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Country Report

Latest Upper Secondary School National Curriculum Standard and Basic Biology Textbooks in Japan

Teiko NAKAMICHI*, Takashi SAIGO, Nobuyasu KATAYAMA
Tokyo Institute of Biology Education, Japan

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The newly revised Upper Secondary School National Curriculum Standard (USS-NCS) was released by the Ministry of Education, Culture, Sports, Science and Technology, Japan (MEXT), in March 2018, and is being enforced from April 2022. The latest USS-NCS particularly emphasizes proactive, interactive and authentic learning, so called "active learning", so that the students, who study under the regulation of this USS-NCS, will be able to keep up with the development of globalism, technological innovation, and other unknown issues, and survive in an unpredictable society. Therefore, student-centered learning that includes critical thinking, decision-making, presentation and discussion, is emphasized more than teacher-centered teaching. In addition, the latest USS-NCS specifies the number of biological key terms used in textbooks to be around 200 - 250 for Basic Biology and 500 - 600 for Advanced Biology, because MEXT asks biology teachers to shift their focus from cramming in knowledge to developing higher-order thinking skills. Thus, in every revised Basic Biology textbook used from the 2022 school year, the number of key terms is less than 250, and they are presented in some different ways such as in boldface type or in the glossary at the end of the book. Furthermore, these textbooks include several scientific methods to empower students to find questions and problems and solve them on their own. Moreover, there are many exercises that lead student to think deeply. Another feature of these textbooks is that, as part of giving priority to information and communication technology (ICT), QR codes have been incorporated to allow students to learn through the Internet.

Key words: *Active learning, Basic Biology, biological key terms, Japan, National Curriculum Standard, student-centered learning, textbook survey, upper secondary school*

***Mrs. Teiko Nakamichi**, Email: teikonakamichi@hotmail.co.jp

INTRODUCTION

In Japan, since 1947, the National Curriculum Standards (NCSs) for primary and secondary education have been revised about every 10 years (Nakamichi and Katayama, 2018).

In the previous USS-NCS, which was being enforced from 2012, biology-related subjects, in particular, were modernized to reflect the rapid progress in life science research. The number of topics increased and the contents became more challenging particularly in the case of Advanced Biology (Nakamichi and Katayama, 2018). As a result, the number of biological key terms used in both Basic Biology and Advanced Biology textbooks to explain key concepts increased remarkably (Nakamichi, 2017). Therefore, students may have been pressured to memorize these terms to pass semester tests and university entrance exams. MEXT expected teachers to help students acquire "abilities of thinking, judgement,

presentation, discussion, etc." through student-centered learning (MEXT, 2012). Thus biology teachers should have shifted their teaching methods to student-centered learning, such as problem-based learning (PBL) (Chin and Chia, 2004; Lambros, 2004) and inquiry-based learning (IBL) (Pedaste *et al.*, 2015) for realizing this idea. But, in our conjecture, many teachers may have persisted in conducting traditional teacher- centered teaching instead of allotting time for inquiry activities including experiments and observations, possibly because they may have felt pressure to help students acquire enough knowledge to pass university entrance exams.

In March 2018, the latest USS-NCS, was released (MEXT, 2018), and is being enforced from April 2022. In the latest USS-NCS, MEXT requires teachers to implement active learning, namely student-centered learning (MEXT, 2015b; MEXT, 2018). University entrance examinations also are going to change in the near feature to remedy a disproportionate emphasis on knowledge (See the Supplemental Note).

In the present paper, we report the features of biology-related subjects in the latest USS-NCS and those of Basic Biology textbooks used currently.

REVISED NATIONAL CURRICULUM STANDARDS

Concepts of Curriculum Design for Latest NCSs

MEXT (2015a) stated the following for revising NCSs: "We must focus on how to face and relate to the accelerating changes in society, including the progress of globalization and ICT. There is an even stronger need for the development of the students' skills required in a complex and rapidly changing society, where the future is difficult to predict, to permeate and materialize into the curriculum of each school and in the teaching of each subject."

Figure 1 (MEXT, 2015b) shows three educational viewpoints to be incorporated into curriculum design from the perspective of "active learning". For making these key concepts manifest, a qualitative improvement of the learning process is requisite to stimulate students' inquiry and problem-solving activities. So, the latest NCS emphasizes "proactive, interactive and authentic learning" (MEXT, 2019) in addition to "thinking, judgement, presentation and discussion" which have already been emphasized in the previous NCS.

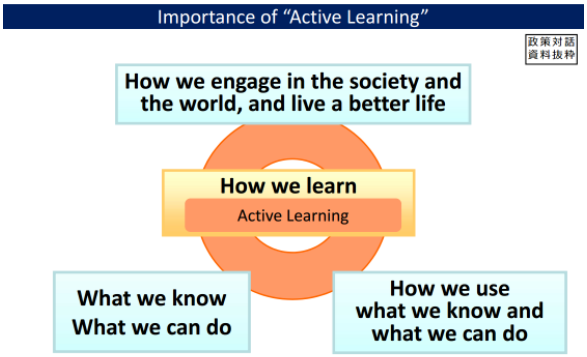

Figure 1: Importance of "Active Learning" (MEXT, 2015)

Science Subjects of Latest USS-NCS

As shown in Table 1, in the latest USS-NCS, there are nine elective subjects: four basic subjects, four advanced subjects and Science and Our Daily Life which covers topics of four science areas. Science Project Study which was set up in the previous NCS has been deleted. Advanced subjects are four-credit ones while the others are two-credit ones. Students are rec-

Table 1: Science Subjects for upper secondary school students

Subjects	Science and Our Daily Life	Basic P / C / B / E*	Advanced P / C / B / E*
Credits	2	2	4

* P: physics, C: chemistry, B: biology, E: earth science

ommended to take at least three basic subjects to acquire fundamental scientific knowledge. Alternatively, they can take Science and Our Daily Life and choose one from the basic subjects.

The same as the Lower Secondary School National Curriculum Standard, for which an English translation version (MEXT, 2022) is only available at present, the latest USS-NCS states that the aim of science subjects is "to develop students' competencies necessary to conduct scientific inquiry into natural objects and phenomena, through experiencing natural objects and phenomena, using discipline-based epistemological approaches of science, and conducting observations and experiments with a comprehensive vision " (MEXT, 2018).

A new interdisciplinary subject area, Inquiry-Based Study of Science and Mathematics, has been set up. The aim of this subject area is "to develop students' competencies necessary to find a solution to a given issue by using combined mathematical and scientific interdisciplinary approaches and conducting scientific inquiry through experiencing various objects and phenomena" (MEXT, 2018). As this subject area focuses on nurturing students' mathematical and scientific perspectives and ways of thinking, it may also help to develop internationally competent human resources in the context of changes, such as increasing global competition in scientific research, as well as, in scientific and technological industry. This subject area is composed of two subjects, (i) Basic Inquiry-Based Study of Science and Mathematics and (ii) Inquiry-Based Study of Science and Mathematics.

Aim of Biology-related Subjects in Latest USS- NCS

Following the previous one, the latest USS-NCS pursues modernization in life sciences. Furthermore, it states that biology teachers should guide students in acquiring not only biological concepts, principles and laws, but also the abilities to cope with potential changes in Japanese society when they become adults.

The aim of Basic Biology is "to develop students' competencies necessary to conduct scientific inquiry into organisms and biological phenomena" (MEXT, 2018a). To achieve this aim, biology teachers are asked "to ensure that students experience organisms and biological phenomena, using scientific epistemological approaches, and conducting observations and experiments with a comprehensive vision. Specifically, students must:

(1) Understand organisms and biological phenomena in relation to daily life and society, and acquire fundamental skills for observations, experiments, and other scientific activities necessary to conduct scientific inquiry into organisms and biological phenomena;
(2) Develop abilities to conduct scientific inquiry through conducting observations, experiments, and other scientific activities;
(3) Develop attitudes toward conducting scientific inquiry through actively experiencing organisms and biological phenomena, toward respecting for life and contributing the conservation of natural environments" (MEXT, 2018).

The aim of Advanced Biology is almost the same as that of Basic Biology except for item (1), *i.e.*, "(1) Deepen knowledge and understanding of fundamental biological concepts, principles and theories, as well as natural objects and phenomena, and acquire fundamental skills for observations, experiments, and other scientific activities necessary to conduct scientific inquiry into organisms and biological phenomena" (MEXT, 2018).

MEXT also asks biology teachers to shift their focus from the cramming in of knowledge to the development of students' higher-order thinking skills. To achieve this objective, the latest

USS-NCS requires that the number of biological key terms used in biology textbooks be reduced to around 200-250 for Basic Biology and 500 – 600 for Advanced Biology (MEXT, 2018).

Contents of Basic Biology and Advanced Biology in Latest USS-NCS

In Basic Biology, there are three units, namely, Characteristics of Organisms, Regulation of Human Body, and Diversity of Organisms and Ecosystems. Each of these units is composed of two sub-units and each sub-unit is composed of one or two topics (Table 2).

In Advanced Biology, there are five units, namely, Evolution, Life Phenomena and Substances, Gene Expression and Ontogeny, Responses to Environmental Stimuli, and Community and Its Environment. Each of these units is composed of two or three sub-units and each sub-unit is composed of one or two topics (Table 3). A prominent feature is that evolution must be taught first. Until now, evolution and phylogeny have been the last units to be taught.

Table 2: Contents of Basic Biology

Major units	Sub-units	Topics
Characteristics of Organisms	1. Characteristics of Organisms	1.1 Unity and Diversity of Organisms 1.2 Organisms and Their Energy
	2. Genes and Their Function	2.1 Genetic Information and DNA 2.2 Genetic Information and Protein Synthesis
Regulation of Human Body	1. Regulations by Nervous and Endocrine Systems	1.1 Transmission Mechanism 1.2 Maintenance Mechanism of Internal Environment
	2. Immunity	2.1 Immunity mechanism
Diversity of Organisms and Ecosystems	1. Vegetation and Succession	1.1 Vegetation and Succession
	2. Ecosystems and Their Conservation	2.1 Ecosystems and Diversity of Organisms 2.2 Balance in Ecosystems and their Conservation

Table 3: Contents of Advanced Biology

Major units	Sub-units	Topics
Evolution	1. Origin of Life and Evolution of Cells	1.1 Origin of Life and Evolution of Cells
	2. Alteration of Genes and Mechanism of Evolution	2.1 Alteration of Genes 2.2 Changes in Gene Combination
	3. Phylogeny and Evolution of Organisms	3.1 Phylogeny and Evolution of Organisms 3.2 Phylogeny and Evolution of Humans
Life Phenomena and Substances	1. Cells and Biomolecules	1.1 Biomolecules and Their functions in Cells 1.2 Roles of Proteins in Life Phenomena
	2. Metabolic Activities	2.1 Respiration 2.2 Photosynthesis
Gene Expression and Ontogeny	1. Genetic Information and Its Expression	1.1 Genetic Information and Its Expression
	2. Ontogeny and Gene Expression	2.1 Regulation of Gene Expression 2.2 Ontogeny and Gene Expression
	3. Genetic Engineering	3.1 Genetic Engineering
Responses to Environmental Stimuli	1. Responses of Animal and Its Behavior	1.1 Reception of Stimuli and Reactions 1.2 Animal Behavior
	2. Responses of Plant to Environmental Stimuli	2.1 Responses of Plants to Environmental Stimuli
Community and Its Environment	1. Population and Community	1.1 Population 1.2 Community
	2. Ecosystems	2.1 Matter Production and Cycle of Matter in an Ecosystem 2.2 Ecosystems and Human Life

FEATURES OF LATEST BASIC BIOLOGY TEXTBOOKS

We surveyed latest Basic Biology textbooks to be used from the 2022 school year to find how the contents of these textbooks have changed. Five publishers respectively publish two or three different versions of Basic Biology textbooks. We randomly chose one from each publisher's textbooks.

Exercises and Examples of Research Methods

Basic Biology textbooks include more exercises for inquiry activities that allow students to think deeply than before.

Figure 2 shows the first page of the chapter "Diversity and Unity of Organisms" in a Basic Biology textbook. In this textbook, at the beginning of each section of each chapter, there is a simple exercise named "Let's Start." The purpose of this exercise is to allow students to generate questions related to the contents of each section before they start learning. The exercise of Let's Start for this section, Diversity of Organisms, includes the question, "Approximately how many kinds of organisms are there on the earth?" (Figure 2, A) At the bottom, there is another question, "Why are there so many diverse species on the earth?" (Figure 2, B) This is designed to get students to think about what they are learning in this section.

Figure 3 shows the first two pages of the same topic in another textbook. In this textbook, there is an introductory question (Quest), "How are the body structures and lifestyles of the mammals in the figure suitable for their environment?" (Figure 3, A) This question may lead students to consider possible answers before studying the contents of the chapter. There also is an exercise that instructs students to "Give specific examples of organisms other than mammals that have forms and functions suitable for their environments." (Figure 3, B) This exercise aims

Figure 2: The first page of the chapter "Diversity and Unity of Organisms" in a Basic Biology textbook of Tokyo Shoseki Co. Ltd.
There are two exercises (questions) A and B (see text in detail).

at encouraging students to think more deeply.

Furthermore, each textbook provides many examples of research methods to empower the students to find questions and problems and to solve them on their own.

Promotion of ICT

As part of giving priority to ICT, all Basic Biology textbooks incorporate QR codes. The QR codes allow students to learn by themselves through the Internet and deepen their thinking independently. There are a variety of websites or webpages the QR codes link to, for example, a QR code in the section "Diversity and Unity of Organisms" links to a webpage on which a short movie about the environments of various mammals and their behaviors is provided. Another example is on a page with a section titled, "Genetic Information and DNA". This links to a webpage of DNA models where students can

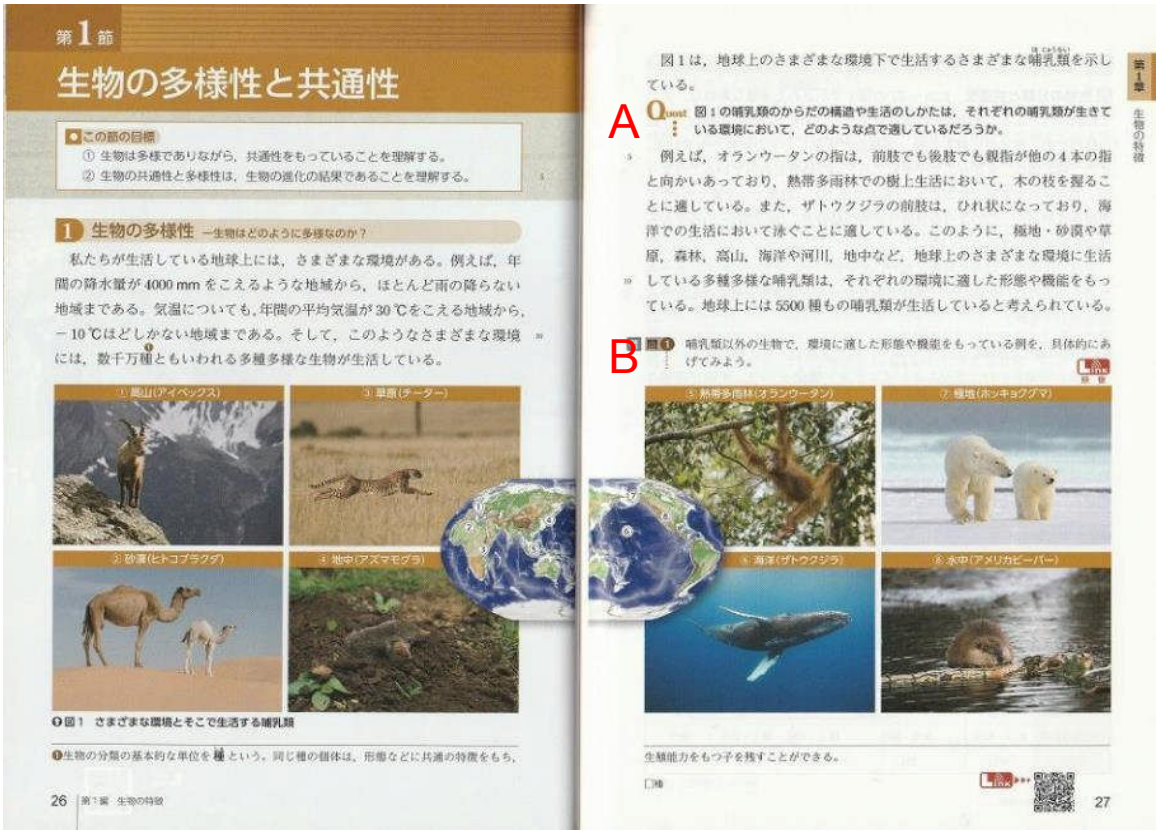

Figure 3: The first two pages of the chapter "Diversity and Unity of Organisms" in a Basic Biology textbook of Suken Shuppan Co. Ltd.

There are two exercises (questions) A and B (see text in detail).

visually comprehend the three-dimensional DNA structure by moving the DNA models on the computer display.

The number of QR codes is quite different among the textbooks surveyed. As an example, the number of QR codes in the section "Genetic Information and DNA" in each textbook, is given in Table 4. In the case of publisher J, there is only one QR code on the index page of the textbook. The QR code links to the index page of a website with seven titles. By clicking on one of these titles, the user can watch a movie with corresponding content. On the other hand, in the case of publisher K, there are 23 QR codes which link to 59 movies, 41 of which are lectures given by tutors. In the cases of publishers J and T, some QR codes link to "NHK for School," a website of video clips supplied by the Japan Broadcasting Corporation (NHK, see the website list).

Table 4: QR code-linked contents in the Chapter Genetic Information and DNA of each textbook

Publisher*	No of QR codes	No of con-tents	Approx. time (min) required for watching all contents
D	8	13	26
J	1	7	8
K	23	59	117
S	11	20	31
T	8	11	7

* D: Dai-ichi Gakushusha Co. Ltd., J: Jikkyo Shuppan Co. Ltd., K: Shinkoshuppansha Keirinkan Co. Ltd., S: Suken Shuppan Co. Ltd., T: Tokyo Shoseki Co. Ltd.

Previously, teachers showed movies to the students all at the same time in their classrooms. By using QR codes, students can access these programs by themselves and study independently. They also can use QR codes to get materials for group discussion. From now on, it will be nec-

essary for teachers to instruct students how to learn through the Internet, how to get programs other than those to which the QR codes refer, and how to use these programs and materials for their study. On the other hand, teachers should be careful that students do not become excessively dependent on the Internet, because hands-on experience and interactive learning are also encouraged (MEXT, 2012; MEXT, 2018).

Biological Key Terms

The number of biological key terms in previous Basic Biology textbooks averaged about 450 each (Nakamichi, 2017). The latest USS-NCS requires a reduction of the number of biological key terms used in Basic Biology textbooks to be around 200-250 (MEXT, 2018). Table 5 shows the number of key terms in each textbook which is almost within the range indicated by the USS-NCS.

Table 5: Number of biological key terms in Basic Biology textbooks

	Publisher*				
	D	J	K	S	T
No. of key terms	222	190	249	253	218

* D: Dai-ichi Gakushusha Co. Ltd., J: Jikkyo Shuppan Co. Ltd., K: Shinkoshuppansha Keirinkan Co. Ltd., S: Suken Shuppan Co. Ltd., T: Tokyo Shoseki Co. Ltd.

These key terms in each textbook are shown in different ways (Table 6). In the text, if key terms are shown in boldface, students may easily notice them. In addition, some textbooks arrange the key terms in orders of higher, middle and lower concepts. This is more effective than just listing the terms in Japanese alphabetical order in the glossary at the end of the book.

Table 6: How biological key terms are shown in Basic Biology textbooks

Publisher*	Manner of key term display
D	Key terms are shown in boldface in the text.
J	Key terms are shown in a yellow-colored box on every page where they appear in the text. At the same time, key terms are compiled in the glossary together with the other terms and arranged in Japanese alphabetical order. Key terms are indicated in red.
K	Key terms are shown in a yellow-colored box on every page where they appear in the text.
S	Key terms are compiled in the glossary and arranged in the order (higher, middle, and lower) of concepts.
T	Key terms are compiled in the glossary and arranged in Japanese alphabetical order.

* D: Dai-ichi Gakushusha Co. Ltd., J: Jikkyo Shuppan Co. Ltd., K: Shinkoshuppansha Keirinkan Co. Ltd., S: Suken Shuppan Co. Ltd., T: Tokyo Shoseki Co. Ltd.

SUPPLEMENTAL NOTE
REFORM OF UNIVERSITY ENTRANCE EXAMINATION SYSTEM

As mentioned above, biology education at the upper secondary level has been considerably affected by university entrance examinations. Therefore, to realize the concepts of the latest USS-NCS, the university entrance examination system should also be reformed.

From 1979 to 1989, the Joint First-Stage Achievement Test was conducted by the National Center for University Entrance Examinations (NCUEE) every January for admissions to national and local public universities. Then, it was replaced by the National Center Test, which was

also conducted by NCUEE from 1990 to 2020 for admissions to national, local public and private universities (NCUEE, 2022). The number of private universities which use this test instead of their own entrance examination has been increasing year by year. Recently, based on a report of the Central Council for Education, 2014, the implementation guidelines and the contents of the National Center Test were revised (MEXT, 2021) and the new test framework, *i.e.*, the Common Test for University Admissions (CTUA), has been implemented from January 2021 (NCUEE, 2022). More than earlier versions, the CTUA requires critical thinking skills. Conversely, questions that simply examine candidates' knowledge have been decreased. In addition to this, the admission scheme of universities has become more diverse. Through the integration of CTUA and respective university examinations, the individuality and diversification of the admissions systems by universities have been promoted. Some examples of university admission schemes are shown in NCUEE's document (NCUEE, 2022).

Thus, a variety of entrance examination methods are being introduced. A remarkable feature of current university admissions is a shift from simple knowledge-based examinations to examinations or screening that can evaluate students' diverse abilities. As a result, there may be a substantial difference in the achievement among enrolled students. To keep students from experiencing difficulties due to gaps between their studies in secondary schools and in universities, collaboration between upper secondary schools and universities continues to progress. (Kawai, 2018; MEXT, 2021).

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