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University of British Columbia

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National Version

PHYSICS & ASTRONOMY
Outreach Program News

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It is the end of the year again - this issue of Physics & Astronomy Outreach News features a recent research study that's making headlines in the news. How can physics improve forensic DNA testing of tiny, contaminated samples? Read all about it in "Physics at Work." Don't forget to also read about upcoming outreach opportunities, as well as the 2009 Physics Olympiad Report.

Thanks for reading and we wish you a wonderful winter holiday!

You can subscribe to our newsletter at our website: **http://www.phas.ubc.ca/outreach/web/emailList.php**.

Contact Us
Theresa Liao, Communications Coordinator
Physics & Astronomy Outreach, University of British Columbia
6224 Agricultural Road, Vancouver, BC V6T 1Z1
Email outreach@phas.ubc.ca; Phone: 604-822-3675; Fax: 604-822-5324

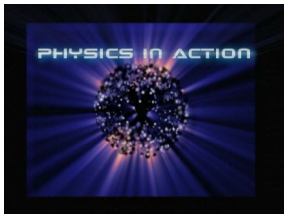
Outreach Opportunities

TRIUMF
Canada's National Laboratory for Particle and Nuclear Physics
Laboratoire national canadien pour la recherche en physique nucléaire et en physique des particules

Physics in Action Video Series

TRIUMF is creating a video series which will use the cutting-edge science at the world's largest cyclotron to teach basic concepts in secondary school physics.

Two of four planned videos have been released. Order your copy today at TRIUMF website: http://www.triumf.ca/physicsinaction/



CAP Award for Excellence in Teaching High School/CEGEP Physics

TRIUMF is honoured to be a national sponsor for these awards to a teacher in each of Canada's five regions who possesses an exceptional ability to motivate his/her students to high academic achievement in physics.

Nominations are now open until January 15, 2010. Visit the CAP website for details: http://www.cap.ca

Physics at Work

Physics improves forensic DNA testing of tiny, contaminated samples - Theresa Liao

DNA analysis is an important tool in criminal investigations and many other research studies. What do you do if you have contaminated DNA? Learn about how physical characteristics of DNA are being used in a recently developed method to better extract DNA from contaminated samples!

If you have seen any of those popular "crime scene investigation" shows, this might be your impression of DNA analysis –

At the crime scene, an investigator collected a blood sample from the victim's jeans with a cotton swab. At the lab, a lab technician placed the tip of the cotton swab in a tube, mixed it with some solution and swirled it around on a machine. The technician then took a small amount of the solution and put it in the tube, which then went into a machine. Within 5 minutes, a DNA profile belonging to someone was generated and in another 5 minutes, a positive match was identified and they now have a suspect!

Is it always so easy in reality, that investigators can easily collect and analyze DNA samples from a crime scene? You can probably guess what we are going to say – of course not! In fact, there are so many more steps happening between a sample collection and a DNA match. Today, let's start by talking about the extraction of DNA from a sample.

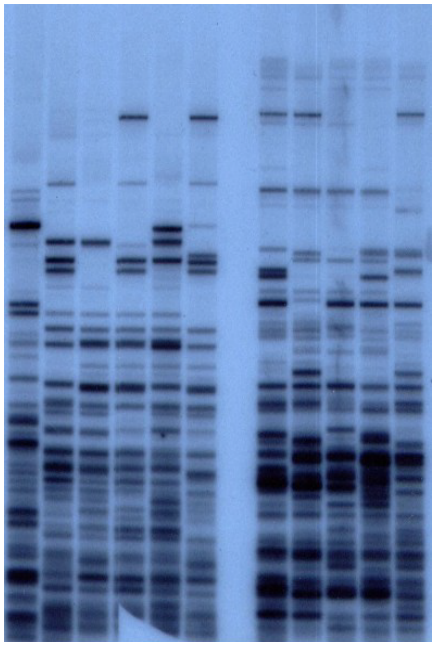


Figure 1[i]: An early DNA fingerprint showing DNA patterns from a mother (lanes 2 and 8) and her four children (adjacent lanes to the right).

You probably already know what DNA is, but let me quickly explain it to those who have little idea. Broadly speaking, DNA, deoxyribonucleic acid, is a very large molecule found inside the cell nucleus. The interesting thing about this molecule is that its chemical composition and structure actually allows it to contain our "genetic code," which is unique for each one of us (almost like your fingerprint). By comparing DNA codes from different samples, we can tell whether the samples come from the same individual, different individuals, or even individuals who are related. Pretty neat, right?

Now here comes a problem. In order to analyze DNA, we need to start with a certain amount of "purified" DNA from the sample. However, when we collect a sample, we collect not only DNA, but a lot of other things (contamination) with it. The sample we collect might have been contaminated with random things like carpet cleaner, juice spilled on the floor, soil, dye on the blue jeans, dust – whatever you can think of, the list goes on. To purify DNA, the general technique is to dissolve the DNA sample in a solution, and use another chemical/particle that has better "affinity" for DNA (something that attracts DNA better) to extract and purify DNA. This purified DNA sample will then go through a few more chemical washes to ensure that all the impurities are washed away. It is a double-edged sword – if you don't wash enough, you get impure DNA, which will not work when you run analysis later on and you end up wasting your sample; OR, you wash the sample so much, in the end you have so little DNA that you might not be able to run an analysis!

What does physics have to do with this? A method recently developed by UBC's Biophysics Professor Dr. Andre Marziali presents a solution to this problem[ii]. Instead of using chemicals to extract DNA, Dr. Marziali and his colleagues decided to exploit the physical properties (things like charges, stiffness, size, etc) of a DNA molecule in the extraction process. By applying an electric field to the sample, we can separate DNA, a large flexible molecule with many electric charges, from other dust, dirt, contaminants that, being either stiffer or less charged, do not move in the same way. In the end, what you get is the purified DNA sample, without having to go through all the washes and wasting precious DNA materials.

Physics at Work (con't)

How important is this? In fact, many forensic cases failed because DNA samples were not usable. So this technique will contribute greatly in crime solving in the future. Dr. Marziali has worked with RCMP in testing some of the "difficult to handle" samples and the method worked well with the test samples provided. The use is not limited to crime fighting – it can also be used to identify bacteria hidden in hard to find places (i.e. Dr. Marziali and his team also extracted DNA from more than 200 different bacteria from oil sand, which in the past was extremely difficult to process using the conventional DNA extraction method), to extract DNA from very old bone samples (fossil identification), or to detect small amounts of mutated DNA in blood that might be a sign of disease such as cancer. That's pretty exciting, uh? Dr. Marziali's team is now working on advancing this technique so that specific DNA sequences can be extracted. Hopefully many more DNA related studies can benefit from this innovative technique in the future!

Acknowledgement
We would like to thank Dr. Andre Marziali for reviewing this article.

References
i. Image by Alec Jeffreys, from Wellcome Images. http://images.wellcome.ac.uk/
ii. Pel J, Broemeling D, Mai L, Poon HL, Tropini G, Warren RL, Holt RA, Marziali A. Nonlinear electrophoretic response yields a unique parameter for separation of biomolecules. Proc Natl Acad Sci USA. 2009 Sep 1;106(35):14796-801.

Want to learn more? Check out the following

- Original Research Article: http://www.pnas.org/content/106/35/14796.abstract
- Media Release from UBC: http://www.publicaffairs.ubc.ca/media/releases/2009/mr-09-096.html
- Dr. Marziali's research website: http://www.physics.ubc.ca/abl/
- Genetics related activities from Genomic Education Canada: http://www.genomicseducation.ca/educationResources/activities/default.asp

More on next page...

Physics Olympiad Report 2009

- Guillaume Chabot-Couture and Andrzej Kotlicki

While most travelers head to Cancun for a beach vacation amongst a sea of tourists, this year, the 40th International Physics Olympiad (IPhO) was held in Merida, Mexico a few hours from Cancun on the calmer Northern edge of the Yucatan peninsula. From the 11th to the 20th of July, a total of 73 countries participated in the competition while 12 countries cancelled their participation due to the swine flu scare. The organizers treated the scare seriously, measuring the skin temperature of each participant daily with an infrared thermometer and having two doctors on staff at all times. In the end, no cases were found among the participants.

The competition was important for the Mexican state of Yucatan whose governor, the honourable Ivonne Pacheco, opened it with a warm, personal speech to participants. Several other speakers from the Organizing Committee, the government, Mexican universities, the Mexican Physical Society and the IPhO organization welcomed the participants, stressed the importance of Science and Education, congratulated the students their achievement in being selected as the team members representing their countries, and wished them success in the competition. The opening ceremony also included songs by a children choir and an entertaining comedian whose physics-filled performance featured crowd interaction, lasers, and even smoke vortices projected across the stage to the delight of all present.

There were a total of three evening lectures presented to students and leaders, including one from the 1993 Nobel Prize Laureate Professor Joseph Taylor on binary pulsars astronomy.

In between the students' examinations or the preparation and administrative work of the leaders, the social program provided both rest and recreation. It featured visits to Chichen-Itza and Uxmal which are famous for their towering Mayan pyramids, giant ball game fields, and other structures of the ancient Mayan civilization. Students and leaders also visited Izama, a colonial town where three cultures coexist. In this town, thousand year-old Mayan pyramids tower over houses in quiet neighbourhoods while a bright yellow Franciscan monastery, dating back to colonial time, marks the center of town.

Moreover, it is also a town where modern shops full of electronic gadgets stand side by side with traditional shops that sell hand-made hammocks. This contrast of the old and the new is also striking amongst the new Mayan generation that can be heard speaking the thousand year-old tongue of their ancestor on their brand-new cell phones. In Merida, the accommodations for both students and leaders were of first class quality. Throughout the Olympiad, we had the occasion to taste many different dishes characteristic of Yucatan food, all excitingly different from what we would normally associate with Mexican food. We also experienced the warm Mexican hospitality wherever we traveled to. One evening, as we were strolling through Izama, we heard music coming from a house so, out of curiosity, we talked towards it. As we walked by, we saw a family in its backyard, celebrating a birthday. We smiled at them and they waved back, inviting us to join them. Just a few moments later we were enjoying an icecold beverage and dancing amongst everybody, in the backyard of a quaint little house. Thinking back, I am still impressed by how easy it was to interact with them, even with our very limited Spanish.

The academic part of the competition was organized by the faculty members from the National University of Mexico, the University of Yucatan and other Mexican universities and research centers. All five problems, both theoretical and experimental, were well prepared and tested the students' original thinking and experimental abilities. Just in time for the 40th anniversary of the first human on the Moon, the theoretical problems featured astronomical problems. The first discussed the transfer of angular momentum from the Earth to the Moon through the tides the latter induces on the former as well as, for example, the yearly increase of the Earth-Moon distance. The second problem discussed the physics of

Physics Olympiad Report 2009 (con't)

laser cooling, an important tool in the creation of Bose-Einstein condensates. The last problem showed to students how quantum mechanical effects are important to the fusion of Hydrogen into Helium that takes place at the center of stars by having them calculate both the fusion temperature and the M/R ratio of stars on the main sequence. The experimental problems were also particularly interesting. The first had the students measure the wavelength of a HeNe laser using the diffraction from a sharp razor blade while, in the second, the students had to characterize the birefringence of a thin slab of mica using polarizers. The marking of all problems was excellent. The marking moderations (the process of establishing the final mark acceptable by both leaders and the local marking team) were also performed in a good collegial atmosphere with very few real controversies.

Canada was represented by the following students:
Remy Abraham Mock, 11th grade, Mt. Douglas Secondary School, Victoria, BC
Jixuan Wang, 11th grade, Don Mills C. I., Toronto, ON
Shawn Xu, 11th grade, Burnaby North Secondary School, Burnaby, BC
Michael Zhang, 11th grade, Crescent School, Toronto, ON
Jonathan Zung, 11th grade, University of Toronto Schools, Toronto, ON

The team leaders were: Dr Andrzej Kotlicki from the Department of Physics and Astronomy of the University of British Columbia and Guillaume Chabot-Couture, a former member of Canadian team at IPhO in 2000 and at present completing his Ph.D. At Stanford University.

The Canadian team performed reasonably well, winning one silver medal (Jixuan Wang), three bronze medals (Remy Mock, Shawn Xu, Jonathan Zung) and an honourable mention (Michael Zhang). A total of 41 gold medals, 70 silver medals, 79 bronze medals and 45 honorary mentions were awarded amongst the 316 participating students.

History was made at this year's Olympiad as, for the first time ever, a woman obtained the best score (48.2 out of 50) and was declared the absolute winner of the Olympiad. Handuo Shi, a young woman from China, bested her closest competitor by only 0.1%. Both students and leaders were delighted with her success and gave her a standing ovation during the closing ceremony (another first in the history of the Olympiad) as well as numerous personal congratulations from peers and leaders during the following events.

In addition to winning the competition and the prize for the best mark in the experimental competition, she was awarded the prize for best female performance. Originally designed to highlight the accomplishments of girls in a male-dominated competition (girls compose less than 5% of the participants), the success of Handuo Shi is perhaps a sign that one day this prize will become obsolete and young female physics students perform as well as their male counterpart.

Finally, acting on behalf of the organizers of the next International Physics Olympiad, the president of the Croatian Physics Society announced that the 41st International Physics Olympiad will be organized in Zagreb, Croatia from July 13th to July 21st 2010. Accompanying her announcement, she presented a movie about historic sites and natural beauty of Croatia and followed it by cordially inviting all the participating countries to attend next year's competition.