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<i>Applied Biotechnology</i>	
Introduction	<p>The world of biotechnology is constantly changing and developing with changes in scientific understanding and technology. In the wide field of biotechnology, researchers are developing solutions for issues in human health, conservation, and agriculture. Some many comment that humans have developed ways to combat the rise in the world population with innovative biological technologies. With all of this dynamic science, students need to understand the tools and the actions needed for real use of biotechnologies. Yet students also need to understand that new and changing scientific fields have many unanswered ethical questions. In order to discuss the ethical implications of biotechnology, we must first understand the “How” and look at the process that scientists take to complete these scientific tasks.</p> <p>In this unit students will use three focused units of study to understand the processes and application of biotechnology and understand the ethical considerations.</p>
Real Science Application	<p>Gene Drives, Nanotechnology, Insect Transgenesis with CRISPR, and other emerging biotechnologies have all been developed in the last 10 years. As these emerging technologies continue to develop, and new technologies appear scientists, and learners alike must discuss the challenges and ethics of each new scientific question that is developed.</p> <p>Working with the IGERT fellowship cohorts to examine Mosquitoes and Human Health, Invasive Populations on Islands and Agricultural Pests, I was able to observe biotechnology in practice. All of these scenarios are current events that researchers across the globe are working to influence. It is important to note that the skills needed to be a scientific researcher, are just as helpful as knowing scientific content. It is important for scientific curriculum and content to create creatively reasoning students that can use their scientific process skills at all levels of scientific understanding.</p>

Curriculum Alignment	<p>NC Essential Standards for Biology:</p> <p>Understand the application of DNA technology.</p> <p>Bio.3.3.1 Interpret how DNA is used for comparison and identification of organisms.</p>
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	<p>Bio.3.3.2 Summarize how transgenic organisms are engineered to benefit society. Bio.3.3.3 Evaluate some of the ethical issues surrounding the use of DNA technology (including cloning, genetically modified organisms, stem cell research, and Human Genome Project).</p> <p>8th Grade Science:</p> <p>Understand how biotechnology is used to affect living organisms. 8.L.2.1 Summarize aspects of biotechnology including:</p> <ul style="list-style-type: none"> • Specific genetic information available • Careers • Economic benefits to North Carolina • Ethical issues • Implications for agriculture
Learning Outcomes	<p>Part A <i>Applied Biotechnology</i>: Designer Insects</p> <ul style="list-style-type: none"> ● Students will creatively engineer an insect that fits into an environment of their choosing. ● Students will present their genetically engineered organism in a poster presentation that showcases the genetics and the environmental implications of their insect. <p>Part B <i>Applied Biotechnology</i>: Exploring Science in Science Fiction</p> <ul style="list-style-type: none"> ● Students will explore the use of genetic engineering techniques in recent movies, TV shows etc. ● Students will present on one example of a scientific in society example that is real and one that is fiction. ● Students will create a poll to assess knowledge, and an infographic to share their findings with their peers and families <p>Part C <i>Applied Biotechnology</i>: Bioethics in Biotechnology</p> <ul style="list-style-type: none"> ● Students will look at case studies of recent uses of DNA technologies. ● Students will evaluate research and prepare and unbiased info sheet about both sides of the issue. ● Students will use their research to complete a philosophical chairs discussion of the ethical issues with genetic engineering.
Time Required and Location	10 Days of 90 minute class periods.

Materials Needed	<p>This section contains 2 lists: one with materials and resources needed by the facilitator and the second with materials and resources needed by participants. Include quantities for all materials, such as books, handouts, technology, paper and pencils, art supplies, and so on.</p> <p>If you use handouts or specific materials for presentation, please make them available as separate files.</p> <table border="1" data-bbox="285 456 2007 748"> <tr> <td data-bbox="285 456 1146 748"> Instructor/Facilitator Resources <ul style="list-style-type: none"> ● Curriculum Map ● Copies of Student Handout ● Glue/Tape for Construct Making ● News Clips for Mosquito Releases ● Science Fiction Clips for Introduction of Exploring Science in Science Fiction </td><td data-bbox="1146 456 2007 748"> Student Resources <ul style="list-style-type: none"> ● Designer Insects Handout ● Transgenic Organism Reading ● Science in Science Fiction Handout ● Philosophical Chairs Reflection Sheet </td></tr> </table>	Instructor/Facilitator Resources <ul style="list-style-type: none"> ● Curriculum Map ● Copies of Student Handout ● Glue/Tape for Construct Making ● News Clips for Mosquito Releases ● Science Fiction Clips for Introduction of Exploring Science in Science Fiction 	Student Resources <ul style="list-style-type: none"> ● Designer Insects Handout ● Transgenic Organism Reading ● Science in Science Fiction Handout ● Philosophical Chairs Reflection Sheet
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Safety	<p>Students will follow all safety rules for the classroom and lab. Review Internet Safety and Data Collection Safety with Students</p>		
Participant Prior Knowledge	<p>Students will complete this unit after completion of the units on evolution and genetics. Students should be familiar with the concepts of natural selection, genes, trait transfer to offspring and biological reproduction. Students will also need knowledge of biological skills, such as scientific questioning, scientific research and scientific reasoning with the scientific method.</p>		
Facilitator Preparations	<p>Curriculum Map provided for flow of unit. Copies of all units activities will be needed. Units may be split or completed in parts.</p>		
Activities	<p><i>This unit allows students be active participants in learning the techniques and the processes that are needed for biotechnology. After experiencing the processes and skills found in biotechnology, students will examine instances of biotech in pop culture and evaluate the ethics of biotechnology in society.</i></p>		

Part A Applied Biotechnology: Designer Insects

Students will create an “Designer Insect” with a structured online module (or modified in class lab). This will take students familiarize students with the technique and tools of DNA technologies.

Part B Applied Biotechnology: Exploring Science in Science Fiction

Students will examine various examples of biotechnology in pop culture and research the validity of the techniques used. Students will present their findings in an infographic to be shared on the class website.

Part C Applied Biotechnology: Bioethics in Biotechnology

Students will use structured debate, class discussion and data collection from surveys to explore the ethical considerations of biotechnology. Students will create information briefs from surveys and individual research to present an unbiased issue brief on one emerging biotechnology.

Curriculum Overview	Instructional Activities	Time	Learning Outcome	Assessment	Additional Information
<p><i>Part A Applied Biotechnology: Designer Insects</i></p> <hr/> <p>Students will create an “Designer Insect” with a structured online module (or modified in class lab). This will take</p>	<ol style="list-style-type: none"> 1. Designer Insects Game 2. Reflect on Game by creating flowchart of genetic engineering process 3. Review Tools and Processes of Biotechnology with a teacher led t-chart 4. OPTIONAL: Designer Insect Stations Modified Activity 	<p>Lesson: 2</p> <p>Days: ~2</p>	<p>Students will engineer a transgenic organism.</p> <p>Students will understand the process of creating a transgenic organism.</p>	<p>Teacher will use a rubric to measure the students understanding using their created flow charts.</p> <p>Teacher will use an exit ticket to understand the students</p>	<p>Student Prior Knowledge: Evolution, Genes, Population Dynamics, Natural Selection, Diversity of Insects, Classification and Taxonomy</p> <p>Instructor Resources: Designer Insects in Class Plasmid Creation Instructions</p> <p>Student Resources: Oxetic Reading Designer Insects Handout</p> <p>Safety: Students will follow all safety rules for the classroom and lab.</p>

	students familiarize students with the technique and tools of DNA technologies.				knowledge of what they learned in class.	
	<p><i>Part B Applied Biotechnology:</i> Exploring Science in Science Fiction</p> <hr/> <p>Students will examine various examples of biotechnology in pop culture and research the validity of the techniques used. Students will present their findings in an infographic to be shared on the class website.</p>	<ol style="list-style-type: none"> 1. Hook: Watch Clip Montage to find tools and processes from Unit Part A. 2. Students choose and research additional examples of biotech in pop culture. 3. General Survey of Biotech knowledge 	<p>Lesson: 1</p> <p>Days: ~3</p>	<p>Students will explore the use of genetic engineering techniques in recent movies, TV shows etc.</p> <p>Students will present on one example of a scientific in society example that is real and one that is fiction.</p> <p>Students will create a poll to assess knowledge, and an infographic to share their findings with their peers and families</p>	<p>Rubric for Project</p>	<p>Student Prior Knowledge: Understanding of Biotechnology and Genetic Engineering Terms</p> <p>Instructor Resources: Science Fiction Video Clip Survey Expectation Sheet</p> <p>Student Resources:</p> <p>Safety: Review Internet Safety and Data Collection Safety with Students</p>

	<p><i>Part C Applied Biotechnology:</i> Bioethics in Biotechnology</p> <hr/> <p>Students will use structured debate, class discussion and data collection from surveys to explore the ethical considerations of biotechnology. Students will create information briefs from surveys and individual research to present an unbiased issue brief on one emerging biotechnology.</p>	<ol style="list-style-type: none"> 1. Hook: Connection to Part B 2. Examine Class Survey Results 3. Introduce PBL Project 4. Case Studies Class Activity 5. Intro to Ethics Mini Lesson 6. Speed Debate 7. Pre-Read for Philosophical Chairs Discussion 8. Philosophical Chairs Discussion 	<p>Lesson: 6</p> <p>Days: ~7</p>	<p>Students will look at case studies of recent uses of DNA technologies.</p> <p>Students will use their research to complete a philosophical chairs discussion of the ethical issues with genetic engineering.</p> <p>Students will use data collected to understand public opinion about biotechnology.</p>	<p>Rubric for Project</p> <p>Rubric for Participation and Project Steps</p> <p>Written Reflection of Philosophical Chairs</p> <p>Written Reflection for Survey Responses</p>	<p>Student Prior Knowledge: Ethics and Ethical treatment, Understanding of DNA Technology, Genetic Engineering and General Public Opinion on Recent Scientific Discoveries</p> <p>Instructor Resources: Case Study Articles Prepared for Individual Students. Instructor decides, based on student level, for students to read different articles, the same article or modified articles.</p> <p>Philosophical Chairs Question Sheet</p> <p>Philosophical Chairs Resource: http://www.ocde.us/AVID/Documents/Philosophical-Chairs.pdf</p> <p>Student Resources: Case Studies</p> <p>Safety:</p>
Assessment	<p>Rubric for Project</p> <p>Rubric for Participation and Project Steps</p> <p>Written Reflection of Philosophical Chairs</p> <p>Written Reflection for Survey Responses</p>					

Critical Vocabulary			
	Vocabulary Word	Definition	Vocabulary Word Tier
	Ethics	Human actions and understanding that determine the right and wrong in situations	2
	Transgenics	Transferring genetic material into another organism to create a	3
	Genetic Engineering	Modifying organisms using DNA	3
	Biotechnology	Using cells and molecules to develop new products and systems that enhance life	2
	Pest	Unwanted organism	2
	Gene	Section of DNA that carries information for a certain protein	2
	Gene Drive	Using natural reproduction of organism to “push” a new gene into a population of organisms.	3
	Human Genome Project	Study and Sequencing of Human Genome	3
	Plasmid	Circular DNA found in Prokaryotic Cells	2
	DNA Construct	Created DNA code for insertion in Transgenic Organism	3
Community Engagement (Required)	Inviting Mentors to visit and participate during presentation of Project. Contacting Graduate student club at NCSU for classroom visits.		

Extension Activities (Optional)	Project presentations for staff and community. Invitations of staff and community members to participate in philosophical chairs discussion.
Author Info (Required)	<p>Kenan Fellow: Elizabeth Helms</p> <ul style="list-style-type: none">● Knightdale High School of Collaborative Design● Freshman Institute Honors Biology● 4 years● ehelms2@wcpss.net <p>Mentor: Jennifer Kuzma</p> <ul style="list-style-type: none">● GES Center

Applied Biotechnology

Kenan Fellows Project Curriculum Outline

Elizabeth Helms

This unit allows students be active participants in learning the techniques and the processes that are needed for biotechnology. After experiencing the processes and skills found in biotechnology, students will examine instances of biotech in pop culture and evaluate the ethics of biotechnology in society.

Part A Applied Biotechnology: Designer Insects

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Students will examine various examples of biotechnology in pop culture and research the validity of the techniques used. Students will present their findings in an infographic to be shared on the class website.

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Students will use structured debate, class discussion and data collection from surveys to explore the ethical considerations of biotechnology. Students will create information briefs from surveys and individual research to present an unbiased issue brief on one emerging biotechnology.

Curriculum Overview	Instructional Activities	Time	Learning Outcome	Assessment	Additional Information
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<p>Part B <i>Applied Biotechnology:</i> Exploring Science in Science Fiction</p> <hr/> <p>Students will examine various examples of biotechnology in pop culture and research the validity of the techniques used. Students will present their findings in an infographic to be shared on the class website.</p>	<ol style="list-style-type: none"> Hook: Watch Clip Montage to find tools and processes from Unit Part A. Students choose and research additional examples of biotech in pop culture. General Survey of Biotech knowledge 	<p>Lesson: 1</p> <p>Days: ~3</p>	<p>Students will explore the use of genetic engineering techniques in recent movies, TV shows etc.</p> <p>Students will present on one example of a scientific in society example that is real and one that is fiction.</p> <p>Students will create a poll to assess knowledge, and an infographic to share their findings with their peers and families</p>	Rubric for Project	<p>Student Prior Knowledge: Understanding of Biotechnology and Genetic Engineering Terms</p> <p>Instructor Resources: Science Fiction Video Clip Survey Expectation Sheet</p> <p>Student Resources:</p> <p>Safety: Review Internet Safety and Data Collection Safety with Students</p>
<p>Part C <i>Applied Biotechnology:</i> Bioethics in Biotechnology</p> <hr/> <p>Students will use structured debate, class discussion and data collection from</p>	<ol style="list-style-type: none"> Hook: Connection to Part B Examine Class Survey Results Introduce PBL Project Case Studies Class Activity Intro to Ethics Mini Lesson Speed Debate Pre-Read for Philosophical Chairs 	<p>Lesson: 6</p> <p>Days: ~7</p>	<p>Students will look at case studies of recent uses of DNA technologies.</p> <p>Students will use their research to complete a philosophical chairs discussion of the ethical issues with genetic engineering.</p>	<p>Rubric for Project</p> <p>Rubric for Participation and Project Steps</p> <p>Written Reflection of Philosophical Chairs</p> <p>Written Reflection for Survey Responses</p>	<p>Student Prior Knowledge: Ethics and Ethical treatment, Understanding of DNA Technology, Genetic Engineering and General Public Opinion on Recent Scientific Discoveries</p> <p>Instructor Resources: Case Study Articles Prepared for Individual Students. Instructor decides, based on student level, for</p>

surveys to explore the ethical considerations of biotechnology. Students will create information briefs from surveys and individual research to present an unbiased issue brief on one emerging biotechnology.	8. Discussion Philosophical Chairs Discussion		Students will use data collected to understand public opinion about biotechnology.		<p>students to read different articles, the same article or modified articles.</p> <p>Philosophical Chairs Question Sheet</p> <p>Philosophical Chairs Resource: http://www.ocde.us/AVID/Documents/Philosophical-Chairs.pdf</p> <p>Student Resources: Case Studies</p> <p>Safety:</p>
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Vocabulary

Vocabulary Word	Definition	Vocabulary Word Tier	Point of Introduction
Ethics	Human actions and understanding that determine the right and wrong in situations	2	Part C
Transgenics	Transferring genetic material into another organism to create a	3	Part A
Genetic Engineering	Modifying organisms using DNA	3	Part A
Biotechnology	Using cells and molecules to develop new products and systems that enhance life	2	Part A
Pest	Unwanted organism	2	Part A
Gene	Section of DNA that carries information for a certain protein	2	Part A
Gene Drive	Using natural reproduction of organism to “push” a new gene into a population of organisms.	3	Part A
Human Genome Project	Study and Sequencing of Human Genome	3	Part A

Plasmid	Circular DNA found in Prokaryotic Cells	2	Part A
DNA Construct	Created DNA code for insertion in Transgenic Organism	3	Part A

Resources:

The Center for Genetics and Society: <http://www.geneticsandsociety.org/index.php>

The National Center for Case Study Teaching in Science <http://sciencecases.lib.buffalo.edu/cs/>

Map of Biotechnology Curriculum Unit

Explicit Teaching of Genetic Engineering

NC Essential Standards for Biology:
Understand the application of DNA technology.

Bio.3.3.1 Interpret how DNA is used for comparison and identification of organisms.

Bio.3.3.2 Summarize how transgenic organisms are engineered to benefit society.

Bio.3.3.3 Evaluate some of the ethical issues surrounding the use of DNA technology (including cloning, genetically modified organisms, stem cell research, and Human Genome Project).

**Language Differences? No Genetic Engineering Mentioned
Needs to Use Phrasing:
BIOTECHNOLOGY**

Project Based Learning Units

Designing Insects:

- Students will engineer an insect that fits into an environment of their choosing.
- They will use information from case studies and labs about genetic engineering processes to complete their task
- Students will present their genetically engineered organism in a poster presentation that showcases the genetics and the environmental implications of their insect.

Examining Science in Science Fiction:

- Students will explore the use of genetic engineering techniques in recent movies, TV shows etc.
- Students will present on one example of a scientific in society example that is real and one that is fiction.
- Students will create a poll to assess knowledge, and an infographic to share their findings with their peers and families

Evaluating Ethics:

- Students will look at case studies of recent uses of DNA technologies.
- Students will evaluate research and prepare an unbiased info sheet about both sides of the issue.
- Students will use their research to complete a philosophical chairs discussion of the ethical issues with genetic engineering.

Elementary & Middle Science Curriculum

8th Grade Science:

Understand how biotechnology is used to affect living organisms.

8.L.2.1 Summarize aspects of biotechnology including:

- Specific genetic information available
- Careers
- Economic benefits to North Carolina
- Ethical issues
- Implications for agriculture

Designer Insects

Constructing DNA: *Using DNA pieces to create Transgenic Organisms*

DNA is the code of life. Using the knowledge of the sequence of this code, scientists can design and rewrite the code to engineer organisms. Genetic Engineers work to solve problems such as the spread of diseases such as malaria, the use of pesticides and the fight against invasive species. The new field of *synthetic biology* scientists are finding ways to write this code and build with DNA to create new solutions to some of our biggest challenges. A transgenic organism has constructed pieces of DNA as well as DNA markers, DNA promoters, and in most cases, a bacterial plasmid host for the DNA.

Organism Challenge

With the recent discovery of water on Mars, scientists would like to engineer an insect that is able to survive in the harsh environment.

Brainstorm some potential traits that this organism would need.

Scientists can manipulate DNA with genes that are currently known and available. Using a DNA database scientists can look up and find genes that may be useful when creating transgenic organisms. Once we have the genes, then we can add them to a DNA construct in order to add the new DNA sequences to our organism. One of the most common insects manipulated is the fruit fly (*Drosophila melanogaster*).

The available genes are listed below.

Highlight the one that you will choose as your gene of interest for your Mars insect:

Gene #1: Codes for increased pesticide resistance: GATTAAGCGTGACA
CTAATTCGCACTGT

Gene #2: Codes for a thicker exoskeleton: GCTTTCTCAAATTCCGAGC
CGAAAGAGTTTAAGGCTCG

Gene #3: Codes for wings: GCGTCAGGTAGGCTAGTATGTGTTTTTCC
CGCAGTCCATCCGATCATACACAAAAAGG

Gene #4: Codes for antenna: CAGGGTCCCTTGGGTGTTTTGCACTA
GTCCCAGGGAACCCACAAAACGTGAT

Gene #5: Codes for resistance to temperature changes: ATTATCGTGTGTGGCCCGTTA
TAATAGCACACACCGGGCAAT

In order to create our organism we will explore the process of **transgenesis**.

What do you need to create your transgenic insect?

Step 1:

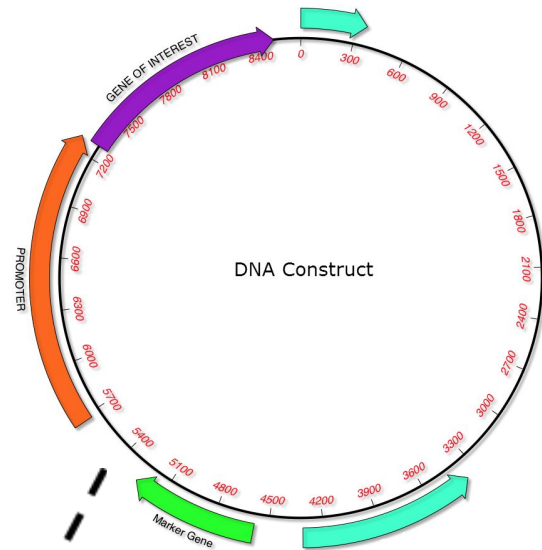
Create your DNA Construct

Marker Gene: Shows that the transgenic organism has the new gene.

Promoter Gene: Helps the modified DNA express the correct information.

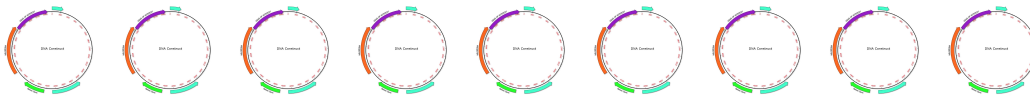
Gene of Interest: Specific modified DNA sequence.

Host DNA: Helps to stabilize the modified DNA sequence.



Step 2:

Use Bacteria to Clone DNA Construct



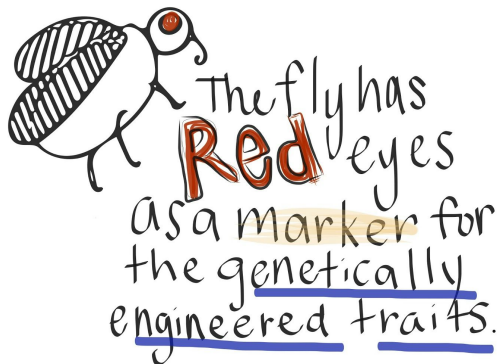
Step 3:

Insert DNA Construct into embryo cells of transgenic organism.



Step 4:

Use marker gene to check for transgenesis.

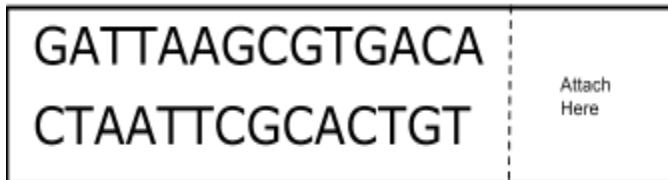


Constructing DNA: *Using DNA pieces to create Transgenic Organisms*

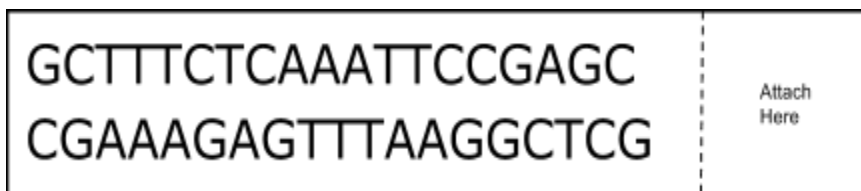
Step #1

Cut out the DNA pieces that you need to create a DNA construct for your transgenic Mars insect. You will need **one** marker gene, **one** gene of interest and one promoter gene to include with your bacteria host genes. Color the genes that you will be including in your DNA construct.

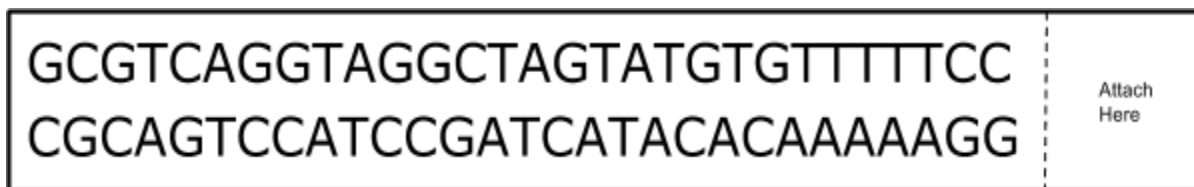
Gene of Interest #1: (Blue)



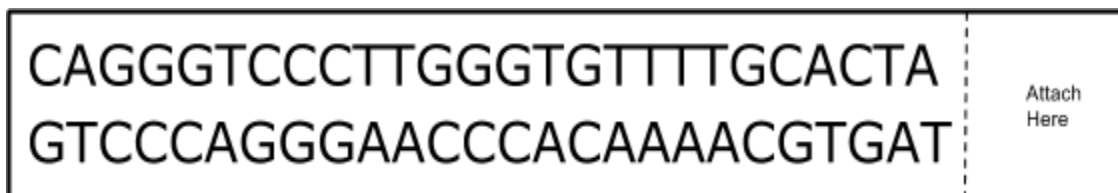
Gene of Interest #2: (Orange)



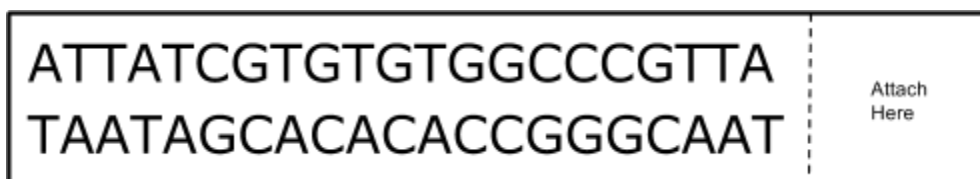
Gene of Interest #3: (Yellow)



Gene of Interest #4: (Purple)



Gene of Interest #5: (Pink)



Red Marker:

GCGTCATTGCGAGTAGTCGTTT CGCAGTAACGCTCATCAGCAAA	Attach Here
--	----------------

Green Marker:

CGCAGTAACGCTCATCAGCAAA GCGTCATTGCGAGTAGTCGTTT	Attach Here
--	----------------

Promoter:(White)

TGCTCGAGTTCGGTCAGA ACGAGCTCAAGCCAGTCT	Attach Here
--	----------------

Bacterial Host DNA:(Grey)

AAGGTCCCCATACACCGACGCACCAGTTTACACGCCGTA TTCCAGGGGTATGTGGCTGCGTGGTCAAATGTGCGGCAT	Attach Here
--	----------------

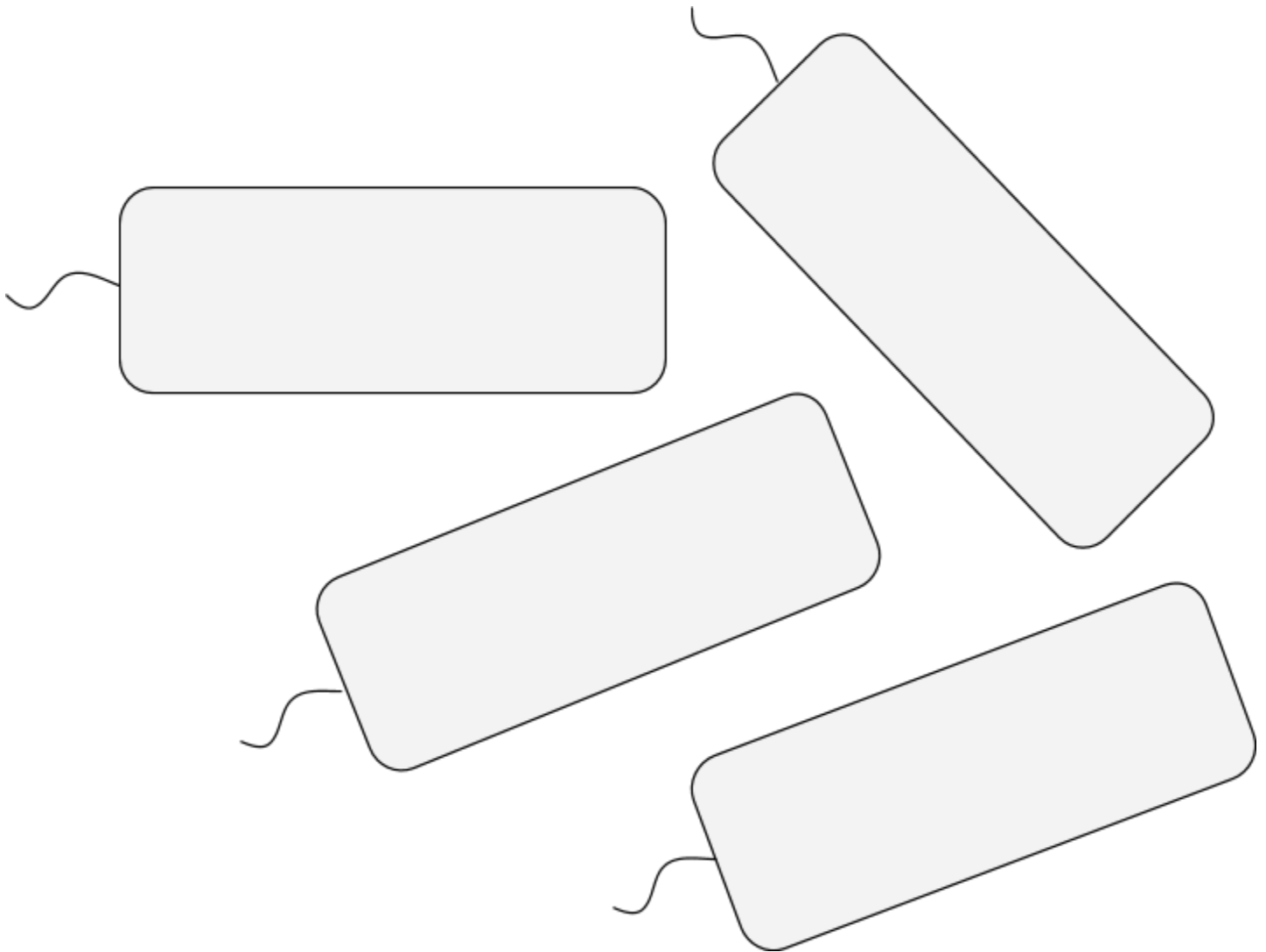
Your DNA construct should make a circular piece of DNA.

Draw your DNA Construct below. Be sure to label the genes and their function.

Cloning DNA Construct in Bacteria

Step #2

Draw your DNA Construct in each of the bacteria:



Step #3

Inserting DNA Construct into Transgenic Organism

Not all of the embryos will survive. So it is important to inject more eggs than needed. Since your constructs work for Fruit Flies, cut and paste the parts of the fruit fly life cycle to show the growth of your transgenic flies.

Egg

Larval

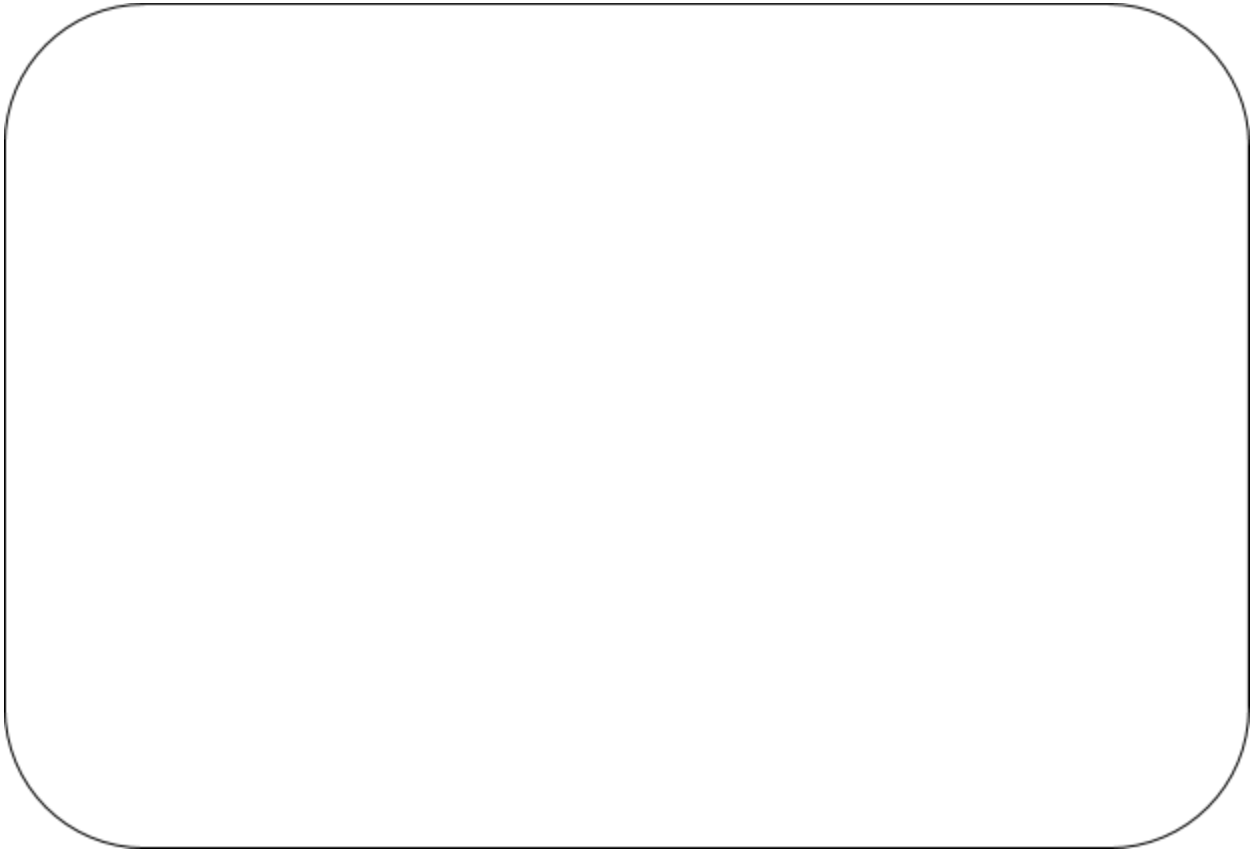
Pupa

Adult

Step #4

Check transgenic adult flies for the new traits from DNA construct.

Draw the final picture of your fly below showing the traits from your DNA Construct.



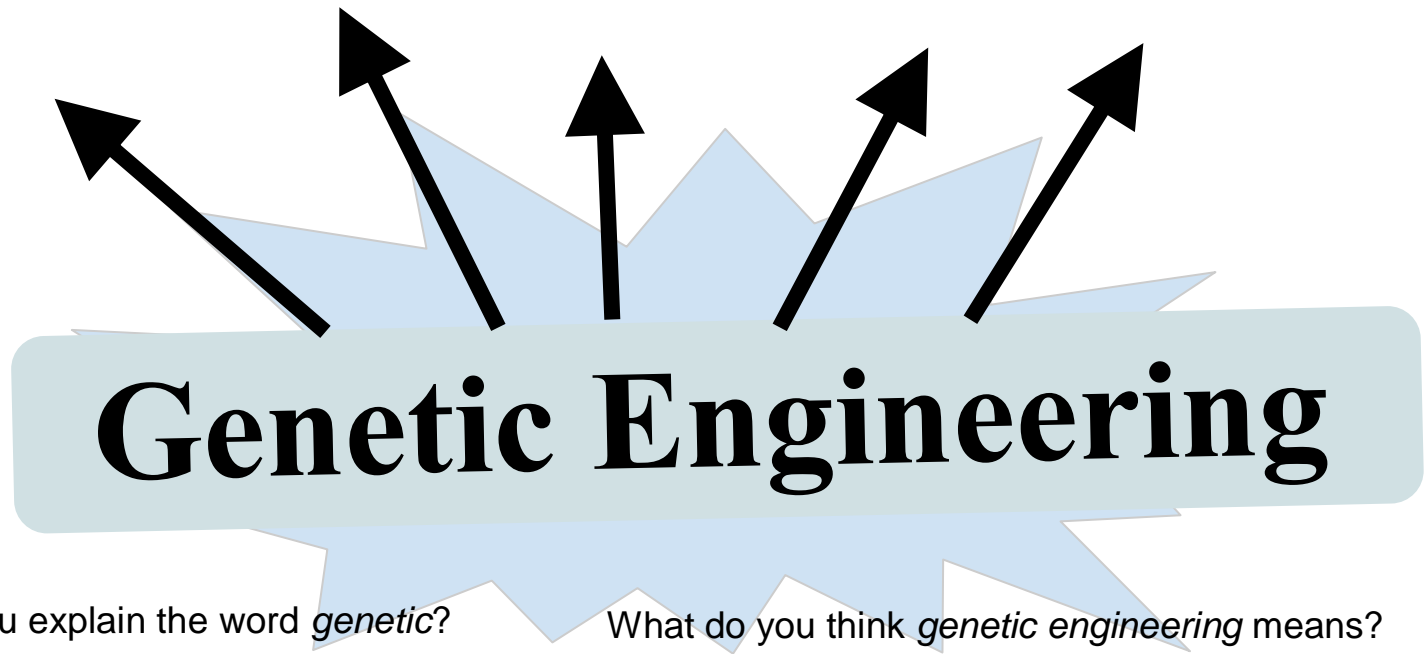
Do you think that this organism could survive on Mars?

Scientists go through this process for each gene that they want to manipulate for an organism. If you could manipulate one gene in an organism, what would that be?

Designing Insects: Simulations Lab Stations

Lab Station #	Station Title: Big Idea	Activity	
1	Research Genes	Research Genes for the Modified Trait Blast Pieces of DNA Write out and transcribe the gene needed	
3	Isolate DNA from Wild Insect	DNA Extraction and Isolation with Berries?	
4	Make DNA Construct Plasmid for Host Bacteria	Plasmid activity on paper. Cut and Paste Plasmid	
5	Grow Plasmid in Bacteria: Incubate for 24 Hours	Look at Bacterial Transformation video, and look at bacteria colonies practice pipetting	
7	Insert DNA into Eggs of Insect	Insect Transgenesis activity	https://science.education.nih.gov/supplements/nih9/bioethics/guide/teacher/Mod6_transgenics.pdf
8	Let Insects grow and check for glowing marker from plasmid	Test to see if gene is accepted into new organisms. ONLY 1/4 Chance	

Write five words or phrases below that would connect to the topic of genetic engineering.



How would you explain the word *genetic*?

How would you explain the word
engineering?

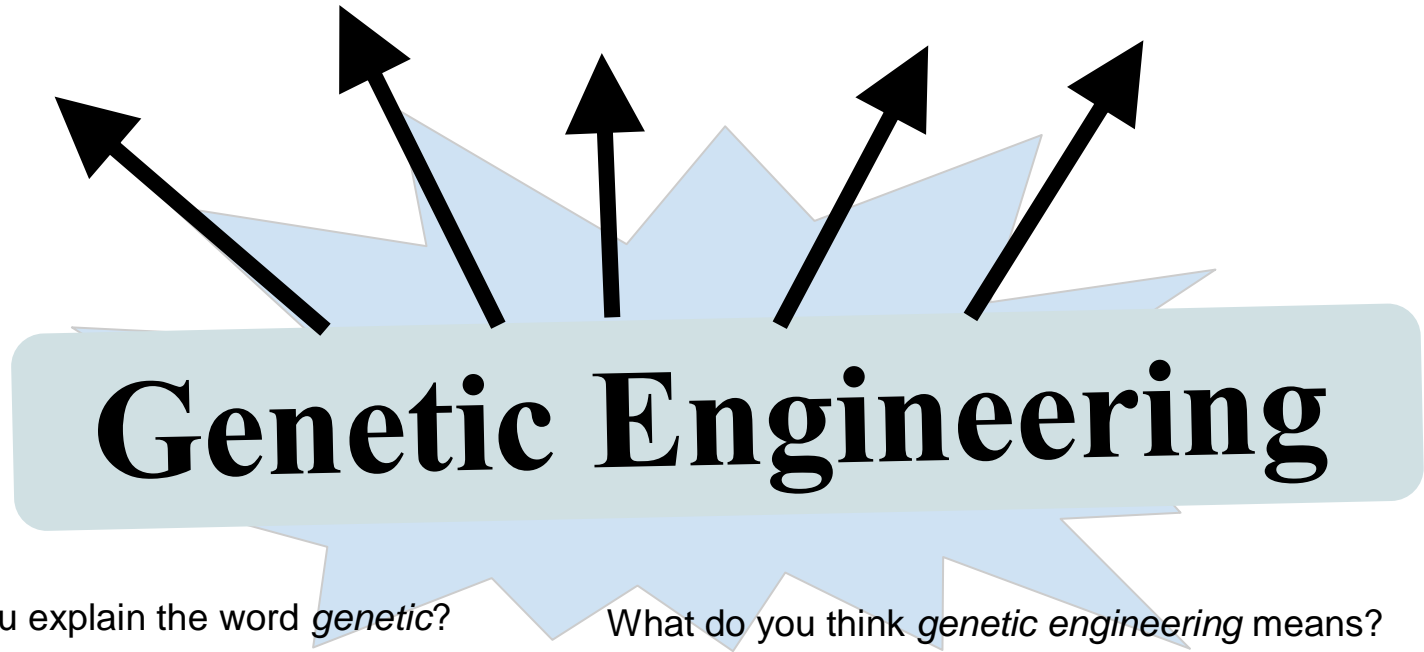
What do you think *genetic engineering* means?

When have you heard this phrase before?

Write five words or phrases below that would connect to the topic of genetic engineering.

Some of the possible words:

Transgenic Organism, DNA, Genes, Genotype, Mutations, Cells, Proteins, Altering Code, Heredity, Cloning, Medical, Testing



How would you explain the word *genetic*?

How would you explain the word
engineering?

What do you think *genetic engineering* means?

When have you heard this phrase before?

Part B *Applied Biotechnology*: Exploring Science in Science Fiction

Genetic Engineering in Society Pop Culture Assignment:

Pop culture is full of scientific references. From Spiderman to Jurassic World to the Hunger Games, movies and books have taken ideas from real scientific concepts and used them to create new ideas about how organisms interact with each other and the environment.

For this assignment, you will be researching five different occurrences of “biotechnology” in pop culture. You may not find the exact words “biotechnology” but you may find other related words.

Biotechnology in the Movies	Biotechnology in the Movies	Biotechnology in Books	Biotechnology in Music
Name of Movie:	Name of Movie:	Name of Book or Story:	Name of Song:
Quote or Reference:	Quote or Reference:	Quote or Reference:	Quote or Reference:
How realistic is this example?	How realistic is this example?	How realistic is this example?	How realistic is this example?
What would actually happen?	What would actually happen?	What would actually happen?	What would actually happen?

Applied Biotechnology: Exploring Science in Science Fiction

Student Handout

Read the articles below about the newest Jurassic World movie:

<http://news.nationalgeographic.com/2015/06/150618-jurassic-world-genetic-engineering-chickenosaurus/>

<http://time.com/3912473/jurassic-world-science-accuracy/>

After learning about genetic engineering, why do you think that the movie changes things from real life?

Do you think that most people know the correct information about genetic engineering?

What is some misinformation that people have about genetically modified organisms?

Task:

- You will be creating a survey to find out about general opinions on genetic engineering.
- You may create a paper survey, or a google form.
- You will create questions and collect data on the responses.
- All surveys should be at least 5 questions long.
- All surveys must be approved before they can be shared with family and friends.

Performance Task Rubric

	Great!	Good	Needs Improvement	Unacceptable
Survey Creation	Has well thought-out questions that have good answer choices. Uses questions to find out about people's opinions. All questions were approved and follow question guidelines.	Uses questions to find out about people's opinions. All questions were approved and follow question guidelines.	Questions need improvement, but some questions are valid.	Did not meet question requirements.
Data Collection	All data collection is shown in a table, is well organized and makes sense.	All data collection is shown in a table.	Some data is shown in a table.	Data is not collected or shown.
Presentation of Data	Data is presented with charts, tables and averages, on paper, with the survey attached.	Data is presented in a table.	Data is missing some information.	Data is not presented and/ or does not match the survey.
TOTALS				

Speed Debate Instructions:

Students desks are arranged in two circles, with students facing their partner. After reading the case studies, students will be asked to sit at one of the desks. For this task all students will “speed debate” a question taped to the desk which they are currently seated. (Question cards are attached below)



Students will have 1.5 minutes with each partner before the center circle will move to the left and partners will debate the next question. Both students should have 30 seconds to speak, while the other partner listens. With time for both to “debate” for the final 30 seconds.

Speed Debate Questions:

Should we have genetically modified foods?	Should genetically modified foods be labeled with a warning?
Is it okay to create transgenic organisms?	Should transgenic organisms be released into the wild?
Should researchers clone organism for genetic research? Even small organisms such as insects?	What circumstance is it okay to genetically modify an organism?
Should we use genetically modified organisms to help in medical situations in developing countries?	Do you think that most people understand genetically modified foods?
Do you think that it is okay for food companies to sell genetically modified types as competitors to normal foods?	What do you think is the most helpful thing we can do with biotechnology?

Philosophical Chairs Instructions:

Students will be given a statement and then have to option to choose a side. They may move sides at any time during the discussion. Only one person speaks at a time, and they must address the previous speaker. Discussion goes from one side to the other.

1. Set up the chairs with two rows facing each other. A third row is then set up at the end.
2. Listen to the statement. Decide whether you agree or disagree. Sit in Row A if you agree with the statement and Row B if you disagree. If you are undecided, sit in Row C.
3. Someone on the pro side of the argument (*A*) begins the discussion with an argument in favor of that position.
4. Then someone from the Con side responds to that argument, explaining why it does not sway him or her.
5. The "undecideds" should state their concerns or reservations at any time.
6. The student rules are as follows:
 - Participants should agree to be open-minded rather than insisting on "standing one's ground".
 - Anyone can change seats at will and should move to the appropriate - row. There is no limit to the amount of times one may move.
 - To agree, sit on one side or the other; you need not agree on all points or the merits of any specific argument.
 - Do not interrupt each other. Listen carefully. Take notes in order to remember important points.
 - The argument should continue back and forth; first side "A", then side "B", and so on. For example, when a participant from one side "A" makes a point, they may not comment again until someone from side "B" has spoken, and then **another participant from side "A" has spoken**, and then another participant from side "B" has spoken. In other words, 3 other people must speak before the same person can speak again.
 - Enjoy the opportunity to discuss an important issue with your classmates.
 - All students should be encouraged to participate.

Instructions, Guide and Rubric for this discussion protocol can be found at the following link: <http://www.ocde.us/AVID/Documents/Philosophical-Chairs.pdf>

Possible Philosophical Chairs Statements for Bioethics:

Transgenic Organisms should be released into the wild to create gene drives to help manage diseases.

Genetically Modified Foods are common and should be treated as normal. We do not need to label and classify these foods any differently than organic or non-GMO food.

It is okay to use genetically modified foods and transgenic organisms in economically disadvantaged places.



All That Glitters May Not Be Gold: A Troublesome Case of Transgenic Rice

by
Gerald F. Combs, Jr.
Division of Nutritional Sciences
Cornell University

It had taken some time for this self-described country girl to become comfortable with the 50-minute metro commute to work each day, but as she signed in at Longworth Building security desk, Cindy Stacey realized she was starting to feel at home in Washington. Quite a long way from Fargo, she mused, in *so* many ways.

Cindy had come to her present position a bit by chance, although others might not have seen it that way. She was a Peace Corps volunteer teaching English in Bangladesh when, as her tour was coming to a close, a friend at the U.S. embassy told her about a job posting on the Internet. A congressman's office was looking for someone with a background in agriculture and international development. She attributed the positive response to her initial query to the fact that the congressman in question was Carl Pomerantz of North Dakota, her home state. But when she had finally interviewed with Campbell Hurst, Rep. Pomerantz's executive assistant, she saw that they were genuinely impressed by her Peace Corps experience.

At any rate, here she was, in the most interesting job she could imagine. It had taken her a few weeks to learn the ropes, but Campbell was giving her more and more responsibility, and she no longer felt quite as much like a "go-for."

Rep. Pomerantz was now in his fourth term. He had the anomalous distinction of being a popular urban Democrat in an overwhelmingly conservative Republican agricultural state. His background was in the insurance industry, and his expertise in agricultural insurance had landed him a seat on the House Agriculture Committee, on which he was now the ranking minority member. He also sat on the Risk Management, Specialty Crops and Research Subcommittee, as well as the House International Relations Committee. He seemed to get along very well with the other members of Congress.

Cindy had met Mr. Pomerantz once before, at a reception in Fargo when she had been home on a winter break from Cornell University, but she was certain that he had not remembered her. She now found him to be considerate of his staff and committed to his job. She liked him very much.

Cindy's feelings for Campbell Hurst were not quite as warm. She realized that his job was to make sure that Mr. Pomerantz had the information he needed when he needed it, which required that he be mindful of the congressman's political agenda. Still, she couldn't help but see personal ambition in this. After all, his career future was tied to Mr. Pomerantz's political success. She suspected that was why he tried to steer the congressman into the most politically safe decisions whenever he could.

Two days ago, Campbell had given Cindy her first meaty assignment: to draft a review of the needs and opportunities in agricultural research with relevance to international markets. This was to be used as part of Mr. Pomerantz's work on the new House agriculture bill. In fact, Mr. Pomerantz had asked her specifically to look into issues surrounding what he had called "hidden hunger," micronutrient malnutrition, since he was interested in redirecting funds now being spent on U.S. surplus commodities under PL480. Campbell had added that she should look through the current activities of the USDA Agricultural Research Service related to GMOs (genetically modified organisms) that might offer potential to increase international markets for American agricultural commodities. It was also clear to her that Campbell would not want to hear much about direct research needs concerning micronutrients since he was very sensitive to what he saw as political liabilities in the use of USDA budgetary support to address non-domestic problems.

But Cindy knew that Campbell had never seen those problems. Neither had she, until she went to Bangladesh. In the poor villages where she had lived, outside of the port city of Chittagong, she had been shocked at the blindness and bone deformities, the goiter and diarrhea she saw. She was also amazed at the number of kids who suffered from stunting and the crippling, brittle bones of old women, both of which were so prevalent that they became an accepted part of the lives of these very poor people. Cindy didn't like the term "hidden hunger" for something that had slapped her in the face. But she was very pleased that Mr. Pomerantz wanted to address. That, in fact, had been the major reason she had taken this job.

Though she had never discussed the matter with the congressman, Cindy suspected that his interest was connected to the fact that his daughter had cerebral palsy. One couldn't miss the passion with which he talked about "hidden hunger," referring to it as a "preventable source of disability." Others in the office dated his interest in this area to an official trip he had made to Mozambique in his second term.

Cindy suspected that for Campbell, on the other hand, "hidden hunger" remained something abstract.

For the last two days, Cindy practically lived at the Library of Congress. She poured over everything she could find, which came mainly from UNICEF and FAO publications as well as some recent research in the plant breeding area. She called one of her old professors at Cornell and talked to a friend at the Beltsville Agricultural Research Center of ARS. During this process, she had come across Golden RiceTM, the transgenic rice into which a beta-carotene gene had been added from another plant species. This foodstuff was being promoted as the solution to global vitamin A deficiency by its developers at the International Rice Research Institute.

Golden Rice fascinated Cindy. She was aware of its politically sensitive GMO status but saw enormous opportunities for products of this type to help millions of children. In fact, Golden Rice seemed to be the *only* micronutrient-enhanced staple being developed by any means, conventional or otherwise. Cindy wondered whether its development might really be sufficient to address the malnutrition in places where rice was the major staple. She wondered whether it might carry any of the risks being suggested for other transgenic crops. She wondered what kind of political resistance it might face. Even if it were effective, she wondered whether somehow its efficacy might be used as an excuse not to fund other international efforts related to food, agriculture, and market development. In short, she was coming up with more questions than answers.

The elevator door opened on the third floor and Cindy stepped out, heading down the long corridor toward Mr. Pomerantz's offices. Campbell asked her to present her initial findings to Mr. Pomerantz after lunch, so she planned to spend the morning preparing her synopsis. Until she finished her research, however, even she didn't yet know what her final conclusions would be.

Dengue and the Landscape: A Threat to Public Health

by

Hannah L. Rusch and Jim Perry

Department of Fisheries, Wildlife & Conservation Biology
University of Minnesota—Twin Cities



Part I – Introduction to the Problem

Kemar labored under the tropical sun all day trying to make progress clearing out the drainage canals surrounding his field. It was slow work whacking reeds with his machete and trying to pry up the roots from the swampy soil. As evening approached, Kemar heard the rumble of thunder over the hills. He straightened his stiff back and looked skyward. A dark wall of clouds announced the approaching rain. After last year's drought, Kemar initially welcomed the rain. However, the intensity of this year's rain presented its own troubles.

Night quickly fell as Kemar gathered his tools and walked home down the gravel road. He saw his neighbor LeJohn out in his yard. "Hello LeJohn, you alright?" Kemar asked.

"I'd be better if there weren't so many mosquitoes," replied LeJohn, as he killed another mosquito. "The mosquitoes are breeding up worse than ever before. They are so thick this year that my family and I can't get any rest at night. And on top of it all, Shanae is sick now," LeJohn complained.

"What does she have?" Kemar asked.

"I'm not sure," said LeJohn. "She's been complaining of a headache and nausea, joint and muscle pain, and today she found a rash on her body."

"Did she go to the hospital yet?" Kemar asked gently. The Port Maria Hospital sat on top of the hill south of Kemar's field. Although it was just a short distance away, Kemar knew that neither LeJohn nor Shanae had regular employment and hadn't had any for a while; he also knew that going to the hospital was expensive.

"Why don't you come inside and see her?" suggested LeJohn, avoiding the question.

The two men walked into LeJohn's humble home. LeJohn, like many people in the community, had built his own house out of ply board. The windows were small and without screens. The storm fluttered the curtains as Kemar and LeJohn approached Shanae, who was resting on the bed. Despite the heat of the day, she was wrapped up in a blanket. Kemar felt Shanae's forehead.

"LeJohn, she has a fever. She needs to see a doctor. I'll take her," Kemar offered.

Kemar and LeJohn supported Shanae as they walked to the nearest taxi stop, which was located next to a newspaper kiosk. Kemar read the headline on a front page, "77 dengue cases." He continued to read:

Wednesday, August 04, 2010

Dengue Fever continues its march across Central American and Caribbean countries. Yesterday the Health Minister told journalists that of the 77 laboratory-confirmed cases, seven are the more severe form of the illness—dengue hemorrhagic fever (DHF).

So far, no cases of dengue shock syndrome had been reported, nor had there been any related deaths.

The Health Ministry is on high alert in light of the growing number of cases of dengue fever and dengue hemorrhagic fever in the country and region. Consequently fogging and oiling activities have been intensified. Fogging is being carried out in approximately 800 communities across the island.

Just then a taxi for the Port Maria Hospital pulled up. Kumar, LeJohn, and Shanae got in and after a short drive they arrived at the hospital.

Question

1. Which of the conditions described in Kumar's landscape are favorable to mosquito breeding?
2. Thinking more broadly, are there other influences that might contribute to increased mosquito breeding?
3. Given what you know so far about this case, develop at least one hypothesis to explain the cause of Shanae's illness.

Part II – Mosquitoes in the City

Dr. Ling approached the bench outside the hospital where Kemar, LeJohn, and Shanae were waiting. “The laboratory test has confirmed that Shanae has dengue fever,” Dr. Ling announced. “Unfortunately, there is not a specific treatment or vaccine for dengue fever. The best we can do is ensure she is hydrated and monitor her health.”

Kemar thought of the article he had just read. “The newspaper is reporting that the number of cases is increasing,” said Kemar.

“Yes,” Dr. Ling replied. “In recent decades, we have seen more dengue fever cases reported not only in Jamaica, but in the tropics all around the world, especially in urban areas. This rise in dengue cases is alarming because it could also lead to an increase in the number of cases of the more dangerous condition, dengue hemorrhagic syndrome.”

“What causes dengue fever?” LeJohn asked.

“Dengue fever is caused by a virus carried by the *Aedes aegypti* mosquito and transmitted by mosquito bites,” said Dr. Ling. “*A. aegypti* thrive in urban areas because there is an abundance of human hosts and favorable breeding sites. Artificial containers such as tin cans, tires, metal drums, and buckets as well as shaded and vegetated areas that hold small pools of water are the mosquitoes’ favored breeding sites. Stagnant water collected in these areas provides excellent breeding conditions. Adults lay their eggs in the small water bodies; the larvae emerge from the eggs and grow to become mature adults within about four weeks. The adults remain close to their hatching sites, ranging only one to thirty meters, which is another reason why the species favors densely populated urban areas.”

“One concern we have is that as the temperature rises, the incubation period of the *A. aegypti* decreases. The probability of a dengue outbreak increases as the number of *A. aegypti* mosquitoes increases.”



Figure 1. An *Aedes (Ochlerotatus) sp.* mosquito on human skin. Photo by ARS Photo Unit, United States Department of Agriculture, Image Number K4705-9, <http://www.ars.usda.gov/is/graphics/photos/mar09/k4705-9.htm>.

Questions

1. What global trends might explain the rise in dengue fever cases around the world in recent decades?
2. Given what you know now about *A. aegypti* breeding sites, can you identify any additional variables in Kemar’s landscape that are favorable to mosquito breeding?
3. What measures might be taken to reduce or prevent dengue fever?

Part III – Formulating Solutions

A few weeks later, the mosquitoes were still dense, but Shanae had recovered from dengue fever. Although the newspaper said that fogging and oiling to prevent mosquito breeding were to be intensified, Shanae was disappointed that there was no sign of increased efforts in her neighborhood. Worried about the health of her community, Shanae decided to find out why no action had been taken. She walked up the hill to the Port Maria Hospital and asked to speak with Mr. Mac, the head of the Vector Control department of the Ministry of Health.

“Mr. Mac, why haven’t mosquito control crews been to my neighborhood? My neighbors and I are getting sick, but no one from the Ministry of Health seems to care,” Shanae complained.

“It’s not that we don’t care, Shanae. It is our duty at the Ministry of Health to promote the well-being of the citizens. We are doing what we can with the resources we have. If we are to increase mosquito control efforts, we will have to divert money from other health programs. It’s not easy to convince people that money should be taken from programs like maternal health and child nutrition or healthy lifestyles and be spent on killing mosquitoes instead.”

“Something must be done though,” Shanae demanded.

“I agree,” said Mr. Mac. “The Ministry of Health needs the help of the citizens to help prevent the spread of dengue fever.”

“What can we do?” Shanae asked.

Questions

1. In class today: Develop a management plan to prevent mosquito breeding. Select the scale you feel is most appropriate (e.g., local, regional, global) and explain why you chose this scale. What are the short- and long-term benefits to public health of your management plan? What are the environmental implications of your management plan?
2. Post to the course site before next class: Design a public education program to educate Shanae’s community members about dengue fever. Your plan should be at least one full page. What message will your education program communicate? How will information be disseminated? What are the three important variables the education program must consider?
3. Read and post a critique (250-word minimum) of the management and education plans of at least one peer. What are the strengths and weaknesses in the plans? Have any important considerations been ignored?



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Torn at the Genes: One Family's Debate Over Genetically Altered Plants

by

Jennifer Nelson

University at Buffalo, State University of New York

It had been a busy day for Marsha Chamberland. She had spent most of it cleaning and running errands in preparation for her brother-in-law Ed's return, and now she was preparing a quick dinner for her family. Ed, an industry official whose job it was to decide whether or not new products needed pre-market approval by the U.S. Food and Drug Administration, had spent the last two weeks in Tennessee expressing his views on genetic engineering in food. He had attended a big conference with various members of the FDA, the Department of Health and Human Services, and business officials to determine what guidelines should be enforced regarding the regulation of transgenic foods—a controversial issue between several consumer protection groups and various government agencies. Ed was coming over later for coffee and to visit with the family.

As Marsha began dinner, she realized that in all the commotion she had forgotten to buy tomatoes for the salad. She knew that her daughter Amy would go for her, and so she called her into the kitchen. At 16, Amy had just gotten her driver's license and she jumped at the opportunity to drive anywhere, even if it was just to the grocery store.

About 10 minutes later, Amy returned and handed her mother the grocery bag. Marsha grabbed inside and pulled out a tomato.

"What's this?" she asked, as she began to read the unfamiliar label stuck on the vegetable in her hand.

"It's a tomato, Mom. The kind that Uncle Ed was talking about. The label said that it was grown special through genetic alterations so that it won't spoil or soften."

"Amy, you know how I feel about this," Marsha replied. At 45, Marsha was very conservative and had a general distrust of new technologies.

"Mom, Uncle Ed has told you over and over again that they're safe and, besides, he would want us to support him."

"Well, Uncle Ed is not your mother, is he? And I just can't accept his ideas without proof that they are safe. Now, where is my change?" Amy rummaged in her pocket and handed her mother some coins; considerably less than what Marsha was expecting.

"That's it? I gave you three dollars."

"They were \$2.99 a pound, Mom. Better quality means more money."

"That's another reason why I don't buy them, Amy. Now go get cleaned up for dinner. I guess we'll just have to have plain lettuce with dinner."

"God, Mom, you're being so old-fashioned. Genetically engineered foods are the wave of the future. Wait until Uncle Ed comes over tonight and I'll ask him. You'll see!"

Ed arrived at the house shortly after dinner and was talking to the entire family about his trip to Tennessee. The conversation eventually turned to the business side of the trip, as Marsha had feared it would. For some reason, Ed's research had always been a bone of contention among the members of the Chamberland family. Everyone seemed to have different opinions for different reasons.

At one end of the spectrum there was Amy, who supported her uncle 100%. She wanted to see more genetically altered foods on the market, but Marsha believed that it was only because Amy thought of it as "trendy." It was the cool thing to have—next to a new car, of course.

Marsha's older daughter Karen, on the other hand, strongly opposed her uncle. A college senior, Karen was actively involved in several environmental clubs and organizations. She was against anything that posed a potential threat to the environment and had launched several protests in the past for different environmental concerns.

Marsha's son Brian, also in college, really didn't have an opinion one way or the other. He was argumentative on both sides of the issue and liked to show off his intelligence by questioning everything and everybody.

Finally, there was Marsha's husband James, who didn't really know where he stood on the issue. He wanted to be supportive of his brother but at the same time he didn't want to take sides for fear of causing further dissension within the family.

Ed began to explain several ideas that were developed during the conference regarding the regulation of genetically engineered foods. Marsha hated when the conversation turned to this, as it usually did when Ed was over.

At this point in the conversation, Amy eagerly jumped at the opportunity to disprove her mother's concerns.

"Uncle Ed, will you please tell Mom how these genetically altered plants work?"

"Well, Amy, scientists have found ways of taking a good gene, say from a bacterium, and putting it into plants such as these tomatoes or beans or corn. The bacterial gene produces a protein that makes the tomato less appetizing to a pest. Or perhaps the gene allows the tomato to survive a heavy dose of chemical spray that farmers sometimes use to control weeds in the fields. Or maybe the scientists find a gene in one species of plant and they put it into another species to help the plant survive the cold better or taste or look better."

"That's all well and good, Ed, but what about the safety issues and the cost?" asked Marsha.

"Uncle Ed, will you please tell Mom that genetically engineered fruits and vegetables are safe!" interrupted Amy. "She doesn't trust them and won't let me eat them."

"Well, safety has been a key consideration in the approval of these products, and has definitely not been overlooked. There have been over a dozen tests performed on more than 50 engineered crops to evaluate the risk and environmental impact they might have. These tests were reviewed in detail by the U.S. Department of Agriculture and they show that such engineered crops present virtually no risk to the human consumer. That's why we concluded at the conference that genetically altered foods should be subject to the same standards of regulation applied to all other foods."

"But," Marsha tried to defend herself, "there is no concrete evidence for the safety of these products. It has never been proven that they are 100% safe. As a matter of fact, I read an article the other day that said just the opposite. It said something about making bacteria resistant to antibiotics. The genes that we put into corn or tomatoes might jump into bacteria in our stomachs. Then the bacteria will suddenly have genes that make *them* resistant to antibiotics. Where would we be without useful antibiotics?"

"Yeah," Ed replied, "that particular study was discussed and debated at the conference. What actually happens is genetic engineers have found that if they want to insert a new beneficial gene into a plant, it works better if you inject a second gene with it. The second gene is one that produces an antibiotic. It is called a marker gene because it is easy to test for its presence and see if both genes have gotten into the plant cell. In fact, the United Kingdom's Advisory Committee on Novel Foods and Processes has declared that this poses an "unacceptable risk."

Marsha nodded and smiled. She had thought for a split second that she had argued a good case, but as Ed continued to explain the process, she knew that he had a comeback for everything and that essentially it was useless to argue with him further.

Ed continued: "But after many tests this doesn't appear to be a problem. Robert Beachy, head of the Division of Plant Biology at Scripps Research Institute, has written that "there is no scientific data indicating that DNA could jump from food to a microbe in the gut of an animal." He concluded that transgenic foods pose "no risk to the public, nor to the farm animals for which they serve as food." In fact, Abigail Salyers, a microbiologist at the University of Illinois, wrote to *Nature* magazine that this is a trivial problem and that researchers ought to be more worried about the fact that we routinely put vast amounts of antibiotics in animal food and overuse antibiotics on ourselves, which creates a much more serious problem of resistance."

Brian turned to his uncle. "But, Uncle Ed, in biology we just learned about mutations and natural selection. Suppose the DNA that protects plants against insects is injected into the plants and it works? Won't the insects eventually evolve a resistance to these toxins?"

"This has been a concern and problem among farmers for many years, but mutations in the insect population are not caused just because of transgenic crops. It happens all of the time. Pests evolve a resistance even to the chemical pesticides being sprayed now. So, yes, it seems likely that the insects might evolve resistance to the toxins in the transgenic plants, since it is all caused by the operation of natural selection. Some researchers have figured out how to slow down natural selection. If farmers planted a small area of traditional crops near fields of genetically modified ones, this would significantly slow down the rate at which insects could adapt. The two different kinds of plants would exist and the insects couldn't specialize for only one."

"See, Mom, I told you there was nothing to worry about," Amy stated proudly. "Genetically altered foods are safe to eat, and plus they taste better. I'm going to go cut up that tomato right now."

Karen, who had been silent until this moment, suddenly stood up and said: "I don't know how all of you can be so naive. The safety of the nation's food supply is being threatened by an eagerness to help companies bring new products to market. Lots of companies aren't even labelling these mutant foods so that we can avoid them. That's not ethical! And on top of this we're risking ruining the whole environment. Uncle Ed may be right that bacterial toxins pose no risk to humans directly, but what happens when insect resistance spreads to populations of plants, like the forests? This would cause sharp declines in entire insect populations, which in turn would lead to declines in predators that feed on these insects, like birds. The whole cycle of life would be disrupted!"

"How is it different from the gallons of toxic fertilizers that people spray on plants now, Karen, to keep insects away? You can't tell us that that is safer," Brian argued. "At least with genetically engineered crops the only insects that are getting hurt are the pests. When you spray pesticides everywhere, everything gets killed or poisoned."

"Brian does have a point," Ed replied. "Much of the standard agricultural and forestry practices, like the heavy use of pesticides, have severe detrimental effects on soil fertility, whereas the direct effect of genetically engineered plants on soil may be relatively small. Proteins, the products of DNA, are quickly broken down by the environment. Pesticides, on the other hand, do not break down quickly and are often harmful to beneficial insects and earthworms that are necessary to conserving a healthy soil biota. Pesticides, such as fungicides, have actually been proven to be carcinogens and account for approximately 70% of the human health problems associated with pesticide exposure. So, in general, genetic alteration methods are a lot safer than using the broad spectrum of pesticides being sprayed now."

"I never said that I was in support of chemical pesticides either," snapped Karen.

"You just don't agree with anything, Karen. And you don't even have a clue as to what you're talking about. You and your little environmental buddies just go parading around campus with your Greenpeace views arguing about everything, thinking you know what's best for the world...."

"Oh, shut up, Brian. I know what I'm talking about. I've watched National Geographic specials, and even talked to Jane Rissler, a specialist with the National Wildlife Federation, so I probably know more than you." Karen continued to argue her point, "Uncle Ed, that still doesn't explain what would happen if the genes from these "super crops" jump into other species and become "superweeds." America will be taken over by uncontrollable weeds that have an unnatural resistance to everything. Weeds will spread everywhere, even to the wildlife preserves, causing drastic declines in the native species. What then?"

Marsha looked at her husband for help. She really didn't understand her daughter's reasoning at all, but was glad that someone was on her side, even if it was for completely different reasons.

James felt his wife glaring at him and tried quickly to change the subject. He hated being stuck in the middle between the opposing views of his brother and wife. He knew eventually at some point down the road he would have to decide and take a stand on the issue. There was no getting around it. He just hoped that it wouldn't have to be anytime soon.

STUDY QUESTIONS

1. What role does the FDA play in the regulation of the nation's food supply?
2. What are the regulations that the FDA enforces regarding genetically altered foods?
3. How do scientists put a gene from one organism into another?
4. What are the differences between using traditional methods of artificial selection and using various transgenic methods of altering crops?
5. What are the health risks associated with the use of genetic alterations?
6. What role do gene markers play in genetic engineering?
7. How do mutations in DNA sequences affect a species (i.e., what do mutations do)?
8. What might happen if the beneficial traits that scientists inserted into agricultural crops spread to non-agricultural settings?
9. How would the soil biota be affected by using traditional chemical pesticides and would this differ from using transgenic methods? Which method would be safer and why?
10. How might insects develop a resistance to Bt toxins? What ecological risks would this have? What could be done to combat this, and do you think that it would be effective?

REFERENCES

- Butler, D. "Trade war looms over gene-altered foods." *Nature* 384(6607):301, November 28, 1996.
- "Council for Responsible Genetics: Consumer Alert." *Yahoo.com*, Online. Internet, 1994.
- Cummins, Ronnie; Purefood@aol.com. *Yahoo.com*, Online. Internet, September 11, 1996.
- Elmer-Dewitt, P. "Fried gene tomatoes." *Time* 142(22):54-56, May 30, 1994.
- Gasser, C.S., and R.T. Fraley. "Transgenic crops." *Scientific American* 266(6):62-69, June 1992.
- Gershon, D. "Genetically engineered foods get green light." *Nature* 357(6377):352, June 4, 1992.
- Haslberger, A.G. "Monitoring and labeling for genetically modified products." *Science* 287(5452):431-432, January 21, 2000.
- Letters. "Pros and cons of foreign genes in crops." *Nature* 385:290, January 23, 1997.
- Luoma, J. "Pandora's pantry." *Mother Jones* 30(1):53-59, January 2000.
- Maryanski, J. "Genetically engineered foods: Fears & facts." *FDA Consumer* 27(1):10-14, Jan./Feb. 1993.
- Miller, H.I. "A rational approach to labeling biotech-derived foods." *Science* 284(5419):1471-1472, May 28, 1999.
- Paoletti, M.G., and D. Pimentel. "Genetic engineering in agriculture and the environment: Assessing risks and benefits." *BioScience* 46(9):665-673, October 1996.
- Rogers, A. "An apple a day keeps the genetic engineers busy." *Newsweek* 131(17):17, April 27, 1998.
- Schiermeier, Q. "Swiss reject curbs on genetic engineering." *Nature* 393(6685):507, June 11, 1998.
- Snow, A.A., and P.M. Palma. "Commercialization of transgenic plants: Potential ecological risks." *BioScience* 47(2):86-95, February 1997.
- Wadman, M. "Genetic resistance spreads to consumers." *Nature* 343(6601):564, October 17, 1996.
- Wolfenbarger, L.L., and P.R. Phifer. "The ecological risks and benefits of genetically engineered plants." *Science* 290(5499):2088-2093, December 15, 2000 (Review Article).
- "The year of the trifids: Genetic engineering." *The Economist* 343(8014):80-83, April 26, 1997.

INTERNET SITES

- U.S. Food and Drug Administration
<http://www.fda.gov/>
- Center for Food Safety & Applied Nutrition
<http://vm.cfsan.fda.gov/list.html>
- Biotechnology Information from the Center for Food Safety & Applied Nutrition and FDA
<http://vm.cfsan.fda.gov/~lrd/biotechm.html>
- Biotechnology: An Information Resource—National Agricultural Library of the U.S. Department of Agriculture
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HEALTH

Should Scientists Use Genetically Modified Insects to Fight Disease?

Two scientists explore the controversies over releasing genetically modified mosquitoes into the wild

By Mark Q. Benedict, Helen Wallace on October 24, 2011



Photograph by David Liittschwager

In the November 2011 issue of *Scientific American*, author Bijal Trivedi looks at the ongoing controversies surrounding the use of genetically modified mosquitoes to fight dengue fever. We asked biologist [Mark Q. Benedict](#) and Helen Wallace, the director of [GeneWatch UK](#), to illuminate the issues surrounding the release of genetically modified insects into the wild.

Genetically Modified Mosquitoes Could Be an Important Tool in the Fight against Disease

By Mark Q. Benedict

Current technologies we use against mosquitoes simply are not adequate: existing measures are losing the war. The choice of implementing GM mosquitoes is not a choice of no risk versus risk, it is a matter of choosing the least risky among all existing choices in a war against very real continuing disease risk. [More »](#)

The Danger of Genetically Modified Mosquitoes

By Helen Wallace

The release of genetically modified (GM) insects should follow a precautionary approach, because what appears well understood in the lab can have unintended consequences when released on a large scale into the environment. On release, GM mosquitoes become part of a complex system involving predators and prey, other mosquito species, four types of dengue virus, other tropical diseases transmitted by mosquitoes, and the humans—including children—who are being bitten and infected. [More »](#)

Genetically Modified Mosquitoes Could Be an Important Tool in the Fight against Disease

By Mark Q. Benedict

Readers of *Scientific American* will appreciate the high failure rate of what seem to be promising innovations. The much ballyhooed "Ginger" was going to change the world and the way our cities are built. Hadn't multitudes of celebrities gushed over Ginger and invested? I could not wait to find out what something given such a sexy code name could be. A new energy source? A new concept for a computing interface? A self-healing material? You may have shared my disappointment when the mysterious Ginger turned out to be a rather clunky, unattractive but easily operated scooter named the Segway. My initial response that Ginger was not going to change the world has thus far been correct. Segways have indeed created a niche populated by policemen and tourists, and it has stimulated the production of other cheaper vehicles that are used in much the same way. They were not the game-changer that was anticipated. I guess I'll wait for Mary Ann.

I was also among those who hopefully (and skeptically) followed cold fusion in 1989. Against the original claims, however, excess heat was not measured in subsequent experiments. The claims didn't hold up. Yes, there are still folks pursuing the idea, and I would be the last to discourage them. The world could use endless clean energy in such a concentrated form.

We can safely say that controlling mosquito populations by releasing genetically modified (GM) mosquitoes is not another cold fusion of innovation, but it may be a Ginger. For the sake of those who need help, I hope not.

Current technologies we use against mosquitoes simply are not adequate: existing measures are losing the war. None are easy and even fewer are affordable for vulnerable individuals and governments charged with mosquito control. They do not fully protect, and their use entails direct risks to human health and the environment. So the choice of implementing GM mosquitoes is

not a choice of no risk versus risk, it is a matter of choosing the least risky among all existing choices in a war against very real continuing disease risk.

Genetically modified mosquitoes are not the only innovative solution being tested in this war: resistance-proof insecticides, anti-mosquito fungi, bioprospecting for drugs and repellents, biopesticides, better education programs and new traps are in play. There is room for all of these, but all of these entail risks, not least of which is diversion of limited resources to little effect.

In this context, we must consider whether releasing sexually sterile GM mosquitoes is safe. History says "yes." Sterile insects have been safely used for decades. Target pests have never become established due to failure of sterility, and sterile insects are often used to prevent the establishment of insects where they do not occur. The sterile mosquito technology is being tested specifically because it is the safest possible means to begin to explore their potential. It is difficult to argue that use of the most common measure—nonspecific insecticides—is a more desirable option.

Novel technologies are always in the midst of a withering process that subjects them to the brutal stresses of real-world trials, and implementation of genetically modified mosquitoes will fly or fail based quite simply on whether they work. And by "work," I include their effects on the environment and acceptability by those at risk. Picking winners among all the options is impossible. We simply know too little of their possibilities or the future to predict their success in myriad disease transmission settings.

Regulatory structures are important controls on the implementation of innovation. They guide safe use and fair testing. As the feature indicates, these are coalescing contemporaneously with the development of genetically modified mosquitoes, but they are not being developed in a vacuum. New guidelines largely reflect ethical and safe practices that are already widely

acknowledged and codified. Any effort to release genetically modified mosquitoes without proper considerations for such existing law, ethics and safety imperils the entire field, so motivation among those conducting trials to stay above board is high. The community developing GM mosquito technology is always looking over its shoulder at the India experience (in 1974, scientists studying the genetic modification of insects for disease control were accused of conducting secret biowarfare research) and is in no mood to repeat it.

Just as the world is a beautiful mosaic of cultures, it is a mosaic of attitudes toward, and regulation of, genetically modified organisms. This is a natural outgrowth of perspectives toward the natural world, the role of science and even religious beliefs. Therefore, regulation will differ as determined by law and treaty of sovereign countries. Whereas many countries will adopt similar standards rather than developing them de novo, the variety of perspectives dictates that in respect for others we must accept a variety of regulatory solutions. Similarly, community engagement must fit the affected people. What may be sufficient engagement for my community (which is accustomed to eating GM foods and having GM crops planted in fields we see every day) may not fit yours. This is natural and should be welcomed.

GM mosquito technology must be evaluated as a complement to existing control measures. Will it entail the risks that some fear? This should be carefully determined in small trials. Will it be too expensive? That is for those considering it to assess based on experience, their economies and the effects of release. Will it cause environmental damage that can be avoided with other technologies? Let's find out, one cautious small step at a time and in comparison with all the alternatives. But there is no scientific basis for the assertion that sterile insect technology will get out of control and should not be tested.

Although I am among those with hopes that GM mosquitoes will improve human health with minimal environmental effects, it is simply too soon to tell.

Because there is no well-financed advocacy machine to push them against demand, GM mosquitoes will have to stand on their own merits in the real world of human diseases. That is the battle which they deserve a chance to fight.

Mark Q. Benedict is currently a Marie Curie Fellow at the University of Perugia, Italy. His professional activities include developing technology for genetic control of mosquitoes, biosafety guidelines and mosquito mass production equipment and facilities. He obtained his PhD and BS at the University of Florida.

Up Next: The Danger of Genetically Modified Mosquitoes

By Helen Wallace

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The release of genetically modified (GM) insects should follow a precautionary approach, because what appears well understood in the lab can have unintended consequences when released on a large scale into the environment. On release, GM mosquitoes become part of a complex system involving predators and prey, other mosquito species, four types of dengue virus, other tropical diseases transmitted by mosquitoes, and the humans—including children—who are being bitten and infected.

An expert report ([pdf](#)) to the European Food Safety Authority lists a wide variety of issues that should be addressed prior to the deliberate release of any GM insects. They include the adverse effects associated with the flow of genes

into the wild population; the interactions of the GM insect with target and nontarget organisms; the impact on agricultural management practices and on management measures to control insects that are vectors for diseases; and a variety of potential effects on human health. The latter include allergies and irritation; the presence of live female mosquitoes; potential changes in the ability of mosquitoes to transmit disease; and accidental ingestion (including of larvae and eggs). Other issues that have been raised elsewhere include: the potential for viruses to evolve into more virulent forms; the impacts on human immunity and hence cases of disease; whether other species of mosquito (transmitting the same or different diseases) might occupy the ecological niche vacated by a falling population of the target species (pdf); and whether infection with dengue has a protective effect against yellow fever.

The first open releases of GM mosquitoes have now taken place in the Cayman Islands, Malaysia and Brazil. In all three countries the biotechnology company Oxitec released GM *Aedes aegypti* mosquitoes (yellow fever mosquitoes) with the intention of reducing the population of this species, which also transmits dengue fever. In choosing the British Overseas Territory of the Cayman Islands to undertake the first releases, Oxitec bypassed the provisions of the Cartagena Protocol (covering impacts on biodiversity) and the Aarhus Convention (covering access to environmental information), both of which would apply in the U.K. The Cayman trials were in an inhabited area where dengue is not endemic; the smaller Malaysian trial was in an uninhabited area in a country where dengue is endemic; and the ongoing, much larger Brazilian trials are in an inhabited area where dengue is endemic. Only in Malaysia did the company openly consult the public, and even there, a small-scale release caused public concerns due to the lack of transparency about the timing and insufficient public information. Further, only a summary of the risk assessment has been published, leaving the regulator's decisions about what hazards to include, and whether or not they were significant, open to dispute.

Although no doubt genuine in its desire to tackle dengue fever, Oxitec is a commercial company with a patented technology to sell (pdf). Its business plan

relies on convincing the governments of dengue endemic countries to pay for ongoing releases of its GM mosquitoes to maintain suppression of the mosquito population. Its investors include the University of Oxford, the venture capital company Oxford Capital Partners (which offers significant tax breaks to its investors), and a Boston-based multimillionaire ([pdf](#)). The former U.K. science minister, Lord Drayson, and the former president of the Royal Society, Lord May, have both acted as advisors to investors in the company. Oxitec has also received significant U.K. government subsidy via the Biotechnology and Biological Sciences Research Council as well as the Technology Strategy Board. Its open-release experiment in Malaysia was funded via a translational grant from the Wellcome Trust. Although the company is a spin-off from Oxford, the university's ethics board plays no role in overseeing its experiments.

Research on public attitudes to potential releases of GM mosquitoes to tackle malaria in Mali found that participants wanted to see evidence that GM mosquitoes could reduce malaria without adverse effects on human health and the environment, and many were skeptical that the technology would work. A majority of participants would support a release that satisfied their conditions, but a substantial minority would not support a release under any circumstances. Whereas it is difficult to extrapolate from a small study in a single country (which included mainly male participants), the study does succeed in raising some important issues. How is people's consent to be obtained for such experiments, given that most people would only grant it if certain conditions were fulfilled? And, is it ethical to undertake experiments if some people continue to oppose them?

Oxitec seems to have treated this ethical problem as largely an issue of public relations. In Cayman it released a video claiming its GM mosquitoes were sterile, rather than explaining that they breed and the offspring die as pupae; it also didn't mention that they were genetically modified. In Brazil activities have included attending carnival dressed up as mosquitoes. Concerns that the technology is not 100 percent effective, leaving some female (biting) mosquitoes to breed, have simply been ignored.

For observers, it is hard to understand how decades of debate at the World Health Organization and elsewhere have come to this. Is there really any regulatory oversight; any data required of any company; and any ethical requirements before GM insects can be released into the open? Decisions appear to be being taken by a small circle of powerful investors who have decided they must rush to commercialize a particular technology, rather than in consultation with the people who will be affected. Who is going to be liable if anything goes wrong? And will any problems be reversible as releases happen on an ever larger scale?

Helen Wallace is the director of GeneWatch UK. She has worked as an environmental scientist in academia and industry and as senior scientist at Greenpeace UK, where she was responsible for science and policy work on a range of issues. She has a degree in physics from the University of Bristol and a PhD in applied mathematics from University of Exeter

Previous: *Genetically Modified Mosquitoes Could Be an Important Tool in the Fight against Disease*

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ABOUT THE AUTHOR(S)

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GM mosquitoes a 'quantum leap' towards tackling malaria

New technique injects mosquitoes with a gene that results in mostly male offspring, eventually leading to a population crash

Adam Vaughan

Tuesday 10 June 2014 11.09 EDT

Scientists have hailed the genetic modification of mosquitoes that could crash the insect's populations as a "quantum leap" that will make a substantial and important contribution to eradicating malaria.

Previous efforts to tackle the disease, that kills more than 1 million people each year - most of whom are African children - have included bed nets to protect people and insecticides to kill the mosquito species most responsible for the transmission of malaria (*Anopheles gambiae*).

The new technique by a team at Imperial College London involves injecting mosquitoes with a gene that causes the vast majority of their offspring to be male, leading to an eventual dramatic decline in population within six generations as females disappear.

"You have a short-term benefit because males don't bite humans [and transmit malaria]," Andrea Crisanti, one of the authors of the new research, which was published in the journal *Nature Communications* on Tuesday, told the Guardian.

"But in the long term you will eventually eradicate or substantially reduce mosquitoes. This could make a substantial contribution to eradicating malaria, combined with other tools such as insecticides."

The scientists injected mosquitoes with a gene from slime mould - a homing endonuclease called I-PpoI - which attached itself to their X chromosome during the male's sperm-making process and effectively shredded part of the chromosome's DNA. The result was that more than 95% of the mosquitoes offspring were males. The researchers found that the modified mosquitoes mated with wild mosquitoes, creating fertile mosquitoes which then overwhelmingly produced male offspring, passing on the gene.

"Under field conditions the accumulation of X chromosome damage would significantly contribute to the demise of target populations," the scientists say in their paper.

"The engineering is a quantum leap in terms of what has been done before," said Crisanti,

who worked on previous research in 2008, which took a similar approach but unintentionally resulted in sterile mosquitoes, meaning the gene's ability to spread was limited. Imperial College London also published work in 2011 on a distinctly different approach to impair the fertility of mosquitoes generally, rather than distorting the makeup of their sex.

Nikolai Windbichler, a research fellow at Imperial College London and co-author, said that the concept of distorting the sex of a pest's population is more than 50 years old but that the technology had not been available until now to execute the idea.

"The concept was suggested by Bill Hamilton [the famous evolutionary biologist, W.D. Hamilton], but until now there wasn't a way to realise it. There are selfish chromosomes around but they're too complicated, so we created something like this from scratch [the homing gene using synthetic biology], he said. "We found mosquitoes have a genetic achilles heel."

Dr Luke Alphey, group leader of the vector-borne viral diseases programme at the Pirbright Institute, who was not involved in the research, described it as a "big step forward" and said field trials could be conducted after further testing. "The overall goal of this research programme is even more ambitious - to develop a version of this genetic system that will spread itself through the target species, removing females and causing population crash or extinction as it goes," he said.

Dr Michael Bonsall, reader in zoology at the University of Oxford, described the research as "super cool work" and said: "This has important implications for limiting the spread of malaria."

Dr Thomas Walker, lecturer at the London School of Hygiene & Tropical Medicine, told the Guardian that the work was "very good science" and "very promising" but said any uncertainty was in how the GM mosquitoes would fare out of the lab and in the field.

"The biggest problem with releasing modified mosquitoes in to the wild, is will they compete with existing males? They need that mating between transgenic males and wild females. There is no evidence to think might not mate in the field, though maybe they will find males are not quite as fit [as wild male mosquitoes] on field release. But the theory is very, very good."

He added that because the researchers were attacking a multi-copy gene - rather than a single gene - the chance of wild mosquitoes evolving to resist the technique was limited.

Dr Helen Williams, director of GeneWatch UK, a not-for-profit group that has been critical of previous GM mosquito research, warned of unintentional consequences of crashing mosquitoes' populations. "We would want to ensure that the risks are properly considered before GM mosquitoes are released into the environment. For example, reducing the population of one mosquito species can increase the population of other mosquitoes, so you can potentially make it worse. If you change an ecosystem and remove a species, another species often moves into that niche."

She said the decision on whether they should be used in the wild should be down to the people living in the countries where the engineered mosquitoes would be released.

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