

Synthetic biology in society

iGEM TU Eindhoven 2016



Target Group: Last years of high school (16-18 years)

Subjects: Biology/Sociology

Timespan: ± 40 minutes

Introduction

Synthetic biology is reprogramming of biologic systems (cells or bacteria) and letting them perform certain tasks. This is achieved by altering the genetic information (DNA) of the cells. It is predicted that genetic modification will have a huge impact on society, however, it doesn't get the attention it deserves on school according to us. It takes some time before this information enters the newest biology and chemistry books. For that reason we developed this lesson. It is important for children to be aware of synthetic biology and to be able to form an opinion about it. In this lesson, the existing knowledge of children (school, (social) media) is combined to introduce children to the societal aspects of synthetic biology.

This lesson is made by student participating in the iGEM team from Eindhoven University of Technology. The iGEM competition is a student competition in the field of synthetic biology. The edition of this year (2016) has over 300 participating teams. Besides the research and lab work part of this project it is important to bring synthetic biology to society and make it accessible for everyone. This is the goal we want to reach with this lesson package.

This lesson package consists of a PowerPoint presentation with slides with an introduction to synthetic biology and the societal aspects. In this teacher's guide, extra information on the PowerPoint slides is included. Also a worksheet (and its answers) is present in the teacher's guide. This worksheet can be handed to the students after the lesson. With this worksheet students can test their knowledge about synthetic biology and can form an opinion on societal issues related to synthetic biology.

For the main page of the lesson package, where the PowerPoint presentation and teacher's guide can be found, visit our site! (http://2016.igem.org/Team:TU-Eindhoven/HP_silver)

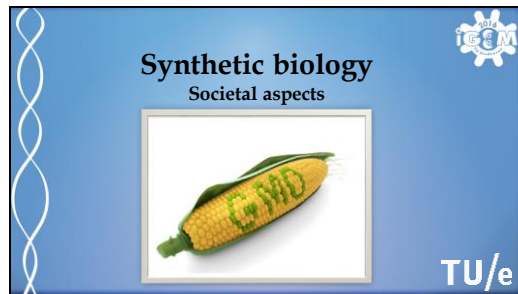
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PowerPoint presentation

Below are the slides of the PowerPoint presentation with next to them extra explanation for each slide. The PowerPoint presentation can be downloaded [here](#).

Slide 1

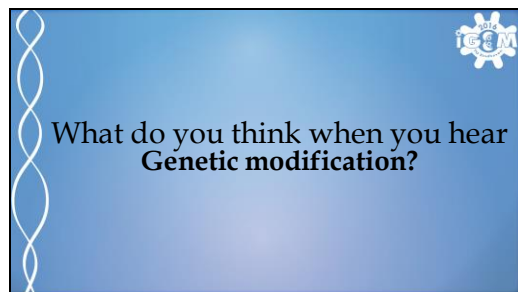


This is a special lesson about synthetic biology. This lesson is made by iGEM TU Eindhoven, a student team in the international iGEM competition about synthetic biology.

Learning goals are to get to know what synthetic biology is, how it affects society and which ethical issues might emerge.

This lessons goal is to let students form an opinion on synthetic biology and open a discussion about it.

Slide 2



Give the students time to think and let a few students explain their thoughts.

Slide 3

The future

Doing it for years

Opportunities

Nicer fruit

AARDAPPELS
HOREN MET JUS
NIET MET
EXTRA GENEN

Scary!!

Dangerous

Not on humans

Unrealiable

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These are common answers on the previous question.

People can have a negative and positive point of view on genetic modification.

Slide 4

What is synthetic biology?

Modifying cells and bacteria, so they can fulfill certain tasks

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Genetic modification means altering the DNA of an organism. Synthetic Biology also does this to cells and bacteria to make them do certain tasks. In this manner, bacteria can serve as protein or gas factories. T-Cells can be used to produce specific antibodies.

Synthetic Biology also focusses on unravelling the many reactions taking place in the cell.

Slide 5

DNA

All cells contain DNA

DNA stores hereditary information

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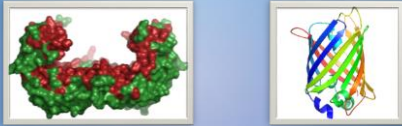
The DNA is basically a kind of book that contains all the information the organism needs to survive. Instead of letters and words, the information is saved in bases and codons.

DNA contains all the blueprints of proteins that the cell needs.

Slide 6

Eiwitten

Essential for organisms
Fulfill various functions in cells





Proteins are made by the cell. The proteins fulfil all kinds of tasks in the cell. They make sure that the cell is the right kind of cell type and that it stays alive.

Slide 7

Bacteria

1 cell organisms
Commonly used by humans





Bacteria are being used in the synthetic biology to produce proteins.

Bacteria are organism that consist of only one cell. Bacteria do not reproduce by combining the DNA of two organisms, but by dividing itself.

Slide 8

Genetically modified bacteria

- Biofuel
- Insulin
- Proteins



What are bacteria used for?

The production of biofuel is optimised due to the use of genetically modified bacteria.

Bacteria are also used in the medical field. In these bacteria a piece of human DNA is inserted, because of this the bacteria can produce "human" proteins, such as the hormone insulin.



Slide 9

Genetically modified food

Why do we use it?

- Protected better
- More nutrient value
- Prettier

Not totally new



Why would we genetically modify our food?

We do this so we can cultivate *more* food.

By applying genetic modification we can protect certain crops against disease, but also optimize to the optimal environmental factors.

The fact that we modify our crops to our preferences is not completely new. For centuries humans have crossed plants with each other.

Watermelons have gone from their original weight of about 80 grams to more than two kilograms, because of these techniques.




Slide 10

Genetically modified organisms

Research into functions of genes

- Knock out mice

"pretty" pets



Why do we apply genetic modification to animals?

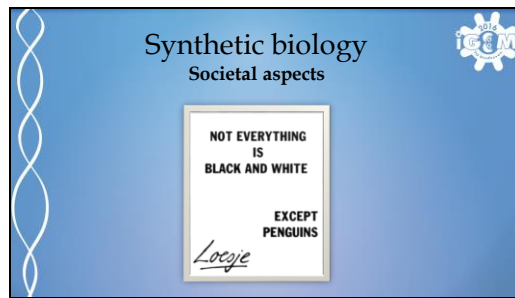
Isn't that sad for the animals? What is the use of this?

The most important reason is research. By modifying certain bits of DNA we can analyse the consequences of the modification.

An example of this are the knock out mice. In these mice certain genes are disabled. Afterwards the mice is being observed to see the consequences of the gene being disabled. Can the mice survive without the gene? What could the gene be responsible for?

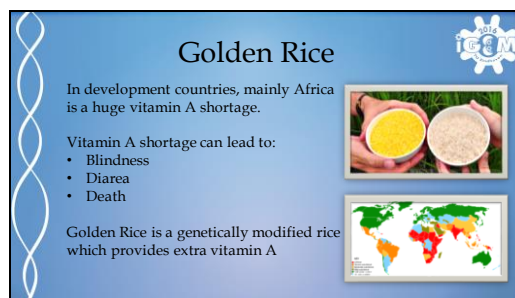
A different reason for genetically modifying organisms, plants and animals is for our own pleasure. Extra red roses and fluorescent fish are already available in shops.

Slide 11



Now it is time to go deeper into the effects of synthetic biology in the society.

Slide 12



The first example is the Golden Rice dilemma. This topic is already a few years ago.

Researchers produced the so called Golden Rice. This rice contains nutrients that would stimulate the production of vitamin A in the body.

In developing countries, especially Africa, a Vitamin A deficiency is a big problem.

A vitamin A deficiency can lead to severe consequences such as, blindness and diarrhea.

A severe case of diarrhea can increase the chance of death greatly.

When the decision to use the rice to help the children in Africa was made, many discussions arose.

Ask the class if they heard of these discussions before?

Slide 13

Golden Rice

Supporters:

- Can save childrens lives
- Not expensive
- Can be produced locally by farmers

Opponents:

- Safety Golden Rice not yet proven
- Brings GGO in the environment



Why did these discussions arise?

There were some very good arguments to send the rice to Africa. It could save lives after all. It wasn't expensive to produce and the farmers could cultivate it themselves.

Then why were so many people against them?

The most common counter argument was that the rice had not been tested on humans yet. At least not in the long term. Can you just eat genetically modified food? Isn't that dangerous?

Another counter argument was that genetically modified organisms could be released in nature without any control that the western world currently has.

Slide 14

If lives could be saved it doesn't matter that there was no possibility to run long term tests on the genetically modified food.

Agree? Or disagree?

Read the question out loud. Let everyone think about it for a bit. Then ask the students to raise their hands if they agree with the statement.

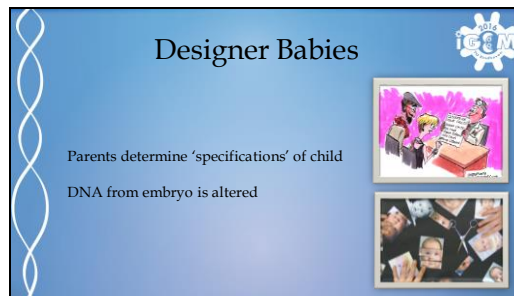
Give a couple of students the opportunity to explain why.

Do the same for the people that do not agree with the statement.

Slide 15

Designer Babies

Parents determine 'specifications' of child
DNA from embryo is altered



Example 2. In the not too distant future it could be possible to choose, as a parent, the characteristics of their child. This is possible by modifying the DNA of the embryo.

It won't take long before we know what most genes are responsible for. Do you prefer a child with blue eyes, black hair, athletic ability or high intelligence?

It could very well become a possibility. So it is a good thing to think about the possible consequences now rather than later.

Of course it is not just about improving embryo's, but also curing hereditary diseases. Carriers of, for example, the sickle cell disease could use these techniques to have healthy children after all.

Slide 16

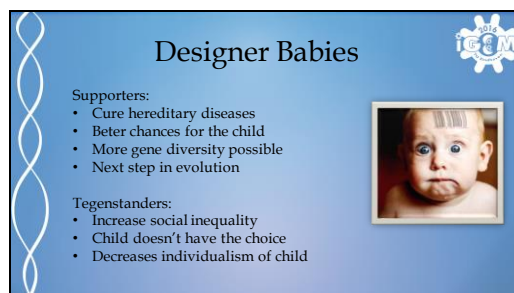
Designer Babies

Supporters:

- Cure hereditary diseases
- Better chances for the child
- More gene diversity possible
- Next step in evolution

Tegenstanders:

- Increase social inequality
- Child doesn't have the choice
- Decreases individualism of child



What could be the advantages and disadvantages of designer babies?

As mentioned before these techniques could cure hereditary diseases. By giving the child better characteristics it could have a better chance at living a good life.

Scientists could also track if there are enough people with different genes. When a serious disease arises it won't affect all of humanity due to these different genes.

The modification of DNA of humans is seen by many as the next step in evolution.

This sounds very positive, but there are of course risks involved in modifying DNA.

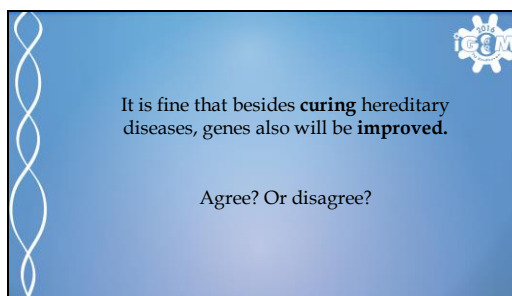
But even when these risks are solved, there are still good counter arguments against these techniques.

It is in fact very likely that these techniques will not be available for all parents. Parents with lots of money will be able to use these techniques earlier than poor parents. This will cause their children to be more successful, intelligent and probably richer. This could cause an even bigger wealth gap in the society.

The children that the techniques is used upon did not choose for it themselves. It could put a lot of pressure on these children to lead a certain life, which they might not want. Do their parents have the right to modify their child? Or does the child have the right to stay as they were?

The idea that modifications of your DNA can determine who you are can lead to a lesser feeling of individualism. Would you still be proud of your football accomplishments if you knew that your parents' choice the optimal genes to be good at football?

Slide 17

A blue rectangular slide with a white DNA double helix on the left side and a gear icon in the top right corner. The text on the slide reads: "It is fine that besides curing hereditary diseases, genes also will be improved." followed by "Agree? Or disagree?"

It is fine that besides **curing** hereditary diseases, genes also will be **improved**.

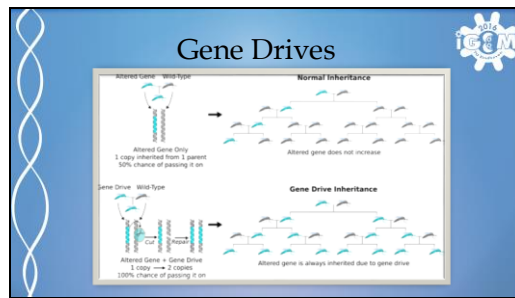
Agree? Or disagree?

Read the question out loud. Let everyone think about it for a bit. Then ask the students to raise their hands if they agree with the statement.

Give a couple of students the opportunity to explain why.

Do the same for the people that do not agree with the statement.

Slide 18



The biological/chemical knowledge behind gene drives is certainly challenging, but the principle of its purpose is easy to understand.

By modifying the DNA of one organism you can affect the whole population of this species.

In the normal situation an organism gets two gene variants. One from the father and one from the mother. Gene drive changes this.

Let's say we got a male rabbit. This rabbit has a gene that we would like every rabbit to have. We could modify the gene in such a way that if in the next generation it is in one of the chromosomes, it will built itself in the second chromosome as well.

If our male rabbit gets a bunch of bunnies they will all contain this special gene from their father. This gene will then cut out the gene from the mother's chromosome and built itself in. When the bunnies get bunnies themselves they will always have the gene from the earlier mentioned father.

Slide 19

Gene Drives

Gene will always be inherited

Supporters:

- Solution for many diseases (zika virus, malaria mug)

Opponents:

- We don't know enough about it
- Can have huge effects
- There is no turning back

The principle is that the gene will always be inherited. With this method the genes that the mosquito has that causes malaria to be transferred could be removed.

This sounds like the solution to many transmittable diseases. Yet there are many people opposing the use of gene drives. They think that there isn't enough knowledge regarding the technique and the consequences. The modifying of an organism could affect entire ecosystems. The danger of the technique is that it cannot be reversed.


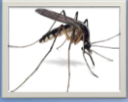
Slide 20

Gene drives must be used if it can cure the zika virus.
Agree? Or disagree?

Read the question out loud. Let everyone think about it for a bit. Then ask the students to raise their hands if they agree with the statement.
Give a couple of students the opportunity to explain why.
Do the same for the people that do not agree with the statement

Slide 21

Nature
Combat vs. protect



Using the gene drive technique many hereditary diseases could be combatted. The human race tries, just like any other species , to survive. Protecting ourselves versus viruses also includes that.

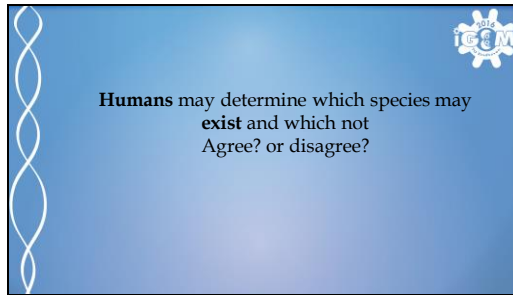
But how far are we allowed to go combatting species, because it suits us better?

Why do we find it bad that the polar bear is being threatened with extinction, but when there is a possibility to exterminate the malaria mosquito, we would do it immediately.

Why are we allowed to use bacteria in the lab and modify their DNA, but using mice or dogs instead would cause a lot of commotion?

And why do these ethical discussion arise when we talk about modifying the human genome.

Slide 22



Humans may determine which species may **exist** and which not
Agree? or disagree?

Read the question out loud. Let everyone think about it for a bit. Then ask the students to raise their hands if they agree with the statement.

Give a couple of students the opportunity to explain why.

Do the same for the people that do not agree with the statement.

This is the end of the lesson. We hope that everyone has become more aware of the influence synthetic biology will have on the future.

Worksheet Synthetic Biology in the society

Name:

Question 1: DNA and proteins

a What is the function of DNA?

.....
.....

b What is a protein?

.....
.....

Question 2: Genetically modified food

a Mention a reason why genetically modified organisms can be favorable for fruit growers and a reason why they aren't favorable for them.

.....
.....

b Why is the modification of food not entirely new?

.....
.....

Question 3: Golden Rice, Designer Babies and Gene Drives.

a Mention an argument which the opposition could use against Golden Rice. Do you agree with that argument?

.....
.....

b Mention an argument that supporters of Designer Babies could use. Do you agree with the argument?

.....
.....

c What is an argument that the opposition could use against Gene Drives?

.....

.....
.....

Question 4: Statements regarding synthetic biology

Indicate whether you agree or disagree with the following statements and explain.

a Genetic modification must be a possibility in the fight against cancer.

.....
.....
.....

b The use of genetically modified organisms must be allowed in industrial processes, such as plastic production.

.....
.....
.....

Solutions workshet synthetic biology in the society

Question 1: DNA and proteins

a What is the function of DNA?

DNA consists of 4 bases A,C,T and G. It has a coding function. It contains all kinds of heritable characteristics. An example of the heritable coding function of DNA is hair colour. At a specific location in the DNA, a specific code of bases determines the colour of your hair.

b What is a protein?

Proteins are encrypted in the DNA and after transcription and translation they can engage each other in a reaction which could influence divers processes in the cell. An example of a protein is haemoglobin. This protein ensures that oxygen is transported in your blood.

Question 2: Genetically modified food

a Mention a reason why genetically modified organisms can be favorable for fruit growers and a reason why they aren't favorable for them.

In this way selective mutations can be applied on their crops which could optimize their profit. For example, better disease resistance or better looks of their crops.

b Why is the modification of food not entirely new?

Many crops are crossbred to make a better crop. For example the crossbreeding of a disease resistant crop and a fast growing crop could produce a more efficient and healthier crop.

Genetic modification has the same purpose, it just reaches its goal faster and more efficient. Crossbreeding is a natural process, while genetic modification is not.

Question 3: Golden Rice en Designer Babies.

a Mention an argument which the opposition could use against Golden Rice. Do you agree with that argument?

Example of answers:

Because of this genetically modified organisms are released in nature.

It is not yet proven that genetically modified organisms do not carry dangerous consequences.

If Golden Rice is used it could cause the consumption of other crops to drastically decrease. This could lead to less diversity of crops, which could lead to soil degradation.

Do you agree with this statement: Own input.

b Mention an argument that supporters of Designer Babies could use. Do you agree with the argument?

Examples of answers:

Due to Designer babies hereditary diseases such as, Alzheimer, haemophilia and colour blindness could be effectively combatted.

Designer Baby's hebben een grotere kans op een succesvol leven.

Directed genetic modification is a logical next step in evolution.

Do you agree with this: Own input.

c What is an argument that the opposition could use against Gene Drives?

Examples of answers:

There isn't enough knowledge regarding Gene Drives

Gene Drives could have disastrous consequences for the environment.

The effect of Gene Drives is irreversible.

Question 4: Statements regarding synthetic biology

Indicate whether you agree or disagree with the following statements and explain.

a Genetic modification must be a possibility in the fight against cancer.

Examples of answers:

Yes, If this happens in a safe manner then this is certainly a good way of approaching it.

No, if the development would start, it wouldn't take long before humans become half human – half robot.

b The use of genetically modified organisms must be allowed in industrial processes, such as plastic production.

Examples of answers:

Yes, if industrial processes could become more efficient with this method, it should definitely be made possible.

No, the use of genetically modified organisms must be limited as much as possible.

Tips

- If there is time left at the end of the PowerPoint presentation it could be fun to have a class conversation regarding Golden Rice, Designer Babies or Gene Drives. These are interesting topics which could lead to interesting conversations.
- If there is less time than planned for the worksheet then it could be discussed with the whole class at once.
- Did you find an error in the worksheets or answer sheets or do you wish to implement an *modification* in the course material? Mail igem@tue.nl with the topic of "synthetic biology course 2016".