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Author(s)	S.K. Lee, W. H. Tan and S. S. L. Lim
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IMPORTANCE OF BIOLOGY IN ENVIRONMENTAL EDUCATION

S.K.Lee, W.H.Tan and S.S.L.Lim
Biology Division, School of Science
National Institute of Education, Nanyang Technological University
469, Bukit Timah Road
Singapore 1025.

ABSTRACT

One of the aims in the Singapore Green Plan is to maintain a more proactive and environmentally conscious population. This can be met through the education of the people. It recognises that one of the most important target groups is the student population. For this to be achieved, the authors contend that it is imperative to make the teaching of biology a core subject in schools. This is to provide a strong foundation for understanding environmental issues as almost all such issues require an understanding of life sciences. This can be illustrated by the ten issues concerning the global environment highlighted at the United Nations Conference on the Environment and Development in June 1992. Through a systematic discussion of each of these issues, the authors illustrate the importance of biological knowledge in understanding the problems, implications and consequences of these issues.

Keywords: biology, environmental education, conservation, school curriculum.

INTRODUCTION

Issues concerning the environment are numerous. At the United Nations Conference on the Environment and Development (UNCED) held in Rio de Janeiro in June 1992, ten issues concerning the global environment were highlighted for discussion. Many of these issues are of direct national concern in many Asian countries such as Japan, the Republic of China and in particular, Singapore. Each of these countries has published common concerns on the state of the environment today and proposals on how to preserve the quality of the environment in the future (Anonymous, 1992a; 1992b). In the case of Singapore, this information is available in the Singapore Green Plan published by the Ministry of the Environment in 1992.

Among the many proposals outlined by the Governments in Japan, the Republic of China and Singapore for the conservation and maintenance of the quality of the

environment, is an educational programme to develop an environmentally-conscious population. In Singapore, the proposed strategy (under the Singapore Green Plan) is to reach out to schools, grassroot organisations, corporations and the media, and to develop long-term plans to promote greater environmental awareness and green consumerism. The rationale of such a proposal is based on the assumption that for any environmental programme to succeed, it needs total support from all sectors of the population. This approach is sound, but, in order to develop a proactive and environmentally-conscious population in the long term, it is necessary to start with those who can best learn and adopt positive attitudes towards the environment. Who can these be but the students of our school system! It is, therefore, not surprising that the Government singled out schools as the main targets in which the environmental education programmes will be launched under the Singapore Green Plan.

To achieve results, a proposal needs an action plan. It is laudable that the Government has taken steps to "cultivate" from a young age, citizens who are "environmental-conscious" through the implementation of these education programmes. But, will "coercion" through such involvement be enough? As Kurt Hahn, an educator once said, "it is wrong to coerce people into opinions, but it is a duty to impel them into experience". Benjamin Disraeli took this concept a step further with his remark, "Experience is the child of thought and thought is the child of action".

What then should be done to impel the students into experience and hence onto action? Education in biology is the answer. Why is this so? Biology, the science of life, is associated with almost every issue concerning the environment. The concern and impact of every environmental issue centres around living things. If each of the ten environmental guideline issues covered by UNCED is analysed in turn, one will realise

how vital biological knowledge is for a clear understanding of each issue. Such an analysis is undertaken and summarised in this paper to illustrate the importance of biology in the understanding of environmental issues and in environmental education.

ISSUE 1 : CONSERVATION OF BIODIVERSITY

Conservation of biodiversity had been on the international agenda for a long time. The emphasis given to this topic had led to the signing of the Convention on Biological Diversity by 157 countries during UNCED in Rio de Janeiro in June 1992. With such wide publicity, have the general public and students recognised the rationale behind the need for the conservation of biodiversity? Statements were published to the effect that biological diversity is essential to the maintenance of the biosphere's life-sustaining systems. The Convention that was signed, conceded that a significant reduction in biodiversity was caused by human activities. The urgency of identifying, attacking and preventing the causes of species and ecosystem loss at their source was also stressed (Saint-Laurent, 1992). There were also calls by many conservation groups for the establishment of gene banks for the preservation of genetic resources. The impact of such campaigns will be amplified many-fold if people understand clearly the concept of "biodiversity". Otherwise, it would be just another "buzz-word" which is fashionable to throw around in conversations! In order to understand the meaning of biodiversity, one has to have some knowledge of genetics, physiology and ecology.

Biodiversity simply refers to the diversity of living things that exist on planet earth. Each of these organisms is there because of the specific genes which it possesses. Each organism interacts, not only with one another but also with the environment. Biological studies of the organisms will reveal that each one of them requires specific

optimum conditions under which they will live and reproduce. If any of the necessary living conditions is changed, the populations of the organisms will change too, and this may lead to extinction of some if the changes are drastic. Ehrlich (1992) commented that the primary cause of the decay of organic diversity is not direct human exploitation or malevolence, but the habitat destruction that inevitably results from the expansion of human populations and human activities.

Biology will explain further the importance of conservation of biodiversity. Ehrlich and Ehrlich (1981) pointed out that the most important anthropocentric reason for preserving diversity is the role that microorganisms, plants and animals play in providing free ecosystem services, without which society in its present form could not persist. If one can realise the intrinsic value of every organism, be it small or large, and the role they play in the ecosystem and the implications of losing one species, one would certainly understand the urgent need for taking measures to preserve our biodiversity. Biological principles will also explain why, that even the loss of some genetically distinct populations within a species is as important as the loss of the entire species. The reason is that once a species is reduced to a remnant, its total extinction in the relatively near future becomes much more likely. By the time an organism is recognised as endangered, it is often too late to save it (Ehrlich, 1992). Biological studies will reveal too, the benefits of the conservation of biodiversity in the sense that organisms in the wild have provided humanity with the very basis of civilisation in the form of crops, domestic animals, a wide variety of industrial products and many important medicines.

It is argued here that if one has a biological background, one would recognise immediately the implications of destruction of natural habitats, and would be in a better position to take or recommend measures to protect them for the conservation of biodiversity.

ISSUE 2 : CONSERVATION OF TEMPERATE AND TROPICAL FORESTS

The conservation of forests has been another sensitive but urgent issue that has received world-wide attention. At UNCED, it was stated that the escalating loss and impoverishment of the world's forests, both temperate and tropical, ranks among the most urgent crises to face the human race. It was felt that UNCED had not addressed the forest problem in a comprehensive manner by seeking to base forest management decisions on a full valuation of the range of goods and services that forests provide (Saint-Laurent, 1992). This statement certainly highlights the importance of biology in dealing with this issue of forest management as biological information provides the basis on which forest management decisions are made. In arriving at certain strategies to manage the forests, one needs to know how the forest ecosystem works, and results from biological research will be able to provide such information.

While there may not be large tracts of forests in Singapore, a comprehensive list of sites of ecological importance has however been outlined in the Green Plan for the purpose of nature conservation and the promotion of nature appreciation. Why is the need for conservation of the forests worldwide as well as small tracts of natural habitats such as those identified in Singapore, of such great importance? Biological science explains this importance as it shows the direct relationship of forest conservation with the issues of biodiversity and climatic changes, in particular global warming. The need to protect natural habitats such as forest ecosystems in order to conserve biodiversity has been explained above. Based on research it was estimated that at least two-thirds of the organisms in the world (a number that amounts to no fewer than three million species) are harboured within tropical forests alone (Raven, 1992). Foresta (1991) in his attempt to conserve the amazon forests commented that the biological value of these

organisms cannot be quantified. Hence, the arguments on the need to conserve biodiversity apply to the conservation of forests as well. Likewise, biological knowledge is important for the understanding of the issue.

As for climatic changes, what role does the forest play? Scientists have established that one of the greenhouse gases that is responsible for global warming is carbon dioxide. This gas is building up in quantity in our atmosphere as a result of industrialisation and the burning of fossil fuel. As carbon dioxide has a high heat absorption capacity, an increased amount of carbon dioxide in the atmosphere will increase heat absorption from the solar radiation, thereby raising global temperatures. The most effective way of preventing global warming is to reduce the carbon dioxide in the atmosphere. It is evident from biological knowledge that plants are the most effective means in removing carbon dioxide as they need this gas for photosynthesis. The conservation of the forests will therefore ensure that there is adequate vegetation to keep the carbon dioxide balance in our atmosphere. Life on earth will be threatened, should the destruction of the forest-cover be allowed to continue. This illustrates again how the understanding of biology will tackle the heart of the issue and hence the importance of conserving forests, be they temperate or tropical for the benefits of mankind. Saint-Laurent (1992) pointed out that many basic points (such as those outlined above) were not clearly dealt with even at UNCED when the Statement of Principles were adopted.

The application of biological science has indeed helped Singapore to take a more enlightened approach towards the conservation of natural habitats. Through the feedback to the planning authorities by biologists involved in various conservation projects, a more pragmatic approach had been adopted to conserve our remaining

natural habitats. In fact, biological knowledge had been professionally applied to formulate the conservation strategies. The Sungei Buloh Ecological Park for example, was developed with the view of increasing the carrying capacity of the park for the birds. Continuing studies are being conducted to gather information for more effective management strategies to be formulated. If students can be educated to understand the importance of biological knowledge in this whole process of conservation, they will certainly be a more supportive group.

ISSUE 3 : SUSTAINABLE DEVELOPMENT AND NATIONAL SUSTAINABLE PLANS

Sustainable development, is a concept or path towards achieving a balance between development and conservation, that is, integrate development and conservation such that the adverse impact on the quality of the environment will not be too severe. To achieve this balance, policies based on sound scientific, in particular, biological principles need to be formulated for implementation. Gomez-Pompa and Burley (1991) commented emphatically that the effective management of the forest for sustainable growth requires indepth knowledge of the biological functions of the forest and in particular, the knowledge of the tree species. They lamented that the current lack of knowledge of the requirements of individual tree species is the greatest hindrance to effective management plans. This could not have been better phrased. Unless one knows how a remaining stand of forest will respond to an adjacent stand being cleared for agriculture or other development, how can plans for sustainable development be drawn? Basic biological knowledge is therefore essential. It is precisely for this reason that the School of Science of the National Institute of Education together with the

Smithsonian Tropical Research Institute embarked on a study of the tree population dynamics at Bukit Timah Forest which is now isolated from the Central Catchment Area with the construction of the Bukit Timah Expressway. A long term study of this nature will yield information on how the forest trees are responding to the isolation, and how preventive measures can, through effective management strategies be taken to prevent deterioration of the vegetation. Such information gathered will also help future decision making by the planning authorities.

If students are conversant with biological knowledge, they will be able to better comprehend the various decisions undertaken by the government on development projects in Singapore, and perhaps will also provide meaningful feedback to further achieve development without adversely affecting the environment. They will also be encouraged to ensure that the natural habitats in Singapore (both terrestrial and marine) which have been earmarked for conservation, are not "abused" in terms of their usage by the public, and will even volunteer to participate in various studies undertaken in these habitats so that they can be more effectively managed.

ISSUE 4 : IMPLICATIONS OF BIOTECHNOLOGY ON THE ENVIRONMENT AND ECONOMY

Both traditional and novel biotechnologies are fully explored for applications throughout the world. Many transnational corporations are extending the biotechnological activities into many sectors including pharmaceutical, forestry and agricultural sectors. There is a growing view that biotechnologies are consequently being used, in pursuit of economic gain to support existing unsustainable food production systems. The impact and implications of biotechnology have reached a magnitude that it has become an issue at UNCED. Saint-Laurent (1992) argued that

while biotechnology could bring benefits to mankind, its implications on the environmental and economic problems must not be ignored. It was claimed that biotechnology could lead to the erosion of genetic diversity and damage to the environment when long-established traditional agricultural techniques are supplanted by high-input agriculture.

Are these fears ill-placed? Once again, one needs to have a good biological background in order to truly comprehend the situation. Biology enables one to understand what is meant by "erosion of genetic diversity" and whether the biotechnological activities will indeed produce such consequences. Will the advantages and benefits of biotechnology outweigh these potential detrimental effects? It is only through sound biology education, that one will be able to rationalise and form an unbiased opinion about such issues.

ISSUE 5 : CLIMATIC CHANGE

The United Nations Framework Convention on Climate Change which was adopted by some 150 countries during the UNCED, focused on the stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climatic system. The main issue is the fear of global warming caused by the increasing quantities of greenhouse gases in the atmosphere. The Convention also clarified that this objective of containing the greenhouse gases to appropriate levels should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change in order to ensure that food production is not threatened and also to enable economic development to proceed in a sustainable manner.

In drawing up the contents of this convention, heavy inputs of biological

knowledge were required. For example, the Convention recognised that greenhouse gases such as carbon dioxide is required by plants, especially crop plants for food production. If any measure taken to lower the carbon dioxide content is too drastic, it will lead to consequences of lower food production, which will generate a whole range of other problems. It therefore illustrates the importance of biological knowledge when dealing with this issue of climatic change. Environmental education to promote better understanding of environmental issues will certainly benefit from the incorporation of biology within the programme.

ISSUE 6 : OCEAN AND COASTAL REGIONS

Ocean and coastal regions concern aquatic and mangrove ecosystems. The problems facing coastal regions and open oceans are complex and require concerted national as well as international efforts if they are to be resolved. What are the problems which the oceans and the coastal regions face? At the UNCED, problems such as destruction of the marine environment by human activities, lack of or little management of fisheries and marine mammals as well as transboundary pollution were discussed. What then, are the implications of these problems? A sound understanding of marine ecology is necessary for one to fully comprehend the repercussions involved in upsetting the aquatic and mangrove ecosystems. The extensive oil-pollution caused by the running- aground of Exxon-Valdez off the coast of Alaska was a prime example of how the delicate balance of the marine environment can be upset by human activities over-night. More recently, the release of crude oil in Kuwait by the Iraqis during the Gulf war caused massive oil-spillage into the Persian Gulf. Numerous aquatic organisms are endemic to the Gulf and as a result of one man's irresponsibility, the very existence

of these organisms is threatened. In both of these cases, biologists were among the first scientists to be consulted to save the flora and fauna and to restore the environment to its natural state. To manage marine ecosystems as well as fisheries (i.e. to ensure continual sustainable resource), one needs to understand how organisms interact and reproduce in the marine environment. For example, in order to maintain sustainable management of, say, cod fishery, one needs to know the life history of cod. Biologists from the Department of Fisheries and Oceans (DFO) in Canada have warned the cod-fishing industry years ago about the diminishing and threatened stocks if fishing practices were not changed. However, their advice went unheeded and as a result, a moratorium was imposed in 1992 for cod fishing in Canadian waters. Thus, over-fishing can be prevented if the growth and reproductive patterns of the fish are known, and fishing policies can then be enforced to ensure continual fish stocks for our future generations.

Singapore coastal habitats are diminishing rapidly in area as well as deteriorating in quality as a result of urbanisation. Our students will be involved in mapping the future of Singapore and if they can be made aware of the consequences of over-urbanisation on our coastal habitats, then conservation will be a reality in the future.

ISSUE 7 : TOXIC CHEMICALS

Toxic chemicals pollute the environment. The impact of toxic chemicals on the environment can only be assessed by studying how chemicals affect organisms (be it a plant, animal or microbe) and this constitutes the field of toxicology in biology.

The World Wildlife Fund International (WWF) regards pollution from toxic chemicals and metals as one of the most serious impediments to environmental

sustainability and the survival of biodiversity. They cautioned that if the world continues to increase its production and consumption of toxic chemicals, it will not be possible to achieve environmental sustainability and to protect biodiversity in many parts of the world, in particular the Southern countries. Is this warning valid? Although this issue was discussed at UNCED, there was, however, little agreement on how to reduce use, emissions and dependence on toxic chemicals. Should the production and usage continue to be left uncontrolled?

Who can forget the tragic fate of victims of the Minamata Bay disease? The deaths of Japanese fishermen at Minamata first alerted scientists that toxic quantities of methylmercury could concentrate in fish. This toxic chemicals was found to be 50 to 30,000 times more concentrated in the aquatic life than in the water (D'Itri and D'Itri, 1977). Yet many of the fish looked perfectly healthy. Human beings, in turn, concentrated the compound as it was passed up the food chain.

A similar major epidemic due to the ingestion of methylmercury-treated seed grains also occurred in Iraq. Whether methylmercury was consumed indirectly in fish or other animals, or directly by eating methylmercury-treated seed grains, the results were the same, that is, permanent damage to the brain and central nervous system. The afflicted person has no symptoms during a latent period in which the deadly compound gradually concentrates. By the time the injury is noticeable, the damage is already done. When fish is no longer safe for human consumption, restrictions on commercial and sport fishing have had a severe economic impact on local areas that depend on tourism or the commercial fishing industry. This problem has arisen in Japan, the US, Canada and Sweden (D'Itri and D'Itri, 1977). In each case the most tragic victims are people who are too poor to purchase other food and continue to eat the fish from the local

waters, notably the poor fishermen at Minamata and the Indians in Ontario, Canada. In the aftermath of the Chernobyl nuclear disaster, inhabitants in the North (particularly the North American Indians and Innuits as well as the Scandanavian natives), were warned not to eat caribou and moose as these animals graze on lichens and grasses that could be contaminated with radio-active chemicals. Biological research provided the necessary information on the members of the food chain in the areas affected by nuclear contamination. Armed with this knowledge, one can successfully avert the threat of another tragedy reminiscent of that of Minamata Bay.

8 : ECONOMIC VALUATION OF NATURAL RESOURCES

At the UNCED, the need for full pricing of natural resources to support their sustainable use was well recognised. Current economic and development models seldom give due weightage to the true value of ecosystems and natural resources, hence the call to internalise costs and for comprehensive integration of environment and development in decision making.

How does one internalise costs and provide a value to natural resources such as an ecosystem? While an ideal and acceptable system is often not possible to devise, biological knowledge can however, help to provide some directions. Taking a 50 year old Tembusu tree as an example, its "value" can be assessed if certain biological parameters are measured and quantified. The computation can be done based on the following parameters,

- a. Volume of wood accumulated over 50 years
- b. Organic matter produced over 50 years
- c. Volume of oxygen produced over 50 years
- d. Fruits for avian population
- e. Aeration of the soil through the spread of the roots
(Equivalent to soil cultivation)

If a quantifiable value can be given to a tree through the gathering of data for the above parameters, then an estimate can be computed for the vegetation within a given habitat. Besides the quantifiable value, there are also the intangible values such as the ornamental value and the shade that the tree provides for man. Both the biologists and economists should discuss this topic to arrive at an acceptable approach towards full economic valuation of natural resources. This again illustrates the importance of biological inputs to resolve an important environmental issue.

ISSUE 9 : STRUCTURAL ADJUSTMENTS

What are structural adjustments and what has biology got to do with structural adjustments? Structural adjustments refer mainly to the economic restructuring and, policy and institutional reforms of a country. An example would be the proposed industrialisation of a country to replace existing agricultural industries that form the current backbone of the country's economy. Fundamental reforms are, therefore, required of all structural adjustment programmes, at both macroeconomic and sectoral lending levels. These reforms can include alterations to the policy framework, changing institutional structures, re-adjusting the planning and analysis procedures of official lending agencies as well as re-shaping the role of public participation in planning, monitoring and evaluation.

Changing the direction of a country's economy will certainly involve land planning and usage, meaning that new development proposals will have an impact on the natural resources of the country. It is therefore of paramount importance that before decisions can be made, a deep understanding of implications of various proposals on the natural resources is required. This is where biological knowledge is important

in understanding the implications of various developments. As this subject relates well with that of sustainable development programmes, the importance of biology in promoting better understanding of this issue applies as well.

ISSUE 10 : TRANSNATIONAL CORPORATIONS

Transnational corporations (TNCs) are multinational companies that operate business activities across the world. They have expanded dramatically in size and economic power over the past three decades. Their influence on patterns of economic development and world trade is reflected in the concentration and continuing accumulation of capital in this sector. It is estimated that worldwide, the top 50 TNCs account for over 70 % of trade and 80% of foreign investment (Saint-Laurent, 1992). Annual turnover for the largest Japanese companies now regularly exceed US\$100 billion each annually. In comparison, the GNP of Malawi was US\$1.2 billion in 1987 and that of Portugal was US\$33.5 billion for the same year. Such an extent of activities by the TNCs would certainly have an impact on the environment.

How then, is biological knowledge important to this issue of TNCs? Biology, as a matter of fact, will be important in evaluating the impact of the activities of the TNCs. Only when implications of activities are clearly known, can a regulatory framework for TNCs be formed to establish essential environmental standards, ensure that companies implement full cost environmental accounting and adopt standards of full disclosure of environmental information.

DISCUSSION

It has been demonstrated through the ten UNCED guideline issues that biological knowledge is crucial towards understanding of conserving our environment. It is the authors' view that in the process of developing an environmentally-proactive population through environmental education, it is necessary that the component of biology be included in the school curricula. Armed with a good foundation in biology, students will be able to understand environmental issues with greater clarity, hence, they will be more committed to support actions that are proposed to conserve our environment. Students, with their creativity may even assist the government in campaigns to conserve our natural heritage, hence will be direct participants in the process. As each generation of students matures and grow into adulthood, a proactive population who will be committed towards conserving our environment will arise.

CONCLUSION

Knowledge in biology will enable one to understand environmental issues with greater clarity and depth because almost all environmental issues are associated with living things in one way or the other. For students to be effectively educated on the importance of our environment, it is necessary that they are provided with a good foundation in biology so that they can better appreciate issues related to the environment. For this to be realised, biology education should be an essential component of the school curricula. Biology education will not only enhance understanding of the environment and ourselves. It will also provide a balance in education among the sciences and the humanities.

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