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A Peep into Genomic Data Management in Malaysia

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Abstract
Malaysia is one of several countries that are still conserving its biodiversity ecosystem despite the on-going infrastructure development of concrete buildings. A well-known nation with almost 70% covered with green leaves of trees for hundreds of thousands of years ago, forest sustainability and biotechnology advancement are two struggling fields which are closely monitored by the government, and several non-governmental organizations (NGOs) in and around the world. Biotechnology in the context of biodiversity is crucially important and issues in maintaining national forest that is rich in ecosystems, efforts of green technology, genetic engineering, de-forestations, re-planting and so on are at the peak of national agendas. Several policies and roadmaps concerning biotechnology, biodiversity and bioinformatics (relating to genomic data) were made as basic guidelines to ensure sustainability of biodiversity is as equally crucial as the advancement of science and technology in this country. This essay aims to provide a brief understanding on the mission, objectives, milestones and failures of these policies. Hopefully, though brief and introductory it may be, the case presented and discussed here will be able to educate the readers on the importance of genomic sustainability.
Keywords: Sustainability, Biodiversity, Bioinformatics, Genomic Data, Policy.

Current Status

The main focus of this study is to look into Malaysia's policies related to Biotechnology, specifically in the management of genomic data comprises of collecting, processing, analyzing, securing, safeguarding and sustaining processes (research and development). The essay reviews on how genomic data can be secured, safeguarded and sustained based on four different Biotechnology and Bioinformatics-related guidelines in Malaysia. They are 1) National Information, Communication and Technology (ICT) Strategic Roadmap (MOSTI, 2011), 2) Malaysia's National Policy on Biological Diversity (Prime Minister's Office, 1998), 3) National Biotechnology Roadmap (MOSTI, 2005) and 4) National Bioinformatics Roadmap (Amazon.com, 2007). Little information about the status of the genomic data protection plan is discussed in these four important documents.

This has aroused few important questions which are 1) do these policies and roadmaps give the best "know-how" guidelines for sustaining our biodiversity and ecosystem through genetic transformation? 2) Are these guidelines being implemented in the case of agriculture-yield improvement? 3) Is there any framework on how to 3.a) Manage *(collecting, processing, analyzing, securing, safeguarding and sustaining)* the genomic data? 3.b) Building database is enough? 3.c) Secure economical values of genomic data? 3.d) How about copyright and intellectual property (IP) laws? With regards to the IP laws, if open access system is the best replacement solution, what would be the challenges to the government and scientific communities? All these questions are related to a primary issue in biotechnology activities not just locally but also worldwide. This issue is that when research findings are not made available to the global scientific community, a corresponding price is paid in lost opportunities, barriers to innovation and collaboration, and the obvious problem of unknowing repetition of similar works. Before these questions can be answered, it is wise to have a brief understanding about the genomic data.

Genomics is a *"discipline in genetics that applies recombinant DNA, DNA sequencing methods, and Bioinformatics to sequence, assemble, and analyze the function and structure of genomes (the complete set of DNA within a single cell of an organism)"* (Wikipedia). DNA is a basic substance in the entire genome which contains information about everything in living things such as the color of our eyes, skins, hairs, and the type of disease we can have, and so on. This information is in the form of a biochemical compounds known as Adenine, Cytocine, Guanine, Tyrocine / Uracil and the combination of these 4 make up the basic unit of a functional protein. This information is what we call "genomic data" or "genomic information" and those substances are what we call "genomic materials". Speaking about sustainability, it is to be understood that both genomic information and materials need to be safeguarded with a very important reason – they contain the information that is needed to sustain our generations.

Until very recently, genomic sustainability was not a popular concern especially in Asian countries where non-genomic agricultural research and development predominantly being endorsed specially by their respective governments and practiced by the locals. This is due to the fact that the scientific development focusing genetic modification though widely known, are still in its' early stage in most Asian countries like Malaysia as compared to developed countries in the West and some other Asian countries like Japan, Korea and Singapore. On top of that, when communities representing public and private sectors are talking about sustainability, genomic sustainability is either treated with least importance or non-exist in the national agendas. The perceptions towards genomic sustainability and its' importance sometimes scares most people, especially when these people are much more concern about the expenditures to be spent as well as the insecurity of making and sustaining profits in the future. Many topics regarding business revenues are being discussed thoroughly but not the importance of safeguarding valuable genomic data in details. The question here is why genomic data is so important? Perhaps in order to understand more about why data itself is valuable is by looking into two important case studies done by researchers in India and a private company in Malaysia.

A group of researchers in India published a paper *"Genomic Interventions in Crop Breeding for Sustainable Agriculture"* in the journal of Encyclopedia of Sustainability Science and Technology (Kulwal, Thudi and Varshney, 2011). According to their studies, it was concluded that the *"available traditional methods of crop improvement are not sufficient to provide enough and staple food grains* *to the constantly growing world population."* An example of a method of crop improvements is the cross-species planting where two different strains of the same plant species are stick together in order to produce a better fruit yield. Furthermore, by continuing traditional crop improvements for at least another decade from now, the situation aforementioned earlier on is projected to be worse by the year 2050 in the context of climate change. It was also predicted that *"the conventional plant breeding practices may not be able to achieve the sustainability in today's agriculture"*.

Another good example of a similar research undertaken by a private company[1] in Malaysia was the sequencing of the oil palm genome which was done in 2008. A press release was published thereafter, announcing the completion of the first draft genomic sequence of the oil palm genome. According to the company's spokesperson, *"by unlocking the knowledge encoded in the genomes could further increase our understanding of these important crops which could lead to substantially improved oil yield. With such enhanced productivity, growing oil palm could be the sustainable solution to fulfilling the world's need for a wide variety of products"* ("Press Release", 2008). 5 years later, through the advancement of sequencing technology and bioinformatics analysis, a remarkable scientific success was announced (Orion Genomics, 2013) by the discovery of *Shell* gene believed to be the holy grail to increase oil palm's yield of oil by 30% (Rajinder, 2013). It is believed that the discovery of *Shell* gene will allow an efficient accurate selection for palms with enhanced oil yields which subsequently stabilizing the acreage devoted to oil palm plantations. This will provide a wider opportunity for the conservation of rainforest reserves in the country. Just by looking into these two case studies, the importance of genomic data are 1) to improve yields, and 2) ensuring food security and human sustainability.

National Policies and Roadmaps

It was mentioned earlier in this paper that there are several questions pertaining to genomic sustainability that need to be addressed. By having a brief idea about genomic and DNA, with few examples of case studies being included here, it is also wise to know about what are those national policies that might or might not addressed the most important question of all – why genomic sustainability is important. A better overview of these 4 policies can be seen in Figure 1 as follow.

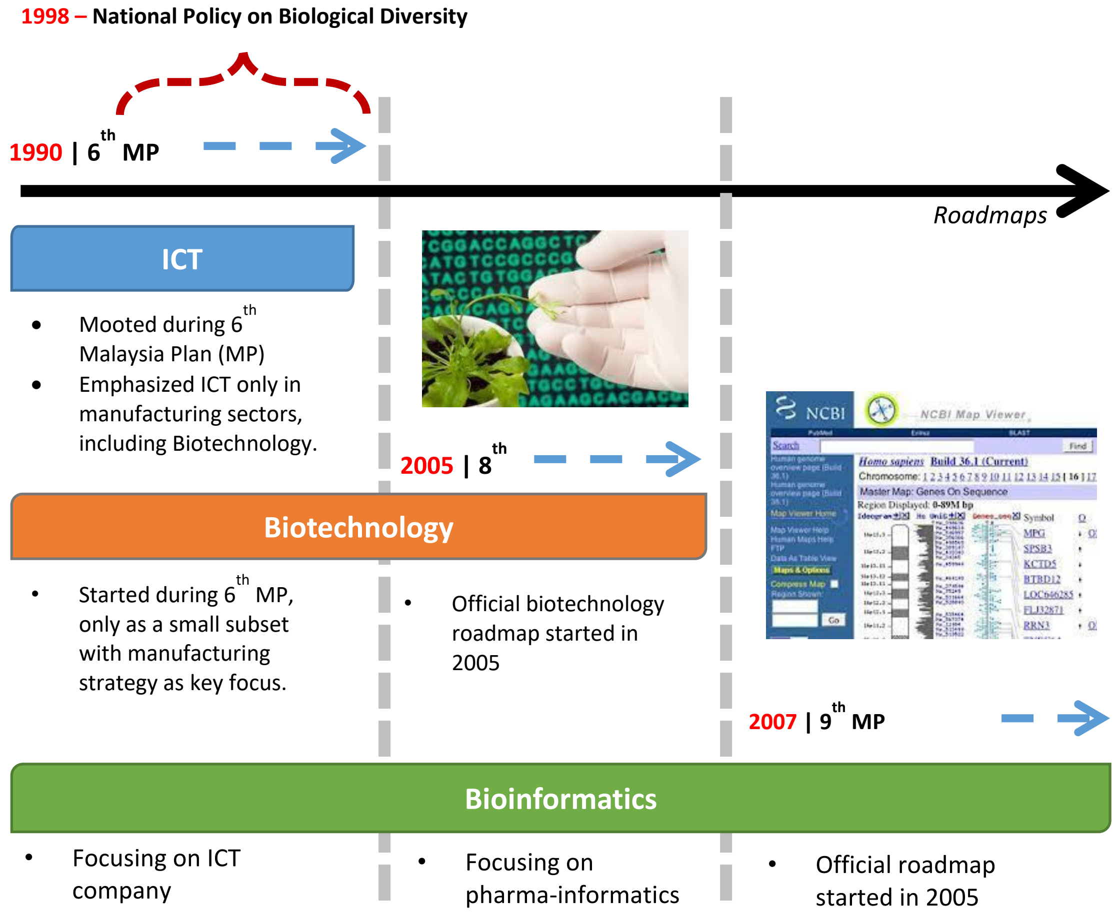

Figure 1: *Brief timeline of the 4 Malaysia's national policies and roadmaps formulation*

Key Issues in Informatics

Many issues pertaining informatics have been faced by various organizations that deal with data management. It is undeniably that any kind of informative data contains social, economic, and political values (so to speak). These values are regarded as equally important as human lives and sometimes are given more priority as compared to human themselves. Reason being is that informative data is seen as a way to sustain business revenues and profitability, both in the public and private sectors. Apart from the impact on economic status, informative data (which in this case genomic data) previously thought to have no greater impact on humanity, environment, cultural and even down to religion and faith. Practically not anymore. It has now been given a special attention as mostly in the developed countries while developing regions are catching up. The advancement of technologies tries to solve several key issues in informatics. Table 1 briefly shows informatics issues in any organization is now facing.

#	Computer Science	Biotech—Informatics
1	Integrate all data developed during the R&D, approval and marketing into a comprehensive enterprise-level "data warehouse".	
2	Facilitate sharing of key data by all researchers & research entities, not only the primary researcher and prime research organization.	
3	Enable pervasive access to the R&D data warehouse.	
4	Store all key documents involved in the research and development process.	
5	Apply GLP/GMP standards of audit, control and verification to all versions of all data so that a comprehensive history of the research process emerges from the raw data.	
6	-	Integrate biological, genomic, computational, clinical, administrative and financial data into a comprehensive enterprise scale information management solution

Table 1: *The table addresses several key issues in informatics both in computer science and in biotechnology discipline. One important issue faced by biotechnology organization is that the integration of biological databases which contain genomic data. Special attention is given to genomic data of important crops in Malaysia as has been discussed in the previous section.*

By summarizing these issues, it is evident that in general, the common issue pertaining informatics has been somehow always about building and providing better infrastructures to keep the data but not so much on how genomic data can play a bigger role in sustaining humanity. It is also perhaps that the mentality towards any type of informative data when it comes to solving key issues in informatics is based on top-down approach. Using this method, organization likes to see the bigger picture of securing such valuable resources even without the knowledge of how important these resources can be. In the eyes of these organizations, physical infrastructures must first be put in the first place. A different approach taken by most scientists are that they see the importance of genomic data and try to sustain them by approaching these organizations.

Strategic ICT Roadmap for Malaysia

The Information, Communication and Technology roadmap for Malaysia has been endorsed since 1990 during the 6th Malaysia Plan. The roadmap is a policy of ICT management that carries several implementation programs up to the 9th Malaysia Plan so far. Key points that have been and are currently being addressed by this roadmap cover the management of ICT in various fields such as in energy resources, Photonics research, pharmaceutical field, microelectronics, aerospace and biotechnology. During the advent of this roadmap, two important organizations have been formed which are Joint Advanced Research Integrated Networking (JARING)[2], the first Malaysian internet service provider, and NITC. During the 7th Malaysia Plan, more emphasis has been given to the formation of electronic community and these are E-economy, E-public Services, E-Community, Elearning, and E-Sovereignty which saw the increased usage of online portals for most services. More implementations on ICT were given special attentions during both 8th and 9th Malaysia Plans which saw the formation of both Biotechnology and Bioinformatics roadmaps. Nevertheless these roadmaps do not address the best solutions to tackle the alarming issues in genomic sustainability. So far, the efforts are to provide infrastructural opportunities.

Biotechnology Policy

In brief, Malaysia Biotechnology policy only covers areas pertaining infrastructures and business opportunities with the vision of continuous sustainable development particularly in agriculture, aquaculture and human health. It was seen in greater view that the application of biotechnology aims to increase productivity and ensure sustainability. However, there is no sector/policy that mentions about genomic sustainability in greater emphasis and details. The Malaysian Biotechnology policy covers 9 important thrusts which are:

1. Agriculture biotechnology development.
2. Healthcare biotechnology development
3. Industrial biotechnology development
4. R&D and technology acquisition
5. Human capital development
6. Financial infrastructure development
7. Financial infrastructure development
8. Legislative and regulatory framework development
9. Strategic positioning
10. Government commitment

Bioinformatics Roadmap

Unlike the Biotechnology roadmap, genomic has been mentioned in Bioinformatics Roadmap which regarded as part of Bioinformatics field. By definition, Bioinformatics is an intermediary discipline between technology and life sciences in general which sees the integration and interoperability between various sub domains. A very good example could be seen in drug discovery where computational biologist tries to predict candidate drugs prior to clinical trial, using computers and Bioinformatics software. Nevertheless, there is no section mentioning about genomic sustainability.

National Policy on Biological Diversity

Perhaps the most exciting policy that elaborates the importance of genomic data can be found in the National Policy on Biological Diversity. In this policy, there are three rationales that formed important guidelines for the management of national biodiversity. These are genetic diversity, species diversity and ecosystem diversity. In the first rationale, it is briefly described in the policy that *"genetic diversity is the diversity within species, as measured by the variation within genes of individual plants, animals and microorganisms. Genetic diversity occurs within and between populations of a species."* Based on such understanding towards genetic diversity, it is explained thoroughly that 1) advances in this field could lead to crop and livestock improvement through genetic engineering, 2) reduction in this biological diversity will upset the balance within ecosystems as it is generally accepted that a certain amount of species and genetic diversity is needed to uphold the cyclical relations within the ecosystems and hence maintain ecological services, 3) losing diversity means losing the ecosystem resilience, leading to adverse effects on human lives, and 4) loss of genetic resources is one of the detrimental effects of the reduction in or loss of biological diversity.

Challenges and Opinion

A quick survey on Bioinformatics research activity was done on 150 participants from various institutions in Malaysia. These were the researchers that are heavily involved in scientific research encompassing Bioinformatics. Three primary information were collected from all respondents which are their areas of research (Figure 2), Bioinformatics involvement in their studies (Figure 3), and the types of Bioinformatics analysis they are doing (Figure 4). Surprisingly most of the Bioinformatics activities mapped in this survey heavily involved genomic sequencing. All these respondents are individual researchers who are not in any way co-researcher with any other respondents. These figures illustrated a surprising yet promising overview on Bioinformatics activities in Malaysia. The primary information that can be gathered from this survey are 1) Bioinformatics is heavily required in biotechnology, and 2) extracting valuable information from the genome is extremely crucial for sustainability, and 3) the future of research areas (Figure 2) sustainability dependent on the advances in science and technology. By using these results, perhaps the scientific community will be able to create a more cooperative (primarily in terms of information-sharing) scientific environment in order to leverage on national's wealth. A good example is the availability of oil palm draft genome[3] by the Malaysian Palm Oil Board (MPOB)[4] in collaboration with Orion Genomics (Orion Genomics, 2013) which now allows scientists to further leverage on the genomic information in order to create a better future for genomic sustainability. The principle of information-sharing ("Genomic Science", 2013) has been widely accepted and endorsed by the research community yet the implementation process over the past few years has been subjected to changes.

Apart from the limitations mentioned in Table 1, the first key challenge is to protect the interests of researchers and this requires computer application that allows a secured access to valuable information comprising raw and analyzed genomic data. This involves putting into place a governance system involving a series of data security measurements (Dawn, 2013). The second is almost personal – the issue of platform's credibility and tough research competition with scientists who have the same scientific interests. The third is monetary quest – the price tag of genomic information is economically and commercially valuable, energizing motivation in profitable activities. All four national policies which have been described were formulated with the intention to secure and sustain humanity through various ways and implementations. For example in the ICT policy, several infrastructures to place these valuable data have been initiated. In the case of our Biotechnology roadmap, much appreciation and focus have been pushed into the bio-economic field. Many efforts have been done to help local start-up biotechnology companies improve their business revenues by giving research funding for their R&D activities. This is also very important to ensure that genomic research will always be an on-going activity in this country.

[3] National Center for Biotechnology Information (NCBI): ASIR00000000.1
[4] http://www.mpob.gov.my/

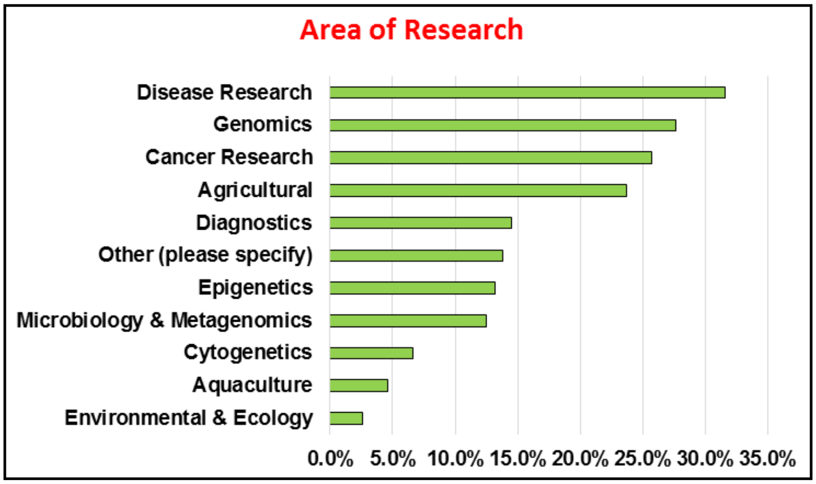

Figure 2: *Percentages of involvements in various scientific research in Malaysia. From 150 respondents, most of the researchers are involved in the research of various diseases types, followed by pure studies in genomics, cancer and so on. It was observed that almost all researchers are engaging with multi-disciplinary research levels, portraying the idea that inter-disciplinary studies are essential in knowledge discoveries.*

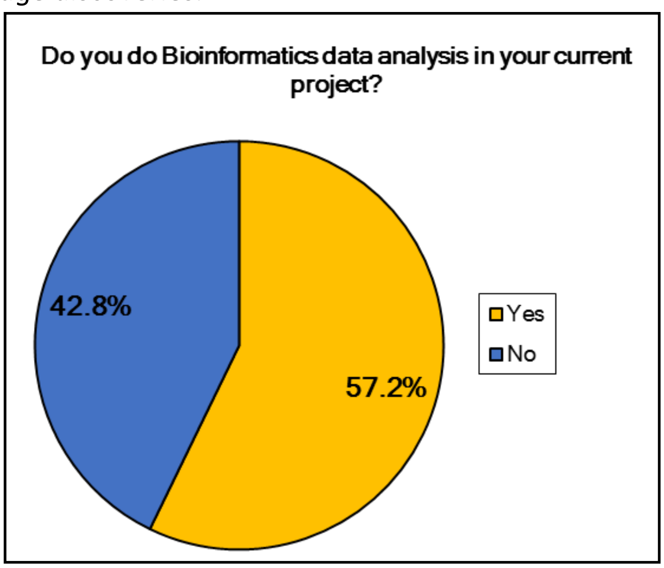

Figure 3: *Percentages of Bioinformatics analysis involvement in their current studies. A subsequent question was asked to each of the respondents on the plan to include Bioinformatics analysis in their future projects (up to September 2015). An increased to 78% respondents do planned to use Bioinformatics analysis for their research in the future. It was observed here that 57.2% respondents who are currently doing Bioinformatics analysis in their projects do not necessarily need it for the future studies, while the remaining 42.8% respondents might have plans to include Bioinformatics in their future studies.*

Apart from that, going back to the fundamental idea about diversity by looking into three different sectors (genomic, species and ecosystem) provide a more holistic understanding towards inter-sustainability in the future. Perhaps the problem statements being formulated in the very beginning of this essay somehow have been answered. But is that enough? Several suggestions could be considered in order to enhance the existing implementations being carried out in all four guidelines that are taking place right now. 1) Identifying important plants to be sequenced, for example Rafflesia[5], 2) setting up national data center to keep all the genomic data, for public use, 3) non-advocating towards gene patenting which allows the sharing of gene information for the betterment of humanity in the context of healthcare (so to speak) and last but not least, 4) educating the society of the importance of genomic data management, research collaboration, open-access scientific publications, research transparency for the sake of sustainability – through ethically efficient practical ways. Perhaps when we look into the implementations of ICT and Biotechnology policies in Malaysia as compared to the developed Asian countries like Japan, Korea and Singapore, we are lagging at least several years behind the technologies in those places.

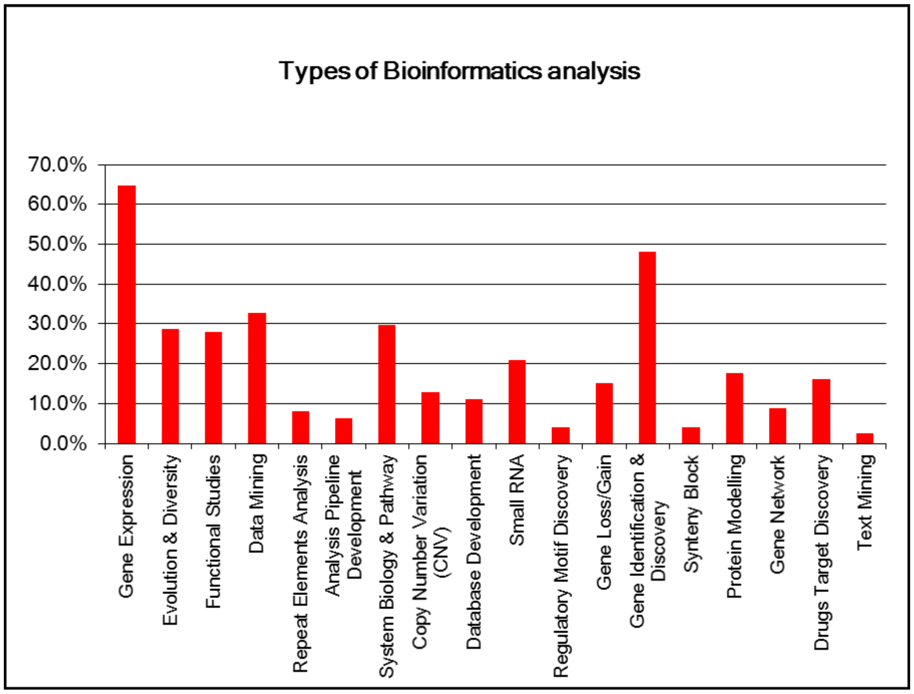

Figure 4: *Types of Bioinformatics analysis undertaken by respondents.*

Though efforts have been amounted since at least a decade ago and various key implementation considerations have been formulated (Malaysia Biotechnology Corporation, 2009), there are still many things to be done especially by the government and followed by the rest of concerned organizations like research universities. Enforcements on these implementations have to be done in efficient manners, and political revolution from within the government itself will provide a greater impact to expedite these policies in order to achieve the far-fetched vision 2020[6] envisioned by the third Prime Minister of Malaysia. It is not fair to put the burden on the government all alone

[5] A genus of parasitic flowering plants. It contains approximately 28 species (including four incompletely characterized species as recognized by Willem Meijer in 1997), all found in southeastern Asia, on Indonesia, Malaysia, Borneo, Sumatra, Thailand and the Philippines. (Wikipedia)

since private sectors have a similar role to be played. The fundamental concept of genetic diversity and sustainability of genomic resources should be the main subject in today's society's daily discussion especially in schools, research laboratories and academic institutions. Of course all these then will lead to the idea of bio-economic which is the current agenda of some concerned organizations in Malaysia. The transformation of genetic materials into Ringgit Malaysia (gene patenting as an example) as new national's economic sustainability factor is very crucial for the development of science and technology in this country. Perhaps when most researchers have already seen this as very promising in their research activities, one question that each of us might want to ponder is this – does the hunger for more money contribute to the hindrance of important genomic information from the scientific community for the sake of personal's interest? This could be another interesting story to be told.

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