Extending Knowledge Beyond The Curriculum: The Biology Grid Computing Project

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Abstract: Acquiring knowledge is not just about achieving good grades. It is more about the passion to find out more than what is required of the curriculum. Four of our Secondary Three students are given the opportunity to become "research scientists" when they participate in the biology grid project. In this project, they will use a computational software called GridBLAST, to compare the DNA sequences of both the human and the chimpanzee. What they are learning now is actually part of what will be covered in the undergraduate module (bioinformatics). They will also learn other skills such as creating a website and oral presentation. Oral presentation is one of the requirements for the Life Science Competition. We also hope that they will be able to apply their oral presentation skills in future.
Keywords: knowledge, bioinformatics, project, website, presentation

Introduction

The field called "Bioinformatics" has made significant contributions by offering easy to use tools to compare genes with each other, e.g. to find informative similarities between genes of humans and those of lower organisms like insects. One particular tool is called GridBLAST. Four of our students are given the opportunity to become "research scientists". They are involved in a biology grid computing project where they use GridBLAST to compare genes of humans and those of chimpanzee (or Pan troglodytes). The chimpanzee has 48 chromosomes whereas the human has 46 chromosomes. Out of the total number of chromosomes, 1 pair contains the sex chromosomes. The male has one X-chromosome and one Y-chromosome; whereas the female has two X-chromosomes.

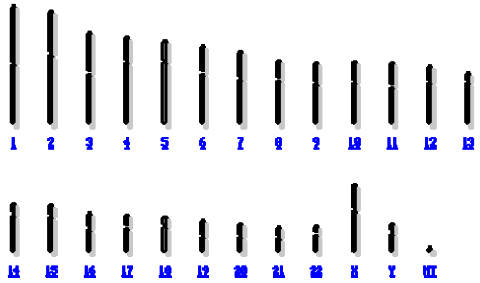

Figure 1: *Chromosomes of human*

Objectives

Through this project, the students are given the opportunity to extend their knowledge in Bioinformatics beyond the curriculum.

A chromosome is a tightly bundled thread of genetic information stored in the nucleus of a cell. Each species has its own number of chromosomes. Chromosomes contain DNA, which stands for deoxyribonucleic acid. Like proteins, DNA are made up of many similar, smaller molecules (called nucleotides) joined into a long chain. Therefore, DNA are polynucleotides.

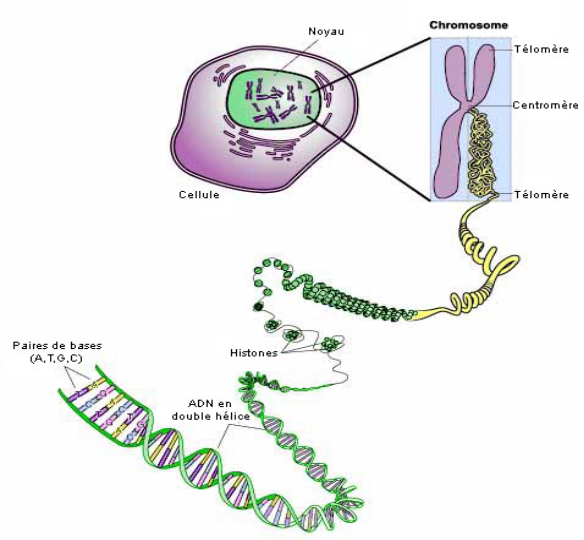

Figure 2: *Diagrams of nucleus, chromosome and DNA*

Nucleotides are made up of three components. There are: a phosphate group; a nitrogen-containing base; a pentose sugar. This sugar can be deoxyribose (in DNA). A base is one of the smallest meaningful units of genetic information inside a gene.

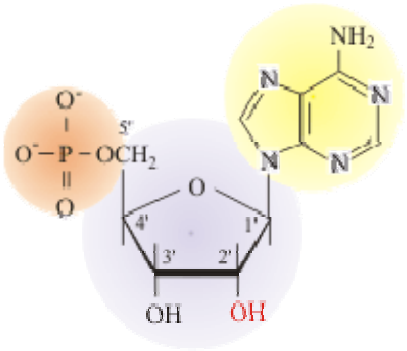

Figure 3: *Diagram of a nucleotide*

There are four bases in DNA: adenine (A), guanine (G), cytosine (C), and thymine (T). The bases are arranged in pairs. Each base has only one pairing partner. Adenine always forms double H-bonds with thymine. Guanine always forms triple H-bonds with cytosine.

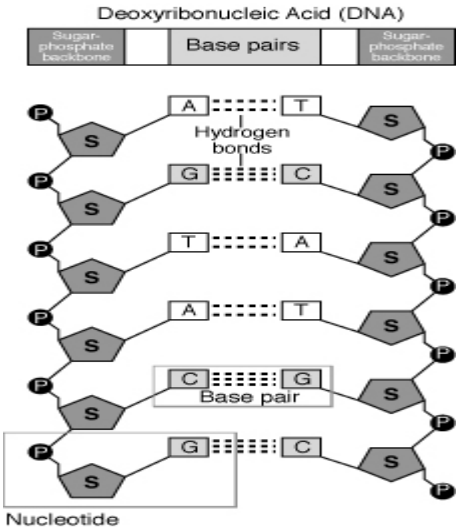

Figure 4: *Hydrogen bonding between bases in opposite DNA strands*

Through this project, the students also learn about IT skills such as using the computational tool GridBLAST and creating a website. What they are learning now is actually part of what will be covered in the undergraduate module (bioinformatics). In this way, they will be more prepared when they proceed to higher level of education. Once the project is completed, we will submit our project for participation in Life Science Competition. Oral presentation is one of the requirements for the Life Science Competition. Hopefully, they can improve their self-confidence through presentation to a large group of audience. We also hope that they will be able to apply their oral presentation skills in future.

Figure 5: Our closest relative, the chimpanzee

Planning

The chimpanzee is our closest living evolutionary relative. Comparing the human genome with the chimpanzee genome will provide great insight into genome evolution and organization, particularly late primate evolution.

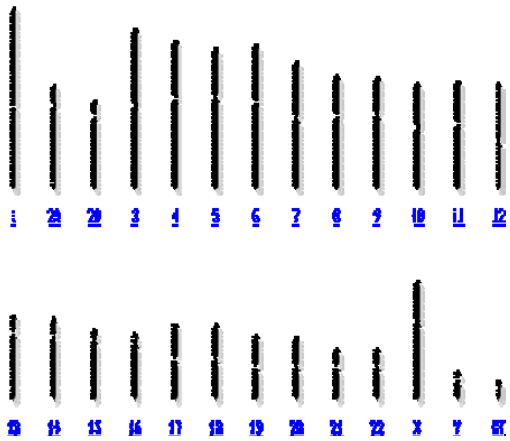

Figure 6: *Chromosomes of chimpanzee*

Procedures

Table 1: *Procedures for Biology Grid Computing Project*

Step 1	Click on the link http://www.ncbi.nlm.nih.gov/genome/guide/chinp/
Step 2	Select the Chromosome with the desired number
Step 3	Click on the link Download/View Sequence/Evidence
Step 4	Click on the link Save to Disk
Step 5	Save the DNA Sequence in a different file
Step 6	Click on the link http://srs1.bic.nus.edu.sg/udblast.html
Step 7	Upload your sequence file into the TCG Blast
Step 8	Type in your e-mail
Step 9	Blast your sequence against the TCG Blast Database
Step 10	Click on the link http://srs1.bic.nus.edu.sg/udblast_retrieve.html
Step 11	Type in your Job ID and e-mail
Step 12	The Blast results will be sent to you via email
Step 13	Click on the link http://srs1.bic.nus.edu.sg/udblast_checkjob.html
Step 14	Type in your Job ID to check if the Blast job is complete

Results

In this project, we have compared the DNA sequences of various chromosomes between the human and the chimpanzee. For example, in the comparison between chromosome 16 of the human and chromosome 16 of the chimpanzee, we obtain a 100% similarity, with all the 19 nucleotides matching together. In the comparison between chromosome 3 of the human and chromosome 3 of the chimpanzee, we obtain a 97% similarity, with 1225 nucleotides matching out of a total of 1252 nucleotides. In the comparison between chromosome 15 of the human and chromosome 15 of the chimpanzee, we obtain a 96% similarity, with 1050 nucleotides matching out of a total of 1088 nucleotides. In the comparison between chromosome 17 of the human and chromosome 17 of the chimpanzee, we obtain a 95% similarity, with 1542 nucleotides matching out of a total of 1612 nucleotides.

Table 2: *Differences between the Chimpanzee and Human DNA Sequences*

Differences between the Chimpanzee and Human DNA Sequences

Difference Type	Observations	% of Total	Frequency Per Position
Transitions:			
Total	16,990	70.3	.0087
At CpG sites	6,770	28.0	.1218
Transversions:			
G↔C	2,185	9.0	.0023
A↔C/G↔T	3,734	15.5	.0019
A↔T	1,256	5.2	.0012
Insertions/deletions	2,407	...	.0012

According to Ingo, E., Dirk, M., Carsten, S., and Svante, P., Table 2 shows the absolute and relative numbers of observed sequence differences between the two species. In total, 24, 165 substitutional differences were seen, resulting in a genomewide average DNA sequence difference between humans and chimpanzees of 1.24%. Among these differences, a 2.4-fold excess of transitions over transversions is seen. Notably, transitions at CpG sites account for 28% of all substitutional differences, whereas CpG dinucleotides consitute only 3.5% of the analyzed sequences. Among the transversions, A↔C/G↔T transversions are the most abundant class. However, per positions where a given substitution can occur, G↔C transversions are found to be 1.2-fold more common than A↔C/G↔T transversions and 1.9-fold more common than A↔T transversions.

Reflections

According to the students, they have acquired knowledge far beyond their curriculum. They are learning something that is targeted at the tertiary level. In this way, they are more prepared for project work when they proceed to junior colleges and universities. In addition, they have mastered some IT skills such as using the computational software called GridBLAST and creating a website. Another important skill that they learn is oral presentation skill, which is an essential judging criteria for the Life Science Competition. Through participation in the Life Science Competition, this will actually improve the students' self-confidence when they present themselves in front of a panel of judges. Last but not least, this project has contributed to the character development of the students such as teamwork, co-operation and leadership qualities.

References

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Diagrams of nucleus, chromosome and DNA.

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Our closest relative, the chimpanzee. http://www.chimpanzoo.org/2005conf/images/headerPhotos.jpg

http://srs1.bic.nus.edu.sg/udblast_results.html