1. BACKGROUND

Research Fronts 2014 and Research Fronts 2015

Research Fronts 2016

2. METHODOLOGY AND PRESENTATION OF DATA

2.1 RESEARCH FRONTS SELECTION

2.1.1 SELECTING THE HOT RESEARCH FRONTS

2.1.2 SELECTING THE EMERGING RESEARCH FRONTS

2.2 FINAL SELECTION AND INTERPRETATION OF KEY RESEARCH FRONTS

classified into 10 broad research areas. Research fronts

the 10 fields. For example, there are 21 research fronts

the core papers have made significant contributions in

2.2.1 FINAL SELECTION OF KEY RESEARCH FRONTS

In Research Fronts 2014

(1) The number of core papers (P)

In the Research Fronts 2016

knowledge, the analysts assessed the significance of the

(2) CPT indicator

their significance. For example, in a comparison of the

economy-wide energy efficiency," it is obvious that the latter is of more practical significance or consequence.

Research Fronts 2015

(2) Interpretation of key emerging research fronts

papers, the figures did not generally lend themselves to

2.2.2 PRESENTATION AND DISCUSSION OF KEY RESEARCH FRONTS

(1) Examination of key hot research fronts

the first two explanations for CPT's values, as discussed

1. HOT RESEARCH FRONT

1.1 TRENDS IN THE TOP 10 RESEARCH FRONTS IN AGRICULTURAL, PLANT AND ANIMAL SCIENCES

crop improvement —“Structure and function of Photosynthetic light-harvesting complex” and “Field high-throughput

practices in the field, and the manufacturing process.

also important countries, contributing six and five core

play significant roles. China has been active in doing the

					Cientificas (CSIC)			

1.3 KEY HOT RESARCH FRONT – “MECHANISM OF PLANT INNATE IMMUNITY”

Cell Host & Microbe

breeding. The discovery of specific recognition receptors

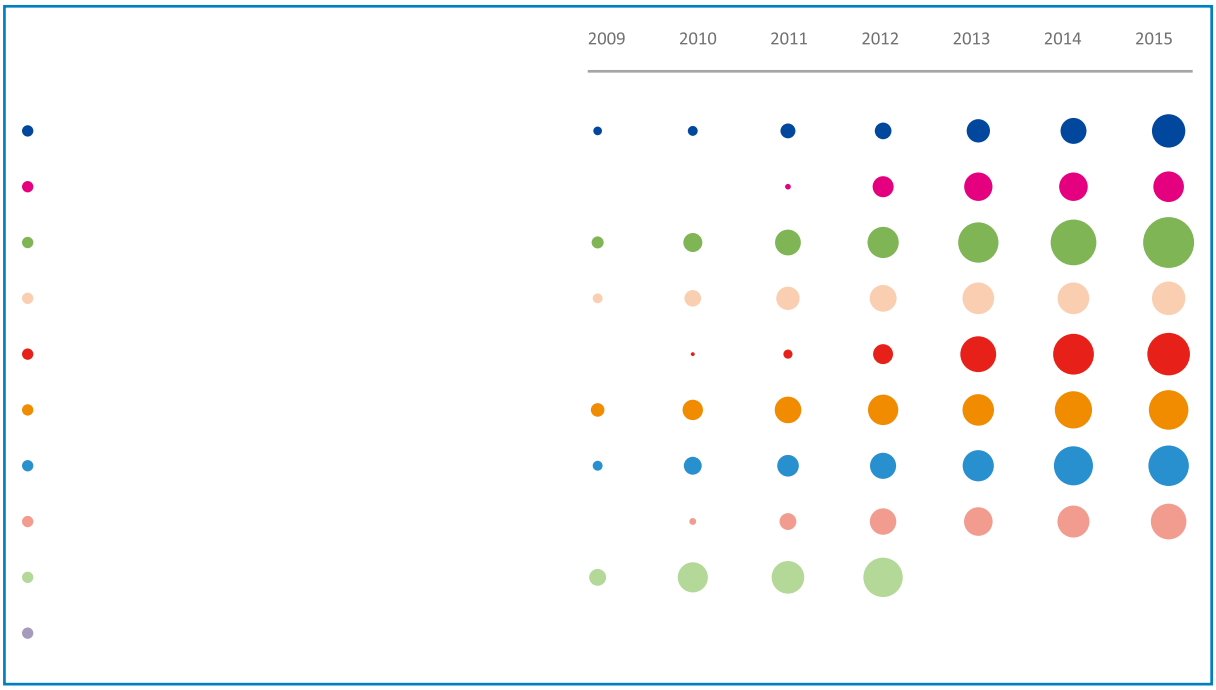
1. HOT RESEARCH FRONT

1.1 TRENDS IN THE TOP 10 RESEARCH FRONTS IN ECOLOGY AND ENVIRONMENTAL SCIENCES

covered in 2013 and 2015, respectively. “Ecosystem services”, “β-diversity” and “Genetic and genomic research on

	β-diversity			

Figure 2 Citing papers of the Top 10 research fronts in ecology and environmental sciences



Environmental Science & Technology
Scientific American

					Commonwealth Scientific and			

1.3 KEY HOT RESARCH FRONT – "BIODIVERSITY LOSS AND ITS IMPACT ON ECOSYSTEM FUNCTIONS AND ECOSYSTEM SERVICES"

2007, Hector and Bagchi were first to quantify the impact

Nature

Science *PNAS*

American Journal of Botany

among the most-prolific institutions

					Scientifique (CNRS)			

2. EMERGING RESEARCH FRONT

2.1 OVERVIEW OF EMERGING RESEARCH FRONTS IN ECOLOGY AND ENVIRONMENTAL SCIENCES

insecticides (neonicotinoids and fipronil) on non-target

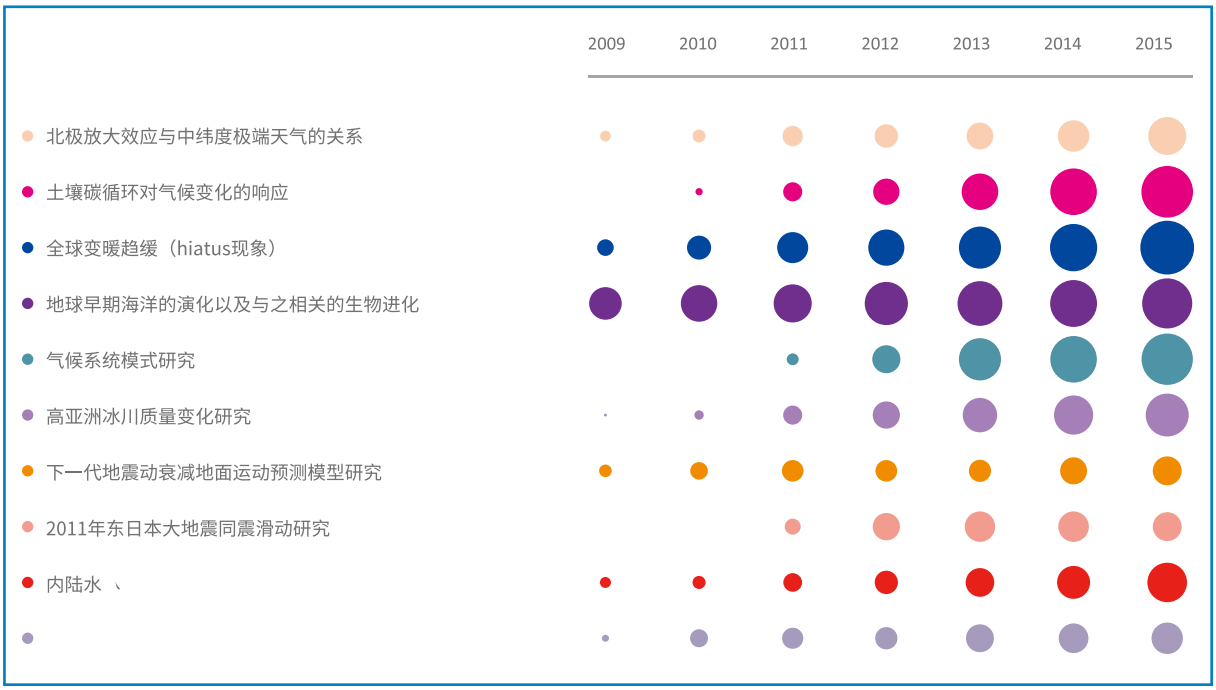
2.2 KEY EMERGING RESARCH FRONT – "EFFECTS OF SYSTEMIC INSECTICIDES (NEONICOTINOIDS AND FIPRONIL) ON NON-TARGET ORGANISMS AND ENVIRONMENT"

and fipronil, not only have the capacity to "accidentally"

1. HOT RESEARCH FRONT

1.1 TRENDS IN THE TOP 10 RESEARCH FRONTS IN GEOSCIENCES

	Links between Arctic amplification and mid-latitude weather			



1.2 KEY HOT RESEARCH FRONT – "GLOBAL WARMING HIATUS"

been quantified. Even though similar global-warming-

recent findings of global-warming hiatus may challenge

					Met Office			
					Commonwealth Scientific and			

1.3 KEY HOT RESARCH FRONT – “CARBON CYCLE OF INLAND WATERS AND THE OCEAN”

carbon are significant in predicting future atmospheric

papers in this field (Table 15) shows that the USA takes

in this area. Uppsala University in Sweden published five

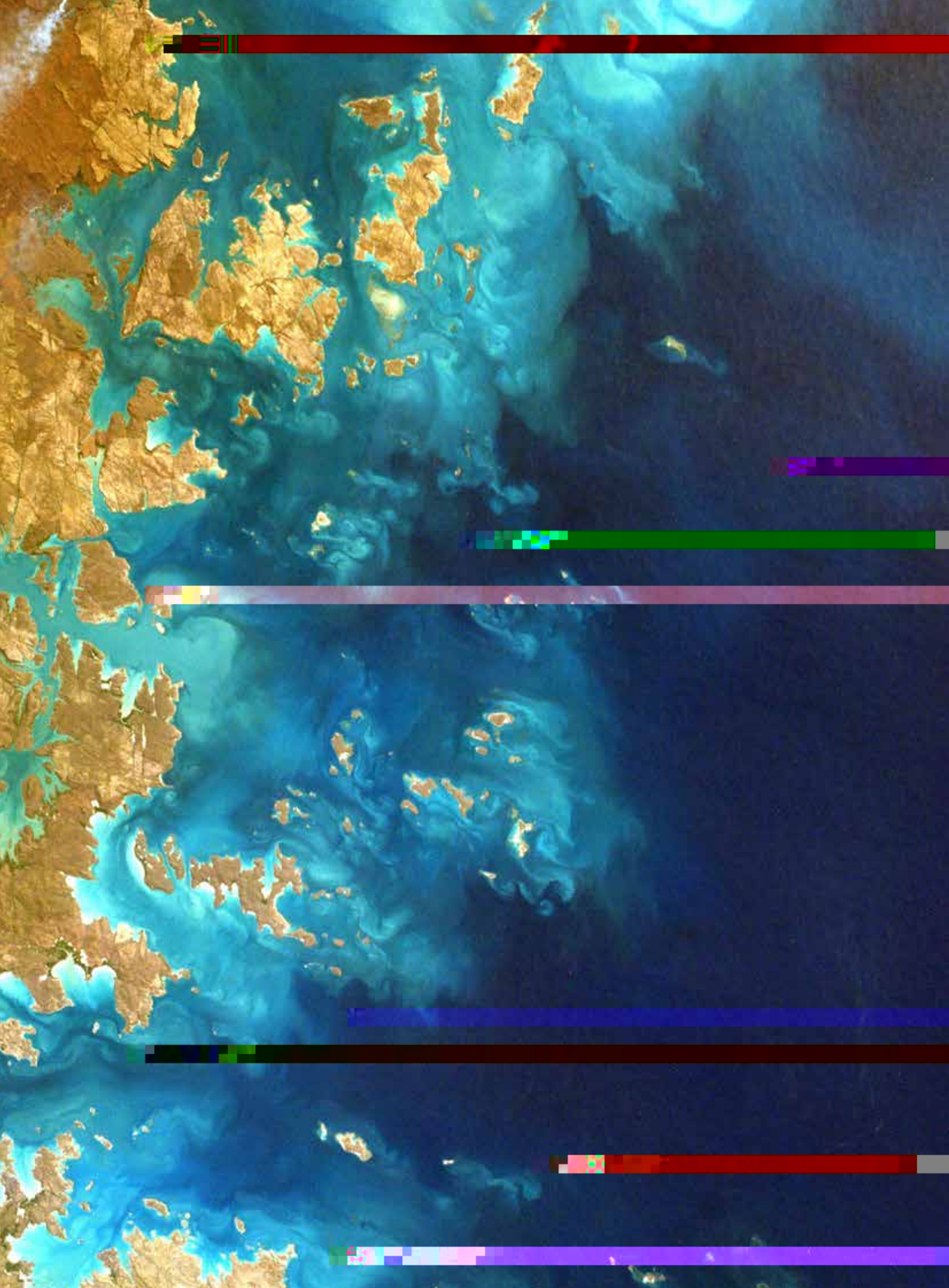
2. EMERGING RESEARCH FRONT

2.1 OVERVIEW OF EMERGING RESEARCH FRONTS IN GEOSCIENCES

2.2 KEY EMERGING RESEARCH FRONT – "ELEMENTAL COMPOSITION OF THE NORTH ATLANTIC OCEAN AND SOUTHERN OCEAN"

Science and Nature

specific trace elements (such as aluminum, manganese,



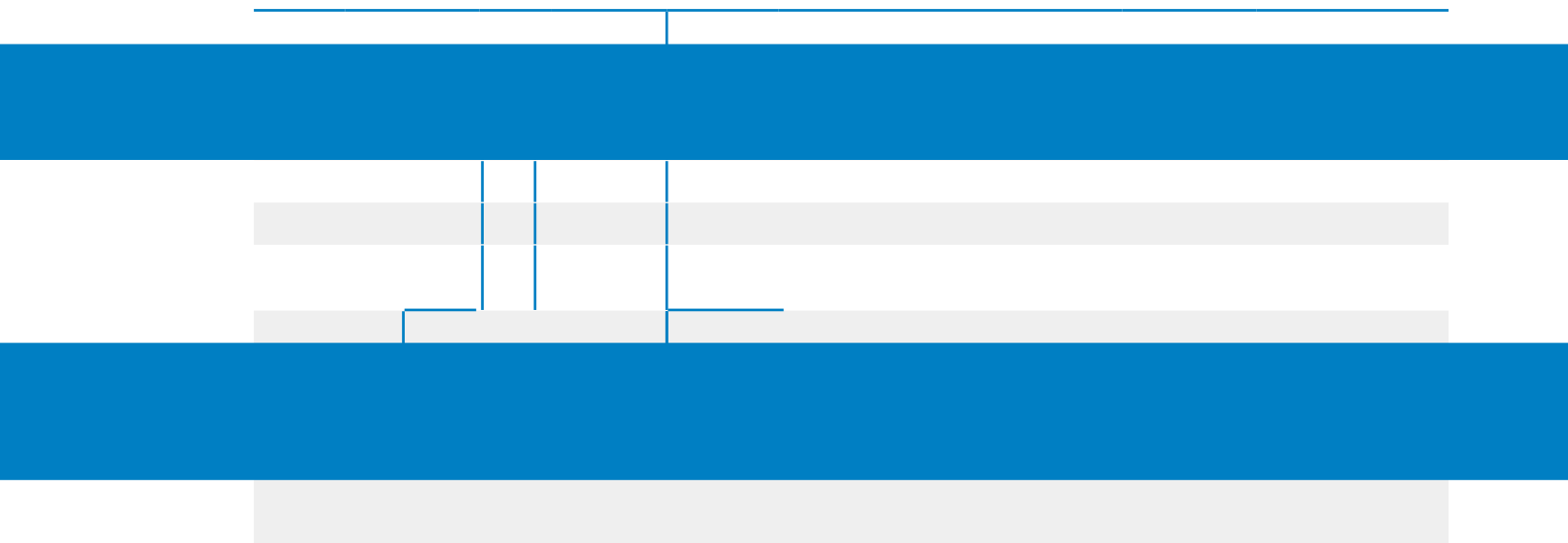
1. HOT RESEARCH FRONT

1.1 TRENDS IN THE TOP 10 RESEARCH FRONTS IN CLINICAL MEDICINE

1.2 KEY HOT RESEARCH FRONT – "CLINICAL TRIALS OF DIRECT-ACTING ANTIVIRALS (DAAs) FOR HEPATITIS C INFECTIONS"

therapy and to ultimately become the first-line treatment

PegIFN-α and RBV limit its development. In December



five-year survival rate is lower than 10%.

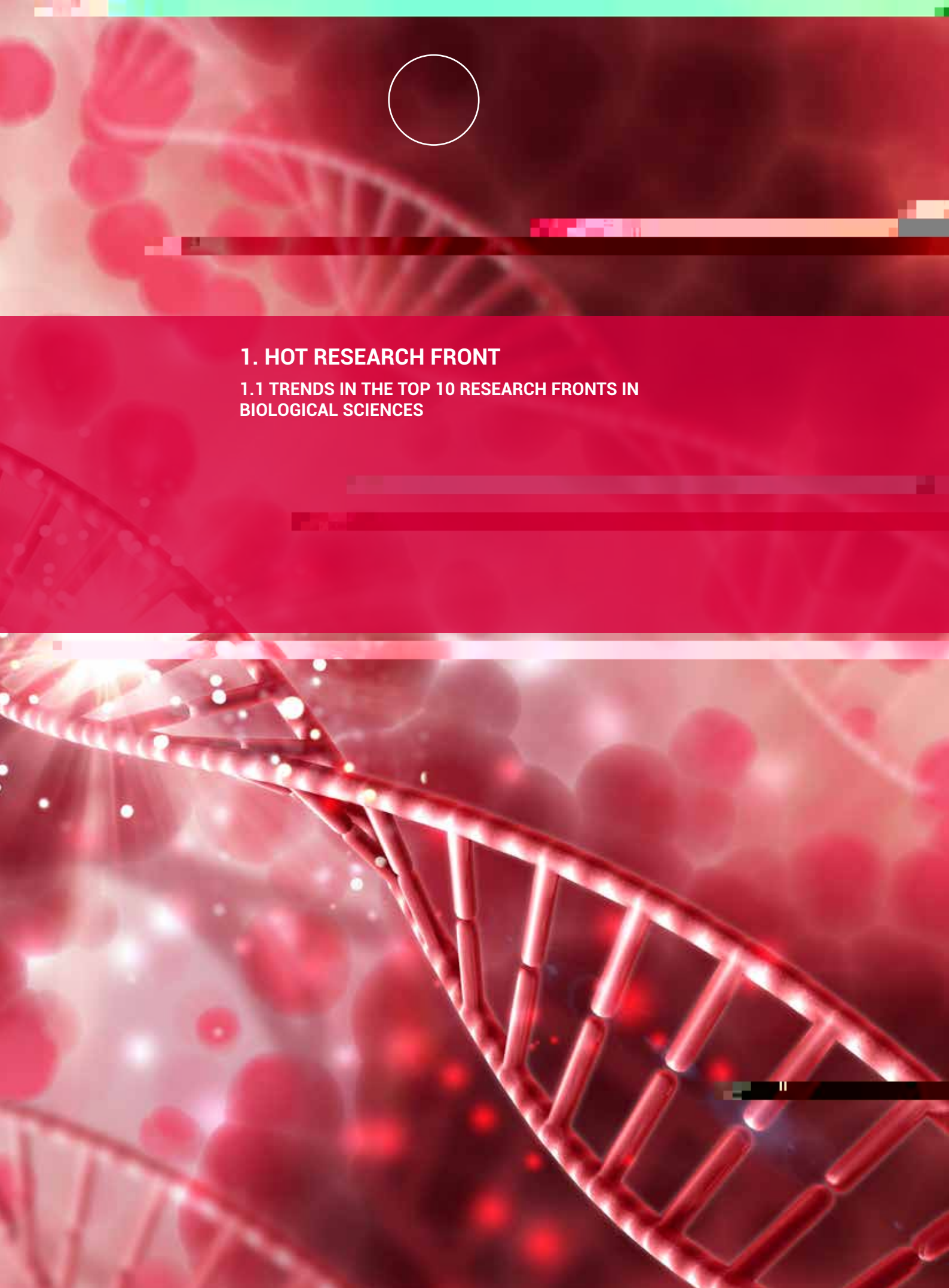
resulted in significantly longer progression-free survival

2. EMERGING RESEARCH FRONT

2.1 OVERVIEW OF EMERGING RESEARCH FRONTS IN CLINICAL MEDICINE

	Benefit of anticoagulation therapy for atrial fibrillation			
	Efficacy of 13-valent polysaccharide conjugate vaccine (PCV13) on			

phase I randomized clinical trial to assess the efficacy



1. HOT RESEARCH FRONT

1.1 TRENDS IN THE TOP 10 RESEARCH FRONTS IN BIOLOGICAL SCIENCES

	modification			

1.2 KEY HOT RESEARCH FRONT – "THE MOLECULAR MECHANISM FOR ORIGIN, DEVELOPMENT AND DIFFERENTIATION OF MACROPHAGE"

researchers from the UK and Singapore also confirmed

this research field, with a considerable amount of paper

					Scientifique (CNRS)			

1.3 KEY HOT RESARCH FRONT – “DIFFERENTIATION, FUNCTION, AND METABOLISM OF T CELLS”

classification rules, T cells can be divided into different

2. EMERGING RESEARCH FRONT

2.1 OVERVIEW OF EMERGING RESEARCH FRONTS IN BIOLOGICAL SCIENCES

identification of CRISPR RNA-guided nucleases (RGNs)

genome-editing technique is sustained and diversified.

	Genome-wide identification of CRISPR RNA-guided nucleases (RGNs)			

2.2 KEY EMERGING RESARCH FRONT – "PRINCIPLES OF CHROMATIN LOOPING AND EVOLUTION OF CHROMOSOMAL DOMAIN ARCHITECTURE"

cell fights off infection, a cone cell helps the eye detect

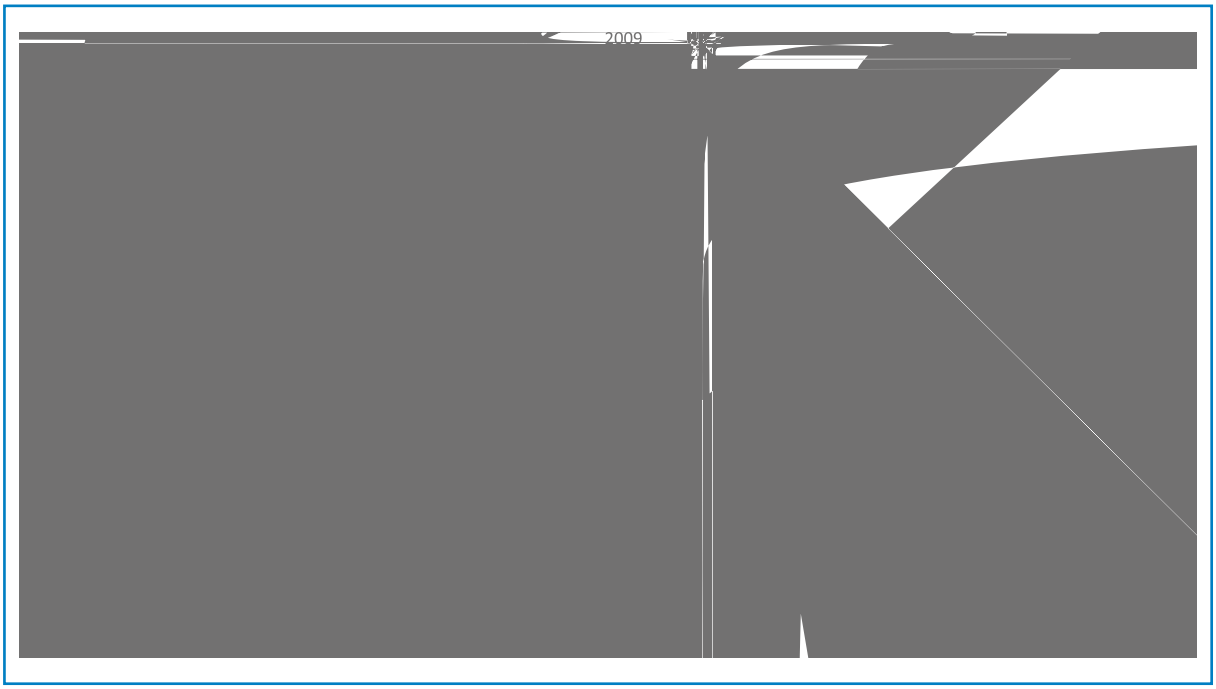
variety of shapes. A centerpiece of the study is the first

1. HOT RESEARCH FRONT

1.1 TRENDS IN THE TOP 10 RESEARCH FRONTS IN CHEMISTRY AND MATERIALS SCIENCE

Research Fronts 2016

	High-efficiency perovskite solar cells			
	Graphene nanofiltration membrane			



1.2 KEY HOT RESEARCH FRONT – “PHOSPHORS FOR WHITE LEDS”

1.3 KEY HOT RESARCH FRONT – “SODIUM-ION BATTERIES”

2. EMERGING RESEARCH FRONT

2.1 OVERVIEW OF EMERGING RESEARCH FRONTS IN CHEMISTRY AND MATERIALS SCIENCE

five positions in the emerging research fronts. Besides

	High efficiency single-junction polymer solar cells			

2.2 KEY EMERGING RESARCH FRONTS: AGGREGATED ANALYSIS OF SIX RESEARCH FRONTS RELATED TO PEROVSKITE

Science

Institute of Technology improved the efficiency to 15%

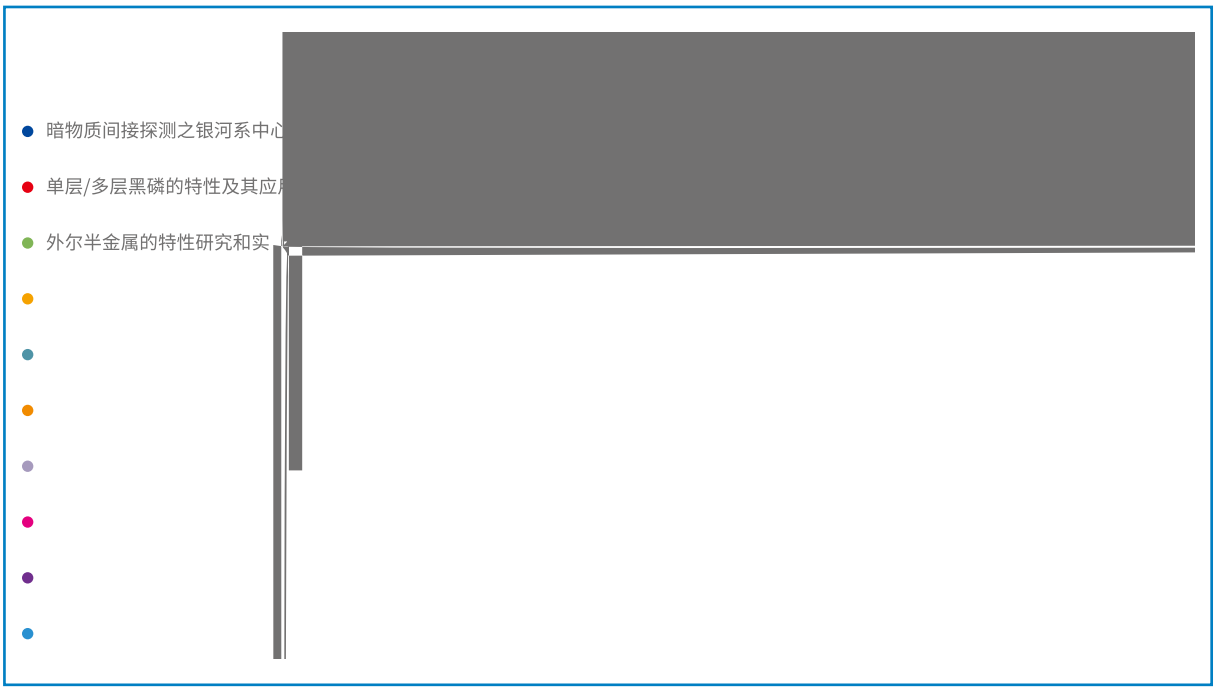
the first time, this allows the comparison of perovskite

in each of the five related emerging research

1. HOT RESEARCH FRONT

1.1 TRENDS IN THE TOP 10 RESEARCH FRONTS IN PHYSICS

	6+δ			
	Research on neutrino oscillations with recent results of the mixing angle θ13			



1.2 KEY HOT RESEARCH FRONT – "GALACTIC CENTER GAMMA-RAY EXCESS"

contribution, five of the top institutions are located in the

most prolific. According to a count of the reprint authors

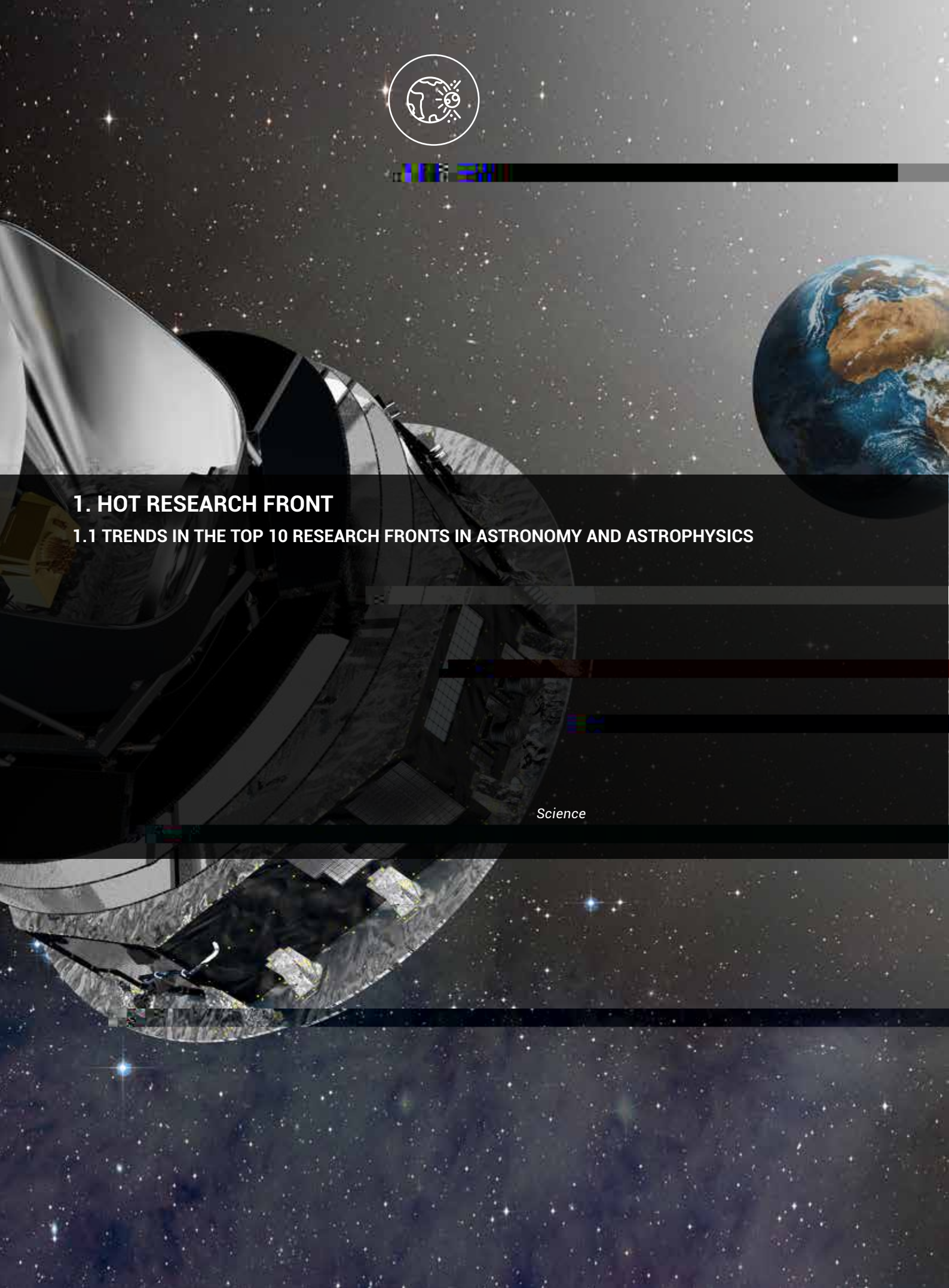
1.3 KEY HOT RESEARCH FRONT – "PROPERTY AND APPLICATION OF MONOLAYER/FEW-LAYER BLACK PHOSPHORUS"

2. EMERGING RESEARCH FRONT

2.1 OVERVIEW OF EMERGING RESEARCH FRONTS IN PHYSICS

2.2 KEY EMERGING RESARCH FRONT – "EXPERIMENTAL REALIZATION OF FRACTIONAL CHERN INSULATORS"

magnetic field and low temperature limit its application.

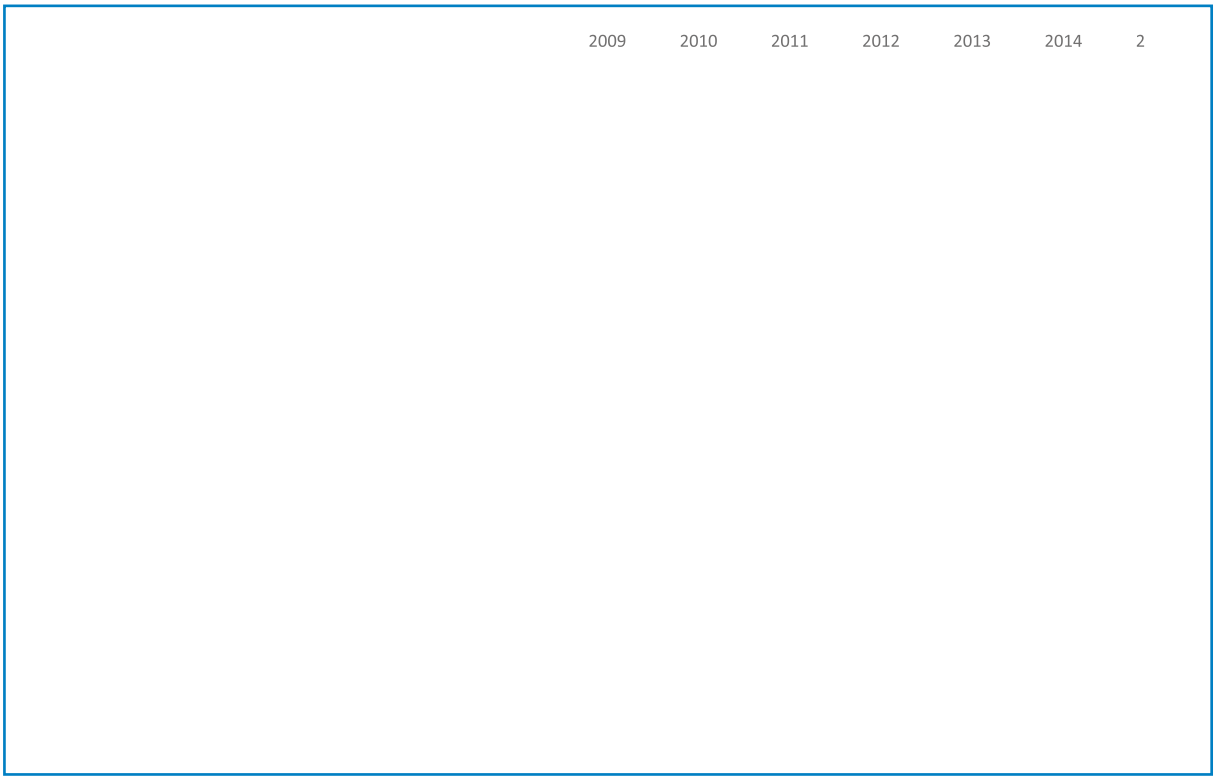


1. HOT RESEARCH FRONT

1.1 TRENDS IN THE TOP 10 RESEARCH FRONTS IN ASTRONOMY AND ASTROPHYSICS

Science

	Solar atmosphere and magnetic field research based on solar			



1.2 KEY HOT RESEARCH FRONT – "OBSERVATIONS OF THE COSMIC MICROWAVE BACKGROUND (CMB) BY PLANCK"

1989, demonstrated for the first timethat the CMB has

Cold Dark Matter (ΛCDM) model opened the era of

2. EMERGING RESEARCH FRONT

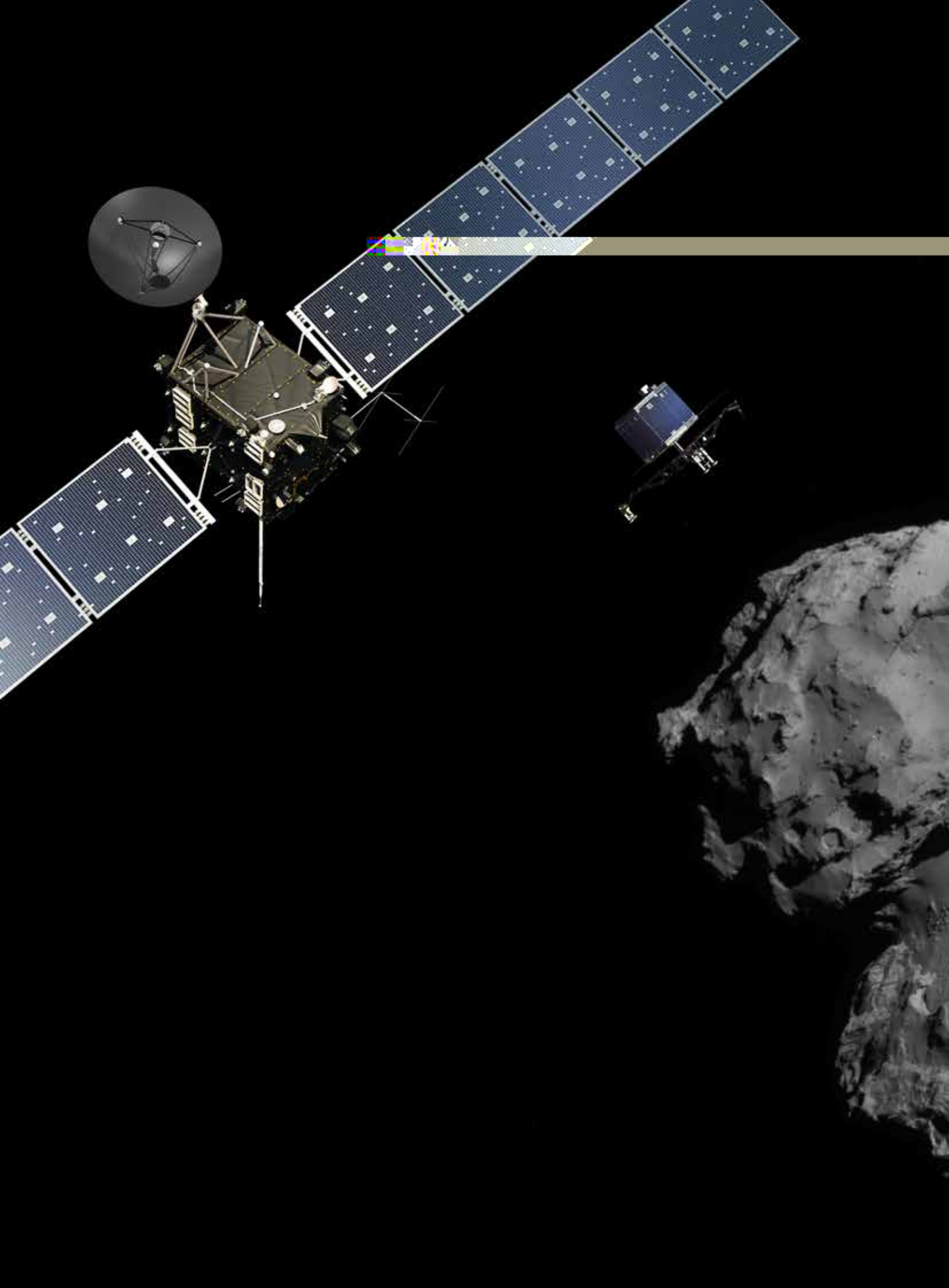
2.1 OVERVIEW OF EMERGING RESEARCH FRONTS IN ASTRONOMY AND ASTROPHYSICS

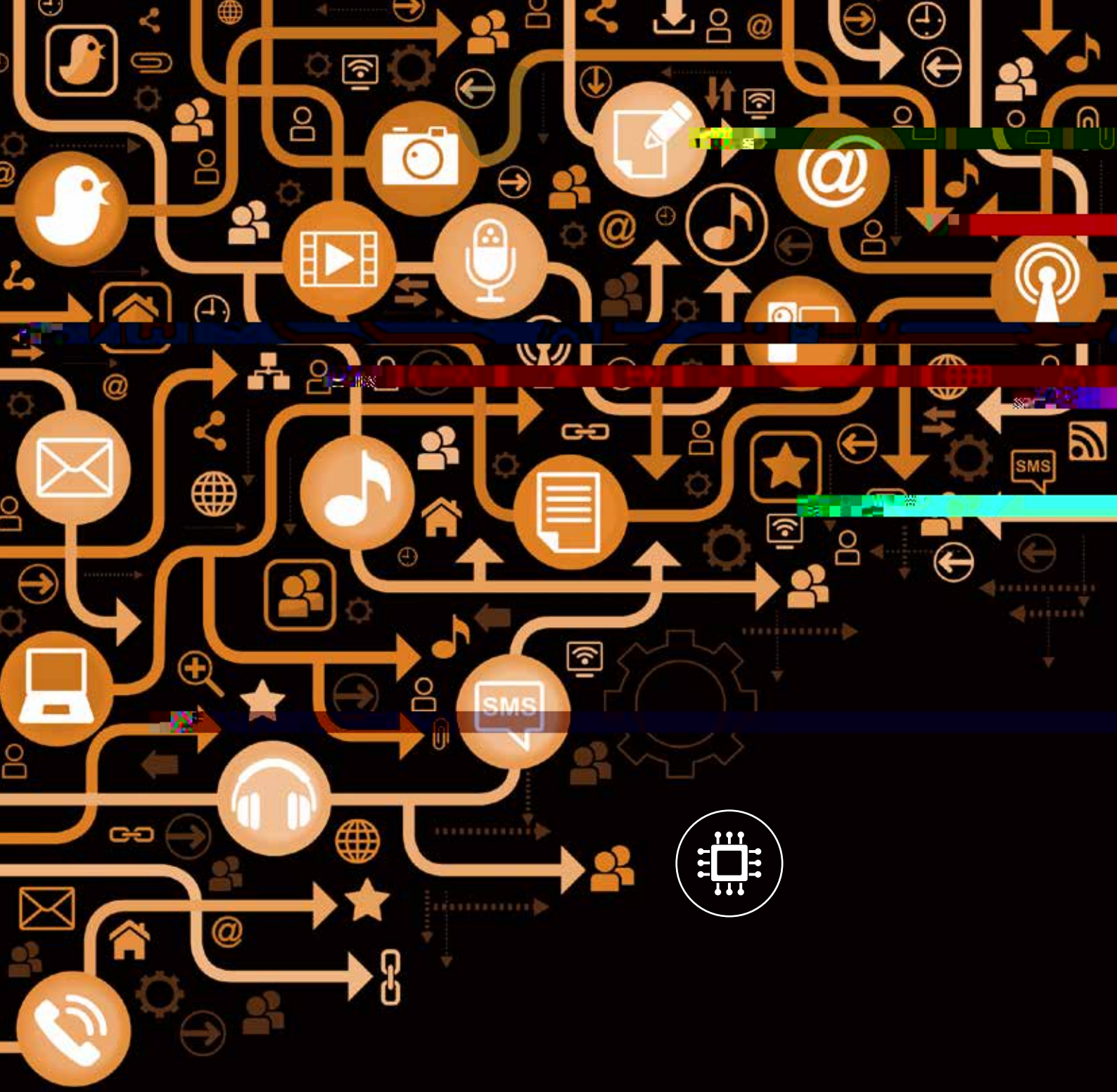
on the first one.

2.2 KEY EMERGING RESEARCH FRONT – "STUDIES OF COMET 67P/ CHURYUMOV-GERASIMENKO BY ROSETTA"

Science

original scientific breakthroughs.

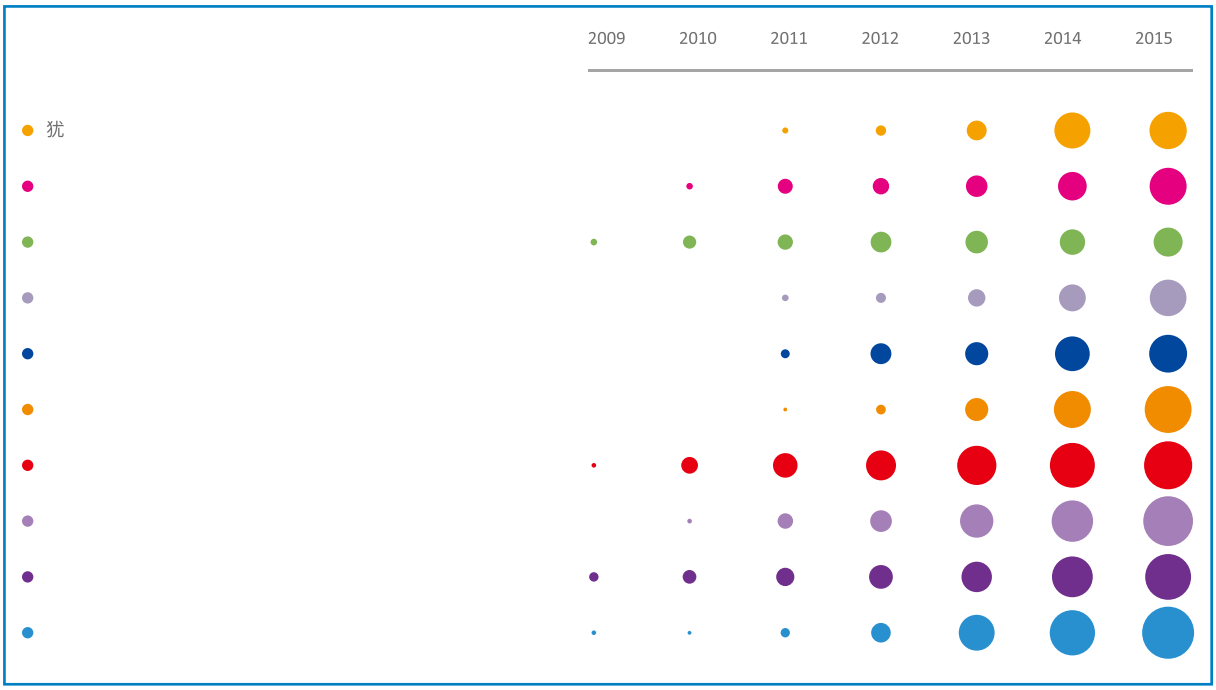




1. HOT RESEARCH FRONT

1.1 TRENDS IN THE TOP 10 RESEARCH FRONTS IN MATHEMATICS, COMPUTER SCIENCE AND ENGINEERING

	Configuration design and heat transfer analysis			



1.2 KEY HOT RESEARCH FRONT – "THE INTERNET OF THINGS, CLOUD MANUFACTURING AND RELATED INFORMATION TECHNOLOGY SERVICES"

Telecommunication Union (ITU) defined the concept of operated in an intelligent and unified way to enable the

everywhere." The IoT is considered the most significant

are affiliated with Chinese reprint authors. Among them,

1.3 KEY HOT RESARCH FRONT – "RESEARCH ON MEASUREMENT-DEVICE-INDEPENDENT QUANTUM KEY DISTRIBUTION"

Physics

Physical Review Letters

European Physical Society also reported their findings.

significant progress in this research front.

2. EMERGING RESEARCH FRONT

2.1 OVERVIEW OF EMERGING RESEARCH FRONTS IN MATHEMATICS, COMPUTER SCIENCE AND ENGINEERING

2.2 KEY EMERGING RESARCH FRONT – "ENERGY MANAGEMENT STRATEGIES OF HYBRID ELECTRIC BUS"

bus has great practical significance.


1693
HOCHBAHN
HH YB 1693

1. HOT RESEARCH FRONT

1.1 TRENDS IN THE TOP 10 RESEARCH FRONTS IN ECONOMICS, PSYCHOLOGY AND OTHER SOCIAL SCIENCES

Among the Top 10 research fronts in economics, psychology and other social sciences, three fronts pertain to psychology, including “Internet addiction,” “Self-injury and suicidal behavior,” and “Musical training and cognitive abilities.” The topic of “Internet addiction,” which featured in ***Research Fronts 2015***, is highlighted again this year. Studies on social issues such as “Related research on electronic cigarettes” and “Amazon's Mechanical Turk and cooperative behavior research” have continued to attract attention and have been selected among the Top 10 hot research fronts for two consecutive years, deepened by recent investigation of additional aspects – a trend evident in many of the hot fronts in this area that have recurred in recent years. Meanwhile, other new social issues emerge this year and enter the list of Top 10 hot research fronts, such as “Impact and effects of U.S. health care reforms” and “Global rise of waterpipe/hookah smoking and its impact on health.” In addition, two research fronts are related to natural resources and the environment, including “Global land and natural resource grabbing” and “DEA (Data Envelopment Analysis)-based assessment of environmental and energy efficiency.” In the area of economics and management, the research topic of family business has been selected for the third time as the Top 10 research fronts (2013, 2014 and 2016). Unlike in previous years, the research in 2016 specifically concentrates on “Impacts of family control (involvement) on the firm's strategic choice and innovation.”

1.2 KEY HOT RESEARCH FRONT – "IMPACT AND EFFECTS OF U.S. HEALTH CARE REFORMS"

Journal of the American Medical Association

have health insurance. The ACA is the most significant

The New York Times

1.3 KEY HOT RESARCH FRONT – “DEA (DATA ENVELOPMENT ANALYSIS) BASED ASSESSMENT OF ENVIRONMENTAL AND ENERGY EFFICIENCY”

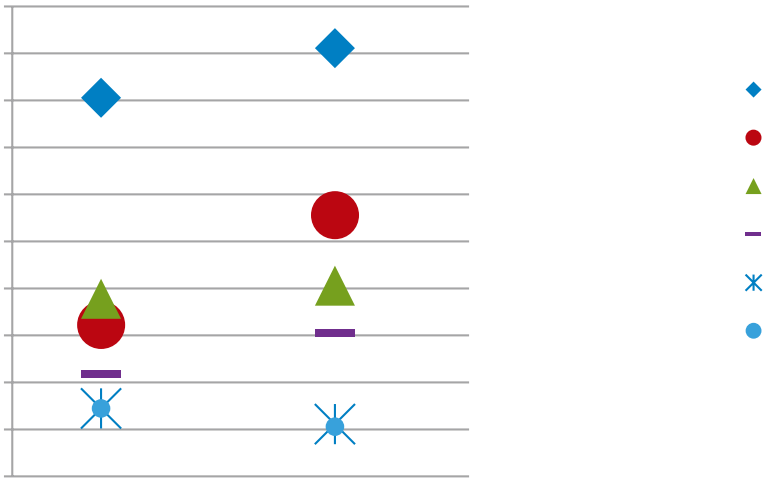
1. INTRODUCTION

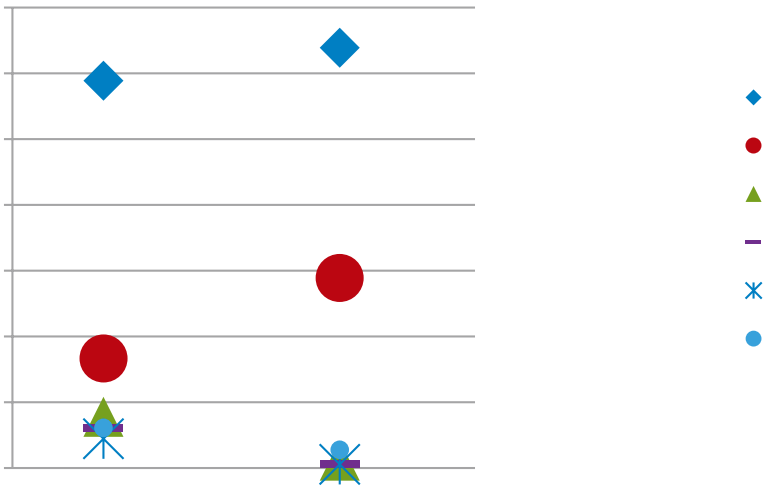
2. GENERAL PERFORMANCE OF SIX COUNTRIES

2.1 STRENGTH AND POTENTIAL DEVELOPMENT

strength in each field's likely future development. There

(~65%) based on the reprint authors' affiliation. By that





Highlights and summaries

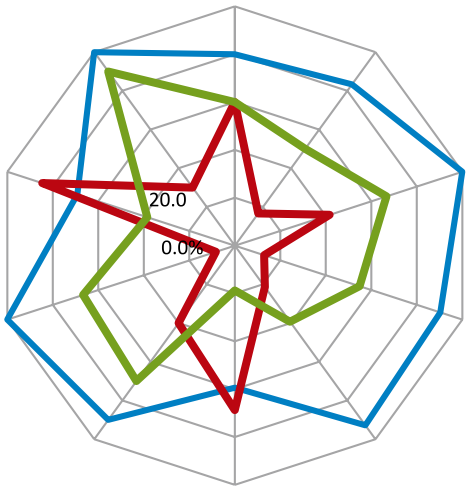
China has reprint author affiliation in around forty percent

. For citing papers reprint author affiliation,

2.2 COVERAGE PERFORMANCE OF SIX COUNTRIES IN 10 RESEARCH AREAS

reprint author affiliation in 10 research areas. The USA

with the other five countries in this indicator. The highest


20.0
0.0%

while the corresponding field for Germany and France is

Highlights and summaries

in nine research areas with core paper reprint affiliation

3. PERFORMANCE OF SIX COUNTRIES IN EACH AREA

analysis will focus on the other five countries.

3.1 AGRICULTURAL, PLANT AND ANIMAL SCIENCES

3.2 ECOLOGY AND ENVIRONMENTAL SCIENCES

3.3 GEOSCIENCES

far behind the other five countries. However, in potential

3.4 CLINICAL MEDICINE

3.5 BIOLOGICAL SCIENCES

and five No.1 potential leading research fronts, while all

3.6 CHEMISTRY AND MATERIALS SCIENCES

USA hold first place in 12 leading research fronts.

3.7 PHYSICS

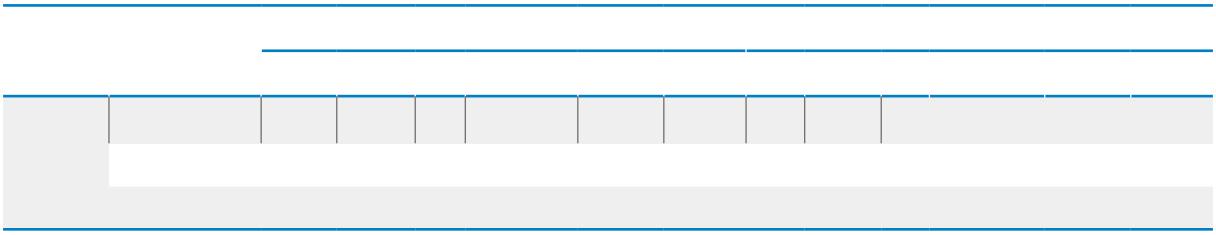
captures first place in four fronts, many more than the

3.8 ASTRONOMY AND ASTROPHYSICS

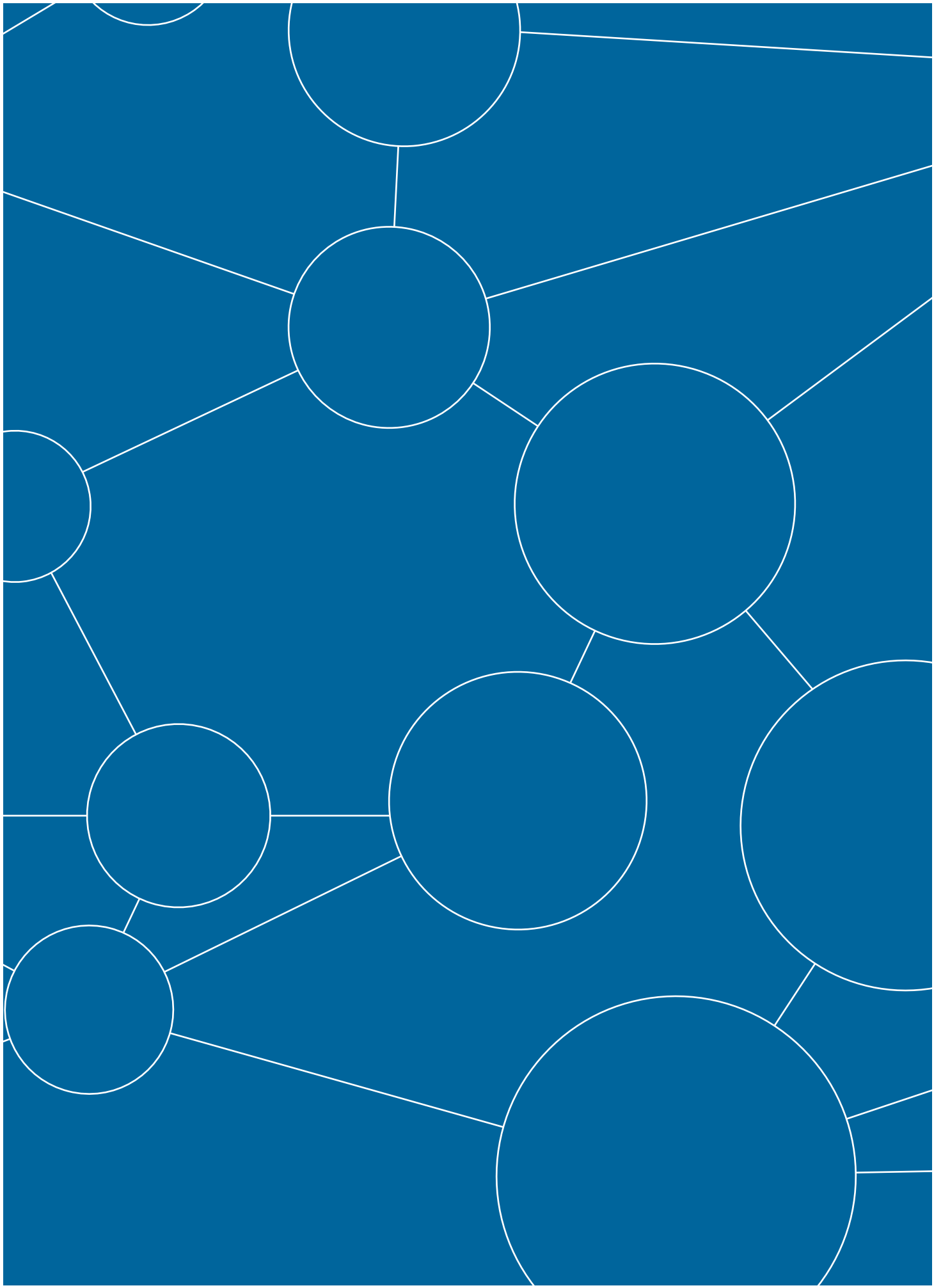
Germany, China and France, respectively, have five, four

3.9 MATHEMATICS, COMPUTER SCIENCE AND ENGINEERING

China holds seven first place leading and 12 first place



3.10 ECONOMICS, PSYCHOLOGY AND OTHER SOCIAL SCIENCES



and that such papers could be associated with specific

1

defining a field of inquiry.[4]

of each publication than are the authors. Garfield called

Torpie, Garfield produced his first historiograph, a linear

emblematic of specific topics, concepts, and methods:

2

3

Citation Index was for information retrieval, Garfield knew

this paper, and using the short-lived field of research on

more specifically in terms of its density of publications

traditionally defined and larger fields. Small also saw the

for monitoring the development of scientific fields, and

scientific literature. With such a topography established,

[12]

[10]

[13,14]

for Scientific Information in Philadelphia hoping to make

[15]

reasons that had captivated and motivated Garfield and

[11]

static because their cited references are fixed, whereas

[16]

The next year, 1974, Small and Belver C. Griffith of Drexel

articles that laid the foundations for defining specialties

17,18

Small and Griffith, the general approach and underlying

characteristic of Garfield.

[23,24]

[25]

[26]

same year, he and Garfield summarized these advances

[27]

research topic, it also identifies related papers that may

[28, 29] Small continued to refine his co-citation

[30, 31]

[32, 33]

[34]

[35]

[36, 37]

to visualize and explore the scientific literature through

[38,39]

landscape allowed the user to travel from the specific to

the field, a period of about 25 years, is curiously about

has firmly taken root and is growing with vigor in many directions. A great life, according to one definition, is "a

REFERENCES

[1] Eugene Garfield. Citation indexes for science: a new dimension in documentation through association of ideas.Science, 122

[2] Eugene Garfield. Citation Indexing: its Theory and Application in Science, Technology, and Humanities. NewYork: John Wiley &

[3] Genetics Citation Index. Philadelphia: Institute for ScientificInformation, 1963.

[4] Eugene Garfield. Citation indexes in sociological and historicresearch. American Documentation, 14 (4): 289-291, 1963.

[5] Eugene Garfield, Irving H. Sher, Richard J. Torpie.The Use of Citation Data in Writing the History of Science. Philadelphia:Institute For Scientific Information, 1964.

[8] Derek J. de Solla Price. Foreword.in Eugene Garfield, Essays of an Information Scientist, Volume 3, 1977-1978,Philadelphia: Institute For Scientific Information, 1979,v-ix.

[9] Derek J. de Solla Price. Networks of scientifi c papers: thepattern of bibliographic references indicates the nature of thescientific

[11] Henry Small. Co-citation in scientifi c literature: a newmeasure of the relationship between two documents. Journal ofthe

Informatsiza Seriya 2, SSR, [Scientific and TechnicalInformation Serial of VINITI], 6: 3-8, 1973.

[13] Robert K. Merton. Singletons and multiples in scientificdiscovery: a chapter in the sociology of science. Proceedingsof the

October 19, 1981 [reprinted in EugeneGarfi eld, Essays of an Information Scientist, Vol. 5, 1981-1982, Philadelphia: Institute for Scientific Information, 1983,279-287]

[22] ISI Atlas of Science: Biochemistry and Molecular Biology,1978/80, Philadelphia: Institute for Scientific Information,1981.

[23] ISI Atlas of Science: Biotechnology and Molecular Genetics, 1981/82, Philadelphia: Institute for ScientificInformation, 1984.

[24] Eugene Garfield. Launching the ISI Atlas of Science: for the new year, a new generation of reviews. CurrentContents, 1: 3-8, January 5, 1987. [reprinted in Eugene Garfield, Essays of an Information Scientist, vol. 10,1987, Philadelphia: Institute for Scientific

[27] Henry Small, Eugene Garfi eld. The geography of science: disciplinary and national mappings. Journal of InformationScience,

[29] Eugene Garfield. Historiographic mapping of knowledge domains literature. Journal of Information Science, 30(2):119-145,

[33] Henry Small. Charting pathways through science: exploring Garfield's vision of a unified index to science. In Blaise Cronin and Helen Barsky Atkins, editors, The Webof Knowledge: A Festschrift in Honor of Eugene Garfield, Medford, NJ: American Society for

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- Institute of Strategic Information of Institutes of Science and Development, Chinese Academy of Sciences

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- Ecology and environmental sciences
- Clinical medicine
- Biological Sciences
- Chemistry and materials science
- Physics
- Astronomy and astrophysics
- Mathematics, computer science and engineering
- Economics, psychology and other social sciences
- National performance

Data Support Team

- Clarivate Analytics
- Institute of Strategic Information of Institutes of Science and Development, Chinese Academy of Sciences

Interpretation Team

About Institutes of Science and Development, Chinese Academy of Sciences

In November 2015, the CAS was identified in the National High-end Think Tanks Building Pilot Program as one of the first 10 high-caliber think-tank organizations directly under the CPC Central Committee, the State Council and the Central Military Commission of the CPC. It clarifies that priority should be given to the establishment of Institutes of Science and Development, Chinese Academy of Sciences (CASISD). CASISD was founded in January 2016. The orientation of CASISD is a research and support organization supporting the Academic Divisions of CAS (CASAD) to play its role as China's highest advisory body in science and technology. It is an important carrier and a comprehensive integration platform for the CAS to build a high-impact national S&T think tank, and an innovation center bringing together elite research forces from both inside and outside the CAS and across the world.

The missions of CASISD are to offer scientific and policy evidence to the government for its macroscopic decision-making through:

- Finding out trends and directions of S&T development in light of scientific rules and conducting research into major issues concerning socioeconomic progress and national security from the point of view of S&T impact by focusing on such areas as S&T development strategy, S&T and innovation policy, ecological civilization and sustainable development strategy, forecasting and foresight analysis, strategic information.
- Capitalizing the CAS advantage in integrating research institutions, academic divisions and universities, pooling together elite research talent both at home and abroad, and building an international strategy and policy research network featuring opening and cooperation.

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The National Science Library, Chinese Academy of Sciences (NSLC) is the largest research library in China. NSLC reserves information resources in natural sciences and high-tech fields for the researchers and students of Chinese Academy of Sciences and researchers around the country. It also provides services in information analysis, research information management, digital library development, scientific publishing (with its 17 academic and professional journals), and promotion of sciences.

NSLC is a member in the International Federation of library Associations and Institutes (IFLA). It also is a member of Electronic Information for Libraries (EIFL) and Confederation of Open Access Repositories (COAR).

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