

BULLETIN



Canadian Society of Zoologists

Advancing the study of animals and their environment

Société canadienne de zoologie

Favoriser l'étude des animaux et de leur environnement

Spring 2012 / Printemps 2012
Volume 43, Issue 2

MountAllison
UNIVERSITY

CSZ

SCZ
2012





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BULLETIN OF THE CANADIAN SOCIETY OF ZOOLOGISTS

The Bulletin is published three times a year (winter, spring, and autumn) by the Canadian Society of Zoologists. Members are invited to contribute short articles in either English or French and any information that might be of interest to Canadian zoologists. Send an electronic file. Figures, line drawings and photographs may be included. All manuscripts submitted are subject to review and approval by the Editors before publication. The views and comments expressed by contributors do not necessarily reflect the official policy of the Society.

BULLETIN DE LA SOCIÉTÉ CANADIENNE DE ZOOLOGIE

Le Bulletin est publié trois fois par année (hiver, printemps et automne) par la Société canadienne de zoologie. Les membres sont invités à collaborer en envoyant au rédacteur en chef de courts articles en français ou en anglais, ainsi que toute information ou anecdote susceptibles d'intéresser les zoologistes canadiens. Les auteurs devront soumettre une copie sur traitement de texte. Les textes peuvent être accompagnés de dessins originaux ou de photographies. Avant d'être publiés, ils seront révisés et devront être approuvés par le rédacteur. Les opinions et commentaires qui apparaissent dans le Bulletin ne reflètent pas nécessairement les politiques de la SCZ.

51st annual meeting of the Canadian Society of Zoologists /

51^{ième} reunion annuelle de la Société Canadienne de Zoologie



Mount Allison
UNIVERSITY

May 7-11, 2012 / 7-11 mai, 2012

Table of Contents

Organizing committee	iii
General information	iv
2012 CSZ awards	1
TMW Cameron award	2
Award information	3
2012 award winner bios	5
Detailed programme	12
Posters	33
Abstracts	42

Table des Matières

Comité organisateur	iii
Informations générales	iv
Priz SCZ 2012	1
Prix TMW Cameron	2
Informations sur lex prix	3
Biographies des gagnants de prix	5
Programme détaillé	12
Affiches	33
Résumés	42



51st annual meeting / 51^{ième} reunion annuelle
May 7-11 / 7-11 mai 2012
Mount Allison University

Organizing committee / Comité organisateur

Suzie Currie (Chair)

Sacha LeBlanc, Maria Thistle, Ron Aiken, Magi Beaton, Diana Hamilton, Matt Litvak, Kurt Gamperl,
Danielle LeBlanc, Vett Lloyd, Lori McCumber, Tyson MacCormack

We wish to thank the following for their contributions:
Nous remercions pour leur contribution:

Mount Allison University

The Canadian Society of Zoologists Zoological Education Trust
Canadian Journal of Zoology and NRC Research Press
The Journal of Experimental Biology and the Company of Biologists
Physiological and Biochemical Zoology and the University of Chicago Press
The Town of Sackville

Trade Show participants:

Fisher Scientific
Comparative Biochemistry and Physiology and Elsevier
ADInstruments
Sartorius
EMD Millipore
Qubit
Environmental Proteomics



General Information / Information Générale

Accommodations / Hébergement

Mount Allison University, Campbell Hall or Harper Hall

Tel: 506-364-2247

Prices: \$34/night for a single room in Harper Hall or \$44/night for an en-suite room in Campbell Hall.

Coastal Inn

15 Wright Street, Sackville, NB, E4L 4P8

Tel: (506)-536-0000 or (888)-704-7444

Fax: 506-536-0009

Marshlands Inn

55 Bridge Street, Sackville, NB, E4L 3N8

Tel: (506) 536-0170

Savoy Arms

47 Bridge St., Sackville, NB, E4L 3N8

Tel: (506) 536-0790 or (800) 583-5133

Fax: (506) 536-0790

Tantramar Motel

4 Robson Street, Sackville NB, E4L 4H8

Tel: (506) 536-1327 or (800) 399-1327

Fax: (506) 364-1306

Taxi / Service de Taxi

The closest airport is Moncton International (YQM) with several flights daily from all parts of Canada most notably Toronto, Ottawa and Montreal. For our US visitors, there are two direct flights daily from Newark, N.J. to Moncton on Continental Airlines. There will be taxis available from the Moncton International Airport to Sackville at about \$60. If you care to rent a car, all major car rental agencies have facilities at the airport. The trip is ~25 minutes in duration.

Sackville Cab: 364-8000

Squires Courtesy Cab: 536-3118

Car Rentals / Location d'auto

All major car rental agencies can be found at the Moncton International Airport.

Parking/ Stationnement

University parking is available at several locations throughout the campus (See campus map).

Local Restaurants/ Restaurants à proximité

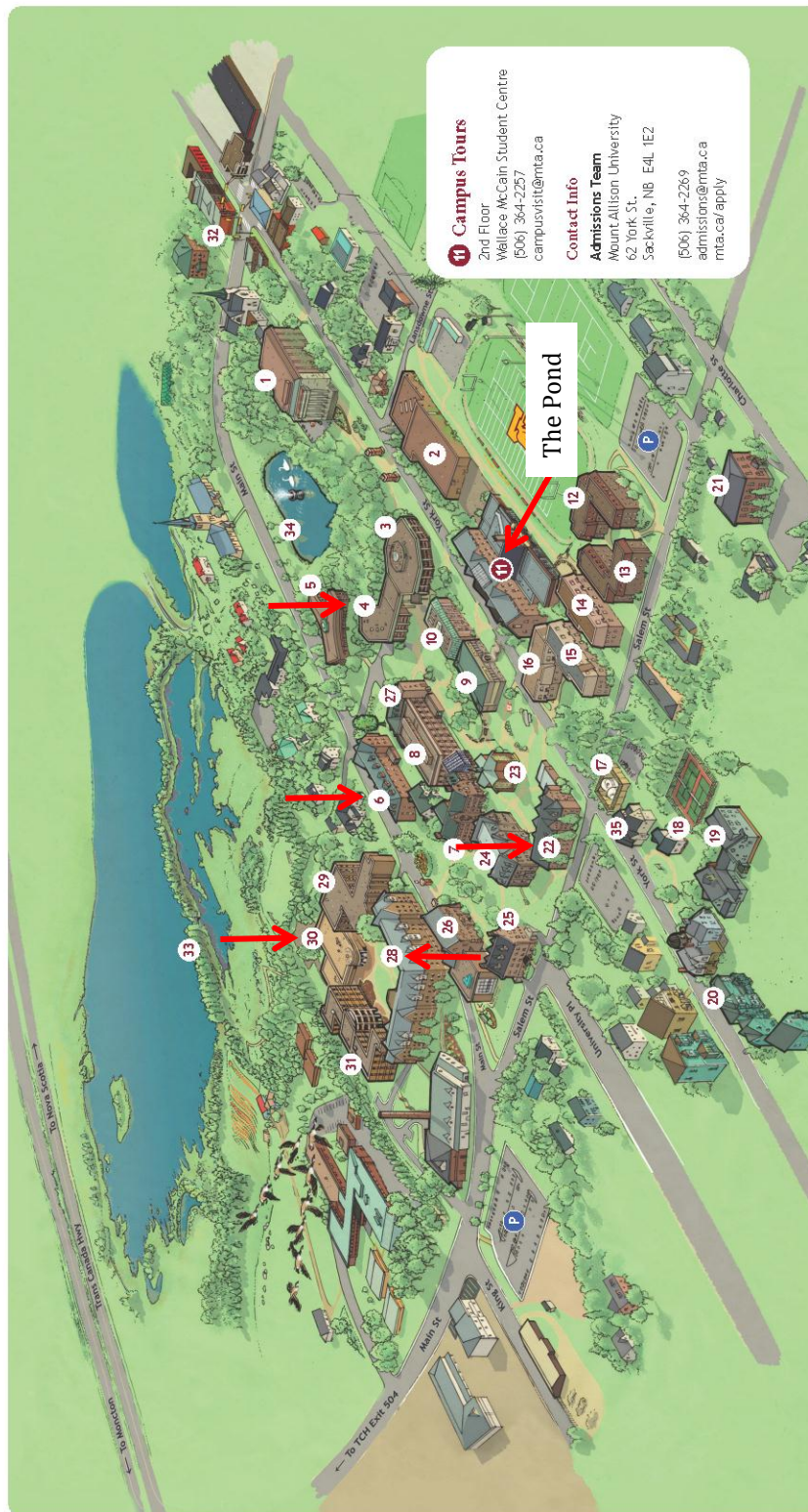
Gracie's cafeteria is located in the McCain Student Centre on the 1st floor. A full list of dining options can be found at <http://sackville.com/visit/dining>. Fast-food restaurants and NB Liquor are located on Main Street, about 1 km North of campus.

Emergency Contact Numbers/ Numéros en cas d'urgence

In cases of emergency, messages may be left at the Biological Sciences main office during normal working hours (506)-364-2500 and Campus security at 506-364-2228 or 506-364-2452. Sackville Memorial Hospital is located at 8 Main Street, about 1.5 km from campus.

Local Emergency Number: 506-364-2228 or 506-364-2452

Mount Allison University – Campus Map (Site of venues)



- Mount Allison UNIVERSITY**
- | | | |
|--|---|------------------------------------|
| 1 Convocation Hall | 11 Wallace McCain Student Centre | 24 Centennial Hall |
| 2 Athletic Centre | International Centre | 25 Bennett Building |
| 3 Ralph Pickard Bell Library | Wellness Centre | 26 Windsor Theatre |
| 4 Crabtree Building | Meighen Centre | 27 Hart Hall |
| 5 Marjorie Young Bell Conservatory of Music | Fitness Centre | 28 Campbell Hall |
| Brunton Auditorium | CHWA Campus Radio | 29 Windsor Hall |
| 6 Avar d-Dixon Building | Campus Pub | 30 Jennings Dining Hall |
| Ron Joyce Centre for Business Studies | Gracie's Café | Academy Gardens |
| 7 Flemington Building | SAC Office | 31 Harper Hall |
| 8 Barclay Chemistry Building | Argosy Student Newspaper | 32 Downtown Sackville |
| 9 Owens Art Gallery | University Bookstore | 33 Sackville Waterfowl Park |
| 10 Gairdner Fine Arts Building | Admissions & Registrar's Office | 34 Swan Pond |
| | Student Affairs | 35 Anchorage House |
| | Tweedle Hall | |
| | | 12 Thornton House |
| | | 13 Edwards House |
| | | 14 Hutton House |
| | | 15 Bennett House |
| | | 16 Bigelow House |
| | | 17 Gemini Observatory |
| | | 18 Carriage House |
| | | 19 Bermuda House |
| | | 20 Cuthbertson House |
| | | 21 Pavillion Bousquet |
| | | 22 Dunn Building |
| | | WU Centre |
| | | 23 Chapel |

2012 CSZ Awards / Prix SCZ 2012

TWM Cameron Outstanding Ph.D. Thesis Award Prix TWM Cameron pour la meilleure thèse de doctorat

Vincent Careau (University of California, Riverside)

Energy expenditure, life-history, and behavior: variation among species, breeds, and individuals.

Dépenses énergétiques, biodémographie et comportement: variation entre espèces, races et individus.

Cameron Award Nominees / Finalistes du Prix Cameron

Tammy Rodela (University of Ottawa)

The role of corticosteroids in nitrogen excretion of the gulf toadfish.

Leon Grayfer (University of Alberta)

The analysis of cytokine regulation of macrophage antimicrobial responses of the goldfish.

Raymond Kwong (University of Saskatchewan)

Dietary divalent metal uptake and interactions in freshwater fish: implications for metal toxicity.

Fry Medal Lecture/ Conférence Fry

Steve Perry (University of Ottawa)

Reelin' in the years: a retrospective look at fish ionic regulation.

Au fil des années: un regard rétrospectif sur la régulation ionique des poisons.

Wardle Lecture/ Conférence Wardle

Allen Shostak (University of Alberta)

Enchanted by the “charismatic microfauna”: an exploration of relationships between the environment, parasites and their invertebrate hosts.

Séduit par la “microfaune charismatique”: une exploration des relations entre l'environnement, les parasites et leurs hôtes invertébrés.

Boutilier Award / Prix Boutilier

Dr. Suraj Unniappan (York University)

Neuroendocrine regulation of energy homeostasis: nesfatin-1 – from genes to physiology.

La régulation neuroendocrinienne de l'homéostasie énergétique: Nesfatin-1 - Des gènes jusqu'à la physiologie.



T.W.M. Cameron

THE T. W. M. CAMERON OUTSTANDING PH. D. THESIS AWARD

This is an annual award, established by the Canadian Society of Zoologists to recognize the author of an outstanding Ph. D. Thesis in Zoology submitted to a Canadian University.

1. The recipient of the award will be invited to present a lecture on the subject of the dissertation to the Annual General Meeting. He/she will be presented with a commemorative scroll at the time. In order to facilitate attendance of the recipient at the meeting, reasonable expenses for air travel at minimum rates and all accommodation and meals at the meeting will be paid by the Society, up to a maximum of one thousand dollars (\$1,000).
2. (a) For nomination, a thesis must have been accepted at a Canadian University within the year preceding the nomination deadline.
(b) Only one thesis may be nominated by a department, though more than one department in a university may nominate a thesis.
(c) A nominated thesis should be accompanied by a joint letter from the Chair of the Department and the Supervisor indicating their reasons for the nomination.
3. Nominated theses will be examined by three judges chosen from among members of the Society. Theses will be judged on the quality of the science and the quality of the presentation.
4. Please provide three bound copies (hardbound or softbound) of the nominated thesis and supporting letters before **15 August 2012**. Contact the Secretary of the Society or visit the CSZ web site for complete terms of the award.

LE PRIX T. W. M. CAMERON POUR UNE THÈSE DE PH. D. EXCEPTIONNELLE

Ce concours annuel a été institué par la Société canadienne de zoologie pour récompenser l'auteur d'une thèse de doctorat en zoologie jugée exceptionnelle et soumise dans une université canadienne.

1. Le gagnant du prix sera invité à donner une conférence sur le sujet de sa thèse lors de la réunion annuelle de la Société. Il recevra alors un parchemin commémoratif. Afin de permettre au récipiendaire d'être présent à la réunion annuelle, une somme maximale de 1000\$ sera allouée par la SCZ pour défrayer les frais de déplacement (billet d'avion, classe économique), les frais de séjour et les repas.
2. (a) Pour être admissible au concours, la thèse doit avoir été acceptée par une université canadienne durant l'année précédant la date limite de mise en candidature.
(b) Un département ne peut présenter qu'une seule thèse au concours, mais plusieurs départements d'une même université peuvent soumettre une thèse.
(c) Chaque thèse présentée doit être accompagnée d'une lettre signée par le directeur de département et le directeur de thèse de l'étudiant expliquant pourquoi la thèse a été sélectionnée.
3. Les thèses seront examinées par trois juges choisis parmi les membres de la Société. Les thèses seront jugées d'après deux critères: la qualité scientifique et la qualité de la présentation.
4. Veuillez fournir trois copies reliées de la thèse (reliure rigide ou cartonnée) et des lettres d'accompagnement **au plus tard le 15 août 2012** au président du comité pour le prix Cameron. Informations supplémentaires relatives à ce prix: contacter le secrétaire de la Société ou consulter notre site Web



William Hoar

Hoar Award: The Hoar Award (named in honour of William S. Hoar, founding member) is given for the best student paper presented orally at the Annual Conference of the Society, and is intended to encourage research and communication by students.

Prix Hoar : Le prix est remis à l'étudiant qui donne la meilleure présentation orale lors du congrès annuel de la Société. Le prix Hoar a pour but d'encourager l'excellence dans les travaux de recherche des étudiants et la présentation de leurs résultats.



Helen Battle

Helen Battle Award: The Helen Battle Award (named in honour of Helen I. Battle; founding member and President, 1962-1963) is given for the best student poster at the Annual Conference of the CSZ and is intended to encourage and acknowledge excellence in scientific research and communication.

Prix Helen Battle : Le prix Helen Battle est remis à l'étudiant qui présente la meilleure affiche lors du congrès annuel de la Société canadienne de zoologie. Le prix Helen Battle a pour but d'encourager les étudiants à exceller dans leurs travaux de recherche ainsi que lors de la présentation de leurs résultats.

Section Awards



George Holeton

George F. Holeton Award: The Holeton Award is given for the most outstanding student poster presentation in Comparative Physiology and Biochemistry.

Prix George F. Holeton : Prix donné pour la meilleure affiche d'un étudiant de la Section Physiologie et Biochimie Comparée.



Brian Hall

Brian K. Hall CMD Award: The Hall Award is given for the best oral presentation by a student on a topic in Comparative Morphology and Development.

Prix Brian K. Hall MDC : Prix donné à la meilleure présentation orale donnée par un étudiant sur un sujet touchant à la Morphologie et Développement Comparés lors du congrès annuel.



Cas Lindsey

Cas Lindsey Award: The Cas Lindsey Book Prize is awarded for the best student presentation (oral or poster) within the fields of behaviour, ecology or evolution.

Prix Cas Lidsay : Le Prix Cas Lindsey de la section d'écologie, d'éthologie et d'évolution est destiné à l'étudiant qui a présenté la meilleure communication ou la meilleure affiche dans l'un des domaines suivants: comportement, écologie ou évolution.



Murray Fallis

Murray Fallis Award: The Fallis Award is given for the best student oral presentation in Parasitology.

Prix Murray Fallis : Prix pour la meilleure présentation orale donnée par un étudiant-chercheur dans le domaine de la parasitologie au cours de l'Assemblée générale annuelle.



Leo Margolis

Leo Margolis Scholarship: This scholarship has been established as a memorial to Dr. Leo Margolis, an internationally preeminent parasitologist and a staunch supporter of the Canadian Society of Zoologists since its inception in 1961.

La Bourse Leo Margolis : Cette bourse a été instituée à la mémoire de Leo Margolis, éminent parasitologiste de réputation internationale et militant fidèle de la Société canadienne de zoologie depuis sa création en 1961.

Student Travel Research Grant: This award will assist students and post-doctoral fellows from Canadian universities with expenses incurred during collaborative visits to other laboratories, research facilities, field stations or sites to conduct zoological research. The intention is to support ancillary research activities that will supplement and enhance the applicant's core research program, and not to fund the core research itself, which is the responsibility of the applicant's supervisor.

Subvention de recherche Étudiants/Chercheurs post-doctoraux : Ce prix vise à aider des étudiants ou chercheurs post-doctoraux à défrayer les coûts inhérents à des visites de collaboration scientifique effectuées dans des laboratoires d'accueil, instituts de recherche, stations ou sites d'études de terrain afin d'y poursuivre des recherches en zoologie. L'objectif de cette subvention est d'accroître les opportunités de recherche au delà de celles qui peuvent être offertes au sein du programme de recherche initial du récipiendaire.

*For information on CSZ and CSZ Section Awards, visit the Society's web site <http://www.csz-scz.ca/>
Pour obtenir de plus amples renseignements sur la SCZ et les prix de la SCZ, veuillez visiter le site web de la
société <http://www.csz-scz.ca/>.*



CSZ 2012 Awards / Prix SCZ 2012

Fry Medal / Médaille Fry

Dr. Steve Perry, University of Ottawa

Reelin' in the Years: A Retrospective Look at Fish Ionic Regulation

Au fil des années: un regard rétrospectif sur la régulation ionique des poissons

Biography

Steve Perry joined the Faculty of Science at the University of Ottawa in 1983 as an NSERC University Research Fellow, after receiving his Ph.D. (1981) from the Department of Zoology at University of British Columbia and carrying out postdoctoral training at McMaster University. Superb mentorship was provided by two of the giants of Comparative Physiology, Dave Randall (doctoral supervisor) and Chris Wood (postdoctoral supervisor). Despite a string of administrative responsibilities (Chair of the Biology Department 2005-2008, Vice-Dean Research of the Faculty of Science 2009-2011, interim Dean of the Faculty of Science, 2011-present), his research program has always been near and dear to his heart. Dr. Perry's research focuses on the interactions among gas transfer, acid-base balance and ionic regulation in fish. His basic approach is to integrate techniques from molecular biology, cell physiology and classical whole animal physiology to elucidate and appreciate the intricate mechanisms that allow fish to inhabit diverse and often labile environments. He is equally enthusiastic about mentoring trainees as they discover this fascinating field. Dr. Perry has published nearly 300 scholarly articles, book chapters and books since 1978, and his research has been recognized with a University of Ottawa University Research Chair (2003), a Killam Research Fellowship (2000-2002), the Award for Excellence in Research from the University of Ottawa (2003), election as a Fellow to the Royal Society of Canada (2008) and the American Fisheries Society Award of Excellence for Fish Physiology (2010). Dr. Perry is also an Editor of the Journal of Experimental Biology.

Presentation abstract

Thanks to my mentor Dave Randall, I joined the wonderful world of fish physiology in 1977, the same year that disco culture hit a new high with the release of "Saturday Night Fever." At the same time, the discovery that there was much to learn about how salts, gases and acid-base relevant molecules cross the gill set the stage for the next 35 years of my life. Those early years piqued my curiosity about how hormones and neurotransmitters affect physiological processes. Thus, much of this talk will focus on the neurohumoral regulation of gill function. In 1982, my other mentor Chris Wood taught me an important lesson - betting on sporting events to determine order of authorship can be highly profitable. Since arriving in Ottawa in 1983, I have been fortunate to supervise some truly exceptional students and PDFs. The past 30 years have witnessed considerable progress in the field, but current students should take note - there still is much to be learned!



Bob Boutilier New Investigator Award / Prix Boutilier

Dr. Suraj Unniappan, York University

Neuroendocrine Regulation of Energy Homeostasis: Nesfatin-1 – From Genes to Physiology

La régulation neuroendocrine de l'homéostasie énergétique: nesfatin-1 – des gènes jusqu'à la physiologie

Biography

Suraj obtained his Ph.D. in Cell Biology and Physiology in 2004 from the University of Alberta, Canada under the supervision of late Dr. Richard Peter. He completed post-doctoral training in biomedical research from the University of British Columbia in 2006, mentored by Dr. Timothy Kieffer. Currently, Suraj is an Associate Professor at the Department of Biology at York University. His Laboratory of Integrative Neuroendocrinology focuses on two research themes: (i) the endocrine regulation of energy homeostasis in mammals, and (ii) the neuroendocrine integration of reproduction and metabolism in fish. Suraj is an author of about 40 peer-reviewed research articles, including reviews and book chapters. He mentors a large number of trainees, and teaches graduate and undergraduate courses in physiology. He is a recipient of several awards including the inaugural Early Researcher Award from the US Endocrine Society, Canadian Institutes of Health Research (CIHR) New Investigator Award, Ontario Ministry of Research and Innovation (MRI) Early Researcher Award, York University Early Researcher Award, Elsevier Top Reviewer and Top Cited Awards, and fellowships from the CIHR, Canadian Diabetes Association and the Michael Smith Foundation for Health Research. His research is funded by grants from the Natural Sciences and Engineering Research Council of Canada, CIHR, MRI, Canada Foundation for Innovation and the James H. Cummings Foundation. He is an editorial board member of General and Comparative Endocrinology, Frontiers in Cellular Endocrinology and Frontiers in Experimental Endocrinology. Suraj also serves as a reviewer for numerous journals and funding agencies.

Presentation abstract

In vertebrates, hormones play an integral role in the maintenance of energy homeostasis. Several tissues, including the brain, gut, pancreas and fat play important roles in energy balance as sources and targets of hormones and metabolites. Nesfatin-1 is a novel, eighty-two amino acid metabolic adipokine encoded in the precursor nucleobindin-2. We found that gut and pancreas are abundant sources of nesfatin-1. Our research discovered an insulinotropic role for nesfatin-1 in rats and mice. We also found that nesfatin-1 regulates whole body energy homeostasis in rats by influencing feeding, ambulatory activity and fat mobilization. The expression and secretion profile of nesfatin-1 in rodents is dependent on nutritional status. Diet induced weight gain and hyperglycemia resulted in an increase in nesfatin-1. Nesfatin-1 also exists in several lower vertebrates, including fish, where it has anorectic, reproductive and stress modulatory effects. Research to date indicates that nesfatin-1 is an important multifunctional protein in animals.



**TWM Cameron Outstanding PhD Thesis Award
Prix TWM Cameron pour la meilleure thèse de doctorat**

Dr. Vincent Careau, University of California, Riverside

*Energy Expenditure, Life-history, and Behavior: Variation Among
Species, Breeds, and Individuals*

*Dépenses énergétiques, biodémographie et comportement : variation
entre espèces, races et individus*

Biography

Vincent Careau was born in Sherbrooke August 4, 1981. He was initiated to nature at age 5 when his parents bought a chalet in the woods. His passion for nature was blended with his scientific curiosity during his BSc in Biology (University of Sherbrooke). As an undergrad, he worked on various field projects involving eastern wolves and black bears (La Mauricie National Park), mountain ibexes (Gran Paradiso National Park, Italy), and broad-winged hawks (Costa-Rica). Vincent went on for a MSc degree (University of Quebec at Montréal), spending two summers in the Canadian Arctic to observe hoarding behaviour of the arctic fox. His writings on the natural history of the arctic fox in relation with ravens have earned him a prize for scientific popularization (ACFAS). He also worked for Ducks Unlimited as a summer field biologist on a study on breeding biology of ducks in Northwest Territories. Through these experiences, Vincent acquired a broad view of ecology and learned several techniques relevant to animal ecology. He returned to Sherbrooke for his PhD where he realized his exceptional ability to ask new questions, formulate new hypotheses, consider “old” issues from a fresh perspective, and perceive relationships hitherto unrecognized. He obtained a NSERC postdoctoral fellowship to pursue his research at the University of California at Riverside, where he is currently learning techniques in evolutionary physiology in an experimental evolution context.

Presentation abstract

Since prehistory, our understanding of animal life is intimately related to the study of respiration, or the fire of life. Today, physiologists are still intrigued by the 2-3 fold variation among individuals in metabolic rate, even when at rest. Similarly, behavioural ecologists attempt to explain why animals consistently behave differently from each other, a.k.a. personality. In this thesis, I asked whether the large variation in energy expenditure is associated with personality. Being the first to explicitly study the energetics of personality, I cast a new look at an old field of research (energetics) while contributing to our understanding of the energetic consequences of animal personality. I tested the relationship between personality and metabolism using various study models, in the laboratory and in the field, and at different levels of biological variation (individuals, breeds, species). I obtained different results depending on the model studied, revealing the complexity of the personality-metabolism relationship.



Wardle Lecture for Outstanding Contributions in Parasitology Conférence Wardle pour Contribution Remarquable dans le domaine de la Parasitologie

Dr. Allen Shostak, University of Alberta

*Enchanted by the “Charismatic Microfauna”: an Exploration of
Relationships Between the Environment, Parasites and their Invertebrate
Hosts*

*Séduit par la “microfaune charismatique”: une exploration des relations
entre l’environnement, les parasites et leurs hôtes invertébrés.*

Biography

Dr. Allen William Shostak is currently the Director & Curator of the University of Alberta Parasite Collection, and a Faculty Service Officer in the department of Biological Sciences. Dr. Shostak has had a long academic relationship with the U. of Alberta where he received his BSc and MSc, before moving to the University of Manitoba to complete his PhD under Professor Terry Dick on the ecology of the cestode, *Triaenophorus crassus*. Following a two year NSERC funded Post-Doc at Wake Forest University, Dr. Shostak went to the Institut Maurice Lamontagne, QC as a visiting fellow. He then returned to Alberta in 1989 as a Parasitology Technologist, a position he held for 15 years, before his current position as Faculty Officer.

Dr. Shostak’s contributions to Parasitology nationally and internationally are unique and outstanding. Despite the lack of a “regular” academic faculty appointment, Dr. Shostak managed to supervise or co-supervise close to 30 undergraduate thesis students as well as serving in various graduate students supervisory or examination committees. As an educator, he is popular with students and his web based parasitology labs are used widely. He also provides statistical support to many researchers. Dr. Shostak has published regularly and his 1997 paper from the *Journal of Parasitology* 83: 575-583, has been cited almost two thousand times, and has averaged over 130 citations annually. As Director and Curator of the University of Alberta Parasite Collection, he delivers invaluable service to the university community and public at large, providing parasite identification as only a few classical parasitologists do.

Dr. Shostak maintains a world class parasite collection, as well as its website that is used by parasitologists world-wide (<http://www.biology.museums.ualberta.ca/en/ParasiteCollection.aspx>). He is also associate editor for the *Journal of Parasitology* and has made extensive contributions to the American Society of Parasitologists for over 25 years.

His service to the Canadian parasitologists stretch beyond the many years he served as treasurer of the CSZ, and includes his service as Chair of the Parasitology section in 2008-09, and local organizer of the 46th CSZ meeting in 2006. He single handedly and voluntarily maintains and updates a listing of over 100 Canadian Parasitologists directory (<http://www.biology.ualberta.ca/parasites/ParSec/indexen/indexeni.htm>), which is hosted within the records/archives of the former CSZ Parasitology section. Every record of this section since 1997 has been meticulously kept and the new face of CSZ’s Parasitology section as **Parasitism, Immunity and Environment (PIE)** owes much to Dr. Shostak, who behind the scenes assisted smoothly into this transition, including the design of its distinctive logo.

Parasitism – Immunity – Environment



Parasitisme – Immunité – Environnement

Dr. Shostak has thus made highly distinguished contributions to Parasitology in Canada and is well deserving of the 2012 Wardle recognition.

Presentation abstract

Helminth parasites commonly use invertebrate animals as intermediate hosts for their larval stages. Some of these relationships produce striking results, such as altered host behavior or parasitic castration. But, by and large, invertebrate hosts in nature are viewed simply as sparsely-infected vessels that, when gobbled up in sufficient numbers, transport larvae to vertebrate hosts where the really interesting things start to happen. I will argue from the opposite point of view. Using both aquatic and terrestrial models, I will show that seemingly uninteresting parasite-invertebrate infections, when suitably prodded, can reveal hidden complexities in the host-parasite-environment relationship.



Leo Margolis Scholarship in Fisheries Biology

Ken Jeffries, University of British Columbia

Biography

Ken was born and raised in Calgary where he completed his B.Sc. (First Class Honours) in ecology and NSERC-funded M.Sc. in environmental physiological ecology at the University of Calgary. His research in Dr. Lee Jackson's Aquatic Ecology Laboratory at the University of Calgary involved studying the effects of point and non-point source pollution on the abundant native minnow, the longnose dace, and resulted in three first-authored peer reviewed publications. After completion of his M.Sc., Ken moved west to Vancouver and began his NSERC-funded Ph.D. in Dr. Scott Hinch's Pacific Salmon Conservation and Ecology Laboratory at the University of British Columbia and Dr. Kristi Miller's Molecular Genetics Laboratory with Fisheries and Oceans Canada in Nanaimo. For his doctoral research, Ken has been studying the effects of elevated water temperature on Pacific salmon survival, blood properties and gene expression by conducting a series of temperature holding studies on wild-caught adult Pacific salmon. Ken has been using microarray technology to examine what biological processes in Pacific salmon are affected by exposure to elevated water temperatures. Ken's work at the University of British Columbia to-date has resulted in three first-authored and three co-authored peer reviewed publications, which includes being a co-author on a paper in the journal *Science*. Ken hopes that his work investigating the potential effects of warming waters on Pacific salmon will aid management agencies in developing strategies to help conserve these amazing species.



**Distinguished Service Award
Médaille de distinction pour services rendus à la Société canadienne
de zoologie**

Dr. William Milsom, University of British Columbia

Service to the CSZ (and the comparative physiology section of CSZ):

1976	Joined the CSZ and have been an active member ever since
1978	First ever recipient of the CSZ Cameron (Best Ph.D. Thesis) Award (Good timing – there were probably no other submissions the first year!)
1986	Chair, Comparative Physiology and Biochemistry Section, CSZ
1984-99	Program Committee Representative, Comparative Physiology Section, CSZ to the International Union of Biological Sciences
1985-88	Associate Editor, "Bulletin" of the Canadian Society of Zoologists
1990-93	Councillor, Canadian Society of Zoologists
1993	President, Canadian Society of Zoologists
1995-99	President, International Union of Biological Sciences, Section of Comparative Physiology and Biochemistry – on behalf of CPB-CSZ
1993-95	Board of Directors, Zoological Education Trust (CSZ)
1999	President, Fifth International Congress of Comparative Physiology and Biochemistry, International Union of Biological Sciences – on behalf of CPB-CSZ
1998-01	NSERC, Grant Selection Committee 31, last two years as co-chair
1999-07	CSZ representative on the Canadian Council on Animal Care
2003	Fry Medal, Canadian Society of Zoology
2006-10	NSERC, Committee on Grants and Scholarships (COGS)

Student Participation:

I take as many of my students as I can to CSZ each year and over time they have won several CSZ awards:

G. Dodd	Battle Award and Hoar Award
G. Funk	Battle Award and Cameron Award
G. Scott	Battle Award
C. Reyes	Battle Award
S. Lee	Holeton Award

Most importantly I have served the west as their goal tender at the quasi-annual CSZ Annual Meeting hockey game for decades. If that is not enduring abuse in the name of the cause, nothing is!



Zoological Education Trust Lecture

Dr. Jayson Semmens

Fisheries, Aquaculture and Coasts Centre, Institute for Marine and Antarctic Studies, University of Tasmania

Fish and Chips: Using Electronic Technology to Understand Marine Animal Behavior and Physiology

Poissons et puces: Utilisation de la technologie électronique pour comprendre le comportement et la physiologie des animaux marins

Biography

After receiving his PhD from James Cook University in 2000, Jayson began an ARC Postdoc at the University of Tasmania in 2001 and has been there ever since. A major focus of his UTAS research has been examining the movement, migration and activity of marine animals, with the aim of understanding the underlying biological and ecological drivers behind these behaviours. Jayson has employed acoustic tracking, telemetry and biologging approaches for a wide variety of marine organisms, including crustaceans, fish, cephalopods, sharks and seals, often with the aim of developing spatial management strategies. More recently he has established physiological telemetry approaches for estimating the metabolic rate of marine animals in the field. This allows for the energetic costs associated with different activities to be estimated and the relative influence on the life history strategies determined. Jayson has also begun to use this field metabolic data to better understand how animals are coping with anthropogenic changes in marine systems.

Presentation abstract

Since the late 1950s marine scientists have utilised electronic systems to examine and understand the behaviour and physiology of marine animals in the world's oceans and estuaries. This work gathered momentum in the late 1990s as the microcomputer and digital revolution spread technology to the masses. Now in 2012, we have a vast array of electronic tagging and tracking devices that can be applied to a wide variety of marine animals in almost every marine habitat. In this talk I will explain how this technology is changing our understanding of marine animals and how they interact with their environment, but also helping managers to ensure the sustainability of commercially targeted or conservation dependant species. To do this I will draw upon examples from my research, which has taken me from the tropics to temperate seas to tag and track animals as diverse as five metre white sharks and giant cuttlefish.

Monday, May 7th / lundi, 7 mai

Summary of Events / Le résumé d'événements

	Events / Les événements	Location / Endroit
08h30-14h00	Council Meeting / Réunion du conseil	Jennings Banquet Room
08h30-17h00	Registration / Inscription	Jennings Hall
12h00-13h00	CJZ Lunch / Lunch CJZ	The Pond
13h00-15h00	Can J Zool Workshop / atelier du Can J Zool	AVDX 112
15h00-15h30	Coffee / café	Jennings Mezzanine
15h15-17h30	Student Welcome and Workshop / Atelier et bienvenue des étudiants	Gracie's
15h30-17h30	Teaching Symposium / Symposium d'enseignement	AVDX 118
17h30-18h30	Welcome, Introduction and Fry Lecture / Bienvenue, Introduction et Conférence Fry	Brunton Auditorium
18h30-20h30	Opening Reception / Réception d'ouverture	Tweedie Hall
20h30-Late	Social / Soirée	The Pond

Tuesday, May 8th / mardi, 8 mai

Summary of Events / Le résumé d'événements

	Events / Les événements	Location / Endroit
08h30-16h00	Registration / Inscription	Jennings Hall
08h30-10h30	CPB Symposium / symposium PBC	Crabtree Auditorium
08h30-10h30	EEE Symposium / symposium ÉÉÉ	Wu Centre
10h30-11h00	Coffee / café	Jennings Mezzanine
11h00-12h30	Contributed Sessions I / Sessions de communications I	
12h30-14h00	CPB Lunch / Lunch PBC	Tweedie Hall
12h30-14h00	EEE Lunch / Lunch ÉÉÉ	Jennings Banquet Room
14h00-16h00	Contributed Sessions II / Sessions de communications II	
16h00-16h30	Coffee / café	Jennings Mezzanine
16h30-17h30	NSERC Information Session / Session d'Information CRSNG	AVDX G12
16h30-17h30	EEE Contributed Session / Sessions de communications ÉÉÉ	AVDX 112
17h30-18h00	Break / Pause	
18h00-19h00	ZET Lecture / Conférence ZET Dr. Jayson Semmens	Brunton Auditorium
19h00-20h30	Student mixer / rencontre sociale des étudiants	The Pond
20h30-Late	Pool Party / Soirée de billards	Uncle Larry's

Wednesday, May 9th / mercredi, 9 mai

Summary of Events / Le résumé d'événements

	Events / Les événements	Location / Endroit
08h00-12h30	Joggins Excursion / Excursion Joggins (08h00 sharp departure for buses) Low tide: 9:21am	King St. Parking Lot
12h30-14h00	AGM Lunch / Lunch des AGA	Tweedie Hall
14h00-16h00	Hoar Award Presentations / Présentations des Prix Hoar	Brunton Auditorium
16h00-16h30	Coffee / café	Jennings Mezzanine
16h30-18h00	Contributed Sessions III / Sessions de communications III	
18h00-19h00	Boutilier Lecture / Conférence Boutilier Dr. Suraj Unniappan	Brunton Auditorium
19h00-20h30	Poster Session & BBQ / Session d'affiches et BBQ	Jennings Mezzanine and Dining Hall
20h30-Late	Social / Soirée –DJ Dance Party	The Pond

Thursday, May 10th / jeudi, 10 mai

Summary of Events / Le résumé d'événements

	Events / Les événements	Location / Endroit
08h30-10h30	PIE Symposium / symposium PIE	AVDX 111
08h30-10h30	CMD Symposium / symposium MDC	Crabtree Auditorium
08h30-10h30	Contributed Sessions IV / Sessions de communications IV	
10h30-11h00	Coffee / café	Jennings Mezzanine
11h00-12h30	Contributed Sessions V / Sessions de communications V	
11h00-12h30	CMD Satellite Symposium / Symposium satellite MDC	AVDX G12
12h30-14h00	CMD Lunch / Lunch MDC	The Pond
12h30-14h00	PIE Lunch / Lunch PIE	Jennings Banquet Room
14h00-15h00	Cameron Lecture / Conférence Cameron Dr. Vincent Careau	Brunton Auditorium
15h00-16h00	Contributed Sessions VI / Sessions de communications VI	
15h00-16h00	Women in Science Symposium / Symposium sur les femmes en science	AVDX G12
16h00-16h30	Coffee / café	Jennings Mezzanine
16h30-17h30	Wardle Lecture / Conférence Wardle	Crabtree Auditorium
17h30-18h00	Break / Pause	
18h00-19h00	Reception and Silent Auction / Réception et encan silencieux	Jennings Mezzanine
19h00-20h30	Banquet	Jennings Dining Hall
20h30-Late	Social /Soirée – Featuring C.R.A.F.T.	The Pond

Friday, May 11th / vendredi, 11 mai

Summary of Events / Le résumé d'événements

	Events / Les événements	Location / Endroit
09h00-12h00	CMD workshop / atelier des CMD	Barclay 215 (Cragg Resource Centre)
09h30-12h30	Council Meeting / Réunion du Conseil	Jennings Banquet Room

Monday, May 7th / lundi, 7 mai

Time	Location: AVDX 118
	Teaching Symposium <i>Chair: Colin Montpetit</i>
15h30 - 1545h	<i>Essential data acquisition techniques in today's animal physiology student laboratory</i> Morgan, Kevin
1545h - 1600h	<i>Teaching zoology : class to book</i> Fenton, Brock
1600h - 1615h	<i>Throwing away our 'cookbooks' to make way for inquiry-based learning in upper-level physiology laboratories</i> LeBlanc, Danielle
1615h - 1630h	<i>Revamping a senior (honours) undergraduate research seminar course</i> Montpetit, Colin
1630h - 1645h	<i>Questions, hypotheses and experimental design: helping students to test what they meant to test</i> Wyeth, Russell
1645h - 1700h	

Tuesday, May 8th / mardi, 8 mai

Time	Location: Crabtree	Location: Wu Centre
	CPB Symposium - Environmental Stressors and Developmental Plasticity <i>Chair: Nick Bernier</i>	EEE Symposium - Recruitment Variability <i>Chair: Heather Hunt</i>
830h - 900h	<i>Effects of prenatal and postnatal environmental stressors on the avian phenotype.</i> Burness, Gary	<i>Reef fish recruitment: connections across life stages</i> Sponaugle, Su
900h - 930h	<i>Stress hormones: mediators of developmental plasticity</i> Denver, Robert	<i>The role of early post-settlement events in recruitment of benthic marine invertebrates</i> Hunt, Heather L.
930h - 1000h	<i>Stress, development, and birdsong: linking stress physiology and sexual selected cognition</i> MacDougall-Shackleton, Scott	<i>Timing of life-history events and the persistence of a rare invertebrate population in a mangrove coastal lagoon</i> Pineda, Jesús
1000h - 1030h	<i>Neonatal stress and its consequences on the developmental trajectory of the respiratory control system</i> Kinkead, Richard	<i>Designing MPAs in the deep sea: what about recruitment?</i> Metaxas, Anna
1030h - 1100h	Coffee / café	

Tuesday, May 8th / mardi, 8 mai

Time	Location: Crabtree	Location: AVDX 118	Location: AVDX G12
	CPB - Osmoregulation and Nitrogen Metabolism 1 <i>Chair: Pat Walsh</i>	CPB - Toxicology 1: From Molecular Mechanisms to Environmental Influences <i>Chair: Greg Goss</i>	CPB - Genomic and Proteomic Studies in Comparative Physiology and Biochemistry <i>Chair: Todd Gillis</i>
1100h - 1115h	<i>Investigation of ASIC4 involvement in Na⁺ uptake in zebrafish larvae using morpholino knockdown technique.</i> Dymowska, Agnieszka	<i>The potential impacts of the β-blocker propranolol on the stress response in the zebrafish <i>Danio rerio</i></i> Mitchell, Kimberly	<i>Interactions between the immune response and stress response in insects (cricket, <i>Gryllus texensis</i>): conflict and collaboration</i> Easy, Russell
1115h - 1130h	<i>To pee or not to pee: Rh versus pH in common carp (<i>Cyprinus carpio</i>)</i> Wright, Patricia A.	<i>Evidence for metabolic imbalance of vitamin A2 in wild fish chronically exposed to metals</i> Defo, Michel Améry	<i>Gene expression in female American lobsters (<i>Homarus americanus</i>): exploring size at maturity using oligonucleotide microarray analysis</i> Moore, Mitchell
1130h - 1145h	<i>Aquaporin-facilitated water movement across the membrane of Pacific hagfish slime mucin vesicles</i> Herr, Julia	<i>Protein expression networks associated with depressed vitellogenin in the female fathead minnows (<i>Pimephales promelas</i>)</i> Martyniuk, Chris	<i>Impact of moderate temperature increase on the Atlantic cod (<i>Gadus morhua</i>) spleen transcriptome response to a viral mimic</i> Hori, Tiago
1145h - 1200h	<i>Social signaling for urea excretion in gulf toadfish (<i>Opsanus beta</i>)</i> Fulton, Jeremy	<i>Characterizing the mechanism of action of the herbicide linuron in the fathead minnow (<i>Pimephales promelas</i>) ovary</i> Ornostay, Anna	<i>Embryonic temperature produces persistent effects on the capacity for thermal acclimation in adult zebrafish</i> Scott, Graham R.
1200h - 1215h	<i>Phosphate uptake in the Pacific hagfish (<i>Eptatretus stoutii</i>): Novel physiological and molecular mechanisms</i> Schultz, Aaron G.	<i>The Acute and Chronic effects of Ni toxicity on <i>Hyalella azteca</i>: Influence of Ca²⁺ and Natural Organic Matter</i> Chan, Katherine	<i>Myocardial Global Gene Expression in Atlantic salmon (<i>Salmo salar</i>) Exposed to Cold Temperatures</i> Costa, Isabel
1215h - 1230h	<i>Responses to Ammonia Loading in the Magadi Tilapia, a Completely Ureotelic Teleost Fish</i> Wood, Chris M.	<i>Influence of salinity and DOC on acute Cu toxicity to the euryhaline shrimp <i>Mysidopsis bahia</i></i> Cunningham, Jessie	<i>Molecular Prospecting: Using global gene expression profiling to identify stage specific developmental processes in American Lobster (<i>Homarus americanus</i>) larvae.</i> Hines, Dan J.
1230h - 1400h	Lunch		

Tuesday, May 8th / mardi, 8 mai

Time	Location: AVDX 112	Location: AVDX 111
	EEE - Recruitment Variability <i>Chair: Gregory Wittig</i>	CMD - Morphology <i>Chair: TBA</i>
1100h - 1115h	<i>Do weather conditions during low tide explain variation in early juvenile mortality of barnacles?</i> Jenewein, Brittany	<i>From cells to slime: slime thread production by the hagfish gland thread cell</i> Winegard, Timothy
1115h - 1130h	<i>Controls on sea urchin populations in Nova Scotian kelp beds</i> Feehan, Colette	<i>Mechanical performance of teleost fish skin</i> Szewciw, Lawrence
1130h - 1145h	<i>Predator Chemical Cue Effects on Barnacle Recruitment Depend on Nearshore Pelagic Food Supply for Prey</i> Ellrich, Julius	<i>The pectoral anatomy of the basal actinopterygian <i>Polypterus senegalus</i></i> Wilhelm, Benjamin
1145h - 1200h	<i>The timing and extent of larval drift in shortnose sturgeon in the Saint John River, NB, Canada</i> Usvyatsov, Sima	<i>Is the salmonid adipose fin a mechanosensory organ?</i> Buckland-Nicks, John
1200h - 1215h	<i>Calibrating a new tool to monitor rocky subtidal biodiversity: the effects of cobble size on biodiversity and lobster abundance</i> Wittig, Gregory	<i>Deciphering the induction and patterning of epithelial placodes required for bone development</i> Jourdeuil, Karyn
1215h - 1230h	<i>Effect of habitat scarcity and shelter size on settlement of American lobster (<i>Homarus americanus</i>)</i> Sigurdsson, Gudjon	
1230h - 1400h	Lunch	

Tuesday, May 8th / mardi, 8 mai

Time	Location: Crabtree	Location: AVDX 118	Location: AVDX G12
	CPB - Metabolism and Energetics 1 <i>Chair: Tom Moon</i>	CPB - Neuroethology <i>Chair: Russell Wyeth</i>	CPB - Responses to Hypoxia and Anoxia <i>Chair: Colin Brauner</i>
1400h - 1415h	<i>Mitochondrial plasticity in the anoxic turtle heart</i> Richards, Jeffrey	<i>Responses of an identified locust interneuron to objects moving along compound trajectories at different velocities</i> Dick, Paul	<i>Early hypoxia exposure alters red blood cell morphology and the Bohr/Root effect in rainbow trout, <i>Oncorhynchus mykiss</i></i> Bianchini, Kristin
1415h - 1430h	<i>Inhibition of mitochondrial succinate oxidation during torpor in hibernating thirteen-lined ground squirrels: potential mechanisms and physiological relevance</i> Brown, Jason C.L.	<i>Auditory responsiveness under dynamic acoustic conditions in the parasitoid fly, <i>Ormia ochracea</i></i> Koucoulas, Dean	<i>Chronic hypoxia exposure during embryonic development impairs aerobic capacity of trout fry</i> Johnston, Elizabeth
1430h - 1445h	<i>Where's the glucose? Dietary methionine restriction eliminates the glucose intolerant phenotype in rainbow trout</i> Craig, Paul	<i>Vibratory signaling and signal transmission in the three-dimensional cob-webs of black widow spiders (<i>Theridiidae</i>: <i>Latrodectus</i>)</i> Sivalinghem, Sen	<i>Implications of acute oxygen deprivation during critical developmental windows in zebrafish (<i>Danio rerio</i>)</i> Robertson, Cayleigh
1445h - 1500h	<i>Respective roles of G3Pase and glycerolipids in glycerol synthesis in smelt: significance for vertebrates</i> Ditlecadet, Delphine	<i>The nudibranch <i>Tritonia diomedea</i> responds to odours trapped in the substrate boundary layer after removal of an odour plume.</i> McCullagh, Greg B.	<i>Hypoxia and thermal tolerance of the adult plainfish midshipman (<i>Porichthys notatus</i>)</i> LeMoine, Christophe M.R.
1500h - 1515h	<i>The effects of acute and chronic hypoxia on muscle metabolism in mice (<i>Mus musculus</i>)</i> Connaty, Alex	<i>Auditory perception in an acoustic parasitoid fly</i> Mason, Andrew	<i>The effect of dissolved oxygen concentration on critical thermal maximum, and the secondary stress response in triploid brook charr, <i>Salvelinus fontinalis</i></i> Ellis, Lauren
1515h - 1530h	<i>Reduced hemoglobin histidine content: an overlooked evolutionary adaptation for enhanced oxygen delivery in small endotherms?</i> Campbell, Kevin L.	<i>Competitive signaling during aggressive encounters in the primitive acoustic insect <i>Cyphoderris monstrosa</i> (<i>Orthoptera</i>: <i>Haglidae</i>).</i> Van Eindhoven, Jennifer E.	<i>Hydrogen sulphide induces compensatory behavioural thermoregulatory adjustments in the zebrafish</i> Tattersall, Glenn J.
1530h - 1545h	<i>Evolution of hypoxia-responsive cytochrome c oxidase genes</i> Moyes, Chris	<i>A complex endocrine network regulates electrocommunication signals in the context of male-male competition in electric fish.</i> Salazar, Vielka	<i>Adenosinergic modulation of central pH/CO₂ chemosensitivity in the brainstem of the Cane toad, <i>Bufo marinus</i></i> Peters, Andrew
1545h - 1600h			
1600h - 1630h	Coffee / café		

Tuesday, May 8th / mardi, 8 mai

Time	Location: AVDX 112	Location: AVDX 111
	EEE - Joint Session in Conservation and Habitat Use and Molecular Ecology <i>Chair: Deborah Austin</i>	PIE - Immunology and Responses to Parasites in Aquatic Organisms <i>Chair: Brian Dixon</i>
1400h - 1415h	<i>Variability in diversity of epifauna at two spatial scales in the shallow rocky sub-tidal zone of the southwestern Bay of Fundy, New Brunswick</i> Wilson, Brent M.	<i>Retention and elimination of <i>Cryptosporidium parvum</i> and <i>Giardia duodenalis</i> by oysters during chronic or acute experimental exposures</i> Willis, Jessica E.
1415h - 1430h	<i>Captive rearing of piping plovers in Atlantic Canada</i> Austin, Deborah	<i>Reduced sensitivity to emamectin benzoate in sea lice (<i>Lepeophtheirus salmonis</i>) is linked to over-expression of P-glycoprotein</i> Igboeli, Okechukwu
1430h - 1445h	<i>Wetlands as dynamic refugia from an introduced predator in Lake Nabugabo, Uganda</i> Reid, Andrea	<i>Combined effects of agriculture and parasites on oxidative stress in leopard frogs (<i>Lithobates pipiens</i>)</i> Marcogliese, David J.
1445h - 1500h	<i>Japanese knotweed (<i>Fallopia japonica</i>) in Nova Scotia: ecological impacts of an invasive weed</i> Larsen, Todd	<i>Development of a larval cell line from cod (<i>Gadus morhua</i>) and their potential applications for enhancing cod aquaculture</i> MacLeod, Michael
1500h - 1515h	<i>Feeding behavior and intestinal helminth communities of Ring-billed Gulls (<i>Larus delawarensis</i>) from the St. Lawrence River</i> Aponte, Veronica	<i>Comparative biology of phagocytic antimicrobial responses</i> Barreda, Daniel R.
1515h - 1530h	<i>Sequencing a seabird food chain – Next generation sequencing of the feces of Atlantic puffin and the stomach contents of their major prey, Atlantic herring</i> Bowser, Kirsten	<i>Cloning and characterization of ERp57 in rainbow trout (<i>Oncorhynchus mykiss</i>).</i> Dixon, Brian
1530h - 1545h	Connectivity in the North Atlantic: population genetics of the key benthic invertebrate <i>Corophium volutator</i> Einfeldt, Tony	
1545h - 1600h	<i>A molecular phylogenetic analysis of green algae associated with amphibian egg masses.</i> Livingstone, Annie	
1600h - 1630h	Coffee / café	

Tuesday, May 8th / mardi, 8 mai

Time	Location: AVDX 112	Location: AVDX 111
	EEE - Populations, Communities, and Biodiversity <i>Chair: Brent Wilson</i>	
1630h - 1645h	<i>Large Scale Dispersal of Intertidal Invertebrates through Ice Rafting</i> Macfarlane, Colin B.A.	
1645h - 1700h	<i>Interactions between salt water cord grass (<i>Spartina alterniflora</i>) and ribbed mussels (<i>Geukensia demissa</i>) in Maritime salt marshes</i> Burse, Laura	
1700h - 1715h	<i>Nature and Possible Causes of the Annual Winter Die-off of Benthic Invertebrates on Intertidal Mudflats in the Bay of Fundy, Canada</i> Gerwing, Travis G.	
1715h - 1730h	<i>Abiotic and Biotic Differences in Salt Pools of Maritime Salt Marshes – Making a Connection</i> Schneider, Dylan	

Wednesday, May 9th / mercredi, 9 mai

Time	Location: Brunton Auditorium
	Hoar Award Presentations <i>Chair: Stephen Reid</i>
1400h - 1420h	<i>A third way: spermcapture mating in barnacles</i> Barazandeh, Marjan
1420h - 1440h	<i>Phosphoinositide 3-kinase interactions with protein kinase C and B signal transduction systems in gonadotropin-releasing hormone actions in goldfish, Carassius auratus</i> Pemberton, Joshua G.
1440h - 1500h	<i>Novel functions for molecular chaperones during diapause of Artemia franciscana embryos</i> King, Allison
1500h - 1520h	<i>Spreading depression-like events in the CNS of the locust (Locusta migratoria): targeting glial mechanisms of K⁺ homeostasis.</i> Spong, Kristin
1520h - 1540h	<i>Adrenergic regulation of Na⁺ uptake in zebrafish, Danio rerio</i> Kumai, Yusuke
1540h - 1600h	<i>Hypoxic cardiac performance in tilapia</i> Speers-Roesch, Ben
1600h - 1630h	Coffee / café

Wednesday, May 9th / mercredi, 9 mai

Time	Location: Crabtree	Location: AVDX 118	Location: AVDX G12
	CPB - Metabolism and Energetics 2 <i>Chair: Paul Craig</i>	CPB - Toxicology 2: From Molecular Mechanisms to Environmental Influences <i>Chair: Carol Bucking</i>	CPB - Comparative Endocrinology <i>Chair: John Chang</i>
1630h - 1645h	<i>Linking intra and interspecific variation in the study of insect flight energetics</i> Darveau, Charles-A.	<i>Significant disruption of serum albumin function by nanoparticles</i> MacCormack, Tyson	<i>Does xenin regulate food intake in goldfish?</i> Kerbel, Brent
1645h - 1700h	<i>A-salted sturgeon: acute effects of saltwater exposure on the swimming behaviour and exercise of shortnose sturgeon</i> Penny, Faith	<i>Mechanisms of nickel toxicity using oxidative stress endpoints in the euryhaline teleost Fundulus heteroclitus</i> Blewett, Tamzin	<i>Reduced hypothalamic-pituitary-interrenal axis responsiveness in rainbow trout infected with the parasite Cryptobia salmositica</i> Madison, B.N.
1700h - 1715h	<i>Impact of cyclic feeding on growth-related traits, fat deposition and the transcriptional regulation of appetite and lipid metabolism in rainbow trout</i> Bernier, Nick	<i>Tissue-specific selenium accumulation and speciation in rainbow trout exposed to elevated dietary selenomethionine</i> Niyogi, Som	<i>Changes in expression of appetite-regulating hormones in the cunner (Tautoglabrus adspersus) during short-term fasting and torpor</i> Babichuk, Nicole
1715h - 1730h	<i>Non-shivering thermogenesis vs. shivering: does heat production have the same energy cost for both mechanisms in muscovy ducklings?</i> Teulier, Loïc	<i>Biometric, enzymatic and transcriptomic study of natural stressors in yellow perch</i> Grasset, Julie	<i>Cross talk between androgen and thyroid hormones during amphibian early development</i> Flood, Diana
1730h - 1745h	<i>Diverging patterns in heat loss may explain bill size differences between sparrows of different habitats</i> Tattersall, Glenn J.	<i>Acute and chronic toxicity of ionic silver and three forms of nanoparticle silver to Daphnia pulex</i> Costa, Emily-Jane	<i>Nesfatin-1 opposes the metabolic effects of ghrelin in rats</i> Vandersluis, Yona
1745h - 1800h		<i>Influence of salinity and DOC on acute Cu toxicity to the rotifer Brachionus plicatilis</i> Cooper, Christopher	

Wednesday, May 9th / mercredi, 9 mai

Time	Location: AVDX 112	Location: AVDX 111
	EEE - Behavioural Ecology <i>Chair: Karen Rickards</i>	CMD - Developmental and Life History Evolution <i>Chair: Doug Fudge</i>
1630h - 1645h	<i>DNA methylation and its role in distinguishing soldier and worker caste development in Camponotus Floridanus</i> Alvarado, Sebastian	<i>Those other gastropod larvae: first study on morphogenesis through metamorphosis of a feeding neritimorph larva</i> Page, Louise
1645h - 1700h	<i>Temperature induced physiological and adaptive responses in the guppy (Poecilia reticulata)</i> Breckels, Ross D.	<i>Towards a theory of settlement and metamorphosis, as it relates to signaling systems and habitat selection</i> Bishop, Cory
1700h - 1715h	<i>Characteristics of air breathing in Lake Magadi tilapia: is there a relationship with diel patterns in reactive oxygen species (ROS) in the lake?</i> Johannsson, Ora	<i>Polypterus: a model organism for the fin to limb transition</i> Standen, Emily M.
1715h - 1730h	<i>Moving at a snail's pace: the effect of temperature and desiccation stress on microhabitat selection in an intertidal snail</i> Rickards, Karen	<i>Developmental origins of normal and anomalous random right-left asymmetry: lateral inhibition versus developmental error in a threshold trait</i> Palmer, A. Richard
1730h - 1745h	<i>Do immune-challenged crickets change behaviour to conserve resources and avoid predators?</i> Fairn, Evan	<i>Scale and tooth phenotypes in medaka with mutated ectodysplasin-A receptor: implication in evolutionary origin of oral and pharyngeal teeth</i> Atukorala, A.D.S.
1745h - 1800h	<i>Effects of temperature and tidal exposure on survivorship and behaviour of Corophium volutator</i> Gilroy, Christine	

Thursday, May 10th / jeudi, 10 mai

Time	Location: Crabtree	Location: AVDX 118	Location: AVDX G12
	CMD Symposium - Metamorphic Transitions in Animals – an Evolutionary Developmental Perspective <i>Chair: Andreas Heyland</i>	CPB - Invertebrate Physiology <i>Chair: Charles Darveau</i>	CPB - Metabolism and Energetics 3 <i>Chair: Christophe LeMoine</i>
830h - 845h	<i>(830h - 910h) External stimulants and internal transitions in metamorphosis of marine invertebrate animals</i> Hadfield, Michael G.		
845h - 900h			
900h - 915h		<i>How to make a zombie brain: host manipulation by the parasitic wasp, Cotesia congregata</i> Adamo, Shelley A.	<i>Changes in the mitochondrial phosphoproteome in mammalian hibernation</i> Chung, Dillon
915h - 930h	<i>(910h - 950h) Nervous system restructuring during insect metamorphosis: a lineage perspective</i> Truman, James	<i>Cold tolerance physiology of the willow leaf beetle (Chrysomela aeneicollis) is life-stage specific</i> Boychuk, Evelyn C.	<i>Regulation of mitochondrial phospholipids in the face of changes in dietary lipids</i> Guderly, Helga
930h - 945h		<i>Trade-offs in neural performance following severe metabolic stress involve the AMPK pathway</i> Money, Tomas G.A.	<i>Expression of lactate transporters in rainbow trout: effects of hypoxia</i> Omlin, Teye
945h - 1000h	<i>(950h - 1030h) Thyroid hormone actions in the development of a frog that lacks a tadpole</i> Elinson, Richard	<i>Hydrogen peroxide facilitated diffusion of iodine in the purple urchin (Strongylocentrotus purpuratus)</i> Miller, Ashley E.M.	<i>Variation in mitochondrial genotype is associated with metabolic rate variation in killifish</i> Haakons, Kristen
1000h - 1015h		<i>Why think statically about a dynamic problem? Good news from work on sodium pumps and metabolic rates in insects</i> Sinclair, Brent J.	<i>Alternative respiratory proteins in animal mitochondria</i> McDonald, Allison
1015h - 1030h		<i>Membrane composition as a function of body size and temperature in species of tropical and North American bees.</i> Rodríguez, Enrique	<i>The influences of vagal feedback and pontine input on breathing pattern are reconfigured during hibernation in golden-mantled ground squirrels</i> Milsom, Bill
1030h - 1100h	Coffee / café		

Thursday, May 10th / jeudi, 10 mai

Time	Location: AVDX 112	Location: AVDX 111
	CPB - Toxicology 3: From Molecular Mechanisms to Environmental Influences <i>Chair: Chris Martyniuk</i>	PIE Symposium - Parasitism, Immunity in the Aquatic Environment <i>Chair: Spencer Greenwood</i>
830h - 845h		
845h - 900h		
900h - 915h	<i>Acetaminophen causes mortality and developmental abnormalities in zebrafish (Danio rerio) through the inhibition of cyclooxygenase activity</i> Galus, Michal	<i>Title TBA</i> Cawthorn, Rick
915h - 930h	<i>Effects of waterborne copper and hypoxia on the oxidative stress response and gene expression in killifish (Fundulus heteroclitus)</i> Ransberry, Victoria	
930h - 945h	<i>Microarray analysis of American lobster larvae (Homarus americanus) exposed to endosulfan during metamorphosis</i> Bauer, Megan	<i>Immunostimulants and their effects on the host-parasite relationship between Atlantic salmon (Salmo salar) and Lepeophtheirus salmonis</i> Fast, Mark
945h - 1000h	<i>Transcriptional responses of the female fathead minnow liver due to phenanthrene exposure</i> Loughery, Jennifer	
1000h - 1015h	<i>Biological and chemical characterization of the protective effects of NOM source on acute Cu toxicity to the freshwater amphipod Hyalella azteca</i> Livingstone, Kelly	<i>Plasma pattern recognition receptors of rainbow trout and walleye</i> Lumsden, John S.
1015h - 1030h	<i>17α-ethynylestradiol (EE2) depresses temperature-induced gonadal development in Northern killifish (Fundulus heteroclitus macrolepidotus)</i> MacLatchy, Deborah	
1030h - 1100h	Coffee / café	

Thursday, May 10th / jeudi, 10 mai

Time	Location: Crabtree	Location: AVDX 118	Location: AVDX G12
	CPB - Osmoregulation and Nitrogen Metabolism 2 <i>Chair: Pat Wright</i>	CPB - Behavioural and Physiological Responses to Environmental Stressors <i>Chair: Brent Sinclair</i>	CMD - Form and Function: Integration of Biology and Technology (Student Satellite Symposium) <i>Chair: Karyn Jourdeuil/Megan Dufton</i>
1100h - 1115h	<i>Urea production in the gut? Adult ammoniotelic teleost fish may not be as ammoniotelic as we thought</i> Bucking, Carol	<i>After the cold: the reestablishment of osmotic balance and neuromuscular function during chill coma recovery of an insect</i> MacMillan, Heath	<i>Quantitative approaches to ontogenetics: geometric morphometrics approaches</i> Sheets, H. David
1115h - 1130h	<i>Searching for the active steroid hormone in Pacific hagfish, <i>Eptatretus stoutii</i></i> Clifford, Alex	<i>Getting fresh: the hypo-osmotic stress response of the spiny dogfish (<i>Squalus acanthias</i>) and the relative roles of chemical and molecular chaperones</i> Tunnah, Louise	
1130h - 1145h	<i>Ammonia excretion in early life stages of rainbow trout – evidence of a $\text{Na}^+/\text{NH}_4^+$-exchange complex</i> Zimmer, Alex M.	<i>The interactive effects of UV radiation and cadmium on physiological stress response, club cell investment and alarm cue production in fathead minnows (<i>Pimephales promelas</i>).</i> Manek Aditya	<i>Morphometric analysis of a putative olfactory structure in <i>Lytechinus variegatus</i> larvae</i> MacNeil, Katelyn
1145h - 1200h	<i>Epithelial barrier functions of tight junction proteins in zebrafish</i> Kwong, Raymond	<i>The goldenrod gall fly's liquid little secret: 3-acetyl-1,2-diacyl-sn-glycerols are associated with natural survival of intracellular freezing in <i>Eurosta solidaginis</i></i> Marshall, Katie E.	<i>Locomotion and fin use of an air breathing fish on land</i> Standen, Emily
1200h - 1215h	<i>Scavenging on the ocean floor: ammonia and urea excretion dynamics in foraging Pacific hagfish (<i>Eptatretus stoutii</i>)</i> Wilkie, Michael	<i>Frost expression is not necessary for cold tolerance in <i>Drosophila melanogaster</i></i> Udaka, Hiroko	<i>Using geometric morphometrics to investigate the effects of manual lens removal on the craniofacial skeleton</i> Dufton, Megan
1215h - 1230h		<i>Thermal effects on the survival and development of lake whitefish (<i>Coregonus clupeaformis</i>).</i> Tompkins, Meagan M.	
1230h - 1400h	Lunch		

Thursday, May 10th / jeudi, 10 mai

Time	Location: AVDX 112	Location: AVDX 111
		PIE - Micro-parasites Chair: Todd Smith
1100h - 1115h		<i>The Trich to safe bird feeding: survivability of Trichomonas gallinae in bird feed and water</i> Kelly-Clark, Whitney
1115h - 1130h		<i>Fecundity reduction in the second gonotrophic cycle of the mosquito, Culex pipiens, infected with the apicomplexan blood parasite, Hepatozoon sipedon</i> Ferguson, Laura
1130h - 1145h		<i>Effects of subzero temperatures on Hepatozoon species (phylum Apicomplexa) in freeze-tolerant wood frogs, Rana sylvatica</i> Hammer, Chelsea
1145h - 1200h		<i>Factors determining the in vitro emergence of sexual stages of Hepatozoon clamatae from erythrocytes of the green frog, Rana clamitans</i> Trites, Michael
1200h - 1215h		<i>In vitro cultivation of Hematodinium sp. isolated from Chionoecetes opilio: characterization of developmental stages</i> Gaudet, Peter H.
1215h - 1230h		<i>Exploring lobster immunology - the American lobster's (Homarus americanus) response to the micro-parasite Anophryoides haemophila</i> Clark, K. Fraser
1230h - 1400h	Lunch	

Thursday, May 10th / jeudi, 10 mai

Time	Location: Crabtree	Location: AVDX 118	Location: AVDX G12
		CPB - Cellular Signaling and Regulation Chair: Suraj Unniappan	Women in Science Symposium Chair: Shelley Adamo
1500h - 1515h		<i>Kisspeptin 1 stimulation of LH and GH secretion from goldfish pituitary cells</i> Chang, John	
1515h - 1530h		<i>Gene regulatory networks involved in early stages (1-74 hpf) of <i>Silurana tropicalis</i> development</i> Langlois, Valerie S.	
1530h - 1545h		<i>Initiation and propagation of the heart beat in an ancestral vertebrate, the Pacific hagfish (<i>Eptatretus stoutii</i>)</i> Wilson, Christopher	
1545h - 1600h		<i>Effect of cold acclimation on troponin I isoform expression in striated muscle of rainbow trout</i> Alderman, Sarah	
1600h - 1630h	Coffee / café		

Thursday, May 10th / jeudi, 10 mai

Time	Location: AVDX 112	Location: AVDX 111
	CPB/CMD - Biomechanics and Locomotion <i>Chair: Rich Palmer</i>	PIE - Macro-Parasites <i>Chair: David Marcogliesi</i>
1500h - 1515h	<i>When behavior and mechanics meet: scallop swimming capacity and their ligaments</i> Tremblay, Isabelle	<i>Community ecology of larval Diplostomum spp. (Digenea: Strigeida) in the eyes of fish from Lake Saint-François in the St. Lawrence River</i> Désilets, Hubert D.
1515h - 1530h	<i>Putting the squeeze on: how do mammalian keratins go from soft to hard?</i> Fudge, Doug	<i>Using gastropods to assess the diversity and prevalence of digenean trematodes in a Cape Breton lake</i> Lawrence, Samantha C.
1530h - 1545h	<i>Do insects have tails? Contributions of leg and abdomen movements to body posture control in freely flying Drosophila</i> Skandalis, Dimitri	<i>Survey of brook trout, Salvelinus fontinalis, for macroparasites from different regions in New Brunswick</i> Caissie, Brad
1545h - 1600h	<i>Jump height is not enhanced by tendons alone: there must be a catch!</i> Syme, Douglas	<i>Distribution, prevalence, mean intensity, relative density and life history implications of worm infections in coyotes (Canis latrans) of Nova Scotia</i> Power, Jason
1600h - 1630h	Coffee / café	

Posters / Affiches

1	<p>Water transport in zebrafish larvae: paracellular versus transcellular pathways, and their regulation by cortisol</p> <p>Le Transport de l'eau dans les larves du poisson zèbre: sentiers paracellulaires versus transcellulaires et leur régulation</p> <p>Raymond Kwong, Yusuke Kumai and Steve Perry</p> <p><i>University of Ottawa</i></p>
2	<p>Probing the role of ASIC in rainbow trout gill MR cells using cell imaging</p> <p>Sondage du rôle du canal ionique de détection d'acide dans les cellules riches en mitochondries des branchies de truites arc-en-ciel en se servant d'imagerie cellulaire</p> <p>Salvatore Blair, Agnieszka Dymowska, Aaron Schultz and Greg Goss</p> <p><i>University of Alberta</i></p>
3	<p>The effect of cold and anaerobic conditions on northern killifish</p> <p>Effet du froid et conditions anaérobiques sur le choquemort nordique.</p> <p>Katelyn Barnes, Hannah Buhariwalla, Regina Cozzi and Bill Marshall</p> <p><i>St Francis Xavier University</i></p>
4	<p>Nitrogen excretion in the freshwater ribbon leech <i>Nephelopsis obscura</i></p> <p>Excrétion d'azote chez la sangsue ruban d'eau douce <i>Nephelopsis obscura</i></p> <p>Alex Quijada-Rodriguez and Dirk Weihrauch</p> <p><i>University of Manitoba</i></p>
5	<p>Messenger RNA expression levels of RhCM, V-ATPase and aquaporin correlate with branchial ammonia excretion rates in green shore crabs <i>Carcinus maenas</i>.</p> <p>Les niveaux d'ARNm de RhCM, de V-ATPase et de aquaporine corrélerent avec les taux d'excrétion d'ammoniac chez le crabe vert (<i>Carcinus maenas</i>)</p> <p>¹Dirk Weihrauch, ¹Sandra Fehsenfeld, ²Sue Edwards and ³David Towle</p> <p>¹University of Manitoba, ²Appalachian State University, ³Mount Desert Island Biological Laboratory</p>
6	<p>Is AQP1 a multi-functional biological gas channel in zebrafish <i>Danio rerio</i>?</p> <p>Est-ce que l'AQP1 est un canal de gaz biologiques multi-fonctionnel chez le poisson zèbre, <i>Danio rerio</i>?</p> <p>Krystle Talbot, Kathleen M. Gilmour and Steve F. Perry</p> <p><i>University of Ottawa</i></p>
7	<p>Mechanisms and capacity of nitrogenous waste excretion during the complex life cycle of the sea lamprey (<i>Petromyzon marinus</i>)</p> <p>Mécanismes et excrétion de déchets azotés durant le cycle de vie complexe de la lamproie marine (<i>Petromyzon marinus</i>)</p> <p>¹James Neal, ¹Michael Wilkie, ²Matt Vijayan, ¹Sean Anthony and ¹Nolan Brody</p> <p>¹Wilfrid Laurier University, ²University of Waterloo</p>
8	<p>Nitrogenous waste excretion by zebrafish, <i>Danio rerio</i>, in an alkaline environment</p> <p>L'excrétion de déchets azotés par le poisson zèbre, <i>Danio rerio</i>, dans un environnement alcalin</p> <p>Yusuke Kumai, Hasanen Al-Rewashdy, Jessica Harris and Steve Perry</p> <p><i>University of Ottawa</i></p>

9	<p>Ammonia excretion in the soil nematode <i>Caenorhabditis elegans</i> occurs via ammonia trapping across the hypodermis</p> <p>L'excrétion d'ammoniac chez le nématode de terre <i>Caenorhabditis elegans</i> se produit par piégeage de l'ammoniac à travers l'hypoderme</p> <p>Aida Adlimoghaddam and Dirk Weihrauch</p> <p><i>University of Manitoba</i></p>
10	<p>High environmental ammonia (HEA) impairs net ammonia secretion over the skin of the African Clawed Frog, <i>Xenopus laevis</i></p> <p>Des niveaux environnementaux d'ammoniac élevés compromettent la sécrétion nette d'ammoniac sur la peau de xénopes du Cap, <i>Xenopus laevis</i></p> <p>Melissa Cruz, Mary M. Sourial and Dirk Weihrauch</p> <p><i>University of Manitoba</i></p>
11	<p>The illogicality of arbitrary statistical cutoffs in zoology and suggestions for better alternatives</p> <p>L'illogisme des seuils statistiques arbitraires on zoologie et des suggestions de meilleures alternatives</p> <p>Joseph Mudge and Jeff Houlahan</p> <p><i>University of New Brunswick, Saint John</i></p>
12	<p>Intracellular localization and regulation of matrix metalloproteinase 2 in zebrafish muscle</p> <p>Localisation intracellulaire et régulation de la métalloprotéinase de matrice 2 du muscle de poissons zèbre</p> <p>Amina Fallata and Bryan Crawford</p> <p><i>University of New Brunswick</i></p>
13	<p>Behavioural phenotyping sensory responses in zebrafish</p> <p>Les réponses comportementales sensorielles phénotypiques du poisson zèbre</p> <p>Angela L. Shamchuk and Keith B. Tierney</p> <p><i>University of Alberta</i></p>
14	<p>Catecholaminergic peripheral neuroanatomy in the nudibranch <i>Tritonia diomedea</i></p> <p>La neuroanatomie périphérique catecholaminergique chez le nudibranche <i>Tritonia diomedea</i></p> <p>Emily Kehoe, Marissa Webber and Russell Wyeth</p> <p><i>St. Francis Xavier University</i></p>
15	<p>A screen for genes associated with coma recovery in drosophila</p> <p>Un dépistage des gènes associés à la récupération d'un coma chez la drosophile</p> <p>Chengfeng Xiao and R. Meldrum Robertson</p> <p><i>Queen's University</i></p>
16	<p>Comparative study of gill tissue composition and genomics between parapatric anadromous and resident populations of brook charr (<i>Salvelinus fontinalis</i> Mitchill)</p> <p>Comparaisons de la composition tissulaire et de la génomique du tissu branchial entre deux populations anadrome et résidente d'ombles de fontaine (<i>Salvelinus fontinalis</i> Mitchill)</p> <p>Andrée-Anne Lemieux and Céline Audet</p> <p><i>Université du Québec à Rimouski</i></p>

17	<p>Molecular signalling cascades underlying increased estrogen production in the fathead minnow ovary after dihydrotestosterone treatment</p> <p>Cascades de signalisation moléculaire sous-jacentes à une hausse en production d'œstrogène dans l'ovaire du tête-de-boule après traitement à la dihydrotestostérone</p> <p>Joshua Marr, Anna Ornostay and Christopher J. Martyniuk</p> <p><i>University of New Brunswick</i></p>
18	<p>Investigating the relationships between γ-amino-butyric acid and estrogen in the fathead minnow (<i>Pimephales promelas</i>) ovary</p> <p>Enquête sur la relation entre l'acide γ-amino butyrique et l'œstrogène dans l'ovaire du tête-de-boule (<i>Pimephales promelas</i>)</p> <p>Katie Biggs and Christopher J. Martyniuk</p> <p><i>University of New Brunswick</i></p>
19	<p>Development of an embryonal cell line from <i>Fundulus heteroclitus</i> with myogenic potential</p> <p>Le développement d'une lignée cellulaire embryonnaire de <i>Fundulus heteroclitus</i> avec un potentiel myogénique</p> <p>¹Sarah J. Gignac, ^{1,2}Nguyen T.K. Vo, ^{1,3}Henry Y. Kwon, ¹Ibrahim Chehade, ¹Deborah MacLatchy and ¹Lucy E.J. Lee</p> <p>¹Wilfrid Laurier University, ²University of Waterloo, ³McMaster University</p>
20	<p>Evolution and ontogenetic expression of CRH family members in sea lamprey, <i>Petromyzon marinus</i>.</p> <p>L'évolution et l'expression ontogénétique des membres de la famille d'hormones de l'hibernation de la corticotropine chez la lamproie marine <i>Petromyzon marinus</i></p> <p>Matthew Endsins, Tara Hicks, Odette Allonby and Richard G. Manzoni</p> <p><i>University of Regina</i></p>
21	<p>Characterization of the Atlantic cod glucocorticoid receptor (GR) cDNA and its expression during embryonic and early larval development</p> <p>Caractérisation de l'ADNc du récepteur glucocorticoïde (RG) de la morue de l'Atlantique et son expression au cours du développement embryonnaire et larvaire</p> <p>¹Tiago Hori, ¹Kurt Gamperl, ¹Jennifer Hall, ²Luis Afonso, ³Stewart Johnson and ¹Matthew Rise</p> <p>¹Memorial University of Newfoundland, ²Deakin University, ³DFO</p>
22	<p>Short-term behavioural and cortisol responses to Alarm Substance in zebrafish, <i>Danio rerio</i></p> <p>La réponse à court terme comportementale et du cortisol due à une substance d'alarme chez le poisson zèbre (<i>Danio rerio</i>)</p> <p>Brian Wilson, Jeff Beardsall, Kirk Hillier and Peter McLeod</p> <p><i>Acadia University</i></p>
23	<p>Nesfatin-1 regulation of the stress axis in goldfish</p> <p>La régulation de l'axe de stress par la nesfatine-1 chez les poissons rouges</p> <p>Vi Pham, Brent Kerbel, Ronald Gonzalez and Suraj Unniappan</p> <p><i>York University</i></p>
24	<p>Nesfatin-1 and ghrelin: two novel endocrine factors that regulate germinal vesicle breakdown in zebrafish</p> <p>La nesfatine-1 et la ghréline: deux nouveaux facteurs endocriniens qui régulent la détérioration des vésicules germinales chez le poisson zèbre</p> <p>Erin Shepperd, Sneha Lohan and Suraj Unniappan</p> <p><i>York University</i></p>

25	<p>Endogenous rhythms of ecdysteroids in an adult insect, <i>Rhodnius prolixus</i> Les rythmes endogènes des ecdystéroïdes dans un insecte adulte: <i>Rhodnius prolixus</i> Nicholas Rapp and Colin Steel <i>York University</i></p>
26	<p>Dual functions of melatonin in <i>Rhodnius Prolixus</i> Les fonctions doubles de la mélatonine chez <i>Rhodnius prolixus</i> Michael Cardinal-Aucoin, Diana Gorbet and Colin Steel <i>York University</i></p>
27	<p>Pro-hormone convertases and ghrelin o-acyl transferase in sprague dawley rats: developmental profile and functional implications La pro-hormone convertases et la ghréline O-acyltransférase chez les rats Sprague-Dawley: profil de développement et ses conséquences fonctionnelles Haneesha Mohan, Micha Gasner and Suraj Unniappan <i>York University</i></p>
28	<p>A method for quantitative analysis of thermoregulatory changes in posture in small mammalian species Une méthode d'analyse quantitative des changements de postures de thermorégulation dans les petites espèces de mammifères Viviana Cadena and Glenn Tattersall <i>Brock University</i></p>
29	<p>Molecular and physicochemical characterization of hemoglobin from the high-altitude Taiwanese brown-toothed shrew (<i>Episoriculus fumidus</i>) La caractérisation moléculaire et physico-chimique de l'hémoglobine de musaraignes de montagnes du Taiwan en haute altitude ¹Kevin L. Campbell, ¹Anthony V. Signore and ²Roy E. Weber ¹University of Manitoba, ²University of Aarhus</p>
30	<p>Investigating DPG sensitivity as an adaptive attribute for fossorial life in mole hemoglobins Enquête sur la sensibilité au DGP de l'hémoglobine en tant qu'attribut adaptatif à la vie fouisseuse de la taupe ¹Michael J. Gaudry, ²Roy E. Weber and ¹Kevin L. Campbell ¹University of Manitoba, ²University of Aarhus</p>
31	<p>Atypical molecular evolution of the laurasiatherian β-globin family: implications for oxygen delivery? L'évolution moléculaire atypique de la famille β-globine de laurasiatherias: implications pour la livraison d'oxygène Michael J. Gaudry and Kevin L. Campbell <i>University of Manitoba</i></p>
32	<p>The acute effects of adenosine on breathing in amphibians Les effets aigus de l'adénosine sur la respiration des amphibiens Joseph Chau and Stephen Reid <i>University of Toronto Scarborough</i></p>

33	<p>Cold lungs, warm heart? Temperature effects on the oxygen-hemoglobin dissociation curve of bar-headed geese</p> <p>Poumons froids, cœur chaud? Les effets de la température sur la courbe de dissociation hémoglobine-oxygène de l'oie à tête barrée</p> <p>Jessica Meir and Bill Milsom</p> <p><i>University of British Columbia</i></p>
34	<p>Recombinant interleukin-1β dilates steelhead trout coronary microvessels</p> <p>L'interleukin-1β recombinante dilate les micro-vaisseaux coronariens de la truite arc-en-ciel</p> <p>¹Isabel Costa, ²Travis Hein, ³Chris Secombes and ¹Kurt Gamperl</p> <p>¹Memorial University of Newfoundland, ²Texas A&M Health Science Center, ³University of Aberdeen</p>
35	<p>Cuttlefish: a new model to study protein metabolism</p> <p>La seiche: un nouveau modèle pour étudier le métabolisme des protéines</p> <p>¹Delphine Ditlecadet, ¹Simon Lamarre, ²David McKenzie, ³Laure Bonnaud and ¹William R. Driedzic</p> <p>¹Memorial University of Newfoundland, ²Station Méditerranéenne de l'Environnement Littoral (CNRS), ³Muséum d'histoires naturelles</p>
36	<p>Hybridization in sunfish influences the muscle metabolic phenotype</p> <p>Hybridation dans le crapet influence le phénotype métabolique des muscles</p> <p>Kate E. Mathers, R. Davies, A.D. Hume, K. Bremer, Y. Wang and C.D. Moyes</p> <p><i>Queen's University</i></p>
37	<p>Changes in body composition and the metabolic response to water loss during short duration flights in the American Robin (<i>Turdus migratorius</i>)</p> <p>Changements dans la composition du corps et la réponse métabolique à la perte d'eau lors de vols de courte durée chez les merles d'Amérique (<i>Turdus migratorius</i>)</p> <p>Alexander Gerson and C.G. Guglielmo</p> <p><i>University of Western Ontario</i></p>
38	<p>MicroRNAs: A «Cool» Family of Ribonucleic Acids</p> <p>MicroARNs: Des molécules d'acides nucléiques qui ne laissent personne de glace</p> <p>Lynn Courteau, Pierre Lyons, Pier Jr Morin</p> <p><i>Université de Moncton</i></p>
39	<p>Effects of feeding status on mRNA expression in rectal gland of the spiny dogfish shark (<i>Squalus acanthias</i>)</p> <p>Les effets du statu alimentaire sur l'expression d'ARNm dans les glandes rectales de l'aiguillat commun (<i>Squalus acanthias</i>)</p> <p>¹Courtney Deck, ²Sheldon McKay, ³Tristan Fiedler, ¹Christophe LeMoine, ⁴Chris Wood and ¹Patrick Walsh</p> <p>¹University of Ottawa, ²Cold Spring Harbor Laboratory, ³Florida Institute of Technology, ⁴McMaster University</p>
40	<p>What factors influence intraspecific variation in metabolic rate in zebrafish, <i>Danio rerio</i>?</p> <p>Quels sont les facteurs qui influencent la variation intraspécifique en terme du taux métabolique du poisson zèbre, <i>Danio rerio</i>?</p> <p>Joshua D'Silva and Kathleen Gilmour</p> <p><i>University of Ottawa</i></p>

41	<p>Does the ancient Atlantic hagfish (<i>Myxine glutinosa</i>) induce heat shock proteins? Est-ce que le poisson ancien, la myxine de l'Atlantique (<i>Myxine glutinosa</i>) induit des protéines de choc thermique?</p> <p>Susan Rogers, Sacha LeBlanc and Suzie Currie <i>Mount Allison University</i></p>
42	<p>Are mummichog (<i>Fundulus heteroclitus</i>) more susceptible to sewage effluent when exposed under different environmental conditions? Est-ce que les choquemorts (<i>Fundulus heteroclitus</i>) sont plus susceptibles aux effluents d'eaux usées lorsqu'ils sont exposés à différentes conditions environnementales?</p> <p>¹Melanie Gallant, ¹Kavish Chandra, ²Thijs Bosker, ³Deborah MacLatchy and ¹Suzie Currie ¹Mount Allison University, ²University of New Brunswick, Saint John, ³Wilfrid Laurier University</p>
43	<p>Progesterone action in the fathead minnow testis L'action de la progestérone dans les testicules de tête-de-boule</p> <p>Chris Martyniuk and Yasmin Chishti <i>University of New Brunswick, Saint John</i></p>
44	<p>Support vector machine classification of linuron as an androgen or anti-androgen. La classification par machine à vecteurs de support du linuron en tant qu'un androgène ou un anti-androgène</p> <p>¹Andrew Cowie, ¹Anna Ornostay, ¹Matthew Hindle, ¹Christopher Baker and ^{1,2}Christopher J. Martyniuk ¹University of New Brunswick, ²Canadian Rivers Institute</p>
45	<p>Transcriptomics profiling of Queen conch in environments with high tributyltin in the British Virgin Islands Profilage transcriptomique du strombe géant dans les environnements avec des niveaux de tributylétain élevés des îles Vierges britanniques</p> <p>¹C.P.H. Titley-O'Neal, ²D.J. Spade, ³Y. Zhang, ⁴R. Kan, ⁴C.J. Martyniuk, ⁵N.D. Denslow and ⁴B. MacDonald ¹Lavitty Community College, ²Brown University, ³University of Florida, ⁴University of New Brunswick Saint John, ⁵University of Florida</p>
46	<p>The effects of salinity on the acute copper toxicity to the mysid shrimp (<i>Mysidopsis bahia</i>) Les effets de la salinité sur la toxicité aiguë au cuivre chez la crevette de mysid (<i>Mysidopsis bahia</i>)</p> <p>Rabia Nasir, Jessie Cunningham and James McGeer <i>Wilfrid Laurier University</i></p>
47	<p>Effect of temperature stress on copper-induced mitochondrial dysfunction in rainbow trout, <i>Oncorhynchus mykiss</i> Les effets du stress thermique sur la dysfonction mitochondriale induite par le cuivre chez la truite arc-en-ciel (<i>Oncorhynchus mykiss</i>)</p> <p>Ravinder Sappal, Mark Fast, Don Stevens and Collins Kamunde <i>University of Prince Edward Island</i></p>
48	<p>The impact of waterborne FLX concentrations on the stress axis in zebrafish, <i>Danio rerio</i> Les effets de la fluoxétine dissoute dans l'eau sur l'axe de stress du poisson zèbre, <i>Danio rerio</i></p> <p>Marilyn Vera Chang and Thomas Moon <i>University of Ottawa</i></p>

49	Effects of nanoparticles on zebrafish hatch under natural conditions Les effets des nanoparticules sur l'éclosion de poisson zèbre sous conditions naturelles Kimberly Ong, Rhett Clark, Jonathan Veinot and Greg Goss <i>University of Alberta</i>
50	Silver (nano and ionic) toxicity in zebrafish (<i>Danio rerio</i>) embryos and rainbow trout (<i>Oncorhynchus mykiss</i>) hepatocytes Toxicité à l'argent (nano et ionique) dans des embryons de poissons zèbre (<i>Danio rerio</i>) et dans des hépatocytes de truites arc-en-ciel (<i>Oncorhynchus mykiss</i>) Andrey Massarsky, Vance Trudeau and Thomas Moon <i>University of Ottawa</i>
51	Anesthetic activity of the essential oil of <i>Aloysia triphylla</i> (L'Hér.) Britton in <i>Rhamdia quelen</i>. L'activité anesthésique de l'huile essentielle de <i>Aloysia triphylla</i> (L'Hér.) Britton chez <i>Rhamdia quelen</i> T.V. Parodi, L.L. Silva, C. Zeppenfeld, L.T. Gressler, B.M. Heinzmann and B. Baldisserotto <i>Universidade Federal de Santa Maria</i>
52	Environmental stress triggers individual variability in Collagenase 3 accumulation in Zebrafish embryos Le stress environnemental déclenche la variabilité individuelle de l'accumulation de la collagénase 3 dans les embryons de poissons zèbre Christopher Small and Bryan Crawford <i>University of New Brunswick</i>
53	Epigenetics and metamorphosis: A preliminary comparison of histone modifications in larvae and adults of <i>Polydora cornuta</i> (Annelida) L'épigénétique et la métamorphose: une comparaison préliminaire des modifications d'histones dans les larves et adultes de <i>Polydora cornuta</i> (Annelida) Robyn Pierce, Corban Hart and Glenys Gibson <i>Acadia University</i>
54	Epigenetics and developmental plasticity in <i>Polydora cornuta</i> (Annelida): a link between environment and phenotype L'épigénétique et la plasticité développementale chez <i>Polydora cornuta</i> (Annelida): un lien entre l'environnement et le phénotype ¹ Corban Hart, ² Vett Lloyd, ¹ Glenys Gibson ¹ Acadia University, ² Mount Allison University
55	The American lobster's (<i>Homarus americanus</i>) stress response to live holding and shipping conditions La réponse au stress causé par les conditions de garde vivante et d'expédition chez le homard américain (<i>Homarus americanus</i>) ¹ Adam R. Acorn, ¹ K. Fraser Clark, ² John Garland and ¹ Spencer J. Greenwood ¹ University of Prince Edward Island, ² Clearwater Seafoods Ltd.
56	Acid-base regulatory patterns in the gills of the green crab, <i>Carcinus maenas</i> Les modes de régulation acido-basiques dans les branchies du crabe vert, <i>Carcinus maenas</i> Sandra Fehsenfeld and Dirk Weihrauch <i>University of Manitoba</i>

57	<p>Calcium homeostasis in <i>Daphnia magna</i> embryogenesis L'homéostasie du calcium dans l'embryogénèse de <i>Daphnia magna</i> Jamie-Lee Giardini and Andreas Heyland <i>University of Guelph</i></p>
58	<p>Novel functions of small heat shock proteins during diapause of <i>Artemia franciscana</i> Des nouvelles fonctions pour les petites protéines de choc thermique au cours de la diapause d'<i>Artemia franciscana</i> Allison King and Thomas MacRae <i>Dalhousie University</i></p>
59	<p>Distribution of putative oxygen-sensing neuroepithelial cells in fish gills Distribution des cellules neuroépithéliales de détection d'oxygène putatives dans les branchies de poissons Y. Judy Kim, Deidre L. Brink, William Milsom <i>University of British Columbia</i></p>
60	<p>Informing hypotheses about the dispersal of the amphipod <i>Corophium volutator</i> Informer des hypothèses sur la dispersion de l'amphipode <i>Corophium volutator</i> ¹Trevor Bringloe, ²David Drolet, ¹Myriam Barbeau, ³Mark Forbes and ¹Travis Gerwing ¹University of New Brunswick, ²Mount Allison University, ³Carleton University</p>
61	<p>Burrow behaviour of the mudflat amphipod, <i>Corophium volutator</i> Comportement de fabrication de terriers de l'amphipode de la vasière, <i>Corophium volutator</i> Stephanie MacNeil and Myriam Barbeau <i>University of New Brunswick</i></p>
62	<p>Temperature preference and trade-off behaviour of juvenile American lobster <i>Homarus americanus</i> in cold environments. Température préférentielle et le comportement de compromis du homard américain <i>Homarus americanus</i> juvénile dans des environnements froids Travis Nielsen and Iain McGaw <i>Memorial University of Newfoundland</i></p>
63	<p>Comparison of two measurements of depth to the redox potential discontinuity in intertidal mudflat sediments Comparaison de deux mesures de la profondeur à la discontinuité du potentiel redox dans les sédiments des vasières d'estrans ¹Travis G. Gerwing, ¹Alyssa M. Allen, ²David Drolet, ²Diana J. Hamilton and ¹Myriam A. Barbeau ¹University of New Brunswick, ²Mount Allison University</p>
64	<p>Dynamics of plants and salt panne animals in restored salt marshes in the Bay of Fundy Dynamique des plantes et des animaux des sebkhas dans les marais salés restaurés de la baie de Fundy ¹Cody Alderson, ¹Laura Bursey, ¹Myriam Barbeau, ¹Dylan Schneider, ²Wade Lewis and ²Nic McLellan ¹University of New Brunswick, ²Ducks Unlimited Canada</p>
65	<p>Observations on the infectivity and development of <i>Nosema apis</i>, a bee microsporidian, on fish cell lines Observations sur la capacité d'infection et le développement de <i>Nosema apis</i>, une microsporidie d'abeille, sur les lignés cellulaires de poisson ¹Alina Reid, ¹Richelle Monaghan, ²Niels Bols and ¹Lucy E.J. Lee ¹Wilfrid Laurier University, ²University of Waterloo</p>

66	<p>Nurse egg formation and apoptosis in a spionid annelid (<i>Polydora cornuta</i>) Formation d'œufs nourriciers et apoptose chez les polychètes spionides (<i>Polydora cornuta</i>) Glenys Gibson, Corban Hart, Claire Coulter and Haixin Xu <i>Acadia University</i></p>
67	<p>Mandibular ossification and symphysis development in two teleosts with different feeding strategies Ossification mandibulaire et développement de symphyse dans deux téléostéens avec différentes stratégies alimentaires ¹Jade Atkins, ²Brittni Milligan and ²Tamara A. Franz-Odenaal ¹Dalhousie University, ²Mount Saint Vincent University</p>
68	<p>Morphometric differences of shortnose sturgeon and Atlantic sturgeon larvae during early ontogeny Différences morphométriques entre les larves des esturgeons à museau court et des esturgeons de l'Atlantique tôt dans l'ontogénie Andrew Taylor, S. Usvyatsov and M.K. Litvak <i>Mount Allison University</i></p>
69	<p>Assessing shape change of cartilage in the first and second pharyngeal arches in larval zebrafish, <i>Danio rerio</i> Évaluer le changement de forme du cartilage dans les premiers et deuxièmes arcs branchiaux chez le poisson zèbre <i>Danio rerio</i> ¹Zoe Kennedy, ¹Megan Dufton and ²Tamara Franz-Odenaal ¹Dalhousie University, ²Mount Saint Vincent University</p>
70	<p>Staining methods for the study of fish fin morphology utilizing microCT scanning Méthodes de coloration pour l'étude de la morphologie des nageoires des poissons en utilisant le balayage par microCT Trina Y. Du, Benjamin Wilhelm, Rui Tahara and Emily M. Standen <i>McGill University</i></p>
71	<p>Investigating the developmental morphogenesis of the zebrafish (<i>Danio rerio</i>) infraorbital bones. Enquête sur le développement morphogénique des os infraorbitaux chez le poisson zèbre (<i>Danio rerio</i>) Carolyn Chang and Tamara A. Franz-Odenaal <i>Saint Mary's University, Mount Saint Vincent University</i></p>
72	<p>MicroCT contrast enhancement of soft tissues in avian embryos Une augmentation de contraste par micro CT des tissus mous des embryons aviaires Rui Tahara and Hans C.E. Larsson <i>McGill University</i></p>
73	<p>Building bone from the ground substance up: extracellular matrix production and cell arrangement in early intramembranous condensations Construction d'os à partir de substances fondamentales: production de la matrice extracellulaire et arrangement cellulaire lors de la condensation intramembranaire initiale James Jabalee and Tamara Franz-Odenaal <i>Mount Saint Vincent University</i></p>
74	<p>Two unique events in chiton reproduction Deux événements uniques dans la reproduction des chitons John Buckland-Nicks <i>St Francis Xavier University</i></p>

ABSTRACTS / RÉSUMÉS

The American lobster's (*Homarus americanus*) stress response to live holding and shipping conditions La réponse au stress causé par les conditions de garde vivante et d'expédition chez le homard américain (*Homarus americanus*)

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The American lobster (*Homarus americanus*) fishery in Atlantic Canada is the most economically important commercial fishery in Canada where the annual landed value exceeds \$600 million. A live lobster demands a premium price but it will face many stressors during its journey from ocean to plate. While in live storage, it is routine for companies to suffer losses of 5-15% due to mortality. This study examined the types of physiological stress that a lobster faces while in storage, with the goal of improving the efficiency of storage and increasing the value to all levels of the fishery. This project uses a novel lobster microarray to monitor gene expression as a means of determining the genetic mediators of a lobster's stress response. We have found that many interesting metabolic and stress genes are differentially regulated during live-storage and shipping including: two PEPCK isoforms, GBH, IDH, tetratricopeptide 36 and modifier of mdg4.

How to make a zombie brain: Host manipulation by the parasitic wasp, *Cotesia congregata*

Manipulation de l'hôte par la hyménoptère parasite, *Cotesia congregata*

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The larvae of the parasitic wasp *Cotesia congregata* develop inside the body of their host, the caterpillar *Manduca sexta*. Once the wasps are ready to emerge from the host, the caterpillar stops feeding and moving. This change in host behaviour benefits the wasps. The parasitic wasps shut down host feeding and manipulate other behaviours using multiple mechanisms. First, they induce a large increase in the neurohormone octopamine, which depresses feeding. Second, the wasp larvae induce a cytokine storm. During emergence, the wasps activate a massive immune response that suppresses feeding and locomotion.

Ammonia excretion in the soil nematode *Caenorhabditis elegans* occurs via ammonia trapping across the hypodermis

L'excrétion d'ammoniac chez le nématode de terre *Caenorhabditis elegans* se produit par piégeage de l'ammoniac à travers l'hypoderme

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University of Manitoba

Generally, aquatic invertebrates excrete their nitrogenous wastes products in form of ammonia, whereas non-aquatic animals excrete, due to water constraints, urea or uric acid. When maintained in liquid media (unbuffered, pH 7.0), the soil nematode *Caenorhabditis elegans* appears to be ammonotelic, excreting $0.267 \mu\text{mol}\cdot\text{gFW}^{-1}\cdot\text{h}^{-1}$ ammonia and $0.096 \mu\text{mol}\cdot\text{gFW}^{-1}\cdot\text{h}^{-1}$ urea. Ammonia excretion depended on an acidification of the unstirred boundary layer (subcuticular space?), since buffering the media (phosphate buffer, pH 7) caused a 49% reduction in ammonia excretion rates. Moreover, media buffered to a pH of 5.5 and 9.5 caused a significant increase and decrease in excretion rates, respectively. Inhibitor experiments revealed further the participation of a H^+ -ATPase, carbonic anhydrase, and Na^+/K^+ -ATPase in the ammonia excretion mechanism. The obtained results suggest that the mode of ammonia excretion in this soil dwelling organism is similar to mechanisms proposed for branchial ammonia excretion in freshwater fish and epidermal ammonia excretion in freshwater planarians and leeches.

Effect of cold acclimation on troponin I isoform expression in striated muscle of rainbow trout

Les effets de l'acclimatation au froid sur l'expression de l'isoforme troponine 1 dans le muscle strié de la truite arc-en-ciel

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The purpose of this study was to characterize which troponin I (TnI) genes and protein isoforms are expressed in the different muscle types of rainbow trout, *Oncorhynchus mykiss*, and determine if isoform expression changes in response to cold acclimation. Semi-quantitative real-time PCR was used to characterize the expression of seven different TnI genes. Gel electrophoresis and tandem mass spectrometry was used to identify the TnI protein isoforms expressed in each muscle type. The results indicate that although each striated muscle type expresses the genes for all seven TnI isoforms, there are differences in the expression pattern of these genes between muscle types and in response to cold acclimation. The proteomics analysis demonstrates that each muscle type contains at least three different TnI isoforms. This study underscores the complex molecular composition of teleost striated muscle and suggests there is an adaptive value to the unique TnI profiles of each muscle type.

Dynamics of plants and salt panne animals in restored salt marshes in the Bay of Fundy

Dynamique des plantes et des animaux des sebkhas dans les marais salés restaurés de la baie de Fundy

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There currently is interest in restoring coastal land to salt marshes, given their many ecosystem services. A salt marsh restoration project was initiated in 2010 at Fort Beausejour, New Brunswick. Two cells of farmland (impacted sites) and two established salt marshes (reference sites) were monitored before and 1-year post breaching the dikes (the impact). Densities of plants and invertebrates were quantified using quadrat sampling, and densities of salt panne animals using activity traps, minnow traps and lift net sampling. Mudflat developed after the breaches in fall 2010 in the impacted sites. By mid-summer 2011, *Spartina pectinata* was spreading through the sites and seed-dispersing halophytic plants (e.g. *Suaeda*) started to colonize. Newly created salt pannes became inhabited by small fish (mummichugs) and amphipods (*Gammarus*, *Corophium*). Taxa richness in the developing marshes was ~ half of that in established marshes. The restoration process from previously diked farmland to salt marsh is underway.

DNA methylation and its role in distinguishing soldier and worker caste development in *Camponotus Floridanus*

La méthylation de l'ADN et son rôle de distinction entre les castes de soldats et de travailleurs dans le développement de *Camponotus floridanus*

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Carpenter ants share near-identical genotypes between individuals within the same colony, yet are capable of establishing polyphenic worker, queen, and soldier castes in their females. Unique transcriptional programs in growth, wing disc and reproduction establish developmental constraints that give rise to different castes independent of genetic determinants. DNA methylation is a reversible epigenetic modification that can regulate transcriptional and splicing events at CpG dinucleotides. We investigated the role DNA methylation plays in the development and caste determination of *Camponotus* workers and soldiers. Global methylation was shown to increase throughout larval development with workers being more methylated than soldiers. Expression differences of known methylation regulators showed marked changes between worker and soldier castes and developmental differences between instars. In addition, EGFR and Chico variants showed caste specific expression and methylation differences. Taken together, the data demonstrates that DNA methylation correlates with a functional role of caste determination in *Camponotus Floridanus*.

Feeding behavior and intestinal helminth communities of Ring-billed Gulls (*Larus delawarensis*) from the St. Lawrence River

Le comportement alimentaire et les communautés intestinales d'helminthes chez le goéland à bec cerclé (*Larus delawarensis*) du fleuve St-Laurent

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Among individual birds in the same population, parasite communities are often highly variable. This can be explained by variation in feeding specialization among individuals, but few studies have tested this idea. Ring-billed gulls (*Larus delawarensis*) are opportunistic omnivores. Little is known about the link between individual feeding specialization in gulls (or other Larids) and helminth communities. We investigated the relationships between habitat use, feeding ecology and intestinal helminth communities in adult gulls. Miniature dataloggers were used to monitor movements of nesting gulls from a large colony in the St. Lawrence River near Montreal for 48 hours, providing a spatial picture of recent feeding habits. We recorded wet and dry weights of each food item category found in their stomachs (corn, insect, debris and plant material). Finally, trophically-transmitted intestinal helminths were counted and identified to genus, and the prey items implied by each were determined from the parasitological literature.

Mandibular ossification and symphysis development in two teleosts with different feeding strategies

Ossification mandibulaire et développement de symphyses dans deux téléostéens avec différentes stratégies alimentaires

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Jaws are an important adaptation of gnathostomes because it allowed for active feeding strategies and a more varied diet. While there has been much research into the molecular processes behind lower jaw development, particularly in mutants, a fine-scale growth series of normal development has not been attempted. This study describes mandibular ossification and symphysis development during the first weeks of development. Zebrafish (*Danio rerio*) and Mexican tetra (*Astyanax mexicanus*) were examined using an acid-free double-stain between 3.5 and 7.0 mm standard length (SL), and 4.5 and 8.0 mm SL, respectively. Histological analyses were also conducted on zebrafish. Results in zebrafish show that ossification is well underway by 4.5 mm SL, Meckel's cartilage begins to retract by 5 mm SL, and ossification occurs around the mandibular symphysis by 5.5 mm SL. It is expected this data set will form a representative fine-scale growth series of the lower jaw. Funded by NSERC.

Scale and tooth phenotypes in medaka with mutated ectodysplasin-A receptor: implication in evolutionary origin of oral and pharyngeal teeth

Phénotype des écailles et des dents chez le médaka avec un récepteur ectodysplasin-A muté: implications pour l'origine évolutive des dents orales et pharyngées

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Ectodermal contribution to induction of pharyngeal teeth that form in endodermal territory of the oropharyngeal cavity in some teleost fishes has been a matter of considerable debate. To find out the role of ectodermal cell signaling in scale and tooth formation and thereby to gain insights in evolutionary origin of teeth, we analyzed scales and teeth in rs-3 medaka mutant characterized by reduced scale numbers due to aberrant splicing of ectodysplasin-A receptor. Drastic loss of teeth was observed in both oral and pharyngeal dentitions in rs-3. In wild-type medaka embryos, there was a direct contact between the surface ectoderm and rostral endoderm in pharyngeal regions before onset of pharyngeal tooth formation. There was no sign of ectodermal cell migration in pharyngeal endoderm. These data suggest differential roles of Eda-Edar signaling in the induction and growth of scales and teeth, and support intrinsic odontogenic competence of the rostral endoderm in medaka

Captive rearing of piping plovers in Atlantic Canada

L'élevage en captivité du pluvier siffleur au Canada atlantique

Deborah Austin and Kendra MacDonald

Parks Canada, Wildlife Preservation Canada

Despite intense recovery efforts, Piping Plovers (*Charadrius melodus*) remain a management dependent species. As one component of a Parks Canada multi-year project to revitalize conservation efforts of the Eastern population, a research project to captive rear Piping Plovers was carried out. Eggs were collected from abandoned nests and incubated at the Magnetic Hill Zoo. After hatching, chicks were reared in brood boxes at the zoo. They were then transported to an outdoor flight pen in their native National Park. Once able to fly and feed independently, they were released into the wild. In 2011, the project was implemented in Kouchibouguac National Park and 5 chicks were successfully released. This represented the second year captive rearing was attempted and allowed for the refinement of the 2010 protocols. This initiative resulted in the development of an effective protocol and an understanding of the opportunities and challenges associated with captive rearing this species.

Changes in expression of appetite-regulating hormones in the cunner (*Tautoglabrus adspersus*) during short-term fasting and torpor

Variation de l'expression génique d'hormones contrôlant la prise alimentaire chez la tanche-tautogue (*Tautoglabrus adspersus*) pendant les périodes de jeûne et de torpeur

Nicole Babichuk and Helene Volkoff

Memorial University

Feeding in vertebrates is controlled by a number of appetite stimulating (orexigenic) and appetite suppressing (anorexigenic) hormones, whose levels increase and decrease following fasting, respectively. Cunnners (*Tautoglabrus adspersus*) survive the winter in shallow costal waters by entering a torpor-like state, during which they remain inactive and undergo prolonged fasting. In order to better understand the mechanisms regulating appetite/fasting in these fish, quantitative real-time PCR was used to measure transcript expression levels of three appetite-regulating hormones, cholecystokinin (CCK) in the gut, and neuropeptide Y (NPY) and orexin in the forebrain (hypothalamus and telencephalon) of fed, short-term fasted and long-term fasted (torpor) cunnners. Our results show that while brain NPY mRNA expression levels change very little, brain orexin mRNA levels increase and CCK gut mRNA expression levels decrease during torpor and fasting, suggesting that both orexin and CCK regulate feeding in cunnners. Funded by NSERC.

A third way: spermcapture mating in barnacles

Une troisième façon: la capture de sperme en tant que mode de reproduction chez les cirripèdes

Marjan Barazandeh, Corey S. Davis, Christopher J. Neufeld, David W. Coltman and A. Richard Palmer

University of Alberta

Most free-living barnacles are hermaphroditic and eggs are presumed to be fertilized by pseudo-copulation or self-fertilization. The Pacific gooseneck barnacle, *Pollicipes polymerus*, is believed to be a mandatory cross-fertilizer. Nonetheless, some isolated *P. polymerus*, well outside the range a penis could reach, have fertilized egg-masses. They must therefore either self-fertilize or obtain sperm from the water. This latter possibility has never been considered in barnacles. However our genetic evidence from 16 single nucleotide polymorphisms (SNP) confirms that isolated *P. polymerus* can capture sperm from the water. All 37 embryo masses tested had at least one locus with a non-parent allele, and 36 had non-parent alleles at two or more loci. Remarkably, even in isolated pairs bearing egg masses (individuals adjacent to one neighbor but multiple body lengths from others), individuals still obtained some sperm from the water. Moreover, preliminary evidence further suggests that spermcapture mating also happens in acorn barnacles.

The effect of cold and anaerobic conditions on northern killifish

Effet du froid et conditions anaérobiques sur le choquemort nordique.

Katelyn Barnes, Hannah Buhariwalla, Regina Cozzi and Bill Marshall

St Francis Xavier University

Chloride cells in the opercular epithelia (OE) of the euryhaline, euryoxic, and eurythermic killifish (*Fundulus heteroclitus*) actively secrete chloride, an energetic process that can be easily measured electrophysiologically as short circuit current (Isc). In this experiment, the response of Isc to decreasing temperature from 30°C to 0.2°C was measured in OE from warm (20°C) and cold (5°C) acclimated fish in aerobic (99% O₂ sat.) and anaerobic (NaCN 0.5mM; N₂ sat.) conditions. We found that the chloride transport in warm acclimated fish was supported mostly (75%) by aerobic metabolism, whereas that of cold acclimated fish was instead more anaerobic. There is a critical temperature, 8°C, below which aerobic Isc drops sharply, suggesting a shift in efficiency in oxidative phosphorylation. From this it was determined that, once acclimated to cold, chloride cells are incapable of increasing their aerobic ATP supply, even when warmed to 30°C. The large aerobic scope of warm acclimated fish favors active foraging at high temperatures, while the low aerobic scope of cold acclimated fish is appropriate to low metabolic levels, anaerobiosis and inactivity.

Comparative biology of phagocytic antimicrobial responses

Biologie comparée des réponses antimicrobiennes phagocytaires

Daniel R. Barreda

University of Alberta

Activation of phagocytic responses provides a potent evolutionarily conserved strategy for the destruction of invading pathogens. However, phagocytes entering a site of infection encounter pathogens and dying apoptotic host cells, which serve as pro-inflammatory and anti-inflammatory signals, respectively. In mammals, these stimuli activate divergent signaling programs that are central to the induction and resolution of inflammation. Murine and teleost fish *in vivo* and *in vitro* models were used to assess the evolutionary conservation of this inflammation control axis at an inflammatory site. Differences in the rate of leukocyte migration to the site of inflammation, the identity of infiltrating leukocytes and the kinetics and strength of the antimicrobial response between teleosts and mammals highlight significant honing of inflammation control mechanisms across evolution. Despite the many benefits, ongoing evolutionary honing may also contribute to some of the disease states associated with deviations in the control of inflammation.

Microarray analysis of American lobster larvae (*Homarus americanus*) exposed to endosulfan during metamorphosis

L'analyse des microréseaux des larves de homard américain (*Homarus americanus*) exposés à l'endosulfan pendant la métamorphose

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Agricultural runoff on Prince Edward Island is suspected to be contributing to fish kills in nearby rivers and streams. Endosulfan is a commonly used agricultural pesticide used to combat the Colorado potato beetle; however it poses a threat to non-target organisms in marine and freshwater environments. Endosulfan is an organochlorine pesticide that has been classified as a persistent organic pollutant (POP) and acts as a moult inhibiting agent in crustaceans. The current research project focuses on the effect of environmentally relevant concentrations of endosulfan on American lobster larvae (*Homarus americanus*) during the critical developmental stage of metamorphosis. Microarray analysis was used to detect changes in genes expression between each concentration and to identify pathways being affected by endosulfan exposure. The results of this study have identified the effects of endosulfan on lobster larvae survival as well as identified specific genes that are significantly different during endosulfan exposure.

Impact of cyclic feeding on growth-related traits, fat deposition and the transcriptional regulation of appetite and lipid metabolism in rainbow trout

L'impact de l'alimentation cyclique sur les traits liés à la croissance, sur les dépôts de graisse et sur la régulation transcriptionnelle de l'appétit et du métabolisme des lipides chez la truite arc-en-ciel

Nick Bernier, Cameron Richardson, Riley Magee, Moira Ferguson and Roy Danzmann

University of Guelph

Although cyclic feeding regimes can have marked effects on growth and body composition, the mechanisms mediating these changes are poorly understood. In this study, rainbow trout were raised from 4 to 18 months of age on a control diet or cyclic feeding regime where reduced and compensatory diets were altered. Overall, cyclic feeding fish had a lower body weight, and lower dorsal epaxial and coelomic fat content. However, as proportions of total weight, viscera and liver weights were higher after compensatory ration in cyclic feeding fish than in controls. Also, the expression of appetite-regulating genes showed little to no difference between treatments, but cyclic feeding resulted in marked changes in the expression of genes involved in liver fatty acid synthesis and muscle lipid uptake. These results suggest that cyclic feeding is associated with limited changes in the regulation of food intake but dynamic adjustments in lipid metabolism and digestive capacity.

Early hypoxia exposure alters red blood cell morphology and the Bohr/Root effect in rainbow trout, *Oncorhynchus mykiss*

L'exposition précoce à l'hypoxie altère la morphologie des globules rouges et l'effet Bohr/Root de la truite arc-en-ciel, *Oncorhynchus mykiss*

Kristin Bianchini and Patricia A. Wright

University of Guelph

Two hemoglobin polymorphs, embryonic and adult, are present during rainbow trout development. Embryonic hemoglobin, which is found in erythrocytes that are more round and have a less conspicuous nucleus than adult erythrocytes, has a higher oxygen affinity and lacks the Bohr and Root effects observed in the adult form (Iuchi 1973, 1973B). We predicted that under chronic hypoxia, oxygen uptake would be facilitated by retaining embryonic hemoglobin into later developmental stages. Under chronic hypoxia (30% of saturation), hemoglobin-oxygen affinity was unaffected at low CO₂, while the Bohr and Root shifts were more pronounced. Erythrocytes from hypoxic embryos had a significantly larger surface area and lacked the normal switch to the adult erythrocyte morphology observed in normoxia. We thus conclude that the hypoxia response of rainbow trout embryos involves a delay in hemoglobin turnover to the adult isoform and an increase in hemoglobin's ability to unload oxygen at the tissues.

Investigating the relationships between γ -amino-butyric acid and estrogen in the fathead minnow (*Pimephales promelas*) ovary

Enquête sur la relation entre l'acide γ -amino butyrique et l'œstrogène dans l'ovaire du tête-de-boule (*Pimephales promelas*)

Katie Biggs and Christopher J Martyniuk

University of New Brunswick

γ -amino-butyric acid (GABA) is the major inhibitory neurotransmitter found in the central nervous system. GABA receptors and metabolic enzymes have also been localized to the peripheral nervous system, including the oviduct, uterus and ovary of mammals. The objectives of this study were to (1) localize the presence of mRNA encoding GABA synthesizing and degradation enzymes in the ovaries of fathead minnows (*Pimephales promelas*) (FHM), (2) examine the effects of GABA on ovarian estrogen (E2) production, and (3) determine the response of GABA metabolic enzymes and steroid-related genes to GABA. Ovary explants from reproductive female FHM (GSI = 10.1%) were incubated in GABA (10⁻¹⁰, 10⁻⁸ and 10⁻⁶M) for 12h. PCR revealed that mRNAs for GABA metabolic enzymes were localized in the FHM ovaries. GABA had no significant effects on E2 production at any concentration. Gene expression analysis will be discussed. This study improves our understanding of GABA action in FHM ovaries.

Towards a theory of settlement and metamorphosis, as it relates to signaling systems and habitat selection.

Vers une théorie de la fixation et la métamorphose, en ce qui concerne les systèmes de signalisation et de sélection de l'habitat.

Cory Bishop

St. Francis Xavier University

Settlement and metamorphosis among marine invertebrates represent a natural interface between ecology, development and evolution. Several endogenous regulators of the timing of metamorphosis have been discovered, but there is no theory of metamorphosis that predicts how specific signaling systems conspire to produce adaptive settlement and metamorphosis behaviours. For example, under what conditions should a larva defer suboptimal habitat and risk a continued search for superior habitat? In this theoretical exercise I will attempt to place the current state of knowledge about signaling systems that control the timing of metamorphosis in an ecological and evolutionary context.

Probing the role of ASIC in rainbow trout gill MR cells using cell imaging

Sondage du rôle du canal ionique de détection d'acide dans les cellules riches en mitochondries des branchies de truites arc-en-ciel en se servant d'imagerie cellulaire

Salvatore Blair, Agnieszka Dymowska, Aaron Schultz and Greg Goss

University of Alberta

In freshwater fish gills, considerable debate regarding the explicit mechanism behind Na^+ uptake has produced conflicting models since the 1930s. Our lab utilizes a technique to isolate rainbow trout gill mitochondrion-rich (MR) cells and intracellular pH (pH_i) imaging to investigate the nature of active transporters on those cells. A previous report demonstrated phenamil-sensitive blockade of Na^+ induced acidification (Parks et al, 2007) suggesting a role for a phenamil-sensitive Na^+ channel in PNA- MR cells. Our lab has recently identified the acid sensing ion channel (ASIC) as a potential Na^+ transport mechanism in the gill of trout and demonstrated a dose response inhibition of whole animal Na^+ uptake by the drug DAPI and Diaminazine. This study is aimed at further investigating the role of ASIC in PNA- MR cells of rainbow trout gills using inhibition of acidification as an end readout.

Mechanisms of nickel toxicity using oxidative stress endpoints in the euryhaline teleost *Fundulus heteroclitus*

Les mécanismes de la toxicité au nickel en se servant des points de terminaison du stress oxydatif chez le téléostéen euryhalin *Fundulus heteroclitus*

Tamzin Blewett and Chris Wood

McMaster University

Nickel (Ni) is considered a respiratory toxicant to aquatic organisms, but the exact mechanism by which this process occurs remains unclear. Some evidence suggests that the mechanism of toxicity relates to production of reactive oxygen species (ROS). This study investigated the effects of Ni on the euryhaline killifish (*Fundulus heteroclitus*), as well as possible interactive effects of salinity. Killifish were exposed to sub-lethal levels (5 mg L^{-1}) of waterborne Ni for 24 and 96 h in 0%, 10%, 30% and 100% sea water (35 ppt). For most metals and species, higher salinity is known to be protective against metal uptake and subsequent toxicity. However salinity had no effect on Ni bioaccumulation, and activity of the antioxidant enzyme superoxide dismutase (SOD) increased 2-4 fold regardless of salinity. This work further emphasizes that Ni is an oxidative stressor in fish and that salinity is not protective against oxidative endpoints. (NSERC CRD).

Sequencing a seabird food chain – next generation sequencing of the feces of Atlantic puffin and the stomach contents of their major prey, Atlantic herring

Séquençage d'une chaîne alimentaire d'un oiseau de mer: séquençage de prochaine génération des fèces du macareux moine et du contenu des estomacs de sa proie importante, le hareng de l'Atlantique

Kirsten Bowser, Antony Diamond and Jason Addison

University of New Brunswick

The unprecedented multi-year abandonment of the largest tern (*Sterna* spp.) colony in the Bay of Fundy coincided with a decline in the proportion of juvenile herring (*Clupea harengus*) observed in seabird chick diet. Despite being a keystone species in this ecosystem, juvenile herring diet data is sparse and outdated. As a result, it is difficult to understand how changes at the base of the food web influence herring availability. Since seabird diet is based on observations of the prey items fed to chicks, we do not know what changes, if any, have occurred to adult diet. I use next-generation sequencing of seabird feces and herring stomach contents to elucidate the links between seabird chicks and adults, and their major prey, herring. Creating a seabird food web increases our power to comprehend how and why changes in herring and seabird populations occur.

Cold tolerance physiology of the Willow leaf beetle (*Chrysomela aeneicollis*) is life-stage specific

La physiologie de tolérance au froid est spécifique au stage de vie chez les coléoptères de feuilles de saule (*Chrysomela aeneicollis*)

Evelyn C. Boychuk and Brent J. Sinclair

Western University

Alpine insects are subjected to greater thermal extremes than insects in lowland habitats due to the tendency of air temperature to shift suddenly at higher altitudes. High altitude populations of the willow leaf beetle, *Chrysomela aeneicollis*, in the Sierra Nevada Mountains of California experience over-night cold snaps frequently throughout the year, so we hypothesized that all life stages of *C. aeneicollis* have some cold tolerance capacity. Although cold tolerance has been characterised in many insect species, few studies have looked at the differences in cold tolerance between the life stages of a single species. Cold tolerance of eggs, three larval instars, and both active and quiescent adults was compared using supercooling points, lower lethal temperature and biochemical correlates. Results indicate large differences in the cold tolerance of the life stages of *C. aeneicollis*, with larval stages susceptible to chilling injury during mild cold exposures while the adults are freeze tolerant.

Temperature induced physiological and adaptive responses in the guppy (*Poecilia reticulata*)

Réponses physiologiques et adaptatives induites par la température chez le guppy (*Poecilia reticulata*)

Ross D. Breckels and Bryan D. Neff

Western University

The Intergovernmental Panel on Climate Change predicts an average global temperature increase of 1.4-5.8°C by 2100. Poikilotherms are expected to be particularly sensitive to this temperature change because their physiological processes are dependent upon ambient temperatures. We investigated the acclimatory and evolutionary responses of sperm and immune response traits in guppies (*Poecilia reticulata*) to increased temperatures. Guppies were acclimated to 23°C, 25°C (control), 28°C, or 30°C, while three populations were exposed to 28°C with three controls. Acclimated guppies had shorter, less motile sperm with increasing temperatures, whereas after 6 months, 28°C 'evolved' guppies had longer sperm compared to controls. These data provide evidence that guppies may be able to survive and reproduce in increased temperatures as predicted for 2100. This study provides much needed data on the response of populations to increased temperature and will thereby help in preserving tropical aquatic biodiversity in the face of global warming.

Informing hypotheses about the dispersal of the amphipod *Corophium volutator*

Informer des hypothèses sur la dispersion de l'amphipode *Corophium volutator*

¹Trevor Bringle, ²David Drolet, ¹Myriam Barbeau, ³Mark Forbes and ¹Travis Gerwing

¹University of New Brunswick, ²Mount Allison University, ³Carleton University

Corophium volutator, a dominant macro-invertebrate inhabiting intertidal mudflats in the upper Bay of Fundy, swims in large numbers (up to 12,000 ind. m⁻³) at night around new or full moon, during the summer. Our objective was to inform hypotheses about why *C. volutator* disperses by comparing swimmers with mud resident individuals at nine mudflats. Nets were used to sample swimmers, while mud cores were collected to sample residents (20-28 June, 10-17 July, 2-11 August 2010). We detected important spatial variation in the density of swimmers between sites, and late summer juveniles (<1.5 mm body length) and young females (4-6 mm) were the most active dispersers. Also, dispersal by *C. volutator* was density dependent, but with proportionally less individuals dispersing as total density or biomass of mud residents increased. Our results identified certain stages that might benefit more by dispersing, and future experimental work should focus on these.

Inhibition of mitochondrial succinate oxidation during torpor in hibernating thirteen-lined ground squirrels: potential mechanisms and physiological relevance.

Inhibition de l'oxydation mitochondriale au succinate durant une période de torpeur du spermophile à treize bandes en hibernation: mécanismes potentiels et pertinence physiologique

Jason CL Brown, Dillon J Chung, Alex N Cooper and James F Staples

Western University

Hibernating ground squirrels alternate between torpor (metabolic rate [MR] reduced for weeks) and interbout euthermia (MR increases 10-fold to normal levels for <24 hours). We have previously shown inhibition of mitochondrial succinate oxidation during torpor in liver and skeletal muscle using saturating succinate levels. In the present study, we measured mitochondrial succinate oxidation in both tissues over a range of succinate concentrations. Succinate oxidation inhibition in torpor was observed regardless of succinate concentration, suggesting this inhibition occurs even at physiologically-relevant substrate concentrations. However, the extent of this inhibition declined with succinate concentration, likely reflecting that succinate transport is not inhibited during torpor. In addition, the apparent Michaelis-Menten constant (K_m) for succinate oxidation was lower during torpor in both tissues. This could reflect uncompetitive inhibition of succinate oxidation during torpor, or changes to succinate dehydrogenase that may include post-translational modification or differential isozyme expression between hibernation states, which we will explore.

Urea production in the gut? Adult ammoniotelic teleost fish may not be as ammoniotelic as we thought.

La production d'urée dans les intestins? Les téléostes ammoniotelique adultes ne sont peut-être pas aussi ammonioteliques que nous le pensions.

C Bucking, C.M.R. LeMoine, P.M. Craig and P.J. Walsh

University of Ottawa

Current evidence suggests embryonic teleost may use ureogenesis to prevent ammonia toxicity in the developing embryo. Rarely, adult fish continue to use urea as their main nitrogenous waste product whereas a majority of adult teleost fish silence this pathway to become ammoniotelic, directly excreting ammonia to the environment. However digestion produces ammonia in the gut lumen to potentially toxic levels. We hypothesized that the intestinal tissue may be detoxifying this ammonia load by producing urea in an ammoniotelic fish, the midshipman. The activity of enzymes essential to produce urea (carbamoyl phosphate synthetase III and glutamine synthetase) were measured in fasted and fed midshipman, and the activities of both increased with feeding. Immunohistochemistry and qPCR were used to visualize and quantify several potential transporters involved. These results indicated that adult midshipman may be detoxifying ammonia in the gut during digestion and that while they are ammoniotelic their intestines are not.

Is the salmonid adipose fin a mechanosensory organ?

Est-ce que la nageoire adipeuse des salmonidés est un organe mécano-sensoriel?

¹John Buckland-Nicks, ²Roger Croll, ²Megan Gillis and ³Tom Reimchen

¹St. Francis Xavier University, ²Dalhousie University, ³Victoria University

Salmonid adipose fins have long been regarded as vestigial, without clear function. We examined the adipose fins of juvenile rainbow and brown trout using light and electron microscopy and found that the structure of the fin was quite different than reported. Most importantly our results revealed, for the first time, an extensive neural network linked to a complex of astrocyte-like cells and fibres, providing evidence for a mechanosensory function for the fin. Positive staining with antibodies to neurons, and glial cells supported other evidence of nervous tissue from silver staining and electron microscopy. These results are consistent with Reimchen and Temple's (2004) prediction based on flow-chamber studies that the adipose fin acts as a precaudal flow sensor and that removal can be detrimental to swimming efficiency of juvenile fish. These findings have implications for fisheries aquaculture as adipose fin 'clipping' is a routine marking technique for millions of hatchery-reared fish.

Two unique events in chiton reproduction

Deux événements uniques dans la reproduction des chitons

John Buckland-Nicks

St Francis Xavier University

Serial sections of oogenesis in *Acanthochiton garnoti* revealed that microapocrine secretions form the egg hull. This novel process, observed for the first time in Mollusca, bi-passes the endomembrane system and releases compounds formed in the cytoplasm directly from the cell surface, via budding of 'microaposomes'. Secondly, at fertilization, the sperm creates a minute pore in the egg hull that allows injection of DNA but blocks entry of sperm organelles. Serial sections confirmed that a membrane bag, abandoned on the egg surface, contained the sperm mitochondria. In virtually all other Metazoa the entire sperm enters the egg and sperm mitochondria are digested by an elaborate system of detection and enzyme destruction. Furthermore, one sperm centriole moves together the two pronuclei to form the zygote nucleus, and later initiates cleavage of the embryo. In the absence of these sperm organelles, the developmental program of the chitonid egg must be unique.

Effects of prenatal and postnatal environmental stressors on the avian phenotype.

Les effets des stressseurs environnementaux prénataux et postnataux sur le phénotype aviaire

Gary Burness, Tosha Kelly, Deanna Moher and Eunice Chin

Trent University

Within a population there exists variation among individuals in physiological and immunological capacity. There is increasing appreciation that the rearing environment, including that prenatally, can affect the adult phenotype and contribute to this variation. In birds, we have been exploring the role that maternally-derived antibodies and in ovo nutrient reserves play in the ontogeny of the acquired and innate immune systems. In an attempt to elevate in ovo antibody levels, we immunized female tree swallows prior to egg laying, with the expectation that maternal antibodies will be passed to the egg. Nestlings that hatched from eggs of immunized mothers had elevated metabolic rates, and a greater capacity to respond to subsequent immune challenges. Ongoing research on Japanese quail is exploring how nutrient levels in ovo and post-hatch influence growth rates, metabolism and development. These studies will be discussed within the context of adaptive maternal programming.

Interactions between salt water cord grass (*Spartina alterniflora*) and ribbed mussels (*Geukensia demissa*) in Maritime salt marshes

Interactions entre la spartine à feuilles alternes (*Spartina alterniflora*) et le moule strié (*Geukensia demissa*) dans les marais salés des Maritimes

Laura Bursey and Myriam Barbeau
University of New Brunswick

A positive interaction has been documented between salt water cord grass (*Spartina alterniflora*) and ribbed mussels (*Geukensia demissa*) in American salt marshes; however, the magnitude of this interaction within Canadian salt marshes remains questioned. A sampling program and two manipulative experiments were carried out in 2010-2011 to assess the possible relationships between *S. alterniflora* and *G. demissa*. From the sampling program, mussel biomass correlated positively ($p=0.001-0.031$) with many grass variables (stem counts and widths) early in the growing season in 2010, but with only one grass variable (stem counts) in 2011. In the experiment manipulating mussel density, grass variables were only minimally affected; however, in the experiment manipulating grass stem density, number of mussels was significantly affected ($p<0.001$). It may be that it takes time for the relationship to become established and/or the relationship is more beneficial to mussels than grass in Maritime salt marshes.

**A method for quantitative analysis of thermoregulatory changes in posture in small mammalian species
Une méthode d'analyse quantitative des changements de postures de thermorégulation dans les petites espèces de mammifères**

Viviana Cadena and Glenn Tattersall
Brock University

Although endotherms primarily use metabolic heat production to maintain a relatively high and constant body temperature, behavioural thermoregulatory mechanisms are low cost means of fine tuning body temperature. Changing body posture is an easy way of modifying thermal conductance aiding in either conserving in the cold or getting rid of excess heat in warm environments. We propose a methodology for quantitatively assessing changes in body posture as a means of thermoregulation. Using rats as models, We looked at the effect of acclimation to cold and hypoxia on body posture. Rats were acclimated to 5°C for four weeks and to hypoxia for the last two weeks of cold acclimation. Thermal images of the rats were taken at several temperatures from 24 to 31°C during the acclimation period, inside a temperature controlled chamber. Using image analysis software (Image J®) we were able to quantify the exposed surface area (# of pixels) of each rat from each image. As expected, the data show an increase in surface area with increasing temperature (coincident with the thermoneutral zone) as well as an intermediate response between hypoxia acclimated rats and cold acclimated rats in rats that were acclimated to both cold and hypoxia.

**Survey of brook trout, *Salvelinus fontinalis*, for macroparasites from different regions in New Brunswick
Sondage des ombles de mer, *Salvelinus fontinalis*, de différentes régions du Nouveau-Brunswick concernant les microparasites**

Brad Caissie and Mick Burt
University of New Brunswick

Brook trout, *Salvelinus fontinalis*, from 4 different watersheds in New Brunswick were sampled: the Magaguadavic River (Southwest NB); Salmon River (Saint John River watershed, mid South-East NB); the Petitcodiac River (East NB); and the Belldune River (Northern NB). Samples of about 30 fish were collected from each location and examined for macroparasites. Species identified included: one *Monogenea*, one *Digenea*, one *Cestoida*, and two or three *Nematoda*. Where possible, parasites were identified to species. No significant difference was noted between different regions with respect to parasite identity; however, both prevalence and intensity of *Digenea* and *Nematoda* were significantly higher in the Salmon River collection compared to other regions. Attempts to explain these differences will be discussed. An ancillary study on presence of lead and mercury in muscle tissue was also conducted, the results of which will be summarised.

Reduced hemoglobin histidine content: an overlooked evolutionary adaptation for enhanced oxygen delivery in small endotherms?

Contenu réduit en histidine d'hémoglobine: une adaptation négligée de l'évolution de la livraison d'oxygène améliorée chez les endothermes petits?

¹Kevin L Campbell, ²Pia Koldkjaer and ²Michael Berenbrink

¹University of Manitoba, ²University of Liverpool

Mass-specific metabolic rates of the smallest endothermic birds and mammals exceed those of their larger relatives by orders of magnitude. It has been suggested that this challenge to the maximal oxygen transport capacity is met by an increased blood hemoglobin concentration, an elevated Bohr effect, reduced diffusion distances and via a lowered blood-oxygen affinity. Here we illustrate distinct evolutionary reductions in predicted proton buffering values (titratable histidine contents) from the primary hemoglobin sequences of four lineages of small endothermic birds and mammals, a finding confirmed by acid-base titrations. As hemoglobin generally constitutes the largest non-bicarbonate buffer system of the blood, we suggest that the observed parallel reductions in specific buffering power foster larger arterial-venous pH shifts than would otherwise occur. This previously overlooked mechanism presumably enhances tissue oxygen supply in small endotherms by allowing elevated blood hemoglobin levels and/or a greater exploitation of the Bohr effect.

Molecular and physicochemical characterization of hemoglobin from the high-altitude Taiwanese brown-toothed shrew (*Episoriculus fumidus*)

La caractérisation moléculaire et physico-chimique de l'hémoglobine de musaraignes de montagnes du Taiwan en haute altitude

¹Kevin L Campbell, ¹Anthony V Signore and ²Roy E Weber

¹University of Manitoba, ²University of Aarhus

Red-toothed shrews exhibit the highest mass-specific metabolic rates recorded among mammals, though surprisingly no data is available on the functional characteristics of their hemoglobin. We therefore investigated the oxygen binding characteristics of *Episoriculus fumidus* hemoglobin and its temperature dependence in the absence and presence of red blood cell effectors. Our data suggest that the allosteric effector sensitivity of this species' hemoglobin is similar to that of the two lowland species of white-toothed shrews examined to date. The efficient exploitation of blood oxygen reserves by *E. fumidus* appears to be achieved via synergistic modulation of oxygen affinity by Cl⁻ and organic phosphates that moreover dramatically lowers the overall enthalpy of oxygenation of their hemoglobin. Oxygen unloading is presumably further enhanced by a high Bohr effect and predicted low proton buffering value of their hemoglobin. Notably, however, the limited data available suggest these latter attributes may be widespread among shrews and hence are not adaptations to chronic altitudinal hypoxia per se.

Dual functions of melatonin in *Rhodnius prolixus*

Les fonctions doubles de la mélatonine chez *Rhodnius prolixus*

Michael Cardinal-Aucoin, Diana Gorbet and Colin Steel

York University

Melatonin is a biological amine that occurs ubiquitously in nature. Its important role in the vertebrate circadian system is well documented. Little is known about melatonin in invertebrates such as insects. Using a radioimmunoassay developed recently in this lab, two patterns of melatonin release have been determined in the insect *Rhodnius prolixus*. The first is a massive peak of the hemolymph melatonin titre immediately after feeding a blood meal, proposed to be associated with plasticization of the cuticle. The second is a daily cycling with peaks during the scotophase. This daily rhythm persists in constant dark and damps in constant light and thus is endogenously controlled. This suggests that melatonin functions in the circadian system of *Rhodnius*, emphasizing the remarkable conservation of the physiological mechanisms by which circadian organization is generated in animals, from insects to mammals.

Energy expenditure, life-history, and behavior: variation among species, breeds, and individuals

Dépenses énergétiques, biodémographie et comportement : variation entre espèces, races et individus

Vincent Careau

University of California

Since prehistory, our understanding of animal life is intimately related to the study of respiration, or the fire of life. Today, physiologists are still intrigued by the 2-3 fold variation among individuals in metabolic rate, even when at rest. Similarly, behavioural ecologists attempt to explain why animals consistently behave differently from each other, a.k.a. personality. In this thesis, I asked whether the large variation in energy expenditure is associated with personality. Being the first to explicitly study the energetics of personality, I cast a new look at an old field of research (energetics) while contributing to our understanding of the energetic consequences of animal personality. I tested the relationship between personality and metabolism using various study models, in the laboratory and in the field, and at different levels of biological variation (individuals, breeds, species). I obtained different results depending on the model studied, revealing the complexity of the personality-metabolism relationship.

The acute and chronic effects of Ni toxicity on *Hyalella azteca*: influence of Ca^{2+} and natural organic matter

Les effets chroniques et aigus de la toxicité au Ni sur *Hyalella azteca*:

Katherine Chan and James McGeer

Wilfrid Laurier University

This study is focused on the influence of Ca^{2+} and natural organic matter (NOM) on the acute and chronic toxicity of Ni to *Hyalella azteca*. Amphipods (source: Hannah Lake, Sudbury) were cultured and tested in soft water (0.1mM Ca, 0.025mM Mg, 0.1mM Na, 0.1mM Cl, pH 7) following standard methods. In acute exposures, increasing Ca (0.1-2.0mM) significantly reduced toxicity as did NOM at concentrations above 6 mgC/L. Tests with NOM collected from various sites across Ontario showed that some sources offered more protection than others. Short term accumulation was used to establish linkages between toxicity mitigation and bioavailability/uptake. Targeted chronic testing was done to establish if protective effects are comparable to acute exposures. Chronic effects of Ni were assessed (growth and survival). Results are considered in the context of the biotic ligand model and understanding the importance of NOM source. Supported by NSERC, Vale and Xstrata under the TALER Research Program.

Investigating the developmental morphogenesis of the zebrafish (*Danio rerio*) infraorbital bones

Enquête sur le développement morphogénique des os infraorbitaux chez le poisson zèbre (*Danio rerio*)

Carolyn Chang and Tamara A. Franz-Odenaal

Saint Mary's University, Mount Saint Vincent University

The degree to which the neural crest derived skeleton is influenced intrinsically versus extrinsically is a question that has been debated. The infraorbital bones of the teleost skull have been shown to have some morphogenetic plasticity as their morphology can be disrupted by mechanical or environmental perturbations. This study provides an investigation into the developmental morphogenesis of the neural crest derived infraorbital bones of the zebrafish (*Danio rerio*) skull. The infraorbital bones make up five of the eight dermal bones found in the orbital region of the zebrafish skull and ossify intramembranously in a set sequence. Analysis of these bones using both live and whole-mount Alizarin red staining techniques as well as a series of laser ablation experiments, will provide a more thorough explanation for the growth and morphogenesis of these bones as well as increase insight into the phenotypic plasticity that these bones possess.

Kisspeptin 1 stimulation of LH and GH secretion from goldfish pituitary cells

La stimulation de la sécrétion de l'hormone de croissance et le l'hormone lutéinisante par la kisspeptine 1 des cellules pituitaires du poisson rouge

¹John Chang, ¹Alan Mar, ¹Michael Wlasichuk and ²Anderson Wong

¹University of Alberta, ²University of Hong Kong

Kisspeptin regulates reproduction via stimulation of hypothalamic gonadotropin-releasing hormone (GnRH) secretion which then induces pituitary luteinizing hormone (LH) release. Kisspeptin also directly stimulates pituitary hormone release in some mammals. However, in teleosts, kisspeptin has been reported either to have no direct pituitary effects (goldfish), to directly stimulate LH and growth hormone (GH) release (goldfish) or to reduce LH mRNA levels (zebrafish). In this study, synthetic goldfish pituitary kisspeptin 1 (1-10, gkiss1) enhances LH and growth hormone (GH) release from primary cultures of goldfish pituitary cells in column perfusion. gKiss1 stimulation of LH and GH secretion were still manifested in the presence of GnRH but were attenuated by two voltage-sensitive calcium channel blockers, verapamil and nifedipine. These results indicate that, in goldfish, direct Kiss1 actions on pituitary LH and GH secretion exist, are independent of GnRH and involve calcium signalling. (Supported by NSERC.)

The acute effects of adenosine on breathing in amphibians

Les effets aigus de l'adénosine sur la respiration des amphibiens

Joseph Chau and Stephen Reid

University of Toronto Scarborough

Previous studies have revealed that exposure of cane toads to chronic hypoxia causes a decrease in pH/CO₂-sensitive fictive breathing measured using isolated brainstem-spinal cord preparations in which motor output from respiratory nerves served as an index of breathing (i.e., fictive breathing). Additional studies suggest that breathing is regulated by central inputs from the midbrain to respiratory centres in the brainstem. This study addressed the hypothesis that depression of breathing in amphibians is mediated by purinergic mechanisms residing within the midbrain. Fictive breathing was measured using isolated brainstem-spinal cord preparations exposed to various doses of adenosine and various levels of artificial cerebral spinal fluid (aCSF) pH. The results indicate that complex interactions exist between the concentration of adenosine and the aCSF pH such that low doses of adenosine attenuate fictive breathing while high doses increase it; with the caveat that these general effects can be influenced by pH.

Changes in the mitochondrial phosphoproteome in mammalian hibernation

Changements dans le phosphoprotéome mitochondrial lors de l'hibernation mammifère

Dillon Chung, Beth Szyszka, Jason Brown, Norm Huner and Jim Staples

University of Western Ontario

In thirteen-lined ground squirrels (*Ictidomys tridecemlineatus*), succinate-fuelled liver mitochondrial respiration is substantially (up to 70%) and maximally suppressed shortly after entrance into torpor (i.e., within 2h). Conversely, reversal of mitochondrial metabolic suppression during arousal from torpor is gradual, and even after 8 hours, liver mitochondrial respiration is only 50% of euthermic levels. To assess mechanisms that account for these changes, we compared the phosphorylation state of liver mitochondrial proteins (using Western-blots and densitometry with phosphospecific antibodies) among summer-active, torpid, and interbout euthermic animals. Our results indicate that several mitochondrial proteins (MWs: 62, 56, 49, and 41kDa) are dephosphorylated during torpor, and we are currently using mass spectrometry to confirm their identities. This work provides the first evidence that post-translational phosphorylation of mitochondrial proteins is important for modulating mitochondrial respiration during hibernation.

Exploring lobster immunology - the American lobster's (*Homarus americanus*) response to the micro-parasite *Anophryoides haemophila*

L'exploration de l'immunologie du homard - La réponse du homard d'Amérique (*Homarus americanus*) au microparasite *Anoohryoides haemophila*

K. Fraser Clark, Adam R. Acorn and Spencer J. Greenwood

University of Prince Edward Island

An adult American lobster (*Homarus americanus*) is resistant to a diverse array of microbial pathogens present in their environment. However, *H. americanus* is particularly susceptible to infection by the micro-parasite scuticociliate *Anophryoides haemophila*. *A. haemophila* infections result in periodic outbreaks of “bumper-car” disease in live-lobster holding facilities in Atlantic Canada which can significantly contribute to post-harvest economic loss. This study examined the genetic mediators of the immune response using a novel lobster microarray. We have found that the *H. americanus* differentially expresses more than 700 genes during the course of an infection in live-holding like conditions. These genes include numerous metabolic and immune genes including: PEPCK, GBH, lectins, crustins, anti-lipopolysaccharide binding proteins, alpha-2 macroglobulins, proteases and a variety of unannotated genes. This is the first high-throughput molecular immunology study of a parasite infection in *H. americanus* and has contributed significantly to the overall understanding of the lobster immune system.

Searching for the active steroid hormone in Pacific hagfish, *Eptatretus stoutii*

À la recherche de l'hormone stéroïde active chez *Eptatretus stoutii*

¹Alex Clifford, ¹James Ede, ¹Aaron Schultz, ¹Brendan Goss, ²Nicolas Bury and ¹Greg Goss

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Considered to be an extant representative of early life history, the hagfish (*Eptatretus stoutii*) is part of the monophyletic lineage of craniates that diverged from the vertebrates ~600 million years ago. Thus, hagfish present an interesting model for the study the evolution of the endocrine system in early vertebrates. Unlike higher vertebrates, hagfish only possess a single corticosteroid receptor. Despite research showing that hagfish CR is activated by a number of different mineralo- and glucocorticoids in *in vitro* assays, the ancestral corticosteroid ligand and the CR function has not been elucidated. To investigate the active steroid, we injected hagfish with varying amounts of cortisol, corticosterone, 11-doxycorticosterone and 11-deoxycortisol and monitored plasma glucose, ATPase activity, and plasma ions (Na⁺, Cl⁻, Mg²⁺). Furthermore, we monitored the ability of the animals to recover plasma SO₄²⁻ following injection of SO₄²⁻ ions. Our results suggest that there is a steroid controlled active glucocorticoid response and mineralocorticoid response in hagfish but the identity remains to be elucidated

The effects of acute and chronic hypoxia on muscle metabolism in mice (*Mus musculus*)

Les effets de toxicité aiguë et chronique de l'hypoxie sur le métabolisme du muscle chez la souris (*Mus musculus*)

Alex Connaty and Grant McClelland

McMaster University

In low oxygen environments animals need to make efficient use of O₂ and maximize the amount of ATP from the fuel they use. During acute hypoxia, sea level natives produce greater amounts of lactate per unit of work than natives exposed to chronic hypoxia, whose peak lactate levels are similar to individuals exercised under normal oxygen tensions (normoxia). This paradoxical phenomenon has been coined the lactate paradox. We investigated the hypothesis that changes in the abundance of different cytochrome c oxidase (COX) subunit isoforms, specifically COX4-1 and COX4-2, contribute to decreased lactate production with the transition from acute to chronic hypoxia. After 2 and 24 hours of hypoxic exposure COX4-2 mRNA expression was observed to be up-regulated in the left gastrocnemius of female CD1 mice. This change in COX4-2 mRNA levels is predicted to have an influence on the levels of COX4-2 protein content and the efficiency of oxidative phosphorylation.

Influence of salinity and DOC on acute Cu toxicity to the rotifer *Brachionus plicatilis*

L'influence de la salinité et de la concentration d'oxygène dissout sur la toxicité aiguë au Cu chez le rotifère *Brachionus plicatilis*

Christopher Cooper, Tara Tait, James McGeer and Scott Smith
Wilfrid Laurier University

Acute copper toxicity tests using the euryhaline rotifer *Brachionus plicatilis* were performed to assess the effects of salinity and dissolved organic carbon (DOC). Rotifers were acclimated to 3 different salinities (3, 16 and 30 ppt), exposed to 4 different concentrations of DOC (0, 2, 4 and 10 mg/L) and total copper concentrations ranging from 0 to 300 µg/L. There was a protective effect of salinity; with the LC50 being significantly higher at 30 ppt (34.4 µg/L), when compared to 3 and 16 ppt (13.5 and 14.6 µg/L, respectively). DOC complexation reduced free copper concentrations, which subsequently reduced copper toxicity. However, the protective effect of DOC did not increase linearly with concentration. This relationship was more pronounced at higher salinities, indicating that salt induced colloid formation of DOC could be occurring. Data from this research will be used in the development of a marine biotic ligand model.

Acute and chronic toxicity of ionic silver and three forms of nanoparticle silver to *Daphnia pulex*

La toxicité aiguë et chronique causée par l'argent ionique et par trois formes de nanoparticules d'argent chez *Daphnia pulex*

Emily-Jane Costa and James McGeer
Wilfrid Laurier University,

This research aims to understand the acute and chronic uptake and toxicity of nanoparticle forms of silver (nAg) to *Daphnia pulex* through comparisons to ionic silver (Ag⁺). A three-step approach considered toxicity, solution characterization, and physiological effects to determine if nAg toxicity is due to individual particles or particle dissolution into Ag⁺. Acute (48h) and chronic (21d) toxicity was determined by lowest observed (LOEC) and 50% effect concentrations (EC50) and ultrafiltration (e.g. <450nm, <100nm, <10nm, and <1nm metal fractions) characterized Ag⁺ and nAg in these solutions. *Daphnia* (6d old) were exposed to the acute LOEC to determine physiological responses by measuring accumulation/depuration kinetics (3h or 48h) and 22Na influx (to determine if nAg disrupts Na balance). Acute (EC50 ~0.8µg/L) and chronic (EC25 ~0.4µg/L) toxicity is similar for Ag⁺ and nAg. However, uptake kinetics and Na disruption differed but is nAg source-specific. This research was supported by NNBNI.

Myocardial global gene expression in Atlantic salmon (*Salmo salar*) exposed to cold temperatures

Expression globale des gènes myocardiques chez le saumon Atlantique (*Salmo salar*) exposé à des températures froides

Isabel Costa, Tiago Hori, Matthew Rise and Kurt Gamperl
Memorial University of Newfoundland

We used the cGRASP 32,000 (32K) salmonid cDNA microarray platform to examine global gene transcription in the ventricular myocardium of Atlantic salmon at their acclimation temperature (10°C), and when temperature was gradually lowered to 1°C over 3 days; samples taken at 5°C, 1 day after the fish reached 1°C, and after 3 weeks at this temperature. As compared with time-matched controls (10°C), the salmon myocardium showed the greatest number of dysregulated genes (296) after 3 weeks at 1°C. QPCR was used to validate 27 microarray-identified cold-responsive genes. Transcripts with stress relevant functional annotations, several of which have been linked previously to myocardial protection, were upregulated in response to cold exposure. Genes involved in pathways known to play a role in cardiac remodeling were also dysregulated at 1°C. These data are consistent with previous studies, which show that cold temperatures cause significant alterations in the fish myocardial transcriptome.

Recombinant interleukin-1 β dilates steelhead trout coronary microvessels

L'interleukin-1 β recombinante dilate les micro-vaisseaux coronariens de la truite arc-en-ciel

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Interleukin (IL)-1 β is associated with hypotension and cardiovascular collapse in mammals during heatstroke, and the mRNA expression of this proinflammatory cytokine increases dramatically in the blood of Atlantic cod at high temperatures. These data suggest that IL-1 β might be vasoactive in fish, and lead to the development of hypotension by decreasing vascular resistance. Thus, we measured the dose-dependent response of isolated trout coronary microvessels (< 150 μ m in diameter) to recombinant (r) IL-1 β at two temperatures (the acclimation temperature of 10°C and 20°C). Recombinant IL-1 β induced a dose-dependent vasodilation with vessel diameter increasing by approximately 8% and 30% at 10⁻⁸ and 10⁻⁷M, respectively. However, this effect was not temperature dependent. The effect of rIL-1 β on trout coronary microvessels appears to be endothelial dependent and mediated through the release of prostaglandins. Both vessel denudation and cyclooxygenase blockade, but not the nitric oxide antagonist L-NIO, inhibited rIL-1 β 's vasodilatory effect.

MicroRNAs: a «cool» family of ribonucleic acids

MicroARNs: Des molécules d'acides nucléiques qui ne laissent personne de glace

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Université de Moncton

Natural models of hypometabolism exist in nature and hold keys to our understanding of biochemical processes at play during freezing. Freeze tolerant insects are examples of such models as they survive the low temperatures associated with winter. Overwintering strategies employed by these models are decreased metabolic rate, reduction in heart rate and significant down-regulation of energy-consuming processes. To gain new perspectives on freeze tolerance, we studied differential expression of members of a novel family of nucleic acids named the microRNAs (miRNAs) in the freeze tolerant fly *Eurosta solidaginis*. miRNAs are small ribonucleic acids capable of inhibiting the energy-consuming process of protein translation by silencing expression of selected transcripts. Expression of miRNAs was assessed in control (+5 °C) and frozen (-15 °C) insects by miRNA microarray. Several miRNAs were identified as differentially expressed in cold insects and one of them, miR-34, was quantified and sequenced in *E. Solidaginis*.

Support Vector Machine Classification of Linuron as an Androgen or Anti-androgen.

La classification par machine à vecteurs de support du linuron en tant qu'un androgène ou un anti-androgène

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Linuron (LIN), a ureic-based herbicide, can act as an aquatic pollutant when it enters water systems from run-off. LIN potentially affects diverse pathways and may act as an agonist or antagonist for steroid receptor signalling. Anti-androgenic effects of LIN have been a suspected mode of action (MOA). Therefore, there is a need for a reliable system for classifying the MOA of a pollutant such as LIN. Using microarrays, real-time PCR and support vector machine classifier, we compare the transcriptomics responses in the fathead minnow ovary to model androgens and anti-androgens in order to better classify LIN's MOA using omics-datasets. MAP3K1 network was identified as significantly up-regulated in both the model anti-androgen and LIN (fold change of 1.15 and 1.14, respectively). This study applies a novel bioinformatics approach (SVM) to transcriptomics data for classification of aquatic pollutants as androgens or anti-androgens and identifies cell pathways that are regulated by an anti-androgenic MOA.

Where's the glucose? Dietary methionine restriction eliminates the glucose intolerant phenotype in rainbow trout

Où est le glucose? La méthionine alimentaire élimine le phénotype intolérant au glucose de la truite arc-en-ciel

Paul Craig and Thomas Moon
University of Ottawa

In aquaculture, there is significant pressure to switch from protein-rich fishmeal based diets towards a more sustainable plant based meal, which inherently increases carbohydrate load, and decreases several essential amino acids, particularly methionine. Methionine restriction (MR) is known to have beneficial attributes in mammalian models, however MR effects in fish are poorly understood. Rainbow trout (*Oncorhynchus mykiss*), a glucose intolerant species, were employed to examine the phenotypic and transcript expressional responses to dietary MR for 8wks. Liver and white muscle was examined for markers of fuel use, beta-oxidation, glycolysis, and lipogenesis. Further examination of MR was assessed in vitro, using trout primary hepatocyte cell culture. MR eliminated the glucose intolerant phenotype 6hr post-feeding, and there was evidence for the reduction in the glycolytic and lipogenic capacity associated with MR, with a reduction in available energy (ATP). Furthermore, carbohydrate load reduced the global genomic methylation status. Studies supported by an NSERC-DG.

High environmental ammonia (HEA) impairs net ammonia secretion over the skin of the African Clawed Frog, *Xenopus laevis*

Des niveaux environnementaux d'ammoniac élevés compromettent la sécrétion nette d'ammoniac sur la peau de xénopes du Cap, *Xenopus laevis*

Melissa Cruz, Mary M. Sourial and Dirk Weihrauch
University of Manitoba, University of Manitoba, University of Manitoba

Skin tissues of *Xenopus laevis* were investigated for their ammonia transport properties in Ussing chamber experiments and in vivo-like transpeithelial osmotic gradients. Metabolically generated ammonia accounted to 24 ± 2 nmol L⁻¹ cm² h⁻¹ (ventral) and 28 ± 2 nmol L⁻¹ cm² h⁻¹ (dorsal) of which 57% and 51% were released towards the apical bath, respectively. Both skins produced a net ammonia efflux when activated by 10mM theophylline, where reasonable ammonia net effluxes occurred only when applied ammonia gradients were above ammonia levels measured in the plasma (364 ± 33 μM). After long term exposure to HEA (1 mM NH₄Cl, ≥ 7d), both skins had a tendency to have lower net ammonia efflux rates than unexposed tissues. Also, dorsal and ventral skin patches did not exhibit appreciable net urea effluxes. After long term HEA exposure, blood urea levels increased, but not urea excretion rates. Furthermore, skin patches remained rather tight for urea following HEA exposure.

Influence of salinity and DOC on acute Cu toxicity to the euryhaline shrimp *Mysidopsis bahia*

L'influence de la salinité et de la concentration d'oxygène dissout sur la toxicité aiguë au Cu chez la crevette euryhaline *Mysidopsis bahia*

Jessie Cunningham, Rabia Nasir and Jim McGeer
Wilfrid Laurier University

The biotic ligand model (BLM) is used to predict the effects of water chemistry (eg. natural organic matter, protective cations) on the acute toxicity of metals to aquatic organisms. Although well established in freshwater systems, an estuarine BLM does not exist. Static acute copper toxicity tests using *Mysidopsis bahia* were performed to assess the effects of salinity and dissolved organic carbon (DOC) on median lethal dissolved copper concentrations (LC50). Acute toxicity tests (96 h) for Cu were done at salinities of 15, 25 and 35 ppt and DOC concentrations of 0, 2, 4 and 10 mg/L. The role of DOC source was also tested. Cu characterization (total and free ion) was by anodic-stripping voltammetry and ion selective electrode. This research will contribute to the development of BLM models for the protection of marine and estuarine organisms. Supported by NSERC, ICA, CDA, NiPERA, ILZRO, IZA, Teck, Xstrata and Vale.

What factors influence intraspecific variation in metabolic rate in zebrafish, *Danio rerio*?

Quels sont les facteurs qui influencent la variation intraspécifique en terme du taux métabolique du poisson zèbre, *Danio rerio*?

Joshua D'Silva and Kathleen Gilmour
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Resting metabolic rate provides an estimate of the energetic cost of self-maintenance for an animal. This cost varies substantially among individuals, but the causes of such intraspecific variation in RMR remain poorly understood. Factors such as genotype, maternal effects, early developmental conditions and differences in biochemistry, physiology, and behaviour are thought to contribute to intraspecific variation in RMR. The present study investigated links between RMR and personality traits, which are among-individual differences in behaviour that are consistent across time and/or contexts. Co-variation in personality traits results in behavioural syndromes; an example of which is stress-coping strategy. Individuals demonstrate either a proactive (aggressive and bold) or reactive (timid and shy) stress coping style, with accompanying differences in stress hormone mobilization. The present study explored correlations between RMR measured as oxygen consumption, and stress coping style assessed as the cortisol response to a standardized stressor.

Linking intra and interspecific variation in the study of insect flight energetics

Lien entre la variation intra et interspécifique dans l'étude de l'énergétique du vol chez les insectes

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University of Ottawa

Metabolic rate varies greatly among species and individuals, and insect flight provides a great opportunity to understand the causes and consequences of this variation. Moreover, the evolutionary links among functional traits associated with locomotion can be elucidated by integrating macro and microevolutionary frameworks. In a series of studies, I have investigated the links between species morphology and flight metabolic rate, and showed the correlated evolution of several traits. Within species, we have shown that similar functional relationships exist and explain phenotypic differences among bumblebee casts, but also variation among individual workers. This metabolic rate diversity is also reflected at the cellular level, where we characterized flight muscle metabolic phenotype variation. Given their reliance on carbohydrate metabolism, we have shown that flight metabolic rate variation is associated with the activity of glycolytic enzymes, both across and within species. I will discuss how evolutionary processes within species yielded interspecific diversity observed.

Le taux métabolique varie de façon importante entre espèces et individus d'une même espèce. Le vol chez les insectes permet d'en étudier les causes et les conséquences, en plus d'intégrer des approches macro et microévolutive dans l'étude d'association fonctionnelle entre caractères. Dans une série d'études, je me suis attardé sur les liens entre la morphologie des espèces et leur taux métabolique, et démontré l'évolution corrélée de plusieurs caractères. Chez une même espèce, nous avons démontré l'existence de liens fonctionnels similaires qui expliquent les différences entre castes de bourdon, et même entre ouvrières. La diversité de taux métabolique est également reflétée au niveau cellulaire, où les phénotypes métaboliques des muscles du vol ont été caractérisés. Nous avons trouvé que la variation de taux métabolique est liée à l'activité d'enzymes glycolytiques, et ce, entre espèces et individus d'une même espèce. Je discuterai des processus évolutifs menant à la diversité interspécifique.

Effects of feeding status on mRNA expression in rectal gland of the spiny dogfish shark (*Squalus acanthias*)

Les effets du statu alimentaire sur l'expression d'ARNm dans les glandes rectales de l'aiguillat commun (*Squalus acanthias*)

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The spiny dogfish (*Squalus acanthias*) is an opportunistic predator that is often forced to fast for varied periods of time between feedings. During these periods of starvation, both morphological and physiological changes have been noted in the rectal gland, consistent with metabolic suppression relative to fed organisms. Our objective was to determine which genes are differentially expressed in the dogfish rectal gland at 6 h, 20 h and 7 days post-feeding. Suppression subtractive hybridization was used to identify which genes were being differentially expressed. Notably, feeding upregulated mRNA expression of several metabolic and transport genes, but also ubiquitin and HSP 71. Quantitative real time PCR is underway on selected genes to supplement these findings. We also examined the biological functions and processes that were being represented by the differentially expressed genes. Most notably, there appears to be an abundance of genes involved in metabolism and molecular binding.

Evidence for metabolic imbalance of vitamin A2 in wild fish chronically exposed to metals

Preuve de déséquilibre métabolique de la vitamine A2 chez les poissons sauvages exposés aux métaux de façon chronique

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In order to investigate the potential impacts of metals on vitamin A2 metabolism, yellow perch (*Perca flavescens*) were sampled in six lakes representing a metal contamination gradient. Significant differences among lakes, mainly linked to Cd-exposure, were observed. Yellow perch from Cd-contaminated lakes had significantly higher concentrations of liver dehydretinol and dehydretinyl esters than fish from reference lakes. However, the increase in retinyl ester stores with increasing Cd concentrations was quantitatively much more important than the increase in free dehydretinol. As a result, a significant decrease in the percentage of free hepatic dehydretinol with increasing renal Cd concentrations was observed. Overall our findings illustrate that vitamin A2 homeostasis can be altered as a consequence of chronic exposure to low Cd concentrations. Thus, in the context of environmental risk assessment, the percentage of free liver dehydretinol could be considered as a biomarker of in situ Cd exposure.

Stress hormones: mediators of developmental plasticity

Les hormones du stress: médiateurs de la plasticité développementale

Robert Denver

University of Michigan

Developmental plasticity is the property of a given genotype to produce different phenotypes in response to environmental conditions experienced during development. Amphibian larvae have immense capacity for developmental plasticity, and therefore offer unique opportunities to study the proximate and ultimate causes for plasticity, and their relationship to phenotypic evolution. Most amphibians have complex life cycles. Environmental conditions experienced during the larval stage affect larval behavior, morphology, the timing of metamorphosis, and can lead to variation in adult phenotypic expression. Hormones of the neuroendocrine stress axis play pivotal roles in mediating environmental effects on animal development. While stress hormones may favor survival in a deteriorating larval habitat, costs may be incurred such as reduced size at metamorphosis. Furthermore, elevations in stress hormones during the tadpole stage can lead to developmental 'programming', with lasting effects that persist into adulthood, leading to altered physiology and behavior in the juvenile adult stage.

Community ecology of larval *Diplostomum* spp. (Digenea: Strigeida) in the eyes of fish from Lake Saint-François in the St. Lawrence River

L'écologie des communautés de larves de *Diplostomum* ssp. (Digenea: Strigeida) aux yeux des poissons du lac Saint-François sur le fleuve Saint-Laurent

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Concordia University, Environment Canada, Concordia University, Environment Canada

Metacercariae in the genus *Diplostomum* are common in fish eyes throughout the Holarctic. Although these larval parasites are pathogenic in fish and intensively studied, little is known of their community ecology because they cannot be identified to species morphologically. Factors that may shape *Diplostomum* communities include spatio-temporal variation, interspecific parasite interactions, and age and size of the host. We investigated these processes in *Diplostomum* spp. collected from *Perca flavescens*, *Notemigonus crysoleucas* and 13 sympatric species (n = 349) at two independent localities in Lake Saint-François in the St. Lawrence River in 2006, 2010, and 2011. Sequences of the barcode region of COI were obtained from 631 *metacercariae* in order to distinguish them at the species level. Preliminary analyses show that 50% of the fish had *Diplostomum* infections in the lenses. Of these, 28% were infected by multiple species. The most common pairing involved species designated as *Diplostomum* 1 and 4.

Responses of an identified locust interneuron to objects moving along compound trajectories at different velocities

Les réponses d'une interneurone identifié de criquet à des objets se déplaçant le long de trajectoires composés à des vitesses différentes

Paul Dick and Jack Gray

University of Saskatchewan

The descending contralateral movement detector (DCMD) is a neuron in the locust visual system that is implicated in controlling escape behavior and is known to encode a ratio of the size and velocity of an object approaching along a single, collision trajectory. Recent studies suggest that the DCMD is also capable of encoding more complex visual information resulting from objects that transition to or from looming trajectories. However, the putative effects of object velocity has not yet been tested for these compound trajectories. We presented locusts with objects moving at different velocities along trajectories that transition to looming within different regions of the locust's visual field. Concomitant extracellular DCMD recordings were analysed to determine if firing rate modulation was correlated with disc expansion properties that reflect transition time and location. Our results will be discussed in the context of how a single pathway could encode behaviourally relevant visual stimuli.

Cuttlefish: A new model to study protein metabolism

La seiche: un nouveau modèle pour étudier le métabolisme des protéines

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Cephalopods are fascinating animals that exhibit a very high growth rate all their life. A high rate of protein synthesis coupled to a minimal rate of degradation was proposed as an explanation to this uncommon feature. Other than a small quantity of lipids stored in the digestive gland, proteins are the sole form of energy storage. Accordingly, we hypothesized that the rate of proteolysis would be accelerated during starvation. Using cuttlefish, *Sepia officinalis*, as a model, we investigated the response of different pathways involved in protein degradation following 7 days of starvation. In the mantle, protein synthesis and degradation were shown to be down- and up-regulated, respectively, as evidenced by changes in key enzymes activities and levels of transcripts. A much different response was observed in gill where both synthesis and degradation were shown to be up-regulated. We proposed gill remodeling as the most likely explanation to this unexpected result.

Respective roles of G3Pase and glycerolipids in glycerol synthesis in smelt: significance for vertebrates
Rôles respectifs de G3Pase et des glycérolipides dans la synthèse du glycerol chez l'éperlan: importance pour les vertébrés

Delphine Ditlecadet and William R. Driedzic
Memorial University of Newfoundland

Rainbow smelt (*Osmerus mordax*) is a small fish that accumulates high amounts of glycerol in winter as a cryoprotectant. Synthesis occurs in liver from different substrates that all lead to glycerol-3-phosphate (G3P). From there, glycerol could be produced by a direct dephosphorylation by a phosphatase or following a transition through the glycerolipid pool. Isolated hepatic cells producing glycerol linearly in cold conditions were used to clarify this point. Results clearly demonstrated that a direct dephosphorylation was the most likely pathway, as glycerolipids could not account for more than 20% of the glycerol produced in this model. Efforts made to characterize G3Pase support a low molecular weight acidic phosphatase located in the cytosolic fraction. This is the first time this route to glycerol production has been unequivocally identified in any animal species. Significance of these results for the comprehension of glycerol metabolism in vertebrates will be put into perspective.

Staining methods for the study of fish fin morphology utilizing microCT scanning

Méthodes de coloration pour l'étude de la morphologie des nageoires des poissons en utilisant le balayage par microCT

Trina Y Du, Benjamin Wilhelm, Rui Tahara and Emily M Standen
McGill University

Recent advances in contrast-enhancing staining methods allow for the visualization of soft-tissues using microCT. These methods have been demonstrated in a range of taxonomic groups for embryonic specimens. However, protocols for larger, adult specimens have not yet been published. Here, we compare the effectiveness of six stains (IKI, I2E, PTA, PMA, modified Alcian blue, and silver nitrate) on the gray bichir (*Polypterus senegalus*) to visualize bone, cartilage, muscles and nerves. Using scan data from these specimens, we determine the stains that achieve the best contrast and resolution for the tissues of interest and establish robust staining protocols for future studies. With in situ visualization of multiple tissue types, microCT scanning can be used as a powerful tool for comparative anatomy.

Using geometric morphometrics to investigate the effects of manual lens removal on the craniofacial skeleton

Utilisation de morphométrie géométrique pour enquêter sur les effets de l'enlèvement manuel de lentilles sur le squelette craniofacial

Megan Dufton, Brian Hall and Tamara Franz-Odenaal
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The Mexican tetra, *Astyanax mexicanus*, exists as two morphs of a single species (sighted and blind). We manually ablated the lens of sighted tetra embryos to investigate the relationship between the developing eye and the craniofacial skeleton. Lens ablation results in one-eyed adults. Morphometric analyses of one-eyed fish show that the patterning and development of bones within and surrounding the eyes are significantly altered by the absence of the lens. The circumorbital bones exceed their usual size, covering the orbit. A comparison with laser lens ablations experiments yields different results. Our research also indicates that taste development does not interact with the lens, while tooth development is linked. This research will help to better understand the relationship between the developing eye, skull, teeth and gustatory system. Funding provided by NSERC PGS.

Investigation of ASIC4 involvement in Na⁺ uptake in zebrafish larvae using morpholino knockdown technique

Enquête sur l'implication de ASIC4 dans l'assimilation de Na⁺ dans les larves de poissons zèbre en se servant d'une technique de knock-down morpholino

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¹University of Alberta, ²University of Ottawa

The molecular identity of the Na⁺ uptake mechanism across the gills of freshwater fish remains the subject of lively debate. Despite extensive evidence for mediation via NHE, the thermodynamic constraints on NHE function suggest that alternate mechanisms may need to exist. Recently, we have demonstrated the presence of an acid sensing ion channel (ASIC), a member of the ENaC/DEG superfamily, in the MR cells of rainbow trout and zebrafish gills. Additionally, we observed substantial inhibition of Na⁺ uptake in these fishes when using ASIC specific pharmacological blockade. To further investigate the role that ASIC4 may play in freshwater fish Na⁺ uptake, we used morpholino knockdown to inhibit ASIC4 translation in zebrafish larvae. While ASIC4 knockdown had no effect on zebrafish larvae reared in normal medium (Na⁺=600 uM), it significantly reduced Na⁺ uptake in larvae reared in low-Na⁺ medium (Na⁺). This suggests that this ASIC4 may play a role in Na⁺ uptake in freshwater fish reared in very soft water.

Interactions between the immune response and stress response in insects (cricket, *Gryllus texensis*): conflict and collaboration

Les interactions entre la réponse immunitaire et la réaction au stress chez les insectes (le grillon, *Gryllus texensis*): les conflits et la collaboration

Russell Easy and Shelley Adamo

Dalhousie University

Immune and stress responses can conflict when they occur simultaneously, leading to immunosuppression. We examine the effect of both responses on the expression of heat shock protein 90 (Hsp90), glutathione-s-transferase (GST) and nitric oxide (NO) synthase gene expression using quantitative PCR. Hsp90 increases in response to heat stress 100 fold compared to control animals. When crickets are injected with paraquat, GST is upregulated 50 fold. Following an immune challenge with heat killed *Serratia marcescens* Hsp90 is upregulated 21 fold at 3 hours and 100 fold at 12 hours and drops to 60 fold at 24 hours compared to non-challenged animals. There is a 2 fold upregulation of GST at 3 hours but no change at 1, 6, 12 or 24 hours. The enzyme NO synthase, which produces NO, is upregulated 5 fold at 24 hours. The effects of acute stress in combination with an immune challenge will be discussed.

Connectivity in the North Atlantic: population genetics of the key benthic invertebrate *Corophium volutator*

La connectivité dans le nord de l'Atlantique: la génétique des populations d'invertébrés benthiques clés, *Corophium volutator*

Tony Einfeldt and Jason Addison

University of New Brunswick

The benthic marine amphipod *Corophium volutator* inhabits intertidal mudflats in the North Atlantic, and contributes to the stability of soft sediment ecosystems both biologically (as a prey item) and physically (through the construction of burrows). To determine the scale of connectivity in *C. volutator* throughout its North American range, I used mitochondrial sequence variation to investigate population structure and infer patterns of gene flow. I detected a biogeographic break between the Bay of Fundy and Gulf of Maine, and a strong pattern of genetic subdivision within the Bay of Fundy. My results show patterns of population divergence that are inconsistent with a range expansion following glacial recession, suggesting that *C. volutator* recently invaded the Bay of Fundy, and that genetic subdivision has largely been driven by genetic drift and limited dispersal.

Thyroid hormone actions in the development of a frog that lacks a tadpole.

Les actions de l'hormone thyroïdienne durant le développement d'une grenouille sans têtard

Richard Elinson

Duquesne University

The frog, *Eleutherodactylus coqui*, develops on land from a large egg directly to a froglet with no tadpole stage. Despite this apparent morphological continuity, thyroid hormone acts on skin, muscle, and other tissues to generate the froglet. While these activities are also present in frogs with tadpoles, a novel activity of embryo-produced thyroid hormone in *E. coqui* is to stimulate the utilization of yolk, stored as nutritional endoderm, for growth of the froglet. This late activity raises the question as to whether early yolk utilization in amphibian embryos depends on maternal supplies of thyroid hormone, present in the egg.

The effect of dissolved oxygen concentration on critical thermal on critical thermal maximum, and the secondary stress response in triploid brook charr, *Salvelinus fontinalis*

Les effets de la concentration d'oxygène dissout sur la température critique et la température critique maximale et la réponse secondaire au stress chez l'omble de fontaine triploïde, *Salvelinus fontinalis*

Lauren Ellis, Tillmann J. Benfey and Charles F.D. Sacobie

University of New Brunswick

Induced triploidy is the most effective method of producing sterile salmonid fishes for aquaculture. However, triploid brook charr (*Salvelinus fontinalis*) have been reported to have reduced tolerance to elevated temperatures and a lower optimum temperature when compared to their diploid counterparts. To determine whether reduced temperature tolerance is a direct effect of temperature or an indirect effect of low dissolved oxygen, diploids and triploids were tested in critical thermal maximum (CTM) trials under varying oxygen conditions. The treatment involving using nitrogen to drive oxygen out had a significant effect on CTM. A ploidy effect also occurs in low oxygen conditions with triploids having a lower CTM than diploids. An in depth study was done on this treatment with blood plasma samples taken during the trial and over an 18-hour recovery period. Statistical analysis for blood glucose and ion concentrations results will be presented.

Predator chemical cue effects on barnacle recruitment depend on nearshore pelagic food supply for prey

Les effets des signaux chimiques des prédateurs sur le recrutement des cirripèdes dépend de l'approvisionnement alimentaire du littoral pélagique pour les proies

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Recruitment is a major process structuring and replenishing populations. For sessile marine invertebrates, recruitment has been shown to be affected by chemical cues from biofilms and conspecifics. However, potential predator cue effects are unknown. Moreover, interactive effects with ecologically relevant large-scale phenomena also remain unknown. We investigated the interactive effects of dogwhelk (*Nucella lapillus*) chemical cues and nearshore pelagic food supply for barnacles (phytoplankton abundance) on the recruitment of intertidal barnacles (*Semibalanus balanoides*). Through a nested experimental design in 2011, we manipulated dogwhelk presence/absence on two Nova Scotia shores that differ in coastal phytoplankton abundance (food supply). Nearby dogwhelk presence decreased barnacle recruitment under low food supply, but had no effect under high food supply. Studies testing possible mechanisms are underway, but it is now clear that predator chemical cue effects on prey recruitment may depend on nearshore food supply levels for prey.

Evolution and ontogenetic expression of CRH family members in sea lamprey, *Petromyzon marinus*

L'évolution et l'expression ontogénétique des membres de la famille d'hormones de l'hibernation de la corticotropine chez la lamproie marine *Petromyzon marinus*

Matthew Endsins, Tara Hicks, Odette Allonby and Richard G. Manzoni

University of Regina

The Corticotropin Releasing Hormone (CRH) family is an ancient neuropeptide family and key regulator of the vertebrate stress response. CRH has additionally been shown to modulate the thyroid and reproductive axes of both non-mammalian and mammalian vertebrates. We have identified three CRH family members (denoted CRHA, B and C), two CRH receptors (CRHR1 and CRHR2) and binding protein (CRH-BP) in the jawless vertebrate, the sea lamprey (*Petromyzon marinus*). These data extend our understanding of the evolution of this peptide family to include agnatha. To understand the ancestral role of CRH family members, we investigated the spatial and temporal (ontogenetic) distribution of the CRH family members in sea lamprey and their potential to modulate the thyroid axis as it pertains to metamorphosis. These data will provide insight into the function of the CRH system in lamprey ontogeny and possibly offer clues as to the function of the system in vertebrate ancestors.

Do immune-challenged crickets change behaviour to conserve resources and avoid predators?

Est-ce que les grillons avec défi immunitaire changent de comportement pour conserver les ressources et éviter les prédateurs?

Evan Fairn and Shelley Adamo

Dalhousie University

Vertebrates mounting an immune response often exhibit a suite of behavioural changes (i.e. sickness behaviour) that can include a decrease in food intake, water intake, reproduction, locomotion, and exploratory behaviour. It is believed that sickness behaviour is adaptive, possibly functioning to conserve resources required to survive infection and reduce exposure to predators when in a debilitated state. Little is known about whether immune-challenged invertebrates exhibit similar behavioural changes. Here, we investigated sickness behaviour in the Texas field cricket *Gryllus texensis*. Consistent with a previous study, we found that this species decreases feeding, but not drinking, during an immune response. We found no evidence that immune challenge affects locomotion, exploratory behaviour/boldness in a novel environment (with or without simulated predator), or propensity to engage in courtship. Decreased motivation to feed during an immune response could result in reduced energy expenditure and decreased exposure to predators by decreasing foraging. However, our results suggest that this species does not employ a broad predator avoidance and energy conservation strategy when immune-challenged.

Intracellular localization and regulation of Matrix metalloproteinase 2 in zebrafish muscle

Localisation intracellulaire et régulation de la métalloprotéinase de matrice 2 du muscle de poissons zèbre

Amina Fallata and Bryan Crawford

University of New Brunswick

Matrix metalloproteinases (MMPs) are zinc-dependent proteases best known for their roles in extracellular matrix remodeling. However, recent evidence has revealed the localization of MMP-2 (Gelatinase A) within rat cardiac myocytes, where it degrades protein components of the sarcomere under conditions of oxidative stress during ischemia/reperfusion injury. Also, human MMP-2 activity is regulated by phosphorylation, which is characteristic of intracellular enzymes. The objectives of my research are to determine if these unexpected intracellular roles of Gelatinase A are evolutionarily conserved in vertebrate muscle, and if so, to establish the zebrafish as a model system for their study. Using confocal and electron microscopy, I have obtained evidence that zebrafish Mmp2 is present in sarcomeres of skeletal muscle. I will use ³²P metabolic labeling and immunoprecipitation to determine if Mmp2 is phosphorylated in zebrafish. Ultimately, I plan to investigate the physiological roles of Mmp2 in muscle cell development and physiology.

Immunostimulants and their effects on the host-parasite relationship between atlantic salmon (*salmo salar*) and *Lepeophtheirus salmonis*

Les stimulants du système immunitaire et leurs effets sur la relation hôte-parasite entre le saumon atlantique (*Salmo salar*) et *Lepeophtheirus salmonis*

Mark Fast

Atlantic Veterinary College (UPEI)

Successful host responses to *Lepeophtheirus salmonis* infection, as seen in coho, pink and to some extent Chinook salmon (*Onchorhynchus kisutch*, *O. gorbuscha*, and *O. tshawytscha* respectively) have previously been characterized by strong inflammatory and hyperplastic responses. However, infections in Atlantic salmon (*Salmo salar*) have been characterized by little to no hyperplastic response, and a biphasic immune response resulting in chronic inflammation as the infection persists. We have been using different immunostimulants, administered through feed, to induce greater inflammatory and mucosal responses in Atlantic salmon in the hopes of providing greater protection to *L. salmonis*. Induction of innate and adaptive responses in Atlantic salmon have been achieved through use of these methods. Enhanced protection is also a hallmark of host immunostimulation, but parasitic responses to these measures indicate incorporation into new management strategies on the farm will not be simple.

Controls on sea urchin populations in Nova Scotian kelp beds

Le contrôle des populations d'oursins dans les lits laminaires de la Nouvelle-Écosse

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¹Dalhousie University, ²Fisheries and Oceans Canada & Institut Maurice-Lamontagne

Along the Atlantic coast of Nova Scotia, dense aggregations of sea urchins (*Strongylocentrotus droebachiensis*) consume kelp beds causing a shift to an urchin-dominated barrens state, while recurrent outbreaks of amoebic disease cause mass mortalities of sea urchins, releasing kelps from grazing pressure and allowing reestablishment of kelp beds. From June 2010–August 2011 we investigated sea urchin population structure in kelp beds in St. Margarets Bay, an area that has been heavily impacted by disease, including 4 outbreaks since 2003. Sea urchin populations in 10 kelp beds surveyed were composed almost exclusively of juveniles (mean test diameter: 14.4 ± 7.2 mm SD). Juvenile urchins (1–2 yr-old) remained in areas where adults had been removed by disease the previous fall, indicating that disease outbreaks have a greater impact on adults than juveniles, perhaps due to behavioral differences that affect exposure to a waterborne pathogen. Juvenile urchins were observed commonly in kelp holdfasts and rarely on exposed substrates, suggesting that holdfasts serve as a refuge from predation. To test this hypothesis, we conducted field and laboratory experiments investigating the effect of holdfasts on the survival of juvenile urchins in the presence of 3 locally abundant, decapod predators: American lobster, Jonah crab and Atlantic rock crab. Preliminary results indicate that holdfasts provide refuge for juvenile urchins up to a threshold size of ~25 mm test diameter, above which urchins are too large to inhabit holdfasts. Our results suggest that predation at a critical sea urchin life phase (late juvenile/early adult) contributes to the pattern of relatively higher juvenile than adult population density caused by disease, and impedes reestablishment of sea urchin populations in kelp beds following disease outbreaks.

Acid-base regulatory patterns in the gills of the green crab, *Carcinus maenas*

Les modes de régulation acido-basiques dans les branchies du crabe vert, *Carcinus maenas*

Sandra Fehsenfeld and Dirk Weihrauch

University of Manitoba

An efficient ion-regulatory apparatus located in the epithelia of 9 gills in the green crab, *Carcinus maenas*, is responsible for its high acclimation potential to diverse environmental stressors. The 3 posterior gills are considered as main osmoregulatory organs in this brachyuran species, while not many studies focussed on the gills' acid-base regulatory capabilities. In order to investigate the mechanisms of acid-base regulation in green crab, isolated posterior and anterior gills were perfused with hemolymph-like saline and varying pH in the bathing solution. After one gill passage, pH of the perfusate was significantly increased by ~0.1 units in all gills of control animals, accompanied by an according decrease in pCO₂. Gills of crabs acclimated to elevated pCO₂ increased the pH of the perfusate even further. Interestingly, one anterior and one posterior pair of gills were identified to be most effective in this regulation, while other posterior gills were considerably less efficient.

Teaching zoology: class to book

Enseigner la zoologie: de la classe jusqu'aux livres

Brock Fenton

University of Western Ontario

I will present some ideas about teaching zoology across the spectrum from classroom to book. The presentation is based on experience with both face-to-face and on line courses. My focus is on engaging students across the range of activities from lecture presentations to laboratory exercises, case studies and essay assignments. One challenge is getting students involved, another is to demonstrate that zoology is very much a "now" subject as opposed teaching what we learned in days past.

Fecundity reduction in the second gonotrophic cycle of the mosquito, *Culex pipiens*, infected with the apicomplexan blood parasite, *Hepatozoon sipedon*

La réduction de la fécondité dans le deuxième cycle gonotrophique du moustique *Culex pipiens*, infecté avec le parasite sanguin apicomplexe, *Hepatozoon sipedon*

Laura Ferguson and Todd Smith

Acadia University

Fecundity reduction is a well-recognized phenomenon of parasite infection in insect vectors. Reduced production of eggs may increase the longevity of a host, as well as release nutrients to both host and parasite that would otherwise be used for oogenesis. The objective of this study was to assess effects on fecundity caused by *Hepatozoon sipedon*, a blood parasite of snakes, in the mosquito, *Culex pipiens*. Numbers of eggs laid in the first gonotrophic cycle by uninfected mosquitoes and by those infected with *H. sipedon* did not differ significantly, indicating that fecundity is not affected during parasite invasion of the gut. However, infected mosquitoes laid significantly fewer eggs in the second gonotrophic cycle, and fecundity was reduced by 100% in mosquitoes with high parasite burdens of more than 50 oocysts. These data suggest that growing parasites compete for nutrients with mosquitoes or impede production of egg proteins by the fat body.

Cross talk between androgen and thyroid hormones during amphibian early development

Diaphonie entre l'androgène et les hormones thyroïdiennes tôt dans le développement amphibien

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¹Queen's University, ²Royal Military College of Canada

Thyroid hormones (THs) role in growth and development is well established across vertebrate species. More recent studies have demonstrated that THs may also play a role in sexual differentiation and gonadal development. There is cumulative evidence that the effects of THs on reproductive development are mediated through the female hormonal axis; however, other studies have also suggested a direct regulation by THs on the male reproductive system. The aim of this study is to assess the TH mechanisms of action in male sexual differentiation and gonadal function. Larvae of the Western clawed frog (*Silurana tropicalis*) were chronically exposed to the goitrogen potassium perchlorate (0, 25, 50 and 100 ppb) during the periods of sexual differentiation and gonadal development. Transcript levels of thyroid- and androgen- related genes measured by real-time RT-PCR will be presented for each treatment.

Putting the squeeze on: how do mammalian keratins go from soft to hard?

Mettre de la pression: comment est-ce que les kératines mammifères passent de la douceur à la fermeté?

D.S. Fudge and Daniel Greenberg

University of Guelph

Mammalian epidermal appendages come in an impressive diversity of forms (hairs, quills, claws, hooves, baleen, etc.) and carry out a wide range of functions (thermoregulation, feeding, defense, etc.). These "alpha-keratin" structures consist mainly of 10 nm keratin filaments embedded in a high-sulfur protein matrix. Recent work suggests that isolated keratin filaments are soft and highly extensible, which raises the question of how alpha-keratins get to be as stiff as they are. One hypothesis is that the network of high sulfur matrix proteins maintains the keratin filaments in a dehydrated, and therefore stiff state, even at high humidity. We tested this "matrix squeeze" hypothesis by measuring the material properties of a variety of mammalian keratins (including hairs, quills, horns, and baleen) possessing a wide range of matrix contents. Our data are consistent with the matrix squeeze hypothesis and suggest that alternative mechanisms may be at play in whale baleen.

Social signaling for urea excretion in gulf toadfish (*Opsanus beta*)

Signalisation sociale pour l'excrétion de l'urée chez le poisson-crapaud (*Opsanus beta*)

Jeremy Fulton and Patrick Walsh

University of Ottawa

The gulf toadfish (*Opsanus beta*) is a member of a very exclusive group of teleosts that have retained their ornithine urea cycle (OUC) through to adult hood and from this the ability to excrete nitrogenous waste in the form of urea (ureotely). The entire days urea-N is excreted in 1-2 fairly quick pulsing events (1-3hr), which occur exclusively via the gills. This study evaluated the hypothesis that urea-N pulsing events in gulf toadfish act as a social signal to conspecifics via a specific waterborne messenger. Using a crowding protocol to induce ureotely, we found that preconditioned water was exclusively responsible for inducing a secondary urea pulsing event in naive conspecifics (social signal; $p=0.031$). Furthermore, using urea-N as a metric for this signaling molecule, it was revealed that other factors such as signal concentration may relay information pertaining to the size, fitness or gender of the pulsing fish to its recipients.

Are mummichog (*Fundulus heteroclitus*) more susceptible to sewage effluent when exposed under different environmental conditions?

Est-ce que les choquemorts (*Fundulus heteroclitus*) sont plus susceptibles aux effluents d'eaux usées lorsqu'ils sont exposés à différentes conditions environnementales?

¹Melanie Gallant, ¹Kavish Chandra, ²Thijs Bosker, ³Deborah MacLatchy and ¹Suzie Currie

¹Mount Allison University, ²University of New Brunswick Saint John, ³Wilfrid Laurier University

The estuarine mummichog (*Fundulus heteroclitus*) experiences daily, often dramatic changes in temperature, salinity and dissolved oxygen. This fish must also cope with environmental toxicants such as sewage effluent, known to contain estrogen mimics. When fish are exposed to these chemicals, males feminize and express the egg yolk precursor protein vitellogenin. Our goal was to determine the susceptibility of the mummichog to effluent at different temperatures (15°C and 26°C) and salinities (0, 16 and 32 ppt). We exposed fish to 3 concentrations of sewage effluent (3% treated, 30% treated and 30% untreated) and measured vitellogenin gene expression in liver using qPCR. To date, we conclude that warm temperatures lead to increases in vitellogenin and thus susceptibility to sewage effluent. We also observed that, overall, vitellogenin gene expression was lower when fish were exposed in brackish water compared to fresh and salt water suggesting that salinity also influences susceptibility to estrogenic contaminants.

Acetaminophen causes mortality and developmental abnormalities in zebrafish (*Danio rerio*) through the inhibition of cyclooxygenase activity

L'acétaminophène provoque la mort et des anomalies de développement chez le poisson zèbre (*Danio rerio*) par l'inhibition de l'activité de la cyclo-oxygénase

Michal Galus, Akash Gugilla and Joanna Wilson

McMaster University

Acetaminophen (ACE) is an analgesic and anti-inflammatory medication that inhibits cyclooxygenase (COX) activity. COX enzymes catalyze the synthesis of prostaglandins (PGs), which are essential for normal development during gastrulation. Embryonic zebrafish exposed to 0.5 and 10 µg L⁻¹ ACE had a 13.5 and 6.0 fold increase in the occurrence of developmental abnormalities when compared to controls. Embryo mortality was 8.0 (0.5 µg L⁻¹) and 5.8 (10 µg L⁻¹) fold higher with ACE exposure. Embryo mortality was preceded by edema in the blastoderm. However, if exposed embryos were supplemented with PGE₂, the blastoderm edema and mortality were not observed. The apparent rescue of blastoderm edema and embryo mortality by PGE₂ strongly suggests that the effects of ACE are mediated through the inhibition of COX activity. We are currently investigating the mechanistic activity of ACE by manipulating COX expression using oligonucleotides during embryogenesis.

In vitro cultivation of *Hematodinium* sp. isolated from *Chionoecetes opilio*: characterization of developmental stages

La cultivation de *Hematodinium* sp. isolés à partir de *Chionoecetes opilio*: caractérisation de stades de développement

¹Peter H. Gaudet, ¹Spencer J. Greenwood, ²Frank J. Morado, ¹Dorota Wadowska and ¹Richard J. Cawthorn

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Hematodinium sp., a parasitic dinoflagellate of economically important crustaceans, was first reported in 1931, and has since spread globally. Infected crustaceans display gross pathological changes (such as milky hemolymph and cuticle discolouration) during late stages of infection. Although understanding *Hematodinium*'s life history and survival strategies could benefit fisheries management, few studies have isolated and cultured *Hematodinium* sp. in vitro and followed its subsequent development. Infected hemolymph was processed for transmission electron microscopy at time 0, then cultured *in vitro*. Cultures were monitored for developmental transitions and further samples were processed every two weeks for transmission and scanning electron, and light microscopy. Trophonts were present in infected hemolymph, which gave rise to syncytial networks, aggregates, clump colonies, schizonts, sporoblasts, and dinospores. Furthermore, development progressed faster at elevated temperatures (0°C vs. 4°C). These findings provide insight into possible transitional stages *in vivo*, and provide clues into factors that might influence parasite behavior.

Investigating DPG sensitivity as an adaptive attribute for fossorial life in mole hemoglobins

Enquête sur la sensibilité au DPG de l'hémoglobine en tant qu'attribut adaptatif à la vie fouisseuse de la taupe

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It has been proposed that a reduced interaction of European mole (*Talpa europaea*) hemoglobin with 2,3-diphosphoglycerate (DPG) – which arises from two amino acid residues (β 4Ser and β 5Gly) adjacent to the DPG binding site – is an “adaptation for fossorial life”, as it promotes oxygen loading in hypoxic tunnel networks. To test this hypothesis, we deduced the primary hemoglobin sequences of the gracile shrew-like mole (*Uropsilus gracilis*), a member of the most ancestral lineage of talpid moles, and measured the intrinsic oxygen affinity and sensitivity of this protein to allosteric effectors. Our comparative analysis indicates that the presence of β 4Ser and β 5Gly (together with other residues implicated in DPG binding) and a low DPG sensitivity both predate the radiation of this group, and thus do not represent specific adaptations for fossorial life per se. In contrast, the high oxygen affinity of European mole blood is attributed to an elevated intrinsic oxygen affinity of its hemoglobin.

Atypical molecular evolution of the laurasiatherian β -globin family: implications for oxygen delivery?

L'évolution moléculaire atypique de la famille β -globine de laurasiatherias: implications pour la livraison d'oxygène

Michael J Gaudry and Kevin L Campbell

University of Manitoba

The HBD (δ) and HBB (β) globin gene pair arose via duplication of a proto β -globin loci in a common ancestor of eutherian mammals. The HBB gene is regarded as being the primary contributor of “ β -type” subunits for late-expressed hemoglobin, whereas HBD is thought to play a negligible role. We have previously reported an exception to this rule in paenungulate mammals (elephants, sea cows and hyraxes), which express a chimeric HBB/HBD fusion gene that arose from an unequal crossover of parental HBD and HBB loci. Here we present a phylogenetic analysis of the β -globin family from 14 species of laurasiatherian mammals, revealing that chimeric HBB/HBD fusion genes arose independently at least twice in this group (cetaceans and carnivores) and confirming that the HBB loci was lost in eulipotyphlans (moles, shrews and hedgehogs). These findings challenge widely accepted views on β -globin family evolution and may have had physiological implications for oxygen transport in these mammalian lineages.

Changes in body composition and the metabolic response to water loss during short duration flights in the American Robin (*Turdus migratorius*)

Changements dans la composition du corps et la réponse métabolique à la perte d'eau lors de vols de courte durée chez les merles d'Amérique (*Turdus migratorius*)

Alexander Gerson and C.G. Guglielmo

University of Western Ontario

During avian flight lipids and protein are catabolized. We have recently shown that the rate of protein catabolism in flight is an adaptive metabolic strategy to provision water. To more fully understand the effect of water loss on the metabolic response to flight, American robins were flown in a climatic wind tunnel under high and low humidity conditions for up to 1.5 h. Body composition and plasma metabolite levels were measured before and after flights. There were significant reductions in mass, lean mass, and fat mass with flight duration, but no significant differences between humidity regimes were apparent. Plasma β -Hydroxybutyrate and non-esterified fatty acids increased and glucose decreased during flight, irrespective of flight duration or humidity regime. Despite dramatic effects of ambient conditions on rates of lean mass catabolism during long duration flights, plasma metabolites of birds flown for short duration remained unaffected by ambient conditions experienced during flight.

Comparison of two measurements of depth to the redox potential discontinuity in intertidal mudflat sediments

Comparaison de deux mesures de la profondeur à la discontinuité du potentiel redox dans les sédiments des vasières d'estrans

¹Travis G Gerwing, ¹Alyssa M. Allen, ²David Drolet, ²Diana J. Hamilton and ¹Myriam A. Barbeau

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The redox potential discontinuity (RPD) is the vertical transition from oxygenated sediment to hypoxic or anoxic sediment. Depth to the RPD is an important measure in studies of intertidal mudflats as most biotic and abiotic variables are influenced by or influence the RPD. Two common methods to measure depth to the RPD in mudflat sediment are with a redox probe or visually. A change from positive to negative redox values usually indicates a transition to hypoxic or anoxic sediments. A change in sediment colour from brown to black is a visual indication of the RPD. We compared the two methods (measured within 1 cm of each other) on 9 intertidal mudflats in the upper Bay of Fundy, Canada. Forty randomly selected locations were examined at each site, and sites were visited every 3 to 6 wk (2009-2011). A significant difference was found between the two methods (t-test). 90% agreement between the two methods was only achieved when the definition of a "match" was relaxed to ± 5 cm. Our study was not designed to test the accuracy of either method; however, care must be taken when using RPD data, as measurements are dependent on the methodology employed.

Nature and possible causes of the annual winter die-off of benthic invertebrates on intertidal mudflats in the bay of fundy, canada

La nature et les causes possibles de la mortalité hivernale annuelle des invertébrés benthiques dans les vasières d'estrans de la Baie de Fundy, Canada

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Invertebrates inhabiting intertidal mudflats experience intense stress during the winter months, and populations have been observed to decline during this period. Our objective was to quantify these declines, and examine possible biotic and abiotic causes. Eight mudflats were monitored before, during and after ice presence (January-March 2010 and 2011) in the upper Bay of Fundy. Proportion of a mudflat covered in ice, and ice type were quantified using aerial surveys. Density and depth of ice scour on the mudflat surface were quantified by ground surveys. Wind exposure and air temperature were measured using cotton tatter flags and temperature loggers, respectively, at each site. Density of invertebrates was quantified (2 transects/site, 12 sediment samples/transect) before and after the ice season. Over winter, most invertebrate taxa declined, a minority showed no change, and one increased. Changes in community structure were not consistent, varying by year and site (PRIMER analysis). Wind, amount and type of ice, scour intensity, and density of other species correlated with taxa-specific declines (principle component analysis). The findings of these analyses will be used to generate testable hypotheses to explain the observed changes in the intertidal mudflat community over winter.

Calcium homeostasis in *Daphnia magna* embryogenesis

L'homéostasie du calcium dans l'embryogénèse de *Daphnia magna*

Jamie-Lee Giardini and Andreas Heyland

University of Guelph

Ambient calcium is declining in soft-water lake habitats. *Daphnia* require environmental calcium for various physiological functions, including fortifying the cuticle. As they are representative of freshwater zooplankton health, *Daphnia* make ideal models for investigating ecological implications of calcium decline. While several studies have investigated extreme calcium deficiency to lethal endpoints within one generation in adults, few have investigated the potential multi-generational effects of calcium deficiency to non-lethal endpoints in embryos. We aim to characterize calcium throughout daphniid asexual embryogenesis and determine how embryonic calcium deficiency may influence future reproductive success. Preliminary tests suggest that calcein can be used as a marker for unbound calcium in *D. magna* and we detected significant amounts of it in gut epithelia. These data allow us to further investigate the calcium storage/uptake mechanisms in *D. magna* and assess how calcium deficiency during embryogenesis affects development and adult fitness both in one and over multiple generations.

Nurse egg formation and apoptosis in a spionid annelid (*Polydora cornuta*)

Formation d'œufs nourriciers et apoptose chez les polychètes spionides (*Polydora cornuta*)

Glenys Gibson, Corban Hart, Claire Coulter and Haixin Xu

Acadia University

Nurse eggs, or trophic eggs, are produced by a wide range of taxa and provide a critical source of extra-embryonic nutrition for developing young. We tested the hypothesis that nurse eggs of *Polydora cornuta* (Annelida, Spionidae) form through an active developmental process (apoptosis) and thus are an adaptive extension of the maternal or zygotic phenotype. Results of a TUNEL assay indicate nuclear fragmentation occurs in a process that is characteristic of apoptosis. Cellular indicators of apoptosis in nurse eggs include activation of caspase-3, a positive Annexin V reaction indicating exposure of phosphatidylserine on the outer cell membrane, and membrane invagination to form yolk vesicles. Furthermore, while apoptosis also occurs in some cells of *P. cornuta* embryos, it was not detected until later in development. These data suggest that nurse eggs originate through heterochrony in a developmental process (apoptosis) that is common to all *P. cornuta* young.

Development of an embryonal cell line from *Fundulus heteroclitus* with myogenic potential

Le développement d'une lignée cellulaire embryonnaire de *Fundulus heteroclitus* avec un potentiel myogénique

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¹Wilfrid Laurier University, ²University of Waterloo, ³McMaster University

The common killifish or mummichog (*Fundulus heteroclitus*), is an estuarine teleost increasingly used in comparative physiology, toxicology and embryology. Their ability to withstand extreme environmental conditions and ease of maintenance have allowed many studies at the organismal level, but complementary cellular level studies have been few. This may be partially due to the lack of available *F. heteroclitus* cell lines. The development and preliminary characterization of KFE-5 (killifish embryo-5), a cell line derived from the mid trunk of a late stage embryo, is reported here. KFE-5 has been passaged over 20x in a span of 10 months. The cells are mostly fibroblastic and contain myoblast-like cells with distinct striations. Conditions enhancing myotube differentiation are being explored as well as their responses to various chemicals and hormones for possible use in toxicology and endocrinology. KFE-5 could become a very convenient model for comparative studies at the cellular, proteomic and genomic levels.

Effects of temperature and tidal exposure on survivorship and behaviour of *Corophium volutator*

Les effets de la température et de l'exposition aux marées sur la survie et sur le comportement de *Corophium volutator*

Christine Gilroy and Diana Hamilton
Mount Allison University

The amphipod *Corophium volutator* is a sediment-dwelling resident of mudflats in the upper Bay of Fundy, and an important food source for migrating shorebirds. Although we know that thermal stress affects *Corophium* vital rates, little is known about how increased temperatures affect behaviour of individuals, and thus their availability as food. We investigated the effect of increased temperature on *Corophium* crawling following tidal recession, their vertical distribution within the sediment, and survivorship. A series of laboratory trials exposed *Corophium* to specific temperature treatments. Throughout trials we recorded surface activity, and at the conclusion, sediment cores were taken to assess the vertical profile and survivorship. Increased temperature led to reduced survivorship, and caused survivors to move deeper into the sediment and cease crawling sooner after exposure. Further increases in temperature may therefore reduce availability of this prey for migrating shorebirds that access them only in the upper layers of the sediment.

Biometric, enzymatic and transcriptomic study of natural stressors in yellow perch

Étude biométrique, enzymatique et transcriptomique des sources de stress naturelles de la perchaude

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Water contamination by metals is well known for its effects on fish health. We have developed a 1000-gene microarray, which, coupled with biometric and physiological endpoints, will ultimately allow us to propose specific biomarkers of the effects of individual metals in wild yellow perch (*Perca flavescens*) exposed to complex metal mixtures as well as natural stressors. To this end, it is essential to characterize the influence of natural stressors on both yellow perch condition and metal-responsive biomarkers. In this project, we examined the effects of temperature, hypoxia and food restriction on yellow perch under controlled laboratory metal exposures using genomic, enzymatic and biometric endpoints. While the overall response of yellow perch to hypoxia and food restriction was modest, temperature induced differential expression of 388 genes particularly involved in apoptosis, glucose and lipid metabolisms and oxidative stress response. The relationship between genomic and physiological responses to heat stress, as well as the implications for the development of metal-specific biomarkers, will be discussed.

Regulation of mitochondrial phospholipids in face of changes in dietary lipids

La régulation de phospholipides mitochondriaux face à des changements en lipides alimentaires

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Of all macromolecules, the adage, “we are what we eat” applies most to lipids, as the quality of dietary lipids markedly influences the fatty acid (FA) composition of triglycerides and phospholipids (PL) in many taxa. We fed rainbow trout two diets, differing only in lipid quality, one having substantially higher levels of polyunsaturated fatty acids (PUFA) than the other. The FA composition of mitochondrial phospholipids changed dramatically, with many FA (particularly 22:6n-3) following the diets. Several FA (22:5n-6 and other n-6 PUFA) changed in the opposite direction to the diets and some remained stable despite dietary differences. When 22:6n-3 rose, n-6 PUFA decreased, leading % PUFA to change much less than in the diets. The diet with higher PUFA decreased the % phosphatidylethanolamine and increased the % phosphatidylcholine in mitochondrial phospholipids, potentially compensating for the higher levels of 22:6n-3 with its membrane destabilising influences. Trout seem to regulate the modifications of mitochondrial phospholipids when faced with a changed quality of dietary lipids.

Variation in mitochondrial genotype is associated with metabolic rate variation in killifish

Variation de l'ADN mitochondrial est associée à la variation métabolique dans les choquemorts

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Mummichogs (*Fundulus heteroclitus*) are small fish that are abundant in Atlantic coastal marshes from the Gulf of St. Lawrence to northern Florida. There are two subspecies (a northern form and a southern form) with a zone of hybridization in New Jersey. We have previously shown that northern fish have a higher routine metabolic rate than do southern fish. Here we use individuals from the hybrid zone to demonstrate that variation in metabolic rate is strongly associated with mitochondrial genotype, such that individuals carrying the northern mitochondrial genotype have a metabolic rate that is approximately 40% greater than that of individuals with the southern genotype. In contrast, there was no relationship between metabolic rate and nuclear genotype, as determined using 30 independent single nucleotide polymorphisms (SNPs). These data suggest that differences in mitochondrial processes may, at least in part, account for the observed differences in metabolic rate between the subspecies.

External stimulants and internal transitions in metamorphosis of marine invertebrate animals

Stimulants externes et transitions internes dans la métamorphose des animaux marins invertébrés

Micheal G. Hadfield

University of Hawaii

Paleontological evidence is now solid that bacteria first appeared on earth more than 4.5 billion years ago and rapidly evolved to create dense communities that coated sea bottoms with a great diversity of phylotypes. The first eukaryotes joined these communities about 1.5 billion years ago, and from them, less than 900 million years ago, the first animals evolved. Thus the history of animal life on earth is one of evolution within a densely populated microbial world. It is not surprising that animals have continued to have intimate relationships with bacteria throughout their lives. We should have expected such relationships to occur during settlement and metamorphosis of marine invertebrate animals, when minute larval stages descend to a benthos densely coated by microbial films. And, it should not be surprising that we find the stimulus for attachment and metamorphosis to arise from benthic bacteria for many -- probably most -- marine invertebrate animals. This distinguishes them from vertebrates and insects whose metamorphic transitions are triggered by hormonal or neuroendocrine factors whose appearance is developmentally timed. A gene set has been identified in a specific bacterial species that encodes products upon which larvae of a sessile marine polychaete, probably a coral and perhaps larvae from other phyla, depend to trigger benthic attachment and metamorphosis. Marine-invertebrate larvae must detect these signals on external receptors, probably born on cilia or flagella, and rapidly transduce them into internal processes that, in most marine invertebrates, consist principally of loss; larva-specific tissues and organs rapidly break down and disappear, liberating already present tissues and organs that make up the body of the juvenile. The massive and complex structures that must rapidly appear during metamorphosis in insects and many vertebrates present a strong contrast with the transformation of invertebrates.

Effects of subzero temperatures on *Hepatozoon* species (phylum *Apicomplexa*) in freeze-tolerant wood frogs, *Rana sylvatica*

Effets de températures sous zéro sur les espèces de *Hepatozoon* (embranchement: *Apicomplexa*) chez la grenouille des bois (*Rana sylvatica*) capable de survie au gel

Chelsea Hammer, Laura Ferguson, Christopher Ogbuah, Cory Dickson, Donald Stewart and Todd Smith

Acadia University

Hepatozoon species are common intraerythrocytic parasites of green frogs (*Rana clamitans*) and bullfrogs (*Rana catesbeiana*), but have a low prevalence and parasitaemia in wood frogs, perhaps because they do not survive when wood frogs freeze during the winter. Objectives were to determine host specificity of two Hepatozoon species for wood frogs, and to observe effects of subzero temperatures on these parasites. Four of 24 adults were naturally infected with *H. catesbiana*. Nineteen laboratory-reared metamorphs were fed mosquitoes containing mixed infections of *H. clamatae* and *H. catesbiana*. Eight became infected with *H. catesbiana* at a moderate parasitaemia, whereas only two became infected with *H. clamatae*, both at very low parasitaemia. Four infected metamorphs and two infected adults were frozen at -3°C for 2 days; identical numbers were not frozen and served as controls. Parasitaemia in frozen metamorphs and adults dropped considerably relative to controls, suggesting that subzero temperatures negatively affect Hepatozoon species.

Mapping evolutionary rates: Hoxa11 and Hoxa13 across the fin-limb transition as a case study

La cartographie des taux évolutionnaires: Hoxa11 et Hoxa13 à travers la transition nageoire-membre comme étude de cas

Luke B Harrison and Hans CE Larsson
McGill University

The proliferation of advanced Bayesian statistical approaches to phylogenetic inference and divergence time dating opens a new avenue for the analysis of rates of evolution. Previous approaches to evolutionary rate typically, although not exclusively, relied on a priori age calibrations for each node in the phylogeny, a set of calibrations and certain molecular clock assumptions or were directly derived from divergence time analysis. Here we redeploy existing Bayesian methods to derive a posterior distribution of chronograms from a reference data set (e.g. housekeeping genes / mtDNA) and new methods to map a gene of interest (of potentially different taxonomic sampling) onto this distribution of evolutionary timescales. This allows us integrate phylogenetic, calibration and parameter uncertainty and to estimate evolutionary rates of even highly nonclock-like genes. The importance of this approach is demonstrated using the fin-limb transition and limb developmental patterning genes where deep, short branches confound rate analysis.

Epigenetics and developmental plasticity in *Polydora cornuta* (Annelida): A link between environment and phenotype

L'épigénétique et la plasticité développementale chez *Polydora cornuta* (Annelida): un lien entre l'environnement et le phénotype

¹Corban Hart, ²Vett Lloyd, ¹Glenys Gibson
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We tested the hypothesis that differences in histone methylation (e.g., monomethylation of histone H3 at lysine 9; H3K9) contribute to developmental plasticity in *Polydora cornuta*. Using immunohistochemistry and confocal microscopy, we examined differences in histone methylation in structures that show divergent phenotypes among larvae. We found that small, planktotrophic larvae exhibit hypomethylation of H3K9 in several structures (e.g., the chaetal sacs and gut) much earlier than their larger, adelphophagic conspecifics. These differences correlated with phenotype: planktotrophic larvae produced significantly more chaetae than did adelphophagic larvae, and were much faster to form a differentiated gut tube and coelom. Moreover, exposure to BPA caused hypomethylation of these tissues much earlier in adelphophagic larvae, and produced a more "planktotrophic" phenotype in these young. These results suggest that histone methylation may provide a mechanism by which developmental plasticity arises in *Polydora cornuta*, and provides a molecular link between environment and phenotype.

Aquaporin-facilitated water movement across the membrane of Pacific hagfish slime mucin vesicles

Le mouvement de l'eau, facilité par l'aquaporine, à travers les membranes des vésicules de mucus de mucine de la myxine du Pacifique

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¹University of Guelph, ²University of Alberta

Hagfish slime gland secretions are composed of mucins and intermediate filament-based protein threads which, when released from the animal, mix with seawater to rapidly form a large mass of defensive slime. The mucins are packaged into large vesicles that are produced by gland mucous cells and are released intact from the gland. When the mucin vesicle comes into contact with seawater, it ruptures due to the effects of calcium and other ions in seawater. We hypothesized that the action of these ions is accompanied by a rapid influx of water into the vesicle through aquaporins (AQP), causing the hydration of mucins. We found that treating mucin vesicles with AQP-inhibiting mercuric chloride caused a decrease in the swelling rate of vesicles, suggesting that aquaporins play a role in facilitating water movement across the mucin vesicle membrane. These data are supported by molecular evidence of AQP-like protein expression in the slime gland.

Molecular prospecting: using global gene expression profiling to identify stage specific developmental processes in American Lobster (*Homarus americanus*) larvae.

Prospection moléculaire: identification de processus d'étapes de développement spécifique dans les larves du homard américain (*Homarus americanus*) en se servant de profils d'expression globale de gènes

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Larval stages of the American lobster (*Homarus americanus*) are characterized by pronounced physiological, behavioural and morphological changes during development and metamorphosis. The processes that regulate and contribute to developmental changes are not fully understood. This is the first study to investigate the global gene expression differences between the three larval and first postlarval stages of American lobster, using a spotted oligonucleotide microarray. The microarray was 40% functionally annotated using GenBank and Gene Ontology databases. A total of 1841 genes were differentially expressed between larval stages. Several genes related to immune, developmental and nutritional processes were activated at different stages of development. Functional annotations were used as a guide to select target genes for verification with RT-qPCR. This information will provide an important basis for directed investigations of larval lobster developmental events. A more thorough understanding of larval development may provide insight into their response to environmental and immune stressors.

Impact of moderate temperature increase on the Atlantic cod (*Gadus morhua*) spleen transcriptome response to a viral mimic

Les impacts de hausse modérée de température sur la morue de l'Atlantique (*Gadus morhua*) en terme de la réponse transcriptome splénique à un imitateur de virus

¹Tiago Hori, ¹Kurt Gamperl, ²Luis Afonso, ³Stewart Johnson and ¹Matthew Rise

¹Memorial University of Newfoundland, ²Deakin University, ³DFO

Stress and disease can, in extreme situations, lead to high levels of fish mortality. Therefore, characterization and study of the stress- and immune-related transcriptome is necessary to better understand the impacts of changes in the environment on fish health. To do so we used a functional genomics approach (i.e. construction and characterization of cDNA libraries, and microarray and QPCR analyses of mRNA expression). We report studies on the effects of heat-shock on cod liver, head kidney and skeletal muscle mRNA expression, and the impacts of increased temperature on the spleen transcriptome response to a viral mimic. We found that heat-shock dysregulates a common set of chaperone-like genes in the studied tissues. Moreover, we have demonstrated that increased temperature causes a shift in the timing of the spleen response to a viral mimic. These findings are valuable to better understand the impacts of increases in temperature on the health and survival of farmed and wild Atlantic cod.

Characterization of the Atlantic cod glucocorticoid receptor (GR) cDNA and its expression during embryonic and early larval development

Caractérisation de l'ADNc du récepteur glucocorticoïde (RG) de la morue de l'Atlantique et son expression au cours du développement embryonnaire et larvaire

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Cortisol is the main glucocorticoid in fish, and is known to influence a multitude of physiological processes. Most of the actions of cortisol are believed to be mediated by its interaction with the glucocorticoid receptors (GRs). We cloned and characterized a partial cDNA representing a putative GR from Atlantic cod. Using this sequence, we then identified two predicted transcripts representing GRs (87% similar at the nucleotide level) in the Atlantic cod draft genome. Phylogenetic analysis indicated that these transcripts represent putative orthologs of the GR1 and GR2 found in most teleosts. QPCR analysis of the early life-stage expression of GR1 in Atlantic cod showed that this transcript is present in day 0 (i.e. mixed cleavage) embryos and increases to day 11 (hatch event), stabilizing thereafter. These results suggest that early life exposure to cortisol (e.g. from stressed female broodstock) could have an impact on the development of Atlantic cod.

The role of early post-settlement events in recruitment of benthic marine invertebrates

Le rôle des premiers événements de post-colonisation dans le recrutement d'invertébrés benthiques marins

Heather L. Hunt

University of New Brunswick Saint John

Recruitment variability can play an important role in the population and community dynamics of benthic invertebrates. Recruitment patterns are influenced not only by larval supply and settlement patterns but also by rates and patterns of early post-settlement mortality and, particularly in soft bottom habitats, dispersal. I will discuss the influence of dispersal and mortality during the early post-settlement period by presenting data from several studies examining the role of early post-settlement events. Spatial variation in rates and distances of dispersal of juvenile bivalves among intertidal sandflats in a New Zealand estuary will be examined. I will also discuss experiments conducted in the rocky subtidal zone of the Bay of Fundy. These experiments test the effects of the community of small organisms living amongst cobbles (primarily grazers) on mortality of recently settled urchins and of larger predators on the community of organisms recruiting to rock-filled collectors.

Reduced sensitivity to emamectin benzoate in sea lice (*Lepeophtheirus salmonis*) is linked to over-expression of P-glycoprotein

La sensibilité réduite à l'émelectine benzoate chez le pou de saumon (*Lepeophtheirus salmonis*) est liée à la surexpression de la glycoprotéine-P

Okechukwu Igboeli, Mark Fast and John Burka

University of Prince Edward Island

There have been reports of reduced sensitivity to the *Lepeophtheirus salmonis* parasiticide, emamectin benzoate (EMB). We hypothesize that prolonged use of EMB selected for a resistant sea lice population over-expressing P-glycoprotein (P-gp). Relative P-gp mRNA expression was determined in adult male and female *L. salmonis* following a 24 h EMB bioassay. Bioassay results indicated a 4 to 26 fold higher EMB EC50 values in 2011 compared to 2002 -2004 results, when the drug was still effective. The parasiticide had a significant concentration-dependent effect on P-gp mRNA in the parasite. Bioassay using a competitive inhibitor of P-gp, verapamil, was also carried out. Exposure of adult male and female *L. salmonis* to verapamil along with EMB caused > 2-fold higher % mortality than when the parasites were exposed to EMB alone. Our results suggest that EMB resistance in *L. salmonis* is linked to selection for resistant strains of the parasite over-expressing P-gp.

Building bone from the ground substance up: extracellular matrix production and cell arrangement in early intramembranous condensations

Construction d'os à partir de substances fondamentales: production de la matrice extracellulaire et arrangement cellulaire lors de la condensation intramembranaire initiale

James Jabalee and Tamara Franz-Odegaard
Mount Saint Vincent University

Intramembranous (direct) bone formation requires that neural crest cells condense and produce a collagen-I rich extracellular matrix. Although the literature describes cell morphogenesis in early mesoderm-derived chondrogenic condensations, studies regarding neural crest-derived osteogenic condensations have failed to keep pace. I use light and electron microscopy to describe cell arrangement and polarization in early condensations of two neural crest-derived, intramembranous bones, the scleral ossicles of the chick (*Gallus gallus*) and the opercle of the zebrafish (*Danio rerio*). My results in chick embryos suggest cells are polarized and collagen secretion occurs parallel to the long axis of the condensation. Zebrafish data are presented in a comparative context. This work elucidates some of the fundamental mechanisms of intramembranous ossification at the cellular level, furthering our knowledge of this important process. This work was primarily funded by the Nova Scotia Health Research Foundation (Canada) and the Natural Sciences and Engineering Research Council of Canada.

Do weather conditions during low tide explain variation in early juvenile mortality of barnacles?

Est-ce que les conditions climatiques durant la marée basse expliquent la variabilité dans les taux de mortalité précoce des cirrhipèdes juvéniles?

Brittany Jenewein and Louis Gosselin
Thompson Rivers University

Populations of marine intertidal invertebrates vary substantially in abundance from year to year and between locations. These differences might be partly due to cohorts experiencing 60 – 99% mortality through the first few days of life. However, the causes of this mortality, including the role of weather conditions experienced during low tide, are not well understood. This study aimed to determine (1) if weather conditions during low tide influence cyprid and early juvenile mortality, (2) if sublethal stress affects survivorship of recruits, and (3) if *Fucus* cover influences cyprid and early juvenile mortality. A field survey of the 2011 cohorts showed the proportion completing metamorphosis was much higher than previous studies, and sublethal stress does not influence juvenile survivorship. Additionally, *Fucus* cover increases mortality of cyprid settlers. If weather conditions are a factor in mortality, we may be able to predict the effects of climate change on future populations.

Characteristics of air breathing in Lake Magadi tilapia: is there a relationship with diel patterns in reactive oxygen species (ROS) in the lake?

Les caractéristiques de la respiration d'air chez les tilapias du lac Magadi: est-ce qu'il y a une relation avec les fluctuations journalières en dérivés réactifs de l'oxygène?

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The Lake Magadi tilapia *Alcolapia grahami* inhabits an extreme environment conducive to high levels of ROS: high temperatures (winter afternoon, 30°C – 36°C and summer up to 42°C), high pH (10.0), high algal productivity and high UV radiation. Strong diurnal patterns in ROS were observed in the 3 locations studied. Air-breathing is a prominent feature of the fish and was first reported in association with hypoxic early morning conditions. More recently, we observed daytime air-breathing under normoxic and hyperoxic conditions. Groups of fish gathered in protected areas to air-breathe and were composed more of smaller fish than larger fish. We consider whether high ROS levels could be related to daytime air-breathing and better define the characteristics of these air-breathing groups through the day.

Chronic hypoxia exposure during embryonic development impairs aerobic capacity of trout fry

L'exposition chronique à l'hypoxie lors du développement embryonnaire altère la capacité aérobie des truites juvéniles

Elizabeth Johnston and Todd Gillis

University of Guelph

Chronic exposure of trout embryos to hypoxia (30% O₂ saturation) alters the cardiac response of embryos and larvae to adrenergic and cholinergic control. To determine the consequences of such changes on the aerobic capacity of hatched fry we have characterized the influence of hypoxia exposure until hatch (~57 days post fertilization; DPF) on maximum sustained swimming speed (Ucrit) of trout fry. The hypoxia treated fry were stage matched to controls to compensate for delayed development. We found that the Ucrit of control fish at stage 36 and 37 (65 and 85 dpf) was greater than that of hypoxia exposed fish (70 and 90 dpf). However, there was no difference in the Ucrit of control and treatment fish at a developmental state equal to 105 DPF in the control. This demonstrates that while hypoxia exposure during embryonic development impairs the fitness of hatched fry, the affected fish catch up over time.

Deciphering the induction and patterning of epithelial placodes required for bone development

Déchiffrement de l'induction et de la structuration des placodes épithéliales nécessaires pour le développement des os

Karyn Jourdeuil and Tamara A. Franz-Odenaal

Dalhousie University, Mount Saint Vincent University

The conjunctival papillae, epithelial thickenings on the surface of the eye, are required for the induction of the underlying neural crest-derived, intramembranous bones. Very little has been done to understand the induction and patterning of the conjunctival papillae. Thus the purpose of this study is to determine the cellular and molecular factors that control the induction and patterning of these papillae. To date, we have discovered that the nasal region may be involved in the induction of the conjunctival papillae and have determined that there is a developmental window during which papillae develop and epithelial competency is established. These findings will be used as a basis for a molecular approach, to determine which genes are responsible for induction and patterning of the papillae. This will allow us to gain insight into the mechanisms of induction and patterning of intramembranous bones.

Catecholaminergic peripheral neuroanatomy in the nudibranch *Tritonia diomedea*

La neuroanatomie périphérique catecholaminergique chez le nudibranche *Tritonia diomedea*

Emily Kehoe, Marissa Webber and Russell Wyeth

St. Francis Xavier University

The peripheral nervous system in the nudibranch *Tritonia diomedea* likely plays an important role in the slug's behaviours, yet we know little about the nervous system outside the brain of this neuroethological model system. Previous studies indicate that peripheral catecholaminergic cells are widespread in gastropods and thus our immediate goal was to map the peripheral catecholaminergic neuroanatomy in *Tritonia*. Using anti-tyrosine hydroxylase immunohistochemistry, we found numerous cells with putative dendrites that penetrate the epithelia of the cephalic sensory organs: the oral veil and rhinophores. Furthermore, we observed two additional types of cells in the rhinophore ganglion which may be involved in either sensory processing or motor control of the rhinophore. Our description of these putative catecholaminergic peripheral cells will facilitate interpretation of future pharmacological manipulations of the sensory cells designed to test both the cells' role during navigation behaviour and the sensory modality of this cell type found throughout the gastropods.

The trich to safe bird feeding: survivability of *Trichomonas gallinae* in bird feed and water

Affouragement des oiseaux sans danger: La capacité de *Trichomonas gallinae* à survivre dans la grain et l'eau

^{1,2,3}Whitney Kelly-Clark, ^{1,2}Spencer Greenwood, ^{1,2,3}Scott McBurney, María Forzán, ^{1,2,3}Raphael Vanderstichel and ²K. Teather

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In the summer and fall of 2007–2009 and 2011, trichomonosis caused mortality in purple finch (*Carpodacus purpureus*) and American goldfinch (*Carduelis tristis*) populations in the Canadian Maritime provinces. Trichomonosis, caused by *Trichomonas gallinae*, was identified at backyard feeding and watering stations, raising questions about the role of these sites in disease transmission. It is commonly hypothesized that indirect bird-to-bird transmission associated with contaminated bird seed, water bowls, or bird baths plays a significant role in the increased incidence of this disease. Therefore, parasite survivability in and isolation from birdfeed and water was investigated. Parasites were added to water and dry/moist bird seed at two concentrations (1,000 parasites/mL; 10,000 parasites/mL) to examine parasite survivability. Results indicate that parasites can survive ≤ 48 hours in moist bird seed and are unable to survive in dry bird seed or clean, clear water.

Assessing shape change of cartilage in the first and second pharyngeal arches in larval zebrafish, *Danio rerio*

Évaluer le changement de forme du cartilage dans les premiers et deuxièmes arcs branchiaux chez le poisson zèbre *Danio rerio*

¹Zoe Kennedy, ¹Megan Dufton and ²Tamara Franz-Odenaal

¹Dalhousie University, ²Mount Saint Vincent University

While many of the developmental pathways that control bone formation are highly conserved among vertebrates, many of their developmental processes remain unclear. In order to assess how the shape of these structures changes over time, we studied the development of the cartilage framework of the first and second pharyngeal arches in the zebrafish, *Danio rerio*. Acid-free double-stains on larvae lengths 3.0 mm standard length (SL) to 4.0 mm SL were used to examine the overall structure of the first two pharyngeal arches, while proliferating and apoptotic cells were visualized using the vital stain acridine orange. Our results show that proliferating chondrocyte are most concentrated in the diaphysis of the cartilages while there is very little apoptosis throughout the element. This study provides detailed insights into the cellular growth patterns of the skeleton, improves our understanding of pharyngeal arch development, and furthers our understanding of skeletal diversity in vertebrates.

Does xenin regulate food intake in goldfish?

Est-ce que le xenin régule la consommation de nourriture du poisson rouge?

Brent Kerbel, Kimberly Badal and Suraj Unniappan

York University

Xenin is a highly conserved 25 amino acid peptide cleaved from the N-terminus of its precursor, cotamer subunit alpha (COPA). In rodents, xenin inhibits food intake, reduces gastric motility, and stimulates exocrine pancreatic secretion. Currently there is no information available on xenin in non-mammalian vertebrates. This project focussed on the characterization of xenin in goldfish. We identified a xenin-encoding partial sequence of COPA from goldfish. The 25 amino-acid goldfish xenin is identical to mammalian xenin. COPA mRNA expression is ubiquitously expressed in goldfish tissues, including the liver, brain and gut. COPA-like immunoreactivity is present in the enteroendocrine cells of the goldfish gut. COPA mRNA expression was significantly reduced (30%) in the gut of fish fasted for 3 days. Both central (32%) and peripheral (48%) injections of xenin reduced food intake in goldfish. Our data indicate that xenin is a novel anorexigen in goldfish.

Distribution of putative oxygen-sensing neuroepithelial cells in fish gills

Distribution des cellules neuroépithéliales de détection d'oxygène putatives dans les branchies de poissons

Yujin Kim

University of British Columbia

Serotonergic neuroepithelial cells (NECs) are the putative O₂ sensing cells in water breathers. Mapping the location of the NECs is crucial to understanding their functions; however, the complete NEC distribution on both hemibranchs in the four gill arches is unknown in any species. Our study examined the distribution of serotonergic NECs from dorsal to ventral regions of a hemibranch; between hemibranchs; and amongst gill arches, in a hypoxia-tolerant fish (*Carassius auratus*) and a hypoxia-intolerant fish (*Oncorhynchus mykiss*). We used fluorescent immunohistochemical markers on gill whole mounts to identify, and high resolution microscopy to map, the serotonergic NECs. We found serotonergic NECs in all arches in both species. NECs were most abundant in gill arch 1 and distributed similarly across hemibranchs. In contrast, the distribution of serotonergic NECs on gill filaments differed between the two species. Funded by the NSERC of Canada.

Novel functions of small heat shock proteins during diapause of *Artemia franciscana*

Des nouvelles fonctions pour les petites protéines de choc thermique au cours de la diapause d'*Artemia franciscana*

Allison King and Thomas MacRae

Dalhousie University

Diapause, a dormant state of enhanced stress tolerance, is a widespread life history strategy common in insects but found in crustaceans and other animals. Developing embryos of *Artemia franciscana* either enter diapause or develop into swimming nauplii. Diapause-destined embryos express three small heat shock proteins (sHSPs), ArHsp21, ArHsp2 and p26 not observed in other embryos. The sHSPs appear at four days post fertilization suggesting similar functions, likely in stress resistance. However, knockdown of each sHSP by RNAi revealed that each protein is likely to have different roles. p26 enhances stress resistance and exhibits novel developmental roles. ArHsp21 has a non-essential role during diapause while knocking down ArHsp22 kills females. The research makes fundamental contributions concerning the role of molecular chaperones in diapause. Additionally this research contributes to the fields of medicine, forestry and agriculture, as many pest and disease vectors exhibit diapause.

Novel functions for molecular chaperones during diapause of *Artemia franciscana* embryos

Des nouvelles fonctions pour les chaperons moléculaires au cours de la diapause des embryons d'*Artemia franciscana*

Allison King and Thomas MacRae

Dalhousie University

Diapause embryos of the animal extremophile *Artemia franciscana*, a crustacean, are metabolically dormant and exceptionally tolerant to stressors such as heat and anoxia, characteristics thought to depend on the protective activity of molecular chaperones. RNAi methodology was used to knock down individual molecular chaperones which are normally up-regulated during *Artemia* diapause, including the α -crystallin related small heat shock proteins (sHsps) p26, ArHsp21 and ArHsp22 and artemin, a species-specific chaperone. The individual sHsps and artemin exhibited different roles during cyst development and *diapause* with only some of these proteins contributing to stress tolerance. p26, for example, enhances stress resistance in *Artemia* embryos, facilitates embryo development and prevents diapause termination whereas ArHsp21 may share none of these attributes. By revealing separate and novel roles for molecular chaperones this work contributes substantially to our understanding of diapause, an important, phylogenetically widespread developmental process.

Neonatal stress and its consequences on the developmental trajectory of the respiratory control system **Conséquences du stress néonatal sur la trajectoire développementale du système de régulation de la respiration**

Richard Kinkad

Université Laval

Developing animals receive valuable cues from their environment regarding the resources available and challenges that they may experience later in life. These signals are transmitted to the offspring either directly from the environment or indirectly via hormonal signals from the mother. They "program" numerous aspects of animal physiology and aim to match behavior and function with the environment in which the organism will grow and ultimately reproduce. Clearly, early life programming can confer an adaptive advantage to the organism, but a mismatch between early life cues and the environment can compromise health. This basic biological principle equally applies to mammals but with the decade of the genome, biomedical research favoured the elusive quest for "key genes" to explain complex diseases. This presentation will review evidence obtained from rats indicating how neonatal stress compromises development of the respiratory control system and predispose to disease and discuss neurobiological mechanisms.

Les animaux en développement reçoivent beaucoup d'information sur l'état de l'environnement dans lequel ils vivront plus tard. Ces signaux -soit transmettent directement de l'environnement ou par le biais de signaux hormonaux provenant de la mère- "programment" divers aspects de la physiologie, permettant ainsi d'arrimer le comportement et la fonction avec l'environnement dans lequel l'organisme grandira et se reproduira. Cette programmation néonatale peut avoir une grande valeur adaptative mais une mauvaise concordance entre les signaux reçus en début de vie et le milieu dans lequel l'animal vivra peut compromettre la santé. Ce principe biologique fondamental s'applique aux mammifères mais au cours de la "décennie du génome", la recherche biomédicale s'est lancée dans une quête visant à découvrir le gène miracle qui expliquerait des maladies complexes. Cette présentation va réviser les données indiquant comment le stress néonatal peut compromettre le développement du système de régulation de la respiration et prédisposer ainsi à la maladie. Les mécanismes neurobiologiques sous-jacents seront discutés.

Evolution of hypoxia-responsive cytochrome c oxidase genes

Evolution de la réactivité hypoxie dans les gènes du cytochrome c oxydase

K.M. Kocha, T. Snider, J. Pearlstein and C.D. Moyes

Queen's University

Among the mechanisms that fine-tune cytochrome c oxidase (COX) levels/activities is an oxygen-dependent switch of paralogs for subunit 4. COX4-1 is constitutively expressed in most tissues; COX4-2 predominates in brain and lung and is induced by hypoxia in other tissues. Though there is considerable evidence that this isoform switch has advantages in COX regulation under energetic stress, the evolutionary origins of the adaptation are unclear. All vertebrates possess single gene copies of both orthologs, though birds lack a functional COX4-2 gene. Mammals, amphibians and reptiles display considerable diversity in the distribution, degeneracy and efficacy of canonical hypoxia-responsive elements (HRE) and oxygen-responsive elements (ORE). Fish share tissue specificities of COX4-1/COX4-2 expression profiles, but we find no evidence that COX4-2 is hypoxia responsive; fish and fish cells do not alter COX4-2 expression under hypoxia or anoxia, and their proximal promoters lack HRE or ORE elements homologous to the human gene. These studies suggest that the COX4-2 paralog is near ubiquitous in vertebrates, but its oxygen responsiveness is perhaps limited to mammals. Even in mammals, its oxygen sensitivity differs among tissues and between cancer lines. Funded by NSERC Canada.

Auditory responsiveness under dynamic acoustic conditions in the parasitoid fly, *Ormia ochracea*

La réactivité auditive de la mouche parasitoïde, *Ormia ochracea*, sous conditions acoustiques dynamiques

Dean Koucoulas, Norman Lee and Andrew C. Mason

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The parasitoid fly, *Ormia ochracea* exploits its cricket hosts by auditory localization of singing males. Prior phonotaxis studies in *Ormia* have described parameters important for recognition and localization of hosts. Little is known, however, of the effects of dynamic stimuli (ie stimuli that change during an on-going behavioural response). Such dynamic stimulus changes may affect the ability to maintain orientation or attention to a single target. Using a spherical trackball system, walking phonotaxis responses of gravid females to paired auditory stimuli combining attractive and unattractive stimuli were assessed. We show that flies will respond to an unattractive stimulus (noise) if it follows an attractive one (cricket song). Furthermore, the nature of the noise response depends on the relative delay between attractive and unattractive stimuli. Results suggest auditory priming as model for studies of attention in the fly.

Nitrogenous waste excretion by zebrafish, *Danio rerio*, in an alkaline environment

L'excrétion de déchets azotés par le poisson zèbre, *Danio rerio*, dans un environnement alcalin

Yusuke Kumai, Hasanen Al-Rewashdy, Jessica Harris and Steve Perry

University of Ottawa, University of Ottawa, University of Ottawa, University of Ottawa

Teleost fish are predominantly ammonotelic, though during larval development, they may excrete proportionally more urea. In the present study, we investigated whether exposure to an alkaline environment could induce ureotely in zebrafish larvae. When larvae were chronically raised in pH 10, the ammonia excretion rate returned to the control level by 5 days post fertilization (dpf). The mRNA expression of Rhcg1, an apical isoform of ammonia-conducting Rh proteins, was significantly elevated in larvae exposed to alkaline water and they also exhibited significantly higher uptake rates of methylamine (an ammonia analog), suggesting elevation in ammonia excretion capacity. When 4 dpf larvae were acutely transferred to pH 10, the ammonia excretion rate returned to the control level within 6 h. These observations suggest when exposed to an alkaline environment, zebrafish larvae augment their ammonia excretion capacity rather than relying to a greater extent on urea excretion, to maintain their nitrogenous waste excretion.

Adrenergic regulation of Na⁺ uptake in zebrafish, *Danio rerio*

La régulation adrénérgique de l'assimilation du Na⁺ du poisson zèbre, *Danio rerio*

Yusuke Kumai, Melissa Ward and Steve Perry

University of Ottawa

Freshwater fish regulate their ion homeostasis tightly in the face of highly variable environments. In the present study, we investigated the potential role of adrenergic systems in regulating Na⁺ uptake by zebrafish larvae. Results of immunohistochemistry demonstrated the innervation of a subset of ionocytes responsible for Na⁺ uptake (H⁺-ATPase-rich cells; HR cells) at 4 days post fertilization (dpf). Pharmacological treatment of larvae at 4 dpf clearly demonstrated the stimulation of Na⁺ uptake via β -adrenergic receptors and a potential inhibitory influence via α -adrenergic receptors. Furthermore, when β -receptor function was prevented either through pharmacological treatment or translational gene knockdown (microinjection of antisense morpholinos), larvae failed to fully stimulate Na⁺ uptake when challenged with low [Na⁺] or low pH environments. These data clearly demonstrate the significance of adrenergic systems in regulating Na⁺ uptake in zebrafish during their early development.

Water transport in zebrafish larvae: paracellular versus transcellular pathways, and their regulation by cortisol

Le Transport de l'eau dans les larves du poisson zèbre: sentiers paracellulaires versus transcellulaires et leur régulation

Raymond Kwong, Yusuke Kumai and Steve Perry

University of Ottawa, University of Ottawa, University of Ottawa

The precise mechanisms for water uptake in teleost fish are largely unknown. Here we investigated the potential contributions of paracellular and transcellular routes to overall water transport in developing zebrafish (*Danio rerio*). Translational knock-down of AQP1a1 with an antisense morpholino significantly reduced water uptake, clearly indicating a transcellular component in water movement. Interestingly, knocking-down claudin-b, a tight junction protein expressed on the larval skin, concurrently increased paracellular permeability and water uptake, suggesting significant paracellular water movement when epithelial permeability is increased. Exposure to cortisol significantly reduced water movement; though it is likely that cortisol affected both trans- and paracellular water fluxes. Additionally, exposure to dexamethasone or aldosterone [agonists for glucocorticoid (GR) and mineralocorticoid receptors (MR), respectively], reduced water transport equally, suggesting that both GR and MR are involved in regulating water uptake. Overall, our study provides new insights into the mechanisms and regulation of water transport in freshwater fish.

Epithelial barrier functions of tight junction proteins in zebrafish

Les fonctions de barrière épithéliale des protéines de jonctions serrées du poisson zèbre

Raymond Kwong and Steve Perry

University of Ottawa

The epithelial barrier is fundamental to the physiology of aquatic vertebrates. Using a GFP-expressing line of transgenic zebrafish (*Danio rerio*), we identified a specific tight junction protein, claudin-b, which is expressed on the skin of larvae. Depletion of environmental calcium severely disrupted tight junction integrity. The reverse genetic technique of translational knock-down of claudin-b in developing zebrafish significantly increased paracellular permeability, clearly indicating a critical role for claudin-b in maintaining epithelial barrier function. Interestingly, claudin-b morphants exhibited a marked increase in sodium uptake, presumably as a compensatory response to the elevated loss of sodium. In adult zebrafish, claudin-b is expressed in specific regions of the gill and kidney. Exposure to ion-poor water caused a significant induction of claudin-b expression as well as a decrease in sodium efflux, suggesting a "tightening" effect of claudin-b on sodium loss. Overall, our study highlights the important physiological functions of tight junctions in freshwater fish.

Gene regulatory networks involved in early stages (1-74 hpf) of *Silurana tropicalis* development

Réseaux de gènes régulateurs impliqués dans le développement précoce (1-74 hpf) chez *Silurana tropicalis*

Valerie S. Langlois and Christopher J. Martyniuk

Royal Military College of Canada, University of New Brunswick

A custom Agilent 4 x 44 K microarray for *Silurana tropicalis* was developed to characterize gene regulatory networks during early development (1, 17, 36, 74 hpf). Cluster analysis revealed that each stage showed unique gene expression profiles and that 1 hpf was most different than the other three stages. There were > 8000 unique gene probes ($p < 0.01$, FDR = 5%) that were differentially expressed between 1 hpf (2 cell stage) and 17 hpf and > 2000 gene probes differentially expressed between 36 hpf and 74 hpf. Gene ontology revealed that genes involved in nucleosome assembly, cell division, pattern specification, neurotransmission, and general metabolism were increasingly regulated throughout development, consistent with active development. Real-time RT-PCR was used to confirm select transcripts through development. This study validates a custom *S. tropicalis* microarray and increases understanding of the spatiotemporal *S. tropicalis* embryonic development using gene regulatory networks.

Japanese knotweed (*Fallopia japonica*) in Nova Scotia: ecological impacts of an invasive weed

La renouée du Japon (*Fallopia japonica*) en Nouvelle-Écosse: les impacts écologiques d'une mauvaise herbe envahissante

Todd Larsen, Nathan Boyd, Vilis Nams and Gordon Brewster
Nova Scotia Agricultural College

Japanese knotweed is an invasive weed in North American riparian areas. In order to quantify the impact of this invasive weed, I evaluated diversity and abundance differences between riparian plant communities (knotweed, grass, and shrub). I also assessed small mammal population abundance and diversity in knotweed vs native habitats. Data from two riparian sites (Antigonish and Truro, NS) indicate decreasing diversity from grass to shrub to knotweed habitats. Small mammals were tracked in 73% of grass plots (33/45); 31% of knotweed patches (14/45); and 18% of shrub habitats (8/45). Further research may provide insight as to why small mammals were more abundant in the mono-specific knotweed patches than native shrub habitats. Overall, this study will provide a better understanding of the site-specific interactions of this invasive weed, and therefore allow land managers more insight towards effective control of Japanese knotweed in Nova Scotia.

Using gastropods to assess the diversity and prevalence of *digenean trematodes* in a Cape Breton lake

Utilisation de gastéropodes pour évaluer la diversité et la prévalence des *trématodes digéniens* dans un lac du Cap-Breton

Timothy A. Rawlings, Samantha C. Lawrence and Crystal L. MacLeod
Cape Breton University

As common intermediate hosts of *digenean trematodes*, freshwater gastropods are ideal for assessing the diversity of these parasites in aquatic ecosystems. Here we examined cercarial shedding in nine species of freshwater snails sampled from a suburban lake near Sydney River, Cape Breton, from June – October, 2010, and May – November, 2011. In total, ten cercarial morphospecies were observed: seven in 2010 and an additional three in 2011. Prevalence of infection varied seasonally, with a low of <2% in the spring and a high of >10% in the fall. Three morphospecies were responsible for the majority of infections. Host specificity varied markedly among parasites: four were specific to a single gastropod species, while two infected five host species. Morphological characteristics of cercariae were used to assign morphospecies to the family level, where possible; molecular analyses are currently underway to refine these identifications.

Throwing away our 'cookbooks' to make way for inquiry-based learning in upper-level physiology laboratories

Mettre nos "livres de recettes" de côté pour faire place à un apprentissage basé sur l'enquête pour les cours de laboratoires de physiologie de niveau supérieur

Danielle LeBlanc and Suzie Currie
Mount Allison University

A switch from the use of traditional "cookbook" labs to inquiry-based labs increases learning and scientific reasoning in undergraduate students. Studies show that inquiry-based labs are more enjoyable leading to greater project involvement, increased enthusiasm and pride and ownership in projects. In an upper-level animal cell physiology course, we introduced an inquiry-based lab using Siamese fighting fish and pharmacological agonists and antagonists of several main neurotransmitter pathways. Once provided with basic supplies and relevant literature, students designed their own experiments linking behavioural change to a physiological mechanism. The students demonstrated keen interest in their projects and were engaged in the research experience through experimental design, data collection and analyses and oral and written dissemination of their independent work. This trial demonstrated that independent, self-designed inquiry-based labs are an effective teaching tool and are more memorable to students than traditional labs.

Comparative study of gill tissue composition and genomics between parapatric anadromous and resident populations of brook charr (*Salvelinus fontinalis* Mitchell)

Comparaisons de la composition tissulaire et de la génomique du tissu branchial entre deux populations anadrome et résidente d'ombles de fontaine (*Salvelinus fontinalis* Mitchell)

Andrée-Anne Lemieux and Céline Audet

Université du Québec à Rimouski

Brook charr *Salvelinus fontinalis* (Mitchill) (family *Salmonidae*) in the Laval River, Quebec, include two genetically distinct parapatric populations, one anadromous and one resident. The anadromous form completes seasonal migrations to salt water while the resident form remains in fresh water. We used 1+-year-old alevins from the two brook charr populations in a controlled environment experiment to test the hypothesis of cellular reorganization in the gill epithelium of the anadromous form. Since the principal factor responsible for the cellular reorganization would be apoptosis, we quantified the gene expression of annexin A2, grancalcin, and transkelotase, which are three genes involved in apoptosis, and we employed optical microscopy to measure all structures in the gill epithelium.

L'omble de fontaine (*Salvelinus fontinalis*) de la famille des *Salmonidae* présente dans la rivière Laval au Québec abrite deux populations parapatriques génétiquement distinctes. Une d'elles est anadrome tandis que l'autre est résidente. La forme anadrome effectue des migrations saisonnières en eau salée alors que la forme résidente demeure en eau douce. Notre expérience a été menée en milieu contrôlé sur des alevins des deux formes et âgés d'un an et plus afin de tester l'hypothèse d'une réorganisation cellulaire au niveau de l'épithélium branchial chez la forme anadrome. La réorganisation cellulaire serait effectuée principalement par apoptose. L'expression de différents gènes tels que l'annexine A2, la grancalcine et la transcélotase liés à l'apoptose a été mesurée afin de comparer les deux formes.. Des mesures quant à la structure des lamelles et filaments branchiaux ont été effectuées en microscopie optique.

Hypoxia and thermal tolerance of the adult plainfish midshipman (*Porichthys notatus*)

Tolérance à l'hypoxie et à la température du pilotin tacheté adulte (*Porichthys notatus*)

Christophe M.R. LeMoine, Carol Bucking, Paul M. Craig and Patrick J. Walsh

University of Ottawa

In the summer, the plainfin midshipman migrates and reproduces in the near shore environment. Parental males establish nests under rocks in the intertidal zone where they reside until their clutch is fully developed. In contrast, females and sneaker males leave the nests shortly after spawning. We examined the physiological resistance of adult midshipman to environmentally relevant stressors (temperature, hypoxia), to test if they exhibited sex-specific differences reflecting their reproductive strategies. While parental males and females exhibited similar responses to both graded thermal and graded hypoxia challenges, parental males could withstand significantly longer exposures to severe hypoxic stress. When we examined their skeletal muscle enzymatic capacity we observed a positive scaling of lactate dehydrogenase activity, a glycolytic enzyme, with body size. These results suggest that the larger size of parental males and associated higher glycolytic capacity may confer them an advantage to sustain the extensive hypoxia bouts they experience in nature.

A molecular phylogenetic analysis of green algae associated with amphibian egg masses.

Une analyse phylogénétique moléculaire des algues vertes associées à des masses d'œufs d'amphibiens.

¹Annie Livingstone, ²Jantina Toxopeus, ²Eunsoo Kim and ¹Cory Bishop

¹St. Francis Xavier University, ²Dalhousie University

Embryos of the salamander *Ambystoma maculatum* form an association with the green alga *Oophila amblystomatis*. Recent work has revealed that *O. amblystomatis* invades the tissues and even cells of *A. maculatum* embryos, constituting the first known vertebrate-algal endosymbiosis (Kerney et al. 2011). We tested whether algae that live in ectosymbiotic association with other amphibian species are closely related to *O. amblystomatis*. Samples of algae associated with *A. maculatum*, the wood frog (*Rana sylvatica*), and the northwestern salamander (*Ambystoma gracile*) egg masses were obtained from several sites in Nova Scotia and (for the latter) from one site in British Columbia. Fragments of both 16s and 18s rDNA sequences were amplified, cloned, sequenced, and along with related green algae, subjected to phylogenetic analysis. Algae derived all three amphibians form a monophyletic group, with algae from *A. gracile*, surprisingly, nested within a clade of algae from *A. maculatum* and *R. sylvatica*.

Biological and chemical characterization of the protective effects of NOM source on acute Cu toxicity to the freshwater amphipod *Hyaella azteca*

Caractérisation biologique et chimique des effets protecteurs de la matière organique naturelle sur la toxicité aiguë au Cu de l'amphipode d'eau douce *Hyaella azteca*

Kelly Livingstone, Scott Smith and James McGeer

Wilfrid Laurier University

The concentration dependent protection that natural organic matter (NOM) provides against Cu toxicity to aquatic organisms is well known. Less understood is source variability and how the upland terrestrial environment influences that protective capacity (quality). This study examines the influence of land disturbance (logging, fire, smelter emissions) on NOM quality by comparing the protective capacity of different sources on Cu toxicity and bioaccumulation in *Hyaella azteca*. Toxicity tests (96h, using Environment Canada standard methods) with Cu (0-4µM) and NOM (5mg/L dissolved organic carbon (DOC), collected by reverse osmosis) showed significant variability among sources with disturbed sites offering less protection than reference sites. These results were supplemented with 6h Cu uptake/binding experiments and optical characterizations (excitation-emission matrix spectroscopy, absorbance at 340nm and fluorescent indices) in an effort to derive a rapid method for predicting NOM quality. This research was supported by NSERC, Vale and Xstrata as part of the TALER Program.

Transcriptional responses of the female fathead minnow liver due to phenanthrene exposure.

Réponses transcriptionnelles du foie de tête-de boule femelle due à l'exposition au phénanthrène

Jennifer Loughery, Angella Mercer, Karen Kidd and Christopher Martyniuk

University of New Brunswick Saint John

Phenanthrene (PHEN), a polycyclic aromatic hydrocarbon (PAH) found in the environment, has been well studied for oxidative stress impacts in teleosts. However recent studies also suggest that PHEN may be an endocrine disrupting substance. Female fathead minnows (*Pimephales promelas*) were exposed for 72hrs to waterborne PHEN at measured concentrations of 0ppb, 29.02ppb and 286.8ppb (environmentally relevant) and a high concentration of 1006ppb. Fish were sacrificed after 24, 48 and 72hrs. Body, liver and gonad weights were recorded and livers frozen for gene expression analyses. Condition was elevated 20% in 1006ppb after 72hrs relative to fish at 24hr. Gonadosomatic index decreased 2.9-fold in 29.02ppb fish at 72hrs relative to 48hr fish. Liversomatic index was elevated 3-fold in 29.02ppb after 72hrs relative to 1006ppb. Gene expression profiling will be performed to better characterize the molecular pathways underlying the changes in physiology. These results improve understanding of PAH modes-of-actions on endocrine systems.

Plasma pattern recognition receptors of rainbow trout and walleye

Reconnaissance des motifs de récepteurs plasmatiques de la truite arc-en-ciel et du doré jaune

John S. Lumsden, Spencer Russell, Karrie Young, Alex Reid, Andrew Peterson and Adrian diNatale

University of Guelph

Microorganisms all contain conserved microbe-associated molecular patterns, for example lipopolysaccharide, that are recognised by pattern recognition receptors (PRRs) present in all animals. Numerous PRRs are being identified, many of which are intimately associated with host defense. Plasma lectins from rainbow trout and walleye were isolated by their ability to bind to pathogenic infectious agents including virus, various bacteria and chitin. Intelectin and ladderlectin were identified from rainbow trout and mannose binding lectin and apolipoprotein were isolated from walleye. Lectin heterogeneity creates functional diversity and ladderlectin was found to have at least two isoforms. Two-dimensional PAGE and western blots resolved multiple electrophoretic forms of both ladderlectin and intelectin that differentially bound microbial targets. Enzyme immunoassays demonstrated that there was significant group and individual variation in plasma lectin concentrations. None of the lectins were acute phase reactants nor were the concentrations substantially altered during experimental infection, however they were often localized by immunohistochemistry in intimate association with microbes *in vivo*. All lectins were widely distributed on mucosal surfaces and some were also identified on the cell surface of leukocytes and on cell lines.

Significant disruption of serum albumin function by nanoparticles

Perturbation significative de la fonction de l'albumine sérique par des nanoparticules

Tyson MacCormack, Christopher Stone and Luke Armstrong

Mount Allison University

Nanoparticles readily bind to proteins and such interactions represent a potentially important avenue of toxicity. Serum albumin is an abundant blood protein which transports hydrophobic ligands such as fatty acids, hormones and pharmaceuticals. Nanoparticles interact with albumin in plasma and alter its structure but their functional impacts are unknown. We assessed the influence of nanoparticles on the ligand binding capacity of albumin using a fluorescent tag (ANS) and inherent tryptophan fluorescence. Long-chain fatty acid binding to serum albumin was significantly reduced while short-chain fatty acid binding was completely abolished by gold nanoparticles. Thyroxine and ibuprofen binding were also significantly reduced and all of these effects were highly dependent upon nanoparticle size and surface charge, suggesting that small differences in nanoparticle properties can greatly influence their toxicity. Our results show that nanoparticles may significantly influence energy metabolism and hormone signaling *in vivo* and we are now investigating this possibility.

Stress, development, and birdsong: linking stress physiology and sexual selected cognition

Le stress, le développement et le chant d'oiseaux: établir le lien entre la physiologie du stress et la cognition sexuellement sélectionnée

Scott MacDougall-Shackleton, Tara Farrell, Kim Schmidt, Buddhadas Kriengwatana and Haruka Wada

Western University

Stressors early in life affect the development of numerous physiological and neurocognitive systems. Brain regions controlling birdsong develop relatively late and are particularly susceptible to nutritional and other stressors. Food restriction and glucocorticoid exposure early in life results in reduced size of song-control regions, and reduced song quality. In addition, early stress affects other neurocognitive systems such as spatial memory, functioning of the HPA axis itself, and immune function. However, we have observed fewer such effects of early stressors on metabolic rates. Thus many, but not all, physiological systems may exhibit developmental correlations. We have also explored the effects of incubation temperature on development of these physiological systems. In contrast to post-natal stressors, the effects of suboptimal prenatal incubation temperature appear limited to early growth and survival in altricial songbirds, with minimal long-term effects. Combined, our studies reveal that the effects of early stress depend on developmental timing.

Large scale dispersal of intertidal invertebrates through ice rafting

Dispersion à grande échelle des invertébrés des estrans à travers le rafting de glace

¹Colin B.A. Macfarlane, ¹David Drolet, ²Myriam A. Barbeau, ¹Diana J. Hamilton and ¹Jeff Ollerhead

¹Mount Allison University, ¹University of New Brunswick

Dispersal of organisms allows colonization of favourable habitats, maintenance of good gene flow and stable metapopulation dynamics. In temperate intertidal environments winters can be harsh; ice and large temperature fluctuations can have detrimental effects on individuals. However, there may also be dispersal-related benefits to ice processes. We examined the role of ice blocks as a potential vector of transportation of intertidal mudflat invertebrates by sampling and tracking ice blocks in the upper Bay of Fundy. Melted portions of ice blocks revealed that these blocks carry significant numbers of live invertebrates, from 8 different taxa. Tagging and tracking showed a substantial number of ice blocks traveled up to 29 km, in some cases crossing portions of the Bay. Based on these results, we suggest that large-scale transport of invertebrates, mediated by ice, is highly likely. This process could be an important vector for dispersal in many temperate intertidal species.

17 α -ethynylestradiol (EE2) depresses temperature-induced gonadal development in northern killifish (*Fundulus heteroclitus macrolepidotus*)

Le 17 α -ethynylestradiol (EE2) supprime le développement gonadique induit par la température chez le choquemort nordique (*Fundulus heteroclitus macrolepidotus*)

¹Deborah MacLachy, ¹Esteban Gillio Meina, ²Tamzin Blewett, ¹Andrea Lister, ³Thijs Bosker, ²Chris Wood, and ³Kelly Munkittrick

¹Wilfrid Laurier University, ²McMaster University, ³University of New Brunswick

Northern killifish (*Fundulus heteroclitus macrolepidotus*) were exposed in vivo for 14 days to 0, 50 and 250 ng/L 17 α -ethynylestradiol (EE2) in 0, 16 and 32 ppt salinity at 18°C and to 0 and 250 ng/L EE2 at 10, 18 and 26°C at 16 ppt. Salinity changes had little impact on reproductive endocrine status. Increased temperature triggered gonadal growth and changes in reproductive endocrine status. EE2 counteracted the effect of temperature by depressing gonadal growth in males. In parallel studies, in killifish acclimated to 18°C at 16 ppt, EE2 uptake was lower after 24h exposure to 10°C and 4°C, and increased after 24h exposure to 26°C. Because initiation of reproductive development in northern mummichog is linked with increases in water temperature, EE2's antagonism to the effects of temperature on reproductive status is a significant concern in estuaries receiving estrogenic contaminants.

Development of a larval cell line from cod (*Gadus morhua*) and their potential applications for enhancing cod aquaculture

Développement de lignées cellulaires à partir des larves de morue (*Gadus morhua*) et leurs applications potentielles pour l'amélioration de l'aquaculture de la morue

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¹Wilfrid Laurier University, ²Center for Cooperative Aquaculture Research

Once plentiful and an important commercial fisheries species in Canada up to the 1990's, the Atlantic cod, *Gadus morhua*, has been Red-Listed as "Vulnerable" species by the International Union for Conservation of Nature. As the cod fishery has yet to recover, development of commercial cod-aquaculture has received major impetus. However, disease outbreaks especially from intracellular pathogens like viruses and microsporidians, have jeopardized the success of these ventures. Convenient cod cell culture models or cell lines that could facilitate their study have been unavailable. In this research, we report on the successful establishment of a larval cod cell line, GML-5, and their ability to support growth of the microsporidian *Loma morhua*. GML-5, has been cultured for over two years in L-15 media with 10% fetal bovine serum supplementation at 18°C. They have been passaged over 25 times and have been successfully cryopreserved and identified as deriving from *Gadus morhua* by "DNA-barcoding".

After the cold: the reestablishment of osmotic balance and neuromuscular function during chill coma recovery of an insect

Après le froid: le rétablissement de l'équilibre osmotique et de la fonction neuromusculaire durant la récupération d'un coma causé par le froid chez les insectes

Heath MacMillan, Caroline Williams, James Staples and Brent Sinclair

Univ of Western Ontario

At low temperatures insects enter chill coma, a reversible loss of neuromuscular function which is associated with flux of ions and water from the hemolymph to the gut. Although it is used regularly to quantify cold-tolerance in insects, little is known about the mechanisms underlying chill coma recovery. Using the fall field cricket (*Gryllus pennsylvanicus*), we characterized the return to ionic and osmotic homeostasis following prolonged chill-coma. During recovery from chill coma, ion concentrations in the hemolymph rapidly returned to a level that permitted movement, coincident with visual observations of recovery. However, hemolymph volume and total ion content did not return to normal for substantially longer. A rise in the rate of resting CO₂ release during chill coma recovery also coincided with the recovery of hemolymph volume. Thus, chill coma recovery appears to require a biphasic reversal of the effects of cold exposure on ion and water balance.

Morphometric analysis of a putative olfactory structure in *Lytechinus variegatus* larvae

Analyse morphométrique d'une structure olfactive putative dans les larves de *Lytechinus variegatus*

Katelyn MacNeil and Cory Bishop

St. Francis Xavier University

Sea urchin planktotrophic larvae have evolved highly elaborate body shapes to increase the surface area for ciliary bands, their feeding and locomotory organ. I am interested in the adoral lobe (ADL), a newly described putative olfactory structure on the ventral surface of *Lytechinus variegatus* larvae. There is considerable interspecific variation in the presence and shape of this structure, the significance of which remains untested. Moreover, some feeding larvae have no such structure. For the purpose of a comparative study my near term goal is to quantitatively describe the shape of the ADL in three dimensions. To do so I am serially sectioning through the ADL at a 1 µm resolution. To describe the overall shape of the ADL I will computationally reconstruct the serial sections and subject the resulting model to morphometric analysis. After establishing a method to conduct a morphometric analysis of the ADL, I will conduct a comparative study to test my hypothesis that the shape of the ADL is related to its function as a simple olfactory organ.

Burrow behaviour of the mudflat amphipod, *Corophium volutator*

Comportement de fabrication de terriers de l'amphipode de la vasière, *Corophium volutator*

Stephanie MacNeil and Myriam Barbeau

University of New Brunswick

Corophium volutator lives in U-shaped burrows in mudflats in the Bay of Fundy. Its behaviour and location in a burrow (top vs bottom) affect its availability as prey to migratory shorebirds. We conducted laboratory experiments with optimal environmental conditions in summer 2011 to determine time budgets and burrow activities of females and males during 4 tidal periods (immediately high, high, immediately low, and low). Females were also observed while simulating pecking of foraging sandpipers at low tide. On average, females spend 82% of the time in a burrow (17% at top, 51% in middle, and 14% at bottom). The main activity was aerating the middle/bottom of the burrow for females, and being near top or out of burrow for males. Our study helps to better understand relationships between *C. volutator* and sandpipers, and possible implications of changes in *C. volutator* behaviours and/or densities on shorebird habitat use and diet.

Reduced hypothalamic-pituitary-interrenal axis responsiveness in rainbow trout infected with the parasite *Cryptobia salmositica*

Réponse réduite le l'axe hypothalamique-pituitaire-surrénal chez la truite arc-en-ciel infectée avec le parasite *Cryptobia salmositica*

BN Madison and NJ Bernier

University of Guelph

Despite clear physiological duress, *Cryptobia salmositica* infection does not appear to stimulate the hypothalamic-pituitary-interrenal (HPI) axis in rainbow trout. Thus, we hypothesized that *Cryptobia* infection diminishes the stress response by inhibiting key effectors of the HPI axis. To test this hypothesis, we characterized the basal activity of the HPI axis and the cortisol response to air exposure in saline- (control) and parasite-injected fish. Relative to controls, parasite-infected fish had reduced plasma cortisol and ACTH levels in response to 60s air exposure with higher CRF gene expression and reductions in the expression of key genes for cortisol synthesis. In vitro superfusion of the interrenals of parasite-infected fish also had significantly lower ACTH-stimulated cortisol release rates than controls. Findings show that *C. salmositica* infection results in complex changes in the transcriptional activity of both central and peripheral regulators of the HPI axis and the reduction of interrenal cortisol synthesis capacity.

The interactive effects of UV radiation and cadmium on physiological stress response, club cell investment and alarm cue production in fathead minnows (*Pimephales promelas*).

Les effets interactifs des radiations UV et du cadmium sur la réponse physiologique au stress, sur l'investissement des cellules clubs et sur la production de signal d'alarme chez le tête-de-boule (*Pimephales promelas*)

Aditya Manek, Maud Ferrari, Jeff Sereda, Som Niyogi and Doug Chivers

University of Saskatchewan

This study investigated the interactive effects of ultraviolet radiation (UVR) and cadmium on the physiological stress response, epidermal club cell investment (ECC), and alarm cue production in fathead minnows (*Pimephales promelas*). The skin of many fish contains ECCs that release alarm cues to warn other fish of danger. Since UVR only exposure and cadmium exposure in the presence of pathogenecity are known to affect ECC investment, we hypothesized that their combined exposure may impair alarm cue production in fish. We found that fish exposed to UVR, with or without cadmium, showed consistent decrease in ECC investment compared to non-exposed controls. However, the combined exposure of UVR and cadmium reduced cortisol levels relative to that in UVR only exposure. Surprisingly, there was no difference in the potency of the cues prepared from the skin of UVR-exposed or non-exposed fish indicating that UVR exposure may have little influence on chemically-mediated predator-prey interactions.

Combined effects of agriculture and parasites on oxidative stress in leopard frogs (*Lithobates pipiens*)
Effets combinés de l'agriculture et des parasites sur le stress oxydatif chez les grenouilles léopards
(*Lithobates pipiens*)

David J. Marcogliese, Kayla C. King and Claire Dautremepuits
Environment Canada, University of Liverpool, Clair'Environnement

In nature, organisms may be exposed to both anthropogenic and natural stressors, but their cumulative effects are rarely studied in assessments of environmental effects. Leopard frogs (*Lithobates pipiens*) were collected from seven localities in agricultural and reference wetlands to examine the combined effects of parasites and/or agricultural activities on substrates and enzymes involved in oxidative stress metabolism in the spleen. Frogs from agricultural wetlands had significantly higher glutathione S-transferase and lower lysozyme activities. However, infection with gorgoderid trematodes also lowered lysozyme activity. Thiol levels and catalase activity were significantly elevated in frogs infected with the intestinal nematode *Oswaldocruzia* sp. Total parasite numbers also were associated with increased thiol levels. Significant interactions between gorgoderid infection and agriculture were detected for thiol levels and lysozyme activity. Thus, field studies of pollution impacts using biomarkers should account for potentially confounding effects of natural parasitic infections.

Molecular signalling cascades underlying increased estrogen production in the fathead minnow ovary after dihydrotestosterone treatment

Cascades de signalisation moléculaire sous-jacentes à une hausse en production d'œstrogène dans l'ovaire du tête-de-boule après traitement à la dihydrotestostérone

Joshua Marr, Anna Ornostay and Christopher J. Martyniuk
University of New Brunswick

The non-aromatizable androgen dihydrotestosterone (DHT) is a potent androgen in female fish, however the molecular mechanisms of DHT action in fish are poorly characterized. The objectives of this study were to characterize the molecular signalling cascades initiated by DHT in the fathead minnow (FHM) ovary. Ovary explants from sexually mature females (GSI ~ 15-19%) were incubated for 6, 9, and 12 hrs with three concentrations of DHT. Despite being a potent androgen, DHT induced estradiol (E2) production at all three time points (10^{-6} M DHT). Time series analysis using microarrays revealed that genes related to prostaglandins and glutamate receptor activation were associated with increasing E2. Functional enrichment analysis identified the molecular functions of G-protein receptor activity, transcription termination, carbohydrate metabolism, and monooxygenase activity being differentially affected by DHT. This study characterizes DHT action in the teleost ovary and more importantly, identifies molecular pathways that are associated to increased E2 production in the female ovary.

The goldenrod gall fly's liquid little secret: 3-acetyl-1,2-diacyl-sn-glycerols are associated with natural survival of intracellular freezing in *Eurosta solidaginis*

Le petit secret liquide de la mouche de verge d'or: les glycérols sn 3-acétyl-1,2-diacyl sont associés avec la survie naturelle au gel intracellulaire chez *Eurosta solidaginis*

¹Katie E. Marshall, ¹Raymond Thomas, ²Aron Roxin, ¹Eric K. Y. Chen, ¹Jason C. L. Brown, ¹Elizabeth R. Gillies and ¹Brent J. Sinclair

¹University of Western Ontario, ²University of Toronto

The fat body cells of the goldenrod gall fly *Eurosta solidaginis* have the unusual ability to naturally withstand intracellular ice formation (IIF). To date, no unique compounds associated with natural IIF survival have been identified for any animal. Here we show that *E. solidaginis* seasonally synthesizes an unusual class of neutral lipid, 3-acetyl-1,2-diacyl-sn-glycerols (acTAGs). acTAGs are accumulated in preparation for winter and at their peak concentration comprise over 19% of the insect's neutral lipid pool while long-chain TAGs (lcTAGs) comprise only 17% percent (by molarity). The acTAGs have a low melting point (-17 °C), and are therefore expected to remain liquid at temperatures where the cells freeze. These acTAGs are not found in other cold tolerant insects, and are not present in the *Solidago* spp. host or other members of the gall community. We suggest these properties are consistent with a role as a candidate molecule for IIF survival.

Understanding *Piscirickettsia salmonis*

Comprendre *Piscirickettsia salmonis*

Sergio H. Marshall

University of Valparaíso

Chilean aquaculture is a major and internationally important industry sector. Impressive growth rates of up to 19.8% per annum have been achieved over the last two decades, but the industry has been challenged more recently due to the emergence and spread of a number of viral and bacterial diseases including infectious salmon anemia (ISA), viral Infectious Pancreatic Necrosis (IPN), although the most aggressive of all continue being Salmon Rickettsial Syndrome (SRS) or *Piscirickettsiosis*, caused by fastidious bacterial pathogen *Piscirickettsia salmonis*, whose biology at present is essentially unknown. Because of this, and due to the low and short-term efficiency of the vaccination procedures against this fish pathogen, my laboratory has considered imperative to improve our understanding of the infection process and the origin and diversity of the virulence factors encoded in the genome of this bacterium. The improvement of detection and control strategies against this pathogen is, as already mentioned, impeded by our incomplete understanding of the of the virulence and resistance factors and how they might potentially interact with the yet not well characterized fish immune system. This scenario reduces our capacity to identify and generate optimal detection and control strategies in order to keep healthy environments for national aquaculture (that usually operate under insufficient sanitary conditions) and maximize fish productivity. This need requires at least a comprehensive investigation of:

- The biology of the diverse *P. salmonis* strains involved in Salmon Rickettsial Syndrome (SRS).
- The potential interactions between the *P. salmonis* virulence factors and the host immune system.
- The conserved/exclusive virulence mechanisms present in different *P. salmonis* strains and other phylogenetically related pathogenic bacteria.
- The potential functional genomic modules that could promote differential infection fitness in *P. salmonis* species.

We will then present and discuss our advances over these important issues.

Protein expression networks associated with depressed vitellogenin in the female fathead minnows (*Pimephales promelas*)

Les réseaux d'expression de protéines associés avec des niveaux bas de vitellogénine chez le tête-de-boule (*Pimephales promelas*)

Chris Martyniuk, Sophie Alvarez, Bonnie P. Lo, James Elphick and Vicki Marlatt

University of New Brunswick, Donald Dansforth Plant Science Center, Nautilus Environmental, Nautilus Environmental, University of the Fraser Valley

Endocrine disruptors that act via androgen receptors (ARs) can result in depressed vitellogenin (VTG) and masculinisation in female fish. Fathead minnows (FHM) were exposed to the model non-aromatizable androgen 5- α dihydrotestosterone (DHT) (100 μ g/L), the ureic-based herbicide linuron (LIN) (100 μ g/L), and a mixture of both compounds for 21d. LIN has been shown to have an anti-androgenic mode of action and inhibit VTG in female FHMs. We measured hepatic proteins using quantitative proteomics (iTRAQ) to construct protein networks that are associated with suppressed VTG. There were 2000 proteins identified (proteins quantified was \sim 1200) with a Velos Orbitrap. Differentially expressed proteins included, programmed cell death, glutathione S transferases, canopy, selenoprotein U, and ribosomal proteins. Sub-network enrichment analysis determined that proteins regulated by interferon and epidermal growth factor signalling are also altered by DHT and LIN. These data provide novel insight into protein networks that are associated with depressed plasma VTG.

Progesterone action in the fathead minnow testis

L'action de la progestérone dans les testicules de tête-de-boule

Chris Martyniuk and Yasmin Chishti

University of New Brunswick Saint John

Progesterone (P4) is a sex steroid that plays a significant role in teleost reproduction. Progesterone has also been detected in aquatic environments because of sewage effluent and run-off from cattle feedlots. The objective of this study was to examine the effects of P4 in the testis of male fathead minnows (*Pimephales promelas*) (FHM). Gonadal tissue of mature male FHM (GSI = 1.2 to \sim 2.0 %) were incubated in P4 (10^{-8} M and 10^{-6} M) for 6 and 12 hr. P4 significantly increased testosterone at 6 hours (10^{-6} M) but did not affect 11KT production with any dose or time point. Microarray analysis revealed that cell pathways involving insulin growth receptor 1 signaling and prostaglandin were significantly depressed with P4 while cell processes such as glycogen and tryptophan metabolism were increased 50-70%. This study improves our understanding of P4 action in the mature male testis and characterizes gene regulatory network that are P4-responsive.

Auditory perception in an acoustic parasitoid fly

Perception auditive chez la mouche parasitique acoustique

Andrew Mason and Norman Lee

University of Toronto Scarborough

The fly, *Ormia ochracea*, is an acoustic parasitoid that must reproduce by placing parasitic larvae on cricket hosts. Female flies obtain hosts by localizing the calls of singing male crickets. Under controlled acoustic conditions, flies localize individual sound sources with great precision using a pair of ears that are exquisitely sensitive to sound direction. We have examined the mechanisms and precision of directional hearing, temporal pattern recognition and source segregation in *O. ochracea*. We show that flies are capable of precise and rapid localization of attractive (host) sound sources under a range of acoustic conditions, and that this ability is largely dependent on a set of peripheral filtering mechanisms that exploit predictable features of cricket acoustic signals. These mechanisms capture much of the functionality of more complex (e.g. vertebrate) auditory systems, but at the cost of greater noise interference.

Silver (nano and ionic) toxicity in zebrafish (*Danio rerio*) embryos and rainbow trout (*Oncorhynchus mykiss*) hepatocytes

Toxicité à l'argent (nano et ionique) dans des embryons de poissons zèbre (*Danio rerio*) et dans des hépatocytes de truites arc-en-ciel (*Oncorhynchus mykiss*)

Andrey Massarsky, Vance Trudeau and Thomas Moon

University of Ottawa

Nanomaterials including nanosilver (nAg) are incorporated into an increasing number of consumer and medical products. However, much remains unknown about the toxicity of nAg but oxidative stress is suggested as a potential mechanism. We thus examined the effects of nAg on zebrafish embryos and rainbow trout hepatocytes. The effects of silver ions (Ag^+) were examined at equivalent concentrations as nAg is known to release Ag^+ in solution. Ag^+ was more toxic than nAg, leading to death and delayed hatching in embryos and cytotoxicity in hepatocytes. The changes in antioxidant glutathione levels were also more pronounced with Ag^+ in both models. Cysteine (Ag^+ chelator) was able to reduce the toxicity of both silver forms in both models. Furthermore, nAg was found to inhibit the stress response of adult zebrafish that were exposed during development, possibly interfering with the formation of the stress axis. Supported by NSERC grants.

Hybridization in sunfish influences the muscle metabolic phenotype

Hybridation dans le crapet influence le phénotype métabolique des muscles

Kate E. Mathers, R. Davies, A.D. Hume, K. Bremer, Y. Wang and C. D. Moyes

Queen's University

Hybridization has the potential to exert pleiotropic effects on metabolism. Effects on mitochondrial enzymes may arise through incompatibilities in nuclear- and mitochondrial-encoded subunits of the enzyme complexes of oxidative phosphorylation. We explored the metabolic phenotype of bluegill (*Lepomis macrochirus*), pumpkinseed (*L. gibbosus*) and their unidirectional F1 hybrids (male bluegill x female pumpkinseed). In hybrids, glycolytic enzyme activities were indistinguishable from or intermediate to parentals, but complex IV activities aligned with pumpkinseed, both 30% lower than bluegill. In isolated mitochondria, the specific activities of complexes I, II, and V were indistinguishable between groups. However, both complex III and IV showed indications of depressed activities in hybrid mitochondria, though no effects on mitochondrial state 3 or state 4 respiration were apparent. The patterns in complex IV activities were due to differences in enzyme content, rather than enzyme V_{max} ; immunoblots comparing complex IV content versus catalytic activity were indistinguishable between groups. The nature of sequence differences in complex IV catalytic subunits (CO1, CO2, CO3) were minor in nature, however the mtDNA-encoded subunit of complex III (cytochrome b) showed 8 differences between bluegill and pumpkinseed, several of which could have structural consequences to the multimeric enzyme, contributing to the depressed complex III catalytic activity in hybrids. Funded by NSERC.

The nudibranch *Tritonia diomedea* responds to odours trapped in the substrate boundary layer after removal of an odour plume.

Le nudibranche *Tritonia diomedea* répond aux odeurs emprisonnées dans la couche de substrat limitée après l'enlèvement d'un jet d'odeur

Greg B. McCullagh and Russell C. Wyeth

St. Francis Xavier University, St. Francis Xavier University

If flow direction in an aquatic habitat is constant, odour sources create plumes that can be used by animals to navigate. In addition, as a plume flows over a substrate, odours will accumulate in the boundary layer between the substrate and the fluid flow above. If flow direction changes, odours will linger in the boundary layer, providing a potential alternative cue for finding or avoiding an odour source. We have previously shown that *Tritonia diomedea* uses odour plumes for navigation, and we tested whether these animals can use odours trapped in the substrate boundary layer for navigation. Our results showed that slugs responded differently to both prey and predator odours trapped in the substrate boundary layer when compared to control seawater without odours. Thus, *T. diomedea* may use the trace of a previously-present odour plume for navigation, suggesting that other animals may also use this potential cue for odour-based navigation.

Alternative respiratory proteins in animal mitochondria

Protéines respiratoires alternatives dans les mitochondries animales

Allison McDonald

Wilfrid Laurier University

Respiratory electron transport complexes in animal mitochondria are depicted as being very linear and are described as an electron transport "chain". Alternative oxidases and alternative NAD(P)H dehydrogenases introduce branch-points in electron transport and have only recently been identified in animal mitochondria. These discoveries have forced us to recognize that this system is more of a network, as opposed to a chain, and to think carefully on existing paradigms about respiratory substrate use, the efficiency of respiration (in terms of ATP production and coupling), and the generation of reactive oxygen species. The physiological roles of these proteins are being investigated at different levels of biological organization and using different animal taxa in a comparative approach. Research in our lab is focused on the cloning of animal alternative oxidases and alternative NAD(P)H dehydrogenases and expressing them in heterologous systems in order to study protein targeting and the post-translational regulation of enzyme activity.

Cold lungs, warm heart? Temperature effects on the oxygen-hemoglobin dissociation curve of bar-headed geese

Poumons froids, cœur chaud? Les effets de la température sur la courbe de dissociation hémoglobine-oxygène de l'oie à tête barrée

Jessica Meir and Bill Milsom

University of British Columbia

Bar-headed geese migrate over the Himalayas where oxygen levels are only 1/2 - 1/3 those at sea-level. While it is well known that the haemoglobin (Hb) of this species has enhanced O₂ affinity, the effects of CO₂ and temperature on oxygen binding have not been well studied. We hypothesized that heavy breathing (producing alkalosis) in cold air at altitude would enhance O₂ loading at the lungs, while acidosis in warm blood in the exercising muscle would enhance O₂ unloading at the tissues. Preliminary evidence suggests that the temperature coefficient of the O₂-Hb equilibrium curve of bar-headed geese is higher than that of other birds and increases with increasing levels of CO₂. This supports our hypothesis and suggests that the combined effects of changes in temperature and CO₂ will have a greater effect on O₂ unloading than on O₂ loading. Funded by the NSERC of Canada and the NSF, USA

Designing MPAs in the deep sea: what about recruitment?

Le design des MPA dans l'océan profond: que se passe-t-il au niveau du recrutement?

Anna Metaxas

Dalhousie University

The deep sea is one of the least explored habitats on earth, despite being the largest biome and hosting among the highest faunal biodiversity on our planet. Less than 5% of the deep sea has been explored and < 0.1% of its seafloor has been studied quantitatively. Additionally, the deep sea includes a wide range of habitats with different geological, chemical and geophysical characteristics, further making generalizations about patterns and process difficult. Resource (mineral and biological) extraction from the deep sea (>3000 m) has become technologically feasible and economically desirable, as we continue to deplete our land reserves. To manage anthropogenic impacts on this remote environment, conservation measures are being proposed, such as areas with partial or full protection from human activities. However, the knowledge needed to design effective closures, such as species distributions, and larval supply and recruitment in many cases does not exist, or is limited at best.

Hydrogen peroxide facilitated diffusion of iodine in the purple urchin (*Strongylocentrotus purpuratus*)

Le peroxyde d'hydrogène facilite la diffusion de l'iode chez les oursins violets (*Strongylocentrotus purpuratus*)

Ashley E. M. Miller and Andreas Heyland

The University of Guelph

Iodine is an essential element with several biological functions. Its transport has been best characterized in the vertebrate thyroid where its translocation is attributed to specific transporter proteins e.g., the apical iodide transporter (AIT) and sodium iodide symporter (NIS). However an alternative mechanism has been demonstrated in marine bacteria and brown kelp: H_2O_2 facilitated diffusion (PFD). Despite this, little is known about iodine accumulation in non-chordates. Our investigations into iodine metabolism of a basal Deuterostome, the purple urchin (*Strongylocentrotus purpuratus*), aim to remedy this. We found that in larvae of *S. purpuratus*, iodine accumulation is not dependent on NIS/AIT, as seen in vertebrates. It is, in fact, a diffusional process facilitated by H_2O_2 . Our data suggest that in the marine environment, PFD is the ancestral mechanism of iodine acquisition. Furthermore PFD of iodine may also be relevant for vertebrates, as they too possess the basic machinery to utilize this mechanism.

The influences of vagal feedback and pontine input on breathing pattern are reconfigured during hibernation in golden-mantled ground squirrels

Les influences de la rétroaction vagale et de l'input pontique sur les patrons de respirations sont reconfigurés en période d'hibernation chez le spermophile à mante dorée

Bill Milsom and Mike Harris

University of British Columbia, University of Alaska

In the present study we show that the role of vagal feedback from pulmonary stretch receptors and from the pontine respiratory group in anesthetized ground squirrels are to modulate the timing and shape of individual breaths, just as in other mammals. During hibernation, however, these same inputs now act to modulate the timing and shape of breathing episodes rather than individual breaths. Vagal feedback increases the number of breaths per episode (increasing total ventilation) while input from NMDA type glutamate receptor mediated processes in the dorsal pons decreases the frequency and number of breaths in each episode (decreasing total ventilation). Neither input has any effect on the timing or shape of the individual breaths within an episode. Importantly, both inputs are required to cluster breaths into episodes. Supported by the NSERC of Canada.

The potential impacts of the β -blocker propranolol on the stress response in the zebrafish *Danio rerio*
Les impacts potentiels de bêta-bloquant propranolol sur la réponse au stress du poisson zèbre *Danio rerio*

¹Kimberly Mitchell, ¹Thomas Moon, ¹Brianna Greenberg and Cecile Bignon

¹University of Ottawa

β -blockers are of environmental concern since they are one of the most commonly prescribed classes of human pharmaceuticals. As such, β -blockers make their way into the aquatic environment and are currently found at concentrations in the ng/L to μ g/L range. The objective of this study was to determine if the β -blocker PROP acts as an endocrine disrupting chemical by modifying the ability of zebrafish to effectively respond to a stressor. A waterborne PROP exposure was performed on adult zebrafish in which blood glucose and whole body cortisol triglycerides and cholesterol were examined. PROP exposed fish were able to increase their blood glucose levels when stressed. Cortisol, triglyceride and cholesterol levels in stressed and PROP treated fish were not significantly different than unstressed groups; however, this data is preliminary and further experimentation is necessary. This experimental work will allow us to assess the potential impacts of a PROP on zebrafish.

Pro-hormone convertases and ghrelin O-Acyl transferase in Sprague Dawley rats: developmental profile and functional implications

La pro-hormone convertases et la ghréline O-acyltransférase chez les rats Sprague-Dawley: profil de développement et ses conséquences fonctionnelles

Haneesha Mohan, Micha Gasner and Suraj Unniappan

York University

Ghrelin is an orexigenic gut hormone. Ghrelin is processed from its precursor by prohormone convertases (PCs) and is acylated by ghrelin O-acyltransferase (GOAT). We determined the ontogenic expression pattern of these three important molecules. A small number of GOAT immunoreactive pancreatic beta cells co-stained ghrelin on postnatal days (PND) 20, 27, and in adults. At PND 27, PC2 is present exclusively in pancreatic alpha cells, but at all other stages, both PC1/3 and PC2 are also present in beta cells. Gastric cells are negative for GOAT and ghrelin immunoreactivity from embryonic day 21 to PND 20. But at PND 27, and in adults, gastric immunopositive ghrelin cells are negative for GOAT. Gastric ghrelin mRNA expression on PND 13 is the highest, while gastric and pancreatic GOAT mRNA expression is highest at 4 weeks post-partum. The expression pattern of ghrelin and its processing enzymes implies that ghrelin functions vary during development.

Trade-offs in neural performance following severe metabolic stress involve the AMPK pathway

Le compromis dans la performance neurale après un stress métabolique important implique la voie de l'AMPK

Tomas GA Money, Zeenia Aga and R Meldrum Robertson

Queen's University

Nervous systems are energetically expensive to maintain and there is now good evidence that circuits can be optimized for efficiency depending on the real-time demands and constraints of the animal's environment. We have tested the hypothesis that severe metabolic stress alters the properties of neural circuits in ways that reduce the energetic demand. The locust, *Locusta migratoria*, was used to study recovery of neural activity following an anoxic coma. Neural function was monitored using the visual looming detector circuit via the descending contralateral movement detector neuron (DCMD). We show that the observed anoxic effects on measures of metabolic rate, flight steering behaviour, and AP properties are modifiable through modulation of the AMPK metabolic pathway. Further, modulation of the AMPK pathway alters the susceptibility of locusts to anoxic treatment. We suggest this is evidence of a coordinated cellular mechanism to reduce neural energetic demand following a severe metabolic stress.

Revamping a senior (honours) undergraduate research seminar course

Un cours de séminaire en recherche au premier cycle (4e année): une nouvelle structure.

Colin Montpetit, Charles Darveau, Antoine Morin, Scott Findlay, Howard Rundle, Adam Brown and Marie-Andrée Akimenko

University of Ottawa

The honours research seminar course in the Department of Biology (uOttawa) aims to provide students opportunities to explore recent primary scientific publications through workshops and weekly student seminars to develop practical skills for assessing and designing biological investigations, writing scientific research proposals and to present oral communications. To improve the teaching and learning effectiveness of the course, efforts during the past 3 years have been directed at revamping the structural organization and pedagogical approaches to specifically address the student learning experience. In this session, presenters will discuss the challenges and strategies for the design, delivery, assessment and the evaluation of the course. Inasmuch, the presentation will elaborate upon the course outline, learning outcomes, student activities, formative and summative assessments, and administrative logistics. Both students and faculty find the new format to be more effective and to provide more guidance to students in how to assess the quality of science.

Gene expression in female American lobsters (*Homarus americanus*): exploring size at maturity using oligonucleotide microarray analysis

L'expression de gènes chez le homard américain femelle (*Homarus americanus*): explorer la taille à la maturité en utilisant l'analyse des microréseaux d'oligonucléotides

¹Mitchell Moore, ²KC Clark, ²AR Acorn, ³M Comeau and ²SJ Greenwood

¹University of Prince Edward Island, ²Atlantic Veterinary College (UPEI), ³Fisheries and Oceans Canada

American lobsters (*Homarus americanus*) fishing is economically valuable to coastal Canadian communities. Currently, minimum legal size is based on female "size at onset maturity" (SOM). Establishing SOM requires killing females to examine their gonads. Ovaries can be staged based on colour, weight, and oocyte size. The latter is precise but time consuming, while colour and weight do not work well for stage 4 ovaries, which are subdivided into 4a (immature) and 4b (mature), and can result in misclassification of the maturity status. Once immature females progress to stage 4b, they are committed to mature and extrude eggs. Using a lobster specific oligonucleotide microarray, we analysed four tissues to discover genes which were statistically significant between all ovary stages. Complementary RT-qPCR of several genes, including vitellogenins, were used to validate the microarray results. Gene expression profiles of significant genes may lead to the development of more objective, non-lethal ovary staging methods.

Essential data acquisition techniques in today's animal physiology student laboratory

Techniques essentielles d'acquisition de données dans les laboratoires étudiants d'aujourd'hui en physiologie animale

Kevin Morgan

ADInstruments

ADInstruments develops and manufactures PowerLab, the world's leading data acquisition system for life science education. The PowerLab system with LabChart, LabTutor and LabAuthor software providing an extensive range of experiments for students enrolled in introductory courses through to post-graduate studies. Kevin Morgan will discuss the software planning and execution required to run a successful and efficient animal physiology laboratory class using everything from cockroaches and locusts, to snails, earthworms, frogs and rabbits. Creative use of classic lab equipment including nerve baths, muscle holders, organ baths and force transducers within the context of experiment design will be discussed. Attendees will take home a number of best practices relating to curriculum implementation and how to create step-by-step protocols including dissection, stimulating responses and applying pharmacological preparations with minimal preparation and focused, experience driven learning outcomes.

The illogicality of arbitrary statistical cutoffs in zoology and suggestions for better alternatives

L'illogisme des seuils statistiques arbitraires en zoologie et des suggestions de meilleures alternatives

Joseph Mudge and Jeff Houlahan

University of New Brunswick Saint John

Arbitrary statistical cutoffs are commonly used in a wide array of both frequentist and Bayesian statistical techniques in zoology. Examples include $\alpha = 0.05$, 95% confidence intervals (or 95% credible intervals), and AIC scores that differ by < 2 . Statistical thresholds are important tools for objective scientific decision making, however the application of arbitrary threshold levels irrespective of study design and/or research question can lead to poor decisions. We highlight a technique for choosing optimal, study-specific α levels that minimize the combined probabilities or costs of Type I errors and biologically meaningful Type II errors for null hypothesis significance tests, discuss the consistent advantages of this approach over using arbitrary α levels, and comment on the potential for choosing biologically transparent and study specific cutoff levels in other commonly used statistical techniques.

The effects of salinity on the acute copper toxicity to the mysid shrimp (*Mysidopsis bahia*)

Les effets de la salinité sur la toxicité aiguë au cuivre chez la crevette de mysid (*Mysidopsis bahia*)

Rabia Nasir, Jessie Cunningham and James McGeer

Wilfrid Laurier University

As salinity changes both the geochemical speciation of Cu and the physiology of organisms are altered. This chemical-biological interaction complicates the understanding of the impacts of Cu in estuarine waters. In this study the acute toxicity of Cu to *M. bahia* was tested using standard EPA methods (96h) over a range of salinities from 5ppt – 40ppt. Total, dissolved and free ion concentrations of Cu were measured, the latter by anodic stripping voltametry. Cu LC50 values did not vary at salinities between 15ppt and 30ppt (mean 277 $\mu\text{g/L}$ (nominal)). Cu was more toxic at low salinities and follow-up was required to distinguish the impacts of Cu from the physiological effects of reduced salinity. This study is contributing to the development of an estuarine Biotic Ligand Model for water quality guidelines/criteria for Cu. This research is funded through a NSERC CRD with ICA, CDA, ILZRO, IZA, Teck, Xstrata Zinc.

Mechanisms and capacity of nitrogenous waste excretion during the complex life cycle of the sea lamprey (*Petromyzon marinus*)

Mécanismes et excrétion de déchets azotés durant le cycle de vie complexe de la lamproie marine (*Petromyzon marinus*)

¹James Neal, ¹Michael Wilkie, ²Matt Vijayan, ¹Sean Anthony and ¹Nolan Brody

¹Wilfrid Laurier University, ²University of Waterloo

Sea lampreys (*Petromyzon marinus*), an ancient jawless fish, have a multi-staged life cycle characterized by a prolonged suspension-feeding larval stage, followed by metamorphosis into a parasitic lamprey that feeds on the protein rich blood of fishes. Because metamorphosis is accompanied by increased capacity to deaminate excess amino acids, we tested the hypothesis that metamorphosis and feeding by parasitic sea lampreys is characterized by marked increases in urea excretion (JUrea) capacity. Metamorphosis was accompanied by marked 10-fold increases in JUrea. Similarly, post-feeding JUrea increased 5-fold in parasitic phase lampreys. Urea transport inhibitors (phloretin, acetamide and thiourea) experiments suggested that JUrea was mediated by facilitated urea transporter (UT). The possibility that life-stage dependent and feeding-induced increases in JUrea are due to increased UT abundance is being tested using western blotting.

Temperature preference and trade-off behaviour of juvenile American lobster *Homarus americanus* in cold environments

Température préférentielle et le comportement de compromis du homard américain *Homarus americanus* juvénile dans des environnements froids

Travis Nielsen and Iain McGaw

Memorial University of Newfoundland

Acquisition of shelter and food are important determinants for the survival of juvenile American lobster, *Homarus americanus*. However, little is known about the temperature preference of early benthic juvenile phases of *H. americanus*, and how this may interact with their sheltering and foraging behaviours. This is important in Newfoundland where they are on their northern range limits and the low temperature may affect feeding, growth, and survival rates. We investigated the preferred temperatures of juvenile *H. americanus*, establishing normal sheltering and foraging behaviours. Using a Loligo Shuttlebox™ system we determined trade-off behaviours for temperature, shelter, and food. Laboratory experiments showed that juvenile *H. americanus* prefer temperatures of approximately 18°C. However, they actively seek out shelter and/or food in temperatures outside preferred ranges even if optimal temperatures are present. These results suggest that, juveniles may choose to remain in “stressful” temperatures to ensure access to shelter and food.

Tissue-specific selenium accumulation and speciation in rainbow trout exposed to elevated dietary selenomethionine

Accumulation de sélénium de façon spécifique au tissu et la spéciation chez la truite arc-en-ciel exposée à des niveaux élevés de sélénométhionine alimentaire

Som Niyogi, Sougat Misra and Derek Peak

University of Saskatchewan

Selenium is an essential micronutrient, but can be extremely toxic to fish at elevated concentration. Selenium exposure to fish occurs primarily in the form of selenomethionine in diet. This study was designed to examine the tissue-specific selenium accumulation and speciation in rainbow trout (*Oncorhynchus mykiss*) exposed to sublethal dietary selenomethionine for 14 days. Our findings indicated that selenomethionine exposure resulted into a marked increase in selenium accumulation in all major tissues including brain. The examination of selenium speciation by X-ray Absorption Near Edge Spectroscopy (XANES) suggested that selenomethionine, selenocystine and selenocysteine were the predominant forms of selenium in all of the tissues; however their relative proportion varied across different tissues. The tissue selenium speciation recorded in this study was in good agreement with our previous in vitro observations on selenium metabolism in trout liver. Collectively, our findings provide new insights into the tissue-specific distribution and speciation of selenium in fish.

Expression of lactate transporters in rainbow trout: effects of hypoxia

Expression des transporteurs de lactate chez la truite arc-en-ciel : effets de l'hypoxie

Teye Omlin and Jean-Michel Weber

University of Ottawa

Partial sequences of the monocarboxylate transporters MCT1b and MCT2 were cloned in rainbow trout. Our goals were: (i) to establish their distribution and mRNA levels in the main tissues of normoxic fish, and (ii) to determine changes in expression during exposure to short hypoxia (25% O₂ for 90 min) or long hypoxia (35% O₂ for 8h). In normoxic fish, MCT1b showed high mRNA levels in heart, liver and red muscle, but low levels in gill, brain, and white muscle. Short and long hypoxia caused a 2- and 3-fold decrease in the expression of liver MCT1b, but had no effects on other tissues. Expression levels of MCT2 were low in all tissues and unaffected by hypoxia. We conclude that: (i) the very low expression of MCTs in white muscle could explain the classic "lactate retention behaviour" of this tissue after intense swimming or hypoxia, and (ii) hepatic gluconeogenesis from lactate is not stimulated during hypoxia.

Des séquences partielles de transporteurs de monocarboxyles MCT1b et MCT2 ont été clonées chez la truite arc-en-ciel. Notre but était: (i) d'établir leur distribution et niveau d'ARNm dans les principaux tissus des poissons en normoxie, et (ii) de déterminer les changements d'expression durant une exposition à une hypoxie de 1h 30 (25% O₂) ou de 8h (35% O₂). En normoxie, le niveau d'ARNm de MCT1b était plus élevé dans le cœur, le foie et le muscle rouge, que dans les branchies, le cerveau, et le muscle blanc. L'hypoxie (de 1h 30 et de 8h) a causé une diminution de l'expression de 2 et 3 fois respectivement, dans le foie, sans effet sur les autres tissus. L'expression de MCT2 est faible dans les tissus, et reste inchangée durant l'hypoxie. Nous concluons que: (i) le niveau très bas des MCT dans le muscle blanc pourrait expliquer "le comportement de rétention du lactate" dans ce tissu suite à une nage intense ou une hypoxie, et (ii) la néoglucogenèse hépatique n'est pas stimulée durant l'hypoxie.

Effects of nanoparticles on zebrafish hatch under natural conditions

Les effets des nanoparticules sur l'éclosion de poisson zèbre sous conditions naturelles

Kimberly Ong, Rhett Clark, Jonathan Veinot and Greg Goss

University of Alberta

Many advances have been made in studying the biological effects of nanoparticles on aquatic organisms in pristine experimental media, but these studies often do not account for natural environmental conditions. We have found that cadmium selenide, silver, and zinc oxide nanoparticles can delay or inhibit hatch of zebrafish (*Danio rerio*) under experimental conditions and we determined that this inhibition is likely through the interaction of nanoparticles with the hatching enzyme. With the knowledge that nanoparticles can have a high affinity for natural matter, we determined whether nanoparticle hatching effects would be attenuated in the presence of natural organic matter or sediments. Furthermore, we established whether salinity could change the effect of nanoparticles on hatch as a result of aggregation and settling of the nanoparticles.

Characterizing the mechanism of action of the herbicide linuron in the fathead minnow (*Pimephales promelas*) ovary

Caractérisation du mécanisme d'action de l'herbicide linuron au niveau des ovaires du tête-de-boule (*Pimephales promelas*)

Anna Ornostay and Christopher J. Martyniuk
University of New Brunswick Saint John

Linuron (LIN), a ureic-based herbicide, is widely used in crop production throughout North America and has been detected in aquatic environments at concentrations in the ng/L to µg/L range. The aim of this study was to better characterize the MOA of LIN in the teleost ovary by comparing the genomic responses of LIN to those of a model androgen (dihydrotestosterone; DHT) and anti-androgen (flutamide; FLUT). To examine the MOA of linuron, ovaries from female fathead minnows (FHMs) were exposed to three concentrations (10^{-6} M, 10^{-7} M, 10^{-8} M) of DHT, FLUT and LIN *in vitro* in a 12 hour incubation. Genes regulated in the ovary as a result of the treatments were identified using microarray analysis. This study begins to characterize cell pathways that underlie altered E2 production in the ovary and provides evidence that LIN and FLUT affect more pathway targets in common than LIN and DHT, consistent with an anti-androgenic MOA.

Those other gastropod larvae: first study on morphogenesis through metamorphosis of a feeding neritimorph larva

Ces autres larves de gastéropodes: première étude sur la morphogénèse par métamorphose d'une larve de neritimorphe qui se nourrit

Louise Page and Sam Ferguson
University of Victoria

Neritimorph gastropods are centrally important for reconstructing the evolutionary history of feeding larvae within the Gastropoda. The phylogenetic placement of neritimorphs has been unstable, but this knowledge is needed to determine if feeding larvae evolved once or twice within gastropods. Adding to the uncertainty is the paucity of information on feeding larvae of neritimorphs, in contrast to abundant information on larval morphogenesis for members of the other two gastropod clades with a feeding larva: caenogastropods and heterobranchs. I report results of the first study on development through metamorphosis of a neritimorph with a feeding larva, as based on sections for light and electron microscopy. Although recent molecular phylogenies place neritimorphs as sister to a clade containing caenogastropods and heterobranchs, suggesting that feeding larvae evolved only once among gastropods, the feeding larvae of *Nerita melanotragus* and caenogastropods are more similar to each other than either is to feeding larvae of heterobranchs.

Developmental origins of normal and anomalous random right-left asymmetry: lateral inhibition versus developmental error in a threshold trait

Origine de développement normal et anormal de l'asymétrie droite-gauche aléatoire: inhibition latérale versus l'erreur développementale dans un trait seuil

A. Richard Palmer
University of Alberta

Dramatic examples of right-left asymmetry often inspire adaptive explanations. But are they necessarily adaptive? Surprisingly, in some species where direction of asymmetry is random, conspicuous asymmetry in bilaterally paired traits appears to arise via developmental error in a threshold trait. Several models of the ontogeny of asymmetry are described for both normal and anomalous random asymmetry of bilaterally paired traits. Each model predicts different frequencies of symmetrical and asymmetrical individuals within a species. Examples of normal and anomalous random asymmetries are reviewed for several animal groups and compared to predictions. A re-examination of the spectacular forelimb asymmetry in empidid dance flies raises doubts about claims that its occurrence and its direction are adaptive, even though enlargement of the forelimbs likely is. This example illustrates nicely how creative biologists can advance wholly plausible, adaptive explanations for what may be purely random phenotypic variation.

Anesthetic activity of the essential oil of *Aloysia triphylla* (L'Hér.) Britton in *Rhamdia quelen*

L'activité anesthésique de l'huile essentielle de *Aloysia triphylla* (L'Hér.) Britton chez *Rhamdia quelen*

T.V. Parodi, L.L. Silva, C. Zeppenfeld, L.T. Gressler, B.M. Heinzmann and B. Baldisserotto
Universidade Federal de Santa Maria

We tested the anesthetic properties of essential oils extracted from the plant *Aloysia triphylla* (collected in different seasons) on juvenile catfish. The increase of concentration decreased time to reach the different stages of anesthesia and a longer time was needed for recovery. Concentrations of the 30, 40 and 50 $\mu\text{L L}^{-1}$ of the oil extracted in spring and autumn were unable to induce stage 4 and showed the lowest recovery times. The lowest concentration able to induce stage 4 was 100 $\mu\text{L L}^{-1}$. For oil extracted in summer and winter the lowest concentration able to induce deep anesthesia was 50 $\mu\text{L L}^{-1}$ with longer recovery times than the same concentration of oil extracted in spring and autumn. These oils induced anesthesia in silver catfish juveniles without causing mortality and could provide an alternative to the synthetic anesthetics currently used in aquaculture. The activity of the plant oils is influenced by seasonal variation.

Phosphoinositide 3-kinase interactions with protein kinase C and B signal transduction systems in gonadotropin-releasing hormone actions in goldfish, *Carassius auratus*

Interactions entre la phosphoinositide 3-kinase et les systèmes de transduction de signal des protéines kinases B et C sur l'action de la gonadolibérine chez le poisson rouge, *Carassius auratus*

Joshua G. Pemberton, James L. Stafford and John P. Chang
University of Alberta, University of Alberta, University of Alberta

In goldfish (*Carassius auratus*), two endogenous gonadotropin-releasing hormones (sGnRH and cGnRH-II) control maturational gonadotropin (LH) and growth hormone (GH) secretion via multiple signalling cascades, including protein kinase C (PKC) and phosphoinositide 3-kinase (PI3K). PI3K is known to target PKC and protein kinase B (Akt) signalling in many systems. Whether and how PI3K interacts with PKC and Akt in the control of LH and GH release from goldfish pituitary cells was investigated. The selective PI3K inhibitor LY294002 did not alter LH or GH release responses to PKC-activators TPA or DiC8. Although both sGnRH and cGnRH-II significantly increased phosphorylation of immunoreactive Akt, a specific Akt inhibitor (Akt 1/2 Inhibitor VIII) did not affect GnRH-stimulated LH or GH release. These results indicate that in terms of GnRH actions on LH and GH secretion in goldfish, PKC is not upstream of PI3K and PI3K action is independent of Akt. (Supported by NSERC).

A-salted sturgeon: acute effects of saltwater exposure on the swimming behaviour and exercise of shortnose sturgeon

Un esturgeon salé: les effets aigus de l'exposition à l'eau salée sur le comportement de nage et l'exercice chez l'esturgeon à museau court

Faith Penny and James Kieffer

University of New Brunswick Saint John

Adult shortnose sturgeon routinely enter saltwater to forage, yet little is known about how (or if) juveniles cope with the associated osmoregulatory pressures. We have previously shown that acute (≤ 24 -hour) saltwater exposure of young shortnose produces significant increases in plasma osmolality/ion concentrations and rapid weight loss ($\approx 17\%$ of total). Similarly elevated plasma ion levels are often related to decreased swimming ability in other fish species. The objective of this study was to determine whether acute saltwater exposure also results in higher levels of disturbances (i.e. swimming behaviour & metabolic) in juvenile shortnose sturgeon. Sturgeon of various sizes were exposed to different salinities (up to 32‰) for 24-hours. Following exposure, critical swimming speed (U_{crit}) and metabolic recovery from exhaustive exercise (oxygen consumption) were measured. Smaller fish were unable to swim at 32‰, yet across all other experimental salinities/sizes there were no differences in U_{crit} or post-exercise metabolism.

Reelin in the years: a retrospective look at fish ionic regulation

Au fil des années: un regard rétrospectif sur la régulation ionique des poissons

Steve Perry

University of Ottawa

Thanks to my mentor Dave Randall, I joined the wonderful world of fish physiology in 1977, the same year that disco culture hit a new high with the release of "Saturday Night Fever." At the same time, the discovery that there was much to learn about how salts, gases and acid-base relevant molecules cross the gill set the stage for the next 35 years of my life. Those early years piqued my curiosity about how hormones and neurotransmitters affect physiological processes. Thus, much of this talk will focus on the neurohumoral regulation of gill function. In 1982, my other mentor Chris Wood taught me an important lesson - betting on sporting events to determine order of authorship can be highly profitable. Since arriving in Ottawa in 1983, I have been fortunate to supervise some truly exceptional students and PhDs. The past 30 years have witnessed considerable progress in the field, but current students should take note - there still is much to be learned!

Adenosinergic modulation of central pH/CO₂ chemosensitivity in the brainstem of the Cane toad, *Bufo marinus*

Modulation adénosinergique de la chimiosensibilité centrale pH/CO₂ dans le tronc cérébral du crapaud, *Bufo marinus*

Andrew Peters and Stephen Reid

University of Toronto Scarborough

The Adenosinergic Modulation of Central Respiratory CO₂/pH Sensitivity:

Amphibians survive bouts of hypoxia by entering a state of metabolic depression. During hypoxia Adenosine (ADO) can increase 100-fold extracellularly and has been implicated in this depression. Since breathing may not be possible during these hypoxic events, we tested whether ADO would decrease respiratory motor output. Using the in vitro brainstem preparation of the cane toad, *Bufo marinus*, and recording from nerves that innervate respiratory muscles, ADO, CCPA, an ADO1 receptor (A1R) agonist, or DPCPX, an A1R antagonist, were individually applied, acutely, to aCSF (40min) at multiple concentrations and pH's, and recording continued for another 12hr. At low pH's, lower concentrations of ADO decreased total fictive ventilation. As pH and/or ADO concentration is increased TFV also increases. At all pH's and concentrations CCPA decreased TFV while DPCPX increased it. CONCLUSION: ADO elicits a concentration-dependent modulation of respiratory motor output which is pH-dependent while depression is mediated by A1R activity.

Nesfatin-1 regulation of the stress axis in goldfish

La régulation de l'axe de stress par la nesfatine-1 chez les poissons rouges

Vi Pham, Brent Kerbel, Ronald Gonzalez and Suraj Unniappan

York University

Nesfatin-1 is a novel metabolic hormone encoded in nucleobindin-2 (NUCB2). Nesfatin-1 co-expresses CRH in the brain, and stimulates both adrenocorticotrophic hormone (ACTH) and cortisol secretion in rats. The main aim of my research is to understand the relationship between the stress/hypothalamo-pituitary-interrenal (HPI) axis and nesfatin-1 in goldfish. I found that nesfatin-1 colocalizes CRH receptor 1 in the hypothalamus and pituitary, and ACTH in the pituitary, suggesting a modulatory role for nesfatin-1 on both CRH and ACTH. Netting and restraint stress upregulates NUCB2 mRNA expression by 50% in goldfish hypothalamus and by 150% in the forebrain. Intracerebroventricular injection of nesfatin-1 caused a significant increase of almost 4-fold in CRH mRNA expression at 30 minutes post-injection. Intraperitoneal injection of nesfatin-1 resulted in a significant 2-fold increase in serum cortisol levels at 15 minutes post-administration. Together, my results indicate that nesfatin-1 is a stress-responsive hormone that modulates the HPI axis in fish.

Epigenetics and metamorphosis: A preliminary comparison of histone modifications in larvae and adults of *Polydora cornuta* (Annelida)

L'épigénétique et la métamorphose: une comparaison préliminaire des modifications d'histones dans les larves et adultes de *Polydora cornuta* (Annelida)

Robyn Pierce, Corban Hart and Glenys Gibson

Acadia University

Metamorphosis is often considered to be a 'reprogramming' of development as it involves a major morphological transition from a larval to a juvenile phenotype. In this preliminary study, we asked: does metamorphosis involve a change in the epigenome, and if so, do epigenetic modifications of larvae and adults differ in sensitivity to the environment? We used immunohistochemistry to examine differences in histone modifications in *Polydora cornuta*. Three histone modifications were detected in most larval tissues but in adults, had a more restricted distribution (H3K14ac, H3K9me, H3K4me2). Exposure to Bisphenol A (a methyl releaser) caused hypomethylation of H3K9me in some tissues of larvae (e.g., chaetal sacs) but not adults, and in contrast, altered the body-wide distribution of H3K14ac in adults but not larvae. These data suggest that histone modifications change during metamorphosis and provide a mechanism by which sensitivity to environmental stressors may vary with life stage.

Timing of life-history events and the persistence of a rare invertebrate population in a mangrove coastal lagoon

Timing des événements d'histoire de vie et la persistance d'une population d'invertébrés dans un lagon de mangrove côtière

Jesús Pineda

Woods Hole Oceanographic Institution

Timing of reproduction and larval developmental time maximize dispersal in tropical barnacles inhabiting mangrove roots. Mature barnacles *Microeuraphia* spp. release larvae synchronously at the beginning of the spring tides, and larvae complete their larval stage and settle ~6 days later by the end of the spring tides. These schedules are advantageous because: (1) these barnacles live in the high intertidal zone, and larvae can settle on adult habitats only on very high tides; (2) larval transport by estuarine salinity fronts is larger in spring than in neap tides, and; (3) short larval developmental time reduces larval mortality. Moreover, tidal salinity fronts, topography and larval behavior play a role in the persistence of an isolated *Microeuraphia* population. Our study highlights how life-history events finely tuned to extreme but predictable environmental variability account for the success of *Microeuraphia*, and the roles of salinity fronts and topography in maintaining a rare barnacle population.

Distribution, prevalence, mean intensity, relative density and life history implications of worm infections in coyotes (*Canis latrans*) of Nova Scotia

Distribution, prévalence, intensité moyenne, densité relative et implications dur l'histoire de vie de l'infection par des vers sur les coyotes (*Canis latrans*) de la Nouvelle-Écosse

¹Jason Power, ²Gary Conboy, ³Mike O'Brien and ¹Todd Smith

¹Acadia University, ²University of Prince Edward Island, ³Nova Scotia Department of Natural Resources

Coyotes were first recorded in Nova Scotia in 1977, but their parasite fauna in the province has not yet been investigated. The objectives of this study were to determine distribution, prevalence, mean intensity and relative density of worm parasites in coyotes from Nova Scotia, and to investigate if these ecological measures were consistent among age classes. Hearts, lungs and gastrointestinal tracts were examined for parasites, and teeth were processed to assess the age of each. The lungworms *Crenosoma vulpis* and *Oslerus osleri* were the most prevalent parasites, found in 31% and 37% of coyotes, respectively. A mean intensity of 6.9 *C. vulpis* and 8.9 *O. osleri* and a relative density of 2.1 *C. vulpis* and 3.4 *O. osleri* were recorded across all age classes, with a significantly higher relative density of each parasite in juveniles. Implications of these findings will be discussed in relation to parasite transmission to domestic dogs.

Nitrogen excretion in the freshwater ribbon leech *Nephelopsis obscura*

Excrétion d'azote chez la sangsue ruban d'eau douce *Nephelopsis obscura*

Alex Quijada-Rodriguez and Dirk Weihrauch

University of Manitoba

Ammonia is a highly toxic nitrogenous waste product of amino acid metabolism.

The Ribbon leech seems to be ammonotelic excreting 164 ± 14 nmol gFW⁻¹ h⁻¹ ammonia and 22 ± 7 nmol gFW⁻¹ h⁻¹ urea. Feeding caused an increase in ammonia but not urea excretion rates. A one-hour exposure period of varying environmental ammonia concentrations resulted in elevated post-exposure ammonia excretion rates after exposure to ≥ 500 $\mu\text{mol l}^{-1}$ (no changes at 100 and 200 $\mu\text{mol l}^{-1}$). This indicated that hemolymph concentrations are likely above 200 μM and below 500 μM . Ammonia excretion in *N. obscura* was pH dependent, with higher and lower rates being detected in media buffered to a low and high pH, respectively. This suggested an ammonia excretion mechanism via ammonia trapping. This assumption is supported by our inhibitor experiments showing a reduced ammonia excretion rate after inhibition of the V-ATPase and/or the carbonic anhydrase.

Effects of waterborne copper and hypoxia on the oxidative stress response and gene expression in killifish (*Fundulus heteroclitus*)

Les effets du cuivre dissout dans l'eau et de l'hypoxie sur la réponse au stress oxydatif et l'expression des gènes du choquemort (*Fundulus heteroclitus*)

Victoria Ransberry and Grant McClelland

McMaster University

Anthropogenic influences have made occurrences of coastal eutrophication and accompanying hypoxia more widespread. If these areas are sites of metal contamination, a combination of multiple stressors is likely to affect aquatic organisms. For example Cu and hypoxia can both induce oxidative stress in fish. We investigated individual and combined effects of Cu and hypoxia on oxidative damage, induction of gene expression and changes in enzyme activity in liver, gill and intestine of killifish. Killifish were exposed to 20 $\mu\text{g/L}$ Cu under 100% and 25%-O₂ saturation, for 96-hours in freshwater. Opercula rate increased in hypoxic and Cu+hypoxic treatments compared to control. However, hematocrit (%) between treatments was unchanged. There is a possible synergistic effect of Cu and hypoxia to induce oxidative stress, since protein carbonyl content was higher after exposure to Cu+hypoxia compared to Cu or hypoxia alone. We predict the same synergy in changes in lipid peroxidation and antioxidant defense responses.

Endogenous rhythms of ecdysteroids in an adult insect, *Rhodnius prolixus*

Les rythmes endogènes des ecdystéroïdes dans un insecte adulte: *Rhonius prolixus*

Nicholas Rapp and Colin Steel

York University

The insect moulting hormones, ecdysteroids, are critical components of the larval circadian system. Little is known about the physiology of the adult circadian system. Recently, this lab demonstrated cycling of ecdysteroid levels throughout oogenesis in the adult insect *Rhodnius prolixus*. To determine whether this daily rhythm is under circadian control, cycling of ecdysteroid levels was investigated in aperiodic conditions. Insects were transferred from 12:12 light:dark to continuous darkness or continuous light and hemolymph and ovaries were collected every 6h for 3 days. Ecdysteroid levels were quantified using radioimmunoassay. The rhythm of ecdysteroid levels persisted in constant dark for at least 3 cycles and damped in constant light, thus these rhythms are endogenously controlled. It is suggested that the circadian rhythms of ecdysteroids in the adult female insect are involved in coordinating egg development. This work enables analysis of the role of endocrine rhythms in the circadian organization of reproduction.

Observations on the infectivity and development of *Nosema apis*, a bee microsporidian, on fish cell lines

Observations sur la capacité d'infection et le développement de *Nosema apis*, une microsporidie d'abeille, sur les lignés cellulaires de poisson

¹Alina Reid, ¹Richelle Monaghan, ²Niels Bols and ¹Lucy EJ Lee

¹Wilfrid Laurier University, ²University of Waterloo

The microsporidians, *Nosema apis* and *Nosema ceranae*, have been linked to colony collapse disorder in honey bees world wide. The obligate intracellular growth cycle of microsporidians and the lack of established honey bee cell lines have made obtaining detailed information regarding “nosemosis”, the disease associated with nosema infections, difficult. Fish cell lines were previously shown to support the growth of an insect microsporidian, *Anncaliia algerae* (formerly *Nosema algerae*), thus fish cell lines were evaluated for their ability to support *N. apis* growth. Infection with *N. apis*, isolated from the western honey bee (*Apis mellifera*) was observed in fish cell lines. However, growth was slow and only 5 to 10% of the cells within a culture, showed signs of infection. Using phase contrast and fluorescence microscopy, the life cycle stages of *N. apis* development could be noted *in vitro*. Preliminary observations of infectivity rate have shown increased spore growth at warmer temperatures.

Wetlands as dynamic refugia from an introduced predator in Lake Nabugabo, Uganda

Zones humides comme refuge dynamique d'un prédateur introduit dans le lac Nabugabo en Ouganda

Andrea Reid, Lauren Chapman and Anthony Ricciardi

McGill University

The impact of introduced predators on native species depends on their spatiotemporal overlap, which determines refugia availability. In Lake Nabugabo, Uganda, wetlands serve as structural and hypoxic refugia for native fishes from introduced Nile perch (*Lates niloticus*). However, interaction with the main lake creates steep gradients within the wetlands, and the encroachment of native hippograss (*Vossia cuspidata*) may have limnological consequences for the refugium. We examined fish distribution in the wetlands and assessed the influence of hippograss on the refugium. We detected declines in water depth, temperature and oxygen, and an increase in structural complexity with distance inshore. Species richness was negatively correlated with temperature and structure, and positively correlated with oxygen. Wetland areas with increased hippograss were on average warmer, more hypoxic and more structured, thus supporting fewer species. These results demonstrate the importance of gradients in shaping refuge assemblages, and suggest that hippograss is reducing refugia availability.

Mitochondrial plasticity in the anoxic turtle heart

La plasticité mitochondriale dans le cœur de tortues anoxiques

Jeffrey Richards and Gina Galli

University of British Columbia, University of Manchester

Freshwater turtles are extraordinary in their ability to survive long-term anoxia. We assessed mitochondrial respiration and electron transport chain (ETC) flux in permeabilized cardiac fibers and isolated cardiac mitochondria from normoxic and anoxic (2 weeks) turtles (*Trachemys scripta*) acclimated to 5°C. Anoxia exposure led to significant reductions in maximum ADP-stimulated respiration rates through ETC complexes I, II and IV at three temperatures (5, 13 & 21°C) and ADP affinity was significantly lower. State II respiration rates and proton leak were slightly reduced in anoxic cardiac fibers. Analysis of isolated ETC protein activity indicates that the reduction in anoxic ETC flux is primarily mediated by decreases in complex V activity.

Moving at a snail's pace: the effect of temperature and desiccation stress on microhabitat selection in an intertidal snail

Voyager à la vitesse d'un escargot: l'effet des stress de température et de dessiccation sur la sélection de microhabitats des escargots d'estrans

Karen Rickards and Elizabeth G. Boulding

University of Guelph

Intertidal animals have been shown to live near their thermal limits and exhibit altered behaviour at low tide. If animals are near thermal limits at low tide, then behavioural change that alters body temperature by a few degrees might improve the likelihood of survival until next tidal immersion. We hypothesized that *Littorina subrotundata* would behaviourally mitigate short term temperature stress through microhabitat selection and predicted snails would select higher quality microhabitats under high thermal and desiccation stress than under low abiotic stress. In the laboratory, temperature had a barely non-significant effect on microhabitat choice. At one field site, snails showed a stronger preference for high quality barnacle microhabitat in August compared to May. However, choosing a barnacle microhabitat did not have a significant effect on water loss during hot days in August suggesting that environmental factors other than desiccation stress select for microhabitat choice.

Implications of acute oxygen deprivation during critical developmental windows in zebrafish (*Danio rerio*)

Implications d'une privation aiguë d'oxygène pendant une fenêtre de développement critique chez le poisson zèbre (*Danio rerio*)

Cayleih Robertson, Patricia Wright and Nick Bernier

University of Guelph

In most organisms the cellular response to hypoxia is mediated by the master regulator hypoxia-inducible factor-1 (HIF-1). Early in ontogeny, zebrafish embryos instead enter suspended animation to tolerate low oxygen but lose this ability over time. We hypothesized that the cellular response to oxygen deprivation would change throughout development to compensate for this loss. We exposed embryos from 3 developmental stages to severe hypoxia (5% dissolved oxygen) or anoxia for 4h and measured gene expression changes of known HIF-1 targets. Early in development (18hpf) there was a marked increase in igfbp-1 and epo mRNA levels in response to hypoxia but not anoxia. In later stages (36hpf), igfbp-1, vegf and epo increased in response to both hypoxia and anoxia. We have shown that developing zebrafish mount two different cellular responses depending on the severity of oxygen deprivation, which could impact their stress response later in life.

Membrane composition as a function of body size and temperature in species of tropical and North American bees

Les effets de la taille et de la température corporelle sur la composition membranaire d'abeilles tropicales et nord-américaines

Enrique Rodríguez, Jean-Michel Weber and Charles-A. Darveau

University of Ottawa

Body size of organisms affects most aspects of their biology, including physiological traits. One trait influenced by size is metabolic rate, but the basis for its variation among organisms remains unclear. Recent work revealed that membrane phospholipid composition also varies systematically with body size, which yielded a membrane “pacemaker” theory of metabolism. It predicts that smaller vertebrates with higher mass-specific metabolic rates have more fluid membranes containing more long chains of polyunsaturated fatty acids (PUFA) and less monounsaturated fatty acids (MUFA). To test for a direct relationship between metabolic rate and membrane composition, we quantified the membrane lipid composition of 26 species of Panamanian orchid bees with a 20-fold range in size. Results for MUFA are in agreement with the pacemaker theory of metabolism, whereas trends for PUFA suggest a role of phylogeny in membrane composition diversity. Membrane diversity associated with variation in body temperature of hymenopterans was also investigated.

La taille corporelle des organismes affecte plusieurs aspects de leur biologie, dont certains traits physiologiques. Le taux métabolique est l'un d'eux, or la base de sa variation entre organismes reste sujette à débat. Des travaux récents ont révélé que la composition des phospholipides membranaires varie aussi systématiquement avec la taille, donnant lieu à la théorie des membranes comme « rythmeur » du métabolisme. Celle-ci prédit que de plus petits vertébrés, aux taux métaboliques plus élevés, auront des membranes plus fluides, contenant plus de chaînes d'acides gras polyinsaturés (PUFA) et moins de monoinsaturés (MUFA). Afin de tester cette relation directe entre taux métabolique et composition membranaire, nous avons étudié la composition des lipides membranaires chez 26 espèces d'abeilles des orchidées du Panama ayant une étendue de taille d'un facteur 20. Les résultats pour les MUFA suivent la théorie du « rythmeur » du métabolisme, tandis que les données pour les PUFA suggèrent un rôle de la phylogénie dans la diversité de composition membranaire. La diversité membranaire associée à une variation de la température corporelle de divers hyménoptères a aussi été étudiée.

Does the ancient Atlantic hagfish (*Myxine glutinosa*) induce heat shock proteins?

Est-ce que le poisson ancien, la myxine de l'Atlantique (*Myxine glutinosa*) induit des protéines de choc thermique?

Susan Rogers, Sacha LeBlanc and Suzie Currie

Mount Allison University

The Atlantic hagfish, at the base of our vertebrate ancestry, is key in understanding the evolutionary basis of the heat shock response (HSR) in fish. Despite this critical position in the evolutionary tree, there is little to nothing known regarding the HSR in hagfish. Thus, we first subjected hagfish red blood cells to an acute heat shock *in vitro* and observed high constitutive levels of HSP70 and HSP90, but no significant heat induction of these proteins. We know that the HSR response is at least partially regulated by stress hormones, thus, it was important to investigate the hagfish HSR following an *in vivo* acute heat shock. Eight to 24 h hours following a 1 h acute heat shock, we observed a significant induction of HSP70 in red blood cells and white muscle and HSP90 in liver and white muscle tissues. Thus, hagfish have a robust HSR that is tissue-specific and likely hormonally regulated.

A complex endocrine network regulates electrocommunication signals in the context of male-male competition in electric fish

Un réseau endocrinien complexe régule les signaux d'électrocommunication dans le cadre de la compétition mâle-mâle dans les poissons

Vielka Salazar

Cape Breton University

Sexually-selected communication signals can be used by competing males to settle contests without incurring the costs of fighting. In the South American electric fish *Brachyhypopomus gauderio*, competing males can dynamically regulate their electrocommunication signals in a context-dependent manner. Here I examine how *B. gauderio* males regulate their electric organ discharge (EOD) in response to changing competitive interactions. Enhanced competition intensity increased EOD amplitude and the levels of androgens and cortisol of competing males. In addition, EOD amplitude can reliably convey information about a male's body condition. As such, the EOD of *B. gauderio* males can act as an honest signal of a male's fighting ability. Accordingly, competing males display hormone-mediated EOD plasticity to optimize their behavioural response to changing social challenges.

Effect of temperature stress on copper-induced mitochondrial dysfunction in rainbow trout, *Oncorhynchus mykiss*

Les effets du stress thermique sur la dysfonction mitochondriale induite par le cuivre chez la truite arc-en-ciel (*Oncorhynchus mykiss*)

Ravinder Sappal, Mark Fast, Don Stevens and Collins Kamunde

University of Prince Edward Island

We investigated the effect of temperature on copper (Cu)-induced mitochondrial toxicity *in vitro*. Mitochondria were isolated from rainbow trout (60-100g) livers by differential centrifugation and exposed to Cu (0.01-2.5 mM) at 5, 15, and 25 °C. States 3 and 4, and uncoupler-stimulated (UCS) mitochondrial respiration rates were measured using Clark-type oxygen electrodes. Copper exposure inhibited UCS respiration indicating impairment of the electron transport chain (ETC). Because the UCS respiration inhibition correlated with reduced malate/glutamate-driven respiration, we concluded that mitochondrial complex I is impaired by Cu. The Cu dose-response relationship depended on the state of respiration. Whereas state 3 respiration was monotonically inhibited by Cu exposure, low and high Cu concentrations stimulated and inhibited state 4 respiration (proton leak), respectively. Moreover, high temperature increased mitochondrial respiration rates and enhanced Cu toxicity. Taken together, Cu impairs the ETC and stimulates proton leak in rainbow trout mitochondria, with high temperature exacerbating these effects.

Abiotic and biotic differences in salt pools of maritime salt marshes – making a connection

Les différences abiotiques et biotiques dans les étangs salés des marais salés des maritimes - établir un lien

Dylan Schneider and Myriam Barbeau

University of New Brunswick

The close proximity of the Northumberland Strait, Bay of Fundy, and Nova Scotia's Atlantic coast permits the study of how different tidal regimes, weather patterns, and sediment loads effect salt pools along their coast. Knowing at which scale significant variation exists (regional or marsh) is important in creating a baseline for planning the restoration of a salt marsh. Water characteristics (temperature, salinity, pH, DO saturation, turbidity, and total suspended volatile and non-volatile solids) were measured in replicate salt marshes per region and replicate sites in the coastal waters of each region. Type and density of panne species were measured in pannes from each marsh using four techniques (minnow trap, invertebrate activity trap, lift net, and sweep net). Depending on the capture method significant differences for biota were found to be at different scales. These differences will be compared with abiotic differences and correlation patterns will be explored.

Phosphate uptake in the Pacific hagfish (*Eptatretus stoutii*): novel physiological and molecular mechanisms

Assimilation de phosphate chez *Eptatretus stoutii*: nouveaux mécanismes physiologiques et moléculaires

A. G. Schultz, S. Guffey, A. Clifford and G.G. Goss

University of Alberta and Bamfield Marine Science Centre

Inorganic phosphate (P_i) is an essential nutrient in all organisms and without it they would not be able to grow, reproduce or survive. In seawater, P_i is a limiting nutrient due to rapid complexation with the high free Ca^{2+} . This study sought to investigate the primary mechanisms of phosphate uptake in the Pacific hagfish. A partial sequence of the sodium-phosphate type IIb co-transporter (NaP_i-IIb) was identified in a hagfish transcriptome and the NaP_i-IIb was cloned from the hagfish gill. RT-PCR confirmed the presence of the co-transporter within the gill, intestine and most interestingly, the skin of hagfish. The potential uptake of phosphate from the environment across the gill and intestine was then investigated using in vitro techniques. Sodium-dependent uptake mechanisms and the effect of phosphonoformic acid (PFA), a NaP_i-IIb inhibitor, on phosphate transport were also investigated. Phosphate uptake across the gills and intestine of hagfish was concentration dependent. Branchial and intestinal phosphate uptake appeared to be sodium independent and was unaffected by the NaP_i-IIb inhibitor, PFA. This is the first study to identify NaP_i-IIb in the gill, intestine and skin of Pacific hagfish and demonstrate branchial and intestinal P_i uptake mechanisms in this unique species of fish.

Do insects have tails? Contributions of leg and abdomen movements to body posture control in freely flying *Drosophila*

Est-ce que les insectes ont des queues? Les contributions des mouvements des jambes et de l'abdomen au contrôle de la posture de drosophiles au vol libre

¹Peter Schützner, ²Dimitri Skandalis, ¹Ruben Andres Berthé and ¹Fritz-Olaf Lehmann

¹Universität Ulm, ²The University of British Columbia

Like in terrestrial locomotion, lizards, birds, and mammals use their tails to stabilise aerial locomotion. Bird tails in particular are thought to be used to generate both lift and drag. Insects do not possess an analogous morphological feature, but little attention has been paid to the role of the abdomen and legs during flight. *Drosophila melanogaster* in tethered flight coordinate wing, leg, and abdominal motions while performing simulated turns. In free flight, abdominal movements could contribute mass and aerodynamic effects, while flies' legs, though small and thin compared to the body, may exert disproportionately high drag because of their very low Reynolds number. We used motion capture techniques on freely flying *Drosophila* to calculate the effective contributions of the abdomen and legs to body yaw, pitch, and roll moments. We discuss our results in the context of recent work on aerial maneuvering and stability.

Embryonic temperature produces persistent effects on the capacity for thermal acclimation in adult zebrafish

La température embryonnaire produit des effets persistants sur la capacité d'acclimatation thermique chez le poisson zèbre adulte

¹Graham R. Scott, ¹Meghan E. Schnurr, ¹Yi Yin and ²Ian A. Johnston

¹McMaster University, ²University of St Andrews

We examined how temperature during embryonic development (22, 27, or 32°C) influences the thermal dependence of swimming performance, muscle phenotype, and gene expression. Temperature treatments were maintained until hatching, after which fish were raised to adulthood at 27°C. Aerobic exercise performance (Ucrit) in adult fish was measured 1d after transfer to 22, 27, or 32°C and after 30d acclimation to 16 or 34°C. Developmental temperature had predictable effects on performance, with 22°C embryos swimming best at 22°C and worst at 32 and 34°C. Surprisingly, performance was ~20% higher in both 32°C and 22°C embryos than in 27°C embryos after 16°C acclimation. Although cold acclimation changed the expression of >3400 transcripts in the white muscle, differences between 27°C and 32°C embryos were only observed for 61 transcripts involved in energy metabolism, angiogenesis, cell stress, and muscle remodelling (RNA-Seq). These data suggest that temperature change during a brief window in embryonic development can have a dramatic and persistent effect on thermal acclimation capacity. Supported by NSERC and the European Commission.

Fish and chips: using electronic technology to understand marine animal behavior and physiology

Poissons et puces: utilisation de la technologie électronique pour comprendre le comportement et la physiologie des animaux marins

Jayson Semmens

University of Tasmania

Since the late 1950s marine scientists have utilised electronic systems to examine and understand the behaviour and physiology of marine animals in the world's oceans and estuaries. This work gathered momentum in the late 1990s as the microcomputer and digital revolution spread technology to the masses. Now in 2012, we have a vast array of electronic tagging and tracking devices that can be applied to a wide variety of marine animals in almost every marine habitat. In this talk I will explain how this technology is changing our understanding of marine animals and how they interact with their environment, but also helping managers to ensure the sustainability of commercially targeted or conservation dependant species. To do this I will draw upon examples from my research, which has taken me from the tropics to temperate seas to tag and track animals as diverse as five metre white sharks and giant cuttlefish.

Cloning and characterization of ERp57 in rainbow trout (*Oncorhynchus mykiss*)

Le clonage et la caractérisation de ERp57 chez la truite arc-en-ciel (*Oncorhynchus mykiss*).

Lital Sever and Brian Dixon

University of Waterloo

ERp57 plays an important role in folding glycoproteins, particularly major histocompatibility complex class I. ERp57 deficient B cells show reduced expression of MHC class I and decreased antigen presentation. The trout ERp57 homologue encodes a 493aa protein including a 16aa signal peptide, 72% sequence identity with mammalian ERp57 and four domains, a, b, b' and a', encoding a thioredoxin-like fold with two conserved CXXC redox motifs. Interestingly, the trout sequence does not have the C-terminal ER retention signal or nuclear localization signal highly conserved in mammalian ERp57 proteins. Stimulation with Poly(I:C) and phytohaemagglutinin induced ERp57 expression in the macrophage-like cell line RTS-11. A23187 calcium ionophore induced a significant increase in ERp57 in peripheral blood leukocytes and RTS-11. Our findings that trout ERp57 levels are upregulated both upon ER stress and poly I:C treatment suggests a role for ERp57 during viral induced ER stress and interferon responses in teleost fish.

Behavioural phenotyping sensory responses in zebrafish

Les réponses comportementales sensorielles phénotypiques du poisson zèbre

Angela L. Shamchuk and Keith B. Tierney

University of Alberta

Animals respond to stimuli in a highly variable manner. This presents a problem in our research on organism responses to olfactory cues (odors). The variability in sensory responses is thought to be based on neurophysiological differences, which may ultimately being accounted for. This study defined behavioral changes in larval zebrafish following water and odor addition to their environment. Zebrafish exhibited typical bursting responses that were diverse in time and magnitude. We endeavored to describe this variation with a new burst analysis method measuring responses as changes in burst speed, frequency and duration. Several behavioural phenotypes were determined by sorting positive and negatives responses as compared to acclimated activity, and further grouping by burst characteristics and baseline activity. Through phenotyping we were able to detect subtle changes in responses that would have been otherwise lost. The detailed analysis available from this technique has potential for application to other animal movement studies.

Quantitative approaches to ontogenetics: geometric morphometrics approaches

Approches quantitatives a l'ontogénétique: approches géométriques morphométriques

H. David Sheets

Canisius College

Geometric morphometrics provides a powerful set of statistical tools for the study of organismal shape. This talk will present an overview of a series of linked studies applying these methods to the detailed comparisons of ontogenies, and the diversification of developmental patterns among closely related species. While the talk will focus on the analysis of ontogenies, the methods are readily adaptable to hypothesis testing of the dependence of shape on other variables, including environmental gradients in space and time.

Nesfatin-1 and ghrelin: two novel endocrine factors that regulate germinal vesicle breakdown in zebrafish

La nesfatine-1 et la ghréline: deux nouveaux facteurs endocriniens qui régulent la détérioration des vésicules germinales chez le poisson zèbre

Erin Shepperd, Sneha Lohan and Suraj Unniappan

York University

Ghrelin is multifunctional gut hormone, while nesfatin-1 is a recently discovered anorexigenic protein. Both ghrelin and nesfatin-1 regulate the hypothalamo-pituitary-gonadal axis in mammals. We wanted to determine whether ghrelin and nesfatin-1 influence ovarian physiology in zebrafish. We found both ghrelin and nesfatin-1 like immunoreactivity in the zebrafish follicular cells. Ghrelin inhibited both basal and maturation inducing hormone (MIH) stimulated oocyte maturation in zebrafish follicles in vitro. When the follicles were incubated with ghrelin and the ghrelin receptor antagonist, the inhibitory effect of ghrelin on germinal vesicle breakdown was abolished. Nesfatin-1 was also found to inhibit basal and MIH-induced germinal vesicle breakdown. Overall, our results indicate that ghrelin and nesfatin-1 are two novel regulators of germinal vesicle breakdown in zebrafish. Further studies are required to elucidate the roles of locally produced endogenous nesfatin-1 and ghrelin on ovarian physiology in zebrafish.

Enchanted by the “charismatic microfauna”: an exploration of relationships between the environment, parasites and their invertebrate hosts

Séduit par la «microfaune charismatique » : une exploration des relations entre l'environnement, les parasites et leurs hôtes invertébrés

Allen Shostak

University of Alberta

Helminth parasites commonly use invertebrate animals as intermediate hosts for their larval stages. Some of these relationships produce striking results, such as altered host behavior or parasitic castration. But, by and large, invertebrate hosts in nature are viewed simply as sparsely-infected vessels that, when gobbled up in sufficient numbers, transport larvae to vertebrate hosts where the really interesting things start to happen. I will argue from the opposite point of view. Using both aquatic and terrestrial models, I will show that seemingly uninteresting parasite-invertebrate infections, when suitably prodded, can reveal hidden complexities in the host-parasite-environment relationship.

Effect of habitat scarcity and shelter size on settlement of American lobster (*Homarus americanus*)

Les effets de la rareté de l'habitat et de la taille du refuge sur la colonisation du homard américain (*Homarus americanus*)

Gudjon Sigurdsson, Lauren Ellis, Gregory Wittig and Rémy Rochette

University of New Brunswick

Relatively little is known about the settlement selection processes of the American lobster outside the laboratory. In this field study, done using settlement collectors in south western Bay of Fundy, we aimed to estimate whether cobble size had an effect on settlement densities observed and whether scarcity of available substrate for settlement in an area could intensify settlement in suitable habitat in that area (“Oasis effect”). Our results show that settlement was higher in smaller and medium sized cobbles, while no settlement was observed in large cobbles. No “oasis effect” (intensification of settlement) was noted in settlement collectors surrounded by poor settlement habitat (sand) in comparison to settlement in collectors surrounded by good settlement habitat (cobble). Juvenile densities were higher in the collectors on sand, suggesting oversaturation of juvenile lobsters in nearby cobble habitats.

Why think statically about a dynamic problem? Good news from work on sodium pumps and metabolic rates in insects

Pourquoi penser à un problème dynamique de façon statistique? Des bonnes nouvelles en provenance de la recherche sur les pompes à sodium et sur le taux métabolique chez les insectes

Brent J. Sinclair, Sarah L. Lake, James F. Staples and Heath A. MacMillan

University of Western Ontario, University of Western Ontario, University of Western Ontario, University of Western Ontario

The dynamic relationship between temperature and performance is central to understanding how ectotherms interact with their thermal environments. Partly because of limitations in measurement and temperature control technology, these dynamic relationships have historically been approximated by measuring parameters at a range of static temperatures. Assuming that these static measurements apply to a dynamic process risks both the accuracy and precision of our estimates of temperature-performance relationships, with consequent uncertainties about the validity of the conclusions. We have developed assays that allow us to explore the thermal sensitivity of metabolic rate of live insects and the V_{\max} of Na^+, K^+ -ATPase across a range of temperatures using both dynamic and static temperature conditions. Dynamic and static measures of both these parameters yield similar values for thermal sensitivity, and the advantages and disadvantages of each approach will be discussed in view of experimental designs.

Vibratory signaling and signal transmission in the three-dimensional cob-webs of black widow spiders (*Theridiidae: Latrodectus*)

Signalisation vibratoire et la transmission de signaux dans les toiles à trois dimensions des araignées veuves noires (*Theridiidae: Latrodectus*)

Sen Sivalingham and Andrew Mason
University of Toronto Scarborough

In many species of spiders, substrate-borne vibrations have been shown to function during prey/mate recognition, localization, and attraction, mate choice, and predator avoidance. Despite the purported importance of signaling substrate on vibration transmission, studies looking at the effect of the signaling environment on vibration transmission have primarily focused on solid-surfaces such as rocks, leaves, sand, and gravel, which are substrates of 'land-dwelling' spiders. In comparison, vibration transmission through web structures has received little attention, with most of the focus on the two-dimensional orb-webs. In this study, we used the black widow spiders (*Theridiidae: Latrodectus*), which build three-dimensional cob-webs, comprised of an irregular network of silk strands, to examine the properties of vibration transmission, and characterize the vibrations of courting males. Our results lend important insights into the possible functions and mechanisms of vibratory signals and signaling in the largely under-studied cob-webs, and elucidate underlying properties of receiver sensory mechanisms.

Environmental stress triggers individual variability in Collagenase 3 accumulation in zebrafish embryos

Le stress environnemental déclenche la variabilité individuelle de l'accumulation de la collagénase 3 dans les embryons de poissons zèbre

Christopher Small and Bryan Crawford
University of New Brunswick

The extracellular matrix (ECM) is crucial during embryogenesis and requires remodelling to accommodate tissue morphogenesis. Matrix metalloproteinases (MMPs) are the primary effectors of ECM remodelling and their misregulation is associated with a growing list of pathologies. We recently characterized the accumulation patterns of many MMPs using immunofluorescence and observe consistent patterns at any given stage of development with one exception - Mmp13 (Collagenase 3). Frequently, same-stage embryos from a given spawning show diverse and inconsistent distributions and abundances of Mmp13. We hypothesized that the diversity of patterns reflects idiosyncratic responses to environmental stress. To test this, I exposed zebrafish embryos to pH stress or bacterial lipopolysaccharides. Both treatments affected Mmp13 distribution and abundance with LPS having a greater effect. I conclude that mmp13 expression is modulated in response to environmental stress, and that the individual variations observed in Mmp13 staining patterns likely represents individual responses to bacterial challenges.

Hypoxic cardiac performance in tilapia

Performance cardiaque du tilapia pendant l'hypoxie

Ben Speers-Roesch and Jeffrey Richards

University of British Columbia

Using *in vivo* and *in vitro* studies of the hypoxia-tolerant tilapia, we tested two hypotheses: 1) hypoxic depression of cardiac power output (CPO, i.e., cardiac energy demand) is required to maintain cardiac energy balance and function, and 2) downregulation of cardiac aerobic energy supply contributes to cardiac hypoxia tolerance. *In vivo* hypoxia exposure ($PO_2=1\text{kPa}$) for ≤ 8 h caused a 50% depression of routine CPO that was associated with sustained hypoxic cardiac function, stable cardiac energy levels, and hypoxic survival. No major hypoxic responses of cardiac aerobic energy supply were observed *in vivo* except for a large decrease in plasma fatty acid provision, which may contribute to cardiac hypoxia tolerance by obviating lipotoxicity. We found, however, that *in situ* cardiac performance under severe hypoxia ($PO_2<0.2\text{kPa}$) was unaffected by fatty acid provision. Indeed, the *in situ* tilapia heart showed impressive hypoxic performance, including the ability to sustain routine CPO for at least 70 min due to a high glycolytic potential. Thus, *in vivo* CPO depression may not be needed to maintain cardiac energy balance but rather may be a strategy to minimize fuel use and waste production.

Reef fish recruitment: connections across life stages

Le recrutement de poissons des récifs: les connections à travers les étapes de vie

Su Sponaugle

RSMAS, University of Miami

Population replenishment is complex for benthic marine organisms with pelagic larvae. Dynamic biological and oceanographic processes create challenges in accurately predicting spatial and temporal patterns in the supply and recruitment of pelagic larvae to nearshore juvenile habitats. We compared observed patterns of larval fish settlement along the Florida Keys to those obtained through model simulations using a high-resolution biophysical model parameterized with species-specific early-life history data. Although model simulations successfully explained 70% of temporal variation in settlement within each of two reef regions, the model did not capture the relative magnitude of observed settlement between the regions. Additional un-modeled pelagic processes include spatially variable patterns of larval growth and survival. Results indicate that growth is higher for nearshore larvae and those within mesoscale eddies than for offshore larvae and those in non-eddy water masses. Further, differential survival during and immediately after settlement influences the composition of the surviving population.

Spreading depression-like events in the CNS of the locust (*Locusta migratoria*): targeting glial mechanisms of K^+ homeostasis.

La propagation d'événements semblables à la dépression dans le SNC du criquet (*Locusta migratoria*): ciblage des mécanismes gliaux de l'homéostasie du K^+

Kristin Spong, Genevieve Rochon-Terry and Meldrum Robertson

Queen's University

Locusts enter a reversible coma in response to severe metabolic stress that is associated with abrupt surges in extracellular potassium concentration ($[K^+]_o$) within the CNS. Interestingly this K^+ disturbance closely resembles cortical spreading depression (CSD) in mammals. We believe that SD-like events in the locust are triggered by a positive feedback cycle initiated when processes of $[K^+]_o$ accumulation overwhelm the ability to clear $[K^+]_o$. Through pharmacological manipulation we planned to elucidate the involvement of glia in locust SD. We monitored SD-like events using K^+ sensitive microelectrodes while pharmacologically targeting glial mechanisms of K^+ homeostasis. We show that inhibition of glial spatial buffering alone can induce repetitive SD and that disruption of the perineurium (specialized glial cells forming the insects' blood brain barrier) can increase the severity of stress-induced SD-like events. We propose that glial cells play a key role in the generation and recovery from locust SD.

Locomotion and fin use of an air breathing fish on land

La locomotion et l'usage des nageoires sur terre chez un poisson à système pulmonaire

Emily Standen, Trina Du, Philippe Laroche and Hans Larsson

Redpath Museum at McGill University

When aquatic vertebrates first moved onto land, they transitioned from an aquatic to a terrestrial mode of locomotion. In this study, *Polypterus senegalus*, an extant air breathing fish, are used to test how fins in a basal, conserved actinopterygian can be used to locomote overland. Fish were filmed at 250 frames per second walking overland and video was analyzed to describe 3-D kinematics. Current hypotheses on how skeletal morphology evolved from swimming ancestors into the modern mammalian anatomy agree that the medial surface of fins would have been used as the support surface during the transition of fins into limbs. In contrast, extant *Polypterus senegalus* used the lateral pectoral fin surface for power and support during walking. These unexpected fin motions suggest that the pectoral fin 'functional landscape' is diverse and that this functional plasticity allowed early aquatic vertebrates to co-opt their fins effectively for terrestrial locomotion.

Polypterus: a model organism for the fin to limb transition

Le Polypterus et la transition des nageoires aux pattes: un organisme modèle

Emily, M. Standen and Hans, C.E. Larsson

Redpath Museum at McGill University

Comparative morphology of relevant fossil and living fishes and amphibians and experimental biomechanics of the extant taxa are essential to understand how aquatic vertebrates first moved onto land. Without having actual transitional taxa alive today, the question becomes; which extant animals best represent hypothetical transitional ancestors? We argue that anatomically, behaviourally, and phylogenetically, *Polypterus spp.* make an excellent model system for studying the fin-limb transition. They are sister to all other extant actinopterygians and their robust lobed fins, paired lungs, and natural behaviour of moving overland between transient water sources make them the best extant analogue for a fin-limb transitional ancestor. We demonstrate how the musculoskeletal anatomy of their paired fins and girdles are the closest living analogue of these extinct antecedents to tetrapods.

Jump height is not enhanced by tendons alone: there must be a catch!

La hauteur d'un saut n'est pas seulement augmentée par les tendons: il doit y avoir un hic!

Douglas Syme and Mariko St.James

University of Calgary

The impressive jumping performance of certain animals is attributed, hypothetically, to storage and release of elastic strain energy in tendons. A 'catch' mechanism, immobilizing or retarding animal movement while muscles first load the tendons, is typically invoked in these systems. No experimental evidence exists testing the role of tendons and catch in improving jumping. We measured how jump height (vertical load lifting) is impacted by incorporating tendons of different lengths in a linear muscle (frog sartorius), tendon (elastic cord), load system, where the only 'catch' was inertia of the load itself. In support of modeling studies, increases in jump height of a few percent were occasionally observed, but compliant tendons mostly did not enhance or impaired jump height. We conclude that a functional catch mechanism, beyond simply inertia of the load, is necessary to realize substantial increases in jumping performance resulting from energy storage in tendons.

Mechanical performance of teleost fish skin

Performance mécanique de la peau de poissons téléostéens

Lawrence Szewciw, Deju Zhu and Francois Barthelat

McGill University

A variety of scalation patterns have evolved across teleosts from several overlapping scales to non-overlapping scales. Here, we show that striped bass exhibit 3 scale overlap, each scale mineralized in its upper region. Puncture tests reveal that the key to penetration resistance of individual scales is their mineral distribution pattern in a collagen cross-ply. Tests on 2-10 scales and on skin samples demonstrate that a higher number of imbricating scales provides greater penetration resistance to fish skin (puncture force 6-51 N), with substantial resistance from the underlying stratum compactum. Puncture tests also reveal a superior penetration resistance of fish scales over polycarbonate discs. These results will be used to develop body armor with similar protective and desirable properties as found in scaled fish skin.

MicroCT contrast enhancement of soft tissues in avian embryos

Une augmentation de contraste par micro CT des tissus mous des embryons aviaires

Rui Tahara and Hans C.E. Larsson

McGill University

Recently iodine staining protocols with I2E and IKI have been published that successfully enhance soft-tissue contrasts via microCT imaging with quantitative measurements of tissue contrasts. This methodology provides an important tool to examine soft-tissue morphology. Given that longer staining times cause shrinkage in embryonic samples, determination of minimum requirements to stain for optimal soft-tissue contrast and minimizing shrinkage is of primary importance. However, shrinkage associated with staining duration between I2E and IKI has not been quantified. We present a refined protocol for iodine staining optimized specifically to a model bird (Japanese quail) embryo by simultaneously examining quantitative measurements of tissue contrasts and shrinkage. We present results from the middle ear sinuses in a series of late stage quail embryos as a case study. The developmental trajectory of this anatomy has been sparsely studied and our aim is to compare it to their complex evolutionary history.

Is AQP1 a multi-functional biological gas channel in zebrafish *Danio rerio*?

Est-ce que l'AQP1 est un canal de gaz biologiques multi-fonctionnel chez le poisson zèbre, *Danio rerio*?

Krystle Talbot, Kathleen M Gilmour and Steve F Perry

University of Ottawa

Previous in vitro studies using *Xenopus oocytes* over-expressing aquaporin 1 (AQP1) have demonstrated that AQP1 has a triple-transporter function, controlling not only water flux but also excretion of CO₂ and NH₃. The current study was designed to provide in vivo evidence for a similar function of the zebrafish (*Danio rerio*) aquaporin homologue AQP1a. The basic approach is comparing water, CO₂ and ammonia fluxes in control zebrafish larvae with larvae experiencing translational gene knockdown (using antisense morpholino oligonucleotides) of aqp1a. Efficacy of knockdown is being assessed by western blotting. Rates of CO₂, O₂ and ammonia transfer are being evaluated using closed system respirometry in larvae at 4 days post-fertilization. We anticipate that the in vivo data obtained from this study will classify zebrafish AQP as a multi-functional biological gas channel.

Diverging patterns in heat loss may explain bill size differences between sparrows of different habitats
Des tendances divergentes en perte de chaleur pourraient expliquer les différences de taille du bec de moineaux provenant de différents habitats

¹Glenn J Tattersall, ¹Viviana Cadena, ²Russell Greenberg and ³Ray M Danner

¹Brock University, ²Smithsonian Migratory Bird Center, ³Virginia Tech

Research on variation in bill morphology has focused on the role of diet. Bills have other functions, however, including heat and water balance. The role of the bill in heat loss may be particularly important in birds where water is limiting. In the eastern US, song sparrows localized in coastal dunes (*Melospiza melodia atlantica*) are similar in body size to, but have bills with a 17% greater surface area than, those that live in mesic habitats (*M. m. melodia*). We tested, using thermal imaging whether sparrows use their bills to dissipate “dry” heat, and if the proportion of heat loss from the bill is higher in *M. m. atlantica* than *M. m. melodia*, which would indicate a role of heat loss and water conservation in selection on bill morphology. Due to its greater surface area and higher temperature, the bill of *M. m. atlantica* dissipated an average of 32% more heat than that of *M. m. melodia*, an amount which could potentially reduce water loss requirements by approximately 7.5%. Therefore, thermal window heat loss capacity could play an important role in the selection for bill size differences between bird populations.

Hydrogen sulphide induces compensatory behavioural thermoregulatory adjustments in the zebrafish
Induction d'ajustements de comportement de thermorégulation compensatoire chez le poisson zèbre au sulfure d'hydrogène

Glenn J Tattersall and Cheryl D Dobell

Brock University

Hydrogen sulfide (H₂S) is a naturally occurring chemical that can influence organism survival. As an inhibitor of cytochrome c oxidase, H₂S is toxic to animals reliant upon aerobic respiration. Hydrogen sulfide is also produced endogenously in organisms and has been shown to be required for various physiological functions. Non-lethal levels of exogenous H₂S have been discovered to lower metabolic rate and cause a suspended-animation like state in mice. Consequently, research investigating the potential therapeutic uses of H₂S has become increasingly popular. We elected to demonstrate whether H₂S (0.02%) will induce a decline in thermoregulatory behaviour in an ectotherm. Using a dual-chamber shuttlebox, we found that zebrafish reduce their normal preferred temperature of 28.9 ± 2.2°C to 21.5 ± 3.4°C when exposed to H₂S. Thus, H₂S may be acting as a modulator of thermotactic behaviour in zebrafish, although within a very limited non-lethal window of concentrations.

Morphometric differences of shortnose sturgeon and Atlantic sturgeon larvae during early ontogeny
Différences morphométriques entre les larves des esturgeons à museau court et des esturgeons de l'Atlantique tôt dans l'ontogénie

Andrew Taylor, S Usvyatsov and Matthew K Litvak

Mount Allison University

Atlantic sturgeon, *Acipenser oxyrinchus*, and shortnose sturgeon, *Acipenser brevirostrum*, are protected species found along the Atlantic coast of North America. Throughout most of their range, the species are sympatric. Larval sampling is an effective tool for determining spawning grounds, as well as estimating reproductive success. Due to the extensive overlap in range, genetic analysis is often necessary to determine the species of larvae captured during sampling. The goal of this study is to develop a fast and inexpensive method of species determination using morphometric differences of larvae from hatching to yolk-sac absorption. Fourier analysis on images of laboratory-reared larvae was used to determine larval shape differences throughout ontogeny within and between species. The algorithms developed using these techniques will allow us to discriminate between species captured during larval sampling.

Non-shivering thermogenesis vs shivering: does heat production have the same energy cost for both mechanisms in muscovy ducklings?

Thermogenèse sans frisson vs. frisson thermique : un coût énergétique équivalent chez les canetons de Barbarie?

¹Loïc Teulier, ²Jean-Louis Rouanet and ²Damien Roussel

¹University of Ottawa, ²Université Claude Bernard

Homeothermy allows birds and mammals to stay active in cold environments, but is energetically costly. The goal of this study was to compare the energetic cost of the two mechanisms responsible for heat production in juvenile birds: 1 – Shivering thermogenesis (ST) and 2- Non shivering thermogenesis (NST). Metabolic rate of cold-acclimated (CA, with capacity for NST) and control (reared at thermoneutrality, TN, without capacity for NST) muscovy ducklings was measured continuously for 24h at 8°C. EMG monitoring showed that CA ducklings were not shivering, whereas TN ducklings were. Results show that energy expenditure was higher in TN than in CA ducklings (+17% at night and +39% during the day). Because both groups maintained the same body temperature, we conclude that NST is a more efficient heat production process than shivering.

L'homéothermie permet aux oiseaux et aux mammifères de rester actifs dans un environnement froid, entraînant en contrepartie une dépense énergétique accrue. Le but de cette étude était de comparer le coût énergétique associé aux deux processus producteurs de chaleur chez les oiseaux: la thermogenèse de frisson (ST) et la thermogenèse sans frisson (NST). Nous avons donc mesuré le métabolisme in vivo chez des canetons de Barbarie acclimatés au froid (CA) et élevés à thermoneutralité (TN) pendant 24h à 8°C. Nous avons vérifié que les canetons CA ne frissonnaient pas et que les canetons TN frissonnaient bien. Nos résultats montrent que pour maintenir une même température interne, la dépense énergétique allouée à la thermorégulation est plus importante chez les TN que chez les CA (+17% pendant la nuit et +39% pendant le jour), ce qui sous-entend que la NST est un mécanisme thermogène plus efficace que le frisson.

Transcriptomics profiling of Queen conch in environments with high tributyltin in the British Virgin Islands

Profilage transcriptomique du strombe géant dans les environnements avec des niveaux de tributylétain élevés des îles Vierges britanniques

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In the British Virgin Islands (BVI), Queen conch (*Strombus gigas*) populations show higher incidence of imposex, the presence of male and female gonad, in polluted environments with high levels of tributyltin (TBT). However, the direct cause and the molecular mechanisms that lead to the condition have not been identified. In the present study, a Queen conch microarray was utilized to identify genes in the ovary that were differentially expressed in two high TBT environments (Road Harbour, RH; Trellis Bay, TB) compared to a reference site (Guana Island) to increase mechanistic understanding of imposex condition. There were few differentially expressed genes in common between the polluted sites (<10%), suggesting that other site-specific factors were driving gene expression profiles rather than TBT alone. At RH, genes related to stress were increased while at TB, lipid-related processes such as lipid biosynthetic process were affected. This study identifies biological pathways that may underlie imposex and reveals there are complex gene expression patterns in TBT-polluted habitats.

Thermal effects on the survival and development of lake whitefish (*Coregonus clupeaformis*)

Les effets thermiques sur la survie et le développement du gand corégone (*Coregonus clupeaformis*)

Meagan. M Tompkins, Andrew Chong, Sanjna Kapoor, Doug Boreham and Joanna. Y Wilson

McMaster University

Temperature is known to effect embryo mortality, abnormalities, and developmental rates in poikilothermic species, such as fish. The current study examines the impact of rearing temperature in developing lake whitefish (*Coregonus clupeaformis*). Embryos were incubated at a constant 5°C or with a 1 hour, weekly transient heat-shock to 8°C. Embryos were reared in 2L McDonald-Bell hatchery jars. Fifty embryos were sampled weekly, formalin fixed for morphometric analysis and viewed under light microscopy to determine viability, developmental stage, and physical abnormalities. Preliminary results indicate increased mortality and developmental rate with transient heat-shock. Morphometric measurements of total body length were positively correlated with head width, negatively correlated with yolk sac diameter but not correlated with embryo diameter. Head width and eye diameter were strongly correlated. Oil globules noted in early stage embryos disappeared quickly over development, leaving yolk size relatively unchanged. This suggests a nutritive function for oil globules in early embryogenesis.

When behavior and mechanics meet: scallop swimming capacity and their ligaments

Lorsque le comportement et la mécanique se rencontrent: Capacité de nage des pétoncles et leur ligament

Isabelle Tremblay, Myriam Samson-Dô, Helga Guderley and John Himmelman

Université Laval, Université Laval, Université Laval, Université Laval

Scallops swim using jet propulsion produced by a succession of abductions and adductions of the valves (Olson and Marsh 1993). The adductor muscle closes the valves while the hinge ligament, composed of a rubber-like material, acts like a spring mechanism to open them (Trueman 1953; Alexander 1966). Hysteresis loop measurements showed a low work loss in scallop ligaments compared to non swimming bivalves, suggesting that scallop ligaments might be more efficient for frequent opening and closing of the valves (Trueman 1953). We hypothesised that scallop species that are more active swimmers should have a more efficient ligament compared to less active scallops given the frequent opening and closing of the valves during swimming. Hysteresis loops, shown by *in situ* ligaments, of 5 scallop species with different morphologies and swimming capacities have been compared. Scallops that reached the highest frequencies of valve claps have ligaments with the lowest work loss in their hysteresis loops.

Factors determining the in vitro emergence of sexual stages of *Hepatozoon clamatae* from erythrocytes of the green frog, *Rana clamitans*

Facteurs qui déterminent l'émergence *in vitro* des stades sexuels de *Hepatozoon clamatae* de la grenouille verte *Rana clamitans*

Michael Trites, Christopher Ogbuah, Cory Dickson and Todd Smith

Acadia University

Hepatozoon clamatae is an apicomplexan blood parasite that infects erythrocytes of green frogs, *Rana clamitans*. Sexual reproduction in mosquitoes, *Culex territans*, requires that sexual stages, or gamonts, of parasites emerge from erythrocytes in the blood meal. Although physiological cues for emergence of gametocytes of *Plasmodium falciparum* from erythrocytes in mosquitoes are well understood, such factors are not known for other apicomplexan parasites. The objective of this study was to investigate conditions that elicit in vitro emergence of gamonts of *H. clamatae*. Infected blood was drawn from frogs and incubated with various concentrations of salt, xanthurenic acid (XA) and pH at different temperatures. We found that salt concentrations between 178 and 200mM, and pH values between 7.4 and 7.7 induced 100% gamont emergence. These data suggest that hyperosmotic conditions typically present as mosquitoes concentrate blood meals may be necessary in initiating sexual development of these parasites.

Nervous system restructuring during insect metamorphosis: a lineage perspective

Restructuration du système nerveux durant la métamorphose des insectes: une perspective de descendance

James Truman

Howard Hughes Medical Institute

Insects exhibiting incomplete versus complete metamorphosis have different strategies for making their CNS. The former group represents the ancestral conditions, and the adult form of the CNS is achieved during embryogenesis with little change occurring during subsequent postembryonic life. In the derived condition of complete metamorphosis, by contrast, the CNS begins to form as in basal groups, but interrupted neurogenesis and suppressed cell death produce a reduced and modified larval CNS. A later reactivation of neurogenesis during larval growth, along with delayed neuronal death and neuronal remodeling at metamorphosis then produce the adult CNS. These two developmental strategies, though, are superimposed on a common set of neuronal stem cells, the neuroblasts. I will discuss these various processes that form the larval and adult versions of the insect CNS from the perspective of the neuroblasts and their subsequent lineages.

Getting fresh: the hypo-osmotic stress response of the spiny dogfish (*Squalus acanthias*) and the relative roles of chemical and molecular chaperones

Devenir frais: la réponse au stress hypo-osmotique de l'aiguillat (*Squalus acanthias*) et les rôles relatifs des chaperons chimiques et moléculaires

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Animal cells and proteins are protected from environmental stressors by molecular and chemical chaperone systems. The spiny dogfish shark (*Squalus acanthias*), like most elasmobranchs, has high endogenous levels of the osmolyte and chemical chaperone trimethylamine oxide (TMAO) and can also induce molecular chaperones (e.g. heat shock proteins; HSPs) with stress. Thus, the dogfish is an ideal model to study the relative roles of chemical and molecular chaperones following an environmental stress, such as a change in osmotic conditions. We cannulated spiny dogfish via the caudal artery and exposed them to 70% seawater while freely swimming for 24 hours. We sampled blood throughout this hypo-osmotic exposure and measured red blood cell HSP70 levels as well as intra and extracellular TMAO and urea concentrations. Our data suggest these fish are able to cope with osmotic stress without inducing HSPs, indicating that physiological levels of TMAO are alone sufficient to mediate osmotic stress.

Frost expression is not necessary for cold tolerance in *Drosophila melanogaster*

L'expression du gel n'est pas nécessaire pour la tolérance au froid chez *Drosophila melanogaster*

Hiroko Udaka, Anthony Percival-Smith and Brent Sinclair

University of Western Ontario

Temperature affects many physiological processes in insects and surviving winter sub-zero temperatures is critical for many insects in temperate and polar zones. Frost is one of candidate genes for cold tolerance in *Drosophila melanogaster* since it's up-regulated during recovery from cold stress. Previous work showed that knockdown of Frost increases chill-coma recovery time, but the role of Frost in cold tolerance remains unknown. To clarify the contribution of Frost to cold tolerance, we used several *D. melanogaster* lines with knocked down Frost expression with the RNAi-mediated GAL4/UAS system and obtained lines with varying Frost expression levels. Chill-coma recovery time, acute cold tolerance and rapid cold-hardening in response to a short-term exposure to a sub-lethal low temperature were measured in each line. There was no correlation between gene expression levels and three different types of cold tolerance, suggesting that Frost is not essential for those cold tolerance phenotypes.

Neuroendocrine regulation of energy homeostasis: nesfatin-1 – from genes to physiology

La régulation neuroendocrine de l'homéostasie énergétique: nesfatin-1 - Des gènes jusqu'à la physiologie

Suraj Unniappan

York University

In vertebrates, hormones play an integral role in the maintenance of energy homeostasis. Several tissues, including the brain, gut, pancreas and fat play important roles in energy balance as sources and targets of hormones and metabolites. Nesfatin-1 is a novel, eighty-two amino acid metabolic adipokine encoded in the precursor nucleobindin-2. We found that gut and pancreas are abundant sources of nesfatin-1. Our research discovered an insulintropic role for nesfatin-1 in rats and mice. We also found that nesfatin-1 regulates whole body energy homeostasis in rats by influencing feeding, ambulatory activity and fat mobilization. The expression and secretion profile of nesfatin-1 in rodents is dependent on nutritional status. Diet induced weight gain and hyperglycemia resulted in an increase in nesfatin-1. Nesfatin-1 also exists in several lower vertebrates, including fish, where it has anorectic, reproductive and stress modulatory effects. Research to date indicates that nesfatin-1 is an important multifunctional protein in animals.

The timing and extent of larval drift in shortnose sturgeon in the Saint John River, NB, Canada

Le moment et l'ampleur de la dérive des larves des esturgeons à museau court dans la rivière Saint-Jean, NB, Canada

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The shortnose sturgeon, *Acipenser brevirostrum*, is protected throughout its range along the Atlantic coast of North America. In Canada, it only occurs in the Saint John River, NB, which fortunately is one of the largest populations. Here we report on larval collections from the Saint John River that were used to 1) estimate larval abundance, and 2) model larval drift vs. environmental parameters using logistic models (presence/absence) and negative binomial models (counts). Approximately 6,900 shortnose sturgeon larvae were caught in 2008-2011, leading to estimates ranging from 20,000 larvae (2009) to 244,000 larvae (2008). Dam discharge, water temperature, day/night and transect location were found to be important predictors of larval drift. We provide the first estimates of larval abundance in shortnose sturgeon and identify parameters important for larval dispersal. Our results will help us to better understand habitat requirements during this vulnerable life stage, and therefore assist conservation and management efforts.

Nesfatin-1 opposes the metabolic effects of ghrelin in rats

La nesfatine-1 oppose les effets de la ghréline sur le métabolisme des rats

Yona Vandersluis and Suraj Unniappan

York University

Nesfatin-1 is a metabolic hormone with insulintropic and anorectic effects in rats and mice. We hypothesized that nesfatin-1 would mediate satiety in rats by inhibiting the ghrelin system, namely, ghrelin, ghrelin-o-acyltransferase, and the ghrelin receptor. Nesfatin-1 infusion caused a significant reduction in preproghrelin mRNA expression in the rat stomach at 210 minutes post-feeding. Synthetic rat ghrelin (400 micrograms/kg body weight) sub-cutaneous infusion caused ~40% increase in both the dark phase cumulative food intake and duration of feeding bouts of rats. Nesfatin-1 (100 micrograms/kg body weight) inhibited basal food intake of rats during the dark phase. Co-administration of both nesfatin-1 with ghrelin at the doses mentioned above caused no changes in feeding of rats, indicating a loss of feeding regulatory activities of both peptides. Together, our results implicate ghrelin as a potential target that mediates the metabolic effects of nesfatin-1.

Competitive signalling during aggressive encounters in the primitive acoustic insect *Cyphoderris monstrosa* (Orthoptera: Haglidae)

Signaux compétitifs lors de rencontres agressives de l'insecte acoustique primitif *Cyphoderris monstrosa* (Orthoptera: Haglidae)

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A dyadic contest is one in which both individuals value the resources equally. When this happens, the contest should end when the weaker competitor (the one with the lowest resource holding power, RHP) makes the strategic decision to give up or withdraw. This project examines direct competition among males of the primitive acoustic insect *Cyphoderris monstrosa* (Orthoptera: Haglidae) in securing mates. Duty cycle of male calls is the only predictor of contest outcomes. This study examines physiological differences between males of varying fighting success. Through a fight tournament, the influence of the rate of energy consumption in combination with morphological traits was assessed for correlates of fighting ability, to physiological characteristics related to RHP. The data suggest that metabolic scope (relative change between resting and active metabolic rates) is correlated with RHP. Males' ability to mobilize energy reserves may be an important factor in contest outcomes.

The impact of waterborne FLX concentrations on the stress axis in zebrafish, *Danio rerio*

Les effets de la fluoxétine dissoute dans l'eau sur l'axe de stress du poisson zèbre, *Danio rerio*

Marilyn Vera Chang and Thomas Moon
University of Ottawa

The growth of pharmaceutical use by humans is beginning to impact aquatic ecosystems. The antidepressant fluoxetine (FLX), the active ingredient of Prozac™, is detected in aquatic environments with concentrations reported as high as 540 ng/L. Fluoxetine functions by increasing brain levels of the neurotransmitter serotonin. Serotonin affects many regulatory functions initiated within the brain including regulation of the hypothalamic-pituitary-interrenal or stress axis. The present project is to study the effects of FLX on the stress axis in the zebrafish. Fish release cortisol when stressed. Cortisol levels and expression levels of stress-linked genes will be quantified to test the hypothesis that FLX acts on the stress axis to decrease plasma cortisol levels in zebrafish. If so, the presence of FLX in the aquatic environment could have effects that are manifested at higher levels of biological organization, since cortisol is important for adaptation and survival. Supported by a NSERC-DG.

Messenger RNA expression levels of RhCM, V-ATPase and aquaporin correlate with branchial ammonia excretion rates in green shore crabs *Carcinus maenas*.

Les niveaux d'ARNm de RhCM, de V-ATPase et de aquaporine corrélerent avec les taux d'excrétion d'ammoniac chez le crabe vert (*Carcinus maenas*)

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Studies were performed on green shore crabs acclimated to sea- and brackish water. In either environment active ammonia excretion rates were significantly lower in the osmoregulatory active, mitochondria-rich posterior gills. An Rh-protein (RhCM) cloned from *C. maenas* gills was highly expressed in the gill epithelium, here with corresponding expression levels with regards to their actual ammonia transport rates. In contrast, Rh-protein expression levels in the antennal gland, hypodermis, hepatopancreas and heart muscle were very low. As seen for RhCM, also expression levels of the V-ATPase (subunit B) and an aquaporin corresponded to branchial ammonia excretion rates. Long term ammonia exposure (14d, 1 mM NH₄Cl) caused in gills of crabs acclimated to sea- and brackish water a significant decrease of the ammonia excretion rates. Moreover, while in seawater animals Rh-protein mRNA expression levels did not alter after ammonia exposure, branchial expression levels in brackish water acclimated crabs doubled.

The pectoral anatomy of the basal actinopterygian *Polypterus senegalus*

L'anatomie pectorale de l'actinoptérygien de base *Polypterus senegalus*

Benjamin Wilhelm, Trina Du and Emily Standen

McGill University

The order *Polypteriformes* is the most basal clade of actinopterygians and includes the gray bichir, *Polypterus senegalus*, a common fish in the aquarium trade. This species was first described over 200 years ago, but a comprehensive study of its pectoral anatomy has not yet been published. Detailed description of the pectoral anatomy is becoming increasingly important, as this species has seen recent interest as a model organism for the fin-to-limb transition. Here we provide the first detailed description of the skeletal, muscular, and nervous anatomy of the pectoral fin of *P. senegalus*, utilizing gross anatomical dissection and high-resolution microCT scans. We also compare its anatomy to that of the most basal polypterid, *Erpetoichthys calabaricus*, as well as other basal actinopterygians. These descriptions provide the most complete picture of polypterid anatomy to date and will provide a valuable resource for future work on these species.

Scavenging on the ocean floor: ammonia and urea excretion dynamics in foraging Pacific hagfish (*Eptatretus stoutii*)

Balayage du plancher océanique: la dynamique d'excrétion d'ammoniac et d'urée de la myxine de Pacifique (*Eptatretus stoutii*) à la recherche de nourriture

¹Michael Wilkie, ²Alexander Clifford, ³Susan Edwards and ²Greg Goss

¹Wilfrid Laurier University, ²University of Alberta, ³Appalachian State University

Hagfishes are jawless chordates that consume carrion on the ocean bottom. Due to the difficulty in getting hagfish to feed in captivity, we monitored ammonia (J_{amm}) and urea excretion (J_{urea}) rates immediately following the capture of hagfish from traps baited with hake on the ocean floor near Bamfield Marine Sciences Centre, BC. Basal rates of J_{amm} were very low, approximately 30 $\mu\text{mol/kg}\cdot\text{h}$. Immediately following capture, however, J_{amm} was 22-fold greater averaging 670 $\mu\text{mol/kg}\cdot\text{h}$ over the first hour following capture, declining by 50% over the next several hours. Lesser increases were observed for J_{urea} , which was approximately 7 $\mu\text{mol/kg}\cdot\text{h}$ in starved animals, but 5-10 fold greater in post-foraging animals. Confinement of starved hagfish in traps in the lab had no effect on J_{amm} or J_{urea} . We conclude that hagfish greatly increase rates of amino acid catabolism, and increase their capacity to excrete ammonia following the ingestion of carrion.

Retention and elimination of *Cryptosporidium parvum* and *Giardia duodenalis* by oysters during chronic or acute experimental exposures

Rétention et élimination de *Cryptosporidium parvum* et de *Giardia duodenalis* par les huîtres durant l'exposition expérimentale aiguë et chronique

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¹Atlantic Veterinary College (UPEI), ²The Government of PEI

The zoonotic parasites *Cryptosporidium parvum* and *Giardia duodenalis* can colonize the gastrointestinal tracts of farm animals and are easily transmitted to surrounding water bodies. Both protozoa have been detected in many bivalves, and can potentially remain infective to humans one week after uptake. There is currently little known regarding the capacity for shellfish to harbour these parasites. A series of acute (1 day) and chronic (7 days) exposure trials were performed to determine how well oysters (*Crassostrea virginica*) could retain these parasites when exposed to varying doses. Results demonstrated that oysters differentially selected *Cryptosporidium* oocysts over *Giardia* cysts, and that oysters could not eliminate (oo)cysts when chronically exposed. Oysters that were acutely exposed did begin to expel (oo)cysts but did not clear themselves of the pathogens by the end of the trial. Examination of oyster feces suggested that the majority of (oo)cysts were expelled as fecal material within 24 hours.

Variability in diversity of epifauna at two spatial scales in the shallow rocky sub-tidal zone of the southwestern Bay of Fundy, New Brunswick

Variabilité dans la diversité de l'épifaune sur deux étendues spatiales dans les estrans peu creux et rocheux dans le sud-ouest de la baie de Fundy au Nouveau-Brunswick

Brent M. Wilson, Rémy Rochette and Heather L. Hunt

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Currently, lack of data and understanding of marine coastal areas remains a major impediment to their sustainable use. Accordingly, this project will contribute to the development of cobble-filled passive larval collectors as a new biodiversity monitoring tool for shallow rocky-bottom habitats through three principal objectives. First, by providing quantitative data on biodiversity patterns in four areas in the southwestern Bay of Fundy (each containing three nested sites), including three proposed Ecologically and Biologically Significant Areas. Second, by contrasting biodiversity patterns at two spatial scales (between areas and between sites within areas), which will help to refine the scope of future collector deployments (e.g., how many sites per area). Finally, by assessing spatial patterns of biodiversity using different levels of taxonomic resolution to support cost-benefit (time/resolution) analyses for future sampling efforts. Preliminary results indicate differences at both spatial scales and that these patterns remain significant with coarser taxonomic resolutions (e.g., order).

Short-term behavioural and cortisol responses to Alarm Substance in zebrafish, *Danio rerio*

La réponse à court terme comportemental et du cortisol due à une substance d'alarme chez le poisson zèbre (*Danio rerio*)

Brian Wilson, Jeff Beardsall, Kirk Hillier and Peter McLeod

Acadia University

Zebrafish are a useful model to study behavioural and endocrine responses to stress. We studied short-term behavioral and cortisol responses to an antipredator pheromone, Alarm Substance (AS), in zebrafish. We placed individual fish in a novel 2.5 gallon aquarium and following an acclimation period of 15 minutes, introduced AS (n=10) or the same volume of water (control; n=10) into the aquarium. Zebrafish activity was filmed during the acclimation period and for 60 minutes post-treatment. Several anxiety-related behaviours were recorded and measured. Separate groups of fish (n=6-8/ group) were treated identically except that they were killed and flash frozen before, and 15, 30 and 60 minutes following water (control) or AS treatments. Total lipid was extracted using ether and whole body cortisol measured using GC-FID. AS treatment caused significantly longer freezing durations compared with controls. Whole body cortisol levels increased in AS-treated zebrafish within the first 15 minutes post-treatment.

Initiation and propagation of the heart beat in an ancestral vertebrate, the Pacific hagfish (*Eptatretus stoutii*)

Initiation et propagation du battement cardiaque dans un vertébré ancestral *Eptatretus stoutii*

¹Christopher Wilson, ²Jonathan Stecyk, ²Christine Couturier, ²Göran Nilsson and ¹Anthony Farrell

¹*University of British Columbia*, ²*University of Oslo*

Pharmacological and molecular methods were used to compare the initiation and propagation of the heart beat in the Pacific hagfish, the most ancestral known vertebrate, to other vertebrates. As in other vertebrates, the heart beat seems to be initiated by the funny current, a steady influx of Na⁺ and K⁺ ions through hyperpolarization-activated cyclic nucleotide-gated (HCN) channels. However, the major HCN isoform present in hagfish hearts is the evolutionarily-ancestral HCN₃, not the typical HCN₄. Also, eight isoforms of HCN were discovered compared to the typical four. Tetrodotoxin (TTX), a Na⁺ channel blocker, had a minor effect on heart rate initiation, slightly reducing contraction rate of both cardiac chambers. Surprisingly however, both chambers continued to contract in 10 µM TTX indicating remarkable TTX resistance. TTX also induced an atrioventricular block equal to that induced by crushing the atrioventricular canal suggesting TTX-sensitive Na⁺ channels are vital for atrioventricular conduction. Supported by NSERC.

From cells to slime: slime thread production by the hagfish gland thread cell

De la cellule au mucus: production de fils du mucus par les cellules de fil glandulaires de la myxine du Pacifique

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University of Guelph

The slime produced by hagfishes contains a unique combination of proteinaceous threads and mucins that viscously entrap seawater to discourage attacks by gill-breathing predators. The intermediate filament (IF) threads that traverse the mass of slime reach up to 15 cm in length and are synthesized for holocrine release by 150 µm gland thread cells (GTCs). Exactly how a 150 µm cell synthesizes a continuous 15 cm IF thread is not known. What is known is that microtubules (MTs) are present during the early and intermediate stages of GTC maturation but subsequently disappear as the GTCs fully mature. This study plans to explore this temporal variability in MT presence and determine what role MTs may be playing in the development of the GTCs IF thread. More specifically this study plans to test the hypothesis that MTs provide a scaffolding on which the IF subunits align and organize during the maturation of the GTCs.

Calibrating a new tool to monitor rocky subtidal biodiversity: the effects of cobble size on biodiversity and lobster abundance

Étalonnage d'un nouvel outil pour surveiller la biodiversité des zones subtidales rocheuses: les effets de la taille des galets sur la biodiversité et l'abondance des homards

Gregory Wittig and Rémy Rochette
University of New Brunswick Saint John

This study is part of a project to develop a tool to monitor biodiversity on rocky subtidal shores. The tool is a modified lobster trap filled with cobble, which acts as a passive collector of settling larvae and individuals that crawl-in from the benthos. The objective of this study was to quantify the effects of cobble size on biodiversity. Each collector was split into three sections and filled with small, medium or large rocks. 10 collectors were deployed from July 7 to October 21, 2010, in Beaver Harbour, southwest Bay of Fundy. Multivariate analysis of similarity did not show significant effects of cobble size on biodiversity, but did reveal small-scale differences between cages. However, a PERMANOVA analysis accounting for the cage effect did reveal a highly-significant effect of cobble size on biodiversity. Interestingly, the American lobster *Homarus americanus* also showed significant differences in settler and juvenile abundance with cobble size.

Responses to Ammonia Loading in the Magadi Tilapia, a Completely Ureotelic Teleost Fish

La réponse aux changements d'ammoniac chez le tilapia *Alcolapia grahamii*: un poisson téléostéen complètement uréotélique

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The tilapia *Alcolapia grahamii* of highly alkaline Lake Magadi, Kenya (pH ~10, alkalinity ~ 300 mequiv L⁻¹) is the only teleost known to be 100% ureotelic. It excretes no ammonia, yet expresses genes for Rh proteins (Rhag, Rhbg, Rhcg - putative ammonia transporters) in various tissues. We examined its responses to high external ammonia (HEA, 500 µmol L⁻¹), a condition known to occur naturally in Lake Magadi. HEA exposure increased urea excretion, blood ammonia, cortisol, lactate, and glucose concentrations, and gene expression of Rhcg, Rhbg, Na⁺,K⁺-ATPase, and the facilitated diffusion urea transporter in the gills. At an enzymatic level, the branchial Na⁺,K⁺-ATPase appears unusual in being activated to a greater extent by NH₄⁺ than by K⁺. The significance of these findings with respect to current views on Rh protein function, and models for gill ammonia and urea transport will be discussed.

To pee or not to pee: Rh versus pH in common carp (*Cyprinus carpio*)

Uriner ou ne par uriner: Rh versus pH chez la carpe commune (*Cyprinus carpio*)

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Metabolic acidosis in vertebrates induces renal ammoniogenesis and acid secretion. We investigated the localization of Rhesus (Rh) glycoproteins in kidney (and gills) and physiological responses of common carp to low water pH (pH 4.0, 3 days), a treatment that induced systemic acidosis. Urine ammonia concentrations increased 4 fold, while urine flow rates decreased. Branchial ammonia excretion rates increased 3 fold, during acid exposure relative to controls. Rh proteins were expressed in the kidney and gills. We propose a renal ammonia excretion model where Rh glycoproteins facilitate renal acid excretion.

Questions, hypotheses and experimental design: helping students to test what they meant to test

Questions, hypothèses et conception expérimentale: aider les étudiants à tester ce qu'ils veulent tester

Russell Wyeth and Marjorie Wonham
St. Francis Xavier University, Quest University

Hypotheses are at the core of all science. Yet possibly because experienced scientists find hypothesis formation transparent, students are rarely explicitly taught how to formulate a good hypothesis. Instead, the implicit assumption is that good critical thinking skills combined with mimicry from reading scientific literature should be sufficient on their own without additional training. In our experience though, students (even good students) can have difficulty translating their excellent questions into testable hypotheses that will actually answer their original question. Moreover, their experimental designs often also end up testing something slightly different than their hypothesis. To combat this, we have developed a conceptual framework that teaches the fundamental concepts of both pattern and mechanism, which then lead students directly to posing good questions, formulating testable hypotheses, and furthermore to clear experimental design. In our experience (and based on student feedback), this effort provides a meaningful improvement of students' scientific abilities.

A screen for genes associated with coma recovery in drosophila

Un dépistage des gènes associés à la récupération d'un coma chez la drosophile

Chengfeng Xiao and R Meldrum Robertson

Queen's University

Organisms enter into a coma when the oxygen level in the environment is reduced. Recovery from coma depends on many factors including exposure time and genetic predisposition. We used a model organism, *Drosophila*, and attempted to identify genes affecting the recovery from coma. Previous work has shown that the atypical guanylyl cyclase genes (*Gyc-89Da*, *89Db* and *88E*) function as neuronal oxygen sensors. Using this mutant as a positive control, we carried out a forward genetic screen for novel genes modifying the recovery. In a pilot study we have identified several genes with tissue specificity in glial cells, and a gene encoding egg-derived tyrosine phosphatase (*EDTP*), that are associated with reduced locomotor activity during recovery. Moreover, *EDTP* mutant flies demonstrated significantly greater survivorship in response to prolonged nitrogen exposure. Together these data identify genes in the CNS, particularly in glia, that play essential roles in hypoxic coma recovery.

Ammonia excretion in early life stages of rainbow trout – evidence of a $\text{Na}^+/\text{NH}_4^+$ -exchange complex

L'excrétion d'ammoniac dans les premiers stades de vie de la truite arc-en-ciel - preuve d'un complexe d'échange $\text{Na}^+/\text{NH}_4^+$

Alex M. Zimmer and Chris M. Wood

McMaster University

Following hatch, the majority of physiological exchanges with the surrounding environment take place cutaneously in developing trout. Recent evidence has suggested that gill development is driven by a need for increased ionoregulation as the cutaneous-to-branchial shifting point occurs significantly earlier for sodium uptake ($J_{\text{Na}_{\text{in}}}$) than for oxygen consumption (MO_2). The timing of this shift for ammonia excretion (J_{amm}) is unknown. We determined that immediately after hatch, 87% of total J_{amm} is cutaneous. By yolk sac absorption, cutaneous excretion accounted for only 16% of total J_{amm} . The cutaneous-to-branchial shift for J_{amm} and $J_{\text{Na}_{\text{in}}}$ both occurred at 11.3 days post-hatch (dph), in agreement with the current " $\text{Na}^+/\text{NH}_4^+$ -exchange complex" model for ammonia excretion, while the shift for MO_2 was seen significantly later at 13.6 dph. Enzyme activity and gene expression of key components of the exchange complex in yolk sac skin, body skin, and gill tissues are being examined. (NSERC Discovery).