Inspiring Excellence: Engaging students in meaningful science experiences

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Maintaining a High Quality of Life

How do we prepare Canadian youth for jobs and citizenship demands of the next 50 years?

Growing Importance of STEM

Increasingly, jobs and citizenship demands have STEM connections.
(STEM = science, technology, engineering and math)

Canada's Global Rankings:

1st – college education (includes CEGEP)
8th – university education (down from 4th in 2009)
20th – Proportion of undergrad degrees in science & engineering *(OECD Scorecard 2009)*
15th – Proportion of doctoral degrees in science & engineering (up from 25th in 2009)
OECD Scorecard 2012

70% of Top Jobs need STEM

1. Top-paying jobs in Canada	2. Top starting salaries	3. Canada's top jobs	4. U.S. top jobs	5. Jobs of the future	6. Career satisfaction	7. Recession-proof careers	8. Most respected occupations
Specialist physicians $179,514	Doctor $100,000	Oil and gas drilling supervisor	Dentist	Mining, oil & gas supervisor	Real estate agent	Computer software engineer	Nurses/doctors (tied)
Judge $178,053	Dentist $90,000	Head nurse and health care manager	Registered nurse	Pilot	Senior quality assurance engineer	Veterinarian	Farmers
Senior managers – communications, financial and other business services $162,376	Petroleum engineer $86,200	Petroleum engineer	Pharmacist	College instructor	Senior sales representative	Financial analyst	Scientists
Senior managers of goods production, construction, utilities, transportation $160,947	Data security analyst $83,250	Electrical and telecommunica-tions contractor	Computer systems analyst	Railway & transportation supervisor	Construction superintendent	Database administrator	Veterinarians
General practitioner and family physician $132,615	Lawyer (first-year associate, large firm) $81,750	School principal and administrator	Physician	Power systems operator	Senior application developer	Dental hygienist	Dentists
Dentist $131,552	Website developer/ user experience designer $80,000	Lawyer	Database administrator	Health care managers	Logistics manager	Forensic science technician	Teachers
Senior managers of trade, broadcasting and other services $124,080	Mobile applications developer $72,500	Real estate and financial manager	Software developer	Education administrator	Construction manager	Mental health counsellor	Engineers
Lawyer $123,632	Chemical engineer $72,407	Senior government manager	Physical therapist	Head nurse	Executive admin-istration assistant	Performance makeup artist	Military officers
Engineering manager $113,403	Financial controller $70,000	Chemical engineer	Web Developer	Railway conduc-tor & brakemen/ women	Network engineer	Skin care Specialist	Architects
Credit, investment, banking manager $101,845	Lawyer (first-year associate, midsize firm) $64,000	Aerospace engineer	Dental hygienist	Dental hygienist	Assistant controller	Personal and home care aide	Police officers

Surprising STEM Requirements

Program/Career	Course Requirements/ Prerequisites	Also Known As...
Acting for film and television	Introduction to arts and science	Science
	Electronic media	Computer technology
Dance	Anatomy	Biology
Chef/baker	Nutrition	Biology and chemistry
	Math foundations and hospitality math	Mathematics
	Fermentation theory and application	Chemistry
Carpenter	Estimating and planning	Mathematics
Welder	Trade math	Mathematics
	Production and properties of metals	Chemistry
Esthetician	Anatomy and physiology	Biology
	Diseases/pharmacology	Biology and chemistry
	Epidemiology	Mathematics
	Nutrition	Biology and chemistry
Journalism	Quantitative research methods	Science and mathematics
	Digital design	Computer technology
Fitness/health promotion	Anatomy and physiology	Biology
	Nutrition	Biology and chemistry
	Business management	Mathematics and computer technology
Industrial design	2D/3D modeling	Mathematics
	Quantitative research methods	Science and mathematics
	Computer aided design	Computer technology
Crime scene investigator	DNA analysis	Biology and chemistry
Agriculture/agribusiness	Genetics	Biology
	Nutrition	Biology and chemistry
	Plant and soil science	Biology and chemistry
	Farm management	Science, mathematics and computer technology
Computer animation	Anatomy and biomechanics	Biology and physics
	Computer science	Computer technology
Early childhood education	Health, safety and nutrition	Science
Business administration/ retail management	Mathematics of finance	Mathematics
	Accounting	Mathematics
	Business economics	Mathematics
Weather forecaster	Understanding weather	Science
	Climate change	Science
	Atmospheric chemistry	Chemistry
	Cloud physics	Physics

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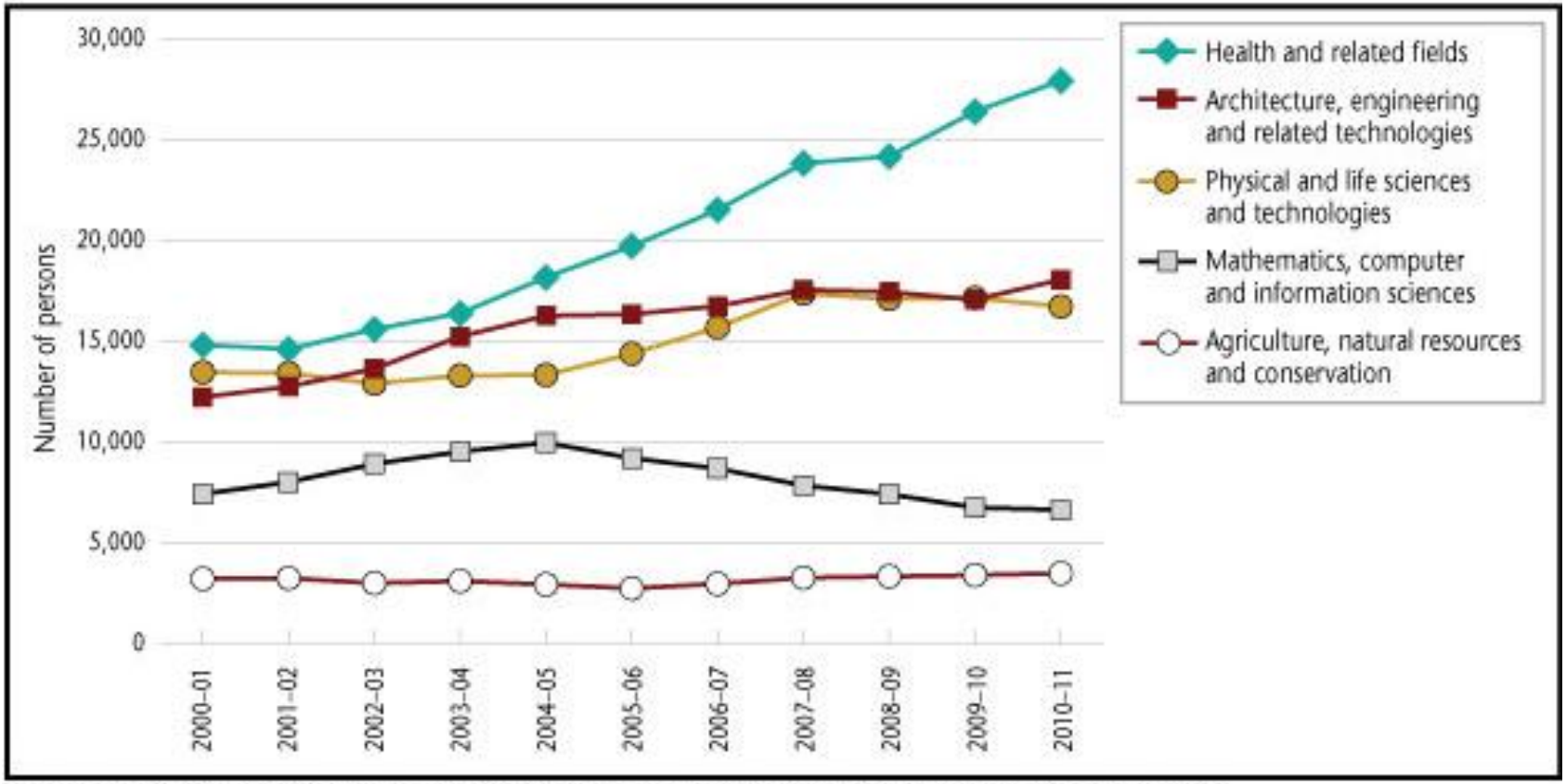
University STEM graduation rates have increased

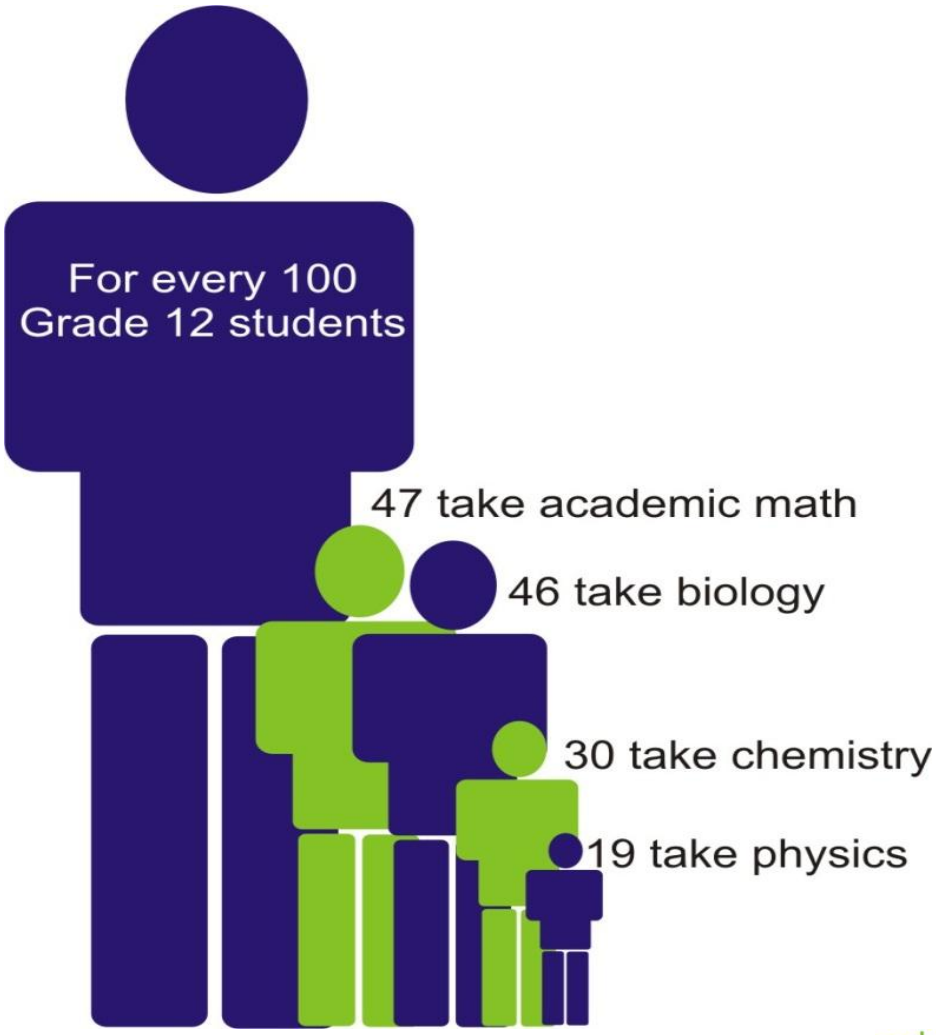
Graduates from Canadian University Undergraduate and Master's level STEM programs



Source: Statistics Canada, CANSIM Table 477-0020 (Post-Secondary Student Information System), February 2013.

(Figure taken from 2013 Science, Technology, Innovation Council report)

But many students are still not engaged



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Barriers exist

- perceived lack of relevance; unclear pathways
- lack of role models; negative image of scientists
- lack of awareness of careers
- teachers, school resources, curriculum
- parents

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Let's Talk Science programs address barriers

Connecting volunteers with youth in Preschool-Grade 12

let's talk science outreach

Competitive event for Grades 6-8

let's talk science CHALLENGE

Web-based program Grades 8-12 students and educators

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Early learning resources and training for educators

IDEAPARK NEW
A FOREST OF EARLY LEARNING RESOURCES

Panel: explore effective ways to engage youth in STEM

- Michael Dixon
- Mike Spear
- Paul Cassar
- Amanda Naaum
- Tawsha Murray

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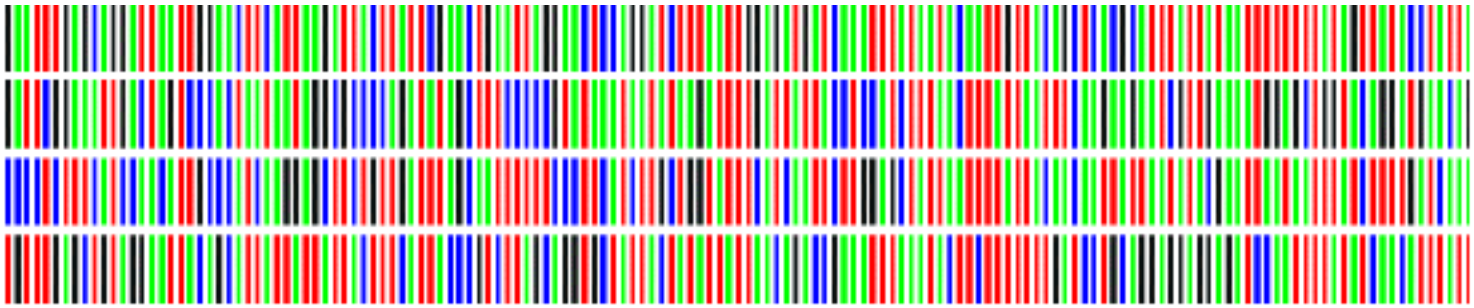
DNA Barcoding
Barcode of Life



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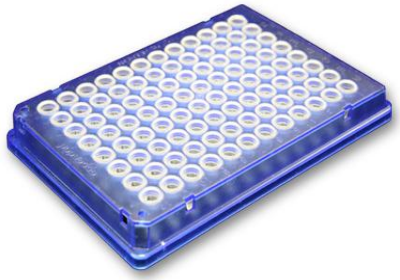
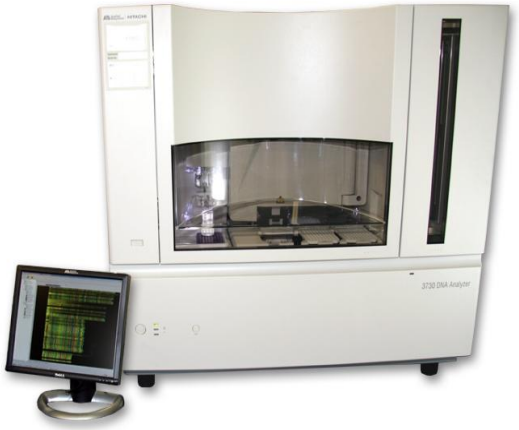
Molecular Biology

Extract DNA → PCR Amplify → Sequence





DNA Barcoding

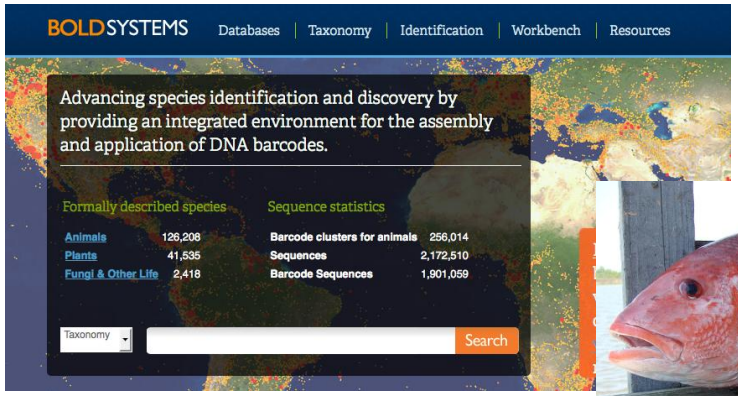
Specimen

Tissue Sample

Extract DNA

PCR Amplify

Sequence



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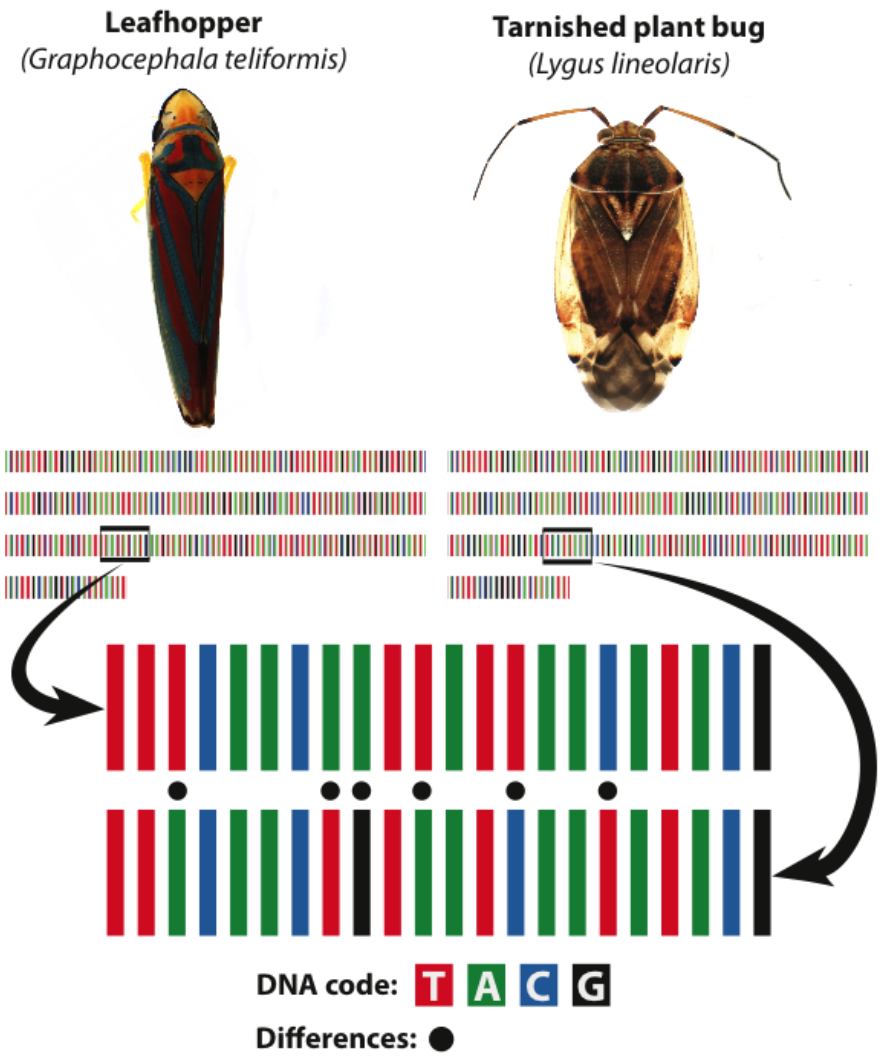
DNA Barcoding



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DNA Barcoding

Example 1:

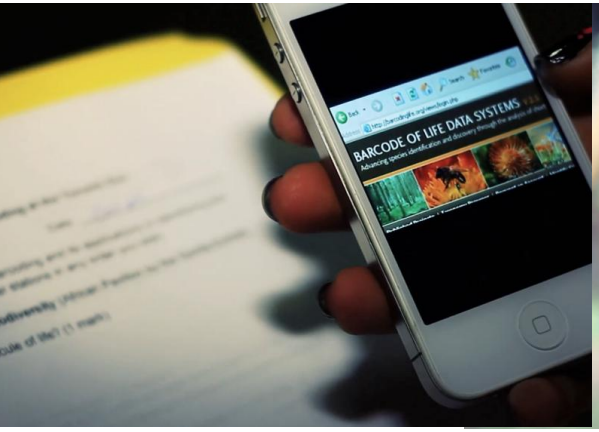
- LTSMS590
  - Market Label: halibut
  - DNA barcode match: *Hyporthodus flavolimbatus* (Yellowfinned grouper)
  - IUCN vulnerable status

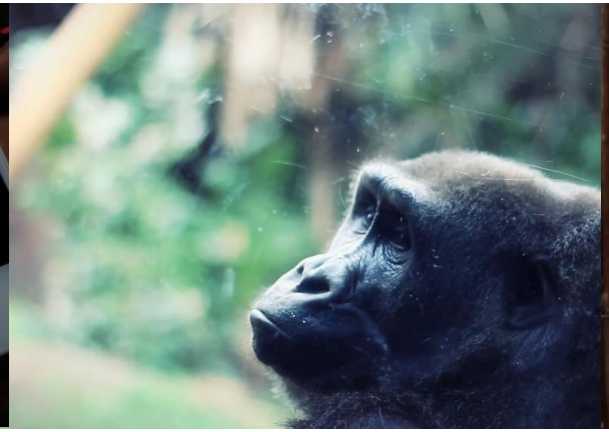
DNA Barcoding

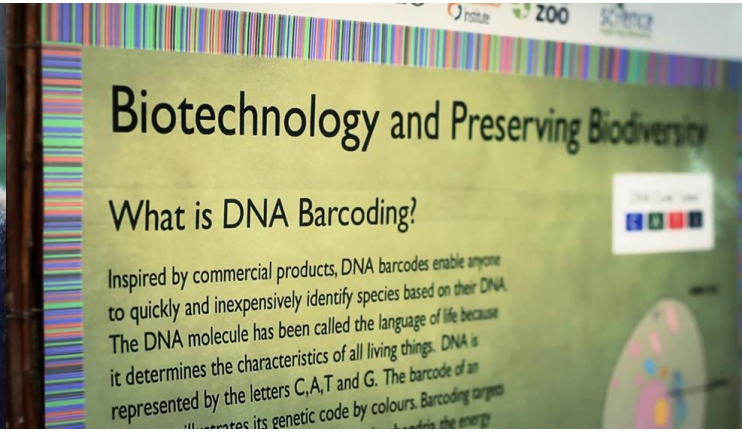
Example 2:

- LTSMS285
  - Market Label: red snapper
  - DNA barcode match:
  - *Oreochromis sp.* (tilapia)
  - Economic and health impacts

DNA Barcoding at the Toronto Zoo







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A Fishy Tail

Canadian Innovation – DNA Barcoding

Poster created by Donald A. Wilson S.S. BioTech. Club in partnership with:

BIO · Ontario Genomics Institute · toronto zoo · let's talk science inspiring discovery

A Fishy Tail

Can you distinguish between these two fish fillets?

(*Differentiation of red snapper from its cryptic species, n.d.*)

It may be nearly impossible to determine fish species once their scales have been removed, but thanks to researchers at the University of Guelph, species can be identified using DNA. This technique, called DNA barcoding, enables regulatory bodies to identify fish that are sold in markets.

Scan the QR code next to each fillet to see a portion of its genetic code and match the fillets to the fish.

(*Comparing prices of Acadian Redfish and Red snapper, n.d.*)

The FISH-BOL Project

Through a division of the International Barcode of Life, called FISH-BOL, Ontario high school students used DNA barcoding to determine that 25% of fish fillets sold were mislabeled. In every case, less expensive fish were marketed as more expensive varieties. In some cases, protected species were being sold and there were potential health implications for humans.

An excellent reference for consumers to make environmentally-conscious decisions in the fish they buy is Seafoodwatch.org. Thanks to DNA barcoding, the "tide is turning" on consumer fraud and consumer's choices are being respected.

The Toronto Zoo is a partner of the Monteray Aquarium Seafood Watch program. This is an initiative to promote consumers and businesses to select ocean-friendly seafood options. With approximately 85% of the world's fisheries overfished, or fished to capacity, it is important for consumers to make purchases that are sustainable and help to conserve diminishing fish populations around the world.

(Border created by DNA barcode of Red Snapper)

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DNA Barcoding in the Protection of Biodiversity

Canadian Innovation – DNA Barcoding

Poster created by Donald A. Wilson S.S. BioTech. Club in partnership with: BIO, Ontario Genomics Institute, toronto zoo, let's talk science inspiring discovery

DNA Barcoding in the Protection of Biodiversity

DNA Barcoding is a process that allows us to easily identify and differentiate between species. The DNA Barcode consists of a short DNA sequence of about 650 base pairs. Various species have differences in their barcoding regions; this allows scientists to be able to tell them apart.

Tracking Global Trade in Exotic Wildlife

Biological diversity is a valuable and vulnerable resource that is unfortunately all too often mistreated. An example of this is the illegal trade of meat and other animal products on the black market. One of the numerous applications of DNA Barcoding is to combat this crime against biodiversity.

Loss of Turtles and Crocodillians

Bushmeat, which is illegally hunted wildlife, is the primary reason for the loss of turtles and crocodillians in

(Border created by DNA barcode of a White Rhino)

Biotechnology Targets Poachers

Similar to the procedure of DNA fingerprinting being used to solve crimes, the process of DNA barcoding can be used to identify protected species that are being sold and transported on the black market. Horns, hides tanned into leather, and meat can be identified by species and sometimes a region of origin can be determined.

Identifying products that are being sourced from a particular species allows organizations to better protect the animals. This targets areas that are responsible for the trafficking of products and poaching of species.

Skins and meat are identified through DNA barcodes.

Cryptic Species

Canadian Innovation – DNA Barcoding

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Cryptic Species

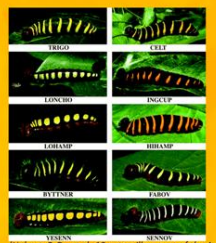
What is a Cryptic Species?

A cryptic species complex is a group of organisms that look strikingly similar, but are very genetically different. They have a recent common ancestor which passed on a similar gene to each species and they often live in similar regions, whether it's geographically the same or with similar conditions. They are species that have become so evolutionarily successful that they have no immediate need to change or mutate.

Importance of Identifying Cryptic Species

Preventing Extinction

When trying to preserve a species from extinction, scientists will often breed two of the same species together in captivity. If the two species turn out to be cryptic species, than there is a higher chance their offspring being sterile. This will not help to conserve the original species because the offspring will not be able to reproduce.



(Hebert, P. D., et al. *10 caterpillars part of the A. Fulgerator cryptic species complex*, 2004)

Controlling Natural Resources

When trying to maintain or control a natural resource, information must be known about all the biological organisms that may come in contact with that resource. Organisms can be used to help manage environmental properties, but with cryptic species you may not end up with a species that does the task you want it to. In a more domestic sense, doctor fish are used by spas to remove the dead skin off of feet. Now if a shipping company sends some Cambodian logsuckers, you are going to go out of business because they eat algae instead of skin. You would have to look extremely closely at the fish to realize that they are slightly bigger than the doctor fish because they have a very similar morphology.

(Border created by DNA barcode of a Two-barred Flasher)

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Whooo's in the Rouge?

Canadian Innovation – DNA Barcoding

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Whooo's In the Rouge?

A DNA barcode is a unique representation that uses colour to represent a species' DNA sequence. This system of species identification is being used globally to catalogue species. This information can be used to map out the distribution of endangered and invasive species.

Identifying Invasive Species

Rouge Park is home to many species that don't belong. Invasive species can be transported from other areas and become established in new ones. They can have negative impacts on native plants and animals such as the dog-strangling vine. Thus has begun to drive out milkweed, a plant that monarch butterflies depend upon. A DNA barcode can help to identify invasive species quickly and it works at any stage of life. Faster identification greatly reduces the cost of eradication and increases the chance of success.

What is a BioBlitz?

BioBlitz is a special field study where scientists and volunteers conduct an intensive 24-hour biological inventory. They try to identify and record all species in a given area. The Toronto Zoo has conducted several BioBlitzes and used the DNA barcode to determine the species present. They have identified over 1350 species of plants and animals and discovered a spider species which has never before been seen in this part of the world. A BioBlitz is a tool used to understand and monitor the changing environment and our impacts on it.

(Border created by DNA barcode of Snapping Turtle)

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Biotechnology and Preserving Biodiversity

Canadian Innovation – DNA Barcoding

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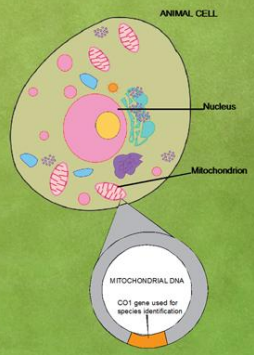
Biotechnology and Preserving Biodiversity

What is DNA Barcoding?

DNA Code "Letter"
C A T G

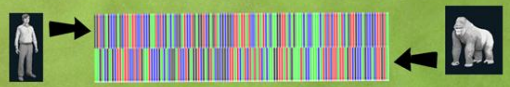
Inspired by commercial products, DNA barcodes enable anyone to quickly and inexpensively identify species based on their DNA. The DNA molecule has been called the language of life because it determines the characteristics of all living things. DNA is represented by the letters C,A,T and G. The barcode of an organism illustrates its genetic code by colours. Barcoding targets a small region of DNA located in the mitochondria, the energy producing sub-unit of the cell, which is only inherited from the mother.



How Does it Work?

The barcoding region is very similar within a species, but highly varied between different species. For example, humans vary from one another on one or two DNA base pairs, but we differ from gorillas at about 70 sites.

Below you can compare a portion of the human and gorilla barcodes:



Why do we Need to Identify Organisms by their DNA?

It is easier to tell a gorilla from a human by simply looking at them. However, most living things such as insects, plants, and fungi are not easily identified. Although the appearance of an organism can change throughout its life and death, the DNA remains constant.

How is the Toronto Zoo Involved?

Many animals of the Toronto Zoo have assisted in the DNA barcoding project by donating their DNA sequence to the Barcode of Life Database. This can help protect species in the wild in many ways, including identifying illegally traded animal parts.

(Border created by DNA barcode of a gorilla)

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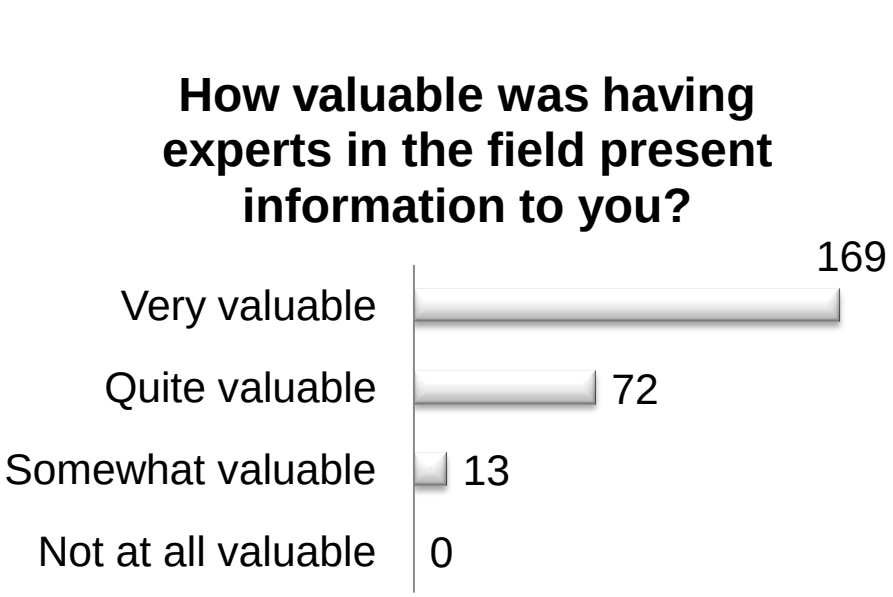
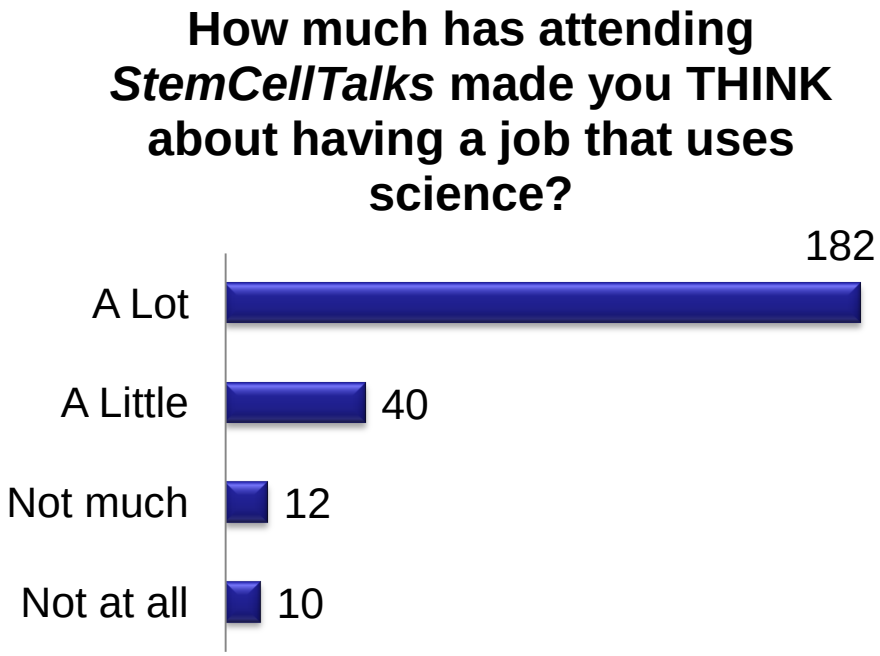
So What?!

Measuring *StemCellTalks* Impact





Data from four 2013 *StemCellTalks* symposia
(N = 329 respondents)

The road ahead for *StemCellTalks*

Partnerships between Let's Talk Science and Stem Cell Network:

- Generation of database of online educational resources (www.ExploreCurioCity.org/Themes/StemCells)
- Consolidation of *StemCellTalks* as a national initiative through formation of the National Advisory Committee (SCT-NAC)
- Development of a national fundraising strategy for sustainable Industry and/or Government support
- Expansion into new Canadian markets (focus on Quebec)

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Tomatosphere

A Space Science Outreach Project

Robert Morrow
Theresa Rondeau Vuk
Mike Dixon
University of Guelph

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ScienceNext
Nov 2013

Space science awareness and communications

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Tomatosphere: An educational outreach project

The project uses the excitement of space exploration as a medium for teaching students about science, space and agriculture …

and the role being played by Canada as a world leader in life support research and technology development.

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Curriculum Goals

- **Increase Student Knowledge in ...**

- **Plants**
- **Space**
- **Nutrition**
- **Environmental Sustainability**

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada
Canadian Space Agency | Agence spatiale canadienne
Heinz
Ontario Centres of Excellence
STOKES
University of Guelph

www.tomatosphere.org

Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada
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S/N 0003
00114396C
DO NOT
OPEN THIS
BAG
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S/N 0001
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Tomatosphere - Overview

- Curriculum-based
- Focus on plants (grades 3/4),
- Space (6 and 9)
- Blind study
- Web-based
- FREE!!! - thanks to our sponsors

Outcomes

- Evaluation of the Project Indicated ..
- Matched curriculum (96%)
- Met classroom needs (92%)
- Introduced/reinforced scientific method (97%)
- Promoted student collaboration (92%)
- INCREASED STUDENT INTEREST IN SCIENCE (98%)


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NSERC AWARD FOR SCIENCE PROMOTION
PRIX DU CRSNG POUR LA PROMOTION DES SCIENCES
TOMATOSPHERE