Dear high school teacher,

Please find enclosed a selection of materials we have developed for high school teachers and pupils in the Netherlands in the context of the Bioinformatics@school programme.

Bioinformatics@school

Since 2006, we organize a travelling DNAlab about bioinformatics called Bioinformatica in de klas/Bioinformatics@school (www.bioinformatica-in-de-klas.nl, www.bioinformaticsatschool.eu). The project has been implemented by NBIC, the Netherlands Bioinformatics Centre, and CMBI, the department of bioinformatics of Radboudumc, Nijmegen. Since the start of the project over 17000 high school pupils have participated in one of our Bioinformatics@school practicals in their own classroom. These pupils gain interest in and knowledge about new scientific subjects like genomics and can use real research technology at their school. Our lab is free of charge for high schools and is taught at the high schools by science students of the Radboud University Nijmegen.

The mission of Bioinformatics@school is to get bioinformatics elements embedded in the high school curriculum by educating pupils and teachers and also to show the relevance of bioinformatics and genomics to a broader audience (for example we use a 3D-beamer to visualize proteins for the general public).

During the years we have developed a large portfolio of activities and materials. Two examples are given here in this booklet:

- A fun classroom activity: Bioinformatics Crossword (duration 15 min), this exercise relates to topics in our travelling DNAlab practical
- The Navigene: a tool to help find your way in bioinformatics and design your own bioinformatics lesson materials. A summary is given here in this booklet, including the Navigene scheme; the complete guide (20 pages) can be downloaded from our website

The lessons that we do in the Dutch high schools can be accessed at www.bioinformaticsatschool.eu, where you can also find teacher materials belonging to this lessons.

We wish you a nice journey through the world of Bioinformatics!

The Bioinformatics@school team:
Judith Rotink & Hienke Sminia (onderwijs@nbic.nl)
Celia van Gelder (celia.vangelder@radboudumc.nl)

November 2014
All Bioinformatics@school materials are licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Licence
Introduction

This crossword puzzle is being used as a follow up after Dutch pupils have done the "Bioinformatics: a bit of life" practical on their school (see www.dnalabs.eu, www.bioinformaticsatschool.eu and www.bioinformatica-in-de-klas.nl).

However, it can also be used separately in other classroom settings in case you like to do a small, fun exercise with your students about bioinformatics.

Students are requested to do the crossword individually. Afterwards they can consult with their fellow students.

This activity takes about 15 minutes.
Across

1. What does a set of three bases code for in RNA?
4. What is ‘Bos taurus’?
6. What is the name of the research area that uses computers to solve biochemical problems?
9. In which inter-atomic interaction is hydrogen involved?
10. What is the charge of the zinc ion?
13. What is the name of the software that enables you to watch proteins in 3D?
15. Can the snake poison be classified as a structural protein, an enzyme or a substrate?
16. What is the name of the software tool that bioinformaticians use to search for proteins in databases?
18. What is the name of the structural protein that is cleaved by the poison of the Texas diamond-back rattlesnake?
20. Which amino acid is abbreviated with the word ‘His’?
22. DNA -> RNA ->... What is the next step in this chain?

Down

2. Which amino acid is represented by the so-called start codon?
3. Which element from the periodic table is the most abundant one in proteins?
5. Which element is represented by a red sphere in the 3D-software?
7. What is the name of the enzyme that digests starch? Hint: It is also present in your mouth.
8. Which atomic interaction can one compare to the functioning of a magnet?
11. Which base can one find in RNA but not in DNA?
12. What is the biological term for the production of a protein?
14. How can one cause a protein to denature?
17. In the lock-and-key principle, is the enzyme the lock or the key?
19. What is abbreviation of deoxyribonucleic acid?
21. What is the name of the secondary structure that looks like a drapery?
Answer Guide

A M I N O A C I D
C A T T L E
B I O I N F O R M A T I C S
P O S I T I V E
I N H Y D R O G E N B R I D G E
N N I E
C B L A S T
O N D
A U S A R A Y
E A E N Z Y M E
L C T A T
O I H T
K C O L L A G E N
S D H I S T I D I N E
H E E
P R O T E I N
The NAVIGENE: a tool to help you find your way in bioinformatics

Within the Dutch Bioinformatics@school project an unique instruction tool, the Navigene, has been developed to help teachers and students navigate through online bioinformatics tools and software and enable them to design their own bioinformatics lesson materials.

You can download the latest version at http://www.bioinformaticsatschool.eu/docenten.php or at www.nbic.nl/education/high-school-programmes/bioinformatics@school/teacher-training/navigene/

Why bioinformatics in the classroom?

The recent flood of data from genome sequences and functional genomics had given rise to a new field, bioinformatics, which combines elements of biology and computer science. Bioinformatics is nowadays an inherent part of research in molecular biology. Gelbart and Yarden\(^1\) write that a bioinformatics learning environment promotes the construction of new knowledge structures of the genetics domain and therefore influences students’ acquisition of a deeper, multidimensional understanding of the domain.

We think that databases and software used in bioinformatics can contribute to several challenges in biology education:

1. **Students understanding of abstract concepts like protein, genome and evolutionary relationship**

Proteins and genes cannot be observed by the human eye. Expensive equipment is needed to visualize these molecules. And even then it remains to be seen whether students would gain a better understanding of the processes and functions. Cheaper and probably more helpful is a computer-based approach. Using 3D-software, you will be able to see a certain protein from all different angles. You can zoom in, turn the protein around and select specific amino acids. A protein structure can be downloaded from the Protein Data Bank. Other databases make it possible to show the structure of genes in a scientific way. You can simply zoom in on a gene and distinguish the exons, introns and regulating domains. You can even make simplistic phylogenetic trees or look directly at proteins that are related to your protein of interest.

We think that when students can work with these tools, abstract genomic concepts become more tangible and therefore easier to understand.

---

2. The coherence between DNA, protein and traits, and other themes in biology

Schoolbooks often discuss the relation between DNA, genes and heredity in the context of visible traits like the colour of the eyes or hair. The fact that humans have 99,9% of (mostly non-visible) heritable characteristics in common is hardly ever taught to students. One way of giving attention to the relationships between DNA and traits outside the chapter on heredity is by making a link to proteins, which are discussed as part of other themes within the biology curriculum. For example: when discussing digestion, you can simply look up on what chromosome the gene for amylase is and/or show the 3D-structure of amylase. These links can be packaged as small assignments (max. ten minutes) directly connected to proteins in the biology curriculum. We think that making more links from different chapters throughout the biology curriculum to genes and proteins helps students' understanding of the genome.

3. Insight in current research methods

Almost every discipline in life science employs bioinformatics. Moreover, bachelor and university programmes in life sciences also use bioinformatics. We think that high school education that aims to provide insight in current research methods, cannot ignore bioinformatics.

What is Navigene?

The NaviGene is a guide that helps you to find your way in online databases and software that are used by bioinformaticians and link it to your biology knowledge and to what you would like to discuss in the classroom with your students. Our experience is that when you are not a bioinformatics expert, it is very difficult to find any useful information in online sources. That is why we set up an understandable instruction guide to make it feasible to get real and authentic research into your classroom.

Who can use the NaviGene?

The NaviGene is initially developed for high school biology teachers. It is our experience that teachers use the Navigene each in their own way. Here are some examples:

- “I use the NaviGene to plenary show my students 3D-proteins when we come across a protein in the text book. This gives them better insight in what these molecules look like.”
- “I made a few assignments for my students with help from the NaviGene. I let students browse into Ensembl and let them make a phylogenetic tree. I couldn’t have made these assignments without the NaviGene.”
- “I used the NaviGene to find background information on blood groups. This blood group system was far more difficult than I expected and Wikipedia couldn’t give me the information that I wanted. So I looked into protein databases to find the right information.”
- “I have the NaviGene printed out in the back of my class. When excellent students want to do something extra in my biology lesson, I let them work from the NaviGene on a subject we just treated in class. Students also used the NaviGene on own initiative for school projects.”
We have several examples of student assignments made by Dutch biology teachers. Please contact us via onderwijs@nbic.nl for more information.

How can I use the NaviGene?

The NaviGene consists of two parts: a scheme and an instruction booklet. In the papers you are holding right now, you will only find the scheme (on the next page). The rest of the booklet can be downloaded at:
http://www.bioinformaticsatschool.eu/docenten.php or at:
www.nbic.nl/education/high-school-programmes/bioinformaticsschool/teacher-training/navigene

You read about the BRCA1-gene in a news article and wonder for what protein this gene codes. Or you find the protein Amylase in the chapter ‘Digestion’ in your biology book. These are excellent starting points for further research with help of the NaviGene.

You start with the Navigene in the grey triangle at the top of the scheme. Let’s take Amylase as an example. Amylase is a protein, so you start at the red box Protein on the left side of the grey triangle. From there you can follow a red arrow to Gene. There is a question linked to that arrow: What gene codes for this protein? P.5. If you want to know the answer on this question for Amylase, than go to page 5 of the instruction booklet. There you will find extended and comprehensible instructions on how to find the answer with help of online tools.

You cannot only ‘move’ around in the grey triangle, but also follow the lighter coloured arrows down. Depending on the information you already have, you go to either structure, name or amino acid sequence. In the case of Amylase you know the name, so you will have to start at I know the name of...
the protein. From there you can hunt down the structure, the amino acid sequence or follow the arrow downward to find out where the protein is located in the cell. All questions in the scheme are followed by $P$ and a number. This refers to a page in the (online) instruction booklet.

The instructions are given in this format:

In coloured bold letters the question from the scheme is repeated.

In the grey text box you will find short instructions to find the answer to your question. These instructions convenient when you are an experienced user of the NaviGene.

The extended instructions are given underneath the grey text box. Just read them through and use them for your specific question.

Each instruction ends with a coloured text box with a small assignment to get you acquainted with the instructions.

At the bottom of the page you can find the page number.

We wish you many useful discoveries and valuable surprises when using the NaviGene!

Finally,

- NAVIGENE is available for you to use under a Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Licence
- We welcome all your feedback. If you have used it and created a student exercise we would be happy to post in on the bioinformaticsatschool.eu.
- If you would like to edit the NAVIGENE guide (translate to your own language, add information or improve otherwise), we are glad to help you. Just let us know!
- NAVIGENE is, and will always be, under development due to updates from tools, websites and new features in bioinformatics resources. Please let us know when you find dead or wrong links. Than we can correct it!
- The original version of NAVIGENE is in Dutch. Updating the English translation is in full progress, but is lagging behind a bit. We trust you can understand that.

The Bioinformatics@school team
Contact: onderwijs@nbic.nl
November 2014