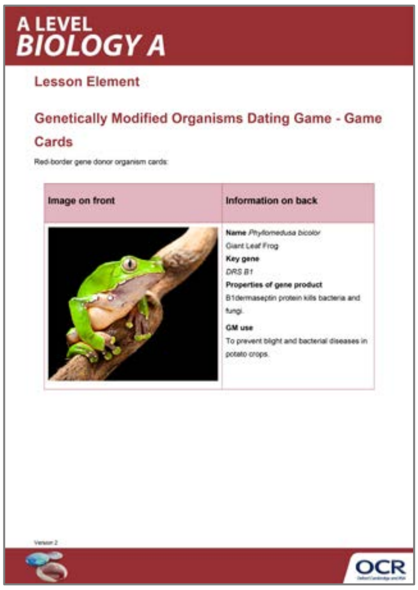
Lesson Element

Genetically Modified Organisms

Dating Game

Instructions and answers for teachers

These instructions should accompany the OCR resource* 'Genetically Modified Organisms Dating Game' *activity *which supports OCR A Level Biology A.*



A LEVEL
BIOLOGY A

Lesson Element

Genetically Modified Organisms Dating Game - Game Cards

Red-border gene donor organism cards:

Image on front	Information on back
	Name *Phyllomedusa bicolor* Giant Leaf Frog **Key gene** *DRS B1* **Properties of gene product** B1dermaseptin protein kills bacteria and fungi. **GM use** To prevent blight and bacterial diseases in potato crops.

Version 2

The Activity:

This resource comprises of 2 tasks.

This activity offers an opportunity for English skills development.

Associated materials:

Genetically Modified Organisms Dating Game' Lesson Element learner activity sheet and Dating Game Cards sheet.

Introduction

The goals of this activity are to:

- introduce students to a range of applications of genetic engineering
- stimulate discussion and decision-making on the positive benefits of GMOs
- stimulate discussion and decision-making on the negative risks of GMOs

The activity can be run in two ways or a combination of the two, such as a couple of rounds of Blind Date followed by a general Speed Date.

- Blind Date involves selected students taking turns playing the game in front of their peers. It takes longer but everyone hears all the interactions.
- Speed Date involves all students simultaneously interacting and will more quickly produce results for the worksheet.

The topic background is **Manipulating Genomes 6.1.3 (f) (g)** and **(h)**.

Prior knowledge: Students must have been taught the principle of extracting genes from one organism and placing them into another **(f) (i)** and ideally will also have studied the techniques involved in **(f) (ii)**. No previous knowledge of **(g)** or **(h)** is required so this activity could form the introduction to this learning outcome.

Common student misconceptions or difficulties with this topic include:

- not realising that genetic engineering, genetic modification and recombinant DNA technology describe the same technique, and that the organisms that result from the process may be alternatively described as transgenic or transformed organisms or genetically modified organisms (GMOs)
- confusing the gene donor organism and the recipient organism in a genetic engineering scenario
- not clearly distinguishing the gene transferred (DNA) from the gene product made (protein)
- seriously underestimating the benefits offered for agriculture, medicine and industry by GM technology
- overestimating the risks of GM technology and being unaware of how the risk evaluation has changed with widespread use of GMOs over the last 20 years
- not having the philosophical framework or language skills to make mark-worthy ethical judgements in exams.

A suggested follow-up activity to the GMOs Dating Game is the Lesson element 'Hoop Jump - Right or Wrong?' which develops skills in evaluating benefits and harm and forming ethical judgements.

Task Instructions

The 24 size game cards need to be printed out and ideally laminated. Each card has a picture of an organism on one side and selected information about that organism on the other side.

- The 12 cards bordered in RED describe how a selection of organisms may be used as sources of DNA (gene donors)
- The 12 cards bordered in BLUE detail organisms used as recipients of foreign DNA.

The games

Blind Date Game

1. The teacher plays the part of a television game show host and directs the game. The red and blue cards should be arranged in separate piles.
2. One volunteer student, the chooser, takes any card and sits in a chair at the front of the classroom.
3. Three volunteer students, the competitors, collect cards o**f the opposite colour to the chooser** and sit in a line opposite him or her.
4. All four players hold their cards up so that the picture sides are visible to the rest of the players and class. The players read the information on the back to be able to answer the game show host's and other players' questions.
5. The game show host asks the players to introduce themselves by name (and maybe by animal noise if applicable!). Students can enter into the spirit of a dating competition by claiming to be a 'playful jellyfish with a good sense of humour' or a 'cheeky little bacterium interested in good food and country walks' for instance.
6. The game show host invites the choosing player to ask the three competitors in turn what they have to offer. Each competitor tries to make a case for how they are a match for the chooser so that if paired up by genetic engineering they can create a more useful or valuable genetically modified organism.
7. The game show host summarises the main biological points from the three competitors before asking the chooser to pick their match. The class audience may get involved shouting out suitable pairings of gene donor and recipient organism.
8. The chooser and their selected competitor keep their cards and sit down together. The details of the match are recorded on worksheets individually and/or on a class computer and projected onto a screen. Unsuccessful competitors return their cards to the bottom of the pile of that colour and go back to their seats in the class.
9. Four new volunteers are picked for the next round. The role of the chooser and competitors should alternate, eg if in round 1 the chooser has a blue card and the three competitors have red cards then in round 2 the chooser takes a red card and the three competitors blue.

10. Either six rounds of blind Date are played, to obtain six genetic engineering scenarios for the worksheet, or after a couple of rounds the rest of the students can pair up using the quicker Speed Date rules below.

Speed Date Game

1. Half the class get red cards, half get blue. Those with blue cards sit down spaced out through the room. Those with red cards are invited to walk round the room and spend 30 seconds with the blue card holder finding out if the two forms a good match for genetic engineering. The teacher rings a bell at the end of each 30 second interval and instructs the red-card players to move on to the next seated blue player.
2. After every red player has met each blue player all players stand up and pair up with the match of their choice.
3. The teacher asks each pair in turn to explain who they are and what GMO they make together. Six pairs need to be formed so that the whole class can complete the worksheet with details of the donor and recipient and gene transferred in each case.

Both games: When six (or more) pairs have been formed and noted on the worksheet the students representing the matched organisms stand up in their pairs and hold up their picture cards.

- The whole class then collaborates in re-arranging the pairs into a line in order of the perceived benefit of each pairing. Discussion and disagreement are to be encouraged. The class order is recorded on the worksheet with 1 for most beneficial and 6 for least beneficial to society.
- The class is then told to rearrange the pairs again in order of perceived risk to human safety or to the environment. The class risk order is recorded on the worksheet with 1 for most risky to 6 for least risky. Risk can be defined as potential harm.

Additional Information for Teachers

The combinations of donors and recipients described on the playing cards are listed as an appendix. These GMOs have been developed and in many cases successfully commercialised. If students come up with novel pairings that are feasible, for example an herbicide resistant carrot, or a fluorescent goat, these could be allowed but students should note which GMOs have been produced in reality. The point that any organism's genes can be inserted into any other organism's genome, giving limitless possibilities in theory, could be made.

The Game Cards

Red-border gene donor organism cards:

Image on front	Information on back
	**Name** *Phyllomedusa bicolor* Giant Leaf Frog **Key gene** *DRS B1* **Properties of gene product** B1dermaseptin protein kills bacteria and fungi. **GM use** To prevent blight and bacterial diseases in potato crops.

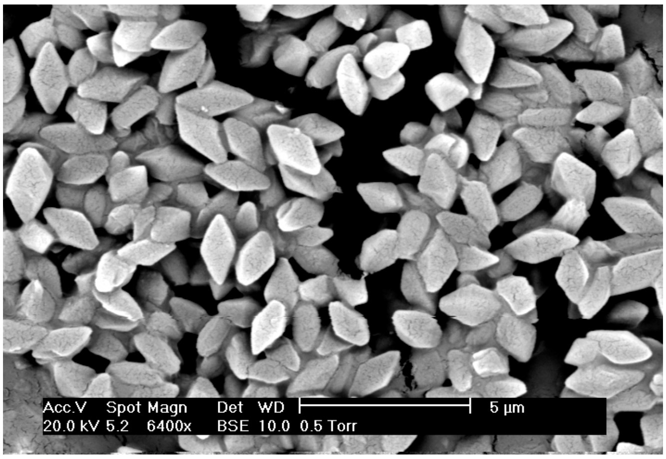
Image on front	Information on back
	**Name** *Bos primigenius* Cattle **Key gene** *Cym* **Properties of gene product** Chymosin is a protease enzyme that curdles milk. **GM use** GM bacteria produce the enzyme which is purified and used to make cheese. Previously chymosin was extracted from the stomachs of calves so cheese made in this way was not acceptable to vegetarians. 80-90% of the cheese sold in Britain is made with GM bovine chymosin.
	**Name** *Bacillus thuringensis* **Key gene** *Cry* **Properties of gene product** Crystal protein kills caterpillars, maggots and beetles that eat the protein. **GM use** To make crops such as maize, cotton and soya bean resistant to herbivorous insects.

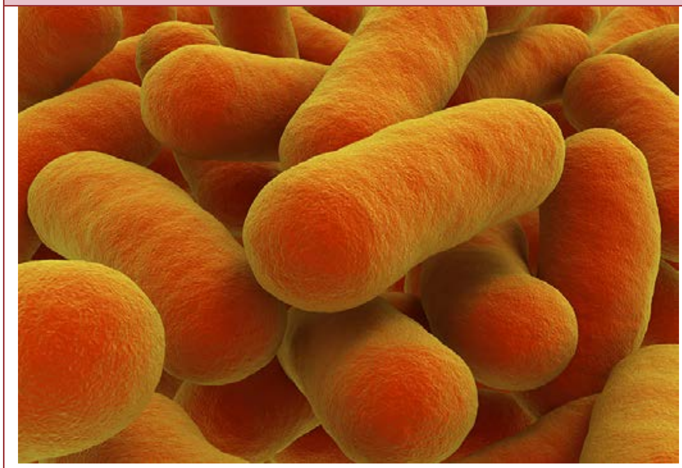
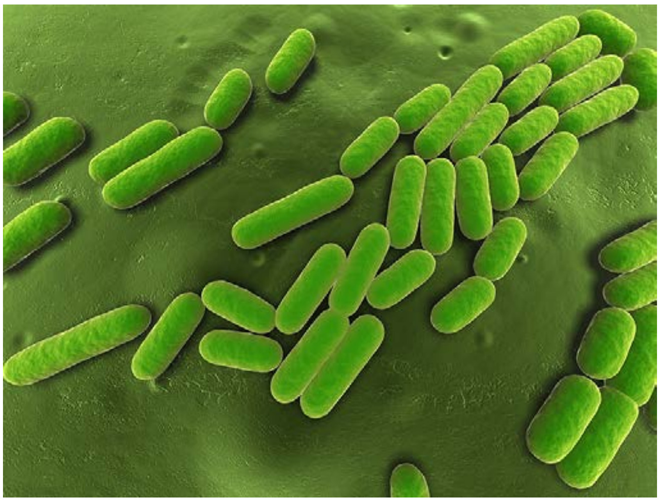
Image on front	Information on back
	**Name** *Agrobacterium sp* C4 strain **Key gene** *C4 EPSPS* **Properties of gene product** EPSP synthase performs a crucial metabolic step in plant chloroplasts. The bacterial version is undamaged by glyphosate. **GM use** To make crops resistant to glyphosate so it can be used as a weed killer without harming the maize, cotton or soya bean crops.
	**Name** *Bacillus subtilis* **Key gene** *cspB* **Properties of gene products** Cold shock protein B helps organisms metabolise normally during abiotic stress. **GM use** To make maize grow more and produce a higher yield under drought conditions.

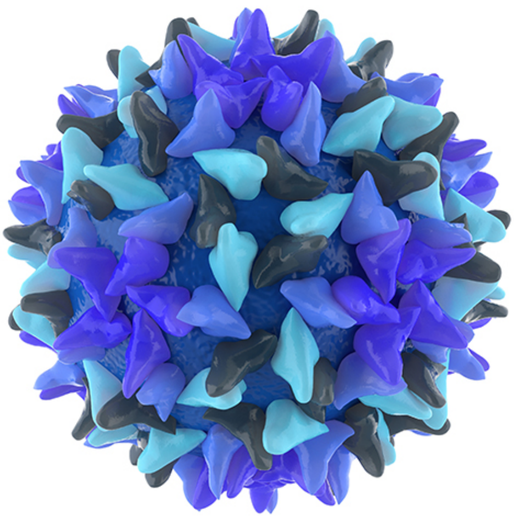
Image on front	Information on back
	**Name** *Nephila clavipes* Golden Orb Weaver **Key gene** *MaSp* **Properties of gene product** High-strength silk fibre for webs. **GM use** Gene is switched on in mammary glands of GM goats to mass-produce the silk fibre for artificial tendons and ligaments and for bullet-proof vests and parachutes.
	**Name** Hepatitis B virus **Key gene** *HBsAg* **Properties of gene product** Surface antigen of virus stimulates an immune response in humans if injected or given orally **GM use** GM potatoes eaten raw in small quantities boost immunity to hepatitis B. Cheap way of delivering vaccines in developing world.

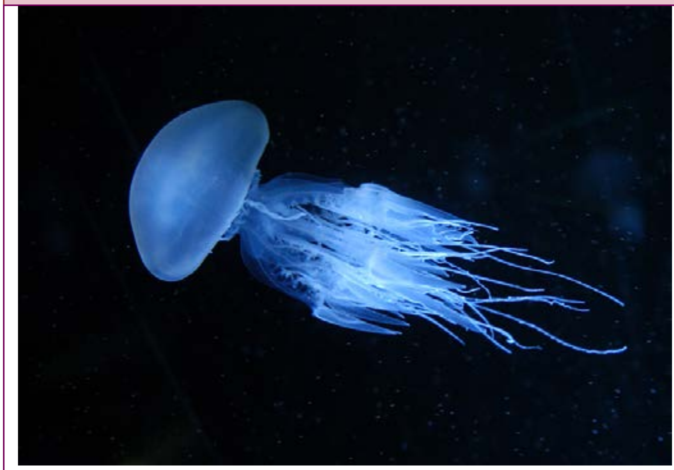
Image on front	Information on back
	**Name** *Aequorea Victoria* Jellyfish **Key genes** *GFP* **Properties of gene products** Green Fluorescent Protein glows under UV light. **GM use** The gene is extensively used as a marker to reveal which organisms have taken up a foreign gene and in which tissues the gene is switched on. Spin-offs include Glo-Fish™ and NeonMice sold as pets in the USA.
	**Name** *Homo sapiens* Human **Key genes** Mutated version of *BRCA1* and activated *Ras* oncogene **Properties of gene products** Cause cancer. The products of the normal versions of the genes repair DNA mutations and suppress tumours. **GM use** Creating cancer research models GM mice engineered to carry the mutant alleles are used to study cancer and treatments for cancer.

Image on front	Information on back
	**Name** *Homo sapiens* Human **Key genes** Normal alleles coding for insulin, lactoferrin, Factor IX, anti-thrombin III and glucosidase. **Properties of gene products** Insulin controls blood glucose concentration. Lactoferrin is an antimicrobial found in colostrum and milk. Factor IX helps blood clot. Anti-thrombin III stops blood clotting. Glucosidase in lysosome function **GM use** **Pharmaceutical drugs** Insulin from GM bacteria treats diabetics. Lactoferrin in GM rice treats diarrhoea in children. Factor IX from GM sheep's milk treats people with haemophilia B. Anti-thrombin III from GM goats' milk is used as an anti-coagulant in surgical procedures. Glucosidase from GM carrot cells in culture treats people with Gaucher's disease.

Image on front	Information on back
	**Name** *Homo sapiens* Human **Key genes** *CFTR* *RPE65* **Properties of gene products** *CFTR* protein allows normal mucus production in lungs and gut. *RPE65* protein is needed in rods and cones for normal vision. **GM use** *Gene therapy* Normal *CFTR* allele is introduced into lung epithelial cells of cystic fibrosis patients. *RPE65* inserted into retinal cells of blind patients with Leber's Congenital Amaurosis restored sight.
	Name Androctonus australis hector Scorpion Key genes AaHIT1 Properties of gene products Toxic to insects but not harmful to mammals. GM use To kill insects on GM cotton crops.

Blue-border recipient organism cards:

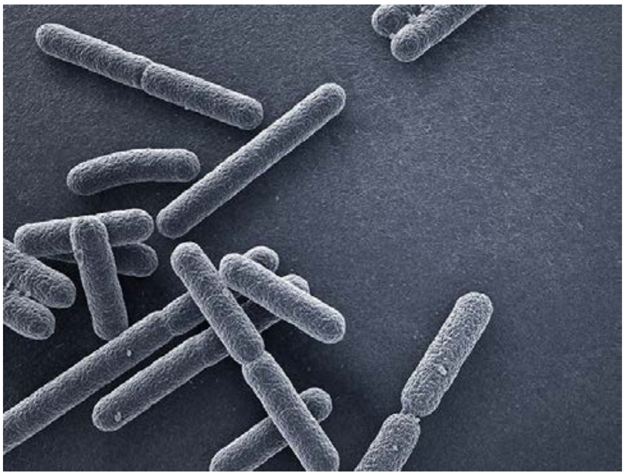
Image on front	Information on back
	**Name** *Zea mays* Maize or Sweetcorn **Suitability as a GM recipient** Major food source for animals and humans and as a source of starch and sugars for processed food. Many insects attack the crop however, its yield falls in drought conditions and the crop must be kept free of weeds.
	**Name** *Gossypium hirsutum* Cotton **Suitability as a GM recipient** Important crop for textile fibres but many insect pests attack it and the crop must be kept free of weeds.

Image on front	Information on back
	**Name** *Glycine max* Soya bean **Suitability as a GM recipient** Major food source for animals and for humans as a source of protein in processed food. Many insects attack the crop however and the crop must be kept free of weeds.
	**Name** *Solanum tuberosum* Potato **Suitability as a GM recipient** Major carbohydrate food source in Europe and America. Potatoes are easy to grow and can give high yields but suffer from many diseases such as blight, which lower yields. They can be engineered to make vaccines but these must be grown under cover to prevent gene flow to other potatoes and to stop antigenic potatoes accidentally entering the human food chain.

Image on front	Information on back
	**Name** *Daucus carota* Carrot **Suitability as a GM recipient** Field-grown crops generally have been found to be unsafe to use as vehicles for production of pharmaceutical drugs but carrot cells grown in culture in bioreactors are a new 'expression platform' for human proteins that can be used as medical drugs.
	**Name** *Oryza sativa* Rice **Suitability as a GM recipient** Major food source in Asia and a suitable vehicle for therapies like treating children with diarrhoea (rice enhanced with human lactoferrin) and preventing vitamin A deficiency (genes from maize or daffodil and a soil bacterium).

Image on front	Information on back
	**Name** *Capra aegagrus hircus* Goat **Suitability as a GM recipient** Female goats produce plenty of milk. A gene is linked to a promoter to switch the gene on in the mammary glands, so that the protein product appears in the milk. So-called 'spider-goats' produce silk in their milk for medical and military applications. Other GM goats produce a drug, human anti-thrombin III, used as an anticoagulant in surgery.
	**Name** *Ovis aries* Sheep **Suitability as a GM recipient** Female sheep produce plenty of milk. A gene for a pharmaceutical protein is linked to a promoter to switch the gene on in the mammary glands, so that the protein appears in the milk. Sheep have been used to make factor IX to treat sufferers of haemophilia B.

Image on front	Information on back
	**Name** *Mus musculus* Mouse **Suitability as a GM recipient** It is a genetic model organism with a well-known, fully-sequenced genome. As a mammal its genome is very similar to that of humans. Mice are small so are cheap to feed and house. Many GM techniques applicable to humans or farm mammals are first tried on mice. Fluorescent GM NeonMice are sold as pets in the USA.
	**Name** *Homo sapiens* Human **Suitability as a GM recipient** People suffering from genetic diseases caused by two recessive non-functional alleles can be treated with gene therapy. The dominant functional allele is inserted into affected somatic cells. Trials have included treatment of cystic fibrosis and Leber's congenital amaurosis. The limitation on treating a human with another human allele is whether the cells that need the foreign DNA are accessible (eg lung epithelium) and stable (not replaced every few days).

Image on front	Information on back
	**Name** *Rerio danio* Zebrafish **Suitability as a GM recipient** It is a genetic model organism with a well-known, fully-sequenced genome. It is a useful simple vertebrate for research. GM zebrafish expressing genes for fluorescent proteins are on sale in the pet trade in the USA marketed as Glo-Fish™.
	**Name** *Escherichia coli* **Suitability as a GM recipient** GM bacteria divide rapidly in a fermenter to produce proteins like human insulin, and bovine chymosin for cheese-making. *E.coli* is a genetic model organism with a well-known, fully-sequenced genome. Its plasmids are widely used as vectors. However some strains of *E.coli* are pathogenic and the GM process may involve inserting antibiotic resistance genes into the bacteria.

Task 1

Record the details of the gene donor and recipient pairs that result from the game in this table. This gives you a checklist of examples of GMOs, their purpose and how they were created. Rank the GMO combinations for how good or risky they are according to a class decision, on a scale of 1 for the most and 6 for the least.

	Gene Donor	Recipient Organism	How good?	How risky?
1	Name of organism	Name of organism		
	Gene transferred	Effect of new gene		
	Function of gene production	Benefit to society		

	Gene Donor	Recipient Organism	How good?	How risky?
2	Name of organism	Name of organism		
	Gene transferred	Effect of new gene		
	Function of gene production	Benefit to society		
3	Name of organism	Name of organism		
	Gene transferred	Effect of new gene		
	Function of gene production	Benefit to society		

	Gene Donor	Recipient Organism	How good?	How risky?
4	Name of organism	Name of organism		
	Gene transferred	Effect of new gene		
	Function of gene production	Benefit to society		
5	Name of organism	Name of organism		
	Gene transferred	Effect of new gene		
	Function of gene production	Benefit to society		

	Gene Donor	Recipient Organism	How good?	How risky?
6	Name of organism	Name of organism		
	Gene transferred	Effect of new gene		
	Function of gene production	Benefit to society		

Task 2 Individual Evaluation of the Benefits and Risks of these GMOs

1. List the six GMOs chosen by your class here.

2. Do you agree with the class rankings of the benefits and risks of each genetically modified organism? If you do, list your supporting arguments for the order here:

3. If you disagree say how you would rank the GMOs and explain your reasons here:

4. Would you be concerned about eating the foods or using the medical products made from these GMOs? List your concerns here:

5. Are you satisfied that these GMOs will not cause harm to the environment? List any concerns you have here:

Appendix for Teachers

This lists the gene donor and recipient pairings that are explicitly mentioned in the playing cards. These examples are well-documented in the literature and many have an established record of commercial use.

Gene donor	Recipient organism	Purpose of gmo
Bacillus thuringensis	Maize	insect resistant crop
Agrobacterium sp. C4		herbicide resistant crop
Bacillus subtilis		drought resistant crop
Bacillus thuringensis	Cotton	insect resistant crop
Agrobacterium sp. C4		herbicide resistant crop
Bacillus thuringensis	Soya bean	insect resistant crop
Agrobacterium sp. C4		herbicide resistant crop
Giant leaf frog	Potato	disease resistant crop
Hepatitis B virus		vaccine production
Human	Carrot	pharmaceutical product for Gaucher's disease patients
Human	Rice	lactoferrin-containing rice treats children with diarrhoea
Erwinia uredovora Maize		Golden Rice 2 with β-carotene to prevent vitamin A deficiency
Golden orb weaver spider	Goat	strong silk fibres for medical and military uses
Human		pharming of anti-thrombin III
Human	Sheep	pharming of factor IX for haemophilia B sufferers
Human	Mouse	mouse cancer models
Jellyfish		NeonMice
Human	Human	gene therapy for recessive genetic disorders like cystic fibrosis and Leber's congenital amaurosis
Jellyfish	Zebrafish	Glo-Fish™
Cow	*Escherichia coli*	GM rennet (chymosin) for cheese-making
Human		insulin for diabetics
Scorpion	Cotton	insect-resistant crop

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