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Strengthening the Molecular Biology Concept of DNA as the Basis for Disease Pathogenesis in MGMP Biology of Malang

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Abstract

Teachers' and students' understanding of the molecular structure of DNA (Deoxyribonucleic acid) is important because it is a fundamental concept that explains the pathogenesis of disease and mutations in cell biology learning. This activity aims to improve Biology teachers' understanding of the molecular structure of DNA. The activity was conducted at SMAN 1 Bululawang Malang, with 39 Biology teachers who were members of Malang's Biology Subject Teachers' Community (MGMP) as participants. The methods used included interactive lectures, group discussions, and case studies on sickle cell anemia. The resources utilized for the community service included laptops connected to Wi-Fi, Google Forms for pre-test and post-test applications, PowerPoint slides for the materials, patient scenario PPT, and laptops. Evaluation was carried out with pre-tests and post-tests to measure the improvement in participants' understanding. The evaluation results showed that participants gave positive feedback regarding the activity. They felt that there was an application of the chemical structure of DNA bands to the shape of DNA, the bioprocess of protein synthesis, and the pathogenesis of sickle cell anemia. A significant increase in conceptual understanding was observed, with an average pre-test score of 67.69 and an average post-test score of 92.05. The five teachers who obtained the highest scores received prizes in the form of medical biology books, which were authored by us. Similar programs are recommended for implementation in other areas to support the improvement of education quality in Indonesia and benefit students who will pursue medical courses.

Keywords: Molecular; Biology; DNA; Teacher; MGMP; Sickle Cell Anemia.

Abstrak

Pemahaman guru dan siswa terhadap struktur molekul pita DNA (Deoxyribonucleic acid) penting karena teori dasar untuk menjelaskan patogenesis penyakit dan mutasi dalam pembelajaran Biologi molekuler. Kegiatan ini bertujuan untuk meningkatkan pemahaman guru Biologi mengenai struktur molekul pita DNA. Kegiatan dilaksanakan di SMAN 1 Bululawang Malang. Mitra kegiatan adalah 39 guru Biologi yang tergabung dalam Musyawarah Guru Mata Pelajaran (MGMP) Biologi di Malang. Metode yang digunakan meliputi ceramah interaktif, diskusi kelompok, dan studi kasus penyakit anemia sel sabit (sickle cell anemia). Properti yang digunakan dalam pengabdian adalah laptop yang terkoneksi dengan wifi, aplikasi google form untuk pretest dan posttest, ppt materi, ppt skenario pasien, dan laptop. Evaluasi dilakukan dengan pre-test dan post-test untuk mengukur peningkatan pemahaman peserta. Hasil evaluasi menunjukkan peserta memberikan respon positif untuk kegiatan ini. Peserta merasakan ada aplikasi struktur kimia pita DNA terhadap bentuk DNA, bioproses sintesis protein, dan

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menjawab patogenesis penyakit anemia sel sabit. Ada peningkatan signifikan dalam pemahaman konsep, dengan nilai rata-rata pre-test sebesar 67,69 dan nilai rata-rata post-test sebesar 92,05. Lima orang guru yang memperoleh nilai tertinggi mendapatkan hadiah berupa buku biologi kedokteran dari kami selaku penulis buku tersebut. Program serupa direkomendasikan untuk diterapkan di tempat lain guna mendukung peningkatan kualitas pendidikan di Indonesia dan siswa yang akan mengambil kuliah jurusan kedokteran.
Kata Kunci: Biologi molekuler; DNA; guru; MGMP, anemia sel sabit.

INTRODUCTION

Molecular biology is a branch of science that focuses on the complex molecular and fundamental mechanisms that control all living organisms (Christian, 2023). Molecular biology also deeply analyzes mutations that occur in DNA and RNA, which often serve as factors causing various genetic diseases. These diseases include cancer, metabolic disorders, and neurodegenerative diseases (Adrianto *et a*l., 2023; Amshawee *et a*l., 2024). Technologies used in molecular biology, such as Polymerase Chain Reaction (PCR) and DNA sequencing, are crucial for diagnosing genetic abnormalities, detecting pathogens, and developing targeted therapies. Genetic engineering techniques like CRISPR-Cas9 have enabled the modification of organisms for various purposes. This includes the production of genetically modified crops and the development of gene therapies, which can directly impact the treatment of genetic diseases (Christian, 2023). Molecular biology is crucial in biotechnology and medicine, driving advancements in genomic medicines, gene therapy, recombinant DNA, CRISPR/Cas9, genome editing, and personalized treatments (Rida, Mustafa and Salar, 2024). Understanding the basics of molecular biology of diseases is crucial for developing effective diagnostic and therapeutic strategies.

The field of molecular biology not only focuses on biological aspects but also establishes close connections with various other disciplines, such as chemistry, enzymology, proteomics, cellular biology, informatics, and mathematics, to explain the principles of molecular interactions in various biological processes and model these biological processes (Adrianto *et a*l., 2023). One branch of molecular biology that is advancing is Computational Molecular Biology. This field combines computer science, statistics, and biology to solve problems in molecular biology, such as understanding the structure and function of biological molecules. This knowledge can be used to design more effective drugs, discover new therapeutic targets, and understand disease pathways and mechanisms (White and Lee, 2023).

Mastery of molecular biology has become a career demand of the 21st century in the biotechnology industry, data science, medical technology, research, education, healthcare professions, and other interdisciplinary fields, making it essential for learners to acquire this knowledge (Black, 2020). Molecular biology is taught in 12th grade in school. However, in 11th grade, students study cellular biology as the foundation for understanding the location of genetic material. Molecular biology remains a mandatory subject at the undergraduate, master's, and doctoral levels in higher education. Previous research has implemented a molecular biology learning method using Project-Based Learning for second-year pharmacy students at KAU, Saudi Arabia. The purpose of PJBL is to enhance communication, project management, and teamwork skills. The study recommends the implementation of PJBL in medical biochemistry and molecular biology education, as PJBL effectively enhances active learning in molecular biology and improves communication and teamwork (Elsamanoud*y et a*l., 2021).

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The discovery of the DNA structure by Watson and Crick in 1953 is recorded as a pivotal moment in molecular biology (Cortés, 2023). This discovery laid the foundation for understanding how genetic information is preserved and transferred, which forms the basis for studying genetic diseases (Privalov, 2020). The structure of DNA is crucial because it provides insight into how genetic information is preserved and passed down from generation to generation. This understanding is fundamental to the study of genetic diseases and the development of biotechnology applications (Christian, 2023). Previous study has reported the impact of teacher competence on students' understanding of the subject matter (Maulidya and Ulfah, 2023). The understanding of both teachers and students regarding the structure of the DNA molecule (Deoxyribonucleic acid) is important to make it easier to explain the pathogenesis of diseases and mutations in biology lessons at school. A study introduced PCR techniques to high school biology teachers in Banjarbaru and Banjar Regency, South Kalimantan, to improve their competence and professionalism (Mursyidi*n et a*l., 2023). DNA isolation can be used as a skill and tool that enables students to observe genetic material using simple materials and affordable equipment (Al*i et a*l., 2023). The development of an Augmented Reality application using the ADDIE method with Unity3D and Vuforia was rated positively by 86% of students and has the potential to become an alternative media for understanding DNA material (Nur'aini, Mukaromah and Muhlisoh, 2019). In this community service, the team will provide an in-depth understanding of molecular biology concepts to the biology teacher community using case studies. The case studies will be written in the form of a narrative about a patient.

GENERAL DESCRIPTION OF THE COMMUNITY, PROBLEMS AND TARGET SOLUTIONS

General description

The MGMP Biology of Senior High Schools in Malang Regency is a community of biology teachers from both public and private high schools spread across Malang Regency. This year, there are 40 active members. In this community service activity, the position of the MGMP Biology of Malang Regency has significant potential and strategic importance in the field of education, namely: (1) Biology teachers have a regular agenda to meet once a month to socialize, discuss, and learn new things to improve their competencies, (2) The majority of biology teachers in Malang Regency are young adults with a high enthusiasm for learning, (3) Biology teachers play a strategic role in providing education and correct understanding to students.

Problem

Molecular biology material was a request from the MGMP Biology community of Malang Regency. Molecular biology remains a challenge for biology teachers in Malang Regency because the material is abstract. Biology teachers must be able to explain molecular biology in a simple and easily understandable way for students. The educational background, which is not from a medical field, also becomes a challenge for biology teachers in connecting molecular biology material with examples of everyday diseases in humans.

Tabel 1. Problem and solution

No	Problem	Solution	Indicators of goal
1	Education: Knowledge level	Knowledge transfer	Increase skor knowledge

Target solution

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The solution provided was to offer a detailed understanding of molecular biology concepts, starting from studying the structure of monomers, polymers, chemical structure, chemical bonds, the molecular structure of DNA, and base mutations in nitrogenous bases. Additionally, the service team designed a scenario of a female patient suffering from sickle cell anemia as an effort to connect the benefits of learning DNA structure and base mutations in explaining the mechanisms of disease occurrence.

METHOD

The distance between the service team's institution and SMA Negeri 1 Bululawang is 109 km. The activity was held at SMA Negeri 1 Bululawang Malang. The partners in this activity were 39 Biology teachers who are members of the Musyawarah Guru Mata Pelajaran (MGMP) Biology in Malang. The first stage involved the service team coordinating with the MGMP Biology management to determine the date, month, location, event rundown, and the material to be presented. The second stage was for the service team to prepare the teaching material and case scenario that would be presented to the participants. The chosen topic for the disease was sickle cell anemia. The third stage was the implementation of the activity, starting with speeches from the principal of SMA Negeri 1 Bululawang Malang, the MGMP Biology supervisor, the chairman of MGMP Biology, and the head of the service team. After the speeches, a group photo was taken. Before the main activity began, participants completed the pre-test, followed by material presentation, discussion, post-test, and completion of the participant feedback questionnaire. Books were given as prizes to participants with the highest scores. The fourth stage was to analyze the results of the pre-test, post-test, and participant feedback.

The methods used in this community service activity included interactive lectures, group discussions, and case studies on sickle cell anemia. The equipment used in the service activity included a laptop connected to Wi-Fi, Google Forms for the pre-test and post-test, PowerPoint presentations for the material and patient scenario, and laptops.

Evaluation was conducted through the pre-test and post-test to measure the participants' understanding of the material presented by the service team. The pre-test and post-test results were analyzed descriptively to obtain data on the class average, highest score, lowest score, and the number of participants who answered each question correctly. The analysis of the participant feedback questionnaire was presented in a descriptive table.

RESULTS AND DISCUSSION

"In general, the community service activity ran smoothly. The event began with the opening by the MC, followed by speeches from the principal of SMA Negeri 1 Bululawang, the supervisor of the MGMP Biology of Malang Regency, the chairman of the MGMP Biology of Malang Regency, and the head of the service team (Figure 1). Before the principal of SMA Negeri 1 Bululawang left, a group photo was taken with all members of the MGMP Biology of Malang Regency and the service team (Figure 2).

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Figure 1. Opening of the activity with a speech

Figure 2. Group photo

The service team began the activity by administering a pre-test to the participants. Participants answered 10 pre-test questions using the Google Form application. After all participants completed the pre-test, the service team proceeded with delivering the material. The team started with a scenario of a female patient suffering from sickle cell anemia. The service team invited participants to discuss where the application of molecular biology concepts could be applied in the scenario (Figures 3-4).

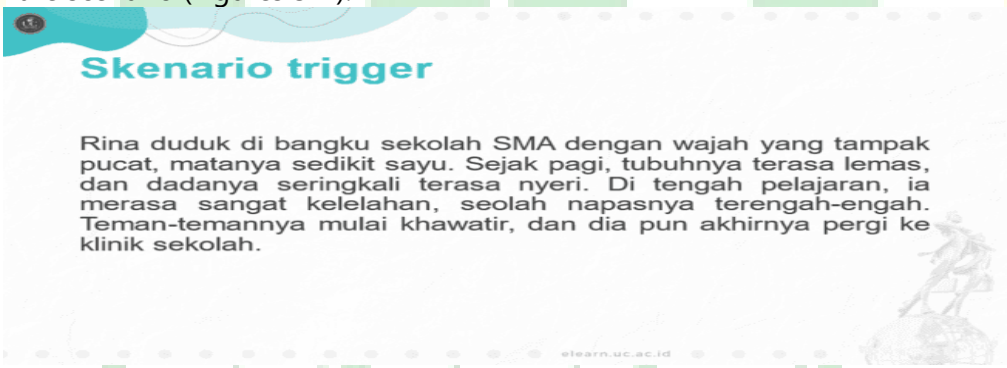

Figure 3. Learning scenario 1

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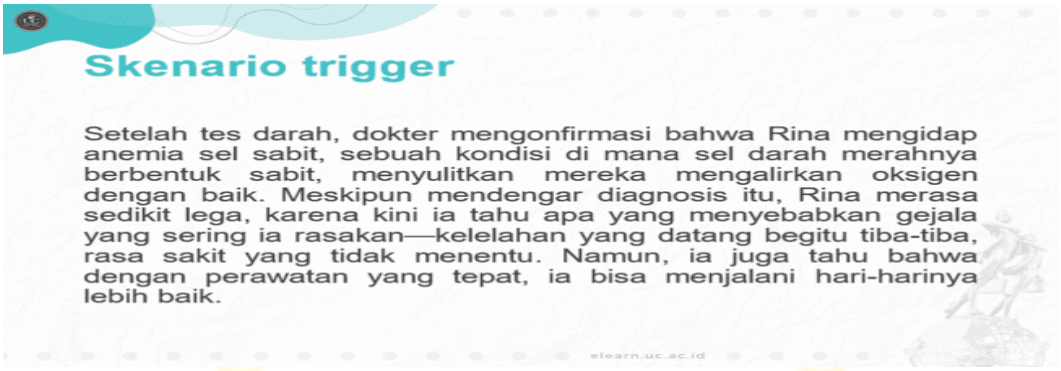

Figure 4. Learning scenario 2

During the material presentation, participants were enthusiastic to discuss and answer questions posed by the service team (Figure 5). Participants were also active and unafraid to ensure the accuracy of their understanding of the material presented (Figure 6).

Figure 5. Participants answering questions posed by the service team

Figure 6. The session where participants asked questions

From the analysis of the pre-test and post-test, it was found that there was an improvement in participants' knowledge, from a score of 67.69 to 92.05. In the post-test results, the lowest score of 50 was still found, with one participant scoring this value. This may be due to some participants also serving as guest receivers or managing the catering (lunch), or because some participants do not teach molecular biology in the 12th-grade class, or they may need more time to quickly understand the biological material (Table 1). This measurement is important to ensure that teachers can avoid misconceptions after learning new material (Santoso and Primandiri, 2020)

Table 1. Pre-test and post-test results of participants

	Pre-test	**Post-test**
Class average	67,69	92,05
Lowest score	30 (3 orang)	50 (1 orang)

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Highest score	100 (2 orang)	100 (23 orang)

The analysis of the number of participants who answered each question correctly in the pre-test and post-test showed that during the pre-test, participants most frequently answered question number 3 correctly and most often answered question number 5 incorrectly. The analysis of post-test answers revealed that 39 participants (100%) answered question number 9 correctly, while 38 participants (97.4%) answered questions number 1, 3, and 6 correctly, and 37 participants (94.8%) answered question number 2 correctly (Table 2)

Table 2. Number of participants answering each question correctly

Question number	Question	Number of participants answering correctly (N= 39)	
		Pre-test	Post-test
1	At which carbon atom of the pentose sugar is phosphate attached?	27/39	38/39
2	What is the name of the monomer of DNA?	30/39	37/39
3	Which of the following is correct regarding purine bases?	39/39	38/39
4	At which carbon atom of the sugar is the nitrogenous base attached?	21/39	31/39
5	At which carbon atom of the sugar is the structural difference between DNA and RNA located?	13/39	34/39
6	How many carbon atoms does the pentose sugar have?	33/39	38/39
7	Which structure of DNA is related to mutation events or abnormal structures?	31/39	36/39
8	Which component is not present in the structure of a nucleoside?	26/39	35/39
9	Which of the following statements about the structure of DNA is WRONG?	30/39	39/39
10	Which of the following statements about nitrogenous bases in DNA is WRONG?	14/39	33/39

In general, participants gave positive feedback, where they gained more in-depth and detailed material. Participants who previously had limited understanding of the material were now able to master it, and those who were confused before are no longer confused. A complete summary of the participants' impressions of the material presented by the service team is shown in Table 3.

Table 3. Participants' impressions

Participants' impressions
I understand the importance of presenting a scenario before starting the material.
A useful takeaway from today's MGMP activity is how we can analogize a subject related to real-life objects that students can understand more easily, as well as gaining a better understanding of the molecular structure of DNA.
It was interesting because I learned something new that I hadn't studied before.

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Participants' impressions
I gained new knowledge.
I can now explain this to my students.
I now know the secrets of the 3' and 5' ends of the DNA strand.
It expanded my knowledge.
The material was very interesting.
The structure of DNA is more complex.
The material was extraordinary and easy to understand.
The material presented was more detailed than what I had previously learned, so I now have a better understanding of genetic material.
The learning was easy to understand.
Today's material was very interesting, where we as teachers often explain DNA issues but haven't really understood its biomolecular details. Thank you very much for the knowledge.
The way to teach students: When biology involves a lot of imagination, don't add more imagination.
I gained new knowledge.
The presentation on the chemical structure of DNA.
I get detailed explanation.
Learning the DNA structure in more detail.
My knowledge has increased.
More detail in the material delivery.
I received a deeper understanding of DNA-related material and was taught how to explain it to students in a more engaging way using real-life analogies.
Explanation of DNA molecule material.
Gained more knowledge about DNA.
Learning more about molecular biology in detail.
It was very interesting because the material provided new knowledge for me.
It broadened my understanding of molecular biology.
It added insight into cell and molecular biology and interpretation that makes it easier for students to understand.
I now understand the structure of DNA in more detail.
I received new material, and it was very detailed.
It was very interesting because I gained a correct and fresh conceptual understanding.
I got clarity and more detailed explanations about genetic material.
Molecular formula with carbon atom specifications.
Simple material.
It increased my knowledge.
It refreshed and deepened my understanding of genetics and molecular biology.
I am very satisfied and found it interesting.
I am now able to understand molecular biology material better.
A little bit of understanding.
The explanation of DNA material was engaging and easy to understand, but I still don't fully grasp the biomolecular processes in detail.

In the future, participants will not only learn theoretical concepts but also be introduced to molecular biology technology and laboratory techniques. Molecular technology has great potential to strengthen Future-Oriented Pedagogy (FOP) and inquiry-based teaching (Sachyan*i*

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et al., 2023). The five participants who successfully completed the questions with the highest scores received a book titled *Biologi Kedokteran* as a prize from the service team. This book was written by the service team themselves. The service team stated that participants could study molecular biology materials more in-depth in the book (Figure 7).

Figure 7. The five participants with the highest scores received prizes

CONCLUSIONS AND SUGGESTIONS

There was a significant improvement in conceptual understanding, with an average pre-test score of 67.69 and an average post-test score of 92.05. Similar programs are recommended to be implemented elsewhere to support the improvement of teacher quality in Indonesia and students who will pursue a medical degree

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