# 'SYNBIO FOR KIDS'

A GUIDE FOR COMMUNICATING SYNTHETIC BIOLOGY TO CHILDREN AND YOUNG PEOPLE

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## The aim of this guide

Warwick and Stockholm iGEM teams collaborated on a guide on how to effectively communicate synthetic biology for children and young people. iGEM (international genetically engineered machines) is a competition in synthetic biology in which teams of students and high school students all over the world aim to solve impactful problems in the society, the environment and science with the help of synthetic biology. An important part of iGEM is the dialogue with the public to ensure transparency and provide a source of easy accessible knowledge to find feasible solutions.

## Warwick's Experience

Warwick iGEM created a video game called 'Ed and Friends' aimed at children aged 5-10 years old to communicate the foundations of synthetic biology and the life of bacteria. This was tested at a regional Family Fun Day event as well as at a national level at a family-friendly science exhibition, 'New Scientist Live.'

We also conducted several outreach days both in the UK and Malaysia, where we engaged secondary school children in understanding the basic principles of synthetic biology as well as delving into debates about the ethics. Moreover, for a period of four weeks over the summer, we hosted two Nuffield Research Placement students who we mentored by teaching them the basics of synthetic biology. These students were inducted into labs also, where they learnt fundamental microbiology techniques.

Our range of experience through a variety of methods inspired our collaboration with iGEM Stockholm to create this guide.

## Stockholm's Experience

Our human practice team created a children's book to communicate the very basics of microbiology and synthetic biology. The children's book was distributed all over Stockholm to reach as many children and their parents as possible. Our main goal was to state the role of bacteria in all day life and give an idea of their look supported by friendly illustrations. We also hope to gain interest of the children's parents and to change their often negative prejudices.

Furthermore we created a board game to make the contents of synthetic biology easily accessible. The game is aimed at young people aged 15 years or older. We incorporated the concept of the iGEM competition in this game to let the player experience the potential of synthetic biology to solve real world problems. The game engages the kids to collaborate, exchange ideas and think about creative solutions. Finally the players learn about basic synthetic biology techniques by answering trivia cards and create their own genetic construct.

During the summer we reached out to children and other parts of the society. We created a "Lab on wheels" by bringing lab tools like pipettes and plates to the public in the streets of Stockholm. We demonstrated standard lab techniques with household reagents and answered many questions from children and adults.
With the help of the aforementioned tools and methods of engagement we gained a lot of experience in creating media to communicate synthetic biology.

## Current knowledge

As public awareness is increasing, the field of synthetic biology is becoming a more and more accessible field for children and high school students. Generally, the first contact with basic synthetic biology techniques occurs, however, only during high school when kids are usually from 15-17 years old even though the latest findings suggest that basic concepts of engineering can be understood by children in the age of 5-7 years (Bers, 2018).

The overall cause could be that an interdisciplinary subject like synthetic biology, which includes aspects from engineering and combining them with life science are thought to be too complex to be part of an elementary school science teaching scope. Despite the growing amount of science teaching in elementary schools there is still an uncertainty of how science teaching is done effectively (Strawhacker et al. 2018; Greenfield, 2015). The knowledge of synthetic biology during elementary school is therefore usually rather limited.

In conversation with Mrs Sarah Simms, a secondary school Biology teacher in the UK, about the challenges of teaching genetic engineering in the school curriculum, she explained that difficulties arise when "at GCSE level we talk about it [genetic engineering] in terms of single cells and therefore it is sometimes hard for students to grasp the fact that we can't genetically engineer a whole adult organism." She explained that this changes for young people aged 16-18 years, "For A level I think it is the length of the whole process that makes it difficult to teach, there is a lot to remember in a particular order." It is perhaps significant to remember that at

secondary school level in the UK, this information is being studied, alongside a wide range of other subjects, for the purposes of examination in national curriculum exams, both at GCSE level (14-16 years) and at A Level (16-18 years). Thus, it is entirely possible that a lack of engagement could occur for young people at this age group as a result of the breadth of knowledge they are expected to learn for exams.

Despite advances in synthetic biology making news headlines consistently, a minimum level of engagement and interest in the subject matter is prerequisite for anyone to gain understanding and knowledge from news sources; when it comes to engaging young people, in particular, a manner of other mediums can be utilised to communicate the principles of synthetic biology. This only emphasises the need for engaging and accessible tools to understand synthetic biology and there has been a rise in the tools being made available for bringing engineering into schools.

## Tools available currently

The growing availability of tools to teach synthetic biology has perhaps arisen through the growing awareness of the importance to an early exposure to engineering science since it builds on a natural curiosity. Besides books and information focused websites there are more pedagogical advanced ways to teach synthetic biology to children. In terms of a hands-on tool, there are now synthetic biology kits designed to apply and learn basic techniques.

BioBits, for example, was created out of a collaboration between Harvard University, MIT and Northwestern University. The kits are cell-free to avoid breaking any regulations and to lower the safety risks. Furthermore, they avoid the difficulty of dealing with an *in vivo* system. It was shown that these kits are easy to operate and results can be detected without sophisticated lab equipment (Stark et al. 2018).

As an alternative to hands on devices there are recently developed videogames to learn about synthetic biology. Nanocraft is a free videogame in which the gamer is able to build a DNA sequences by considering the Chargaff Rules of base pairing (Barone, 2015). Another videogame freely available is “Hero.Coli” made by the Center for Research and Interdisciplinarity (CRI) in Paris, which allows the gamer to move an E.coli bacterium in an aquatic environment and pick up different molecular tools as well as DNA sequences. The CRI also provides a free synthetic biology course called “SYNTHETIC BIOLOGY ONE” addressed to undergraduate students and teachers. The described games are an innovative

and clever medium to engage children in synthetic biology since they incorporate fun with knowledge. However we think these tools address children only in an age up to 12. In addition to the aforementioned tools, there are a rising number of events promoting engineering to children, for example those teaching computational coding. The event “Kids Hack Day” is one of a platform where children can learn how to code. The platform can also be used to introduce similar concepts in synthetic biology which was done in a cooperation between iGEM Stockholm 2017 and the Kids Hack Day community.

## The different mediums of communicating SynBio to kids

There are many different mediums of communicating synthetic biology which have been used, and iGEM teams, in particular, have been very experimental with the mediums they choose.

The media of communication used by iGEM teams, and other bodies interested in improving public engagement with synthetic biology, can be broadly categorised into four areas:

1. Classroom-style teaching
2. Interactive tools and multimedia
3. Books and board games
4. In-laboratory visits and interacting with scientists

These four mediums have each shown different results and levels of engagement when used with children; the effectiveness of each method can only be determined, however, by tailoring the communication method to both age group, prior knowledge and considering the aims of the communication i.e. is the idea of synthetic biology merely being introduced or is a platform for brainstorming and debate being created for those who already know a basic level on the subject matter.

1. Classroom-style teaching

Classroom-style teaching which led into debates and discussions were a core component of Warwick iGEM’s outreach work with schools. Many of the young people who participated in these workshops had little to no knowledge of synthetic biology at the beginning yet since the debates raised were integral to our everyday lives, everyone was able to participate and engage in discussion. This form of engagement is particularly useful in smaller groups as

discussion can be more natural and open but it is useful to have a range of arguments raised at the opening of each debate to spark critical thinking in the students.

2. Interactive tools and multimedia

An modern and innovative method of communicating the potential of synthetic biology is through virtual reality. Warwick Integrative Synthetic Biology (WISB) centre have created a virtual reality game in which users are introduced to gene-editing tool CRISPR and use this technology to change the society we live in; the futuristic game involves putting genes for fluorescence into trees so that glowing trees replace street lamps, akin to a setting like in the 2009 James Cameron movie, *Avatar*. The positive about this communication method is that it attracts people of all ages and explains the basic concepts of synthetic biology in an engaging and jargon-free way. When this was used at the WISB stall at London event *New Scientist Live*, every user of the VR system that we observed seemed incredibly engaged and excited by the end of the experience.

Videos about synthetic biology are also becoming increasingly popular. YouTube has proven to be an excellent tool in giving everyone, including young people, access to a wide range of information. The rise of science-based YouTube channels such as '*Kurzgesagt – In a Nutshell'*, which use graphics and accessible language to communicate complex and emerging fields, such as synthetic biology, has enabled not only young people, but people of all ages, to learn more about the advancing biotechnologies around us.

3. Books and board games

Books are a great medium to engage parents and children and provide a tool that can be adapted to certain levels of knowledge. By adding lively illustrations books give the possibility to create an idea of basic synthetic biology concepts.

Board games can serve as a great playful medium for children older than 12 depending on the level of the content and the conception of the game. The big advantage of this medium is that different concepts of synthetic biology can be combined and taught iteratively by implementing tools like trivia cards or simulating various science related scenarios.

4. In-laboratory visits and interacting with scientists

Exhibitions, such as *New Scientist Live*, enable synthetic biologists to reach a wide audience of people in a short time span; this is a particularly useful strategy for improving engagement if the opportunity is used interactively and inventively. Additionally, many attendees of such events already have an interest in science; as a result, the synthetic biologist merely has to engage them in understanding the advances in the field.

During the summer, Warwick iGEM hosted and mentored two Nuffield Research Placement students, who were both 17 years of age. The students learnt a variety of foundational microbiology techniques, such as PCR and gel electrophoresis. The students' learning was then assessed by the Nuffield foundation through a detailed lab report on the work they did with us as well as a presentation. By the end of their experience, the students had learnt some of the core principles behind synthetic biology and were noticeably more engaged and interested in the field. In addition, one of Warwick iGEM's team members this year, Gurpreet, had undertaken a Nuffield Research Placement two years prior, also aged 17, with the Warwick iGEM 2016 team. After her experience, she was significantly more interested in synthetic biology as a field, which led her to apply for the iGEM team in her first year at university. It seems, therefore, that introducing young people into the lab, where they can witness laboratory science is an excellent way of engaging them in synthetic biology.

## Guidance on choosing an appropriate method of communication

| Medium | Suggested age group | Advantages and suggestions of when to use | Successful examples |
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| Virtual Reality (VR) | All ages, but specifically up to 14 years | • Particularly engaging with large audiences, such as at an exhibition<br>• Incredibly popular and new technology currently so many people are excited by it<br>• Makes learning about synthetic biology fun | Warwick Integrative Synthetic Biology (WISB) Centre's VR tool |

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| Video game | Up to 14 years | • Reaches many people, especially when turned into an app or online PC game<br>• Easy to use<br>• Makes learning about synthetic biology fun | Imperial iGEM 2016's 'Go Culture' game |
| Board game | Up to 16 years | • Can be used in a family and a school environment | iGEM Exeter 2016 "BioMech" |
| Children's book | Up to 8 years | • Weaving scientific knowledge into a story narrative could help it appeal to audiences/children that the field wouldn't typically appeal to | iGEM Melbourne 2014 "The adventures of E.coli" |
| Lab visit | 14-18 years | • Gives young people an insight into laboratory work<br>• Destigmatises science<br>• Makes synthetic biology seem more approachable | Warwick iGEM 2016's Nuffield Research Placement student who then became a member of Warwick iGEM in 2018 |
| Exhibition | 10-18 years | • Friendly environment with people who already have an interest in science<br>• Great when you have a large audience and many different stalls | iGEM Stockholm 2017 and the Kids Hack Day community |
| Lecture/Debate | 14-18 years | • Enables children to think more critically about the science<br>• Encourages active engagement | Warwick Integrative Synthetic Biology (WISB) Centre's school outreach programme |

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| Videos | 14-18 years | • Can be widely accessed by people<br>• Visual medium is useful for explaining complex processes<br>• Good quality graphics and accessible narration are key | 'Genetic Engineering Will Change Everything Forever – CRISPR' by *Kurzgesagt – In a Nutshell* |

## Resource list

A list of useful resources available for educators and parents to use when talking to children about SynBio.

Imperial 2016 iGEM's 'Go Culture' Game

Nuffield Council for Bioethics

BioBits

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