The Role of Bioinformatics in Science and Education

Gabriel Dall'Alba, Guilherme B. Guzzo and Scheila de Avila e Silva

UCS UNIVERSIDADE DE CAXIAS DO SUL

bioinfo - UCS

UNIVERSITY OF TORONTO MISSISSAUGA

Objectives

- Discuss the role of Bioinformatics in the scientific scenario and its interdisciplinary concepts.

- How Didactic transposition and interdisciplinary concepts can give new insights on how to improve Science education in high school and college.

◎ *A Brief Introduction about Bioinformatics*

◎*Biology as an Informational Science*

◎*The Concept of Interdisciplinarity*

◎ *Didactic Transposition (Michel Verret & Chevallard)*

◎*Didactic Transposition and Bioinformatics approaches on Education*

◎*Conclusion*

A Brief Introduction about Bioinformatics

HGP
Human Genome Project (2001)

A Brief Introduction about Bioinformatics

The European Bioinformatics Institute (EBI) stored over 20 petabytes of biological data (2013).

(1 Petabyte is 10^{15} bytes)

Tendency to double each year

A Brief Introduction about Bioinformatics

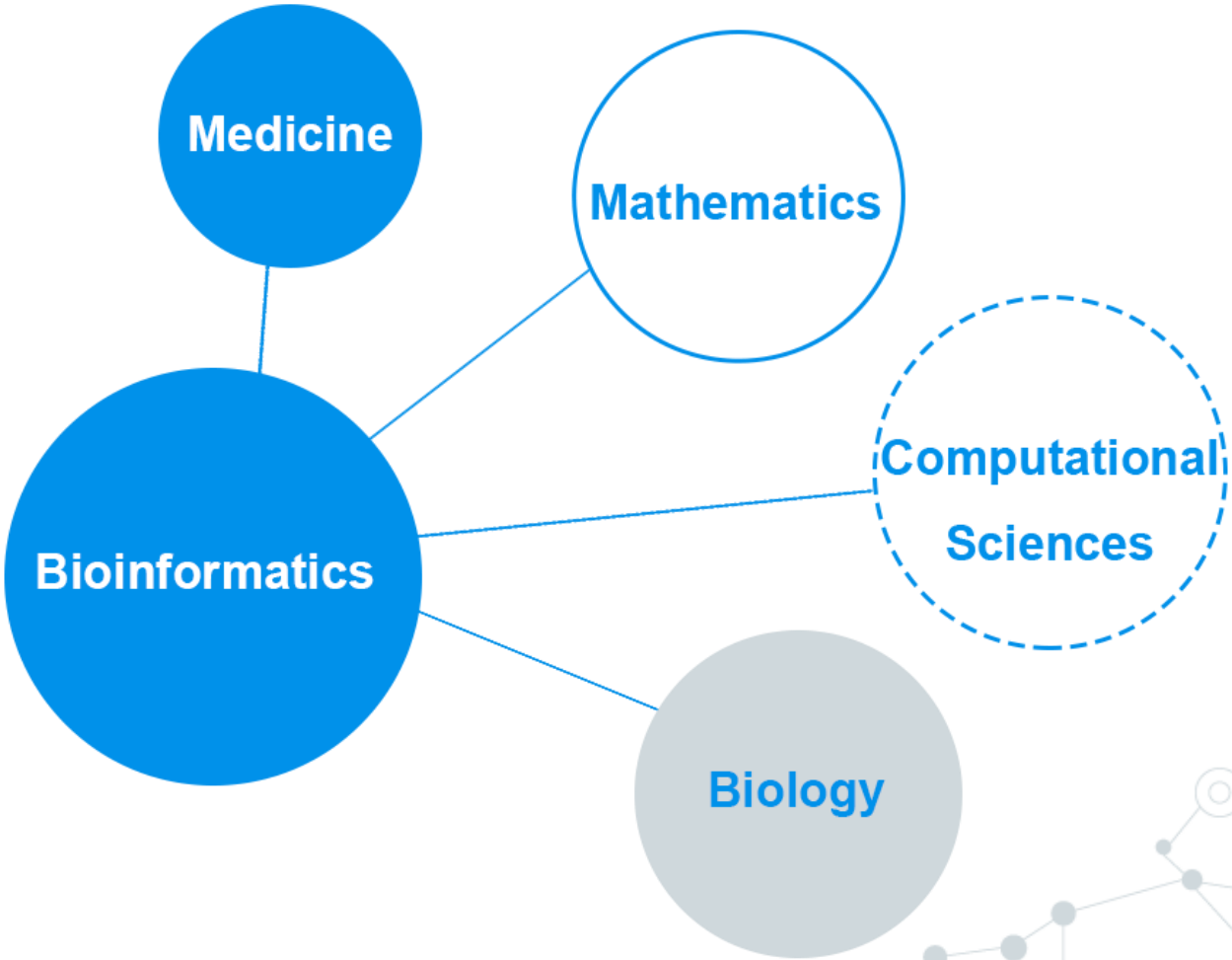
Era called “The Big Data”: Larger amounts of information released per year.

Bioinformatics begins to play an important role in life sciences.

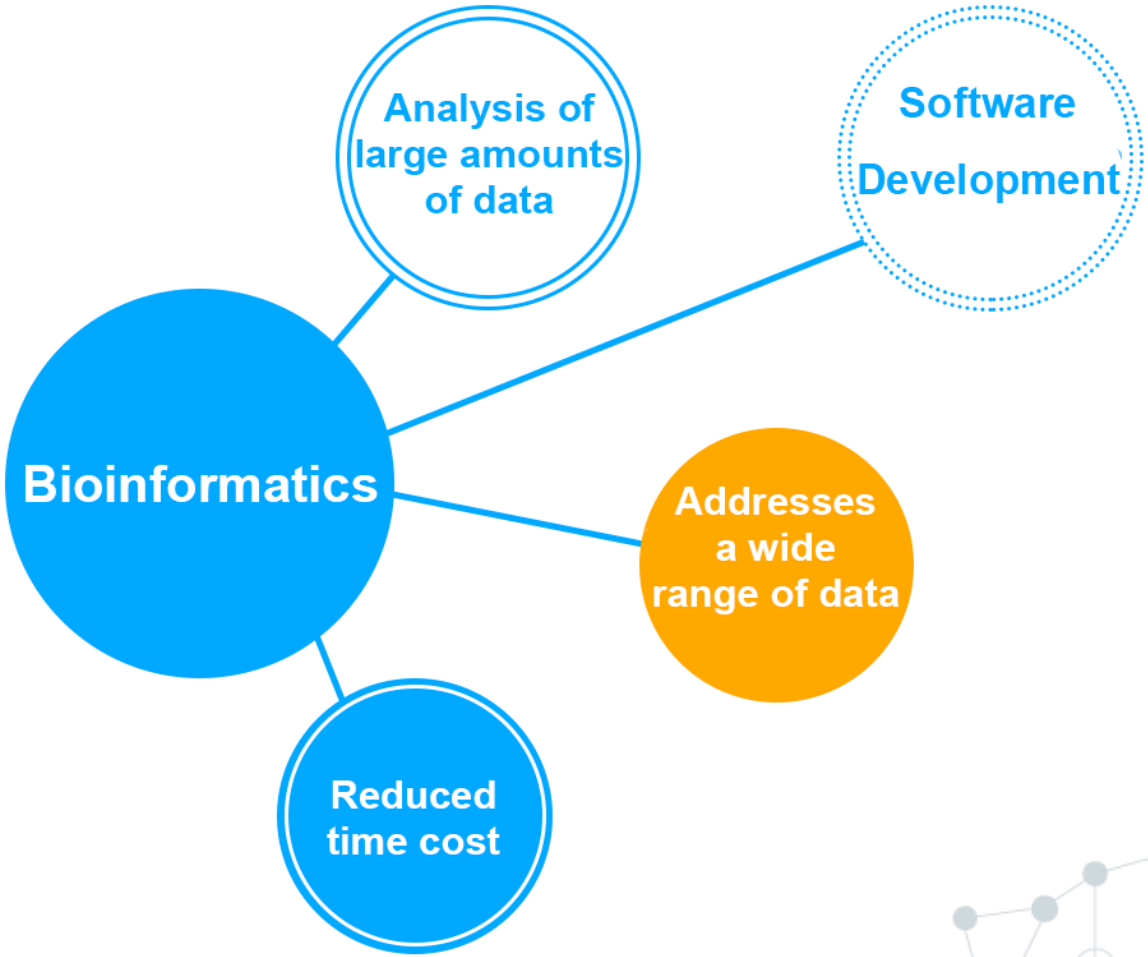
A Brief Introduction about Bioinformatics

Bioinformatics is a interdisciplinary field.

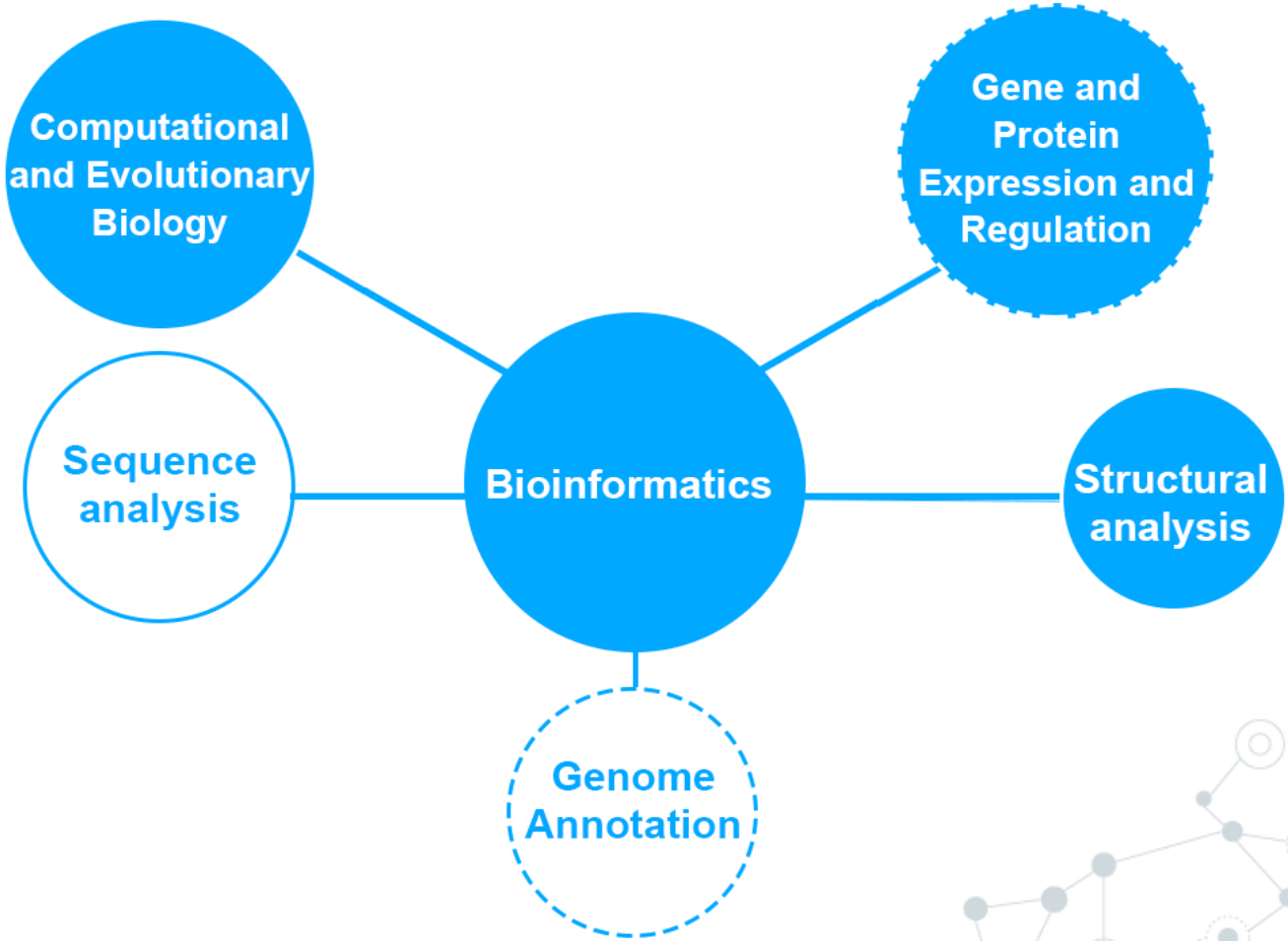
A Brief Introduction about Bioinformatics



A Brief Introduction about Bioinformatics



A Brief Introduction about Bioinformatics



Biology as an Informational Science

This scenario is moving biology to a new perspective, setting it as an ***informational science.***

As a result, technologies from other fields are being used to analyze biological data.

Biology as an
Informational Science

Interdisciplinary approaches facilitate the understanding of complex issues

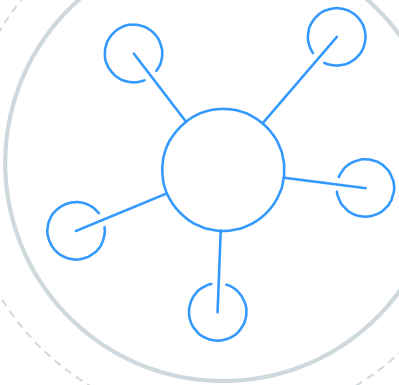
The concept of Interdisciplinarity

The focus on domain-specified knowledge is being surpassed by the development of cross-boundary skills (Spelt et al., 2009) (Newell, 2007).

For this reason, education's interest on the matter increased over the past years

E. J. H. Spelt et al. "Teaching and Learning in Interdisciplinary Higher Education: A Systematic Review", Educational Psychology Review, 2009, pp. 365378.
W. H. Newell, "Decision making in interdisciplinary studies", in G. Morçöl (Ed.), Handbook of decision making, New York: CRC, 2007.

The Concept of Interdisciplinarity



According to Aboelela (2007):
"Integration of two or more scientific disciplines to solve a specific problem."

S. W. Aboelela et al. "Defining Interdisciplinary Research: Conclusions from a Critical Review of the Literature", Health Services Research, 2007, pp. 329-346.

The constant advances in science amplify the amount of information available.

A challenge to the students

There is a need of building a connection between the scientific information and the student.

Didactic Transposition

- Michel Verret (1975) and revisited by Yves Chevallard (1985).

- Involves the pathway where knowledge is taken from scientific research to the school.

- Transition made possible by the educators.

Didactic Transposition

- Scientific information is widely available to public access.

- However, technical concepts and theories are not easily understood by lay people.

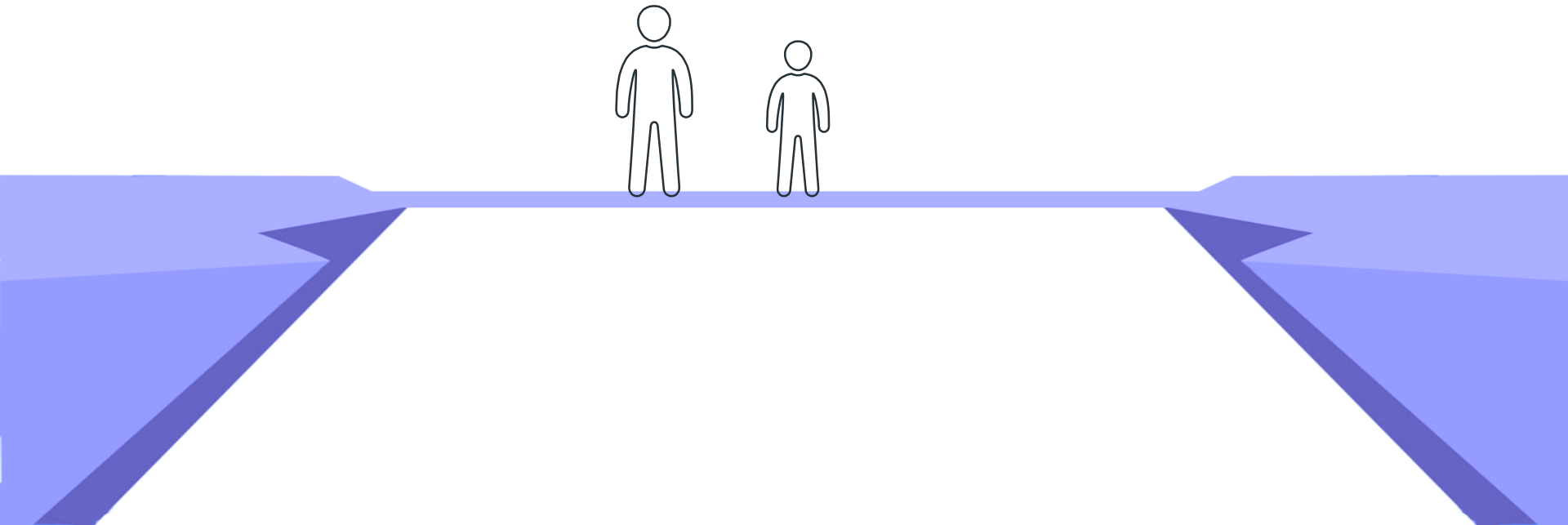
- A student may find difficulties in comprehending certain ideas, therefore being unable to interpret an article content.

Didactic Transposition

There is a gap between the student and science.

Didactic Transposition

An educator can aid in the building of this bridge connecting science and students.



The required effort from a teacher in order to refine scientific information is big, however, ***rewarding*** *.*

Didactic Transposition

When presenting a scientific idea to a classroom, the educator must be prepared to:

- Properly understand the subject.

- Swap scientific terms into more accessible ones to students.

- Organize, sustain and explain the main concepts approached through a more simplified and enlightening text, presentation or practical activity.

- Clarify any doubts that may emerge among the students.

Didactic Transposition

- Both ideas offer approaches that organize the scientific content.
- More accessible language.
- The student is encouraged to investigate and comprehend more challenging issues.
- It facilitates the development of critical thinking.

Topics with a wide array of concepts depends on ***how well organized*** *the main idea is.*

Didactic Transposition and Bioinformatics approaches on Education

- The interdisciplinary methods of Bioinformatics have a direct relation with life sciences.

- Bioinformatics can be introduced as a tool to assist in the teaching of certain areas of biology.

Didactic Transposition and Bioinformatics approaches on Education

- The complexity of certain issues in science may pose some difficulties for students to learn them.

- For example: Genetics

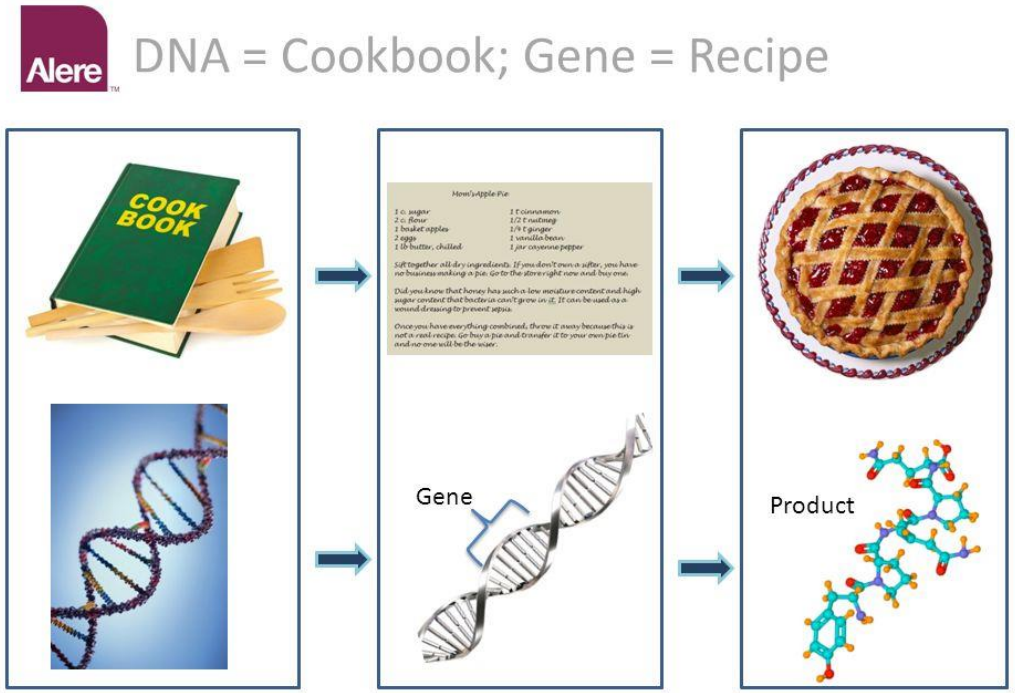
Didactic Transposition and Bioinformatics approaches on Education

◎ According to Banet and Ayuso (2000), there are misconceptions of what a gene and DNA mean:

1. Genes having a completely diferent function and location compared to the DNA
2. Learning by metaphorical models of the gene concept (Gene as a recipe).

Didactic Transposition and Bioinformatics approaches on Education

- These models often are thinking of the gene as a particle with certain effects related to it and as a sequence of instructions.



Didactic Transposition and Bioinformatics approaches on Education

- From the standpoint of didactic transposition:

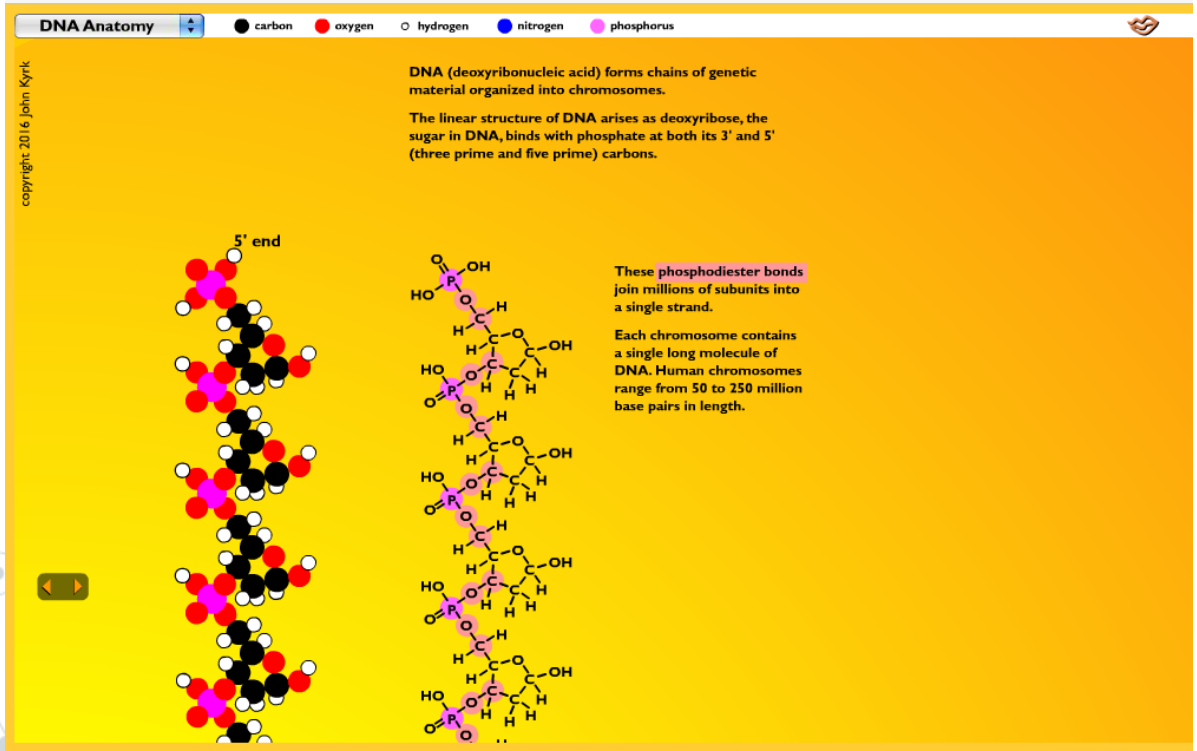
Simulations of Bioinformatics researches can be applied in order to improve the student's comprehension about genetics.

Projects related to proteins, DNA and RNA issues.

Didactic Transposition and Bioinformatics approaches on Education

- This can be achieved by videos, softwares and associated tools:

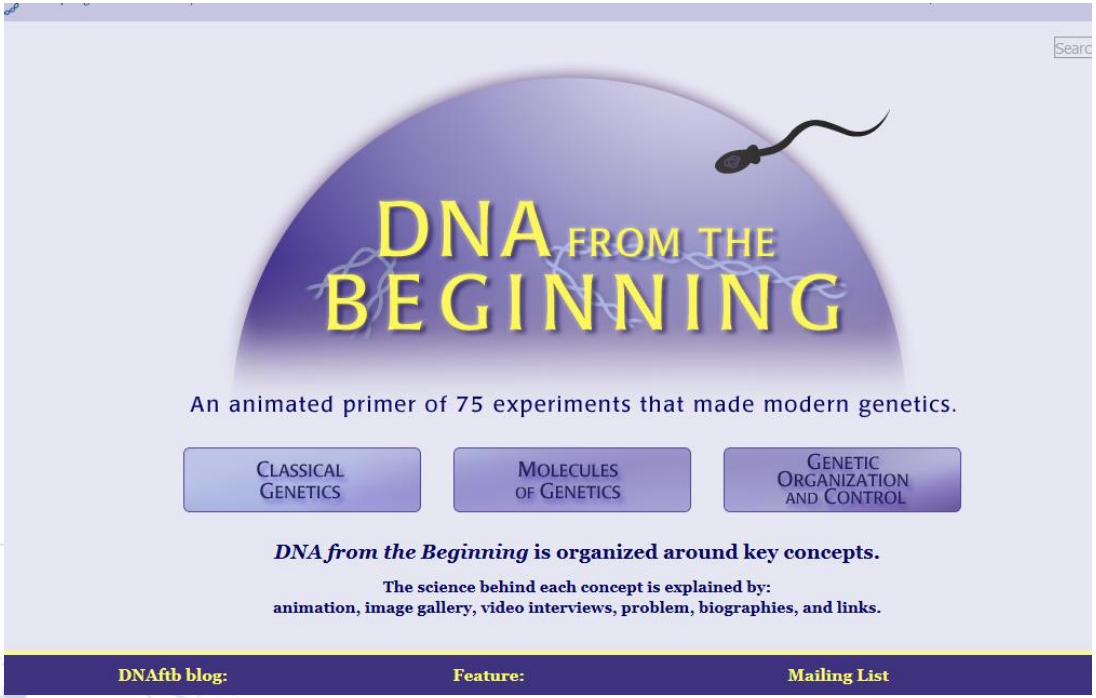
John Kyrk Cell Biology Animations



Didactic Transposition and Bioinformatics approaches on Education

- This can be achieved by videos, softwares and associated tools:

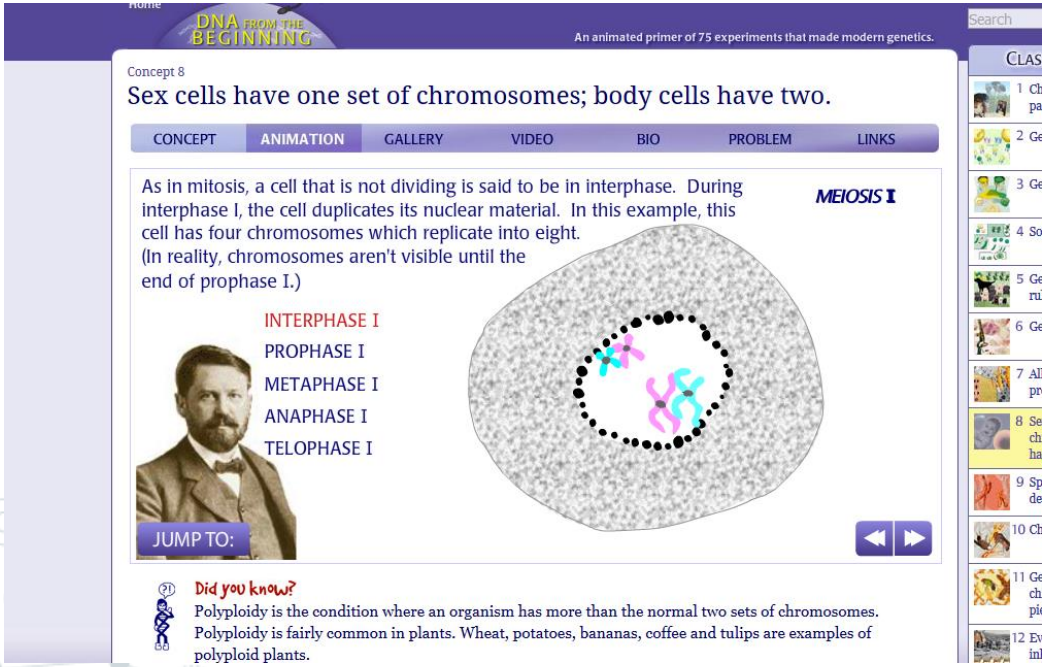
DNA from the Beginning



Didactic Transposition and Bioinformatics approaches on Education

- This can be achieved by videos, softwares and associated tools:

DNA from the Beginning



A clear visualization on topics that are harder to conceive allows a better comprehension of them.

Providing the key elements to link those concepts with other important topics (i.e., the link between genetic material and cell division)

Leroy Hood *(2013) writes a metaphor about a group of blind men coming across an elephant.*

Each one of them touches a different part of the animal and describes it.

Even though their guesses miss from the right answer, they make sense from their individual point of view.

However, a collaboration and integrated study would likely turn out to reveal the truth.

Conclusion

The metaphor was applied by the author on the complexity of biological systems, but can also be applied on life sciences education.

The correlation of bioinformatics, interdisciplinary concepts and didactic transposition result in new perspectives on how to address disciplines with a high level of complexity.

Conclusion

The main objectives from such an approach cover both external and internal concepts of a student, as it encourages:

- The development of critical thinking.
- Improved relationships between the student and the educator.
- Investigation of scientific topics.
- Better understanding of complex disciplines.

A well-versed student can approach scientific information without the fear of not understanding it.

The improvements on life sciences education assist the student on both school environment and personal life.

References

- G. Stoesser et al. “The EMBL Nucleotide Sequence Database”, Nucleic Acids Research, Oxford University Press, 2002, pp. 21-26
- E. J. H. Spelt et al. “Teaching and Learning in Interdisciplinary Higher Education: A Systematic Review”, Educational Psychology Review, 2009, pp. 365378.
- W. H. Newell, “Decision making in interdisciplinary studies”, in G. Morçöl (Ed.), Handbook of decision making, New York: CRC, 2007
- S. W. Aboelela et al. “Defining Interdisciplinary Research: Conclusions from a Critical Review of the Literature”, Health Serv Res Health Services Research, 2007, pp. 329-346.
- W. Callebaut, “Studies in History and Philosophy of Biological and Biomedical Sciences”, Studies in History and Philosophy of Biological and Biomedical Sciences, 2012, pp. 69-80.
- L. Hood, “Systems Biology and P4 Medicine: Past, Present, and Future”, Rambam Maimonides Medical Journal, 2013, pp. 1-15.
- M. Verret, “Le Temps Des Études”, Lille: Atelier Reproduction Des Thèses, Université De Lille III, 1975.
- Y. Chevallard, “La Transposition Didactique: Du Savoir Savant au Savoir Enseigne”, Grenoble: La pensee Sauvage, 1985.
- E. Banet, E. Ayuso. “Teaching genetics at secondary school: a strategy for teaching about the location of inheritance information”. Science Education. 2000, pp. 313. [
- N. M. Gericke, M. Hagberg. “Definition of historical models of gene function and their relation to students' understanding of genetics”. Science Education, 2006, pp. 849-881
- C. Wilson and S; Doniach, “A computer model to dynamically simulate protein folding: Studies with crambin”, Proteins: Structure, Function and Genetics Proteins, 1989, pp. 193-209.
- John Kyrk, “Cell Biology Animations” http://www.johnkyrk.com. (Access date: 23 February 2016).
- Cold Spring Harbor Laboratory, “DNA from the Beginning”, http://www.dnaftb.org. (Access date: 23 February 2016).

Thanks!

Any questions?

You can find me at:
gdalba@ucs.br