

nature

The Living Record of Science
《自然》学科经典系列

总顾问：李政道 (Tsung-Dao Lee)

英方总主编：Sir John Maddox
Philip Campbell

中方总主编：路甬祥



化学的进程

PROGRESS IN CHEMISTRY

(英汉对照)

英方主编：Philip Ball 中方主编：朱道本 万立骏

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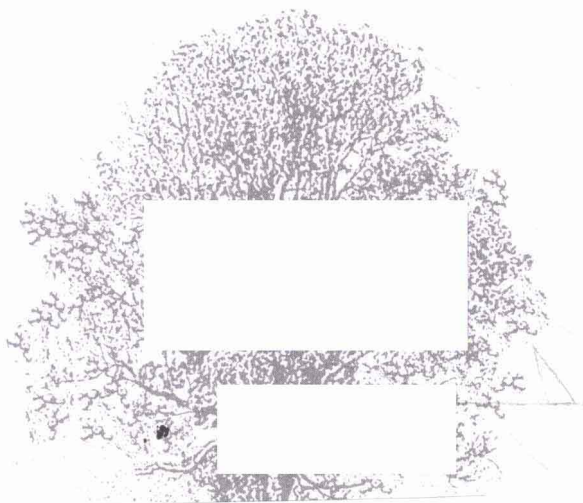
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Foreword by Tsung-Dao Lee

We can appreciate the significance of natural science to human life in two aspects. Materially, natural science has achieved many breakthroughs, particularly in the past hundred years or so, which have brought about revolutionary changes to human life. At the same time, the spirit of science has taken an ever-deepening root in the hearts of the people. Instead of alleging that science is omnipotent, the spirit of science emphasizes down-to-earth and scrupulous research, and critical and creative courage. More importantly, it stands for the dedication to working for the wellbeing of humankind. This is perhaps more meaningful than scientific and technological achievements themselves, which may be closely related to specific backgrounds of the times. The spirit of science, on the other hand, constitutes a most valuable and constant component of humankind's spiritual civilization.

In this sense, *Nature: The Living Record of Science* presents not only the historical paths of the various fields of natural science for almost a century and a half, but also the unremitting spirit of numerous scientists in their pursuit of truth. One of the most influential science journals in the whole world, *Nature*, reflects a general picture of different branches of science in different stages of development. It has also reported many of the most important discoveries in modern science. The collection of papers in this series includes breakthroughs such as the special theory of relativity, the maturing of quantum mechanics and the mapping of the human genome sequence. In addition, the editors have not shunned papers which were proved to be wrong after publication. Included also are the academic debates over the relevant topics. This speaks volumes of their vision and broadmindedness. Arduous is the road of science; behind any success are countless failures unknown to outsiders. But such failures have laid the foundation for success in later times and thus should not be forgotten. The comprehensive and thoughtful coverage of these volumes will enable readers to gain a better understanding of the achievements that have tremendously promoted the progress of science and technology, the evolution of key and cutting-edge issues of the relevant fields, the inspiration brought about by academic controversies, the efforts and hardships behind these achievements, and the true meaning of the spirit of science.

China now enjoys unprecedented opportunities for the development of science and technology. At the policy level, the state has created a fine environment for scientific research by formulating medium- and long-term development programs. As for science and technology, development in the past decades has built up a solid foundation of research and a rich pool of talent. Some major topics at present include how to introduce the cream of academic research from abroad, to promote Sino-foreign exchange in science and technology, to further promote the spirit of science, and to raise China's development in this respect to the advanced international level. The co-publication of *Nature: The*

李政道序

如何认识自然科学对人类生活的意义，可以从两个方面来分析：一是物质层面，尤其是近百年来，自然科学取得了许多跨越性的发展，给人类生活带来了许多革命性的变化；二是精神层面，科学精神日益深入人心，这种科学精神并不是认为科学万能、科学可以解决一切问题，它应该是一种老老实实、严谨缜密又勇于批判和创造的精神，更重要的是，它具有一种坚持为人类福祉而奋斗的信念。这种科学精神可能比物质意义上的科技成就更重要，因为技术进步的影响可能与时代具体的背景有密切关系，但科学精神却永远是人类精神文明中最可宝贵的一部分。

从这个意义上，这套《〈自然〉百年科学经典》丛书的出版，不仅为读者呈现了一个多世纪以来自然科学各个领域发展的历史轨迹，更重要的是，它展现了无数科学家在追求真理的过程中艰难求索、百折不回的精神世界。《自然》作为全世界最有影响力的科学期刊之一，反映了各个学科在不同发展阶段的概貌，报道了现代科学中最重要的发现。这套丛书的可贵之处在于，它不仅汇聚了狭义相对论的提出、量子理论的成熟、人类基因组测序的完成这些具有开创性和突破性的大事件、大成就，还将一些后来被证明是错误的文章囊括进来，并展现了围绕同一论题进行的学术争鸣，这是一种难得的眼光和胸怀。科学之路是艰辛的，成功背后有更多不为人知的失败，前人的失败是我们今日成功的基石，这些努力不应该被忘记。因此，《〈自然〉百年科学经典》这套丛书不但能让读者了解对人类科技进步有着巨大贡献的科学成果，以及科学中的焦点和前沿问题的演变轨迹，更能使有志于科学研究的人感受到思想激辩带来的火花和收获背后的艰苦努力，帮助他们理解科学精神的真意。

当前，中国科学技术的发展面临着历史上前所未有的机遇，国家已经制定了中长期科学和技术发展纲要，为科学研究创造了良好的制度环境，同时中国的科学技术经过多年的积累也已经具备了很好的理论和人才基础。如何进一步引进国外的学术精华，促进中外科技交流，使科学精神深入人心，使中国的科技水平迅速提升至世界前列就成为这一阶段的重要课题。因此，外语教学与研究出版社和麦克米伦出

Living Record of Science by Foreign Language Teaching and Research Press and Macmillan Publishers Limited will prove to be a huge contribution to the country's relevant endeavors. I sincerely wish for its success.

Science is a cause that does not have a finishing line, which is exactly the eternal charm of science and the source of inspiration for scientists to explore new frontiers. It is a cause worthy of our uttermost exertion.

T. D. Lee

Editor's note: The foreword was originally written for the ten-volume *Nature: The Living Record of Science*.

版集团合作出版这套《〈自然〉百年科学经典》丛书，对中国的科技发展可谓贡献巨大，我衷心希望这套丛书的出版获得极大成功，促进全民族的科技振兴。

科学的事业永无止境。这是科学的永恒魅力所在，也是我们砥砺自身、不断求索的动力所在。这样的事业，值得我们全力以赴。

李政道

编者注：此篇原为《〈自然〉百年科学经典》（十卷本）的序。

Foreword by Zhu Daoben and Wan Lijun

Progress in Chemistry is part of a five-volume sequel to the ten-volume *Nature: The Living Record of Science* (English-Chinese bilingual edition), co-published by Foreign Language Teaching and Research Press and Macmillan Publishers Limited. *Nature: The Living Record of Science* is a collection of more than 840 of the most well-known papers published in the world's most influential science journal *Nature* since its inauguration in 1869. The initial selection was first made by the former chief editor of *Nature*, Sir John Maddox, who chose over 2000 of *Nature*'s most prestigious articles. This expansive list was condensed and supplemented by Philip Ball, who was then a consultant editor for *Nature*. While the ten-volume series features selected *Nature* articles in chronological order starting from 1869, the five-volume series presents the most influential research papers respectively on chemistry, physics, life sciences, astronomy and geoscience. This collection of almost 100 classic documents not only reflects the past development and characteristics of the subject, but also indicates new areas of growth and possible future directions in terms of interdisciplinary studies which are important for new breakthroughs.

Chemistry is a science concerned with the composition, structure, properties and changes of matter, and, on this basis, the creation of new substances. Chemistry has played an irreplaceable role in the history of human development. In modern society, chemistry has permeated into all aspects of human life, including clothing, food, housing and traveling, and is of extreme importance for the construction of a sustainable society. With its rapid development in the early 20th century, basic research and applied chemistry have enjoyed great progress in China. Hou's process for soda manufacture (a modification of the Solvay process which was developed by Hou Te-pang in the 1930s), for example, opened up a new era in the world's soda ash industry. Science has enjoyed new developments since the founding of the People's Republic of China in 1949. Achievements such as the successful chemical synthesis of crystalline bovine insulin and the discovery of artemisinin have contributed significantly to the national economic development.

Progress in Chemistry includes papers on chemistry and related interdisciplinary subjects published in *Nature* since its inauguration. Without covering each and every aspect of the evolution of chemistry and its branches, these papers, first published in the world's leading academic journal, nevertheless represent some of the newest and most attention-grabbing achievements in their times, and many of them are now recognized as milestones in the development of chemistry. Interaction and integration with other sciences have contributed to many innovations in this discipline. New subdisciplines of chemistry, and interactions with other disciplines, are constantly emerging, which deeply influence the progress of human society. For example, nuclear chemistry and radiochemistry have arisen at the

朱道本、万立骏序

《〈自然〉学科经典系列》是外语教学与研究出版社与麦克米伦出版集团合作推出的《自然》杂志分学科论文精选集，是之前这两家出版机构共同策划、出版的按年代划分的十卷本丛书——《〈自然〉百年科学经典》（英汉对照）的衍生丛书。

《〈自然〉百年科学经典》收录了国际顶尖学术期刊《自然》自1869年创刊以来发表过的八百四十余篇精华论文。最初的选篇由《自然》杂志的前任主编约翰·马多克斯爵士完成，他选出了《自然》上最有影响力的两千篇左右的文章，后由时任《自然》杂志顾问编辑的菲利普·鲍尔进行浓缩和补充。在《〈自然〉百年科学经典》的基础之上，《〈自然〉学科经典系列》分为化学、物理、生命科学、天文和地球科学共五个分卷，各分卷分别以学科发展为主线，总结并收录了《自然》杂志自创刊以来在该学科及与其他学科交叉发展中最具影响力的近百篇经典论文。对这些经典文献的回顾研究不但能反映该学科的发展历程和学科特点，还能从学科交叉等方面展现该学科新的生长点和发展方向，以期实现新的突破。

化学是研究物质的组成、结构、性质及其变化规律，并在此基础上创造新物质的学科。在人类历史的发展进程中，化学发挥了不可替代的作用。在现代社会中，化学已经渗透到了人们生活中的衣、食、住、行等各个方面，对社会的可持续发展至关重要。20世纪初，全世界化学发展迅速，我国化学的基础研究和化工行业也有了长足的进步。例如，20世纪30年代由侯德榜在索尔韦制碱法的基础上发展起来的侯氏制碱法，开创了世界制碱工业的新纪元。新中国成立后，中国化学科学蓬勃发展，取得了诸如牛胰岛素的人工合成和青蒿素的发现等若干具有国际影响力的成果，为国民经济的发展作出了重要贡献。

《〈自然〉学科经典系列——化学的进程》收录了《自然》杂志创刊以来化学以及交叉学科方面的经典论文。这样的选篇虽然不一定能够完全展现化学及其各分支学科的历史全貌，但作为最具影响力的一流学术期刊，《自然》杂志上收录的均为当时最新也最为社会关注的重要成果。这恰恰体现了博大精深的化学学科在不同历史时期的发展特点和重点，其中的很多成果也被认为是化学学科各发展阶段的里程碑。在与其他学科的相互影响和渗透过程中，化学学科得到了迅速的发展和创新，

interface of chemistry and nuclear physics, while atmospheric chemistry, geochemistry and marine chemistry have come from the integration of chemistry with the geosciences. Thanks to the integration of chemistry with biology, scientists have successfully discovered the molecular structure of DNA and proteins. Chemical biology has established a solid foundation for our understanding of life's processes and origins. Energy chemistry, environmental and materials chemistry are all important topics that have evolved from the interaction with other areas of science. All these have had a profound effect on society. The papers in this volume that describe the research underpinning some of these developments may help chemists to understand the historical status of and interrelationships between different branches of this science—an understanding that might motivate new research projects. With finely rendered Chinese translations alongside the original texts, *Progress in Chemistry* provides greater access for researchers in both science popularization and science education.

We dedicate this volume to the International Year of Chemistry, and to the celebration of the great achievements made by chemists and of the contributions made by chemistry to human civilization. We also hope it will turn out to be a source of inspiration for chemists and scientists in general in their effort to further develop the science of chemistry in our country.



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Chemistry, CAS

新兴的化学分支学科和边缘学科不断涌现，影响了人类社会的发展历史：化学与核物理学的交叉诞生了核化学与放射化学；化学与地球科学的结合出现了大气化学、地球化学和海洋化学；化学与生物学的结合使人们成功地解析出了DNA和蛋白质的分子结构，化学生物学的建立为人类从分子水平认知生命过程和生命起源奠定了坚实的基础；化学与能源、环境和材料科学的融合孕育了能源化学、环境化学和材料化学。这些重要的发展对人类社会意义重大且影响深远，本卷所收录的大部分选篇作为这些研究成果的基础，将有助于化学研究者了解化学以及各分支学科的历史地位及相互关系，并能为化学研究的选题提供借鉴和参考。作为英汉对照的科学主题丛书，本辑在不改变各篇论文原意的基础上，通过译者的文字润色使文章更具科学教育和科学普及的功能。

今年是国际化学年，谨以此书向国际化学年献礼，并庆贺化学家们所取得的伟大成就，纪念化学学科对人类文明的贡献，促进我国化学科学的繁荣昌盛。

朱道本

中科院院士

中科院化学所学术委员会主任

萬立骏

中科院院士

中科院化学所所长

Foreword by Philip Ball

This book presents a selection of 97 of the most important papers that have appeared in the international science journal *Nature* since it began publication in 1869. Over the past century and a half, *Nature* has published some of the most important discoveries in the chemical sciences, including the discoveries of nuclear fission, the structure of DNA, the “ozone hole” and the all-carbon molecules C_{60} and carbon nanotubes. Many of these papers became key contributing factors in the awarding of Nobel prizes, not just in chemistry but also in medicine or physics. *Progress in Chemistry* collects these papers together to offer a record of how the chemical sciences have evolved from the late nineteenth to the early twenty-first centuries. These papers are for the first time made readily accessible here to readers in China by simultaneous publication in English and in Mandarin Chinese, as well as being accompanied by short introductions that explain the context and implications of the work described.

This volume is the first in a series of collections of papers in specific scientific disciplines drawn from *Nature: The Living Record of Science*, a multi-volume compilation of contributions to *Nature* in all areas of science, of which publication commenced in 2009.

Chemistry has traditionally been one of China’s great scientific strengths. China’s pre-eminence in materials technologies such as the production of paper, silk and gunpowder has relied on empirical chemical expertise in the pre-scientific age, and Chinese alchemy exerted an important influence on the development of early chemistry in the West, not least because of its focus on medicinal rather than gold-making objectives. More recently, China has established a globally important profile in areas such as pharmaceutical organic synthesis and the chemistry of rare earth elements, of which the country has large reserves. It is partly for this reason that it is appropriate for the first of these discipline-specific volumes of *Nature: The Living Record of Science* to be dedicated to chemistry.

Chemistry has come to be recognized as one of the sciences central both to economic growth and wealth creation and to securing a safer future for humankind. The development of new drugs, for example, will be essential for attacking infectious, potentially fatal diseases such as malaria and AIDS, and for improving the quality of life for millions of people afflicted with chronic illness. Far from being a challenge that science has increasingly met, drug development is looking ever more difficult and uncertain for a variety of reasons—for example, the accelerating emergence and spread of resistance among pathogenic organisms, the slowing pace of drug discovery now that some of the

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本卷精选了国际著名科学期刊《自然》自 1869 年创刊以来化学领域最重要的 97 篇文章。在过去的一个半世纪里，《自然》杂志刊载了很多化学领域的重大发现，这些发现包括原子核裂变、DNA 结构、“臭氧空洞”以及全碳分子 C_{60} 和碳纳米管。其中许多文章成为荣获诺贝尔奖的关键因素，不仅是诺贝尔化学奖，还有诺贝尔医学奖和诺贝尔物理学奖。《〈自然〉学科经典系列——化学的进程》将这些文章收录在一起，见证了化学自 19 世纪末到 21 世纪初的发展历程。这些文章被首次译成中文并以中英对照的形式呈现给读者，同时辅以简短的编者按来解释所述研究工作的前因后果和意义。

于 2009 年首发的《〈自然〉百年科学经典》丛书囊括了《自然》杂志中出现的所有学科，本卷《化学的进程》为该丛书的姊妹篇——按学科分类分卷出版的《〈自然〉学科经典系列》丛书的第一卷。

化学是中国的传统优势学科。中国在材料工艺学方面作出了诸如造纸、丝绸和火药等方面的杰出贡献，这些都是在科学不发达时代、基于实践化学经验而发展起来的技术；中国的炼丹术对西方化学早期的发展也产生了重要的影响，影响主要在于其针对医药的关注而非炼金术的研究。近年来，中国已经在一些领域里成为了国际上的重要力量，比如药物的有机合成和稀土元素的化学研究等，中国稀土的储量也是非常丰富的。编者将《化学的进程》作为《〈自然〉学科经典系列》丛书的第一卷首先推出的部分原因正是出于这方面的考虑。

在促进经济增长、创造财富和确保人类拥有更安全的未来等方面，化学被认为是具有重要作用的学科之一。比如，新药的研发对于抵抗传染病，治愈如疟疾、艾滋病等致命性疾病和改善数百万受慢性疾病折磨的人们的生活质量都是非常必要的。科学的发展不断面临挑战，但药物研发工作却远不只是科学发展中遇到的那些挑战，一系列的因素使得药物研发工作变得日益艰难且充满不确定性，比如，病原微生物抗药性的加速产生及传播；人类所面临的一些较容易解决的健康问题已被攻克，然而，剩下的问题解决起来异常困难，导致新药的探索 and 发现正逐步放缓；

most accessible health problems have been addressed, and problems with the economic context in which drug discovery is supported. This means that advances in pharmaceutical and biomedical chemistry are required today more urgently than ever.

Equally, many of the problems that beset the natural environment, from ozone depletion and the contamination of water resources to the demands for “clean” sources of energy, require chemical solutions. Chemistry is central, for example, to the production of “green” fuels and the exploitation of solar energy. From the development of stem-cell medical therapies to the creation of new engineering materials, the skills of chemists will play a vital part in our global future. *Progress in Chemistry* reveals how some of these issues have evolved in the chemical sciences over the past century or so, and some of the papers here also point to ways in which chemistry has helped to find answers to practical problems, or will do so in years to come. China is rapidly emerging as one of the principal players in these international efforts to make chemistry serve the well-being of the planet’s population.

Moreover, this collection illustrates that the fundamental questions in chemistry are by no means all now understood. Increasingly, new techniques have revealed chemistry as a subtle and vibrant discipline, which continues to examine profound issues such as how new, artificial elements can be created and how the motions of molecules may be as important as their atomic-scale shapes in determining the behaviour they exhibit.

While this collection will provide a valuable reference source for working chemists, whether in academia or industry, and for science historians, the editorial introductions and the character of the selected works will also make it accessible to and useful for students of chemistry, or indeed for anyone interested in how this subject has developed in the modern age. Most of the papers here were also selected for *Nature: The Living Record of Science*; but these have been augmented both with additional important chemical papers identified in *Nature*’s past pages and with some papers published during the most recent years after the selection for *Nature: The Living Record of Science* was completed. The collection here therefore offers the most up-to-date and comprehensive record of what *Nature* has published in this discipline. This is of course not to say that it includes everything of significance in chemical sciences that has appeared in the journal’s pages, for there was simply not space to include all that might have been selected. To mention just a few examples, some of the early work on the molecular structures of fibrous proteins (the fabrics of biological tissues), and *Nature*’s prominent role in the development of artificial zeolites (porous solids) as industrial catalysts, are not represented here. And there is a vast body of modern research on the atomic-scale structures and functions of biological molecules—the foundational work for understanding the biochemistry of living cells—that could not possibly be done justice in a collection of this sort. Nonetheless, we hope that the selection of papers here will contain