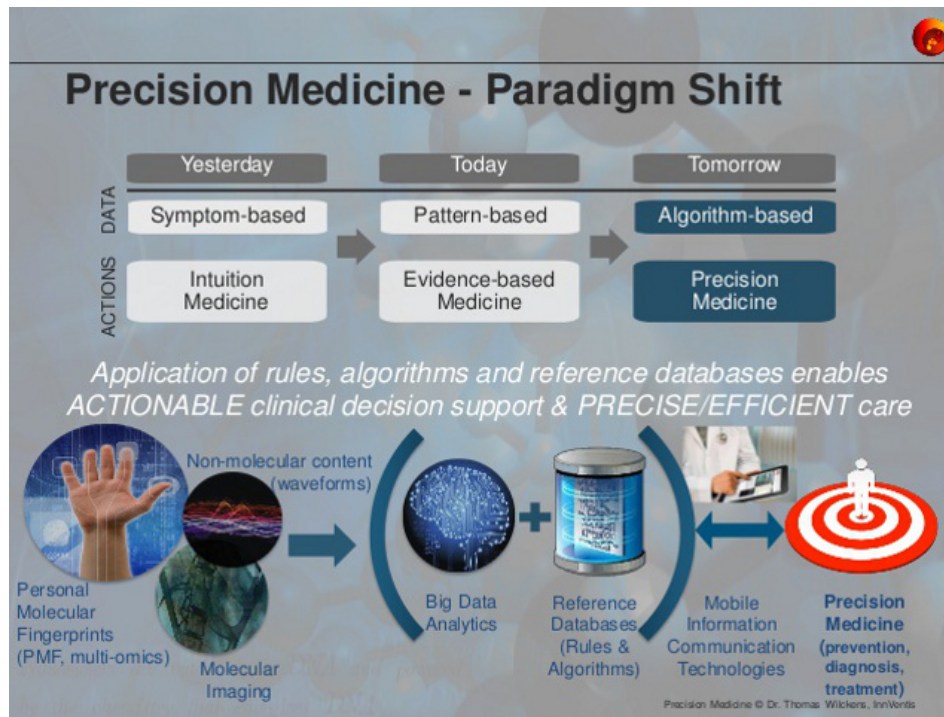
Precision Medicine (Individualization and precision in medicine)



Intuition medicine (health care works' "rule of the thumb")

Evidence-based medicine (basic and clinical research outcome)

Individual and refined medicine (database integrated information processing)



“And that’s why we’re here today. Because something called precision medicine ... gives us one of the greatest opportunities for new medical breakthroughs that we have ever seen.”

President Barack Obama
January 30, 2015

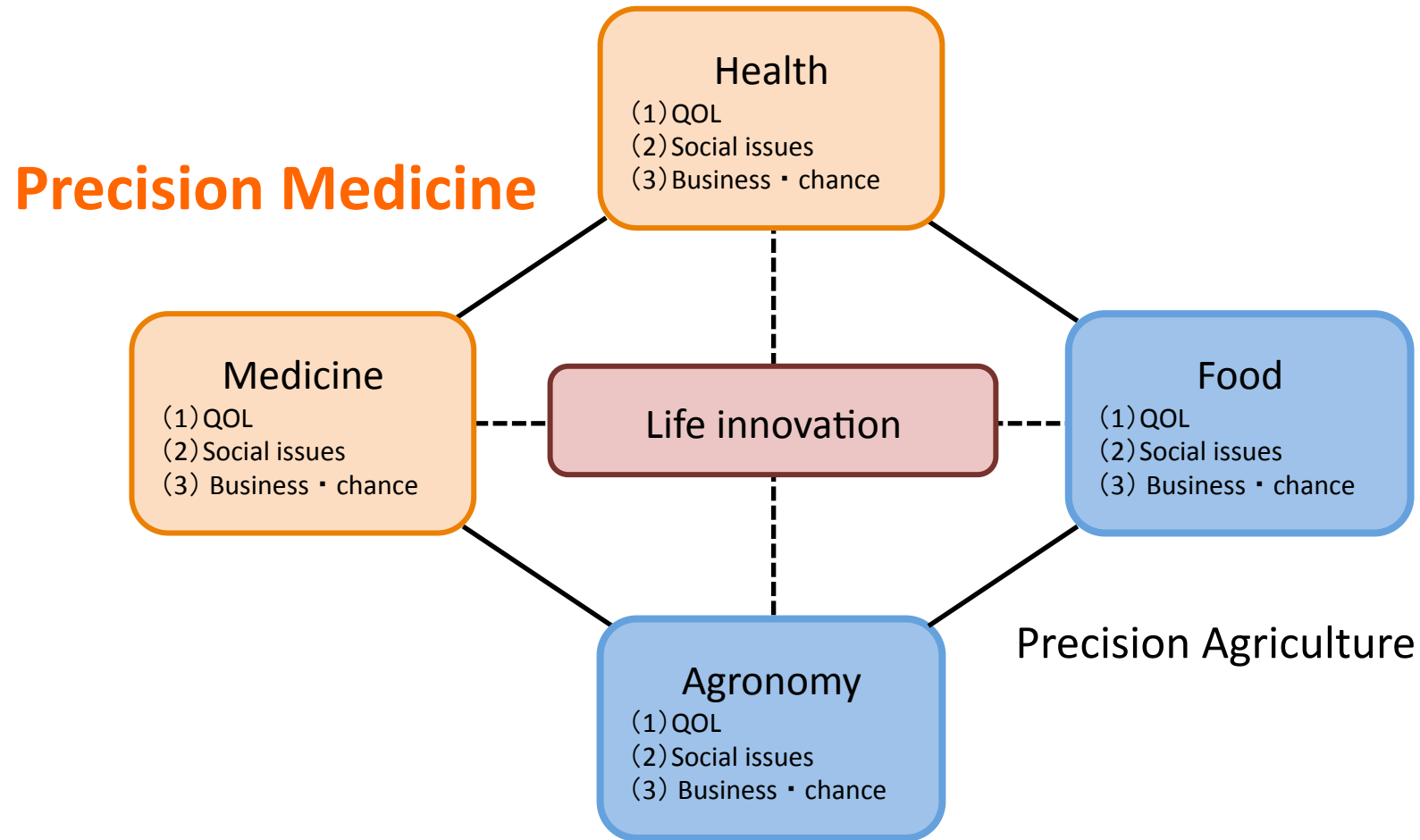


Japan Agency for Medical Research and Development

The Japan Agency for Medical Research and Development (AMED) engages in research and development in the field of medicine, establishing and maintaining an environment for this R&D, and providing funding, in order to promote integrated medical R&D from basic research to practical applications, to smoothly achieve application of outcomes, and to achieve comprehensive and effective establishment / maintenance of an environment for medical R&D.

Providing a one-stop service for research expenses, AMED consolidates budgets for research expenses, which had previously been allocated from different sources -- the Ministry of Education, Culture, Sports, Science and Technology, the Ministry of Health, Labour and Welfare, and the Ministry of Economy, Trade and Industry. In addition to making possible an integrated approach to providing research funding and establishing / maintaining research environments, the unification of points of contact and procedures for research expenses can be expected to reduce the administrative burden on institutions and researchers receiving allocations for research expenses. AMED aims to achieve the world's highest level of medical care / service and to form a society in which people live long, healthy lives by promoting integrated research and development, from basic research to practical application, and by establishing and maintaining an environment therefor, and linking this to various forms of growth in medical R&D.

Regulatory science of nutrition and health paradigm shift in Medicine and Agronomy



http://www.nikkeibp.co.jp/lab/techroad2016_med/ (modified)

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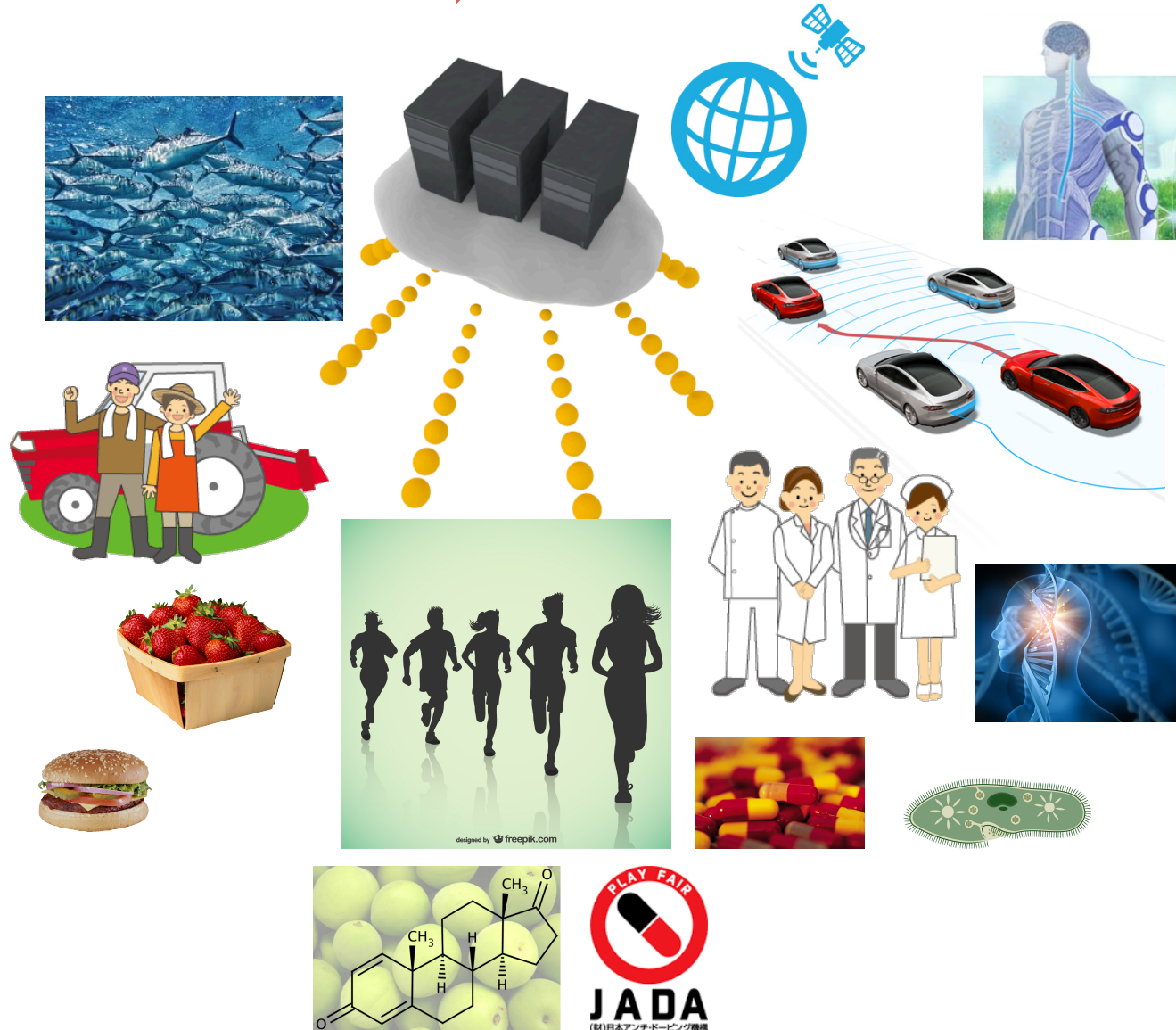
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Life, Humans, Information Sciences



Safety · Reassurance · Pleasant Society



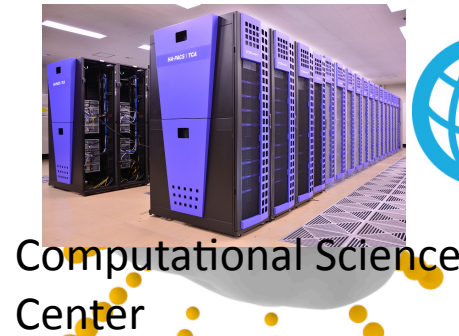
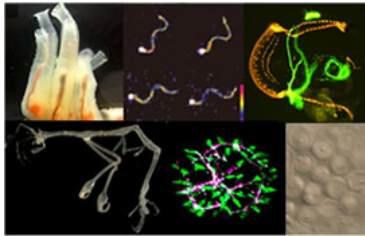
Examples from the University of Tsukuba

Life, Humans, Information
Sciences

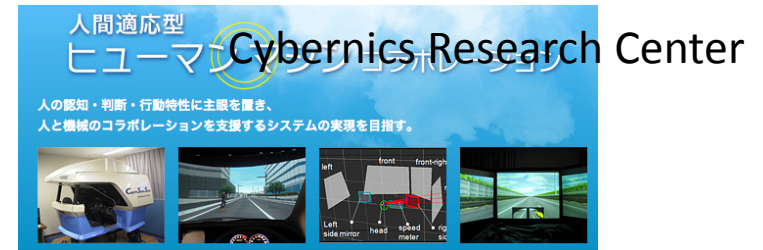
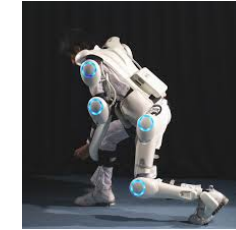


Safety · Reassurance · Pleasant Society

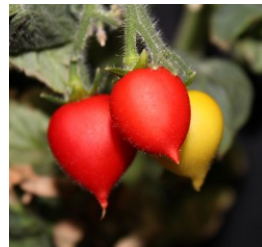
Shimoda
Marine
Science
Center



Computational Science
Center



Gene
Research
Center



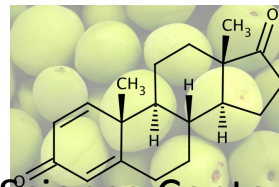
University Hospital



TARA Center



Sports Science Center



WPI: IIIS





Life Science Center, Tsukuba Advanced Research Alliance,
University of Tsukuba



Research Director
Fumio Hanaoka



<http://tara.tsukuba.ac.jp/en/information-list/>

We plan to strengthen life science research within the center and enhance our capabilities to communicate information internationally. We will fan out the new TARA Center activities from our base within the University to Tsukuba Science City and develop a strong international presence.

Our aim is not simply to unify and coordinate the traditional vertical divisions in the life sciences between Medicine, Biology, Agriculture, Pharmacology and Health Sciences. Rather, we plan to fuse these disciplines with Human Arts and Science, Cultural Science, Social Science, and Art and Education in order to carefully consider the relationships between human life and society and living organisms. We hope to develop our center as an leading academic research center in the field of life science internationally.

Robotics
+
Psychology
+
Kansei
+
Ethics

ROBO-ETHICS AND “MIND-BODY-SCHEMA” OF HUMAN AND ROBOT

Challenges for a Better Quality of Life

International Symposium

International Conference Hall - January 23, 2015

- 09:45 - 10:15 **Keynote Address**
President, University of Tsukuba: Prof. Dr. Kyosuke NAGATA
- Welcoming Addresses**
Chair of IATS-Program, University of Tsukuba: Prof. Dr. Koetsu SATO
German Embassy: Monika SOMMER, Counsellor
University of Tsukuba: Prof. Dr. Akira MATSUMURA, Vice-President
- 10:15 - 12:15 **1. Session: Robo-Ethics and Education Based on a Body Schema of Human and Robot**
Plenary Address: Prof. Dr. Makoto NAKADA, University of Tsukuba
Prof. Dr. Toshiyuki SANKAI, University of Tsukuba
Prof. Dr. Rafael CAPURRO, Chair, International Center for Information Ethics (ICIE)
Prof. Dr. Koetsu SATO, University of Tsukuba
30 Minute Discussion
Moderator: Prof. Dr. Martin POHL, University of Tsukuba
- 12:15 - 13:00 **Lunch Break**
- 13:00 - 14:20 **2. Session: Robo-Ethics and the Role of the Public Authority**
German Perspective: Dr. h.c. Juergen GOHDE, Advisor to the German Government,
President: Board of Trustees of the German Society of the Aged
Japanese Perspective: Hidenobu OTANI, Director General, Ministry of Health, Labour and Welfare
30 Minute Discussion
Moderator: Prof. Dr. Yutaka TSUJINAKA, University of Tsukuba
- 14:50 - 16:30 **3. Session: Robo-Ethics as Challenge for Management of the Robot-related Industry**
Prof. Dr. Martin POHL, University of Tsukuba
Dr. Yoshihide KIYOSAWA, Chief Engineer, Harmonic Drive Systems, Tokyo
Dr. Rainer BISCHOFF, KUKA, Head of Technology Development, Augsburg
Dr. Andreas BLEY, CEO, Metra Labs, Illmenau
30 Minute Discussion
Moderator: Prof. Naoki FUKUHARA, University of Tsukuba
- 16:45 - 17:30 **Summary Panel Discussion**
Moderator: Prof. Naoki FUKUHARA
- 17:30 **Closing Remark**
Prof. Dr. Michiyoshi AE, Vice-President, University of Tsukuba
- 18:00 - 20:00 **Reception on invitation of Friedrich-Ebert-Foundation**

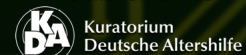
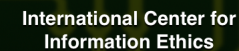
Organizers



Supporters



CYBERDYNE



For more information, please email roboethics@japan-germany.org

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—Science for the society—

Life ▪ health ▪ pharmacy ▪ medical innovation

Industry-university cooperation [3 barriers: river, valley, sea]



The Devil's River

From the basic research towards the function confirmation stage

Industry-university cooperation among various organizations



The Valley of the Death

Commercialization, manufacturing research stage

Industry-university cooperation among various industries



The Darwinian Sea

Market competition stage

Industry-university cooperation among various trans-border industries



Resolution of global issues



Prospects of drug development and evaluation

The United States' Executive Branch and President's Council of Advisors on Science and Technology proposed that **industry, government and academia should unitedly strive to drugs' discovery**, development and evaluation for the purpose of doubling the output of new drugs within 10~15 years.

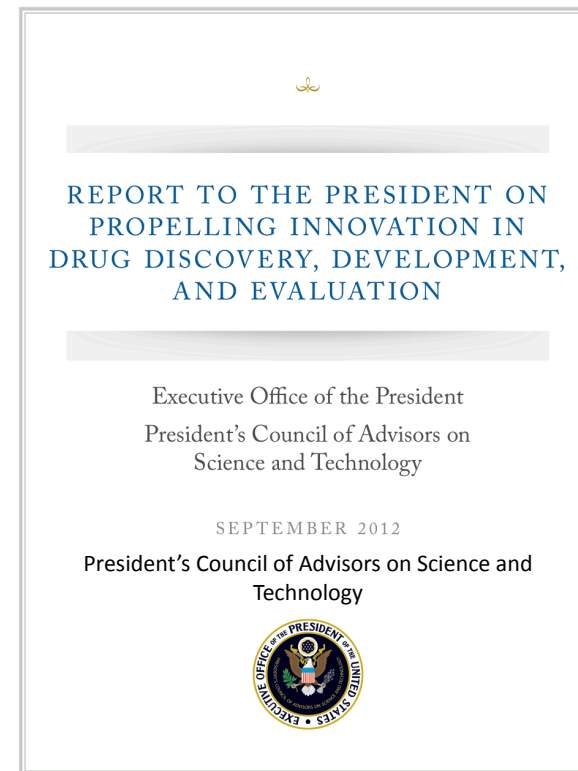


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President's Council of Advisors on Science and Technology



Welcome to the President's Council of Advisors on Science and Technology, known as PCAST.





Innovation of Automated Driving for Universal Services

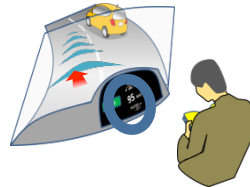
Mobility bringing everyone a smile!



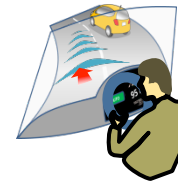
TOYOTA



HONDA
The Power of Dreams



trading of control



TOYOTA

TOYOTA-TSUKUBA collaborative project for accessible society

- AI & ICT
- robotics
- fine art
- disability sciences



Driving Automation and Legal Systems conforming to human performance and limitations

PI, University of Tsukuba



Legal Systems

- authority and responsibility
- legal systems for automated driving



Cognitive Psychology

- trust in and reliance on driving automation
- guidelines for human-machine interface



Engineering Design

- human-machine interaction for situation and intent recognition
- sharing and trading of control between human and automation



Joint research with Toyota Motor Corporation “The next generation of cars and society”

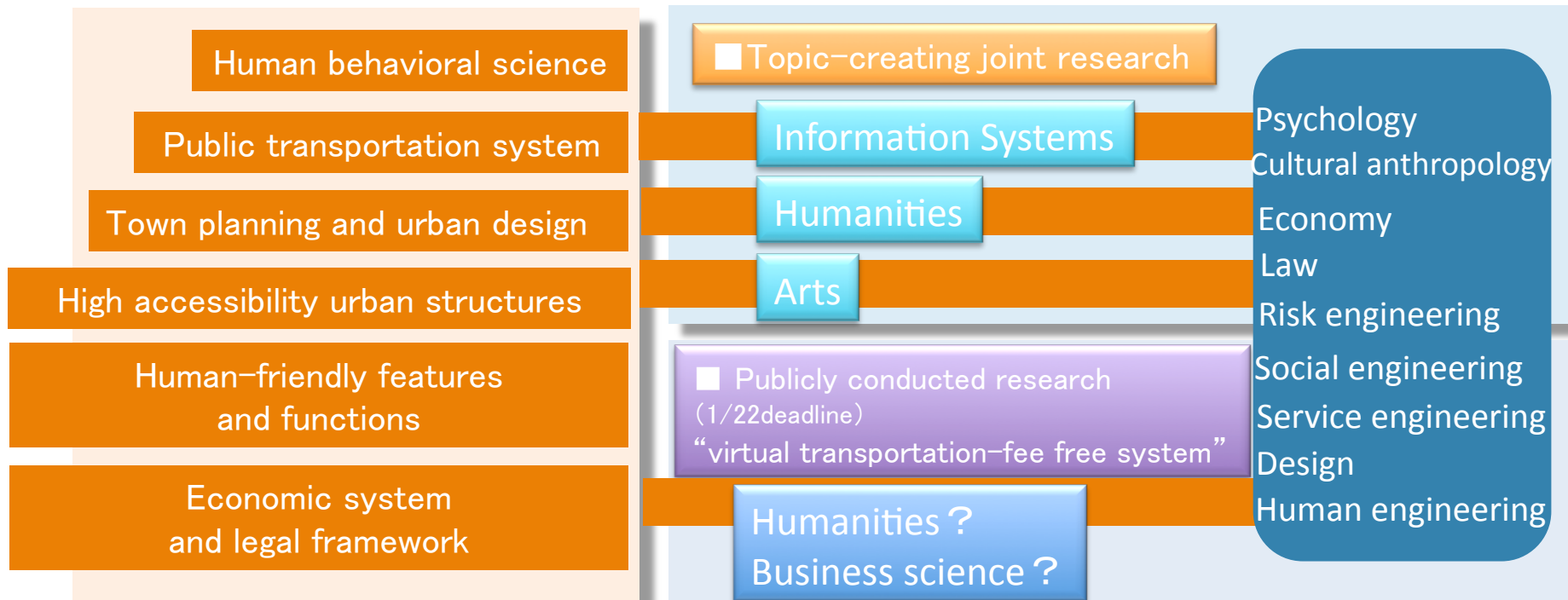
For the next generation study of the social systems, in addition to the technology involved in the urban construction and transportation system, acceptability study for civilians (social sciences, psychology, human engineering, economics, law, etc.), moreover, a wide range of research areas extending to interdisciplinary explorations are necessary.

- Joint research “Research model for the next generation social systems and mobility”
- Special joint research project “Basic research for the next generation accessible society”



Challenges of the next generation social systems

University of Tsukuba’s Interdisciplinary Research



An example of education with the industry

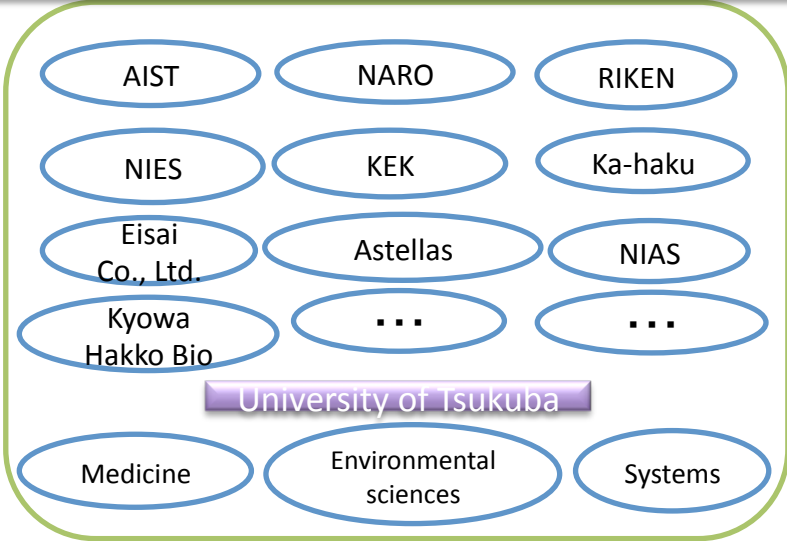
Life Innovation degree program

- Research and development corporations of Tsukuba area, business research division consultation units and the University of Tsukuba as the parent research institution
- Participation of foreign universities, such as the University of Oxford

(Features) Specific institutions/ organization of faculty members/structure of researchers with integrity, which jointly provide desired education program



Tsukuba Society for Life Sciences Promotion



« Participation »

PI Researchers

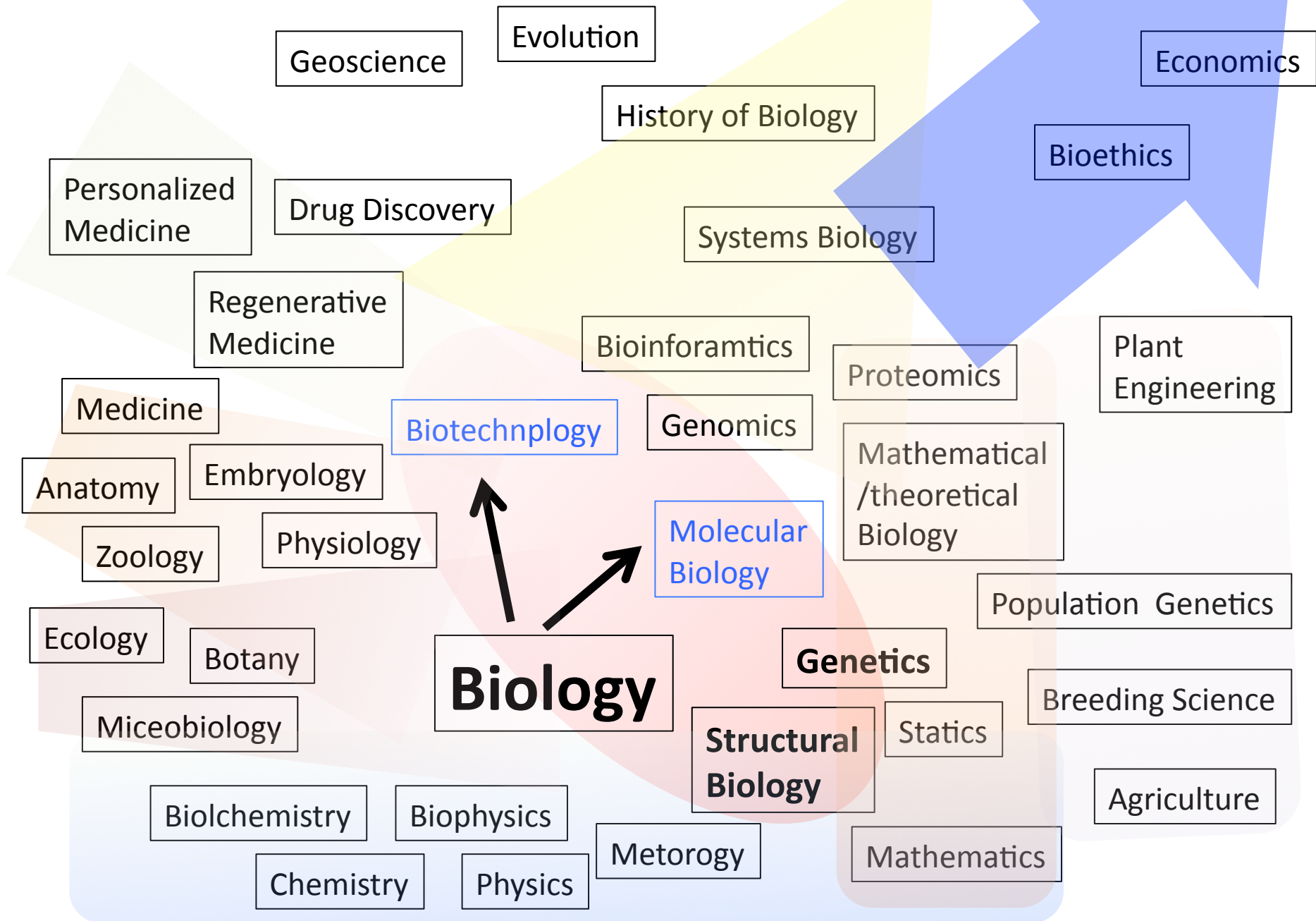
Not each participating institution separately, but rather group of staff from related institutions create curriculum and share the leadership



University of Tsukuba (Global Education Institute) 33

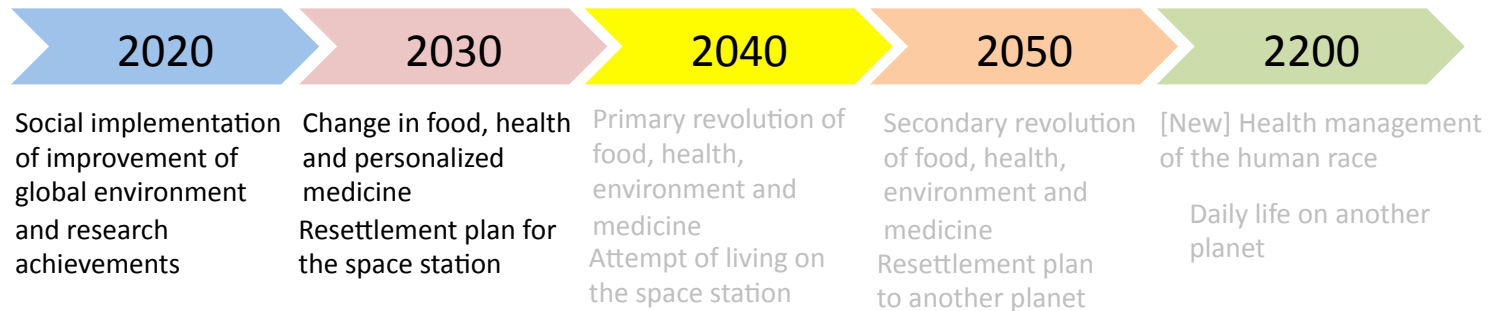
Origin of Life

Where Biology is going?



Paradigm Shift in Life Science for Improvement of Human Health

1. Vision



2. Deepening of human science

Along with the population diseases eradication, and with the understanding of rare diseases, science for diseases prevention has led to new biological discoveries, and by combining it with medical IT technology, created a huge ripple effect on diagnostics and drugs development

* Japanese food has been internationally acknowledged to be healthy, and observing from the point of view of food and nutrition - it is beneficial for disease prevention, personalized and precision medicine

3. A view from the horizon into ocean (sea) and space (sky)



4. Innovation of life, health and medical science

* By looking into ocean (sea) and space (sky), Human sciences paradigm is shifting

Human sciences (health and medical care) by understanding the outer space are lead to new biological discoveries and which has a huge ripple effect on the Earth therapeutic sciences (drug development, diagnostics and clinical studies)