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# COGNITIVE SYSTEM PROFILE OF PROSPECTIVE TEACHERS IN CELL BIOLOGY LEARNING

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**Abstract**

This study aims to describe the profile of the cognitive system of prospective teachers in cell biology learning. The method in this study is a descriptive method with a quantitative approach. The subjects are 32 fourth-semester students who have taken cell biology courses at one of the Private Educational Institutions and Education Personnel in the City of Bandung. The instrument used is a knowledge test instrument in terms of the cognitive system developed based on New Taxonomy Marzano at level 1. retrieval, level 2. Comprehension, Level 3. Analysis: Level 4. Knowledge utilization of cell division, metabolism, and protein synthesis materials. The results showed that the profile of the student's cognitive system in cell biology learning level 1retrieval and level 2 comprehension showed a percentage (45.14% - 42.45%) in the sufficient category. This indicates that students can retrieve stored information from their cognitive system and can integrate it into conceptual understanding. While level 3 analysis and level 4 knowledge utilization shows the percentage (39.53% - 31.53%) in the lower category, this shows students have not been able to develop analytical skills and utilize their knowledge to obtain solutions. Overall the cognitive system through information procedures in cell biology learning needs to be improved in the good and very good categories.

Keywords: Biology Teacher Prospective Student, Cell Biology, Cognitive System.

## 1. Introduction

Biology is one of the difficult subjects, needing some strategies in teaching process[1-4]. Common issues faced by students when studying biology include misconceptions, biases, and abstract concepts that are difficult to understand [5], such as processes of cell division, mitosis, meiosis, genetic material, haploid/diploid concepts, and the number of chromosomes is considered complex, difficult to learn, and a challenge for students from elementary to higher education levels [5, 6]. In fact, understanding this subject has a direct correlation for further applications [7-13].

Research conducted on meiosis is one of the central concepts in studying biology and genetics. However, this concept is often presented in textbooks as a rote list without a deep understanding [6]. Some of the difficulties in understanding the concept of meiosis lie in the underlying concepts, namely, DNA, genes and chromosomes, the structures involved in meiosis, differences in chromosomes and chromatids, the stages of meiosis that occur, meiotic/mitotic division patterns, and the process of chromosomal separation and duplication [14,15]. Thus, if students study this content in depth, there is a high probability that these phases of the process will become poorly understood [14]. However, some misconceptions are usually persisted in the difficult subject [16-21]. Specifically, in the material on cell division, there are issues with the inability of students to distinguish between replication, synapsis, and disjunction, determining whether this process occurs in mitosis, meiosis, or both [15]. Further misconceptions exist in the basic terms of a chromatid, chromosome, or chromosomal replication [15]. This material is the teacher's attention because the process of cell division is very important to understanding growth, development, reproduction, and genetics [15, 22]. Some of the problems in the concept of protein synthesis include difficulties in studying the mRNA process, interpreting the symbolism of the DNA and RNA concepts, interpreting and representing the orientation signals of DNA molecules 5'---3', translating the DNA replication process, and transcription/translation [23]. Based on the research findings related to cell biology concepts that are difficult for students to understand, they are protein synthesis, cell division, cell metabolism, cell junction, and communication between cells.

Research investigating the application of Ausubel cognitive assimilation theory (A'sCAT) in medical biochemistry and molecular biology (MBMB) learning to help students overcome difficulties in conceptual understanding shows that A'sCAT encourages students to use cognitive skills in learning and understanding MBMB, able to overcome learning barriers, and able to guide students to participate in active learning by building a “scaffolding” for student-centered learning [24]. Research with the topic Misconceptions in biology: a meta-synthesis study of research, 2000-2014 identified methods used by several researchers to overcome misconceptions including Analogy and modeling, Computer and laboratory, Concept cartoon, Concept mapping, Conceptual change text, Cooperative learning, Dual situated learning, Mind map and POE (Prediction-Observation-Explanation). From a total of 67 articles identified, general topic articles and cell biology were the most studied [25].

This study described the profile of the student's cognitive system on material that is considered complex, complicated, abstract, and difficult to understand in cell biology learning, especially the material on cell division, protein synthesis, and

metabolism. Although this concept has been studied by many researchers before, it has not been able to provide a significant solution, which can change students' perceptions of the 3 concepts that are considered difficult.

## 2.Literature Review

Cell biology is very important to study [8,9]. It provides the basic concepts needed for a full understanding of other fields, such as embryology, developmental biology, and histology, as well as for various applications of cell and molecular biology to medicine, biotechnology, and agriculture [26]. Figure 1 shows the structure, function, and molecular composition of a complex cell. Cells as the basic unit of life have physiological activities in them starting at the microscopic, sub-microscopic, and molecular levels. Most concepts of cell biology provide explanations of aspects of science that cannot be directly observed as "unobservable". Cell biology itself can be defined as the study of the structure, function, and molecular composition of cells [27]. Studying cell biology presents three main challenges [27]:

(i) an abundant and increasing amount of information,
(ii) frequent changes in related models and theories,
(iii) the need for deep practice to understand the content and acquire skills.

A major challenge in cell biology is understanding the activity and function of cellular organelles and compartments and their role in cell metabolism and physiology, the molecular mechanisms that control important aspects of cell physiology, and the complexity of how molecular regulatory networks can respond under normal and stressful conditions. A new paradigm condition linking molecular biology with cell physiology and fundamental cell biological processes, such as growth, signaling, differentiation, and cell death. Very complex, depending on a large number of molecules and different molecular interactions [28, 29].

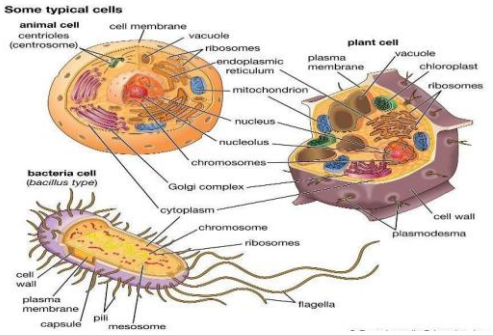


**Fig.1. Some typical cells (https://www.britannica.com/science/cell-biology on 25 Aug 2022)**

## 3.Method

This study used a quantitative descriptive approach to describe the profile of the cognitive system of prospective teachers in cell biology learning. This research was carried out by the Biology Education Study Program at a Private University in Bandung, Indonesia. The sample of this research was taken by simple random sampling where the student represents a population of 32 students who have taken cell biology courses. This study used a cognitive ability test instrument to determine the achievement of student knowledge after studying cell biology, especially the

material on cell division, cell metabolism, and protein synthesis. The number of questions in this study was 46 questions consisting of 20 multiple-choice questions and 26 essay questions. The test was given in 2 sessions with a time of 4 x 60 minutes. The research procedure was carried out by giving tests to all students in the 2019-2020 class. The data analysis technique was carried out by examining the test results, giving scores, compiling and organizing data into categories, and describing the results so that conclusions were obtained.

## 4. Results and Discussion

Research has been conducted to obtain information about the profile of students' cognitive systems in cell biology learning (see Table 1). Table 1 shows the profile of students' cognitive systems in cell biology learning at level 1. Retrieval shows a percentage of 45.14% in the sufficient category. This indicates that students' cognitive systems in recognizing, remembering, and executing information procedures show precise, clear but inaccurate. The profile of the student's cognitive system as a whole in cell biology learning is quite capable of retrieving information from previously obtained learning. However, the process of retrieval of information on the student's cognitive system still needs to be improved again to the good and very good categories.

**Table 1. Profile of students' cognitive systems in cell biology learning.**

| Cognitive system | Cell Biology Material | | | Total % | Category |
|---|---|---|---|---|---|
| | Cell division | Cell metabolism | Protein synthesis | | |
| Level 1. Retrieval | 43.17% | 48.39% | 43.85% | 45.14 % | sufficient |
| Level 2. *Comprehension* | 32.03 % | 43.36 % | 51.95 % | 42.45 % | sufficient |
| Level 3. *Analysis* | 37.66 % | 39.06 % | 41.88 % | 39.53 % | Low |
| Level 4. *Knowledge Utilization* | 35.74 % | 28.91 % | 29.95% | 31.53 % | Low |

At the sub-level, recognizing through images of the microscopic structure of the nucleus and sorting the largest to smallest structures in the chromosomal structure, the image observation error is quite significant. This is indicated by 32 students who answered correctly only 4 people. Two of the most common student misconceptions about meiotic cell division are related to the structure of chromosomes [29].

Cell biology is basic knowledge for students in taking further learning in the Biology Education Study Program. Although learning about cells started at the elementary school level, students still have difficulty understanding the basics of cell physiology. In the concept of cell reproduction, several misconceptions were found, including the differences between mitosis and meiosis (90%), the division process (76%), and the underlying concept (75%). The profile of the student's cognitive system in cell biology learning level 2 Comprehension shows a percentage of 42.45% in the sufficient category. This indicates that the student's cognitive system in integrating and symbolizing knowledge through information procedures shows precise, clear but inaccurate. The overall ability of students is

quite able to take information from the learning that has been obtained into conceptual understanding. However, level 2 comprehension needs to be improved again in the good and very good categories. The percentage results at level 2 comprehension that were netted through the cell division information procedure showed the lowest percentage of understanding (32.03%), the concept of metabolism (43.36%), and the concept of protein synthesis (51.95%). The data is supported by the results of a field study conducted on students related to the most difficult material to understand sequentially on the concepts of protein synthesis, cell division, and metabolism. The results of previous research on biology students related to the most difficult topics in high school including cell division, Genetics, Metabolism, and Cells. Cell division is the basis for genetics, reproduction, growth, and development. The majority of students or teachers evaluate topics such as chromosomes, genes, DNA, and cell division as difficult topics to learn [15].

The profile of the student's cognitive system in cell biology learning level 3 analysis shows a percentage of 39.53% in the low category. This indicates that the student's cognitive system is in matching, classifying, analyzing errors, generalizing, and determining through procedures that the overall information is not correct, unclear, and not accurate. The low ability to analyze information procedures is identified in the ability to make connections and interconnections from previously obtained information into high-level understanding. In several cases that were given to students who were identified as low, they were: (i) The process of meiosis was associated with the occurrence of genetic diversity, (ii) the process of fermentation that occurred in muscle cells, (iii) the process of transcription and translation, (iv) analyzing the process errors in the offspring of mules resulting from mating between horses with donkeys, and (v) One of the contextual cases presented to analyze the error that occurs when cyanide poison blocks the electron transport chain. Based on this, the ability to analyze through information procedures on the student's cognitive system still needs to be improved again to the sufficient, good, and very good categories. Based on level 3 analysis, the low category was identified in the concept of cell division at 37.66%, the concept of metabolism at 39.06%, and the concept of protein synthesis at 41.88%. Based on the results of the analysis of the three materials, the student's ability to identify important parts of the problems given in the context and content is less able to capture meaning. Thus, the explanations and arguments given are not comprehensive. In line with the analysis of images and interviews, it shows that student-teacher candidates have a series of problems and misconceptions about cell division material, especially those related to meiosis, mitosis, and the stages of cell division. Some misconceptions include DNA replication occurs in prophase during cell division, interphase is the resting phase of mitosis, the number of chromosomes doubles in prophase of mitosis and is halved in anaphase of mitosis, the number of chromosomes remains the same during meiosis-I and is halved during meiosis-II, and chromosomes are always two chromatids during cell division [15].

The student's cognitive system is at level 4. Knowledge Utilization shows a percentage of 31.53% in the low category. This indicates that the student's cognitive system in making decisions, solving problems, and conducting experiments and investigations through information procedures shows inappropriate, unclear, and inaccurate. The low cognitive system at level 4 Knowledge Utilization was identified in the ability to develop analysis and relate it to the use of previously owned knowledge. In some of the cases presented, it can be seen that the ability to analyze experimental results is less sharp and accurate so the solutions provided

are less meaningful. Another case of the low ability of students to interpret the results and draw conclusions was identified in the questions that presented the G2 phase experiment which was then induced (miosis I phase) with progesterone treatment. On average, the students answered that they forgot and did not know. Based on the investigative ability to make hypotheses and assumptions related to the dangers of cigarette smoke causing cancer, where carcinogenic substances have entered the bloodstream and some substances irreversibly bind to DNA, it can be seen that students' investigative and analytical abilities are low. Based on this, the ability to use knowledge through information procedures on students' cognitive systems still needs to be improved again to the sufficient, good, and very good categories. Based on the level 4 cognitive system, knowledge utilization was identified as low on the concept of cell division with a percentage of 35.74%, the concept of metabolism with a percentage of 28.91%, and the concept of protein synthesis with a percentage of 31.53%. The results of the analysis indicate that students have difficulties connecting concepts with new knowledge even though informationally the new knowledge is in the form of previously known information procedures. That is why the additional strategies in teaching are important, especially when delivering difficult subjects [30-36]. Based on the results of the analysis, the profile of students' cognitive systems in cell biology learning as a whole needs to be improved, especially in mastering and deepening content. The development of the times and technology requires students to be more literate about global problems. Thus, they can develop their thinking skills towards higher-order thinking skills [37-41]. The development of cell and molecular biology requires students to continue to improve their cognitive abilities. This is because development is very rapid along with the times.

## 5. Conclusion

This study demonstrated the ability of students in analyzing concepts that have not been able to match, classify, analyze errors, generalize and determine the relationship between concepts correlated with the ability to make decisions, solve problems, and conduct testing with experiments and investigations. Thus, this ability still needs to be improved in the good and very good categories. Various efforts are needed to improve students' thinking skills through deepening cell biology content and learning that lead students to thinking skills, both high-level thinking and critical and creative thinking in welcoming 21st-century learning.

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