

# Assessment of Biological Literacy Levels Among Third-Grade Secondary School Students in Medina

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## Abstract

This research aims to assess the levels of biological literacy (nominal, functional, structural, and multi-dimensional) among students of the third grade of scientific secondary school in Medina. To achieve the objectives of the research, the researcher used the descriptive and analytical method, and a sample of (340) students was selected by the random cluster method. A scale was prepared in the light of Project (2061) Vision, and the Uno and Bybee model (Uno & Bybee, 1994) to assess students' ability to identify biological concepts (nominal literacy), define some biological concepts (functional literacy), and understand biological diagrams (structural literacy), and measuring some students' skills on understanding a short biological text (multi-dimensional literacy). The results reflected a high level of nominal literacy and a low level of multi-dimensional literacy. The results also showed that the students possessed the functional level and the structural level. The study recommends that biology teachers use effective teaching methods that enable them to present biological knowledge in the form of social issues and problems related to technology and other sciences.

**Keywords:** biological literacy, Project (2061), secondary school, Uno and Bybee's model

## 1. Introduction

Biology is one of the most important and dangerous sciences in the 21st century thanks to biological achievements and the developments and changes they have brought about in human life and the surrounding environment. In fact, the current era is called the era of the "biological revolution" (Al-Wasimi, 2003). Biology is the pioneering science and foundation in the daily lives of people in general (Suwono, Pratiwi, Susanto, & Susilo, 2017). This places on the shoulders of scientific education the responsibility of preparing a generation capable of life in accordance with the requirements of the time.

Rutherford (2009) pointed out that through reports that showed the weakness of scientific education curricula and science education in preparing a scientifically educated generation; the Global Reform Project (2061) came to light in (1985). Project (2061) targets educate for a scientific literacy that encompasses all students so that they can understand and comprehend scientific processes and events going on around them, and learn how the natural and technical worlds work and interact with each other (Dass, 2005).

Scientific literacy is a major goal of scientific education in the 21st century (Juma, 2015). Biology contributes to the support and development of the scientific literacy of learners to a degree more than other sciences. Biology is a valuable resource and an important resource for developing the scientific literacy of learners (Wei & Xia, 2016). biological literacy is the supreme goal and primary purpose of teaching biology according to scientific standards of modern teaching of biology (Xiuli, 2015).

Biological literacy refers to scientific literacy in biology subjects (Suwono et al., 2017). So, a biologically educated individual should be scientifically educated. A biologically educated individual needs knowledge of biological concepts and their historical development, biological principles and human impacts on the biosphere, knowledge of the impact of biological diversity and biotechnology on the society, as well as awareness of the importance of biology. Therefore, the essence of biological literacy is to understand the general principles of biology and their implementation in personal and social life (Onel & Durdukoca, 2019).

The biological literacy model developed by Uno and Bybee (1994) represents different levels of students' understanding of biological concepts. The model includes four levels of biological literacy, namely: Nominal,

functional, structural and multi-dimensional. These levels differ according to the students' characteristics, as shown in Table 1.

Table 1. Assign students to the four levels of biological literacy according to Uno and Bybee Model

Level	Attributes
Nominal	Define concepts of a biological nature
	May have misconceptions
	Offer naive explanations for biological concepts
Functional	Use of biological vocabulary
	Define the terms correctly
	Deaf memorization of concepts
Structural	Understand conceptual diagrams of biology
	Possesses knowledge and procedural skills
	Interprets biological concepts in his own way
Multi-dimensional	Realizes the value of biology among other disciplines
	Knowledge of the history and nature of biology
	Understand the interactions between biology and society

Source: Uno and Bybee (1994, p. 554).

Biological concepts are among the most important components of biological literacy. Their understanding does not aim to achieve attainment in itself. Rather, it requires the learner's ability to apply them in understanding biological phenomena and issues (Zaki, 2012). Biological literacy is not an endpoint that can be reached during the completion of the biology course. It is, rather, a continuous process aimed at improving the understanding of individuals throughout their lives. Also, biological literacy is not a goal that the individual achieves or does not achieve, in the sense that he is biologically literate or not biologically literate; rather, each individual occupies a specific position along a continuum of biological literacy of different biological concepts (Uno & Bybee, 1994).

The student may have different levels of biological literacy at the same time. The student may attain a low level of biological literacy on the subject of meiosis, while possessing a high level in zoology. The student may be classified within the nominal level of biological literacy on the subject of plant physiology while it is in a multi-dimensional level in terms of human physiology (Onel & Durdukoca, 2019). A student can gradually move across levels of biological literacy to the highest level, while most students cannot (Uno & Bybee, 1994).

The educational literature reported several studies that dealt with the dimensions and levels of biological literacy. So, Onel and Durdukoca (2019) conducted a study aimed at determining the predictive power of biological literacy in the academic achievement of secondary school students in Turkey. The results showed that students have a high level of biological literacy in all its dimensions (nominal, functional, structural, and multi-dimensional).

Purwani, Sudargo, and Surakusumah (2019) conducted a study aimed at analyzing the scientific literacy skills of tenth grade students in Indonesia. The results showed that the students' scientific literacy skills are low.

Fitriani, Harahap, and Manurung (2018) conducted a study aimed at assessing the scientific literacy skills of biology among eleventh grade students in Indonesia. The results showed that the students possess a low level of scientific literacy.

Al-Rasheed (2018) conducted a study aimed at revealing the extent of the availability of the dimensions of scientific literacy in the exam questions for science teachers for the first grade of secondary school in Saudi Arabia. The results of the study showed the weakness of the availability of the scientific literacy dimensions in the test questions with the exception of the scientific knowledge dimension.

Post, Semilarski, and Laius (2017) conducted a study aimed at assessing the cognitive components of biological literacy in Estonia's tenth and eleventh graders. The results showed that the students had a high level of biological knowledge, a medium level of problem-solving skills, a low level of decision-making skills and creative fluency.

Al-Lulu (2010) conducted a study aimed at identifying the level of biological literacy among student's science teachers in Palestinian universities in Gaza. The results of the study showed that students having of all the requirements of biological literacy are less than the required standard.

Faqihi (2010) conducted an analytical study of the content of biology books at the secondary stage in Saudi Arabia

in the light of the scientific education standards. The results showed a low level of achieving the following standards within the content of biology books: (Science and technology, science from a personal and social perspective, research and experimentation). And that the content of biology books did not cover biological topics sufficiently, at a rate of 43.20%.

Ghoneim (2006) conducted a study aimed at investigating the extent to which female students of the third grade of scientific secondary school in Saudi Arabia have acquired the elements of scientific literacy. The results of the study showed that the level of scientific literacy among female students is low and less than the required level.

Bakhsh (2004) conducted a study aimed at measuring the level of scientific literacy among a sample of pre-university students in Saudi Arabia. The results of the study showed a low level of scientific literacy for male students at a rate of 60% compared to that of female students of 90%.

It is evident from the above and from the review of the theoretical framework and related previous studies that there is a global and local interest in scientific and biological literacy. Researchers' methods of evaluating scientific and biological literacy have varied according to their different philosophies and interests. Some of them focused on measuring the knowledge dimension, or measuring skills or trends, while other focused on analyzing the content of biology books or exam questions. The results of previous studies regarding the level of scientific and biological literacy among students varied. Some indicated a low level and others a high level. It was also noted that the studies are similar in the tools of measuring the level of scientific and biological literacy. Most studies used essay tests and multiple-choice, note cards, and questionnaires, and the student's score in the test or scale were used to determine the level of biological literacy that represents an integral unit. Most studies did not determine the level of biological literacy in detail for each dimension. There was noticed a scarcity of Arab studies that investigated the topic of biological literacy in general, beside absence of a study in the Saudi environment that examined the level of biological literacy among public or university education students in particular. From here this research came to explore levels of biological literacy for third-grade secondary students in Saudi Arabia using different and appropriate measurement tools for each level, according to Project (2061) Vision, and the Uno and Bybee Model for Biological Literacy.

### *1.1 Research Problem*

The general objectives document for science education in the Kingdom of Saudi Arabia mentioned some goals related to scientific literacy, the most important of which is the learner's possession of a scientific and technical literacy that enables him to keep pace with scientific and technical developments, and make the right decisions in daily life situations, and educate the learner in a way that enables him to maintain his safety and the health of his community in addition to the development of learner behaviors as to positively address environment and natural resources (Ministry of Education, 2002).

The results of PISA in (2018) showed that Saudi Arabia ranked (65) among (78) participating countries. Its results in science were (386) points, while the international average was (489). About 61.4% of the participating students did not achieve the baseline for proficiency in science (<http://www.oecd.org/pisa>). The results of the TIMSS test in (2015) showed that Saudi Arabia's ranking for the second intermediate grade science test was (32) with a total of 396 points. As for the fourth-grade science test, Saudi Arabia's ranking was (40) with a total of 390 points, out of (64) Participating countries (<http://www.timss.org>).

Zaki's (2012) study indicated that the learners suffer from a severe lack of scientific and cultural knowledge, and it is necessary to study the biological achievements that constitute one of the important factors for preparing educated and aware future students. Al-Shahrani (2000) believes that the interest of science teachers revolves around one dimension of scientific literacy, which is the knowledge aspect only and the absence of other dimensions for the teacher and his students. 90% of Saudi students think that the efforts made to spread scientific literacy in the Saudi society are insufficient (Sabry & Al-Yamani, 2008). Hence, this research came to assess levels of biological literacy among third-grade scientific secondary students in Medina.

### *1.2 Research Objective and Questions*

This research aims to assess the biological literacy levels of third-grade scientific secondary students in Medina. It answers the following questions:

- 1) What is the level of nominal biological literacy to third-grade scientific secondary students in Medina?
- 2) What is the level of functional biological literacy to third-grade scientific secondary students in Medina?
- 3) What is the level of structural biological literacy to third-grade scientific secondary students in Medina?
- 4) What is the level of multi-dimensional biological literacy to third-grade scientific secondary students in

Medina?

### *1.3 Research Importance*

The theoretical importance of research lies in the revelation of the learners' biological literacy levels, formed as a result of their educational experiences over years of general education. This research provides a cognitive (theoretical) framework on the subject of biological literacy to be of help to interested persons and researchers. This research is also considered one of the rare researches in the Saudi environment, according to the researcher's knowledge, which dealt with the revelation of biological literacy levels.

The practical importance of research is evident in clarifying levels of biological literacy and learner characteristics for each level for biology teachers. This may be reflected in their techniques and methods of teaching about enhancing the understanding of biological knowledge among learners. The research provides a suitable method for biology educators to assess the level of biological literacy in their students, and may adapt and develop it to create their own evaluation models that befit the nature of the biological topic and the level of their students. The results of this research may be useful in providing feedback to those responsible for authoring and developing biology textbooks regarding their role in developing biological literacy among learners.

### *1.4 Research Limitation and Determinants*

The results of the research are generalizable in light of the following limitations and determinants:

- The limits of the research are limited in its application to a sample of male students in the third grade of scientific secondary school in government secondary schools affiliated to the Northern Region Education Office Administration in Medina. The research was implemented during the second semester of the academic year 2020.
- The determinants of research in collecting data are limited to dealing with the topic of genetics in biology, and evaluating the biological literacy levels of students through the scale prepared by the researcher.

### *1.5 Definitions conceptual and Procedural of Research Terms*

A number of basic terms were mentioned in this research, the following are their procedural and conceptual definitions.

**Biological Literacy:** It means the student's ability to understand biological principles and concepts and their applications in a comprehensive manner and appropriate methods for activities from a social and personal perspective" (Zaidan, Abu Samra, Jaber, & Al-Barghouti, 2004, p. 193).

Onel and Durdukoca (2019, p. 216) defined levels of biological literacy as follows:

**Nominal Level of Biological Literacy:** "The student at this level can distinguish the concepts that belong to biology, but he has little knowledge of their meaning and uses." Procedurally: It is the student's ability to knowledge of biological concepts according to the Likert three-way scale.

**Functional Level of Biological Literacy:** The student at this level can define the biological concepts correctly, but he has a limited understanding of the concepts due to the weakness of the cognitive structure of the concepts. Procedurally: It is the student's ability to choose the correct concept for each definition within a list of biological concepts.

**The Structural Level of Biological Literacy:** "The student at this level understands the conceptual knowledge diagrams for biology and the ideas that contribute to the organization of all biological thinking, and can explain biology topics in his own words. The student at this level would like to have more information about the biology topics that he is interested in". Procedurally: It is the students' ability to understand the following two biological charts (red-green color blindness disease, and Down's syndrome).

**The Multi-Dimensional Level of Biological Literacy:** "It is the highest level of biological literacy, and requires detailed knowledge of biology topics to encompass philosophical, historical, social and technological dimensions. "A student who possesses a multi-dimensional biological literacy can relate biology topics to other topics and disciplines. Procedurally: It is the students' ability to understand a biological text and answer the essay questions that follow.

**Project 2061:** "It is a future vision adopted by the American Association for the Advancement of Science (AAAS) to develop (reform) science curricula to create scientifically, mathematically, and technologically educated citizens, where they acquire an understanding of the principle of science learning in order to know how to interact between science, technology, and society, and hence have the ability to use and apply this understanding for personal and societal benefit "(Al-Maghrabi, 2019, p. 464).

Uno and Bybee Model: “It is a model of biological literacy through which the scholars Uno and Bybee defined four dimensions of biological literacy, namely (nominal, functional, structural, and multi-dimensional), and the characteristics of the learner within each dimension in the light of his knowledge of biological concepts and principles” (Uno & Bybee, 1994, p. 554).

## 2. Research Methodology and Procedures

This research is classified within the descriptive studies that follow the analytical method. It deals with the study of concepts, phenomena and practices in which the researcher does not interfere, and he can describe and analyze them.

### 2.1 Research Community and Sample

The research community consisted of third-grade scientific secondary students in government secondary schools affiliated to the Northern Region Education Office in Medina, for the second semester of the academic year 2020, and their number 1108 students distributed to 13 schools, according to the official records of the Office Education Administration. As for the research sample, it reached 340 students from 5 secondary schools, who were chosen by the random cluster method. The sample was chosen from the third-grade scientific secondary school students because they studied many biology and science courses in the previous school stages, and thus they formed a variety of biological knowledge.

### 2.2 Research Tool: Biological Literacy Level Assessment Scale

To collect research data, the researcher built the search tool by the according to the following steps:

- Review of the educational literature and previous studies related to assessing the level of biological literacy (Onel & Durdukoca, 2019; Fitriani et al. 2018; Post et al. 2017; Al-LuLu, 2010; Ghoneim, 2006; Bakhsh, 2004).
- Revision to biology textbooks in the Kingdom of Saudi Arabia for the secondary level; To get acquainted with their biological contents and issues. The content, questions and activities of the textbooks have been used in selecting the scientific material (genetics), and designing the research tool.
- A scale was prepared to assess biological literacy levels in the light of Project (2061) Vision, which confirms that the learner has scientific and functional knowledge that enables him to make the right decision in his daily life, in addition to the learner’s ability to understand the overlap between science, technology and society (Al-Maghrabi, 2019; Hathout, 2019). In addition, the Uno and Bybee Model (1994) was adopted, including four levels of biological literacy, namely: (Nominal, functional, structural, multi-dimensional), in addition to the characteristics of the learner within each level. The scale includes four parts:

#### 1) Identify biological concepts (nominal level)

This part aims to assess the nominal level of biological literacy, by presenting a list of five biological concepts, namely: Gametes, genetic crossing over, law of segregation, genetic code (codon) and hybrid. Then the student determines his level of familiarity with the concept within the Likert three-way scale: I don’t know the concept completely - I know the concept partially - I understand the meaning of the concept.

#### 2) Definition of biological concepts (functional level)

This part aims to assess the functional level of biological literacy, by presenting the definition of five biological concepts, namely: (DNA genetic fingerprint, genetic engineering, mutation, recessive trait and morphological patterns). The definition of the concept was presented scientifically and socially (how to use it in daily life). The student was then asked to choose the correct concept for each definition within a list of biological concepts.

#### 3) Understanding biological diagrams (structural level)

This part aims to assess the compositional level of biological literacy, by presenting two biological diagrams, the first related to red-green color blindness, followed by six statements that measure the student’s level of understanding of the diagram and the extent to which he understands the application of knowledge in his daily life, by evaluating the student’s decision about the statement authenticity.

The second diagram relates to Down’s syndrome, and the student was asked to complete the (6) blanks by choosing the correct answer from among three alternatives, which shows the extent of the student’s possession of scientifically and socially correct biological knowledge.

#### 4) Biological text titled sickle cell anemia (multi-dimensional level)

This part aims to assess the multi-dimensional level of biological literacy, by proposing a paragraph about sickle

cell anemia, and then posing four essay questions that measure students' biological knowledge and the extent to which they have four skills, namely: Using prior biological knowledge, linking biological knowledge to daily life (society), linking knowledge to scientific and technical advancement (technology), and linking biological knowledge to other scientific knowledge (physical, chemical, environmental).

### 2.3 Search Tool Validation

The tool was presented to a group of experienced and specialized from among the teaching staff specializing in science curricula and teaching methods, measurement and evaluation specialization, and biology teachers in order to judge the nature and suitability of the methods that were used to measure each level of biological literacy, as well as the validity and suitability of the scientific content for the age level in the study sample. The reviewer's comments were taken in to account, including making slight amendments to the scientific and linguistic formulation. The search tool was applied to (30) students from outside the target research sample in order to know the time required to apply the research tool. It was found that it needed (45) minutes.

### 2.4 Search Tool Stability

The stability of the search tool was calculated using the internal consistency method, using the Kuder-Richardson 20 equation, where the stability coefficient was (0.79), which is a statistically acceptable value (Odeh, 2010). For confidence in the method of analysis for the answers to the essay questions, the writings of five students from outside the target sample were analyzed in the research, and the researcher coded them with the help of another experienced colleague before the actual start of the research. They analyzed the data as a training method before going into the formal analysis, each using his characteristics independently, with discussion of some details, and the consensus percentage was calculated, and the process was repeated until the agreement rate became above 80%.

### 2.5 Research Data Analysis

- To correct the part related to the nominal level, Likert three-way scale was adopted, and the number (3) was given to indicate "I understand the meaning of the concept", the number (2) to indicate "I know the concept partially", and the number (1) to indicate "I do not know the concept completely".
- For the correction of the functional and compositional level part, one score was given for the correct answer, and zero was given for the wrong answer.
- To correct the section related to the multi-dimensional level, the students' written responses were analyzed according to scale (1-3) as follows:
  - Grade (1): For general answers and explanations that are inconsistent with scientifically correct biological knowledge, reveal a lack of understanding, or are irrelevant.
  - Grade (2): For partially correct answers, which are either contradictory that is, in agreement with scientifically correct biological knowledge in some parts and different in other parts, or that include partial understanding, i.e., showing a limited ability to understand.
  - Grade (3): For correct answers that are consistent with scientifically correct biological knowledge, and which demonstrate the ability to understand.

To judge the level of familiarity with biological concepts (the nominal level), and the level of multi-dimensional literacy according to the students' answers, the scores that fall between (1-3) degrees were converted, and the knowledge level was divided into three levels (low, medium, and high), and by subtracting the highest degree of the lowest degree is the result (2), then divide this score by (3), which is the number of knowledge levels, so the result is (0.66). This number has been adopted for the length of the category that determines the level, as follows: The level is low: Grade (1-1.66), intermediate level: Grade: (1.67-2.33), High-level score: (2.34-3).

### 2.6 Statistical Processors

The arithmetic means, standard deviations, percentages and frequencies were calculated to answer the research questions.

## 3. Search Results and Discussion

### 3.1 Discuss the Results Related to the First Question: What Is the Level of Nominal Biological Literacy to Third-Grade Scientific Secondary Students in Medina?

To answer this question, arithmetic means and standard deviations were calculated for students' answers for each of the proposed biological concepts and for the concepts as a whole. As shown in Table 2.

Table 2. Arithmetic means and standard deviations of students' answers to the familiarity with biological concepts

Concept	Arithmetic mean	Standard deviation
Gametes	2.86	0.654
Genetic crossing over	2.40	0.762
Law of segregation	2.56	0.512
Genetic code (codon)	2.48	0.621
Hybrid	2.45	0.654
All concepts	2.55	0.432

The results showed that the arithmetic mean of the level of familiarity with biological concepts as a whole (2.55) of the maximum degree (3), which means that the level of nominal biological literacy among students is high. The level of familiarity with biological concepts was calculated for the study sample, as shown in Table 3.

Table 3. Number and percentages of participating students on the level of familiarity with biological concepts (nominal level)

Concept familiarity level	Biological concepts					Total
	Gametes	Genetic crossing over	Law of segregation	Genetic code (codon)	Hybrid	
Understand the meaning of the concept (high familiarity)	88.23% (300)	52.94% (180)	51.18% (174)	47.1% (160)	46.47% (158)	57.18% (972)
I know the concept partially (medium familiarity)	8.24% (28)	32.94% (112)	44.11% (150)	47.6% (162)	48.82% (166)	36.35% (618)
I don't know the concept completely (weak familiarity)	3.53% (12)	14.12% (48)	4.71% (16)	5.3% (18)	4.71% (16)	6.47% (110)
Total	100% (340)	100% (340)	100% (340)	100% (340)	100% (340)	100% (1700)

The results, regarding the level of familiarity with biological concepts, showed that 57.18% of the participating students had a high familiarity with all concepts, while 36.35% of the participating students had a moderate familiarity with the concepts. Only 6.47% of students do not have familiarity with the concepts presented.

The results of this question agreed with the results of the study of Onel and Durdukoca (2019), which showed that students have a high nominal level of biological literacy. The results of this question differed with the results of Al-Lulu's (2010), Ghoneim's (2006), and Bakhsh's (2004) study, which showed that the level of biological and scientific literacy among students is lower than the required level.

This result can be explained by the fact that all the concepts presented were mentioned in the biology textbook for the third grade of secondary school, and were presented within the science curricula in the previous school stages, which gave students the opportunity to learn about them. Also, in order for the student to be able to understand the biology lessons or any scientific topic, he should be able to know and distinguish the basic concepts. General education in schools focuses on the learner's possession of a great deal of concepts and terminology in the textbook, so that he can build knowledge that helps him understand and perceive the scientific content. This confirms what Ghoneim's (2006) study indicated, that scientific concepts take a special priority within the science curricula in Arab countries in general.

Accordingly, the learner's possession of this level forms the basic foundation for understanding biological issues and passing through other biological literacy levels. Although the nominal level is the simplest level of biological literacy, the students' lack for this level means that they are at the level of biological illiteracy (Bybee, 1997).

### 3.2 Discussing the Results Related to the Second Question: What Is the Level of Functional Biological Literacy to Third-Grade Scientific Secondary Students in Medina?

To answer this question, the number and percentage of students who knew the genetic concepts correctly were calculated, as shown in Table 4.

Table 4. Number and percentage of students who have correctly defined the genetic concepts (functional level)

Concept	Percentage of correct answers	Number of students who answered correctly (the total number is 340)
DNA genetic footprint	70.6%	240
Genetic Engineering	63.2%	215
The boom	56.5%	192
Recessive trait	82.4%	280
Formal models	83.9%	285

The results showed that the percentage of correct answers ranged between 56.5% and 83.9%. The results of this question agree with the results of the study of Onel and Durdukoca (2019), which showed that students have a high functional level of biological literacy. And the results of Post et al. (2017) showed that students have a high level of biological knowledge.

The results of this question differed with the results of the study of Purwani et al. (2019), which showed that the skills of scientific literacy in general among students are low, and the results of the results of Al-Lulu' (2010), Ghoneim's (2006), and Bakhsh's (2004) study that showed the level of biological and scientific education among students is low and below the required level.

According to the results of this question, we note that more than two-thirds of the students have the ability to define biological concepts correctly, and this means that the students possess the functional level of biological literacy, and this result can be explained by the fact that students dealt with biological concepts and their definitions by presenting them in the textbook or during it is covered in the lessons of the biology course, in addition to the fact that students are exposed to questions within the school tests concerned with defining scientific concepts, and this confirms what Al-Rasheed (2018) indicated that the science teachers' exam questions focus on the dimension of scientific knowledge. And the previous theoretical literature referred to the interest of science teachers in the cognitive aspect as a dimension of scientific literacy (Zaidan & Al-Jallad, 2007; Al-Shahrani, 2000).

The explanation of students' ability to define concepts scientifically and socially is that the genetic concepts contained in the research tool have an impact on the student's daily life. The student may hear about them through the media, social media, health awareness campaigns, or discuss them with others in the environment in which he lives, which improves the student's curiosity to participate and debate about it by offering scientifically-based views and opinions.

### 3.3 Discussing the Results Related to the Third Question: What Is the Level of Structural Biological Literacy to Third-Grade Scientific Secondary Students in Medina?

In order to answer this question, the number and percentage of correct and false answers and "I don't know" answers were calculated for students on understanding the two biological diagrams. Students were asked to evaluate the correctness of the statements in relation to the first diagram, and to choose the correct answer in relation to the second diagram, as shown in Table 5.

Table 5. The number and proportions of correct, wrong, and "don't know" answers about understanding the two biological diagrams

The diagram	Percentage of correct answers	Percentage of wrong answers	Percentage of "I don't know" answers	Total answers
Red-green color blindness	68.23% (1392)	22.65% (462)	9.12% (186)	100% (2040)
Down's syndrome	66.47% (1356)	24.90% (508)	8.63% (176)	100% (2040)
Total	67.35% (2748)	23.78% (970)	8.87% (362)	100% (4080)

The results showed that the percentage of correct answers to understand the two diagrams ranged between 66% and 68%. The results of this question agree with the results of the study of Onel and Durdukoca (2019), which showed that students have a high structural level of biological literacy. And the results of Post et al. (2017) showed that students have a high level of biological knowledge, and a medium level of problem-solving skills.

The results of this question differed with the results of the study of Purwani et al. (2019) which showed that the



scientific literacy skills are generally low among students. And the results of Al-Lulu study (2010), which showed that students' level about of all biological literacy requirements is less than the required level, and the results of Ghoneim study (2006), which showed that the level of scientific literacy among students is low and less than the required level.

According to the results of this question, it is evident that most students are able to understand biological diagrams. This means that students have the structural level of biological literacy. This result can be interpreted that students are able to deal with conceptual diagrams and organize their biological ideas due to the fact that the biology courses, activities and questions contain many biological diagrams, offering to students an opportunity to train and handle them.

This result can be explained by presenting and discussing the diagrams between the teacher and his students during the lessons of the biology course in terms of how they are constructed and the relationship between the concepts and variables they contain, in addition to their understanding and interpretation. This, in turn, develops the students' ability to efficiently and effectively interact with biological subjects. This result can also be explained by the fact that understanding biological diagrams requires students to master biological concepts and link them together in a scientific way. And most students have proven their knowledge of the nominal and functional level of biological literacy, which was reflected on their structural level.

### 3.4 Discussing the Results Related to the Fourth Question: What Is the Level of Multi-Dimensional Biological Literacy to Third-Grade Scientific Secondary Students in Medina?

To answer this question, the arithmetic averages and standard deviations of the students' answers were calculated for each of the skills needed for multiple biological literacy, and for the skills as a whole. As shown in Table 6.

Table 6. Arithmetic means and standard deviations of students' answers about the skills needed for multiple biological literacy

Skill	Arithmetic mean	Standard deviation
Use of prior biological knowledge	1.68	0.532
Linking knowledge to society	1.48	0.556
Linking knowledge to technology	1.39	0.728
Linking biological knowledge to other scientific disciplines	1.28	0.896
All skills	1.46	0.512

It is noted from the results of the question that the arithmetic mean of the skills as a whole is (1.46) of the maximum degree (3), which means that the level of multi-dimensional biological literacy among students is low. The level of skills required for multi-dimensional biological literacy was also calculated for the study sample, as shown in Table 7.

Table 7. Numbers and percentages of students on the level of skills required for multi-dimensional biological literacy

Skill level (grade)	Skills				Total
	Using prior knowledge	Linking knowledge to society	Linking knowledge to technology	Linking biological knowledge to other disciplines	
(3)	18.82% (64)	5.88% (20)	2.35% (8)	1.18% (4)	7.06% (96)
(2)	29.41% (100)	25.88% (88)	23.53% (80)	22.35% (76)	25.29% (344)
(1)	51.77% (176)	68.24% (232)	74.12% (252)	76.47% (260)	67.65% (920)
Total	%100 (340)	%100 (340)	%100 (340)	%100 (340)	100% (1360)

These results show that 67.65% of the students were not able to use previous biological knowledge and link it to society, technology and other disciplines, while 25.29% of the students showed partial understanding and limited ability of the required skills, and showed a small percentage of students 7.06% advanced level of skills necessary

for multi-dimensional biological literacy.

The results of this question differed with the results of the study of Onel and Durdukoca (2019), which showed that students have a high level of multi-dimensional biological literacy. The results of this question are consistent with the results of the study of Fitriani et al. (2018), which showed that students have a low level of scientific literacy as a whole and for each skill separately. And the results of Post et al. (2017) showed that students have a low level of decision-making skills and creative fluency about biological literacy. And the results of Al-Lulu study (2010), which showed that students' possession of all the requirements of biological literacy is less than the required level. And the results of Ghoneim study (2006), which showed that the level of scientific literacy among female students is low and less than the required level.

The low level of multi-dimensional biological literacy among students can be explained by the lack of adequate opportunities and tasks that require students to use their previous knowledge and link their biological knowledge to their social life, technology and other scientific disciplines. This may be due to several reasons, including traditional teaching methods that focus on transferring scientific knowledge as it is without linking it to the student's daily life. In addition to the passive role of the student who receives, memorizes and retrieves knowledge during the test without thinking about its dimensions and looking at it from different sides. In addition to the lack of interest in the practical side of the biology course, and the failure to activate biology laboratories in schools in the required manner that enables a learner to apply the scientific knowledge he has learned. As well as the lack of visits to factories, institutions and scientific centers to see the practical environments that use scientific knowledge.

Also, these skills necessary for the development of a multi-dimensional biological literacy are not being taken care of or developed in the manner required in the school environment, whether during classroom activities or as part of exam questions or homework that is concerned with the cognitive aspect at the expense of other aspects. This is consistent with what was indicated by the results of Al-Rasheed's (2018) study regarding the weakness of the availability of the scientific literacy dimensions (the nature and history of science, scientific trends and methodology, science, technology and society) in test questions of science teachers.

This result can also be attributed to the nature of the biology curriculum by presenting biological knowledge using activities, pictures and illustrations without integrating them in an integrated manner with other scientific disciplines, and discussing the impact of social and technological aspects on them. Sometimes biological knowledge with a social and technological impact is presented in the form of enrichment activities that are not included in the curriculum plan and the learner does not pay them sufficient attention. This is consistent with what the results of the study of Faqihi (2010) indicated to the low achievement of the following scientific education standards (science and technology, science from a personal and social perspective, research and experimentation) within the content of biology books at the secondary stage in Saudi Arabia.

#### **4. Recommendations**

In light of the research results, the following recommendations can be made:

- 1) As the results of the research have shown a remarkable decline in the level of multi-dimensional biological literacy among students of the third grade of scientific secondary school. So, the researcher recommends the authors and designers of biology curricula to integrate biological knowledge into the social life of the learner, discuss the technological impact on it, in addition to its integration with various scientific disciplines.
- 2) The researcher recommends that biology teachers' pay attention to the practical side of the biology course, such as activating the role of the library and laboratory, attending seminars and scientific lectures, and making scientific trips. In addition to the use of various evaluation methods that measure different skills and abilities of students, such as the ability to analyze and evaluate, the ability to solve the problem and make decisions, and the ability to practice thinking of its various types through the use of various evaluation tools such as conducting research and practical projects, visiting scientific places and submitting reports on them, as well as reading and criticizing scientific articles.
- 3) The researcher recommends biology teachers to use effective teaching methods and strategies that enable them to present biological knowledge in the form of social events, issues, and problems related to technology and other sciences such as brainstorming, scientific investigation, and creative thinking, thus providing opportunities for students to keep abreast of modern biological developments and make the right decision towards them.
- 4) Conducting further educational research to assess different aspects and levels of scientific literature among secondary and university students, such as: Physical culture, chemical culture, in addition to the evaluation of sub-domains of biological literacy such as: Food culture and health culture.

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