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The Biological Revolution

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Abstract

Since the 1950s biological sciences are on the rise. Today the rise of biological sciences have become so drammatic that its role has evolved from a single discipline to completely new sets of disciplines which we call today as life sciences. Due to the advancements in genomic technologies the fields of life sciences like molecular biology, biotechnology, molecular medicine, nanobiotechnology and neuroscience have evolved rapidly. The positive impact of these developments are not only evident in science and technology but also in economic growth and development.

Keywords: genomics, biology, molecular biology, genetic engineering, biotechnology

The nineteenth century was the age of engineering which served as a fuel for industrial revolution in Europe and North America (Wengenroth, 2000). The twentieth century was the age of chemistry and physics, despite the fact that key discoveries in biological sciences begin to emerge during this period, too (Agar, 2012). New discoveries and foundations in chemistry and physics like radioactivity, theories of atom, quantum and relativity, has revolutionized the science and technology.

The twenty first century is definitely the age of biology. Many discoveries and inventions like DNA sequencing, restriction enzymes and PCR, caused biology to become dramatically differentiated and this boosted the development of new disciplines collectively called life sciences. Especially young fields like molecular biology, modern biotechnology, molecular medicine, nanobiotechnology and neuroscience have developed rapidly. This trend can be easily tracked by a snapshot of Noble prizes given in the last decade. Interestingly, the majority of Noble Prizes in Chemistry have been awarded for the subjects of biology since the beginning of 2000s. Table 1 lists the topics of biology (highlighted by blue color) awarded by Noble prize in the field of chemistry. Between the years of 2002 to 2015, nine Nobel prizes of chemistry out of fifteen went to subjects of biology or subjects related to biology. Thus, the life sciences are on the rise.

The rise of the life sciences is very much dependent on the genomic research and associated technologies. The genome is defined as the total genetic information of a species. Today the genomic sequence of many species including *Homo sapiens* is publicly available already. This means that genomic sequence of human for example, is decoded, numbered, catalogued and stored in the publicly available databases –thanks to the power of Human Genome Project (Lander ES, Linton LM, Birren, et al., International Human Genome Sequencing Consortium, 2001). However, now, in this post-genomic era, we still do not know the exact meaning of this code which is composed of billions of nucleotides arranged in the form of forty six chromosomes in each somatic cells of our body. Even the number of genes in the human genome is not known precisely. So, the current challenge of the post-genomic era is to identify all of the genes found in the human genome and to determine their functions and their interactions with each other and with the environment.

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Despite the need of further work to fully benefit from the post-genomic era, it is already visible that genomic technologies are becoming very significant for economic growth and development. For example, according to a report published by Battelle Technology Partnership Practice (Tripp and Grueber, 2011), the economic impact of genomic research is estimated as $796 billion between the years 1988 and 2010. In fact the return of investment has been calculated as 141:1 which implies that for every $1 invested by the U.S. government a $141 economic activity is generated. In addition, according to the same study, genomics generated at least 51,000 jobs, and indirectly supported at least 310,000 jobs leading to an increase of $20 billion in personal income and $67 billion contribution to the U.S. economy. These figures clearly indicate that developments in life sciences are not only crucial for further analysis of natural phenomena but also important for economic growth and development.

The strong economic impact of life sciences is not limited to recent impact of genomic research as explained above. The biotechnology companies like Genentech (acquired by Roche now) in the Silicon Valley has already been seeded in the 1970s when, for example, insulin is cloned in bacteria and produced as recombinant drug by the techniques of genetic engineering. Genetic engineering allows scientists to manipulate DNA for a specific purpose. Thus, it is possible to inactivate, exchange or mutate a gene or genes of a given species. For example, when a gene is inactivated in the genome of a species it is called a knock-out (KO) organism (Tsien et al., 1996) and KO animals have provided the basis of many studies directed to understand the function of a selected gene during health and disease. Genetic techniques like cre/loxP systems help scientists manipulate genes in specific neuron types or tissues of brain (Tsien et al., 1996) Thus, ranging from knocking out genes to spatio-temporal control of gene activity, there are a wide variety of genetic engineering approaches to manipulate genomes. These methods and approaches are likely to increase in the future and thus more development in medicine, biotechnology, neuroscience, bio-nanotechnology and pharmacogenetics is expected in the future.

Table 1. Topics of Noble prizes in the field of chemistry since 2002. Rows highlighted by blue color show subjects of biology or subjects related to biology (source: nobelprize.org)

Year	Topic	Nominee
2002	Biological macromolecules	John B. Fenn, Koichi Tanaka, Kurt Wüthrich
2003	Channels in cell membranes	Peter Agre, Roderick MacKinnon
2004	Protein degradation	Aaron Ciechanover, Avram Hershko Irwin Rose
2005	Metathesis method in organic synthesis	Yves Chauvin, Robert H. Grubbs, Richard R. Schrock
2006	Eukaryotic transcription	Roger D. Kornberg
2007	Chemical processes on solid surfaces	Gerhard Ertl
2008	Green fluorescent protein (GFP)	Osamu Shimomura, Martin Chalfie, Roger Y. Tsien
2009	Structure and function of the ribosome	Venkatraman Ramakrishnan, Thomas A. Steitz, Ada E. Yonath
2010	Palladium-catalyzed cross couplings in organic synthesis	Richard F. Heck, Ei-ichi Negishi, Akira Suzuki
2011	Quasicrystals	Dan Shechtman
2012	G-protein-coupled receptors	Robert J. Lefkowitz, Brian K. Kobilka
2013	Multiscale models for complex chemical systems	Martin Karplus, Michael Levitt, Arieh Warshel
2014	Super-resolved fluorescence microscopy	Eric Betzig, Stefan W. Hell, William E. Moerner
2015	DNA repair	Tomas Lindahl, Paul Modrich, Aziz Sancar

While the developments briefly described so far are revolutionary, there exists many associated problems. Among these problems is the lack of equal opportunity. The impact of the biological revolution is not equally felt across the globe. There is no enough stimulation in the developing countries and people in these countries continue to suffer from the diseases for which science will have found cures (WHO Repor t, 2006). Thus, we need to develop awareness to address the requirement for the equality of opportunity for the knowledge and benefits of biological revolution.

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