Ontario Science Curriculum links to SNOLAB

Although we feel that the SNOLAB, its people, careers and science can be beneficial in many areas of the high school curriculum, the following indicate direct links into the science curriculum.

Grade 9 , Academic
D. Earth and Space Science: The Study of the Universe

1. Assess some of the costs, hazards, and benefits of space exploration and the contributions of Canadians to space research and technology
   i. Depending on how you define 'space exploration', SNOLAB and its experiments can fit very well in this category. By definition, the goal of SNOLAB is to study particles and their properties that will give insight into the creation and evolution of the stars, galaxies and ultimately the Universe itself.
   ii. SNOLAB is located 2 km underground; this carries a multitude of additional costs and risks.
   iii. SNOLAB is currently the deepest and cleanest laboratory in the world for this kind of astroparticle physics research.
2. Investigate the characteristics and properties of a variety of celestial objects visible from Earth in the night sky.
   i. *Sun (celestial object visible in the day, night)*
   ii. *Supernova*
3. Demonstrate an understanding of the major scientific theories about the structure, formation, and evolution of the Universe and its components and of the evidence that supports these theories.
   i. *Standard Model*
   ii. *Standard Model Particle Physics and Neutrino properties*
   iii. *Standard Solar Model*
   iv. *How the sun shines!*

Grade 9, Applied
D. Earth and Space Science: Space Exploration

1. Analyse the major challenges and benefits of space exploration, and assess the contributions of Canadians to space exploration;
   i. Depending on how you define 'space exploration', SNOLAB and its experiments can fit very well in this category. By definition, the goal of SNOLAB is to study particles and their properties that will give insight into the creation and evolution of the stars, galaxies and ultimately the Universe itself. Investigate the properties of different types of celestial objects in the solar system and the Universe;
2. Demonstrate an understanding of major astronomical phenomena and of the principal components of the solar system and the universe.
   i. *Supernova*
   ii. *Planetary Nebula*
   iii. *Dark Matter*
   iv. *Neutrinos (solar, geo)*

Grade 12, University Preparation
Physics
D. Gravitational, Electric, and Magnetic Fields
F. Revolutions in Modern Physics: Quantum Mechanics and Special Relativity
We have included student activities and a teachers guide, courtesy of The Contemporary Physics Education Project that brings particle physics to the classroom with meaningful activities.

Grade 12, University Preparation
Earth and Space Science
B. Astronomy (Science of the Universe)

1. Analyse the development of technologies that have contributed to our understanding of the Universe, and evaluate the impact of milestones in astronomical theory or knowledge on the scientific community
    i. *The Sudbury Neutrino Observatory (SNO) results have provided revolutionary insight into the properties of neutrinos and the core of the Sun.*
    ii. *On 18 June 2001, the first scientific results of SNO were published, bringing the first clear evidence that neutrinos oscillate as they travel in the Sun. This oscillation implies that neutrinos have mass. The total flux of all neutrino flavours measured by SNO agrees well with the theoretical prediction. The Sudbury Neutrino Observatory (SNO) results have provided revolutionary insight into the properties of neutrinos and the core of the Sun.*
    iii. *SNO was a heavy-water Cherenkov detector designed to detect neutrinos produced by fusion reactions in the sun. It used 1000 tonnes of heavy water loaned from Atomic Energy of Canada Limited (AECL), and contained by a 12 meter diameter acrylic vessel. Neutrinos reacted with the heavy water (D2O) to produce flashes of light called Cherenkov radiation. This light was then detected by an array of 9600 photomultiplier tubes mounted on a geodesic support structure surrounding the heavy water vessel. The detector was immersed in light (normal) water within a 30 meter barrel-shaped cavity (the size of a 10 story building!) excavated from Norite rock. Located in the deepest part of the mine, the overburden of rock shielded the detector from cosmic rays. The detector laboratory, still functioning as part of the new SNOLAB facility, is extremely clean to reduce background signals from radioactive elements present in the mine dust which would otherwise hide the very weak signal from neutrinos. Plans are currently underway to upgrade the SNO detector for the new SNO+ experiment.*
    iv. *SNO's results were the first to directly demonstrate oscillations in solar neutrinos. The results of the experiment had a major impact on the field, as evidenced by the fact that two of the SNO papers have been cited over 1,500 times, and two others have been cited over 750 times.*
2. Investigate and analyse the properties of the Universe , particularly the evolution and properties of stars, in both qualitative and quantitative terms;
3. Demonstrate an understanding of the origin and evolution of the Universe, the principal characteristics of its components, and techniques used to study those components.

i. *see poster "History of the Universe"*
ii. *see article in the **Physics Teacher** for explanation of the experiments at SNOLAB*

If you require more information relating to these topics or any other that is mentioned in this package, please feel free to contact us. We will be happy to prepare and send any additional information that you may require.