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Research Note

Organisms Appearing in Japanese and Korean Elementary School Science Textbooks – A Preliminary Study –

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Similarities in the science curricula between Japan and Korea have been frequently pointed out. The purpose of the present study was to compare the organisms appearing in elementary science textbooks used in Japan and Korea and identify their similarities and differences in the contents from the viewpoint of biology education for biodiversity. In Korea, there is only one series of science textbooks for the third grade to the sixth grade students published by the government. On the other hand, there are 6 series of science textbooks for the third grade to the sixth grade students published by private publishers in Japan; so, we selected the leading one from among them for this study. The organism names appearing in these textbooks from both countries are mostly species names, but sometimes genus, family or order names. The number of the organism names in Korean textbooks is almost twice as large as that in Japanese textbooks. In both textbooks, most organisms are "higher" plants and "higher" animals: there are 7 protists, 1 lichen, 61 plants and 65 animals in Japanese textbooks and 2 protists, 2 fungi, 111 plants and 115 animals in Korean textbooks.

Keywords: comparative study, elementary science textbook, Japan, Korea, organisms, textbook survey

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BACKGROUND AND OBJECTIVE OF PRESENT RESEARCH

Similarities in the science curricula between Japan and Korea (see Note 1) have been frequently pointed out. At present, in elementary schools, science is taught from the third grade to the sixth grade in conformity with the national science curriculum in both countries. We carry out cooperative research work to compare the contents of science teaching in elementary schools in Japan and Korea. The present study aimed mainly to compare the organisms used for teaching science in elementary schools in both countries from the viewpoint of biodiversity education (see Note 2).

Although the newly revised national science curriculum for elementary schools has been enforced from the 2011 school year in both countries, in the present study, we surveyed Japanese and Korean elementary science textbooks used in 2010. In the survey, the organisms appearing in these science textbooks were listed and compared. We know the most important things regarding organisms are "how

these organisms are dealt with in these textbooks" and "what topics are taught by using these organisms." Therefore, when we surveyed textbooks, we recorded not only organisms' names but also how these organisms were dealt with. In the present paper, however, we only note organism names appearing in the textbooks, sort them taxonomically and analyze the differences between Japanese and Korean textbooks, because we consider it also important that students realize the diversity of organisms.

Katayama and Kanaizuka (2004) surveyed science textbooks for Japanese compulsory schools published within a time span of about 50 years from the 1950s to 2002 and reported the changes in how algae had been dealt with. Umeno (2007) also surveyed biological terms including organism names appearing in science textbooks for Japanese compulsory schools. Such surveys of organisms and biological terms appearing in school science and biology textbooks can give valuable information about biology education in the corresponding country. The information also may contribute to the development of biology education in other countries. Therefore, the present results, together with the reports mentioned above, may be useful as basic information for analyzing and comparing the contents of elementary science textbooks in further studies as well as for producing or revising elementary science textbooks in the future.

TEXTBOOK SURVEY

In Japan, six series of elementary science textbooks are published. Among them, the series of textbooks published by Dainippon-tosho Co. Ltd. was selected, because this series was chosen by schools most among the six series of textbooks (The Jiji Press, 2009; also, see websites of the National Institute for Educational Policy Research and the Textbook Publishers Association of Japan). The textbook series we surveyed was published in 2005. In this report, we refer to it as the Japanese textbook.

In Korea, there is only one series of elementary science textbooks edited by the national government (Department of Education and Human Development) and published by Daehan Printing & Publishing Co. Ltd. The textbook series we surveyed was published in 2007. In this report, we refer to it as the Korean textbook.

The names of organisms mentioned in the text or mentioned with photographs or with illustration in these textbooks were listed, and then, the organisms were classified into taxonomic groups (These organism names are shown in the Appendix). Although Cavalier-Smith (2004) recently proposed the concept of six kingdoms, we adopted five kingdoms proposed by Whittaker (1969), i.e., Monera, Protista, Fungi, Plantae and Animalia.

In the textbooks surveyed, some organisms were mentioned by their species' names and the others were mentioned by their genus names or by generic names (general names). We regarded organisms in the same family, one of which was mentioned by species name and another by generic name (e.g. kidney bean, *Phaseolus coccineus*, and bean), as different organisms for the sake of convenience.

THE CONTENTS OF JAPANESE AND KOREAN TEXTBOOKS

The chapters and sub-chapters related to organisms in the Japanese textbook and the Korean textbook are shown in Table 1 and Table 2, respectively. Although topics of the textbook for students in each grade were somewhat different between the two countries, the contents of the textbook series of both countries as a whole were not so different.

Table 1: The contents related to organisms and their environments in the Japanese textbook (published by Dainippon-tosho)

<For the third grade> Expedition in Nature How Plants Grow (1) Let's sow seeds: Sowing seeds, germination of seeds (2) How well the plants grow: Plant body structure, root, stem, leaf (3) Flower blooms; then fruit is borne (4) Fruit ripens: Lifecycle of various plants Raising a Butterfly From egg to larva, insect food, from pupa to imago Let's Examine Insects Examine the body structure of various insects, the pattern of insect growth, food and habitat of insects
<For the fourth grade> Let's Examine Various Organisms in Different Seasons (1) In spring Let's examine animals around us Let's examine plants around us (2) In summer Let's examine animals around us Let's examine plants around us (3) In late summer (4) In autumn Let's examine animals around us Let's examine plants around us (5) In winter Let's examine animals around us Let's examine plants around us Look for organisms passing the winter (6) In early spring
<For the fifth grade> The Continuity of Life (1) Seed germination Conditions of germination, germination and seed storage nutrients (2) Nutrients and sunlight which encourage plant growth (3) Embryo development and birth: a mysterious event (Select A or B) A. Development of fish embryo Male and female killifish, development of killifish embryos, food for pond fish B. Development of a human embryo (4) Production of fruit and seeds Stamen and pistil, role of pollen, pollination, means of pollen transportation
<For the sixth grade> Organisms and Nourishment (1) Plant leaves and sunlight Photosynthesis (2) Plants eaten by animals Herbivores, detritus feeders, Animal (Human) Body Structure Respiration, digestion and absorption, blood circulation, skeletons and muscles Organisms and Their Natural Environment The way of life of various organisms, organism-air relationship, organism-water relationship, organism-nourishment relationship, our life and the environment

Table 2: The contents related to organisms and their environments in the Korean textbook

<For the third grade>
Organisms in Water
Organisms in water, conditions for raising fish in a fishbowl, body structure of aquatic animals such as fish, predator-prey relationships
The Lifecycle of *Drosophila*
Body structure of insects, lifecycle of insects, holometaboly and hemimetaboly
Plant Leaves and Stems
Methods of leaf observation, classification of leaves based on their morphologies, leaf positioning, various features of stems / trunks, function of stems: pathways of water and nutrients, trunks and year rings
<For the fourth grade>
Beans
Conditions of seed germination, conditions of plant growth, lifecycle of kidney beans and garden balsam
Plant Roots
Structure and function of roots
Body Structure of Animals
Body structure of various animals, classification of animals based on their morphologies, the habitats and lifestyles of animals
Male and Female Animals
Difference between males and females, mating behaviour, animal propagation methods, animal growth and life span
<For the fifth grade>
Flowers
Classification of flowers based on their morphologies, male flowers and female flowers, Role of flowers, pollination, means of pollen transportation
Functions of Leaves
Photosynthesis, stomata and transpiration, how to operate a microscope
Microorganisms
Microorganisms living in water, microorganisms living in the soil
Organisms and Their Environment
Temperature-organism relationship, light-organism relationship, water-organism relationship, relationships among organisms, adaptation of animals, human impacts upon the environment
Fruits
Fruit production, various fruit and seeds, methods of seed propagation, fruit and seeds in our lives
<For the sixth grade>
Structure and Function of Human Body
Skeleton and muscles, the respiratory system, the circulatory system, the digestive organ system, the excretory organ system, the nerve and sensory organ system
Organisms around Us
Inquiry into organisms around us, rough classification of organisms around us, classification of animals, classification of vertebrates based on their features, classification of invertebrates based on their features, classification of plants, phanerogams and cryptogams
Comfortable Environment
Requirements for organism survival, producers, consumers and decomposers, predator-prey relationships (food chain), ecological pyramid and the balance of the ecosystem, environmental issues and environmental conservation

RESULTS OF TEXTBOOK SURVEY

Organism names mentioned in the text and shown by photographs in both Japanese and Korean textbooks were domestic names most of which indicated the species or genus. Sometimes generic names which indicate a genus or organisms classified into some different genera were used (e. g., the generic name "mame" in Japanese may include all sorts of legumes). In the Japanese textbook, the names of organisms were sometimes not mentioned, especially when these organisms were shown by illustrations. On the other hand, in the Korean textbook, the names of most organisms shown, not only by photographs but also by illustrations were mentioned.

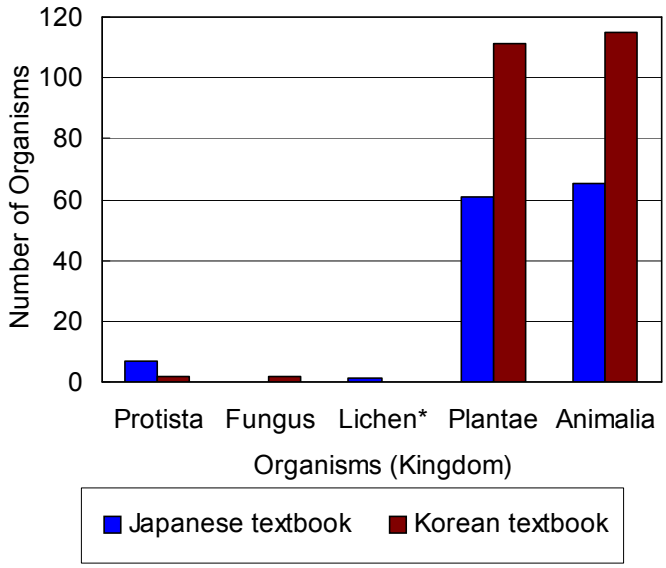

Figure 1: Total number of organism names from each kingdom appearing in the Japanese and Korean textbooks.
* Lichen species cannot be classified into any kingdom.

The number of organisms, whose names appeared in the Japanese textbook and in the Korean textbook, in every kingdom was shown in Figure 1 and in Table 3. In the Japanese textbook, litmus which is the genus name of lichen *Roccella* appeared in the explanation of the litmus test. Lichens could not be classified into any kingdom. Therefore, in Figure 1 and Table 3, the lichen is shown separately. The total number of organism names appearing in the Japanese textbook was 134, and most of them were species names or genus names. The total number of organism names appearing in the Korean textbook was 229, about 1.8 times larger than that in the Japanese textbook. As shown in Figure 1, the organisms appearing in textbooks of both countries belonged mostly to the plant kingdom (61 in Japanese, 111 in Korean) and the animal kingdom (65 in Japanese, 115 in Korean).). No names of Monera appeared in the textbooks of either country.

As shown in Table 3, in both Japanese and Korean textbooks, most of the organisms belonging to the plant kingdom were dicotyledonous angiosperms, and as for the organisms belonging to the animal kingdom, insects and vertebrates were large in number. To examine the number of organisms belonging to each classifi-

cation group in detail, there were some differences between the Japanese textbook and the Korean textbook (See Table 3 and Appendix).

Table 3: The number of organism names which appeared in the Japanese and Korean textbooks

Classification			Number of organism names	
			J*	K**
Protista			7	1
Lichen***			1	0
Fungi			0	2
Plantae	Bryophyta		0	2
	Pteridophyta		0	1
	Gymnosperms		2	8
	Angiosperms	Dicotyledon	50	81
		Monocotyledon	9	19
Animalia	Cnidaria		0	2
	Platyhelminthes		0	1
	Annelida		1	1
	Mollusca		3	5
	Echinodermata		0	2
	Arthropoda	Arachnida	1	2
		Crustacea	3	6
		Diplopoda	1	0
		Insecta	27	29
	Chordata	Pisciformes	8	10
		Amphibia	1	4
		Reptilia	0	4
		Aves	5	23
		Mammalia	15	26
Total			134	229

*J: Japanese textbook (published by Dainippon-tosho), **K: Korean textbook.

*** Lichen is not a kingdom, but lichen species cannot be classified into any kingdom.

In the Japanese textbook, although Katayama and Kanaizuka (2004) reported that no algal names appeared in the previous textbook series published in 2002, there were 7 protists which were phytoplankton and seaweeds. There was no name of fungi. Plants appearing in the Japanese textbook were only gymnosperms and angiosperms most of which were cultivated ones (See Appendix). The number of organisms belonging to Arthro-

pods, most of which were insects, was larger than that of vertebrates. Most vertebrates were fish and mammals and there was no reptile. The selection of organisms for Japanese elementary science textbooks was quite unbalanced, and seemed to be inappropriate for studying biodiversity.

In the Korean textbook, one genus name of protists and two generic names of fungi (mold and mushroom) appeared. Among the plants appearing in the textbook, two mosses and one fern were included. As for invertebrate animals, the names of coelenterates, flatworms and echinoderms appeared, which were lacking in the Japanese textbook, although most of them were generic names. The number of organisms belonging to vertebrates was nearly two times larger than that of Arthropods and all classes of vertebrates were covered. It is noteworthy that the number of organisms belonging to the class Aves was quite large and nearly equal to that of mammals. Although the Korean textbook covered the plant and animal kingdoms more widely than the Japanese textbook, the selection of organisms in the Korean textbook also did not seem to be satisfactory from the viewpoint of biodiversity education.

The number of organism names appearing in the textbooks from the third grade to the sixth grade fluctuated depending on the contents of the textbook (Table 4). Textbooks dealing with ecosystems, the Japanese textbook for the sixth grade and the Korean textbook for the fifth grade, were somewhat rich in the number of organism names. On the other hand, in the Japanese textbook for the fourth grade, the number of organism names was considerably smaller than in others, because some selected organisms were dealt with throughout the year.

Table 4: The number of organisms in each kingdom* whose names appeared in the Japanese and Korean textbooks for each grade

Grade	Japanese textbook (published by Dainippon-tosho)					Korean textbook				
	Pr	L	F	Pl	A	Pr	L	F	Pl	A
3rd	0	0	0	21	20	0	0	0	55	22
4th	0	0	0	13	10	0	0	0	19	57
5th	0	0	0	22	17	1	0	2	54	40
6th	7	1	0	26	27	0	0	0	26	43

*Pr: Protista, L: lichen, F: Fugi, Pl: Plantae, A: Animalia.
Lichen is not a kingdom, but lichen species cannot be classified into any kingdom.

In addition to the difference in the total number of organism names, there was another distinct difference between Japanese and Korean textbooks. We examined how often each organism appeared in the textbook series. We considered organisms whose names appeared on at least four pages in the textbook series to be key organisms. Table 5 shows the domestic names and scientific names of these key organisms. In the Japanese textbook, some organisms were dealt with repeatedly in different chapters and subchapters. Therefore, the names of some particular organisms appeared on many pages in one textbook. Such organisms

maybe appeared in the textbook series of other publishers and are considered to correspond closely to the "organisms of high universality" in the report of Umeno (2007). In the Korean textbook, the number of such key organisms was very small compared to that in the Japanese textbook. In the Japanese textbook, the key organisms sometimes were dealt with throughout the year; that means students learn some different topics by these organisms.

Table 5: The names of "key organisms*" in the Japanese and Korean textbooks

Grade	Japanese textbook (published by Dainippon-tosho)	Korean textbook
3rd	Okra (*Abelmoschus esculentus*) Garden balsam (*Impatiens balsamina*) Oriental longheaded locust (*Acrida cinerea*) Cabbage butterfly (*Pieris rapae*)	Daimyo oak (*Quercus dentata*) Cherry tree (*Prunus* sp.) Bamboo grass (*Sasa* sp.) Fruit fly (*Drosophila* sp.) Crucian carp (*Carassius carassius)*
4th	Fat hen (*Chenopodium album*) Balsam pear (*Momordica charantia*) Sponge gourd (*Luffa aegyptiaca*) Chinese mantis (*Tenodera aridifolia*) Japanese rhinoceros beetles (*Trypoxylus dichotomus*) Japanese toad (*Bufo japonicus*) Barn swallow (*Hirundo rustica*)	Bean (*Phaseolus coccineus*) Korean stag beetle (*Lucanus maculifemoratus dybowskii*)
5th	Morning glory (*Ipomoea nil*) Kidney bean (*Phaseolus coccineus*) Killifish (*Oryzias latipes*) Human (*Homo sapiens*)	
6th	Kidney bean (*Phaseolus coccineus*) Potato (*Solanum tuberosum*) Pillbug (*Armadillidium vulgare*) Rabbit (*Oryctolagus cuniculus*) Cattle (*Bos taurus*) Human (*Homo sapiens*)	Rice (*Oryza sativa*)

* Organisms whose names appeared on at least four pages in the textbook series are considered to be key organisms. Plant names are shown in green and animal names in purple.

DISCUSSION

The results of the present survey indicate that, compared to the Korean textbook, the Japanese textbook seems to select biological materials more carefully for science teaching in elementary schools, although the viewpoint of biodiversity education is lacking. We surmise the reasons as follows:

Recently in Japan, it has been pointed out (see Note 3 in detail) that 1) Most elementary

school teachers are not good at teaching science, because they were not science education majors in pre-service teacher training courses, 2) On biology education in elementary schools, many teachers know few organism names because they are not familiar with organisms, and 3) Many elementary school teachers wish to use some very familiar organisms for teaching materials and they expect to reduce the number of organisms appearing in science textbooks (see Note 3 in detail). The small number of organism names appearing in the Japanese textbook and the fact that the majority of plants were cultivated species may reflect this situation. On the other hand, such problem seems to have not occurred yet in Korea, because most Korean elementary school teachers have been instructed well in biological teaching materials at teacher training colleges and in-service training programs (Professor Jae-Young Kim's personal communication).

However, to confirm these differences in biological knowledge of elementary school teachers in both countries, we have to carry out a survey on how well elementary school teachers in both countries know the organisms which appear in the textbooks they are using. The same survey to elementary school children will also give us meaningful information on the teaching skills in science of elementary school teachers in both countries. In addition, a survey on whether these organisms are easily available to elementary school teachers is also required. Together with the results of the present study, these results would be useful for selecting organisms for elementary school science education in the future.

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Note 1: In the present paper, we refer to the Republic of Korea simply as Korea.

Note 2: The present paper was read at the 23th Biennial Conference of AABE, Singapore (2010).

Note 3: There are several reports, written in Japanese, on this topic, for example, Tsuchida and Hayashi (2005), Japan Science and Technology Agency (2010, 2012), Benesse Educational Research and Development Institute (2010), Nakata *et al*. (2012) and Naganuma (2015).

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Appendix (List of organism names appearing in the Japanese and Korean textbooks)

Organism names are basically shown by their species names or genus names. The organisms whose scientific names cannot be determined are printed in their domestic names or generic names (sometimes family names are indicated).

[Japanese textbook]

Protista: green laver (*Enteromorpha* sp.), duckweed (*Spirogyra* sp.), *Closterium ehrenbergii*, *Biddulphia* sp., *Arachnoidiscus ehrenbergii,* kelp (*Laminaria* sp.), *Undaria pinnatifida*

Lichen: litmus (*Roccella* sp.)

Plantae: **Gymnosperms** *Ginkgo biloba*, *Cryptomeria japonica*; **Angiosperms** <**Dicotyledon>** *Fagus crenata*, *Ficus carica*, *Ficus erectus*, *Morus bombycis*, *Chenopodium album*, *Achyranthes bidentata*, *Portulaca oleracea*, *Nymphaea tetragona*, *Cabomba caroliniana*, *Magnolia denudate*, *Brassica campestris* var. *napus*, *Brassica campestris* var. *perviridis*, *Brassica oleracea* var. *capitata*, red cabbage (*Brassica oleracea* var. *capitata*), *Raphanus sativus*, *Hydrangea macrophylla*, *Fragaria ananassa*, cherry tree (*Prunus* sp.), *Prunus mume*, *Malus pumila*, *Trifolium repens*, *Phaseolus coccineus*, *Vicia angustifolia*, *Vicia cracca* var. *japonica*, *Pueraria lobata*, *Zanthoxylum piperitum*, *Poncirus trifoliate*, mikan (*Citrus* sp.), grapefruit (*Citrus* sp.), *Impatiens balsamina*, *Abelmoschu esculentus*, *Daucus carota* var. *sativa*, *Petroselinum sativum*, *Cathananthus roseus*, *Ipomea nil*, *Ipomea batatas*, *Salvia splendens*, mint (*Mentha* sp.), *Lycopersicon esculentum*, *Solanum tuberosum*, *Momordica charantia*, *Luffa cylindrical*, pumpkin (*Cucurbita* sp.), *Cucumis melo*, *Xanthium occidentale*, *Artemisia princeps*, *Ambrosia artemisiaefolia*, *Erigeron canadensis*, *Cosmos bipinnayus*, *Helianthus annuus*; <**Monocotyledon**> *Egeria densa*, *Phragmites communis*, *Oryza sativa*, *Setaria viridis*, *Triticum aestivum*, *Miscanthus sinensis*, *Zea mays*, *Spirodela polyrhiza*, lily (Lilium sp.)

Animalia: **Annelida** earthworm; **Mollusca** terrestrial snail (*Euhadra* sp.), *Radix auricularia japonica*, river snail (*Cipangopaludina* sp.); **Arthropoda** <**Arachnida**> *Argiope amoena*, <**Crustacea**> *Procambarus clarkia*, *Armadillidium vulgare*, water flea (*Daphnia* sp.), <**Diplopoda**> millipede, <**Insecta>** cicada, *Graptopsaltria nigrofuscata*, aphid, locust, *Acrida cinerea*, grasshopper (*Oxya* sp.), phasmids (*Entoria* sp.), *Tenodera aridifolia*, *Allomyrina dichotoma*, *Luciola cruciata*, *Coccinella septempunctata*, dragonfly, *Orthetrum albistylum speciosum*, springtail, *Camponotus japonicus*, honey bee (*Apis* sp.), species of Chalcidoidea, species of Agaonidae, *Colias erate*, *Pieris rapae*, *Papilio xuthus*, *Papilio machaon*, *Sasakia charonda* (*Diadema charonda*), *Bombyx mori*, *Biston robustus robustus*, species of Syrphidae, chironomids lavea (*Chronomus* sp.); **Chordata** <**Pisciformes**> *Rhincodon typus*, *Salvelinus* sp., *Oncorhynchus keta*, *Gambusia affinis*, killifish (*Oryzias* sp.), orange-colored mutant killifish (*Oryzias* sp.) , *Carassius carassius*, *Carassius auratus auratus*, <**Amphibia**> *Bufo japonicus*, *Anas acuta*, <**Aves**> *Dendrocopos leucotos*, *Hirundo rustica*, *Motacilla alba*, *Gallus gallus domesticus*, <**Mammalia**> *Canis lupus familiaris*, *Ailuropoda melanoleuca*, *Felis silvestris catus*, *Panthera leo*, *Oryctolagus cuniculus*, *Mesocricetus auratus*, *Glirulus japonicus*, mole, *Bos taurus*, goat (*Capra* sp.), *Giraffa camelopardalis*, *Equus caballus*, elephant, whale, *Homo sapiens*

[Korean textbook]

Protista: duckweed (*Spirogyra* sp.)

Fungi: mold, mushroom

Plantae: **Bryophyta** *Marchantia polymorpha*, hair moss (*Polytrichum* sp.); **Pteridophyta** *Pteris aquilinum*; **Gymnosperms** *Ginkgo biloba*, *Cycas revolute*, *Torreya nucifera*, pine (*Pinus* sp.), *Pinus densiflora*; *Pinus koraiensis*, *Abies firma*, *Thuja orientalis*; **Angiosperms** <**Dicotyledon**> *Quercus acutissima*, *Quercus dentate*, *Quercus mongolica*, *Corylus heterophylla*, *Betula platyphylla*, *Zelcova serrata*, *Viscum album*, *Chenopodium rubrum*, *Mirabilis jalapa*, *Dianthus caryophillus*, *Dianthus superbus* var. *longicaly-*

cinus, *Nelumbo nucifera*, *Cercidiphyllum japonicum*, *Pulsatilla cernua*, *Magnolia liliflora*, *Magnolia denudate*, *Dicentra spectabilis*, red cabbage (*Brassica oleracea* var. *capitata*), *Raphanus sativus*, *Platanus occidentalis*, *Fragaria ananassa*, *Malus pumila*, rose (*Rosa* sp.), *Rosa multiflora*, *Rosa rugosa*, cherry tree (*Prunus* sp.), *Prunus armeniaca* var. *anzu*, *Prunus persica* var. *vulgaris*, pear (*Pyrus* sp.), bean, black bean (*Glycine max*), *Robinia pseudo-acacia*, *Phaseolus coccineus*, *Trifolium repens*, *Lespedeza maximowiczii*, mikan (*Citrus* sp.), *Buxus microphylla*, *Rhus javanica*, *Euonymus japonicus*, maple (*Acer* sp.), *Impatiens balsamina*, *Impatiens textori*, *Zizyphus jujube*, *Vitis coignetiae*, *Vitis vinifera*, *Parthenocissus tricuspidata*, *Hybiscus syriacus*, *Gossypium indicum*, camellia (*Camellia* sp.), violet (*Viola* sp.), begonia (Begonia sp.), cactus (*Opuntia* sp.), *Trapa natans*, *Panax schinseng*, *Daucus carota* var. *sativa*, azalea (*Rhododendron* sp.), *Ipomea nil*, *Calystegia japonica*, *Syringa dilatata*, *Forsythia suspense*, *Cornus officinalis*, *Elsholtzia ciliate*, *Solanum tuberosum*, *Lycopersicon esculentum*, *Petunia hybrida*, pumpkin (*Cucurbita* sp.), *Luffa cylindrica*, *Cucumis sativus*, *Zinnia elegans*, *Helianthus annuus*, *Kalimeris yomena*, *Cosmos bipinnayus*, *Bidens bipinnata*, *Bidens tripartita*, *Chrysanthemum morifolium*, *Artemisia princeps*, thistel (*Cirsium* sp.), *Cirsium japonicum* var. *ussuriense*, *Arctium lappa*, dandelion (*Taraxacum* sp.), *Taraxacum albidum*; <**Monocotyledon**> *Typha latifolia*, *Hydrilla verticillata*, bamboo grass (*Sasa* sp.), *Oryza sativa*, *Triticum aestivum*, *Hordeum vulgare*, *Phragmites communis*, *Setaria viridis*, *Zoysia japonica*, *Miscanthus sinensis*, *Zea mays*, *Spirodela polyrhiza*, *Commelina communis*, *Tradescantia reflexa*, *Eichhornia crassipes*, lily (*Lilium* sp.), *Lilium lancifolium*, *Narcissus tazetta*, *Iris sanguinea*

Animalia: **Cnidaria** sea anemone, jellyfish; **Platyhelminthes** *Planaria* sp.; **Annelida** earthworm; **Mollusca** terrestrial snail (*Euhadra* sp.), *Semisulcospira libertina*, river snail (*Cipangopaludina* sp.), *Turbo sazae*, squid; **Arthropoda** <**Arachnida**> spider, *Argiope bruennichii*, <**Crustacea**> *Cambaroides japonicus*, crab, *Ocypode stimpsoni*, *Armadillidium vulgare*, corn barnacle, water flea (*Daphnia* sp.), <**Insecta**> cicada, *Graptopsaltria nigrofuscata*, *Hyalessa maculaticollis*, *Aquarius paludum*, *Ranatra chinensis*, locust, *Ducetia japonica*, grasshopper (*Oxya* sp.), *Oxya chinensis*, praying mantis (*Tenodera* sp.), *Cybister japonicus*, *Paracycrotrachelus longiceps*, *Lucanus maculifemoratus dybowskii*, *Massicus raddei*, firefly (*Luciola* sp.), ladybird (*Coccinella* sp.), dragonfly, *Crocothemis servilia*, ant, butterfly, *Papilio xuthus*, moth, *Adris tyrannus*, *Actias aliena*, *Eristalis tenax*, *Musca domestica*, fruit fly (*Drosophila* sp.), mosquito; **Echinodermata** starfish, *Patiria pectinifera*; **Chordata** <**Pisciformes**> *Gasterosteus aculeatus*, *Cyprinus carpio*, *Carassius carassius*, *Carassius auratus auratus*, *Pungtungia herzi*, *Tanakia lanceolata*, *Zacco temmincki*, *Amphiprion clarkia*, mackerel (*Scomber* sp.), flying fish (*Cypselurus* sp.); <**Amphibia**> newt (*Cynop*s sp.), frog, green tree frog (*Rhacophorus* sp.), *Pelophylax nigromaculatus*; <**Reptilia**> turtle, iguana, lizard, snake; <**Aves**> *Aix galericulata*, *Ardea cinerea*, white heron (*Egretta* sp.), *Grus japonensis*, *Numenius arquata orientalis*, *Larus crassirostris*, hawk (*Accipiter* sp.), *Aegypius monachus*, *Strix uralensis*, *Bubo bubo*, *Caprimulgus indicus*, *Halcyon coromanda*, *Upupa epops*, *Alauda arvensis*, *Hirundo rustica*, *Ficedula zanthophygia*, *Phoenicurus auroreus auroreus*, *Zosterops japonica*, *Passer montanus*, *Columba livia*, *Pavo cristatus*, *Anas platyrhynchos* var. *domesticus*, *Gallus gallus domesticus*, <**Mammalia**> bat, *Canis lupus familiaris*, Korean Jindo dog, sand fox, *Vulpus lagopus*, *Ursus thibetanus*, *Felis silvestris catus*, *Panthera leo*, *Panthera tigris*, *Oryctolagus cuniculus*, squirrel, *Sciurus vulgaris corea*, camel (*Camelus* sp.), *Bos Taurus*, goat (*Capra* sp.), *Ovis aries*, deer, *Cervus elaphus*, *Capreolus capreolus*, *Sus scrofa domesticus*, *Giraffa camelopardalis*, elephant, dolphin, *Delphinus delphis*, *Pan troglodytes*, *Homo sapiens*

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Biological Resource

Teaching the Vertebrate Skeletal Systems with Cast and Models Avoiding Animal Dissection

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Teaching and the study of the vertebrate skeletal systems is an integral part of any undergraduate / postgraduate animal sciences curricula. The traditional method of teaching skeletal systems has been through dissection of an animal to expose the various systems. However, with the growing concern regarding discontinuation of animal dissections and implementation of animal ethical rules in many countries, it is becoming increasingly difficult for the teaching fraternity to cover these topics in the classroom / laboratories. Here we present a method to replicate the skeletal systems of various animals using a foam fibre material. The imitations of skeletons made of this material are sturdy and can last for several years without degradation. Since they can be made to look exactly like the true biological specimen, they can be easily and interestingly used in teaching the vertebrate skeletal systems. Thus, teaching the vertebrate skeletal systems is possible without having to sacrifice animals.

Keywords: *alternatives to animal dissection, artificial bone model, teaching skeletal systems*

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INTRODUCTION

The method of dissection for teaching anatomy and physiology of animals has been an age-old practice spanning several decades. The institutions usually purchase a skeleton from the dealers and manufacturers who supply biological educational materials especially for teaching about vertebrate skeletal systems. Nowadays, it is becoming increasingly difficult to procure animal skeletons due to ethical and legal restrictions on animal killing (Balcombe, 2000; Balcombe, 2003). This is also an issue raised by organisations such as the People for the Ethical Treatment of Animals (PETA, See website). Dissection of animals in undergraduate and post-graduate laboratories has come under severe criticism in many countries leading to widespread concern amongst educators in Zoology (Kramer, 2007; Hart *et al*., 2008). The University Grants Commission (UGC), the highest policy making body in the Indian education system, directed colleges and universities to discontinue animal dissection and has recommended to explore alternative pedagogical methods (UGC, 2011). This promulgation has put forth challenges to biology educators to replace traditional teaching methods of vertebrate anatomy with suitable alternatives (Balcombe, 2003).

The advent of software-based pedagogical tools, especially the digital dissection software as alternatives to live dissection of animals to study

vertebrate anatomy, attracted considerable attention amongst biology educators (Jukes and Chiuia, 2003; Duncan, 2008; Lalley *et al.*, 2010). Several commercial bodies got engaged in such endeavours (Jukes and Chiuia, 2003; Lalley et al., 2010). Unfortunately, so far as teaching of skeletal systems is concerned, virtual education through software-based demonstration does not give an opportunity to students to 'feel' and 'conceptualize' bones with their own hands. This pedagogical challenge has inspired us to look for alternatives.

The 3Rs principle of 'replacement', 'reduction' and 'refinement' is often referred to as the concept of alternatives (Russell and Burch, 1959). In view of this, one can witness a growing demand for discontinuation of animal dissection and instead to use 'non-animal' methods. In this paper, we have proposed imitative means of representing bones of vertebrates which can be used for testing of students' knowledge and understanding of various skeletal systems and their structure-function relationships. Several cost-effective materials such as plaster of Paris, modelling clay, foam fibre and glass fibre were tried. Among these materials, foam fibre was found to be the most convenient material for the proposed use. This material is eco-friendly as well as sturdy and therefore an excellent substitute for obtaining 'original bones' by dissecting animals. At the same time, the model proposed in this paper can be used for 'hands-on' and 'minds-on' training of comparative aspects of vertebrate skeletal systems.

MATERIALS AND METHODS

(a) Preparation of models of bones as study material

In the present study, three representative groups of vertebrates, namely Amphibia, Reptilia and Mammalia, were selected. Commercially available skeletons (one each) of frog (*Rana tigrina*), lizard (*Calotes versicolor*) and rat (*Rattus rattus*) were obtained from Namit Modellers, New Delhi, India, an authorized supplier for educational institutes. The skeletal parts were disarticulated into individual components. These skeletal items were used as templates to prepare models.

The individual pieces of bones were made dust-free and clean. Bone pieces were then coated with petroleum jelly to make the template bones non-stick to casting material. The template bones were covered and coated with plaster of Paris mixed with water (1:2) and allowed to get completely dried and harden. Subsequently, each cast was broken to obtain the mould of selected bone. Foam fibre (one of the possible sources to procure foam fibre is Kavita Trading Co., Mumbai, India) was used to get the desired shape and contour of the bone surface and was allowed to dry. The specimen was then detached from the mould and reassembled for final display. The entire process takes approximately six days from the day of procurement of the template.

(b) Practices using skeletal models

The fabricated skeletal models were used in designed tasks for vertebrate anatomy which were pre-tested in trial rounds on high school science students under the Government-funded National Biology Olympiad Programme of the Biology Cell, Homi Bhabha Centre for Science Education (HBCSE), TIFR. These artificial animal bones were used in an experimental test during the 19th International Biology Olympiad (IBO) held at Mumbai by framing a laboratory task under Animal Anatomy and Physiology. The laboratory task (Practical Test 2, Task 1, Study of Animal Skeletal Systems; total points 54; duration 45 minutes), comprising comparative study of skulls, vertebral columns and limbs of frog, lizard and rat, can be viewed at the IBO website. The task was performed by 220 students from 55 countries.

RESULTS AND DISCUSSION

The purpose of the present study was to use the models as an alternative to actual skeletons especially since there are restrictions on sacrificing of animals in various countries. In view of this, foam fibre models of the skeletal systems (Figures 1 A - C) were provided to each of the 220 students at the 19th International Biology Olympiad. The task and models were presented to the juries of participating countries (about 100 members) prior to executing the same to the students. The models were examined by the juries and they readily approved the models for the proposed use.

The performance of the students post the experimental test was analysed. An alternative method to give the proposed task would have been to provide images of the various skeletal systems of the three animals. However, it is often found that any three-dimensional structure given in pictorial form becomes too straightforward for deductions if the various parts are labelled while it may be too difficult to interpret if these parts are not labelled. Thus, the use of skeletal mimics would reduce the risk of either over-simplifying the task or making it too difficult. This was reflected in the correlation coefficient between the scores of students in this lab and the overall performance (total score) of students. The correlation coefficient was found to be 0.71 which is considered to be a satisfactory score.

With the advent of software-based pedagogical tools, especially the emergence of digital dissection software, the alternative to live dissection of animals for the demonstration of skeletal parts have been accomplished by many educational institutes worldwide (Jukes and Chiuia, 2003; Lalley *et al*., 2010). However, hands-on training of skeletal systems apparently suffered a compromising pedagogy, because software-based virtual dissection cannot replace the realistic understanding of skeletal components when students comprehend the shapes and contours by touching the bones with their own hands and learn how to differentiate one from another. Therefore, the models presented here can address this issue effectively.

Also, our study design ruled out the influence of factors like age groups, differences of teaching environments and ethnicity by executing the task in the 19th IBO, because the participants were high school students but had different 'teaching-learning' backgrounds, ethnicity and cultural roots. On the basis of our analysis we can conclude that the artificially made imitations of skeletal components could be successfully used in testing students' knowledge and understanding of various structures and the structure-function relationships of various parts.

Visual exposure to skeletal systems on the computer screen does not satisfy the student inquisitiveness and therefore real-time exposure to imitation of animal bones can provide students with intellectual satisfaction. Mimics of bones presented in this paper can be touched and handled by the students, thereby can compensate pedagogical lacunae of the use of 'Information and Communication Technology.' We hope, the alternative materials proposed here to replace animal dissection for teaching vertebrate skeletal systems will partly resolve the ethical issues being encountered by biology educators.

ACKNOWLEDGEMENTS

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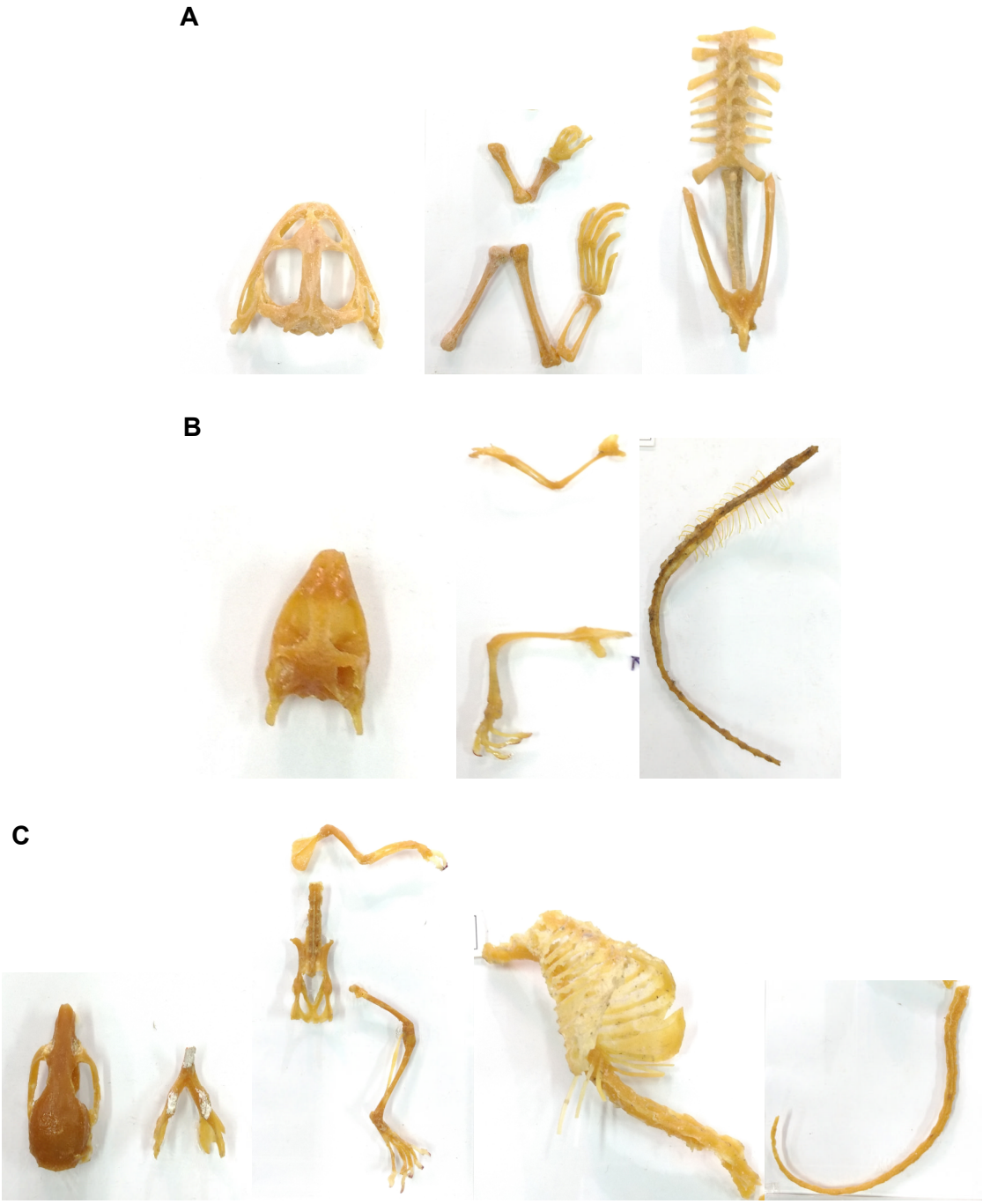

Figure 1: Artificial bones which are imitations of (A) Frog (B) Lizard (C) Rat skeletal systems

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Country Report

A Partnership Approach to Develop National Biology Curriculum in Singapore*

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Biological education in Singapore mainly mirrored the curriculum in UK in early decades. From 1970s, biology curriculum was developed by Curriculum Planning and Development Division (CPDD), Ministry of Education (MOE), Singapore. The curriculum undergoes a typical 6-year review cycle, with an intermediate third-year review to ensure currency of the curriculum. Over years, a partnership framework for curriculum design and implementation has established to foster close collaborations among ministry curriculum developers, school leaders, science educators and practitioners. The developed national curriculum is very explicit to teachers, parents and even students across various educational levels (as shown in **Figure 1**). The entire body of curricular stakeholders (curricula developers, curricula resource developers, science educators, examinations board and teachers) has to understand the philosophy, intent and details of the curriculum to see through the successful implementation of the curriculum. A partnership (various dynamic forms of working together) plays pivotal roles in this process.

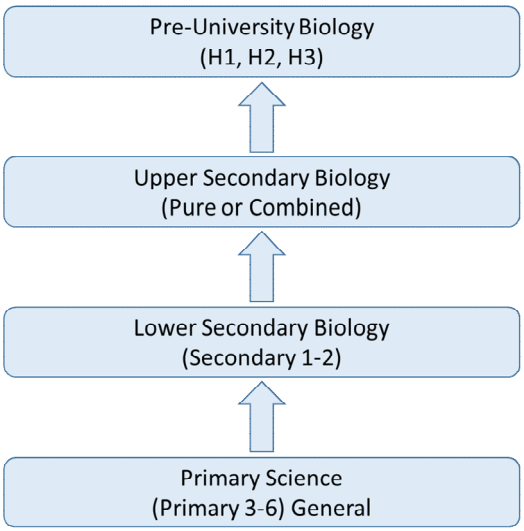

Figure 1: An overview of biology offered across educational levels in Singapore

A typical partnership framework of curriculum design and implementation includes: 1) Scanning literature and practices [curriculum planning officers from CPDD/MOE and partners from National Institute of Education (NIE) as curriculum review committee members]; 2) School leaders and practitioners providing feedback on the existing curriculum [head of department (HOD) or teachers from schools]; 3) Consulting expert panel of curriculum developers, school leaders, biology educators and practitioners [Academy of Singapore Teachers (AST), NIE, various departments (such as Educational Technology Division, Gifted Education Branch) and schools from MOE, and Singapore Examinations and Assessment Board (SEAB)]; 4) Consulting senior educators and administrators on curriculum and implementation [senior educators and administrators from MOE Headquarters]; 5) Producing textbooks and resources, with reviews by school practitioners [HOD and teachers from schools]; 6) Supporting professional development [pre-service and in-service professional developments by NIE, master teachers from AST, schools, and CPDD].

Taking an example of recent revisions on H2 Biology syllabus, the two new Extension Topics are based on important emerging biological issues impacting both the local and global contexts. They require students to demonstrate assimilation of the Core Ideas and extend their knowledge and understanding to real-world challenges. Furthermore, Extension Topics will equip students with the necessary knowledge and process skills to make informed decisions about scientific issues. In line with this, the two Extension Topics chosen are (A) Infectious Diseases and (B) Impact of Climate Change on Animals and Plants. Both Extension Topics take up about 10% of the total H2 Biology curriculum.

As part of MOE's commitment to nurturing future-ready learners, all students in Singapore schools have been supported in their learning since this year by the Singapore Student Learning Space (SLS), an online learning platform (https://learning.moe.edu.sg) that contains curriculum-aligned resources and learning tools. With the SLS, students will be able to learn better through the use of technology. Students will be able to learn anytime, anywhere, and at their own pace, whether independently or with their peers. Teachers will also be able to use the SLS to complement their classroom teaching, further enriching students' learning experience. Such a platform is also under a partnership approach in which CPDD is working with NIE, AST, SEAB, etc., to develop meaningful contents and engaging ICT materials to improve students' learning experience.

Keywords: *biology education, curriculum, online learning, partnership, professional development, Singapore*

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Country Report

India Report*

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*Reported at the 27th Biennial Conference of the AABE

After 25th AABE at Kula Lumpur, India hosted 26th AABE at Goa from September 20-23, 2016 and during this period we formed AABE India Chapter. The members of AABE India Chapter are organizing various activities: workshops, seminars, demonstrations and excursion. Apart from AABE India Chapter, there are many associations in India which are working in the area of biology education from school to college level.

The following activities have been conducted by AABE India Chapter's EC members.

1. Activities Organized by Dept of Microbiology, St. Ann's College for Women, Hyderabad

Hepatitis Awareness Programme

Department of Microbiology of St. Ann's College for Women joined hands with Department of Gastroenterology, Nizam's Institute of Medical Sciences (NIMS), to create and increase awareness about Killer Hepatitis B viral infection and educate common people about the importance of vaccination and prevention of this disease. Six student volunteers studying final year microbiology actively took part in all activities carried out by Department of Gastroenterology, NIMS.

- Volunteers helped in organizing *Viral Hepatitis B Poster Competition 2016* at about 10 schools in twin cities (Hyderabad and Secunderabad). The competitions have been conducted for 8, 9 and 10 class students of different schools. Schools where the volunteers conducted the competitions are as follows:
  - Hanuman Vidhyashala State
  - Hanuman Vidhyashala CBSC
  - R. P. H School
  - Naya Pool Government School
  - Gitanjali Dharmashalay
  - V. V. Vidhya Kanyashalay School
  - Vivekanand School
  - St. Andrews High School
  - St. Anns Girls School
  - Johns Boys High School
- Student volunteers participated in *Hepatitis Awareness Walk*.
- Volunteers took part in *Hepatitis Screening Camp* at NIMS.



Feedback of Students

All student volunteers expressed that they had enhanced knowledge on Hepatitis B viral infection (transmission, immunization, prevention, diagnosis and control) at the end of the pro-

gramme and felt happy in participating in this event.

2. Preparation of 'Extraction of DNA Video'

Collaborative Undergraduate Biology Education (CUBE) is an initiative of Homi Bhabha Centre for Science Education, TIFR. CUBE inculcates interactive and participatory learning in science education among students.

CUBE organized a competition for students titled 'DNA: THE JUGAAD WAY' using common household (kitchen) chemicals for "Anil Sadgopal People Science Award" for popularizing biology.

Students of II year B. Sc. have prepared video under our guidance. For semester IV these students study microbial genetics. Practical syllabus has hands-on activities like 'Extraction of genomic and plasmid DNA from Bacteria,' 'Transformation as a method of genetic recombination in bacteria' and 'Agarose gel electrophoresis for separation of DNA.' In this view, DNA extraction is a first step and, therefore, they could do it independently by giving inputs in preparation of this video as a product. Students have prepared a video on *Extraction of DNA from Banana* using common household materials as a basic aid for understanding the concept of molecular biology.

3. Workshop on Isolation & Preservation of Pure Cultures

Workshop

On 25th November, 2016, a workshop on *Isolation and Preservation of Pure Cultures* was organized for 30 students of M. Sc., Department of Biotechnology, A. V. College, Himayat Nagar, Hyderabad. Dr. Sneha Gogte, HOD, Department of Microbiology, St. Ann's College for Women was the resource person along with two final year B. Sc. microbiology student volunteers.

Workshop started with a thought-provoking lecture on the importance of studying microorganisms by Dr. Sneha. The participants were then demonstrated step-by-step, the techniques of isolation and preservation of pure cultures using PowerPoint presentations. Petri plates with various live cultures were shown and biochemical tests were demonstrated so as to show the importance of having pure cultures in identification and diagnosis. The importance and details of various culture collection centres both at home and abroad were also discussed. The lecture was closed by presentations on modern research areas in microbiology like biosensors and quorum sensing, thus providing the students a leap into the current research.

Feedback of Students

All participants reported positive feedback and indicated that the lecture ranged from a useful to invaluable learning experience.

4. Integration of ICT in Learning Process & Developing Virtual Lab Exercises

Go Digit All

Dr. Sneha Gogte and Ch. Jyothi, Department of Microbiology, St. Ann's College for Women, Hyderabad, organized the activities.

Final year students of microbiology were involved in making video demonstrations of laboratory exercises in microbiology. Students were guided to the use of Information and Communication Technologies (ICT), and hands-on sessions from their curriculum in B. Sc. microbiology were selected to develop virtual lab in Microbiology Department at St. Ann's College for Women, Hyderabad. Nineteen video demonstrations are available in the Department as e-resources for hands-on practical sessions. Virtual lab on Gram staining technique, Pure cul-

ture isolation methods, IMVic tests, Negative staining, Coliform test, and MBRT are a few to name.

Discovery Science Exploratory (DSE)

Learning Science is Doing Science

Mobile Science Lab for Schools

Hands-on Science & Skills Workshops

- DSE is a hands-on learning program which has been introduced into the educational systems seamlessly.
- The initiative has a fully equipped and staffed science, mathematics and vocational skills lab on a mobile platform that visits each school once every week.
- The hands-on nature of the programme ensures development of all learning abilities. The skills classes make students understand the processes from raw material to finished products. The learning of Science, Technology, Engineering and Mathematics (STEM) becomes the natural base in this model. The trades taught are based on making student acquire all trades for Roti-Kapada–Makan (Food–Clothing-Shelter), basic requirements to sustain one's life.
- This experiential learning makes to explore the world using their own five senses and a rational frame of mind.
- Students acquire knowledge, become competent and develop intellect to lead life in joyous way.
- The world of gathering information turns into understandable way of acquiring knowledge.
- The models are built, experiments are performed by their own hands which make life come true, labs bring science to life.
- Peer-to-peer education is another facet of this model which happens as offshoot of interactive sessions.
- DSE Science and Skills programme has reached out to five private and two government schools consistently for last two years.
- The two government schools were part of social outreach programme of DSE.
- Another milestone, this scheme has achieved, is reaching out to differently challenged – DIVYANG students of Aashay Aakruti School – a school for hearing-impaired students. Fifty students so far got the benefit of learning skills through our programme.

Feedback of students

This technology-enriched exercise greatly enhanced students' motivation and developed positive attitude towards the course. Students emphasized that need of having clarity and in-depth knowledge on the subject. This activity also helped students to gain organization skills and enhanced their practical skills.

Our Activities 2016-2018

Food - Agriculture and Environment -

Students produce a variety of vegetables using organic ways of cultivation. Students are trained in cultivation by Vertical Gardening method.

Students are trained in making Biogas.

Vertical Gardening

Biogas production

Feedback of students

- Enjoy learning process
- Learning skills help as they can be applied in

day to day life.

- Problem solving capacity is enhanced.
- Learning skills help in understanding science and mathematics conceptually.

Feedback of DSE Trainers and Director

- Student's involvement and engagement is high.
- It provides joy of learning.
- It encourages students to observe, interpret, analyse processes.
- It builds analytical thinking, divergent thinking, figural memory and spatial abilities of a child.
- Student can relate to real time life situations through this experiential learning programme.

Dr. Sneha, Dr. Vishwanath Gogte and Dr. Dinesh Khedkar conducted many workshops for students and teachers at Amravati on folding microscope and research-based pedagogy tool.

Dr. Narendra Deshmukh also conducted many workshops for students and teachers on microscopes and biology-learning by doing and observing at different places of the country.

Other EC members also organized various workshops related to health, environment and teaching biology in their respective regions.

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Report of the 27th Biennial Conference of the AABE and Abstracts of the Papers Presented at the Conference

The 27th Biennial Conference of the AABE (AABE27) was held at the Emerald Hotel, Bangkok, Thailand, from 30th November to 2nd December, 2018.

The conference was organized by AABE (Executive Director: Prof. Kiyoyuki Ohshika; Conference Convenor: Dr. Churdchai Cheowtirakul) and Biotechnology Faculty, Assumption University of Thailand (ABAC).

The main theme of the conference was "Biology Education for Future Asia." There were six sub-themes:

(1) Biodiversity and its conservation;
(2) Environmental issues in biology education;
(3) Genetics and molecular biology;
(4) Technology-based biology education;
(5) Interdisciplinary approach;
(6) Current trends in biology education and research.

Fifty-five people from China, Hong Kong SAR (China), India, Japan, Malaysia, Philippines, Singapore and Thailand attended (Figure 1).

At the Opening Ceremony of the conference, Rev. Bro. Bancha Saenghiran, President of Assumption University, delivered the opening address (Figure 2) and Dr. Churdchai Cheowtirakul (Conference Convener), Dean of School of Biotechnology, Assumption University, gave the welcome speech (Figure 3).

Four persons were invited as plenary speakers: Prof. Glenn M. Young of UC Davis, USA; Dr. Verawat Champreda, National Center for Genetic Engineering and Biotechnology, Thailand; Dr. Chen Zhong, National Sciences and Science Education, Singapore; Dr. Orasa Choosakul, The Institute for the Promotion of Teaching Science and Technology, Thailand.

Figure 1: The attendants of the AABE27 (photo provided by Assumption University)

There were 26 oral presentations, eight poster presentations (Figure 4), and six country reports. In addition, eight posters were presented by Assumption University students.

The Best Poster Presentation Awards were given to Ms. Tomomi Sawa (Most Excellent Prize), Dr. Takahiro Yamanoi (1st Prize), and Ms. Sae Katayama (2nd Prize).

The Book of the Abstracts of Papers was published and provided to the attendants of the conference. The following abstracts are reprinted from the book.

Figure 2: Opening Ceremony
Rev. Bro. Bancha Saenghiran, delivered the opening address

Figure 3: Opening Ceremony
Welcome speech was given by Dr. Churdchai Cheowtirakul (leftmost)

Figure 4: Poster presentations
Ms. Sawa (left) was awarded the Most Excellent Poster Presentation

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<Plenary Talks>

Education Aimed at Improving Food Safety for People of Low and Middle Income Countries

Glenn M. Young
University of California, U. S. A.

Our goal is to develop educational programs that improve value chains supporting safe food systems extending from farms to markets. For Low-Medium Income Countries (LMIC), food systems driven by consumer-driven markets are limited by value chain actors' (VCAs) lack of knowledge, capital, technology and technical training. Technical innovations and new techniques can improve food safety, but they must align with solving bottlenecks in food production and food quality. In addition, adoption of technologies and practices by VCAs is often hindered by social and logistical constraints. To address the wide range of problems experienced by VCAs seeking a higher standard of living, both natural science and social science solutions are required. Our research has defined a mechanism for overcoming multiple constraints VCAs face when attempting to change their food production, processing and handling practices. Community-driven

research projects were organized around the shared interests of individuals involved in various aspects of the agricultural supply chain in six villages in Cambodia. These Shared Interest Participatory Action Research projects were designed to serve 1) as an organizing platform for team building, 2) to collectively identify problems and test solutions, and 3) to provide education and dissemination outlets for early scaling of technologies resulting in food safety improvements. This case study proposes an innovative model for effectively mitigating multiple constraints that hinder LMIC food systems activities leading to healthier food consumption.

Keywords: consumption, food safety, technical innovation

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Exploration of Uncultured Microbial Bioresource Using Metagenomics Approach

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The world is now stepping towards the age of bioeconomy. Bio-resources are being explored as the renewable starting materials for conversion to biofuels, chemicals, and biomaterials and on another side, as a valuable genetic resource for searching potent microbes and enzymes for industries. The research activities at the Enzyme Technology Laboratory, BIOTEC aim to understand the complex cooperative microbial processes on plant biomass degradation in nature and translate the knowledge into efficient enzymes for greener industries. Our works span from searching potent lignocellulose-degrading enzymes from the rich microbial bio-resource of the country, developing synergistic enzyme systems for lignocellulose hydrolysis and modification as well as on biocatalyst fabrication in various immobilization designs, to optimizing bio-processes for enzyme prototype production. The culture-independent metagenomic technique has been applied as an effective tool to explore the world of uncultured microbes, which represents up to 99% of the total biodiversity. A collection of environmental metagenomes from ecosystems active in lignocellulose degradation e.g. peatswamp forest, termite gut, and bagasse collection site has been explored using combination of activity-based screening and next-generation sequencing with the use of advanced bioinformatics tools for gene mining and in-depth analysis of the dataset. This provides an insight into the diversity and dynamics of lignocellulolytic microbial communities and genes encoding for biomass-degrading enzymes, contributing to our capability to understand biochemical processes on plant biomass decomposition in nature.

Keywords: biodiversity, lignocellulolytic enzyme, metagenome, next generation sequencing, uncultured microorgamisms

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Innovation on Biology Education

Chen Zhong
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Biology is a natural science subject studying life and living organisms. Biology education faces challenges to explain the structure, function, growth, evolution, distribution, and taxonomy of living systems. At the same time, there is a need to elucidate how life form works and interconnects from molecule, cell, tissue, organ, organism and ecosystem levels. Currently a stereotype composition of university biology courses includes 2-hour sessions in classrooms with heavy

use of PowerPoint slides accompanied by lecturer's monologue narration throughout the lecture. Such lecturing is a passive learning style that encourages note-taking and rote memorization as the means of assimilating knowledge. In the era of online learning it is imperative for educators to recognize that students have different learning styles, and hence to improve on the effectiveness of our methods of instruction. In recent years white board animations are popular in social media and commercial platforms. They are high-quality animations that instantly catch the attention of audience by means that whiteboard markers start squeaking and pictures magically appear, perfectly illustrating the narrator's words. Insightful illustrations by visualizing abstract ideas engage the viewer as the illustrator artfully captures the narrator's concepts. The words are temporally accompanied with the dynamic pictures which seamlessly present a powerful narrative cartoon instead of a dry monologue, adding further depth to the spoken terms. We foresee the huge application potential of whiteboard animation in the education industry. Hereby I will present our efforts in creating whiteboard animations in biology education done at National Institute of Education, Singapore. I will also briefly mention our latest project using virtual and augmented reality in biology education.

Keywords: biology, education, innovation

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Biology Education and Research in a New Horizon

Orasa Choosakul
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Aiming to build Thailand to be a sustainable and advanced country in the areas of economics and society, the appropriate usage of research and innovation, knowledge and innovation is necessary. Biology education research can help expanding the frontier of biological knowledge, planning and developing a meaningful biology curriculum, assessment, and class teaching. Moreover, the trend information about the fields in biology education research is useful for career paths and academic publications. There are many articles in biology education research that were published in the international journals; 1) teacher education, 2) teaching, 3) learning students' conceptions, 4) learning-classroom contexts, 5) goals, policy and curriculum, 6) culture, social and gender issues, 7) history, philosophy, epistemology and the nature of science, 8) educational technology, 9) informal learning.

Keywords: biology education, biology education research

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<Country Reports>

Thailand Report

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Compulsory education system in Thailand is composed of six years in primary school and three years in lower secondary school. The National Scheme of Education B.E. 2560-2579 (2017-2036) emphasizes the importance of the national education development. Because of the 21st century employment trend to require high work skill, the demographic changes in Thailand that the number

of elder population is increasing, and the unsustainable economic growth. Therefore, it is necessary for Thailand to prepare the suitable future education. The Institute for the Promotion of Teaching Science (IPST) is the independent authority under the Ministry of Education, with the responsibility in the development of national curriculum, educational media/ tools, science standard and quality assessment, mathematics and technology education in primary to upper secondary school, training for teachers and students, science talents promotion activities, and giving advices in the science education policy. The 2008 national science curricula objective was set up by IPST based on the principles, concepts and theories of basic science, thinking skills development. It also clarified the decision-making based on diverse data/ evidences, and also demonstrated the applications of science and technology in daily life and society. The science curricula standard in Thailand is based on 8 strands composition; 1) biological science, 2) physical science, 3) earth and space science, 4) biology, 5) chemistry, 6) physics, 7) Earth astronomy and space, 8) technology.

Keywords: *Science curricula, Science strand, Thailand education*

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Japan Report: Features of the New Courses of Study for Japanese Elementary and Secondary Schools

Naoyuki Tashiro

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In Japan, the courses of study for elementary school education and lower secondary school education were revised in 2017 and the course of study for upper secondary school education was revised in 2018. In this presentation, I'll share features of the revised courses of study, with a focus on science education. These revisions emphasize more focus on proactive, interactive and deep learning. They also emphasize ways of thinking in various scientific disciplines. New courses of study for Biology haven't change much in content, but now stress scientific ways of thinking and the concept of 'unity and diversity' in living things.

Keywords: biology education, Course of Study, proactive, interactive and deep learning, scientific ways of thinking

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Hong Kong Report: An Update on Biology Education in Hong Kong – STEM Education

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Since the policy address delivered in 2015 by the Chief Executive of the Hong Kong Special Administrative Region (HKSAR), Science, Technology, Engineering and Mathematics (STEM) education has been initiated as a major developing direction in the education community of HKSAR. Apart from financial support from Education Bureau to the schools for organizing STEM-related activities, the curriculum of science education at the junior secondary level, as well as the curriculum of General Studies, the subject that accommodates all the science education in primary schools, has been updated in 2017 to incorporate more components of STEM in the learning and teaching of science subject. The curriculum of Biology at the senior secondary school level, however, has not been revised since 2015. Secondary biology teachers and universities' scholars (or university scientists) have formed small-scale communities to support each other on the biology-related STEM activities to be implemented in the schools. For example, secondary teachers, with the support of students,

have cultivated Scleractinian corals in their schools for teaching modules like classification and features of living organisms. The Education University of Hong Kong has assisted the Hong Kong Wetland Park to develop STEM-oriented modules to be implemented by local schools in the Park. Teacher training workshops were well received by both the local primary and secondary schools.

Keywords: curriculum, Policy Address, STEM education, teacher community

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<Oral Presentations>

SUB-THEME 1: BIODIVERSITY AND ITS CONCERVATION

Development and Practice of ESD Program to Understand Biodiversity and Alien Species in a Local Environment by High School Students

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In Japan, various ESD activities are being developed through school education, as a representative example of UNESCO ASPNet after the Decade of Education for Sustainable Development. These schools are engaged in activities on biodiversity issues such as endangered species and alien species as a main theme. A new environmental learning promotion project for high school students "Aichi's Future Creation Club" has begun in 2017. The objective of this project is to develop an educational program to solve regional problems based on the results of biological survey by high school students as the main body. The students of Chiryu East Senior High School, which is one of the schools participating in the project, conducted an ecological survey of various turtles inhabiting the rivers around schools, and clarified the differences in the number and eating habits between native species and alien species. Based on the survey results, they have developed an educational program "Kame-Masu" to understand the ecology of turtles. The high school students practiced classes at elementary and junior high schools using developed programs, and it allowed students who attended the classes to understand the ecology of turtles around the area. They consider how to apply the program not only to school education but also to lifelong education in the region in the future.

Keywords: alien species, biodiversity, ESD, high school student, local environment

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Freshwater Atyid Shrimps in Hong Kong: Integrating Teaching and Research in a Biodiversity Conservation Project

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Rapid economic development in Asia has threatened our high biodiversity, particularly the freshwater fauna. While more researches are necessary to yield information for rationalizing conservation strategies, it is increasingly important to educate the public about conservation. We conducted a most comprehensive ecological and genetic assessment of freshwater atyid shrimp species in Hong Kong, a highly developed city in East Asia. We recruited undergraduates to participate in this study to test if such experience could positively impact their conservation attitude. Our study uncovers a new atyid species record in Hong Kong and indicates that

some species exhibit extremely strong population structure such that a stream-by-stream conservation would be warranted. With an adequate guidance, undergraduates can conduct scientific research that yields important information for conservation planning. Participants' reflections indicate that the involvement not only taught them field and experimental techniques, but also granted them a mind-opening experience towards better understanding of the local fauna, and a sense of contribution towards conservation as well as formulating their career planning. We conclude that integrating teaching and research in biodiversity conservation projects creates a win-win situation: the new scientific knowledge improves imminent conservation plans, while the experience empowers the next generation to better conserve the environment.

Keywords: atyidae, caridea, conservation, genetic diversity

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Terrestrial Macrophytes Assessment in Camp Higher Ground, Barotac Viejo, Province of Iloilo, Philippines

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This study was conducted to establish baseline data on the terrestrial macrophytes in Camp Higher Ground (CHG), Brgy. San Nicolas, Barotac Viejo, Iloilo. Specifically, this study determined the terrestrial macrophyte level of plant diversity in terms of species richness, species composition, and relative abundance; and determined the conservation status of plant species in the area. The assessment was on September 2017–January 2018 employing descriptive survey method. The sampling area was 1000 m^2, 10 quadrats of 10 x 10 m. Results revealed 123 plant species, 100 genera and 61 families. Specifically, trees were 56.9%; shrubs, 13.8%; vines, 13.0%; herbs, 7.3%; ferns, 5.7%; and palms, 3.3%. Shannon-Weinner diversity index for CHG was high (H'=3.867). Thirty-one (25.2%) macrophytes were categorized threatened. Among these, two were critically endangered: *Mussaenda philippica* L.C. Rich. and *Clerodendrum quadriloculare* (Blanco) Merr. The endangered species were Duklitan (*Planchonella duclitan* (Blco.) Bakh. f.), *Ormosia calavensis* Azaola, and *Cratoxylum formosum* Benth & Hooker. However, 30 (24.3%) plant species were considered endemic. During the conduct of the study, some forest clearing, wood harvesting, and minor charcoal-making operations were observed which posed threats to this natural habitat especially of threatened and endemic macrophytes. Proper conservation program should be implemented by the CHG management to prevent further biodiversity loss.

Keywords: conservation, critically endangered, endemic, macrophytes, terrestrial, threatened

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Preliminary Study on Weaverbirds Distribution and Density along Two Selected Rivers in Batu Pahat District, Johor, Malaysia

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The weaverbirds are often found to make nests on the banks of a river as much agricultural land has been planted with palm trees in Batu Pahat District, Johor, Malaysia. This preliminary study was conducted to estimate the weaverbirds distribution and density along two selected rivers. Data were collected three times through on-site observations and the point-count method from June 2018 to September 2018. River I had fifteen point-count stations, while eighteen point-count stations were set for River II. The total mean of weaverbirds and nests distribution along the two rivers were 101.3±62.9

weaverbirds and 50±30.6 nests. Meanwhile, the mean density of weaverbirds and nests for both rivers were 6.14±1.06 weaverbirds per kilometre and 3.03±0.48 nests per kilometre. River I had a higher mean weaverbirds and nests distribution and density compared to River II. Statistical analysis showed that the distribution and density of weaverbirds and nests differed significantly between the two rivers ($p<0.05$). In this study, only one species of weaverbirds was found which means the two selected rivers possesses a low variety of weaverbirds. Overall, low findings in distribution, density and variety of weaverbirds in this area indicate that conservation programs may be needed to prevent their extinction in the future.

Keywords: weaverbirds, distribution, density, variety, extinction

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Morpho-Biochemical Characterization of Cutaneous Bacterial Isolates of Three Endemic Frogs from Mindanao Island, Philippines

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Morphological features and some biochemical tests were used to characterize bacterial isolates from the skin of three endemic frog species: *Kalophyrnus sinensis*, *Limnonectes magnus*, and *Megophrys stejnegeri* from Mt. Andapon Barangay Campawan, in Baganga, Davao Oriental, Philippines. The bacterial isolates were acquired through skin swabs from five representative adult individuals per species, grown in select solid media, and subjected to various standard biochemical tests. Nine bacterial isolates were obtained: *Citrobacter* sp., *Salmonella* sp., *Pseudomonas* sp., *Enterobacter* sp., *Micrococcus* sp., *Proteus* sp., *Staphylococcus* sp., *Staphylococcus aureus*, and *Diplococcus* sp. Eight of these isolates were found in *Megophrys stejnegeri* (Taylor, 1920). Many of the bacterial isolates obtained were associated with soil. *Citrobacter* sp. was the common bacterial isolate found in all the frog species on both dorsal and ventral sides. The presence of bacterial isolates on these frogs may be suggestive of a mutualistic relationship. Further studies maybe done to decipher role of these bacterial isolates and to validate if these are the only microorganism thriving on the skin of these Philippine endemic frogs.

***Keywords**: anurans, biochemical features, cutaneous microbiota, ecological associations, morphology*

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SUB-THEME 2: ENVIRONMENTAL ISSUES IN BIOLOGY EDUCATION

Limnological Survey and Heavy Metal Analysis of Fishes from Estero de Sampaloc, Manila, Philippines

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Estero de Sampaloc is one of the biggest polluted creeks that flow into the Pasig River found within Metro Manila, Philippines. Rapid industrialization and urbanization have caused its degradation which needs rehabilitation. Different types of solid wastes and heavy metals are dumped in the creek that may undergo bioaccumulation inside the bodies of fishes particularly *Gambusia affinis* and *Rasbora maculate*. Limnological survey of the creek water was done to determine the extent of pollution of the creek using fishes as biological

indicators. The study of the physicochemical parameters showed that the water was shallow, slow-moving, warm, basic, turbid, with less DO, high BOD and COD, and high total suspended solids, total nitrogen and total phosphorus count. Average values of these parameters fell under the Class D water quality criterion indicative of a highly degraded estero. Heavy metal analysis in fishes showed an average of 0.01ppm, 0.003ppm, and 0.001ppm for lead, cadmium, and mercury, respectively. These values fell below the limits set by US-EPA. However, the heavy metal concentrations can biomagnify in the tissues of fishes as well as in humans. Shannon Index value of 0.093 indicated a low diversity of estero fishes. Evenness index of 0.309 showed uneven distribution of fishes per species. A 0.895 dominance index value was confirmed by the high population count of resilient fishes *Gambusia affinis* over *Rasbora maculata*.

Keywords: bioaccumulation, estero, fishes, Gambusi affinis, limnological survey, physicochemical parameters, Rasbora maculate

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Environmental Education for Conservation of Borneo's Ecosystem Using Role-Playing

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In Japan, most people eat palm oil used in bread, cake and many other foods. The annual consumption of palm oil per one Japanese is about 4 kg. Then, palm oil is closely related to Japanese life. Borneo's people expand plantation of oil palm trees to produce palm oil. Borneo's native forest were cut down and burned down for expanding the plantation. The orangutan, the Borneo pygmy elephant and many other species are on the verge of extinction by reduction of native forests. Oil palm has enriched the Borneo's economy, though oil palm is destroying Borneo's ecosystem. It is important for students to know this fact and to think about how to solve the situation. Therefore, I carried out a role-playing lesson in which students could learn about the mechanism of destroying Borneo's ecosystem and the difficulty of conserving the ecosystem. In this lesson, almost all students decided to expand the plantation of oil palm despite the fact that we destroy the ecosystem. Then, students thought how to solve the situation. This lesson seemed to be effective for teaching conservation of ecosystem. I'll report details of this class and I'd like to exchange opinions how to teach conservation of ecosystem.

Keywords: Borneo, ecosystem, environmental, role-playing

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SUB-THEME 3: GENETICS AND MOLECULAR BIOLOGY

Simple and Reproducible PCR Protocols Using Petals from Ornamental Plants to Promote Student Understanding of Molecular Biology

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Molecular biology, and the technologies based on it, has advanced considerably since the end of the 20th century. Indeed, molecular techniques are used extensively in a variety of biological fields, including evolutionary and developmental biology, physiology, and ecology. In addition, numerous advances in the medical and agricultural fields have been facilitated by molecular biology, and technologies such as recombinant DNA, gene diagnosis, and gene therapies have become important in our lives. Although knowledge of molecular biology has become increasingly im-

portant, molecular biology is difficult for high school students to understand and it is still unfamiliar to most people. We therefore developed simple and reproducible experimental protocols to promote an understanding of molecular biology. Experiments are based mainly on the polymerase chain reaction (PCR), but also DNA isolation, electrophoresis, and DNA detection. The protocols provide ways to understand plant genetic diversity at the DNA level and illustrate the scientific basis of genetic diagnosis. Experience with the protocols helps students to better understand molecular biology; indeed, all of the experimental methods were designed with this aim. To optimize PCR, we used plant materials to prepare DNA. We intend to present simple yet robust PCR protocols to high school students.

Keywords: crude DNA from petals, DNA analysis, genetic diagnosis, genetically modified organisms (GMO), plant genetic diversity, polymerase chain reaction (PCR)

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SUB-THEME 4: TECHNOLOGY-BASED BIOLOGY EDUCATION

Fostering Global Competence in Environmental Education: A Class Activity Using Web-Based Teaching Materials Combined with Real Specimens and Historical Photographs

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Global competence requires the capacity to examine and understand international issues, an attitude toward cultural diversity and tolerance, and it acts for collective well-being and sustainable development. As OECD adopted it in PISA 2018, it is an important idea to foster in curriculum. Over the past 18 years, our team has developed web-based simulation software, SimRiver, which is accompanied by several modules. This educational system is open to the public in 25 languages at the DiatomProject web site. Content is continually revised in response to user's feedback. SimRiver allows students the opportunity to participate in a hands-on environmental management and manipulation activity that allows an understanding of the relationship between organisms and environmental disturbance. Class activities with SimRiver have been implemented in various lesson plans containing proactive learning for inquiry. In this study, we focused on evoking and fostering of global competence with newly developed teaching materials and teaching plan. Today developing countries suffer from severe water pollution and more developed countries have a negative history with riverine environment. From locations in Japan, America and India, we utilized historical and modern river photographs as well as diatom specimens as a proxy for aquatic environments. This combination of materials and SimRiver lead students to think about intercultural issues without stereotype and provided normalized perspective to share the experience of pollution.

Keywords: diatoms, global competency, inquiry, pollution, proactive learning, river environment, simulation.

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The Application of Augmented Reality in Biology Students' Academic Performance

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One of the most powerful forms of contextual mobile learning is Augmented Reality (AR). AR brings a remarkable potential to complement information with the use of computers and mobile

phones in the classroom where instruction can be made more collaborative with the use of technology. While AR has been used in other countries, the documented use in the Philippines is scarce. Quite a few researches have been done in the Philippines integrating AR as a tool for learning but rarely about bringing this technology in the Basic Education setting. With these in mind, the study aims to determine the effect of AR application using mobile devices in learning Biology for Grade 8 junior high school students, specifically in the topic on biodiversity. A quasi-experimental non-randomized pretest and posttest group design was used in this study. Two groups were classified into traditional and AR learning groups, each with 32 students. Both groups received the same classroom instructions except that the AR group used AR applications through their mobile devices. Results showed an improvement in their posttest academic performance for both traditional and AR learning group however, normalized gain score analysis revealed that AR learning group ($\bar{x}$ =.6806, σ =.1151) had a statistically significant higher academic performance than the traditional learning group ($\bar{x}$=.5087, σ =.1672) with a *p*-value of .007 at 0.05 level of significance.

Keywords: Augmented Reality (AR), AR learning, academic performance, biodiversity, mobile devices, Biology, technology

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Active Learning Utilizing ICT in Biology Class

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Osaka Public School Association for Biology Education Study Group and Osaka Private School Informatization Study Group organized "The iPad Workshop for Beginners" and created "The Digitized Experimental Procedure" on iBooks in 2013. We later published it on the Apple iBooks Store. It is currently available not only in Japan, but also in 14 countries around the world. In the unit on kidneys, I used iBooks for experiments and the camera time-lapse function in order to track the urine movement route and concentration ratio of each component in the kidneys. Additionally, each student was tasked with physically performing a specific role of the urine movement route on the school ground. In the unit on the Central Dogma, I utilized the Stop Motion Studio and Google Drive apps. To explain the Central Dogma, the students made a stop motion video, organized a lot of specialized words and constructed knowledge of gene expression. My students and private school students in Yokohama shared Google Cloud files and exchanged a "Codon Letter", in which 3-letter words are used to express DNA sequence information. Each student at both schools translated and transcribed the letter in order to read a cipher message.

Keywords: *active learning, Codon Letter, iBooks, ICT*

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Flipping the Classroom for 21st Century Learning: A Student-Centered Approach in Teaching Biology

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The utilization of technological tools in educating the new breed of 21st century learners helps in the development of student learning through provisions of a wide range of multimedia information, which can enable the students to conduct their own investigation and search for answers to their queries. A new method of blended learning that can be implemented to explore the potential value of technology-infused instruction is the Flipped Class-

room. This study aims to design instructional materials in Biology wherein learner-centered principles are applied to help students discover new knowledge and explore at their own pace. A group of teacher-observers quantitatively analyzed the instructional materials through descriptive statistics. Results revealed that the instructional materials possess high evidence of remarkable qualities of flipped classroom based on the following parameters: academic involvement, student-peer-teacher involvement, and time allotment. To strengthen the analysis, the teacher-observers' perceptions towards the utilization of flipped classroom in biology were qualitatively analyzed through thematic coding, and results showed the student-centered characteristics of the instructional materials. The quantitative and qualitative assessment of the instructional materials signifies that the flipped classroom promotes collaboration and engagement among students, which can contribute to better learning in biology. Therefore, flipping the classroom in teaching biology concepts appears as a novel way of teaching that promotes highly evident collaborative, and active student-teacher and student-student interaction for better learning.

Keywords: *biology, blended learning, flipped classroom, instruction, technology*

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Use of Multimedia for Dislodging School Students' Misconceptions

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Researches on the use of multimedia for remediation of students' misconceptions and increasing students' subject understanding revealed that the technology is useful not only to facilitate classroom learning-teaching process but also to create curiosity, interest and zeal among the learners. It is also employed in the conceptual change approaches with other instructional methods such as traditional methods, hands-on activities and field study in the remediation of students' misconceptions and increasing students' understanding of science in general and abstracting biological concepts. Multimedia technology may be used for identification of students' common misconceptions and to measure students' levels of understanding. This study explores the effectiveness of multimedia during the implementation of remedial modules in the classroom. The aim of the study was to understand high school students' conceptions and to develop remedial material to dislodge potential misconceptions about life processes. The researcher used the purposive sampling procedure and selected one semi-urban school, where science and AV laboratory facility was available. The strength of this class was 73 students. Each module on life processes was implemented by using multimedia. Many of the life processes cannot be observed in real life but they can be presented to the students using video clips having simulations. The results of the study showed that the use of technology in implementation of remedial material is significantly effective for rectification of students' misconception.

Keywords: remedial module, school science, students' misconceptions, technology

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Biology in Cinema: *Bridging Fantasy with Reality*

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Today, our students arrive in the classrooms equipped with wide array of knowledge from current and controversial science issues, most of which were acquired through watching popular science movies. These movies with varying degrees of accuracy have undoubtedly influenced students'

understanding of science content and process. Moreover, the National Science Foundation and other researches' investigation of the impact of fictional science movies to the public understanding of science have argued that fictional cinema and television have proven very effective at blurring the distinction between fact and fiction and that it has corroded the public's critical skills and hindered the development of a scientifically literate society. With the growing list of movies depicting biological concepts, it is very evident that the media particularly Hollywood, have long exploited biology as a source of bankable plot material. The rationale for this paper lies in the notion that movies with biology underpinnings can be effectively integrated in the classroom to present difficult to visualize concepts such as movies with genetics and molecular biology themes. However, educators must play a pivotal role not only in extracting the kernels of scientific truth from these popular movies by teaching students how to discern what is viable from what is improbable but more importantly in developing critical thinking skills through case-based analysis needed for today's information-rich society. The paper also presents a process-oriented framework to help biology educators integrate these resources into a minds-on and technology-infused learning environment to build deep interest for real science while capitalizing on the motivational "cinemagic" of popular movies.

Keywords: active learning, case-based analysis, science fiction, science issues, technology-infused learning

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SUB-THEME 5: INTERDISCIPLINARY APPROACH

Application of STEAM Activity in Japanese Biology Education

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STEAM is the abbreviated name for "Science, Technology, Engineering, Arts, and Mathematics" that integrates some teaching subjects. It has already been conducted in South Korea, especially almost of all teaching units have each activity about it in science textbooks on lower secondary schools. On the other side, integrated subjects education has been conducted on curriculum in Japan. But, it is very difficult to connect students' abilities directly between each subjects and integrated subjects education. If STEAM is used in science class activities in Japan, the effectiveness of STEAM appears in solving the problem. I focused on a teaching unit which is studied about evolution, because it had rare activities in biology education in Japan. Therefore, I implemented STEAM activity "Creating Living Things in Future" to university students in my class. As the result, they created plants, animals, insects, human, and fusing living things in future by drawing on paper. And they wrote explanation about the living things concretely that was made based on the present information. I think that ideas of STEAM bring new activities and effectiveness to biology education in Japan.

Keywords: *evolution, integrated education, Japanese biology education, STEAM*

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Entrepreneurship-Based Biology in Teaching and Learning: Students' Academic Achievement

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This study aimed to investigate the effects of integrating entrepreneurship in teaching biology on the students' academic achievement. There were two groups of 31 student participants se-

lected for Control (Traditional Learning Group, TLG) and Experimental (Entrepreneurship-based Biology Learning Group, EBLG). A fifty-item examination regarding the topic was given to determine their mental ability. The pretest mean scores of the TLG ($\bar{x}$ = 14.8; S = 3.93) and EBLG ($\bar{x}$ = 15.7; S = 4.28) have no significant difference (p = 0.390) which suggests that both groups started with the same level of understanding. The traditional way of teaching and learning were applied for both the TLG and EBLG but the experimental group was given additional basic entrepreneurial activities. The students experienced taking loan, designing goods' labels, marketing, and paying off loan. After the intervention, t-test analysis showed that the students' levels of understanding of both TLG ($\bar{x}$ = 23.19, S = 4.91) and EBLG ($\bar{x}$ = 30.6, S = 7.16) had significantly improved (t (60) = 6.77; $p < 0.001$); however, analysis of the normalized gain score showed that the EBLG's achievement in learning biology was significantly higher than the TLG ($\bar{x}$ = 0.24; S = 0.12). The significance therefore proves that integrating entrepreneurship positively affects the students' academic achievement in biology education. The result of this study shows that the method of integrating entrepreneurship in biology stimulates deeper scientific knowledge while attaining entrepreneurial skills which could be used for gainful employment.

Keywords: academic achievement, entrepreneurship, entrepreneurship-based biology learning, traditional learning

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Creating Indigenous Learning Resources through Environmental Projects Using Inexpensive Materials in Collaboration with Students of Saraswati Junior College, Paras

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The present research paper is about classroom efforts which resulted in developing perennial learning resources to promote interdisciplinary approach. Participation of students, constructivist approach, and the use of inexpensive and easily available materials are main features. The researcher used match box pictures, coins, currency notes, postage and philately stamps, feathers and self-taken photographs of India and abroad to activate the students. Small efforts taken at local level crossed regional boundaries and reached global level. Also these resources proved helpful in learning other subjects. Educational institutes inviting for programs confirmed the validity and novelty of the work. With each passing year, the enrichment mounted. The projects highlight hidden potential around us. Also it marks that each challenge has a silver lining. Focusing on available materials is what one has to consider. Environment projects are actually unique opportunities to understand nature in its minutest parts. Simplicity, collaboration and cooperation are the underlying currents of the humble efforts.

Keywords: collaboration, creating, indigenous, inexpensive material, junior college, learning resources

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Medical Consultation Role-Playing Game for Internal Environment of Human Body in Basic Biology

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Having the good knowledge of biology is crucial to human life today. It helps us to sustain healthy life and also allows for the prevention and the early detection of severe diseases. Most of the high school students in Japan learn how the internal environment of a human body functions in a subject called Basic Biology. In order to deepen students' learning in classes, I have carried out an activity that en-

ables students to understand more effectively the details of some of the diseases and how the corresponding treatment works. This was done in the form of role-playing. One student plays the role of doctor and he/she explains the details of the disease until another student, who plays the role of patient, fully understands. The student who plays the role of patient has the responsibility to ask questions until he/she is fully convinced with the doctor's explanation and is able to select an appropriate treatment of method. This activity has successfully made students be aware of the importance of listening to the doctor's explanations carefully and ask questions when necessary. In addition, those students who did the activity now pay closer attention to their families' health conditions.

Keywords: Basic Biology, healthy life, internal environment of human body, role-playing

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SUB-THEME 6: CURRENT TRENDS IN BIOLOGY EDUCATION AND RESEARCH

China's Policy on Construction of World Class Discipline and Its Impact on Biology and Bio-Engineering

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China has replaced its traditional elite university program "211" "985" with a new scheme "world-class university" and "world-class discipline". The new scheme takes a dynamic standard and the status of the universities and disciplines is reevaluated for every five years. The new policy poses a significant impact on the discipline biology: financial investment, research grants and prominent researchers will be gradually accumulated to the very few top universities, causing an imbalance nation-wide and eventually hurting biology education in China. Meanwhile, with the establishing of the new discipline of bio-engineering, many universities are seeking to move to a cross-disciplinary development from biology to bio-engineering, seeking a new breakthrough in the competition.

Keywords: bio-engineering, biology, world–class discipline, world-class university

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A Survey on The Implementation Status of Research Ethics Education by High School Teachers in Japan

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Recently the importance of research ethics education (including bioethics) has been recognized by many researchers. In Japan, researchers are obliged to take research ethics education when applying for research grants. In addition, project research is promoted at high school in "*Risu Tankyu* (A new subject of the next Course of Study in Japan)" and Super Science High School project, etc. Therefore, enrichment of research ethics education is indispensable. I conducted a survey on the implementation status of research ethics education. The subjects of the survey are high school teachers in Ehime prefecture, with a total of 38 teachers, including 19 science teachers, 6 mathematic teachers and 13 others. About 40% of the respondents in the questionnaire were conducting research ethics education, but except for one teacher, almost all those teachers did not use reference of research ethics. This result revealed that it is hard to say that a comprehensive research ethics education is being implemented. It is necessary to develop teaching materials for research ethics education.

Keywords: bioethics, project research, research ethics, Super Science High School project

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Efforts into the International Biology Olympiad of Japan – Past Results, Problems and Preparing for IBO2020 Held in Japan (Nagasaki) –

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The International Biology Olympiad (IBO) is an international contest for high school students interested in biology. Japanese representatives first participated in the IBO in 2005, the 16th convention. Since 2005, "Japan Biology Olympiad (JBO)" has been held every year, selecting Japanese representatives and sending them to the international convention. The selection procedure is as follows: Participants' application → Preliminary test → Secondary selection test → Final selection test. In the past 13 years, the number of participants of preliminary test has been increasing remarkably. In 2018, over 4600 students participated in the JBO. The reasons of the increase are, first, having good grades of the test is advantageous for entrance examination of university, and second, students interested in biology can get good chance to talk with scientists and to interact with biology-lover students after the secondary selection. At recent international conventions, all four Japanese representatives won medals, and deepened relationships with colleagues around the world. In 2020, the 31st IBO2020 will be held in Nagasaki, Japan. This is the second IBO hosted by Japan following IBO2009 in Tsukuba. One Japanese person was elected as the 3rd chairman of IBO. Around 2020, International Olympiad of many science fields including biology will be held in Japan. The Science Olympiad Promotional Council has been organized for supporting all the fields. The problem for us is to establish a sustainable organization and to get funds.

Keywords: contest, high school students, International Biology Olympiad, Nagasaki

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Influence of Nematode Taxa on Labile Carbon of Soil Planted with *Brassica rapa chinensis* (Bok Choy)

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Our study focused on the influence of soil nematodes on the labile carbon content of soil planted with *Brassica rapa chinensis* (Bok Choy). We collected nematodes from a soil sample using the Baermann Funnel technique. The nematodes were introduced in a sterile soil and thereafter planted with Bok Choy. The labile carbon concentration of the soil was obtained before inoculation of the nematodes, after inoculation, and after planting using spectroscopy. The isolated nematodes belong to the orders Dorylaimida and Rhabditida. We noted a statistically significant decrease in soil labile carbon and significant changes in the growth of Bok Choy based on root and shoot length as well as number of leaves compared to the control set-up. Our data implies the significance of maintaining diverse nematode taxa in soil to promote better soil health which may also have positive implications in agriculture.

Keywords: Davao City, environment, labile carbon, soil health,

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Observation and Experiment Using Insects at Scientific Events in Chubu Area of Japan

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Biology Laboratory of Faculty of Education of Kogakkan University conducted observation and experiment classes using insects at the "Bio Laboratory" of Nagoya City Science Museum

and the "Children's Experience Festival" at Ise City Lifelong Learning Center, Isetopia. The purpose of the "Bio Laboratory" is to learn immunity by observing the phagocytosis using insect hemocytes. The purpose of the "Children's Experience Festival" is to have interests in and attention to insects and living things by actually observing and touching insects. The latter exhibition was divided into four categories: "Insect body and characteristics", "Observation and experiment", "Let's touch it", and "Craft". We conducted a questionnaire survey on understanding about, interests in, and attention to insects and immunity before and after children had participated in each class. As a result, observation and touching of insects and detailed explanation from university students who were studying insects and immunity tended to increase children's understanding and interests in insects and immunity.

Keywords: Chubu area in Japan, immunity, insect, Mythimna separata*, observation and experiment, scientific event*

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Inquiry into the Onion

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In Japan, inquiry activities have been introduced into science subjects for upper secondary schools since 1994. However, these activities are still being under-utilized. Through these inquiry activities students are expected to address issues actively, think deeply by themselves, and feel pleasure in solving problems. Here, I will present a sample of inquiry activities which relate to the morphology and growth of the onion bulb. At first, the question, "Which part of the onion do you eat: root, stem, leaf, flower or fruit?" is asked. Usually most of the students cannot give the correct answer. This gap between students' answers and the correct answer can foster students' interests. This part is easy and inexpensive, and it can be carried out within one school hour. The next part is also inexpensive, but more challenging. The question, "How does the onion bulb get bigger?" is asked. Students are required to carry out the following activities to verify their answers: making a hypothesis, designing an experiment, carrying out experiment and observation, collecting data, analyzing and discussing the results, and finally deciding whether the hypothesis is acceptable. These activities are usually done in groups. Through these activities and writing a report, students can cultivate their abilities of logical thinking, decision-making, and expression.

Keywords: *expression, inquiry activities, logical thinking, observation, onion*

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House Dust Mites as Tools for Biology Education and Research

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House dust mites (HDMs) are microscopic arachnids considered as clinically important sources of allergens that trigger allergic diseases such as allergic asthma, allergic rhinitis and atopic dermatitis. HDMs are ubiquitously found in indoor environments in tropical to temperate countries. Cultures of house dust mites are invaluable specimens in invertebrate zoology as well as important sources of biological reagents for allergy-related research. In this lecture, the use of the HDM species *Dermatophagoides farinae* (Df), *Blomia tropicalis* (Bt) and *Suidasia pontifica* (Sp) cultures to study the life cycle of arachnids, their morphological features, response to environmental stresses, and other biological characteristics will be presented as a specimen in an undergraduate Biology laboratory class. Likewise, the lecture will focus on the House Dust Mite Allergy Project of the University of Santo Tomas, Manila, Philippines, where Df, Bt, and Sp cultures were used in the cloning, expres-

sion, and characterization of fourteen (14) HDM allergens as performed by graduate and undergraduate biology students. Sensitization profiles of Filipino allergic patients to the allergens from Df, Bt, Sp and other HDM species; and the screening of natural products for acaricidal activities will also be presented. As an example of an applied research on allergy diagnostics, a prototype HDM allergen detection kit using recombinant HDM allergens for the monitoring of HDM sensitizations will be discussed.

Keywords: allergy, Blomia tropicalis, Dermatophagoides farinae, *house dust mites,* Suidasia pontifica

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<Poster Presentations>

Ecological Diversity of Three *Nothofagus* Species in Isla Navarino, Southern Chile: A Comparative Study of Chile and Japan

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Three *Nothofagus* species in close lineage are distributed in cool temperate Isla Navarino, southern Chile. *N. antarctica* and *N. pumilio* are deciduous trees, while *N. betuloides* is evergreen one. This study examined ecological characteristics of the diversified *Nothofagus* species, comparing them with tree species in Japan. Typical forests of this island were mixed forests of deciduous *N. pumilio* and evergreen *N. betuloides*. Saplings of *N. betuloides* existed in understory of its evergreen canopy, while those of *N. pumilio* did not. Under canopy gap, both species inhabit, and their elongation growth rates were similar. At open site out of the forests, elongation growth of *N. pumilio* saplings was faster than that of *N. betuloides*. These results suggest that deciduous *N. pumilio* is early successional fast-growing species demanding high light intensity, while evergreen *N. betuloides* is late successional shade-tolerant species. These regeneration strategies of deciduous and evergreen species are similar with those in Japan. On the other hand, *N. antarctica* was not found in the forests but found in wasteland. It had a short form with branched trunks, thick leaves, and heavy wood. These traits might contribute to the adaptation to strong wind in Patagonia.

Keywords: *cool-temperate forest, early successional species, ecological diversity, forest regeneration, late successional species, relative growth rate*

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Isolation of Bacteria in Sea Sand and Seawater in San Pedro College – Marine Station

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The objective of this study is to identify isolated bacteria found in sea sand and seawater in San Pedro College – Marine Station. Isolation of bacteria was used by three media agars: Nutrient Agar; Mueller-Hington Agar and Inorganic Salt Starch Agar. A total of four isolated bacteria were identified using biochemical tests and morphological characteristics. These isolates were *Actinomyces* spp., *Micrococcus* spp., *Staphylococcus* spp., and *Enterobacter* spp. Most isolated bacteria were gram-negative, belonging to the family of Enterobacteriaceae. In conclusion, Island Garden City of Samal has the potential for

future natural antibiotics, mainly because of *Actinomyces* spp. found.

Keywords: biochemical tests, isolation of bacteria, marine ecology, morphological characteristic

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Are Unicorn Beetles Insects? - Development of Junior High School Class to Investigate Arthropod Morphology from an Evolutionary Perspective -

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Japanese junior high school students learn invertebrates, including arthropods, in their regular curriculum. However, students rarely perform any laboratories in this class, and most students cannot recognize arthropods as invertebrates even after the class. Therefore, we developed a class to expand students' understanding of arthropod body structure, focusing on a main feature of body structure, that each segment has a pair of appendages. Unicorn beetles have the typical insect body plan of head, thorax and abdomen, and the thorax has six legs, but the prothorax is separated from the rest of the thorax. We hypothesized that students would gain understanding of the central feature of insect body structure, that each segment has a pair of appendages, when they attempted to explain that unicorn beetles are an insect on the basis of their body structure. Students performed observations of centipedes and juvenile plecopterans, in addition to unicorn beetles, to better understand evolutionary processes within arthropods. Results of questionnaire surveys indicated that, after completing the class, students could explain precisely that unicorn beetles are an insect on the basis of their body structure, and that students' understanding of the arthropod body structure and the evolutionary processes was enhanced.

Keywords: evolution, insect, Japan, teaching method

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Biology Teacher "Today's Course"

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Currently, we are trying to develop interesting teaching materials in science for university students who aim to become science teachers in junior high and high schools. The purpose of this report is to present "Today's Course," a collection of science and biology teaching materials and equipment that interest students, which can be introduced in science classes and observation-based experiments at university-level teacher training courses. The meaning of "Today's Course" is different from the one used for a la carte meals, and the expression is used to represent high-quality teaching materials. Some examples of the topics are: 1) Mammalian skulls and deer antlers, 2) Physical laws on the falling and reflection of a paper money, 3) Cross-sectional structure of early-stage amphibian embryos made of clay, 4) Inversion phenomenon in mirror reflections, 5) The bracts of *Houttuynia cordata* and *Lysichiton camtschatcense* (Schott), 6) Distinction between *Erigeron philadelphicus* and *Erigeron annuus*, 7) See a rainbow in the room, and 8) Introducing the examination paper for fish dissection. These topics can be utilized as teaching materials that can be confirmed by students using visual and tactile perceptions, which may lead to an increased interest and motivation and enhanced educational impacts.

Keywords: biology teacher, science, Today's Course, teaching materials, university students

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Examination of Experimental Methods of Phagocytosis

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Experiment of phagocytosis by hemocytes in Biology textbooks of Japanese high schools is not easy to carry out. Therefore, we studied in the following three aspects in order to find a method of experiment which is easy for high school students. 1) Test insects: It is necessary to have the following conditions: It is easy to collect hemolymph, there are many hemocytes showing phagocytosis, and phagocytosis is exhibited in a short time. As a result of examination, the insects that fulfill these conditions are larvae of the order Lepidoptera. 2) Foreign substance: India ink was the easiest to observe, and then an acrylic paint was effective. The best concentration of India ink was obtained when an ink stick was rubbed 10 times on an ink stone with 2 ml of water. 3) Experimental method: We improved an existing method and developed a new one. In the improved *in vivo* method, foreign substances were injected into the body cavity of insects, and the hemolymph was collected after 15 minutes and observed. In the newly developed *in vitro* method, foreign substances were uniformly applied on a slide glass with a drop of insect hemolymph, and it was observed after 15 minutes.

Keywords: hemocyte, high school, immunity, insect, Lepidoptera, phagocytosis, teaching material

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Observation Practice on Phagocytosis Using Armyworm Hemocytes

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Information about studying insect immunity in high school biology has increased after the recent revision of the Course of Study and its guidelines in Japan. Examination of phagocytosis by hemocytes of several kinds of insects was described in one of the Basic Biology textbooks. The main species consist of crickets and grasshoppers in the order orthoptera were used to observe the insect hemocytes that have incorporated the foreign substances such as ink particles. Orthoptera has high glutinous body fluid that is difficult to be collected and it takes more than 24 hours to complete the examination. On the other hand, armyworm (*Mythimna separata*) of Lepidoptera; Noctuidae has a large amount of body fluid and it is easy to be observed by insect hemocytes. Thus, it is appropriate to use armyworm in this experiment. Furthermore, we developed a new *in vitro* method by which the hemocytic activity was easily observed within 50 minutes. *In vitro* experiments were also evaluated: drops of insect's hemolymph on the slide glass were mixed with ink particles without using injectors. We practiced the *in vitro* method for high school students in Ise City and surveyed by questionnaire. The results will be shown in this presentation.

Keywords: Basic Biology, hemocyte, high school, insect immunity, Mythimna separata, phagocytosis, teaching material

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Study on Observation Method of Cytoskeletons without Using Fluorescence Microscopes

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The commentary "to deal with the structure and function of cytoskeletons" is described in the current Course of Study for Japanese high school Advanced Biology (announced in 2009). So, the pictures of cytoskeletons appear at the unit of biological matter

and cell in all high school *Advanced Biology* textbooks that have been screened by the Ministry of Education, Culture, Sports, Science and Technology of Japan. As almost all pictures of cytoskeletons in *Advanced Biology* textbooks were taken by a fluorescence microscope (partially by an electron microscope), the same microscopic observations are impossible unless we use fluorescence microscopes. Since few Japanese high schools have fluorescent microscopes, we attempted to develop teaching material for high school students in biology laboratory classes in order to observe the cytoskeletons without using fluorescence microscopes. As a result, microtubules and actin filaments could be observed with student optical microscopes, by using enzyme-antibody technique instead of fluorescence-antibody technique. Also, by using this method, we had a lecture for advanced experiment in high school classes. Through this practice, the students could deeply understand cytoskeletons.

Keywords: cytoskeletons, high school biology, microscopic observation, student's optical microscope,

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Mouse Macrophage Engulfs Color Emulsion Particles: A Study toward the Development of Novel Observation Method for Animal Cells

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Generally, the cells of multicellular animals are more dynamic than the cells of multicellular plants. Observation of living animal cells might be effective for understanding the formation of multicellular animal body. However, such observation experiments are hardly done in secondary schools. This is because most of the schools do not have the facilities and budget necessary for animal cell culture. Therefore, I have tried to develop an inexpensive culture method for the cells. Here, I report the culture technique of mouse peritoneal macrophages without using centrifuge, clean bench and CO_2 incubator. In addition, I introduce the observation method for phagocytosis using color emulsion. The cells were obtained from mouse peritoneal cavity. These were incubated in culture dish with Hanks' balanced salt solution (HBSS) at 37°C for 30 min. Then, adherent cells were used as macrophages. For long time culture of them, the HBSS was replaced with RPMI 1640 medium supplemented with serum. The dish was immediately transferred to a sealed container with a beaker containing sodium bicarbonate solution and incubated. For observation of phagocytosis, the emulsion solution (*New Sakura Color*, Sakura Color Products Co., Japan) was added to the medium at a low concentration. Phagocytosis was confirmed by phase contrast microscopy. Since the color particles have translucent and fluorescent, it could be reconfirmed by combined microscopic observations of bright field, dark field and fluorescence image.

Keywords: *animal cell culture, endocytosis, macrophages, microscopic observation, phagocytosis*

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Publications

Biology Education for Social and Sustainable Development (ISBN: 978-94-6091-925-1) was published in 2012 by Sense Publishers, Rotterdam, Netherlands (http://www.sensepublishers.com/). Some papers presented at **the 23rd Biennial Conference of the AABE** which was held in Singapore in October 2010 were compiled in this book by Dr. Mijung Kim and Dr. C. H. Diong. You can refer to the abstracts of these papers in **the sixth volume of the *Asian Journal of Biology Education*** (2012).

Biology Education and Research in a Changing Planet (2015) (ISBN 978-981-287-523-5) was published by Springer (http://www.springer.com/in/book/9789812875235). Some papers presented at **the 25th Biennial Conference of the AABE** which was held in Malaysia in October 2014 were compiled in this book by Dr. Esther Gnanamalar Sarojini A Daniel. The abstracts of these papers were included in **the eighth volume of the *Asian Journal of Biology Education*** (2015).

From the Editor-in-Chief

The eleventh volume of the *Asian Journal of Biology Education* (AJBE) contains one research note, one report on biological resource, two country reports, the conference report of the 27th Biennial Conference of the AABE (AABE27) which was held in Thailand in 2018 and abstracts of the papers presented at the AABE27.

Several articles contributed from the AABE members and others are in the reviewing process and some of them may be included in the next issue which will possibly be published by the end of 2020. The next issue will include the report of the next (28th) Biennial Conference of the AABE which will be held probably in Tianjin, China, in 2020 and the abstracts of the papers presented at the conference.

The manuscripts contributed to AJBE have been reviewed by the following persons as well as the Editorial Board members during last two years: Dr. Chi Chiu Cheang (The Education University of Hong Kong), Dr. Catherine Genevieve B. Lagunzad (Ateneo de Manila University, Philippines), Dr. Takeshi Katayama (Takasaki University of Health and Welfare, Japan), Emeritus Professor Hideo Kitano (Tokyo Gakugei University, Japan), Professor Kim Kyoungho (Gongju National University of Education, South Korea), Mrs. Teiko Nakamichi (Tokyo Institute of Biology Education, Japan), Dr. Danny Ng (The Chinese University of Hong Kong, China), Dr. Jason Orozco (Philippine Normal University, Philippines), Dr. Takayuki Sato (Hirosaki University, Japan), Dr. Robert Wallis (Federation University, Australia), and Dr. Shigeyoshi Watanabe (Kumamoto University, Japan). I am very thankful to them for their efforts to review the articles.

Dr. Nobuyasu Katayama