

The New Biotechnologies, Water Quality and Safety Regulation: Impending Issues for the Caribbean

By

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Biotechnology is touted to be
the driving force of 21st
Century Trade and
Development

Biotechnology is very much newsworthy -
Remember Stem Cells, Cloning, GM Foods?



What is Biotechnology?



There are several definitions of biotechnology, for example:

- It is the application of scientific and engineering principles to the processing of materials by biological agents to provide goods and services
- The use of various techniques by humans to modify plants, animals and their products for desired traits or "value"

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The Scientist

- Aug. 23, 2005 DAILY NEWS
- **German candidates debate science**
- *Education and research minister reverses herself on stem cell law and criticizes potential successor*
- By Ned Stafford
- In an indication that scientific research has become a major issue in Germany's national elections next month, Federal Education and Research Minister Edelgard Bulmahn has reversed previous statements and signaled her support for amending Germany's strict human embryonic stem cell law. She and others in her left-of-center SPD party, headed by Chancellor Gerhard Schroeder, also sharply attacked the qualifications of Annette Schavan, who main opposition chancellor candidate Angela Merkel has pegged to become education/science minister if she defeats Schroeder in the September 18 election.

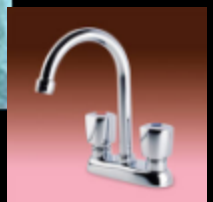
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Biotech-News!

BBC NEWS

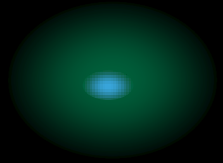
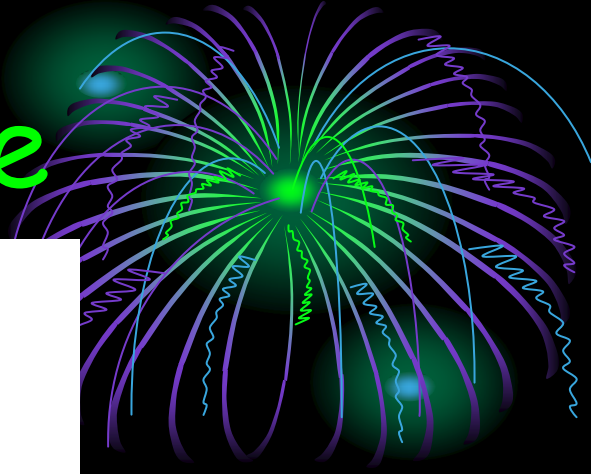
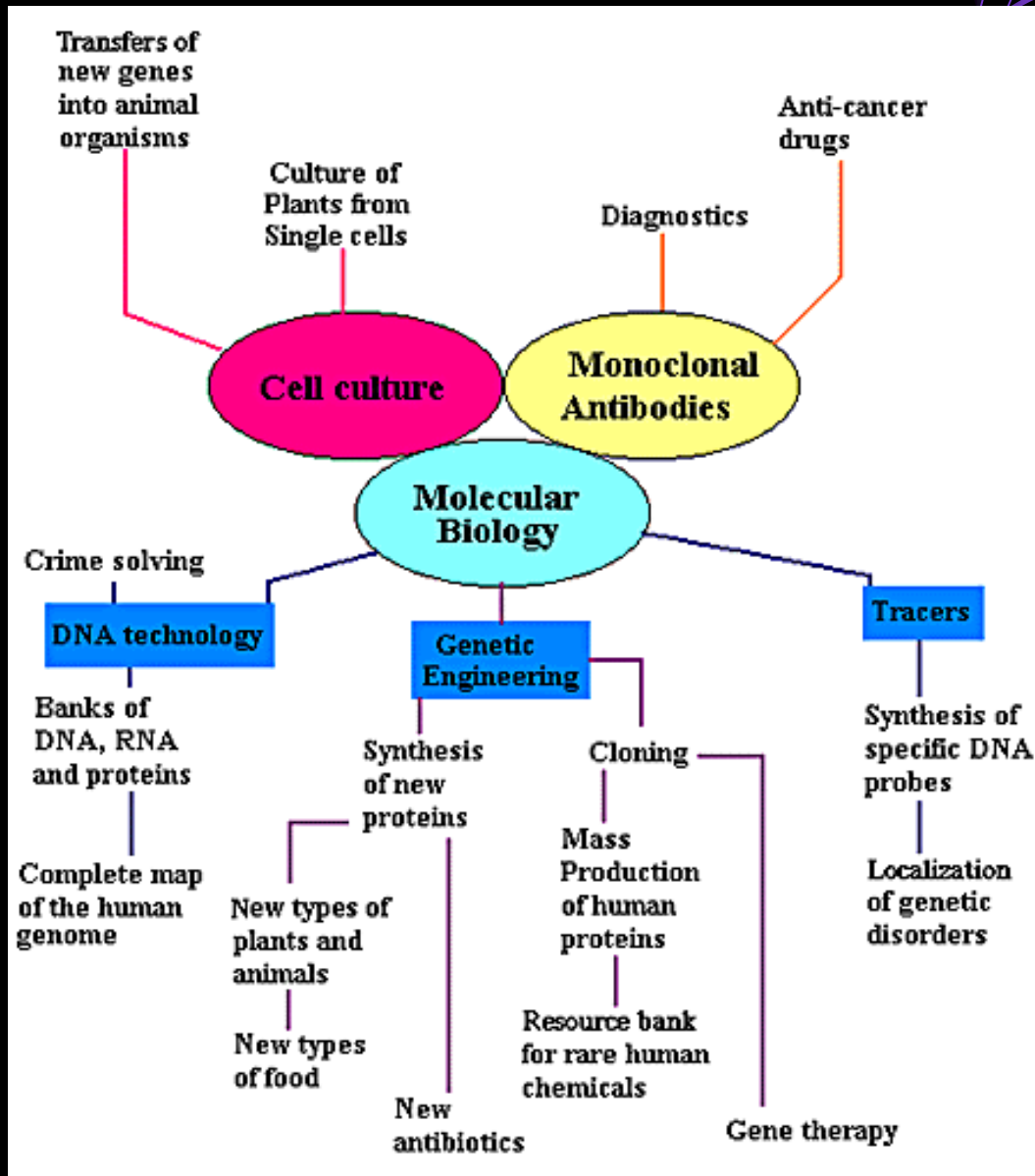
Tuesday, 23 August 2005, 10:37 GMT

- **Step towards making human lungs**
- **Scientists say they have made a significant step towards making human lungs for transplantation.**
- **The UK team at Imperial College London took human embryonic stem cells and encouraged them to grow into cells found in adult lungs.**
- **These lung cells are the type needed to allow oxygen to cross into the blood.**

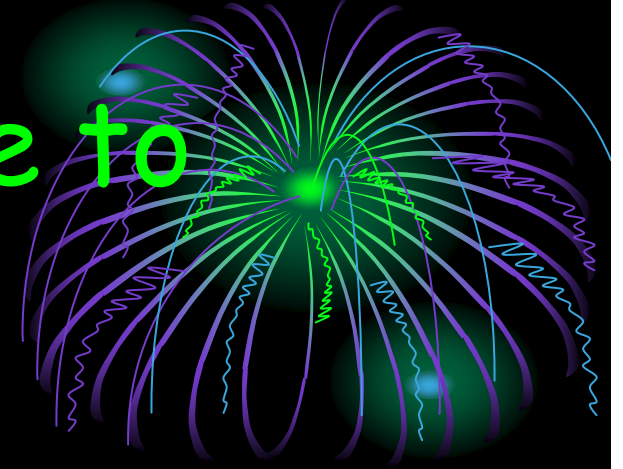


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Biotechnology Promise



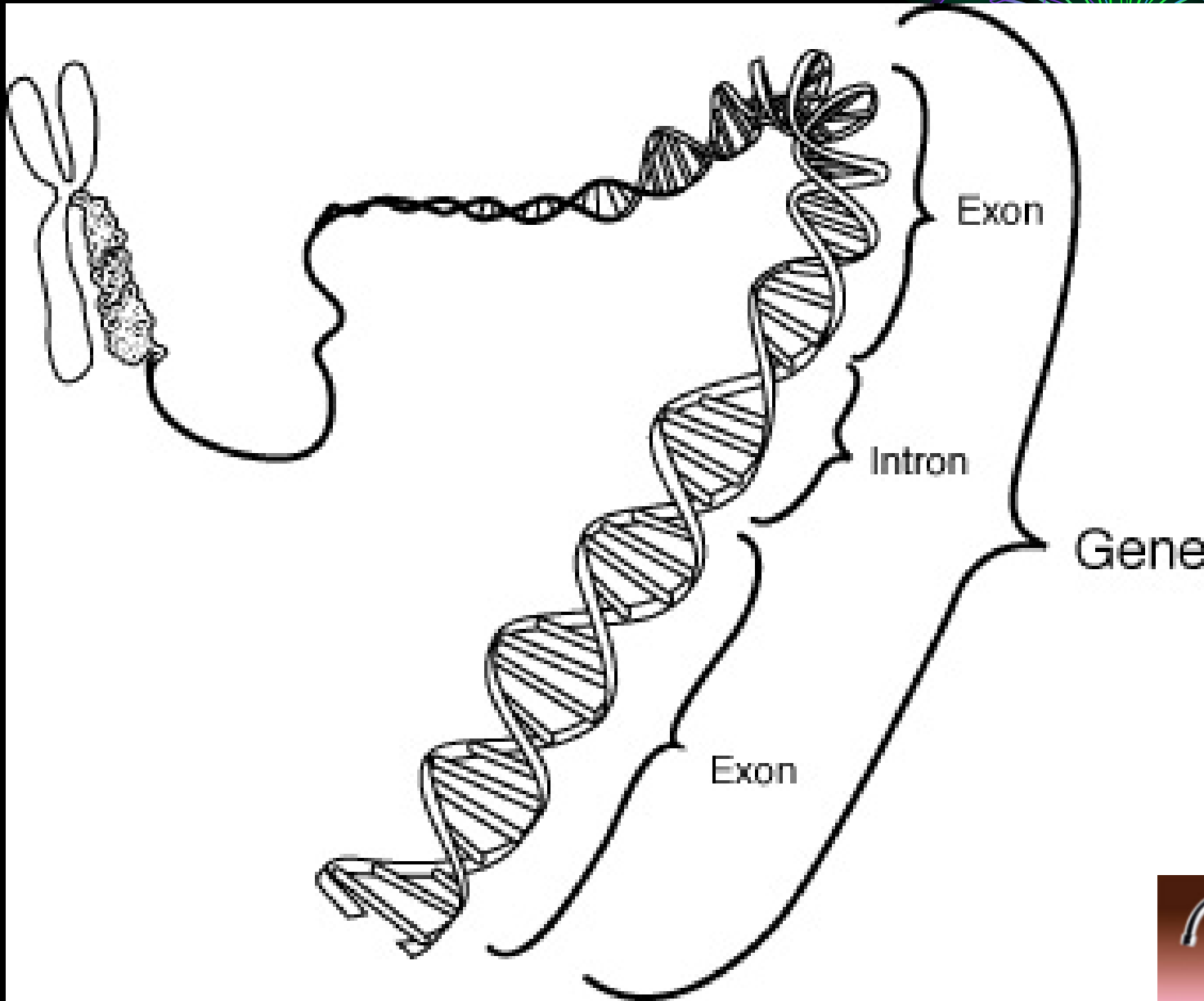
Reducing high science to basic definitions



- **Low biotechnology** –
breeding, fermentation, cheese making
- **High biotechnology** = Modern biotechnology -
Genetic engineering e.g. isolation and
insertion of the human hereditary material
[= gene =portion of DNA] responsible for
insulin production into bacteria which then
become programmed to produce insulin
outside the human body!

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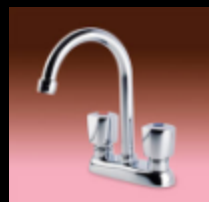
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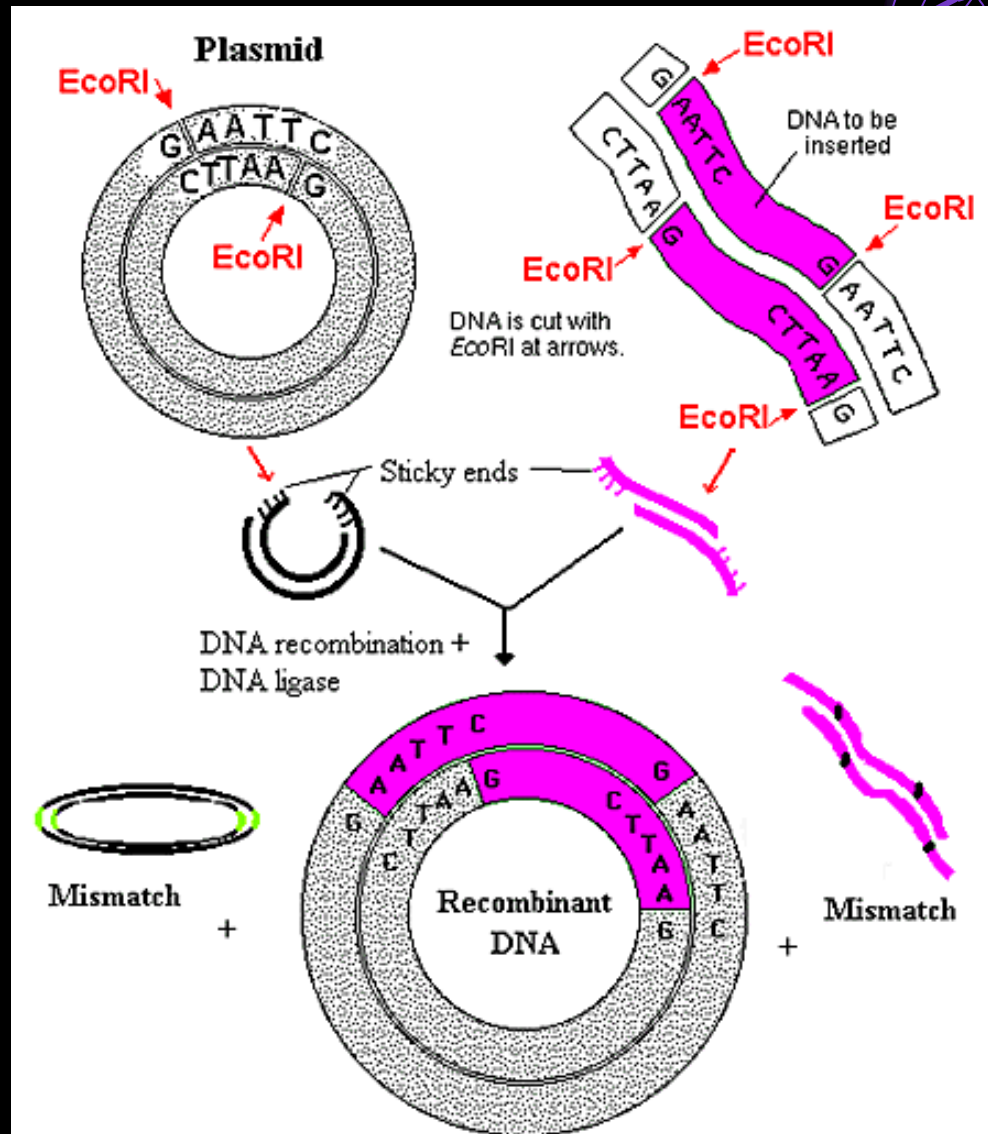
Reducing high science to basic definitions



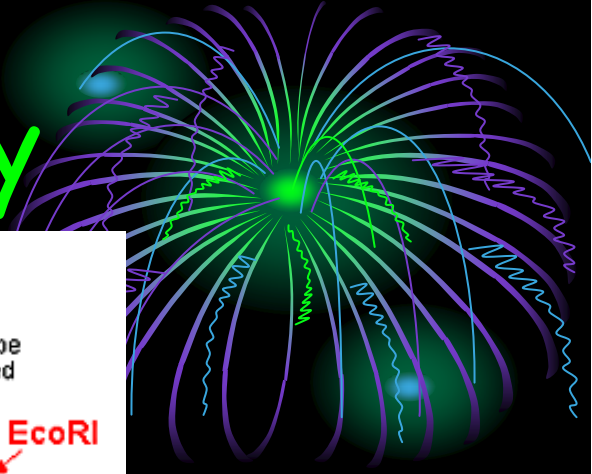
- Organisms produced from the application of "modern biotechnology" methods are called *GMOs* [=genetically modified organisms] or *LMOs* [=living modified organisms] or *GE organisms* [=genetically engineered organisms]

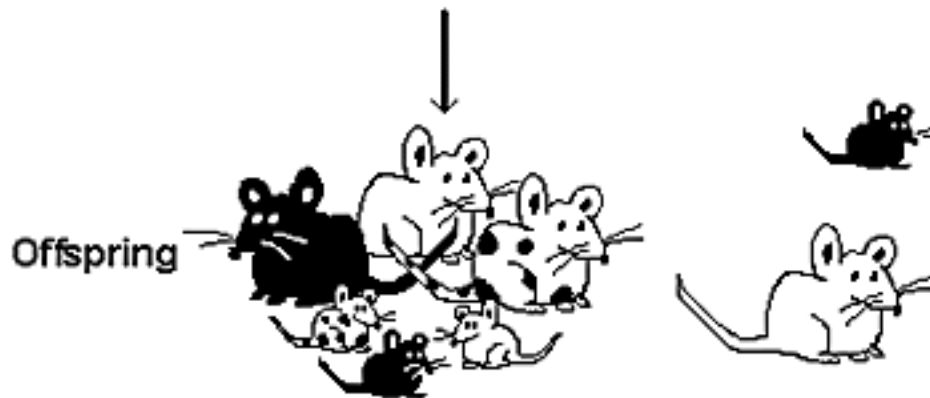


Modern Biotechnology



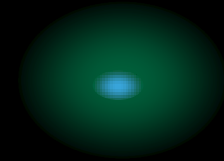
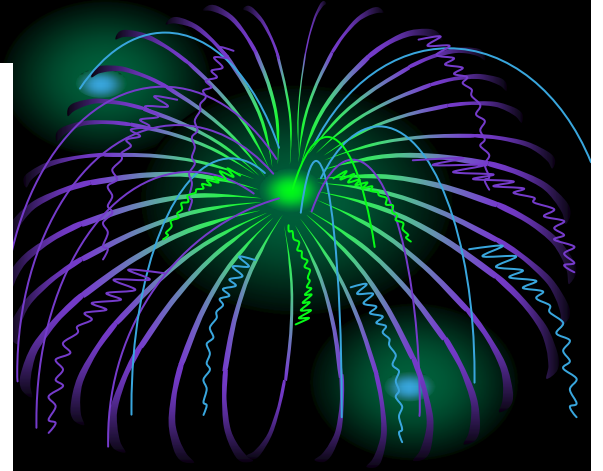
Inserting a DNA Sample into a Plasmid





Transgenic Mice

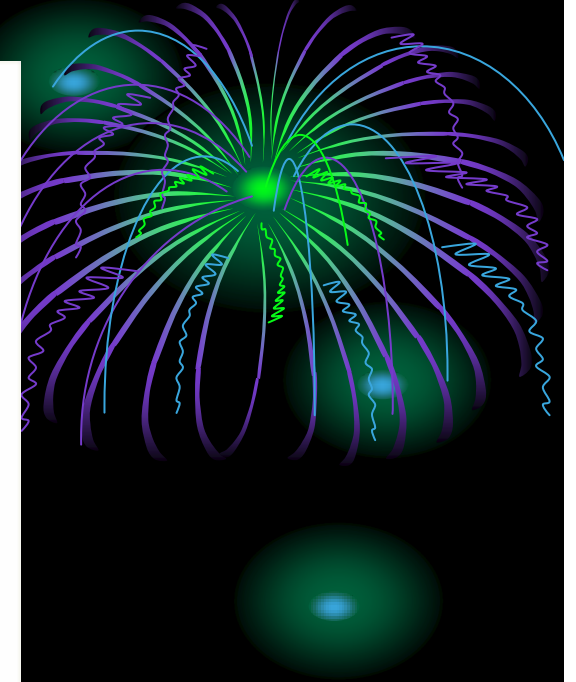
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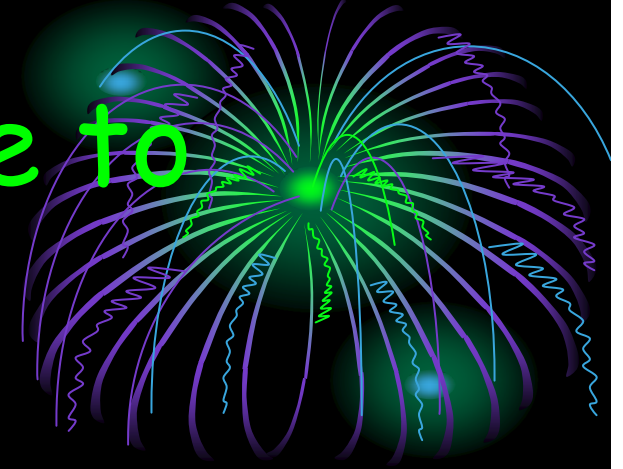


We're out of eye of newt...How 'bout some
sonicated salmon sperm and a little β -ME?

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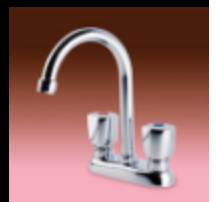


Reducing high science to basic definitions



- Foods derived from GMOs are referred to as GM foods
- For example corn syrup made from genetically modified corn with inserted *Bacillus thuringiensis* gene for the synthesis of biopesticide to kill the corn stem borer insect

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Reducing high science to basic definitions



- GMOs/LMOs are referred to technically as TRANSGENICS [=organisms derived from the hightech transfer of genes]



Transgenic soybean

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Transgenic food crops under field trials in developing countries



Beans

Cabbage

Cauliflower

Chili

Maize

Melon

Mustard

Papaya [=pawpaw]

Peanut

Pepper

Potato

Rape [=Canola]

Rice

Soybean

Squash

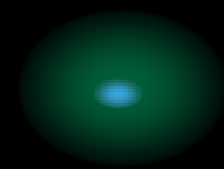
Strawberry

Sugarcane

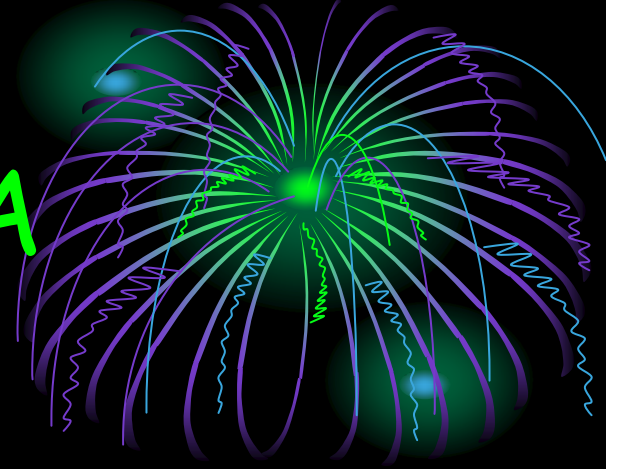
Sweet potato

Tomato

Wheat

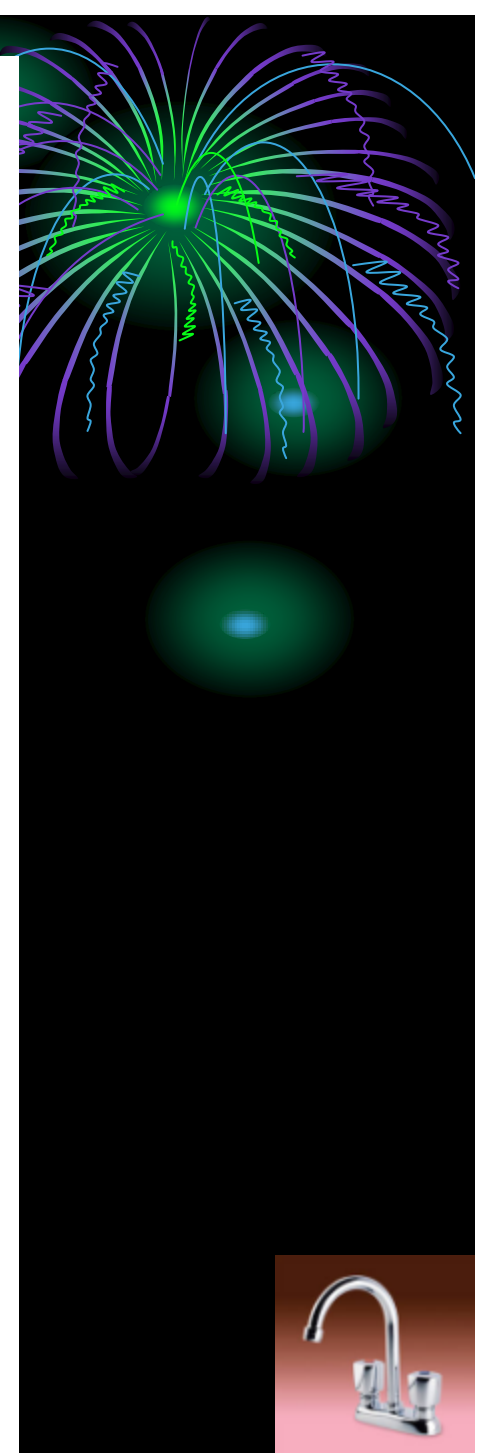
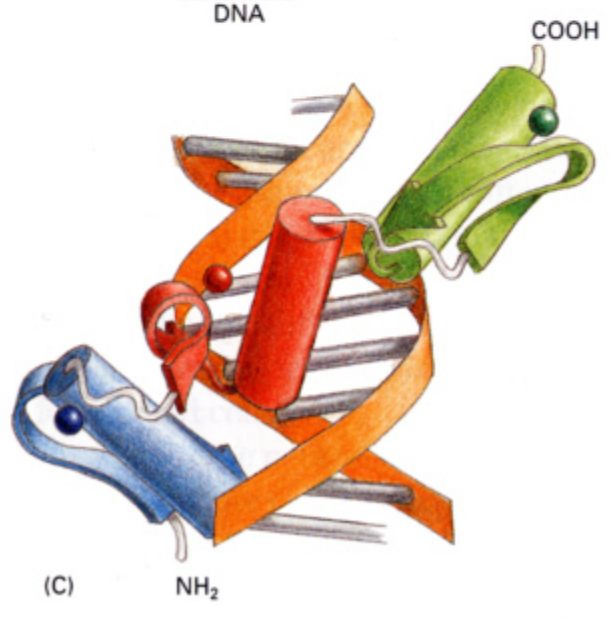
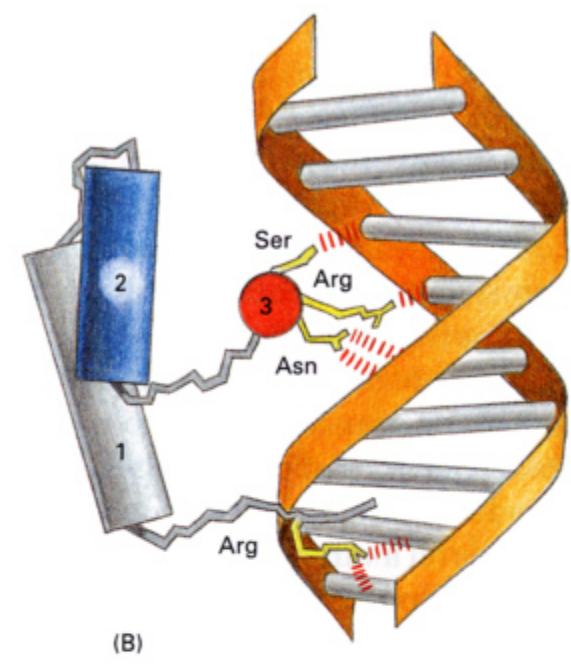
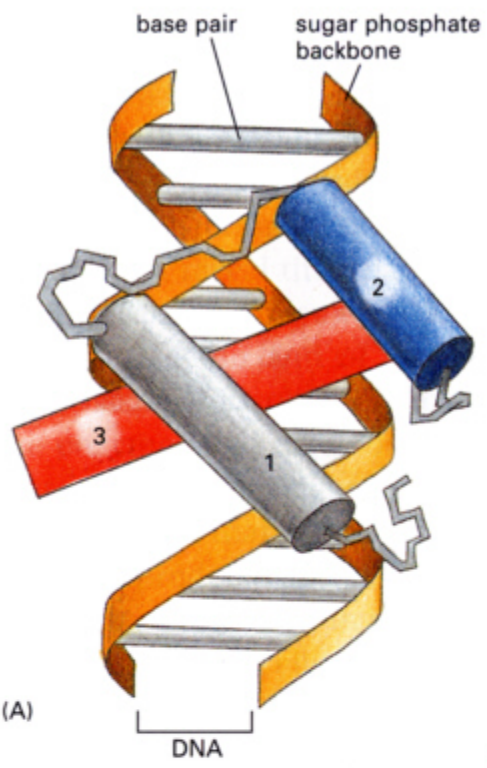


Basics of DNA



- "DNA makes RNA, RNA makes protein, and proteins make us." Francis Crick

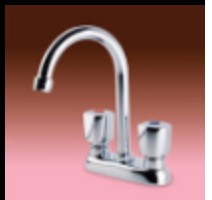




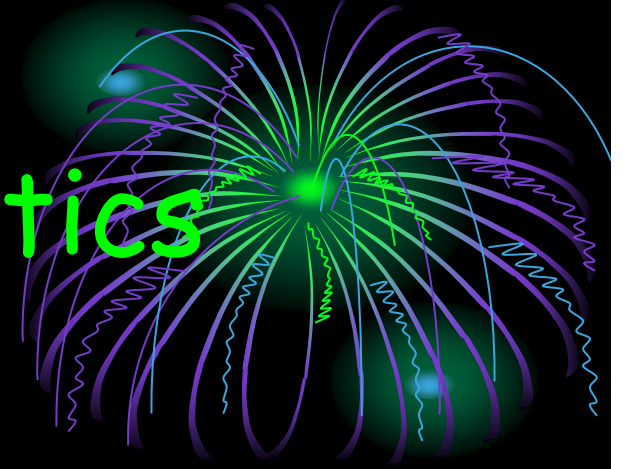
Basics of DNA Recombination



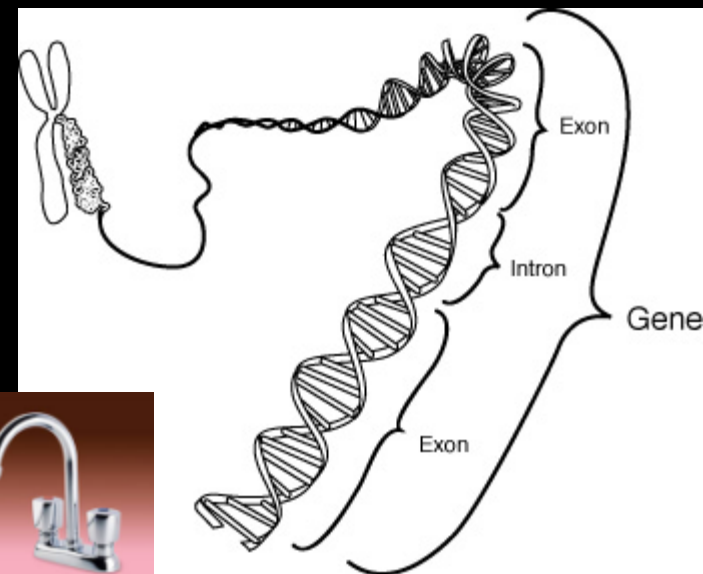
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Blood Type Genetics



OO = blood type O
AO = blood type A
BO = blood type B
AB = blood type AB
AA = blood type A
BB = blood type B



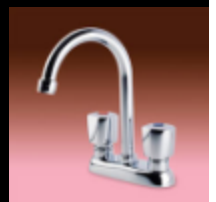
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Biotechnology Applications



- Agricultural Biotechnology
- Medical Biotechnology
- Industrial Biotechnology
- Environmental Biotechnology

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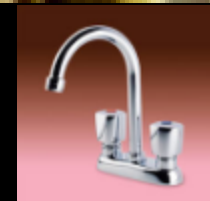
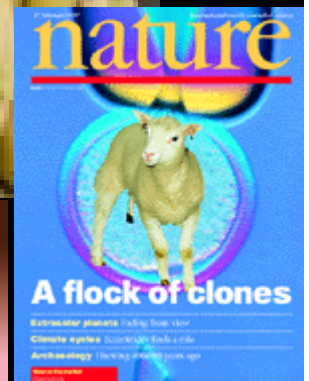


Agricultural Biotechnology



GE for better crops

- Less pesticide use
- More nutritious foods
- Less post-harvest losses
- Higher yields to feed the poor
- Acid soil-resistant crops, etc.



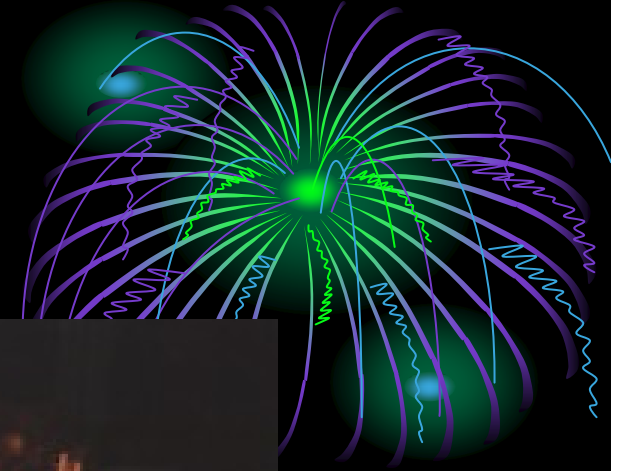
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Examples of Agricultural Biotech Products

- Viral resistance in rice (e.g. to rice yellow mottle virus), cassava, papaya, sweet potatoes, pepper
- Nematode resistance in various cereal and other (e.g. banana) crops
- Terminator gene technology (suicide seeds)
- Frost tolerance (gene from the Arctic flounder fish into strawberry, sugar beet, tomato, and potato)

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- Bio-Pharming - crops and animals 'pharmed' to produce pharmaceuticals (e.g. sheep and pigs* modified to produce human proteins in their milk, such as insulin, interferon, and the human blood clotting protein factor 8;
- Rice modified to produce alpha-antitrypsin, a protein valuable for treating liver disease and haemorrhages).

*Bioethical issue - religion - - Islam and pigs!

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Medical Biotechnology



Top 10 biotechnologies;

- Molecular diagnostics
- Recombinant vaccines
- Vaccine & drug delivery
- Bioremediation
- Sequencing of pathogen genomes
- Female-controlled protection against STDs
- Bioinformatics
- Enriched GM crops
- Recombinant therapeutic proteins
- Combinatorial chemistry

- ***Gene Therapy (2005)***

12, 1313–1323. doi:
10.1038/sj.gt.3302530; published
online 28 April 2005

- **Efficient gene delivery to human and rodent islets with double-stranded (ds) AAV-based vectors**

- K K Rehman¹, Z Wang¹, R Bottino², A N Balamurugan², M Trucco², J Li¹, X Xiao¹ and P D Robbins¹

- ¹Department of Molecular Genetics and Biochemistry, University of Pittsburgh School of Medicine, Pittsburgh, PA, USA

- ²Department of Pediatrics, Division of Immunogenetics, University of Pittsburgh School of Medicine, Pittsburgh, PA, USA

Industrial Biotechnology

- Biobased plastics - bioplastics
- Sweetener production
- Vitamin production
- Biopolymers for automobile parts
- Pharmaceuticals
- Bioethanol for transportation
- Enzyme food processing aids
- Biological fuel cells

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Environmental Biotechnology

- Bioremediation
- Environmentally-friendly bioextraction of precious metals
- Biodegradable biopolymers for plastic packaging

These have significant impact on Caribbean biotrade and competitiveness.

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GMO Hysteria/concerns



- Exaggeration of genetically engineered freaks
- Potential for risks resulting from unintended GE products likely
- Ecological Analogies from invasive species-induced evolutionary trends (Mooney & Cleland, 2001)

Genetic Contamination Impacts of Invasive Species



- Evolutionary response
 - Case of seed shape and colour of weed species in response to human activities
 - Rice mimic *Echinochloa crus-galli* (Harlan, 1965)

Similar trends occur even faster with micro-organisms, including those we monitor for water quality and safety assurance. Intrusion of GM microbes!

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Genetic Contamination Impacts of Invasive Species

- Hybridization & introgression

- Mallard ducks, *Anas platyrhynchos*, and large genetic effects on (Rhymer & Simberloff, 1996):

- New Zealand gray duck, *Anas superlisisosa superlisisosa*

- Florida mottled duck, *Anas fulvigula fulvigula*

Similar phenomenon occur much faster with microbes including those of water quality importance!

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Genetic Contamination Impacts of Invasive Species

- New taxa (forms of organisms) through hybridization & introgression:
 - *Helianthus annuus* x *Helianthus debilia* = *H. annuus texanus* = A new subspecies!! (Abbott, 1992 Trends in Ecology & Evolution)

New Bacterial strains emerge within several hours - the basis for antibiotic resistance!

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Genetic Contamination Impacts of Invasive Species

Indirect evolutionary impacts of mixing

- Competitive exclusion
- Extinctions
- Mutualisms

– Mooney & Cleland (2001)



There is reasonable probability GMOs could have similar ecological/evolutionary impacts in the long-term. Hence the precautionary principle and case-by-case risk assessment, bioconfinement, etc. - the essence of the Biosafety Protocol

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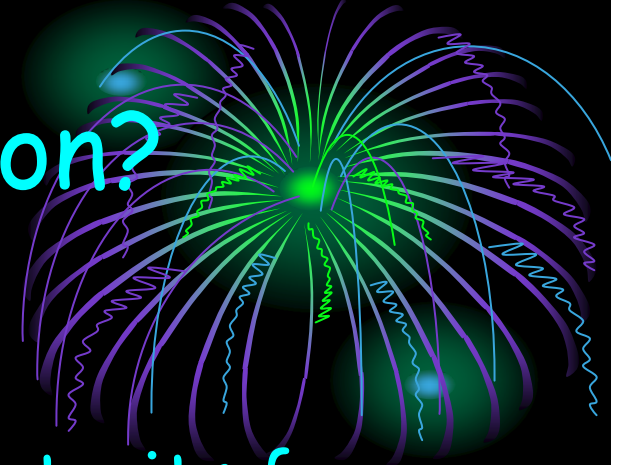
Ecosystem side effects of human activity (Western, 2001)

- Loss of soil organisms
- Invasive non-homogenous species
- Side effects of fertilizers, herbicides, insecticides - most importantly possible deleterious GM-derived types
- Genetic loss of wild & domestic species
- New and virile infectious diseases

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What is Genetic Pollution?



- Unintended transfer of genetic traits from genetically modified organisms to wild relatives and impacts on food webs and ecosystem dynamics - biodiversity & ecosystem health
- Contamination of biodiversity and ecosystems by undesirable and possibly deleterious genetic traits or reconstituted genes derived from transgenic organisms

Transgenics and potential Genetic Pollution

- Mexico - the centre of origin of maize - local races and wild teosintes
- Possible consequences of the persistence of transgenes after gene flow

- Mexican - Oxapaca GMO maize vs wild relative gene transfer controversy



Benchmarking Biopollution and the Mechanisms of Biodiversity loss?

1. Pollution of soil, water and atmosphere
2. Global climate change
3. Industrial activities, agriculture & forestry



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What is Biosafety?



Efforts or mechanisms used to reduce and eliminate the potential risks/harmful effects of biotechnology to the environment and human health while ensuring the environmentally sound application of biotechnology for the benefit of human welfare.

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Biotechnology and Convention on Biological Diversity



Article 16(1) of the Convention articulates the recognition and basis for the "access to and the transfer of [biotechnology] among Contracting Parties as essential elements for:

- attainment of the Convention's objectives
- technology transfer
- conservation of biodiversity
- sustainable use of biodiversity
- use of genetic resources
- do not cause significant damage to the environment



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Cartagena Protocol on Biosafety

- The Protocol is a supplementary agreement to the Convention on Biological Diversity
- Adopted on January 29, 2000
- Enshrines the "precautionary approach" as a principle of international environmental law
- Places environmental issues on par with international trade-related issues
- Establishes information sharing mechanisms
- Establishes capacity building mechanisms for countries to meet their obligations
- Provides mechanisms for assistance to countries for its implementation

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What next?

"Biotechnology has emerged as one of the methods that can be used to address health and other challenges in developing countries. The realization of this potential, however, depends on a diverse set of policy measures aimed at translating scientific discoveries into goods and services" - Juma & Yee-Cheong

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GMOs & Water? So What?



- Water is a human right
- Water is a social good
- Must have access to minimum 30-50 litres high quality per day
- Price must be affordable

– Zehnder et al.(2003) *Aquatic Science*



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GMOs & Water? The Link

Classification of Water use (OECD, 2005):

- Domestic
- Agricultural
- Industrial
- Environmental

Agriculture accounts for 65% globally. In LDCs it accounts for 80 - 90%.

Vast majority of Genetic Engineering products are agriculture-based.

Therefore agricultural contaminants of water resources impinge on water quality beyond the traditional standards of water quality today.



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Resistance of Enteric micro-organisms to disinfectants [OECD, 2005]

Disinfectant

- Chlorine
- Ozone
- Ultraviolet light
- Sunlight
- Heat

Most resistant pathogen

Cryptosporidium parvum

& Helminth ova (worm eggs)

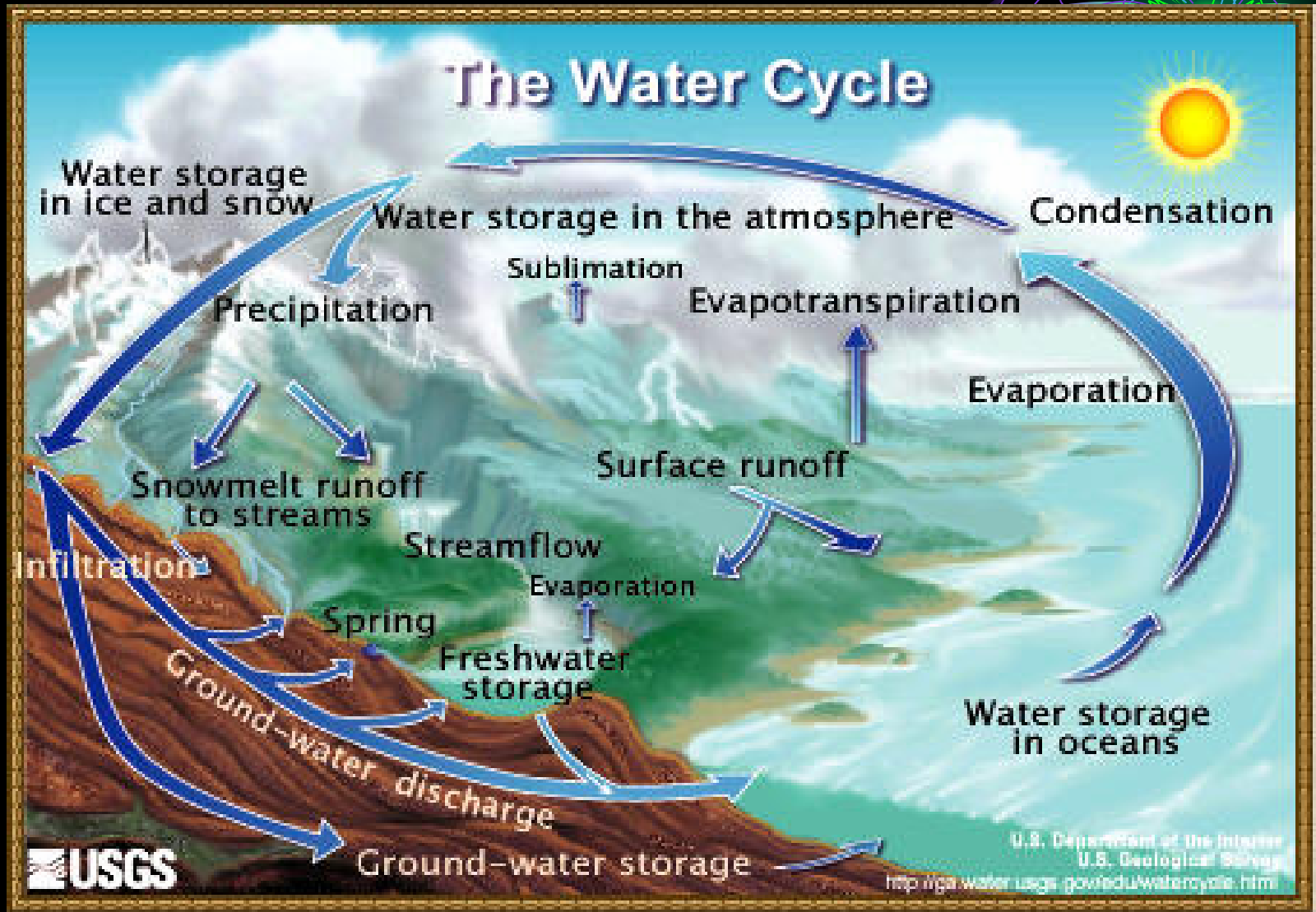
C. Parvum cysts & worm eggs

Adenovirus

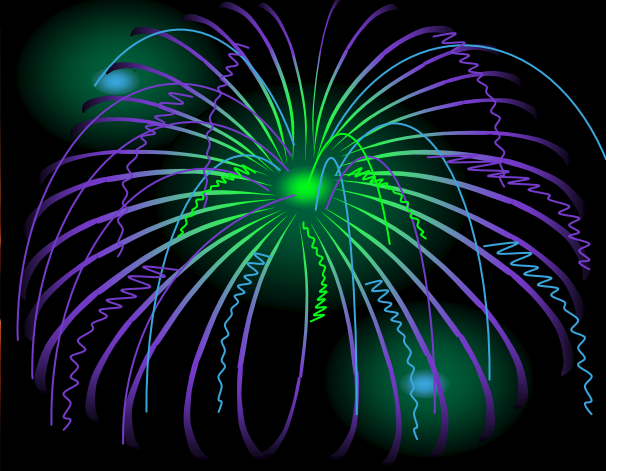
Enteric viruses

Hepatitis A virus


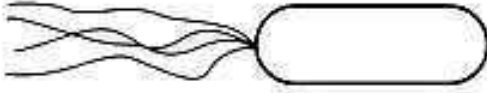
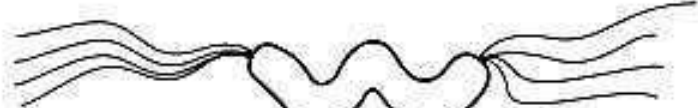
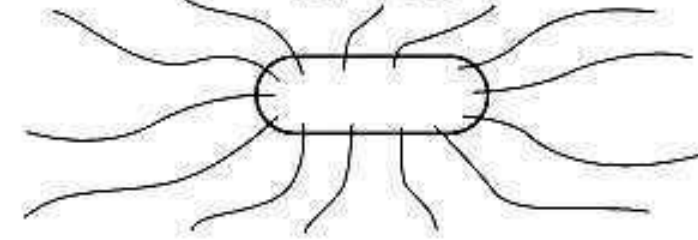




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E. Coli and *Enterobacter aerogenes* *Bacillus subtilis*

Structure	Flagella Type	Example
	Monotrichous	<i>Vibrio cholerae</i>
	Lophotrichous	<i>Bartonella bacilliformis</i>
	Amphitrichous	<i>Spirillum serpens</i>
	Peritrichous	<i>Escherichia coli</i>

Emerging evidence

- Fecal indicator species such as *E. coli* and *Streptococci* may not directly correlate with the presence of pathogens [Applied Environmental Microbiology 2001 & Environmental Science & Bio/Technology 2002]
- Bio-monitoring of oestrogens using recombinant yeast engineered with the human oestrogen receptor (hER) gene
Linking the "oestrogenic mimickry" of metabolites

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Emerging evidence



- Cyanobacteria (bluegreen algae) and cyanotoxins - Acute liver failure - the "Carauru Syndrome"
- Possible bio-pollution of water-borne infectious organisms?
- Lessons from SARS/Avian Flu, *E. coli* 0157:H7 and *Legionella*



Impending Issues for Regulation of Water Quality in the Caribbean



- Water Safety Management policy/plans [which take GM contamination of water-borne microbes into account]
- Water Quality & Safety Assessment
- Trade policy versus - WTO, CSME
- Biotechnology policy
- Biosafety policy
- Health policy



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"Drinking water is tested for the presence of E. coli and related bacteria not because these bacteria are dangerous but because they are an indication of contamination by sewage, and sewage may contain organisms (e.g., Salmonella, hepatitis A virus) that are dangerous."



Issues for Regulation of Water Quality in the Caribbean

- Potential Checklist

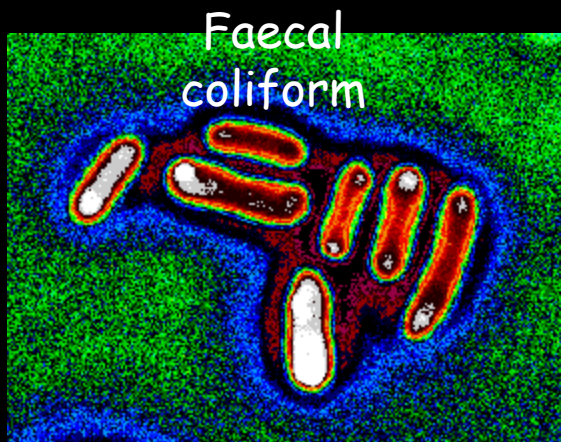
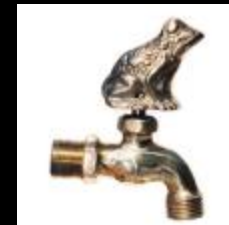
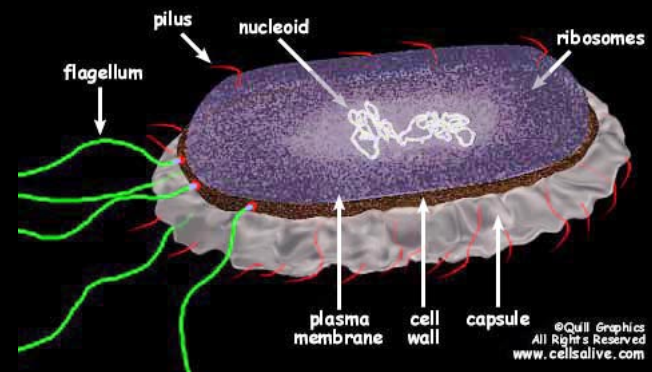
- Industrial policy
- Poverty alleviation policy
- Global threats & security - national policy
- Regulatory governance
- National Development policy/strategy
- Research priorities policy

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Issues for Regulation of Water Quality in the Caribbean

- Scope
- Capacity
- Needs
- Trade-offs
- Public perception



Faecal coliform

©James A. Sullivan www.cellsalive.com

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Perceptions

1st year 2004-2005 biology class

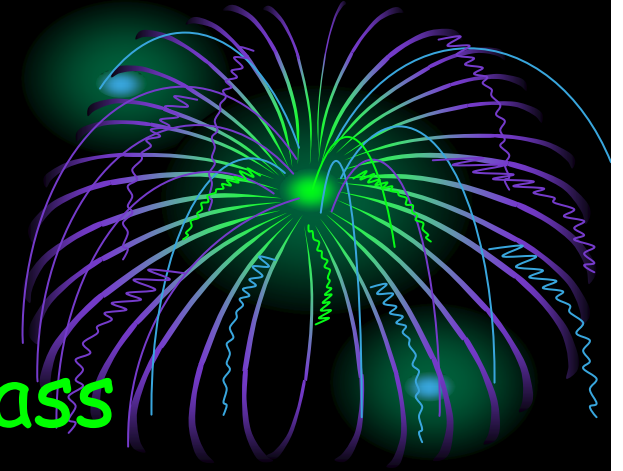
Would you eat GM foods if it would help prevent illness - e.g. cancer, heart disease?

- YES 89.8%
- NO 10.2%

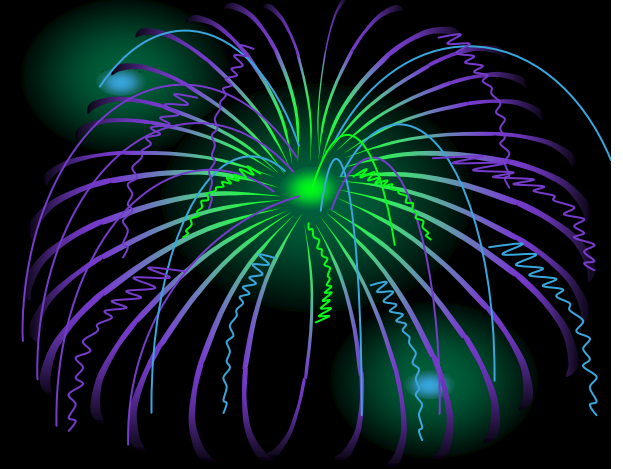


*Rhodospirillum
rubrum*

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Perceptions



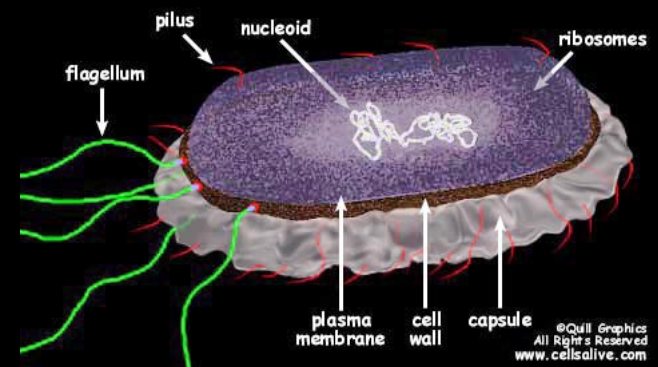
Do you think there are health effects involved with eating GM food?

YES 61%

NO 10%

DON'T KNOW 19%

Similar responses emerge for drinking water contaminated with GM microbes



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Some notes

- The Caribbean can positively exploit biotechnology for sustainable human development
- The precautionary approach, judiciously applied with a case-by-case GM water contamination impact assessments relevant
- Molecular methods of water testing
Capacity building and leveraging from sister CARICOM countries necessary

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More views

- Draft policy developed through NBF project is a very important start
- Development & Harmonization of water safety plans/policies with those of CARICOM countries relevant because of CSME, FTAA and WTO and related SPS
- Regional policies must be coherent but must demonstrate enough plasticity to ensure strategic national interests are recognized and assured without jeopardizing regional harmony, without undermining minimum basic water quality & safety standards

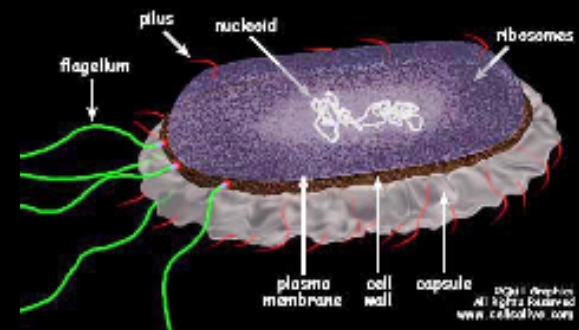


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More views

- Need for establishing a regional Water Safety Plan/Policy within the OOCUR framework to harmonize national interests in the context of the *Caribbean Single Market and Economy* [CSME]
- Need for strengthening regional sister institutions for servicing less endowed countries



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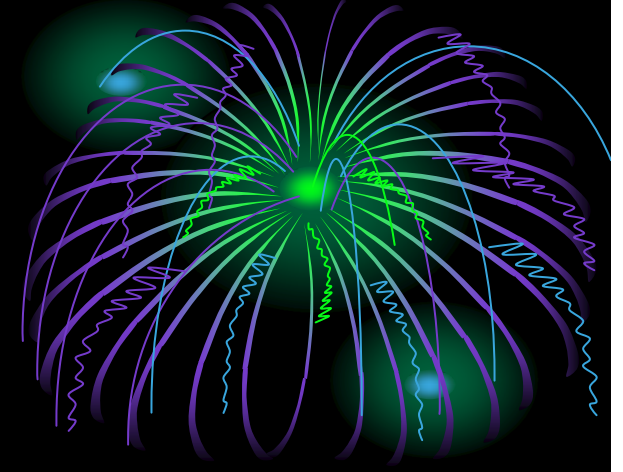
I hope You have had a Unique & Dynamic Regulatory Insight



**Worm gonads!...I've spent the last four years
studying worm gonads...**

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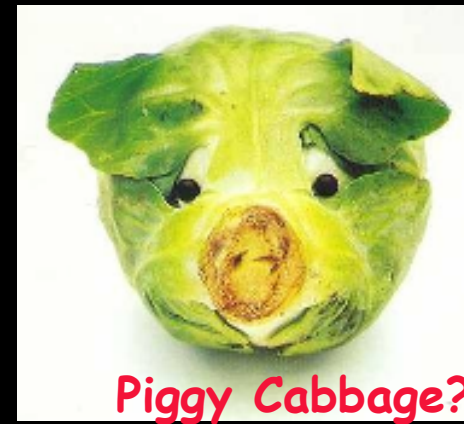
Thank you



Birdie Lettuce pepper?



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Piggy Cabbage?