FEMSTEAM MYSTERIES: STEAM SCENARIO

Title

Cracking the Heredity Code: What makes me look like my parents?

Authors

Hercules Panayiotides, Katerina Kekkouri,

Summary

The scenario is developed in the framework of the discovery of the role of DNA in heredity. DNA, as is well known today, is the stuff that defines a person's biology and his or her relation to other human beings and the wider animal kingdom. This was not always known neither was the structure of the DNA chemical understood. The understanding of the structure of DNA and its role as a highly complex information code for the building and operating of organisms is one of the defining moments in science. Many contributed to our understanding about DNA but some have not been given the recognition due to them. The scenario while developing the story of the discovery of the structure of this most important biochemical will give attention to the achievements and contribution of Rosalind Franklin in its discovery while not ignoring the better known work of James Watson and Francis Crick. Students will be led on a journey of exploration and discovery to appreciate the complex workings of living organisms, the work of scientists who have contributed to our understanding of DNA's role in heredity, the cooperation between scientists, the technology they have used and the beauty and the art that is there in nature brought to light by science and technology.

Subjects

- The topic falls within the subject of the history of science. This brings out the aspect of science which has to do with the progress of learning, with each generation of scientists depending on those before and standing so to speak on the shoulders of those who came before and so to be able to see new things. The cooperative nature of science will be underlined but also the difficulties that women had in functioning in the field
- The science around DNA is mainly biology and chemistry: biology since the inheritance of characters in organisms and the general field of genetics falls within biology; chemistry will be involved as well since the factors or agents in inheritance are biochemicals. There will also be some physics involved since the technology that Rosalind Franklin used – xray crystallography – is a technology that has grown out of physics
- Art will be utilised for students to produce 2-D and 3-D representations of the parts and the whole of the DNA molecule.

Real- life questions

The real-life questions that students will be dealing with leading from "*Cracking the Heredity code: What makes me look like my parents?" are*:

- What are the expertise and uniqueness of FemSTEAM Mystery game role-models?
- What are the important contributions or achievements of these people?
- What are codes?
- What is at the heart of the mechanism of inheritance?

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- Do I appreciate the beauty and complexity that is there hidden in my body?
- Is there always fairness in science between the people who work there? What is my responsibility as a budding scientist or STEAM person?
- Do I want to study further STEAM subjects and/or a career? Explain: what and why/ why not.

Aims of the scenario

The scenario aims:

- *to open the eyes of students to the amazing and wonderful things that are hidden in their bodies and in all living things*
- *to help students to grow in respect for the field of science and of the people who have contributed to science and STEAM throughout history*
- *to help students value and respect those of the opposite gender and be willing to promote equality of rights and opportunities for all*
- *to encourage students to reject false stereotypes that discriminate between men and women,*
- *to develop students' key skills in the use of information sources for acquiring knowledge*
- *to develop students' critical thinking skills*
- *to help students develop cooperative skills*
- *to help students get a better appreciation of the different scientific disciplines and to see how history and art play a part in the sciences*
- *to lead students to know and accept the functioning of their own bodies and appreciate artistic creation*
- *to help students consider their social responsibilities as developing adults towards other fellow human beings and especially to those of the opposite sex*

Connection to STEAM careers

The students will develop critical and creative thinking concerning FemSTEAM role-models and relevant careers.

Age of students

13-14 years olds

Time

Preparation time: 1 hour

Teaching & assessment time:

- **STEAM History of Science: 45 mins**
- **STEAM Information technology: 45 mins**
- **STEAM Biology: 45 mins**
- **STEAM History of Science: 45 mins**
- **STEAM Physics: 45 mins**
- **STEAM Chemistry & Arts: 90 mins**

Teaching resources (material & technological tools)

Materials:

Ball and stick model sets for building the DNA components, tempera paint and A2 poster paper

Online tools:

FemSTEAM Mysteries game

Webpage information about STEAM role-models

Online graphics

21st century skills

This educational scenario will enhance among the students the following skills, defined as 21st century skills:

- Collaborative work will help to increase student's competence in linguistic communication, because students should interact in oral and written form in a coherent and appropriate manner.
- Digital competence will be enhanced through the Internet searches that the students do
- Creative skills will be encouraged through the creation of 2-D and 3-D models
- Problem-solving is presented through the idea of decryption of encrypted messages
- The treasure hunt will challenge students to persevere and collaborate with others

Teaching approaches and learning strategies/theories Educational scenario

- Selecting relevant information from online sources both video and script
- Group discussion in small as well as large groups
- Practical activities – model making and painting
- Games that develop thinking and analysing skills
- Written activities

Name of activity	Procedure	Time
1st Lesson: *FEMSTEAM Mysteries game*		
STEAM History of Science	*Informing students that they will play a game with the aim of learning biographical facts about FemSTEAM-role models.* *Playing with the rooms 1 and 8 of the FemSTEAM Mysteries Game.* *Summarising the main information of the two selected role models using the information page of the FemSTEAM Mysteries Game.* *Discussion on:* *What are the expertise and uniqueness of FemSTEAM Mystery game role-models?* *How do these people promote gender equality?*	*30'*
Learning products	*Individual document of all about the biographical facts of the role-models selected in the game and individual answers to the three questions posed for the discussion*	*15'*
2nd Lesson: Some things are hidden in code		
STEAM: Information	*Students are given a very simple sentence in which the words have jumbled letters (they have been encrypted by the teacher) and they are asked to figure out/*	15'

Name of activity	Procedure	Time
technology - Code breaking exercise	*decrypt the sentence and find the meaning first without a key and then with the help of a key (See Appendix A for Lesson 2)*	
Treasure hunt using codes to find the hidden treasure	*A treasure hunt is set up where students, using the key from the previous exercise, try to find the hidden treasure that is somewhere on their floor of the school. As they decrypt the clues that they find they can proceed towards their goal.*	20’
Brainstorming	*Group discussion: We all start life as one tiny cell. What might there be in that one cell that allows it (or helps it to “know” how) to develop and change to become a whole organism? (HINT: If you had the pieces to create a big machine what might you want to help you along?)* *Pool the ideas of the groups. Give a brief description of how scientists discovered that there is a code in each of our cells which provides instructions for growth and for the working of each cell and our whole body.*	10’
3rd Lesson: THE DNA code that makes you ‘you’		
STEAM Subject Biology	*The code we talked about in the previous lesson is in the DNA. Your DNA has all the coded information that makes you you and half came from your dad and half from your mum.* *Watch video on what DNA is and how it works:* *https://www.youtube.com/watch?v=zwibgNGe4aY* *Explain how every living organism has its own DNA and how no two humans have exactly the same DNA unless they are identical twins* *For further reading: (More historical details of the discovery of the makeup of DNA* *https://profiles.nlm.nih.gov/spotlight/sc/feature/doublehelix*	20’
Learning products	*Students complete a digital or printed paper copy of a formative assessment exercise on the video they watched. See Appendix B for lesson 3*	20’
Plenary	*Play odd one out (students explain in as many ways as possible which one of the three does not fit with the other two): adenine, guanine, vitamin; DNA, nucleus, protein*	5’
4th Lesson: An important scientist		
STEAM subject: History of Science	*Students read the article below on Rosalind Franklin:* *https://www.nature.com/scitable/topicpage/rosalind-franklin-a-crucial-contribution-6538012/*	10’
Learning products	*A worksheet is provided for group work with questions for all-class discussion: See attachment Appendix C for Lesson 4*	35’
5th Lesson: The first DNA Picture		

Name of activity	Procedure	Time
STEAM Physics	*The history and technology behind Rosalind Franklin's historic photograph 51 will be explored. Students will watch the two videos below:* 1. This video describes the actual process which Rosalind Franklin followed to create her famous photo 51. https://ib.bioninja.com.au/higher-level/topic-7-nucleic-acids/71-dna-structure-and-replic/structure-of-dna.html 2. This video shows a simulation of Ms Franklin's method that we can also repeat in our labs at school. https://www.youtube.com/watch?v=pRZ7cSP1zMM	20'
Learning products	*1. Students contrast the two methods by making a list, in groups of 4, of similarities and differences in the two methods.* *2. They produce a procedure on the basis of the 2nd video simulation procedure to be trialled in a lab at the school. The write-up must include:* *a. A list of equipment required* *b. A detailed procedure to be followed that ends with a photo of a diffraction pattern which they can present.*	*25'*
6th Lesson: Creating DNA		
STEAM Chemistry & Arts	*1. Students, using the link below as a guide, will use ball and stick model parts to build the different molecules that form the DNA macromolecule. They will build the types of bases as well as the sugar and phosphate parts that comprise the DNA molecule.* https://www.dreamstime.com/stock-illustration-thymine-molecule-molecular-structure-chemical-structural-formula-model-image65628926 *2. Putting their models together as they would connect to form the DNA molecule they can photograph their molecules. They can put their photos in a group powerpoint presentation.* *3. Students that are more capable at drawing and painting or who would prefer to draw and paint will create a painting on a large (A2) poster*	*90'*

Name of activity	Procedure	Time
	sized paper of the DNA molecule. Paintings will also show the chemical detail as well as the overall shape and form of the molecule.	
Learning products	*A presentation of the powerpoint and the paintings will be presented with explanation of what is portrayed*	

Assessment

Initial assessment

Individual document of all about the biographical facts of the role-models selected in the game and individual answers to the three questions posed for the discussion

Formative evaluation

- *Provided for within the lesson plans*

Final assessment

Assessment of the development of beliefs among students

- *How did my ideas about scientists change as a result of these lessons?*
- *"I would like to pursue a job in STEAM". Explain: why or why not*
- *"I am more willing to be responsible and to make sure that all people have equal opportunities to choose what they want to do in life" True or False? Why?*

Student feedback

- Students commented on the game:
    - The realism of the game could be improved.
    - The controls were less intuitive than they would have been if they had used the standard 'WASD' gaming convention.
    - Opinion was divided on the overall experience. Several thought it was fun. Others thought it needed work. Some found it too complex and did not understand the overall point.
- Some students enjoyed the scenario tasks.
- Around a third of the class understood the role model and the significance of her contribution to modern science.
- Some students found that the lesson content on DNA and the different G-A-T-C colours, was useful and interesting to know.

- Some students found the scenario to be actively interesting.

Teacher feedback

The teachers are expected to provide feedback on how the lessons were received and implemented.

- The art task was skipped due to time constraints.
- Student were engaged and eager to learn information on heredity and the discovery of DNA.
- Rosalind Franklin was brought as an example of a female role model, and the students were interested to find out about her how her discovery was overshadowed by male scientists. The discussion was completed on whether her discovery was stolen and how this can be prevented now.
- The overall teaching of the year was not affected and it blended into the current topic.

Appendices

APPENDIX A for Lesson 2

The teacher gives the students an encrypted message which they must try to decrypt. For example:
G JMTC KW QRSBCLRQ *(Below is given the key for decrypting this coded message)*

Students must be given the key to enable them to decrypt the message. So, for example, the phrase QRSBW GQ JMTCJW
(which is encrypted in the same code) says: "Study is lovely". Use this hint to help you solve/ decrypt the first coded message. Do your best to figure out the key to decrypting the coded message.

Key for decrypting the message:
An "A" in the secret (encrypted) message stands for a "C", a "B" stands for a "D", a "C" stands for an "E" and so on. So the message at the top really says: "I LOVE MY STUDENTS"

APPENDIX B for Lesson 3.

This is a multiple choice exercise. Choose the one best answer for each question. When you have finished wait for the teacher to put you into your groups to discuss your answers within your group

1. The full name of DNA is:
    a. Detoxic nucleic acid
    b. Deoxyribonucleic acid
    c. Denitronucleic acid
2. The shape of the DNA molecule is:
    a. Like a long rope
    b. Like a Christmas tree
    c. A long twisted or spiral ladder
3. DNA contains coded information or a blueprint or a recipe for making:
    a. A tree
    b. A dog
    c. A dinosaur
    d. A human
    e. All of the above and every other living thing as well
4. DNA works by
    a. Giving instruction to a cell to make proteins
    b. Giving instructions to a cell to make viruses
    c. Giving instructions to a cell to make tissues
5. The code in the DNA is found in:
    a. The order of the 4 bases (A, T, C & G)
    b. The number of twists in its chain
    c. The colours of the different parts
6. The DNA in a cell can have how many pieces of code
    a. Tens
    b. Hundreds
    c. Thousands
    d. Millions
7. The name of the chemical that comes to the nucleus to copy the DNA code is:
    a. ONA

   b. QNA
   c. RNA
   d. VNA

8. Ribosomes are:
   a. The protein destroying machines of a cell
   b. The protein building machines in the cytoplasm of the cell
   c. The protein eating organs of a cell
9. Which sequence of events is the correct one describing how cells do their work?
   a. Protein is copied by RNA; RNA is used to produce DNA; DNA helps to build the cell and do all the jobs in the cell
   b. DNA is copied by RNA; RNA is used to make proteins; Proteins are used to build the cell and to do the jobs the cell needs to do
   c. RNA is copied by DNA; DNA is used to build proteins; Proteins are used to build the cell and to do the jobs the cell needs to do

APPENDIX C for Lesson 4.

DO THIS TRUE/ FALSE EXERCISE AND THEN IN SMALL GROUPS DISCUSS YOUR ANSWERS AND SEE IF YOU AGREE

1. Maurice Wilkins, Rosalind Franklin as well as James Watson and Francis Crick were all working to find out the structure of DNA – or to understand how DNA is built

2. These four people (of question 1) were all working in the same laboratory

3. Rosalind Franklin became very famous for helping us to understand how DNA is built

4. Ms Franklin produced an x-ray photograph which was very important in understanding how DNA is built

5. Almost all the fame for the discovery of how DNA is built and the Nobel prizes went to Watson and Crick.

FOR ALL-CLASS DISCUSSION

1. Do you think it matters that Wilkins showed Watson and Crick Rosalind Franklin's picture of DNA without her knowing?

2. Why were unfair things done? What might have led to one person "cheating" another?

3. How would you or how should you think and behave differently if you were one of these people that did wrong? Be specific