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**Invited Paper**

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## **Sustainable Development and Minamata Disease Some Lessons from Japan's High-Speed Economic Growth**

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(Received for Publication: January 9, 2003)

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### **Chapter 1 Introduction**

Because of the impact of economic growth on the earth's environmental capacity, various environmental problems, such as global warming, water pollution, large-scale waste accumulation, and so on, are increasing everywhere in the world and the future of our global life support system is threatened today (Meadows *et al.* 1992).

In East Asia, after the second half of 1980, economic growth saw a period of high-speed industrialization and urbanization, and the region's market share of world trade began increasing from 4.4% in 1974 to 17.4% in 1994. One result is that various pollution problems, including mercury poisoning, are being created in countries of the region such as China, Philippines, Vietnam, Thailand, and Indonesia (Harada 1995). The Chinese government officially recognized China- Minamata disease in 2000. And these countries can be said to consider the High-Speed Economic Growth of Japan as the development model.

In this context, especially after the "Earth Summit" in 1992, a search began for a new growth alternative, which could continue to

develop permanently while keeping the global environment ecologically sound. With that in mind, investigations began on how to build a social system which would not be environmentally destructive. This new area of subject is known as the "integrated governance of environment and economic growth" (OECD 2002). Such research will inevitably need an interdisciplinary approach.

"Sustainable Development"<sup>1</sup> (or 'SD' for short) consists of regaining the ways in which genuine economic growth ought to be and maintaining the healthy cycles of natural assets (ecosystem) on which economic growth is dependent. The examination of this concept raises two issues.

(1) How is the rate of economic growth controlled within the range which maintains the soundness of natural assets? So to speak, this is a subject that can be termed the governance of the rate of growth.

(2) How can a social system be built that can minimize the stress which economic growth has on the soundness of natural assets? So to speak, this is a subject that can be termed the governance of the quality of growth.

That is, the SD concept calls on us to pur-

pursue both subjects, i.e. governance of the rate of growth and governance of the quality of economic growth.

Needless to say, Minamata disease was the benchmark pollution problem of the postwar period of Japan and did the most serious damage to the local residents. But its creation was firmly connected with the so-called high-speed economic growth policy of Japan. High-speed economic growth was evidenced by growth in GNP of 9.2% per annual over the 18 years from 1955 to the “Oil Shock” in 1973, resulting in the revival of the Japanese economy, the improvement in national income and in Japan’s catching-up to the developed world. However, it also created various pollution problems, Minamata disease notable among them, sprinkled all over Japan. Furthermore, it destroyed rural communities and agriculture, and had a major negative influence on regional economies.

However, the view that evaluates the Minamata disease problem simply as a negative experience in postwar Japan is incomplete. During the long struggle for recognition of this environmental disaster, valuable precedents have been set, that have proved useful in a wide range of other pollution and public health problems. Formal recognition of Minamata disease came in 1956, and the cause scientifically demonstrated in 1959. Patients and their supporters began a long fight for recognition of corporate and governmental responsibility, gaining extended national support through many trial fights. In 1996, a political conclusion was finally reached, during a critical situation of the ruling conservative political party, 41 years after the formal recognition of Minamata disease. The tenacity and the national spread of the “Save Minamata Disease Patients Movement” are the pride of the citi-

zens’ movement of Japan, and contributed to the development of the private citizens in Japanese society, and thus to the development of Japanese democracy (National Liaison Conference for Minamata Disease Victims 1997, 1998).

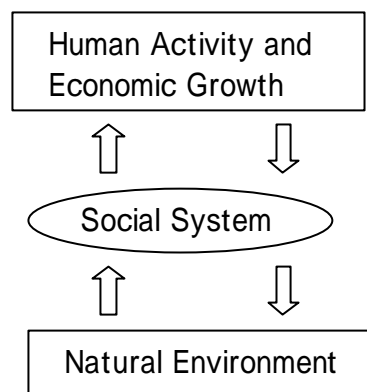
It can be said that Minamata disease is one of the most convincing examples of the need to seek the way to “Sustainable Development.” In this paper I want to consider the social and economical causes of Minamata disease in relation to the period of Japanese high-speed economic growth, and, from the viewpoint of “Sustainable Development,” to extract some lessons for our common future.

## Chapter 2 Methodological Framework

Some key concepts used in this paper are explained here at the beginning.

Generally speaking, in human activity, especially industrial production, a certain amount of resources and energy of high quality are consumed, and, in addition to the products, some wastes, such as carbon dioxide, waste water, smoke, energy of low quality etc., are inevitably produced. In terms of the creation of various forms of waste, the same can be said of consumption, and other human activities.

Figure 1.



The exploitation of natural resources and these resulting wastes cause damage to the ecosystem. These effects on the environment, that accompany human activity, are collectively referred to as 'stress.' Economic growth has a trade-off relation to the environment, i.e., economic growth surely creates a certain amount of stress on the environment. However, even if GNP levels or energy consumption levels are

the same, different societies do not inflict the same degree of stress on the environment. That is to say, given an increase of 1% in economic growth, the degree of stress on environmental assets differs greatly in different societies. In other words, we can have various types of trade-off patterns. For example, we can attain the same p.c. GDP by various industrial structures (See Table 1).

**Table 1. Comparison of Status of World Economies and the Environment**

Title	World share of population	P.C. GDP, 1998	Annual rate of real economic growth, 1990-98	P.C. energy consumption, 1997	Annual rate of CO2 emission, 1990-97	P.C. CO2 emission	Energy efficiency per million US\$, 1997	Ratio of primary industry employers to all employers, mid 1990s
Unit	‰	US\$	%	Kilograms	%	Kilogram of carbon dioxide	Tons/million US\$	%
Australia	2.99	20125	3.3	5511	2.7	-	-	4.9
Canada	4.83	19642	2.0	7832	1.7	18.35	0.615	3.7
China	194.05	777	10.0	692	5.6	2.89	0.928	47.4
France	9.47	24739	1.6	3853	0.8	7.29	0.081	5
Germany	13.72	26183	1.4	3984	-1.6	10.80	0.063	2.8
India	141.57	422	5.7	294	7.4	1.21	0.583	-
Italy	9.89	20659	1.3	2903	0.8	7.77	0.026	7.5
Japan	21.01	29956	1.8	3632	1.2	9.80	0.027	8.3
Korea, Rep. of	7.46	6956	5.8	3221	11.0	9.59	0.070	12.2
Netherlands	2.51	24956	2.8	5318	1.6	12.08	0.181	3.2
New Zealand	0.61	13985	2.1	4139	1.7	8.00	0.256	8.5
Russian Fed.	24.59	1936	-6.2	3945	-6.2	10.17	3.347	15.5
Sweden	1.44	26790	1.2	4540	0.3	6.63	0.103	2.6
Thailand	9.12	1890	5.6	1016	16.9	3.83	0.256	51.3
UK	9.43	23934	1.9	3810	-0.8	9.70	0.190	1.7
USA	41.60	31746	2.7	7756	1.4	22.03	0.192	2.7
World Monde	1000.00	5010	2.1	1427	-	-	-	-

(Source) UN Statistical Year Book [20]

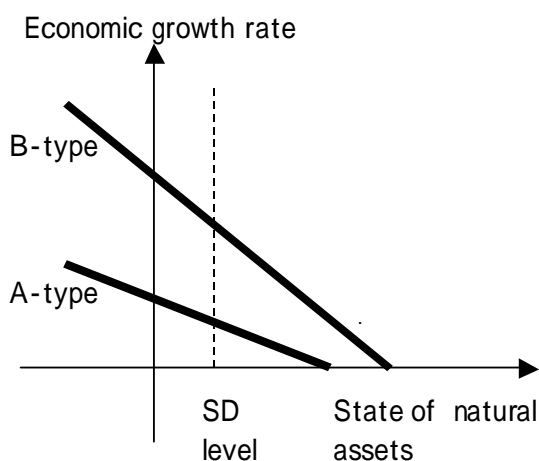
Now, let's think of an axis of coordinates with the horizontal axis presenting the state of natural assets, and the vertical the economic growth rate (See Figure 2). We can identify two types of economy by the trade-off patterns between economic growth and environmental preservation. An A-type economy achieves lower economic growth rate if it keeps natural

assets constant. On the other hand, a B-type economy can attain a higher economic growth rate than an A-type even while keeping natural assets constant. Moreover, even if the economic growth rate of an A-type economy were zero, the growth rate of natural assets is lower than that of a B-type. In a B-type, even if the economic growth rate is zero, the state of natural

assets will be higher than in an A-type.

Assuming, for the sake of illustration, that the state of natural assets at a sustainable level, shown in Figure 2 as the SD level, is located lower than the level which will be attained when both economic growth rates become zero<sup>2</sup>, the patterns of trade-off may differ as shown in Figure 2. A B-type economy will attain a much greater growth rate compared to an A-type, with the same level of environmental damage. Thus, even if the economic growth rate is the same, damage to the natural environment can be reduced, by changing from an A to a B-type economy. Or, if natural assets required to maintain at the SD level, then a higher economic growth rate can be attained by switching from an A to a B-type.

Figure 2.

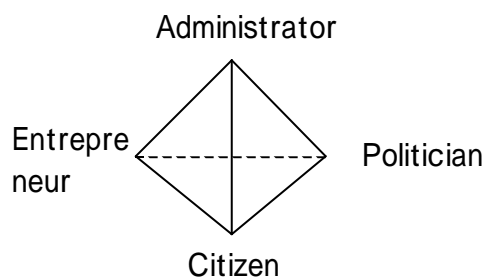


In other words, an A-type economic growth is the one with greater environmental destruction, while a B-type will have less environmental destruction, or even environmental preservation. According to my personal impression, Japan and the United States are A-types, and Northern Europe and Germany are B-types.

The concepts of a social system and social cost are required to explain the difference in these patterns of trade-off relations between

economic growth and environmental preservation. The concept of a social system expresses a certain whole that has regulated human activities and human relations in relation to the natural environment (See Figure 1). We can think of the social system like a shock absorber or an amplifier. It has three activity dimensions, political, economical and cultural. It also has four key players: first, commercial enterprises or industry; second, residents or citizens; third, the political establishment; and fourth, administrators. These relations are diagrammed as a regular tetrahedron (See Figure 3).

Figure 3.



For the purposes of this discussion, the role of citizens is the most crucial. Especially in a democratic society, the residents or citizens can influence politics, as sovereignty is ultimately vested in them, even though they are also dependent, in their daily lives, on commercial enterprise and administration. In particular, politically and/or environmentally aware citizens have the power of changing the social system in various ways. Especially, in non-profit or low profit areas of activity, in which commercial enterprises do not normally intervene, citizens can have a big influence on society, performing useful functions through the activities of various NGOs or NPOs. The following areas of activity can be mentioned as examples: social welfare, social justice and

environmental preservation.

Private cost is the expenditure of private economic players to exclusively acquire the fruits of economic activities. But in their economic activities, including production, transportation, marketing, consumption and disposal process, all economic players will cause some damage and stress to the natural environment knowingly or not. Much expense would be required to remove such stress and to restore what was destroyed and exhausted to its original state, even if that were

possible. Social cost reflects of entire expenses required in order to keep the natural environmental assets constant or healthy and includes the external expenses not paid by the market dealings of the private economic players. For example, the collection and processing expense of garbage or waste is one example of social cost, and so is the expense of a sewage disposal plant. In my opinion, the social infrastructure cost should be included in the social cost, especially in Japan (See Table 2).

**Table 2 Example of Social Cost of Automobile in Japan**

	Benefits	Costs
Private	<ul style="list-style-type: none"> <li>• Convenience</li> <li>• Time &amp; labor saving</li> </ul>	<ul style="list-style-type: none"> <li>• Purchase expense</li> <li>• Parking and operating expense</li> </ul>
Social	<ul style="list-style-type: none"> <li>• Employment and income</li> <li>• Increasing tax</li> <li>• Acquisition of foreign currency</li> </ul>	<ul style="list-style-type: none"> <li>• Road construction costs</li> <li>• Car disposal costs</li> <li>• Air pollution</li> <li>• Noise</li> <li>• Traffic accidents</li> <li>• Traffic jams</li> <li>• Depletion of fossil fuel</li> <li>• Global warming</li> </ul>

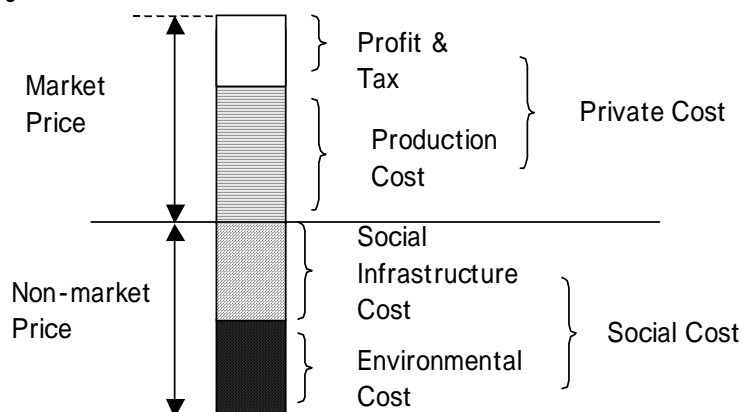
The size of social cost may differ depending on the social systems, i.e. the degree of priority placed on industrialization by the national government; the speed of economic growth; the freedom of corporate activity; the use, if any, of environmental taxes; and citizens' level of environmental awareness and activity, etc.

The burden problem of social cost cannot be fully solved by the market mechanism alone. For example, a company will tend to avoid the burden of social cost often required to control pollution processing for profit maximization. Moreover, when a possibility of immediate profit presents itself, a company does not tend to consider the future risk but to act in the short term. Similarly, a household also becomes

egocentric and a "free rider" of public goods easily. These are unavoidable problems in the market economy. That is, the market economy cannot pay the social cost automatically and willingly, and market prices fail to reflect socially desirable outcomes (See Figure 4). These problems are commonly known as "Market Failure."

It is clear that many national policies or national decision-making systems are influential in harmonizing the environment and social development. Furthermore, the political structures, including the judicial system, tax system, financial system and public works system can also have an effect on the level of stress on the environment. These policies and systems all have a certain rational basis. But

Figure 4.



the government's intervention in a market economy may also aggravate a problem and even delay the solution. For example, it is often the case that wasteful public works may be planned by alliance among leading politicians, senior bureaucrats, and the leaders of big business, and these may result in an increasing budget deficit. The special relation that has evolved among these three is called the “Iron Triangle” or “Sei-Kan-Zai Yuchaku” in Japanese. “Sei-Kan-Zai Yuchaku” distorts the problem of sharing the burden of social cost. This type of problem is known as “Government Failure”(Kondo, 2000).

Neither a company nor the government can solve the social cost burden allocation problem because of both “Market Failure” and “Government Failure.” If democracy is immature in a society, the socially weak people within the community are, in general, made to pay a larger proportion of the social cost. The citizens’ movements and environmental NGOs can compensate for both “Market Failure” and “Government Failure.” And they can play an important role in the field of not only local autonomy but also environmental preservation as well as the social cost burden allocation problem. This is becoming a global trend.

This general trend is described by Profes-

or Friedman as a sort of “development of inclusive democracy asking for alternative development” (Friedman, 1995). Professor Salamon describes this same phenomenon as a “Global Associational Revolution” (Salamon, 1997). Also in Japan, when converting a social system from an environmentally destructive type into an environmental harmony type, it can be said that the efforts of environment NGO/NPOs are making an important contribution.

### Chapter 3 Model Analysis of the “Tragedy of Minamata Disease”

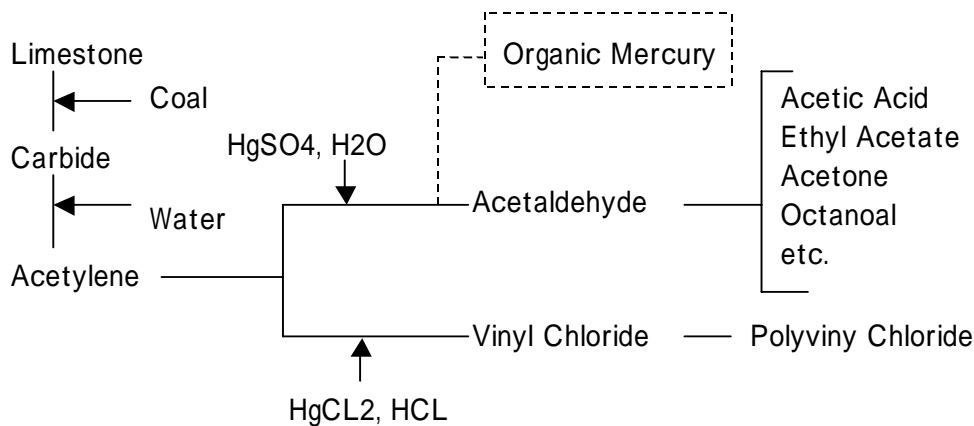
Minamata disease collectively describes various pathological changes that arose in local residents who ate the fish and shellfish from the Shiranui Sea, in Kumamoto Prefecture. In those days, the Chisso Corporations Minamata plant used mercury as a catalyst when producing acetaldehyde, and its industrial waste water, containing the organic mercury (methylmercury), was released to the sea, where it was polluting fish and shellfish (See Figure 5).

Although formal recognition of Minamata disease as a medical condition was made in 1956, the cause was scientifically concluded to be organic mercury only in 1959. However, it

took the government until 1968 to recognize Minamata disease as a pollution-caused illness, and the number of victims continued increasing in the meantime. Furthermore, the discovery of

the “second Minamata disease” was announced in Niigata Prefecture in 1965. According to Table 3, the total victims of Minamata disease are presumed to be about 20,000 persons.

Figure 5. Illustration of Old System of Acetaldehyde (Acetylene Method)



(Source) Minamata-city [10]

Table 3. Administrative Status of Patients (2000)

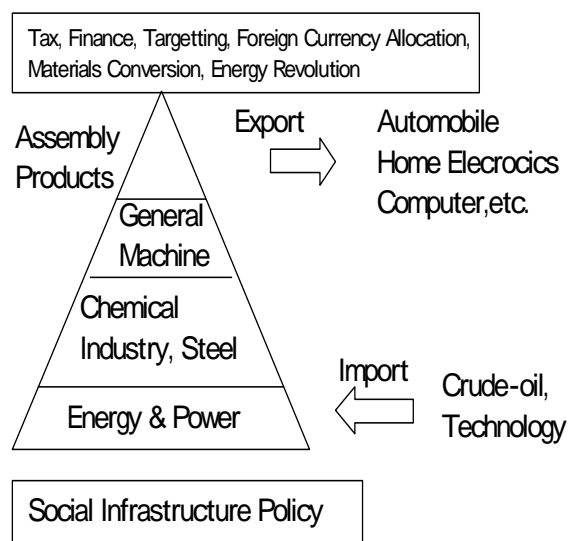
	Total Application Number	Certified Minamata Disease Patients	Partially Compensated Patients
Kumamoto Pref.	13142	1774	7989
Kagoshima Pref.	4269	489	2361
Niigata Pref.	2001	690	799
Total	19412	2953	11149

\* Deceased patients included

( Source ) Minamata Kyoritsu Hospital Group [12]

Although the Chisso Minamata plant which produced acetaldehyde was a company with excellent technology, it did not pay necessary attention to industrial waste water, and the danger which it has on the environment, and did not willing to pay expense required for appropriate processing, simply because it hurried pursuit of profits and high speed growth. Furthermore, the petrochemical industry association of those days and the Ministry of International Trade and Industry (MITI) were aware of the necessity of minimizing the cost of export products in order to quickly promote the heavy and chemical industrialization of Japan<sup>3</sup>.

Figure 6. MITI's Industrial Policy



This structural comprehensive policy system of MITI became known worldwide as Japan's "centralized industrial policy" (See Figure 6).

Therefore, MITI encouraged industry to abandon the comparatively high-priced system acetylene method of producing acetaldehyde, which used carbide and acetylene. MITI advocated a plan to build new factories to convert to the method (the Wacker method), new acetaldehyde production which used ethylene generated from cheap crude oil (See Tabel 4). The implementation of this plan consisted of using factory equipment employing the older method

as much as possible without investing in proper maintenance, thus producing larger profits, the idea being that the profits so obtained would be applied to the introduction of new technology as soon as possible<sup>4</sup>. Actually, as is clearly apparent in Figure 7, acetaldehyde production using the old acetylene method at Chisso's Minamata plant was greatly increased, especially after an in-house experiment, the results of which were suppressed, revealed that the cause of Minamata disease was in the company's own industrial waste.

**Table 4. Cost comparison of the old and new system of acetaldehyde**

	Cost(yen/kg)	Method	Material	Price(yen/kg)	Production
New method	50.24	Wacker	Ethylene	50	60,000 t/year
Old method	56.30	Acetylene	Acetylene	70	12,000 t/year

(Source) Japan Petrochemical Industry Association [3], p.34.

Furthermore, in order to increase the competitive power of Japan in the international market, from around 1960 to 1965, MITI orchestrated the large-scale transition of the primary energy supply structure from coal-centered to oil-centered. This is known as the "Energy Revolution" in Japan, and as a result of this shift, various industrial processes involving coal-based materials were phased out, and processes employing petrochemicals adopted. At the Chisso Minamata plant acetaldehyde production was ended in 1968. Also in 1968, perhaps not coincidentally, the Ministry of Health and Welfare (MHW) at last officially recognized Minamata disease as a pollution-caused illness. This was 9 years after identification of the cause (in 1959) and 12 years after the official recognition of Minamata disease. Throughout that entire time, Minamata disease patients continued increasing in number, and a whole new locus of the disease,

with an identical cause, emerged in Niigata. This is known in Japan as "Dai-ni Minamata Byo" or second Minamata disease. Thus, the outbreaks of Minamata disease were closely connected with the energy revolution for strengthening Japan's competitive power in the international market, and the victims of the disease sacrificed for that purpose.

In this context, it is necessary to understand the problem of Minamata disease not only as a one-company problem, but also as a problem arising from the nurturing of the petrochemical industry as one part of MITI's powerful comprehensive industrial policy of Japan.

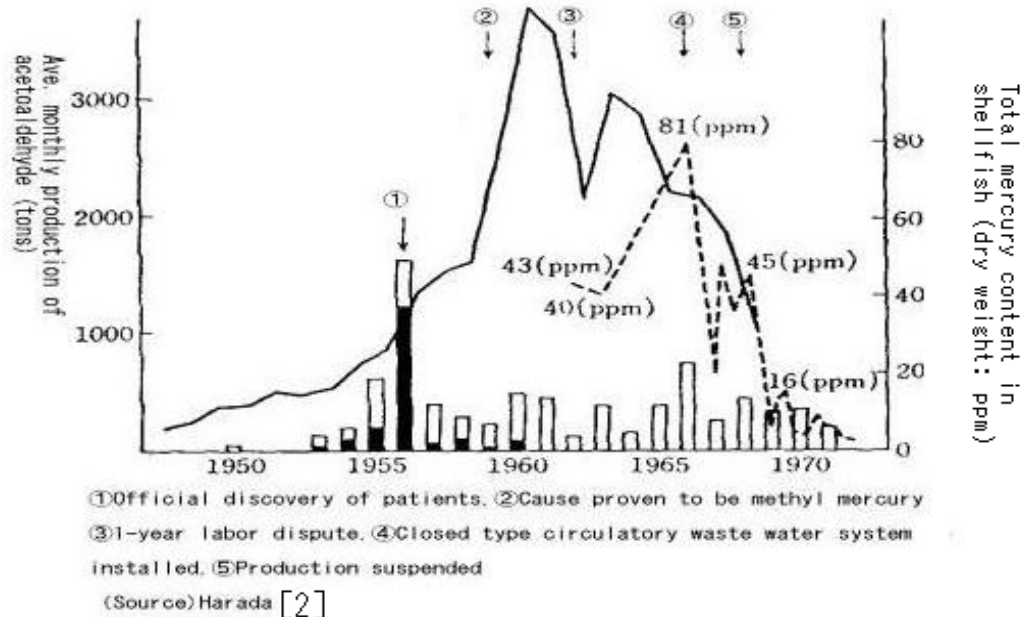
This brief historical explanation of the Minamata disease problem will have to suffice as, in this paper, I want to concentrate on the social and economic aspects of the tragedy of Minamata disease, elucidating the essential structure by using some model analysis.

**The Model and Assumptions**

(1) The sea is considered as a shared resource of an area.

(2) The quantity of production of a certain company (the Chisso Minamata plant) is set to  $x$ .

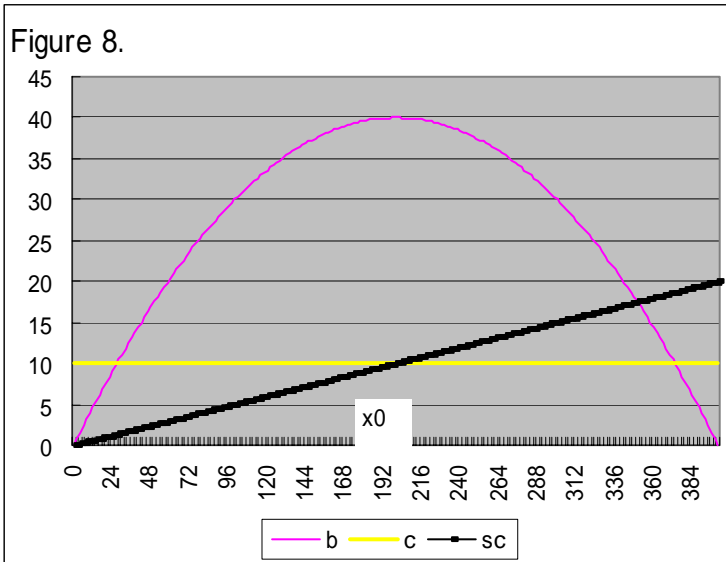
Figure 7. Chronological changes in acetaldehyde production, onset of Minamata Disease, and mercury content in the Shellfish of Minamata Bay



(3) Production cost per unit product is set to  $c$ . For simplicity, it is presupposed that  $c$  is constant.

(4) The revenue per unit product (=market price) is set to  $b$ . So,  $b \cdot x$  means gross income.  $b$  is a function of  $x$ , and  $b$  is an increasing function until a certain production level,  $x_0$ , and becomes a reducing function if  $x$  surpasses  $x_0$ . That is, revenue increases if a company with monopolistic technology increases production up to the level of  $x_0$ . However, if  $x_0$  is exceeded and it produces superfluously, the price will fall because of superfluous supply and profits will decrease (See Figure 8).

(5) Social cost<sup>5</sup> per unit product is set to  $sc$ .



$sc$  is the function of  $x$  and is taken as a monotonous increasing function. Therefore, social cost =  $sc(x) \cdot x$  increases at an increasing tempo as production level increases.

A company acts so that its profits may be maximized.

Expressed as an equation,

$$\begin{aligned} \text{Profit}(1) &= \text{gross income} - \text{production cost} \\ &= b(x) \cdot x - c \cdot x. \end{aligned}$$

The necessary condition for profit maximization is that the marginal revenue gained by an additional unit of production and the marginal cost of producing an additional unit become equal, and makes  $x^*$  the production level which fulfills this condition. On the other hand, seen from the viewpoint of social welfare, what does the optimum quantity of production become? Social cost is clearly increased by non-processed industrial waste water effluence which accompanies an increase of production. Thus, from the standpoint of social welfare, to maximize social net benefit, it is necessary to subtract both production cost and social cost from social benefit. For ease of analysis, we will assume that social benefit and private revenue are in agreement, and also suppose that the production cost is excluded from social cost. That is,

$$\begin{aligned} \text{Social net benefit} &= \text{social benefit} - \text{production cost} - \text{social cost} \\ &= b(x) \cdot x - c \cdot x - sc(x) \cdot x. \end{aligned}$$

The necessary condition for maximization of social net benefit is that marginal social benefit and marginal private cost + marginal social cost which are gained by addition of production become equal, and makes  $x^{**}$  the production level which fulfills this condition. It is clear that  $x^* > x^{**}$ , and the production level determination by private enterprise can easily exceed a desirable production level, seen from the viewpoint of social welfare. That is, when private enterprise is allowed, untrammelled, to determine production level, resources and the environment will be destroyed beyond necessity.  $x^* - x^{**}$  (the difference between

the optimum production level for profit maximization and the optimum production level for social net benefit maximization) can be described as “Market Failure” because it is the overproduction portion of  $x^*$ . Or, in other words, if  $b(x^*)$  is called “market price” and  $b(x^{**})$  is called “social price”, under the market economy, we can say that social price surely exceeds market price, i.e.  $b(x^{**}) > b(x^*)$ .

In order to avoid this, what measures are needed? Government subsidies covering outlays for pollution control are one possibility. Imposing an environmental tax and/or an industrial-waste-water tax is another option, one that could be described as a sort of “negative subsidy” for those firms that take the necessary measures to avoid such punitive taxes. A third approach is influencing production level decisions of private enterprise by regulations of water quality in industrial waste water, both in regard to concentration of pollutants in discharged waste water and total emissions (to prevent companies from simply diluting their waste before discharging it). Typically, a comprehensive approach would combine aspects of all three of these options. For example, if  $c$  is increased deliberately through an environmental tax, the optimum production level of a private enterprise can be guided to  $x^{**}$  from  $x^*$ .

Next, how can the influence of government industrial policy be expressed in mathematical terms?

Industrial policy in Japan promoted the shift in production materials for acetaldehyde to ethylene and the disposal of old equipment, thus giving Chisso the incentive, by maximizing profits at all costs, to invest in new equipment and technology. Consequently, Chisso depreciated old equipment as soon as possible.

When seen from the viewpoint of social welfare, increasing  $c$  was desirable to control pollution, but instead, Japanese industrial policy reduced the amortization cost of old equipment, and had the effect of reducing  $c$ . The result was the tragedy at Minamata.

Supposing  $a$  to be the fall in production cost per product unit as a result of industrial policy, Chisso maximized profits as follows: That is,

Profit(2) = gross income – revised production cost

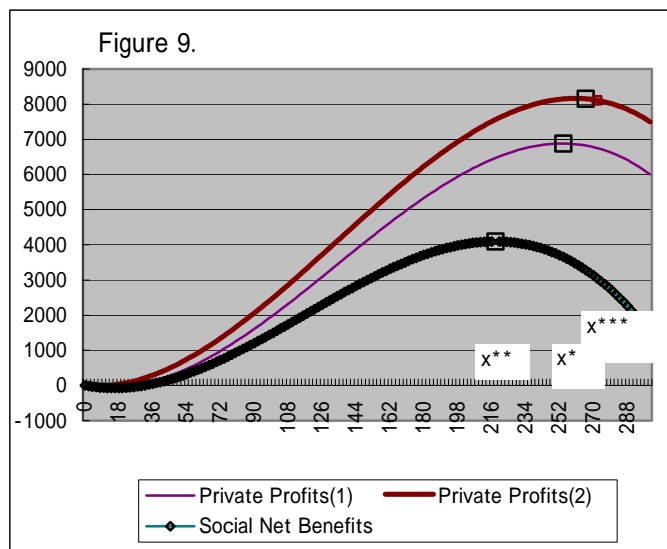
$$= b(x) \cdot x - (c - a) \cdot x.$$

It will become  $x^{**} < x^* < x^{***}$  where the quantity of production which Chisso chose is  $x^{***}$ . Clearly, the quantity of production of Chisso exceeds  $x^*$  and the degree of excess was accelerated further by Japan's industrial policy.  $x^{***} - x^*$  is the overproduction portion caused by “Government Failure” (See Figure 9).

As mentioned above, the cause of the pollution which brought about the tragedy of Minamata disease can be understood as compound problem of both “Market Failure” and “Government Failure.”

In addition, I want to add a comment as to why the MITI of those days could have had such power and influence as to overwhelm other ministries in the government offices. It is one aspect of the structural alliance between MITI and politicians over a period of many years. Many upper-level bureaucrats of MITI, after leaving government office, became politicians in the governing party, a couple of them at least even becoming Prime Minister and Deputy Prime Minister. Others took up high-level positions in various industries, including petro-chemical industry. It is possible to state that the Minamata disease problem was one social symptom of “Sei-Kan-Zai Yuchaku”

(Prestowitz 1988; Wolferen 1989; and see in Chapter 2 above).



## Chapter 4 Conclusions

### Japanese Model from the viewpoint of “Sustainable Development”

The high-speed economic growth model of Japan was a controlled economy type model dominated by the government-business relationship, for a rapid heavy industry catch-up aiming at an import substitute and export promotion. By laying private cost on social cost, it succeeded in curtailment of cost and succeeded in the advancement of an energy revolution. On the other hand, Minamata disease was generated, Japan was changed into “Pollution Islands,” and the regional economy, such as agriculture and fishery, decayed. High-speed economic growth of Japan was the growth which was connected with disregard of social cost, and disregard of local residents’ life and health, and became possible rather just because of it. It was the result of “Market Failure” and “Government Failure” carrying out po-

lymerization in the worst form.

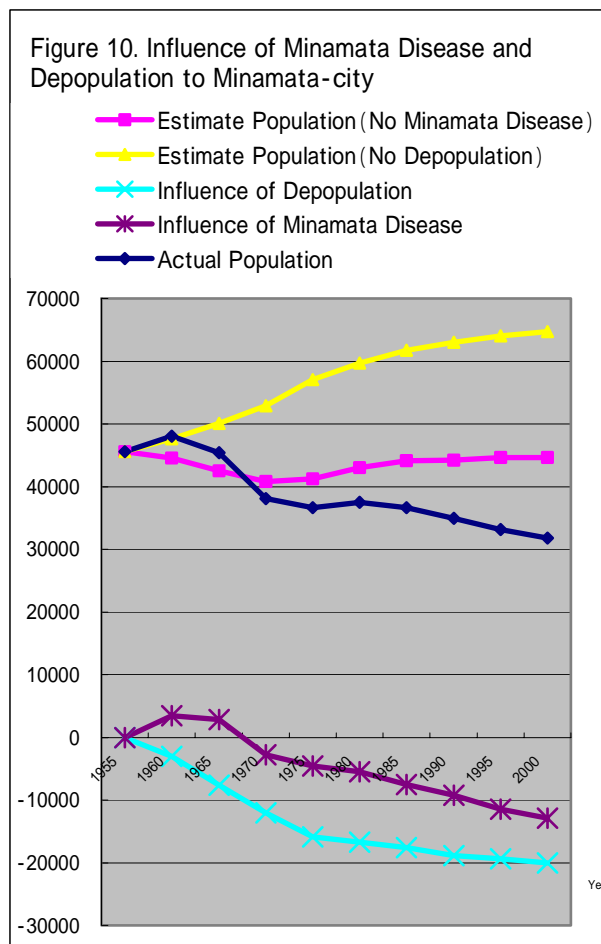
It destroyed not only the natural environment but also the regional economy. Figure 10 shows how the population of Minamata-city was influenced by both high-speed economic growth and Minamata disease. The population which was at 45,532 persons in 1955 decreased at 31,789 persons in 2000. If there is neither Minamata disease nor high-speed economic growth, it would be estimated that the population of Minamata would have increased to 64,734 persons in 2000. Among these, it was estimated in 2000 that 20,074 persons were lost by depopulation and 12,871 persons were lost under the influence of Minamata disease. That is, no less than 51% of population was lost from Minamata-city, and the regional economy was destroyed.

High-speed economic growth of Japan was the typical case of “non-sustainable development,” and not only the side of the brilliant success but also the dark portion should be gazed at justly to pull out the right lessons.

### Six Lessons from Minamata Disease

(1) (Stop the “Market Failure”): Although Chisso knew through animal experimentation in 1959 that the factory effluent was the cause of Minamata disease, it hid the cause, blocked cause investigation, extended the measure against waste water, and continued acetaldehyde production till 1968. It was the typical example of “market failure” which is going to avoid the burden of social cost for the profits of the near future of itself. It is necessary to incorporate environmental costs into private cost by economic means, such as an environmental tax, to correct the “Market Failure,” and force companies through direct regulation to meet the social costs of their conduct.

(2) (Stop the “Government Failure”): In order that the Japanese government including the MITI might achieve high economic growth,



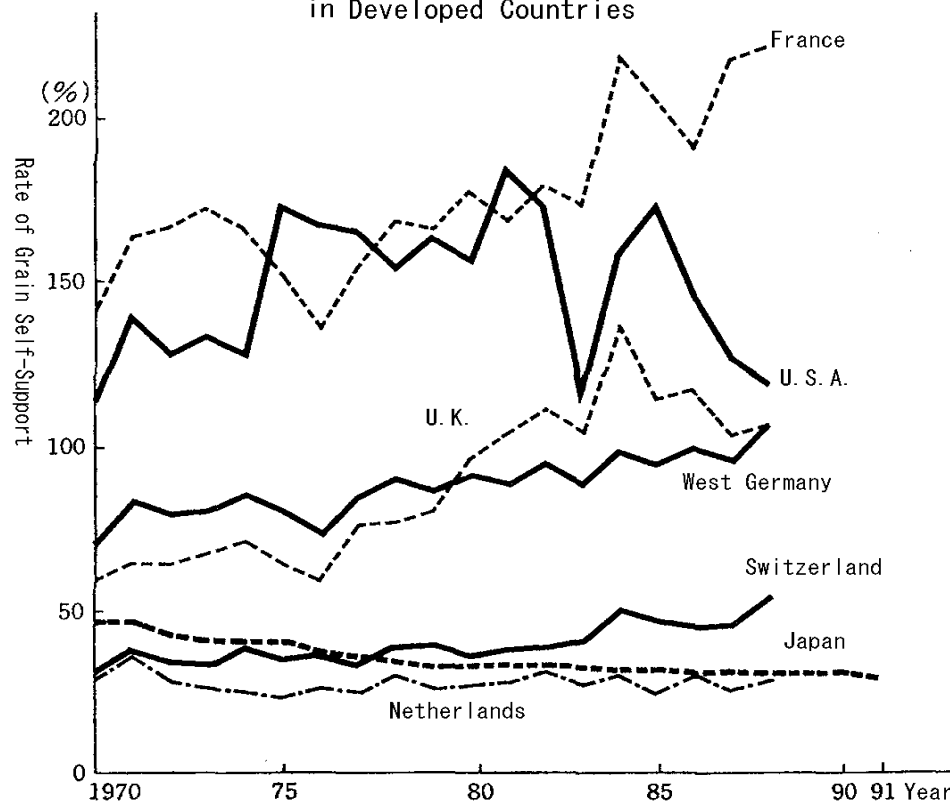
and an import substitute and export promotion, it made the supreme proposition strengthening and materials conversion of competition in the international market, and gave priority to the profits of industry. Consequently, generation of the second, third, and fourth Minamata disease was not prevented. Furthermore, it did not consider how to accept the administrative responsibility itself, but the pain beyond necessity was given to the victim by the patient omission policy, and the trial fight was made to protract. This was a typical example of “Government Failure.” High-speed economic growth also produced the problem involving

the portion of growth. Only some of persons or companies should not monopolize economical abundance, but the fruits are universally distributed to people in the true economic growth. The room of people's life, a happy circle with a family, social welfare and independence of local economy must be secured. The main portion was utilized for the economical fruits which high-speed economic growth produced for accumulation of capital rather than for people. We have to grope for conversion of political/social structure called "Sei-Kan-Zai Yuchaku," for connecting economic growth to improving social welfare in a broad sense. For that purpose, reform of a political/administrative dimension is inevitable in Japan. Moreover, we should stress the im-

portance of change of political power and parliamentary independence.

(3) (Converting the Decision-Making System and Strengthening Public Involvement): People have to know that economic policy and the political system are connected with their lives, and have to search for the democratic structure in which the demands of the community are reflected in decision making process of national government. The rigidity of a bureaucratic system, continuation of long-term one party rule, and the system of alliance of politician, bureaucrats, and industrial world delay and aggravate the solution of problems. Developing the freedom of information, residents' surveillance and citizens' participation in mu-

Figure 11 Transitions of the Rate of Grain Self-Support in Developed Countries



(Source) MAFF, Syokuryo Jukyu Hyo.

nicipal affairs must be strengthened. And the alternative economic development plan by residents should be submitted.

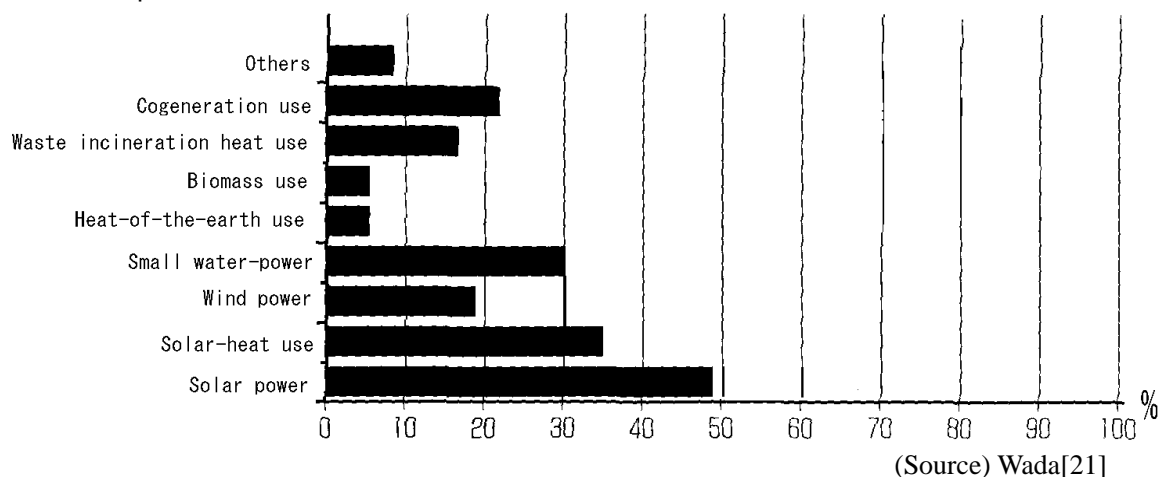
(4) (Promoting Local Economy, including Agriculture and Fishery, and Restoration of healthy Environment): High-speed economic growth destroyed both regional substance circulation, including regional economy circulation, and the environment. For example, the rate of Japanese self-sufficiency in food production became the worst in the developed countries (See Figure 11). We should perform natural substance circulation, environmental reproduction and promote the regional economy destroyed by development. The regional economies should utilize their resources and pursue industrialization, i.e. the local industrial policy with the balance containing agricultural reproduction. For that purpose, the role of the state and local government should be improved so that the regional economy can become relatively independent and a source of revenue should be decentralized, and development of local autonomy should be secured.

(5) (Strengthening of Human Right and Democracy): Fighting for 40 years of Minamata

disease pulled up democracy of Japan and increased community participation certainly<sup>6</sup>. We have to connect the lessons of Minamata disease to the development of resident autonomy. We should know that ultimately the protection residents' safety and health is dependent on the community itself.

(6) (Improvement in the Rate of Energy Self-support and Promoting Technological Development of Natural Energy): The harmonization of a global intensified competition and achievement of SD is becoming the important problem. In order to protect economic independence to global intensified competition, we should aim at diversification of primary energy supply structure, and the improvement in the rate of energy self-support. Especially, for independence of the regional economy, practical use of natural energy is important. (See Figure 12) We should pursue independence of the regional economy by introduction of the natural energy by expansion of citizen participation and citizen possession. It will convert the existing system into the "Sustainable Society" simultaneously.

Figure 12. Rates of Various Natural Energy Use of Self-Governing Bodies (Prefecture Level) to the Whole in Japan, 1999



## NOTES

<sup>1</sup> According to the “Brundtland Commission,” sustainable development is defined as the development that “meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). And also, in the preamble of “Agenda 21,” it states that “integration of environment and development concerns and greater attention to them will lead to the fulfillment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future (<http://www.unep.org>).”

<sup>2</sup> In this paper, the levels of natural assets in case the economic growth rates of both economies become zero assume that a B-type economy is at least higher than an A-type.

<sup>3</sup> In 1955, MITI determined the “Measure for promotion of the petrochemical industry.” This was intended to import European and American technology and promote the growth of the petrochemical industry, which was the start from nothing, as a national policy. The main points of this measure included

(1) Guaranteeing stable supplies of the raw material of synthetic resins, such as synthetic fibers (nylon and acetate, etc.), and phenol resin, and meta-acrylic resin,

(2) A changeover to domestic production of raw-material goods, such as acetylene system products, that until then had totally relied on imported production.

(3) Supply price reduction of main chemical industry materials.

And through these policies, it was intended to promote the Japanese competitiveness in the in-

ternational market and the advancement of Japan's industrial structure, the chemical industry and related industry. MITI framed a plan favoring a select few companies through enforcement of the quota system of foreign currency, special taxation measures, the loan system, etc., in order to achieve this purpose and to promote accelerated depreciation of old equipment, and new equipment investment. International Trade and Industry Minister Tanzan Ishibashi conducted, in 1955, the transfer to private industry of old army fuel depots in Yokkaichi, Tokuyama and Iwakuni. This was called the “Ishibashi Plan.” This plan was a factor in the revival of the great pre-war “Zaibatsu” or business conglomerates. It also contributed to the petrochemical industry development in Japan, and domestic production of petrochemicals (Japanese Petrochemical Industry Association, 1981).

<sup>4</sup> A petrochemical company in West Germany developed the basic technology of ethylene direct oxidization in 1956, in response to this in 1960, the Hoechst=Wacker company of the same country completed a full-scale production facility of acetaldehyde employing the petrochemical system called the Wacker method. The predominance of the Wacker method became clear gradually and the full-scale materials conversion progressed from 1964 and many new plants were built from 1964 to 1968 in Japan as well. At Goi in Chiba Pref., in July, 1964, Chisso also completed a new plant using the Wacker method with a yearly acetaldehyde production capacity of 48000t. Materials conversion of acetaldehyde was completed in Japan in 1969 and, by using the Wacker method mercury became unnecessary in acetaldehyde production (Japanese Petrochemical Industry Association, 1981).

<sup>5</sup>.According to my simple estimation, the social cost of Minamata disease in Japan at 2000 present value is estimated at about 230 billion yen (1.92 billion US\$).

<sup>6</sup>. The role played by the nation-wide citizens' movement calling for redress of Minamata disease victims in the development of democracy of Japan is not fully considered by this paper.

### ACKNOWLEDGEMENT

I thank the Ryosui Alumni Association of Shiga University, Faculty of Economics, for financing this research.

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**Research Paper**

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**Development of an Inquiry Laboratory Experiment for Upper Secondary School Biology - A Simple Preparation Method for *Bacillus natto* Cells from a Traditional Japanese Food “Natto” for Gram Staining and DNA Extraction -**

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**Abstract**

In the present study, we designed a student laboratory experiment for a DNA extraction. At the first step, *Bacillus natto* cells were isolated from a traditional Japanese food “natto.” By using the isolated bacterial cells, Gram staining was carried out to confirm the Gram stain type. Then, DNA was extracted from the bacterial cells after lysing the cells with lysozyme. The laboratory experiment developed in the present study was tested in some in-service training courses for biology teachers in Osaka Prefecture, and positive evaluation was obtained from the attendees. The laboratory experiment was implemented in a senior high school advance biology class which was offered as an elective subject to the third-year students whose majors were science and mathematics. The implementation was successful. Therefore, the laboratory experiment developed is suitable for an inquiry activity in advanced biology classes.

*Key words: Bacillus natto, DNA extraction, Gram staining, inquiry laboratory experiment, senior high school advanced biology*

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**INTRODUCTION**

Many students in the upper secondary schools are in favour of science laboratories. They want to do special technological experi-

ments such as “DNA Extraction and DNA Analysis.” Using new technologies may enhance their interest in learning. The motivation is also very important in studying science. If they can derive satisfaction for their inquisi-

tive minds from the successful completion of laboratory experiments, they will come to study science harder. However, teachers are too busy to prepare these experiments. For such biology teachers, we need to develop some simple inquiry laboratory experiments.

For student laboratory use, the method of DNA extraction from plant and animal tissues has been simplified (Aihara 1986, Nakayama and Maekawa 1998, Maekawa 1999, Kusumoto et al. 1999). Shibazaki (1986) tried to introduce an experiment for DNA extraction from a bacterium, *Bacillus natto*, into student laboratories. However, for ordinary biology teachers who are not familiar with bacterial culture, the procedures should be simplified further.

“Natto,” a traditional Japanese fermented food, is made by storing boiled soybeans with *B. natto*, which serve as an agent for fermentation, under suitable conditions. *B. natto* is a kind of hay bacterium which commonly exists in hay, soil, rice stubble and even in the air. Traditionally, natto was made as follows: boiled soybeans were packed into a sack of rice straw and then the sack was stored at a temperature around 40°C. The boiled soybeans become very soft and sticky due to the proliferation of *B. natto* whose spores adhere to rice straw.

The bacterium produces various enzymes, vitamins, and amino acids during natto fermentation. Some of the unique compounds in natto are thought to be effective in preventing cancer, osteoporosis, obesity and intestinal diseases caused by pathogens. Many Japanese eat natto every day, so small packages of fresh natto can be purchased easily and cheaply at supermarkets and convenience stores. If we could isolate *B. natto* cells from

natto, we would easily be able to use the bacterium in biology laboratory exercises without any equipment for fermentation.

In the present study, we developed a very simple method to collect *B. natto* cells from commercially sold natto. We also developed an inquiry laboratory experiment in which the isolated *B. natto* cells are used.

## Materials and Methods

### Preparation of *B. natto* cells

Materials and equipment used in the isolation of *B. natto* cells are shown in Figure 1. Fifty grams of fresh natto were transferred into a paper cup and mixed well with 30 ml of warm water (60°C). Then, the mixture was filtered with a sheet of nylon mesh. This filtrate with high viscosity contains a large number of *B. natto* cells. The viscous filtrate was then used for Gram staining and DNA extraction.



**Figure 1** Small packages of fresh “natto,” a traditional Japanese food, nylon mesh sheets and paper cups

### Gram staining

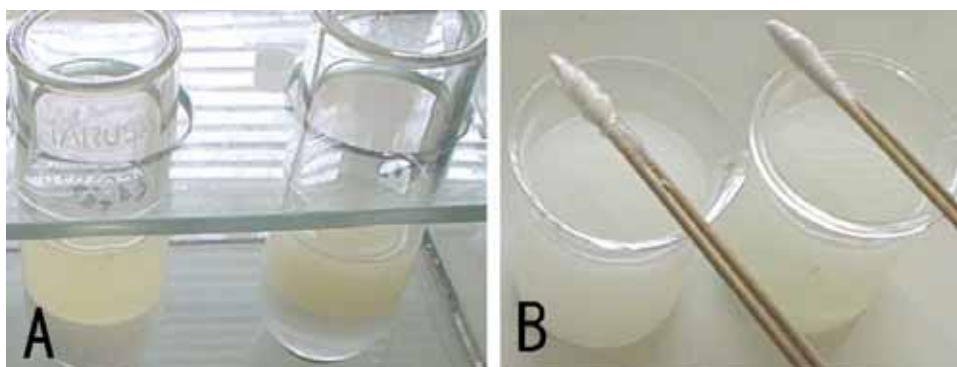
Gram staining is a technique for staining bacteria and yeast (Okuhira et al. 1999). A drop of the viscous filtrate mentioned above was spread on a clean glass slide and air-dried. The specimen was fixed to the glass slide by

passing it a few times over a flame. Stock solution of crystal violet (crystal violet 0.3 g, ethanol 20 ml) was mixed with 80 ml of 0.1% ammonium oxalate solution to make a diluted crystal violet solution. The slide was flooded with the crystal violet solution for 1 minute and was rinsed with water. Then, the slide was flooded with Gram's iodine solution (iodine 2 g, potassium iodine 2 g, water 300 ml) for 1 minute and rinsed with water. The slide was decolorized by rinsing with ethanol for 10 seconds and then rinsed with water. The slide was flooded with a saffranin solution (saffranin 0.25 g / ethanol 10 ml, water 90 ml) for 1 minute, rinsed with water, and dried in the air. The slide was observed under a microscope at low magnification (x 100) to find the best observation area and then viewed at a higher magnification (x 1000) by oil immersion lens. Gram-positive bacteria and yeasts are stained purple and Gram-negative bacteria are stained pink.

#### DNA Extraction

The methods for DNA extraction described by Kainuma (1969a, 1969b) and Shi-

bazaki (1986) and were modified partially in the present study. In a test tube 10 ml of the viscous filtrate mentioned above were mixed with 1 ml of 2% lysozyme solution and the same volume of an EDTA, ethylenediamine-tetraacetic acid, solution (1 M EDTA, 1.5 M NaCl, Na-phosphate buffer pH 8.0). The mixture was incubated at 40°C for 15 min. Then, 2.5 ml of 20% SDS, sodium dodesylsulfate, solution and 1.5 ml of 30% trichloroacetic acid were added to the mixture and incubated again at 60°C for 5 min. After incubation, the mixture was poured into a glass centrifuge tube. Into the tube, 14 ml of a mixture of chloroform and octyl alcohol (99:1 v/v) was added and the tube was capped tightly. The capped tube was shaken well for 5 min and was centrifuged for 5 min at 2000 rpm (Fig. 2-A). The upper layer in the tube was removed to a beaker and 8 ml of 95% cold ethanol was poured carefully down along the side of the beaker to form a layer. DNA precipitate formed in the alcohol layer, and at the interface of the two layers a stirring rod was swirled, around which the thin threads of DNA were wound.



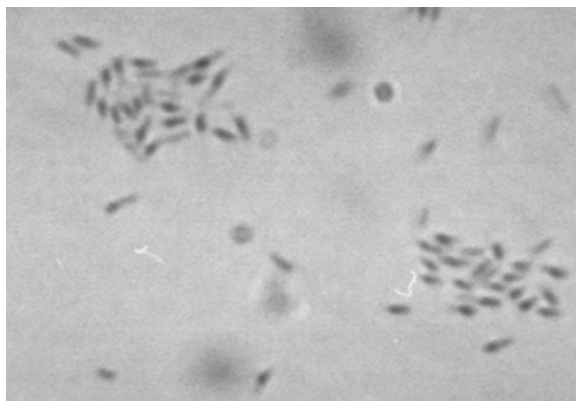
**Figure 2** DNA extraction of *Bacillus natto* isolated from a commercially sold natto. **A:** A mixture in glass tubes centrifuged for 5 min at 2000 rpm; **B:** Natto DNA wound around the stirring rods

**Results and Discussion**

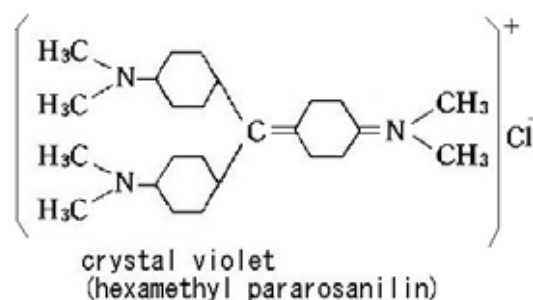
The viscous fluid obtained from a commercially sold small package of fresh natto (50 g) contains a large number of *B. natto* cells. Therefore, by the method explained in the present paper, one can easily obtain enough bacterial cells to use in a student laboratory exercise without using any other equipment for fermentation.

*B. natto* was shown to be a Gram-positive bacterium, because the bacterial cells were stained purple (Fig. 3). The chemical formula of crystal violet is shown in Figure 4 (Okuhira et al. 1999). In the case of a Gram-negative bacterium, crystal violet which binds with Gram's iodine is washed away with alcohol. On the other hand, in the case of a Gram-positive bacterium, crystal violet which binds with Gram's iodine is linked together with teichoic acid and  $Mg^{2+}$  (Okuhira et al. 1999). Teichoic acid is peculiar to the cell

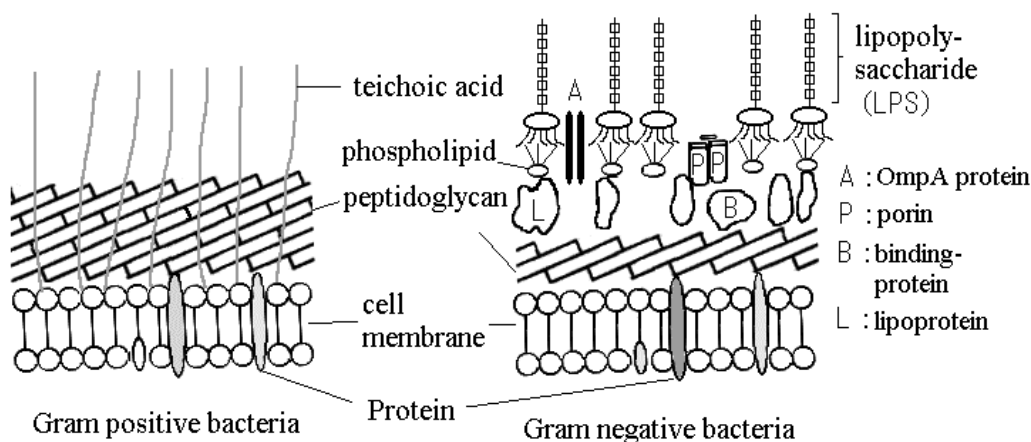
walls of Gram-positive bacteria (Sakurai 2000, Fig. 5).



**Figure 3** *Bacillus natto* cells stained purple with Gram staining (x 1000)



**Figure 4** The chemical formula of crystal violet



**Figure 5** The molecular compositions of cell walls in Gram-positive bacteria and Gram-negative bacteria (partially modified from Sakurai 2000)

After confirming the Gram stain type of *B. natto*, students can decide the method of DNA extraction. Compared to Gram-negative bacteria, Gram-positive bacteria have a thicker peptidoglycan layer at the cell wall. In order to extract DNA from the Gram-positive bacteria, one must degrade the bacterial cell wall. Peptidoglycan can be broken down into *N*-acetylglucosamin and *N*-acetylmuramic acid with the enzyme, lysozyme. Students are expected to select a sound method of lysing *B. natto* cells.

By the methods explained above, DNA could be extracted from the isolated *B. natto* cells. As shown in Figure 2-B, bacterial DNA threads could be wound around a stirring rod. The bacterial DNA obtained had an absorption peak of 260 nm (data not shown). In a student laboratory one can confirm by staining with Schiff's reagent that the threads wound around a stirring rod contain DNA (Aihara 1986, Nakayama and Maekawa 1998, Maekawa 1999).

The laboratory experiment developed in the present study has been tested in some in-service training courses for biology teachers in Osaka Prefecture. The number of attendees in each course was 12-20. Biology teachers attending these courses could carry out the experiment without any trouble. Most of the attendees evaluated the experiment positively. The laboratory experiment was also implemented once in the inquiry activity of a senior high school biology class which was offered to science and mathematics majors. The implementation was successful. However, it was suggested that a large-scale centrifuge is required for the DNA extraction to obtain a good result and the number of students in a laboratory class is preferably less than 20.

If the student number is 40, which is the ordinary number of students in one class in Japanese senior high school, the implementation of this laboratory experiment may be difficult.

Whenever students carry out inquiry laboratory experiments, it is very important for them to consider the best way to attain the purpose of their experiment and to consider the reason for each step of the method in the experiment. The experiment developed in the present study, therefore, is considered to be suitable for the inquiry laboratory experiment in the new biology course.

Not only in Japan, but also in other Asian countries, there are many sorts of products of fermentation from fungi such as *Rhizopus oligosporus*, *Mucor hiemalis*, and *Neurospora crassa* (Murao and Arai 1998). These, as well as the products of bacterial fermentation, may be used as the sources of experimental materials.

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**Research Paper**

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**A Study on Ferns as Teaching Material***Toshiyuki KAWAKAMI \* and Hideo IKEDA**Department of Science Education, Graduate School of Education,  
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(Received: 7 January 2003; Accepted: 4 September, 2003)

**Abstract**

The Japanese national curriculum for elementary school and junior high school was reviewed in 1998 and that for senior high school was reviewed in 1999. The school hours and teaching contents were reduced by about 30% from the former curriculum. From a historical viewpoint, we examined the contents concerning "Ferns" in each version of the Japanese national curriculum and the science textbooks. Ferns were contained in some chapters in textbooks for both elementary and junior high school until the last revision. As a result of the latest revision of the textbooks, the fern was eliminated from the chapters "Investigating Plants in All Seasons" in elementary school and "Life of Plants and Their Kinds" in junior high school in which the fern had been contained. In almost all senior high school science textbooks, the fern has been used in the chapters "Structure" and "Life Cycle," so we developed new teaching materials on fertilization and cell division, because experiments of fern were only culture of spore and observation of vascular system. As a result of new teaching materials, we found that ferns could also be used in other chapters besides "Structure" and "Life Cycle," and we therefore can conclude that ferns are valuable plant material in biology education.

*Key Word: Fern, Japanese biology education, textbook analysis, teaching material*

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**Introduction**

In Japan, the national curriculum "The Course of Study," which prescribes the school teaching contents, is stipulated by the Ministry of Education, Culture, Sports, Science and Technology. "The Course of Study" for elementary

schools and junior high schools was stipulated in 1947 and has been reviewed 6 times, the latest review being carried out in 1998. For senior high schools, it was stipulated in 1948 and has been reviewed 7 times, the latest review being carried out in 1999. Since Japanese education has been centralized under the government, all Japanese

school curricula were changed from 2002-03. The transitions in science and biology education in the Course of Study are shown in Table 1.

In the updated “The Course of Study”, the teaching contents were reduced from the previous 1989 curriculum, because of the reduction of school days per week from six to five from 2002. The number of unit school hours not only for science but also for all the other subjects was reduced. Some controversial issues about student attitudes to science literacy were raised by the latest review. Such issues were called “Crisis in science education in Japan.”

Ferns, having characteristics different from seed plants, are an important plant group to understand the plant kingdom. Their characteristics are as indicated below;

- a) The fern is non-flowering plant.
- b) Its sporophyte and gametophyte grow separately.

c) It is considered that the fern developed from water to land in the process of plant evolution.

d) The fern is one of the major plants covering the forest floor.

The fern was eliminated from elementary and junior high school science textbooks in the latest review of the curriculum, although it is a key plant group to understand the plant kingdom.

In this study, we made the contents related to ferns in the textbooks clear from the historical viewpoint of Japanese biology education. From the results of this study, we shall discuss various concepts related to ferns to make the relation map in order to clarify the relationship between the concepts and activities.

The second objective of this study was to develop a new teaching material. The reason was that very few experiments could be found in the textbooks surveyed, so we shall discuss how

**Table 1 Transition of science and biology education in Japanese Course of Study**

Elementary School (1-6)		Junior High School (7-9)		Senior High School (10-12)	
1947	Science	1947	Science	1948	Biology
1952	Science	1952	Science	1952	Biology
1958	Science	1958	Science (Second field) *	1956	Biology
				1960	Biology
1968	Science	1969	Science (Second field) *	1970	Biology Biology
1977	Science	1977	Science (Second field) *	1978	Science Biology
1989	Science (3-6) **	1989	Science (Second field) *	1989	Biology A Biology B Biology
1998	Science (3-6) **	1998	Science (Second field) *	1999	Biology Biology

\* First Field (Chemistry, Physics)  
 Second Field (Biology, Earth & Space)  
 \*\* 1-2 : Life Environment Studies

to carry out new experiments. The studies on teaching materials using ferns were carried out by Yuasa (1984), Chilton and Graham (1988), and Watanabe and Ikeda (1994). They used living spores and sperms, but to observe fertilization they used only fixed materials. Thus, there were no reports on the fertilization of ferns using living materials. Therefore, we developed a new observation method on fern fertilization.

### Chapters and Exercises Dealing with Ferns in Japanese Science Textbooks

#### *For Elementary Schools*

The chapters in elementary school science textbooks which dealt with ferns and how ferns are used in these chapters are shown in Table 2. In these textbooks, the fern had been covered in the chapters “Investigating Plants in All Seasons,” “Forest Development” and “Evolution.

Ferns had been used in the chapter “Investigating Plants in All Seasons” until the latest review, however they were eliminated from this chapter in the 1989 version. The main exercise was field activity to collect young plants of *Equisetum arvense* and *Osmunda japonica* in spring

season.

The chapter “Forest Development” was in the science textbook contents from the 1952 version to the 1977 version, and the main exercise was field observation. In this chapter, a few kinds of fern, such as *Gleichenia japonica* and *Cyrtomium fortunei* that grow in various parts of Japan, had been presented as shade plants. However, this chapter was eliminated in the 1989 version.

The chapter “Evolution” occurred in textbooks until the 1952 review and the fern was used in this chapter. However, in this chapter there were only explanations of tree ferns, e.g. *Calamites* and *Lepidodendron*, but no exercises were included.

#### *For Junior High Schools*

The chapters in junior high school science textbooks which dealt with ferns and how ferns are used in these chapters are shown in Table 3.

In these textbooks, the fern had been used in the chapter “Life and Kinds of Plants” until 1989 review. In this chapter, the structure of sporophyte and spores was the major topic concerning ferns in observation activities. A few textbooks

**Table 2 Chapters and Exercises Dealing with Fern in Japanese Elementary School Science Textbooks**

Year of publication	Chapter		
	Investigating Plants in All Seasons	Forest Development	Evolution
1947	Field Observation	<i>No Chapter</i>	Explanation
1952	Field Observation	Field Observation	Explanation
1958	Field Observation	Field Observation	<i>No Chapter</i>
1968	Field Observation	Field Observation	<i>No Chapter</i>
1977	Field Observation	Field Observation	<i>No Chapter</i>
1989	<i>No Exercise</i>	<i>No Chapter</i>	<i>No Chapter</i>
1998	<i>No Exercise</i>	<i>No Chapter</i>	<i>No Chapter</i>

**Table 3 Chapters and Exercises Dealing with Fern in Japanese Junior High School Science Textbooks**

Year of publication	Chapter			
	Life and Kinds of Plants	Reproduction	Evolution	Classification
1947	Explanation	Observation (Spore) Explanation (Asexual Reproduction)	Explanation	Explanation
1952	Observation (Structure• Spore)	Explanation (Asexual Reproduction)	Explanation	Explanation
1958	Observation (Structure• Spore)	Explanation (Asexual Reproduction)	Explanation	Explanation
1969	Observation (Structure• Spore)	<i>No Fern</i>	Explanation	Explanation
1977	Observation (Structure• Spore)	<i>No Fern</i>	Explanation	Explanation
1989	Observation (Structure• Spore)	<i>No Fern</i>	Explanation	Explanation
1998	<i>No Fern</i>	<i>No Fern</i>	<i>No Fern</i>	<i>No Fern</i>

dealt with the culture of spores. In these observation activities, *Athyrium niponicum* which grows in various parts of Japan was commonly used.

Apart from this chapter, the fern had also been used in the chapter “Reproduction,” i.e., asexual reproduction such as sporic reproduction and the proliferation by subterranean stems.

The objectives of these observations were comparison with flowering-plant and could be developed the knowledge into the topics “Classification” and “Evolution.”

However, in the latest version the fern was eliminated completely.

#### *For Senior High Schools*

The chapters in senior high school science textbooks which dealt with ferns and how ferns

are used in these chapters are summarized in Table 4.

In these textbooks, the fern was used for exercise in the chapters “Reproduction” and “Structure”.

In the chapter “Reproduction,” the fern had been explained the life cycle using the terms of sporophyte, spore, prothallium, sperm, antheridium and archegonium, until the latest review when the life cycle of the fern was eliminated. Although the observation activities appeared in a few textbooks.

In the chapter “Structure,” the fern had also been used until the latest review, it had been used for the observation of vascular bundle in a few textbooks.

There are some other chapters in which the fern have been used still the updated textbooks,

**Table 4 Topics and Activities Dealing with Ferns in the Japanese High School Biology Textbooks**

Year of publication	Chapter					
	Structure	Reproduction	Classification	Phylogeny	Evolution	Distribution
1948	Observation (Vascular bundle)	Observation (Spore)	Explanation		Explanation	Explanation
1952	Observation (Vascular bundle)	Observation (Spore· Sperm)	Explanation		Explanation	Explanation
1956	<i>No Fern</i>	Observation (Spore)	Explanation			Explanation
1960	Observation (Vascular bundle)	Observation (Spore· Sperm)	Explanation		Explanation	Explanation
1970	Explanation	Observation (Spore)	Explanation			Explanation
1978	Explanation	Observation (Spore)	Explanation			Explanation
1989	Explanation	Observation (Life Cycle)	Explanation		Explanation	Explanation
1999	<i>No Fern</i>	Explanation (Asexual Reproduction)	Explanation		Explanation	Explanation

such as “Classification,” “Phylogeny,” “Evolution” and “Distribution.” However, there were only explanations and no exercises were presented.

### Discussion on Teaching Materials

There were a lot of studies about using ferns as teaching material. *Ceratopteris thalictroides* (Kato, 1987) and *Adiantum* (Kudo, 1988) were introduced into the study of the life cycle. *C. thalictroides* is an edible wild plant found domestically in Japan. Its life cycle is known to be very short, about 2 months. In the USA, a material kit for studying the fern life cycle using *Ceratopteris* is being sold (Hickok and Warne, 1998). *Adiantum* can be used for the observation of life cycle and spores in all seasons, if the plant

is kept in warm temperatures. The plant is easy to get and to culture since it is sold in gardening shops.

*Osmunda* which has the smallest chromosome number  $2n = 44$  in Filicales has been used for the observation of the mitotic and meiotic cell division by the common squash method. *Osmunda japonica* has commonly been used as a material for study mitotic cell division (Takamiya, 1988) because it is easily obtainable in Japan as it is one of the familiar edible wild plants in this country.

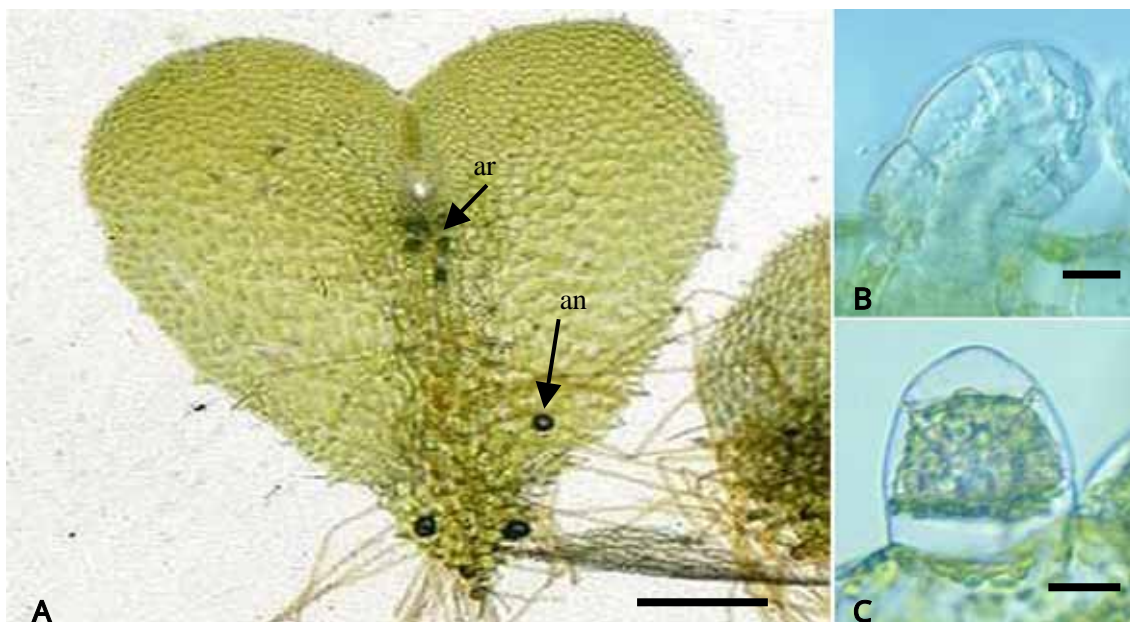
Unfortunately, spore formation of *O. japonica* is limited in spring. Therefore, this species is not good for the observation of meiotic cell division. On the other hand, *Osmunda banksiifolia* has been proved to be useful to culture sporophyte and prothallium *in vitro*. Since a

young sporophyte forms fertile leaves and roots *in vitro*, we can use them to observe the cell division at any time of the year. Using this species, we could observe all the phases of mitotic cell division using the root tip cells and could count  $2n = 44$  chromosomes in metaphase. Using sporangia of this species, we also could observe meiotic cell division and spore formation and could count  $n = 22$  bivalent chromosomes in metaphase I (Kawakami and Ikeda, in preparation).

In addition to this new material, we developed a new method for the observation of the fertilization process using living material. The material used in this experiment was *Pteridium aquilinum*.

The prothallium of *Pteridium aquilinum* was cultured *in vitro*. The prothallium matured about 1.5 months after germination (Fig. 1A). On a matured prothallium, some archegonia (Fig. 1B) and antheridia (Fig. 1C) were formed. Antheridia were formed at the basal part, and arche-

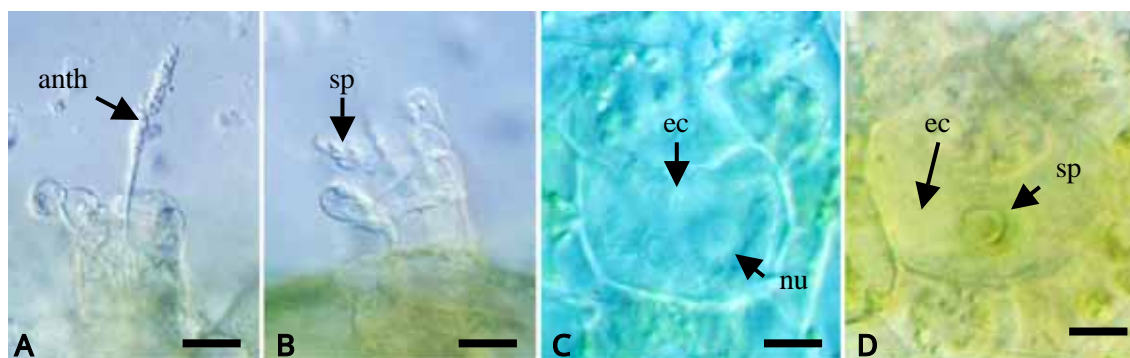
gonia were formed at the central part of the prothallium. When the antheridium was soaked in water, the cap cell opened (Fig. 2A), then many spermatocytes went out into the water. Immediately the spermatocytes changed their shape to sperms (Fig. 2B), and they swam in the water using cilia. When the archegonium was soaked in water, the neck cell opened, and the antheridogen which is a substance attractive to the sperms went out into the water (Fig. 3A). The sperms led by antheridogen swam to the open neck cell and entered into the archegonium (Fig. 3B). Unfortunately, it was impossible to observe the following fertilization process directly from outside of the whole archegonium. To solve this problem, we made a vertical section of archegonium using a razor blade carefully so as not to damage the egg (Fig. 3C). After this treatment, sperm suspension was poured onto the archegonium specimen. Then, we could observe the sperms going to the egg cell and the fertilization process taking place (Fig. 3D). This



**Figure 1** A prothallium of *Pteridium aquilinum* cultivated *in vitro*  
 A: Prothallium (1.5 months after germination); B: Archegonium (ar); C: Antheridium (an). Bars: for A, 1mm; for B-C, 10µm.



**Figure 2 Release of sperm from an antheridium**  
 A: The Cap Cell (cc) opening; B: Sperm (n: nucleus, ci: cilium).  
 Bars: for A, 10µm; for B, 5µm.



**Figure 3 Process of fertilization in an archegonium**  
 A: The neck cell opens and antheridogen (anth) come out into the water; B: Sperm (sp) enters into archegonium; C: Section of an archegonium (ec: egg cell, nu: nucleolus); D: Sperm in the archegonium. Bars: for A-B, 20µm; for C-D, 10µm.

method allows us to observe the fertilization process *in vitro*.

**Suggestions to Biology Classes**

The fern is a very important plant group to understand the plant kingdom because it is a link between moss and flowering plants in the course of plant evolution.

We analyzed the topics related to the fern in Japanese science textbooks and picked up 11 characteristics (Fig. 4). From this Figure, we found that all characteristics of the fern had some connections to certain activities. These characteristics and related exercises would be covered in

the chapters “Vegetation and Ecosystem,” “The Cell and Its Function,” “Reproduction and Development” and “Evolution and Phylogeny.” Especially, “Reproduction and Development” are basal concepts to understand the evolution, classification, phylogeny, and distribution of the plant kingdom in the sequence of Japanese biology education.

Observation of ferns is not difficult, since special instruments except the microscope are not needed. Students can understand the “Vegetation and Ecosystem” by observation of plants in a forest.

“Reproduction and Development” can also be understood through simple experiments by

using the fern as the experimental material. It is possible to observe all the stages including spore formation and fertilization. It is

well-known among biology teachers that the observation of the embryo sac of the angiosperm is difficult, because the organ is surrounded by

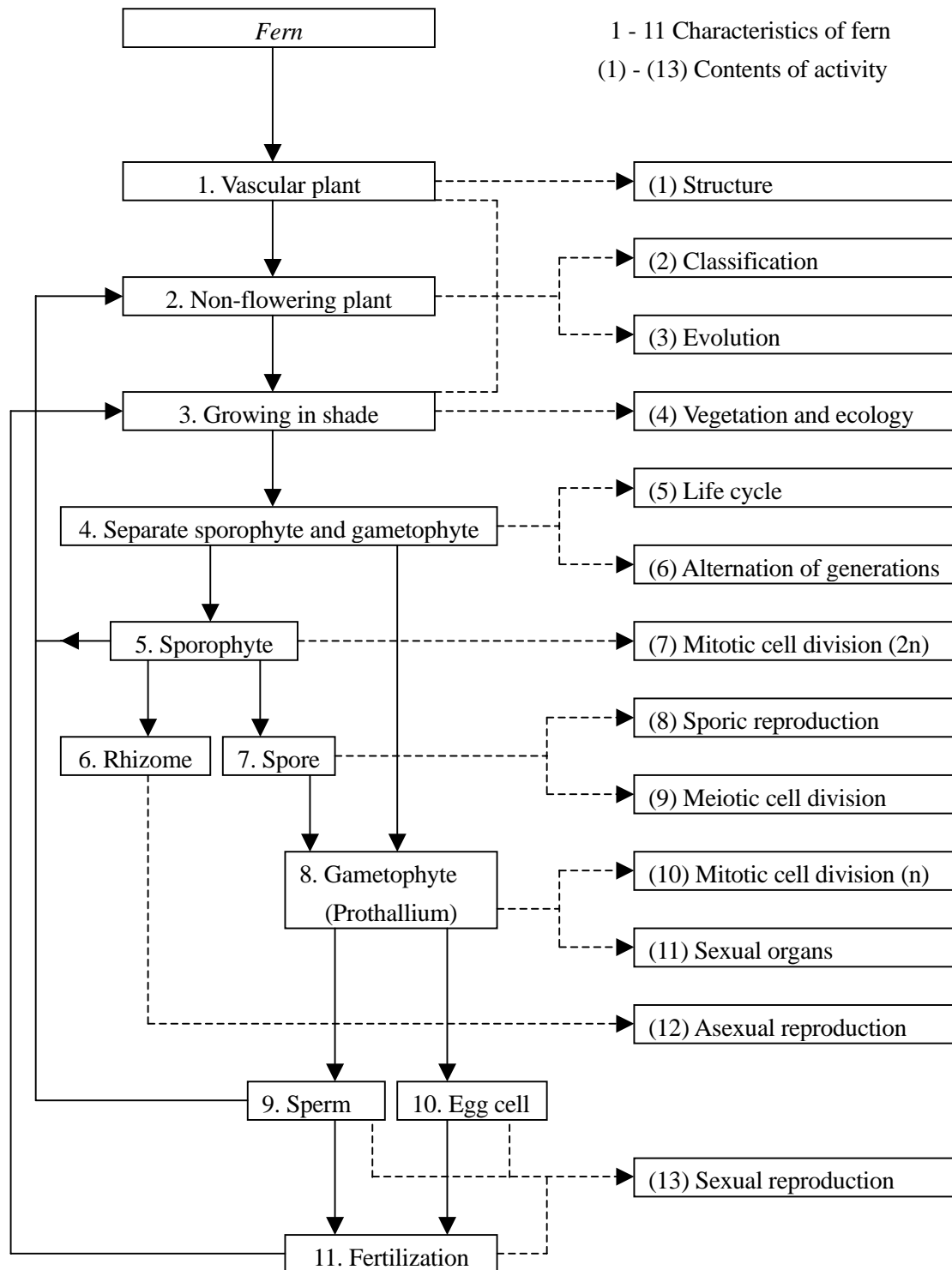


Figure 4 Characteristics of ferns as teaching material

some layers of cells, is embedded in the nucellus and integuments of the ovule. The archegonium and the antheridium of the fern, however, can be observed easily under the microscope. The egg and fertilization process can also be observed by the method mentioned above. It is easy to observe the generations of both sporophyte and gametophyte since they grow separately.

Recently environmental education is becoming important as it reflects contemporary social conditions. The understanding of the ecosystem is one of the important elements in the study of environment. The fern is one of the main plants in forest ecosystems. Although the fern tends to be eliminated in “The Course of Study” in Japan, it should be noted that the fern is a very important plant group to understand terrestrial ecosystems as well as other biological phenomena such as reproduction, life cycle, and the evolution of higher plants. Therefore, in conclusion we would strongly recommend insist that the fern be taught more to students in biology classes.

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**Research Paper**

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## **Fluctuating Asymmetry: An Early Warning Indicator of Environmental Stress**

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### **Abstract**

To ensure sustainable development of our environment, it is important to maintain its health. We, therefore, need indicators or markers that tell us if our environment is stressed even before actual deterioration of its quality takes place. Measuring the physico-chemical changes in an environment is one way of determining environmental quality. However, these usually do not have much meaning unless they are measured in relation to the biological health of the living organisms in that environment. Fluctuating asymmetry appears to be a good bioindicator of the state of environmental quality. This is an easy to do and inexpensive way of determining if the environment is capable of sustainable development. Preliminary data measuring the fluctuating asymmetry of the gill rakers, pelvic fins and pectoral fins of the Nile tilapia, *Oreochromis niloticus* from two lakes in the Philippines indicate that fluctuating asymmetry may indeed be a good bioindicator of the quality of an environment.

**Keywords:** *bioindicator, environmental quality, environmental stress, fluctuating asymmetry, Nile tilapia.*

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### **Introduction**

Van Valen first introduced fluctuating asymmetry as a measure of environmental degradation and developmental stability in 1962. Several researchers later picked up the methodology, but it was Palmer in 1994, who really generated several researches when he came up with his primer. Very recently the group of Lens and Van Dongen (2000, 2002) contributed to refining the statistical analysis

associated with the methodology. They also established the real worth of fluctuating asymmetry as a measure of environmental stress.

A group of Russians led by Zakharov (2001a, 2001b) also firmly established fluctuating asymmetry as the major morphogenetic methodology in measuring environmental stress. They also established five-grade scales for estimating the level of developmental stability and fluctuating asymmetry in several indicator organisms. They recom-

mended that in order to get the total view of environmental stress, all aspects of homeostatic disturbance must be measured. The parameters to be measured are found in Table 1.1 next page.

### What is Fluctuating Asymmetry?

There are three kinds of asymmetry, directional, antisymmetry and fluctuating. As the term implies, directional symmetry (DA) shows skewness towards either the right or the left direction. Antisymmetry (AS) on the other hand shows di-

vergence from symmetry while fluctuating asymmetry (FA) are random differences between the left and right sides of bilaterally symmetrical characters in an organism. The asymmetry therefore fluctuates between left and right and will eventually cancel out each other.

Fluctuating Asymmetry (FA) measurement is based on the following assumptions:

- Identical sets of genes control the development of two sides of a bilaterally symmetrical organism
- Fluctuations are environmental in origin.

**Table 1 Homeostatic disturbances measured to determine environmental stress**  
(Adapted from Zakharov et al, 2001)

Parameters Measured	What It Measures
Morphogenetic homeostasis	Developmental stability
Cytogenetic homeostasis	Chromosome aberrations
Physiological homeostasis	Energy metabolism, growth, photosynthesis
Biochemical homeostasis	Oxidative stress, metabolic products
Immunological homeostasis	Blood cells, antibodies

As the level of environmental stress or instability increases, the ability of the organism to maintain homeostasis at various levels will be affected. Thus, this inability to maintain homeostasis is manifested as deviations from normal symmetry. Increase in the level of fluctuating asymmetry (FA) is therefore shown as a good indicator of environmental stress even before any decline in population number or reproduction occurs (Lens et al, 2002; Lens and Van Dongen, 2002; Oxnevad et al, 2002; Aparicio, 2000; Pelabon and Van Breukelen, 1998).

### How is Fluctuating Asymmetry Measured?

Left-right asymmetries can be measured using two groups of characters: meris-

tic (numerable) characters and plastic or metric (measurable) characters.

For meristic or numerable characters, asymmetry in each organism is determined as the difference in the number of a specific character on the left and right sides. For example, Oxnevad et al (2002) counted three meristic characters in their study of the perch population: the number of gill rakers on the lower first branchial arch, the number of gill rakers on the upper first branchial arch, and the number of pectoral fin rays.

For plastic or metric characters, measuring the left and right sides of a specific character and determining the differences in measurements between the two sides determine fluctuating asymme-

try. Pelabon and Van Breukelen (1998) for example, measured asymmetry in antler size in roe deer.

### Preliminary Data

Our own work with fluctuating asymmetry involves counting the upper and lower gill rakers as well as the pectoral and pelvic fin rays of the Nile tilapia (*Oreochromis niloticus*) from two lakes in the Philippines. Gill rakers aid in the feeding of fishes and they differ in shape and number among different fishes. For example, fishes that eat large prey such as other fishes have short, widely spaced gill rakers while fishes that eat smaller prey have longer, thinner and more numerous gill rakers. Gill rakers are therefore good characters to use as indicators of changes in diet and environmental stress. However, pelvic fin and pectoral fin rays did not show much fluctuating asymmetry and therefore appear not to be good indicators of environmental stress for the Nile tilapia.

Our preliminary data using the four meristic characters mentioned (upper and lower gill rakers, pectoral and pelvic fin rays) of Nile tilapia from two lakes in the Philippines (Laguna and Taal lakes), indicate an FA index of .43 and .4233 respectively. These are taken from the meristic character counts of 75 fishes each from the two lakes. Based on the five-grade scale for developmental stability in fishes recommended by Zakharov et al (2001b), these values fall within the Grade IV level. This means that both lakes already affect the developmental stability of the Nile tilapia. This index is especially significant since this fish is known to be resistant to heavy metal pollution (Aralar and Aralar, 1994).

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**Research Paper**

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**Environment, Resource Sustainability and Sustainable Behaviour:  
Exploring Perceptions of Students in South West Victoria***Anne WALLIS\* and Laurie LAURENSEN**School of Ecology and Environment, Deakin University*

(Received: 5 January 2003; Accepted: 5 September 2003)

**Abstract**

The movement toward a sustainable future has begun in many parts of the world, as the seriousness of the environmental problems faced by the planet become more widely recognised. Waste reduction, improved efficiency of energy use, water saving devices and changes in modes of transport are the first steps in the transition to a sustainable future. The students of today will be the decision makers of tomorrow and, thus, can have a significant effect on future development and the environmental impacts of that development. If students today are to become active participants in the environmental decision-making process, education for sustainability becomes a key component in ensuring sustainable futures. There is a need to establish data describing students' attitudes toward environmental and resource sustainability issues so that challenges to implementing sustainable development policy can be better recognised. The aims of this study were to identify the perceptions of students in the south west region of Victoria regarding environment and resource sustainability, and to identify their level of participation in sustainable behaviours. A survey of students has found that global environmental issues perceived by students as being in urgent need of attention were access to freshwater, loss of tropical rainforest and exhaustion of natural resources. At the local level the most urgent issues identified were water pollution, salinization and soil degradation, and clearing of native vegetation. Students perceive that Australians are overusing natural resources. They indicated particular concern for the sustainability of fossil fuels, water, coastal environments and fisheries resources. The results of this study indicate that students are responding to concerns for the environment and resource sustainability by embracing some forms of sustainable behaviour. However, as educators we need to ensure that the link is made between environment and resource sustainability and the implementation of policies that will further encourage sustainable behaviour.

**Keywords:** *resource sustainability, sustainable development, sustainable behaviour, students and environment.*

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## Introduction

The movement toward a sustainable future has begun in many parts of the world, as the seriousness of the environmental problems faced by the planet becomes more widely recognised. Australia has developed a National Strategy for Ecologically Sustainable Development (Commonwealth of Australia, 1992). In developing this strategy, Ecologically Sustainable Development has been defined as “using, conserving and enhancing the community’s resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased” (Commonwealth of Australia, 1990; Harding, 1998). Empowering citizens to take responsibility for their action in their own backyard may be one way of providing a foundation for moving toward a sustainable future (Friere, 1973; Fals-Borda and Rahman, 1991; Cuthill, 2002). Another will be to ensure the decision makers of tomorrow have a broad understanding of environmental and resource sustainability issues.

It is argued that higher education students are the elite members and decision makers of society (Wong, 2001), and therefore these students will have a significant effect on future development and the environmental impacts of that development. If students today are to become active participants in the environmental decision-making process, education for sustainability becomes a key component in ensuring a sustainable future. According to Fien (1997, p. 25), sustainability education should develop the “critical thinking, reflection and action skills needed to make lifelong decisions about the nature of a better world”. There is a need to establish data describing

student attitudes toward environmental and resource sustainability issues so that challenges to implementing sustainable development policy can be better recognised.

Wong (2001) completed a study of Taiwan university students and their perceptions of environment resources sustainability and green consumerism, but to date, such a study has yet to be completed in South West Victoria. It is therefore the aim of this study to identify perceptions of students at university, TAFE (Technical and Further Education tertiary colleges) and secondary school regarding environment and resource sustainability, and to identify their level of participation in sustainable behaviours.

## Methods

This survey targeted students studying in educational institutions in Warrnambool, south west Victoria. Stratified quota sampling (Robson, 1993) was conducted with samples taken from Deakin University, SW TAFE, and Warrnambool College. A highly structured force-choice questionnaire was pre-tested and distributed to these institutions during October/November 2002. A total of 218 questionnaires were completed and respondents were stratified according to their educational institution and area of study (science or humanities) they were undertaking. Forty-eight percent of respondents were from university, 29% from TAFE and 23% were year 11 school students. One hundred and sixty-eight respondents could be identified by discipline: 64% science and 36% humanities. Data collected was entered into SPSS 11.0 for Windows (software for statistical analysis) and descriptive statistics were employed. Where comparisons were made

between different groups of students, analysis of variance (ANOVA) was used along with LSD post hoc tests to determine where the differences lay. Students were asked to respond

to three main themes: environment, resource sustainability and sustainable behaviour. The questionnaire included questions allowing students to assess the urgency of local and global

**Table 1 Perceived urgency of global environmental issues**

Environmental Issues	Urgency*	Standard deviation
Depleted access to freshwater	4.51	0.79
Loss of tropical rainforest	4.37	0.78
Exhaustion of natural resources	4.28	0.87
Ozone depletion	4.15	0.78
Loss of biodiversity	4.13	0.91
Enhanced greenhouse effect	4.09	0.84
Depletion of fish stocks	4.05	1.07
Fossil fuel depletion	3.9	1.05
Desertification	3.79	1.00
Climate change	3.75	1.03
Acid rain	3.69	1.05

\*Urgency: the degree of urgency as perceived by students on a five point Leichart scale with 1 = not at all urgent and 5 = extremely urgent.

**Table 2 Perceived urgency of local environmental issues**

Environmental Issues	Urgency*	Standard deviation
Water Pollution	4.4	0.78
Salinization and soil degradation	4.14	0.97
Clearing of native vegetation	4.1	0.99
Soil erosion	4.1	0.94
Waste disposal	4.07	0.93
Water allocation	4.07	0.95
Loss of biodiversity	3.89	0.99
Air pollution	3.73	1.16
Urban encroachment	3.65	0.95

\*Urgency: the degree of urgency as perceived by students on a five point Leichart scale with 1 = not at all urgent and 5 = extremely urgent.

environmental issues; to demonstrate what they understand sustainable development to be and what development options they think might be appropriate to achieve this goal; and to indicate their levels of participation in environmental activities and sustainable behaviours.

### **The Urgency of Environmental Issues**

The pursuit of economic development has resulted in environmental consequences at both the national and global levels. Human activity has created a diversity of problems including ozone depletion, loss of forested area, resource depletion, loss of species, increasing levels of carbon dioxide and pollution of our waterways. In this study students were asked to consider 11 global and 9 local environmental issues and to assess the urgency with which they felt each needed to be addressed. The urgency of these issues as perceived by the students is presented in Tables 1 and 2. Overall, the students indicated a sense of urgency for all of the issues presented.

Students involved in this study identified depleted access to freshwater, loss of tropical rainforest and exhaustion of natural resources as the most urgent environmental issues that need to be addressed at the global level. Eighty-nine percent of students identified depleted access to fresh water as very urgent, 87% identified loss of rainforest as very urgent, and 83% identified exhaustion of natural resources as very urgent.

Water pollution, salinization and soil degradation, and the clearing of native vegetation were identified as the three most urgent environmental issues that need to be addressed at the local level. Eighty-nine percent of students identified water pollution as very urgent,

79% identified salinization and soil degradation as very urgent, and 76% identified clearing of native vegetation as very urgent.

The south west region of Victoria has suffered extensively from agricultural development resulting in a number of easily identifiable environmental problems. High quality freshwater is an important natural asset, which in south west Victoria is being threatened by pollution, run-off from agricultural activities, erosion and overuse. Students recognize the importance of good water resource management as vital to the local region. Australian soils are generally infertile and salinization of the soil is one of Australia's major land degradation problems (Conacher and Conacher, 2000). In southwest Victoria salinity is impacting heavily on agricultural production, as well as environmental, heritage and infrastructure assets (Glenelg Hopkins Catchment Management Authority, 2002). The Australian Dryland Salinity Assessment 2000 indicates the south west is a high hazard risk area for dryland salinity (National Land and Water Resources Audit, 2001). It is therefore not surprising that students perceive this as a local issue that urgently needs to be addressed.

Rapid and extensive landscape modification has occurred in Australia since Europeans arrived 200 years ago (Hobbs and Hopkins, 1990). This is particularly so in western Victoria where the removal and fragmentation of native vegetation has led to major reductions in wildlife habitat, erosion and salinization (Glenelg Hopkins Catchment Management Authority, 2002). This is an issue recognized not only by students as needing to be addressed but by government agencies, landholders and the general community who are embracing revegetation projects in rural communities.

The results shown in Tables 1 and 2 demonstrate that students in the south west are concerned about environmental issues at both the local and global level. Most interesting was their concern for water:

- 89% of students identified depleted access to freshwater as very urgent;
- 89% of students identified water pollution as very urgent; and
- 72% identified water allocation.

These results reflect the problems we are facing in Australia with regard to water allocation and this no doubt is being reinforced by the current drought conditions being experienced.

### Understanding 'Sustainable Development'

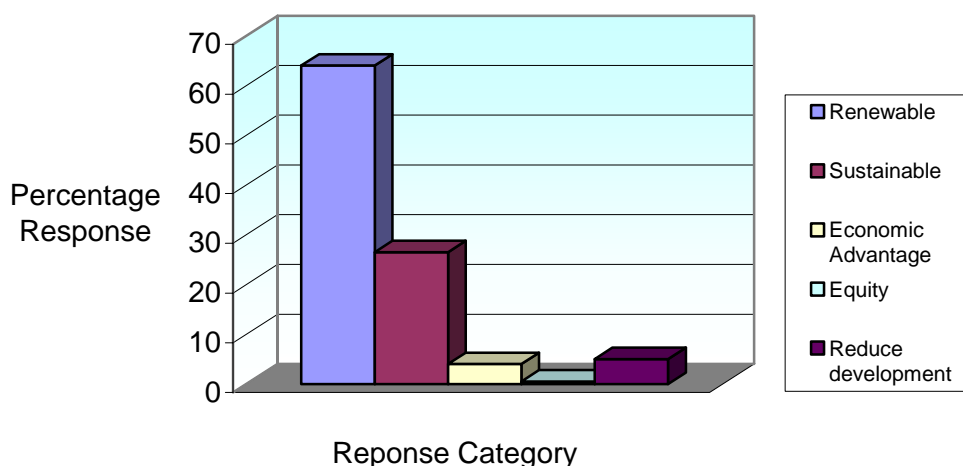
In Australia, the National Strategy for Ecologically Sustainable Development, 1992 provides the framework for encouraging sustainable development. The principles and core objectives of Ecologically Sustainable Development are cited in Australian govern-

ment policies, industry guidelines, community strategies and legislation (Harding, 1998). However, no such strategy can be completely successful without public support. This requires informed citizens, be they politicians, administrators, members of the private sector, people in the street or students studying in schools and tertiary institutions.

The questionnaire asked students to demonstrate their understanding of resource sustainability by selecting, from five alternative statements (Table 3), the one that they felt best described sustainable development. As can be seen in Figure 1 the majority of students selected alternative A. This demonstrates that their understanding of sustainable development equated with that of renewable resource replacement (the old idea of sustainable yield), rather than the more complex idea of using resources without compromising resource availability for future generations (alternative B). Lack of familiarity with and/or misunderstanding of sustainable development can act as a barrier to the implementation of Ecologi-

**Table 3 The five alternative descriptions of sustainable resource use presented to students for determining their understanding of sustainable development**

<p>Which of the following statements best describes your understanding of sustainable development.</p> <p>A. Resources should be used at such a rate that there is time for them to be naturally replenished. (<i>renewable</i>)</p> <p>B. Resource use should be such that future generations' use of resources is least compromised. (<i>sustainable</i>)</p> <p>C. Resources are used to gain maximum economic advantage. (<i>development</i>)</p> <p>D. Resource use is equitable between different social groups. (<i>socialist</i>)</p> <p>E. Resources should be reduced even if this means there is no economic development.</p>
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**Figure 1 Students understanding of sustainable development as shown by their selection of alternative descriptions presented**

cally Sustainable Development.

It is not surprising that students demonstrate some confusion interpreting the term sustainable development, as there are a plethora of definitions and perspectives that can be found in the literature. Although there are a variety of approaches to understanding sustainable development, it is generally agreed that it should ensure that development pursued will ‘meet the needs of the present without

compromising the ability of future generations to meet their own needs’ (Brundtland, 1987). One of the challenges for educators will be to take account of the varying perspectives and provide an interdisciplinary approach to sustainable education.

**Strategies for Sustainable Development**

There is a growing concern that human

**Table 4 Student support for future development options**

Strategies for Sustainable Futures	Agree	Unsure	Disagree
Australians are overusing resources	<b>64%</b>	25%	11%
● Economic growth despite the environmental and social costs	24%	17%	<b>59%</b>
● More environmental protection policies above economic growth	<b>58%</b>	27%	15%
● Investment in environmental protection above social welfare	32%	<b>46%</b>	22%
● Encourage lifestyle change	<b>66%</b>	19%	15%
Australian students are prepared to change their lifestyle to ensure resource sustainability	<b>42%</b>	34%	23%

economic activity has resulted in environmental problems across the globe, however, there is a reluctance to modify activities that are causing these problems (Beder, 1993) and to develop the strategies required to address them. Economic growth is still central to government policy in Australia. Yet Ecologically Sustainable Development will require that the economy be managed without compromising social well-being or the environment's ability to support biodiversity and to maintain ecological life support services.

In this study, as shown in Table 4, 64% of students indicated that they considered Australians are overusing resources. This is driven by the materialistic nature of the Australian society in which unnecessary consumption is driven by advertising (Harding, 1998) and by the idea that economic growth is good. To ensure a sustainable future, compromise will be required between the development options available, for example, economic growth, equity, and environmental protection.

According to student responses, economic programs should not be given priority over social and environmental programs. Fifty-nine percent of students did not agree that economic growth should be sought despite social and environmental costs. In fact they indicated that environmental programs should have priority over economic growth, but they were less certain about balancing social and environmental options. Two third of the students supported individuals being encouraged to change their lifestyle and yet they were not so certain about student preparedness to make such lifestyle changes.

Students seem to believe that a reorientation of development strategies away from economic growth and toward environmental

and social well-being is required to ensure sustainable development. Students are willing to compromise economic options in favour of environmental programs, but they are uncertain about where the social options fit in.

### **Taking Action and Behaving Sustainably**

Concern for the environment and resource sustainability can be addressed through citizens taking individual action. The results of this study indicate that students have developed positive attitudes toward the environment, and this is reinforced by their level of participation in actions that protect or enhance environmental quality.

As can be seen in Figure 2, the environmental activity in which students in southwest Victoria are most likely to have participated is tree planting. This type of activity is often encouraged in Victorian schools and hence it can be anticipated that students who have attended schools in Victoria may have had the opportunity to be involved in such environmental action.

Landcare Australia, a volunteer organization, also provides easy opportunities for the community to become involved in tree planting programs. Students also show high participation rate in volunteering for environmental management activities. There are numerous such activities that are accessible to students through groups such as Landcare, Coastcare and Junior Naturalist Clubs. The actions in which students are least likely to have been involved in are contributing to an environmental newsletter or becoming a member of an environmental group.

When comparing the action of students from different institutions it was found that

TAFE students were significantly more likely than university and secondary school students to have been a member of an environmental group ( $p=0.041$  and  $p=0.003$  respectively) and to have made a contribution to an environ-

mental newsletter ( $p=0.012$  and  $p=0.008$  respectively). TAFE students are significantly less likely than university students to have been involved in tree planting ( $p=0.042$ ) but significantly more likely than school students

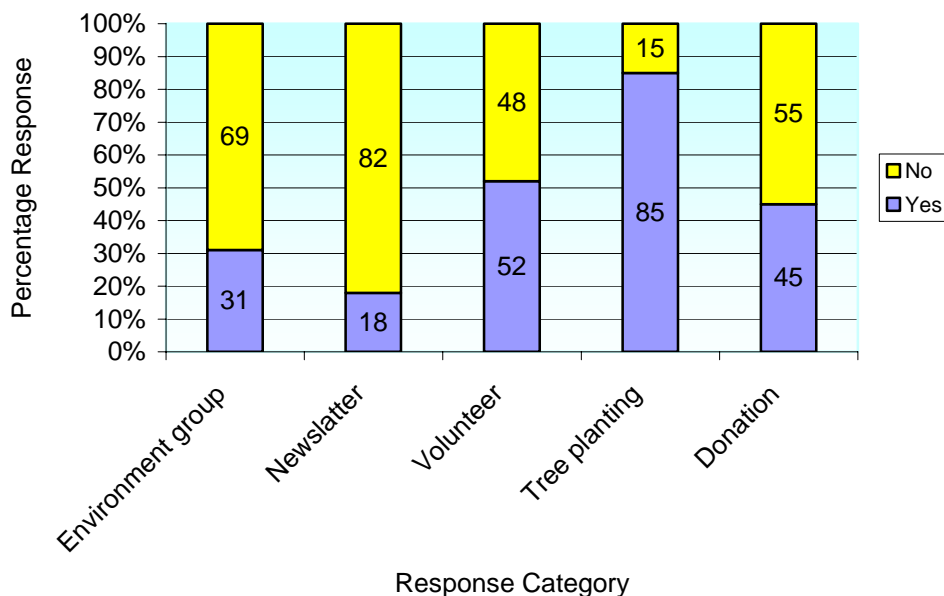


Figure 2 Student participation in environmental action

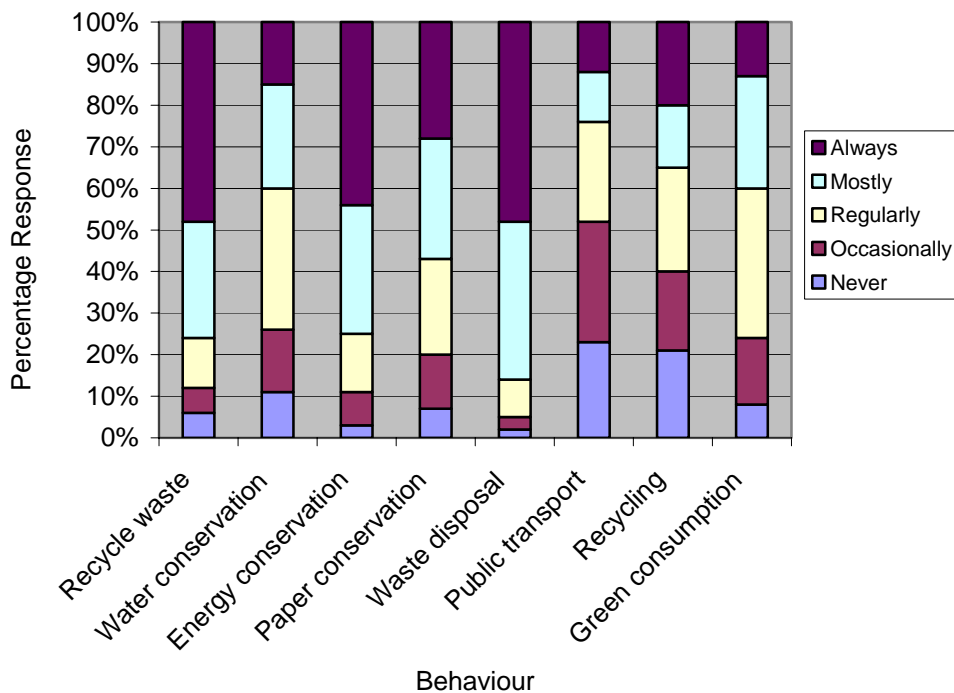


Figure 3 Student patterns of sustainable behaviour

to have made a donation to an environmental group ( $p=0.011$ ). This reflects that differences do occur between the different cohorts of students at the different institutions.

One of the challenges facing our society is the adoption of behaviours that will foster sustainable development. This will require changes in lifestyle so that we do not outstrip the earth's ability to cope with the demands of humanity. In a number of ways students in south west Victoria are demonstrating changes in behaviour that will foster sustainable development. The majority of the students dispose of their litter appropriately, separate waste for recycling and display energy conservation by turning off lights when vacating a room (Figure 3). This indicates that students have some knowledge of behaviours that reduce their environmental impacts and resource use and perceive the benefits of such behaviours. Students are least likely to use public transport. This most likely reflects the barriers to using such transport, particularly in the south west region. Where we can reduce the barriers to sustainable behaviour (lack of knowledge, access difficulties, etc.) then it is more likely that sustainable behaviours will be adopted (McKenzie-Mohr and Smith, 1999).

No significant difference in the behaviour patterns declared by students was found between the different educational institutions.

## Conclusion

The Australian Government's discussion paper on Ecologically Sustainable Development (Commonwealth of Australia, 1990) recognises community concern that "in pursuing material welfare, insufficient value has often been placed on the environmental factors that

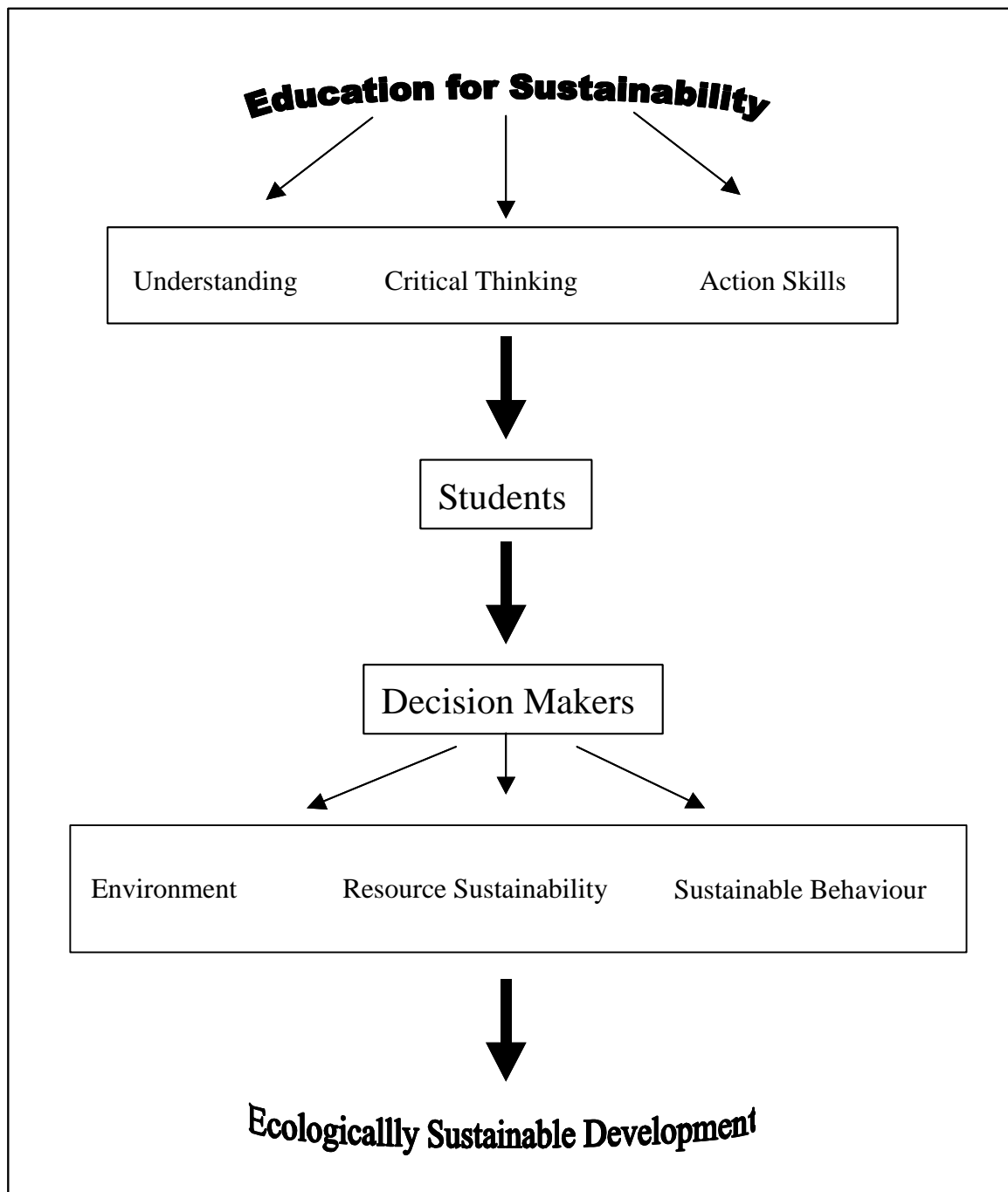
also contribute to our standard of living." In moving toward ESD, a reorientation of policies and practices will be required to address the environmental degradation problems being experienced. It is generally agreed that this will only be achieved if the managers and policy makers of the future have a breadth of knowledge, understanding and multidisciplinary skills to cope with the challenges of sustainable development (Hailey, 1998; Wong, 2001).

This study demonstrated that students attending south west Victorian educational institutions are concerned about global and local environmental issues and consider that there is an urgent need to address these. They recognise the need to reorient strategies from an economic emphasis toward environmental protection and the need for Australians to accept changes in their lifestyle in order to ensure sustainable resource use. These results are comparable with the results found for students in Taiwan by Wong (2001). Although the global and local issues identified by students in the different countries differed, both cohorts of students expressed an urgency about these issues, they indicated a need for a fundamental shift in development strategies and declared that they are backing up this concern with action that includes adopting more sustainable behaviours.

Educators can be encouraged by student attitudes toward environment and resource sustainability. However, attention needs to be given to ensuring students have a clear understanding of sustainable development such that they can analyse environmental and resource sustainability issues and assess the appropriateness of development strategies. Within each discipline area, education for sustainable

development will require openness to new ideas, taking on an interdisciplinary approach and recognition of the importance of non-exploitive values and ethical norms. As summarised in Figure 4, education for sustainable development should ensure students

are provided with the understanding, are encouraged to critically analyse a changing environment, and are armed with action skills that in the future will allow decision makers to be environmentally responsible, select development options that use resources sustainably,



**Figure 4 Education for sustainability must equip students with the skills to make future decisions that will foster sustainable development**

and encourage sustainable lifestyles.

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**Research Paper**

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## **Current State of Nature Experiences Activities and Nature Schools in Japan with Special Reference to Educational Reform**

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### **Abstract**

In Japan today, the importance of nature experiences activities (NEA) has been recognized in school and social education. Recently, about 1000 Nature Schools (NSs) have come into existence in Japan. Most of the NSs have a function to provide opportunities for NEA for the general public, especially for the young generation. This paper presents a brief discussion on the reasons why the number of NSs is recently increasing in Japan and on the current state of NSs. The work was conducted along the following lines: (1) Brief summary of educational reform; (2) Present situation of the relationship between Japanese children and NEA; (3) Current state of NSs in Japan.

**Key words:** *Educational reform, environmental education, five-day school week system, nature school, nature experiences activities, period for integrated study, zest for living.*

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### **INTRODUCTION**

In Japan today, the importance of nature experiences activities (NEA) has been recognized in school and social education. The term social education in Japan refers to all forms of organized educational activities done outside the range of educational activities conducted as part of a school curriculum (<http://www.mext.go.jp/english/org/social/06a.htm>, 2002/07/26).

This article holds the view that NEA stud-

ies, nature studies, rural studies, field work, environmental studies, outdoor education and adventure education seem almost self-explanatory, being a group of approaches to education that share a focus on environmental experiences (Palmer 1998).

Palmer (1998) states that in the early days of “nature” and “rural” studies, emphasis was very much on teacher-directed “show and tell” techniques. In more recent years, fieldwork and environmental studies have encompassed more of what might be described as participa-

tory, problem-solving techniques, but with a strong emphasis on scientific approaches involving detailed observation, measurements, and the gaining of empirically derived knowledge. Outdoor and adventure education are broader in scope and encompass outdoor activities in which students engage with the environment, such as canoeing, hiking and climbing. They aim to provide opportunities that encourage enjoyment, appreciation and awareness of the environment. Those working in the outdoor and adventure education fields strive to help change attitudes by exposing young people to new and relevant experiences which will lead to a better understanding of themselves as well as their environment. Such activities often operate from centers or specialist bases, rather than schools. In this article, we call such a center a Nature School (NS).

Recently, about 1000 NSs have come into existence in Japan. Most of the NSs have a function to provide opportunities for NEA to the general public, especially to the young generation.

This paper presents a brief discussion on the reasons why the number of NSs is recently increasing in Japan and on the current state of the NS. The work was conducted along the following lines :

- (1) Brief summary of educational reform in Japan.
- (2) Present situation of the relationship between Japanese children and Nature Experiences Activities.
- (3) Current state of Nature Schools in Japan.

## MATERIALS AND METHODS

Most of the data concerning the educa-

tional reform were obtained from home pages of the Ministry of Education, Science, Sports and Culture (MEXT) as follows:

<http://wwwwp.mext.go.jp/eky2000/index-1.htm> (2002/06/12)

<http://www.mext.go.jp/english/org/reform/03.htm> (2002/06/14).

Several NSs' data were obtained from their home pages and pamphlets.

The information on the current state of the NSs in Japan was given from the Report on Outdoor Education Programs of Private Organizations (The Outdoor Education Society 1999).

## RESULTS AND DISCUSSION

### 1. Brief summary of educational reform in Japan

“Why is educational reform necessary now?” has been published by MEXT's home page as follows :

Today, as we stand before the dawn of the 21st century, Japan is seeing the rapid advancement of an aging society with a dwindling birth rate, the information society and internationalization. In addition, economic activities, which had been consistently increasing and developing during the postwar period, now have long been at a standstill, employment issues are worsening and other problems are emerging. Therefore, we are now said to be gearing toward a new phase of reform following the Meiji Restoration and the revival during the period after the Second World War. Consequently, bold reforms have been moved forward as existing systems are reviewed across various sectors of society, including politics, administration, finance and economic structure.

In the field of education, the cornerstone of all social systems, there is a need to move forward actively and swiftly with spearheading reforms befitting a new age while being based on the results of education to date.

Since the end of the Second World War, education in Japan has been conducted under the fundamental ideology of realizing equal opportunity in education, in which opportunities for education are equally assured in accordance with capability, aptitude and will, and regardless of birth, household income or class status. It has spread remarkably, promoted by the nationality that set great store by education and the improvement in income levels of the Japanese people to among the highest in the world. The remarkable dissemination of education itself has served as the engine for what we now can refer to as Japan's miraculous development.

At the same time, a dwindling birth rate, the trend toward nuclear families and the advancement of urbanization have led to a striking decline in the educational functions of the home and local community which had always shouldered the responsibilities of teaching children how to behave with people, cultivating self-discipline and collective spirit, and passing on culture and traditions. Such circumstances have formed a backdrop against which various problems have emerged, including bullying, non-attendance at school and the worsening issue of juvenile delinquency. Moreover, school education to date has fallen into a form by which knowledge is one-sidedly instilled in students, thus leading to the neglect of education and activities that cultivate thinking faculties and an enriched humanity. In addition, with the excessive emphasis placed on equal opportunities in education, the con-

cept of education in accordance with the essentially diverse individuality and capabilities of each and every child has not been taken into full consideration. These are many points upon which we must reflect.

On the other hand, if one casts a glance around the rest of the world, education reform has become one of the most important common challenges facing developed countries, and at the G8 Summit held in Cologne, Germany, in June 1999, education was raised for the first time as a major topic and active discussion was conducted (<http://www.mext.go.jp/eky2000/index-4.html>, 2002/06/12).

The 15th session of the Central Council on Education started in September 1995. The first report was issued in July 1996. In this report, entitled "The desirable shape of Japanese education in the perspective of the 21st century," it is stated that against the framework of severe and turbulent social change, there is a need for children to be imbued with a "Zest for living," in other words, "To have the abilities and aptitudes required to identify issues, learn for themselves, think independently, make their own judgments, act independently and work toward better solutions."

Also "while standing on their own feet, to cooperate with others and develop a rich fund of emotions and a spirit that shows considerations for and sympathy toward others;" also "to develop a healthy body that will enable them to lead a strong and vigorous life" (Kozawa 1998).

In order to promote Zest for Living, the NEA is vitally important and effective. Therefore, in July 2001, both the school education law (Article 18-2) and the social education law (Article 5-12) were revised and the following phrase was added: to try to enhance experi-

enced study activities including the NEA and social service through volunteer activities of children and young people.

In addition, MEXT is implementing measures such as (1) providing opportunities to engage in a variety of outdoor activities, such as long-term stays of about two weeks at outdoor activity facilities or family farms, environmental conservation activities in national parks, and other outdoor activities at rivers, seas, and forests, (2) promoting hands-on activities to foster sociability such as community service activities and hands-on activities that target troubled youth through schools and communities, (3) expanding the Children's Dream Fund, which assists private sector youth organizations that sponsor hands-on activities and other programs, (4) providing opportunities and venues for a variety of hands-on activities for young people as well as training instructors at the National Olympic Memorial Youth Center and youth educational facilities such as National Youth Nature Houses and National Youth Houses throughout the country, and (5) assisting youth organizations that play an important role in sponsoring various activities for young people

A New system in Japanese school life, that is, the Comprehensive Five-day School Week System, started in April, 2002. It aims at letting the children spend more time free from pressure at home and in the communities and engage in social contribution activities and nature oriented experiences to nurture "Ikiru Chikara" in Japanese (zest for living) in their daily lives including the abilities to learn and think by themselves, rich humanity, and healthy development and physical strength to lead vigorous lives. This system should be realized only with mutual cooperation among

schools, families, and communities with their respective skills in education.

In 1994, the MEXT conducted a survey on "Concerns for five-day school week system."

Parents of elementary school were asked "What activities do you think should be emphasized at elementary school?" The result was hands-on activities 74%, environmental education 37%, health education 33%, volunteer activities 27%, international understanding 26%, education corresponding to IT society 20%, other 1% (Eda 1999).

MEXT is also implementing "Comprehensive Promotion of Educational Abilities and Experience Activity Programs in the Communities" as follows:

Besides schools, homes and communities are requested to work together to act out their own roles to develop the neighboring environment suitable for raising children and to improve the approaches to nurture them to be emotionally sound and tough. For the purpose of activating the community educational abilities, nurturing the humanity of young people including sociality and compassion, MEXT establishes the nationwide system and supports schools and communities for the activities to give youth more abundant opportunities to have a variety of activities, including social service such as volunteer activities inside and outside schools, as well as nature-oriented experiences.

From the beginning of the new school year in 2002, a new curricular system, "Period for Integrated Study (PIS)" started. The new system is a required subject for elementary to upper secondary school levels. Annually, 105 or 110 school hours are allocated to PIS for 3rd, 4th, 5th and 6th graders at elementary school

and more than 70 school hours for lower secondary school students, 105-210 hours for upper secondary school students (Kimura 2001).

The PIS aims at helping children develop the ability to discover problems by themselves and solve those problems properly. Interdisciplinary and comprehensive studies, which reflect each individual school's efforts, and studies based upon children's own interest will help children independently and creatively cope with problem-solving activities and/or inquiry activities, and deepen their understanding of their own way of life. It is assumed that children's knowledge and skills acquired in individual classes will be related to each other and deepened through the activities in the PIS, and that they will work comprehensively for children (Kimura 2001).

In order to introduce the five-day school week system and the PIS, MEXT reduced learning contents by 30% and shifted that content to upper grades. So, some citizens and scientists are anxious that the academic ability of Japanese children may be lowered due to the reduction of the content taught to children through the revision of the Course of Study (national curriculum standard and guidelines for teaching).

MEXT's answer to this anxiety is as follows: the amount of total knowledge they acquire will be lower, but we aim to firmly establish basic abilities and skills through the respective studies in a flexible school life, and to cultivate in children the desire to learn by themselves and to teach children study methods, maintaining the existing standards of educational content at the upper secondary school level in order to prevent the lowering of academic ability.

## 2. Present situation of the relationship between Japanese children and nature experiences activities

The Youth Education Activity Research Group conducted a comparative survey of lower secondary school students with regard to their outdoor experiences in 1984 and 1995 (Eda 1999).

The questions were "Have you ever ----"

- Climbed a mountain higher than one thousand meters?
- Picked fruits, nuts or mushrooms to eat?
- Seen a sunrise or sunset?
- Fished?
- Climbed a tree taller than your height?
- Caught a butterfly or a dragonfly?
- Slept in a tent? "

"Yes" decreased for every question in 1995 compared to 1984.

The Japanese educational system is drastically changing through the educational reform, and nowadays as the aging society come rapidly, we must make our life plan for a long span of 80 to 85 years rather than 50 years in the past (Kozawa 1998). As a result, we need "lifelong learning." MEXT explains lifelong learning as follows: the maturation of Japanese society, as evidenced by expanding leisure time, and the aging of the population, is reflected in increasing demand for learning activities that contribute to spiritual enrichment and enjoyment of life.

From a consideration of the above-mentioned results, it may be concluded that the reasonable factors for the increase in the number of NSs in Japan are educational reform, the maturation of our society, and the decrease in the number of children who have NEA.

Currently, a large number of Japanese people consider NS very useful and important for

implementing educational reform and for increasing the number of children who have nature-oriented experiences, NEA.

### 3. Current state of Nature Schools in Japan

The Outdoor Education Program Society conducted a survey to gauge the current status of Japanese NSs and published the report on the present program of public or private organizations engaged in the outdoor education in 1999. The purpose of the survey is to obtain the basic data for developing a new standard program adapted to outdoor education in the 21st Century. The questionnaires were distributed to the representative 118 organizations and individuals, not including YMCA, YWCA, National Camping Association of Japan, Scout Association of Japan and Japanese Association of Recreation.

Fifty three percent of those questioned responded. The respondents were mainly specialists of public organizations, NGOs and NPOs engaged in the development of NEA.

A brief summary of the questionnaire results is as follows:

#### (1) Distribution of Nature Schools in Japan.

Thirty seven percent of NSs were located in Tokyo.

#### (2) Type of administration at Nature Schools in Japan.

The results are as follows:

- a) NS has become independent of the mother company, or joint-stock company and has been managed as a profit-pursuing organization (28.8 %).
- b) NS has been managed as an individual company (22.0 %).
- c) NS has been managed as an arbitrary NPO or NGO (20.3 %).

d) NS has been managed as a public service corporation such as a foundation (13.6%).

e) NS has been managed as a profit-pursuing section of the enterprise such as a limited company (6.8 %).

f) NS has been managed as a nonprofit-pursuing section of the enterprise (3.4 %).

g) NS has been managed as a public facility business (1.7%).

h) Others

#### (3) Do you have your own facilities and fields for nature experiences activities?

Fifty one percent of the respondents answered "Yes."

#### (4) Do you have accident insurance for the participants?

Ninety five percent of the respondents answered "Yes."

#### (5) Do you have liability insurance for the participants?

Eighty three percent of the respondents answered "Yes."

#### (6) What kind of program for NEA do you have?

Over 150 items from programs were generated. Representative items of the programs are shown in Table 1.

#### (7) Costs for nature experiences activities.

Thirty nine percent of the respondents answered that a two-day course (nightly rate) is ¥ 11,000 (US\$ 88) on average and ranges from ¥ 6,000 (US\$ 48) to ¥ 15,000 (US\$ 126).

As a result of the questionnaire survey, a complete image of Japanese NSs and their current state have roughly come into view.

**Table 1 Program for Nature Experiences Activities in Nature School - Best 20 -**

<b>Rank</b>	<b>Category of program items</b>	<b>No. items used</b>
1	Ice-breaking game	20
2	Camping	19
3	Camp fire	18
4	Nature game	17
4	Group work training	17
6	Initiative game	16
6	Hiking with nature observation	16
8	Nature craft	15
9	Night hiking	13
10	Mountain climbing	12
11	Canoeing	10
11	Stone painting	10
14	Alpine skiing	9
14	Town watching	9
14	Meditation	9
14	Camping on the snow	9
18	Slide program	8
18	Camping solo	8
18	Nature skiing	8
18	Observation of constellation	8

The number of NSs has surely increased in comparison with that of 10 years ago; however, there are several problems with the present NSs in Japan.

First, although items in the NEA program were not investigated qualitatively in the survey, it is necessary to perform a qualitative guarantee of the educational content of the NEA program. Most of the NSs in Japan maintain very poor standards in their NEA programs and cannot be compared with the NSs of Australia, New Zealand, Canada, South America, Europe or the USA. In Japan, the Council for Outdoor and Nature Experiences (CONE) was founded in 2002 as an NPO, and

it includes about 150 organizations which are interested in environmental education through NEA. The main purpose of CONE is to develop a standard curriculum and manual for leaders involved with NSs. In order to solve the above-mentioned problem, the activity of CONE is very important and useful.

Secondly, we do not have a so-called market price for the program that a NS has to offer. In Japan, a NS is not yet approved socially as a business. We have to make efforts to construct a social system which can correctly value and reward the quality of the program.

From now on, it will be necessary for NSs in Japan to seek customers' opinions of the

quality of the organization's products (NEA programs) and services, and to build up mutual cooperation and allot roles to social education directors, librarians of the public libraries, museum curators, leaders of parent-teacher associations, youth associations, and other private-sector social education bodies at the national, prefectural and regional levels.

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**Research Paper**

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## **Development of Teaching Material Using a Cellphone to Connect to the Internet - For Collecting Liverworts to Use Them for Observation Activities in the Classroom and in the Field**

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### **Abstract**

Recently, teachers have begun to focus on web teaching materials that would be effective in class activities. So, we have developed web teaching material which is accessible by a cellphone through the Internet. It helps teachers and students to collect liverworts in the field. We could refer to the following four advantages of the teaching material for cellphones. 1) Possibility of collecting liverworts throughout the year, 2) Possibility of using the teaching material anywhere, even in field activities, 3) Relation to classroom activities, 4) High accessibility for teachers and students. We compared this teaching material for cellphones with the other teaching materials. We found other advantages and disadvantages to it. As for advantages, the cellphone is easy to carry, teachers and students are able to exchange information and research data anywhere, and they can use the material provided in the classroom or in field activities. One of the major disadvantages is the limited memory of cellphones to download a heavy page from a web site. In addition, as the markup languages have not yet been standardized among Japanese cellphone companies, we needed to develop different file adapted to each different cellphone company.

**Key words:** *Cellphone, development of teaching material, field activities, Internet, liverworts*

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### **Introduction**

Teachers have recently begun to focus on teaching materials that would be effective in class activities using computers. There are

various precedent studies in biological education on using computers in class activities. Development and implementation of a database in reference for seed plant identification revealed some good results (Ohkawa 1997, 1999,

2000, 2001-02, Ohkawa and Okazaki 2001). The software "Scientist Library" developed by Mitsuishi *et al.* (1999) can give teachers and students some information about Japanese biology researchers. Provision of teaching material through the Internet is another good example. Nowadays, almost all teachers can use many web sites on the Internet in class activities for obtaining information and research data. These sites are made and opened by laboratories, companies, teachers and students.

There have been some studies on biology education through the Internet such as the provision of material for teaching the reproduction of plants on a web site (Ohshika and Ikeda 1997), and the assessment of developed web teaching materials (Ohshika *et al.* 2001). The advantages of developing and using web teaching materials are as follows: Ease of content renewal, simultaneity in teaching and learning, and interactivity of releasing and receiving information (Ohshika *et al.* 2001).

However the use of computers in class activities is restricted. For example, since the costs for purchasing and maintaining computers are still expensive for schools, most activities are limited to classroom or computer room. The Japanese government has provided with a few dozen of computers in computer room for all of the public schools, and teachers can use them in their teaching activities. Recently, the government has started to set some computers in each classroom and to link them to Local Area Network (LAN). But, we consider that some activities are still limited to the exchange of information.

Meanwhile, as a social trend in Information and Communication Technology (ICT), laptop computers and Personal Digital Assistant (PDA) are spreading in developed countries.

In 1999, NTT DoCoMo, Inc. (one of the companies providing cellphone service in Japan) started the service of connecting cellphones to the Internet. Nowadays, this service is offered by the other cellphone companies in Japan. The cellphone has spread rapidly among Japanese secondary school students. They are using cellphones as their main tool of telecommunications (conversation and e-mail).

Some web teaching materials for cellphone have been developed for science education, such as simulation of chemical reactions ("i-mode Kagaku" [http://www2d.biglobe.ne.jp/~chem\\_env/i/](http://www2d.biglobe.ne.jp/~chem_env/i/)), the encyclopedia of birds ("Mijikana Toritachi" <http://www.pleasuresky.co.jp/hi/nature/bird/>), etc. But, some of these teaching materials are not yet designed well enough to match the classroom environment.

We have developed teaching material for cellphones on a web site for collecting liverworts. Teachers and students can collect different kinds of liverworts in the field by accessing the web site by cellphone and by comparing their characteristics.

## Materials

We selected six common species of liverwort: *Marchantia polymorpha*, *M. paleacea*, *Dumortiera hirsuta*, *Reboulia hemisphaerica*, *Conocephalum conicum*, *C. supradecompositum*.

## Development and composition of our teaching material

In Japan, there are three main companies providing cellphone service. They are "NTT DoCoMo, Inc," "J-PHONE" and "KDDI CORPORATION." The names of their Inter-

net services for cellphone are “i-mode<sup>®</sup>,” “J-sky” and “ez-web,” respectively. Each of them is made up of different markup language and has a different format system of displaying image files. Furthermore, the upper limit of memory per page of web site is different. Therefore, we needed to make three different files of our teaching material to adapt to each Internet service.

Before we developed our teaching material as these three files, we examined the markup languages adopted by each company (Table1). “NTT DoCoMo, Inc.” has adopted C-HTML (Compact Hyper Text Markup Language). It is a simplified version of HTML (Hyper Text Markup Language) that is usually used for making web sites for computers. “J-PHONE” has adopted MML (Mobile Markup Language) which can run on HTML. For “NTT DoCoMo, Inc.” and “J-PHONE,” we could use the software “Notepad” for making our web teaching material. On the other hand, “KDDI CORPORATION” has adopted HDML (Handheld Device Markup Language). HDML is not compatible with HTML, and therefore

we had to use the software EZ@EZ (ver.1.0-c) for cellphones from this company.

The contents of our web teaching material were composed of original image files (photographs and sketches), explanations and link buttons. Taking the monitor size and limited memory of cellphones into consideration, we reduced the contents of each image files to be as simple as possible.

### How to use our web teaching material

When teachers and students connect their cellphones to the Internet and access our web teaching material (Fig. 1), they can refer to the “Front page.” Then, they can acquire some information about the identification of liverworts. After that, they can proceed to “Shall we find Marchantiales?” where there are two link buttons: “1 = From photographs” and “2 = From reference.” Depending on which link button the users choose, they can proceed to the next page where they can identify liverworts using either a photograph or a reference key.

**Table 1 Comparison of the characteristics of cellphones among the 3 main companies in Japan**

	Corporation		
	NTT DoCoMo, Inc.	J-PHONE	KDDI CORPORATION
Internet service	i-mode <sup>®</sup>	J-sky	ez-web
Markup language	C-HTML	HTML MML	HDML
Image format	BMP*	PNG**	PNG**
Upper limit of memory per page	10KB	6KB	---***
Cost for downloading our teaching material	¥180	¥150	¥60

\*Bitmap, \*\*Portable Network Graphics, \*\*\*The data was not indicated by this company

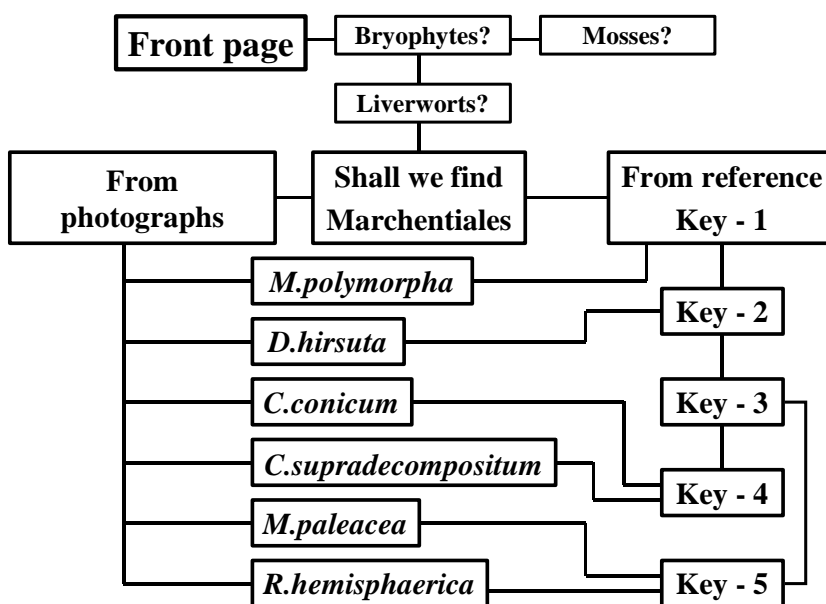


Figure 1 Composition of our teaching material for cellphones

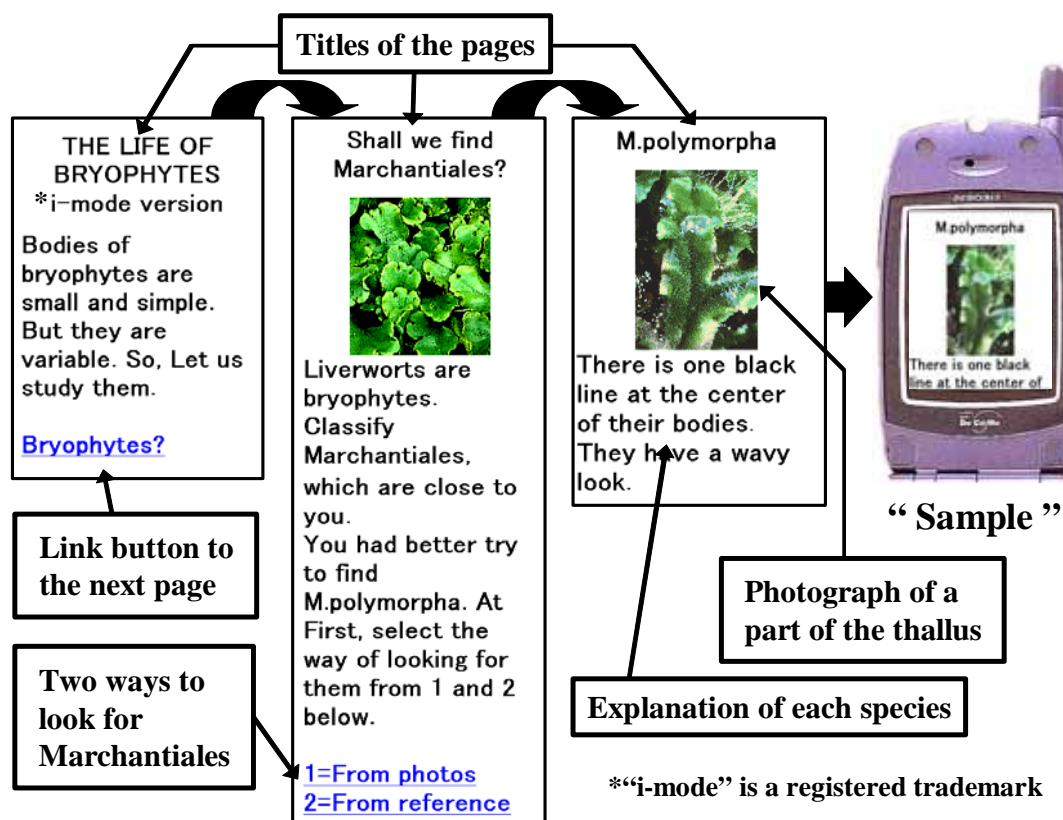


Figure 2 Mobile version of “THE LIFE OF BRYOPHYTES”

On the page “From photographs,” there are six scientific names of Marchantiales with link

buttons. Then, users can refer to the page for each species that is composed of a scientific

name, a color photograph showing the surface of the thallus and an explanation of its characteristics.

On the other hand, on the page "From reference," there are a reference of key characteristics and two link buttons. Depending on which link button they choose, they can refer to the page of the identified species (Fig. 2). For the use of ordinal computers, the "Return" button is helpful for the users to return to the previous page or front page of the web site. However, since the monitor on a cellphone is very small, cellphone users need to scroll to see different parts of a page. It is difficult to know where they are in the web site. So, we did not set the "Return" button on the cellphone page.

#### **Advantages of our web teaching material**

Following are four advantages of our teaching material for cellphones.

##### *1. Possibility of collecting liverworts throughout the year*

Morphological identification of Marchantiales is usually based on characteristics of the female receptacle, the male receptacle and ventral scales. But, among species, female and male receptacles are formed at particular times. Ventral scales formed on the lower surface of the thallus are very small. Therefore we need to observe them under a microscope. Hence, it is difficult to identify Marchantiales for teachers and students.

On the other hand, the six species can be identified according to the upper surface characteristics of each thallus which is shown in our teaching material. In all species thalli grow throughout the year, so users can identify them at anytime.

##### *2. Possibility of using the teaching material anywhere, even in the field*

Our teaching material utilizes the telecommunicational function of cellphones to connect to the Internet within the service area.

From the results of our own observations of liverworts, we have set the explanations of species and reference to key characteristics at the level of naked-eye observation. Then, if users carry their cellphones, they can identify Marchantiales in the field without any extra information such as a monograph or an illustrated book.

##### *3. Relation to classroom activities*

We had developed another web teaching material for ordinal computers entitled "THE LIFE OF BRYOPHYTES" on a web site. We tried to use it in biology class activities (Sato *et al.*, in preparation). If teachers and students could use the present teaching material for cellphones, collecting Marchantiales for biology class activities might become much easier. After they come back from the field activity using cellphone, they can refer to the web teaching material for ordinal computers in classroom activity. Then, they may have much more detailed information by using the column "Observation of *M. polymorpha*" in the computer as the observation manual.

##### *4. High accessibility for teachers and students*

According to the research data obtained in one high school in Hiroshima, Japan in the year 2001, 58% of male students and 74% of female students had their own cellphone or PHS (Personal Handy-Phone System) equipment (Information unit of PTA, Attached Junior-senior High School of Hiroshima University 2001). In one class of this school, over half of the students (20 students out of 38) had their own cellphone which could connect to the

Internet by contract with “J-PHONE” or “KDDI CORPORATION.”

### **Assessment of the present teaching material for cellphones in comparison with the web teaching materials for ordinal computers**

We compared this teaching material for cellphones with web teaching materials which are used on ordinal computers. As a result, we found some advantages and disadvantages to the teaching material for cellphones.

One of the major advantages is its accessibility. The Internet was limited to use in classrooms and computer rooms at schools until recently, but nowadays we can access the Internet by a cellphone from anywhere in Japan. If users use this basic telecommunication function of cellphones effectively, they can release and receive information from anywhere. We consider that the use of cellphones will increase the opportunities of long distance telecommunications and information exchange will become more effective.

On the other hand, one of the major disadvantages is the memory limitation of cellphones. The cellphone memory available for the Internet is not enough to download a large memory file. The upper limit of memory is 10 KB for “NTT DoCoMo, Inc” and 6 KB for “J-PHONE,” but it is uncertain for “KDDI CORPORATION” (Table 1). If you make a page requiring memory over the limit of the cellphone on your web site, the page cannot be displayed correctly on the monitor of a cellphone. For example, when we access “THE LIFE OF BRYOPHYTES” developed for ordinal computers using a cellphone, we can read only the letters; none of the image files can be seen in the cellphone monitor because the

memory size of each file is heavy. In addition, as a cellphone has a very narrow monitor and has only the vertical scrolling function, we need to compose a file with simple pages. When you develop teaching material for cellphones, you should choose the contents which can match the characteristics of cellphones. When you arrange some image files in the material, you should compress the memory size of each image file.

Another disadvantage is that, the file systems have not yet been standardized among the models of cellphones provided by the three companies (Table1). Both the markup language and the display system of image files are different among these companies. If you develop web teaching materials useful for all cellphones, you need to make different types of files which can match different systems, although the content is the same. It takes a lot of time to edit them. These systems should be integrated into a world standard and be compatible with each other.

We calculated the communication expenses; we found that our web teaching material can be used with less than ¥200 in total (Table1). If used in a group, the cost could be cut down.

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#### Addresses of the web sites in this paper

“THE LIFE OF BRYOPHYTES”

for computer:

<http://scied123.ed.hiroshima-u.ac.jp/koke/index.html>

for i-mode®:

<http://scied123.ed.hiroshima-u.ac.jp/koke/i/index.html>

for J-sky:

<http://scied123.ed.hiroshima-u.ac.jp/koke/j/index.html>

for ez-web:

<http://scied123.ed.hiroshima-u.ac.jp/koke/e/index.html>

“THE LIFE OF BRYOPHYTES” English version for computer

<http://scied123.ed.hiroshima-u.ac.jp/koke/indexe.html>

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**Research Paper**

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**Effects of Cadmium on Oxygen Consumption and Tissue Accumulation in Tiger Shrimp *Penaeus monodon* Fabricius***Nongnud TANGKROCK-OLAN and Voravit CHEEVAPORN\***Department of Aquatic Science, Faculty of Science, Burapha University, Thailand*

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**Abstract**

Tiger shrimps (*Penaeus monodon*) were exposed to various concentrations of cadmium as cadmium chloride ( $\text{CdCl}_2 \cdot 2\frac{1}{2}\text{H}_2\text{O}$ ) for 96 hours. Survival rates and the lethal concentration fifty ( $\text{LC}_{50}$ ) of shrimps with cadmium concentrations of 0.0, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 and 4.0 mg/l within 96 hours were 100%, 100%, 100%, 90%, 67%, 17%, 13% and 0%, respectively, and the  $\text{LC}_{50}$ -96 hours was 2.42 mg/l. Cadmium also reduced rates of oxygen consumption ( $\text{Mo}_2$ ). The rates of oxygen consumption of shrimps reared in seawater for 1 month with cadmium concentrations of 0, 0.1, 0.5 and 1.0 mg/l were  $6.21 \pm 1.53$ ,  $6.92 \pm 1.21$ ,  $4.87 \pm 1.24$  and  $4.37 \pm 1.28$   $\mu\text{mol/g/h}$ , respectively. The concentration of cadmium in the reared shrimps was found to be higher in the head region than that found in the body. The concentrations found in both regions increased with the concentration of cadmium. From the results, it is indicated that shrimps did not abruptly die after exposure to cadmium. But the cadmium may accumulate in shrimps and result in changes to their physiology. The changes in the rates of oxygen consumption may reflect the changes in environmental pollution which occur in habitats where shrimps live.

*Key words: Penaeus monodon, shrimp, cadmium, oxygen consumption:*

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**Introduction**

Heavy metals occur naturally in seawater in very low concentrations. However in many marine environments heavy metal concentrations may exceed natural levels. High concentrations of metals can enter the coastal environments as the result of human activities. Investigations of

heavy metals in aquatic organisms are an important aspect of environmental pollution control since anthropogenic activities progressively increase the concentrations of metal in the marine environment. Metals from industrial discharges can also be deposited in a wide variety of ecosystem components such as water, sediment and suspended particulate matter in the water

column, and biota. Helz et al. (1975) indicated that concentrations of cadmium and other metals in water might decrease rapidly downstream from a wastewater treatment plant discharging into an estuarine environment, whereas high concentrations of metals may occur in the sediment all the way from the discharge point to the mouth of the estuary.

Aquatic organisms experience direct waterborne contact with heavy metal pollutants. Several studies of aquatic invertebrates revealed a high degree of variability in the uptake and accumulation of heavy metals (Wong and Rainbow 1986, Moore and Rainbow 1987, Rainbow and White 1989, 1990, Donker and Bogert 1991). The burrowing and feeding activities of some benthic invertebrates such as shrimps may lead to the mobilization of metals from the sediments. The utility of marine shrimp as bioindicators of heavy metal pollution for environmental monitoring studies has been emphasized by several investigators (Clark et al. 1987, Darmono 1990, Mizutani et al. 1991, Palmer and Presley 1993, Dallinger 1994).

The tiger shrimp *Penaeus monodon* is sediment-dwelling and detritus-feeding shrimp found abundantly in mangrove and estuarine environments. This shrimp species is also one of the most economically important shrimps in Thailand. In an attempt to predict some of the possible biological effects of heavy metal pollution on this shrimp, cadmium was used as a heavy metal substance for this study. The objectives of the present investigation were (1) to determine the acute toxicity of cadmium in juvenile tiger shrimps, (2) to study the effect of sublethal cadmium concentrations in seawater on the oxygen consumption capacity of the shrimp, and (3) to determine the level of cadmium in tissues of the shrimp.

## Materials And Methods

### *Animals and Maintenance*

Juvenile tiger shrimps, *P. monodon*, with body length 4-5 cm and weighing between 0.6-1.4 g, were used in this study. All shrimps were bought from a shrimp farm in Chachoengsao province. They were then transported to the Department of Aquatic Science, Burapha University and acclimated to the laboratory conditions in well-aerated seawater (20 ppt in salinity) under a natural photoperiod at seasonal temperature for at least 1 week before testing. During this period they were fed every day with shrimp pellets.

### *Survival study*

Before performing the oxygen consumption experiments, it was necessary to know whether shrimps had the ability to survive in a given cadmium concentration. Therefore, the rates of survival of shrimps were determined after 96 hours of exposure to eight different concentrations (0, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 and 4.0 mg/l) of cadmium solutions at 25°C. Cadmium solutions were prepared using  $\text{CdCl}_2 \cdot 2\frac{1}{2}\text{H}_2\text{O}$  and seawater (20 ppt in salinity) and its concentration is expressed as that of  $\text{CdCl}_2 \cdot 2\frac{1}{2}\text{H}_2\text{O}$ . Three experimental treatments with ten individuals were maintained in each experimental cadmium concentration.

A mortality count was taken after 24, 48, 72 and 96 hours in all tested concentrations. Shrimps were determined to be dead as they stopped moving and lay on the bottom. The ability of shrimps to survive in different concentrations of cadmium was expressed as percentage survival.  $\text{LC}_{50}$  for 96 hours was also calculated.

### *Oxygen consumption study*

Measurements of oxygen consumption rates were done in shrimps which reared for 30 days in three different concentrations of cadmium (0.1, 0.5 and 1.0 mg/l) and in one control. The highest concentration (1.0 mg/l) of cadmium solution prepared was the concentration in which all shrimps could survive up to 96 hours. The oxygen consumption rates of 10 individuals from each treatment were determined on day 30. Each individual was placed in a closed respiratory chamber of 750 ml capacity filled with sterilized seawater of 20 ppt salinity. The chamber was placed in a water bath to keep the temperature at 25°C. Shrimps were acclimated for three hours and the oxygen concentration in the seawater was measured by means of an oxygen electrode of about 1 hour at a temperature of 25°C. Oxygen consumption rate was expressed as micromole of oxygen per hour.

Prior to each experiment, shrimps ( $n = 10$  shrimps at each concentration) were rinsed thoroughly to remove or to kill any exterior microorganisms. After measuring the oxygen consumption rate, shrimps were towel-dried to remove surface water and weighed for wet weight. Weight specific oxygen consumption ( $Mo_2$ ) was then calculated.

### *Tissue accumulation study*

Cadmium concentrations in the tissues of *P. monodon* were investigated in shrimps which had been used in the oxygen consumption study. Shrimps were killed by freezing, freeze-dried and stored at -80°C until investigation. Prior to analysis, four shrimps were dissected into two parts: head and body. Sample preparation and analysis were carried out according to the procedure described by Bernhard (1976). Each body part was dried at 105°C for 48 hours and weighed

for dry weight. The dried material was then digested with a mixture concentrated nitric acid and concentrated perchloric acid (2:1 v/v) at 120°C for 3 hours. After dilution of the reaction mixture, the cadmium content of each part was measured by an atomic absorption spectrophotometer.

### *Data analyses*

The survival rate of shrimps in different concentrations of cadmium was expressed as percentage survival. Data analysis of survival was performed by the Log-probit plots of percentage survival at 96 hours against the cadmium concentration.

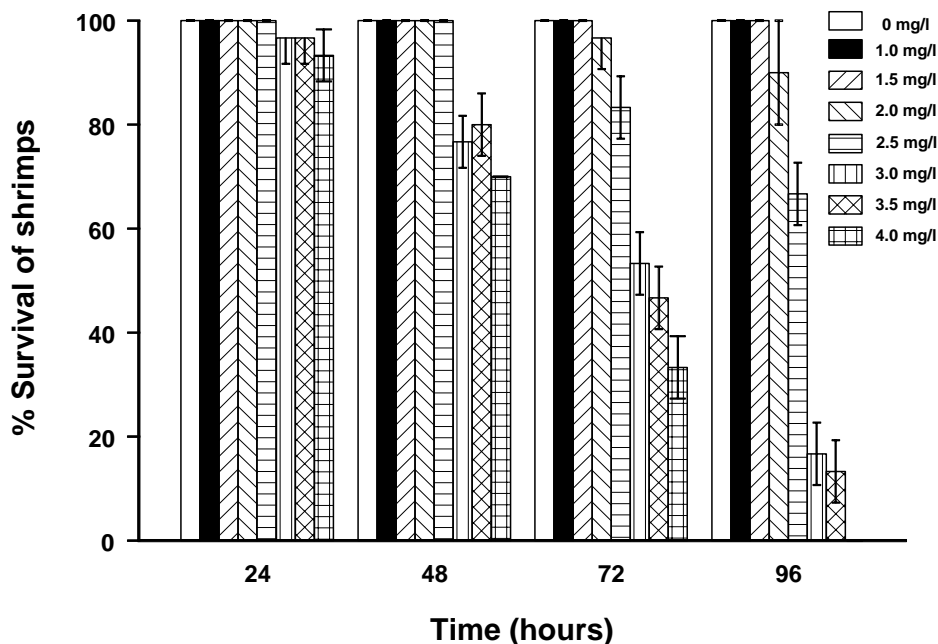
Mass-specific metabolic rates are illustrated by plotting against body mass in a double logarithmic regression. Differences in mean  $Mo_2$  among treatment groups were tested by analysis of covariance and including mass as a covariate. Pairwise comparisons among treatment were made using Scheffe (post hoc) test.

Comparison of cadmium in tissue was made by ANOVA. Subsequent multiple comparisons of means were performed using Scheffe pairwise comparisons method.

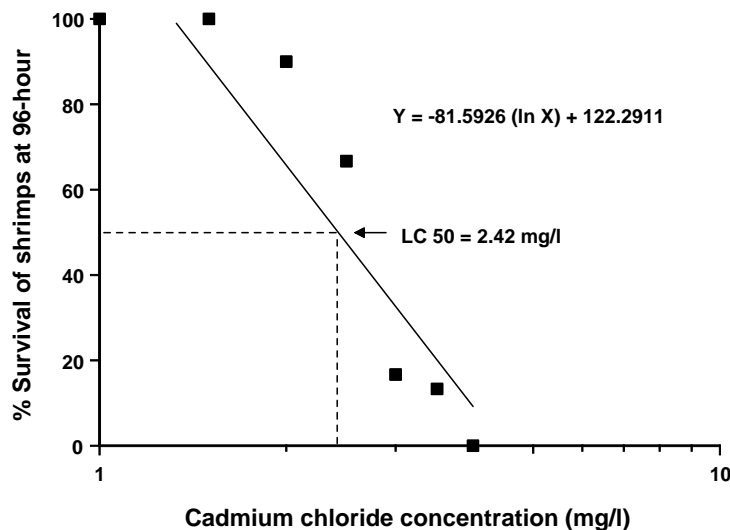
## **Results**

### *Survival study*

Shrimps exposed to 0.0, 1.0 and 1.5 mg/l cadmium concentrations survive 100% for 96 hours. Mean ( $\pm$ SD) values of percentage survival of juvenile tiger shrimps in 20 ppt seawater after exposure to 2.0, 2.5, 3.0, 3.5 and 4.0 mg/l cadmium concentrations for 96 hours were 90%, 67%, 17%, 13% and 0%, respectively (Fig. 1). The percentage survival of shrimps at 96 hours gave a 96-hours  $LC_{50}$  of 2.42 mg/l (Fig. 2).



**Figure 1** Mean ( $\pm$ SD) values of percentage survival of juvenile tiger shrimps in seawater of 20 ppt in salinity after exposure to different concentrations of cadmium for up to 96 hours at 25°C (n = 30 for each bar).



**Figure 2** Log-probit plots of the percentage survival at 96-hours against (versus) the cadmium concentration. The LC<sub>50</sub> value of the cadmium is 2.42 mg/l.

*Oxygen consumption rate*

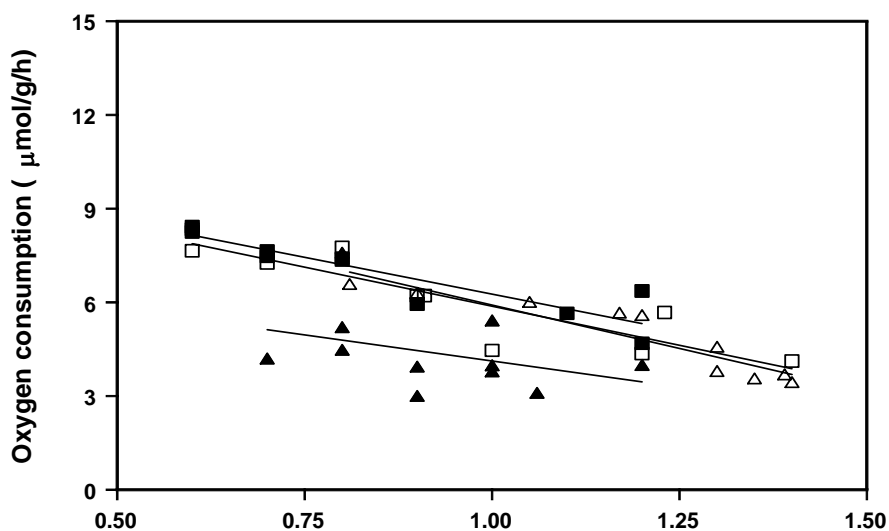
Mean oxygen consumption rates for shrimps reared in seawater for 1 month with cadmium concentrations of 0, 0.1, 0.5 and 1.0 mg/l were

6.21  $\pm$  1.53, 6.92  $\pm$  1.21, 4.87  $\pm$  1.24 and 4.37  $\pm$  1.28  $\mu$ mol/g/h, respectively. However, the regression line between the weight specific oxygen consumption (Mo<sub>2</sub>) and body weight

showed a decrease of  $Mo_2$  with increase in the body weight of shrimps (Fig. 3).  $Mo_2$  values of one-gram body weight calculated from the regression equation were 5.54, 6.07, 5.71 and 3.99  $\mu\text{mol/h}$  in shrimps reared in cadmium concentrations of 0, 0.1, 0.5 and 1.0 mg/l, respectively.  $Mo_2$  values of shrimps reared in cadmium solutions at the concentrations of 0, 0.1, 0.5 mg/l were found to be similar but higher than

for those reared in the cadmium concentration of 1.0 mg/l.

Analysis of covariance and Scheffe's statistical test showed that the mean  $Mo_2$  values of shrimps reared in cadmium concentrations of 0, 0.1 and 0.5 mg/l were significantly higher than for those reared in the cadmium concentration of 1.0 mg/l (Table 1).



**Figure 3** The relationship between weight specific oxygen consumption and body weight of juvenile shrimp, *Penaeus monodon* after being reared in different concentrations of cadmium for 30 days ( $\square$  = 0 mg/l,  $\blacksquare$  = 0.1 mg/l,  $\triangle$  = 0.5 mg/l and  $\blacktriangle$  = 1.0 mg/l). Measurement was done in seawater of 20 ppt in salinity at 25°C.

**Table 1** Regression equations for the weight specific oxygen consumption ( $\mu\text{mol/g/h}$ ) of juvenile shrimp, *Penaeus monodon* after being reared in different concentrations of cadmium for 30 days. Measurement was done in seawater of 20 ppt in salinity at 25°C.

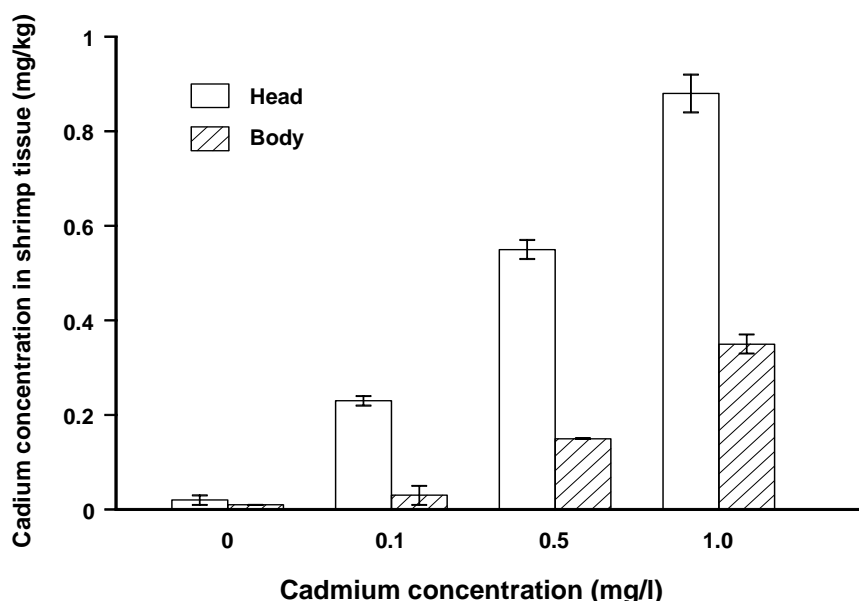
Concentration of Cadmium (mg/l)	Regression equation	r	n
0	$Mo_2 = 5.54 W^{-0.78}$	0.89	10
0.1	$Mo_2 = 6.07 W^{-0.63}$	0.90	10
0.5	$Mo_2 = 5.71 W^{-1.22}$	0.88	10
1.0	* $Mo_2 = 3.99 W^{-0.66}$	0.39	11

\* Asterisk indicates the significant differences ( $P < 0.05$ ) in the mean  $Mo_2$  from the corresponding groups.

*Accumulation in tissue*

The concentration of cadmium in tissues of shrimp reared in the seawater of 20 ppt salinity at cadmium concentrations of 0, 0.1, 0.5 and 1.0 mg/l for 30 days was shown in Figure 4. The metal levels in both head and body regions were increasingly higher in shrimps exposed to 0.1 and 0.5 mg/l and rose markedly in those exposed to 1.0 mg/l. At every cadmium concentration, the

cadmium content in the head region is more than twice higher than that in the body region. Analysis of variance and Scheffe's statistical test showed that the mean cadmium contents accumulated in both the head and the body regions of shrimps reared in all cadmium concentrations were significantly higher than for those in the control group (Table 2). When comparing the values on the analysis of variance and Scheffe's



**Figure 4** Mean ( $\pm$ SD) values of cadmium concentrations accumulated in the head and body regions of juvenile tiger shrimps, *Penaeus monodon* after being reared in different concentrations of cadmium for 30 days (n = 4 for each bar).

**Table 2** Average cadmium concentrations accumulated in the head and body regions of juvenile tiger shrimps, *Penaeus monodon*, after being reared in different concentrations of cadmium for 30 days

Cadmium concentration (mg/l)	Cadmium accumulation (Mean $\pm$ SD)		n
	Head	Body	
0	0.02 $\pm$ 0.01	0.01 $\pm$ 0.00	4
0.1	*0.23 $\pm$ 0.01	0.03 $\pm$ 0.02	4
0.5	*0.55 $\pm$ 0.02	**0.15 $\pm$ 0.00	4
1.0	*0.88 $\pm$ 0.04	**0.35 $\pm$ 0.02	4

\*, \*\* Asterisks indicate the significant differences ( $P < 0.05$ ) in the mean from the control and the corresponding groups.

statistical test, it was also found that the mean cadmium contents in the head regions of shrimps reared in cadmium concentrations of 0.5 and 1.0 mg/l were significantly higher than those found in the body regions (Table 2).

### Discussion

There is no evidence that cadmium at any concentration is essential or beneficial to living organisms, but this metal accumulates in the tissues of a wide variety of marine organisms (Eisler 1971, Bjerregaard and Depledge 1994). A number of studies have reported the toxicity of small amounts of this metal to marine animals (McCahon and Pascoe 1988, Sosnowski and Gentile 1978).

The 96-hour  $LC_{50}$  value for cadmium obtained in the present study (2.42 mg/l, in shrimps acclimated to seawater of 20 ppt salinity) is about three to five times lower than the values reported for other euryhaline crustaceans, fishes and bivalve molluscs tested in normal seawater (Eisler 1971, Wright 1977, GESAMP 1985, White and Rainbow 1986, Patel and Anthony 1991) but more than 17 times higher than those found for freshwater or marine amphipods and copepods (Sosnowski and Gentile 1978, Wright and Frain 1981, McCahon and Pascoe 1988, Zanders and Rojas 1992). The cadmium  $LC_{50}$  value thus reveals a slightly low tolerance of *P. monodon* to this metal, differing from other decapods.

Shrimps exposed to cadmium appeared to be less active than those in the control group. Inhibition of respiration by cadmium has been reported in mud crabs (Collier et al. 1973). A similar response was observed in shrimps in the present study. A cadmium concentration of 1.0 mg/l appeared to have an influence on the oxygen consumption rate of *P. monodon*. The  $Mo_2$  values for shrimps reared in cadmium at concentra-

tions of 0, 0.1, 0.5 mg/l were found to be similar but higher than for those reared in a cadmium concentration of 1.0 mg/l. The lower  $Mo_2$  values obtained for the shrimps reared in cadmium at a concentration of 1.0 mg/l may be due to damage to their gills and this leads to the respiratory impairment. The reduced  $Mo_2$  values may be caused by other factors, for example, metabolism may be depressed in this shrimp as a result of energy intake limitations.

The levels of cadmium in *P. monodon* were significantly different between the head and the body regions. The cadmium content in the head region was found to be higher than that found in the body region. This is not surprising, since the hepatopancreas and gill tissues are located in the head region and it is well known that the hepatopancreas is the main regulatory organ in crustacean species and as such it would be the prime site for metal storage and detoxification in these animals (Lyon et al. 1983, Thaker and Haritos 1989, Darmono and Denton 1990). Heavy metals mainly accumulate in metabolically active tissues. The hepatopancreas and gill tissues were highly active in the uptake and storage of heavy metals. Crustaceans (shrimp) respond to heavy metal exposure by producing metallothionein, particularly in hepatopancreas (Darmono 1990, Howard and Hacker 1990, Dallinger 1994). High levels of metals found in the head region of shrimp is possibly due to binding of the cadmium to metallothionein proteins in the hepatopancreas. The gill was also a tissue in which active and passive exchanges occurred between the animal and the aquatic environment.

Invertebrates, particularly crustaceans, were very sensitive to heavy metals (Thorp and Lake 1974). A number of studies show that concentrations of cadmium in aquatic organisms depend mainly on their environmental levels (Amiard et

al. 1987, Health 1987, Bryan and Langston 1992). Shrimps from clean environments contain very low levels of metals. However they can accumulate substantial quantities of these metals under polluted conditions. Higher metal concentrations were found in the tissues of *Palaemonetes varians* caught in a polluted area (Frenet and Alliot 1985). Zanders and Rojas (1996) reported that accumulation of cadmium in tissues of fiddler crabs is enhanced under conditions of low salinity. Wright and Frain (1981) and McCahon and Pascoe (1988) reported that high salinities (or  $\text{Ca}^{2+}$  concentrations) diminish the uptake and toxicity of heavy metals, especially cadmium, in crabs and amphipods.

In conclusion, chronic sublethal exposure to waterborne cadmium resulted in physiological changes and accumulation of cadmium in the tissues of shrimp *P. monodon* in this study. Thus, cadmium may not be immediately harmful to shrimp populations, but it may accumulate and have effects (they may become affected) in the long term, such as in changes in metabolic rates. Besides the effects of cadmium uptake on metabolism, other processes may also become affected in the long term; for instance, incipient disturbances of reproduction or molting cycles. Habitat of *P. monodon* are close to the mouth of the river which is the area affected by heavy pollution. Further research using new approaches and alternate methods should be required to understand or to predict the biological impact of cadmium and other metals on this and other aquatic organisms.

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**Research Paper**

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**Crisis of Biology Education in Japan**

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**Abstract**

As a result of the latest reform of the national curriculum framework, the Course of Study (CS), by the Japanese Ministry of Education (MEXT), some problems have occurred in biology education at the primary and secondary school levels. The major problems are as follows: (1) The contents of study have decreased because the time allotted to science classes was reduced. This has resulted in the incomplete biology education at the compulsory level. (2) In upper secondary schools, students are required to take one of the 2-credit general science subjects, and to select at least one subject among the individual 3-credit science subjects. Therefore, many students possibly do not study enough biological topics to understand the current issues related to life and environmental sciences. (3) Some very important concepts in biological science such as evolution and the continuity of life have lacked from the contents of study not only at the compulsory level, but also in ordinary biology course in upper secondary schools. Molecular biology has also been missing from ordinary biology course in upper secondary schools. (4) Some important concepts related to biology education in other areas of science education such as ions, energy, the characteristics of light, atoms and molecules, etc., have been transferred from the lower secondary school level to the upper secondary school level. Thus, these topics have to be covered in biology education in upper secondary school. (5) The process of textbook “authorization,” which is the screening of textbooks for primary and secondary schools carried out by the officers of MEXT, makes the issues more serious. The contents of each textbook are checked severely to see if they deviate from the CS and its guidelines. As a result, the explanations of some important biology concepts and of the concepts in other science areas which might be required for understanding biological phenomena were requested to be deleted from biology textbooks. This results in restricting biology education and makes it more difficult. **Key words:** *biology education, curriculum framework and guidelines, primary education, Japanese science education, secondary education.*

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## Introduction

The modern Japanese national curriculum framework, the Course of Study (CS), and its guidelines for elementary schools were enacted in 1951 and revised four times until 1998: in 1958, 1968, 1977 and 1989. Those for lower secondary schools were also enacted in 1952 and revised in 1958, 1969, 1977 and 1989 (Takakura and Murata 1998, Katayama 1998a, 1998b). The Ministry of Education, Science, Sports and Culture, Japan, which amalgamated with the Department of Science and Technology in 2000 into the Ministry of Education, Culture, Sports, Science and Technology (MEXT), has made the CS and its guidelines (Takakura and Murata 1998, Katayama 1998a, Ministry of Education, Science, Sports and Culture 2000, MEXT website<sup>\*</sup>).

As was mentioned previously (Katayama 1998b), the CS was revised in 1998. The revised CS for elementary schools and for lower secondary schools was enforced from this year (2002) and that for upper secondary schools will be enforced from 2003. In the present report, the authors mention some problems which have occurred and will possibly occur in science education, especially in biology education, at the primary and secondary school levels as a result of the new CS enforcement.

## Some Issues in Biology Education at the Primary and Secondary Levels in Japan

### *Reduction in time allotted to science and biology education*

Compared to the previous CS (Ministry of Education, Science, Sports and Culture 1989a, b), the total time allotted to science classes in the new CS (Ministry of Education, Science, Sports and Culture 1998a, b) is reduced by about 17% in elementary schools (Table 1) and by 8% in lower secondary schools (Table 2). According to the new CS for upper secondary schools (Ministry of Education, Science, Sports and Culture 1998c), students are required to take one of the general science subjects, all of which are 2-credit courses (2 hours per week). In addition, students are required to select at least (but enough to satisfy the requirement) one subject among eight individual science subjects, all of which are 3-credit courses (3 hours per week) (Table 3). In the present curriculum framework, students are asked to select at least two of the 4-credit subjects shown in Table 3 (Ministry of Education, Science, Sports and Culture 1989c). Therefore, the time allotted to science classes at the upper secondary school level will possibly be reduced in the new CS.

**Table 1 Comparison of the time\* allotted for science classes in elementary schools in the previous and current curriculum frameworks**

	Grade				Total
	3	4	5	6	
Previous Curriculum Framework	105	105	105	105	420
Current Curriculum Framework	70	90	95	95	350
Reduction (%)	33	14	10	10	17

\* The number of school hours (one school hour is 45 min) of lessons per school year

**Table 2 Comparison of the time\* allotted for compulsory science classes in lower secondary schools in the previous and current curriculum frameworks**

	Year			Total
	1	2	3	
Previous Curriculum Framework	105	105	105	315
Current Curriculum Framework	105	105	80	290
Reduction (%)	0	0	24	8

\* The number of school hours (one school hour is 50 min) of lessons per school year

**Table 3 Subjects in science for general education in the present and new curriculum framework for upper secondary schools**

Present Curriculum Framework		New Curriculum Framework	
Subject	Credits*	Subject	Credits*
Integrated Science	4	Basic Science	2
		Integrated Science A	2
		Integrated Science B	2
Physics IA	2	Physics I	3
Physics IB	4		
Physics II	2	Physics II	3
Chemistry IA	2	Chemistry I	3
Chemistry IB	4		
Chemistry II	2	Chemistry II	3
Biology IA	2	Biology I	3
Biology IB	4		
Biology II	2	Biology II	3
Earth Science and Astronomy IA	2	Earth Science and Astronomy I	3
Earth Science and Astronomy IB	4		
Earth Science and Astronomy II	2	Earth Science and Astronomy II	3

\* 35 school hours (one school hour is 50 min) of lessons per school year are counted as one credit.

The reduction in time allotted to science classes results in the reduction of the contents of study. Some topics, which had been thought to be difficult to understand for students of a certain year or a certain school level in the previous CS, were transferred to an upper year or upper school level. Some others were simplified or even deleted from the contents of study. As a result, some serious problems have occurred or will occur as described

below.

#### *Incomplete biology education at the compulsory level*

As a result of the revision of the CS for lower secondary schools, one of the most important concepts, the evolution of organisms, was deleted from the contents of study. In science textbooks for students in lower secondary schools, strata and fossils appear as topics

of earth science, but there is no explanation of evolution (Katayama and Kanaizuka 2001). Among the topics related to the continuity of life, reproduction is included in the contents of study, but the principles of heredity such as Mendel's Laws are taught only partially at the lower secondary level (Ministry of Education, Science, Sports and Culture 1998b).

Organisms used as teaching materials are restricted very much in the new CS for lower secondary schools (Ministry of Education, Science, Sports and Culture 1998b). As a result, most of the organisms appearing in science textbooks for lower secondary schools are vascular plants and vertebrates (Katayama and Kanaizuka 2001). Using such textbooks, students can hardly understand the diversity and unity of organisms.

In the case of the CS for elementary schools, the previous one (Ministry of Education, Science, Sports and Culture 1989a) already lacked the idea of teaching the above-mentioned concepts. In the revision of the CS, the contents of study decreased and nothing was added (Ministry of Education, Science, Sports and Culture 1998a). Thus, biology education at the compulsory level can be said to have become more incomplete.

#### *Incomplete biology education at the upper secondary level*

In ordinary biology (Biology I), the concept of evolution is completely deleted. As well, organisms are taught without any viewpoint of systematics in this subject. As mentioned above, the systematics and evolution of organisms are excluded from the contents of study at the compulsory level. The idea of the "five-kingdoms" presented by Copeland, Whittaker and Margulis is very important to understand not only the systematics of organ-

isms, but also the evolution of organisms (Margulis et al. 1994). Unfortunately, such an idea is missing from the contents of study in ordinary biology in upper secondary schools, as well as at the compulsory level.

Integrated Science B is a subject for upper secondary schools dealing with topics of biology and earth science, and Integrated Science A deals with topics of physics and chemistry (Table 3). The contents of these subjects look like they are there to compensate for the failure of science education at the compulsory level. Systematics (biodiversity) and evolution are included in the contents of Integrated Science B. The principles of heredity including Mendel's Laws are also taught in this subject, although the contents do not fully cover this study area. However, this subject does not deal with cellular and sub-cellular phenomena. In advanced biology (Biology II), students can be taught systematics and the evolution of organisms as well as molecular biology. But, if upper secondary students do not choose any of these subjects, they graduate from secondary school without understanding the world of organisms.

#### *Molecular biology has been missing from the ordinary level in upper secondary schools*

As in the present CS for upper secondary schools, the topic "genetic information and its expression" is excluded from the contents of ordinary biology (Biology I) in the new CS. In addition, the topic "proteins and their function in organisms" is also excluded. As a result, most of the topics in biochemistry and molecular biology are only taught in advanced biology (Biology II). It is predicted that the number of students who take Biology II will be very small, so that most students may not have enough knowledge required for considering

current biological and medical issues.

*Biology education should cover any lack of important concepts related to biology from other subjects*

Some important concepts related to biology education in other areas of science education such as “ions,” “energy,” “the characteristics of light,” “atoms and molecules,” etc., have been transferred from the lower secondary school level to the upper secondary school level. Thus, these topics may have to be covered in biology education in upper secondary schools.

*Severe textbook screening was carried out by MEXT*

There has been a system of screening these textbooks by MEXT before publication to check whether their contents deviate from the curriculum framework and its guidelines. This process is now called “authorization” (Takakura and Murata 1998, Ministry of Education, Science, Sports and Culture 2000, MEXT website<sup>\* \*\*</sup>). “In the process of authorization of textbooks, books compiled and edited by the private sector are examined to decide whether they are appropriate for use as textbooks through the careful deliberations of the Textbook Authorization Council” (MEXT website<sup>\*\*</sup>). Science textbook authorization has been carried out by certain examiners in the Elementary and Secondary Education Bureau, MEXT, who have scientific and educational backgrounds.

A laudable purpose of textbook screening might be the correction and improvement of the material in textbooks, but in practice, the purpose of the authorization has become to check that the contents of textbooks do not deviate from the curriculum framework and its

guidelines (Katayama and Kanaizuka 2001, Katayama 2002). As a result of textbook authorization, the diversity of the contents among textbooks seems to have been lost. In the process of authorization of science textbooks for lower secondary schools, as well as Biology I textbooks for upper secondary schools, the explanations related to systematics and evolution were requested to delete completely. Explanations of concepts in other science areas, which might be required for understanding biological phenomena, were also requested to delete from biology textbooks (Katayama 2002). This results in restricting biology education at the upper secondary level and makes biology more difficult to teach.

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- The following resources are on the MEXT Website.
- \* Elementary and Secondary Education Bureau <<http://www.mext.go.jp/english/org/struct/function.htm>> (Nov. 2002)
- \*\* Textbook Administration <<http://www.mext.go.jp/english/org/eshisaku/eshotou.htm>> (Nov. 2002)

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**Practical Report**

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**A SURVEY OF INSECTS IN THE MANGROVE FOREST AT THE MOUTH OF THE BANGPAKONG RIVER IN THAILAND**

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**Abstract**

The dipteran fauna in a mangrove forest at the mouth of the Bangpakong River in Thailand was sampled at intervals of approximately two weeks throughout one year. Samples were collected during the hours of daylight and darkness. A total of 390 samples were examined, in which 73 species were identified representing 3 suborders, 18 superfamilies, 32 families and 32 genera. Diversity of these insects was greatest for mosquitoes and punkies with 14 and 11 species respectively present. The importance of these taxa to medicine, veterinary and forestry was discussed.

**Keywords:** *Bangpakong River, diversity, dipteran fauna, mangrove, Thailand.*

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**Introduction**

Natural resources of mangrove forests are directly and indirectly useful to humans and other animals. The mangrove ecosystem is composed of biotic and abiotic components. Insects in the mangrove forests contribute importantly to the various food chains and also to human and veterinary medicine. Among the insects, those in the order Diptera (flies) are prominent in their numbers and influence. Some species are beneficial in their ecological roles as predators and parasites and as pollinators of economically important plants. Others contribute to soil fertility by breaking down dead plant tissues. Some are parts of the food chain of fish, crabs, small shrimps and other animals. In mangrove

forest at the mouth of the Bangpakong River, the kinds of species of dipterans are not known yet. So the diversity of the dipterans in mangrove forest in this region should be discovered by this project.

**Methodology**

Eleven index stations were established to represent the ecological subregions within the mangrove forest at the mouth of the Bangpakong River (Figs. 1-3). At intervals of approximately two weeks, samples were collected from each of the eleven index stations. At each interval, samples were collected by day and by night. Day samples of adult dipterans were collected with sweep nets, while light traps were used at

night. Immature dipterans were collected from water and trees with a dip net and an aspirator. Adults were killed in chloroform, then, transferred to sample boxes for subsequent identification. Immature dipterans were brought back to the laboratory and reared to the adult stage for identification. Each sample was examined for species diversity using the taxonomic keys.

**Results**

The dipteran fauna in a mangrove forest at the mouth of the Bangpakong River was sampled at intervals of approximately two weeks throughout one year. A total of 390 samples were examined, in which 73 species were identified representing 3 suborders, 18 superfamilies, 32 families and 32 genera (Table1).

**Discussion and Conclusion**

In the dipteran fauna in a mangrove forest at the mouth of the Bangpakong River, diversity was greatest for Culicidae (mosquitoes) and Ceratopogonidae (punkies) with the presence of 14 and 11 species, respectively. Besides these there were many species of Tabanidae (horse flies), Muscidae (house flies) and Calliphoridae (blow flies). Other families present included Stratiomyidae (soldier flies), Ephydriidae (shore flies), Dolichopodidae (long-legged flies), Surphidae (surphid flies), Drosophilidae (pomace flies), Sarcophagidae (flesh flies), Tachnidae (tachnid flies), Sciariidae (dark-winged fungus flies) and Pipunculidae (big-headed flies), but each was represented by only a few species. The families in which taxa could not be identified as to species were Trichoceridae, Tipulidae, Psychodidae, Chironomidae, Anisopodidae, Mycetophilidae, Asilidae,



Figure 1 Mangrove forest of the mouth of Bangpakong River, Thailand.



Figure 2 Location of insects survey of the mouth of Bangpakong River, Gulf of Thailand.

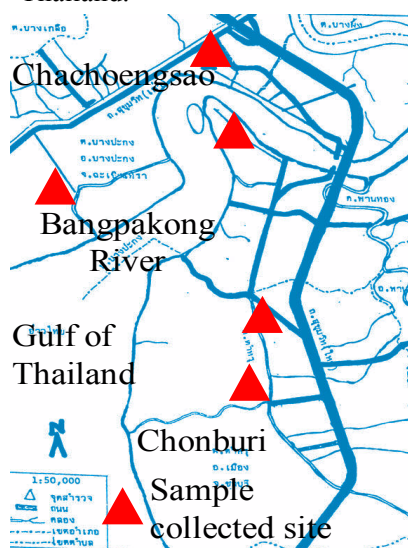


Figure 3 Spots of insects survey of the mouth of Bangpakong River, Gulf of Thailand

Platypezidae, Tephritidae, Sepsidae, Sciomyzidae, Lauxaniidae, Chamaemyiidae, Canaceidae, Chloropidae, Agromyzidae, Trixoscelididae and Anthomyiidae. Some of these insects are beneficial through their roles as predators and parasites while others are harmful to plants and animals, particularly as vectors of disease. Consequently, they are of great agricultural, forestry, medical and veterinary importance. Many dipterans are also important components in the mangrove ecosystem.

### Acknowledgements

Thanks to the Medical Science Department, Ministry of Public Health, and Mahidol University for the kind support of equipment and help in identifying species of some families. F. W. H. Beamish kindly provided editorial assistance.

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Table 1 Dipteran fauna in a mangrove forest at the mouth of the Bangpakong River

No.	Scientific Name	Family	Superfamily	Division	Suborder	Common Name
1	-	Trichoceridae	Tipuloidea		Nematocera	winter crane flies
2	-	Tipulidae	Tipuloidea		Nematocera	crane flies
3	-	Psychodidae	Psychodoidea		Nematocera	moth flies, sand
4	<i>Aedes aegypti</i>	Culicidae	Culicoidea		Nematocera	mosquitoes
5	<i>Aedes lorrainea</i>	Culicidae	Culicoidea		Nematocera	mosquitoes
6	<i>Aedes platylepidus</i>	Culicidae	Culicoidea		Nematocera	mosquitoes
7	<i>Aedes vigilax</i>	Culicidae	Culicoidea		Nematocera	mosquitoes
8	<i>Anopheles aconitus</i>	Culicidae	Culicoidea		Nematocera	mosquitoes
9	<i>Culex gelidus</i>	Culicidae	Culicoidea		Nematocera	mosquitoes

Table 1 (continued)

No.	Scientific Name	Family	Superfamily	Division	Suborder	Common Name
10	<i>Culex quinquefasciatus</i>	Culicidae	Culicoidea		Nematocera	mosquitoes
11	<i>Culex sitiens</i>	Culicidae	Culicoidea		Nematocera	mosquitoes
12	<i>Culex tritaeniorhynchus</i>	Culicidae	Culicoidea		Nematocera	mosquitoes
13	<i>Culex vagans</i>	Culicidae	Culicoidea		Nematocera	mosquitoes
14	<i>Mansonia bonnea</i>	Culicidae	Culicoidea		Nematocera	mosquitoes
15	<i>Mansonia indiana</i>	Culicidae	Culicoidea		Nematocera	mosquitoes
16	<i>Mansonia uniformis</i>	Culicidae	Culicoidea		Nematocera	mosquitoes
17	<i>Mimomyia luzomensis</i>	Culicidae	Culicoidea		Nematocera	mosquitoes
18	<i>Uranotaenia</i> sp.	Culicidae	Culicoidea		Nematocera	mosquitoes
19	<i>Atrichopogon</i> sp.	Ceratopogonidae	Culicoidea		Nematocera	punkies
20	<i>Culicoides flavescens</i>	Ceratopogonidae	Culicoidea		Nematocera	punkies
21	<i>Culicoides flumineus</i>	Ceratopogonidae	Culicoidea		Nematocera	punkies
22	<i>Culicoides gemellus</i>	Ceratopogonidae	Culicoidea		Nematocera	punkies
23	<i>Culicoides geminus</i>	Ceratopogonidae	Culicoidea		Nematocera	punkies
24	<i>Culicoides orientalis</i>	Ceratopogonidae	Culicoidea		Nematocera	punkies
25	<i>Culicoides</i>	Ceratopogonidae	Culicoidea		Nematocera	punkies
26	<i>Culicoides peregrinus</i>	Ceratopogonidae	Culicoidea		Nematocera	punkies
27	<i>Culicoides schultzei</i>	Ceratopogonidae	Culicoidea		Nematocera	punkies
28	<i>Culicoides shortti</i>	Ceratopogonidae	Culicoidea		Nematocera	punkies
29	<i>Culicoides similis</i>	Ceratopogonidae	Culicoidea		Nematocera	punkies
30	<i>Culicoides simislis</i>	Ceratopogonidae	Culicoidea		Nematocera	punkies
31	<i>Forcipomyia</i> sp.	Ceratopogonidae	Culicoidea		Nematocera	punkies
32	-	Chironomidae	Culicoidea		Nematocera	midges
33	-	Anisopodidae	Anisopodoidea		Nematocera	wood gnats
34	-	Mycetophilidae	Mycetophiloidea		Nematocera	fungus gnats
35	<i>Sciara</i> sp.	Sciaridae	Mycetophiloidea		Nematocera	fungus gnats
36	<i>Hermetia</i> sp.	Stratiomyidae	Tabanoidea		Brachycera	soldier flies
37	<i>Ptecticus</i> sp.	Stratiomyidae	Tabanoidea		Brachycera	soldier flies
38	<i>Stratiomyia</i> sp.	Stratiomyidae	Tabanoidea		Brachycera	soldier flies
39	<i>Stratiomys</i> sp.	Stratiomyidae	Tabanoidea		Brachycera	soldier flies
40	<i>Chrysops vespa</i>	Tabanidae	Tabanoidea		Brachycera	horse flies
41	<i>Tabanus atratus</i>	Tabanidae	Tabanoidea		Brachycera	horse flies
42	<i>Tabanus brunipennis</i>	Tabanidae	Tabanoidea		Brachycera	horse flies
43	<i>Tabanus lineola</i>	Tabanidae	Tabanoidea		Brachycera	horse flies
44	-	Asilidae	Asiloidea		Brachycera	robber flies
45	<i>Dolichopus</i> sp.	Dolichopodidae	Empidoidea		Brachycera	long-legged flies

Table 1 (continued)

No.	Scientific Name	Family	Superfamily	Division	Suborder	Common Name
46	<i>Melanderia</i> sp.	Dolichopodidae	Empidoidea		Brachycera	long-legged flies
47	<i>Tomosvaryella</i> sp.	Platypezidae	Phoroidea	Aschiza	Cyclorrhapha	flat-footed flies
48	<i>Eristalis</i> sp.	Pipunculidae	Syrphoidea	Aschiza	Cyclorrhapha	big-headed flies
49	-	Syrphidae	Syrphoidea	Aschiza	Cyclorrhapha	syrphid flies
50	-	Tephritidae	Tephritoidea	Schizophora	Cyclorrhapha	fruit flies
51	-	Sepsidae	Sciomyzoidea	Schizophora	Cyclorrhapha	sepsids
52	-	Sciomyzidae	Sciomyzoidea	Schizophora	Cyclorrhapha	marsh flies
53	-	Lauxaniidae	Lauxanioidea	Schizophora	Cyclorrhapha	lauxaniid flies
54	-	Chamaemyiidae	Lauxanioidea	Schizophora	Cyclorrhapha	aphid flies
55	-	Canaceidae	Milichioidea	Schizophora	Cyclorrhapha	beach flies
56	<i>Ephydra</i> sp.	Ephydriidae	Drosophiloidea	Schizophora	Cyclorrhapha	shore flies
57	<i>Drosophila</i> sp.	Drosophilidae	Drosophiloidea	Schizophora	Cyclorrhapha	pomace flies
58	-	Chloropidae	Chloropoidea	Schizophora	Cyclorrhapha	chloropid flies
59	-	Agromyzidae	-	Schizophora	Cyclorrhapha	leaf miner flies
60	-	Trixoscelididae	-	Schizophora	Cyclorrhapha	trixoscelidid flies
61	-	Anthomyiidae	Muscoidea	Schizophora	Cyclorrhapha	anthomyiid flies
62	<i>Fannia</i> sp.	Muscidae	Muscoidea	Schizophora	Cyclorrhapha	house flies
63	<i>Hydrotaea</i> sp.	Muscidae	Muscoidea	Schizophora	Cyclorrhapha	house flies
64	<i>Limnophora</i> sp.	Muscidae	Muscoidea	Schizophora	Cyclorrhapha	house flies
65	<i>Musca asiatica</i>	Muscidae	Muscoidea	Schizophora	Cyclorrhapha	house flies
66	<i>Musca domestica</i>	Muscidae	Muscoidea	Schizophora	Cyclorrhapha	house flies
67	<i>Musca sorbens</i>	Muscidae	Muscoidea	Schizophora	Cyclorrhapha	house flies
68	<i>Chrysomyia</i>	Calliphoridae	Oestroidea	Schizophora	Cyclorrhapha	blow flies
69	<i>Hemipyrellia ligurriens</i>	Calliphoridae	Oestroidea	Schizophora	Cyclorrhapha	blow flies
70	<i>Melinda scutellata</i>	Calliphoridae	Oestroidea	Schizophora	Cyclorrhapha	blow flies
71	<i>Parasarcophaga knabi</i>	Sarcophagidae	Oestroidea	Schizophora	Cyclorrhapha	flesh flies
72	<i>Archytas</i> sp.	Tachinidae	Oestroidea	Schizophora	Cyclorrhapha	tachinid flies
73	<i>Winthemia</i> sp.	Tachinidae	Oestroidea	Schizophora	Cyclorrhapha	tachinid flies

## Abstracts of the Papers Presented at the 19th Biennial Conference of the AABE

### **The Asian Association for Biology Education – Thirty Years on**

*Robert L. Wallis  
Deakin University*

AABE is holding its 19th consecutive biennial conference, a remarkable feat considering the Association's humble beginnings and its very broad goals and membership base. AABE is a society of biology educators with interests in the Asian region. AABE's aims include improvement in teaching and promotion of biology education in Asia, as well as providing an opportunity for biologists, education researchers and teachers to network for the mutual benefit of their own professional development. In this paper I present a brief history of the Association, its aims, achievements and future possibilities.

*Key words: AABE, achievements, aims, future possibility, history.*

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### **Greening the University Campus**

*Anna Boustead and Jeremy Sayers  
Faculty of Arts, Deakin University*

Anna Boustead attended the National Conference for Sustainable Universities in Melbourne this year (2002). She will be presenting ideas from the conference and through her work as Environment Representative for Deakin University Student Association Warrnambool, about ways in which universities can work with staff, students and community groups towards Ecologically Sustainable Development. She will briefly address waste management, water management, reducing energy consumption, improving biodiversity on campus and community

engagement.

*Key words: Campus activities, Ecological Sustainable Development, student association.*

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**(The full paper will be included in the next issue)**

### **A Preliminary Assessment of Macroinvertebrate Composition along the Eumeralla River Estuary, South West Victoria**

*Melanie Barrrot, Kylie Bishop  
and Laurie Laurenson*

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Deakin University*

In March 2002 a series of 62 dip net samples were taken at various sites along the estuarine section of the Eumeralla River to assess macroinvertebrate composition. Macroinvertebrate samples were taken at a total of 43 sites, with water chemistry data recorded for each sampling location. Of the 43 sites, 37 were taken within the channel and the remaining 6 taken from accessible inundated areas. Geographical Information Systems (GIS) was used to map and plot site locations within the sample area. ArcView 3.2a, a GIS computer package, was used to visually represent species distribution and abundance, also allowing for the visual determination of species 'hot spots.' The program was also used to determine any calanoid copepods the most abundant and widely distributed species. Other species found to be widely distributed included amphipods and *Pomatopygrus* sp. Overall, instead areas of high abundance were noticed at irregular locations. Inundated areas showed relatively high species richness and abundance, compared to that of samples taken from within the channel.

*Key words: Eumeralla River estuary, GIS, macro-invertebrate fauna, water quality.*

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(The full paper will be included in the next issue)

**Arthropod Biodiversity of the UST  
Biological Station, Zambales,  
Northern Philippines**

*Gil A. Cauyan and Klaus D. Schwetmann*

*College of Science, University of Santo Tomas*

An inventory study of the arthropod fauna at the University of Santo Tomas (UST) Biological Station and its vicinity was taken into account. Of the four study sites, results showed 20 orders, 25 families and 70 species of arthropods identified. The most abundant species are the beetles, followed by the grasshoppers and butterflies of the Orders Coleoptera, Hymenoptera and Lepidoptera, respectively. Species of arthropods with public health and economic importance were also noted.

Biting flies of the Order Ceratopogonidae which bites sea lovers and vacationers voraciously, causing allergy abounds in the study sites. *Chrysops dimidiata*, a tabanid fly which infects and destroys the flowers of mangoes was also noted. Mites, ticks, fleas and louse of the Order Siphonatera, Mallophaga and Anoplura were collected from domesticated animals in the areas of study. These ectoparasitic arthropods cause great annoyance and discomfort to the local inhabitants of the area. Species of edible crabs and shrimps of the Order Decapoda which serve as food for the seashore folks were listed.

This includes the rare species of *Birgo latro*, the coconut crab about the size of a basketball, which can climb the coconut tree, unhusk the fruit and break its shell. Rare arachnid species endemic only in this part of the Philippines like the "black widow spider" scientifically known as *Latrodectus*

*mactans*, as well as the giant scorpion known as *Palamneus* sp. were studied. A species of micro crustacean of the Order Amphipoda, *Orchestia agilis*, were noted as a good indicator of water pollution as they abound in areas in which water is highly polluted and absent in non-polluted areas.

The species of arthropods collected were brought at the Department of Biological Sciences, UST and become a part of the lesson in Invertebrate Zoology Taxonomy class. Proper methods of preservation, mounting and pinning of the specimen were taught to the students. The rich arthropod fauna of the place become the haven for biology students performing entomological research and a way for appreciating the arthropods in their natural ecosystem. They were also taught conservation of arthropod species especially those which are in danger of extinction.

*Key words: Arthropod, biodiversity, educational use, fauna, Philippines.*

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**Development and Utilization of Web Teaching  
Material on Biological Experiments and Observations**

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In biological education it is very important to observe living things and carry out experiments. However, many of the students have very limited opportunities to carry out experiments and make observations during class lessons and they learn from the textbooks only. It is therefore difficult for them to acquire and improve the techniques and skills of observation and experimentation. We have developed several web materials since 1996<sup>(1)</sup>.

<sup>2, 3)</sup>. Our web materials have taken so many accesses, (over 10 thousand), and we have already received many responses from students and teachers. The Web materials have the merit that anybody can get many kinds of the information in all places. In this research, we have developed a Web teaching material on biological experiments and observations using plant materials to support the experiments and observations and carried out for Asian and African teachers and students. In this material, we have selected three areas of plant biology based on secondary school biology contents: structure, functions and reproduction. Each area includes several activities on experimentation and observation. We have practiced many experiments, carried out observations, and taken many photographs of the procedure and the results. We have made new material and released them in September 2002. When users are using this material, they open up the Internet Explorer, and type the Internet address\* (<http://scied123.ed.hiroshima-u.ac.jp/experiment/indexe.html>) or look for this material from the search engine. On its cover page, there is an index list of experiments and observation. They click the activity item they want to refer. Each activity consists of three web pages: one page for material, one page for procedure, and one page for observation. By viewing these pages in this order, users will be able to learn the procedure of experiment or observation. In the procedure page, for instance, the methods of experiment or observation are shown by many photographs which are used for explanation thus making it easier for users to understand the experiment/observation procedures. Users can use the photographs in the result page to compare with their results. When it is difficult for students to carry out an experiment or an observation in school, it is also possible for them to learn plants by viewing the pictures on the result page, and summarize the result of experiments or observations using the information. In the case of laboratory room or classroom where there is no computer, teachers can use the laminated and

printed papers. Furthermore, we take some in-service training for teachers from Asian and African countries every year. We use this material in the training course, and we therefore consider it as good material for helping them to understand and learn the protocol of basic experiments and observation. Using this teaching material, the users will acquire knowledge and skills on how to carry out experiments and observations. It will enable them to study any biological topic effectively.

<sup>(1)</sup> Ohshika, K. and Ikeda, H. (1997) Application of the Internet system to biological education – Making a World Wide Web (WWW) teaching resource on plant reproduction. *Jpn. J. Biol. Educ.* **37**: 9-16.

<sup>(2)</sup> Ohshika, K., Treyes, R., Alcaide, E. and Ikeda, H. (1998) The use of the Internet system in biology education: Making homepages about experimental and visual information on selected topics in biology. *Proceedings of the 17th Biennial Conference of AABE*, 92-95. <sup>(3)</sup> Ohshika K., Yamashita K. and Ikeda H. (2001) Application of the Internet System to Biological Education II –Application and evaluation of the developed internet materials by analyzing the response of the questionnaire. *Jpn. J. Biol. Educ.* **42**: 21-29.

Websites  
Experiments and Observations in Plants: <http://scied123.ed.hiroshima-u.ac.jp/experiment/indexe.html> (accessed 12/25/02)  
Plant Reproduction: <http://scied123.ed.hiroshima-u.ac.jp/plantrep/indexe.html> (accessed 12/25/02)  
Plant Mitosis: <http://scied123.ed.hiroshima-u.ac.jp/mitosis/indexe.html> (accessed 12/25/02)

*Key words: Experiments and observations, Web teaching material.*

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**Inhibitory Effect of Mycelial Culture Broth of Edible Mushroom on Growth of Certain Bacteria**

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The inhibitory effect of mycelial culture broth of fifteen species of edible mushrooms on the bacterial growth was investigated. Mycelial culture of each mushroom on potato dextrose agar was grown in potato dextrose broth and incubated in shaking incubator at the optimum temperature of each mushroom. The culture broth was taken every 3 days for 30 days and evaporated until 5 ml remained. The broth was tested for the inhibitory activity on the growth of *Bacillus cereus*, *Escherichia coli*, *Micrococcus luteus*, *Salmonella enteritidis* and *Staphylococcus aureus* by paper disc diffusion method. It was found that the mycelial culture broth of nine mushrooms were able to inhibit the growth of the tested bacteria i.e. *B. cereus* was inhibited by *Auricularia polytricha*, *Pleurotus pulmonarius*, *Agrocybe cytindracea*, *P. cystidiosus*, *Ganoderma lucidum* and *Lentinus edodus*. *Staph. aureus* was inhibited by *Au. polytricha*, *P. pulmonarius*, *Ag. cytindracea*, *Microcybe crassum* and *L. edodus*. *S. enteritidis* was inhibited by *P. cystidiosus* and *L. edodus*. *Micrococcus luteus* was inhibited by *Au. polytricha*, *P. pulmonarius*, *P. cystidiosus*, *P. ostreatus*, *Ag. cytindracea*, *G. lucidum*, *L. edodus*, *L. squarrosulus* and *M. crassum*. *E. coli* was only inhibited by *L. edodus*. The culture broth of *L. edodus* inhibited the growth of all the tested bacteria at 6-30 days cultivation. At the 15th day, the mycelial culture broth of this mushroom was then subjected to Thin Layer Chromatography and 2 bands with Rf 0.09 and 0.41 were obtained. Each band was tested against the tested bacteria but no inhibitory effect was observed. The culture broth of the other six mushrooms i.e. *P. ostreatus* var. *florida*, *L. polychrous*, *Shcizophyllum commune*, *P. sajor-cju*, *Au. fuscossuccinia* and *Corpinus cinereus*

were not able to inhibit the growth of any tested bacteria.

*Key words:* Bacterial growth, edible mushroom, inhibitory effect, mycelial culture broth.

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**The Growth Responses of the Floating Weed *Pistia stratiotes* to Lead and Cadmium Uptake**

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The floating water weed *Pistia stratiotes* was examined for its phytoremediation potential for Pb and Cd absorption and accumulation. *Pistia stratiotes* were grown in half-strength Hoagland solution amended with either Pb or Cd: 0, 0.1, 0.5, 1.0 and 3.0 mg L<sup>-1</sup> for 14 days inside a greenhouse. The Pb and Cd concentrations in plant tissues significantly increased with increasing levels of the heavy metals in the culture solution. The biological concentration factor (BCF) significantly decreased with increasing Pb exposure. Significant reduction in the BCF was noted in plants treated with 3.0 mg Cd L<sup>-1</sup>. There was no significant effect of Pb treatments on the total plant biomass. The leaf production of *Pistia* plants exposed to 3.0 mg Pb L<sup>-1</sup> was not significantly different with the control. Increasing Cd treatments in the culture solution significantly decreased the total plant biomass and the number of leaves of *Pistia* plants. The total leaf chlorophyll content of *Pistia stratiotes* significantly reduced with increasing Pb and Cd amendments. Based on the growth responses of the plants, they can tolerate high levels of Pb and Cd, hence, can be utilized as scavengers of the heavy metals in contaminated freshwaters and industrial sewage effluents.

*Key words:* Cadmium floating weed, growth response, heavy metal uptake, Lead, *Pistia stratiotes*.

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**ISO14001 and Environmental Education in High Schools**

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ISO14001, the International Standard for Environmental Management Systems, has become very popular in Japan, with the number of certified organizations rising to more than 10,000 as of September 2002. Although this trend started in private companies mainly in the manufacturing industry, many local governments and even some educational institutions have been applying for this certification. The Government of Mie Prefecture has been promoting the introduction of ISO14001 in its own offices, municipal governments and small companies in an effort to make the region an "Environmentally Advanced Prefecture." Three high schools in Mie have also been granted ISO14001 certification so far.

Certification of high schools has only begun recently, and it is too early to comment on the effects of these programs, but systematic environmental education is being implemented in the certified schools.

The biggest obstacle is the cost involved in obtaining certification. This problem can be solved by creating simpler, domestic environmental management systems, such as the "Plan-Do-Check-Action" (PDCA) cycle, which incorporate ISO 14001 principles but which are easier to implement.

*Key words: Environmental education, high school, ISO14001, "Plan-Do-Check-Action" cycle.*

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**Dividing into the Gene Pool:  
Teaching the Mathematical Consequences of  
Sexual Reproduction and Evolution  
Using XLGene, a Microsoft Excel-based Population Genetic Simulation Program**

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Courses in population genetics, the study of the dynamics of gene frequency change in populations of organisms or gene pools, are demanding for students and challenging for teachers. The combination of sexual reproduction and the diversity of evolutionary processes that influence gene frequencies means that difficult new concepts need to be mastered by students and the field relies heavily on mathematics. The first difficult concept that students have to come to grips with is that sexual reproduction ensures that every new individual or genotype created is genetically unique, never to recur.

The life expectancy of a genotype is therefore a single generation; in contrast the genes themselves transcend the mortality of the individual. Thus it is genes not genotypes that get transmitted to the next generation making the gene frequency the currency of population genetics. To understand, let alone teach students about the dynamics of gene frequency change in natural population it is necessary to make certain simplifying assumptions. These allow the behaviour of genes to be described by simple mathematical equations which constitute the essence of classical population genetics. In the pre-computer days innovative teachers used bags to represent populations and coloured beans (bean bag genetics) and had students randomly sampling beans from bags in pairs to illustrate sexual reproduction and the basic models of population genetics.

In this technological age we can use computers instead of bean bags to help teach basic concepts in population genetics and a number of different programs or packages in a range of formats and of

varying merit have been developed. This paper reviews some of these programs and introduces a program, XLGene, which runs under Microsoft Excel written by one of us (RC) that models the behaviour of genes under a range of conditions. The simplicity of the program and its innovative use of graphics make it a powerful teaching tool which greatly facilitates the transmission of genetic concepts from one generation to another.

*Key words:* CAI, dynamics of gene frequency change, gene pool, Microsoft Excel program, population genetics, sexual reproduction.

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#### **An Example on the Practice of the Integrated Study in the Yoshii River etc**

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In the present study, the trial of the Integrated Study was carried out through outdoor activities mostly in the Yoshii River, following the learning plan under the title of "The Time for Good Friends" in the 4th grade at the Yoshii Elementary School, in Okayama Prefecture on 6th July, 2001. As a result of the trial, kids attempted to apply the knowledge and practiced in their actual lives, and to make their lives better – they joined the local environmental campaign willingly, whatever they could do – never made leftover food, utilized the soap made of used oil and the acryl swab, sprayed the rice washing water to plants, etc.

*Key words:* elementary school, Integrated Study, outdoor activities, Yoshii River.

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**(The full paper will be included in the next issue)**

#### **Major Antigens of *Cryptosporidium parvum* Recognized by Serum Antibodies from Newborn Calves Using Western Blotting and SDS-PAGE Electrophoresis**

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*Cryptosporidium parvum* is a protozoan parasite which is mostly pathogenic to neonate animals (especially ruminants) and immunocompromised humans (AIDS patients). The infection in the host is characterized by profuse aqueous diarrhea with anorexia and fever. Diarrhea is self-limiting in immunocompetent hosts but is life threatening in immunosuppressed humans and young animals.

In this study two main target antigens, having molecular weights of 15-17 and 23 kDa were recognized by the newborn calves, based on the evaluation of the serum humoral immune response in their blood and saliva. Serum IgA intensively recognized the 15-17 kDa antigens. Electrophoretic and Western blot analysis showed that specific animal antibody response appeared between Day 3 and Day 16 post challenge. This study demonstrates that these two antigens are consistent targets of humoral immune response and therefore can be of great interest in studies concerning therapy and prophylaxis against *Cryptosporidium parvum*.

*Key Words:* Antibody, antigen, *Cryptosporidium parvum*, SDS-PAGE, Western blot.

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#### **The Taxonomy and Ethnobotanical Studies of *Dioscorea* (Dioscoreaceae) among the Aetas in Bataan, Philippines**

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A total of 4 *Dioscorea* species (*D. alata*, *D. hispida*, *D. esculenata*, and *D. pentaphylla*) were collected, processed, examined and identified in Duale, Limau, Bataan. Distinctive morphological features such as root characters, presence of spines on the stem, nature of the stems type and indumentum of the leaves were included in the taxonomic key. The ethnic people called Aetas (Kulots), were provided with questionnaires to determine the conventional agricultural practices, utilization, conservation and ecological distribution of the said genus. The gathered data were classified, analyzed and tabulated. The most common yams are *D. alata* and *D. esculenata* utilized as sources of food and medicine. **Key words:** *Aetas*, *Dioscorea*, *ethnobotany*, *Philippines*, *taxonomy*.

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**Opening-Closing Movements in Response to Light Stimuli in Processed Leaves of *Oxalis corymbosa* DC.**

**- A Study of Light Responses As Subject Matter for Biology Education -**

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Fully opened leaves of potted plants of *Oxalis corymbosa* DC. closed completely by folding their leaflets downward after keeping the plant in the dark for 2 hours. The folded leaflets, then, moved upward gradually after exposure to light. We developed the methods to measure the leaf movement quantitatively. 1) A paper protractor folded every 10° was devised to measure angles, opening angles, between stalks and main vein of each leaflet. 2) The greater parts of lamina of an excised leaf with its stalk were removed to measure

its stalk were removed to measure the opening angles more correctly. It was confirmed that the processed-excised leaf exhibited the opening-closing movement in response to light stimuli in the same manner as an intact leaf. We investigated the effects of light quality (blue, red and white) on leaf movements with the processed-excised leaf and the paper protractor. Blue and red light was obtained by covering the fluorescent lamps with red and blue cellophane filters. It was demonstrated that the pulvini cells of *O. corymbosa* perceived blue light and regulated their turgor pressure to open the leaflets.

**Key words:** *leaf movement*, *nastic movements*, *Oxalis corymbosa*, *response to light stimuli*.

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**Rare Actinomycetes Isolated from Coastal Soils As Antimicrobial Producers**

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Eleven soil samples from eleven sites were collected from Pai Island in Chonburi Province. Total actinomycetes colonies appearing on the Actinomycetes Isolation Agar, Starch Casein Agar and Glucose Asparagine Agar plates were quantified and examined. Representative colonies were picked up and morphological and some chemical characteristics of cells were studied. Out of 159 isolates, 13 antibiotic producing strains were found and most of which were *Streptomyces*, *Micromonospora* and *Microbispora*. Other non-antibiotic producing strains were *Streptomyces*, *Micromonospora*, *Pseudonocardia*, *Actinomadura*, *Nocardia*, *Nocardioopsis*, *Saccharopolyspora*, *Microbispora Promicromonospora*, *Saccharomonospora*, *Kineosporia* and *Thermoactinomyces*. The predominant species were *Streptomyces* and *Micromonospora*. Total

number of bacteria in soil was  $18.58 \times 10^3$  cfu/g soil ( $3.6 \times 10^3 \sim 57.4 \times 10^3$ ) in average. Most of the soil texture was silt and sandy in a small area. Soil humidity was 8.18 percent and humic acid was 0.58 percent in average. Furthermore, 93.79 percent of all isolates might be marine or halotolerant species. Eighty nine out of 159 isolates were thermotolerant actinomycetes and could grow at 40°C and some

strains could grow at higher temperature up to 55°C.

*Key words: Actinomycetes, Antimicrobial producer, Coastal soil, Thailand.*

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