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Article Review

Biology in the 21st-Century: Transformation in biology science and education in supporting the sustainable development goals

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ABSTRACT

The transformation in education must be directed in accordance with Sustainable Development Goals (SDGs) program. This article aimed to discuss the potential support of New Biology in achieving the formulated SDGs. This literature review covered 31 articles which were published since 2010 to 2019. The keywords used to collect the data were new biology, future biology, biology education, biological science, and biology. The review results informed that New Biology can potentially enact five goals of SDGs, i.e. goal 2 (Zero Hunger), goal 3 (Good Health and Well-being), goal 4 (Quality Education), goal 6 (Clean Water and Sanitation), and goal 7 (Affordable and Clean Energy). By considering the findings, it is suggested to promote New Biology approach in Indonesian educational system.

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INTRODUCTION

Nowadays, several challenges, such as educational inequality, climate changes, and social challenges faced by human being have been increasing. Those challenges should be overcome through transforming education which consider the sustainable development goals (Hudson, 2001). Every crisis in the world must have a problem solving (Coombs & Laufer, 2018). Problems occur in every sector of life such as health (Wibowo, 2019; Wibowo & Indrayana, 2019), clean water resources (Meena & Luhar, 2018; Wibowo, Maryani, et al., 2019), air pollution (Zhang, Chen, & Zhang, 2018), land problems (Haowei et al., 2019), poverty in developing and underdeveloped countries (Mitra, Posarac, & Vick, 2013), clean energy (Hongtao & Wenjia, 2018), economic growth (Liang & Yang, 2019), industrial innovation (Liu, Gao, Chen, Yu, & Zhang, 2018), infrastructure (Morshedlou, González, & Barker, 2018), hunger (García, 2018), health problems (Lavie et al., 2018), education quality (Wen, Xiao, Hui, & Zhang, 2018), and many other problems.

Every problem has been introduced in as the Sustainable Development Goals (SDGs) in 2014 initiated by the USA. Indonesia as a developing country supports the SDGs to solve the problems (Stalker, 2008). In the last 40 years SDGs process, the countries with the lowest 25% ranking have increased the Human Development Index (HDI) to 82% (United Nations Development Programme, 2005). SDGs have focused on solving 17 international problems, especially in developing countries. Every problem in SDGs can be reduced by making quality standards and education levels in the right way. Education is a very important thing that continues to change (Siew-eng et al., 2015). Every single problem in the world can be overcome with quality education. Several studies have informed various problems, especially in developing countries (Muralidharan & Niehaus, 2017), can be resolved through quality education.

Biology science and education provide the concept about how to manage natural resources in an appropriate up to date ways, think about how to attract attention to the excitement of biology, and retain undergraduates. The new biology of the 21st-century is necessarily interdisciplinary, system-oriented, quantitative skills, initiative problem solve, and integrative (Labov, Reid, & Yamamoto, 2010). Both the SDGs and the new biology science and education assume great challenges as their focus (Ozdemir, 2016). Instead of being limited to a particular topic or discipline, the focus was tackling social problems and so-called "perverse problems", such as extreme poverty and climate change, severe effects on the populations of developing countries because many of these depend heavily on agriculture for income, have large impoverished rural populations, which are difficult to solve as individuals; they demand collective action (Seaman, Sawdon, Acidri, & Petty, 2014). By virtue of its mission and ambition to address the challenges, the new biology education and the SDGs will remain on the global scientific agenda for at least the next two decades. Some of the emerging-omics fields (El-Magd, Hermas, & Bastawesy, 2010), such as metagenomics (Alves et al., 2018) and pharmacomyrobiomy, directly report the relevance of the end points for the new biology education, ecosystem health and the SDGs (Wood et al., 2018), provide insights into the both its potentialities and current challenges. This article reviews the source of biology science and biology education from reputable journal, the purpose of this paper was to analyze the possible part of the new biology science and education in supporting the objectives of SDGs.

METHOD

In order to obtain profound and detail comprehension of the new biology science and education as detail as their potentials and challenges, the systematic review was done on as many as 31 articles. The articles chosen were those which were published between 2010 and 2019. Furthermore, there were five keywords used to collect the data in term of finding the articles i.e. new biology, future biology, biology education, biological science, and biology.

RESULTS AND DISCUSSION

Fundamental interaction of biology science and education with SDGs

Higher education and research department are the most significant indicators of a national progress (Schwab, 2014) which gives an impact for economic growth (Peet et al, 2015). Therefore, higher education is able support SDGs by producing high quality and highly competitive human resources. Universities are part of higher education that also support SDGs. This due to the people who achieved good education, especially in Universities, have clear knowledge about environmental and SDGs (Beynaghi et al., 2016).

Biology science and education in universities is a combination treatment utilized for supporting SDGs; bioprocesses such as soil remediation, nitrogen fertilization, and some biological treatments have been successfully supporting SDGs (Yu et al., 2019). Moreover, biology process in term of bioremediation has successfully maintained the availability of clean water (Life, 2018), biology science supports education for sustainable development (Azlina, Amran, & Radiah, 2013), biology science could make clean energy from co-gasification of coal and biomass (Kamble et al, 2018).

As we can see, biology science and education support SDGs especially on clean water and energy, soil remediation, and education quality (Figure 2). For instance, the biology treatment has been successfully utilizing the biology community for nitrogen fertilization, as it can overcome various problems of soil changes by using protist communities (Zhao et al., 2019). In addition a “biological drinking water treatment” is a biology process which has been used to maintain the availability of clean water (Brown et al., 2015).

Biology science and education phenomena

Biology science has been developed every single year. For example, about systems biology of auxin in developing embryos. Biology systems are oriented to signal pathways in their biology context in which the aim is to need a model that ignores foreign factors and focus on the most important path of the process given. Developing embryo is an important process in plants' development. Hence, understanding their interaction will be the key in designing plants which can maximize yield in more quantities. The information about the role of biological development are generally highlight the latest advances in our understanding of biological science and education as well as discussing their implications to the understanding of the development system (Mironova et al, 2017), such as biotechnology. Trends on biotechnology has described about developing of biology systems on single-cell aging (Song et al, 2018).

Several studies that informed about biology science and education in the world are sciences in the living world (Konopka, 2002). Biology science and education are the part of knowledge that can solve future problems, so it is important to teach students or college student to make connections between biology science and education in the classroom and their life. It is a compulsory for researchers who concern in biology, as they recognize the negative implications of doing science, to be silent. They must communicate this matter to local, national, and international legislators and find the solutions to deal with the environmental problems, particularly those which have been covered in SDGs. Moreover, biology instructors should teach biology devoid of social context and convince the students that they can make the connections between biology science and education and their roles in solving the issues emerged. Thus, biology science and education must be comprehensive and including everything in the world and powerful to solve the problems emerged to support SDGs (Chamany et al, 2008).

Based on biology science education standard, students' first real experience of science learning is key role in the development of their skills, dispositions, practices and knowledge in helping students to learn about science (Reiss, 2018). Hence, the lecturers must teach and discuss about biology in students' daily life, as well as bring the students the social issues, particularly those which have been mentioned in sustainable development goals. There are several learning models can be used to teach the students in an interesting way. For instance, Rotating Trio Exchange which demands the student to discuss about environmental problems in three members (Sadikin, 2017).

Introductory Biology has been pre-requisite course for all undergraduates of Massachusetts Institute of Technology (MIT), Boston, United State of America. Introductory Biology has been taken each year. There are three educationally equivalent versions of Introductory Biology offered. The all three versions of the course including genetics biochemistry, molecular biology, recombinant DNA technology, gene regulation and immunology. One of the versions covers additional material concerning the nervous system, cancer, and genomics; while the others comprised of cancer and development, genetics of microorganisms, additional biochemistry, and ecology (Chamany et al., 2008).

There are two major educational goals of the Introductory Biology courses are preparing biology the students who took this major to perform well and to create understanding of key ideas by providing the tools to approach questions related to biology which possibly faced by the society. This will additionally serve the students with a framework for their future studies in biology. By understanding these ideas, the students will be aided to determine their personal or public decisions (Peet et al., 2015).

Biology has been developing in every aspect in our life. Biology discuss about epigenetic which link genetic to the environmental and disease issues. It informs that epigenetic mechanisms that maintain cell identities during an individual's development and throughout its life, as shown in Figure 1, including environmental epigenetics and regulation in animals, metabolism and epigenetics, transgenerational epigenetic, relation of epigenetic, health and disease, the epigenetic of ageing, transgenerational inheritance, developmental epigenetic and disease and cancer epigenetic (Cavalli & Heard, 2019). Biological science has an interaction with chemistry and physic (Nostro & Ninham, 2012). Biological phenomena in applied biology have developed in plasma biotechnology and plasma medicine (Machala & Pavlovich, 2018). Molecular biology is a fundamental reduction mechanism in understanding biology. It will not see the forest role for the trees, but molecular biology is only taken as the approach to open it: it clear-cut the forest. Molecular biology is a different way to see biological phenomena (Woese, 2004).

All of phenomena in the world are covered in biology such as human body. Biology can design the biomaterial for medical device, as shown in Figure 2. Furthermore, it can also develop the challenges and directions in biomaterial research. Biomaterial research in biological science including synthetic replacements for biological tissues, designing materials for specific medical applications, and materials for new applications such as diagnostics and array technologies (Langer & Tirrell, 2004). In biology science, materials can be developed into biomaterial and utilized as medical devices to help patients. Materials which are inserted into human body are referred as biomaterials such as ceramic, polymers, metals and composites. Biomaterials can be utilized as dental implant by considering its biocompatibility. Biomaterials in biological phenomena are created from metals, stainless steel, Co-Cr alloys, Ti and its alloys and other metallic biomaterials, polymer, ceramics and composites (Mahyudin & Hermawan, 2016). Recent advances in the area of biomaterials which have revolutionized the field of tissue engineering and regenerative medicine to replace the conventional methods in repairing and restoring tissue functions are successfully done. (Bhat & Kumar, 2012; Webb et al., 2018). The complex structures of biomaterials are constructed from biological active components derived from nature. Thus, the integration of biological science as well as chemical and physical science has informed that biology is always happened in our life.

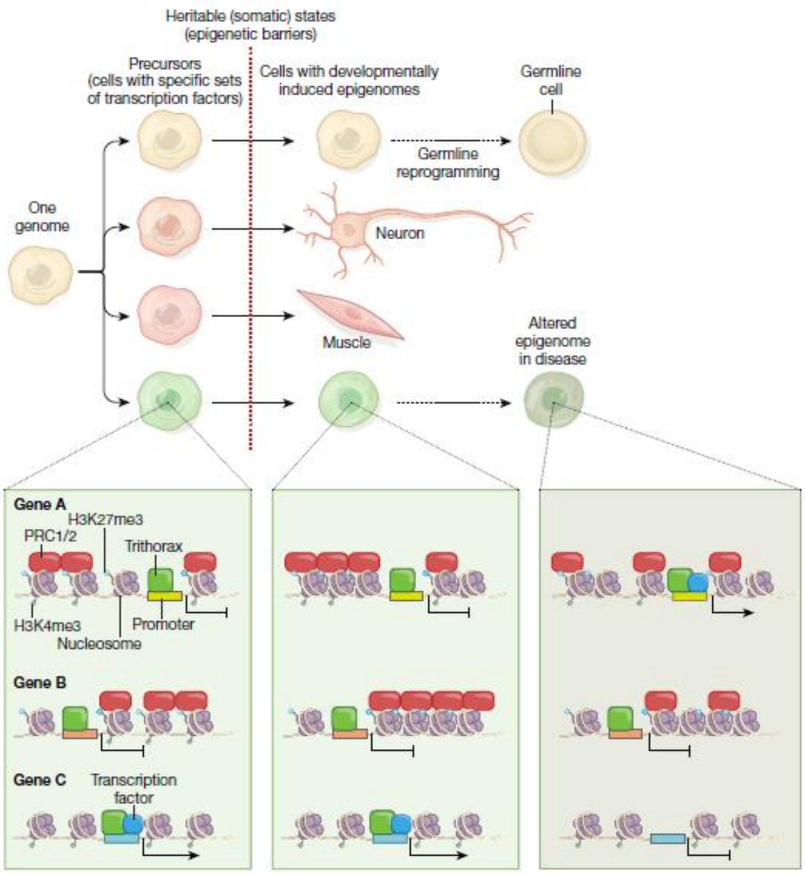

Figure 1. Epigenetic mechanisms that maintain cell identities during development and throughout life
(Source: Cavalli & Heard, 2019)

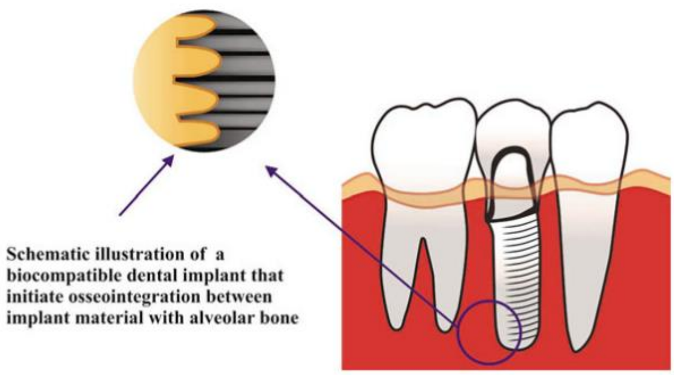

Figure 2. Biomaterial on medical device
(Source: Siswomihardjo, 2016)

Biology science and education have been developed in every country with different level, education levels will give an impact on earnings on Latin America and Caribbean Country, as shown in Table 1.

Table 1. Mean earnings of the labor force by level of education –Latin America and Caribbean countries (index)

Country	No. Education	Primary	Secondary	University
Argentina	35	62	100	171
Bolivia	74	77	100	219
Brazilia	60	81	100	201
Chile	55	59	100	311
Colombia	42	64	100	253
Costa Rica	50	63	100	202
Dominican Rep.	56	76	100	251
El Savador	42	63	100	208
Guatemala	30	55	100	247
Honduras	38	52	100	265
Jamaica	5	65	100	113
Mexico	19	54	100	173
Panama	50	54	100	224
Paraguay	51	63	100	212
Peru	73	82	100	253
Uruguay	40	77	100	154
Venezuela	47	75	100	172
Average	**44**	**66**	**100**	**213**

(Source: Psacharopoulos & Ng, 1994)

The long historical and contemporary impact of Western academic models, practices and orientations on Asian universities in such countries as India, Malaysia, Indonesia and Singapore shaped the nature of higher education systems in these countries. The Japanese colonial impact in Korea and Taiwan is also significant. Several Asian countries, including Thailand, Japan and China were not formally colonized, but the mixture of influence on the academic institutions that has developed in these countries reflects considerable Western influence. Contemporary factors such as the international knowledge system, the numbers of students studying in Western nations and patterns of scientific interaction also have a major impact on the growth of universities in Asia (Beynaghi et al., 2016). Education has been developing in Asia such as Hongkong, Japan, Malaysia, Singapore, Taiwan, Indonesia and else (Lee, Grossman, Kennedy, & Fairbrother, 2004). The Indonesian education system is immense and diverse. Indonesian education system, with over 60 million students and almost 4 million teachers in 340,000 educational institutions, is the third largest education system in the Asia region and the fourth largest in the world (after Republic of China, India, and the United States). The two ministries which have the responsibility in managing the education system are Ministry of Education and Culture (MOEC) (which handling 84% of schools) and Ministry of Religious Affairs (MORA) which handling the remaining 16%. Private schools are also play an important role in Indonesia. There are 7% of primary schools are private, the share increase to 56% of junior secondary schools and 67% of senior secondary schools. The education levels in Indonesia are classified by age as shown in Table 2.

Table 2. The distribution of population, students, educational institutions and teachers, by age and level of education in Indonesia, 2013

Age	Population (million)	Education Level	Students (million)	Number of Institutions	Teachers/ Professors
3-6	18.52	Early childhood	10.60	162 753	517 858
7-12	26.04	Primary	26.77	148 272	1 682 263
13-15	12.04	Junior Secondary	9.65	35 527	587 610
16-18	12.57	Senior Secondary	8.46	22 780	452 041
19-23	21.19	Tertiary	5.82	3 189	209 830
Total	**01.09**		**61.30**	**372 521**	**3 449 602**

(Source: OECD/Asian Development Bank, 2015)

New biology science and education

In the 1800s, those who studied living world were called "naturalists" and they were highly interdisciplinary, combining observations from biology, geology, and physics to describe the natural world. In this 200th anniversary year of Darwin's birth, after decades of highly productive specialization, the study of life is again becoming more interdisciplinary, by necessity combining previously disparate fields to create a "New Biology." The essence of the New Biology is re-integration of the subdisciplines of biology, along with greater integration with the physical and computational sciences, mathematics, and engineering in order to devise new approaches that tackle traditional and systems level questions in new, interdisciplinary, and especially, quantitative ways, as shown in Figure 3.

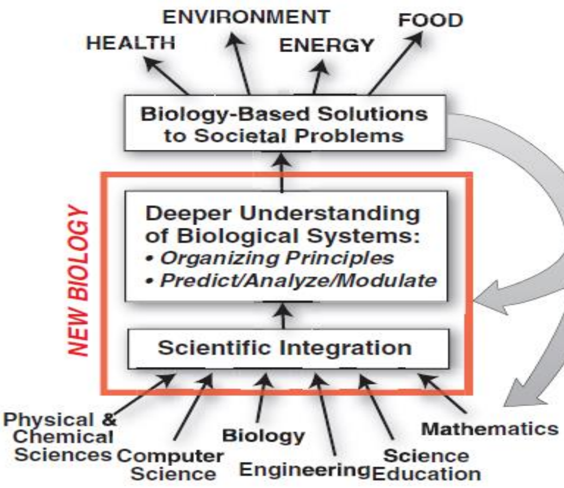

Figure 3. New biology for the 21st-century
(Source: National Research Council, 2009)

New Biology relies on integrating knowledge from many disciplines to derive deeper understanding of biological systems. That deeper understanding allows both the development of biology-based solutions for societal problems and also feeds back to enrich the individual scientific disciplines that contributed to the new insights. It is critically important to recognize that the New Biology does not replace the research that is going on now. The research is the foundation on which the New Biology rests and on which it will continue to rely. If we compare our understanding of the living world to the assembly of a massive jigsaw puzzle, each of the subdisciplines of biology has been assembling sections of the puzzle. The individual sections are far from complete; thus, continuing work to fill those gaps is critical. Indeed, biological systems are so complex, so that, the major new discoveries are still to be expected. New discoveries are frequently come from individual scientists who make the intellectual leap from the particular system they study to an insight that illuminates many biological processes. Additional contribution of the New Biology is to focus on the connections between the partially assembled puzzle sections and dramatically speed up overall assembly (Labov et al., 2010; National Research Council, 2009). New Biology education must facilitate human development, in particular, the development towards greater student autonomy, which can be done in ways that have been tried and allowed for high quality of biology teaching and learning (Reiss, 2018).

New biology can solve the problem about hunger by utilizing biotech (Keats, 2012), synthetic biological material (see Figure 4) to find new advance materials (Le Feuvre & Scrutton, 2018), and the potential of biodiversity conservation (Redford, Adams, & Mace, 2013). New biology is able to drive inter-sectoral, interdisciplinary and international connectivity. Meanwhile, the leveraging of existing investments in synthetic biology, materials science, allied sciences and technology areas, is the major challenge in delivering the Materials from Biology vision. This is alongside a need to establish early stage partnerships with industry to define unmet needs in advanced materials and to maintain continued engagement from early-stage discovery and development, through to manufacturing delivery and commercialization. Unification of these fields will create major opportunities for new materials discovery, their sustainable and affordable manufacture and application to unmet needs for industry (Le Feuvre & Scrutton, 2018).

The Indonesian education system (see Figure 5) has to attend the needs of a large, growing, diverse and widely dispersed population with great disparity in enrolment rates between regions (Susanti, 2011). Table 2, shows the current distribution of population, students, institutions and teachers at the various educational levels in which every single education level has biology science and education system that supporting SDGs.

Biology science and education in supporting SDGs

Besides the European Union, an increasing number of countries are developing and implementing bioeconomy strategies. More than 40 nations have attended Global Economic Summit to make bioeconomy work for SDGs (Global Economic Summit, 2015). Bioeconomy is a worldwide used strategy to cope with ecological, social, and economic sustainability challenges. However, impact indicators to quantify the environmental burden induced by national activities in foreign countries are especially lacking. The environmental burdens which possibly occur are 1) the risk of disappointment because promises of the strategies are difficult to achieve, 2) bioeconomy is not the only way to low carbon economy, 3) persistent conflicts of biomass uses for food, material and energy production could lead to unstable policy supported with short-term shifts, 4) new societal conflicts over bioeconomy if efficiency gains, cascading use, residue use and sustainability certification are not sufficient to ensure a sustainable supply of biomass, 5) the acceptance of bioeconomy could be compromised if bioeconomy policies continue to ignore the on-going societal debates on agriculture and food (Egenolf & Bringezu, 2019).

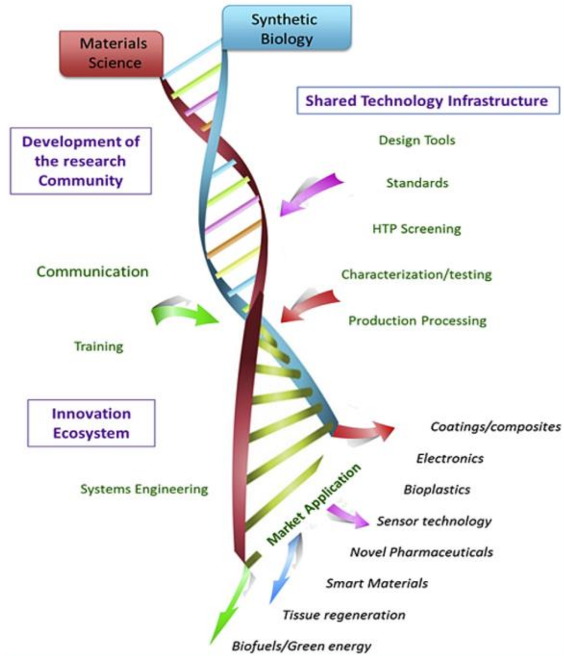

Figure 4. Synthetic biological materials
(Source: Le Feuvre & Scrutton, 2018)

Age	School Year	Education Level	Education Delivery: Decentralised	Education Delivery: Centralised
Above 22	23, 22, 21			Doctoral (includes general & Islamic, and vocational, academic & professional)
	20, 19			Master (includes general & Islamic, and vocational, academic & professional)
22, 21, 20, 19	18, 17, 16, 15	Higher Education		Undergraduate (includes general & Islamic, and vocational & academic)
18, 17, 16	14, 13, 12	Secondary Education	General senior secondary & vocational senior secondary (SMA & SMK)	Islamic general senior secondary & Islamic vocational senior secondary (MA & MAK)
15, 14, 13	11, 10, 9		Junior secondary (SMP)	Islamic junior secondary (MTs)
12, 11, 10, 9, 8, 7	8, 7, 6, 5, 4, 3	Basic Education	Primary (SD)	Islamic primary (MI)
6, 5	2, 1	Early Childhood Education	Kindergarten (TK)	Islamic kindergarten (RA)

Figure 5. Indonesian education system
(Source: OECD/Asian Development Bank, 2015)

Sustainability has to be the key concept behind the bioeconomy which predominantly requires the base resource, processes and products, circular processes of material fluxes (Gawel, Pannicke, & Hagemann, 2019). Bioeconomy has based an economic on biology and bioscience to develop around US$ 2 trillion of product in agriculture, food, bioenergy, biotechnology and green chemistry which were exported worldwide in 2014 (El-Chichakli et al, 2016). Bioeconomy has led people to use biotechnology as an important tool in green chemistry, demonstrate new applications for biopolymers, biofuels and as alternatives to make chemical processes more sustainable and better protect our planet (Fasciotti, 2017). However, comprehensive approaches to measure and monitor bioeconomy progress are frequently lacking; hence, bioeconomy monitoring must be strengthened and leveraged to measure progress towards sustainable goals (Bracco, Calicioglu, Juan, & Flammini, 2018). An evaluation of SDGs must consider the key objectives and relevant criteria for the environmental, economic, and social issues (Egenolf & Bringezu, 2019). The proposed solutions relied greatly on innovation and technological development. Bioeconomy expertise should be shared in close cooperation between developed and developing economies to reach UN Sustainable Development Goals (SDGs). A supportive political framework would be the ultimate goal towards furthering the progress of a future bioeconomy all over the world (Issa, Delbrück, & Hamm, 2019). As particularly important key objectives and the indicators, these sectors are central to at least half of the UN SDGs, from food security to ensuring energy access and health. But conflicting national priorities make it hard to align bioeconomic policies to meet the SDGs on a global scale. Innovation on the bioeconomy that scoring SDGs can be seen in Table 3.

Table 3. Innovation biotechnology to support SDGs

	How Biotechnology Could Solve
End hunger	Food security is the priority on international issues (Sahn, 2015). More-efficient animal production and meat substitutes are needed. Chicken is more sustainable than beef in term of owing to lower greenhouse-gas emissions and water needs. Genomic technologies will need to be applied for more foods, as they have been done in dairy cattle, chicken, salmon, tilapia, rice and banana. Farmed seafood production must be boosted and will require new vaccines and molecular diagnostics to reduce antibiotic use, as well as sources of protein-rich feed.
Ensure healthy lives	Sustainability on medicine has been developing (McKee, 2018). World Health Organization has developed a framework for health system that comprised of six building blocks (World Health Organization, 2010). Neural stem cell (NSC) improved cellular, tissue, and functional outcomes in middle-aged rodents (Webb et al., 2018). Sustainable medicine can be learned from the past (World Health Organization, 2010) and the future medicine such as microRNA polymorphisms (Mishra & Bertino, 2009), production of semi-synthetic artemisinin from microbially sourced artemisinin acid is an early success story for combining metabolic engineering and synthetic biology in commercial production of drugs against malaria.
Water and sanitation for all	Biotreatment has the potential for helping utilities in achieving compliance of several future drinking water regulations. Biological processes can efficiently treat a wide range of drinking water contaminants and may provide several advantages over "conventional" treatment processes (Brown et al., 2015). In developing countries, 90% of sewage and 70% of industrial wastes are discharged without treatment. Advances in biological wastewater treatment, including phosphorus removal and nitrification hold potential if they are implemented in wider scale. Small modular systems should spread to remote communities, and large intensive plants can cater for city-sized populations. Biotechnology can solve wastewater problem by using biomaterial such as biochar and bentonite (Naswir et al., 2019; Wibowo & Naswir, 2019; Wibowo et al., 2019).
Clean energy	Most of developing countries have unreliable energy systems. Just as the recycling of nutrients from waste material, nutrient recycling from all forms of waste will be increasingly important in the future for sustaining agricultural productivity on Earth (Kilbane, 2016). Burning wood or manure leads to health problems, premature deaths and deforestation. Decentralized, the modern solutions that combine bioenergy with other renewables are needed. For example, an Indian social enterprise has implemented dairy and biogas production and local mini-grids electrified by biogas from waste or by eco-briquettes.
Soil remediation	Using AM fungal communities and the sustainability of soil remediation in Daliuta coal mining subsidence area (Bi et al, 2018). Protists are the most susceptible microbiome component to the application of nitrogen fertilizers. As protist communities also exhibit the strongest seasonal dynamics, they are served as the most sensitive bioindicators of soil changes (Zhao et al., 2019), electro-kinetic remediation for the removal of organic contaminants in soils (Cameselle & Gouveia, 2018), and other biotechnology remediation treatment for soil (Kremer, 2017).
Education quality	Bioethical has been developing in teaching biology to make education quality well (Iancu, 2014) such as lessons learned for student of craniofacial biology: What this might mean for orthodontic professional education and clinical practice in the 21st-century (Slavkin, 2017). Several research would to know the key of cell biology and science education (Miller, 2010) and else.

CONCLUSION

Biology education and science could support sustainable development goals (SDGs). To end the hunger, biology education and science can assure the food security. Thus, a more-efficient animal production and meat substitutes are needed. As its potential in owing to lower greenhouse-gas emissions and water needs, chicken is more sustainable than beef. Biology education and science ensure healthy lives by utilizing the development of biological medic to distribute water and sanitation for all, keep clean energy, soil remediation and developing education quality.

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