The Biotechnology Revolution

Introduction:

Biotechnology gives us an insight into the most intimate characteristics of a living being – its genetic code – and even allows us to alter it. But to what extent should scientists be allowed to alter and create living things? What restrictions should be in place regarding selection and implantation of embryos? How does biotechnology affect developing countries? To what extent do we have the right to know and not to know about genetic predisposition to illnesses? Who should assume the cost of providing such genetic information?

Groups of 8-12 students discuss the issues raised by each statement and choose where each card should go between 'agree' and 'disagree'. Larger groups could use the resource to have a free discussion of the topic or you could use formats that require the students to work more formally or in smaller groups.

Contents:

The resource consists of:

• An AGREE and a DISAGREE card

• 12 Discussion Cards, which include a statement on some aspect of drug development and access, and if appropriate some further information

• 6 Info Cards, containing more detailed information on elements referred to by the discussion cards

Gameplay:

1. Players form small groups, up to 12 per group. Each group is given an AGREE and DISAGREE card and 12 discussion cards.
2. Within each group, the AGREE card and DISAGREE card are placed on the floor/table about one metre apart, to represent the two extremes of the continuum. The space in between is where the discussion cards will be placed.
3. The first player reads the first discussion card to the rest of the group. The player should check everyone understands the card, and use information sheets where necessary to ensure the group understands the statement.
4. The first player then decides to what extent s/he agrees with the first card. S/he places the card face up, anywhere on the discussion continuum, closer to AGREE or DISAGREE as s/he chooses. This is entirely the choice of the individual player, and is not discussed by the group. The player can give a reason, if s/he wishes.
5. Each player in turn then reads a card, checks that everyone understands, and chooses individually where to place it on the continuum in a similar way.
6. When all the cards have been read, understood and placed on the continuum, the discussion begins. The aim is to place the cards between AGREE and DISAGREE in an order that most of the players agree on. Players should pick a card for discussion, and debate whether to move it.
7. At the end of the discussion, each group should have a continuum which they mostly agree with.
8. If several groups are playing at the same time, the facilitator may wish to bring the different groups' results together. Are they similar? Can someone from each group explain their choices on particular cards?

Discussion continuum developed by Ecsite, in collaboration with Barcelona Science Park, in the context of the Xplore Health project.

Thanks to At-Bristol for the development of the discussion continuum format: www.at-bristol.org.uk

Agree

Disagree

Discussion cards

Text in bold is the "statement" which the player can agree or disagree with. Text in italics is additional information. For even more additional information, players can refer to Info cards.

"No new technology should be used, or even developed, until we can be 100% sure that it is not dangerous to human health."

See Info Card F, Precautionary principle

"Members of my family have a genetic condition for which no cure is available. I may be a carrier for this disease, but I think I have the right to choose not to be tested, because I don't want to know."

People can be genetically tested to find out their predisposition to certain illnesses.

"Mortgage and loan companies should have access to your genetic records - they don't want to lend money to someone who might get ill or die."

People can be genetically tested to find out their predisposition to certain illnesses.

“It should be illegal to combine genes from humans and chimpanzees or apes, as this is a step towards creating an ape-human hybrid species, which would be profoundly unethical.”

See Info Card C, Xenotransplantation

“It’s ethically wrong to breed genetically modified animals to use their organs for human transplantation.”

The process of introducing a new gene into a living thing to change its properties and those of its offspring is called transgenesis. Transgenesis in pigs, for example, can produce organs to be transplanted to humans. See Info Card C, Xenotransplantation.

“When selecting embryos to be implanted for fertility treatment, it is immoral to select only “perfect” embryos. We should not test these embryos for predisposition to non-fatal diseases – we should leave that to nature.”

See Info Card B, Embryo screening

“It is perfectly ethical to obtain human stem cells for therapeutic purposes by doing a nuclear transfer (so-called therapeutic cloning). This research can help treat and prevent diseases and should be strongly supported.”

“Funding on biotechnology research projects on diseases mainly affecting the Western world, like diabetes, should be decreased and increased on diseases affecting the third world, like vitamin deficiencies.”

Biotechnology projects for developing countries include the Golden Rice project and the search for a malaria vaccine. See Info Card F, Distributive Justice.

“If a child has an incurable disease and no cell transplant is available, parents should have the option to select an embryo that will become a brother or sister who can provide the right cell transplant.”

A “saviour sibling” is a child born to provide an organ or cell transplant to a sibling who is affected with a fatal disease, such as cancer or Fanconi anaemia, which can best be treated by stem cell transplantation.

“Doctors must respect patients’ privacy. If someone is diagnosed with a predisposition to a certain illness, the patient has a right to choose not to tell his family.”

Biotechnology allows people to be genetically tested to find out their predisposition to certain illnesses. But since this predisposition is genetic, a patient’s close family, brothers and sisters for example, are more likely to have the same predisposition.

“Parents should never be able to choose whether their baby will be a boy or a girl.”

See Info Card B, Embryo screening.

“If enough tests are done to show that it is safe, there is no reason why scientists should not create completely new species by building their genetic code in labs.”

Synthetic biology is the design and construction of new biological functions and systems not found in nature. *See Info Card G, Synthetic biology.*

Info Card A:

Stem cell research

What are stem cells?

Stem cells are cells that can develop into other types of cell in the body such as skin, muscle or blood cells. They are the body's natural reservoir and are unique because they can renew themselves, producing more stem cells, and they can also produce more specialised cell types.

Stem cells are often divided into two groups: adult stem cells (for example, stem cells in the skin which give rise to new skin cells to replenish old or damaged cells) and embryonic stem cells. Embryonic stem cells occur in the five-day old embryo when it is a tiny ball of about 100 cells. They also occur in significant numbers in the developing foetus and in cord blood at birth.

In late 2007, scientists identified conditions that would allow some specialised adult human cells to be reprogrammed genetically to assume a stem cell-like state. These stem cells are called induced pluripotent stem cells (iPSCs).

What are the potential applications of stem cell research?

- Stem cells can be used to study development, helping us understand how a complex organism develops from a fertilised egg, and to develop treatments for illnesses such as cancer and birth defects.
- Stem cells can replace damaged cells and treat disease - this property is already used in the treatment of burns, and to restore the blood system in patients with leukaemia.
- Stem cells may also hold the key to replacing cells lost in many other devastating diseases for which there are currently no sustainable cures, like Parkinson's, stroke, heart disease and diabetes.
- Stem cells could be used to model disease processes in the laboratory, and better understand what goes wrong.
- Stem cells could provide a resource for testing new medical treatments, reducing the need for animal testing.

Embryonic stem cell research is closely regulated in most countries. This is because it involves starting a stem cell line (culturing a bank of stem cells) that requires the destruction of a human embryo or performing a therapeutic cloning. Both are highly specialised techniques that are not without their controversy. In the European Union, stem cell research using the human embryo is permitted in Sweden, Finland, Belgium, Greece, Britain, Denmark, Spain and the Netherlands; however, it is illegal in Germany, Austria, Ireland, Italy, and Portugal.

Source: EuroStemCell FAQ, http://www.eurostemcell.org/faq

Info Card B:

Embryo screening

What is embryo screening?

Embryo screening, also known as pre-implantation genetic diagnosis, is a technology which enables potential parents to select some characteristics of their unborn child even before gestation starts.

What is the advantage of embryo screening?

This enables them to avoid passing on a genetic disorder or disability, thus avoiding the dilemma of whether or not to terminate an affected pregnancy. Conventional *in vitro* fertilisation techniques (IVF) are used to create embryos for pre-implantation genetic diagnosis.

How is embryo screening carried out?

At around the eight-cell stage of development, one or two cells are extracted from the embryo and the DNA is analysed to check for specific characteristics. If free from the specific genetic disorder being tested for, the embryo can be transferred to the uterus (womb) and pregnancy can continue.

What are the ethical issues linked to embryo screening?

The technique can be used to determine the gender of the embryo and can thus be used to select embryos of one gender in preference over the other in the context of “family balancing”. In the future, it may be possible to make other "social selection" choices.

Costs are substantial and may not always be covered by health insurance companies or national health systems. Thus, embryo screening widens the gap between people who can afford the procedure and the majority of patients, who might benefit but cannot afford the service.

Pre-implantation genetic diagnosis has the potential to screen for genetic issues unrelated to medical necessity. The prospect of a “designer baby” is closely related to this technique.

Source: PlayDecide game PGD http://www.playdecide.eu/play/topics/preimplantation-genetic-diagnosis-pgd/en
Wikipedia PGD page:
http://en.wikipedia.org/wiki/Preimplantation_genetic_diagnosis#Ethical_issues

Info Card C:

Xenotransplantation

What is xenotransplantation?

Xenotransplantation (xenos- from the Greek meaning "foreign") is the transplantation of living cells, tissues or organs from one species to another. Xenotransplantation covers:

- The transplant of whole organs
- Cell transplant therapies
- Bioartificial Liver Devices (BAL) – where pig liver cells are used to perform the essential functions of the natural liver.

Traditional transplants

Since the first heart transplants, live (human) organ transplantation has been the preferred approach to transplantation. For every organ donated, there are 5 patients waiting for an organ transplant. This shortfall is known as the 'organ gap' and is a serious problem because there are usually no alternative treatments. Sufferers of cystic fibrosis, an inherited disease, are unlikely to live beyond the age of thirty without a lung or heart-lung transplant.

Solving the problem of the "organ gap"

Xenotransplantation could solve the shortage of organs for transplant (the 'organ gap') using pig or primate organs (mainly apes and monkeys) because they are similar to humans in size and structure. Pigs are the preferred species as organ donors for humans because their organs are about the right size, they are relatively cheap and they raise fewer ethical concerns than using monkeys or apes.

As well as whole organs, studies are being conducted on using nerve cells from pigs to treat Parkinson's and Huntington's disease.

Overcoming rejection

The difficulty with xenotransplantation is that the human immune system detects the new organ as 'foreign' and reacts against it. The transplant of human organs has become more successful because immunosuppressive drugs inhibit rejection and because surgical techniques have improved. To overcome rejection with xenotransplants, scientists are genetically modifying animals by removing the molecule that marks other species as foreign to the human immune system or by introducing human genes into pigs.

Source: Xenotransplantation Decide Game,
http://www.playdecide.eu/decide_kits/xenotransplantation/en

Info Card D:

Cloning (SCNT)

Cloning, or somatic cell nuclear transfer (SCNT), is the technique used to produce Dolly the sheep, the first animal to be produced as a genetic copy of another adult.

In this procedure, the nucleus of an egg cell is removed and replaced by the nucleus of a cell from another adult. In Dolly's case, the cell came from the mammary gland of an adult ewe. This nucleus contained that ewe's DNA. After being inserted into the egg, it is artificially stimulated to divide and behave in a similar way to an embryo fertilised by sperm. After many divisions in culture, this single cell forms a blastocyst (an early stage embryo with about 100 cells) with almost identical DNA to the original donor who provided the adult cell – a genetic clone.

At this stage, cloning can go one of two ways:

Reproductive cloning

To produce Dolly, the cloned blastocyst was transferred into the womb of a recipient ewe, where it developed and when born, quickly became the world's most famous lamb. When the cloning process is used in this way, to produce a living duplicate of an existing animal, it is commonly called reproductive cloning. This form of cloning has been successful in sheep, goats, cows, mice, pigs, cats, rabbits and dogs.

This form of cloning is unrelated to stem cell research. In most countries, it is illegal to attempt reproductive cloning in humans.

Therapeutic cloning

In therapeutic cloning, the blastocyst is not transferred to a womb. Instead, embryonic stem cells are isolated from the cloned blastocyst. These stem cells are genetically matched to the donor organism, holding promise for studying genetic disease. For example, stem cells could be generated using the nuclear transfer process described above, with the donor adult cell coming from a patient with diabetes or Alzheimer's. The stem cells could be studied in the laboratory to help researchers understand what goes wrong in diseases like these.

Another long-term hope for therapeutic cloning is that it could be used to generate cells that are genetically identical to a patient. A patient transplanted with these cells would not suffer the problems associated with rejection.

To date, no human embryonic stem cell lines have been derived using therapeutic cloning, so both these possibilities remain very much in the future.

Source: EuroStemCell FAQ, http://www.eurostemcell.org/faq

Info Card E:

Precautionary principle

What is the precautionary principle?

The precautionary principle states that no new technology should be used (or even developed) until enough proof has been obtained to show that it is harmless.

Although the precautionary principle could be applied to any new technology, it has been especially invoked in biotechnology.

Advantages of the precautionary principle

The principle implies that there is a social responsibility to protect the public from exposure to harm. These protections can be relaxed only if further scientific findings emerge that provide sound evidence that no harm will result.

Criticisms of the precautionary principle

Critics of the principle argue that it is impractical, since every implementation of a technology carries some risk of negative consequences. It can impair scientific progress if applied to its extreme. Most technologies have dual aspects and misuse of them towards undue or perverse objectives should not impair their development.

Present knowledge and technologies are based on the knowledge developed by previous generations of scientists. Present science becomes the groundwork for future knowledge. Banning certain research can cause delays and undesired effects on future generations. Philosopher Immanuel Kant (1784) established the necessity of scientific improvement in his essay “Answer to the Question: What is Enlightenment?” when he wrote “An epoch cannot conclude a pact that will commit succeeding ages, prevent them from increasing their significant insights, purging themselves of errors, and generally progressing in enlightenment. That would be a crime against human nature whose proper destiny lies precisely in such progress...”

For instance, transgenic technology or somatic cell nuclear transfer (cloning for therapeutic aims) in humans have evolved much more slowly due to this prevention. It therefore seems clear that, although not everything that can be done should actually be done, invoking the precautionary principle may impair the development of new technologies that might offer better living conditions to future human generations.

Seeking a balance between advantages and risks (proportionality principle) is an alternative approach to this apparent conflict.

Source: Xplore Health ”Background information on biotechnology”, by Dr. Luis Ruiz Avila and Dr. Josep Santaló, to be found in the section “Resources for educators”.

Info Card F:

Distributive justice

Distributive justice is concerned with the fair distribution of healthcare resources.

Biotechnology is a high technology field, so it is time-consuming and expensive, making it available only to well developed countries or to economically powerful people. This produces a drift in the way biotechnology evolves, often leaving some interesting research aside, not because it won't help more people, but because it is less profitable.

This is an issue in developing countries, where the need for improved healthcare is the greatest but the availability of biotechnology is the lowest.

Examples of research which benefit developing countries include the malaria vaccine and "golden rice".

Golden rice

Golden rice is a variety of Oryza sativa rice produced through genetic engineering to biosynthesize beta-carotene, a precursor of pro-vitamin A in the edible parts of rice. Golden rice was developed as a fortified food to be used in areas where there is a shortage of dietary vitamin A. The scientific details of the rice were first published in Science in 2000. It is not currently available for human consumption.

Arguments for golden rice

The research that led to golden rice was conducted with the goal of helping children who suffer from vitamin A deficiency (VAD). At the beginning of the 21st century, 124 million people in 118 countries in Africa and South East Asia were estimated to be affected by VAD. The deficiency is responsible for 1–2 million deaths.

Supporters of GMOs argue that there is no direct proof of GMOs causing detrimental effects on the environment.

Arguments against golden rice

Although golden rice was developed as a humanitarian tool, it was met with significant opposition from environmental and anti-globalisation activists, some of whom opposed the release of any genetically modified organisms into the environment, and some of whom were concerned that golden rice was a Trojan horse that would open the door to more widespread use of GMOs. There is no evidence that GMOs are safe for the environment.

Source: Xplore Health "Background information on biotechnology", by Dr. Luis Ruiz Avila and Dr. Josep Santaló, to be found in the section "Resources for educators".
Wikipedia page on Golden Rice: http://en.wikipedia.org/wiki/Golden_rice

Info Card G:

Synthetic biology

Synthetic biology is one of the most modern fields of development in biotechnological research. It refers in general to the discipline (and industry behind it) which aims towards developing methodologies for the design and construction of new biological components, functions and systems not found in nature.

Synthetic biologists engineer new organisms with functions that cannot be found in nature, focused mainly on energy production, bioremediation and healthcare. The creation of a completely new organism (a bacterium) requires designing its entire genetic code. Such processes are generally referred to at present as “Global transgenic” since they are the result of the combination of various genes coming from different organisms.

One of the most well-known examples of current synthetic biology is the Mycoplasm developed by the famous biologist Craig Venter, an all-synthetic and fully functional bacterium whose entire DNA was made in a machine.

What are the potential applications of synthetic biology research?

Developments inside synthetic biology are mainly aimed towards advancements in a number of specific research fields in bioengineering, chemistry and biology at large. The ultimate goal of being able to design and build engineered biological systems is the possibility to process information, manipulate chemicals and fabricate materials and structures which will help us maintain and enhance human health and our environment, produce energy through the creation of useful new biochemicals, provide new forms of food production and study the origins of life.

Biologists also use synthetic biology as a way to test their current understanding of a natural living system by building an instance (or version) of the system in accordance with their current understanding of it. Health treatments and environment protection are the fields where synthetic biology generates most expectations, e.g. the hope of eventually synthesizing bacteria to manufacture hydrogen and biofuels, and also to absorb carbon dioxide and other greenhouse gases.

What are the ethical issues linked to synthetic biology?

Arguments against synthetic biology come from the perspective of seeing it as something going against the natural order of things. Most arguments are based on the precautionary principle (see info card E) and the fact that unforeseen and uncontrollable effects may appear when developing such technologies.

Source: Xplore Health ”Background information on biotechnology”, by Dr. Luis Ruiz Avila and Dr. Josep Santaló, to be found in the section “Resources for educators”.
Wikipedia page on Synthetic biology:
http://en.wikipedia.org/wiki/Synthetic_biology