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Genetically Engineered Food: Altering the Blueprint

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by Karen A. Beitler

Introduction

Written as background for teachers and high school biology students, this unit assumes student knowledge of macromolecules, genes and how traits are passed from parent to offspring. Students should be aware of basic human needs and have explored food labels in terms of healthy choices of food intake. The narrative discusses the impact of genetic modification in the realm food production and effects on the environment as background for teachers of biology **.** A brief introduction into biotechnology will provide the reader with information for laboratory activities that simulate removal and replacement of genes to create recombinant organisms. The intention is to give the reader instruction in the processes and procedures of genetic modification as a precursor to the State of Connecticut Science and Technology embedded task; Genetically Modified Foods.

Narrative

Are the foods we eat responsible for the high incidence of obesity and diabetes in this country, or is it merely the habits we have? What is a healthy diet, healthy lifestyle? Our national dependence on fast food has increased childhood obesity and diabetes to epidemic proportions. Is it the food itself that is causing these risk factors? In the fascinating world of genetic modification, Virginia Ursin, a senior scientist at Monsanto Corporation is experimenting with adding the fish gene for Omega-3 oil to soy bean crops to increase the available amount of this heart healthy oil enough to help improve cardiovascular health. How about a rice that provides essential vitamins and minerals, potatoes that absorb less oil, oil seed crops that have more unsaturated, than saturated fat, sugar beets engineered to contain lower calories sugars(McHughen,235)? Genetic modification is also being applied to produce chemicals, pharmaceuticals, cosmetics, cotton, flax and flowers. This is just the beginning; imagine what we will be able to do in the future. Just how does genetic engineering work? A brief look at the processes involved in cutting up genes(RFLP), duplication of genes(PCR), identification of genes (DNA fingerprinting) and transformation of genes, is provided here. And lastly, but most importantly, who has the right to know if a food is genetically modified and how do these "new" foods affect us, our bodies and our environment.

Rationale

Many studies have been done to document the need for education of children on how they contribute to the health of their environment (Beech, 1999, Murphy, 1994, Russell 1994, Falciglia, 1997, Lin, 2001). Students who are informed about their environment are more likely to make smart choices that contribute to healthier bodies, healthier lifestyles and a healthier world (Guthrie, 2005). Schools can be identified as a key setting for promoting healthy choices for children. Many of the students in urban settings have little contact with the world outside their neighborhood and have no knowledge of where their food comes from outside the corner store. Some do not even know how a label describes the food within the package it is on. Our first order of business is education.

The National Restaurant Association estimates that more than 47% of the money spent on food will be in restaurants in 2005 that is almost double the 25% that was spent in 1955 (Horowitz, 2005). Our students eat out, or bring in food from take-out restaurants. They don't have a real connection with where foods come from or what requirements they have for growth or even how to put them together to make a meal (Pirouznia 2001). Because humans evolved over thousands of years in a world where salt, sugar and fat were difficult to come by, our bodies are programmed to seek out those ingredients (Schwader, 2005). Now that society has an overabundance of salt, sugar and fat available our brain doesn't know how to shut the cravings for these things off. We overindulge. If we want to have a healthy contributing society that is sustainable, we need to educate our young people; teach them how to eat and show them why, and shape responsible young adults that curb their own desires in favor of a healthy lifestyle. This is where genetic modification of foods comes in. Fresh fruits and vegetables don't have the appeal that a Big Mac with fries has, GM food companies seek to produce foods that have universal appeal and universal nutrition.

What are genes?

The central dogma of molecular biology describes the flow of the DNA message from the nucleus of our cells to a messenger called RNA which translates the message into proteins. What is that message? The message is how to replicate the order of the 20 amino acids that make up our cells. This genetic information determines what each cell will become determining our individual traits. Each trait is decided by a gene that has two alleles, inherited from each parent, which dictate what traits an organism will display. Much of agriculture today is based on Mendel's original principles of inheritance. Scientist and researches use these principles to cross breed plants to obtain desired characteristics. This process is time consuming, often many generations of a plant need to be bred to obtain the desired trait. Genetically engineering new types of plants is much faster and offers an advantage of transferring traits between species.

Understanding the structure of DNA is important to gaining insight into how foods are genetically modified. Deoxyribonucleic acid is found in the nucleus of cells. The shape is similar to a twisted ladder. The rungs of the ladder are called the sugar phosphate backbone of the structure. The pentose sugar, deoxyribose in each nucleotide is bound to the phosphate in the next by a strong covalent bond. A nucleotide is made of the sugar, phosphate and a nitrogen base. There are four nitrogen bases; two are double-ringed purines, Guanine and Adenine and two single-ringed pyrimidines; Thymine and Cytosine. The bases always pair up in the same way Adenine (A) with Thymine (T) and Cytosine (C) with Guanine (G). These bases are connected by hydrogen bonds and make up the rungs of the ladder. Each set of three nucleotide sequences is called a codon and translates to an amino acid. There are 20 amino acids that make up all the proteins (Campbell-Reece, 88-89). Amino acids make up the proteins that determine function. The pairs of bases, in triplets (codons) are put together in a specific order to make up genes. Genes are specific to the production of a particular protein

(Holt, 187).

One way to think of DNA is to envision a story written on a long roll of parchment. The narrative chronicles the complete story (organism). Each chapter in the story is a chromosome with paragraphs (genes), words (codons) and letters (nucleotides). If a letter is out of place or missing, the word doesn't make sense - then the sentence may not make sense. This could cause confusion in the paragraph and the chapter, and the story may deliver the wrong message.

In eukaryotic cells, DNA seeks to avoid confusion by being semi-conserved; one half of the original molecule binds with a newly made second half to make a molecule that is half old and half new. The series of nucleotides that make up the DNA ladder matches each A with T and C with G. Theses nitrogen bases are joined by a weak hydrogen bond that can be 'unzipped' by the enzyme helicase to separate the ladder into two chains that are exactly opposite. New amino acids match up and reform the ladder and each half is 'zippered' by another enzyme called DNA polymerase. This is, of course, a brief over view of the process, the 'code' must be read by messenger RNA (mRNA), altered to leave the nucleus so that only exons (the sections of the molecule that code for proteins leave) and travel to the ribosome. At the ribosome, the exon code is translated and transcribed and the amino acids are linked together in chains three nucleotides long strung end to, which travel back to the nucleus.

One half of the 'unzippered' parent molecule is bound to new amino acid chains and introns(internal non-coding parts of DNA) in the 3' to 5' direction, using it as a template; this is called the leading strand. On the other strand, short discontinuous segments of polynucleotide called Okazaki fragments are bound and another enzyme, called DNA ligase, stitches them, with their introns, into the lagging strand. The short chains match up with the parent DNA in the nucleus and reform the ladder, when all the DNA is replicated the cell is ready to go through mitosis.

In prokaryotic cells, such as bacteria, all or most of an organism's genetic information is stored in one long, circular ring. DNA replication begins at a fixed location called replication origin and the process takes less than an hour to complete. Bacterial cells also contain circular rings of extra-chromosomal DNA called plasmids. Bacteria have a short replication time and duplicate exponentially making many new plasmids. Scientists often use bacterial cells as vectors to make copies of a gene they are interested in. This is one important process in genetic engineering and is used in forensic science, pharmaceuticals and modification of foods as well.

Genetic Engineering

Genetic engineering or genetic modification is actually a collection of many technologies. Genetic modification changes the genetic content - the DNA sequence - of a cell, many cells, or a whole organism. Genetic modification is possible in bacteria, plants, and animals.

The process begins with identification of a gene, or gene sequence that determines a specific trait. Once the gene responsible for a trait is identified, then recombinant gene technology is used to artificially combine genetic material from one or more organisms (BIO, 1). Special enzymes are used to 'cut' the isolated gene from a chromosome. Many enzymes have been identified that will separate gene sequences at specific location on a chromosome. The set of technologies includes techniques for extracting genes, inserting them into a host DNA, cloning or multiplying them and the making of a unique new fingerprint to identify them.

If gene-splicing, cutting up the DNA into pieces, and then connecting the DNA back together, is probably the

technique most people think of when referring to genetic modification. Imagine a long chain of pop beads of four different colors. Suppose a tool is needed to separate the pop beads, perhaps a different tool for each triplet sequence in a chromosome. Scientists have identified which tool will slice which gene sequence in a particular way. Now that the sequence is cut, it can be recombined in a bacterial plasmid's DNA and replicated many times or placed in a plant or organism's DNA to change the traits expressed. The application of these techniques to a cell that will later replicate and divide making a new and different organism is known as a transgenic or genetically transformed, or modified organism (BIO, 2).

Let's take a look at how genes are transferred. Imagine a chromosome containing thousands of genes and scientists have identified a gene that helps an organism break down fats in a fish. A researcher is looking to help fight the obesity challenge in the United States. The researcher learns of the gene that breaks down fats for fish. The process begins to extract the gene from the fish, perhaps using enzymes, known as restriction enzymes, and place the gene in a commonly available food that is easy to grow, like corn. The researcher will need to make many copies of the gene.

Restriction endonucleases are enzymes that protect the bacterial cell against intruding DNA from other organisms. Theses specific enzymes work by cutting up the foreign DNA, a process called restriction. Scientists have identified and isolated thousands of these enzymes and because each is specific and recognizes only one particular short sequence of DNA, they can be used to cut DNA into restriction fragments. A restriction enzyme cuts DNA in a reproducible way. The most useful restriction enzymes cleave the sugar-phosphate backbone of DNA in a staggered way resulting in restriction fragments that have at least one single-stranded end, called the sticky end. The short sticky ends can forms temporary hydrogen bonded base pairs with other sticky end on any other DNA strand with the complementary sticky end cut with the same enzyme. These temporary bonds can be made permanent with the addition of the enzyme called DNA ligase. This enzyme catalyzes the formation of a covalent bond that closes up the sugar phosphate backbone, thus joining DNA from two different molecules to produce a stable recombinant DNA molecule (Holt, 140).

An original DNA molecule is sometimes called a cloning vector because it can carry DNA from another molecule and clone it (Avise, 687). Bacteria make good cloning vectors because they have a circular DNA molecule, called a plasmid. The plasmid DNA can be easily isolated from bacteria, manipulated into forming recombinant DNA by insertion of a foreign gene, and reintroduced into a bacterial cell. Bacterial cells reproduce quickly and in the process multiply any foreign DNA that they carry.

Molecular biologists use a method called RFLP to trace a specific sequence of DNA as it is passed on to other cells. Sample DNA is cut (digested) with one or more restriction enzyme and resulting fragments are separated according to molecular size using gel electrophoresis (Avise, 688). Scientists can then calculate the genetic distance between two genes. RFLPs can be used to measure recombination rates.

Back to the fish gene, the scientist has isolated the gene and will now need to make many copies to experiment with. They may use the bacterial cell to make those copies or another method called polymerase chain reaction (PCR). A gene can be inserted into a plasmid that can replicate exponentially in a bacterium. The bacteria will duplicate its DNA with the newly inserted gene, cloning and purifying the gene. DNA molecules can also be quickly amplified in a three step cycle that brings about a chain reaction producing an exponentially growing population of identical DNA molecules. Using heating and cooling and providing the ample genetic material, the gene is quickly cloned. Students can practice PCR in an online tutorial at the website called Polymerase Chain Reaction (Cold Spring Harbor, 1). This website simulates rising and falling temperature, denaturing DNA, annealing and extending primers through all three cycles and then lets the

students graph the exponential growth of the DNA fragment. An animated picture of PCR can be seen at Principle of the PCR (Vierstraete, 2). Now that we have the fragments multiplied many times, what do we do with them?

Electrophoresis is a means of separating proteins and purifying molecules by size using electricity and a porous medium. Because the phosphates of DNA have a negative charge, they will migrate towards the positive pole in an electrophoresis chamber. In a buffered solution, short strands move through the porous gel more quickly than the longer stands and thus are separated from each other. When stained, this makes a pattern that is unique. There is a logarithmic relationship between the distance a fragment travels and the molecular weight of the fragment (Campbell-Reese, 148) . The molecular size of unknown DNA fragments can be compared to a standard for identification Genes can be identified in this way, because each piece of DNA leave a unique fingerprint when separated by this method.

Three pictorial, manipulative gel electrophoresis websites; *Gel Electrophoresis for Separation of DNA molecules* (Hughes, 2) Graphics Text , *Learn Genetics* and the *Gene Almanac* are available to practice gel electrophoresis.

Genetic engineering can be used to repair a genetic defect for example; gene therapy in humans or to increase growth rate or resistance to a disease or damage from an insect or to enable an organism to do something it doesn't ordinarily do. GMOs have enabled microorganisms to produce human insulin for diabetics and make blood clotting proteins for hemophiliacs (BIO, 3). The benefits of discovery can be applied to many industries that use biotechnology: pharmaceuticals, agriculture, the processing of food, and forestry. There are currently two broad categories where genetically modified organisms have created controversy; ethical issues (including political, social and religious concerns) and scientific issues.

GMO's; Ethical issues

Ethical issues currently in debate are based around whether it is acceptable or not to modify the genes or utilize any other the genetic transformation techniques we now have available. While most people will agree that we have developed the tools and therefore should utilize them, the debate begins when discussion centers on how and why we should utilize them. Altering genes to produce medicine to make better insulin for a diabetic is acceptable, but altering genes to produce oil with cholesterol lowering abilities is not. One is considered necessary medicine, the other is not. The issues seem to lie in changing living things that humans consume and in the product that is changed. The lack of knowledge about, and misunderstanding of the process of genetic modification, may be the reason for concern (McHughen, 32).

Traditional breeding methods have produce hybrid plants for generations, the difference today is in the method used to transfer genetic information. Early farmers would breed generation after generation of plants until they had breed out undesired traits and obtain a plant that contained just the characteristics they preferred. There are hundreds of varieties of tomatoes; each hybrid has specific qualities the farmer saw as desirable and lacks those that were unwanted. A hybrid plant is one that contains genes of two differing species of plants and is genetically a combination of the two but phenotypically different from both (Teitel, 15). A phenotype is how an organism looks, or its physical qualities. A genotype is the record of the actual genes in an organism, often represented by letters (Holt, 172). For hundreds of years local growers in each part of the world have breed the traditional plants of their forefathers, refining the character of the areas crops. These traditional practices have provided us with unique varieties of plants that often bare the name of their homeland. The unique flavor of a fruit from certain area is dependent on several factors that contribute to the amount of sugar the plant makes. Varieties of fruits and vegetables obtain their flavors from where they

are grown, soil content, sunlight, rainfall and when a fruit is picked are all factors in plant flavor. Greenhouses and fertilizers and mechanical pickers can not imitate these conditions. Have you noticed that some 'fresh" fruits and vegetables just don't seem to have any flavor? We have gone from the individual farmer to large corporation farming - where a single variety of crop is grow on overused land with an abundance of fertilizers, pesticides and machinery to harvest the crop.

In the last half of the twentieth century the average crop yields of rice, corn, and wheat doubled or tripled and the number of tractors went from seven million to twenty-eight million (Ruse, 136). Large farm production drove down the prices of food while the farmer's costs rose. The hey-day of the family farm was over in developed nations and huge differences in food production exist between developed and undeveloped countries widened (Pringle, 3). The driving factor in the development of genetically modified food has been a desire to feed the worlds growing populations and the effort to keep down costs. Few people know how to farm today and are highly dependent on farmers to produce their food for them. As farming has become more and more industrialized, science has helped farmers reduce the difficulties of agriculture through development of machinery to reduce labor costs and through modification of the crop to reduce other factors. Breed varieties resistant to disease, produce larger yield and more flavorful varieties have been engineered to please the public.

The most famous GMO is the modification of corn to reduce pesticide use by inserting a gene that resists herbicides. Monsanto foods had developed a product called Round-up in the 1980"s containing a non-selective herbicide called glyphosate (Mchughen, 38). Glyphosate inhibits ESPS synthase, an enzyme, in almost all plants, except petunias. . Monsanto scientists were able to isolate and clone a petunia EPSP synthase gene, modify it and insert it - thus making the first herbicide-tolerant plant, a corn that could survive Round up (McHughen, 40). This began the competition for patented seeds which has substantially reduced the variety of seeds available in agriculture. Soon afterwards, a gene bank was formed. Here researchers could deposit seeds to grow specific types of plants. Deposits and withdrawals are free. The advent of genetic modification was upon us.

The most pressing issues early on in genetic modification were for producing high yield crops; early maturing crops, enhanced weed control and overall grain yield. However, managed environments can produce can produce herbicide resistant plants, the so-called 'superweeds'. Fortunately, these plants are usually resistant to only one herbicide, not all herbicides (MuHughen, 127).

All new products carry some degree of risk; developers of conventional products do not indicate their products are risk free either. We can only compare the products and make our own informed decision- GMO's are a matter of risk assessment.

GMO's; scientific issues

Genes change all the time and can affect the phenotype or the functional of an organism drastically. So what is the controversy in manipulating genes to produce better products?

Food produced on a large agricultural farm is consumed at our tables. What are the scientific issues that the public needs to be concerned with? The idea of being able to move genes between species initially caused alarm in the scientific community and a ban was recommended on experimentation that involved placing a gene from one species into another (Ruse, 34). The fear was that "super bugs" would take over naturally occurring organisms. After a few years of strictly controlled testing, the Institutes of Health in the mid 1980's

lifted the ban because they found adding almost any gene to bacterial cells only weakened the organism. Top scientists agreed that modified bacteria cells were not dangerous (Ruse, 35). The Environmental Protection Agency (EPA) and Food and Drug Administration (FDA) took co-authority over the business of genetic modification. Research began on moving genes between species, bacteria were used to produce human insulin for diabetics and experimentation began on modifying foods. A major player in the business, Monsanto Foods, Inc. developed a plan to introduce biotechnology to the public. To solve political problems a document was drawn up encourage support for biotechnology from regulators around the world. Officials recognized early on that while public opinion regarding biotechnology used to develop new drugs for those in need would be acceptable. However, the modification of plants and animals, moving genes between species, would not go well with consumers. The leaders in biotechnology at the time agreed that keeping an open dialogue with consumer groups and important stake holders would be the best way to ensure support (Ruse, 37).

The government's position was loose and different aspects of genetic modification were shared by the FDA and EPA. Monsanto, under new leadership lobbied heavily in Washington and pushed through genetically modified food policies. As a result, many genetically modified foods made it to market ignoring religious, social, cultural, ethical and economic issues (Ruse, 37). Scientists at the FDA Center for veterinary medicine concluded that the move was premature to accept genetically modified foods and that toxicity studies were necessary. The industry dismissed the worries and stated that foods could be tested by the producers of GM foods and that labeling of GM foods would only mislead the public (Ruse, 38). The FDA's hands-off policy led to hundreds of groups protesting and began the movement against GM foods and biotechnology. By 1992 a petition reached the government offices that demanded a change in the GM food policy to include toxicity testing and specific labels on any food produced that had been modified in any way. GM foods had reached the market without any indication that they had been genetically modified. The public felt duped when they discovered that GM food had been in the marketplace without them knowing. There were many questions from a public that was naive about biotechnology. Questions like whether a genetically modified food makes a food product more allergenic remains to be answered. Until we fully understand the allergenic process we can not make this claim. Certainly, careful consideration and further monitoring needs to be continued. The controversy about genetically modified foods will endure and will keep the questions coming. Recombinant DNA technology will continue and will provide opportunity and scrutiny of practice and application. As we continue to try to provide food for all people we will learn more about how genes perform.

Environmental Issues

There have been many environmental concerns with the advent of GM Foods. Will superweeds be generated by gene flow when plants able to resist weeds are planted? Can the spread of pollen contaminate far-off fields making transgenic traits appear in other species of plants? In the organic way of farming cow manure is spread to fertilize plants. If the concern is use of massive tracks of land for organic farming, then shouldn't there be concern for the amount of land needed for cows to graze on to produce the manure to fertilize crops? What is the best way to produce food? The future of agriculture will need to be flexible and diverse in the technologies that are used today and those that can be developed in the future to bring to market safe and healthy foods.

To slow the ongoing loss of biodiversity we will have to be diligent in our monitoring of the preservation of wetlands, rivers, lakes and coral reefs. The destruction of tropical rainforests, mangroves and open spaces must be stopped (Ruse, 231). We do not yet know what we are destroying and we will never know what we have lost. Man must look to the whole biosphere and considers its preservation as well as its development.

Some scientists are working on a new method of improving crop yield; this is the science of Transgenomics. Transgenomics is a method halfway between the natural evolution of a plant and artificial genetic modification (Pringle, 196). The belief is that similar plants and animals have evolved to have certain traits, and then there must be a way to induce them to switch on or off certain traits to achieve the same type of results as we have by implanting genes from other species. Scientists have know for decades that corn has its own transposons, genes that appear when the plants is under stress and cause a genetic reorganization to help the plant survive (Pringle, 198). To manipulate a plant to cause a certain trait to appear is the aim of this new science. These new hybrids would theoretically have been forced to 'evolve' without insertion of a foreign gene. Perhaps this will be the farming method in the future. What label will be put on this type of foods- genetically evolved? The future of agriculture is still uncertain. What is certain is that we must continue to ask questions about the source of the goods we use and consume.

Lesson Plans

Overall Unit Objectives

1 Review how information is passed from parent to offspring; DNA,--->protein
2 Define genetic engineering.
3 Explain how restriction enzymes can be used to make recombinant DNA.
4 List the steps in a gene-transfer experiment.
5 Distinguish between the following laboratory techniques: RFLP analysis, gel electrophoresis and polymerase chain reaction.
6 Explain how DNA technology can be used to produce food & medicine.
7 Describe some ways that DNA technology can be used to improve crops.
8 Discuss some environmental and ethical issues in genetic engineering

LP 1 - DNA & Genes - what are they, how we use them, how can they be influenced?

LP 2 - Genetic engineering -RFLP, PCR & DNA fingerprinting

LP 3 -Transferring genes - pGLO lab

LP 4 - Environmental & Ethical Issues in Genetics

Lesson plans may take more than one day. Lessons are presented in an order the writer believes will be most beneficial to the student. Depending on your student population and available time, additional depth and research may be explored.

LP 1

Topic: DNA & Genes - what are they, how we use them, how can they be influenced?

Objectives

The student will. . .

Explain the principal function of DNA

Describe the structure of DNA

Summarize the main features of DNA replication.

Explain the primary function of RNA.

Summarize the process of transcription and translation.

Distinguish between a codon and an anticodon, and state where each is found.

Lesson 1

1. Lecture & Discussion: What is DNA? How does it reproduce?
2. *DNA Twizzlers Lab* (Appendix B)
3. DNA Webquest (Appendix C)

Lesson 2

1. Lecture & Discussion: DNA replication; processes & function
2. DNA- The Double Helix (see Student resource 13)

LP 2

Topic: Genetic engineering - PCR & DNA fingerprinting

Objectives

The student will. . .

Explain the primary functions of DNA and RNA.

Summarize the process of transcription and translation.

Define genetic engineering.

Explain how restriction enzymes can be used to make recombinant DNA.

Explain how cloning vectors can be used to clone and transfer genes.

Lesson 1

1. Lecture & Discussion: What is genetic engineering?
2. *Nucleus to Fingerprint* (Trace the life of a gene in a poster)
3. Resource *: Lifeedu.org*

Lesson 2

1. Lecture & Discussion: What is PCR?
2. Practice PCR in an online tutorial at the website called Polymerase Chain Reaction (Cold Spring Harbor, 1)
3. View the Principle of the PCR at http://users.ugent.be/~avierstr/principles/pcrani.html

Lesson 3

1. Lecture & Discussion: Methods in Genetic engineering
2. *Learn Genetics* website practice
3. *Gel electrophoresis* - run standards and DNA fragments *or* practice online

LP 3

Topic- Genetic Transformation

Objectives

The student will. . .

Explain how gene therapy may be used in humans

Explain how DNA technology can be used to produce medical products.

Lesson 1

1. Lecture & Discussion: What is RFLP?
2. *Paper Genetics lab* -email me for a copy
3. Or clone a mouse at http://gslc.genetics.utah.edu/

Lesson 2

1. Prelab discussion: Bacterial transformation (see *pGLO* kit instructions)
2. *pGLO* lab from BioRad *or* similar tranformation lab

LP 4

Topic- Environmental & Ethical Issues in Genetics

Objectives

The student will. . .

Discuss environmental and ethical issues in genetic engineering.

Describe some ways that DNA technology can be used to improve crop yields and

the food supply.

Lesson 1

1. Lecture & Discussion: Ethical Issues in Genetic modification
2. Student Webquest of Ethical Issues

Lesson 2

1. Lecture & Discussion: Environmental Issues in Genetic modification
2. Student research essay Environmental Issues

Lesson 3

1. Lecture & discussion; How to Persuade
2. State wide STS Activity; GM Food Persuasive Pamphlet

Lesson 4 - *optional addition*

1. Lecture & Discussion: Biomedical Engineering
2. PowerPoint presentation - *Careers in Biomedical Engineering* (Farrell, 1)

Lesson 5 - *optional addition*

1. *Designing a Career in Biomedical Engineering* (EMB 2003)
2. Student research; Careers in Biotechnology
3. Student presentations; Careers in Biotechnology

Methods and Materials

DNA Twizzlers Lab

A package Twizzler candy, round toothpicks, a package of multi-colored mini marshmellows, index cards with three codons (9 amino acid bases coding for 3 proteins) Optional - DNA codon interpretation sheet. This lab leads nicely into naming the 20 amino acids if you have set up a class set that contains all the possibilities.

Reproducible can be found at : http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/C/Codons.html

What is genetic engineering?

Download a PowerPoint at LIFEedu.org -

http://lifeedu.org/course_EDC920main.html

PCR - http://www.dnalc.org/ddnalc/resources/shockwave/pcranwhole.html and

http://users.ugent.be/~avierstr/principles/pcrani.html

Learn Genetics - online simulations of biotechnical techniques.

http://gslc.genetics.utah.edu/units/biotech/index.cfm

Paper Genetics lab - email karen.beitlernew-haven.k12.ct.us

pGLO -

Info: chem.pdx.edu/~yanm/ **pGLO** lab.doc

Student manual - http://biosci.usc.edu/courses/2002-fall/documents/bisc300-lab_bactrans.pdf

Lab info: http://www.rlc.dcccd.edu/mathsci/reynolds/micro/lab_manual/transformation.html

GM Food Persuasive Pamphlet - http://www.sde.ct.gov/sde/cwp/view.asp?a=2618&q=320892

Careers in Biomedical Engineering - www.brown.edu/Students/Biomedical_Engineering_Society/dl/Industry_October_16_03.ppt

Designing a Career in Biomedical Engineering - http://www.bmes.org/careers.asp

Resources for Students

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Resources for Teachers

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Appendix A

National Science Education Standards

LS 1a: Cells have particular structures that underlie their functions. **LS 1c:** Cells store and use information to guide their functions **LS 1d:** Cell functions are regulated.

LS 1f: Cells can differentiate. Complex multicellular organisms are formed from highly organized arrangements of differentiated cells.

LS 2a: In all organisms, the instructions for specifying the characteristics of the organisms are carried in DNA.

LS 3a: Species evolve over time.

LS 3b: The great diversity of organisms is the result of more than 3.5 billion years of evolution that has filled every available niche with life-forms.

LS 3d: The millions of different species of plants, animals, and microorganisms that live on Earth today are related by descent from common ancestors.

LS 4c: Organisms both cooperate and compete in ecosystems.

LS 4e: Human beings live within the world's ecosystems.

LS 4d: Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite.

LS 5d: The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism.

PS 2: Structure and properties of matter

PS 3: Chemical reactions

PS 6: Interactions of energy and matter

UCP 1: Systems, order, and organization

UCP 2: Evidence, models, and explanation

UCP 3: Change, constancy, and measurement

UCP 5: Form and function

ST 1: Abilities of technological design

ST 2: Understandings about science and technology

SAI 1: Abilities necessary to do scientific inquiry

SAI 2: Understandings about scientific inquiry

SPSP 1: Personal and community health

SPSP 2: Population growth

SPSP 3: Natural resources

SPSP 4: Environmental quality

SPSP 6: Science and technology in local, national, and global challenges

HNS 1: Science as a human endeavor

HNS 2: Nature of scientific knowledge

Appendix B

This works better if copied in landscape format before printing. . .

DNA Twizzler/Marshmellow Lab

Background Information

Students should have read and understand the chapter on DNA replication. It is important that students know the base pairs and understand the bonds that hold these bases together. The student will demonstrate his or her knowledge of the process of replication by completing this activity.

Materials Needed (For Each Group) 2 Twizzlers or similar type of candy 7 toothpicks 14 colored marshmallows (a variety of 4 colors) trays Index Cards with 7 bases listed Cooperative Attitude

Lesson

- Each material represents: Marshmallows= Base, Toothpicks= Hydrogen Bond, Twizzlers=Phosphate and Sugar (trays are to keep their materials on)
- Devise a key for the colors of marshmallows (which base equals which color)
- Each group has an index card that lists the bases for a strand of DNA.
- The students will construct the given strand of DNA.
- The students will construct the other strand through replication.
- After matching the bases, students add the second Twizzlers.
- The students twist the Twizzlers in order to make the winding staircase design.

Conclusion

Students will write the missing strand of DNA on the index card. Each group will present their DNA strand to the class and answer one question on the topic of DNA. The group will turn in their index card and may eat their strand of DNA if they choose to.

Evaluation Each individual will be evaluated by using the following rubric.

(table available in print form)

14-16= A, 11-13= B, 8-10= C, 10>=F

Total_____of 16pts.

Appendix C

DNA & RNA Webquest

Website; ***www. dnaftb.org*** - click on *Molecules of Genetics*

On the right side you will see chapter numbers they will be displayed 15 to show you where to find the information to fill in the blanks.

15 Read the introduction then click on Animation

1. Who isolated nuclein from cells? _____
2. What did he do to isolate it? _____
3. What did he think it was? _____
4. What did Phoebus Levene find? _____
5. What are proteins made up of? _____
6. What are the 4 subunits of DNA called? _____
7. What are they made up of? _____

Click on Problem write the answers here:

- _____
- _____
- _____

17 A Gene is made of DNA

What is the transforming principle? _____

Click on Audio/Visual. Click on gene - write the definition here
_____Click on [X]

19 The DNA molecule is shaped like a _____ _____ what is it composed of?
_____

Click on Animation

James _____ and Frances _____ found that _____ _____ are linked in a series. Erwin _____ isolated DNA from different organisms and measured the levels of each of four _____ _____. He found that the amount of adenine was close to the amount of _____ and the amount of cytosine was approximately as much as _____. At Cal Tech, Linus _____ used X-ray crystallography to discover the _____ _____. Rosalind _____ and Maurice _____ made DNA X-ray _____ patterns and were able to calculate the basic _____ of the DNA molecule. Frances Click found that there must be _____ nucleotides between each helical repeat. From the X-ray diffraction pattern, Click deduced DNA should be a _____ _____

With phosphate groups on the outside and _____ on the inside. James Watson found that the _____ base pair was about the same width as the G/C _____ pair. Guanine makes _____ hydrogen bonds with _____ and adenine makes 2 _____ bonds with thymine. Therefore, DNA is like a twisted _____ where the _____ and _____ are the rails and the base _____ are the rungs. The rails run in _____

orientation to each other. Wherever there is a _____ on one strand there is a thymine on the other strand. Similarly, wherever there is a cytosine there is a _____ on its opposite strand.

What was the concluding statement in Watson and Clicks 900 word statement on the structure of DNA? Write it here_____

_____
_____.

20

Watson and Crick proposed that one half of the DNA ladder serves as a template for recreating DNA. What did the experiment using nitrogen isotopes show? _____

21

Describe the "central dogma" of genetic information.

Click on Animation

Name three differences between DNA & RNA

DNA RNA

_____ _____

_____ _____

_____ _____

Paul _____ was interested in _____ _____. He made an extract using rat liver cells, added radio labeled _____ _____, incubated and centrifuged them. He identified a large cellular structure later named the _____, where protein assembly occurs. Mahlon _____ found amino acids were activated by _____. With Mary _____ he found a low molecular weight "soluble" RNA later named transfer RNA. Sydney _____, Francois _____, Mathew _____ shower there was a third type of RNA that carries the DNA message to the ribosome. Using phase-infected bacteria, they found that one ribosome is made up of _____. The larger of which was the heavier RNA, the carrier called _____

Click on Problem

- _____
- _____
- _____

22 DNA words are three letters long. A three letter code is called a _____

Click on Problem

Appendix D

Note to teachers- I have this pretest with pictures in Power Point; email me and I will send it to you. (karen.beitlernew-haven.k12.ct.us)

GM Foods Pretest Name_____

1. Do tomatoes have genes?
2. Are genetically modified foods in the supermarkets now?
3. Does genetic modification of food mean inserting genes from one chromosome to another to enhance the food in some way?
4. Does inserting a fish gene into a tomato mean the tomato will taste "fishy"?
5. Can the genes from a genetically modified food enter your genes and be passed onto your future children?
6. Are there risks to health and the environment in the current method of breeding new varieties of food?
7. Has there ever been any documented harm to anyone from a genetically modified food?
8. Name two genetically altered foods.
9. Name a food process that is on the label of any food?
10. Is labeling of genetically modified food fair?

GM Foods Pretest ANSWERS

From the lecture "Science, Society and the Real Threats Posed by GM Foods" given by the author of the popular book Pandora's Picnic Basket Dr. Alan McHughen.

1. Do tomatoes have genes?

Of course tomatoes have genes - they are living eukaryotic cells!
2. Are genetically modified foods in the supermarkets now?
Yes there have been genetically modified foods in the supermarkets for over ten years!
3. Does genetic modification of food mean inserting genes from one chromosome to another to enhance the food in some way?
Yes! Genetic engineering involved removing a gene from one cell and inserting it into another.
4. Does inserting a fish gene into a tomato mean the tomato will taste "fishy"?
That's just silly! A gene that is inserted will perform as the scientist intended- why would a scientist want a "fishy" tasting tomato?
5. Can the genes from a genetically modified food enter your genes and be passed onto your future children?
No! Food is processed in your system and digested; foods don't change your genes.
6. Are there risks to health and the environment in the current method of breeding new varieties of food?
Yes! There are always risks in agriculture, but GM Foods may have lower risks than current methods.
7. Has there ever been any documented harm to anyone from eating a genetically modified food?
No! There has never been any documented harm from GM foods.
8. Name two genetically altered foods on the market today.
85 % of corn and 65% of soybeans are genetically engineered
9. Name a food process that is on the label of any food.
There isn't one, processes aren't on labels; genetic engineering is a process.
10. Is labeling of genetically modified food fair?
Opinion

Appendix E

State of Connecticut Embedded Task for High School Biology **Strand IV: Cell Chemistry and Biotechnology** can be found at http://www.sde.ct.gov/sde/cwp/view.asp?a=2618&q=320892

Other resources for this investigation:

General Information about GM Foods - Presenting Both Pros and Cons of GM Foods: Courtesy of Mary M. McMullen, MA, MLS - Library Media Specialist

http://www.ornl.gov/sci/techresources/Human_Genome/elsi/gmfood.shtml

http://www.nlm.nih.gov/medlineplus/ency/article/002432.htm

http://library.thinkquest.org/TQ0312650/food.htm

http://www.americans-world.org/digest/global_issues/biotechnology/biotech3.cfm#top

http://www.ext.colostate.edu/pubs/foodnut/09371.html