



TEACHING IDEAS SHARED FROM SAILS TEACHER EDUCATION PROGRAMME

Biotechnology – Millions that can generate Billions?



This resource has been developed through the SAILS Teacher Education Programmes (2012-2015) but was not developed as a finalized SAILS Inquiry and Assessment Unit. These materials are shared to inspire further use of inquiry and assessment of inquiry skills in the science classroom.

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Institute of Education – University of Lisbon

Biotechnology – Millions that can generate Billions?¹

Summary	Role play debate on the <i>pros</i> and <i>cons</i> of the funding (by the government) of biotechnology research laboratories and commercial companies working in this area (developing new products)
Disciplinary areas Grade (target group)	Natural Sciences (Biology); Lower Secondary
Goals	<p>To interpret and understand scientific laws and models;</p> <p>To recognize science and technology limitations' solving personal, social and environmental problems;</p> <p>To use information sources (books, the internet, papers,...) autonomously - locating, organizing and treating information.</p> <p>To analyze and discuss reports of scientific findings, confronting scientific explanations with common sense.</p> <p>To observe and interpret data presented in different forms.</p> <p>To use scientific language through the interpretation of diverse sources of information;</p> <p>To express power of analysis and synthesis;</p> <p>To draw conclusions, communicating them in oral and written form using a variety of means;</p> <p>To reveal curiosity, perseverance and integrity at work, while respecting and questioning the results obtained;</p> <p>To reveal assertiveness defending their own conclusions on the subject matter.</p> <p>To recognize the contribution of the development of scientific knowledge in the field of Genetics;</p> <p>To mention some consequences of the manipulation of genetic material;</p> <p>To understand that there are ethical restrictions on scientific research;</p> <p>To reveal a responsible attitude and criticism of the arguments that support the discussions on the use of cloning and genetic engineering processes applied to humans and the environment.</p>
Estimated time (number of lessons)	6 lessons of 50min.

¹ This activity was set up under the 1st SAILS Portuguese workshop for teachers: "Why is there so much talk about INQUIRY across Europe? A proposal to work with the science curriculum in the classroom" (May 2013). It was proposed by Ana Vicêncio and adapt to the SAILS unit structure.

Resources	Worksheet; Natural sciences textbook; Informatics tool's (computer and internet connection); Encyclopaedia and other relevant information sources.
Involved Institutions	Schools

Content

Mendelian Inheritance (Mendel's Laws); genetics; recombinant DNA and genetic techniques; genetically modified organisms; assisted human reproduction.

Inquiry skills

- Searching and selecting information sources
- Gathering and synthesizing information and data
- Elaborating coherent arguments - construct arguments and defend conclusions
- Communication skills

Suggested Learning Sequence

<i>Engage</i>	<p>Teacher:</p> <ul style="list-style-type: none"> - Distributes the worksheet with the newspaper article "<i>Portugal 'propitious' to the development of biotechnology</i>" (DN, 2009). - Presents the scenario - Presents the activity and incentivizes each student to take a role. <p>Students:</p> <ul style="list-style-type: none"> - Read the newspaper article; - Briefly discuss the newspaper article; - Engage in the activity by helping setting up the scenario and taking a role;
<i>Explore</i>	<p>Teacher:</p> <p>Helps evaluating the information sources presented by students; Poses challenging questions about students under construction arguments;</p> <p>Students:</p> <p>Search and select information according to their role; Prepare argumentative texts (key arguments and supporting evidence) on their position towards government funding of Biotechnology research and development (Worksheet).</p>
<i>Explain</i>	<p>Teacher and students:</p> <p>Role-play debate moderated by the teacher. Class discussion followed by a synthesis of the key arguments discussed over the debate is elaborated on the white board.</p> <p>Students:</p> <p>Final critical analysis on the debate and the subject matter underlying it (Worksheet).</p>

<p><i>Elaborate/ Extend</i></p>	<p>Teacher and students:</p> <ul style="list-style-type: none"> - Dividing the class into 2 groups: writing an article for the school's newspaper (or online page) on the theme of Biotechnology (presentation and characterization of the theme and main conclusions). A group should look into the positive aspects and the other on the less positive aspects of Biotechnology. <p>Going further ...</p> <p>In groups, students may discuss what they learned from the activity and whether and how they would like to deepen their knowledge. For example:</p> <ul style="list-style-type: none"> - Organize a seminar with invited experts, open to the school community, about biotechnology; - Organize an exhibition at school on the subject (with everyday products and short presentations on the role of biotechnology in their development and improvement, for example ...); - School field trips to companies / laboratories / Institutions of Higher Education; ... <p>After the drafting of proposals for future activities the group presents their proposal to the class and the class defines the activities and strategies to new tasks.</p>
<p><i>Evaluate</i></p>	<p>Engage and Explore lessons: Observation of behavior and attitudes (checklist grid) Oral feedback on students' work</p> <p>Explain and Extend lessons: Argumentative text and critical analysis (rubric*) Written feedback on students' work Observation of behavior and attitudes (checklist grid)</p>

Rubric

Searching and selecting information sources:

Needs work	Competent	Excellent
<p>The student does not identify what information is important to search.</p>	<p>The student identifies the information that is relevant to search but cannot analyze it or distinguish between essential and secondary elements.</p>	<p>The student mobilizes his/her knowledge and skills and critical thinking: judging the relevance of the information and selecting it according to its relevance.</p>

Synthesizing and analyzing gathered information:

<i>Needs work</i>	<i>Competent</i>	<i>Excellent</i>
The student does not correctly resume information from different sources or does not correctly transfer gathered information into his/her key arguments.	The student correctly resumes information from different sources but fails to elaborate strong and evidence based arguments.	The student resumes correctly resumes information from different sources, constructing strong key arguments based on evidence and knowledge.

Communication skills:

<i>Needs work</i>	<i>Competent</i>	<i>Excellent</i>
The student does not provide and / or does not explain the arguments in his/her own words (construction) ; key arguments aren't properly develop .	The student presents and explains his/her arguments, explaining the key arguments but not completely.	The student presents and explains his/her arguments in his/her own words (construction), properly developing the key arguments.

Diário de Notícias

(Daily News – Lisbon)

2009/10/19

Portugal “propitious” the development of biotechnology

Portugal is one of the European countries with biotech companies in operation for longer, which reflects a "more propitious" environment for development industries in this sector, according to a study of the association EuropaBio.

This is one of the conclusions of the study to be released today at the IV National Meeting of Biotechnology Companies that join entrepreneurs, investors and academics to discuss "strategies for the future" and that takes into account the fact that Portugal is one of the European countries that has invested more in this area.

"The BIOMEET 2009 comes at a time of high dynamic and fast development in this sector in national and international terms," said the Portuguese Association for Bio-industries (APBio), responsible for organizing the meeting. According to a study for EuropaBio by *Critical* - "Biotechnology in Europe: 2006 Comparative Study", Portugal, Finland, Hungary, Ireland, Switzerland and the UK are the European countries with biotech companies with greater seniority, which shows a more favorable environment to the development of this sector.

The event will include a space for the presentation of Portuguese biotechnology companies and another to discuss access to funding.

Biotechnology is a set of advanced technologies that enables the discovery and use of the secrets of life from genes to the complex workings of the human body, through the study and use of microorganisms in industrial processes as replacements for chemical reactions. This area has application in the fields of health, agriculture, chemical and food industry and environmental protection.

Lusa

For more details consult:

http://www.dn.pt/inicio/ciencia/interior.aspx?content_id=1395088

The scientific and technological development brings advantages but also severe problems and serious dilemmas. Given the current economic scenario, the Portuguese Government has decided to hear from all citizens in order to develop the next State Budget, in particular, the funding of research projects and business in the field of Biotechnology. In order to improve the knowledge of the population of your school community and clarify some questions you and your classmates must organized a debate (open to the community), in the school auditorium, to which you must invite experts from various areas affected by the distribution of the funds in the State Budget for the area of Biotechnology ...

TERMS AND CONCEPTS:

<ul style="list-style-type: none"> ▪ <i>Mendelian Inheritance Laws</i> ▪ Gene ▪ Genetics ▪ Chromosome ▪ Karyotype 	<ul style="list-style-type: none"> ▪ Genetic Engineering ▪ GMOs ▪ Biotechnology ▪ Recombinant DNA and genetic techniques ▪ Assisted Human Reproduction ▪ Bioethics
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CHARACTERS:

Distinctly in FAVOUR	Distinctly AGAINST	Enrichment of the debate
<ul style="list-style-type: none"> • Researcher in human genetics; • Geneticist - Director of a Clinic of Assisted Reproduction internationally renowned; • Researcher of a pharmaceutical biotechnology industry; • Researcher in the field of Biotechnology - GMOs in the food industry - animals and plants; • Entrepreneur of the Agricultural Area; • Researcher in the field of Biotechnology / improvement of industrial production processes and pollution abatement • Representative of Criminal Investigation - Police. 	<ul style="list-style-type: none"> • Member of NGO (Non-Governmental Organization) against cloning and the use of embryos in scientific research; • Clinic Board Director - Specialist in Alternative Medicines; • President of the Consumers Association; • Farmer – Organic Farming; • Medical Doctor Specialist in Human Reproduction; • Human Rights Activist / Animal Rights / Against Globalization and Capitalism • University Professor - Area of Sustainable Development and demographics 	<ul style="list-style-type: none"> • Jurist - Law Specialist in Life Sciences; • Humanist philosopher; • Biologist (Representative of Association of Biologists);

Note: Each character should present arguments (for or against) consistent with his/her. You should also know some of the arguments of your closest opponents so you can counter them assertively.

✓ **SUGGESTIONS OF INFORMATION SOURCES:**

WWW:

- ✓ **Bionetonline** – To better understand the Life Sciences and discuss controversial issues. [*online*].
<http://www.bionetonline.org/portugues/default.htm> [Junho, 2013].
- ✓ **CientIC**– Genetic Heritage [*online*]. <http://www.cientic.com/portal/> [June, 2013].
Entrance> Topic: Biology> Genetics and Inheritance> Genetic Heritage
- ✓ **Disclosure of Biotechnology** (Blog). [*online*]. <http://cibpt.wordpress.com/> [June, 2013].
- ✓ **Projecto “O Genoma Humano” – Ciência Viva** – Support materials. [*online*].
<http://www.cienciaviva.pt/projectos/genoma2003/materiais.asp> [June, 2013].
- ✓ **Hereditariedade e Clonagem**. *Institute of Biosciences, University of S. Paulo - Readings and Texts* . [*online*].
<http://www.ib.usp.br/textos/> [June, 2013].
- ✓ **Organismos Geneticamente Modificados – Glossário EUROPA** - [*online*]
http://europa.eu/scadplus/glossary/genetically_modified_organisms_pt.htm
 . [June, 2013].
- ✓ **OGM e Engenharia Genética das Plantas** [*online*]. <http://plantasgm.wordpress.com/> . [June, 2013].
- ✓ **Ordem dos Biólogos (Portugal). Biotecnologia?** [*online*].
<http://www.ordembilogos.pt/Arquivo/Pedro%20Fevereiro1.html> e
<http://www.ordembilogos.pt/Arquivo/Pedro%20Fevereiro2.html> [June, 2013].
- ✓ **Pareceres do Conselho Nacional de Ética para as Ciências da Vida**.. [*online*].
<http://www.cneqv.pt/pareceres.php> [June, 2013].
- ✓ **Instituto de Bioética, UCP**. [*online*]. - <http://www.bioetica.porto.ucp.pt/> [June, 2013].
- ✓ **Carvalho, Margarida G.** – Artigos [*online*]. -
<http://www.apagina.pt/?aba=7&user=Margarida%20Gama%20Carvalho&mid=2> [June, 2013].

Book:

Douzou, P. (1997). *A Saga dos Genes Contada aos Jovens*. Coleção Livros Didáticos para Crianças e Jovens. Terramar.

Film:

Gattaca, directed by Andrew Niacol. [*Vide:*

<http://www.cienciaviva.pt/projectos/genoma2003/filme.pdf>

1. Preparation:

1.1 References, information sources (books, articles, WWW pages, ...) examined (must select between 3-5 documents that you have analyzed to build your argument):

1.2 Synthesis (resume) of gathered information:

1.3 Key arguments:

2. **Write your argument** (you should refer to evidence, graphs, studies or authors [scientists] that reflects the position of your role).

3. **Final critical review** (to do at the end of the role play debate)

4. Self-assessment and peer assessment:

4.1 How do you assess your performance (debate preparation, posture during the debate - assertiveness and conclusions):

4.2 How do you assess the way the debate took place (quality of discussion and arguments presented and the performance of your classmates)?

4.3 Which classmate(s) would you like to highlight for his (her) efforts?

[Assessment opportunities](#)

- Searching and selecting information sources;
- Gathering and synthesizing information and data;
- Elaborating coherent arguments - construct arguments and defend conclusions;
- Communication skills;

- Interpreting data and scientific evidence;
- Debating with others/Assertiveness.

Guidelines for the construction and application of an instrument for formative assessment²

Purpose: It is intended with this task that students learn the scientific contents provided in the respective planning and develop Inquiry skills. This task allows students to develop several Inquiry skills; however, for data collection about the assessment process it will be focus on Searching and selecting information sources; Gathering and synthesizing information and data; and Communication skills.

Teacher actions

1. Before class
 - a. Build an assessment instrument considering that the main focus will be in Searching and selecting information sources; Gathering and synthesizing information and data; and Communication skills;
 - b. Adapt the task to students and to the context.
2. In class
 - a. At the beginning of the process clarify the assessment criteria (in particular those relating to Searching and selecting information sources; Gathering and synthesizing information and data; and Communication skills).
 - b. At the end of the process, apply a semantic differential to students for identification of their perceptions related to the assessment process.
3. After class
 - a. Assess students ' productions having regard to the developed instrument and produce a written feedback;
 - b. Reflect on the assessment process.

Transfer

Going further ...

In groups, students may discuss what they learned from the activity and whether and how they would like to deepen their knowledge. For example:

- Organize a seminar with invited experts, open to the school community, about biotechnology;
- Organize an exhibition at school on the subject (with everyday products and short

² According to the performance criteria for inquiry skills provided by the ILIT project – Between tide marks: Integrating literacy's - [PTDC/CPE-CED/117923/2010] - Principal Investigator: Cláudia Faria (IEUL) - Duration: 3 years (February 2012 to January 2015).

presentations on the role of biotechnology in their development and improvement, for example ...);

- School field trips to companies / laboratories / Institutions of Higher Education; ...

After the drafting of proposals for future activities the group presents their proposal to the class and the class defines the activities and strategies to new tasks.

Teacher and students:

- Dividing the class into 2 groups: writing an article for the school's newspaper (or online page) on the theme of Biotechnology (presentation and characterization of the theme and main conclusions). A group should look into the positive aspects and the other on the less positive aspects of Biotechnology.

SAILS Case Study

Topic:	“Biotechnology – Millions that can generate billions?”
Inquiry skills, reasoning skills, and scientific literacy:	Searching and selecting information sources; Gathering and synthesizing information and data; Communication skills
Student group:	89 students (3 classes) – Lower secondary

(i) How was the learning sequence adapted?

The activity was set up under the 1st SAILS Portuguese workshop for teachers: “*Why is there so much talk about INQUIRY across Europe? A proposal to work with the science curriculum in the classroom*” on May 2013 and implemented this school year (2013-14) with lower secondary students. It culminated in a role-play debate about Biotechnology and government funding. Before engaging students in the activity, and since it was the first time they were invited to work within an *Inquiry* methodology, it was necessary to create a *worksheet* that could set some “guidelines” for students work and provide some *assessment evidences* for the teacher in order to allow follow up and supporting students through the task. Therefore, the *worksheet* contained a newspaper article and presented the scenario that introduced the role-play debate. A list of all the fifteen roles was provided in the same *worksheet* so that students could know their opponents as well as the roles that could assist them on the debate. A set of references about biotechnology (websites, books and documentaries) was supplied as well as the assessment criteria. The *worksheet* was organized in four steps: engaging in the activity (newspaper article and scenario), preparing the argumentation, the role-play debate and a final critical analysis on the main arguments stated at the debate. In order to prepare their arguments, students had to fulfill the *worksheet* with three to five references that they considered to be the most useful for their argumentation, a resume of the most important information and data they had gathered, three to five key arguments elaborated from the information and data they’ve presented, and finally, an argumentative text (*essay*) asserting their position on the role-play debate.

(ii) How were the skills assessed?

The elements of inquiry that this activity assessed were: Searching for information, Debating with peers and Forming coherent arguments. The rubric that was discussed with students at the first lesson on the unit and that was applied in order to grade students’ work (summative assessment) presented the following criteria:

- Search, selection and analysis of information;
- Synthesize information;
- Organization of argumentation and linguistic and syntactic accuracy;
- Scientific content;
- Assertiveness;
- Final critical appreciation (Self and peer assessment)

For each criterion were described three performance levels (3 - “excellent”, 2 - “competent” and 1 - “needs work”).

(iii) Evidence Collected:

Teacher opinion:

Assessment took place throughout the activity but only on the lesson when the role-play debate was held, students wrote their critical analysis and delivered the *worksheet* so that it could be graded.

Using the rubric was not very hard, most of student’s answers fall into one of the performance levels considered for each assessment criterion, especially concerning to searching and selecting information sources or synthesizing and analyzing gathered information.

However applying the performance levels on the argumentative text, considering strength, clearness and organization of the arguments, was more difficult. Often the structure of the argumentative text produced by the student didn’t fall in any of the three performance levels considered. I came to believe that is very difficult to create effective rubrics for hard competences.

Applying criteria assessment on an oral interaction (the role play debate) was also very difficult: fifteen students presented their main arguments and engaged in a debate with their peers discussing and responding to each other’s arguments. Regulation by the teacher was required so, at that time, one must be able to moderate the debate and assess individual student’s interventions.

As a teacher I can only state that implementing this activity made me feel like being the supporting actor and the director at the same time. Assessment can work as the script that allows and predicts free acting but also helps keeping the correct storyboard.

Sample student artefacts:

Evidences (Student A/Role: Farmer (livestock)– Information sources):

1.1 Referências bibliográficas, fontes de informação (livros, artigos, páginas da WWW, ...) pesquisadas (deves selecionar entre 3 a 5 documentos a que recorrerás para recolher e construir a tua argumentação):

www.ordenambiotecnologia.pt/Arquivo/PubroFocarcino1.html
www.biotechonline.org
www.cpac.embrapa.br/publico/usuarios/ uploads / curso biotec 2 / folder / programacao 2 .pdf
Enciclopédia Larousse da editora Circulo de Letras
Bioferra emitido na RTP1 dia 25 de dezembro das 6H 01 Min às 6H 30 Min
Bioferra emitido na RTP2 dia 25 de dezembro das 12H 42 Min às 13H 12 Min



*Sites from reliable institutions;
Encyclopedia;
National TV Educational
Resources.*

1
1.2 Síntese (resumo) da informação recolhida:

A Biotecnologia é a "tecnologia ao serviço da investigação na área da biologia". A finalidade da biotecnologia é a produção de bens e serviços através de tecnologias avançadas que também permitem a descoberta, utilização e modificação das propriedades hereditárias dos organismos vivos, de modo a torná-los mais interessantes para a indústria, agricultura e bem-estar do homem.
Transgênicos ou organismos geneticamente modificados (OGM) são organismos cujas características genéticas foram alteradas através da introdução de um ou mais genes modificados.
Todos os animais, seres humanos, plantas e bactérias contêm genes que determinam as suas características próprias.
Um clone é um ser vivo descendente apenas de um progenitor com as mesmas características genéticas; A clonagem pode ser reprodutiva ou terapêutica. A clonagem reprodutiva é um processo cuja finalidade é a criação de um indivíduo geneticamente igual ao seu progenitor. Já a clonagem terapêutica tem como objetivo a obtenção de tecidos ou órgãos para tratamento de doenças.
Hoje em dia, com o aumento da população mundial, torna-se necessário que haja uma produção de alimentos em larga escala, porém, existem alguns países que não são autossuficientes, ou seja, não produzem alimentos em quantidade suficiente para satisfazer as suas necessidades, sendo, por isso obrigados a recorrer à importação de alimentos.



Synthesis:
Presents general information and clarifies definitions on the basic concepts used in the argument – Biotechnology, GMO's, clone, cloning strategies, and food and global economy and sustainability.

Evidences (Student B/Role: Organic Farmer - Information sources):

1) of p 3mp .blogs .pt
 2) ec. europa. eu / orgculture / organic / eu - policies / bio . pt
 3) - stopogm. net
 4) - usia. supa. pt / usia / 134 / 13445 / Alimentos Bica - d 826da 7412 8209c9d0 e 3 c 76951 be 842 . pdf
 5) amnevas. supa . pt / agricultura . pdf.



References are not correctly identified and include blogs.

OGM é a sigla de organismos geneticamente modificados ou também conhecidos por transgênicos, estes são organismos que sofreram alterações em relação ao seu genoma genético, isto é, a través da tecnologia de pontar e a transferência de material genético, incluindo criação de transgênicos, num determinado organismo, que de outra forma, nunca poderia existir.
 Ou, como resultado biológico seu contro os OGM, bem como a outra natureza.
 A **biotecnologia** é uma ciência que trata da aplicação de organismos, células ou partes delas em processos ou sistemas industriais, por métodos de base científica.
 Um dos seus ramos é a aplicação em organismos ou células essencialmente microscópicas.
 Na microbiologia os organismos não possuem ser geneticamente alterados.



Synthesis:
 Provides general information on biotechnology and GMO's but doesn't explain the relations between this and his/her role (organic farmer). Doesn't explain what organic farming is.

Student's worksheet – Detail on the step considering the selected references and information resume. Student "A" references include National Biologists Organizations web page, Encyclopedias and Public Television Shows (specialized in science communication). Performance level – 3: Excellent. Student "B" references are not correctly identified and include blogs. Performance level – 1: Needs work.

(iv) Criteria for judging assessment data:

- Search, selection and analysis of information:

<i>Needs work</i>	<i>Competent</i>	<i>Excellent</i>
The student does not identify what information is important to search.	The student identifies the information that is relevant to search but can't analyze it or distinguish between essential and secondary elements.	The student mobilizes his/her knowledge and skills and critical thinking: judging the relevance of the information and selecting it according to its relevance.

- **Synthesizing and analyzing gathered information**

<i>Needs work</i>	<i>Competent</i>	<i>Excellent</i>
The student does not correctly resume information from different sources or does not correctly transfer gathered information into his/her key arguments.	The student correctly resumes information from different sources but fails to elaborate strong and evidence based arguments.	The student resumes correctly resumes information from different sources, constructing strong key arguments based on evidence and knowledge.

- **Communication skills**

<i>Needs work</i>	<i>Competent</i>	<i>Excellent</i>
The student does not provide and / or does not explain the arguments in his/her own words (construction); key arguments aren't properly developed.	The student presents and explains his/her arguments, explaining the key arguments but not completely.	The student presents and explains his/her arguments in his/her own words (construction), properly developing the key arguments.

- **Assertiveness/ Debating with peers:**

<i>Needs work</i>	<i>Competent</i>	<i>Excellent</i>
<p>The student does not show appropriation to the researched information.</p> <p>The student shows an inaudible speech, with monotonous and / or insecure, uninflected voice and expressiveness.</p>	<p>The students shows some appropriation of researched information and elaborates arguments, however is unable to justify / argue correctly.</p> <p>Audible speech during most of the presentation without inflections and / or expressiveness.</p>	<p>The student shows appropriation of content and deep knowledge of his/her arguments, justifying / arguing with ease.</p> <p>Audible speech throughout the presentation, good voice articulation.</p>