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"Researcher for a Day": Creating and Shaping a New Generation of Scientific and Medical Researchers

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Science is the engine of prosperity, helping society respond to the important issues it faces. We are presently witnessing a worldwide decline in high school students' interest in science, regardless of gender. To overcome this problem, developing science promotion programs and activities that inspire young people to become the scientists of tomorrow is critical. We strongly believe in the leadership of research centers in creating such programs, which could have a significant impact on the next generation of scientists. Here we present the "Researcher for a Day" program, which offers senior high school students immersion days in a scientific workplace dedicated to microbiology, as an example for other institutions that would like to implement such a program. Researcher for a Day has already helped more than 4,000 young students who are considering their career choices discover the world of science. Similar approaches could be implemented virtually anywhere to extend these efforts to promote science among young people.

INTRODUCTION

The scientific world is at a turning point: the wealth of knowledge, the technological development and the possibilities of revolutionary breakthroughs have never been so great. However, many young students with promising potential are missing the opportunity to engage in studying science. They do not know what training is required to access the diversity of scientific careers. This is currently reflected in a worldwide trend toward the loss of interest in science and technology at school (1–6). Teenagers can be impressed by new technology that surrounds them, but developing a scientific culture during adolescence remains challenging (2). It is more than ever essential to reach future generations through concrete actions to promote scientific and technological careers in order to adequately shape the scientists of tomorrow. In addition to the overall decline in interest for science, there is still a significant gender gap in science, and the number of women working in science continues to be largely insufficient to ensure optimal exploitation of our society's talent (7–10). To offset these global trends, several initiatives are promoting science and technology to young students around the world, such as spring break or summer internships, science weeks and science festivals, or "Open House" activities (11–24).

Researcher for a Day (R-1-D), a unique program that aims to connect students with research scientists to stimulate their interest in science and foster the development of future scientific careers, was created at the Infectious Diseases Research Centre (IDRC, founded by Dr. Michel G. Bergeron (25); cri.ulaval.ca/en/) of Université Laval (ulaval.ca/en.html). In line with global efforts to promote women and girls in science (26, 27), in every R-1-D workshop, we illustrate the importance of girls in scientific careers. During R-1-D, students have the opportunity to model themselves on both female and male researchers who stand out on the world stage, in an innovative, state-of-the-art environment. More importantly, R-1-D enlists researchers to illustrate how cool science can be (28).

The Researcher for a Day program in brief

The Researcher for a Day program was initiated in 1998 by Doctors Michel G. Bergeron and Yves Bergeron, in collaboration with the College of Levis-Lauzon. The program is designed to connect senior high school students with health science and biotechnology researchers to stimulate youth interest in science and technology and to promote future scientific careers. Every Wednesday during the school year, R-1-D offers groups of 10 to 15 teenagers at secondary 4 and 5 levels, corresponding to grades 10 and 11 of the K–12 education system (29, 30), the opportunity to live a day-long guided immersive experience in a research setting in full

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activity. This formula demystifies the world of research for girls and boys from all backgrounds, allowing them to glimpse the possible careers in microbiology and related fields, to witness the busy life of a laboratory and interact with real scientists, to perform hands-on laboratory manipulations, to attend workshops on topics of current research, to be exposed to recent discoveries and advanced technologies, and to see cutting-edge innovations (Table 1). It also allows teachers and career counselors to gain a wide view of life science developments in their region to better guide young students toward exciting future scientific careers. The R-1-D program has been a great success over the last 21 years, as indicated by the participation of 76 educational institutions in the greater Quebec City area (population ~1.25 million). To date, close to 4,800 people have taken part in these scientific days (Fig. 1) from 46 public and 30 private institutions from 10 school boards (districts). This unique immersive activity has become a highlight for several high schools that have participated diligently year after year, and the comments provided by the school workers accompanying the students are very positive. Table 2 provides examples extracted from these testimonies, reporting that the program is helping students in their career choice, initiating them to science facts and sophisticated instruments, and helping them to discover their passion. The scientific community recognized R-1-D's relevance as early as 1999, when it was a finalist for the Industrial Research Association of Quebec Award, in the "Supporting the Changing Generation of Science" category. In 2009, R-1-D was the recipient of the Canadian Institute for Health Research (CIHR) Synapse Award for outstanding contributions to promotion of science to young people and to the next generation of scientists in Canada. Recently, R-1-D was a finalist in the "Relève Technoscience" category at the 2018 annual Innovation Awards Gala of the Association for the Development of Research and Innovation in Quebec (ADRIQ) (32). Over the years, several partners have shared our vision of science promotion and have generously supported this program, including the Government of Quebec (Ministry of Economy, Science and Innovation; Ministry of Research, Science and Technology; Ministry of Economic Development, Innovation and Export Trade), the Youth Forum, 'Boîte à sciences' (Recreational Science Development Organization), the Natural Sciences and Engineering Research Council of Canada (NSERC), the Canadian Institutes of Health Research (CIHR), Fisher Scientific, as well as Université Laval.

Researcher for a Day, step by step

The R-1-D schedule comprises an admixture of hands-on workshops and seminars (see Table 1), which are prepared and offered by career scientists and graduate student researchers. It is engaging for young students to hear about topics that are featured in news headlines, such as HIV, Ebola, influenza, antimicrobial resistance, rapid (<1 h) molecular diagnostic tests and innovative preventive tools such as vaccines and microbicides. The extensive collaboration established for past and ongoing IDRC research projects lets speakers exemplify concretely the importance of teamwork and trans-disciplinary approaches for translating discoveries into applications.

1. Introduction. The journey starts with an interactive presentation introducing students to the world of health research with the example of the IDRC. The vast majority of research laboratories are structured similarly; only projects change. The emphasis is on passion at work, reinforced by several characteristics such as curiosity, perseverance, and ingenuity. We illustrate this with a biography of key researchers, such as our founder (25). We present some statistics about IDRC researchers, graduate students, important published scientific articles and patents, the funding process, and companies created by IDRC researchers. The different areas of basic, applied and clinical research are briefly explained, and the various research job positions are then presented, along with the academic studies required. What is a researcher? What is his/her daily reality? How does one obtain a merit scholarship for a summer internship or a master's or doctorate degree?

2. Laboratory tour. Before the visit, each student dons a lab coat; they like the "uniform." We start the visit by stressing basic laboratory safety. Our laboratory complies with the Canadian Biosafety Standards and Guidelines (33). We indicate emergency exits and safety equipment, such as fire blankets and eye washes and body showers. We explain that rooms have been specifically designed to work with microorganisms that may be pathogenic but that the students are never exposed to pathogens at any time during the day. They can peek through the door window of a biosafety level (BSL) 2 room to see specially gowned people working in biosafety hoods. We briefly talk about the various research projects, presenting instruments such as centrifuges, incubators, -80C freezers, and electrophoresis chambers. We pause at a dedicated bench, and students are invited to sit down for a visual demonstration of bacterial antibiotic resistance using antibiograms showing the phenomenon of bacterial growth and inhibition by antibiotics. We explain the antimicrobial resistance dilemma that physicians face and the need to develop rapid DNA-based diagnostic tests that give the resistance genotype (this is the subject of the last presentation of the day). A common laboratory instrument, the micropipettor, is then presented to students, who experiment with it by performing a colorimetric pH test (wearing gloves and protective goggles). Photographs of students in action are taken (with permission) and are available for them and their schools.

3. State-of-the-art bio-imaging. This workshop presents various microscopy techniques for observing outside and inside cells. Students enter into the bio-imaging platform laboratory facility, where basic notions of optics

TABLE 1.
A typical Researcher for a Day journey.

Time	Title	Activity	Topics	Material *(Site)*	Purpose of the activity
8:30 am	Welcome. What is science?	Interactive presentation	• What is scientific research? Definition of a researcher's career • Multiple fields of research and development, science and engineering, and health sciences • Typical day in the life of a researcher, qualities required • Definition of basic, applied, and clinical research • What is a research team and the professional skills required to work in a laboratory • Possible paths from high school to research laboratory • Types of employment (researcher, project manager, research assistant, technician, etc.) • Potential employers: research centers, industries, universities, army, government, hospitals, etc. • Current research topics at IDRC • IDRC discoveries and products (commercial diagnostic kits and REVOGENE, innovative genetic vaccines, new therapeutic approaches, INVISIBLE CONDOM, etc.)	• Computer and multimedia *(Conference room)*	To orient students to a career as a research scientist and to the necessary and available schooling options and scholarship opportunities
9:30 am	A view of the laboratory	Interactive visit	• Biosafety: the most important step before working in a lab • Interactions with researchers at work • Effect of antibiotics on bacterial growth • Students perform basic experiment with micropipettor • Souvenir photos of students wearing lab coats and gloves, for schools and website	• Lab coats, gloves, goggles • Micropipettors • Colorimetric pH test • Antibiogram *(Laboratory)*	To teach students basic laboratory safety and introduce them to basic laboratory equipment
10:45 am	State-of-the-art bio-imaging	Interactive workshop	• Bio-imaging is much more than the microscope of my childhood: use in basic and medical research and discovery • Laser technology, fluorescence, 3D reconstruction • Electron microscopy (magnification 100,000 X, principles of use) • Observation of samples (fluorescence and electronic)	• Computer and multimedia • Confocal microscope • Fluorescence microscope • Electron microscope *(Bio-imaging platform)*	To expose students to state-of-the-art equipment used in science
12:00 pm	Lunch	Social interaction	• Friendly lunch among students • Discussion with a researcher: discovering the personal and human side of the researcher, their work and challenges	• Lunch *(Conference room)*	To have direct contact with a researcher and to discuss their experience
1:00 pm	HIV/AIDS, Ebola, Zika	Interactive workshop	• Information about biosafety laboratory dedicated to HIV research • A volunteer dresses for HIV research (souvenir photos of students, for schools and their website) • Demystify Ebola: biosafety laboratory dedicated to Ebola research, mammal reservoirs, vaccine and therapy; Zika	• HIV laboratory observation window • HIV gowning *(Laboratory)*	To expose students to an exciting example of cutting-edge research

TABLE 1.
Continued

Time	Title	Activity	Topics	Material *(Site)*	Purpose of the activity
1:45 pm	Development of new medications/ Technology transfer	Interactive presentation	• Entrepreneurship and technology transfer • What are the steps in product development? • The INVISIBLE CONDOM: polymer-based anti-STIs microbicide gel and vaginal applicator to empower women to protect themselves against STIs and unintended pregnancy • Clinical trials (Phases I, II, and III) • Importance of patents, industrial development, and regulatory agencies	• Computer and multimedia • The INVISIBLE CONDOM as an example of tech transfer *(Conference room)*	To introduce students to the interface between science and product development/entrepreneurship
2:45 pm	Molecular diagnostics and nanotechnologies	Interactive presentation	• Genomics, microbiome and microbiota, microfluidics and nanotechnologies • REVOGENE of GenePOC (mobile point-of-care system), developed at IDRC by engineers in electronics, mechanics, and optics • Applications in the agro-food, environmental, aerospace, civil protection, and defense sectors • Information on the impact of research and the importance of science for society	• Computer and multimedia • REVOGENE instrument as an example of molecular diagnostic tool *(Conference room)*	To provide examples of real-world applications of laboratory techniques
3:30 pm	End of the day	Closing	• Quick assessment of the day by the students • Encouragement to persevere in studies • Delivery of a certificate of participation • Internet links to access the conference documents and photos sent to the students and teachers/school counselors	• Questionnaire • Certificate *(Conference room)*	Evaluation of activity

IDRC = Infectious Diseases Research Center; STIs = sexually transmitted infections.

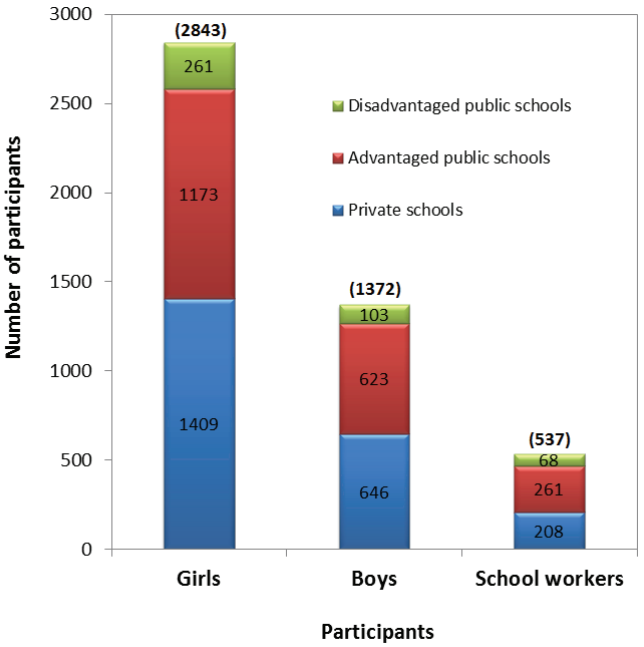

FIGURE 1. Participation in the Researcher for a Day (R-1-D) program from 1998 to 2019. R-1-D received a total of 4,752 participants, distributed as follows: 2,263 (1,409 girls, 646 boys, and 208 school workers) from private schools, 2,057 (1,173 girls, 623 boys, and 261 school workers) from advantaged public schools* and 432 (261 girls, 103 boys, and 68 school workers) from disadvantaged public schools*. Total participants are in parentheses. * Schools are ranked on a scale of 1 to 10, with rank 1 considered the least disadvantaged (1–6 are considered advantaged) and rank 10 as the most disadvantaged (7–10 are considered disadvantaged), according to the socio-economic index (31).

are presented and linked with their physics course. A brief history of the discovery and development of fluorescent molecules and their multiple uses is presented, followed by the observation of cell organelles labeled with fluorescent molecules. Students see other microscopes, including a system performing 3D reconstitutions of cells, and another for capturing live videos of cellular events. The workshop finishes with the observation of inactivated viruses under the electron microscope.

4. Lunch. During the first part of the lunch break we check the impressions and comments of youth about their visit thus far. The second part gives students the chance to talk with an invited researcher. They are encouraged to ask questions while the researcher tells them about their motivations and choices for a research career, their tasks and responsibilities, as well as their daily challenges.

5. Virology workshop. The purpose of this workshop is to present research topics on really threatening microbes that make news headlines. Students receive basic information about HIV, its mode of transmission, treatments and vaccine development, as well as the HIV laboratory. A volunteer is invited to wear the biosafety work clothing and a photograph of the group is taken. Then they hear about Ebola, a Risk Group 4 pathogen. They are informed about the bio-containment laboratory, with a video showing the different stages of preparation to access a high containment laboratory so they can appreciate the difference from the precautions they saw for HIV. We also illustrate mobile facilities available in the field during epidemics and how the

TABLE 2.
Testimonies (key points) from various schools participating in the Researcher for a Day program.

Related topics	Testimonies
Career orientation	• Learn about exceptional career paths from a researcher, builder, and scientific promoter. • Help demystify medical research and scientific jobs for young students. • The visit and program provide guidance and choices for future studies and possible careers.
Passion	• Having the students inoculated with researchers' passion for science. • Passionate researchers present captivating and exciting topics. • Many eyes were shining around the table.
Relation to school	• Students make the connection between theory and practice. • Students relate technologies to what they learn in class. • Students identified this day/visit as one of the most interesting activities they had in the context of their course.
Sciences	• Having the students introduced to new technologies and fascinating scientific instruments. • Students enjoy working with researchers, discussing with them, questioning them about current and future research projects. • Students learn to take a stand against diseases (e.g., STIs). • Materials used and biological methods developed are concrete examples for our students.
Usefulness	• Very useful not only for students, but also for science teachers. • We believe in the benefits of this kind of activity for the motivation and development of our future scientists.

STIs = sexually transmitted infections.

Ebola virus is inactivated before being identified by molecular testing. Animal reservoirs are discussed as well as treatment and vaccine development.

6. Technology transfer. This interactive presentation briefly describes the different steps in product development: the R&D stage, the phases of clinical studies, technology transfer, the importance of patents to protect intellectual property, and submission to regulatory agencies as well as entrepreneurship. The example used to illustrate the process is the INVISIBLE CONDOM, a polymer-based microbicide/spermicide vaginal gel formulation and special vaginal applicator developed at IDRC to empower women to protect themselves against sexually transmitted infections (STIs) and unwanted pregnancy. Students are also made aware of the dramatic impact of STIs on women's health, and of the importance of developing female-controlled products such as the INVISIBLE CONDOM to reduce mortality and morbidity in women (34).

7. Molecular diagnostics and nanotechnologies. This interactive workshop allows consolidation of science notions learned at school with a focus on genomics, microbiome, microfluidics, and nanotechnologies. We use the gut microbiota to illustrate the size of cells, weight of microbes in a human, role of DNA in heredity, and adaptation of microbes to their environment. We stress the benefit of human bacterial flora and describe its capacity as a reservoir of antibiotic resistance genes, which can be transferred to pathogens, leading to resistance and therapeutic failure. We also present a new point-of-care diagnostic system developed at IDRC by molecular biologists in collaboration with experts in medicine, engineering, nanotechnology, microfluidics, electronics, mechanics and optics and now commercialized worldwide (35). This is another example of the power of trans-disciplinarity in health research and how entrepreneurship can bring about effective solutions for society.

8. End of the day. We ask participants to fill out an assessment form to measure their degree of satisfaction about R-1-D. Each student receives a personalized participation certificate. They get access to electronic versions of the presentations and structured information about life science careers.

Effectiveness of Researcher for a Day

During academic years 2017–2018 and 2018–2019, all 647 R-1-D participating students completed a five-question survey. The results (see Table 3) show that the R-1-D immersive experiment attracted a lot of interest for the majority (82.9%) of them. More than half (57.2%) of the students agreed that R-1-D increased their interest in a career in science (36.0% somewhat agreed, and only 6.8% did not agree); more than 90% said that R-1-D had had an influence on their decision to go into science (45.3% agreed and 46.5% somewhat agreed). An encouraging fact is that 56.4% indicated their intention to pursue a university program in science (33.2% are still undecided); and R-1-D actively changed the perception of research for 72.5% and somewhat for 23.2% of them. These results show that our program is successful in at least immediately influencing students' views of science.

Researcher for a Day: An exportable and adaptable program

All the topics covered in R-1-D are based on the expertise of the IDRC laboratory and can be adapted to the research topics of other laboratories wishing to implement such programs in their own laboratories. This has been demonstrated at the University of Québec in Montreal with the implementation of the program Biologists for a Day (36) by a former doctoral student of IDRC who is now a researcher at that institution. Science awareness efforts based on R-1-D can start with occasional half-days to test the target audience and see how the project fits in with the educational programs in the community. Receiving feedback from students and school staff is very important in judging the relevance of the activity and knowing what to keep and what to change. During its 21 years of activity, R-1-D has continuously improved and adapted according to current laboratory projects, the evolution of the scientific techniques used, and the staff and financial resources available. The first year, we received only 78 individuals, then 162 and 165 during years 2 and 3. Now, we receive about 400 people a year. The agenda and topics have considerably evolved over the past 21 years. We were not talking about nanotechnology and microfluidic PCR systems in 1998. On the other hand, projects on the development of DNA-based diagnostic tools were in their infancy and we were able to talk about DNA and the emergence of antibiotic resistance in bacteria. Similarly, advanced microscopy techniques now show more details about cell components. With the arrival of Dr. Gary Kobinger (37) in 2016, we added an Ebola/Zika section to the virology workshop. The R-1-D program can simply be adapted according to the strengths and expertise of each institution to develop a student immersion scientific activity. Laboratories can choose equipment they have available, including state-of-the-art instrumentation. They can highlight their own scientific advances or products, putting them in the context of everyday life. Most importantly, students want to see amazing things. Do not bore them with abstract theoretical concepts that mean nothing to them. They want to see and touch. Touching a micropipettor for the first time, knowing it can measure microliters, is impressive and captivating for a high school student. R-1-D is only an example designed to give scientists the taste to share their passion with students.

DISCUSSION

The R-1-D program has been fortunate for 21 years to count on financial partners, such as the provincial and federal

TABLE 3.
Results of the five-question survey (*n*=647).

		Yes	Somewhat	No
1.	Was the visit of interest for you?	82.8%	16.2%	0.9%
2.	Did your R-1-D journey strengthen your decision to go into science?	57.2%	36.0%	6.8%
3.	Did your R-1-D journey convince you to go into science?	45.3%	46.5%	8.2%
4.	Will you study science at university?	56.4%	33.2%	10.4%
5.	Did your visit change your perception of research?	72.5%	23.2%	4.3%

governments of Quebec and Canada (38, 39) and other organizations that believe in the importance of educating and promoting science to teenagers. This financial support has allowed high standards to be maintained for R-1-D, such as i) offering the program once a week throughout the school year; ii) providing a full day experience; iii) accessing facilities, equipment and consumables for hands-on laboratory experiences; iv) interacting with busy researchers; and v) all this continuously for 21 years. We present R-1-D as an example of how scientists can be, "active partners in promoting science education to young people outside school classrooms" (26).

At the present time, we can only estimate the potential impact of R-1-D through the survey participants complete after their experience. Although the impact appears positive, we haven't had a means to measure the proportion of R-1-D student participants who pursued higher education in science. Do these results actually reflect the choices of students for university studies? Which science sector would they choose? Did they choose a research-oriented career? To answer these questions and provide data on the actual impact of our program, we are currently drafting a project to develop a virtual tracking tool to anonymously follow the academic path of the student cohorts who participated in R-1-D. This information technology tool will use the permanent code of the Quebec Ministry of Education (40) required for registration at an educational institution in Quebec. Various science promotion programs could then use this tracking tool to evaluate their importance, scope, and impact. This project will be implemented in partnership with several organizations promoting science and the Quebec College of Guidance and Career Counsellors.

CONCLUSION

In the face of declining youth interest in science, we must intervene to stimulate their minds and demonstrate the importance of science in ensuring our society continues to be productive and able to respond to the major challenges facing us. Researcher for a Day is an example of a program for a large number of high school students who are concerned about their careers but who do not yet really know which career to embrace. In addition to offering them the opportunity to live an immersive experience in a research laboratory with its skilled workers, sophisticated instruments, and state-of-the-art technologies, R-1-D initiates them to the mechanics of scientific research in an ultra-competitive sector that requires extensive knowledge and trans-disciplinary skills. The program aims to infuse students with this wealth of knowledge and curiosity from the scientific world.

A program such as R-1-D should be available everywhere. It is essential to develop similar programs in order to introduce young people to the prevailing challenges in their regions and to make them aware of the fact that they have the potential to become the scientists of tomorrow who will tackle these challenges. The format may vary and programs need to be adapted to regions based on factors such as demographics, socio-economic backgrounds, specific needs and challenges, and the ability to attract host institutions to offer these integration activities. It is essential to transmit the passion for science to young people so that the flame continues to burn bright for these future scientists needed to shape our world and hopefully improve our lives.

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