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Exploring Common Misconceptions on the Cell Concept

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Abstract: The concept of cells is the basis of understanding in biology because this concept forms an understanding of various biological processes and structures. However, there are still many students who have difficulty in understanding it. This study aims to identify and analyze the misconceptions that often occur in the concept of cells, the causes of misconceptions and methods to uncover misconceptions. In this study, we systematically reviewed of ten scopus indexed articles and eight nationally indexed articles. The literature review was conducted by searching, screening, analyzing, and synthesizing the articles. The results of the literature review showed that some common misconceptions in cell concepts include misconception about cell structure, cell organelle function, membrane transport, and cell division. Misconceptions that occur are also caused by two factors, namely factors from students and from outside students. Factors from students are their prior knowledge and confidence level. External factors include books, peers, and teachers. There are several methods that can be used to uncover misconceptions such as open-ended questions, multiple choice, diagnostic test, interview, and drawing test. The results of identifying misconceptions can be used as a reference or consideration for teachers and students so that they are more careful when learning cell concepts. This research can also be used as material for improvement from the teacher factor, because misconceptions are retention, it is necessary to improve learning strategies that pay attention to these misconceptions that can improve students' understanding of cell concepts and improve student learning outcomes.

Keywords: Misconception, Cell structure-function, Diagnostic test

Introduction

The concept of cells is fundamental in biology (Fernández & Tejada, 2018), forming the basis of understanding for various biological processes and structures (Beck et al., 2024). However, despite its significance, students often harbor misconceptions regarding this foundational concept (Suwono et al., 2020; Rahma et al., 2022). These misconceptions may arise due to several factors, including inadequate teaching methods (Suparno, 2013), cognitive biases (Suparno, 2013; Marshall & Gilmour, 1990) and the complexity of cellular structures and functions (Halim et al., 2018; Suwono et al., 2020).

The cell as a structural and functional unit is still considered a metaphysical concept, not concrete, invisible, and related to microscopic observations (Clement, 2007). In addition, there are misconceptions about the role and function of the organelles that make up cells (Suwono et al., 2019; Rahma et al., 2020; Afifah & Asri, 2020). As a result, students may struggle to understand the complexity and diversity of cell organization and function,

hindering their ability to understand more advanced biological concepts. This is because misconceptions can hinder the process of accepting and integrating new knowledge in students' thinking. Concepts in biology are interlinked and serve as fundamental elements for comprehending other ideas. Failure to address misconceptions about a specific concept promptly can lead to the emergence of misconceptions in other areas of study (Tekkaya, 2002).

Misconceptions experienced by students can arise from their own experiences (Chabbra & Bavaja, 2012), ability to analyze and associate several concepts (Mentari et al., 2014), associative thinking (Marshall & Gilmour, 1990), prior knowledge, and activeness in learning (Sopiany & Rahayu, 2019). Factors from outside students such as teachers, the learning process, and teaching materials used can also lead to misconceptions (Suparno, 2013).

Efforts are needed to reduce or prevent the emergence of misconceptions in future learning, namely by detecting misconceptions. There are several methods for detecting misconceptions, such as interviews, open-ended tests, ordinary multiple choice tests, and graded multiple choice tests (two, three and four) (Gurel et al., 2015). Interview diagnostic tests and open tests have shortcomings, namely difficulties in data analysis. Ordinary multiple choice tests and two-tier with multiple choice tests cannot differentiate not understanding the concept from misconceptions so that all answer errors are considered misconceptions (Pesman & Eryilmaz, 2010). The three-tier test still struggles to completely distinguish between the confidence level in selecting the primary answer (first tier) and the confidence level in providing reasons (second tier) (Gurel et al., 2015). So Caleon and Subramanian (2010) developed diagnostic tests from three tier to four tier.

The four-tier diagnostic test is a tool designed to identify misconceptions, particularly suitable for implementation with a large student population. This test comprises multiple tiers, with the first tier consisting of a standard multiple-choice assessment. The second tier evaluates the confidence level associated with the responses from the first tier. In the third tier, students provide reasons for their answers from the first tier. Finally, the fourth tier assesses the confidence level regarding the responses provided in the third tier (Gurel et al., 2017). The selection of the four-tier diagnostic test was based on its ability to distinguish between the confidence levels in answers and the confidence levels in the reasons behind students' choices. This enables a more thorough exploration of the misconceptions experienced by students (Rusilowati, 2015). Based on the background above, it is imperative to conduct research aimed at analyzing students' misconceptions regarding cellular material.

Method

The type of research in this article is literature research through literature review (Cooper et al., 2018; Paré, & Kitsiou, 2016), that reveals students' misconceptions on the concept of cells through multi-tier diagnostic tests in the cell concepts and also articles on other misconceptions. The literature review was conducted by searching, screening, analyzing, and synthesizing the articles. We systematically reviewed ten scopus-indexed articles and eight nationally indexed articles. The results of the literature review showed that some common misconceptions in cell concepts include misconception about cell structure, cell organelle function, membrane transport, and cell division. Misconceptions that occur are also caused by two factors, namely factors from students and from outside students. Factors from students are their prior knowledge and confidence level. External factors include books, peers, and teachers. There are several methods that can be used to uncover misconceptions such as open-ended questions, multiple choice, diagnostic test, interview, and drawing test. Then the scientific analysis became a review of the results of the literature study on misconceptions experienced by students. The research goal is to produce a literature study of student misconceptions on the concept of cells that can support learning outcomes or objectives with students being able to avoid misconceptions on the concept of cells.

Results and Discussion

Understanding Misconceptions

According to Hammer (1996), misconceptions are understanding concepts contained in students' minds that conflict with scientific concepts, which are influenced by students' experiences. Fowler and Jaoude (1987) explain misconceptions as inaccurate understanding of concepts, incorrect use of concepts, incorrect classification of concept examples, confusion between different concepts, and inappropriate hierarchical relationships between concepts. Misconceptions can occur if students' understanding of concepts is incomplete.

Meanwhile, Suparno (Suparno, 2013) defines misconception as a person's interpretation or understanding of a concept that does not match the concepts of experts.

From the understanding of experts, it can be concluded that, misconceptions are concepts that are inaccurate, incomplete and the relationship between concepts is not in accordance with expert concepts where these concepts are contained in the minds of students and are influenced by factors originating from students and outside students. Several terms are used to express concepts that are different from experts' concepts other than misconceptions, such as alternative concepts (Suparno, 2013), alternative frameworks (Driver & Easle, 1978) and naive theory (McCloskey, 1983). The effort that needs to be made to find misconceptions is to investigate misconceptions using diagnostic tests. The purpose of diagnosis is to show each student's strengths and, more importantly, weaknesses in attributes that the student has not yet fully mastered (Fan et al., 2021). Diagnostic tests are tests that aim to determine students' strengths and weaknesses when learning something, so that the results can be used as a basis for providing follow-up. This test can take the form of a number of questions or a request to do something (Rusilowati, 2015).

Types of Diagostic Tests

Ordinary Diagnostic Tests (One-tier) and Two-tier Diagnostic Test

Ordinary diagnostic tests have the advantage that they can be given to a large number of individuals quickly, but cannot investigate student responses. If the multiple choice test is only one-tier, it can be interpreted excessively, because students can be interpreted as not having the ability by seeing the wrong answers. However, wrong answers to ordinary multiple choice questions do not necessarily indicate that students do not understand the concept (Lack Knowledge). The shortcomings of the multiple choice diagnostic test (One-tier Test) are complemented by the Two-tier Test diagnostic test (Gurel et al., 2017).

Typically, a two-tier test functions as a diagnostic tool characterized by a first tier containing multiple-choice questions addressing content, and a second tier comprising multiple-choice questions accompanied by justifications for the responses provided in the first tier (Li, 2022; Lim & Poo, 2021). In a two-tier test, correctness of a student's answer to each question is contingent upon both the choice and the accompanying reason being accurate. As a result, this testing format facilitates the identification and calculation of incorrect responses with correct reasoning (false negatives) as well as correct responses with flawed reasoning (false positives). However, the two-lier test cannot differentiate between not understanding and misconceptions so all answer errors are considered misconceptions (Pesman & Eryilmaz, 2010). Next, a three-tier test was developed.

Three-Tier Diagnostic Test

With a three tier test, misconceptions can be differentiated from not understanding. Misconceptions are not just errors in answering questions and the reasons. Diagnostic tests are also used to identify students' misconceptions in Biology (Suwono et al., 2019; Andriana et al., 2020; Soeharto & Csapo, 2022; Yeo et al., 2022). However, misconceptions typically involve errors that are strongly held with confidence. In specific instances of misconceptions, incorrect answers and flawed reasoning are closely intertwined. Hence, while all misconceptions are errors, not all errors necessarily qualify as misconceptions. In a three-tier test, a student's response to each item is deemed correct when both the correct choice and the appropriate reason are selected, and the student demonstrates confidence in their choices across the first two tiers. Conversely, a student's response to any item is classified as a misconception when an incorrect choice and its associated specific incorrect reason are selected with high confidence. Although three-tier test appear to address the limitations of two-tier tests, they still face challenges in fully distinguishing between confidence levels for primary answers (first tier) and confidence levels for reasons (second tier). As a result, there is a risk of overestimating students' proficiency while underestimating their lack of comprehension (Gurel et al., 2015).

Four-tier Diagnostic Test

The four-tier diagnostic test developed in the research produces a test instrument that functions to reveal student misconceptions (Aksoy & Erten, 2022). It is possible for every student to experience misconceptions about the material they have studied (Suprapto, 2020). Presently, Caleon and Subramaniam (2010) have developed a four-tier diagnostic test, from three tier to four tier. The four-tier diagnostic test is a form of multi-tier multiple-

choice diagnostic assessment. The first tier comprises questions and answer choices similar to typical multiple-choice tests. The second tier involves assessing the confidence level associated with the responses from the first tier. In the third tier, relevant principles are provided to justify the responses selected in the first tier. Finally, the fourth tier evaluates the confidence level associated with the responses provided in the third tier (Gurel et al., 2017). Diagnostic tests aimed at identifying student misconceptions have evolved from one-tier to two-tier, three-tier, and four-tier formats.

Table 1. Four tier misconceptions diagnostic test analysis categories (Kiray & Sena, 2021)

First tier	Second tier	Third tier	Fourth tier	Category
Correct	Certain	Correct	Certain	Scientific Concept
Correct	Certain	Incorrect	Certain	False Positive
Incorrect	Certain	Correct	Certain	False Negative
Incorrect	Certain	Incorrect	Certain	Misconceptions
Correct	Certain	Correct	Uncertain	Not understand
Correct	Uncertain	Correct	Certain	Not understand
Correct	Uncertain	Correct	Uncertain	Not understand
Correct	Certain	Incorrect	Uncertain	Not understand
Correct	Uncertain	Incorrect	Certain	Not understand
Correct	Uncertain	Incorrect	Uncertain	Not understand
Incorrect	Certain	Correct	Uncertain	Not understand
Incorrect	Uncertain	Correct	Certain	Not understand
Incorrect	Uncertain	Correct	Uncertain	Not understand
Incorrect	Certain	Incorrect	Uncertain	Not understand
Incorrect	Uncertain	Incorrect	Certain	Not understand
Incorrect	Uncertain	Incorrect	Uncertain	Not understand

Based on the table, it can be interpreted that misconceptions occur when respondents answer incorrectly with a certain level of confidence.

Causes of Misconceptions

Misconceptions that occur in students can be caused by several things, such as self-confidence, textbook, student, teacher, and peers. First, overconfidence in a concept can hinder reconceptualization of learning at an advanced level. Excessive self-confidence makes students believe that their understanding of a concept is correct, when in fact it is not. Therefore, students need to increase awareness of the inaccuracy of their assessment of a concept (Adriana et al., 2020). Second, textbooks solely relied upon by teachers as their primary instructional resource contribute to the prevalence of misconceptions, impacting both educators and students (Yunanda et al., 2020). This situation arises because teachers may lack a deep comprehension of the concepts presented, leading to a failure to provide relevant contextual examples that could help clarify concepts within the students' environment. (Leksono et al., 2013). Third, students, teachers, teaching materials or literature, and contextual factors all play crucial roles in shaping the occurrence and persistence of misconceptions (Suprapto, 2020). And the fourth cause are peers, peer review can give rise to misconceptions that students have (Halim et al., 2013).

Biology Misconceptions

Misconceptions can occur in all fields of science such as physics (Fariyani et al, 2015), chemistry (Mentari et al., 2013), mathematics (Sopiany & Rahayu, 2019), and biology (Yates & Marek, 2014). Misconceptions about biological concepts based on previous research are presented as follows:

Based on the data presented in Table 2, it was found that students had misconceptions in various aspects of cell biology, including cell structure, cell organelles, membrane transport, and cell division. For example, regarding cell structure, students had difficulty distinguishing between cell walls in prokaryotic and plant cells. Students' misconceptions in identifying the chemical components of cells based on their criteria, and incorrectly describing the types and characteristics of cells (prokaryotic and eukaryotic) (Saputra et al., 2021). The presence of a cell wall in prokaryotic cells can cause some students to mistakenly think that the cell is a plant cell (Tambo et al., 2003). The inability to distinguish other organelles indicates a lack of understanding or skill in distinguishing what makes up a cell. In line with Setyaningsih's research (2020) which found that students still experience higher misconceptions in the part of distinguishing prokaryotic cells and misconceptions than the part of cell structure.

Table 2. List of biology misconceptions found from previous research

	Sub-concept	Misconceptions
Cell concept	Cell structure	Students have difficulty distinguishing between plant and animal cells
		Students have difficulty distinguishing between prokaryotic and eukaryotic
		Students have difficulty understanding the structure of the cell nucleus
	Cell Organelles and function	Students have misconceptions about the function of organelles, such as mitochondria and do not have a clear idea about chloroplasts
		Students have difficulty in understanding chloroplasts, including their location and function
	Membrane transport	Passive transport requires ATP hydrolysis
		Students struggle to understand the concept of material transport through membranes, especially regarding active transport involving Na+ or K+ pumps and Na+ or glucose transporters. Students mistakenly consider this process as passive transport (diffusion)
	Cell Division	Students have misconceptions about the concepts of mitosis and meiosis.
		Students have the belief that mitosis does not produce the same number of chromosomes after the process

Misconceptions about cell structure were also found in the study of Rahma et al (2022) which also found that students assume cells must consist of a complete form with a cell nucleus. These findings suggest that most students struggle to understand the unique characteristics of prokaryotic cells. This could be attributed to students' lack of knowledge about cells without nuclei, as students' lessons in high school mainly focus on cell models with clear nuclei.

Another misconception regarding the structure of chloroplasts is that students answer and believe correctly that the organelle that has a flat-shaped internal membrane (thylakoid) is the golgi apparatus or endoplasmic reticulum (Rafika, 2015). Another misconception that arises is when students cannot distinguish between the functions of lysosomes and the golgi apparatus. Students strongly believe that the Golgi apparatus is responsible for lysing the cells that make up the tadpole tail (Rafika, 2015). Whereas in the research of Suwono et al (2019) students prefer to choose the Golgi apparatus as the vesicle responsible for secreting insulin. In addition, misconceptions related to the function of the nucleus, students consider the nucleus as a place where cellular respiration takes place (Syarif et al., 2023).

In terms of membrane transport, many students have difficulty in understanding the mechanism of material transport through membranes. Misconceptions mainly occur in active transport involving Na+/K+ pumps and Na+/glucose transporters. Students believe that these ions can pass through cell membranes due to the small size of the ions, and not because of the influence of ATP (Suwono et al., 20219). Test analysis revealed students' lack of confidence in choosing the correct answer, indicating an overall deficiency in mastering the concept of membrane transport (Suwono et al., 2019; Rahma et al., 2020). In addition, some students mistakenly believe that the process of membrane transport is passive and does not require ATP hydrolysis, which may be due to the complexity of the subject matter (Oztas, 2014).

The plasma membrane structure in the phospholipid bilayer is also a part that is often misunderstood by students. Students have difficulty understanding parts of the plasma membrane structure. Students answered that the tail consists of phospholipids and proteins (Sunarto et al., 2021). Supported by Affifah's research (2020), which found that students also experience misconceptions in determining that the hydrophobic plasma membrane structure is phospholipid molecules and the hydrophilic ones are protein molecules. Coupled with the research of Syarif et al (2023), who found that the part of the cell membrane that has hydrophilic and hydrophobic parts is phosphorus. In some studies, this plasma membrane misconception is higher than other concept sub-materials (Affifah, 2020; Saputra & Munir, 2021; Silaban & Pranoto, 2022).

Moreover, misconceptions were prevalent regarding cell division, particularly concerning mitosis and meiosis. Students frequently misunderstood fundamental concepts, such as chromosome numbers post-mitosis (Suwono et al., 2019). The utilization of multi-tier diagnostic tests proves beneficial in elucidating students' conceptual

understanding. Such assessments can effectively identify students' grasp of concepts, pinpoint misconceptions, and highlight areas where understanding is lacking (Yeo et al., 2022).

Shortcomings and Suggestions of Previous Research

From the previous research, there are some research suggestions written in research articles on misconceptions. First, it is important to conduct more research related to the biology context to inform teachers about the appropriateness of assessment tools. Although a number of similar assessment tools have been developed by other countries, they should be carefully adapted or referenced due to differences in curriculum, education system, language, and culture (Li, 2022). Second, by administering a multi-tier diagnostic test or post-test, educators can optimally design and structure courses to produce competent teachers who master all biology concepts, which will then be taught to their students in the future (Suwono et al., 2019). Third, university courses should cover appropriate content both theoretically and practically in the field. Only in this way can future teachers contextually relate in a meaningful way to their students in science lessons or in the context of the surrounding environment (Schmaing & Grotjohann, 2022). Four, biology teachers are responsible for helping students build a more accurate understanding. Therefore, an appropriate assessment tool is needed to scientifically measure misconceptions so that it can assist biology teachers in overcoming misconceptions related to knowledge and reasoning, so that teachers are able to teach certain concept materials appropriately (Kantahan et al., 2022). Fifth, encourage other researchers to further explore the level of difficulty of questions in cross-disciplinary science concepts. Understanding the level of difficulty of questions can help teachers be more careful and caring when carrying out learning activities to convey concepts that are difficult for students to understand. For future research, one could explore in more detail one's estimates of identifying student misconceptions and investigate whether there are student misconceptions due to guessing answers or having inconsistent answer patterns (Soeharto & Csapo, 2021).

Conclusion

Misconceptions about cell concepts can occur in the sub-topics of cell structure, structure and function of organelles, membrane transport and cell division. These misconceptions can be caused by students' personal factors, namely students' self-confidence, and external factors such as books, teachers' teaching methods, and students' friends. Misconceptions found can be identified using a multi-tier diagnostic test, and the results can be used as a reference during cell learning and also as an effort to prevent student misconceptions from both students and teachers.

Recommendation

The limitations of this literature review include its reliance only on published sources, which may not cover all relevant perspectives, and the potential for interpretation bias without empirical data. Recommendations suggest conducting an empirical study to validate the findings by identifying student misconceptions on the cell concept and using broader sources for a more comprehensive understanding. Apart from that, efforts to prevent and reduce misconceptions also need to be researched further.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPESS Journal belongs to the authors.

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References

Afifah, Y. N., & A., M. T. (2020). Profil miskonsepsi pada submateri struktur dan fungsi sel menggunakan four tier test. *Bioedu*, 9(3), 390-396.

Aksoy, A. A. C., & Erten, S. (2022). A four-tier diagnostic test to determine preservice science teachers' misconception about global warming. *Journal of Baltic Science Education, 21*(5), 741-761.

Andriana, A., Zubaidah, S., Mahanal, S., & Suarsini, E. (2020). Identification of biology students' misconceptions in human anatomy and physiology course through three-tier diagnostic test. *Journal for the Education of Gifted Young Scientists, 8*(3), 1071-1085.

Beck, M., Covino, R., Hänelt, I., & Müller-McNicoll, M. (2024). Understanding the cell: Future views of structural biology. *Cell, 187*(3), 545-562.

Caleon, I., & Subramaniam, R. (2010). Do students know what they know and what they don't know? Using a four-tier diagnostic test to assess the nature of students' alternative conceptions. *Research in Science Education, 40*(3), 939-961.

Campbell, N. A., Reece, J. B., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P., & Jackson, R. B. (2020). *BIOLOGI Edisi 12*. Erlangga. Jakarta, Indonesia.

Chabbra, M., & Bavaja, B. (2012). Exploring minds: Alternative conceptions in science. *Procedia - Social and Behavioral Sciences, 55,* 1069-1078.

Clement, J. (1987). Overcoming students' misconceptions in physics: The role of anchoring intuitions and analogical validity. *In Proceedings of Second International Seminar Misconceptions and Educational Strategies in Science and Mathematics* (pp. 1241-1257). Ithaca, NY: Cornell University.

Cooper, C., Booth, A., Varley-Campbell, J., Britten, N., & Garside, R. (2018). Defining the process to literature searching in systematic reviews: A literature review of guidance and supporting studies. *BMC Medical Research Methodology, 18*(1), 1-14.

Driver, R., & Easle, J. (1978). Pupils and paradigms: A review of literature related to concept development in adolescent science students. *Studies in Science Education, 5*(1), 61-84.

Fan, T., Song, J., & Guan, Z. (2021). Integrating diagnostic assessment into curriculum: A theoretical framework and teaching practices. *Language Testing in Asia, 11*(2), 1-23.

Fariyani, Q., Rusilowati, A., & Sugianto. (2015). Pengembangan four-tier diagnostic test untuk mengungkap miskonsepsi fisika siswa SMA kelas X. *Journal of Innovative Science Education, 4*(2), 41-49.

Fernández, M. del M. F., & Jiménez Tejada, M. P. (2019). Difficulties learning about the cell: Expectations vs. reality. *Journal of Biological Education, 53*(1), 1-15.

Fowler, T. W., & Jaoude, B. S. (1987). Using hierarchical concepts/proposition maps to plan instruction that addresses existing and potential student misunderstandings in science. *In Proceedings of the Second International Seminar on Misconceptions and Educational Strategies in Science and Mathematics* (pp. 182-186). Ithaca, NY: Cornell University.

Halim, A. S., Finkenstaedt-Quinn, S. A., Olsen, L. J., Gere, A. R., & Shultz, G. V. (2018). Identifying and remediating student misconceptions in introductory biology via writing-to-learn assignments and peer review. *CBE Life Sciences Education, 17*(2), 1-12.

Hammer, D. (1996). Misconceptions or p-prims: How may alternative perspectives of cognitive structure influence instructional perceptions and intentions. *The Journal of the Learning Sciences, 5*(2), 97-127.

Gurel, D. K., Eryilmaz, A., & McDermott, L. C. (2015). A review and comparison of diagnostic instruments to identify students' misconceptions in science. *Eurasia Journal of Mathematics, Science and Technology Education, 11*(5), 1470-1138.

Gurel, D., Eryilmaz, A., & McDermott, L. C. (2017). Development and application of a four-tier test to assess pre-service physics teachers' misconceptions about geometrical optics. *Research in Science and Technological Education, 35*(2), 1-21.

Kantahan, S., Junpeng, P., Punturat, S., Tang, K. N., Gochyyev, P., & Wilson, M. (2020). Designing and verifying a tool for diagnosing scientific misconceptions in genetics topic. *International Journal of Evaluation and Research in Education (IJERE), 9*(3), 564-571.

Kiray, S. A., & Simsek, S. (2021). Determination and evaluation of the science teacher candidates' misconceptions about density by using four-tier diagnostic test. *International Journal of Science and Mathematics Education, 19*(5), 935-955.

Koray, C., & Bal, Ş. (2002). Misconceptions in science teaching and conceptual change strategy. *Gazi University Kastamonu Education Journal, 10*(1). 83-90.

Li, M. (2022). An exploration concept teaching knowledge of biology teachers in lower-secondary schools. *Journal of Baltic Science Education, 21*(1), 121-139.

Lim, H. L., & Poo, Y. P. (2021). Diagnostic test to assess misconceptions on photosynthesis and plant respiration: Is it valid and reliable? *Jurnal Pendidikan IPA Indonesia, 10*(2), 241-252.

Marshall, S., & Gilmour, M. (1990). Problematical words and concepts in physics education: A study of Papua New Guinean students' comprehension of non-technical words used in science. *Physics Education, 25*(6), 330-337.

McCloskey, M. (1983). *Naive theories of motion. Mental Models*, 75–98. Department of Psychology, The Johns Hopkins University, Baltimore, Maryland.

Mentari, L., Suardana, I. N., & Subagia, I. W. (2014). Analisis miskonsepsi siswa sma pada pembelajaran kimia untuk materi larutan penyangga. *Journal Kimia Visvitalis Universitas Pendidikan Ganesha Jurusan Pendidikan Kimi*a, *2*(1), 76-87.

Leksono, S. M., Rustaman, N., & Redjeki, S. (2013). Kemampuan profesional guru biologi dalam memahami dan merancang model pembelajaran konservasi biodiversitas di SMA. *Cakrawala Pendidikan, 32*(3), 408-419.

Oztas, F. (2014). How do high school students know diffusion and osmosis? High school students' difficulties in understanding diffusion & osmosis. *Procedia - Social and Behavioral Sciences*, 116, 3679-3682.

Paré, G., & Kitsiou, S. (2016) . Methods for literature reviews. In Francis Lau and Craig Kuziemsky, *Handbook of eHealth Evaluation: An Evidence-based Approach* (pp157-170). University of Victoria, Canada.

Pesman, H., & Eryilmaz, A. (2010). Development of a three-tier test to assess misconceptions about simple electric circuits. *Journal of Educational Research, 103*(3), 208-222.

Rafika, A., Rachmadiarti, F., & Isnawati. (2015). Identifikasi miskonsepsi siswa pada subtopik struktur dan fungsi organel sel menggunakan ınstrumen crı dan wawancara diagnostik. *Berkala Ilmiah Pendidikan Biologi, 4*(2), 908–912.

Rahma, B., Zaki, M., Boujemaa, A., Nadia, B., & Lhoussaine, M. (2020). University students' knowledge and misconceptions about cell structure and functions. *European Journal of Education Studies, 9*(10), 121-138.

Rusilowati, A. (2015). Pengembangan tes diagnostik sebagai alat evaluasi kesulitan belajar fisika. *Prosiding Seminar Nasional Fisika dan Pendidikan Fisika (SNFPF)* Ke-6 2015 (h. 1-10). Semarang: Program Studi Pendidikan Fisika, Universitas Negeri Semarang.

Saputra, N. R., Safilu, & Munir, A. (2021). Diagnostik miskonsepsi siswa pada materi sel di SMA Negeri 1 Wakorumba Selatan kelas XI IPA. *AMPIBI: Jurnal Alumni Pendidikan Biologi*, *6*(2), 80-89.

Schmaing, T., & Grotjohann, N. (2022). Conceptions of prospective biology teachers about the Wadden Sea ecosystem. *Heliyon, 8*, 1-14.

Silaban, O. R., & Pranoto, H. (2022). Analysis of student misconceptions on cell material as the smallest unit of life. *Biosfer: Jurnal Pendidikan Biologi*, *15*(1), 44-50.

Soeharto, S., & Csapo, B. (2021). Evaluating item difficulty patterns for assessing student misconceptions in science across physics, chemistry, and biology concepts. *Heliyon, 7*, 1-10.

Soeharto, S., & Csapo, B. (2022). Exploring Indonesian student misconceptions in science concepts. *Heliyon, 8*, 1-10.

Sopiany, H. N., & Rahayu, W. (2019). Analisis miskonsepsi siswa ditinjau dari teori konstruktivisme pada materi segiempat. *Jurnal Pendidikan Matematika*, *13*(2), 185-200.

Suparno, P. (2013). Miskonsepsi dan perubahan konsep dalam pendidkan fisika. Grasindo. Jakarta, Indonesia.

Suprapto, N. (2020). Do we experience misconceptions?: An ontological review of misconceptions in science. *Studies in Philosophy of Science and Education (SiPoSE), 1*(2), 50-55.

Suwono, H., Prasetyo, T. I., Lestari, U., Lukiati, B., Fachrunnisa, R., Kusairi, S., Saefi, M., Fauzi, A., & Atho'Illah, M. F. (2019). Cell biology diagnostic test (CBD-Test) portrays pre-service teacher misconceptions about biology cell. *Journal of Biological Education*, *55*(1), 1-24.

Syarif, N., Alberida, H., Fitri, R., & Yogica, R. (2023). Identifikasi miskonsepsi materi sel pada peserta didik di kelas XI IPA MAN 2 Kota Padang. *Bioilmi: Jurnal Pendidikan, 9*(2), 54-52.

Tambo, E. M. Z., Mukaro, J. P., & Mahaso, J. (2003). Some misconceptions on cell structure and function held by a-level biology students: Implications for curriculum development. *Zimbabwe Journal of Educational Research, 15*(2), 122–131.

Tekkaya, C. (2002). Misconceptions as barrier to understanding biology. *Hacettepe Universitesi Egitim Fakultesi Dergisi-Hacettepe University Journal of Education*, 23, 259-266.

Yates, T. B., & Marek, E. A. (2014). Teachers teaching misconceptions: A study of factors contributing to high school biology students' acquisition of 53 biological evolution-related misconceptions. *Evolution: Education and Outreach, 7*(1), 1-18.

Yeo, J.-H., Yang, H.-H., & Cho, I.-H. (2022). Using a three-tier multiplechoice diagnostic instrument toward alternative conceptions among lower-secondary school students in taiwan: Taking ecosystems unit as an example. *Journal of Baltic Science Education, 21*(1), 69-83.

Yunanda, I., Susilo, H., & Ghofu, A. (2020). Biology teachers' misconception of mgmp malang are moderate in biodiversity and low in protist. *Journal of Physics: Conference Series, 1440*, 1-6.

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