K-12 STEM Education
Vol. 4 No. 2, Apr-Jun 2018, pp.341-362

Interdisciplinary M-Biotech-STEM (MBS) Module for Teaching Biotechnology in Malaysia

Ruhizan Mohammad Yasin[1]
Latifah Amin[2]
Kok Kean Hin[1]*
[1]*Faculty of Education, National University of Malaysia, Bangi, Malaysia*
[2]*Pusat Citra, National University of Malaysia, Bangi, Malaysia*
**Corresponding author: khkok76@gmail.com*

Abstract

An interdisciplinary approach of teaching of Science, Technology, Engineering & Mathematics (STEM) has been emphasized in Malaysia. This study focused on the development of Malaysian (M)-Biotech-STEM (MBS) module for secondary students ages 16-18 in a suburban area who have had little exposure to biotechnology knowledge. The validity and reliability of the module and its instrument namely, achievement test and 21st century skills questionnaire, have been approved by the experts from Malaysia Ministry of Education and Malaysian universities. Results from a preliminary study showed that the module could foster the interest of the students in learning biotechnology and able them to improve their achievement and inculcate 21st century skills such as digital era literacy skills and inventive skills.

Keywords: biotechnology, interdisciplinary, 21st century skills

Introduction

The interdisciplinary approach is holistic in that it links all related disciplines in order to make the learning process meaningful and relevant to the students in their daily life (Jacobs, 1989; Smith & Karr-Kidwell, 2000). According to Bybee (2010), an interdisciplinary approach is the best approach to teach students how to solve real life world problem in the current 21st century new curriculum. According to a report by the Malaysia Ministry of Education's Curriculum Development Centre (2016), hands-on activities are able to foster the interest of students, especially boys, and explore the higher order thinking skills needed to solve many non-routine problems, for which the answers could not be found in their school textbooks. In the 21st century, empathy and interdisciplinary are the two concepts that receive a lot of attention and they are relevant across all professions, including in research and the academic world (Hutchinson, 2016). The integration of empathy and interdisciplinary not just assists students in improving their critical thinking skills and collaboration skills, they also emphasize communication skills, writing skills and ethics. However, the exposure of students to an interdisciplinary approach is limited (Hutchinson, 2016; Jacobs, 1991). In general, most subjects are still being taught compartmentalized knowledge and assignments are still mainly discipline-specific.

Like other competitive countries in the world, Malaysia needs to strengthen the ability to compete in the 21st century. The recent outcome of Programme for International Student Assessment (PISA) 2015 showed that Malaysian students are still lagging behind and have not adapted to the changing world compared to the students in Singapore, China, Japan and South Korea (OECD, 2016). Although there was improvement in PISA 2015 compared to PISA 2009 and PISA 2012, 33.7% of the 8661 students did not secure the minimum score of 410 in science achievement in PISA 2015 (MOE, 2016; OECD, 2016).

Rationale of MBS implementation in Malaysia

Malaysia is becoming a hub of biotechnology. The biotechnology industry is estimated to provide 280,000 job opportunities and contribute 5% to the nation's gross income with the investment of RM 8 billion (US$2 billion) in 2020 (MIDA, 2014). However, the country is lacking in high-skilled workforces in the fields of Science, Technology, Engineering and Mathematics (STEM). The policy of attaining 60% science students and 40% art students enrolled in higher education STEM courses has not been successful since its first implementation in 1967. It is reported that only 35% students choose to enroll in the science / technical streams (MOE, 2014). The Ministry of Education Malaysia (MOE) is very concerned about the current low intake of science enrolment and have been actively taking drastic actions to remedy the situation. Otherwise, it would stunt the effort of the government to achieve high income nation status by 2020.

Past research studies from Lee & Kamisah (2015), President's Council of Advisors on Science and Technology (2010) and Wan Nasriha & Zanaton Iksan (2014) showed that the use of STEM modules improved students' knowledge and achievement. Rashidah (2016) also reported that the introduction of a biotechnology module improves the knowledge of the treatment groups of students. It also assists biology teachers in teaching abstract topics of biotechnology. However, the STEM module from these past studies gave general exposure to biotechnology and less emphasis on interdisciplinary approaches to teach biotechnology. According to MOE (2016), the recent improvement of PISA 2015 was the integration of high order thinking skills across disciplines. Therefore, the interdisciplinary STEM approach is a future trend that was given emphasis by the MOE. In this study, the researchers developed an M-Biotech-STEM (MBS) module to assist teachers in teaching biotechnology with an interdisciplinary approach.

SAMPLE

The sample population consists of Form 4 students (16-18 years old) who chose "Additional Science" as their elective subject. The researchers chose Perak state in northern Malaysia to conduct the preliminary two-week study, which involved a teacher and twelve students.

METHODOLOGY

The researchers developed the M-Biotech-STEM (MBS) module based on the Morrison, Ross, Kalman and Kemp (MRK) model (Morrison, Ross, Kalman & Kemp, 2013). The instruments developed are a biotechnology achievement test and a 21st century skills questionnaire. The biotechnology achievement test was constructed by the researchers based on the Additional Science Curriculum Specification, past year examination papers and the textbook. The 21st century skills questionnaire was modified from the questionnaire developed by Kamisah, Tuan Mastura & Nurazidawati (2010) to accommodate this study. The module and its instruments were referred to subject matter experts for validity and reliability before carrying out the preliminary study. Table 1 below shows an activity carried out in this study.

Table 1
Example of an activity in the MBS module

Title:	Cloning
Time:	160 minutes
Learning objective:	To understand cloning
Teaching & learning strategies:	Information communication technology, group discussion, portfolio.

Briefing: In the activity, students play a role of a biotechnologist. Students need to apply their prior knowledge in STEM, biotechnology, computer and mathematics to solve problems about cloning. They need to plan a solution with budget, consider environmental factors and the readiness of the society to accept their new application. The solution must take into account the benefit of the present generation and could be extended to future generation.

Phase I: Engagement

1) Teacher uses a video clip to introduce DNA to students
2) Teacher relates DNA to cloning
3) Students make observations and refer to the examples in the website.

Phase II: Exploration

1) Students need to find a solution to save our Sumatra rhinoceros that is in danger of going extinct. There are only three wild Sumatra rhinoceroses left according to the observations of biology conservationists of Borneo Rhino Alliance in Tabin Wildlife Reserve, Sabah, Malaysia.

Details:

The Sumatran rhinoceros is a solitary animal that does not prefer to stay in a group. Therefore, it is very difficult to breed among the species. Eggs from two female rhinoceroses, Iman and Putung, have been extracted and preserved while the sperm cells from a male rhinoceros, Tam have also been frozen. In the future, scientists will look for a means to increase the number of this species (Sathibalan, 2016).

2) After students identify the problems, they need to analyse information and find appropriate solutions. The students generate new ideas in their group discussion. They then attempt to solve the problem according to their plan.
3) Given the above details, students act as biology conservationists to save the Sumatra rhinoceros with possible techniques, e.g., cloning.
4) Students use the related information from the website for their group discussion.

Phase III & IV: Exploration & Elaboration

1) Students prepare a portfolio of their new ideas.
2) Students share their ideas with their peers though a group presentation.
3) Students keep the experience in the class exhibition corner and the school's official platforms such as website and school magazine.

Phase V: Evaluation

1) Teacher evaluates the performance of the students.
2) Students reflect upon their new learning experiences.
3) Teacher reflects upon his teaching experience as well.

Procedure of the preliminary study

The researchers first obtained permission from the Ministry of Education to conduct the preliminary study in a school located in Kinta Utara District, Perak state of Malaysia. The researchers then carried out a preliminary test with the permission of the school principal, teachers and parents. The researchers briefed the teacher about the preliminary study. The teacher conducted the lesson with the MBS module and instruments in two weeks during school hours. After the preliminary study, the teacher and students gave their reflections and comments on the module and instruments.

ANALYSIS OF DATA

The data were analysed with descriptive statistics. The qualitative data from the reflection of students and teachers were used to support the quantitative data collected in this study.

RESULT

Content validity of the MBS module

Four experts from the Malaysia Ministry of Education and Malaysian universities evaluated the content validity of the MBS module. The experts agreed with the appropriateness of the module constructed for this preliminary study. The items in the survey were evaluated with a Likert 5-point scale, which ranged from 1: strongly disagree to 5: strongly agree. Table 2 shows that the average mean for the items evaluated is 4.19.

Table 2
Expert's assessment form for M-Biotech-STEM module

No.	Items	Mean
1.	M-Biotech-STEM module helps in teaching and learning inquiry approach.	4.00
2.	M-Biotech-STEM module helps in learning based on real life problem.	4.50
3.	M-Biotech-STEM module helps in designing experiments based on the STEM Research Process.	4.00
4.	M-Biotech-STEM module integrates digital technologies accurately in teaching and learning processes.	4.25
5.	The 5E (Engage, Explore, Explain, Elaborate, Evaluate) learning model is aligned with the STEM principle.	4.75
6.	The Thayer Engineering Model is suitable for students to solve real life complex problems.	4.00
7.	M-Biotech-STEM module assesses teaching and learning based on performance.	4.25

8.	M-Biotech-STEM module uses both task and non-task specific rubrics to assess formative and summative tests.	3.75
9.	M-Biotech-STEM module incorporates students in digital age literacy.	4.25
10.	M-Biotech-STEM module incorporates students in inventive thinking skills.	4.00
11.	M-Biotch-STEM module incorporates students with spiritual and noble values.	3.75
12.	M-Biotech-STEM module encourages students to work independently and collaboratively.	4.00
13.	M-Biotech-STEM module inculcates 21st century skills when delivering the content of biotechnology.	4.25
14.	The timeline to implement M-Biotech-STEM module in school is practical.	4.25
15.	M-Biotech-STEM module is aligned with the Curriculum Specification Form 5 Additional Science (Refer to exception of the document: Biotechnology).	4.50
16.	M-Biotech-STEM module emphasizes hands-on, minds-on and learning by doing.	4.50
17.	M-Biotech-STEM module is suitable for Form 4 and Form 5 students (aged 16-18).	4.25
	Average of all means	4.19

In addition, the researchers conducted a correlation analysis for content validity of the module suggested by Ahmad (2014) and Chua (2014). The outcome of the analysis shows that correlation was strong among the experts, with the correlation constant r between 0.73-0.97. All experts agreed on the appropriateness of the MBS module in this study.

In this study, two language experts were employed to examine the appropriateness of the language used in the module and instruments. The language experts were satisfied with the language used and agreed that the language is appropriate and its content would be easily understood by the teachers and students.

Content validity of the biotechnology achievement test

The content validity of the biotechnology achievement test was prepared based on the Test Specification Schedule and Curriculum Specification of Additional Science. After the achievement test was prepared, it was referred to a biotechnology expert and a science education expert. It was further referred to an expert from the Curriculum Development Centre, Malaysia Ministry of Education. The experts evaluated the instrument with the evaluation form given. They agreed with the accuracy of the 41 items according to the topic content and cognitive dimension in Bloom Taxonomy, except for items 15, 16 and 34. The researchers improved the items before proceeded to the preliminary study. The validity of the items was important. If the items were not valid, then the items would not be able to evaluate the study accurately. Table 3 shows the modification of the three selected items.

Table 3

Outcome of the analysis on content validity and dimension cognitive level of the achievement test for item 15, item 16 and item 34.

Item no.	Topic Content	Accuracy		Suggested Cognitive Dimension	Accuracy		Corrected Cognitive Dimension
		Agree	Disagree		Agree	Disagree	
15	Food fermentation	✓	-	Evaluate	-	X	Understand
16	Pharmaceutical fermentation	✓	-	Evaluate	-	X	Remember
34	Genetic engineering	✓	-	Remember	-	X	Incomplete

Reliability of the biotechnology achievement test

After the content validity of the biotechnology achievement test had been done, the researchers conducted the preliminary test to identify the reliability of the achievement test.

The achievement test consisted of 40 multiple choice items and an essay question. The test was conducted in a school that did not participate in the real study. It was carried out within school hours. The teacher and students provided their responses in an evaluation form.

The answer scripts were collected and assessed with the appropriate marking scheme. Then, the difficulty index (p) and discrimination index (D) were calculated. According to Hilezan, Parimalarani & Tan (2014), an item with discrimination index equal to or less than 0.20 would be rejected as the item could not differentiate the proficient students from the average students or if the average students perform better than the proficient students. As for difficulty index, items with value between 0.29 to 0.81 are accepted because they are appropriate for all type of students.

After the analysis, the researchers found that all items could be accepted except items 20, 28 and 29. These three items needed to be modified and rewritten before proceeding to the next stage of study. Table 4 shows the outcome of the difficulty index (p) and discrimination index (D) of the selected items.

Table 4
*Outcome of the difficulty index (p) and discrimination index (D) of items 20, 28 and 29.**

Item no.*	Difficulty index (p)	Discrimination index (D)	Item interpretation	Action
20	0.11	0.22	difficult	modify
28	0.44	0.00	moderate	rewrite
29	0.11	0.22	difficult	modify

** These items (original) may be found in the achievement test in Appendix 1*

Reliability of the 21st century skills questionnaire

The 21st century skills questionnaire is modified from the M-21CSI questionnaire constructed by Kamisah, Tuan Mastura & Nurazidawati (2010). After the preliminary test, the researchers conducted a reliability test with the Cronbach Alpha reliability index. Results show that all Cronbach Alpha values for the domains in 21st century skills are more than 0.50. According to Sidek & Jamaludin (2005) and Chua (2014), Cronbach Alpha values between 0.50 to 0.95 are accepted and therefore the entire 21st century skills questionnaire is appropriate for this study. Table 5 shows the number of items and Cronbach Alpha value of the domains in 21st century skills

Table 5
Number of item and Cronbach Alpha value of the domains in 21st century skills

Domain in 21st century skills	Number of items	Cronbach Alpha
Digital era literacy skill	18	0.855
Inventive thinking skill	20	0.953
Spiritual values	15	0.740
Overall	53	0.904

DISCUSSION

Feedback from the teacher and students are encouraging after the preliminary study. However, minimal changes have to be done on the MBS module and the achievement test for the next stage of the study. From the summary of the reflections given by the teacher and students, the module helps them in the teaching and learning of biotechnology. The strength of the module and the language are appropriate, the visuals and video used help the students to understand cloning, it is easier to teach this abstract topic, and the activity in the module could be adopted well in the school. However, a few weaknesses have been identified in the module and the achievement test. The video, which is explained in some specific terms might discourage the academically weak students. The essay question might not be appropriate because the writing of a biotechnology article is seldom carried out in lower secondary school. Additionally, most of the students had under performed in the previous public examination. It was suggested that the essay question on biotechnology topic could be brought forward to Form 5 students who are better prepared after learning the biotechnology topic in their syllabus. The researchers considered the feedback positively and rectified the module and the instruments accordingly.

CONCLUSION

The construction of the M-Biotech-STEM module and the instruments have been evaluated. The formative assessment shows that the module and the instruments are valid and reliable for this study. Furthermore, the module and the instruments could be used to further examine their effectiveness to improve student achievement and foster 21st century skills in biotechnology topics in a real study.

Ruhizan Mohammad Yasin *is a professor in the Faculty of Education, National University of Malaysia. Dr. Yasin's research interests include technology and vocational education, curriculum & evaluation.*

Latifah Amin *is a professor in Pusat Citra, National University of Malaysia. Dr. Amin's research interests include Science in society, Malaysian public attitude, awareness & policy towards biotechnology & bioethics.*

Kok Kean Hin *is a lecturer in the Science Department at the Institute of Teacher Education, Johor Bahru Campus. He is a PhD candidate in the Faculty of Education, National University of Malaysia*

References

Ahmad Hashim, 2014. *Panduan analisis data secara efisien*. Bangi: Dubook Press.

Bybee, R.W., 2010. Advancing STEM education: a 2020 vision. *Technology and Engineering Teacher, 70*(1): 30-35.

Chua, Y. P., 2014. *Research methods*. Kuala Lumpur: McGraw Hill.

Hilezan Zainal, Parimalarani, S. & Tan, K.L., 2014. *Amalan Pentaksiran Dalam Matematik.* Kuala Lumpur: Freemind Horizons.

Hutchison, M., 2016. The empathy project: Using project-based learning assignment to increase first-year college student's comfort with interdisciplinary. *Interdisciplinary Journal of Problem-Based Learning, 10*(1): 1-13.

Jacobs, H.H., 1989. The Growing Need for Interdisciplinary Curriculum Content. In: H. H. Jacobs (Ed.), *Interdisciplinary curriculum: Design and implementation.* Association for Supervision and Curriculum Development, pp.1-11.

Jacobs, H.H., 1991. The integrated curriculum. *Instructor, 101*(2): 22-23.

Kamisah, O., Tuan Mastura, T.S. & Nurazidawati, M.A., 2010. Development and validation of Malaysian 21st Century Skills Instrument (M-21CSI) for science students. *Procedia Social and Behavioral Sciences, 9*: 599-601.

Lee, C.H. & Kamisah, O., 2015. An interdisciplinary approach for Biology, Technology, Engineering and Mathematics (BTEM) to enhance 21st century skills in Malaysia. *K-12 STEM Education, 1*(3): 137-147.

Malaysia Investment Development Authority (MIDA), 2014. *Laporan prestasi pelaburan Malaysia 2013: anjakan ke tahap tinggi.* Kuala Lumpur Malaysia.

Ministry of Education Malaysia (MOE), 2014. *Laporan tahunan 2013. Pelan Pembangunan Pendidikan Malaysia*. Putrajaya Malaysia.

Ministry of Education Malaysia (MOE), 2016*. Laporan Programme for International Students Assessment 2015 (PISA 2015).* Retrieved from www.moe.gov.my/my/pemberitahuan-view?page=1&id=5463

Morrison, G.R., Ross, S.M., Kalman, H. & Kemp, J.E., 2013. *Designing effective instruction*. Hoboken, NJ: John Wiley & Sons.

Organisation for Economic Co-operation and Development (OECD), 2016.

PISA 2015: results in focus. Paris: OECD. Retrieved from https://www.oecd.org/pisa/pisa-2015-results-in-focus.pdf

President's Council of Advisors on Science and Technology, 2010. *Report to the President. Prepare and inspire: K-12 education in Science, Technology, Engineering and Mathematics (STEM) for America's future.* Executive office of the president, Washington, D.C. Retrieved from http://www.whitehouse.gov/ostp/pcast

Rashidah, B.G., 2016. Pembangunan modul bioteknologi bagi mata pelajaran biologi sekolah menengah.PhD thesis. Universiti Malaya.

Sathibalan, S.I., 2016. The Last Survivors, *The Sun Daily*, p: 25. 6 September. Kuala Lumpur.

Sidek Mohd Noah & Jamaludin Ahmad, 2005. *Pembinaan modul: bagaimana membina modul latihan dan modul akademik*. Serdang: Penerbit Universiti Putra Malaysia.

Smith, J. & Karr-Kidwell, P.J., 2000. *The interdisciplinary curriculum: A literacy review and a manual for administrators and teachers.* Washington, D.C.: ERIC.

Wan Nasriha Wan Mohamad Salleh & Zanaton Iksan, 2014. "Analisis keperluan pembinaan modul pembelajaran berasaskan projek (PBP) bagi mata pelajaran biologi KBSM Tingkatan 4". Paper presented at the *Proceedings International Seminar on Global Education II: A Developed Nation*, Universiti Kebangsaan Malaysia.

Appendix 1

BIOTECHNOLOGY ACHIEVEMENT TEST

Information for students:

The paper is divided into two parts as follows:

Part A: 40 multiple choice items

Part B: 1 short essay item

Answer all questions

Instruction: Answer all the questions. Write the answer in the box provided.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	36.
37.	38.	39	40.														

1. Why is fermentation an anaerobe process?

A. It does not require glucose.
B. It does not require carbondioxide.
C. It does not require oxygen.
D. It does not require nitrogen.

2. What is the purpose of food being fermented?

I. to enrich the food with nutrient
II. to enrich the taste and texture of the food
III. to prolong the freshness of the food
IV. to reduce the time used to cook

A. I & II
B. I & III
C. I,II & III
D. I,II, III & IV

Starch + yeast ⟶ glucose ⟶ S ⟶ Acetic acid

Diagram 1

3. Diagram 1 refers to a process of making fermented food. What is S?

   A. fatty acid
   B. protein
   C. ethanol
   D. salt

4. Here is the product produced by the process of fermentation except

   A. fermented soy bean cake
   B. bread
   C. buttermilk
   D. crackers

5. What substance makes the product of fermentation sour?

   A. sodium chloride
   B. calcium carbonate
   C. magnesium oxide
   D. Lactic acid

Diagram 2

6. Diagram 2 shows fermented tapioca. Why does the fermented tapioca sometimes taste bitter?

   A. the starch in the tapioca taste bitter
   B. the glucose change into ethanol
   C. the glucose change into acetic acid
   D. the presence of carbon dioxide

7. Why does the bread mix come up during the process of making bread?

   A. the high temperature of heating
   B. the presence of water in the process of heating
   C. the release of alcohol during the heating
   D. the presence of carbon dioxide from fermentation causes the formation of air bubbles in the flour mix to rise.

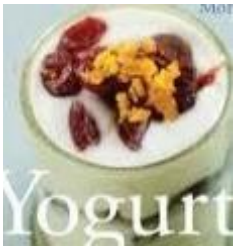


Diagram 3

8. Diagram 3 shows yogurt. Why is yogurt considered a type of healthy food?

A. yogurt is sour
B. the glucose and galactose in yogurt are easily absorbed by our body
C. yogurt is made of milk.
D. yogurt could replace all other classes of food that provide all nutrients for our human body.

9. Biodetergent contains enzyme.What is the function of enzyme in the biodetergent?

A. to clean the oily dirt on the clothes
B. to ensure the softness of the clothes
C. to protect the colour of the clothes
D. to protect the texture of the clothes

Diagram 4

10. Why is insulin in Diagram 4 given to diabetic patients?

A. as a replacement for food resources
B. Insulin is more effective than other medicine
C. to control the blood sugar
D. Insulin helps the patients by making them feel full the whole day

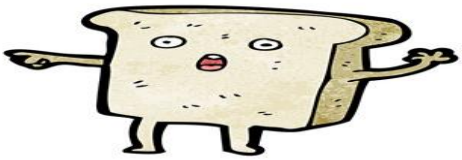
11. In the preparation of yogurt, the sterile milk needs to be boiled until 900C. Why does this step need to be carried out?

A. to kill the germs
B. to decompose the milk protein in order to prevent coagulation
C. to maintain the freshness of the milk
D. to cease the reaction of bacteria

Diagram 5

12. What is the function of yeast powder in fermentation in Diagram 5?

A. to break the starch in tapioca into sugar, water and carbon dioxide
B. to slow down the fermentation process
C. to prevent the starch from oxidation
D. to prevent the starch from decomposition during the process of fermentation



13. What is the possible replacement for yeast, if yeast could not be provided during the making of bread?

A. Soda bicarbonate
B. sugar solution
C. brown sugar
D. black coffee powder

14. Bacteria that are normally used in the preparation of yogurt in the market are...

I. Lactobacillus acidophilus
II. Lactobacillus bulgaricus
III. Streptococcus thermophiles
IV. Aspergillus flavus

A. I & II
B. I & III
C. I,II & III
D. I,II,III & IV

15. What is the advantage of cheese being a food resource?

I. rich in calcium
II. lower the blood pressure
III. protein source
IV. to prevent osteoporosis

A. I & II
B. I & III
C. I, II & III
D. I,II, III & IV

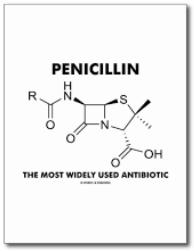


Diagram 6

16. Why is antibiotic such as Penicillin in Diagram 6 a very important discovery for human health?

A. to prevent reproduction and destroy bacteria
B. to replace spoilt body cells
C. protein source for healthy cells
D. successfully prevent all types of diseases

17. Choose the plants that have been grown with tissue culture.

I. Kelapa sawit / oil palm
II. Orkid / Orchid
III. Pisang / banana
IV. Nanas / pineapple

A. I & II
B. I & III
C. I, II & III
D. I,II,III & IV

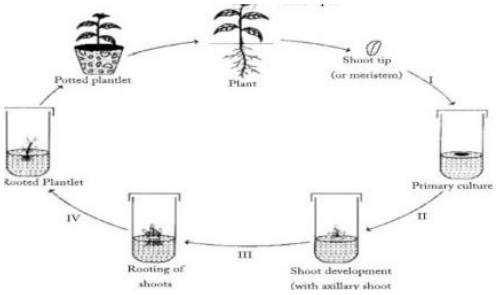


Diagram 7

18. Which of the following is not the advantage of tissue culture shown in Diagram 7?

A. The plants produced are similar to the mother plant in terms of quality and the traits
B. The plants could be grown throughout the seasons
C. There is a variation in plants
D. The maturity period of the young plants is shorter

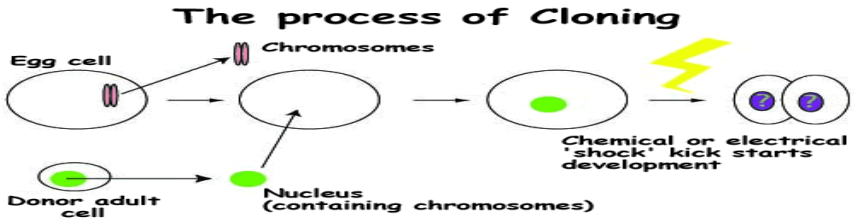


Diagram 8

19. The following are the advantages of cloning shown in Diagram 8 except

A. The cloned poultry is healthier and resistant towards sickness
B. The quality of cloned animal meat would be increased
C. Pollination agent is needed
D. Reproduction of organism in a short period of time

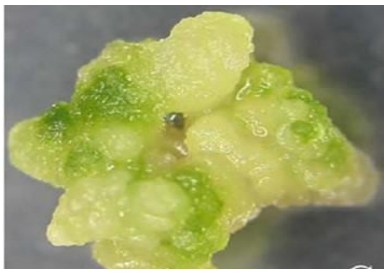


Diagram 9

20. The tiny pieces from leaves, shoots, stems or roots of the plant tissues (Diagram 9)used in tissue culture is known as

A. medium
B. platelet
C. matured cells
D. active growth cells

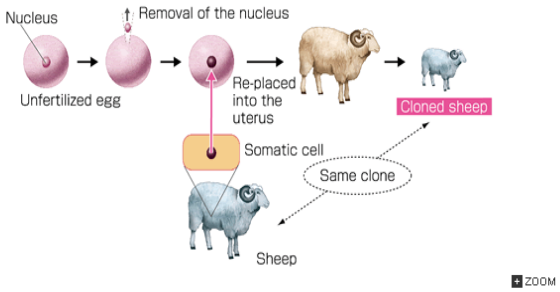


Diagram 10

21. Based on Diagram 10, cloning is a process that involves reproduction by

A. sexual
B. natural
C. asexual
D. chemical

22. The nutrient used in tissue culture is mixture of the following except

A. hormone
B. mineral salts
C. glucose
D. fats

Diagram 11

23. What is the purpose of putting all the equipment into the pressure cooker in Diagram 11 during the tissue culture experiment?

A. to clean the equipment
B. to heat the equipment
C. to stabilize the surrounding pressure
D. to kill the germs and make sure that all equipment is sterile

24. The orchid planter is thinking of using S as a part of the medium mixture because S contains auxin and cytokinine that stimulate tissue growth. What is S?

A. sugar cane solution
B. soy milk
C. coconut solution
D. oil palm waste

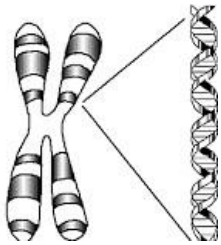


Diagram 12

25. Based on Diagram 12, genes refer to

A. a complete set of chromosome
B. a pair of homologous chromosomes
C. DNA base unit
D. segment of a chromosome

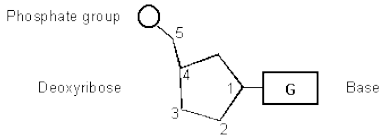


Diagram 13

26. Refer to Diagram 13, the following is not a base found in DNA chain?

A. Thiamine
B. cytosine
C. Uracil
D. Adenine

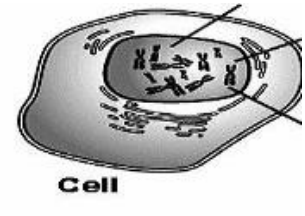


Diagram 14

27. From Diagram 14, where is the genetic information kept in the cell?

A. cytoplasm
B.nucleus
C. ribosome
D. mitochondria

28. Arrange the correct order of the procedures of genetic engineering?

W: insert selected genes into vectors

X:cut the DNA of the selected genes

Y:duplicate the copies of genes

Z:insert a vector into the host cell

A. W,X,Y,Z
B. W,Y,X,Z
C. X,W,Y,Z
D. X,Y,W,Z

29. Which of the following is true about the techniques used in agriculture?

	method	technique
A.	breeding	grow the organism without DNA
B.	tissue culture	produce new variations of organism
C.	recombinant DNA	produce few copies of DNA
D.	transgenic organism	produce a genetically modified organism

30. Which organism below could be modified with genetic engineering to produce human insulin?

A. bacteria
B. fungi
C. protozoa
D. virus

31. Which human organ that produces insulin?

A. liver
B. heart
C. kidney
D. pancreas

32. Genetic engineering could change the genes in plants for the following commercial purpose, which is…..

A. affects the growth of seeds
B. affects the growth of roots
C. to produce a smaller fruit
D. to increase the productivity in agriculture

33. Which of the following is the disadvantage of genetic engineering?

A. the actual species will loss its original traits.
B. the transfer of new genes in the genetically modified food have no impact on the existing genes
C. the alien genes that inserted into the animal cell would not cause diseases
D. the safety and effect of genetically modified food is guaranteed

34. Example of commercialized agricultural product produced in large scale from genetic engineering is

A. banana
B. papaya
C. guava
D. mangosteen

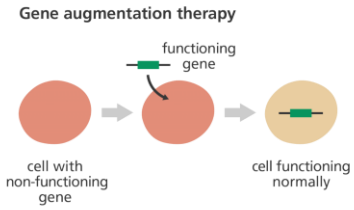


Diagram 15

35. Based on Diagram 15, gene therapy could modify non-functioning gene to functioning gene in human body.

From this technique, gene therapy has successfully treated two types of genetic diseases as stated below in the laboratory

A. diabetes and fibrosis sista
B. Huntington's disease and fibrosis sista
C. colour blindness and diabetes
D. fibrosis sista and eye cancer

36. Choose the plant that is genetically modified in order to improve its quality in the world market

I. soy vean II.sugar cane III. Banana IV.cocoa

A. I & II
B. I & III
C. I,II & III
D. I,II,III & IV

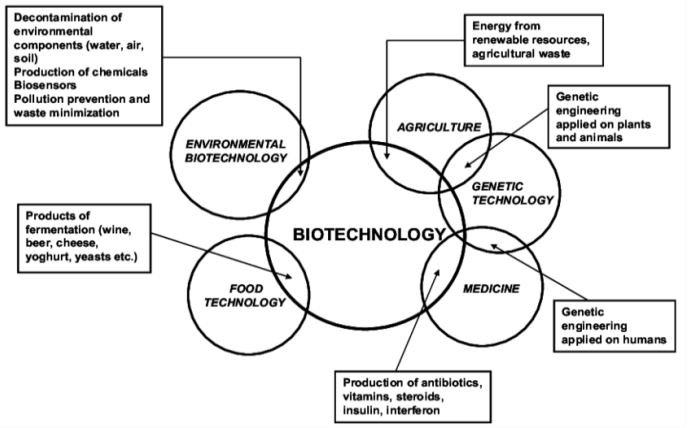


Diagram 16

37. Based on Diagram 16, the field of biotechnology has progressed rapidly especially in the field of medicine and agriculture with genetic engineering.

Choose the possible issues that could come out with the production of genetically modified organism

I. the ethical issues and the acceptance of society towards genetically modified organism
II. the high production cost of commercialized genetically modified organism
II. side effects towards human health
IV. the effects of genetically modified organism on nature

A. I & II
B. I & IIII
C. I, II & III
D. I, II, III & IV

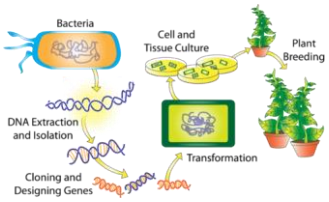


Diagram 17

38. Choose the advantages of genetic engineering when it is applied in agriculture as shown in Diagram 17.

    I. the natural process of plant reproduction might be affected
    II. to produce a nutrient-enriched plant
    III. to reduce the use of pesticide
    IV. could kill the pollination agents such as honeybees and butterflies

A. I & II
B. II & III
C. I & IV
D. III & IV

39. Below is the importance of biotechnology except

    I. food could be kept longer
    II. organic fertilizer could be produced
    III. could control the water resource in the wood
    IV. could bring back the real animals that have long disappeared

A. I & II
B. I & III
C. I & IV
D. III & IV

40. A form of renewable energy, Y could be produced from oil palm waste and palm oil. Y is referred to...

A. biomass
B. biodiesel
C. biodetergent
D. bioscience

Instruction: Answer the essay question in space provided.

1. The food shortage still happens in a few countries in Africa.

As a genetic engineer, find the possible ways to solve the food shortage problems.

_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

--------THE END----------

Appendix 2

Table A. Outcome of the analysis on content validity and dimension cognitive level of the achievement test (item 1-41)

Item no.	Topic Content	Accuracy		Suggested Cognitive Dimension	Accuracy		Corrected Cognitive Dimension
		Agree	Disagree		Agree	Disagree	
1	Food fermentation	✓	-	understand	✓	-	-
2	Food fermentation	✓	-	understand	✓	-	-
3	Food fermentation	✓	-	understand	✓	-	-
4	Food fermentation	✓	-	understand	✓	-	-
5	Food fermentation	✓	-	understand	✓	-	-
6	Food fermentation	✓	-	understand	✓	-	-
7	Food fermentation	✓	-	understand	✓	-	-
8	Food fermentation	✓	-	understand	✓	-	-
9	Pharmaceutical fermentation	✓	-	understand	✓	-	-
10	Pharmaceutical fermentation	✓	-	understand	✓	-	-
11	Food fermentation	✓	-	understand	✓	-	-
12	Food fermentation	✓	-	understand	✓	-	-
13	Food fermentation	✓	-	apply	✓	-	-
14	Food fermentation	✓	-	remember	✓	-	-
15	Food fermentation	✓	-	evaluate	-	X	understand
16	Food fermentation	✓	-	evaluate	-	X	remember
17	Tissue culture	✓	-	remember	✓	-	-
18	Tissue culture	✓	-	remember	✓	-	-
19	Cloning	✓	-	analyze	✓	-	-
20	Tissue culture	✓	-	remember	✓	-	-
21	Cloning	✓	-	remember	✓	-	-
22	Tissue culture	✓	-	remember	✓	-	-
23	Tissue culture	✓	-	understand	✓	-	-
24	Tissue culture	✓	-	create	✓	-	-
25	Gene	✓	-	remember	✓	-	-
26	Gene	✓	-	remember	✓	-	-
27	Gene	✓	-	remember	✓	-	-
28	Genetic engineering	✓	-	understand	✓	-	-
29	Biotechnology	✓	-	apply	✓	-	-
30	Genetic engineering	✓	-	remember	✓	-	-
31	Genetic engineering	✓	-	remember	✓	-	-
32	Genetic engineering	✓	-	understand	✓	-	-
33	Genetic engineering	✓	-	evaluate	✓	-	-
34	Genetic engineering	✓	-	remember	-	X	incomplete
35	Genetic engineering	✓	-	understand	✓	-	-
36	Genetic engineering	✓	-	understand	✓	-	-
37	Genetic engineering	✓	-	understand	✓	-	-
38	Genetic engineering	✓	-	understand	✓	-	-
39	Biotechnology	✓	-	understand	✓	-	-
40	Biotechnology	✓	-	remember	✓	-	-
41	Biotechnology	✓	-	create	✓	-	-

Appendix 3

Table B. Outcome of the difficulty index (p) and discrimination index (D) of the item in Biotechnology Achievement Test

Item no.	Difficulty index (p)	Discrimination index (D)	Item Interpretation	Action
1	1.00	0.67	easy	accept
2	1.00	0.67	easy	accept
3	1.00	0.67	easy	accept
4	1.00	0.67	easy	accept
5	1.00	0.67	easy	accept
6	1.00	0.67	easy	accept
7	1.00	0.67	easy	accept
8	1.00	0.67	easy	accept
9	1.00	0.67	easy	accept
10	1.00	0.67	easy	accept
11	0.89	0.44	easy	accept
12	1.00	0.67	easy	accept
13	1.00	0.67	easy	accept
14	1.00	0.67	easy	accept
15	1.00	0.67	easy	accept
16	1.00	0.67	easy	accept
17	0.78	0.67	moderate	accept
18	0.89	0.44	easy	accept
19	1.00	0.67	easy	accept
20	0.11	0.44	difficult	modify
21	0.33	0.67	moderate	accept
22	0.67	1.00	moderate	accept
23	0.78	0.89	moderate	accept
24	1.00	0.67	easy	accept
25	1.00	0.67	easy	accept
26	1.00	0.67	easy	accept
27	1.00	0.67	easy	accept
28	0.44	0.00	moderate	rewrite
29	0.11	0.22	difficult	modify
30	0.78	1.00	moderate	accept
31	0.78	1.00	moderate	accept
32	1.00	0.67	easy	accept
33	0.44	0.67	easy	accept
34	0.67	1.00	moderate	accept
35	0.89	0.44	easy	accept
36	0.89	0.44	easy	accept
37	0.56	0.67	moderate	accept
38	0.78	1.00	moderate	accept
39	0.78	0.67	moderate	accept
40	0.89	0.89	easy	accept