Introduction. Japan: its tradition and hot topics in biological sciences

The year 2008 marks the 150th anniversary of the Anglo-Japanese Treaty of Amity and Commerce, which secured the basis for the first diplomatic mission in Edo and opened a new era of Meiji in Japan. Thereafter, Japan rapidly modernized and assumed a leading role in the world of science and technology.

This issue of Philosophical Transactions B profiles three specific areas of current Japanese biological science research. It was not easy limiting ourselves to just three areas. We wanted to showcase the tremendous range of biological research being done in Japan, but too much breadth would have come at the expense of depth. We believe that the three specific mini-themes we finally selected would provide a representative snapshot while allowing space for five papers on each topic.

The mini-themes are: (i) Stem Cell Biology (session editor: Hideyuki Okano), (ii) Single-molecule Imaging (session editor: Toshio Yanagida), and (iii) Neuroscience (session editor: Atsushi Iriki). Each of these areas has seen significant and exciting progress in recent years. As a whole, we believe that they characterize Japan’s enduring, cutting-edge contribution to the global advancement of biological science.

1. STEM CELL BIOLOGY

Immediately after the Meiji restoration, Japanese academics began inviting European professors from diverse fields to help bring them up to speed with the state of the art of modern Western science. Many of the biologists who came happened to be major developmental biologists and embryologists, and subsequently presided over zoology departments in imperial universities across the country. As a result, developmental biology became one of Japan’s earliest areas of world-class research. Owing to Japan’s insular geography and deep cultural attachment to the sea, marine embryology (on sea urchin roes and the like) dominated the field from the beginning. As time went on, this work extended to study how to manipulate development as it unfolds, epigenetic environmental factors affecting development, and eventually led to studying reprogramming. In the decades following World War II, as biochemistry and molecular biological theories became highly advanced, Japan became a renowned innovator of cutting-edge molecular manipulation technologies, and its population of molecular biologists expanded greatly. On these historical bases, Japan has been notably enthusiastic in its interest in stem cell biology.

Agata & Umesono (2008) present innovations in regenerative biology based on insights from traditional developmental biology. Following the same basic approach, Yamanaka (2008) presents novel developments in somatic cell-derived induced pluripotent stem-cell technology, an alternative to embryonic stem-cell technology and currently one of the hottest topics in biology. Ema & Nakao (2008) present various technological and research developments, such as the cell sorter assay, that made Japan a leader in the subfield of haematopoietic stem-cell research. Finally, the exciting topic of neural stem-cell technology is addressed by two papers: Namihira et al. (2008) discuss the epigenetic regulation of the differentiation of neural stem cells, and Okano & Sawamoto (2008) describe the basic mechanisms of adult neurogenesis and their potential applications in regenerative brain repair.

2. SINGLE-MOLECULE IMAGING

The Japanese enthusiasm for biophysics encompasses not just the aggregate statistical characterization of the dynamics of biological molecules in vivo, but also the dynamics of individual molecules. This latter interest is driven by a strong sense that the behaviours of individual molecules, far from comprising mere ‘noise’, must have functional biological significance that mass averaging cannot capture. It is tempting to attribute this sense to the Japanese mentality of prizing the harmony of society as a whole while simultaneously appreciating the roles played by individuals, in all their detail and complexity, which cannot be regarded as mere noise. Of course, accurately measuring the movements and transformations of individual molecules is extremely technically challenging. As the following five papers demonstrate, the exceptional dexterity, patience and technical and engineering prowess of Japanese researchers have come together to make Japan a leading innovator in this important field.

Yanagida et al. (2008) describe common phenomena that demonstrate that individual molecular dynamics do indeed have functional significance which is not discernible from statistical averaging. Articles by Aoki et al. (2008) and Nakanishi-Matsui & Futai (2008) represent typical extensions of Japan’s cellular physiology tradition, describing the dynamics of molecules inside living cells. Finally, two demonstrations observing single molecules directly under natural conditions, both optically (Nagayama & Danev 2008) and mechanically (Ikai 2008), are presented.

3. NEUROSCIENCE

The Japanese penchant for co-emphasizing reductionistic, elemental, individual-agent-based perspectives with holistic, harmonized, integrated viewpoints informs much of the country’s scientific thought and
approach to research. This has certainly been true in the biological sciences from the very beginning, and is very much in evidence in the Japanese approach to neuroscience. For example, throughout Japanese society (including the lay public) the term ‘brain science’ is generally preferred to ‘neuroscience’ because it carries a wider scope of meaning. The term was coined by the Japanese neuroscience community ca 1990 because they felt that neuroscience, as it is commonly understood and pursued, is limited to the study of the brain as a biological information-processing organ. Brain science seeks an integrated, consilient view of brain, mind, body, society, environment and technology. It encompasses theory, practice and implementation in medicine, psychology, engineering, the traditional humanities and many other spheres of human endeavour. Indeed, in 1997 the Japanese government established the Brain Science Institute (BSI) as an arm of the RIKEN Institute to push forward this ambitious synthetic scientific agenda. Meanwhile this sense of the term ‘brain science’ became more widely understood and embraced by the global scientific community.

In the spirit of this more expansive research framework, Kano et al. (2008) document their search for the molecular mechanisms of cerebellar long-term depression, a fundamental phenomenon in systems neuroscience that also happened to be a major discovery of modern Japanese neurophysiology. Osada et al. (2008) exquisitely integrate primate neurophysiology with various related fields of neuroscience to shed light on higher cognitive functions. Kawato (2008) describes the construction of a high-tech humanoid robot based on a computational approach for understanding and replicating the information-processing systems of the brain. Mizuno et al. (2008) bring a basic molecular biology technique to clinical neurology to uncover important mechanisms in familial Parkinson’s disease, which have implications for its treatment. Finally, Iriki & Sakura (2008) integrate recent neuroscience data with ideas from traditional Japanese primatology and propose a novel framework for studying the evolution and structure of human intellectual abilities based on their precursors in the brains of non-human primates.

From the very beginning, Japanese biological science has advanced and thrived by importing the best methods and techniques of Western natural science while still allowing its own native cultural perspectives to inform its approaches. Throughout its history as a modern nation, Japan has been a world leader in biology. This issue represents the first attempt to cover and introduce the wide spectrum of the cutting-edge biological science research being done in Japan. The three individual topic areas showcased here represent only a tiny sliver of the research being done in Japan. The three individual topic areas showcased here represent only a tiny sliver of the research being done in Japan.

Modern Japan takes pride in the skill and enthusiasm of its biologists, and the findings and perspectives of modern biological science have permeated deeply into the nation’s cultural fabric. His Majesty the Present Emperor, the first King Charles II medallist of the Royal Society, and Japanese royal family members over recent three generations have been earnest biologists. The previous Emperor of Showa, was also a biologist, and fellow of the Royal Society. To commemorate Emperor Showa’s sixtieth year of reign and his long devotion to biological research, the annual International Prize for Biology was established in 1985 to recognize world-class excellence in biological research. The prize has been awarded through the Japan Society for the Promotion of Science, to which we are grateful for co-sponsoring this issue. We also extend our hearty gratitude to the Royal Society for publishing this special issue in this year to help commemorate Japan’s entry onto the modern world stage. We hope this issue will lead to wider appreciation for our nation’s considerable, ongoing contribution to the global efforts to improve human health, happiness, wisdom and social well-being through the noble enterprise of biological science.

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