Preface to Special Issue “Life Science”

by Norio Mukai

Life Science Business Department, Analytical & Measuring Instruments Division, Shimadzu Corporation, Kyoto, Japan

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1. Introduction

The original goal of the life sciences was to triumph over disease, live a healthy life, improve food security and self-sufficiency, and resolve challenges in the environment. Research and development continues today in pursuit of these goals in a wide range of fields, including pharmaceutical sciences, agriculture, and food chemistry. As this research evolves, analytical instruments and software have become more advanced, omics-based techniques for the comprehensive analysis of genes, proteins, and metabolites have been developed, and understanding biology as an integrated whole has grown in importance.

Under these circumstances, the rapid spread of the SARS-CoV-2 virus which started at the end of last year caused untold damage throughout the world and forced us to change the way we act and think. The COVID-19 pandemic demonstrated how a crisis can catalyze a dramatic mobilization of budgets and human resources, creating new technologies and driving change. Universities, institutions, and companies such as ours with a leading role in the life sciences are called on to deliver innovative solutions, and fulfilling these expectations necessitates entry into other sectors and strengthening collaboration with other industries.

As a recent example of this, working from home has increased at a pace that exceeded the imaginations of many workplaces and laboratories, calling for more efficient working practices capable of consolidating limited resources and maintaining and even increasing productive capacities despite effective restrictions on economic activity. This special issue of Shimadzu Review covers analytical instruments, assay kits, new technologies, and applications in the life sciences that offer labor savings and automation in the laboratory.

2. Infectious Disease Control

Real-time PCR testing has entered common language in relation to its use in detecting the SARS-CoV-2 virus. The 2019 Novel Coronavirus Detection Kit sold by Shimadzu was designed to detect the SARS-CoV-2 virus in saliva and produce results quickly and simply without the need for complex and labor-intensive RNA isolation and purification steps. One article in this section describes the principle behind this technology and an LC/MS/MS system with a fully automated sample preparation unit that facilitates quicker clinical studies of COVID-19 therapeutics.

Glycans are intimately involved in such basic biological processes as immunity, development, and differentiation, and understanding glycan structure is essential to the deployment of infection control measures and development of antibody drugs. Another article in this section describes a technique that uses MALDI-MS to analyze sialyl glycans with sialic acid residues at their terminus that could be used in drug discovery for infectious diseases.

3. Cell Culture Technology

There are high expectations that regenerative medicine, which uses cultures of induced pluripotent stem (iPS) cells and other types of stem cells, will be able to cure illnesses that have proven resistant to other treatments. Cell culture is also a key technology in the development of antibody drugs. Nevertheless, many challenges remain before cell culture can become an established technology in medicine and industry. For example, the procedures used to grow stem cells and associated quality controls involve numerous manual techniques only perfected at laboratory scale that require the skill of an experienced operator. Shimadzu hopes to use its measurement and observational technologies to overcome these issues, and accelerate the industrialization of cell culture technology by improving efficiency at each step of cell research, drug discovery, cell therapy, and regenerative medicine. The articles in this section describe improvements in the reproducibility and working efficiency of cell culture processing through the automation of steps in the cell culture process, and a deep learning

-based method of evaluating cells in real time that reduces human involvement.

4. New Chromatography and Mass Spectrometry for Improved Efficiency

Liquid chromatographs (LC) and mass spectrometers (MS) are essential tools in biological analysis and drug discovery research. These instruments also support a major part of Shimadzu's business and a large amount of resources are invested by Shimadzu into their technological development. This section presents the following three notable new technologies of liquid chromatography and mass spectrometry instrument.

1) The new Nexera series of ultra high performance liquid chromatograph (UHPLC) systems is built on the highest level of HPLC performance and uses M2M, IoT, and AI technologies to offer automation, labor savings, and efficiency improvements.
2) A semi-preparative supercritical fluid chromatography (SFC) system has been developed in collaboration with a U.S. pharmaceutical consortium to save labor in separation and purification (preparative analysis) processes that are typically time-consuming and consume large amounts of environmentally harmful organic solvents.
3) The MALDImini-1 matrix-assisted laser desorption/ionization mass spectrometer uses proprietary digital ion trap technology to achieve a system size no larger than an A3 paper and records MS/MS and MS3 spectra for the structural analysis of glycoproteins and other biological analytes.

5. Mass Spectrometry Imaging

Metabolite studies and pharmacokinetic analysis typically isolate target compounds from sample tissue before they are analyzed, and this isolation step does not retain data on the position of the target compounds in the sample tissue. Mass spectrometry (MS) imaging is a technique that provides information on the location of compounds in biological tissue and offers a direct method of ascertaining the distribution of target compounds in a biological sample. In this respect, MS imaging offers a new approach to metabolic research in living organisms. This article presents notable features of the iMScope QT imaging mass microscope, including integration with optical microscopy, excellent spatial resolution, speed, and sensitivity characteristics, and switching with LC-Q-TOF during operation, along with new sample processing techniques, analytical software, and real-world applications.

6. Applications in the Pharmaceutical Sciences and Other New Applications

Mass spectrometry techniques have developed to satisfy the demands of pharmaceutical research. This section attempts to cover a number of areas related to mass spectrometry applications in drug discovery.

1) Fatty acids play an important role in biology as the building blocks of membranes and as energy storage. We now understand that unsaturated fatty acids with multiple double bonds suppress the progression of cancer and reduce allergic symptoms. The position of these double bonds is closely associated with physiological function, and a new chemical ionization technique for GC-MS developed by Shimadzu that uses an organic solvent (acetonitrile) may have a useful role to play in this research.
2) Although the market for biopharmaceuticals is growing every year, the antibody drugs that form the core of this market are expensive due to cell culture-based production and pose quality control challenges due to their complex structure. There is growing interest in nucleic acid drugs that can be synthesized chemically similar to low molecular weight drugs while still offering high levels of specificity. An article in this section describes a simple method of the qualitative and quantitative analysis of oligonucleotides using LC-Q-TOF and LC-MS/MS. Another article focuses on microflow LC-MS/MS, an analytical technique that does not require the high level of expertise of nano-flow LC but can be used to perform highly sensitive quantitative analysis of low levels of drugs and drug metabolites in blood.

7. Conclusions

The challenges to overcome in healthcare, environment, food, and other branches of the life sciences cover a wide range of topics, including improving the efficiency of drug discovery, developing methods of early diagnosis, creating smart cell technology, and the development of biodegradable plastics. The number of societal issues that deserve attention is also increasing, with the COVID-19 pandemic being a prime example. Through the research and development of analytical instruments and peripheral systems, and through the deployment of these instruments and systems in society, Shimadzu aims to create new markets and leverage increased growth while enhancing its positive impact on society. We hope that readers find this special issue on the life sciences relevant to their specialist field and is an opportunity for fresh perspectives and understanding.