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Science Map 2008

Study on Hot Research Areas (2003–2008) by Bibliometric Method

May 2010

Research Unit for Science and Technology Analysis and Indicators
National Institute of Science and Technology Policy (NISTEP)

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This material is the English translation of the main points extracted from the "Science Map 2008 (original version, Japanese)" issued by NISTEP in May 2010.

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Science Map 2008 Highlights

1. What is the Science Map?

The National Institute of Science and Technology Policy's Science Map project aims to periodically observe dynamic change in scientific research.[1] The unit of the mapping is research area.

Analysis of scientific research using Science Map is carried out through 1) structuring of research areas through the clustering of research papers, 2) visualization of research areas by mapping, and 3) content analysis of hot research areas.

Science Map 2008 used the top 1% highly-cited research papers (approximately 50,000) during each year in each of 22 fields (e.g. clinical medicine, plant and animal science, chemistry, physics, etc.) among research papers published during the six years 2003 through 2008. These highly-cited research papers were clustered in two stages (research papers → research fronts → research areas) by using "co-citation." Six hundred forty-seven research areas were obtained. Of these, detailed content analysis was performed on 121 hot research areas above a certain size.

Time-series analysis of Science Map 2002 (1997 through 2002), Science Map 2004 (1999 through 2004), and Science Map 2006 (2001 through 2006) was preformed. In these Highlights, results of the following analyses are given, along with the trial results of a questionnaire survey of experts and an interactive Science Map.

- ○ Science Map 2008's snapshot of the current status of scientific research
- ○ The trend of scientific research as viewed through Science Map
- ○ Changes in the nature of inter-/multi-disciplinary research areas
- ○ The status of activities in major countries as seen through Science Map
- ○ Differences between the UK and Germany, whose degree of participation in scientific research is increasing, and Japan

[How to read the Science Map]

In the main part of this report, two Science Maps (the Individual Research Area Map and the Research Area Correlation Map) are used to visualize and analyze trends of scientific research. In this summary, only analysis using the Research Area Correlation Map is described, so the Research Area Correlation Map will be referred to as "the Science Map."

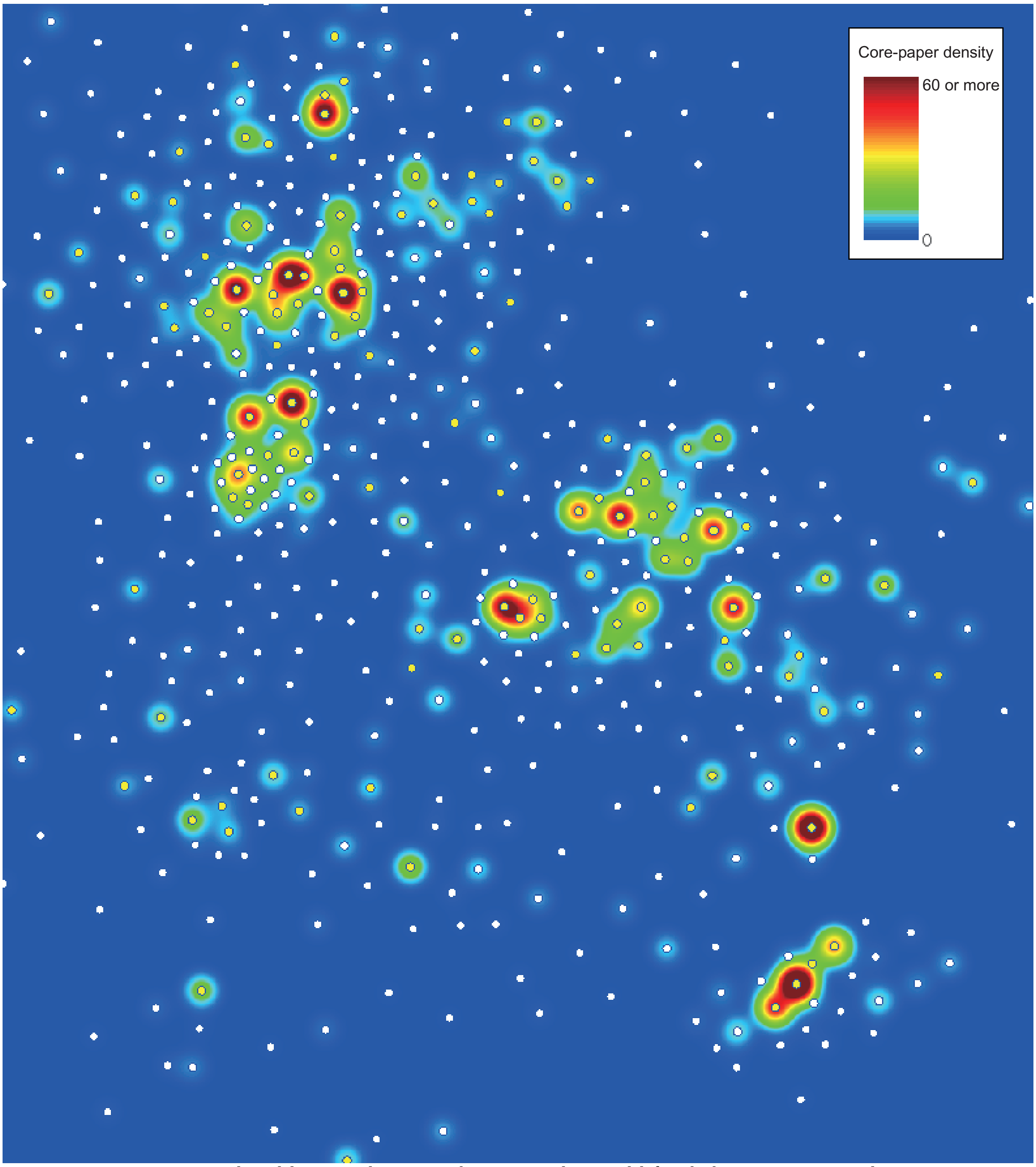
Highlights Figure 1 depicts the Science Map. The unit of visualization is research area. Research areas with a high degree of co-citation are located near one another.

In the Science Map 2008, all 647 research areas obtained by clustering research papers were mapped. By showing the positions of 121 hot research areas for which content analysis was performed, the roles of the hot research areas within scientific research as a whole become evident. In Highlights Figure 1, the white dots represent the positions of research areas, and the yellow dots the positions of hot research areas. The Science Map can be regarded as a two-dimensional aerial map showing the accumulations of core papers and the formation of mountains of science on the land. The hot research areas are mountains that exceed a certain elevation.

Because showing all 647 research areas on the Science Map makes it overly complex, hot research areas alone are shown in these Highlights. (See Highlights Figure 2.)

1 This is the fourth report. The first report is NISTEP REPORT No. 95, Study on Rapidly-developing Research Area (May 2005); the second report is NISTEP REPORT No. 100, Science Map 2004 (March 2007); and the third is NISTEP REPORT No. 110, Science Map 2006 (June 2008).

Highlights Figure 1: Science Map 2008 (showing the positions of all research areas)



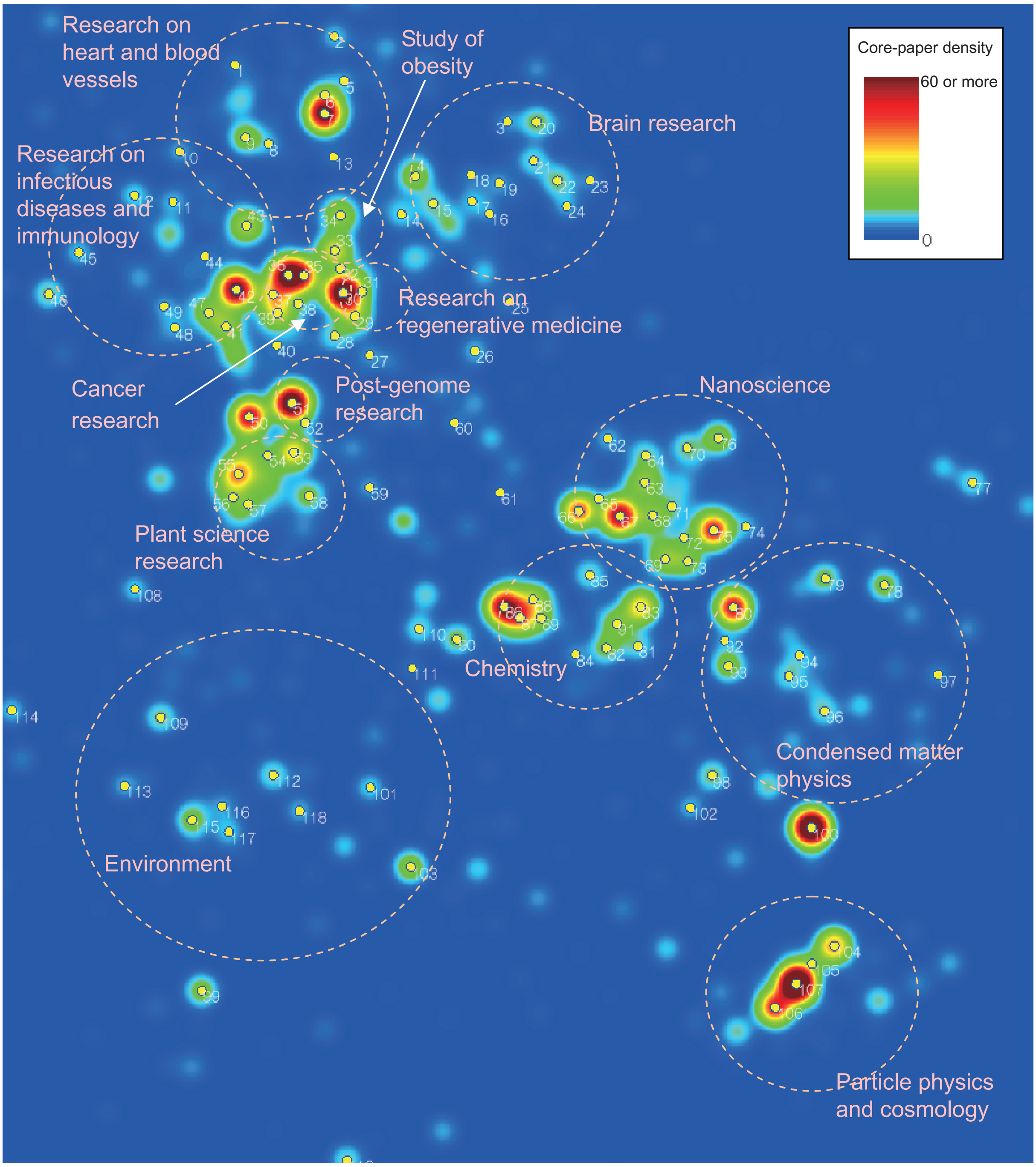
Note 1: Because a gravitational model was used to create this map, up-down and left-right have no meaning; relative position carries meaning. In these Highlights, life science happens to be positioned at the upper left and particle physics and cosmology at the lower right.

Note 2: White dots indicate the positions of research areas, and yellow dots the positions of hot research areas. Some research areas (IDs 114, 119, 120, 121) with a low rate of co-citation with other areas are so far from the center of the map that they are not included above.

Note 3: This map was created through a four-step process. 1) Determine the location of each research area according to the strength of co-citation relationships with the other research areas. 2) Express the position of each research area with a dot, and establish hypothetical spreads for research areas. 3) Divide that map into a grid with squares of a given area, calculating core-paper density (number of core papers divided by mesh area) for each square of the grid. 4) Based on these values, assign colors.

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy

Highlights Figure 2: Science Map 2008 (showing the positions of hot research areas)



Note 1: The yellow circles indicate the center locations of hot research areas. The numbers next to the yellow circles are the hot research areas' ID numbers.

Note 2: Some research areas (IDs 114, 119, 120, 121) with a low rate of co-citation with other areas are so far from the center of the map that they are not included above.

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy

2. Science Map 2008's Snapshot of the Current Status of Scientific Research

(1) Life science

Life science accounts for the largest area on the map. Clinical research (research on heart and blood vessels, study of obesity, cancer research, research on regenerative medicine) and basic research (research on infectious diseases and immunology, brain research, post-genome research, plant science research) were observed to continue to have a strong relationship and to be developing.

<New developments in research on regenerative medicine>

The very large research area "Regenerative medicine and stem cell research (2008, ID 30)," which includes Dr. Yamanaka's establishment of iPS cells at Kyoto University, was derived. This research area is formed by the fusion of three research areas in the Science Map 2006. Experts cited research on heart and blood vessels, brain research, cancer research, research on infectious diseases and immunology, and post-genome research as a group of research areas that is likely to develop into the future and to deepen their relationship to research on regenerative medicine. In order for the research area to develop, "collection of data and search of substances on a different order of magnitude" are necessary. Current post-genome research, life science after the sequencing of the genome, requires more efficient and swifter data collection. The ability to mine this data has also become necessary. Base on such ability of data mining, the post-genome research seeks to strengthen relationships with a broad group of research areas in life science as a target of application.

<The advancement of brain research>

The position of brain research shifted on Science Map 2008, in part because of the influence of the new developments in research on regenerative medicine discussed above. Through Science Map 2006, it was firmly within the clinical medicine related groups of research areas in life science, next to cancer research. In 2008, it is a group of research areas spreading towards the upper right. In the map's upper left are located neurophysiological research such as "Molecular mechanisms of Alzheimer's disease and development of prevention and treatment (2008, ID 15)," psychiatric research such as "Brain-derived neurotrophic factor/brain morphology of schizophrenia/mood disorders (2008, ID 19)," and research with neurophysiological and cognitive science aspects such as "Neural mechanisms of emotion, empathy, imitation, and context (2008, ID 24)." These three different research approaches are distinctively grouped together.

<The position of post-genome research in life science research>

Continuing from Science Map 2006, in 2008 post-genome research forms a bridge between plant science research, which researches mainly plants and fungi; and research on heart and blood vessels; brain research; study of obesity; cancer research; and research on infectious diseases and immunology, which research mainly animals and fungi. Interestingly, "Network science (2008, ID 50)" appears near post-genome research. The large amounts of data such as individual proteins, molecules, and drugs accumulated through post-genome research are being used as the basis of research considering their interactive networks.

(2) Chemistry and nanoscience

Nanoscience, chemistry, and condensed matter physics are adjacent to each other. This indicates their close relationship. Research areas that relate to biology, medical care, and environment are scattered within chemistry and nanoscience. Nanoscience is gradually developing and its breadth on the map is increasing.

<Chemistry>

The chemistry group of research areas is characterized by a core of two hot research areas, "Catalytic asymmetric synthesis (2008, ID 86)" and "Molecular conversion reaction using transition metal catalyst (2008, ID 87)," and by its formation of the hot research areas while having relationships with other nearby groups of research areas. "Nanochemistry of gold (2008, ID 81)," "New-generation density functional theory for large-scale molecular computing (2008, ID 82)," and "Complex hydrides related to hydrogen production and storage and fuel cells (2008, ID 91)," which are mapped close to nanoscience and condensed matter physics, are new hot research areas on Science Map 2008. The research scale of "Microbial fuel cells/microbial batteries/enzyme-based biofuel cells (2008, ID 90)," which is mapped between the chemistry and environment groups of research areas, expanded between Science Map 2006 and Science Map 2008, turning it into a hot research area.

<Nanoscience>

The content of the research areas that comprise nanoscience on the map vary by the locations on the map. "Microchannel devices (2008, ID 62)," "Research on nanofiber creation and applications (2008, ID 64)," etc., are mapped near life science. These research areas have the elements of life science such as applications of nanofibers to regenerative medicine and creation of nanostructures using DNA. The hot research area "Organic/organic oxide semiconductors, opto-electronic functional materials and elements (2008, ID 75)," which forms a large peak near condensed matter physics, is a research area involving the development of nanomaterials and devices that use them. Research areas such as "Nanomaterial synthesis in ionic liquids/hollow and mesoporous materials (2008, ID 72)," which involves the synthesis of materials with specific structures by using ionic liquids, are mapped near chemistry. There is some research areas related to environment research. Looking in detail at the content of research areas, keywords such as organic EL elements, solar batteries, and fuel cells are found.

Chemistry and nanoscience experts believe that relationships among the two groups of research areas and condensed matter physics should be strengthened. They indicated that mutual sharing and exchange of knowledge are important to the development of the research areas. Experts on other groups of research areas, such as cancer research and research on infectious diseases and immunology, responded that relationships with chemistry and nanoscience should be strengthened.

(3) Condensed matter physics and particle physics and cosmology

In the condensed matter physics group of research areas, there are clear changes in research topics over time. Particle physics and cosmology is essentially unchanged as a group of research areas. However, the fusion of research areas originating in condensed matter physics and particle physics and cosmology is observed in Science Map 2008. It indicates the increase of the mutual interaction between condensed matter physics and particle physics and cosmology groups of research areas.

<Condensed matter physics>

Looking at changes in the condensed matter physics group of research areas from Science Map 2002 to Science Map 2008, there has been a major shift in the concentration of core papers over time. In other words, there has been a clear change in research topics. Co-citation links among research areas are small. Each research area likely develops independently.

Among the hot research areas in condensed matter physics, "Physics and chemistry of molecular substances (2008, ID 80)" has shown rapid growth. Of the 54 research fronts comprising the research area, 12, about 20 percent, show a rapid increase in citations. Most involve research on graphene (monolayer graphite). Experts pointed out that the physics and chemistry of graphene are rapidly developing. The creation of graphene in 2004, the subsequent discovery of its quantum Hall effect, and so on have shown a renewed spotlight on carbon materials.

A quasi-hot research area comprising two research fronts stemming from the discovery of iron-based superconductors in 2008 by a research team of Dr. Hosono in Tokyo Institute of Technology's was derived. Because it includes research fronts with particularly rapid increases in the number of citations, iron-based superconductors might be observed as a hot research area in Science Map 2010 and beyond.

<Particle physics and cosmology>

Except for "Strongly interacting many body systems (2008, ID 100)," a research area of particle physics and cosmology showed no changes in position or spread on the Science Map. This indicates that there were no major changes in the pattern of research activities. This is because particle physics and cosmology has ultimate goals such as the construction of unified field theory and understanding of the origin of the universe, and research continues to evolve in those directions.

3. The trend of Scientific Research as Viewed through Science Map

(1) Dissemination and integration of knowledge as seen between groups of research areas

Although the distribution of large groups of research areas on the map did not change from Science Map 2002 to Science Map 2008, the percentage of research papers in life science research areas has been in decreasing trend since Science Map 2002. On the other hand, the percentage of papers in non–life science areas such as nanoscience has been in increasing trend.

With the previous study's Science Map 2006 as the standard, a four-point time-series variation was completed by connecting Science Maps 2002 and 2004 and the latest study, Science Map 2008. (See Highlights Figure 4.)

Looking at the time-series variation, the life science group of research areas showed a relatively high concentration of research papers in Science Map 2002. The research areas of life science tended to spread over the map in Science Maps 2004 and 2006. In the latest Science Map, Science Map 2008, there is a change towards a relatively high concentration of research papers similar to that in Science Map 2002. Nanoscience seems to be a step behind life science. In Science Maps 2002, 2004, and 2006, it also showed a relatively high concentration of research papers, but research areas tend to be more scattered in Science Map 2008. Since Science Map 2002, life science research area has been in decreasing trend in terms of number of research papers, while the number of research papers in nanoscience and other non–life science groups has been rising. (See Highlights Figure 3.)

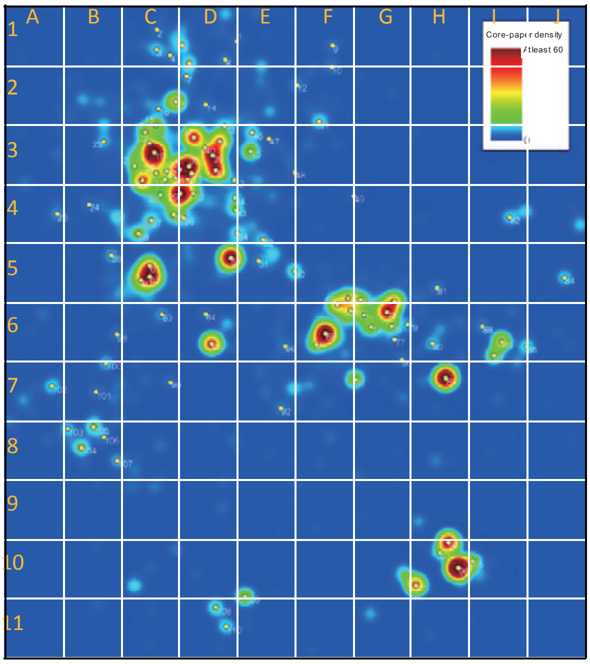
Highlights Figure 3: Quantification of Science Map time-series variation

Map grid no.	Primary groups of research areas positioned	Science Map 2002	Science Map 2004	Science Map 2006	Science Map 2008
No. of core papers in all research areas		15410	15531	15165	15826
A1-J11	Number of core papers within Map boundaries	14655	14821	14452	14986
		95.1%	95.4%	95.3%	94.7%
A1-F3, A4-E4, A5-D5	Life science	7614	7281	6831	6875
		49.4%	46.9%	45.0%	43.4%
F5-G6	Nanoscience and Chemistry	1979	2287	2353	2207
		12.8%	14.7%	15.5%	13.9%
E4-I7	Near Nanoscience and Chemistry	3481	3668	3899	4129
		22.6%	23.6%	25.7%	26.1%
G6-I7	Condensed matter physics	1739	1342	1425	1619
		11.3%	8.6%	9.4%	10.2%
G8-I9	Condensed matter physics and Particle physics and cosmology	150	344	682	906
		1.0%	2.2%	4.5%	5.7%
G10-I11	Particle physics and cosmology	1376	1436	1212	1200
		8.9%	9.2%	8.0%	7.6%
A6-D9	Environment	1185	1172	1006	1048
		7.7%	7.5%	6.6%	6.6%

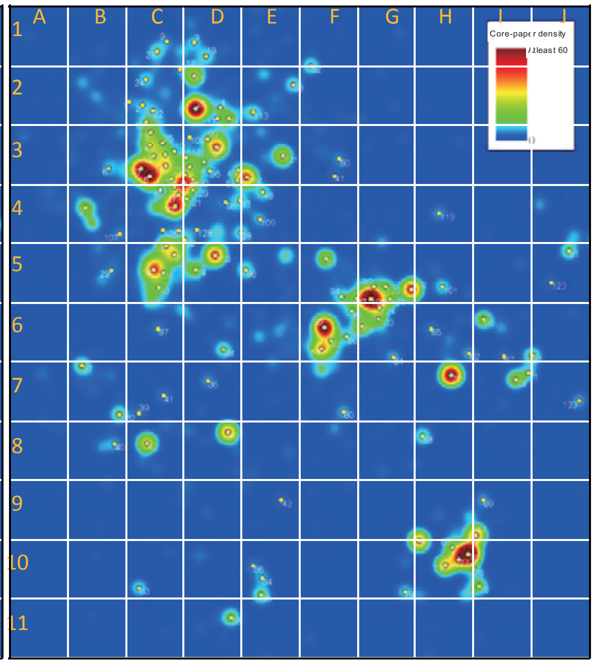
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy

Highlights Figure 4: Science Map 2002–2008

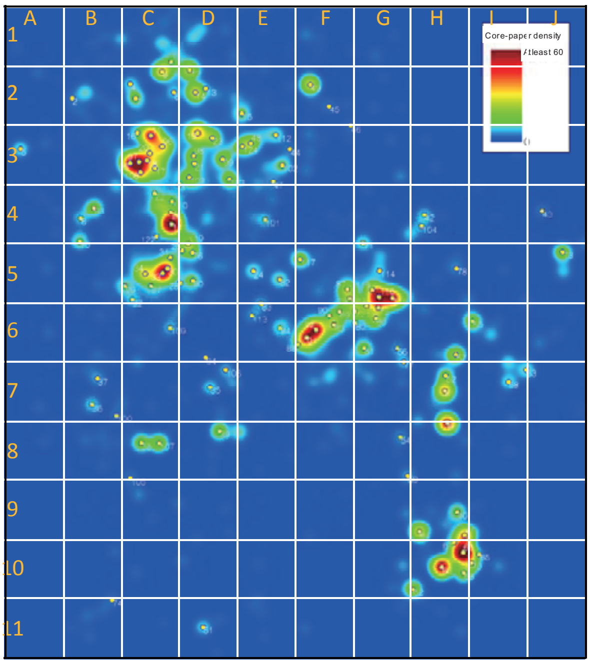
(A) Science Map 2002



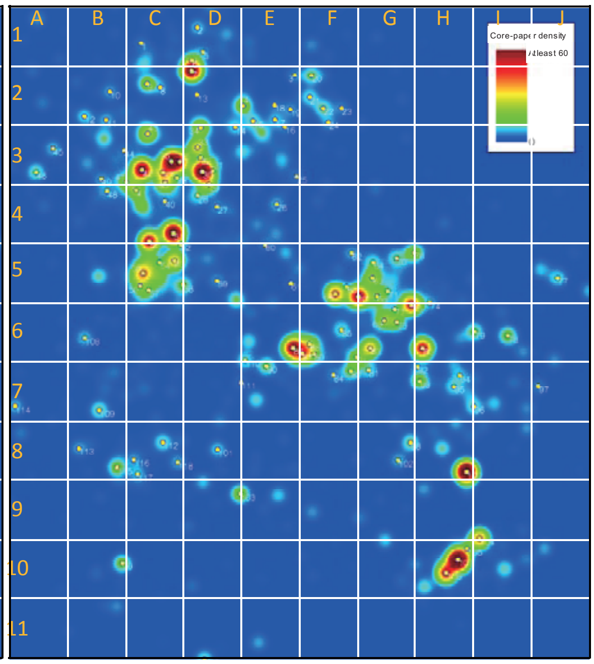
(B) Science Map 2004



(C) Science Map 2006



(D) Science Map 2008



Note 1: The yellow circles indicate the center locations of hot research areas. The numbers next to the yellow circles are the hot research areas' ID numbers.

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy

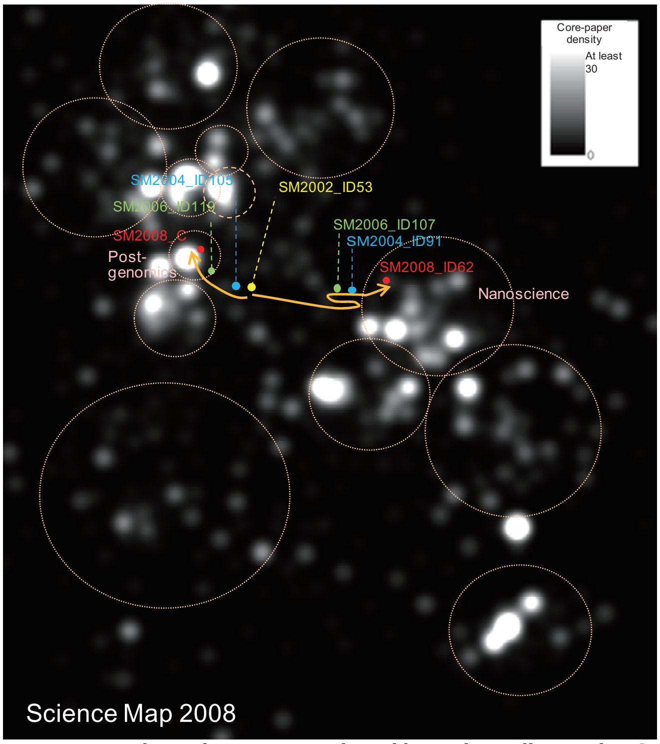
(2) Changes in position of research area on the science map in response to the dissemination and integration of knowledge

The dynamics of research areas, e.g. the fusion of research areas, the movement of the position of research areas, was observed on the map, especially in research areas between life science and nanoscience and between condensed matter physics and particle physics and cosmology. These changes may be responses to the dissemination and integration of knowledge.

The distribution of research areas in the space between life science and nanoscience is not dense. However, that space is the location of research areas that play an important role in linking the two groups. Science Map 2002's ID 53 began intermediate between life science and nanoscience. The research area has split towards both life science and nanoscience during its continuous development. Looking at its trajectory towards life science, it has been "Research on proteome (2004, ID 105)" and "Isotope labeling/quantitative mass spectrometry/protein analysis (2006, ID 119)." In Science Map 2008, it is not a hot research area, but it was still observed as a quasi-hot research area. It is located near "Gene silencing/plant hormones (2008, ID 51)" at the center of Post-genome research. In its evolution to the direction of nanoscience, it has been "Chemical-/bio-system with microchips (2004, ID 91)," "Micro-bio system and micro chemical system (2006, ID 117)," and "Microchannel devices (2008, ID 62)." Currently the research area is located at nanoscience. The exhaustive study with ultra-micro, rapid, and highly sensitive analysis used for research such as DNA and protein sequencing became the mainstream in life science. Many microchip systems were developed as ways to achieve this. Two streams of research were stemmed from the microchip system; a stream to use these systems for research to understand life and a stream to develop applications to apply microchannel devices to chemical reaction control and bioanalysis. As a consequence, the research of microchip system has been accelerated research in both life science and nanoscience.

In Science Map 2008, "Strongly interacting many body systems (2008, ID 100)" was found in the space between condensed matter physics and particle physics and cosmology. It is a hot research area originating in the fusion of condensed matter physics and particle physics and cosmology. In Science Map 2002, quark research and research on Bose-Einstein condensation and superconductivity/superfluidity were separated. Over time, however, 1) the position of quark research moved towards condensed matter physics, and 2) the position of research on Bose-Einstein condensation and superconductivity/superfluidity moved towards particle physics and cosmology. In Science Map 2008, they are fused into a single hot research area, as can be seen from their trajectories.

Highlights Figure 5: The trajectories of Science Map 2002 ID 53, which was intermediate between life science and nanoscience

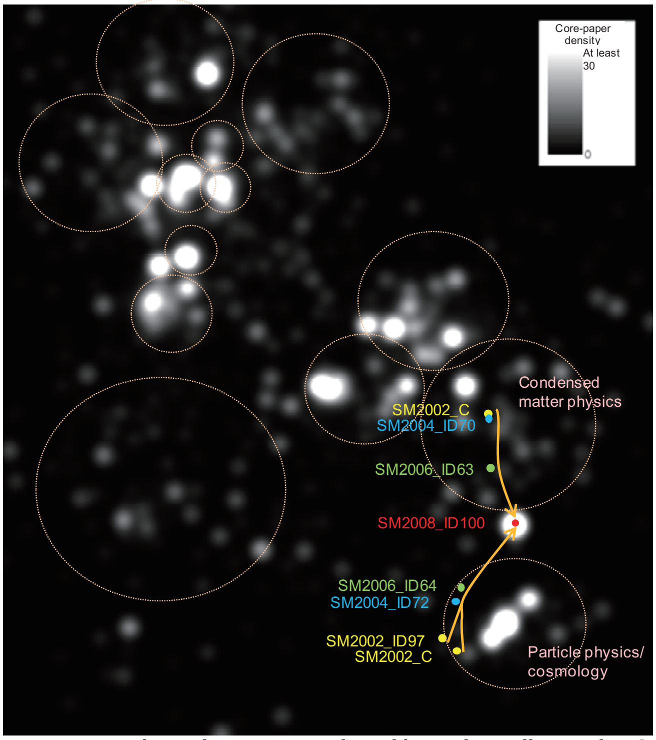


Science Map	ID	Research area name
2002	53	-
2004	105	Research on proteome
2006	119	Isotope labeling/quantitative mass spectrometry/ protein analysis
2008	C	
2002	53	-
2004	91	Chemical-/bio-system with microchips
2006	117	Micro-bio system and micro chemical system
2008	62	Microchannel devices

Note: Research area locations are indicated by circles. Yellow circles: Science Map 2002; blue circles: Science Map 2004; green circles: Science Map 2006, red circles: Science Map 2008. ID numbers refer to hot research areas. Those marked with "C" are quasi-hot research areas and thus have no ID and no research area name.

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy

Highlights Figure 6: The trajectories of Science Map 2002 ID 100, which was intermediate between particle physics and cosmology and condensed matter physics



Science Map	ID	Research area name
2002	C	-
2004	70	Quantum optics, atom optics, quantum nanostructure, and their application to quantum information processing
2006	63	New quantum condensed phase where substances strongly interact with each other
2008	100	Strongly interacting many body systems
2002	97	-
2002	C	-
2004	72	Quantum chromodynamics
2006	64	Search for quark matter through high-energy nuclear collision
2008	100	Strongly interacting many body systems

Note: Research area locations are indicated by circles. Yellow circles: Science Map 2002; blue circles: Science Map 2004; green circles: Science Map 2006, red circles: Science Map 2008. ID numbers refer to hot research areas. Those marked with "C" are quasi-hot research areas and thus have no ID and no research area name.

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy

4. Qualitative changes in inter-/multi-disciplinary research areas

Qualitative changes of interdisciplinary research and multidisciplinary research can be read in the Science Map. These trends were also noted by experts who carried out content analysis of hot research areas.

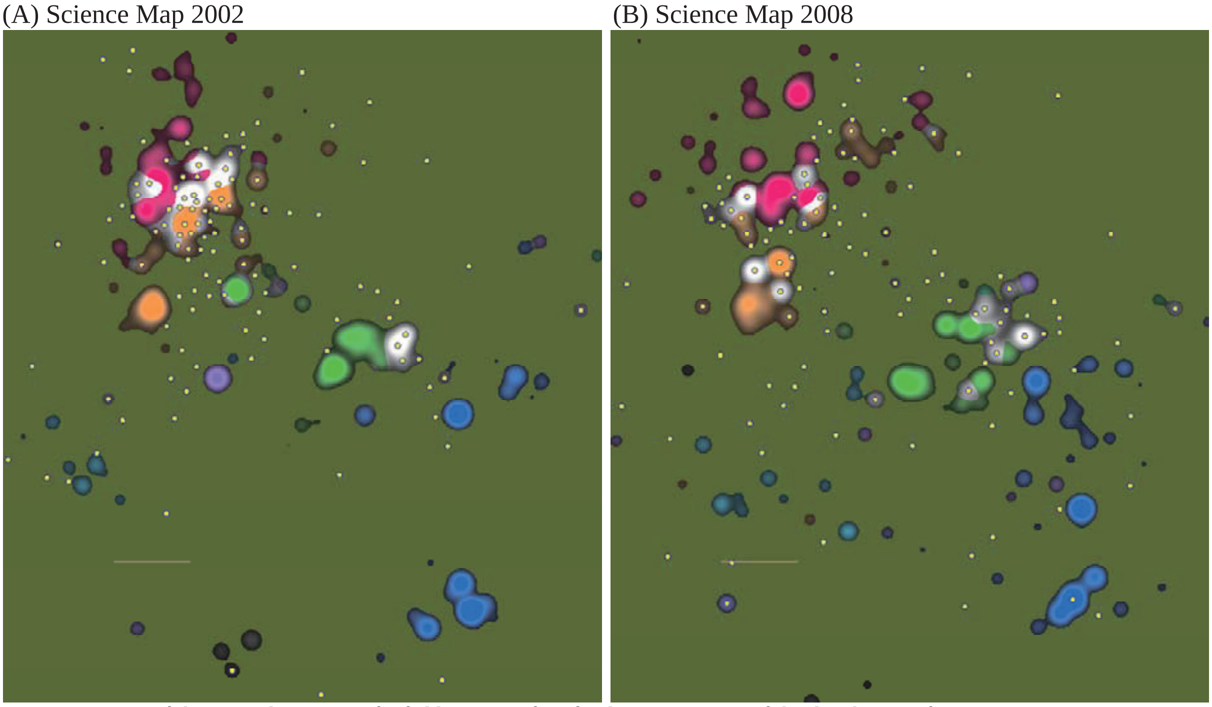
Of the 647 research areas, 151 (23 percent) are inter-/multi-disciplinary research areas.[2] A remarkable increase in the number of citations in such areas was found. In addition, relatively new research results were incorporated in these research areas.

There was little change in the percentage of research areas on the map accounted for by inter-/multi-disciplinary research areas. It was in the about 20% for each of the four Science Maps, 2002–2008. However, there were positional changes. Comparison of Science Map 2002 and Science Map 2008 shows that inter-/multi-disciplinary research areas were concentrated in the life science group in 2002, but have spread all over the map in 2008. (See Highlights Figure 7.) There has been an increase in combinations of life science and non–life science that comprise inter-/multi-disciplinary research areas.

The experts handling content analysis of hot research areas indicated that active utilization of knowledge from other fields is an effective means of bringing about major advances in various research areas. In addition, many of the topics that the experts listed as currently drawing much attention and promising strong movement over the next few years can be considered inter-/multi-disciplinary. The experts' opinions may be conforming to qualitative changes in inter-/multi-disciplinary areas seen in the bibliometric analysis.

Highlights Figure 7: Changes in the positions of inter-/multi-disciplinary research areas

(A) Science Map 2002 (B) Science Map 2008



Note: Portions of the map where a specific field accounts for of at least 60 percent of the distribution of core papers comprising a given research area are given that field's color. When less than 60 percent of core papers are distributed in a specific field, research areas are considered to have a highly interdisciplinary/multidisciplinary nature and are not given a color. Yellow circles represent inter-/multi-disciplinary research areas.

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy

- Chemistry
- Materials science
- Physics & Space sciences
- Computer science & Mathematics
- Engineering
- Environment/Ecology & Geosciences
- Clinical medicine & Psychiatry/psychology
- Basic biology
- Other

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[2] For the Science Map, when a specific field accounts for of at least 60 percent of the distribution of core papers comprising a given research area, that area is considered to belong to that field. All other cases are considered "inter-/multi-disciplinary research areas."

5. Status of Activities in Major Countries As Seen through Science Map

(1) Major countries' shares of papers as seen in Science Map

In terms of hot research results appearing in the Science Map, Japan's degree of participation and degree of contribution are both declining.

Highlights Figure 8 shows a time-series variation for various countries' shares of research papers in all research areas. Japan's degree of participation (whole count method)[3] in Science Map 2008 is 8.0 percent, fifth behind the USA, the UK, Germany, and France. This is a decline from Japan's peak in Science Map 2004. Japan's degree of contribution (fractional count method)[4] is 5.4 percent in Science Map 2008, fourth behind the USA, the UK, and Germany. This is also a decline since Science Map 2002.

Both degree of participation and degree of contribution are declining for the USA. However, since that country's degree of participation in Science Map 2008 is 57.9 percent, and its degree of contribution is 43.5 percent, the USA is clearly an important source of knowledge for science as a whole.

Degree of participation for the UK, Germany, and France is on an upwards trend since Science Map 2002. On the other hand, degree of contribution varies, with the UK declining, Germany rising, and France remaining roughly the same. Those countries vary widely in degree of participation and degree of contribution.

China's degree of participation and degree of contribution are both on an upward trend. Comparing Science Maps 2002 and 2008, degree of participation has risen by 5.9 percentage points to 7.2 percent. China's presence is particularly strong in nanoscience, where it surpasses Japan.

Highlights Figure 8: Time-series variation in all research areas for various countries

(A) Whole count method

Whole count method	USA	Germany	UK	Japan	France	South Korea	China
Science Map 2002	62.9	11.1	12.4	8.6	7.0	1.1	1.3
Science Map 2004	61.9	12.1	12.3	8.7	7.2	1.7	2.7
Science Map 2006	61.0	13.5	12.9	8.5	7.5	1.8	4.5
Science Map 2008	57.9	13.9	13.4	8.0	8.4	1.9	7.2

(B) Fractional count method

Fractional count method	USA	Germany	UK	Japan	France	South Korea	China
Science Map 2002	51.8	6.7	7.8	6.4	3.9	0.7	0.8
Science Map 2004	49.7	7.2	7.3	6.2	3.8	1.0	1.7
Science Map 2006	47.6	7.7	7.2	5.7	3.7	1.1	2.9
Science Map 2008	43.5	7.4	7.0	5.4	3.8	1.0	5.2

Note: Shares of core papers comprising all research areas.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy

[3] Degree of participation (whole count method) counts papers with joint authors from more than one country as one paper for each country. Thus, the combined shares of all countries exceed 100 percent.

[4] Degree of contribution (fractional count method) counts papers with joint authors from more than one country as a fractional of a paper for one country. For example, a paper with authors from Country A and Country B would be counted as 1/2 a paper for Country A and 1/2 a paper for Country B. Thus, the combined shares of all countries total 100 percent.

(2) Status of major countries by field as seen in Science Map

Japan is losing share in clinical medicine and inter-/multi-disciplinary research area relative to the UK and Germany.

When the shares for each research area are overlaid on the Science Map, it becomes possible to visualize not only Japan's overall share, but also which research areas have a strong Japanese presence and which do not. (See Highlights Figure 10.)

In Japan's case, there is a relatively high amount of red research areas in chemistry, nanoscience, and condensed matter physics. Areas with high shares include "Novel electron states for high-temperature superconductors (ID 97)," "Interferon production through natural immunity (ID 41)," "Metal spintronics (ID 79)," "Molecular mechanisms of plasticity at excitatory synapses (ID 25)," and "Complex hydrides related to hydrogen production and storage and fuel cells (ID 91)."

As for the UK, it has a relatively uniform share across the map for degree of participation (whole count method), but its degree of contribution (fractional count method) is limited somewhat to brain research, environment, and particle physics and cosmology. The gap between degree of participation and degree of contribution stems from international co-authorship of papers.

Highlights Figure 9 shows each country's share by field. The figure shows that the differences between Japan's share and those of the UK and Germany are stemming from clinical medicine and inter-/multi-disciplinary research areas.

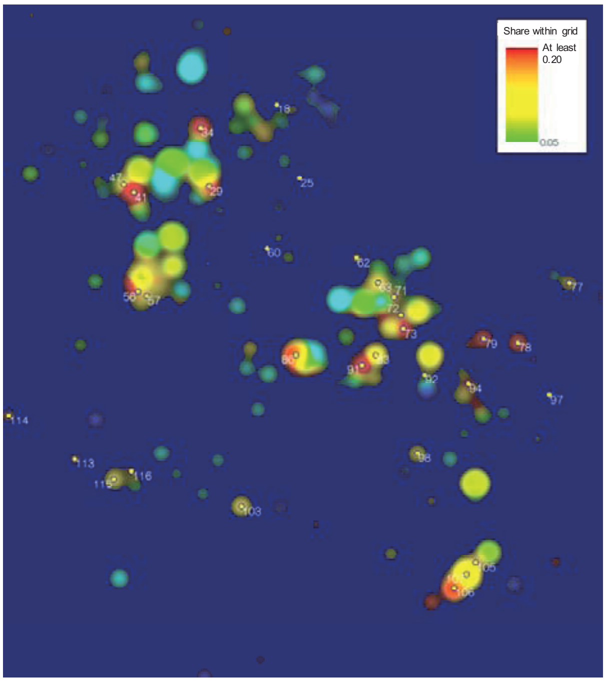
Highlights Figure 9: Countries' shares by field in Science Map 2008

Field	All	USA	Germany	UK	Japan	France	South Korea	China
Agricultural sciences	0.7%	0.2%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%
Biology and biochemistry	0.8%	0.5%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%
Chemistry	13.3%	6.0%	1.6%	1.1%	1.1%	0.7%	0.3%	1.2%
Clinical medicine	19.1%	12.7%	3.0%	3.0%	0.9%	2.2%	0.2%	0.4%
Computer science	1.3%	0.9%	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%
Economics and business	0.7%	0.6%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Engineering	4.0%	1.2%	0.2%	0.2%	0.1%	0.1%	0.1%	0.9%
Environment/Ecology	1.6%	0.9%	0.2%	0.3%	0.1%	0.1%	0.0%	0.1%
Geosciences	3.3%	2.2%	0.6%	0.7%	0.3%	0.4%	0.0%	0.5%
Immunology	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Materials science	0.7%	0.4%	0.1%	0.0%	0.1%	0.0%	0.0%	0.1%
Mathematics	1.0%	0.4%	0.1%	0.1%	0.0%	0.1%	0.0%	0.2%
Microbiology	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Molecular biology & genetics	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Neuroscience and behavioristics	2.0%	1.4%	0.2%	0.3%	0.2%	0.1%	0.0%	0.0%
Pharmaceutical science/toxicology	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Physics	14.4%	8.1%	2.7%	1.9%	1.7%	1.7%	0.5%	1.1%
Plant and animal science	4.2%	1.9%	0.9%	0.8%	0.6%	0.3%	0.1%	0.2%
Psychiatry/psychology	1.2%	0.9%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%
Social science, general	1.0%	0.6%	0.0%	0.2%	0.0%	0.1%	0.0%	0.0%
Space sciences	0.8%	0.7%	0.2%	0.3%	0.1%	0.2%	0.0%	0.0%
Inter-/multi-disciplinary resarch areas	29.1%	17.6%	3.7%	4.0%	2.6%	2.2%	0.6%	2.5%
Total	100.0%	57.9%	13.9%	13.4%	8.0%	8.4%	1.9%	7.2%

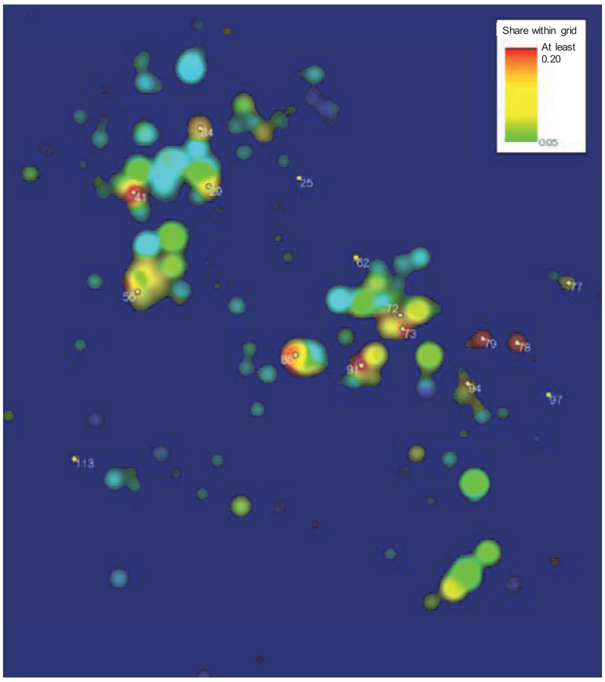
Note: For example, Japan has an 8.0 percent share in Science Map 2008 and a 1.7 percent share comes from physics.

Highlights Figure 10: Share of research papers overlaid on Science Map 2008

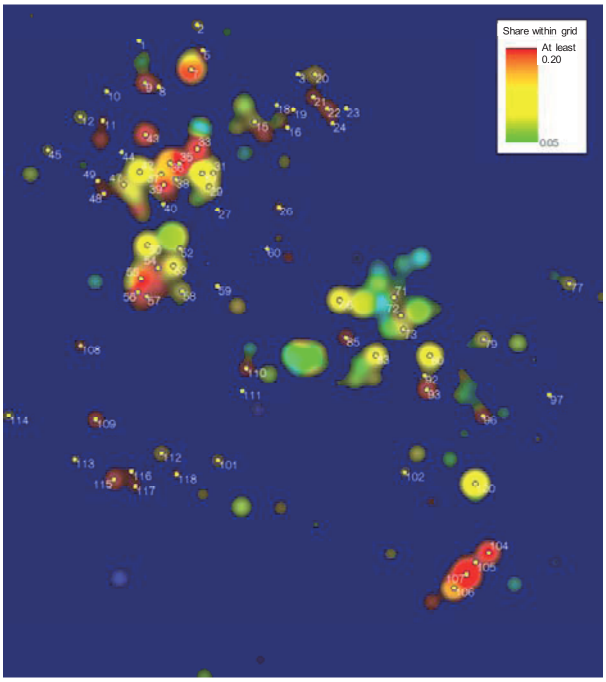
(A) Japan (whole count method)



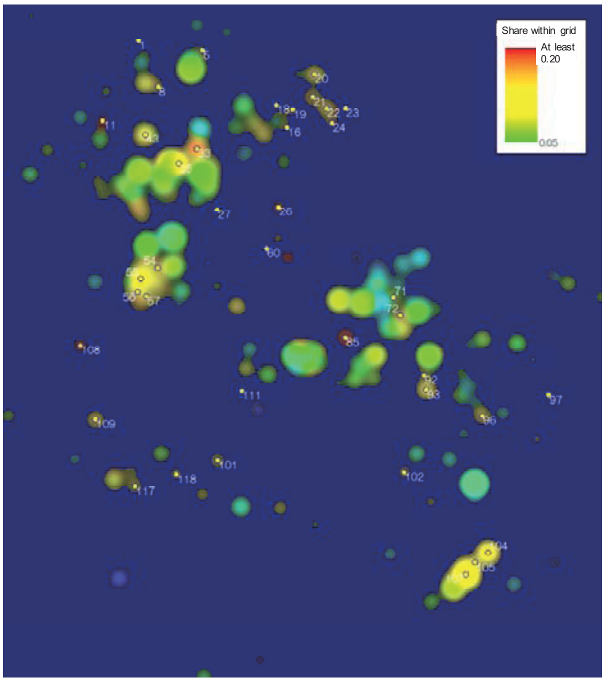
(B) Japan (fractional count method)



(C) UK (whole count method)



(D) UK (fractional count method)



Note: A paper share of 5 percent is indicated with light blue, while a share of 20 percent or above is red. The whole count method is used to calculate paper share. Yellow circles with numbers indicate the locations and ID numbers of hot research areas with paper shares of at least 9 percent.

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy

6. Differences between the UK and Germany, Whose Degrees of Participation in Scientific Research is Increasing, and Japan

In the Science Map, that draws research areas attracting international attention, Japan lags behind the UK and Germany in terms of degree of participation. Below, the differences between the UK and Germany, whose degrees of participation on the Science Map are increasing, and Japan are discussed.

(1) Compared to UK and Germany, Japan has less diversity in the areas in which it participates

The first difference between the UK and Germany, whose degrees of participation on the Science Map is increasing, and Japan is the percentage of research areas to which the country is participated in. The UK and Germany have at least one core paper in about 60 percent of research areas (participation areas). In contrast, the degree of participation of Japan is about 40 percent. Japan's percentage of participation areas has not changed significantly since Science Map 2002. This indicates that Japan has less diversity in its participation areas than the UK and Germany do. The difference in the number of participation areas stems from the inter-/multi-disciplinary and clinical medicine research areas.

Highlights Figure 11: Comparison of the number of Science Map 2008 areas participated in for Japan, the UK, and Germany

Field	Relevant research areas	Japan	UK	Germany
Agricultural sciences	8	3	4	4
Biology and biochemistry	11	6	4	6
Chemistry	64	28	32	38
Clinical medicine	116	41	82	75
Computer science	17	4	8	10
Economics and business	9	0	5	1
Engineering	44	9	12	14
Environment/Ecology	15	4	10	9
Geosciences	30	19	26	21
Immunology	1	1	1	1
Materials science	7	4	1	3
Mathematics	14	1	3	6
Microbiology	5	1	4	0
Molecular biology & genetics	5	2	4	3
Neuroscience and behavioristics	17	12	12	12
Pharmaceutical science/toxicology	3	1	0	1
Physics	61	35	39	39
Plant and animal science	36	20	24	24
Psychiatry/psychology	12	2	7	6
Social science, general	13	1	7	5
Space sciences	8	3	7	7
Inter-/multi-disciplinary	151	66	96	81
Total	647	263	388	366

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy

(2) Japan is losing share in the top 1% highly-cited research papers, which is the analytical population

The second difference between Japan and the UK and Germany is the share of the top 1% highly-cited papers, which constitutes the analytical population. Japan's degree of participation and degree of contribution are both declining in terms of papers in the top 1% highly-cited papers. This is probably the cause of Japan's declining presence in the Science Map.

Underlying the high degree of participation of the UK and Germany in the Science Map is those two countries' very high rates of international co-authorship, 73 percent and 72 percent respectively. The worldwide percentage of papers with international co-authorship is increasing along with the globalization of research. They receive more citations than domestic papers. However, 52 percent of the Japanese papers used by Science Map have international co-authorship. This is much higher than the percentage for all papers[5].

[5] The percentage of international co-authorship papers within all papers is 46 percent for the UK, 48 percent for Germany, and 24 percent for Japan in 2007.

Science Map 2008

PART Ⅰ

1. Introduction

The Third Science and Technology Basic Plan advocates the securing of a certain amount of resources for basic research that brings about diverse knowledge and innovation and the steady advancement of such research. As basic research, the Plan lists research based on the free ideas of researchers and research based on policies that aims for future applications. In the promotion of basic research, although the former is eliminated by principles of theme selection and resource concentration, it is necessary to monitor the status of field balance and inter/multi-disciplinary research areas and to confirm that the national government is steadily promoting them. In other words, it is necessary to regularly monitor the status of basic science and to perform effective benchmarking of long-term basic science policy.

Based on awareness of these issues, the National Institute of Science and Technology Policy began monitoring the status of scientific research by using databases of scientific papers in FY2003[1]. This research has the following two purposes:

(i) Creation of "Science Maps" that provide a panoramic view of recent trends in science, especially in basic research.
(ii) Extraction of hot research areas that are garnering the attention of researchers and producing many scientific papers and observation of those research areas over time.

There is a long history of attempts to describe the structure and development of science and technology knowledge from the bibliometric perspective. The dramatic development of information processing technology and enhancement of databases of scientific papers and patents in recent years have brought innovation to research in this field. The mapping of knowledge is drawing attention as a new type of research, and a variety of studies are being conducted, mainly in the US and Europe[2]. The targets of mapping are diverse. They include analysis of relationships between fields of science through examination of journal citations and analysis of co-authorships by country, organization, and researcher. The National Institute of Science and Technology Policy's Science Maps are distinctive in that the target of their mapping is research areas.

The method for clustering scientific papers, which is an important step in creating the Science Maps, was established in Science Map 2004 (NISTEP REPORT No. 100), and this method has been used since then. However, because of a different method for clustering scientific papers, NISTEP REPORT No. 95: Study on Rapidly-developing Research Areas (1997-2002) could not be included in the time-series analysis. <u>Therefore, this time, "Science Map 2002" was newly created based on the 1997-2002 data by constructing research areas according to the method currently employed for clustering scientific papers.</u> This allowed time-series analysis of the four time periods, that are, Science Maps 2002, 2004, 2006 and 2008.

By using Science Maps 2002 to 2008, this report performs analysis and provides results of "Dynamism of scientific research" (Chapter 3) and "Strengths and weaknesses in the status of activities of major countries" (Chapter 4). The outline of survey methods is discussed in Chapter 2.

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[1] This is the fourth report. The first report is "NISTEP REPORT No. 95: Study on Rapidly-developing Research Areas (May 2005)"; the second report is "NISTEP REPORT No. 100: Science Map 2004 (March 2007);" the third report is "NISTEP REPORT No. 110: Science Map 2006 (March 2008)"

[2] For a comprehensive review, see Börner, K., Chen, C., and Boyack, K. W. (2003), "Visualizing Knowledge Domains", Annual Review of Information Science and Technology, 37, 179-255.

2. Methodology

Analysis of scientific research using the Science Maps can be performed in three steps: 1) construction of research areas by clustering scientific papers, 2) visualization of research areas through mapping, and 3) content analysis of hot research areas. Below, an overview of the survey method is given, and a web-based survey and the creation of a co-authorship network of research institutions are discussed.

2-1 Construction of research areas by clustering scientific papers

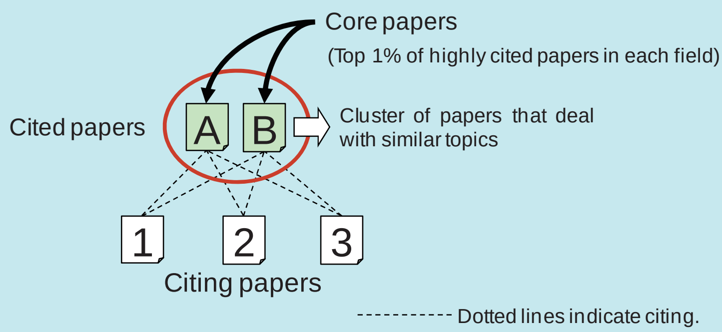
The method for clustering scientific papers is the same as that in NISTEP REPORT No. 100 Science Map 2004. In Science Map 2008, clustering of scientific papers obtained 647 research areas. Of these, 121 hot research areas of at least a certain size were analyzed in detail.

For clustering of scientific papers, the top 1 percent of highly-cited papers (approximately 56,000) during each year in each of 22 fields[3] (including clinical medicine, plant and animal science, chemistry, physics, etc.) among scientific papers published during the six years 2003 through 2008 were used. These highly-cited papers were grouped (Reference figure 2) in two stages (scientific papers → research fronts → research areas) by using "co-citation (Reference figure 1)."

[Co-citation]

Co-citation occurs when two notable scientific papers are both cited by another scientific paper. Frequently co-cited scientific papers are likely to have a certain amount of commonality of content. Groups of scientific papers with commonality of research content can therefore be obtained by clustering scientific papers with strong co-citation relationships. In this study, the groups of scientific papers that comprise the core of a research area are called "core papers," and scientific papers that cite core papers are called "citing papers."

Reference figure 1 Image of co-citation



In the co-citation analysis, the degree of co-citation between Papers A and B (co-citation level) is evaluated using the following formula:

$$N_{norm} = N_{AB} / \sqrt{N_A N_B} \quad (1)$$

Here, N_{AB} represents the number of papers that cited both Paper A and B, and N_A and N_B each represents the number of papers that cited either Paper A or B, and N_{norm} is the standardized number of times the papers were co-cited, which is regarded as a co-citation level.

[3] 22 Fields are as follows: agricultural sciences, biology and biochemistry, chemistry, clinical medicine, computer science, economics and business, engineering, environment/ecology, geosciences, immunology, material science, mathematics, microbiology, molecular biology and genetics, inter-/multi-disciplinary research areas, neuroscience and behavioristics, pharmaceutical science and toxicology, physics, plant and animal science, psychiatry/psychology, social science and general, and space sciences.

(References on co-citation analysis)

Small, H. and Sweeney, E. (1985a), "Clustering the Science Citation Index using Co-citations. I. A Comparison of Methods", Scientometrics, 7, 3-6, 391-409.

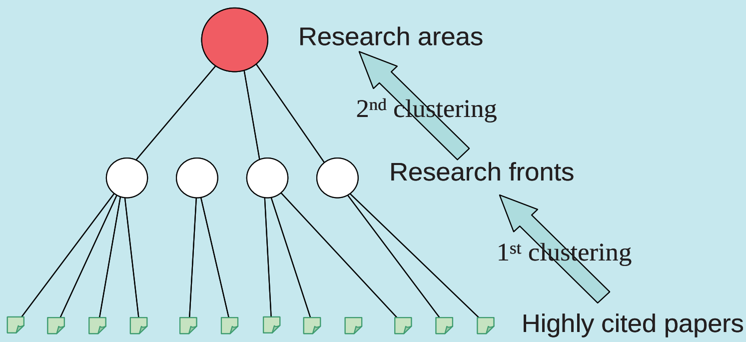
Small, H., Sweeney, E., and Greenlee, E. (1985b), "Clustering the Science Citation Index using Co-citations. II. Mapping Science", Scientometrics, 8, 5-6, 321-340.

Reference figure 2 shows the image of the clustering of scientific papers. The research fronts (5,726 research fronts) compiled in Thomson Reuters' Essential Science Indicators (ESI) were used as clusters of scientific papers in the first-stage clustering. The threshold value of co-citation level for the clustering is 0.3.

As the second stage, these research fronts were grouped again to obtain 647 research areas. During this clustering, calculations were made (1) by setting the threshold value for clustering research areas at 0.1, (2) for research areas that have two or more research fronts and (3) by setting the maximum number of research fronts included in a research area at 100. Of the 647 research areas, 121 research areas, each consisting of at least six research fronts were selected as hot research areas to be subjected to content analysis by experts.

Reference figure 3 shows the detail of clustering. In addition to Science Map 2008 to be reported this time, Science Map 2002 is also included in the table, for which reserach areas were contructed according to the current clustering method by using the data from 1997 to 2002.

Reference figure 2 Image of the clustering of scientific papers using co-citation relationships



Reference figure 3 Details of clustering
(Comparison of Science Maps 2002, 2004, 2006 and 2008)

		Science Map 2002	Science Map 2004	Science Map 2006	Science Map 2008
Research subject	Period	1997-2002	1999-2004	2001-2006	2003-2008
	Highly-cited research papers	About 45,000	About 47,000	About 51,000	About 56,000
	Point of time when citation was calculated	End of 2002	End of 2004	End of 2006	End of 2008
First-stage clustering	No. of research fronts	5,221	5,350	5,538	5,726
	No. of core papers included	21,183	21,411	21,428	22,669
Second-stage clustering	No. of research areas	598	626	687	647
	No. of research fronts included	3,415	3,502	3,551	3,635
	No. of research fronts included	15,410	15,531	15,165	15,826
	No. of hot research areas	112	133	124	121
	No. of quasi-hot research areas	486	493	563	526

Note 1: Hot research area Research area made up at least six research fronts
Note 2: Quasi-hot research area Research area made up of five or fewer research fronts

2-2 Visualization of research areas through mapping

In order to analyze the interrelationships among research fronts and the interfaces between research areas, the following two types of maps were created. Part I of this report describes the results of a panoramic analysis of science as a whole using the Research Area Correlation Map. Part II describes the results of analysis of individual hot research areas using the Individual Research Area Map.

(1) Individual Research Area Map (see Part II)

This map shows what kinds of research themes comprise each hot research area. The unit of visualization is research fronts. The greater the degree of co-citation in the research fronts that comprise a hot research area, the closer they are located on the map.

(2) Research Area Correlation Map

This map shows correlations between research areas. The subject of visualization is research areas. Research areas with a high degree of co-citation are located near one another.

<Creation of Research Area Correlation Map>

Same as the previous report, in Science Map 2008, all 647 research areas obtained by clustering scientific papers are mapped in the Research Area Correlation Map. By mapping all 647 research areas and showing the 121 hot research areas for which content analysis was performed, the aim was to make clearer the position and function of the hot research areas in scientific research as a whole.

This mapping took a hint from topographical maps. The hot research areas in the Science Map are those that reach a certain volume in terms of their number of scientific papers. If we liken the Science Map to a topographical map, these areas would be like only mountains that surpass a certain elevation. For a mountain climber who wishes to travel from mountain to mountain, the information only about peaks of mountain would be incomplete. This is because information on how the mountains are connected (whether there are peaks or valleys between the high mountains, how deep the valleys are, and so on) would not be included.

Returning to the Science Map, this is similar to the question of how the hot research areas are connected (whether there is interconnected research). In order to cover this information, it is necessary to add the between-mountain data to the map. This was the intention behind creating the Research Area Correlation Map using all 647 research areas.

<Visualization Method for Research Area Correlation map>

Regarding the visualization method for the Research Area Correlation Map, the positions of research areas are likened to mountain peaks and mapped to show gradations depending on the density of core papers in research areas. This method is used to make the visualization easier to understand in analogy with the contour lines of topographical maps.

Ordinarily, mapping obtains only the center positions of research areas. There is therefore some freedom in how to depict the breadth of individual research areas on the map. On the Individual Research Area Maps, the breadth of research areas is expressed using the radiuses of circles.

Research area breadth on the Research Area Correlation Map in this report is expressed using a Gaussian function. This has two factors. The first factor is the design-based decision to analogize the map with topographical maps, as described in the main text. The second factor is a technical issue involving the use of circles. Because the maximum number of core papers in a research area divided by the minimum number is on the order of 10^2, it is difficult to use circles to express size on a map.

In concrete terms, research areas' core papers were distributed in terms of a Gaussian function, centered on positions found with a mapping program. Core paper distribution in the Science Maps is expressed by superposing the Gaussian function obtained for each research area ρ (x, y) (the 647 research areas in Science Map 2008). The value of ρ (x, y) integrated for all surfaces is the total number of core papers.

For actual visualization, in order to express the distribution of core papers on a two-dimensional plane by using computers, the Science Map was divided into micro areas dx × dy. Next, the number of core papers included in a micro area were counted, and core paper density (number or core papers/(dx×dy)) was calculated to approximate ρ (x, y). For the Research Area Correlation Map, colors were determined in accordance with the core-paper density in each micro area.

<The characteristic of areas on the Research Area Correlation Map with high core-paper density>

The research Area Correlation Map can be regarded as depicting an aerial map with accumulations of core papers forming mountains of science on the land. On the Research Area Correlation Map, areas with red gradation are those with high core-paper density. Core-paper density is high in research areas and group so research areas in which many hot (highly-cited) scientific papers are published and frequently co-cited. This is characteristic of all parts of the map with high densities.

<Connection of the Research Area Correlation Maps from four periods>

In order to track changes in the Research Area Correlation Maps in four different periods from Science Maps 2002 through 2008, Research Area Correlation Maps obtained from these different periods were connected. Specifically, in addition to the attraction forces between research areas in a same period, which are determined by the degree of co-citation, a model that considers virtual attraction forces between research areas with shared core papers was conceived (parallel mapping). By using parallel mapping, Research Area Correlation Maps can be created in consideration of "History based on the past research areas" and "Current relationships between research areas at the same time."

The Research Area Correlation Maps from the four periods were connected according to the following procedure. The location of research areas in Science Map 2006 in NISTEP REPORT No. 110 were used as a basis for parallel mapping.

By using the coordinate of Science Map 2006 as a base, Research Area Correlation Maps 2006 and 2008, and Research Area Correlations Maps 2006 and 2004 were connected by means of parallel mapping. In connecting the maps, the research area coordinate of Research Area Correlation Map 2006 is kept fixed and immobile. Next, by using the coordinate of Research Area Coordination Map 2004 obtained from the above-mentioned steps, Research Area Correlation Map 2004 and 2002 were connected. In connecting the maps, the coordinate of Research Area Correlation Map 2004 was kept fixed.

Research Area Correlation Maps from the four periods (2002, 2004, 2006 and 2008) were connected according to the above-mentioned procedure. The location of research areas on the Research Area Correlation Maps from the four periods obtained here will remain the same. When creating new Research Area Correlation Maps in the future, the connection of maps will be made in series using Research Area Correlation Maps that were created one period earlier.

In parallel mapping, the optimization of Research Area Correlation Maps for the next period is made based on consideration of the history of a research area from the past. This makes it possible to compare the location information on research areas in different time periods. That is to say, the movement of research areas carries the meaning. For example, if a research area does not change its location from 2002 to 2008, that research area is regarded to have continued without changing its relationships with other research areas. On the other hand, a research area that changes its location is regarded to have continued as it changes its relationships with other research areas. Therefore, tracking the changes of the location of research areas (the trajectory of research areas) in Science Maps from 2002 to 2008 provides an understanding of the position and function of research areas in scientific research as a whole.

(3) Creation of Co-authorship Networks among Research Institutions

Individual Research Area Maps and Research Area Correlation Maps show the relationships between research content using the co-citation relationship. They are the maps in a cognitive space. On the other hand, it is also possible to explore the relationships between the participants of a research area by focusing attention on the co-authorships of the scientific papers that comprise individual research areas. This is the mapping in a social space.

In Science Map 2008, a network of co-authorships between research institutions was depicted by paying particular attention to institutional co-authorships. This makes it possible to analyze the characteristics of research areas from the viewpoint of correlations between institutions. An attempt was made to make clear the following characteristics by using the co-authorship networks of research institutions:

(i) The characteristics of the co-authorship networks of research institutions per research area (e.g. the density of the institutional co-authorship network)

(ii) The position and function of each country's institutions in the international co-authorship networks of research institutions

(iii) The topology of co-authorship networks of research institutions especially in the inter-/multi-disciplinary research areas

For creation of the co-authorship networks of research institutions, the number of each institution's scientific papers included in the core papers that comprise each research area was calculated using whole counting, and approximately 200 top institutions were extracted for the mapping. In the case where the number of institutions is less than 200, all institutions were extracted. In the case where the number of institutions exceeds 200, about 200 top institutions were extracted based on the number of scientific papers.

When the co-authorship networks of research institutions are depicted taking into consideration all of the co-authorships between the abovementioned 200 institutions, co-authorships become too complex to obtain a clear view of the structure of the co-authorship networks of research institutions. Therefore, when drawing the co-authorship networks of research institutions, only the co-authorships that involve about 20 top institutions[4] were used for mapping, instead of considering all co-authorships between the abovementioned 200 institutions. It is also usual that one institution often collaborates with multiple institutions in writing scientific papers. In such cases, only the co-authorships that have the largest number of joint scientific papers were extracted. The combination of these methods enables the extraction of the structure that forms the backbone of the co-authorship networks of research institutions which mainly consist of about 20 top institutions. The analysis in this report is intended to have an accurate understanding of the characteristics of the co-authorship networks of research institutions, and the cleaning of names of individual institutions in terms of spelling or notation was not made. Therefore, it is not appropriate to

[4] More specifically, (1) co-authorships between about 20 top institutions and (2) co-authorships between about 20 top institutions and other institutions were considered.

evaluate individual institutions using the co-authorship networks of research institutions as shown in this report.

2-3 Content analysis of hot research areas

Names and overviews of the hot research areas obtained by clustering scientific papers were determined through content analysis by experts. In addition, in Science Map 2008, a web questionnaire was carried out and invitation to participate in the creation of Interactive Science Map was issued for those responsible for the conent analysis regarding the developmental status of hot research areas in an attempt to capture the dynamism of scientific research.

(1) Content analysis of hot research areas

In Science Map 2008, a list of Japanese experts was created from the authors of core papers that make up hot research areas. Core paper authors and experts recommended by core paper authors were asked to carry out content analysis. When there were no Japanese among the authors of core papers that make up a hot research area, researchers whose work is seen as close according to information gathered over the Internet and so on were asked to perform that task. Specific work include (1) reading of the list of scientific papers (English) and maps of individual research areas, (2) writing of the names (up to 25 characters) and content (up to 400 to 500 characters) of research areas and (3) writing of key words in the Individual Research Area Maps. [See Part II 1. How to read the results of content analysis of hot research area and 2. Results of content analysis of hot research area])

For Science Map 2002, only reserach areas were constructed through clustering of scientific papers, and content analysis of hot research areas were not carried out.

(2) Web questionnaire survey on the development status of hot research areas

A web questionnaire survey was given to those who carried out the content analysis of hot research areas. They were asked about the following questions: [See Part II 3. Web Questionnaire survey]

[Questionnaire form]

Question 1. Characteristics of research area	
(1) Which of the following three statements apply to the changes that took place in the research area you were in charge of before 2002 and during the period between 2003 and 2008 (the survey's subject period)? Please select one that best applies.	
1	Research areas that existed separately before 2002 tended to fuse and form a research area as research subsequently advanced.
2	Before 2002, this kind of research was not recognized, but as research subsequently advanced, a research area formed.
3	The research area existed before 2002 as well, and continues as it increases the amount of research.

(2) Research area for which you were responsible					
Situation surrounding the research area					
1. Is there no participation, or is there any participation of researchers from the fields that were not involved in the research around 2002?					
No.	Yes	Unknown			
2. At present, are the connections with social agenda (infectious disease measures, creation of new industries, etc.) strong or weak?					
Weak	Somewhat weak	Average level	Somewhat strong	Strong	Unknown
3. During the period between 2003 and 2008, did the connections with social agenda decrease or increase?					
Decreased	Increased	No change	Unknown		

The situation surrounding the research area and the situation of competition (Please answer the situation viewed from your research group.)					
4. During the period between 2003 and 2008, did the number of overseas research groups (competitors) that are in a competitive relationship with your research group increase or decrease?					
Decreased	Increased	No change	Unknown		
5. Compared to your competitor whose situation you can grasp, what about the current situation of the research and development funds?					
The competitor has more funds	The competitor has slightly more funds	Same range	My group has slightly more funds	May groups has more funds	Unknown
6. Compared to your competitor whose situation you can grasp, did the difference in the amount of research funds narrow or widen during the period between 2003 and 2008?					
Narrowed	Widened	No change	Unknown		
7. Compared to the competitor whose situation you can grasp, what about the size of the membership of the current research group?					
The competitor has more members	The competitor has slightly more members	Same range	My group has slightly more members	My group has more members	Unknown
8. Compared to the competitor whose situation you can grasp, did the difference in the size of the research groups' membership narrow or widen during the period between 2003 and 2008?					
Narrowed	Widened	No change	Unknown		

Question 2. Means towards further development of research areas	
(1) To what extent do you think each of the following is effective to bring about a significant progress in the research area you were in charge of? Please answer each item on a five-point scale (0 for the lowest to 4 for the highest).	
a	Active utilization of knowledge from other fields (e.g., utilization of computer science in plant genome research, etc.).
b	Collection of data through international cooperation (Establishment of a global observation networks, sharing of work by countries, etc.).
c	Innovative metrological and measurement technology that exceeds the current limitations (Significant improvement in time resolution, processing speed and space resolution, etc.).
d	Several to several dozen units of large-scale experiment systems/facilities in the world (Accelerators, super computers, telescopes, etc.).
e	Enormous amount of collection of data and search of substances on a different order of magnitude from the past.
f	Structuring and systemization of enormous amount of knowledge obtained to date.
g	Implementation of research focusing on application (Development of clinical research, industry-university cooperation, etc.).
h	Other (Please check the right column and specify the detail.).
(2) In the research area for which you were responsible, please select one (1) most important thing from among the eight options which Japan should focus on to promote research.	

Question 3. Direction towards further development of research area			
Please select research area groups from among A to M and Other, with which the research area you were in charge of should strengthen the relationship for future development.(Multiple answers up to 3 items are acceptable). Please include research area groups that contain the research area you were in charge.			
A	Heart and blood vessels research	I	Environment
B	Research on infections diseases/immunology	J	Chemistry
C	Brain and nerve research	K	Nanoscience
D	Study of obesity	L	Condensed matter physics research
E	Cancer research	M	Particle physics/cosmology
F	Research on regenerative medicine		Other
G	Post-genomics research		Unknown
H	Plant science research		
Question 5. If you have any comments on Science Map and opinions on survey methods, please fill them in below. Also if you have any suggestions on the use of Science Map, please let us know.			

(3) Attempt to create an interactive Science Map

Grasping the status of science through the analysis of scientific papers is effective in that it shows the results of analysis in a quantitative form. However, because the analysis uses information such as the bibliographic data and frequency of citations of scientific papers, the results are in the near-past status and the necessity to fill the gap between the near-past and current status has been pointed out by the researchers who participated in the survey and analysis.

In addition to the part where the conventional quantitative analysis works, collecting “information on the research areas that are currently experienced and recognized by researchers” is considered effective for filling the gap between near-past and current/near future and is expected to grasp more accurate status of science. In addition, by using Science Map 2008 as the world’s coordinate axis of science and by performing the work to add “information on the research areas that are currently experienced and recognized by researchers,” the time and effort to organize the relationships between responses from researchers can be reduced.

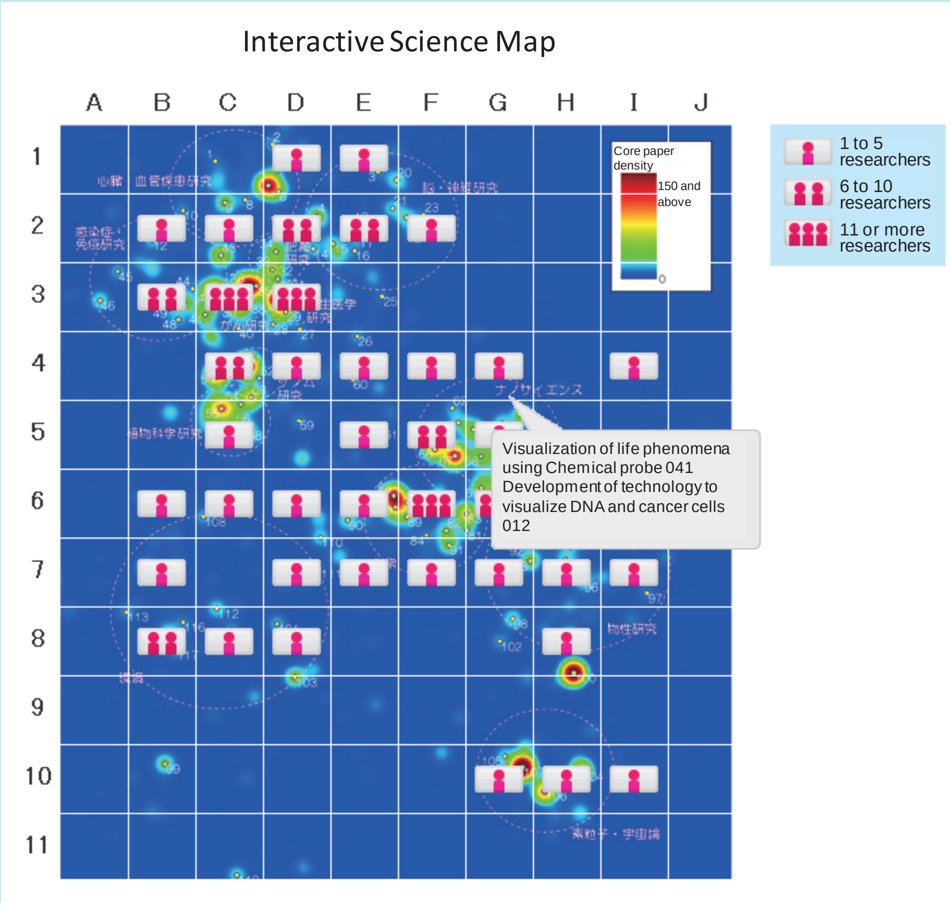
The map created by the combination of the quantitative approach which is the result of scientific paper analysis and the qualitative approach based on the feeling of researchers is called “an interactive science map” (See Reference figure 4). Specifically, the following questions were asked on the web screen. [See Part II 4. An attempt of Interactive Science Map]

[Creation of interactive science map: Operation is performed on the web screen]

For Science Map 2008, the scientific papers published from 2003 through 2008 were used. Because science advances day by day, the map is considered to represent a near-past status. Therefore, by collecting the current and near-future information from researchers, we would like to fill the gap caused by the time difference and create an interactive science map. According to the following procedure, please provide answers regarding research areas that are now rapidly attracting attention and the research areas that are expected to make a move in the next few years. At the same time, please add the location information of the research areas in the Science Map.

- *Icons can be placed at up to three locations.*
- *Select a desired location using the vertical and horizontal axis and enter a research area name and key words (in English). By clicking "register," an icon is added to the map in real time.*
- *By placing a mouse on the icon, its research area name and the ID of the research area you are in charge of are displayed. You can also check the answers of other researchers in real time.*

Reference figure 4 Interactive Science Map



2-4 Points to bear in mind regarding research areas obtained with the Science Map

The research areas in the Science Map were obtained through a process that includes the extraction and clustering of highly-cited papers. The results therefore depend on what kind of scientific papers were compiled in the database and on the threshold value used for clustering. Thus, when using the results reported here, the following two points should be borne in mind.

(i) Some fields are very active in terms of publishing research results in the form of scientific papers, but other research areas focus on applied development and publish few papers. The maps obtained through this study therefore cannot provide a comprehensive overview of science as a whole.

(ii) This study examined trends over the past few years for research areas that have reached a certain number of published scientific papers. Research areas in which change is very rapid or that are small in scale therefore may not have been captured by this study.

3. Dynamism of Scientific Research Seen in the Science Map

3-1 Overview of the Science Map 2008

(1) List of hot research area

For Science Map 2008, the 121 hot research areas shown in Figure 1 were derived. The content of individual hot research areas is shown in Part II.

Figure 1 List of hot research areas

ID	Research Area	ID	Research Area
1	Critically ill patient management (Particularly in cases of acute respiratory distress syndrome)	32	Metabolism control through PGC-1α and insulin resistance
2	Effects and prognostics of device therapy for advanced heart failure	33	Genetic epidemiologic research on complex genetic disease
3	Medical therapy for neuropathic pain and fibromyalgia syndrome	34	Elucidation of pathogenic mechanism of lifestyle-related diseases resulting from obesity
4	Physiological function of endogenous cannabinoid system in central nervous system	35	Development of drug therapy/genome sequencing technology for breast cancer
5	Clinical research on the control of cardiovascular incidents by antihypertensives and their impacts on diabetes	36	Molecular biological approach to human malignancies
6	Coronary CT (computed tomography)	37	Multiple myeloma/new medicament
7	Treatment of acute coronary syndrome using antiplatelet drugs	38	Research on the development of molecular targeting anticancer drugs including HDAC inhibitors
8	Research on adverse effect of COX inhibitors	39	Activation of tyrosine kinase and its drug resistance
9	Mineral and bone metabolism disorders in chronic kidney disease	40	Role of ubiquitin modification system in NF-kB activation
10	Prostate cancer/endocrine therapy/radiotherapy/effect and adverse effect	41	Production of interferon by innate immunity
11	Pathological condition and treatment of bronchial asthma	42	Differentiation mechanism of T cell subsets and their role in disease
12	Clinical research on early diagnosis, prevention and treatment of deep mycosis	43	Control of autoimmune disease by immunoregulatory mechanism of biological drugs
13	Effect and adverse effect of hormone replacement therapy (HRT)	44	NK cell receptor and its ligand that inhibits activation
14	Research on physiological role of peptide hormone in the brain	45	Development of human papillomavirus vaccine
15	Molecular mechanism of the onset of Alzheimer's disease and the development of ways to prevent and treat the disease	46	Development of drug resistance in Staphylococcus aureus and ways to cope with it
16	Clinical research for Parkinson's disease	47	Process of early infection with Hepatitis C virus and its treatment
17	Neurogenesis in adult hippocampus (the understanding of phenomena and the development of clinical application)	48	Control of HIV infection
18	Genetic research on schizophrenia and molecular pathogenesis investigations developed from the research	49	Research on anti-HIV drugs
19	Brain-derived neurotrophic factor/brain morphology in schizophrenia/mood disorder	50	Network science
20	Clinical research on treatment of schizophrenia and bipolar disorder	51	Gene silencing/plant hormone
21	Molecular neuroscience of emotion and its pathological conditions	52	Redox control
22	Research on higher brain functions unique to humans using functional brain imaging	53	Environmental responses of plants/metabolome analysis/proteome analysis
23	Brain neural mechanisms for decision-making	54	Mechanisms for generation of nitric oxide in plants and its physiological role
24	Neural mechanisms for emotion/empathy and imitation/context	55	Defense mechanism of plants against infection
25	Molecular mechanisms for excitatory synaptic plasticity	56	Plant-microorganism interactions/strigolactones
26	Biological implication of protein aggregation from the viewpoint of common denominators in transmissible aggregate "prion" and amyloid-like	57	Plant developmental genetics/carbohydrate metabolism
27	Hydroxylation modification of HIF and HIFα and regulation of mitochondrial function	58	Microorganism ecosystem
28	Molecular mechanism of apoptosis (cell death)	59	Systems biology/synthetic biology
29	Role of autophagy in health and disease	60	Structure and functions of G-protein-coupled receptor
30	Research on regenerative medicine and stem cells	61	Analysis of dynamic behavior of proteins
31	Research on aging-suppression and longevity-control factors in individual and organ stem cells	62	Microchannel device

Data: Tabulated by the National Institute of Science and Technology Policy based on Thomson Reuters' "Essential Science Indicators."

List of hot research areas (Continued)

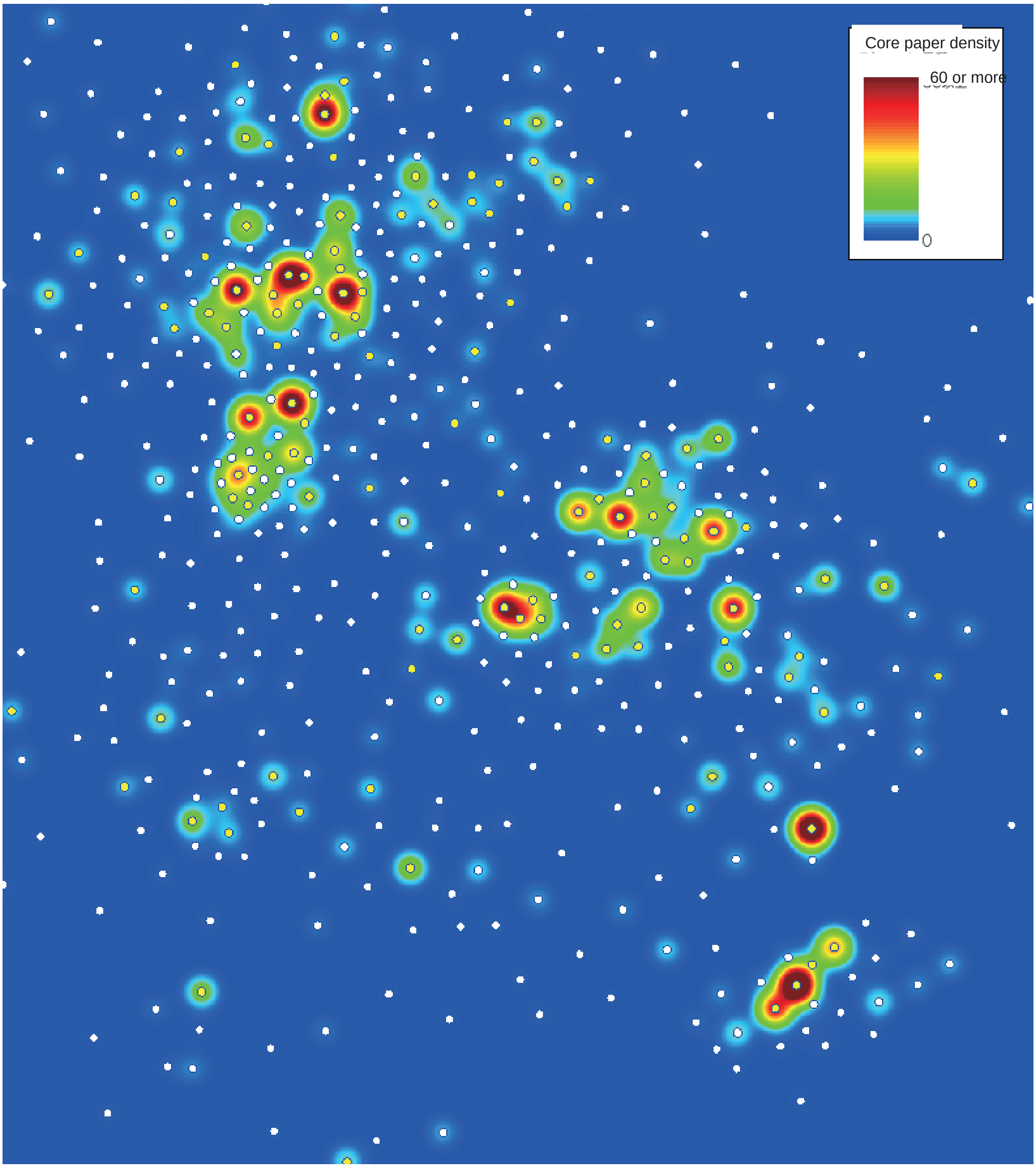
ID	Research Area	ID	Research Area
63	Semiconductor-spintronics material/magnetic semiconductors	94	Optical quantum information/communication, optical nanoscience
64	Research on creation and application of nanofibers	95	Qubits using semiconductor quantum dots/electronic charge, electron spin and nuclear spin
65	Development of nanostructure using nucleic acid	96	Quantum information science using atomic system/photons
66	Living radical polymerization/click reaction/molecular machine	97	Novel electronic order in high-temperature superconductivity
67	Synthesis, function and toxicity of sensors/SWNTs/functional DNAs/nanoparticles, etc.	98	Ultrafast and ultraintense optical science
68	Bioapplications of gold nanorods	99	Limitation and application to signal processing/information theory using "sparse" property of source
69	High-efficiency electroluminescence (EL) element	100	Strongly interacting quantum many-body system
70	Superhydrophobic surface	101	Studies on the evolution of air and living organism in early earth and its analytical approach
71	Mesoporous material/silica, carbon and metal oxide	102	New technologies related to solid oxide fuel cell (SOFC)
72	Nanomaterial synthesis in ionic liquid/hollow and mesoporous material	103	Earth in the Precambrian era
73	Ionic liquid	104	Gauge/gravity theory correspondence and black hole solutions
74	Development materials from carbonate following the examples of nanocarbons and living organisms	105	Gamma‐ray burst
75	Organic/organic-oxide semiconductors　Photo- and electro-functional materials and elements	106	Elementary particle physics/elementary particle astrophysics
76	Solid macromolecule type fuel cell	107	New developments in cosmology and elementary particles theory owing to advancement in precise observation of space
77	Formation of bulk metallic glass/transformation of metal glassy alloys	108	Emergence process of Homo sapiens
78	Ferroelectric property in new materials such as multiferroics, etc.	109	Warming impact/bio- and eco-systems
79	Metal-based spintronics	110	Environmental chemistry of bromine flame retardant
80	Physics and chemistry of molecular substance	111	Environmental burden of drugs and other industrial chemicals and technologies to reduce the burden
81	Nanochemistry of gold	112	Organic aerosol
82	New-generation density functional theory for large-scale molecular calculation	113	Observational studies on carbon balance in continental ecosystem
83	Design and functions of configurational space and coordination lattice	114	Stability discrimination/stabilizing control of delay system using matrix inequality
84	Research on hydrogen bonding	115	Atmospheric composition and minor constituents
85	Anion sensors	116	Climate change simulation including aerosol effects
86	Catalytic asymmetric synthesis	117	Sea level fluctuations/seawater density/ice sheet/water circulation
87	Molecular conversion reaction using transition metal catalyst	118	Restoration of the past global environmental change
88	Synthesis of N-Heterocyclic carbene (NHC) and its application to catalytic reactions	119	Corporate governance
89	Direct carbon bond formation through transition metal catalytic reactions	120	New asymptotic expansion method for nonlinear differential equation and its application
90	Microbial fuel cells/microbial cells/enzyme-based biofuel cells	121	New trends in economic geography - Evolutionary economics and relational logic -
91	Complex hydrides associated with hydrogen production and storage and fuel cells		
92	Electromagnetic response of surface plasmon in artificial structures		
93	Meta material		

Data: Tabulated by the National Institute of Science and Technology Policy based on Thomson Reuters' "Essential Science Indicators."

(2) Research Area Correlation Map

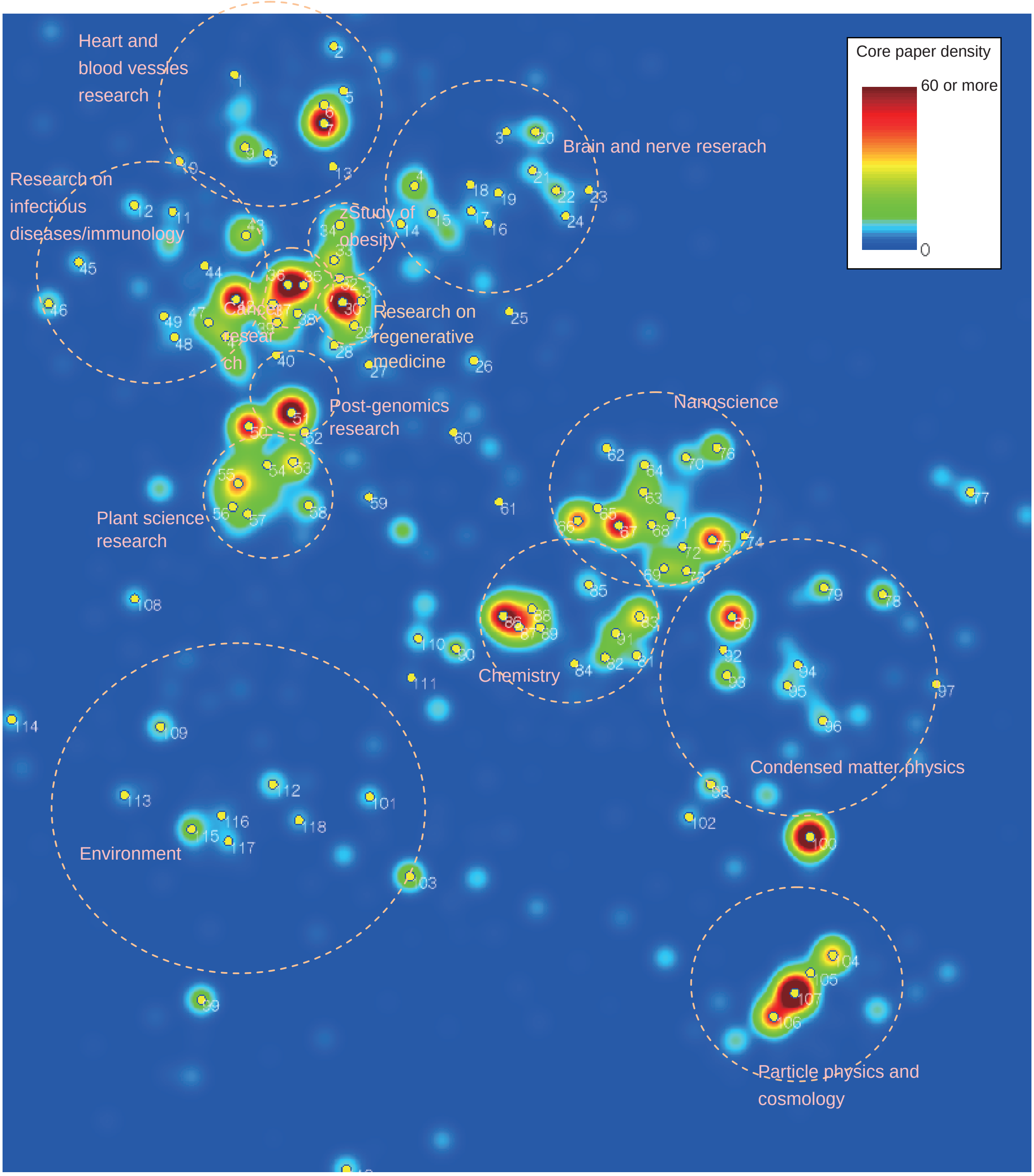
Figure 2 and Figure 3 are Research Area Correlation Maps. The unit of visualization is research areas. The stronger the degree of co-citation, the closer together the research areas are on the map.

Figure 2 Research Area Correlation Map (showing the positions of all research areas)



Note 1. Because a gravitational model was used to create this map, up-down and left-right have no meaning; relative position carries the meaning. In the map, life science happens to be positioned at the upper left and particle physics/cosmological research at the lower right.
Note 2. Yellow dots indicate the positions of hot research areas, and white dots the center positions of quasi-hot research areas.
Note 3. This map was created through a four-step process. 1) Determine the location of each research area according to the strength of co-citation relationships with the other research areas. 2) Express the position of each research area with a dot, and establish hypothetical spreads for research areas. 3) Divide that map into a certain micro area, calculating core-paper density (number of core papers divided by the mesh area) for each micro area. 4) Based on these values, assign colors.
Data: Tabulated by the National Institute of Science and Technology Policy based on Thomson Reuters' "Essential Science Indicators."

Figure 3 Research Area Correlation Map (showing the positions of hot research areas only)



Note 1. The yellow circles indicate the center locations of hot research areas. The numbers next to the yellow circles are the hot research areas' ID numbers.
Note 2. Some research areas (ID119, 120 and 121) with few co-citations with other research areas are so far from the center of the map that they are not included above.
Data: Tabulated by the National Institute of Science and Technology Policy based on Thomson Reuters' "Essential Science Indicators."

In Research Area Correlation Map, all 647research areas derived from clustering scientific papers were mapped and analysis of the map was conducted. The aim of showing 121 hot research areas is to clarify the position of the hot research areas within scientific research as a whole. The yellow circles in Figure 2 indicate the positions of hot research areas, while the white circles indicate the center position of quasi-hot research areas. Because showing all 647 research areas on the Science Map would make it overly complex, in this report, only the positions of 121 hot research areas are shown on maps, as in Figure 3 Gradations in the map correspond to the density of core papers. Warm colors represent greater concentrations of core papers, with colors becoming cooler as the density of core papers decreases.

From the Correlation Map, one can see that the 121 hot research areas divide into groups of research areas (research area groups), and that groups are interrelated. The research areas at the lower right of the Correlation Map are related to particle physics/cosmology. The group of research areas related to condensed matter physics spreads out above them. There are two groups of research areas at the center of the Correlation Map. The group of research areas related to nanoscience is at the center-right, and the group of research areas related to chemistry at the center left. To the left and below chemistry is the group of research areas related to environmental research. Unlike the group of research areas related to chemistry that concentrate close together, this group is spread out on the map.

Groups of research areas related to life science are at the upper left of the Correlation Map. The lowest of these groups and the closest to the group of chemistry is plant science research. Above it spreads post-genomics, with linkage to research on infectious diseases/immunology, cancer research, study of obesity, regenerative medicine research and brain research. At the top is the group of research areas related to research on heart and blood vessels. Post-genome research forms a bridge between plant science research, where the research subject is plants, and cancer research, study of obesity, and so on, where it is animals.

(3) Characteristic of areas on the Research Area Correlation Map with high core-paper density

The Research Area Correlation Map shown in Figure 2 can be regarded as depicting an aerial map with accumulations of core papers forming mountains of science on the land. On the Research Area Correlation Map, areas with red gradation are those with high core-paper density. Core-paper density is high in research areas and groups of research areas in which many hot (highly-cited) scientific papers are published and frequently co-cited. This is characteristic of all parts of the map with high densities.

The isolated location of the particle physics/cosmology group on the map is attributable to its core papers being cited only by citing papers in a limited number of fields. Particle physics/cosmology has ultimate goals such as structuring a unified field theory and understanding the origin of the universe, and experimental and theoretical research have co-evolved over time in deep entanglement. There is thus a tendency towards co-citation among specific scientific papers and research areas, resulting in a relatively narrow distribution for the group of research areas on the map. Because co-citation with research areas other than particle physics/cosmology is limited, even in time series, the peaks of particle physics/cosmology will probably change little, and core papers will remain concentrated.

The situation is different for the group of research areas related to life science. The subjects of life science research are diverse (plants, animals, fungi, etc.), as are its approaches (i.e., the molecular, cellular, organ, and individual level). Thus, widely diverse themes can be set and joined in complex combinations to advance understanding of nature.

This makes it possible for research areas that have developed separately to link, for research areas to shift, and for new research areas to appear as science advances. There is therefore no need for the core papers to concentrate in a specific region the way those of particle physics/cosmology do.

Furthermore, citation of life science related scientific papers begins sooner after publication than with other fields. In other words, the process of research area formation is more volatile. A snapshot of a given time such as the Science Map should therefore enable one to view research areas in various phases of development. In fact, on the Research Area Correlation Map that plots 647 research areas (Figure 2), the majority of research areas are observed in the life science related region, indicating the variety of its research themes.

Thus, although high core-paper density is shown in red is seen for both life science and particle physics/cosmology on the Research Area Correlation Map, the characteristic of their peaks differs.

<Visualization Method for Research Area Correlation map>

Ordinarily, mapping obtains only the center positions of research areas. There is therefore some arbitrariness in how to depict the breadth of individual research areas on the map. On the Individual Research Area Maps, the breadth of research areas is expressed using the radiuses of circles.

Research area breadth on the Research Area Correlation Map in this report is expressed using a Gaussian function. This has two factors. The first factor is the design-based decision to analogize the map with topographical maps, as described in the main text. The second factor is a technical issue involving the use of circles. Because the maximum number of core papers in a research area divided by the minimum number is on the order of 10^2, it is difficult to use circles to express size on a map.

In concrete terms, research areas' core papers were distributed in terms of a Gaussian function, centered on positions found with a mapping program. Core paper distribution in the Science Maps is expressed by superposing the Gaussian function obtained for each research area ρ (x, y) (the 647 research areas in Science Map 2008). The value of ρ (x, y) integrated for all surfaces is the total number of core papers.

For actual visualization, in order to express the distribution of core papers on a two-dimensional plane by using computers, the Science Map was divided into micro areas $dx \times dy$. Next, the number of core papers included in a micro area were counted, and core paper density (number or core papers/($dx \times dy$)) was calculated to approximate ρ (x, y). For the Research Area Correlation Map, colors were determined in accordance with the core-paper density in each micro area.

3-2 The dynamics of scientific research as glimpsed through the Science Map

(1) Changes in the Science Map over time

Figure 6 are Research Correlation Maps depicted over time from 2002 through 2008. A comparison of time-series Science Maps indicates that the height and positions of the mountains formed by research area groups are changing. To quantify this phenomenon to some extent, cells of the map were used to calculate the number of papers in a cell in an attempt to capture the changes (Figure 4). This allows the comparison of positions on the map over time, as described in the survey method.

Figure 4 Quantification of changes in the Science Map over time

Map squares	Main research area groups located	Science Map 2002	Science Map 2004	Science Map 2006	Science Map 2008
	Number of core papers in all research areas	15410	15531	15165	15826
A1-J11	Number of core papers included in the map	14655	14821	14452	14986
		95.1%	95.4%	95.3%	94.7%
A1-F3, A4-E4, A5-D5	Life science	7614	7281	6831	6875
		49.4%	46.9%	45.0%	43.4%
F5-G6	Nanoscience/chemistry	1979	2287	2353	2207
		12.8%	14.7%	15.5%	13.9%
E4-I7	In the vicinity of nanoscience and chemistry	3481	3668	3899	4129
		22.6%	23.6%	25.7%	26.1%
G6-I7	Condensed matter physics	1739	1342	1425	1619
		11.3%	8.6%	9.4%	10.2%
G8-I9	Condensed matter physics and particle physics/cosmology	150	344	682	906
		1.0%	2.2%	4.5%	5.7%
G10-I11	Particle physics/cosmology	1376	1436	1212	1200
		8.9%	9.2%	8.0%	7.6%
A6-D9	Environment	1185	1172	1006	1048
		7.7%	7.5%	6.6%	6.6%

Data: Tabulated by the National Institute of Science and Technology Policy based on Thomson Reuters' "Essential Science Indicators."

In the Science Maps from 2002 through 2008, the numbers of core papers and the total numbers of core papers on the map mostly remain unchanged. However, in the region consisting of 27 cells from A1to F3, from A4 to E4 and from A5toD5, where many of research areas related to life science are mainly located, the ratio of the number of scientific papers included in this region to the total number of scientific papers decreased to 43.4% in 2008 from 49.4% in 2002.

Next, let us turn our attention to the four cells from F5 to G6. In the Science Map 2008, this is the region where the group of research areas related to nanoscience and chemistry is located. Comparison of the time-series maps shows that the research area group related to chemistry which was close to nanoscience in the Science Maps from 2002 through 2006 moved to the position (E-6) some distance from nanoscience, and the research area group of nanoscience itself also increased its spread. It is the region with significant changes. From the quantitative viewpoint, however, although the percentage of core papers increased in the

Science Maps from 2002 though 2006, it decreased in 2008. This is the result of the impact from the shift of the research area group related to chemistry.

Furthermore, a slightly broader calculation was made for the 20 cells from E4 to I7. This region includes part of research on chemistry, condensed matter physics and life science, each located close together (i.e., high degree of co-citation) centering around nanoscience. One can see that the number of core papers increased steadily starting from Science Map 2002, indicating the possibility that the research in the neighboring area was stimulated by the qualitative change in the research content of nanoscience and produced the increase in the amount of research.

Changes in the relationship were also observed in the map between condensed matter physics and particle physics/cosmology, so the number of scientific papers was calculated by dividing the map into cells. The region consisting of the six cells from G8 to I9 is located between condensed matter physics and particle physics/cosmology, where the number of scientific papers is increasing steadily since the Science Map 2002. On the other hand, although the number of scientific papers for particle physics/cosmology from G10 to I11 has decreased, the total number of scientific papers in the 18 cells from G6 to I11 where the research areas related to condensed matter physics and particle physics/cosmology are scattered about tends to increase.

Next, changes in the percentage of the core papers in the 22 fields which comprise all research areas in the map were analyzed (Figure 5). Compared to the aforementioned method that analyzes which areas saw an increase in the amount of scientific papers based on positions on the map, the method here can find out on which fields core papers are more likely to place their focus. Comparison of the number and percentage of core papers in life science and in the fields other than life science shows that the core papers in life science has a higher percentage in the Science Map 2002, but in and after the Science Map 2004, the percentage of core papers in the fields other than life science is higher and this trend is growing.

Figure 5 Percentage of the 22 fields of core papers that comprise all research areas in the Science Map

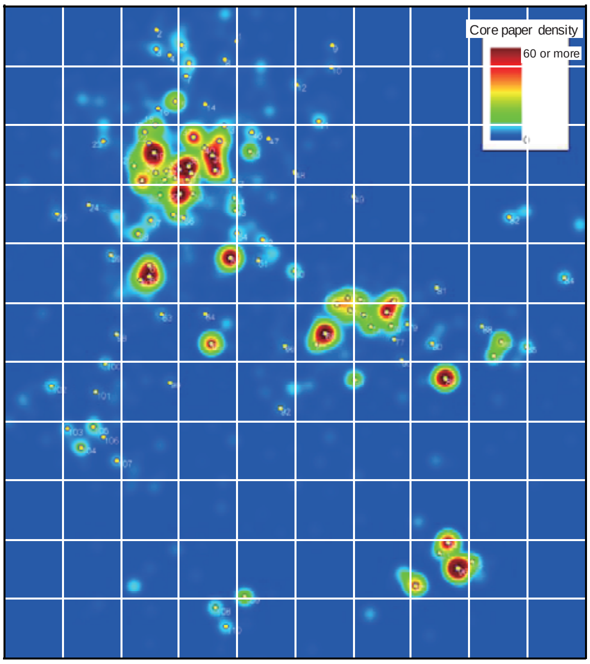
	All research areas in Science Map 2002	All research areas in Science Map 2004	All research areas in Science Map 2006	All research areas in Science Map 2008
Agricultural Sciences	111	131	56	106
Biology & Biochemistry	992	963	763	713
Chemistry	2245	2353	2286	2376
Clinical Medicine	3402	3471	3351	3458
Computer Science	122	157	335	350
Economics & Business	152	166	109	125
Engineering	735	729	730	971
Environment/Ecology	293	322	309	364
Geosciences	392	395	381	503
Immunology	310	287	254	259
Materials Science	494	545	606	597
Mathematics	139	155	142	218
Microbiology	291	247	319	289
Molecular Biology & Genetics	663	563	494	555
Inter-/Multi-disciplinary Research Areas	69	63	36	27
Neuroscience & Behavior	633	457	432	444
Pharmaceutical Science/Toxicology	175	134	134	103
Physics	2395	2644	2692	2742
Plant & Animal Science	1008	923	979	849
Psychiatry/Psychology	150	195	234	233
Social Science, general	323	304	193	177
Space Sciences	316	327	330	367
Total	15410	15531	15165	15826

Number of core papers in life science	7735	7371	7016	7009
Number of core papers other than life science	7675	8160	8149	8817
Percentage shared by life science	50.2%	47.5%	46.3%	44.3%
Percentage shared by fields other than life science	49.8%	52.5%	53.7%	55.7%

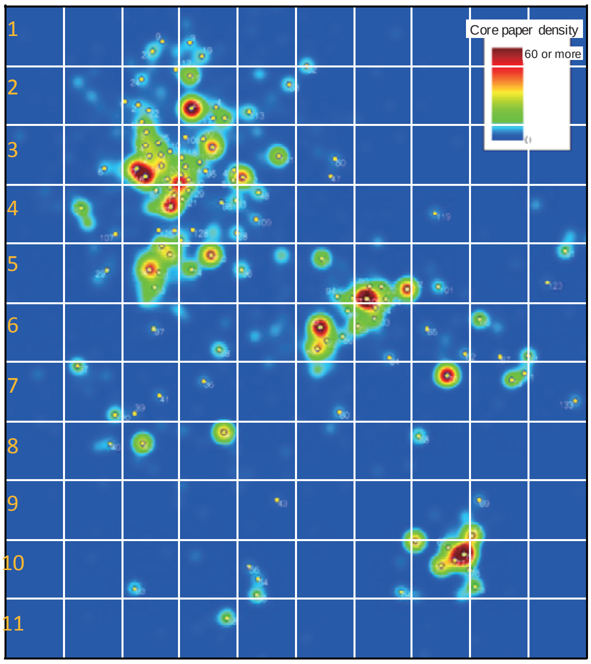
Note: In the table, colored fields indicate life science.
Data: Tabulated by the National Institute of Science and Technology Policy based on Thomson Reuters' "Essential Science Indicators."

Figure 6 Science Map 2002-2008

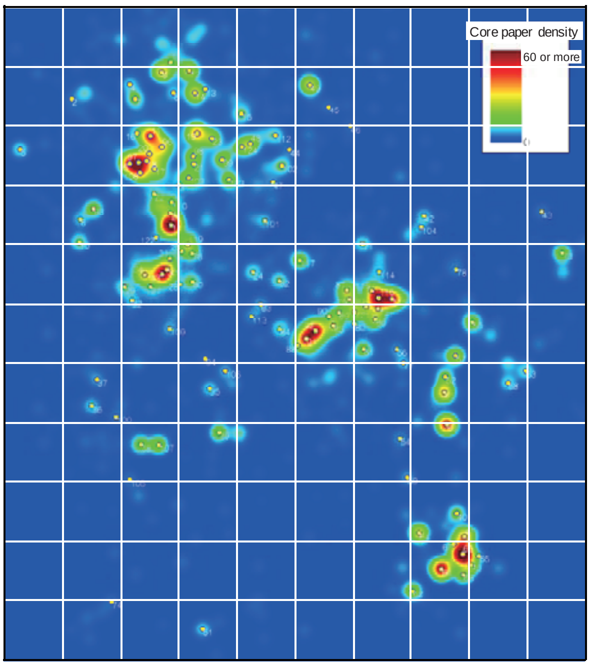
(A) Science Map 2002



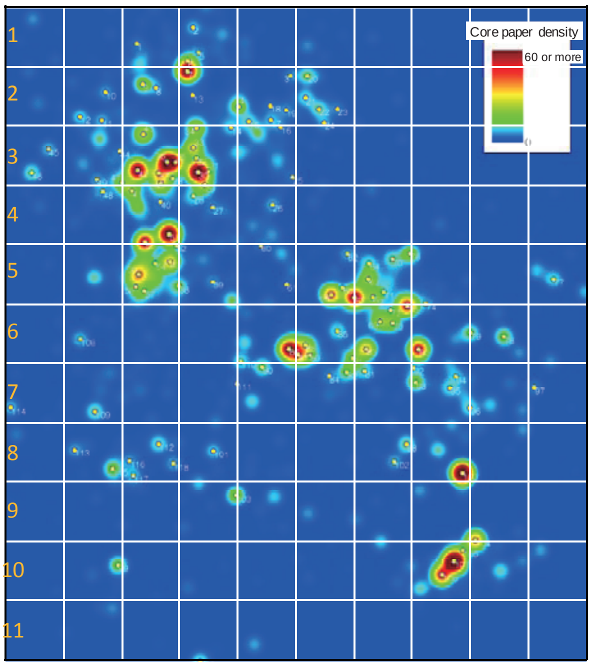
(B) Science Map 2004



(C) Science Map 2006



(D) Science Map 2008

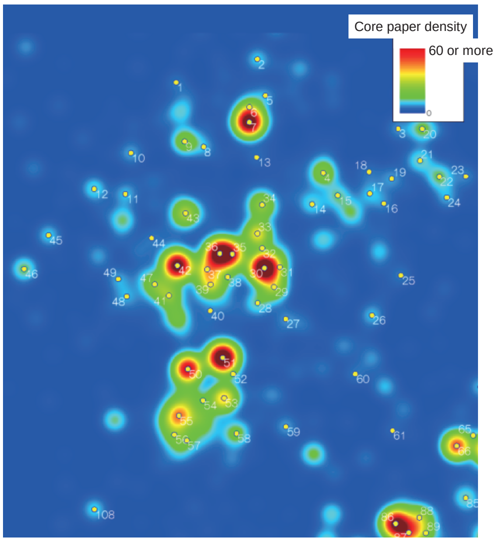


Note: The yellow circles indicate the center location of hot research areas. The numbers next to the yellow circles are the hot research areas' ID numbers.
Data: Tabulated by the National Institute of Science and Technology Policy based on Thomson Reuters' "Essential Science Indicators."

(2) Life science

Although the range of distribution of the group of life science research areas in the Science Map as a whole tends to decrease (Figure 4) in terms of the number of scientific papers, the research areas show active changes. The changes that took place are described together with the results of the Science Map 2008, a questionnaire survey on experts who conducted content analysis and the interactive map.

Figure 7 Science Map 2008 (expanded view of life science and list of research areas: A1-F5)



ID	Research Area	ID	Research Area	ID	Research Area
1	Critically ill patient management (Particularly in cases of acute respiratory distress syndrome)	21	Molecular neuroscience of emotion and its pathological conditions	41	Production of interferon by innate immunity
2	Effects and prognostics of device therapy for advanced heart failure	22	Research on higher brain functions unique to humans using functional brain imaging	42	Differentiation mechanism of T cell subsets and their role in disease
3	Medical therapy for neuropathic pain and fibromyalgia syndrome	23	Brain neural mechanisms for decision-making	43	Control of autoimmune disease by immunoregulatory mechanism of biological drugs
4	Physiological function of endogenous cannabinoid system in central nervous system	24	Neural mechanisms for emotion/empathy and imitation/context	44	NK cell receptor and its ligand that inhibits activation
5	Clinical research on the control of cardiovascular incidents by antihypertensives and their impacts on diabetes	25	Molecular mechanisms for excitatory synaptic plasticity	45	Development of human papillomavirus vaccine
6	Coronary CT (computed tomography)	26	Biological implication of protein aggregation from the viewpoint of common denominators in transmissible aggregate "prion" and amyloid-like aggregate.	46	Development of drug resistance in Staphylococcus aureus and ways to cope with it
7	Treatment of acute coronary syndrome using antiplatelet drugs	27	Hydroxylation modification of HIF and HIFα and regulation of mitochondrial function	47	Process of early infection with Hepatitis C virus and its treatment
8	Research on adverse effect of COX inhibitors	28	Molecular mechanism of apoptosis (cell death)	48	Control of HIV infection
9	Mineral and bone metabolism disorders in chronic kidney disease	29	Role of autophagy in health and disease	49	Research on anti-HIV drugs
10	Prostate cancer/endocrine therapy/radiotherapy/effect and adverse effect	30	Research on regenerative medicine and stem cells	50	Network science
11	Pathological condition and treatment of bronchial asthma	31	Research on aging-suppression and longevity-control factors in individual and organ stem cells	51	Gene silencing/plant hormone
12	Clinical research on early diagnosis, prevention and treatment of deep mycosis	32	Metabolism control through PGC-1α and insulin resistance	52	Redox control
13	Effect and adverse effect of hormone replacement therapy (HRT)	33	Genetic epidemiologic research on complex genetic disease	53	Environmental responses of plants/metabolome analysis/proteome analysis
14	Research on physiological role of peptide hormone in the brain	34	Elucidation of pathogenic mechanism of lifestyle-related diseases resulting from obesity	54	Mechanisms for generation of nitric oxide in plants and its physiological role
15	Molecular mechanism of the onset of Alzheimer's disease and the development of ways to prevent and treat the disease	35	Development of drug therapy/genome sequencing technology for breast cancer	55	Defense mechanism of plants against infection
16	Clinical research for Parkinson's disease	36	Molecular biological approach to human malignancies	56	Plant-microorganism interactions/strigolactones
17	Neurogenesis in adult hippocampus (the understanding of phenomena and the development of clinical application)	37	Multiple myeloma/new medicament	57	Plant developmental genetics/carbohydrate metabolism
18	Genetic research on schizophrenia and molecular pathogenesis investigations developed from the research	38	Research on the development of molecular targeting anticancer drugs including HDAC inhibitors	58	Microorganism ecosystem
19	Brain-derived neurotrophic factor/brain morphology in schizophrenia/mood disorder	39	Activation of tyrosine kinase and its drug resistance	59	Systems biology/synthetic biology
20	Clinical research on treatment of schizophrenia and bipolar disorder	40	Role of ubiquitin modification system in NF-kB activation	60	Structure and functions of G-protein-coupled receptor
				61	Analysis of dynamic behavior of proteins

Data: Tabulated by the National Institute of Science and Technology Policy based on Thomson Reuters' "Essential Science Indicators."

<New developments in research on regenerative medicine>

To begin with, as a significant change in the Science Map 2008, the very large research area "Regenerative medicine and stem cell research (2008, ID 30)" which includes Dr. Yamanaka's establishment of iPS cells at Kyoto University is seen at position D3. This research area is formed by the fusion of the research areas in the Science Map 2006 namely "Study on regulation of tissue stem cell by extracellular environment and characteristics of cancer stem cell (2006, ID21)," "Biological elucidation and clinical application of damaged tissue repair mechanism (2006, ID23,)" and "Embryonic stem cell/neural induction (2006, ID99)." Although the research on embryonic stem cells was likely to be done by limited research institutions due to the controversy over the implementation of the research in terms of bioethics and so on, the situation changed after research results were reported by Dr. Yamanaka and others. It made it possible for all research institutions to participate in this research, and therefore the competition was expected to intensify. And as expected, the embryonic stem cell research became a research area that drew many researchers and formed a large mountain rising out of the Science Map.

According to the results of a questionnaire survey among experts, this research area group is "an area that has connections with social agenda and has been growing," and the most effective way for the future development is "to implement research focusing on application." Those who are awaiting medical treatments have dreams and expectations for Dr. Yamanaka's report. Researchers also bear in mind the same expectations in implementing their research; therefore, both sides mutually share the same prospect. Also, "enormous amount of collection of data and search of substances on a different order of magnitude from the past" has been pointed out. This is because the development of regenerative medicine using iPS cells requires adaptation to various organs and pathological conditions, and researchers feel the need to effectively collect a vast amount of data of related genes and proteins depending on each case of adaptation process. Furthermore, experts cited research on heart and blood vessels, brain research, cancer research, research on infections diseases and immunology, and post-genome research as groups of research areas with which regenerative medicine should deepen its relationships in order for the research area to develop in the future. Current post-genome research, life science after the sequencing of the genome, requires more efficient and swifter data collection. The ability to mine this data has also become necessary. Based on such ability of data mining, the post-genome research seeks to strengthen relationships with a broad group of research areas in life science as a target of application.

<The advancement of brain research>

The position of brain research shifted on Science Map 2008, in part because of the influence of the new developments in research on regenerative medicine discussed above. Through Science Map 2006, it was firmly within the clinical medicine related groups of research areas in life science, next to cancer research. In 2008, it is a group of research areas spreading towards the upper right, which indicates that brain research has a close relationship with research on regenerative medicine. This also coincides with the fact that experts selected research on regenerative medicine as a research area group with which brain research should strengthen its relationship based on the evaluation that brain research continued with the increase in the amount of research and on the fact that the research existed even before 2002.

In the map's upper left are located neurophysiological research such as "Molecular mechanisms of Alzheimer's disease and development of prevention and treatment (2008, ID 15)" and "Neurogenesis in adult hippocampus (2008, ID 17)," psychiatric research such as "Brain-derived neurotrophic factor/brain morphology of schizophrenia/mood disorders (2008, ID 19)," "Clinical research on treatment of schizophrenia and bipolar disorder (2008, ID20)," and "Molecular neuroscience of emotion and its pathological conditions (2008, ID 21)" and research with neurophysiological and cognitive science aspects such as "Neural mechanisms of emotion, empathy, imitation, and context (2008, ID 24)" and “Molecular mechanisms for excitatory synaptic plasticity (2008, ID 25.)” These three different research approaches are distinctively grouped together.

This group of research areas includes a number of inter-/multi-disciplinary research areas. “Brain neural mechanisms for decision-making (2008, ID 23)” is an area that integrates research related to decision-making mechanisms in brain that have been handled separately by the existing cognitive psychology, neurophysiology, behavioral economics, information engineering, artificial intelligence and so on. Experiment technique and theories accumulated in these fields were organically linked and made a significant advancement. This hot research area includes an attempt to explain neural mechanisms of irrational behavior such as impulsive behavior and dependent behavior using the mathematical models for selecting human behavior which was part of economics. In connection with this, a person working on the economics/business research area (ID 119) responded that “Neuro economics” will rise in the neighborhood of F2 as a research area that is currently drawing much attention and promising a movement over the next few years. It is anticipated that a more distinct research area than it is will be established as an area that fuses humanities and sciences.

Experts consider the “Implementation of research focusing on application” as an effective means to promote research for this research area group. The idea is coupled with the issues that have come under the spotlight including measures to cope with the increase in patients with psychiatric diseases in an increasingly stressful society and the improvement of quality of life. Experts also pointed out the “Innovative metrological and measurement technology that exceeds the current limitations” as an effective way to advance research. As seen in “Research on higher brain functions unique to humans using functional brain imaging (2008, ID22)” in the Science Map 2008, the research on the relationship between psychological functions and brain areas of humans using noninvasive functional brain imaging advanced since the latter half of the 1980s, which allowed access to the higher brain functions that are unique to humans. It is the advancement of metrological and measurement technology that made possible this kind of approach and this is the reason that this technology is valued as an effective tool for promoting research in this research area.

As a research area which is currently drawing much attention and promising movement over the next few years, experts listed research that fuses optics and genetics in the E2 region in the map, such as “Elucidation of brain functions through optogenetics.” In addition, experts listed “Brain genome diversity,” and “Genome analysis for psychiatric diseases” in the D4 region, location of which is not in the brain research region but in the post-genome research region. This suggests that, following the Science Map 2008, this group of research areas will promote research through the exploration of innovative metrological and measurement technology and use knowledge and approaches from different fields.

<Present situation and future of plant science research>

Next, let us turn our attention to plant science research, which addresses mainly plants and fungi. Four research areas were extracted in the Science Map 2008, which is a decrease from eight research areas in the previous Science Map 2006. The analysis of the research area track from the past shows that “Defense mechanism of plants against infection (2008, ID55)” was extracted every time since the Science Map 2002 and is a unique research area that has not changed its position in the map. Although changes in research content within each of hot research areas are confirmed, the movement of plant science research as a whole is small compared to other groups of research areas in life science. However, under this situation, not only U.K. and Germany present a high share of scientific papers, but also China, as in the Science Map 2006, increased its share of scientific papers in the Science Map 2008, although the amount of share itself is low

(See Part II “6. Changes in shares of scientific papers of major countries over time shown on the Science Map”). So this trend bears watching.

Experts consider the “Implementation of research focusing on application” an effective means to promote research, and list post-genome research and environment as the research area groups with which plant science research should strengthen its relationship. As is confirmed on the map, the relationship with post-genome research is also strong at present, suggesting that the research group focuses primarily on research on environment as an application (exit), while keeping the relationship with post-genome research.

<The position of post-genome research in the life science research>

Looking at life science as a whole in Science Map 2004 and Science Map 2006, in Science Map 2006, its research areas are laid out vertically like a backbone. This is because post-genome research is in a position bridging plant science research that focuses mainly on plants and fungi and heart and blood vessels research, brain research, study of obesity, cancer research, and research on infectious diseases/immunology that focus mainly on studying animals and fungi. In more specific terms, although “Research on epigenetic transcriptional regulation (2004, ID130)” and “Analysis of mechanism and regulation of plant growth (2004, ID33)” were extracted as independent hot research areas in Science Map 2004, they fused to form “Multi-hierarchical regulatory mechanism of life phenomena (2006, ID111)” in Science Map 2006 and built bridges between research area groups. In Science Map 2008, a change that looks like dividing the research on animals and plant/fungi into two was observed, which is regarded as if the bridge between the two disappeared. However, looking at the network among research areas, “Gene silencing/plant hormones 2008, ID51” has a function as a strong hub. This indicates that post-genome research including ID51 is a core research area group in connecting research on animals and research on plants/fungi to continue advancing the understanding of life.

Interestingly, “Network science (2008, ID50)” appears near post-genome research. Since around 2000, common characteristics observed in the phenomena that can be expressed using networks are being revealed, and analysis of various networks using these characteristics and the application of its findings to real world are advancing rapidly. The appearance of network science at this position in the map indicates the progress of the research that considers the network of mutual interactions between proteins, molecules, chemical drugs and so on based on the large amount of information that has been accumulated for each single item by post-genome research. ID50 is an inter/multi-disciplinary research area that formed a research area from the standpoint of network and expands to a broad range of fields including life science, engineering, medicine and others, and is therefore expected to change the platform of post-genome research.

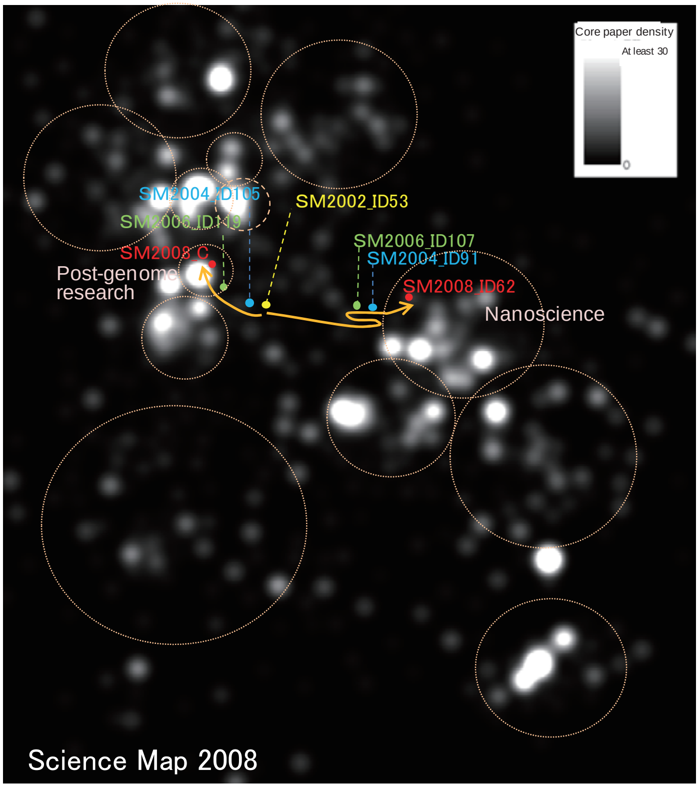
Researchers of life science most often cite post-genome research as a group of research areas that should deepen its relationship to life science for the future development of research. On the other hand, researchers involved with post-genome research consider “active utilization of knowledge from other fields” a most effective means to develop research and list nanoscience and environment as research groups with which post-genome research should strengthen its relationship. Therefore, it is predicted that post-genome research will also take the role of bridge builder in the future which connects post-genome research with other research area groups, while maintaining the role as a hub of life science.

<The relationship between life science and nanoscience>

In Science Map 2008, the space between life science and nanoscience is dotted with research areas such as “Hydroxylation modification of HIF and HIFα and regulation of mitochondrial function (2008, ID27)” and “Structure and functions of G-protein-coupled receptor (2008, ID60).” Although the distribution of research areas is not dense, that space is the location of research areas that play an important role in linking life science and nanoscience.

Science Map 2002's ID 53 began intermediate between life science and nanoscience. The research area has split towards both life science and nanoscience during its continuous development. Figure 8 shows the trajectiries of ID53. Looking at its trajectries towards life science, it has been "Research on proteome (2004, ID 105)" and "Isotope labeling/quantitative mass spectrometry/protein analysis (2006, ID 119)." In Science Map 2008, it is not a hot research area, but it was still derived as a research area. It is located near "Gene silencing/plant hormones (2008, ID 51)" at the center of Post-genome research. In its evolution in the direction of nanoscience, it has been in that group continuously, with "Chemical-/bio-system with microchips (2004, ID 91)," "Micro-bio system and micro chemical system (2006, ID 117)," and "Microchannel devices (2008, ID 62)." Originally an area of life science research, the exhaustive study with ultra-micro, rapid, and highly sensitive analysis used for research such as DNA and protein sequencing became mainstream. Many microchip systems were developed as ways to achieve this. They divided into a trend to use these systems for research to understand life and a trend to develop applications to apply microchannel devices to physical manipulation of liquid drops, chemical reaction control, highly functional emulsion and production of functional microparticles and bioanalysis methods such as single-cell analysis. The effect has been to accelerate research in both life science and nanoscience.

Figure 8 The trajectries of Science Map 2002 ID 53, which was intermediate between life science and nanoscience



Science Map	ID	Research Area
2002	53	-
2004	105	Research on proteome
2006	119	Isotope labeling/quantitative mass spectrometry/protein analysis
2008	C	
2002	53	-
2004	91	Chemical-/bio-system with microchips
2006	117	Micro-bio system and micro chemical system
2008	62	Microchannel devices

Note: Research area locations are indicated by circles. Yellow circles: Science Map 2002; blue circles: Science Map 2004; green circles: Science Map 2006, red circles: Science Map 2008. ID numbers refer to hot research areas. Those marked with "C" are quasi-hot research areas and thus have no ID and no research area name.

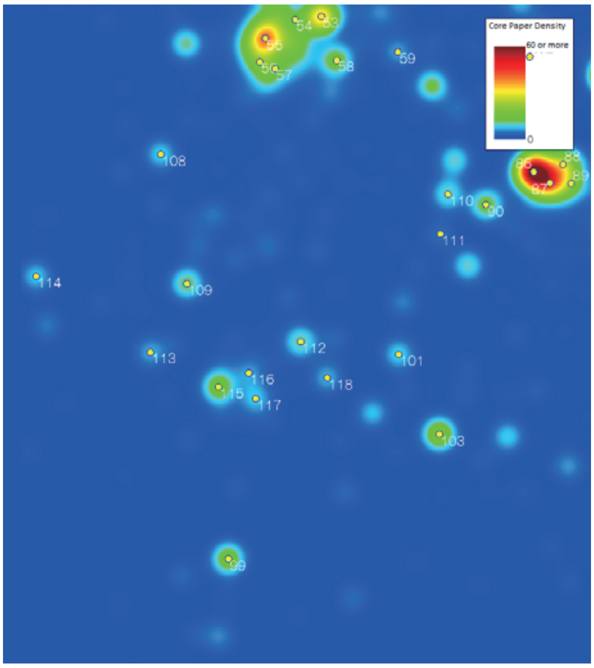
According to the responses from experts regarding research areas that are currently drawing much attention and promising movement over the next few years, research areas that consider life science as the target of application (exit) are expected to rise, such as “the application of nanofibers to regenerative medicine” in E4 located near the nanoscience research areas, and “the application of biopolymers to medical treatment” in F5. Persons working on life science (Research on infectious diseases/immunology, ID 12 and ID 45) predict the emergence of research areas on “Development of technologies to visualize DNAs and cancer cells” and “Visualization of life phenomena using chemical probe” in the proximity of nanoscience (G4), which suggests the expectations for the spread of research from life science to nanoscience. The emergence of new research areas has also been pointed out: “the development of materials that excel living organisms using an environmentally-friendly process by learning from living organisms” in F5, “the development of functional materials using plant-derived resources” in F6 and “biomimetic nanomachines” in I4, which indicates a trend of applying the findings in life science to nanoscience. Therefore, a stronger two-way relationship between life science and nanoscience is expected in the future.

(3) Environment

The group of research areas in environment in the Science Map is characterized by their scattered distribution and the absence of strong connections among research areas that are observed in other research area groups. This characteristic remains unchanged over time.

The research areas themselves include research that has continued to be in hot research areas since the Science Map 2002. The content of research areas that have continued does not completely remain the same and their positions changed depending on the relationship with other fields, such as “Environmental chemistry of bromine flame retardant (2008, ID110)” in the Science Map 2008 which moved from chemistry to environment and moved back again in the direction of chemistry, and “Environmental burden of drugs and industrial chemicals and technologies to reduce the burden (2008, ID111),” which moved towards the center of environment from the position near life science in environment.

Figure 9 Science Map 2008
(Enlarged view of environment research areas and list of research areas: A6-F9)



ID	Research Area
90	Microbial fuel cells/microbial cells/enzyme-based biofuel cells
101	Studies on the evolution of air and living organism in early earth and its analytical approach
103	Earth in the Precambrian era
108	Emergence process of Homo sapiens
109	Warming impact/bio- and eco-systems
110	Environmental chemistry of bromine flame retardant
111	Environmental burden of drugs and other industrial chemicals and technologies to reduce the burden

ID	Research Area
112	Organic aerosol
113	Observational studies on carbon balance in continental ecosystem
115	Atmospheric composition and minor constituents
116	Climate change simulation including aerosol effects
117	Sea level fluctuations/seawater density/ice sheet/water circulation
118	Restoration of the past global environmental change

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

In Science Map 2008, four hot research areas on fuel cell, to which increased attention is being paid from the environmental point of view, appeared even in regions outside the group of environment research areas. They are "solid macromolecule type fuel cell (ID76)," "Microbial fuel cells/microbial cells/enzyme-based biofuel cells (ID 90), "Hydride chain related to hydrogen production and storage and fuel cells (ID 91)," and "New technologies related to solid-oxide fuel cells (SOFC) (ID 102)." The fuel cell hot research areas have a strong focus on applying their research as environmental technology; however, because of its base research being conducted in a broad range of research area groups such as chemistry, nanoscience and condensed matter physics, these hot research areas are situated in regions outside the group of environment research areas. This indicates that the breadth of research related to environment can be considered broader than the breadth shown in Figure 9.

As a means of developing the group of research areas in environment in the future, experts suggest “the innovative metrological and measurement technology that exceeds the current limitations” and “the collection of data through international cooperation.” This is because environmental research requires the establishment of a worldwide observation network and the collection and analysis of data obtained from that network.

The group of research areas in environment also won the highest number of votes from other research area groups as a group that should deepen its relationship with them in order for research to develop into the future. It was confirmed that the research on environment, post-genome and plant science should strengthen each other’s relationships as a triangular structure. In addition, it has been confirmed that the triangular structure of nanoscience, chemistry and condensed matter physics should strengthen its relationship with environment by way of chemistry. It is predicted that from now on, these six research area groups will be closely linked together centering on environment and produce knowledge.

(4) Chemistry

In Science Map 2008, two hot research areas formed large mountains in the group of research areas in chemistry. One is “Catalytic asymmetric synthesis (2008, ID86),” and the other is “Molecular conversion reaction using transition metal catalyst.” The former is continuing since 2004, the latter since 2002, using transition metal catalyst indicating active research being conducted. Of the two hot research areas, “Molecular conversion reaction using transition metal catalyst (2008, ID87)” is the research area led by Ryoji Noyori, a 2001 Nobel Laureate for chemistry. This asymmetric synthesis using transition metals as catalysts is characterized by high catalytic activity, with minute amounts of platinum or iridium producing large quantities of salvaged materials.

The chemistry group of research areas is characterized by a core of the above-mentioned two hot research areas and its formation by hot research areas while having relationships with other nearby groups of research areas. "Nanochemistry of gold (2008, ID 81)," "New-generation density functional theory for large-scale molecular computing (2008, ID 82)," and "Complex hydrides related to hydrogen production and storage and fuel cells (2008, ID 91)," which are mapped close to nanoscience and condensed matter physics, are new hot research areas on Science Map 2008. The research area of "Microbial fuel cells/microbial batteries/enzyme-based biofuel cells (2008, ID 90)," which is mapped between the chemistry and environment groups of research areas, expanded between Science Map 2006 and Science Map 2008, turning it into a hot research area.

In the hot research areas of chemistry, “Design and functions of configurational space and coordination lattice (2008, ID83)”showed a characteristic movement from Science Map 2002 through Science Map 2008. This hot research area consists of ligand-macromolecule research and research on molecular quantum nanomagnets. They were present as a separate research area from Science Map 2002 through Science Map 2006. In Science Map 2002, the former was observed in the position of nanoscience, the latter in the position of condensed matter physics. Subsequently, these two research areas gradually changed their positions following the trajectries shown in Figure 11 and fused into one hot research area in Science Map 2008.

Experts consider “active utilization of knowledge from other fields” an effective means to bring about a significant progress in the research areas of chemistry in the future. As is observed in the Science Map as well, the group of research areas in chemistry formed while having the relationship with other research area groups such as nanoscience, matching the opinion of the experts. Experts also consider “the enormous amount of collection of data and search of substances on a different order of magnitude from the past” an effective tool for the research areas in chemistry to evolve. Looking at the individual research area map (See Chapter II) for “Catalytic asymmetric synthesis (2008, ID86)” as an example, a number of research fronts are heavily connected together through the co-citation relationship and a diverse range of research is being implemented. As can be seen from this, experts consider that search of enormous amount of substances is necessary in order to discover a high-performance catalyst and a substance that has a new function. On the other hand, chemistry is also characterized by the lowest evaluation received in terms of the effects of “the collection of data through international cooperation.” It was also found that the percentage of the international co-authorship is low in the group of research areas in chemistry. This seems to be associated with a sort of research style in chemistry.

Experts in chemistry consider that the relationship with nanoscience and condensed matter physics should be strengthened in order to further develop the research areas. Many groups of research areas consider chemistry as a research group with which they should deepen their relationship. In more specific terms, experts of cancer research, research on infectious diseases and immunology, nanoscience, condensed matter physics and environment cited chemistry as a research group with which the groups should strengthen their relationship. All experts in chemistry, nanoscience and condensed matter physics think that the groups should tighten their relationship (a triangular structure), and consider the sharing and exchange of each other’s knowledge important for the development of the research areas.

(5) Nanoscience

Fusion of research in different fields is advancing steadily in nanoscience. Looking at the change in the Science Map over time, the group of research areas in nanoscience is expanding its area from Science Map 2002 through Science Map 2008. In Science Map 2002, the groups of research areas in nanoscience and chemistry were observed as one fused form. In Science Map 2008, the research areas in nanoscience were somewhat away from chemistry and increased its spread compared to the areas in the previous maps.

The hot research areas that comprise nanoscience are characterized by the difference in their research content depending on their locations on the map. "Microchannel devices (2008, ID 62)," "Research on nanofiber creation and applications (2008, ID 64)," “Research on creation and application of nanofibers using nucleic acid (2008, ID65)” and “Bioapplications of gold nanorods (2008, ID68)” are mapped near life science. These research areas include life science elements such as applications of nanofibers to regenerative medicine and creation of nanostructures using DNA. The hot research area "Organic/organic oxide semiconductors, opto-electronic functional materials and elements (2008, ID 75)," which forms a large mountain near condensed matter physics, is a research area involving the development of nanomaterials and devices that use them. Research areas such as "Nanomaterial synthesis in ionic liquids/hollow and mesoporous materials (2008, ID 72)," which involves the synthesis of materials with specific structures by using ionic liquids, are mapped near chemistry.

In addition to the above, looking in detail at the content of research areas, keywords such as organic EL elements, solar batteries, and fuel cells are found, indicating that there are also research areas related to environment research. This suggests that contributions from nanoscience through the creation of materials and devices are essential to the development of environment technology.

Looking at the trajectries of research areas over time, “Living radical polymerization/click reaction/molecular machine (2008, ID66)” shifted the position near life science and became a hot research area in nanoscience. Among research areas, “Semiconductor-spintronics material/magnetic semiconductors (2008, ID63)” is showing a characteristic movement. This research area was mapped in the research in condensed matter physics in Science Map 2006. It significantly moved its position to nanoscience in

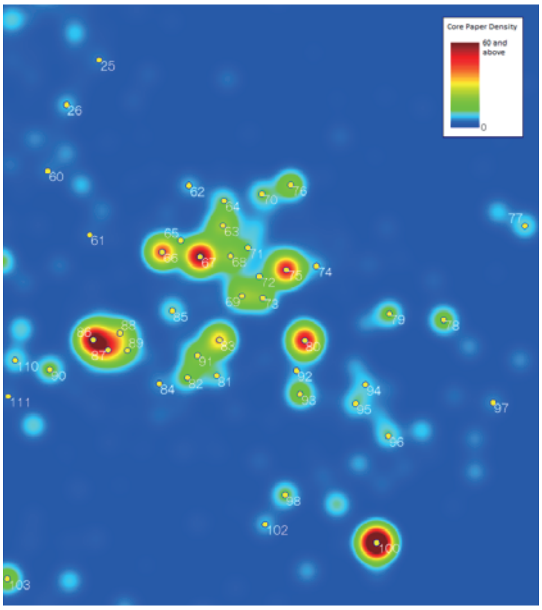
Science Map 2008. This research area includes some scientific papers related to the application of the semiconductor quantum dots having a certain connection with hot research areas in life science. With the expansion of the scope of research that uses semiconductor quantum dots, its positioning in the Science Map changed. The trajectries of research areas also indicate the function of nanoscience as a place for fusion with different research fields.

As a means of further development of research areas in nanoscience, “the implementation of research focusing on application,” and “active utilization of knowledge from other fields” are considered effective. For “the implementation of research focusing on application,” the effectiveness of nanoscience is evaluated as highest among the groups of research areas except life science.

For the future development of nanoscience, chemistry, condensed matter physics and environment are listed as the groups of research areas with which nanoscience should strengthen its relationship. Looking at the responses to the Interactive Science Map, environment-conscious research areas including solar cells, organic electronics, nano-scale thermal conversion engine and energy devices are listed as the research areas that are rapidly drawing attention and are promising a movement in the future. This indicates that the respondents are highly conscious of environment as the target application of nanoscience.

As in chemistry, experts in many fields consider that their research should strengthen the relationship with nanoscience. Specifically, experts in cancer research, research on infectious diseases/immunology, post-genome research, chemistry cited nanoscience as research with which they should strengthen the relationship from now on.

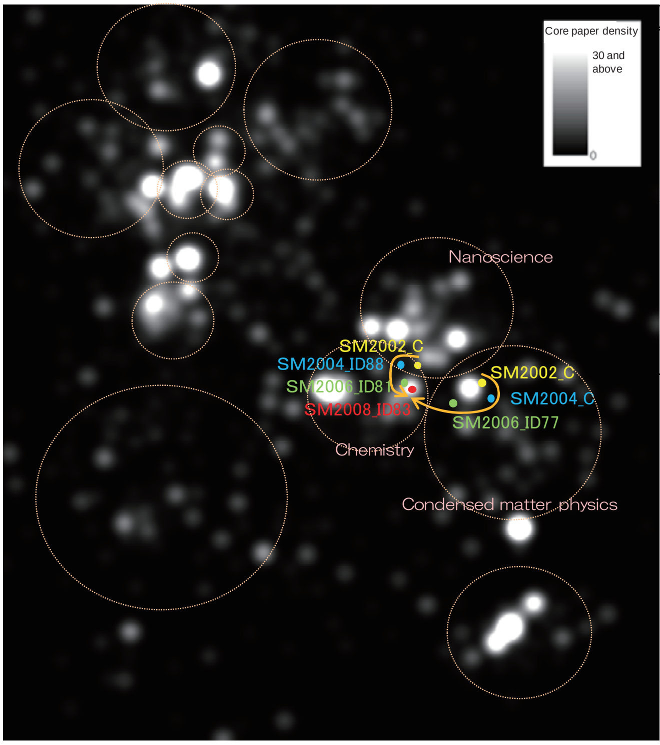
Figure 10 Science Map 2008 (Enlarged view of chemistry/nanoscience/condenses matter physics research areas and list of research areas)



ID	Research Area	ID	Research Area
62	Microchannel device	81	Nanochemistry of gold
63	Semiconductor-spintronics material/magnetic semiconductors	82	New-generation density functional theory for large-scale molecular calculation
64	Research on creation and application of nanofibers	83	Design and functions of configurational space and coordination lattice
65	Development of nanostructure using nucleic acid	84	Research on hydrogen bonding
66	Living radical polymerization/click reaction/molecular machine	85	Anion sensors
67	Synthesis, function and toxicity of sensors/SWNTs/functional DNAs/nanoparticles, etc.	86	Catalytic asymmetric synthesis
68	Bioapplications of gold nanorods	87	Molecular conversion reaction using transition metal catalyst
69	High-efficiency electroluminescence (EL) element	88	Synthesis of N-Heterocyclic carbene (NHC) and its application to catalytic reactions
70	Superhydrophobic surface	89	Direct carbon bond formation through transition metal catalytic reactions
71	Mesoporous material/silica, carbon and metal oxide	91	Complex hydrides associated with hydrogen production and storage and fuel cells
72	Nanomaterial synthesis in ionic liquid/hollow and mesoporous material	92	Electromagnetic response of surface plasmon in artificial structures
73	Ionic liquid	93	Meta material
74	Development materials from carbonate following the examples of nanocarbons and living organisms	94	Optical quantum information/communication, optical nanoscience
75	Organic/organic-oxide semiconductors　Photo- and electro-functional materials and elements	95	Qubits using semiconductor quantum dots/electronic charge, electron spin and nuclear spin
76	Solid macromolecule type fuel cell	96	Quantum information science using atomic system/photons
77	Formation of bulk metallic glass/transformation of metal glassy alloys	97	Novel electronic order in high-temperature superconductivity
78	Ferroelectric property in new materials such as multiferroics, etc.	98	Ultrafast and ultraintense optical science
79	Metal-based spintronics	102	New technologies related to solid oxide fuel cell (SOFC)
80	Physics and chemistry of molecular substance		

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

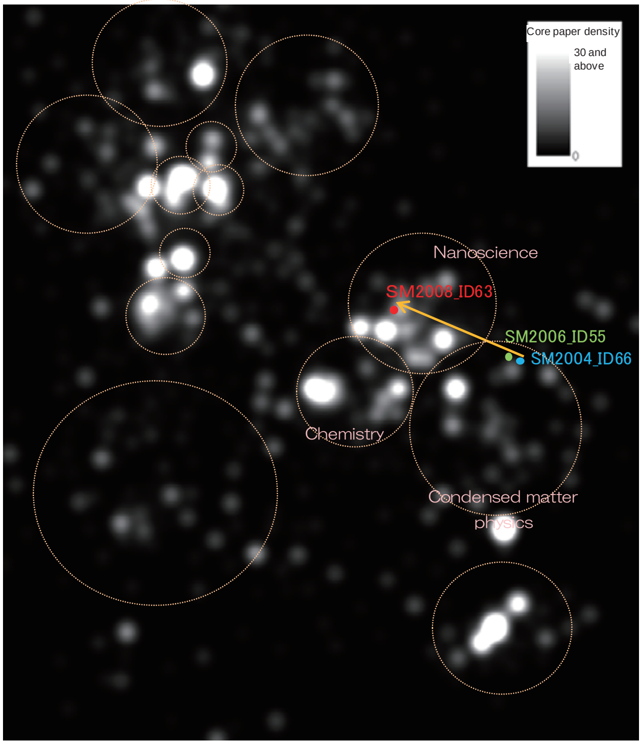
Figure 11 Trajectory of hot research area ID83 in Science Map 2008



Science Map	ID	Research Area
2002	C	-
2004	88	Metal: Organic hybrid porous materials
2006	81	Porous coordination polymer
2008	83	Design and functions of configurational space and coordination lattice
2002	C	-
2004	C	-
2006	77	Molecule-based nano-quantum magnet
2008	83	Design and functions of configurational space and coordination lattice

Note: Research area locations are indicated by circles. Yellow circles: Science Map 2002; blue circles: Science Map 2004; green circles: Science Map 2006, red circles: Science Map 2008. ID numbers refer to hot research areas. Those marked with "C" are quasi-hot research areas and thus have no ID and no research area name.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Figure 12 Trajectory of hot research area ID63 in Science Map 2008



Science Map	ID	Research Area
2004	66	Spintronics
2006	55	Ferromagnetic semiconductor spintronics
2008	63	Semiconductor-spintronics material/magnetic semiconductors

Note: Research area locations are indicated by circles. Yellow circles: Science Map 2002; blue circles: Science Map 2004; green circles: Science Map 2006, red circles: Science Map 2008. ID numbers refer to hot research areas. Those marked with "C" are quasi-hot research areas and thus have no ID and no research area name
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

<Relationship between chemistry and nanoscience>

In order to examine the relationship between chemistry and nanoscience, this section analyzes the position of research areas in chemistry and nanoscience from Science Map 2002 through Science Map 2008 and how the spread of research areas changed during that period.

Specifically, as shown in Figure 13 (a), the analysis was conducted with focus on a specific region of the Science Map that covers research areas in chemistry and nanoscience. It is difficult to accurately define the boundary between chemistry and nanoscience. Here, the area enclosed by ACC'A' is regarded as mainly chemistry, and the region enclosed by CBB'C' as mainly the region consisting of research areas of nanoscience. Figure 13 (a) shows the region in Science Map 2008, and the same region was analyzed for Science Map 2002 through Science Map 2006. Changes in the amount of scientific papers from Science Map 2002 through Science Map 2008 is shown in Figure 13 (b). The amount of scientific papers increased in both chemistry and nanoscience. The amount of the increase in scientific papers is greater in nanoscience than in chemistry.

Next, let us turn our attention to the position relationship of the groups of research areas and the spread of each research area group. Figure 13 (c) looks at the region enclosed by ABB'A' in Figure 13 (a) horizontally from the direction of the white arrow. The figure can be regarded as the view of the mountains formed by scientific papers in chemistry and nanoscience.

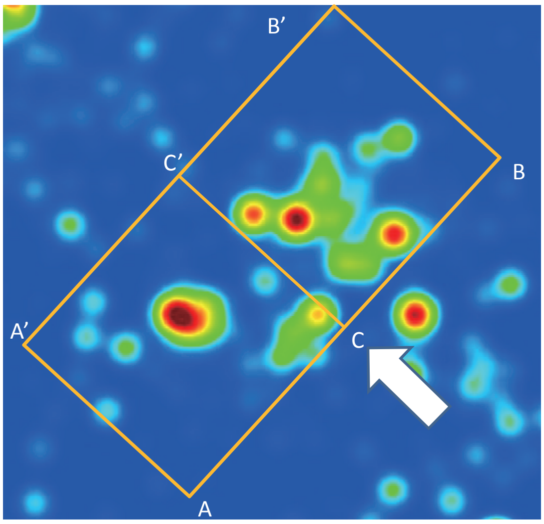
The group of research areas in chemistry evolved around "Catalytic asymmetric synthesis (2008, ID86)" and "Molecular conversion reaction using transition metal catalyst (2008, ID87)." Looking at changes from Science Map 2002 through Science Map 2008, these research areas were located near C in Science Map 2002 and gradually shifted the position towards A. There was no significant change in the height and spread of the mountains during this period.

The height of the mountains of nanoscience diminished gradually after its peak with "Development of nanostructure and its application to molecular devices (2004, ID 106)." By contrast, the research areas are gradually spreading to wider areas. As observed in Figure 13 (b), although the amount of scientific papers is increasing, the peaks of the mountains formed by each research area have lowered, which also confirms the spread of research areas.

The content of research areas shows that it now contains elements of life science and environment. As a result of the progress being made in the fusion of research with different fields in nanoscience, the territory that nanoscience occupies in the Science Map is increasing.

Figure 13 Change in the spread of nanoscience in Science Map

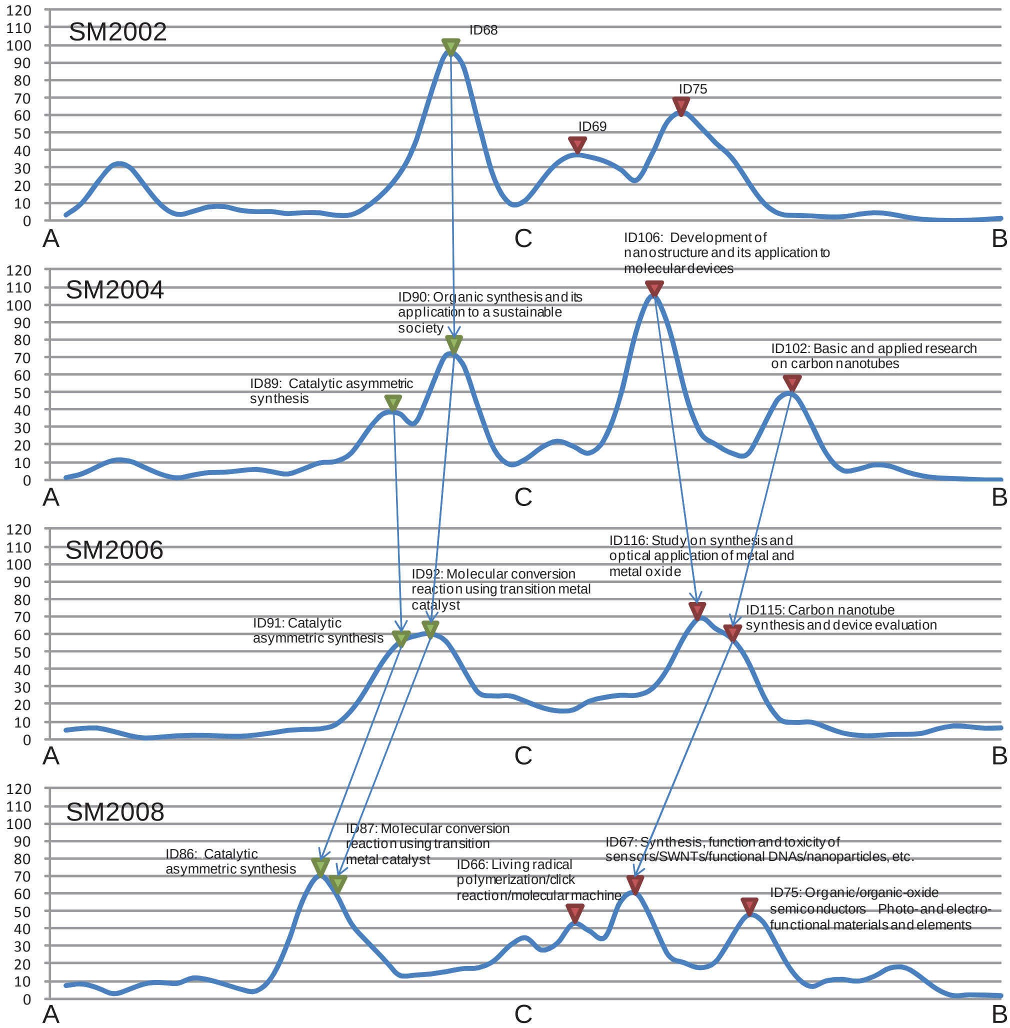
(a) Area and direction of projection in Science Map (SM 2008)



(b) Change in the amount of scientific papers in chemistry and nanoscience

	Around chemistry	Around nanoscience
SM2002	1176	1318
SM2004	1155	1646
SM2006	1202	1672
SM2008	1403	1743
2008/2002 ratio	1.19	1.32

(c) Projection drawing of Science Map 2002 – 2008



Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

(6) Condensed matter physics

The groups of research areas in condensed matter physics are observed in a scattered manner on the Science Map. The content of the research areas are broad, including ferroelectrics, spintronics, molecular substance, meta-material, optical quantum communication, semiconductor quantum dots, quantum information processing, high-temperature superconductor, ultrafast and ultraintense optical science and so on. Because each research area is connected together with a weak co-citation relation compared to nanoscience and others, the research areas are scattered over a wide range on the map.

Looking at the comparison with Science Map 2006, the following three new hot research areas were extracted: “Ferroelectric property in new materials such as multiferroics, etc. (2008, ID78),” “Metal-based spintronics (2008, ID79)” and “Electromagnetic response of surface plasmon in artificial structures (2008, ID92).” A precursor research area existed for ID79 since Science Map 2004 and for ID 78 and ID92 since Science Map 2006. The amount of scientific papers in these precursor research areas increased over time and they were extracted as hot research areas in Science Map 2008.

Most of the research areas in condensed matter physics extracted in Science Map 2006 are observed in Science Map 2008 as well, in a form continued or divided from the previous map. However, “Ferromagnetic semiconductor spintronics (2006, ID55),” which was mapped to the location of condensed matter physics in the Science Map 2006, greatly shifted the position in Science Map 2008 and is mapped to the location of nanoscience (“Semiconductor-spintronics material/magnetic semiconductors (2008, ID63)”).

Among the hot research areas in condensed matter physics, “Physics and chemistry of molecular substance (2008, ID80)” is growing rapidly. Of the 54 research fronts that comprise the research area, the rapid increase in the number of citations is observed in 12 research fronts that accounts for about 20% of all research fronts. Many of these research fronts conduct research on graphene (a monolayer of graphite). Experts pointed out that the extraction of graphene in 2004 and the subsequent discovery of quantum hall shed new light on the physical properties of material made of carbon, resulting in rapid progress in physics and chemistry on graphene.

Research on iron-based superconductors discovered by the group of Professor Hosono at Tokyo Institute of Technology in 2008 was extracted as a quasi-hot research area consisting of two research fronts. Since Science Map 2008 constructed research areas based on the number of citations as of end of 2008, the time from the publication of scientific papers on iron-based superconductors to the end of the year 2008 is short. This is the reason why co-citation networks of iron-based superconductivity did not grow to the level at which it is extracted as a hot research area. Because the quasi-hot research areas in iron-based superconductors include the research fronts in which increase in the number of co-citations is particularly noticeable, hot research area in iron-based superconductors is expected to be formed in and after Science Map 2010.

The research areas on magnesium diboride which continued since Science Map 2002 disappeared in Science Map 2008. Possible factors include that the research reached a certain stage of development and that research results are now published in a form other than scientific papers as the research progressed from the basic phase to the application phase, but further analysis of the actual situation is necessary.

Looking at changes from Science Map 2002 to Science Map 2008, the positions of the regions where core papers are concentrated changed significantly over time in the groups of research areas in condensed matter physics. This means that changes in research themes are clear. By contrast, the connection between research areas through co-citation is weak, and it looks like each research area is growing independently. In the previous survey, experts pointed out that researchers in condensed matter physics tend to flock to research in which some breakthroughs took place, such as the discovery of high-temperature superconductivity in 1986, the realization of Bose-Einstein condensation in a neutral atomic gas in 1995, the discovery of iron-based superconducting material in 2008 and so on. In other words, the transfer of knowledge between research areas is more likely to occur when researchers themselves move between research areas. The changes observed in the map explain this characteristic of research in condensed matter physics.

As a means of further developing the research areas, “the innovative metrological and measurement technology that exceeds the current limitations” was determined to be most effective, followed by “the active utilization of knowledge from other fields.” For the further development of condensed matter physics, chemistry and nanoscience are cited as a research group with which condensed matter physics should strengthen its relationship. On the other hand, experts in chemistry, nanoscience and particle physics/cosmology consider that they should strengthen their relationship with condensed matter physics.

(7) Particle physics/cosmology

Except for “Strongly interacting quantum many-body system (2008, ID100),” the positions of the research areas in particle physics/cosmology in the Science Map mostly remain unchanged and are observed at the same positions. “Gauge/gravity theory correspondence and black hole solutions (2008, ID104)” continued to be extracted as a hot research area since Science Map 2004. Likewise, “Elementary particle physics/elementary particle astrophysics (2008, ID106)” and “New developments in cosmology and elementary particles theory owing to advancement in precise observation of space (2008, ID107)” continued to be extracted as hot research areas since Science Map 2002. “Gamma-ray burst (2008, ID105)” was extracted as a hot research area in Science Map 2002, 2006 and 2008[5].

During the period between Science Map 2002 and Science Map 2008, the positions and breadth of the groups of the research areas in particle physics/cosmology remained the same, indicating that the pattern of research activity itself did not change during this period. This is because particle physics/cosmology has ultimate goals such as construction of a unified field theory and understanding of the origin of the universe, and research continues to evolve in those directions.

As a means of further development of research areas, “several- to several dozen units of large-scale experiment systems/facilities in the world” was determined to be most effective. This reflects the characteristics of particle physics/cosmology which require large-scale accelerators in order to conduct most-advanced research. “The innovative metrological and measurement technology that exceeds the current limitations” was considered highly effective as well, because a highly-sensitive metrological and measurement technology, such as photomultiplier tubes used for neutrino observation is, is required for the measurement of elementary particles. In addition, the effectiveness of “the enormous amount of collection of data and search of substances on a different order of magnitude from the past” was also ranked high.

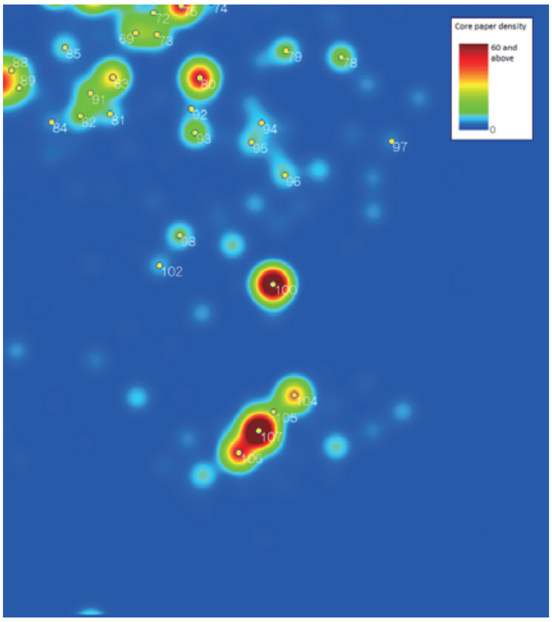
As a group of research areas with which particle physics/cosmology should strengthen its relationship for its future development, condensed matter physics was cited. Transfer of knowledge between condensed matter physics and particle physics/cosmology are also observed in changes in the Science Map over time. “Strongly interacting quantum many-body system (2008, ID100)” observed between condensed matter physics and particle physics/cosmology in Science Map 2008 is a hot research area which was formed by the fusion of condensed matter physics and particle physics/cosmology. While this research area is broadly divided into (1) research on quarks and (2) research on Bose-Einstein condensation and

[5] Since it was extracted as a quasi-hot research area in Science Map 2004, it was extracted as a research area by some form continuously in Science Maps 2002-2008.

superconductivity/superfluidity, they are bound together by the idea of spontaneously symmetry broken quantum field. As is evident from the fact that Dr. Yoichiro Nambu won Nobel Prize in 2008 for “the discovery of the spontaneous broken symmetry in elementary particle physics and nuclear physics,” spontaneous symmetry breaking is an important concept in physics. It is associated with superconductivity and superfluidity in condensed matter physics, and with the origin of mass in particle physics/cosmology.

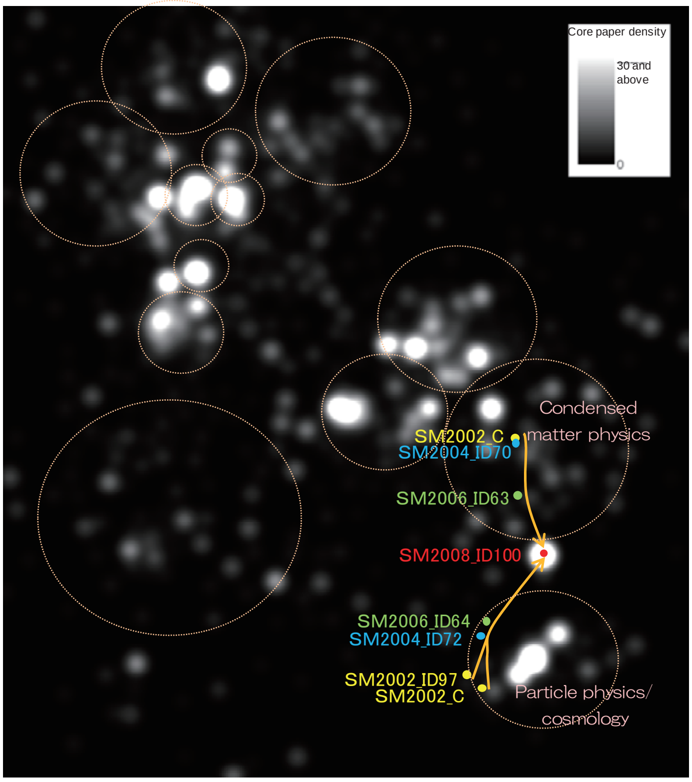
The research on quarks and the research on Bose-Einstein condensation and superconductivity/superfluidity were separately existed in Science Map 2002. The former was a hot research area in particle physics/cosmology, and the latter a hot research area in condensed matter physics. These two hot research areas developed the mutual relationship and became one hot research area in Science Map 2008. The changes in the relationship of these two hot research areas are observed as the trajectiries of research areas in the Science Map (Figure 15). As the trajectries indicate, research on quarks and research on Bose-Einstein condensation and superconductivity/superfluidity separately existed in Science Map 2002. As time progresses, (1) the research on quarks moved towards the direction of condensed matter physics and (2) the research on Bose-Einstein condensation and superconductivity/superfluidity shifted towards the direction of particle physics/cosmology, and they fused to form one hot research area in Science Map 2008.

Figure 14 Science Map 2008 (Enlarged view of particle physics/cosmology and list of research areas)



ID	Research Area
100	Strongly interacting quantum many-body system
104	Gauge/gravity theory correspondence and black hole solutions
105	Gamma-ray burst
106	Elementary particle physics/elementary particle astrophysics
107	New developments in cosmology and elementary particles theory owing to advancement in precise observation of space

Figure 15 The trajectries of Science Map 2008 ID 100, which was intermediate between particle physics/cosmology and condensed matter physics



Science Map	ID	Research Area
2002	C	-
2004	70	Quantum electronics and its application to quantum information processing
2006	63	New quantum condensed phase where substances strongly interact with each other
2008	100	Strongly interacting quantum many-body system
2002	97	-
2002	C	-
2004	72	Quantum chromodynamics
2006	64	Search for quark matter through high-energy nuclear collision
2008	100	Strongly interacting quantum many-body system

Note: Research area locations are indicated by circles. Yellow circles: Science Map 2002; blue circles: Science Map 2004; green circles: Science Map 2006, red circles: Science Map 2008. ID numbers refer to hot research areas. Those marked with "C" are quasi-hot research areas and thus have no ID and no research area name

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

3-3 Newly-found hot research areas

Figure 16 shows 30 hot research areas whose core papers have no overlap with the core papers of the 124 hot research areas derived for Science Map 2006. In other words, these are “newly-found hot research areas” in Science Map 2008. The average number of core papers comprising these hot research areas is low at 44.0, about half the 84.8 average of the 121 hot research areas. Average year of publication should roughly indicate the period within which a research area formed. The average year of publication in these research areas was 2005.6, while for all 121 hot research areas it was 2005.4. These newly-found hot research areas can be divided into three patterns (A, B, and C).

<Pattern A>

There is overlap between the hot research area’s core papers and the core papers of all research areas in Science Map 2006, and the average year of publication is old (before 2005. 4). In most cases, there was somewhat mature precursor research, and that area grew, or part of that area split off and was derived as a new hot research area for Science Map 2008. Example: Effects and prognostics of device therapy for advanced heart failure (ID2)

<Pattern B>

There is overlap between the hot research area’s core papers and the core papers of all research areas in Science Map 2006, and the average year of publication is new (after 2005. 4). There was already precursor research, but newly published scientific papers formed strong co-citation relationships, and a new field was derived for Science Map 2008. Example: Systems biology/synthetic biology (ID59)

<Pattern C>

There is no overlap between the hot research area’s core papers and the core papers of all research areas in Science Map 2006, but there is overlap with the core papers that comprise all research fronts. The average year of publication is new (2006. 4). Precursor research had not yet formed, but they surfaced as hot research areas after Science Map 2006. Example: New technologies related to solid oxide fuel cell (SOFC) (ID102)

Figure 16 Newly-found hot research areas

ID	Research area	Pattern	Number of core papers	Average year of publication	No. of core papers overlapped with the core papers comprising all research fronts in Science Map 2006
2	Effects and prognostics of device therapy for advanced heart failure	A	34	2004.3	22
3	Medical therapy for neuropathic pain and fibromyalgia syndrome	B	24	2005.5	7
6	Coronary CT (computed tomography)	A	51	2005.3	31
11	Pathological condition and treatment of bronchial asthma	A	31	2004.9	15
16	Clinical research for Parkinson's disease	B	19	2005.5	9
31	Research on aging-suppression and longevity-control factors in individual and organ stem cells	A	32	2005.0	11
32	Metabolism control through PGC-1α and insulin resistance	A	14	2003.5	9
33	Study on genetic epidemiology of complex genetic trait	B	137	2006.4	33
40	Role of ubiquitin modification system in NF-kB activation	A	14	2004.1	6
45	Development of human papillomavirus vaccine	B	35	2005.9	6
59	Systems biology/synthetic biology	B	27	2005.4	11
60	Structure and functions of G-protein-coupled receptor	B	18	2006.2	4
70	Superhydrophobic surface	A	51	2005.3	21
77	Formation of bulk metallic glass/transformation of metal glassy alloys	A	46	2004.9	22
78	Ferroelectric property in new materials such as multiferroics, etc.	B	70	2005.5	26
79	Metal-based spintronics	A	61	2004.8	35
81	Nanochemistry of gold	B	45	2005.6	16
82	New-generation density functional theory for large-scale molecular	B	60	2005.7	24
84	Research on hydrogen bonding	A	23	2004.6	15
89	Direct carbon bond formation through transition metal catalytic reactions	B	53	2006.5	14
90	Microbial fuel cells/microbial cells/enzyme-based biofuel cells	B	60	2005.7	22
91	Complex hydrides associated with hydrogen production and storage and	B	74	2005.9	10
92	Electromagnetic response of surface plasmon in artificial structures	A	20	2004.0	11
99	Limitation and application to signal processing/information theory using "sparse" property of source	A	71	2004.9	28
102	New technologies related to solid oxide fuel cell (SOFC)	C	32	2006.5	1
108	Emergence process of Homo sapiens	B	37	2006.0	8
114	Stability discrimination/stabilizing control of delay system using matrix	A	35	2005.1	7
117	Sea level fluctuations/seawater density/ice sheet/water circulation	B	34	2005.7	15
118	Restoration of the past global environmental change	C	31	2006.2	3
120	New asymptotic expansion method for nonlinear differential equation and its application	C	82	2006.5	14

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

3-4 Observation of inter-/multi-disciplinary research on the Research Area Correlation Map

This section discusses observations of inter-/multi-disciplinary research areas on the Research Area Correlation Map. The data for the distribution of the core papers of 22 fields that comprise hot research areas is based on "5 (1) Field distribution of core papers making up hot research areas" in Part II of this report. The 22 field classifications were compressed into 8 field classifications on the map. Figure17 shows the relationship between the 22 fields and the 8 fields. The field classification was performed on a journal-by-journal basis.

Although it is difficult to define inter-/multi-disciplinary research areas, in this report, regions where core-paper distributions in a specific field is less than 60 percent are regarded as "inter-/multi-disciplinary research areas." Therefore, regions where core-paper distribution in a specific field is more than 60 percent are considered as research areas of that field.

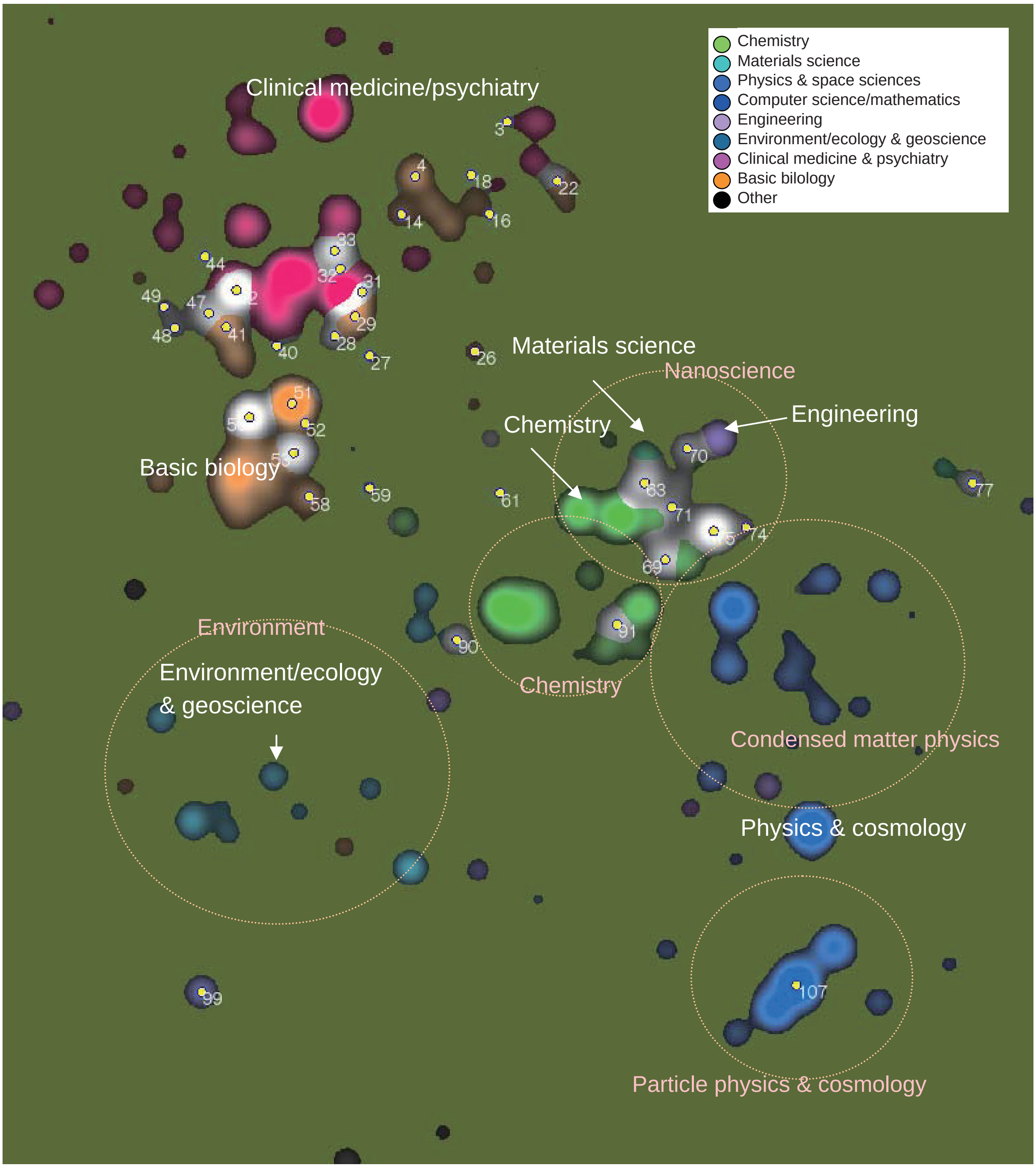
The colors of fields on the Research Area Correlation Map correspond to the colors shown in Figure 17. Inter-/multi-disciplinary research areas where core-paper distribution is less than 60 percent are assigned no colors (white color).

Figure 17 Relationship between the 22 fields and the 8 fields

<table>
<tr><th>22 fields</th><th>8 fields</th></tr>
<tr><td>Chemistry</td><td>Chemistry</td></tr>
<tr><td>Materials science</td><td>Materials science</td></tr>
<tr><td>Physics</td><td rowspan="2">Physics & space sciences</td></tr>
<tr><td>Space sciences</td></tr>
<tr><td>Computer science</td><td rowspan="2">Computer science/mathematics</td></tr>
<tr><td>Mathematics</td></tr>
<tr><td>Engineering</td><td>Engineering</td></tr>
<tr><td>Environment/ecology</td><td rowspan="2">Environment/ecology</td></tr>
<tr><td>Geosciences</td></tr>
<tr><td>Clinical medicine</td><td rowspan="2">Clinical medicine & psychiatry</td></tr>
<tr><td>Psychiatry/psychology</td></tr>
<tr><td>Agricultural sciences</td><td rowspan="8">Basic biology</td></tr>
<tr><td>Biology & biochemistry</td></tr>
<tr><td>Immunology</td></tr>
<tr><td>Microbiology</td></tr>
<tr><td>Molecular biology & genetics</td></tr>
<tr><td>Neuroscience & behavioristics</td></tr>
<tr><td>Pharmaceutical science/toxicology</td></tr>
<tr><td>Plant & animal science</td></tr>
<tr><td>Economics & business</td><td rowspan="3">Other</td></tr>
<tr><td>Multidisciplinary</td></tr>
<tr><td>Social sciences, general</td></tr>
</table>

Figure 18 shows the field distribution of core papers on the Research Area Correlation Map, with inter-/multi-disciplinary hot research areas plotted. Groups of the research areas in condensed matter physics, chemistry and particle physics/cosmology are comprised of scientific papers in chemistry, physics & space sciences, respectively, and are shown in similar tones. By contrast, in the groups of research areas in nanoscience which is generally regarded as multi-disciplinary field, white regions indicating inter-/multi-disciplinary research areas share a large part in addition to chemistry, engineering and materials science. On the other hand, the groups of research areas in environment which is also considered as multi-disciplinary just as nanoscience are shown in similar tones just like the groups in condensed matter physics and others, indicating that the groups consist of scientific papers in environment/ecology and geosciences.

Figure 18 Positioning of inter-/multi-disciplinary research areas on the Research Area Correlation Map 2008



Note: Regions with core-paper distribution of at least 60 percent in a specific field are shown with the field's corresponding color. Regions where core-paper distribution in a specific field is less than 60 percent are considered to have a high degree of interdisciplinary/multidisciplinary nature and are assigned no colors (white). Yellow dots and numbers indicate the locations and IDs of hot research areas that have a high degree of interdisciplinary/multidisciplinary nature. White letters indicate 8 fields. Pink letters are the names of research area groups.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

In Science Map 2008, the numbers of hot research areas in the 8 fields are as follows: 15 in chemistry, 1 in materials science, 14 in physics & space sciences, 3 in engineering, 10 in environment/ecology and geosciences and 3 in other. There are 24 hot research areas in clinical medicine & psychiatry, 11 in basic biology and 35 (29%) in life science. There are no hot research areas in computer science and mathematics, but they are included in core papers that comprise 12 research areas. As a characteristic of Science Map 2008, research areas in environment/ecology and Geoscience increased to 10 from 5 in Science Map 2006. Also, research areas in physics & space sciences in Science Map 2008 decreased to 14 from 21 in Science Map 2006.

Figure 19 Time-series changes in the numbers and ratio of hot research areas in the 22 fields

	Science Map 2002		Science Map 2004		Science Map 2006		Science Map 2008	
Agricultural sciences	1	1%	0	0%	1	1%	1	1%
Biology & biochemistry	1	1%	1	1%	0	0%	1	1%
Chemistry	14	13%	11	8%	16	13%	15	12%
Clinical medicine	21	19%	27	20%	23	19%	21	17%
Computer science	0	0%	2	2%	3	2%	0	0%
Economics & business	2	2%	2	2%	1	1%	1	1%
Engineering	1	1%	2	2%	2	2%	3	2%
Environment/ecology	1	1%	3	2%	3	2%	3	2%
Geosciences	5	4%	4	3%	2	2%	7	6%
Immunology	0	0%	0	0%	0	0%	0	0%
Materials science	3	3%	2	2%	3	2%	1	1%
Mathematics	0	0%	0	0%	0	0%	0	0%
Microbiology	2	2%	1	1%	0	0%	0	0%
Molecular biology & genetics	0	0%	0	0%	2	2%	0	0%
Multidisciplinary	0	0%	0	0%	0	0%	0	0%
Neuroscience & behavior	1	1%	5	4%	5	4%	5	4%
Pharmacology/toxicology	0	0%	0	0%	0	0%	0	0%
Physics	10	9%	20	15%	19	15%	13	11%
Plant & animal science	7	6%	6	5%	8	6%	4	3%
Psychiatry/psychology	4	4%	2	2%	1	1%	3	2%
Social sciences, general	2	2%	4	3%	1	1%	2	2%
Space sciences	2	2%	2	2%	2	2%	1	1%
Inter-/multi-disciplinary areas	35	31%	39	29%	32	26%	40	33%
Total	112	100%	133	100%	124	100%	121	100%

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

On the other hand, out of the 121 hot research areas, 40 (33%) are in the inter-/multi-disciplinary research areas. Looking at the positions of inter-/multi-disciplinary hot research areas as plotted in the Research Area Correlation Map, most are found in the nanoscience and life science (especially in brain research, research on regenerative medicine, research on infectious diseases/immunology and post-genome research) fields.

Of the 32 hot research areas that are inter-/multi-disciplinary research areas in Science Map 2006, 19 areas continued into Science Map 2008. Among them, 6 areas shifted into hot research areas in specific fields. "Water environment (2006, ID106)" continued into "Environmental burden of drugs and other industrial chemicals and technologies to reduce the burden (2008, ID111)" in environment/ecology and geosciences. Also, "Embryonic stem cell/neural induction (2006, ID99)" continued into "Research on regenerative medicine and stem cells (2008, ID30)." Similar phenomena were also observed between Science Map 2004 and 2006. The process by which inter-/multi-disciplinary research areas shift into specific fields is probably related to the process by which researcher communities form. The following is a hypothesis.

When research is emerging and its researcher community is not yet clearly defined, each researcher publishes in his or her own specialty field. Scientific papers thus appear in various fields. These research areas are classified as inter-/multi-disciplinary research areas, because research areas are judged to be "inter-/multi-disciplinary research areas" based on field distribution of core papers in this analysis. Subsequently, however, as time passes and the researcher community determines the most important venues for representing results, opportunities to publish scientific papers in journals in a specific field increase. This results in inter-/multi-disciplinary research areas shifting into specific fields. From this hypothesis, we can surmise that because the content of inter-/multi-disciplinary research areas is constantly changing, there is no reason that the number of inter-/multi-disciplinary research areas derived for the Science Map should remain fixed. It could constantly change.

Figure 20 analyzes the characteristics of inter-/multi-disciplinary research areas. It shows the numbers of research areas, average research fronts, rapidly increasing research fronts and research fronts in the latest year from Science Map 2002 through Science Map 2008. Looking at the percentage of inter-/multi-disciplinary research areas to the number of research areas, it almost remains fixed in low 20 percent range, and was 23 percent in Science Map 2008. Next, looking at the average numbers of research fronts, rapidly increasing research fronts and research fronts in the latest year, inter-/multi-disciplinary research areas outnumbers other research areas in every item. This indicates that inter-/multi-disciplinary research areas tend to include a comparatively large number of topics, show significant increase in the number of citations and introduce relatively new research results. In other words, compared to other research areas, active production of knowledge is taking place in inter-/multi-disciplinary research areas. By identifying the positions of these research areas on the map, the positions of research areas where movement is more active can be confirmed.

Figure 20 Characteristics of inter-/multi-disciplinary research areas

Science Map 2002

	No. of research areas	Average no. of RFs	Average no. of RFs in which the no. of citations rapidly increased	Average no. of RFs in the latest year
Inter-/multi-disciplinary research areas	150	6.86	0.75	0.59
Research areas other than the above	448	5.33	0.51	0.40
Total	598	5.71	0.57	0.45

Science Map 2004

	No. of research areas	Average no. of RFs	Average no. of RFs in which the no. of citations rapidly increased	Average no. of RFs in the latest year
Inter-/multi-disciplinary research areas	137	7.63	0.90	0.66
Research areas other than the above	489	5.02	0.52	0.38
Total	626	5.59	0.60	0.45

Science Map 2006

	No. of research areas	Average no. of RFs	Average no. of RFs in which the no. of citations rapidly increased	Average no. of RFs in the latest year
Inter-/multi-disciplinary research areas	146	6.75	0.73	0.53
Research areas other than the above	541	4.74	0.48	0.38
Total	687	5.17	0.54	0.41

Science Map 2008

	No. of research areas	Average no. of RFs	Average no. of RFs in which the no. of citations rapidly increased	Average no. of RFs in the latest year
Inter-/multi-disciplinary research areas	151	7.21	0.89	0.69
Research areas other than the above	496	5.14	0.55	0.49
Total	647	5.62	0.63	0.54

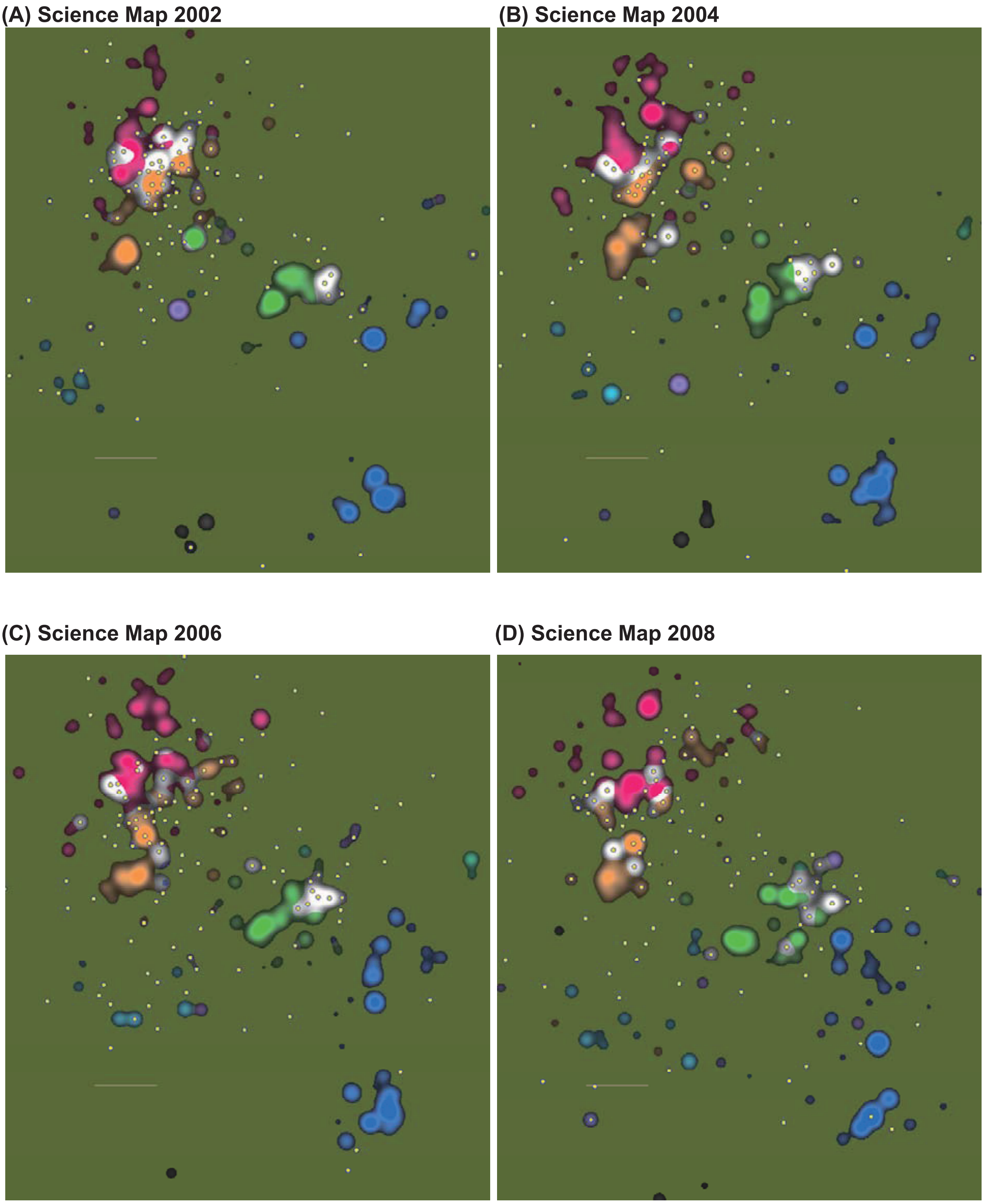
Note1. Rapidly increasing research fronts were determined by the following method: When the slope of the regression line of each year's increase and decrease in the number of citations per core paper in each research front exceeds the mean slope in each field, and when the average year of the publication of core papers is in the latter two years of the analysis period (in and after 2007 in the case of Science Map 2008), such research fronts were extracted as rapidly increasing fronts.

Note 2. RFs in the latest year are the research fronts that appeared newly in the last year of the analysis period (2008 in the case of Science Map 2008).

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

From the above-mentioned standpoints, when looking at the time-series changes in the positioning of inter-/multi-disciplinary research areas on the Research Correlation Map as shown in Figure 21, changes in the positions of inter-/multi-disciplinary research areas in life science can be observed first. In Science Maps 2002 and 2004, a number of these research areas are mostly scattered around research on cancers near the boundary between clinical medicine and basic biology in life science. In Science Map 2006, these positions became more broadly scattered, and in Science Map 2008, these inter-/multi-disciplinary research areas are localized near brain research, research on regenerative medicine, research on infections diseases/immunology and post-genome research.

Figure 21 Time-series changes in the positioning of inter-/multi-disciplinary research areas on the Research Correlation Map

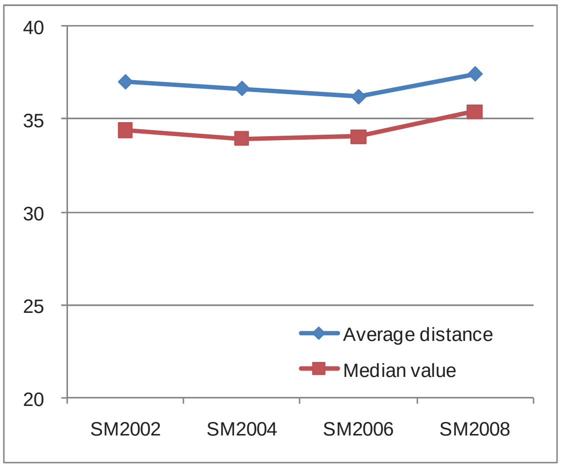


Note 1. Regions with core-paper distribution of at least 60 percent in a specific field are shown with the field's corresponding color. Regions where core-paper distribution in a specific field is less than 60 percent are considered to have a high degree of interdisciplinary/ multidisciplinary nature and are assigned no colors (white). Yellow circles represent inter-/multi-disciplinary research areas.
Note 2. The length corresponding to a 10-unit distance is shown in the map as a scale.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

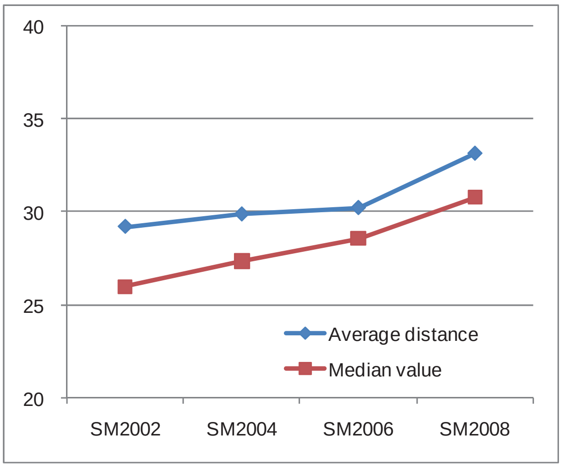
Figure 22 is the quantification of the changes in the positions of inter-/multi-disciplinary research areas on the Science Map. Figure 22 (A) shows the average distance and median values for the combinations of all research areas. The average distance somewhat decreased from Science Map 2002 to Science Map 2006 and slightly increased in Science Map 2008. As is shown by the comparison of Science Maps, these changes reflect the spread of research areas comprising brain research and nanoscience. Figure 22 (B) shows the average distance and median values for all combinations between inter-/multi-disciplinary research areas based on the calculated distance. Both the average distance and median values are on the increase in and after Science Map 2002. This also confirms, in a quantitative manner, that the distribution of inter-/multi-disciplinary research areas on the Science Map is becoming increasingly broader. In addition, Figure 22 (C) shows the frequency distribution of the distance between inter-/multi-disciplinary research areas. Compared with Sciences Maps 2002 to 2006, Science Map 2008 shows a certain amount of distance between the distributed positions of research areas.

Figure 22 Average distance and median values between all research areas and all inter-/multi-disciplinary areas

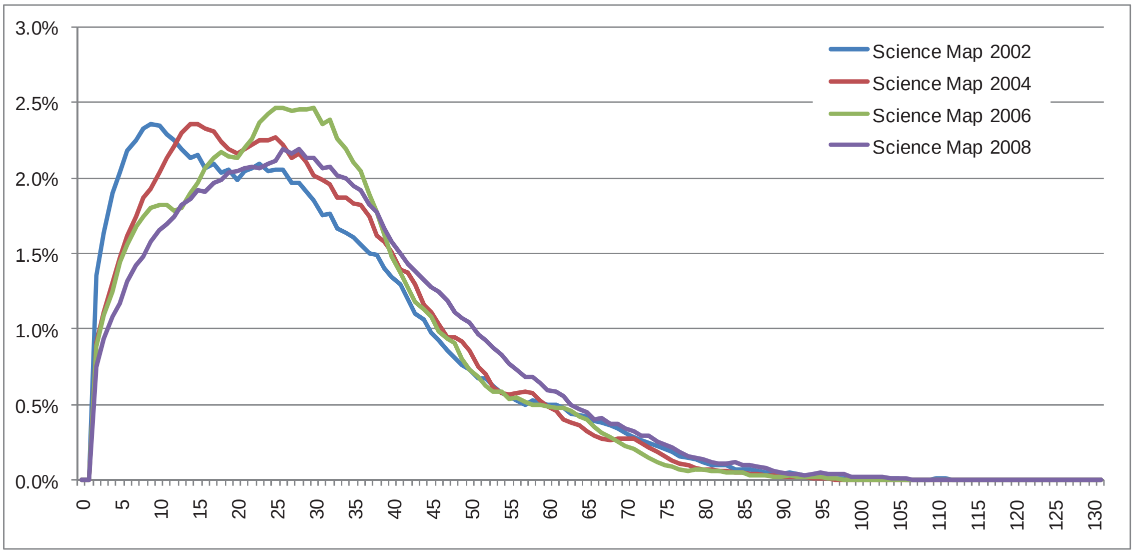
(A) All research areas



(B) Inter-/multi-disciplinary research areas



(C) Frequency distribution of distance between inter-/multi-disciplinary research areas



Note. The length corresponding to a 10-unit distance is shown in the map of Figure 21 as a scale.

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

As a potential impact on changes in the positions on the Science Map, changes in the combinations of fields that comprise inter-/multi-disciplinary research areas were examined (Figure 23). The combinations of fields that comprise inter-/multi-disciplinary research areas were extracted from Science Map 2002 through 2008 to find out the degree of the participation of other fields. For example, in the combinations that include clinical medicine, psychiatry/psychology participated in 11 percent of the combinations and biology/ biochemistry in 51 percent. Other combinations were categorized in the same manner.

Figure 23 (A) indicates that, in the combinations of fields in life science (circled items in Figure 23 (A)), not only life science, but also non-life science fields such as chemistry also participated in many cases. Furthermore, in the combinations of non-life science fields, participation of life science is still so evident that there is not much difference in the degree of participation of life science in the non-life science fields. These combinations are shown in Figure 23 (B). In this figure, the number of combinations in which the participation of life science exceeds 20 percent (the number of colored cells in Figure 22 (A)) was counted. The figure shows that inter-/multi-disciplinary combinations are not increasing within life science or within fields other than life science. Instead, the increase in inter-/multi-disciplinary combinations are occurring between life science and fields other than life science.

The result matches the changes in the positions of inter-/multi-disciplinary research areas observed in the Science Map. As is shown in Figure 23 (B), in Science Map 2002, most of combinations are seen within life science. Reflecting this, most of inter-/multi-disciplinary research areas are observed in life science in Science Map 2002.

In Science Map 2008, combinations increased between life science and other fields. When combinations occur between life science and other fields, these research areas tend to be mapped between life science and other research area groups for the sake of placement of research areas in the Science Map. This resulted in inter-/multi-disciplinary research areas in Science Map 2008 being spread over the map.

Figure 23 Combinations of fields that comprise inter-/multi-disciplinary research areas

(A) Combinations of fields that comprise inter-/multi-disciplinary research areas in Science Map 2008

Combinations including the following fields	Clinical medicine	Psychiatry/psychology	Agricultural sciences	Biology & biochemistry	Immunology	Microbiology	Molecular biology & genetics	Neuroscience & behavior	Pharmacology & toxicology	Plant & animal science	Chemistry	Physics	Space sciences	Computer science	Engineering	Materials science	Mathematics	Environment/ecology	Geosciences	Economics & business	Social sciences, general	Multidisciplinary
Clinical medicine (○)		0.11	0.09	0.51	0.27	0.29	0.38	0.36	0.27	0.13	0.24	0.04	0.00	0.09	0.09	0.02	0.02	0.04	0.02	0.02	0.07	0.11
Psychiatry/psychology (○)	0.50		0.00	0.10	0.00	0.00	0.10	0.70	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.10
Agricultural sciences (○)	0.57	0.00		0.14	0.14	0.14	0.00	0.14	0.29	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.14	0.00	0.00	0.14	0.00
Biology & biochemistry (○)	0.51	0.02	0.02		0.18	0.29	0.53	0.27	0.16	0.22	0.40	0.11	0.00	0.18	0.16	0.11	0.04	0.16	0.04	0.02	0.00	0.18
Immunology (○)	1.00	0.00	0.08	0.67		0.58	0.58	0.25	0.17	0.17	0.17	0.08	0.00	0.17	0.08	0.00	0.08	0.00	0.00	0.08	0.00	0.17
Microbiology (○)	0.68	0.00	0.05	0.68	0.37		0.58	0.11	0.11	0.32	0.26	0.05	0.00	0.26	0.16	0.11	0.11	0.16	0.05	0.05	0.00	0.16
Molecular biology & genetics (○)	0.59	0.03	0.00	0.83	0.24	0.38		0.41	0.14	0.24	0.31	0.07	0.00	0.24	0.14	0.03	0.07	0.07	0.03	0.03	0.00	0.21
Neuroscience & behavior (○)	0.70	0.30	0.04	0.52	0.13	0.09	0.52		0.26	0.09	0.26	0.04	0.00	0.04	0.04	0.00	0.00	0.00	0.00	0.04	0.04	0.13
Pharmacology & toxicology (○)	0.80	0.13	0.13	0.47	0.13	0.13	0.27	0.40		0.00	0.53	0.07	0.00	0.07	0.20	0.07	0.00	0.00	0.00	0.00	0.07	0.07
Plant & animal science (○)	0.40	0.00	0.00	0.67	0.13	0.40	0.47	0.13	0.00		0.27	0.07	0.00	0.33	0.27	0.07	0.13	0.27	0.20	0.07	0.07	0.13
Chemistry	0.37	0.00	0.00	0.60	0.07	0.17	0.30	0.20	0.27	0.13		0.23	0.00	0.20	0.40	0.33	0.03	0.07	0.00	0.03	0.00	0.13
Physics	0.13	0.00	0.00	0.31	0.06	0.06	0.13	0.06	0.06	0.06	0.44		0.06	0.19	0.44	0.50	0.19	0.00	0.06	0.00	0.00	0.25
Space sciences	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Computer science	0.25	0.00	0.00	0.50	0.13	0.31	0.44	0.06	0.06	0.31	0.38	0.19	0.00		0.56	0.19	0.38	0.06	0.06	0.13	0.00	0.13
Engineering	0.15	0.00	0.08	0.27	0.04	0.12	0.15	0.04	0.12	0.15	0.46	0.27	0.00	0.35		0.35	0.23	0.15	0.08	0.00	0.00	0.04
Materials science	0.07	0.00	0.00	0.33	0.00	0.13	0.07	0.00	0.07	0.07	0.67	0.53	0.00	0.20	0.60		0.13	0.07	0.00	0.00	0.00	0.07
Mathematics	0.14	0.00	0.00	0.29	0.14	0.29	0.29	0.00	0.00	0.29	0.14	0.43	0.00	0.86	0.86	0.29		0.00	0.00	0.00	0.00	0.14
Environment/ecology	0.15	0.00	0.08	0.54	0.00	0.23	0.15	0.00	0.00	0.31	0.15	0.00	0.00	0.08	0.31	0.08	0.00		0.23	0.00	0.08	0.08
Geosciences	0.17	0.00	0.00	0.33	0.00	0.17	0.17	0.00	0.00	0.50	0.00	0.17	0.00	0.17	0.33	0.00	0.00	0.50		0.00	0.00	0.17
Economics & business	0.33	0.00	0.00	0.33	0.33	0.33	0.33	0.33	0.00	0.33	0.33	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00		0.33	0.00
Social science, general	0.43	0.43	0.14	0.00	0.00	0.00	0.00	0.14	0.14	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.14		0.00
Multidisciplinary	0.50	0.10	0.00	0.80	0.20	0.30	0.60	0.30	0.10	0.20	0.40	0.40	0.00	0.20	0.10	0.10	0.10	0.10	0.10	0.00	0.00	

(B) Changes in combinations

Pattern	Science Map 2002	Science Map 2004	Science Map 2006	Science Map 2008
Strong involvement of life science in life science fields	48	43	41	44
Strong involvement of non-life science in life science fields	6	10	10	14
Strong involvement of life science in non-life science fields	8	24	17	30
Strong involvement of non-life science in non-life science fields	23	23	23	29

Note. In Figure (A), Multidisciplinary was excluded from the analysis. The circles after the names of fields are the fields in life science. The color was assigned to the cells whose value exceeded 20 percent.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

4. Status of activities in major countries and their strengths and weaknesses as seen in the Science Map

4-1 Status of activities in Japan and major countries as seen in the Science Map

(1) Methods of counting research papers to grasp the status of activities in individual countries (Whole count method and fractional count method)

Compared to the early 1980s, the amount of scientific papers published around the world increased from about 500,000 to 1million. Research activities across the world have consistently been on an expansion trend in terms of quantity.

Given these situations, as an “easy-to-understand benchmark” to measure the basic research capabilities of individual countries and quantify the scientific research capabilities that countries have, the number of research papers is used for measuring the amount of the capabilities. On the other hand, in the case of indicating the quality of the capabilities, the number of citations, the number of the top 10 percent scientific papers, or the number of the top 1 percent scientific papers which is employed in this report, are used. To calculate the number of papers, it is necessary to select a counting method according to which of the two, “the degree participation in the world’s scientific papers” or “the degree of contribution to the production of the world’s scientific papers,” is desired for measurement as shown in Figure 24.

Particularly in recent years, a number of international co-authored papers have been published in European countries, but there are differences in the number of papers and shares depending on methods of counting. Therefore, when comparing the status of individual countries, the obtained results need to be examined and read thoroughly.

Figure 24 Whole count method and fractional count method

	Whole count method	Fractional count method
Calculation method	A paper with joint authors from more than one country is counted as one paper for each country. Thus, the combined shares of all countries exceed 100 percent.	A paper with joint authors from more than one country (e.g., collaboration of countries A and B) is counted as 1/2 a paper for country A and 1/2 a paper for country B. Thus, the combined shares of all countries total 100 percent.
Interpretation of applying the method to the number of top 1% papers	Degree of participation in the world's very high-impact papers	Degree of contribution to the production of the world's very high-impact papers.
Interpretation of applying the method to the number of top 10% papers	Degree of participation in the world's high-impact papers.	Degree of contribution to the production of the world's high-impact papers.
Interpretation of applying the method to the number of papers	Degree of participation in the world's papers.	Degree of contribution to the production of the world's papers.

If the comparison between the results of the whole count method and fractional count method finds significant difference and higher country share in the whole count method, that country is considered to have a high percentage of international co-authored papers. In other words, referring to results of the fractional count method is recommended when looking at a country’s unique research capabilities, whereas, referring to results of the whole count method is recommended to grasp the overall research capabilities of the country including its international co-authorships.

(2) Overall status of activities in individual countries

In order to make a rough comparison of individual countries first, a time-series analysis of various countries' shares of research papers in all research areas (hot research areas + quasi-hot research areas) was carried out using the whole count method and the fractional count method (Figure 25)

Figure 25 Time-series changes in all research areas for various countries' shares

(A) Whole count method

Whole count method	USA	Germany	UK	Japan	France	Korea	China
Science Map 2002	62.9	11.1	12.4	8.6	7.0	1.1	1.3
Science Map 2004	61.9	12.1	12.3	8.7	7.2	1.7	2.7
Science Map 2006	61.0	13.5	12.9	8.5	7.5	1.8	4.5
Science Map 2008	57.9	13.9	13.4	8.0	8.4	1.9	7.2

(B) Fractional count method

Fractional count method	USA	Germany	UK	Japan	France	Korea	China
Science Map 2002	51.8	6.7	7.8	6.4	3.9	0.7	0.8
Science Map 2004	49.7	7.2	7.3	6.2	3.8	1.0	1.7
Science Map 2006	47.6	7.7	7.2	5.7	3.7	1.1	2.9
Science Map 2008	43.5	7.4	7.0	5.4	3.8	1.0	5.2

Note: Shares of core papers comprising all research areas.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Looking at Japan's participation in the production of research papers (whole count method), its share fell after the peak in Science Map 2004. From Science Map 2006 to Science Map 2008, the share fell 0.5 percentage points to the lowest value since the start of the analysis. In terms of the degree of contribution to the production of research papers, (fractional count method), Japan's share has also been on a declining trend since Science Map 2002, reaching the lowest value since the start of the analysis.

Compared to Japan's aforementioned presence, what about the status of other countries? The US share is declining since Science Map 2002 both in the whole count method and in the fractional count method. Taking into consideration the current situation in which various countries started taking part in the production of research papers, the share of the US which has been the highest will tend to fall. However, the fact that it still maintains a higher ratio of research papers demonstrates that the US continues to be an important source of knowledge for science as a whole, even under the situation where various countries are increasing the production of research papers.

Similar impacts will affect countries that have higher shares of research papers; however, Germany, the UK and France in Europe all increased the shares of papers in the whole count method compared to Science Map 2002. Because France, in particular, increased its share in Science Map 2008, Japan dropped into the fifth place in the world. On the other hand, looking at shares in the fractional count method, no significant changes are observed in Germany, the UK and France. Although its share declined, Japan is in the fourth place, and the difference compared to Germany and the UK is not as great as that in the whole count method.

In recent years, European countries are placing greater emphasis on international co-authored papers among research papers, for which the shares of research papers in the whole count method tend to rise. This tendency is particularly strong in highly-cited papers that are the target of analysis for the Science Map. This is due to the effect of the shift in research activities in Germany, the UK and France to the activities using researcher networks that produce international co-authored research papers.

When looking at Asian regions, changes in China's share of research papers is remarkable. Comparing Science Maps 2002 and 2008, China's share has risen by 5.9 percentage points in the whole count method and by 4.4 percentage points in the fractional count method. In degree of contribution to the production of research papers (fractional count method), Japan has only a 0.2 percentage point lead in Science Map 2008. Korea, on the other hand, shows no significant changes.

The result of the analysis revealed the declining trend of Japan's share. In order to investigate the cause of the decline, each country's shares in the top 1 percent research papers which is the parent population of Science Map were analyzed (Figure 26). The results found that Japan's share also declined by 0.4 percentage point, indicating that the decline in Japan's share is occurring in the top 1 percent research papers. However, comparing Figure 25 and Figure 26, Japan's share is prominently higher in the Science Map than in the top 1 percent research papers.

Figure 26 Time-series changes in each country's shares in the top 1 percent research papers during the period of analysis for Science Map

(A) Whole count method

Whole count method	USA	Germany	UK	Japan	France	Korea	China
Science Map 2006	59.8	11.5	13.2	6.5	7.0	1.4	3.6
Science Map 2008	57.0	11.7	13.6	6.1	7.3	1.8	5.4

(B) Fractional count method

Fractional count method	USA	Germany	UK	Japan	France	Korea	China
Science Map 2006	48.7	6.8	8.1	4.6	3.8	0.9	2.5
Science Map 2008	45.2	6.6	8.0	4.1	3.7	1.1	3.9

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

An analysis was then made for the relationship between each field of all research areas in the top 1 percent papers and in the Science Map (Figure 27). As mentioned earlier, the percentage of fields other than life science is higher in the Science Map. Comparing the ratio of life science and other fields in the top 1 percent papers, the percentage of other fields is higher in the Science Map. The previous Science Maps also reported that Japan's strength centers mainly on chemistry and physics. This proves that, for countries that have strength in fields other than life science, shares are higher in Science Maps than in the top 1 percent research papers.

Figure 27 The relationship between each field of all research areas in the top 1 percent papers and in the Science Map

	Top 1 pct papers during the SM2008 period	All research areas in SM2008	Percentage of papers included in SM2008 from Top 1 pct papers
Agricultural sciences	1151	106	9%
Biology and biochemistry	3298	713	22%
Chemistry	6777	2376	35%
Clinical medicine	11550	3458	30%
Computer science	1789	350	20%
Economics and business	924	125	14%
Engineering	4940	971	20%
Environment/ecology	1541	364	24%
Geosciences	1707	503	29%
Immunology	714	259	36%
Materials science	2717	597	22%
Mathematics	1342	218	16%
Microbiology	908	289	32%
Molecular biology & genetics	1603	555	35%
Multidisciplinary	99	27	27%
Neuroscience and behavior	1725	444	26%
Pharmacology/toxicology	1086	103	9%
Physics	5231	2742	52%
Plant and animal science	2987	849	28%
Psychiatry/psychology	1366	233	17%
Social science, general	2280	177	8%
Space sciences	690	367	53%
Total	56425	15826	28%

Number of core papers in life science	26388	7009
Number of core papers other than life science	30037	8817
Share of life science	46.8%	44.3%
Share of other than life science	53.2%	55.7%

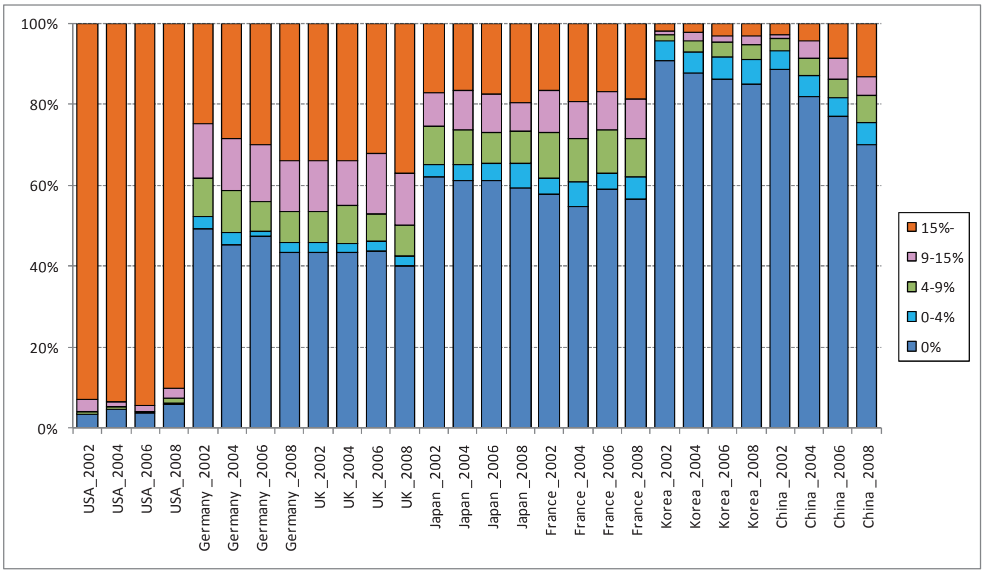
Note: Colored fields are life science
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Figure 28 shows time-series changes in the distribution of all research areas by share of research papers. Let us take a look at Japan's status using the whole count method. Although the percentage of research areas in which Japan has 0 percent share decreased from 62 percent in Science Map 2002 to 59 percent in Science Map 2008, Japan's presence is still only 40 percent in all research areas. The percentage of research areas in which Japan has more than 9 percent share and shows its presence did not change greatly between Science Map 2002 and Science Map 2008.

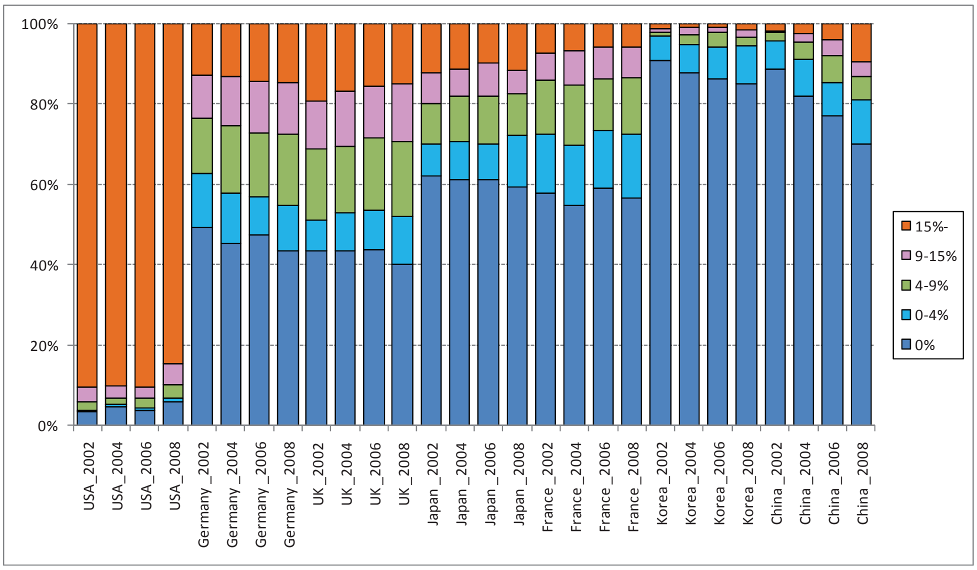
Although the percentage of research areas in which Japan has more than 9 percent share did not change greatly in the whole count method, the percentage of research areas with more than 9% share is gradually declining in the fractional count method. It is suggested that behind this overall decline lies the high percentage (60 percent) of research areas with no Japanese presence and Japan's weakening power to maintain high shares with its own strength.

Figure 28 Time-series changes in the distribution of all research areas by the share of research papers

(A) Whole count method



(B) Fractional count method



Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

As seen in Figure 25, the UK, Germany and France are the countries that have a large difference between shares in the whole count method and in the fractional count method. First, compared to Japan, there are few research areas in which these countries' shares are 0 percent. In Germany and the UK, research areas in which the countries have more than a 9 percent share, particularly those more than 15 percent, are steadily increasing, which contributed to an increase in each country's shares in the whole count method.

In the fractional count method, on the other hand, research areas in which Germany has more than a 9 percent share increased from Science Map 2002 through Science Map 2006, have hovered at around the same level in Science Map 2008. For the UK, the percentage of research areas in which the country has more than a 9 percent share decreased from Science Map 2002 through Science Map 2006, but slightly increased in Science Map 2008. Although these changes are observed, a common characteristic of the two countries is a marked difference in the situations between the case of whole count method and the case of fractional count method. This indicates that the UK and Germany acquired their presence through participation in the field of more research areas where knowledge is produced by using a scientific research system called international co-authorship.

China is steadily increasing the share of research papers in and after Science Map 2002. This matches the increase in the percentage of research areas in which China has more than a 9 percent share and through which it can exhibit its presence. China's steady increase in the number of research areas in which it has such a high share not only in whole count method but also in fractional count method indicates that the country is developing its research strengths within the country, while at the same time responding to the change in a scientific research system called international co-authorship.

Figure 29 shows the comparison of the numbers of research areas (participation areas) in which Japan, the UK or Germany has at least one top 1 percent research paper. The fields in which the UK and Germany show a significant difference from Japan in the number of participation areas are clinical medicine and inter-/multi-disciplinary research areas.

Figure 29 Comparison of the numbers of participation areas in Science Map 2008 between Japan, the UK and Germany

Field	Relevant research areas	Japan	UK	Germany
Agricultural sciences	8	3	4	4
Biology and biochemistry	11	6	4	6
Chemistry	64	28	32	38
Clinical medicine	116	41	82	75
Computer science	17	4	8	10
Economics and business	9	0	5	1
Engineering	44	9	12	14
Environment/ecology	15	4	10	9
Geosciences	30	19	26	21
Immunology	1	1	1	1
Materials science	7	4	1	3
Mathematics	14	1	3	6
Microbiology	5	1	4	0
Molecular biology & genetics	5	2	4	3
Neuroscience and behavior	17	12	12	12
Pharmacology/toxicology	3	1	0	1
Physics	61	35	39	39
Plant and animal science	36	20	24	24
Psychiatry/psychology	12	2	7	6
Social science, general	13	1	7	5
Space sciences	8	3	7	7
Inter-/multi-disciplinary research areas	151	66	96	81
Total	647	263	388	366

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

(3) Status of activities in Japan as seen in the Science Map

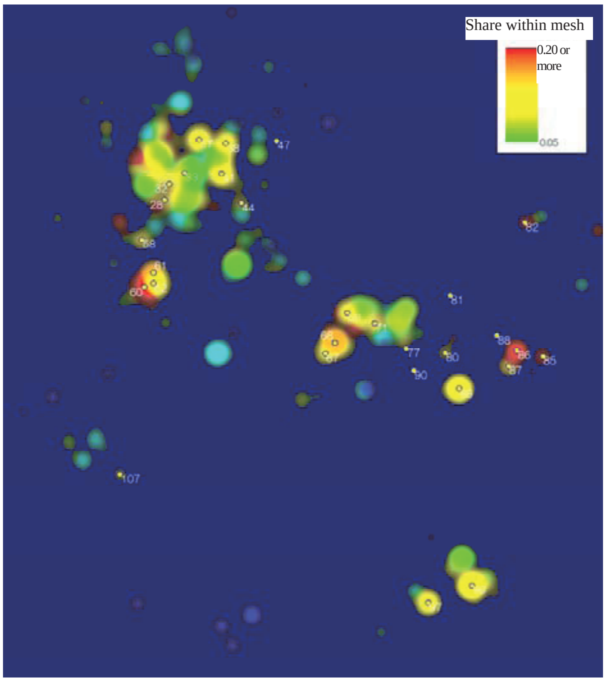
In the previous sections, each country's shares were shown using a single value. By adding shares in each research area on the Science Map to be able to give an overview of shares, the map can visualize not only simple overall shares, but also the exact positions of research areas in which Japan has a presence, and locations of the research areas in which Japan shows no presence.

Figure 30 are Science Maps from 2002 through 2008 on which information on Japan's share during each map's period is added. The share information is based on the whole count method. Regions where the percentage of Japan's research papers is 5 percent are shown in light blue, and regions where the percentage is 20 percent or more are in red. Regions in warmer colors indicate the high share held by Japan. In the case of Japan, red regions are scattered on the maps. They are relatively concentrated around research areas in chemistry and condensed matter physics, but still look like scattered islands.

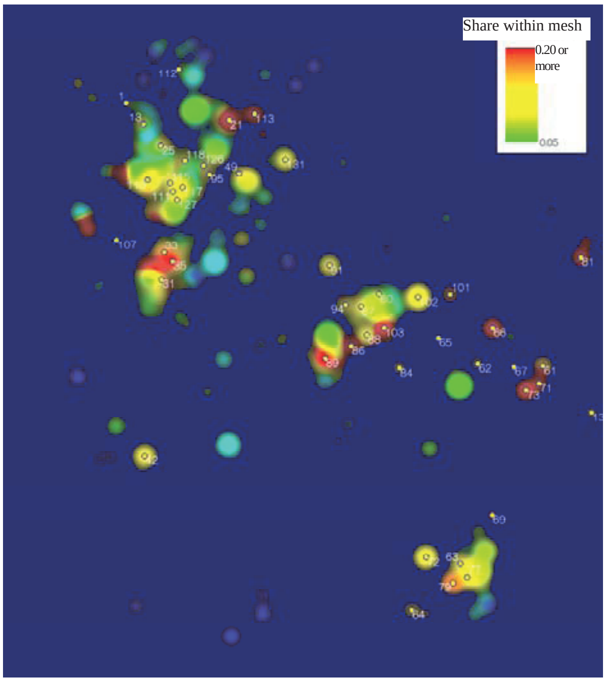
Figure 31 are Science Maps from 2002 through 2008 on which information on Japan's share during each map's period is added based on the information of research paper share calculated by the fractional count method. In the case of Japan, difference in the trend of results between the whole count method and fractional count method was not significant. In the fractional count method, research areas in which Japan has a high share are observed near chemistry and condensed matter physics from Science Map 2002 through Science Map 2008. This suggests the existence of researchers in Japan who have a presence in these research areas. However, the positions of research areas where Japan holds a high share and which are considered as the country's strengths are also scattered in this Figure.

Figure 30 Japanese shares of research papers in the Science Map

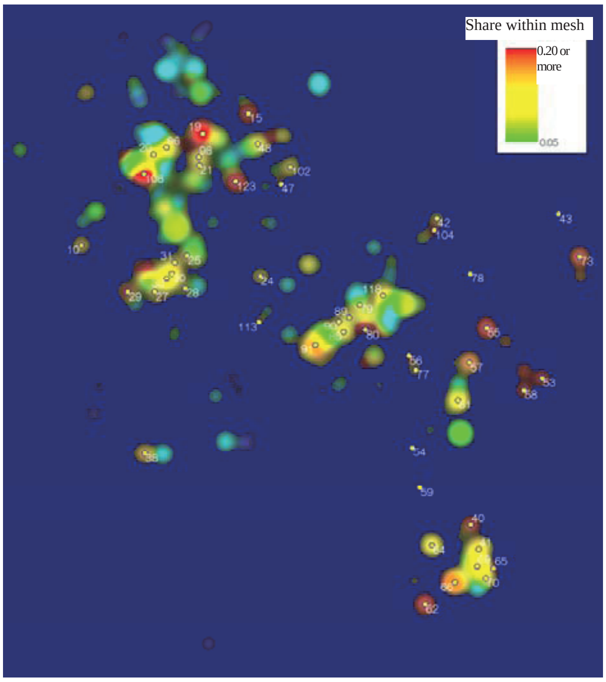
(A) Science Map 2002 [Whole count method]



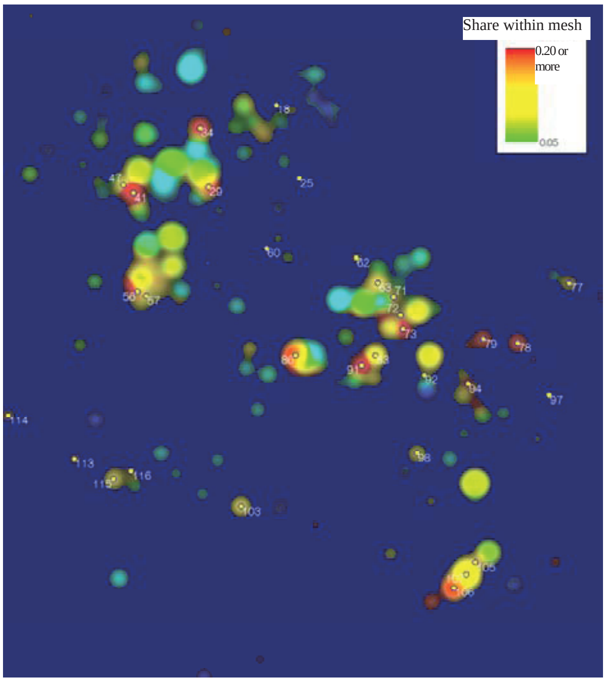
(B) Science Map 2004 [Whole count method]



(C) Science Map 2006 [Whole count method]



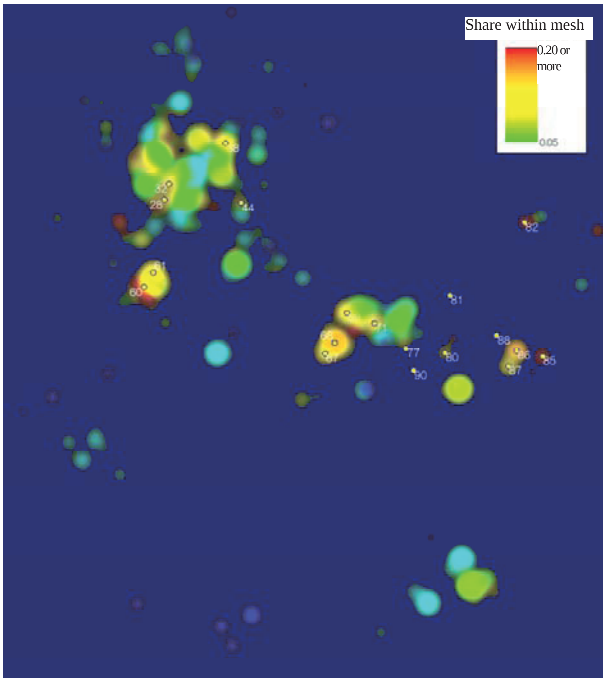
(D) Science Map 2008 [Whole count method]



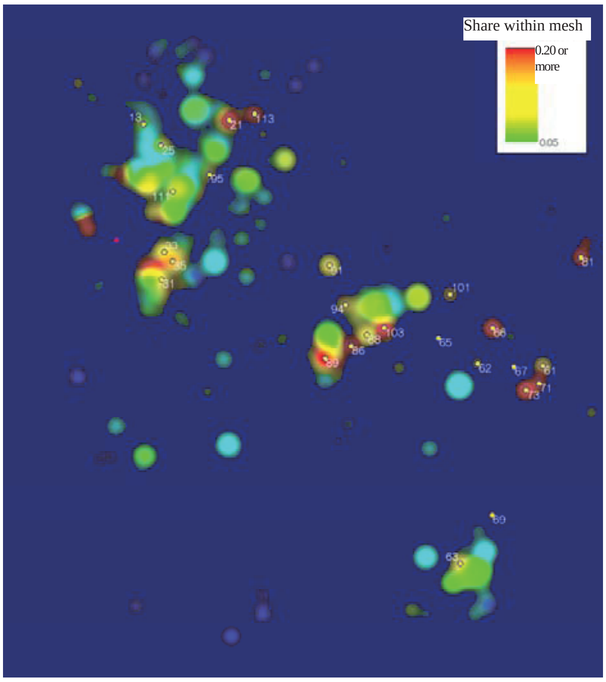
Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using whole count method. Yellow dots and numbers are the positions and IDs of hot research areas in which Japan the countries have a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Figure 31 Japanese shares of research papers in the Science Map

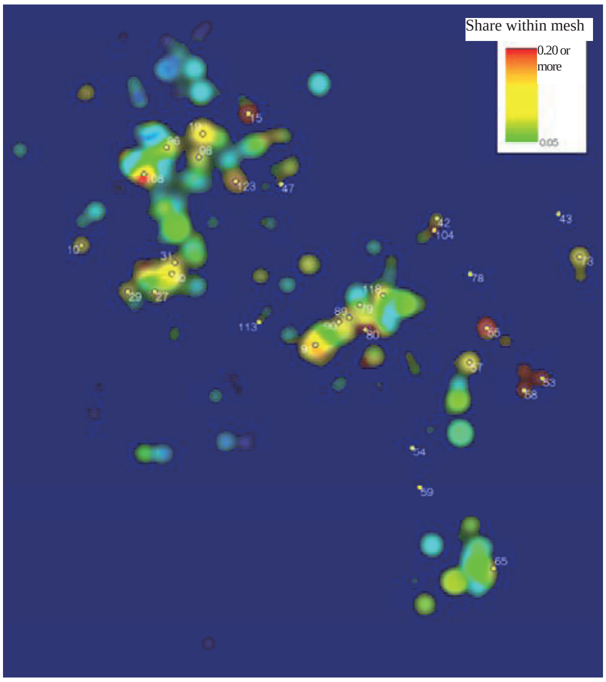
(A) Science Map 2002 [Fractional count method]



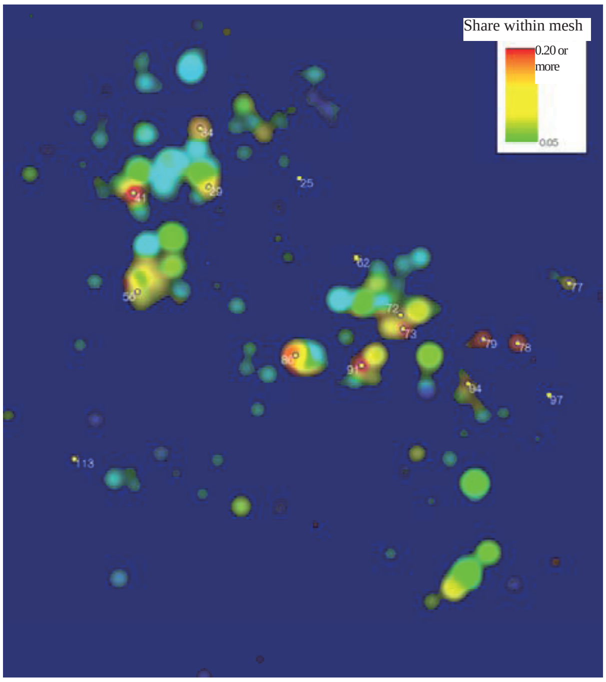
(B) Science Map 2004 [Fractional count method]



(C) Science Map 2006 [Fractional count method]



(D) Science Map 2008 [Fractional count method]



Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using the fractional count method. Yellow dots and numbers are the positions and IDs of hot research areas in which Japan has a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

To have a clear picture, hot research areas that can be considered as Japan’s strengths and in which Japanese share of research papers exceeds 9 percent are shown in Figure 32. The hot research area with the highest share of core papers in the whole count method is “Novel electronic order in high-temperature superconductivity (ID97),” whose share reached 52.2 percent. Following this, Japanese share of papers is high in “Production of interferon by innate immunity (ID41),” “Metal-based spintronics (ID79),” “Molecular mechanisms for excitatory synaptic plasticity (ID25)” and “Complex hydrides associated with hydrogen production and storage and fuel cells (ID91).” Of these, ID97 and ID25 are relatively small and isolated research areas in the map.

A hot research area with the highest share of core papers in the fractional count method is “Metal-based spintronics (ID79),” whose share reached 31.7 percent. Following this, Japanese share of papers is high in “Production of interferon by innate immunity (ID41),” “Complex hydrides associated with hydrogen production and storage and fuel cells (ID91),” “Optical quantum information/communication, optical nanoscience (ID94),” and “Ferroelectric property in new materials such as multiferroics, etc. (ID78).” Of these, ID79 and ID78 are isolated research areas in the map.

Of the 121 hot research areas, Japan’s presence is relatively strong in hot research areas in the fields of physics, basic biology (plant and animal science, neuroscience and behavior, biology and biochemistry and agricultural sciences).

In the field of physics, Japanese share of research papers exceeds 9 percent in 7 out of the 13 hot research areas. Among them, there are 6 hot research areas whose research paper shares exceed 15 percent. The hot research area with the highest Japanese share of research papers related to physics is “Novel electronic order in high-temperature superconductivity (ID97),” share of which is 52 percent. Compared to physics in Science Map 2006 in which Japanese share of research papers exceeded 9 percent in 14 out of the 19 hot research areas, Japanese presence slightly declined in Science Map 2008.

In areas in the field of life science, Japanese share of research papers exceeds 9 percent in 2 out of the 4 hot research areas in plant and animal science. Among them, the research areas related to “Plant-microorganism interactions/strigolactones (ID56)” hold a particularly high share of research papers of 21 percent.

In the field of chemistry, Japanese share of research papers exceeds 9 percent in 4 out of the 15 hot research areas. Japanese papers accounted for more than 15 percent in “Ionic liquid (ID73)” (24 percent) “Catalytic asymmetric synthesis (ID86)” (19 percent), and “Microchannel device (ID62)” (17 percent). Compared to chemistry in Science Map 2006 in which Japanese share of research papers exceeded 9 percent in 8 out of 16 hot research areas, Japanese presence somewhat declined in Science Map 2008.

In inter-/multi-disciplinary research areas, Japanese share exceeded 9 percent in 19 (49 percent) out of the 39 areas in Science Map 2004, 8 (25percent) out of the 32 areas in Science Map 2006 and 10 (25 percent) out of the 40 areas in Science map 2008. Considering that research activities in inter-/multi disciplinary areas are comparatively strong in the Science Map and that research in these research areas is considered to be rapidly drawing attention and tend to move, the stagnant status in these areas bears mentioning.

Figure 32 Hot research areas in which Japan's share of core papers is 9% or more (A) Whole count method

ID	Name of research area	22-field classification	# of core papers	# of Japanese Papers	Ratio of Japanese papers
97	Novel electronic order in high-temperature superconductivity	Physics	23	12	52.2%
41	Production of interferon by innate immunity	Inter-/multi-disciplinary	93	39	41.9%
79	Metal-based spintronics	Physics	61	22	36.1%
25	Molecular mechanisms for excitatory synaptic plasticity	Neuroscience and behavior	19	6	31.6%
91	Complex hydrides associated with hydrogen production and storage and fuel cells	Inter-/multi-disciplinary	74	23	31.1%
94	Optical quantum information/communication, optical nanoscience	Physics	30	8	26.7%
78	Ferroelectric property in new materials such as multiferroics, etc.	Physics	70	18	25.7%
73	Ionic liquid	Chemistry	75	18	24.0%
29	Role of autophagy in health and disease	Inter-/multi-disciplinary	99	22	22.2%
34	Elucidation of pathogenic mechanism of lifestyle-related diseases resulting from obesity	Clinical medicine	98	21	21.4%
116	Climate change simulation including aerosol effects	Geosciences	24	5	20.8%
56	Plant-microorganism interactions/strigolactones	Plant and animal science	53	11	20.8%
86	Catalytic asymmetric synthesis	Chemistry	289	56	19.4%
106	Elementary particle physics/elementary particle astrophysics	Physics	238	45	18.9%
105	Gamma-ray burst	Space sciences	45	8	17.8%
113	Observational studies on carbon balance in continental ecosystem	Agricultural sciences	29	5	17.2%
114	Stability discrimination/stabilizing control of delay system using matrix inequality	Engineering	35	6	17.1%
62	Microchannel device	Chemistry	30	5	16.7%
72	Nanomaterial synthesis in ionic liquid/hollow and mesoporous material	Inter-/multi-disciplinary	30	5	16.7%
77	Formation of bulk metallic glass/transformation of metal glassy alloys	Inter-/multi-disciplinary	46	7	15.2%
71	Mesoporous material/silica, carbon and metal oxide	Inter-/multi-disciplinary	33	5	15.2%
57	Plant developmental genetics/carbohydrate metabolism	Plant and animal science	31	4	12.9%
18	Genetic research on schizophrenia and molecular pathogenesis investigations developed from the research	Inter-/multi-disciplinary	16	2	12.5%
107	New developments in cosmology and elementary particles theory owing to advancement in precise observation of space	Inter-/multi-disciplinary	519	63	12.1%
63	Semiconductor-spintronics material/magnetic semiconductors	Inter-/multi-disciplinary	94	11	11.7%
60	Structure and functions of G-protein-coupled receptor	Biology and biochemistry	18	2	11.1%
83	Design and functions of configurational space and coordination lattice	Chemistry	165	18	10.9%
98	Ultrafast and ultraintense optical science	Physics	57	6	10.5%
115	Atmospheric composition and minor constituents	Geosciences	69	7	10.1%
92	Electromagnetic response of surface plasmon in artificial structures	Physics	20	2	10.0%
103	Earth in the Precambrian era	Geosciences	83	8	9.6%
47	Process of early infection with Hepatitis C virus and its treatment	Inter-/multi-disciplinary	76	7	9.2%

Note: Research paper shares were calculated using whole counting.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

(B) Fractional count method

ID	Name of research area	22-field classification	# of core papers	# of Japanese Papers	Ratio of Japanese papers
79	Metal-based spintronics	Physics	61	19.3	31.7%
41	Production of interferon by innate immunity	Inter-/multi-disciplinary	93	26.6	28.6%
91	Complex hydrides associated with hydrogen production and storage and fuel cells	Inter-/multi-disciplinary	74	19.0	25.7%
94	Optical quantum information/communication, optical nanoscience	Physics	30	7.3	24.4%
78	Ferroelectric property in new materials such as multiferroics, etc.	Physics	70	15.0	21.4%
73	Ionic liquid	Chemistry	75	16.0	21.3%
97	Novel electronic order in high-temperature superconductivity	Physics	23	4.6	20.1%
86	Catalytic asymmetric synthesis	Chemistry	289	54.5	18.9%
25	Molecular mechanisms for excitatory synaptic plasticity	Neuroscience and behavior	19	3.5	18.4%
34	Elucidation of pathogenic mechanism of lifestyle-related diseases resulting from obesity	Clinical medicine	98	17.3	17.7%
29	Role of autophagy in health and disease	Inter-/multi-disciplinary	99	15.3	15.5%
62	Microchannel device	Chemistry	30	4.5	15.0%
72	Nanomaterial synthesis in ionic liquid/hollow and mesoporous material	Inter-/multi-disciplinary	30	3.5	11.7%
77	Formation of bulk metallic glass/transformation of metal glassy alloys	Inter-/multi-disciplinary	46	5.2	11.2%
113	Observational studies on carbon balance in continental ecosystem	Agricultural sciences	29	3.2	10.9%
56	Plant-microorganism interactions/strigolactones	Plant and animal science	53	5.2	9.8%

Note: Research paper shares were calculated using fractional counting.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

(4) Activities in the UK, Germany and China as seen in the Science Map

The status of activities in the UK, Germany and China will be discussed hereafter while comparing them with those in Japan. Figure 33 shows maps with research area shares of Japan, UK, Germany and China calculated using the whole count method and fractional count method.

First of all, for Japan and China, there is no significant difference on the maps resulting from the two counting methods. The shares of the UK and Germany are notably high in the whole count method compared to those in the fractional count method. As has been discussed, this is because the UK and Germany have already established their presence in the world of science through international co-authorship.

The characteristics of the UK and Germany is that both countries have a certain amount of share all over the science map in the whole count method, while in the fractional count method, research areas in which the countries have high share are concentrated in specific research area groups. For example, when looking at the map in the fractional count method, research areas in which Germany has a high share of research papers (9 percent or more) tend to concentrate in plant science, chemistry, nanoscience and the like. By contrast, in the whole count method, hot research areas in which Germany's share of research papers exceed 15 percent spread broadly across the Science Map. This tendency is also found for the UK. These two countries are considered to be retaining the diversity of knowledge as a country by participating in knowledge production through international co-authorship even in small research areas that do not contribute much to the knowledge production of their own countries.

Looking at the difference between the UK and Germany, the UK is not only highly active in brain research within the country, but also has a presence in the activities of international collaboration. Germany is not active in the activities of this research area group. Brain research is a research area group that saw a significant move in Science Map 2008, and its linkage with research in social science is expected to strengthen in the future. The UK seems to have gained a foothold for its research activities in this kind of research group.

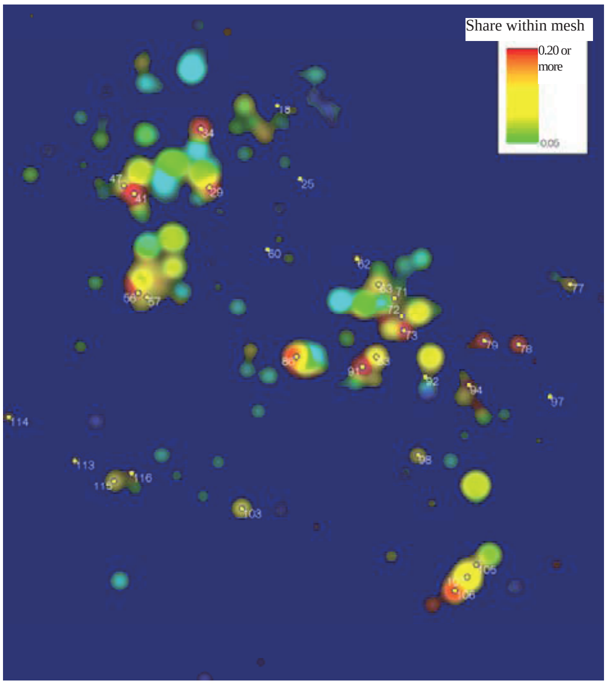
Germany, on the other hand, is characterized by its research activity within the country and presence in the activity of international collaboration in the field of chemistry where the UK has no presence. Considering the fact that the relationship of chemistry with environmental research is drawing more attention in addition to the previous relationship with nanoscience and condensed matter physics, gaining strength in this kind of research area group is effective when thinking of future developments of this group into other research area groups.

It is evident that the status in China is increasing both the range and degree of activities of scientific research when looking at "6. Time-series changes in shares of research papers in major countries in the Science Map" in Part II of this report. The range of activities of scientific research in China focuses on nanoscience. Although the area of activities is spreading towards life science, China has not been able to show its presence in that field. This made the strengths and weakness of the country clearly visible. In the region of nanoscience, there are a number of hot research areas in which China's research paper share exceeds 9 percent even in the fractional count method. This means that, even when looking at only the research activities within the country, China has a presence because of its high activities. Most of hot research areas in nanoscience are inter-/multi-disciplinary research areas. They are relatively new and the degree of attention is increasing rapidly. In other words, China has a presence in research areas where new knowledge is produced without being caught up in the existing fields. In this respect, Japan is forced to face an uphill battle in terms of the fractional count method.

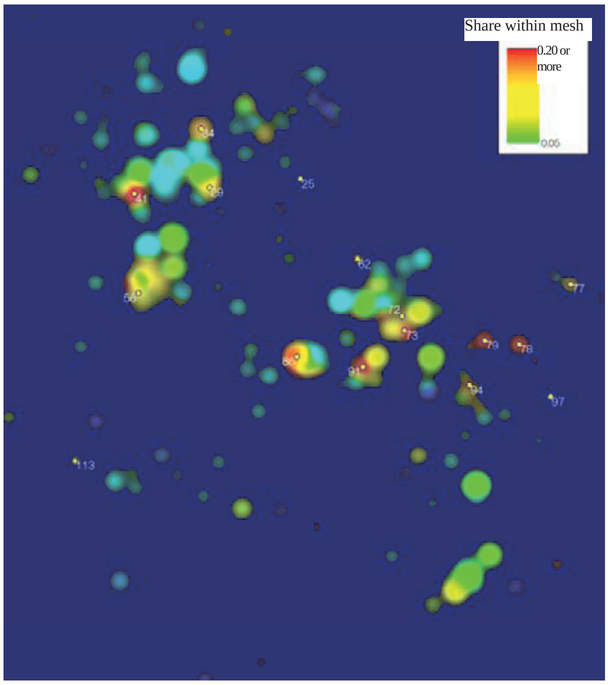
Comparing Japan with the UK, Germany and China, research areas in which these three countries hold high shares are somewhat clustered in the map. (Please see the yellow dots and numbers in the figure.) In the case of Japan, some research areas which Japan has high activity are clustered in nanoscience and particle physics/cosmology, but they are basically scattered in places that are distant from each other. Looking at individual hot research areas, there does exist research areas in which Japan has a presence, but their activities are limited and do not expand into neighboring regions. In other words, there is the possibility that Japan has not been able to have a presence in the world, because the breadth of researchers is not broad enough to produce mass effects. In this respect, the UK and Germany are considered to have an international presence by increasing participation in scientific research as a whole through international co-authorships.

Figure 33 Comparison of the share of research papers between Japan and the UK, Germany and China on Science Map 2008

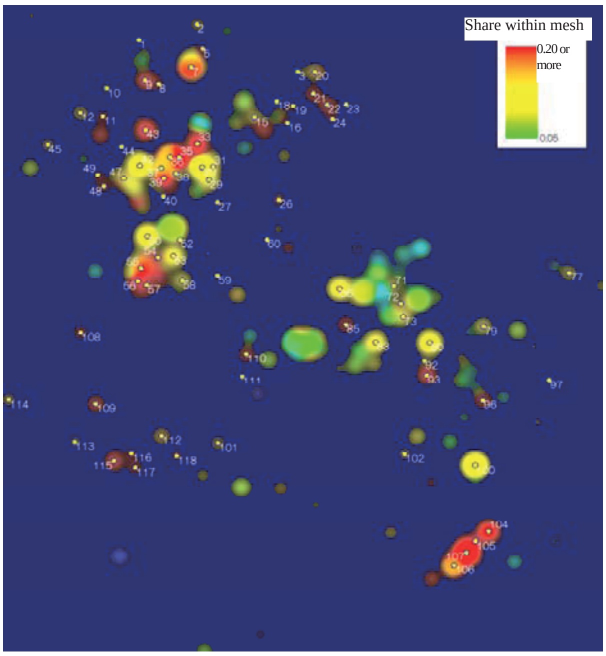
(A) Japan [Whole count method]



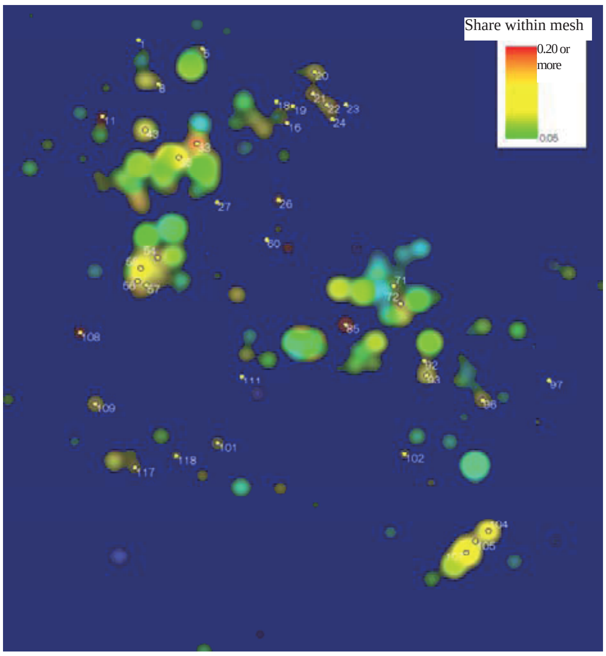
(B) Japan [Fractional count method]



(C) UK [Whole count method]

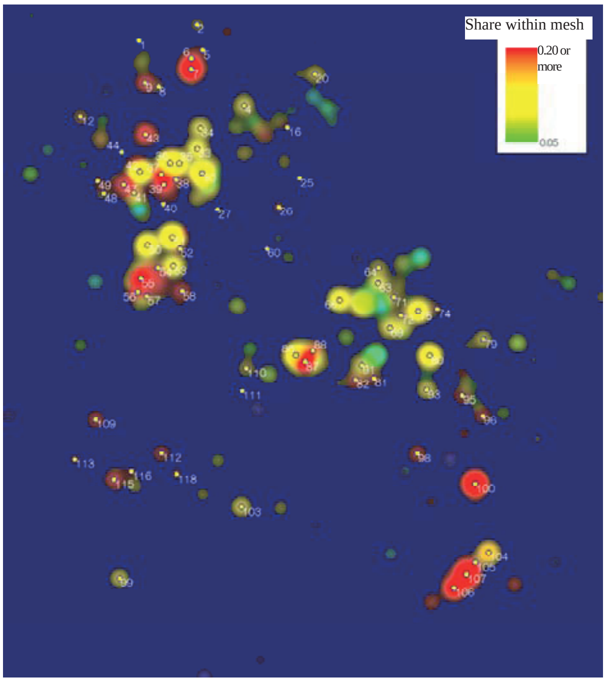


(D) UK [Fractional count method]

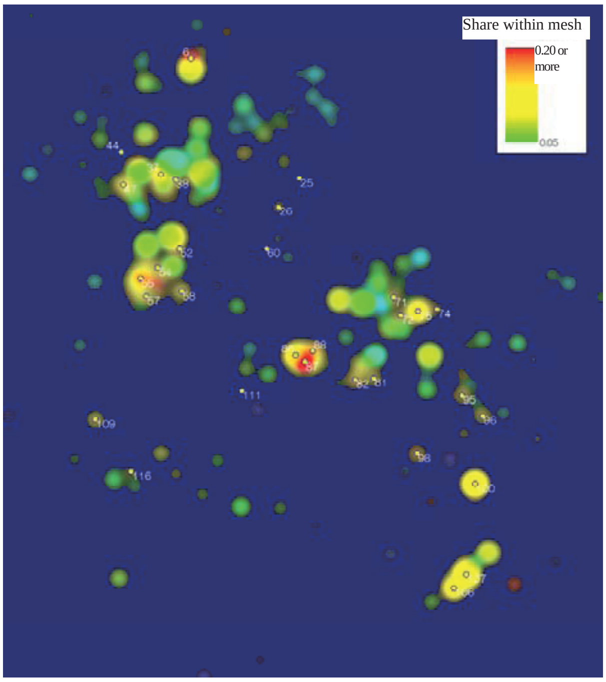


Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using whole counting. Yellow dots and numbers are the positions and IDs of hot research areas in which the countries have a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

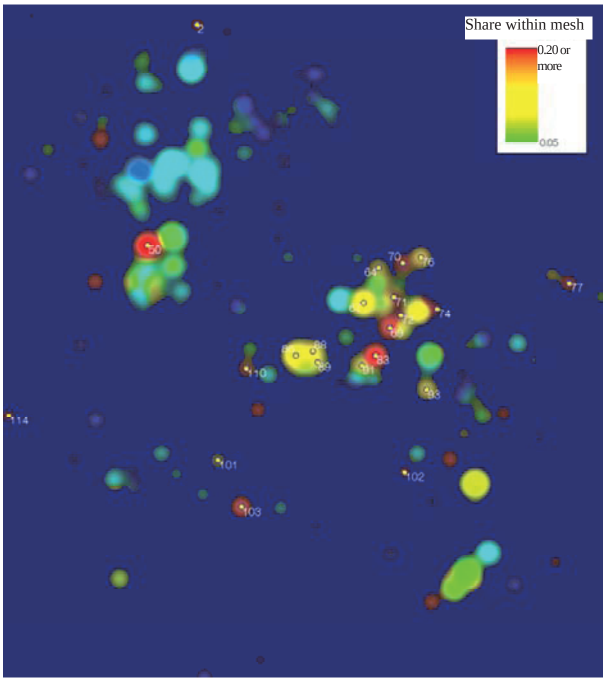
(E) Germany [Whole count method]



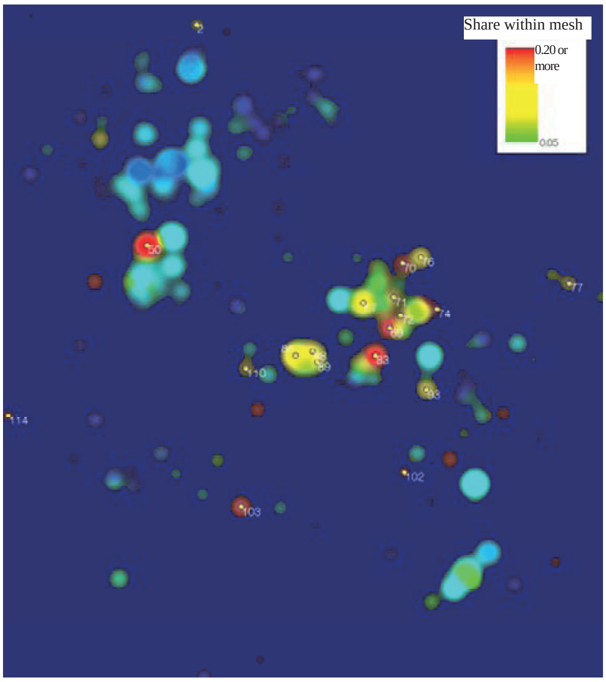
(F) Germany [Fractional count method]



(G) China [Whole count method]



(H) China [Fractional count method]



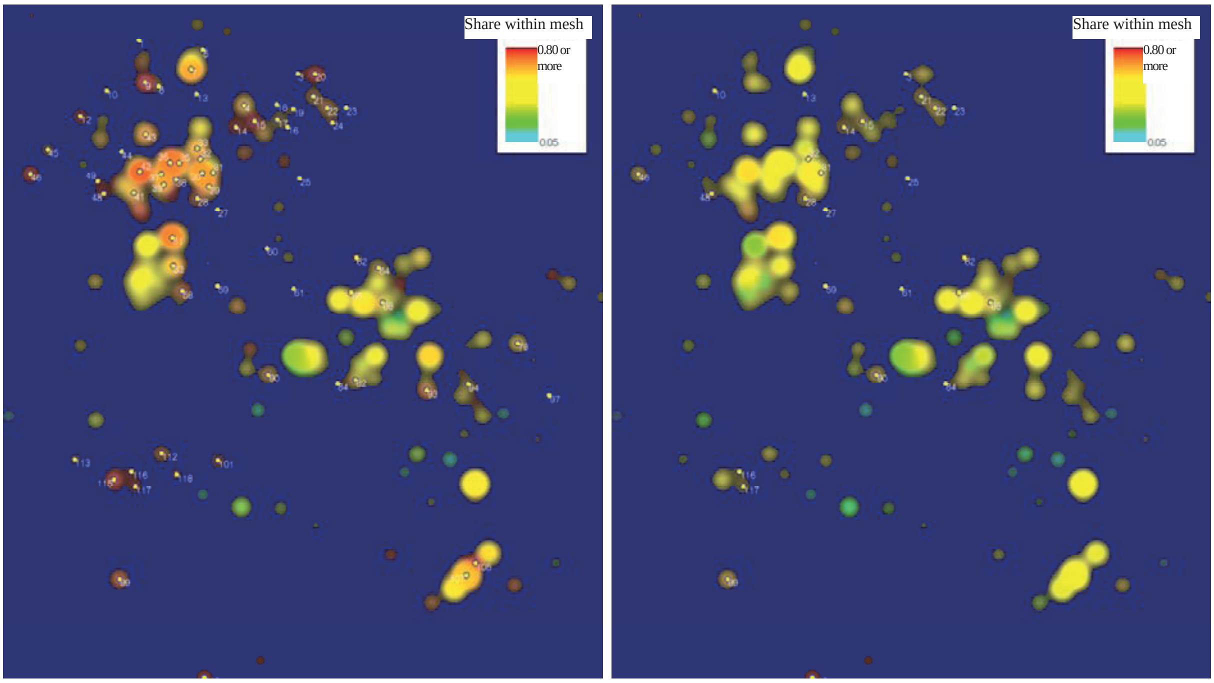
Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using fractional counting. Yellow dots and numbers are the positions and IDs of hot research areas in which the countries have a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

(5) Status of activities in the US as seen in the Science Map

Figure 34 is the Science Map 2008 on which US shares in research areas are added. As shown in Figure 25, the US shares in core papers is exceptional compared to those of other countries, which indicates that the US is taking the lead in scientific research. However, looking at the overall balance of the Research Area Correlation Map, there are gradations in shares of core papers. Compared to the groups of research areas in life science and environment that show extremely high shares of research papers, the shares in research area groups in chemistry and nanoscience are small. This trend is observed in the same manner in both counting methods.

Figure 34 US share of research papers plotted on Science Map 2008

(A) US [Whole count method] **(B) US [Fractional count method]**



Note: Research paper shares of 5 percent are depicted in light blue, and shares of 80 percent or more in red. Shares of research papers were calculated using whole counting. Yellow dots and numbers are the positions and IDs of hot research areas in which the US has a 60 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

(6) Gap in the distribution of research papers between the Science Map and individual countries

Here, we will discuss the gap between the distribution of research papers in the Science Map and in individual countries (Figure 35). This is to confirm whether distribution follows the world's standard or has unique characteristics. More specifically, the gap between the distribution of the world's research papers in the Science Map and the distribution of research papers in individual countries was assessed using the following formula.

$$\sum_{\mathrm{i,j}} \left\{ \mathrm{N_{All}(i,j)} - \mathrm{N_{Country\ A}(i,j)} \right\}^2$$

$\mathrm{N_{All}(i,j)}$ here indicates the number of research papers included in the (i and j)th micro areas in all the core papers comprising the Science Map. $\mathrm{N_{Country\ A}(i,j)}$ is the number of research papers included in the (i, j)th micro areas. The sum is calculated for the entire Science Map. The formula was standardized so that the sum of the entire Science Map is 1 for both$\mathrm{N_{All}(i,j)}$ and $\mathrm{N_{Country\ A}(i,j)}$. This value becomes 0 when the distribution of research papers in Country A in the Science Map is identical to the distribution of the world's research papers and increases as the gap increases.

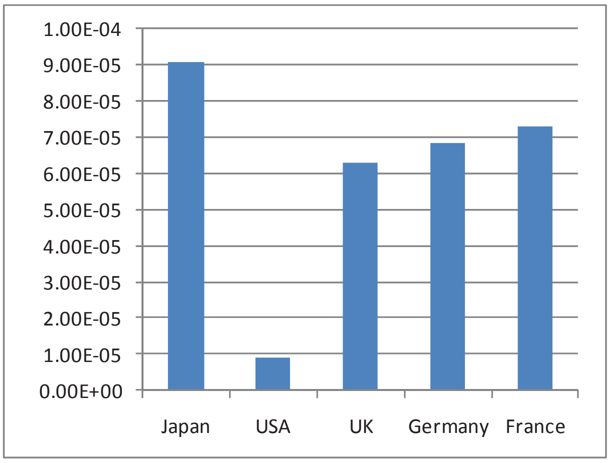
Comparing (A) and (B), Japan, the UK and Germany come closer to the world's standard from Science Map 2002 through Science Map 2008. France, by contrast, got away from the world's standard, indicating that the country has its own portfolio. The gap in the US is extremely small.

As can be seen from the distribution of research papers in France shown in (C) and (D), in Science Map 2002, the country has a relatively high share in research areas in environment, but research papers cover almost the entire Science Map. Compared to this, the country's presence is strong in research areas in clinical medicine in Science Map 2008, while it is weak in nanoscience and chemistry. This indicates changes in the distribution of research papers in the map.

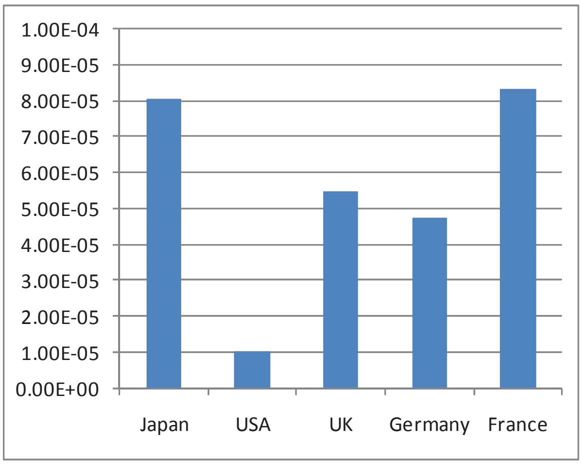
Although the UK, Germany and France increased shares in Science Map 2008, the trend in the distribution of research papers on the Science Map varies.

Figure 35 Gap in the distribution of research papers between the Science Map and individual countries

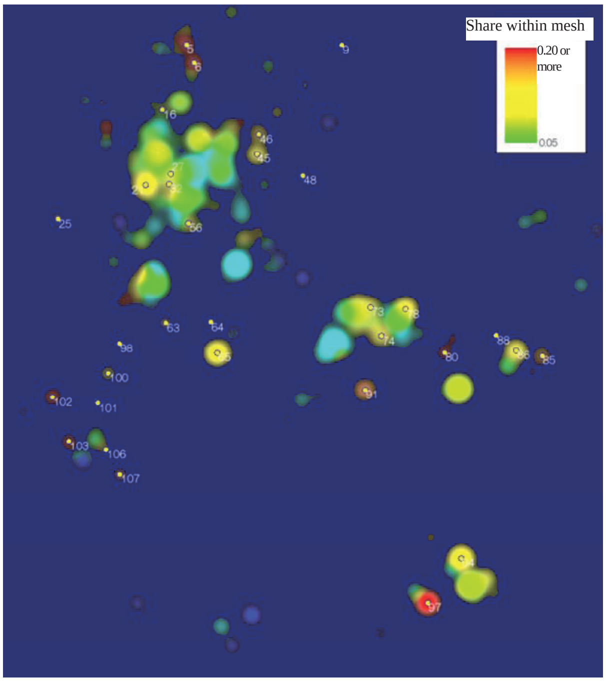
(A) Science Map 2002



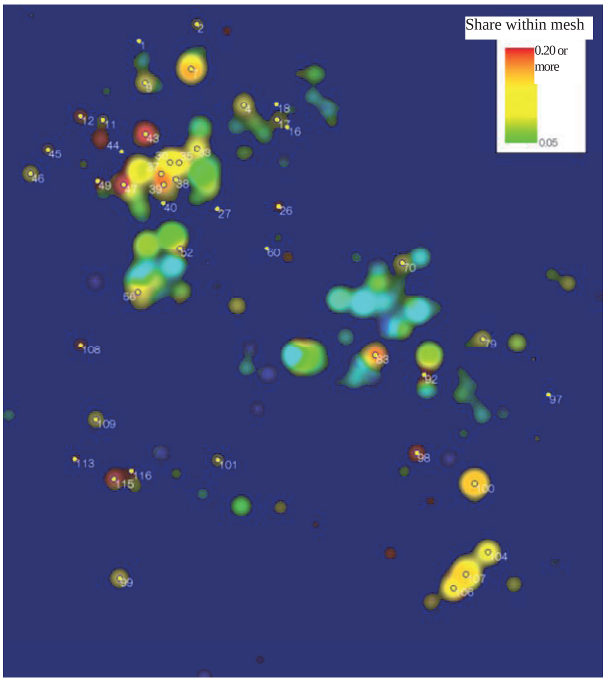
(B) Science Map 2008



(C) Science Map 2002 France [Whole count method]



(D) Science Map 2008 France [Whole count method]



Note: In Figure (C) and (D), research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using fractional counting. Yellow dots and numbers are the positions and IDs of hot research areas in which the countries have a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

4-2 Exploration of research areas that have high continuity and spread effects

Here, we will introduce results of the exploration of research areas that have high continuity over time and could have significant spread effects on other research areas. More specifically, an analysis was carried out using the following procedure.

(1) Analysis of the relationship between the continuity and spread effects of research areas and the number of core papers and network index using Science Map 2004

For the research areas obtained from Science Map 2004, 1) how much of them continued into Science Map 2008 (continuity) and 2) how many of them spread to research areas in Science Map 2008 and how is the degree of the spread (spread effects) were explored, and research areas that have high continuity and spread effects were classified using the number of core papers and network index.

As shown in Figure 36, the results found that the continuity of research areas is higher as the number of core papers increases, and of these research areas, those that have higher degree centrality result in more spread research areas. Also, research areas that have higher betweenness centrality tend to expand the breadth of their spread research areas on the map.

(2) Application of the methodology to Science Map 2008

The classification method for the research areas obtained in Science Map 2004 was applied to Science Map 2008, and hot research areas that have a potential in terms of continuity and spread effects were extracted.

Figure 36 Relationship between the continuity and spread effects, and the number of core papers and network index

	Measurement method	Indexes related to continuity and spread effects		
		Number of core papers	Network index	
			Degree	Betweenness
Continuity	Existence of research areas whose degree of commonality is 0.2 or more	◎	△	—
Spread effects	Number and breadth of research areas (spread research areas) that share at least one same core paper	○	Number of spread research areas ○	Breadth of spread research areas ○

[Continuity and spread effects of research areas]

(Continuity of research areas)

Continuity of research areas was assessed using the degree of commonality of core papers between research areas. First, research areas in Science Map 2006 (B) that are connected with a research area in Science Map 2004 (A) with the degree of commonality of 0.2 or more were extracted. Next, the existence of research areas in Science Map 2008 (C) which are connected with the research areas (B) with the degree of commonality of 0.2 or more was examined. If the research areas (C) exist, the research area (A) was determined as a research area continued from Science Map 2004.

(Spread effects of research areas)

Spread effects of research areas were examined from the aspects of quantity (number of spread research areas) and breadth.

The number of spread research areas was determined using the number of same core papers shared between research areas. First, research areas (b) in Science Map 2006 that share at least one same core paper with a research area (a) in Science Map 2004 were extracted. Next, research areas (c) in Science Map 2008 which share at least one same core paper with the research areas (b) were extracted and were determined as spread research areas of the research area (a).

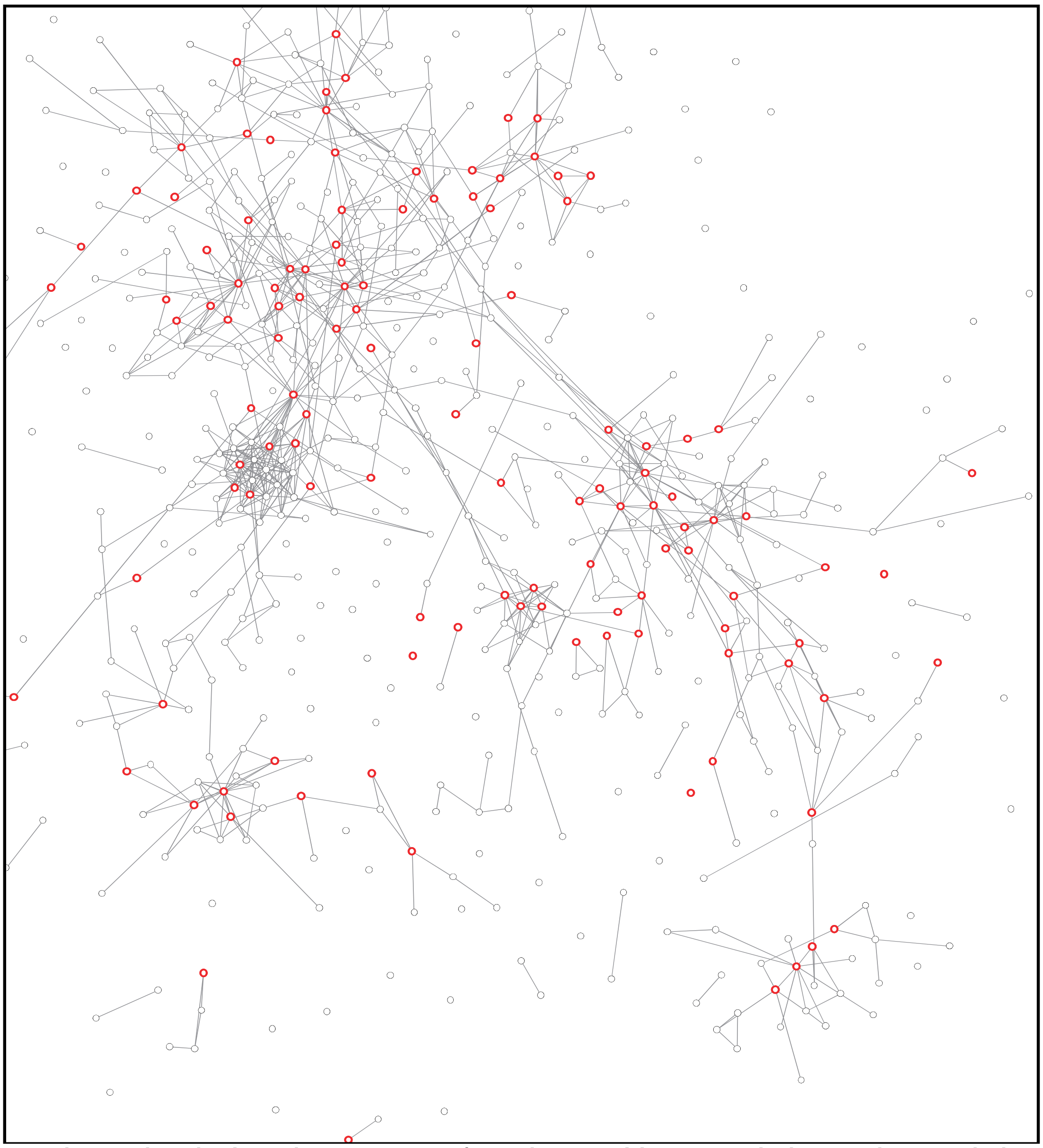
The breadth of spread was grasped by confirming positions and calculating distance on the Science Map.

4-2-1 Indexes used for the analysis

(1) Network index

As a network index, attention was focused on the three centralities; degree centrality, closeness centrality and betweenness centrality. In order to analyze a research area network that works as a backbone of the Science Map, the links that have the standardized degree of co-citation of 0.02 or more (Figure 37, the links shown with solid lines) was used to calculate the centralities. In calculating the network index, all of the links that have the degree of co-citation of 0.02 or more were weighed as 1. Figure 38 summarizes the outline of the method of calculation of each centrality and its meaning in the Science Map. The detailed calculation method is shown in "7. How to calculate centrality" in Chapter II.

Figure 37 Science Map 2008 Network graph



Note: Dots in the network graph indicates the center positions of research areas. Red dots correspond to hot research areas. Links that connect research areas with the co-citation degree of 0.02 or more are visible in the image.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Degree centrality was calculated for all research areas. The calculation was made for 626 research areas in Science Map 2004 and 647 research areas for Science Map 2008.

For closeness centrality and betweenness centrality, a cluster that has the largest number of research areas connected via links in the Science Maps was analyzed. A cluster of 338 connected research areas was analyzed for Science Map 2004, whereas, a cluster of 442 connected research areas was analyzed for Science Map 2008.

Figure 38 Calculation methods of degree, closeness and betweeness centralities and their meaning in the Science Map

Type of centrality	Outline of centralities calculation method	Meaning of centrality in the Science Map
Degree centrality	The number of research areas to which a particular research area is connected with the co-citation relationship of 0.02 or more.	A value which considers only the relationship with most adjacent research areas. It indicates the relationship with neighboring research areas in the Science Map. The value tends to increase in a research area which is the center of a research area group.
Closeness centrality	After calculating the number of steps to reach from a research area to another in the shortest step (a shortest path), the average number for all research areas is calculated. (Research areas that are not connected via links are excluded from analysis.)	A value indicating the average shortest distance to other research areas. Because research areas in life science account for about half of the Science Map, the value of closeness centrality tends to increase in research areas in life science.
Betweenness centrality	An indicator for the characteristics to bridge two research areas. Among all shortest paths that connect two research areas (A and B), the number of paths that pass through one particular research area is calculated. The pair A and B is assigned to all research areas on the Science Map. The research area that need to be passed through in reaching B from A has a high betweenness centrality (Research areas that are not connected via links are excluded from analysis.)	The value indicates the extent of involvement of a research area in a shortest path that connects any two given research areas. In the Science Map, the value tends to be higher in a research area that plays the role of connecting two different research area groups.

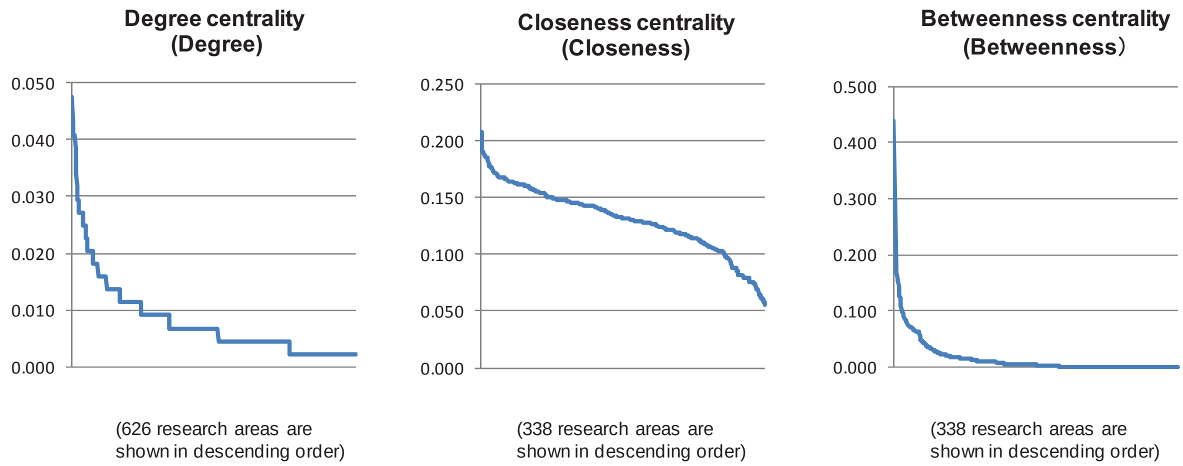
First, Figure 39 shows the distribution of the values of degree centrality, closeness centrality and betweenness centrality calculated for each research area and sorted in descending order. Comparing these values, the difference between higher and lower values is more than ten times in degree centrality and betweenness centrality, whereas, the difference in closeness centrality is about 4 times and thus the values are not greatly distributed. Based on these results, research areas were classified into the ranges of the top 0-5 percent, 5-20 percent, 20-50 percent and 50-100 percent by degree of each of the three centralities.

Next, the distribution of fields was analyzed for each range of degree of the three centralities (Figure 40). Looking at the balance between life science and the fields other than life science in hot research areas, the percentage of hot research area in life science is greater in the top 0-5 percent range in degree centrality and betweenness centrality. As can be seen from Figure 37, this derives from the difference in degree of connection of research areas via links between life science and fields other than life science.

For closeness centrality, all hot research areas of up to the top 20 percent are in life science. This is because, in addition to the degree of linkage between research areas, closeness centrality is a value that largely depends on the balance of the number of research areas in life science and those other than life science.

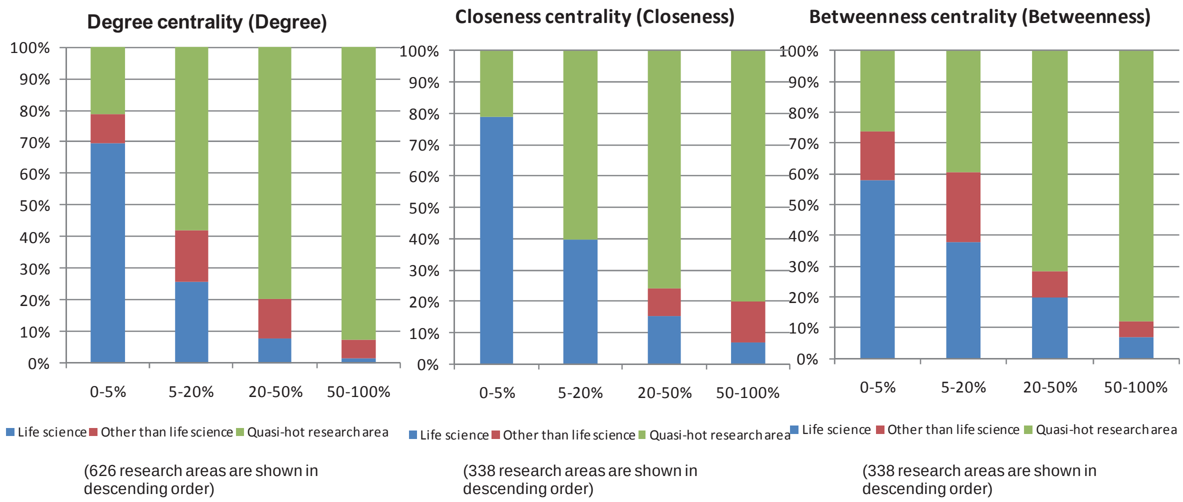
The report hereafter analyzes the continuity and spread effects of research areas using degree centrality and betweenness centrality.

Figure 39 Distribution of degree, closeness and betweenness centralities (Science Map 2004)



Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Figure 40 Distribution of fields by the range of degree of centralities (top 0-5 percent, 5-20 percent, 20-50 percent and 50-100 percent) (Science Map 2004)

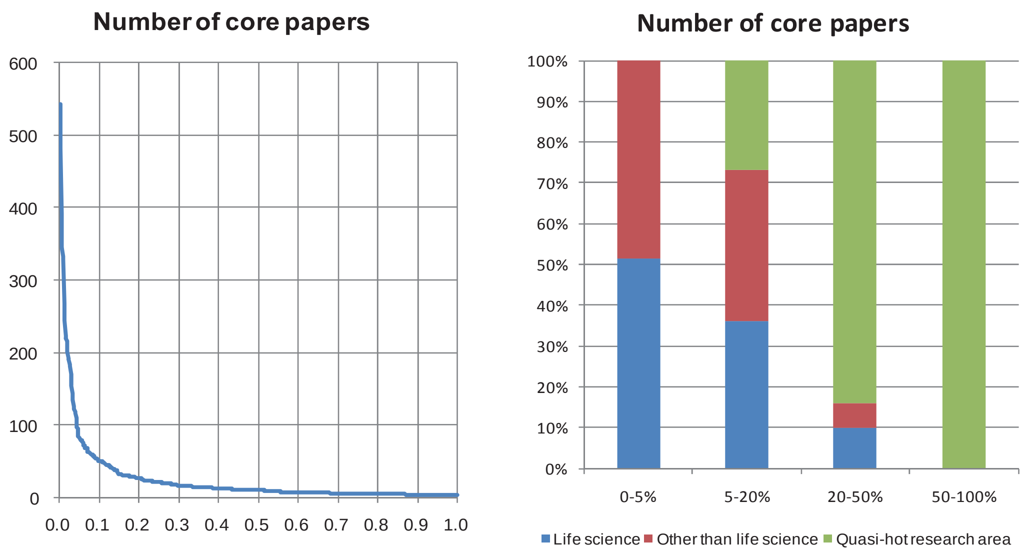


Note 1. Hot research areas were classified into life science and other than life science
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

(2) Number of core papers

Figure 41 shows the distribution of the number of core papers in the 626 research areas in Science Map 2004. As in degree centrality and betweenness centrality, core papers also concentrate in research areas that are classified into higher-ranking research areas. However, looking at the proportion between life science and other than life science, both fields share almost the same percentage in the top 0-5 percent, 5-20 percent, 20-50 percent and 50-100 percent ranges in the number of core papers.

Figure 41 Distribution of the number of core papers and the distribution of fields by range of the number of core papers (Top 0-5 percent, 5-20 percent, 20-50 percent and 50-100 percent) (Science Map 2004)



Note 1. Hot research areas were classified into life science and other than life science
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

4-2-2 Relationship between the continuity of research areas and the number of core papers/degree centrality

First, we will discuss results of the analysis of the relationship between the continuity of research areas, and the number of core papers and degree centrality.

Out of all research areas (626 research areas) in Science Map 2004, 163 research areas continued into Science Map 2008, indicating that about 25 percent of the research areas continued. Figure 42 and Figure 43 respectively shows the number of research areas in Science Map 2004 and the continuity of these research areas through Science Map 2004 to Science Map 2008, after categorizing them into the top three ranges of 0-5 percent, 5-20 percent and 20-100 percent using the number of core papers and degree centrality.

Of the 31 research areas that are in the top 0-5 percent in terms of the number of core papers, about half of them is also in the top 0-5 percent in terms of degree centrality. Also, of the 33 research areas in the top 0-5 percent in degree centrality, about half of them are also in the top 0-5 percent in the number of core papers. The correlation coefficient between degree centrality and the number of core papers is 0.54.

87 percent of research areas that are in the top 0-5 percent in the number of core papers continued, whereas, 58 percent of research areas that are in the top 0-5 percent in degree centrality continued. This indicates that the percentage of research areas that continue tends to be higher in research areas with a higher number of core papers and higher level of degree centrality. Comparing the number of core papers and degree centrality, the probability of research areas to continue was higher when research areas with a higher number of core papers were extracted.

Figure 42 Number of research areas (classification by the number of core papers and degree centrality) (Science Map 2004)

Degree centrality

Number of core papers	Top 0-5 %	Top 5-20 %	Top 20-100 %	Overall
Top 0-5 %	15	6	10	31
Top 5-20%	10	35	52	97
Top 20-100%	8	57	433	498
Overall	33	98	495	626

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Figure 43 Number of research areas continued and the percentage of continuity (Classificaton by the number of core papers and degree centrality) (Science Map 2004)

Degree centrality

Number of core papers	Top 0-5%	Top 5-20%	Top 20-100%	Overall
Top 0-5%	12(0.80)	6(1.00)	9(0.90)	27(0.87)
Top 5-20%	5(0.50)	19(0.54)	33(0.63)	57(0.59)
Top 20-100%	2(0.25)	13(0.23)	64(0.15)	79(0.16)
Overall	19(0.58)	38(0.39)	106(0.21)	163(0.26)

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

4-2-3 Relationship between the spread of research areas and the number of core papers/network index

(1) Number of spread research areas

Next, we will analyze how many spread research areas were derived from research areas in Science Map 2004. Figure 44 shows the number of spread research areas per research area. Research areas that are in the top 0-5 percent in the number of core papers contributed to about 5.9 spread research areas, whereas, research areas in the top 0-5 percent in degree centrality were about 5.3 spread research areas. Figure 45 shows that, among research areas whose numbers of core papers are in the same range, research areas that have higher degree centrality have a greater number of spread research areas.

Especially research areas that are in the top 0-5 percent in both the number of core papers and degree centrality have a particularly large number of spread research areas, indicating their strong impacts on other research.

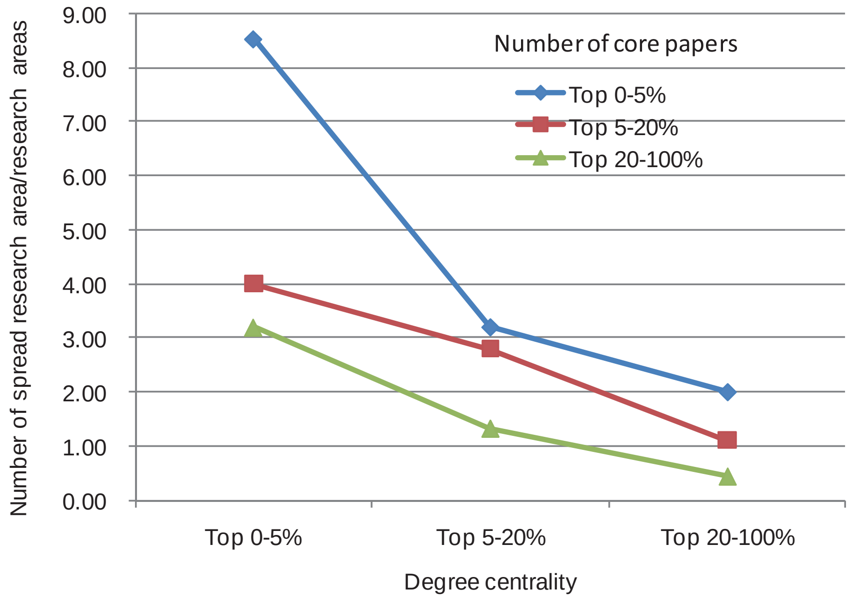
Figure 44 Number of spread research areas
(Classification by the number of core papers and degree centrality) (Science Map 2004)

Degree centrality

Number of core papers	Top 0-5%	Top 5-20%	Top 20-100%	Overall
Top 0-5%	8.53	4.00	3.20	5.94
Top 5-20%	3.20	2.80	1.33	2.05
Top 20-100%	2.00	1.11	0.44	0.54
Overall	5.33	1.89	0.59	

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Figure 45 Dependence of the number of spread research areas on degree centrality (Science Map 2004)



Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

The observation up to now found that research areas that are high in both the number of core papers and degree centrality has a high continuity and produces many spread research areas. Figure 46 and Figure 47 show results of the classification of hot research areas in Science Map 2004 which was made using the number of core papers and degree centrality.

As was seen in Figure 40, when degree centrality is compared in life science and other than life science, values of degree centrality in life science tends to be higher. Therefore, life science and other than life science were indicated separately in Figure 46 and Figure 47.

When looking at the hot research areas that are in the top 0-5 percent in the number of core papers, the percentage of hot research areas in life science is highest in the top 0-5 percent in degree centrality, whereas, the number of hot research areas other than life science is highest in the top 20-50 percent range in degree centrality. This also indicates that the degree of interaction with other research areas differs between research areas in life science and other than life science, even if the size of research areas based on core papers is the same.

Figure 46 Classification of hot research areas using the number of core papers and degree centrality (Life science, Science Map 2004)

	Top 0-5 percent in degree centrality	Top 5-20 percent in degree centrality	Top 20-50 percent in degree centrality	Top 50-100 percent in degree centrality
Number of core papers 0-5 percent	14 Research on cancer therapy 16 Research on molecular pathogenesis and leukemia therapy 26 Signal transducing molecules associated with lifestyle-related diseases 27 Stem cell therapy on nervous, hematopoietic, and cardiovascular system 33 Analysis of mechanism of regulation of plant growth 34 Stress response in plants 35 Study of biological clock 105 Research on proteome 110 Research on infection mechanism and therapy of HCV and HIV 116 Research on immune system 117 Research on molecular mechanism in apoptosis 130 Research on epigenetic transcriptional regulation	15 Clinical trial of therapeutic agent for cardiovascular disease 132 Research on Alzheimer's disease and Parkinson's disease	131 TRP channel and cellular senses	5 Research on SARS and avian influenza
Number of core papers 5-20 percent	11 Research on multiple myeloma therapy 21 Molecular mechanism of adipocytokines and the onset of metabolic syndrome 25 Effects of COX-2 inhibitor against cancer 30 Plant genome research 31 Functional analysis on abscisic acid, a plant hormone 99 Signal transduction in metabolic pathway 100 Hypoxia-inducible factor and tumorigenesis 114 Molecular mechanism of PI3/Akt signal transduction pathway 121 Signal transduction in immune system	2 Clinical treatment of severe sepsis and septic shock 12 Research on diseases for which Rituxan is effective 13 Research on osteoclastic mechanism 18 Autoimmune disease 22 Research on breast cancer therapy 24 Clinical research on COX-2 inhibitor as anti-inflammatory drug 28 Structures and functions of G-protein-coupled receptor 32 Dynamics and regulation of cytoskeleton 52 Clinical trials for phobias, mood disorders and anxiety disorders 74 Network analysis and its application to genome, social-network, and infection transmission 93 Drug discovery research 113 Ghrelin; its mechanism of action 115 Genetic diagnosis and therapy of Crohn's disease 118 Research on multipotency and differentiation mechanism of stem cells in cardiovascular system, cancer, and embryos 126 Function study of mammalian TOR 127 Molecular mechanism of DNA damage and repair	3 Cardiac resynchronization therapy for intractable heart failure 4 Diversity of arrhythmia-related genes 6 Research on allergy therapy 19 Prevention of post-coronary angioplasty restenosis with drug-eluting stents 23 Research on venous thromboembolism therapy 48 Glutamate receptors in plasticity brain 49 Research on neurodegenerative mechanism in Huntington's disease based on transgenic mice 50 Visual stimulation and oscillatory brain activities 53 Early diagnostics and therapy of schizophrenia 109 Research on prion diseases	
Number of core papers 20-50 percent		1 Research on medical examination of colorectal cancer 17 Functional analysis of peroxisome proliferator-activated receptor 20 Gene therapy targeting hematopoietic stem cells and its side effects 29 Utility of agrobacterium-mediated genetic engineering and the genomic character 51 Mechanism of molecules involved in formation of brain 111 Cancer therapy with histone deacetylase (HDAC) inhibitor 129 Mechanism of control of life-span	9 Development of imaging techniques for cardiovascular system 47 Brain function imaging of cognitive psychological phenomena 98 Research on infection mechanism of HIV 107 Genome analyses of Helicobacter pylori and Mycobacterium tuberculosis 112 Intake of soy- and plant-derived estrogen/isoflavone and its effects on age-associated diseases 125 Development of statistics method for microarray data analysis 128 Nucleocytoplasmic traffic and cell function	7 Research on countermeasures to bioterrorism 8 Therapy of multiple sclerosis 95 Signal conduction of the lysophospholipids receptors

Note: There are no hot research areas whose number of core papers is in the range of top 50 percent or more.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Figure 47 Classification of hot research areas using the number of core papers and degree centrality (Other than life science, Science Map 2004)

	Top 0-5 percent in degree centrality	Top 5-20 percent in degree centrality	Top 20-50 percent in degree centrality	Top 50-100 percent in degree centrality
Number of core papers 0-5 percent	78 Cosmic microwave background fluctuation and inflationary cosmology 90 Organic synthesis and its application to a sustainable society 106 Development of nanostructure and its application to molecular devices	44 Large-scale structure of the universe 77 Neutrino oscillation and creation of material universe 89 Catalytic asymmetric synthesis 91 Chemical-/bio-system with microchips	42 Effects of aerosol and air pollutant on climate and atmospheric circulation model 46 Research on spectroanalysis 70 Quantum electronics and its application to quantum information processing 73 Bi-based high-temperature superconductors 79 Supersymmetry and CP violation 88 Metal: Organic hybrid porous materials 102Basic and applied research on carbon nanotubes	72 Quantum chromodynamics
Number of core papers 5-20 percent		37 Study on biodiversity in plants 54 Law and behavioral science 76 Quantum gravity 85 Dendrimer research 87 Research on living free-radical polymerization 92 Metal-organic complex and its catalytic activity 96 Water and iron transport mechanism in organism 103 High-efficiency dye-sensitised solar cell 104 Synthesis of nano-structures form microstructure with microparticles and polymers 120 Research on global carbon cycle 124 Research on high efficiency organic LED	40 North Atlantic Oscillation and climate change 55 Political power and human rights 58 Research on corporate governance 60 Stability and vitrification of supercooled liquid 61 Physical attributes and material process of MgB2 62 Quantum computing devices 63 Noncommutative field theory and super string theory 66 Spintronics 68 Basic and applied research on ultra-short-pulse laser 71 Superconductors with anisotropic gaps 75 Super string theory and spatiotemporal physics 81 Research on plastic deformation in nano-crystals 84 Catalytic activity of gold clusters 86 High performance catalysis for olefin polymerization 94 Detection of negative ions by chemical methods 122 Research on high performance organic thin film transistor	36 Environment pollution and risk of persistent organic halide pollutants (PCB and PBDE) 38 Aquatic pollution by toxic chemical compounds 45 Research on meshless finite element method 64 Baryon consisting of five quarks 69 Relativistic astronomy and gravity waves 83 Research on modulation schemes for ultra-wideband communications 101 Nanocomposites consisting of inorganic nano materials and organic polymers 119 Development and application of proton-exchange membrane fuel cells 133 Research on nitride compound semiconductor
Number of core papers 20-50 percent		80 Formation of nanostructures based on block copolymers	39 Carbon cycle in south Pacific Ocean 41 Research on paleoclimate 65 Photonic crystal and devices 67 Physics in high-temperature superconductor junctions 97 Molecular phylogenetic analysis	43 Mars exploration 56 Research on intellectual property right problems 57 Study on local economy and regional integration 59 Research on venture capital 82 Application of cryptographic technologies to digital information distribution 123 High-dielectric gate insulating technology for semiconductor integrated circuits

Note: There are no hot research areas whose number of core papers is in the range of top 50 or more.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

(2) Measurement of the breadth of spread effects using betweenness centrality

The report hereafter focuses on 12 hot research areas in life science where both the number of core papers and degree centrality are in the top 0-5 percent range, and on 7 hot research areas in other than life science where the number of core papers is in the top 0-5 percent range and degree centrality is in the top 0-20 percent range.

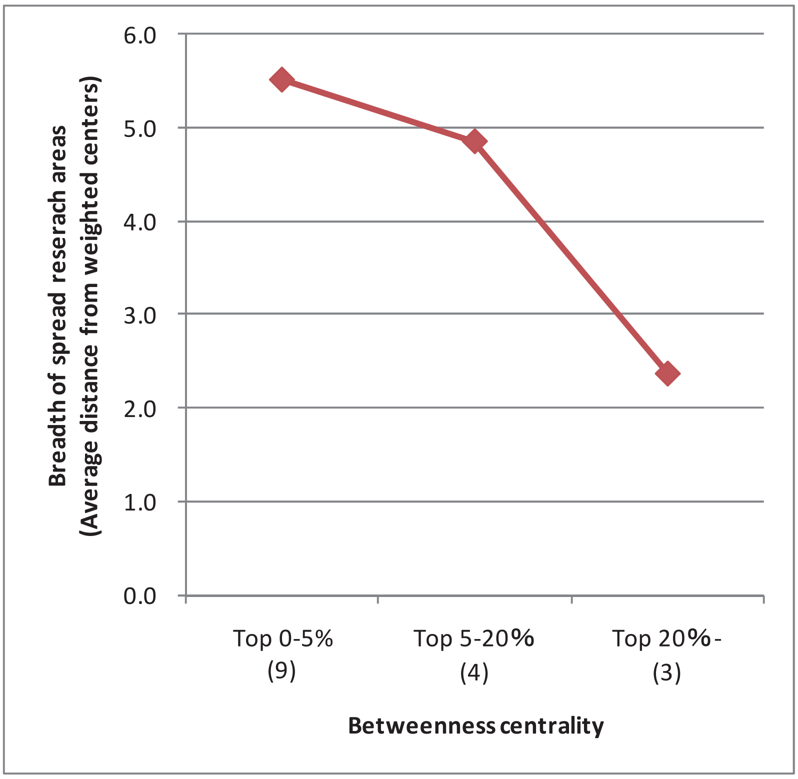
Compared to other research areas, these 19 hot research areas are connected with a greater number of spread research areas, but their extent of impact varies. Therefore, in order to look at the range of impact, the 19 research areas were classified by the magnitude of betweenness centrality. As indicated in the definition shown in Figure 38, betweenness centrality is an index that increases in a research area that serves as a bridge to connect difference group of research areas. Thus, research areas that have high betweenness centrality among the 19 hot research areas are considered to have a potential to spread in wider areas.

Figure 48 shows dependency of the breadth of spread research areas on betweenness centrality. The breadth of spread research areas were calculated using the following formula:

$$\frac{1}{N}\sum_{i}\sqrt{\left(x_i - x_g\right)^2 + \left(y_i - y_g\right)^2}$$

Here, x_i and y_i indicate the coordinates of the spread research areas in Science Map 2008, N is the number of spread research areas in Science Map 2008, and x_g and y_g are the weighted centers of the spread research areas. Of the 19 hot research areas, results were shown for 16 hot research areas for which the calculation of betweenness centrality was possible. From Figure 48, one can see that the higher the betweenness centrality of hot research areas, the wider the breadth of spread research areas tend to become.

Figure 48 Dependency of the breadth of spread research areas on betweenness centrality (Science Map 2004)



Note: The breadth of spread research areas is based on the information on Science Map 2008.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

In Figure 49, 12 hot research areas in life science are shown in order of the magnitude of betweenness centrality. "Research on proteome (2004, ID105)" has the largest betweenness centrality, followed by "Research on epigenetic transcriptional regulation (2004, ID130)."

Figure 49 Classification of hot research areas using degree centrality and betweenness centrality (Science Map 2004)

(a) Hot research areas in life science

Research area ID	Research area	Degree centrality	Betweenness centrality
105	Research on proteome	0-5% (0.0224)	0-5% (0.2889)
130	Research on epigenetic transcriptional regulation	0-5% (0.0416)	0-5% (0.2526)
26	Signal transducing molecules associated with lifestyle-related diseases	0-5% (0.0304)	0-5% (0.1222)
33	Analysis of mechanism and regulation of plant growth	0-5% (0.0368)	0-5% (0.1073)
34	Stress response in plants	0-5% (0.0256)	0-5% (0.1001)
27	Stem cell therapy on nervous, hematopoietic, and cardiovascular system	0-5% (0.0304)	0-5% (0.0958)
117	Research on molecular mechanism in apoptosis	0-5% (0.0288)	0-5% (0.0939)
116	Research on immune system	0-5% (0.0256)	5-20% (0.0558)
14	Research on cancer therapy	0-5% (0.0224)	5-20% (0.0536)
110	Research on infection mechanism and therapy of HCV and HIV	0-5% (0.0224)	5-20% (0.0205)
16	Research on molecular pathogenesis and leukemia therapy	0-5% (0.0176)	20%- (0.0094)
35	Study of biological clock	0-5% (0.0192)	20%- (0.0061)

(b) Hot research areas other than life science

Research area ID	Research area	Degree centrality	Betweenness centrality
106	Development of nanostructure and its application to molecular devices	0-5% (0.0256)	0-5% (0.2101)
90	Organic synthesis and its application to a sustainable society	0-5% (0.0192)	0-5% (0.0904)
91	Chemical-/bio-system with microchips	5-20% (0.0096)	5-20% (0.0206)
89	Catalytic asymmetric synthesis	5-20% (0.0112)	20%- (0.0038)
78	Cosmic microwave background fluctuation and inflationary cosmology	0-5% (0.0176)	
44	Large-scale structure of the universe	5-20% (0.0112)	
77	Neutrino oscillation and creation of material universe	5-20% (0.008)	

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

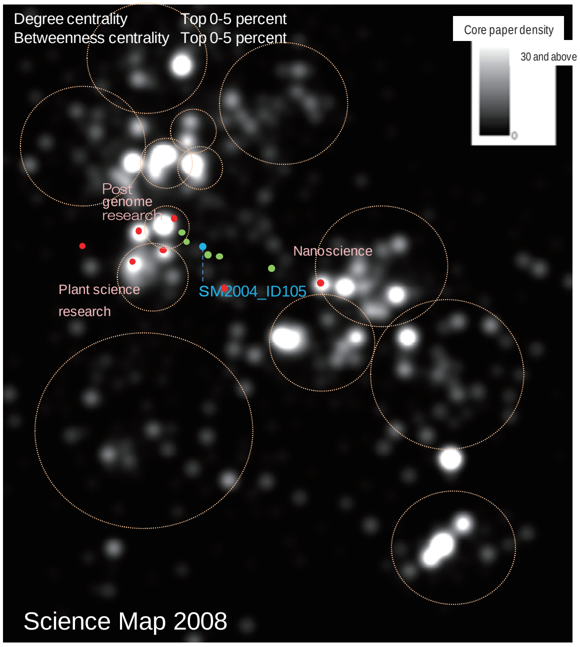
Analysis of betweenness centrality was carried out for clusters that have the largest number of research areas and are connected via links in the Science Map. In Science Map 2004, 338 research areas were analyzed. ID78, 44 and 77 were not included in the 338 research areas and thus there are no values for betweenness centrality. This indicates that, during the period of Science Map 2004, these research areas were connected only within the group of research areas in elementary particle physics/cosmology and the relationship with other research area groups was extremely weak.

Looking at the spread of research areas originating from "Research on proteome (2004, ID105)" in the Science Map, one can see that the knowledge of this research area spread to the groups of the research areas in post genome research, plant science and nanoscience (Figure 50 (a)). For "Research on epigenetic transcriptional regulation (2004, ID130)," spread of the knowledge to post-genome research, research on plant science, research on regenerative medicine and research on cancer is observed (Figure 50 (b)).

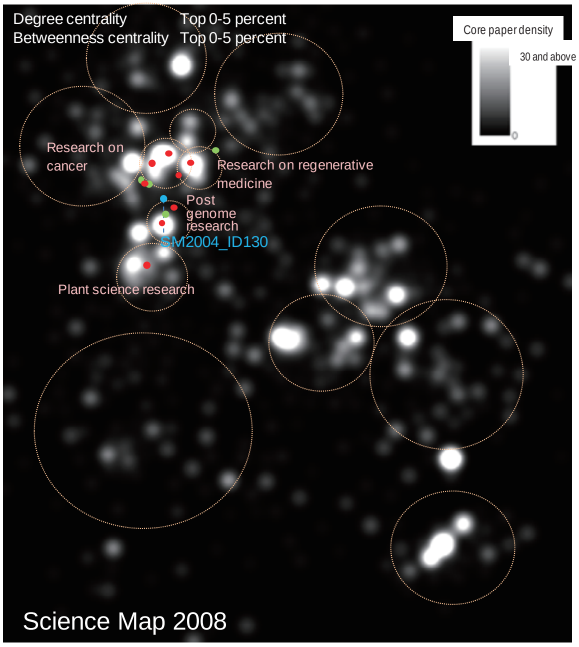
In research areas other than life science, betweenness centrality is distinctly high in "Development of nanostructure and its application to molecular devices (2004, ID106)." In Science Map 2008, the group of research areas in nanoscience was observed to have increased its breadth than before. And the spread of this research area is seen across the entire group of research areas in nanoscience and in part of the group in condensed matter physics (Figure 50 (c)).

Figure 50 Spreading research areas (When both degree and betweenness centralities are high)

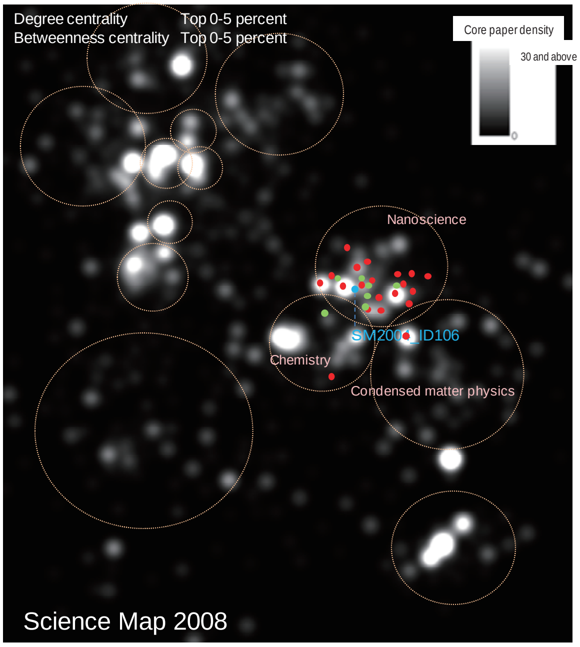
(a) Research on proteome (2004, ID105)



(b) Research on epigenetic transcriptional regulation (2004, ID130)



(c) Development of nanostructure and its application to molecular devices (2004, ID106)



- Positions of spread research areas in Science Map 2008
- Positions of spread research areas in Science Map 2006
- Positions of hot research areas in Science Map 2004

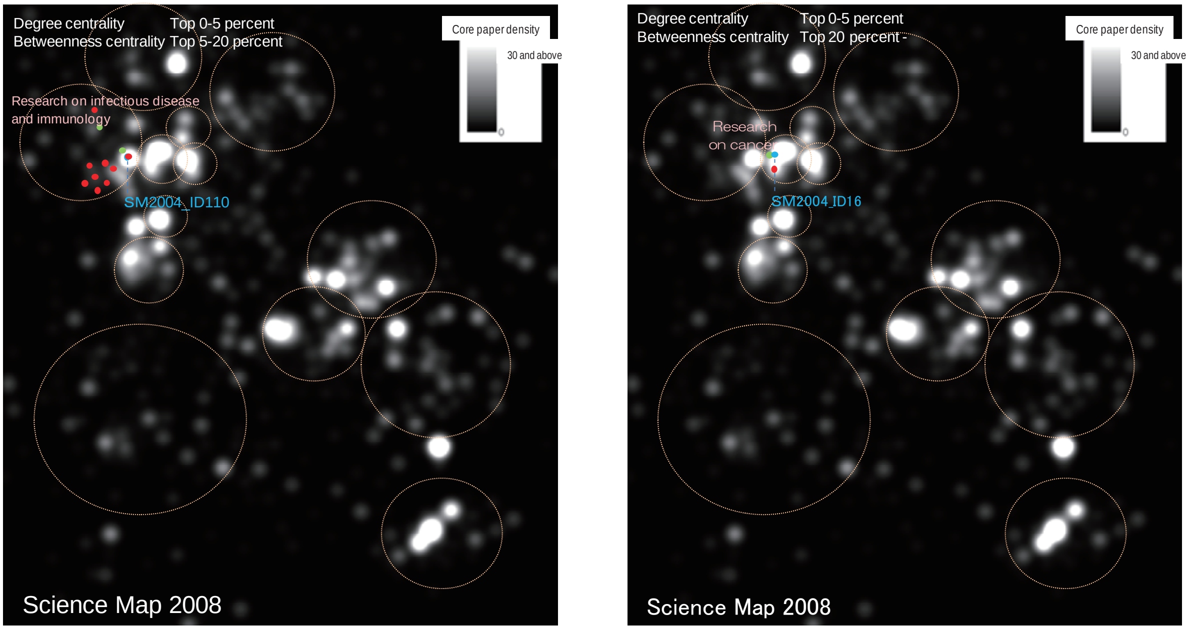
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Even in research areas that are classified into the same range of degree centrality, spread effects of knowledge vary depending on the difference in value of betweenness centrality. Figure 51 (a) (b) shows the spread of knowledge in two hot research areas in life science. Although a certain amount of breadth is observed around the spread research areas of “Research on infection mechanism and therapy of HCV and HIV (2004, ID110)” whose betweenness centrality is in the top 5-20 percent range, its spread effects remain within the group of research areas in research on infectious disease/immunology. The spread effects are small in “Research on molecular pathogenesis and leukemia therapy (2004, ID16)” whose betweenness centrality in the range of the top 20 percent and above.

Figure 51 Spreading research areas (Comparison between the cases of high and low betweenness centrality)

(a) Research on infection mechanism and therapy of HCV and HIV (2004, ID110)

(b) Research on molecular pathogenesis and leukemia therapy (2004, ID16)



- Positions of spread research areas in Science Map 2008
- Positions of spread research areas in Science Map 2006
- Positions of hot research areas in Science Map 2004

Data: Tabulated from Thomson Reuters’ “Essential Science Indicators” by the National Institute of Science and Technology Policy.

4-2-4 Application to Science Map 2008

The observations up to now found that research areas that are high in the number of core papers and degree centrality have a high continuity and a greater number of spread research areas, and that research areas with a high betweenness centrality, in particular, have the potential to spread over a wide area.

The results of analysis obtained up to now are based on Science Map 2004. Using the same methodology, classification was then made on hot research areas on Science Map 2008, and hot research areas that have a potential to have significant spread effects in the future were extracted, the results of which are detailed below:

For Science Map 2008, the calculation of degree centrality was made for 647 research areas. The analysis of betweenness centrality was conducted for a cluster that has the largest number of research areas connected via links in the Science Map. For Science Map 2008, a cluster that has 442 connected research areas was analyzed.

Figure 53 and Figure 54 show results of the classification of hot research areas in Science Map 2008 which was made using the number of core papers and degree centrality. Same as in Science Map 2004, focus was placed on hot research areas whose number of core papers and degree centrality are both in the top 0-5 percent range in the case of life science. In the case of other than life science, focus was placed on hot research areas whose number of core papers and degree centrality are in the top 0-5 percent and 0-20 percent, respectively. 10 research areas in life science and 13 research areas in other than life science fall into these categories. Figure 52 shows these hot research areas listed in order of the magnitude of betweenness centrality, and Figure 55 shows their positions on Science Map 2008.

(Research areas that are expected to continue as a core of research area group and have high spread effects on other research area groups)

The red triangles (10 research areas) on Science Map 2008 are the hot research areas whose degree and betweenness centralities are both in the top 0-5 percent range.

In life science, betweenness centrality is distinctly high in “Research on regenerative medicine and stem cells (2008, ID30),” and it therefore has the potential to have significant spread effects on overall research areas in life science in Science Maps 2008 through 2012. For the other 5 hot research areas that are high in both degree and betweenness centralities, they are not only expected to become a core of the a group where each of them belongs to, but are also expected to develop while having spread effects on other groups of research areas as well.

In research areas other than life science, the three hot research areas interacting with nanoscience, that are, “Semiconductor-spintronics material/magnetic semiconductors (2008, ID63),” “Synthesis, function and toxicity of sensors/SWNTs/functional DNAs/nanoparticles, etc. (2008, ID67),” and “Bioapplications of gold nanorods (2008, ID68),” have a higher number of core papers and show high values in both degree and betweenness centralities. It is expected that nanoscience will continue to evolve around these research areas, while keeping relationships with a number of research area groups.

Among these research areas, Japan has a 9 percent or more share in “Semiconductor-spintronics material/magnetic semiconductors (2008, ID63),” and “New developments in cosmology and elementary particles theory owing to advancement in precise observation of space (ID107)” in whole counting.

(Research areas that are considered to continue as a core of research area group)

The orange triangles (12 research areas) in Science Map 2008 are the hot research areas whose degree centrality is in the top 0-5 percent or in the top 5-20 percent, and whose betweenness centrality is in the top 5-20 percent or in the top 20 percent or above.

Two hot research areas, “Molecular conversion reaction using transition metal catalyst (2008, ID87)” and “Catalytic asymmetric synthesis (2008, ID86),” both of which are cores of the groups of research areas in chemistry, fall under this category. These research areas are expected to develop while having high spread effects mainly within the research area group.

Among these research areas, Japan has a 9 percent or more share in whole counting in “Elucidation of pathogenic mechanism of lifestyle-related diseases resulting from obesity (2008, ID34),” “Production of interferon by innate immunity (2008, ID41),” “Design and functions of configurational space and coordination lattice (2008, ID83)”, “Catalytic asymmetric synthesis (2008, ID86)” and “Elementary particle physics/elementary particle astrophysics (2008, ID106).”

(Research areas that are considered to function as a bridge between research area groups)

The green triangle on Science Map 2008 (1 research area) is the hot research area whose degree and between centralities are in the top 5-20 percent and in the top 0-5 percent, respectively.

Although there were no hot research areas that fall under this category in Science Map 2004, in Science Map 2008, “Strongly interacting quantum many-body system (2008, ID100)” belongs to the category. The value of between centrality of this hot research area is higher than that of degree centrality. The research area is situated between condensed matter physics and particle physics/cosmology, and it is expected that research will develop in the future as a place for fusing knowledge of the two research area groups.

Figure 52 Classification of research areas using degree and betweenness centralities (Science Map 2008)

(a) Hot research areas in life science

Research area ID	Research Area	Degree centrality	Betweenness centrality	Japan's share (in percent, whole counting)	Japan's share (in percent, fractional counting)
30	Research on regenerative medicine and stem cells	0-5% (0.0279)	0-5% (0.4396)	6.8%	4.9%
36	Molecular biological approach to human malignancies	0-5% (0.0279)	0-5% (0.1775)	6.3%	3.7%
51	Gene silencing/plant hormone	0-5% (0.0294)	0-5% (0.1261)	7.7%	5.8%
7	Treatment of acute coronary syndrome using antiplatelet drugs	0-5% (0.0232)	0-5% (0.1242)	1.8%	0.9%
42	Differentiation mechanism of T cell subsets and their role in disease	0-5% (0.0279)	0-5% (0.0998)	8.0%	4.5%
35	Development of drug therapy/genome sequencing technology for breast cancer	0-5% (0.0170)	0-5% (0.0818)	5.7%	1.9%
34	Elucidation of pathogenic mechanism of lifestyle-related diseases resulting from obesity	0-5% (0.0139)	5-20% (0.0614)	21.4%	17.7%
41	Production of interferon by innate immunity	0-5% (0.0139)	5-20% (0.0351)	41.9%	28.6%
55	Defense mechanism of plants against infection	0-5% (0.0325)	5-20% (0.0311)	4.4%	3.9%
53	Environmental responses of plants/metabolome analysis/proteome analysis	0-5% (0.0139)	20%- (0.0179)	8.4%	6.6%

(b) Hot research areas other than life science

Research area ID	Research Area	Degree centrality	Betweenness centrality	Japan's share (in percent, whole counting)	Japan's share (in percent, fractional counting)
63	Semiconductor-spintronics material/magnetic semiconductors	0-5% (0.0201)	0-5% (0.3141)	11.7%	7.4%
67	Synthesis, function and toxicity of sensors/SWNTs/functional DNAs/nanoparticles, etc.	0-5% (0.0170)	0-5% (0.1429)	5.5%	4.5%
68	Bioapplications of gold nanorods	0-5% (0.0186)	0-5% (0.1316)	1.2%	1.2%
100	Strongly interacting quantum many-body system	5-20% (0.0077)	0-5% (0.1084)	8.1%	4.4%
107	New developments in cosmology and elementary particles theory owing to advancement in precise observation of space	0-5% (0.0155)	0-5% (0.0813)	12.1%	4.9%
80	Physics and chemistry of molecular substance	5-20% (0.0062)	5-20% (0.0670)	8.7%	6.3%
87	Molecular conversion reaction using transition metal catalyst	0-5% (0.0155)	5-20% (0.0654)	3.3%	3.3%
75	Organic/organic-oxide semiconductors Photo- and electro-functional materials and elements	0-5% (0.0217)	5-20% (0.0556)	8.9%	8.2%
106	Elementary particle physics/elementary particle astrophysics	5-20% (0.0077)	5-20% (0.0447)	18.9%	8.6%
86	Catalytic asymmetric synthesis	0-5% (0.0139)	5-20% (0.0285)	19.4%	18.9%
66	Living radical polymerization/click reaction/molecular machine	5-20% (0.0093)	5-20% (0.0269)	1.4%	1.2%
83	Design and functions of configurational space and coordination lattice	5-20% (0.0093)	20%- (0.0152)	10.9%	8.0%
88	Synthesis of N-Heterocyclic carbene (NHC) and its application to catalytic reactions	5-20% (0.0124)	20%- (0.0104)	1.1%	0.5%

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Figure 53 Classification of hot researc areas using the number of core papers and degree centrality (in life science, Science Map 2008)

	Degree centrality Top 0-5 percent	Degree centrality Top 5-20 percent	Degree centrality Top 20-50 percent	Degree centrality Top 50-100 percent
Number of core papers 0-5 %	7 Gene silencing/plant hormone 30 Research on regenerative medicine and stem cells 34 Elucidation of pathogenic mechanism of lifestyle-related diseases resulting from obesity 35 Development of drug therapy/genome sequencing technology for breast cancer 36 Molecular biological approach to human malignancies 41 Production of interferon by innate immunity 42 Differentiation mechanism of T cell subsets and their role in disease 51 Gene silencing/plant hormone 53 Environmental responses of plants/metabolome analysis/proteome analysis 55 Defense mechanism of plants against infection	29 Role of autophagy in health and disease 33 Genetic epidemiologic research on complex genetic disease 37 Multiple myeloma/new medicament 39 Activation of tyrosine kinase and its drug resistance 43 Control of autoimmune disease by immunoregulatory mechanism of biological drugs	50 Network science	
Number of core papers 5-20%	21Molecular neuroscience of emotion and its pathological conditions 57 Plant developmental genetics/carbohydrate metabolism	2 Effects and prognostics of device therapy for advanced heart failure 4 Physiological function of endogenous cannabinoid system in central nervous system 10 Prostate cancer/endocrine therapy/radiotherapy/effect and adverse effect 15 Molecular mechanism of the onset of Alzheimer's disease and the development of ways to prevent and treat the disease 17Neurogenesis in adult hippocampus (the understanding of phenomena and the development of clinical application) 20 Clinical research on treatment of schizophrenia and bipolar disorder 24 Neural mechanisms for emotion/empathy and imitation/context 28 Molecular mechanism of apoptosis (cell death) 31 Research on aging-suppression and longevity-control factors in individual and organ stem cells 38 Research on the development of molecular targeting anticancer drugs including HDAC inhibitors 47 Process of early infection with Hepatitis C virus and its treatment 56 Plant-microorganism interactions/strigolactones	6 Coronary CT (computed tomography) 9 Mineral and bone metabolism disorders in chronic kidney disease 12 Clinical research on early diagnosis, prevention and treatment of deep mycosis 14 Research on physiological role of peptide hormone in the brain 22 Research on higher brain functions unique to humans using functional brain imaging 46 Development of drug resistance in Staphylococcus aureus and ways to cope with it 58 Microorganism ecosystem 59 Systems biology/synthetic biology	11 Pathological condition and treatment of bronchial asthma 26 Biological implication of protein aggregation from the viewpoint of common denominators in transmissible aggregate "prion" and amyloid-like aggregate. 45 Development of human papillomavirus vaccine
Number of core papers 20-50 percent		1 Critically ill patient management (Particularly in cases of acute respiratory distress syndrome) 5 Clinical research on the control of cardiovascular incidents by antihypertensives and their impacts on diabetes 13 Effect and adverse effect of hormone replacement therapy (HRT) 18 Genetic research on schizophrenia and molecular pathogenesis investigations developed from the research 19 Brain-derived neurotrophic factor/brain morphology in schizophrenia/mood disorder 23 Brain neural mechanisms for decision-making 32 Metabolism control through PGC-1α and insulin resistance 40 Role of ubiquitin modification system in NF-kB activation 48 Control of HIV infection 52 Redox control 54 Mechanisms for generation of nitric oxide in plants and its physiological role	3 Medical therapy for neuropathic pain and fibromyalgia syndrome 8 Research on adverse effect of COX inhibitors 16 Clinical research for Parkinson's disease 25 Molecular mechanisms for excitatory synaptic plasticity 44 NK cell receptor and its ligand that inhibits activation 49 Research on anti-HIV drugs	27 Hydroxylation modification of HIF and HIFα and regulation of mitochondrial function 60 Structure and functions of G-protein-coupled receptor

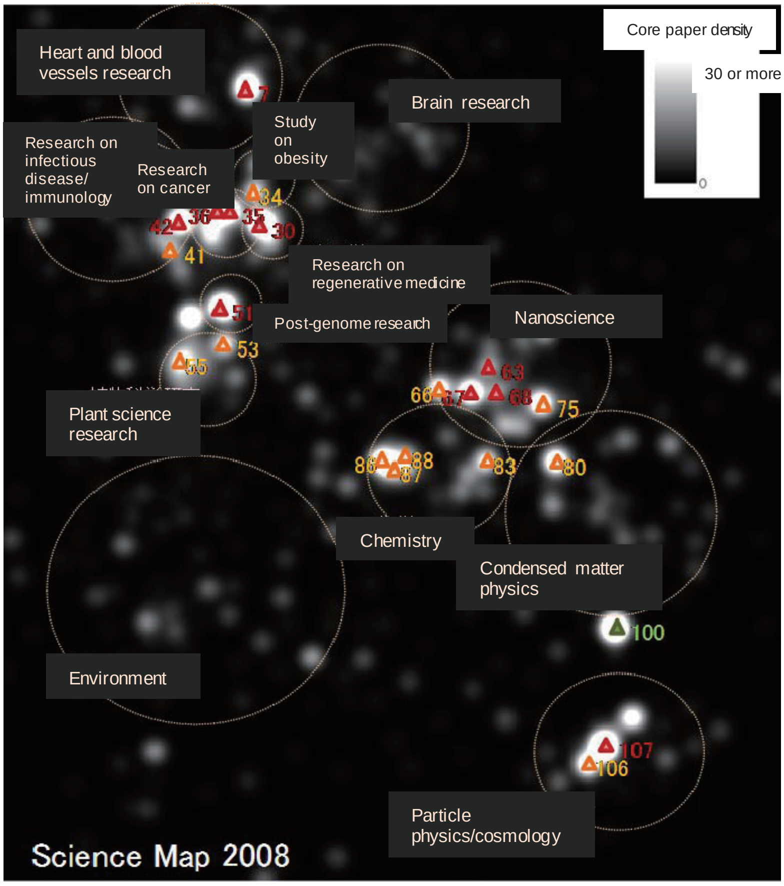
Note There are no hot research areas whose number of core papers is in the top 50- percent range.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Figure 54 Classification of hot research areas using the number of core papers and degree centrality (in other than life science, Science Map 2008)

	Degree centrality Top 0-5 percent	Degree centrality Top 5-20 percent	Degree centrality Top 20-50 percent	Degree centrality Top 50-100 percent
Number of core papers Top 0-5%	63 Semiconductor-spintronics material/magnetic semiconductors 67 Synthesis, function and toxicity of sensors/SWNTs/functional DNAs/nanoparticles, etc. 68 Bioapplications of gold nanorods 75 Organic/organic-oxide semiconductors Photo- and electro-functional materials and elements 86 Catalytic asymmetric synthesis 87 Molecular conversion reaction using transition metal catalyst 107 New developments in cosmology and elementary particles theory owing to advancement in precise observation of space	66 Living radical polymerization/click reaction/molecular machine 80 Physics and chemistry of molecular substance 83 Design and functions of configurational space and coordination lattice 88 Synthesis of N-Heterocyclic carbene (NHC) and its application to catalytic reactions 100 Strongly interacting quantum many-body system 106 Elementary particle physics/elementary particle astrophysics	69 High-efficiency electroluminescence (EL) element 76 Polymer electrolyte fuel cell 104 Gauge/gravity theory correspondence and black hole solutions	
Number of core papers Top 5-20 percent		64 Research on creation and application of nanofibers 72 Nanomaterial synthesis in ionic liquid/hollow and mesoporous material 74 Development materials from carbonate following the examples of nanocarbons and living organisms 89 Direct carbon bond formation through transition metal catalytic reactions 93 Meta material 94 Optical quantum information/communication, optical nanoscience 95 Qubits using semiconductor quantum dots/electronic charge, electron spin and nuclear spin 96 Quantum information science using atomic system/photons 103 Earth in the Precambrian era 109 Warming impact/bio- and eco-systems 112 Organic aerosol 115 Atmospheric composition and minor constituents 117 Sea level fluctuations/seawater density/ice sheet/water circulation	62 Microchannel device 70 Superhydrophobic surface 73 Ionic liquid 79 Metal-based spintronics 81 Nanochemistry of gold 82 New-generation density functional theory for large-scale molecular calculation 85 Anion sensors 91 Complex hydrides associated with hydrogen production and storage and fuel cells 98 Ultrafast and ultraintense optical science 99 Limitation and application to signal processing/information theory using "sparse" property of source 101 Studies on the evolution of air and living organism in early earth and its analytical approach 105 Gamma-ray burst 108 Emergence process of Homo sapiens 113 Observational studies on carbon dioxide balance in continental ecosystem 114 Stability discrimination/stabilizing control of delay system using matrix inequality 118 Restoration of the past global environmental change 120 New asymptotic expansion method for nonlinear differential equation and its application	71 Mesoporous material/silica, carbon and metal oxide 77 Formation of bulk metallic glass/transformation of metal glassy alloys 78 Ferroelectric property in new materials such as multiferroics, etc. 90 Microbial fuel cells/microbial cells/enzyme-based biofuel cells 102 New technologies related to solid oxide fuel cell (SOFC) 110 Environmental chemistry of bromine flame retardant 119 Corporate governance
Number of core papers Top 20-50 perce	116 Climate change simulation including aerosol effects	65 Development of nanostructure using nucleic acid	61 Analysis of dynamic behavior of proteins 84 Research on hydrogen bonding 92 Electromagnetic response of surface plasmon in artificial structures	97 Novel electronic order in high-temperature superconductivity 111 Environmental burden of drugs and other industrial chemicals and technologies to reduce the burden 121 New trends in economic geography - Evolutionary economics and relational logic

Note There are no hot research areas whose number of core papers is in the top 50- percent range.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Figure 55 Positions of hot research areas that are considered to have high spread effects (Science Map 2008)



Note: The colors of the triangles indicate the following: Red – Research areas whose degree and betweenness centralities are both in the top 0-5 percent. Orange – Research areas whose degree centrality is in the top 0-20 percent, and betweenness centrality in the top 5percent and above. Green: Research area whose degree centrality is not in the top 0-5 percent, but betweenness centrality is in the top 0-5 percent.

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

4-3 Time-series changes in shares of research papers with international co-authorship as seen in the Science Map and the visualization of institutional co-authorship networks

(1) Time series changes in shares of research papers with international co-authorship in all research areas

When comparing each country's share in the Science Map, there are countries like the UK, Germany and France whose shares are significantly higher in the whole count method than in the fractional count method, while countries like Japan has no significant difference in shares between the two methods. International co-authorship is one of the factors contributing to this phenomenon. Although the whole count method counts each research paper with international co-authorship as one, the fractional count methods divides this number by the number of countries participated in the writing (the countries where collaborating institutions exist), which makes a difference in the number of shares between the count methods. First, Figure 56 shows time-series changes in the percentage of international co-authorship in each country.

Figure 56 Time-series changes in the percentage of international co-authorship of each country in all research areas

	World	USA	Germany	UK	Japan	France	Korea	China
Science Map 2002	28.6	31.0	62.6	60.1	42.3	69.7	64.8	60.3
Science Map 2004	30.4	33.6	64.2	64.6	47.0	72.4	64.3	55.3
Science Map 2006	33.6	36.9	66.8	68.8	52.8	75.4	62.0	54.0
Science Map 2008	36.1	41.3	71.7	73.0	52.3	79.3	65.8	46.6

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Next, differences in the percentage of international co-authorship in each research area group were investigated on the Science Map, as shown in Figure 57.

Comparing the Science Maps from 2002 through 2008, a steady increase is observed in shares of research papers with international co-authorship shown on the map. In Science Map 2002, the percentage of international co-authorship is seen only in the research area group in particle physics/cosmology which held a share of 50 percent or more. Subsequently, in Science Map 2004, research areas showing an international co-authorship percentage of 50 percent or more emerged in part of the research area groups of heart and blood vessels research, research on infectious diseases/immunology, environment and condensed matter physics. In Science Map 2006, research areas with a 50 percent or greater international co-authorship percentage also appeared in plant science research and cancer research. In Science Map 2008 which is the latest version, the number of research areas with a higher percentage of international co-authorship is increasing in each research area group.

However, in this increasing trend of shares of international co-authorship, the shares of the group of research areas in chemistry has almost remained the same from Science Map 2002 through 2008, indicating the group's extremely low share of international co-authorship. It is also observed that, compared to other research area groups, the shares of international co-authorship are not high in the research area groups of nanoscience, post-genome research and research on regenerative medicine.

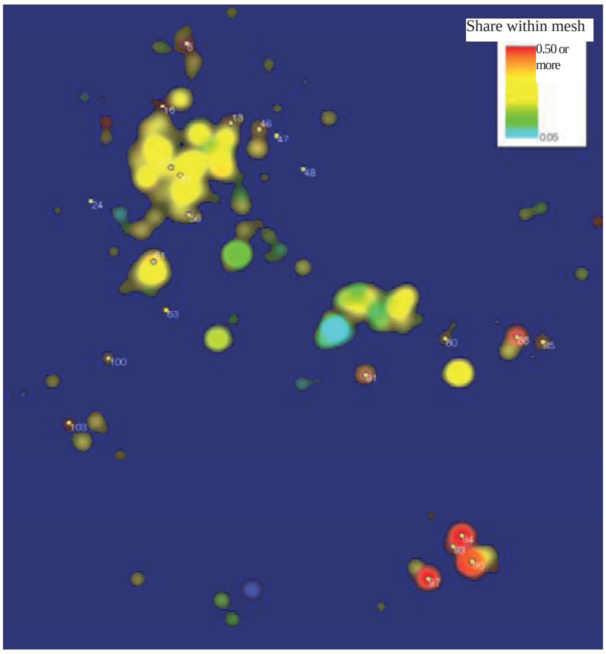
By comparison, in Research Material No. 170, Japanese Technology and Science Indicators 2009 (by NISTEP, released in 2009), shares of international co-authorship in all research papers in each field are published. According to the material, the shares of international co-authorship in 2007 were 20.3 percent for all fields. Looking at each field, shares are comparatively high in "Physics/space sciences" and

"Environment/ecology and geosciences" at 28.8 percent, and relatively low in "clinical medicine and psychiatry/psychology" and "chemistry" at 15.7 percent and 17.0 percent, respectively.

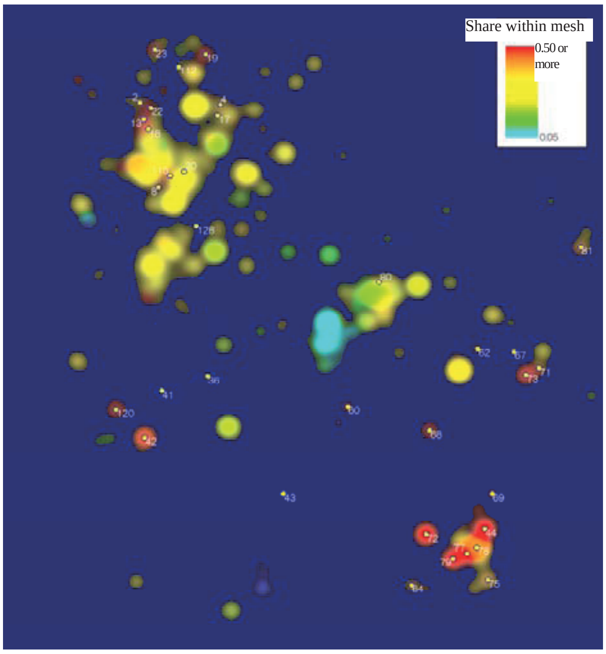
This indicates that a greater number of research papers with international co-authorship are included in highly-cited papers analyzed for the Science Map than in all research papers[6].

Figure 57 Percentage of international research papers over time shown on the Science Map

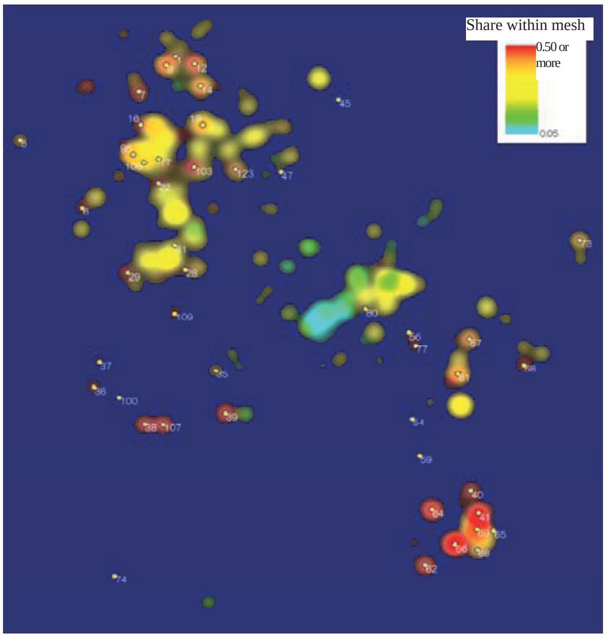
(A) Science Map 2002



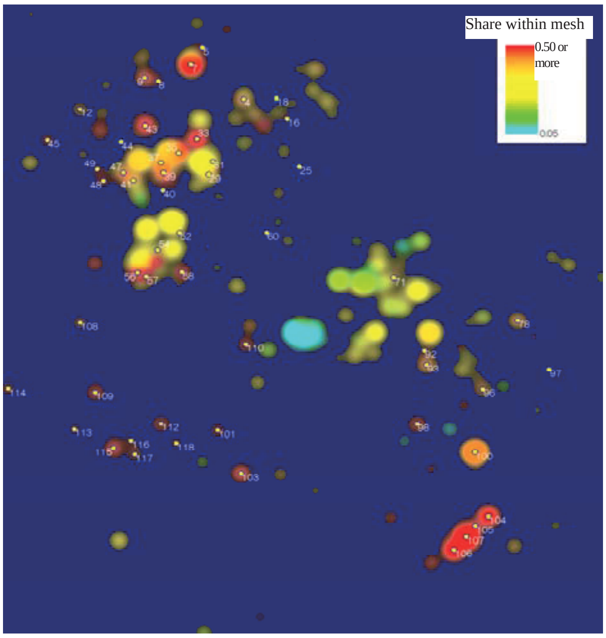
(B) Science Map 2004



(C) Science Map 2006



(D) Science Map 2008



Note: Shares of research papers with international co-authorship of 5 percent is depicted in light blue, and shares of 50 percent or more in red. Yellow dots and numbers are the positions and IDs of hot research areas in which shares of research papers with international co-authorship is 40 percent or more.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

[6] With regard to chemistry, a trend of all research papers is the same as a trend of Science Maps and there are few research papers with international co-authorship.

Figure 58 Number of research papers with international co-authorship and the average number of participating countries and institutions in all research areas

	World	USA	Germany	UK	Japan	France	Korea	China
Number of papers with international co-authorship	5711	3783	1583	1549	664	1055	196	533
Average number of participating countries	3.0	3.2	4.1	4.0	3.8	4.6	5.4	3.9
Average number of participating institutions	5.7	6.5	8.6	8.5	9.1	10.4	17.0	9.9

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Figure 58 shows the number of research papers with international co-authorship and the average numbers of participating countries and institutions in all research areas. The number of participating countries and institutions themselves in Japan are at the same level compared to the other countries.

Figure 59 Changes in the percentage of international co-authorship in each field and in inter-/multi-disciplinary areas

	Science Map 2002	Science Map 2004	Science Map 2006	Science Map 2008
Agricultural sciences	19.8%	17.1%	12.0%	38.8%
Biology and biochemistry	25.4%	22.4%	25.9%	30.8%
Chemistry	14.3%	11.4%	16.0%	17.8%
Clinical medicine	31.8%	32.2%	37.6%	40.4%
Computer science	32.6%	23.5%	25.0%	27.8%
Economics and business	21.2%	22.0%	21.9%	22.9%
Engineering	18.3%	19.3%	22.1%	23.4%
Environment/ecology	22.4%	32.6%	41.9%	44.7%
Geosciences	38.9%	44.1%	53.7%	54.5%
Immunology	32.8%	34.1%	23.1%	33.3%
Materials science	22.1%	36.6%	31.4%	23.2%
Mathematics	31.4%	43.2%	33.0%	31.6%
Microbiology	28.8%	39.8%	31.4%	33.3%
Molecular biology & genetics	30.3%	37.9%	35.8%	35.1%
Neuroscience and behavioristics	26.6%	28.4%	30.0%	35.6%
Pharmacology/toxicology	34.3%	ND	16.7%	20.0%
Physics	41.7%	45.4%	46.4%	45.2%
Plant and animal science	31.0%	30.9%	36.0%	40.4%
Psychiatry/psychology	18.2%	24.3%	23.4%	34.2%
Social science, general	4.5%	9.5%	10.1%	25.0%
Space sciences	59.1%	66.3%	72.4%	74.6%
Inter-/multi-disciplinary	27.5%	27.6%	29.6%	36.4%
Total	28.6%	30.4%	33.6%	36.1%

Note: The percentage of international co-authorship of each research area was calculated after classifying all research areas into fields to which they belong and inter-/multi-disciplinary areas. Fields with a higher percentage of international co-authorship than the overall average in each map are colored.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Figure 59 shows changes in the percentage of international co-authorship in each field and in inter-/multi-disciplinary areas. Comparison between fields shows that the percentage of international co-authorship is high in space sciences and geosciences. Also, the percentage increased in inter-/multi-disciplinary fields and clinical medicine.

Figure 60 Shares by country

(A) Breakdown of each country's share in whole counting by field

Field	Overall	USA	Germany	UK	Japan	France	Korea	China
Agricultural sciences	0.7%	0.2%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%
Biology and biochemistry	0.8%	0.5%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%
Chemistry	13.3%	6.0%	1.6%	1.1%	1.1%	0.7%	0.3%	1.2%
Clinical medicine	19.1%	12.7%	3.0%	3.0%	0.9%	2.2%	0.2%	0.4%
Computer science	1.3%	0.9%	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%
Economics and business	0.7%	0.6%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Engineering	4.0%	1.2%	0.2%	0.2%	0.1%	0.1%	0.1%	0.9%
Environment/ecology	1.6%	0.9%	0.2%	0.3%	0.1%	0.1%	0.0%	0.1%
Geosciences	3.3%	2.2%	0.6%	0.7%	0.3%	0.4%	0.0%	0.5%
Immunology	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Materials science	0.7%	0.4%	0.1%	0.0%	0.1%	0.0%	0.0%	0.1%
Mathematics	1.0%	0.4%	0.1%	0.1%	0.0%	0.1%	0.0%	0.2%
Microbiology	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Molecular biology & genetics	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Neuroscience and behavioristics	2.0%	1.4%	0.2%	0.3%	0.2%	0.1%	0.0%	0.0%
Pharmacology/toxicology	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Physics	14.4%	8.1%	2.7%	1.9%	1.7%	1.7%	0.5%	1.1%
Plant and animal science	4.2%	1.9%	0.9%	0.8%	0.6%	0.3%	0.1%	0.2%
Psychiatry/psychology	1.2%	0.9%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%
Social science, general	1.0%	0.6%	0.0%	0.2%	0.0%	0.1%	0.0%	0.0%
Space sciences	0.8%	0.7%	0.2%	0.3%	0.1%	0.2%	0.0%	0.0%
Inter-/multi-disciplinary	29.1%	17.6%	3.7%	4.0%	2.6%	2.2%	0.6%	2.5%
Total	100.0%	57.9%	13.9%	13.4%	8.0%	8.4%	1.9%	7.2%

(B) Breakdown of each country's share in fractional counting by field

Field	Overall	USA	Germany	UK	Japan	France	Korea	China
Agricultural sciences	0.7%	0.1%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%
Biology and biochemistry	0.8%	0.4%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%
Chemistry	13.3%	5.4%	1.3%	0.8%	1.0%	0.4%	0.2%	1.0%
Clinical medicine	19.1%	9.0%	1.4%	1.3%	0.6%	0.8%	0.1%	0.2%
Computer science	1.3%	0.7%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%
Economics and business	0.7%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Engineering	4.0%	1.0%	0.1%	0.1%	0.1%	0.1%	0.1%	0.7%
Environment/ecology	1.6%	0.6%	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%
Geosciences	3.3%	1.4%	0.2%	0.3%	0.1%	0.1%	0.0%	0.3%
Immunology	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Materials science	0.7%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Mathematics	1.0%	0.3%	0.1%	0.0%	0.0%	0.1%	0.0%	0.1%
Microbiology	0.2%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Molecular biology & genetics	0.2%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Neuroscience and behavioristics	2.0%	1.1%	0.1%	0.2%	0.1%	0.0%	0.0%	0.0%
Pharmacology/toxicology	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Physics	14.4%	5.6%	1.3%	0.9%	1.1%	0.8%	0.1%	0.6%
Plant and animal science	4.2%	1.5%	0.6%	0.5%	0.5%	0.2%	0.0%	0.1%
Psychiatry/psychology	1.2%	0.7%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Social science, general	1.0%	0.5%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Space sciences	0.8%	0.4%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Inter-/multi-disciplinary	29.1%	13.4%	1.9%	2.1%	1.7%	1.1%	0.4%	1.8%
Total	100.0%	43.5%	7.4%	7.0%	5.4%	3.8%	1.0%	5.2%

(C) Shares after subtracting each country's shares in fractional counting from those in whole counting

Field	Overall	USA	Germany	UK	Japan	France	Korea	China
Agricultural sciences	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%	0.0%
Biology and biochemistry	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Chemistry	0.0%	0.7%	0.3%	0.2%	0.1%	0.2%	0.1%	0.1%
Clinical medicine	0.0%	3.7%	1.6%	1.7%	0.3%	1.4%	0.1%	0.2%
Computer science	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Economics and business	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Engineering	0.0%	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.2%
Environment/ecology	0.0%	0.3%	0.1%	0.1%	0.0%	0.1%	0.0%	0.0%
Geosciences	0.0%	0.8%	0.4%	0.4%	0.2%	0.3%	0.0%	0.2%
Immunology	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Materials science	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mathematics	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Microbiology	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Molecular biology & genetics	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Neuroscience and behavioristics	0.0%	0.3%	0.1%	0.1%	0.1%	0.1%	0.0%	0.0%
Pharmacology/toxicology	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Physics	0.0%	2.5%	1.4%	1.0%	0.7%	0.9%	0.3%	0.5%
Plant and animal science	0.0%	0.5%	0.4%	0.3%	0.1%	0.1%	0.0%	0.1%
Psychiatry/psychology	0.0%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Social science, general	0.0%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Space sciences	0.0%	0.4%	0.1%	0.2%	0.1%	0.2%	0.0%	0.0%
Inter-/multi-disciplinary	0.0%	4.2%	1.8%	1.9%	0.9%	1.1%	0.2%	0.6%
Total	0.0%	14.4%	6.6%	6.5%	2.6%	4.6%	0.8%	2.1%

Note: Fields in which increase in shares from fractional counting is 0.1 – 0.5 percent are indicated in light yellow, 0.5 – 1.0 percent in orange and 1.0 percent and above in pink.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

In Figure 60, each country's shares were broken down by field. (A) shows results in the whole count method. One can see difference in Japan's share in clinical medicine and inter-/multi-disciplinary areas compared to the UK and Germany. (B) shows results in fractional counting. Difference in Japan's share compared to the UK and Germany is observed in clinical medicine. (C) shows difference between (A) and (B) resulting from the impact of international co-authorship. Looking at the differences in the whole fields, Japan is at 2.6 percent, compared to Germany at 6.6 percent, the UK at 6.5 percent and France at 4.6 percent. This indicates that the portion of international co-authorship had impacts on the formation of shares in the UK, Germany and France.

As seen in Figure 56 and Figure 58, in Science Map 2008, the difference in the percentage of international co-authorship in Japan compared to Germany and the UK is about 20 percent. There is no significant difference in the average number of participating countries, which is about four. However, when looking at the ratio of the shares of research papers between whole counting and fractional counting, the ratio in Japan is 1.5 times, while that of the UK and Germany is 1.9 times. This is due to the fact that an increase in shares of research papers in whole counting resulting from an increase in the percentage of international co-aouthorship is faster than a linear increase as shown below:

Given that the number of research papers in whole counting is N_w, the number of research papers in fractional counting is N_f, the rate of international co-authorship is x, and the average number of countries participating in interntional co-authorship is α, the relationship between the number of research papers in whole counting and fractional counting is as follows. Here we assumed $\beta = 1 - \alpha^{-1}$

$$N_f = (1 - x)N_w + \alpha^{-1}xN_w = (1 - x\beta)N_w$$

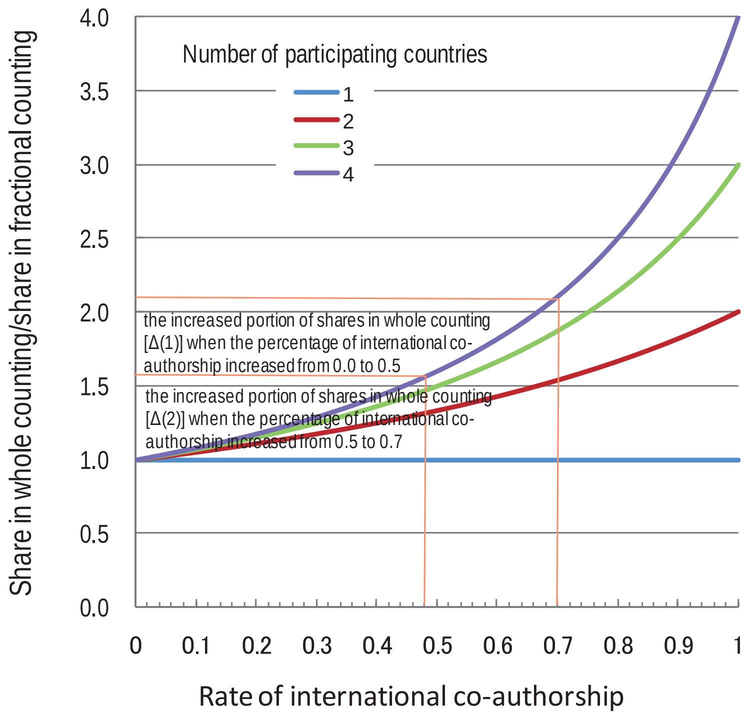
By transforming the formula shown above, the ratio of research paper shares between whole counting and fractional counting is represented in the following formula.

$$\frac{N_w}{N_f} = \frac{1}{1 - x\beta}$$

Changes in the ratio of research paper shares in whole and fractional counting to the percentage of international co-authorship are shown in Figure 61. The examples shown here are the cases where the average number of participating countries is 1, 2, 3 and 4. When all research papers become those with international co-authorship, the ratio of shares between whole counting and fractional counting becomes α (the average number of participating countries). As the percentage of international co-authorship x increases, the ratio of shares between whole and fractional counting increases at a rate of $(1 - x\beta)^{-1}$, instead of at a linear rate. Consequently, the increased portion of shares in whole counting [Δ(1)] when the percentage of international co-authorship increased from 0.0 to 0.5, and the increased portion of shares in whole counting [Δ(2)] when the percentage of international co-authorship increased from 0.5 to 0.7 become almost equal.

For this reason, in spite of around 20 percent difference in Japan in the percentage of international co-authorship compared to Germany and the UK, the ratio between whole and fractional counting in research paper shares becomes significantly different in Japan compared to the UK and Germany.

Figure 61 Relationship between the values after dividing the rate of international co-authorship and shares in whole counting by shares in fractional counting



In addition, in Figure 62, a comparison of trends in partner countries for co-authorship was made between all research areas in Science Map 2008 and all research papers (Research Material No. 158, Benchmarking Research & Development Capacity of Japan Based on Dynamic Alternation of Research Activity in the World. (by NISTEP, released in 2008))

First, compared to the case involving all research papers, the number of co-authored papers by the US and other countries is overwhelmingly large in highly-cited papers such as those in Science Map 2008, which is followed by co-authored papers by the UK and Germany. In the case of Japan, China and Korea are the 2^{nd} and 5th partner countries when looking at all research papers, whereas, this order changed to the 5^{th} and 10^{th} respectively in the Science Map. In the case of the US, Germany comes first, followed by the UK when looking at all research papers, while this order reversed in all research areas in Science Map 2008.

On the other hand, Japan is ranked lower in other countries in Science Map than in all research papers, but the country's share in co-authorship in the Science Map is almost the same or tends to grow. As a partner country of the UK for co-authorship, Japan is ranked 12^{th} with a share of 8.5 percent.

Figure 62 Partner countries for co-authorship in each country

(A) All research areas in Science Map 2008

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
USA	UK	Germany	Canada	France	Italy	Japan	China	The Netherlands	Switzerland	Spain
	24.6	24.3	18.0	15.8	12.2	10.9	9.1	8.8	8.4	7.3
Germany	USA	UK	France	Italy	The Netherlands	Switzerland	Canada	Spain	Japan	Sweden
	58.0	29.1	23.9	18.3	15.2	15.0	12.6	11.6	9.8	8.1
UK	USA	Germany	France	Canada	Italy	The Netherlands	Switzerland	Spain	Australia	Sweden
	60.0	29.8	22.6	17.0	15.9	14.4	11.9	11.1	9.3	9.1
Japan	USA	Germany	UK	France	China	Canada	Italy	Russia	Switzerland	Korea
	61.9	23.3	19.9	16.3	12.7	11.4	10.5	10.5	9.2	8.9
France	USA	Germany	UK	Italy	Switzerland	Canada	The Netherlands	Spain	Belgium	Japan
	56.7	35.8	33.2	25.1	16.7	15.2	15.2	14.7	12.1	10.2
China	USA	UK	Germany	Japan	France	Russia	Australia	The Netherlands	Canada	India
	64.5	21.2	20.3	15.8	12.9	11.1	9.9	9.0	8.8	8.4
Korea	USA	Germany	Japan	France	Russia	China	UK	Taiwan	India	Poland
	79.6	31.6	30.1	27.0	21.9	19.4	17.9	17.9	15.3	14.8

(B) All research papers

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
USA	Germany	UK	Canada	Japan	France	Italy	China	Australia	The Netherlands	Korea
	13.3	12.7	11.3	9.4	8.2	6.7	6.1	4.7	4.2	4.2
Germany	USA	UK	France	Switzerland	Russia	Italy	The Netherlands	Japan	Austria	Spain
	29.6	13.6	11.3	8.2	8.1	8.0	6.9	5.1	5.0	4.9
UK	USA	Germany	France	Italy	The Netherlands	Australia	Canada	Spain	Japan	Switzerland
	30.0	14.4	11.1	8.7	7.0	6.6	6.3	6.0	4.8	4.5
Japan	USA	China	Germany	UK	Korea	France	Canada	Russia	Australia	Italy
	39.5	11.6	9.6	8.5	6.9	6.0	5.0	4.6	3.8	3.6
France	USA	Germany	UK	Italy	Spain	Switzerland	Belgium	Canada	The Netherlands	Russia
	24.9	15.3	14.2	11.1	7.7	6.8	6.2	5.9	5.6	5.1
China	USA	Japan	UK	Germany	Australia	Canada	France	Singapore	Korea	Taiwan
	36.2	16.3	10.1	9.8	6.7	6.7	5.1	4.6	4.1	3.3
Korea	USA	Japan	China	Germany	UK	Russia	Canada	India	France	Taiwan
	53.5	21.2	8.9	6.0	5.7	5.5	5.2	3.7	3.5	2.9

Note: Shares of partner countries for co-authorship were calculated after extracting research papers with international co-authorship of these countries. Data for partner countries for co-authorship involving all research papers are based on Research Material No. 158 Benchmarking Research & Development Capacity of Japan Based on Dynamic Alternation of Research Activity in the World. (by NISTEP, released in 2008)

Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

(2) Visualization of co-authorship networks of research institutions

What are the characteristics of co-authorship networks of research institutions in each research area group? We visualized co-authorship relations between research institutions. This allows us to analyze characteristics of research areas from the viewpoint of the mutual relationships between institutions. By using co-authorship networks of research institutions, for example, an attempt was made to find out characteristics of the following:

(i) Characteristics of the co-authorship networks of research institutions in each research area (e.g. the density of the co-authorship networks of research institutions)

(ii) The position and function of each country's institutions in the international co-authorship networks of research institutions

(iii) The topology of co-authorship networks of research institutions especially in inter- /multi-disciplinary research areas

For creation of the co-authorship networks of research institutions, the number of each institution's research papers included in the core papers that comprise each research area was calculated using whole counting, and approximately 200 top institutions were extracted as the units for mapping. In the case where the number of institutions is less than 200, all institutions were extracted. In the case where the number of institutions 200 or more, about 200 top institutions were extracted based on the number of research papers.

If the co-authorship relations between all of the above-mentioned 200 institutions are taken into consideration when depicting the co-authorship networks of research institutions, co-authorship relations are too complex to obtain a clear view of the structure of the co-authorship networks of research institutions. Therefore, when drawing the co-authorship networks of research institutions, only the co-authorships that involve about 20 top institutions[7] were used for mapping, instead of considering all co-authorships between the abovementioned 200 institutions. Usually, one institution often collaborates with multiple institutions in writing research papers. In such cases, only the co-authorship relations that produce a largest number of co-authored research papers were extracted. The combination of these methods enables the extraction of a structure that forms a backbone of the co-authorship networks of research institutions which mainly consist of about 20 top institutions. The analysis in this report is intended to have an accurate understanding of the characteristics of the co-authorship networks of research institutions, and the clearning of names of individual institutions in terms of spelling or notation was not made. Therefore, it is not appropriate to evaluate individual institutions using the co-authorship networks of research institutions.

When there are two or more networks within a research area, there are no co-authorship relations between them, so they are shown separately in the following figure. It should also bear in mind that co-authorship relations represent only a part of substantive collaborative relationships between research institutions.

Co-authorship networks of research institutions in the research area of "Research on regenerative medicine and stem cells (2008, ID30)" are shown (Figure 63). Contents of this research area include research on embryonic stem cells (ES cells) and the maintaining of undifferentiation state and induction of differentiation in iPS cells established by Dr. Yamanaka of Kyoto University. It is a very large research area consisting of 385 core papers, in which there are 26 core papers from Japan. First, Harvard University plays a central role, to which a number of research institutions are linked. And there are University California Los Angeles and University of Washington, both of which are observed to have a function as a hub, although

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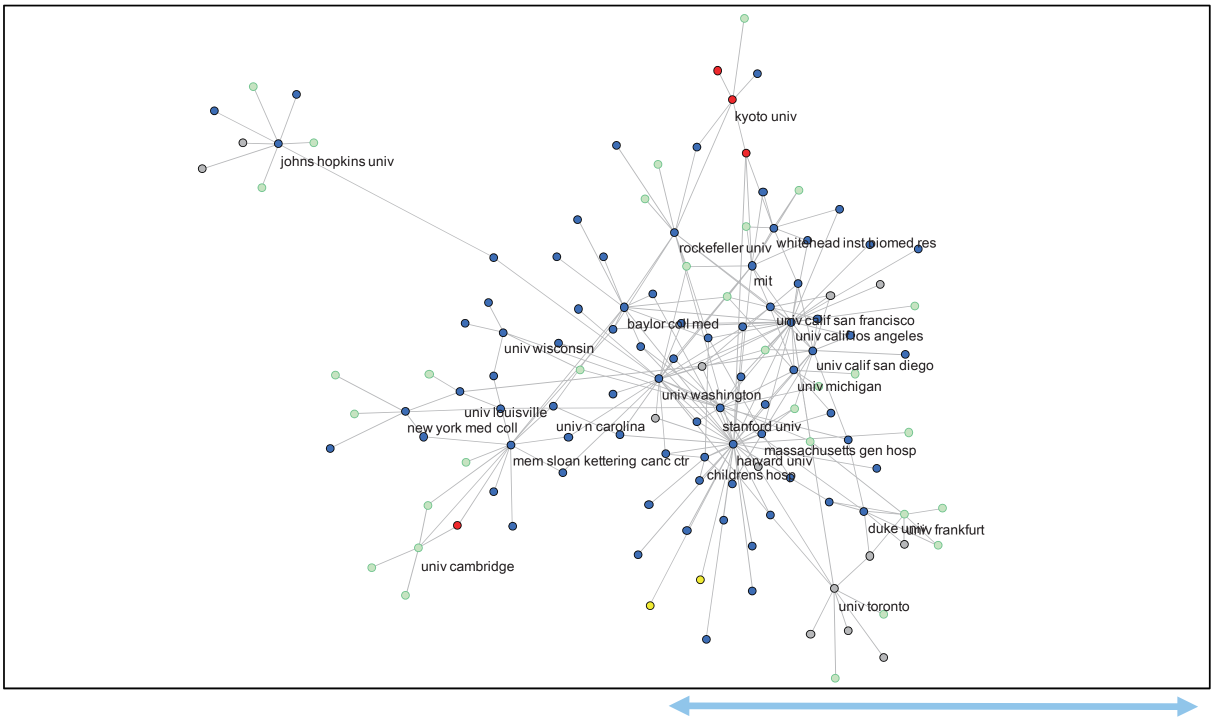
[7] More specifically, (1) co-authorships between about 20 top institutions and (2) co-authorships between about 20 top institutions and other institutions were considered.

the size of the linkage slightly smaller compared to that of Harvard University. Basically, most of the institutions linked with these universities are US based. There are a certain number of research institutions of European regions, but they do not appear to have a hub-like function and their universities are not observed to concentrate somewhere. Instead, they are broadly penetrated in the network.

Four Japanese institutions are included in the network. Although there are some links with US institutions, the figure indicates that the Japanese institutions are not incorporated in the center of the co-authorship networks of research institutions. Research in this area is progressing at an extremely fast pace and global competition is predicted to be intense; therefore, it may not be necessarily effective to seek international collaboration. However, looking at the global situations as shown here, knowledge propagation routes for this research area are nearing its completion.

Figure 63 Co-authorship networks of research institutions ID_30
Research on regenerative medicine and stem cells



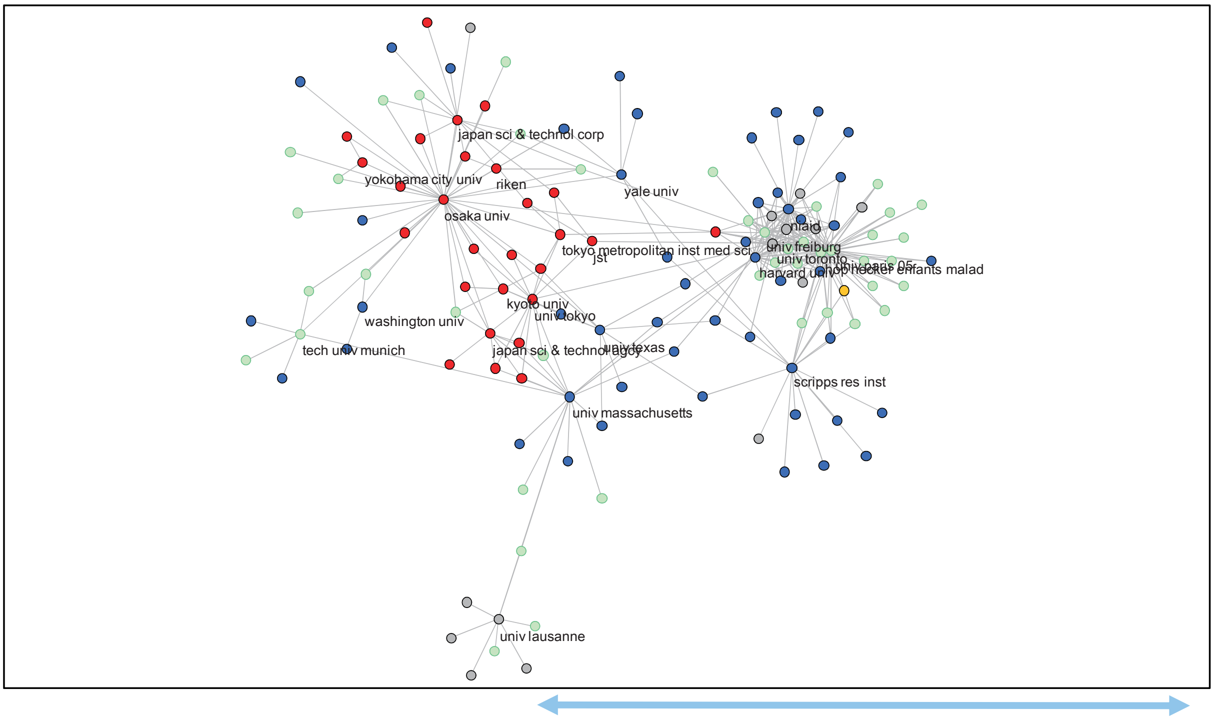
Note: Each dot corresponds to one research institution. Red dots indicate Japanese research institutions, blue US, green European, orange Chinese and yellow Asian (excluding Japanese and Chinese institutions). Gray dots indicate other institutions. Names of about 20 top institutions in terms of shares of core papers comprising a research area are shown next to the dots. Names of the institutions are not consolidated in terms of spelling and notations. The blue arrow is a distance scale for comparing networks between different research areas.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Here, co-authorship networks of research institutions within the research area of “Production of interferon by innate immunity (2008, ID41)” are shown (Figure 64). This is a research area continued from “Research on immune system (2004, ID116)” in Science Map 2004 and “Innate immunity (2006, ID108)” in Science Map 2006. The number of core papers in “Research on immune system (2004, ID116)” is 329, with a Japanese share (in the whole count method) of 13 percent. “Innate immunity (2006, ID108)” has 108 core papers, with a Japanese share of 38 percent. There are 93 core papers in this research area with a Japanese share of 42 percent. This is an area where Japan has a very strong presence.

The magnitude of the presence of Japanese institutions can be observed from the network structure. Osaka University, which has links with overseas research institutions in the US and European regions, performs its function as a hub, while playing a central role in Japanese research institutions. The university’s success in fulfilling its function as a hub in a research area that has continued is an outcome of its steady efforts in building networks with institutions abroad while taking into consideration the securing of and linkage with a certain number of research institutions within Japan.

In the US, Scripps Research Instituts (US) and University of Massachusetts assume an important role. On the other hand, as shown on the right of this figure, Harvard University (US), Hôpital Necker (France), Université Paris V (France), University of Toronto (Canada), National Institute of Allergy and Infectious Diseases (US), Albert-Ludwigs Universität Freiburg (Germany), and so on, have a strong co-authorship link with each other and are present as a group of research institutions, although the number of core papers is small.

Figure 64 Co-authorship networks of research institutions ID_41
Production of interferon by innate immunity

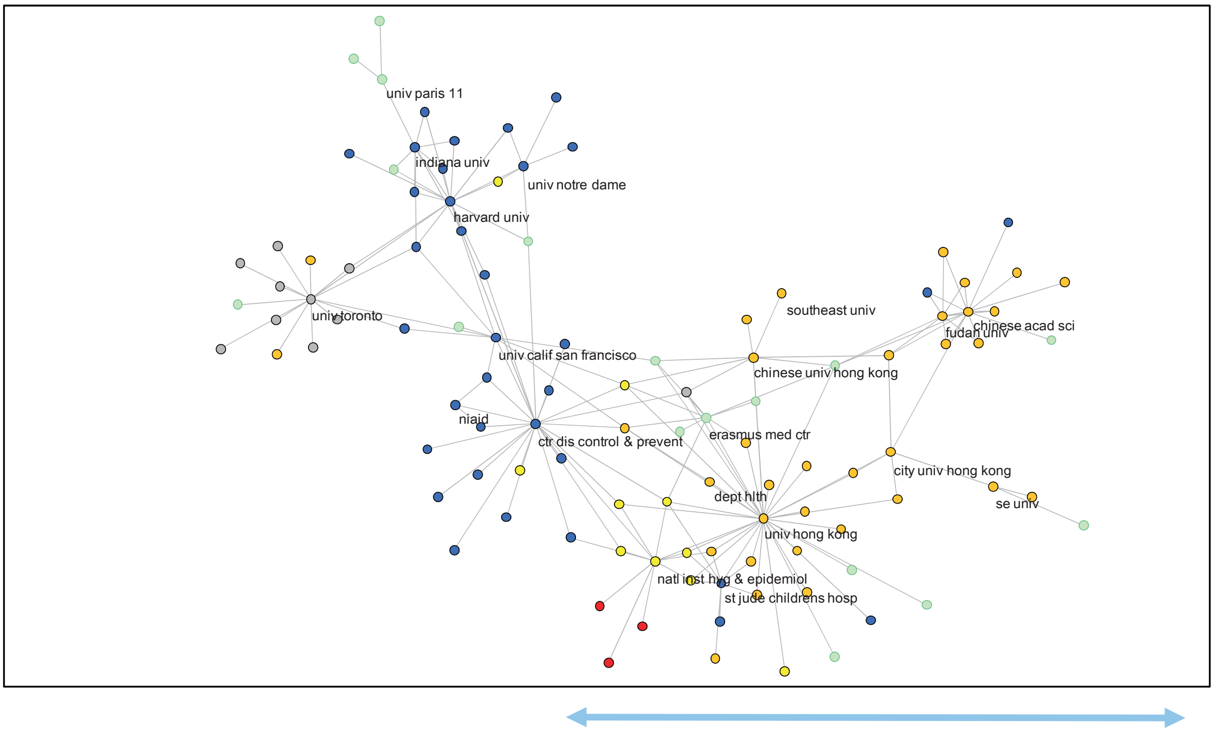


Note: Each dot corresponds to one research institution. Red dots indicate Japanese research institutions, blue US, green European, orange Chinese and yellow Asian (excluding Japanese and Chinese institutions). Gray dots indicate other institutions. Names of about 20 top institutions in terms of shares of core papers comprising a research area are shown next to the dots. Names of the institutions are not consolidated in terms of spelling and notations. The blue arrow is a distance scale for comparing networks between different research areas.
Data: Tabulated from Thomson Reuters’ “Essential Science Indicators” by the National Institute of Science and Technology Policy.

Here (Figure 65) shows co-authorship networks of research institutions within the research area of "Network science (2008, ID50)." This is a research area that continued from "Research on SARS and avian influenza (2004, ID5)," and "Pathogenic mechanism and preventive/therapeutic method of severe acute respiratory syndrome (SARS) (2006, ID93)." The research area is connected to other research areas from the viewpoint of network, instead of the previous viewpoint of research on infectious diseases. It is an inter-/multi-disciplinary area including content that expands to a broad range of fields from a basic structural analysis to applications such as life science, engineering and medical science. Situated in the neighborhood of post-genome research on the Science Map, the research area's similarity with post-genome research is also pointed out in terms of handling a large amount of data. It is an interesting research area that is taking a new turn.

Looking at the structure of the network, there are a group of Chinese research institutions centering on the University of Hong Kong (China) and the Chinese Academy of Sciences (China) and a group of research institutions where Centers for Disease Control and Prevention (US), Harvard University (US) and University of Toronto (Canada) serve as a hub. Japan belongs to a part of the group of Chinese research institutions. Centers for Disease Control and Prevention (US) performs research on SARS and influenza viruses. Harvard University (US) and University of Toronto (Canada) carry out research on protein, molecule and drug interaction networks and the structure and dynamics of network, which is closer to that in the adjacent post-genome research on the Science Map. The University of Hong Kong (China) and the Chinese Academy of Sciences (China) perform research on both infectious diseases and the stability of neural networks, suggesting that the institutions are playing an important role in terms of both the content of the research area and co-authorship networks of research institutions.

Figure 65 Co-authorship networks of research institutions ID_50 Network science

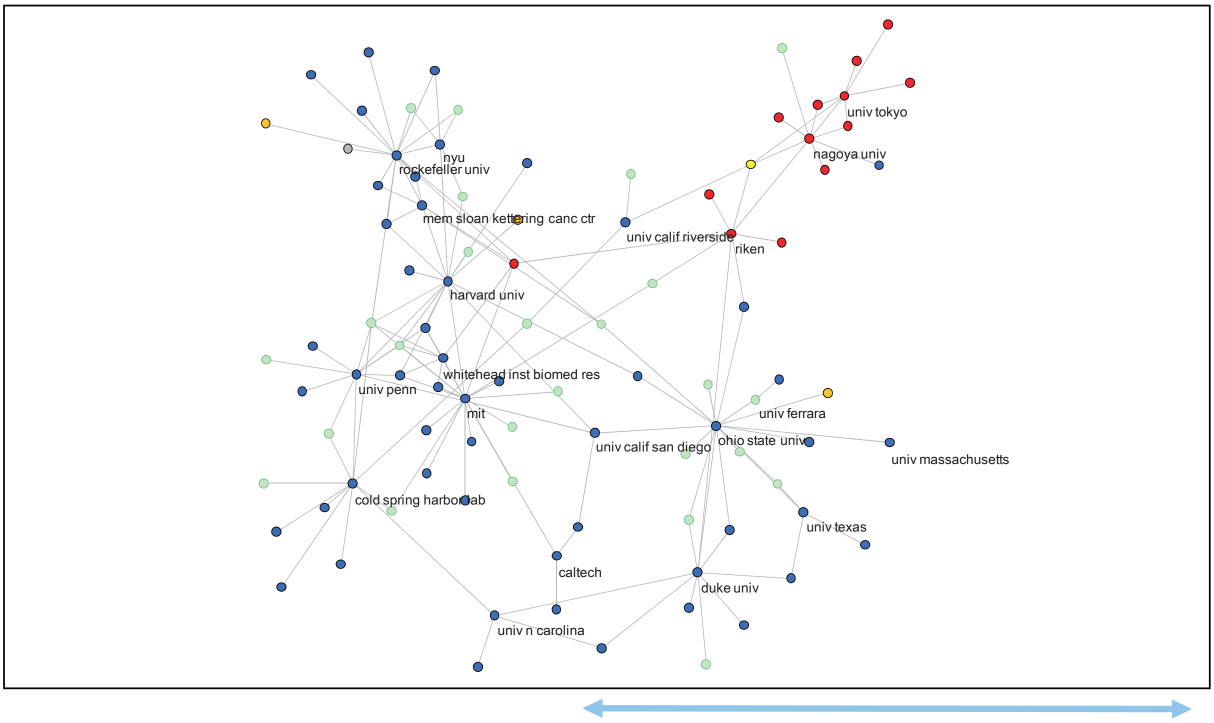


Note: Each dot corresponds to one research institution. Red dots indicate Japanese research institutions, blue US, green European, orange Chinese and yellow Asian (excluding Japanese and Chinese institutions). Gray dots indicate other institutions. Names of about 20 top institutions in terms of shares of core papers comprising a research area are shown next to the dots. Names of the institutions are not consolidated in terms of spelling and notations. The blue arrow is a distance scale for comparing networks between different research areas.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Here (Figure 66) shows co-authorship networks of research institutions within the research area of "Gene silencing/plant hormone (2008, ID51)." This research area is the center of post-genome research and has high degree and between centralities in the network of research institutions. The research area has continued since Science Map 2002 and has since been present, while at the same time merging with other areas. Judging from the nature of its composition of 22 fields, the research area can be regarded as an inter-/multi-disciplinary area in life science.

Looking at co-authorship networks of research institutions in this research area that has such characteristics, Massachusetts Institute of Technology (US), the Ohio State University (US) and Harvard University (US) take the central role. This is followed by University of Pennsylvania (US), Cold Spring Harbor Laboratory (US) and Duke University (US), indicating that US institutions are in the center of networks, around which European institutions are also widely present. As for Japanese institutions, the University of Tokyo, Nagoya University and RIKEN are present as a group in the upper left of the figure. This indicates stronger relationships within Japanese institutions, while there do exist some links with institutions in the US and in the European region.

Figure 66 Co-authorship networks of research institutions ID_51 Gene silencing/plant hormone



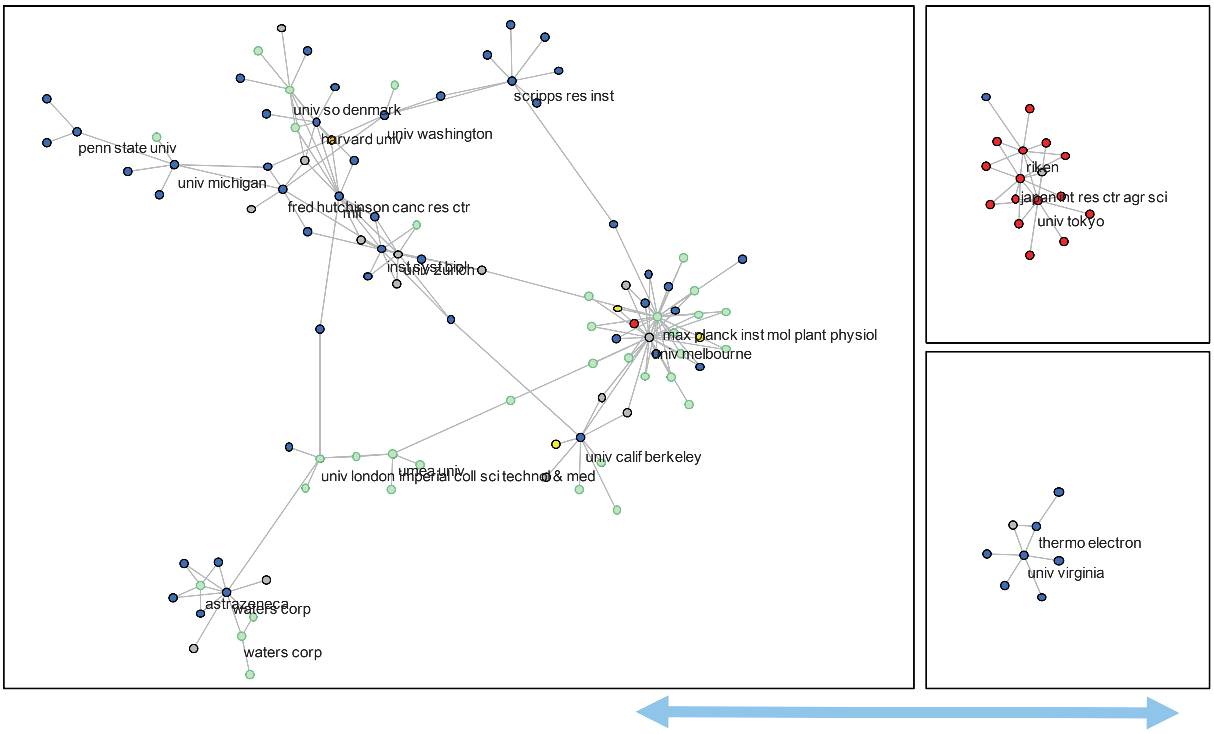
Note: Each dot corresponds to one research institution. Red dots indicate Japanese research institutions, blue US, green European, orange Chinese and yellow Asian (excluding Japanese and Chinese institutions). Gray dots indicate other institutions. Names of about 20 top institutions in terms of shares of core papers comprising a research area are shown next to the dots. Names of the institutions are not consolidated in terms of spelling and notations. The blue arrow is a distance scale for comparing networks between different research areas.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Here (Figure 67) shows co-authorship networks of research institutions within the research area of "Environmental responses of plants/metabolome analysis/proteome analysis (2008, ID53)." This research area has continued since Science Map 2002 while at the same time merging with other research areas. The research area can be regarded as an inter-/multi-disciplinary area judging from the nature of its composition of 22 fields, and there are currently three research themes blended together in the research area.

In a research area that has such characteristics, the structure of co-authorship networks is considerably different from those shown in the previous figures. It consists of three independent structures of network. The largest network is the one shown on the figure to the left in which Max-Planck-Institut (Germany) and the University of Melbourne (Australia) play a central role. A characteristic of the network is that it is formed of institutions based in Europe and other regions although there are a number of US research institutions present in the network. These institutions perform research on any one or more of the themes of Environmental responses of plants/metabolome analysis/proteome analysis, but their research generally covers these three themes.

A co-authorship network of research institutions shown in the figure to the upper right is formed of Japanese research institutions, including RIKEN, the University of Tokyo and Japan International Research Center for Agricultural Sciences. Although their research papers include those concerning environmental responses of plants which is one of the themes in this research area, research papers on the other issues (Metabolome analysis/proteome analysis) are not included. This shows that Japanese institutions have established their very strong presence in part of the content of this research area. However, in order to promote research with an eye on links with metabolome analysis/proteome analysis under the situation where the three themes of environmental responses of plants/metabolome analysis/proteome analysis begin to build links with each other through co-citation relation, it is necessary for Japanese institutions to consider building relationships with the group of research institutions in the figure to the left. The Figure bottom right is a network of US research institutions centering on University of Virginia, where proteome analysis is conducted.

Figure 67 Co-authorship networks of research institutions ID_53 Environmental responses of plants/metabolome analysis/proteome analysis



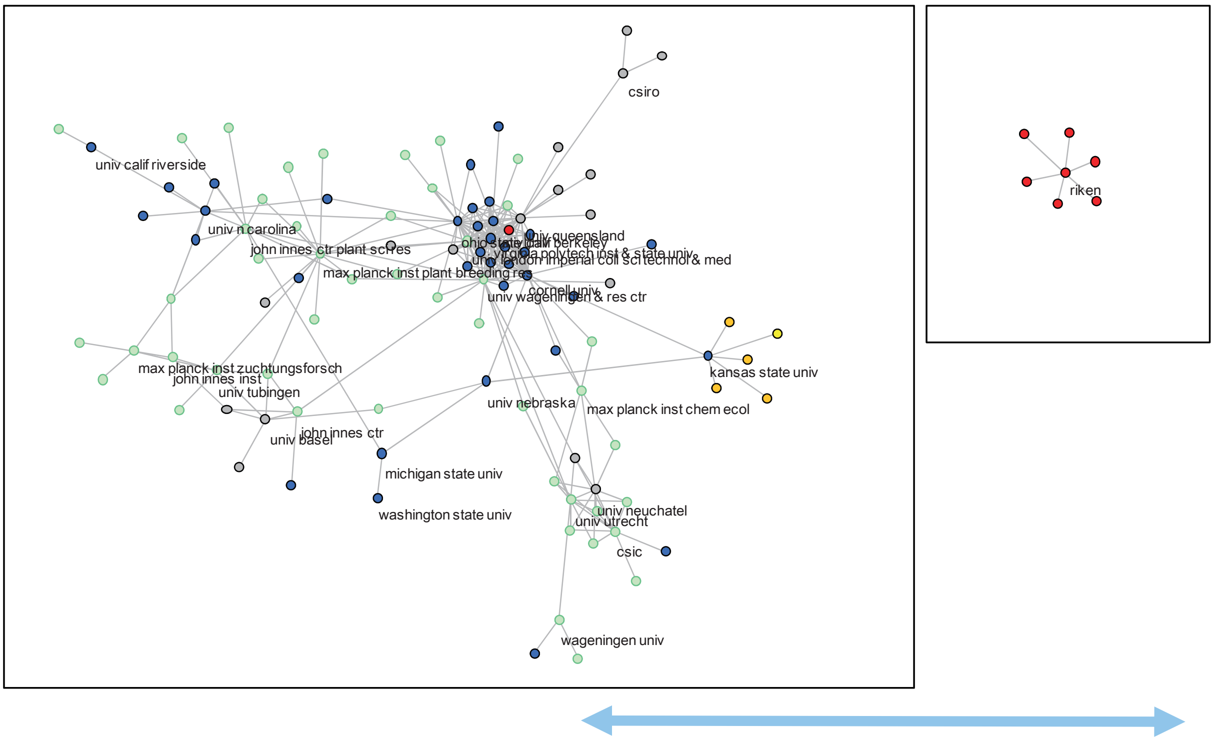
Note: Each dot corresponds to one research institution. Red dots indicate Japanese research institutions, blue US, green European, orange Chinese and yellow Asian (excluding Japanese and Chinese institutions). Gray dots indicate other institutions. Names of about 20 top institutions in terms of shares of core papers comprising a research area are shown next to the dots. Names of the institutions are not consolidated in terms of spelling and notations. The blue arrow is a distance scale for comparing networks between different research areas.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Here (Figure 68) shows co-authorship networks of research institutions within the research area of "Defense mechanism of plants against infection (2008, ID55)." This research area has continued since Science Map 2002, and was a hot research area as "Stress response in plants (2004, ID34)" in Science Map 2004 and as "Plant defense against infection/plant immunity (2006, ID34)" in Science Map 2006. The research area is in the region of plant science research on the Science Map and this position remains unchanged.

Looking at the structure of co-authorship networks of research institutions within this research area, there are two network structures. A co-authorship network of Japanese institutions shown in the Figure to the right is built independently. It has already been proved that research papers with international co-authorship tend to be cited highly, therefore, the strong presence shown by only Japanese institutions centering on RIKEN through co-authorship relations is particularly notable.

By focusing attention on the structure in Figure to the left, one can see that co-authorship networks were formed centering around US research institutions and others to become a core. By having co-authorship relationships with these research institutions, European research institutions have a strong presence.

Figure 68 Co-authorship networks of research institutions ID_55 Defense mechanism of plants against infection



Note: Each dot corresponds to one research institution. Red dots indicate Japanese research institutions, blue US, green European, orange Chinese and yellow Asian (excluding Japanese and Chinese institutions). Gray dots indicate other institutions. Names of about 20 top institutions in terms of shares of core papers comprising a research area are shown next to the dots. Names of the institutions are not consolidated in terms of spelling and notations. The blue arrow is a distance scale for comparing networks between different research areas.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

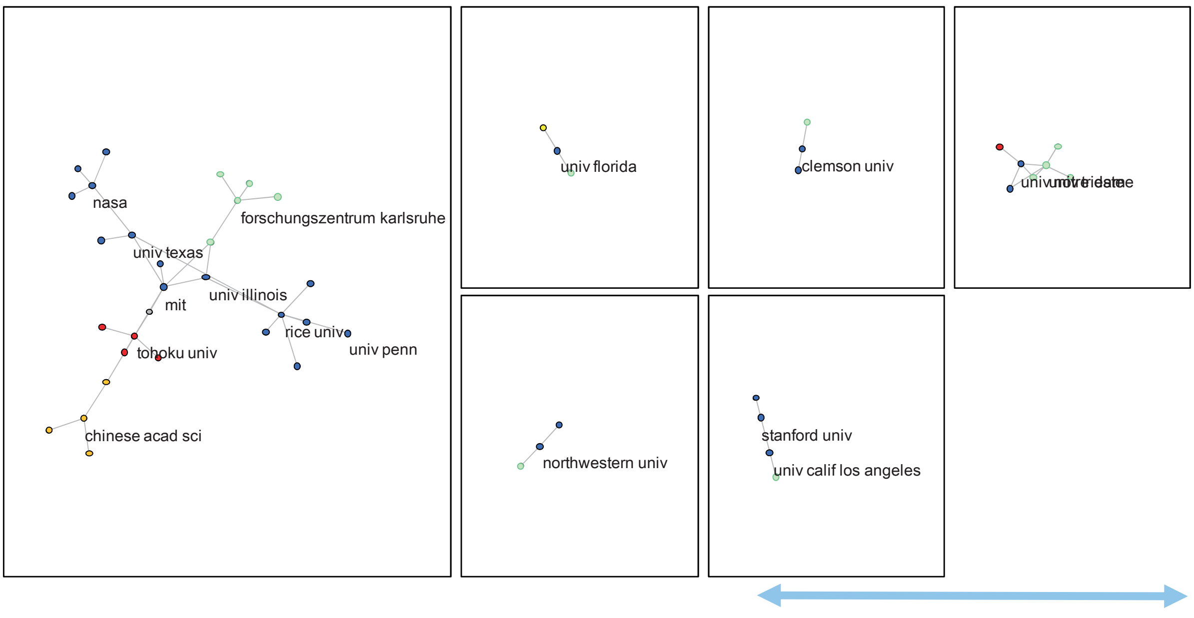
Co-authorship networks of research institutions of “Synthesis, function and toxicity of sensors/SWNTs/functional DNAs/nanoparticles, etc. (2008, ID67)” is shown in Figure 69. There are few co-authorship relations between research institutions in this research area, and co-authorship networks of research institutions are divided into several fragments. Also, hub structures centering around particular research institutions are not observed.

Because this research area involves a diversity of research subjects including carbon nanotubes, nanomaterial, supramolecules, functional DNAs, and so on, each of the fragmented co-authorship networks of research institutions could be linked to a particular research subject. However, no evident links are observed between the structure of co-authorship networks of research institutions and the structure of individual research area maps; therefore, co-authorship networks of research institutions are not fragmented by content of research. In other words, even if research themes are close to each other, research in this research area tends to be conducted individually by each research institution.

Core papers that comprise this research area are in the field of chemistry. It has already been known that there are few co-authorship relations in chemistry compared to other fields; therefore, the absence of apparent structures of co-authorship networks of research institutions in this research area might represent characteristics of the field.

On the other hand, if international collaboration through exchange of specimens, and so on, is necessary for this research area, the research area can be currently in the process of building co-authorship networks of research institutions. Research institutions that could become a discernible hub are not observed in this research area; therefore, there is a possibility for Japan to take initiative in building an international base by actively engaging in international collaborative research.

Figure 69 Co-authorship networks of research institutions ID_67 Synthesis, function and toxicity of sensors/SWNTs/functional DNAs/nanoparticles, etc.



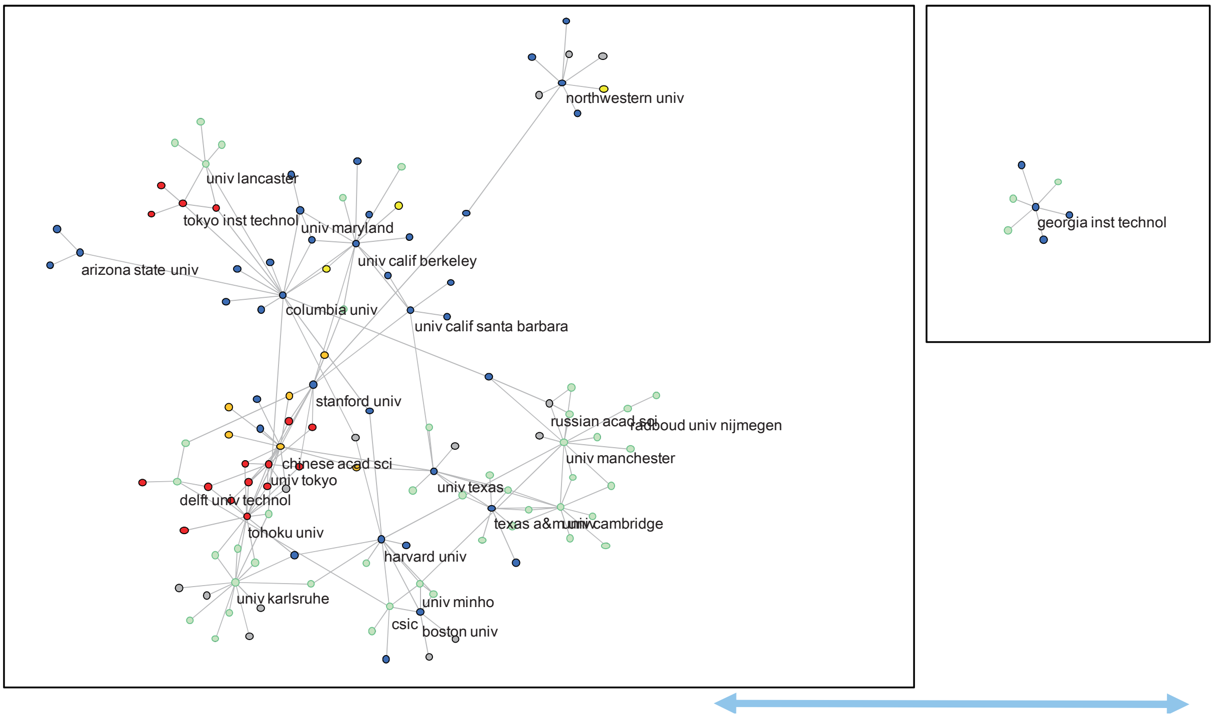
Note: Each dot corresponds to one research institution. Red dots indicate Japanese research institutions, blue US, green European, orange Chinese and yellow Asian (excluding Japanese and Chinese institutions). Gray dots indicate other institutions. Names of about 20 top institutions in terms of shares of core papers comprising a research area are shown next to the dots. Names of the institutions are not consolidated in terms of spelling and notations. The blue arrow is a distance scale for comparing networks between different research areas.
Data: Tabulated from Thomson Reuters’ “Essential Science Indicators” by the National Institute of Science and Technology Policy.

Co-authorship networks of research institutions of “Physics and chemistry of molecular substance (2008, ID80)” are shown in Figure 70. This research area includes research that is roughly divided into four themes; (A) Physics and chemistry of graphene and graphite, (B) Physics and chemistry of carbon nanotubes, (C) Molecular and organic electronics and (D) Spin-related quantum transfer phenomena

Looking at each research organization, Columbia University (US) has 18 (out of 264) core papers which the largest, followed by the University of Manchester (UK) and Stanford University (US). While Columbia University and the University of Manchester have many research papers co-authored with US and European research organizations, respectively, Stanford University has many research papers collaborated with Japan and China.

There are 16 Japanese research institutions, filling a place in the research area network. They are present not in isolation in the network, but are performing research while maintaining a certain level of relationships with US, European and Chinese research institutions. At present, shares of Japanese research papers in whole counting in this research area is 8.7 percent, which is not high as a Japanese share in condensed matter physics, but it is possible for Japan to increase its presence by increasing participation in international co-authorship networks of research institutions.

Figure 70 Co-authorship networks of research institutions ID_80 “Physics and chemistry of molecular substance



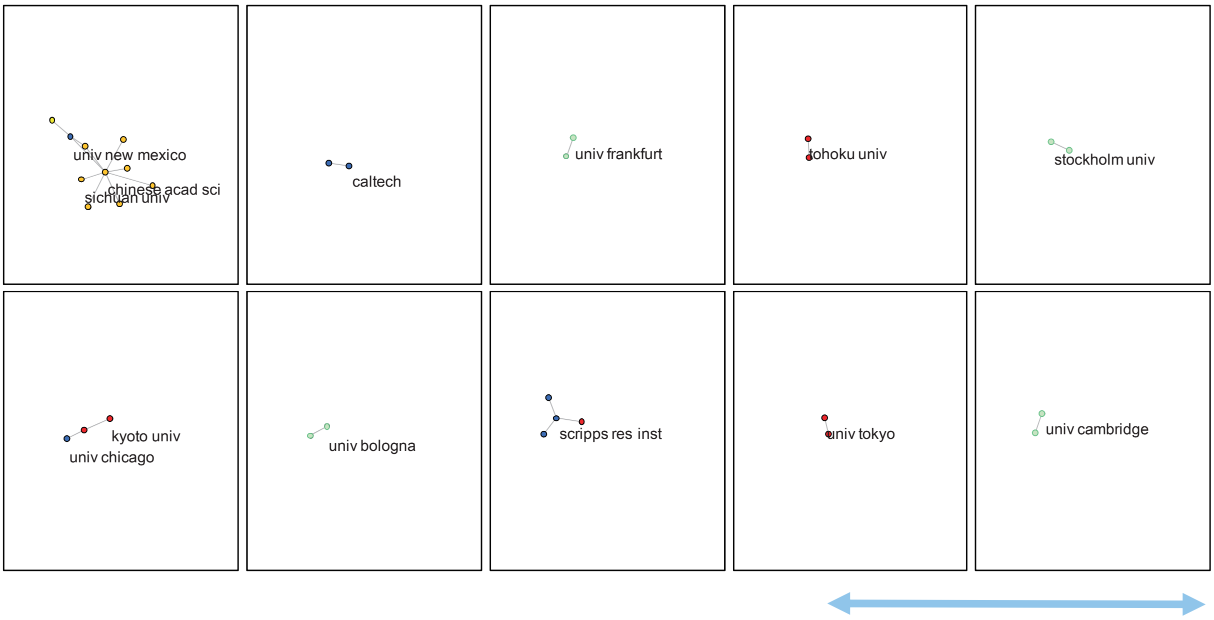
Note: Each dot corresponds to one research institution. Red dots indicate Japanese research institutions, blue US, green European, orange Chinese and yellow Asian (excluding Japanese and Chinese institutions). Gray dots indicate other institutions. Names of about 20 top institutions in terms of shares of core papers comprising a research area are shown next to the dots. Names of the institutions are not consolidated in terms of spelling and notations. The blue arrow is a distance scale for comparing networks between different research areas.
Data: Tabulated from Thomson Reuters’ “Essential Science Indicators” by the National Institute of Science and Technology Policy.

Co-authorship networks of research institutions of “Catalytic asymmetric synthesis (2008, ID86)” are shown in Figure 71. There are very few co-authorship relations between research institutions in this research area. Almost no structures are observed in the co-authorship networks of research institutions, and those consisting of a small number of research institutions are divided into a number of fragments.

While there are no structures in the co-authorship networks of research institutions, research fronts in individual research area maps are linked with particularly dense citations. It is predicted that, in this research area, research institutions perform research individually even when their research themes are strongly associated with each other, and that exchange of knowledge is performed through high citations of research papers.

It has already been known that there are few research papers with international co-authorship research papers in chemistry compared to other fields. This research area typifies the characteristics of the field. From the viewpoint of co-authorship networks of research institutions, in order for Japan to have a presence in this type of research area, it is important to secure sufficient numbers of research institutions that have a certain level of research capability.

Figure 71 Co-authorship networks of research institutions ID_86 Catalytic asymmetric synthesis



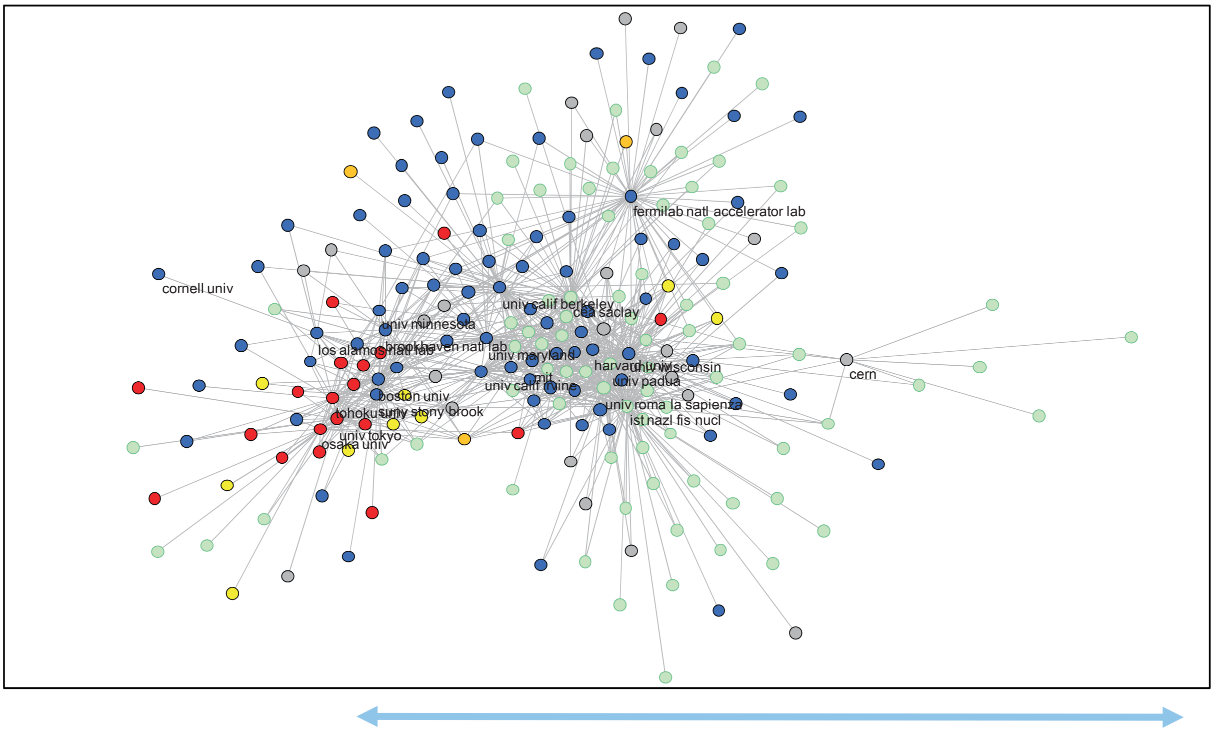
Note: Each dot corresponds to one research institution. Red dots indicate Japanese research institutions, blue US, green European, orange Chinese and yellow Asian (excluding Japanese and Chinese institutions). Gray dots indicate other institutions. Names of about 20 top institutions in terms of shares of core papers comprising a research area are shown next to the dots. Names of the institutions are not consolidated in terms of spelling and notations. The blue arrow is a distance scale for comparing networks between different research areas.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Co-authorship networks of research institutions of “Particle physics/Astroparticle physics (2008, ID106)” are shown in Figure 72. Research papers are frequently co-authored between research institutions in this research area. The research area is characterized by its dense link structures found in the co-authorship networks of research institutions. Another characteristic of this research area is that, in its co-authorship network of research institutions, there are research institutions that have a large scale facilities, such as Super-Kamiokande (the University of Tokyo), KamLand (Tohoku University), Fermi National Accelerator Laboratory (US) and European Organization for Nuclear Research (CERN) , and National Institute of Nuclear Physics (Italy). Because large-scale facilities are essential for particle physics and astroparticle physics, co-authorship networks of international research institutions are formed centering on research institutions with large-scale facilities. There are a number of Japanese institutions participating in the co-authorship networks of research institutions and Japanese shares of research papers in whole counting is high at 18.9 percent, which indicates significant participation by Japanese institutions in the developments of the research area.

CERN has the largest share of core papers that comprise this research area. However, from the standpoint of co-authorship networks of research institutions, the number of links from CERN is few. Although the reason for this requires investigation, it is possible that CERN does not need collaboration with other research institutions, because it attracts many researchers from around the world and can secure a diversity of researchers within the institution.

In research areas where research is carried out with a central focus on large-scale facilities, possession of large-scale facilities is considered to be an important factor in building a base. However, large-scale facilities are not always necessary for obtaining knowledge of this research area. As can be seen in the structures of the dense co-authorship networks of research institutions, it is possible even for countries without large-scale facilities to participate in knowledge production, by entering these co-authorship networks of research institutions.

Figure 72 Co-authorship networks of research institutions ID_106 Particle physics/astroparticle physics



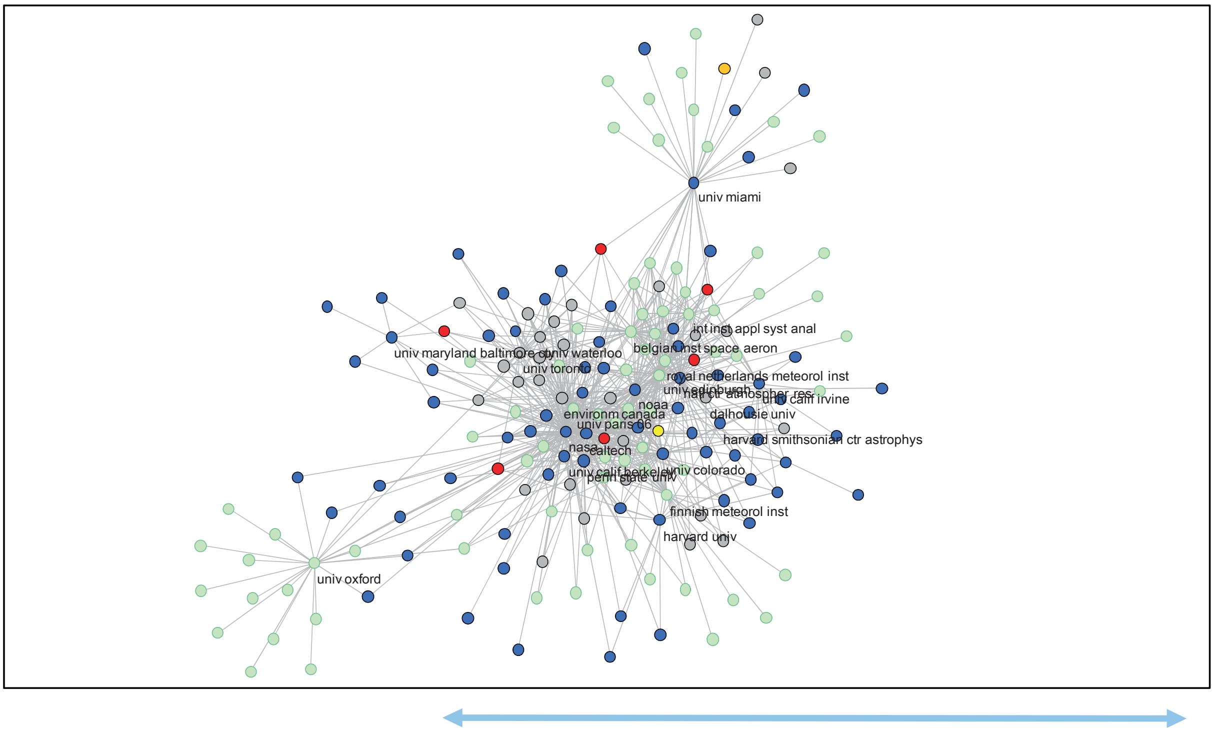
Note: Each dot corresponds to one research institution. Red dots indicate Japanese research institutions, blue US, green European, orange Chinese and yellow Asian (excluding Japanese and Chinese institutions). Gray dots indicate other institutions. Names of about 20 top institutions in terms of shares of core papers comprising a research area are shown next to the dots. Names of the institutions are not consolidated in terms of spelling and notations. The blue arrow is a distance scale for comparing networks between different research areas.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Co-authorship networks of research institutions of “Atmospheric composition and minor constituents (2008, ID115)” are shown in Figure 73. Same as in “Particle physics/astroparticle physics (2008, ID106),” research papers are frequently co-authored between research institutions in this research area and dense co-authorship networks of research institutions are formed.

Although there are not many Japanese research institutions, they are participating in research networks without isolating themselves in the research area. Japan’s share of research papers in fractional counting is 1.2 percent in this research area, but it increases nearly ten times to 10.1 percent in whole counting. This is an example of increased participation in a research area through participation in co-authorship networks of research institutions.

From the content of this research area, one can see that it is a research area that requires collection and analysis of data through international collaboration, such as satellite observation of atmospheric minor constituents and radiation/water vapor/clouds. In order to grasp the situation of atmospheric constituents around the globe, cooperation from each country is essential; therefore, Japan will continue to have a presence by entering co-authorship networks of research institutions through sharing of data.

Figure 73 Co-authorship networks of research institutions ID_115 Atmospheric composition and minor constituents



Note: Each dot corresponds to one research institution. Red dots indicate Japanese research institutions, blue US, green European, orange Chinese and yellow Asian (excluding Japanese and Chinese institutions). Gray dots indicate other institutions. Names of about 20 top institutions in terms of shares of core papers comprising a research area are shown next to the dots. Names of the institutions are not consolidated in terms of spelling and notations. The blue arrow is a distance scale for comparing networks between different research areas.
Data: Tabulated from Thomson Reuters’ “Essential Science Indicators” by the National Institute of Science and Technology Policy.

Basic data of each research area that have been explored so far is shown in Figure 74. Many of the research papers in ID106 and 115 are co-authored by ten or more research institutions, which matches a higher density of co-authorship networks of research institutions compared to those of other research areas. Characteristics of co-authorship networks of research institutions are summarized in Figure 75. As shown in this figure, co-authorship networks can be broken down into patterns based on the characteristics of each research area, the numbers of Japanese institutions participating and the coverage of the content by research area. The percentage of international co-authorship is increasing in the world's research system. In this trend, it is important for Japan to consider how to deal with co-authorship relationships. When doing so, the fact that networks vary among research area as shown in this section should be borne in mind and measures that respond to each case should be taken.

Figure 74 Basic data of each research area

ID	Name of research area	Classification into 22 fields	Number of core papers	Average number of institutions	10 institutions or more		Japan		Number of institutions appeared (Note 1)	Number of institutions as a mapping unit (Note 2)	Number of institutions comprising a network (Note 3)	Share of the number of institutions comprising network in the number of insitutions as a mapping unit
					Number of core papers	Share in core papers	Number of core papers	Share in core papers				
30	Research on regenerative medicine and stem cells	Clinical medicine	385	5.1	22	6%	26	7%	590	172	128	74%
41	Production of interferon by innate immunity	Inter-/multi-disciplinary	93	5.3	6	6%	39	42%	151	151	135	89%
50	Network science	Inter-/multi-disciplinary	271	4.7	18	7%	10	4%	450	149	108	72%
51	Gene silencing/plant hormone	Inter-/multi-disciplinary	389	4.1	8	2%	30	8%	412	157	96	61%
53	Environmental responses of plants/metabolome analysis/proteome analysis	Inter-/multi-disciplinary	155	3.9	2	1%	13	8%	205	205	125	61%
55	Defense mechanism of plants against infection	Pland and animal science	160	3.5	2	1%	7	4%	146	146	112	77%
67	Synthesis, function and toxicity of sensors/SWNTs/functional DNAs/nanoparticles, etc.	Chemistry	293	3.4	0	0%	16	5%	266	94	49	52%
80	Physics and chemistry of molecular substance	Physics	264	3.4	0	0%	23	9%	221	221	127	57%
86	Catalytic asymmetric synthesis	Chemistry	289	2.4	0	0%	56	19%	124	124	31	25%
106	Particle physics/astroparticle physics	Physics	238	9.2	36	15%	45	19%	472	220	218	99%
115	Atmospheric composition and minor constituents	Geosciences	69	7.8	17	25%	7	10%	196	196	189	96%

Note Average number of institutions is for 1 research paper. Japan's share in core papers is calculated using the whole count method.
Note 1 The number of institutions appeared is the number of those appeared in all core papers. Names are not consolidated.
Note 2 The number of institutions as a mapping unit is the number of those determined as mapping units at the time of the creation of co-authorship networks of research institutions.
Note 3 The number of institutions comprising a network is the number of those included in co-authorship networks of research institutions that appear in this report. Institutions that do not have co-authorship links with other institutions are not included in this figure, even if they are mapping units.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Figure 75 Patterns of co-authorship networks of research institutions

Network structure	Pattern	Description	Example of research area	Interpretation
Identified	Network forming type	Roughly one large structure of co-authorship network of research institutions	Research on regenerative medicine and stem cells (ID_30)	A research area in a particular field. Research content matches co-authorship networks of research institutions.
			Production of interferon by innate immunity (ID_41)	Being a inter-/multi-disciplinary research area, content is complex, but is included in one co-authorship network of research institutions.
			Network science (ID_50)	
			Gene silencing/plant hormone (ID_51)	
		Mix of large and small networks	Synthesis, function and toxicity of sensors/SWNTs/functional DNAs/nanoparticles, etc. (ID_67)	A research area in a particular field which includes multiple themes and research subjects. However, there is no obvious relationships between research content and multiple co-authorship- networks of research institutions.
			Physics and chemistry of molecular substance (ID_80)	
			Environmental responses of plants/metabolome analysis/ proteome analysis (ID_53)	Being an inter-/multi-disciplinary research area, there are multiple types of research content. Mix of large and small co-authorship networks of research institutions. The large networks include all types of content, in which specialized institutions conducting research form small co-authorship networks.
			Defense mechanism of plants against infection (ID_55)	
	Dense network forming type	Dense co-authorship networks of research institutions are formed	Particle physics/astroparticle hysics (ID_106)	A research area in which research is carried out centering on large-scale facilities, and co-authoring between research institutions frequently takes place.
			Atmospheric composition and minor constituents (ID_115)	A research area that requires collection and analysis of data through international cooperation. Co-authoring between research institutions frequently takes place.
Not identified	Non-network forming type	No clear structures of co-authroship networks of research institutions are observed	Catalytic asymmetric synthesis (ID_86)	A research area in which co-citation links between research fronts are dense, but research is conducted individually by research institutions.

5. Conclusion

The National Institute of Science and Technology Policy's Science Map project aims to periodically observe dynamic change in scientific research[8]. The unit of mapping is research areas.

Science Map 2008 used the top 1 percent highly-cited research papers (approximately 50,000) during each year in each of 22 fields (including Clinical medicine, Plant and Animal Science, Chemistry, Physics, etc.) among research papers published during the six years 2003 through 2008. These highly-cited research papers were clustered in two stages (research papers →research fronts →research areas) by using "co-citation." Six hundred forty-seven research areas were obtained. Of these, detailed content analysis was performed on 121 hot research areas above a certain size. In addition, a time-series analysis was performed between Science Map 2002 (from 1997 through 2002), Science Map 2004 (from 1999 through 2004) and Science Map 2006 (from 2001 through 2006). The following is a summary of the report.

5-1 Conclusion

(1) Changes in scientific research as seen in Science Map 2008

1) Relationships among research areas in scientific research

Groups of research areas related to life science are at the upper left of the Science Map. At the top is the group of research areas related to research on heart and blood vessels, with linkage to research on infectious diseases/immunology, cancer research, study of obesity, research on regenerative medicine, and brain research. Below it spread post-genome research and plant science research. The group of research areas related to nanoscience is at the center-right, and the group of research areas related to chemical synthesis at the center left. To the left and below chemistry is the group of research areas related to environmental research. Unlike the group of research areas related to chemistry that concentrate close together, this group is spread out on the map. To the right and below nanoscience are condensed matter physics and particle physics/cosmology.

In and after Science Map 2002, the percentage of research areas on the map accounted for by life science is in decreasing trend, whereas, the number of research papers is increasing in the neighborhood centering on nanoscience and chemistry, in condensed matter physics and in a region between condensed matter physics and particle physics/cosmology.

2) Identification of active areas seen in inter-/multi-disciplinary areas

Of the 121 hot research areas, 40 (33 percent) are inter-/multi-disciplinary areas. These areas include a relatively a large number of topics and shows remarkable increase in the number of citations. In addition, relatively new research results tend to be incorporated in these research areas. Looking at the positions of inter-/multi-disciplinary research areas on the map, most are found in nanoscience, environment and life science (especially in brain research, research on regenerative medicine, research on infectious diseases/immunology and post-genome research). This means that there is a more active movement of these research areas in science.

[8] This is the fourth report. The first report is NISTEP REPORT No. 95, Study on Rapidly-developing Research Area (May 2005); the second report is NISTEP REPORT No. 100, Science Map 2004 (Marhc 2007); and the third is NISTEP REPORT No.110, Science Map 2006 (June 2008).

(2) Changes in scientific research as seen in Science Map 2008

Comparison of Science Map 2008 (covering the years 2003-2008) and Science Maps 2002, 2004 and 2006 and interviews with experts confirmed steady, ongoing changes. The important points are as follows:

1) Life science

<New developments in research on regenerative medicine>

The very large research area "Regenerative medicine and stem cell research (2008, ID 30)," which includes Dr. Yamanaka's establishment of iPS cells at Kyoto University, was derived. This research area is formed by the fusion of three research areas in the Science Map 2006. Experts cited research on heart and blood vessels, brain research, cancer research, research on infectious diseases and immunology, and post-genome research as a group of research areas that is likely to develop into the future and to deepen their relationship to research on regenerative medicine. In order for the research area to develop, "the enormous amount of collection of data and search of substances on a different order of magnitude from the past" are necessary. Current post-genome research, life science after the sequencing of the genome, requires more efficient and swifter data collection. The ability to mine this data has also become necessary. Based on such ability of data mining, the post-genome research seeks to strengthen relationships with a broad group of research areas in life science as a target of application.

<The advancement of brain research>

The position of brain research shifted on Science Map 2008, in part because of the influence of the new developments in research on regenerative medicine discussed above. Through Science Map 2006, it was firmly within the clinical medicine related groups of research areas in life science, next to cancer research. In 2008, it is a group of research areas spreading towards the upper right. In the map's upper left are located neurophysiological research such as "Molecular mechanisms of Alzheimer's disease and development of prevention and treatment (2008, ID 15)," psychiatric research such as "Brain-derived neurotrophic factor/brain morphology of schizophrenia/mood disorders (2008, ID 19)," and research with neurophysiological and cognitive science aspects such as "Neural mechanisms of emotion, empathy, imitation, and context (2008, ID 24)." These three different research approaches are distinctively grouped together.

<The position of post-genome research in life science research>

Continuing from Science Map 2006, in 2008 post-genome research forms a bridge between plant science research, which researches mainly plants and fungi; and research on heart and blood vessels; brain research; study of obesity; cancer research; and research on infectious diseases and immunology, which research mainly animals and fungi. Interestingly, "Network science (2008, ID 50)" appears near post-genome research. The large amounts of data such as individual proteins, molecules, and drugs accumulated through post-genome research are being used as the basis of research considering their interactive networks.

<The relationship between life science and nanoscience>

Although the distribution of research areas between life science and nanoscience is not dense, that space is the location of research areas that play an important role in linking life science and nanoscience.

Science Map 2002's ID 53 began intermediate between life science and nanoscience. The research area has split towards both life science and nanoscience during its continuous development. Taking a look at its trajectries towards life science, it has been "Research on proteome (2004, ID 105)" and "Isotope labeling/quantitative mass spectrometry/protein analysis (2006, ID 119)." In Science Map 2008, it is not a hot research area, but it was still derived as a research area. It is located near "Gene silencing/plant hormones (2008, ID 51)" at the center of Post-genome research. In its evolution in the direction of nanoscience, it has been in that group continuously, with "Chemical-/bio-system with microchips (2004, ID 91)," "Micro-bio system and micro chemical system (2006, ID 117)," and "Microchannel devices (2008, ID 62)." Originally an area of life science research, the exhaustive study with ultra-micro, rapid, and highly sensitive analysis used for research such as DNA and protein sequencing became mainstream. Many microchip systems were developed as ways to achieve this. Two streams of research were stemmed from the microchip system; a stream to use these systems for research to understand life and a stream to develop applications to apply microchannel devices to chemical reaction control and bioanalysis. As a consequence, the research of microchip system has been accelerated research in both life science and nanoscience.

2) Chemistry, nanoscience

<Chemistry>

The chemistry group of research areas is characterized by a core of two hot research areas, "Catalytic asymmetric synthesis (2008, ID 86)" and "Molecular conversion reaction using transition metal catalyst (2008, ID 87)," and by its formation of the hot research areas while having relationships with other nearby groups of research areas. "Nanochemistry of gold (2008, ID 81)," "New-generation density functional theory for large-scale molecular computing (2008, ID 82)," and "Complex hydrides related to hydrogen production and storage and fuel cells (2008, ID 91)," which are mapped close to nanoscience and condensed matter physics, are new hot research areas on Science Map 2008. The research scale of "Microbial fuel cells/microbial batteries/enzyme-based biofuel cells (2008, ID 90)," which is mapped between the chemistry and environment groups of research areas, expanded between Science Map 2006 and Science Map 2008, turning it into a hot research area.

<Nanoscience>

The content of the research areas that comprise nanoscience on the map vary by the locations on the map. "Microchannel devices (2008, ID 62)," "Research on nanofiber creation and applications (2008, ID 64)," etc., are mapped near life science. These research areas have the elements of life science such as applications of nanofibers to regenerative medicine and creation of nanostructures using DNA. The hot research area "Organic/organic oxide semiconductors, opto-electronic functional materials and elements (2008, ID 75)," which forms a large peak near condensed matter physics, is a research area involving the development of nanomaterials and devices that use them. Research areas such as "Nanomaterial synthesis in ionic liquids/hollow and mesoporous materials (2008, ID 72)," which involves the synthesis of materials with specific structures by using ionic liquids, are mapped near chemistry. There is some research areas related to environment research. Looking in detail at the content of research areas, keywords such as organic EL elements, solar batteries, and fuel cells are found.

Chemistry and nanoscience experts believe that relationships among the three groups of research areas and condensed matter physics should be strengthened. They indicated that mutual sharing and exchange of knowledge are important to the development of the research areas. Experts on other groups of research areas, such as cancer research and research on infectious diseases and immunology, responded that relationships with chemistry and nanoscience should be strengthened.

3) Condensed matter physics, particle physics/cosmology

<Condensed matter physics>

Looking at changes in the condensed matter physics group of research areas from Science Map 2002 to Science Map 2008, there has been a major shift in the concentration of core papers over time. In other words, there has been a clear change in research topics. Co-citation links among research areas are small. Each research area likely develops independently.

Among the hot research areas in condensed matter physics, "Physics and chemistry of molecular substances (2008, ID 80)" has shown rapid growth. Of the 54 research fronts comprising the research area, 12, about 20 percent, show a rapid increase in citations. Most involve research on graphene (monolayer graphite). Experts pointed out that the physics and chemistry of graphene are rapidly developing. The creation of graphene in 2004, the subsequent discovery of its quantum Hall effect, and so on have shown a renewed spotlight on carbon materials.

A quasi-hot research area comprising two research fronts stemming from the discovery of iron-based superconductors in 2008 by a research team of Dr. Hosono in Tokyo Institute of Technology's was derived. Because it includes research fronts with particularly rapid increases in the number of citations, iron-based superconductors might be observed as a hot research area in Science Map 2010 and beyond.

<Particle physics and cosmology>

Except for "Strongly interacting many body systems (2008, ID 100)," research areas of particle physics and cosmology showed almost no changes in position on the Science Map, and was observed to be at the same position. The mountains of the group of research areas in particle physics/cosmology are conspicuously high and narrow. These characteristics did not change during the period between Science Map 2002 and Science Map 2008. This indicates that there were no major changes in the pattern of research activities. This is because particle physics and cosmology has ultimate goals such as the construction of unified field theory and understanding of the origin of the universe, and research continues to evolve in those directions.

(3) Status of activities of major countries as seen in the Science Map

1) Research papers with international co-authorship in highly-cited research papers

The National Institute of Science and Technology Policy reported its findings that, in recent years, the number of research papers published every year is increasing, but even more notable is a rapid increase in the percentage of research papers with international co-authorship (research papers co-authored by research institutions in multiple countries) in these research papers, and that research papers with international co-authorship is more highly cited compared to those authored by domestic institutions. In response to this, status of highly-cited papers that are the target of the Science Map were analyzed. Comparison of Science Maps from 2002 to 2008 found steady increase in the percentage of research papers with international co-authorship shown on the map. In Science Map 2008, the percentage of research papers with international co-authorship was 36.6 percent, which is significantly higher than the percentage in all research papers which is 20.3 percent. Looking at the percentage of international co-authorship in major countries, the UK, Germany and France in Europe were at the 70 percent level, while Japan is at 52.3 percent.

Looking at status by research area group, 50 percent or higher percentage of international co-authorship was observed in the entire part of particle physics/cosmology and in part of heart and blood vessels research, research on infections diseases/immunology, cancer research, plant science research, environment and condensed matter research physics. In the research group of chemistry, on the other hand, share of research papers with international co-authorship remained almost unchanged and is extremely low compared to other research area groups.

2) Major countries' shares of papers as seen in Science Map

Japan's degree of participation (whole count method) in the production of research papers declined from 8.5 percent in Science Map 2006 to 8.0 percent in Science Map 2008. The country's degree of contribution (fractional count method) to the production of research papers is also declining after its peak in Science Map 2004. It is 5.4 percent in Science Map 2008.

The hot research area with the highest share of Japanese core papers (whole count method) is "Novel electronic order in high-temperature superconductivity (ID97)," whose value reached 52.2 percent. This is followed by "Production of interferon by innate immunity (ID41)," "Metal-based spintronics (ID79)," "Molecular mechanisms for excitatory synaptic plasticity (ID25)" and "Complex hydrides associated with hydrogen production and storage and fuel cells (ID91)," in which Japanese share of research papers is high.

In inter-/multi-disciplinary areas, Japanese share exceeded 9 percent in 19 (49 percent) out of the 39 areas in Science Map 2004, 8 (25percent) out of the 32 areas in Science Map 2006 and 10 (25 percent) out of the 40 areas in Science map 2008. Considering that inter-/multi disciplinary areas are comparatively active in the Science Map, and are rapidly drawing attention and expected to change, the current stagnant status in these areas bears mentioning.

3) China's presence

Changes in shares of research papers is remarkable in the fastest-growing China. Comparing Science Maps 2002 and 2008, China's share has risen by 5.9 percentage points to 7.2 percent in the whole count method and by 4.4 percentage points to 5.2 percent in the fractional count method. Since China's share in research papers with international co-authorship is lower than that in Japan, this represents the rise of China under a research system that does not rely on research papers with international co-authorship. China has a strong presence especially in nanoscience which is the group of research areas based on physics and chemistry that are Japan's strengths.

(4) Status of activities in major countries based on network analysis

1) Identification of critical research areas and shares of major countries in these areas by research areas network analysis

By analyzing networks between research areas and calculating three indexes including betweeness centrality, research areas that are located at positions that are considered important in terms of propagation of knowledge were identified. Research areas with a greater number of core papers and with high degree and betweeness centralities show high continuity and spread effects. Increased degree of participation in research areas with higher network indexes is considered to be one of effective measures to strategically increase our country's degree of participation in knowledge production.

2) Japan's position in co-authorship networks of research institutions

Shares of research papers (degree of participation) of the UK and Germany are in an increasing trend. Both countries use a research system that produces research papers with international co-authorship. Analysis of co-authorship networks of research institutions within a research area shows that European institutions are widely present all over the network and are penetrated into the network. China has also entered co-authorship networks built by the US and European countries, although the number of participating research institutions is small. As for Japan, a certain number of research institutions are observed, but they often cling together in groups of only Japanese institutions. The percentage of international co-authorship is increasing in the world's research system. In this trend, it is important for Japan to consider how to deal with co-authorship relationships.

5-2 Points to be considered for future development of research in Japan

In the Science Map, that draws research areas attracting international attention, Japan lags behind the UK and Germany in terms of degree of participation. Below, the differences between the UK and Germany, whose degrees of participation on the Science Map are increasing, and Japan are discussed.

(1) Compared to UK and Germany, Japan has less diversity in the areas in which it participates

The first difference between the UK and Germany, whose degrees of participation on the Science Map is increasing, and Japan is the percentage of research areas to which the country is participated in. The UK and Germany have 60 percent of research areas (participation areas) of one or more top 1% highly-cited papers. In contrast, the degree of participation of Japan is about 40 percent. Japan's percentage of participation areas has not changed significantly since Science Map 2002. This indicates that Japan has less diversity in its participation areas than the UK and Germany do. The difference in the number of participation areas stems from the inter-/multi-disciplinary and clinical medicine research areas.

(2) Japan is losing share in the top 1% highly-cited research papers, which is the analytical population

The second difference between Japan and the UK and Germany is the share of the top 1% highly-cited papers, which constitutes the analytical population. Japan's degree of participation and degree of contribution are both declining in terms of papers in the top 1% highly-cited papers. This is probably the cause of Japan's declining presence in the Science Map.

Underlying the high degree of participation of the UK and Germany in the Science Map is those two countries' very high rates of international co-authorship, 73 percent and 72 percent respectively. The worldwide percentage of papers with international co-authorship is increasing along with the globalization of research. They receive more citations than domestic papers. However, 52 percent of the Japanese papers used by Science Map have international co-authorship. This is much higher than the percentage for all papers[9].

[9] The percentage of international co-authorship papers within all papers is 46 percent for the UK, 48 percent for Germany, and 24 percent for Japan in 2007.

Science Map 2008

PART Ⅱ

1. Explanation of results of content analysis of hot research areas

Results of content analysis of the 121 hot research areas established through database analysis are shown beginning on page 127. Content analysis of the hot research areas consisted of the following matters.

(i) Hot research areas names and hot research area IDs

Hot research areas were assigned names expressing their content. The hot research area ID numbers are consecutive numbers.

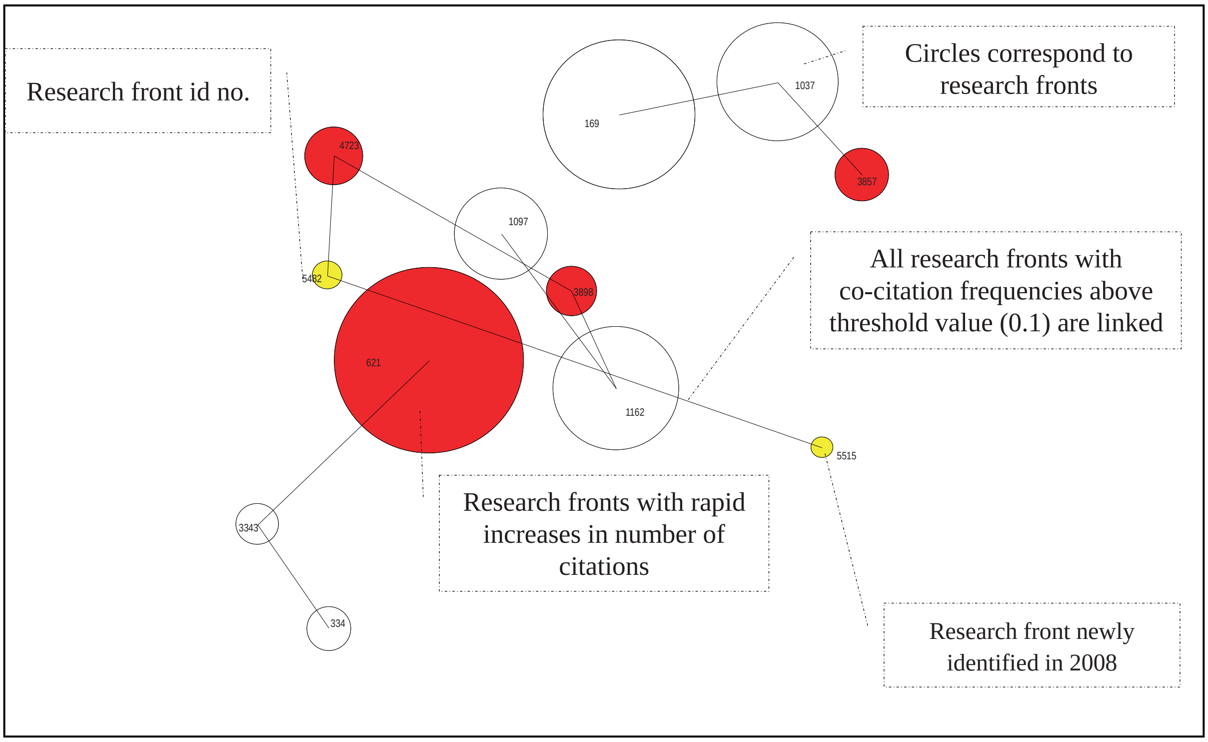
(ii) Statistical information on hot research areas

The number of research fronts that comprise hot research areas, those in which the number of citations rapidly increased, the number of core papers comprising a research front and the number of Japanese core papers, the number of cited papers, the number of times cited, and the average year of core paper publication were addressed.

(iii) Individual Research Area Map

Individual Research Area Maps were made in order to express visually the relatedness of research fronts within hot research areas. The following is an explanation of the map of individual research areas.

- ○ Circles in the Individual Research Area Maps correspond to research fronts.
- ○ The number next to a circle is the id number of that research front.
- ○ The area of a given circle is proportional to the total number of citations of core papers in that research front.
- ○ Red indicates research fronts whose citations of core papers increased markedly (rapidly developing research fronts).
- ○ Yellow indicates a research front that is new in 2008.
- ○ The stronger the co-citation relationship between research fronts, the closer the location of their circles. The weaker the relationship, the more distant of their circles.
- ○ Research fronts with a certain degree of co-citations are connected by lines.



Rapidly increasing fronts were identified according to the following procedure:

- ○ The number of citations of the core papers included in a research front is counted for each year from 2003 through 2008. By dividing these numbers by the number of core papers published within each corresponding year, the number of citations per core paper for each year is obtained. For the increase and decrease in the number of citations per core paper, a slope of regression line is calculated.
- ○ Next, average slopes of regression lines by field are calculated. With respect to the fields of research fronts, the distribution of core papers in the 22 fields are examined, and the areas with the highest percentage of core papers were grouped into the primary group and the second highest into the secondary group, which allows multiple belongings.
- ○ Out of the research fronts, those that exceed the mean slope of the regression line in a field and were on average published in and after 2007 were extracted as rapidly developing research fronts. In the case of research fronts that belong to a number of fields, if one research front exceeds the average in one field, it is identified as a rapidly increasing front.

In addition, the content of research fronts is indicated in Individual Research Area Maps in accordance with either the following (1) or (2).

(1) When a group of research fronts with similar contents in Individual Research Area Map can be presented, the relevant group of research fronts was bracketed and its contents were described in the map.

(2) When it is difficult to present a group of research fronts in Individual Research Area Map, research fronts that are considered important (those linked with many research fronts or those with a rapidly increasing number of citations, etc.) were illustrated and their contents were described in the Map.

(iv) Explanation of hot research areas

As the explanation of hot research areas, an “Outline of areas and contents of research fronts” were given. This item was linked with 3) Interpretation of Individual Research Area Map, as closely as possible. A general explanation was given on hot research areas and research contents of research fronts that constitute a research area. The contents of research fronts were described in accordance with either the following (1) or (2). The content analysis results for hot research areas have already been rechecked and confirmed by those responsible for the content analysis.

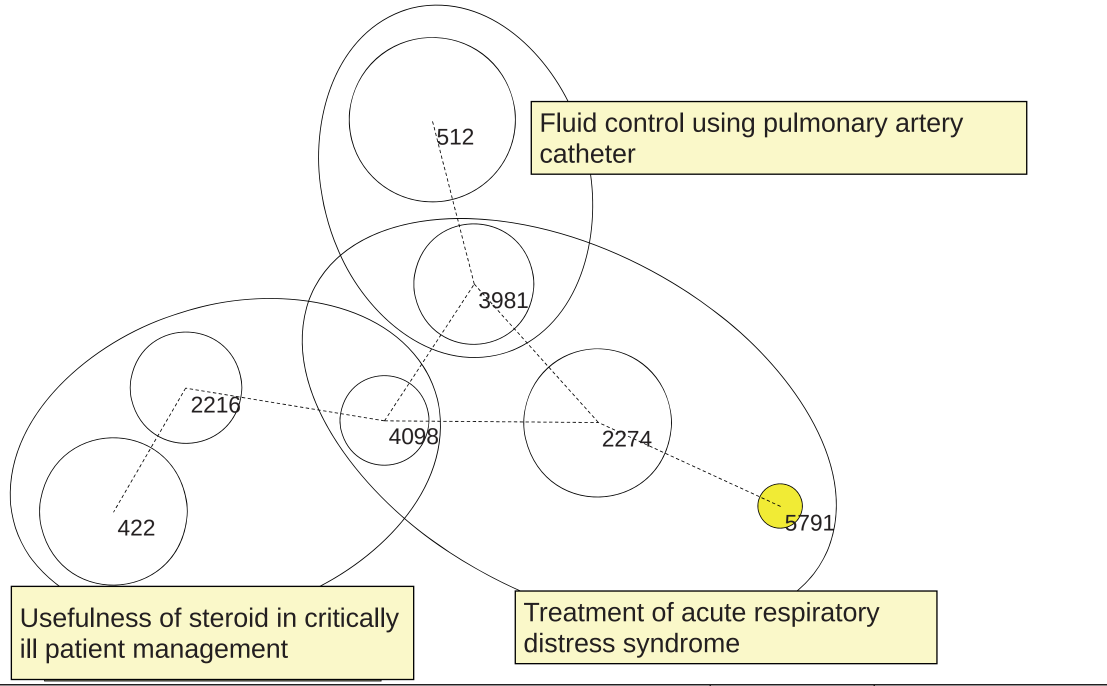
(1) When a group of research fronts with similar contents can be presented, the contents were itemized.

(2) When it is difficult to present groups, the contents of research fronts that are considered important (those linked with many research fronts or those with a rapidly increasing number of citations, etc.) were itemized.

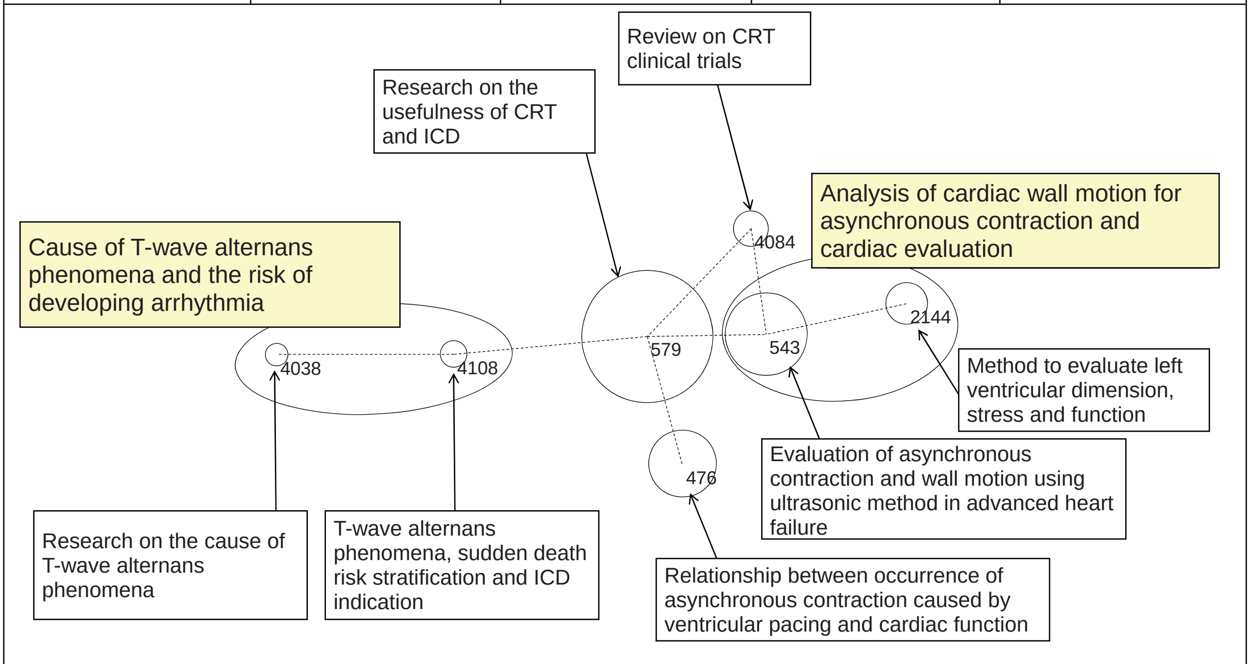
2. Results of content analysis of hot research areas

Following are the table of contents and results for the 121 hot research areas.

Name of RA	Critically ill patient management (Particularly in cases of acute respiratory distress syndrome)	RA ID	1	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
7(0)	18(0)	1484	2291	2005.2

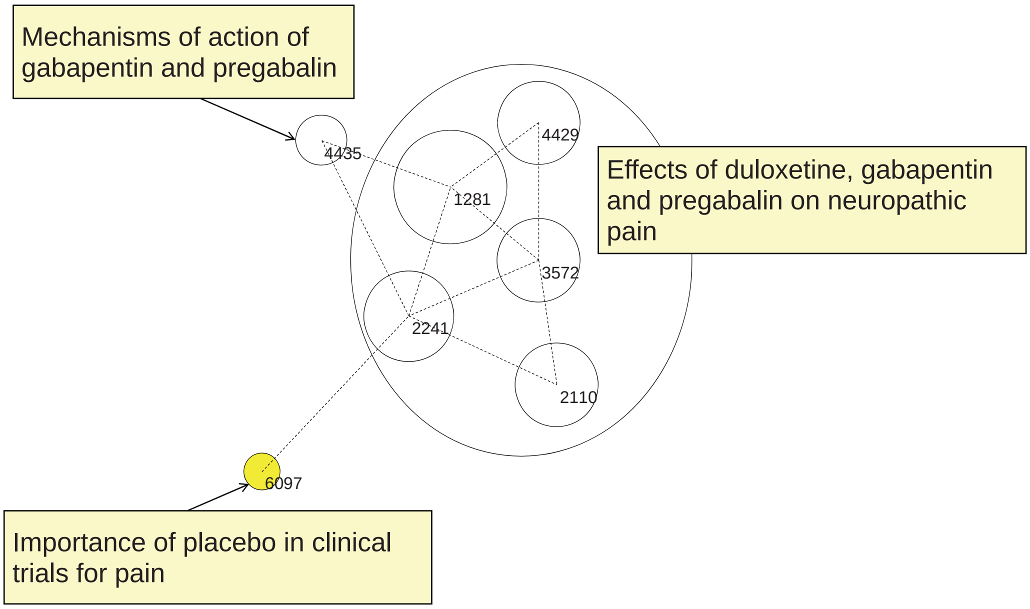


Name of RA	Effects and prognostics of device therapy for advanced heart failure	RA ID	2	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
7(0)	34(0)	2922	6985	2004.3



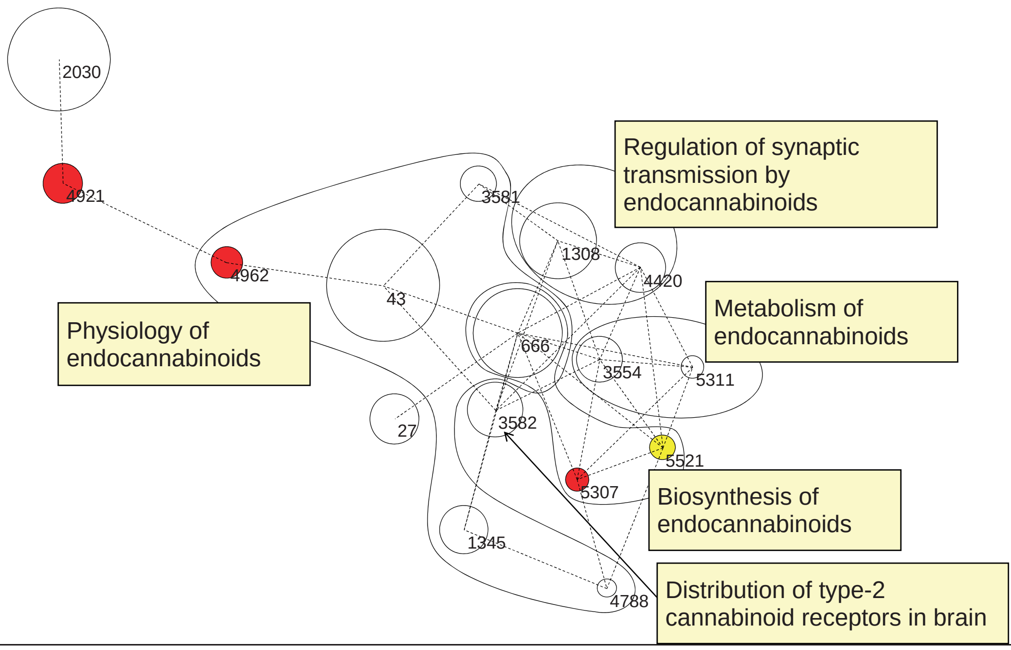
Name of RA	Medical therapy for neuropathic pain and fibromyalgia syndrome	RA ID	3

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
7(0)	24(0)	821	1822	2005.5

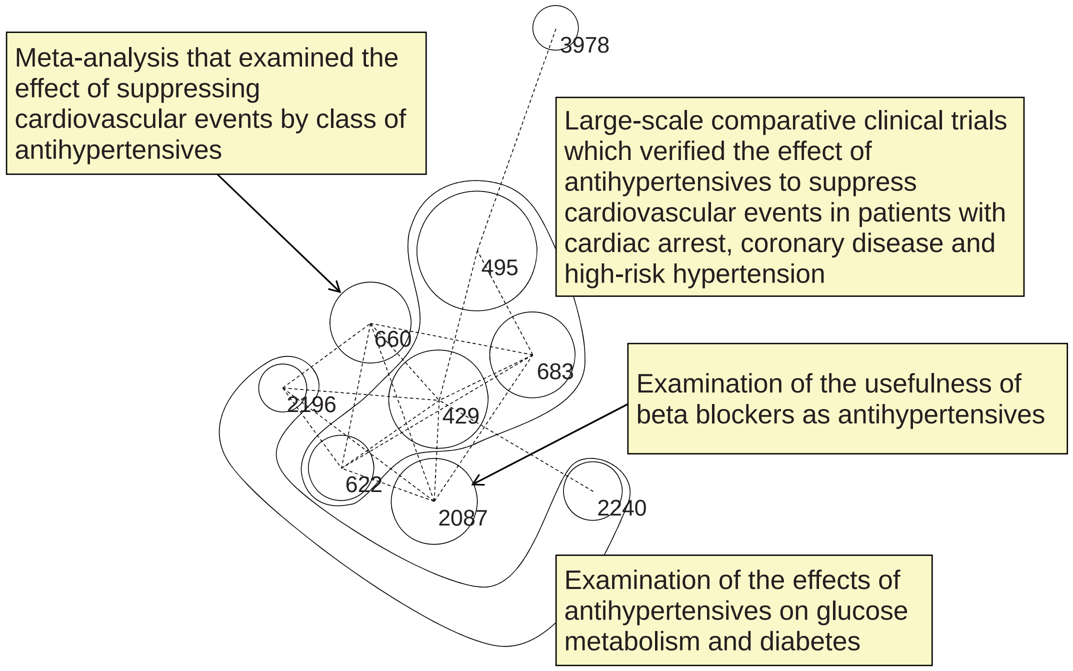


Name of RA	Physiology of endocannabionoid system in central nervous system	RA ID	4

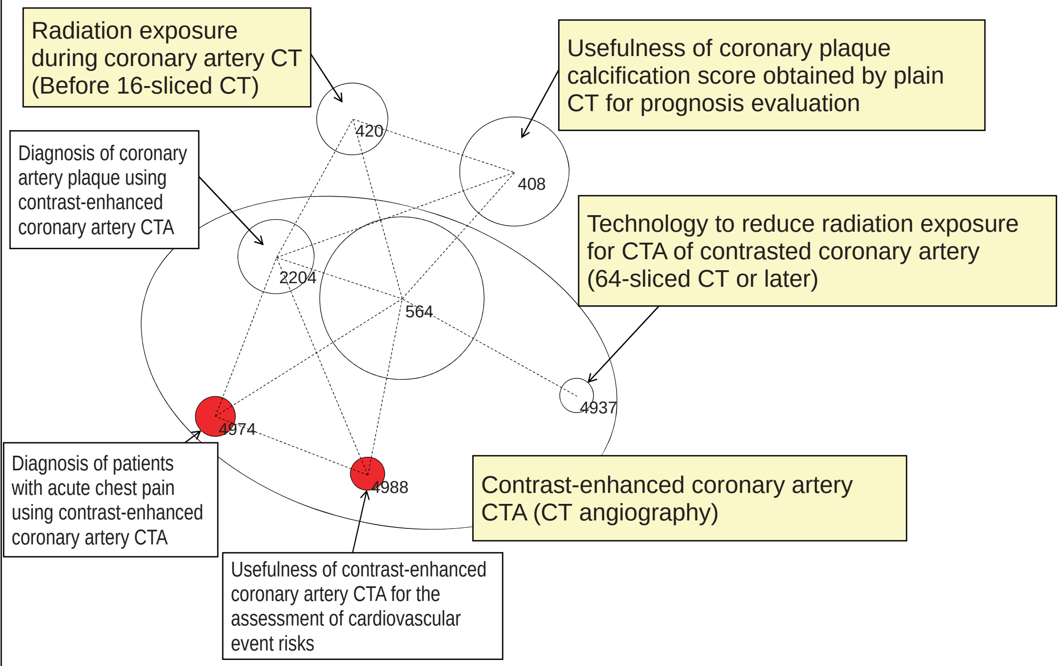
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
16(3)	81(5)	3630	8945	2005.8



Name of RA	Clinical research on the control of cardiovascular incidents by antihypertensives and their impacts on diabetes	RA ID	5	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
9(0)	24(0)	3818	7463	2004.0

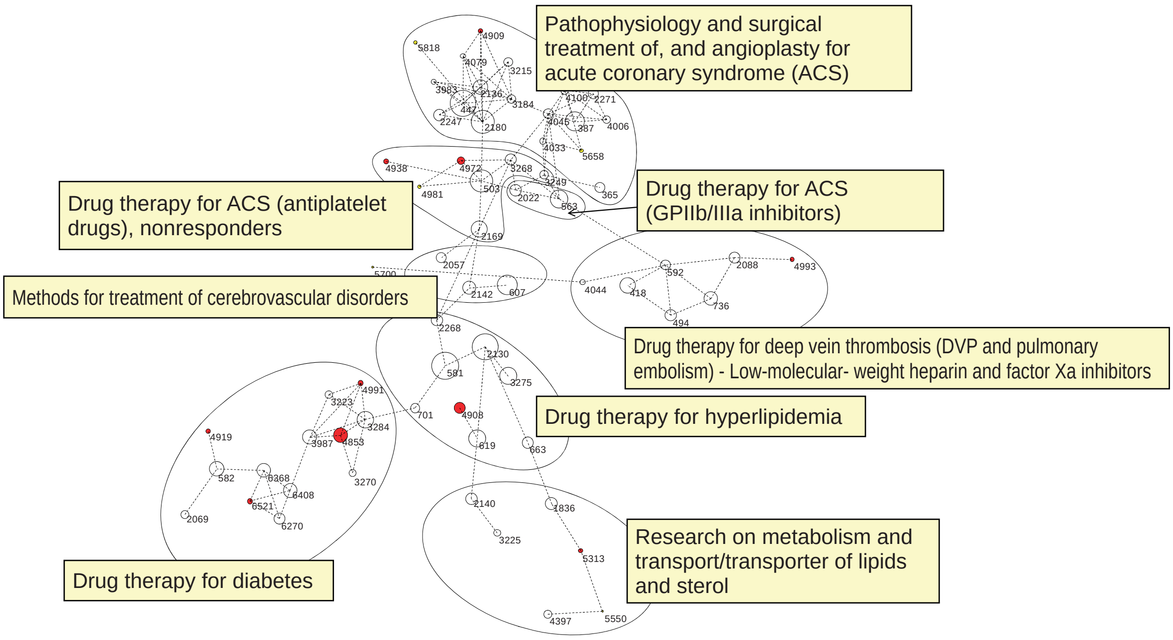


Name of RA	Coronary CT (computed tomography)	RA ID	6	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
7(2)	51(1)	2050	7088	2005.3



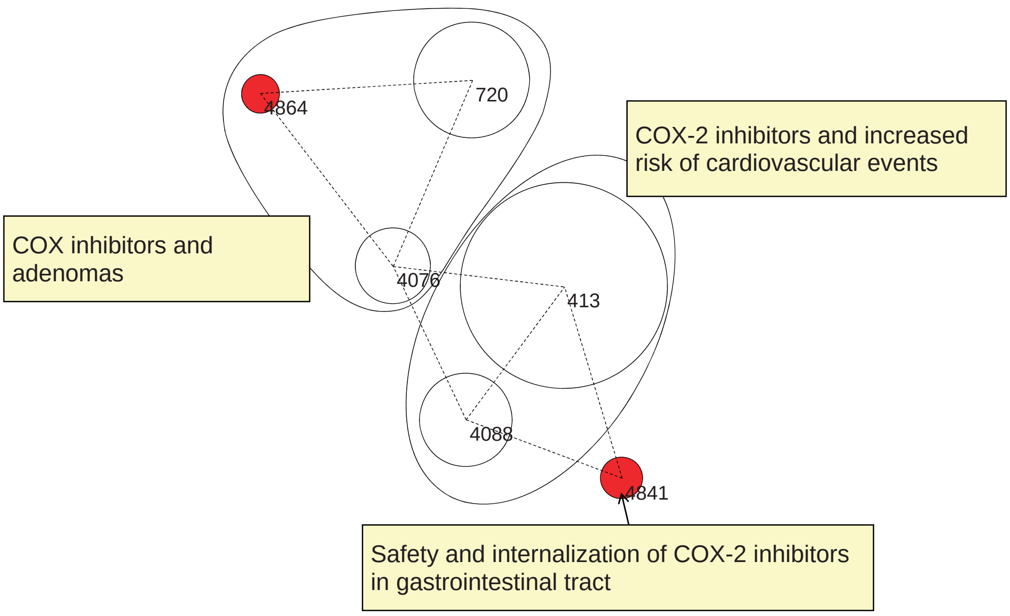
Name of RA	Treatment of acute coronary syndrome using antiplatelet drugs	RA ID	7

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
65(10)	336(6)	17686	49147	2005.5



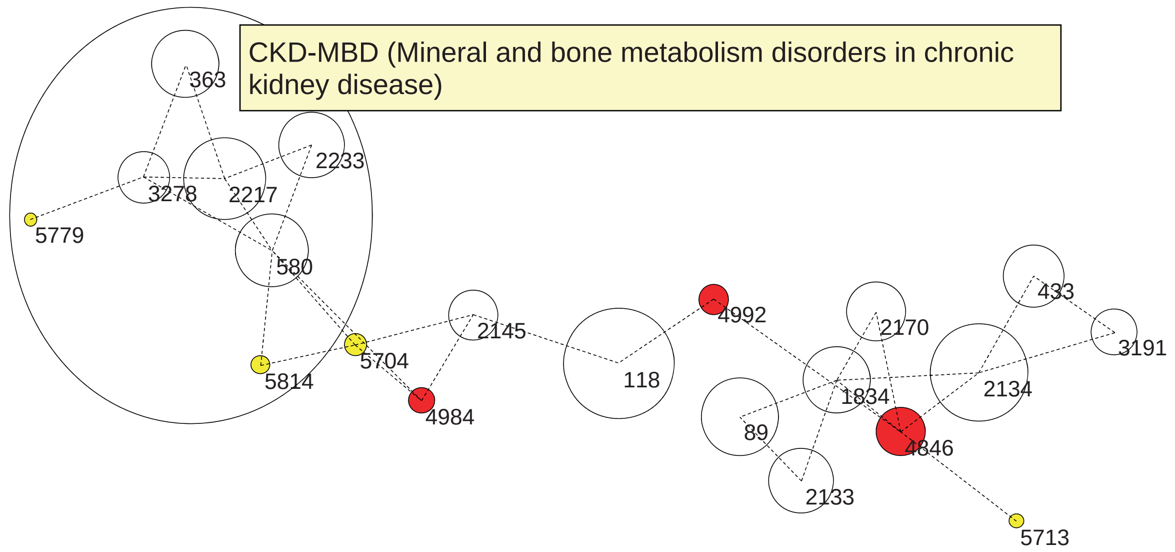
Name of RA	Research on adverse effect of COX inhibitors	RA ID	8

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(2)	26(0)	2153	5248	2005.1



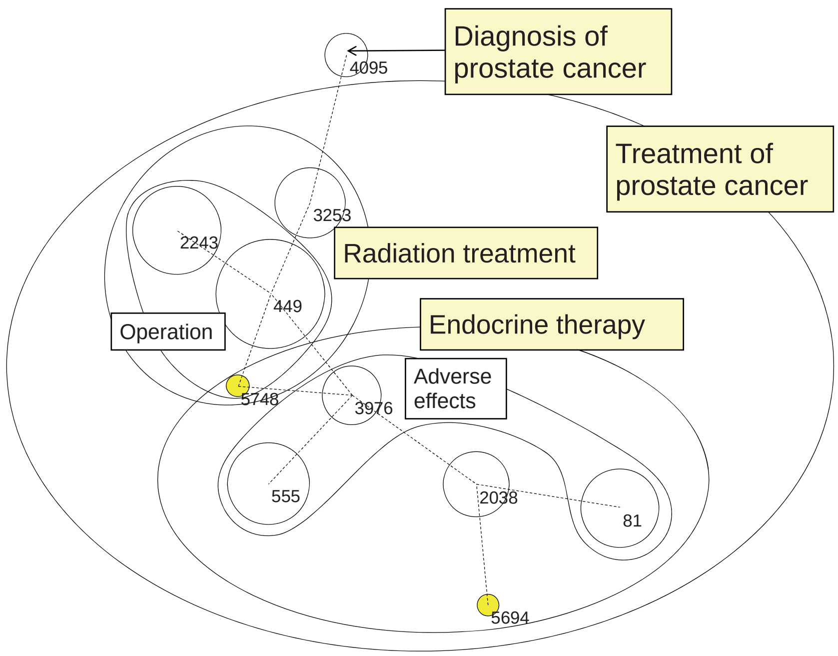
Name of RA	Mineral and bone metabolism disorders in chronic kidney disease	RA ID	9

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
21(3)	77(2)	4113	9096	2005.3

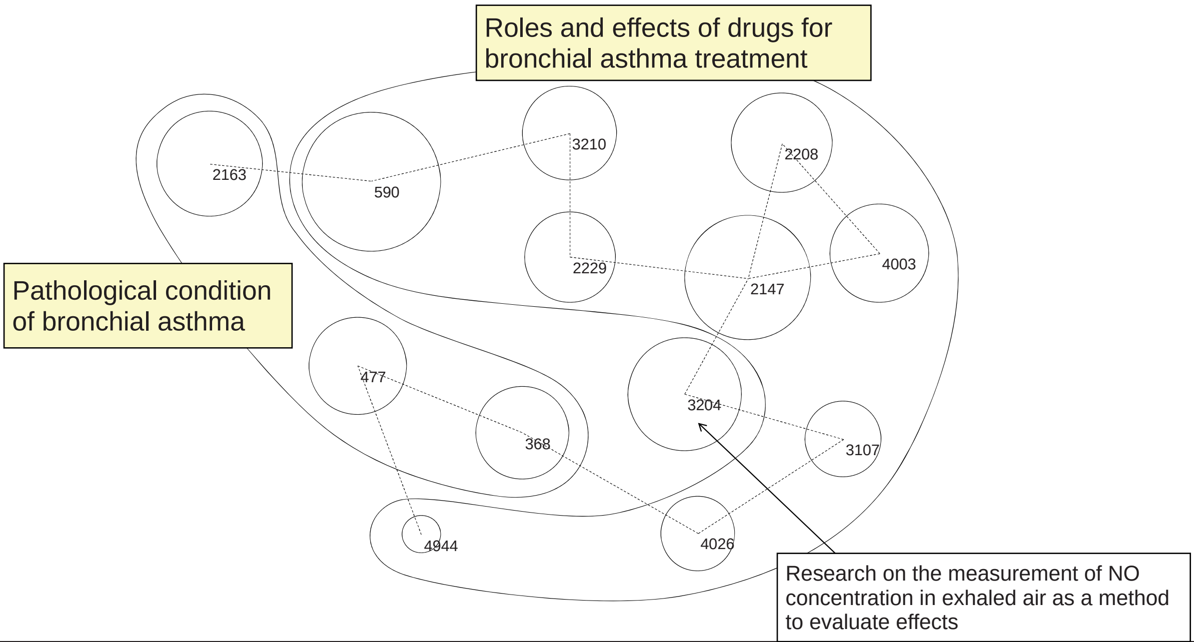


Name of RA	Prostate cancer/endocrine therapy/ radiotherapy/effect and adverse effect	RA ID	10

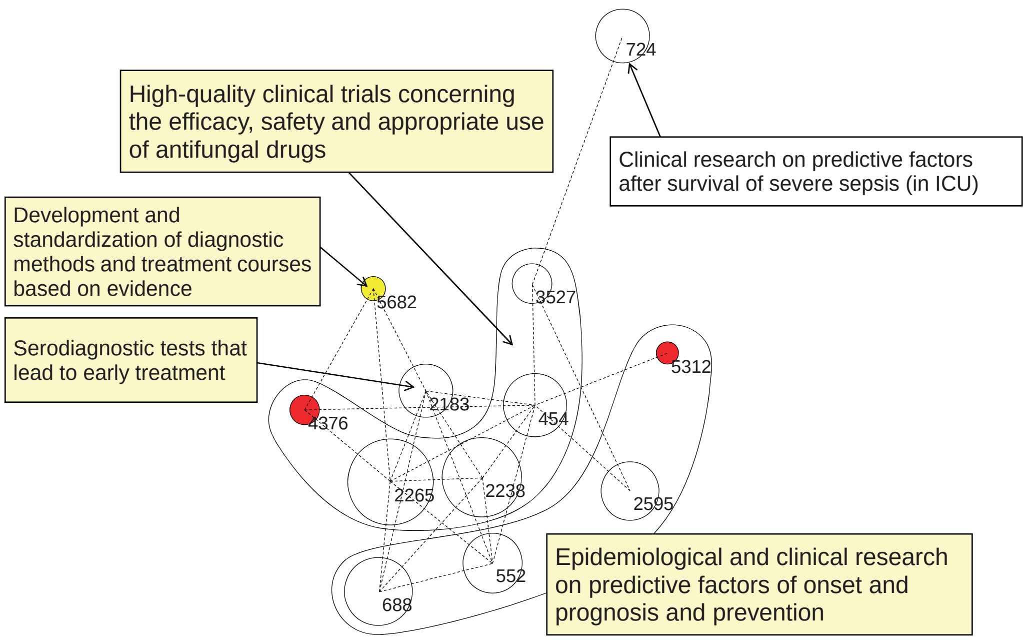
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
10(0)	28(0)	1700	2937	2005.4



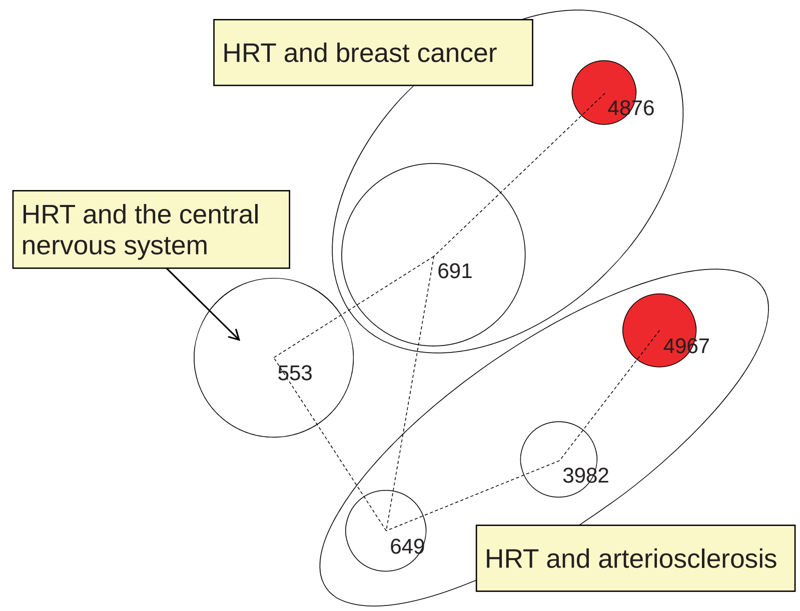
Name of RA	Pathological condition and treatment of bronchial asthma	RA ID	11	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
13(0)	31(0)	2130	3847	2004.9



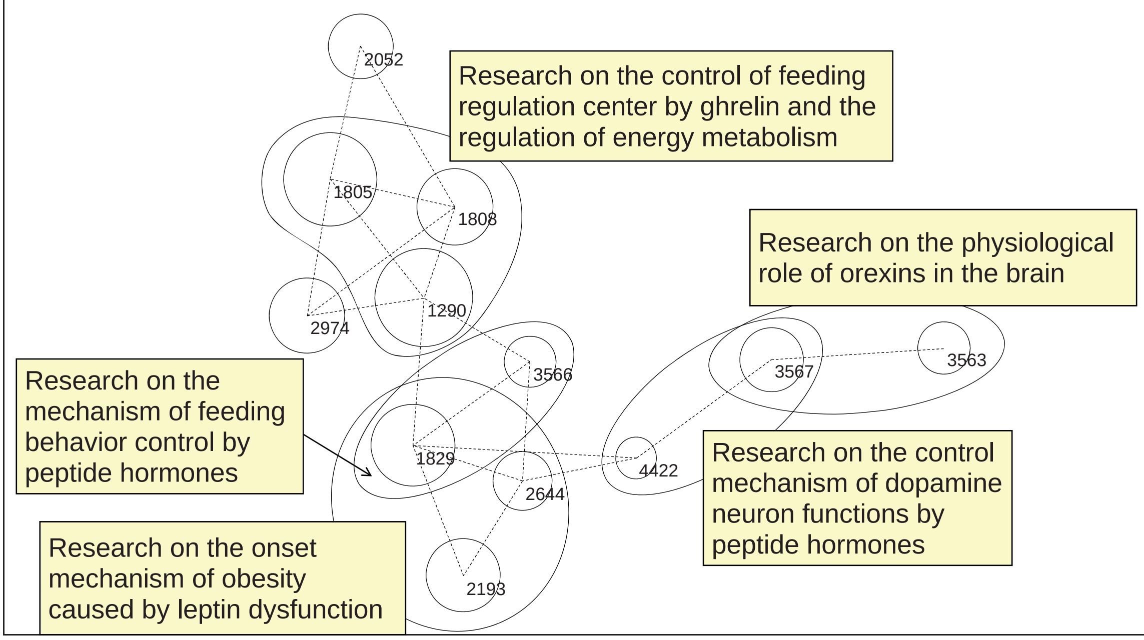
Name of RA	Clinical research on early diagnosis, prevention and treatment of deep mycosis	RA ID	12	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
12(2)	41(1)	1816	3943	2005.4



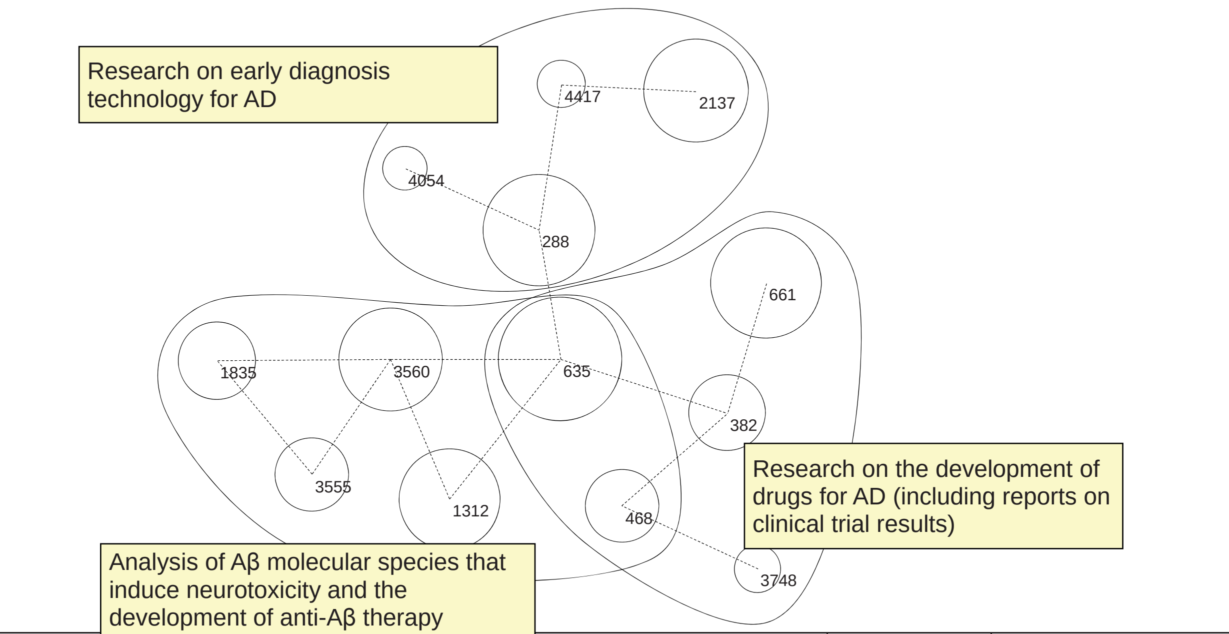
Name of RA	Effect and adverse effect of hormone replacement therapy (HRT)	RA ID	13	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(2)	15(0)	2405	3900	2004.8



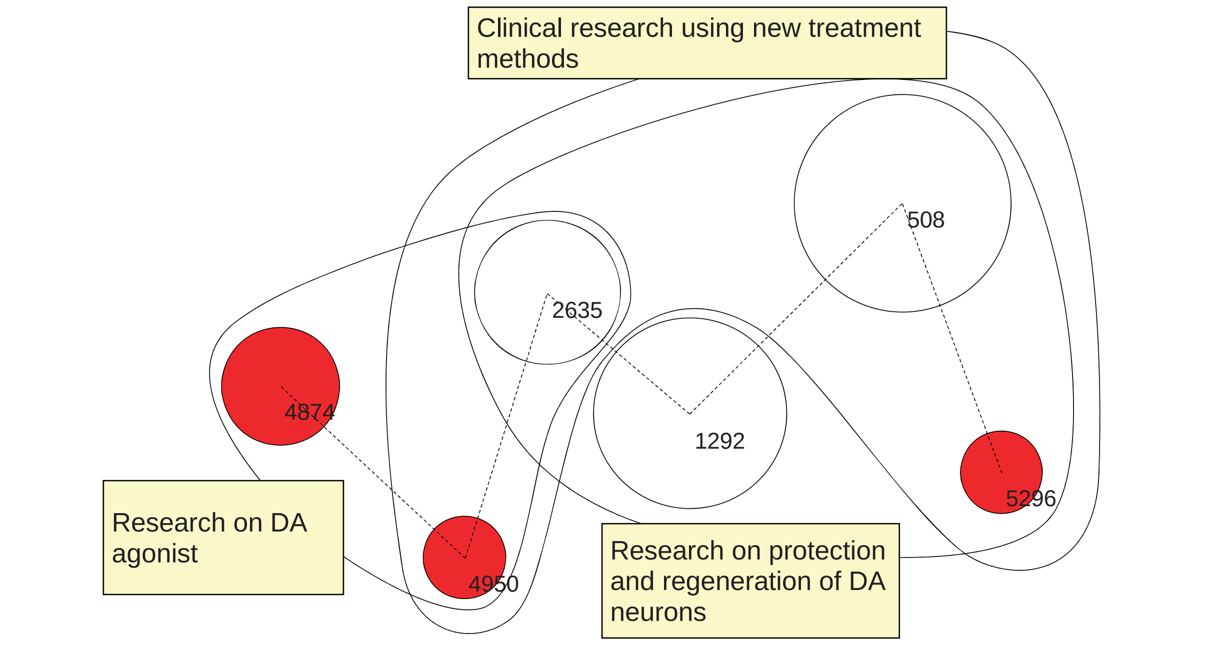
Name of RA	Research on physiological role of peptide hormone in the brain	RA ID	14	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
12(0)	38(2)	2104	4141	2005.2



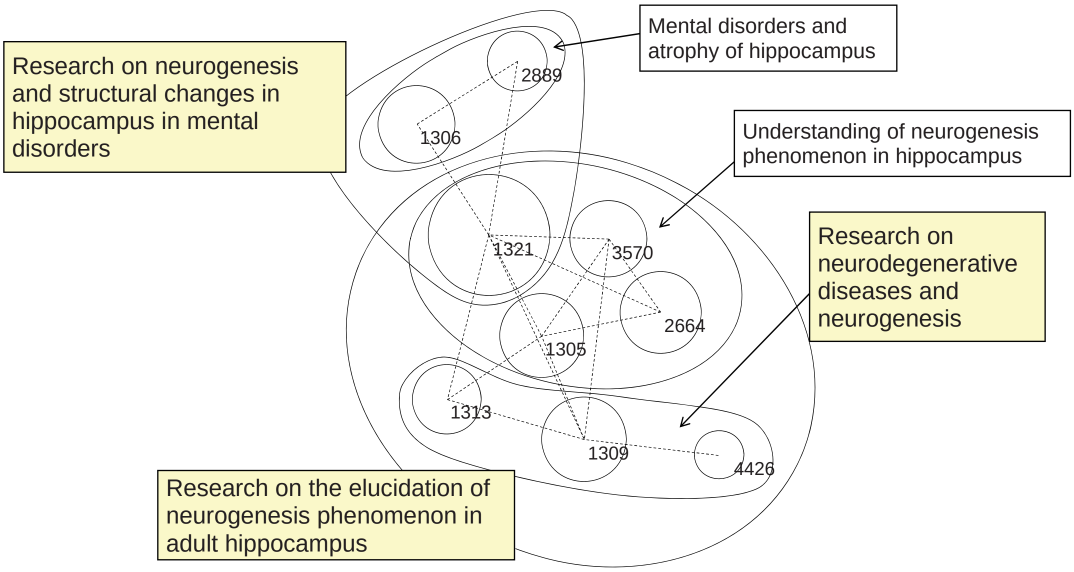
Name of RA	Molecular mechanism of the onset of Alzheimer's disease and the development of ways to prevent and treat the disease	RA ID	15	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
13(0)	45(2)	3937	7330	2005.0



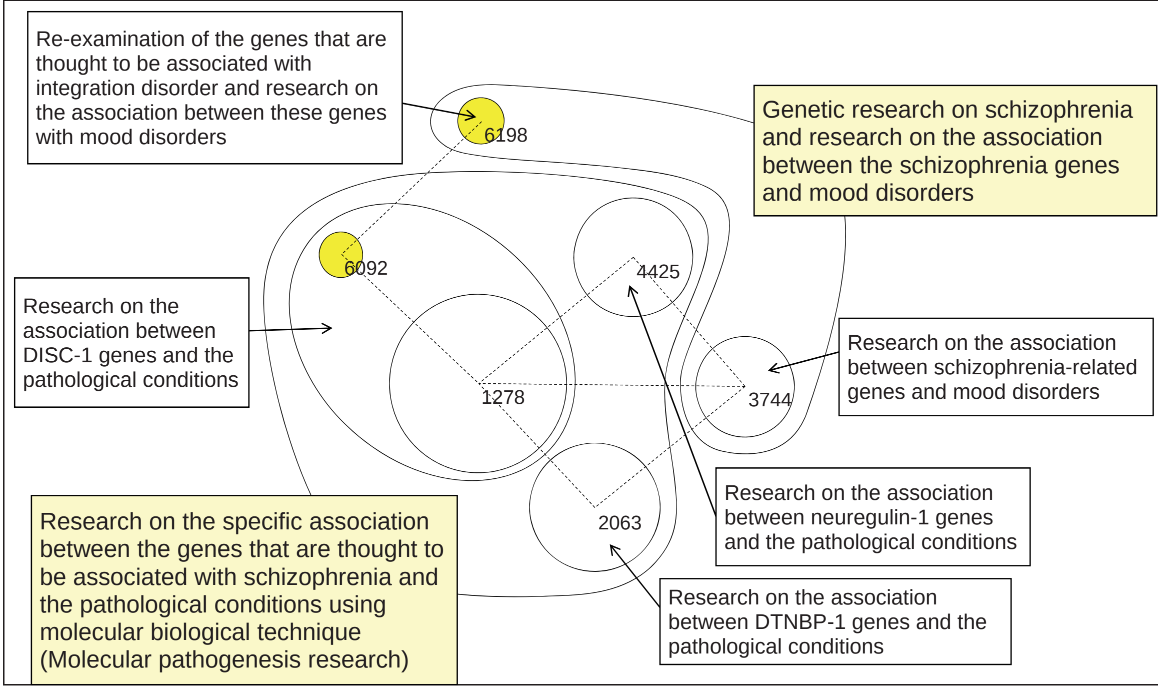
Name of RA	Clinical research for Parkinson's disease	RA ID	16	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(3)	19(0)	1111	1985	2005.5



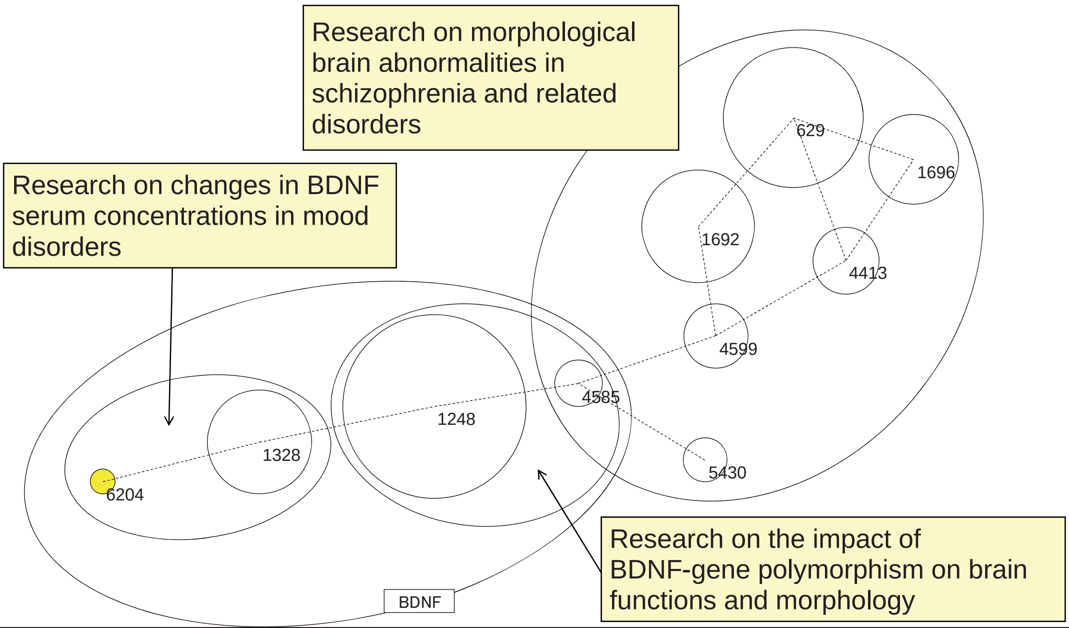
Name of RA	Neurogenesis in adult hippocampus (the understanding of phenomena and the development of clinical application)	RA ID	17	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
9(0)	29(1)	2413	4415	2004.9



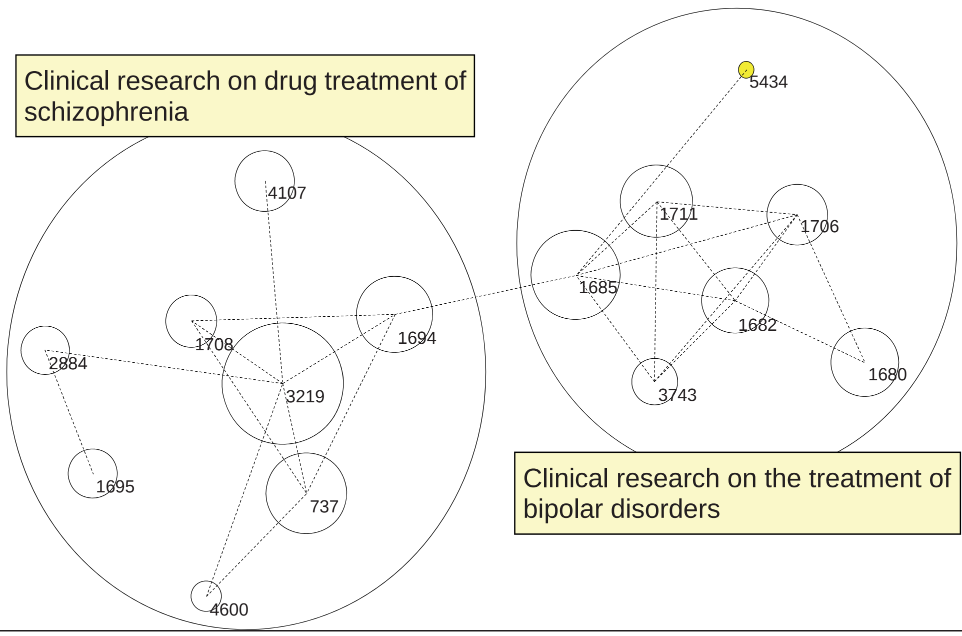
Name of RA	Genetic research on schizophrenia and molecular pathogenesis investigations developed from the research	RA ID	18	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(0)	16(2)	630	1102	2005.7



Name of RA	Brain-derived neurotrophic factor/brain morphology in schizophrenia/mood disorder	RA ID	19	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
10(0)	25(2)	1557	2426	2005.2

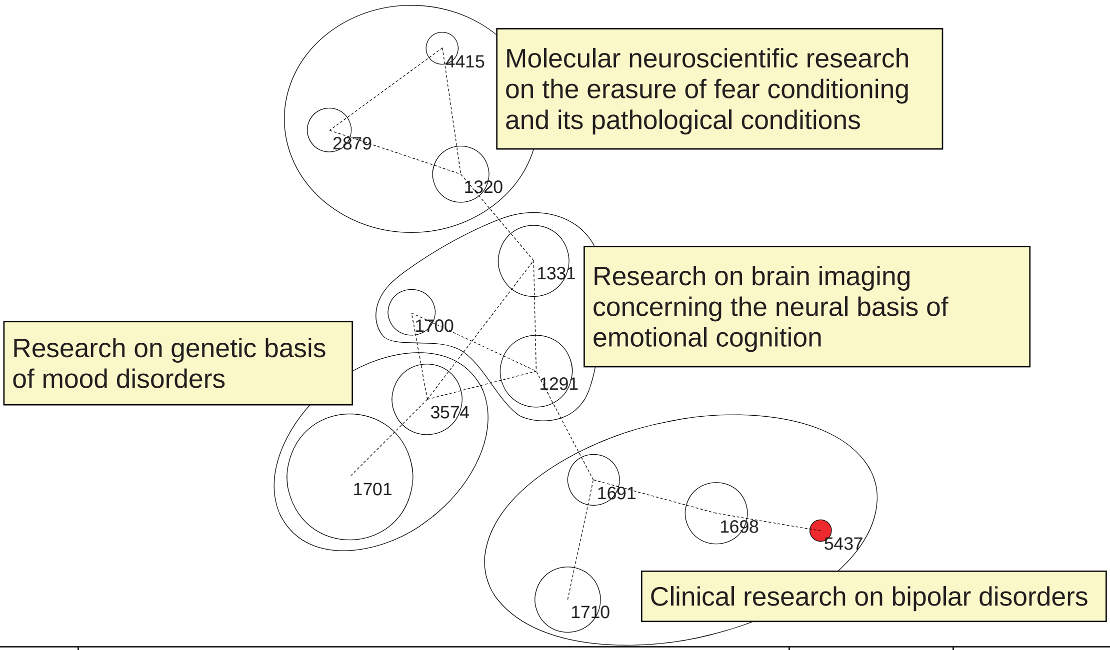


Name of RA	Clinical research on treatment of schizophrenia and bipolar disorder	RA ID	20	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
15(0)	57(2)	3242	6970	2004.5



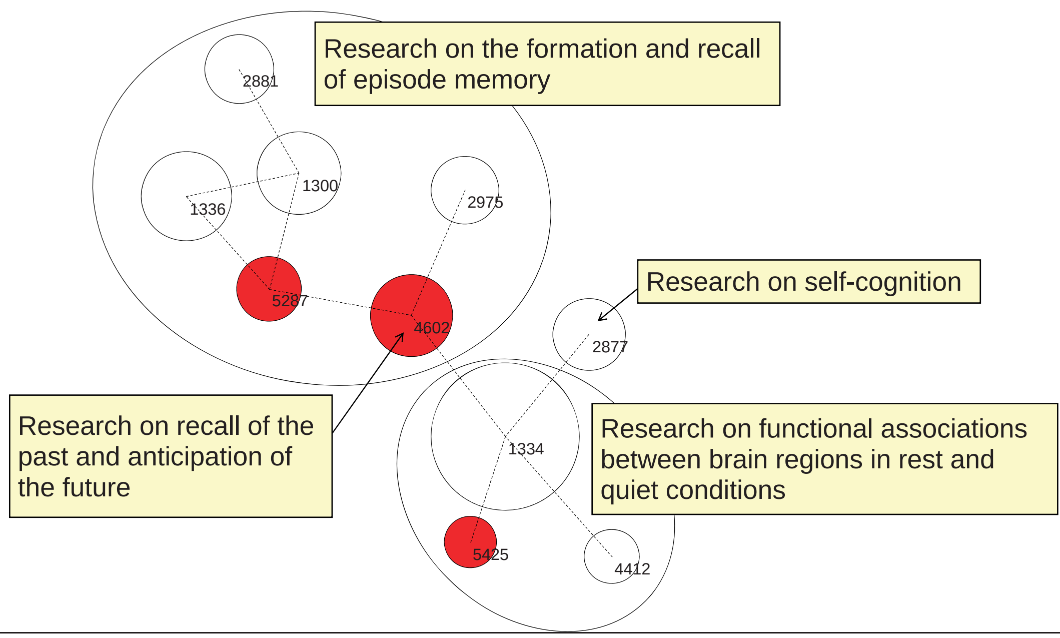
Name of RA	Molecular neuroscience of emotion and its pathological conditions	RA ID	21

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
12(1)	45(0)	3549	6207	2004.7

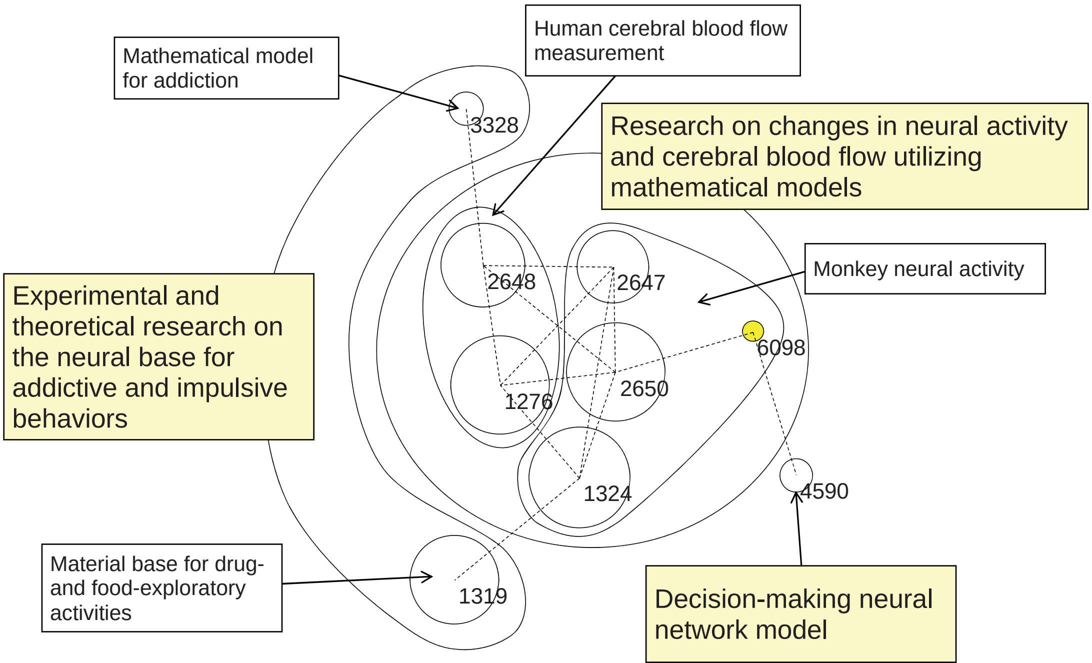


Name of RA	Research on higher brain functions unique to humans using functional brain imaging	RA ID	22

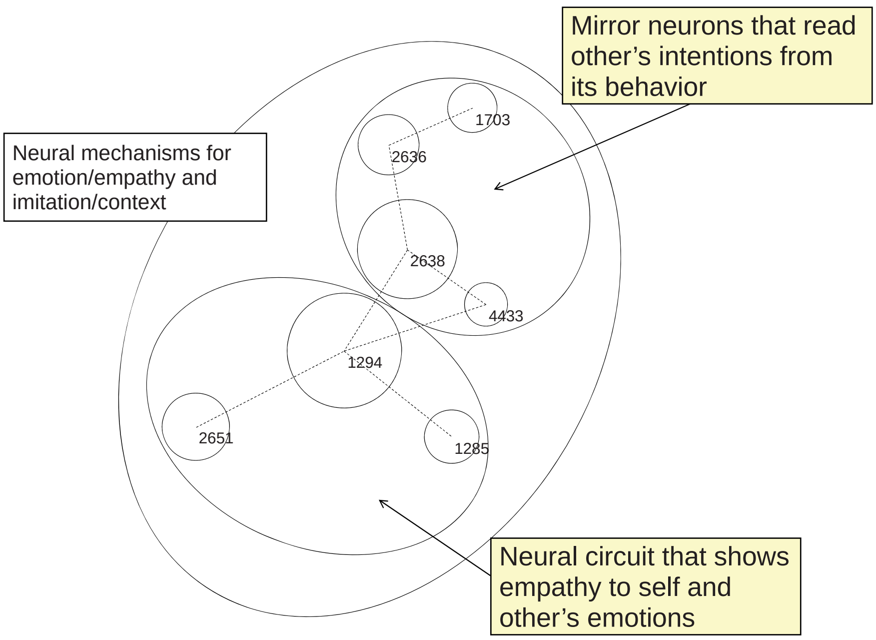
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
10(3)	52(0)	1526	3128	2006.1



Name of RA	Brain neural mechanisms for decision-making		RA ID	23
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
9(0)	22(1)	1371	2388	2005.0

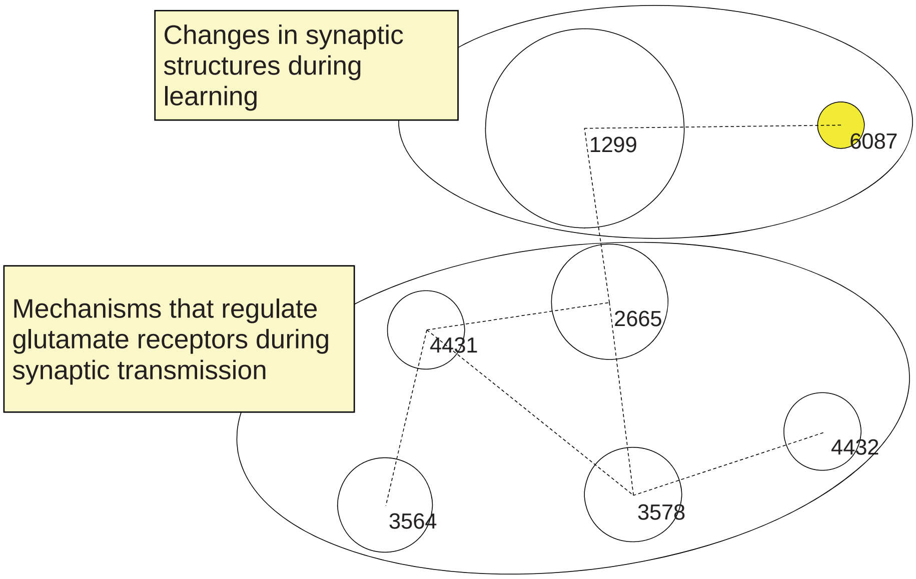


Name of RA	Neural mechanisms for emotion/empathy and imitation/context		RA ID	24
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
7(0)	28(0)	2301	3992	2004.8



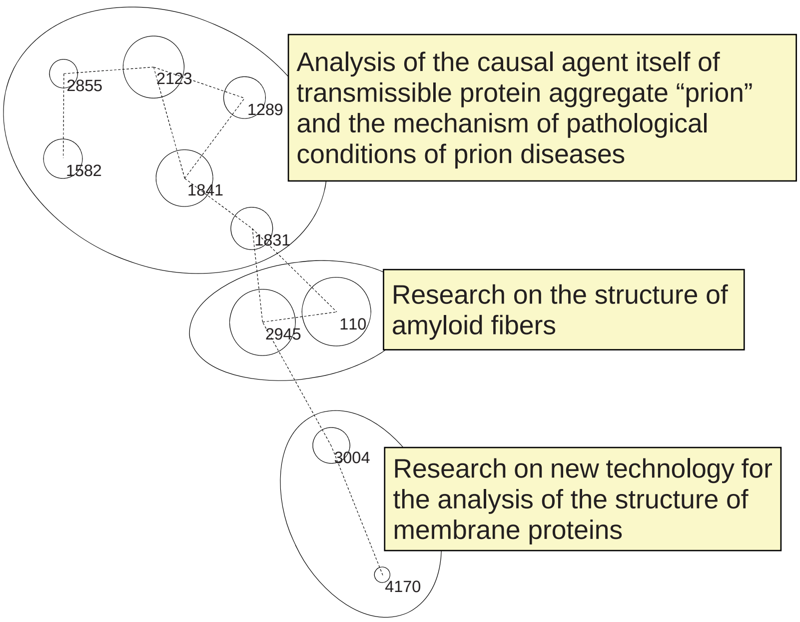
Name of RA	Molecular mechanisms for excitatory synaptic plasticity	RA ID	25

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
7(0)	19(6)	964	1675	2005.5

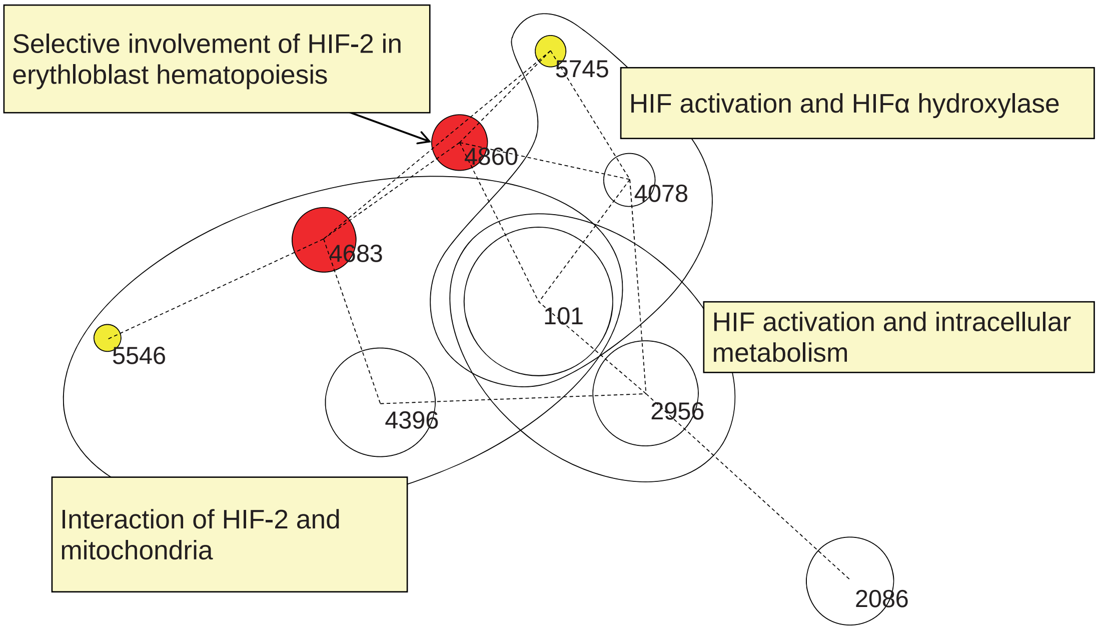


Name of RA	Biological implication of protein aggregation from the viewpoint of common denominators in transmissible aggregate "prion" and amyloid-like aggregate	RA ID	26

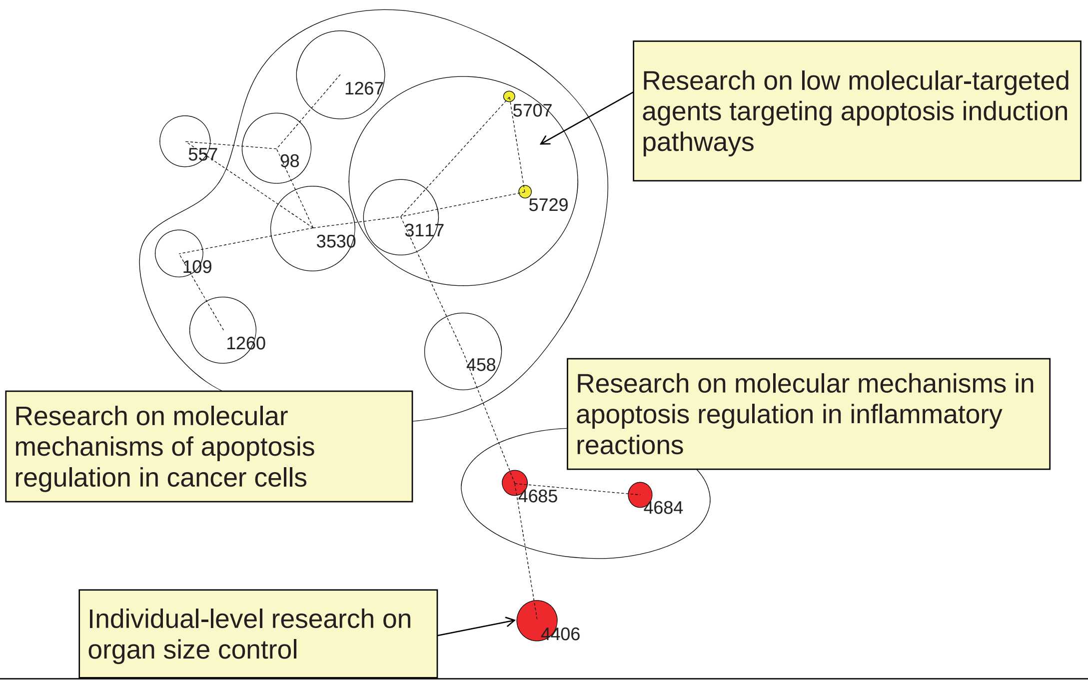
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
10(0)	32(0)	2323	4372	2005.0



Name of RA	Hydroxylation modification of HIF and HIFα and regulation of mitochondrial function	RA ID	27	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
9(2)	21(0)	987	1751	2006.1

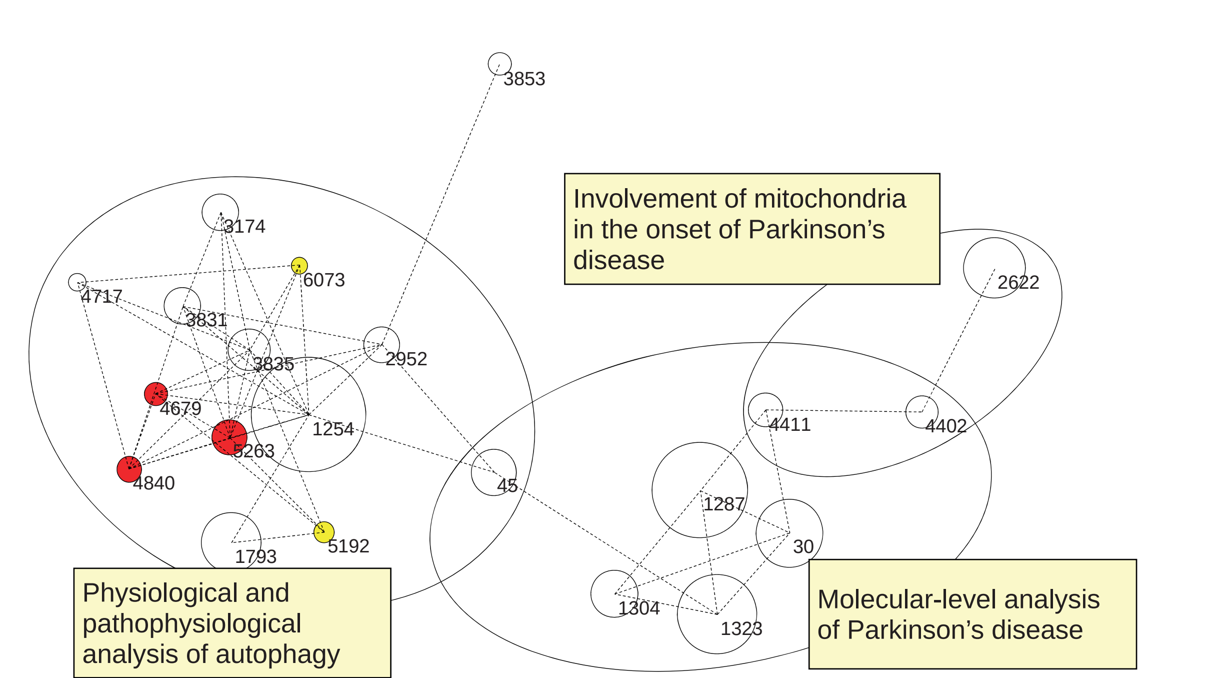


Name of RA	Molecular mechanism of apoptosis (cell death)	RA ID	28	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
13(3)	45(0)	3195	6061	2005.7



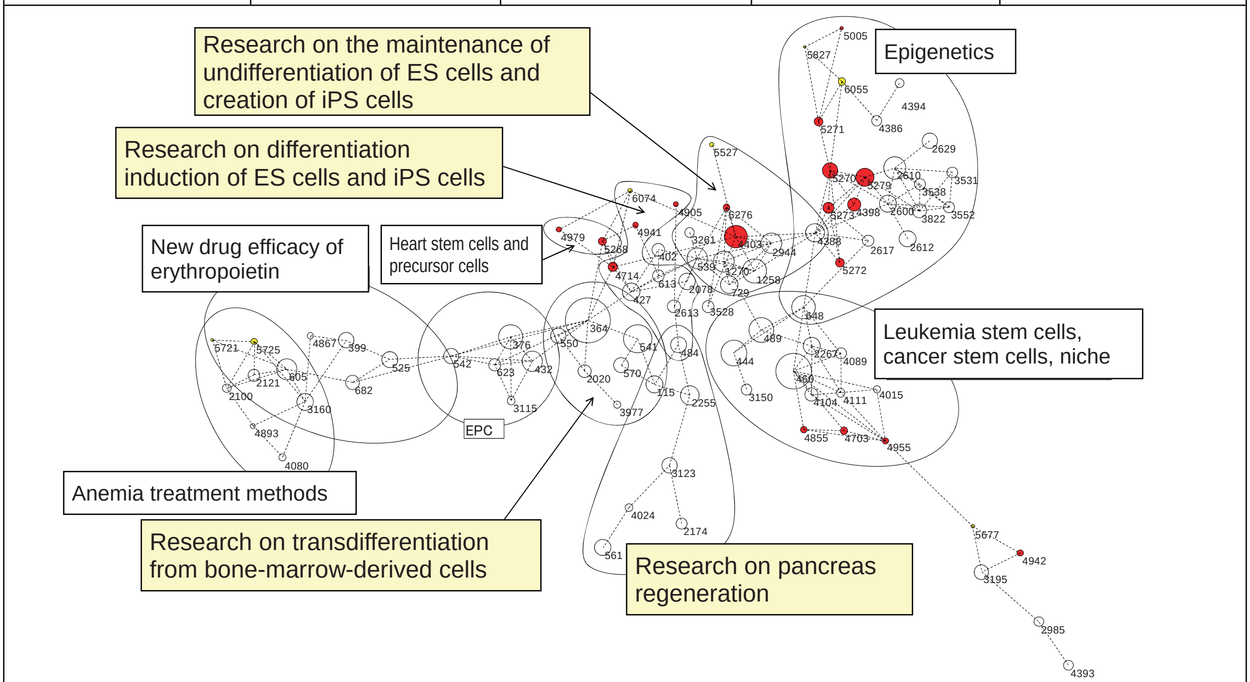
Name of RA	Role of autophagy in health and disease	RA ID	29

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
21(3)	99(22)	5105	14814	2005.4



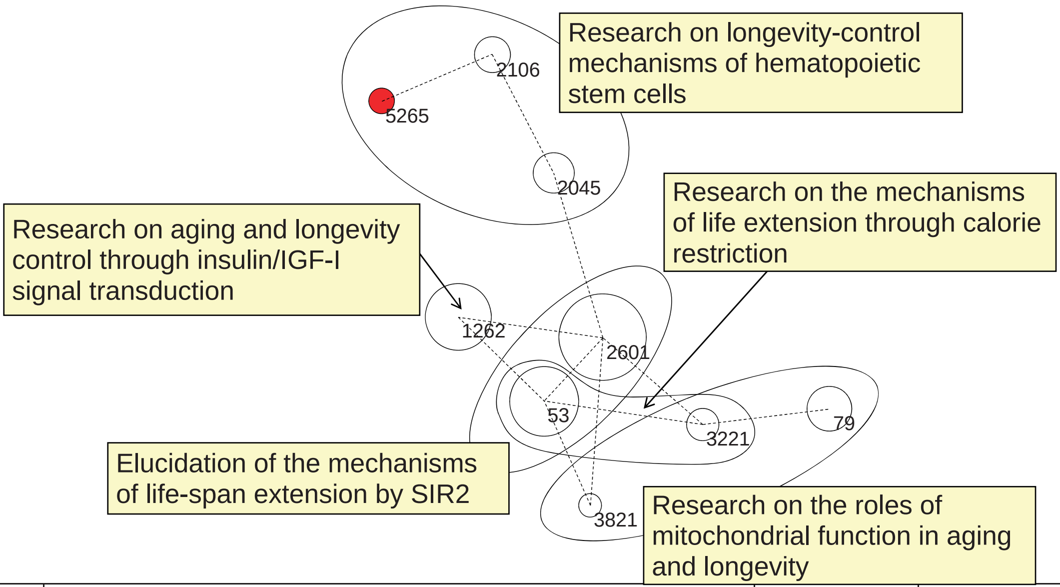
Name of RA	Research on regenerative medicine and stem cells	RA ID	30

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
90(18)	385(26)	21051	61605	2005.4



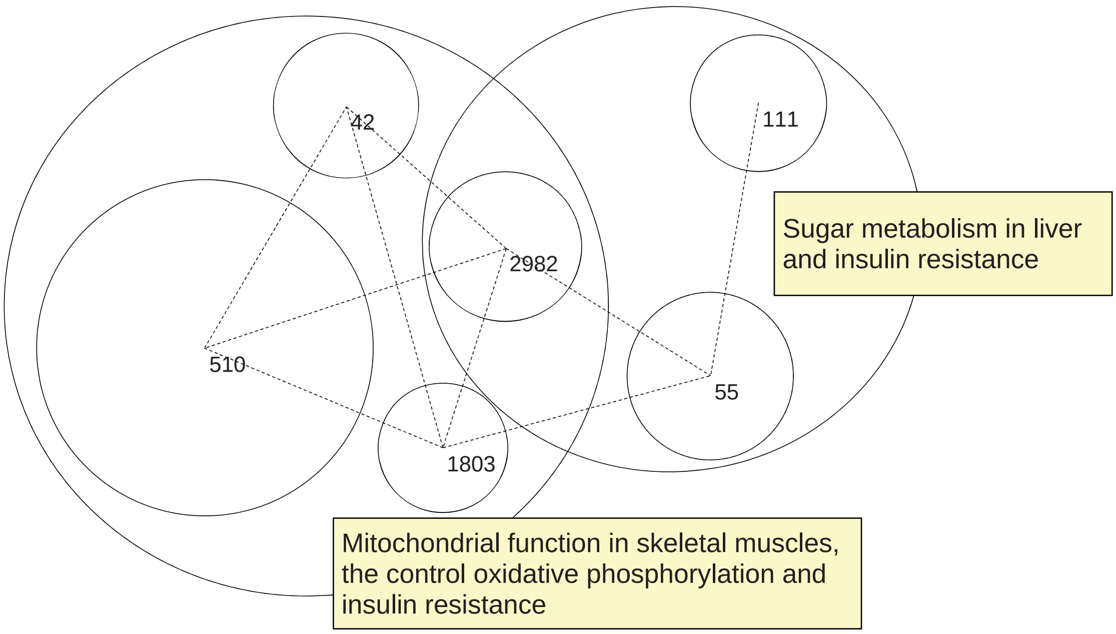
Name of RA	Research on aging-suppression and longevity-control factors in individual and organ stem cells	RA ID	31

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
9(1)	32(2)	2682	5560	2005.0

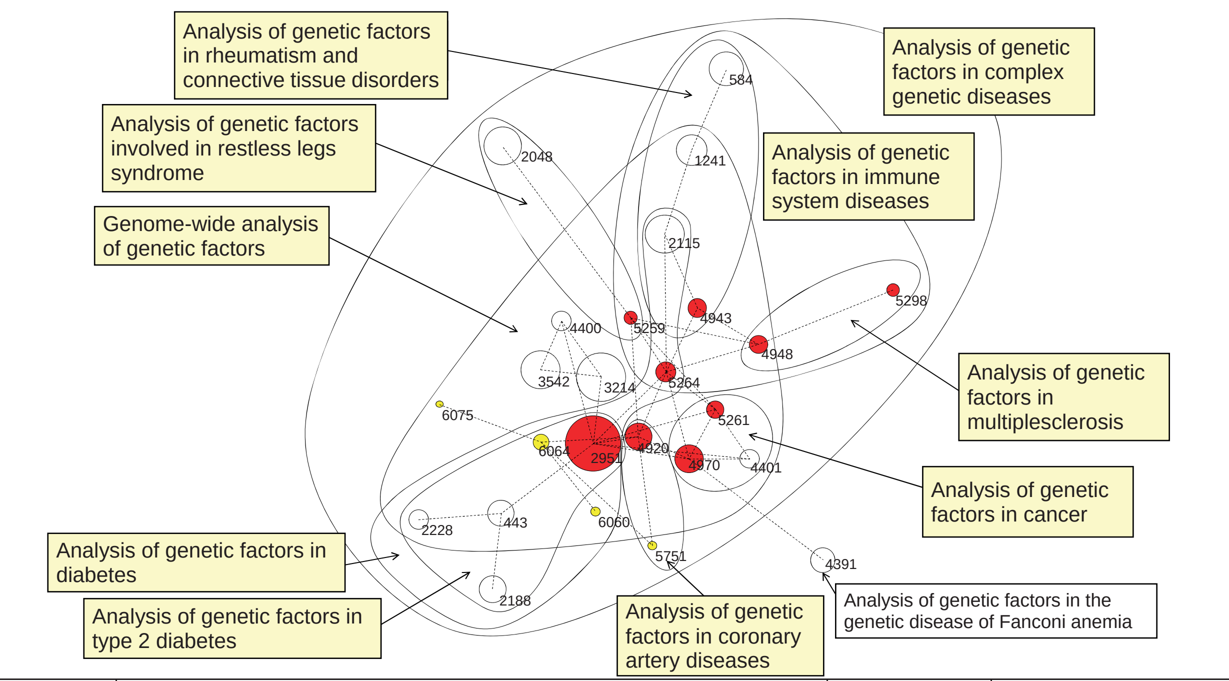


Name of RA	Metabolism control through PGC-1α and insulin resistance	RA ID	32

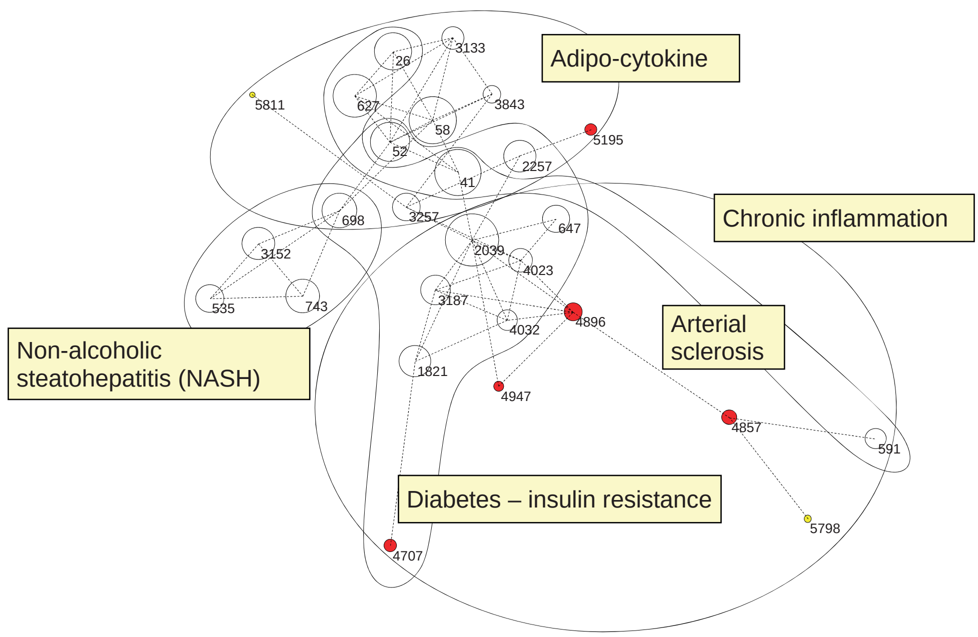
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(0)	14(0)	2161	3651	2003.5



Name of RA	Genetic epidemiologic research on complex genetic disease	RA ID	33	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
25(9)	137(3)	5408	14265	2006.4

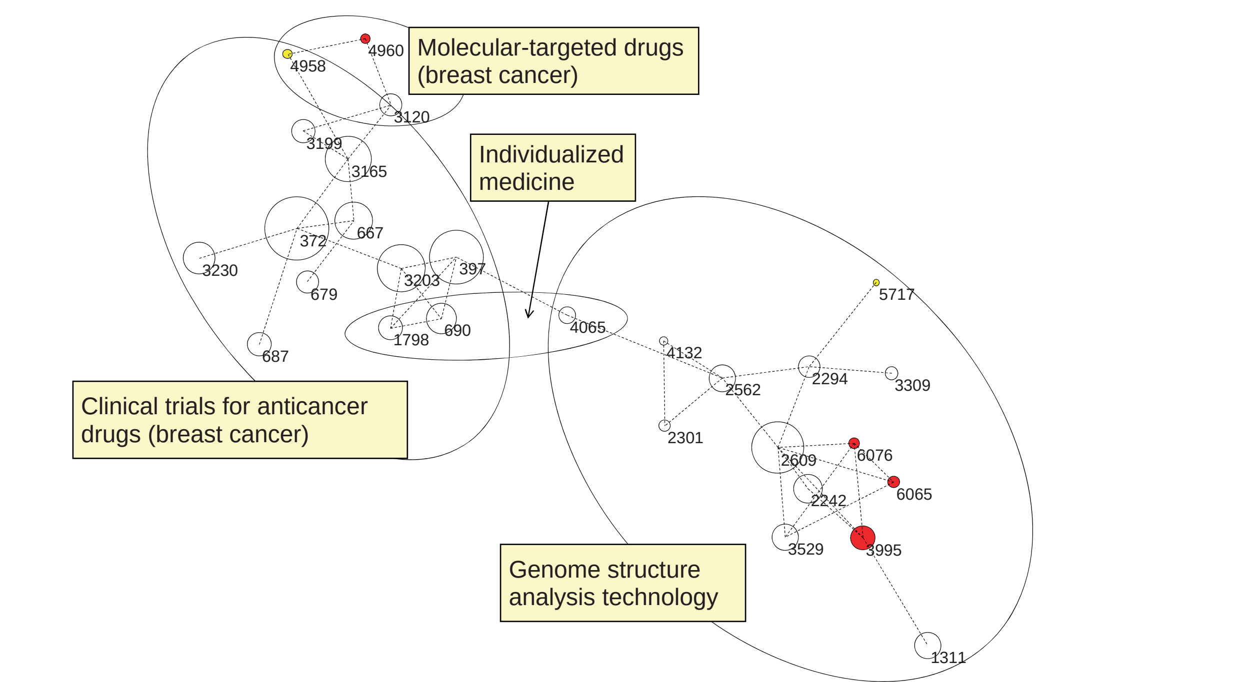


Name of RA	Elucidation of pathogenic mechanism of lifestyle-related diseases resulting from obesity	RA ID	34	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
27(5)	98(21)	6287	14979	2005.0



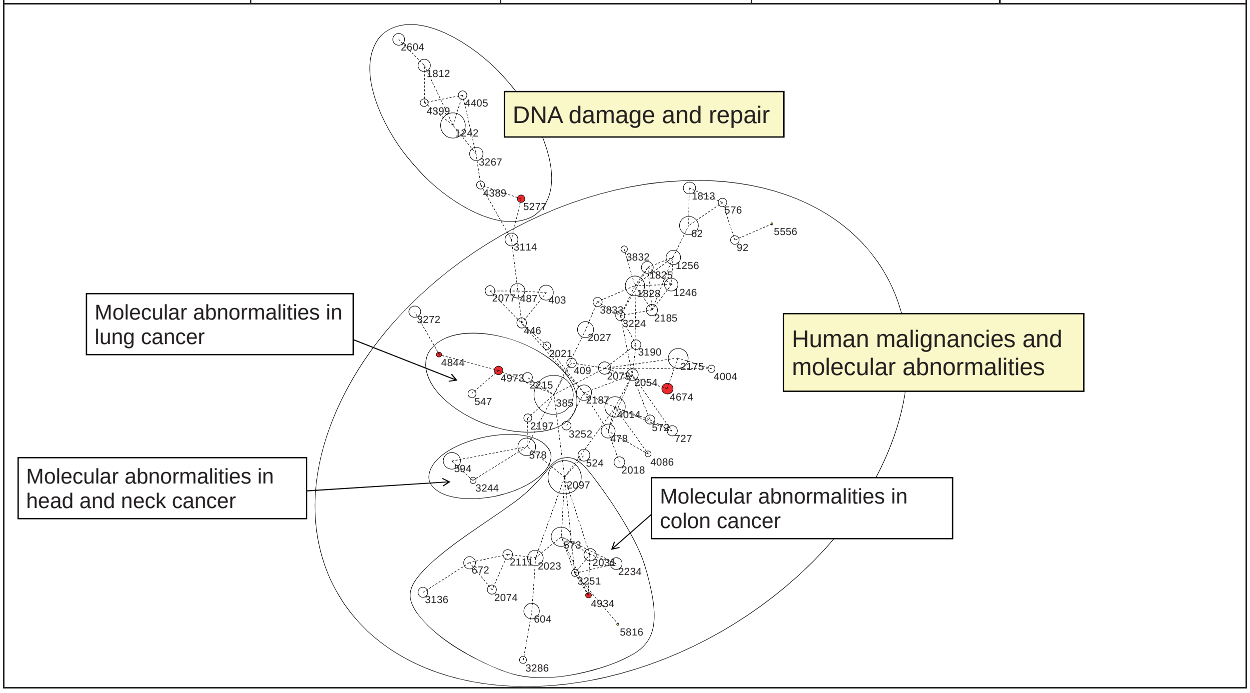
Name of RA	Development of drug therapy/genome sequencing technology for breast cancer	RA ID	35

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
28(4)	158(9)	8968	23238	2005.6



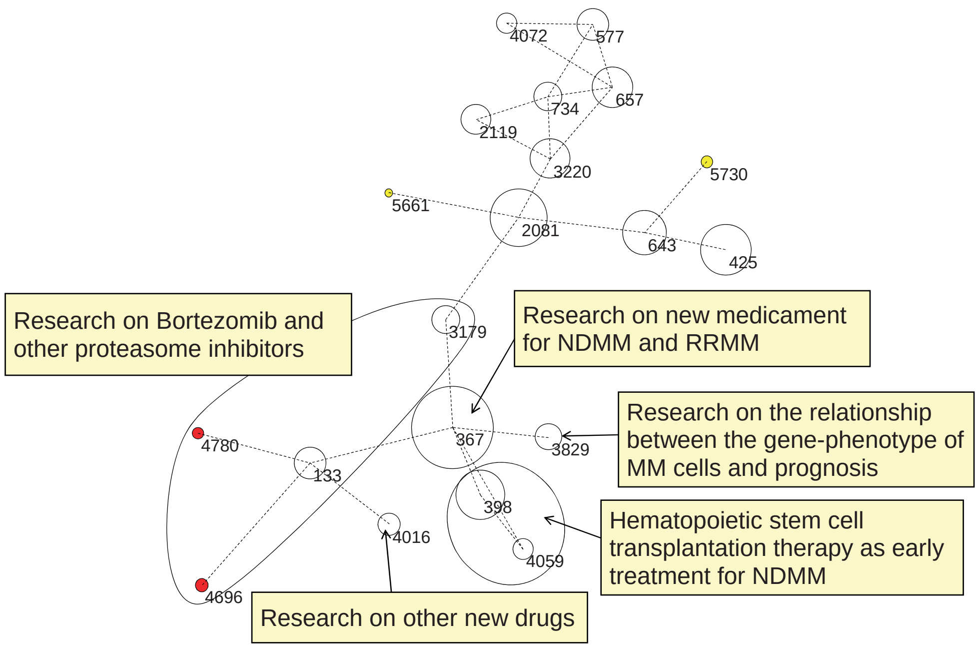
Name of RA	Molecular biological approach to human malignancies	RA ID	36

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
68(5)	331(21)	22305	63511	2005.2



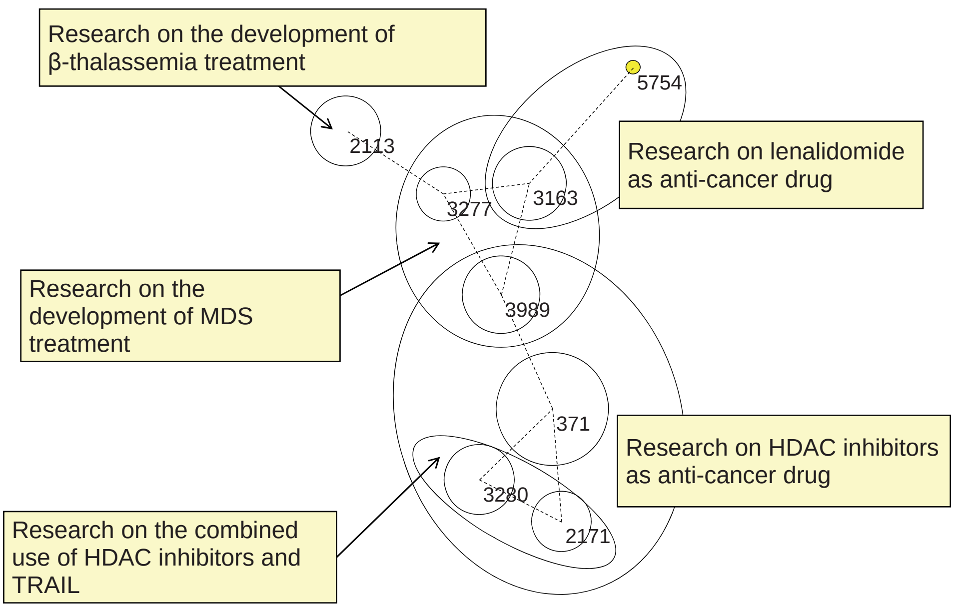
Name of RA	Multiple myeloma/new medicament	RA ID	37

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
20(2)	113(1)	4964	12913	2005.6



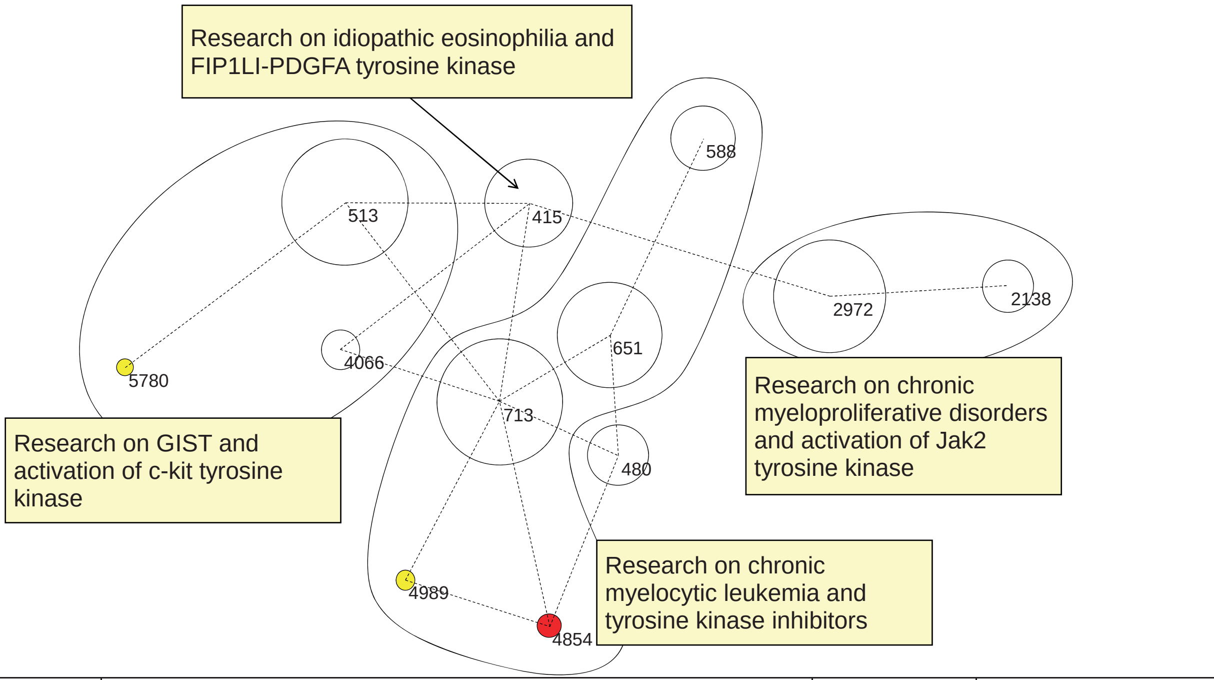
Name of RA	Research on the development of molecular targeting anticancer drugs including HDAC inhibitors	RA ID	38

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
8(0)	33(1)	1562	2843	2006.0



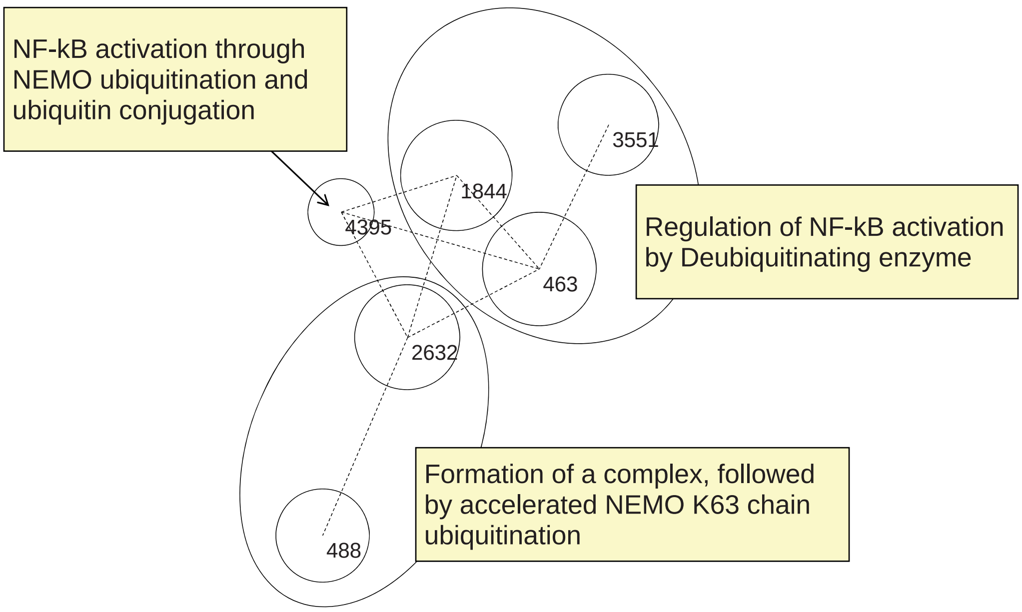
Name of RA	Activation of tyrosine kinase and its drug resistance	RA ID	39

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
12(1)	114(3)	5004	15351	2005.7



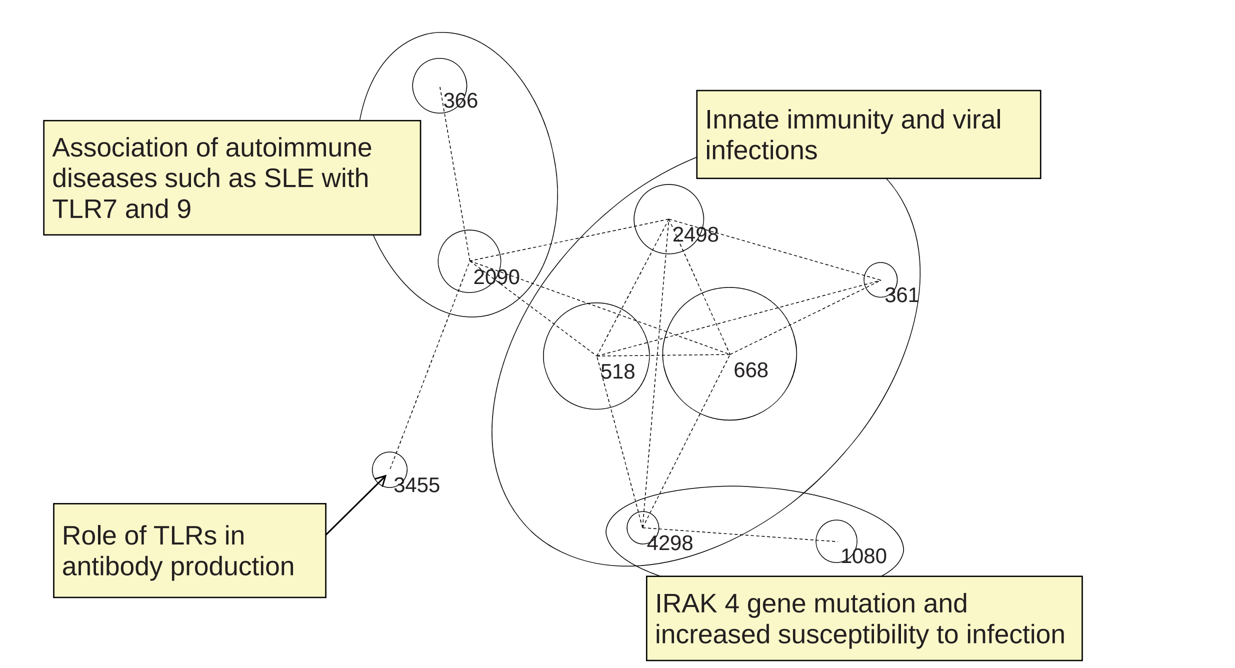
Name of RA	Role of ubiquitin modification system in NF-kB activation	RA ID	40

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(0)	14(0)	1344	2411	2004.1



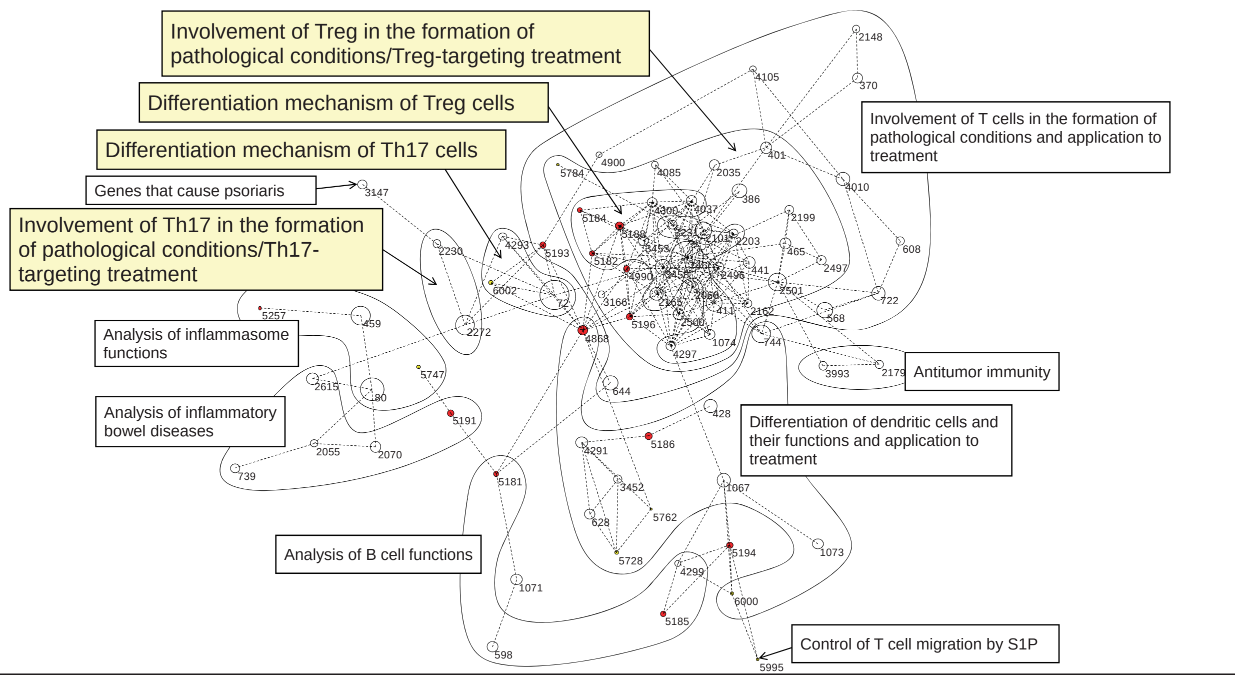
Name of RA	Production of interferon by innate immunity	RA ID	41

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
9(0)	93(39)	5307	18780	2004.9

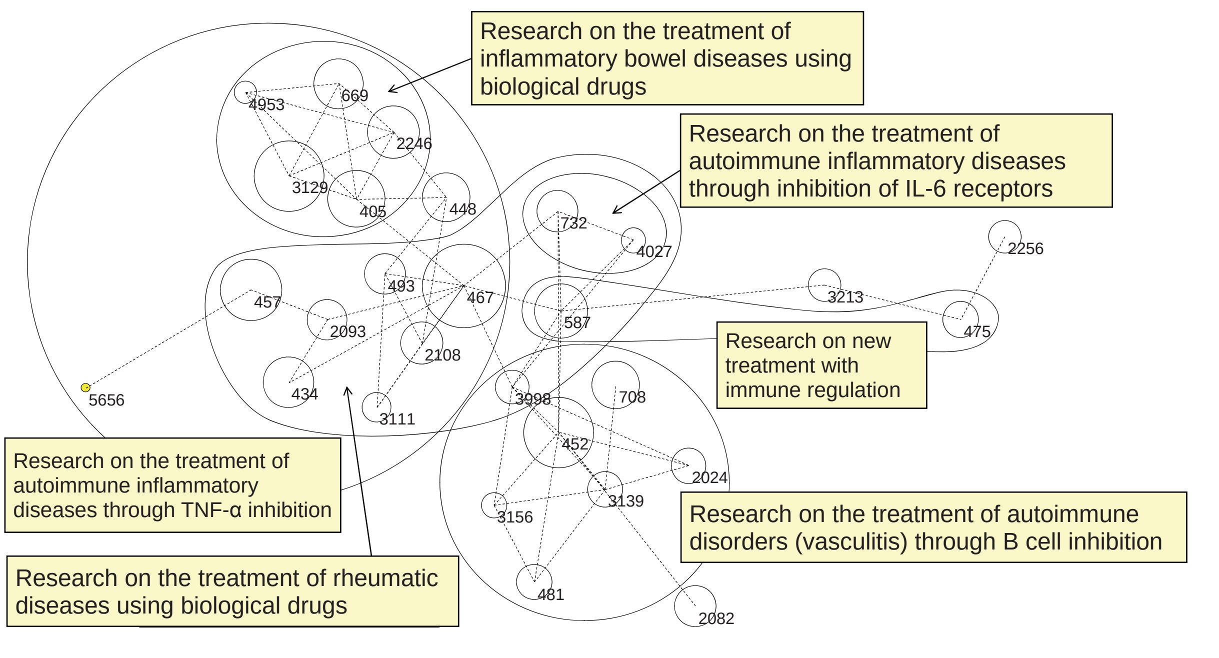


Name of RA	Differentiation mechanism of T cell subsets and their role in disease	RA ID	42

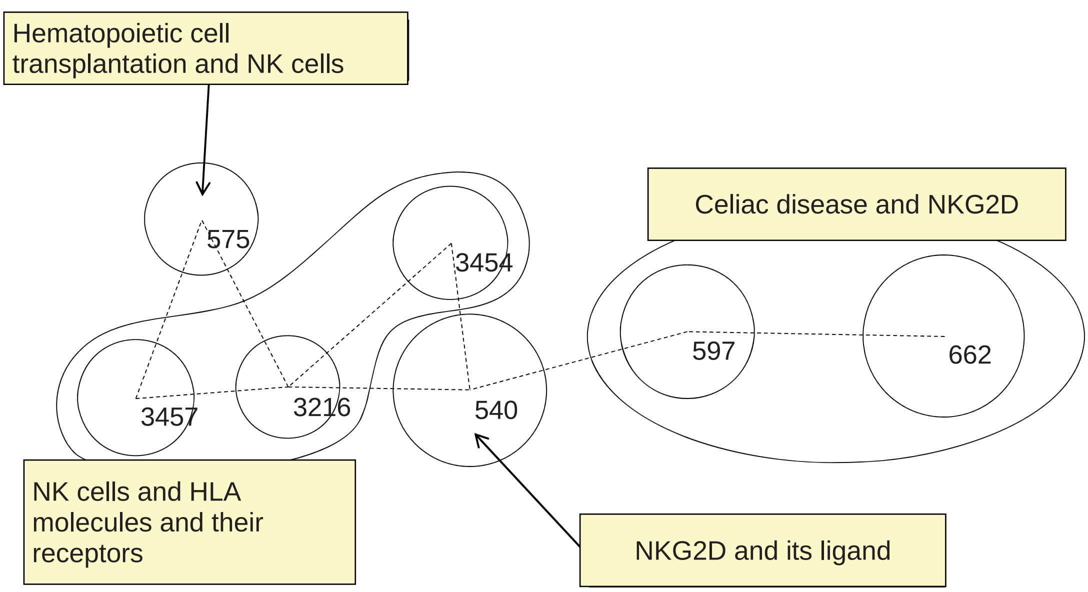
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
78(13)	327(26)	15585	49758	2005.5



Name of RA	Control of autoimmune disease by immunoregulatory mechanism of biological drugs	RA ID	43	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
28(0)	113(5)	7092	16224	2004.9

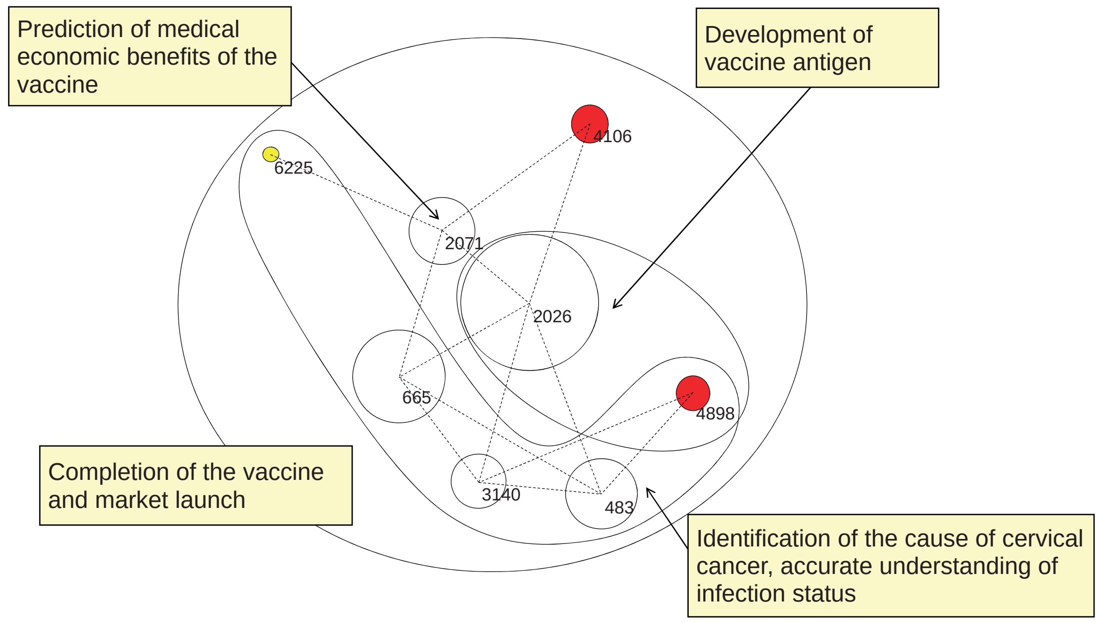


Name of RA	NK cell receptor and its ligand that inhibits activation	RA ID	44	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
7(0)	16(0)	1574	2539	2004.3



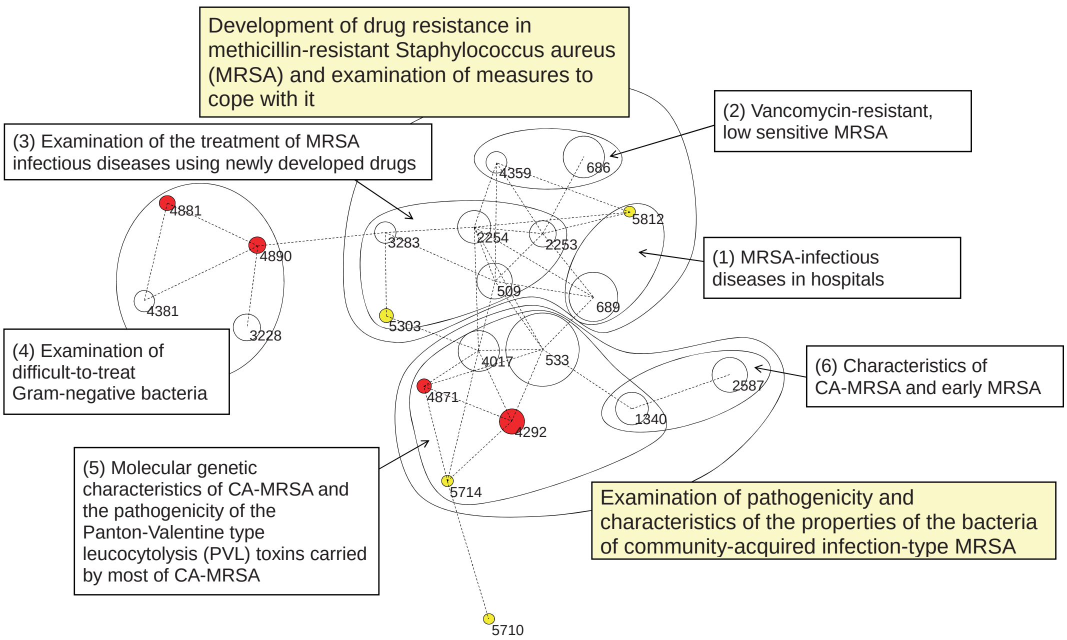
Name of RA	Development of human papillomavirus vaccine	RA ID	45

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
8(2)	35(0)	1616	4214	2005.9

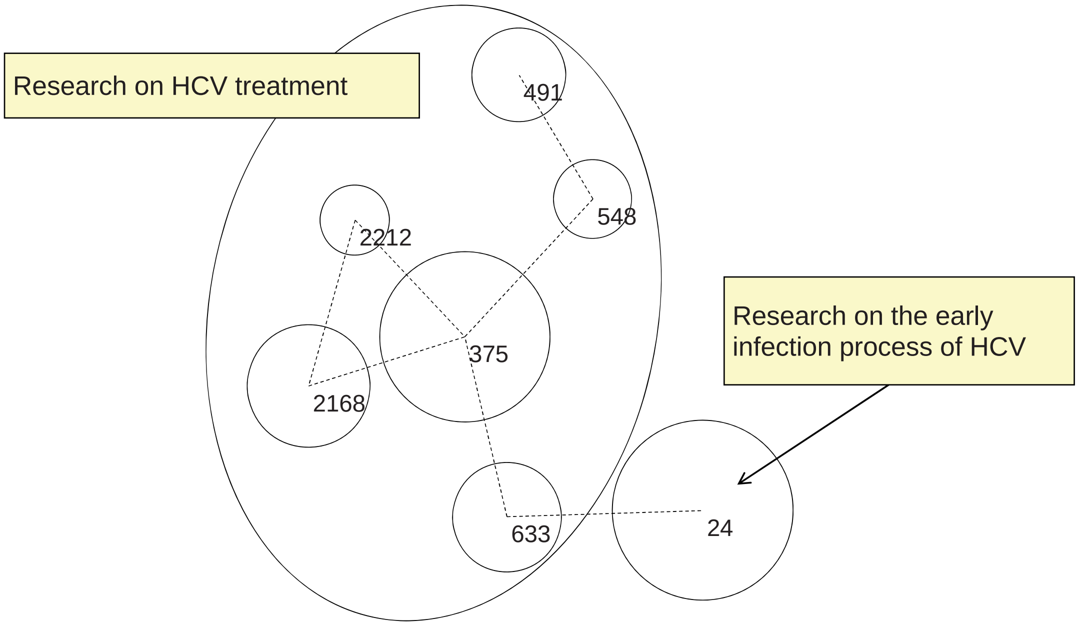


Name of RA	Development of drug resistance in Staphylococcus aureus and ways to cope with it	RA ID	46

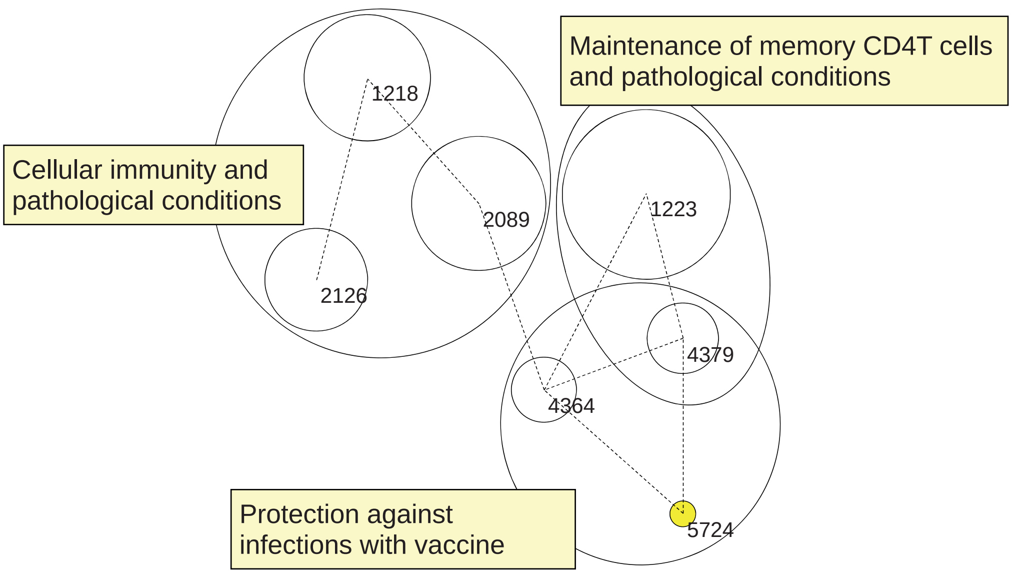
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
21(4)	54(3)	3175	6464	2005.7



Name of RA	Process of early infection with Hepatitis C virus and its treatment	RA ID	47	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
7(0)	76(7)	3027	8717	2005.5

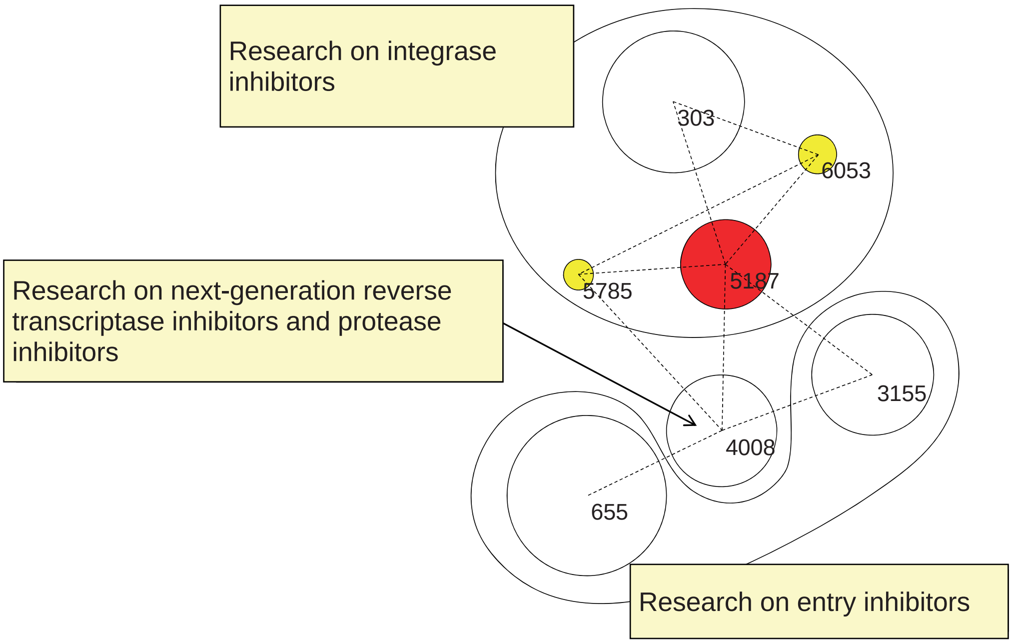


Name of RA	Control of HIV infection	RA ID	48	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
7(0)	25(0)	1322	2914	2005.4



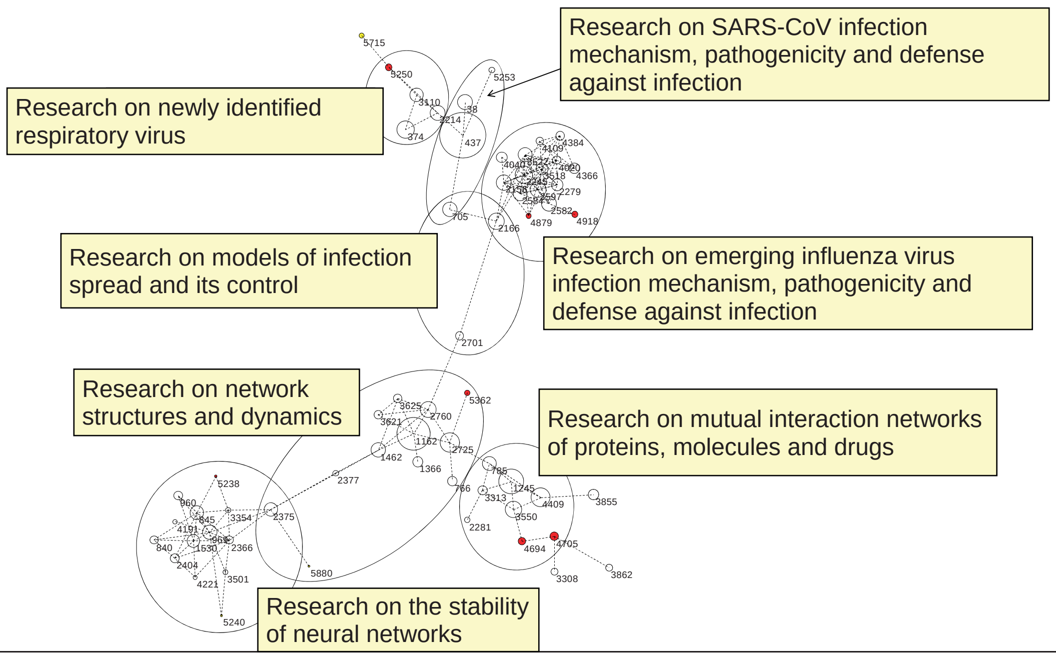
Name of RA	Research on anti-HIV drugs	RA ID	49

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
7(1)	26(2)	1090	2143	2006.1



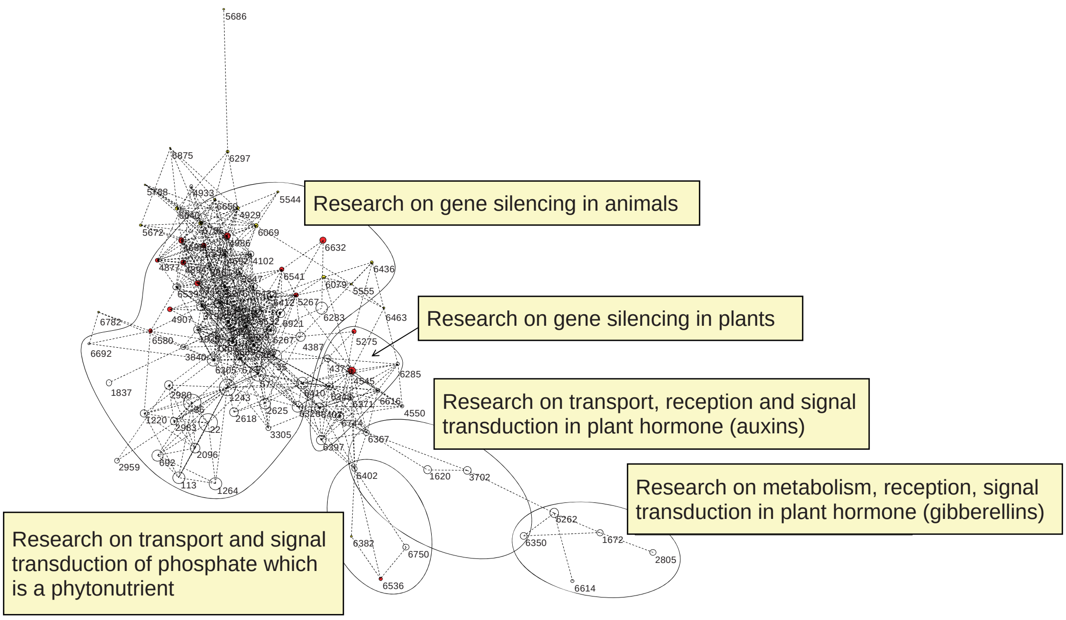
Name of RA	Network science	RA ID	50

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
62(7)	271(10)	11993	35275	2005.1



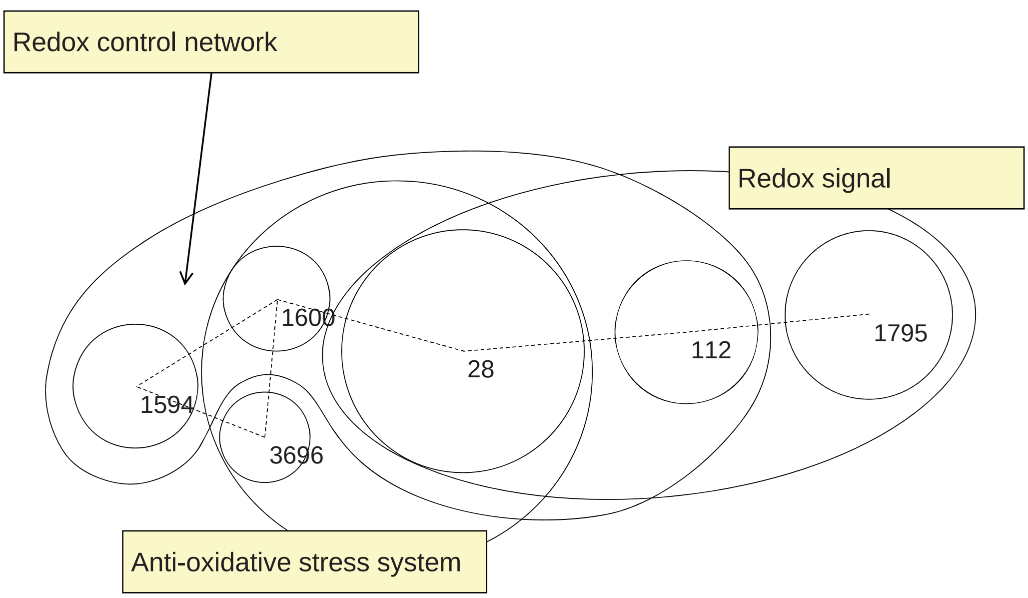
Name of RA	Gene silencing/plant hormone	RA ID	51

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
96(14)	389(30)	11493	49126	2005.6



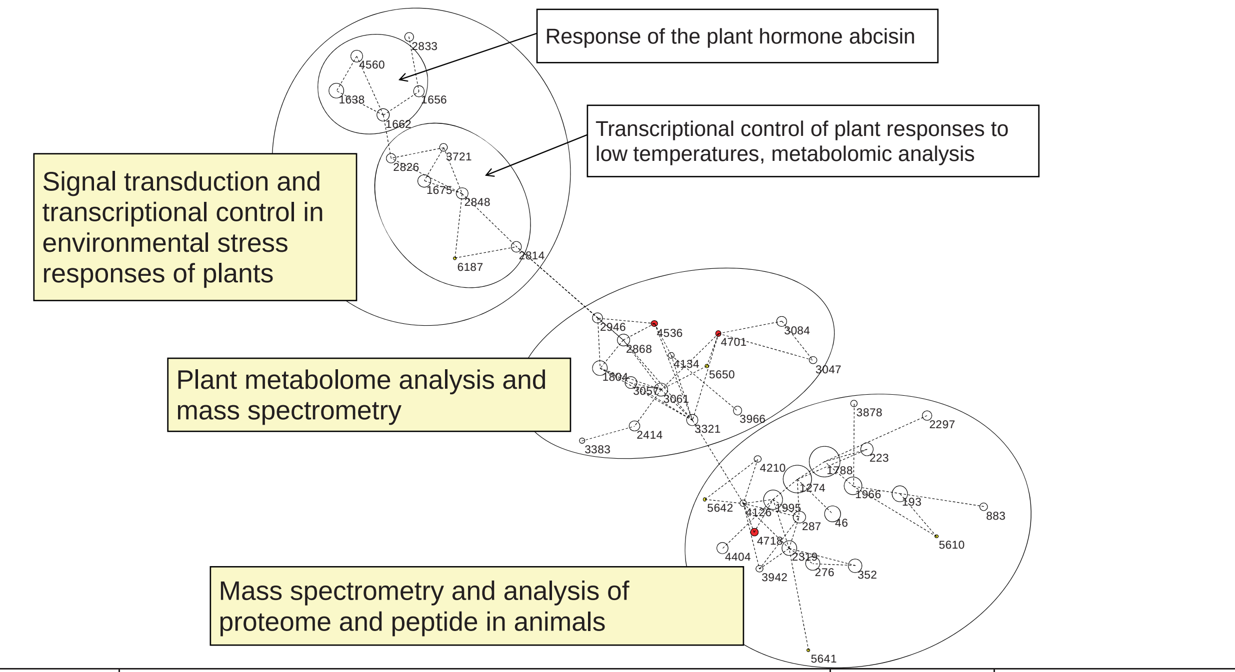
Name of RA	Redox control	RA ID	52

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(0)	20(1)	1664	2804	2003.9



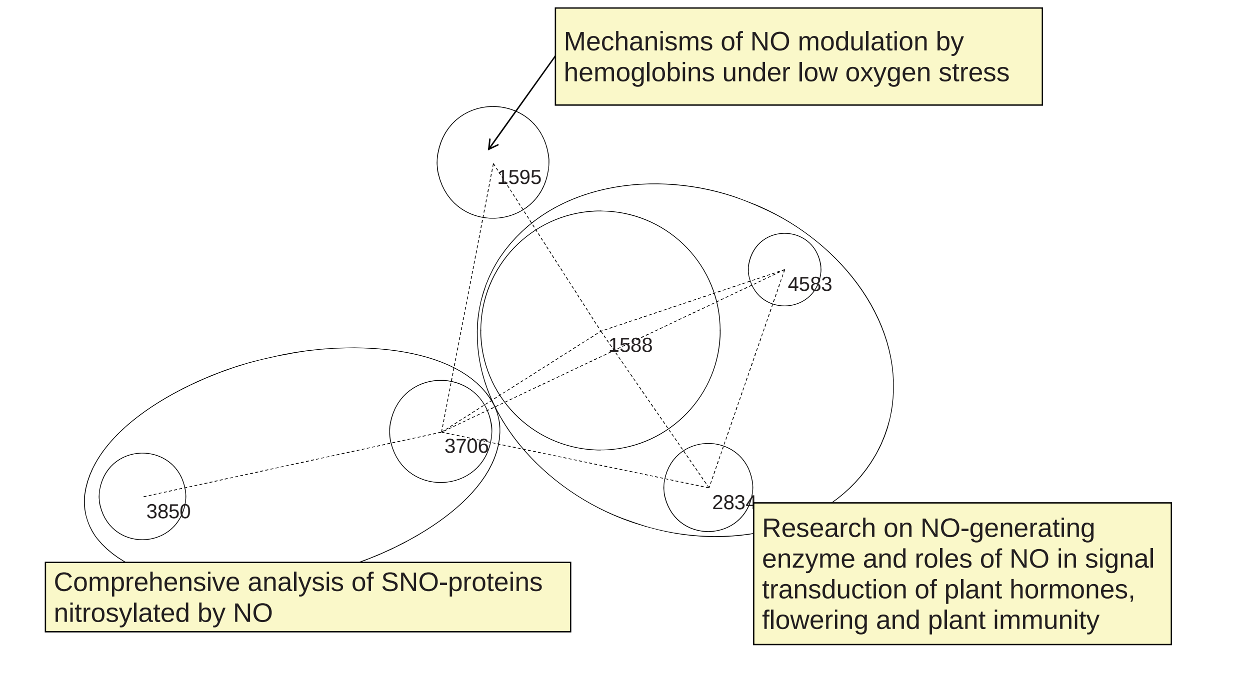
Name of RA	Environmental responses of plants/metabolome analysis/proteome analysis	RA ID	53

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
48(3)	155(13)	6142	12823	2005.3

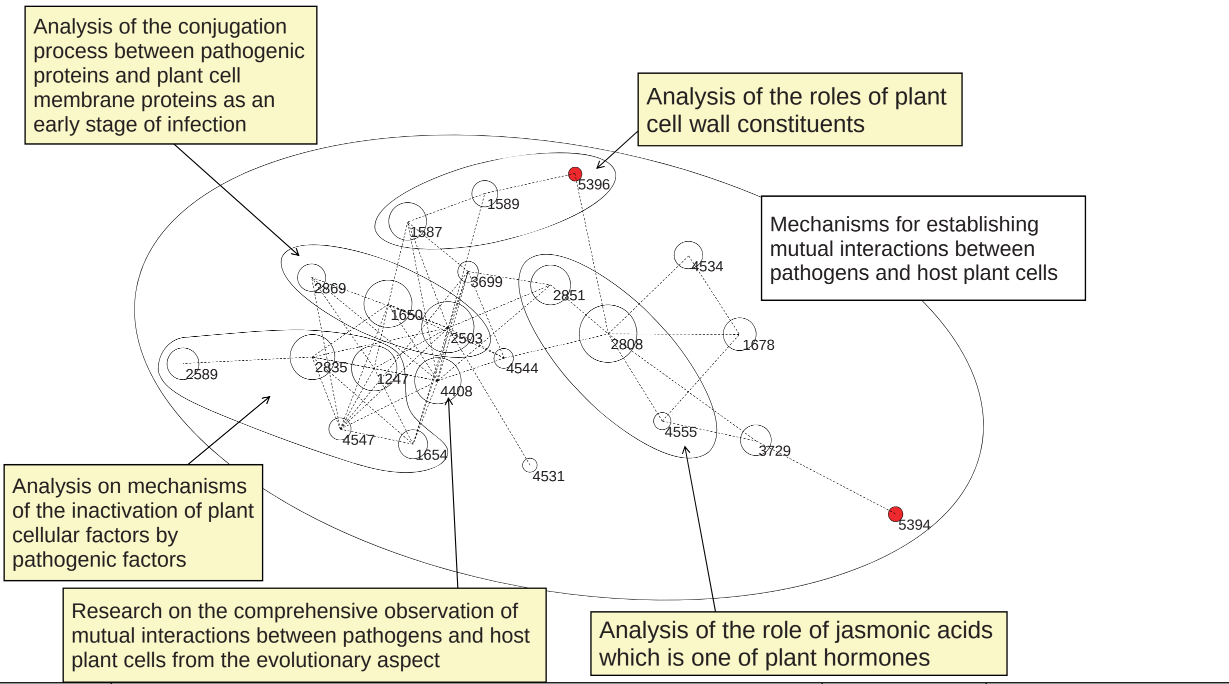


Name of RA	Mechanisms for generation of nitric oxide in plants and its physiological role	RA ID	54

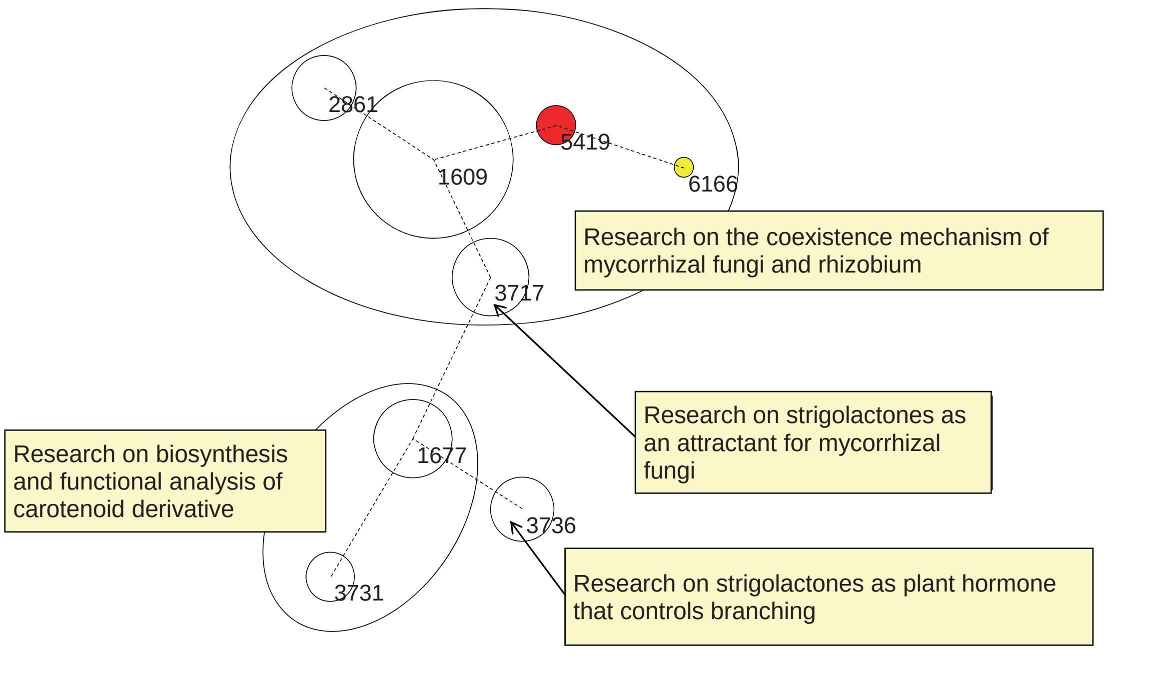
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(0)	25(0)	868	2059	2004.4



Name of RA	Defense mechanism of plants against infection	RA ID	55	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
22(2)	160(7)	3101	8682	2005.9

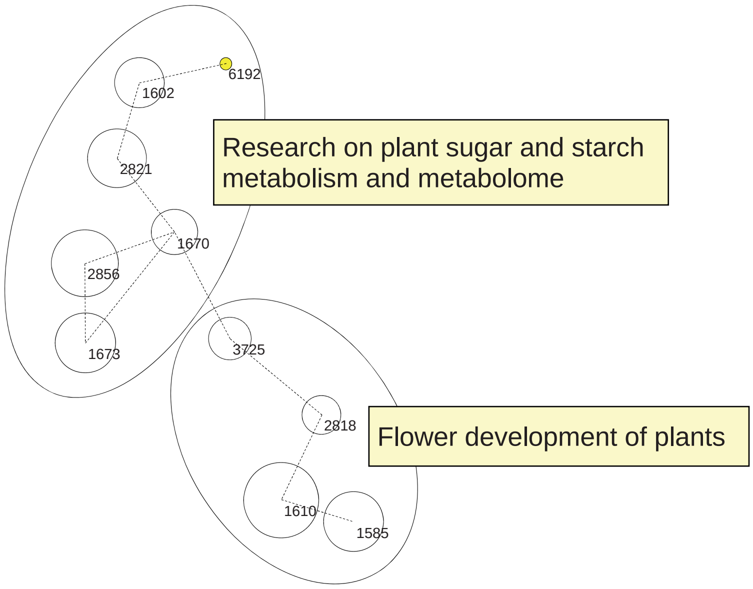


Name of RA	Plant-microorganism interactions/strigolactones	RA ID	56	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
8(1)	53(11)	1034	2622	2005.5



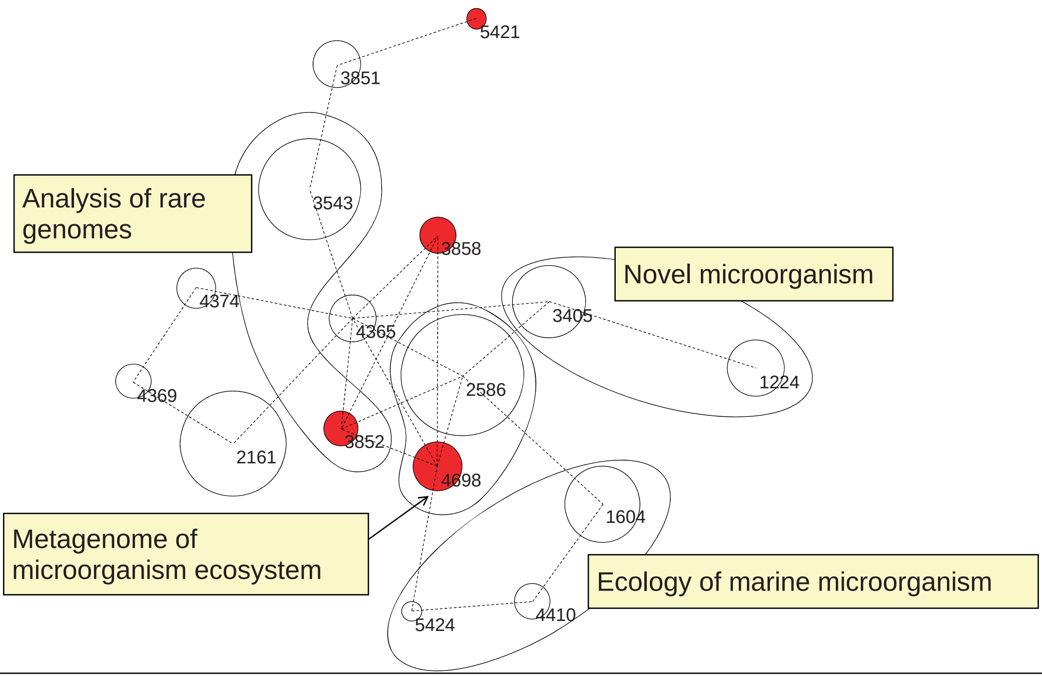
Name of RA	Plant developmental genetics/carbohydrate metabolism	RA ID	57

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
10(0)	31(4)	1245	2177	2004.5



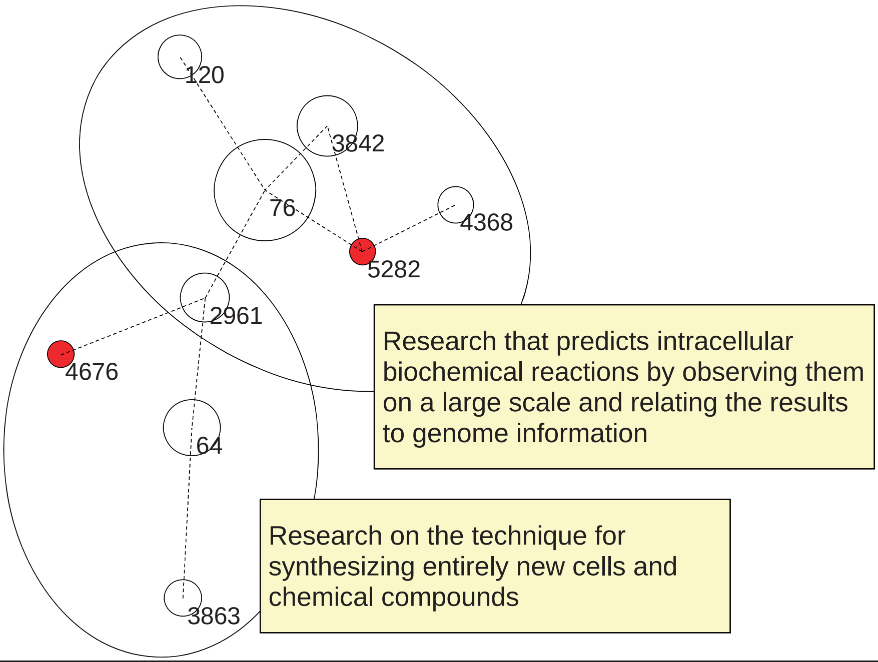
Name of RA	Microorganism ecosystem	RA ID	58

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
16(4)	62(1)	3640	7029	2005.9



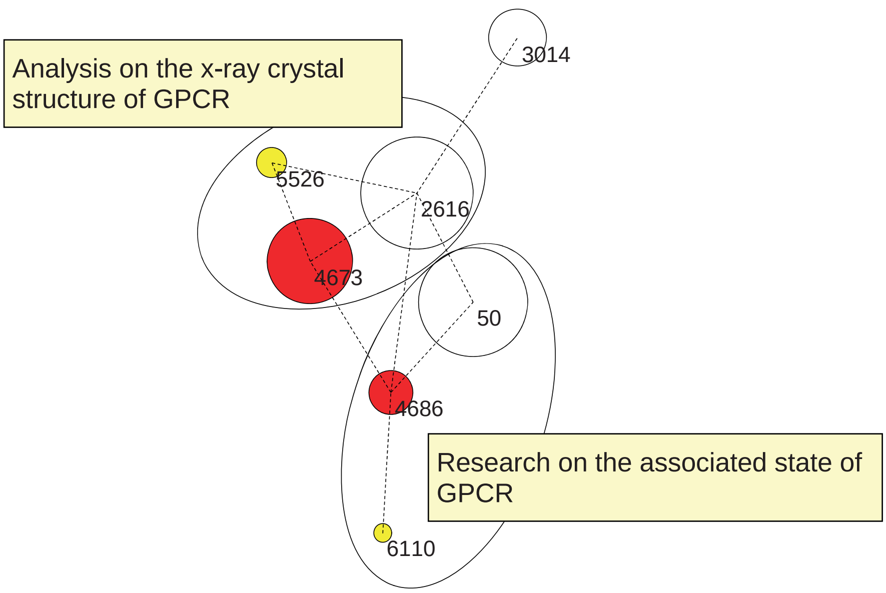
Name of RA	Systems biology/synthetic biology	RA ID	59

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
9(2)	27(1)	1506	2763	2005.4

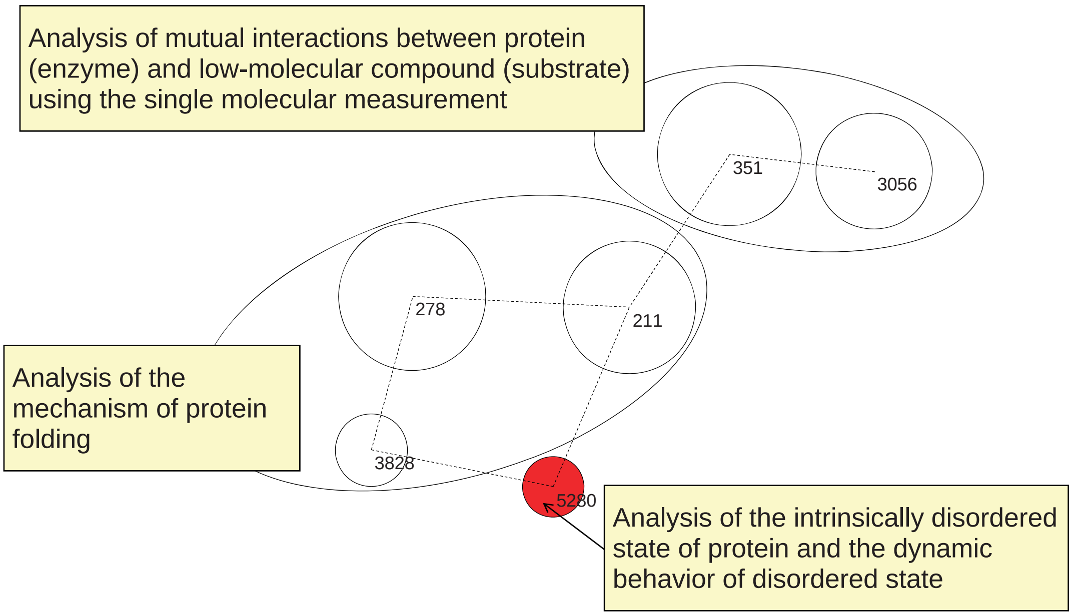


Name of RA	Structure and functions of G-protein-coupled receptor	RA ID	60

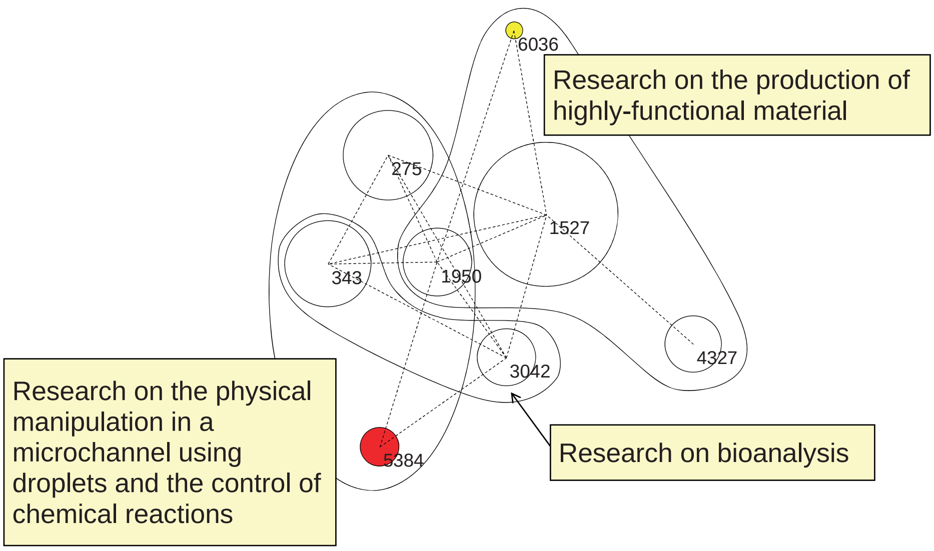
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
7(2)	18(2)	955	1663	2006.2



Name of RA	Analysis of dynamic behavior of proteins		RA ID	61
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(1)	13(0)	871	1288	2004.9

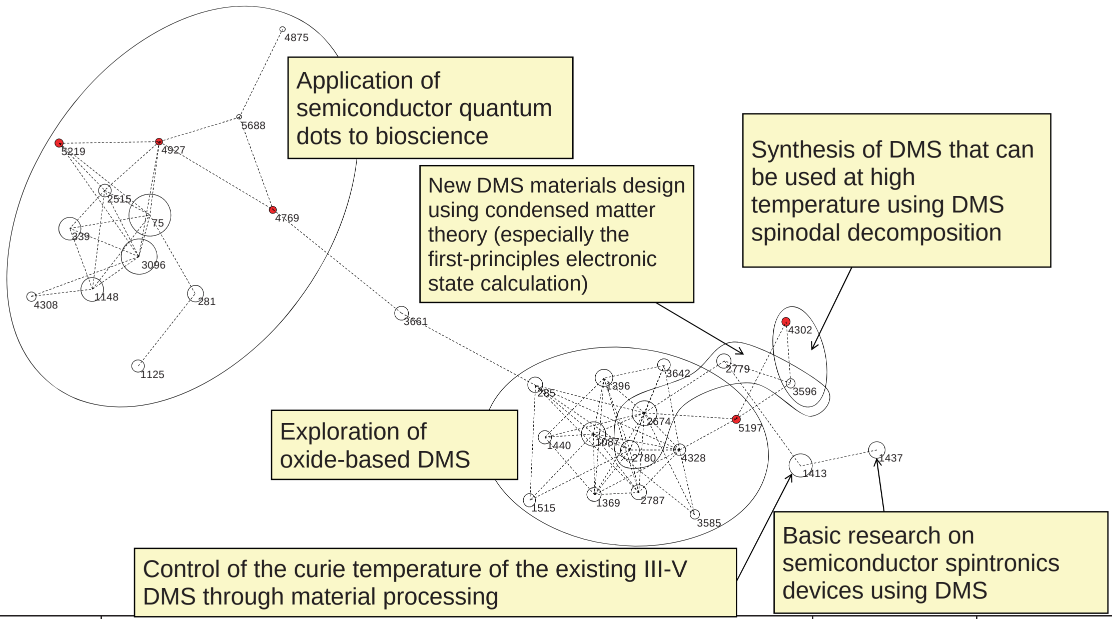


Name of RA	Microchannel device		RA ID	62
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
8(1)	30(5)	1020	2433	2005.1



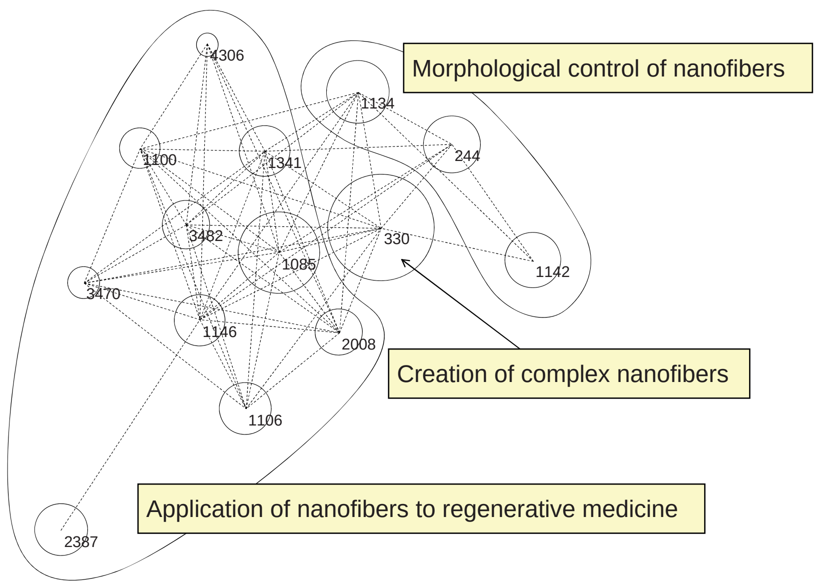
Name of RA	Semiconductor-spintronics material/magnetic semiconductors	RA ID	63

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
32(5)	94(13)	5598	12938	2004.7



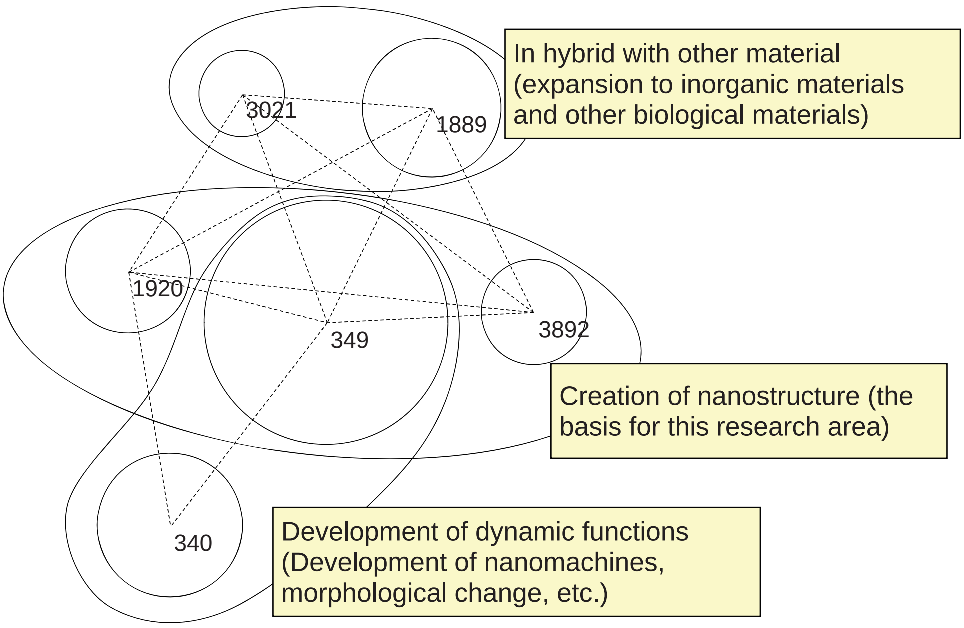
Name of RA	Research on creation and application of nanofibers	RA ID	64

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
14(0)	47(2)	2319	5448	2004.5



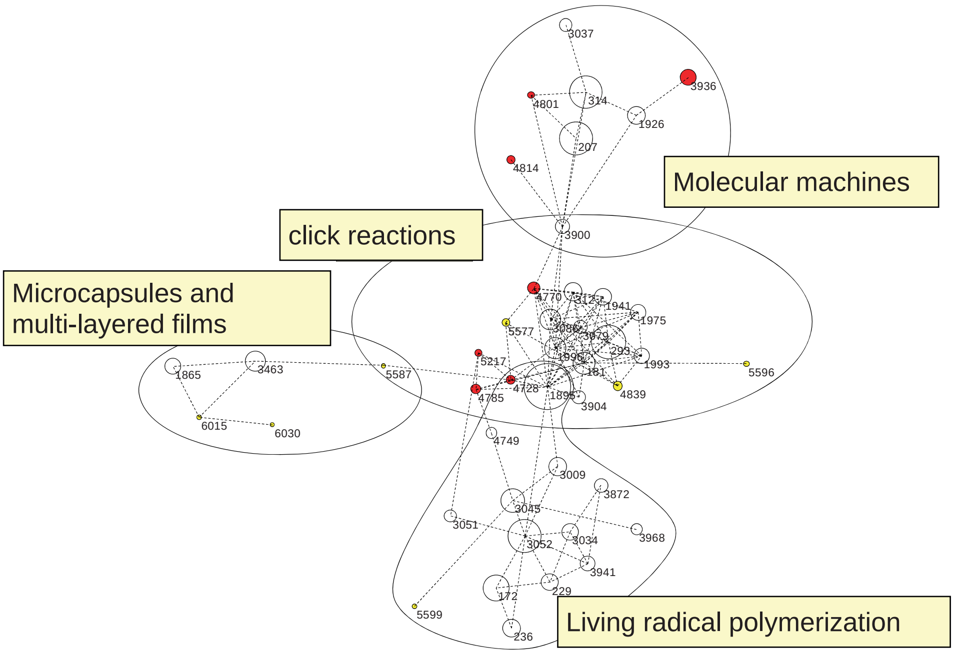
Name of RA	Development of nanostructure using nucleic acid	RA ID	65

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(0)	16(0)	1080	1994	2004.6

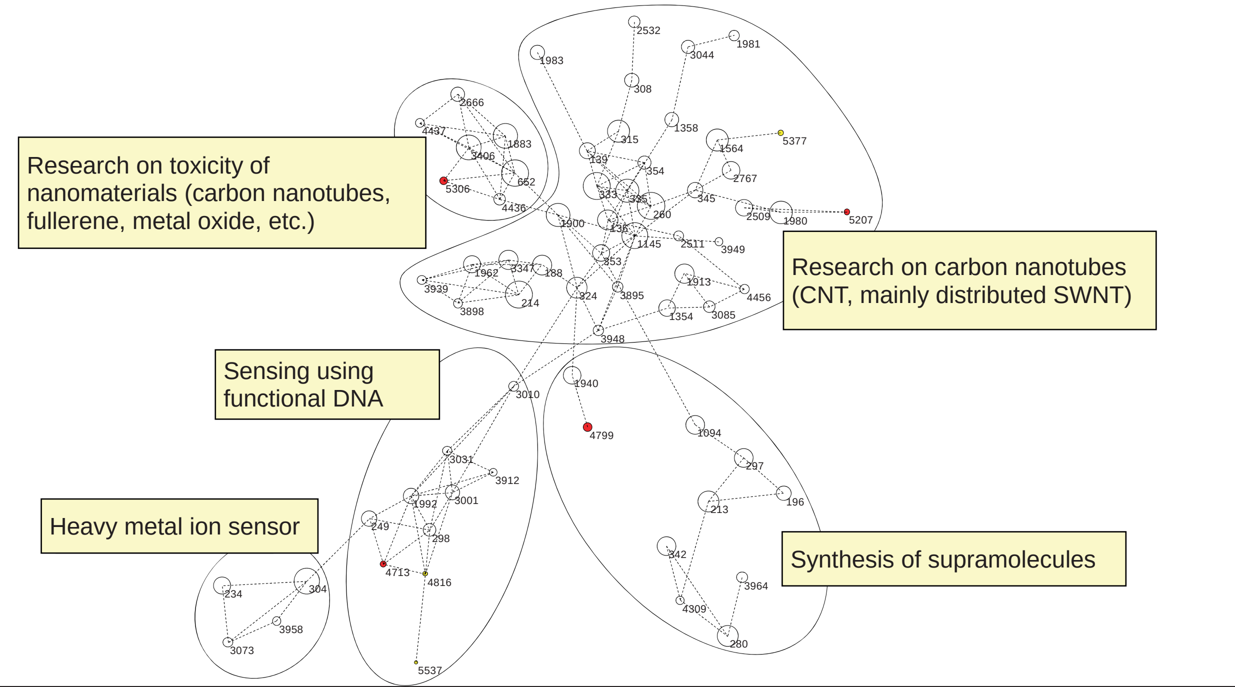


Name of RA	Living radical polymerization/click reaction/molecular machine	RA ID	66

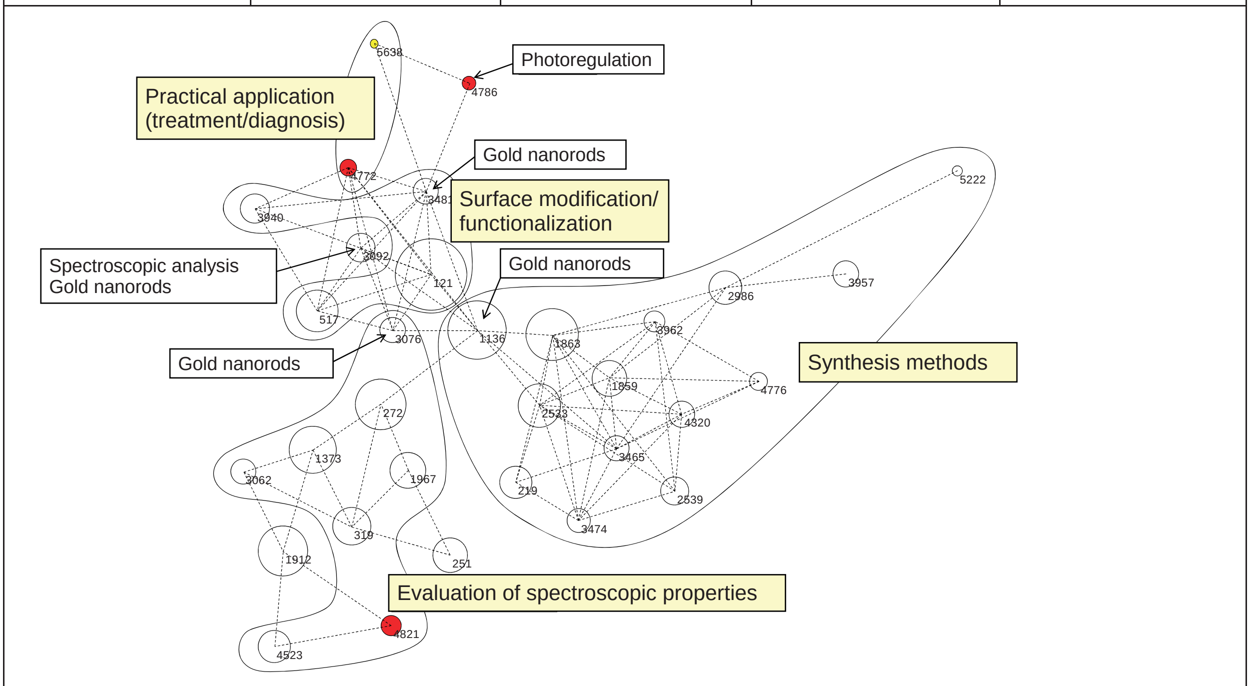
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
44(7)	208(3)	4909	14111	2005.8



Name of RA	Synthesis, function and toxicity of sensors/SWNTs/functional DNAs/nanoparticles, etc.	RA ID	67	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
69(4)	293(16)	11966	29759	2005.1

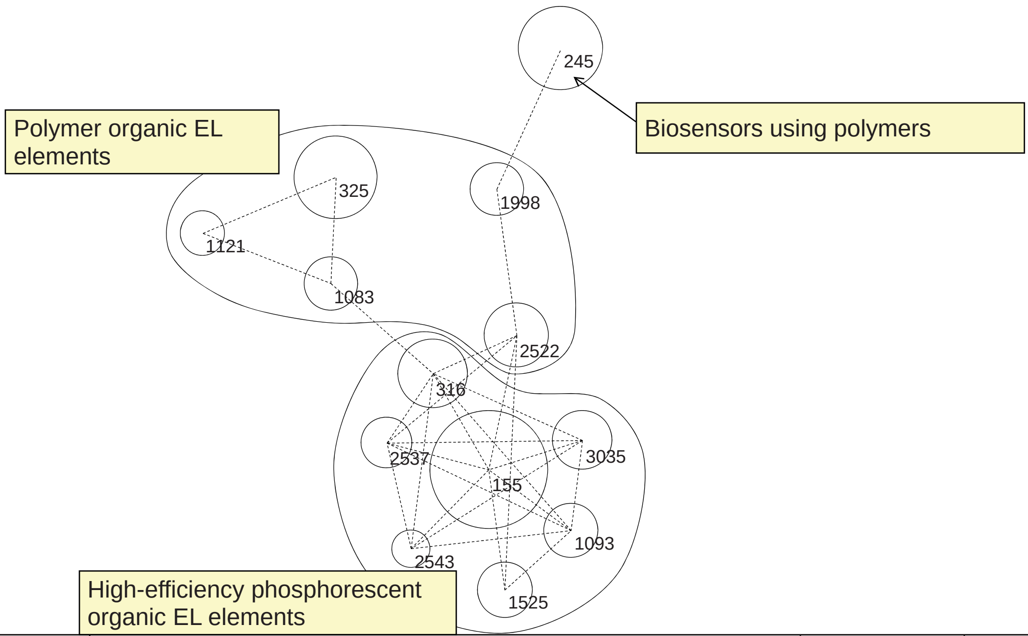


Name of RA	Bioapplications of gold nanorods	RA ID	68	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
32(3)	86(1)	3732	8109	2005.2



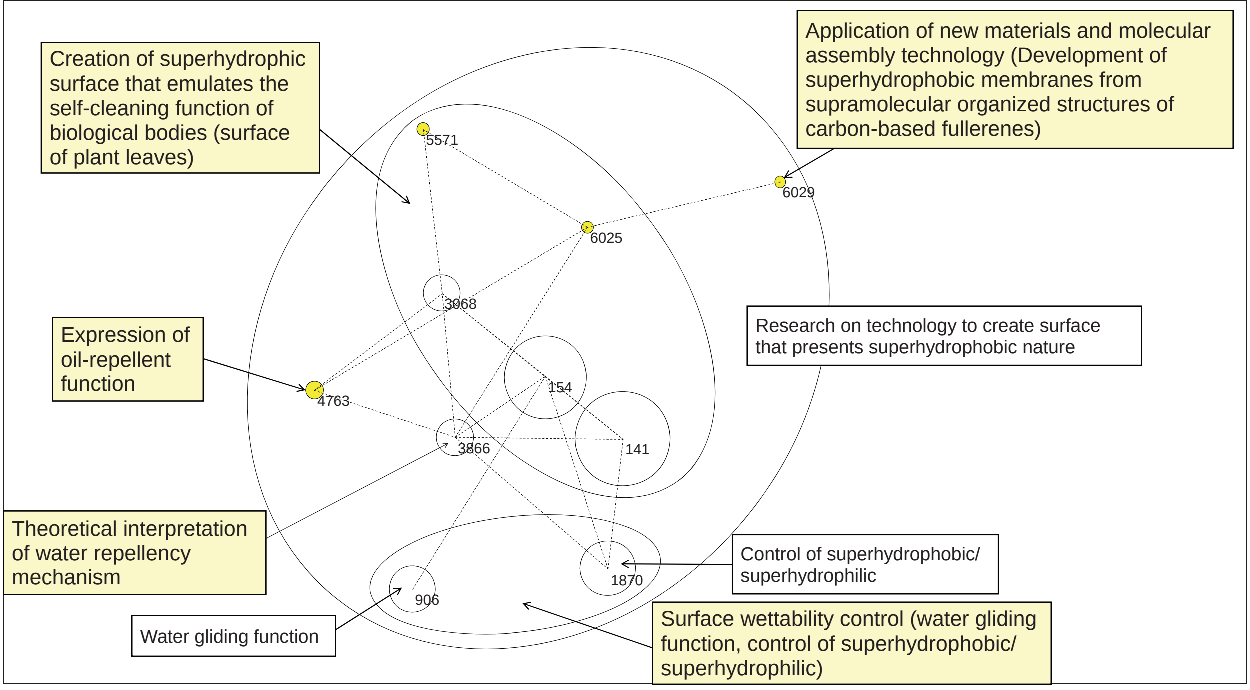
Name of RA	High-efficiency organic electroluminescence (EL) element	RA ID	69

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
13(0)	90(7)	2617	7066	2004.8

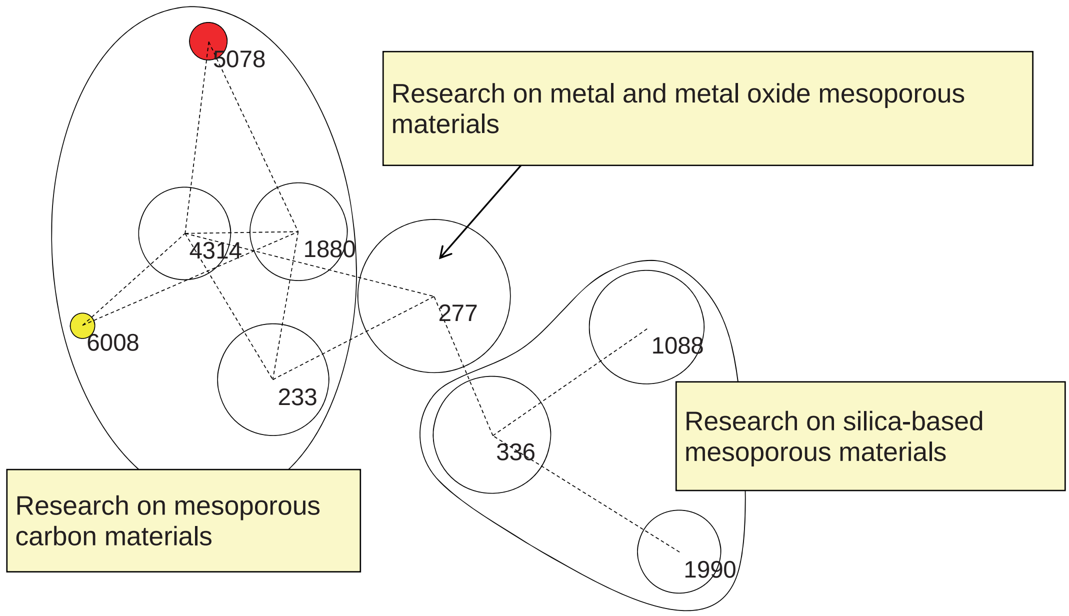


Name of RA	Superhydrophobic surface	RA ID	70

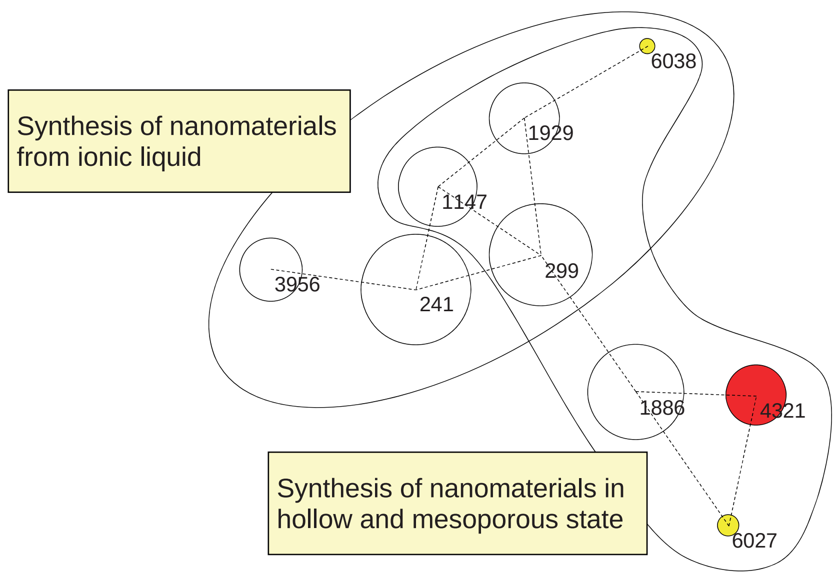
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
10(0)	51(2)	1733	4789	2005.3



Name of RA	Mesoporous material/silica, carbon and metal oxide	RA ID	71	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
9(1)	33(5)	1214	2393	2005.1

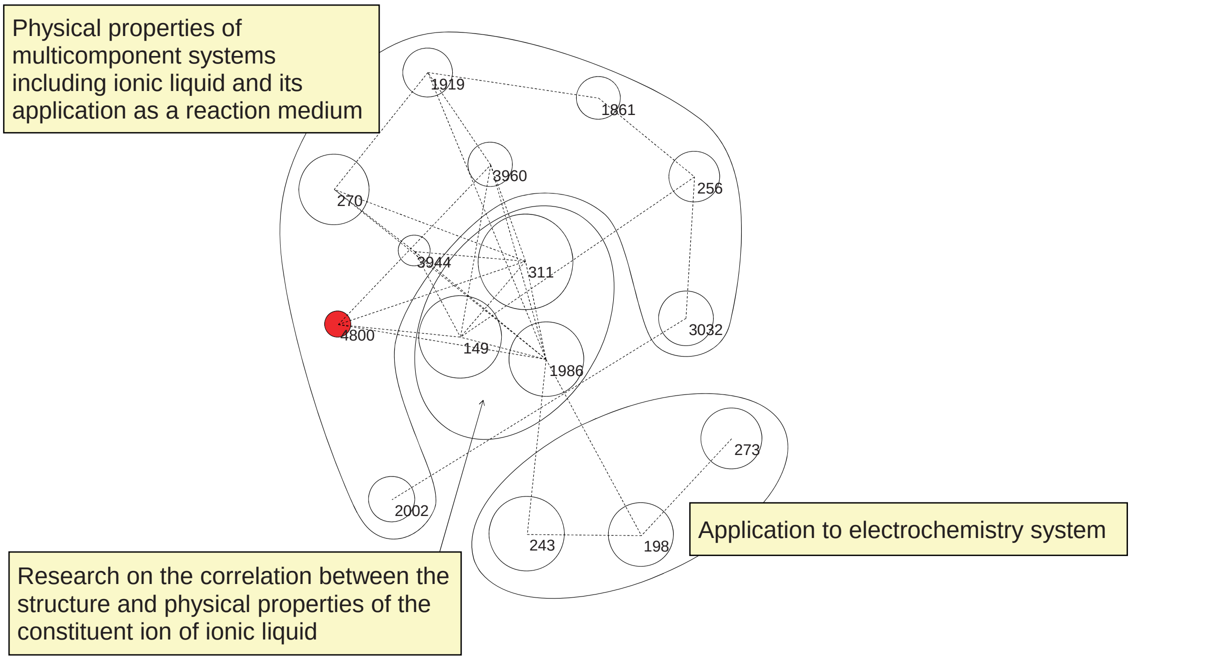


Name of RA	Nanomaterial synthesis in ionic liquid/hollow and mesoporous material	RA ID	72	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
9(1)	30(5)	1111	1961	2005.4



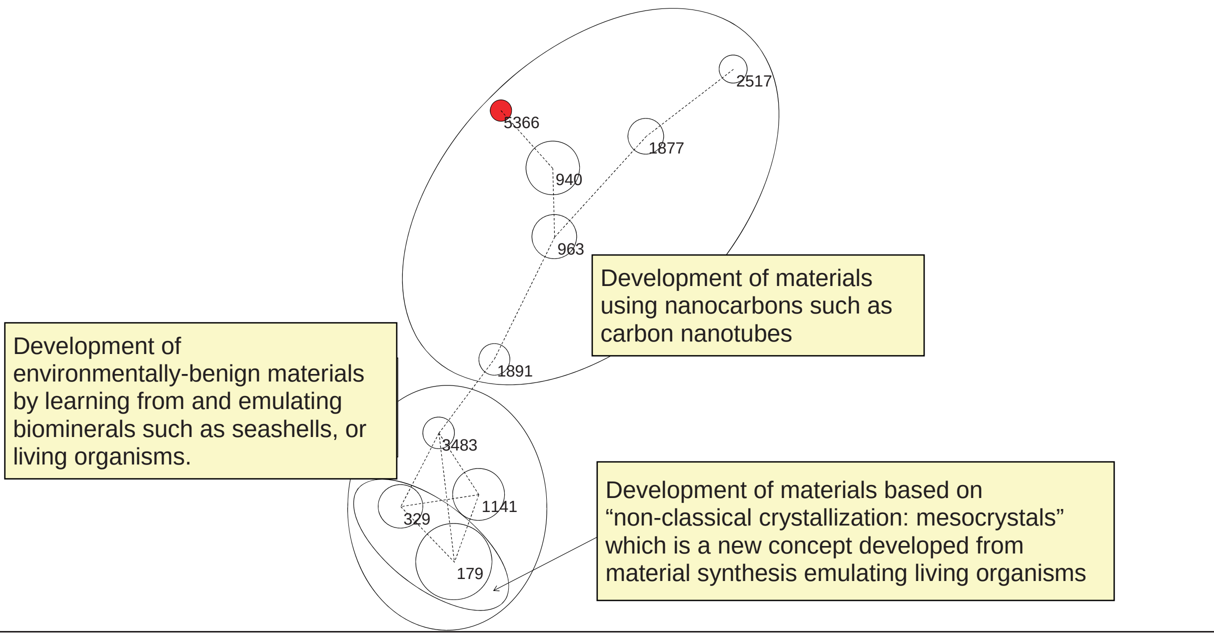
Name of RA	Ionic liquid	RA ID	73

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
15(1)	75(18)	2104	5509	2005.1

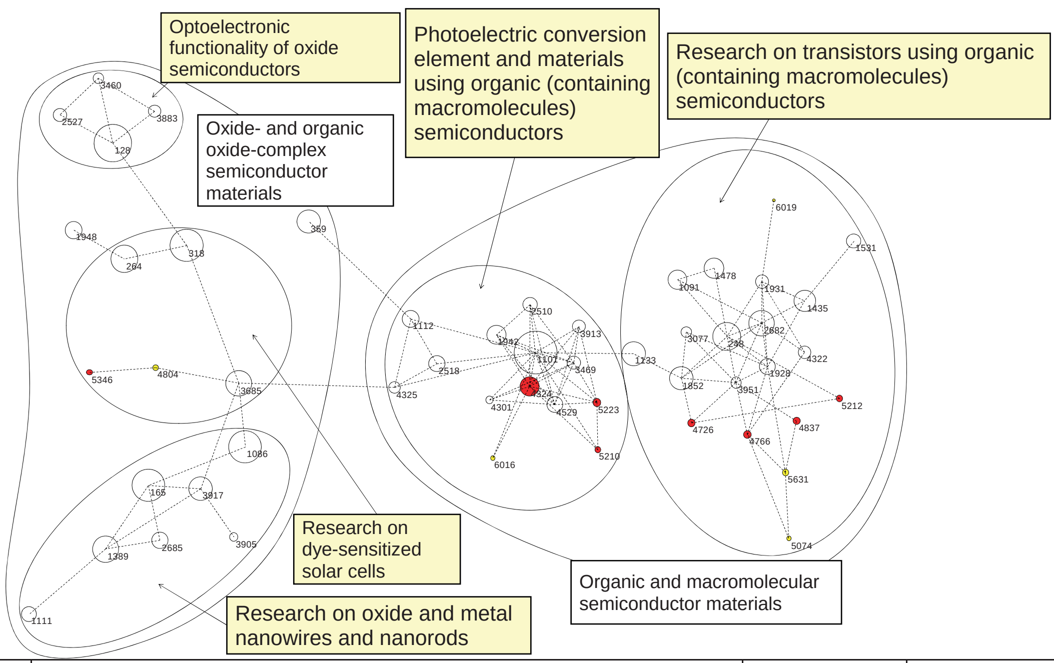


Name of RA	Development materials from carbonate following the examples of nanocarbons and living organisms	RA ID	74

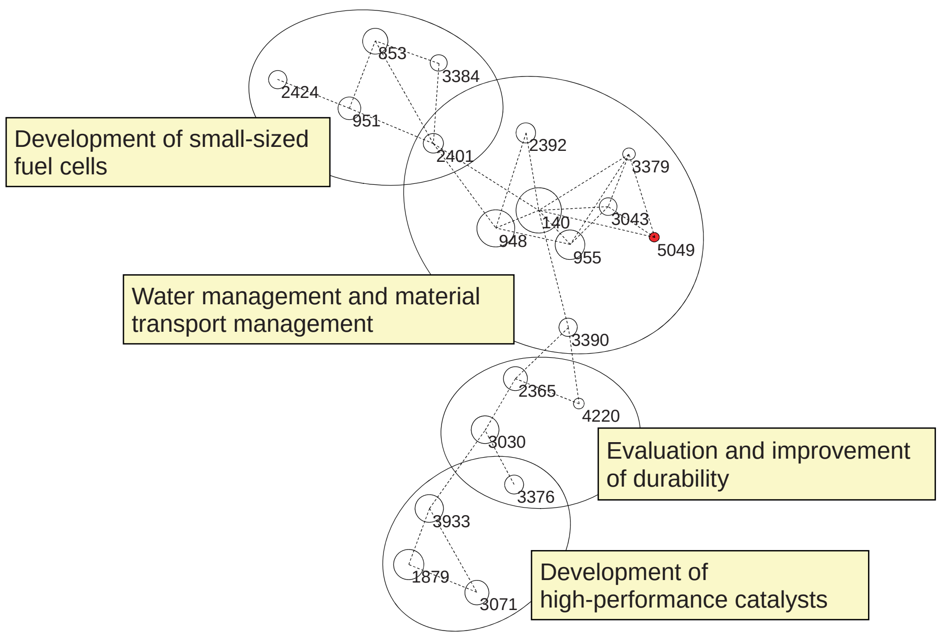
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
10(1)	28(1)	1520	2496	2004.4



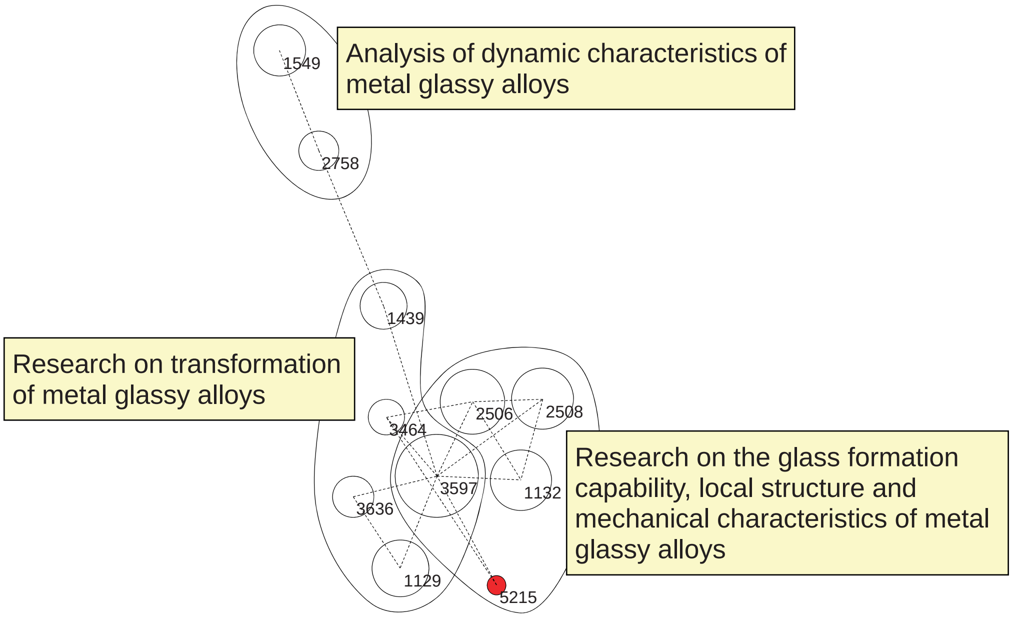
Name of RA	Organic/organic-oxide semiconductors Photo- and electro-functional materials and elements		RA ID	75
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
52(8)	237(21)	9023	22986	2005.2



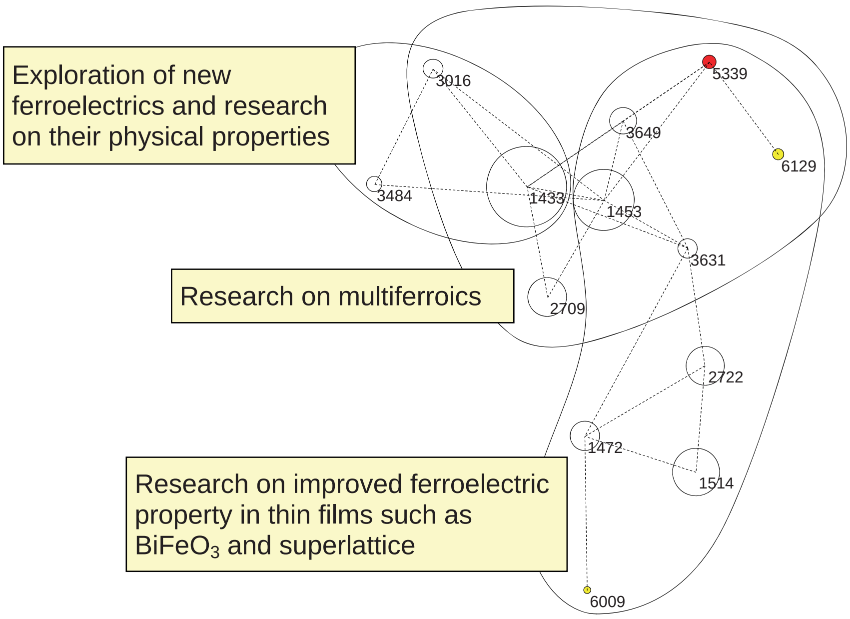
Name of RA	Solid macromolecule type fuel cell		RA ID	76
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
20(1)	89(3)	1852	4294	2005.3



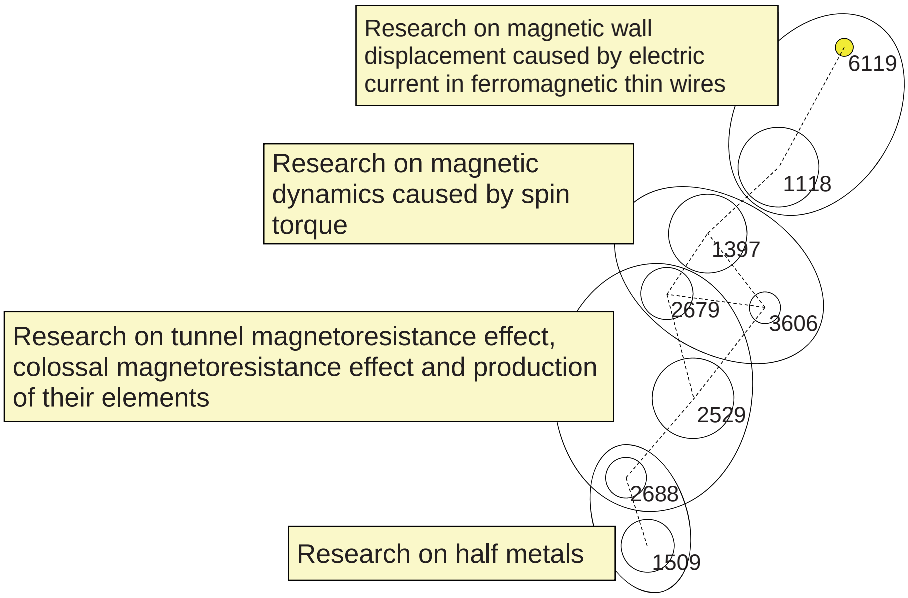
Name of RA	Formation of bulk metallic glass/transformation of metal glassy alloys	RA ID	77	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
11(1)	46(7)	1768	4108	2004.9



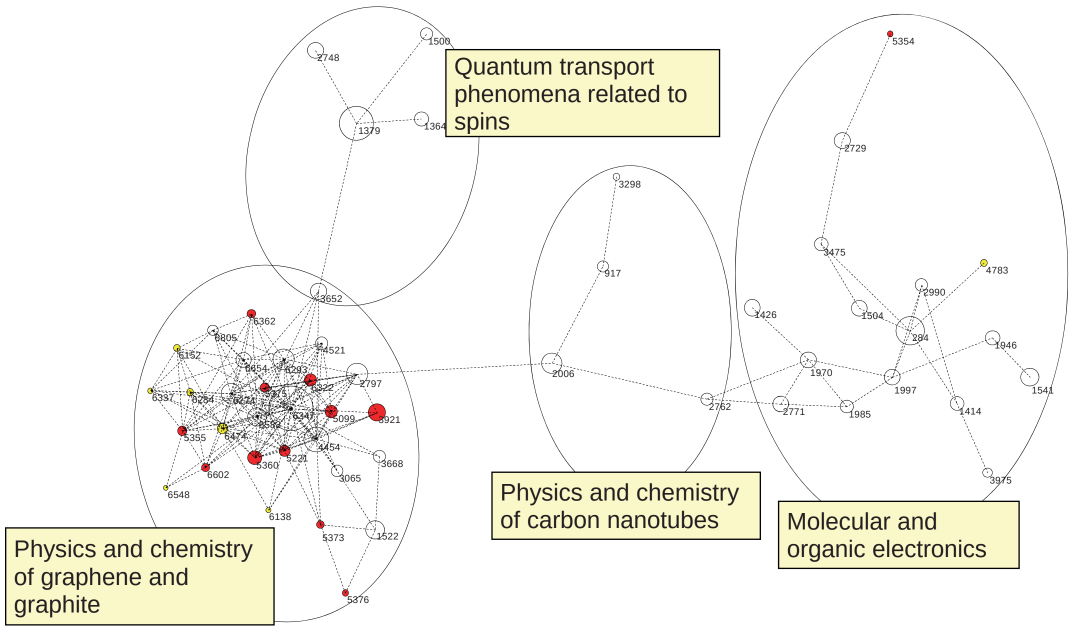
Name of RA	Ferroelectric property in new materials such as multiferroics, etc.	RA ID	78	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
13(1)	70(18)	2751	7964	2005.5



Name of RA	Metal-based spintronics		RA ID	79
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
8(0)	61(22)	2094	6002	2004.8

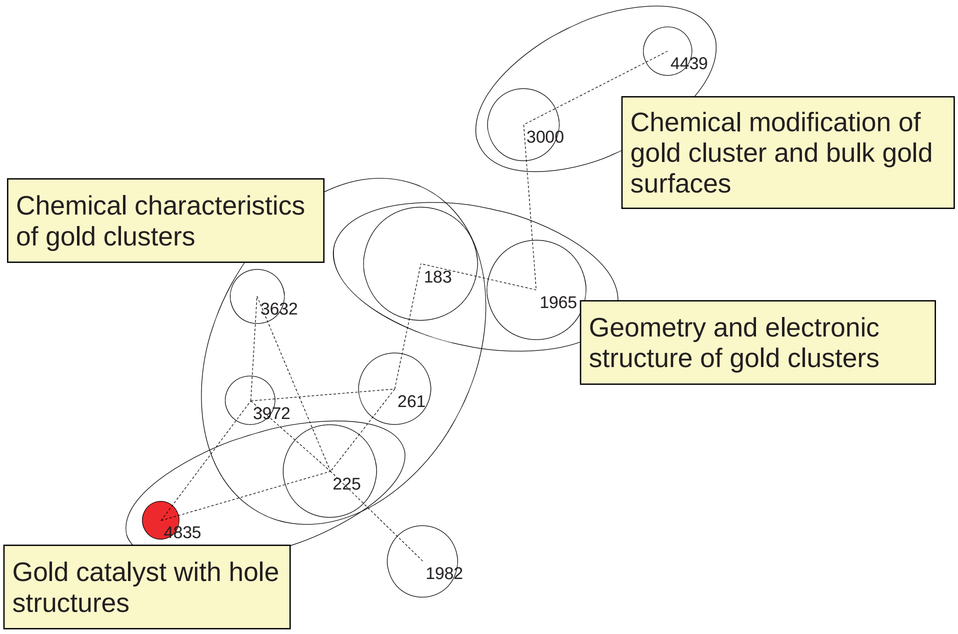


Name of RA	Physics and chemistry of molecular substance		RA ID	80
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
54(12)	264(23)	5879	21734	2005.9



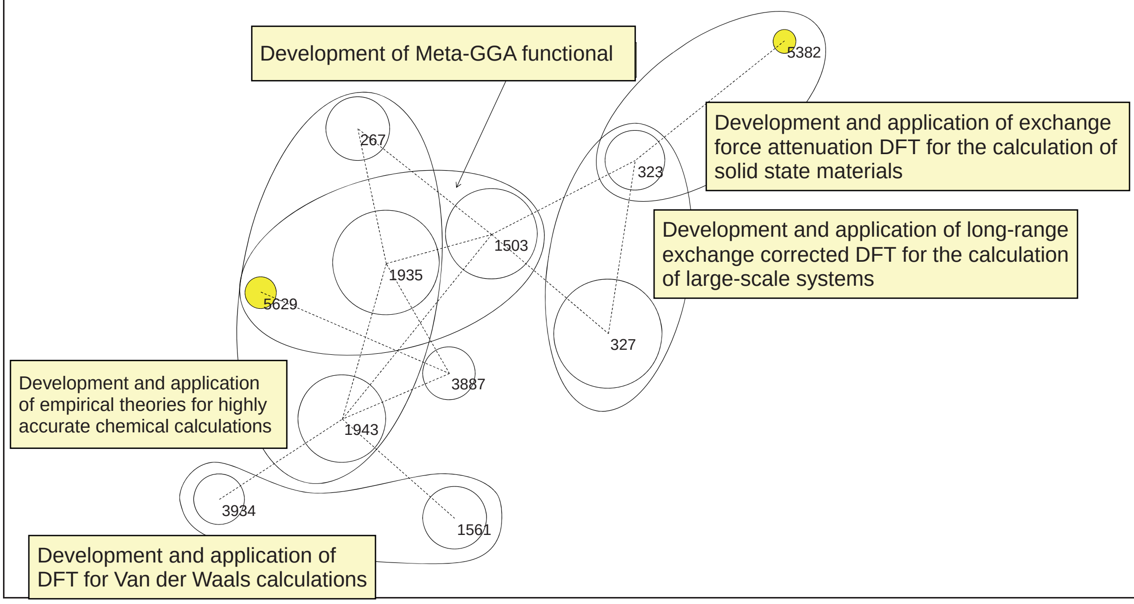
Name of RA	Nanochemistry of gold	RA ID	81

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
10(1)	45(4)	1485	2892	2005.6



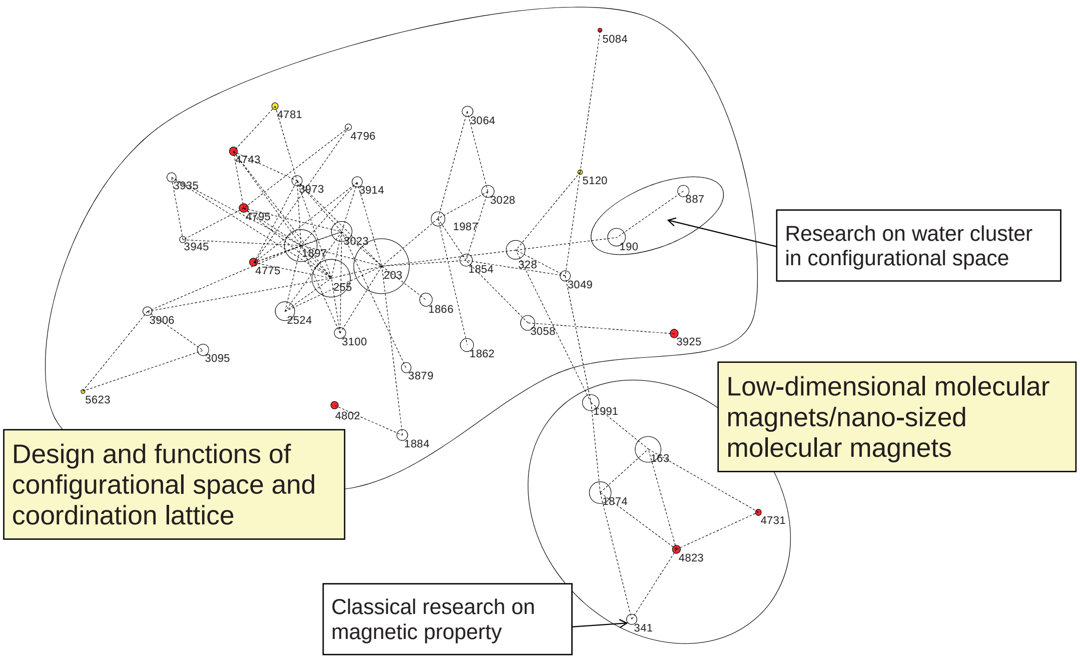
Name of RA	New-generation density functional theory for large-scale molecular calculation	RA ID	82

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
11(0)	60(2)	2419	5230	2005.7



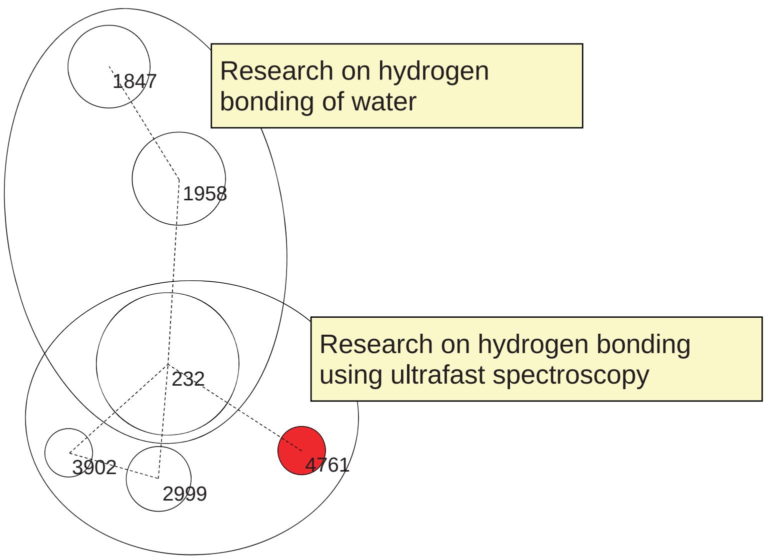
Name of RA	Design and functions of configurational space and coordination lattice	RA ID	83

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
41(8)	165(18)	6197	17354	2005.6

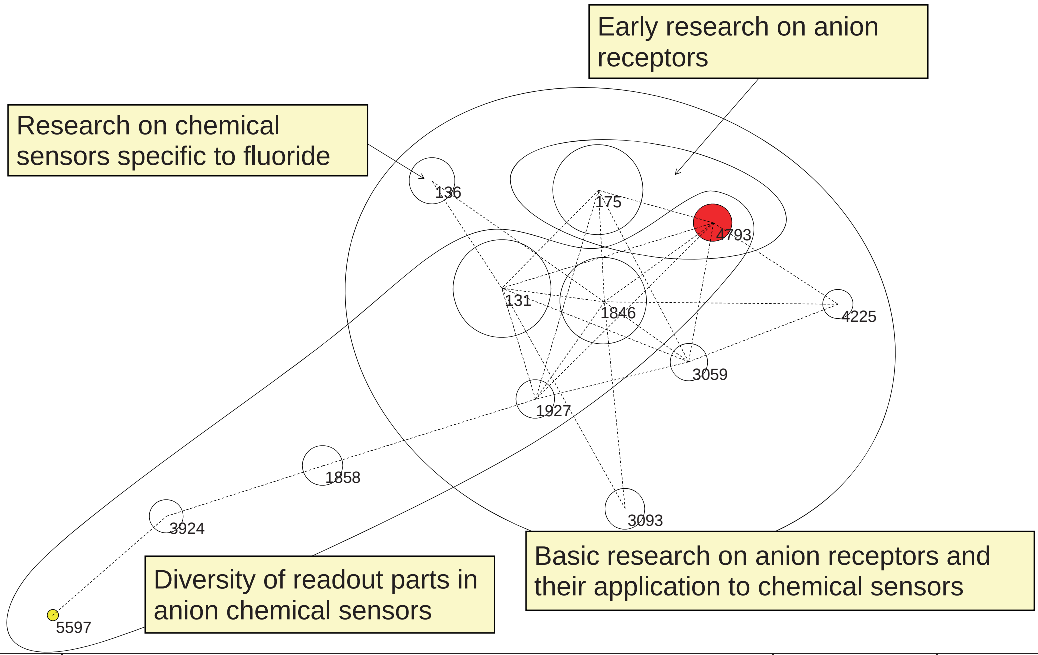


Name of RA	Research on hydrogen bonding	RA ID	84

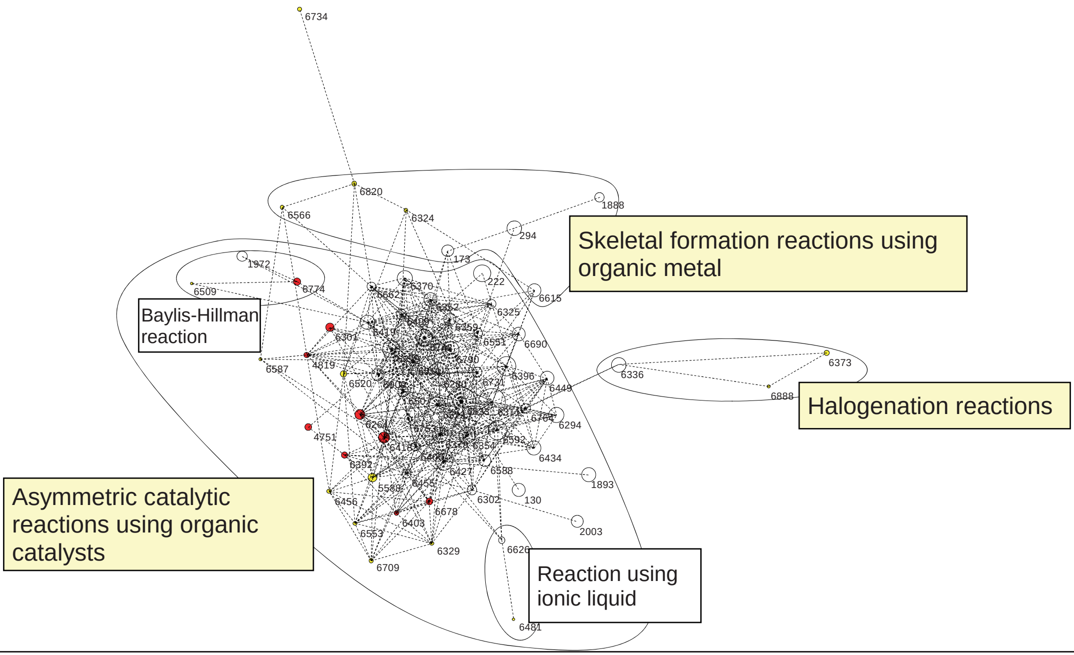
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(1)	23(0)	1197	2413	2004.6



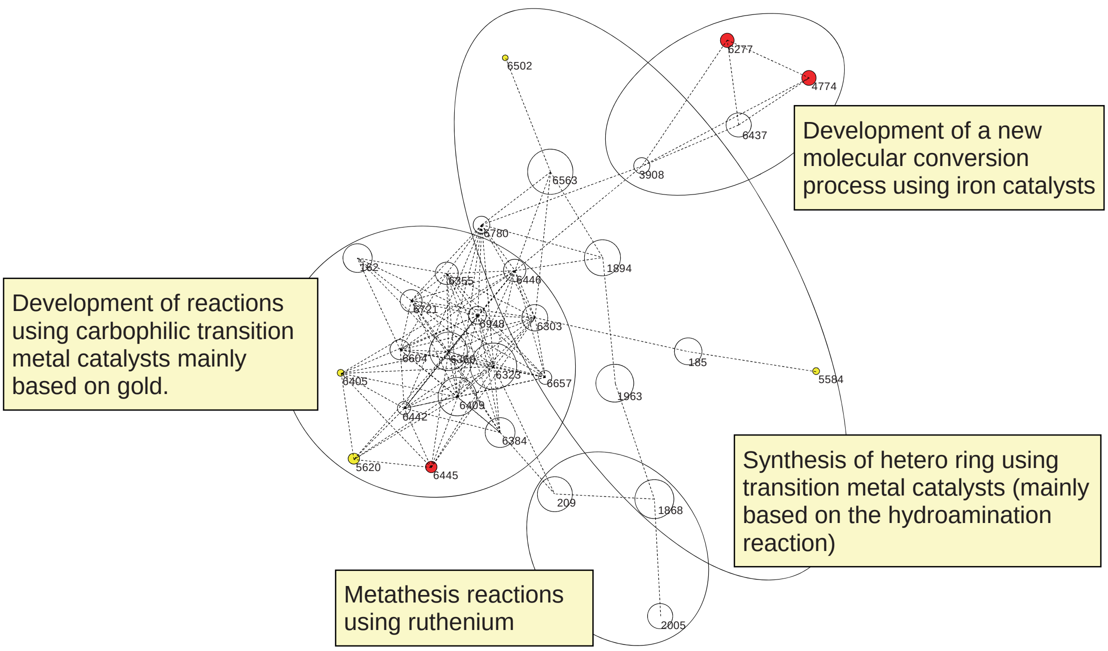
Name of RA	Anion sensors	RA ID	85	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
12(1)	48(2)	1858	4476	2005.2



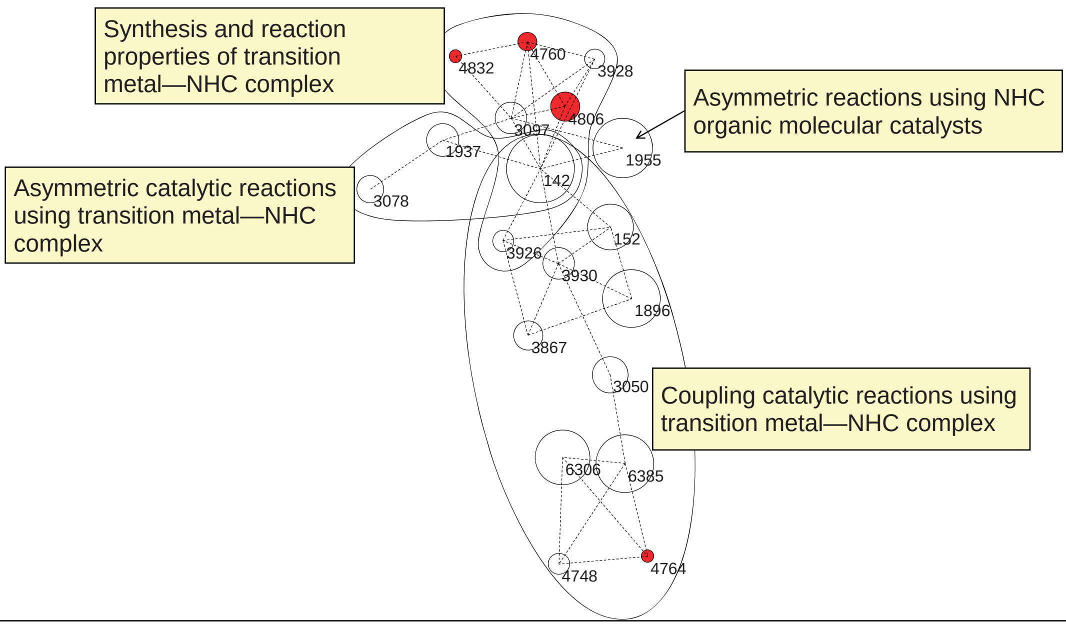
Name of RA	Catalytic asymmetric synthesis	RA ID	86	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
69(9)	289(56)	4846	23672	2005.7



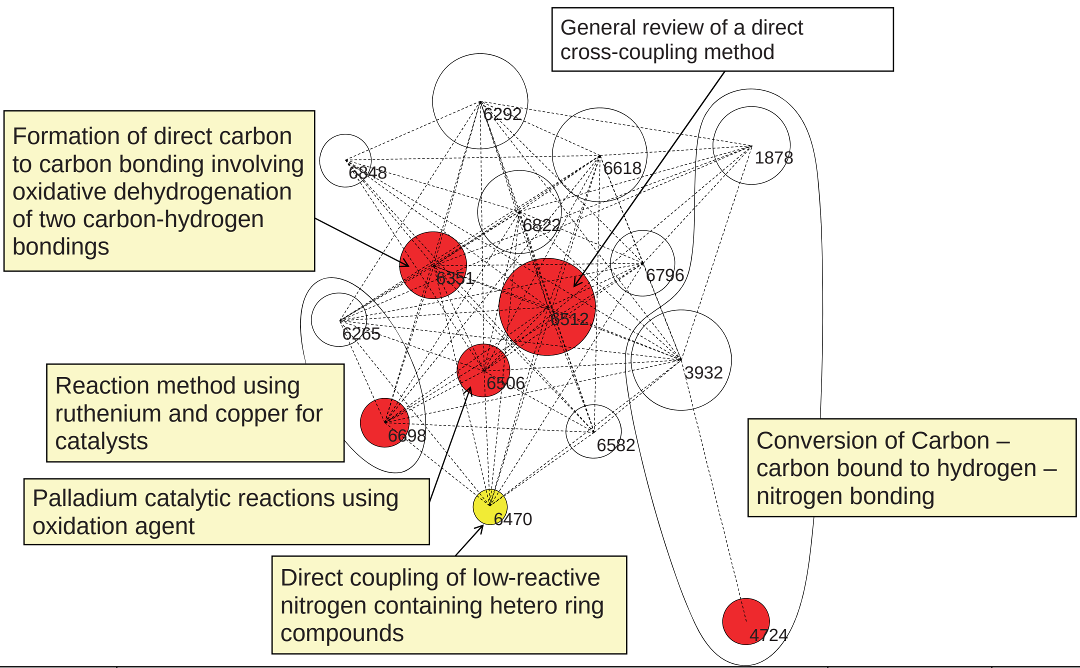
Name of RA	Molecular conversion reaction using transition metal catalyst	RA ID	87	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
30(3)	151(5)	3727	12458	2005.7



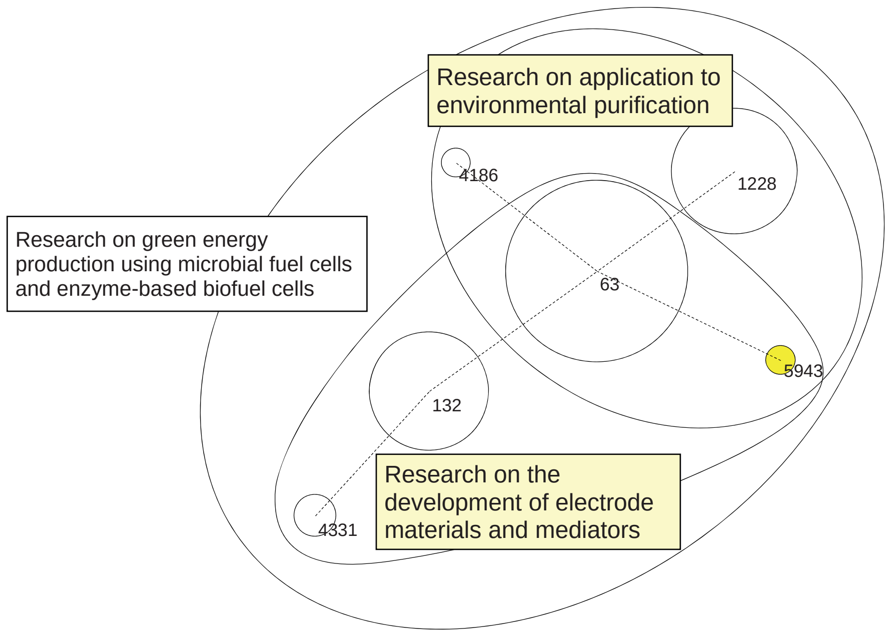
Name of RA	Synthesis of N-Heterocyclic carbene (NHC) and its application to catalytic reactions	RA ID	88	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
19(4)	95(1)	3044	7444	2005.9



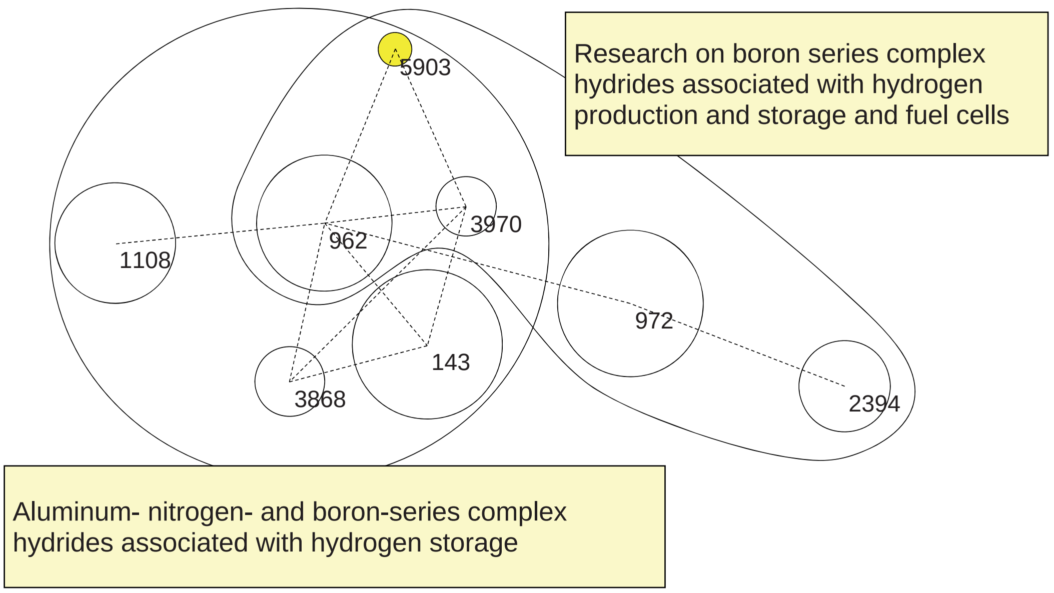
Name of RA	Direct carbon bond formation through transition metal catalytic reactions	RA ID	89	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
15(5)	53(2)	801	2670	2006.5



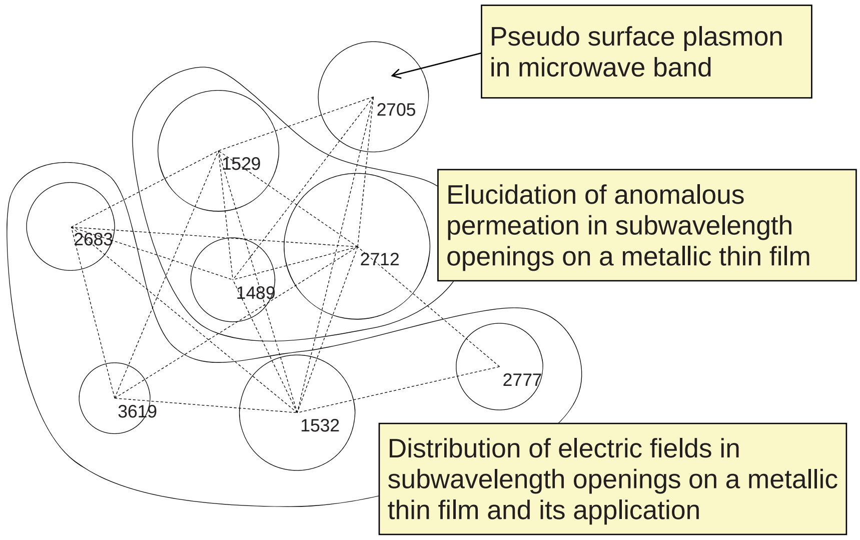
Name of RA	Microbial fuel cells/microbial cells/enzyme-based biofuel cells	RA ID	90	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(0)	60(2)	1174	3936	2005.7



Name of RA	Complex hydrides associated with hydrogen production and storage and fuel cells	RA ID	91	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
8(0)	74(23)	949	2783	2005.9

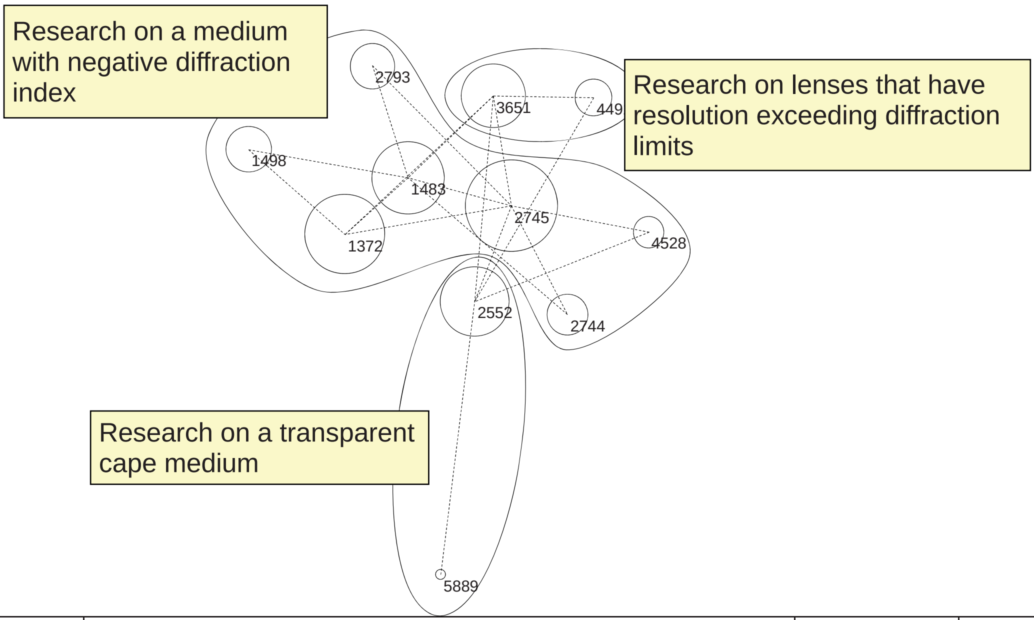


Name of RA	Electromagnetic response of surface plasmon in artificial structures	RA ID	92	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
8(0)	20(2)	1026	2165	2004.0



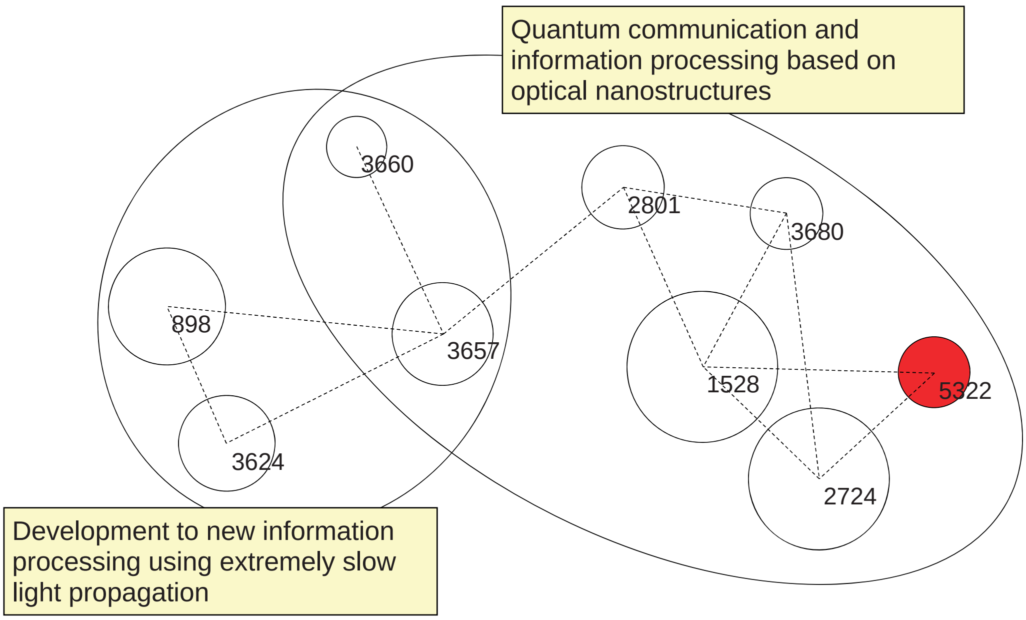
Name of RA	Meta material	RA ID	93

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
11(0)	76(0)	2167	6829	2005.8

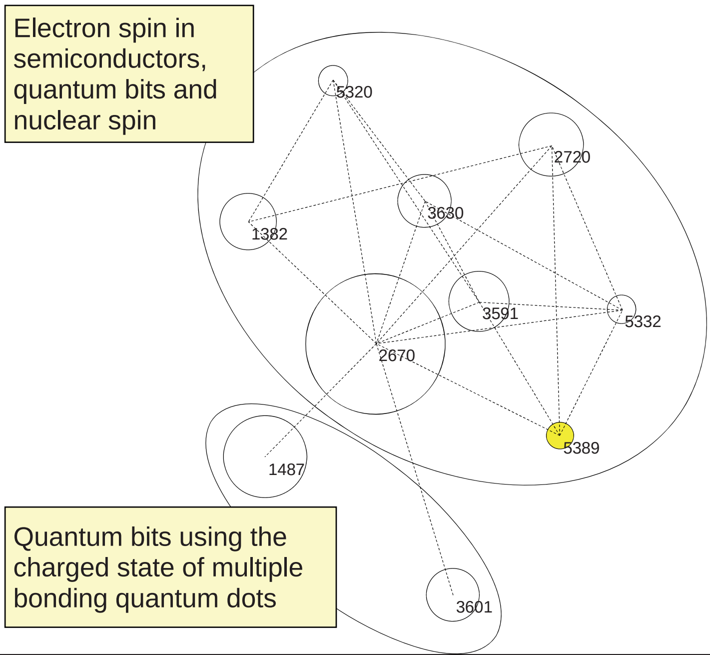


Name of RA	Optical quantum information/communication, optical nanoscience	RA ID	94

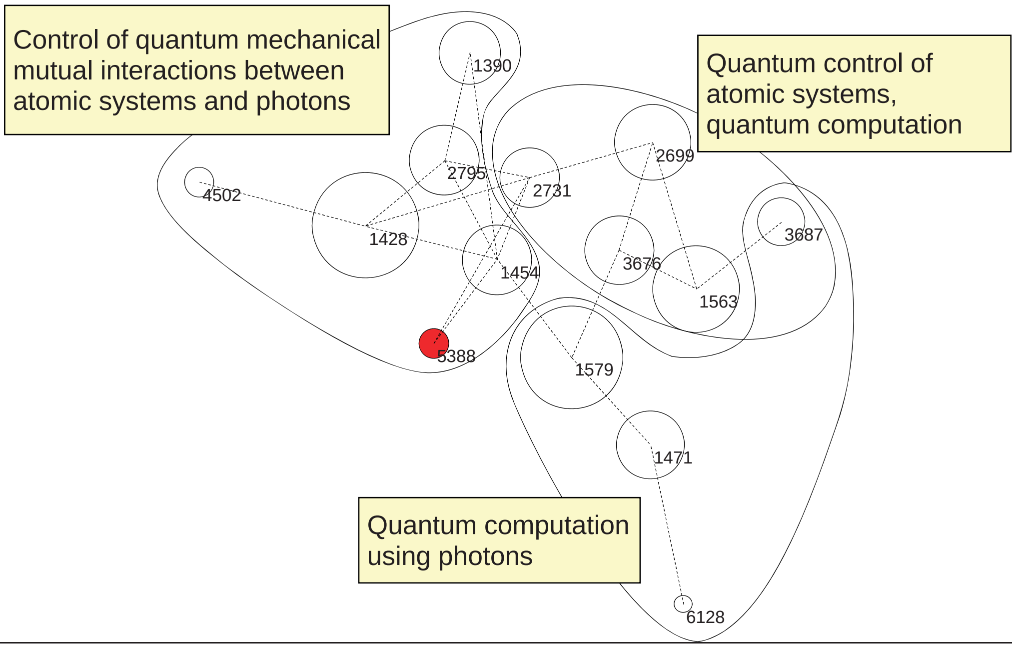
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
9(1)	30(8)	1709	3440	2005.0



Name of RA	Qubits using semiconductor quantum dots/electronic charge, electron spin and nuclear spin	RA ID	95	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
10(0)	43(3)	1539	3793	2005.5

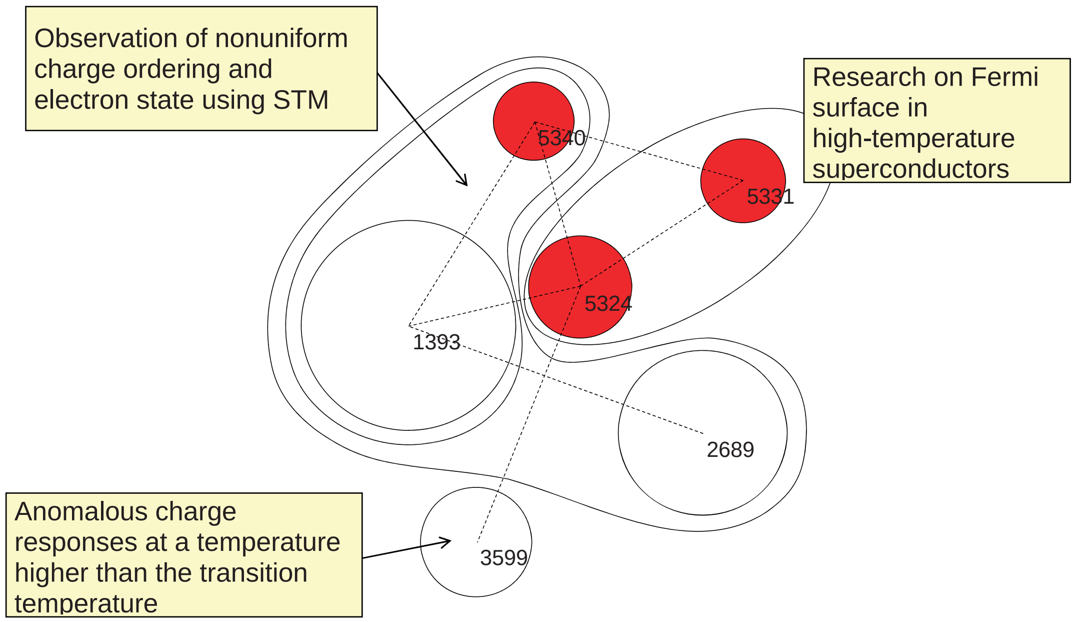


Name of RA	Quantum information science using atomic system/photons	RA ID	96	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
14(1)	47(2)	2289	5348	2004.7



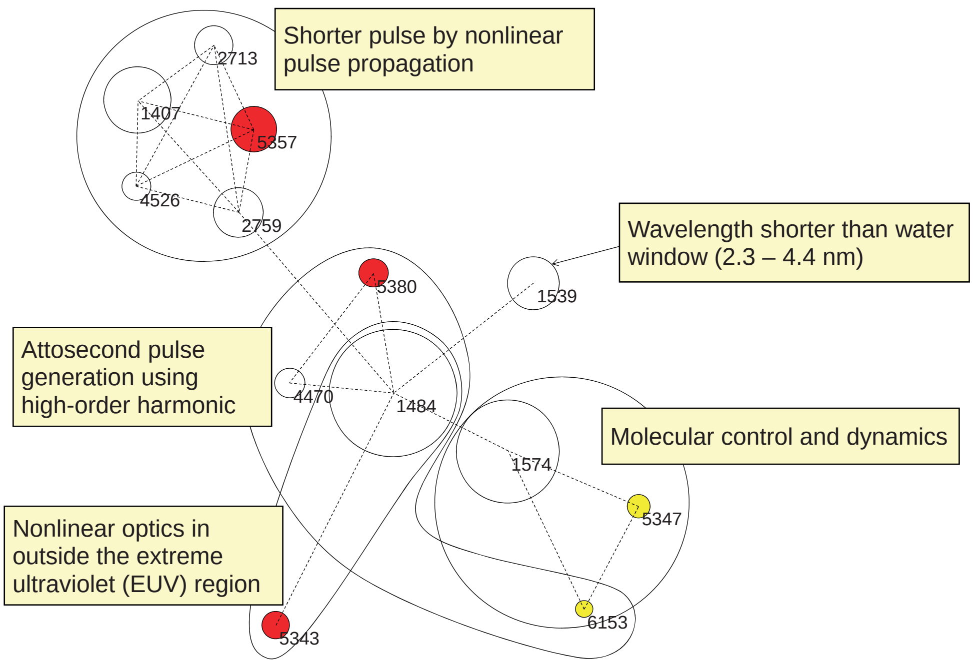
Name of RA	Novel electronic order in high-temperature superconductivity	RA ID	97

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(3)	23(12)	949	1943	2005.6



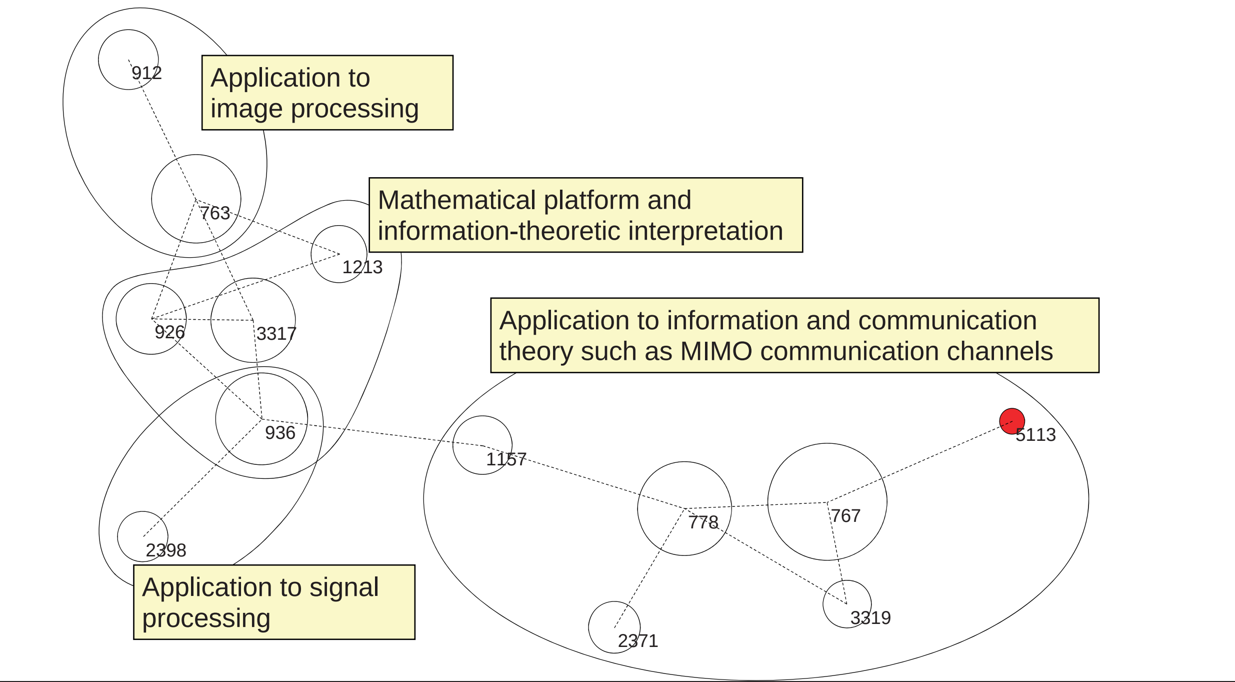
Name of RA	Ultrafast and ultraintense optical science	RA ID	98

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
13(3)	57(6)	2049	4509	2005.6



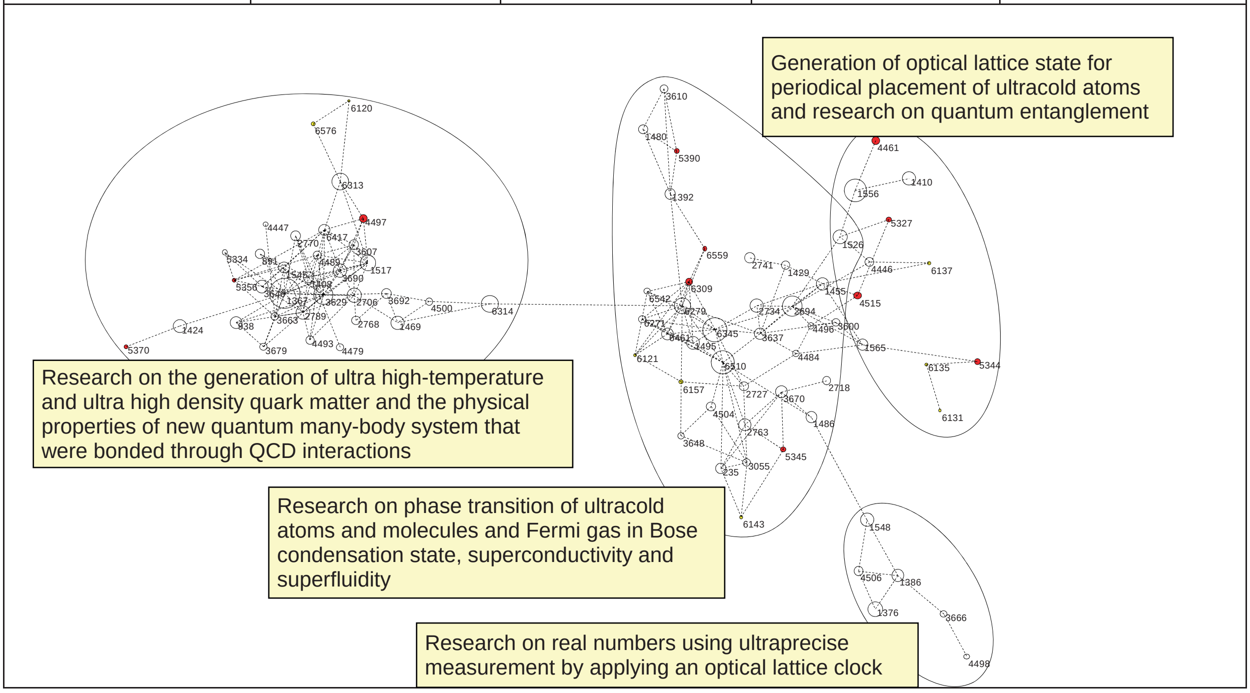
Name of RA	Limitation and application to signal processing/information theory using "sparse" property of source	RA ID	99

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
13(1)	71(1)	1324	3335	2004.9

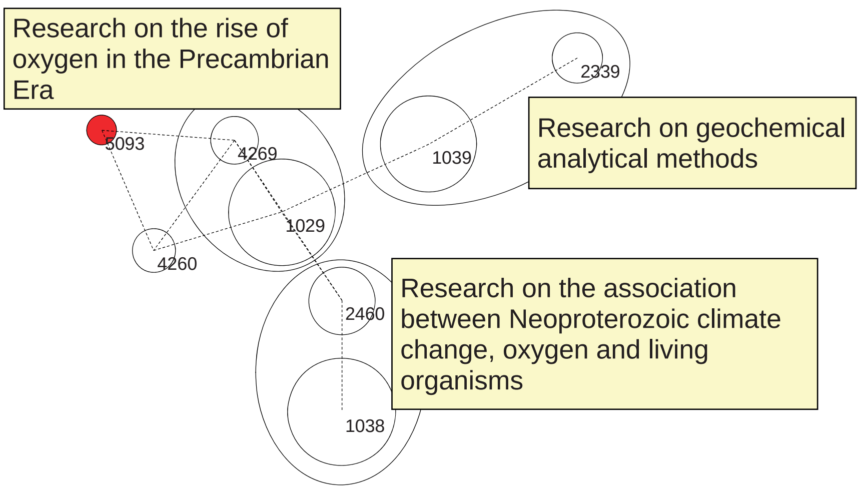


Name of RA	Strongly interacting quantum many-body system	RA ID	100

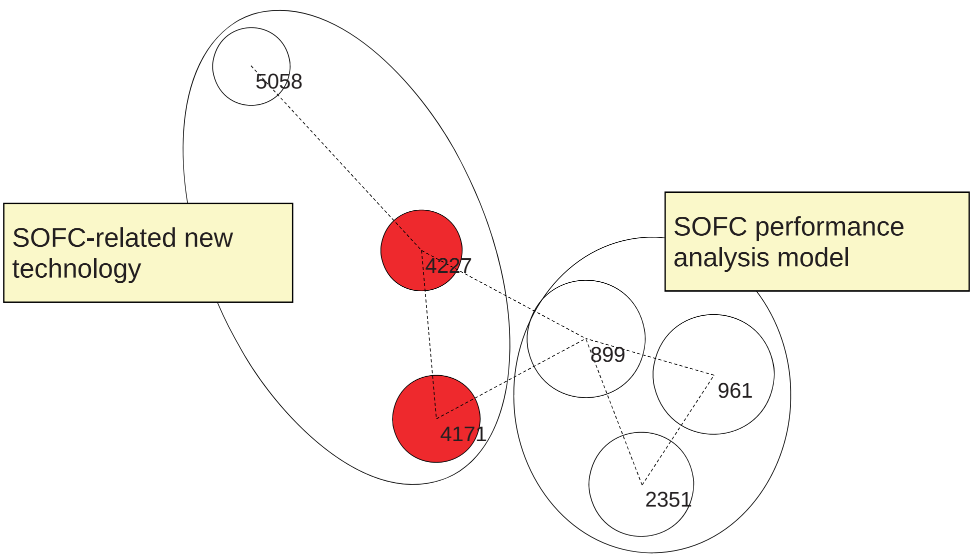
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
86(11)	471(38)	10271	40311	2005.4



Name of RA	Studies on the evolution of air and living organism in early earth and its analytical approach	RA ID	101	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
8(1)	38(1)	1003	2067	2005.2

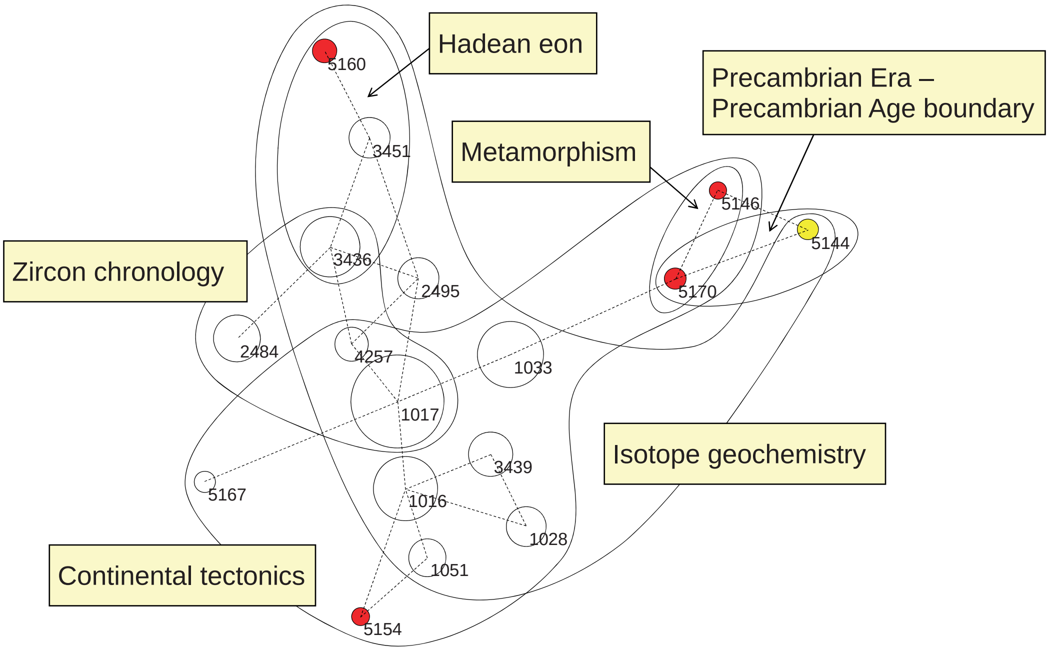


Name of RA	New technologies related to solid oxide fuel cell (SOFC)	RA ID	102	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(2)	32(0)	288	560	2006.5



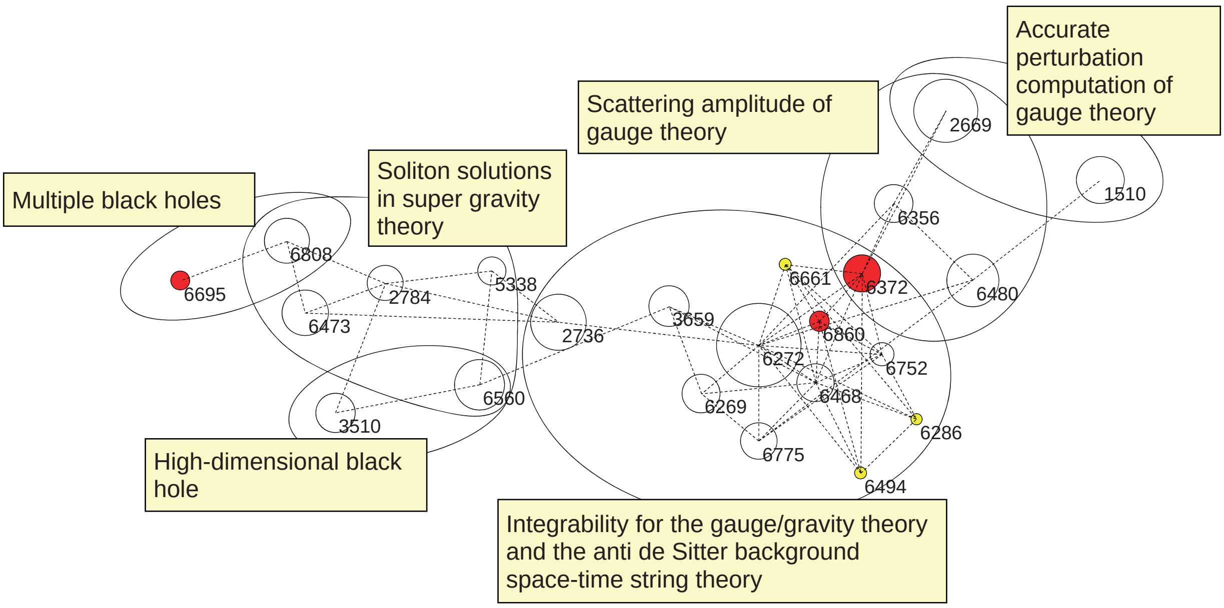
Name of RA	Earth in the Precambrian era	RA ID	103

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
17(4)	83(8)	1875	4491	2005.4



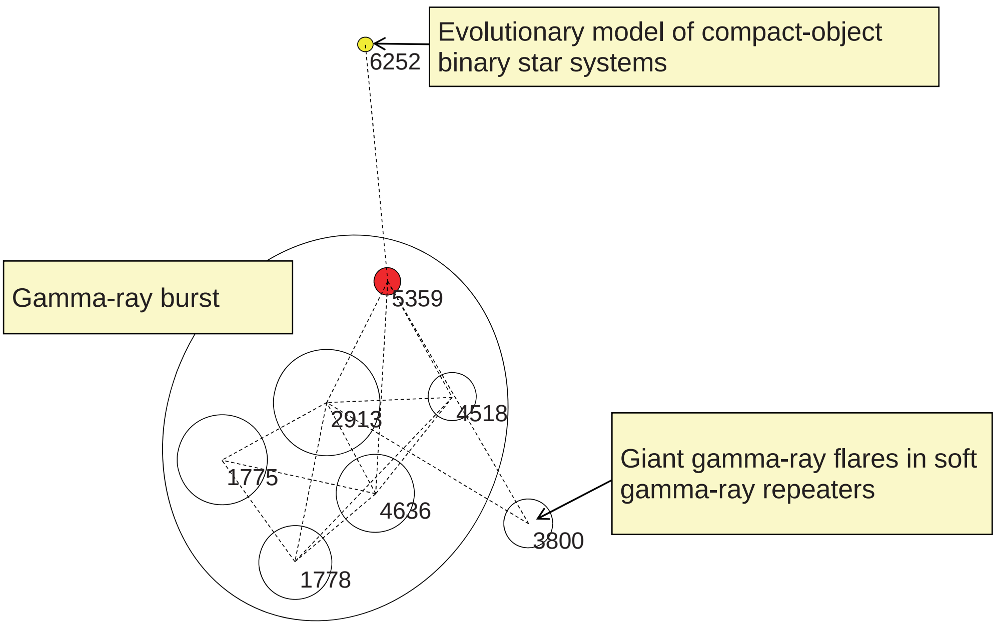
Name of RA	**Gauge/gravity theory correspondence and black hole solutions**	RA ID	104

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
23(3)	186(12)	2329	11295	2005.9



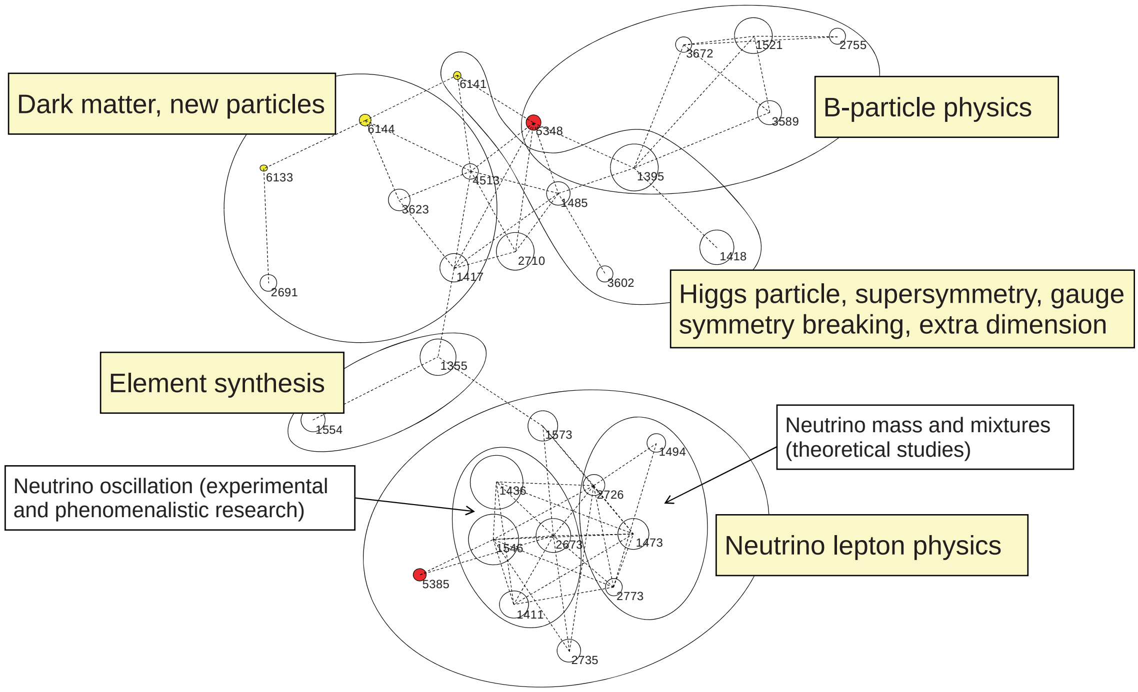
Name of RA	Gamma-ray burst	RA ID	105

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
8(1)	45(8)	1655	5488	2005.6



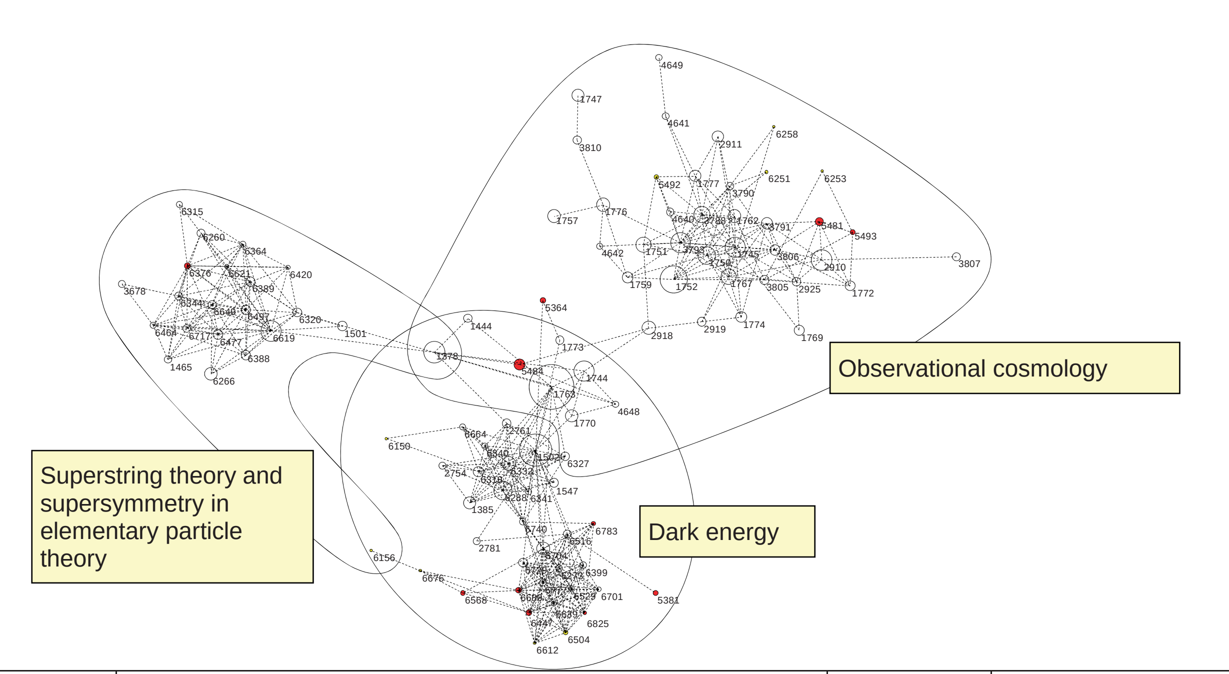
Name of RA	Elementary particle physics/elementary particle astrophysics	RA ID	106

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
30(2)	238(45)	5847	18762	2005.3



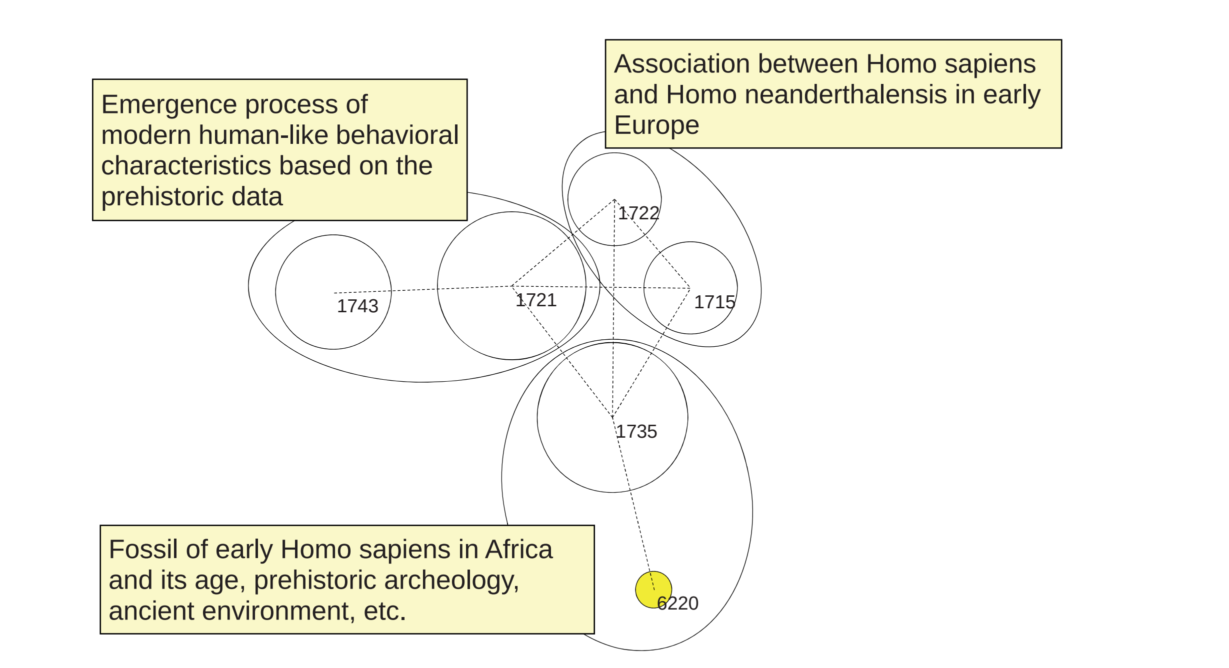
Name of RA	New developments in cosmology and elementary particles theory owing to advancement in precise observation of space	RA ID	107

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
100(11)	519(63)	16049	59338	2005.4

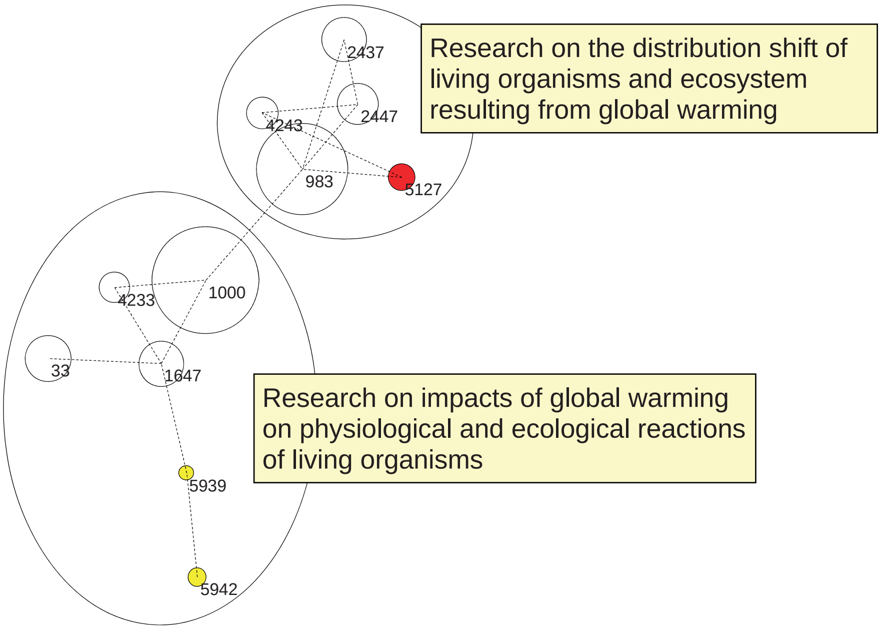


Name of RA	Emergence process of Homo sapiens	RA ID	108

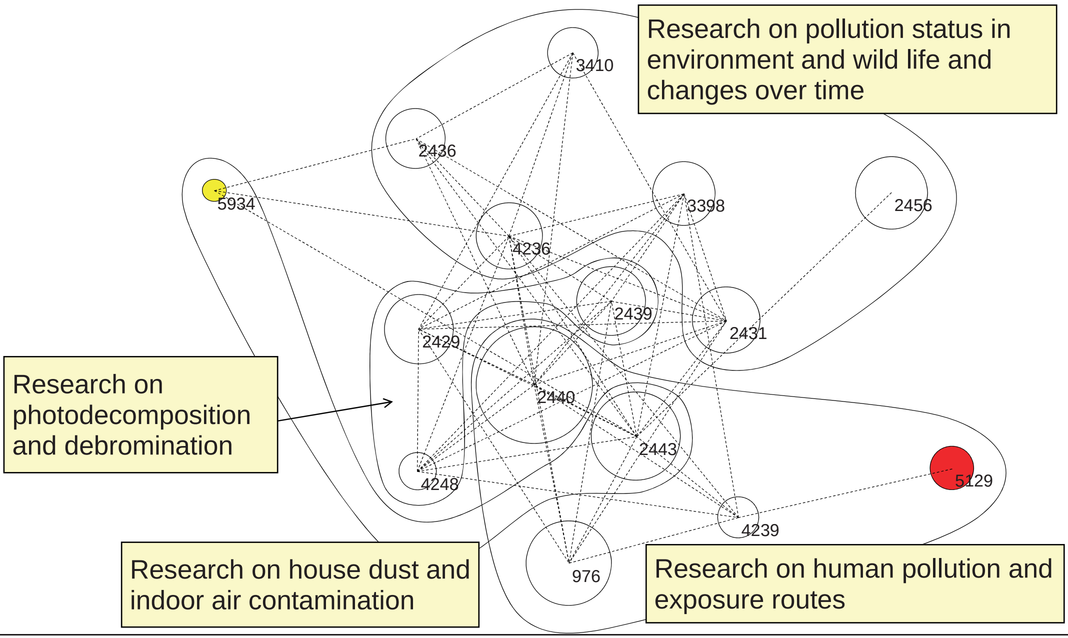
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(0)	37(2)	535	1045	2006.0



Name of RA	Warming impact/bio- and eco-systems	RA ID	109	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
11(1)	54(0)	2204	4375	2006.0

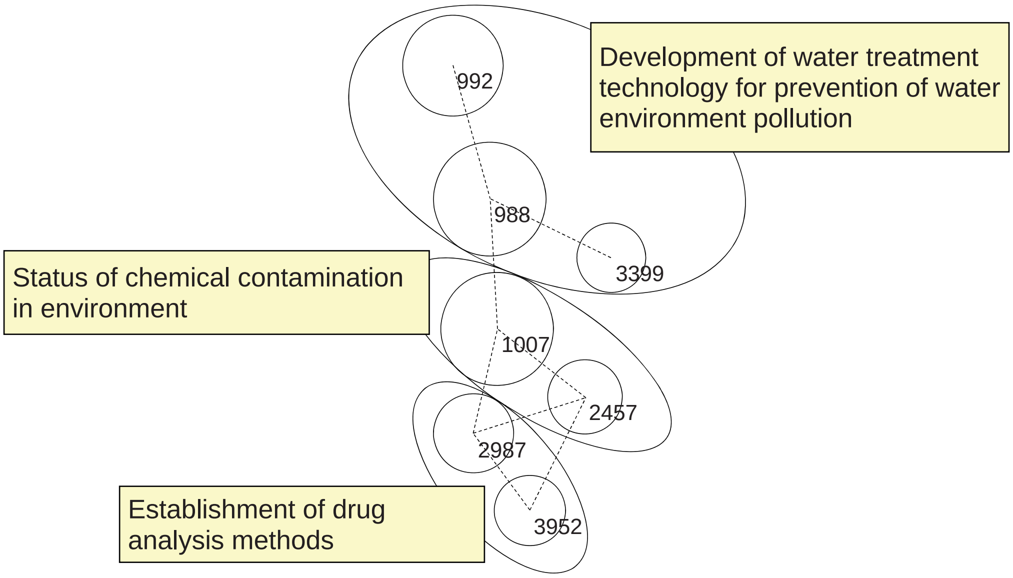


Name of RA	Environmental chemistry of bromine flame retardant	RA ID	110	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
15(1)	46(1)	1091	2927	2005.5



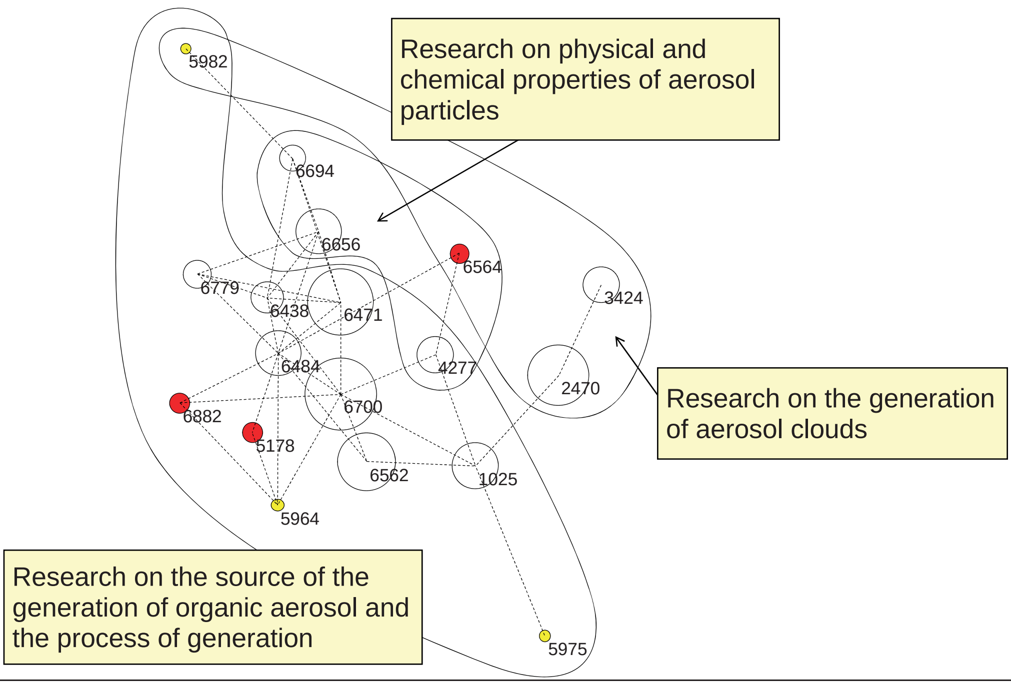
Name of RA	Environmental burden of drugs and other materials and products related to daily life and technologies to reduce the burden	RA ID	111

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
7(0)	16(0)	876	1394	2004.4

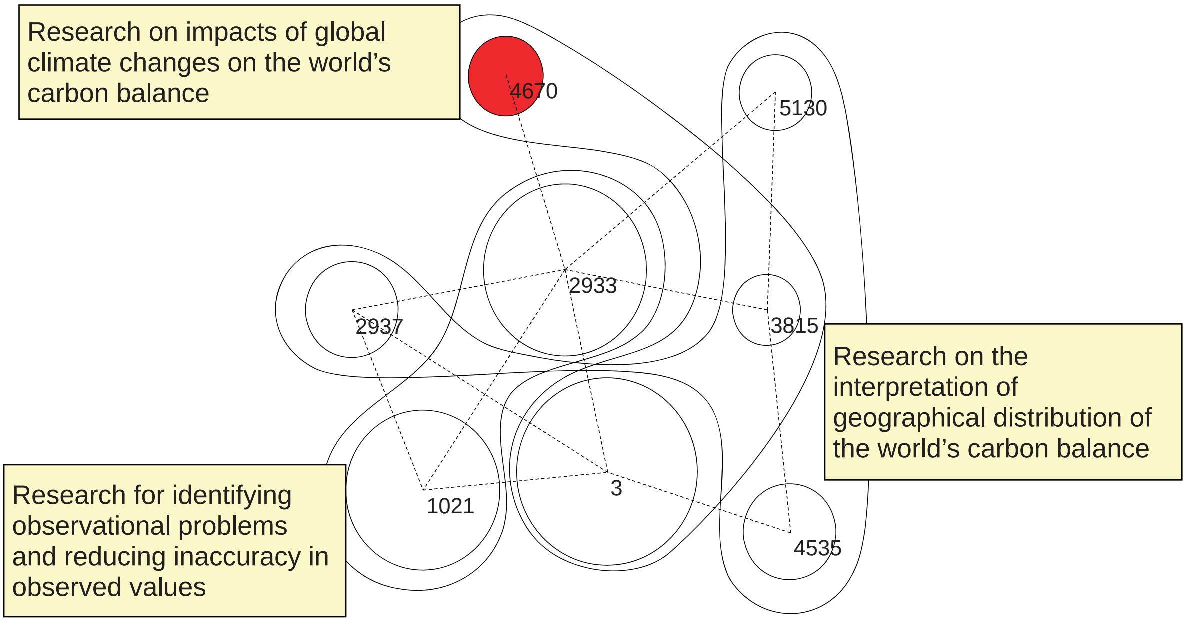


Name of RA	Organic aerosol	RA ID	112

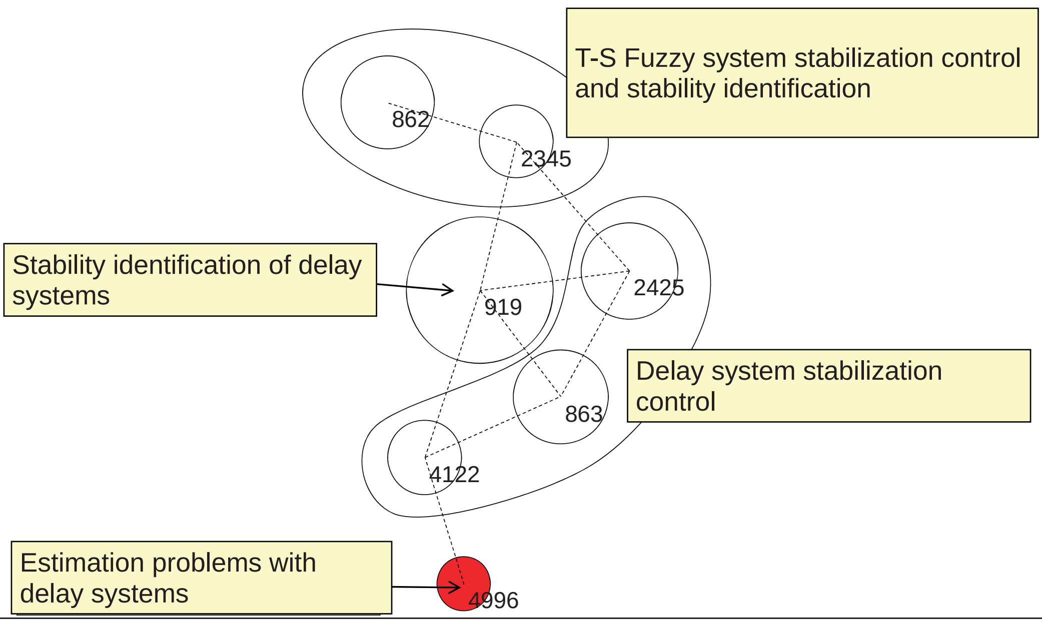
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
18(3)	50(1)	1324	3156	2005.4



Name of RA	Observational studies on carbon dioxide balance in continental ecosystem	RA ID	113	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
8(1)	29(5)	498	1066	2005.6

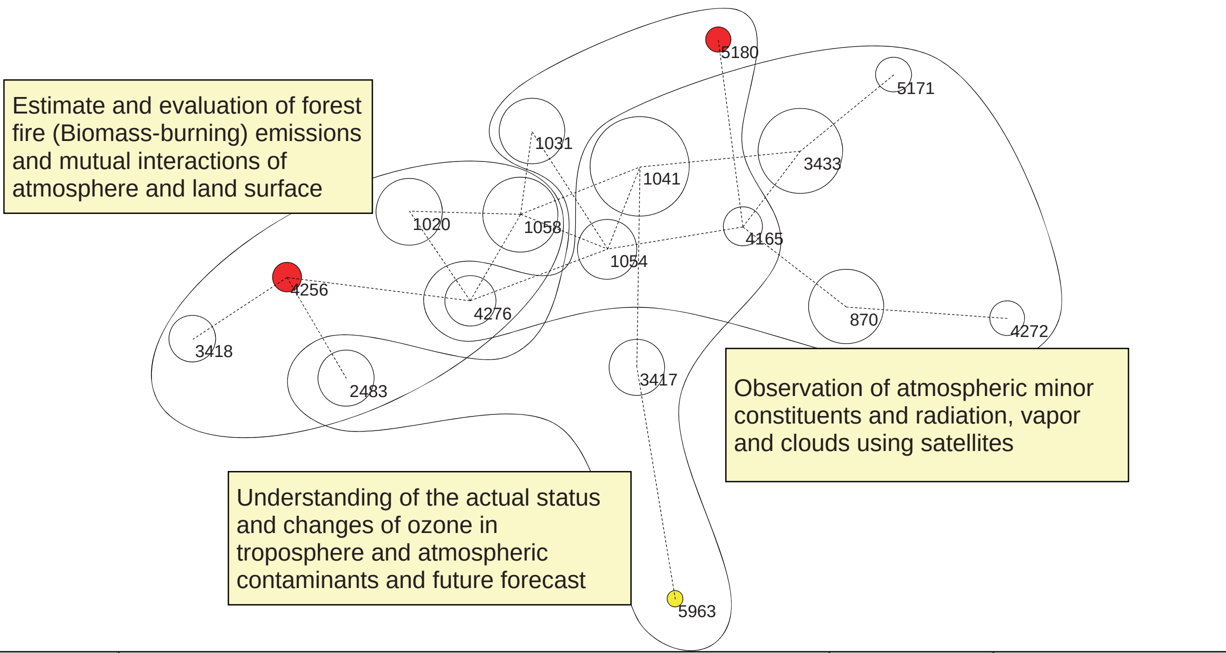


Name of RA	Stability discrimination/stabilizing control of delay system using matrix inequality	RA ID	114	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
7(1)	35(6)	703	1606	2005.1



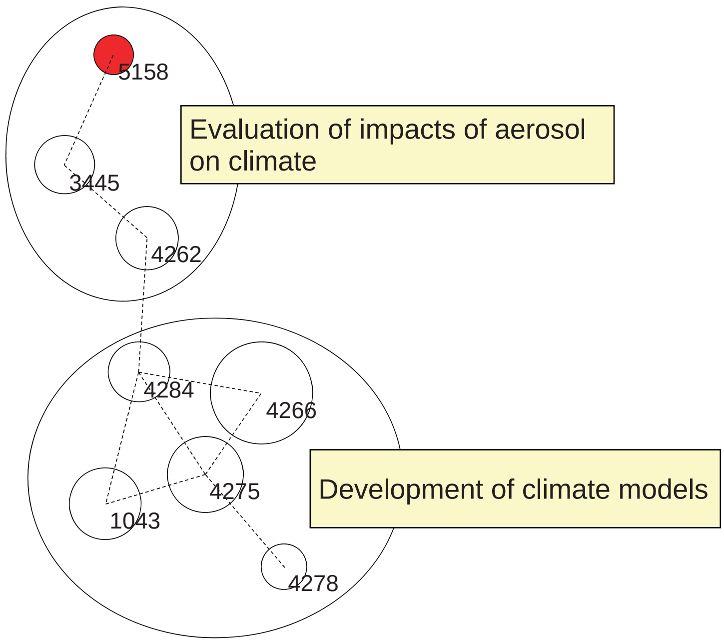
Name of RA	Atmospheric composition and minor constituents	RA ID	115

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
17(2)	69(7)	1645	3345	2005.4



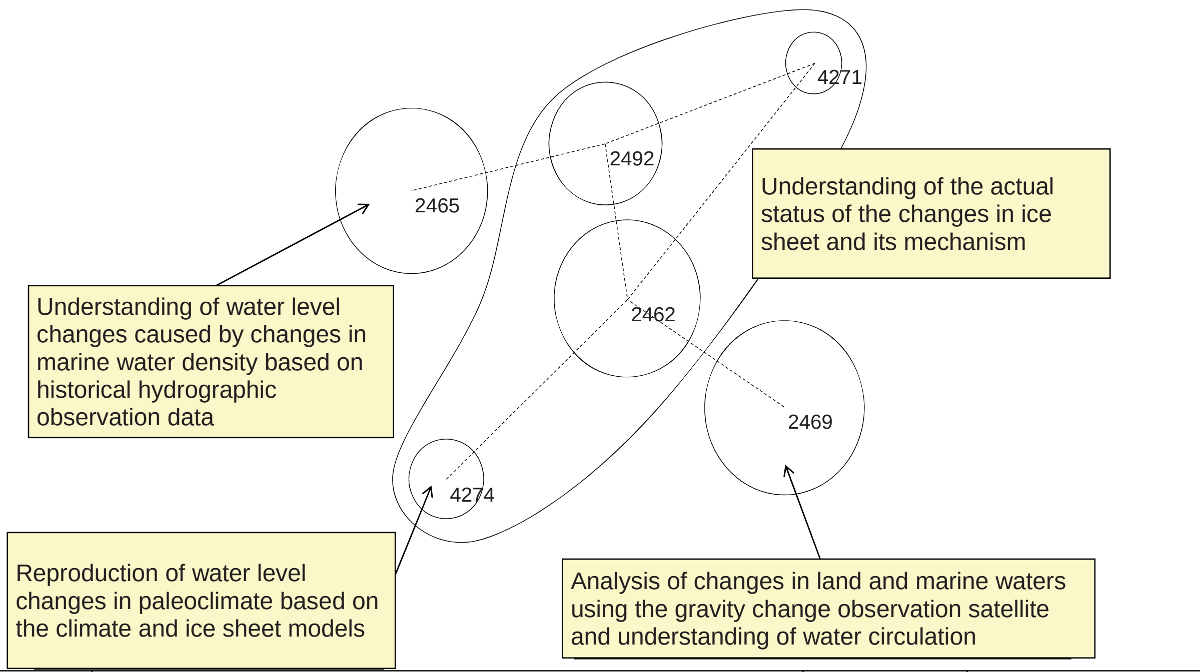
Name of RA	Climate change simulation including aerosol effects	RA ID	116

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
8(1)	24(5)	836	1426	2005.9



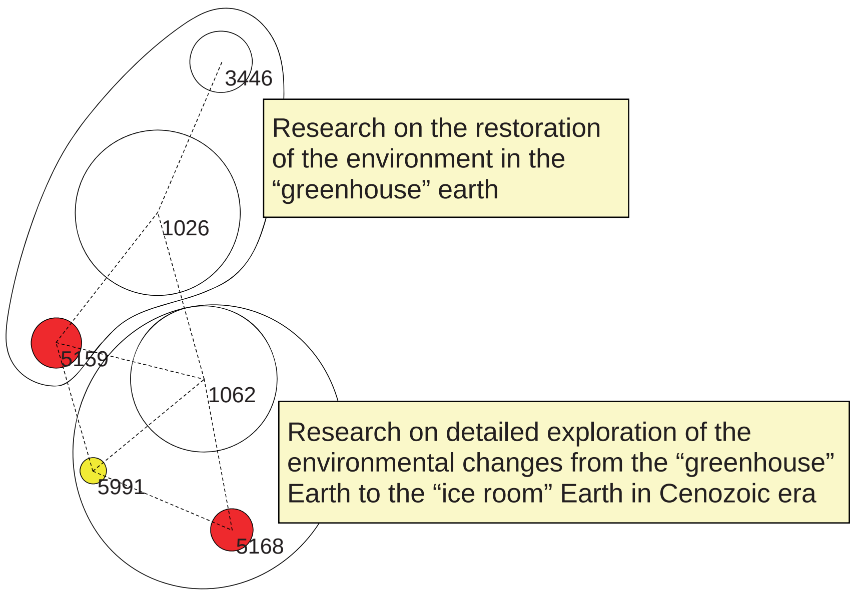
Name of RA	Sea level fluctuations/seawater density/ice sheet/water circulation	RA ID	117

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(0)	34(1)	982	1914	2005.7



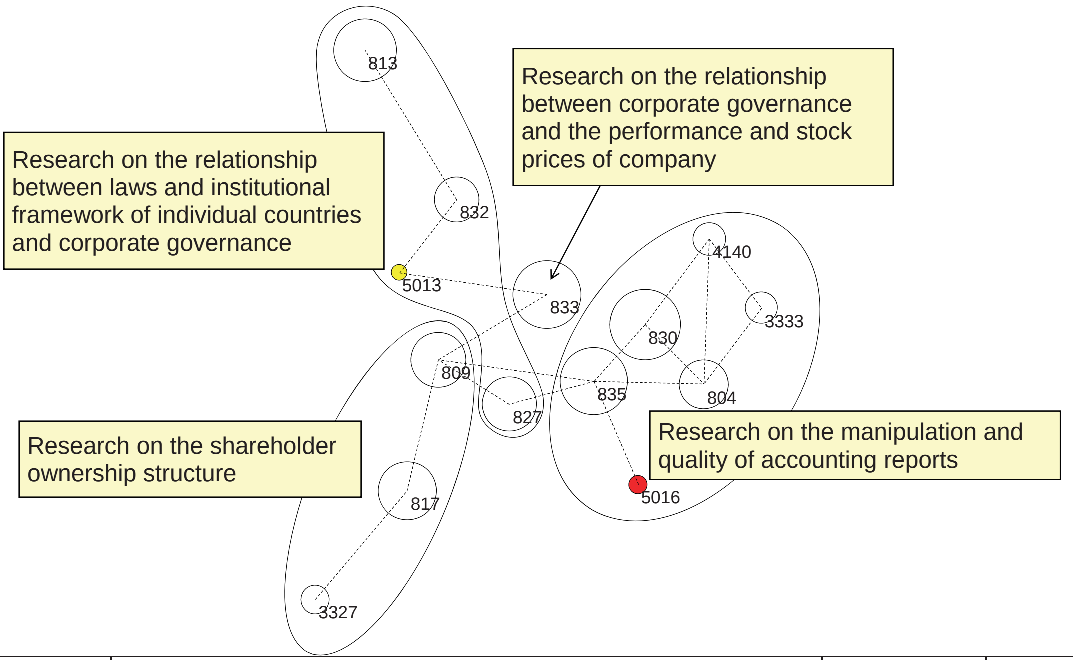
Name of RA	Restoration of the past global environmental change	RA ID	118

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
6(2)	31(1)	655	1228	2006.2



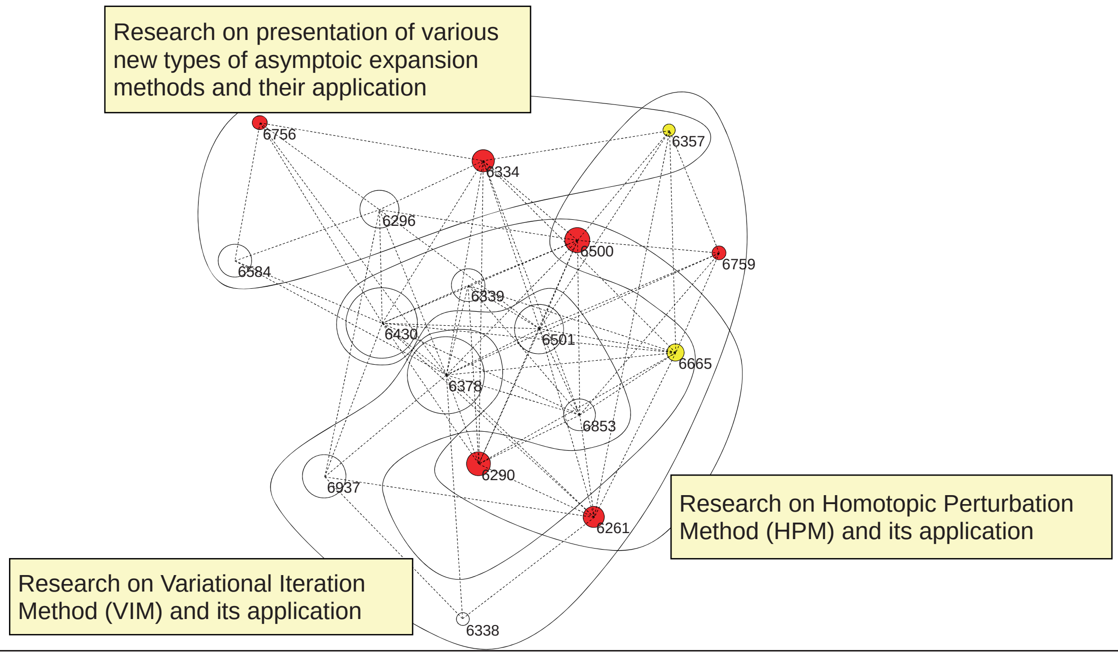
Name of RA	Corporate governance	RA ID	119

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
14(1)	48(0)	1221	2195	2005.1

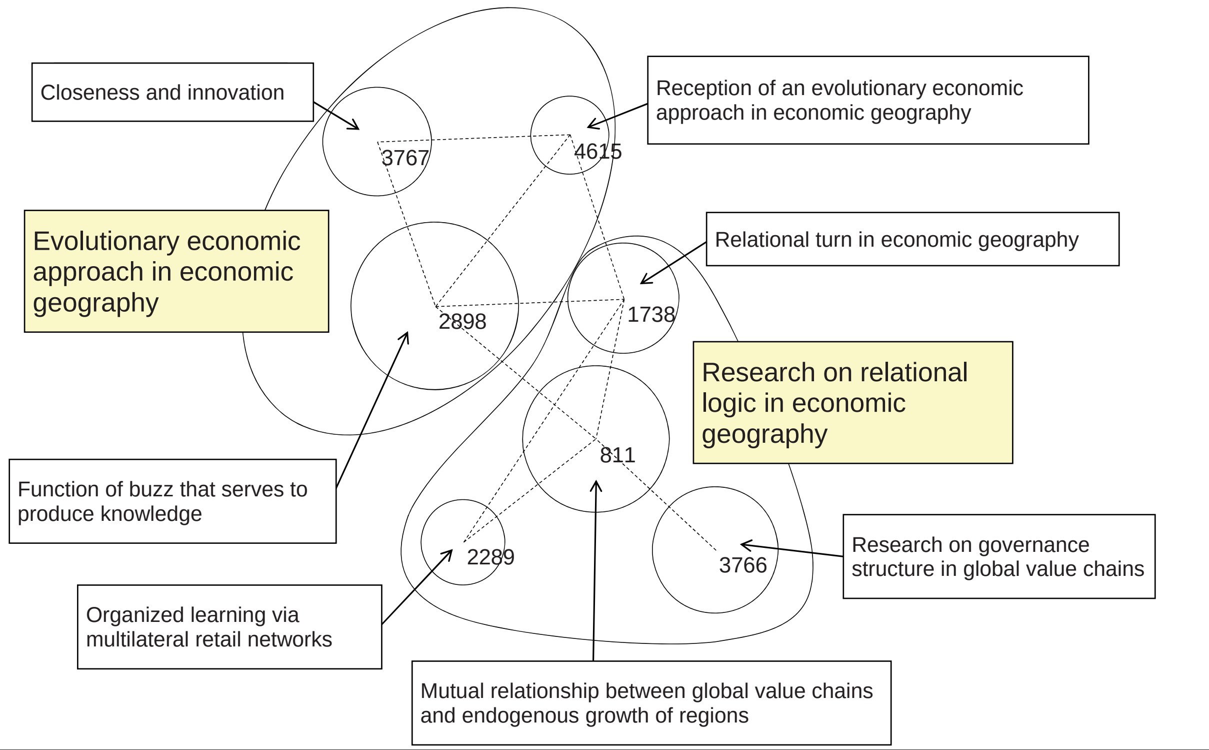


Name of RA	New asymptotic expansion method for nonlinear differential equation and its application	RA ID	120

# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
17(6)	82(0)	626	3583	2006.5



Name of RA	New trends in economic geography - Evolutionary economics and relational logic -	RA ID	121	
# of RFs (# Hot RFs)	# of core papers (# of Japanese core papers)	Unique citations	Citations	Mean publication year
7(0)	14(0)	554	900	2004.5



3. Web questionnaire survey

In Science Map 2008, a web questionnaire survey regarding the developmental status of hot research areas was carried out on those responsible for the content analysis in an attempt to capture the dynamism of scientific research.

The survey period, those surveyed and the number of respondents are as follows:
Survey period: January 13 – January 27, 2010 (Final deadline set at February 9 after reminders.)
Those who were surveyed: 121 experts responsible for content analysis
Number of respondents: 121 (100-percent response rate was obtained.)

(1) Situation of changes in research areas over time

Survey was conducted on changes observed in each research area between the period 2003 and 2008 (the period on which the survey is based) compared to the situation before 2002. As shown in Reference figure 1, the respondents of the survey were asked to select the one that best applies from among the three alternatives. About half of the respondents answered, “The research area already existed before 2002 and continued while at the same time increasing the amount of research.” Thus it is observed that research areas themselves have basically been maintained and the amount of research papers increased.

The second largest percentage of respondents answered, “Research areas that existed separately before 2002 tended to fuse and form a research area as research subsequently advanced,” and “Before 2002, this kind of research was not recognized, but as research subsequently advanced, a research area formed,” indicating that a movement that could bring about a new phase and change the characteristics of a research area itself is observed in about half of the research areas. Especially, the characteristics of fusion of research areas were more prominently detected in study on obesity, post-genome research, plant science research, life science and others.

Reference figure 1 Characteristics of hot research areas

(A) Number of responses

	Research areas that existed separately before 2002 tended to fuse and form a research area as research subsequently advanced	Before 2002, this kind of research was not recognized, but as research subsequently advanced, a research area formed	The research area existed before 2002 as well, and continues as it increases the amount of research	Unanswered	Total
Heart and blood vessels research	3	2	4	0	9
Brain research	4	2	7	1	14
Study on obesity	2	1	0	0	3
Research on regenerative medicine	1	0	2	0	3
Cancer research	0	2	3	0	5
Research on infectious diseases/immunology	1	3	7	0	11
Post-genome research	2	0	0	0	2
Plant science research	3	0	3	0	6
Life science and others	2	1	0	1	4
Chemistry	3	4	3	0	10
Nanoscience	4	4	6	1	15
Condensed matter physics	3	2	4	1	10
Particle physics/cosmology	0	1	3	0	4
Environment	3	1	6	0	10
Others	3	5	7	0	15
Total	34	28	55	4	121

(B) Shares

	Research areas that existed separately before 2002 tended to fuse and form a research area as research subsequently advanced	Before 2002, this kind of research was not recognized, but as research subsequently advanced, a research area formed	The research area existed before 2002 as well, and continues as it increases the amount of research
Heart and blood vessels research	33%	22%	44%
Brain research	31%	15%	54%
Study on obesity	67%	33%	0%
Research on regenerative medicine	33%	0%	67%
Cancer research	0%	40%	60%
Research on infectious diseases/immunology	9%	27%	64%
Post-genome research	100%	0%	0%
Plant science research	50%	0%	50%
Life science and others	67%	33%	0%
Chemistry	30%	40%	30%
Nanoscience	29%	29%	43%
Condensed matter physics	33%	22%	44%
Particle physics/cosmology	0%	25%	75%
Environment	30%	10%	60%
Others	20%	33%	47%
Total	29%	24%	47%

Note: The grouping of research areas are based on the position information of Science Map 2008. The unanswered portion in (A) are excluded from the total in Reference figure (B) showing shares.

(2) Situation surrounding hot research areas

Next, changes in the situation surrounding hot research areas were surveyed (Reference figure 2). 89 percent of respondents answered that there is participation of researchers in the field where there was no participation around 2002. This indicates that new knowledge is introduced in many fields when research areas make a new progress such as continous development and fusion.

Reference figure 2 Participation of researchers in the field where there was no participation around 2002

(A) Number of responses

	No	Yes	Unknown	Unanswered	Total
Heart and blood vessels research	1	7	1	0	9
Brain research	0	10	4	0	14
Study on obesity	0	3	0	0	3
Research on regenerative medicine	0	3	0	0	3
Cancer research	0	5	0	0	5
Research on infectious diseases/immunology	0	10	1	0	11
Post-genome research	0	2	0	0	2
Plant science research	0	6	0	0	6
Life science and others	0	4	0	0	4
Chemistry	2	7	1	0	10
Nanoscience	0	15	0	0	15
Condensed matter physics	1	9	0	0	10
Particle physics/cosmology	0	3	0	1	4
Environment	0	10	0	0	10
Others	0	13	2	0	15
Total	4	107	9	1	121

(B) Shares

	No	Yes	Unknown
Heart and blood vessels research	11%	78%	11%
Brain research	0%	71%	29%
Study on obesity	0%	100%	0%
Research on regenerative medicine	0%	100%	0%
Cancer research	0%	100%	0%
Research on infectious diseases/immunology	0%	91%	9%
Post-genome research	0%	100%	0%
Plant science research	0%	100%	0%
Life science and others	0%	100%	0%
Chemistry	20%	70%	10%
Nanoscience	0%	100%	0%
Condensed matter physics	10%	90%	0%
Particle physics/cosmology	0%	100%	0%
Environment	0%	100%	0%
Others	0%	87%	13%
Total	3%	89%	8%

Because the Science Map is created based on the data base of academic papers, it represents the situation of the so-called basic research. On the other hand, expectations from society are also increasing for basic research itself. As shown in Reference figure 3, survey was conducted on views of researchers regarding the current relationship between social agenda (measures for infectious diseases, creation of new industry, etc.) and their research areas using a five-point scale of the strength of the relationship. Characteristics of each field can be observed from the variation of index.

An overall average index of 3.6 indicates that the respondents judged the relationship between the research areas they were in charge of and social agenda to be relatively strong. Fields with higher index scores include, in descending order, cancer research, study on obesity, research on infectious diseases/immunology, heart and blood vessels research, research on regenerative medicine, life science and others and nanoscience. While most of those with higher scores are the groups of research areas in life science which have field sites for clinical medicine as a contact point with real world, nanoscience is also placed high which is worth noting.

Reference figure 3 Current strength of relationship with social agenda (Measures for infectious diseases, creation of new industries, etc.)

(A) Number of responses and index

	Weak (1)	Somewhat weak (2)	Average (3)	Somewhat strong (4)	Strong (5)	Unknown	Total	Index
Heart and blood vessels research	1	0	1	3	4	0	9	4.0
Brain research	2	1	1	4	5	1	14	3.4
Study on obesity	0	0	1	0	2	0	3	4.3
Research on regenerative medicine	0	0	1	1	1	0	3	4.0
Cancer research	0	0	1	0	4	0	5	4.6
Research on infectious diseases/immunology	0	1	2	3	5	0	11	4.1
Post-genome research	0	0	1	1	0	0	2	3.5
Plant science research	1	0	2	3	0	0	6	3.2
Life science and others	0	0	1	2	1	0	4	4.0
Chemistry	1	2	2	3	2	0	10	3.3
Nanoscience	0	1	5	2	7	0	15	4.0
Condensed matter physics	1	0	4	4	1	0	10	3.4
Particle physics/cosmology	3	1	0	0	0	0	4	1.3
Environment	3	2	1	2	2	0	10	2.8
Others	1	4	1	4	5	0	15	3.5
Total	13	12	24	32	39	1	121	3.6

(B) Share

	Weak (1)	Somewhat weak (2)	Average (3)	Somewhat strong (4)	Strong (5)	Unknown
Heart and blood vessels research	11%	0%	11%	33%	44%	0%
Brain research	14%	7%	7%	29%	36%	7%
Study on obesity	0%	0%	33%	0%	67%	0%
Research on regenerative medicine	0%	0%	33%	33%	33%	0%
Cancer research	0%	0%	20%	0%	80%	0%
Research on infectious diseases/immunology	0%	9%	18%	27%	45%	0%
Post-genome research	0%	0%	50%	50%	0%	0%
Plant science research	17%	0%	33%	50%	0%	0%
Life science and others	0%	0%	25%	50%	25%	0%
Chemistry	10%	20%	20%	30%	20%	0%
Nanoscience	0%	7%	33%	13%	47%	0%
Condensed matter physics	10%	0%	40%	40%	10%	0%
Particle physics/cosmology	75%	25%	0%	0%	0%	0%
Environment	30%	20%	10%	20%	20%	0%
Others	7%	27%	7%	27%	33%	0%
Total	11%	10%	20%	26%	32%	1%

In addition, Reference figure 4 investigated how the relationship with social agenda changed during the period between 2003 and 2008 (period on which the analysis is based). 71 percent of the respondents evaluated that the relationship with social agenda increased during this period. As shown in Reference figure 5 the relationship with social agenda was also evaluated to have increased in the groups of research areas which were found to have a strong relationship at present in Reference figure 3, whereas, no changes in the relationship with social agenda are observed and the relationship itself is not strong in particle physics/cosmology.

Reference figure 4　Increase and decrease in relationship with social agenda (during the period between 2003 and 2008)

(A) Number of responses

	Decreased	Increased	No change	Unknown	Total
Heart and blood vessels research	0	6	3	0	9
Brain research	0	10	2	2	14
Study on obesity	0	2	1	0	3
Research on regenerative medicine	0	3	0	0	3
Cancer research	0	4	0	1	5
Research on infectious diseases/immunology	0	9	2	0	11
Post-genome research	0	1	1	0	2
Plant science research	0	4	2	0	6
Life science and others	0	4	0	0	4
Chemistry	0	8	2	0	10
Nanoscience	0	12	2	1	15
Condensed matter physics	0	8	2	0	10
Particle physics/cosmology	0	0	4	0	4
Environment	0	7	3	0	10
Others	0	8	6	1	15
Total	0	86	30	5	121

(B) Shares

	Decreased	Increased	No change	Unknown
Heart and blood vessels research	0%	67%	33%	0%
Brain research	0%	71%	14%	14%
Study on obesity	0%	67%	33%	0%
Research on regenerative medicine	0%	100%	0%	0%
Cancer research	0%	80%	0%	20%
Research on infectious diseases/immunology	0%	82%	18%	0%
Post-genome research	0%	50%	50%	0%
Plant science research	0%	67%	33%	0%
Life science and others	0%	100%	0%	0%
Chemistry	0%	80%	20%	0%
Nanoscience	0%	80%	13%	7%
Condensed matter physics	0%	80%	20%	0%
Particle physics/cosmology	0%	0%	100%	0%
Environment	0%	70%	30%	0%
Others	0%	53%	40%	7%
Total	0%	71%	25%	4%

Reference figure 5　Relationship between the strength and changes in the relationship with social agenda

	Current relationship with social agenda (Measures for infectious diseases, creation of new industries, etc.)							
	Weak (1)	Somewhat weak (2)	Average (3)	Somewhat strong (4)	Strong (5)	Unknown	Total	Index
Decreased	0	0	0	0	0	0	0	-
Increased	0	6	15	29	36	0	86	4.1
No change	12	6	8	2	2	0	30	2.2
Unknown	1		1	1	1	1	5	-
Total	13	12	24	32	39	1	121	3.6

As changes in the situation surrounding research areas, the increase and decrease in the number of groups abroad, the relationship with which is competitive (in rivalry), during the period between 2003 and 2008 (the period on which the analysis is based) were investigated in Reference figure 6. 93 percent of the respondents answered that the number of groups abroad with which the relationship is competitive increased. Next, the current situation of research and development funds was surveyed in comparison with the groups abroad whose situation can be monitored and with which the relationship is competitive (Reference figure 7). 78 percent of the respondents answered that their competitors have more research and development funds.

Reference figure 8 investigated changes in the amount of funds during the period between 2003 and 2008 (the period on which the analysis is based). 39 percent of the respondents answered that the difference in research and development costs widened, whereas 27 percent answered unknown. This indicates that it is difficult for researchers to grasp these changes.

Reference figure 6 Increase and decrease in the number of groups abroad the relationship with which is competitive (rivals) (during the period between 2003 and 2008)

(A) Number of responses

	Decreased	Increased	No change	Unknown	Total
Heart and blood vessels research	0	7	1	1	9
Brain research	0	12	1	1	14
Study on obesity	0	3	0	0	3
Research on regenerative medicine	0	3	0	0	3
Cancer research	1	4	0	0	5
Research on infectious diseases/immunology	0	10	1	0	11
Post-genome research	0	2	0	0	2
Plant science research	0	6	0	0	6
Life science and others	0	4	0	0	4
Chemistry	0	10	0	0	10
Nanoscience	0	15	0	0	15
Condensed matter physics	1	9	0	0	10
Particle physics/cosmology	0	4	0	0	4
Environment	0	10	0	0	10
Others	0	14	1	0	15
Total	2	113	4	2	121

(B) Share

	Decreased	Increased	No change	Unknown
Heart and blood vessels research	0%	78%	11%	11%
Brain research	0%	86%	7%	7%
Study on obesity	0%	100%	0%	0%
Research on regenerative medicine	0%	100%	0%	0%
Cancer research	20%	80%	0%	0%
Research on infectious diseases/immunology	0%	91%	9%	0%
Post-genome research	0%	100%	0%	0%
Plant science research	0%	100%	0%	0%
Life science and others	0%	100%	0%	0%
Chemistry	0%	100%	0%	0%
Nanoscience	0%	100%	0%	0%
Condensed matter physics	10%	90%	0%	0%
Particle physics/cosmology	0%	100%	0%	0%
Environment	0%	100%	0%	0%
Others	0%	93%	7%	0%
Total	2%	93%	3%	2%

Reference figure 7 Current status of research and development funds in comparison with rivals whose situation can be monitored

(A) Number of responses

	Rival has more funds	Rival has somewhat more funds	Same level	My group has somewhat more funds	My group has more funds	Unkown	Total
Heart and blood vessels research	7	0	1	0	0	1	9
Brain research	9	3	2	0	0	0	14
Study on obesity	3	0	0	0	0	0	3
Research on regenerative medicine	2	0	0	1	0	0	3
Cancer research	3	1	1	0	0	0	5
Research on infectious diseases/immunology	6	2	1	0	0	2	11
Post-genome research	2	0	0	0	0	0	2
Plant science research	5	1	0	0	0	0	6
Life science and others	2	2	0	0	0	0	4
Chemistry	4	2	2	0	0	2	10
Nanoscience	6	4	3	0	0	2	15
Condensed matter physics	5	5	0	0	0	0	10
Particle physics/cosmology	2	0	1	0	0	1	4
Environment	7	0	2	0	0	1	10
Others	10	2	0	0	1	2	15
Total	73	22	13	1	1	11	121

(B) Share

	Rival has more funds	Rival has somewhat more funds	Same level	My group has somewhat more funds	My group has more funds	Unkown
Heart and blood vessels research	78%	0%	11%	0%	0%	11%
Brain research	64%	21%	14%	0%	0%	0%
Study on obesity	100%	0%	0%	0%	0%	0%
Research on regenerative medicine	67%	0%	0%	33%	0%	0%
Cancer research	60%	20%	20%	0%	0%	0%
Research on infectious diseases/immunology	55%	18%	9%	0%	0%	18%
Post-genome research	100%	0%	0%	0%	0%	0%
Plant science research	83%	17%	0%	0%	0%	0%
Life science and others	50%	50%	0%	0%	0%	0%
Chemistry	40%	20%	20%	0%	0%	20%
Nanoscience	40%	27%	20%	0%	0%	13%
Condensed matter physics	50%	50%	0%	0%	0%	0%
Particle physics/cosmology	50%	0%	25%	0%	0%	25%
Environment	70%	0%	20%	0%	0%	10%
Others	67%	13%	0%	0%	7%	13%
Total	60%	18%	11%	1%	1%	9%

Reference figure 8 Changes in difference in research and development funds compared with those of rivals whose situation can be monitored (During the period between 2003 and 2008)

(A) Number of responses

	Narrowed	Widened	No change	Unknown	Total
Heart and blood vessels research	1	2	3	3	9
Brain research	0	6	6	2	14
Study on obesity	1	1	0	1	3
Research on regenerative medicine	1	2	0	0	3
Cancer research	1	2	1	1	5
Research on infectious diseases/immunology	0	3	2	6	11
Post-genome research	0	0	2	0	2
Plant science research	0	5	0	1	6
Life science and others	0	2	0	2	4
Chemistry	1	3	3	3	10
Nanoscience	0	5	2	8	15
Condensed matter physics	2	5	3	0	10
Particle physics/cosmology	0	2	1	1	4
Environment	1	4	4	1	10
Others	2	5	4	4	15
Total	10	47	31	33	121

(B) Share

	Narrowed	Widened	No change	Unknown
Heart and blood vessels research	11%	22%	33%	33%
Brain research	0%	43%	43%	14%
Study on obesity	33%	33%	0%	33%
Research on regenerative medicine	33%	67%	0%	0%
Cancer research	20%	40%	20%	20%
Research on infectious diseases/immunology	0%	27%	18%	55%
Post-genome research	0%	0%	100%	0%
Plant science research	0%	83%	0%	17%
Life science and others	0%	50%	0%	50%
Chemistry	10%	30%	30%	30%
Nanoscience	0%	33%	13%	53%
Condensed matter physics	20%	50%	30%	0%
Particle physics/cosmology	0%	50%	25%	25%
Environment	10%	40%	40%	10%
Others	13%	33%	27%	27%
Total	8%	39%	26%	27%

Next, the size of the membership of the current research groups was surveyed in comparison with that of rivals whose situation can be monitored (Reference figure 9). As in the case of research and development funds, 78 percent of the respondents answered that there are more members in their rivals' groups. Changes in difference in the size of membership during the period between 2003 and 2008 (the period on which the analysis is based) were surveyed in Reference figure 10. 37 percent of the respondents answered that the difference in size widened, while 22 percent responded unknown. This indicates that it is difficult for researchers to grasp changes in research and development funds and size of membership.

Reference figure 9 Size of research groups' membership compared that of rivals whose situation can be monitored

(A) Number of responses

	Rival has more members	Rival has somewhat more members	Same level	My group has more members	My group has somewhat more members	Unknown	Total
Heart and blood vessels research	7	0	1	0	0	1	9
Brain research	9	2	1	0	0	2	14
Study on obesity	3	0	0	0	0	0	3
Research on regenerative medicine	2	0	1	0	0	0	3
Cancer research	3	0	2	0	0	0	5
Research on infectious diseases/immunology	6	0	1	0	2	2	11
Post-genome research	1	0	1	0	0	0	2
Plant science research	5	0	1	0	0	0	6
Life science and others	3	1	0	0	0	0	4
Chemistry	4	3	2	0	0	1	10
Nanoscience	10	1	2	0	1	1	15
Condensed matter physics	8	0	2	0	0	0	10
Particle physics/cosmology	3	0	1	0	0	0	4
Environment	9	0	1	0	0	0	10
Others	13	2	0	0	0	0	15
Total	86	9	16	0	3	7	121

(B) Share

	Rival has more members	Rival has somewhat more members	Same level	My group has more members	My group has somewhat more members	Unknown
Heart and blood vessels research	78%	0%	11%	0%	0%	11%
Brain research	64%	14%	7%	0%	0%	14%
Study on obesity	100%	0%	0%	0%	0%	0%
Research on regenerative medicine	67%	0%	33%	0%	0%	0%
Cancer research	60%	0%	40%	0%	0%	0%
Research on infectious diseases/immunology	55%	0%	9%	0%	18%	18%
Post-genome research	50%	0%	50%	0%	0%	0%
Plant science research	83%	0%	17%	0%	0%	0%
Life science and others	75%	25%	0%	0%	0%	0%
Chemistry	40%	30%	20%	0%	0%	10%
Nanoscience	67%	7%	13%	0%	7%	7%
Condensed matter physics	80%	0%	20%	0%	0%	0%
Particle physics/cosmology	75%	0%	25%	0%	0%	0%
Environment	90%	0%	10%	0%	0%	0%
Others	87%	13%	0%	0%	0%	0%
Total	71%	7%	13%	0%	2%	6%

Reference figure 10　Changes in difference in size of the membership of research groups compared to the size of rivals whose situation can be monitored (during the period between 2003 and 2008)

(A) Number of responses

	Decreased	Increased	No change	Unknown	Total
Heart and blood vessels research	0	2	3	4	9
Brain research	0	5	3	6	14
Study on obesity	1	1	0	1	3
Research on regenerative medicine	0	3	0	0	3
Cancer research	0	1	3	1	5
Research on infectious diseases/immunology	1	2	5	3	11
Post-genome research	0	0	2	0	2
Plant science research	0	4	1	1	6
Life science and others	1	1	0	2	4
Chemistry	1	3	5	1	10
Nanoscience	0	5	7	3	15
Condensed matter physics	1	4	4	1	10
Particle physics/cosmology	0	2	2	0	4
Environment	0	5	4	1	10
Others	3	7	2	3	15
Total	8	45	41	27	121

(B) Share

	Decreased	Increased	No change	Unknown
Heart and blood vessels research	0%	22%	33%	44%
Brain research	0%	36%	21%	43%
Study on obesity	33%	33%	0%	33%
Research on regenerative medicine	0%	100%	0%	0%
Cancer research	0%	20%	60%	20%
Research on infectious diseases/immunology	9%	18%	45%	27%
Post-genome research	0%	0%	100%	0%
Plant science research	0%	67%	17%	17%
Life science and others	25%	25%	0%	50%
Chemistry	10%	30%	50%	10%
Nanoscience	0%	33%	47%	20%
Condensed matter physics	10%	40%	40%	10%
Particle physics/cosmology	0%	50%	50%	0%
Environment	0%	50%	40%	10%
Others	20%	47%	13%	20%
Total	7%	37%	34%	22%

(3)　Means towards further development of research areas

Effective means towards further development in the future should vary by research areas. Therefore, degree of effectiveness (on a five-point scale from 0 to 4) was examined for each of the seven items that are considered to bring about major advances in research areas. Indexed degree of effectiveness is shown by item in Reference figure 11. 4 is the highest score. As we all know, it is already recognized that the development and utilization of highly capable personnel is essential to the promotion of research areas; therefore, means except this are discussed.

First, looking at the total points, the means that was evaluated as most effective is the "active utilization of knowledge from other fields." This means is regarded as effective in a wide range of research areas in post-genome research, nanoscience and study on obesity. The means identified as next effective is the "implementation of research focusing on application." However, the effectiveness of this means varies greatly depending on research areas, such as those with high marks (cancer research, heart and blood vessels research, research on regenerative medicine, research on infectious diseases/immunology and nanoscience) and those with low marks (particle physics/cosmology and environment). Most of the research areas that gave high marks have already assumed medicine as their target application, but something noteworthy here is that nanoscience is included in this group. The effect of this means was found to be dependent on contents of research areas. The means that was ranked 3rd in degree of effectiveness is the “innovative metrological and measurement technology that exceeds the current limitations.” The degree of effectiveness of this means is assessed as being high in the research areas of particle physics/cosmology, condensed matter physics and environment. The degree of effectiveness is also high in research areas of life science such as brain research, study on obesity and post-genome research.

“An enormous amount of collection of data and search of substances on a different order of magnitude from the past” was evaluated as being high in study on obesity, research in regenerative medicine, chemistry and particle physics/cosmology, suggesting that search operation including data collection and data mining is in progress in the fields of both life and non-life science. In connection to this, the “structuring and systematization of enormous amount of knowledge obtained to date” was evaluated as being high in study on obesity. High evaluation of “data collection through international cooperation” in research on heart and blood vessels and cancer research is assumed to be due to implementation of cohort studies and collection of participants’ data involved with these studies. The effectiveness of this means is also high in environment probably because the research requires the establishment of observation networks on a global scale and collection and analysis of data obtained from the observation. As for the “several- to several dozen units of large-scale experiment systems/facilities in the world,” which was the least effective overall, the difference between the highest and lowest scores is substantial, but the degree of effectiveness was supported as being very high in particle physics/cosmology.

Reference figure 12 surveyed a most important means Japan should focus on in advancing research, by using the single-choice method. The “implementation of research focusing on application” and “active utilization of knowledge from other fields” were selected.

Reference figure 11　Degree of effectiveness of the means that bring about major advances in research areas

	1. Active utilization of knowledge from other fields (e.g., utilization of computer science in plant genome research, etc.)	2. Collection of data through international cooperation (Establishment of global observation networks, sharing of work by countries, etc.)	3. Innovative metrological and measurement technology that exceeds the current limitations (Significantly improved time resolution, processing speed, spatial resolution, etc.)	4. Several- to several dozen units of large-scale experiment systems/facilities in the world (Accelerators, super computers, telescopes, etc.)	5. Enormous amount of collection of data and search of substances on a different order of magnitude from the past	6. Structuring and systematization of enormous amount of knowledge obtained to date	7. Implementation of research focusing on application (Deployment to clinical medinine, industry-university cooperation, etc.)
Heart and blood vessels research	2.8	3.1	2.1	0.8	2.4	2.1	3.7
Brain research	2.9	2.3	3.0	1.1	2.2	2.4	3.2
Study on obesity	3.3	2.0	3.0	2.0	3.0	3.0	2.7
Research on regenerative medicine	2.7	2.7	2.7	1.3	3.0	2.0	3.7
Cancer research	3.2	3.4	1.6	0.8	1.8	1.4	4.0
Research on infectious diseases/immunology	2.5	2.4	2.5	1.5	2.3	2.6	3.5
Post-genome research	3.5	2.5	3.0	2.0	2.5	2.0	3.0
Plant science research	2.8	2.3	2.3	1.7	2.3	2.8	3.2
Life science and others	3.3	1.5	1.8	1.3	2.0	2.8	2.8
Chemistry	3.3	1.3	2.9	2.9	3.0	2.5	2.9
Nanoscience	3.4	1.8	2.7	1.1	1.9	2.4	3.5
Condensed matter physics	3.2	2.1	3.4	2.3	2.4	2.2	2.4
Particle physics/cosmology	2.5	2.8	3.5	3.8	3.0	1.5	0.5
Environment	2.9	3.1	3.3	2.5	2.7	2.3	1.8
Others	3.1	2.1	2.3	1.1	2.2	2.4	2.5
Total	3.0	2.3	2.7	1.6	2.4	2.3	2.9

Reference figure 12　Most important means Japan should focus on in implementing research

	1. Active utilization of knowledge from other fields (e.g., utilization of computer science in plant genome research, etc.)	2. Collection of data through international cooperation (Establishment of global observation networks, sharing of work by countries, etc.)	3. Innovative metrological and measurement technology that exceeds the current limitations (Significantly improved time resolution, processing speed, spatial resolution, etc.)	4. Several- to several dozen units of large-scale experiment systems/facilities in the world (Accelerators, super computers, telescopes, etc.)	5. Enormous amount of collection of data and search of substances on a different order of magnitude from the past	6. Structuring and systematization of enormous amount of knowledge obtained to date	7 .Implementation of research focusing on application (Deployment to clinical medinine, industry-university cooperation, etc.)	8. Other	Unanswered	Total
Number of responses	25	6	12	5	8	6	44	14	1	121
Share	21%	5%	10%	4%	7%	5%	37%	12%	1%	100%

Responses that were given as Other

Area ID	Response given as Other	Area ID	Response given as Other
2	More detailed linkage between gene expression and physiology, reverse mechanism of remodeling in dilatation and fibrosis.	69	Total amount of research funds for universities
3	Although development of therapeutic drug comes first, it is important to elucidate pathogenesis and pathophysiology.	70	The importance of research themes that emulate functions in the natural world
7	Global cooperation, international clinical research collaboration and implementation of tests for life science technology.	73	Collaborative research through accumulation of high-quality personnel from different fields.
12	Development of systematization of innovative POCT technology	76	Innovative ideas free from conventional thinking (Material system)
18	The general public's understanding of and cooperation to research (as trial participants)	79	Activation of application-oriented basic research in companies
21	Allocation of research funds matched to burden of illness, support to research on clinical medicine and clarification of the missions of university hospitals.	82	Positions for researchers (obvious decline in the field of computer science) and labor costs
32	Continuous basic research	83	Mutual enhancement and cooperation between the research that aims to collect basic data and the research that aims for deployment into application
35	Increased research funds for clinical trial research	99	New theoretical results
42	Reinforced services including enhancement, production and supply of research resources such as genetically-modified mice.	104	Active collaborative research with not only physicist but also with mathematicians
49	Application of anti-HIV agents that have a new mechanism for treating AIDS.	107	International personnel exchanges
53	Development of research that bridges the data obtained from experimental environment such as a hothouse and the actual field data.	108	Long-term continuous research in field surveys and primary source analysis and increased stable employment positions of young reserachers
54	Understanding of plant immune system	110	Securing and development of high-quality personnel and improvement, maintenance and management of infrastructure such as research environment.
55	In order to analyze the infection mechanism of pathogenetic organism, experiments in laboratories and fields only are not sufficient. It is necessary to establish a large-scale plant growing facility in the country for shared use where various plant growing environments are programmed and can be reproduced repeatedly.	112	Development of numerical models that incorporate the latest findings
57	Increased research funds in basic research fields (Setting-up large scale projects that can hire researchers in basic fields)	118	Increased diversity of researchers
59	Discovering high-quality personnel who can create new ideas free from established concepts and the technology required for the discovery.	120	Structural change and the construction of an organizational support system for it in order to activate applied research of basic theoretical science (mathematics and others)

(4) Groups of research areas with which the relationship should be strengthened for further development of research areas

The “active utilization of knowledge from other fields,” which was the answer to the above-mentioned means towards further development research areas, was evaluated as being effective to the broad range of research areas. In response to this, a survey was conducted to identify specific groups of research areas with which each research area should strengthen its relationship (Reference figure 13). Multiple answers (up to 3) were acceptable and researchers were allowed to select a research area group which includes research areas that the researchers themselves were in charge of.

The number of research areas included in each group of research areas varies, which makes a difference in the number of respondents and the average number of responses per respondent. To solve this problem, the total of each research area group was set to 1 and numbers were represented in shares (Reference figure 12 (B)). This information was added to a diagram on the Science Map and is shown in Reference figure 14.

Reference figure 13 Research area groups with which the relationship should be strengthened for future development

(A) Number of responses

			Research area groups with which the relationship should be strengthened for future development														
	Number of respondents	Average number of responses per respondent	Heart and blood vessels research	Brain research	Study on obesity	Research on regenerative medicine	Cancer research	Research on infectious diseases/immunology	Post-genome research	Plant science research	Chemistry	Nanoscience	Condensed matter physics	Particle physics/cosmology	Environment	Others	Unknown
Heart and blood vessels research	9	2.4	6	3	3	3	2	1	3	0	0	1	0	0	0	0	0
Brain research	14	2.5	2	12	3	6	1	0	7	0	1	2	1	0	0	1	0
Study on obesity	3	2.3	2	2	2	0	0	0	1	0	0	0	0	0	0	1	0
Research on regenerative medicine	3	2.7	1	1	0	2	2	1	1	0	0	0	0	0	0	0	0
Cancer research	5	2.6	0	0	1	2	5	1	2	0	1	1	0	0	0	0	0
Research on infectious diseases/immunology	11	2.6	0	0	1	1	4	10	7	0	2	2	0	0	2	1	0
Post-genome research	2	3.0	0	0	0	0	0	0	1	2	0	1	0	0	2	0	0
Plant science research	6	2.3	0	0	0	0	0	1	5	3	1	0	0	0	4	0	0
Life science and others	4	2.5	1	0	0	2	3	3	0	0	0	0	0	0	1	0	0
Chemistry	10	3.0	0	0	0	0	0	0	0	0	9	9	9	0	3	0	0
Nanoscience	15	3.0	0	0	0	1	0	0	2	0	12	14	8	0	8	0	0
Condensed matter physics	10	2.5	0	1	0	0	0	0	0	0	5	9	9	1	0	1	0
Particle physics/cosmology	4	1.5	0	0	0	0	0	0	0	0	0	0	2	4	0	1	0
Environment	10	2.2	0	1	0	0	0	0	2	2	5	1	0	2	9	1	0
Others	15	2.1	1	6	0	1	1	3	3	0	3	3	4	1	5	4	0
Total	121	2.5	13	26	10	18	18	20	34	7	39	43	33	8	34	10	0

Note Multiple answers are accepted up to 3. Respondents are allowed to select research area groups which include research areas that they are in charge of.

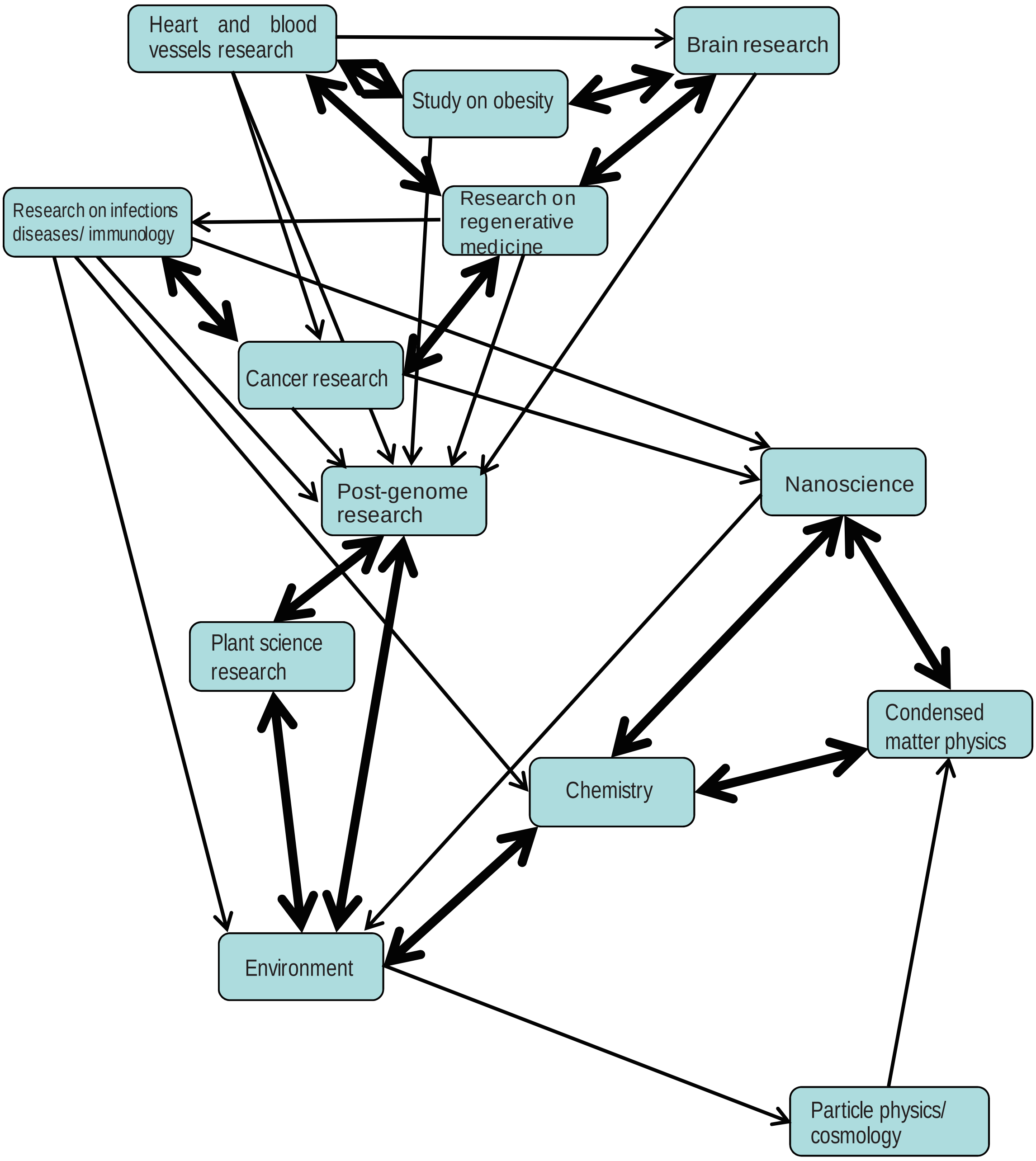
(B) Share

	Number of respondents	Research area groups with which the relationship should be strengthened for future development: Heart and blood vessels research	Brain research	Study on obesity	Research on regenerative medicine	Cancer research	Research on infectious diseases/immunology	Post-genome research	Plant science research	Chemistry	Nanoscience	Condensed matter physics	Particle physics/cosmology	Environment	Total
Heart and blood vessels research	9		0.19	0.19	0.19	0.13	0.06	0.19	0.00	0.00	0.06	0.00	0.00	0.00	1.00
Brain research	14	0.09		0.13	0.26	0.04	0.00	0.30	0.00	0.04	0.09	0.04	0.00	0.00	1.00
Study on obesity	3	0.40	0.40		0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Research on regenerative medicine	3	0.17	0.17	0.00		0.33	0.17	0.17	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Cancer research	5	0.00	0.00	0.13	0.25		0.13	0.25	0.00	0.13	0.13	0.00	0.00	0.00	1.00
Research on infectious diseases/immunology	11	0.00	0.00	0.05	0.05	0.21		0.37	0.00	0.11	0.11	0.00	0.00	0.11	1.00
Post-genome research	2	0.00	0.00	0.00	0.00	0.00	0.00		0.40	0.00	0.20	0.00	0.00	0.40	1.00
Plant science research	6	0.00	0.00	0.00	0.00	0.00	0.09	0.45		0.09	0.00	0.00	0.00	0.36	1.00
Chemistry	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.43	0.43	0.00	0.14	1.00
Nanoscience	15	0.00	0.00	0.00	0.03	0.00	0.00	0.06	0.00	0.39		0.26	0.00	0.26	1.00
Condensed matter physics	10	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.56		0.06	0.00	1.00
Particle physics/cosmology	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00		0.00	1.00
Environment	10	0.00	0.08	0.00	0.00	0.00	0.00	0.15	0.15	0.38	0.08	0.00	0.15		1.00
Total	121	0.04	0.09	0.03	0.06	0.06	0.07	0.11	0.02	0.13	0.14	0.11	0.03	0.11	1.00
Life science and others	4	0.10	0.00	0.00	0.20	0.30	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.10	1.00
Other	15	0.03	0.19	0.00	0.03	0.03	0.10	0.10	0.00	0.10	0.10	0.13	0.03	0.16	1.00

(Note 1) Relationships indicated with a double-headed arrow in the next figure are shown in boldface. (Note 2) From the total number of responses, the number of responses in the research area group to which individual respondents belong and the number of responses in "other" were subtracted. Among the rest of the responses, when the percentage of the responses that the relationship should be strengthened exceeds 10 percent, the cell of that research area group is shown in red. In the case of heart and blood vessels research, 22 responses were received, from which the 6 responses which selected heart and blood vessels research were excluded and the remaining 16 responses were used as a denominator. Of this, 3 responses selected brain research as a research area group with which the relationship should be strengthened, hence, the share is 3/16 = 0.19.

A number of research area groups responded that they should strengthen the relationship with post-genome research, environment, nanoscience and chemistry, indicating that these research area groups are drawing a great deal of attention. The heavy lines with double-headed arrows in the figure indicate the relationships which the respondents think should be strengthened. From the lines, strong relationships can be observed among heart and blood vessels research, study on obesity, brain research and research on regenerative medicine. Also, there are triangular structures, one consisting of post-genome research, plant science research and environment, and the other consisting of nanoscience, chemistry and condensed matter physics. Because it is recognized that the relationship between chemistry and environment should be strengthened, these two triangular structures can be viewed as one cluster, with chemistry and environment serving as intermediaries. The role of post-genome research is also considered important as a function to connect clinical medicine with these six research area groups.

Reference figure 14 Relations of the research area groups seen in the Science Map, with which the relationship should be strengthened for future development



Note: Single-headed arrow indicates responses of 10 percent or more. Areas that select each other are indicated with the bold double-headed arrow.

Responses given as Other are as follows:

Area ID	Response given as Other	Area ID	Response given as Other
22	Cognitive psychology	107	Mathematics
33	Data mining research	109	Informatics (Processing of DNAs and other biological information in large quantity and at a high speed)
41	Systems biology	111	Mathematics (Especially statistics)
92	Computational electromagnetics	119	Governance of governmental organizations
99	Significant development is expected in the fields of signal processing, information theory, and measuring equipment using them.	120	Research on flying and swimming ways of living creatures
104	Theoretical research on superconductivity and superfluidity is being started recently using gravity-gauge theory correspondence.	121	Evolutionary economics, econometrics, network science

Next, verification was made on the relationship between these responses from experts on the research area groups with which the relationship should be strengthened for further development and changes in the Science Map during the period from 2006 and 2008 (Reference figure 15).

First, the relationship between nanoscience and chemistry is shown with the double-headed arrows in Reference figure 14, indicating that experts think both fields need each other's knowledge for future development. Then, when taking a look at ID 66 in nanoscience and ID86 in chemistry in Science Map2008, each of them is found to be a research area that has continued from Science Map 2006, and each corresponds to ID79 in nanoscience and ID91 in chemistry. The co-citation degree of ID79 and ID91 in Science Map 2006 was 0.0025, and that of ID66 and ID86 in Science Map 2008 was 0.01, showing that the relationship has changed to one that is about four times stronger.

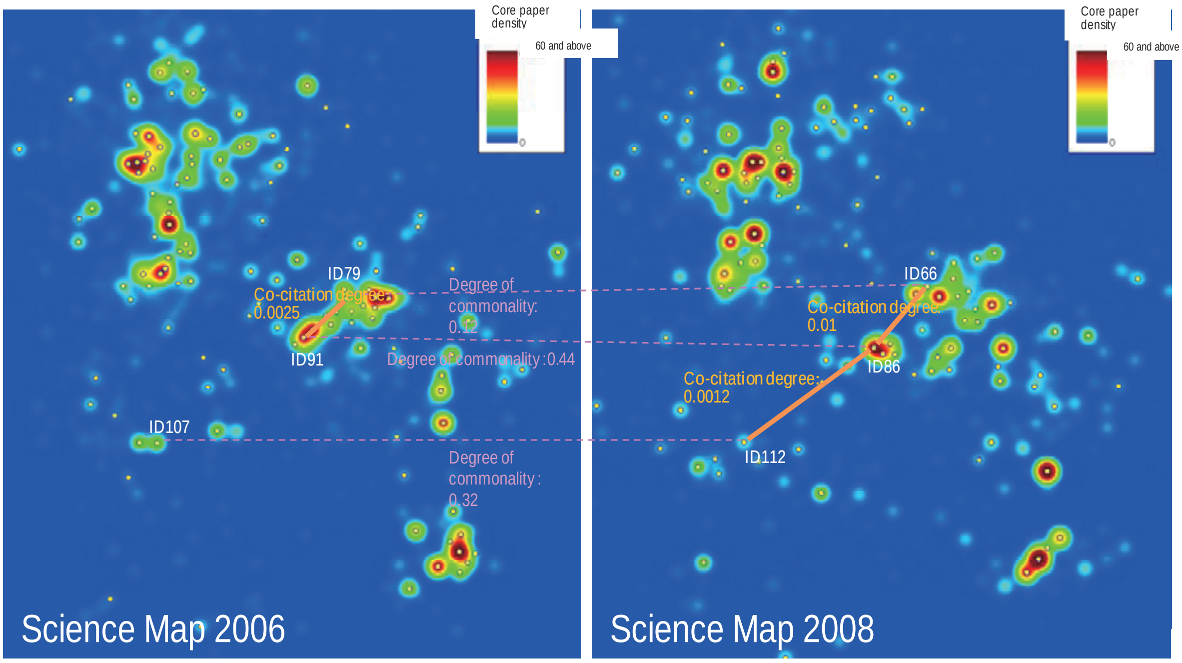
Next, the relationship between chemistry and environment is also shown with the double-headed arrow in Reference figure 14, indicating that experts think both fields need each other's knowledge for future development. Then, when looking at ID 86 in chemistry and ID112 in environment in Science Map 2008, each of them is found to be a research area that has continued from Science Map 2006, and each corresponds to ID91 in chemistry and ID107 in environment. The co-citation degree of ID91 and ID107 in Science Map 2006 was 0, and that of ID86 and ID112 in Science Map 2008 was 0.0012, showing that the co-citation relationship emerged between the two research areas.

Reference figure 14 indicates that particle physics/cosmology should strengthen its relationship with condensed matter physics for future development. So, looking at ID107 in particle physics/cosmology and ID100 in condensed matter physics in Science Map 2008, each of them is found to be a research area continued from Science Map 2006, and each corresponds to ID69 in particle physics/cosmology and ID63 in condensed matter physics. The co-citation degree between ID69 and ID63 in Science Map 2006 was 0.0013, and that of ID107 and ID100 in Science Map 2008 was 0.0126, showing that the relationship has changed to one that is about ten times stronger.

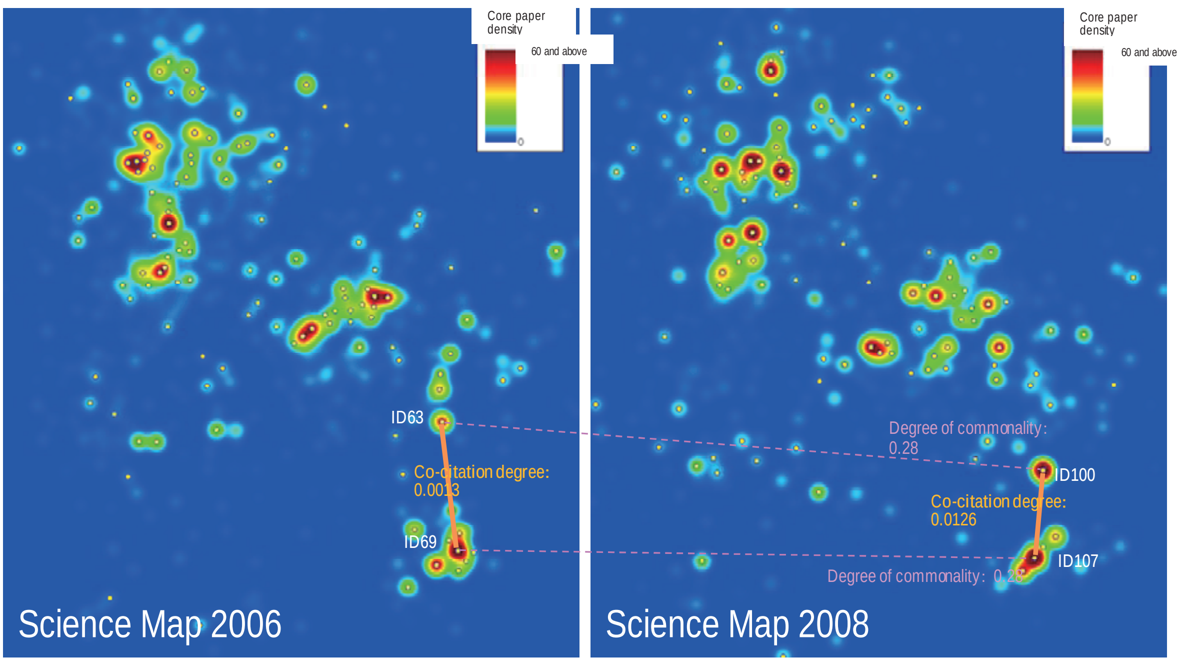
As seen in these examples, there is a certain amount of relationship between views of experts and changes in the Science Map.

Reference figure 15 Relationship between the views of experts and co-citation degree between research areas

(A) Nanoscience ←→ Chemistry ←→ Environment



(B) Particle physics/cosmology → Condensed matter physics



Names of hot research areas

Science Map 2006		Science Map 2008	
79	Living radical polymerization	66	Living radical polymerization/click reaction/molecular machine
91	Catalytic asymmetric synthesis	86	Catalytic asymmetric synthesis
107	Aerosol	112	Organic aerosol
63	New quantum condensed phase where substances strongly interact with each other	100	Strongly interacting quantum many-body system
69	Observational cosmology and an elementary model for it	107	New developments in cosmology and elementary particles theory owing to advancement in precise observation of space

4. Attempt of an Interactive Science Map

In Science Map 2008, a web questionnaire survey regarding the developmental status of hot research areas was conducted with those who carried out content analysis, and a request for their participation in the creation of Interactive Science Map was also made in an attempt to capture the dyanmism of scientific research. The survey was conducted over the web using the question and answer method.

Grasping the status of science through the analysis of scientific papers is effective in that it shows the results of analysis in a quantitative form. However, because the analysis uses information such as the bibliographic data and frequency of citations of scientific papers, the results are in the near-past status and the necessity to fill the difference between the near-past and current status has been pointed out by the researchers who participated in the survey and analysis for the Science Map.

Therefore, in addition the conventional quantitative analysis that works well in some cases, collecting “information on the research areas that are currently experienced and recognized by researchers” is considered effective for filling the gap from the near-past to the present/near future, and is expected to capture a more accurate status of science. Also, by using Science Map 2008 as the world’s coordinate axis of science and by having researchers add “information on the research areas that are currently experienced and recognized by them” to the map, it is expected that the time and effort required for organizing the relationships between responses from researchers can be reduced.

As explained above, a map created by the combination of the quantitative approach which is a result of scientific paper analysis and the qualitative approach based on the feeling of researchers shall be referred to as “Interactive Science Map.” Specifically, questions were asked on the web screen as shown in Reference figure 16.

The survey period, those surveyed and the number of effective responses are as follows:
Survey period: January 13 – January 27, 2010 (Final deadline set at February 9 after reminders)
Those who were surveyed: 121 experts responsible for content analysis
Numer of effective responses: 170 (Excluding 10 due to incomplete reponses, etc.)

Reference figure 16　Interactive Science Map fill-out screen on the web

[Page 5/6]

Save the responses so far and exit

Work C: Questionnaire survey after an overview of Science Map 2008 (4/5)

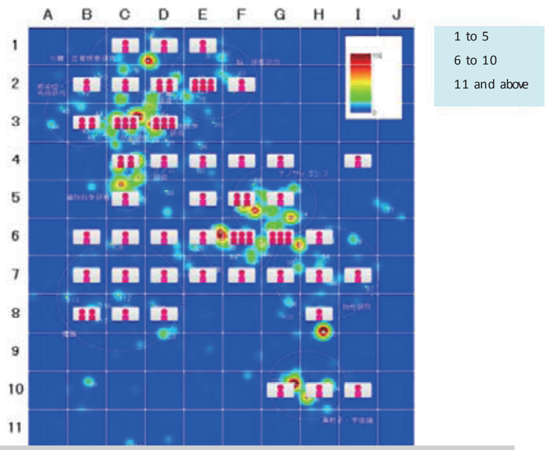
Question 4

For Science Map 2008, the scientific papers published from 2003 through 2008 were used. Because science advances day by day, the map is considered to represent a near-past status. Therefore, by collecting the current and near-future information from researchers, we would like to fill the gap caused by the time difference and create an interactive science map.
According to the following procedure, please provide answers regarding research areas, except the 121 research areas **listed in this report, that are now rapidly drawing attention and the research areas that are highly likely to change in the next few years.** At the same time, please enter them in the Science Map with the addition of their location information in the map.
(Reference) Detailed explanation of the survey objective

- Icons can be placed at up to three locations.
- Select a desired location using the vertical and horizontal axis and enter a research area name and key words. By clicking "register," an icon is added to the map.
- A new research area can be placed at a location where other icons have already placed by others.
- By placing a mouse on a icon, its research area name and the ID of the research area you are in charge of are displayed. Answers of other researchers can also be checked in real time.

Open the research area name lis　　Open the PDF file for printing

Interactive Science Map



Research area names shall be easy to understand and shall be entered within 25 characters in double-byte.
Enter English key words in single byte. If there are multiple words, separate them with commas.

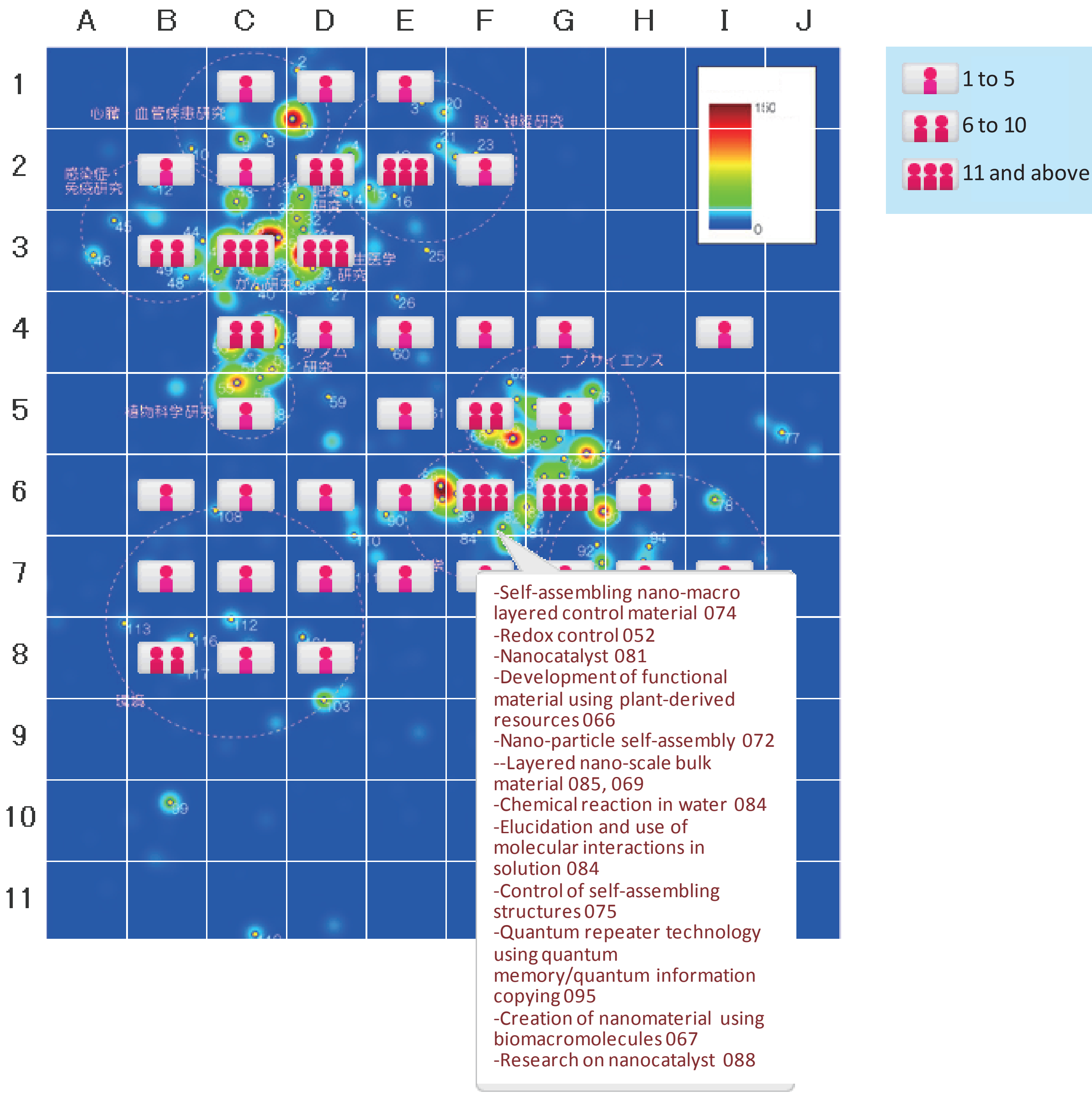
	Item	Entry field
1	Vertical axis	--↓ Please select
	Horizontal axis	--↓ Please select
	Research area name	
	Keyword (English)	
2	Vertical axis	--↓ Please select
	Horizontal axis	--↓ Please select
	Research area name	
	Keyword (English)	
3	Vertical axis	--↓ Please select
	Horizontal axis	--↓ Please select
	Research area name	
	Keyword (English)	

Register

Back　　Next

Reference figure 17 shows how the entered information is displayed in the interactive map. The number of researchers who entered information and its content can be confirmed on the screen. Also, if information is in a temporarily saved state, comparison with information entered by other researchers and changes to information can be made. This made it possible for researchers to determine locations while interacting with each other by referring responses of other researchers on the Science Map.

Reference figure 17 Information entered on Interactive Science Map



Note: A word balloon shown above appears on each cell, with which research topics entered by each researcher and researchers' ID numbers (same as research area IDs assigned for content analysis) can be confirmed.

Reference figure 18 Topics that are rapidly drawing attention and are highly likely to change within the space of the next few years

	B		C		D		E	
	Research area name	Key word	Research area name	Key word	Research area name	Key word	Research area name	Key word
1			Early detection and prevention of atherosclerotic disease	Early detection and prevention of atherosclerotic disease	Elucidation of neural control mechanism of entire body organs Brain research	cell sensor, brain-organ integration neurotransmitter	Development of biological markers for mental disorders	Biological markers for mental disorders
2	Regression of ectopic calcification Life-cycle of HPV	regression of ectopic calcification life-cycle of HPV	Drug characteristics of SERM Obesity and immunity	SERM obese, immunology	Wearable and implantable artificial kidney Elucidation of biological onset mechanism of eating disorder and development of treatment Quality control of organelles Physical activity and energy metabolism Research on life style diseases caused by nutritional signals Elucidation of onset mechanism of life style diseases caused by obesity	wearable artificial kidney Biological mechanisms and treatment of Eating Disorders Quality control, Organelles Exercise and energy metabolism Nutrition signal, life-style disease obesity, onset of life style diseases	Elucidation of brain functions using optogenetics Epigenetic control mechanism in the onset of central neurological diseases Research on regeneration and differentiation of central nerves Creation of therapeutic agents for neurological disorders using synapse disorders as a benchmark Brain functional recovery of patients with schizophrenia Postmortem brain studies of mental disorders Neurotransmitter disorders and emotional disorders Synaptic plasticity and emotional disorders Research on brain and central nerves system Development of preventive therapeutic methods for conformation diseases	Channelrhodopsin Epigenetic modification Regenerative medicine synapse, neurological disorder Schizophrenia, brain function Postmortem brain studies of mental disorders Dopamine Glutamine acid Brain、central nervus system aggregation mechanism, amyloid firbrilation mechanism
3	Allergy treatment using anti-cytokine antibody Relation between virus infection and allergic disease Changes in higher brain functions caused by systemic/ peripheral inflammation Influenza Application of combined immune response modulation to treatment Regulation of activity through NK cell receptor and its ligand Accurate understanding of the actual state of HPV infection Infection control Research on anti-HIV drugs Early infection process and treatment method of Hepatitis C virus	new anti-cytokine drugs for allergy virus infection and allergic disease Neuroimmunology influenza Application of combined immunomodulation for immune-mediated disease NKG2D, MICA/B, ULBP, NK cell reliable HPV surveillance Infection control, MRSA, virus HIV, New antiviral agent HCV, New antiviral agent	Elucidation of cellular functional protein Endocrine therapy for prostate cancer Rapid and real-time microbial detection technology and its application Cancer genome Drug development targeting for proteolysis Search for metabolic products that regulate cell state Cancer research Infectious diseases/immunity Cancer research Search for markers for anticancer drug sensitivity Research on cancer Role of cytokines in carcinogenesis Drug for cancer treatment Search for pathogens in idiopathic diseases Cancer research	Proteomics, protein control prostate cancer androgen depletion therapy microbial detection, real-time cancer genomics Drug development, Proteolysis Metabolic products human cancer, genome, molecular biology immune reconstitution gene expression, targeted therapy biomarker micro RNA tumorigenesis, cytokine Drugs、 cancer idiopathic disease, etiology, pathogen anticancer	Cellular regenerative medicine Cell/regenerative medicine Regenerative medicine Development of evaluation systems towards early practical application of iPS cells Elucidation of pathological conditions of intractable diseases and development of treatment methods Regenerative medicine Research on cancer stem cells Regenerative medicine Regenerative medicine Research on regenerative medicine and stem cells	iPS, myocardial regeneration, stem cell cell therapy iPS cells, evaluation technology Intractable diseases pathogenesis therapeutics regenerative medicine cancer stem cell bone remodeling liver regeneration Regeneration, stem cell		
4			Elucidation of the mechanism of allergic genes Metabolome Molecular diagnosis using enzyme activity as a benchmark Plant hormone Gene silencing Epigenome control Epigenetics Research on drug discovery based on protein structure	genomic analysis of allergy metabolome enzymomics auxin, gibberellin and cytokinin RNAi, sRNA epigenomics epigenetics, chromatin remodeling protein structure, rational drug design	Genome diversity in the brain Genome analysis of mental disorders Post genome Post genome	Genome diversity in the brain Genome analysis of mental disorders deep sequencing glycans	Optogenetic neural control studies Biological significance of protein aggregation Application of nanofibers to regenerative medicine	Optogenetics, uncaging amyloid prion conformational diseases culture, 3D structure, 3D cell growth
5			Redox regulation Environmental responses and omics analysis of plants Diversity and genomic change in plants Closer fusion of environmental biology, biological science and environmental science Cellular signal transduction and cell fate determination	redox regulation plant stress response, omics SNP analysis, biodiversity Ecology, generation, gene expression, evolution, environment change cell communication, peptide signal, cell fate			Chemical biology Cell production	chemical biology Cell production

(Reference figure continued)

	F		G		H		I	
	Research area name	Key word	Research area name	Key word	Research area name	Key word	Research area name	Key word
1								
2	Social brain science using neuroimaging Research on temporal context memory Neural mechanisms of emotional decision making Neuro economics	social brain science using neuroimaging temporal context memory motivation, pleasant, unpleasant neuro economics						
3								
4	Nano-bio-engineering	nanoparticles, plasmon, bioprobe	Development of technology to visualize DNA and cancer cells Visualization of life phenomena using chemical probes	DNA cancer visualizations Imaging			Bio-imitated nano-machine	Bio-imitated nano-machine
5	Microchannel device Nano-bio materials Creation of functional substances using biopolymer Application of biopolymer to medicine Material development based on environmentally-benign processes learning from and exceeding organisms	microfluidics tissue fusion nano-material, bio-polymer, protein, nucleic acids drug delivery nucleic acid drugs, anti-body bioinspired materials, biomimetic, materials synthesis, environmental benign, solution processes	Nanoscience Morphological control of nanofibers Nanostructured battery material Nanoscience that uses structure-forming properties in liquid	nano electrospinning, water treatment, protective clothing, catalyst electric double-layer capacitor, fuel cell liquid, structure-forming property, nano-science				

(Reference figure continued)

	B		C		D		E	
	Research area name	Key word	Research area name	Key word	Research area name	Key word	Research area name	Key word
6	Ecotoxicology	Ecotoxicology	Analysis of molecular mechanism in environmental carcinogenesis Environmental epidemiology	carcinogenesis Environmental Epidemiology	Biological energy conversion system Environmental chemistry of metabolite	biological energy conservation Environmental Metabolomics	Highly efficient organic synthesis technology Synthetic reaction using organocatalysts Asymmetric synthesis Catalytic reactions in water Bio-process development using microbial enzymes	organic synthesis organocatalyst asymmetric synthesis asymmetric, water Bio-process development using microbial enzyme
7	Biodiversity science Integrated terrestrial ecosystem observation based on terrestrial observing network and satellite observation	ecosystem function, ecosystem service, conservation integrated terrestrial ecosystem observation	Assessment of impacts of global warming on terrestrial ecosystems Long-term and time-series environmental observation and biogeographical changes	effects of global warming on terrestrial ecosystems Long-term monitoring, environmental change, biogeography	Environmental chemistry of bromine flame retardant	persistent chemical	Research on organomaterial Biorefinery Bio-plastic production	organomaterial science biofuel, biochemical Bio-plastic production
8	Atmospheric constituents derived from biogenic sources Atmospheric environment in Asia Elucidation of biological feedback to climate change Elucidation of mutual interactions between air pollution and climate change Satellite observation of atmospheric composition Development of integrated geoenvironmental simulation model Elucidation of long-term climate changes with advanced oceanographic observations Detailed observation of environmental variations in high latitude and polar regions	Biogenic sources, Trace gas, Aerosol Asia, Atmospheric environment biological feedback to climate change atmospheric chemistry, aerosol, chemical climate model greenhouse gas, minor constituents climate change, atmospheric pollution, carbon cycle, ocean circulation Investigation of long-term climate changes with advanced oceanographic observations environmental variations, high latitudes, polar regions	Environmental change and gene evolution Long-term variation of aerosol including the past Detailed reconstruction of paleoceanographic conditions	environmental change, genome, evolution Long-term trend, Aerosol high-resolution paleoceanography				
9								
10								
11								

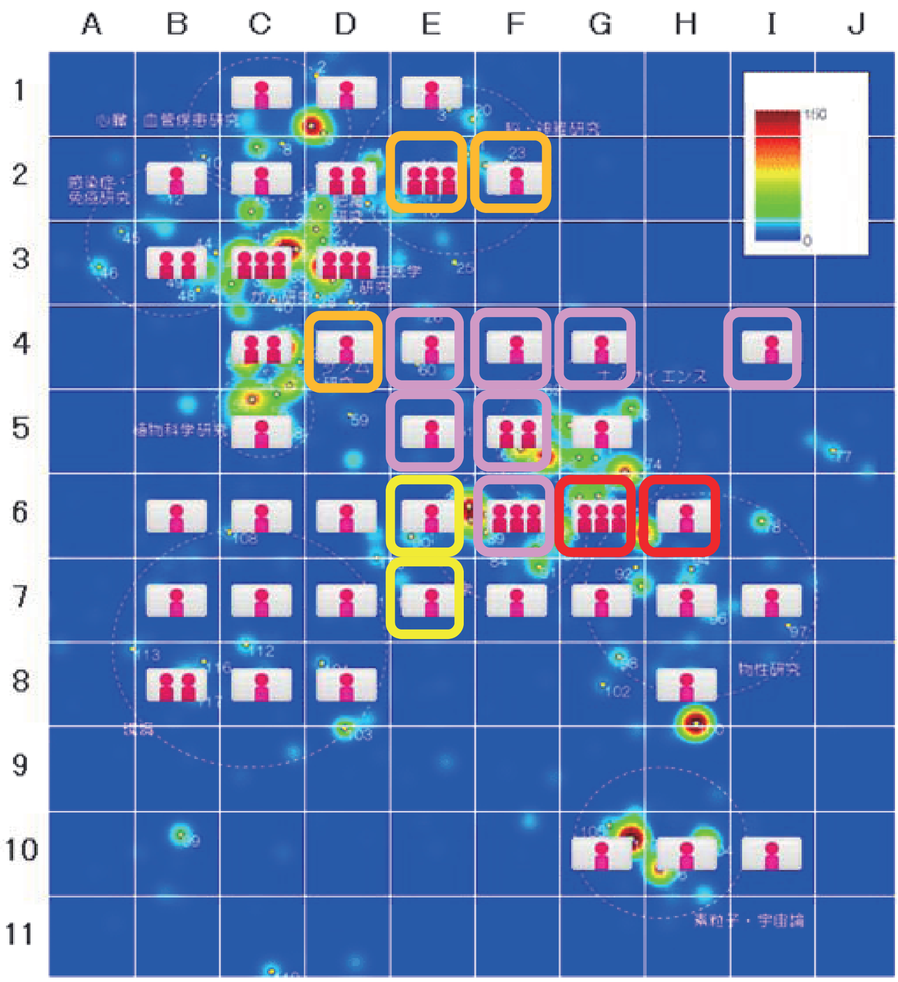
(Reference figure continued)

	F		G		H		I	
	Research area name	Key word	Research area name	Key word	Research area name	Key word	Research area name	Key word
6	Redox control	thiol	Process integration	Fusion of top-down and bottom-up processing	Nanostructured energy-creating material	nanostructure, energy material		
	Development of functional material using plant-derived resources		Supramolecular material	Self-assembly	Creation of complex nanofibers	electronics, solar cell, secondary cell, fuel cell, sensor		
	Creation of nanomaterials using biopolymer	nano-material, bio-polymer, protein, nucleic acids	Next-generation electro-chemical devices by nano-structural control	nanomaterials, hierarchical structures, electrochemical devices	Creation of an innovative energy device based on novel physical properties	energy device		
	Self-assembly of nanoparticles		Organic electronics	organic electronics				
	Self-assembling nano-macro hierarchical structure control material	hierarchical structures, self-organization	Production of energy devices by controlling hierarchical structure	energy device, material with hierarchical structure				
	Control of self-assembling structures	self ordering	Creation of nanomaterials that have hierarchical structure and elucidation of functional expression mechanism	Materials that have hierarchical structure				
	Nanocatalysts	catalyst	Development of material for new photoelectric conversion element	unconventional photoelectric device				
	Chemical reactions in water	green chemistry, reaction in water	Nano-scale heat conversion engine	nano-scale heat conversion engine				
	Elucidation and use of molecular interactions in solution	solution, intermolecular force	Quantum computational design of nanomaterials	theoretical nano material design				
	Layered nano-scale bulk material	Self-assembly/ organic structural material/organic electronic material	Organic electronics	organic luminescent material, organic semiconductor, organic solar cell				
	Research on nanocatalysts	nano-catalyst	Multiple functions of complex hydride	complex hydride, hydrogen, ionic conductivity, ionic liquid				
	Quantum repeater technology using quantum memory/quantum information copying	Quantum memory, Quantum repeater						
7	Organic thin-film solar battery	photovoltaics, solar battery	Application of quantum chemistry to research on condensed matter physics	new-generation density functional theory, long-range corrected DFT	Semiconductor spintronics materials/magnetic semiconductor	semiconductor, magnetic property, spintronics	New iron-based superconductors	iron-based superconductors
	Applied electric biochemistry	Applied electric biochemistry	Organic separation materials	Separation materials/energy generation	Spin current	spin current		
			Opto-mechanics	Opto-Mechanics	Molecular spintronics	Molecular spintronics		
					Heterointerface control and spintronics	heterointerface, spintronics		
8					Precise spatio-temporal measurement and verification of relativity and cosmology	optical frequency standard, relativity, cosmology		
9								
10			First-generation celestial bodies of space	fist star, galaxy formation, reionization	Particle physics/ cosmology	quantum gravity	Particle physics/geometry	particle physics, geometry
			Gravitational wave	gravitational wave	Particle physics/ cosmology	high-energy physics		
			Cosmic ray acceleration	comic ray, ultra high energy cosmic ray, acceleration				
11								

By conducting a survey on topics of most-advanced science, responses are obtained from researchers and a list of research topics can be prepared, but how to organize the results of the survey is very difficult. If the results are limited to a particular field, classification can be performed by those who are experts in that field. However, when it comes to capturing the entire picture of sicence, the organizing work cannot be performed unless experts cover all fields of sicence, which itself is not easy. In that sense, the approach taken this time (Reference figure 18) has an advantage in that the list can be completed without going through classification, by showing researchers, who are experts, the positioning of research content on the Science Map beforehand, having them exmaine the relationship between their answers and research content on the map and describe their answers.

As a topic that is rapidly drawing attention at present and is highly likely to change within the next few years, the number of responses was high in the regions around cancer research (C3), research on regenerative medicine, and around the regions where chemistry and nanoscience are overlapped (F6, G6). This is because these regions include a number of research areas on the map. However, entries from researchers are also seen in cells that are not their responsible research areas. For example, cases were confirmed that “Development of technology to visualize DNA and cancer cells” and “Visualization of life phenomena using chemical probes” are entered by researchers in charge of life science (infectious diseases/immunology) in the region near nanoscience (G4), and that “Neuro economics” was entered by the researcher (ID119) responsible for economics and business administration in a brain research cell (F2). This indicates that respondents consider positions on the map when they decide where to enter their answers. The below explains the research areas (the regions surrounded by frame in Reference figure 19) in which a certain characteristics are observed from the relationship between the responses and the Science Map:

Reference figure 19　Trend in entries on the interactive map



<Brain research (framed in orange)>

The group of research areas in brain research which saw changes in Science Map 2008 also found a number of topics entered, among which “Neuro economics” was entered in F2 by a researcher (ID119) in charge of a research area in economics/business administration. ID119 is an area not shown on Science Map 2008 because of its significantly low degree of co-citation with other research areas. This suggests that a researcher in a different field, the relationship with which has never been visible on the map, is augmenting the knowledge of this region.

In E2, there is an entry of “Elucidation of brain functions through optogenetics” which is integrated research of optics and genetics. In D4, which is outside brain research and within the region of post-genome research, topics of “Brain genome diversity” and “Genome analysis on mental disorders” are entered as integrated research approached by genome. This suggests that research in the groups of these research areas will advance following Science Map 2008 while merging knowledge and approaches from different fields. For example, there was also the response of “Optogenetic neural control studies” in E4 in optogenetics from another researcher. This indicates that researchers entered their responses in different cells based on the standpoints of their research that are establishing techniques (E4) and elucidation through this approach (E2).

<Region between life science and nanoscience (framed in pink)>

Although the distribution of research areas is not dense in the region between life science and nanoscience in Science Map 2008, there are topics that set life science as the research direction focused on application (exit), such as “Application of nanofibers to regenerative medicine” in E4 and “Application of biopolymer to medicine” in F5.

There are also cases where researchers (ID12, ID45) in charge of life science (infectious disease, immunization research) entered “Development of technology to visualize DNAs and cancer cells” and “Visualization of life phenomena using chemical probes” in the region near nanoscience (G4), suggesting life science’s expectations for nanoscience.

Furthermore, as seen in F5 “Material development based on environmentally-benign processes learning from and exceeding organisms,” F6 “Development of functional material using plant-derived resources” and I4 “Bio-imitated nano-machine,” an intention to effectively utilize the findings of life science is observed in nanoscience. This indicates that both life science and nanoscience are strengthening the relationship. Also, some research topics in this region carry titles that represent integrated research, such as “Nano-bio engineering” in F4, “Nano-bio materials” in F5 and “Chemical biology” in E5.

<Region between chemistry and environment (Framed in yellow)>

The topics in this region have the findings of chemistry as their base and thus often include the term “bio,” such as “Bio-process development using microbial enzymes,” in E6, “Biorefinery” in E7, and “Bio-plastics production.” Topics also include those focused on life science as an application (exit). One can see that the nature of research shown here is different from that of the answers given in the above-mentioned region between life science and nanoscience, which confirmed that topics are quickly classified by having researchers enter them on the map.

<Regions of condensed matter physics and nanoscience and region near the boundary of condensed matter physics (Framed in red)>

In this region, the term “energy” is included in many of the topics, such as “Production of energy devices by controlling hierarchical structure” in G6, “Nanostructured energy-creating material” in H6 and “Creation of innovative energy devices based on novel physical properties.” In Science Map 2008, multiple numbers of research areas related to fuel cell were extracted as hot research areas. Although these areas contain energy factors, it is likely that research will be advanced with particular attention paid to these hot research areas.

Through the survey using the interactive map which was attempted for the first time, the new style of collecting views from experts utilizing positions in the map proved to be satisfactory. In the future, the effective use of the Science Map not only for collecting views but also as a common field for discussion should be explored. In interviews and other surveys, experts often express their views based on their background. In that respect, it is meaningful for them to discuss the advancement of scientific research, and so on, based on a data provided such as the Science Map which is common to researchers from different fields. By sharing the arena for a dialogue, researchers will be able to have discussions among them and with decision-makers as well, while adjusting the sense of distance with each other.

5. Information on hot research areas

(1) Distribution of fields of core papers that comprise hot research areas

- The following pages provide lists of the field distribution (in percent) of the core papers comprising each of the 121 hot research areas that were extracted for this report. For each hot research area, the fields in which the share of core papers exceeds 60 percent are shaded. For example, all core papers for “Critically ill patient management (Particularly in cases of acute respiratory distress syndrome) (ID1)” are classified into clinical medicine, which makes the percentage of clinical medicine 100 percent, and thus the field is shaded.

- The areas in which research area IDs and names of hot research areas are shaded indicate inter-/multi-disciplinary research areas. The inter-/multi-disciplinary research areas here mean the hot research areas that do not contain fields with a core paper share of more than 60 percent. For example, in “Medical therapy for neuropathic pain and fibromyalgia syndrome (ID3),” even the largest share of core papers held by neuroscience/behavior remains at 45.8 percent, therefore, this research area was determined as an inter-/multi disciplinary research area.

(2) Detailed information on hot research areas

- The above-mentioned lists are followed by the lists showing research area IDs, fields to which research belong, shares of major countries (in whole count method and fractional count method), the percentage of international co-authorship and values of network index (degree centrality, closeness centrality and betweeness centrality). The percentage of international co-authorship of 50 percent or more is shown in color. The hot research areas whose degree centrality is in the top 5 percent of all research areas are indicated in color. The hot research areas whose betweeness centrality is in the top 5 percent of the research areas linked with network is shown in color.

Inter_Co: International Co-Authorship paper
DC: Degree Centrality
CC: Closeness Centrality
BC: Betweeness Centrality

Research area ID	Research area	AGRICULTURAL SCIENCES	Biology & Biochemistry	CHEMISTRY	CLINICAL MEDICINE	COMPUTER SCIENCE	ECONOMICS & BUSINESS	ENGINEERING	ENVIRONMENT/ECOLOGY	GEOSCIENCES
1	Critically ill patient management (Particularly in cases of acute	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
2	Effects and prognostics of device therapy for advanced heart failure	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
3	Medical therapy for neuropathic pain and fibromyalgia syndrome	0.0	0.0	0.0	29.2	0.0	0.0	0.0	0.0	0.0
4	Physiological function of endogenous cannabinoid system in central nervous	0.0	17.3	1.2	29.6	0.0	0.0	0.0	0.0	0.0
5	Clinical research on the control of cardiovascular incidents by	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
6	Coronary CT (computed tomography)	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
7	Treatment of acute coronary syndrome using antiplatelet drugs	0.0	1.8	0.9	96.1	0.0	0.0	0.0	0.0	0.0
8	Research on adverse effect of COX inhibitors	0.0	0.0	0.0	96.2	0.0	0.0	0.0	0.0	0.0
9	Mineral and bone metabolism disorders in chronic kidney disease	0.0	5.2	0.0	94.8	0.0	0.0	0.0	0.0	0.0
10	Prostate cancer/endocrine therapy/radiotherapy/effect and adverse	0.0	7.1	0.0	92.9	0.0	0.0	0.0	0.0	0.0
11	Pathological condition and treatment of bronchial asthma	0.0	0.0	0.0	96.8	0.0	0.0	0.0	0.0	0.0
12	Clinical research on early diagnosis, prevention and treatment of deep	0.0	0.0	0.0	80.5	0.0	0.0	0.0	0.0	0.0
13	Effect and adverse effect of hormone replacement therapy (HRT)	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
14	Research on physiological role of peptide hormone in the brain	0.0	42.1	0.0	18.4	0.0	0.0	0.0	0.0	0.0
15	Molecular mechanism of the onset of Alzheimer's disease and the	0.0	8.9	2.2	20.0	0.0	0.0	0.0	0.0	0.0
16	Clinical research for Parkinson's disease	0.0	0.0	0.0	42.1	0.0	0.0	0.0	0.0	0.0
17	Neurogenesis in adult hippocampus (the understanding of phenomena and the	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	Genetic research on schizophrenia and molecular pathogenesis investigations	0.0	0.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0
19	Brain-derived neurotrophic factor/brain morphology in schizophrenia/mood	0.0	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0
20	Clinical research on treatment of schizophrenia and bipolar disorder	0.0	0.0	0.0	8.8	0.0	0.0	0.0	0.0	0.0
21	Molecular neuroscience of emotion and its pathological conditions	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	Research on higher brain functions unique to humans using functional brain	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	Brain neural mechanisms for decision-making	0.0	0.0	0.0	0.0	0.0	9.1	4.5	0.0	0.0
24	Neural mechanisms for emotion/empathy and imitation/context	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	Molecular mechanisms for excitatory synaptic plasticity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	Biological implication of protein aggregation from the viewpoint of common denominators in transmissible	0.0	34.4	15.6	12.5	0.0	0.0	6.3	0.0	0.0
27	Hydroxylation modification of HIF and HIF α and regulation of mitochondrial	0.0	42.9	0.0	42.9	0.0	0.0	0.0	0.0	0.0
28	Molecular mechanism of apoptosis (cell death)	0.0	24.4	4.4	44.4	0.0	0.0	0.0	0.0	0.0
29	Role of autophagy in health and disease	0.0	26.3	0.0	16.2	0.0	0.0	0.0	0.0	0.0
30	Research on regenerative medicine and stem cells	0.0	8.8	0.0	64.9	1.0	0.0	0.0	0.0	0.0
31	Research on aging-suppression and longevity-control factors in individual	0.0	34.4	0.0	15.6	0.0	0.0	0.0	0.0	0.0
32	Metabolism control through PGC-1 α and insulin resistance	0.0	57.1	0.0	28.6	0.0	0.0	0.0	0.0	0.0
33	Genetic epidemiologic research on complex genetic disease	0.0	5.1	0.0	52.6	0.0	0.0	0.0	0.0	0.0
34	Elucidation of pathogenic mechanism of lifestyle-related diseases resulting from	0.0	17.3	0.0	81.6	0.0	0.0	0.0	0.0	0.0
35	Development of drug therapy/genome sequencing technology for breast cancer	0.0	2.5	0.0	61.4	10.1	0.0	0.0	0.0	0.0
36	Molecular biological approach to human malignancies	0.0	10.6	0.0	76.7	0.0	0.0	0.0	0.0	0.0
37	Multiple myeloma/new medicament	0.0	3.5	2.7	92.0	0.0	0.0	0.0	0.0	0.0
38	Research on the development of molecular targeting anticancer drugs	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0
39	Activation of tyrosine kinase and its drug resistance	0.0	4.4	0.9	94.7	0.0	0.0	0.0	0.0	0.0
40	Role of ubiquitin modification system in NF-kB activation	0.0	14.3	0.0	35.7	0.0	0.0	0.0	0.0	0.0
41	Production of interferon by innate immunity	0.0	1.1	0.0	28.0	0.0	0.0	0.0	0.0	0.0
42	Differentiation mechanism of T cell subsets and their role in disease	0.0	2.8	0.0	54.4	0.0	0.0	0.0	0.0	0.0
43	Control of autoimmune disease by immunoregulatory mechanism of	0.0	0.0	0.0	99.1	0.0	0.0	0.0	0.0	0.0
44	NK cell receptor and its ligand that inhibits activation	0.0	0.0	0.0	56.3	0.0	0.0	0.0	0.0	0.0
45	Development of human papillomavirus vaccine	0.0	0.0	0.0	88.6	0.0	0.0	0.0	0.0	0.0

Immunology	MATERIALS SCIENCE	MATHEMATICS	Microbiology	Molecular Biology & Genetics	MULTIDISCIPLINARY	NEUROSCIENCE & BEHAVIOR	Pharmacology	PHYSICS	PLANT & ANIMAL SCIENCE	PSYCHIATRY/PSYCHOLOGY	SOCIAL SCIENCES, GENERAL	SPACE SCIENCES
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	45.8	12.5	0.0	0.0	12.5	0.0	0.0
0.0	0.0	0.0	0.0	1.2	0.0	24.7	25.9	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.4	0.0	0.0	14.6	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	36.8	2.6	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	62.2	2.2	0.0	0.0	4.4	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	52.6	5.3	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	89.7	0.0	0.0	0.0	10.3	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	43.8	0.0	0.0	0.0	43.8	0.0	0.0
0.0	0.0	0.0	0.0	4.0	0.0	20.0	0.0	0.0	0.0	68.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	91.2	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	28.9	0.0	0.0	0.0	71.1	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	57.7	0.0	0.0	0.0	40.4	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	81.8	0.0	0.0	0.0	4.5	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	67.9	0.0	0.0	0.0	28.6	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	3.1	0.0	6.3	0.0	0.0	21.9	0.0	0.0	0.0
0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	24.4	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	1.0	32.3	0.0	23.2	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	23.1	1.0	0.3	0.0	0.0	0.8	0.0	0.0	0.0
0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	14.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	40.1	0.7	1.5	0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	2.5	0.0	18.4	0.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	11.5	0.0	0.6	0.6	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.1	0.0	0.0	0.0	35.7	7.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52.7	0.0	0.0	16.1	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
36.4	0.0	0.0	2.4	3.7	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
43.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.6	0.0

Research area ID	Research area	AGRICULTURAL SCIENCES	Biology & Biochemistry	CHEMISTRY	CLINICAL MEDICINE	COMPUTER SCIENCE	ECONOMICS & BUSINESS	ENGINEERING	ENVIRONMENT/ECOLOGY	GEOSCIENCES
46	Development of drug resistance in Staphylococcus aureus and ways to	0.0	0.0	0.0	68.5	0.0	0.0	0.0	0.0	0.0
47	Process of early infection with Hepatitis C virus and its treatment	0.0	5.3	0.0	55.3	0.0	0.0	0.0	0.0	0.0
48	Control of HIV infection	0.0	0.0	0.0	48.0	0.0	0.0	0.0	0.0	0.0
49	Research on anti-HIV drugs	0.0	0.0	15.4	46.2	0.0	0.0	0.0	0.0	0.0
50	Network science	0.0	5.2	0.0	29.2	3.7	0.0	16.6	0.0	0.0
51	Gene silencing/plant hormone	0.0	20.3	0.3	23.4	1.8	0.3	0.0	0.0	0.0
52	Redox control	0.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
53	Environmental responses of plants/metabolome analysis/proteome	0.0	7.7	38.1	0.0	11.0	0.0	9.0	0.0	0.0
54	Mechanisms for generation of nitric oxide in plants and its physiological role	0.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
55	Defense mechanism of plants against infection	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.6	0.0
56	Plant-microorganism interactions/strigolactones	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
57	Plant developmental genetics/carbohydrate metabolism	0.0	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
58	Microorganism ecosystem	0.0	11.3	0.0	4.8	1.6	0.0	0.0	12.9	1.6
59	Systems biology/synthetic biology	0.0	55.6	11.1	0.0	0.0	0.0	0.0	0.0	0.0
60	Structure and functions of G-protein-coupled receptor	0.0	72.2	11.1	0.0	0.0	0.0	0.0	0.0	0.0
61	Analysis of dynamic behavior of proteins	0.0	38.5	46.2	0.0	0.0	0.0	0.0	0.0	0.0
62	Microchannel device	0.0	0.0	63.3	0.0	0.0	0.0	3.3	0.0	0.0
63	Semiconductor-spintronics material/magnetic semiconductors	0.0	5.3	23.4	6.4	0.0	0.0	0.0	0.0	0.0
64	Research on creation and application of nanofibers	0.0	0.0	14.9	0.0	0.0	0.0	2.1	0.0	0.0
65	Development of nanostructure using nucleic acid	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
66	Living radical polymerization/click reaction/molecular machine	0.0	1.9	89.9	0.0	0.0	0.0	0.0	0.0	0.0
67	Synthesis, function and toxicity of sensors/SWNTs/functional	0.0	1.4	61.1	1.0	0.0	0.0	1.4	8.5	0.0
68	Bioapplications of gold nanorods	0.0	0.0	65.1	4.7	0.0	0.0	0.0	0.0	0.0
69	High-efficiency electroluminescence (EL) element	0.0	0.0	37.8	0.0	0.0	0.0	2.2	0.0	0.0
70	Superhydrophobic surface	0.0	2.0	51.0	0.0	0.0	0.0	7.8	0.0	0.0
71	Mesoporous material/silica, carbon and metal oxide	0.0	0.0	45.5	0.0	0.0	0.0	3.0	0.0	0.0
72	Nanomaterial synthesis in ionic liquid/hollow and mesoporous material	0.0	0.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0
73	Ionic liquid	0.0	0.0	86.7	0.0	0.0	0.0	12.0	0.0	0.0
74	Development materials from carbonate following the examples of nanocarbons	0.0	0.0	28.6	0.0	0.0	0.0	35.7	0.0	0.0
75	Organic/organic-oxide semiconductors Photo- and electro-functional materials	0.0	0.0	37.1	0.0	0.0	0.0	4.2	0.0	0.0
76	Solid macromolecule type fuel cell	0.0	0.0	27.0	0.0	0.0	0.0	71.9	0.0	0.0
77	Formation of bulk metallic glass/transformation of metal glassy	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0
78	Ferroelectric property in new materials such as multiferroics, etc.	0.0	0.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0
79	Metal-based spintronics	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	Physics and chemistry of molecular substance	0.0	0.0	18.6	0.0	0.4	0.0	2.7	0.0	0.0
81	Nanochemistry of gold	0.0	0.0	71.1	0.0	0.0	0.0	0.0	0.0	0.0
82	New-generation density functional theory for large-scale molecular	0.0	0.0	86.7	0.0	0.0	0.0	0.0	0.0	0.0
83	Design and functions of configurational space and coordination lattice	0.0	0.0	89.7	0.0	0.0	0.0	3.0	0.0	0.0
84	Research on hydrogen bonding	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
85	Anion sensors	0.0	0.0	95.8	0.0	0.0	0.0	2.1	0.0	0.0
86	Catalytic asymmetric synthesis	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
87	Molecular conversion reaction using transition metal catalyst	0.0	0.0	98.7	0.0	0.0	0.0	0.0	0.0	0.0
88	Synthesis of N-Heterocyclic carbene (NHC) and its application to catalytic	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
89	Direct carbon bond formation through transition metal catalytic reactions	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
90	Microbial fuel cells/microbial cells/enzyme-based biofuel cells	0.0	6.7	10.0	0.0	0.0	0.0	8.3	55.0	0.0

Immunology	MATERIALS SCIENCE	MATHEMATICS	Microbiology	Molecular Biology & Genetics	MULTIDISCIPLINARY	NEUROSCIENCE & BEHAVIOR	Pharmacology	PHYSICS	PLANT & ANIMAL SCIENCE	PSYCHIATRY/PSYCHOLOGY	SOCIAL SCIENCES, GENERAL	SPACE SCIENCES
1.9	0.0	0.0	24.1	0.0	0.0	0.0	5.6	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	39.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	52.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.5	0.0	0.0	19.2	0.0	0.0	0.0	7.7	0.0	0.0	0.0	0.0	0.0
1.1	0.0	5.5	14.4	4.1	0.7	0.0	0.0	18.5	1.1	0.0	0.0	0.0
0.3	0.0	0.0	3.6	28.8	0.0	0.5	0.0	0.0	20.8	0.0	0.0	0.0
0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	55.0	0.0	0.0	0.0
0.0	0.6	0.6	0.6	7.1	0.0	0.0	0.0	0.0	25.2	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	88.0	0.0	0.0	0.0
0.6	0.0	0.0	1.3	2.5	0.0	0.0	0.0	0.0	94.4	0.0	0.0	0.0
0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0	98.1	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	93.5	0.0	0.0	0.0
0.0	0.0	0.0	50.0	6.5	1.6	0.0	0.0	0.0	9.7	0.0	0.0	0.0
0.0	0.0	0.0	7.4	7.4	18.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	11.1	0.0	0.0	5.6	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	7.7	0.0	0.0	7.7	0.0	0.0	0.0	0.0
0.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	13.3	0.0	0.0	0.0	0.0
0.0	14.9	0.0	0.0	0.0	0.0	0.0	1.1	48.9	0.0	0.0	0.0	0.0
0.0	76.6	0.0	0.0	0.0	0.0	0.0	6.4	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
0.0	11.6	0.0	0.0	0.0	0.0	0.0	5.5	8.2	1.0	0.0	0.3	0.0
0.0	19.8	0.0	0.0	0.0	0.0	0.0	0.0	10.5	0.0	0.0	0.0	0.0
0.0	55.6	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	0.0
0.0	29.4	0.0	0.0	0.0	0.0	0.0	0.0	9.8	0.0	0.0	0.0	0.0
0.0	51.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	36.7	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0
0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	10.7	0.0	0.0	0.0	0.0
0.0	42.2	0.0	0.0	0.0	0.0	0.0	0.0	16.5	0.0	0.0	0.0	0.0
0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	47.8	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0
0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	87.1	0.0	0.0	0.0	0.0
0.0	8.2	0.0	0.0	0.0	0.0	0.0	0.0	91.8	0.0	0.0	0.0	0.0
0.0	4.9	0.0	0.0	0.0	0.0	0.0	0.0	73.5	0.0	0.0	0.0	0.0
0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	24.4	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.3	0.0	0.0	0.0	0.0
0.0	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	1.7	0.0	18.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

RA_ID	Name of Resarch Area	AGRICULTURAL SCIENCES	Biology & Biochemistry	CHEMISTRY	CLINICAL MEDICINE	COMPUTER SCIENCE	ECONOMICS & BUSINESS	ENGINEERING	ENVIRONMENT/ECOLOGY	GEOSCIENCES
91	Complex hydrides associated with hydrogen production and storage and	0.0	0.0	20.3	0.0	0.0	0.0	44.6	0.0	0.0
92	Electromagnetic response of surface plasmon in artificial structures	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0
93	Meta material	0.0	0.0	0.0	0.0	1.3	0.0	3.9	0.0	0.0
94	Optical quantum information/communication, optical	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0
95	Qubits using semiconductor quantum dots/electronic charge, electron spin and	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
96	Quantum information science using atomic system/photons	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
97	Novel electronic order in high-temperature superconductivity	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
98	Ultrafast and ultraintense optical science	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
99	Limitation and application to signal processing/information theory using	0.0	0.0	0.0	0.0	46.5	0.0	26.8	0.0	0.0
100	Strongly interacting quantum many-body system	0.0	0.0	0.4	0.0	0.0	0.0	0.8	0.0	0.0
101	Studies on the evolution of air and living organism in early earth and its analytical	0.0	0.0	0.0	0.0	0.0	0.0	10.5	0.0	89.5
102	New technologies related to solid oxide fuel cell (SOFC)	0.0	0.0	0.0	0.0	0.0	0.0	90.6	0.0	0.0
103	Earth in the Precambrian era	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
104	Gauge/gravity theory correspondence and black hole solutions	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
105	Gamma-ray burst	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
106	Elementary particle physics/elementary particle astrophysics	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0
107	New developments in cosmology and elementary particles theory owing to	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
108	Emergence process of Homo sapiens	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.9
109	Warming impact/bio- and eco-systems	0.0	1.9	0.0	0.0	0.0	0.0	0.0	87.0	0.0
110	Environmental chemistry of bromine flame retardant	0.0	0.0	0.0	0.0	0.0	0.0	0.0	95.7	0.0
111	Environmental burden of drugs and other industrial chemicals and technologies to	0.0	0.0	31.3	0.0	0.0	0.0	0.0	68.8	0.0
112	Organic aerosol	0.0	0.0	4.0	0.0	0.0	0.0	12.0	12.0	72.0
113	Observational studies on carbon balance in continental ecosystem	69.0	0.0	0.0	0.0	0.0	0.0	0.0	17.2	6.9
114	Stability discrimination/stabilizing control of delay system using matrix	0.0	0.0	0.0	0.0	22.9	0.0	77.1	0.0	0.0
115	Atmospheric composition and minor constituents	1.4	0.0	0.0	0.0	0.0	0.0	26.1	1.4	68.1
116	Climate change simulation including aerosol effects	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
117	Sea level fluctuations/seawater density/ice sheet/water circulation	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	97.1
118	Restoration of the past global environmental change	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
119	Corporate governance	0.0	0.0	0.0	0.0	0.0	97.9	0.0	0.0	0.0
120	New asymptotic expansion method for nonlinear differential equation and its	0.0	0.0	0.0	0.0	17.1	0.0	53.7	0.0	0.0
121	New trends in economic geography － Evolutionary economics and relational	0.0	0.0	0.0	0.0	7.1	14.3	0.0	0.0	0.0

Immunology	MATERIALS SCIENCE	MATHEMATICS	Microbiology	Molecular Biology & Genetics	MULTIDISCIPLINARY	NEUROSCIENCE & BEHAVIOR	Pharmacology	PHYSICS	PLANT & ANIMAL SCIENCE	PSYCHIATRY/PSYCHOLOGY	SOCIAL SCIENCES, GENERAL	SPACE SCIENCES
0.0	31.1	0.0	0.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	95.0	0.0	0.0	0.0	0.0
0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	93.4	0.0	0.0	0.0	0.0
0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	93.3	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
0.0	0.0	26.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98.3	0.0	0.0	0.0	0.4
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	9.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	99.5	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0	0.0	93.3
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	98.3	0.0	0.0	0.0	0.8
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.1	0.0	0.0	0.0	43.9
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	81.1	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.9	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	1.4	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0
0.0	0.0	9.8	0.0	0.0	0.0	0.0	0.0	19.5	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78.6	0.0

RA_ID	Name of Resarch Area	ESI based Classification	Japan(W)	Japan(F)	US(W)	US(F)	UK(W)
1	Critically ill patient management (Particularly in cases of acute	CLINICAL MEDICINE	0.0	0.0	61.1	50.9	11.1
2	Effects and prognostics of device therapy for advanced heart failure	CLINICAL MEDICINE	0.0	0.0	58.8	44.5	14.7
3	Medical therapy for neuropathic pain and fibromyalgia syndrome	Inter-/multi disciplinary research area	0.0	0.0	83.3	71.5	12.5
4	Physiological function of endogenous cannabinoid system in central nervous	Inter-/multi disciplinary research area	6.2	5.3	63.0	44.8	7.4
5	Clinical research on the control of cardiovascular incidents by	CLINICAL MEDICINE	0.0	0.0	62.5	26.3	37.5
6	Coronary CT (computed tomography)	CLINICAL MEDICINE	2.0	2.0	41.2	31.0	2.0
7	Treatment of acute coronary syndrome using antiplatelet drugs	CLINICAL MEDICINE	1.8	0.9	67.0	41.9	19.3
8	Research on adverse effect of COX inhibitors	CLINICAL MEDICINE	0.0	0.0	65.4	34.1	38.5
9	Mineral and bone metabolism disorders in chronic kidney disease	CLINICAL MEDICINE	2.6	1.0	85.7	54.9	23.4
10	Prostate cancer/endocrine therapy/radiotherapy/effect and adverse	CLINICAL MEDICINE	0.0	0.0	67.9	61.6	10.7
11	Pathological condition and treatment of bronchial asthma	CLINICAL MEDICINE	0.0	0.0	51.6	38.3	48.4
12	Clinical research on early diagnosis, prevention and treatment of deep	CLINICAL MEDICINE	2.4	0.8	87.8	58.4	12.2
13	Effect and adverse effect of hormone replacement therapy (HRT)	CLINICAL MEDICINE	0.0	0.0	86.7	83.3	6.7
14	Research on physiological role of peptide hormone in the brain	Inter-/multi disciplinary research area	5.3	2.6	81.6	66.4	7.9
15	Molecular mechanism of the onset of Alzheimer's disease and the	NEUROSCIENCE & BEHAVIOR	4.4	1.4	86.7	66.9	11.1
16	Clinical research for Parkinson's disease	Inter-/multi disciplinary research area	0.0	0.0	63.2	38.6	42.1
17	Neurogenesis in adult hippocampus (the understanding of phenomena and the	NEUROSCIENCE & BEHAVIOR	3.4	3.4	62.1	51.7	0.0
18	Genetic research on schizophrenia and molecular pathogenesis investigations	Inter-/multi disciplinary research area	12.5	6.3	62.5	42.7	50.0
19	Brain-derived neurotrophic factor/brain morphology in schizophrenia/mood	PSYCHIATRY/PSYCHOLOGY	8.0	6.0	60.0	45.3	20.0
20	Clinical research on treatment of schizophrenia and bipolar disorder	PSYCHIATRY/PSYCHOLOGY	3.5	1.2	82.5	58.8	15.8
21	Molecular neuroscience of emotion and its pathological conditions	PSYCHIATRY/PSYCHOLOGY	0.0	0.0	68.9	60.7	22.2
22	Research on higher brain functions unique to humans using functional brain	Inter-/multi disciplinary research area	0.0	0.0	71.2	63.1	21.2
23	Brain neural mechanisms for decision-making	NEUROSCIENCE & BEHAVIOR	4.5	4.5	68.2	65.9	31.8
24	Neural mechanisms for emotion/empathy and imitation/context	NEUROSCIENCE & BEHAVIOR	0.0	0.0	71.4	58.9	21.4
25	Molecular mechanisms for excitatory synaptic plasticity	NEUROSCIENCE & BEHAVIOR	31.6	18.4	84.2	63.2	5.3
26	Biological implication of protein aggregation from the viewpoint of common denominators in transmissible	Inter-/multi disciplinary research area	0.0	0.0	56.3	41.7	18.8
27	Hydroxylation modification of HIF and HIF α and regulation of mitochondrial	Inter-/multi disciplinary research area	0.0	0.0	85.7	62.7	28.6
28	Molecular mechanism of apoptosis (cell death)	Inter-/multi disciplinary research area	0.0	0.0	75.6	68.3	4.4
29	Role of autophagy in health and disease	Inter-/multi disciplinary research area	22.2	15.5	68.7	53.0	13.1
30	Research on regenerative medicine and stem cells	CLINICAL MEDICINE	6.8	4.9	67.5	55.7	9.1
31	Research on aging-suppression and longevity-control factors in individual	Inter-/multi disciplinary research area	6.3	4.7	78.1	62.0	15.6
32	Metabolism control through PGC-1 α and insulin resistance	Inter-/multi disciplinary research area	0.0	0.0	100.0	89.3	0.0
33	Genetic epidemiologic research on complex genetic disease	Inter-/multi disciplinary research area	2.2	1.8	64.2	32.5	44.5
34	Elucidation of pathogenic mechanism of lifestyle-related diseases resulting from	CLINICAL MEDICINE	21.4	17.7	53.1	40.8	2.0
35	Development of drug therapy/genome sequencing technology for breast cancer	CLINICAL MEDICINE	5.7	1.9	69.0	44.6	31.6
36	Molecular biological approach to human malignancies	CLINICAL MEDICINE	6.3	3.7	72.5	54.7	13.9
37	Multiple myeloma/new medicament	CLINICAL MEDICINE	0.9	0.1	65.5	48.1	14.2
38	Research on the development of molecular targeting anticancer drugs	CLINICAL MEDICINE	3.0	3.0	72.7	57.0	12.1
39	Activation of tyrosine kinase and its drug resistance	CLINICAL MEDICINE	1.8	1.8	67.5	44.6	21.9
40	Role of ubiquitin modification system in NF-kB activation	Inter-/multi disciplinary research area	0.0	0.0	57.1	46.4	14.3
41	Production of interferon by innate immunity	Inter-/multi disciplinary research area	41.9	28.6	65.6	48.8	8.6
42	Differentiation mechanism of T cell subsets and their role in disease	Inter-/multi disciplinary research area	8.0	4.5	74.3	59.0	11.9
43	Control of autoimmune disease by immunoregulatory mechanism of	CLINICAL MEDICINE	4.4	3.2	69.0	37.7	28.3
44	NK cell receptor and its ligand that inhibits activation	Inter-/multi disciplinary research area	0.0	0.0	68.8	49.0	18.8
45	Development of human papillomavirus vaccine	CLINICAL MEDICINE	0.0	0.0	71.4	34.6	14.3

UK(F)	Germany(W)	Germany(F)	France(W)	France(F)	China(W)	China(F)	Korea(W)	Korea(F)	Inter_Co	DC	CC	BC
11.1	11.1	3.7	16.7	13.0	0.0	0.0	0.0	0.0	27.8	0.0077	0.1328	0.0026
2.4	11.8	1.9	14.7	4.8	20.6	13.0	0.0	0.0	29.4	0.0062	0.1277	0.0069
4.8	8.3	2.4	8.3	1.6	0.0	0.0	0.0	0.0	33.3	0.0031	0.1108	0.0000
4.7	11.1	4.3	13.6	8.0	0.0	0.0	0.0	0.0	43.2	0.0077	0.1535	0.0276
10.9	12.5	7.3	4.2	2.1	0.0	0.0	0.0	0.0	58.3	0.0108	0.1457	0.0294
2.0	49.0	36.9	2.0	1.0	0.0	0.0	0.0	0.0	31.4	0.0046	0.1639	0.0271
6.6	20.5	8.2	16.7	5.7	1.2	0.6	0.9	0.3	49.7	0.0232	0.1672	0.1242
13.9	15.4	3.3	0.0	0.0	3.8	3.8	0.0	0.0	50.0	0.0031	0.1334	0.0135
8.6	20.8	6.7	13.0	2.0	2.6	0.4	0.0	0.0	48.1	0.0031	0.1354	0.0022
6.5	0.0	0.0	3.6	0.9	0.0	0.0	0.0	0.0	25.0	0.0093	0.1422	0.0111
27.3	3.2	0.4	12.9	4.6	3.2	0.5	0.0	0.0	38.7	0.0015	0.1029	0.0000
2.8	17.1	3.3	19.5	6.6	0.0	0.0	0.0	0.0	43.9	0.0046	0.1399	0.0160
6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0077	0.1624	0.0200
4.5	7.9	2.4	2.6	2.6	5.3	2.6	2.6	1.3	34.2	0.0031	0.1435	0.0000
7.2	4.4	2.2	6.7	1.4	0.0	0.0	0.0	0.0	37.8	0.0093	0.1457	0.0091
16.5	31.6	8.6	15.8	2.5	0.0	0.0	0.0	0.0	63.2	0.0046	0.1454	0.0045
0.0	6.9	5.2	10.3	5.2	0.0	0.0	0.0	0.0	27.6	0.0062	0.1556	0.0715
37.5	0.0	0.0	12.5	5.2	0.0	0.0	0.0	0.0	50.0	0.0077	0.1244	0.0057
10.7	0.0	0.0	0.0	0.0	8.0	3.3	4.0	2.0	32.0	0.0124	0.1407	0.0333
9.5	10.5	3.1	5.3	1.5	0.0	0.0	0.0	0.0	38.6	0.0093	0.1244	0.0022
15.9	2.2	2.2	2.2	1.1	0.0	0.0	0.0	0.0	24.4	0.0186	0.1374	0.0595
14.4	3.8	1.9	0.0	0.0	1.9	1.9	0.0	0.0	25.0	0.0046	0.1210	0.0000
25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.6	0.0062	0.1210	0.0000
15.5	3.6	1.2	7.1	3.0	0.0	0.0	0.0	0.0	32.1	0.0093	0.1212	0.0091
2.6	15.8	10.5	5.3	5.3	0.0	0.0	0.0	0.0	42.1	0.0031	0.1283	0.0090
18.8	18.8	13.5	21.9	8.9	0.0	0.0	0.0	0.0	37.5	0.0015	0.1272	0.0000
14.2	9.5	1.6	14.3	6.4	0.0	0.0	4.8	1.6	38.1	0.0015	0.0880	0.0000
3.3	8.9	5.0	4.4	4.4	2.2	0.6	0.0	0.0	22.2	0.0108	0.1675	0.0197
6.5	6.1	2.3	8.1	3.9	1.0	0.5	3.0	2.0	40.4	0.0124	0.1677	0.0379
5.3	13.0	8.2	4.2	1.9	2.1	1.7	1.0	0.7	29.9	0.0279	0.2074	0.4396
7.3	0.0	0.0	6.3	4.2	0.0	0.0	0.0	0.0	43.8	0.0124	0.1848	0.0450
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.4	0.0077	0.1639	0.0009
18.6	13.1	4.6	13.1	4.1	5.1	1.5	2.9	0.6	64.2	0.0093	0.1634	0.0365
0.9	10.2	6.0	4.1	2.0	2.0	0.9	1.0	1.0	31.6	0.0139	0.1670	0.0614
12.6	12.7	3.1	15.2	4.7	1.3	0.1	0.0	0.0	48.7	0.0170	0.1872	0.0818
6.5	11.8	3.6	12.1	5.7	1.8	0.6	1.2	0.8	38.1	0.0279	0.1915	0.1775
4.9	21.2	12.4	18.6	6.2	0.9	0.1	0.0	0.0	42.5	0.0108	0.1683	0.0140
3.4	21.2	9.9	12.1	2.9	0.0	0.0	0.0	0.0	39.4	0.0124	0.1626	0.0086
7.2	21.1	5.5	18.4	4.8	2.6	1.0	2.6	0.3	46.5	0.0124	0.1670	0.0122
6.0	14.3	6.0	14.3	4.8	0.0	0.0	0.0	0.0	50.0	0.0077	0.1547	0.0090
3.8	16.1	6.4	6.5	1.7	3.2	1.2	0.0	0.0	40.9	0.0139	0.1660	0.0351
7.0	11.6	5.6	8.3	5.2	0.3	0.3	0.3	0.2	36.4	0.0279	0.1733	0.0998
9.3	28.3	7.4	21.2	5.6	0.9	0.9	0.0	0.0	53.1	0.0062	0.1548	0.0209
8.3	18.8	10.4	12.5	8.3	0.0	0.0	0.0	0.0	56.3	0.0031	0.1479	0.0000
6.4	2.9	0.5	17.1	6.6	5.7	0.7	0.0	0.0	57.1	0.0015	–	–

RA_ID	Name of Resarch Area	ESI based Classification	Japan(W)	Japan(F)	US(W)	US(F)	UK(W)
46	Development of drug resistance in Staphylococcus aureus and ways to	CLINICAL MEDICINE	5.6	5.6	81.5	63.6	7.4
47	Process of early infection with Hepatitis C virus and its treatment	Inter-/multi disciplinary research area	9.2	5.5	59.2	38.1	17.1
48	Control of HIV infection	Inter-/multi disciplinary research area	0.0	0.0	92.0	60.0	24.0
49	Research on anti-HIV drugs	Inter-/multi disciplinary research area	7.7	7.7	80.8	39.9	26.9
50	Network science	Inter-/multi disciplinary research area	3.7	1.4	37.6	25.8	9.6
51	Gene silencing/plant hormone	Inter-/multi disciplinary research area	7.7	5.8	70.7	58.0	7.2
52	Redox control	Inter-/multi disciplinary research area	5.0	5.0	50.0	27.5	10.0
53	Environmental responses of plants/metabolome analysis/proteome	Inter-/multi disciplinary research area	8.4	6.6	64.5	51.8	13.5
54	Mechanisms for generation of nitric oxide in plants and its physiological role	PLANT & ANIMAL SCIENCE	0.0	0.0	36.0	27.3	24.0
55	Defense mechanism of plants against infection	PLANT & ANIMAL SCIENCE	4.4	3.9	46.3	37.4	20.6
56	Plant-microorganism interactions/strigolactones	PLANT & ANIMAL SCIENCE	20.8	9.8	34.0	22.5	32.1
57	Plant developmental genetics/carbohydrate metabolism	PLANT & ANIMAL SCIENCE	12.9	8.1	41.9	27.7	32.3
58	Microorganism ecosystem	Inter-/multi disciplinary research area	1.6	0.2	77.4	56.6	12.9
59	Systems biology/synthetic biology	Inter-/multi disciplinary research area	3.7	3.7	92.6	82.7	11.1
60	Structure and functions of G-protein-coupled receptor	Biology & Biochemistry	11.1	8.3	61.1	39.8	16.7
61	Analysis of dynamic behavior of proteins	Inter-/multi disciplinary research area	0.0	0.0	76.9	65.4	7.7
62	Microchannel device	CHEMISTRY	16.7	15.0	70.0	63.3	0.0
63	Semiconductor-spintronics material/magnetic semiconductors	Inter-/multi disciplinary research area	11.7	7.4	53.2	49.1	7.4
64	Research on creation and application of nanofibers	MATERIALS SCIENCE	4.3	2.1	63.8	51.8	0.0
65	Development of nanostructure using nucleic acid	CHEMISTRY	0.0	0.0	81.3	78.1	6.3
66	Living radical polymerization/click reaction/molecular machine	CHEMISTRY	1.4	1.2	53.8	48.6	11.1
67	Synthesis, function and toxicity of sensors/SWNTs/functional	CHEMISTRY	5.5	4.5	56.3	49.9	8.5
68	Bioapplications of gold nanorods	CHEMISTRY	1.2	1.2	67.4	62.6	0.0
69	High-efficiency electroluminescence (EL) element	Inter-/multi disciplinary research area	7.8	7.8	33.3	28.7	5.6
70	Superhydrophobic surface	Inter-/multi disciplinary research area	3.9	2.0	47.1	46.1	3.9
71	Mesoporous material/silica, carbon and metal oxide	Inter-/multi disciplinary research area	15.2	7.3	18.2	12.1	15.2
72	Nanomaterial synthesis in ionic liquid/hollow and mesoporous material	Inter-/multi disciplinary research area	16.7	11.7	0.0	0.0	20.0
73	Ionic liquid	CHEMISTRY	24.0	21.3	32.0	31.3	9.3
74	Development materials from carbonate following the examples of nanocarbons	Inter-/multi disciplinary research area	3.6	3.6	32.1	24.4	7.1
75	Organic/organic-oxide semiconductors Photo- and electro-functional materials	Inter-/multi disciplinary research area	8.9	8.2	48.1	41.7	6.8
76	Solid macromolecule type fuel cell	ENGINEERING	3.4	2.2	58.4	52.5	2.2
77	Formation of bulk metallic glass/transformation of metal glassy	Inter-/multi disciplinary research area	15.2	11.2	58.7	48.6	13.0
78	Ferroelectric property in new materials such as multiferroics, etc.	PHYSICS	25.7	21.4	60.0	41.7	7.1
79	Metal-based spintronics	PHYSICS	36.1	31.7	44.3	42.6	9.8
80	Physics and chemistry of molecular substance	PHYSICS	8.7	6.3	59.8	48.5	11.7
81	Nanochemistry of gold	CHEMISTRY	8.9	7.4	46.7	37.0	8.9
82	New-generation density functional theory for large-scale molecular	CHEMISTRY	3.3	2.5	63.3	53.1	6.7
83	Design and functions of configurational space and coordination lattice	CHEMISTRY	10.9	8.0	39.4	32.0	10.9
84	Research on hydrogen bonding	CHEMISTRY	0.0	0.0	87.0	76.4	8.7
85	Anion sensors	CHEMISTRY	4.2	3.1	27.1	19.4	29.2
86	Catalytic asymmetric synthesis	CHEMISTRY	19.4	18.9	27.3	25.8	3.8
87	Molecular conversion reaction using transition metal catalyst	CHEMISTRY	3.3	3.3	32.5	31.5	4.6
88	Synthesis of N-Heterocyclic carbene (NHC) and its application to catalytic	CHEMISTRY	1.1	0.5	43.2	41.4	4.2
89	Direct carbon bond formation through transition metal catalytic reactions	CHEMISTRY	3.8	3.8	47.2	47.2	3.8
90	Microbial fuel cells/microbial cells/enzyme-based biofuel cells	Inter-/multi disciplinary research area	3.3	1.3	70.0	63.3	6.7

UK(F)	Germany(W)	Germany(F)	France(W)	France(F)	China(W)	China(F)	Korea(W)	Korea(F)	Inter_Co	DC	CC	BC
4.0	5.6	2.5	11.1	5.9	0.0	0.0	0.0	0.0	35.2	0.0046	0.1229	0.0091
7.2	31.6	12.2	28.9	12.2	1.3	1.3	0.0	0.0	48.7	0.0093	0.1540	0.0054
7.0	16.0	4.7	0.0	0.0	0.0	0.0	0.0	0.0	56.0	0.0077	0.1535	0.0078
8.7	30.8	4.4	38.5	8.8	0.0	0.0	0.0	0.0	57.7	0.0031	0.1189	0.0090
4.9	10.7	6.5	7.0	3.0	36.5	28.7	3.0	2.3	33.9	0.0031	0.1194	0.0135
4.0	11.8	7.5	5.4	3.2	4.1	2.3	1.3	1.0	31.6	0.0294	0.1869	0.1261
7.5	30.0	20.8	35.0	25.0	5.0	1.7	5.0	2.5	45.0	0.0093	0.1369	0.0026
7.0	12.9	6.4	1.3	1.0	4.5	3.0	3.9	2.2	30.3	0.0139	0.1470	0.0179
17.3	20.0	10.7	4.0	1.3	4.0	2.0	0.0	0.0	40.0	0.0124	0.1487	0.0020
11.7	30.0	19.2	2.5	0.9	2.5	1.9	0.0	0.0	32.5	0.0325	0.1652	0.0311
16.3	20.8	8.9	24.5	13.1	0.0	0.0	0.0	0.0	60.4	0.0093	0.1451	0.0006
12.4	25.8	18.0	3.2	1.6	3.2	1.6	3.2	1.6	67.7	0.0263	0.1641	0.0344
3.9	24.2	9.5	6.5	2.0	1.6	0.8	1.6	0.5	53.2	0.0031	0.1608	0.1565
5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.5	0.0046	0.1559	0.0241
10.2	33.3	19.4	16.7	7.4	0.0	0.0	5.6	2.8	61.1	0.0015	0.1055	0.0000
7.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.8	0.0046	0.1382	0.0045
0.0	0.0	0.0	3.3	3.3	0.0	0.0	3.3	3.3	16.7	0.0046	0.1474	0.0085
4.4	9.6	5.5	6.4	5.9	5.3	4.8	2.1	1.6	22.3	0.0201	0.1902	0.3141
0.0	12.8	5.0	0.0	0.0	10.6	4.6	14.9	12.8	34.0	0.0062	0.1466	0.0181
3.1	6.3	6.3	6.3	6.3	0.0	0.0	6.3	3.1	12.5	0.0062	0.1473	0.0048
8.1	10.6	8.3	3.4	2.6	2.9	2.4	0.5	0.5	18.3	0.0093	0.1485	0.0269
7.1	8.2	5.7	2.7	1.4	10.6	9.3	3.4	3.2	18.1	0.0170	0.1712	0.1429
0.0	2.3	1.7	1.2	1.2	4.7	2.7	5.8	3.9	17.4	0.0186	0.1729	0.1316
4.3	10.0	6.1	0.0	0.0	25.6	22.8	1.1	1.1	18.9	0.0046	0.1291	0.0000
2.9	7.8	5.9	11.8	11.8	21.6	21.6	0.0	0.0	7.8	0.0031	0.1280	0.0045
10.1	18.2	13.6	3.0	1.5	30.3	18.9	18.2	16.7	42.4	0.0015	0.1392	0.0000
15.0	20.0	13.3	0.0	0.0	26.7	21.7	6.7	6.7	23.3	0.0062	0.1506	0.0131
8.7	8.0	4.4	6.7	3.1	6.7	4.7	0.0	0.0	21.3	0.0031	0.1313	0.0003
5.4	21.4	17.9	3.6	3.6	25.0	17.9	0.0	0.0	32.1	0.0062	0.1489	0.0243
4.8	13.5	10.9	3.0	1.9	8.9	6.5	2.1	1.3	25.3	0.0217	0.1481	0.0556
0.8	3.4	2.5	1.1	1.1	14.6	12.4	9.0	6.5	18.0	0.0031	–	–
6.5	4.3	2.2	8.7	3.3	21.7	14.5	8.7	7.6	32.6	0.0015	0.1033	0.0000
4.8	7.1	4.0	7.1	5.5	2.9	2.9	2.9	1.2	42.9	0.0000	–	–
6.3	9.8	4.4	11.5	6.3	0.0	0.0	3.3	2.5	19.7	0.0031	0.1644	0.0278
6.2	13.6	8.1	6.8	4.1	4.2	2.4	1.9	1.3	36.0	0.0062	0.1503	0.0670
6.3	20.0	13.0	0.0	0.0	2.2	2.2	0.0	0.0	33.3	0.0046	0.1531	0.0483
5.8	20.0	16.7	3.3	1.7	0.0	0.0	1.7	0.8	26.7	0.0031	0.1175	0.0000
7.8	3.6	3.3	18.2	9.8	26.7	24.7	4.2	2.3	28.5	0.0093	0.1197	0.0152
3.6	8.7	3.3	0.0	0.0	0.0	0.0	4.3	2.2	26.1	0.0031	–	–
23.6	6.3	3.8	2.1	2.1	4.2	4.2	12.5	10.4	22.9	0.0031	0.1475	0.0090
3.8	13.1	13.1	1.0	1.0	11.1	10.2	0.0	0.0	5.2	0.0139	0.1445	0.0285
4.0	29.1	27.8	7.3	6.6	6.6	6.3	0.0	0.0	6.0	0.0155	0.1509	0.0654
3.7	18.9	16.7	6.3	4.0	13.7	13.7	0.0	0.0	8.4	0.0124	0.1326	0.0104
3.8	5.7	5.7	3.8	1.6	9.4	9.4	0.0	0.0	3.8	0.0108	0.1321	0.0023
5.0	6.7	4.5	0.0	0.0	1.7	1.7	1.7	0.4	16.7	0.0015	–	–

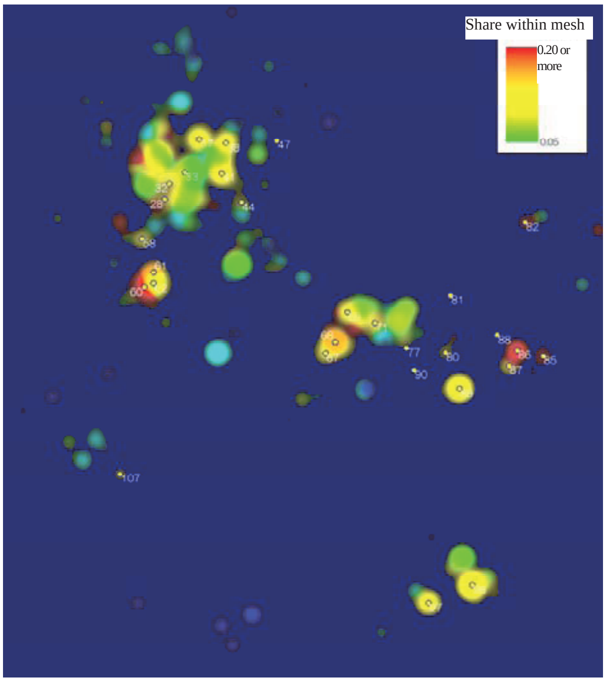
RA_ID	Name of Resarch Area	ESI based Classification	Japan(W)	Japan(F)	US(W)	US(F)	UK(W)
91	Complex hydrides associated with hydrogen production and storage and	Inter-/multi disciplinary research area	31.1	25.7	31.1	26.6	5.4
92	Electromagnetic response of surface plasmon in artificial structures	PHYSICS	10.0	7.5	30.0	25.0	15.0
93	Meta material	PHYSICS	0.0	0.0	75.0	52.4	21.1
94	Optical quantum information/communication, optical	PHYSICS	26.7	24.4	60.0	54.2	3.3
95	Qubits using semiconductor quantum dots/electronic charge, electron spin and	PHYSICS	7.0	4.3	51.2	38.0	4.7
96	Quantum information science using atomic system/photons	PHYSICS	4.3	1.8	51.1	40.4	25.5
97	Novel electronic order in high-temperature superconductivity	PHYSICS	52.2	20.1	73.9	40.7	26.1
98	Ultrafast and ultraintense optical science	PHYSICS	10.5	7.9	26.3	16.2	8.8
99	Limitation and application to signal processing/information theory using	Inter-/multi disciplinary research area	1.4	0.5	76.1	65.3	0.0
100	Strongly interacting quantum many-body system	PHYSICS	8.1	4.4	55.2	37.1	9.3
101	Studies on the evolution of air and living organism in early earth and its analytical	GEOSCIENCES	2.6	0.9	76.3	52.9	15.8
102	New technologies related to solid oxide fuel cell (SOFC)	ENGINEERING	0.0	0.0	12.5	10.9	9.4
103	Earth in the Precambrian era	GEOSCIENCES	9.6	6.7	26.5	17.3	7.2
104	Gauge/gravity theory correspondence and black hole solutions	PHYSICS	6.5	5.6	57.5	35.1	23.7
105	Gamma-ray burst	SPACE SCIENCES	17.8	4.6	95.6	39.7	51.1
106	Elementary particle physics/elementary particle astrophysics	PHYSICS	18.9	8.6	55.9	35.4	16.4
107	New developments in cosmology and elementary particles theory owing to	Inter-/multi disciplinary research area	12.1	4.9	61.7	36.3	22.4
108	Emergence process of Homo sapiens	SOCIAL SCIENCES, GENERAL	5.4	1.6	56.8	30.9	35.1
109	Warming impact/bio- and eco-systems	ENVIRONMENT/ECOLOGY	0.0	0.0	31.5	21.1	25.9
110	Environmental chemistry of bromine flame retardant	ENVIRONMENT/ECOLOGY	2.2	0.7	43.5	30.3	21.7
111	Environmental burden of drugs and other industrial chemicals and technologies to	ENVIRONMENT/ECOLOGY	0.0	0.0	0.0	0.0	12.5
112	Organic aerosol	GEOSCIENCES	2.0	0.3	74.0	52.4	16.0
113	Observational studies on carbon balance in continental ecosystem	AGRICULTURAL SCIENCES	17.2	10.9	62.1	28.9	10.3
114	Stability discrimination/stabilizing control of delay system using matrix	ENGINEERING	17.1	6.7	2.9	1.4	14.3
115	Atmospheric composition and minor constituents	GEOSCIENCES	10.1	1.2	84.1	51.3	27.5
116	Climate change simulation including aerosol effects	GEOSCIENCES	20.8	4.6	87.5	60.8	25.0
117	Sea level fluctuations/seawater density/ice sheet/water circulation	GEOSCIENCES	2.9	2.9	85.3	62.7	26.5
118	Restoration of the past global environmental change	GEOSCIENCES	3.2	0.3	83.9	44.7	25.8
119	Corporate governance	ECONOMICS & BUSINESS	0.0	0.0	89.6	81.6	6.3
120	New asymptotic expansion method for nonlinear differential equation and its	Inter-/multi disciplinary research area	0.0	0.0	8.5	6.1	0.0
121	New trends in economic geography – Evolutionary economics and relational	SOCIAL SCIENCES, GENERAL	0.0	0.0	7.1	3.6	50.0

UK(F)	Germany(W)	Germany(F)	France(W)	France(F)	China(W)	China(F)	Korea(W)	Korea(F)	Inter_Co	DC	CC	BC
4.5	9.5	7.9	0.0	0.0	10.8	7.4	5.4	5.4	20.3	0.0031	0.1122	0.0047
10.0	0.0	0.0	45.0	25.0	0.0	0.0	0.0	0.0	50.0	0.0046	0.1496	0.0000
12.5	10.5	4.8	2.6	1.1	14.5	11.2	0.0	0.0	44.7	0.0093	0.1521	0.0756
1.1	3.3	0.8	3.3	3.3	0.0	0.0	0.0	0.0	16.7	0.0093	0.1361	0.0632
4.7	23.3	15.1	4.7	3.1	0.0	0.0	2.3	1.2	30.2	0.0108	0.1347	0.0614
15.4	25.5	12.8	2.1	0.5	4.3	3.2	0.0	0.0	44.7	0.0108	0.1233	0.0991
9.9	8.7	3.6	21.7	7.8	4.3	1.4	0.0	0.0	78.3	0.0015	0.0916	0.0000
3.5	33.3	17.0	24.6	12.7	1.8	1.8	1.8	0.9	64.9	0.0031	0.1163	0.0045
0.0	9.9	6.3	14.1	10.3	7.0	3.8	0.0	0.0	29.6	0.0031	–	–
3.7	24.2	12.2	15.5	6.0	8.3	2.2	4.5	0.8	43.9	0.0077	0.1120	0.1084
11.0	7.9	4.6	13.2	6.6	13.2	6.1	0.0	0.0	50.0	0.0031	0.0620	0.0000
9.4	0.0	0.0	6.3	6.3	62.5	60.9	3.1	3.1	3.1	0.0000	–	–
3.5	10.8	4.7	4.8	1.6	65.1	43.4	0.0	0.0	55.4	0.0062	0.0621	0.0136
12.6	15.6	8.3	11.8	6.0	2.2	0.6	0.0	0.0	58.1	0.0046	0.0688	0.0180
14.2	15.6	2.5	6.7	0.9	6.7	1.4	0.0	0.0	80.0	0.0046	0.0932	0.0909
7.5	23.9	11.2	13.9	5.2	5.9	1.2	5.9	0.8	57.1	0.0077	0.0794	0.0447
9.8	24.1	9.8	15.0	5.2	5.4	4.1	4.0	1.5	58.4	0.0155	0.0859	0.0813
21.4	5.4	3.2	21.6	7.7	0.0	0.0	0.0	0.0	45.9	0.0031	0.1385	0.0045
14.8	20.4	9.5	11.1	5.2	0.0	0.0	0.0	0.0	50.0	0.0093	0.1149	0.0643
8.2	13.0	6.1	2.2	0.3	19.6	15.9	0.0	0.0	52.2	0.0015	–	–
12.5	18.8	12.5	0.0	0.0	0.0	0.0	0.0	0.0	18.8	0.0000	–	–
5.4	22.0	8.4	0.0	0.0	2.0	0.3	2.0	1.0	58.0	0.0077	0.0817	0.0030
1.3	34.5	5.3	24.1	2.9	0.0	0.0	0.0	0.0	69.0	0.0046	0.0958	0.0425
5.7	0.0	0.0	2.9	2.9	57.1	37.1	0.0	0.0	48.6	0.0031	0.1068	0.0090
7.6	21.7	4.5	20.3	3.8	1.4	0.1	0.0	0.0	56.5	0.0108	0.0884	0.0349
6.7	25.0	9.8	29.2	8.8	0.0	0.0	0.0	0.0	50.0	0.0186	0.0820	0.0149
14.7	8.8	3.4	5.9	2.9	0.0	0.0	0.0	0.0	47.1	0.0093	0.0882	0.0691
9.5	32.3	8.6	6.5	0.9	3.2	1.6	3.2	1.1	74.2	0.0046	0.0707	0.0314
4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.8	0.0015	–	–
0.0	0.0	0.0	0.0	0.0	26.8	26.2	0.0	0.0	7.3	0.0031	–	–
34.5	14.3	9.5	14.3	10.7	0.0	0.0	0.0	0.0	35.7	0.0015	–	–

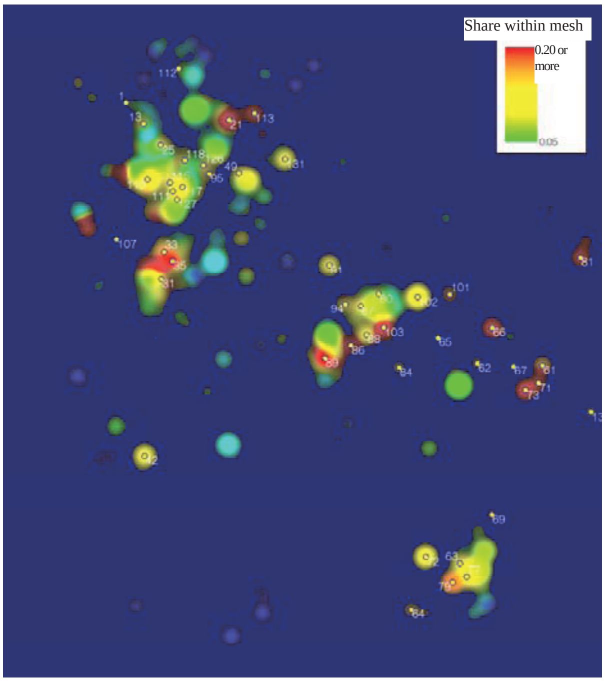
6. Shares of research papers in the Science Map

Reference figure 20 Japanese shares of research papers in the Science Map

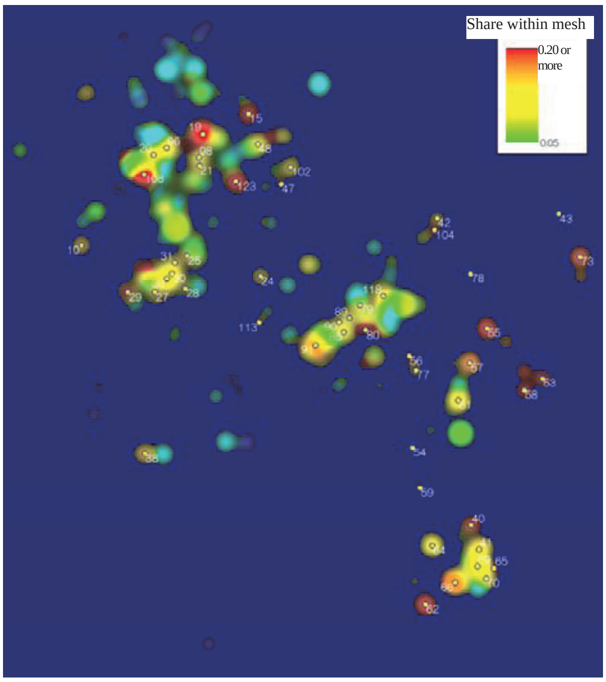
(A) Science Map 2002 [Whole count method]



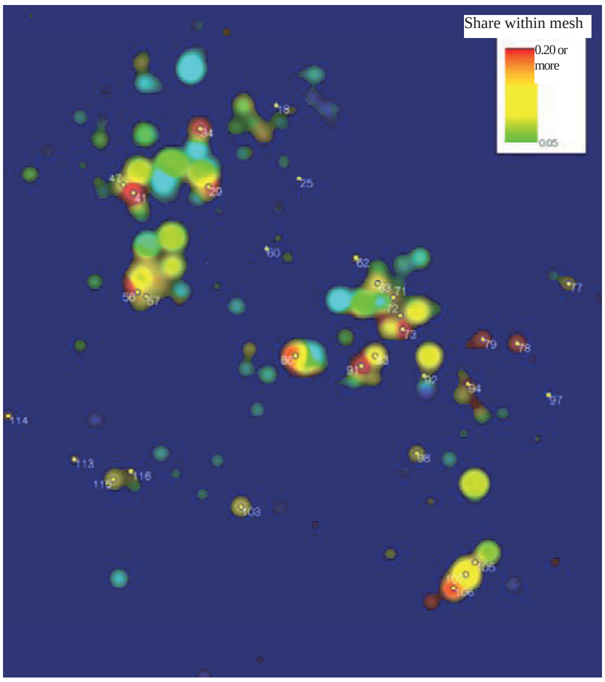
(B) Science Map 2004 [Whole count method]



(C) Science Map 2006 [Whole count method]



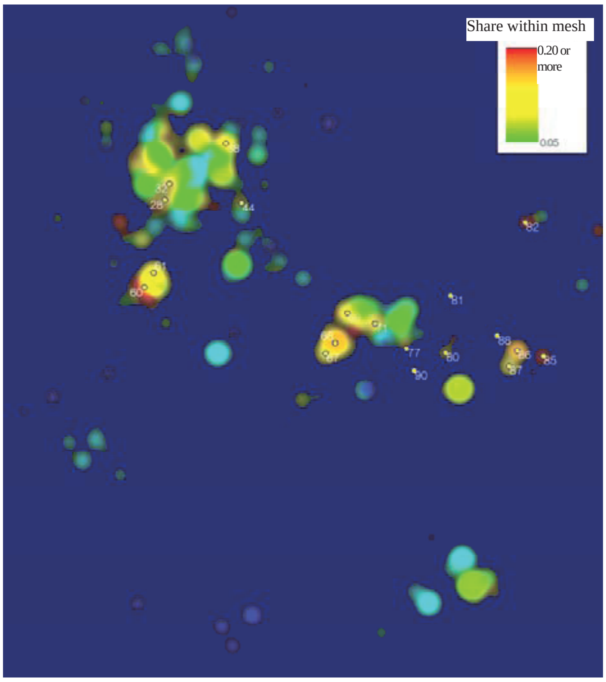
(D) Science Map 2008 [Whole count method]



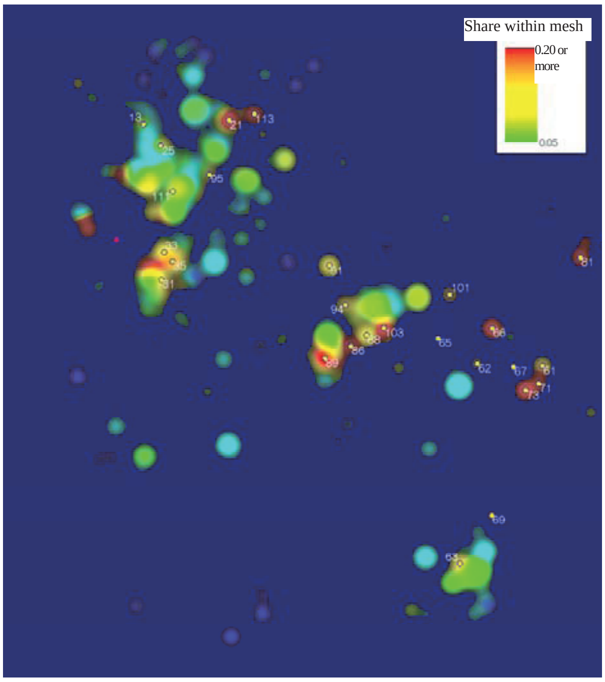
Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using whole count method. Yellow dots and numbers are the positions and IDs of hot research areas in which Japan the countries have a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Reference figure 21 Japanese shares of research papers in the Science Map

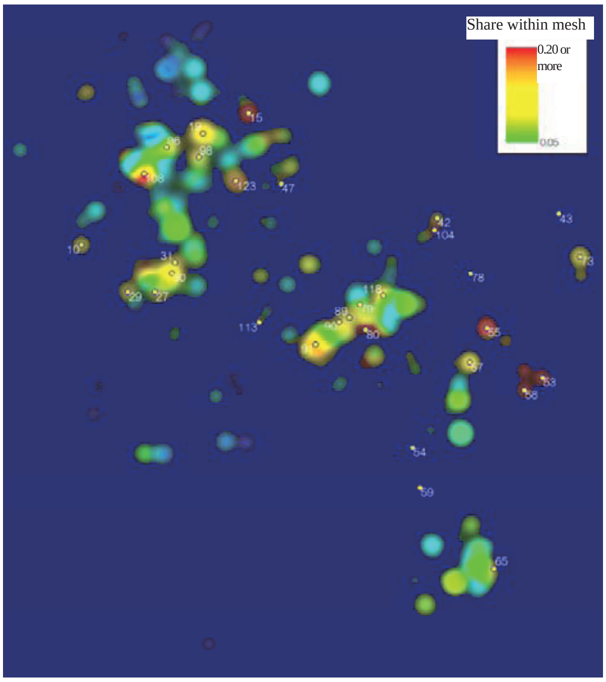
(A) Science Map 2002 [Fractional count method]



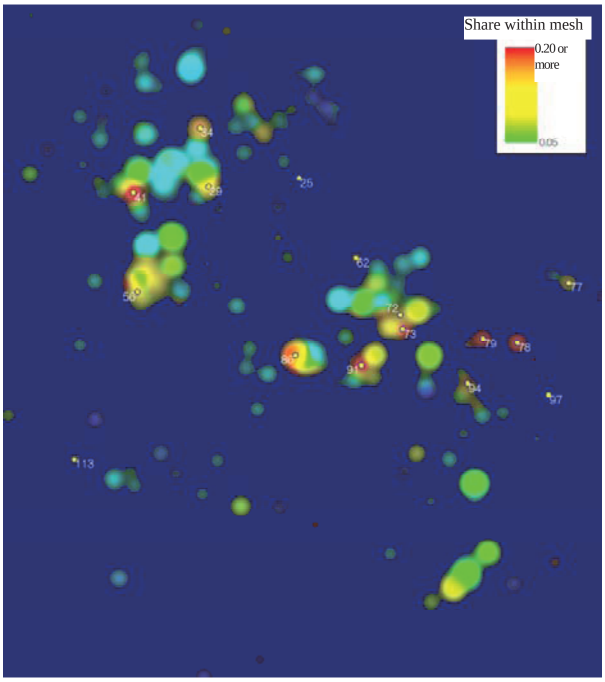
(B) Science Map 2004 [Fractional count method]



(C) Science Map 2006 [Fractional count method]



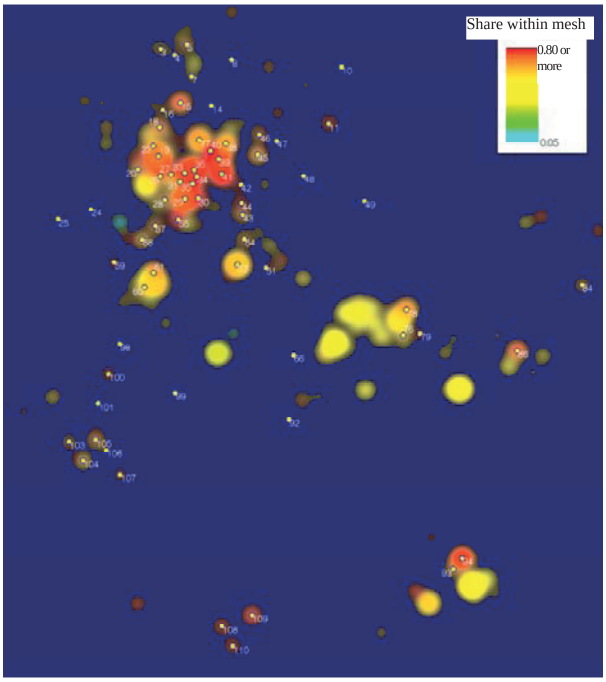
(D) Science Map 2008 [Fractional count method]



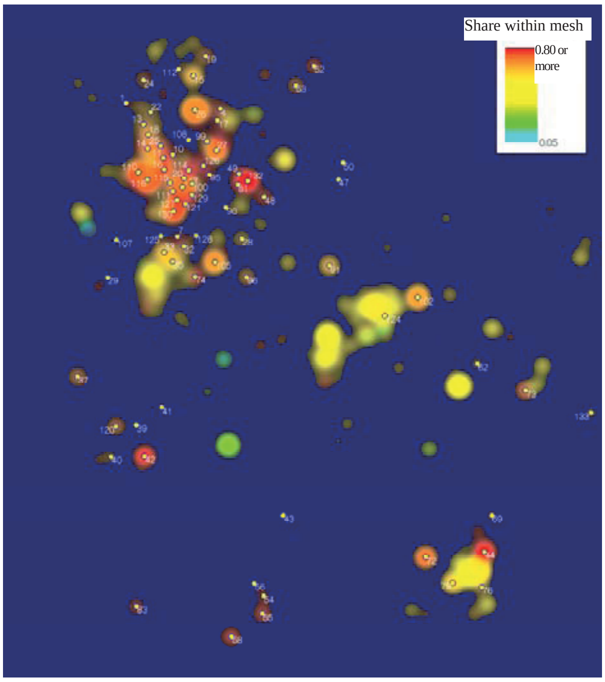
Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using the fractional count method. Yellow dots and numbers are the positions and IDs of hot research areas in which Japan has a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Reference figure 22　US shares of research papers in the Science Map

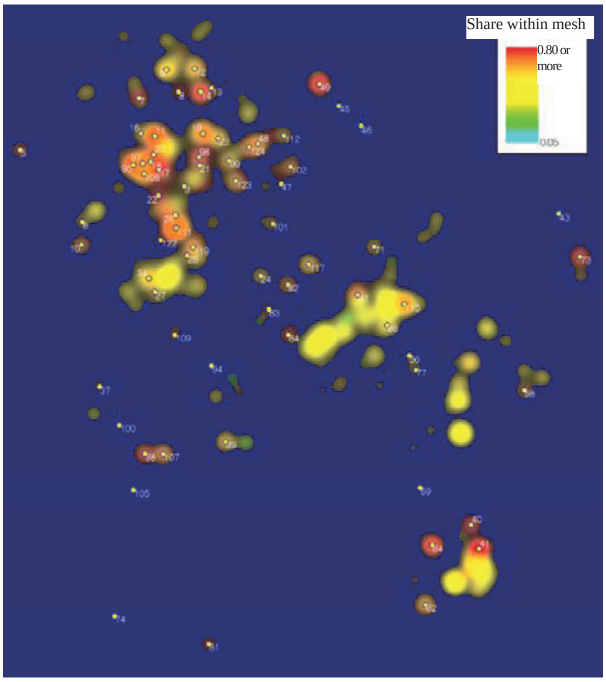
(A) Science Map 2002 [Whole count method]



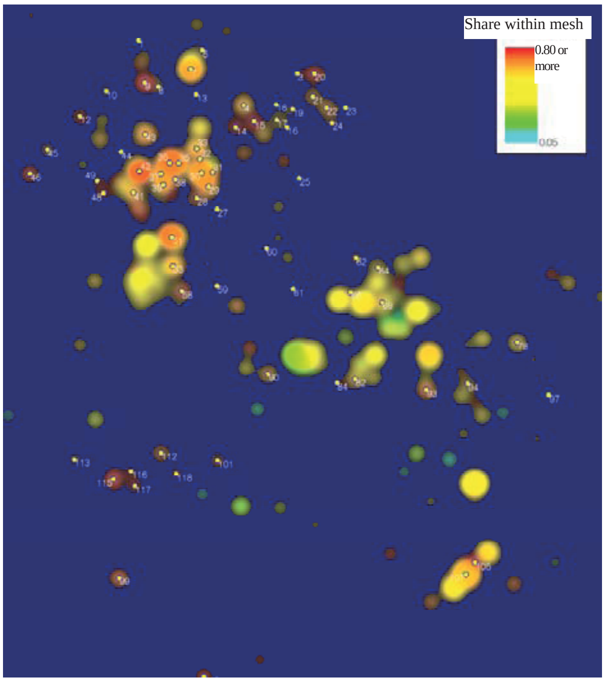
(B) Science Map 2004 [Whole count method]



(C) Science Map 2006 [Whole count method]



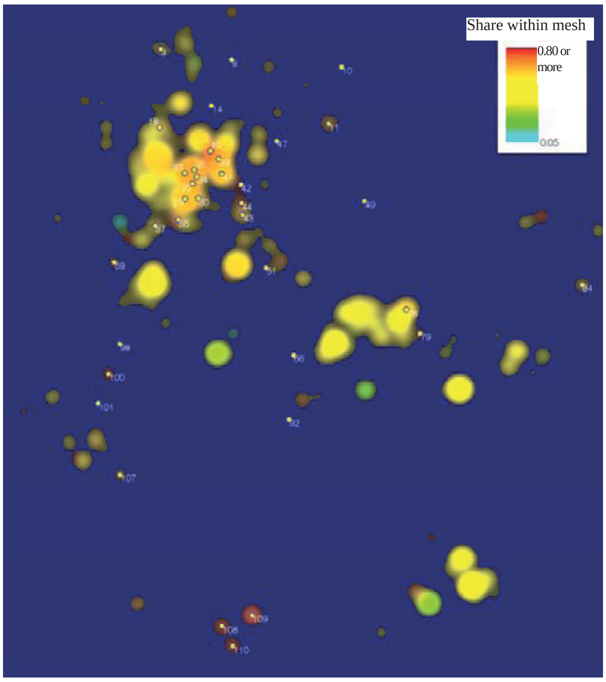
(D) Science Map 2008 [Whole count method]



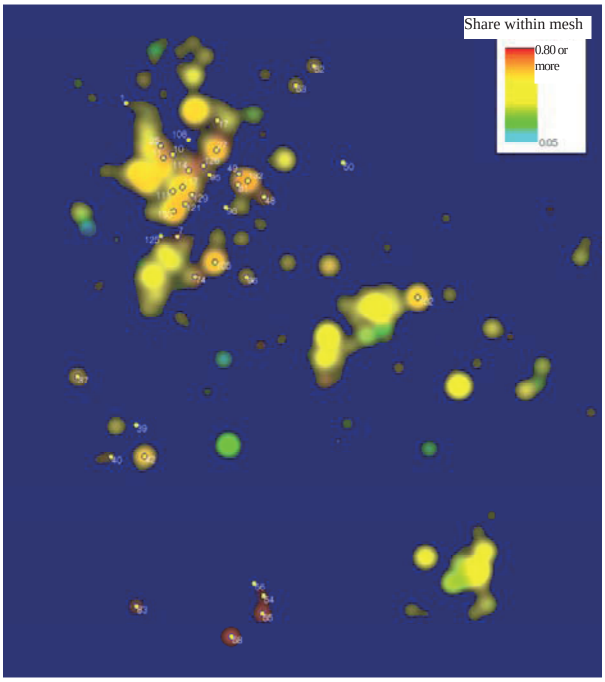
Note: Research paper shares of 5 percent are depicted in light blue, and shares of 80 percent or more in red. Shares of research papers were calculated using whole count method. Yellow dots and numbers are the positions and IDs of hot research areas in which US the countries have a 60 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Reference figure 23 US shares of research papers in the Science Map

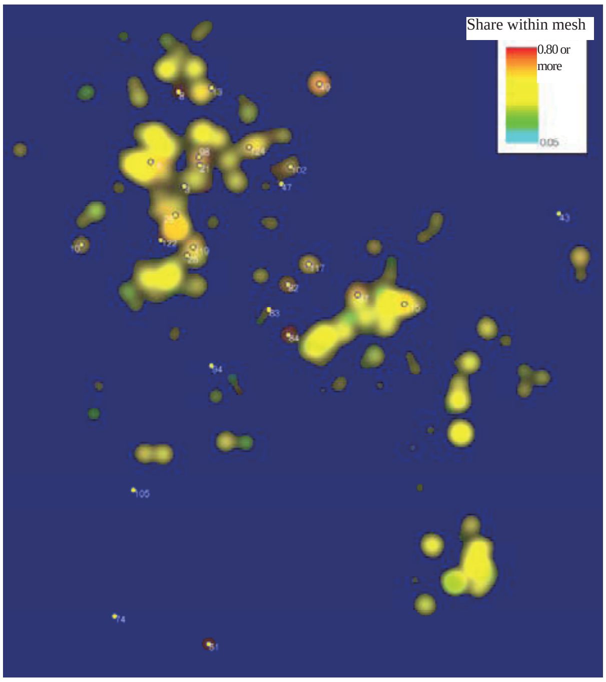
(A) Science Map 2002 [Fractional count method]



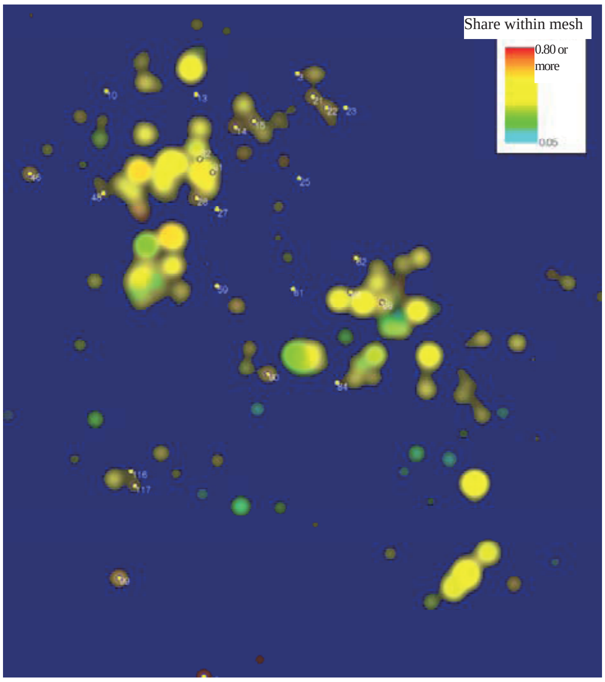
(B) Science Map 2004 [Fractional count method]



(C) Science Map 2006 [Fractional count method]



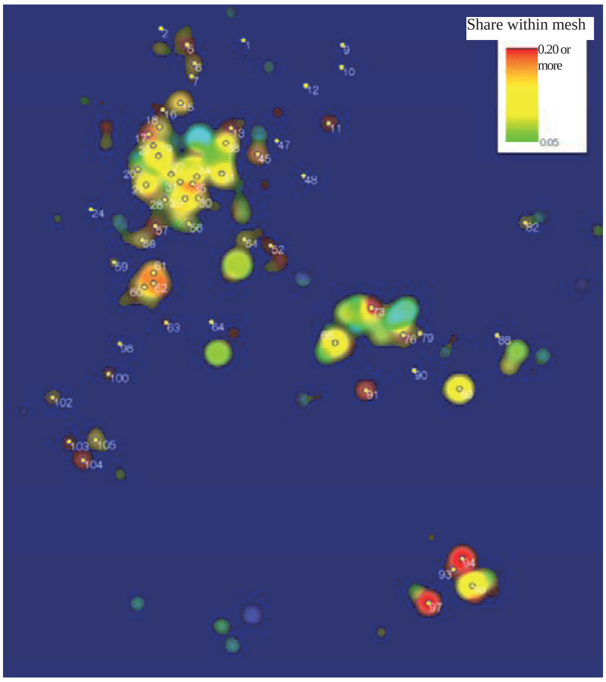
(D) Science Map 2008 [Fractional count method]



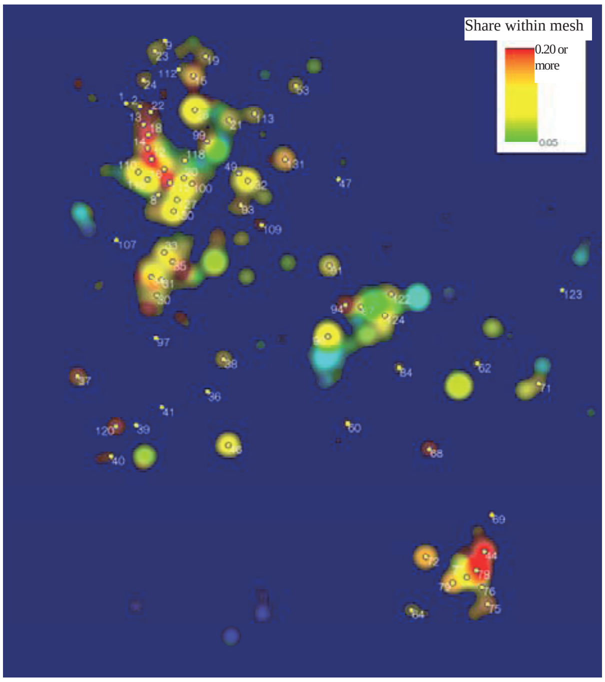
Note: Research paper shares of 5 percent are depicted in light blue, and shares of 80 percent or more in red. Shares of research papers were calculated using whole count method. Yellow dots and numbers are the positions and IDs of hot research areas in which US the countries have a 60 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Reference figure 24 UK shares of research papers in the Science Map

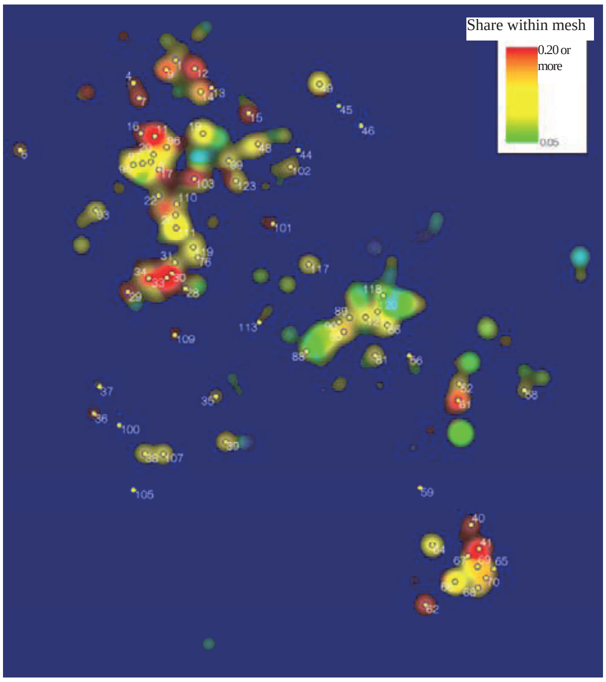
(A) Science Map 2002 [Whole count method]



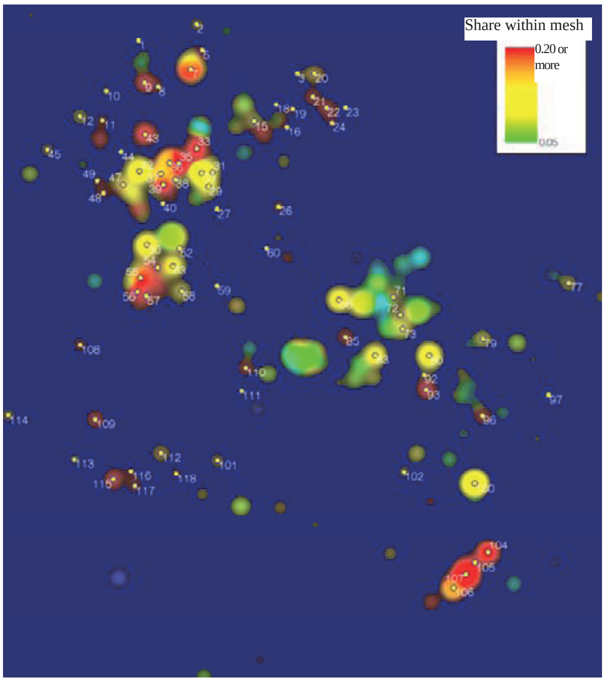
(B) Science Map 2004 [Whole count method]



(C) Science Map 2006 [Whole count method]



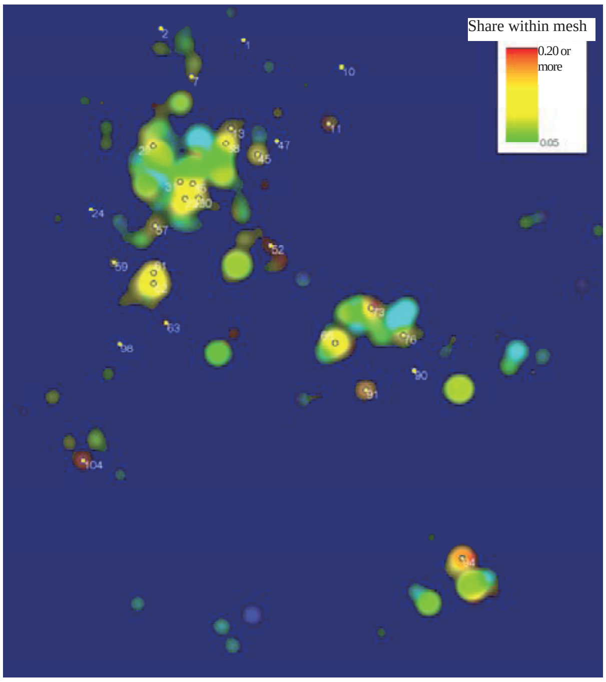
(D) Science Map 2008 [Whole count method]



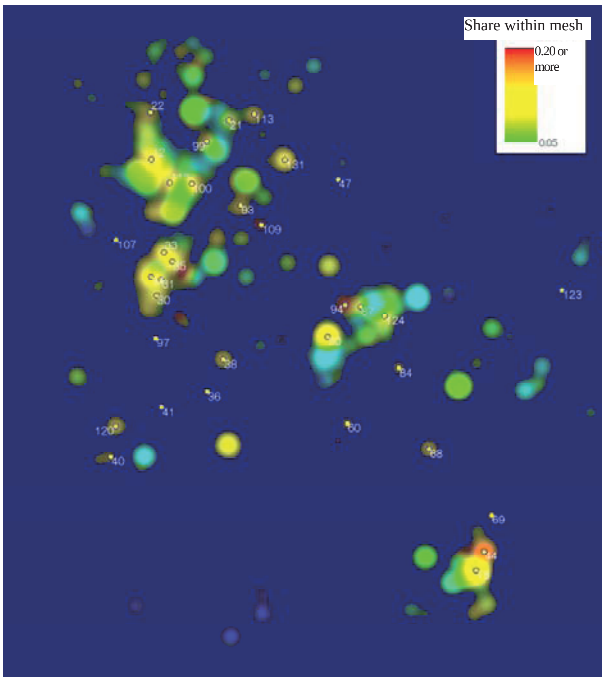
Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using whole count method. Yellow dots and numbers are the positions and IDs of hot research areas in which UK the countries have a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Reference figure 25 UK shares of research papers in the Science Map

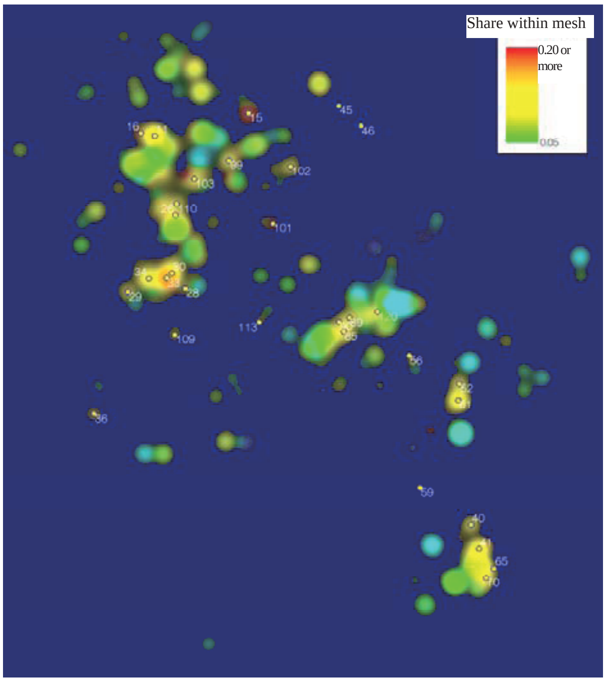
(A) Science Map 2002 [Fractional count method]



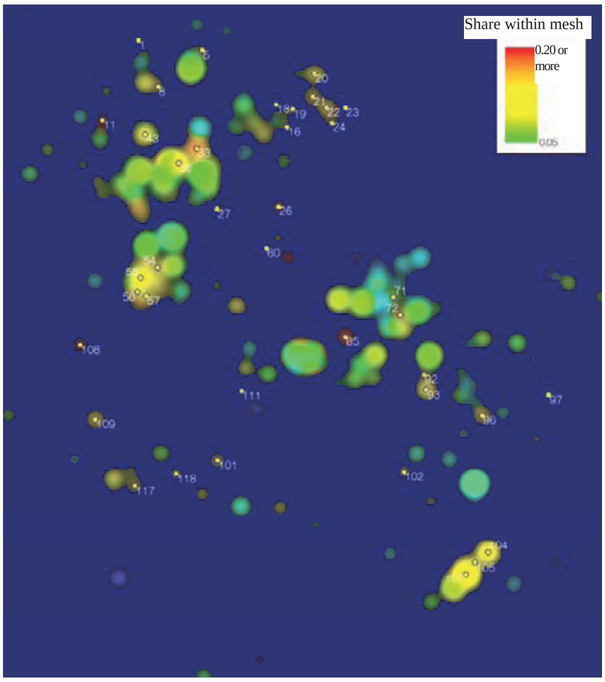
(B) Science Map 2004 [Fractional count method]



(C) Science Map 2006 [Fractional count method]



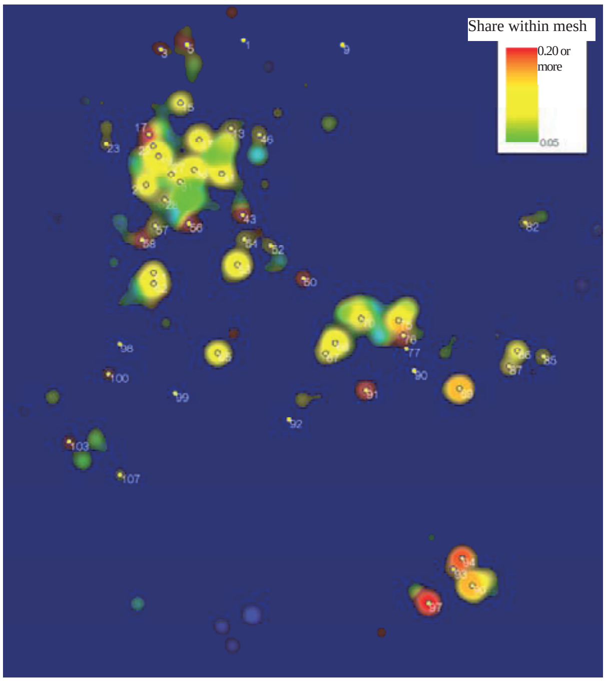
(D) Science Map 2008 [Fractional count method]



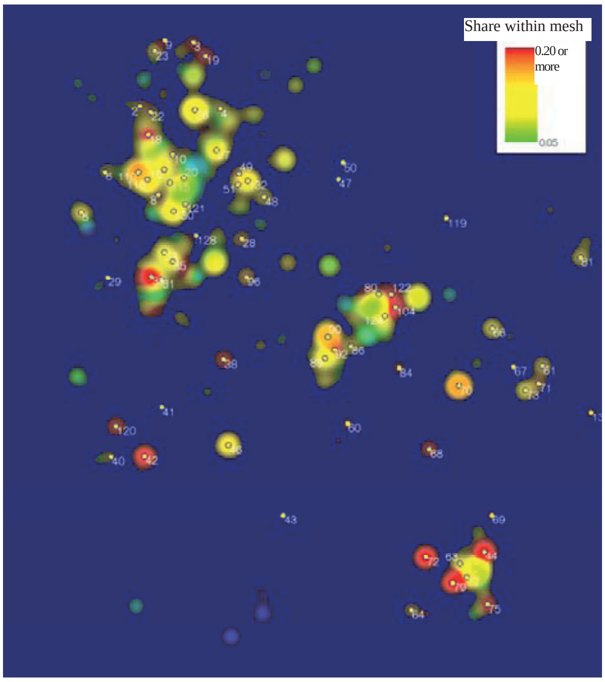
Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using whole count method. Yellow dots and numbers are the positions and IDs of hot research areas in which UK the countries have a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Reference figure 26 German shares of research papers in the Science Map

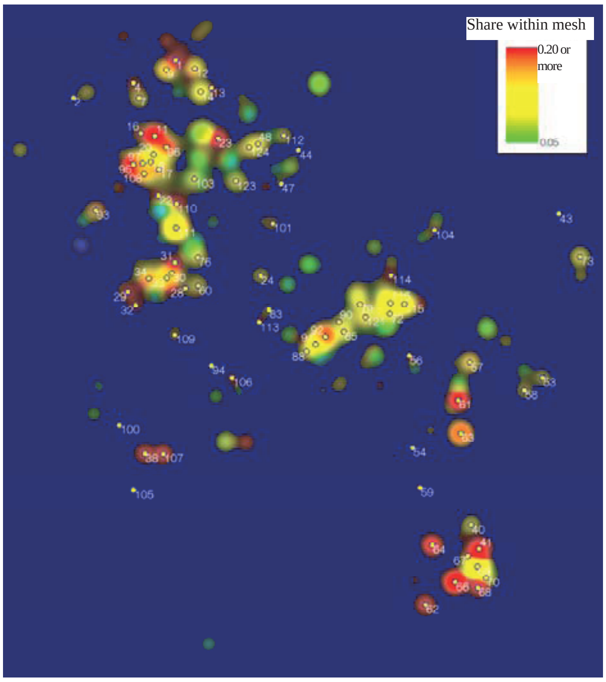
(A) Science Map 2002 [Whole count method]



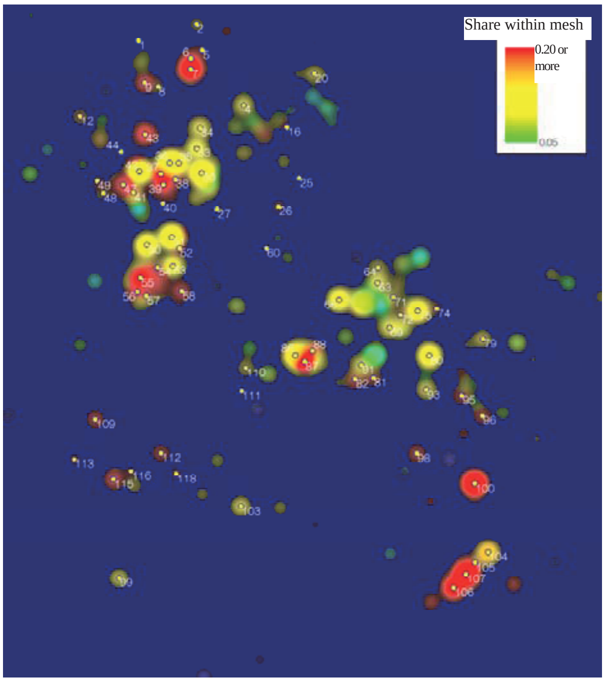
(B) Science Map 2004 [Whole count method]



(C) Science Map 2006 [Whole count method]



(D) Science Map 2008 [Whole count method]

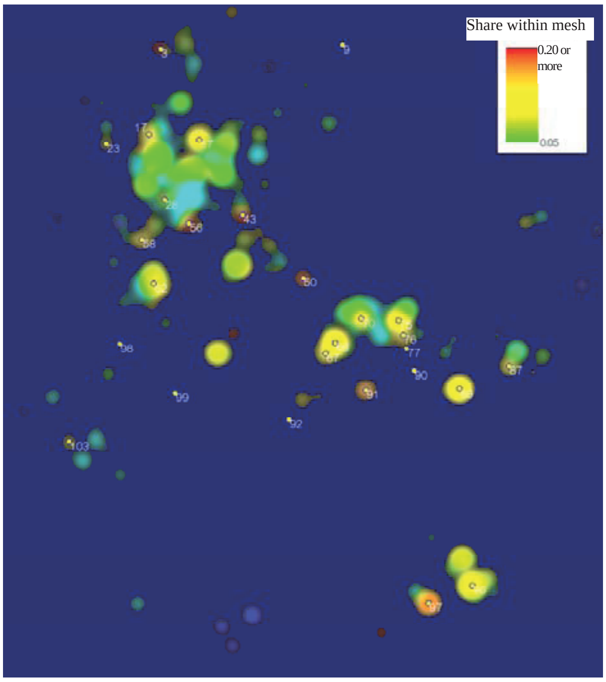


Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using whole count method. Yellow dots and numbers are the positions and IDs of hot research areas in which Germany the countries have a 9 percent or more shares of research papers.

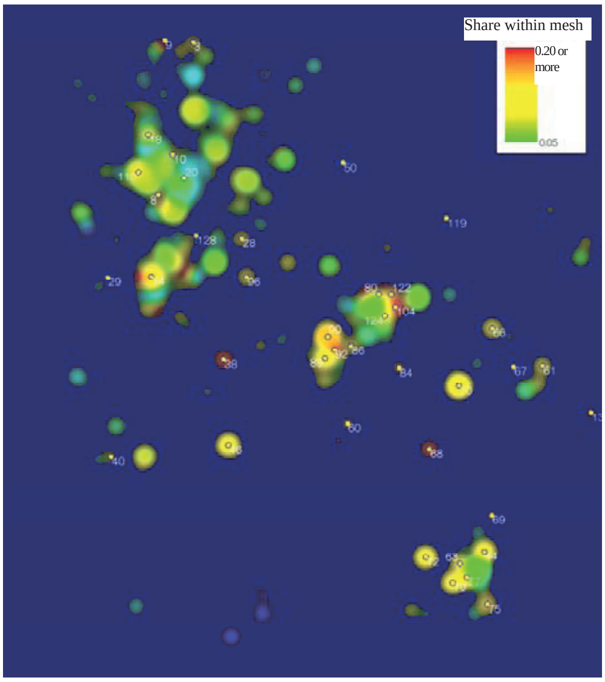
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Reference figure 27 German shares of research papers in the Science Map

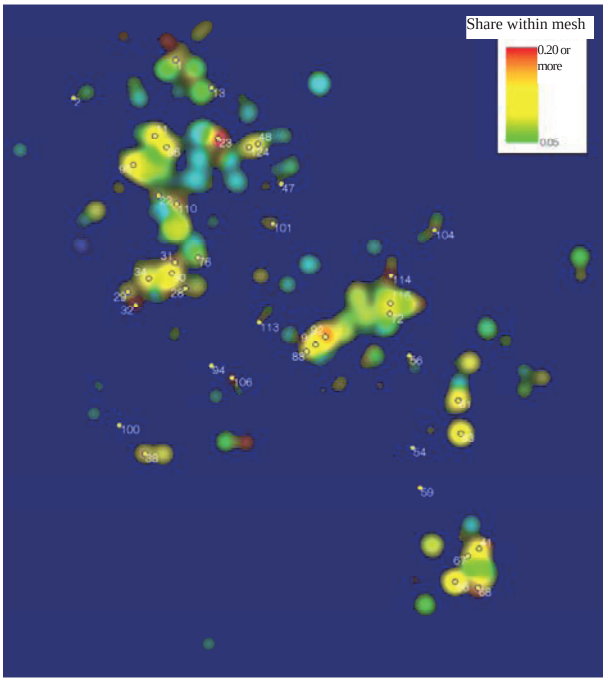
(A) Science Map 2002 [Fractional count method]



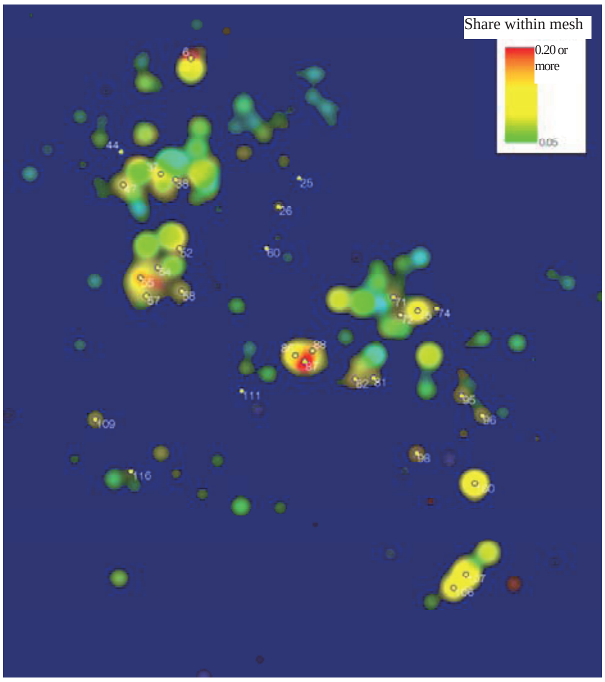
(B) Science Map 2004 [Fractional count method]



(C) Science Map 2006 [Fractional count method]



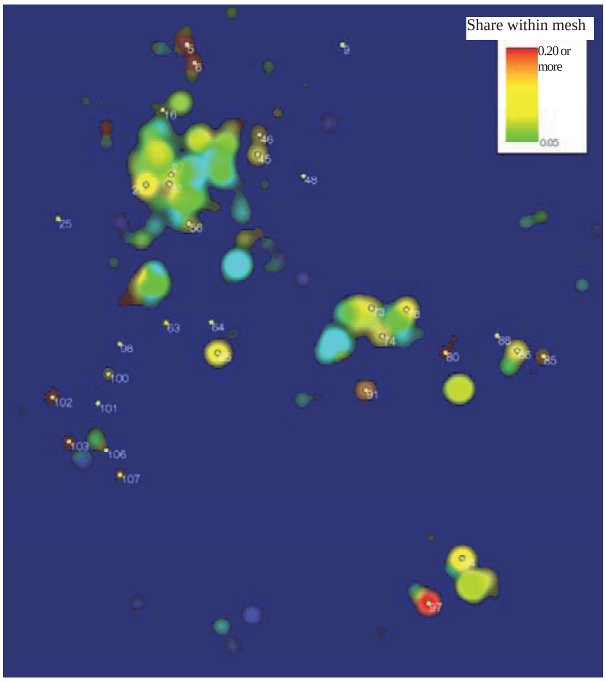
(D) Science Map 2008 [Fractional count method]



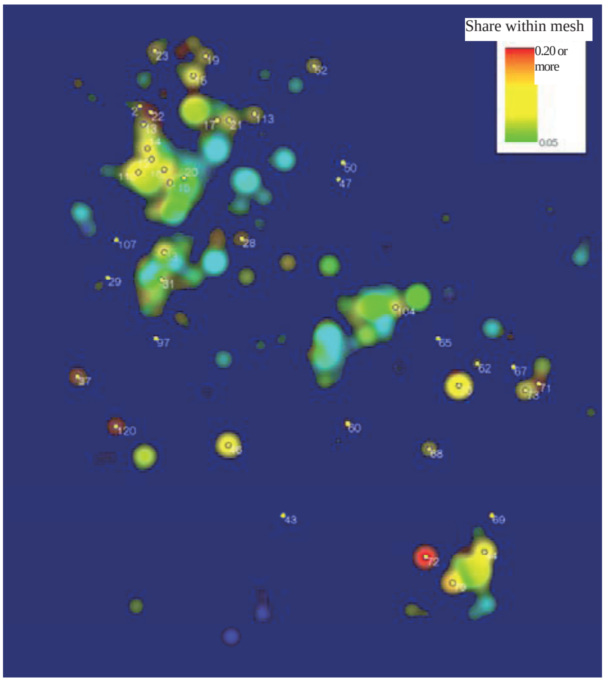
Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using whole count method. Yellow dots and numbers are the positions and IDs of hot research areas in which Germany the countries have a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Reference figure 28 French shares of research papers in the Science Map

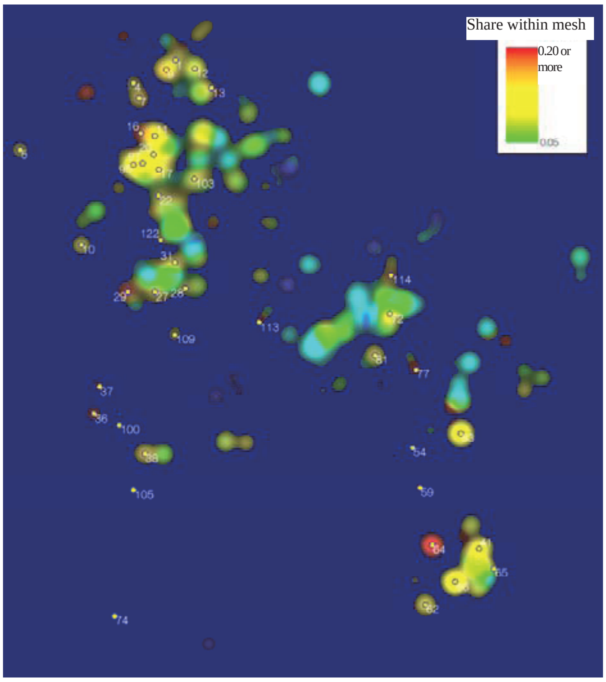
(A) Science Map 2002 [Whole count method]



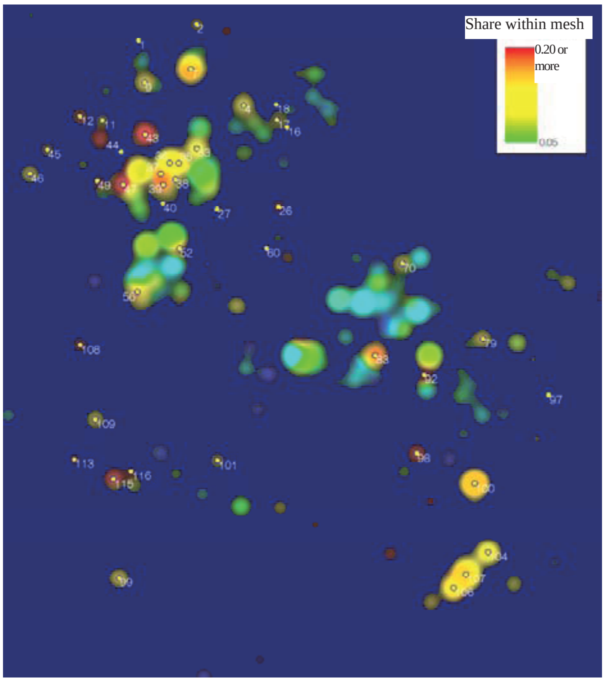
(B) Science Map 2004 [Whole count method]



(C) Science Map 2006 [Whole count method]



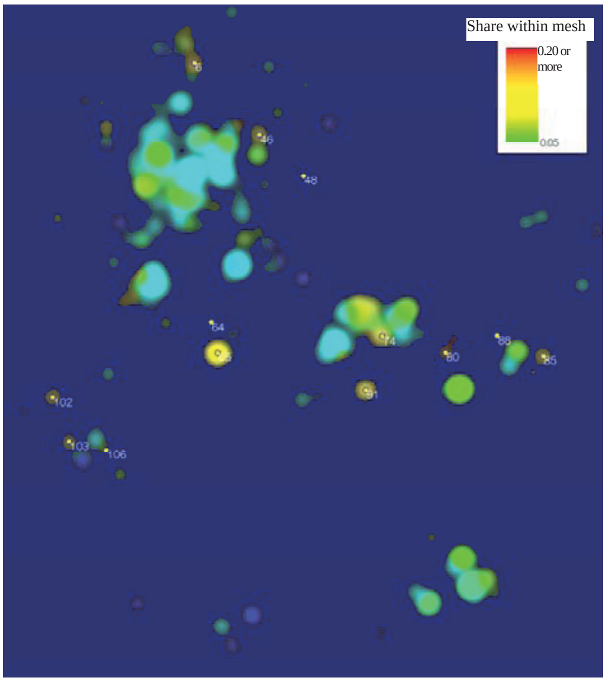
(D) Science Map 2008 [Whole count method]



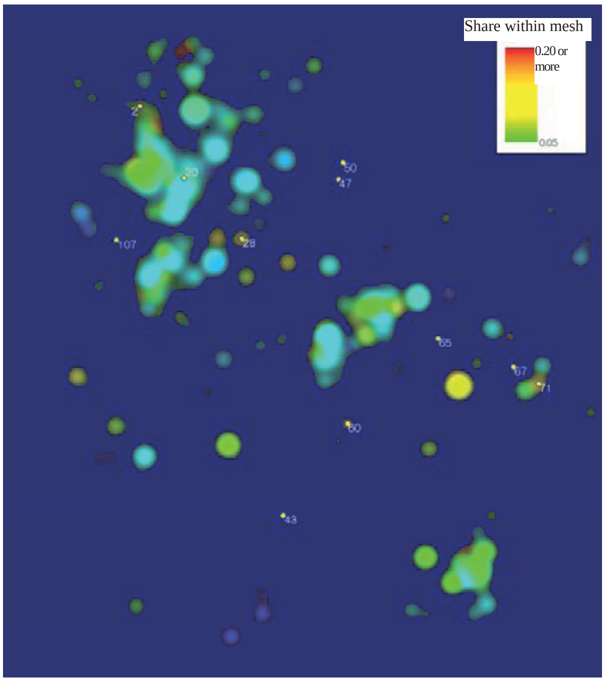
Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using whole count method. Yellow dots and numbers are the positions and IDs of hot research areas in which France the countries have a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Reference figure 29 French shares of research papers in the Science Map

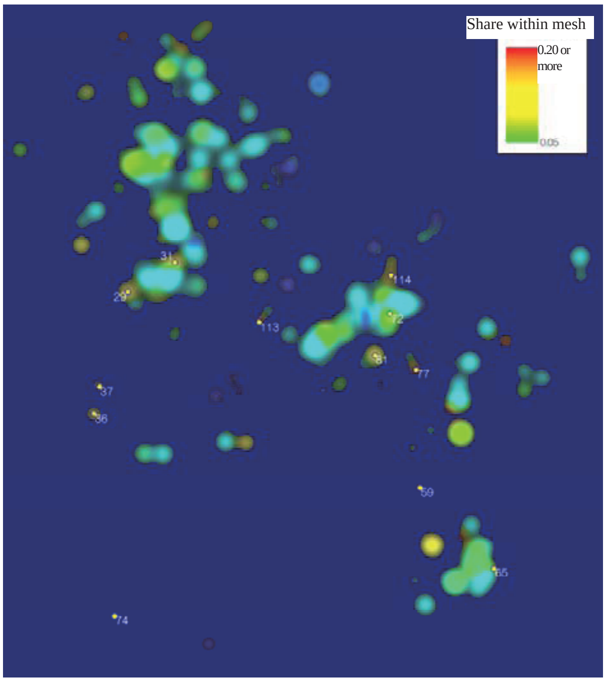
(A) Science Map 2002 [Fractional count method]



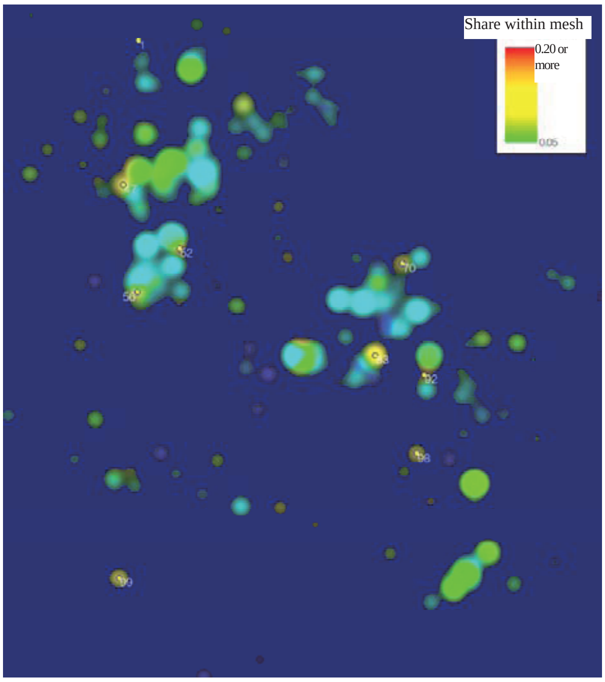
(B) Science Map 2004 [Fractional count method]



(C) Science Map 2006 [Fractional count method]



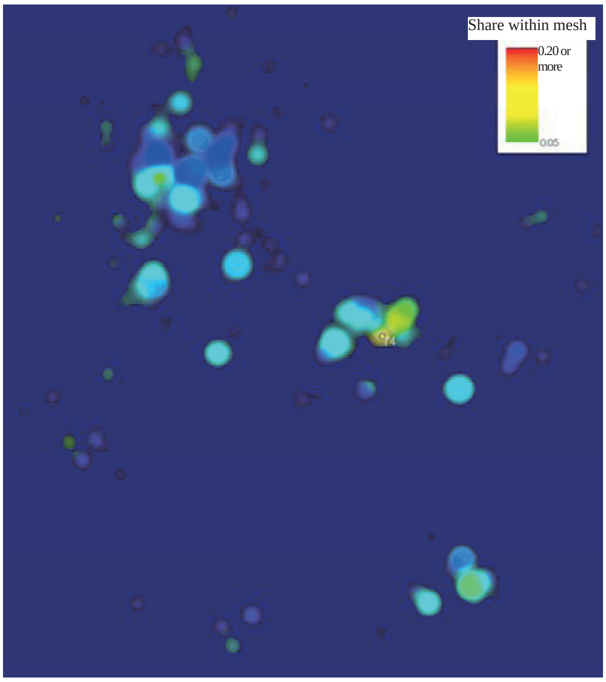
(D) Science Map 2008 [Fractional count method]



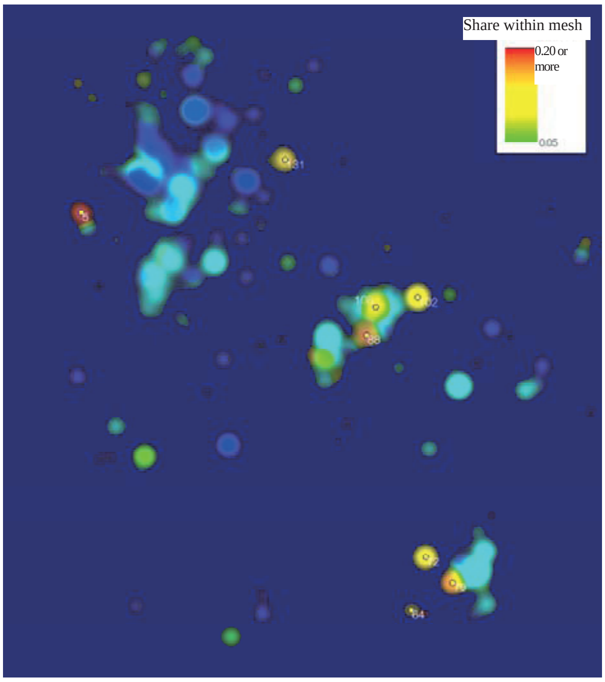
Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using whole count method. Yellow dots and numbers are the positions and IDs of hot research areas in which France the countries have a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Reference figure 30 Chinese shares of research papers in the Science Map

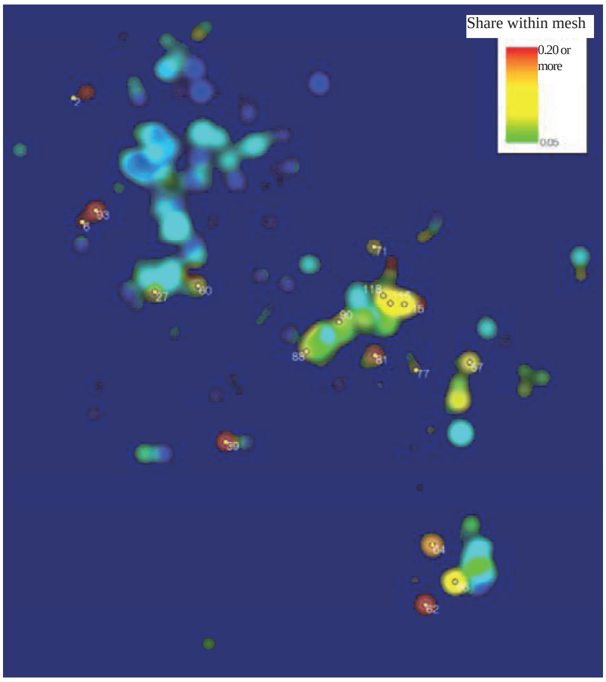
(A) Science Map 2002 [Whole count method]



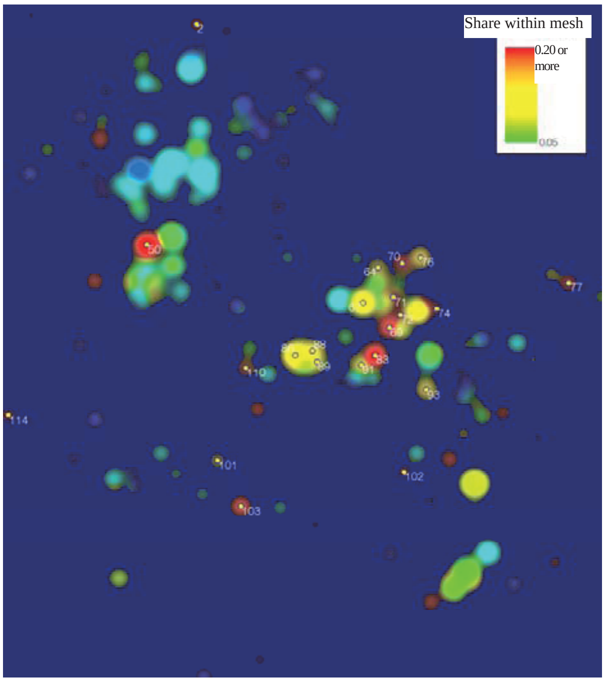
(B) Science Map 2004 [Whole count method]



(C) Science Map 2006 [Whole count method]



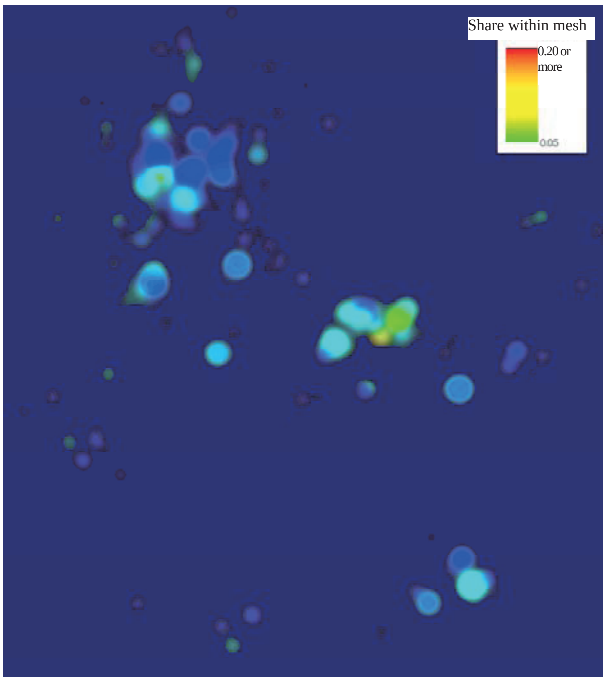
(D) Science Map 2008 [Whole count method]



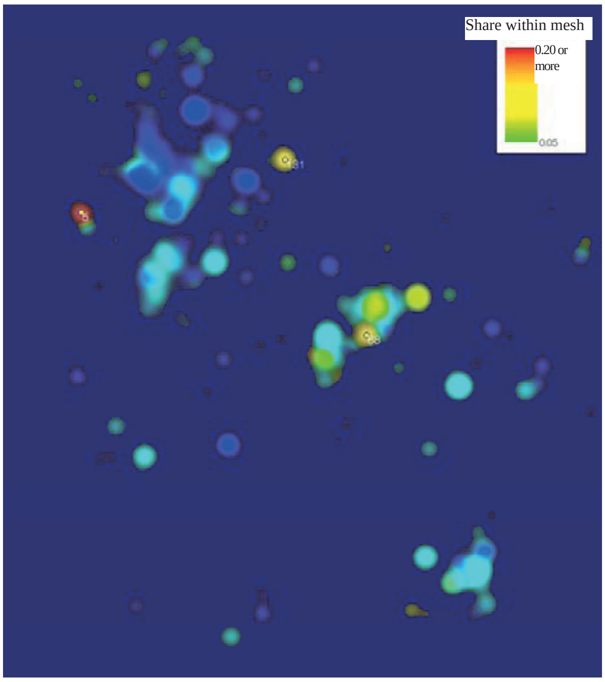
Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using whole count method. Yellow dots and numbers are the positions and IDs of hot research areas in which China the countries have a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Reference figure 31 Chinese shares of research papers in the Science Map

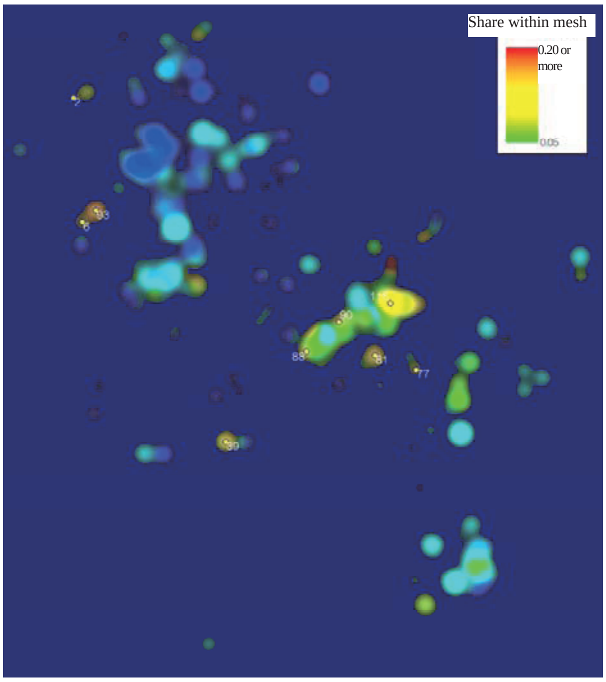
(A) Science Map 2002 [Fractional count method]



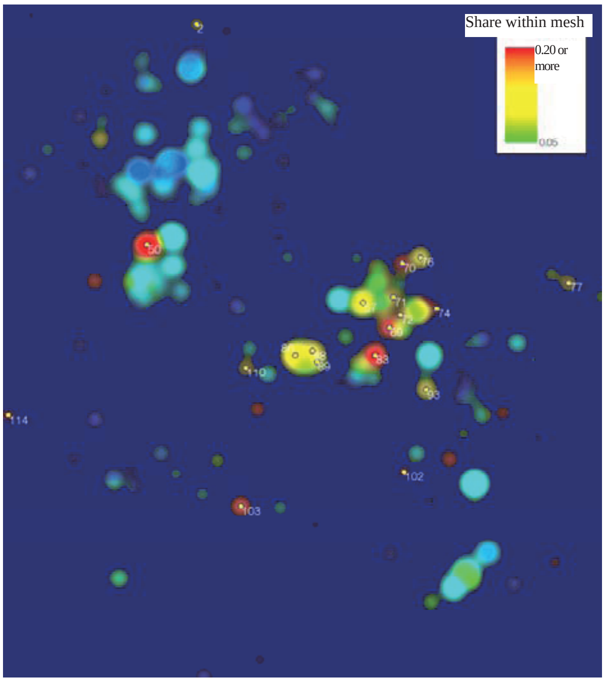
(B) Science Map 2004 [Fractional count method]



(C) Science Map 2006 [Fractional count method]



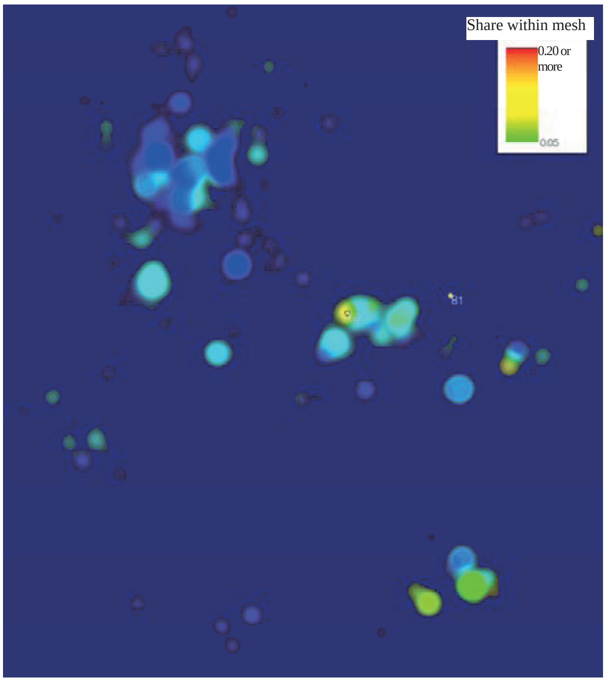
(D) Science Map 2008 [Fractional count method]



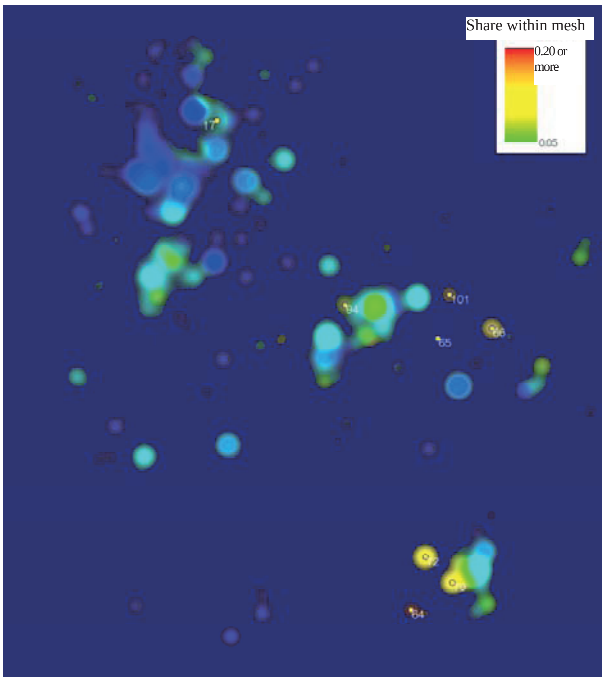
Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using whole count method. Yellow dots and numbers are the positions and IDs of hot research areas in which China the countries have a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Reference figure 32 Korean shares of research papers in the Science Map

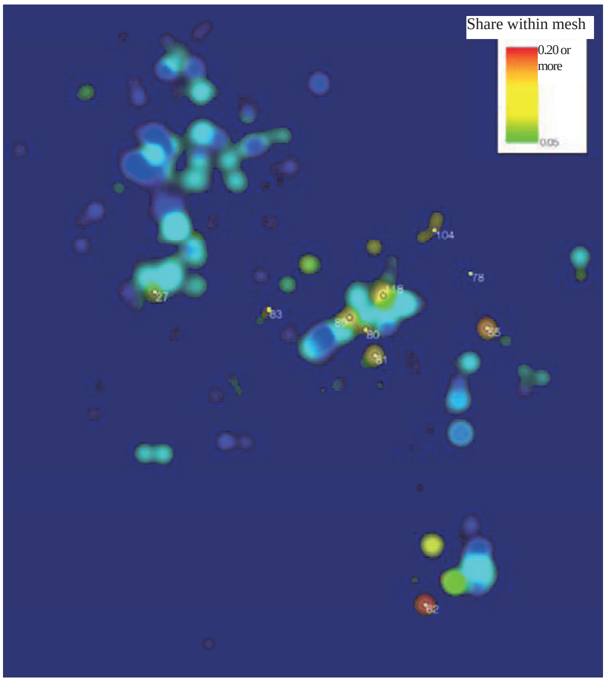
(A) Science Map 2002 [Whole count method]



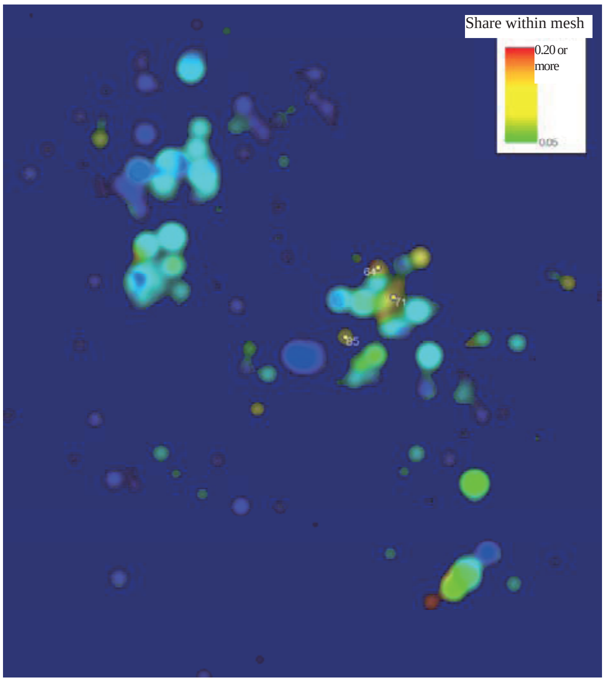
(B) Science Map 2004 [Whole count method]



(C) Science Map 2006 [Whole count method]



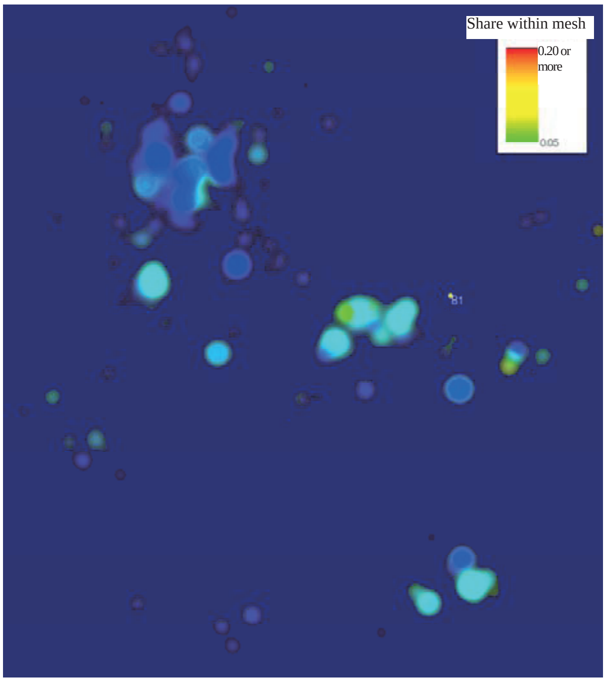
(D) Science Map 2008 [Whole count method]



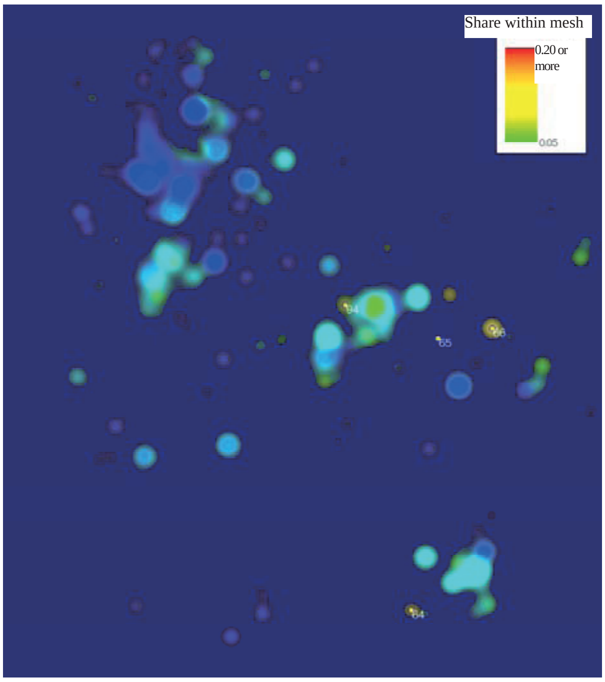
Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using whole count method. Yellow dots and numbers are the positions and IDs of hot research areas in which Korea the countries have a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

Reference figure 33 Korean shares of research papers in the Science Map

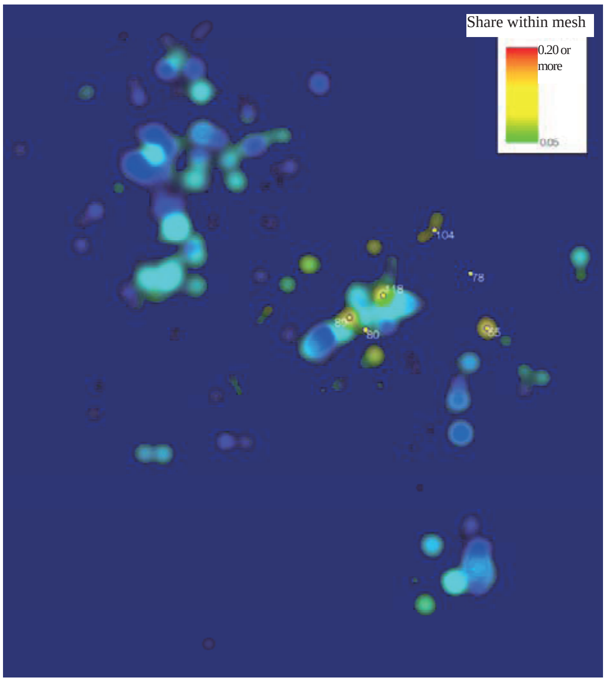
(A) Science Map 2002 [Fractional count method]



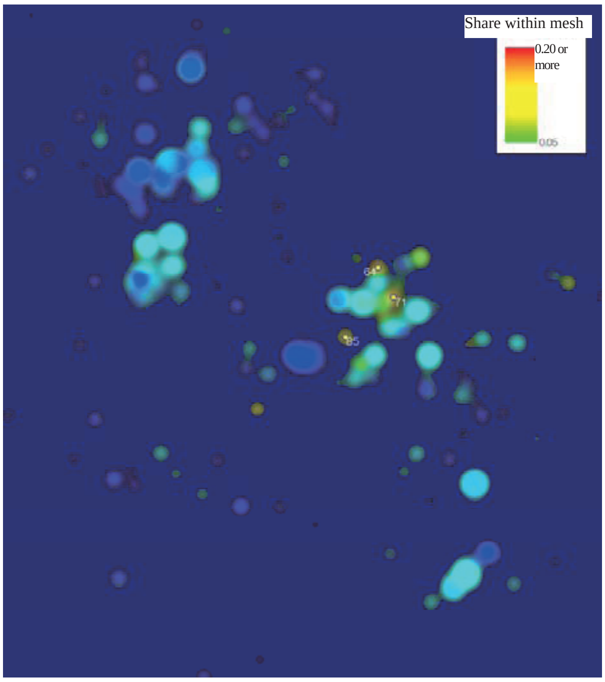
(B) Science Map 2004 [Fractional count method]



(C) Science Map 2006 [Fractional count method]



(D) Science Map 2008 [Fractional count method]



Note: Research paper shares of 5 percent are depicted in light blue, and shares of 20 percent or more in red. Shares of research papers were calculated using whole count method. Yellow dots and numbers are the positions and IDs of hot research areas in which Korea the countries have a 9 percent or more shares of research papers.
Data: Tabulated from Thomson Reuters' "Essential Science Indicators" by the National Institute of Science and Technology Policy.

7. Method to calculate centrality

This section summarizes methods to calculate the three centrality indexes namely, degree, closeness and betweeness, which were introduced in this report. In the following description, the matrix which indicates the connection between research areas via co-citation relationship is denoted by $X = \{x_{ij}\}$. When the research areas i and j is connected with the co-citation of 0.02 or more, this matrix shall be $x_{ij} = 1$, and in other cases $x_{ij} = 0$. There is no direction on the edge, therefore, the relationship of $x_{ij} = x_{ji}$ is established.

(1) Degree centrality

The degree centrality of the node n_i was calculated by the following formula using the matrix X.

$$C_d(n_i) = \sum_j x_{ij}/(g-1)$$

The degree centrality takes the value of $0 \leq C_d(n_i) \leq 1$. Here, $g-1$ is a normalization constant and g is the number of nodes included in the network. When the node n_i is connected with all nodes and edges, the degree centrality becomes the maximum value of 1 based on $C_d(n_i) = \sum_j 1/(g-1) = (g-1)/(g-1)$. If the node n_i does not have connection with any node, $C_d(n_i)$ becomes the minimum value of 0.

(2) Closeness centrality

The closeness centrality of the node n_i was calculated by the following formula:

$$C_c(n_i) = (g-1)\Big/\sum_{j=1,j\neq i}^{g} d(n_i, n_j)$$

The closeness centrality takes the value of $0 \leq C_c(n_i) \leq 1$. Here, $d(n_i, n_j)$ is the number of steps required to reach the node n_j from the node n_i, g is the number of nodes included in the network. If the node n_i is connected to all nodes $(g-1)$ with one step, the closeness centrality becomes the maximum value of 1 based on $C_c(n_i) = (g-1)/\sum_{j=1,j\neq i}^{g} 1 = (g-1)/(g-1)$. As the number of steps required to reach other nodes from the node n_i increases, the value of the denominator of $C_c(n_i)$ increases, and the value of $C_c(n_i)$ decreases. The minimum value of $C_c(n_i)$ is 0.

(3) Betweeness centrality

The betweeness centrality of the node n_i was calculated by the following formula:

$$C_b(n_i) = \sum_{j<k} \left(g_{jk}(n_i)/g_{jk}\right)/\{(g-1)(g-2)/2\}$$

The betweeness centrality takes the value of $0 \leq C_b(n_i) \leq 1$. Here, g_{jk} is the number of routes that reaches the node n_k from the node n_j with the minimum steps $d(n_j, n_k)$, and $g_{jk}(n_i)$ is the number of the routes that pass the node n_i among the g_{jk} routes. That is, $g_{jk}(n_i)/g_{jk}$ corresponds to the weight of the node n_i in the shortest routes connecting the node n_j and the node n_k. If there is no need to pass the node n_i, $g_{jk}(n_i)/g_{jk}$ becomes 0. If the node n_i has to be passed, the value becomes 1.

For the routes of all combinations of nodes, the one that takes the sum of $g_{jk}(n_i)/g_{jk}$ corresponds to the betweeness centrality. $(g-1)(g-2)/2$ is a normalization constant, which corresponds to the number of all combinations between the $g-1$ nodes excluding the node n_i. In the combination of all nodes n_j, n_k, if the node n_i has to be passed, $C_b(n_i)$ becomes the maximum value of 1.

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(As of May 31, 2010)

Science Map 2008

Study on Hot Research Areas (2003-2008) by Bibliometric Method

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