

Abstracts of the Papers Presented at the 21st Biennial Conference of the AABE

The 21st Biennial Conference of the AABE was held at Kongju National University, Gongju, South Korea from 25 to 28 October, 2006. The themes of the Conference were “Biology Education through Field Excursion: Bird Watching” and “Recent Trends in Biology Education.” There were two plenary lectures, 13 oral presentations and 24 poster presentations. On 27 October, a school visiting program to Seoryeong High School and a fieldtrip to Seosan for bird watching were carried out.

<Plenary Lectures>

Bird Watching in South Korea

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Although about 400 species of birds have been recorded in Korea, so far identifying a particular bird usually is not too difficult. As in developing any skill, however, a bit of pleasant effort is required. Ultimately, proficiency is achieved only through practice looking at birds in the field. But field observations must be supplemented with study of a field guide. Here are a few pointers to help the beginning birder learn to identify birds more quickly.

Determining the correct identify of a bird is essentially a process of elimination. First you must be able to recognize the family to which a bird belongs, for example if it is a seagull, a woodpecker, or heron. To do this you must pay close attention to the size and shape of the bird and in many cases to its bill. Study the field guide, including the pictures on the book, to become familiar with the bird families which occur in Korea. Then look through the pictures to see the birds you might en-

counter in the field. Pay special attention to the pictures which point to the field marks so you will learn the kinds of things to look for when you see a new bird. You will see that the yellow tip of the bill of Spot-billed Duck, the blue back of the Common Kingfisher, and the crest of the Lapwing are field marks which will help you to identify these birds at a glance. Some will be more difficult because there are species which look almost alike, but the distinguishing characteristics can be learned with study and practice.

In the field, train yourself to observe birds in flight, carefully looking for colors and pattern, silhouette, the way the wings are held, and the manner of flight. The behavior of a bird can also give important clues to its identify. Pay attention to such things as how it files, how it swims, how it moves the tail, whether it walks or hops, and if it occurs in flocks. From the beginning take note of calls and songs. Most species have distinctive voices. Knowing them can be an invaluable aid in identification.

Additional factors which will be helpful in narrowing your options are season, habitat, and location. For example, the Common Cuckoo cannot be found in Korea during the winter, seagulls cannot be found in the mountains, and often similar species do not occur in the same parts of Korea. In most cases there is little exciting to find a bird where it doesn't belong or at a time of year when it does not belong or at a time of year when it does not normally occur in Korea, but until you have become more proficient it is best to assume you have selected the wrong species. For this information please refer to the status and the distribution map for each species.

Don't expect to be able to identify every bird you see. You should, however, soon learn to know

within two or three possibilities what bird you have seen. There will always be birds on any day in the field which you will not see well enough to identify.

Good birders recognize this and avoid guessing when they have not seen a bird well enough to make a positive identification.

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“AABE with New Era” and Science Curriculum Innovation in Japan

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In my speech, I will give you two sorts of information; one is about the history of the AABE and the other is on the current movement of curriculum improvement in Japan.

I. The history of the AABE

The Asian Association for Biology Education was established in 1966 by joining many leading biology teachers, educators and researchers among Asian countries. The first conference was held in Manila. So far, we have had conferences biennially in not only at cities in Asian countries, but also in Israel and Australia (Table 1).

In past 40 years, biological research has made remarkable progress. This makes us review the study contents of biology and biology curriculum frequently. The biennial conference of the AABE is good opportunity for us to exchange information, ideas, teaching materials, etc. (Table 1: on the next page). I keenly hope the activity of the AABE will be continued and enhanced more in this millennium.

II. The current movement of curriculum improvement in Japan

The Section for Investigation of Curriculum Framework of the Central Council for Education,

organized by Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan, has been investigating the present situation of science education at the primary and secondary levels in Japan and found some issues to be resolved. Based on the investigation, the section members prepared a proposal which suggested some ways of improving science education in Japan. The contents of the proposal are as follows:

1. Reconsidering the science objectives while keeping the major objectives of “Science” in the present CS.
2. Allowing students to acquire basic, fundamental scientific knowledge and skills such as understanding of scientific key concepts
3. Developing students’ abilities to think and to explain scientifically
From the viewpoint of developing students’ abilities of thinking and explaining scientifically, the following learning activities should be encouraged while taking into account the age and developmental stage of students and the contents of study.
4. Encouraging observation, experimentation, scientific experiences and experiences in nature
5. Enhancing the motivation for studying science to deal with the development of science and technology
6. Elementary school science: arranging study contents into two disciplines
7. Junior high school science: reconsidering the learning sequence of contents
8. Senior high school science: reconsidering subject composition
9. Enriching teaching resources

Based on this proposal and further discussion at the Curriculum Council, which is related to the Central Council for Education, the revised Course of Study will be made by the end of 2007.

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Table 1 The History of the Asian Association for Biology Education

	Date	City (Country)	Director and Convener	Conference Theme(s)	No. of Participants [No. of Countries]
1	Dec. 1966	Manila (Philippines)	Liceria B. Soriano Dolores F. Hernandez	School Biology in Asia: A New Orientation	100 [14]
2	August 1968	Tokyo (Japan)	Yoshito Shinoto Kazuhiko Nakayama	Enrichment of School Biology: Content and Techniques	107 [15]
3	Dec. 1970	Manila (Philippines)	Hilary Cruz Dolores F. Hernandez	The Utilization of Investigative Research Projects in School Biology Teaching: Reflect the Peculiarities of the Region	45 [13]
4	Dec. 1972	Jerusalem (Israel)	Alexandra Poljakoff-Mayber R. Bitman	1. Evaluation in Science Education 2. The Uses of Educational Technology in Science Education	101 [15]
5	June 1974	Singapore	Wee Heng Tin John Yip	Biology Education for Rural and Urban Areas in Asia	116 [9]
6	July-Aug. 1976	Bangkok (Thailand)	Twee Hormchong Sanga Sappasri	Preparation of Teachers for Biology Teaching	101 [13]
7	Dec. 1978	Kuala Lumpur (Malaysia)	Cheong Siew Yoong S. Kanagasabai	Multidisciplinary Biology Education Relevant to Community Development	157 [12]
8	Oct.-Nov. 1980	Osaka & Gifu (Japan)	Kozo Imahori Yutaka Koshida	Biology Education for the Next Decade - Linking Biology to Social Studies - Using Living Organisms for Field Study and Laboratory Work	80 [21]
9	Dec. 1982	Melbourne (Australia)	David M. Stakes Robert L. Wallis	The Role of Biology Education in Enhancing the Quality of Life	39 [6]
10	Dec. 1984	Chiang Mai (Thailand)	Panee Chiowanich Morakot Sukchotiratana	Biology Education and Technology	50 [5]
11	Dec. 1986	Quezon City (Philippines)	Dolores F. Hernandez Vincenta F. Reyes	Research and Evaluation in Biology Education and Its Implication for the Teachers	120 [12]
12	Dec. 1988	New Delhi (India)	R. K. Mohta B. G. Pitre	Explosion of Biological Knowledge and the Challenges for Secondary Education and Teacher Preparation	21 [5]
13	August 1990	Seoul (Korea)	Yong Jai Chung Yung Chil Hah	Environmental Education in the Curriculum of Biological Education	Ca.65 [7]
14	Dec. 1992	Melbourne (Australia)	Robert L. Wallis Peter Brown	Environmental management in Asia	53 [7]
15	August 1994	Tokyo (Japan)	Yutaka Koshida Hideo Kitano	Biology Education for Non-biology Majors	107 [7]
16	Dec. 1996	Chiang Mai (Thailand)	Morakot Sukchotiratana	Excellence in Biology Education: Research, Practice and Experience	ca.120 [10]
17	Dec. 1998	Pasai City (Philippines)	Carmen G. Kanapi Salvasion P. Angtuaco	Biology Education in the Third Millennium: Focus on Information Technology and Environmental Education	ca.150 [6]
18	August 2000	Hong Kong	Park L. Tang	Biology Education in the New Millennium	ca 60 [9]
19	Nov. 2002	Warrnambool (Australia)	Robert L. Wallis	Ecological Sustainable Development in Education	38 [6]
20	Dec. 2004	Chiang Mai (Thailand)	Morakot Sukchotiratana	Roles of Modern Technologies in Biology Education	ca.45[4]
21	Oct. 2006	Gongju (Korea)	Kyoung Ho Kim Kew Cheol Shim	Biology Education through Field Excursion: Bird Watching Recent Trends in Biology Education	

<Oral Presentations>

**Use of Marine Food Chain as
an Educational Model for
Biological Magnification of Mercury**

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Three hundred and ninety samples of marine organisms were collected from the East Coast of Thailand for total mercury analysis. The results indicated that mercury levels of fish and other marine organisms from the East Coast of Thailand are within the safety limit. However, biological

magnification of mercury residue in the marine food chain was observed. Organisms of higher trophic levels have higher mercury residue than those in the lower trophic levels. Statistical analysis showed positive linear regression between the size of the marine organisms and mercury contents of some species of marine organisms. Results of investigation reveal that marine food chain could be used as an effective model for biological magnification study of pollutants such as mercury residue in the environment.

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**The Practice of Environmental Education
in Japanese Junior High School Science
– Introducing the Environmental Education
Program “Project WILD” and “Project
WET” –**

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As for practicing environmental education in Japanese junior high school, Science is an important subject with two units emphasizing on environmental learning. However, there are few activities and experiments allow students to link their basic knowledge to real life situation in their unit. Therefore, students have difficulty to develop environmental ability and attitude in their science study.

Project WILD (PW) and project WET (PWET) are widely-used environmental education programs in several countries. They are packaged program based on the experimental learning cycle. There are several types of PW and PWET activities, e.g., role-play card game, outdoor exercise, debate, etc. In this study, we have practiced the environmental study using the activities of PW and PWET in science class, and discussed the validity of teaching

materials and the effectiveness to the students learning. We had chosen some of the activities, and modified and applied them to the junior high school science in Japan. Based from the results of practice on the unit “nature and human” in science II using these materials, our findings are as follows:

- Students could participate positively using the adapted activities from PW and PWET in their science class.
- Students have not only been able to learn the knowledge about nature ecology, but raise their interest about neighborhood environment and environmental issues.
- Students were able to simulate the long-term change of ecosystem through some activities, and they were able to understand the science process through the results of their activities.
- Students could develop the scientific thinking skills and the decision making for environmental sustainability and conservation.

The findings mentioned above indicate the positive effect to students the practicing of environmental education in science class using the activities from PW and PWET. Therefore, these programs were able to carry out environmental education in science class.

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**Application of the Environmental
Education Program “Project WET” to
Japanese Biology Curriculum**

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In Japanese schools, students have less chance to study about the environment. Environmental education has not established its framework in a

subject or teaching unit clearly. Therefore, it is a problem that students are not aware of their surrounding environment through the subjects.

“Project WET (PWET)” is a program developed in the USA for environmental education, which focuses on water and water environment. PWET has issued the curriculum and activity guide that includes 91 activities: research, simulation, puzzle game, and so on. It was imported and spread into Japan since 2004.

In this study, we compared both the contents of PWET and Japanese science curriculum particularly biology from elementary school to high school. Then, we discussed the application of PWET to these curricula.

As the results, we found out that some activities of PWET are possible to be used in each biology curriculum at all school levels, and they are expected to be used as teaching materials for hands-on study. For example, their simulations and puzzle games are possible to be used instead of the observation or experiments that are difficult to be performed as class activity.

We concluded that students develop their skills and abilities in environmental education by experiencing these activities. In addition, we think that students can deepen their understanding of the environment and apply their basic science knowledge to their surrounding environment. Therefore, we believe that PWET is a good teaching material for studying the environment in the subject of science including biology.

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**The Principles of Phylogenetics:
An Example in the Tribe Mussaendeae
(Rubiaceae)**

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Traditional plant systematics has in the past char-

acters from morphology, anatomy, embryology, chromosome, palynology, secondary plant compounds and protein. More recently, DNA sequence information has provided an important source of characters and has led to the rapidly developing field of molecular systematics (also called phylogenetics). There are undeniable advantages of molecular data because their interpretation is simpler and that there are simply more molecular characters available. Molecular data have often resolved systematic questions where morphological evidence is inconclusive and revealed relationships that are not suspected in the basis of traditional morphological characters. As a result, it is now widely used for generating phylogenetic hypotheses.

In this lecture, a practical introduction to the study of molecular systematics will be presented. The theory, fundamental terms, approaches, methodologies, and genomic markers useful in phylogenetics will be outlined. The value of molecular data, inferred from chloroplast (*trnT-F*) and nuclear (ITS) DNA data, will be discussed using the genetic conflicts in the tribe Mussaendeae (Family Rubiaceae) as an example.

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**The More Experience Teachers Have with
Laboratories and Field Activities,
the More Laboratories They Include in
Their Lessons!
— From the Results of a Survey of Upper
Secondary School Biology Teachers
in Japan —**

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In November 2005, we conducted a survey on upper secondary school biology education in Japan.

We sent a questionnaire to biology teachers at 1,000 upper secondary schools selected randomly among approximately 5,000 upper secondary schools in Japan and received answers from 654 teachers. Though the questionnaire covered a broad range of topics, we will report the results pertinent to one of the themes of this conference, "Biology Education through Field Excursions."

The vast majority of biology teachers at upper secondary schools have had the experience of collecting, growing or raising plants or insects when they were elementary school children. Only one third have had relatively abundant experience in biology laboratories (observations and experiments) during upper secondary school. However, two thirds have had relatively abundant experience of field activities in university.

From the results of this survey, it appears that the more experience they have had with biology laboratories in upper secondary school, and the more field activities they have experienced in university, the more likely upper secondary school biology teachers are to include student laboratories in their lessons.

Taking the importance of observations and experiments in biology education into account, it is desirable that biology teachers be provided with as much experience in field activities as possible during their training in addition to experience in laboratory activities.

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Pigmented Actinomycetes from Coastal Areas and Their Bioactive Secondary Metabolites

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Forty soil samples collected along the coastal areas

of Chonburi, Rayong and Chantaburi Provinces were isolated for Actinomycetes having some bioactive secondary metabolites. Pre-treated soil samples were 10 fold-diluted and incubated to starch casein agar plates. Various colorful actinomycetes were picked up after 7 – 14 d incubation at 32°C and purified and 147 isolates were screened. Out of 147 isolates, 92 were active against gram positive and/or gram negative bacteria, including yeasts. Bacterial test strains were: *Micrococcus luteus* TISTR 884, *Staphylococcus aureus* TISTR 885 and *Pseudomonas aeruginosa* TISTR 781. Yeast test strains were: *Candida albicans* TISTR 5239, *Candida tropicalis* TISTR 5045, *Debaryomyces hansenii* TISTR 5265, *Pichia kluyveri* TISTR 5150 and a *Candida* sp. hospital strain. All of them, both antimicrobial producers and non-antimicrobial producers were able to produce pigments both in spore mass and at colony reverse in various colors: gray, white, yellow, pink, light orange, red, brown, yellow-brown and purple. Furthermore, some isolates could produce soluble pigments into the agar medium. The present study showed that coastal soils can be one of the interesting sources of actinomycetes isolation for these worth useful bioactive secondary metabolites.

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Comparative Studies on Blood Osmolalities of the Mud Crab (*Scylla serrata*) and the Blue Swimming Crab (*Portunus pelagicus*) Exposed to Different Salinity Levels

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Blood osmolalities of the mud crab (*Scylla serrata*) and the blue swimming crab (*Portunus pelagicus*) were examined after 0, 1, 3, 6, 9, 12, 24,

48, 72 and 96 hr transferred from seawater at salinity of 30 ppt to salinities of 5, 10, 15, 20, 25, 30 (control), 35 and 40 ppt at 25°C. Blood osmolality of both crab species reached constant levels within 72 hr. *S. serrata* survived in all test salinities within 95 hr whereas *P. pelagicus* survived in salinities of 15, 20, 25, 30, 35 and 40 ppt within 96 hr but died 24 hr after being transferred to seawater at salinities of 5 and 10 ppt. Thus, the salinity ranges over which osmoregulations were performed efficiently were 5 – 40 ppt for *S. serrata* and 15 – 40 ppt for *P. pelagicus*. The result on value of blood osmolalities showed that *S. serrata* is a strong hyper-osmotic regulator whereas *P. pelagicus* is an osmoconformer.

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Introduction of Diatoms for Studying River Environment

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Diatoms are microalgae distributed in almost all aquatic environment and take major role in global ecosystem, because 20 – 25% of photosynthesis in the world is contributed by them. Diatoms are one of useful bio-indicators and water quality evaluation methods using diatoms are applied in many countries. In spite of these facts, diatoms are less informed in biology education. Using video movies and simulation software, we tried to introduce the diatoms to biology education for understanding relationship between human activities and river water quality. Because of their small size, observation of diatoms is usually not easy for many students. In addition, identification of diatoms is difficult for beginners, as over 300 species occur in Japanese rivers. To solve these problems,

we developed the simulation software “SimRiver.” We have had several classes using these learning materials since 2002. In some classes, field learning was also combined with indoor learning. In conclusion, it was indicated that students enjoyed the learning with SimRiver and understood the change of species diversity according to water pollution, and their thinking to environment was promoted.

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Analysis of Secondary School Science Teachers’ Perceptions of and Practice in Microcomputer-based Laboratories

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Recently, secondary school science laboratories and the experimental tools in them are improving and developing due to the science laboratory modernization policy to activate and reform science education in Korea. Related to this, the Microcomputer-based Laboratory (hereafter, MBL) has become one of the technologies attracting the attention of science teachers and science educators.

In this research, secondary school science teacher’s perception of MBL and its usage in schools were investigated using survey methods. One thousand secondary school science teachers across the country were surveyed through online for one month in May 2006, and their responses were analyzed. Through this research, the ways to improve the effectiveness and efficacy of scientific inquiry or experiments by implementing MBL in science education were expected to find out.

The survey results showed that only 53.3% of science teachers have even heard of MBL and 31.7% of teachers have experienced MBL directly or in-

directly, usually through teacher training programs. Also, a very small percentage of secondary schools (6.1%) were equipped with MBL tools and used them mainly for demonstration by teachers because of the low quantity of MBL tools. Thus, it was found that only a small percentage of secondary school science teachers understood the meaning and value of MBL in terms of improving science experiments.

Meanwhile, 70 – 80% of teachers had a positive opinion about the effectiveness and practicability in using MBL in science experiments, and 80.8% of teachers intend to participate in teacher training program on MBL in the future. Moreover, they requested MBL tools in schools and teaching materials about MBL experiments for activating the usage of MBL in science education.

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Philippine Science High School (Main Campus) Biology Unit: Gearing Secondary Level Gifted Students towards Careers in Biology through Field Biology

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Philippine Science High School – Main Campus

The– Main Campus Biology Unit, true to its vision and mission of contributing to nation-building by increasing the number of biological science oriented students at the secondary level, re-organized a field biology course offered to incoming 4th year high school Filipino students. The program aimed to promote learning in the ecology of terrestrial and aquatic environments and in ecological field techniques, develop conservation-minded students, and improve inter-cultural interaction. Linkages both local and foreign were forged with conservation project institutions, university field

laboratories and local government units to achieve the minimum level of competency required of in a multidisciplinary field of nature conservation, awareness, and preservation.

The Philippines is a mega diverse country, but it has much natural resources still waiting to be discovered. Its current condition as a “hotspot country” prompted the authors to intensify the campaign of field discovery and field education.

Bird watching, as part of the Field Biology program, offered students the opportunity to patiently wait and to identify birds of different species using the current literatures published on Philippine Birds and aided with the expertise of a research station staff.

The Philippine Science High School Biology Unit is continuously looking for opportunities for an active cooperation of external scientific bodies and institutions, both local and foreign, to reshape once again the interest of students in fieldwork and exploration amidst financial, equipment, and expertise constraints.

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Myxomycetes in Hokkaido, Northern Japan, and Introduction to a Simple Method to Collect Myxomycetes

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Myxomycetes (also called “slime molds”) are fungus-like organisms commonly found in forests throughout the world. They are very interesting organisms because of their life cycle. At one stage, they produce mold-like masses that give rise to spores, and at the other stages they move and feed on bacteria in an animal-like fashion. Although myxomycetes occur in any kinds of wood-

land, most people overlook because of a lack of knowledge of them. In the course of this study, we have devised a simple method to collect myxomycetes for teachers and students.

Asahikawa is located at the central part of Hokkaido, and is climatically situated in the cool-temperate zone. Five hundreds and thirty specimens were recorded as field collections during 2004 – 2006, and 93 taxa of myxomycetes were recognized. Seasonal development of fructification was observed at the research area. In spring (April and May), abundant fructification of peculiar “snow bank myxomycetes” were found near melting snow and 14 taxa of this group could be enumerated. In summer (June to August), 46 taxa were recognized, and most of these were known as cosmopolitan species which widely range from tropical to temperate zones. In autumn (September to December), 44 taxa were recorded, including 14 species which are regarded as typical autumn species and which have been recorded also from mountain regions of the central part of Honshu Isl., Central Japan.

We have devised a simple method to collect myxomycetes which is convenient for teachers and students to easily find and collect myxomycetes in forests and schoolyards.

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Development of Inventing Future Animal for Students of Elementary School

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“The Future is Wild” is a TV program made by Animal Planet and BBC. In this program, there are many future animals like “Megasquid.” Many famous scientists create these animals with scientific prediction. Scientists believe that, 200

million years in the future, the eight-ton “Megasquid” may roam Earth. According to experts of this program, it is not difficult to imagine that squids may one day live on land, since all land-living animals are descendants of marine organisms.

In Korean Elementary Science 4th Grade, there is a lesson for creating students’ own animal of conjecture. But, more imagination of students’ own animal is not appropriate to nurture scientific thinking. Before drawing or developing students’ own animal introducing the animals of “The Future is Wild” would be a good guide to elementary students for making scientific animal and would be a good material to explain evolution.

Before making students own animal of imagination, the surrounding environment and many variables of nature should be explained thoroughly to make animals of scientific imagination.

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Biodiversity of Birds in Wiang Kosai National Park, Thailand

Surakan Payakkhabut

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Wiang Kosai National Park was designated as the 35th national park of Thailand on October 9, 1981. It covers an area of 410 km² in Phrae Province and Lampang Province. The landscape of the national park is high steep mountains covered with dry evergreen forest and mixed deciduous forest. The highest peak reaches a height of 1,267 m m.s.l. The forests are important water source of Yom River. In the past, the forests were the living place of various kinds of wild animals, i.e. tiger, elephant, and deer. However, poaching and illegal cultivation, past to present, has regrettably destroyed the rich natural forests much. The pur-

pose of this research was to study biodiversity of birds in Wiang Kosai National Park. Since the natural forests are habitats and food sources of birds, therefore, we can use information about biodiversity of birds as a factor to indicate the fertility of natural forests. The more species of bird we can find, the more fertile the forest is. The research had been conducted from July, 2005 to June, 2006. In this study, 51 species of birds are found in Wiang Kosai National Park. There have been both common residents and winter visitors. The number of birds increases in winter. The dominant species is Black-crested Bulbul. It shows that Wiang Kosai National Park is still a beautiful fertile forest and very suitable for nature study. We must not allow anybody to take further advantages or damage it again.

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<Poster presentations>

The New Circumscription and Biogeography of *Mussaenda* (Rubiaceae) Inferred from Chloroplast (*trn*T-F) and Nuclear (ITS) DNA Data

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Although recognition of *Mussaenda* as a separate genus has been widely accepted, its generic circumscriptions have always been controversial. In this first molecular phylogenetic study focused specifically on *Mussaenda* sensu lato (s.l.) and its allied genera, parsimony analyses were based on both ITS and *trn* T-F sequence data to (1) test the monophyly of *Mussaenda* s.l. as presently circumscribed and (2) make inferences on the bio-

geographical origin of *Mussaenda*. Results highly support the polyphyly of *Mussaenda* s.l. as currently delimited. The Malagasy *Mussaenda* are more closely related to *Landiopsis* than they are to the African and Asian *Mussaenda*. As a result, *Mussaenda* is now restricted to include only the African and Asian *Mussaenda* representatives. A new genus *Bremeria* is described to accommodate all Indian Ocean (Madagascar and the Mascarenes) *Mussaenda* species. The newly delimited *Mussaenda* is diagnosed by reduplicate-valvate aestivation and glabrous styles, whereas *Bremeria* can be distinguished from the remaining *Mussaendeae* genera by having both reduplicate- and induplicate-valvate aestivation and densely pubescent styles. This study strongly suggests an African origin of the newly delimited *Mussaenda*.

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The Learning of Plant Diversity, Adaptation and Evolution by Inquiring into the Vascular Bundle

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The aims of learning of vascular bundle system are to understand the structure and function of vascular bundle that consists of phloem and xylem, to classify the angiosperms into two large groups – the monocotyledons and dicotyledons – based on the form and arrangement of vascular bundle, and to appreciate that the acquisition of vascular system is one of the major factors in plant evolution and adaptation to dry land environment. To develop the suitable materials and method for learning, we observed the hand sections of stem and analyzed the morphological

features of vascular bundle in 85 species. We used 70 common wild plants, 10 garden plants, and 5 aquatic plants that can be gotten easily in surroundings of school. The aquatic plants are useful to inquire the plant evolution and adaptation because the vascular system degenerated in water. The results of our study are below:

- 1) Dicotyledonous *Mirabilis jalapa* has an exceptional vascular system which is similar to monocotyledonous type.
- 2) The number and position of vascular bundle were related to that of sclerenchyma in some species, such as *Lamium amplexicaule*, *Clinopodium micranthum*, and *Vicia angustifolia*.
- 3) The proportion of vascular bundle area to stem cross section was high in climbing plants, such as *Pueraria lobata* and *Dioscorea batatas*.
- 4) The aquatic plants, such as *Egeria densa*, *Ceratophyllum demersum*, had degenerate vascular system and developed inter cellular space.

Students should find out plant diversity, structure and function, adaptation, and evolution through comparative observation using stem cross sections of some species mentioned above.

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SimRiver – Simulation Software to Study Relationship between Human Activity and River-water Quality Using Diatoms

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SimRiver is a sort of simulation software and provides an opportunity for students to understand relationship between human activities in river wa-

tershed and water quality using diatoms. Operation of SimRiver is game-like and all students over junior high school age can use it without difficulty. At first, students create environment along a river in monitor by choices of environmental factors, namely land use, population and sewage treatment plant, then decide season. At this point in operation, water quality is estimated in five collecting sites as COD, though the value is not shown to students. After students choose a site for collecting diatoms, microscopic view of permanent slide of diatom is synthesized in the monitor. Students can easily identify each specimen by electronic diatom guide, and mark them for counting. Counting sheet is also automatically prepared with diatom names, which are correspond to the specimen in the permanent slide view. Saprobic index, which shows degree of water pollution, is calculated by student using this counting sheet. The operation procedure of SimRiver will be demonstrated in poster session.

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Unraveling the Genus *Villaria* Rolfe: Endemic Philippine Rubiaceae

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The genus *Villaria* is one of the endemic Philippine Rubiaceae (coffee family) which is imperfectly known to the present day. To this data, there is no published exact account in terms of its species number, comprehensive vegetative and reproductive descriptions, and distribution of the genus. Herbarium materials of *Villaria* in major herbaria are likewise limited. Although *Villaria* is widely accepted as a separate genus, its tribal circumscription has been controversial because of its one-celled ovary. Accordingly, the present

study is a contribution to the understanding of the Philippine's endemic genus. A preliminary investigation of the genus morphological structure is represented by the *Villaria odorata* collected from General Nakar, Quezon. It is typically shrub; leaves opposite, coriaceous; stipules intrapetiolar, persistent; inflorescences axillary, cyme, few-many flowered; bracts basally connate; flowers small; calyx tube infundibular, the lobes 5, dentate; corolla hypocrateriform, the throat with villous indumentums, the lobes 5, white, spreading, contorted; stamens 5, exserted, the filaments extremely short; anthers subsessile, dorsally fixed, linear, acute at apex; ovary unilocular; style slender at base, the apex fusiform; ovule 4-8, embedded in 2, parietal placenta; fruits green, fleshy, with persistent calyx lobes.

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Students' Conceptions of Decomposition and Circulation of Materials in Ecosystems

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This study is to identify students' conceptions about decomposition and circulation of materials in ecosystems. The conceptualized tendencies were analyzed and connected with contents of science textbooks through kindergarteners to 10th graders. Students' ideas of the concepts categorized through the series of written tasks and individual interviews were nature of growth, nature of substance in ecosystem, role of plants as producers, fate of organisms, and cause and process of decomposition and circulation of materials in ecosystems. One hundred and eighty subjects from a preschool, a kindergarten and 3rd, 5th, 8th, and 10th grades were responded to each question.

Qualitative data was collected, transcribed and analyzed to investigate their conceptual differentiation. Many students who are below the 3rd grade did not understand decomposition concept biologically; however, they had experienced sometimes the decay phenomenon at their everyday life. Most of pre-3rd grade students did not understand decomposition conceptions, however, they understood decay phenomenon. Some of the 5th and 8th graders understood the cause and process of decomposition conceptions and 10th grade students began to understand the phenomenon of circulation of materials in ecosystem. Because science textbooks for only the 6th graders contained the contents, the 3rd and 5th graders could not find any chance to meet the concepts through their formal school programs. Therefore, the 8th graders develop the concept of the decomposition process and cause of materials. Students' scientific conceptions of circulation of materials in ecosystems at last were found from the 10th graders after they had learned with the chapters for "metabolism" in high school textbooks.

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Association between Students' Attitude toward Science and Students' Age, Gender and Learning Environment

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Attitude toward science is one of important motivation factors for science learning and it influence satisfaction of science subjects and learning quality. Therefore, it is necessary to investigate where students' attitude toward science is influenced. Students' age, gender and learning environment in

which they influence science work were considered in this study. TOSRA (Test of Science-Related Attitudes) was used for measuring students' attitude toward science, and questionnaire was developed for investigate students' science learning environment. Questionnaire was administered to 666 elementary, middle and high school students and the data collected was analyzed. Among the research factors, positive association was appeared both students' environmental factors and students' science-related attitudes ($P < 0.01$). Specially, positive association was appeared relatively highly at the both factors of parents' concern about science and friends' concern about science. As students' school age was more greatly associated from low grade to high than the students' learning environmental factor and attitude toward science. It was turn out that there was generally no difference between students' gender and attitude toward science by t-test.

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Students' Conceptions of Evolution and Their conceptualizing Traits in Terms of the Subjects: Human, Animals and Plants

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The purpose of this study was to identify students' conceptions and perceptions of evolution in terms of their explanation subjects: human, animals, and plants. Questionnaire was specially developed to make sure students' conceptions and perceptions of evolution and students' explanation patterns with the five evolutionary explanations: creationism, internal will explanation, teleological explanations, use and disuse explanation, and mutation and then

natural selection, and the perceived ideas of evolution in terms of the subject characters of human, animals and plants. It was administered to 1,540 elementary, middle and high school students. The data was collected and analyzed longitudinally by their ages. Results showed that there was difference between the students' evolutionary explanations in terms of human, animals and plants. Students had more "teleological explanations" than "internal will explanation" and "Use and disuse explanation" about plant evolution. "Mutation and then natural selection explanation" was less explained about human. This result showed that the anthropocentric thoughts had influenced students' evolution conceptions. According as student's age was increasing, "teleological explanation" and internal will explanation" were getting less and "use and disuse explanation" was more. Many students recognized that evolution was a kind of scientific hypothesis with small evidence. They have had little interest in evolution and conceptualized it through informal educational sources. This study mentioned that teaching evolution make effectively, first of all, teachers should make "use and disuse explanation" adhered strongly to students' cognitive structure eliminate.

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Biology Teachers' Perception of Inquiry-Based Instruction

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Korean science education researchers were concerned with science inquiry and laboratory activities over the past two decades. With this effort, it has been influenced on improving Korean students' inquiry ability and science teachers' teach-

ing methods in terms of inquiry-based instruction. Because a teacher variable specially has great influence on inquiry instruction, teacher factors need to be verified. In this study, 110 biology teachers teaching at the Korean secondary schools have participated. To figure out how well biology teachers perceive the inquiry-based instruction, a questionnaire was specially designed and administered to them. The questionnaire included the definition of inquiry and its relation with experiment through selected-response. Also teachers' perception on inquiry instruction and students who are invited in inquiry and the inquiry environment had been asked through five levels Likert scale. The major results of the study are as follows. Firstly, the higher teachers evaluate their inquiry instruction, the more frequently they teach using the strategy while the lower teachers evaluate their inquiry, the more they make it conceive difficulty. Secondly, biology teachers perceived what they could not be overlooked would be their own capabilities. Many biology teachers have been misunderstood about characteristics of inquiry learning and experiment learning. The results mean that biology teachers have conceptualized their own notion about inquiry learning and it has great influence on their instructions.

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Phytotoxic Effect of Phenolic Compounds from *Erigeron canadensis* and *Artemisia princeps* var. *orientalis* on the Seed Germination and Seedling Growth

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Phytotoxic effects of the aqueous extracts from *Erigeron canadensis* and *Artemisia princeps* var. *orientalis* were studied. *Digitaria sanguinalis*, *Rumex acetocella* and *Cirsium pendulum* were used as test materials. Quantitative identification of chemical compounds from plant species analyzed benzoic acid, caffeic acid, coumaric acid, ferulic acid, gentistic acid, protocatechuic acid, salicylic acid, sulfosalicylic acid, vanillic acid, and scopoletin by HPLC. Three phenolic compounds (ferulic acid, sulfosalicylic acid and vanillic acid) accelerated the germination of *Rumex acetocella*. The seed of *Cirsium pendulum* was inhibited significantly both germination and seedling growth by the extracts of five plants. In case of leaf extracts, the magnitude of inhibition was as follows: *Artemisia princeps* var. *orientalis* > *Erigeron canadensis*.

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A study of Appropriateness Concerning Photosynthetic Products' Experiments Presented in Science Textbooks

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Science textbooks at elementary and secondary school present biology experiments with methods which were mostly like a cook-book recipe in order to confirm the theoretical results. Students may develop the inquiring ability while practicing experiments presented in the textbooks. However, there are some cases for teachers and students to experience many difficulties in the process of practicing biological experiments because of inappropriate experimental tools or methods presented in science textbooks. Therefore, some problems occur where students may not understand the bio-

logical concepts in relation to the experiments and this may decrease their interests and hopes for biological experiments. This study analyzed the appropriateness of experimental methods to confirm the material (starch) and gas (oxygen) production by photosynthesis. We selected Korean science textbooks which present the experiments of the photosynthesis for this study. There are 19 different science textbooks (one textbook in grade-5, nine textbooks in grade-7, eleven textbooks in grade-10) published according to the 7th National Education Curriculum of Korea, which was instituted by the government in 1997. In addition to textbooks' analyses, we investigated the practical difficulties in the process of those experiments to confirm photosynthetic production, we were able to improve the experimental methods and suggested new methods in photosynthetic products' experiments. We show that it is necessary to present the experimental methods correctly on the basis of the practice of experiments by the biology textbook's authors.

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Examination of the Best Balance of Hormones for Dedifferentiation, Multiplication of Callus Cells of *Daucus carota* and a Method for Inducing Plant Growth from Adventitious Embryos

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Among the authorized textbooks for senior high school Biology I and II published in 1994 or 1998, some textbooks did not give sufficient attention to hormone balance for plant morphogenesis. So, we re-examined the best medium and hormone

balance for dedifferentiation and multiplication of the callus cells of *Daucus carota*, and best method to grow the plants from adventitious embryos.

The best medium for the dedifferentiation of explants of *D. carota* was Murashige and Skoog (MS) solid medium supplemented with 8.75 mg/l Indole-3-acetic acid (IAA), and 0.2 - 0.4 mg/l kinetin, and 0.5 mg/l 2,4-dichlorophenoxyacetic acid (2,4-D). Three weeks after placing callus cells on the MS solid medium, those callus cells were then placed on the White solid medium supplemented with the 10% coconut water and left for three weeks.

Many adventitious embryos grew into small plants. Then, the small plants were placed on the 0.3% Hyponex solid medium. The small plants grew up vigorously. The conditions of the room were 25°C, 5000Lux, 16hr light - 8hr dark, 50% humidity.

The importance of inquiry laboratory experiments was approved by many Japanese upper secondary school biology teachers. The new curriculum for senior high schools was started in 2003. Although several inquiry laboratory experiments are included in new biology textbooks, biology teachers expect many more inquiry laboratory experiments to be developed. Many students of upper secondary schools prefer laboratory experiments. They want to carry out special technical experiments such as plant tissue culture. Thus, new techniques in science education may enhance their interest in learning. The motivation is likewise very important in studying science. If they can derive satisfaction in their inquisitive mind from the successful completion of laboratory experiments, they will come to study science harder.

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The Development of Web-Based Biological Learning Program for Middle School Students – Human Heredity –

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The purpose of this study is to develop effective Web-based instruction data for assisting the learning, which was difficult to achieve by experiments and practices, in secondary school biology. To do this purpose, learning cycle model was applied about the “human heredity” part of a “heredity & evolution” unit in a middle school science textbook. The developed instruction data were re-constructed to HTML web pages and flash data according to a curriculum and the entire formation were as follows:

- Learning contents: Inquiry activity was dealt essentially with in 7th curriculum and presented in exploration phase. Inquiry activity mentioned all the contents of seven textbooks. Flash data were applied to induce the student’s interest. Seven authorized textbooks were analyzed and summarized in concept introduction phase. In concept application phase, the similar data to contents performed in exploration phase were presented for fixing the concepts introduced in exploration phase and concept introduction phase.
- The science in a living: In the science in a living, it was presented to data not only recorded in the textbook but also quoted from newspapers and science journals.
- Reference data: The reference data about polygenic inheritance were shown to avoid a misconception, e.g. “One inherited character was operated by only one gene.”
- Evaluation: For evaluating achievement of lessoned students, several questions related with “human heredity” unit were presented.
- Arrangement of terms: To help students learning, essential terms for comprehending the concepts of “human heredity” unit were recorded. The terms were arranged in the Korean alphabetical

order for ease access of students.

- Related sites: Students may have a question about not only in human heredity unite but also in other units in learning. For this case, easily available sites were categorized and presented according to the universities, organizations, personal home- pages, and textbook publishes.

Web-based instruction data developed in this study were considered to be a great assist for students’ expansion of inquiry ability and improvements of learning achievement of “human heredity” unit at a school and home study scene.

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Research Trends in Science Education

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The trends of researches are reflected in that it is about the strong-and weak points of previous researches but also a guideline for future research. This study explored the trend in the topic of science education research. The articles in 1982 – 2006 of the *Journal of Korean Association for Research in Science Education* and 1973 – 2006 of the *Korean Journal of Biological Education* were analyzed and categorized by the research aims, methods, strands, subjects and contents. The frameworks of research strands were borrowed from that of the 2006 NARST (National Association for Research in Science Teaching) conference. The use of the NARST strands makes it possible to compare the science education research trends in Korea with the international ones. As the results of this study, three domains of research were found to be predominant; the understanding of the conceptual status of students using questionnaires, developing teaching materials and analyzing their

effects through implementation, and exploring the affectional elements such as motivation and attitudes toward science with questionnaires and interviews. In addition, efforts to enhance students' scientific literacy and understanding the Nature of Science have been increased. Implications from analyzing research trends on science education will be discussed.

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Developing of Biology Inquiry Field-Trip Program for Elementary Pre-service Teachers: at Woopo, the Greatest Swamp in Korea

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This study aimed to develop an inquiry program of biology fieldtrip for elementary pre-service teachers and to implement it. Learning inquiry skills are as important as concept learning on elementary biology education. Biology inquiry field work needs some different teaching-learning techniques from those of biology classroom work, because of open space, various inquiry materials, many choice of themes wanted by students, self-inquiry to self-choosing theme, and above all self-learning of knowledge making ability as an essential character of science work as well as basic inquiry skills and higher thinking for science inquiry. Therefore, it will make a significant contribution to administer biology inquiry field trip program as a curriculum for elementary pre-service teachers to improve the quality of elementary biology education. In our research, 120 Korean elementary pre-service teachers participated in the program, they each acted in a team with 3 or 4 members. The program had three parts, which were pre-work at school, fieldwork at the location, and post-work at school. In pre-work, they had learnt science in-

quiry process, investigated the location by the Internet of books, discussed their inquiry with team members, and written temporary inquiry plan. It took 3 days to inquiry at the location. During fieldtrip, they inspected Woopo, explored the possibility of their plan, inquired the plan or new theme which they decided better at the location, performed it, and presented it. In post-work, they submitted a final report which included the conclusion of research and the added examination and information.

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Development and Application of Bioethics Course Program Using Norm Cards

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The important goal of science education is to develop scientific literacy for solving everyday problems. As biotechnology develops rapidly, value judgments about bioethics issues is becoming prominent. In this study, we developed asset of norm cards to make a reference in dealing with bioethics issues, in high school context. The norm cards were drawn from a various category of philosophy, ethics, laws, medical science, etc. Bioethics course program was implemented during 4 class periods: One for understanding relevant science concepts and the others for decision making about three issues including abortion, human embryonic reproduction, and an organ transplant. To investigate the effectiveness of the classes, both of value judgments test and scientific concept test were carried out through the preliminary and post inspection. This study has found that the students which used the norm cards made moral decisions with more various norms and there were associations among students' attitude, achieved scores,

and value judged ability. This study included discussion for the revitalization of bioethics education.

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A Suggestion of Performance Assessment Developing Model to Assess Science Creative Problem Solving for the Science Gifted

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The Science Gifted has been recognized the leading group which will improve the country and serve it as well as their outstanding scientific achievement. Creative Problem Solving has been considered absolutely essential way through which people could solve various problems the most valuable. It would raise the quality of personal life, too. Therefore, it is very important to develop science creative problem solving assessing tools with high validity and reliability. However, creative problem solving is the one which is constructed with several unknown factors so that it is uneasy that we assess it valid. Performance assessment has been known as a useful tool capable of assessing various abilities in teaching-learning situation. This study suggested a performance assessment developing model to assess various abilities in science creative problem solving process. Firstly, the assessment framework was made up. It had a 3 dimensional structure which was composed of scientific components, creative components, and problem solving process components. The tools must have three essential parts such as performance task, students' format, and assessors' scoring system. The performance task had to be in situation which demanded

scientific knowledge. The students' format must be made through a selected problem solving process, and one or more components of creative thinking must be able to assess at each step in the process. There must be the rubrics about creative components at each step in assessors' scoring system. And there must be also the rubrics about the level of scientific knowledge, cognitive thinking, and problem solving components.

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Ideal Education with Synthetic Horizons: Need for the Establishment of the New Subject "Culture" in the Curriculum

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Science and technology have made a remarkable progress in the last half century. It is because of many scientific fields formed through the natural science studies. For instance, the discovery of DNA is the result of a combined effort of biology and chemistry together, and furthermore the physical technology.

In early years, the studies of physics, chemistry, biology and earth science were done within its own category. But lately, it is getting more and more important to put the stress on the studies in the interdisciplinary fields. Moreover, the investigation also from the social and human-and cultural sciences cannot be ignored.

I want to bring out a part of educational problems now in Japan, and advocate the better way to bring up youth who shall carry and support Japan in future. It is desirable and necessary that the young people should be encouraged to learn and study the culture and tradition of their own country. People who study their own culture well, will be able to

esteem the culture of other countries and the people behind. That can be a step to create the better mutual understanding between the nations. With such a horizon for the education, I think, it is necessary to establish "Culture" as the new subject in the curriculum, and put it into practice.

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The Effect of Project Learning about "Organism and Environment" in Biological Class

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The purpose of this study was to find out educational effect of project learning about "organism and Environment" in biological class. For this study, we designed students-centered project learning materials. These materials were made of 3 steps; introduction, small group activity, presentation of their own products. Students had to do a mission for 4 weeks. That was so called "create creature." Two students made a group and each group selected its own ecosystem. The groups created their own creature in various ecosystems. At first week, teacher introduced the relation of organism and environment. At second week, each group aggregated some information about its own ecosystem and animals in textbook, science magazine, the Internet, etc. At third week, each group had made its own creature that well adapted themselves to its own ecosystem. At the last week, each group presented their products. In this study, 154 students in the 10th grade of the Science High School were implemented. The results of this study was as follows: first, most of students showed great interests and enjoyed the class of this style, and they thought it was a good

chance for creative thinking; second, it was easy to understand about the animals in each ecosystem. From these, we concluded that project learning facilitated meaningful learning and scientific attitude.

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The Qualitative Change of Students' Attitude through Student-Centered Guided Discovery Learning in Biology Classroom

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Students can understand everything by themselves in studying biology in the classroom. That means the fact that teachers do not teach the knowledge, but do the principle. From this educational viewpoint, we can find out the qualitative change in the student behavior's aspect through the discovery learning organized and guided, studying by themselves, expressing, discussing things together. This just is the purpose of this study.

As the way and subject of study, we selected and experimented three equivalent groups of girl students of the second year in Kongju Girls High School in small and medium city.

As the result of study, we did compare the scores between when the students did not finish the discovery learning and when they did it: the score in the mid term exam, the score in the final exam.

In class "A," 63% (17 students) of the class increased the score, 4% (1 student) were the same level and 41% (11 students) decreased the score. In class "B," 54% (14 students) increased the score, 15% (4 student) were the same level and 35% (9 students) decreased the score. In class

“C,” 70% (19 students) increased the score and 30% (9 students) decreased the score. The class “C,” grouped by the relationship between the students, showed more increase than the class “A,” grouped by the school record and the class “B,” grouped by the name code.

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An Analysis of the Editorial Design on Science Textbook of High School and the Cognition of Students

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The purpose of this research was to suggest improved plans for a development of the next textbook through analysis of the external format and the editorial design further various opinions against the editorial design between the present textbook and the new generation one.

The method of the study was to analyse the design of seven different kinds of the 7th science textbooks at high school and to investigate satisfaction and requests on the science textbook's design of 319 high school students.

The major findings of this study were as follows:

First, the size of the textbooks used at present was unified to 4.6-size in all step schools. Such a restriction for the external format of textbooks may hinder various editorial designs. Only 34.6% of high school students were satisfied with the science textbook's size. And 66.4% of high school students think that its thickness and quality was not appropriate.

Second, although 68.2% of students think that color of science textbook was clear, some did not answer affirmatively about harmony (21.5%).

Third, only 22.5% of students answered pictures

and drawings of science textbook had a realistic description and only 19.7% answered it because of the students' curiosity.

Fourth, the space of science textbook was too small to ensure proper learning.

Fifth, only 13% of students recognized that textbook induced interest. It was judged that a change of design contribute to improvement of learning effect.

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The Effect of Using Animal Dissection of Science Achievement and Attitude toward Dissection Experiments in “Structure and Function of Visual Organs” for Middle School Students

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The aim of this study was to find out how the students were influenced by the cow-eye dissection experiment when learning about the structure and function of visual organs in unit “Stimulus and Reaction” of middle second grade. The participants of this study were 138 students from “K” Middle School in the province of Gyeonggi. Two classes were an experiment group and the other two classes were a control group. Science achievement and attitude test were carried out before and after classes and the results revealed the cow-eye dissection experiment was more effective in improving science achievement and the attitude toward dissection experiments.

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Learning Ability and Color Remembering of Great Hornbill in Captivity at Chiang Mai Zoo

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The learning and color-remembering abilities of 6 (3 couples of male and female) Great Hornbills (*Buceros bicornis*), in Chiang Mai Zoo, were studied from June 2005 to May 2006. The study used 2 models: color-remembering model and mechanical food box. The first set of model consisted of 4 plastic bowls, which were yellow, red, green, and blue in color. The bowls were covered with paper sheets having the same colors as the bowls, but only the red bowl contained some food. The second model was the mechanical food box, with a lid, containing food. The result of the model testing showed that the Great Hornbills had a good learning ability, and could recognize colors.

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The Development of Science History - CPS Teaching Model for Improvement of the Gifted-in Science Students' Creative Problem Solving Ability

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A new teaching program is needed to improve the creative problem solving ability of the gifted-in science students, which includes the creative strategies in general and specific field such as science. Therefore, CPS (Creative Problem Solving) model that is the general creative problem solving strategy was integrated with the scientists' creative problem solving strategies based on sci-

ence history to produce science history – CPS teaching program. The scientists' problem solving strategy appeared in the science history include both the scientific content which corresponds to propositional knowledge, and the scientific research process, which is procedural knowledge. According to this teaching model, heredity teaching program was developed and applied with the forty-eight first grade students of the science high school.

The results showed that the students achieved a significant improvement in fluency, flexibility, and originality, which are the sub-elements of the general creativity. Also, they showed meaningful development in understanding of the problem, generating of an idea, planning and practice, the sub-elements of the problem solving ability which corresponds with procedural knowledge of the science specific strategy. The achievement level of heredity concepts was also improved more significantly after class, which corresponds to the proportional knowledge of the specific strategy in the field.

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***Haematococcus*, Unicellular Green Alga, Is Useful for a Student Laboratory Experiment on "The Response of Organisms to Environmental Changes"**

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Haematococcus is a motile unicellular green alga common in small pools. The cell comes to be an immobile resting cell called akinete when the environmental conditions, such as nutrients, pH and temperature, become worse. During akinete formation, the color of the cell turns red because it

accumulates a large amount of the red carotenoid, astaxanthin. The akinete again comes to be motile and green when it is transferred to the conditions appropriate for its growth. Since such color changes seem to be detected easily by the naked eye, we thought that this alga could be used for a laboratory experiment on the response of organisms to environmental changes.

Green motile *Haematococcus* cells were obtained from a subculture inoculated into liquid "C medium" every two weeks. Red immobile akinetes were prepared by leaving the green cells in liquid C medium for five to six months without changing the medium. The cells were cultured at 20°C under a light intensity of $40 \pm 5 \mu\text{mol/m}^2/\text{s}$ with a 12 hr photoperiod. Carotenoid (Car) and chlorophyll (Chl) were extracted by 90% acetone. Their concentrations were determined photometrically and the Car/Chl ratio was calculated. The ratio can be used as an indicator of cell color, e.g., 0.5 = green, 1.2 = brown, 2.7 = red.

The Car/Chl ratio of green motile cells rose from 0.23 to 1.6 three weeks after the cells were transferred into a nitrogen-deficient liquid C medium. The Car/Chl ratio of red akinetes fell from 2.50 to

0.95 during the same period after they were transferred into liquid C medium. However, the color changes in both cases were hard to detect by the naked eye. On the other hand, when the red immobile cells were cultured on the solid C medium (C medium with agar), the cells quickly changed their color to green and the Car/Chl ratio fell from 2.80 to 0.61 within three days. This color change could be detected easily by the naked eye. In contrast, the change in cell color was considerably slower when the green mobile cells were cultured on the water-agar medium (with no nutrient).

Thus, it is easy to carry out a student laboratory experiment to confirm that *Haematococcus* akinete quickly responds to nutrient supply, but it takes a longer time to confirm that its motile cells respond to nutrient shortage. As *Haematococcus* is obtainable anywhere and cultured easily, the alga can be used more often in biology teaching.

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