

# The Environmental Benefits from Molecular Biotechnology Application

Shu-Hao Chang

## ABSTRACT

In the 20<sup>th</sup> century, there were a lot of environmental pollution problems which had not been solved. However, the new types of environmental pollutions are still coming with as fast as the technology innovations in 21<sup>st</sup> century. Therefore, not only the old problems are needed to solve by new techniques, but also the new problems are required to figure out the answers. Molecular biotechnology is considered as one of the most important subjects which can prevent the pollution and recover our environment becoming healthy. In this study, it will focus on how the environmental science and technology application of molecular biotechnology try to enhance the environmental prevention and reclamation at the following parts: environmental monitor and inspection, pollutant removal, soil and groundwater treatment, molecular nanotechnology, green technology, and examination responsibility of environmental disputes.

## KEYWORDS

molecular biotechnology, environmental benefits, biotechnology, environmental pollution.

## INTRODUCTION

Since 20<sup>th</sup> century, the problems of the environmental pollution have become worst. Facing the new science and technology improvement so fast in the present time, could these old problems of environmental protection break through the bottleneck by the new technology? The answer is positive because of the progress of molecular biotechnology. No matter on the microbial detection, pollutant appraised, pollution control, green production, or risk assessed...etc, the molecule biotechnology can be used for every kind of mediums ,such as environmental monitor, environmental inspection and removal pollutants. For this article, I attempt to analyze and classify the new technical applications of molecular biotechnology which will help us to understand the power and benefits from those significant techniques. For example, consider an environment in which pollution of a particular type is the most of all. Let us think about the effluents of a food industry which has mixed up with a local water body like a lake or pond. We can find huge deposits of food wastes which are not so easily taken up for degradation by microorganisms except for a few exemptions. We isolate a few microorganisms from the polluted site and scan for any significant changes in their genome like mutations or evolutions. Such this kind of process, we can usually find which all applications of molecule biotechnology are using for monitoring and inspecting then we can find the way to treat those pollutants. By the following, I will use six regions to describe the environmental benefits of molecular biotechnology:

- Environmental monitoring and inspecting
- Environmental management and risk evaluation
- Soil and ground water treatment
- Molecular Nanotechnology
- Green Technology
- Examination Responsibility of environment disputes

## ENVIRONMENTAL MONITORING INSPECTING

Surrounding our living environment or in the municipal health, there are many places having pathogen or virus that need environmental monitor and inspection. For instance, we have to monitor and inspect or measure the microbial growth and decline, drinking water, and the sewer microorganism in water treatment plant. There are two main groups which can help us to monitor and inspect the species of the pathogen or virus:

### ➤ PCR, RT-PCR, Quantitative Competitive-PCR

The polymerase chain reaction (PCR) is a technique widely used in molecular biology. It derives its name from one of its components, a DNA polymerase used to amplify (or replicate) & a piece of DNA (the target) by *in vitro* enzymatic replication. By recombining a lot of this species, we can get the sequence data base, and make the phylogenetic tree. Then, we can use the phylogenetic tree to provide the microbial characteristic of the environmental samples or pure culture. Because the virus is not only DNA, but also RNA which needs to do the reverse process called reverse transcription- polymerase chain reaction (RT-PCR). The Quantitative competitive PCR (QC-PCR) is the fragment data of PCR adding into the sample which has the target model that we want (Kim et al, 2002). Through the previous process, the high concentration target model is very similar to our sample.

## POLYMERASE CHAIN REACTION

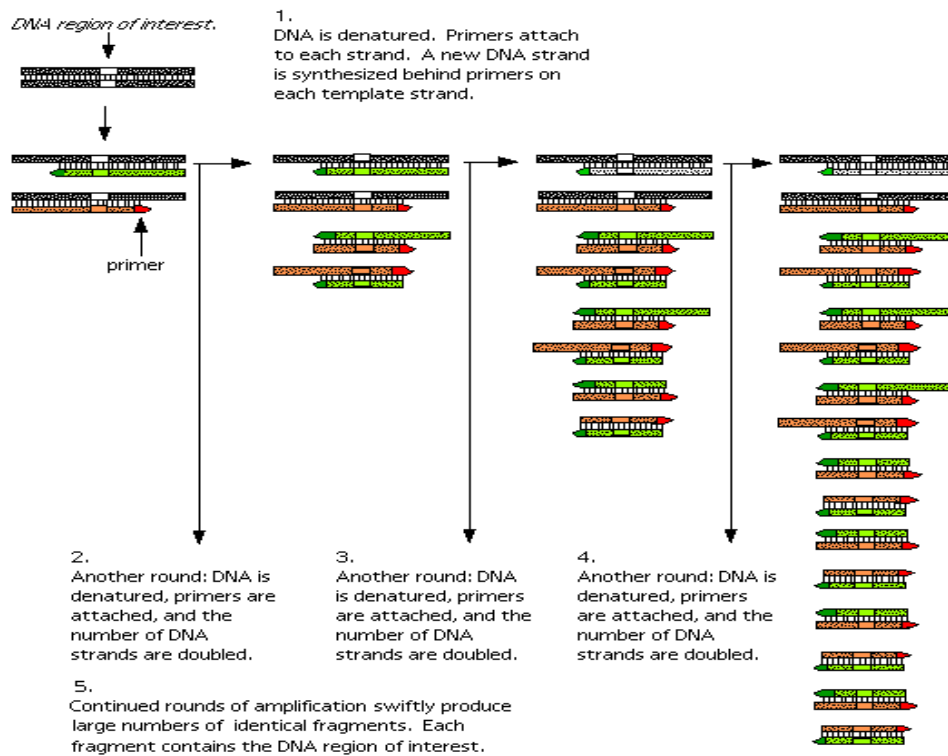


Figure 1. the process of polymerase chain reaction (Access Excellence,1999)

## ➤ FISH

FISH (Fluorescent *in situ* hybridization) is a cytogenetic technique which can be used to detect and localize the presence or absence of specific DNA sequences on chromosomes. It uses fluorescent probes binding parts of the chromosome to show a high degree of sequence similarity. Fluorescence microscopy can be used to find out where the fluorescent probe bound to the chromosome. FISH is often used for finding specific features in DNA. These features can be used in genetic counseling, medicine, and species identification. (Wilderer et al, 2002) For the environmental application, we can use FISH not only to detect the bacteria and virus easily, but also to get the accurate location in our sample. Therefore, this powerful technique will let the environmental monitoring and inspecting become easier.

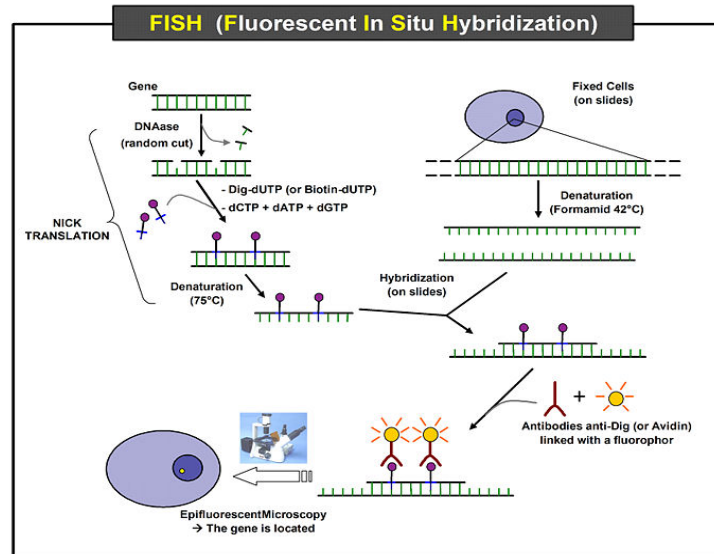


Figure 2. The principle of the FISH Experiment to localize a gene in the nucleus. (Wikipedia, 2007)

## ENVIRONMENTAL MANAGEMENT AND RISK EVALUATION

The new molecular biotechnology can be used on the management, risk evaluation and pollution prevention of the environmental jobs. Microarray genomics, DNA chips, antibody or protein chips, all can be used for inspection and examination, such as toxicity pollutants, chemical substances, and bacteria and microorganisms. Gene chip is one kind of new technology of DNA microarray. It can analyze the gene expression in a whole bunch of genes. This technology does not like the traditional technology, which are very expensive and spend a lot of time to inspect or examine a lot of microorganisms to confirm the pollutants. On the contrary, it can reduce not only the inspecting time but also the number of biological experiments. Recently, most of environmental toxicity inspections usually used this technology to shorten the period of biological tests. Also, if we need to use amount of animals' experiments and just focus on one type of pollution, the new bioassay technology, such as DNA microarray, can detect the cadmium chloride ( $\text{CdCl}_2$ ) or trichloroethylene in the liver of our examination quickly. Furthermore, the other technology, like DNA-chip, PCR and genotoxic Effects, are both expected nice tools for environmental detection. Therefore, after those technologies, are widely applied to solve a great number of environmental management problems and decrease the risk of the environmental evaluation.

## SOIL AND GROUND WATER TREATMENT

There are a lot of pollutants throughout the soil and ground water; Trichloroethylene (TCE) is one type of pollutants in which we mostly can find. It can decompose at aerobic and anaerobic condition, and need to process during co-metabolism and at aerobic condition. The research indicates enzyme includes soluble and particulate methane monooxygenase (sMMO & pMMO); it usually reduces and form dichloroethylene (DCE) and vinyl chloride (VC) at anaerobic condition, and it will become completely mineralization after totally oxidation. In aerobic or anaerobic bioreactor (CANOXIS or UASB), after TCE decomposes microorganisms by using PCR to understand its' composition, we can design the appropriate primers to research functional genomics. (Tresse, 2005) Furthermore, in order to decompose those pollutants, we need appropriate enzymes in microorganisms' bodies to be one kind of proteins. Composing those proteins, we need DNA to transfer the message to mRNA. During the transferring process, we also need RNA polymeras. The position of DNA and RAN polymeras is at the special space on the promoter; therefore, increasing the numbers of mRNA and enhancing the activity of the promoter can directly or indirectly multiply enzymes we need. As the result, we can increase the decomposition of microorganisms' ability. There are several similar techniques in Peter C.K Lau and Victor De Lorenzo's article (Peter et al, 1999):

1. Using starvation signals to stimulate the activity of promoter, it can make few polymeras do its' function; then, the DNA also can transfer to mRNA easier.
2. Using the other genes' recombination to produce hybrid, it will make original bacterium have widely substrate specificity to induce other pollutants degrading.
3. By inducing the genie mutation, it can increase the survival rate of microorganism.

By the way of these techniques, it can increase the decomposition ability of microorganism and reduce the time spending of soil pollution treatment.

## MOLECULAR NANOTECHNOLOGY

While conventional chemistry uses inexact processes driven toward some balance to obtain inexact results, and biology exploits inexact processes to obtain definitive results, molecular nanotechnology would employ original definitive processes to obtain definitive results. The desire in molecular nanotechnology would balance molecular reactions in positional-controlled locations and orientations to obtain ideal chemical reactions and to build systems by further assembling the products of these reactions. Therefore, acid rain, global warming, ozone depletion have become the common language in everyone's daily life. Today, environmental sustainability relies on technology is pessimistic. However, emerging molecular nanotechnology takes the lead of all industry development, such as nanoelectronics, nanobiotechnology, nanomaterial, nanoenergy, and etc. It is the first one which offers radical tools for human beings to be on the upper hand in the struggle toward to sustainable and economic growth. Furthermore, it provides human civilization not only to remediate environmental liabilities since industrial revolution in the 18<sup>th</sup> century, but also to produce unlimited material and energy within ultra green processes. For the following, I will briefly talk about the molecular nanotechnology application on the acid rain and smog, global warming, toxic wastes and water and soil contaminations

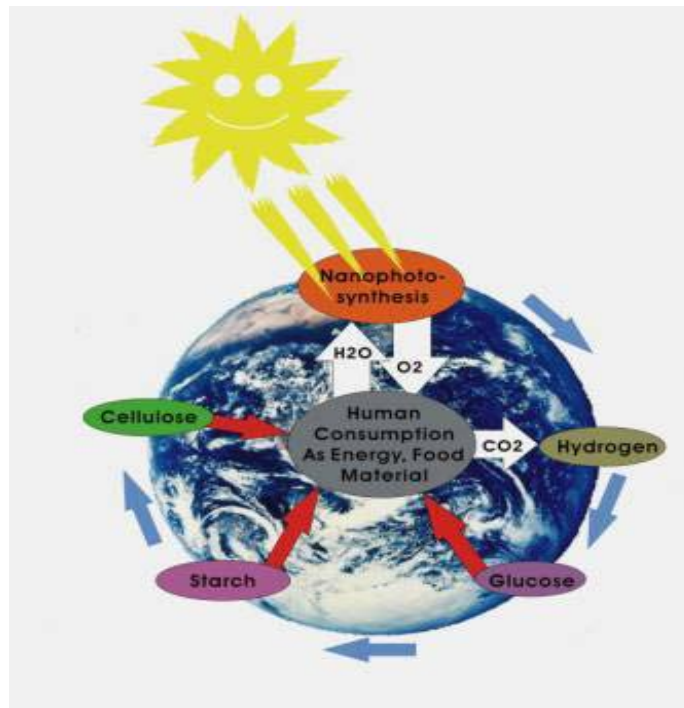
### ➤ Acid Rain and Smog

Sulfur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>) are the main causes of acid rain and smog. Acid rain causes acidification of lakes and streams and consequential damage the forests. Also, acid rain can destroy the surface of building materials and paints. The power of the

effects inversely depends on how the buffer capacity of water and soil involve. In atmosphere,  $\text{SO}_2$  and  $\text{NO}_x$  gases and their derivatives harm the visible degradation and public health. Therefore, Nanobots such as nano-desulfurizer can be sent up to the atmosphere to capture  $\text{SO}_2$  gas, and reduce sulfur precipitate to earth surface. Nano-sulfur-precipitator contains calcium or magnesium ion sent up into sky to oxidize  $\text{SO}_2$  to form  $\text{CaSO}_4$  or  $\text{MgSO}_4$  salts. Furthermore, nanobots like nano-catalytic-converter can also sent up into atmosphere to convert  $\text{NO}_x$  into nitrogen and oxygen.

### ➤ Global Warming

The damage of global warming is from gas- $\text{CO}_2$  that the fuel burning discarded into the atmosphere. Thus, to apply molecular nanotechnology for energy production will enable solar power to generate at the affordable cost and benefit. This will eliminate fossil fuel power generation as well as  $\text{CO}_2$  emission. Molecular nanotechnology also can develop nanomachines or nanobots, such as nano-photosynthesizer (Sayama, 2001), nano-chlorophyll, nano-carbon-fixer, and etc. Created by the inexpensive solar energy, these nanobots not only can be manipulated to extract excess  $\text{CO}_2$  from atmosphere, but also can be transformed into a lot of valuable materials. The carbon extracted by nanobots can be used in synthesizing functional and structural materials. It can also be extracted by other nanobots and further be synthesized into sugar, starch, and cellulose to supplement our demand for food, paper and etc. (See Figurer. 3).



Figurer 3. Molecular Nanotechnology Carbon Based Material Production System (Sinclair, 2003)

## **GREEN TECHNOLOGY**

### ➤ **Transgenic Technology**

In Golovan's group, those researchers discovered and developed the new technology which can change the pig's gene called transgenic pigs". There are special phytases in transgenic pig's saliva, and those special phytases will help the pigs to decompose phosphate in the feeds when they eat. Therefore, we don't need add the inorganic phosphorus in the feed, and it can automatically reduce the phosphorus contents of swine wastes around 75%. A pig usually needs 2.5kg calcium phosphate throughout its' life; in the opposite, a transgenic pig does not need any calcium phosphate throughout its' life. As this result, we can decrease the pollutants in our environment by reducing the swine waste. Also, producing phytases from the transgenic pig that can decompose the phosphate. It shows that the new molecular biotechnology can really help to decrease the pollution in our environment on the animal husbandry. Furthermore, it cannot only reduce mining the phosphate source but also can prevent the pollution by the following after mining. (Golovan et al, 2001)

### ➤ **Green Energy**

Green energy is a term to describe what is environmental and efficient resources of power and energy. Typically, it means to the renewable and non-polluting energy sources. Green energy includes natural and energetic processes that only within little pollution. Anaerobic digestion, geothermal power, wind power, small-scale hydropower, solar power, biomass power, tidal power and wave power are all under the previous category. For example, methane production from the waste is one type of green energy. Ethanol is a renewable fuel source that can be derived from a variety of biomass sources. In the United States, most fuel ethanol is derived from corn. When corns were produced the ethanol, we can still use their sludge to make the methane by the anaerobic digestion.

### ➤ **Green Production**

To reduce the cost of environmental pollution treatment is the best economic way for the business. By using gene engineering to subvert the bacteria and the function of enzyme is becoming one of popular way of all treatments in modern industry development. Because the enzyme usually was catalyzed at normal temperature, pressure and neutral pH, it does not only synthesize enzyme to reduce the bad intermediates forming, but also reduce the cost of energy and resolve the problem of neutralization with acid from wastewater. Besides the industry production, molecular biotechnology can also apply to reduce the on agriculture and environment. For example, the design of transgenic plants are growing under the specific environmental conditions which have certain agricultural chemicals. All we hope is green biotechnology might help human beings explore more solutions that what the traditional industrial agriculture can't do. An example of this is the engineering of a plant to express a pesticide, thereby eliminating the need for external application of pesticides. An example of this would be Bt-corn. Bt-corn is a type of genetically modified organism (GMO). A GMO might be a plant or animal that has been genetically modified through the addition of a small amount of genetic material from other organisms through molecular bio-techniques. Currently, the GMOs have been given genetic traits to protect pests, tolerance to pesticides, or improve its quality in the modern society. Whether or not, the green biotechnology products are ultimately is considerable issue with debate.

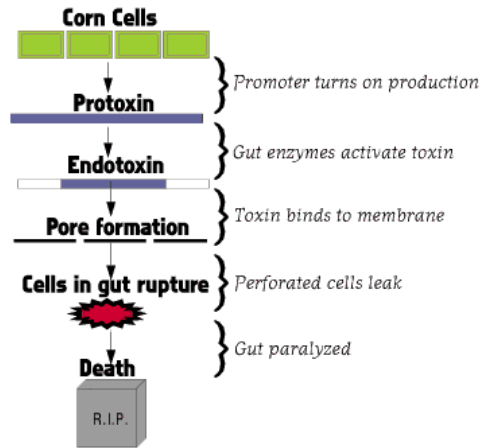
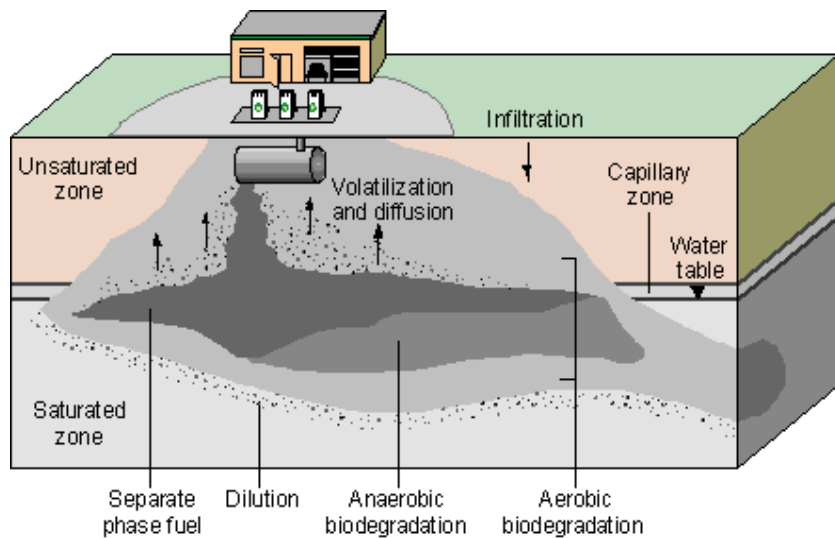


Figure 4. Corn borers may eat a toxic dose of Cry proteins in just a few bites from a Bt corn leaf (K. Ostlie, 2003).

➤ **Natural Attenuation**

Currently, natural attenuation (NA) as well as natural bioremediation or enhanced bioremediation are attractive remediation options for contaminated sites due to their economic and environmental benefit. In general, in situ microorganisms at the contaminated site play a very important role in site restoration. The strategy of using monitored natural attenuation as a remediation involves filing a formal regulatory application to allow natural biological, chemical, and physical processes to treat groundwater contaminants and monitor these processes are effective. In many cases, the feasibility of a natural attenuation strategy depends on whether the regulatory goal is to clean up the contaminant plume targeting at drinking water standards or whether a less stringent, risk-based goal applies, such as preventing the plume from expanding. (EPA, 1997)



Figurer 5. Conceptual illustration of the important natural attenuation processes that affect the fate of petroleum hydrocarbons in aquifers (EPA, 1997)

## EXAMINATION RESPONSIBILITY OF ENVIRONMENT DISPUTES

Before talking about the examination of environment disputes, let me talk about the DNA fingerprinting. What is the DNA fingerprinting? In order to defense the virus invasion, the bacteria will compose the restriction enzyme in the cell to destroy the DNA which came from out of cell. The restricted enzyme is specific, which can recognize the special order of DNA, and stay in the position, which is between the original DNA and cut or broken DNA. Due to the special of restricted enzyme, the sizes and numbers of DNA fragmentary depend on the order of DNA and the type of restriction enzymes. In other words, those different types of DNA fragmentary will have different sizes and numbers after the restricted enzyme have suitably cut or broken. Then, it will form a map after one of the DNA fragmentary did the electrophoresis treatment. We usually call these kinds of maps are DNA fingerprinting. Therefore, DNA hybridization and DNA fingerprinting technology can effectively exanimate DNA from what kind of organisms. Due to this reason, they usually are used for examination the responsibility of environment disputes. There is one famous example in 1993, Milwaukie County, Wisconsin. At that year, there were four hundred thousands of people suddenly felt uncomfortable in a few days, and near one hundred of people died. Acceding to the expertise report was showed those patients drank the polluted water which was infected by *Cryptosporidium parvum*. The city government accused the one meat manufacturer which arbitrarily topples over their waste meat products, and cause the ground water polluted. Hereafter, United State Centers for Disease Control (USCDC) focus on this epidemic situation, and inspect the cows' DNA around the nation. However, USCDC used the DNA fingerprinting technology to analyze, and find the bacteria of this epidemic situation only can be found in the human body's sample. So, it obviously showed that the original pollution wasn't from waste meat products. In order of this DNA result, this meat manufacturer claimed from the city government and Water Company, and then Water Company paid 1.5 million dollars for compromise, and city government was fined hundred thousand dollars for punishment. (Anthony, 2000)

## CONCLUSION

"Digital technology" changing human's behavior; "molecular biotechnology" changing human's lifestyle. After the first structure of DNA was found in 1953, the research of human genome project has already begun in 1990, and the post genomic eras have been started since 2002. The new technique of molecular biotechnology not only can apply on the medical science or pharmaceuticals, but also attribute on the study of environmental protection.

We can understand that the benefits from molecular biotechnology application, such as environmental monitoring and inspecting, pollutant removal, soil and groundwater treatment, molecular nanotechnology, green energy and so on, really make the great changes in our environment and living life.



## <References>

- Kim, Y; Saad, M. G; Nancy, L. S; Tom, p. B., (2002) Comparison and verification of quantitative competitive reverse transcription polymerase chain reaction (QC-RT-PCR) and real time RT-PCR for avian leucosis virus subgroup J. *Journal of Virological Methods*, **102**, 1.
- Wackett, L. P.; Bruce, N. C., (2000) *Environmental Biotechnology Towards Sustainability*. Current Opinion in Biotechnology. Elsevier Science Ltd., 229.
- Tresse, O.; Mounien, F.; Lévesque, M.-J; Guiot, S. (2005) Comparison of the microbial population dynamics and phylogenetic characterization of a CANOXIS reactor and a UASB reactor degrading trichloroethene. *Journal of Applied Microbiology*, **98**, 440.
- Environmental Protection Agency .(1997)Use of monitored natural attenuation at Superfund, RCRA Corrective Action, and underground storage tank sites. Office of Solid Waste and Emergency Response, **9200**,4.
- Peter C. K. LAU; Victor de Lorenzo, (1999) The Frontier of Bioremediation, *Environment Science and Technology*, **33**, 124.
- United States Environmental Protection Agency (EPA), *Environmental Effects of Acid Rain*; <http://www.epa.gov/acidrain/what/index.html>.
- Oberdorster, G., (2004) An Emerging Discipline- Proceedings of International Symposium on Environmental Technology. *Nanotoxicology*, **2**, 234.
- Golovan, S. P. *et al.* (2001). Pigs expressing salivary phytase produce low-phosphorus manure. *Nature Biotechnology*, **19**. 741.
- Anthony, C; Jeffrey, M., (2000), Expanding use of forensics in environmental science, *Environmental Science & Technology*, **34**, 262.
- Sayama K.; Mukasa, K.; Abe, R.; Abe, Y.; Arakawa, H.; (2002) Photocatalytic Water Splitting System into H<sub>2</sub> and O<sub>2</sub> under Visible Light Irradiation Mimicking a Z-Scheme Mechanism in Photosynthesis, Solar Light Energy Conversion Team, Photoreaction Control Research Center, Advanced Industrial Science and Technology, Poster Presentation: [http://www.aist.go.jp/aist\\_e/new\\_research/20011206\\_1/20011206\\_1.html](http://www.aist.go.jp/aist_e/new_research/20011206_1/20011206_1.html)
- Ken Hews-Taylor, (2002) Artificial Photosynthesis, Basic Research in Biomimetic Applications: Multilayer Organic Photovoltaic Cell, *CSIRO*, **4**, 32.
- Bt Corn & European Corn Borer Long-Term Success Through Resistance Management, University of Minnesota, <http://www.extension.umn.edu/distribution/cropsystems/DC7055.html>
- Access Excellence, the national health museum resource center : <http://www.accessexcellence.org/RC/VL/GG/polymerase.html>
- Wikipedia, Fluorescent in situ hybridization: [http://en.wikipedia.org/wiki/Image:FISH\\_%28Fluorescent\\_In\\_Situ\\_Hybridization%29.jpg](http://en.wikipedia.org/wiki/Image:FISH_%28Fluorescent_In_Situ_Hybridization%29.jpg)

- Sinclair T, Toward Total Environmental Sustainability Via Emerging Molecular Nanotechnology:  
<http://www.tainano.com/CCRN/TOWARD%20REAL%20SUSTAINABILITY%20BY%20NANOTECHNOLOGY.htm>