院士思维

卷三

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为院士思维出版题

重视思考 善于思考

一九九八年四月吴阶平

科学家的天职叫我们应当
继续奋斗，彻底揭露自然界的
奥秘，以使能在将来造福人类。

引自《约里奥·居里传》
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李政道
一九九八年五月

提倡科学思维
推动社会进步

周光召

九八年四月十六日

科学思维也是以严肃的科学态度真正的科学精神和科学方法进行的思维，只有真正的科学思维才能推进社会进步，我们提倡和发扬的就是这样的科学思维

于光远

一九八八年四月

正确的科学思维方式是科技工作者的灵魂

（序　言）

人的思维是以大脑为物质基础的一种高级物质运动和精神活动形式。从实质上说，思维运动乃是人的中枢神经系统（特别是大脑）反映客观物质世界运动、发展、变化等各种外界刺激而引发的认知活动；人类认识世界、改造世界的实践—认识—再实践的全过程都始终离不开思维运动。

从古至今，科技思维活动源远流长，贯穿于科学技术起源、发展、变革和创新的全部历程。从根本上说，一部人类科学技术史，就是人们不断推动科技进步、促进社会发展的思维运动史。早在古希腊时代，自然哲学大师亚里士多德就提出了以“三段论”为中心的形式逻辑思维方法，巴普斯在其《解题术》一书中则从几何学观点谈论过创造性思维与创造方法。近代科学方法论的首创者培根和笛卡尔，分别创立了逻辑思维的归纳法和演绎法；笛卡尔在其《方法论》中还把欧几里德几何学称为演绎方法系统思维的典范，并论述了创造性直觉的重要性。19世纪中叶，马克思、恩格斯在创立辩证唯物主义尤其是自然辩证法时，更特别强调了哲学理论思维和多种科学思维形式的运用，指出“科学是实验的科学，科学就在于用理性方法去整理感性材料。归纳、分析、比较、

观察和实验是理性方法的主要条件”。20世纪伟人列宁、毛泽东和邓小平都先后深刻阐明了从实践到理论、从感性认识到理性认识、“实践是检验真理的唯一标准”等科学思维原则和方法。

大凡在近现代科学上能独树一帜、在理论上有重大发现、在技术上有划时代发明创造的卓越科学家和发明家，往往都十分重视在哲理思维引导下的科学思维，并在科技方法论上显示了新颖独特的风格。近代自然科学革命的先驱者哥白尼创立日心地动说，最直接的启示就来自古希腊的自然哲学。他从长期天体观测实践中深信：“理论是月亮的光辉，事实是太阳的光辉。”这一富有哲理的名言反映了他在科学思维中始终坚持科学理论依赖客观事实而反射光辉的辩证逻辑。20世纪的科学巨人爱因斯坦，从科学探索中深知哲学“是全部科学研究之母”。同时，他又强调“想像力是科学研究中的实在因素”，“真正可贵的因素是直觉”。薛定谔在创立量子力学和分子生物学的实践中，亲身体验到哲学思维的科学方法论功能，形象地称“哲学是科学家的支柱、脚手架、先遣队”。著名物理学家玻恩留下了“真正的科学是富于哲理性的”，“每一个现代物理学家……都深刻地意识到自己的工作是同哲学思维错综地交织在一起的”等名言。提出基本粒子结构“坂田模型”的著名日本科学家坂田昌一临终前写下了肺腑之言：“恩格斯的《自然辩证法》在我40年的研究生活中经常地授给我珠玉般宝贵的光辉。”我国杰出科学家钱学森院士在1985年更直截了当地断言：“应用马克思主义哲学指导我们的工作，这在我国是得天独厚的……马克思主义哲学确实是一件宝贝，是一件锐利的武器。我们搞科学研究

时（当然包括搞交叉科学研究），如若丢掉这件宝贝不用，实在是太傻了。”他在我国首倡并率先开展了在马克思主义哲学指导下的“思维科学”等交叉科学研究。我国以李四光、竺可桢、吴有训、华罗庚、周培源、严济慈等等为代表的优秀科学家，为我们树立了以先进哲学思维为导向，依托多种科学思维形式，创建光辉科技业绩的榜样。

科学的本质特征是追求真理，科学的生命力在于不断地在揭示自然奥秘中开拓创新！我认为，要实现我国科学技术的持续创新，既要靠现代化的先进仪器设备作为“硬件”，又要靠丰富的图书文献资料提供可靠信息源和信息载体，更要靠多样化的现代科学思维方式作为“软件”。大量事实证明，正确的科学思维方式确实堪称近现代科技工作者的灵魂，犹如科学宏观研究的望远镜和微观研究的显微镜一样重要。

20世纪30年代以来，美、前苏联、德、日等国相继兴起了专门探讨科技创造发明活动的一般规律和方法的创造学与创造工程学研究热潮；从国际科坛到国内科坛陆续涌现出一些专门论述科技实践（科学发现、技术发明）活动规律及其思维技巧、方法的论著。其中，国外主要有：[美] V. L. 罗文菲尔德著《创造活动的本质》(1939年)；[前西德] M. 韦特默著《创造性思维》(1943年)；[英] W. I. B. 贝弗里奇著《科学研究的艺术》(50年代在英国多次重版发行，1979年科学出版社首次印发中文版)；[前苏联] С. П. 鲁宾斯坦著《关于思维及其研究方法》(1958年)；[美] J. P. 吉尔福德著《创造性思维的智力因素》(1967年)；[前苏联] В. Н. 普希金著《创造学——关于创造性思维的科学》(1967年)；[日] 汤川秀澍著《向创

造飞跃》(1969年);[日]市川龟久弥著《创造性科学》(1970年);[日]恩田彰著《创造性研究》(1971年);[美]华勒斯著《思考的艺术》(1976年)等。我国学者的相关论著主要有:王梓坤著《科学发现纵横谈》;姜念涛著《科学家的思维方法》;钱学森主编《关于思维科学》,等等。这些论著在国内外科技界产生了广泛而深远的影响。然而,上述论著主要反映了西方科学家的科技思维与科研方法,对我国古今学者仅有零星的介绍,对其进行系统研究的专著更是尚付阙如。

华夏大地,人杰地灵,群星灿烂,英才辈出!1955年以来,我国从人数众多的科技大军中先后优选出一千多位中国科学院院士和中国工程院院士,他们就是我国科技界的群星和精英。他们已经或正在把用毕生心血和聪明才智创造的优秀科技成果奉献给伟大祖国和全人类,他们的智慧才能是中华民族的宝贵精神财富,是实施"科教兴国"战略的坚强支柱,是我国科技这个"第一生产力"的典型代表。他们的科研思想大致代表了我国当代科学思想的特点和走向;他们的思维方式反映了中华民族优秀传统文化的精髓和氛围。我们在世纪之交组织编辑出版《院士思维》的宗旨,就是为了系统地挖掘、整理、研究院士先进的科学思想和独特的科研思维方法,追寻他们在长期科技实践中,及其实现理论发现、技术发明中闪烁的思维之光,并从他们对当代各门学科的现状分析和21世纪科技发展的前景展望中明确未来主攻方向。通过这套专著的出版,必将填补对我国科学、工程专家思维方式和科研方法进行系统实证研究的学术空白,客观真实地记录诸院士在科技创造活动中思维运动的主轨迹,给我国广大科技人员和后辈学者树

立学习、借鉴老一辈科学家科研思维技巧和方法的榜样，更好地弘扬中华民族优秀传统文化的精华，让当代科技的接力棒代代相传，推动后人去创造更新、更美、更高境界的物质文明和精神文明。同时，这也有利于向国际科坛展示、传播、交流中国学者特有的思维方式和新颖的科研方法，使中国科学家更好地走向未来国际科技大舞台。

展望21世纪，现代科学技术革命必将实现更加巨大的新突破，一个交叉科学（尤其是系统科学、非线性科学）和高新技术产业大发展的信息化智能化文明时代已显露曙光，以知识取代权力和资本的知识经济时代正悄然到来。此时此刻，不禁使我想起了中国科学院首任院长郭沫若同志临终前在《科学的春天》一文中留下的珍贵遗言："科学是讲究实际的……同时，科学也需要创造，需要幻想。""既异想天开，又实事求是，这是科学工作者特有的风格。"我愿把这句名言再推荐给全国科技工作者，让我们以马克思主义哲学和邓小平科技思想为指导，坚持以先进的科学思维为导向，不断变革和更新科学思维方式，善用形象思维和逻辑思维，激发幻想、直觉、灵感等创造性思维，巧用系统整体思维和非线性思维，力求在众多科技领域创立具有东方特有风格的中国学派，再创无愧于我们伟大民族的辉煌科技业绩，为"科教兴国"再展宏图，跻身于21世纪世界科技的前列！

1999年4月8日

Correct Thought in Science is the Soul of Scientists

(preface)

Human being's thinking is an advanced form of material movement and spiritual activity, brain as its material base. In essence, thinking is the cognitive response of human being's central nervous system (especially the brain) to such external stimuli as the movement, development and changes of the objective material world. The whole process, from the practice of understanding and reforming the world to the cognition, and then to the re-practice, can never operate without thinking activity.

Thinking activity in science and technology has witnessed its long track from ancient times to the present, going through the whole history of science and technology from the origin to the development, innovation and creation. Essentially, the history of human being's science and technology is the history of human being's thinking movement to keep developing science and technology and the whole society as well. As early as in ancient Greek times, Aristotle, a master of natural philosophy, proposed the formal logic thinking method focusing on syllogism. Bapus discussed creative thinking and creation methods in

his book *Solutions* from the viewpoint of geometry. Bacon and Descartes, founders of modern scientific methodology, established inductive methods and deductive methods respectively. In his book *Discourse on Methodology*, Descartes praised Euclidean geometry as the model of deductive systematic thought and illustrated the importance of creative intuition. In the middle of the 19th century, Marx and Engels founded dialectical materialism, especially dialectics of nature, and emphasized in particular the employment of philosophical theoretical thought and various forms of scientific thought. "Science bases its theories upon experiments;" they stated, "it lies in the employment of rational methods to sort out perceptual materials. Induction, analysis, comparison, observation and experimentation are the main premises of rational methods." Lenin, Mao Zedong and Deng Xiaoping, giants of the 20th century, thoroughly formulated such scientific thinking principles and methods as from practice to theory, from perceptual knowledge to rational knowledge, and "practice as the sole criterion to test truth".

Generally, those outstanding scientists and inventors who have made significant theoretical or technological breakthroughs pay much attention to scientific thought under the guidance of philosophical thought and display their originalities in terms of scientific and technological methodology. Copernicus, a pioneer inmodern natural science revolution, established the heliocentric theory of which the

most direct enlightenment was from ancient Greek natural philosophy. Through his long-term observation and measurement of celestial bodies, he concluded: "Theories are lights of the moon, and facts lights of the sun." This famous and philosophic remark showed Copernican ideology that scientific theories should be based upon objective facts. Einstein, a giant in science of the 20th century, understood through numerous scientific researches that philosophy "is the mother of all scientific researches". Meanwhile, he stated, "imagination is the substantial element in scientific research" and "the truly valuable element is intuition". "Philosophy is the backbone, scaffold and advance party of scientists," said Schrodinger, who himself learned the strength of scientific methodology with philosophical thought when he was establishing quantum mechanics and molecular biology. As a famous physicist, Born said, "Real science is philosophical," and"Every modern physicist is fully conscious of the fact that his work is associated in a complicated way with philosophical thought". Sakata Shoichi, a Japanese scientist who proposed the "Sakata model" for the structure of elementary particles, wrote before he passed away, "Throughout my forty years' research, the book *Dialectics of Nature* by Engels never stops giving me enlightenment as valuable as pearls and jades." Chinese outstanding scientist Qian Xuesun affirmed more directly in 1985, "Employing Marxism philosophy to guide our work enjoys exceptional advantages in

China." "Marxism philosophy is really a treasure, a powerful weapon," said Qian, "and it will be too stupid if we throw this treasure away while engaged in scientific research (including crossdisciplinary study, of course)." Qian is the first one in China who initiated such crossdisciplinary studies as "the science of thought" under the guidance of Marxism philosophy. Other Chinese scientists, Li Siguang, Zhu Kezhen, Wu Youxun, Hua Luogeng, Zhou Peiyuan and Yan Jici as the representatives, set for us good examples to make brilliant scientific achievements under the guidance of advanced philosophical thought and with the help of various forms of scientific thoughts.

In the final analysis, science is featured by the pursuit of truth and the vitality of science lies in the continuous creations through explorations of natural mysteries. Continuous scientific and technological creations in China, as far as I think, shall be based on modern advanced equipment and facilities as the "hardware", rich literature and data as the information source and information carrier, and diversified modern scientific thoughts as the "software". It is proved by infinite facts that correct thought in science is the soul of modern scientists, as important as the telescope for macro stu-dies and the microscope for micro studies.

Since the 1930s there have been tides of studies on the science of creativity and creativity engineering to explore in particular the general principles and methods of scientific and technological creations and inventions *in*

America, Russia, Germany, Japan, etc. Internationally and domestically, many books have been published, discussing the principles and thinking skills and methods of scientific practices (scientific discoveries and inventions). Among the books by foreign authors are *Nature of Creative Activities* by V. L. Rovinfield (in America in 1939), *Creative Thinking* by M. Wehtmoe (in Germany in 1943), *Arts of Scientific Research* by W. I. B. Beverage (three continuous publications in Britain in 1950s, first Chinese version published by Chinese Science Publishing House in 1979), *On Thought and Its Research Methods* by C. Л. Rubinstan (in former USSR in 1958), *Intelligent Factors of Creative Thought* by J. P. Gilford (in America in 1967), *Science of Creativity —— the Science on Creative Thought* by B. H. Pushkin (in former USSR in 1967), *Leap To Creation* by Yukawa Hideki (in Japan in 1969), *Science of Creativity* by Ichikawa Kikoya (in Japan in 1970), *Study on Creativity* by Onda Akira (in Japan in 1971), *Arts of Thinking* by Wallace (in America in 1976), etc. The books by Chinese scholars are *Discussions on Scientific Discoveries* written by Wang Zikun, *Thinking Methods of Scientists* written by Jiang Niantao, *On Science of Thought* edited by Qian Xuesen, etc. All these books have produced profound influences both at home and abroad. Nevertheless, these books mainly reflect the scientific thoughts and research methods of western scientists. Only fragmentary introductions of Chinese ancient and