

## CSM Murray Award for Career Achievement Recipient:

Dr. Sylvain Moineau, Université Laval, Quebec, QC



**Professor Sylvain Moineau** graduated with a BSc degree in Microbiology from the Université Laval in 1987. He continued at the same university but in Food Sciences, where he obtained his PhD in 1993 for his studies investigating phages biology. During his PhD, he also spent 18 months at North Carolina State University. He then undertook an industrial postdoc in Florida within a division of the multinational Unilever. In 1996, he moved back to Canada and the University Laval as an Assistant Professor in Microbiology to work on phage biology and resistance mechanisms in lactic acid bacteria. He was appointed full Professor of Microbiology in 2005 and since 2011, he holds the Canada Research Chair in Bacteriophages. Since 2002, he is also the Curator of the Félix d'Hérelle Reference Center for Bacterial Viruses, the world largest collection of reference phages ([www.phage.ulaval.ca](http://www.phage.ulaval.ca)). Over the years, Professor Moineau has won numerous teaching and research awards and he has developed one of the leading international phage research programs. Prof. Moineau's team has made a number of landmark discoveries that have changed our views of phage-host interactions, including his work on CRISPR-Cas systems. In 2016, Prof. Moineau was awarded the Flavelle

Medal by the Royal Society of Canada for his outstanding contribution to biological sciences. In 2017, he won the NSERC John C. Polanyi Award for his Canadian-based research that led to an outstanding advance in natural sciences. Professor Moineau was also on Thomson Reuters's list of highly cited researchers in the Microbiology Category for the last three years (2014, 2015, 2016).



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### **CRISPR-Cas systems: from humble beginnings to today's headlines**

**Sylvain MOINEAU**, Université Laval, Quebec, QC

This year marks the 100th anniversary of the publication by Félix d'Hérelle entitled: An invisible microbe that is antagonistic to the dysentery bacillus (*Comptes Rendus de l'Académie des Sciences* 165:373-375). With it, the field of phage biology was born. Viruses are now recognized as the most abundant biological entities on the planet and display a remarkable genetic diversity. Not surprisingly, bacteria have a plethora of diverse defense mechanisms to combat their phages. Four decades after the discovery of one such defense mechanism, restriction enzymes, another bacterial anti-phage system that cleaves foreign DNA was identified—one that acts as an adaptive immune system. Clustered regularly interspaced short palindromic repeats (CRISPR) and their associated cas genes protect microbial cells against infection by foreign nucleic acids, including phage genomes and plasmids. Bacterial CRISPR-Cas type II systems function by first incorporating short DNA 'spacers', derived from invading phage genomes or plasmid sequences, into a CRISPR array located in their genome. This step is known as adaptation or vaccination. The CRISPR array is then transcribed and matured into short RNAs (the maturation step), which, by recruiting a Cas endonuclease, act as surveillance complexes that recognize and cleave invading matching sequences (the interference step). The cleavage occurs near a short motif, called the PAM, adjacent to the sequence targeted by the spacer. Phages can bypass the protection provided by CRISPR-Cas through point mutations, deletions, or the production of anti-CRISPR proteins. Exploiting this system has also resulted in the development of the much-publicized CRISPR-Cas9 technology for precise genome manipulation of various organisms. This seminar will mostly recall the roles played by phages in the discovery and understanding of CRISPR-Cas systems. Finally, I will highlight the use of CRISPR-Cas9 technology for viral genome editing in order to better understand phage-host interactions.