Understanding the Code of Life

Educators' Science and Mathematics Institute Series
EXPLORATIONS IN LIFE SCIENCE
Understanding the Code of Life
Jon Stasiuk

Introduction:

The focus of the work I did centered around three main objectives found in our curriculum and the Michigan Curriculum Framework. They are:

The learner will use text, critical listening, and lecture material to draw, label, construct and describe the function of DNA.

The learner will model the process of DNA replication.

The learner will compare and contrast different views on alternating DNA and biotechnology, and their implications using local media, Internet, and prompts.

Overview of the Project:

My main concern as it became time to do the project was to successfully see that the three objectives above were reached. I think it was moderately successful. In the process, and due to curriculum time constraints, some of my project was not implemented. The omitted items are in italics.

Introductory Lesson - introduction of topic
Students researching historical background of DNA and other DNA related topics.

Lesson 1 - Historical background of DNA
Activity - Understanding Codes

Lesson 2 - Function and Structure of DNA
Activity - DNA Decorations

Lesson 3 - Modeling DNA and DNA replication
Activity - Building DNA - DNA Replication

Lesson 4 - DNA to Proteins - Protein Synthesis
Activity - DNA Relay
Assignment - Simulating Protein Synthesis

Lesson 5 - Recombinant DNA and Biotechnology
Activity - Video
Assignment - Writing

Wrap up
Activity - DNA Scavenger Hunt
Assignment - Cracking the Code

Pre and Post Assessment Questions
These questions were graded using a predetermined rubric for each question

Example of pre test responses in italic
Example of post test responses in bold

Explain the process of how DNA replicates itself.
What is DNA and what does replicate mean?
Most were successful in this based upon relating it to the activity that we did in class.

Where in the cell is DNA found?
Inside - most were not familiar with the nucleus
Estimate of 95% achieved the correct response and explanation

What is the structure of DNA called (shape)?
Had no idea
The term helix did not sit with them but they could sure tell you it was a twisted ladder.

Who discovered the structure of DNA?
Had no idea
Better idea afterwards although this topic was included within a chapter about cells, which dealt with the discovery of cells and the cell theory. They confused the names.

What are the functions of DNA?
Very few new that DNA related two other terms of which they were familiar - genes and chromosomes.
Most could discuss the functions of DNA especially relating it to a code.

Describe the Human Genome Project
They had never heard of this.
Some could briefly describe the project.

List some of the benefits of genetic technology.
Once they understood the meaning of genetic technology, many were able to discuss some small aspect based upon their experience with the hybrid corn companies in our town.
They were more able to discuss it using appropriate terms, relating it to the video we watched.

List some of the drawbacks of genetic technology.
Most were able to respond but once again in very limited terms.
They were more able to discuss it using appropriate terms, relating it to the video we watched.

Because of my knowledge of my student's background, I tried to keep the pretest and posttest nonthreatening - designing it more like a survey of knowledge. I knew that their background was very limited in this topic, and I was concerned with their self-image and self esteem which for my students is already very low.

I have 44 General Science 2 students, half of which are certified special education students. They are split into three classes. I team-teach one of the sections with a special education teacher. She is available to help other students as needed. 75% of my classes are labeled as at risk and receive additional help in their daily schedule.

They really had no idea on why they had to fill out the survey two times so my survey data will most likely not be good. I did administer the surveys in the correct procedure.

What worked well
DNA Decorations - although it took them two days to build them.
DNA replication
Understanding the Code of Life

Biotechnology Video - related to their previous knowledge and work experience dealing with the hybrid corn companies in our town.

What didn't work well

I did not even do lesson 4. The idea was more than these students could handle at this time.

The computer network was down for several days in an untimely fashion and with no additional resources, I discussed the contents of the historical background part of this lesson.

I did not do the writing assignment as a five paragraph paper. Our school has integrated writing throughout the curriculum using a certain method. (five paragraph paper). It was the Science teachers time to give a writing assignment back in September as each subject assigns one of these papers. We were not on this topic at that time. Therefore, the writing prompts were incorporated as part of a class discussion.

I think that I picked a tough topic and tried to relate it to a population of students who did their best. It proved to be very challenging. If given another opportunity, I would pick a different topic such as classification or scientific method which are also discussed in the Michigan Curriculum Framework.

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EXPLORATIONS IN LIFE SCIENCE

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Introduction:

Topics relating to DNA are in the media on a daily basis. Whether it is through a news program on television or an article in the daily newspaper, DNA is a topic that more students are showing an interest in. It is no longer an acronym that is only understood by the brightest scientists. Students have an interest in this topic, as DNA has become a common everyday word in their generation.

The focus of the work I am doing centers around three main objectives found in our curriculum and the Michigan Curriculum Framework. They are:

- The learner will use text, critical listening, and lecture material to draw, label, construct and describe the function of DNA.
- The learner will model the process of DNA replication.
- The learner will compare and contrast different views on alternating DNA and biotechnology, and their implications using local media, Internet, and prompts.

Rationale for the Project:

I have not had very much training in biology. DNA is a topic that is addressed in the Michigan Curriculum Framework. It is the topic that I have a weak background but strong interest in. I want to bring this topic to my lower level and special education tenth grade students at a level that they can understand. After seeking advice from one of my colleagues on what topic to cover in this paper, she recommended what I thought. The suggestion was to write the lesson on the topic that I was least familiar with. I am writing this to not only help my students but also to improve myself.

Overview of the Project:
I have included many activities and non-traditional assignments that actively engage the students. I have found that this works well for the students that I am targeting for this lesson.

**Introductory Lesson - introduction of topic**
Students researching historical background of DNA and other DNA related topics.

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Activity - Understanding Codes

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Activity - DNA Relay
Assignment - Simulating Protein Synthesis

**Lesson 5 - Recombinant DNA and Biotechnology**
Activity - Video
Assignment - Writing

**Wrap up**
Activity - DNA Scavenger Hunt
Assignment - Cracking the Code

**Resources**

* Biology, Peter Alexander  Copyright 1986 by Silver Burdett

* Exploring Life Science, Anthea Manton  Copyright 1995 by Prentice Hall

* Biology: The Dynamics of Life, Alton Biggs Copyright 2000 by The McGraw-Hill Companies

* Biology, Kenneth R. Miller and Joseph Levine  Copyright 1991 by Prentice-Hall


http://library.thinkquest.org/29599/genetic_basics.htm

**Standards Addressed:**

*From the Michigan Curriculum Framework (Science)*

I.1.7, I.1.8, II.1.1, II.1.4, III.1.2, III.1.4, III.3.1, III.3.3

I. Construct New Scientific and Personal Knowledge
All students will ask questions that help them learn about the world; design and conduct investigations using appropriate methodology and technology; learn from books and other sources of information; communicate their findings
using appropriate technology; and reconstruct previously learned knowledge.
Gather and synthesize information from books and other sources of information
Discuss topics in groups by being able to restate or summarize what other have said, ask for clarification or elaboration and take alternative perspectives.

II Reflect on the nature, adequacy and connections across scientific knowledge
All students will analyze claims for their scientific merit and explain how scientists decide what constitutes scientific knowledge; how science is related to other ways of knowing; how science and technology affect our society; and how people of diverse cultures have contributed to and influenced developments in science.
Discuss the historical development of key scientific concepts and principles.
Describe the historical, political, and social factors affecting developments in science.

III Use scientific knowledge from the life sciences in real-world contexts
All students will apply an understanding of cells to the functioning of multicellular organisms and explain how cells grow, develop and reproduce.
2 Explain how multicellular organisms grow, based on how cells grow and reproduce.
Compare and contrast the chemical composition of selected cell types.
3 All students will investigate and explain how characteristics of living things are passed on through generations; explain why organisms within a species are different from one another; and explain how new traits can be established by changing or manipulating genes.
Explain how characteristics of living things are passed on from generation to generation.
3 Explain how new traits may be established in individuals/populations through changes in genetic material (DNA)

Introductory Lesson
Introduce the topic segment from the news / newspaper article. This will instigate a class discussion. Using the Internet and the computer lab, the students will be in groups of three and prepare a small report of the historical background of DNA

Assign each group one of these personalities and write a biographical sketch that includes birthplace, education, influences, important discoveries or theories.

Gregor Mendel 1860
Frederick Griffith 1928
Oswald Avery 1944
Alfred Hershey & Martha Chase 1952
James Watson & Francis Crick 1953

The science of genetics is relatively new and discoveries in this field have increased rapidly in the last few decades. Here are some other topics to research for the remaining groups. These will be discussed and used later in the lesson plan.
Recombinant DNA
Reproductive technology
Human Genome Project
Biotechnology

Lesson 1

*Historical background of DNA*

Students groups will report their findings from their research. This will serve as an overview into this topic.

Students do not have a sense of appreciation for the work with the DNA model that was deciphered by Watson and Crick. The problem in decoding the DNA model was similar to problems involved in deciphering ancient hieroglyphs.

Morse code, music, and the binary code of computers are all examples of how symbols are used to represent information. Hieroglyphs were initially hard to decipher until the code was broke.

*Activity: Deciphering Codes*

Using hieroglyphics or number patterns, students will attempt to solve a coded message.

Lesson 2

*Function and structure of DNA*

DNA is found in nucleus of cell. It stores all of the information needed for a cell to function. DNA contains instructions for making proteins and carries messages about an organism that are passed from parent to offspring. Nucleic acids are the carriers for the blueprint of life. The DNA remains in the nucleus and the RNA leaves the nucleus through pores in the nuclear membrane.

DNA is composed of four nitrogen bases

- Adenine (A)
- Thymine (T)
- Guanine (G)
- Cytosine (C)

They pair up A-T and G-C

*Activity: DNA decorations*

Obtain two pieces of 24 gauge wire, each piece approximately 2 feet long. Count out the following plastic beads:

- 14 red (phosphate groups)
- 14 white (deoxyribose sugars)
- 3 yellow (Adenine bases)
- 3 blue (Thymine bases)
- 3 pink (cytosine bases)
- 3 purple (guanine bases)

Slide a red bead (phosphate) halfway down one wire. Slide a white bead down the other wire and twist to anchor the beads. You will have two double-stranded pieces.

String a white bead (sugar through the wire holding the red bead. Slide a red bead on the wire that contains the white bead. The beads on one strand should read: red, white and the other strand should read white, red.

Using one strand of a doubled wire, string one yellow bead (adenine) and one blue bead (thymine). Take one strand of the other doubled wire and pass it through the same two beads in the opposite direction. You have now joined the two stands by placing a pair of bases between them.

Place a red, then a white bead on the strand that already has the red, white order, and a
white then red bead on the strand that has the white, red order, to repeat the phosphate-
sugar backbone.
Using one strand of a side, string one purple bead (guanine) and one pink bead (cytosine).
Taking the longer strand on the opposite side, string the same beads in an opposing
direction.
Continue to lengthen your molecule by repeating the alternating phosphate-sugar beads
with base pairs to model the following sequence, starting from the bottom of the
molecule:

A - T
G - C
C - G
T - A

Finish your model by placing a final phosphate - sugar segment at the top. Tie off the wires
and make a loop for hanging or attach a key ring if you wish.
Twist the molecule into the shape of a double helix

Lesson 3
Modeling DNA and DNA replication

DNA has two main functions:
   It has the recipe to make the proteins that make up the cells.
   It has the recipe to duplicate itself to create another identical cell.

When DNA duplicates itself, which is called replication, it unzips. Since all the rungs on the
ladder are really two chemicals joined together, they let go; the two halves of the DNA
molecule then move apart. Floating around in a cell are lots of extra molecules needed to
make DNA. As the ladder unzips, adenine is on its own. When an unattached thymine comes
near, it joins up with adenine to form a new complete rung of the ladder. That process
continues until the entire strand of DNA is rebuilt. Once the DNA is rebuilt, the cell splits apart
into a perfect replica of itself.

The duplication process is not perfect, but mistakes are very rare. Those mistakes are known
as mutations. In your body, every cell's DNA is 99.99% identical. Every human being's DNA is
about 99.5% the same. Your friends may be taller or have a different color eyes, but they have
basically the same DNA as you have. The molecules in all DNA everywhere are the same:
adenine, thymine, cytosine, and guanine. The only difference between you and a giraffe, or a
tomato, is the recipe - the instruction on how the proteins are put together.

Activity: Building DNA - DNA Replication

Make up the pieces
Divide the class into four equal groups
Group One - line up single file at the front of the room, each placing their left hand on the
shoulder of he person in front of them. Give each person a paper base at random, and
have him or her hold it out to the right.

Group Two - Come up and stand parallel to group one on their right side. Place their
right hands on the shoulder of the person in front of them, and extend their left hands
out to meet group one.

Give each member of group 2 a paper base that matches the group 1 base they're next
to color and shape coded. When everyone's got a base, have each matched pair in
group one and two hold their paper pieces together to form a "ladder."
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You now have a molecule of DNA. Have the students call out the sequence of matched base pairs and copy it down on the chalkboard.

You are now ready for replication. Have groups one and two separate down the middle, but stay connected to the person in front and back of them. Have group two move a few feet away.

Call up groups three and four. Give each student a paper base at random. Don't have groups three and four link up together. Each student is a "free-floating" single base.

Have groups three and four mingle around groups one and two. When a student from group three or four finds a "match" in group one or two, he or she stopped there.

Continue matching until all students in group one and two have a match.

Have the groups link up to form the ladder shape as before. Ask each of the students to call out their base-pairs in order, and copy them on the board.

Compare the base pairs to the original set copied to the board. They should be identical matches. You now have two identical copies of the original DNA.

Discuss again other things in the real world that match as pairs. If you are given one of the pair can you determine what the other item had to be to match it? How?

Is it possible to sometimes combing things that aren't supposed to be paired together? (ex: pick a lock, make a fake footprint, put a sock on your fist). Could this be possible with DNA pairs? What happens if DNA accidentally matches up base pairs incorrectly? (All future copies would be wrong-this is a mutation.) Would all mutations necessarily be bad> (no this leads to variability in evolution).

Lesson 4

**DNA to proteins - Protein Synthesis**

The sequences of nucleotides in DNA contain information. This information is put to work through the production of proteins. DNA encodes the instructions for making proteins. These proteins have many uses in living things such as aiding in digestion, residing in walls of blood vessels and muscle fibers.

There are two steps in this process of making proteins.

**Transcription**

Enzymes unzip the DNA molecule like in DNA replication.

Free RNA nucleotides pair with complementary DNA nucleotides on one of the strands. When the process of base pairing is completed, the mRNA (messenger RNA) molecule breaks away as the DNA strands rejoin. The mRNA leaves the nucleus and enters the cytoplasm.

**Translation**

The mRNA joins with a tRNA (transfer RNA) and is transferred to an amino acid (protein).

**Activity: DNA Relay**

This activity is set up for groups of five. It can be easily adapted to groups of other sizes. This is an original creation from the files of Cheryl Hach who teaches at the Kalamazoo Math and Science Center in Kalamazoo Michigan.

Each group is supplied with appropriate letter triplets printed on cards of five different colors. Each student is also supplied with the mRNA codon chart. Below is the key for the relay race. Each group has exactly the same cards and should get the same result. Students are in their groups at one side of the basketball court (or appropriate place). They are each issued their starting triplet. The remaining cards are placed face up at the other side of the court. At the starting signal, the first person will walk across the court and pick up their appropriate matching triplet and walks back. After checking and verifying with the next person in line, the second
person does the same and then so on through the rest of the team.

Heat 1 to Heat 2 is the process of transcription  
Heat 3 to Heat 4 is the process of translation

<table>
<thead>
<tr>
<th>Person 1</th>
<th>Person 2</th>
<th>Person 3</th>
<th>Person 4</th>
<th>Person 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATG</td>
<td>GCT</td>
<td>TAC</td>
<td>CGA</td>
<td>ATT</td>
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<tr>
<td>TAC</td>
<td>CGA</td>
<td>ATG</td>
<td>CCT</td>
<td>TAA</td>
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<td>Extra</td>
<td>GAT</td>
<td>CCG</td>
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<td>stop</td>
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<tr>
<td>Extra</td>
<td>valine</td>
<td>lysine</td>
<td>serine</td>
<td>glyaine</td>
</tr>
</tbody>
</table>

Assignment: Simulating Protein Synthesis - CHNOPS
This assignment is from the Biology book from Prentice-Hall listed in the resources for this paper. It is an activity where students will follow through the protein synthesis steps of translation and transcription. Using amino acid sequences that match up with a physical trait, students will simulate the mechanism of protein synthesis and determine the traits inherited by a fictitious organism called CHNOPS.

Lesson 5
Recombinant DNA and Biotechnology
Video and newspaper articles brought in by students, and the reports from students from the introductory lesson will lead a class discussion.

Assignment - Writing
There are many important social and ethical issues that surround the field of genetics. Students will address one of the following in a five paragraph paper.

- How safe is recombinant DNA research as we genetically engineer crops to withstand frost and insect pests or add genes for enzymes which prevent fruit from spoiling too fast?

- Will genetically engineered crops be safe for consumption? If herbicide resistance is built into crops will the farmer use more herbicide to get rid of the weeds, and thereby threaten ground water drinking supplies?

- How should we care for frozen human embryos? What about parent's who decide that they have enough children and have frozen embryos, which remain? What if parents die and their embryos remain in freezers?
Will there come a time when we can select which genes will be found in our offspring once the Human Genome Project identifies all genes?

Will employers discriminate against us based on our genetic make-up, which might show a predisposition to Alzheimer's disease or cancer or alcoholism? Should our genetic make-up be considered personal information and be protected by Constitutional rights?

How are we applying what we learn in terms of genetic technology? How are we to control genetic technology? Who will be the decision makers? What research needs to be held in check until ethical issues are studied? Will there be abuse and exploitation of the new technology?

Wrap up

Activity: DNA Scavenger Hunt
This activity is from Access Excellence and is listed in my resources. The student is issued code for DNA is instructed to change it to mRNA codon and look each triplet up in a chart that matches it to a letter of the alphabet. The clues lead the students to a reward (a treat of some kind).

Assignment: Cracking the Code
This activity is similar to the scavenger hunt and uses the same ideas. It is designed for individual use where the student deciphers a code using the steps in protein synthesis.

Sample of Pre and Post Assessment Questions
These questions will be graded using a predetermined rubric.

Explain how DNA replicates.
Describe the process of protein synthesis.
During which process is mRNA produced?
Where in the cell is DNA found?
What is the structure of DNA called (shape)?
Who discovered the structure of DNA?
What are the functions of DNA?
What are some functions of proteins?