SCHOOLS DEBATES 2011 NATIONAL TOPIC

South Africa has a rich body of indigenous knowledge, recognised biodiversity hotspots as well as a fairly technologically advanced society. Can biotechnology be used to conserve our biodiversity?

Biodiversity refers to the variety of living organisms in a particular ecosystem or on the whole earth. Biodiversity can be seen and studied at different levels: genetic, organismal and ecological. It can refer to both natural environments on land and sea as well as agricultural and other man-made surroundings. The biodiversity we observe today is the result of 3.5 billion years of evolution. The number of species of plants, animals and eukaryotic micro-organisms is probably around 10 million today, but only 1.4 million have been characterized and named by scientists.

South Africa occupies only 2% of the world’s surface area but is home to nearly 10% of the world’s plants (approximately 24,000 species), around 7% of the world’s vertebrate species, and 5.5% of the world’s known insect species (only about half of which have been described). In terms of the number of endemic species of mammals, birds, reptiles and amphibians, South Africa ranks as the fifth richest country in Africa and the 24th richest in the world.

The loss of biodiversity can be measured by a loss of individual species, groups of species or decreases in numbers of individual organisms. In a given location the loss will often reflect degradation or destruction of a whole ecosystem. The Convention on Biological Diversity, an international legally binding treaty, has ranked the priority of threats to global biodiversity in the following order:

1. Habitat loss (most of it through the expansion of cultivated land), comes not only from taking more land under the plough, but also from expanding cities and road building. In addition, habitats can be damaged by flooding, lack of water, climate changes, salination etc., all of which are phenomena that may be either natural or man-made.

2. The introduction of exotic species, which in addition to changing an entire habitat, places ecosystems at risk by crowding out or replacing native species that are beneficial to the habitat. Alien species can also lead to genetic pollution (or gene mixing), which is the phenomenon where an introduced species “swamps” the gene pool of the indigenous species. This is usually problematic where the genome of rare species is overtaken by that of a more common, genetically “fit” species, causing extinction of the rare species.

Other threats include:

- Overexploitation - this occurs when a natural resource is used at an unsustainable rate for example excessive logging, over-fishing or hunting, or poor soil conservation in agricultural practices.
- Climate change - it is predicted that if the current rates of climate change continue, coral reefs will disappear in the next 20 to 40 years and 10% of species will become extinct by 2050.

- Overpopulation – the growth of the human population was described by Sir David King (a South African born scientist who was the chief scientific adviser to the UK government under both Tony Blair and Gordon Brown) as having the single biggest impact on biodiversity. The world population is currently estimated at 6.39 billion and is expected to grow to 10.5 billion by 2050.

Conservation may be in situ or ex situ, that is it can take place either in the natural or semi-natural habitat (in situ), or in some purpose-built environment (ex situ). In situ conservation will involve the maintenance and protection of natural habitats, while botanical gardens and seed banks are used for the ex situ conservation.

Biotechnology (which can be defined as the use of living things to create useful tools and products) can be applied to the study of virtually any biological phenomenon. Biotechnology has proven particularly useful in the field of biological conservation. There are two quite different applications of biotechnology that are relevant to conservation of biodiversity. The first is the use of biotechnology as a tool for acquiring knowledge about the genetics of species and individuals. Genetic diversity is one of the three fundamental levels of biodiversity and conservation of biodiversity benefits greatly from a thorough understanding of the genetic structures and genetic variability in a population or species. Conservation genetics is field in its own right, making use of genetic markers and DNA fingerprinting to assess the genetic variability within species and between individuals. Different techniques use different parts of the genome to measure variability in DNA sequences. For example, mitochondrial DNA in animals can be used to determine difference between individuals. This knowledge can be used, for example, to direct better breeding programmes for species that are in danger of extinction, to reduce the extent of inbreeding and increase the genetic variability that makes a population more adaptable.

The second application of biotechnology in conservation of biodiversity is the direct intervention in plant and animal breeding, such as through the transfer of genes and the creation of transgenic organisms. The creation of genetically modified organisms (GMOs), such as transgenic food crops which contain a gene from a “foreign” species, is still controversial and is believed by some to have a negative impact on natural biodiversity. This is because “natural” varieties are being replaced by “unnatural” genetically modified (GM) varieties and are being cultivated on large scale due to their improved characteristics. Also, the possibility exists that the “foreign” genes can be transferred from GM crops to natural species by cross-pollination if they are grown close to each other, and this will impact on the genetic makeup of the natural species. However, the argument for transgenic crops in conserving biodiversity lies in the fact that high-yielding transgenic crops can be grown in smaller areas of land, therefore reducing the expansion of farm land and encroaching less on natural vegetation rich in biodiversity in comparison to the cultivation of other, lower-yielding non-transgenic crop varieties which require more land to produce the same yield.

In addition to the use of biotechnology, the rich body of indigenous knowledge in South Africa could also be a resource for the protection of our biodiversity. The question to be asked then is can biotechnology, be used to conserve biodiversity? The five pillars of science communication will provide the basis for our answer.

**Utilitarian**

The usefulness of biodiversity to humans is almost incalculable. The current range of cosmetic products, for example, would not be half as vast but for biodiversity (just think of the shampoos and body scrubs that...
use grapefruit extract, linseed oil lemon extract and numerous other natural ingredients). Recently an ointment that uses crocodile oil was launched in Port Elizabeth, demonstrating that almost any natural product could conceivably have benefits for humans. Natural ingredients account for 49% of patent activity in cosmetics. We have benefitted not only in terms of cosmetics but also in the areas of medicine, agricultural and pure aesthetic value (bird watchers, butterfly collectors and hikers would not have half as much fun without natural variety). There is thus much utility derived from biodiversity itself. Biotechnology, since it could be used to conserve biodiversity (for example the use of genetic markers as explained above), would also have great utility as a means of protecting our natural environment.

One other major contribution that biotechnology can make is in the area of bioprospecting. Bioprospecting can be described as scientific research that looks for useful applications, processes, or products in nature. In many cases, bioprospecting is a search for useful organic compounds in microorganisms, plants and fungi that grow in environments such as rainforests, deserts, and hot springs, although it is not limited to this context. Bioprospecting is nothing new and has been around since prehistoric times where, for example, new plants were sought out to cure new diseases and ailments. However in modern times, biotechnology has both contributed to and benefited from bioprospecting. A famous example of this is the Taq polymerase enzyme that is derived from the Thermus aquaticus organism which was discovered by Thomas Brock in 1966 while he was studying microorganisms living in Yellowstone's hot pools. This microorganism lives and thrives in water so hot that it would kill an ordinary animal. The enzyme that was isolated from the organism now forms the key reagent in a biotechnological process known as the Polymerase Chain Reaction (PCR) which is used to multiply, quite rapidly, any genetic material (either DNA or, using reverse transcript PCR, RNA). PCR is a core component of modern biotechnology, and is now used as part of biodiversity conservation efforts, for example, in determining genetic markers. Furthermore, because there is now a very important use for Thermus aquaticus, it is likely that every effort will be made to conserve it, showing how bioprospecting can prove useful as a means of conservation.

**Socio-cultural**

Since the 1990’s there has been increased emphasis on compensation and benefit-sharing in bioprospecting. This is especially true where a discovery comes as a result of prior indigenous knowledge. In terms of the National Environment Management: Biodiversity Act of 2004, the interests of specific individuals who possess traditional knowledge must be protected. Anyone who commercialises a project based on the traditional knowledge of a specific individual must enter into a benefit-sharing agreement with the individual.

It has long been a concern that when indigenous knowledge is required for almost any facet of commercialisation of a natural product (or conservation etc.) the local communities who possess that knowledge are exploited. This led to the creation of the umbrella term “indigenous intellectual property”, which refers to the legal rights that indigenous populations have to their knowledge. An International Indigenous Peoples’ Summit on sustainable development met on Koi-San Territory, where they reaffirmed declarations and statements made at previous summits and declared:

"Our traditional knowledge systems must be respected, promoted and protected; our collective intellectual property rights must be guaranteed and ensured. Our traditional knowledge is not in the public domain; it is collective, cultural and intellectual property protected under our customary law. Unauthorized use and misappropriation of traditional knowledge is theft."

The provision in the National Environment Management: Biodiversity Act seeks to protect the rights of indigenous people but does not guarantee that this will happen.

Another aspect of ownership relates to genetic sovereignty which can be defined as the capacity of a people, a country or nation to own and control both access to and use of, samples, data and knowledge concerning or emanating from genomic material. This definition relates to genetic material of human,
animal and plant origin. There is growing concern that far too many conservation studies impose themselves on local communities, taking plant and animal samples, but not leaving any benefit for the communities themselves. The question as to who owns the genetic material must be answered before it can be said with any measure of certainty that the communities should in fact benefit from the research. This is an area of great interest especially in the legal world, which seeks to establish the right to genetic material for local communities.

The turtle conservation programme in Maputaland provides an excellent case study of how conservation efforts can have a positive socio-cultural impact. The programme is community based and local residents have been trained as conservation officers, turtle monitors, tour operators and guides. This, apart from being a source of job creation, empowers the very people who live in the area to take responsibility for its conservation. The benefit here is that the project has some measure of sustainability because its manpower has a vested interest in its continuation. Social impacts may also extend to the interaction with tourists, the erection of schools and libraries, bursary programmes and projects or programmes that add value to the lives of the local communities. If the biotechnology is also used as part of conservation efforts, the effect is even greater as local people are equipped with new knowledge and skills.

**Economic**

The link between economics and conservation may not be immediately obvious. At first glance, one can see the negative impact of economics on biodiversity, for example if one thinks of how much money is being made from the deforestation of the Amazon and the resulting loss of biodiversity. However, a closer look reveals that there is much to be said for the amount of money conservation could save us, and in fact how much money it could generate in micro-economies. Take the example of deforestation: suppose that the Tsitsikamma Forest in the Western Cape were felled. The result would be soil erosion into the rivers in the area. All the farmers who rely on those rivers as a source of water for their grape vineyards and other deciduous fruit plantations would be faced with a problem. The air quality would decrease and the health of the local people may be compromised. These are economic considerations that ought to be assessed when deciding if conservation is worth it.

Let’s stay with the Tsitsikamma example. If you have been fortunate to go there, you will know that it is one of the most beautiful parts of South Africa. It is a premier holiday destination. Conservation of that area maintains the tourism industry that has been built to include local communities as tour guides, housekeepers etc.

Another major example of the interplay between conservation, indigenous knowledge and the economy is the exportation of Rooibos tea. Rooibos grows exclusively in the Western Cape and is becoming increasingly popular in Western countries, particularly among health-conscious consumers as it is believed to assist with nervous tension, allergies and digestive problems. The creation of an industry around a valued and exclusively South African plant is one of the ways in which the conservation effort may become profitable. Job creation and an export industry are two of the main benefits of such an initiative. Hoodia, which is famed for its ability to suppress appetites (and so has been used as a weight-loss supplement), is another such example. The use of biotechnology and indigenous knowledge would require that money be spent. Training local communities, gathering, recording and investigating the knowledge that they possess – all this would require money. As examined above however, it more than pays itself off in the long run.

**Advancement of Science**

One of the great benefits of the use of indigenous knowledge and biotechnology is that it has reciprocal benefit for both the biotechnologists and the local communities who are able to share their scientific
knowledge. The goal, however should be harnessing both forms of knowledge in support of conservation. Provided the information and skills sharing is mutual, and that indigenous communities are not exploited, it seems that there are many levels on which biotechnology and conservation sciences will be advanced.

Scientists are always striving to break new ground with their research and advance their science. Science will advance as new information about biodiversity is gained through the applications of biotechnology, and this may have further reaching implications into other fields of science. For example, the results of genetic studies not only provide information about the current genetic diversity in a population to assist in the way forward for breeding strategies, but also provide information about the past and the evolution of the species, which offers insight into how a species has adapted and what environmental challenges may have driven its adaptation.

An example of a phylogenetic tree showing the relatedness of various feline and other species, which evolved from a common point at some stage in history. The tree is determined by comparisons of sequences of DNA in the mitochondria. This shows, for example, that a cheetah is more closely related to a puma than a leopard, based on its mitochondrial DNA, as it shows more recent divergence of the puma and cheetah species from a common ancestor. This is an example of biotechnology advancing other sciences such as palaeontology.

(source: www.computational-genetics.net)

Democratisation of Science

This method of tackling the conservation problem may prove to be the most advantageous for the democratisation of science. Biotechnological concepts can be made more accessible to people who would not otherwise have any reason to encounter it. Conversely, scientists will be able to engage with forms of knowledge that are not taught in the universities and colleges. Also of great importance, greater knowledge of the laws surrounding conservation, indigenous knowledge and biotechnology will become more tangible and useful for the people they were written for. It would require co-operation between the government, private sector, conservation NGO’s and communities of ordinary South Africans to ensure that the efforts at improving conservation are successful. Bringing these groups together would be beneficial for conservation efforts and would provide a good model for how many interest groups can work together to achieve a goal that will benefit not only the environment but South Africans too.

Conclusion

Biotechnology has already proven to be a very useful technology. Can it be expanded to assist in conservation efforts? Is it worth our time and money to even consider indigenous knowledge? How can biotechnology be used together with indigenous knowledge to help with conservation?

Consider what you have read above and research the topic further. The answers are yours for the finding.

Good luck!
Resources:
http://www.cbd.int/
http://www.cbd.int/countries/profile.shtml?country=za#status
http://www.hc2d.co.uk/content.php?contentId=18645
http://www.plosbiology.org/article/info%3Adoi%2F10.1371%2Fjournal.pbio.0040360

Suggested Additional Reading:
http://www.guardian.co.uk/commentisfree/libertycentral/2009/nov/19/comprehensive-dna-database
http://www.spaceship-earth.de/Letters/Editor/A_voluntary_DNA_database.html
http://www.angryharry.com/esdnadatabase.htm
http://news.bbc.co.uk/2/hi/uk_news/8354740.stm
http://www.timesonline.co.uk/tol/news/uk/crime/article2477559.ece
http://news.bbc.co.uk/2/hi/uk_news/7764069.stm
http://www.guardian.co.uk/commentisfree/henryporter/2009/nov/12/uk-defying-eu-law-dna-database
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