THE CANADIAN ASTROBIOLOGY TRAINING PROGRAM: A NEW DRIVING FORCE FOR ASTROBIOLOGY IN CANADA. G. R. Osinski[1], L. Whyte[2], N. Banerjee[1], E. Cloutis[3], J. Nadeau[4], , W. Pollard[5], R. Pudritz[6], B. Sherwood Lollar[7], G. F. Slater[8], H. Vali[9], B. Wing[10], [1]Dept. of Earth Sciences, University of Western Ontario, London, ON (gosinski@uwo.ca), [2]Dept. of Natural Resource Sciences, McGill University, Montreal, QC, [3]Dept. Geography, University of Winnipeg, Winnipeg, MN, [4]Dept. Biomedical Engineering, McGill University, Montreal, QC, [5]Dept. Geography, McGill University, Montreal, QC, [6]Dept. Physics, McMaster University, Hamilton, ON, [7]Dept. Geology, University of Toronto, Toronto, ON, [8]School of Geography and Earth Sciences, McMaster University, Hamilton, ON, 9Faculty of Dentistry, McGill University, Montreal, QC, [10]Department of Earth and Planetary Sciences and GEOTOP, McGill University, Montreal, QC

Introduction: Are we alone? With the constant stream of data arriving almost daily from the surface of Mars, this fundamental question of humanity has never been so significant. What makes it so compelling is the recent realization that microbial life is extremely hardy and can survive and even thrive in very harsh environments previously thought uninhabitable on Earth: acidic streams, alkaline ponds, salt lakes, hot springs, and cryoenvironments. Such discoveries have revolutionized our view of the microbial world and have united researchers across disciplines in order to test the limits of life. At the same time, the recent discovery of a SuperEarth exoplanet in the habitable zone around its central star is another major breakthrough. Chemists, physicists, earth scientists, microbiologists and engineers are collaborating to discover and define analogue sites (conditions) and quantify the sensitivity of life-detection instruments. These discoveries have also opened the possibility that similar "extremophile" microorganisms existed, or still exist, in similar environments on other solar system bodies.

Astrobiology in Canada: Since 1999, astrobiology has been a discipline of the Canadian Space Agency's (CSA) Space Exploration Program and Canada's Space Plan. As noted by the CSA: "the search for life, either extinct or extant, on Solar System bodies beyond Earth is of the highest scientific interest and possibly of the greatest potential impact on human society." The 2008 CSA Exploration Roadmap includes direct initiatives for Canadian participation in Mars Exploration missions, including direct CSA involvement in a Mars sample return mission. As noted (Sept. 03 2008) by The Honourable Jim Prentice, PC, QC, MP Minister of Industry, "... in the next phase of the great adventure, our vision is to ensure that Canada stays at the forefront of space exploration and development. At this crossroads, Canada will take the road that leads to a future of scientific and technological excellence. Canada will be among those bold nations that go on to new exploration and new development."

Terrestrial analogue sites for astrobiology – A Canadian strength. Canada is in an enviable position of hosting a number of well-established and unique sites for astrobiology analogue studies especially those that approximate conditions that exist on Mars. In particular, the Canadian Arctic offers a plethora of analogue sites, including vast regions of continuous permafrost/ground ice, meteorite impact craters, glacial landscapes, perennial saline springs, ice-covered lakes, and ancient rock formations. Through the CSA Canadian Analogue Research Network (CARN) program, several Canadian analogue sites were recently established as world-class bases for Astrobiology-related field studies, including the McGill Arctic Research Station (MARS) and the Haughton impact crater in the high Arctic, and Pavilion Lake in British Columbia. These sites serve as training and testing grounds for students, PDFs, and researchers and for instruments and technologies, by both Canadian and international teams.

Research relevance. With almost half of Canada's GDP growth in the knowledge-intensive sectors of the economy, Canadian Space Science is a key driver behind continued leadership on the world stage, new opportunities for industry and scientists, and long-term social and economic benefits for all Canadians.

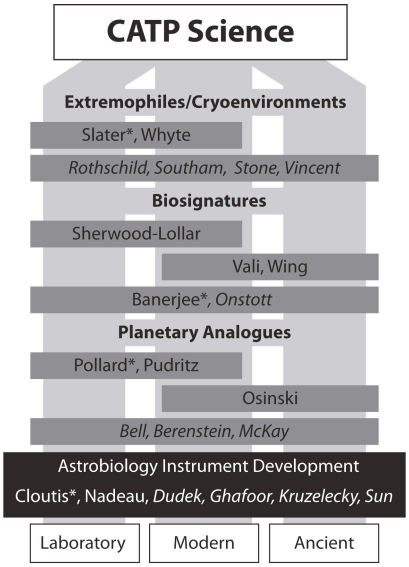

Figure 1. Expertise of key researchers and collaborators (italics) divided into three primary research foci and three different approaches: laboratory investigations, and modern and ancient environments.

NSERC CREATE Canadian Astrobiology Training Program Grant: The Canadian Astrobiology Training Program (CATP) is the first of its kind in Canada. Funded through NSERC's new Collaborative Research and Training Experience (CREATE) Program, the CATP is a cross-disciplinary, multi-institutional undergraduate, graduate and postdoctoral training program in Astrobiology. *The overall objective of the CATP is to train teams of outstanding Highly Qualified Personnel (HQP) in Astrobiology.* As Astrobiology is a fundamentally integrative science, this will be accomplished through interdisciplinary research approaches containing elements of geology, chemistry, physics, astronomy, microbiology, and robotics, all of which will be implicated in constructing the program at the participating universities and institutions (Fig. 1). CATP comprises leading scientists from major nodes of astrobiology and planetary research in Canada: Quebec (McGill University) and Ontario (University of Western Ontario, McMaster University, and University of Toronto) as well the University of Winnipeg.

CATP trainees (~70 graduate and undergraduate students, PDFs over 6 years) will be exposed to innovative research and training approaches, combining fieldwork at unique Canadian analogue sites with laboratory work at cutting edge analytical facilities at participating university, government, and industry partners. CATP HQP trained in various aspects of astrobiology will be at the forefront of the search for life beyond the Earth. Indeed, CATP will address the recognized lack of HQP in space science and lead to new scientific opportunities and promote Canadian participation in future missions to Mars with the ultimate goal of having Canadian scientists actively participating on such missions within 2-5 years as well as a future Mars sample return mission; both are direct initiatives of the 2008 CSA Exploration Roadmap. The skills acquired through this program will be directly transferable to various other disciplines, such as Earth and environmental sciences, robotics, medicine, and astronomy. Professional training will be enhanced by training rotations with our collaborators at CSA, MDA Space Missions, and our international partners, including NASA Ames.

Program structure: CATP consists of the following structure to optimally enhance the HQP training experience:

Graduate Student Training. The goal of our program is to provide students with the broadest possible exposure to astrobiology and its applications to the industrial, public, and academic sectors. The graduate students recruited into the program have the choice of several departments in which to register: at McGill, Natural Resource Sciences, Physics, Microbiology, Earth and Planetary Sciences, Geography, or Engineering; at McMaster, Physics and Astronomy, Biology, Geography and Earth Sciences. and Biochemistry. At Western: Earth Sciences, Physics and Astronomy, Geography, or Engineering; at U. Winnipeg – Bioscience, Technology, and Public Policy.

The MSc and PhD programs will consist of coursework, research, and field work according to the existing models in the host departments, with four innovative features provided by CATP: *graduate option, interdisciplinary supervision, rotations, and videoconferencing.* Rotations are a key innovative feature of CATP training and will be available and encouraged for all CATP students, funded in part by monetary and in-kind contributions from partners. These rotations will consist of 4–12 week internships in partner labs, either academic government or industrial sites (e.g. CSA, MDA Space Missions, MPB Communications, NASA Ames, Desert Research Institute (DRI)). *We identify three tracks based upon field of study: an "analogue fieldwork" track; a "wet lab" track; and an "instrumentation" track* (Table 1).

Analogue Fieldwork Track (Pollard, Wing, Whyte, Osinski, Banerjee, Cloutis)	**Wet Lab Track** (Nadeau, Vali, Sherwood-Lollar, Banerjee, Osinski, Slater, Whyte)	**Instrumentation Track** (Nadeau, Cloutis, Osinski, Pollard)
Choice of supervisors and planning of seasonal field trips	Optional: Enrolment in BMDE506 "Molecular Biology Methods"	Choice of two supervisors: one in engineering and one in biology/ planetary sciences
Rotation in analoge field site(s): 2-4 weeks per site	Laboratory-based research project with two co-supervisors	Rotation in wet lab to test real biological question with developed technology
Analysis of materials from analogue sites in the field and lab	8-10 week rotation at co-supervisor's institution or laboratory	Field testing in non-remote sites; sharing of technology with those travelling to remote sites
Field testing and deployment of instruments in analogue sites	Shorter visits as needed to NASA Ames, DRI, etc	Industrial or government rotation (CSA, MDA, etc)

Table 1. Research tracks for CATP Trainees, with names of faculty participants and locales for fieldwork/internships.