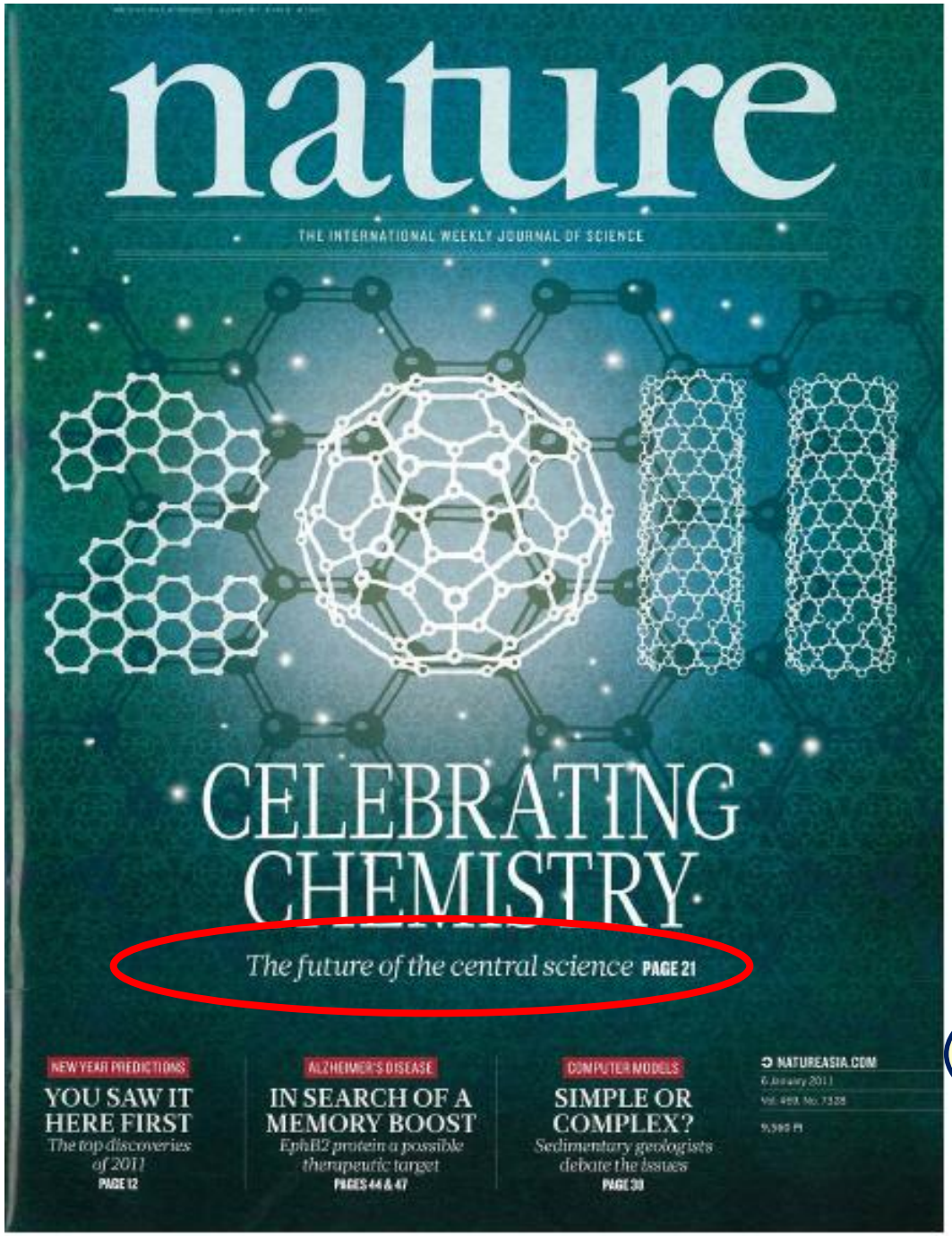
Rethinking Chemistry for the Future
- The Beauty and Benefits -

2013年3月24日、日本化学会
有本建男
政策研究大学院大学（GRIPS),
科学技術振興機構 (JST)



"Remember 2011!"

" 3.11 and the International Year of Chemistry "

"The future of the central science"

WORLD VIEW Legal highs raise troubling issues for chemists p.7

SUNDOWN Spain rolls back generous subsidy for solar-power schemes p.8

BRAZIL South American giant joins European Southern Observatory p.8

Chemistry's understated majesty

The International Year of Chemistry is under way. Chemists should celebrate their discipline's past as the foundation of other fields, and face the future with increasing confidence.

"Chemistry can be a good and bad thing," said US comedian Adam Sandler. "Chemistry is good when you make love with it. Chemistry is bad when you make crack with it."

The plentiful good points of chemistry are to be promoted to the public this year. Under the official United Nations banner of the International Year of Chemistry, chemists across the world are to join hands to celebrate their subject. Why 2011? Formally, it is to mark the 100th anniversary of Marie Curie receiving the Nobel Prize in Chemistry, for her discovery of radium and polonium. Informally, chemists are no doubt keen for their time in the sun. Last year was the Year of Biodiversity and 2009 was the Year of Astronomy. The International Polar Year stretched from 2007 into 2008, and 2005 was the Year of Physics. Chemistry's time has surely come — it is 350 years, after all, since Robert Boyle published *The Sceptical Chymist* and put the discipline firmly on the modern scientific map (see page 30).

It is regrettable for chemistry's champions that its iconic figures have to be shared with other disciplines. In the English-speaking world, Boyle is perhaps most commonly associated with his law relating the pressure and volume of a gas, and so with physics. And he is not the only shared standard bearer. Even the organizers of this year's chemistry extravaganza are trading on the reputation of someone whose fame relies heavily on her fatal fascination with radioactivity, for which Curie was awarded the 1903 Nobel Prize in Physics.

This situation is even more acute in modern research. Chemistry is often central, with principles and discoveries that enable work in other subjects. Its ability to react and rearrange matter for applications such as energy storage, new materials and more efficient industrial processes is vital for modern technology. Yet often, other disciplines such as materials science emerge as the public faces of such successes.

UNSUNG HEROES

Nature drew attention to this syndrome in 2001 (*Nature* 411, 399; 2001). The "lack of an accurate and identifiable chemistry 'brand' means that the discipline is easily misunderstood", we wrote, "and those working in it are frequently under-appreciated". A decade on, this has become a popular cause for those who seek to promote the benefits of the chemical sciences. The organizers of this year's celebration, for example, want to "improve the understanding and appreciation of chemistry by the public" and "promote the role of chemistry in contributing to solutions to global challenges".

There is no question that chemistry's important advances often lack the widespread recognition they deserve. What can be done to change this? Although chemists are right to stress that their work underpins much of modern science, those foundations are rarely acclaimed. But perhaps chemistry has less a problem of public image than a lack of desire to assert itself. For beneath the utilitarian way that chemistry feeds into other disciplines, it has a rare and wonderful majesty on its own terms. Perhaps this is satisfaction enough for many. Witness this week's issue of *Nature*: alongside varied perspectives about chemistry and its future (see page 23), we publish three important papers across the field, in supramolecular chemistry, organic chemistry and biochemistry (see pages 72, 76 and 116). And as the year unfolds, we intend to publish more outstanding research from the molecular sciences, as well as a series of reviews on some of the most compelling topics in the field.

Nevertheless, as science funding becomes more competitive and is judged on visible results, the organizers of the chemistry year are right to seek credit where it is due. Perhaps the spotlight will shift towards chemists as boundaries between fields continue to blur. As biologists, for instance, zoom in on the action of molecules to probe physiological and cellular processes, including how cells communicate, they are effectively working as chemists — albeit chemists who work with oversized molecules.

> *"There is no shortage of problems to which chemists can contribute solutions."*

There are other ways to boost the profile of chemistry. In biology papers, and many synthetic-chemistry papers, key basic-chemistry references — descriptions of synthesis and characterization of individual compounds — are often relegated to supplementary information, where they can languish unnoticed and uncredited. Chemists often grumble that citation analysis should be changed to account for this.

GLOBAL REACH

One important function of the year of chemistry will be to bring to light hidden contributions to science and society at large. Certainly, there is no shortage of global problems to which chemists can contribute solutions, such as the search for clean energy. And the Royal Society of Chemistry in London claims that some 20% of Britain's gross domestic product is already down to the work of chemists.

Chemistry is a mature field, but its exciting, productive and influential days are far from over. In the past few years alone, *Nature* has published cutting-edge research from chemists across the discipline. Some have probed the properties of the emerging material graphene (see page 14) and experimented with the new tool of DNA nanotechnology to design and assemble molecular machinery. Others have published details of new and improved materials for energy-storage devices. Organic chemists have shown how complex molecules can be made without the need for the sheltering protective groups commonly used to shield fragile molecules from decomposition during reactions. And the use of gold nanoparticles in oxidation reactions has revealed fundamental details of catalysis — the engine of much of chemistry and of life — and bolstered the wider work of chemists who strive to develop cleaner and less polluting industrial processes (see page 18).

If chemistry can truly be both good and bad, as Sandler observed, then much the same can be said for all the sciences, as for all human endeavour. But when chemistry is good, it is very, very good. It deserves its celebration. ■

Nature Editorial

"Chemistry's understated majesty"

Nature 469,5(06 January 2011)

"The International Year of Chemistry is under way. Chemists should celebrate their discipline's past as the foundation of other fields, and face the future with increasing confidence."

“The International Union of Pure and Applied Chemistry and the United Nations Educational, Scientific and Cultural Organization are sponsoring 2011 as the International Year of Chemistry. So Nature starts the year with an issue focused on chemistry - in many respects the central science and a vital resource for physicists and biologists. In a Comment on page 21, George Whitesides and John Deutch argue that academic chemistry is at a crossroads. 'Business as usual' is not an option, they say: to solve new problems, chemistry will need to be braver in its research choices and in how it organizes them. ”

“What’s in a name -Chemistry is here to stay- ”, (“Nature”,Aug.3,2006)

- **Chemistry is a key component in all the scientific disciplines. But does that it is nothing more than a handy tool.**
- **Are there still major chemical questions to crack?**
- **Undouted movement of the discipline’s centre of gravity.**
- **Chemistry needs to reassert itself as a core scientific discipline.**
- **Chemistry has to find away of establishing its centrality in the mysterious process we call life.**
- **Chemistry is poor public image.**
  It rebrand itself with a sexier label-molecular sciences, perhaps.
- **University reshuffles, that might displace parts of chemistry to other departments**

The strongly synthetic character of chemistry sets it apart from the ‘discovery’ sciences such as physics, biology, astronomy, and the Earth sciences.

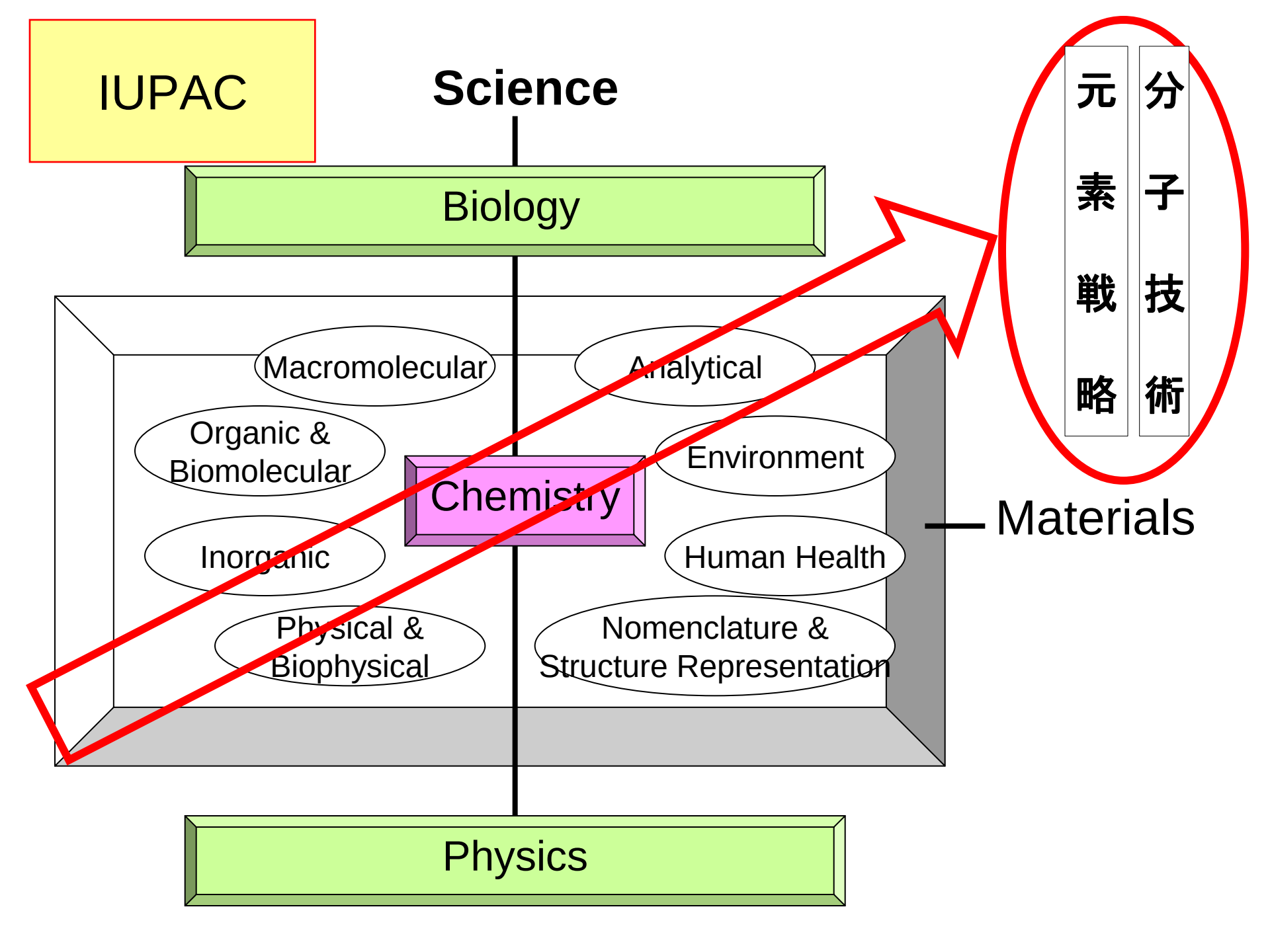
「世界の化学者が自信を失った時代、世界的に化学、ｹﾐｽﾄﾘｰという言葉が使われなくなってきた。しかし、ｹﾐｽﾄﾘｰには夢がある。新しい学問領域との融合。」

東レ榊原社長（化学経済、2007年1月号）

21世紀の分子科学のフロンティア

- ○複雑系生物システム
- ○フェムト秒科学：化学反応素過程の生物システムへの適用。
- ○メゾスコピック科学：ミクロとマクロをつなぐ。
  超分子科学
- ○環境科学
- ○進化科学

ノーベル賞１００年記念ＷＳに
集まった世界の化学者たち
（ストックフォルム郊外,2001年12月）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Science
Biology
Macromolecular
Analytical
Organic &
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Environment
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Human Health
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元素戦略
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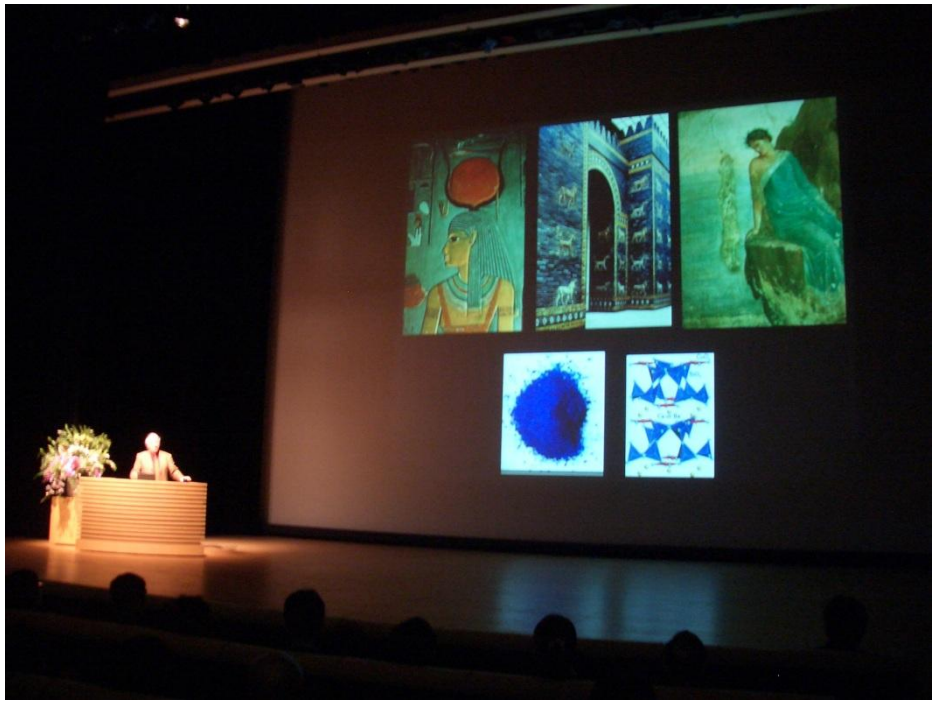

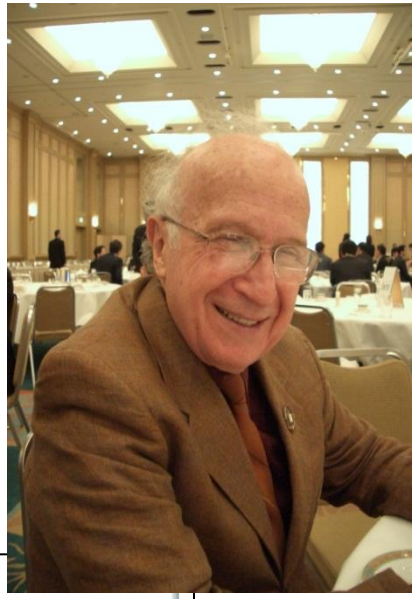

Chemistry's Essential Tensions: Different Ways of Looking at a Science

Roald Hoffmann

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Abstract: In this lecture, several views of chemistry will be presented, stressing its psychological dimension and its tie to culture and the arts: First of all, chemistry is, as it has always been, the art, craft, business of substances and their transformations. It is now also the science of microscopic molecules, both simple and complex. In both of these definitions there are inherent strong ties to the surrounding culture, a connection to artistic representation. And then there are people's perceptions of chemistry —alternating between seeing the healing and the hurting aspects of this truly anthropic science. That's just one of the psychological tensions of underlying chemistry; people do not have unambiguous reactions to fundamental change, which is at the heart of chemistry.

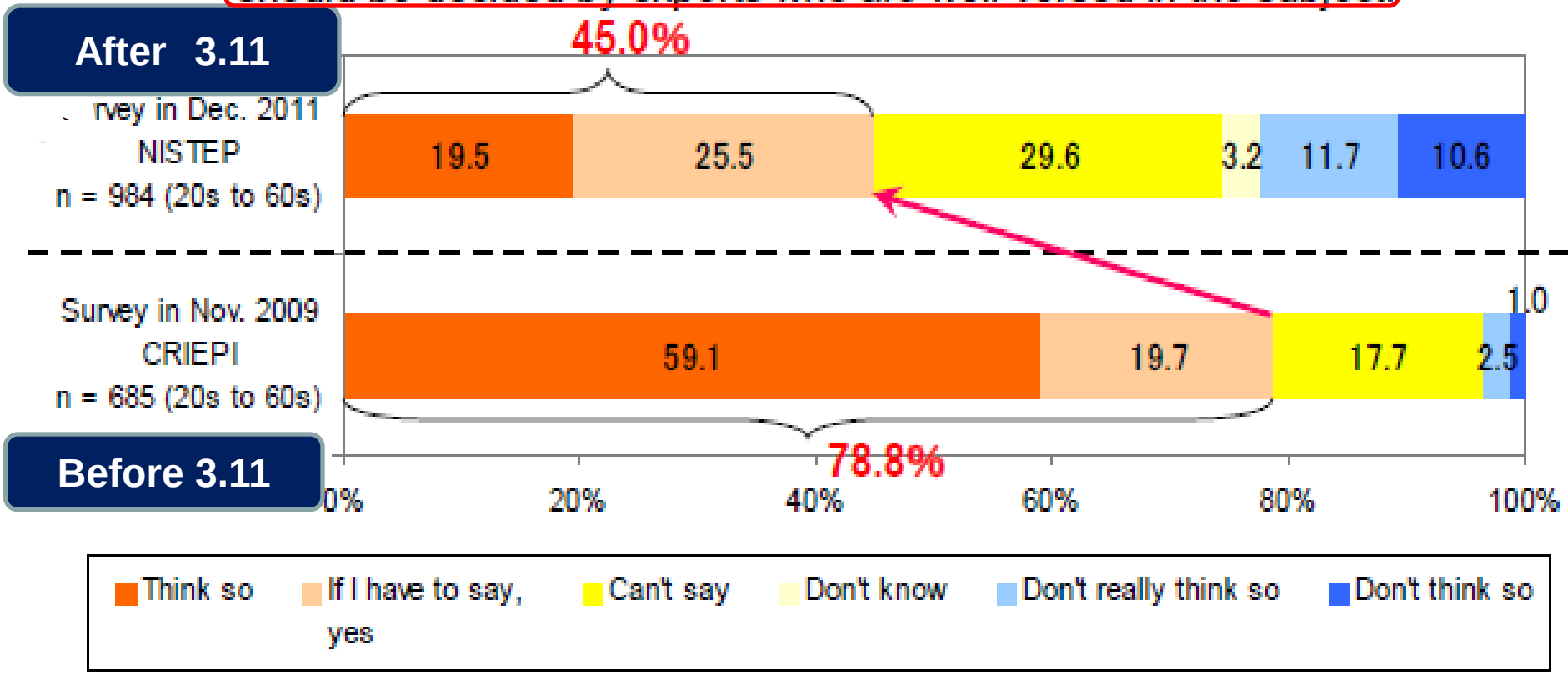
Here are some of the images that you will see in this lecture, among many others. To see how they are connected, you just have to come!

Before and After 3.11 2011

Should experts decide the direction of S&T ?

Question: What do you think of the following opinion regarding science and technology?

The direction of research and development in science and technology should be decided by experts who are well-versed in the subject.



S & T and Innovation in the 21st century

- STI for knowledge
- STI for profit
- STI for competitiveness
- STI for growth
- STI for employment
- STI for wellbeing & quality of life
- STI for safety, security & social cohesion
- STI for sustainability & resilience

The Great Transformation
New values, New age of responsibility, Shaping new models
Redesigning STI system and policy process of STI

EDITORIAL

Rethinking the Science System

AS THE U.S. BUDGET ENVIRONMENT FOR SCIENCE AND TECHNOLOGY (S&T) THREATENS TO GET WORSE, it is essential for the scientific community to go beyond just advocating for special consideration. There is a strong case for maintaining investments in S&T as a foundation for long-term economic growth and social well-being. But when resources are constrained, it is essential that they be used effectively and efficiently to avoid losing scientific momentum and to ensure that society will benefit maximally from S&T's potential. The scientific community cannot afford to simply adapt passively to reduced budgets. The impact of impending cuts can be at least partially mitigated by some fundamental rethinking of the ways in which S&T are both funded and conducted. Although the United States is used as the example here, the same issues will apply in many other parts of the world.

Alan I. Leshner is the chief executive officer of the American Association for the Advancement of Science and executive publisher of *Science*.

Some relatively inexpensive process and policy changes could make a big difference. For example, the Federal Demonstration Partnership has reported that 42% of an American scientist's research time is spent on administrative tasks. Much of that burden comes from redundant reporting and assurance requirements that vary across granting agencies and universities. The National Science and Technology Council, which represents all of the U.S. research funding agencies, should intensify its efforts to harmonize funding and reporting policies across granting agencies to reduce wasted effort. As another example, in the face of potentially lower success rates that could end up generating even more proposals to review, new forms of shorter grant proposals or the use of preliminary proposals might help greatly in reducing the burden on funding agency program officers, on already overworked peer reviewers, and on project investigators. New models of streamlined or batch-processed peer review might also substantially improve efficiencies.

Another long-discussed issue that should be addressed at this time

Rethinking the science system.

funding awarded to any single investigator. This would make more funds available for young investigators or those new to the field.

The time is right for a fundamental re-envisioning of the system. Crisis can breed opportunity as well as hardship. Some in-depth analyses of the U.S. S&T enterprise are already under way and can provide excellent starting points for continued discussion. For example, the President's Council of Advisors on Science and Technology is currently studying the U.S. S&T enterprise and writing a report. The National Research Council is nearing completion of a study on the future of research universities. The difficult decisions will, of course, ultimately be made by policy-makers, but these decisions must be informed by a broadly inclusive conversation among all the stakeholders—government agencies and other policy-makers, industry, academia, patient groups, and researchers. The National Institutes of Health has recently sought broad input on its efforts to manage in fiscally challenged times (http://nexus.od.nih.gov/all/rock-talk/), and the S&T community should respond. Although consensus on the specifics may not be possible, the participants in the S&T system must all be willing to entertain truly bold and innovative ideas for moving forward in the new budget climate.

– Alan I. Leshner

10.1126/science.1215299

Science, Nov.11,2011

THIS WEEK

Tough choices

Scientists must find ways to make more efficient use of funds – or politicians may do it for them.

Scientists in the United States can find plenty of good news as they page through President Barack Obama's 2013 budget proposal. Despite substantial cuts elsewhere — and fierce pressure from Republicans to cut more — Obama called for healthy overall increases in both fundamental research and science education (see page 283).

But the good news, of course, is tempered by reality. Obama's budget document is one long struggle to balance two contradictory goals: to stimulate the lagging US economy and to curb the annual budget deficit,

"Researchers, societies and funding agencies

NSF, under the guise of making management of science more efficient.

White House officials insist that no one in the administration is even contemplating such a wholesale restructuring. But the arithmetic of the deficit is unavoidable. Individual researchers, scientific societies and science funding agencies can no longer afford to be purely reactive, responding to each cut as it comes along. They need to be part of the debate, thinking systematically about how

Tough choices; Scientists must find ways to make more efficient use of funds – or politicians may do it for them.

streamline agencies on his own initiative — and suggested that one early application would be to transfer the National Oceanic and Atmospheric Administration from the Department of Commerce to the Department of the Interior. If Congress were to give Obama that power, it is possible to imagine him — or some future Republican president — sending all of the NSF's science-education programmes to the Department of Education, or merging the DOE's particle and nuclear physics research into the

Nature, Feb.16,2012

2009 THE DAILY YOMIURI

NATIONAL

Nov.2009

Science budget cuts slammed

The Yomiuri Shimbun

The Yomiuri Shimbun

Seated from left, Leo Esaki, Susumu Tonegawa, Shigefumi Mori, Ryoji Noyori and Makoto Kobayashi at a press conference at Tokyo University on Wednesday

country's five leading scientists, including four Nobel Prize-winners, on ...day strongly criticized the Government ...t Revitalization Unit's budget reductions for science and technology projects. ...is unusual for top scientists to attack ...tral government's policies, and their remarks are being seen as an indication of ...strength of their opposition to the government's plan.

...e four Nobel Prize-winners, Leo Esaki, ...koto Kobayashi, Ryoji Noyori, Susumu ...negawa, and Fields Medal recipient ...gefumi Mori held a joint press conference ...e at Tokyo University.

...bayashi said: "I just can't understand ...all. There's no consistency between the ...cies of [Prime Minister Yukio] Hatoyama's administration [aimed at] leading the world in the fields of science and technology and the [decision to cut funding for these fields]."

...d by the Liberal Democratic ...ference at a joint conference ...ding a committee ...s dur- ...reen-

"The future of Japan is at risk if such decisions [on cutting science spending] continue," one of them said.

Noyori, 71, who won the Nobel Prize in 2001, is president of Riken physical and chemical research institute, which is playing a principal role in coordinating the su-

public can hardly see any benefits to the project and cited this as the reason for the budget reduction.

At the joint conference, Noyori said: "Like the Olympic games, advanced countries are fiercely competing to develop supercomputers—putting their national prestige on the line. The moment Japan freezes the budget for the supercomputer project, other nations will overtake us.

"I want to ask those people who claim the budget for the supercomputer project should be frozen: Are you ready to be judged by the court of history?"

"Science and technology are Japan's lifeline. We shouldn't consider these budgets using short-term cost-benefit analysis," Noyori said.

Asked by an LDP member whether waste was an integral part of science, Noyori said, "There are many failures in science, but without science and technology we wouldn't have seen the improvement in life expectancy enjoyed by advanced countries."

Wakata touts space development

Meanwhile, astronaut Koichi Wakata on Wednesday stressed the importance of promoting space development from a long-term point of view.

Wakata, who became the first Japanese to make an extended stay aboard the International Space Station, spoke to reporters after receiving the prime minister's award at the Prime Minister's Office.

After receiving a certificate and plaque from Hatoyama, Wakata said to reporters: "The importance of space development has been supported strongly by the prime minister before. We need to advance space development based on a long-term approach."

"Why m... world's... wrong w...?"

Problems to be solved; Environment, Energy, Resources, Health, Aging, Disaster, Food etc.

Politics (normative, value)

Policy & Science Continuum

Science (objective, value free)

“ Responsible conduct in the global research enterprise”
InterAcademy Council, Oct.2012

***Communicating with Policy Makers and the Public**

Researchers need to communicate the policy implications of their results clearly and comprehensively to policy makers and the public —including a clear assessment of the uncertainties associated with their results—while avoiding advocacy based on their authority as researchers.

Scientific policy advice to governments, industry, or nongovernmental organizations should undergo peer review and should not be made from an advocacy perspective.

***Institutional Responsibilities: Research Institutions, Public and Private Funding Agencies, Journals, and Academies**

····**Funding agencies** should also support efforts of research institutions to develop education and training programs on responsible research conduct.

論説

大学人は国家のあり方から大学を論じる言葉を作り出せ

Takahiro UEYAMA 上山隆大 上智大学経済学部 教授

大学へのバッシングと大学人の無自覚

日本の大学へのバッシングが，かつてなく厳しくなっている。一昨年，Times Higher Education のランキングによって，東京大学が世界の30位に過ぎないと発表されたことは，大学関係者や文部科学省に大きな衝撃を与えた。また，文部科学省の科学技術政策研究所が公表してきた調査によれば，アメリカとヨーロッパはもちろんのこと，中国，韓国，シンガポールなどの東アジアの科学研究も，その論文数と引用件数が急成長する一方で，日本のそれらは明らかに伸び悩んでいるという。そして，日本における自然科学研究の拠点を占めている国立大学が，その責めを一身に負わされている。国立大学法人化が断行されて10年，日本の大学は一体何をしてきたのかという批判である。法人化によって国立大学は，一般企業と同様の私的な組織へと変貌し，その運営はかつてよりもはるかに身軽なものになったはずだ。だから，大学は自ら率先して，グローバルな競争に打ち勝つだけの強固な組織へと変革できていたはずではないか，というのである。このような攻撃は大学の現状を知らない無神経さだと思う一方で，悪化の一途をたどる現場の悲鳴を救い上げることができないのは，大学や大学人の無自覚と危機感のなさにも大きな責任があるのだ，という意見を筆者は持っている。

日本の大学の悲惨な研究環境

一方，欧米の大学で研究活動に従事したことのある自然科学系の研究者なら，アメリカの大学における研究環境と日本のそれとのあまりの違いに，暗澹たる気持ちになったことがあるはずだ。この彼我の隔たりを前にどうやって彼らに太刀打ちすればいいのかと。先頃ノーベル医学生理学賞を受賞した京都大学の山中伸弥教授は，授賞式の講演の中で，3年間のアメリカでの研究生活を終えた後，彼自身が名づけたPADという鬱病を発症した。それを Post America Depression と言う，と語って会場の笑いを誘った。だが，このユーモアの背後には，偽らざる心情もあったに違いない。ことはなにもアメリカとの比較だけではない。たとえば近年，科学研究とイノベーションに国として注力しているシンガポールと比べても，我が国の大学研究の現場は悲惨である。しばしば指摘される，対GNP比での公的資金のアカデミアへの支援の低さを持ち出すまでもなく，日本の研究環境の劣悪さは厳然たる事実として存在し，それが日本の科学研究を世界の高みへと飛び立つことを妨げている。

アメリカの公的資金と科学研究

アメリカの科学技術政策を研究している筆者は，科学研究のフロンティア開拓と公的な研究資金の間に明確な正の相関があることを確信している[1)]。科学研究には，それぞれの時代ごとにフロンティアを突き進んでいく突出した分野が表れ，そこに公的資金が投下されることによって科学研究は，じわじわとそのフロントラインを広げていく。だから，その成長点ともいえる研究を見つけ積極的な財政支援を行っていくことが，その国の科学全体の可能性を広げていくことなる。アメリカのエリート大学の多くは私立大学だが，その研究費の70%近くは政府資金で守られている。科学研究のフロンティアが極めて大型化している現在において，政府からの財政支援がなければ，その膨大なコストを賄うことなどできないのである。

ではなぜアメリカにおいて，私立のエリート大学にあれほど巨額の公的資金が投入されるのか。アメリカの知識人に，「アメリカのグローバルな力の源泉はどこにあると思いますか」と問いかければ，おそらく次のような言葉が返ってくるだろう。未だにアメリカは世界のGDPの最も大きな部分を占めている。アメリカを支えているのは外交力である。我が国は世界で最も強力な軍事力を備えている。それに加えて，アメリカ

「大学人は国家のあり方から大学を論じる言葉を作り出せ」、上山隆大

「化学と工業」、論説、2013年3月号。

Thank you very much for your attention!!

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