



ANNUAL REPORT

JULY 1, 2015 – JUNE 30, 2016

SECTION 1 – OVERVIEW

1.1 MISSION STATEMENT

In June 2008, the Centre for Comparative Genomics & Evolutionary Bioinformatics (CGEB) was officially approved by the Dalhousie Senate, with the mission to foster collaborations amongst comparative genomics/bioinformatics and microbial evolution researchers and trainees at Dalhousie. The main focus of the Centre's research is to discover how microbial genomes evolve and diversify, and our research programs collectively span computational biology, biological oceanography, computer science, statistical modeling and comparative genomics, with a strong focus on method and theory. However, through collaborations with new CGEB associates, our focus has expanded to include environmental microbiology and human disease microbiomics.

The CGEB Centre's primary goals are to: 1) recruit top-notch postdoctoral fellows and Ph.D. trainees to CGEB labs through the provision of Tula Foundation fellowships and research allowances, and more recently through the CGEB-Herzberg Fellowships; 2) maintain a CGEB Seminar Series to attract world-class speakers to interact with CGEB principal investigators and trainees; 3) fund CGEB trainees to attend and present their work at national and international scientific meetings; and 4) provide an intellectual forum that promotes collaborations between CGEB members and associates and facilitates applications for external research funding. For each of the last eight years, we have met or exceeded all of these goals.

1.2 NEW AND ONGOING ACTIVITIES OF THE CENTRE

A. CGEB - Integrated Microbiome Resource (CGEB-IMR)

In 2014, Ford Doolittle and the CGEB microbiome group, together with several others at the university (CGEB Associates: Sean Myles, John Rohde, Johan van Limbergen and Julie LaRoche, and gastroenterologist Andy Stadnyk) applied for, and were awarded a Strategic Research Initiatives Fund (SRIF) grant from Dalhousie Research Services to set up the CGEB-Integrated Microbiomics Resource (CGEB-IMR; <http://cgeb-imr.ca/>) (\$200,000 over two years). This facility is now operating efficiently and productively, encouraging many new internal and external collaborations and contributing support to the writing of many grant applications, many already funded. Under the capable direction of project resource manager Dr. André Comeau, and Gavin Douglas, MSc as Bioinformatician, this facility has produced more than 715 gigabases of DNA sequence, representing 168 different projects, for 55 different principal investigators. What started as a means to consolidate microbiome research internally at Dalhousie has now blossomed into an in-demand resource also being utilized by outside researchers in Canada, the US and multiple other countries on a total of four different continents (see <http://cgeb-imr.ca/achieve.html> for a breakdown of client locations). Samples range from community diversity studies of the North Atlantic and the Bedford Basin, Crohn's disease, algal bioreactors, fish guts, exercising mice, commercial blueberries, bumblebees, WWII shipwrecks and domestic pets. The wealth of external fee-for-service work helps support the IMR so that CGEB researchers can collaborate on projects

addressing the environmental diversity and functions of microbes. Pricing remains competitive and, with the wind-down of SRIF funds in October 2016, we can project that the operating costs (including salaries) of the CGEB-IMR should be fully met by internal and external fees paid.

B. Dalhousie Microbiome User Group (DalMUG) website: <http://dalmug.org/>

Dr. Morgan Langille (CGEB faculty member) continues to lead the Dalhousie Microbiome User Group (DalMUG) that was founded in January 2014 and is sponsored by CGEB. This group is made up of researchers and clinicians that are primarily affiliated with Dalhousie University and who are interested in various aspects of microbiome research. DalMUG aims to foster collaborations, share resources, and build an interdisciplinary community. In the past year, the group has expanded from 48 to 58 members from various academic disciplines. DalMUG also hosts a journal club every second week during the school year and is focused on training students at the undergraduate and graduate level. DalMUG has also sparked collaborations on several research projects and has resulted in successful grants such as the Nova Scotia Health Research Fund (Langille and Van Limbergen as co-applicants), Nova Scotia Department of Agriculture (Yurgel (PI) & Langille (co-PI), and the Dalhousie Medical Research Foundation: Molly Appeal 2016/2017 fundraiser.

C. CGEB - Herzberg Fellowships

In 2013, CGEB Member Dr. W. Ford Doolittle was awarded the Gerhard Herzberg Gold Medal award by NSERC, Canada's top award for scientific achievement, for his work in the field of microbial evolution and the tree of Life (funding award 2014-2019). Dr. Doolittle has pledged roughly half of his Herzberg award (a total of ~\$500,000 over 5 years) to support the CGEB – Herzberg Fellowships to trainees (over this reporting period - one postdoctoral fellowship and three graduate student fellowships were awarded), as well as \$34,000/year toward CGEB administration.

D. CGEB Microbiome Initiatives

Concomitant with the establishment of the CGEB-Integrated Microbiome Resource (CGEB-IMR), a number of microbiomic projects have been initiated in the last three years through CGEB collaborations. These include:

Pan-African Study of Neonatal Sepsis: Advancing Science and Gathering Evidence (PASSAGE): This is an international collaboration investigating the efficacy and mechanism by which probiotic treatment can lower neonatal sepsis in Africa. Discussions with the Bill and Melinda Gates Foundation are ongoing, and proposal writing will be starting soon. The CGEB Microbiome group (Rob Beiko, Morgan Langille, Joe Bielawski, Andrew Roger, Johan van Limbergen) are leading the computational analysis for this project).

MAREEN (Metagenomic approach to Remission in Crohn's disease using enteral nutrition): A 16S-rDNA, 18S-rDNA and whole-metagenome study of mucosa-associated microbiota in treatment-naive pediatric Crohn's disease and investigation

- of changes in microbiome community structure during induction and maintenance of remission in pediatric Crohn's disease using exclusive enteral nutrition (funded by NASPGHAN/CCFA awarded to CGEB Associate Johan van Limbergen in collaboration with CGEB members Morgan Langille, Joe Bielawski and Andrew Roger).
- Microbiomic studies of children affected by IBD and their healthy siblings: 16S-rDNA based and whole-metagenome at diagnosis and after induction of remission in pediatric IBD (in collaboration with Nikhil Thomas, Tony Otley, CGEB member Joe Bielawski).
- Microbiomic metagenome changes associated with exclusive and partial enteral nutrition in a randomized clinical trial in pediatric Crohn's disease (in collaboration with Arie Levine (Israel), Tony Otley and CGEB member Joe Bielawski).
- Role of microbiome in response to methotrexate (MTX) in children with chronic inflammatory disease (led by CGEB member Morgan Langille in collaboration with Johan van Limbergen (Pediatric Gastroenterology) and Adam Huber (pediatric Rheumatology)).
- The role of the complement system in post-colitis colonization and recovery from injury (Andy Stadnyk (lead), CGEB member Rob Beiko). This involves conducting 16S rDNA profiling of the gut microbiome in a mouse model that has gene knockouts in the immune complement system.
- Microbiome of the aging mouse: (CGEB member Rob Beiko and Morgan Langille as collaborator, together with Ken Rockwood and Sue Howlett). They will be using established mouse models of frailty and to investigate changes in the microbiome associated with aging.
- A pilot project to assess the gut microbes of patients in an assisted living facility: (CGEB members Beiko, Bielawski, Doolittle and Roger in collaboration with Ken Rockwood and Sue Howlett). Fecal samples from 48 patients in an assisted care facility have been collected, and the composition of the fecal microbiota is currently being evaluated using 16S and 18S rRNA marker gene data, metagenome data, and metatranscriptome data, along with a comprehensive frailty assessment, to identify if linkages between frailty and the microbiome exist.

E. CGEB Seminar Series

The seminar series successfully hosted 12 well-attended seminars from July 1, 2015 to June 30, 2016, all sponsored or co-sponsored by funding from the Tula Foundation.

- Dr. Nathaniel Comfort, Johns Hopkins University
"Origins of the RNA world" [Academic Lecture: June 23, 2016], and *"Play-Doh Republic: Controlling Human Evolution, From Ancient Greece to the Age of CRISPR"* [Public Lecture: June 24, 2016]
- Dr. Toni Gabaldon, Centre for Genomic Regulation-Barcelona
"Mitochondria and the origin of eukaryotes", June 6, 2016
- Dr. Jason de Koning, University of Calgary
"Modelling the population genetics of molecular evolution", May 5, 2016
- Dr. Ashley Shade, Michigan State University
"Tales of rarity and disturbance: the interplay of community structure and dynamics"
April 7, 2016.
- Dr. Betul Kacar, Harvard University
"Tempus fugit: Design, construction and evolution of ancestor-descendant hybrid organisms in the laboratory", March 16, 2016
- Dr. Jerry A. Coyne
"Faith versus fact: The incompatibility of science and religion" [Public Lecture: February 23, 2016]
- Dr. Jeffrey Thorne, North Carolina State University
"Incorporating disease data and interlocus gene conversion into evolutionary inference",
December 7, 2015
- Dr. Erin Bertrand, Dalhousie University
"The role of cobalamin in diatom molecular physiology and interactions with bacteria: implications for Southern Ocean productivity", December 2, 2015
- Dr. Laura Parfrey, University of British Columbia
"Eukaryotes in the mammalian gut", August 17, 2015
- Dr. Michael Dietrich, Dartmouth College
"DNA evolution and the multi-model regress in molecular systematics", August 6, 2015
- Dr. Thomas Richards, University of Exeter
"Horizontal gene transfer and the evolution of osmotrophic phenotypes", July 30, 2015
- Dr. Maureen O'Malley, University of Sydney
"From correlation to causation in microbiome research", July 28, 2015

F. Meeting / Symposia Sponsorship

CGEB provided funding support for two events this past year through its Seminar Series Fund and/or CGEB New Opportunities Fund.

1. Co-sponsorship (with Centre for Inquiry Canada & Penguin Random House) of a ‘3-part Series on Science and Religion’ co-organized by Sharon Woodill (Evolution Studies Group at Dalhousie) and W. Ford Doolittle). Guest lecturer: Dr. Jerry A. Coyne, author of two popular books, *Why Evolution is True*, and *Faith vs. Fact*. Public Lecture held at the Halifax Public Library, February 23, 2016.
2. Sponsorship of a discussion meeting on ‘microbiomics and genomics’ at the *International Society for History, Philosophy and Social Studies of Biology (ISHPSSB) Conference* in Montreal, July 7, 2015.

G. CGEB Journal Clubs

The *CGEB Journal Club* (since 2007) meets bi-weekly throughout the school year, and is open to participation for all CGEB faculty members and their trainees. Participants select and present a current research paper for analysis and discussion, often outside their own immediate research area.

Since 2013 a more specialized *Dalhousie Microbiome User Group (DalMUG) Journal Club* meets bi-weekly and involves faculty and trainees from several CGEB labs. This group focuses more specifically on methods of metagenomic and bioinformatic analysis as they apply to human (microbiomic) and environmental microbial communities.

H. CGEB Weekly Lab and Monthly Joint Lab Meetings

In addition to weekly lab meetings of the Roger-Archibald-Doolittle-Gray-Slamovits-Simpson labs, we also hold monthly CGEB ‘joint lab meetings’ that include our 12 CGEB faculty members, associate members, and their trainees. The purpose of these meetings is to introduce CGEB faculty and trainees to the ever-expanding group of new trainees in the various labs and to initiate collaborative projects between departments. Faculty members and/or their trainees provide an overview of their research in a seminar-style format, with adequate time allotted for questions, constructive criticism, and open discussion.

I. Publications and Presentations

During the reporting period, CGEB faculty and trainees have published **64** refereed papers and **6** book chapters (*see Section 2.2.I.*), including contributions in high impact journals such as *Nature*, *Current Biology*, *Proceedings of the National Academy of Sciences USA*, and *PLoS Biology*. The international profile of CGEB researchers is further demonstrated by the **47** invited presentations by CGEB faculty given at international conferences and invited seminars (*see Section 2.3*). In addition, CGEB

trainees collectively contributed **46** presentations at local and international events (*see Section 2.4*).

J. CGEB Developed Software

A large portion of CGEB research efforts is directed at development of computer software tools for evolutionary modeling analyses and bioinformatics. Since 2007, CGEB has produced 35 bioinformatics software tools (*see Section 2.7 for new software development*). These are ‘open-source’ software tools (or suites of tools) for analysis of genomic data that have been created, published and made available (or soon will be) to the international scientific community through free web access.

K. External Funding

CGEB researchers have been extremely successful in attracting external funding, collectively garnering a total of just over \$2,795,000 of external grant support and research awards over 2015-2016 from NSERC, CIHR, CFI, Canada Research Chairs, Canadian Institute for Advanced Research, Genome Canada, NSHRF, and the Tula Foundation (*see Section 3.2.1*).

1.3 COMING YEAR’S ACTIVITIES

The main core activities that have really sustained the productivity of the CGEB Centre to date (see above descriptions) will continue in the next year. These include:

- weekly lab meetings and monthly joint lab meetings
- bi-weekly CGEB Journal club, and DalMUG Journal Club
- CGEB Seminar Series (invited speakers)
- continued sponsorship of student presentations at domestic and international events
- meetings of CGEB PIs to discuss Centre business (annual meeting, plus occasional *ad hoc* meetings)
- annual meeting of the Deans Committee Meeting (includes CGEB Director, Deans of Medicine, Science & Computer Science, and Assoc. VP (Research) designate).

In addition to the above regular activities, in the coming year we plan to organize a “CGEB Research Day-Mixer” on campus to take place on an afternoon/early evening to which all members of the CGEB community will be invited. The purpose of this activity will be to further the opportunities for CGEB PIs, associates and trainees to interact to discuss their research and to facilitate future collaborative research projects or grant applications. This event will be sponsored through our CGEB New Opportunities Fund (Section 3.1 – IV).

SECTION 2 – DETAILED DESCRIPTION OF ACTIVITIES

2.1 CORE GROUP OF PERSONNEL (July 1, 2015 – June 30, 2016)

Position	#
CGEB Faculty Members	12
CGEB Associate Members	8
Research Associates	3
Administrative & Technical Staff	5
Postdoctoral Fellows	16
Doctoral Students	12
Master's Students	20
Undergraduate Students (incl. Honours, co-op & summer students)	15
Total	91

2.1.1 CGEB Faculty Members

1. Dr. Andrew Roger, Professor and Tier I Canada Research Chair, Biochemistry and Molecular Biology
2. Dr. W. Ford Doolittle, Professor Emeritus, Biochemistry and Molecular Biology
3. Dr. John Archibald, Professor, Biochemistry and Molecular Biology
4. Dr. Claudio Slamovits, Associate Professor, Biochemistry and Molecular Biology
5. Dr. Michael Gray, Professor Emeritus, Biochemistry and Molecular Biology
6. Dr. Joseph Bielawski, Professor, Biology
7. Dr. Alastair Simpson, Professor, Biology
8. Dr. Erin Bertrand, Assistant Professor and Tier II Canada Research Chair, Biology
9. Dr. Robert Beiko, Professor and Tier II Canada Research Chair, Computer Science
10. Dr. Christian Blouin, Professor, Computer Science, and Biochemistry and Molecular Biology
11. Dr. Edward Susko, Professor, Mathematics and Statistics
12. Dr. Morgan Langille, Assistant Professor and Tier II Canada Research Chair, Pharmacology

2.1.2 CGEB Associate Members

1. Dr. Norbert Zeh, Professor, Computer Science
2. Dr. Julie LaRoche, Professor of Biology (Marine Geochemistry), and Tier I Canada Research Chair
3. Dr. Sean Myles, Assistant Professor, and Tier I Canada Research Chair, Faculty of Agriculture
4. Dr. Hong Gu, Associate Professor, Mathematics and Statistics
5. Dr. Johan Van Limbergen, Clinician Scientist and Assistant Professor, Pediatrics, IWK Health Centre
6. Dr. John Rohde, Assistant Professor, Microbiology and Immunology
7. Dr. Christopher Field, Professor Emeritus, Mathematics and Statistics
8. Dr. Robert Lee, Adjunct Professor, Biology

2.1.3 CGEB Research Associates

1. Dayana Salas-Leiva, Research Associate – Roger lab
2. André Comeau, Research Associate – Langille lab
3. Huaichun Wang, Research Associate – Susko lab

2.1.4 CGEB Administrative and Technical Staff

1. Wanda Danilchuk, CGEB Administrator
2. Marlena Dlutek, Lab Manager/Technician – Archibald & Roger labs
3. Gavin Douglas, Bioinformatician – Langille lab
4. Nehil Jain, Software Developer (completed Sept. 2015) – Beiko lab
5. Kevin Stemmler, Lab Technician (completed Aug. 2015) – Slamovits lab

2.1.5 CGEB Postdoctoral Fellows

Name / Status	Department(s)	Supervisor(s)
Booth, Austin (completed 07/2016)	Biochem. & Mol. Biol. and Philosophy	Dr. Ford Doolittle & Dr. Letitia Meynell
Breglia, Susana (in progress)	Biochem. & Mol. Biol.	Dr. Claudio Slamovits
Cenci, Ugo (completed 01/2016)	Biochem. & Mol. Biol.	Dr. John Archibald
Curtis, Bruce (in progress)	Biochem. & Mol. Biol.	Dr. John Archibald & Dr. Andrew Roger
Dhanani, Akhilesh (in progress)	Computer Science	Dr. Robert Beiko
Eme, Laura (in progress)	Biochem. & Mol. Biol.	Dr. Andrew Roger
Gile, Gillian (completed 08/2015)	Biochem. & Mol. Biol.	Dr. John Archibald
Grisdale, Cameron (in progress)	Biochem. & Mol. Biol.	Dr. John Archibald
Hess, Sebastien (in progress)	Biology	Dr. Alastair Simpson & Dr. Andrew Roger
Joshi, Jyoti (completed 03/2016)	Computer Science	Dr. Robert Beiko
Leger, Michelle (completed 08/2016)	Biochem. & Mol. Biol.	Dr. Andrew Roger
Mariscal, Carlos (completed 06/2016)	Biochem. & Mol. Biol. and Philosophy	Dr. Ford Doolittle & Dr. Gordon McOuat
Moog, Daniel (completed 04/2016)	Biochem. & Mol. Biol.	Dr. John Archibald
Salas-Leiva, Dayana (completed 12/2015); now Research Associate	Biochem. & Mol. Biol.	Dr. Andrew Roger & Dr. Alastair Simpson
Stairs, Courtney (completed 04/2016)	Biochem. & Mol. Biol.	Dr. Andrew Roger
Zukowski, Kacper (completed 03/2016)	Computer Science	Dr. Robert Beiko

2.1.6 Visiting International Students and Researchers

1. Lea Lincker: Visiting 4th year Engineering student (research internship) from ENSTA ParisTech Universite (in Roger lab; May 18-July 30, 2016).
2. Lee O'Brien Andersen: Visiting PhD student from Statens Serum Institut, Denmark (in Roger lab; July 18-Sept. 18, 2015).
3. Dr. Bernard Lemire: Visiting Sabbatical Professor from University of Alberta (in Roger lab; March 17-August 12, 2015).
4. Carlos Reyna: Visiting 4th year Undergraduate Student in Genomic Science from National University of Mexico (in Slamovits lab; June-August 2015).
5. Alex Fernandes: Visiting 4th year Undergraduate Student in Medical Biotechnology from Univ. of Rio Grande do Norte, Brazil (in Slamovits lab; June-August 2015).
6. Susan Clayden: Visiting PhD Researcher (part-time) from UNB (in Simpson lab; July 2015-July 2016).
7. Chen Changjiang: Visiting Scholar from Fujian Agriculture & Forestry University, China (in Blouin lab; Oct. 2015 – Sept. 2016)
8. Vojtech Zarsky: Visiting PhD student from Charles University, Czech Republic (in Roger lab; June 2-Aug. 4, 2015).
9. Fabien Mejia: Visiting ELAP (Emerging Leaders in the Americas Program) MSc student from Universidad CES, Colombia (in Slamovits lab; Oct. 30, 2015 – March 9, 2016).
10. Dr. Ryoma Kamikawa: Visiting Professor from Kiyota University, Japan (in Roger lab; Sept. 20, 2014-Sept. 21, 2015).

2.2 PUBLICATIONS (July 2015 – June 2016)

Publication Type	
• Peer reviewed publications	65
• Invited book chapters	6
• Other publications	2
Total:	73

Note: CGEB faculty and trainees' names are highlighted in bold.

I. Peer Reviewed Publications

Archibald, J.M. (2015) Genomic perspectives on the birth and spread of plastids. *Proc. Natl. Acad. Sci. USA* 112: 10147-53.

Archibald, J.M. (2015) Endosymbiosis and eukaryotic cell evolution. *Curr. Biol.* 25: R911-921.

Baker, J.L., **Dunn, K.A., Mingrone, J.**, Wood, B.A., Karpinski, B.A., Sherwood, C.C., Wildman, D.E., Maynard, T.M. and **Bielawski, J.P.** (2016) Functional divergence of the nuclear receptor *NR2C1* as a modulator of pluripotentiality during Hominid evolution. *Genetics* 203: 905-922.

Beiko, R.G. (2015) Microbial malaise: how can we classify the microbiome? *Trends Microbiol.* 23: 671-679.

Bertrand, E.M., McCrow, J.P., Moustafa, A., Zheng, H., McQuaid, J.B., Delmont, T.O., Post, A.F., Sipler, R.E., Spackeen, J.L., Xu, K., Bronk, D.A., Hutchins, D.A. and Allen A.E. (2015) Phytoplankton-bacterial interactions mediate micronutrient colimitation at the coastal Antarctic sea ice edge. *Proc. Natl. Acad. Sci. USA* 112: 9938-9943.

Bielawski, J.P., Baker, J.L. and **Mingrone, J.** (2016) Inference of episodic changes in natural selection acting on protein coding sequences via CODEML. *Curr. Protoc. Bioinformatics* 54: 6-15.

Booth, A. and **Doolittle, W.F.** (2015) Eukaryogenesis, how special really? *Proc. Natl. Acad. Sci. USA* 112: 10278-85.

Booth, A. and **Doolittle, W.F.** (2015) Reply to Lane and Martin: Being and becoming eukaryotes. *Proc. Natl. Acad. Sci. USA* 112: E4824.

Brunet, T.D. (2016) Aims and methods of biosteganography. *J. Biotechnol.* 226: 56-64.

Brunet, T.D. and **Doolittle, W.F.** (2015) Multilevel selection theory and the evolutionary functions of transposable elements. *Genome Biol. Evol.* 7: 2445-2457.

Buchwald, R.T., Feehan, C.J., Scheibling, R.E. & **Simpson, A.G.B.** (2015) Low temperature tolerance of a sea urchin pathogen: implications for benthic community dynamics in a warming ocean. *J. Exp. Marine Biol. Ecol.* 469: 1-9.

Castro, S.I., **Hleap, J.S.**, Cárdenas, H. and **Blouin, C.** (2016) Molecular organization of the 5S rDNA gene type II in Elasmobranchs. *RNA Biology* 13: 391-399.

Cenci, U., **Moog, D.**, **Curtis, B.A.**, Tanifuji, G., **Eme, L.**, Lukes, J. and **Archibald, J.M.** (2016) Heme pathway evolution in kinetoplastid protists. *BMC Evol. Biol.* 16: 109.

Cenci, U., Ducatez, M., Kadouche, D., Colleoni, C. and Ball, S.G. (2016) Was the Chlamydial adaptive strategy to Tryptophan starvation an early determinant of plastid endosymbiosis? *Front Cell Infect Microbiol.* 6: 67.

David, V., Flegontov, P., Gerasimov, E., Tanifuji, G., Hashimi, H., Logacheva, M.G., Maruyama, S., Onodera, N.T., **Gray, M.W.**, **Archibald, J.M.** and Lukeš, J. (2015) Gene loss and error-prone RNA editing in the mitochondrion of *Perkinsela*, an endosymbiotic kinetoplastid. *mBio* 6: e01498-15.

de Vries, J., **Stanton, A.**, **Archibald, J. M.** and Gould, S.B. (2016) Streptophyte terrestrialization in light of plastid evolution. *Trends Plant Sci.* 21: 467-476.

Dhanani, A.S., Block, G., Dewar, K., Forgetta, V., Topp, E., **Beiko, R.G.** and Diarra, M.S. (2015) Genomic comparison of non-typhoidal *Salmonella enterica* Serovars

Typhimurium, Enteritidis, Heidelberg, Hadar and Kentucky isolates from broiler chickens. *PLoS ONE* 10: e0128773.

Dhillon B.K., Laird M. R., Shay J.A., Winsor G.L., Lo R., Nizam F., Pereira, S.K., Waglechner N., McArthur A.G., **Langille M.G.** and Brinkman F.S. (2015) IslandViewer 3: more flexible, interactive genomic island discovery, visualization and analysis. *Nucleic Acids Res.* 43: W104-108.

Doolittle, W.F. and Brunet, T.D. (2016). What is the tree of life?. *PLoS Genet.* 12: e1005912.

El Swais, H., Dunn, K.A., Bielawski, J.P., Li, W.K. and Walsh, D.A. (2015) Seasonal assemblages and short-lived blooms in coastal north-west Atlantic Ocean bacterioplankton. *Environ. Microbiol.* 17: 3642-3661.

Eme, L. and Doolittle, W.F. (2015) Archaea. *Curr. Biol.* 25: R851-855. Special issue 'History of Life on Earth.'

Gawryluk, R., Eme, L. and Roger, A.J. (2015) Gene fusion, fission, lateral transfer, and loss: not-so-rare events in the evolution of eukaryotic ATP citrate lyase. *Mol. Phylogenet. Evol.* 91: 12-16.

Gile, G.H., James, E.R., Okamoto, N., Carpenter, K.J., Scheffrahn, R.H. and Keeling, P.J. (2015) Molecular evidence for the polyphyly of macrotrichomonas (Parabasalia: Cristamonadea) and a proposal for Macrotrichomonoides n. gen. *J. Euk. Microbiol.* 62: 494-504.

Gray, M.W. (2015) Mosaic nature of the mitochondrial proteome: Implications for the origin and evolution of mitochondria. *Proc. Natl. Acad. Sci. USA* 112: 10133-10138.

Groussin, M., Boussau, B., Szölloosi, G.J., **Eme, L.,** Gouy, M., Brochier-Armanet, C. and Daubin, V. (2016) Gene acquisitions from bacteria at the origins of major archaeal clades are vastly overestimated. *Mol. Biol. Evol.* 33: 305-310.

Hamann, E., Gruber-Vodicka, H., Kleiner, M., Tegetmeyer, H., Riedel, D., Littmann, S., Chen, J., Milucka, J., Viehweger, B., Becker, K., Dong, X., **Stairs, C.W.,** Hinrichs, K., Brown, M.W., **Roger, A.J.** and Strous, M. (2016) Environmental Breviatea harbor mutualistic *Arcobacter* epibionts. *Nature* 534: 254-258.

Heiss, A.A., Lee, W.J., Ishida, K. and **Simpson, A.G.** (2015). Cultivation and characterization of new species of apusomonads (the sister group to opisthokonts), including close relatives of Thecamonas (*Chelonomonas* n. gen.). *J. Eukaryot. Microbiol.* 62: 637-649.

Hleap, J.S. and Blouin, C. (2016) The semantics of the modular architecture of protein structures. *Curr. Prot. Peptide Sci.* 17: 62-71.

- Kamikawa, R., Shiratori, T., Ishida, K., Miyashita, H. and **Roger, A.J.** (2016) Group II intron-mediated trans-splicing in the gene-rich mitochondrial genome of an enigmatic eukaryote, *Diphylllea rotans*. *Genome Biol. Evol.* 8: 458-466.
- Karnkowska, K., Vacek, V., Zubáčová, Z., Treitli, S., Petrželková, R., **Eme, L.**, Novák, N., Žárský, V., Barlow, L., Herman, H., Soukal, P., Hroudová, M., Doležal, P., **Stairs, C.W.**, **Roger, A.J.**, Elias, M., Dacks, J., Vlček, C. and Hampl, V. (2016) A eukaryote without a mitochondrial organelle. *Curr. Biol.* 26: 1274-1284.
- Keeling, P.J., McCutcheon J.P. and **Doolittle, W.F.** (2015) Symbiosis becoming permanent: Survival of the luckiest. *Proc. Natl. Acad. Sci. USA* 112: 10101-10103.
- Kureshi, N., Abidi, S.S. and **Blouin, C.** (2016) A predictive model for personalized therapeutic interventions in non-small cell lung cancer. *IEEE J. Biomed. Health Inform.* 20: 424-431.
- Laird, M.R., **Langille, M.G.I.** and Brinkman, F.S.L. (2015) GenomeD3Plot: A library for rich, interactive visualizations of genomic data in web applications. *Bioinformatics* 31: 3348-3349.
- Lee, P.A., **Bertrand, E.M.**, Saito, M.A. and DiTullio, G.R. (2015) Influence of vitamin B12 availability on oceanic dimethylsulfide and dimethylsulfoniopropionate. *Env. Chem.* 13: 293-301.
- Leger, M.M.**, Petru, M., Žárský, V., **Eme, L.**, Vlček, Č., **Harding, T.**, Lang, B.F., Eliáš, M., Doležal, P. and **Roger, A.J.** (2015) An ancestral bacterial division system is widespread in eukaryotic mitochondria. *Proc. Natl. Acad. Sci. USA* 112: 10239-46.
- Mariscal, C.** and **Doolittle, W.F.** (2015) Eukaryotes first: how could that be? *Philos. Trans. R. Soc. Lond. B. Biol. Sci.* 370: 20140322.
- Meehan, C.J.**, **Langille, M.G.** and **Beiko, R.G.** (2015) Frailty and the microbiome. *Interdiscip. Top Gerontol. Geriatr.* 41: 54-65.
- Miller, R.R., **Langille, M.G.**, Montoya, V., Crisan, A., Stefanovic, A., Martin, I., Hoang, L., Patrick, D.M., Romney, M., Tyrrell, G., Jones, S.J.M., Brinkman, F.S.L. and Tang, P. (2016) Genomic analysis of a serotype 5 *Streptococcus pneumoniae* outbreak in Canada 2005-2009. *Can J. Infect. Dis. Med. Microbiol.* 2016: 5381871.
- Moog, D.**, Rensing, S.A., **Archibald, J.M.**, Maier, U.-G. and Ullrich, K.K. (2015) Localization and evolution of putative triose phosphate translocators in the diatom *Phaeodactylum tricorutum*. *Genome Biol. Evol.* 7: 2955-2969.
- Moore-Connors, J.M., **Dunn, K.A.**, **Bielawski, J.P.** and Van Limbergen, J. (2016) Novel strategies for applied metagenomics. *Inflamm. Bowel Dis.* 22: 709-718.

Muñoz-Gómez, S.A., Slamovits, C.H., Dacks, J.B. and Wideman, J.G. (2015) The evolution of MICOS: Ancestral and derived functions and interactions. *Commun. Integr. Biol.* 8: e1094593.

Navia, A.F., Mejía-Falla, P. A. and **Hleap, J.S.** (2016) Zoogeography of the elasmobranchs in the Colombian Pacific Ocean and Caribbean Sea. *Neotropical Ichthyology* 14: e140134.

Ning, J. and **Beiko, R.G.** (2015) Phylogenetic approaches to microbial community classification. *Microbiome* 3: 47.

Paerl, R.W., **Bertrand, E.M.,** Allen, A.E., Palenik, B. and Azam, F. (2015) Vitamin B1 ecophysiology of marine picoeukaryotic algae: Strain-specific differences and a new role for bacteria in vitamin cycling. *Limnology and Oceanography* 60: 215-228.

Pánek, T., Zadrožílková, E., Walker, G., Brown, M.W., Gentekaki, E., Hroudová, M., Kang, S., **Roger, A.J.,** Tice, A.K., Vlček, Č. and Čepička I. (2016) First multigene analysis of Archamoebae robustly reveals its phylogeny and shows that Entamoebidae represents a deep lineage of the group. *Mol. Phylogenet. Evol.* 98: 41-51.

Park, J.S. and **Simpson, A.G.** (2016) Characterization of a deep-branching Heterolobosean, *P. turkanaensis* n. sp., isolated from a non-hypersaline habitat, and ultrastructural comparison of cysts and amoebae among Pharyngomonas strains. *J. Eukaryot. Microbiol.* 63: 100-111.

Park, J.S. and **Simpson, A.G.** (2015) Diversity of heterotrophic protists from extremely hypersaline habitats. *Protist* 166: 422-437.

Pesaranghader, A., Matwin, S., Sokolova, M. and **Beiko R.G.** (2016) simDEF: definition-based semantic similarity measure of gene ontology terms for functional similarity analysis of genes. *Bioinformatics* 32: 1380-1387.

Powell, R. and **Mariscal, C.** (2015) Convergent evolution as natural experiment: the tape of life reconsidered. *Interface Focus* 5: 20150040.

Rutherford, K., Meehan, C.J., **Langille, M.G.,** Tyack, S.G., McKay, J.C., McLean, N.L., Benkel, K., **Beiko, R.G.** and Benkel, B. (2016) Discovery of an expanded set of avian leukosis subgroup E proviruses in chickens using Vermillion, a novel sequence capture and analysis pipeline. *Poult. Sci.* 95: 2250-2258.

Safatli, A. and Blouin, C. (2015). Phylogeny: an open-source Python framework for phylogenetic tree reconstruction and search space heuristics. *PeerJ Comput. Sci.* 1:e9.

Scharf, C. *et al.* [30 authors incl. **Carlos Mariscal**] (2015) A strategy for origins of life research. *Astrobiology* 15: 1031-1042.

Sierra, R., Cañas-Duarte, S.J., Burki, F., Schwelm, A., Fogelqvist, J., Dixelius, C., González-García, L.N., Gile, G.H., **Slamovits, C.H.**, Klopp, C., Restrepo, S., Arzul, I. and Pawlowski J. (2016) Evolutionary origins of rhizarian parasites. *Mol. Biol. Evol.* 33: 980-983.

Stairs, C.W., Leger, M.M. and Roger, A.J. (2015) Diversity and origins of anaerobic metabolism in mitochondria and related organelles. *Philos. Trans. R. Soc. Lond. B. Biol. Sci.* 370: 20140326.

Susko, E. (2015). Bayesian long branch attraction bias and corrections. *Syst. Biol.* 64: 243-255.

Tanifuji, G., **Archibald, J.M.** and Hashimoto, T. (2016) Comparative genomics of mitochondria in chlorarachniophyte algae: endosymbiotic gene transfer and organellar genome dynamics. *Scientific Rep.* 6: 21016.

Torruella, G., de Mendoza, A., Grau-Bové, X., Antó, M., Chaplin, M.A., del Campo, J., **Eme L.**, Pérez-Cordón, G., Whipps, C.M., Nichols, K.M., Paley, R., **Roger, A.J.**, Sitjà-Bobadilla, A., Donachie, S. and Ruiz-Trillo, I. (2015) Phylogenomics reveals convergent evolution of lifestyles in close relatives of animals and fungi. *Curr. Biol.* 25: 2404-2410.

Whidden, C., Beiko, R.G. and Zeh, N. (2016) Fixed-parameter and approximation algorithms for maximum agreement forests of multifurcating trees. *Algorithmica* 74: 1019-1054.

Wong, D.H. and Beiko, R.G. (2015) Transfer of energy pathway genes in microbial enhanced biological phosphorus removal communities. *BMC Genomics* 16: 526.

Xu, X., **Dunn, K.A.** and Field, C. (2015) A robust ANOVA approach to estimating a phylogeny from multiple genes. *Mol. Biol. Evol.* 32: 2186-2194.

Zhan, L., Paterson, I.G., Fraser, B.A., Watson, B., Bradbury, I.R., Nadukkalam, Ravindran P., Reznick, D., **Beiko, R.G.** and Bentzen, P. (2016) Megasat: automated inference of microsatellite genotypes from sequence data. *Mol. Ecol. Resource*, Jun 22; doi: 10.1111/1755-0998.12561.

Zhang, Q., Táborský, P., Silberman, J.D., Pánek, T., Čepička, I. and **Simpson, A.G.** (2015) Marine isolates of *Trimastix marina* form a Plesiomorphic deep-branching lineage within Preaxostyla, separate from other known Trimastigids (Paratrimastix n. gen.). *Protist* 166: 468-491.

II. Invited Book Chapters

Cenci, U., Moog, D. and Archibald, J.M. (2016) Origin and spread of plastids by endosymbiosis. In M. Grube, L. Muggia & J. Seckbach (Eds.), *Algae Symbioses*, Springer-Verlag, *in press*.

Mariscal, C. (2015) Universal biology: Assessing universality from a single example. In *The Impact of Discovering Life Beyond Earth*, S.J. Dick (Ed.), pp. 113-126, Cambridge University Press.

Meehan C.J., **Langille, M.G.I.** and **Beiko, R.G.** (2015) Frailty and the microbiome. In O. Theou and K. Rockwood (Eds.), *Frailty in Ageing: Biological, Clinical and Social Implication*, Vol. 41 in the series *Interdisciplinary Topics in Gerontology*, pp. 54-65, Karger, Basel.

Sharpe, S.C., Eme, L., Brown, M.W. and **Roger, A.J.** (2015) Timing the origins of multicellular eukaryotes through phylogenomics and relaxed molecular clock analyses. In: *Evolutionary Transitions to Multicellular Life, Advances in Marine Genomics 2*, I. Ruiz-Trillo and A.M. Nedelcu (Eds.), pp. 3-29, Springer Science.

Simpson, A.G.B. and **Eglit, Y.** (2016) Protist diversification. In R.M. Kliman (Ed.), *Encyclopedia of Evolutionary Biology*, Vol. 3, pp. 344-360, Oxford: Academic Press.

Susko, E. (2016) Support measures, Phylogenetic Tree. In R.M. Kliman (Ed.), *Encyclopedia of Evolutionary Biology*, Vol. 4, pp. 256-260, Oxford: Academic Press.

III. Other Contributions – Non-Refereed

Archibald, J.M. (2015) Evolution: Gene transfer in complex cells. *Nature* 524: 423-424. [Invited News & Views]

Doolittle, W.F. (2015) Rethinking the Tree of Life. *Microbe* 10: 319-323.

2.3 PARTICIPATION IN EVENTS FOR RESEARCH DISSEMINATION

Presentations by CGEB Faculty (July 1, 2015 – June 30, 2016)

- All were invited talks, unless indicated otherwise (i.e. poster presentations)

Archibald, John. “One plus one equals one: endosymbiosis and genome mosaicism in eukaryotic evolution.” Microbiology & Immunology Seminar Series, Dalhousie University, October 26, 2015.

Archibald, John. “One plus one equals one: symbiosis and the evolution of complex life. Invited plenary speaker, 6th European Phycological Congress, London, UK, August 23-28, 2015.

Archibald, John. “Gene transfer in eukaryotes: frequency, patterns and implications.” EMBO/EMBL Symposium, Heidelberg, Germany, January 26-29, 2016.

Archibald, John. “One plus one equals one: historical and modern perspectives on the evolution of eukaryotic photosynthesis.” Invited plenary speaker, Harvard Plant Biology Symposium, Harvard University, May 2-3, 2016.

Archibald, John. “Euks in euks: Evolution of an obligate endosymbiont from a free-living kinetoplastid protist.” Annual Meeting of the CIFAR – Integrated Microbial Biodiversity Program, Toronto, June 4, 2016.

Archibald, John. “Endosymbiosis and genome mosaicism in microbial eukaryotes.” Invited plenary speaker, DFG ‘Origin and Function of Metaorganisms’, Kiel University, Germany, June 8-10, 2016.

Archibald, John. “One plus one equals one: historical and modern perspectives on endosymbiosis.” Invited speaker and discussion leader, Gordon Research Conference on Mitochondria and Chloroplasts, Mount Snow, Vermont, June 19-24, 2016.

Beiko, Robert. “Soil, lateral gene transfer, and hybrid genomes.” 7th Annual Argonne Soil Metagenomics Meeting, Chicago, October 21-23, 2015.

Beiko, Robert. “The microbiome and its impact on aging and frailty.” 2015 Gerontological Society of America (GSA): Annual Scientific Meeting, Orlando, Florida, November 18-22, 2015.

Beiko, Robert. “Phylogeography with GenGIS.” 3rd EMBO Conference on Visualizing Biological Data (VIZBI 2016), Heidelberg, Germany, March 9-22, 2016.

Beiko, Robert. “Aging, frailty and the microbiome: new methods, new insights.” 5th Annual Canadian Human and Statistical Genetics Meeting, Halifax, April 16-18, 2016.

Beiko, Robert. “Metagenomics.” GLBIO/CCBC Great Lakes Bioinformatics and Canadian Computational Biology Conference 2016, University of Toronto, May 16-19, 2016.

Beiko, Robert. “What can the microbiome tell us about frailty?” Northwood 6th Annual Research Symposium, Dartmouth, N.S., May 13, 2016.

Bertrand, Erin. “Micronutrient demand and microbial interactions in a changing Southern Ocean.” Princeton EGGs Seminar, Princeton University, April 28, 2016.

Bertrand, Erin. “Phytoplankton need their vitamins too: micronutrient demand in a changing Southern Ocean.” Columbia University and Barnard College, April 29, 2016.

Bielawski, Joseph. *(i)* “Codon substitution models and phylogenetic analysis of protein coding sequences”, *and (ii)* “Tutorial on analyzing gene sequences for presence of sites evolving under adaptive evolution.” North American Workshop on Molecular Evolution, Woods Hole, MA, July 2015.

Bielawski, Joseph. “Phylogenetic methods for inferring functional divergence among proteins.” 2015 European Workshop on Molecular Evolution, Český Krumlov, South Bohemia, Czech Republic, January 2015.

Doolittle, Ford. “Hugging the tree of Life.” Philosophy Department Seminar Series, Dalhousie University, July 3, 2015.

Doolittle, Ford. Keynote Lecture – “Hugging the tree of Life.” International Society for the History Philosophy and Social Studies of Biology, Montreal, July 8, 2015.

Doolittle, Ford. “The tree of Life, from all sides now.” George R. Carmody Lecture in Biology, Carleton University, Ottawa, September 25, 2015.

Doolittle, Ford. “Life and Life only.” Joint Genome Institute, Exploring Diversity of Life Workshop, Pacifica, California, December 16, 2015.

Doolittle, Ford. Oral History Interviews on “The Origins of the RNA World.” Library of Congress, Washington DC, March 17, 2016.

Doolittle, Ford. “Life and Life only.” Philosophy Department Seminar Series, Dalhousie University, April 22, 2016.

Doolittle, Ford. “Debating Life’s family tree.” Scientific Debate with Norman Pace at Unseen Partners: Manipulating Microbial Communities that Support Life on Earth, University of Michigan, Ann Arbor, May 17, 2016.

<https://www.youtube.com/watch?v=WmBMnYXAvW0>

Doolittle, Ford. Keynote Speaker – “Life and Life only.” 2016 Philosophy of Biology at Madison Conference, Wisconsin, May 21, 2016.

Gray, Michael. “Properties and evolution of a mitochondrial tRNA editing system.” MitoCross Symposium 2015: Mitochondria at the Crossroad.” Strasbourg, France, September 21-22, 2015.

Gray, Michael. Opening Lecture – “Mitochondrial genomes - anything goes.” EMBO Conference on Exploring the Genomic Complexity and Diversity of Eukaryotes, Sant Feliu de Guixols, Girona, Spain, October 17-22, 2015.

Gray, Michael. “Mitochondrial evolution: what, how and why.” Evolution of Cells, Genomes and Proteins, Nanyang Technological University, Singapore, February 1-3, 2016.

Gray, Michael. “Properties and evolution of a tRNA editing enzyme.” Evolution of Cells, Genomes and Proteins, Bintan, Indonesia, February 4-6, 2016.

Langille, Morgan. “Functional Inference, Statistics, and Visualization: PICRUSt & STAMP.” Strategies and Techniques for Analyzing Microbial Population Structure, Marine Biological Laboratory, Woods Hole, August 14, 2015.

Langille, Morgan. “Exercise, drug metabolism, and the gut microbiome”, Centre for Comparative Genomics & Evolutionary Bioinformatics Seminar Series, Dalhousie University, October 15, 2015.

Langille, Morgan. “Microbiome insights into aging, exercise, and drug metabolism.” Dalhousie UNB Departmental Seminar Series, Saint John, NB, January 14, 2016.

Langille, Morgan. “Unraveling the complexities of the human microbiome.” Microbiology and Immunology Seminar Series, Dalhousie University, April 4, 2016.

Langille, Morgan. “Unraveling the complexities of the human microbiome.” Genetics and Genomics Seminar Series, Life Sciences Research Institute, Halifax, April 20, 2016.

Langille, Morgan, Robert Beiko, Mike Hall. “Microbiome analysis: 16S & metagenomic.” GLBIO/CCBC Great Lakes Bioinformatics and Canadian Computational Biology Conference 2016, University of Toronto, May 16-19, 2016.

Roger, Andrew. “Diversity and origins of anaerobic metabolism in mitochondria and related organelles.” VII ECOP-ISOP Joint Meeting, Seville, Spain, September 7, 2015.

Roger, Andrew. “From mud-flats to the human gut: Anaerobic eukaryotic microbes.” International Symposium of Global Collaboration on Education, Research and Business in Environmental Studies, Kyoto University, Japan, December 12, 2015.

Roger, Andrew. “Adaptation of eukaryotes and their mitochondria to low oxygen.” University of Exeter, College of Life and Environmental Science, Exeter, UK, February 25, 2016.

Roger, Andrew. “Genomic mechanisms of adaptation of eukaryotic microbes to anaerobic conditions and the gut environment.” Molecular Structure and Function Seminar Series, The Hospital for Sick Children, Toronto, May 30, 2016.

Simpson, Alastair. “The biodiversity and evolution of halophilic protozoa.” Halophiles 2016, San Juan, Puerto Rico, May 24, 2016.

Simpson A.G.B. Keynote lecture – “Protist biodiversity and evolutionary history of eukaryotes.” 35th Annual Meeting of the German Society for Protozoology, Saignelégier, Switzerland, February 23, 2016.

Simpson A.G.B. “Eukaryote Taxonomy.” 1st EukRef Workshop, Vancouver, July 19, 2015.

Slamovits, C. “Nephromyces, an apicomplexan with a unique symbiotic lifestyle.” iGRAD-Plant Program Seminar Series, Institute for Population Genomics, Heinrich-Heine University, Düsseldorf, Germany, November 2015.

Slamovits, C. “Genomic analysis of Nephromyces sheds into an enigmatic symbiotic system between a tunicate and a divergent apicomplexan.” PROTIST2016 Conference, Moscow, Russian Federation, June 2016.

Slamovits, C. (with J.A. Fernández-Robledo, S.A. Breglia) “Developing a transformation system for the dinoflagellate *Oxyrrhis marina*.” EMBO/EMBL Symposium: A new age of discovery for aquatic microeukaryotes, Heidelberg, Germany, January 2016. Poster presentation.

Slamovits, C. (with J.A. Fernández-Robledo - presenter) “Transfection strategies for marine protozoa.” EMBO/EMBL Symposium: A new age of discovery for aquatic microeukaryotes, Heidelberg, Germany, January 2016. Poster presentation.

Susko, E. Plenary Speaker - “Phylogenetic estimation and inference.” The Atlantic Universities Science Atlantic Mathematics, Statistics and Computer Science Conference, Wolfville, N.S., October 23-24, 2015.

2.4 STUDENT RESEARCH ACTIVITIES

The following is a list of CGEB Graduate and Undergraduate Student trainees for the period July 1, 2015 – June 30, 2016.

Student Name / Status / Supervisor / Doctoral Thesis Title (if applic.)

Bashwih, Rana: Master’s student (completed 08/2016) – Bielawski
Brunet, Tyler: Master’s student (completed 04/2016) – co-supervisors Doolittle & Blouin
Buchwald, Robyn: Master’s student (completed 08/2016) – Simpson
Burnard, Claire: Honours student (completed 05/2016) – Simpson
Chen, Chang: Master’s student (completed 08/2016) – Beiko
Colp, Morgan: Co-op summer student (in progress) – Archibald
David, Vojtech: PhD student (in progress) – Archibald
Durnin, Keira: Co-op summer student (completed 08/2016) – Slamovits
Eglit, Yana: PhD student (in progress) – Simpson
Hall, Michael: Master’s student (completed 08/2016; now PhD student) – Beiko
Harding, Tommy: PhD student (in progress) - co-supervisors Roger & Simpson
Hayes, Mary (Molly): NSERC summer student (completed 08/2016) – co-supervisors Langille & Roger
Jones, Casey: Honours student (completed 04/2016) – Langille
Jones, Chris: PhD student (in progress); co-supervisors Susko & Bielawski
Keddy, Alex: Master’s student (completed 05/2016) – Beiko
Kennedy, Kassandra: Honours Student (completed 04/2016) – Slamovits
Khalafvand, Amin: Master’s student (completed 08/2015) - Blouin
Lamoureux, Emily: Master’s student (in progress) – Langille
Lax, Gordon: PhD student (in progress) – Simpson
LeBlanc, Travis: Master’s student (completed 08/2016) – Langille
Leger, Michelle: PhD student (completed 07/2015; now PDF) – Roger
Thesis title: *The Diversity and Origins of Mitochondrion-Related Organelles*
Lindenfield, Brett: Co-op summer student (completed 08/2016) – Slamovits
Liu, Chaoyue: Master’s student (completed 04/2016; now PhD student) – Beiko
Lozano, Sergio Hleap: PhD student (completed 12/2015) – Blouin
Thesis title: *Comparative Quantitative Genetics of Protein Structures: A Composite*

Approach to Protein Structure Evolution

Lu, Simiao (Michelle): PhD student (in progress) – Blouin
McPhee, Michael: Honours student (completed 04/2016) – Archibald
Mingrone, Joseph: PhD student (in progress) – co-supervisors Susko & Bielawski
More, Kira: Honours student (in progress) – Simpson
Mundy, Samuel: Honours student (completed 04/2016) – Slamovits
Munoz-Gomez, Sergio: PhD student (in progress) – co-supervisors Roger & Slamovits
Nguyen, Steven: Honours student (completed 05/2016) – Bielawski
Ning, Jie: Masters student (completed 08/2015) – Beiko
Nomi, Eyre: Master's student (ended 10/2016) – co-supervisors Beiko & Roger
Perrie, Jonathan: Honours student (completed 08/2016) – Beiko
Radan, Katherine (Katya): summer student (completed 08/2017) – Roger
Ravindran, Praveen Nadukkalam: PhD student (in progress) – Beiko
Ryan, Jack: Honours student (completed 05/2016) – Blouin
Shala, Donika: Master's student (in progress) – Slamovits
Sharpe, Susan: Master's student (completed 11/2015) – Roger
Sibbald, Shannon: Master's student (in progress) – Archibald
Stanton, Amanda: Summer student (completed 08/2015) – Archibald
Streight, Steven: Summer student (completed 08/2016; now Honours student) – Simpson
Sylvester, Emma: Master's student (in progress) – Beiko
Tang, Chongci: Master's student (completed 08/2016) – co-supervisors Bielawski & Susko
Wong, Dennis: PhD student (in progress) – Beiko
Yang, Jiwon: Master's student (completed 07/ 2016) – Roger
Youssef, Noor: Master's student (completed 09/2016; now PhD student) – Bielawski
Zhan, Luyao (Catherine): Master's student (completed 08/2016) – Beiko

PRESENTATIONS BY CGEB TRAINEES

[Includes presentations by students listed in Section 2.4 above, and PDFs listed in Section 2.1.5. Presenter's name is underlined if presentation is multi-authored.]

NOTE: Select list only – some presentations by previous trainees (now gone) were not available for inclusion in this report.

Austin Booth. “Ontology and microbial evolution.” Philosophy Department Seminar Series, Dalhousie University, December 4, 2015. Invited talk.

Susana Breglia, Lee, R. and Slamovits, C.H. “Studies on nuclear and genomic biology of the dinoflagellate *Oxyrrhis marina*.” VII European Congress of Protistology (ECOP), Sevilla, Spain, September 2015. Poster presentation.

Tyler Brunet. “Disciplinology: Representations of the structure of science and the humanities.” M.Sc. Defence, Computer Science, Dalhousie University, April 1, 2016.
Tyler Brunet. “Disciplinology: An application of phylogenetics to the study of disciplines.” ISHPSSB Annual Meeting, Montreal, July 8, 2015. Invited talk.

Tyler Brunet. “Disciplinology: An empirical approach to structure representations of knowledge.” Philosophy Department Seminar Series, Dalhousie University, August 21, 2015. Invited talk.

Ugo Cenci and Archibald, J.M. “Complete nuclear genome sequence of *Goniomonas avonlea*, a plastid-lacking cryptomonad.” International Society of Protistologists/VII European Congress of Protistology, Seville, Spain, September 2015. Oral presentation.

Andre Comeau and Langille, M.G.I. “Integrated Microbiome Resource (IMR): Developing an open and streamlined experimental and analysis pipeline for microbiome research.” American Society for Microbiology Microbe, Boston, MA, June 2016. Poster presentation.

Vojtech David. “Genome(s) of kinetoplastid protist *Perkinsela* sp. and its host *Paramoeba Pemaquidensis*.” 46th Jirovec’s Protozoological Days (Czech Society for Parasitology), May 2, 2016. Oral presentation.

Yana Eglit. “Parallels in linguistic and biological evolution.” Biology Department FISH Seminar Series, February 26, 2016. Invited talk.

Laura Eme, Williams, T.A. and Roger, A.J. “Rooting the tree of eukaryotes.” American Society of Microbiology Meeting, Boston, May 2016. Invited talk.

Laura Eme and Roger, A.J. “The role of lateral gene transfer in the adaptation of *Blastocystis* to the gut environment.” Departmental seminar - Laboratory of Ecology, Systematics and Evolution, Université Paris-Sud, France, March 2016. Invited talk.

Laura Eme, Stairs, C.W., Karnkowska, A., Hampl, V. and Roger, A.J. “Lateral gene transfer is an overlooked mechanism in the adaptation of microbial eukaryotes to new environments.” Society for Molecular Biology and Evolution Conference, Vienna, Austria, July 2015. Poster presentation.

Laura Eme, Stairs, C.W., Karnkowska, A., Hampl, V., Roger, A.J. “Lateral gene transfer is an overlooked mechanism in the adaptation of microbial eukaryotes to new environments.” VII European Congress of Protistology (ECOP), Seville, Spain, September 2015. Poster presentation.

Cameron Grisdale and Archibald, J.M. (2015) “Alternative splicing and the evolution of chlorarachniophyte algae.” International Society of Protistologists/VII European Congress of Protistology, Seville, Spain, September 2015. Oral presentation.

Michael Hall, Jonathan Perrie and Robert Beiko. “Time-series clustering enables the exploration of temporal patterns in marker gene data.” GLBIO/CCBC Great Lakes Bioinformatics & Canadian Computational Biology Conference, University of Toronto, May 18, 2016. Invited talk.

Tommy Harding, Brown, M.W., Simpson, A.G.B. and Roger, A.J. “Adaptations to high-salt environments in two bacterivorous halophiles.” VII European Congress of Protistology, Seville, Spain, September 2015. Oral presentation.

Sebastien Hess. “Molecular mechanisms during food acquisition and gliding locomotion in viridiraptorid amoebflagellates - a transcriptomic study of *Orciraptor agilis* (Cerczoa, Rhizaria).” Black Forest Summer School, Germany, September 14, 2015. Oral presentation.

Sebastian Hess. “Viridiraptorid protoplast-feeders and their interactions with algal prey cells.” Annual Meeting of CIFAR – Integrated Microbial Biodiversity Program, Toronto, June 3, 2016. Invited talk.

J. Sergio Hleap-Lozano. “Comparative qualitative genetics of protein structures: A composite approach to protein structure evolution.” Ph.D. Thesis Defence, Department of Biochemistry & Molecular Biology, Dalhousie University, December 8, 2015.

S. Andrew Inkpen. “Demarcating nature, defining ecology: Creating a rationale for the study of nature’s primitive conditions.” Biology Department Seminar Series, Dalhousie University, May 5, 2016. Invited talk.

Chris Jones, Douglas, G., Comeau, A.M., Van Limbergen, J., Hansen, R., Russell, R., Hold, G. and Langille, M.G.I. “Host-microbe interactions influence the development of Inflammatory Bowel Disease.” Crossroads Conference 2016, Halifax, March 2016. Oral presentation.

Kassandra Kennedy. “Genome exploration of the marine bacterium *Marinobacter* spp., which is associated with dinoflagellates.” Honours Student Research Presentation, Department of Biochemistry & Molecular Biology, Dalhousie University, March 22, 2016. Oral presentation.

Emily Lamoureux. “Machine learning reveals microbiome differences in an exercise mouse model.” PREP Graduate Student Research Day, Dalhousie University, May 17, 2016. Oral presentation.

Gordon Lax and Alastair G.B. Simpson. “Building the first SSU database of phagotrophic euglenids using single-cell approaches.” EukRef Workshop, Vancouver, July 2015. Poster presentation.

Gordon Lax and Alastair G.B. Simpson. “Single-cell multigene and transcriptomics-based cataloging of phagotrophic euglenids: towards multigene phylogenetics.” ECOP VII, Seville, Spain, September 2015. Oral presentation.

Gordon Lax and Alastair G.B. Simpson. “Single-cell cataloging: addressing phylogenetic biodiversity and phylogenomics in phagotrophic euglenids.” Lett Symposium, Dalhousie University, February 2016. Oral presentation.

Gordon Lax and Alastair G.B. Simpson. “Single-cell phylogenetic approaches on phagotrophic euglenids.” Department of Ecology, Technical University of Kaiserslautern, Germany, April 2016. Invited talk.

Travis LeBlanc. “Drug metabolism potential of the human microbiome varies by age.” PREP Graduate Student Research Day, Dalhousie University, May 17, 2016. Oral presentation.

Michelle Leger, Markéta Petrů, Vojtěch Žárský, Laura Eme, Čestmír Vlček, Tommy Harding, B. Franz Lang, Marek Eliáš, Pavel Doležal and Andrew Roger. “An ancestral bacterial division system is widespread in eukaryotic mitochondria.” Protist 2016, Moscow, June 2016. Invited talk.

Michelle Leger. “The diversity and origins of mitochondrion-related organelles.” PhD Thesis Defence, Department of Biochemistry & Molecular Biology, Dalhousie University, July 30, 2015.

Michelle Leger, Markéta Petrů, Vojtěch Žárský, Laura Eme, Čestmír Vlček, Tommy Harding, B. Franz Lang, Marek Eliáš, Pavel Doležal and Andrew Roger. “An ancestral bacterial division system is widespread in eukaryotic mitochondria.” EMBO/EMBL Symposia - A New Age of Discovery for Aquatic Microeukaryotes, Heidelberg, Germany, January 2016. Poster presentation.

Dayana Salas-Leiva, Martin Kolisko, Bruce Curtis, Laura Eme, Ryoma Kamikawa and Andrew Roger. “A draft genome of the anaerobic flagellate *C. membranifera*, a free-living relative of metamonad parasites.” 2015 VII European Congress of Protistology and International Society of Protistologists (ECOP/ISOP) Annual Meeting, Seville, Spain, September 2015. Poster presentation.

Simiao Lu. “Capturing major conformational motions in the folding of the intrinsically disordered amyloid- β peptide.” Department of Biochemistry & Molecular Biology Seminar Series, Dalhousie University, March 30, 2016. Invited talk.

Simiao Lu, Sergio Hleap and Blouin, C. “Discovery of major conformational motions from the misfolding of the amyloid- β peptide.” NeuroconX, Charlottetown, Canada, July 14, 2015. Poster presentation.

Carlos Mariscal. “Making sense of evolution in a universal context.” Canadian Society for the History and Philosophy of Science Annual Conference, University of Calgary, May 28-30, 2016. Invited talk.

Michael McPhee. “Using comparative genomics to study trans-splicing of *Paramoeba* endosymbionts.” Honours Student Research Presentation, Department of Biochemistry & Molecular Biology, March 23, 2016. Oral presentation.

Daniel Moog. “A reduced glycosome in the kinetoplastid endosymbiont of parasitic *Paramoeba* species?” Annual meeting of the International Society of Endocytobiology (ISE-G 2015), Berlin, September 21, 2015. Oral presentation.

Daniel Moog, Curtis, B.A., Tanifuji, G., Dlutek, M., Archibald, J.M. “Genomic insights into *Paramoeba* species and their kinetoplastid endosymbionts.” Black Forest Summer School 2015, Germany, September 14, 2015. Oral presentation.

Sergio Munoz-Gomez, Wideman, J.G., Leger, M.M., Roger, A.J., Slamovits, C.H. “The evolutionary history of MICOS reveals the pre-endosymbiotic origin of mitochondrial cristae.” XVII International Society of Endocytobiology - German Section (ISE-G), Berlin, and: VII European Congress of Protistology (ECOP), Sevilla, Spain, September 2015. Oral presentations.

Sergio A. Muñoz-Gómez, Kassandra J. Kennedy, Mary B. Saffo, Chris E. Lane, Chris Paight and Claudio H. Slamovits. “Comparative genomics of *Nephromyces* communities from tunicate renal sacs.” Black Forest Summer School 2015, Germany, September 14-17, 2015. Oral presentation.

Sergio Muñoz-Gómez, Kennedy, K.J., Saffo, M.B., Lane, C.E., Paight, C., Slamovits, C.H. “The multiple infection hypothesis for *Nephromyces* symbiosis and an updated apicomplexan phylogeny.” VII European Congress of Protistology and International Congress of Protistology (ECOP/ICOP), Sevilla, Spain, and: Black Forest Summer School 2015: To see the (Black) Forest for the trees: NGS Data for Phylogenetics, Herzogenhorn, Germany, September 2015. Poster presentations.

Jack Ryan. “Uncertainty in protein residue contact matrices: a geometric and graph theoretical approach.” Honours Student Research Presentation, Dept. of Biochemistry & Molecular Biology, Dalhousie University, March 24, 2016. Oral presentation.

Dayana Salas-Leiva, Kolisko, M., Curtis, B., Eme L., Kamikawa R., Roger A. “A draft genome of the anaerobic flagellate *Carpediemonas membranifera*, a free-living relative of metamonad parasites.” International Society of Protistologists Annual Meeting (ISOP), 1st International Symposium on Soil Protistology (ISOSP) and 5th Russian Conference on the Ecology of Free-living Protists in Terrestrial and Aquatic Ecosystems, Moscow, Russian Federation, June 6-10, 2016. Poster presentation.

Susan Sharpe. “The protistan origins of multicellularity: Timing and evolution of cell adhesion molecules.” M.Sc. Thesis Defence, Department of Biochemistry & Molecular Biology, Dalhousie University, November 4, 2015.

Shannon Sibbald, Cenci, U., O’Kelly, C. and Archibald, J.M. 2015. “Diversity and evolution of *Neoparamoeba* species and their kinetoplastid endosymbionts.” International Society of Protistologists/VII European Congress of Protistology, Seville, Spain, September 2015. Poster presentation.

Courtney Stairs. “Hacking the electron transport chain to live without oxygen.” Recipient of the 2015 Patrick Prize Award – Department of Biochemistry & Molecular Biology Seminar, Dalhousie University, April 6, 2016. Invited talk.

Courtney Stairs, Eme, L. and Roger, A.J. “Evolution and cellular localization Of Rhodoquinone biosynthesis in *Pygsuia biforma* and other anaerobic eukaryotes.” International Congress of Protistology/European Congress of Protistology, Seville, Spain, Sept. 5-10, 2015. Oral presentation.

Jiwon Yang. “Mononucleotide insertion-type RNA editing in mitochondria of the deep branching heterolobosean amoeba ‘BB2’.” Department of Biochemistry & Molecular Biology Seminar Series, Dalhousie University March 30, 2016. Invited talk.

2.5 MEDIA ENGAGEMENT / PUBLIC AWARENESS / EDUCATION

John Archibald (2015) — Coordinator, IB Biology and Chemistry High School Research Day (~30 Park View Education Centre students visited the Department to carry out their research projects).

John Archibald (2016) – Co-Lead Organizer, Trainee Summit, EMBL, Heidelberg, Germany.

John Archibald, Alastair Simpson, Claudio Slamovits – Editors of *Handbook of the Protists (Second edition)*, Springer. Expected publication date April, 2017.
<https://www.amazon.ca/Handbook-Protists-John-M-Archibald/dp/331928147X>

Publication: Karnkowska K, Vacek V, Zubáčová Z, Treitli S, Petrželková R, **Eme L**, Novák N, Žárský V, Barlow L, Herman H, Soukal P, Hroudová M, Doležal P, **Stairs C**, **Roger AJ**, Elias M, Dacks J, Vlček C and Hampl V. (2016) A eukaryote without a mitochondrial organelle. *Current Biol.* 26: 1274-1284.

Media coverage of this publication in:

[Science Mag] [The Scientist] [PNAS] [Scientific American] [LA Times] [NPR]
[Washington Post] [Daily Mail] [CBC] [IFL Science] [Phys. Org] [HNGN]

2.6 OUTREACH STRATEGY

- see Section 1.2 (Current Year’s Activities – E. CGEB Seminar Series, and F. Sponsorship of Local and International Meetings)

2.7 TECHNOLOGY DEVELOPMENT, PATENT OR COMMERCIALIZATION

(New) CGEB Developed Software (2015 – 2016)

Program Name: MEGASAT

Main Author: Luyao Zhan

Description: Automated inference of genotypes from microsatellite DNA sequence data.

Website: <https://github.com/beiko-lab/MEGASAT>

Program Name: simDEF

Main Author: Ahmad Pesaraghader

Description: Definition-based semantic similarity measure of GO terms for functional similarity analysis of genes.

Website: <http://iwera.ir/~ahmad/dal/>

Program Name: *Proteus*

Author: Joe Bielawski

Description: A large program under current development that implements a wide variety of Markov models for molecular data that can be applied to real data in either a maximum likelihood or Bayesian inference framework (currently > 70,000 lines of code).

Distribution: <https://bitbucket.org/EvoWorks>

(private repository while under development; release expected in 2017 under an open source licence).

Program names: *bptaxon_split*, *rbic_taxon_split*, *taxa_split_support*, *tree2treein*

Author: Edward Susko

Description: The programs give phylogenetic stability measures. They implement the methods described in: Wang, H., Susko, E. and Roger, A.J. (2016). Split-specific Bootstrap Measures for Quantifying Phylogenetic Stability and the Influence of Taxon Selection. *Mol. Phylogenet Evol.* 105: 114-125.

Website: <http://www.mathstat.dal.ca/~tsusko>

Program name: *Pylogeny*

Author(s): Alexander Safatli and Christian Blouin

Description: An open-source Python framework for phylogenetic tree reconstruction and search space heuristics.

Citation: Safatli, A. and Blouin, C. (2015) *PeerJ Comput. Sci.* 1: e9.

Website: <http://github.com/AlexSafatli/Pylogeny>

SECTION 3 – FINANCIAL INFORMATION

Summary of Funding Sources:

- I. Tula Foundation (2007-2015)
- II. Herzberg - CGEB Trainee Fellowships & support for CGEB administration (2014-19)
- III. Dalhousie University - Faculties of Medicine, Science, Computer Science, and VP-Academic & Provost (2007-2019)

Annual Operating/Administration Funds in Reporting Year:

I. TULA FOUNDATION

A. *Administration/Seminar Series/Student Travel* (\$50,000 per annum): this includes \$25,000 for CGEB administration, \$15,000 for seminar series speakers, and \$10,000 for trainees travel to meetings. This support commenced in July 2007, with an 8-year commitment from Tula (i.e. 2007-2015). Aggregate over 8 years: \$400,000
There are currently residual funds remaining in our administration account to be used for seminar series, and student travel to meetings.

B. *Research Traineeships (for Postdocs & PhD students)*: these are 5-years of funding awarded to each CGEB faculty for a postdoc or PhD trainee, including research allowance. Listed below are current accounts that were still active during the reporting period (8 other P.I.'s labs previously received their entire 5-year installments from Tula).

Archibald lab (April 2011 – 2016): \$64,000/year

Slamovits lab (Dec. 2011 – 2016): \$64,000/year

II. HERZBERG-CGEB TRAINEE FELLOWSHIPS AND SUPPORT FOR CGEB ADMINISTRATION

In 2014 CGEB member Dr. W. Ford Doolittle pledged to support a new CGEB Trainee Fellowship program and CGEB Administration from funds awarded to him as part of the NSERC Herzberg Gold Medal. This program has provided majority support for stipends for 2-3 graduate students/year and 1 postdoctoral fellowship for the five years of his award (2014-2019). These fellowships are awarded on a competitive basis to applicants from the CGEB community (Members and Associates).

- \$35,000 p.a. for 2 years for postdoctoral fellowships
- \$15,000 for 2 years for M.Sc. and up to 5 years for Ph.D. student stipends

The remaining stipend of the trainee is contributed by the trainee supervisor from grants awarded to them. The first round of these awards were made as follows: Three M.Sc. studentships were awarded in the first round: Ms. Eyre Nomi (Comp. Sci.), Mr. Tyer Brunet (Comp.Sci.), Ms. Yun Cai (Math/Stats), and one postdoctoral fellowship (Dr. Dayana Salas-Leiva, Biochem.).

Dr. Doolittle has also pledged \$34,000 p.a. towards supporting a portion of the CGEB administrator's salary from 2015-2019.

The total support for CGEB from Doolittle's Herzberg monies is currently \$114,000 p.a. but will vary according to the number of fellowships given each year.

III. DALHOUSIE UNIVERSITY

The Faculties of Medicine, Science, and Computer Science, and Office of the VP-Academic & Provost initially collectively committed funding for Years 1-7 (i.e. 2008-2015) to at least match the funds from the Tula Foundation for CGEB administration. On March 14th, 2014 Dr. John Newhook obtained a commitment from each of the Deans for an additional four more years of funding (April 2015-April 2019), to coincide with Dr. Ford Doolittle's Herzberg Award funding contribution toward CGEB trainees and administration (see II. above).

Summary of Institutional Support Commitments to CGEB:

Fiscal Year April 1 – March 31	Faculty of Medicine	Provost & VP Academic	Faculty of Science	Faculty of Computer Science	TOTAL
Year 1: 2008-2009	\$15,000	\$10,000	N/A	N/A	\$25,000
Year 2: 2009-2010	\$15,000	\$10,000	\$1,000	\$1,000	\$27,000
Year 3: 2010-2011	\$10,000	\$10,000	\$6,000	\$3,000	\$29,000
Year 4: 2011-2012	\$10,000	\$10,000	\$7,000	\$4,000	\$31,000
Year 5: 2012-2013	\$10,000	\$10,000	\$8,000	\$5,000	\$33,000
Year 6: 2013-2014	\$10,000	\$10,000	\$8,000	\$5,000	\$33,000
Year 7: 2014-2015	\$10,000	\$10,000	\$8,000	\$5,000	\$33,000
Year 8: 2015-2016	\$10,000	\$10,000	\$8,000	\$5,000	\$33,000
Year 9: 2016-2017	\$10,000	\$10,000	\$8,000	\$5,000	\$33,000
Year 10: 2017-2018	\$10,000	\$10,000	\$8,000	\$5,000	\$33,000
Year 11: 2018-2019	\$10,000	\$10,000	\$8,000	\$5,000	\$33,000

IV. OTHER – CGEB NEW OPPORTUNITIES FUND

Another source of funds available to finance specific CGEB activities is the *CGEB New Opportunities Fund*. This 'special purpose account' (68292) was originally opened to receive transfers of revenue that was previously generated from CGEB members' activities (i.e. scientific meetings). The current balance in this account is \$28,000. The purpose of this fund is to provide additional partial funding or 'seed' monies for CGEB activities, the costs of which either exceed existing allocated funds (e.g. the Trainee Travel to Meeting fund, the Seminar Series fund), or one-time events/activities/opportunities that fall within the CGEB mandate (see Section 1.2 – F. for meeting events sponsored in 2015-16). To date these funds have also been used for costs associated with recruitment of trainees to CGEB labs (e.g. interview travel costs), occasional public lecture sponsorship, as well as the initial CGEB website design.

3.2 RESEARCH FUNDING AND AWARDS TO CGEB FACULTY MEMBERS

3.2.1 Current External Research Grants and other Funding

Collectively, CGEB faculty received (including ongoing awards) **\$2,795,000** from external research grants and other awards during this reporting period. Grants involving collaborative CGEB faculty members as co-applicants were only counted once (i.e. for the primary P.I.) to obtain the above total.

John Archibald

- 2014-2019 **NSERC Discovery Grant**—*Endosymbiosis and genome evolution in eukaryotic microbes*: \$85,000/year for 5 years
- 2012-2017 **Canadian Institute for Advanced Research, Integrated Microbial Biodiversity Program**—research allowance for program senior fellows: \$24,000/year for 5 years
- 2011-2016 **Canadian Institutes of Health Research – Operating Grant**: *Endosymbiosis, parasitism, and genome evolution*: \$115,000/year for 5 years

Robert Beiko

- 2015-2020 **NSERC Strategic Network Grant**: *CHONe II: Conservation strategies for Canada's changing oceans*: \$4,980,000 (\$45,000 to R.Beiko)
(P.I. – P. Snelgrove, with 30 co-applicants incl. R. Beiko)
- 2012-2017 **Canada Research Chair – Tier II (CIHR) in Bioinformatics**: \$100,000/year
- 2012-2017 **NSERC - Discovery Grant**: *Untangling the complex geographic and evolutionary patterns of microbes*: \$33,000/year
- 2013-2016 **Genome Canada – Bioinformatics and Computational Biology**: *A federated bioinformatics platform for public health microbial genomics*: approx. \$1.5M total (\$50,000 to R. Beiko)
(P.I. – F. Brinkman, with 3 co-investigators incl. R. Beiko)
- 2015-2016 **Nova Scotia Health Research Foundation, Discovery / Innovative Grants**: *Assessing microbial signatures of periodontitis in an aging population*: \$14,300
(P.I. – R. Beiko, with four co-applicants)
- 2014-2016 **National Research Council - IRAP**: *Development of a genetic marker panel to predict fertility and longevity traits in Holstein dairy cattle*: \$165,000 over 2 years
- 2013-2016 **NSERC – Strategic Project Grants**: *Genomics approaches to the management of mixed stock fisheries in Canada*: \$593,000 over 3 years (\$100,000 to R. Beiko)
(P.I. – P. Bentzen, with co-applicants I. Bradbury & R. Beiko)
- 2013-2016 **Nova Scotia Health Research Foundation, Discovery / Innovative Grants**: *A pilot project to assess the gut microbes of patients in an assisted living facility*: \$15,000

2015-2016 **MITACS - Accelerate** – *Genetic control of reproductive longevity in mouse and validation of a genetic marker panel to predict fertility and longevity traits in Holstein Dairy Cattle: \$90,000*

Erin Bertrand

2015-2020 **NSERC – Discovery Grant: Micronutrient-based interactions in marine microbial communities: \$32,000/year**

2015-2020 **Canada Research Chair – Tier II (CIHR) in Marine Microbial Proteomics: \$100,000/year**

2015 **Canadian Foundation for Innovation: A liquid chromatography triple quadrupole mass spectrometry system: \$312,000**

Joseph Bielawski

2016-2018 **Nova Scotia Health Research Foundation: Role of fecal microbiome in optimizing aparaginase therapy in childhood acute lymphoblastic leukemia: \$149,833 over 2 years (co-applicant)**

2015-2020 **NSERC – Discovery Grant: A general framework for modeling functional divergence at the molecular level, and investigating relationships to phenotype: \$21,000/year for 5 years**

2015-2017 **Schulich Ocean Studies Centre: Dynamics of complex microbial communities and metabolic potential during the spring bloom in the Gulf of Aqaba, Red Sea: \$150,000 over 2 years (co-P.I.)**

Christian Blouin

2016-2021 **NSERC – Discovery Grant: Novel approaches to protein engineering based on geometric and modularity analyses: \$23,000/year**

2015-2017 **Nova Scotia Health Research Foundation – Scotia Support Training Grant: Enzymology and molecular simulations: \$66,000 over 2 years**

W. Ford Doolittle

2014-2019 **NSERC – Gerhard Herzberg Canada Gold Medal for Science and Engineering: \$1,000,000 over 5 years**

2014-2016 **Dalhousie University, Office of VP (Research) – Strategic Research Initiatives Fund (SRIF): An integrated resource for metagenomics and microbiomics in Atlantic Canada: \$100,000/year for 2 years**
P.I. – W. F. Doolittle, with 10 others (incl. A.J. Roger, J. Bielawski, M. Langille)

Morgan Langille

2016 – 2021 **Canada Research Chair – Tier II (CIHR) in Human Microbiomics: \$500,000/year over 5 years**

2016 – 2021 **Canada Foundation for Innovation: John R. Evans Leaders Fund – Integrating, classifying, and inferring the human microbiome: \$312,395 over 5 years**

- 2016 – 2021 **NSERC Discovery Grant:** *Integrating and modeling host-microbiome interactions:* \$150,000 over 5 years
- 2016 **Nova Scotia Department of Agriculture - Research Acceleration - Rhizo-microbiome as a tool for understanding *V. angustifolium*-microbe interaction:** \$40,000 for one year (co-applicant with P.I. - Svetlana Yurgel)
- 2016 **Occupational Health and Safety Futures Research Funding Program - Exposure to welding fume and the effect on the human respiratory microbiome:** \$45,000 for one year (co-applicant with P.I.s - Anil Adishes & Jeremy Beach)
- 2015-2020 **Canada Foundation for Innovation - Innovation Fund – Research program for rare pediatric diseases:** \$21,000,000 over 5 years (collaborator with P.I. – Kym Boycott)
- 2015-2018 **Canadian Breast Cancer Foundation - Identification of genes which determine paclitaxel sensitivity and resistance in breast cancer:** \$150,000 over 3 years (collaborator with P.I. - Paola Marcato)
- 2015-2017 **Nova Scotia Department of Agriculture - Research Acceleration:** *Evaluation of bacterial and fungal diversity in natural and managed blueberry habitats:* \$76,000 over 2 years (co-applicant with P.I. – Svetlana Yurgel)
- 2015 **Banting Research Foundation Discovery Award – Design and implementation of a human microbiome interaction knowledge base:** \$25,000 for one year (P.I. – Morgan Langille)
- 2014-2019 **Canadian Institutes of Health Research - Team Grant - Restitution Enhancement in Arthritis and Chronic Heart disease:** \$2,500,000 over 5 years (collaborator with P.I. – Jean Marshall)

Andrew Roger

- 2016-2021 **NSERC Discovery Grant – Phylogenomic approaches to inferring ancient relationships amongst eukaryotes:** \$51,000/year for 5 years
- 2015-2020 **Canadian Institutes of Health Research, Operating Grant – Anaerobic eukaryotic microbes and the human microbiome: a genomic and metagenomic study:** \$144,993/year (A. Roger, P.I., with co-applicant A. Simpson)
- 2015 – 2017 **Nova Scotia Health Research Foundation, Scotia Support Grant,** \$24,750/year for 2 years – “*Genomic and metagenomic approaches to elucidating the roles of protozoan parasites in the human gut microbiome*”
- 2012-2017 **Canadian Institute for Advanced Research - Program in Integrated Microbial Biodiversity—** research allowance for program senior fellows: \$24,000/year
- 2010-2017 **Canada Research Chair – Tier I (CIHR) in Comparative Genomics and Evolutionary Bioinformatics:** \$200,000/year (includes 7-yr. salary award, 20% of which is research allowance)

Alastair Simpson

- 2016 **NSERC Research Tools Grant:** \$58,576 (co-applicant with P.I. – Sophia Stone)

- 2014-2019 **NSERC Discovery Grant:** *Linking microscopy-based identities to molecular identities for problem- or problematic protozoa:* \$27,000/year
- 2012-2017 **Canadian Institute for Advanced Research - Program in Integrated Microbial Biodiversity** – research allowance for program senior fellows: \$24,000/year

Claudio Slamovits

- 2015-2020 **NSERC Discovery Grant:** *Genome evolution and radical lifestyle changes in eukaryotic microbes:* \$30,000/year
- 2015-2016 **Gordon and Betty Moore Foundation:** *Experimental Model Systems:* total \$157,163 USD with \$69,750 USD assigned to Slamovits (co-applicant with José Fernández-Robledo, Bigelow Laboratory for Ocean Sciences)
- 2014-2016 **DFO-ACRDP** – *Group grant to develop an oyster breeding program resistant to the oyster parasite Haplosporidium nelson:* total \$404,548 with \$36,000 allotted to Slamovits (co-applicant with P.I. – Sarah Stewart-Clark, Faculty of Agricultural Sciences)
- 2012-2017 **CFI-NSRIT – Leaders Operating Fund** (support for infrastructure maintenance): \$5,000/year
- 2011-2016 **Tula Foundation – CGEB Postdoctoral Research Fellowship** (funding for postdoctoral trainee plus research allowance): \$64,000/year
- 2012-2017 **Canadian Institute for Advanced Research - Program in Integrated Microbial Biodiversity** – research allowance for program members: \$24,000/year

Ed Susko

- 2014-2019 **NSERC – Discovery Grant:** *Statistical methods for molecular evolution:* \$23,000/year

3.2.2 Honours, Awards, Distinctions Received [or Currently Held] by CGEB Faculty

Here we list new awards received in 2015-2016, as well as ongoing salaried fellowships and scholarships, and lifetime fellowships and honorary memberships.

John Archibald

- Elected Member, College of New Scholars, Artists and Scientists of the Royal Society of Canada (2016-2021)
- University Research Professorship, Dalhousie University (2016-2021)
- Vice-President, International Society of Protistologists (2015-2016)
- Elected Fellow, American Academy of Microbiology (2015)
- Senior Fellow, Canadian Institute for Advanced Research - Integrated Microbial Biodiversity Program (2012-2017)

Robert Beiko

- Canada Research Chair (Tier II) in Bioinformatics (2006-present)

Erin Bertrand

- Ruth and Paul Fye Award for Excellence in Oceanographic Research: Best Graduate Student Paper, MIT/WHOI Joint Program (2015)
- Canada Research Chair (Tier II) in Marine Microbial Proteomics (2015-2020)

Joseph Bielawski

- Co-director, North American Workshop on Molecular Evolution, Marine Biological Laboratory (MBL), Woods Hole, MA (2016-2017)

W. Ford Doolittle

- Recipient of Max Beberman Distinguished Alumni Award, University High School, Urbana, Illinois (2015)
- Awarded NSERC Gerhard Herzberg Canada Gold Medal for Science and Engineering (funding award 2014-2019)
- Elected Member, The Norwegian Academy (2009-present)
- Institute Fellow, Canadian Institute for Advanced Research (2008-present)
- Member, U.S. National Academy of Sciences (2002-present)
- Fellow, American Academy of Microbiology (1999-present)
- Fellow, Royal Society of Canada (1991-present)
- Fellow, American Association for the Advancement of Science (1985-present)

Michael Gray

- Fellow, American Academy of Microbiology (2013-present)
- Fellow, Royal Society of Canada (1996-present)

Morgan Langille

- Canada Research Chair (Tier II) in Human Microbiomics (2016-2021)
- Chair Elect (3 yr. term), American Society of Microbiology – Division R: Evolutionary and Genomic Microbiology (2015-2018)

Andrew Roger

- Fellow, American Academy of Microbiology (2014-present)
- Fellow, Royal Society of Canada (2012-present)
- Senior Fellow, Canadian Institute for Advanced Research - Integrated Microbial Biodiversity Program (2012-2017)
- Canada Research Chair (Tier I) in Comparative Genomics and Evolutionary Bioinformatics (2010-2017)

Alastair Simpson

- Vice-President, International Society of Protistologists (2016 – 2017)
- Senior Fellow, Canadian Institute for Advanced Research - Integrated Microbial Biodiversity Program (2012-2017)

Claudio Slamovits

- Scholar, Canadian Institute for Advanced Research - Integrated Microbial Biodiversity Program (2012-2017)

Edward Susko

- Appointed Killam Professor of Mathematics and Statistics, Dalhousie University (2015)