A Web-Based Resource for the Nuclear Science/Technology High School Curriculum – a summary

Author: Clair Ripley, Communication/Liaison Officer, Atomic Energy of Canada Limited, Saint John, NB
e-mail:ripleyc@aecl.ca. Phone: 506 488 2922

On November 15, 2008, the CNA launched a new Nuclear Science Technology High School Curriculum Website. Located at www.cna.ca the site was developed over a decade, first with funding from AECL and finally by the CNA, as a tool to explain concepts and issues related to energy and in particular nuclear energy targeting the public, teachers and students in grades 9–12. It draws upon the expertise of leading nuclear scientists and science educators.

Full lesson plans for the teacher, videos for discussion, animations, games, electronic publications, laboratory exercises and quick question and answer sheets will give the student greater knowledge, skills and attitudes necessary to solve problems and to critically examine issues in making decisions.

Eight modules focus on key areas: Canada's Nuclear History, Atomic Theory, What is Radiation?, Biological Effects of Radiation, World Energy Sources, Nuclear Technology at Work, Safety (includes Waste Disposal) in the Nuclear Industry and Careers.

Title: A Web-Based Resource for the Nuclear Science/Technology High School Curriculum website: www.cna/curriculum/default.asp

1. Rationale:

Especially in the last half of the 20th century nuclear technologies have had a significant role in Canada's development. We have a proud legacy of achievements in all aspects of nuclear science. As well, our nuclear scientists and engineers have earned the respect of the international community for their resourcefulness, innovative abilities and achievements. It is important for us, as Canadians, to be aware of how this knowledge-based industry has given us the tools to help build and to enjoy a strong, healthy economy and a high standard of living.

This website is a step forward in giving teachers and students a better understanding of the nuclear industry from the contributions of Canadian scientists to its wide range of applications. The value of the website is to explain nuclear technology from atoms and radiation to how it is used in producing energy, in research and development, and in a wide range of industry such as medicine, manufacturing, agriculture and space. Students also need to be aware of the many career opportunities available in various aspects of the industry. It is our hope that the science curriculum in our schools will reflect the value of this technology and its importance to the economy, to the environment and to society.

2. Objectives:

From 1993 to 1998 as an Education Officer for Atomic Energy of Canada Limited (Atlantic Region) I visited all but a few high schools in Atlantic Canada – more than 20/year - to speak to teachers and students about Canada's nuclear industry. In that time it became evident that there was a need to develop resources specific to the high school science curriculum for a number of reasons:

1 To satisfy teacher demands. Teachers, I discovered, were very reluctant to teach nuclear topics for two reasons: firstly, they did not feel qualified as very few had any background in nuclear science and secondly, the resources they had were mostly from the nuclear industry and they had too little time to produce lesson plans from material that was, for the most part, highly technical. They requested

material that was teacher/student friendly, clear, concise and in every-day language.

2 To satisfy student demands. Students were very receptive to information about all aspects of the nuclear industry and were interested in exploring various careers available in the nuclear field. There was no central point of contact for this information and guidance officers in their schools had very limited resources. A demand for career information was clearly evident.

-2-

3 To improve public relations and the image of the industry. There are many myths surrounding the nuclear industry and high school science teachers are often carriers of some of these myths due to not having access to accurate scientific information. The industry needs an outreach program to help dispel misinformation.

4 To highlight Canadian scientific accomplishments. More than 20 years ago, [1]Thomas H.B. Symons, author of "To Know Ourselves", in a Report to the Commission on Canadian Studies, observed "Canadian school children learn of the accomplishments and impact of science in other countries.... but they learn virtually nothing about the impact of science in their own country. And the reason is that they are not being taught such matters." It is a concern that Canadian students are unaware of the societal importance of the contributions of Canadian nuclear scientists and technology.

5 To illustrate how a resource can be used for maximum economic and social impact. Canadians are often concerned that we are "hewers of wood and drawers of water" and that our exported raw materials result in manufacturing jobs abroad[2]. The Canadian Nuclear Industry is a good example of how our resources are used in Canada for the greatest economic and social benefit, also demonstrating the interconnectiveness of science, technology, environment and society.

6 To satisfy the growing interest in the nuclear industry. That there is a renaissance in nuclear technologies is largely accepted by global leaders. The fact that nuclear energy production produces virtually no carbon dioxide emissions makes the environmental case for nuclear compelling from the perspective of global climate change. Increased abilities of new nuclear technologies to enhance our lives through

nuclear medicine, improved methods of agriculture, food irradiation, water purification, manufacturing, and aeronautics and space exploration has also led to greater awareness and interest in the industry.

7 To encourage scientific literacy. Providing clear, concise scientifically accurate information that is user-friendly will encourage use by teacher and student. Full lesson plans for the teacher, interactive applications, videos for discussion, animations, games, electronic publications, laboratory exercises and quick question and answer sheets will encourage critical thinking and give the student greater knowledge, skills and attitudes necessary in solving problems and making decisions.

-3-

3. Production:

Development of the materials for the Nuclear Technology website did not follow a consistent process.

In 1998, under a grant from Atomic Energy of Canada Limited, Clair Ripley, Education Officer was given the task of producing nuclear materials for teachers and students for a technology program used in New Brunswick schools. The product could be refined, adapted and found useful in other science courses in Atlantic Canada and elsewhere. This grant was renewed for a period of four additional years. The Atlantic Canadian Provinces had just adopted a Science Curriculum Foundations Document[3] as a framework for science education. This document described learning in terms of knowledge, skills and attitudes developed throughout the curriculum, based on outcomes students were expected to demonstrate at key stages on their way to a high school graduation. This framework gave focus to the course curriculum we were to develop over the next few years. Much research was done and six units were developed – Atomic Theory, Radiation, Nuclear Medicine, The CANDU

Reactor, Nuclear Technology at Work, and Waste Management/Safety. Question sheets and laboratory exercises accompanied each module.

Funding for further work on producing teacher/student material was withdrawn by AECL in 2004. The project went into sleeping mode but was not forgotten.

In the meantime, since there was great demand for useful materials, four three-day teacher workshops were held – modeled after the CNS workshop for physics teachers at McMaster University in 1998[4]. Two of these workshops were held in Nova Scotia and two in New Brunswick – all fully attended. The Nova Scotia workshops were also specific for physics teachers and the idea was to put through all 98 physics teachers in four workshops (only two were held). The two New Brunswick workshops were open to all science teachers. At all these workshops the early draft of materials developed for teachers was distributed and participants were asked to assess its value for classroom use. They were very positive in their assessment. (I have since learned that teachers were so short of materials on nuclear technologies that the draft materials were being used by some teachers.)

This gave me the impetus needed to continue to seek financial support to complete the project. The CNS and AECL were both approached and although interest was there, funding was not.

-4-

In 2007 the Canadian Nuclear Association became aware of the program. A preliminary meeting was held with Murray Elston, President and CEO of the CNA and Claudia Lemieux, CNA's Director of Communications and Media Relations to access the value of the materials developed and to ask for a proposal for funding. After taking the proposal to the Board of Directors the CNA agreed to provide the funding necessary to complete the program and develop a website. Queenstown Education Development Inc. (QED) was given a contract for control and organization of the execution of the project. This included the production of materials and teacher/student resources – information sheets, instructional media, animations, videos, games, lesson plans, laboratory exercises, classroom activities and other resources. As chief officer of that company I employed six New Brunswick teachers to finish the following modules, focusing on eight key areas:

Canada's Nuclear History

Atomic Theory

What is Radiation?

Biological Effects of Radiation

World Energy Sources*

Nuclear Technology at Work

Safety in the Nuclear Industry (includes waste disposal)

Careers*

* the sole responsibility of the Canadian Nuclear Association.

The CNA as the funding agency (beginning 2007) assumed the role as the managing company and as such:

(a) established the process for developing an expert review with the Canadian Nuclear Society. Both QED and the CNA selected the reviewers from energy- based industries, universities and authors of scientific works. Management of reviewers was likewise shared by the two organizations with the final arbitration being the sole responsibility of the CNA. Attachment #1

(b) organized two one-day education symposiums for leading Canadian science educators, including the provincial Science Coordinators. This allowed for feedback from educational experts and opened up the review process to the education community

(c) carried out the final editing, revision, and all website design, layout and translation

(d) takes responsible for the project to the next level which will includes marketing it nationally.

4. Curriculum Focus:

4.1 Audience:

The cross curricular material on this web-site is useful for several audiences. Although developed mainly for teachers and students in grades 9-12 it is

also useful for parents and those members of the public who want to learn more about the nuclear industry[5].

"Rapid technological change, global competitive pressures and new patterns of work are demanding a more sophisticated set of transferable skills, such as problem solving, communication, decision making, teamwork, leadership, entrepreneurship, and adaptability. The development of these skills requires embracing a view of learning that goes beyond the provision of formal education." [6]

4.2 Presentation:

The materials are presented in such a way that the teacher and student will find them interesting and intrinsically rewarding.

Guidelines for the Pan-Canadian Framework[7] for a common curriculum for the teaching of science were followed. This includes focusing on outcomes for specific grade levels and describing learning in terms of an understanding of:

the nature of scientific knowledge and technology;

the interrelationship of science, technology, the environment and society;

the use of scientific knowledge and cognitive skills in investigating the natural world and in solving problems and making informed decisions;

communicating an understanding of the major concepts and principles of science and technology; and

developing scientific attitudes and positive attitudes towards science and technology.

Materials and lesson plans in this website are mainly for teachers/students in grades 9 – 12 in the following subject areas: physics, chemistry, biology, environmental science, general science, geography, world issues, social studies and history.

-6-

The materials have also been developed with the participation and support of all Science Curriculum Coordinators from provincial and territorial Ministries of Education from across Canada.

5. Module Highlights and Outcomes

Canada's Nuclear History: The module describes the origin of nuclear energy and provides an overview of its international roots leading from Europe to Canada. It identifies important key figures and events relating to Canada's long nuclear history.

Atomic Theory: The module presents information about the basic structure of the atom and of elements. Users will be able to describe the basic structure of the atom and elements and be able to describe nuclear fission and identify important people internationally and in Canada who made important discoveries in the area of nuclear physics.

What is Radiation?: The module describes how radiation is a part of our environment; defines the difference between ionizing and non-ionizing radiation; observes radioactive decay using a cloud chamber; defines alpha, beta and gamma radiation and calculates the daughter isotope of an alpha or beta radioactive decay. Students will learn how to measure ionizing radiation from various sample sources, understand the concept of radioactive half-life and the difference between natural and man-made sources of ionizing radiation.

Biological Effects of Radiation: The module provides a basic understanding of the biological effects of radiation. Students will learn the difference between irradiation and contamination; the difference between somatic and genetic effects of ionizing radiation and gain an understanding of how ionizing radiation can enter the body.

World Energy Sources: The module provides a broad overview of the role of energy in the world and its impacts on people's lives, the economy and the environment. Students will learn how electricity generation works; will be able to identify the different energy sources available and used throughout the planet — such as hydroelectricity, nuclear, fossil fuels, biomass, wind, solar, tidal and hydrogen; gain an understanding of carbon dioxide emissions and our carbon footprint; and gain an understanding of the pros and cons of each energy source and how our growing electrical needs impact our day to day lives.

Nuclear Technology at Work: The module covers uranium mining, electricity generation, food irradiation, nuclear medicine, manufacturing, inspection and monitoring of nuclear facilities, scientific research, aeronautics and space exploration. Students will gain an understanding of the important role played by nuclear power in Canada's energy mix and its important role in our research and development infrastructure.

Safety in the Nuclear Industry: The module provides a general understanding of risk assessment and the risks associated with various technologies. Students will gain a general understanding of how risk is managed and controlled in the nuclear industry in Canada and worldwide.

About Careers: The module covers a wide range of career options offered in the energy and nuclear sectors, ranging from trades to engineering and science opportunities, manufacturing, medicine, agriculture and research and development

6. The Canadian Nuclear Association

The Canadian Nuclear Association (CNA) is a non-profit organization established in 1960 to represent the nuclear industry in Canada and promote the development and growth of nuclear technologies for peaceful purposes. The CNA has over 100 members including power utilities, labour unions, manufacturers, uranium mining and fuel processing companies, engineering companies, universities and associations.

The Nuclear Science Technology High School Curriculum Website is available in both official languages at www.cna.ca. For more information please contact Claudia Lemieux, Director of Communications and Media Relations at lemieuxc@cna.ca or Matthew Foster, Communications Officer, at the Canadian Nuclear Association — by emailing fosterm@cna.ca or by calling 613-237-4262.

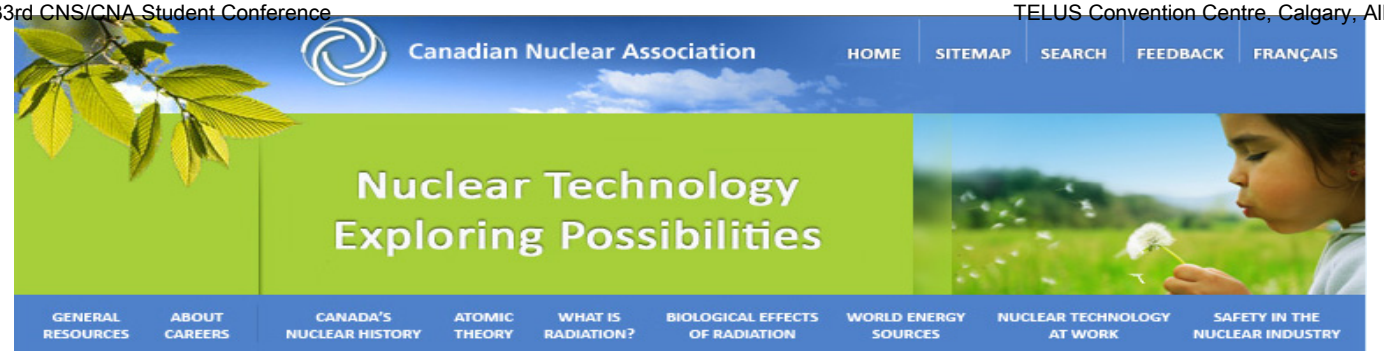
ATTACHMENT #1

SCIENCE CURRICULUM PROJECT MANAGEMENT

Subject: FW:lead vetters in bold

Module	#	Title	Editor	E-mail
1		**Canada's Nuclear History**	**Dave Jackson**	**jacksond@mcmaster.ca**
1		Canada's Nuclear History	Jeremy Whitlock	whitlockj@aecl.ca
1		Canada's Nuclear History	Morgan Brown	brownmj@aecl.ca
1		Canada's Nuclear History	Willy Cook	wcook@unb.ca
1		Canada's Nuclear history	Colin Hunt	huntc@cna.ca
2		Atomic Theory	Andy Justason	justason@unb.ca
2		**Atomic Theory**	**Bryan White**	**bwhite_cns@sympatico.ca**
2		Atomic Theory	Jeremy Whitlock	whitlockj@aecl.ca
2		Atomic Theory	Roger Steed	rgsteed@nbnet.nb.ca
2		Atomic Theory	Willy Cook	wcook@unb.ca
3		What is Radiation?	Bryan White	bwhite_cns@sympatico.ca
3		**What is Radiation?**	**Jeremy Whitlock**	**whitlockj@aecl.ca**
3		What is Radiation?	Roger Steed	rgsteed@nbnet.nb.ca
3		What is Radiation?	Willy Cook	wcook@unb.ca
4		Biological Effects of Radiation	Blair Bromley	bromleyb@aecl.ca
4		Biological Effects of Radiation	Bryan White	bwhite_cns@sympatico
4		Biological Effects of Radiation	Doug Boreham	boreham@mcmaster.ca
4		**Biological Effects of Radiation**	**Jeremy Whitlock**	**whitlockj@aecl.ca**
4		Biological Effects of Radiation	Richard Osborne	osborner@magma.ca
5		World Energy Sources	Ben Rouben	roubenb@alum.mit.edu
5		**World Energy Sources**	**Bill Garland**	**garlandw@mcmaster.ca**
5		World Energy Sources	Dave Novog	novog@mcmaster.ca
5		World Energy Sources	Simon Day	dayese@mcmaster.ca
5				
6		Nuclear Technology at Work	Julie West	Julie.west@rogers.com
6		Nuclear Technology At Work	Bill Garland	garlandw@mcmaster.ca
6		**Nuclear Technology At Work**	**Bryan White**	**bwhite_cns@sympatico.ca**
6		Nuclear Technology At Work	Dave Kingdon	dave.kingdon@amec.com
6		Nuclear Technology At Work	Jeremy Whitlock	whitlockj@aecl.ca
6		Nuclear Technology At Work	Victor Snell	snell@interlog.com
7		Safety/Waste	Bill Garland	garlandw@mcmaster.ca
7		**Safety/Waste**	**Dan Meneley**	**mmeneley@sympatico.ca**

7	Safety/Waste	Jeremy Whitlock	whitlockj@aecl.ca
7	Safety/Waste	Victor Snell	snell@interlog.com
7	Safety/Waste	Tineka Briggs	briggst@aecl.ca



Project Site Map

Canada's Nuclear History

- Introduction

Uranium Mining

- What is Uranium?
- History of Uranium
- History of Uranium Mining
- Uranium Mining in Northern Saskatchewan

Chalk River

- Chalk River
- ZEEP
- NRX Reactor
- NRU Reactor
- Canada's first nuclear power generator-NPD
- Slowpoke
- Maple

Famous People

- Introduction
- Dr. B. Brockhouse
- Dr. H. Johns
- Dr. G. Laurence
- Dr. Wilfrid B. Lewis
- Sir E. Rutherford

Power Generation

- Atoms for Peace and the IAEA
- CANDU Worldwide
- India and Pakistan
- Argentina, Romania, South Korea and China
- Nuclear Power in Canada

Canada's Economy

- Nuclear Industry's impact on the Canadian economy

Atomic Theory

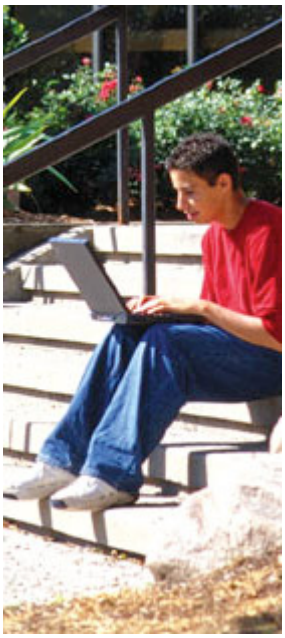
- Introduction
- Electrons
- Elements
- Periodic Table
- Atomic Symbols
- Ions
- Isotopes

Fission

- Nuclear Fission
- Energy from Fission

Fusion

- Nuclear Fusion
- Fusion in the Sun
- Energy from Fusion



What Is Radiation?

- Introduction
- Sea of Radiation
- Electromagnetic Spectrum
- Non-Ionizing Radiation
- Ionizing Radiation
- X-Rays
- Nuclear Radiation

Sources of Radiation

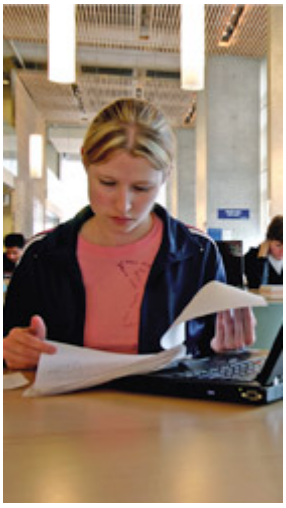
- Natural Sources
- Radon
- Fossil Reactor
- Man Made Sources

Nuclear Decay

- Radioactive Decay
- Parents and Progeny
- Half Life
- Alpha Decay
- Beta Decay
- Gamma Rays
- Decay of Uranium-238

Biological Effects of Radiation

- Introduction
- How Ionizing Radiation Enters the Body
- Calculating Exposure
- Irradiation vs. Contamination
- Direct and Indirect Action of Ionizing Radiation on DNA
- Somatic Effects vs. Reproductive Effects
- Alexander Litvinenko



World Energy Sources

- Introduction
- World's Rising Energy Needs
- Canada's Rising Energy Needs
- Understanding Carbon Dioxide Emissions
- Energy Sources
- How Electricity Generation Works
- Comparison of Electrical Generation
- Hydroelectricity
- Fossil Fuels
- Nuclear Energy
- Wind Energy
- Solar Energy
- Biomass
- Tidal Energy
- Hydrogen Economy

Nuclear Technology at Work

- Introduction
- How a Nuclear Reactor Works
- Major Reactor Types
- The CANDU Reactor
- Nuclear Fuel Cycle
- Uranium Mining
- Uranium Processing
- Nuclear Waste

Medical Applications

- Introduction
- Nuclear Medicine and Diagnostics
- Cobalt-60 Therapy Unit

Commercial Applications

- Introduction
- Smoke Detectors
- Food Irradiation
- Desalination
- Insect Irradiation

Space and Aeronautical Applications

- Introduction
- Radioisotope Thermo Electric Generators
- Nuclear Rockets

Safety in the Nuclear Industry

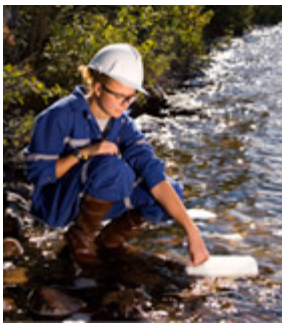
- Introduction
- Canadian Nuclear Safety Commission
- How Safe Are CANDU Reactors?
- The Three C's
- Nuclear Power Accidents
- Nuclear Waste
- How is the Environment Protected in Uranium Mining
- Fuel Reprocessing
- Non-proliferation
- Time Distance Shielding
- Transport of Nuclear Materials
- Insurance

General Resources

- Facts
- Glossary
- Publications
- Videos
- Interesting Links

About Careers

- Introduction
- Careers in Nuclear
- Career Profiles
- Nuclear Industry Leaders



Teachers' Resources	Students' Resources	

By Subject

- Atomic Theory
- What is Radiation?
- Canada's Nuclear History
- World Energy Sources
- Biological Effects of Radiation
- Nuclear Technology at Work
- Safety in the Nuclear Industry

By Type

LP Lesson Plans
QQ Quick Questions
SA Student Activities

By Subject

- Atomic Theory
- What is Radiation?
- Canada's Nuclear History
- World Energy Sources
- Biological Effects of Radiation
- Safety in the Nuclear Industry
- Facts
- Glossary
- Publications
- Videos
- Interesting Links

Notes

1. Thomas H.B. Symons, ***To Know Ourselves,*** Report on the Commission on Canadian Studies, Association of Universities and Colleges in Canada, Ottawa, 1975, volume 1,p.162.

2. Ministry of Education, Ontario (1988). ***Science is Happening Here. A Policy Statement for Science in the Intermediate and Senior Divisions.*** Program Outline and Policy Draft Edition. Toronto: Ministry of Education.

3 Atlantic Provinces Education Foundation (1995). ***Foundation for the Atlantic Canada Science Curriculum***. Governments of New Brunswick, Newfoundland and Labrador, Nova Scotia, Prince Edward Island.

4 McMaster University and the Canadian Nuclear Society, in Cooperation with AECL, Ontario Hydro, CNA, and Oakville Trafalgar High School. ***Science for Nuclear Energy and Radiation. A Comprehensive Course for Science Teachers.*** Bill Garland, David Jackson Ben Rouben et al. June, 1998

5. Canadian Council on Learning. ***Towards a Learning Future.*** http://www.ccl-cca.ca/ccl/reports/stateoflearning/. July 2008

6 Canadian Council on Learning, State of Learning in Canada: ***Towards a Learning Future EXECUTIVE SUMMARY.*** Report on Learning in Canada. 2008

7 Council of Ministers of Education Canada. http;//www.cmec.ca/science/framework/. ***Pan Canadian Protocol for Collaboration on School Curriculum***. Common Framework of Science Learning Outcomes. Revision 1997.11.24.