IHTC
SINCE 1951

The 15th International Heat Transfer Conference
August 10-15, 2014 Kyoto
−The Role of Thermal Science in Meeting Societal Challenges−

Plenary Lecture

Science of Scientific Advice

Hiroyuki Yoshikawa

Director, Center for Research and Development Strategy (CRDS)
Japan Science and Technology Agency

Past President of the University of Tokyo and the International Council of Science

Abstract

As the most part of society is affected by scientific knowledge, the wisdom of its use is indispensable. The use contains various issues. As an example, heat is definitely a discipline in science, so scientists with special knowledge research the heat. Looking at the heat in society, however, we find it everywhere as complicated systems. In all artefacts such as machinery of various kinds it often plays the major role. Heat is essential for household, too.

Heat system of living beings is another which is to be admired. Thus, society is full of heat systems and the governance of all is now a high priority for security and sustainability; this requests the disciplinary mix even of fields other than heat. Then, who will care and govern it? Definitely government is obliged to do it. As politicians or civil servants are not specialists in heat, they can act correctly only when they receive right advices from scientists. In this lecture, this role of scientists will be discussed more generally to depict new scientists as a good advisor to government.

Contents

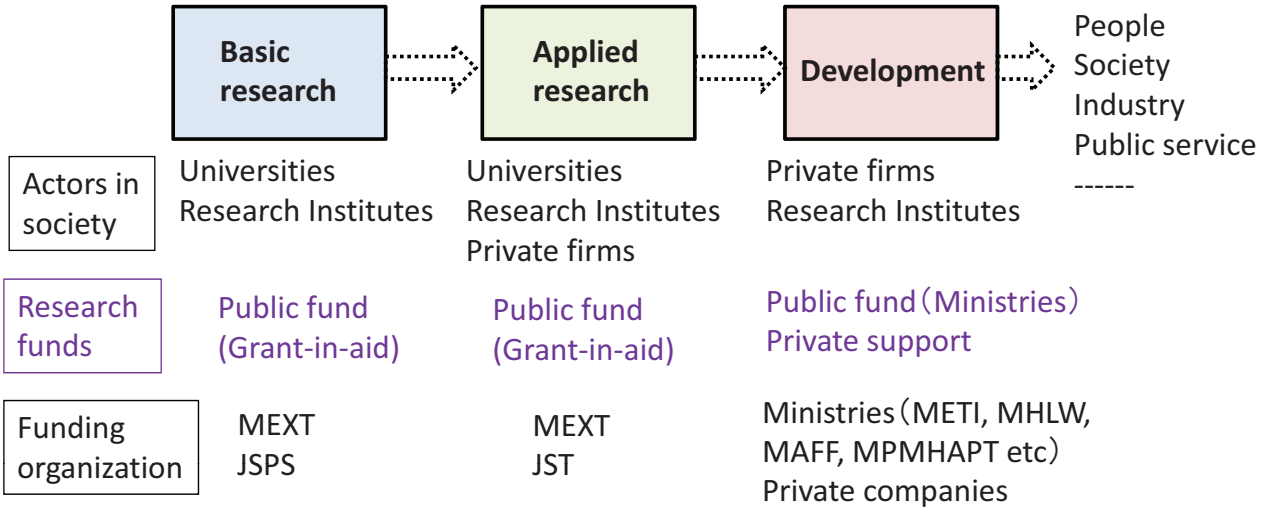
1. New Contract between Society and Science

Declaration of World Conference on Science (Budapest 1999)

3

Linear Model of Creation and Application of Scientific Knowledge

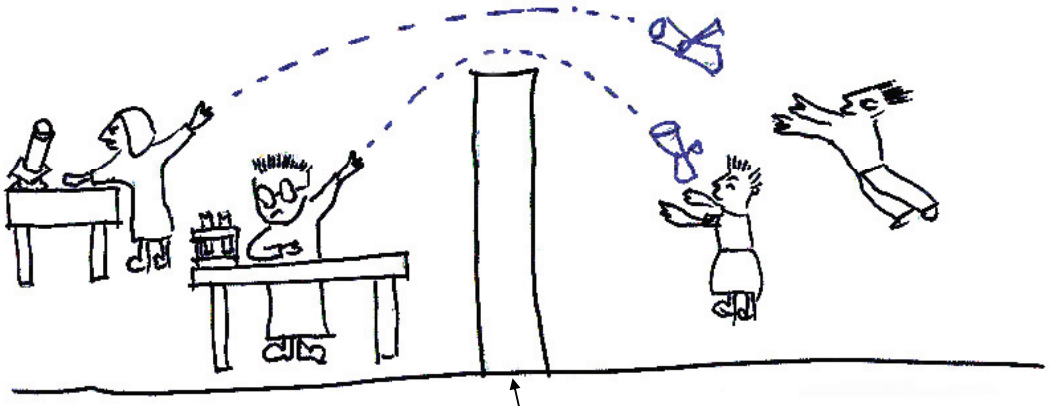
The linear model has been successful so far, but now it does not work due to:
①no specific societal target ②wrong division of basic and applied research
③no integration of disciplines ④no cooperation between scientists.



4

Scientific Research and Use of Knowledge under linear model

Results of research
(knowledge about truth)



Curiosity-driven research is conducted by scientists who work in laboratory.

Society accepts the knowledge (results of research) and use it for benefits separately or arbitrarily.

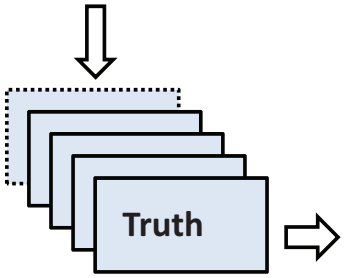
Thick wall
(unilateral communication)

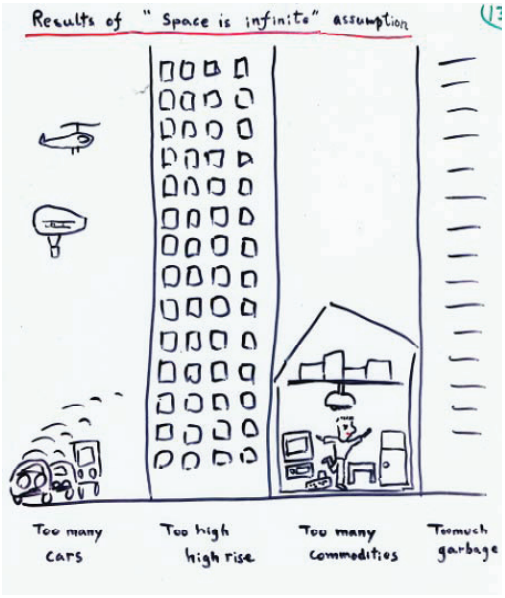
5

Scientific Knowledge has Realised Rich Society

Rich society realised by scientific knowledge

Scientific Research





Flood of artefacts!

"Science, the Endless Frontier" by *Vannevar Bush (1945)*

"Limits to the Growth" by *Club of Rome* (*D. Meadows et al (1972)*)

Rich society consists of abundant products, each of which was made with scientific knowledge of relevant discipline.

6

Past Evils

Storm
Drought
Flood
Earthquake

Disease(germ)
Vermin
Fierce animals

Pirates
Burglar
Tyrant
Wicked desire
Poverty(shortage of food, house and clothes)

They are visible enemies which attacked human beings from outside. We know how to fight against them.

Modern Evils

Global warming
Worsening of global environment
New diseases

Population explosion and starvation
Cleavage between rich and poor
Poverty in megacity
Larger accident of artificial systems

Racial dispute
Terrorism

Solitude in city
Cyber crime

When we face these modern evils, we can not identify the visible enemies in front of us. Perhaps the enemies lurk behind our intention or action and attack us before we notice them.
It is more difficult to fight against them.

7

New Social Contract between Scientific Community and Society

UN Conference on Environment and Development,
Rio de Janeiro (Earth Summit) 1992

"Sustainable Development" by G.H.Brundtland

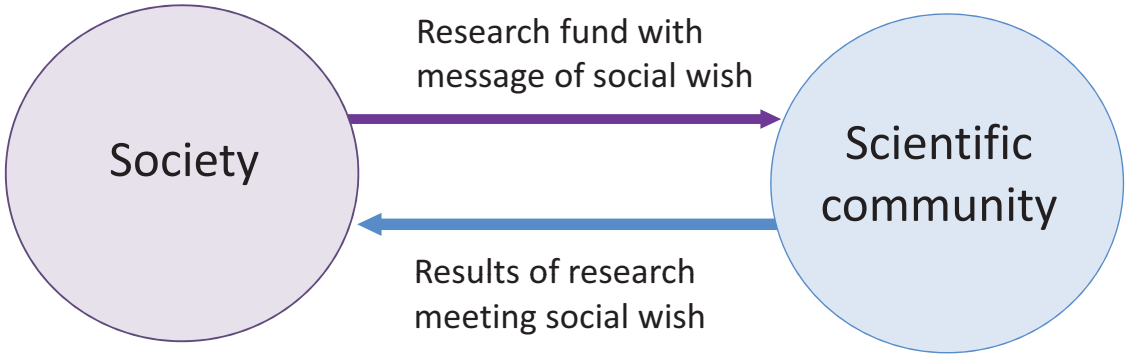
⇒ An influential essay in SCIENSE 1998 ⇐

New social contract between science and society by J.Lubchenco

ICSU / UNESCO World Conference on Science, Budapest,1999

Declaration on "Science and the Use of Scientific Knowledge"

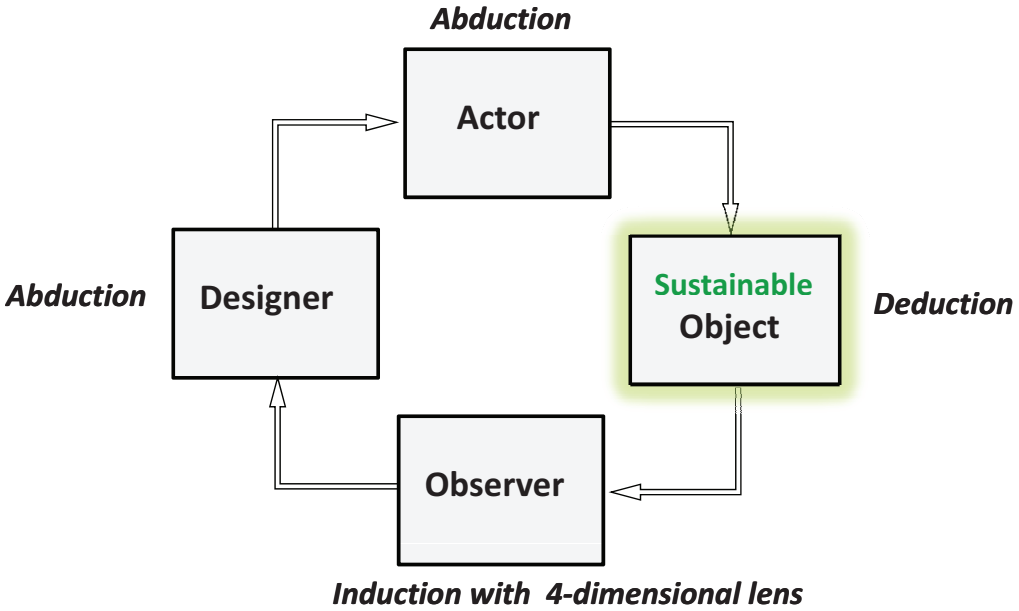
1.Science for knowledge
2.Science for peace
3.Science for development
4.Science in society and science for society



8

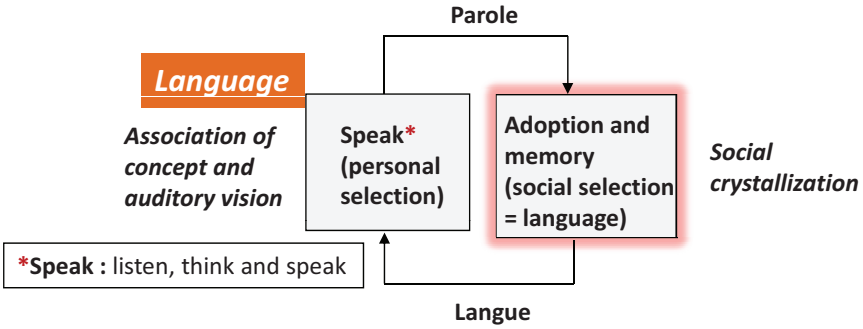
2. Sustainability Science

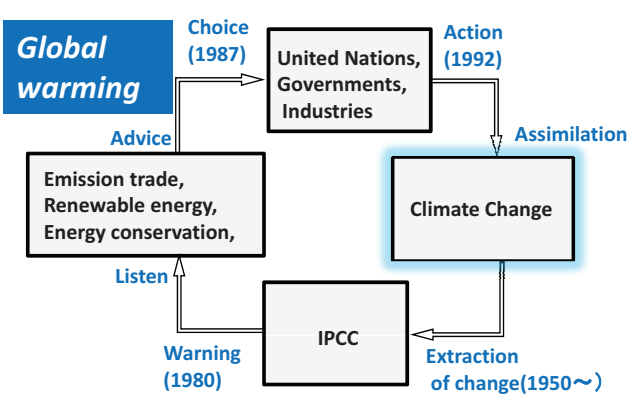
Basic Loop for Evolution:
Piecemeal abduction for sustainable evolution

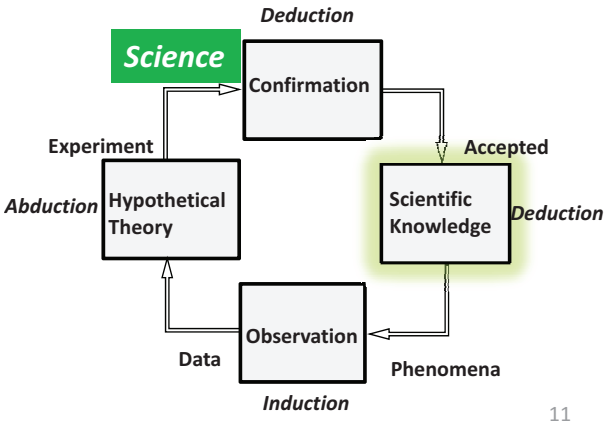


1. Ferdinand de Saussure (Evolution of language),
2. Charles Sanders Pierce (Abduction in creative thinking),
3. Karl Popper (Piecemeal progress by social technology)

Examples of Knowledge Evolution

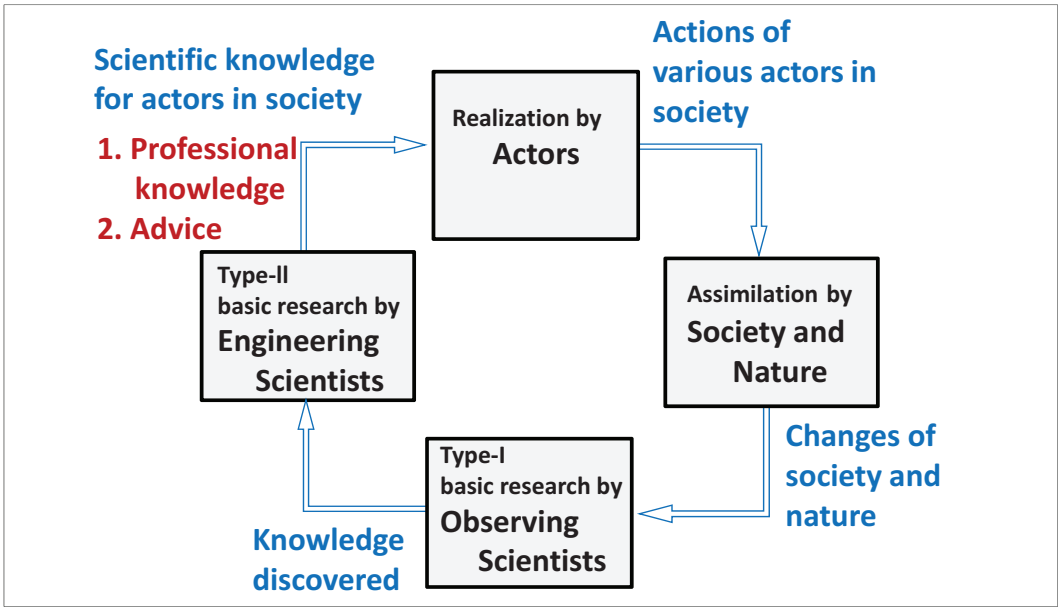


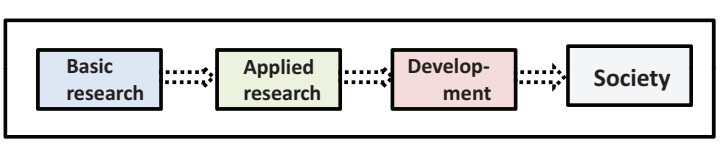




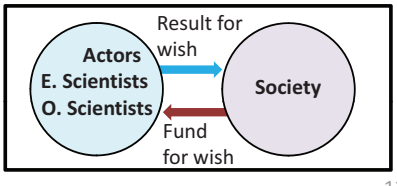
11

Close-loop Structure including Society for Sustainability Science





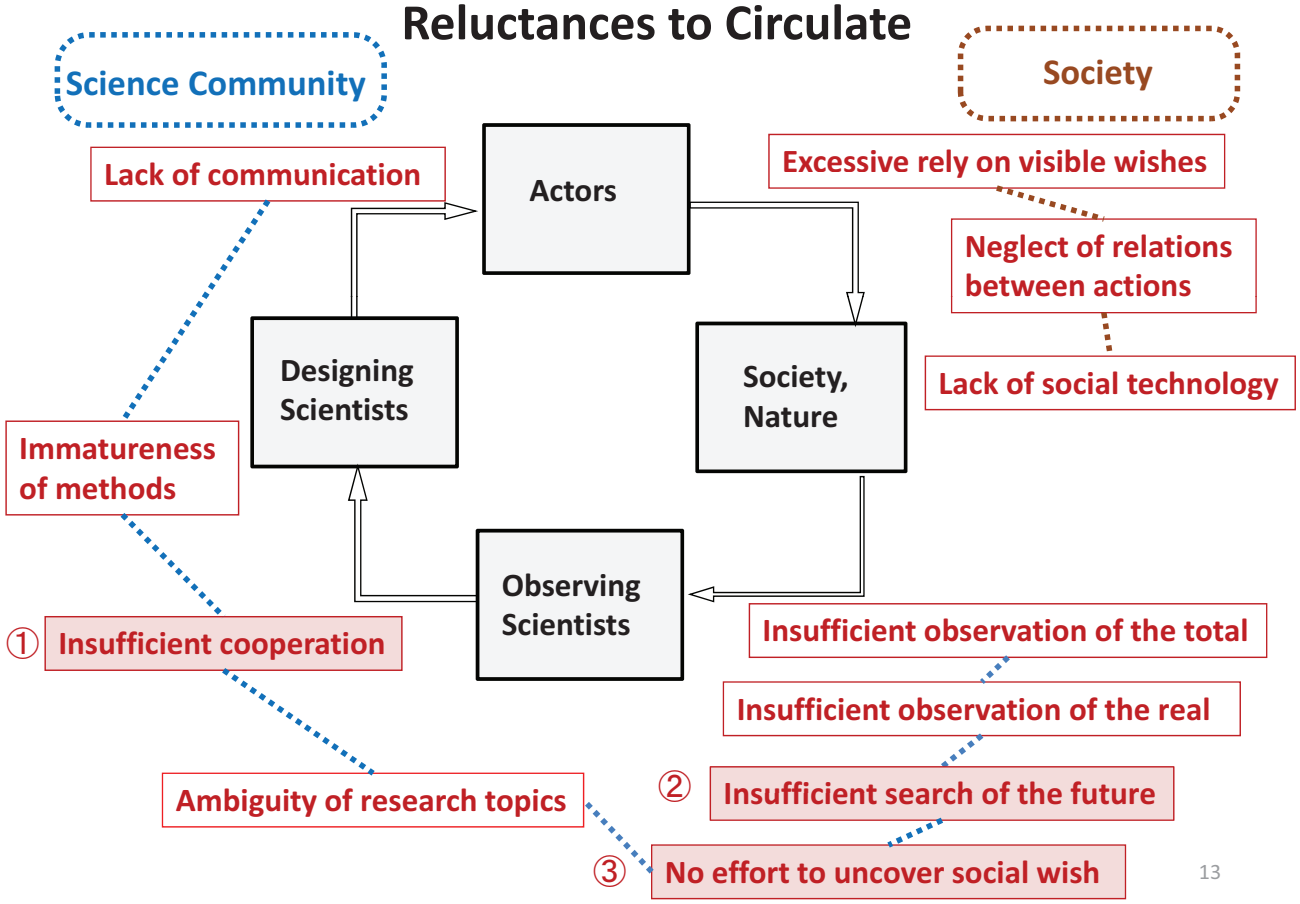
Linear Model



New Contract (loop)

12

Reluctances to Circulate



13

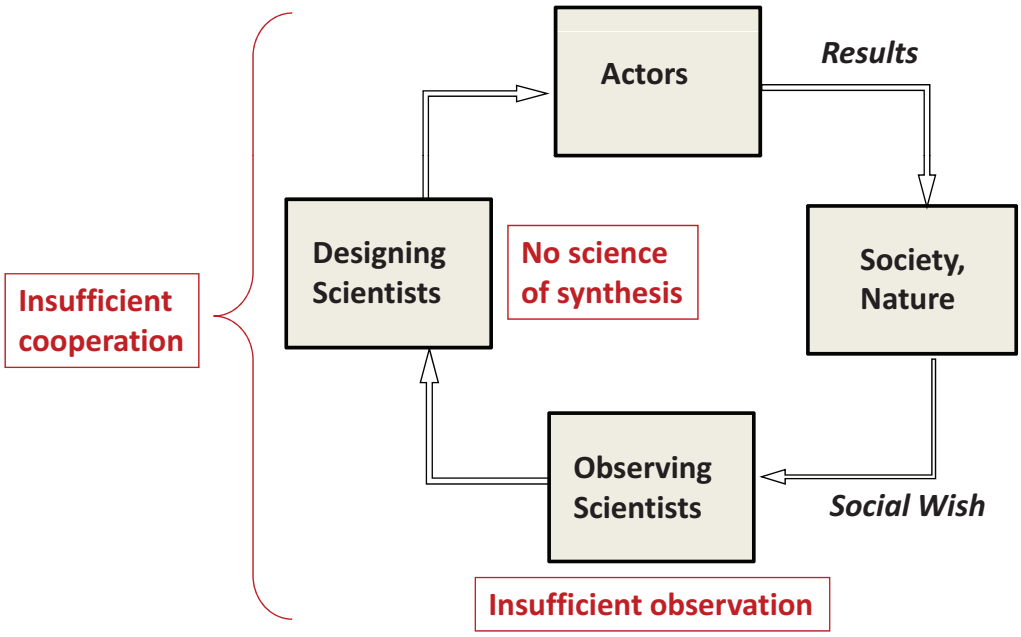
Factors to Accelerate Circulation

Discovery of social wish is the key for acceleration

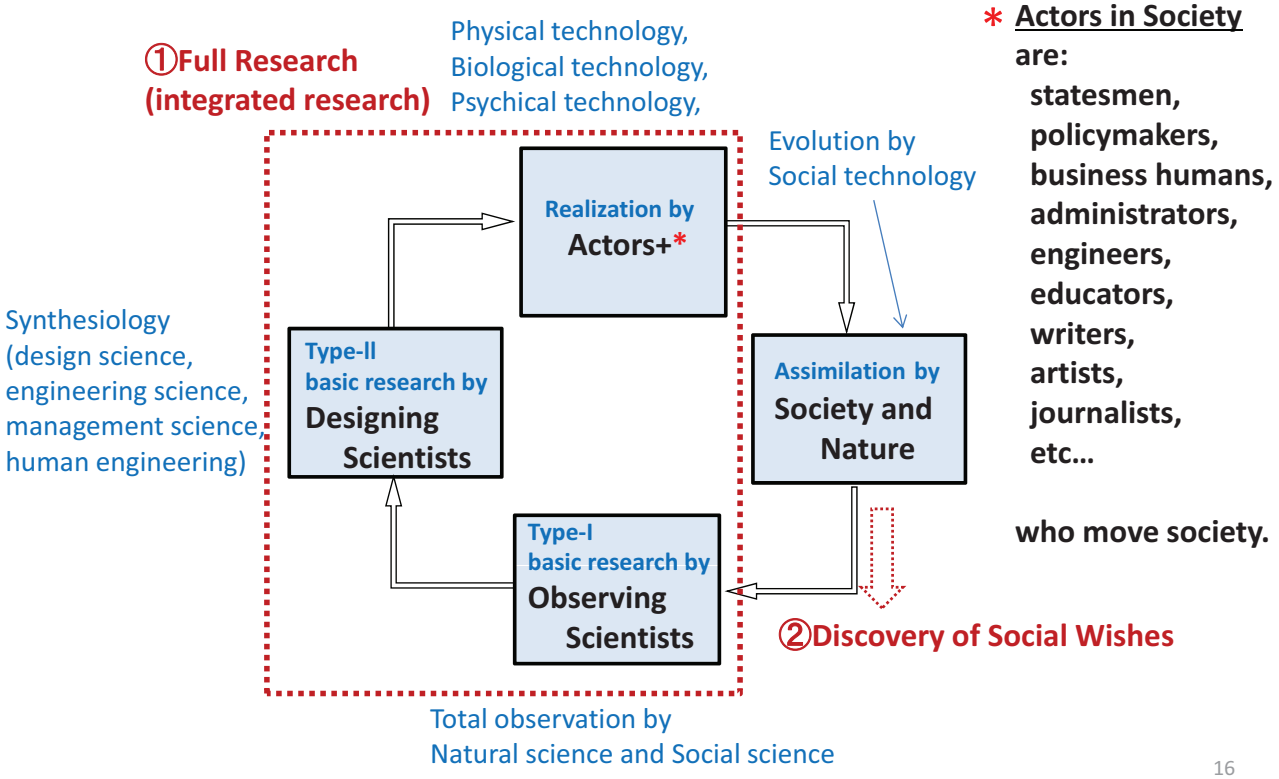
1. Develop a relevant evolutionary loop of four elements in society.
2. Good communication between neighbour elements
3. *Observing Scientists*
   Observation of the present states of nature and society
   Observation of the total of nature and society
   No neglect of observed abnormalities
   Discover social wish of 3rd level (invisible wish)
   Warning to society
4. *Designing Scientists*
   Collaboration with and learning from observing scientists
   Recognizing the essential role of designing scientists for the circulation
   Develop science of design to improve the advices
   Input the results to society(industry etc) and neutral advices to government
5. *Actors in Society*
   Private enterprise: flexibility, social responsibility, challenge, altruism
   Government: for the people, for the private enterprise, no useless conflict within politics,
6. *Society*
   Social Technology

14

Possible Policy for Acceleration
(practical proposals)



Research Integration and Discovery of Social Wish

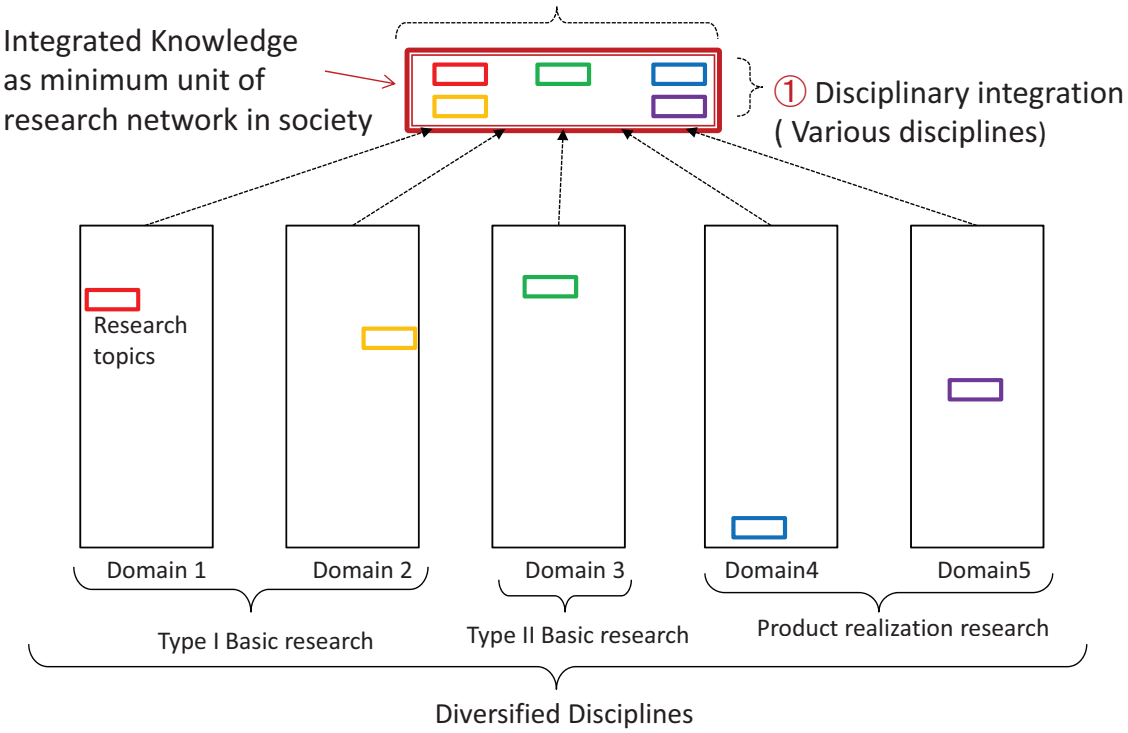


* **Actors in Society** are:
statesmen,
policymakers,
business humans,
administrators,
engineers,
educators,
writers,
artists,
journalists,
etc…

who move society.

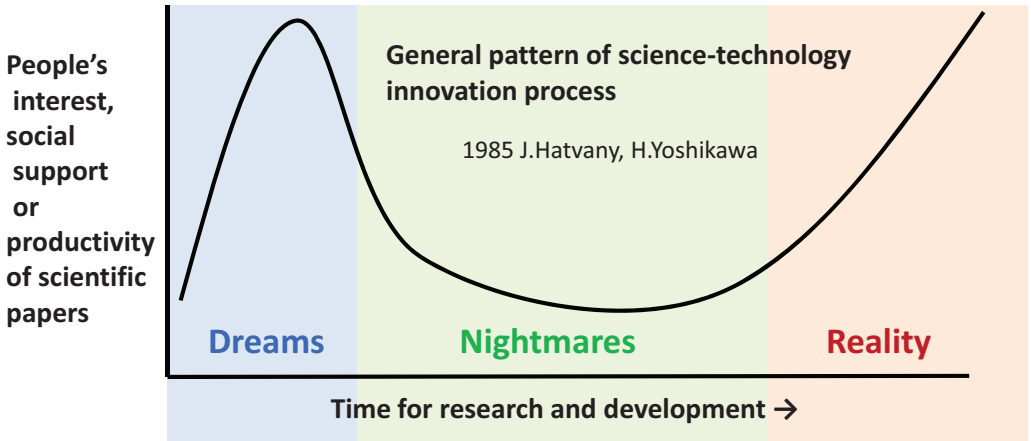
① Research by Integrated Knowledge "Full Research"

② Process integration(Basic research, Applied research, Product realization)



17

"Full Research" Necessary for Bridging Scientists observing and designing

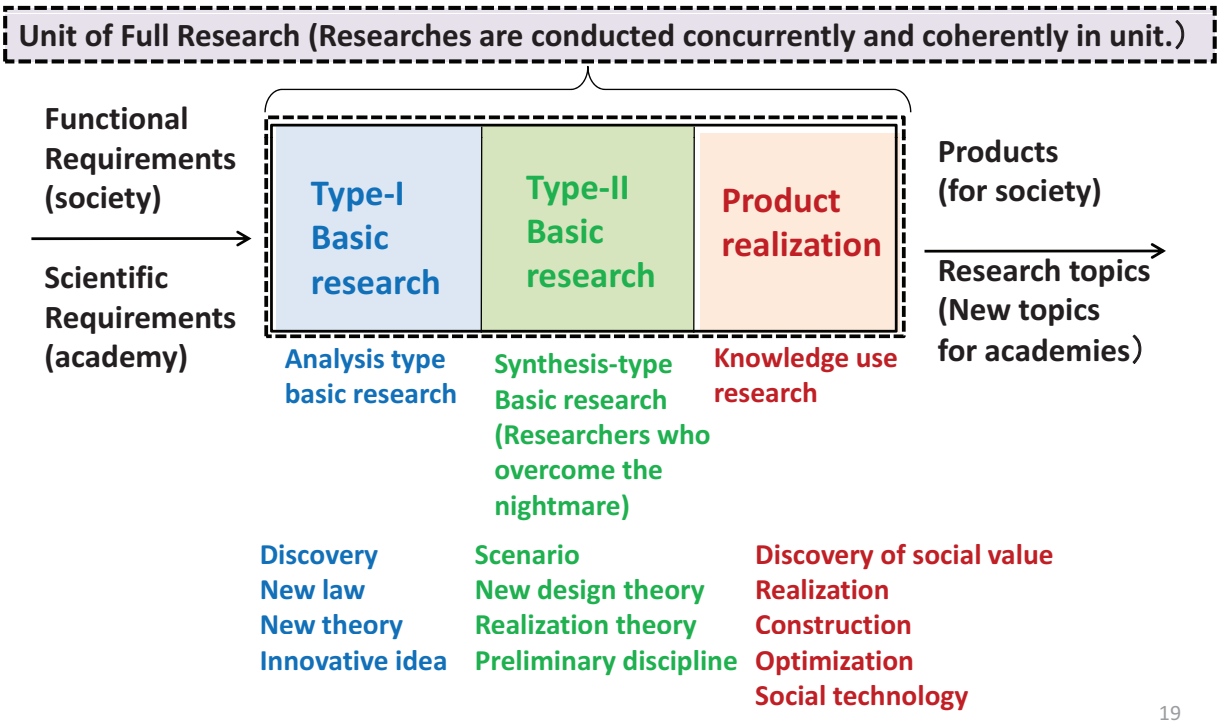


Research phases	Type1 basic research	Type2 basic research	Product realization
Methods	Scientific (analysis)	Intuitive (synthesis)	Business
Results	Discovery of truth	Creation of artefacts/actions	Production of goods

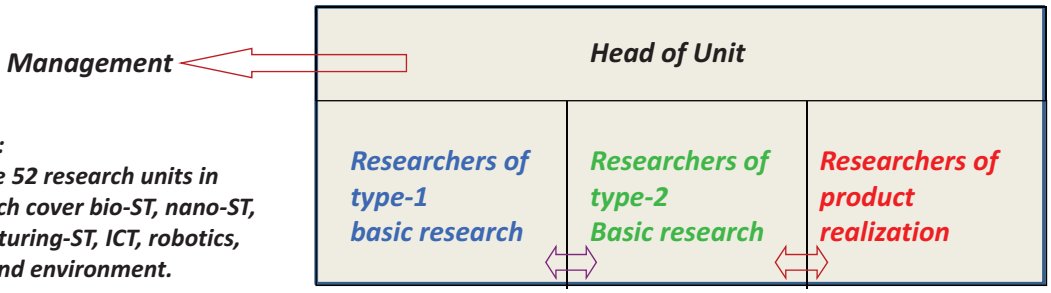
The research for discovery is fully supported by scientific methods, but for creation of artefacts/actions is less supported. We need to establish a new method.

18

Full Research
(fully integrated research)



Research Unit for Full Research (AIST)

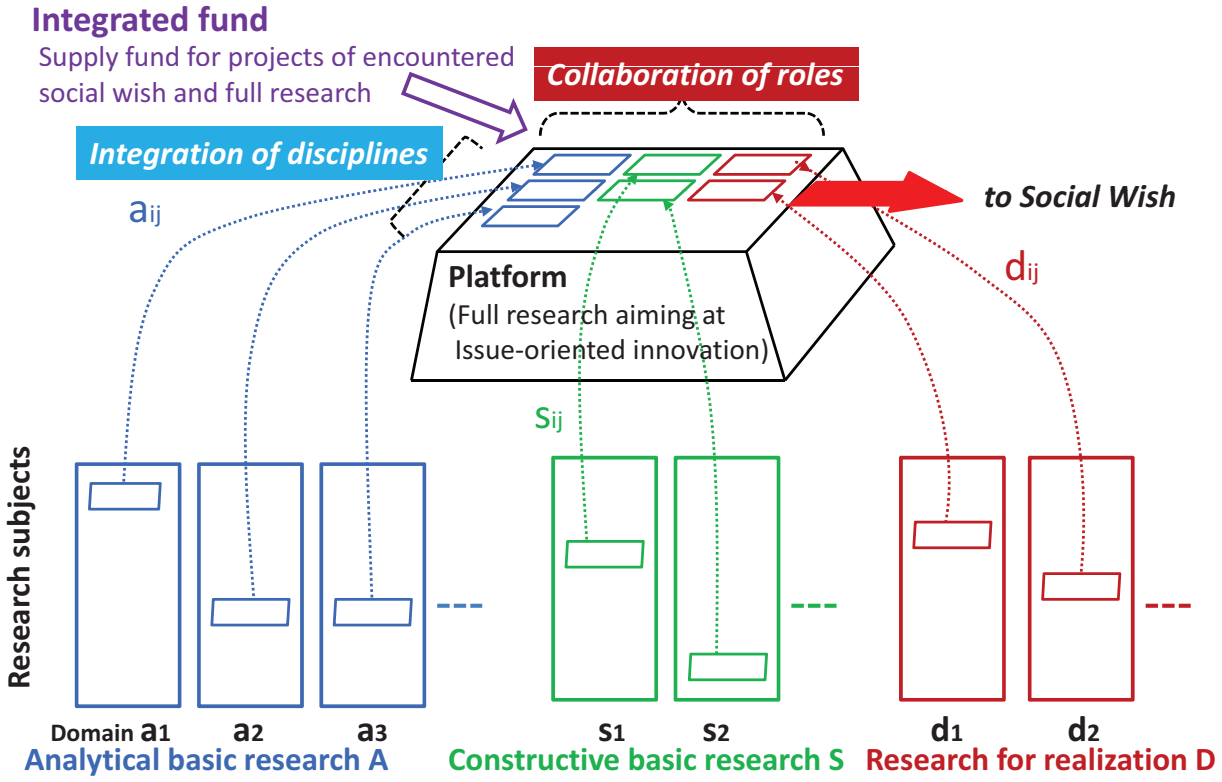


Evidence:
There are 52 research units in AIST which cover bio-ST, nano-ST, manufacturing-ST, ICT, robotics, energy and environment.

(1) Unit has a mission to innovate particular knowledge/technology for society/industry.
(2) Head of unit directly communicates the management of AIST.
(3) Head of unit is given full autonomy for conducting the research.
(4) Management keeps the authority of start/reform/abolition of unit.
(5) All researchers in the unit always bear its mission in mind.
(6) Type-1 basic researchers aim at generating new scientific knowledge.
(7) Type-2 basic researchers aim at creating new values for society.
(8) Product-realizing researchers aim at creating products/knowledge for society.
(9) Three groups are integrated by the head to conduct research coherently and concurrently.
(10) Researchers are free to move among three categories.
(11) In order to realize such research unit, head of unit must be a "philosophical thinker".

Full Research

Integration of disciplines X Collaboration of roles



21

② Discovery of Social Wish

It has been long time said that scientific research is to be conducted by scientists who are driven by their own curiosity within the autonomous community of scientists. It was historically proved that the system of scientific knowledge, which is neutral, has been developed through this process.

In the 21 century, however, human beings are confronted with problems to be solved urgently, such as environment worsening and terrorism, which are new and fatal for the survival if failure. This requests us to achieve knowledge necessary to cope with them within the limited time. We must realize that the process of knowledge acquisition under such circumstances is different from that driven by curiosity. We need to develop new means useful for such acquisition. We may not wait only for the curiosity driven research.

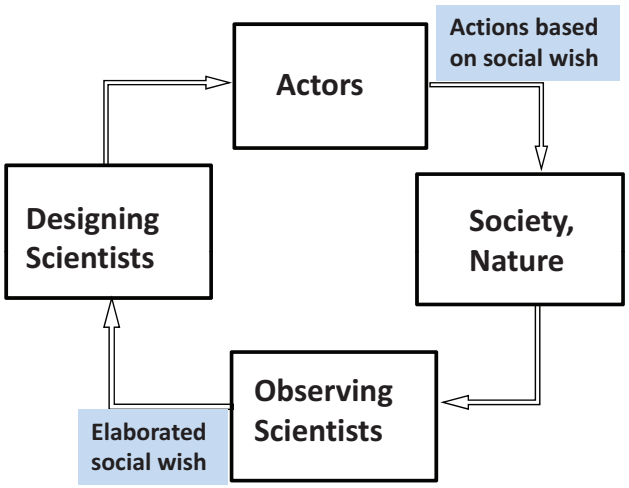
Before going into the development of those means, we must solve a difficult problem. It is the identification of the issues to be studied. We unanimously approve that we need scientific knowledge useful for sustainability. But we have not been successful to identify exact research subjects of high priority for sustainability. People, including scientists and others, only know vague contour of science for sustainability.

Issues to be studied and solved scientifically are not only apparently defined in society but also floating dimly among people and even absolutely invisible for people, and even for scientists. Therefore, they must be discovered.

Here, we call them "social wishes" which have three levels: (1)exactly known, (2)floating among people and (3)invisible. Especially the discovery of the level three is one of the most important target of scientific research on sustainability.

22

Social Wishes to Accelerate Circulation



GENERAL(MACRO) SOCIAL WISHES to be elaborated scientifically

Wishes to progress changes toward sustainability such as
- Concurrent growth of prosperity and sustainability,
- Improvement of freedom and diversity,
- Higher safety,
- Cooperation among people,
- Favorable changes of human values, etc

Wishes to stop changes diverting from sustainability such as
- Worsening of environment,
- Increase of danger
- Loss of equality,
- Social pressure on people,
- Unfavorable changes of human values, etc

Observation:
(1) State of society and nature (abnormalities and unfavorable changes)
(2) Panoramic observation of changes in society and nature.

Some researchers(observing scientists) have been interested not only in properties of objects in the nature and society (so-called truth), but also in changes of nature and society to evaluate the progress/deterioration of sustainability of the earth. These researchers should be increased in the era of sustainability.

Diversified Elements of Sustainability

Problem-solving innovations (for social wishes) are requested.

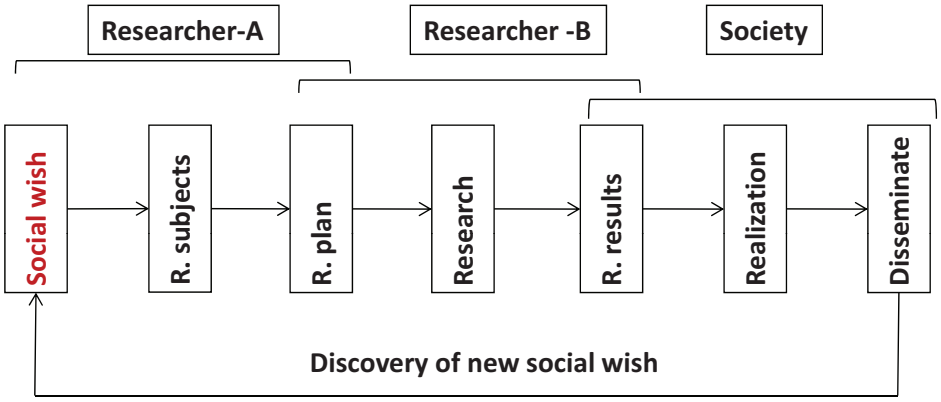
Scale of Action = Design component

- **Society**
  - World*
  - State
  - Community
- **Group**
  - Organization
  - Corporation
  - Club
- **Individual**
  - Family
  - Couple
  - Person
- **Element**
  - Cell
  - Molecule
  - Atom

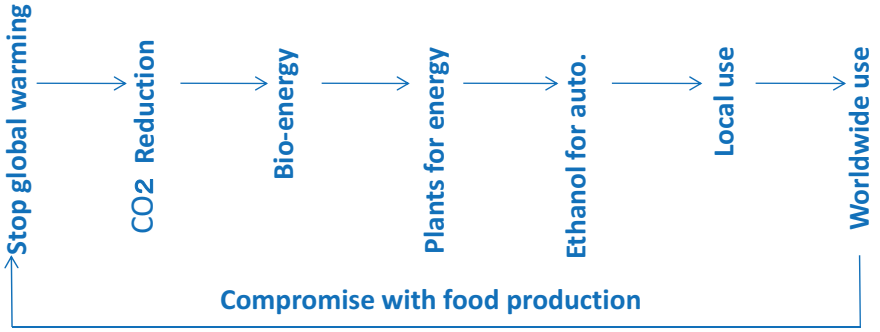
(*In case of human)

Reach of Action= Design solution

Research into Social Wish Discovered



example: Social wish = Stop global warming



25

Characteristics of Sustainability Science (summary)

1. Acquisition of knowledge involves recursive process including human beings.

2. Subjects are described by integrated knowledge.

3. Observation is requested with the aid of 4-dimensional lens(forecast of future).

4. Verification of appropriateness of conclusion is done only through evolutional processes in society.

5. Abduction is the main logics in the process of leading to conclusion.

6. The aim is to realise sustainability , including the finding of truth behind the slow changes of nature and society.

26

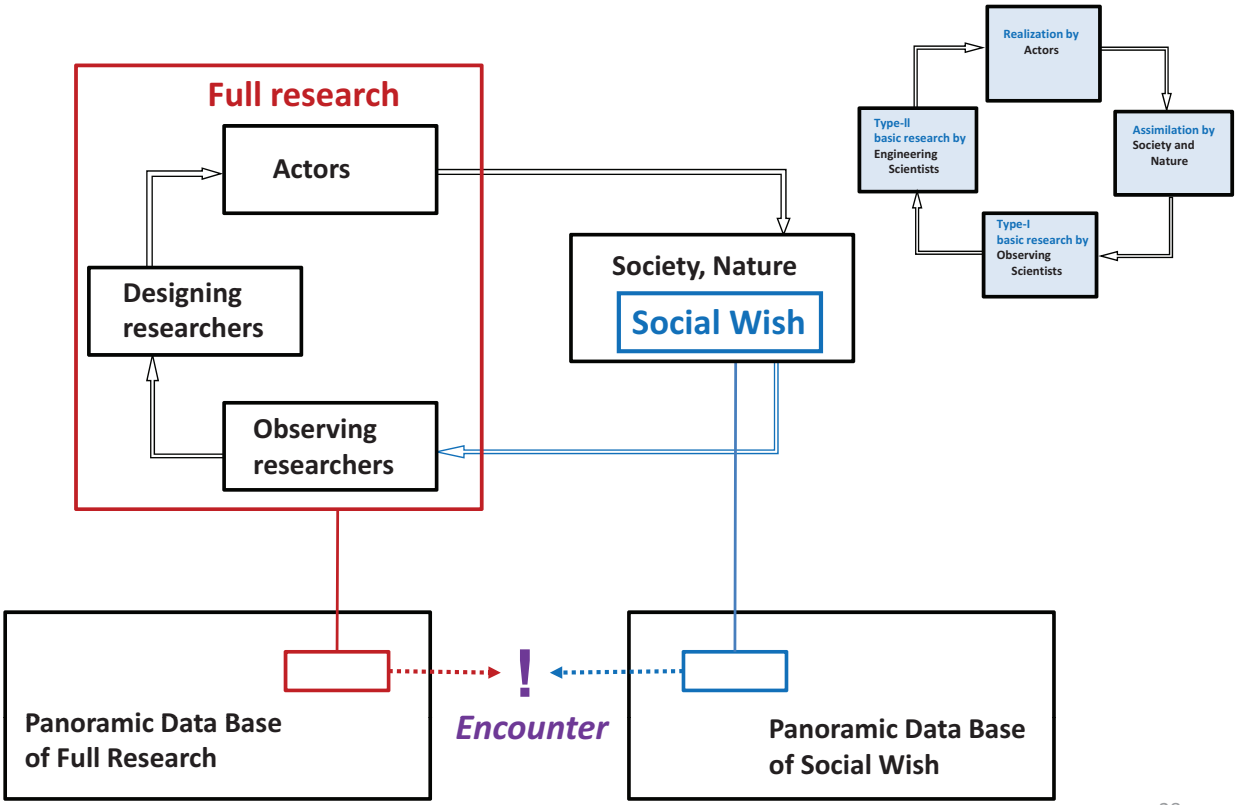
Normal science and Sustainability science
Complementary knowledge

Science (What to know)	Normal Science (The TRUTH, universal behind each phenomenon)	Sustainability Science (Causes of long term changes of the total earth)	Difference universality/ uniqueness
Aim of research	To understand everything and manage individuals	To understand everything and manage the total	separate/total
Object of research	Anything generally existing in the universe	Local and individual things in the earth	abstract/concrete
Observation	Unchangeable Existence*	Slow change	stable/unstable
Truth verification	Experiments	Evolution	certain/uncertain
Result of research	Knowledge for understanding	Knowledge for action	analysis/synthesis
Expected practical results	Prosperity of human beings	Sustainability of the earth	prosperity/ sustainability

*Any change can be deduced from existence

27

Acceleration by Encounter of Full Research and Social Wish



28

3. Advices by Scientists

Policy for Science and Science for Policy

29

Advice 1: Policy for Science

Policies to protect science

Freedom of scientific research – rights and ethics

***Rights*: Freedom of selecting research subjects**
Freedom of move, presentation and of establishing own theory
Independence of politics and religions
Mutual evaluation (peer review)
***Ethics*: Prohibition of plagiarism, falsification, appropriation and sabotage**
Compliance with rules of intellectual property
Balance between researches of basic and applied

Policies to promote science

Request and petition

Total budget of scientific research
Allocation of budget (budget for personnel, facilities and buildings)
Priorities of research

30

Advice 2: Science for Policy

Many policies had significant relations to science and needed scientific advices, but many were caught in difficulties ------

Advices for political decision	*Advices for salvation from disaster*
Organ transplant	Minamata disease
Gene therapy	HIV-infected blood product
Reproduction therapy	BSE
Genetically modified food	Asbestos
Construction of dams	Bird influenza
Utilization of resource	Aftermath of earthquake/tsunami
Development of energy	Plant accident (Fukushima)

---- because of lack of *Neutral Advices*:
"Provide advice on scientific consensus, including conclusions and uncertainties, and the degrees of assurance about the unknowns."

Authoritative Voice of Scientists for Advice

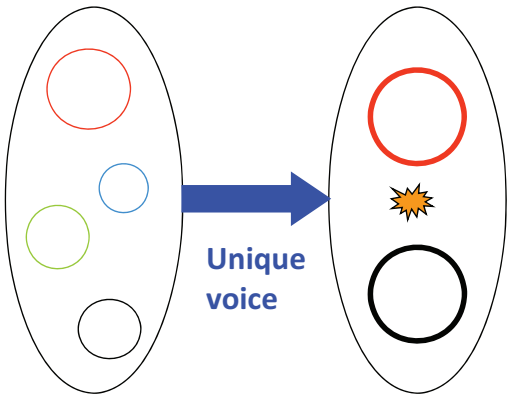
"Independent, balanced and non-partisan voice by scientists"

Policy decisions are ultimately in the hands of legislators. But science can and should inform policy formulation. What policy makers need from advisors, such as ICSU, **is authoritative statements which identify the limits of scientific knowledge that are relevant to the particular issue.**

Frequently, **there will not be a consensus , but this equivocation in all its dimensions is necessary for the policy makers to understand.** ICSU could provide a major service by setting the different points of view ; on an issue in an objective way, and **it should not shirk controversial issues.** It should help clarify the issues and contribute to public debate about them.（ICSU, 1996)

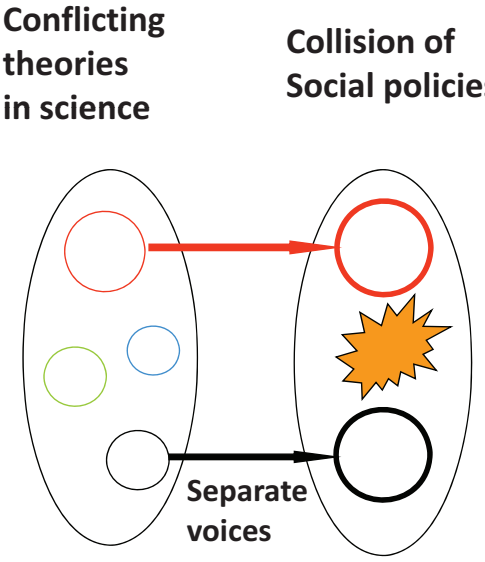
Independent Scientific Voice of Scientists

Neutral Advice



Authentic voice of scientist brings about sober dialogue among policies

Individual Voices of Scientists



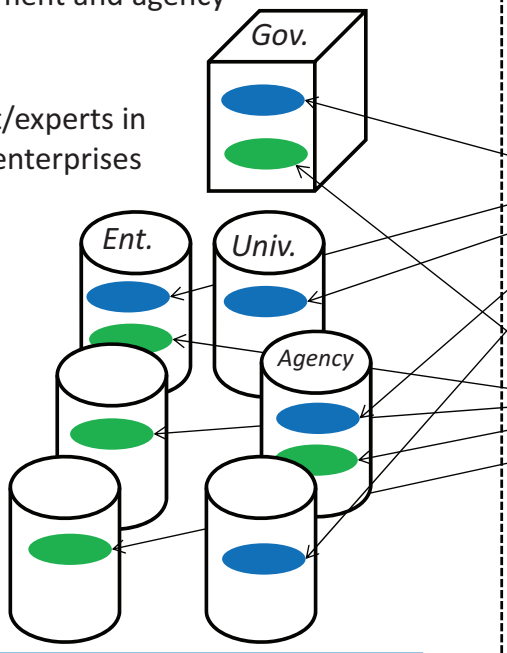
Separate advices to policies intensify collisions among policies

33

Dual Roles of Scientist・Experts in Organisation

Scientists/experts in government and agency

Scientist/experts in private enterprises



Scientists/experts can be neutral to make public advices independently of their organisations. The independency must be agreed between the organisations and them.

Science community

Science council of Japan

Experts community

Neutral advices to the public

M.doctors, Lawyers, Entrepreneurs, Engineers

Scientists/experts have to pledge loyalty to organisations.

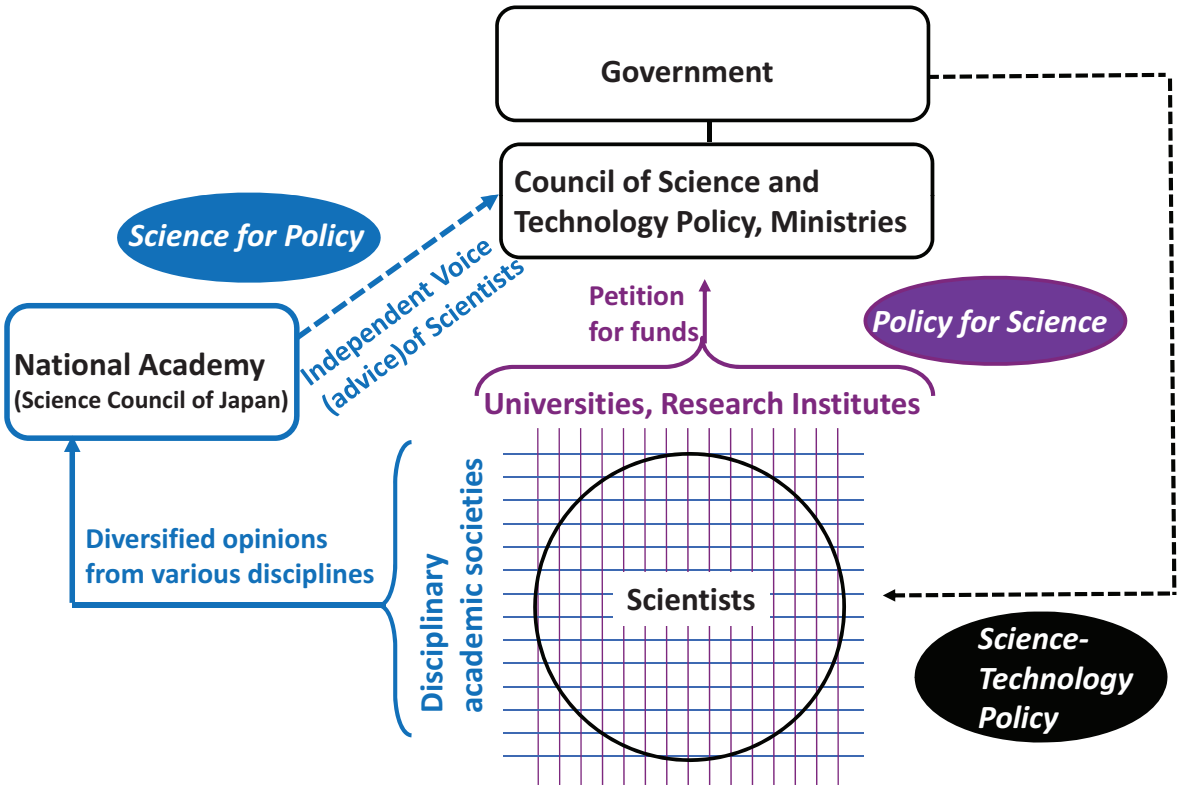
in | **out**

Scientists/experts are responsible to their scientific specialty .

34

Strategy and Decision-making for S-T Policy

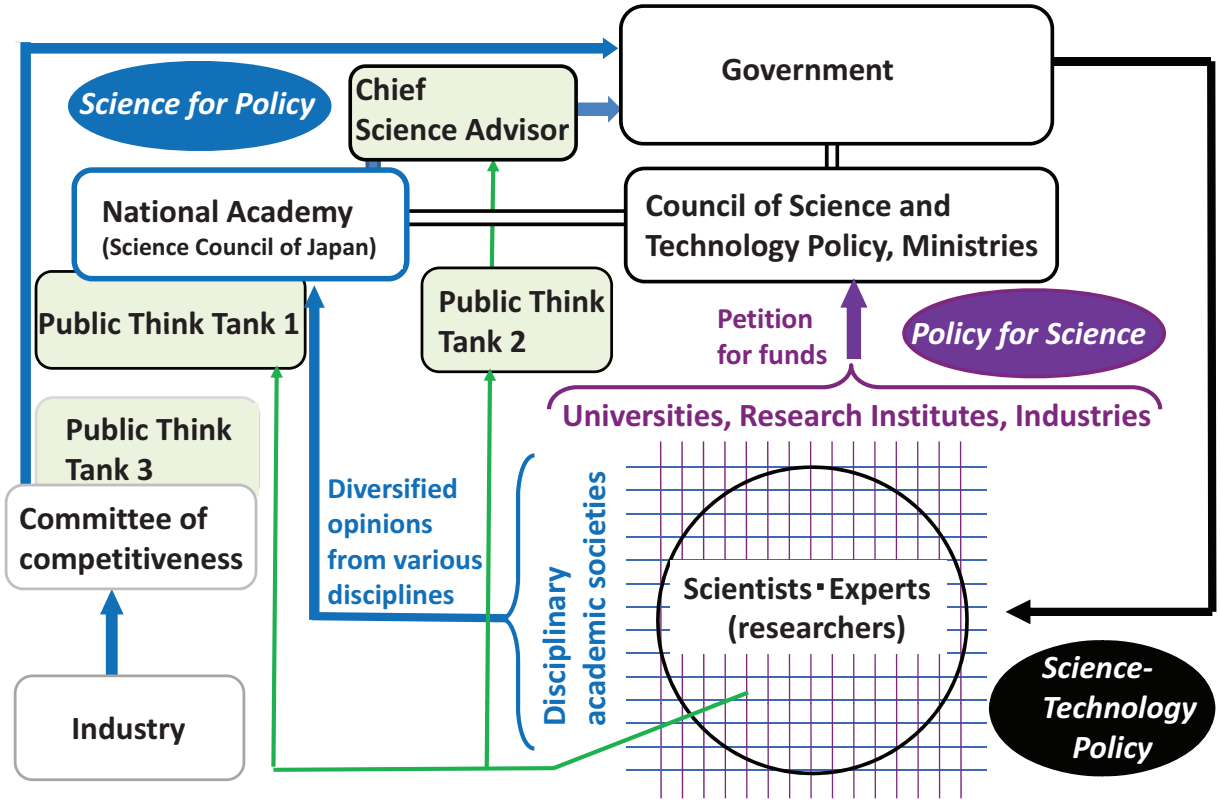
Present Systems of Organisations



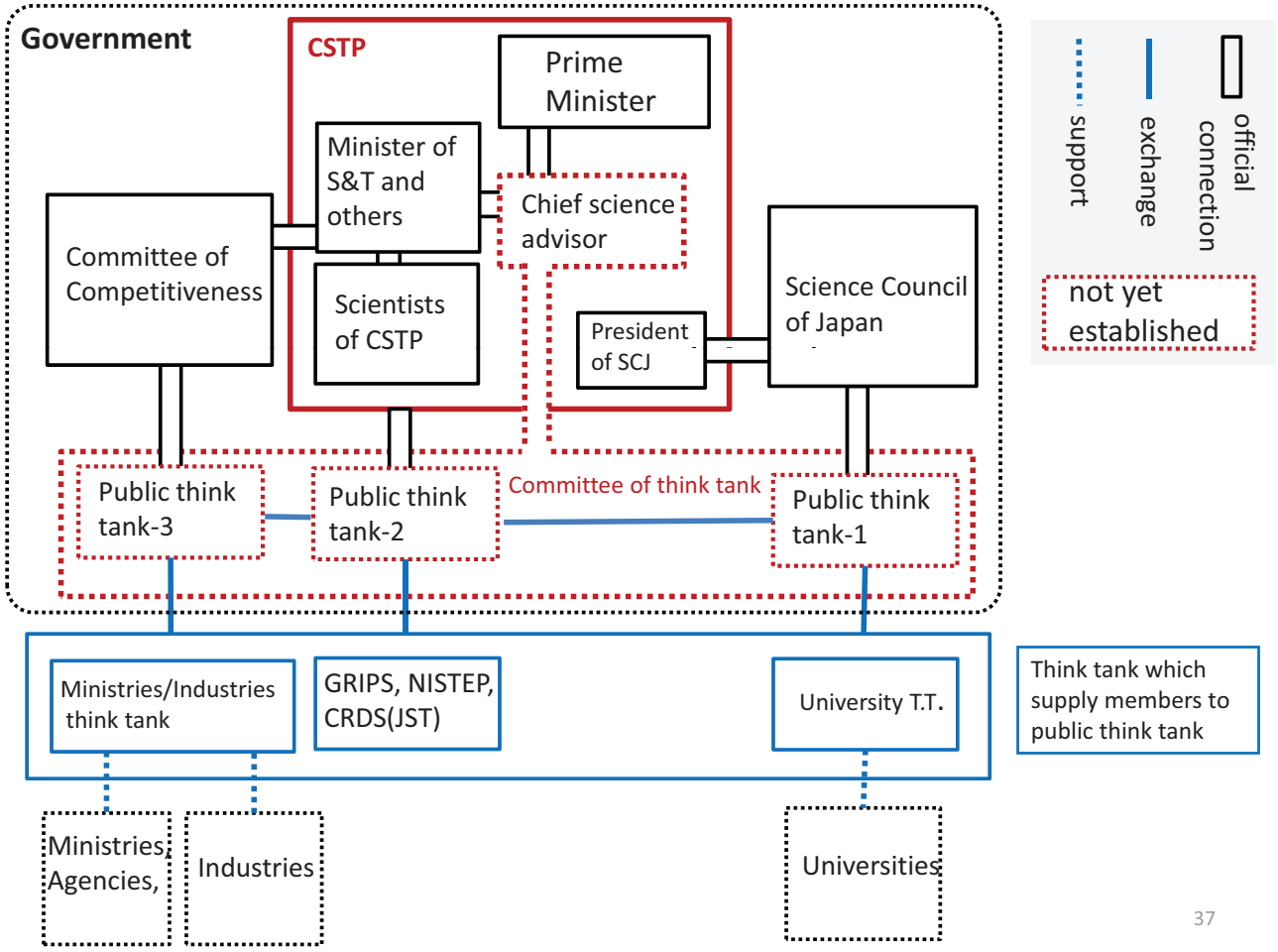
35

Strategy and Decision-making for S-T Policy

—Advices from National Academy and Public Think Tank —



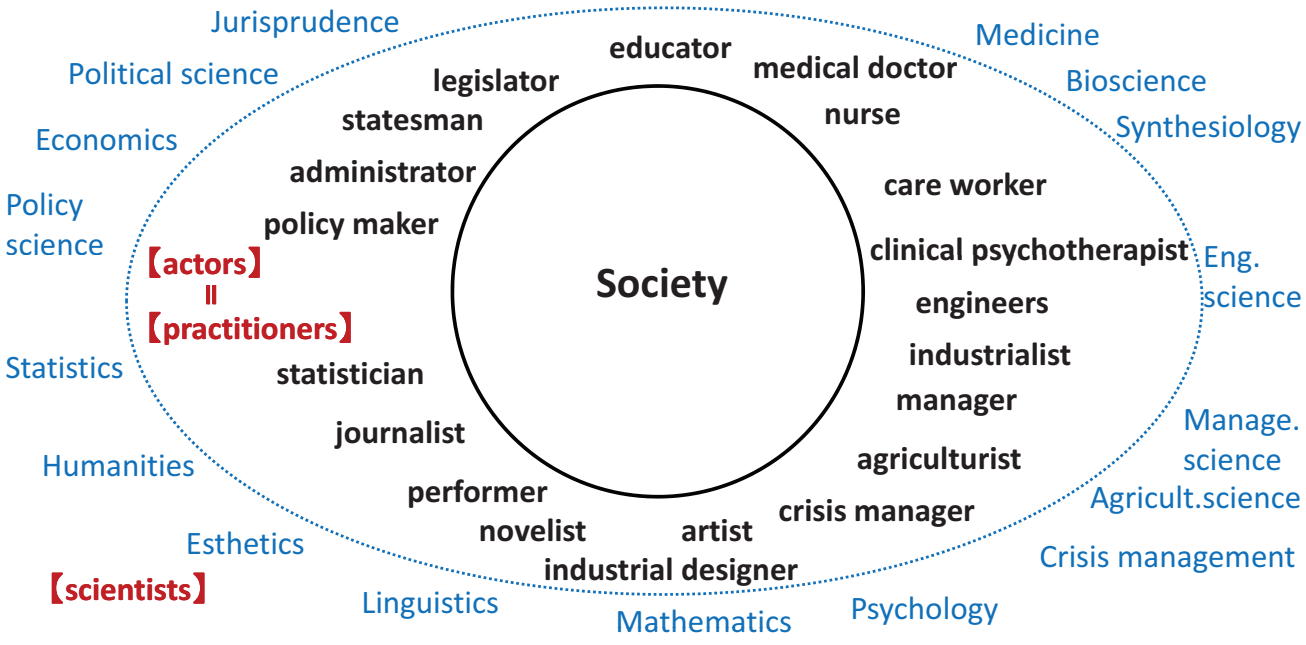
36



37

Social Contribution of Scientists and Practitioners

Scientists (researchers) create knowledge and offer it to practitioners.

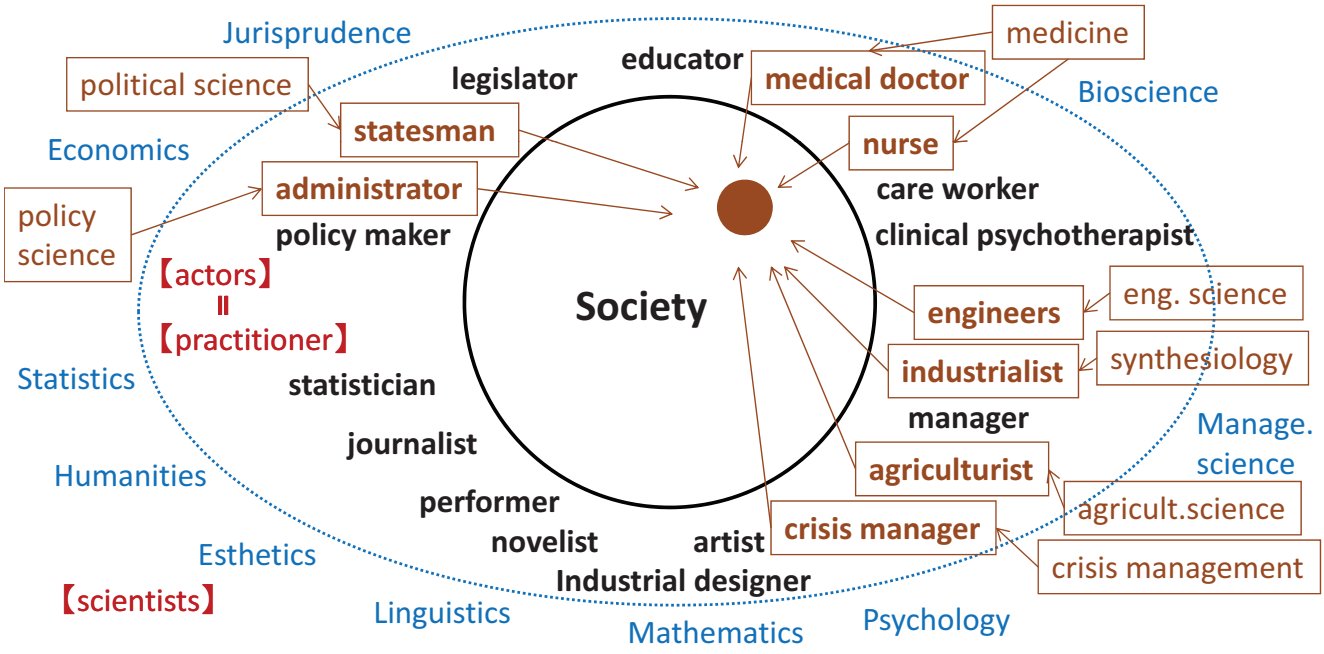


Society is sustained by contribution of practitioners.

38

Actions on the Crisis

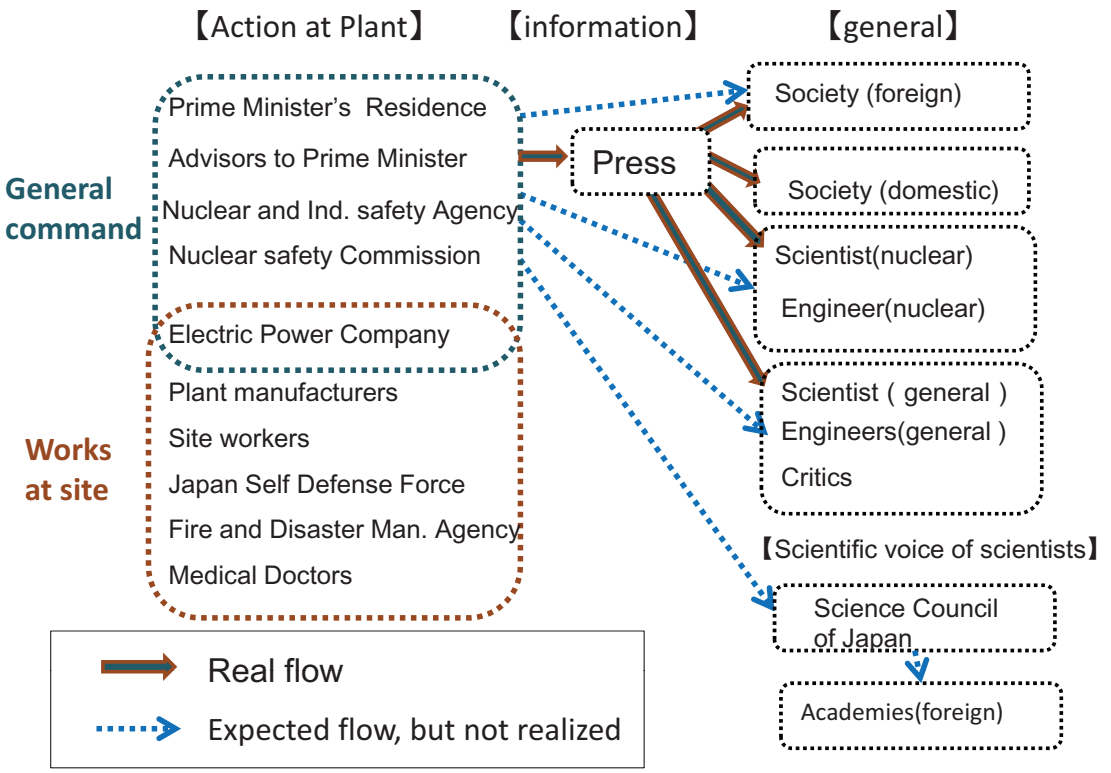
Scientists collect knowledge practitioners want and advice to them.



In crisis, practitioners and scientists cooperate beyond disciplines.

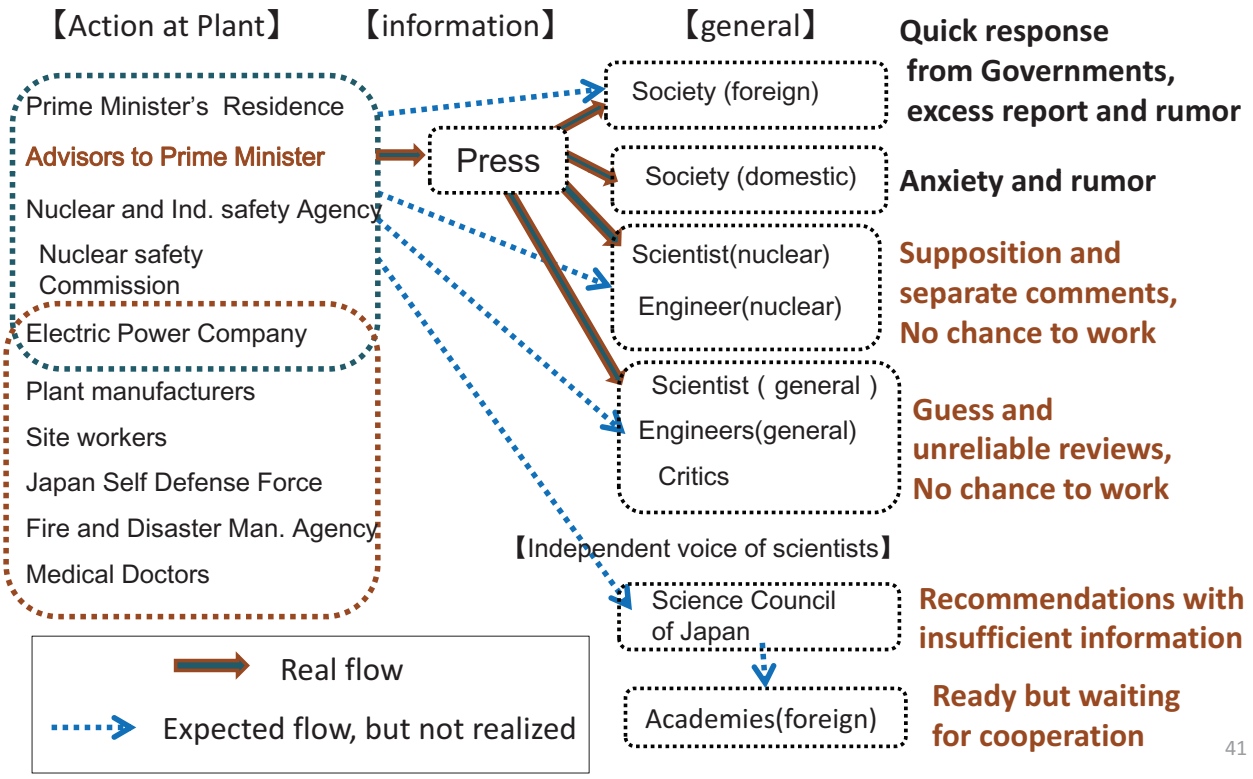
39

Information Flow at Fukushima



40

Difficulties in real cooperation



41

Actual Performances of Scientists at Fukushima

A case of ill-communicated collaboration between scientists and practitioners

An example: The diffusing-radiation monitoring instrument "SPEEDY" was not used effectively.

Reason (interpretation by the private investigation committee)

1. Too low reliability of data by inspection
2. MEXT was not given the right to use its data for practical use.
3. No share of data among related institutions (MEXT, METI)
4. Roles of institutions have not been defined definitely
5. Fear by the headquarters to raise people's panic
6. Ambiguity of authority of public release of data related to accidents

SPEEDY was an excellent instrument, but it was not sufficiently designed for the practical use, management of data, and application of data in the real accident. There was no room for scientists to work actually for the application. We should conclude that the daily collaboration of practical users and scientists who designed are essential for successful application.

42

Issues to be Learned

Important issues for learners to watch and not to avert

Necessity to institutionalize the memory for better communications

A. Crisis management system
   1. Chain of command in government, structure and personnel
   2. Assign of experts of safety operations to proper posts
   3. Implementation of practical place-based rules for safety at levels of depth

B. Management of firms for safety and security
   1. Maintain experts who can immediately act
   2. Responsible person for various jobs expected in crisis

C. Science and Technology
   1. Responsibility of each scientist for safety and security in any field
   2. Recognition of relationship between own discipline and safety of plants
   3. Wider views of plant systems beyond own disciplines

D. Communication between policy makers and actors(including scientists)

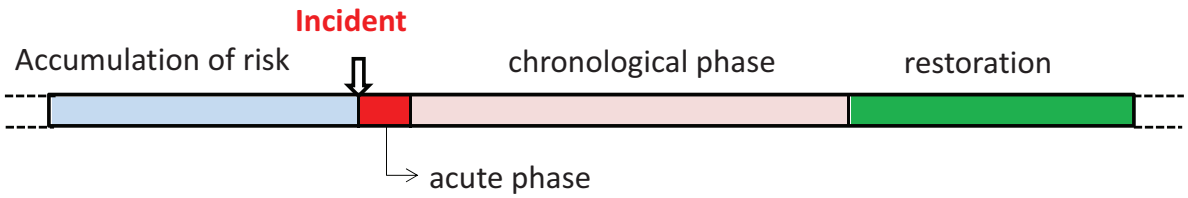
---

1. General structure of institution composed of people who have memory to be informed and exchanged within the institution must be established.
2. In order to maintain the institutional memory, we should understand the specific structure of people in individual institutions respectively.

We must learn that these have not been satisfied in Japan.

43

Scientist's Action in Crisis (Use of expertise)



1. Grasp of the incident and presentation

Crisis due to an incident contains various factors, such as cause, phenomenon, effects to human/environment, etc. Scientists and practitioners of various disciplines are requested to present data: including observation, measurement and analysis; necessary to understand the incident as correct as possible.

2. Professional responsibility for crisis

Crisis is caused by various phenomena which request particular actions for the mitigation and rescue of people. Actions require specific knowledge relevant including science. Therefore, scientists must participate.

3. Flight from the crisis and restoration

Crisis causes unpredictable damages on people, material and society general. Variety of scientific knowledge is essential for salvation and restoration from the damage, in both phases of planning and doing.

44

Preparation for Disaster and Sustainability Science

After the long development of nature by human beings, the earth indicates its limit at the end of 20th century. Scientific knowledge has expanded together with the development, hence it inevitably entails usefulness for development. In 21st century, however, scientific knowledge should be mainly used for sustaining the earth. Changes are requested:

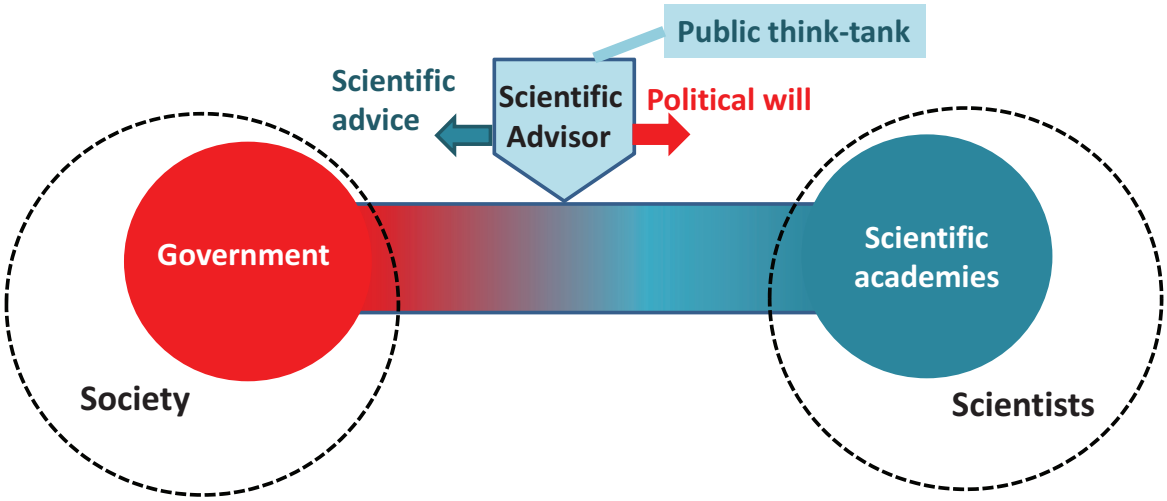
	Motivation	Discipline	Objects of research	Method	Logic	Output
Development Science	Discovery of the laws of Nature for comprehension	Research within a discipline	Observation of individual phenomenon	Analysis	Deduction	Scientific papers
Sustainability Science	Discovery of the problems of the Earth and society for remedy	Research in integrated disciplines	Total observation of nature and society	Synthesis	Abduction	Advices to actions

This table shows that the scientific research for failure/disaster is a part of sustainability science. We understand it easily because failure/disaster is the worst factor which deteriorates the earth. We Japanese scientists have recognised that the lack of comprehension of this necessary change in science caused the insufficient participation of scientists to activities for prevention, initial stage reaction and mitigation of the East Japan Disaster including earthquake, tsunami and Accident. We should endeavour to develop the sustainability science coping with the worsening environment.

45

Scientific Advisor

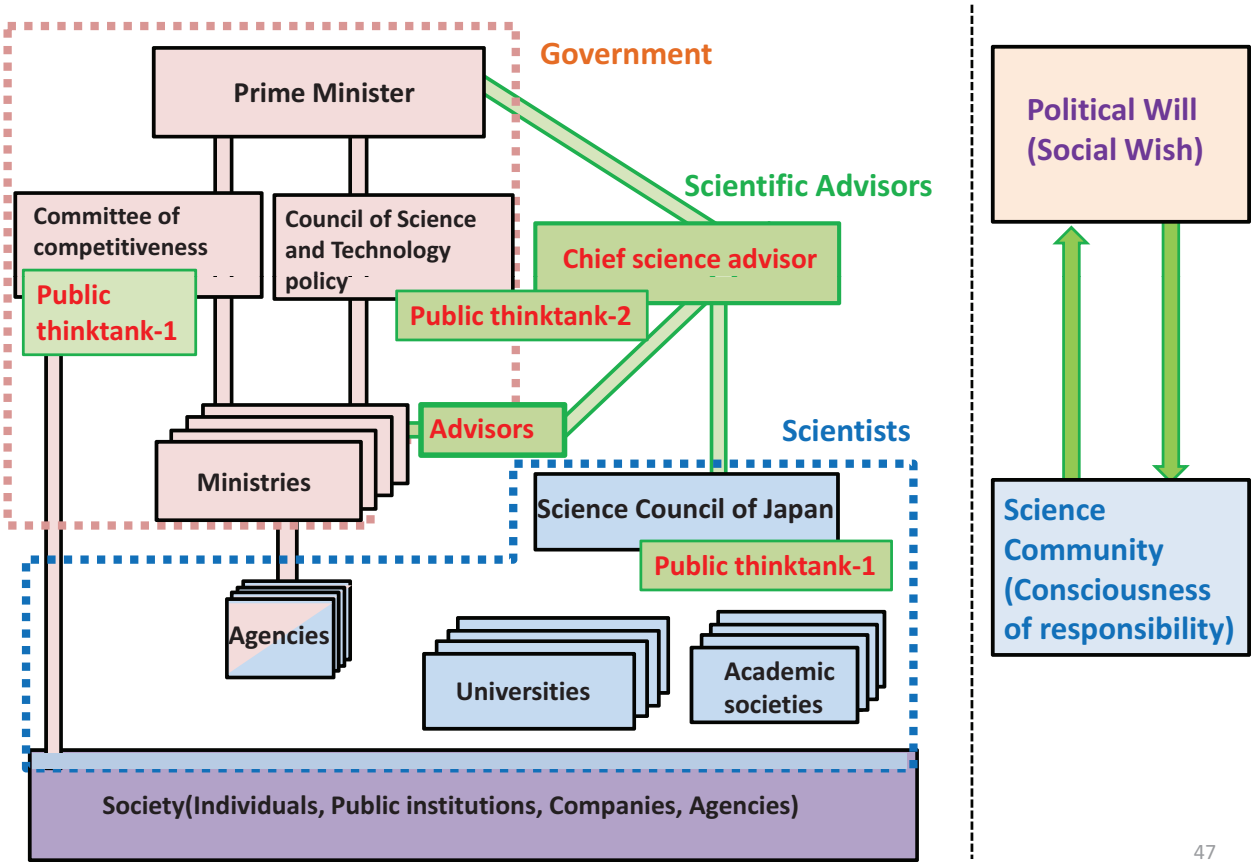
Scientific advisor as a "knot" of government and scientific community
(who advises the government and inform the political will to scientists.)



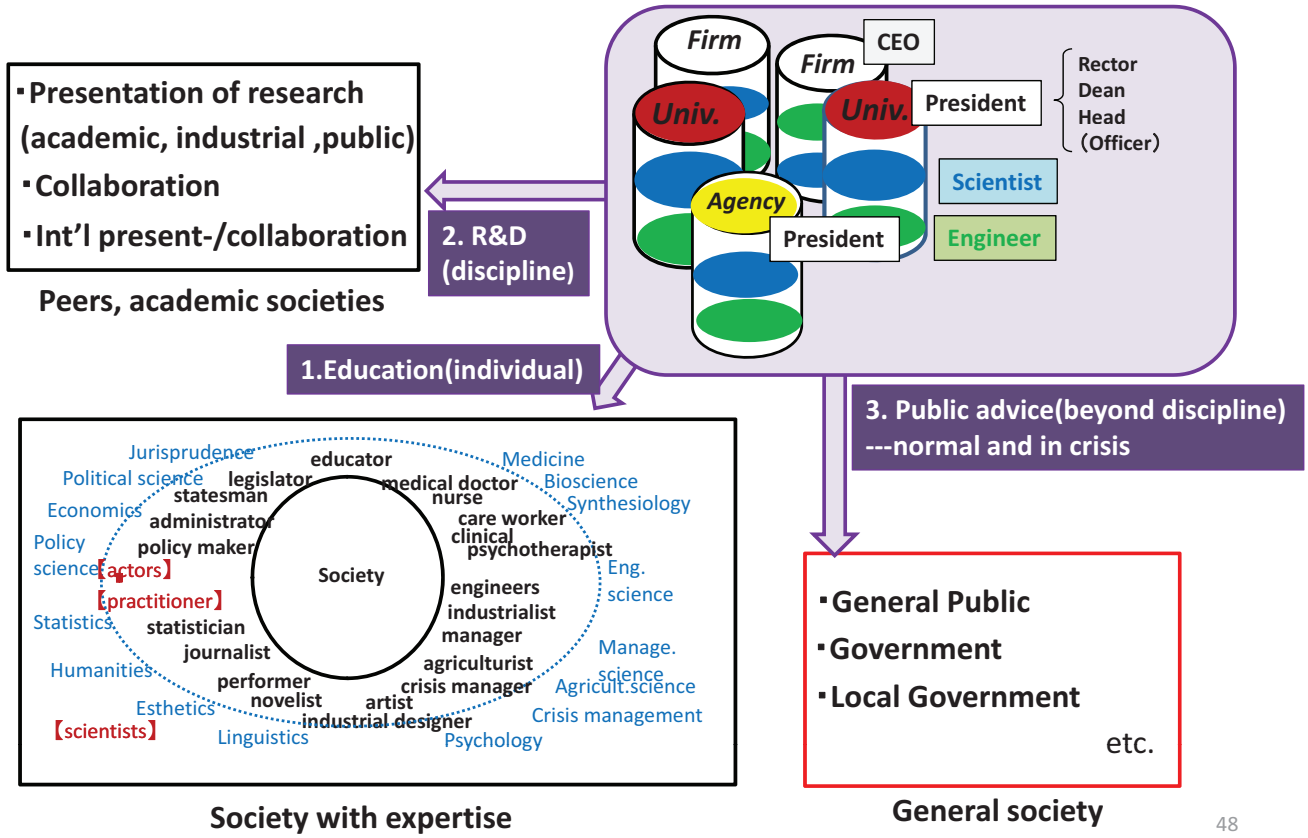
- **Capacity of Scientific Advisor:①Excellent achievement on research and education:②Panoramic view of science domains:③Historical knowledge of relation between science and society:④Insight for effect of science and technology to society:⑤ Comprehension of evidence-based policy**
- **Quality of Scientific Advisor:①Strong will to represent all scientists:②Ethics not straining at own field:3 ③Global sense:④Robust equity not yielding under strong pressure by specific domain:⑤Independence of special interest group**

46

Political Will and Roles of Scientists/Experts



Missions of Scientists and Experts : R&D・Education・Advice



Summary

1. New relationship between science and society has emerged:
   Communication in one-way from science to society has changed to mutual communication.

2. Move of central gravity from “Developing Science” to “Sustainability Science”:
   (1) from “Discovery of the truth” to “Recognition of the real”
   (2) from Analysis to Design

3. A factor useful to improve the relationship between science and society:
   From communication between “science and industry” to “science and policy”
   i.e. Scientific Advisor to Ministers (to Prime Minister and other Ministers)

4. Scientists should not forget that they live within society, although they are independent of it.

Hosting Organizations

The Heat Transfer Society of Japan

Science Council of Japan

Umbrella Organization

The Assembly for International Heat Transfer Conferences

Supporting Organizations

International Centre for Heat and Mass Transfer

The Japan Society of Mechanical Engineers

The Society of Chemical Engineers, Japan