

## Research Article

### The Possibility of Historical Approach in Cells Teaching for Explicit Nature of Science

Pornpaka Chamnanwong and Chokchai Yuenyong

Department of Science Education, Faculty of Education, Khon Kaen University, Thailand

**Abstract:** This study aimed to discuss the possibility of historical approach in cells teaching for explicit nature of science. The propose of this study was to review literature about the advantages of teaching Nature of Science (NOS) and how to teach NOS through biology history. In Thailand, science curriculum aims to help learners attain an adequate understanding of the Nature of Science (NOS). In general, the NOS involve the process through which scientific knowledge is generated and the characters of science derived from an analysis of eight international science standard documents (IPST (Institute of Promotion of Science and Technology Teaching), 1999). The study will discuss how the history about cells could apply to cells teaching for Thai science curriculum. And, the way of explicit NOS in cells historical teaching approach also will be clarified for enhancing students' understanding of NOS. This study has implications for explicit nature of science in biology teaching.

**Keywords:** Cells, historical approach, nature of science

#### INTRODUCTION

Student understandings of the Nature of Science (NOS) have been a central goal of science education programs in many countries (Lederman, 1992; McComas and Olson, 1998). The nature of science is an important element of scientific literacy that students should be encouraged to develop through their schooling. An understanding of NOS can function as a powerful means of developing various aspects of science students' education and can help students to better understand scientific content, as well as maintain a positive attitude towards science and scientific attitudes (McComas *et al.*, 1998). To help students reach an understanding of NOS, educators have an important role in providing them with learning opportunities. Unfortunately, many studies consistently show that science teachers possess inadequate conceptions of NOS (Haidar, 1999; Lederman, 1992). Further, science teachers seem to believe that science is an application of technology (Yalvac *et al.*, 2007), scientific knowledge is objective and absolute (Akerson and Donnelly, 2008), scientific methods are the only way to gain knowledge (Abd-El-Khalick and BouJaoude, 1997; Lederman, 1992), science is a step-by-step process, scientific theories are laws that govern the behavior of scientific phenomena (Haidar, 1999; Lederman, 1992) and finally that science, technology and society are independent (Yalvac *et al.*, 2007). Finally, science teachers seldom integrate aspects of NOS or make it explicit to students in science learning activities (Mellado *et al.*, 2007). Thai science teachers

also lack of understanding nature of science (Faikhamta, 2013). The Nature of Science (NOS) seems to be new concept for Thai science teachers, particularly primary science teachers. An enhanced appreciation of the nature of science, therefore, inherently involves an understanding of the role and the nature of models. Teaching science is a 'matter of conveying mental models of science' (Bliss, 1995). Mental models refer to students' personal knowledge while conceptual models refer to scientifically accepted knowledge.

The target of this study was to review literature about the advantages of teaching Nature of Science (NOS) and how to teach NOS through biology history. Science teachers in Thailand are currently undergoing a period of reform in which they are expected to understand NOS and be able to present their understandings to students in an accessible way (IPST (The Institute of Promotion of Science and Technology Teaching), 2002). As a teacher educator, the author intended to develop science teachers' understandings of NOS and therefore develop his own strategies for teaching it.

**The nature of science:** The term "Nature of Science" (NOS) has been defined by several science educators. Like scientific knowledge, conceptions of the nature of science are tentative and dynamic (Lederman *et al.*, 2002). They have changed throughout the development of science and as a result of systematic thinking by various researchers about its nature and functioning. McComas *et al.* (1998) argue that NOS is the

**Corresponding Author:** Chokchai Yuenyong, Department of Science Education, Faculty of Education, Khon Kaen University, Thailand

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combination of various social studies of science including the history, sociology and philosophy of science and also research from the cognitive sciences that provides a rich description of what science is, how it works, how scientists operate as a social group and how society itself both directs and reacts to scientific endeavors. Lederman (1992) argues that NOS refers to the epistemology and sociology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development. There is a consensus with respect to certain specific aspects chosen for study in research reports on teachers' views on NOS. These aspects are: definition of science (Yalvac *et al.*, 2007); characteristics of scientific knowledge (Haidar, 1999; Lederman, 1992); characteristics of scientists (Haidar, 1999; Lin and Chen, 2002); and interaction of science, technology and society (Yalvac *et al.*, 2007). Succinctly, the AAAS (American Association for the Advancement of Science) (1993) suggests, the nature of science can be divided into three main aspects: scientific world view, scientific inquiry and scientific enterprise. In the first aspect, the world is viewed as an understandable entity within which science attempts to describe, explain and predict natural phenomena. Science cannot provide answers to all questions, since scientific knowledge, while durable, has a tentative character and scientific knowledge relies heavily, but not entirely, on observation.

In the second aspect, science demands evidence and is a blend of logic and imagination. Also experimental evidence requires rational arguments and skepticism. Scientists are creative and scientists require accurate record keeping, peer review and explicability. Finally, in the third aspect, science is viewed as a series of complex social activities, science and technology impact each other and scientific ideas are affected by their social and historical context. The dilemma is that before an understanding of the nature of science can be fostered in students, the science teachers need to have a fairly sophisticated understanding of it. The nature of science because it is both a problematic and contentious concept is difficult to define (Duschl, 1990). However, science educators agree that there is a measure of agreement on a number of points relevant to the school science curriculum (Hodson, 1993). Lederman (1992) has listed the concepts of the nature of science that are important for school science. Therefore, this study regarded the following 8 aspects of the nature of science:

- Scientific knowledge is simultaneously reliable and tentative.
- Scientific knowledge relies heavily, but not entirely, on observation, experimental evidence, rational arguments and skepticism.
- Laws and theories serve different roles in science.
- There is no universal step-by-step scientific method.

- Observations are theory-laden.
- Scientists are creative.
- Science and technology impact on each other.
- Scientific ideas are affected by their social and historical milieu.

#### **Thai science curriculum about the Nature of Science**

**(NOS):** The National Education Act, 1999 aims to develop Thai people to be perfect human beings, physically and mentally, intellectually and morally, with ethic and culture in daily life as well as happiness. As regarded as the most important lessons, education should encourage the students to develop their full natural potential. In addition, the National Education Act, 1999 stipulated the way of education that education shall be based on a principle that every student has the ability to learn and develop themselves and the student centered principle. The education should encourage students to develop themselves in accordance with their full natural potential (Office of The National Education Commission, 1999). Likewise, the Institute for the Promotion of Teaching Science and Technology; IPST (1995) introduced the modern concept of science teaching; science teaching emphasized on the process that importantly students shall learn by themselves and teachers will only serve as for students to learn by their own rather than a person telling the students to remember any content.

Thai science curriculum aims to help learners attain an adequate understanding of the Nature of Science (NOS). In general, the NOS involve the process through which scientific knowledge is generated and the characters of science derived from an analysis of eight international science standard documents.

Science is not only content, but also scientific process. However, most teachers and students do not have sufficient understanding of NOS. Researchers have demonstrated that understanding the NOS will enhance the students' understanding of science and students' understanding the many effects of scientific knowledge on human life.

#### **The importance of teaching the nature of science in**

**classroom:** The NOS was included in the goals of Thai science curriculum for decades. Even though NOS has provided in the Thailand science curriculum since 2008, there is not widely teaching NOS in Thai science classroom. If students understand the nature of science, students will also be enhanced science learning and scientific attitude. There are many research in Thailand reported that Thai science teachers lack of understanding of the concept of NOS (Buaraphan, 2009; Chaisri and Thathong, 2014; Yuenyong and Sumranwanich, 2012).

Students also have an understanding of the nature of science at a level that is not satisfactory. It seemed that some of Thai science teachers understand the

concept of NOS but they could not organize NOS science teaching, particularly primary school science teachers. In fact, explicit and reflective NOS in science teaching are not only understood the concept of NOS but also concept of scientific concepts. Primary school science teachers also not well understanding scientific concepts. The study tries to give example of how to organize explicit NOS in science teaching in particular concept.

Cells are interesting concepts for the students in primary school because they can investigate scientific concepts from their surrounding context. The cell theory holds true for all living things, no matter how big or small. Since according to research, cells are common to all living things, they can provide information about all life. Likewise, all cells come from other cells, scientists can study cells to learn about growth, reproduction and all other functions that living things perform. By learning about cells and how they function, you can learn about all types of living things. Cells are the building blocks of life. The cell theory, or cell doctrine, states that all organisms are composed of similar units of organization, called cells. The concept was formally articulated in 1839 by Schleiden and Schwann and has remained as the foundation of modern biology. The idea predates other great paradigms of biology including Darwin's theory of evolution (1859), Mendel's laws of inheritance (1865) and the establishment of comparative biochemistry (1940). Above information suggests that students should be enhanced to learn about cells related to the historical view about cells because students could understand scientific concepts and nature of science. The study, then, discuss the possibility of historical approach in cells teaching for explicit nature of science.

**History of cells and teaching nature of science through history of the cells:** The cell was first seen by Robert Hooke in 1665. He examined (under a coarse, compound microscope) very thin slices of cork and saw a multitude of tiny pores that he remarked looked like the walled compartments a monk would live in. Because of this association, Hooke called them cells, the name they still bear. However, Hooke did not know their real structure or function. Hooke's description of these cells (which were actually non-living cell walls) was published in *Micro graphia*. His cell observations gave no indication of the nucleus, and other organelles found in most living cells (Wikipedia, 2012).

The first person to make a compound microscope was Zacharias Jansen, while the first to witness a live cell under a microscope was Anton van Leeuwenhoek who in 1674 described the algae *Spirogyra* and named the moving organisms animalcules, meaning "little animals". Leeuwenhoek probably also saw bacteria. Cell theory was in contrast to the vitalism theories

proposed before the discovery of cells (Wikipedia, 2012).

The idea that cells were separable into individual units was proposed by Ludolph Christian Treviranus in 1811 and Johann Jacob Paul Moldenhawer in 1812. All of this finally led to Henri Dutrochet formulating one of the fundamental tenets of modern cell theory by declaring that "The cell is the fundamental element of organization"(Wikipedia, 2012).

**Teaching nature of science through history of the cells:** Cells in teaching elementary science content in Thailand. In grade 5 primary school, student learning about cells include cells, cell membrane, nucleus, cytoplasm (IPST, 2002). The study of the nature of science and an indication that reflected the nature of science can be integrated with teaching and learning in elementary education through the history of several cells. We, therefore, raised some aspects of NOS in historical approach of cells teaching including empirical based, tentativeness, laws and theories, no universal step-by-step scientific method, theory-laden, creativity and science and technology impact on each other.

The cell is the basic structural and functional unit of all known living organisms. It is the smallest unit of life that is classified as a living thing (except virus, which consists only from DNA/RNA covered by protein and lipids) and is often called the building block of life. From historical of cells, the cell theory, or cell doctrine, states that all organisms are composed of similar units of organization, called cells (Wikipedia, 2012). The concept was formally articulated in 1839 by Schleiden and Schwann and has remained as the foundation of modern biology. The idea predates other great paradigms of biology including Darwin's theory of evolution (1859), Mendel's laws of inheritance (1865) and the establishment of comparative biochemistry (1940). Regarding to history of investigation for cells, teacher may bring its history to enhance students' concept of NOS such as tentative of scientific knowledge, no universal step-by-step scientific method, observations as theory-laden and creativity.

Tentative of scientific knowledge could be introduced through formulation of the cell theory. For example, the cell was first discovered and named by Robert Hooke in 1665. He remarked that it looked strangely similar to cellula or small rooms which monks inhabited, thus deriving the name. However what Hooke actually saw was the dead cell walls of plant cells (cork) as it appeared under the microscope. Formulation of the cell theory showed sense of tentative of scientific knowledge. In 1838, Theodor Schwann and Matthias Schleiden summarized his observations into three conclusions about cells including:

- The cell is the unit of structure, physiology and organization in living things.
- The cell retains a dual existence as a distinct entity and a building block in the construction of organisms.
- Cells form by free-cell formation, similar to the formation of crystals (spontaneous generation).

We know today that the first two tenets are correct, but the third is clearly wrong. The correct interpretation of cell formation by division was finally promoted by others and formally enunciated in Rudolph Virchow's powerful dictum, *Omnis cellula e cellula*,: "All cells only arise from pre-existing cells". As with the rapid growth of molecular biology in the mid-20<sup>th</sup> century, modern cell theory was summarized as six aspects including:

- All known living things are made up of cells.
- The cell is structural and functional unit of all living things.
- All cells come from pre-existing cells by division (Spontaneous Generation does not occur).
- Cells contain hereditary information which is passed from cell to cell during cell division.
- All cells are basically the same in chemical composition.
- All energy flow (metabolism and biochemistry) of life occurs within cells (Rhoads, 2007).

Teachers can teach students to understand NOS that deals with scientific knowledge is tentative by the students study the work of scientists who are trying to deepen the study of cells. Of the test many times until his discovery that cells have some characteristics in common and each species a different cells.

In 1626 Redi postulated that living things do not arise from spontaneous generation. In 1655 Hooke described 'cells' in cork. In 1674 Leeuwenhoek discovered protozoa. He saw bacteria some 9 years later. In 1833 Brown described the cell nucleus in cells of the orchid. In 1838 Schleiden and Schwann proposed cell theory. In 1840 Albrecht von Roelliker realized that sperm cells and egg cells are also cells. In 1856 N. Pringsheim observed how a sperm cell penetrated an egg cell. In 1858 Rudolf Virchow (physician, pathologist and anthropologist) expounds his famous conclusion: *omnis cellula e cellula* that is cells develop only from existing cells (cells come from preexisting cells). In 1857 Kolliker described mitochondria and in 1869 Miescher isolated DNA for the first time (Rhoads, 2007). The history of cells has been suggested that many scientists have researched on the theory of multiple cells before a summary. Knowledge production in science shares many common factors and shared habits of mind, norms, logical thinking and

methods (such as careful data recording, truthfulness in reporting, care in observation, etc.) However, no universal step-by-step scientific method by which all science is done. Experiments are not the only route to knowledge. Science uses both inductive reasoning and hypothetico-deductive testing. Scientific conclusions are peer reviewed but observations and experiments are not generally repeated. The teacher let the students compare the methods of different scientists in the history of cell (McComas, 2004).

In 1838, Theodor Schwann and Matthias Schleiden were enjoying after-dinner coffee and talking about their studies on cells. It has been suggested that when Schwann heard Schleiden describe plant cells with nuclei, he was struck by the similarity of these plant cells to cells he had observed in animal tissues. The two scientists went immediately to Schwann's lab to look at his slides. Schwann published his book on animal and plant cells (Schwann, 1839) the next year, a treatise devoid of acknowledgments of anyone else's contribution, including that of Schleiden in 1838. He summarized his observations about cells. In 1880 Walther Flemming study found that the cell nucleus contains chromosomes. Subsequently, many scientists have conducted studies about cells and cell components by used microscope lens and have developed steadily until in 1932 two German scientists were E. Ruska and Max Knoll changed processes of microscope from light and the lens that used electrons instead (Harris, 1999). They could see components of the cell were more granular. Which human eyes cannot observe most of the cells? How can scientists study about cells? Scientist Invention of the microscope from the experiments several times. The history of cells that show scientists are creative. The teachers can teach explicit and reflective about NOS that explain scientist invention of the microscope from the experiments several times.

## CONCLUSION

Nature of Science (NOS) has become a central goal of science education in many countries including Thailand since students' understanding about the nature of science and scientific knowledge can be applied in everyday life. Science teachers should be provided opportunities to develop not only an understanding of NOS but also an understanding of how to teach NOS. This study presents guidelines for teachers to study and understand the nature of science, particularly to teach cells in the grade 5 primary school through the use of history of science. It is important to note that the historical teaching approach should be used in conjunction with the explicit-reflective approach for the best effectiveness.

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