This year, our team decided to raise public awareness about synthetic biology and biotechnology. To fulfill our goal we created a quiz-survey. The survey served two purposes: to estimate the level of knowledge of the participants about some facts in synthetic biology and biotechnology and to educate them by providing correct answers and explanations. We have distributed the survey across the whole summer and successfully collected and analyzed data. Below you will find a summary of the results we got.

Altogether 147 participants took part in the survey. Around 70% of them were between 18-24 years old (Figure 1) and have different levels of education (Figure 2).

![Figure 1. Age distribution of the survey participants.](image-url)
Distribution of the average number of correct answers between age groups was as follows: participants above 40 years old gave the highest number of correct answers (5.2), while people from the youngest group (below 18 years old) gave the lowest number of correct answers (4.11). However, the difference between the groups was not statistically significant (Figure 3).
What is the first biopharmaceutical (any pharmaceutical drug product manufactured in, extracted from, or semi-synthesized from biological sources) approved for therapeutic use?

More than half of responded (54.4%) know that the first biopharmaceutical was insulin, which is one of the most important hormones in the human body, necessary for glucose utilization. Almost 40% of participants chose paracetamol, pain-relieving and fever-reducing drug that can be found in every first aid kit. 6.1% of participants selected Minoxidil, which is used as an active substance in hair loss remedies.
This question takes third place among the most difficult ones! 42.9% of participants responded, that the product is the same in every batch, which is wrong. **Biopharmaceuticals** are subjected to certain modifications inside the living cells. Due to subtle variations in production conditions, modifications and, as a result, changes in the abundance of different variants may vary too. Only 41.5% answered correctly. The minority (15.6%) said that the products are less complex and smaller. However, it is not true, as bioproduction gives
the same active compounds, and the only factors that might slightly affect it are mentioned above.

Biosimilar medicines are the same as generic medicines

This question was the simplest one for our audience: more than 78% of participants answered correctly! A biosimilar medicine is a highly similar version of a reference biological medicine, while a generic drug has exactly the same active substance as the original, but it may differ in some characteristics such as a manufacturing process, etc.

For how long do you think mankind has been using microbial production?

Surprisingly, more than 30% of participants did not know microbial production is used for thousands of years. For example, wine is being produced since ~6000 BC! Since the topic of this question has a stronger connection to our everyday life, compare to other ones in this quiz, we found the results quite unexpected.
Cleaning the environment and breaking down persistent chemicals in soil and water by microorganisms is...

61.2% answered correctly. The correct answer is bioremediation - the application of a biological treatment, mainly microbes, to clean up hazardous contaminants in soil and surface or subsurface waters. However, it was not so difficult to get confused, because biostimulation involves the modification of the environment to stimulate existing bacteria capable of bioremediation. And bioventing is quite a similar process to bioremediation - stimulating the natural biodegradation of contaminants in soil by providing air or oxygen to existing soil microorganisms.
Figure 11: “Cleaning the environment and breaking down persistent chemicals in soil and water by microorganisms is ...?” answers distribution diagram

Novel protein foods (alternative source of protein for humans) are produced by using...

That was the second simplest question for our participants: more than 76.2% of people gave the right answers! Indeed, the biomass or protein extract from the yeast or bacteria cultures may be used as an ingredient for protein-rich foods and is suitable for human consumption. Of course, viruses and mammalian tissue are not used for that purposes.

![Pie chart showing distribution of responses](image)

Figure 12: “Novel protein foods are produced by using ...?” answers distribution diagram

What is one of the reasons yeast is not a very common organism for bioproduction?

That was the second difficult question for the audience: almost 50% of responded answered that yeasts are not suitable for the production of a large number of compounds, but it is not true. As we know, yeasts are widely used for industry-scale production of different proteins and chemicals, for example, ethanol and carotenoids. The correct answer is that yeast has a rigid cell wall, which makes extraction of compounds more difficult and expensive.
In the second part of the survey, respondents should choose the correct statements based on their opinion/knowledge. It appeared to be the most difficult part of the quiz. Four out of six statements were correct:

- **Bioproduction of chemicals produce less waste** because living systems govern their chemical reactions more efficiently than man-made chemical refineries, and most of the wastes they generate are recyclable or biodegradable.
- **One of the disadvantages of synthetic bioproduction is the need to purify products.** Indeed, the necessary step of bioproduction is a recovery of the product followed by downstream processing to prepare the product for sale.
- **85% of all atmospheric pollutants are produced by the burning of fossil fuels.**
- **Biofuels can be obtained from plant matter and microalgae.**

The following statements were incorrect:

- **Chemicals produced by living organisms are cheaper.**
  It is wrong because purification of the compound can account for more than 85% of total production costs in a biomanufacturing process and it is often more expensive, in comparison to chemical synthesis.
- **Farmers would never cultivate biotechnologically modified crops.**
  It is wrong since millions of farmers in ~30 countries worldwide have already adopted biotech crops at unprecedented rates.

Only 14.3% chose all the correct options, while 2% (3 persons) did not choose any of them.
Conclusions

Overall, due to the small sample size, it is difficult to draw conclusions. For example, it is hard to find any direct connections between the age, nationality or even education level and the knowledge in synthetic biology they have. The observed difference in results is either not prominent and statistically insignificant or, in some cases, the results are not very reliable, as different groups are represented by a different number of participants. However, there are some tendencies that might become more pronounced in case if more people will fill the survey.

Overall, we understood that the general public awareness with synthetic biology and biotechnology is far from being comprehensive. For instance, almost 40% of responded did not know, that microorganisms are being used by humanity for more than a few thousand years, while half of the participants did not know yeast is capable to produce a large number of different chemical compounds.

It means that the work that iGEM and our team are doing is meaningful. The more people know about synthetic biology and its application, the more they support it. We hope our quiz helped to engage the audience and raised the interest of the general public in this field. Based on the survey results, we have decided to continue public engagement in synthetic biology. We have started with participating in 15x4 event in Tartu where our team gave a lecture on our iGEM project and synthetic biology and described how it impacts our everyday life.