A Suncor employee gives Dr. Gerrit Voordouw and colleagues a site tour and safety orientation prior to coring an exploratory well. Dr. Voordouw's research is assisting in the greener production and extraction of hydrocarbon energy. Suncor photo

Genomics and Energy:
HARNESSING THE POWER OF BIOLOGY TO DEVELOP CLEAN AND SUSTAINABLE SYSTEMS

Pierre Meulien

When the Deepwater Horizon disaster dumped crude oil into the Gulf of Mexico in 2010, it was oil-degrading microbes that contributed overwhelmingly to the clean-up. Every day, Canadian and international researchers are finding out more and more about how the energy sector can benefit from naturally occurring organisms and genomics is the science behind the innovation.

Canada's energy sector is one of the key engines of its economy. The sector represents some 9.6 percent of GDP, has annual export revenues of $111 billion, and employs some 5 per cent of the Canadian workforce. With growing global demand for energy, the sector is critical to this country's future.

Some of the challenges the sector faces, though, will require greater innovation to boost productivity and global competitiveness, and to ensure that extraction processes are carried out in the most

environmentally responsible way.

The energy sector will need to look beyond its traditional zone of influence and partnerships to find solutions to some of the serious issues it faces. Already, biological systems are seen as providing innovative solutions to some of the industry's most intractable problems.

In the case of the Deepwater Horizon oil spill in the Gulf of Mexico in 2010 (the largest oil spill in the petroleum industry ever recorded), the role of naturally existing oil-degrading microbial communities was critical in the cleanup of this environmental disaster. What if we could harness the biological power exhibited by these microbes to clean up existing polluted sites or more rapidly remediate the detrimental effects of tailings ponds—the result of extraction of oil from the oil sands of Alberta?

The application of genomics—the science focused on understanding the genetic makeup (the DNA) of individual life forms—is emerging as a viable solution to some of the most pressing issues facing the sector, both in terms of maximizing the yield of petroleum extraction and minimizing the potential damage from environmental release.

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We know that microbial communities can play both a positive and negative role in tailings ponds. They can accelerate pond settling and help to degrade toxins, but on the flipside, they can generate greenhouse gases.

Recent technological advances are now allowing us to read DNA code 1 million times faster and cheaper than was possible 15 years ago and this in turn is allowing us to understand which microbes already present in environmental samples can help us with the remediation issues we face on such a grand scale.

Energy sector stakeholders are now collaborating to increase our knowledge in this area.

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Already, scientists from both academia and industry are tackling some of these questions. We're getting a clearer picture of these fascinating microbes with the goal of knowing which ones are where, what they're doing, and how we can we steer their actions to our advantage.

Over the past four years, a team of researchers co-led by Dr. Gerrit Voordouw of the University of Calgary and Julia Foght of the University of Alberta analyzed 250 samples collected from eight tailings ponds. From the DNA of millions of microbes, they generated genomic profiles of the ponds' whole microbial communities. These revealed that each pond has a unique community of naturally occurring bacteria, but the predominant microorganisms are similar and they have common biological processes.

Ten industrial partners were involved in this particular project, which will make publicly available a catalogue of oil sand's microorganisms, genes and biological processes, something that is of great value for companies to better manage the oil sands and reduce risk.

Other Canadian research projects in Quebec and Ontario are devising new environmentally friendly approaches to decontaminating various polluted sites. In one case, a team of chemical engineers, biologists and consultants are working with industry to apply their knowledge of gene sequencing and computer modeling to identify, screen and analyze communities of microbes capable of restoring contaminated land and water. Understanding the natural function of such indigenous recyclers to break down contaminants, the team has developed and commercialized a microbial culture (called KB-1®) that is already being used for groundwater clean-up at sites around the world.

Meanwhile, Canada's well-established biomonitoring framework—which is critical for ringing the bell on environmental stresses before they reach critical thresholds—is getting a complete overhaul through new genomics tools and technologies that cut down on biological sampling costs while dramatically increasing the amount of information that can be gleaned from samples. A research project called Biomonitoring 2.0 is coordinating closely among industry, government, Aboriginal and non-government stakeholders to improve Canada`s ability to manage its natural resources and maintain its strength in biomonitoring.

Enhancing energy extraction is, of course, another area of exploration for genomics researchers. There is huge potential in this area both for mining and energy extraction, though so far with limited commercial success. Through a better understanding of the microbial activities operating in natural resource environments,

scientists are confident that genomics and related sciences can improve the effectiveness of biotechnological solutions to raise recovery rates well above current low and diminishing levels.

The world of biofuels is also going through dramatic change as microbial communities are being used to help in the biochemical conversion processes necessary to convert biomass to useful fuel. These new biologically based conversion technologies promise to decrease the energy used to produce a whole new generation of biofuels.

Genomics is still a young science. Its power and potential, especially in areas outside its more evident spheres of influence such as health and agriculture, are just beginning to be probed.

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The sector's sustainability issues need to be addressed urgently. Energy companies and government policy makers need to work closely together to create an environment where data sharing practices and interfaces between academia and industry are as productive as possible. Much more needs to be done to ensure Canada's future as a responsible energy superpower.

Harnessing the power of biology in industrial processes at scale must be a compelling priority for the federal and provincial governments if we as a country wish to remain competitive. Given Canada's footprint in the life sciences and the importance of our traditional industries to our economy, this should be feasible. P

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