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PERSPECTIVE

From the Ashes of a Pandemic: Leveraging Omics for R&D

Lyre Anni E. Murao[1]

[1]Philippine Genome Center Mindanao, University of the Philippines Mindanao,
Mintal, Davao City 8000 Philippines, lemurao@up.edu.ph

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Abstract

The COVID-19 pandemic caught the world unprepared for a global catastrophe. With the uncertainty of a vaccine in the near future, the pandemic marks the start of a new world that has to co-exist with the virus. COVID-19 has been a wake-up call to the lingering but neglected issues on environmental health and global food security but is also a timely opportunity to rise from the ashes, reboot our framework, and act with resolve for sustainable and resilient ecosystems and communities. The emerging tools and disciplines in the field of omics can be leveraged for a systems-level understanding of biological processes to accelerate advancements on knowledge, innovations, and policies towards a more sustainable utilization and management of resources in this post-pandemic age. In developing regions, omics research centers can serve as a gateway to this technology by providing access, building capacities, and facilitating collaborative and harmonized research engagements.

Keywords: *omics, COVID-19, R&D, environmental sustainability, food security*

On March 11, 2020, the World Health Organization declared COVID-19 a pandemic [1], with more than ten million cases and half million deaths scattered among 213 countries by the end of June 2020 [2, 3]. The COVID-19 pandemic caught the world unprepared for a global catastrophe that impacted all streams of life from public health to the environment, economy, and society. A nano-scopic virus stopping the entire world in its tracks was just a textbook idea- highly unexpected for our modern and advanced society. Yet the virus is now making headway as cases continue to rise, leaving behind damages in various sectors of the society.

COVID-19 is here to stay. Mathematical projections in the US predict that social distancing measures may have to be implemented until 2022, and resurgences could occur even up to 2024 [4]. With the uncertainty of a vaccine in the near future, the pandemic marks the start of a new era, a world that has to co-exist with the virus. In such a world, we need to rethink, rebuild, and reform existing systems to rise beyond the devastating effects of the disease. At the core of this is science, technology, and innovation. Ngozi Okonjo-Iweala, the former Minister of Finance from Nigeria and a member of Gavi, the Vaccine Alliance, predicts that billions worth of investments will continue to pour in for research on medical and non-medical interventions in response to the pandemic [5]. Okonjo-Iweala further anticipates that, due to the demand for sustainable supply of critical goods in a pandemic scenario, nations will start to increase support on local R&D [5]. Hence, R&D will remain crucial to rebuild a more resilient and sustainable world after the pandemic.

Omics is a powerful tool that performs large-scale analysis of molecular data from biological entities to enable a systems approach in understanding biological processes. Integrating omics in R&D promises to accelerate discoveries and innovations, possibly even at pandemic speed, in order to deliver effective evidence-based products and policies. During the 1918 flu pandemic that killed 50 million people all over the world, the etiological agent remained unknown until the first isolation of human influenza virus in the 1930s [6, 7], and the genome of the 1918 virus was only completely sequenced in 2005 [8], almost 100 years later. In contrast, SARS-CoV-2, the causative agent of COVID-19, was promptly identified and genetically characterized through next generation sequencing within a month since the first reported outbreak of December 2019 in Wuhan, China [9], allowing health agencies to immediately plan for contingency measures to contain its spread. Omics has been a valuable tool for various emergency solutions such as the development of SARS-CoV-2 diagnostics, vaccines, and antivirals [10]. But as we face bigger challenges in the post-pandemic world, omics can offer long-term solutions through R&D.

Environmental Health and Sustainability

One of the strongest messages of COVID-19 to humanity is the call to restore environmental health and sustainability. Anthropogenic activities such as land use conversion, habitat and resource exploitation, tourism, etc. have been associated with zoonosis or the transmission of diseases from animals to humans [11]. Prior to COVID-19, such zoonotic infections have already been circulating worldwide, inflicting at least 2.4 billion people annually with 2.2 million deaths [12]. COVID-19 and other zoonotic diseases are just some of the concrete negative consequences when the complex and dynamic interplay within our ecosystem is perturbed [13]. Furthermore, the socio-economic damages of the pandemic pose a threat as rural populations that rely on their local environment for livelihood may resort to over-exploitation of natural resources and ecosystems [14]. This is therefore an opportune moment to redirect the new economy to green and sustainable initiatives [13]. For example, the World Wildlife Fund has lobbied for an end to illegal wildlife trading, protection and restoration of natural habitats, promotion of biodiversity, environmental sustainability and resilience, and a One Health approach to policy and governance in response to the pandemic [15].

Biodiversity is a key determinant of environmental health. Monitoring of environmental health can be achieved through large-scale biosurveillance, which unfortunately has been a slow undertaking given the constraints of documenting and characterizing every species, emphasizing the need to improve our tools and techniques for biodiversity assessment [16]. DNA barcoding is a fast and accurate approach to complement the traditional method of morphological characterization by using short fragments of DNA as an identification code for plant, animal, or microbial species, which is useful even for materials with degraded DNA [17,18]. To standardize the use of these sequences for species identification, the Consortium for the Barcode of Life (CBOL; www.barcodeoflife.org) has developed a global DNA barcode database of 170,000 species from more than 50 countries [17]. Beyond basic research on taxonomy, biodiversity, and ecological interactions, DNA barcoding has now been expanded to investigations on illegal trade of protected or endangered flora and fauna, especially when samples are no longer recognizable and prior knowledge about its composition is not available [18]. The Asian Development Bank estimates that illegal wildlife trading in the Philippines can cost up to USD 1 billion per year [19], hence technologies in aid of wildlife tracking would bring socio-economic benefits to the country.

DNA barcoding is useful when analyzing individual specimens. In some cases, however, biosurveillance would require specimens such as environmental samples or processed materials like traditional medicines which are a composite of a few to thousands of unknown species [16,18]. With the advent of next-generation sequencing technologies, simultaneous sequencing of multiple species in one sample is now possible. Referred to as metabarcoding, this technique mass amplifies one or more genetic barcodes using universal primers to obtain a collection of barcodes for several species at one time [18]. This powerful tool has the potential for massive upscaling of biosurveillance initiatives [16, 18] in order to accelerate ecological studies and improve wildlife tracking. The Philippines is one of the biodiversity hotspots in the world, with more than 30% of the birds, 60% of mammals, and 65% of plants as endemic [20]. These tools are therefore critical in monitoring the country's rich natural resources to evaluate the impact of anthropogenic activities. However, setting up this system in the country would require a highly collaborative engagement involving various agencies and institutions for widespread validation and implementation.

Omics can also be applied to other environmental issues such as climate change and pollution. In ecotoxicology, the intention is to use omics for the development of environmental monitoring tools on the basis that stress responses are preceded by molecular processes, which could thereby serve as sensitive markers for early detection of potential adverse events in the environment [21]. Using various omics technologies (transcriptomics, proteomics, epigenetics, metabolomics, etc.), molecular mechanisms of action in response to environmental contaminants can be investigated, organismal adaptation can be understood, and biomarkers for specific environmental stressors can be screened [21, 22]. This can be a sensitive and accurate tool for monitoring and regulation of anthropogenic activities in the Philippines such as mining, industrial wastes, pesticide use, etc. However, application of omics in environmental regulation may still come a long way as there is yet a large gap in the development of standardized and reproducible tests [23].

Food and Nutrition Security

The pandemic has exposed the worsening problem on global food security. The World Food Programme projects that by the end of 2020, the number of people in low and middle-income countries suffering from food insecurity will double to 265 million if the effects of the pandemic are not immediately addressed [24]. On top of the existing issues such as agricultural diseases, natural disaster, climate change, and political conflicts, pandemic lockdowns and the imminent global recession increase the threat to food systems with dire consequences on health and nutrition [25, 26]. Among the severely affected are also the half billion smallholder farmers who are responsible for almost 80% of food production in Asia and Africa but now have limited access to quality seeds, animal feeds, inputs, supplies, or services; lack manpower; suffer from post-harvest losses; and cannot engage in trade, among others [25,27,28]. According to the Association of International Research and Development Centers for Agriculture, COVID-19 has imparted three important lessons for agriculture: the need for science, technology, and innovation; the attention to neglected vulnerable populations; and the value of a resilient food system that thrives on diversity and nutrition [25]. It is high time for governments to invest on a revolutionized agriculture by reformatting our food systems to make them more inclusive, sustainable, and resilient [26, 28].

Omics can be explored to facilitate the delivery of agricultural innovations for a resilient and sustainable bioeconomy with benefits for human health. Omics has a wide range of potential applications that include: 1) improvement of traits to optimize value, yield, bioresilience, environmental footprint, etc.; 2) selection of high-quality materials through biomarkers, 3) understanding nutritional and disease pathways to promote crop or animal health management; 4) development of detection tools for threats such as pathogens, pests, and toxic materials; 5) promoting an ecosystem approach through an understanding of microbial and ecological interactions; and 6) supporting food production to develop nutritious and safe food products [29].

The future of agriculture is in systems-based omics-driven approaches for crop or livestock management. One of the emerging fields in this direction is “phenomics”, defined as “the acquisition of high-dimensional phenotypic data on an organism-wide scale” [30]. Phenomics goes beyond genomics by identifying the sum genetic and environmental factors that lead to a specific phenotype, which could be challenging to characterize because phenotypes vary in different tissues across time[30]. Phenomics intends to utilize genomic information by linking it to the phenotype, although most phenomics projects are still based on model organisms and would require multi-disciplinary expertise [30, 31]. In agriculture, phenomics has potential applications in crop management by understanding complex and intractable traits of plant quality, yield, and health [31]. Forward phenomics explores the genetic basis for phenotypes through high-throughput genetic screening of phenotypic variants. On the other hand, reverse phenomics introduces genetic variations to elucidate the molecular mechanisms of various phenotypes. Such tools can be used to accelerate the development of lines for breeding purposes to improve and diversify crops. This technology, however, is mostly available for large agricultural companies. This is where academe can step in by facilitating research initiatives that can benefit the small-scale farmers who otherwise have no access to advanced innovations.

Another developing discipline proposed by Garnatje, et al. [32] is “ethnobotanical convergence”, which uses phylogenetic inferences to identify plants with similar uses on the premise that genetically related plants may produce similar bioactive compounds. Bioprospecting guided by ethnobotanical knowledge combined with omics will be a much powerful tool for hunting bioactive compounds from plants and could lead to novel discoveries for biomedical or nutritional applications [32]. This strategy is envisioned to help accelerate the discovery of natural ingredients and diversify food products including functional foods. This has promising applications for the rich natural resources and indigenous knowledge in the Philippines, especially for the growing industry of natural health products which had a total export value of around USD153 million in 2011 [33]. Ethnobotanical convergence will help build a wider range of natural products for health and wellness to facilitate sustainable resource utilization while contributing to the economy.

In the arena of livestock, Sun and Guan [34] proposed the concept of "feedomics" for food animal research, whereby omics is used to explore the biological mechanisms responsible for animal health and productivity as a product of its genes, physiology, environment, and microflora. This systems-level approach towards animal production, nutrition, and health can be applied in various ways. Genetic variations associated with traits such as single nucleotide polymorphisms (SNPs) can be utilized for marker-assisted breeding [34]. Nutrigenomics, the study on how food and the genome interact to influence dietary outcomes, will be important for diet formulation [34, 35]. Animal phenomics, nutrigenomics, and metagenomics of the microbiome can also generate vital information to help develop optimal practices in livestock management. Feedomics intends to make food animal production sustainable. It is still a budding discipline, thereby opening several opportunities for R&D in the Philippines.

The Way Forward

COVID-19 has been a wake-up call to the lingering but neglected issues on environment and agriculture. This pandemic is a timely opportunity to rise from the ashes, reboot our framework, and act with resolve for sustainable and resilient ecosystems and communities. With its vast potential to revolutionize R&D, omics can be leveraged for the advancement of knowledge, innovations, and policies towards a more sustainable utilization and management of resources in the post-pandemic age. However, omic technologies would require a huge investment on technology and computing resources and yearly maintenance that could reach millions of dollars, making it even more difficult for developing countries [36]. Furthermore, omics is still an emerging discipline in the Philippines, hence the need to expand the pool of human resource through trainings. These challenges can be addressed through the establishment of omics research centers in the country which can provide access to the technology, build capacities, and facilitate collaborative and harmonized research initiatives. Critical to this is a multisectoral engagement to promote a socio-political climate in the country that will support R&D as a key mobilizer of long-term growth and development.

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