

## STUDENT MISCONCEPTION PROFILE IN PROTEIN SYNTHESIS TOPIC USING FOUR-TIER DIAGNOSTIC TEST TECHNIQUE

### *Profil Miskonsepsi Peserta Didik pada Materi Sintesis Protein menggunakan Teknik Four-Tier Diagnostic Test*

**Shinta Nadya Mega Ariesta**

Biology Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya

Email: [shinta.17030204009@mhs.unesa.ac.id](mailto:shinta.17030204009@mhs.unesa.ac.id)

**Endang Susantini**

Biology Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya

Email: [endangsusantini@unesa.ac.id](mailto:endangsusantini@unesa.ac.id)

#### **Abstract**

Misconception is students' misunderstanding in interpreting a concept within scientific theory. Amongst the biological topics that often cause misconceptions is protein synthesis. Protein synthesis is considered as a topic with complex concepts. This research was aimed to describe the students' misconceptions profile in protein synthesis topic and the causing factors of students' misconception in protein synthesis topic. This research was a descriptive quantitative study using four-tier diagnostic test instrument; 1st tier was questions with 5 possible answers, 2nd tier was level of answer confidence, 3rd tier was 5 possible reasons, and 4th tier was level of reason confidence. This research was conducted during the Covid-19 pandemic, which made it difficult to meet directly, so the data was collected online via google form and google meet. The study subjects were 34 students of grade XII MIPA-4 SMA Negeri 1 Gresik. Results showed that 32.37% misconceptions occurred in the protein synthesis topic. The highest misconception was in the concept of RNA characteristics, with the percentage of 65%. Factors that cause misconceptions were the students' lack of interest in protein synthesis topic, the teacher were too fast in explaining the information, limited selection of learning methods during Covid-19 pandemic, and the information in the textbook was incomplete and difficult to understand. Implementation testing of models, methods, or learning media can be done to reduce students' misconceptions in protein synthesis topic, especially in the concept of RNA characteristic, DNA replication, and translation process.

**Keywords:** misconception, protein synthesis, four-tier diagnostic test.

#### **Abstrak**

Miskonsepsi diartikan sebagai kesalahpahaman peserta didik dalam menafsirkan suatu konsep dengan teori ilmiah. Salah satu materi pada biologi yang rawan terjadi miskonsepsi yaitu sintesis protein. Sintesis protein dianggap sebagai materi dengan konsep-konsep yang kompleks. Penelitian ini bertujuan untuk mendeskripsikan profil miskonsepsi peserta didik pada materi sintesis protein menggunakan Four-Tier Diagnostic Test serta mendeskripsikan faktor penyebab miskonsepsi peserta didik terjadi pada materi sintesis protein. Jenis penelitian ini adalah deskriptif kuantitatif menggunakan instrumen Four-Tier Diagnostic Test terdiri atas 4 tier, tier-1 berupa pertanyaan dengan 5 opsi jawaban, tier-2 berupa opsi tingkatan keyakinan terkait opsi jawaban, tier-3 berupa 5 opsi alasan, dan tier-4 berupa tingkatan keyakinan terkait opsi alasan. Penelitian dilaksanakan pada saat masa pandemi Covid-19 yang tidak memungkinkan untuk bertatap muka, sehingga pengambilan data dilakukan secara online melalui google form dan google meet sebagai upaya pembatasan sosial (social distancing). Subjek penelitian ini yaitu 34 peserta didik kelas XII MIPA-4 di SMA Negeri 1 Gresik. Hasil penelitian menunjukkan bahwa terjadi miskonsepsi pada materi sintesis protein sebesar 32,37%. Miskonsepsi tertinggi terdapat pada konsep ciri-ciri RNA yaitu sebesar 65%. Faktor penyebab miskonsepsi yaitu kurang minatnya peserta didik terhadap materi sintesis protein, guru terlalu cepat dalam menjelaskan materi, pemilihan metode pembelajaran yang terbatas saat pandemi Covid-19, dan informasi pada buku teks yang kurang lengkap dan sulit dipahami. Uji penerapan model, metode, atau media pembelajaran dapat dilakukan untuk mereduksi miskonsepsi peserta didik pada materi sintesis protein, khususnya pada konsep ciri-ciri RNA, replikasi DNA, dan proses translasi.

**Kata Kunci:** miskonsepsi, sintesis protein, tes diagnostik four-tier.

## INTRODUCTION

Concept is definition form that produces knowledge products such as principles, laws, and theories that come from the thoughts of an individual or group of individuals (Sagala, 2012). The ability of students who are good at capturing the concepts conveyed makes it easier for these concepts to be remembered so that further concept learning will be more meaningful (Siswana, et al., 2017).

Students' mastery of concepts that are not in line with the actual concept is referred to as a misconception (Ibrahim, 2012). Misconceptions can also be interpreted as misunderstandings of students in interpreting a concept with scientific theory. Misconceptions make students feel that the concept they believe is true, but in reality this is different from the real basic concept. Learning with the lecture method by the teacher will affect concept capture in students with low concept mastery abilities. The accuracy of teachers in choosing teaching methods and preparing for learning can make students better understand a concept (Wedi, 2017).

Teachers having incomplete can lead students' misconceptions. There are many concepts that must be understood when studying biology subjects. As a result, if the mastery of concepts is disturbed, the learning outcomes of students are also affected (Yuliono, et al., 2018).

Biology topic often regarded as subject of research among educators is the difficulty of students to grasp the concept of genetic substance. Ahillah & Susantini (2018) in their research stated that the mastery of genetic substances topic in high school students is still low due to the complex topic so that high-order thinking skills are needed. One of them is in the protein synthesis topic (Suhermiati, 2015; Permata, 2018). Permata (2018) stated that students' misconceptions on the concept of the difference between DNA and RNA were 87%. Suhermiati (2015) also stated that there was a misconception of 62.5% in the concept of understanding RNA, 60% in the concept of genetic code, and 52.5% in the concept of the transcription stage. Thus, it can be concluded if the misconception in protein synthesis topic is still high.

The results of interviews conducted with teachers and grade XII student of SMA Negeri 1 Gresik showed that students had problems understanding the process of replication, transcription, and translation due to several factors, such as abstract topic, lack of interest, and novel terms foreign to them. This showed that students were not able to understanding every concept contained in protein synthesis topic. A good understanding of the

concept is needed to avoid misconceptions (Yuliono, et al., 2018). Misconceptions in protein synthesis topic needs to be identified because students will find it difficult to connect old concepts with new concepts because of the interrelated concepts (Farihah, et al., 2016).

To diagnose misconceptions, a diagnostic test which aims to measure the level of understanding of the main concepts of a topic in students is necessary, especially those that are often cause misunderstanding, such as the topic of protein synthesis. The type of diagnostic test that can be applied is the Four-Tier Diagnostic Test. The test is a modification of Three-Tier Test that has not been able to categorize the level of confidence in 1st and 2nd tier. Thus, the Four-Tier Diagnostic Test can be more optimal in diagnosing the misconception that occurs. The Four-Tier diagnostic test instrument is consisting of 4 tiers; the 1st tier is a question with 5 possible answers, the 2nd tier is the level of confidence (sure or not sure) about the chosen answer, the 3rd tier is the 5 possible reasons, and 4th tier is the level of confidence (sure or not sure) about the chosen reason. The Four-Tier diagnostic test can reveal students who already understand the concept, do not understand the concept, and misconceptions (Fratwi, et al., 2016).

Based on the previous descriptions, it is necessary to identify students' misconceptions in protein synthesis topic using the Four-Tier Diagnostic Test technique. This research was aimed to describe the student misconception profile at SMA Negeri 1 Gresik in protein synthesis topic and its causing factors.

## METHODS

This quantitative descriptive research was carried out by collecting data to describe the condition of the object under research and using the Four-Tier Diagnostic Test Decision-Making criteria by Gurel, et al. (2015) for understanding the concept as a comparison. Gurel, et al. (2015) classified the concept understanding criteria based on three groups, there are understanding the concept, not understanding the concept, and misconception. Thus, information will be obtained on the percentage of students misconceptions. The research was carried out in November - December 2020 and was composed of three steps, including preparation, data collection and completion.

The preparation step included the process of preparing a Four-Tier diagnostic test instrument through the adaptation of a validated Three-Tier test instrument by Permata (2018) research in the form of online questions via google form. The research instrument including a

Four-Tier diagnostic test instrument and an interview instrument. The diagnostic test instrument presented 20 multiple choice questions related to protein synthesis topic. Each item consisted of 4 tiers, the 1st tier was a question with 5 possible answers, the 2nd tier was the level of confidence (sure or not sure) about the chosen answer, the 3rd tier was the 5 possible reasons, and 4th tier was the level of confidence (sure or not sure) about the chosen reason.

The implementation step was data collection by providing Four-Tier diagnostic test instruments to students online via google form and also interviews via google meet. The implementation step involved 34 students of grade XII MIPA-4 in SMA Negeri 1 Gresik who had received protein synthesis topic. The Four-Tier diagnostic test instrument was shared online via WhatsApp-group due to the social distancing program. The google form link was stopped receive answers automatically after 90 minutes

The completion step covered data processing, analyzing, and concluding. The data obtained presented as table. The data analysis technique referred to Four-Tier diagnostic test decision-making criteria in Gurel's study as illustrated in **Table 1**.

**Table 1.** Four-Tier Diagnostic Test Decision-Making Criteria (Gurel, et al., 2015)

Tier				Decision
1st	2nd	3rd	4th	
C	S	C	S	Understanding the Concept
C	S	C	NS	Not Understanding the Concept
C	NS	C	S	
C	NS	C	NS	
C	S	I	S	Misconception
C	S	I	NS	Not Understanding the Concept
C	NS	I	S	
C	NS	I	NS	
I	S	C	S	
I	S	C	NS	
I	NS	C	S	Misconception
I	NS	C	NS	
I	S	I	S	Not Understanding the Concept
I	S	I	NS	
I	NS	I	S	
I	NS	I	NS	

C: Correct; I: Incorrect; S: Sure; NS: Not Sure

The percentage of students' understanding was obtained through the following formula (Riduwan, 2011):

$$P = \frac{f}{N} \times 100\%$$

P = Percentage of groups

F = Number of students in the group

N = Total sample of students

The percentage results obtained were then interpreted according to the categories in **Table 2** (Didik, et al., 2020).

**Table 2.** Percentage category of misconceptions

Percentage	Misconception Category
61% - 100%	High
31% - 60%	Medium
0% - 30%	Low

Interviews were conducted with three students who had the highest proportion of misconceptions as supporting data of misconceptions causing factors. Interviews during the Covid-19 pandemic were carried out online by utilizing google meet due to the social distancing program. The interviews' guide contained questions related to the factors that cause misconceptions. The factors causing misconceptions in students were divided into 4 groups, students themselves, teachers, teaching methods, and textbooks (handbooks). Data analysis was carried out through making conclusions and generalizations based on the answers of the respondents.

## RESULTS AND DISCUSSION

The Research was aimed to describe the level of students' misconceptions in protein synthesis topic and its causing factors. After analyzing the data, the percentage (%) of students' misconceptions in protein synthesis topic for each concept is presented in **Table 3**.

**Table 3.** Percentage of students' misconception in protein synthesis concepts

Concept	Misconception (%)
DNA characteristics	52
DNA function	15
Nitrogen base	35
DNA Nitrogen base pairs	32
Nucleotides arrangement	26
Polynucleotide bonds	32
Watson & Crick's DNA molecule	50
Difference between DNA and RNA	35
Helicase enzyme function	15



Concept	Misconception (%)
DNA replication process	35
DNA replication	53
RNA characteristics	65
RNA Nitrogen base pairs	26
tRNA function	15
mRNA function	9
Transcription process	21
Transcription	15
Translation process	53
Genetic code	31
<b>Average</b>	<b>32,37</b>

Based on **Table 3**, misconceptions occurred in all concepts in the protein synthesis topic on average of 32.37%. The highest misconception was in the concept of RNA (Ribonucleic Acid) characteristics, with the percentage of 65%. Students answered incorrectly and sure that RNA is composed of deoxyribose sugar, has double strands, and does not carry genetic information. The correct concept is that RNA is composed of ribose sugars, phosphates, and nitrogenous bases, has a single nucleotide band, and contains four nitrogenous bases like DNA, except that the Uracil (U) replaces the Thymine (T) (Rachmadiarti, et al., 2007). This could occur due to the similarity of terms between DNA and RNA, so that students had difficulty distinguishing the characteristics between them.

The second highest misconception was in the concept of DNA (Deoxiribonucleic Acid) replication with the percentage of 53%. Students answered incorrect and sure that the hypothesis of the two old DNA strands in the conservative model of DNA replication would separate and the new strand would produce the same strand as the parent. The correct concept related to the hypothesis regarding the conservative model of DNA replication is that the two old DNA strands will remain and do not change (not separate) and function as templates for two new DNA strands (Bolsover, et al., 2004). Misconceptions on this concept could occur because of the terms were new to them, so it was difficult for them to understand.

High misconceptions also found in the concept of the translation process with the percentage of 53%. Students answered incorrect and sure that ligation is one of the stages of the translation process. The right concept is that the ligation stage is not a stage of the translation process because ligation is the joining of the 3' end of the DNA to another part of the lagging strand and the joining of

Okazaki fragments which is the DNA replication stage (Randall, et al., 2019).

Students also had misconceptions on the concept of DNA characteristics and Watson & Crick's DNA molecules, with each percentage of 52% and 50%. Students assumed that DNA has a single strand and parallel orientation. The correct concept is DNA has a double helix strand and antiparallel oriented (Yuwono, 2005).

Misconception was also found in the nitrogen base concept with the percentage of 35%. Students assumed that DNA contains nitrogenous bases Uracil (U), Adenine (A), Cytosine (C), and Guanine (G). The correct concept is that DNA contains nitrogen bases Thymine (T), Adenine (A), Cytosine (C), and Guanine (G) (Rachmadiarti, et al., 2007). This can occur due to the similarity of terms between DNA and RNA, so that students have difficulty distinguishing the characteristics between them.

Misconception also occurred in the concept of DNA replication process with the percentage of 35%. Students believed that only one strand of DNA serves as a template for the replication process. The correct concept is that in the process of replication, the two strands of DNA can act as templates. This is because DNA has an anti-parallel orientation characteristic (Yuwono, 2005).

On the concept of differences between DNA and RNA, misconception occurred with the percentage of 35%. Students believed that RNA is only present in the cell nucleus. The correct concept is that RNA is not only present in the cell nucleus, but also in the cytoplasm (Chatterjee, et al., 2018).

The next misconception occurred in the concept of RNA nitrogen base pairs with the percentage of 32%. Students answered incorrect and sure that the nitrogen base Adenine (A) was paired with Thymine (T) and Guanine (G) was paired with Cytosine (C). The right concept is Adenine (A) pairs with Uracil (U), while Guanine (G) pairs with Adenine (A) (Rachmadiarti, et al., 2007). This is because RNA does not have Thymine (T), but replaced by Uracil (U). This could occur due to the similarity of terms between DNA and RNA, so that students have difficulty distinguishing the characteristics between them.

Misconception also occurred in the concept of polynucleotide bonds with the percentage of 32%. Students assumed that the bonds among the nucleotides are hydrogen bonds. The correct concept is that the bonds among the nucleotides are phosphodiester bonds. The phosphodiester bond is a glycosidic bond that connects the pentose sugar of a nucleotide with a sugar

group on another nucleotide which will form a polynucleotide chain (Bolsover, et al., 2004). Misconceptions on this concept can occur because of the terms that are new to them, so it is difficult for them to understand.

On the concept of genetic code, misconceptions occurred at percentage of 31%. Students assumed that methionine (amino acid) is encoded by three codons. The correct concept is that methionine is coded only by one codon, that is AUG. Codons or genetic codes are three nucleotides that encode an amino acid (Bolsover, et al., 2004). Misconceptions on this concept possibly occurred because students found it difficult to distinguish between codons and nucleotides.

Misconception also occurred in the concept of nucleotide arrangement with the percentage of 26%. Students believed that a nucleotide is composed of a nitrogenous base attached to a phosphate group which is bound to an amino acid. The right concept is that a nucleotide is composed of a nitrogenous base attached to a sugar group which is bound to a phosphate (Bolsover, et al., 2004).

There was also misconception in the concept of DNA nitrogen base pairs with the percentage of 26%. Students assumed that Guanine (G) pairs with Cytosine (C) and Uracil (U) pairs with Adenine (A). The correct concept is Guanine (G) pairs with Cytosine (C), while Thymine (T) pairs with Adenine (A) (Rachmadiarti, et al., 2007). This could occur due to the similarity of terms between DNA and RNA, so that students have difficulty distinguishing the characteristics between them.

Misconceptions in the concept of transcription and the transcription process were 15% and 21%. Students believed that transcription is defined as the process of genetic code translation. The correct concept is that transcription is defined as the process of copying the genetic codes of DNA molecules into RNA molecules (Kadonaga, 2019). The stages of transcription include initiation (binding with RNA polymerase and transcription initiation), elongation (lengthening of the RNA strand), and termination (ending of transcription). This could occur due to the similarity of terms between transcription and translation, so that students had difficulty in distinguishing them.

Misconception occurred in the concept of DNA function with the percentage of 15%. Students believed that DNA only serves as a template to make copies of RNA in the transcription process. The correct concept is that DNA not only functions in the process of making RNA copies, but also has a function as a template to

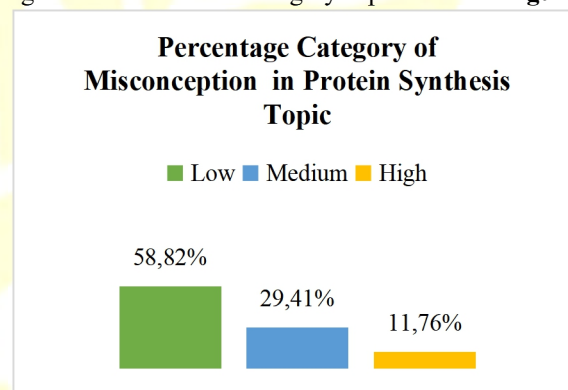
form new strands in the DNA replication process (Kadonaga, 2019).

There was also a misconception in the concept of tRNA function with the percentage of 15%. Students had the opinion that tRNA plays a role in binding proteins. The correct concept is that tRNA play a role to bind amino acids. Amino acids that are bound from the cytoplasm will be carried to the ribosome and translated with other amino acids to be assembled into polypeptides and form proteins (Zambaldo, et al., 2020).

The concept of the helication enzyme function, was misconception at 15%. Students believed that the helicase enzyme functions to bind the initiation complex. The correct concept is that the helicase enzyme has a function to separate the double strands of DNA that will form a replication fork (Windgassen, et al., 2018).

The lowest misconception was in the concept of mRNA function by 9%. Students answered incorrect and sure that the carrier of genetic information from DNA is DNA itself and rRNA. The correct concept of the genetic information carrier from DNA is mRNA (Permata, 2018).

Based on the results stated before, it was found that the average proportion of students' misconceptions was 32.37%, did not understand the concept was 25%, and understood the concept was 42, 63%. Misconceptions in protein synthesis topic for students grade 12 of SMA Negeri 1 Gresik in each category is presented in **Figure 1**.



**Figure 1.** Percentage of misconception category in protein synthesis topic.

The percentage of each category of misconceptions is different, because the cognitive abilities of each student are different. The low interest of students in protein synthesis topic affects the level of misconceptions. The lower the students' interest in this topic, the higher the percentage of misconceptions occurred (Puspitasari, et al., 2019).

Misconceptions can also occur because students are tricked in answering a question. This can be used as an indicator that students are incorrect in analyzing the

questions (Auwalayah & Raharjo, 2017). Misconceptions can be caused by several factors, including students themselves, teacher, teaching methods, and textbooks (handbooks). To identify the causes of misconceptions, interviews were conducted with three students with the highest overall percentage of misconceptions. The results of interviews with informants (students) are shown in Table 4.

**Table 4.** The results of interviews with respondents

Misconception	
Causing Factors	Student Respond
Student	<ul style="list-style-type: none"> <li>Protein synthesis is an abstract topic and difficult to understand because there are new terms, difficult to memorize, and have the same terms so that it does not attract students to learn</li> <li>Student get protein synthesis concept from the internet so that the source cannot confirm the correctness of the concept</li> </ul>
Teacher	<ul style="list-style-type: none"> <li>Students feel that the teacher's explanation is too fast, so they cannot follow the lesson well</li> </ul>
Learning method	<ul style="list-style-type: none"> <li>The teacher apply the lecture method using power point media. Students are less comfortable with this method</li> </ul>
Textbook	<ul style="list-style-type: none"> <li>There is no explanation or incorrect information in the textbook, but several pictures and explanations are difficult to understand.</li> <li>Two students stated that the book is complete, but one student stated that text books is incomplete so other sources are needed.</li> </ul>

Based on the results of interviews, it can be known the factors causing misconceptions in protein synthesis topic. In accordance with the statement of Tridiyanti & Yuliani (2017) that the causes can come from students, teachers (teachers), teaching methods, and textbooks (handbooks).

Factors that cause misconceptions by students can occur because students' understanding of a concept is not yet complete, different preconceptions (initial knowledge)

of students, intuitive errors, incomplete reasoning, humanistic thinking, and associative thinking (Tridiyanti & Yuliani, 2017). The results of the interview proved that the difficulties experienced by students in protein synthesis topic were caused by the assumption that protein synthesis topic was abstract and difficult to understand because of novel terms, which were difficult to memorize, and had similarity with other terms which resulted in the lack of willingness of the students to learn more. In accord with Ahillah & Susantini (2018) statement, mastery of genetic substance topic in high school students was still low due to the complex and abstract topic. The low interest of students in learning a concept makes it difficult to understand the concept (Puspitasari, et al., 2019). Misconceptions can also arise when students combine newly obtained concepts with concepts that have been learned (Tridiyanti & Yuliani, 2017).

Inaccurate delivery of information by teachers can cause misconceptions in students (Wedi, 2017). The results of the interview showed that the teacher explained too fast so that some students had difficulty following it. This is in line with the ability to absorb information is not the same between students (Rahmadani, et al., 2017).

The next source of misconceptions can come from the way teachers teach. Inaccurate selection of learning methods can also lead to misconceptions (Ibrahim, 2012). The results of the interviews showed that the teacher applied the lecture method when giving explanations related to protein synthesis topic. This was due to the limited learning methods that can be applied during the Covid-19 pandemic. Wedi (2017) states that the lecture method is considered less suitable for learning biology because it does not motivate students to be active in learning so that misconceptions can occur.

Another misconception factor can come from textbooks that students use as a guide. The use of book language that is too complicated so that students cannot understand it (Rahmadani, et al., 2017). The results of the interviews indicated that textbooks in schools contained images and explanations that were difficult to understand. In addition, the incomplete information contained in textbooks causes students to tend to look for other sources whose concepts have not been confirmed (Pribadi, 2018).

## CONCLUSION

Based on the research results, the highest misconception in protein synthesis topic was in the concept of RNA characteristics with the percentage of 65%, RNA translation by 53%, DNA replication by 53%



and DNA characteristics by 52%. The lowest misconception was in the concept of mRNA function with the percentage of 9%. The factors that cause misconception were students' lack of interest in protein synthesis topic, teachers were too fast in explaining the information, learning methods were limited during the Covid-19 pandemic, and the information in textbooks was incomplete and difficult to understand.

## SUGGESTION

Testing the application of models, methods, or learning media that are able to reduce student misconceptions on protein synthesis topic, especially in the concept of RNA characteristics, DNA replication, and the translation process.

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