BULLETIN

Western University

Annual Meeting / Rencontre Annuelle

May 9 - 13 mai 2015

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 2016/Printemps 2016

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OFFICERS OF CSZ 2015-2016 CONSEIL DE LA SCZ

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BULLETIN OF THE CANADIAN SOCIETY OF ZOOLOGISTS: The Bulletin is usually 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.

The Canadian Society of Zoologists is a diverse and inclusive scientific society that welcomes members of any gender, race, ethnicity, religion and sexual orientation. The society aims to reflect this diversity at all levels, ranging from participation at meetings, to representation on council and committees, to the recipients of its awards. The Canadian Society of Zoologists is proud to promote and support equality for all members interested in zoology.

La Société canadienne de zoologie se veut une société scientifique diversifiée et inclusive qui admet dans ses rangs toute personne intéressée à la zoologie, sans égard au sexe, à l'origine ethnique, la religion ou l'orientation sexuelle. La Société a pour objectif que cette diversité se reflète à tous les niveaux que ce soit au niveau de la participation aux conférences, de la représentation au sein du conseil ou de ses comités qu'à celui des récipiendaires des prix et récompenses. La Société canadienne de zoologie est fière de promouvoir et de supporter l'égalité entre tous ses membres.

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Canadian Society of Zoologists
Société Canadienne de Zoologie

55th Annual Meeting / 55ième Réunion Annuelle

May 9 – 13 mai, 2016

Western University

London, Ontario

Organizing committee/Comité organizateur

Brent Sinclair (Chair)
Yolanda Morbey (Treasurer)
Susan Anthony
Laura Ferguson
Jackie Lebenzon
Kate Mathers
Beth MacDougall-Shackleton
Scott MacDougall-Shackleton
Jeremy McNeil
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Graham Thompson
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We thank our sponsors.

THE ROYAL SOCIETY PUBLISHING

Journal of Experimental Biology

Welcome from the Local Organizing Committee

Welcome to CSZ2016, to London, ON, and to Western University's beautiful campus!

It is a pleasure to host the meeting, and I hope we can all look forward to a week of stellar science, stimulating conversations with friends old and new, and celebrations of the successes of our wonderful membership. It's a packed schedule, but we've done our best to make sure that beverages and food will flow freely so you can concentrate on the science and make the most of Western's campus.

I have been part of an exceptional LOC, and I particularly want to thank Yolanda Morbey, who has handled so many of the finance and other details behind the scenes, Kate Mathers and Scott MacDougall-Shackleton for collecting the abstracts and putting together this programme document, and Jackie Lebenzon for handling the website and graphics. There were many other members of the LOC (you'll see their names in the programme) and we have also been lucky to have a great team of student volunteers. They've all worked hard to make the meeting a success, so if you see them around, please say thanks!

Western University has supported this meeting at all levels, and I'd like to specifically acknowledge the VP Research, the deans of Science and Social Science and the School of Graduate and Postdoctoral Studies for their support. The LOC symposium and ZET lecture are sponsored by *The Journal of Experimental Biology*, and you'll be caffeinated thanks to Sable Systems International and the *Journal of Insect Physiology*. We've received much other sponsorship, and you'll see those sponsors acknowledged in the programme and throughout the meeting.

I wish you all a splendid meeting.

Brent Sinclair

Chair, CSZ 2016 Local Organising Committee

Bienvenue à la SCZ 2016, à London, ON, et au magnifique campus de la Western University.

C'est un plaisir d'accueillir le congrès, et j'espère que nous pouvons tous espérer une semaine de science prestigieuse, de conversations stimulantes avec des amis vieux ou neufs, et de célébrations des succès de nos merveilleux membres. C'est un horaire chargé, mais nous avons fait notre possible pour assurer que les breuvages et la nourriture coulent à flot pour que vous puissiez vous concentrer sur la science et vivre au maximum le campus de Western.

J'ai fait partie d'un comité d'organisation exceptionnel, et je veux particulièrement remercier Yolanda Morbey, qui a géré une grosse part des finances et d'autres détails en arrière de la scène, Kate Mathers et Scott MacDougall-Shackleton pour la réception les extraits et l'assemblage du programme, et Jackie Lebenzon pour la gestion du site web et des illustrations. Il y avait plusieurs autres membres dans le comité d'organisation (vous verrez leurs noms dans le programme) et nous avons été chanceux d'avoir une équipe grandiose de bénévoles étudiants. Ils ont tous travaillé fort pour rendre cette conférence un succès, donc si vous les voyez, veuillez les remercier!

La Western University a supporté cette conférence à tous les niveaux, et j'aimerais spécifiquement remercier le vice-président en recherche, les doyens des sciences et des sciences sociales, ainsi que l'École des Études Graduées et Postdoctorales pour leur support. Le symposium du comité d'organisation et la présentation du Fonds pour l'Éducation en Zoologie sont parrainés par *The Journal of Experimental Biology*, et remercions Sable Systems International et le *Journal of Insect Physiology* pour la dose de caféine. Nous avons reçu bien d'autres dons, et vous verrez nos reconnaissances pour ceux-ci dans le programme et pendant la conférence.

Je vous souhaite à toutes et à tous une conférence splendide.

Brent Sinclair

Président, Comité Organisateur Local de la SCZ 2016

Welcome from CSZ President

On behalf of the Council I would like to welcome you to the 55th annual meeting of the Canadian Society of Zoologists. It has been 18 years since Louise Milligan organized the last meeting here at UWO. Those of you who attended might notice that the campus has changed significantly since 1997. One thing that has not changed is our latitude – with the exception of Windsor, London is as far south as CSZ meetings are likely to happen. I know that many of you have had a long and challenging winter, so take advantage of our sunlight and Carolinian blossoms while you can!

The local organizing committee, led by Brent Sinclair and Yolanda Morbey, have done a great job providing an excellent mix of science, education, engagement, professional development, and social activities. With so many high-quality submissions and sessions, however, there are some inevitable conflicts, so budget your time prudently. Be sure to save some time and energy to reconnect with old friends and make new ones. Welcome and enjoy the meeting!

Jim Staples

CSZ President

Au nom du Conseil j'aimerais vous accueillir à la 55e conférence annuelle de la Société canadienne de zoologie. Il y a 18 ans, Louise Milligan a organisé le dernier congrès ici à la UWO. Ceux d'entre vous qui y ont assisté pourraient remarquer que le campus a changé significativement depuis 1997. Une chose qui n'a pas changé est notre latitude – à l'exception de Windor, London est le plus au sud où les conférences de la SCZ peuvent avoir lieu. Je sais que plusieurs d'entre vous ont eu un hiver long et difficile, donc profitez de notre soleil et des floraisons caroliniennes pendant que vous le pouvez!

Le comité organisateur local, dirigé par Brent Sinclair et Yolanda Morbey, a fait un travail remarquable en amenant un mélange excellent de science, d'éducation, d'engagement, de développement professionnel, et d'activités sociales. Avec autant de soumissions et de sessions de haute qualité, il y aura inévitablement quelques conflits d'horaire, donc planifiez votre temps prudemment. Soyez certains de garder du temps et de l'énergie pour reconnecter avec vos vieux amis et en faire de nouveaux. Bienvenue et profitez bien de la conférence!

Jim Staples

Président de la SCZ

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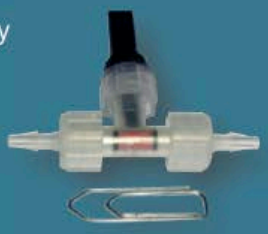

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General information

Emergency contact numbers

- **Call 911 in general emergency** (Police, fire and ambulance)
- **519-661-3300** (Campus Police Service: Non-emergencies or inquiries, open 24 h)
- University Hospital is located at 339 Windermere Road
- Conference Service: Room 150, Lambton Hall,
  Tel: 519 661-3545

Registration and Presentations

Check-In

Monday, May 9, 14:00-18:00 – Ontario Hall, Front Desk (check-in for B&B guests)

Registration

Monday	12:00 -17:30, 18:30-19:30	SSC 2050
Tuesday	08:00 -12:00	SSC 2050
Wednesday	08:00 -11:00	UCC 59 (speaker ready room)
Thursday	08:00 -11:00	UCC 59 (speaker ready room)

Speaker Ready Room UCC 59

Talks

All talks will be held in the **University Community Centre (UCC)** or in the **Social Science Centre (SSC)**, except the ZET Lecture which will be held in **North Campus Building (NCB).**

Poster presentations

The poster session(s) will be in the Physics and Astronomy Atrium
The presenters are able to put posters up at the coffee breaks on the day of the poster session. Set-up after Tuesday 9:00 AM, take-down before Wednesday 4:00 PM.

Internet

If you will stay at London or Ontario Hall during the conference, user name and passwords are provided at front desk, and username and passwords are provided at the registration desk for participants not staying in residence.

Accommodations

Western Bed & Breakfast
Tel: 519 661-3476 or 1 888 661-3545 (toll free)
http://www.stayatwestern.ca/

Ontario Hall (Western Bed & Breakfast)
230 Sarnia Road, London, Ontario, Canada N6G 1M9

The Windermere Manor
200 Collip Circle**,** London, Ontario, Canada N6G 4X8
Tel: 519-858-1414 or 1-800-997-4477 (toll free)
http://windermeremanor.com/

Ivey Spencer Leadership Centre
551 Windermere Road, London, Ontario, Canada N5X 2T1
Tel: 519-679-4547 or 1-800-834-7410
http://www.iveyspencerleadershipcentre.com/

Hotel Metro
32 Covent Market Place, London, Ontario, Canada N6A 1E8
Tel: 519-518-9000 or 1-866-626-3876
http://hotelmetro.ca/

Doubletree by Hilton London Ontario
300 King Street, London, Ontario, Canada N6B 1S2
Tel: 519-439-1661
http://doubletree3.hilton.com/en/hotels/ontario/doubletree-by-hilton-hotel-london-ontario-YXUKSDT/index.html

Delta London Armouries Hotel
325 Dundas Street, London, Ontario, Canada N6B 1T9
Tel: 519-679-6111 or 1-800-668-9999
https://www.deltahotels.com/Hotels/Delta-London-Armouries-Hotel

Station Park All Suite Hotel
242 Pall Mall Street, London, Ontario, Canada N6A 5P6
Tel: 519-642-4444 or 1-800-561-4574 Ext. 0 5
http://www.stationparkhotel.com/

Guesthouse on the Mount
1486 Richmond St - Ignatia Hall, London, Ontario N6G 2M3
Tel: (519) 641-8100
http://www.guesthouseonthemount.ca/

Banks and banking machines

Bank close to campus

TD Canada Trust 1137 Richmond St. (near Elgin Hall)

Machines on campus

UCC main floor (TD, Bank of Montreal, Royal Bank)
UCC lower level (CIBC, Bank of Montreal, Scotiabank)
Natural Science Centre, main floor (Royal Bank)

Automatic Teller Machines (ATMs)

Elgin Hall (Residence), Althouse college, Spencer Engineering Building, Law School, Somerville House, Talbot College, Medical Science, Natural Sciences, UCC, Thompson Recreation centre, Social Science Building (Food services locations)

Restaurants

On campus

The Grad club (lower level, Middlesex College)
The Wave (2nd floor, UCC)
Spoke (main floor of UCC)

Off Campus

There are many restaurants downtown (Bus routes 2 and 6) and along the following bus stops: "Dundas Street/Talbot Street", "Dundas Street/ Richmond Street" (Route 2) and between "Richmond Street/Oxford" and "Richmond/ Dundas" (Route 6).

Local transportation

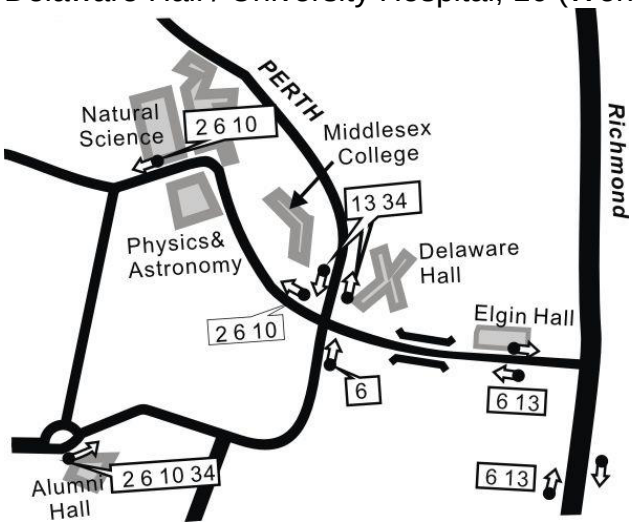
Bus: LTC (London Transit Commission) controls the bus service in London and schedules and for a complete London map with the bus routes go to www.ltconline.ca

To go to downtown (10-15min)

Natural Science / Alumni Hall: 2A or 2B (Dundas), 6 (Richmond)
Delaware Hall / University Hospital: 13 (Wellington)
Western Road bus stop by Ontario or London Hall: 2A or 2B

To Masonville shopping mall (~10 min)

Delaware Hall / University Hospital, 10 (Wonderland), 13, 34 (Medway), Alumni Hall, 10, 34



Taxi: Fare from University campus to downtown is approximately $ 10-12 (+ tips, usually 10 to 15 percent of the price charged) and a taxi from London Airport to University takes about 20 min and costs ~$35. Credit card is available.

Aboutown Taxi Service 519-432-2222
Checker Limousine 519-659-0400
U-Need-A Taxi Service 519-438-2121
Yellow London Taxi 519-657-1111

Parking

Parking for participants is complimentary in Ontario lot N & Althouse lot H (both are located behind Ontario Hall, SW corner of Sarnia Road & Western Road; see http://www.uwo.ca/parking/find/pdf/parking_2014_final_4.pdf).

Programme of Events

For Program-At-A-Glance see insert in badge holder.

Events

Monday – 9 May

CSZ Council Meeting	10:00-16:30	Ontario Hall 3C04
CJZ Workshop	15:00-16:00	UCC 56
NSERC Scholarship Workshop	16:00-17:00	UCC 56
NSERC Discovery Grants Workshop	16:00-17:00	UCC 37
Welcome/ Order of Proceedings/ Fry Lecture	17:30-18:30	SSC 2050
Opening Reception	18:30-21:00	Physics & Astronomy Atrium

Tuesday – 10 May

AGM Lunch	12:30-14:00	Great Hall (in Sommerville House)
Boutilier Award Lecture	14:00-15:00	SSC 2050
Poster Session	16:30-18:30	Physics & Astronomy Atrium
Student Meet & Greet	18:30-19:00	The Wave (UCC 2nd floor)
Student Success Workshop	19:00-21:00	The Wave (UCC 2nd floor)

Wednesday – 11 May

CPB Lunch	12:30-13:30	SSC 2050
PIE Lunch	12:30-13:30	UCC 65
Cameron Award Lecture	13:30-14:30	SSC 2050
Education Workshop	17:00-18:00	UCC 56
Diversity Workshop	17:00-18:00	UCC 37
ZET Lecture	19:00-20:00	NCB 101
ZET Reception	20:00-22:00	Physics & Astronomy Atrium

Thursday – 12 May

CMD Lunch	12:30-13:30	UCC 63
EEE Lunch	12:30-13:30	UCC 65
Presidents' Award Talks	13:30-15:00	SSC 2050
W.S. Hoar Award	15:30-17:00	SSC 2050
Banquet with live band (Grackles)	18:00-24:00	Great Hall (in Sommerville House)

Friday – 13 May

CSZ Council Meeting	09:00-13:00	Ontario Hall 3C04

Monday 9 May / lundi 9 mai

summary / résumé

10:30-14:30	Council Meeting / Réunion du conseil Coffee&Lunch	Ontario Hall 3C04
15:00-16:00	Can J Zool Workshop / Atelier du Can J Zool	UCC 56
15:00-16:00	Wardle Lecture / Conférence Wardle	SSC 2050
16:00-17:00	NSERC Workshops	UCC 56/ UCC 37
17:00-17:30	break/ pause	
17:30-18:30	Welcome / Fry Lecture Bienvenue / Conférence Fry	SSC 2050
18:30	Opening Reception / Réception d'ouverture	Physics/Astronomy Atrium

Notes:

CJZ Workshop
15:00-16:00
UCC 56

Can J Zool Workshop / Atelier du Can J Zool

What do editors expect from reviewers?

There is no doubt that across the realm of scientific publishing a shortage of reviewers is an important challenge for editors. But often people who are invited to review decline to participate because of the time that can be involved. The purpose of this session is to review the kinds of information that editors expect to receive from reviewers when they invite colleagues to review submitted manuscripts. The intention is to help those new to the game to establish themselves as trusted reviewers. The same information should be valuable to those trying to get their papers through the hurdle en route to publication.

Atelier RCZ
«Canadian Science Publishing» publie la Revue canadienne de zoologie. L'atelier RCZ est normalement centrée sur le processus de publication, incluant la préparation des manuscrits et la révision, et est conçue pour les étudiants et les stagiaires postdoctoraux.

NSERC Workshops
16:00-17:00
UCC 56 and 37

NSERC Grants Workshop - Atelier Subventions du CRSNG

16:00- 17:00
UCC 37

A representative from NSERC will discuss the latest NSERC Discovery Grants round, any forthcoming changes to that process, and any of NSERC's new and ongoing research funding and partnership initiatives.

Un représentant du CRSNG va discuter de la dernière ronde du Programme de subventions à la découverte du CRSNG, de changements envisagés pour le processus, et de financements de recherche, nouveaux ou toujours en cours, et d'initiatives de partenariat du CRSNG.

NSERC Scholarship Workshop - Atelier Bourses du CRSNG

16:00- 17:00
UCC 36

A representative from NSERC as well as several former panel members will discuss NSERC graduate scholarships and PDF application processes. This session is organised by the Students Section and the PDF councillor.

Un représentant du CRSNG ainsi que plusieurs anciens membres vont discuter des processus d'application pour les bourses d'études graduées et postdoctorales du CRSNG. Cette session est organisée par la Section étudiante et le conseiller des bourses postdoctorales.

R. A. Wardle Award

15:00-16:00
SSC 2050
Chair: Carl Lowenberger

Dr. Martin Olivier
McGill University

Trekking in Host-Parasite Interaction: An Exciting Journey…
Marche Parmi les interactions Hôtes-Parasites : Un Voyage Remplit d'Extase…

The intramacrophage protozoan parasites of *Leishmania* genus have developed sophisticated ways to subvert the innate immune response permitting their infection and propagation within the macrophages of the mammalian host. Several *Leishmania* virulence factors have been identified and found to be of importance for the development of leishmaniasis. However, recent findings are now further reinforcing the critical role played by the zinc-metalloprotease GP63 as a virulence factor that greatly influence host cell signaling mechanisms and related functions. GP63 has been found to be involved not only in the cleavage and degradation of various kinases and transcription factors, but also to be the major molecule modulating host negative regulatory mechanisms involving for instance protein tyrosine phosphatases. Those latter being well recognized for their pivotal role in the regulation of a great number of signaling pathways. In this presentation, I will provide a complete overview of our most recent findings in regards to *Leishmania* GP63, its enrichment in extracellular vesicules named exosome and their role in the mechanisms underlying the infectious process and cutaneous leishmaniasis dévelopment.

Les parasites protozoaires du genre Leishmania ont développé des moyens sophistiqués pour éviter la réponse immunitaire innée leur permettant d'infecter efficacement les macrophages et se propager dans leurs hôtes mammifères. Plusieurs facteurs de virulence des leishmanies ont été identifié et démontré comme important pour le développement de la leishmaniose. Néanmoins, des découvertes récentes ont actuellement renforcées le rôle critique la zinc-métalloprotéase GP63 comme un facteur de virulence influençant grandement les mécanismes signalétiques et les fonctions des macrophages. GP63 est reconnue pour être impliquer non seulement dans le clivage et la dégradation de plusieurs kinases et facteurs de transcription, mais aussi pour être responsable de la modulation des mécanismes de régulations négatives de la cellule hôte comme les protéines tyrosines phosphatases. Ces dernières étant bien reconnues pour leurs rôles pivots dans le contrôle d'un grand nombre de voies signalétiques. Au cours de ma présentation, je vais tenter de faire une couverture complète de nos plus récentes découvertes en ce qui concerne la GP63 des leishmanies, son enrichissement dans les vésicules extracellulaires nommées exosome et leur rôle dans les mécanismes impliquées dans l'induction de l'infection et le développement de la leishmaniose cutanée.

Monday / lundi

R. A. Wardle Award
Dr. Martin Olivier
McGill University

Martin Olivier, Ph.D. is an Immuno-Parasitologist and Full Professor at the Departments of Medicine, Microbiology and Immunology at McGill University and the Research Institute of the McGill University Health Centre (MUHC) for the last 14 years. He is internationally known for his findings in host-parasite interactions, pathogen evasion mechanisms and innate immune response that have been reported in over 150 original papers. His research has translated into the development of nanovaccine technology, anti-inflammatory molecules and immunomodulators. In addition, he is the recipient of many awards including CIHR Investigator, Burroughs Wellcome Fund and the Canadian Society for Immunology Investigator Awards. Prior to become Professor at McGill University, he spent 9 years as assistant/associate professor at Université Laval and the Centre de Recherche du CHUL. He obtained his PhD in Parasitology from McGill University and his MSc in Microbiology and Immunology of Université de Montréal where he started as soon as 1981 to work on leishmaniasis, trypanosomiasis and malaria.

Martin Olivier, Ph.D. est un immuno-parasitologiste et Professeur Titulaire aux départements de Médecine et de Microbiologie et Immunologie de l'Université McGill et au centre de recherche du Centre Universitaire de Santé McGill (CUSM) au cours des 14 dernières années. Il est reconnu mondialement pour ses découvertes sur les interactions hôtes-parasites, les mécanismes d'évasions des pathogens et sur la réponse immune innée, qui ont été rapportées dans plus de 150 papiers originaux. Sa recherche a conduit au développement de technologie nanovaccinal, de molecules anti-inflammatoires et d'immunomodulateurs. De plus, il est le récipiendaire de plusieurs prix donc celui de chercheur des IRSC, du prix international Burroughs Wellcome Fund et national de chercheur de la Société Canadienne d'Immunologie. Avant de devenir professeur à l'Universit McGill, il a passé 9 années comme professeur adjoint et agrégé à l'Université Laval et au centre de recherche du CHUL. Il a obtenu son Ph.D. en Parasitologie de l'Université McGill et son diplôme de M.Sc. en Microbiologie et Immunologie de l'Université de Montréal ou il a commence dès 1981 à travailler sur la leishmaniose, la trypanosomiase et la malaria.

Welcome/ F. E. J. Fry Award,
17:30-18:30
SSC 2050

Order of Proceedings

Welcome: Dr. Louise Milligan, Associate Dean, Faculty of Science, Western University

Introduction: Dr. Jim Staples, President, Canadian Society of Zoologists

Dr. Brock Fenton
University of Western Ontario

The Endless Allure of Bats

I will describe my addiction to bats, from the onset to the ongoing. This means talking about evolution and echolocation, about the structure of bat communities, and the astonishing diversity of bats. I also will speak about science and bats, misconceptions and realities. Bats do eat mosquitoes? Probably not. I will allude to the business of bats and diseases, and finish up with some examples of bats and folklore (ours about them).

Je vais décrire mon addiction aux chauves-souris, depuis le début jusqu'à présent. Je parlerai donc de l'évolution et de l'écholocation, de la structure des communautés de chauves-souris, et de la diversité incroyable des chauves-souris. Je vais aussi parler de la science autour des chauves-souris, des idées fausses et des réalités. Les chauves-souris mangent-elles des maringouins? Probablement pas. Je vais faire allusion aux affaires liant les maladies et les chauves-souris, et terminer avec quelques exemples de chauves-souris dans le folklore (le nôtre à propos d'elles).

Tuesday 10 May / mardi 10 mai

summary / résumé

08:00-08:30	Refreshments	
08:30-10:00	LOC Symposium *Animal movement and migration*	SSC 2050
10:30-11:00	Refreshments *sponsored by Sable Systems*	
11:00-12:30	Contributed Sessions	
	Hemoglobin and oxygen delivery	UCC 56
	Environmental contaminants	UCC 41
	Biomechanics and morphology	UCC 37
	Neurobiology	UCC 58
	Host-parasite and host-pathogen interactions	UCC 60
12:30-14:00	AGM Lunch (Lunch provided)	Great Hall (in Sommerville House)
14:00-15:00	Boutilier Award Lecture	SSC 2050
15:00-16:30	Contributed Sessions	
	Hypoxia I	UCC 56
	Foraging, feeding, digestion	UCC 41
	Ecologically relevant stressors	UCC 37
	Healing, growth and morphology	UCC 58
	Stress endocrinology	UCC 60
16:30-18:30	Poster Session with Refreshments *sponsored by Sable Systems*	Physics & Astronomy Atrium
18:30-19:00	Student Meet & Greet	The Wave (UCC 2nd floor)
19:00-21:30	Student Success Workshop	The Wave (UCC 2nd floor)

Notes:

08:30-10:30 Local Organizing Committee (LOC) Symposium

S1 - Animal Movement and Migration
SSC 2050
Chair: Beth MacDougall-Shackleton

S1-1 08:30	Doug Altshuler, Roslyn Dakin, Kevin Middleton, Paolo Segre *University of British Columbia* Biomechanics of maneuvering flight in hummingbirds
S1-2 09:00	Christopher G. Guglielmo *University of Western Ontario* The challenge of empirically testing hypotheses about the physiology of global-scale migrations of birds
S1-3 09:30	Sonia Altizer *University of Georgia* Animal migration, infectious disease risk and response to environmental change
S1-4 10:00	Michael Stokesbury *Acadia University* Predicting the effects of in-stream tidal power turbines on migrating Atlantic sturgeon

Sponsored by

11:00-12:30 CONTRIBUTED SESSIONS

C1 - Hemoglobin and oxygen delivery
UCC 56
Chair: Dillon Chung

C1-1 11:00	Dillon Chung, Heather Bryant, Philip Morrison and Patricia Schulte *University of British Columbia* Thermal acclimation and local adaptation effects on hemoglobin and mitochondrial oxygen binding affinities
C1-2 11:15	Sajeni Mahalingam, Grant McClelland and Graham Scott *McMaster University* High-altitude ancestry and hypoxia acclimation affect mitochondrial physiology in deer mice
C1-3 11:30	Matthew J.H. Gilbert, Hamid Safi, Anthony P. Farrell *University of British Columbia* Atrioventricular dyssynchrony may underlie cardiac collapse at warm temperatures in fish
C1-4 11:45	Neal J. Dawson, Kevin G. McCracken and Graham R. Scott *McMaster University and University of Miami* Muscle physiology and oxidative capacity in high-altitude Andean ducks and geese

C2 - Environmental contaminants
UCC 41
Chair: Erin McCallum

C2-1 11:00	Laura Dindia, Sarah Alderman, Anthony Farrell, Christopher Kennedy and Todd Gillis *University of Guelph* Identification of plasma biomarkers for bitumen exposure in sockeye salmon (*Oncorhynchus nerka*)
C2-2 11:15	Laura Tessier and Mike Wilkie *Wilfrid Laurier University* Body mass and metabolic rate are predictors of the lampricide sensitivity of invasive sea lampreys (*Petromyzon marinus*)
C2-3 11:30	Prachi Deshpande and Jim McGeer *Wilfrid Laurier University* Nickel and Copper Mixture Toxicity to Daphnia in Soft Water
C2-4 11:45	Yanju Ma, Cristina Perez, Brian Branfireun and Chris Guglielmo *University of Western Ontario* Flight performance in a migratory songbird exposed to elevated dietary methyl-mercury
C2-5 12:00	Nguyen (Nathan) T. K. Vo, Colin B. Seymour, Soo H. Byun and Carmel E. Mothersill *McMaster University* Effects of low doses of alpha, beta, and gamma-emitting radionuclides on the innate antiviral responses in fish cells
C2-6 12:15	Erin S. McCallum, Sherry N. N. Du, Graham R. Scott, and Sigal Balshine *McMaster University* Exposure to wastewater effluent differentially affects the behaviour and physiology of two Great Lakes fish species

C3 - Biomechanics and morphology
UCC 37
Chair: James Kieffer

C3-1 11:00	Kevin Duclos, Thomas Grünbaum, Richard Cloutier and Bernard Angers *Université de Montréal* Show me yours, I'll show you mine: phenotypic differences in sympatric clonal hybrids
C3-2 11:15	Jessica Theodor *University of Calgary* Four toes good, two toes bad: complex patterns of digit reduction in artiodactyls
C3-3 11:30	James Kieffer, Adam Downie and Lindsay May *University of New Brunswick* A split decision: The impact of substrate type on the swimming behaviour and UCrit of shortnose sturgeon
C3-4 11:45	Robert Shadwick *University of British Columbia* Necrophysiology lives! Predicting blood pressure in the Greenland shark from aortic elasticity
C3-5 12:00	Scott Seamone and Douglas Syme *University of Calgary* Escape responses provide insight into the function of the whip-like tail during locomotion in stingrays
C3-6 12:15	Jeneni Thiagavel and John M. Ratcliffe *University of Toronto* Big mouth strikes again: gape as an underestimated correlate of echolocation call peak frequency in vespertilionid bats

C4 - Neurobiology
UCC 58
Chair: Richard Kinkead

C4-1 11:00	Kristin Spong and R Meldrum Robertson *Queen's University* Variation in the severity of spreading depolarization in the brain of *Drosophila*
C4-2 11:15	Sophie St-Cyr, Marian Wong, Susan Marsh-Rollo, Jennifer Reynolds, Sigal Balshine and Nadia Aubin-Horth *Université Laval* Reach for the top: changes in brain transcriptome of females that become dominant in a highly-social fish species
C4-3 11:30	Stéphanie Fournier, Simon Chamberland, and Richard Kinkead *Université Laval* Developmental changes in trigeminal motoneuron properties in the American bullfrog, *Lithobates catesbeianus*
C4-4 11:45	Peter L. Hurd, Sayeed Devraj-Kizuk, Walter AS Espinoza, Yondu Mori, and Michele K Moscicki *University of Alberta* Development of sex and sex differences in brain and behaviour in cichlid
C4-5 12:00	Mélanie F. Guigueno, Scott A. MacDougall-Shackleton, and David F. Sherry *University of Western Ontario* Sex and seasonal differences in hippocampal volume and neurogenesis in brood-parasitic brown-headed cowbirds

C5 - Host-parasite and host-pathogen interactions
UCC 60
Chair: Shawna Semple

C5-1 11:00	Matthew Watson, Joel Slade, Greg Gloor, Beth MacDougall-Shackleton *University of Western Ontario* MHC diversity as a predictor of survival and a correlate of neutral-locus heterozygosity in free-living songbirds
C5-2 11:15	Dino Milotic and Janet Koprivnikar *Ryerson University* Road salt reduces larval amphibian parasite avoidance behaviour but not resistance to infection
C5-3 11:30	Susan Wang, Glenn J Tattersall, and Janet Koprivnikar *Brock University* Studying Effects of Trematode Infection on Thermoregulatory Behaviour in Tadpoles
C5-4 11:45	Raine Kortet, Ann Hedrick and Anssi Vainikka *University of Eastern Finland* Does parasitism affect ecology of animal personalities?
C5-5 12:00	Shawna L. Semple, Dan D. Heath and Brian Dixon *University of Waterloo* The impact of outbreeding on the immune performance of Chinook salmon when challenged with *Vibrio anguillarum*
C5-6 12:15	Patrick C. Hanington, Michelle A. Gordy, Sydney P. Rudko, Alethe L. Kabore, Valerie K. Phillips, Mahmoud Tarrabain and Emmanuel A. Pila *University of Alberta* Endogenous induction of snail hemocyte development conveys resistance to *Schistosoma mansoni* infection

R.G. Boutilier Young Investigator Award

14:00-15:00
SSC 2050
Chair: Jim Staples

Dr. Jay Treberg
University of Manitoba

From environmental challenge to electron transfer efficiency and back again: Metabolism at the centre of it all
Des défis environnementaux vers l'efficacité du transfert des électrons et vice versa: Le métabolisme au centre de tout cela

Metabolism can mean many things. Most phenomena linked to energy or nutritional requirements and processing seem to be referred to as metabolism in one circle or another; however, the level of biological organization examined varies from subatomic to whole animal. The integral role metabolism has in homeostatic mechanisms makes this discipline an intuitively attractive window into complex biological systems. Such research tends to focus on predetermined subsets of the overall system, leading to potential trade-offs in order to reduce complexity. In other words, this requires assuming emergent properties are not overly confounding, a challenge common to any reductionist approach. And yet, when applied at multiple levels of organization, mechanistic knowledge derived from reductionist techniques can be turned back outward. To this end I use metabolism as an intraorganismal window into the influences of extraorganismal changes and challenges. To illustrate, I will discuss examples of i) nutrient processing for water regulation in fishes, ii) the consequences of mitochondrial electron transfer efficiency and iii) potential constraints on distribution and aquatic habitat exploitation to demonstrate the utility of applying the study of internal metabolic processes to better understand environmental level influences on organisms.

Le terme métabolisme peut désigner beaucoup de choses. La plupart des phénomènes liés à la demande énergétique ou aux besoins nutritionnels et leur traitement semblent être nommés métabolisme; cependant, le niveau d'organisation biologique examiné varie de subatomique à l'animal entier. Le rôle central que joue le métabolisme dans les fonctions homéostatiques fait de cette discipline une fenêtre intuitivement attrayante pour étudier les systèmes biologiques complexes. Ce type de recherche tend à se concentrer sur certains éléments prédéterminés de l'ensemble du système, ce qui mène à l’utilisation de compromis afin d’en réduire la complexité. En d'autres termes, on suppose que des propriétés émergentes ne seraient pas trop confondantes, un défi commun à toute approche réductionniste. Pourtant, lorsqu'elles sont appliquées à de multiples niveaux d'organisation, les connaissances mécanistiques obtenues de techniques réductionnistes peuvent être retournées vers l'extérieur. J'utilise le métabolisme comme une fenêtre interne pour étudier l’influence des changements et des défis externes sur les organismes. Pour illustrer ceci, je discuterai i) du traitement des éléments nutritifs pour la régulation de l'eau dans les poissons, ii) des conséquences de l’efficacité du transfert des électrons dans la mitochondrie et iii) des contraintes potentielles sur la distribution et à l'exploitation de l'habitat aquatique pour démontrer l'utilité d’étudier des processus métaboliques internes pour mieux comprendre les influences de l'environnement sur les organismes.

R. G. Boutilier New Investigator Award
Prix R. G. Boutilier pour jeune chercheur
Jason R. Treberg
University of Manitoba

Dr. Jason (Jay) Treberg is a Tier 2 Canada Research Chair in Environmental Dynamics and Metabolism at the University of Manitoba. After a BSc. In Marine Biology (University of Guelph) he went on to MSc. and Ph.D. studies with Dr. William R. Driedzic at Memorial University of Newfoundland's Ocean Sciences Centre. Following that Jay began a CIHR postdoctoral fellowship at Memorial University with Dr. John (Sean) T. Brosnan studying nutritional biochemistry and metabolic regulation. He then joined Dr. Martin Brand's lab (Buck Institute for Research on Aging) to study the link between mitochondrial energetics and free radical production. Dr. Treberg joined the Department of Biological Sciences at the University of Manitoba as a CRC in 2011 and later joined the Department of Human Nutritional Sciences (cross-appointment). His research group studies metabolic responses to environmental conditions (for example temperature and diet quality) using a range of rodent and ectotherm species with an emphasis on mitochondrial linked aspects of metabolism.

Le Dr Jason (Jay) Treberg est titulaire de la Chaire de Recherche du Canada sur la Dynamique Environnementale et le Métabolisme à l'Université du Manitoba. Suite à son baccalauréat en Biologie Marine (Guelph), il a complété une maitrise et un doctorat avec le Dr William R. Driedzic à l'Ocean Sciences Centre de l'Université Memorial de Terre-Neuve. Jay a ensuite obtenu une bourse postdoctorale des IRSC avec le Dr John (Sean) T. Brosnan (Memorial) pour étudier la biochimie nutritionnelle et la régulation métabolique. Il a ensuite rejoint le laboratoire du Dr Martin Brand (Buck Institute for Research on Aging) afin d'y étudier le lien entre la bioénergétique mitochondriale et la production de radicaux libres. Le Dr. Treberg a joint le Département des Sciences Biologiques de l'Université du Manitoba en tant que titulaire de chaire en 2011. Il a rejoint plus tard le Département des Sciences de la Nutrition Humaine (nomination-conjointe). Son groupe de recherche étudie les réponses métaboliques à diverses conditions (température, diète, etc.) en utilisant plusieurs modèles dont les rongeurs et des animaux ectothermes et en mettant l'accent sur les aspects du métabolisme liés aux mitochondries.

C6 - Hypoxia I
UCC 56
Chair: Sabine Laguë

C6-1 15:00	Velislava Tzaneva, Jennifer Ho, Heidi Li, and Steve F. Perry *University of Ottawa* The effects of HIF-1α on control of ventilation in zebrafish larvae (*Danio rerio*) exposed to hypoxia
C6-2 15:15	Jordan C. Roberts, Christian Carnevale, Devyn Ramsay, A. Kurt Gamperl and Doug A. Syme *University of Calgary* Effects of Hypoxia on Contractile Properties of the Compact and Spongy Myocardium of Steelhead Trout *Oncorhynchus mykiss*
C6-3 15:30	Andy J. Turko, Suzanne Currie, Ryan L. Earley, Alexis Platek, Andrei Tatarenkov, D. Scott Taylor, and Patricia A. Wright *University of Guelph* Behaviour not genetics explains differences in hypoxia tolerance in the selfing fish *Kryptolebias marmoratus* in the wild
C6-4 15:45	Kelly Levesque, Nicholas Bernier and Patricia Wright *University of Guelph* Effects of warm temperature on the hypoxia response of developing zebrafish
C6-5 16:00	Sabine L Laguë, Beverly Chua, Anthony P. Farrell, P. B. Frappell, Catherine M. Ivy, Kevin G. McCracken, Graham R. Scott, Yuxiang Wang, and William K. Milsom *University of British Columbia* Altitude matters: Cardiovascular and respiratory responses to hypoxia in high- and low-altitude geese and ducks
C6-6 16:15	Eric Turenne, Kevin Choi and Jean-Michel Weber *University of Ottawa* Prolonged hypoxia causes restructuring of goldfish membranes

C7 - Foraging, feeding, and digestion
UCC 41
Chair: Kenneth Welch

C7-1 15:00	Nadia Bayram, Mary Shehata, L. Gerardo Herrera M. and Kenneth C. Welch Jr. *University of Toronto Scarborough* Hummingbirds modulate the use of single nectar meals differently as energetic demands change
C7-2 15:15	Chris Glover, Som Niyogi, Tamzin Blewett, Chris Wood *Athabasca University* Eating with your mouth closed: the promiscuity and functionality of hagfish skin as a transport epithelium
C7-3 15:30	Steve Chung and Jason Brown *University of Toronto* What does gall size tell a bird about the galls it preys upon when its meal is a mystery
C7-4 15:45	Vladimir Kodzhahinchev, Drago Kovacevic, and Carol Bucking *York University* Magnesium transport in the gut and gill of freshwater fish
C7-5 16:00	Junho Eom and Chris M. Wood *the University of British Columbia* Is ammonia excretion affected by gill ventilation in rainbow trout *Oncorhynchus mykiss*?
C7-6 16:15	Alyssa M Weinrauch, Alexander M Clifford, and Greg G Goss University of Alberta Post-prandial alterations in the physiology and intestinal morphology of Pacific hagfish

C8 - Ecologically-relevant stressors
UCC 37
Chair: Andrea Boyer

C8-1 15:00	Suzanne Currie, Louise Tunnah, Emily Corey, Tyson MacCormack *Mount Allison University* Do prior diel thermal cycles influence the physiological response of Atlantic salmon to subsequent heat stress?
C8-2 15:15	Brittney G. Borowiec and Graham R. Scott *McMaster University* Distinct physiological strategies for coping with constant hypoxia & intermittent hypoxia in killifish (*F. heteroclitus*)
C8-3 15:30	Marie-Catherine French, Nicole Beckett, Madeline Campbell, Jessica Fahey, Laura Ferguson, Todd Smith, and Shelley Adamo *Acadia University* Examination of the effects of variable environmental factors on the fecundity of the mosquito, *Culex pipiens*
C8-4 15:45	Michelle A. Gordy, Janet Koprivnikar, Lisa Kish, Valerie K. Phillips, Mahmoud Tarrabain, and Patrick C. Hanington *University of Alberta* Natural variation and the impact of environment on snail-digenean communities in central Alberta lake ecosystems
C8-5 16:00	Laura Hall and Shelley Adamo *Dalhousie University* The not very hungry caterpillar: Potential molecular conflict between detoxification and immune defense in *Manduca sexta*
C8-6 16:15	Andrea Boyer and Scott MacDougall-Shackleton *University of Western Ontario* Effects of recurrent inclement winter weather cues on white-throated sparrows

C9 - Healing, growth, and morphology
UCC 58
Chair: Michael Jonz

C9-1 15:00	Anthony Russell and Michele Delaguerre *University of Calgary* Let's rock: differential effectiveness of alternate adhesive pad configuration in geckos
C9-2 15:15	Ryan Horricks, Christophe Herbinger, and John S. Lumsden *University of Guelph* Regeneration of artificial lesions in the Caribbean star coral, *Montastraea cavernosa*
C9-3 15:30	Michael Jonz, Anna Mierzwa, Frederic Nguyen and Mark Xue *University of Ottawa* Chemoreceptor proliferation, innervation and vascularization in regenerating gill filaments of zebrafish (*Danio rerio*)
C9-4 15:45	Heather A. Jamniczky, Amie Le, Tegan N. Barry, Sean M. Rogers *University of Calgary* Armour plate bone mineral density varies with habitat in Threespine Stickleback
C9-5 16:00	Elizabeth Johnston and Todd Gillis *University of Guelph* MicroRNA-induced inhibition of extracellular collagen in rainbow trout cardiac fibroblasts

C10 - Stress endocrinology
UCC 58
Chair: Matt Vijayen

C10-1 15:00	Carol Best, Deborah Kurrasch and Matt Vijayan *University of Calgary* Maternal cortisol stimulates neurogenesis and affects larval behaviour in zebrafish
C10-2 15:15	Erin Faught and Matt Vijayan *University of Calgary* Stress Bubbles: Role of Exosomes in Cellular Stress Response in Rainbow trout
C10-3 15:30	Naomi Pleizier, Alexander D.M. Wilson, Aaron D. Shultz, Steven J. Cooke *University of British Columbia* Overextended: Personality, performance, and the effects of cortisol in pufferfish
C10-4 15:45	Marie-Ève Bélair-Bambrick, Laurence Dionne-Wilson and Kathleen Gilmour *University of Ottawa* Regulation of cortisol production by serotonin in the head kidney of rainbow trout (*Oncorhynchus mykiss*)
C10-5 16:00	Kelsey Halliwushka and Andreas Heyland *University of Guelph* Sublethal effects of fluoxetine on *Daphnia magna*
C10-6 16:15	Trevor Partch, Nicholas Bernier, and Glen Van Der Kraak *University of Guelph* Anti-steroidogenic actions of corticotropin-releasing factor in the zebrafish ovary

16:30-18:30 POSTER SESSION
with Refreshments sponsored by Sable Systems

The Poster Session will be held in the Physics & Astronomy Atrium.

Posters **should be printed at a size of 36″ (91 cm) H x 44″ (112 cm) W.**

Poster setup **- Please set up your poster after Tuesday, 9:00 am. Posters should be affixed to boards with Velcro hook & loop tape only (this will be provided).**

Poster removal - Please take down your poster before Wednesday, 4:00 pm.
For Helen Battle Poster Award Finalists – Please set up your poster after Monday, 9:00 am (top floor, Atrium); take down before Thursday, 9:00 am.

POSTER PRESENTERS: Please stand by your poster at the following times:
Odd numbers: 16:30-17:30
Even Numbers: 17:30-18:30

La session des affiches se tiendra dans l'Atrium de Physique et Atronomie.

Les affiches devraient être imprimées à une hauteur de 36 pouces (91 cm) et une largeur de 44 pouces (112 cm).

Installation des affiches – Veuillez installer votre affiche après 9h am, mardi. Les affiches devraient être apposées aux panneaux avec les crochets et anneaux Velcro seulement (Ceci sera fourni).

Retrait des affiches – Veuillez enlever votre affiche avant 4h pm, mercredi.
Pour les finalistes du concours d'affiches Helen Battle – Veuillez installer voyre affiche après 9h am, lundi (à l'étage la plus haute de l'Atrium); enlevez la avant 9h am, mardi.

PRÉSENTATEURS D'AFFICHES : Veuillez rester près de votre affiche à ces heures :
Chiffres impairs : 16h30 – 17h30
Chiffres pairs : 17h30 – 18h30

Poster Session

P1	Garett Allen, Alex Quijada-Rodriguez, Stephanie Hans, Dirk Weihrauch *University of Manitoba* Branchial acid-base regulation in the osmoconforming Dungeness crab, *Metacarcinus magister*
P2	Chloé Berger, Carole Di-Poi, Jennyfer Lacasse and Nadia Aubin-Horth *Institut de Biologie Intégrative et des Systèmes, Université Laval* Evolutionary divergence of behavior, coloration, MC1R expression and sequence between marine and freshwater sticklebacks
P3	Juan Ignacio Bertucci, Mario Oswaldo Tovar, Javier Edgardo Herdman, Luis Fabián Canosa and Suraj Unniappan *University of Saskatchewan* Distribution of ghrelin and nesfatin-1 in the brain and gut of pejerrey (*Odontesthes bonariensis*)
P4	Juan Ignacio Bertucci, Ayelén M. Blanco, Oswaldo Tovar, Luis Fabián Canosa and Suraj Unniappan *University of Saskatchewan* Dietary protein and lipid levels affect growth and expression of growth-related genes in pejerrey larvae
P5	Juan Ignacio Bertucci, Mario Oswaldo Tovar, Javier Edgardo Herdman, Luis Fabián Canosa and Suraj Unniappan *University of Saskatchewan* Ghrelin and nesfatin-1 modulate the expression of digestive enzymes in goldfish intestine and hepatopancreas in vitro
P6	Tessa S. Blanchard, Andy J. Turko and Patricia A. Wright *University of Guelph* A new twist to an old method- Measuring the critical oxygen tension (P_{crit}) in air
P7	Ayelén M. Blanco, María J. Delgado, Ana I. Valenciano and Suraj Unniappan *University of Saskatchewan* Ghrelin and nesfatin-1 modulate the expression of digestive enzymes in goldfish intestine and hepatopancreas in vitro
P8	Sarah Boggett and Douglas Fudge *University of Guelph* How to Survive a Shark Attack: Lessons from a Hagfish
P9	Amanda Carter, Rachel Bowden, Ryan Paitz *Illinois State University* Seasonal variation in sex ratios driven by maternal estrogens and incubation regime
P10	Stefanie Bradley, Morag Dick, Christopher G. Guglielmo, Alexander Timoshenko *University of Western Ontario* Seasonal and flight related variation of galectin expression in heart, liver and flight muscle of yellow-rumped warblers
P11	Taylor Brooks, Amber Schlater, Cayleih Robertson, Grant McClelland *McMaster University* Sensitivity of the HIF-1α pathway in cultured myotubes during chronic hypoxia
P12	Heather J. Bryant and Patricia M. Schulte *The University of British Columbia* Uncoupling Proteins and Temperature Acclimation and Adaptation in Killifish
P13	Kylie Caplan, Clare Fletcher, Richelle Monaghan *Wilfrid Laurier University* Pedagogical Approaches to Post-Secondary Biological Sciences for the Blind - A Tactile Poster
P14	Aderinsola Odetunde and Joseph M. Casto *Illinois State University* Does blood loss explain ectoparasite-induced changes in nestling development?
P15	Kentaro Chiba and David C. Evans *University of Toronto* Growth curve reconstruction of the white-tailed deer (*Odocoileus virginianus*) based on limb bone growth marks
P16	Dylan Cole, Erik Folkerts, Danuta Chamot, Samuel Guffey, and Greg Goss *University of Alberta* Characterization of hagfish NaPi-II function in Xenopus oocytes
P17	Alysha Cypher and Brian Bagatto *The University of Akron* Lipid composition and cardiovascular health of *Danio rerio* embryos with maternal to Bisphenol A

P18	Perrine Delompré, Tamzin Blewett, Yuhe He and Greg Goss *University of Alberta* The ultimate toxicological mixture: how hydraulic fracturing spills affect key species in the Canadian ecosystem
P19	Pranav Dhakal and Carol Bucking *York University* Comparing the gut microbiome of two fish species with overlapping habitats before and after diet manipulation
P20	Sandra Fehsenfeld and Chris M. Wood *University of British Columbia* Goldfish renal tubules: More than meets the eye
P21	Clare Fletcher, Richelle Monaghan, Chris Wood and Scott Smith *Wilfrid Laurier University* Potentiometric Determination of Copper Interactions with Suspended Rainbow Trout Gill Cell Line
P22	Jonathan Ford and James McGeer *Wilfrid Laurier University* Rare Earth Elements - How Toxic are They?
P23	Meghan Fuzzen, Hadi Dhiyebi, Leslie Bragg, Gerald Tetreault, Mark McMaster and Mark Servos *University of Waterloo* Does parental experience impacts progeny response to municipal wastewater effluent exposure?
P24	Lauren Gatrell, Alyssa Weinrauch and Todd Gillis *University of Guelph* What fuels the hagfish heart during anoxia exposure?
P25	Chelsea Penney and Glenys Gibson *Acadia University* Is Maternal or Embryonic Environment More Important in Developmental Plasticity?
P26	Sharn K Gill, Allison Seow, Yvonne A Dzal, Danielle Chung, William K Milsom and Matthew E Pamenter *University of Ottawa* Naked mole rat glutamatergic receptors do not contribute to the control of ventilatory responses to hypoxia
P27	Alexander Hare and Kathleen M Gilmour *University of Ottawa* Growing pains: early life stress influences HPI axis function and anxiety-related behaviour in zebrafish (*Danio rerio*)
P28	Josh Hooper and Stephanie DeWitte-Orr *Wilfrid Laurier University* Determining the presence of gap junctions in rainbow trout cells
P29	Hossein Mehdi, Heather Ikert, Shahithiya Santoskhumar and Paul M. Craig *University of Waterloo* Multi-stressor impacts on fish energetics: from pharmaceutical contaminants to climate change
P30	Malcolm Hughes and Steve Perry *University of Ottawa* Physiological roles of internal convection on respiratory gas exchange in larval zebrafish (*Danio rerio*)
P31	Maryam Jangjoo, Stephen F. Matter, Jens Roland, Nusha Keyghobadi *University of Western Ontario* Connectivity rescues genetic diversity after a demographic bottleneck
P32	Ken Jeffries, Christine Verhille, Theresa Dabruzzi, Nann Fangue and Richard Connon *UC Davis* Population differences in salinity tolerance in a threatened estuarine fish
P33	Qiwu Jiang and Iain J. McGaw *Memorial University of Newfoundland* Effects of feeding states on physiological responses to hypoxia in rock crabs (*Cancer irroratus*)
P34	Elizabeth Johnston, Laura Dindia and Todd Gillis *University of Guelph* The role of testosterone in regulating cold-induced cardiac hypertrophy in rainbow trout
P35	Justine E. Doherty and Jonathan M. Wilson *Wilfrid Laurier University* A missing link in the ionoregulatory strategy of lamprey and lungfish: A closer look at the non-gastric H^+/K^+ATPase

P36	Tomonari Kaji, Keiichi Kakui, Naoyuki Miyazaki, Kazuyoshi Murata, A. Richard Palmer *University of Alberta* Mesoscale 3D morphology viewed at nanoscale: Advanced serial block-face SEM of a novel crustacean silk spinneret system
P37	Sirpa Kaunisto, Laura V. Ferguson and Brent J. Sinclair *University of Western Ontario* Can we predict the effects of multiple stressors?
P38	P.H. Pham, J. J. Kim, Y.J. Huang, B. Sadeghimakki, Y. Zheng, A. Hu, K. Oakes, S.X. Tang, S., Sivoththaman and N.C. Bols *University of Waterloo* Evaluating cytotoxic effects of nanomaterials on mammalian cells and virucide effects on viruses using fish virus models
P39	Alexia M Kirby and Matthew E Pamenter *University of Ottawa* Naked mole rats use atypical thermal and behavioural strategies in hypoxia
P40	Shruti Kumar and Tamara A. Franz-Odendaal *Saint Mary's University* Investigating FGFRs during Scleral Ossicle Induction
P41	Leanna Lachowsky and Mary Reid *University of Calgary* Development time and synchrony of emergence in individual broods of mountain pine beetles
P42	Laura Dindia, Sarah Alderman and Todd Gillis *University of Guelph* Rainbow trout (*Oncorhynchus mykiss*) cardiac proteome remodelling in response to exercise
P43	Jacqueline E. Lebenzon and Brent J. Sinclair *University of Western Ontario* Interference in the cold: manipulating cryoprotectants to investigate cold tolerance in the Colorado potato beetle
P44	Heidi Li, Greg Sigel, Velislava Tzaneva, Steve Perry *University of Ottawa* Circulating catecholamines modulate the hypoxic hyperventilatory response in larval zebrafish (*Danio rerio*)
P45	Lisa Jørgensen, Johannes Overgaard and Heath A. MacMillan *York University* Paralysis and heart failure precede ion balance disruption in heat-stressed European green crabs
P46	Milica Mandic, Velislava Tzaneva and Steve F. Perry Role of HIF1α paralogs in the hypoxic ventilatory response of adult zebrafish (*Danio rerio*)
P47	Sarah V. McFarlane, Katherine E. Mathers and James F. Staples *University of Western Ontario* Reduced temperature sensitivity of brown adipose tissue mitochondrial respiration during torpor
P48	Amrit Mehta and J. David Spafford *University of Waterloo* Origins of voltage-gated sodium and calcium channels in primordial single-celled eukaryote *Salpingoeca rosetta*
P49	Evan W. Mercer, Janet C. Tait, and William S. Marshall *St. Francis Xavier University* Salinity Preference and Halocline Behaviour in an Estuarine Teleost Fish
P50	Lygia S. Nogueira, Anne Crémazy, Fabiola V. Domingos, Chris M. Wood *The University of British Columbia* Zinc and calcium pathways in the green crab *Carcinus maenas*
P51	Phuc H. Pham, Fotini Papazotos, Jun-Wen Li, Niels C. Bols *University of Waterloo* Effects of nutrient deprivation on the ability of fish cells to support fish virus replication
P52	Tamara Provencher, Céline Audet, Réjean Tremblay, Frédéric Olivier *Université du Québec à Rimouski* Behaviour and burying capacity of juvenile winter flounder according to sediment type, salinity and current speed

P53	Ashley Reynolds *University of Toronto* Growth patterns in wild and captive lions (*Panthera leo*) and Amur tigers (*Panthera tigris altaica*)
P54	David Rocco and Jean-Paul Paluzzi *York University* Elucidating the Distribution and Function of an Ancient Glycoprotein Hormone System in the Mosquito, *Aedes aegypti*
P55	Federico Sacchi, Joshua G. Pemberton, and John P. Chang *University of Alberta* PI3K involvement in basal and ghrelin-stimulated LH and GH release from goldfish pituitary cells.
P56	Yusuf Saibu, Ankur Jamwal, Renfei Feng and Som Niyogi *University of Saskatchewan* Distribution of zinc and its interactions with copper and cadmium in fish gills using X-ray fluorescence imaging
P57	Amber Schlater, Nicole Pranckevicius, and Grant McClelland *McMaster University* Skeletal muscle physiology and performance in low and high altitude deer mice (*Peromyscus maniculatus*)
P58	Sarah Schorno, Guylaine LaRochelle, Douglas Fudge and Andreas Heyland *University of Guelph* Temporal and morphometric dynamics of slime gland refilling in hagfish
P59	Laura Shaw, Craig Jurkiewicz, Sarah Alderman, Frederic Laberge and Todd Gillis *University of Guelph* The effects of hypoxia and exercise on relative brain size in juvenile rainbow trout (*Oncorhynchus mykiss*)
P60	Christopher Small, Bryan Crawford, and Tillmann Benfey *University of New Brunswick - Fredericton* Exposure to hypoxia in early development increases the number of hematopoietic stem cells in zebrafish embryos
P61	Hanna Grover, Kristin Spong and R Meldrum Robertson *Queen's University* Aging prolongs stress-induced coma in *Locusta migratoria*
P62	Phinyaphat Srithiphaphirom, Darius Soo Lum and Mel Robertson *Queen's University* Acclimation of chill coma mechanisms in the CNS of *Locusta migratoria*
P63	Robert Stephens, Wendy Guan, Omar Mourad, and David Spafford *University of Waterloo* Domain II/IV Extracellular Turrets as Determinants of Ion Selectivity in LCav3, a T-type Channel from *Lymnaea stagnalis*
P64	Janet C. Tait, Evan W. Mercer and William S. Marshall *St Francis Xavier University* Osmotic regulation of ion transport outstrips hormonal regulation in cold acclimated fish
P65	Elias Taylor and Andreas Heyland *University of Guelph* The effect of thyroid hormones on skeletogenesis in larval sea urchins of *Strogylocentrotus purpuratus*
P66	Jonathan Tea, Sarah L Alderman and Kathleen M Gilmour *University of Ottawa* Neurogenesis in adult zebrafish: how social stress affects the brain
P67	Jantina Toxopeus, Vladimír Koštál, Brent J Sinclair *University of Western Ontario* Crickets on ice: dissecting the mechanisms underlying insect freeze tolerance
P68	Wesley Truong and Jim McGeer *Wilfrid Laurier University* The sublethal physiological effects of exposure to copper and silver mixtures on rainbow trout (*Oncorhynchus mykiss*)

P69	Andy J. Turko, Kelly D. Levesque, Tessa Blanchard, Andrew Leinonen, and Patricia A. Wright *University of Guelph* A low-cost, modular, and highly configurable 3D printed system for building metabolic rate chambers for air or water
P70	Kurtis F Turnbull, Jeremy N McNeil and Brent J Sinclair *University of Western Ontario* Does microhabitat, phenology and metabolic plasticity reduce overwintering energy use in the western bean cutworm?
P71	Carly Tward, Jaspreet Singh, and Allison McDonald *Wilfrid Laurier University* Alternative Oxidase in Copepods
P72	Fabíola Xochilt Valdez Domingos and Chris Wood *University of British Columbia* Does realistic concentrations of single and combined copper, nickel and cadmium affect sodium fluxes in zebrafish?
P73	Paige Vroom, Esther Peters and John Lumsden *University of Guelph* Regeneration in Corallimorpharia
P74	Marissa Webber and Dr. Russell C. Wyeth *St. Francis Xavier University* Consistent and inconsistent patterns of GABA-, histamine-, and FMRFamidergic neuroanatomy of *Hermissenda*
P75	Dirk Weihrauch, Aida Adlimoghaddam, Andrew Donini, Stephanie Hans, Ashley Tripp *University of Manitoba* Ammonia transporters (AMTs) in invertebrates
P76	Melanie Williams, Vladimir Kodzhahinchev, Andrew Biancolin and Carol Bucking *York University* Quantifying Calcium and Magnesium Flux in the Pyloric Ceca of Oncorhynchus mykiss using the SIET
P77	Veronica Ells and Russell Wyeth *St. Francis Xavier University* At least three shades of gray: a true test of colour effects on marine invertebrate biofouling
P78	Xinjian Xu, Huahui Lan, Xiangjie Zhu, Shujing Zhou, Bingfeng Zhou *Fujian Agriculture and Forestry University* Effects of Thermal Stress on Sealed Brood Development of Queen Honeybee, *Apis mellifera*
P79	Jeff Kang Nian Yap, Karilyn C. Harris, Oh Run Kim, Tony D. Williams *Simon Fraser University* Physiological cost of training for increased foraging effort
P80	Gil Yerushalmi, Heath MacMillan and Andrew Donini *York University* Salt stress confers cold tolerance in *Drosophila*
P81	Yangfan Zhang, Florian Mauduit, Denis Chabot, Guy Claireaux, Anthony P. Farrell *The University of British Columbia* Chemically dispersed oil has chronic residual effects on hypoxia resistance in European sea bass (*Dicentrarchus labrax*)

Student Success Workshop

19:00- 21:30

The Wave, UCC second floor Student/PDF social will follow in the same location.

This workshop is a venue for students and PDFs to interact with established professors to learn more about how to succeed in their careers. In the style of speed-dating, students/PDFs spend approximately 15 minutes at each station and then move on to the next, leaving the facilitators to entertain and enlighten a fresh crop of hopeful faces and burning questions.

This year, we will cover:

1. Publish or perish: tips for publishing productivity
2. How to find a job/building your job package
3. Grant writing tips and tricks
4. How to supervise your supervisor: managing and understanding conflict in student-supervisor relationships
5. Winning teaching techniques
6. What to expect from a career in academia
7. Careers outside of academia
8. Make the most of your time: time management during grad school and in academia
9. Expanding research beyond the lab; utilizing species and habitats in research on a global scale
10. Science outreach and communication
11. Balancing science: achieving the elusive work-life balance
12. Networking tips and tricks

Atelier Succès aux études

Cet atelier est une occasion pour les étudiants et les stagiaires postdoctoraux d'interagir avec des professeurs bien établis et d'apprendre plus sur comment réussir dans leurs carrières. Dans le style «speed-dating», étudiants/stagiaires postdoctoraux passent environ 15 minutes à chaque station et ensuite procèdent à la prochaine et ainsi de suite. Des animateurs s'occupent à divertir et à éclairer les nouveaux venus, ainsi que leurs questions brulantes.

Cette année, nous allons couvrir:

1. Publier ou périr: trucs pour la productivité de publication
2. Comment trouver un emploi/construire son dossier pour l'emploi
3. Trucs pour l'application pour les subventions
4. Comment superviser son directeur: gérer et comprendre les conflits dans les relations étudiants-directeurs
5. Techniques d'enseignements gagnantes
6. À quoi s'attendre d'une carrière dans le monde universitaire
7. Carrières en dehors du monde universitaire
8. Optimiser son temps: gestion du temps pendant les études graduées et dans le monde universitaire
9. Accroitre la recherche au delà du laboratoire; utiliser les espèces et les habitats pour la recherche à l'échelle mondiale
10. Diffusion de la science et communication
11. Équilibrer la science: atteindre le délicat équilibre travail-loisir
12. Trucs et astuces de réseautage

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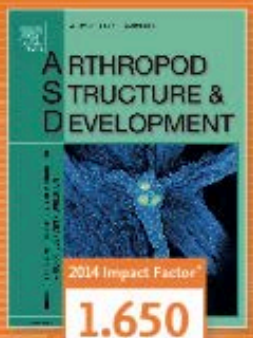

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Wednesday 11 May / mercredi 11 mai

summary / résumé

08:00-08:30	Refreshments	
08:30-10:00	CPB Symposium	SSC 2050
	PIE Symposium	UCC 56
10:30-11:00	Refreshments *sponsored by Journal of Insect Physiology*	
11:00-12:30	Contributed Sessions	
	Behaviour	UCC 56
	Epithelial transport, gills, osmoregulation	UCC 41 UCC 37
	Physiological variation, phenotypic plasticity	UCC 58 UCC 60
	Breathing	
	Metamorphosis and morphogenesis	
12:30-13:30	CPB Section Lunch (pizza with ticket)	SSC 2050
	PIE Section Lunch (pizza with ticket)	UCC 65
13:30-14:30	Cameron Award Lecture	SSC 2050
14:30-16:30	Don Stevens Symposium	SSC 2050
	CSP Symposium	UCC 56
	Contributed Sessions	
	Environmental contaminants II	UCC 41
	Space and time	UCC 37
	Molecular cellular immunology, parasitology	UCC 60
16:30-17:00	Refreshments *sponsored by Journal of Insect Physiology*	
17:00-18:30	Education Workshop	UCC 56
	Diversity Workshop	UCC 37
19:00-20:00	ZET Lecture	NCB 101
20:00-22:00	ZET Reception	Physics/Astronomy Atrium

Notes:

08:30-10:30
S2 - CPB (Comparative Physiology and Biochemistry) Section Symposium: "Integrative physiology of locomotion"

SSC 2050
Chair: Charles Darveau

S2-1 08:30	Emily Standen *University of Ottawa* Locomotion in a novel environment: a web of physiological impacts
S2-2 09:00	Doug Syme *University of Calgary* The benefits of bouncing: ups and downs in theory and practice
S2-3 09:30	Timothy E. Higham and Anthony P. Russell *University of California Riverside* Running with an innovation: the mechanisms and consequences of using adhesion during locomotion in geckos
S2-4 10:00	Stan L. Lindstedt and Kiisa C. Nishikawa *Northern Arizona University* Ratchets, springs, bungees and winding: Recent insights into muscle filaments

08:30-10:30
S-3 - PIE (Parasitology Immunology and Environment) Section Symposium: "Microbiomes: Shaping Parasitism and Immunity"

UCC 56
Chair: Richelle Monaghan

S3-1 08:30	Bhagirath Singh *University of Western Ontario* Regulation of Immunity and Autoimmunity by Microbiome
S3-2 09:10	George Dimopoulous *Johns Hopkins Bloomberg School of Public Health* How mosquito microbiome can influence infections with parasites and viruses
S3-3 9:50	John R. Barta and Kayla R. Price *University of Guelph/ Alltech Canada* From the jungle to the broiler house: Domestication of a host-parasite-microbiome ecosystem

11:00-12:30 CONTRIBUTED SESSIONS

C11 - Behaviour
UCC 56
Chair: Joel Slade

C11-1 11:00	Yolanda E. Morbey, Ivan Maggini, J. Morgan Brown, Stu Mackenzie, and Christopher Guglielmo *University of Western Ontario* Mechanisms of protandry in the Black-throated Blue Warbler
C11-2 11:15	Kyle H. Elliott, Gustavo S. Betini, D. Ryan Norris and Ian Dworkin *McGill University* Scared fitless: context-dependent response of fear to loss of predators over evolutionary time
C11-3 11:30	Joshua Robertson, Ryan Caldwell and Dr. James Quinn *McMaster University* Does Parental Effort Correlate with Reproductive Contribution in Communal Nests? Patterns of Reproductive Skew in a Social Cuckoo
C11-4 11:45	Shannon K. Mischler and Scott A. MacDougall-Shackleton *University of Western Ontario* Song control or vocal control? The role of HVC in black-capped chickadee learned call production
C11-5 12:00	Terrence T. Chang and Andrew C. Mason *University of Toronto Scarborough* Acoustic Signaling, Metabolic Rate, and Size in Competing Male Cyphoderris monstrosa (Orthoptera: Haglidae)
C11-6 12:15	Joel Slade, Matthew Watson, Tosha Kelly, Mark Bernards, Greg Gloor, Elizabeth MacDougall-Shackleton *University of Western Ontario* Preen oil as a signal of MHC genotype in a songbird

C12 - Epithelial transport, gills, and osmoregulation
UCC 41
Chair: Michael Wilkie

C12-1 11:00	Jeffrey Richards, Joshua Emerman, Victor Chan, Yuanchang Fang and Colin Brauner *The University of British Columbia* Defining the optimal salinity for growth of coho and Atlantic salmon in recirculating aquaculture systems
C12-2 11:15	Kathleen M Gilmour and Michael Brannen *University of Ottawa* Carbonic anhydrase expression in the ionocytes of the rainbow trout gill
C12-3 11:30	David F.J. Lisser, Zachary P. Lister, Graham R. Scott, and Michael P. Wilkie *Wilfrid Laurier University* Reactive Oxygen Species (ROS) Cause Brain Swelling in Goldfish (*Carassius auratus*) Exposed to High Environmental Ammonia
C12-4 11:45	Marina Giacomin, Patricia Schulte and Chris Wood *University of British Columbia* The two faces of the osmorespiratory compromise in *Fundulus heteroclitus*
C12-5 12:00	Tina E Suntres, Gheylen Daghfous, Réjean Dubuc, Barbara Zielinski *University of Windsor* Solitary Chemosensory Cells During the Sea Lamprey Life Cycle
C12-6 12:15	Chris M. Wood, Ilan M. Ruhr, Ed Mager, and Martin Grosell *University of Miami and University of British Columbia* The euryhaline killifish: new insights into the osmorespiratory compromise in fresh water and sea water

C13 - Physiological variation and phenotypic plasticity
UCC 37
Chair: Heath MacMillan

C13-1 11:00	Trine Olsson, Anders Malmendal, Heath MacMillan, Nils Nyberg, Dan Stærk and Johannes Overgaard *York University* Hemolymph metabolites are tightly linked to cold tolerance of Drosophila species
C13-2 11:15	Christelle Leung, Sophie Breton and Bernard Angers *Université de Montréal* Phenotypic variation in clonal fish: when the environment leaves its mark
C13-3 11:30	Brett Culbert and Kathleen Gilmour *University of Ottawa* Recovery from social subordination in rainbow trout
C13-4 11:45	Verena Tams *Universität Hamburg, Germany* Influence of local adaptation on intraspecific phenotypic variation in *Daphnia galeata*
C13-5 12:00	Justin Bridgeman and Glenn J. Tattersall *Brock University* Strength of individual turning bias in round gobies, *Neogobius melanostomus*, when experiencing acute temperature changes
C13-6 12:15	Taylor C. Gibbons, David C. H. Metzger, Timothy M. Healy and Patricia M. Schulte *University of British Columbia* Intraspecific variation in the response of the gill transcriptome to freshwater acclimation in threespine stickleback

C14 - Breathing
UCC 58
Chair: Bill Milsom

C14-1 11:00	Sarah Jenkin and Bill Milsom *University of British Columbia* Developmental changes in the hypercapnic ventilatory response of neonatal rats
C14-2 11:15	Neha Acharya-Patel and Bill Milsom *University of British Columbia* Control of cardio-respiratory synchrony in the dogfish, *Squalus suckleyi*
C14-3 11:30	Catherine M. Ivy and Graham R. Scott *McMaster University* Evolution of respiratory physiology in high-altitude deer mice (*Peromyscus maniculatus*)
C14-4 11:45	Julia York, Beverly Chua, Catherine Ivy, Graham Scott, Sabine Lague, Kevin McCracken, Neal Dawson, Peter Frappell, Luis Alza, and William Milsom *University of British Columbia* Pulmonary mechanics and morphometrics comparing five high-altitude duck species and six low-altitude sister species
C14-5 12:00	Alexander M. Clifford, Alex M. Zimmer, Chris M. Wood and Greg G. Goss *University of Alberta* It's all in the gills: Evaluation of O2 uptake in Pacific hagfish refutes a major respiratory role for the skin

C15 - Metamorphosis and morphogenesis
UCC 60
Chair: Michael Lim

C15-1 11:00	J. Stone *McMaster University* Testing Developmental Flexibility in Sea Urchin Skeletons to Make Sense of Sand Dollars (and Rudimentary Speculations)
C15-2 11:00	Glenys Gibson and Olivia Genereux *Acadia University* Bisphenol A (BPA) disrupts regeneration in *Pygospio elegans* (Annelida)
C15-3 11:15	Keegan Lutek and Andreas Heyland *University of Guelph* The distribution and function of suH1R in *Strongylocentrotus purpuratus*
C15-4 11:30	Christine L. Hammer and Tamara A. Franz-Odendaal *Saint Mary's University* The effect of hydrocortisone injections on the sclerotic ring
C15-5 11:45	Michael Y.T. Lim, Richard G. Manzon, Chris M. Somers, Douglas R. Boreham and Joanna Y. Wilson *McMaster University* Impacts of temperature and chemical stressors on the embryonic development of Round whitefish (*Prosopium cylindraceum*)

13:30-14:30 Cameron Award Lecture

SSC 2050
Chair: Jim Staples

T.W.M. Cameron Outstanding Ph.D. Thesis Award: **Dr. Adam T. Ford, UBC,**

“The mechanistic pathways of species interactions in an African savanna”

The mechanistic pathways of trophic interactions in human-occupied landscapes
There is growing interest in large carnivore ecology among the public and scientific community. This interest coincides with the restoration of carnivore populations in a number of human-occupied landscapes, prompting two key questions: (1) *How do we quantify the interaction of large carnivores, prey, and plants?* (2) *What role do large carnivores play in shaping ecosystem structure?* To help answer these questions, I describe a series of field studies conducted in an East African rangeland. I combined GPS telemetry of an abundant antelope (impala) and its main predators (leopards, wild dogs) to show that risk-avoidance behavior and plant defenses interact to determine tree distributions. I also documented a putative trophic cascade following the restoration of African wild dogs to a Kenyan rangeland. Together, this research provides insight on how we can better understand and sustain the ecological role of large carnivores.

Les voies mécanistiques des interactions trophiques des paysages occupés par l’humain
L’intérêt du public et de la communauté scientifique pour l’écologie des carnivores de grandes tailles est croissant. Cet intérêt coïncide avec le rétablissement des populations de carnivores dans plusieurs paysages habités par l’humain, soulevant deux questions clefs : (1) Comment quantifie-t-on l’interaction entre grands carnivores, proie, et les plantes? (2) Quel rôle les grands carnivores jouent-ils pour structurer de l’écosystème? Afin de répondre à ces questions, je décrie une série d’études de terrain effectuées dans un parcours d’Afrique de l’Est. J’ai combiné la télémétrie GPS d’une antilope abondante (impala) et ses prédateurs principaux (léopard et chiens sauvages) pour démontrer que les comportements d’évitement du risque et les défenses des plantes interagissent pour déterminer la distribution des arbres. J’ai également documenté une cascade trophique présumée suivant le rétablissement de chiens sauvages africains dans un parcours du Kenya. Dans son ensemble, cette recherche apporte des connaissances afin de mieux comprendre le rôle écologique des grands carnivores de façon durable.

T. W. M. Cameron Outstanding Ph.D. Thesis Award
Prix T. W. M. Cameron pour une thèse de Ph.D. exceptionnelle

Adam T. Ford
University of British Columbia

Biography / biographie:
Adam is a wildlife ecologist interested in how predator-prey interactions are shaped by human-modified landscapes. He received his BSc from the University of Victoria, a MSc from Carleton University, and his Ph.D. from the University of British Columbia with Dr. Jacob Goheen. Adam won the Top PhD Dissertation award from the Faculty of Science at UBC and was the recipient of the 2015 Governor General Gold medal from UBC. Adam is currently a Liber Ero Postdoctoral Fellow in Conservation Science, at the Department of Integrative Biology, University of Guelph, and will be starting a new position as Assistant Professor in the Department of Biology at the IK Barber School of Arts & Sciences, University of British Columbia- Okanagan Campus in July. Adam is also the recipient of the prestigious Science & SciLifeLab Prize in the category of Ecology & Environment for 2015 (a $10,000 award from the AAAS) for his essay on the relationships of people, large carnivores, their herbivore prey, and plants in an East African savanna.

14:30-16:30
S4 – Don Stevens Symposium

SSC 2050
Chair: Douglas Syme

S4-1 14:30	Douglas Syme *University of Calgary* The imbalance of power - assessing functional consequences of muscle fatigue
S4-2 14:45	Douglas Fudge *University of Guelph* Unraveling the mysteries of hagfish slime: a biophysical approach
S4-3 15:00	Kurt Gamperl, Doug Syme, Christian. Carnevale, Jordan Roberts, Alexander Thomas and Devyn Ramsay *Memorial University of Newfoundland* Myocardial Strips are Really Interesting: Who Would Have Thought?
S4-4 15:15	Jean-Marc Renaud *University of Ottawa* K_{ATP} channel and how skeletal muscle protects themselves against fiber damage and contractile dysfunction during fatigue
S4-5 15:30	Patricia Wright *University of Guelph* Fundamentals of respiration in fish embryos - lessons I learned from Don
S4-6 15:45	Mike Pearson *Pearson Ecological. Ltd.* A Hidden Menace: Hypoxia in Fraser Valley Streams
S4-7 16:00	Cosima Porteus, Tamsyn Uren-Webster, Eduarda Santos, and Rod W. Wilson *University of Exeter* The effects of simulated ocean acidification on global transcriptomic profiling in a marine teleost
S4-8 16:15	Don Stevens Gratitude

14:30-16:30
S5 - CSP (Canadian Science Publishing) funded symposium: "Spineless tales: development and evolution of invertebrates"

UCC 56
Chair: Timothy HIgham

S5-1 14:30	Louise Page, Brenda Hookham and Amelia Hesketh *University of Victoria* Evolution of the gastropod foregut viewed through a developmental lens
S5-2 15:00	Ab. Matteen Rafiqi, Arjuna Rajakumar, Travis Chen, Ehab Abouheif *McGill University* Ant endosymbiont drives duplication and neofunctionalization of germ plasm, with novel epistatic hox gene interactions.
S5-3 15:30	Marc Laflamme *University of Toronto Mississauga* Ediacaran diversity in space and time: The first Mass Extinction of Complex Life
S5-4 16:00	Elaine Seaver and Alexis Lanza *University of Florida* Evolution of development: the paradox of spiralian embryogenesis

14:30-16:30 CONTRIBUTED SESSIONS

C16 - Environmental contaminants II
UCC 41
Chair: Jim McGeer

C16-1 14:30	Abigail Lee, Ana Campos, and Joanna Wilson *McMaster University* Chronic exposure of environmentally relevant concentrations of fluoxetine and carbamazepine on *Hydra oligactis*
C16-2 14:45	Jennifer Jeffrey, Kelly Hannan, Caleb Hasler and Cory Suski *University of Illinois* Molecular and whole-animal responses to elevated carbon dioxide exposure in a freshwater mussel
C16-3 15:00	Tamzin Blewett, Erin Leonard, Elissa Dow, Chris Wood, James McGeer and D. Scott Smith *University of Alberta* Composition matters! How dissolved organic carbon ameliorates nickel toxicity in marine invertebrates
C16-4 15:15	Wesley Truong and Jim McGeer *Wilfrid Laurier University* The sublethal physiological effects of exposure to copper and silver mixtures on rainbow trout (*Oncorhynchus mykiss*)
C16-5 15:30	Jim McGeer, Alexandria Loveridge, Jonathan Ford, Oliver Vukov, Che Lu and D. Scott Smith *Wilfrid Laurier University* Rare earth elements in the aquatic environment, a cause for concern?
C16-6 15:45	Patricia L. Gillis, Rodney McInnis, Joseph Salerno, Shane R. de Solla, Mark Servos, Erin M. Leonard *University of Waterloo and McMaster University* Freshwater mussels in an urban watershed: Impacts of anthropogenic inputs and wastewater treatment effluent
C16-7 16:00	Phillip Pham-Ho *Wilfrid Laurier University* Changes in Brain Water Content in the Rainbow Trout (*Oncorhynchus mykiss)* due to High External Ammonia Exposure
C16-8 16:15	Oana Birceanu, Alam Mohammad, Owen Woody, Brendan McConkey, Neel Aluru and Matt Vijayan *University of Waterloo and University of Calgary* Multigenerational effects of bisphenol A on the rainbow trout transcriptome

C-17 Space and time
UCC 37
Chair: Tosha Kelly

C17-1 14:30	Melissa Lucas and Nusha Keyghobadi *University of Western Ontario* Assessing the spatial genetic structure of populations of the alpine butterfly *Parnassius smintheus* using RAD sequencing
C17-2 14:45	Tosha Kelly, A. Lymburner, E. MacDougall-Shackleton, K. Hobson, and S. MacDougall-Shackleton *University of Western Ontario* Testosterone, migration distance, and migratory timing in song sparrows *Melospiza melodia*
C17-3 15:00	Marin Milotic and Janet Koprivnikar *Ryerson University* Density and complexity of aquatic vegetation does not affect larval amphibian parasitism
C17-4 15:15	Donnell Gasbarrini, David Lesbarrères, Anna Sheppard, Ed Morris, Jacqueline Litzgus *Laurentian University* An Investigation into the Cause of a Mass Mortality Event of Blanding's Turtles (*Emydoidea blandingii*)
C17-5 15:30	Yanina Sarquis-Adamson and Elizabeth MacDougall-Shackleton *University of Western Ontario* Song sparrows (*Melospiza melodia*) have a home-field advantage in defending against sympatric malarial parasites
C17-6 15:45	Candis Lepage, Meghan Kerr, Michael Trites, Erin Kelly, Laura Ferguson and Todd Smith *Acadia University* Infection dynamics of intraerythrocytic blood parasites of the genus Hepatozoon in green frogs, *Rana clamitans*
C17-7 16:00	Caryn Dooner, Amanda J Moehring, and Susanne E Kohalmi *University of Western Ontario* Characterizing the genetic basis of behavioural isolation between Drosophila species
C17-8 16:15	Benoit Talbot, Maarten J. Vonhof, Hugh H. Broders, Brock Fenton and Nusha Keyghobadi *University of Western Ontario* Evolutionary genetic aspects of host-parasite interactions in an ectoparasite of bats

C-18 Molecular and cellular immunology parasitology
UCC 60
Chair: Stephanie DeWitte-Orr

C18-1 14:30	Harsh Sidhu, Kamal Moghrabi, J Andrew Alexander, Sarah Van Es, Nguyen TK Vo, Niels C Bols and Lucy EJ Lee *University of the Fraser Valley* Characterization and toxicological applications of a continuous cell line derived from rainbow trout ovarian fluid
C18-2 14:45	Sabrina M. Inkpen, Khalil Eslamloo, Rune Andreassen, Matthew L. Rise *Memorial University of Newfoundland* Characterization and Expression Studies of Interferon Regulatory Factor Genes in Atlantic cod (*Gadus morhua*)
C18-3 15:00	Maxwell P. Bui-Marinos, Nguyen T.K. Vo, Niels C. Bols and Barbara A. Katzenback *University of Waterloo* Development of in vitro continuous cell culture systems from *Xenopus laevis* ventral and dorsal skin to examine frog viru
C18-4 15:15	Sarah Poynter, Graeme Lisser, Amal Aloufi and Stephanie DeWitte-Orr *Wilfrid Laurier University* Type I Interferon mediated innate antiviral mechanisms in rainbow trout
C18-5 15:30	Lena Jones, Chenjie Fei, Dustin Lillico, Myron Zwozdesky, and James Stafford *University of Alberta* Examination of fish immunoregulatory receptor-mediated signaling events during the phagocytic process
C18-6 15:45	Michael Trites and Daniel Barreda *University of Alberta* Contributions of immune transferrin to acute inflammation in goldfish, *C. auratus*
C18-7 16:00	Cheryl Soulliere, Lital Sever, Susy Lam, N.T.K. Vo, Jack Iwanczyk, Joel Kooistra, Neils Bols and Brian Dixon *University of Waterloo* Regulation of rainbow trout (*Oncorhynchus mykiss*) IFNγ, IL-1β, and TNFα and the pro-inflammatory response
C18-8 16:15	Dustin Lillico, Myron Zwozdesky, Chenjie Fei, Lena Jones, Joshua Pemberton and James Stafford *University of Alberta* Examining teleost immunoregulatory receptor-mediated phagocytic pathways

Diversity Workshop
17:00-18:30
UCC 37

Atelier Diversité

Un atelier sur la communication interculturelle dans la salle de classe. Ceci est destiné autant aux professeurs qu'aux enseignants (et ceux qui aspirent à en devenir). Davantage de détails suivront.

Mentoring Graduate Students in Academia: Strategies for Success

This workshop will be led by Western's own Aisha Haque. Aisha is a Language and Communication Instructor at Western University where she designs programs to support graduate student development. In particular, her work focuses on helping International Teaching Assistants improve their teaching and cross-cultural communication skills. Aisha also sits on the executive committee of Teaching Assistant and Graduate Student Advancement (TAGSA), a special interest group of STLHE, and teaches courses on Bollywood Cinema at Fanshawe College. Her current research focuses on intercultural teaching competence and disciplinary approaches to TA training.

The ability to communicate across cultures is a salient factor in the successful supervision of international graduate students. Effective cross-cultural supervision includes not only an ability to bridge differences in communication styles but also the ability to clarify differing assumptions about the nature of writing and conducting research in Canadian academia. During this session, we will discuss several factors that contribute to the academic success of international graduate students. In particular, participants will gain concrete strategies they may use when working with graduate students across cultures - strategies such as establishing clear expectations that help to clarify the norms of Canadian academia and giving feedback that is sensitive to cultural differences in communication styles. Participants will leave the session with resources that will help them to successfully mentor international graduate students at all stages of their academic journey.

Teaching Workshop for TAs
17:00-18:30
UCC 56

Atelier Enseignement pour les démonstrateurs

Les étudiants qui assistent à cet atelier vont développer leurs habiletés à l'enseignement et au leadership pour mieux diriger les discussions dans une salle de classe et optimiser leur expérience comme démonstrateur.

Effective TAing: Challenges and Solutions

Students who attend this workshop will develop their teaching and leadership skills to better lead laboratories and make the most of their experience as a TA.This workshop will be facilitated by Bonnie Alberry, Jantina Toxopeus, and Joel Slade, three biology PhD students at Western, who have been TAing for many years. Bonnie has led several workshops for teaching assistants in her role as Western's Lead Science TA. Jantina facilitated workshops for Dalhousie's TA training program during her MSc, and currently trains new teachers for The Princeton Review. Joel has had extensive training in university teaching and learning from his time as a Western Faculty of Science Learning Development Fellows. Jantina and Joel have both taught courses and supervised TAs.

ZET Lecture
17:00-18:00
NCB 101
Chair: Jim Staples

Dr. Shelley Adamo
Dalhousie University

Making Zombies: How a parasitic wasp hijacks the brain of its host.
Zombies! Comment une guêpe parasite détourne le cerveau de son hôte

Some parasites, such as the parasitic wasp *Cotesia congregata*, manipulate the behaviour of their hosts. The wasp lays its eggs inside the body of the tobacco hornworm caterpillar. The wasp larvae develop inside the caterpillar, drinking its blood. The caterpillar behaves normally until the wasp needs to exit the host. The wasp larvae then drill their way through the body wall of the caterpillar, spin a cocoon, and emerge from the cocoon as adult wasps a few days later. The wasp larvae secrete a substance that numbs the area of the skin through which the wasp exits, preventing the caterpillar from reacting to the skin irritation. The caterpillar also stops feeding and moving spontaneously just before the wasps emerge. The caterpillar turns into a 'bodyguard' for the wasps. The wasps exploit communication pathways between the caterpillar's immune system and nervous system. The wasps activate an immune response in the caterpillar as they drill out of the host. They increase its amplitude and duration, leading to a shut down in caterpillar feeding. Without this shutdown, the caterpillars eat the cocoons. The wasp larvae have direct effects on the caterpillar's brain, resulting in a permanent loss of feeding and spontaneous movement.

Certains parasites manipulent le comportement de leurs hôtes. Par exemple, la guêpe parasite, *Cotesia congregata*, pond ses oeufs à l'intérieur du corps de la chenille du tabac de sphinx. Les larves de guêpe développent à l'intérieur de la chenille, boivent son sang, mais n'endommagent pas les organes internes. La chenille se comporte normalement jusqu'à ce que les larves de guêpe doivent quitter l'hôte. Les larves de guêpes creusent à travers la paroi du corps de la chenille, tissent un cocon, puis sortent comme adultes dans 4 ou 5 jours. La chenille cesse de se nourrir et de se déplacer juste avant que les larves de la guêpe émergent. La chenille se transforme en "garde du corps" pour les larves de guêpe. Pendant qu'ils émergent les larves de guêpe sécrètent une substance qui engourdit la peau de la chenille que les larves rongent à travers, ce qui empêche la chenille de réagir à l'irritation de la peau. Les larves induisent une réponse immunitaire dans la chenille, et cela contribue à assurer que les trous faits par les guêpes sont scellés une fois que les guêpes ont quitté le corps. Les cellules immunitaires de la chenille libèrent des substances chimiques (cytokines) lorsqu'ils sont activés qui leur permettent d'envoyer des signaux au cerveau. Les larves de guêpe exploitent ce système de communication et augmentent l'amplitude et la durée, ce qui conduit à un arrêt dans l'alimentation de la chenille. Les larves de guêpes ont aussi des effets directs sur le cerveau de la chenille, ce qui entraîne une perte permanente de l'alimentation et le mouvement spontané de la chenille.

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Journal of Experimental Biology

Thursday 12 May / jeudi 11 mai

summary / résumé

08:00-08:30	Refreshements	
08:30-10:00	CMD Symposium	SSC 2050
	EEE Symposium	UCC 56
08:30-10:00	Contributed Sessions	
	Mitochondria, metabolism, and aging	UCC 37
10:30-11:00	Refreshments	
11:00-12:30	Contributed Sessions	
	Hypoxia II	UCC 56
	Evolutionary Biology	UCC 41
	Global Change	UCC 37
	Parasitomics and parasite diversity	UCC 58
	Molecular physiology	UCC 60
12:30-13:30	CMD Section Lunch (pizza with ticket)	UCC 63
	EEE Section Lunch (pizza with ticket)	UCC 65
13:30-15:00	Presidents' Award (PDF Competition) Talks	SSC 2050
15:00-15:30	Refreshments	
15:30-17:00	W.S. Hoar Award	SSC 2050
18:00-00:00	Banquet (with ticket)	Great Hall Sommerville House
	Live Band: Grackles	

Notes:

08:30-10:30

S6 - CMD (Comparative Morphology and Development) Section Symposium: "The Integrative Paleontologist: deep-time approaches to current problems"

SSC 2050

Chair: Hillary Maddin

S6-1 08:30	Casey Holliday, Kaleb Sellers, Henry Tsai, Alida Bailleul, Matthew Vickaryous, Callum Ross, Laura Porro, Julian Davis, Lawrence M Witmer *University of Missouri* PMJs and TMJs: Convergence in the craniomandibular joints of crocodyliforms and mammals
S6-2 09:00	Kirstin S. Brink, Robert R. Reisz, Joy M. Richman *University of British Columbia* Using advanced imaging modalities to unravel microstructural complexity in non-mammalian dentitions
S6-3 09:30	David Evans, Kentaro Chiba and Nicolas Campione *University of Toronto* Developmental Mass Extrapolation: An Empirical Test
S6-4 10:00	Stephanie E. Pierce, Katrina E. Jones, Kenneth D. Angielczyk *Harvard University* A deep-time perspective on the evolution of the mammalian backbone

08:30-10:30

S7 - EEE (Ecology Evolution Ethology) Section Symposium: "Contemporary approaches to wildlife conservation science"

UCC 56

Chair: Martinez Garcia

S7-1 08:30	Albrecht Schulte-Hostedde *Laurentian University* Conservation biology and zoos – integrating ecology and evolution
S7-2 09:00	Trevor Pitcher *University of Windsor* Infusing ecology and evolution into fish conservation breeding programs
S7-3 09:30	Suzanne M. Gray, Laura H. McDonnell, Nicholas E. Mandrak, and Lauren J. Chapman *The Ohio State University* The influence of turbidity on the physiology of imperiled blackline shiners (*Notropis spp.*) in the Great Lakes
S7-4 10:00	Steven J. Cooke *Carleton University* Conservation physiology

08:30-10:30 CONTRIBUTED SESSIONS

C19 - Mitochondria, metabolism, and aging
UCC 37
Chair: Charles-A Darveau

C19-1 08:30	Charles-A Darveau, Loïc Teulier, Julie Crevier, Rebecca Rabinovitch *University of Ottawa* Evolution of mitochondrial metabolism in hymenopterans
C19-2 08:45	Amanda MacCannell, Kevin Sinclair, Lanette Friesen-Waldner, Charles McKenzie, and James Staples *University of Western Ontario* Water-Fat MRI Suggests an Endogenous Rhythm of Brown Adipose Tissue Proliferation in a Hibernator
C19-3 09:00	Morag Dick and Christopher Guglielmo *University of Western Ontario* Management of oxidative stress during endurance flight in yellow-rumped warblers
C19-4 09:15	Kate Mathers, Sarah McFarlane and Jim Staples *University of Western Ontario* Regulation of mitochondrial metabolism during hibernation by post-translational modification
C19-5 09:30	Janice Gomes, and Jason C.L. Brown *University of Toronto Scarborough* Do ageing theories based on animal studies apply to plants? The effects of exogenous H_2O_2 on annual and perennial flax
C19-6 09:45	Cayleih Robertson, Glenn Tattersall and Grant McClelland *McMaster University* Altitude ancestry and the ontogeny of thermoregulation in the North American deer mouse (*P. maniculatus*)
C19-7 10:00	Rashpal S. Dhillon, Paul R. van Ginkel, Vivian Fu, Tomas A. Prolla, and John M. Denu *University of Wisconsin* Effects of SIRT3-mediated deacetylation on mitochondrial function of aging mice
C19-8 10:15	Vincent Chapdelaine, Léo Deremiens, Logan Schwartz, Annie Angers, Hélène Glémet and Bernard Angers *University of Montréal* Express yourself* according to your mitochondria

C20 - Hypoxia II
UCC 56
Chair: Yvonne Dzal

C20-1 11:00	Gregory Jensen and Steve Perry *University of Ottawa* The role of serotonin in the hypoxic ventilatory response of larval zebrafish
C20-2 11:15	Lisa Borecky and Matthew Pamenter *University of Ottawa* Hypoxia-inducible factor 1 mediates ventilatory and metabolic suppression in African naked mole rats
C20-3 11:30	Tegan A. Williams, Jillian Bergstrome, Juliana Scott and Nicholas J. Bernier *University of Guelph* CRF and urocortin 3 protect the heart from hypoxia/reoxygenation-induced apoptosis in zebrafish
C20-4 11:45	Phillip R. Morrison, Colin J. Brauner *University of British Columbia* A sensitivity analysis to identify factors that limit $\dot{V}O_2$ max in two exceptionally athletic fishes: the rainbow trout
C20-5 12:00	Shuang Qiu, Chengfeng Xiao and R Meldrum Robertson *Queen's University* Involvement of CNGL channel in responses to hypoxia in adult Drosophila
C20-6 12:15	Yvonne A. Dzal, Julia M. York, Paul A. Faure and William K. Milsom *University of British Columbia* Are hibernating bats just big babies? Metabolic, thermoregulatory, and ventilatory responses of bats to hypoxia

C21 - Evolutionary Biology
UCC 41
Chair: Christopher Cameron

C21-1 11:00	Jesse Kelly *Auckland University of Technology* Systematics of the Octopoteuthidae Berry, 1912 (Cephalopoda: Oegopsida)
C21-2 11:15	Érik L'Heureux and Bernard Angers *Université de Montréal* Following in the footsteps of the Arion subfuscus/fuscus species complex
C21-3 11:30	Matheus Sanita Lima, Laura C. Woods, Matthew W. Cartwright, David Roy Smith *University of Western Ontario* The (in)complete organelle genome: exploring the use and disuse of available technologies for characterizing mitochondria
C21-4 11:45	Christopher Cameron *Université de Montréal* An Ambulation through Ambulacraria & Chordate Gill Evolution
C21-5 12:00	France Beauregard and Bernard Angers *Université de Montréal* Epigenetic compensation for exclusively gynogen individuals in a complex of kleptogen hybrids

C22 - Global change
UCC 37
Chair: Andrea Morash

C22-1 11:00	Caleb T. Hasler, John A. Tix, Jennifer D. Jeffrey and Cory D. Suski *University of Illinois* Elevated carbon dioxide and fish movement
C22-2 11:15	Bryan Neff, Nico Muñoz, Ross Breckels, Anthony Farrell *University of Western Ontario* Capacity of fishes to respond to climate change
C22-3 11:30	Alex Quijada-Rodriguez, Yung Che Tseng, Po-Hsuan Sung, Pou-Long Kuan, Pung Pung Hwang, Dirk Weihrauch *University of Manitoba* Getting Crabby: The effects of freshwater acidification on branchial acid-base regulation in the Chinese mitten crab
C22-4 11:45	Susan Anthony, Brent Sinclair, and Christopher Buddle *University of Western Ontario* The spider who came in from the cold: Variability and plasticity of spider thermal biology
C22-5 12:00	Anshul Sidhu and Liette Vasseur *Brock University* Understanding the diamondback moth performance in alternative cropping systems
C22-6 12:15	Andrea J. Morash, Suzanne Currie and Jayson M. Semmens *Mount Allison University* Potential ecophysiological impacts of aquaculture on the endangered Maugean Skate (*Zearaja maugeana*)

C23 - Parasitomics and parasite diversity
UCC 58
Chair: Elizabeth Boulding

C23-1 11:00	Cylita Guy, Jeneni Thiagavel, Nicole Mideo, and John M. Ratcliffe *University of Toronto* Who You Live With Matters: Determinants of Viral Richness in Bats
C23-2 11:15	Elizabeth G. Boulding, Melissa K. Holborn, Christina M. Rochus, Jane J. Tosh, Keng Pee Ang, Frank Dussault, J. A. K. Elliott, Brian D. Glebe, Harald Grove, Matthew P. Kent, Steven Leadbeater, Sigbjørn Lien, Thomas Moen, Frank Powell and Lawrence R. Schaeffer *University of Guelph* Genome wide association studies for salmon louse resistance in Atlantic salmon using a new North American 50K SNP chip a
C23-3 11:30	Khalil Eslamloo, Xi Xue, Marije Booman and Matthew L. Rise *Memorial University of Newfoundland* Global gene expression of Atlantic cod macrophages in response to viral mimic stimulation
C23-4 11:45	Francois Olivier Hebert, Stephan Grambauer, Iain Barber, Christian R. Landry, Nadia Aubin-Horth *Université Laval* Moving through a complex life cycle: transcriptome-wide reprogramming in a cestode infecting sticklebacks and birds
C23-5 12:00	Ferris Zahlan and Janet Koprivnikar *Ryerson University* Parasitism of invasive and native species: evaluation of endohelminths in rock bass and smallmouth bass from Algonquin
C23-6 12:15	Lucie Grecias, Chloé Berger, Iain Barber and Nadia Aubin-Horth *Université Laval* Is the stickleback manipulated by its parasitic flatworm? Combining phenotypic engineering and transcriptomic approaches

C24 - Molecular physiology
UCC 60
Chair: John Chang

C24-1 11:00	Céline Audet and Louis Bernatchez *Université du Québec à Rimouski* Integrating genomics and ecophysiology: another way to look at and to understand the biology of brook charr Withdrawn
C24-2 11:15	Lana Shaya and Joanna Y. Wilson *McMaster University* The role of the aryl hydrocarbon and estrogen receptors in cytochrome P450 gene regulation in zebrafish
C24-3 11:30	Joshua Pemberton and John Chang *University of Alberta* PtdIns(3,4,5)P3-dependent signalling differentially modulates basal and stimulated goldfish pituitary hormone secretion.
C24-4 11:45	Courtney A Deck and Patrick J Walsh *University of Ottawa* Glucose transporter expression in the North Pacific spiny dogfish shark (*Squalus acanthias*) in response to glucose loadi
C24-5 12:00	Katelin Spiteri, Anton Korenevski, and Stephanie DeWitte-Orr *Wilfrid Laurier University* Immunomodulation using nanoparticle Phytospherix™ in rainbow trout cells

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13:30-15:00 Presidents' (PDF) Award Talks

S8 – Presidents' Award
SSC 2050
Chair: Lucy Lee

S8-1	Sarah L. Alderman, Anthony P. Farrell, Chris J. Kennedy, and Todd E. Gillis *University of Guelph* From cells to performance: effects of diluted bitumen on the cardiovascular system of juvenile sockeye salmon
S8-2	Tomonari Kaji, Arthur Anker, Christian Wirkner, A. Richard Palmer *University of Alberta* Evolutionary origin of "snapping" shrimps: Crossing the gap between pinching and snapping claws
S8-3	Daniel Munro, Matthew E Pamenter and Jason R Treberg *University of Manitoba* Longevity and mitochondrial ROS metabolism: a new twist on the mouse vs. naked mole-rat comparison
S8-4	Alex Zimmer and Chris Wood *University of Ottawa* Acute exposure to high environmental ammonia (HEA) triggers emersion in the green shore crab (*Carcinus maenas*)

15:30-17:00 W.S. Hoar Award Competition Talks

S9 – W.S. Hoar Competition
SSC 2050
Chair: Lucy Lee

S9-1	Lauren Des Marteaux and Brent Sinclair *University of Western Ontario* Effects of cold acclimation on structure and transport function in insect ionoregulatory tissues
S9-2	Laura V. Ferguson, Golnaz Salehipour-shirazi, David E. Heinrichs and Brent J. Sinclair *University of Western Ontario* How do pathogens and immunity shape insect success at low temperatures?
S9-3	Shamaila Fraz, Abigail Lee and Joanna Wilson *McMaster University* Multi generational effects of pharmaceutical exposure in zebrafish (*Danio rerio*)
S9-4	Kristin Jonasson and Christopher Guglielmo *University of Western Ontario* A hard day's night: migration strategies male and female silver-haired bats
S9-5	Anthony V. Signore, Phillip R. Morrison, Colin J. Brauner and Kevin L. Campbell *University of Manitoba* Temperature dependent effector binding: the definitive molecular mechanism underlying hemoglobin thermal sensitivity
S96	Dimitri A. Skandalis, Joseph W. Bahlman, Paolo S. Segre, Derrick Groom, Christopher C. Witt, David Lentink, Jimmy A. McGuire, Robert Dudley, Douglas L. Altshuler *University of British Columbia* Allometry of aerodynamic force reveals hummingbirds minimize wing velocity to maximize performance

Friday 13 May / vendredi 11 mai

summary / résumé

09:00-12:30	CSZ Council Meeting	Ontario Hall 3C04

Notes:

NOTES


Monday May 9th
Tuesday May 10th
Wednesday May 11th
Thursday May 12th
Friday May 13th
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refreshments
LOC symposium
refreshments
Contributed sessions
AGM Lunch
Great Hall
Boutilier Award lecture
SSC 2050
Contributed sessions
Poster Session
P&A Atrium
Student meet & greet
Student Success workshop
The Wave
Social
refreshments
Symposia
2 sections, concurrent
CBP
PIE
refreshments
Contributed sessions
CPB & PIE Section Lunches
Cameron Award lecture
SSC 2050
Contributed sessions
+Don Stevens symposium
+CMD extra session
refreshments
Education & Diversity
Workshops
ZET Lecture
NCB 101
ZET Reception
P&A Atrium
refreshments
Symposia
2 sections, concurrent
CMD
EEE
refreshments
Contributed sessions
CMD & EEE Section Lunches
PDF competition talks
refreshments
Hoar Award
Cocktails + Banquet
Great Hall
Music by "Grackles"
CSZ Council Meeting
(catered)
CSZ Council Meeting
(catered)
CJZ Workshop/Wardle Lecture
NSERC Workshops
break
Fry Lecture
SSC 2050
Opening reception
P&A Atrium
Meetings/workshops
Plenary sessions
Receptions
Refreshment breaks
Concurrent sessions
Symposia

Presentations / Présentations

Acharya-Patel, Neha and Bill Milsom
University of British Columbia
Control of cardio-respiratory synchrony in the dogfish, *Squalus suckleyi*
Elasmobranchs have no direct sympathetic innervation of the heart. Cardiac regulation is primarily via inhibitory vagal input. Cardio-respiratory synchrony (CRS), a 1:1 heart beat to breath ratio, has been proposed to co-ordinate the rates of flow of blood through, and water over the gills, maximizing gas exchange. We investigated the nature of this modulation in response to changing environmental oxygen conditions in *Squalus suckleyi*. Cardiorespiratory synchrony was only found intermittently during hyperoxia post atropine when heart rate was completely uninhibited and ventilation was slowed due to the increase in oxygen supply. Our data suggest that while CRS can occur in *Squalus suckleyi*, it is not a controlled process. While it may maximize gas exchange, it occurs only when vagal tone is eliminated, and even then it is transient drifting in and out of phase. Supported by the NSERC of Canada.

Adamo, Shelley
Dalhousie University
Making Zombies: How a parasitic wasp hijacks the brain of its host.
Zombies! Comment une guêpe parasite détourne le cerveau de son hôte
Some parasites, such as the parasitic wasp *Cotesia congregata*, manipulate the behaviour of their hosts. The wasp lays its eggs inside the body of the tobacco hornworm caterpillar. The wasp larvae develop inside the caterpillar, drinking its blood. The caterpillar behaves normally until the wasp needs to exit the host. The wasp larvae then drill their way through the body wall of the caterpillar, spin a cocoon, and emerge from the cocoon as adult wasps a few days later. The wasp larvae secrete a substance that numbs the area of the skin through which the wasp exits, preventing the caterpillar from reacting to the skin irritation. The caterpillar also stops feeding and moving spontaneously just before the wasps emerge. The caterpillar turns into a 'bodyguard' for the wasps. The wasps exploit communication pathways between the caterpillar's immune system and nervous system. The wasps activate an immune response in the caterpillar as they drill out of the host. They increase its amplitude and duration, leading to a shut down in caterpillar feeding. Without this shutdown, the caterpillars eat the cocoons. The wasp larvae have direct effects on the caterpillar's brain, resulting in a permanent loss of feeding and spontaneous movement.

Alderman, Sarah L., Anthony P. Farrell, Chris J. Kennedy and Todd E. Gillis
University of Guelph
From cells to performance: effects of diluted bitumen on the cardiovascular system of juvenile sockeye salmon
Crude oil is a known cardiotoxic aquatic contaminant that disrupts heart development, morphology, and function in embryonic fish, but the sensitivity of other life stages is poorly studied. Pipelines carrying diluted bitumen (dilbit) from the Alberta Oil Sands traverse coastal watersheds of British Columbia, potentially putting millions of Pacific salmon at risk of exposure to this crude oil. Since these anadromous fish must perform two considerable lifetime migrations, impaired heart function caused by dilbit exposure could have population-level consequences. Therefore, the present study exposed sockeye salmon parr (*Oncorhynchus nerka*) to environmentally relevant levels of the water-soluble fraction of dilbit for one and four weeks to determine the molecular, morphological, and performance effects on the heart. Liver detoxification was maximally activated in all exposed fish. Critical swimming speed was significantly reduced in fish exposed to the highest contaminant level for four weeks, relative to unexposed fish. The hearts of fish in the high exposure group also up-regulated cellular markers of toxicity and showed histological changes to the compact myocardium that may underlie this reduced performance. Taken together, these results provide concrete support of dilbit-induced cardiotoxicity in juvenile salmonids, which may have important ecological consequences if a pipeline leak occurs.

Altshuler, Doug, Roslyn Dakin, Kevin Middleton, Paolo Segre
UBC
Biomechanics of maneuvering flight in hummingbirds
Despite recent advances in the study of animal flight, the biomechanical determinants of maneuverability are poorly understood. It is thought that maneuverability may be influenced by intrinsic body mass and wing morphology, and by physiological muscle capacity, but this hypothesis has not yet been evaluated because it requires tracking a large number of free flight maneuvers from known individuals. We used an automated tracking system to record flight sequences from 20

Anna's hummingbirds flying solo and in competition in a large chamber. We found that burst muscle capacity predicted most performance metrics. Hummingbirds with higher burst capacity flew with faster velocities, accelerations, and rotations, and they used more demanding complex turns. In contrast, body mass did not predict variation in maneuvering performance, and wing morphology predicted only the use of arcing turns and high centripetal accelerations. Collectively, our results indicate that burst muscle capacity is a key predictor of maneuverability.

Anthony, Susan, Brent Sinclair, and Christopher Buddle
Western University
The spider who came in from the cold: Variability and plasticity of spider thermal biology
Spiders are key terrestrial predators, whose performance is influenced by temperature. However, little is known about the effect of temperature on spiders and their ability to acclimate to new temperatures, such as those predicted due to climate change. The objective of our research is to test the effect of temperature on spider performance, and to assess the plasticity of the thermal responses in acclimated groups. We compared the critical thermal minimum (CT_{min}) and maximum (CT_{max}) of activity among wolf spiders from the Yukon (*Pardosa moesta*, *P. lapponica*, *P. sodalis*, *P. glacialis*) and Southwestern Ontario (*Pardosa* sp.), as well as the effect of acclimation on CT_{min} and CT_{max} of a subset of these species (*P. moesta*, *P. lapponica*, *Pardosa* sp.). We found that southwestern Ontario lycosid have similar CT_{max}s as the Yukon species, with higher CT_{min} than two Yukon species (*P. sodalis, P. glacialis*). Acclimation did effect the CT_{min} and CT_{max} in Yukon *P. moesta* and Ontario *Pardosa* sp., however there was no effect on Yukon *P. lapponica*. We can conclude that spiders may have the ability to acclimate to new temperatures, however we do not know the long-term effects of the acclimation and its effect on species' fitness.

Aubin-Horth (presenter), Sophie St-Cyr, Marian Wong, Susan Marsh-Rollo, Jennifer Reynolds, Sigal Balshine and Nadia Aubin-Horth
Université Laval
Reach for the top: changes in brain transcriptome of females that become dominant in a highly-social fish species
Changements du transcriptome du cerveau des femelles qui atteignent un statut social dominant chez une espèce de poisson hautement sociale
The social status of an individual within a group affects a large array of fitness-related traits, including behaviours. Dominance status is labile, and thus the same individual expresses very different behaviours during its lifetime depending on its social status. This behavioural plasticity is due in part to molecular and hormonal alterations in the brain associated with the shift in dominance status. While we have information on transcriptome differences between stable subordinate and dominant phenotypes on a genome-wide scale in some systems, we know much less about the gene expression changes that happen specifically during ascension to dominance, especially in females. We studied females of the cooperatively breeding African cichlid *Neolamprologus pulcher* in Lake Tanganyika. We observed and manipulated social groups composed of a dominant breeding pair and subordinate helpers. We sampled behaviour and brains of subordinate and dominant females, as well as of newly-ascended females that became dominant after removal of the dominant female from their social group. These newly dominant females expressed a distinctive behavioural profile. This social manipulation allows us to uncover differences in brain transcriptome associated specifically with the shift in dominance and to determine if molecular pathways are modulated in a sex-specific way with dominance status.

Beauregard, France and Bernard Angers
Université de Montréal
Epigenetic compensation for exclusively gynogen individuals in a complex of kleptogen hybrids
Compensation épigénétique chez des individus exclusivement gynogènes dans un complexe d'hybrides kleptogènes
Phenotypic variation is critical to the persistence of organisms over time and the colonization of new habitats. The main consistent sources of phenotypic variation are genetics and epigenetics. Epigenetics was proposed as a valuable asset for asexual organisms to compensate for a lack of genetic diversity. The objective of this study is to assess whether lack of genetic variation is compensated by epigenetics by comparing methylation patterns of gynogen and kleptogen individuals of the blue-spotted salamander hybrids. Individuals sampled clustered in five genetically differentiated groups, derived from the very same paternal *A. jeffersonianum* haplome. Two out of the five groups are exclusively gynogenetic, for either ecological or genomic factors. The other three groups occasionally formed kleptogen individuals, since they display a higher genetic variation within sites than among sites, in addition of displaying highly divergent alleles found in high frequency in the sympatric *A. laterale* populations. Epigenetic patterns are variable and distinct among the five genetic groups. Gynogenetic groups are the only one to display a significant environmental effect on their epigenetic pattern, suggesting clonal individuals must be able to make the most from their epigenetic variation potential to deal with environmental variations.

Bélair-Bambrick, Marie-Ève, Laurence Dionne-Wilson and Kathleen Gilmour.
University of Ottawa
Regulation of cortisol production by serotonin in the head kidney of rainbow trout (*Oncorhynchus mykiss*)
There is evidence of serotonergic regulation of the hypothalamic-pituitary-interrenal (HPI) axis in teleost fish but the mechanisms involved are not clear. We hypothesized that serotonin (5-HT) plays a paracrine role in regulating cortisol production by interrenal cells in the head kidney of rainbow trout (*Oncorhynchus mykiss*). Head kidney tissue contained detectable levels of 5-HT4 receptor mRNA, and cellular localization was investigated using *in situ* hybridization. Cortisol production was significantly increased in head kidney preparations incubated with 5-HT, or with the 5-HT4 receptor agonist cisapride, and this elevated cortisol production was blocked by the 5-HT4 receptor antagonist GR125487. Localization of 5-HT by immunohistochemistry using markers for interrenal cells and chromaffin cells as well as neuronal markers on head kidney sections revealed that 5-HT was present in the head kidney, but not localized to interrenal cells, chromaffin cells or nerves. In conclusion, 5-HT could act in a paracrine fashion at the head kidney level to regulate cortisol production, probably via the 5-HT4 receptor.

Birceanu, Oana, Alam Mohammad, Owen Woody, Brendan McConkey, Neel Aluru and Matt Vijayan
Wilfrid Laurier University
Multigenerational effects of bisphenol A on the rainbow trout transcriptome
Les effets multigénérationnels de Bisphenol A sur le transcriptome de la truite arc-en-ciel
Bisphenol A (BPA), an endocrine disruptor ubiquitously present in the environment, is maternally transferred to the eggs and affects offspring development in fish. Here, we investigated the impact of BPA accumulation in eggs on the embryo transcriptome at hatch (42 days post-fertilization, dpf) in two generations of rainbow trout (*Oncorhynchus mykiss*). RNA sequencing (RNAseq) by next generation sequencing with the Illumina platform was used to construct and characterize the rainbow trout transcriptome. Quantification and differential expression analysis, along with gene ontology enrichment analysis, revealed 148 genes that were stable in the genome and could be used as biomarkers of BPA toxicity. Therefore, their expression was further investigated in the BPA groups. Of these, 16 genes were consistently downregulated in both generations and most were related to embryo and lens development, cellular response to stress and xenobiotic detoxification. Induced network module analysis mapped 14 of the 16 downregulated genes to 21 distinct proteins that were involved in development, metabolism, stress and cell-to-cell signaling, growth and xenobiotic detoxification. Overall, BPA accumulation in eggs impacts the embryo transcriptome in multiple generations, leading to the proposal that maternal transfer of BPA affects developmental programming, and some of these effects may be heritable in trout.

Blewett, Tamzin, Erin Leonard, Elissa Dow, Chris Wood, James McGeer and D. Scott Smith
University of Alberta
Composition matters! How dissolved organic carbon ameliorates nickel toxicity in marine invertebrates
Dissolved organic carbon (DOC) is ubiquitous in natural waters, and is known to ameliorate the toxicity of metals in freshwater environments. However, predictions based on geochemical modelling suggest that DOC will not be as protective in the marine environment. This hypothesis was tested using nickel (Ni) toxicity to early life-stages of the marine invertebrates *Strongylocentrotus purpuratus* (sea urchin) and *Mytilus edulis* (blue mussel). Acute (48h) toxicity tests were conducted by exposing embryos to Ni, then examining effects on development, uptake kinetics and the protective effects of DOC. Different DOC sources had different protective effects against embryo-larval toxicity in the tested species. These protective effects were related to both the concentration of DOC and its molecular composition. Contrary to expectations, these results suggest that DOC is an important component influencing Ni toxicity in marine waters. Furthermore, accounting for DOC composition will be key factor to consider in the development of predictive models, such as the biotic ligand model, of Ni toxicity in marine waters (NSERC CRD grant, NiPERA).

Borecky, Lisa and Matthew Pamenter
University of Ottawa
Hypoxia-inducible factor 1 mediates ventilatory and metabolic suppression in African naked mole rats
Environmental hypoxia has driven the evolution of stimuli-dependent modifications to ventilatory and metabolic activity: the hypoxic ventilatory response (HVR) and hypoxic metabolic response (HMR), respectively. Although the mechanisms that elicit these responses remain poorly understood, recent evidence demonstrates hypoxia-inducible factor-1 (HIF-1) facilitates the HVR and potentially the HMR through altered patterns of gene expression. Naked mole rats (NMRs) live in lifelong chronic hypoxia and thus provide an excellent model in which to investigate the role of HIF-1 in mediating the HVR and HMR of a

hypoxia-tolerant species. We treated NMRs with a pharmacological HIF-1 inhibitor (echinomycin; 1mg/kg; 8 days) and then examined the HVR and HMR in awake animals exposed to acute hypoxia (7% O_2; 1 hr) using plethysmography and respirometry. We found that: 1) the HVR was blunted in HIF-deficient NMRs compared to controls 2) basal metabolic rate decreased in echinomycin-treated NMRs, affecting the magnitude of their HMR and 3) the respiratory exchange ratio (RER) increased from .0728 to .0939 with acute hypoxia in controls indicating a switch to glucose-fueled metabolism; however, this fuel switch was prevented in HIF-deficient NMRS. We propose NMRs constitutively express HIF-1 in normoxia, which contributes to decreased ventilatory activity and metabolic remodeling during acute hypoxia.

Borowiec, Brittney G. and Graham R. Scott
McMaster University
Distinct physiological strategies for coping with constant hypoxia & intermittent hypoxia in killifish (*F. heteroclitus*)
Fish often encounter daily cycles of hypoxia in the wild, but the physiological strategies for coping with intermittent hypoxia, compared to constant hypoxia, are poorly understood. We compared the hypoxia coping strategies that arose with acclimation to constant versus intermittent patterns of hypoxia in the estuarine killifish, *Fundulus heteroclitus*. Acclimation to constant hypoxia (PO_2 of 2 kPa) for 28 d led to a significant reduction in O_2 consumption rate (MO_2) and plasma lactate concentrations in hypoxia, suggesting a strong reliance on metabolic depression to match O_2 supply and demand. This did not occur in fish acclimated to intermittent hypoxia (12 h normoxia: 12 h hypoxia at 2 kPa), which maintained higher MO_2 in hypoxia and exhibited a pronounced elevation in MO_2 with reoxygenation, suggesting that they instead rely upon high capacities for O_2 transport and for using and recovering from anaerobic metabolism. Unexpectedly, levels of reactive oxygen species were generally elevated by constant hypoxia, but not intermittent hypoxia, in several tissues. Our results suggest that constant hypoxia and intermittent hypoxia favour divergent strategies for matching O_2 supply and demand in hypoxia, and have distinct implications for oxidative stress. Supported by NSERC.

Boulding, Elizabeth G., Melissa K. Holborn, Christina M. Rochus, Jane J. Tosh, Keng Pee Ang, Frank Dussault, J. A .K. Elliott, Brian D. Glebe, Harald Grove, Matthew P. Kent, Steven Leadbeater, Sigbjørn Lien, Thomas Moen, Frank Powell and Lawrence R. Schaeffer
University of Guelph
Genome wide association studies for salmon louse resistance in Atlantic salmon using a new North American 50K SNP chip a
Within the past two years Kelly Cove Salmon Ltd. (KCS) has made a rapid transition to a modern breeding program using genomic selection. The KCS breeding program required custom technology transfer because they are only permitted to use one strain of Atlantic salmon, the Saint John River Aquaculture Strain (SJR), in their marine net pens in Atlantic Canada. SJR was founded from the indigenous North American subspecies so fewer genomic resources had been developed. Funding from Genome Canada GAPP has permitted the University of Guelph, KCS, AquaGen, and CIGENE to develop a custom Affymetrix 384 peg 50K SNP chip and a low density SNP assay to provide the necessary high-throughput platforms. This was required to implement genomic selection for disease traits that cannot be measured on candidate broodstock reared entirely in freshwater. In year 2 of GAPP we first used our OFFSPRING™ Agena MassARRAY™ SNP assay to determine the parentage of communally-reared candidate broodstock. The fastest and slowest growing candidate broodstock from each family were then genotyped on our NA_Ssa_50K SNP chip. We challenged smolts with copepodite densities sufficient to result in densities of 30 salmon lice (*Lepeophtheirus salmonis*) at the chalimus stage. Genome wide association methods were used to find the effects of the SNPs on lice counts while accounting for fish contemporary group, body size, and complex population structure (genomic relationships). Broodstock with high genomic breeding values for fast growth and low lice counts were used to create the next generation. Funding: Genome Canada GAPP, KCS, IRAP, ACRDP, NSERC.

Boyer, Andrea and Scott MacDougall-Shackleton
Western University
Effects of recurrent inclement winter weather cues on white-throated sparrows
Climate change has been linked to an increasing frequency of inclement weather and winter storms. As such, it is important to understand the effects changing weather patterns have on birds. We investigated the effects of experimental recurrent inclement winter weather cues on body composition, glucocorticoid hormones, and behaviour of white-throated sparrows (*Zonotrichia albicollis*). We used a hypobaric climatic wind tunnel to simulate storms by altering barometric pressure and temperature accordingly, and measured behavioural responses, body composition, and baseline corticosterone levels in birds exposed, or not exposed, to weekly simulated storms over a three month period. Experimental birds developed significantly higher fat and lean masses. Baseline corticosterone levels decreased over time in both groups, and time spent at food cups increased over time in both groups, however there was no effect of experimental treatment. Thus, although manipulations did

not have a detectable effect on baseline corticosterone, it did affect body composition. This research provides novel experimental evidence that birds detect changing weather patterns and respond appropriately, and indicates that repeated exposure to inclement weather cues directly affects birds' energy reserves.

Bridgeman, Justin and Glenn J. Tattersall.
Brock University

Strength of individual turning bias in round gobies, *Neogobius melanostomus*, when experiencing acute temperature changes

Behavioural lateralisation can be described as the preferential use of one side of body or limbs, which influences behaviours that are executed in one particular direction. There is limited research on the effects of acute temperature changes on fish behavioural lateralisation in a detour task, with one recent study on a marine fish species investigating population-level lateralisation. The focus of this study is to investigate the strength of behavioural lateralisation in wild-caught round gobies, *Neogobius melanostomus*, in response to acute temperature changes. While prior field studies observed higher water temperatures in streams invaded by gobies, it is unclear whether behavioural lateralisation is optimal when gobies experience thermal stresses during acute warming events. We examined individual fish turning bias in a T-maze over a period of 3 days at 12°C, 15°C, and 18°C. An individual turning bias was present in round gobies, though not at the population-level. The strength of individual turning bias remained unchanged across 3 days at 12°C. Diurnal fluctuations are especially evident in the streams and rivers that invasive round gobies inhabit, and findings of this study will help in understanding the effects of acute temperature changes on fish behavioural responses.

Brink, Kirstin S., Robert R. Reisz, Joy M. Richman
University of British Columbia

Using advanced imaging modalities to unravel microstructural complexity in non-mammalian dentitions

The microstructure of tooth tissues and the interplay between them can strongly influence the structure and function of a tooth. Using advanced imaging modalities, the microstructure fossilized and non-fossilized teeth can be examined in detail to answer questions about development, dietary preference, and evolution. In this study, we used histology, synchrotron radiation-based Fourier transform infrared (SR-FTIR) microspectroscopy, and third-harmonic generation microscopy (THG) to visualize dentine tubule structure at the dentine-enamel junction in several species of dinosaurs and other living and extinct taxa (203-65 MYA). Results show that carnivorous theropod dinosaurs have a novel dental morphology that consists of a special arrangement of globular and sclerotic dentine that develops to strengthen the tooth internally. Moving forward, the development and mineralization patterns in extant reptile teeth will be examined through the use of fluorescent labeling and Optical Projection Tomography (OPT), which we show to be effective at visualizing dentine, enamel, and attachment tissues in 3D. These experiments offer a new view on the misunderstood structural and tissue-level complexity of non-mammalian dentitions.

Cameron, Christopher
Université de Montréal

An Ambulation through Ambulacraria & Chordate Gill Evolution
L'évolution des fentes branchiales pharyngiennes dans Ambulacraires et Chordés

A pharynx perforated with gill slits is an ancient and significant morphological innovation elaborated on in chordates, echinoderms and hemichordates. Here I provide evidence for this from functional morphology, development, comparative genomics, and palaeontology. i) Comparative morphology of feeding adaptations between acorn worms, echinoderms and chordates suggests that the original role of gill slits was filter feeding. ii) A comparative analysis of hemichordate genomes has identified a conserved genomic cluster of co-regulated transcription factor genes associated with the development of pharyngeal gill slits, showing an ancient regulatory linkage across deuterostomes. iii) Numerous gene novelties shared by hemichordates and chordates imply physiological, metabolic, and developmental specializations of the filter-feeding deuterostome ancestor, including some novelties plausibly acquired through horizontal gene transfer from marine microbes. iv) The fossils *Spartobranchus tenuis* and *Oesia disjuncta* from the Burgess Shale of British Columbia puts backwards the record of acorn worms, with well-developed gills, to the mid-Cambrian (505 mya). Several extinct echinoderm classes also possessed gills. The molecular clock calibrates the divergence of the hemichordate-echinoderms at 559 mya and the chordate lineage at 579 mya.

Lepage, Candis, Meghan Kerr, Michael Trites, Erin Kelly, Laura Ferguson and Todd Smith
Acadia University

Infection dynamics of intraerythrocytic blood parasites of the genus *Hepatozoon* in green frogs, *Rana clamitans*
Hepatozoon clamatae and *Hepatozoon catesbianae* are erythocytic apicomplexan parasites that preferentially infect the red blood cells of green frogs and bullfrogs, respectively, and mixed infections often occur in both species of frogs. The objective of this research was to investigate infection dynamics of these blood parasites, either as pure infections or in mixed infections, by monitoring parasitaemia levels in laboratory-raised green frogs inoculated with various combinations of the two species. Mosquitoes previously fed on green frogs naturally infected with one or both *Hepatozoon* species and subsequently infected with parasite oocytsts were fed to laboratory-raised frogs, and their parasitaemia was monitored every 20 days for 120 days. In frogs infected only with *H. clamatae*, there was a significant decrease in parasitaemia between 80 and 120 days post-inoculation (dPI). In frogs infected with a 3:1 ratio of *H. clamatae* to *H. catesbianae*, the infection level remained significantly higher than *H. catesbianae* throughout the sampling period; however, a significant interaction between the two parasites was not observed over this experimental time frame, suggesting that exploitation or apparent competition does not occur between these closely related species.

Chang (presenter), Joshua Pemberton and John Chang
University of Alberta
PtdIns(3,4,5)P3-dependent signalling differentially modulates basal and stimulated goldfish pituitary hormone secretion.
Receptor-mediated activation of class I phosphoinositide 3-kinases (PI3Ks) generates phosphatidylinositol 3,4,5-trisphosphate (PtdIns(3,4,5)P3), which through direct interactions with pleckstrin homology (PH) binding domains facilitates the recruitment of canonical downstream signalling molecules. We have recently demonstrated that PI3Ks mediate the luteinizing hormone (LH) and growth hormone (GH) secretion responses to the endogenous gonadotropin hormone-releasing hormones, GnRH2 and GnRH3, in goldfish. In this study, the involvement of PH domain-dependent signalling downstream of PI3K activation during hormone release responses in primary cultures of dispersed goldfish pituitary cells in column perifusion was investigated. Treatments include the use a small molecule mimetic of PtdIns(3,4,5)P3 to antagonize PH domain binding interactions in general, as well as selective inhibitors of classical PtdIns(3,4,5)P3-dependent effectors 3-phosphoinositide-dependent protein kinase 1 (PDK1), Akt (protein kinase B), and Bruton's tyrosine kinase (BTK). Results indicate that PtdIns(3,4,5)P3-sensitive transduction components differentially participate in the integrated control of basal and GnRH-stimulated hormone release in a cell-type- and agonist-specific manner. (Supported by NSERC, Killam Trusts, and AIHS.)

Chang, Terrence T. and Andrew C. Mason
University of Toronto Scarborough
Acoustic Signaling, Metabolic Rate, and Size in Competing Male *Cyphoderris monstrosa* (Orthoptera: Haglidae)
When competing for resources such as mates or territory, male ensiferan Orthoptera (e.g. crickets) will often stridulate before attempting physical combat. Various components of song are correlated with competitive ability; therefore, song is considered a reliable signal for resource holding power (RHP). Size and metabolic rate are also indicators of male aggressiveness. Previous research shows that *Cyphoderris monstrosa* (Orthoptera: Haglidae) are relatively insensitive to the frequency content of their own song, yet males still produce and communicate using acoustics in the context of competition. Here, I examined the relation of size, diet, duty cycle (i.e. time spent singing), and metabolic rate with *C. monstrosa* RHP. Using a round-robin tournament, I compared performance of males fed with sugar and protein to males fed with only sugar. I also measured body structures used for fighting, duty cycle during a competitive bout, and metabolic rate at two ecologically relevant temperatures (22°C and 10°C). Overall, winners had higher duty cycles and a more rapid increase in metabolic rate when singing suggesting that fights are purely energetic competitions. Whereas, overall competitive ability in *C. monstrosa* is influenced by physiological performance, as well as body and head size suggesting fixed phenotypic traits have an effect.

Chapdelaine, Vincent, Léo Deremiens, Logan Schwartz, Annie Angers, Hélène Glémet and Bernard Angers
University of Montréal
Express yourself according to your mitochondria
S'exprimer selon sa mitochondrie
Phenotypic plasticity allows individuals to respond to environment through epigenetic processes. This phenomenon is rarely studied in the perspertive of the cellular environment in terms of allospecific mitochondria . Within the fish species *Chrosomus eos* (northern redbelly dace) there are natural cytoplasmic hybrid (cybrids) along with wild type biotypes. The cybrids have a *Chrosmus neogaeus* (finescale dace) mitochondrial genome, despite a divergence of 10 million years between *C. eos* and *C. neogaeus* species. In addition, the cybrids mitochondria originated from different glacial refugia and diverged by approximately 100 000 years. The wild type and both cybrids have been found in sympatry in some lakes in the southern part of Québec. This

gave us the opportunity to assess the influence of different allospecific mitochondria on the regulation of nuclear genes. Our results revealed the influence the mitochondria on the methylome, transcriptome and proteome.

Chung, Dillon, Heather Bryant, Philip Morrison and Patricia Schulte
University of British Columbia
Thermal acclimation and local adaptation effects on hemoglobin and mitochondrial oxygen binding affinities.
Thermal constraints on whole-organism performance have been suggested to occur due to processes acting on aerobic metabolism. These effects may act at the level of O_2 transport systems and mitochondria. Here, we tested the effects of thermal acclimation and adaptation on hemoglobin (Hb) and mitochondrial O_2 binding-affinity using northern and southern populations of Atlantic killifish (*Fundulus heteroclitus*). Thermal acclimation significantly affected Hb-O_2 affinity, and there was a significant interaction between population and acclimation temperature. In southern killifish, 5°C acclimation was associated with lower Hb O_2 binding-affinity when compared to 15°C controls. In contrast, 33°C acclimation was associated with improved O_2 binding-affinity in northern killifish. Mitochondrial O_2 affinity differed between populations, with southern killifish having higher oxygen affinity compared to northern killifish, which may reflect the previously demonstrated hypoxia tolerance of southern individuals. Acclimation to either 5 or 33°C reduced mitochondrial O_2 affinity for both populations. This effect was assay temperature-specific in 33°C acclimated killifish, as mitochondrial O_2-binding improved to control levels when assayed at 15°C. These data thus provide evidence of the role that changes in aerobic metabolism can play in allowing killifish to maintain performance following thermal and perhaps hypoxic stress.

Chung, Steve and Jason Brown
University of Toronto
What does gall size tell a bird about the galls it preys upon when it's meal is a mystery
According to the optimal foraging theory, animals hunt to maximize the amount of energy gained while minimizing the time and effort put into the searching for food. Many birds forage on galls of goldenrod plants (Solidago) in which an insect, *Eurosta solidaginis*, takes up residence. Previous studies have shown that birds choose larger galls, and we set out to determine whether large galls act as a maximal energy and/or minimal effort signal for birds. After performing measurements in four different locations, we have determined that larger galls have thicker walls, likely requiring more effort, but did not necessarily have larger gall flies, contrary to studies conducted 40 years ago. Moreover, larger galls were not more likely have gall flies, were not located farther from the ground, and did not act as a signals of gall density. We believe these observations could be due to some adaptive behavior where larger *Eurosta solidaginis* have gradually shifted to smaller galls over the last 40 years to avoid predation by birds, thereby undermining the bird's foraging efforts

Clifford, Alexander M., Alex M. Zimmer, Chris M. Wood and Greg G. Goss
University of Alberta
It's all in the gills: Evaluation of O_2 uptake in Pacific hagfish refutes a major respiratory role for the skin.
Having diverged ~500 million years ago, hagfishes are the most ancient extant craniates, and a model for understanding the origins of vertebrate physiology. Hagfish skin has been reported as an important site for ammonia excretion and as the major site of systemic O_2 acquisition. However, there remains debate whether cutaneous O_2 uptake is the dominant route of uptake; all evidence supporting this hypothesis has been derived using indirect measurements. Here we use separating chambers and direct measurements of O_2 consumption and ammonia excretion to quantify cutaneous and branchial exchanges in Pacific hagfish (*Eptatretus stoutii*) at rest and following exhaustive exercise. We hypothesized that following exercise, hagfish would increase cutaneous O_2 uptake and branchial ammonia excretion. At rest, hagfish primarily used the gills for both O_2 uptake (81.0%) and ammonia excretion (70.7%). Following exercise, both O_2 uptake and ammonia excretion increased, but only across the gill; cutaneous exchange was unchanged. When branchial O_2 availability was reduced by exposure to anteriorly-localized hypoxia (~4.6 kPa O_2), as might occur when the head is immersed in prey during feeding, hagfish did not utilize cutaneous mechanisms to supplement whole-animal metabolic requirements. These results refute a significant role for cutaneous O_2 acquisition in hagfish (NSERC Discovery).

Cooke, Steven J.
Carleton University
Conservation physiology
Conservation physiology is a nascent interdisciplinary field that evolved in response to the growing number of anthropogenic threats facing the world's biodiversity. To that end conservation physiology aims to understand physiological responses of organisms to human alteration of the environment that might cause or contribute to population declines with a specific focus

on identifying cause and effect relationships. Moreover, conservation physiology uses physiological knowledge to evaluate and inform conservation and management actions, and to shape policy. Here I discuss the historical context, current state and future of conservation physiology. I also provide an overview of a conceptual framework for conservation physiology and highlight examples of success stories emerging from conservation physiology research.

Culbert, Brett and Kathleen Gilmour
University of Ottawa
Recovery from social subordination in rainbow trout
Rainbow trout (*Oncorhynchus mykiss*) held in pairs form dominance hierarchies where subordinates exhibit reduced activity and feeding, coupled with the depletion of energy stores, and maintain chronically elevated levels of the glucocorticoid stress hormone, cortisol. To determine how subordinates recover from such chronic social stress, pairs were separated following 4 days of interaction. Circulating cortisol and glucose values of 'recovered' subordinates had returned to baseline by 2 days of separation from the dominant, suggesting that the hypothalamic-pituitary-interrenal (HPI) axis had regained normal activity. This was supported by the ability of 'recovered' subordinates to mount a cortisol response to an acute stressor, whereas non-recovered subordinates could not. However, 'recovered' subordinates continued to exhibit reduced feeding and were unable to achieve non-subordinate status when paired with a socially naïve fish. These findings suggest that recovery of the HPI axis precedes behavioural recovery, and that subordinate behaviours persist after chronic social stress subsides.

Currie, Suzanne, Louise Tunnah, Emily Corey, Tyson MacCormack
Mount Allison University
Do prior diel thermal cycles influence the physiological response of Atlantic salmon to subsequent heat stress?
The Miramichi River has the largest remaining Atlantic salmon run in North America and fish now regularly experience temperatures exceeding the apparent lethal limit. We hypothesized that thermal preconditioning underpins their ability to physiologically cope with these conditions. We mimicked environmentally relevant thermal diel cycles to determine their effect on the response to an acute thermal event in wild fish and compared these responses to fish held at a stable acclimation temperature (16°C). We predicted that exposure to diel warming temperatures would offer protection from a subsequent heat shock. We observed that acclimation to a diel cycle of 16-21°C resulted in higher critical thermal maximum (CTmax) than fish acclimated to 16°C. CTmax increased further after 1 day of diel warming to 27°C. Prior exposure to 3 distinct thermal regimes over 84 h did not affect resting metabolic rate nor was metabolic rate different between these groups following an acute heat shock at 27°C. Heat shock proteins and ubiquitin were induced with diel warming and the nature (acute vs. cycling) of the prior thermal experience did influenced expression levels. Our results indicate a lack of thermal preconditioning and thus plasticity suggesting heightened susceptibility to climate warming in wild salmon.

Darveau, Charles-A., Loïc Teulier, Julie Crevier, Rebecca Rabinovitch
University of Ottawa
Evolution of mitochondrial metabolism in hymenopterans
Évolution du métabolisme mitochondrial chez les hyménoptères
Insect flight muscles have diverse metabolic properties. Bees are thought to be strict users of carbohydrates as metabolic fuel for flight, likely due to their high metabolic rate and ecological specialization feeding on flower nectar. Nevertheless, the possibility that hymenopterans evolved the capacity to oxidize another important metabolic fuel used by some insects to power flight, the amino acid proline, has been hypothesized but no clear evidence has been found so far. In a series of studies using high-resolution respirometry performed on flight muscle fibers, we have investigated the mitochondrial metabolism of bees and wasps species. While the honeybee shows no appreciable capacity to oxidize the amino acid proline, a closely related bumblebee species, and a more distant wasp more than double their mitochondrial respiration rate when proline is combined with carbohydrate derived substrates. Using a combination of substrates and inhibitors, we further show that in a bumblebee, proline oxidation provides reducing equivalents and electrons directly to the electron transport system. The mitochondrial physiology of our bumblebee model species was further described, including the kinetics to substrates and thermal sensitivity. Hymenopterans provide a great system to investigate the evolution of mitochondrial metabolism, which is diverse in this order of animals.

Dawson, Neal J., Kevin G. McCracken and Graham R. Scott
McMaster University and University of Miami
Muscle physiology and oxidative capacity in high-altitude Andean ducks and geese.

High-altitude environments are both cold and hypoxic, which requires that highland animals maintain high rates of O_2-consumption for locomotion and thermogenesis in exceedingly O_2-thin air. Specializations in respiratory physiology and metabolism have been suggested to help mitigate challenges at high-altitude in some highland taxa, but we know little about whether convergent strategies are employed across independent highland lineages. This study compared locomotory muscles of several sister taxa of high- and low-altitude waterfowl from the Andes, by measuring the activity of 16 enzymes from main pathways of energy metabolism, myoglobin levels, fibre-type composition, and capillarity. Convergent strategies to cope with high-altitude were evident in two independent highland taxa (cinnamon teal and ruddy ducks), in which aerobic capacity in flight muscle (as reflected by the activity of several oxidative enzymes) was increased. In highland torrent ducks, aerobic capacity (enzyme activities and muscle fibre respiration) was enhanced in the gastrocnemius muscle rather than the flight muscle. Interestingly, torrent ducks inhabit fast flowing rivers, and unlike the other species, they may use the gastrocnemius for swimming more often than the pectoralis for flying. Our data suggests that increases in muscle aerobic capacity are a common strategy to help sustain locomotion and thermogenesis at high-altitudes.

Deck, Courtney A. and Patrick J Walsh
University of Ottawa
Glucose transporter expression in the North Pacific spiny dogfish shark (*Squalus acanthias*) in response to glucose loading
Elasmobranchs are generally carnivorous, thus consuming very few carbohydrates, and it has been suggested that they are glucose intolerant. However, certain species, such as the spiny dogfish (*S. suckleyi*), incorporate molluscs and crustaceans into their diets which can consist of up to 25% carbohydrates, possibly leading to surges in plasma glucose. In a previous study, we identified glucose transporters (*GLUT*s) in three elasmobranch species and observed changes in mRNA levels in the dogfish in response to a protein meal and thus in this study, we sought to determine the effects of a glucose load. We hypothesised that glut mRNA increases in muscle and liver to allow greater glucose uptake and a reduction in plasma levels. Each dogfish was given an injection of glucose or saline and sacrificed at 6, 24, or 48h post-injection. In the glucose-injected fish, plasma glucose was still elevated at 6h post-injection but returned to control levels by 48h. In addition, muscle glycogen, *glycogen synthase*, and *gluts 1* and *4* were all significantly elevated following glucose injections. *Glut4* was also elevated in the liver. These responses are similar to those observed in mammals indicating a conserved mechanism for glucose homeostasis.

Des Marteaux, Lauren and Brent Sinclair
University of Western Ontario
Effects of cold acclimation on structure and transport function in insect ionoregulatory tissues
Insects lose ion and water homeostasis when chilled, implying that epithelial transport function is lost at low temperatures. Cold-acclimated insects are able to maintain homeostasis to lower temperatures than warm-acclimated conspecifics, but little is known about the mechanisms underlying loss of transport function in the cold, or how cold acclimation alters that function. The insect hindgut and Malpighian tubules (major sites of ionoregulation) are likely targets for modification during cold acclimation. To generate hypotheses about how homeostasis is either lost or maintained in the cold, we investigated the effects of cold acclimation on gene expression, hindgut structure, Malpighian tubule secretion, and active transport activity in chill-susceptible *Gryllus pennsylvanicus* crickets.

Deshpande, Prachi and Jim McGeer
Wilfrid Laurier University
Nickel and Copper Mixture Toxicity to *Daphnia* in Soft Water
Cu and Ni can be present at elevated concentrations in lakes, including those in the Sudbury, ON region. Their divalent-cation state (Cu^{2+} and Ni^{2+}) can be toxic at high concentrations in the water. The free-ion toxicity of these metals has been studied in isolation, but rarely as a mixture. The objectives were to: (1) determine Cu and Ni mixture toxicity to *Daphnia* through acute LC50 tests; (2) determine the appropriate model for analysis (concentration addition, independent action, or toxic units); (3) determine how dissolved organic carbon (DOC), influences toxic responses. It is hypothesized that these metals are transported across the membrane through different mechanisms, therefore mixture effects were hypothesized to be additive and follow an independent action (IA) model. Results indicate that Ni-Cu mixtures can be additive, synergistic or antagonistic depending on the metal concentrations. Most combinations tested produced a less-than-additive effect according to the IA and Toxic Unit models. Single-metal 48h LC50 for Cu was 2.43 µg/L (95% CI 2.15-2.82 µg/L) while Ni LC50 was 995 µg/L (877- 1125 µg/L). DOC was protective against 'Cu-only' and 'Cu-Ni mixture' exposures but not Ni alone. DOC protection varied by source composition. Clearwater Lake DOC was the most protective, followed by Daisy Lake, and Luther Marsh. This research is supported by a NSERC CRD, Vale, Xstrata, the City of Sudbury and the Ontario MOECC.

DeWitte-Orr (presenter), Sarah Poynter, Graeme Lisser, Amal Aloufi and Stephanie DeWitte-Orr
Wilfrid Laurier University, Department of Health Sciences

Type I Interferon mediated innate antiviral mechanisms in rainbow trout

Viruses are important fish pathogens and have devastating effects on fish farmed within aquaculture facilities worldwide. We study how viruses such as viral hemorrhagic septicemia virus, subtype IVb (VHSV-IVb), which presents a serious threat to many fish species in the Great Lakes and frog virus 3 (FV3), an emerging pathogen in North America, replicate in rainbow trout cells. We have found that both viruses produce double-stranded RNA during replication; indicating innate immune detection is possible at the cellular level in fish. We have found that this viral dsRNA, isolated from virus infected cells, is able to induce an innate immune response based on type I interferons. Additionally, the mechanisms behind FV3's replication, induced cell death and immunomodulation are also being explored. Collectively, this work is laying the groundwork for a better understanding of virus-host interactions in the economically important rainbow trout, with the goal of developing better aquaculture husbandry methods.

Dhillon, Rashpal S., Paul R. van Ginkel, Vivian Fu, Tomas A. Prolla, and John M. Denu
University of Wisconsin

Effects of SIRT3-mediated deacetylation on mitochondrial function of aging mice

The impact of SIRT3 expression has been shown to have a marked impact on mitochondrial acetylation status and may be responsible for attenuating age-related oxidative stress. Furthermore, caloric restriction, which induces SIRT3 expression, has been linked to increased longevity. However, the impact of acetylation on mitochondrial function over the lifespan of an organism remains largely unknown. Here, we used a multi-tissue approach to compare an array of physiological and biochemical parameters within the mitochondria of C57BL/6 mice in the SIRT3 $^{+/+}$ and $^{-/-}$ condition, fed control and calorically restricted diets, at 5, 15, and 25 months of age. Gastrocnemius, brain, liver and heart were measured for respiratory capacity, acetylomic status, mitochondrial structure, mtDNA expression, and protein expression. Generally, all tissues had markedly different respiratory responses to treatments, however, oxygen flux through complex II was responsive in almost all conditions. Our findings suggest that SIRT3 may play a pivotal role in the age-related response of the mitochondrial respiratory chain in a tissue-specific manner.

Dick, Morag and Christopher Guglielmo
University of Western Ontario

Management of oxidative stress during endurance flight in yellow-rumped warblers

Migratory flight requires birds to sustain high levels of ATP production. A consequence of this is increased production of reactive oxygen species (ROS), which birds must manage. Membrane polyunsaturated fatty acids (PUFA) are prone to oxidative damage, which could impair cell function. However, PUFA may also help lower mitochondrial ROS production. We examined how birds manage oxidative stress during endurance flight when fed diets high in long chain PUFA. Yellow-rumped warblers were fed diets low in long chain PUFA, or high in long chain n-3 PUFA or n-6 PUFA for 6 weeks. Half the birds in each diet were sampled as controls, and the other half were voluntarily flown for up to 6 h. In the flight muscle, superoxide dismutase activity increased by 17% during flight, with a similar trend for catalase. By increasing the activity of antioxidants, birds are better equipped to manage the oxidative challenge created by flight. Furthermore, this response is not altered based on the proportions PUFA in the flight muscles. We will also report on additional antioxidants and markers of cellular damage in the flight muscle. Overall, our study is one of the first to examine how birds manage ROS during endurance flight.

Dindia, Laura, Sarah Alderman, Anthony Farrell, Christopher Kennedy and Todd Gillis
University of Guelph

Identification of plasma biomarkers for bitumen exposure in sockeye salmon (*Oncorhynchus nerka*)

Pipelines transporting diluted bitumen (dilbit) transect the freshwater habitat of Pacific salmon. Critically, exposure to crude oil and its constituents can affect the development, reproductive capacity, and aerobic fitness of fish; therefore, identification of a plasma biomarker for dilbit exposure that also predicts performance impairment will be a valuable management tool. Juvenile sockeye were exposed to an environmentally relevant level of the water-soluble fraction of dilbit (WSFd) for one or four weeks, and half of the exposed fish also underwent an exhaustive swimming test. The plasma proteomes were then characterized using isobaric tags for relative and absolute quantitation (iTRAQ). Three proteins were robust predictors of WSFd exposure, independent of exposure duration or exercise, namely complement component C7, hemopexin, and alpha-2-marcoglobulin. In non-exercised salmon, WSFd altered plasma levels of 17 proteins related to coagulation, immune, and stress responses. In WSFd-exposed and exercised salmon, 20 proteins were significantly altered including increased abundance of energy transport proteins and myosin, suggesting that WSFd exposure exacerbates exercise-induced muscle injury. This study has identified

several potential plasma biomarkers for WSFd exposure and suggests that dilbit exposure could impair the capacity of salmon to sustain or recover from intensive exercise.

Dooner, Caryn, Amanda J Moehring, Susanne E Kohalmi
University of Western Ontario
Characterizing the genetic basis of behavioural isolation between *Drosophila* species
Species can be characterized as reproductively isolated populations. Behavioural isolation can occur due to divergence in aspects of courtship and mating, and can contribute to reproductive isolation. *Drosophila melanogaster* and *D. simulans* are found in overlapping geographical regions but are behaviourally isolated from one another, as *D. simulans* females will not mate with *D. melanogaster* males. A previous mapping study identified *Nmt* as a gene that contributes to female rejection behaviour between *D. melanogaster* and *D. simulans*. The purpose of this study is to determine how *Nmt* contributes to female rejection behaviour. The gene region for *Nmt* has been sequenced in both *D. melanogaster* and *D. simulans* for comparative analysis. Preliminary semi-quantitative expression data suggest that *Nmt* expression levels are similar across tissue types and life cycle stages tested when comparing both species. Quantitative analysis is being used to determine if more subtle differences exist. The GAL4/UAS system has been used to rescue *Nmt* expression in a tissue-specific manner in an effort to determine particular tissues that contribute to *Nmt*-mediated female rejection behaviour. The results from this study will contribute to understanding what, at the molecular level, contributes to behavioural isolation between two model species of *Drosophila*.

Duclos, Kevin, Thomas Grünbaum (UdeM), Richard Cloutier (UQàR), Bernard Angers (UdeM)
Université de Montréal
Show me yours, I'll show you mine: phenotypic differences in sympatric clonal hybrids
Montre moi ton clone, je te montrerais le mien: différences phénotypiques entre des hybrides clonaux en sympatrie
Phenotypic plasticity can modify the range of habitats for a given organism by increasing variation in functional traits regardless of genetic variation. Therefore, this mechanism is expected to reduce competition between closely related organisms by allowing them to change their habitat use. The *Chrosomus eos-neogaeus* complex includes several clonal lineages resulting from interspecific crosses between *C. eos* and *C. neogaeus*. East-Québec is characterized by the presence of a widespread lineage in addition to few lineages with narrow distributions. This widespread lineage offers an ideal model system to assess the role of phenotypic plasticity in creating ecological variation and in niche partitioning in the absence of genetic variation. This project investigates whether coexistence with additional sympatric lineages of *C. eos-neogaeus* results in phenotypic differences due to a niche shift. Using µCt-scanned models of the skeleton, the mandibles, pharyngeal arches, pectoral girdle and opercular series were segmented and measured using 3D geometric morphometric analyses. The widespread lineage revealed impressive phenotypic plasticity in different habitat types for each selected structure. However, the shape of trophic structures is not affected by sympatry suggesting the presence of an additional lineage is not interpreted as an alternative environmental signal, at least for this lineage.

Dzal, Yvonne A., Julia M. York, Paul A. Faure and William K. Milsom
University of British Columbia
Are hibernating bats just big babies? Metabolic, thermoregulatory, and ventilatory responses of bats to hypoxia
There are striking parallels in physiological traits between all newborn mammals and adults of species capable of hibernation. Tolerance to low environmental oxygen (hypoxia) is one of these. Hypoxia tolerance is not present in adults of most non-hibernators. Accordingly, we hypothesized that differences in hypoxia tolerance in adult hibernators and non-hibernators reflect developmental changes in the way oxygen demand and supply are matched. To test this hypothesis, we exposed newborn and adult hibernators (big brown bat), adult daily heterotherms (Argentine brown bat), and adult non-hibernators (little yellow-shouldered bat) to hypoxia and measured their metabolic, thermoregulatory, and ventilatory responses. Severe hypoxia (7% O_2) led to a profound depression in oxygen demand in newborn (-57 ± 6%) and adult (-43 ± 12%) hibernators, and adult daily heterotherms (-40 ± 14%), independent of decreases in body temperature. However, adult non-hibernators maintained oxygen demand in hypoxia (+19 ± 23%), by increasing oxygen supply through a significant increase in ventilation (+105 ± 21%) instead. Our results suggest that bats employ divergent strategies to tolerate hypoxia. Non-hibernators match oxygen supply to demand in hypoxia by a brisk ventilatory response, while adult hibernators, and daily heterotherms are just big babies, suppressing oxygen demand to match supply.

Elliott, Kyle H., Gustavo S. Betini, D. Ryan Norris and Ian Dworkin
McGill University
Scared fitless: context-dependent response of fear to loss of predators over evolutionary time
La réaction de peur à la perte des prédateurs au cours du temps évolutionaire dépend du context
Fear of predation can disappear rapidly in the absence of predators, as bolder individuals outcompete for food and mates those that take fewer risks, yet laboratory animals maintain fear of predation seemingly indefinitely. To examine the evolution of fear in a seasonal environment, we exposed Drosophila to mantid predators in the breeding season, non-breeding season or neither. We compared three Drosophila lines that were maintained in captivity: (1) for ~45 years ('stock'), and for ~5 years (2) without mantid predators ('control-evolved') and (3) with mantid predators ('predator-evolved'). The presence of predator scent during the non-breeding season caused reduced fecundity during the breeding season, but the effect did not vary with evolutionary line. The presence of predator scent during the breeding season caused offspring to emerge earlier, and this effect was more pronounced in the 'predator-evolved' lines. Thus, the fear response was higher in the predator-evolved lines only at the larval life stage, which is when foraging competition and hence the cost of fear was highest.

Eom, Junho and Chris M. Wood
University of British Columbia
Is ammonia excretion affected by gill ventilation in rainbow trout *Oncorhynchus mykiss*?
In ammoniotelic teleost fish, ammonia is the third respiratory gas. Recent studies have shown that elevations in plasma ammonia act as a specific ventilatory stimulant in trout, acting at least in part via the neuroepithelial cells (NECs) on gill arches 1 and 2. These are the same cells which mediate hyperventilatory responses to O2 and CO2. However it has been argued that branchial ammonia excretion is diffusion-limited, such that changes in ventilatory water flow would not affect ammonia efflux across the gills. Why then should elevated plasma ammonia stimulate ventilation ? However, the diffusion-limitation argument was made before the discovery of Rh proteins (ammonia channels) in fish gills, which are known to be induced by ammonia loading, thereby greatly increase gill ammonia permeability. In this study we are using variations in environmental O2 levels to manipulate breathing in trout (hypoxia –> hyperventilation; hyperoxia-> hypoventilation) while simultaneously quantifying ventilation and ammonia excretion, under control and ammonia-loaded conditions. Results to date indicate that changes in ventilation under control conditions have only minimal effects on ammonia excretion. (NSERC Discovery).

Eslamloo, Khalil, Xi Xue, Marije Booman and Matthew L. Rise
Department of Ocean Sciences, Memorial University of Newfoundland, NL, A1C 5S7, Canada
Global gene expression of Atlantic cod macrophages in response to viral mimic stimulation
Functional genomics techniques were used to investigate the transcriptome response of Atlantic cod (*Gadus morhua*) macrophages to the viral mimic polyriboinosinic polyribocytidylic acid (pIC). Macrophages from 6 fish, treated with phosphate-buffered saline (control) or 50 μg/ml pIC for 24 h, were used for microarray analysis. We identified 285 significantly up-regulated and 161 significantly down-regulated probes in pIC-stimulated macrophages. qPCR assays using cod (n=6) macrophages stimulated by pIC and sampled at time points from 3 to 48 h validated the microarray results for 79% of studied genes. The microarray and qPCR analyses revealed that pIC induced the expression of cod macrophage transcripts involved in TLR-dependent pathogen recognition. We identified several pIC-responsive transcripts involved in signal transduction and transcriptional activation. In addition, some genes associated with oxidation-reduction process were down-regulated in pIC-stimulated macrophages. qPCR showed the up-regulation of some transcripts (e.g. irf7 and irf10) by pIC at 12 h post-stimulation. However, peak expression for pIC-responsive transcripts was at either 24 h (e.g. *tlr7*, *irf7*, *mip2*) or 48 h (e.g. *tlr3*, *lgp2*, *stat1*). In addition to conserved antiviral effectors such as *isg15* and *viperin*, pIC stimulation also triggered the expression of potentially fish-specific immune effectors such as *mig2* and *bty* in cod macrophages.

Evans, David, Kentaro Chiba and Nicolas Campione
University of Toronto
Developmental Mass Extrapolation: An Empirical Test
In the last two decades, paleobiologists have reconstructed growth curves of extinct reptiles (primarily dinosaurs) using skeletochronology and sophisticated age retrocalculation methods, combined with limb-scaling methods for estimating body mass, in ontogenetic series of specimens. However, estimation of juvenile body masses is problematic because intraspecific limb-body mass scaling patterns, which are poorly constrained in fossil taxa, do not necessarily follow interspecific ones. To address this problem, Developmental Mass Extrapolation (DME), a simple geometric scaling method, was proposed for estimating the mass of juveniles. It has been commonly employed in paleobiological growth studies, but has never been empirically tested. In order to test DME, body masses for ontogenetic series in four phylogenetically disparate taxa (*Alligator*

mississipiensis, *Iguana iguana*, *Procyon lotor*, and *Struthio camelus*) were estimated using DME and two interspecific limb scaling equations (all tetrapod, subclade-level), using both femur length and circumference as standards, and compared against their actual masses using mean percent prediction errors. As predicted, DME consistently performed best. However, femur circumference performed better than length, which is typically used for DME, since it is subject to less allometric variation with respect to body mass. These results validate DME, and therefore alleviate uncertainty surrounding growth curve reconstructions in extinct forms.

Faught, Erin and Matt Vijayan
University of Calgary
Stress Bubbles: Role of Exosomes in Cellular Stress Response in Rainbow trout
Exosomes are a subtype of cell-secreted extracellular vesicles, approximately 40-100 nm in diameter. They are formed from endosomal compartments, and contain both proteomic and genomic information. Mammalian studies suggest a key role for secreted exosomes in cell to cell signalling, but very little is known about their role in lower vertebrates. Recently we showed that the intracellular chaperone, heat shock protein 70 (Hsp70) is exported into the plasma of rainbow trout (*Oncorhynchus mykiss*), independent of cell lysis. Therefore, we tested the hypothesis that exosomes mediate export of Hsp70 into the plasma, and may play a role in cross-tissue communication in trout. Exosomes in trout plasma were confirmed by electron microscopy and enzyme measurements. The exosome payload composition was established by mass spectrophotometry and RNA sequencing. Hsp70 protein levels were enriched in the exosome fraction of trout plasma. We further postulated that the Hsp70 found in plasma exosomes was derived from the liver. Our results suggest that not only are Hsp70 positive exosomes released from hepatocytes, but that its abundance may be modulated by the stress hormone cortisol. Overall, this novel finding underscores a key role for exosomes in modulating cell to cell signaling during stress in fish.

Ferguson, Laura V., Golnaz Salehipour-shirazi, David E. Heinrichs and Brent J. Sinclair
University of Western Ontario
How do pathogens and immunity shape insect success at low temperatures?
The interactions between animals and biotic pressures, such as pathogens, shape success under different thermal landscapes. To understand how these interactions dictate success at low temperatures, we explored the thermal biology of the insect immune system. We examined cold-activation, thermal plasticity, and seasonal fluctuations in immune activity, as well as the thermal interactions between hosts and pathogens. We find that immune activity appears to trade-off with the response to cold, manifesting as a compensatory increase in activity following cold stress, and a paradoxical narrowing of thermal performance following cold acclimation. Seasonal fluctuations in immune activity are idiosyncratic among species, but point to selection for individuals with strong immune responses, and a dependence of spring immunity on microhabitat and energy use. Lastly, the outcome of host-pathogen relationships depends on thermal plasticity, and whether hosts and pathogens are matched in their thermal performance. Overall, we demonstrate that the activity of the immune system, and thus the ability to respond to pathogens, is tightly linked to the thermal environment and the physiological response to cold. Therefore, changes in the thermal environment will shift both acute and seasonal immune responses, the outcome of infections, and the success of insects in a changing climate.

Fraz, Shamaila, Abigail Lee and Joanna Wilson
McMaster University
Multi generational effects of pharmaceutical exposure in zebrafish (*Danio rerio*)
Reproduction serves an important eco-toxicological assessment tool and multiple pharmaceutical compounds appear to disrupt reproduction in fish. Previous research in our lab has shown that exposure of zebrafish to carbamazepine and gemfibrozil altered fecundity and increased atretic oocytes; plasma 11-ketotestosterone (KT) concentrations were lowered with carbamazepine exposure. We exposed adult zebrafish to 10µg L-1 of either carbamazepine or gemfibrozil for 6 weeks and determined effects on the parents and their offspring reproductive physiology. Exposure of parents impacts reproduction, sperm speed and morphology, male courtship and aggression, and sex steroid levels. We have reared F1 – F3 offspring in clean water and have evidence of effects in at least the F1 and F2 generation indicating toxic effect transfer across generations. Hence, chronic parental exposure to gemfibrozil and carbamazepine can lead to endocrine disruption and may intervene with normal reproductive processes vitally regulated by sex hormones.

French, Marie-Catherine, Nicole Beckett, Madeline Campbell, Jessica Fahey, Laura Ferguson, Todd Smith, Shelley Adamo
Acadia University
Examination of the effects of variable environmental factors on the fecundity of the mosquito, *Culex pipiens*

Culex pipiens is the most widespread species of mosquito in the world, accountable for transmitting West Nile Virus and other blood-borne pathogens among many hosts. There is little known about the role of ecological factors on fecundity of these mosquitoes, particularly on availability of food between blood meals and increased temperatures characteristic of climate change. The objective was to determine the effects of availability of sucrose and variable temperatures on the fecundity of *Culex pipiens*. Female mosquitoes were divided into six cohorts, provided with either a 2% or 20% sucrose solution, and incubated at either 22, 25, or 30 C. Egg rafts oviposited by mosquitoes were subjected to fecundity analyses based on length, width, and cross sectional area of each egg, number of eggs per raft and hatching success of larvae. Results revealed a significant increase in mean number of eggs from 22 C to 25 C and a significant decrease in mean number of eggs from 25 C to 30 C. However, there was no significant difference in mean number of eggs between the 2% w/v to 20% w/v sucrose diet. There was a significant decrease in mean egg length comparing 22 C and 25 C to 30 C, but no differences in mean width or cross-sectional area. Lastly there was a significant decrease in mean egg length, width, and cross-sectional area from a 2% w/v to 20% w/v sucrose diet.

Fudge, Douglas
University of Guelph
Unraveling the mysteries of hagfish slime: a biophysical approach
Hagfishes thwart attacks by fish predators by producing an unusual defensive slime, which differs from other slime secretions in that it is permeated by thousands of silk-like fibres. Other unique features of the slime include a remarkably fast set up time, and an ability clog flow across gills even at very low concentrations of mucus and fibres. I will discuss our attempts to understand the function of the slime using a biophysical approach. This will include an elucidation of the processes of slime production in the slime glands, slime deployment in seawater, and the biophysics of gill clogging. It will also include a discussion of our attempts to understand how the enigmatic gland thread cell produces an elaborately coiled and spring-loaded thread within its cytoplasm that is 100,000 times longer than it is wide.

Gamperl, Kurt, Doug Syme, Christian Carnevale, Jordan Roberts, Alexander Thomas and Devyn Ramsay
Memorial University of Newfoundland
Myocardial Strips are Really Interesting: Who Would Have Thought?
While an M.Sc. student at the University of Guelph, who was only interested in working on live animals and nothing 'smaller than my thumb', Don exposed me to a wide range of physiological techniques that I never thought I would use (including isolated muscle techniques!). My research career has come full circle, and in this talk I will present data from experiments using cycling myocardial strips that investigate two aspects of fish cardiac function. First, I will show that: 1) the diminished ability of the trout heart to pump after 10°C-acclimated fish are exposed to chronic hypoxia (40% air saturation) is due to a decrease in shortening work (i.e. decrease in inotropy), not lengthening work; and 2) that the capacity of the myocardium to perform work and power during progressive hypoxia is less, not more, in hypoxia-acclimated fish and that recovery is poorer. Second, I will show that the capacity of fish (trout) heart muscle to develop work and power is highly dependent upon the interaction of strain (change in muscle length) and frequency at 10°C, but not at 22°C. These data provide significant insights how the fish heart functions, and is impacted by, changing environmental conditions.

Gasbarrini, Donnell, David Lesbarrères, Anna Sheppard, Ed Morris, Jacqueline Litzgus
Laurentian University
An Investigation into the Cause of a Mass Mortality Event of Blanding's Turtles (*Emydoidea blandingii*)
Mass mortality events (MMEs) can remove up to 90% of individuals in a population, which is especially damaging to long-lived species with low capacity for recovery. Our study aims to determine the causes of a MME of threatened Blanding's turtles (*Emydoidea blandingii*), in Misery Bay Provincial Park (MBPP), Ontario, Canada. The typical anthropogenic threats to turtles are virtually absent in the MBPP setting, and yet 53 Blanding's turtles were found dead without obvious cause in 2013. Potential causes of death under consideration include predation, failed overwintering through either metabolic/respiratory acidosis, and freezing. Telemetry and mark-recapture studies were used to monitor live animals, to look for clues to the cause of death, and to monitor overwintering habitat. Motion-sensor activated trail cameras were paired with a Blanding's turtle decoy to identify predators within the park. Potential predators identified include otter, mink, coyote, and raccoon. No significant differences in temperature and dissolved oxygen content of water were found between known overwintering sites and sites near where turtle carcasses were found. Based on evidence collected to date, predation seems a likely cause of death. Our study will be informative for the conservation of this population, and for the management of future MMEs.

Giacomin, Marina, Patricia Schulte and Chris Wood
University of British Columbia
The two faces of the osmorespiratory compromise in *Fundulus heteroclitus*
The characteristics of the fish gill that maximize gas exchange, such as large surface area and thin diffusion distance, are the same as those that promote diffusion of ions from the blood to water or vice versa. We investigated the potential physiological trade-offs at the gills of *F. heteroclitus* under hypoxia at different salinities. Our hypothesis was that animals would be more tolerant of hypoxia when tested at their isosmotic salinity. Hypoxia tolerance (through loss of equilibrium (LOE) test) was assessed in animals acclimated to 0, 3, 11 (isosmotic), 15 and 35 ppt at their acclimation salinity and after acute transfer to 11ppt. Additionally, Na+ influx and efflux rates; Cl^-, K^+ and NH^+ net fluxes were measured in fish acclimated to O, 11 and 35 ppt under hypoxia. Our results indicate that hypoxia tolerance is reduced at acclimate salinities below 11ppt, but not at salinities above the isosmotic point. Acute transfer to isosmotic salinity did not affect hypoxia tolerance (NSERC Discovery).

Gibson, Glenys and Olivia Genereux
Acadia University
Bisphenol A (BPA) disrupts regeneration in *Pygospio elegans* (Annelida)
BPA is a common environmental contaminant that is known to disrupt development as, for example, in mice where BPA acts as both an endocrine disruptor and also by demethylating DNA. This raises the question of what effect BPA has on the development of estuarine invertebrates as most estuaries are exposed to BPA in wastewater discharge. Also, recent work has found that BPA bioaccumulates in some marine species. We tested the effects of BPA on regeneration in *Pygospio elegans*, a spionid polychaete that is abundant in estuaries and tidal flats of the North Atlantic. *P. elegans* exposed to BPA had delayed blastema formation and growth, relative to controls. Preliminary results suggest this is due to inhibition of mitosis (Click-It Plus Edu cell proliferation kit) and also of apoptosis (Click-It Plus Edu TUNEL). Subsequent treatment with folate/ vitamin B_{12} 'rescued' blastema development leading to complete regeneration. These results suggest that BPA disrupts regeneration by inhibiting typical cell cycles, but also, that these effects may be reversed in early blastema formation by exposing the worms to a different environment.

Gilbert, Matthew J.H., Hamid Safi, Anthony P. Farrell
University of British Columbia
Atrioventricular dyssynchrony may underlie cardiac collapse at warm temperatures in fish
Fish generally increase their heart rate with temperature to a maximum after which heart rate either becomes arrhythmic, or decreases and then becomes arrhythmic. This performance limitation obviously constrains oxygen delivery at supra-optimal temperatures and is also thought to contribute to setting the upper thermal tolerances of fish. To elucidate mechanisms that may underlie temperature induced cardiac arrhythmias we analyzed electrical (ECGs) and mechanical characteristics of cardiac function during acute warming. Prior to arrhythmia we identified changes in the interval between atrial and ventricular contractions and a common atrioventricular (AV) dyssynchrony during arrhythmia that consisted of rhythmic atrial contractions with missed ventricular contractions. These findings suggest that thermally induced cardiac arrhythmia may arise because of an AV conduction blockage or the atrial signal overlapping the ventricular refractory period. Supported by NSERC

Gilmour, Kathleen M. and Michael Brannen
University of Ottawa
Carbonic anhydrase expression in the ionocytes of the rainbow trout gill
Current models of branchial ion uptake in freshwater rainbow trout (*Oncorhynchus mykiss*) propose two main ionocyte types; the peanut lectin agglutinin-positive (PNA+) mitochondrion-rich cell (MRC) takes up Cl^- in exchange for HCO_3^-, whereas active Na^+ uptake occurs across PNA- MRCs in exchange for H^+. Both HCO_3^- and H^+ are supplied by intracellular hydration of CO_2 catalyzed by cytosolic carbonic anhydrase (CAc). Thus, both ionocyte types are expected to express CAc.
Immunohistochemical approaches revealed that under control conditions, CAc was present primarily in PNA- MRCs, and these cells increased in number in response to systemic acidosis. The number of PNA+ MRCs that expressed CAc under control conditions was low but increased markedly in response to systemic alkalosis. These results suggest that regulation of CA within PNA+ MRCs plays a role in activating base secretion to respond to an acid-base disturbance.

Glover, Chris, Som Niyogi, Tamzin Blewett, Chris Wood
Athabasca University
Eating with your mouth closed: the promiscuity and functionality of hagfish skin as a transport epithelium

The skin of hagfish is capable of absorbing amino acids directly from the water, making it the only known vertebrate that can eat with its mouth closed. Recent studies have explored two key questions regarding the nutritive role of the hagfish cutaneous epithelium: is this a locus for the absorption of other nutrient substrates, and what is the functional role of this phenomenon? This presentation will explore evidence showing that the skin of hagfish is a site of uptake for inorganic trace elements, focussing on the absorption of iron. In addition, and contrary to initial expectations, studies in fed versus fasted hagfish appear to indicate that the skin plays a relatively more important role in basal nutrition, rather than supplementing dietary nutrient absorption during periods of immersive feeding in decaying carcasses. The evolutionary and environmental importance of the skin as an absorptive epithelium will be discussed.

Gomes, Janice and Jason C.L. Brown
University of Toronto Scarborough
Do ageing theories based on animal studies apply to plants?: The effects of exogenous H_2O_2 on annual and perennial flax
The oxidative theory of ageing suggests that reactive oxygen species (ROS, e.g., H_2O_2) cause oxidative damage that results in ageing. While this theory has been extensively studied in animals, its extension to plants remains untested. Based on the theory, we predicted that germination and vegetative growth in annual and perennial flax (*Linum*) would be differentially affected by exogenous H_2O_2 exposure. H_2O_2 stimulates germination but negatively affects vegetative growth. We therefore predicted that annual (but not perennial) flax exposed to H_2O_2 would germinate faster due to lower rates of ROS scavenging. We further predicted that vegetative growth would be negatively affected by H_2O_2 in annuals but not perennials. We found that H_2O_2 stimulated germination in both annuals, but only two of three perennials, as *Linum flavum*, which is more distantly-related to the annuals and other perennials used, did not germinate faster upon H_2O_2 exposure. Vegetative growth was not significantly affected by H_2O_2 in either annuals or perennials. We conclude that some perennial species may have higher antioxidant levels to limit the damaging effects of H_2O_2, but more work is required to clarify whether differences in ROS production underlie differences in lifespan in plants as in animals.

Gordy, Michelle A., Janet Koprivnikar, Lisa Kish, Valerie K. Phillips, Mahmoud Tarrabain, and Patrick C. Hanington
School of Public Health, University of Alberta
Natural variation and the impact of environment on snail-digenean communities in central Alberta lake ecosystems
Digenean trematodes are a highly diverse group of parasitic flatworm, with an estimated 18,000 species, known, collectively, to infect the largest diversity of animals on the planet. The geographical distribution of digeneans is driven by host compatibility and availability within a suitable environment. However, the crux of digenean life cycles is their reliance on particular snail intermediate hosts for their larval development, which most often takes place in aquatic environments. Very little is known about digenean and snail diversity, compatibility, and community structure within Canadian lake ecosystems, nor how environmental impacts may affect these communities. A three year, longitudinal survey was conducted among six lakes in central Alberta to acquire relevant information to begin these assessments. The purpose was to gain an understanding about snail-digenean communities and the potential for transmission to definitive hosts, and how this may be affected by alterations to environmental or ecological factors. Models were used to assess the natural variation across communities and determine if particular factors could be considered as key drivers of community structure in these ecosystems.

Gray, Suzanne M., Laura H. McDonnell, Nicholas E. Mandrak, and Lauren J. Chapman
The Ohio State University
The influence of turbidity on the physiology of imperiled blackline shiners (*Notropis* spp.) in the Great Lakes
Increased sedimentary turbidity associated with human activities is often cited as a key stressor contributing to the decline of fishes globally. The mechanisms underlying negative effects of turbidity on fish populations are not well understood, but may include effects on behavior (e.g., visual impairment) and/or respiratory function (e.g. clogging of the gills). The decline or disappearance of several blackline shiners (*Notropis* spp.) in the Laurentian Great Lakes has been associated with increased turbidity. Here, we used non-lethal physiological methods to assess the responses of three blackline shiners (Pugnose, *N. anogenus*; Bridle, *N. bifrenatus*; Blacknose, *N. heterolepis*) to increased turbidity. Fish were exposed for 3-6 months to continuous low levels of turbidity (~10 NTU). To test for effects on respiratory function, we measured both resting metabolic rate and critical oxygen tension (the oxygen partial pressure at which the resting metabolic rate of fish declines). Our results suggest that critical oxygen tensions are negatively affected by long-term exposure to low levels of sedimentary turbidity in imperiled Pugnose and Bridle Shiner, but not the more abundant Blacknose Shiner. These results indicate inter-specific variation in the effects of turbidity on respiratory performance, which may contribute to the current status of the three species.

Grecias, Lucie, Chloé Berger, Iain Barber and Nadia Aubin-Horth
Université Laval
Is the stickleback manipulated by its parasitic flatworm? Combining phenotypic engineering and transcriptomic approaches L'épinoche est-elle manipulée par un vers plat? La combinaison des approches d'ingénierie phénotypique et de transcriptomique.
Sticklebacks infected by the parasitic flatworm *Schistocephalus solidus* show large changes in phenotype, including a lack of the typical behavioral response to predator presence. Interestingly, these changes occur when the parasite is ready to move to its final host (a piscivorous bird) to reproduce, which makes it an ideal model for studying the mechanisms of behavioral modification by parasites. However, whether this drastic behavior change is a by-product of facing a parasitic infection, or the result of a direct manipulation by the parasite is unknown. We used two approaches to test predictions arising from these hypotheses. First, we used phenotypic engineering to recreate the behavioral modifications using pharmacological manipulations. We were able to recreate some aspects of the behavioral modifications observed in a parasitized fish, but not others. Second, we used an RNA-Seq analysis to compare the whole-brain transcriptome of healthy, exposed, infected and pharmacologically manipulated (fluoxetine) sticklebacks, to define a genomic signature of *Schistocephalus* infection in the host brain, and to uncover overlaps in transcriptomes between infected and fluoxetine-treated fish. Our use of a combined approach to uncover the causes of behaviour modification by a parasite will contribute to shed a new light on this parasite-host interaction.

Gregory, Jensen and Steve Perry
University of Ottawa
The role of serotonin in the hypoxic ventilatory response of larval zebrafish
Neuroepithelial cells (NEC) are oxygen sensitive chemoreceptor cells found throughout the skin of larval zebrafish (*Danio rerio*). Zebrafish larvae are sensitive to changes in PO_2 as early as 2 days post fertilization (dpf), and they hyperventilate in response to hypoxia. Tryptophan hydroxylase is the rate limiting enzyme in serotonin synthesis and there are three tph paralogs in zebrafish (tph1a, tph1b and tph2). The purpose of this study was to determine the role of serotonin in regulating the hypoxic ventilatory response in larval zebrafish. This was accomplished by using immunohistochemistry to visualize the localization of tph within NECs. This was followed by pharmacological inhibition and genetic manipulation of tph. PCPA, a non-selective tph inhibitor was used for pharmacological inhibition, while morpholino antisense oligonucleotides and CRISPR-Cas9 were used for tph knockdown and knockout respectively. The ventilatory response of larval zebrafish with diminished serotonin in their NECs implicate serotonin as a key neurotransmitter regulating the hypoxic ventilatory response.

Guglielmo, Christopher G.
University of Western Ontario
The challenge of empirically testing hypotheses about the physiology of global-scale migrations of birds
Physiologists are empiricists who want to know how animals work, and physiological ecologists seek to extend this knowledge into the context of free-living animals in nature. Migratory birds offer excellent models to study the limits of high intensity endurance exercise. Flapping flight is the most energy expensive form of aerobic exercise, and long-distance migrants have evolved the capacity to sustain flight for days or even more than a week. Studying the physiology of exercise that lasts for so long, may take place at high altitude, and moves your study animals over such great distances presents special challenges. Much has been learned by examining seasonal changes in physiology and biochemistry, but conducting studies at the whole animal level is difficult. I will review what has been learned about the physiology of bird migration from captive birds manipulated into the migratory state and flying them in wind tunnels, and from wild birds migrating with biotelemetric devices. I will discuss the effects of factors like diet, high altitude, humidity, and environmental contaminants on flight performance, and illustrate how conditions have never been better to study bird migration physiology in the lab and field.

Guy, Cylita, Jeneni Thiagavel, Nicole Mideo, and John M. Ratcliffe
Department of Ecology and Evolutionary Biology, University of Toronto – Toronto, ON
Who You Live With Matters: Determinants of Viral Richness in Bats
Bats (Order Chiroptera) are important reservoirs for viral pathogens, a number of which are high impact zoonotic diseases. We investigate determinants of viral richness in bats, expanding on prior analyses that have considered life history traits and geographic distribution. Specifically, in conjunction with life history, we examine how foraging ecology (diet, foraging mode), migration status, and group characteristics (size, social structure, roosting associations) may explain patterns of viral diversity. Results from preliminary species level analyses are in accordance with prior work, suggesting larger bats and those that give birth more frequently may carry more viruses. Sympatry has also been shown to be an important determinant of viral richness

in bats. Our data more specifically indicate that the number of other bat species a bat shares a roost with is positively related to viral diversity. We also found a positive correlation between viral diversity and intraspecific social group size. As had authors before us, we found no strong support for the idea that migration is a means of circumventing viruses, in addition to ecto- and endoparasites. To further consider the effects of shared ancestry and interactions between variables, we are currently analyzing data in a comparative and multivariate framework.

Hall, Laura and Shelley Adamo
Dalhousie Univeristy
The not very hungry caterpillar: Potential molecular conflict between detoxification and immune defense in *Manduca sexta*
Like other animals, larval *M. sexta* lose their appetite after an immune challenge, yet the biological function of this illness-induced anorexia is poorly understood. This research examines the hypothesis that illness-induced anorexia allows the caterpillar *M. sexta* to shift molecular resources from food detoxification to immune function. Appetite loss occurred after injection of either sephadex beads, which induce encapsulation, heat-killed Gram negative bacteria (*Serratia marcescens*) or Gram positive bacteria (*Bacillus cereus*), which induce nodulation. Therefore, illness-induced anorexia appears to be a general response to immune activation in *M. sexta*, as it is in vertebrates. Caterpillars that received an immune challenge were more likely to die after ingesting permethrin than that those did not. Conversely, a sublethal dose of permethrin reduced resistance to the Gram negative bacterium *S. marcescens*. These results suggest that there is a negative interaction between detoxification and immune defense. During an immune challenge, caterpillars were less likely to consume food containing traces of quinine. We used qPCR to test for a potential molecular conflict between detoxification and immune defense. We examined the expression of detoxification and immune genes to test for this shift.

Halliwushka, Kelsey and Andreas Heyland
University of Guelph
Sublethal effects of fluoxetine on *Daphnia magna*
Pharmaceuticals are found at increasing levels in wastewater treatment plant effluents, and surface waters around the world. After being ingested by humans, these compounds are excreted into wastewater systems unchanged or as active metabolites. Fluoxetine hydrochloride (FLX) is one of the most prescribed antidepressants, and has a high persistence in aquatic environments. Fluoxetine is known to have toxic effects on various aquatic species, and levels of FLX ranging from 50ng to 99ng/L have been detected in the Great Lakes Region. The purpose of this study is to look at how the exposure of *Daphnia magna* to environmentally relevant levels of FLX affects their development, physiology, and reproduction. Our study looked at the heartrate of *D. magna* exposed to FLX. It was shown that there is a significant reduction in the heartrate of the *Daphnia* exposed to FLX. In addition, a transgenerational study consisting of 4 generations of *D. magna*, with only the first generation exposed to FLX during embryogenesis, saw an increase in the number of offspring produced by FLX treated *Daphnia* in the first generation. However, in the third and fourth generations, *D. magna* offspring whose first generation were exposed to FLX were significantly smaller than the control.

Hammer, Christine L. and Tamara A. Franz-Odendaal
Saint Mary's University
The effect of hydrocortisone injections on the sclerotic ring
The loss of the sclerotic ring has occurred in several vertebrate lineages, including mammals, over the course of evolution. The developmental aspects which led to this loss are not understood. In reptiles, the sclerotic ring is composed of a series of bones or scleral ossicles. These ossicles are situated in the sclera of the eye and are induced by thickenings of the overlying conjunctival epithelium. Our lab has previously used localized disruption methods to prevent the development of single ossicles. Recently, we expanded this research to include a global disruption method in an attempt to disrupt the entire sclerotic ring. We injected hydrocortisone (the pharmaceutical version of the stress hormone cortisol) onto the chorioallantoic membrane of developing chick embryos. Chickens normally have 13-15 scleral ossicles per eye, however 64.3 % of hydrocortisone treated embryos developed only 0-4 scleral ossicles per eye, and 78.6% had severe defects in ossicle morphology. Because hydrocortisone is known to affect formation of vasculature and extracellular matrix composition, we next investigated whether these factors are altered in our system. Our research provides important insights into understanding the role of the extracellular matrix in ossicle development and contributes to our understanding of sclerotic ring loss over evolution.

Hanington, Patrick C., Michelle A. Gordy, Sydney P. Rudko, Alethe L. Kabore, Valerie K. Phillips, Mahmoud Tarrabain and Emmanuel A. Pila
University of Alberta
Endogenous induction of snail hemocyte development conveys resistance to *Schistosoma mansoni* infection
Schistosomes must undergo their larval development within specific species of snail intermediate host, a trait that is shared among almost all digenean trematodes. It is well supported that the snail immune cells (haemocytes) are important for protecting against schistosome infection; however, little is understood regarding the factors that drive their development. A granulin (BgGRN) was identified as part of a peptide screen of proteins that differed in abundance between the *Schistosoma mansoni*-resistant (BS-90) and susceptible (M-line) strains of *Biomphalaria glabrata*. We found that BgGRN was able to induce the proliferation of a particular subset of TLR-positive adherent haemocytes that participate in the anti-schistosome immune response. Proliferation of these haemocytes in M-line snails prior to *S. mansoni* challenge resulted in significant increases in the abundance of this subset in the circulation to the point that a reversal of the highly susceptible phenotype was observed, yielding a 54 % less infected snails compared to controls. This represents the first functional characterization of an endogenous growth factor of any gastropod mollusc, and is also the first gain-of-resistance study in a snail-digenean infection model using a defined factor to induce snail resistance to infection.

Hasler, Caleb T., John A. Tix, Jennifer D. Jeffrey and Cory D. Suski
University of Illinois
Elevated carbon dioxide and fish movement
The marine environment has experienced increases in the partial pressure of carbon dioxide (pCO_2) as a result of climate change, and this increase has had a host of negative consequences for marine fishes, including movement and activity. Recent work has suggested that increases in freshwater pCO_2 are likely in some areas, but the consequences of these increases for fish have not been defined. We undertook both laboratory and field investigations to quantify how exposure to elevated pCO_2 alters fish movement. Laboratory studies consisted of exposing fathead minnows and bluegills to various pCO_2 and monitoring volitional swimming speed, distance travelled, and lateralization. Field investigations involved a two-week telemetry study of tagged largemouth bass following exposure to elevated pCO_2. In the laboratory, exposure to elevated pCO_2 had minimal impacts on swimming speed and lateralization. In the field setting, however, largemouth bass exposed to elevated pCO_2 demonstrated altered diel movement patterns for 10 days. Together, our findings suggest that freshwater fish may experience altered movement patterns following exposure to elevated pCO_2, but consequences appear to be less severe than those observed in marine fishes.

Hebert, Francois Olivier, Stephan Grambauer, Iain Barber, Christian R. Landry, Nadia Aubin-Horth
IBIS - Université Laval
Moving through a complex life cycle: transcriptome-wide reprogramming in a cestode infecting sticklebacks and birds
Endoparasites with a complex life cycle need to accurately react to a vast array of environmental changes through several host transitions. Understanding the mechanistic determinants underlying the success of these organisms thriving in sometimes wildly different complex hosts remains a central and unresolved challenge in biology. This holds true even for classic study systems in parasitology, like the cestode *Schistocephalus solidus*, which successively infects a copepod, the threespine stickleback and a wide range of birds. With more than 250 years of research on this system, empirical evidence explaining the molecular mechanisms responsible for its success in intermediate and final hosts still remains scarce. Such information could help uncover the evolutionary mechanisms that led to the development of complex life cycles. We dissected the functional responses of S. solidus at the *plerocercoid* stage during three key developmental states by measuring transcriptional activity during the infection of its fish and bird hosts, using RNA-seq. Our results suggest major events of transcriptome-wide reprogramming, allowing the activation and repression of stage-specific functional pathways. Uncovering this complex biology of parasites will help further understand the traits that control and facilitate the distribution and abundance of organisms in space and time, a central goal in ecology.

Holliday, Casey, Kaleb Sellers, Henry Tsai, Alida Bailleul, Matthew Vickaryous, Callum Ross, Laura Porro, Julian Davis, Lawrence M Witmer
University of Missouri
PMJs and TMJs: Convergence in the craniomandibular joints of crocodyliforms and mammals.
Few evolutionary transformations are as iconic as the flattening of the crocodyliform skull or the transformation of the mammalian middle ear. Although the characteristic pterygoid buttress of crocodyliforms has long been recognized to articulate with the mandible, the anatomical components, biomechanical significance, and evolution of the articulation are poorly

understood. Here we present evidence from the anatomy, biomechanics, and fossil record of crocodylomorphs that reveals that they evolved a second craniomandibular joint, the pterygomandibular joint (PMJ). The joint is an enthesis organ where a cartilaginous sesamoid glides between the articular surfaces of the pterygoid and coronoid region of the mandible. The PMJ receives significant moments from jaw musculature and is a second fulcrum of the mandible, stabilizing it from long axis rotation and medial bending. Acquisition of the PMJ preceded the evolution of akinesis and laterally-wrapping pterygoideus muscles. Reciprocally, these findings inspired new interpretation of the mammalian jaw joint and ear. We hypothesize the TMJ articular disc is actually a sesamoid within the mammalian lateral ptergyoideus musculature, spanning the connection between the dentary and the malleus via the discomallear ligament, a vestige of the primitive attachment to the articular bone. Thus, suchians and synapsids convergently evolved dual craniomandibular joint systems.

Horricks, Ryan, Christophe Herbinger, and John S. Lumsden
University of Guelph
Regeneration of artificial lesions in the Caribbean star coral, *Montastraea cavernosa*
Given the extreme decline in coral cover in the Caribbean since the 1970s it is critical to determine the factors that most strongly affect coral regeneration in this region. *Montastraea cavernosa* is one of the most commonly encountered scleractinian species at intermediate (10-20m) depths. 12mm diameter x 2mm deep circular lesions were made on 124 healthy *M. cavernosa* colonies at 10-12m depths in marine regions of interest in the coastal waters of Grenada and Carriacou and photographed weekly. Images were captured every 0.5m along 0.5m x 30m long belt transects near targeted coral heads both inside and outside marine protected areas (MPAs). Water samples were collected weekly for organic nutrient component analysis. Analysis of benthic diversity as a proxy for ecosystem heath, organic nutrient levels, and the presence of a MPA were examined for their potential impact on *M. cavernosa* tissue regeneration rates. While significant differences were found between islands and sites for the ecological measures, none of these predictors had a significant effect on tissue regeneration. There were significant differences detected in the rates between islands. Additional coral polyps were sampled and snap-frozen in liquid nitrogen to test for differential protein expression using iTRAQ labeling and mass spectrometry.

Hurd, Peter L., Sayeed Devraj-Kizuk, Walter AS Espinoza, Yondu Mori, and Michele K Moscicki
University of Alberta
Development of sex and sex differences in brain and behaviour in cichlid
We investigate correlates of growth rate variation in cohorts of convict cichild fry. We hypothesized that flaster growing fry would follow a life history strategy involving a more bold personality. We also expect that faster growing fry would be more likely to be males, and we expect that graowth rate would be correlated with more asymmetrical brain and behavioural lateralization. Previous work in the related Midas cichlid has suggested that sex at adulthood is determined by relative position in the size heirarchy during early development. We find no evidence for such an effect in cohorts of convict cichlid fry experimentally manipulated to be larger or smaller than their tankmates. We do find an effect of growth rate on both boldness and asymmetries in behaviour and brain. While we find no evidence that growth rate early in life determines sex in convict cichlids, it may account for some persistent behavioural differences between individuals.

Inkpen, Sabrina M., Khalil Eslamloo, Rune Andreassen, Matthew L. Rise
Memorial University of Newfoundland
Characterization and Expression Studies of Interferon Regulatory Factor Genes in Atlantic cod (*Gadus morhua*)
Atlantic cod (*Gadus morhua*) is an important food species with a unique immune system among teleost fish. The study of genes and molecular pathways involved in cod immune responses is thus important to our understanding of vertebrate immune system evolution, and is also of value in maintaining the health of aquaculture stocks. The interferon regulatory factor (IRF) gene family encodes transcription factors which have important roles in regulating Type I interferon expression, and also in growth, development and regulation of oncogenesis. In this study, nine IRF family members in Atlantic cod were characterized at the cDNA and putative amino acid levels. Reverse transcription PCR was used to investigate IRF transcript expression in multiple tissues, and during embryonic development. Unique IRF developmental expression profiles were observed, indicating potential stage-specific roles. To determine how IRF expression is affected by immune stimulation, Atlantic cod macrophages were stimulated with either LPS or the viral mimic poly (I:C), and transcript expression was analyzed using QPCR. Transcripts were also analyzed for potential microRNA (miRNA) binding sites, and several cod miRNAs were identified that could potentially regulate IRF expression. QPCR analysis indicated a possible relationship between expression of cod *miR_218a* and *IRF7*, which will be further investigated.

Ivy, Catherine M. and Graham R. Scott
McMaster University
Respiratory Adaptations to High-Altitude Hypoxia in Deer Mice (*Peromyscus maniculatus*)
The unremitting hypoxia at high altitudes challenges small endotherms to extract enough oxygen from the environment to support thermoregulation and locomotion. We compared the control of breathing and pulmonary gas-exchange between highland and lowland populations of deer mice to determine the physiological specializations necessary for life at high altitudes. Mice were acclimated to normoxia or hypobaric hypoxia (simulating hypoxia at ~4300m) for 5 months. The hypoxic ventilatory response (HVR) was measured during step-wise reductions in inspired O2 tension (PO2). Hypoxia acclimation enhanced the HVR in lowlanders, such that total ventilation and arterial saturation were higher across a range of low inspired PO2. Hypoxia acclimation also made breathing pattern more effective in lowlanders, reflected by higher tidal volumes and lower breathing frequencies at any given total ventilation, and led to substantial growth of the carotid body (the arterial chemoreceptor). In contrast, hypoxia acclimation had no effect in highlanders, who exhibited a fixed HVR and breathing pattern similar to hypoxia-acclimated lowlanders. Nevertheless, highlanders always maintained higher arterial saturations and heart rates in hypoxia than lowlanders. Our results suggest that deer mice have adapted to high altitudes by enhancing O2 transport in hypoxia. Supported by NSERC.

Jamniczky, Heather A., Amie Le, Tegan N. Barry, Sean M. Rogers
University of Calgary
Armour plate bone mineral density varies with habitat in Threespine Stickleback
Threespine stickleback (*Gasterosteus aculeatus*) have been shown to exhibit rapid, parallel changes in armour phenotype when adapting to new habitats, including significant reduction in plate counts during adaptation to freshwater environments. Here, we test the hypothesis that changes in plate number and morphology are accompanied by changes in bone mineral density (BMD), reflecting differences in ion concentration in different habitats. We predict that marine habitats will enable more robust bone development, and stickleback from these habitats will have denser armour than those adapted to habitats with greater fresh water influence. We use microcomputed tomography to image and quantitatively describe armour from sticklebacks occupying three marine habitats and one tidally-influenced freshwater stream, and measure hydroxyapatite density as a proxy for BMD. We observe variation in BMD within plates and across habitats, and find that stickleback inhabiting a stream environment have significantly reduced BMD across the entire plate in association with changes in plate phenotype, suggesting that chemical composition of different habitats is also influencing robustness of armour development in these fish. Further work will focus on determining the role of environmental chemistry in facilitating rapid adaptive evolution in stickleback.

Jeffrey, Jennifer, Kelly Hannan, Caleb Hasler and Cory Suski
University of Illinois
Molecular and whole-animal responses to elevated carbon dioxide exposure in a freshwater mussel
Freshwater mussels are some of the most imperilled species in North America and are particularly susceptible to environmental change. One environmental disturbance that mussels in the Midwest may encounter is an increase in the partial pressure of CO_2 (pCO_2). The present study examined the impact of acute (6 h) and chronic (up to 32 d) exposure to elevated pCO_2 on genes associated with shell growth (chitin synthase; CS) and the stress response (heat shock protein 70; HSP70) in *Fusconaia flava*. Oxygen consumption (MO_2) was also assessed over the chronic CO_2 exposure. Although mussels initially exhibited an increase in CS following exposure to elevated pCO_2 for 6 h, long-term exposure resulted in a decrease in CS mRNA abundance. In response to an acute elevation in pCO_2, mussels increased HSP70 mRNA abundance in mantle and adductor muscle and a similar increase was observed in the gill and adductor muscle in response to a chronic elevation in pCO_2. A chronic elevation in pCO_2 also increased mussel MO_2. Together, these results suggest that freshwater mussels respond to elevated pCO_2 by increasing the machinery necessary to 'deal with' the stressor and over the long-term, mussels may reduce their investment in processes such as shell growth.

Johnston, Elizabeth and Todd Gillis
University of Guelph
MicroRNA-induced inhibition of extracellular collagen in rainbow trout cardiac fibroblasts
Thermal acclimation causes remodeling of the extracellular matrix (ECM) in the rainbow trout heart. Extracellular collagen increases in the trout heart with cold temperatures but decreases with warm acclimation. We have recently shown that the cytokine transforming growth factor-beta 1 (TGF-β1) induces collagen deposition by inhibiting MMP production and activity, as well as upregulating collagen gene expression. TGF-β1 is also known to downregulate the expression of microRNA-29b (miR-

29b). miRs are small non-coding RNA molecules involved in the knockdown of messenger RNA (mRNA). MiR-29b has been shown to be important in regulating the ECM by inhibiting the translation of collagen mRNA. Currently, we are testing the hypothesis that miR-29b prevents ECM collagen deposition by knocking down the collagen type I (COL1) messenger RNA sequence. To test this, cardiac fibroblasts grown from male rainbow trout ventricles were lipofectamine-transfected with the mature zebrafish miR-29b mimic. Preliminary results suggests that transfected cells over-express the miR-29b sequence. Other cells incubated for 72h post-transfection demonstrate a 22.3-fold downregulation of the collagen type I alpha I (COL1A1) gene. These results suggest miR-29b also plays a role in ECM turnover in the rainbow trout heart. Currently we are working on extending the timescale and sensitivity of the experiment.

Jonasson, Kristin and Christopher Guglielmo
Western University
A hard day's night: migration strategies male and female silver-haired bats
Remarkably little is known about the behaviors of spring migrating bats. Impetus to investigate bat migration has come from high incidence of bat fatalities at wind energy facilities. There is no single "best" way to allocate time and energy during migration. Differential selection on migration timing is expected when the consequences of early or late arrival are contingent on traits such as sex. We hypothesize male and female bats have different priorities and consequently different strategies during spring migration. Female bats are preparing to raise pups at the end of their journey, so early arrival and ample fat stores would be beneficial. Whereas males have already mated and have less incentive to migrate quickly. We investigated sex differences in: arrival timing, body composition, and torpor expression. Bats were captured nightly in spring 2012-2014 at Long Point, Ontario. We quantified torpor expression in 23 free-ranging bats using temperature-sensitive radio-transmitters. Females passed through the study site earlier and with greater fat stores than males in two of three study years. Torpor use could not explain the greater fat stores of female bats. Female bats appear to be more dependent on en-route foraging to meet their energetic needs than males.

Jones, Lena, Chenjie Fei, Dustin Lillico, Myron Zwozdesky, and James Stafford
University of Alberta
Examination of fish immunoregulatory receptor-mediated signaling events during the phagocytic process
Phagocytosis, the receptor-mediated and actin-dependent internalization of large extracellular targets, is an evolutionarily conserved process vital for immunity, development, and tissue homeostasis. As an innate immune barrier from infections, phagocytosis is pivotal for the capture, engulfment, and destruction of various pathogens as well as subsequent activation of other potent immune defense pathways. Professional phagocytes express a diverse array of surface receptors capable of binding specific targets then triggering signal transduction pathways that control the actin-dependent membrane remodelling events required for capture and engulfment of targets. The receptor-types and signaling pathways that control phagocytosis in mammals are well-studied but very little is known about phagocytic mechanisms in other animals. Consequently, we are interested in understanding how teleost leukocyte immune-type receptors (LITRs), a family of immunoregulatory receptors related to many mammalian receptors, mediate immune functions such as phagocytosis. We have previously shown that LITRs can mediate cytokine secretion, degranulation, NK-mediated cytotoxicity and phagocytosis. My research focuses specifically on developing an imaging-based approach to map teleost LITR-mediated signal transduction pathways during phagocytosis with the aim of reconstituting both conserved and perhaps unique modes of target engulfment in vertebrates. Recent results from my spatial and temporal examinations of LITR-mediated phagocytic signaling will be presented.

Jonz, Michael, Anna Mierzwa, Frederic Nguyen and Mark Xue
University of Ottawa
Chemoreceptor proliferation, innervation and vascularization in regenerating gill filaments of zebrafish (*Danio rerio*)
The gills retain cells that support gas exchange and sense hypoxia so as to drive compensatory respiratory responses. Their mammalian counterparts (i.e. lung and carotid body) display some restorative capability, but the cellular basis of these processes is not well understood. Based on our previous observation of stem-like cells in the gills, we describe *de novo* replacement of multiple cell types in the gill filaments of zebrafish, and are investigating the regenerative capacity of this organ. Resection or complete amputation of gill filaments initiated immediate production of a proliferative zone, or blastema, that was labelled with antibodies directed against the proliferating cell nuclear antigen (PCNA). Within days, significant neurogenesis was observed. New serotonergic neuroepithelial cells (NECs) had repopulated regenerating filament tips, and axon growth led to their innervation. In Tg(fli1:EGFP) transgenic zebrafish we observed vascularization of regenerating gill filaments and respiratory lamellae. Thus, the gas exchange and O_2-sensing regions of the gills appear to fully regenerate, unlike the case in mammals. Future physiological and cell lineage studies will ascertain the full potential of gill regeneration.

Kaji, Tomonari, Arthur Anker, Christian Wirkner, A. Richard Palmer
University of Alberta
Evolutionary origin of "snapping" shrimps: Crossing the gap between pinching and snapping claws
Snapping claws, which occur in both alpheid and palaemonid shrimps, are spectacular offensive weapons that create intense cracking sounds and shockwaves toward prey and opponents. True snapping involves: a) rapid claw closure facilitated by an energy storing mechanism at the joint, b) creation of a cavitation bubble, and c) destructive shock waves induced by cavitation bubble collapse. How such an extraordinary weapon evolved from ordinary pinching claws is not known. We examined claw form in 90 species of caridean shrimp including several snapping taxa using modern visualization techniques (e.g., micro-CT, confocal microscopy). This survey revealed a unique type of energy storage mechanism in the snapping claw of basal Alpheidae and Palaemonidae: a "slide-and-cock system" similar in form to the "sliding" type joint widely shared by non-snapping caridean shrimp. To assess the relation between form and function we conducted physical experiments using remarkable, enlarged, 3D printed scale models of claws. These experiments revealed a minute yet functionally significant quantitative difference in joint structure that clearly demarcates pinching from snapping claw function. This previously unrecognized sliding-type joint in non-snapping caridean shrimp claws appears to be an evolutionary precondition for the subsequent evolution of spectacular snapping claws.

Kelly, Jesse
Auckland University of Technology
Systematics of the Octopoteuthidae Berry, 1912 (Cephalopoda: Oegopsida)
Octopoteuthid squids have been collected from every ocean except the Arctic and are an ecologically important group, being both key prey for apex marine predators as well as active predators themselves. However, due to the family's taxonomic disarray and the difficulty of species identification, they have remained poorly studied. Recent accounts place the number of valid taxa at two genera and between six and eight species. However, a global review of the family undertaken over the last five years resulted in the recognition of sixteen species, five accommodated in *Taningia* (previously considered monotypic) and eleven in *Octopoteuthis*; clear species-groups supported by both morphology and genetics are evident within *Octopoteuthis*. Of the sixteen species, ten are undescribed with seven having never before been reported. Morphologically, the family is distinctive but very conservative, with species of *Octopoteuthis* being nearly morphometrically identical. Photophore patterning and arm hook morphology are considered the most valuable taxonomic characters within the family, though additional, newly recognised characters are required for identification to species. Most octopoteuthid species appear to have geographic ranges limited to a single ocean basin or a part thereof, with the exception of one cosmopolitan, antipolar species and two temperate southern hemisphere species.

Kelly, Tosha, A. Lymburner, E. MacDougall-Shackleton, K. Hobson, and S. MacDougall-Shackleton.
Western University
Testosterone, migration distance, and migratory timing in song sparrows *Melospiza melodia*
In seasonally migratory animals, migration distance often varies substantially within populations, such that individuals breeding at the same site may overwinter different distances from the breeding grounds. Shorter migration may allow earlier return to the breeding grounds, and may be particularly advantageous to males competing to acquire a breeding territory. However, little is known about potential mechanisms that may mediate migration distance. We investigated naturally-occurring variation in androgen levels and its relationship to migration distance in male and female song sparrows. We used stable isotope analysis of hydrogen in winter-grown claw tissue to infer relative overwintering latitude (migration distance), combined with 14 years of capture records from a long-term study population to infer the arrival timing of males versus females. Relative to females, males had higher circulating androgen levels, migrated shorter distances, and were more likely to be caught early in the season. Males that migrate short distances may benefit from early arrival at the breeding grounds, allowing them to establish a breeding territory. Even after controlling for sex and date, androgen levels at the time of arrival on the breeding grounds were highest in individuals that migrated shorter distances. Our findings suggest that androgens such as testosterone are related to variation in migration distance within and between sexes. If so, selection on androgen levels may therefore have correlated effects on optimal migration strategies.

Kieffer, James, Adam Downie and Lindsay May
University of New Brunswick
A split decision: The impact of substrate type on the swimming behaviour and UCrit of shortnose sturgeon

Sturgeon use their flattened rostrum and large pectoral fins to substrate skim and station hold (to resist swimming) and maintain their position in fast currents. Since a rough substrate may provide a surface for the fish to grip, it was predicted that substrate skimming and station holding on a rough substrate would delay fatigue. Critical swimming (UCrit) tests were performed in a linear flume to evaluate whether different substrate configurations (i. smooth, ii. pebble, iii. pebble on the left side /smooth on the right side, and iv. pebble on the right side/smooth on the left side) would impact UCrit of juvenile shortnose sturgeon (*Acipenser brevirostrum*), and if the sturgeon would select for a particular substrate configuration at different speeds. Overall, there was no clear preference for a particular substrate at a specific speed, and substrate configuration did not affect UCrit.

Kinkead (presenter), Stéphanie Fournier, Simon Chamberland, and Richard Kinkead
Université Laval

Developmental changes in trigeminal motoneuron properties in the American bullfrog, *Lithobates catesbeianus*
Développement des motoneurones trijumeaux chez le Ouaouaron, *Lithobates catesbeianus*

In frogs, the neural circuits generating gill and lung ventilation are distinct, yet their activities converge on the same groups of motoneurons located in the brainstem, including the trigeminal, hypoglossal, and vagal motoneurons. Because lung ventilation requires more forceful contractions to "push" air back into the lungs, it is plausible that the basic electrophysiological properties of respiratory motoneurons that activate the buccal musculature change during tadpole development in ways that facilitate lung ventilation; however, this hypothesis remains untested. To address this issue we used an electrophysiological approach to compare the functional properties of trigeminal motoneurons between pre-metamorphic tadpoles and adult frogs. Retrograde labelling of trigeminal motoneurons was performed with the fluorescent marker DiI at least 14 days prior to experiments. Using a coronal slice preparation, we performed whole-cell recordings from fluorescently-tagged cells to measure basic motoneurons properties. Electrophysiological characterization was performed by measuring membrane potential responses to steps of current injections. Unexpectedly, the trigeminal motor pool seemed to be composed of two distinct motoneuron populations based on cell size. Resting membrane potential did not differ between populations or developmental stages (~-54 mV). The smaller cells were generally more excitable than the larger ones as indicated by a lower rheobase (49 ± 7 versus 275 ± 48 pA) and a more hyperpolarized action potential threshold (-43 ± 2 versus -38 ± 2 mV). The density of the hyperpolarization-activated inward current (Ih) was more than 10 times greater in smaller cells. With regards to development, recordings revealed lower membrane resistance in frogs than tadpoles; this developmental change was more important in the smaller cells. Finally, the amplitude of evoked action potentials was greater in frog motoneurons than tadpoles; the developmental augmentation was more important in the smaller cells. While morphometric assessment of each cell type is underway, the cell heterogeneity observed in the trigeminal motor nucleus raises the possibility that the different cell types are associated with different motor commands (gill versus lung ventilation). Owing to the developmental changes observed in the smaller cells, we propose that this population is associated with the production of air breaths. Supported by NSERC.

Kodzhahinchev, Vladimir, Drago Kovacevic, Carol Bucking
York University

Magnesium transport in the gut and gill of freshwater fish

Facing constant diffusive losses to their hypotonic environment, freshwater fish have evolved cellular mechanisms to recapture ions across their intestine. Magnesium equilibrium has recently been shown to be of great importance to the normal development and vitality of fish. However, the lack of readily available magnesium radioisotopes has impeded our understanding of magnesium transport. That is why we propose an alternative to traditional piscine methodologies, instead using the scanning ion-selective electrode technique (SIET) to detect the net flux of magnesium across the gill and gastrointestinal tract (GIT). To this end, we dissected out the gastrointestinal tract from a goldfish (*Carassius auratus*), and suspended it in a dish filled with Cortland saline, tracing the length of the serosal side of the GIT with a selective electrode. We found significant differences in the flux along the length of the intestine, as well as between fed and unfed specimen. To better understand what was causing this, we took chime samples from different parts of the GIT and used ion-selective micro electrodes (ISMEs) to see how the magnesium load of digesta changes along the tract. Furthermore, we quantified the mRNA transcript levels of Solute Carrier 41a1 (SLC41a1), a reported magnesium exchanger found in enterocytes.

Kortet, Raine, Ann Hedrick and Anssi Vainikka
University of Eastern Finland

Does parasitism affect ecology of animal personalities?

Consistent, individually characteristic, expressions of behavioral traits (i.e. animal personalities) and their evolutionary importance have been over the recent years a topic of intensive research interest among ecologists and evolutionary biologists.

We, together with other researchers, have suggested that parasites and pathogens play an important role in the ecology of animal personalities. Theoretically, parasitism could provide an ultimate explanation for the evolution and diversification of animal personalities. By inducing and maintaining genetic variation in host immune function, parasites affect the optimal behavior of individuals. The stronger is the risk of parasitism, the more strictly individuals are predicted to follow their optimal behavioral trajectories. Therefore, consistent individual differences in behavior should be most commonly detected in highly parasitized populations. We have some indicative supporting evidence, but yet more research is needed to verify these ideas.

Laflamme, Marc
University of Toronto Mississauga
Ediacaran diversity in space and time: The first Mass Extinction of Complex Life
The Ediacara biota are globally-distributed and temporally restricted (579-542 Ma) organisms representing a diverse assortment of unrelated higher-order groups (clades?) including extinct lineages and rare animals. The higher-order disparity of Ediacaran-aged macroorganisms is however poorly resolved. The necessity to understand the evolutionary relationships among these enigmatic fossils is staggering, especially considering the fact that these organisms form the prelude to the Cambrian explosion of bilaterian animals. Previous classification schemes had a tendency to ally all of these macroscopic forms into a single clade, be it as stem and crown Metazoa or more controversially as an extinct clade on par with metazoans - the Vendobionta. Instead, it is proposed herein that Ediacara-type biota consist of several higher-order groups both within and outside of Metazoa. A detailed reevaluation of the classification hierarchy of Ediacaran fossils is proposed, with the goal of building a framework for future phylogenetic and evolutionary studies. Without a proper phylogenetic hierarchical scaffolding in place, Ediacaran studies of diversity, disparity, community ecology, and overall evolutionary patterns are difficult to construct and almost impossible to evaluate. This novel classification identifies shared derived morphological, behavioral, ontogenetic, and taphonomic-based characters allowing for hierarchical constructions within individual clades, and sets the framework for future studies pertaining to Ediacaran diversity and evolution.

Laguë, Sabine L., Beverly Chua, Anthony P. Farrell, P. B. Frappell, Catherine M. Ivy, Kevin G. McCracken, Graham R. Scott, Yuxiang Wang, and William K. Milsom
University of British Columbia
Altitude matters: Cardiovascular and respiratory responses to hypoxia in high- and low-altitude geese and ducks
Many waterfowl live at high altitude (HA). Andean geese (AG; *Chloephaga melanoptera*) reside lifelong in the Andes (4,000-5,500m), while bar-headed geese (BHG; *Anser indicus*) migrate across the Himalayas (>5,000m). We compared the hypoxic ventilatory and cardiovascular responses of wild, acclimatized (3,200m) AG in Peru and BHG in Tibet to determine the physiological strategies used to maintain oxygen supply during hypoxia. Cannulated birds were exposed to progressive hypoxic exposures simulating altitudes higher than the summit of Mt. Everest while measuring cardiovascular, respiratory and metabolic variables. While progressive hypoxia doubled cardiac output, AG predominantly increased stroke volume and BHG primarily increased heart rate. Moreover, AG did not change ventilation, but increased lung oxygen extraction by ~90%, while BHG increased ventilation 3.5-fold and maintained oxygen extraction. Additional studies comparing five HA-resident Andean duck species with six LA duck species found little changes in heart rate and oxygen pulse during hypoxia. Instead, most HA ducks exhibited hematological enhancements (decreased P_{50}, increased hematocrit, and/or increased hemoglobin concentration) favouring increased oxygen carrying capacity. These, the first studies of resident HA waterfowl, reveal radically different strategies for maintaining oxygen supply during hypoxia that are proposed to reflect the demands of acute HA performance and chronic HA residency.

Lee, Abigail, Ana Campos, Joanna Wilson.
McMaster University.
Chronic exposure of environmentally relevant concentrations of fluoxetine and carbamazepine on *Hydra oligactis*.
Pharmaceuticals in the environment are emerging contaminants of concern. Most studies on the effects of pharmaceuticals have focused on fish. Using an invertebrate model species in toxicity testing for environmentally relevant concentrations of pharmaceuticals may provide important and cost-effective data for risk assessment and for prediction of effects in aquatic invertebrates. We exposed *Hydra oligactis* to three concentrations (0.1,1.0, and 10 μgl^{-1}) of fluoxetine (FLX) and carbamazepine (CBZ) for 14 days and analyzed multiple sensitive endpoints: morphology, population growth, feeding behaviour, regenerative capacity, and cell ratios (epithelial:interstitial stem cells). We hypothesized that chronic low doses of FLX and CBZ would have significant impacts on feeding behaviour, reproduction and regeneration. Exposure to FLX and CBZ does not impact *Hydra* morphology. Exposure of *Hydra* to 0.1 μgl^{-1} and 10 μgl^{-1} FLX, but not 1.0 μgl^{-1} FLX, reduced budding compared to controls. After 14, but not 7, days, *Hydra* exposed to 1.0 μgl^{-1} and 10 μgl^{-1} FLX had reduced regenerative capacity. Analyses for feeding

behaviour and cells counts are underway. CBZ exposed *Hydra* have reduced budding at 10 μgl^{-1}, but there was no impact of exposure on regeneration. These preliminary results suggest that *Hydra* survive chronic low concentration exposure to FLX and CBZ.

Leonard (presenter), Patricia L. Gillis, Rodney McInnis, Joseph Salerno, Shane R. de Solla, Mark Servos, Erin M. Leonard
University of Waterloo and McMaster University
Freshwater mussels in an urban watershed: Impacts of anthropogenic inputs and wastewater treatment effluent.
Freshwater mussels are known to be among the most imperiled groups of animals, in fact 70% of the North American species are designated as either threatened, endangered or in decline. The Grand River watershed is an example of an anthropogenically-impacted area which has shown a dramatic decline in the number of mussel species from 31 (early 1900s) to 17 species (late 1990s). Through timed visual searches, the abundance, diversity and size structure of freshwater mussel populations in an urbanized region of the central Grand River was assessed. The influence of water quality on mussel populations was assessed by comparing population structure to long-term water quality data (Provincial Water Quality Monitoring Network). In addition to a 60% decline in mussel abundance, size structure of the most common species, *Lasmigona costata*, was significantly different downstream of the urban area in comparison to upstream. We observed a significant correlation between the absence of mussels in a 7.1 km reach downstream of a large wastewater treatment plant to elevated ammonia, nitrite, phosphate, and decreases in dissolved oxygen. These results indicate that chronic exposure to a complex mixture of urban contaminants negatively impacts freshwater mussel populations.

Leung, Christelle, Sophie Breton and Bernard Angers
Université de Montréal
Phenotypic variation in clonal fish: when the environment leaves its mark
Phenotypic variation is crucial for the persistence of a population in heterogeneous and fluctuating environments. Epigenetic processes are known to increase the range of phenotypic options available to a genotype. Both environmentally-induced and stochastic epigenetic changes represent alternative sources of variation and may explain the ecological success of genetically identical organisms. This study aims at quantifying the phenotypic variation that can be generated by such epigenetic processes. Variation in trophic morphology of the all females clonal fish *Chrosomus eos-neogaeus* was compared to the one of a sexual species *C. eos.* Both organisms are ecologically closely tied as the all females hybrids parasite sexual male for their sperm. Even in the absence of genetic difference among individuals, morphologic variation of the *C. eos-neogaeus* clones is as great as the one of the sexual species. Moreover, analyses of individuals from controlled and natural conditions revealed that environments and stochastic factors can be both source of phenotypic variation, highlighting therefore the ecological and evolutionary importance of epigenetic processes.

Levesque, Kelly, Nicholas Bernier and Patricia Wright
University of Guelph
Effects of warm temperature on the hypoxia response of developing zebrafish
Interacting environmental stressors, such as warm temperature and hypoxia, can pose a threat to aquatic species. Previous studies suggest that these stressors may induce a similar physiological response through activation of the highly conserved hypoxia-inducible factor-1 (HIF-1) cellular response. We asked whether elevated temperatures during rearing (from 27 to 32°C) would enhance the HIF-1-mediated transcriptional response to hypoxia in early stages of zebrafish and result in phenotypic changes in larvae. Embryos reared at 32°C had significantly higher baseline levels of *hif-1α* and *igfbp-1* gene expression suggesting that temperature has an impact on the hypoxia-responsive pathway. Rearing temperature also had an impact on heat-sensitive genes, as *hsp90* mRNA expression was hypoxia-inducible in embryos reared at 32°C. Furthermore, the respiratory function (P_{crit}) of four day-old larvae, previously exposed to warm temperature and hypoxia, was assessed to determine whether gene expression changes had consequences at the whole animal level. Our data suggest a possible mechanistic link for responding to warm temperature and hypoxia in developing fish and suggest that HIF-1 is an important factor for regulating developmental plasticity to changing environments.

L'Heureux, Érik et Bernard Angers
Université de Montréal
Following in the footsteps of the *Arion subfuscus/fuscus* species complex
Sur les traces du complexe d'espèces *Arion subfuscus/fuscus*
Exotic slugs of the European *Arion subfuscus/fuscus* species complex are amongst the most commonly encountered slugs in North America, representing threat to agriculture and indigenous plants. Very little information is available about identity,

ecology and current distribution for each of these species in North America, most studies still referring to the complex rather than individual species. The objectives of this study are to assess the origins, the distribution and the habitat of these species based on their mitochondrial identity. A total of 538 specimens collected on 71 sites across Quebec were analysed. Our results revealed a widespread distribution of this species complex compared to the few localised locations detected in the 1960s. Several mitochondrial haplotypes and distinct species from various European origins were detected. Multiple introductions of the species *A. subfuscus* has been detected, but these haplotypes only display a limited distribution. This contrasts with *A. fuscus* that is by far the most common species, being highly abundant in all regions and habitats sampled. In addition, preliminary results showed that the widespread and generalist *A. fuscus* has nearly no nuclear genetic diversity. Further investigation is underway to understand the invasion success of this single genotype.

Lim, Michael Y.T., Richard G. Manzon, Chris M. Somers, Douglas R. Boreham and Joanna Y. Wilson
McMaster University

Impacts of temperature and chemical stressors on the embryonic development of Round whitefish (*Prosopium cylindraceum*)

Temperature plays a key role in fish embryo development and optimal temperatures vary between species. While most studies incubate fish embryos at constant temperature, in nature, temperature fluctuates both diurnally and seasonally, and may be exacerbated by human activities. Thermal effluent from industrial plants may transiently raise water temperature several degrees above ambient. These temperature fluctuations may impact development, particularly for cold-adapted species like Round whitefish. Thermal effluent may also carry low doses of chemicals like morpholine, which is used for reducing pipe corrosion. In this study, we have reared Round whitefish at constant temperatures (2, 5, 8°C), with seasonal temperatures (gradually decreasing/increasing temperature to represent changing seasons), with 3°C fluctuations every other day, and with seasonal temperatures combined with 3°C fluctuations. Additionally, Round whitefish were raised at a constant 5°C and exposed to 0, 10, 100, 500, or 1000 mg/L of morpholine. We compare development (e.g. survival, dry body weight, oxygen consumption rate) between these groups to clarify the effects of non-constant incubation temperature and chronic morpholine exposure on Round whitefish embryos. This study not only addresses the lack of information of these stressors on Round whitefish, but also allows a comparison to a similarly affected species – Lake whitefish.

Lindstedt, Stan L. and Kiisa C Nishikawa
Northern Arizona University

Ratchets, springs, bungees and winding: Recent insights into muscle filaments

Skeletal muscle accounts for 40% of body mass. During exercise, muscle alone sets the demand for maximum oxygen uptake; it is the location of most of the body's total mitochondrial volume. While often conceived as a machine that uses energy to produce work, in fact the complement of muscle functions spans a very broad range including thermogenesis, ballistic power, isometric "catch" and noise making. Though seemingly improbable, all of these functions are accomplished by shifts in very few muscle structures rather than the "invention" of novel ones. The understanding of these structures and their function has been an interesting example of episodic discovery. Putting the current puzzle pieces together, a new version of the sliding filament theory emerges. Importantly, though first proposed by Hansen and Huxley, there is a third filament in the sarcomere, unknown to the Huxleys in 1954. By incorporating titin into the myofibrils, several aspects of muscle function are elucidated. Titin partners with the "ratchetting" crossbridges functioning as a variable stiffness spring. We explore both the passive and active properties of this enormous protein in light of the current evidence. Its function in skeletal and cardiac muscle are contrasted.

Lucas, Melissa and Nusha Keyghobadi
University of Western Ontario

Assessing the spatial genetic structure of populations of the alpine butterfly *Parnassius smintheus* using RAD sequencing.

Landscape is an important factor in determining the spatial genetic structure of populations – landscape features may facilitate or inhibit dispersal and consequently gene flow, affecting the extent of differentiation between populations. Understanding how populations are genetically structured informs predictions about how they will respond to changes in their environment. The butterfly *Parnassius smintheus* inhabits alpine meadows interspersed with forest, with dispersal between populations limited by the extent of forest cover. I apply restriction site associated DNA sequencing (RADseq) to identify SNPs and assess the spatial genetic structure of populations of *P. smintheus* from three geographically distinct regions of western Alberta. I validate the SNP dataset by comparing the spatial genetic structure identified with SNPs to previous analyses using microsatellites. I will continue to use the RADseq library I have developed to assess the effects of temporal and spatial landscape heterogeneity on genetic diversity and spatial structure in a *P. smintheus* population network that undergoes

periodic population collapses. The results demonstrate the utility of next-generation sequencing techniques in population genetics, and are pertinent to understanding the spatial genetic structure of species with similar patchy distributions.

Lutek, Keegan and Andreas Heyland
University of Guelph

The distribution and function of suH1R in *Strongylocentrotus purpuratus*

Histamine (HA) acts as a modulator of metamorphic competence in *Strongylocentrotus purpuratus*. There is an extensive network of histaminergic cells seen throughout larval and juvenile stages of development. We hypothesize that these cells aid in the attainment and maintenance of metamorphic competence. Despite evidence for histamine function in metamorphic competence, the receptor responsible for mediating these functions remains unknown. Here, we analyze the distribution and function of sea urchin histamine receptor 1 (suH1R), a candidate receptor for the modulatory action of HA. Our results suggest that suH1R is found in the mouth region throughout larval development. In addition, we believe that there is a second functional cluster of suH1R positive cells in the arm tips of larval *S. purpuratus*. We demonstrate and explain the function of these suH1R functional clusters in larval metamorphosis and their relation to the well-established histaminergic nervous network. Our data provide preliminary support for suH1R function in programmed cell death.

Ma, Yanju, Cristina Perez, Brian Branfireun and Chris Guglielmo
University of Western Ontario

FLIGHT PERFORMANCE IN A MIGRATORY SONGBIRD EXPOSED TO ELEVATED DIETARY METHYL-MERCURY

Many songbirds migrate and are exposed to different mercury (Hg) concentrations during their annual cycle, and mounting evidence indicates that environmental Hg exposure may cause reductions in avian fitness. However, how the Hg levels we observe in migratory songbirds affect migration is still unknown. Our dosing experiment show that yellow-rumped warblers in a hyperphagic, migratory state rapidly bioaccumulated dietary Hg to 10 to 20 fold over 2 weeks. In vertical take-off study, no significant difference between pre and post dosing speeds were observed in both groups when weight change was controlled as a covariate. In 2-hour wind tunnel study, the median of numbers of strikes, strike duration and flight duration were all significantly correlated in both treatment groups. But, Hg treated group showed a significant correlation between total blood Hg concentration and the median of strikes ($p = 0.049$). In terms of energetic used, represented as the cost of transport, KJ / KM, COT, Hg group had a nearly significant greater COT ($P = 0.065$), which was likely due to more strikes. In conclusion, environmental Hg concentration observed in the wild may negatively affect the flight behaviour of songbird due to fly more erratically in their long-term migration.

MacCannell, Amanda, Kevin Sinclair, Lanette Friesen-Waldner, Charles McKenzie, and James Staples
University of Western Ontario

Water-Fat MRI Suggests an Endogenous Rhythm of Brown Adipose Tissue Proliferation in a Hibernator

During winter, hibernating mammals cycle between periods of low body temperature (~5°C) lasting for several days, and brief arousal periods with normothermic body temperature near 37°C. During these spontaneous arousals brown adipose tissue (BAT) is the primary source of heat production. In hibernators white adipose tissue volumes and brown fat-specific genes increase in autumn, even when animals are housed at warm temperatures, but seasonal rhythms of changes in BAT quantity have not been studied. In non-hibernating mammals BAT proliferation requires extensive acclimation to cold environmental temperatures. We predicted that the total volume of BAT increases as hibernation season approaches, in the absence of cold acclimation. We used water-fat MRI to measure total BAT volume in ground squirrels at ~10 day intervals from late spring until hibernation began in late autumn. During that time BAT volumes increased significantly from 0.59% to 4.44% of total body volume. Moreover the MRI fat fraction signal from the BAT changed over that time period, suggesting a relative increase in water content, possibly due to increased proportions of mitochondria or vasculature. Showing for the first time, that BAT volume increases in hibernating squirrels as the hibernation season approaches, in the absence of acclimation to cold temperatures.

MacDougall-Shackleton (presenter), Yanina Sarquis-Adamson and Elizabeth MacDougall-Shackleton
University of Western Ontario

Song sparrows (*Melospiza melodia*) have a home-field advantage in defending against sympatric malarial parasites

Hosts and parasites interact on both evolutionary and ecological time-scales. The outcome of these interactions, specifically whether hosts are more resistant to their local parasites (sympatric) than to parasites from another location (allopatric), is likely to affect the spread of infectious disease and the fitness consequences of host dispersal. We conducted a cross-infection experiment to determine whether song sparrows (*Melospiza melodia*) have an advantage in dealing with sympatric parasites.

We captured birds from two breeding sites 437 km apart, and inoculated them with avian malaria (*Plasmodium* spp.) cultured either from their capture site or from the other site. Infection risk was lower for birds exposed to sympatric than to allopatric Plasmodium lineages, suggesting that song sparrows may have a home-field advantage in defending against local parasite strains. This pattern was observed at one capture site but not at the other, consistent with mosaic models of host-parasite interactions. Home-field advantage may arise from evolutionary processes, whereby host populations become adapted to their local parasites, and/or from ecological interactions, whereby host individuals develop resistance to the local parasites through previous immune exposure. Our findings suggest that greater susceptibility to novel parasites may represent a fitness consequence of natal dispersal.

MacMillan (presenter) Trine Olsson, Anders Malmendal, Heath MacMillan, Nils Nyberg, Dan Stærk and Johannes Overgaard
York University

Hemolymph metabolites are tightly linked to cold tolerance of *Drosophila* species

Like most insects, *Drosophila* succumb to biochemical effects of chilling that are unrelated to freezing, but species in this genus can widely vary in their chill tolerance. For susceptible species, cold exposure causes a loss of extracellular ion and water homeostasis, leading to hyperkalemia, chilling injury, and ultimately death. Chill-tolerant species instead maintain ion and water homeostasis during cold exposure and recover from an identical cold stress uninjured. Here, I will describe how these tolerant species maintain comparatively low hemolymph [Na^+], and how this "missing" Na^+ is "replaced" by other compatible osmolytes that help to maintain osmotic balance at low temperatures. We use NMR to compare the metabolite profiles of the hemolymph of five drosophilid species at their rearing temperature (20°C) and immediately following cold exposure (4h at 0°C). Chill tolerant species constitutively maintain higher levels of specific organic osmolytes in their hemolymph and better maintain metabolic homeostasis during cold stress. Levels of these classical "cryoprotectants" in chill-tolerant species suggest a non-colligative or osmotic role for these compounds in determining chilling tolerance.

Mahalingam, Sajeni, Graham Scott and Grant McClelland
McMaster University

High-altitude ancestry and hypoxia acclimation affect mitochondrial physiology in deer mice

Hypoxia is a major stressor at high altitudes that limits tissue oxygen availability. It has been suggested that hypoxia-induced impairments in ATP synthesis capacity could be offset by increases in tissue oxidative capacity. We explored this hypothesis in North American deer mice (*Peromyscus maniculatus*), from populations native to high and low altitude. We compared mitochondrial volume densities, intracellular distribution, respiratory capacities, and enzyme activities of the mitochondrial complexes in the locomotory muscle between lab-raised mice of highland and lowland ancestry, after normoxic and hypoxic acclimation. Highlanders had higher mitochondrial volume densities than lowlanders, entirely due to an increased abundance of mitochondria in a subsarcolemmal location next to capillaries. Hypoxia acclimation increased cristae surface density in both populations but abundance was unaffected. Mitochondria from highland mice also had higher mitochondrial respiratory capacities and cytochrome c oxidase activity in control conditions, but the populations converged after hypoxia acclimation. Our results suggest that adaptations and/or phenotypic plasticity in mitochondrial physiology are advantageous for performance and hypoxia resistance at high altitudes

Bui-Marinos, Maxwell P., Nguyen T.K. Vo, Niels C. Bols and Barbara A. Katzenback
University of Waterloo

Development of *in vitro* continuous cell culture systems from *Xenopus laevis* ventral and dorsal skin to examine frog virus

Frog virus 3 (FV3) is contributing factor in the worldwide decline of amphibian populations and enters the amphibian host via direct contact or water-borne transmission. We report on the generation of *Xenopus laevis* dorsal skin (Xela DS) and ventral skin (Xela VS) continuous cell cultures (>70 passages) and their use as an *in vitro* model system to study the inital amphibian host-FV3 pathogen interaction. Xela DS and Xela VS cells have an epithelial-like morphology, low beta-galactosidase activity and grow optimally at 26°C in amphibian Leibovitz's L-15 medium supplemented with ≥10% fetal bovine serum. Upon FV3 challenge, cells lose adherence and exhibit a time and dose-dependant decrease in cell viability. Xela DS and Xela VS cells support FV3 viral replication, evidenced by the detection of viral transcripts and increasing viral titres. Examination of FV3-epithelial cell interaction will provide insight into the entry of FV3 and the subsequent host innate immune response.

Mathers, Kate, Sarah McFarlane and Jim Staples
University of Western Ontario

Regulation of mitochondrial metabolism during hibernation by post-translational modification

Many small mammals such as the 13-lined ground squirrel (*Ictidomys tridecemlineatus*) hibernate to deal with the energetic challenges of winter. During hibernation these animals undergo periods of torpor, where body temperature and whole-animal metabolic rate are significantly suppressed for 12-14 days. Torpor is periodically interrupted by interbout euthermia (IBE), where body temperature and metabolic rate are rapidly (~2 hours) increased and maintained at euthermic levels for ~8 hours. The transition back into torpor is extremely rapid as well, and is preceded by a 70% suppression of liver mitochondria. Due to the rapid and reversible nature of this transition, we hypothesized that the changes in mitochondrial metabolism between torpor and IBE are regulated by post-translational modifications (PTMs) of mitochondrial proteins. We investigated the role of PTMs by comparing total acetylation and phosphorylation in liver mitochondria between torpor and IBE, and suggest that PTMs play an important role in regulating rapid changes in mitochondrial metabolism during hibernation.

McCallum, Erin S., Sherry N. N. Du, Graham R. Scott & Sigal Balshine
McMaster University
Exposure to wastewater effluent differentially affects the behaviour and physiology of two Great Lakes fish species
As human use of products like pharmaceuticals, personal care products, and pesticides continues to rise, wastewater effluents contain an ever-increasing complex mixture of contaminants. While we know that fish living near sources of wastewater are known to have altered reproductive biology, we understand very little of how it affects non-reproductive physiology and behaviour. To examine how fish cope with chronic exposure to wastewater effluent in the wild, we caged two fish species (bluegill sunfish, *L. macrochirus* and round goby, *N. melanostomus*) for three weeks at varying distances from a wastewater effluent outfall. We then evaluated the effects of this exposure on their behaviour and physiology. Fish from both species caged closer to the effluent experienced higher mortality over the three-week exposure. Round goby that survived were resilient to effects of exposure on behaviour (aggression, boldness, activity) and showed no changes to their physiology (metabolism, hypoxia tolerance). However, bluegill sunfish showed altered boldness behaviours, and incurred a metabolic cost, with higher metabolic rates following exposure near the outfall. We will relate our results to contaminant load and water quality near the outfall, and discuss how contaminated environments may be selecting for individuals equipped to cope with the costs of effluent exposure.

McGeer, Jim, Alexandria Loveridge, Jonathan Ford, Oliver Vukov, Che Lu and D. Scott Smith
Wilfrid Laurier University
Rare earth elements in the aquatic environment, a cause for concern?
The growing use of rare earth elements (REEs) in personal electronic devices, green technologies and medical applications results in a developing concern for impacts in aquatic environments. However, there are no water quality guidelines/criteria for REEs and few studies available. The overall objective of this research is to contribute data towards the establishment of assessment tools for the effects of REEs. We have studied the toxicity of Ce, Sm, Dy and Tm to fish and sensitive invertebrates (e.g. *Hyalella azteca* and *Daphnia pulex*). The toxicity modifying influences of cationic competition (Ca, Mg and Na) and dissolved organic matter (DOM) was assessed with the goal of developing toxicity prediction models. Standard methods (Environment Canada) were used for culture and testing which was done in intermediate hardness waters (60 mg/L $CaCO_3$, pH 7.2, Ca 0.5 mM, Mg 0.15 mM). With some exceptions, Ca and DOM provide protection against toxicity but the incorporation of these effects into toxicity prediction models was inhibited by a lack of understanding of solution geochemistry. The pH of test solutions had a significant influence on toxicity with, for example, low pH resulting reduced Dy toxicity. Funded by NSERC and Environment Canada via a Strategic Grant.

Guigueno, Mélanie F., Scott A. MacDougall-Shackleton, and David F. Sherry
University of Western Ontario
Sex and seasonal differences in hippocampal volume and neurogenesis in brood-parasitic brown-headed cowbirds
Les différences entre les sexes et les saisons dans le volume et la neurogénèse de l'hippocampe chez le vacher à tête brune, parasite de niches
Brown-headed cowbirds (*Molothrus ater*) are one of few species in which females show more complex space use than males. Female cowbirds search for and parasitize host nests, outperform males on an open field spatial task, and, according to one study, have a larger hippocampus than males, a region of the brain involved in spatial memory. Neurons produced by adult neurogenesis may help form new memories and replace older neurons that could cause interference in memory. We tested for sex and seasonal differences in hippocampal volume and neurogenesis in cowbirds and closely related non-brood-parasitic red-winged blackbirds (*Agelaius phoeniceus*) to determine whether these differences reflected space use in the wild. Females had a larger hippocampus than males in both species, but hippocampal neurogenesis, measured by doublecortin immunoreactivity (DCX+), was greater in female than in male cowbirds in the absence of any sex difference in blackbirds, supporting the

hypothesis of hippocampal specialization in female cowbirds. Cowbirds of both sexes had a larger hippocampus with greater hippocampal DCX+ than blackbirds. Hippocampal DCX+ was greater post-breeding, indicating that old memories may be lost through hippocampal reorganization following breeding. Our results support, in part, the hypothesis that the hippocampus of cowbirds is specialized for brood parasitism.

Milotic, Dino and Janet Koprivnikar
Ryerson University
Road salt reduces larval amphibian parasite avoidance behaviour but not resistance to infection
Road salt has various effects on aquatic organisms but has never been considered in the context of host parasite-interactions. Increases in salinity may stress organisms, which can lower their immunocompetence, activity, and competitive ability. This has been demonstrated in larval amphibians and other freshwater animals. Our objectives were to determine if: 1) road salt affected the susceptibility of larval *Rana sylvatica* (wood frogs) to infection by the trematode *Ribeiroia ondatrae*; and, 2) road salt exposure affected tadpole parasite avoidance behaviour. Twenty tadpoles were exposed to each of three treatments (0, 400 and 800 mg/L) for two weeks. After twelve days, we exposed them to 20 cercariae each and recorded their behaviour before and after parasite addition. We found that road salts do not have a significant effect on the growth of wood frog tadpoles, or on their infection status, cyst abundance, or cyst intensity. However, there was a significant difference between activity in the 0 mg/L and 400 mg/L concentrations, and a marginally insignificant difference between the 0 mg/L and 800 mg/L concentrations. Our results suggest that intermediate levels of road salt may impact amphibian anti-parasite behaviour, and perhaps to other natural enemies as well.

Milotic, Marin and Janet Koprivnikar
Ryerson University
Density and complexity of aquatic vegetation does not affect larval amphibian parasitism
Macrophytes can provide refuges for larval/juvenile animals from predators, and may potentially serve a similar role for other natural enemies such as parasites. Previous studies examining the structural complexity of aquatic environments suggest this might affect the host-finding success of free-swimming trematode cercariae. Alternatively, this could influence host anti-parasite behaviours, such as detection or escape. Macrophytes can range from high to low density, and can be structurally complex (many leaflets) or simple (few broad leaves). The purpose of our experiment was to examine whether the structural complexity of aquatic vegetation affects larval amphibian infection by the trematode *Ribeiroia ondatrae*. We used plastic plants to form four treatments (five replicates each) based on plant structural complexity: low density/low complexity, low density/high complexity, high density/low complexity, and high density/high complexity. Each replicate contained five *Rana sylvatica* tadpoles that were exposed to 100 *R. ondatrae* cercariae for 2 hours. We found that neither vegetation density nor complexity had a significant effect on host infection status or number of cysts within our model system. Further studies are needed to explore how changes in structural complexity potentially associated with invasive species can influence host-parasite interactions.

Milsom (presenter) Sarah Jenkin and Bill Milsom
University of British Columbia
Developmental changes in the hypercapnic ventilatory response of neonatal rats
On the first day of life, rat pups exhibit a large increase in ventilation in response to hypercapnia due entirely to increases in tidal volume (V_T). This CO_2 sensitivity declines to a minimum by post-natal day 8 and then increases to adult levels of sensitivity. We used the in vitro brainstem-spinal cord preparation, a preparation lacking peripheral chemoreceptor and mechanoreceptor feedback to investigate the extent to which the changes occurring over the first four days of life arise specifically from changes in ponto-medullary respiratory control. We observed a decrease in V_T and an increase in f_R of these preparations while increasing levels of artificial cerebrospinal fluid CO_2. This shows that in addition to changes in the pons and medulla that affect the CO_2 response, the maturational changes seen in vivo are also shaped by excitatory and inhibitory inputs extrinsic to the pons and medulla. Supported by the NSERC of Canada.

Mischler, Shannon K. and Scott A. MacDougall-Shackleton
Advanced Facility of Avian Research, University of Western Ontario
Song control or vocal control? The role of HVC in black-capped chickadee learned call production
Songbirds are one of the few animal clades to have developed the capacity for vocal learning. During development (the sensory phase) birds must be exposed to adult birdsong in order to learn their song. The song-control system, including the brain region HVC, in the songbird brain is crucial for the learning, production and maintenance of song. In contrast to birdsong, bird calls are

typically thought to be innate and are used in a variety of contexts: in aggressive encounters, to maintain contact or to indicate mild alarm. In some cases calls are plastic, and may therefore have a learned component. Black-capped chickadees produce a variety of complex calls in addition to their song. This study aimed to determine the behavioural role of HVC in the production of the chick-a-dee, gargle and tseet calls in black-capped chickadees. Immediate-early gene expression is high in HVC during production of gargle calls as well as song, suggesting that HVC is important for the production of learned calls. In the current study chickadees' calls were recorded, and a baseline of each call type was acquired. The birds then underwent an HVC lesion surgery, and calling behaviour was examined post-surgery. Results will be discussed.

Morash, Andrea J., Suzanne Currie and Jayson M. Semmens
Mount Allison University

Potential ecophysiological impacts of aquaculture on the endangered Maugean Skate (*Zearaja maugeana*)

The endangered Maugean skate (*Zearaja maugeana*) is subject to large environmental variability coupled with anthropogenic stressors. However, little is known about the basic biology/physiology of this skate, or how they will respond to the continual increase in human activities that threaten its only habitat. These skates live at an average depth of approximately 9m where the oxygen levels are moderate (~55%). However, these skates are not limited to their preferred location, and are frequently exposed to highly variable environments. Given that their preferred depth has rather low oxygen levels, we sought to investigate their response to further decreases in dissolved oxygen, such as those expected to arise from intensive salmonid farming. We measured oxygen consumption, haematological parameters, tissue enzyme capacity and heat shock protein (HSP) expression in skates exposed to 55% O_2 (control) and 20% O_2 for 24 hours. We found that the Maugean skate appears to be an oxyconformer, but that there is no difference in the rate of O_2 consumption, muscle enzyme function or HSP expression at lower oxygen levels. Increases in blood glucose and lactate at 20% O_2 suggest that skates are relying more on anaerobic metabolism to tolerate periods of very low oxygen.

Morbey, Yolanda E., Ivan Maggini, J. Morgan Brown, John Brzustowski, Jacopo Cecere, Stu Mackenzie, Phil Taylor and Christopher Guglielmo
Western University

Mechanisms of protandry in the Black-throated Blue Warbler

In long distance migrants, the seasonal timing of migration is part of an evolved strategy to deal with spatio-temporal environmental variability and competition for resources. A dominant sex-specific migratory pattern is protandry, whereby males migrate and arrive earlier at breeding areas than females, likely as a strategy to maximize mating opportunities. Different sex specific behaviours can underlie protandry, but the importance of each mechanism seem to depend on the species, for reasons we do not yet understand. In a radiotelemetry study using the MOTUS Wildlife Tracking System, we tested for sex differences in the stopover behaviour of the sexually-dichromatic Black-throated Blue Warbler at Long Point, Ontario. This species shows protandry in arrival at stopover sites, but in the two years of our study, we found no sex differences in the onset or duration of diel foraging activity or in minimum length of stay before departure. Therefore, sex differences in refueling activity does not appear to be a major driver of protandry in the Black-throated Blue Warbler. We discuss this result in relation to other studies that do show sex differences in refueling at stopover.

Morrison, Phillip R. and Colin J. Brauner
University of British Columbia

A sensitivity analysis to identify factors that limit $\dot{V}O_2$ max in two exceptionally athletic fishes: the rainbow trout

Maximal endurance swimming capacity is exceptional in salmonids and tunas, which requires maximizing O_2 flux through all steps of the O2 transport cascade from the environment to mitochondria. We used published data for rainbow trout (*Oncorhynchus mykiss*), and yellowfin tuna (*Thunnus albacares*) swimming near $\dot{V}O_2$max, to model the O_2 cascade as an integrated system limiting $\dot{V}O_2$max, which has not previously been conducted for fish. In both species, tissue diffusion capacity posed a slight limitation to $\dot{V}O_2$max, but the greatest limitation to $\dot{V}O_2$max was observed at the level of the cardiovascular system (i.e., cardiac output, and hemoglobin concentration); however, inclusion of the Bohr effect at the tissues reduced hemoglobin-O_2 affinity and enhanced O_2 offloading and $\dot{V}O_2$max. It appears that the large Bohr effect that is typical of most teleost hemoglobins benefits O_2 offloading and delivery to the tissues during exercise, and may contribute substantially to $\dot{V}O_2$max in athletic fishes.

Munro, Daniel, Matthew E Pamenter and Jason R Treberg
University of Manitoba

Longevity and mitochondrial ROS metabolism: a new twist on the mouse vs. naked mole-rat comparison

Longevité et ROS mitochondriaux: une nouvelle perspective sur la comparaison entre le rat taupe-nu et la souris
After 26 years of research, the putative inverse relationship between animal longevity and mitochondrial H_2O_2 production remains equivocal. One major outlier is the remarkably long-lived naked mole-rat (NMR). Mitochondria from NMRs and mice generate H_2O_2 at similar rates but NMRs live far longer (> 20 y versus < 4 y). However, previous studies suffered an important technical caveat: detection systems are confined to the assay medium, only measuring H_2O_2 that diffuses across mitochondrial membranes, whereas H_2O_2 is mostly produced inside mitochondria. Thus, a portion of the H_2O_2 produced is consumed by mitochondrial antioxidants, remaining "invisible" to the detection system. We recently developed methods to inhibit mitochondrial antioxidants and found that true H_2O_2 production may be underestimated by > 80%. Using this novel antioxidant-inhibition approach, we re-evaluated the NMR vs. mouse comparison. We found that true mitochondrial H_2O_2 production was generally lower in NMRs than in mice, particularly when respiration was fuelled by substrates that best mimic *in vivo* conditions. NMR mitochondrial antioxidants also consumed H_2O_2 at greater rates than mice, potentially further alleviating oxidative damage. In contrast with previous studies, we found support for the ROS/longevity hypothesis using NMRs, which suggests that re-examination of other classical comparative models is needed.

Neff, Bryan, Nico Muñoz, Ross Breckels, Anthony Farrell
Western University Capacity of fishes to respond to climate change
Increasing global temperatures represent a major stress for fishes and may limit the ability of species to persist in their current habitats.
We use two complementary systems to examine the capacity of fishes to respond to climate change. First, using guppies, we show that acclimation to warmer temperatures alone is insufficient to maintain performance at fitness and life history traits. Improvements to some traits were observed after four generations of experimental evolution at high temperatures, but strong selection for thermal performance led to a significant reduction in genetic variation relative to control populations. Second, using Chinook salmon, we show that both acclimation and genetic variation contribute to physiological performance at high temperatures. However, neither acclimation nor genetic variation affects the arrhythmic temperature of the heart, constraining the upper thermal limit. Linking this constraint on thermal tolerance with present-day river temperatures and projected warming scenarios, we predict a 17% chance of catastrophic loss in the studied population by 2100 based on the average warming projection, with this chance increasing to 98% in the maximum warming scenario. Climate change mitigation is thus critical to ensure the future viability of global fish populations.

Page, Louise, Brenda Hookham and Amelia Hesketh
University of Victoria
Evolution of the gastropod foregut viewed through a developmental lens
Why have some clades diversified explosively, while others have not? One hypothesis suggests that 'evolvability' may be facilitated by the organization of developmental systems into semi-autonomous modules that can spin off variant phenotypes without disrupting the developmental integrity of the whole. I will review comparative developmental data from gastropods that suggests the foregut consists of dorsal and ventral developmental modules. The existence of these modules is inferred by their independent modifications during evolution of different life histories and different post-metamorphic feeding systems. Heterochronic shift between these two modules may have allowed the emergence of feeding larvae from non-feeding ancestral larval forms, and subsequent tinkering facilitated nurse egg feeding by fully encapsulated larvae. The almost complete physical separation of dorsal and ventral modules during the development of neogastropods was an innovation that may have facilitated the 'evolvability of post-metamorphic feeding systems within this species-rich clade of predatory gastropods

Partch, Trevor, Nicholas Bernier, Glen Van Der Kraak
University of Guelph
Anti-steroidogenic actions of corticotropin-releasing factor in the zebrafish ovary
Beyond its central role in the coordination of the stress response, recent studies have implicated the corticotropin-releasing factor (CRF) system in the regulation of physiological functions in peripheral tissues. In this study, we sought to characterize the ovarian CRF system in zebrafish and its role in the regulation of steroidogenesis. We established that all the components of the CRF system are expressed in zebrafish ovary (CRFR1 >> CRFR2 > CRF > UCN3 = UTS1 = CRFBP), that whole ovary CRF and CRFR1 gene expression are highest at 7:00 when ovulation is expected to occur, and that CRFR1 expression levels are higher in full grown follicles than in earlier stages. In vitro, incubating follicles with CRF suppressed human chorionic gonadotropin (hCG)-stimulated production of 17-Beta estradiol and testosterone in a dose-dependent fashion, effects that were abolished by the CRFR1 receptor antagonist antalarmin. Incubating follicles with CRF also suppressed hCG-stimulated increases in

steroidogenic acute regulatory protein (StAR) and P450 aromatase gene expression. Collectively, these results suggest that the CRF system may modulate steroidogenesis via autocrine or paracrine actions in the fish ovary.

Pearson, Mike
Pearson Ecological. Ltd.
A Hidden Menace: Hpoxia in Fraser Valley Streams
The Fraser Valley supports the most productive streams in Canada due to its mild climate and marine energy inputs in the form of anadromous salmon. It also supports the highest density of agricultural livestock in Canada, and one of the highest in the world, but there are no legal limits to how much manure can be spread on land. Nutrient loading far in excess of crop requirements has been documented by others in several areas of the Fraser Valley. Unchecked nutrient loading typically leads to eutrophication and hypoxia. Here I assess hypoxia risk in the 11 Fraser Valley streams that support the endangered Salish sucker (*Catostomus cf. catostomus*) using over 3000 spot measurements of dissolved oxygen supplemented by logger data. The data suggests that in dry summers more than 45 % of 180 of km channel will experience severe hypoxia (<2.5 mg/l) and that an additional 23 % will experience moderate hypoxia 2.5-4 mg/l). The extent and severity of hypoxia observed suggest that it limits many fish populations across the Fraser Valley.

Pham-Ho, Phillip
Wilfrid Laurier University
Changes in Brain Water Content in the Rainbow Trout (*Oncorhynchus mykiss*) due to High External Ammonia Exposure
Internal concentrations of ammonia are highly variable in fishes, and can increase due to a number of factors including exposure to high environmental ammonia, feeding and vigorous exercise. Excessive build-ups of internal ammonia target the nervous system, leading to ammonia toxicity, which is characterized by overactivation of NMDA receptors, oxidative damage and brain swelling resulting in permanent brain damage or death. In some fishes, swelling is reversible, which may reflect the routine fluctuations in internal ammonia that fish undergo due to feeding or exercise. However, the underlying mechanism and sequence of events leading to brain swelling in fishes are unclear. To test the hypothesis that ammonia resulted in brain swelling by interfering with ion transport processes in brain, rainbow trout (*Oncorhynchus mykiss*) were exposed to 1mmolL^{-1} HEA for 48h, followed by measurements of brain ion and water content and Na^+/K^+-ATPase activity. Exposure to HEA was accompanied by 3-fold elevations of brain ammonia concentration, and a corresponding 12% increase in brain water content. Approximately 60% elevations in dry-brain Na^+ content, along with 30% reductions in dry-brain K^+ content, suggested that elevated ammonia resulted in marked internal ionic disturbances, that lead to osmotics shifts into the brain. This was further supported by 50% reductions in brain Na^+/K^+-ATPase. We conclude that ammonia-induced brain swelling is caused by ammonia-induced inhibition of the Na^+/K^+-ATPase, which leads to ionic disturbances leading to the osmotic shifts that result in elevated brain water content.

Pierce, Stephanie E., Katrina E. Jones, Kenneth D. Angielczyk
Harvard University
Origin of the mammalian backbone: insights from the fossil record
Mammals are known for their great range of locomotor behaviors, including unique asymmetric gaits such as galloping and bounding. Asymmetric gaits are made possible by the subdivision of the dorsal vertebral column (the area between the pectoral and pelvic girdles) into two morphologically and functionally distinct regions. Anteriorly, the thoracic region bears ribs and is specialized for respiration, whereas posteriorly the dorsoventrally mobile lumbar region functions in locomotion. Combined, the regionalized dorsal vertebrae allow mammals to breathe and move simultaneously, permitting the use of high speed gaits for prolonged periods of time. But, how did this key mammalian trait evolve? Modern species provide little information for examining this fundamental evolutionary question, as they all possess distinct thoracic and lumbar regions. However, the clade to which mammals belong, Synapsida, has a rich fossil record that provides a detailed view of the origin and evolution of mammals. Here we introduce a new project that is using cutting-edge morphometric, biomechanical, and 3D digital modeling techniques to examine functional regionalization of the vertebral column in fossil and extant synapsids, and to trace the origin and evolution of the mammalian thoracolumbar region and dorsoventral mobility.

Pitcher, Trevor
University of Windsor
Infusing ecology and evolution into fish conservation breeding programs
Each year millions of fish are caught and used for conservation breeding programs that attempt to augment natural populations that are threatened with extinction. These programs typically mate individuals haphazardly and as such they

overlook the importance of ecology and evolution (e.g. genetic quality comprising both good and compatible genes arising from sexual selection) to offspring fitness and ultimately to ensuring population health. Here, I will draw on my lab's data from studies of fish (with a focus on salmonids) to discuss what is genetic quality in the context of natural and sexual selection, what are the current strategies used in conservation breeding programs and how to potentially improve conservation breeding programs through the incorporation of knowledge gleaned from a better understanding of the ecology and evolution of wild populations. Overall, I will argue that instead of the current paradigm of maintaining as much genetic diversity possible, we need a more comprehensive approach combining both genetic diversity and genetic quality to effectively enhance targeted species and populations (via captive breeding, supportive breeding and translocations programs) in order to mitigate enduring wild population declines.

Pleizier, Naomi, Alexander D.M. Wilson, Aaron D. Shultz, Steven J. Cooke
University of British Columbia

Overextended: Personality, performance, and the effects of cortisol in pufferfish

Consistent individual-level differences in behaviour are pervasive among species and are expected to play a role in how populations respond to changing environments. However, little is known about the physiological mechanisms that regulate these individual differences in wild animals. The hormone cortisol has received particular attention in both conservation and behavioural science for its role in the physiological response to stress, yet there are few studies to suggest how cortisol levels are related to consistent individual-level differences in performance and behaviour in wild animals. We examined whether checkered pufferfish (*Sphoeroides testudineus*), from a dynamic tidal mangrove creek in The Bahamas, have repeatable individual-level differences behaviour and performance in response to simulated predator threats. We tested whether these individual characteristics were consistent between the lab and natural enclosures, and whether they were related to displacement in the field. We also explored whether a cortisol treatment affects individual consistency in behaviour and performance.

Porteus, Cosima, Tamsyn Uren-Webster, Eduarda Santos, and Rod W. Wilson
University of Exeter

The effects of simulated ocean acidification on global transcriptomic profiling in a marine teleost

Marine fishes exposed to end-of-the-century levels of ocean acidification (OA) show altered sensory behaviour that is likely to affect survival of both individuals and populations. Recently we have shown that elevated CO_2 seawater can have a direct negative effect on the olfactory sensitivity of European sea bass (*Dicentrarchus labrax*), an economically important species. Here we aimed to characterize and compare the global gene expression responses to OA acting in the olfactory epithelium (OE) and the olfactory bulb (OB - brain). Sea bass were exposed for 2 and 7 days to either control (~400 µatm) or OA (~1000 µatm) seawater and 4-6 tissues replicate samples for each treatment were sequenced using an Illumina HighSeq 2500 platform. A high quality *de novo* transcriptome was built using the Trinity pipeline. After 2 days of exposure, differentially expressed genes in the OE predominantly included those involved in sodium bicarbonate transport. After 7 days of exposure many more genes were differentially expressed including those involved in ion transport, peptidase activity, olfactory receptors, and alternative spicing. Overall fewer genes were differentially expressed in the OB. These data highlight the temporal dynamics of the response to OA at the molecular level underpinning the decrease in olfactory sensitivity.

Qiu, Shuang, Chengfeng Xiao and R Meldrum Robertson
Queen's University

Involvement of CNGL channel in responses to hypoxia in adult *Drosophila*

Rapid behavioral responses to hypoxia require oxygen-regulated ion channels, including voltage-dependent K^+ channel, and Ca^{2+} and ATP-sensitive K^+ channel in vertebrates, and cGMP-gated cation channel (CNG) in *C. elegans*. Little is known about ion channels mediating responses to hypoxia in adult *Drosophila*. Here we show that *Drosophila* CNG-like mutant ($Cngl^{MB12199}$) displayed reduced activity to hypoxia (2% oxygen), and recovered faster from a short period of anoxia compared with control strain w1118. In addition, $Cngl^{MB12199}$ showed an absence of initial elevation of extracellular potential in response to the onset of anoxia, which was typical in the early stage of direct-current potential shift (DC shift) to anoxia in control. These data demonstrate an aberrant ionic flux associated with abnormal behavioral responses to hypoxia in *Cngl* mutant.

Quijada-Rodriguez, Alex, Yung Che Tseng, Po-Hsuan Sung, Pou-Long Kuan, Pung Pung Hwang, Dirk Weihrauch
University of Manitoba

Getting Crabby: The effects of freshwater acidification on branchial acid-base regulation in the Chinese mitten crab

While the degree of freshwater acidification due to rising atmospheric CO_2 is difficult to predict global studies on freshwater systems have shown average pCO_2 levels of 100Pa and 300Pa in lakes and rivers respectively, with a maximum of ~630Pa. In the present study, we investigated the effect of freshwater acidification through elevation of environmental pCO_2 levels to 550Pa on the highly invasive euryhaline Chinese mitten crab *Eriocheir sinensis*. In the first 6 hours of high pCO_2 exposure a metabolic depression with ammonia excretion recovering after 48 hours was observed, while O_2 consumption never recovered. Additionally, hemolymph pH (control = 8.09 ± 0.01) decreased after 6 hours and remained 0.05 units below controls after 7 days. Hemolymph pCO_2 and ammonia became elevated while HCO_3 was not accumulated in response to the high pCO_2 exposure. The ability of anterior and posterior gills to regulate acid-base status will also be assessed through gill perfusion experiments before and after long-term (7 days) high pCO_2 exposure.

Rafiqi, Ab. Matteen, Arjuna Rajakumar, Travis Chen, Ehab Abouheif
McGill University
Ant endosymbiont drives duplication and neofunctionalization of germ plasm, with novel epistatic hox gene interactions.
One of the broad themes of eco-evo-devo is to integrate developmental symbiosis into evolutionary theory. Endosymbiotic associations are present in almost all multicellular organisms and play a major role in development and evolution, yet the evolution of novel endosymbiotic associations and the developmental genetic consequences of these associations are largely unknown. Here, we use ants of the genus *Camponotus* (carpenter ants), which possess stable endosymbionts, and show that the cells that harbour endosymbionts are derived from a duplicated pole plasm in the early embryo. We also show that this duplication co-occurs with novel rearrangements of tissue precursor fields in the early embryo. These rearrangements have driven evolution of novel epistatic interactions and *Ubx* and *AbdA* phenotypes.

Renaud, Jean-Marc
University of Ottawa
K_{ATP} channel and how skeletal muscle protects themselves against fiber damage and contractile dysfunction during fatigue
Le canal K_{ATP} et comment les muscles squelettiques se protègent contre les dommages et les dysfonctions durant la fatigue
Fatigue is a phenomenon that protects skeletal muscle against ATP depletion that can cause fiber damage even death when skeletal muscle no longer generate sufficient ATP to sustain contractions. One important mechanism of fatigue involves the ATP sensitive K^+ channel. The channel is activated by decreases in intracellular ATP, increases in intracellular ADP and H^+ and extracellular adenosine. It prevents fiber damage and contractile dysfunctions by two mechanisms. First, it lowers action potential amplitude to reduce Ca^{2+} release by the sarcoplasmic reticulum in order to reduce ATP demand by Ca^{2+} ATPase and myosin ATPase. Second, it prevents excessive depolarization of the cell membrane preventing at rest the activation of the CaV1.1 channels that trigger the Ca^{2+} release channels of the sarcoplasmic reticulum. This second mechanism is especially critical because in the absence of K_{ATP} channel activity, myoplasmic [Ca^{2+}] increases causing contracture and increasing ATP demand and the likelihood damaging ATP depletion.

Richards, Jeffrey, Joshua Emerman, Victor Chan, Yuanchang Fang and Colin Brauner
The University of British Columbia
Defining the optimal salinity for growth of coho and Atlantic salmon in recirculating aquaculture systems
Recirculating aquaculture systems (RAS) are currently being considered for salmon aquaculture to reduce reliance on open net-pen farming. However, because RAS is costly, fish must be reared under optimal conditions to enhance growth and maximize profitability. In order to define the optimal salinity for the growth and physiological performance of salmon in RAS, we reared coho (*Oncorhynchus kisutch*) and Atlantic (*Salmo salar*) salmon from smolt to ~2 kg at five salinities ranging from freshwater to seawater (0, 5, 10, 20, 30 ppt). In coho salmon, the fastest growth rate and lowest feed conversion ratio (FCR) occurred at 10 ppt, which is nearly isosmotic with blood. Growth rate at 10 ppt was almost double that at 0 or 30 ppt at some stages. In Atlantic salmon, there was no effect of salinity on growth rate or FCR, although growth rates were high in all salinities and consistent with those seen in industry.

Roberts, Jordan C., Christian Carnevale, Devyn Ramsay, A. Kurt Gamperl and Doug A. Syme
University of Calgary
Effects of Hypoxia on Contractile Properties of the Compact and Spongy Myocardium of Steelhead Trout *Oncorhynchus mykiss*.
Trout ventricles have an outer compact layer supplied with well-oxygenated arterial blood from the coronary circulation and an inner spongy myocardium supplied with low O_2 from the venous blood that percolates through it. We tested the hypotheses that: 1) the contractile performance of the spongy myocardium, given its routine exposure to low PO_2, would perform better

under oxygen limiting conditions relative to the compact layer; and 2) compact myocardium would show a greater improvement in performance, as compared to the spongy myocardium, following chronic hypoxia exposure (40% air saturation). Work output was measured in ventricular strips from trout acclimated to normoxia and hypoxia when exposed to a series of decreasing PO_2 levels (100%, 65%, and 10% air saturation) and when returned to air saturation. Work output of the spongy and compact myocardium dropped to a similar extent when PO_2 was lowered, and recovery of contractile performance was comparable. In contrast, hypoxia acclimation had a negative effect on the work output of spongy, but a positive effect on compact myocardium. Thus, the spongy myocardium does not appear better suited to function under low PO_2 conditions.

Robertson, Cayleih, Glenn Tattersall and Grant McClelland
McMaster University
Altitude ancestry and the ontogeny of thermoregulation in the North American deer mouse (*P. maniculatus*)
Low oxygen and temperature at altitude are particularly challenging for small mammals due to their high energetic demands and thermogenic costs. The first month of life in small rodents is a period of high mortality with potential of high selective pressure for early development of independent endothermy. We tested the hypothesis that selection has accelerated the ontogeny of thermoregulation at high altitude using lab-reared descendants of deer mice native to low (LA; 400 m a.s.l) and high (HA; 3500 m a.s.l.) altitude environments. We determined the onset of thermogenesis in response to acute cold in pups aged 0-10 days using time-lapse video thermography and indirect calorimetry. This was combined with measures of pup growth rates and the maturation of the primary thermoeffector organs, skeletal muscle and brown adipose tissue (BAT). We found that the onset of independent endothermy coincides with the growth of BAT in both groups. Contrary to our predictions the thermogenic capacity of HA mice matured more slowly than LA mice. Although this suggests a relaxation of selective pressure in early life HA mice have a much greater thermogenic capacity as adults. This adaptive trait is likely driven by the complex interaction of genetic and environmental factors.

Robertson, Joshua, Ryan Caldwell and Dr. James Quinn
McMaster University
Cooperative breeders provide parental care to non-filial offspring – a behaviour known as alloparental care.
Hypotheses for the evolution of alloparental care often follow inclusive fitness theory; however, genetic analyses have revealed that cooperatively breeding group members are often unrelated (eg. *Ceryle rudis*). Where relatedness amongst group members is low, theory predicts that the degree of parental and alloparental care should therefore be proportional to ones contribution to mixed broods, depending upon reproductive options. We used genotyping data across 5-11 microsatellite loci for ten social groups (17 adults and 47 nestlings) to assess the hypothesis of proportional parental investment in a population of Smooth-billed Anis (*Crotophaga ani*), a joint-nesting cuckoo species thought to form social groups with non-kin. Nocturnal incubation in this species is thought to be risky and appears biased towards a single male, similar to closely related Greater Anis (*Crotophaga major*) and Groove-billed Anis (*Crotophaga sulcirostris*). We confirm low relatedness across social group members ($r = 0.159$, $n = 44$ dyads) and report a positive correlation between nocturnal incubation behaviour and reproductive contribution to communal nests. Our results support the parental investment hypothesis, suggesting mild skew in a joint-nesting species with reportedly low reproductive skew.

Russell, Anthony and Michele Delaguerre
University of Calgary
Let's rock: differential effectiveness of alternate adhesive pad configuration in geckos.
Adhesive pads of geckos take two basic forms – basal (beneath the middle portion of the digits) and terminal (situated distally). There is no functional explanation for their difference, although terminal pads are seemingly associated with rupicolous habits. A natural experiment provides insight. Giraglia Island (Corsica) harbours the native leaf-toed *Euleptes europaea* and the basal-padded *Tarentola mauritanica* (an aggressive colonizer) which arrived in 1950. *Tarentola* has remained confined to the walls of the island's only concrete building and has not colonized the prasinite outcrops making up the island (upon which *Euleptes* is common). Prasinite's surface is dusty, coated in particles of 5-40µm diameter. *Euleptes* can disengage its adhesive pads (by folding them towards the long axis of the digit) from dusty terrain while keeping its claws firmly engaged with surface asperities, thus functionally decoupling claws and adhesive apparatus. *Tarentola*, cannot disengage its basal pads without also disengaging its claws. Its pads thus become saturated with prasinite particles, it loses adhesion and its ability to climb. Mechanical differences in digit configuration enable *Euleptes* to navigate both dusty and "clean" surfaces but limit *Tarentola* to the latter. Our observations corroborate the hypothesis that terminal pads are suited to rocky surfaces, especially "powdery" ones.

Sanita Lima, Matheus, Laura C. Woods, Matthew W. Cartwright, David Roy Smith
University of Western Ontario
The (in)complete organelle genome: exploring the use and disuse of available technologies for characterizing mitochondri
Today, DNA sequencing technologies epitomize the slogan "faster, easier, cheaper, and more,". Given their relatively small sizes and high copy numbers per cell, organelle DNAs are among the most highly sequenced kind of chromosome. But characterizing an organelle genome require much more than DNA sequencing and bioinformatics analyses. Organelle genomes are surprisingly complex and exhibit convoluted modes of gene expression. Unraveling this complexity demands a wide assortment of experiments, from pulsed-field gel electrophoresis to Southern and Northern blots to RNA analyses. Here, we show that it is exactly these types of "complementary" analyses that are often lacking from contemporary organelle genome papers, particularly short "genome announcement" articles. Consequently, crucial and interesting features of organelle chromosomes are going undescribed, which could ultimately lead to a poor understanding and even a misrepresentation of these genomes and the genes they express.

Schulte (presenter) Taylor C. Gibbons, David C. H. Metzger, Timothy M. Healy and Patricia M. Schulte
University of British Columbia
Intraspecific variation in the response of the gill transcriptome to freshwater acclimation in threespine stickleback.
Following the last glaciation, threespine stickleback (*Gasterosteus aculeatus*) colonized newly available freshwater habitats in British Columbia. This colonization was associated with adaptive divergence in a variety of traits, including changes in salinity tolerance. Here, we used a combination of RNA-seq and real-time quantitative PCR to examine the response of the gill transcriptome to freshwater acclimation in marine and freshwater ecotypes of stickleback. RNA-seq comparing fish acclimated to fresh water and salt water revealed that expression of more than 2,000 genes changed in response to acclimation salinity, and more than 2,000 genes differed in expression between stickleback ecotypes independent of acclimation salinity. In addition, 36 genes demonstrated a significant interaction between ecotype and salinity ($P<0.05$ after FDR correction), among which were several important ion transporters. Using real time PCR, we also examined the expression of a set of candidate ion transporters at 0, 0.3, 2, 11, and 30 ppt. These transporters displayed a variety of changes in expression patterns among ecotypes. Taken together, these data demonstrate that the adoption of a freshwater-resident life history and the associated adaptation to freshwater involves important changes in gill gene expression and its regulation.

Schulte-Hostedde, Albrecht
Laurentian University
Conservation biology and zoos – integrating ecology and evolution
Zoos and aquariums are rapidly becoming conservation centres, with research and conservation explicitly mentioned in their strategic plans. This presents an opportunity to integrate ecology and evolution into a research context dominated by veterinary expertise. For example, captive breeding protocols undermine natural mating systems by forcing monogamy on species that may be otherwise polyandrous or polygynous. I will outline recent projects we have conducted with the Toronto Zoo and other zoo organizations. Using inbreeding coefficients (F) available from studbooks, we investigated the effects of inbreeding on sperm morphometry of black-footed ferrets and red wolves from captive breeding programs, to determine if more inbred males produced sperm with low quality sperm morphometry. Our results indicate that inbreeding affects functionally important aspects of sperm morphometry, such as tail length and head size and shape which can affect sperm swimming speed. The stress axis is also an area of interest for conservation, and I will outline a project examining hair cortisol in both wild and captive Vancouver Island marmots. Finally, I will describe a unique training program funded by the NSERC CREATE program (ReNewZoo) that will train conservation biologists for the zoo of the 21st century.

Seamone, Scott and Douglas Syme
University of Calgary
Escape responses provide insight into the function of the whip-like tail during locomotion in stingrays
The caudal fin powers swimming in many fishes, but in stingrays swimming is powered mostly by the pectoral fins, and a role for the narrow, whip-like caudal region is unclear. Using the ocellate river stingray, *Potamotrygon motoro*, we analyzed escape responses via high-speed video to explore the function of the caudal region. During escape, the rostrum and caudal region were observed to pinch towards one another forming a C-shape; rotation of both in the same direction was never observed. An increase in both the angle of rotation and angular velocity of the rostrum was significantly correlated to an increase in the angle of rotation and angular velocity of the caudal region, respectively. Furthermore, angular velocity of the caudal region was always greater than that of the rostrum, suggesting that caudal rotation was active and not passive. In contrast, the return flip of the caudal region was highly variable in performance, and it was never observed to accelerate across the longitudinal

midline of the animal. Thus, we argue that stingrays perform a modified form of the C-start escape response common to body-caudal-fin swimming fishes, whereby the caudal region has a significant role in rotation of the body, but not in generating forwards thrust.

Seaver, Elaine and Alexis Lanza
University of Florida
Evolution of development: the paradox of spiralian embryogenesis
Spiralian development is a highly conserved developmental program characterized by stereotypic spindle orientation and cell geometry in early stage embryos, and of ultimate cell fates. Spiralian development is exhibited by diverse taxa such as mollusks, annelids and nemerteans, and researchers have long been intrigued by the apparent paradox of how such a similar program of early development results in the diverse body plans of its members. We analyzed features of early development in the annelid *Capitella teleta*, including fates of early stage blastomeres and cell signaling events, and compare these with similar features in mollusks. Our fate mapping studies revealed many fates shared among spiralians, and a novel origin for trunk mesoderm. Previous studies in mollusks identified an 'organizing activity', a cell-cell signal that serves to influence development of the surrounding embryo. By deleting targeted cells with a laser, we identified an organizing activity in *C. teleta*, localized to a single cell, called 2d. The organizing activity in *C. teleta* has a different cellular origin and utilizes a distinct molecular signaling pathway than that for mollusks. Our results highlight previously underappreciated cellular and molecular variation among spiralian embryos, and contribute to our understanding of evolution of developmental programs.

Semple, Shawna L., Dan D. Heath and Brian Dixon
University of Waterloo
The impact of outbreeding on the immune performance of Chinook salmon when challenged with *Vibrio anguillarum*
With capture fishery production reaching a plateau in 1993 the increasing demand for fish protein can only be met through aquaculture. Currently aquaculture in North America is dominated by Atlantic salmon, but there has been an increasing interest in the culture of species native to the Pacific coast such as Chinook salmon (*Oncorhynchus tshawytcha*). As a developing aquaculture species, the selection and propagation of appropriate Chinook salmon stocks are essential for success. Often genes from wild stocks are incorporated into farmed stocks to avoid the decrease in performance that is associated with inbreeding. The current study focuses on assessing the immunological performance of 7 different hybrid stocks of Chinook salmon after challenge with the marine pathogen, *V. anguillarum*. These hybrid groups showed a large degree of variability in mortality throughout infection indicating that certain crosses were able to combat bacterial infection more effectively than others. To further explore this variation in immune performance, antibody development, cytokine expression and MHC alleles will also be compared between these groups. Understanding the impact of outbreeding on farmed, and often inbred, Chinook salmon could aid in the development of high-quality aquaculture stocks for the future.

Shadwick, Robert
UBC
Necrophysiology lives! Predicting blood pressure in the Greenland shark from aortic elasticity
Necrophysiology vit ! Prédire la pression artérielle chez le requin du Groenland de l'élasticité aortique
The level of activity of a fish is reflected by the pressure generated by its heart. Some sharks are slow moving with low metabolic rate, such as dogfish, while others with high metabolism swim fast, such as lamnids. The Greenland shark is generally considered to be very sluggish but its blood pressure has not been measured. Here we use an indirect method to estimate mean blood pressure in the Greenland shark, based on ventral aorta elasticity. From circulation mechanics we know that all vertebrate aortas are compliant at low pressures but become much stiffer at higher pressures, and this transition occurs in the region of the mean resting blood pressure. We inflated ventral aortas from dead Greenland sharks while measuring changes in diameter with increasing pressure. Our results show that the ventral aorta is very compliant at pressures below 3kPa, but becomes very stiff with further increase in pressure. Based on this result we estimate the mean blood pressure to fall in the range of 2-3kPa. For comparison, mean pressure is about 10kPa in a mako shark and about 4kPa in a spiny dogfish. These results support the idea that Greenland sharks are indeed a sluggish and likely slow-moving species.

Shaya, Lana and Joanna Y. Wilson
McMaster University
The role of the aryl hydrocarbon and estrogen receptors in cytochrome P450 gene regulation in zebrafish.
Mammalian Cytochrome P450 (CYP), family 3 enzymes are highly expressed in detoxification organs and play a critical role in xenobiotic metabolism. In fish, the CYP3 family is diversified and includes several subfamilies not found in mammals. The

regulational and functional roles of novel 3B, 3C and 3D proteins in fish are not clear. Multiple CYP3C genes were more highly expressed in zebrafish liver and/or intestine from at least one gender, suggesting a role in xenobiotic metabolism. Response elements for the aryl hydrocarbon (AHR) and estrogen receptor (ER) elements were found upstream of CYP3C genes, suggesting a role for multiple nuclear receptors in fish CYP3 gene regulation. We have exposed zebrafish to beta-napthoflavone (AHR agonist) and ICI 182 780 (ER antagonist) and assessed CYP3C gene expression via quantitative PCR. Exposure to 1uM beta-naphthoflavone caused an up-regulation of all the CYP3C genes in intestine, liver or gonad of adult zebrafish. Interestingly, exposure to 1uM ER antagonist caused an up-regulation of CYP3C genes. This suggests that the estrogen pathway may have a suppressive role in CYP3C gene regulation. Understanding how these genes are regulated will allow for a better understanding of the zebrafish physiology and provide insight on the CYP3 family in fish.

Sidhu, Anshu and Liette Vasseur
Brock University
Understanding the diamondback moth performance in alternative cropping systems.
The diamondback moth (DBM) (*Plutella xylostella*) (L.) (Lepidoptera: Plutellidae) is one of the most widespread and harmful insect pests almost exclusively targeting plants belonging to the Brassicaceae family, such as kale and radish. The damaging effects of this pest are predominantly due to its rapid growth, short generation time, and ability to develop insecticide resistance. DBM is resistant to all classes of insecticide currently available on the market. Understanding of DBM's behaviour and ecology is therefore crucial to develop novel, economically and environmentally friendly methods of control. The objective of my research is to examine the response of DBM to intercropping as an integrated pest management strategy. In this experiment, 2 male and female DBM were exposed to either kale or kale grown with onions in controlled conditions to assess their performance and kale damage. Results indicate that, eggs laying was delayed when insects are exposed to intercropping, which also reduced the abundance of 3rd and 4th instars, which are responsible for majority of the damage. It is hypothesized that onions may either release volatiles or interact with kale, rendering the environment less suitable for DBM. Further chemical analyses and field testing will help elucidate mechanisms affecting DBM and see its efficiency in operating conditions.

Sidhu, Harsh, Kamal Moghrabi, J Andrew Alexander, Sarah Van Es, Nguyen TK Vo, Niels C Bols and Lucy EJ Lee
University of the Fraser Valley
Characterization and toxicological applications of a continuous cell line derived from rainbow trout ovarian fluid
The fish ovarian fluid is a unique source for developing cell lines from adult fish specimens with no injury or death of the donor animal. The ovarian fluid especially from salmonids like Rainbow trout, Atlantic salmon and Arctic char, are routinely and readily "stripped" in aquaculture facilities without deleterious effects to the animals. The salmonid ovarian fluid contains large amounts of viable cells consisting of a mixture of mesothelial, lymphatic, ovarian follicular cells and others. Various cell culture attempts at growing cells from the stripped fluid of the adult female salmonid species noted above, resulted in positive primary cultures that could be passaged and made into continuous cell lines. In this study we report the establishment and use of RTovfl-2, now a 12 yr old cell line derived from the ovarian fluid collected during routine stripping of a ripe female rainbow trout (*Oncorhynchus mykiss*) at Alma Aquaculture Station in Guelph, ON, in 2004. These cells grow well in Leibovitz-15 media (L-15) supplemented with 10% fetal bovine serum (FBS) at 18C. The cell line consists of a mixture of fibroblastic and epithelial cells with adult stem cell characteristics. They readily form embryoid bodies, are negative for Beta-gal senescence staining and have been successfully cryopreserved and thawed in multiple occasions beginning from passage 5 onwards. The cells originally consisted of a mixture of epithelial and fibroblastic cells with ciliated cells that maintained their differentiated and functional cilia up to passage 5. Eventually, cells became undifferentiated and the ciliary phenotype was lost. Attempts to induce cilia by exposure to dimethylsulfoxide were negative. The cells however are phagocytic and respond in a dose dependent manner to pesticide treatment reducing their phagocytic activity with increasing doses of neonicotinoid insecticides. This is also true for their ability to wound repair when evaluated with scratch assays, which is reduced with increasing doses of neonicotinoids.

Signore, Anthony V., Phillip R. Morrison, Colin J. Brauner and Kevin L. Campbell
University of Manitoba
Temperature dependent effector binding: the definitive molecular mechanism underlying hemoglobin thermal sensitivity
As hemoglobin's affinity for O2 is inversely related to temperature, Arctic species may experience reduced O2 offloading to poorly insulated appendages. However, select species have evolved hemoglobin proteins with reduced thermal sensitivity that can maintain O2 delivery at low temperatures. This phenotype has historically been attributed to the binding of additional allosteric effectors to the hemoglobin moiety relative to that of non-cold adapted species. Conversely, recent evidence indicates that hemoglobin from the extinct Steller's sea cow binds fewer allosteric effectors than those of its tropical relatives (dugongs and manatees), yet surprisingly, the presence of these ligands reduces its thermal sensitivity to a greater extent. To

elucidate the mechanisms underlying this phenomenon, we measured the O2 affinity of woolly mammoth, elephant, and sirenian hemoglobins in the presence of serially increasing allosteric effector concentrations at both 25 and 37C. Quantitation of effector binding revealed that total effector binding (i.e., number of effector molecules bound) is not directly linked to the thermal sensitivity of hemoglobin. Rather, effector binding is revealed to be temperature dependent (i.e., it increases as temperature decreases), with cold adapted hemoglobins exhibiting greater increases in relative effector binding – and hence, a lower thermal sensitivity – than those of non-cold adapted species.

Singh, Bhagirath
University of Western Ontario
Regulation of Immunity and Autoimmunity by Microbiome
Microbes and immune system have a strong reciprocal relationship in maintaining health. The microbes are essential for normal development and function of the immune system but they can also cause dysbiosis. This could result in immune dysregulation leading to many chronic diseases such as autoimmunity, allergy and cancer. The immune system maintains balance between host and microbes and profoundly shapes the host immunity. The developmental aspects of the adaptive immune system are influenced by intestinal microbial colonization. Although immune system is designed to control microbes but it is likely to be regulated by microbiota that inhabit the gut. The microbiota that resides in the gastrointestinal tract provides many essential health benefits to its host, particularly by regulating immune homeostasis. Moreover, sex differences strongly influence the development of autoimmunity by modifying the gut microbiota. In our studies we have found microbial agents such as mycobacteria downregulate autoimmunity and prevent disease progression such as type 1 diabetes by inducing regulatory T cells. Better understanding of the immunomodulatory pathways induced by microbes and altering host microbiota will open new approaches to maintain health and prevent disease.

Skandalis, Dimitri A., Joseph W. Bahlman, Paolo S. Segre, Derrick Groom, Christopher C. Witt, David Lentink, Jimmy A. McGuire, Robert Dudley, Douglas L. Altshuler
University of British Columbia
Allometry of aerodynamic force reveals hummingbirds minimize wing velocity to maximize performance
Hummingbirds' wing areas grow unusually rapidly relative to body mass (allometry with exponent 1, compared to 0.72 in other birds), potentially providing important insights into the biomechanical evolution of flight. We examine the functional implications of wing area allometry through basic aerodynamic theory, which integrates biogeography (through elevation and thus air density), morphology (wing area), and biomechanics (wing velocity and force coefficient). Each variable's allometric exponent represents its contribution to weight support, and comparing exponents among and within species can reveal the likely origin of interspecific scaling patterns. Among hummingbird species across elevations, weight support is solely a function of rapidly increasing wing area, and significantly, wing tip velocity is independent of both body mass and air density. Within species, weight support derives from a combination of wing area and wing velocity, and low air densities are compensated by increasing wing velocity. Reliance on wing velocity to provide weight support and overcome air density challenges increases the cost of routine flight and decreases competitive performance. This suggests that hummingbird evolution has favoured minimising wing velocity to maximise performance. Shifting emphasis in this way from single allometric exponents across all clades to clade-specific exponents reveals distinct selective regimes in flying animals.

Slade, Joel, Matthew Watson, Tosha Kelly, Mark Bernards, Greg Gloor, Elizabeth MacDougall-Shackleton
University of Western Ontario
Preen oil as a signal of MHC genotype in a songbird
In vertebrate animals, genes of the major histocompatibility complex (MHC) encode proteins that recognise, bind and present non-self antigens to T cells for destruction. MHC loci thus play a fundamental role in adaptive immunity. Because selection at MHC often favours highly heterozygous individuals and/or individuals with particular “good” alleles, assessing the MHC profile of a potential mate should be advantageous. In mammals and fish, this is accomplished using odour cues, but candidate mechanisms remain largely unexplored for birds. Feather preen oil may represent a source of odour cues through which birds might assess the MHC profiles of potential mates and other conspecifics. We examined the relationship between MHC genotype and the chemical/odour profile of preen oil in free-living song sparrows (*Melospiza melodia*). We used next-generation sequencing to genotype birds at the hypervariable class IIß exon 2 of MHC, and used, gas chromatography (GC) to characterize the chemical composition of their preen oil. Pairwise genetic similarity at MHC was related to pairwise similarity in preen oil composition for male-male and female-female dyads, but not for male-female dyads, suggesting that chemical cues in avian preen oil represent a useful candidate cue for assessing MHC profiles.

Soulliere, Cheryl, Lital Sever, Susy Lam, N.T.K. Vo, Jack Iwanczyk, Joel Kooistra, Neils Bols and Brian Dixon
University of Waterloo

Regulation of rainbow trout (*Oncorhynchus mykiss*) IFNγ, IL-1β, and TNFα and the pro-inflammatory response

In mammals, interferon gamma (IFNγ), interleukin 1 beta (IL-1β) and tumor necrosis factor alpha (TNFα), have been well characterized and identified as key players of the pro-inflammatory response. However, investigation of these cytokines in teleosts has primarily focused on gene regulation rather than protein regulation thus, the functional roles these cytokines play in fish health is poorly understood. Polyclonal antibodies produced in rabbit, chicken and goat were used to develop quantitative enzyme-linked immunosorbent assays (ELISA) and enzyme-linked immunosorbent spot (ELISpot) assays. Quantitative polymerase chain reaction (qPCR) was optimized to investigate corresponding gene regulation. *In vivo* rainbow trout time course trials as well as in vitro time course trials using rainbow trout cell lines, RTS11 and RTgutGC, were conducted using Poly I:C and Vibrogen 2 vaccine as immunostimulants. Protein and ribonucleic acid (RNA) were extracted from each sample and protein and gene expression patterns of IFNγ, IL-1β and TNFα were investigated. A comparison of the protein and gene expression profiles of these key cytokines provides further insight into the regulation of the innate immune response of teleosts. Understanding the regulation of inflammation and fish immunity could lead to improved disease management strategies and the development of effective fish vaccines.

Spiteri, Katelin, Anton Korenevski. and Stephanie DeWitte-Orr
Wilfrid Laurier University

IMMUNOMODULATION USING NANOPARTICLE PHYTOSPHERIX™ IN RAINBOW TROUT CELLS

Mirexus' proprietary PhytoSpherix^{TM} (PHX) is a biomaterial composed of monodispersed nanoparticles. We are investigating the impact of PHX on the type I interferon (IFN) response; either chemically modified PHX or PHX conjugated to nucleic acids. Preliminary studies indicate that chemically modified PHX interacts with cells by preventing IFNs and IFN-stimulated genes (ISGs) expression. PHX also prevents a protective innate antiviral immune response in cells when infected with viral hemorrhagic septicemia virus (VHSV)-IVb or chum salmon reovirus (CSV). Double-stranded (ds)RNA is a potent inducer of IFN response within the cell. Commercially available dsRNA, polyinosinic: polycytidylic acid (poly IC), was conjugated to PHX and cells responded with higher IFN and ISGs expression compared to poly IC alone. This suggests when PHX is functioning as a carrier for dsRNA, it can stimulate the IFN-mediated innate immune response but when chemically modified and acting alone, exhibits IFN-suppressive characteristics.

Spong, Kristin and R Meldrum Robertson
Queen's University

Variation in the severity of spreading depolarization in the brain of *Drosophila*

Spreading depolarization (SD) manifests as a massive redistribution of ions coinciding with an arrest in electrical activity that propagates throughout neural tissue. Mammalian SD underlies a continuum of neural pathologies from migraine to stroke damage while SD in the insect CNS is involved in environmental stress-induced neural shutdown. Here we show that the *Drosophila* brain supports repetitive SD induced by ouabain treatment (inhibition of the Na^+/K^+-ATPase) or by application of high KCl providing a model system on which control mechanisms of SD can be genetically dissected. Using wild-type flies we show that young adults are more resistant to SD compared to older adults, demonstrating that fly SD is age-dependent. Furthermore, we show that the susceptibility to SD differs between wild-type flies and w1118 mutants indicating that our ouabain-model is influenced by genetic strain. Lastly, we show that flies with low levels of protein kinase G (PKG) activity are more resistant to SD compared to flies with higher levels. These results confirm the PKG pathway as a modulator of insect SD and, given the conserved nature of the signalling pathway, suggest that it could play a similar role during SD in the mammalian CNS.

Standen, Emily
University of Ottawa

Locomotion in a novel environment: a web of physiological impacts

When animals expand their range or enter new habitats they encounter new challenges. Few animals meet more of these challenges than fish moving from water onto land. From a locomotory perspective, mechanical forces that their musculoskeletal system must overcome - such as gravity - change dramatically. We use *Polypterus senegalus*, a predominantly aquatic fish that can breathe air and walk over land, as a model to understand how ancestral fishes may have explored novel terrestrial environments. *Polypterus* that are exposed to a terrestrial environment for an extended period of time show remarkable plasticity in behaviour and skeletal anatomy, resulting in what appears to be a more 'effective' strategy for locomotion over land. The physics of mechanical loading may cause these changes but it is the physiological plasticity of the

animals that allow them to remain in and respond to their novel environment. We are interested in how these basal fish respond to terrestrial challenges in hopes that it will give us insight into how physiological processes change and influence anatomy and functional morphology.

Stevens, Don
UPEI
Thanks.
Merci.
1. Thanks! / 2. We have the greatest job in the world! / 3. Thanks to NSERC for supporting average researchers!

Stone, J.
McMaster University
Testing Developmental Flexibility in Sea Urchin Skeletons to Make Sense of Sand Dollars (and Rudimentary Speculations)
Developing echinoids, such as sea urchins and sand dollars, exhibit dramatic morphological flexibility in response to nutrient variation. The extent to which echinoids display this flexibility has been explored incompletely and research has been conducted primarily on larval structures and morphologies. Experimental investigations into the extent to which a juvenile structure, the developing rudiment, exhibits flexibility among individuals in three sea urchin species are described. Rudiment regression and complete resorption as a response to starvation during echinoid larval development is reported for the first time. Given these observations and previous suggestions by other researchers about nutrients and flexibility in metamorphosis, echinoid rudiments might provide means for buffering development during unfavorable conditions. Speculations on the morphological evolutionary implications among echinoids for rudiment flexibility, formulated with computational models, are offered.

Suntres, Tina E, Gheylen Daghfous, Réjean Dubuc, Barbara Zielinski
University of Windsor
Solitary Chemosensory Cells During the Sea Lamprey Life Cycle
The sea lamprey, *Petromyzon marinus*, is a basal lineage vertebrate with a diffuse chemosensory system with microvillous solitary chemosensory cells (SCCs) located on small papillae on the surface of the body, including gill pores. The objectives of this study were to assess the abundance of these gill pore SCCs across life stages, and to characterize the biochemical properties. The SCCs were most abundant in the migrating and spawning stages, compared to the earlier life stages, suggesting a role during reproduction. Prominent calretinin and serotonin labeling show SCC homology to previously identified taste cells and to SCCs in other vertebrates. Labeling for phospholipase C (also seen in mammalian SCCs) suggests that chemosensory signal transduction occurs by an IP3 mediated cascade. This study suggests that SCC function is important during the migrating and spawning stages of the sea lamprey life cycle and shows homology between lamprey SCCs and more derived vertebrates.

Syme, Doug
University of Calgary
The imbalance of power - assessing functional consequences of muscle fatigue
Defined as performance that is less than expected, muscle fatigue is commonly assessed as the failure to produce force, and the functional capacity of muscle to perform a task is then interpreted from this. Through application of the work-loop technique, new insights have been gained into the functional consequences of muscle fatigue, beyond those afforded by studying force alone. These include i) a failure of the ability of muscle to power movement that is markedly more rapid in onset and extensive than that predicted based on the ability to produce force, ii) that the ability of muscle to produce cyclic movement is not a simple reflection of the ability to produce force while shortening, iii) that fatigue of mechanical work is notably distinct between relatively fast and slow muscles and depends on power not just force, and iv) that the ability of muscle to do work appears to fatigue and recover at different rates (relative to force), suggesting that mechanisms beyond just those impacting force generation are important in fatigue. Analysis of work output, as a currency of energy, holds the potential to offer considerable insight into the functional consequences of muscle fatigue, and perhaps insight into mechanisms of fatigue.

Syme, Doug
University of Calgary
The benefits of bouncing: ups and downs in theory and practice

The ability of elastic structures (e.g. tendons) to absorb and then release mechanical energy during locomotion, as a mechanism to enhance locomotor performance or economy of cyclic movement, has been touted as an important design feature in some animals. Theoretical accounts and some empirical measures hint that these mechanisms do occur and contribute to enhancing movement. However, there still exists little direct evidence to demonstrate the extent to which such gains are realized by animals during locomotion, largely due to the challenges of using experimental manipulation to test hypotheses about these mechanisms. I will present results of theoretical predictions and direct empirical measures of the effects of energy absorption by elastic structures on the economy of doing work and on the enhancement in mechanical performance of muscle-tendon systems. Enhancements in economy of cyclic movements appear potentially significant, although gains in economy are likely traded against flexibility in movement. Enhancements in mechanical performance appear less impressive, perhaps being limited to extreme examples. The mechanisms and extents to which tendons may enhance movement and economy require further exploration.

Talbot, Benoit, Maarten J. Vonhof, Hugh H. Broders, Brock Fenton and Nusha Keyghobadi
University of Western Ontario
Evolutionary genetic aspects of host-parasite interactions in two bat species and an ectoparasitic insect
Aspects évolutifs et génétiques des interactions hôte-parasite chez deux espèces de chauves-souris et un insecte ectoparasitic
Movements and demography of parasites and hosts are often linked. Therefore, parasites can often inform on ecology of their hosts, and vice versa. *Cimex adjunctus* is a parasite of bats, known to be generalist in that they often switch between individual hosts and may even switch between bat species. In my doctoral project, I have examined large- and fine-scale genetic structure of *C. adjunctus* throughout North America. I collected cimicid insect samples from bat colonies throughout Canada and United States. I also collected data and samples from big brown bats and little brown myotis, which are two key hosts of *C. adjunctus*. I then analyzed Cytochrome Oxydase 1 mitochondrial gene, for all three species, and I used 7 and 8 microsatellite loci to genotype *C. adjunctus* and big brown bats, respectively, in the lower Great Lakes area. I found higher levels of genetic structure and differentiation in *C. adjunctus* than in its hosts, differential effects of habitat composition between *C. adjunctus* and big brown bats, and evidence of local extinctions and recolonizations in *C. adjunctus*. Overall, my results show that key ecological differences between a host and a parasite can produce large differences in gene flow patterns and demography.

Tams, Verena
Universität Hamburg, Germany
Influence of local adaptation on intraspecific phenotypic variation in *Daphnia galeata*
Species adaptation to environment occurs at the population level, and thus can greatly increase the intraspecific variance of both genotypes and phenotypes. However, in evolutionary experiments on *Daphnia* species the population dimension is often missing, a few clonal lineages acting as representatives for a whole species. The importance of the intraspecific variation for adaptive potential is therefore rarely addressed. To understand the genetic background of rapid adaptation to environmental changes in *Daphnia galeata*, I will use a combined approach of ecological and genomic techniques. In an experiment the effect of predation (proxy: fish kairomones) on life history traits have been recorded in four different European populations of D. *galeata* maintained in the lab. Each population is represented by 6 genotypes. The results show how the variance in life history traits is distributed within and among these D. *galeata* populations in the absence or presence of a potential predator. Since gene expression profiles are available for the studied genotypes, we can further address following questions: (i) Are gene expression profiles correlated with the fitness of individuals? (ii) Is there a correlation between differentiation at the genotypic and phenotypic level? Combining experimental and genome-wide results we get unprecedented insights into the dynamics of local adaptation processes of this ecologically relevant species.

Tessier, Laura and Mike Wilkie
Wilfrid Laurier University
Body mass and metabolic rate are predictors of the lampricide sensitivity of invasive sea lampreys (*Petromyzon marinus*)
Invasive sea lampreys contributed to massive declines in Great Lakes' fish populations in the early- to mid-twentieth century. In the last fifty years, populations of sea lamprey have been controlled through applications of the lampricide (TFM) to streams where their larvae are present in high densities. Residual larvae that survive treatments remain a challenge, however. This study tested the hypothesis that larger larval sea lampreys were a more likely source of TFM treatment residuals due to lower mass specific metabolic and TFM uptake rates. Accordingly, oxygen consumption (MO_2) was quantified using static respirometry, and ^{14}C-TFM used to track rates of TFM uptake in different sizes of larvae (0.1g–3.7g). SMATR (R version 3.0.3) computed the scaling exponents for MO_2 and TFM uptake rate from the equation $Y=aM^b$. Both MO_2 ($b=0.75$; $P<0.0001$;

R^2=0.57) and TFM uptake rates (b=0.38; P=0.001; R^2=0.30) were negatively correlated and scaled allometrically with body mass. Yet, regardless of size, larvae had the same capacity to eliminate injected (intraperitoneal) ^{14}C-TFM. We conclude that larger larval sea lamprey are a likely source of residuals following lampricide applications because their lower metabolic rates lead to lower mass specific rates of TFM uptake and accumulation.

Theodor, Jessica
University of Calgary
Four toes good, two toes bad: complex patterns of digit reduction in artiodactyls
Digit reduction has long been recognized as an important evolutionary feature of artiodactyls, but the variability of digit reduction among extinct lineages has seldom been appreciated. Most morphological phylogenetic analyses have coded digit reduction assuming that digit reduction has not reversed and not been strongly convergent. However phylogenetic reconstructions imply that digit reduction among artiodactyls has been considerably more complex. Reduction and loss of D2 and D4 in cow and pig have been demonstrated to be a result of posterior restriction and downregulation of Ptch-1 expression in the limb bud, while in camels, Ptch-1 expression shows the ancestral unrestricted pattern. Instead, camel digit reduction results from extensive apoptosis in D2 and 4, which is not found in pig and cow. While mechanisms are unknown for most other artiodactyls, reconstructing the evolution of digit reduction patterns suggests that 1) patterns of loss of manual D1 and pedal D1 are not congruent and are convergent among lineages 2) reduction of D2 and D4 in cainotheres and xiphodontids may represent a third developmental mechanism for digit reduction 3) the three-toed morphology observed among some anoplotheres may provide additional insight into the diversity of digit reduction mechanisms.

Thiagavel, Jeneni and John M. Ratcliffe
University of Toronto
Big mouth strikes again: gape as an underestimated correlate of echolocation call peak frequency in vespertilionid bats
Small vespertilionid bat species emit echolocation calls with higher peak frequencies than do larger vespertilionid species. This negative relationship between peak frequency and body size has been explained (i) by allometry, (ii) as a limitation of minimum detectable prey size, or (iii) as a means by which small bats achieve a directional (i.e. long, narrow) sonar beam when flying in open space. Here, we use a combination of published and measured body and echolocation call parameters to test the allometry and directionality hypotheses. We found that while gape and body measures both well-explained variation in peak frequency, gape size became the better predictor when outliers were removed and when bats with different preferred foraging habitats and available prey-capture strategies were considered categorically. Our study supports the hypothesis that gape size is an important correlate of open space echolocation call peak frequency and that preferred foraging guild is essential to understanding how different bats shape biosonar to perceive their surroundings.

Trites, Michael and Daniel Barreda
University of Alberta
Contributions of immune transferrin to acute inflammation in goldfish, *C. auratus*.
Transferrin is an evolutionary conserved protein that in addition to having a critical role in iron transport also has been shown to have immunomodulary effects in vitro. Both bovine and teleost transferrin fragments have been shown to induce anti-microbial responses in bovine and teleost macrophages systems. Using a self-resolving model of inflammation in goldfish (*Carassius auratus*) we demonstrate the presence of cleaved transferrin *in vivo*. We find that cleaved transferrin fragments are present in pathogen induced, but not sterile, inflammation. Additionally, we find that macrophages, and neutrophils cooperate in generating cleaved transferrin products. Macrophages, but not neutrophils, exhibit inducible expression of transferrin. However neutrophils, but not macrophages, posses the ability to enzymatically digest transferrin. We propose a model where these leukocytes have a long-standing partnership to promote transferrin-induced responses during acute inflammation.

Truong, Wesley and Jim McGeer
Wilfrid Laurier University
The sublethal physiological effects of exposure to copper and silver mixtures on rainbow trout (*Oncorhynchus mykiss*)
The mechanisms behind metal-metal interactions in freshwater environments are currently not well understood. The goal of this research was to build a better understanding of the interactions between copper (Cu) and silver (Ag) by investigating the chronic impacts of metal mixtures on the rainbow trout (*Onchorhynchus mykiss*). Juvenile trout were exposed for 10 and 14 days to Cu-only, Ag-only, or a Cu + Ag mixture. The effects of Cu-Ag interactions were assessed by measuring whole tissue bioaccumulation and subcellular distribution in gills, liver and kidney, as well as plasma Na and Cl. Cu and Ag accumulation was significant in all tissues of mixture-exposed fish as a result of a more than additive effect by metal interactions; however, these

effects were not observed on hepatic Ag. Subcellular distribution of Cu mainly occurred in metal sensitive fractions while Ag accumulated predominately in biologically detoxified fractions. Mixture-exposed fish experienced a more than additive disruption on plasma Na and Cl as ion levels were significantly less than those exposed to Cu or Ag-only. Overall, the effect of Cu-Ag interactions on bioaccumulation and ion regulation in rainbow trout was dependent on exposure concentrations. This research was supported by the NSERC.

Turenne, Eric, Kevin Choi and Jean-Michel Weber
University of Ottawa
Prolonged hypoxia causes restructuring of goldfish membranes
L'hypoxie prolongée cause la restructuration des membranes du poisson rouge
Ectotherms are known to modulate membrane composition when they cope with changes in temperature, osmolarity or exposure to some toxins. However, no *in vivo* information is available about the potential effects of prolonged hypoxia on membrane structure that may be needed to regulate the activity of key membrane proteins like electron transport chain enzymes and Na^+/K^+ ATPase. To evaluate this possibility, adult goldfish (*Carassius auratus*) were exposed to normoxia (controls) or hypoxia (10% air saturation) for 30 days at 13°C. The fatty acid composition of membrane phospholipids was only altered by hypoxia in the liver, but remained constant in other tissues. Liver membranes showed a large increase in the n-3/n-6 ratio (from 2.3 to 3.3) and a decrease in % monounsaturated fatty acids. More importantly, membrane cholesterol levels increased particularly strongly in gills (+140%) and muscle (+50%), but decreased in liver (-53%). We conclude that chronic hypoxia causes the fundamental remodelling of goldfish membranes, presumably to protect normal function when oxygen supply becomes limiting. We propose that the drastic increase in cholesterol observed in the gills could be essential to maintain plasma buffering capacity by slowing down CO_2 efflux when metabolic rate is suppressed and glycolysis produces more protons.

Turko, Andy J., Suzanne Currie, Ryan L. Earley, Alexis Platek, Andrei Tatarenkov, D. Scott Taylor, and Patricia A. Wright
University of Guelph
Behaviour not genetics explains differences in hypoxia tolerance in the selfing fish *Kryptolebias marmoratus* in the wild
The osmo-respiratory compromise hypothesis proposes that the gill surface area of fishes depends on a trade-off between the need to obtain oxygen (favoured by a large surface area) versus effective ionoregulation (favoured by small surface area, especially when osmotic gradients are large). Laboratory studies have provided support for this idea, but tests under field conditions are lacking. On Long Caye, Belize, we found an ideal "natural experiment" to test the osmo-respiratory compromise hypothesis: two adjacent but genetically distinct populations of mangrove rivulus *Kryptolebias marmoratus*, one living in relatively well-oxygenated freshwater and the other inhabiting virtually anoxic brackish crab burrows. Contrary to expectations, we found that fish caught in the hypoxic crab burrows had significantly less gill surface area and reduced oxygen uptake ability (higher critical oxygen tensions) than those from freshwater. Behavioural experiments found that crab burrow fish spent significantly more time out of water than freshwater fish, thereby avoiding the severely hypoxic aquatic crab burrow conditions. Laboratory studies suggest that frequently leaving water causes gill remodelling that reduces gill surface area and oxygen uptake ability. Thus, under natural conditions behaviour interacts with environmental conditions to influence gill morphology and respiratory performance in mangrove rivulus.

Tzaneva, Velislava, Jennifer Ho, Heidi Li, Steve F. Perry
University of Ottawa
The effects of HIF-1α on control of ventilation in zebrafish larvae (Danio rerio) exposed to hypoxia
Hypoxia inducible factor-1α (HIF-1α) is a master regulator of cell homeostasis under low oxygen (hypoxic) conditions. In fish, it has been shown to increase in tissues such as the liver in response to acute and chronic hypoxia. In this study, we specifically investigate the role of the HIF-1aa paralog in control of ventilation in the larval zebrafish (*Danio rerio*). Zebrafish larvae were injected with a HIF-1 morpholino (MO) oligonucleotide to knock down HIF-1 or a sham MO and left to develop until 4 days post fertilization (dpf) at which time experiments were performed. Acute hypoxia exposure (30 min, water PO_2 ~20 Torr) caused a significant increase in the ventilation frequency of all groups. HIF-1 MOs, however, exhibited a blunted response to acute hypoxia. Separate groups of sham and HIF-1 MO larvae were raised in hypoxic conditions (water PO2 ~30-40 Torr) until a developmental age of 4 dpf. This pre-exposure to hypoxia did not alter the hyperventilatory response to low water PO2 levels in sham or HIF-1 MO larvae. Overall, HIF-1 plays a role in stimulating the hyperventilatory response to hypoxia when the larvae are raised in normoxic conditions but not when they are raised in water with low water PO_2.

Vo, Nguyen (Nathan) T. K., Colin B. Seymour, Soo H. Byun and Carmel E. Mothersill
McMaster University
Effects of low doses of alpha, beta, and gamma-emitting radionuclides on the innate antiviral responses in fish cells
In Canada, nuclear power currently supplies 14 % of gross electricity production. Nuclear power is recognized as "clean" relative to fossil fuels. Because of the highly fluctuating oil market, the impacts of tar sands development in the Northern territories, and the consequences and public and federal acceptance of climate change, the contribution of nuclear power to Canada's electricity production will mostly likely increase in the future. In Ontario alone, 57 % electricity is generated by nuclear power. However, there have always been uncertainties in radiation risks in the environment. A particular point of concern is associated with exposure of low doses of contaminating radionuclides in the watersheds to aquatic life and food sources because possible different mechanisms, often unpredictable, may govern the radiobiological effects. Our research group has discovered some of these effects in fish. Wild and farmed fish constantly succumb to infections; yet very little is known about the effects of radionuclides on immune responses in fish. Here we present experimental data on the effects of low doses of radium-226 (alpha emitter), tritium (beta emitter), and cesium-137 (gamma emitter) on the innate antiviral responses in established cell models derived from zebrafish, rainbow trout, and bluegill.

Vijayan (presenter), Carol Best, Deborah Kurrasch and Matt Vijayan
University of Calgary
Maternal cortisol stimulates neurogenesis and affects larval behaviour in zebrafish
Prenatal exposure to excess glucocorticoid due to maternal stress is thought to affect developmental programming in vertebrates, but the mechanisms are far from clear. We tested the hypothesis that elevated zygotic glucocorticoid exposure affects neurogenesis and compromises larval behaviour in zebrafish (*Danio rerio*). Elevation of glucocorticoid levels in the zygote was accomplished by microinjecting cortisol into the yolk to mimic deposition due to maternal stress. Primary neurogenesis, measured by the incorporation of the thymidine analogue 5-ethynyl-2'-deoxyuridine (EdU) at 24 hours post-fertilization, was increased in a region-specific manner in the forebrain. Specifically, cortisol stimulated neurogenesis in the preoptic area and the pallium, which is analogous to the hippocampus in higher vertebrates. Increased neurogenesis corresponded with higher transcript abundance of the proneural genes neuronal differentiation 4 (*neurod4*) and orthopedia b (*otpb*) in zebrafish brain. Larvae at 4 days post-fertilization displayed increased activity levels in light and decreased thigmotaxis (propensity to remain close to arena walls), suggesting increased boldness in response to cortisol stimulation. Overall, this study demonstrates for the first time that elevated zygotic cortisol content, mimicking maternal stress, affects neurogenesis leading to developmental changes including altered behavioural traits in zebrafish.

Wang, Susan, Glenn J Tattersall, and Janet Koprivnikar
Brock University
Studying Effects of Trematode Infection on Thermoregulatory Behaviour in Tadpoles
Behavioural fever, where ectotherms in response to pathogens prefer warmer temperatures, has an adaptive value by increasing survival of infected animals. While much of this research has been conducted with viruses and bacteria, the aim of this study was to understand how parasitic infections affect temperature selection. Given recent amphibian declines, the model studied was the infection of pathogenic trematode *Ribeiroia ondatrae* in *Lithobates sylvaticus* tadpoles. 96 tadpoles were exposed to 25 trematodes or sham-exposed with water and placed in the experimental apparatus one, two, or three days post-exposure. Tadpoles were placed in either a thermal gradient or in a gradient at room temperature and behaviourally selected preferred temperature by swimming. Tadpoles were able to respond to temperature and linear mixed modeling indicated that the two factors significant in explaining thermoregulatory behaviour were exposure to parasites and elapsed time in the experimental apparatus. However individual infection intensity could not significantly explain thermoregulatory behaviour, suggesting that temperature selection may be contingent on whether tadpoles were simply exposed to parasites or if they were infected. Consequences of exposure to parasites that affect thermoregulatory behaviour may cause large repercussions in tadpoles as body temperature plays a large role in ectothermic growth.

Watson, Matthew, Joel Slade, Greg Gloor, Beth MacDougall-Shackleton
Western University
MHC diversity as a predictor of survival and a correlate of neutral-locus heterozygosity in free-living songbirds
Genetic diversity is critical in shaping the adaptive capacity of natural populations and the fitness of individuals. Genetic diversity is often assessed using selectively neutral markers such as microsatellites, but neutral-locus diversity may not accurately reflect diversity at functional loci subject to natural selection. For example, the major histocompatibility complex (MHC) is the most polymorphic region in the vertebrate genome, presumably because diversity at MHC confers enhanced

resistance to infectious disease. We investigated whether MHC diversity covaries with neutral-locus (microsatellite) diversity, and whether MHC diversity is associated with apparent annual survival, in free-living Song Sparrows (*Melospiza melodia*). MHC diversity in the study population was high (296 unique alleles found in 69 individuals, with 3-18 alleles per individual, indicating multiple duplications at this locus) but was not predicted neutral-locus diversity. Longitudinal and cross-cohort (adult, yearling, juvenile) analyses of apparent survival in relation to MHC diversity will be discussed. This information will aid in conservation and management guidelines for how best to assess genetic diversity and adaptive potential in wild populations.

Weinrauch, Alyssa M., Alexander M Clifford, Greg G Goss
University of Alberta
Post-prandial alterations in the physiology and intestinal morphology of Pacific hagfish
The physiology of fed hagfish has never before been examined, yet hagfish occupy a unique trophic niche being demersal scavengers that consume both live and dead prey. We characterized the post-prandial status of the hagfish via four methods: 1) specific dynamic action (SDA) 2) acid/base status 3) nitrogenous waste excretion and 4) intestinal morphology. Resting metabolic rate was 0.64 μmol g^{-1} h^{-1} and the peak of SDA (1.87 μmol g^{-1} h^{-1}) occurred 8h post-feeding with a scope of 2.91. The peak correlated with a significant base equivalent efflux (2981.99 μmol kg^{-1} h^{-1}) that was 11-fold greater than controls. We suggest that hagfish utilize acidic digestion and display the alkaline tide phenomenon. Nitrogenous waste excretion increased nearly 15-fold from 19.4 μmol g^{-1} h^{-1} to 277.8 μmol g^{-1} h^{-1} at 36h post-feeding. Finally, alterations to the intestinal morphology will be measured via light, scanning electron and transmission electron microscopy. Increased surface area as determined by increases in mucosal thickness and microvilli length will be examined.

Welch (presenter) Nadia Bayram, Mary Shehata, L. Gerardo Herrera and Kenneth C. Welch Jr.
University of Toronto Scarborough
Hummingbirds modulate the use of single nectar meals differently as energetic demands change
Physiological adaptations that enhance flux through the sugar oxidation cascade permit hummingbirds to rapidly switch between burning lipids when fasted to burning ingested sugars when fed. Hummingbirds may be able to exert control over the timing and extent of use of ingested sugars by varying crop emptying rate. We hypothesized that hummingbirds would modulate the timing of a switch to reliance on ingested sugars differently when facing distinct energetic demands (cool versus warm temperatures) or at different times of the day, as hummingbirds would be under increased pressure to accumulate lipid as the overnight fast approached. The timing of use of a single nectar meal to fuel metabolism was assessed by respirometry. As predicted, birds showed a more rapid switch in respiratory exchange ratio (RER = rate of O_2 consumption/CO_2 production) when held at cool temperature compared to warm. In both cases, RER peaked just above 1.0 indicating ingested sugar fueled ≈100% of resting metabolism while available as well as likely supporting lipogenesis. Contrary to our predictions, the timing and extend of nectar meal did not differ among times of day. Our findings suggest energy intake and fuel use are modulated by both pre- (foraging frequency/intensity) and post-ingestion behaviour.

Wilkie (presenter) David F.J. Lisser, Zachary P. Lister, Graham R. Scott and Michael P. Wilkie
Reactive Oxygen Species (ROS) Cause Brain Swelling in Goldfish (*Carassius auratus*) Exposed to High Environmental Ammonia
Toxic build-ups of ammonia can lead to potentially fatal brain swelling (encephalopathy) in mammals. However, ammonia-induced brain swelling is reversible in the anoxia- and ammonia-tolerant goldfish (*Carassius auratus*). To determine what role reactive oxygen species (ROS) generation plays in mediating ammonia-induced brain swelling and toxicity, we measured brain water content and quantified oxidative stress markers in the brain and liver of goldfish acutely exposed to high external ammonia (HEA; 5 mmol/L) at warm (14°C) and cold (4°C) temperatures. We predicted that the lower metabolic rates commensurate with lower temperatures would attenuate ROS production and brain swelling during HEA exposure. Exposure to HEA resulted in a 6- to 7-fold increase in brain ammonia concentration at both warm and cold temperatures, but brain swelling was only observed at 14°C, where brain water content increased by 20 %. Similarly, cellular oxidative damage in the brain and liver were restricted to warm water, in which there were 2-fold increases in thiobarbituric-acid reactive substances (TBARs) and 3–fold increases in protein carbonyls. We conclude that ammonia-induced increases in brain water content in the goldfish are a direct consequence of ROS production, and that goldfish are likely less susceptible to ammonia toxicity in cooler waters.

Williams,Tegan A., Jillian Bergstrome, Juliana Scott and Nicholas J. Bernier
University of Guelph
CRF and urocortin 3 protect the heart from hypoxia/reoxygenation-induced apoptosis in zebrafish

Fish routinely experience environmental hypoxia and have evolved various strategies to tolerate this challenge. Given the key role of the corticotropin-releasing factor (CRF) system in coordinating the response to stressors and its cardioprotective actions against ischemia in mammals, we sought to characterize the cardiac CRF system in fish and its role in hypoxia tolerance. We established that all components of the CRF system are expressed in the heart of zebrafish: *crfr1* > *crfa* = *crfbp* = *crfr2* > *ucn3* > *crfb* > *uts1*. In vivo, exposure to 5% O_2 saturation for 15 min and 90 min recovery resulted in 4-5 fold increases in whole heart *crfb* and *ucn3* expression. *In vitro*, pre-treatment of excised whole hearts with CRF or *UCN3* for 30 min prevented the increases in caspase 3/7 activity and the number of TUNEL-positive cells associated with exposure to <1% O_2 saturation for 30 min and 24 h recovery. Lastly, addition of a non-selective CRF receptor antagonist prevented the cytoprotective effects of CRF. We show that the CRF system is expressed in fish heart, is up-regulated by hypoxia, and is cytoprotective. These findings identify a novel role for the CRF system in fish and strategy to tolerate hypoxia.

Wood, Chris M., Ilan M. Ruhr, Ed Mager, and Martin Grosell
University of Miami, University of British Columbia
The euryhaline killifish: new insights into the osmorespiratory compromise in fresh water and sea water
The demand for continued O_2 uptake during hypoxia or increased O_2 uptake during exercise is met by increases in the effective permeability of the gills to respiratory gases. Increased branchial gas permeability is achieved by elevations in exchange area, reduced blood-to-water diffusion distance, and altered blood perfusion patterns. Traditionally, the osmorespiratory compromise reflected the cost of these adjustments - i.e. unfavorable elevations in passive ion and water fluxes. These fluxes would occur in opposite directions depending on salinity, and were thought to involve mainly paracellular pathways. We examined the responses of the common killifish (*Fundulus heteroclitus*), which is both euryhaline and hypoxia-tolerant, to severe hypoxia (10% saturation, 3h) and recovery, as well as to aerobic exercise (2 body lengths/sec, 1 h), in both freshwater and seawater. $^{3}H_2O$ exchange was used to examine branchial transcellular permeability (aquaporins), while ^{14}C-PEG-4000 was used to measure both branchial paracellular permeability and drinking rate. Hypoxia had profound effects on these parameters, all of which differed from the traditional osmorespiratory compromise, and some of which differed between freshwater and seawater. These data illuminate previously unknown elements of gill and gut function which help balance the needs of respiration and osmoregulation (NSERC Discovery, NSF).

Wright, Patricia
University of Guelph
Fundamentals of respiration in fish embryos - lessons I learned from Don.
Encapsulated fish embryos must exchange gases and ions with the environment, while ridding themselves of potentially toxic nitrogen wastes. Getting enough oxygen over protracted development in water can be a challenge. The chorion, although porous, creates additional boundary layers that restrict embryonic growth and movement. The oxygen gradient next to developing embryo is influenced by developmental stage, water flow, body movements and bulk water O_2 levels. Don Stevens and I collaborated with students on projects aimed at understanding the limitations to O_2 uptake during early life stages in salmonids. More recently we are interested in fish embryos that are deposited above the water line which may benefit from the higher O_2 content of air. Our work shows that development in embryos of the amphibious *Kryptolebias marmoratus* out of water is faster with lower energetic costs relative to embryos in water. Part of the reduced costs in air was associated with lower rates of opercular movement presumably to dispel stagnant boundary layers compared to embryos reared in water. Terrestrial incubation of young would be especially beneficial to amphibious fishes that occupy aquatic habitats of poor water quality, assuming low terrestrial predation and dessication risks.

York, Julia, Beverly Chua, Catherine Ivy, Graham Scott, Sabine Lague, Kevin McCracken, Neal Dawson, Peter Frappell, Luis Alza, and William Milsom
University of British Columbia
Pulmonary mechanics and morphometrics comparing five high-altitude duck species and six low-altitude sister species
Breathing has a metabolic cost, and over the lifetime of an animal increasing the efficiency of respiration can accrue significant energy savings. This may have little fitness consequence for animals that only occasionally encounter situations in which they are limited by metabolic energy availability, but for organisms living in metabolically challenging environments, such as hypoxia, a trade-off may exist between maximizing oxygen supply and the cost of increasing respiration. In this case, traits may have evolved to reduce the cost of resting breathing and allow for more oxygen to be supplied during critical and expensive moments, such as escape by flying or diving. We measured the cost of breathing and compared mechanics and morphometrics in eleven species of ducks including four pairs of high-altitude/low-altitude sister species to investigate whether the species at high-altitude had increased breathing efficiency. Preliminary results suggest that while the static mechanics of the respiratory

systems are similar, high-altitude birds have larger vital capacities allowing greater volumes of air to be ventilated inexpensively. We also found low-altitude species that had no high-altitude sister species had lower lung volume for their body size, suggesting that a high lung volume be an exaptation for high-altitude radiation.

Zahlan, Ferris and Janet Koprivnikar
Ryerson University
Parasitism of invasive and native species: evaluation of endohelminths in rock bass and smallmouth bass from Algonquin
Exotic and invasive species often differ in their parasite fauna compared to native hosts within their introduced range. This can have important consequences for their establishment success, but also for local transmission dynamics. We examined 112 invasive rock bass (*Ambloplites rupestris*) and 59 native smallmouth bass (*Micropterus dolomieu*) from 8 different lakes in Algonquin Park, ON, Canada to evaluate their endohelminth parasites. Our results indicate that smallmouth bass are not only more likely to be infected with trophically transmitted parasites such as cestodes and acanthocephalans than rockbass, but also have a higher infection intensity and greater diversity of endohelminths. There was no significant difference between the two fish species with respect to non-trophically transmitted trematode metacercariae. Along with host size, fish diet and habitat use will be discussed to demonstrate how the ecology of different species influences their probability of infection and endohelminth communities. As environmental perturbations such as climate change alter ecosystems, and species continue to shift their ranges, this may have important consequences for host-parasite interactions and their broader ecological communities.

Zimmer, Alex and Chris Wood
University of Ottawa
Acute exposure to high environmental ammonia (HEA) triggers emersion in the green shore crab (*Carcinus maenas*)
Littoral crabs exposed to large fluctuations in physiochemical parameters within tide pools can emerse from adverse environments such as hypoxia. Ammonia can also accumulate substantially (up to 5 mmol/l) in tide pools, yet the behavioural response to high environmental ammonia (HEA) has not been addressed in crabs. Using an experimental arena containing a rock bed onto which crabs could emerse, we established that exposure to HEA (4 mmol/l NH_4HCO_3) for 15 min triggers emersion in crabs. In experiments utilizing $NaHCO_3$ control exposures and NH_4HCO_3 injections, we further determined that emersion was triggered specifically by external ammonia and was independent of internal ammonia accumulation or secondary systemic acid-base and respiratory disturbances caused by HEA. Moreover, our data suggest that upon emersion, NH_3 may be volatilized, which maintains arterial pHa and decreases NH_3 partial pressure. Overall, emersion may be an important adaptive response in habitats periodically subjected to HEA. (NSERC Discovery, IDRC).

Posters / Affiches

Allen, Garett, Alex Quijada-Rodriguez, Stephanie Hans, Dirk Weihrauch
University of Manitoba

Branchial acid-base regulation in the osmoconforming Dungeness crab, *Metacarcinus magister*

Recent studies unraveled some mechanistic features and characteristics of acid-base balance in hyperosmoregulating invertebrates, however few studies have investigated this physiological mechanism in their osmoconforming relatives. This study applies gill perfusion techniques to determine the capacity of isolated gills of the osmoconforming Dungeness crab, *Metacarcinus magister*, to maintain acid-base homeostasis and actively excrete ammonia (200:200 µM NH_4Cl external seawater vs. perfusion solution). Preliminary data has shown that anterior and posterior gills are capable of actively excreting ammonia (3.39 µmol NH_4^+ gFW^{-1} Hr^{-1} 1.43 µmol NH_4^+ gFW^{-1} Hr^{-1}, respectively) in control seawater (pH 8.10). Active ammonia excretion rates increase in anterior and posterior gills when bathed in low pH seawater (pH 7.15) (8.28 µmol NH_4^+ gFW^{-1} Hr^{-1}, 6 +/- 2 µmol NH_4^+ gFW^{-1} Hr^{-1}, respectively). Inhibition of basolateral Na+/K+-ATPase (NaK) by oubain reduced active ammonia excretion rates in anterior and posterior gills (3.93 µmol NH_4^+ gFW^{-1} Hr^{-1}, 2 +/- 1 µmol NH_4^+ gFW^{-1} Hr^{-1}, respectively). NaK inhibition reduced the capacity of gills bathed in low pH seawater to maintain control perfusate pH (pH 8.10) instead producing perfusate of pH 7.76. Importance of NaK in low pH may indicate that NaK feeds pH-housekeeping transporters while also being involved in active ammonia excretion.

Berger, Chloé, Carole Di-Poi, Jennyfer Lacasse and Nadia Aubin-Horth
Institut de Biologie Intégrative et des Systèmes,
Université Laval

Evolutionary divergence of behavior, coloration, MC1R expression and sequence between marine and freshwater sticklebacks.

Understanding the proximal mechanisms that contribute to behavioral diversity in nature is one of the main challenges in biology. Studies with fish selection lines demonstrated that individuals selected for low stress responsiveness (cortisol levels) were also more aggressive and darker. This suggests that the molecular components associated with the stress response and coloration could be functionally involved in behaviours such as aggressiveness. It is crucial to determine if these relations can also be found in natural populations. Using threespine stickleback *Gasterosteus aculeatus* from a marine and a freshwater population reared in a controlled common environment, we found that freshwater sticklebacks are more aggressive, active and less social compared to marine fish. They also display a lower adrenergic response to stress (ventilation rates) and a larger cortisol level change post-stress. We found that freshwater sticklebacks are darker than marine fish. We then showed that this divergence of coloration is associated with expression differences in the Melancortin 1 Receptor (*MC1R*) gene, which encodes for a receptor mainly involved in coloration. Finally, we found a SNP in the coding region of MC1R that segregates between these two populations. Our study helps to decipher the molecular mechanisms responsible for phenotypic divergence in nature.

Bertucci, Juan Ignacio, Mario Oswaldo Tovar, Javier Edgardo Herdman, Luis Fabián Canosa and Suraj Unniappan.Laboratory of Integrative Neuroendocrinology, Department of Veterinary Biomedical Sciences, Western College of Veterinary Medicine, Saskatoon, Saskatchewan.

Can Sunflower Oil Replace Dietary Fish Oil Without Compromising Growth in Pejerrey larvae (Odontesthes bonariensis)?

Pejerrey (*Odontesthes bonariensis*) is an inland water fish from Argentina, with commercial importance. In order to determine if sun flower oil (SfO) can replace dietary fish oil (FO) during early stages, pejerrey larvae were fed with diets containing different proportion of FO/SfO: 100%FO; 50%FO-50%SfO; 20%FO-80%SfO; 100%SfO. Biometric standards were measured at 0, 15, 30 and 45 days. Then, samples of head, body and tail were collected and expression of genes implicated in somatic growth, fatty acid metabolism and food intake regulation were quantified by RT-qPCR. Results showed no differences in weight, standard length, condition factor, survival and food intake among the different experimental groups. *Gh*, *ghr-I* and *ghr-II* showed an increased expression in 100%SfO group. Expression of *igf-II* was higher in body of 100%SfO group compared with larvae fed with 100%FO. *Δ6-desaturase* mRNA levels were higher in head and body of larvae fed with 100%SfO diet. Feeding with 80%SfO and 100%SfO led to a decrease in *NUCB2/nesfatin-1* transcripts in body compared to 100% FO group. These results suggest that pejerrey larvae can process low unsaturated fatty acids present in SfO, modifying the expression of genes implicated in growth, food intake and fatty acid metabolism but without compromising growth and development.

Bertucci, Juan Ignacio, Mario Oswaldo Tovar, Javier Edgardo Herdman, Luis Fabián Canosa and Suraj Unniappan,
Laboratory of Integrative Neuroendocrinology, Department of Veterinary Biomedical Sciences, Western College of Veterinary Medicine, Saskatoon, Saskatchewan.

Dietary protein and lipid levels affect growth and expression of growth-related genes in pejerrey larvae

Pejerrey is an argentinian fish appreciated for its commercial importance. This work aimed to determine if food protein and lipid affect biometric parameters, and expression of genes implicated in somatic growth, fatty acid metabolism and food intake regulation. Larvae were fed with diets containing different proportion of protein (P) and lipid (L) (12%L-40%P (control), 20%L-40%P, 12%L-50%P or 20%L-50%P) during 45 days. Total number, biomass and standard length were measured throughout the experiment, and gene expression was quantified at the end. Larvae fed with low L diets show the highest increase in weight and standard length, although no differences were observed in the condition factor, survival rate and food intake. Feeding on 20%L-40%P diet led to an increase in head *gh* expression and body *ghr-II* and *NUCB2/nesfatin-1*, while produced a decrease in head NUCB2/nesfatin-1 and Δ6-desaturase. Larvae fed on a 12%L-50%P diet showed increased head *igf-II* and *NUCB2/nesfatin-1* but decreased *gh* and *Δ6-desaturase* levels. Expression of head *igf-II* and body *ghr-I* were downregulated by 20%L-50%P diet, while *Δ6-desaturase* was upregulated. This work show that changes in dietary protein and lipid content affect pejerrey growth and body weight and modulate the expression of genes involved in somatic growth and food intake behavior.

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Distribution of ghrelin and nesfatin-1 in the brain and gut of pejerrey (*Odontesthes bonariensis*)

Ghrelin and nesfatin-1 are two peptide hormones with important roles in many physiological functions, particularly food intake regulation. While both peptides are known to be expressed in the brain and gut of both mammals and fish, very few studies are available on their anatomical distribution using imaging techniques, especially in fish. Therefore, the aim of this study was to characterize the anatomical distribution of ghrelin and nesfatin-1 in the brain and gut of an inland water fish from Argentina, pejerrey (*Odontesthes bonariensis*), using immunohistochemistry. Results show that both ghrelin and nesfatin-1 have a similar anatomical distribution in the brain, with the highest immunoreactivity detected in some hypothalamic nuclei (such as the preoptic nucleus and the posterior recess nucleus) and in the pineal gland, and lower levels observed in telencephalon, optic tectum, cerebellum and some hindbrain nuclei. In the gut, the two peptides were localized in cells of the submucosa, although ghrelin showed a considerably stronger immunoreactivity. Together, results from the present study show an important presence of ghrelin and nesfatin-1 in the pejerrey gut and many brain areas known to participate in the central regulation of food intake, in accordance with the roles of ghrelin and nesfatin as appetite modulators.

Blanchard, Tessa S., Andy J. Turko and Patricia A. Wright
University of Guelph

A new twist to an old method- Measuring the critical oxygen tension (P_{crit}) in air

Critical oxygen tension (P_{crit}) is defined as the minimal PO_2 at which an organism can maintain routine metabolic rate. This parameter is also widely used as an indicator of hypoxia tolerance in aquatic animals. Pcrit in organisms is known to vary as a result of both physiological (i.e. respiratory surfaces) and environmental factors (i.e. temperature). Interestingly, the critical oxygen tension (P_{crit}) has never been measured in organisms in air. Therefore, we present a new method for determining P_{crit} in air. Fish are inserted into custom-made respirometry chambers, where changes in oxygen consumption are measured using oxygen sensor spots in a step-wise hypoxia protocol. P_{crit} can then be determined from the relationship between oxygen consumption rate (µmol/g/h) and oxygen saturation (% PO_2) using Yeager and Ultsch's algorithm. This approach to measuring P_{crit} in air will provide new insights on the ability of air-breathing fish to extract oxygen from the environment. Moreover, this parameter could be used to understand how air-breathing fish modulate oxygen uptake through plasticity of their respiratory traits.

Blanco, Ayelén M., María J. Delgado, Ana I. Valenciano and Suraj Unniappan
Laboratory of Integrative Neuroendocrinology, Department of Veterinary Biomedical Sciences, Western College of Veterinary Medicine, University of Saskatchewan

Ghrelin and nesfatin-1 modulate the expression of digestive enzymes in goldfish intestine and hepatopancreas *in vitro*

Ghrelin and nesfatin-1 are two appetite regulatory hormones with opposite effects on food intake. These peptides, particularly ghrelin, modulate the expression of digestive enzymes in mammals, but very little is known in fish. Therefore, this study aimed to determine the role of *ghrelin* and *nesfatin-1* as modulators of digestive enzymes expression in goldfish (*Carassius auratus*) using an in vitro approach. Cultured intestine and hepatopancreas were exposed to both peptides (0.1, 1 and 10 nM) for 30, 60

and 120 minutes, and the expression of *isomaltase, trypsin, aminopeptidase* and *lipase* was quantified by RT-qPCR. Exposure to ghrelin resulted in a significant upregulation of *isomaltase* levels in intestine at 30 and 120 min and in hepatopancreas at 30 min, while a downregulation was observed in intestine at 60 min. Treatment with ghrelin also led to a concentration-dependent induction of *aminopeptidase* in intestine, and of lipase in both tissues. Concerning *nesfatin-1*, the major effects were observed in hepatopancreas, where a time-dependent downregulation of *trypsin* and *lipase* mRNA levels was observed. Overall, results demonstrate that the expression of digestive enzymes in goldfish is stimulated or inhibited by *ghrelin* and *nesfatin-1*, respectively, in accordace with the orexigenic (*ghrelin*) and anorexigenic (*nesfatin-1*) role of these peptides.

Boggett, Sarah and Douglas Fudge
University of Guelph
How to Survive a Shark Attack: Lessons from a Hagfish
Hagfish have long been known to use slime to defend themselves from predators. However, in the case of biting predators, slime release only occurs after the hagfish has been attacked, which raises the question of how the hagfish survives these initial bites. One possibility is that hagfish avoid damage from predatory bites by possessing skin that exists in a state of negative pre-strain (i.e. is 'slack') and a body that is only loosely attached to the skin. We tested this hypothesis by manipulating the amount of pre-strain on the skin as well as the amount of adhesion between the skin and body, and measuring the damage done by a model shark tooth as these variables were varied. Our results have implications for understanding the eco-mechanics of predator interactions with hagfishes, and may also shed light on other species that must withstand initial attacks by predators before other defence mechanisms can take effect. Our study may also inspire novel materials and products that are designed to avoid damage from sharp objects.

Bowden (presenter) - Amanda Carter, Rachel Bowden, Ryan Paitz
Illinois State University
Seasonal variation in sex ratios driven by maternal estrogens and incubation regime
Sex-specific maternal effects can be an adaptive source of phenotypic plasticity. Reptiles with temperature-dependent sex determination (TSD) are a powerful system to investigate such maternal effects because offspring phenotype, including sex, is sensitive to maternal influence via maternal steroids and incubation temperatures. In red-eared slider turtles (T*rachemys scripta*), concentrations of maternally derived estrogens and incubation temperatures increase across the nesting season; we wanted to determine if sex ratios shift in a seasonally concordant manner, creating the potential for sex-specific maternal effects. Eggs from early and late season clutches were incubated under thermally fluctuating regimes, maternally derived estradiol concentrations were quantified via radioimmunoassay, and hatchling sex was identified. We found that both maternally derived estrogens and increases in thermally fluctuating incubation temperatures affected sex ratios; the synergistic effect of estrogens and temperature resulted in a 49% increase in the production of females in late season clutches. Our data demonstrate that maternally derived estrogens reinforce sex determination patterns in species with TSD, and further suggest the potential for sex-specific phenotypic matches across the nesting season driven by maternal effects.

Bradley, Stefanie, Morag Dick, Christopher G. Guglielmo, Alexander Timoshenko
Western University
Seasonal and flight related variation of galectin expression in heart, liver and flight muscle of yellow-rumped warblers.
Avian migration is energetically costly requiring physiological tradeoffs. These tradeoffs may be evident in changes in gene expression that result from the physiological stress associated with muscle damage, muscle catabolism, oxidative stress, inflammation, and immune changes – all occurring during migration and migratory flight. Galectins - a family of carbohydrate-binding proteins – are known to differ in expression depending on factors such as exercise, oxidative stress, inflammation and immune function, cellular proliferation, mitosis, transcriptional processes, and apoptosis. This study assesses the seasonal and flight-related changes in galectin mRNA expression profiles in a migratory songbird, the yellow-rumped warbler (*Setophaga coronata*). Warblers were sampled during the fall migratory period at rest and after a 4 hour endurance flight in a wind tunnel, and during the winter non-migratory period. Gene expression of galectin-1, galectin-2, galectin-3, galectin-4, and galectin-8 were measured in flight muscle, liver and heart using quantitative PCR. Preliminary analysis of flight muscle showed that migratory flight was associated with the upregulation of galectin-2 and downregulation of galectin-3. Seasonal change had a significant effect on the expression of galectin-4 in flight muscle, potentially reflecting the changes in oxidative enzyme activity between fall and winter in the flight muscle of birds. No correlations were found among galectin expression levels in flight muscle, indicating that they may be independently regulated due to the unique functional aspects of each galectin.

Brooks, Taylor, Amber Schlater, Cayleih Robertson, Grant McClelland.

McMaster.

Sensitivity of the HIF-1α pathway in cultured myotubes during chronic hypoxia.

High altitude and exercise subject skeletal muscle to oxygen deficits. Decades ago, a '*lactate paradox*' was observed, whereby lactate accumulates during acute hypoxia but its production returns to nearly normoxic levels after acclimation. Hypoxia inducible factor 1α (HIF-1α) helps mediate hypoxic stress when stabilized at acute hypoxia through enhanced glycolytic capacity and angiogenesis, while the concomitantly expressed pyruvate dehydrogenase kinase (PDK1) plays a regulatory role on pyruvate dehydrogenase (PDH). The latter precedes lactate production through phosphorylation of PDH, thereby decreasing pyruvate flux through Krebs cycling. Following suit with the lactate paradox, the HIF-1a response has also been shown to dampen with acclimation, returning to near-normoxic levels in vivo despite persistent hypoxic stress. To further characterize the HIF-1a response to acclimation and the respective role of PDK1, we cultured C2C12 myotubes at varying doses of acute and chronic hypoxia over a 7 day differentiation period (1% O2 for 4 hours, 24 hours, and 4 days against 21% O2 normoxic controls). HIF-1α and PDK1 protein levels were measured through western blotting. *In vitro* results will be compared to the HIF-1α response *in vivo* to shed light on mechanistic interactions involving changes in HIF-1α and PDK1 expression and function after chronic hypoxic acclimation at the cellular level.

Bryant, Heather J., and Patricia M. Schulte.

The University of British Columbia.

Uncoupling Proteins and Temperature Acclimation and Adaptation in Killifish.

Mitochondria are a critical component of an animal's response to environmental stressors such as temperature. Mitochondrial uncoupling proteins (UCPs) are involved in temperature response in mammals, for example in helping to generate heat in mammalian brown adipose tissue upon cold exposure. UCPs are also present in ectotherms but their functional role in these animals is not well understood. I am using Atlantic killifish, *Fundulus heteroclitus*, as a model organism in which to address the role of UCPs in thermal acclimation and adaptation in ectotherms. To characterize UCPs in killifish, I have determined the gene sequences and tissue-specific expression of members of the UCP family (UCP1, UCP2, UCP3, and UCP5) in Atlantic killifish. In general, the tissue-specific expression of these genes was similar to that in other fish species, with the exception of UCP3, which is muscle-specific in other fish species, but was highly expressed in gill and was present only at extremely low levels in other tissues, including muscle, in killifish. Currently, I am examining how expression of these UCP mRNAs changes with temperature acclimation in both northern and southern subspecies of killifish.

Caplan, Kylie, Clare Fletcher, Richelle Monaghan.

Wilfrid Laurier University.

Pedagogical Approaches to Post-secondary Biological Sciences in Accessibility and Teaching the Blind – A Tactile Poster.

Post-secondary science programming has been relatively immune to pedagogical modifications to address accessibility for the blind. This immunity is, in part, due to the fact that blind students have traditionally been discouraged from pursuing higher education in the sciences, and do not have equivalent access to university science pre-requisites as their sighted peers. However, with advances in technological assistance for the blind, and changing cultural values that encourage the blind to pursue their aptitudes, enrolment in post-secondary sciences can be expected to increase. A growing number of jurisdictions either legally require accessible programming for the academically eligible, or legislation is imminent. As a result, university science instructors may be required, with little notice or assistance, to reimagine their courses and provide Universal Design that includes accessibility for blind students. Traditionally visual content such as the molecular structure and function of the cell heavily rely on sighted students learning from illustrations, photos and videos. While these approaches continue to be important, this work describes pedagogical approaches in the topics of biology that were successfully used to provide accessibility. Outlining the developed approaches is intended to be a resource for educators with an additional goal of improving accessibility awareness.

Casto (Presenter), Aderinsola Odetunde and Joseph M. Casto

Illinois State University.

Does blood loss explain ectoparasite-induced changes in nestling development?

We investigated responses to mite infestation or experimental blood loss in nestling European starlings (*Sturnus vulgaris*). We first microwaved nests to reduce ectoparasites in all nests one day after egg laying ceased, and assigned the nests to one of three treatments: control, blood loss and infestation. To simulate infestation, we then immediately inoculated nests with ≈40 northern fowl mites (*Ornithonyssus sylviarum*). Growth measures and survival were assessed on brood days (BD) 5, 10 and 15. On BD 5 and 10, we collected ≈10% of the blood from nestlings in the blood loss treatment and much smaller samples from nestlings in infestation and control treatments. Nestlings in all treatments were bled similarly on BD 15. We measured blood

glucose, hemoglobin and hematocrit. Growth parameters and blood glucose increased significantly with age, without significant treatment effects. The mite infestation treatment had lower levels of hematocrit and hemoglobin than the other two treatments, especially on BD 15. The effects of mite infestation appear to extend beyond those of mere blood loss, perhaps due to developmental trade-offs with immune activation. Tests of nestling immune function should provide further insight into between-group differences.

Chiba, Kentaro and David C. Evans.
University of Toronto.
Growth curve reconstruction of the white-tailed deer (*Odocoileus virginianus*) based on limb bone growth marks.
Studies of animal growth in wild populations have fundamental importance for understanding their physiological responses to their environment and population dynamics. However, construction of growth datasets often requires labour intensive, long-term effort, notably mark-recapture sampling. In this regard, methods developed for reconstructing growth curves in paleontological studies may circumvent this issue. Here, age and body mass can be estimated simultaneously from histological analysis of growth marks in limb bones. Age of each individual is estimated by fitting growth models to the incremental pattern of preserved growth marks to take into account the number of obliterated marks, and the circumference of each mark is converted to mass using interspecific limb–mass relationship with consideration of intraspecific scaling. We applied the growth-mark-based method to *Odocoileus virginianus* from Ontario and Quebec. Preliminary results indicate that growth curves based on growth marks follow the general pattern of observational growth curves. Both types of curves exhibit no statistically-significant difference and very similar growth rates and asymptotic sizes. Since sampling for the skeletal growth marks does not need long term and continuous effort to produce a reliable growth curve, it provides an alternative method for studying growth of wild mammal populations that is easier, cheaper, and less invasive.

Cole, Dylan, Erik Folkerts, Danuta Chamot, Samuel Guffey, and Greg Goss.
University of Alberta.
Characterization of hagfish NaP_i-II function in Xenopus oocytes.
Inorganic phosphate (P_i) is crucial for several basic cellular processes and in the maintenance of key homeostatic systems; e.g. plasma pH, bone mineralization. Vertebrates rely almost exclusively on intestinal transport for Pi acquisition. The NaP_i-II (SLC34) family of sodium-dependent phosphate transporters contributes significantly to Pi uptake by the intestinal epithelium. Interestingly, Pacific hagfish, *Eptatretus stoutii*, possess the unique ability to acquire P_i through non-intestinal routes, specifically, across the gills and skin. NaP_i-II expression and involvement in P_i uptake in these tissues was previously identified. Here, we have functionally characterized the Pacific hagfish NaP_i-II transporter using the *Xenopus laevis* expression system. We used ^{32}P to track concentration dependence and inhibitor profiles of $hfNaP_i$-II P_i uptake across the oocyte membrane. Confirmation of HA= tagged NaP_i-II expression within the oocyte membrane will be confirmed by confocal microscopy. This research provides insight into a unique mechanism of nutrient uptake in a primitive vertebrate (NSERC).

Cypher, Alysha and Brian Bagatto
The University of Akron.
Lipid composition and cardiovascular health of Danio *rerio* embryos with maternal to Bisphenol A.
Bisphenol A (BPA) is a polycarbonate synthesizer known for its ability to mimic estrogen that is capable of disrupting estrogen-regulated processes like vitellogenesis. The yolk, which is entirely provided by maternal resources through vitellogenesis, is the only energy source for the initial development of nearly every organ system. The health and function of many organ systems rely on the availability of polyunsaturated fatty acids (PUFAs) which can be used as an energy source, structural component to membranes, and precursors to hormones that mediate red blood cell function and vascular homeostasis. We hypothesized that maternal exposure to BPA would alter the lipid composition of eggs and ultimately the cardiovascular health of larvae. A MS/MS/ALL shotgun lipidomics approach was used to detect a broad range of lipid classes in egg, ovary, liver, and whole mount tissue while video microscopy was used to assess cardiovascular health in zebrafish larvae. Data requires further analysis but differences in phospholipid classes have been indicated with BPA exposure in all four tissue types. Reproductive dysfunction due to the exposure limited the ability to retrieve fertilized eggs for cardiovascular analysis.

Delompré, Perrine, Tamzin Blewett, Yuhe He and Greg Goss.
University of Alberta - Biological Sciences.
The ultimate toxicological mixture : how hydraulic fracturing spills affect key species in the Canadian ecosystem.

Hydraulic fracturing (HF) is a process allowing access to gas or oil trapped in sedimentary deposits. To fracture the rocks, a high-pressure liquid is injected into wells and when pressure is later released, the Flowback and Produced Water (FPW) is pumped to the surface. The goal of this research is to study FPW and understand the mechanisms of toxicity of these mixtures. *Daphnia magna* are an essential keystone species in Canada's freshwater environment, and a widely used model for toxicity testing. Parallel analytical techniques for the organic and inorganic compositions and bioassays to determine FPW composition and toxicological impacts have been performed. 48h-LC50 was performed on D. magna and in addition, whole body tissue responses for both CYP enzyme activity (EROD) and TBARS (to measure oxidative stress) was performed. Quantitative PCR for Vtg, Cyp1a, GST, CAT, Arnt and AhR was used to quantify toxicological impacts of FPW. Results reveal that D. magna are sensitive to these mixtures with 48h-LC50 for D. magna occurring at dilutions <1% of FPW. This study is the first to characterize FPW constituents and its toxicological impacts on the aquatic biota and will be used to both assess potential hazard and assess risk of FPW. (NSERC)

Dhakal, Pranav and Dr Carol Bucking.
York University.
Comparing the gut microbiome of two fish species with overlapping habitats before and after diet manipulation
Firmicutes, Bacteroides and *Proteobacteria* are the dominant bacterial phyla found in the gastrointestinal tract (GIT) microbiome. The proportional representation of each phyla is known to change with varying diets. For example, increases in the proportion of Firmicutes is seen in species eating high calorie diets (such as protein-based diets) whereas an increase in Bacteroides is seen in species fed a plant based diet. Central stonerollers (herbivores) and rainbow darters (carnivores) with overlapping habitats were wild-caught from Irvine Creek, a Grand River tributary. Wild-caught fish were also returned to the laboratory where and subjected to various diet treatments. Briefly, each species was fed either an algae, fish-feed, or bloodworm diet daily for up to 3 months. We aseptically extracted the entire GIT from wild caught individuals and following 1or 3 month exposures to the experimental diets. Pure genomic bacterial DNA was extracted from each sample and pyrosequenced using next generation sequencing to characterize the bacteria found in the GIT microbiome. Analyzing the sequencing dataset bioinformatically revealed interesting results. Overall, understanding the GIT microbiome with changed diet and across time points between same and different species was just an initial step to understand the complex aquatic host-microbe mutualistic digestive physiology

Dindia, Laura, Sarah Alderman and Todd Gillis
University of Guelph
Rainbow trout (*Oncorhynchus mykiss*) cardiac proteome remodelling in response to exercise
Fish hearts have a significant ability to remodel in response to physiological stressors, but the molecular underpinnings are not well understood. The present study used proteomics to investigate the temporal remodelling of the rainbow trout ventricle to a well-characterized physiological stressor, exercise. Juvenile trout were held in a constant current (2.6 BL s-1, ~60% Ucrit) for 0, 4, 7, and 14 days. The ventricular proteome was then characterized with isobaric tag for relative and absolute quantitation (iTRAQ), and significant changes were observed in 129 of 1351 identified proteins. While there was no change in relative ventricle mass, an up-regulation of contractile and cell integrity proteins was evident on day 4, supporting an early remodelling response to exercise. Changes in proteins for energy metabolism suggest a shift towards anaerobic pathways by 14 days, and a similar response was observed in skeletal muscle based on enzyme activity levels. An increase in four-and-a-half LIM domain protein at all time points relative to day 0 suggests a role for this myocyte differentiating protein in exercise-induced cardiac remodelling. This study provides in-depth characterization of exercise-induced ventricular remodelling that is initiated within days of exercise onset.

Doherty, Justine E. and Jonathan M. Wilson
Wilfrid Laurier University.
A missing link in the ionoregulatory strategy of lamprey and lungfish: A closer look at the non-gastric H^+/K^+ATPase
The hydrogen/potassium H^+ /K^+-ATPase (HKA) and its potential role(s) in acid-base and potassium (K^+) regulation are investigated in fishes. There are two types of vertebrate HKA: the gastric and non-gastric forms. This work is focusing on the non-gastric (ng) HKA form that is composed of a unique α subunit (HKα2, gene *atp12a*). In tetrapods, the ngHKA is expressed in kidney, colon and brain and is involved in K^+ and acid-base regulation; however, in fishes data is lacking. To date the ngHKA has only been found in lamprey and lungfish but not yet in any of the teleost fishes. These non-teleost fishes are also lacking in the gastric isoform (HKα1/β4, gene *atp4a*/*atp4b*). It is hypothesized that the ngHKA plays a role in K^+ and acid-base regulations in lamprey and lungfish. Immunohistochemistry and immunoblotting will be used as tools to determine tissue distribution and whole tissue expression levels, respectively. Function will then be assessed by using acid-base disturbances and K^+ fluxes, using

rubidium (Rb^+) as a tracer. In both species we have shown HKα1 expression in both gill and kidney, the main ionoregulatory organs in fishes, and that there is Rb^+ uptake.

Fehsenfeld, Sandra and Chris M. Wood
University of British Columbia
Goldfish renal tubules: More than meets the eye
In freshwater teleosts like the common goldfish, *Carassius auratus*, the major function of the kidney is to excrete excess water and retain solutes, producing highly diluted urine. The high glomerular filtration rate and presence of epithelial transporters for monovalent ions, however, also indicate a considerable role for the kidney in ion, ammonia and acid-base regulation. In accordance with the mammalian kidney, Na^+/K^+-ATPase, V-H^+-ATPase, Na^+/H^+-exchanger as well as Rhesus proteins can hence be expected to also be present in goldfish renal tubules. The goldfish kidney tubule consists of a glomerulus connected to a proximal segment, leading over into the distal tubule that then is connected to the collecting duct via a connecting tubule. The present study aimed to characterize these different renal segments with respect to mRNA expression of distinct transporters known to be involved in ion, ammonia and acid-base balance. This work was funded by an NSERC Discovery Grant.

Fletcher, Clare, Richelle Monaghan, Chris Wood, Scott Smith
Wilfrid Laurier University
Potentiometric Determination of Copper Interactions with Suspended Rainbow Trout Gill Cell Line
In aquatic organisms, the effects of Cu contamination include electrolyte imbalances and oxidative stress. The Biotic Ligand Model (BLM) is a toxicology assay used to assess the bioavailability of metals, including Cu, and the binding of these metals to gill cells. Previous data from potentiometric titrations of Cu used primary rainbow trout gill cells prepared from both pavement (PV) and a mixture of PV and mitochondrial rich (MR) cell types. These data were compared with potentiometric titrations of Cu using the continuous rainbow trout gill cell line (RTgill-W1) in suspension. The goal was to determine if Cu would bind to suspended RTgill-W1 cells similarly to the PV and PV/MR primary cultures. Suspended RTgill-W1 cells were found to display a lower Cu binding than their primary culture counterparts. Thus, preliminary data suggest that the suspended cells were not an alternative to primary cultures in the BLM model. Further investigation will focus on oriented cell lines, as they are more analogous to primary cultures. (NSERC Discovery)

Ford, Jonathan and James McGeer
Wilfrid Laurier University.
Rare Earth Elements - How Toxic are They?
Rare Earth Elements (REEs) are a group of elements which are of growing environmental concern due to their usage in green technologies. Based on preliminary studies, thulium (Tm) was the most toxic of the rare earth elements with a 96 h LC50 (concentration inducing 50% mortality) to the amphipod *Hyalella azteca* of 0.01 µg/L (Borgmann et al. 2005). The objective of this research was twofold; develop an understanding of the aquatic toxicity of Tm, and determine the effects of cation competition, dissolved organic matter (DOM) and temperature toward Tm toxicity. Acute toxicity tests were conducted using the standard method provided by Environment Canada (EPS 1/RM/33) in a reconstituted water test medium at a hardness of 62 mg $CaCO_3$/L. A range of temperatures, cation and DOM concentrations were compared. Test results showed the LC50 of Tm was 280 µg/L (95% confidence interval of 192 to 374 µg /L). Additional tests showed that protective effects occurred in tests with DOM, but did not occur with calcium, magnesium or sodium. In tests completed at lower temperatures (15° C), there was delayed toxicity compared to tests done at standard temperature (21° C). This research is supported by Environment Canada, the Ontario MOECC and NSERC with contributions from Avalon Rare Metals Inc.

Fuzzen, Meghan, Hadi Dhiyebi, Leslie Bragg, Gerald Tetreault, Mark McMaster and MarkServos
University of Waterloo
Does parental experience impacts progeny response to municipal wastewater effluent exposure?
Over 30 fish species have been reported to show an intersex condition (ova-testes) after exposure to municipal wastewater effluent (MWWE), suggesting that the feminization of male fish is a widespread phenomenon. Previous studies in the Grand River watershed have shown that male rainbow darter (*Etheostoma caeruleum*) collected near the Kitchener MWWE outfall are feminized. While it is well recognized that MWWE has direct impacts on the sexual development and performance of the F0 generation, little is known about the consequences of MWWE exposure on subsequent generations of fish. The purpose of this study was to determine whether parental exposure history had an impact on the response of progeny to subsequent exposure. Progeny of rainbow darter collected from rural (reference) and MWWE exposed sites were exposed to either de-chlorinated tap water (control), 10% MWWE, or 10 ng/L ethinylestradiol (EE2) from 21 to 100 days post hatch (dph). Parentage had an

impact on overall survival and condition at 100 dph. Exposure to EE2 resulted in a completely female population in larvae and exposure to MWWE led to an increase in intersex incidence. Parental experience did not affect sexual development in this study.

Gatrell, Lauren, Alyssa Weinrauch and Todd Gillis
University of Guelph
What fuels the hagfish heart during anoxia exposure?
The heart of the Pacific hagfish (*Eptatretus stoutii*) remains functional over 36 hours of anoxia. Recent work, using an excised heart preparation, suggests that on board glycogen stores can support the metabolic requirements of the heart during relatively short periods of anoxia exposure (<1.5 h). However, these stores are not able to support the measured rate of ATP production during prolonged periods of anoxia exposure (8-16 h). One fuel source that could supplement the glycogen stores is lipid droplets present in the hagfish myocardium. These lipids could supply glycerol that would be funneled into anaerobic glycolysis. The purpose of this study is to determine if these lipid droplets supplement anaerobic metabolism in the hagfish heart during long-term anoxia exposure. Hagfish hearts will be excised and then perfused in anoxia for 16 hours before enzymatic and metabolite analysis. Glycerol kinase and lipase activity will be quantified to evaluate lipolysis in the myocardium during anoxia. Glycerol, triglyceride, free fatty acids and lactate levels will also be assayed in ventricular tissue following chronic anoxic or normoxic exposure for the same purpose. This could indicate the presence of a novel metabolic pathway in cardiac metabolism that can use lipid without oxygen.

Gibson (presenter) - Chelsea Penney and Glenys Gibson.
Acadia University.
Is Maternal or Embryonic Environment More Important in Developmental Plasticity?
Species with developmental plasticity produce more than one morph of offspring in different environments. How important is the parental environment in determining offspring morph (i.e., is form transmitted epigenetically) or can embryos "correct" the phenotype induced by parental environment? We asked this question in a marine invertebrate (*Polydora cornuta*, Annelida) that produces both small, dispersive larvae and large, benthic juveniles. Parents were cultured in four groups: seawater (control), +a methyl releaser (bisphenol A, BPA), +methyl donors (folate/vitamin B_{12}), and +a potential environmental signal (methionine). Broods were divided into four groups, each exposed to the same four treatments. Data were analysed in a nested design. Two treatments (BPA, methionine) induced a shift towards the production of small, dispersive larvae. Controls and treatment with folate/ B12 had a shift towards the production of large, benthic juveniles. Both parental and embryonic environment affected larval phenotype (Generalized Linear Model, df=1, 15, p=0.000). Embryonic environment was able to over-ride parental environment for some treatments (folate/ B12) but not others (BPA), suggesting some factors in the parental environment have persistent effects on the development of young. Both maternal and embryonic environments influence plasticity in offspring phenotype.

Gill, Sharn K., Allison Seow, Yvonne A Dzal, Danielle Chung, William K Milsom and Matthew E Pamenter
University of Ottawa.
Naked mole rat glutamatergic receptors do not contribute to the control of ventilatory responses to hypoxia
In most adult rodents hypoxia induces a reflex increase in ventilation (i.e. the hypoxic ventilatory response: HVR) and a decrease in metabolic rate (i.e. the hypoxic metabolic response: HMR). With chronic sustained hypoxia (CSH) a second time-dependent increase in ventilation occurs, termed ventilatory acclimatization to hypoxia (VAH). In most adult mammals, VAH is partially mediated by plasticity of glutamatergic receptors (NMDARs and AMPARs) in the ventilatory control circuits. Naked mole rats (NMRs) are among the most hypoxia-tolerant mammals identified but their ventilatory responses to CSH have not been explored. To address this knowledge gap, we treated NMRs in room air or CSH (8% O_2) for 8-10 days and measured their HVR before and after systemically administering AMPAR or NMDAR antagonists. We found that 1) when exposed to 7% O_2 NMRs exhibited a ~ 64% decrease in ventilation, which was matched by a ~ 70% decrease in metabolic rate, 2) following acclimatization to CSH, NMRs did not exhibit VAH, 3) AMPAR or NMDAR antagonism had no effect on the HVR or HMR in any condition. Our results indicate that, contrary to all other adult rodents studied, glutamatergic synaptic transmission is not involved in the acute HVR or VAH of NMRs.

Hare, Alexander and Kathleen M Gilmour
University of Ottawa
Growing pains: early life stress influences HPI axis function and anxiety-related behaviour in zebrafish (Danio rerio)

Cortisol is the primary glucocorticoid stress hormone produced by teleosts in response to a stressor, and functions to alter physiology and behaviour to regain homeostasis. Although acute increases in circulating cortisol are considered to be adaptive, chronic elevation of cortisol can have detrimental effects, such as decreasing growth and reproduction. The production of cortisol is controlled primarily through the hypothalamic-pituitary-interrenal (HPI) axis. Although the function of the HPI axis is reasonably well understood, there is a lack of research examining how early life stress influences HPI axis activity later in life. In the current study, larval zebrafish were subjected to air exposure as an acute stressor twice a day for two days starting at 24 or 96 hours post hatch. The effects of repeated acute stress on stress responsiveness, anxiety-related behaviour, growth, and metabolic rate were then examined at developmental points until one-month post fertilization. The results of this study will provide insight into the effects that early life stress has on the development of personality and the HPI axis in a commonly used vertebrate model.

Hooper, Josh and Stephanie DeWitte-Orr.
Wilfrid Laurier University.
Determining the presence of gap junctions in rainbow trout cells.
Gap junctions are small intercellular channels that mediate cell-to-cell communication. Considering their possible role in innate immunity, presence of gap junctions in rainbow trout cells was elucidated. Connexin43 (Cx43), a gap junction protein, was identified at the transcript and protein level in three rainbow trout cell lines, RTgill-W1, RTgut-GC and RTG-2. Gap junction intracellular communication (GJIC) was examined using fluorescence microscopy using Lucifer yellow in conjunction with phorbol 12-myristate 13-acetate (PMA), a well-known gap junction inhibitor. RTG-2 and RTgill-W1 cells demonstrated coupling that was inhibited by PMA treatment, while and RTgut-GC did not. Human fibroblastic foreskin cells (HFF1) were used as a positive control for gap junction communication. Taken together, our data shows that RTgill-W1 and RTG-2 cells express proteins that can be used to make gap junctions and are able to perform GJIC. The role of gap junctions in the innate antiviral immune response is currently under investigation.

Hughes, Malcolm, and Dr. Steve Perry
University of Ottawa.
Physiological roles of internal convection on respiratory gas exchange in larval zebrafish (*Danio rerio*)
Historically, in higher vertebrates, homeostasis of the respiratory gases, carbon dioxide (CO_2) and oxygen (O_2), were considered to be dependent on the circulatory system. This broad pairing however, may not apply generally across all life stages. This research is focused on elucidating the role of internal convection on respiratory gas exchange in larval zebrafish (*Danio rerio*). Vascular endothelial growth factor A (VEGF-A) is critical to angiogenesis in larval zebrafish and its knockdown results in incomplete blood vessel formation and a non-functional circulatory system. Transient knockdown of the VEGF-A protein was achieved via the injection of anti-sense morpholino at the 1-cell stage, creating a model with an incomplete circulatory system and no internal convection. Respirometry was performed on morpholino and sham-injected larvae to determine the rates of O_2 consumption and CO_2 excretion. Comparison between these two groups will provide insight on the role of internal convection on aerobic gas exchange in larval zebrafish.

Jangjoo, Maryam, Stephen F. Matter, Jens Roland, Nusha Keyghobadi
Western university
Connectivity rescues genetic diversity after a population collapse: empirical evidence from a butterfly population netwo.
Demographic bottlenecks that occur when populations fluctuate in size erode genetic diversity, but that diversity can be recovered through immigration. Connectivity among populations and habitat patches in the landscape enhances immigration and should in turn facilitate recovery of genetic diversity after a sudden reduction in population size. For the conservation of genetic diversity, it may therefore be particularly important to maintain connectivity in the face of factors that increase demographic instability, such as climate change. However, a direct link between connectivity and recovery of genetic diversity after a demographic bottleneck has not been clearly demonstrated in an empirical system. Here, we show that connectivity of habitat patches in the landscape contributes to the maintenance of genetic diversity after a demographic bottleneck. We were able to monitor genetic diversity in a network of populations of the alpine butterfly, *Parnassius smintheus*, before, during, and after a severe reduction in population size. We found that allelic diversity in the network declined after the demographic bottleneck, but that less allelic diversity was lost from populations occupying habitat patches with higher connectivity. Our results demonstrate directly the ability of connectivity to mediate the rescue of genetic diversity in a natural system.

Jeffries, Ken, Christine Verhille, Theresa Dabruzzi, Nann Fangue and Richard Connon
UC Davis.

Population differences in salinity tolerance in a threatened estuarine fish.
Differences in physiological responses to environmental stressors between populations of fishes may be partly attributed to genetic differences associated with local adaptation. Using a common-garden design, we examined the effects of salt water on two populations of wild-caught Sacramento splittail (*Pogonichthys macrolepidotus*), a threatened semi-anadromous fish with a distribution limited to Northern California. One population is relatively saltwater tolerant while the other population is saltwater sensitive. We used RNA-sequencing to compare transcriptome-wide responses in both populations after exposure for 72hrs and 168hrs to 14ppt salt water. We compared these responses to a fresh water control group for each population. We found evidence of a conserved general response to salt water in the two populations suggestive of phenotypic plasticity. We also found distinct differences in the transcriptomic profiles with the saltwater tolerant population upregulating the expression of ionoregulatory mechanisms and gill remodeling at 168hrs suggesting an enhanced ability to acclimate to higher salinities, patterns not observed in the saltwater sensitive population. These differences in the transcriptome-wide response to salinity, in addition to transcriptomic sequence variation, suggest that the populations have adapted to their local environmental conditions. Understanding how populations respond to environmental conditions is critical for the conservation of threatened species.

Jiang, Qiwu and Iain J. McGaw.
Ocean Sciences, Memorial University.
Effects of feeding states on physiological responses to hypoxia in rock crabs (*Cancer irroratus*).
All animals must feed in order to survive, the subsequent digestion of the meal is associated with an increase in metabolism termed the specific dynamic action (SDA). Coastal hypoxia has increased exponentially in recent years and can affect the physiology and distribution of organisms. The aim of this study was to determine how rock crabs (*Cancer irroratus*) regulate their oxygen demands during feeding and digestion in hypoxia. Three feeding states, each associated with a different oxygen demand, were used in experiments (starved – 28d, fasted – 4d, fed – 1h postprandial). In normoxia starved crabs had a lower resting metabolic rate than fasted or fed crabs. However, fasted crabs had a lower Pcrit compared with starved or fed crabs. The characteristics of the SDA were also affected by hypoxia, resulting in a dose-dependent decrease in the metabolic scope, but an increase in the time to peak metabolic rate and the duration of the SDA response. The increase in duration resulted in a substantial increase in energy expenditure during hypoxia, and these effects were more pronounced in the fasted crabs. These results are discussed in relation to the potential effects on the growth and distribution of rock crabs in their natural environment.

Johnston, Elizabeth, Laura Dindia and Todd Gillis.
University of Guelph.
The role of testosterone in regulating cold-induced cardiac hypertrophy in rainbow trout.
Thermal acclimation of rainbow trout causes significant remodeling of the ventricular myocardium. With cold acclimation, muscle fibre bundles undergo hypertrophy and this effect has been shown to occur most consistently in male fish. As testosterone is known to stimulate muscle growth, this sex steroid may be playing a role in the cardiac hypertrophy that occurs in male fish with cold acclimation. To test this hypothesis, sexually mature male and female fish were kept under control or "winter" for 8 weeks. Within these temperatures, fish were injected with either cyproterone acetate (CYA), ethinyl estradiol (EE2) or the cocoa butter carrier (sham) and PIT tagged. CYA is an androgen antagonist. Results indicate that CYA caused a decrease in plasma concentrations of 11-Keto testosterone (11-KT). Overall, males had a greater relative ventricular mass (RVM) than females and RVM was significantly greater in the EE2-treated group. Relative atrial mass (RAM) was significantly lower in the cold. The relative liver mass (RLM) was greater in the cold acclimated group and also increased with EE2 treatment. EE2 treatment also increased gonadal somatic index (GSI) in the control temperature group. These results demonstrate that the interaction between steroid injection and temperature alter cardiac and reproductive physiology.

Kaji, Tomonari, Keiichi Kakui, Naoyuki Miyazaki, Kazuyoshi Murata, A. Richard Palmer
University of Alberta
Mesoscale 3D morphology viewed at nanoscale: Advanced serial block-face SEM of a novel crustacean silk spinneret system
The study of morphology is experiencing a renaissance due to rapid improvements in technologies for 3D visualization of complex structures. But 3D visualization of the internal structure of mesoscale objects — those in the 10 - 1000 µm range — remains problematic. SBF-SEM allowed us to describe well-resolved components (glands, ducts, pores, and associated nerves and muscles) of the spinneret system in the thoracic legs and body segments of *Sinelobus* sp. (Crustacea, Peracarida, Tanaidacea), a tube-building crustacean only 2 mm in body length. The 3D reconstruction by SBF-SEM revealed at nanoscale resolution a unique structure to the gland and duct systems: In each of three thread-producing thoracic segments, two

separate ducts (derived from two separate glands located in the body) run through the entire leg and merge at the leg tip just before the spinneret pore opening. Our results significantly expand our understanding of the diversity of spinneret systems in the Crustacea by providing the first well-resolved view of spinneret components in the peracarid crustacean order Tanaidacea. More significantly, our results reveal the great power of SBF-SEM technology for comprehensive studies of the morphology of microscopic animals.

Kaunisto, Sirpa, Laura V. Ferguson and Brent J. Sinclair.
Western University.

Can we predict the effects of multiple stressors?

Organisms must respond to various natural stressors, but also to increasing array of anthropogenic stressors. Climate change and other stressors form a complex multi-stressor environment with many potential interactions between stresses. Although important, combined effects of multiple stressors are particularly difficult to study. Published research in this area is still mainly of a phenomenological and descriptive in character, missing mechanistic, predictive understanding. There are many examples on interactive and counterintuitive effects of multiple stressors, which leads to the concern that their complexity will make accurate predictions of the consequences of anthropogenic change impossible. We provide an overview of the current knowledge about the impacts and interactions of different stressors in animals, and assess how well this information transfers to insects. In particular, we note that multiple stressors are perhaps best understood for non-insect animals in aquatic ecosystems, but research on insects is scarce and seldom include more than two stressors, and that ecotoxicology seems to be more advanced than other areas of environmental physiology. We also discuss how to extend descriptive understanding of multiple stressors to the mechanistic, predictive understanding. There is an urgent need to identify which stressor interactions can be predicted, and which are idiosyncratic, species-dependent.

Kim (presenter) P.H. Pham, J. J. Kim, Y.J. Huang, B. Sadeghimakki, Y. Zheng, A. Hu, K. Oakes, S.X. Tang, S., Sivoththaman and N.C. Bols.
University of Waterloo.

Evaluating cytotoxic effects of nanomaterials on mammalian cells and virucide effects on viruses using fish virus models

Nanomaterials, such as quantum dots (QDs), titanium dioxide (TiO_2) and carbon nanotubes (CNTs), are increasingly used in commercial products. This results in greater exposure to people and the environment with unknown effects. Although, bactericide activities of nanomaterial is well documented, few studies examined effects of QDs on human cells and of TiO_2 and CNTs on viruses of lower vertebrates. Therefore, the cytotoxic effects of QDs on HeLa cells and virucide effects of TiO_2 and CNTs on three lower vertebrate viruses, viral hemorrhagic septicemia virus (VHSV), chum salmon reovirus (CSV) and frog virus 3 (FV3), were studied. QDs CdSe and CdSe/ZnS were cytotoxic to HeLa at approximately 0.625 µg/substrate and higher, while CIS and CIS/ZnS required 25 µg/substrate and higher. With respect to viruses, single-walled CNT-NH2 can inactivate VHSV while other functional groups and mutli-walled CNTs cannot. TiO_2 in suspension reduced titer of VHSV and FV3 but not CSV. Under long wavelength UV (L_{UV}), TiO_2 enhanced the inactivation of VHSV but not FV3 or CSV. However, under short wavelength UV (S_{UV}), TiO2 protected VHSV from the more damaging effect of S_{UV}. These results showed that some QDs can be cytotoxic to human cells and nanomaterials may have an ecological impact.

Kirby, Alexia M. and Matthew E Pamenter
University of Ottawa

Naked mole rats use atypical thermal and behavioural strategies in hypoxia.

In hypoxia, most rodents lower body temperature (T_b) to conserve energy by seeking colder environments and reducing behavioural activity. Naked mole rats (NMRs; *Heterocephalus glaber*) are among the most hypoxia tolerant mammals identified; however, their behavioural and thermal responses to hypoxia are poorly understood. To address this knowledge gap, we placed NMRs in a custom-designed apparatus comprising two temperature-controlled chambers; one chamber was held at the thermoneutral zone of NMRs (30˚C), and the other was held at either warmer (38˚C) or colder (20˚C) temperatures. Animals were exposed to 1 hr each of normoxia (21% O_2), acute hypoxia (7% O_2), and normoxic recovery. T_b, behavioural activity and metabolism were measured continuously. We found that, relative to normoxic controls, NMRs exposed to acute hypoxia: (1) exhibited a reversible 52% and 67% decrease in activity in cold and warm temperature settings respectively, (2) preferred the warmest chamber available during hypoxia and recovery, unlike in other rodent species, and (3) maintained T_b when the 38˚C chamber was available but reversibly decreased T_b ~ 8% when only the 20 and 30˚C chambers were available. These data suggest that NMRs are able to utilize atypical thermal and behavioural strategies to adapt to hypoxia.

Kumar, Shruti and Tamara A. Franz-Odendaal

Saint Mary's University

Investigating FGFRs during Scleral Ossicle Induction.

Fibroblast growth factors (FGF) are known to be one of the most important factors for organogenesis during early vertebrate development. The FGF ligands bind to their membrane bound receptors (FGFR) and activate downstream signalling pathways. Although FGF/FGFRs have been widely studied in endochondral bone development, we know little about their role in neural crest derived intramembranous bone development. Scleral ossicles are bones, in the chicken (*Gallus gallus*) eye that have been identified as a model to study intramembranous bone development. A ring of conjunctival epithelial thickenings called conjunctival papillae induce the formation of these bones. The involvement of the FGF pathway in the induction of these bones will be determined by inhibiting its signalling via bead implantation of a known inhibitor, Su5402 during scleral ossicle induction. Whole mount *in situ* hybridization will be used to identify the spatial-temporal expression pattern of four FGFRs at different stages of scleral ossicle development. This study would help to identify possible FGFs involved in scleral ossicle development. Moreover, it will pave the path for further investigation into possible protein signalling pathways that may influence or be influenced by the expression of FGFs during intramembranous bone formation.

Lachowsky, Leanna and Mary Reid.

University of Calgary.

Development time and synchrony of emergence in individual broods of mountain pine beetles.

Life history traits such as body size at maturity and growth rates are likely to influence mortality during development. In mountain pine beetles, *Dendroctonus ponderosae*, female-biased sexual size dimorphism and changing sex ratios during the emergence period suggest different growth trajectories of males and females. Development time and final body size are expected to depend on habitat or maternal quality. When sexual size dimorphism exists, differential energetic demands can lead to sex-biased mortality. This is a proximate mechanism that could explain biased sex ratios. Mountain pine beetles typically have female biased populations (2:1) and females are 37% larger by volume than males. We reared mountain pine beetles in the lab at a constant temperature and examined individual broods for development time and synchrony of emergence in relation to the mortality experienced during development, number of offspring, sex and final body size.

Lebenzon, Jacqueline E. and Brent J. Sinclair.

Western University.

Interference in the cold: manipulating cryoprotectants to investigate cold tolerance in the Colorado potato beetle.

Overwintering insects risk freezing of their body fluids when exposed to temperatures below zero. By lowering their supercooling points (SCP; temperatures at which they would normally freeze) some insects are able to avoid freezing altogether. Lower SCPs are often correlated with the accumulation of small cryoprotectants (such as polyols or amino acids) *via* fat body metabolism, however we do not understand the causative role these molecules play in insect overwintering physiology. Using the Colorado potato beetle (*Leptinotarsa decemlineata*), we will investigate the role of cryoprotectant metabolism in freeze-avoidant insects. First, we will identify polyols and free amino acids that are accumulated in overwintering beetles using molecule-specific spectrophotometric assays and quantitative direct injection mass spectrometry, respectively. Having identified possibly cryoprotective molecules, we will next identify target metabolic enzymes involved in cryoprotectant synthesis that are transcriptionally upregulated in overwintering beetles using real-time quantitative PCR. Finally, we will manipulate enzyme mRNA abundance of upregulated target enzymes via RNA interference, and whole organism cryoprotectant concentrations via injection and feeding of target cryoprotectants. These results will help determine the extent to which cryoprotectants are really necessary for cold tolerance.

Li, Heidi, Greg Sigel, Velislava Tzaneva, Steve Perry

University of Ottawa

Circulating catecholamines modulate the hypoxic hyperventilatory response in larval zebrafish (*Danio rerio*).

There are conflicting views regarding the role of catecholamines in the control of ventilation in fish. In the present study, we investigated the potential role of catecholamines in contributing to the hypoxic hyperventilatory response in larval zebrafish (*Danio rerio*). Acute exposure of larvae to catecholamines (adrenaline or noradrenaline) increased ventilation frequency (Vf). This increase in Vf was prevented by prior exposure of fish to the β-adrenergic receptor antagonist, propranolol. Moreover, pre-treatment of fish with propranolol eliminated the hypoxic hyperventilatory response. To distinguish the effects of circulating catecholamines from neuronally-released catecholamines, fish were subjected to gene knockdown of vascular endothelial growth factor (VEGF) to prevent development of the circulatory system. Unlike control larvae, VEGF morphants did not increase Vf during acute hypoxia exposure. Collectively, these results suggest a stimulatory role of β-adrenergic receptors in the control of breathing in hypoxic zebrafish larvae, which are likely mediated by catecholamines of endocrine origin.

MacMillan (presenter) - Lisa Jørgensen, Johannes Overgaard and Heath A. MacMillan.
York University.
Paralysis and heart failure precede ion balance disruption in heat-stressed European green crabs.
Exposure to critically high temperatures causes injury and death, and for crustaceans this mortality has been associated with impaired oxygen transport, loss of ion and water homeostasis, and synaptic failure. It is difficult to discern which of these factors, if any, is the proximate cause of heat injury because, for example, loss of ion homeostasis can impair neuromuscular function (including cardiac function), and impaired oxygen transport can reduce ATP supply and can thus reduce ion transport capacity. We held crabs at temperatures just below their critical thermal maximum and measured extracellular (hemolymph) and intracellular (muscle) ion concentrations. Heat stress depolarized both the Na^+ and K^+ equilibrium potentials. We then exposed crabs to the same temperatures, but this time measured ion concentrations at the individual-specific times of complete paralysis (from which the crabs never recovered) and heart failure. Ion balance was disturbed only after both paralysis and heart failure had occurred. Thus, loss of neuromuscular function is not caused by a loss of organismal ion homeostasis, but more likely that tissue damage following irreversible neuromuscular failure leads to a loss of ion homeostasis.

Mandic, Milica, Velislava Tzaneva and Steve F. Perry.
University of Ottawa.
Role of HIF1α paralogs in the hypoxic ventilatory response of adult zebrafish (*Danio rerio*).
Hypoxia-inducible factor 1α (HIF1α), a transcription factor found in all vertebrates, alters transcription patterns of many hypoxia-inducible genes and is widely considered to be one of the central players in the cellular response to hypoxia. Most species have lost one of the paralog pairs of HIF1α that arose during the teleost-specific whole genome duplication with the exception of the cyprinid lineage of fishes which has retained both copies (HIF1α-aa and HIF1α-ab). Little is known about the specific roles of the HIF1α paralogs and the contribution of each paralog to control of the hypoxic ventilatory response in fish. In this study, we are examining the hypoxic ventilatory response in wild-type, HIF1α-aa knockout and HIF1α-ab knockout lines of adult zebrafish (*Danio rerio*). Specifically, ventilation frequency and amplitude will be recorded for each zebrafish line acutely exposed to three progressive levels of hypoxia (PwO_2 = 60, 30, 15 Torr) and normoxic recovery.

McFarlane, Sarah V., Katherine E. Mathers, James F. Staples.
University of Western Ontario.
Reduced temperature sensitivity of brown adipose tissue mitochondrial respiration during torpor.
Small hibernating mammals, such as the 13-lined ground squirrel, exhibit hibernation cycles comprised of torpor bouts (10-15 days, T_b ~5°C) that are interrupted by spontaneous arousals into interbout euthermia (IBE) (8-12 hours, T_b ~37°C). Arousal from torpor into IBE happens within ~2 hours and requires thermogenic brown adipose tissue (BAT) to produce this drastic rise in T_b over such a short time. Our lab has demonstrated that liver mitochondrial metabolism is suppressed by 70% in torpor relative to IBE. There is evidence that these differences are due to molecular changes in the electron transport system (ETS) enzymes. We predicted, however, that because BAT mitochondrial function is primarily regulated by adrenergic signals, oxygen consumption rates in isolated BAT mitochondria would not significantly differ between torpor and IBE. The Q_{10} values calculated from oxygen consumption rates of isolated BAT mitochondria indicate that ETS enzymes in mitochondria isolated from torpid animals function better at colder temperatures (10°C) while mitochondria isolated from individuals in IBE function better at warmer temperatures (37°C). Our results suggest that, while there likely is no active suppression of oxygen consumption rates between IBE and torpid BAT mitochondria, there are differences in the temperature sensitivity of the ETS enzymes.

Mehdi, Hosein, Heather Ikert, Shahithiya Santoskhumar and Paul M. Craig
University of Waterloo.
Multi-stressor impacts on fish energetics: from pharmaceutical contaminants to climate change.
Aquatic organisms face numerous stressors simultaneously in their environments. While each of these stressors pose great threats to aquatic life, studying each stressor individually is not sufficient, as these stressors are not independent, but work cumulatively and synergistically to alter aquatic ecosystems. The objective of this study was to examine the impact of chronic exposure to multiple, mainstream stressors that aquatic organisms continuously face. Our study set out to understand the effects of environmentally relevant concentrations of venlafaxine, an antidepressant pharmaceutical contaminant found abundantly in wastewater treatment plant effluents, in combination to elevated water temperatures and hypoxia on the metabolism and swimming performance of zebrafish (*Danio rerio*). Adult zebrafish were exposed to a series of treatments consisting of different combinations of these stressors for 21-days. Muscle tissue was sampled immediately post-exposure to

measure enzyme activity of major metabolic enzymes. We measured standard and active metabolic rates using respirometry, allowing us to calculate total aerobic scope to assess the metabolic capacity of zebrafish. The results of this study will contribute to the recognized importance of including multi-stressor approach assessments to make predictions regarding the impact of stressors on fish health and abundance.

Mehta, Amrit and J. David Spafford.
University of Waterloo.
Origins of voltage-gated sodium and calcium channels in primordial single-celled eukaryote Salpingoeca rosetta.
We have isolated a complement of gene homologs from the simplest extant eukaryotic species to possess voltage-gated sodium (Na+) and calcium (Ca2+) channels. Recent evidence suggest that single cell bacteria use voltage-gated potassium channels to transmit long range signals through biofilms. We envisage that these homologs of voltage-gated Ca2+ and Na+ channels found in single cell choanoflagellate Salpingoeca rosetta may generate Ca2+-dependent action potentials that signal between cells of choanoflagellate colonies, regulate intra-cellular events, or control movement of it's single flagellum or cilia. The full complement of Ca2+and Na+ channels in Salpingoeca include an L-type calcium channel (SroCav1), T-type calcium channel (SroCav3), and a sodium channel (SroNav2). SroNav2 codes for an 1831 amino-acid transmembrane protein of four repeat domains with a selectivity filter ring, DEEA, resembling Ca2+-selective sodium channel genes found exclusively in non-vertebrate animals. Transfection and expression of SroNav2 in Human Embryonic Kidney-293T (HEK-293T) cells generates a voltage-dependent ionic current. The structurally similar to Nav1, SroNav2, passes both calcium and sodium ions equally. Characteristically, calcium as a charge carrier can be replaced in most calcium channels by divalent barium, however SroNav2 is impermeable to barium ions, operating as a dose-dependent blocker of the Ca2+ current. We are interested in evaluating this unusual non-selective channel that is impermeable to barium ions, and to understand the roles SroNav2 may play in Salpingoeca.

Mercer, Evan W., Janet C. Tait, and William S. Marshall.
St Francis Xavier University.
Salinity Preference and Halocline Behaviour in an Estuarine Teleost Fish.
Haloclines are common features of estuaries, but how fish react to them is not well known. Mummichogs have ability to acclimate to extreme salinities and prefer seawater, yet they spawn in dilute brackish water. The objective was to reveal how mummichogs (Fundulus heteroclitus)select microhabitats in the estuary. Artificial haloclines were constructed to test isothermal salinity preference, between 28‰ full strength seawater (SW, below) and 10% SW (3.0‰, above). Mummichogs of both sexes acclimated to 5°C in SW strongly preferred SW. Surprisingly, freshwater (0 % SW) acclimated mummichogs at 21°C also preferred SW. In sexually mature fish acclimated to 21°C SW, only the males preferred SW; the females showed no significant preference for SW, meaning they freely entered low salinity. SW preference was manifested by a stereotypic passive aversion to the dilute upper layer at the halocline. We conclude that the overall movement of mummichogs into summer breeding grounds of low salinity is driven by maturation of females and their preference for warmer water (regardless of salinity) that overcomes the general tendency of the immature and male fish to avoid dilute waters. Supported by NSERC Discovery Grant RGPIN3698-2009 to WSM and UCR scholarship to JCT.

Nogueira, Lygia S., Anne Crémazy, Fabiola V. Domingos, Chris M. Wood.
The University of British Columbia.
Zinc and calcium pathways in the green crab *Carcinus maenas*.
The purpose was to determine the pathways by which calcium and zinc are taken up from ambient sea water by the green shore crabs (*Carcinus maenas*), by investigating the relative contribution of uptake through the gill versus uptake across the carapace. Alive, dead and carapace-covered crabs were exposed to radiolabelled Ca and Zn individually for 24 h at 2°C, 12°C and 22°C and the spatial distribution of each element was determined. Our results indicate that Zn uptake pathway occurs mainly through the gills (~75%) and via biosorption in the carapace surface (~25%), while the Ca uptake pathway is via gills (~90%). The distribution of radiolabelled Zn occurred mainly in the gills (~70%), while the Ca was observed mostly in the carapace (~60%). No change was observed between 2°C and 12°C. An increase of Zn in the gills (~290%) and both ions in the carapace (Ca= ~280%; Zn= ~300%) was observed at 22°C relative to 12°C. Despite the increased uptake of the two metals, the pathway of Zn and Ca uptake remained similar to 12°C (via gills, ~73% and ~88% respectively). However, the pathway of Zn deposition in the carapace differed. The deposition occurred via biosorption (~65%) and through the gills (~35%) followed by distribution to the carapace. (IDRC, NSERC Discovery)

Pham, Phuc H., Fotini Papazotos, Jun-Wen Li, Niels C. Bols.

University of Waterloo.

Effects of nutrient deprivation on the ability of fish cells to support fish virus replication.

Cellular metabolism is important for replication of many types of viruses. Processes during viral replication that required cellular metabolism can include genome replication or transcription, viral protein and other macromolecules production and lipid synthesis in the case of enveloped viruses. While the link between cellular metabolism and mammalian virus replication is well established, the effects of metabolic depression on fish virus replication have not been explored in detail. Therefore, in this work, the ability of nutrient deprived fish fathead minnow cells, EPC, and Chinook salmon cells, CHSE-214, to support viral hemorrhagic septicemia virus (VHSV) and chum salmon reovirus (CSV) was examined and compared to cells under full medium. Cells were exposed to four medium conditions of decreasing nutrient content, 15% FBS/L15, L15 alone (serum starvation), L15 Ex, which has only galactose and pyruvate (amino acid and vitamin starvation), and L15 salts with no amino acids, vitamins and energy sources (complete starvation). VHSV successfully replicated in all medium conditions in EPC but to a lesser extent in L15 salts, which is free of all nutrients. Similarly CSV also replicated in all medium conditions in CHSE-214 cells but FBS was observed to protect some of the cells from CSV infection.

Provencher, Tamara, Céline Audet, Réjean Tremblay, Frédéric Olivier.

Université du Québec à Rimouski.

Behaviour and burying capacity of juvenile winter flounder according to sediment type, salinity and current speedComportement des plies juvéniles (Pseudopleuronectes americanus) en fonction de trois facteurs abiotiques: courant, sédiment et salinité

Winter flounder (*Pseudopleuronectes americanus*) is a benthic flatfish species economically important for recreational and commercial fishing in North America. In the last twenty years, the species went under a drastic decline mainly due to anthropic influence. Aquaculture of winter flounder for release in natural habitat exists in the United States, but post-release survival is very low. The goal of this study is to gain knowledge on habitat preferences and behaviour of juvenile winter flounder, in order to improve the management of natural stocks and optimise the timing and the choice of release sites for juveniles. Three abiotic factors that may influence the distribution of juveniles were tested in a flume: type of sediment, current speed, and salinity. Time-budgets of observed behaviours such as swimming, orientation, or burying capacity were evaluated using videos of the experiments. Preliminary results of repeated measures Anova with three factors (sediment, salinity and within-subjects current speed) were analysed. The results indicate that current speed did not influence the orientation according to current (rheotaxis) of juvenile winter flounder. However, burying capacity seemed to increase proportionnaly with current speed and would be higher in fine sand compared to gravel. Also, juvenile winter flounder in the experiments used frequently passive drifting to move in the flume.

La plie rouge (*Pseudopleuronectes americanus*) est un poisson plat benthique important en Amérique du Nord pour la pêche récréative et commerciale, mais les populations connaissent un déclin drastique dû à plusieurs facteurs anthropiques. Afin d'y remédier, l'aquaculture de juvéniles de plie rouge aux États-Unis est utilisée pour le réensemencement, cependant la survie des juvéniles demeures très faible en milieu naturel. Cette étude vise à élucider certains aspects du comportement et de la sélection d'habitats favorables à la survie des juvéniles pour améliorer la gestion des populations sauvages et optimiser les conditions de réensemencement. Trois facteurs abiotiques influençant la distribution des poissons plats ont été testés dans un canal hydrodynamique sur des juvéniles de plie rouge de deux ans, soit le type de sédiment, la vitesse du courant et la salinité. Par un suivi vidéo et une analyse budgets-temps des différents comportements observés, nous avons pu établir l'impact des différents facteurs. Selon les résultats préliminaires d'Anova multifactorielle avec un facteur à mesures répétées (la vitesse de courant), les plies juvéniles ne semblent pas s'orienter face au courant en fonction de l'augmentation du courant. Cependant, la capacité d'enfouissement semble augmenter proportionnellement avec la vitesse de courant et serait favorisée par le sédiment de type 'sable fin'.

Reynolds, Ashley.

University of Toronto.

Growth patterns in wild and captive lions (*Panthera leo*) and Amur tigers (*Panthera tigris altaica*).

Acquiring life history data for wild populations is often more time-consuming and costly than obtaining the same data from captive individuals. However, growth studies based on captive individuals of a species can be met with scepticism by the scientific community. Here, I statistically compare Von Bertalanffy growth curves for data compiled from the literature for both wild and captive individuals in two species of large felids, *Panthera leo* and *Panthera tigris altaica*. Preliminary results show that both cohorts of female tigers reach an asymptotic body size at approximately 3 years of age, while wild and captive male tigers reach their asymptote at 6 and 3 years, respectively. Lions express a similar pattern, with both cohorts of females reaching asymptote at age 5 and wild and captive males at ages 7 and 4, respectively. Two-tailed Welch's *t*-tests suggest that there is no

statistically significant difference between the computed mean growth curves for wild and captive cohorts in both species. This study suggests that certain life history traits for carnivoran mammals, such as asymptotic body size and growth pattern, can be reliably determined from healthy captive individuals, and that such traits may be more strongly influenced by genetic rather than environmental factors.

Rocco, David and Jean-Paul Paluzzi
York University
Elucidating the Distribution and Function of an Ancient Glycoprotein Hormone System in the Mosquito, *Aedes aegypti*.
GPA2/GPB5 is a glycoprotein hormone found in most bilateral metazoans including the mosquito, *Aedes aegypti*. Transcript expression of the GPA2/GPB5 subunits and its receptor in insects, the leucine-rich repeat-containing G protein-coupled receptor 1 (LGR1), provide evidence for involvement in development and hydromineral balance. To further elucidate the function of GPA2/GPB5, we have examined LGR1 protein-level expression and analyzed its tissue- and sex-specific distribution patterns in adult *A. aegypti.* Western blot analyses on protein isolated from HEK293T cells expressing LGR1 yielded an appropriate-sized band at ~105kDa associated with membrane-protein fractions. Immunohistochemical analysis in adult mosquitoes revealed LGR1-like immunoreactivity is widespread in the alimentary canal. Staining localized specifically to basolateral regions of the epithelium and also appears as punctate staining dispersed intracellularly. Interestingly, strong LGR1-like immunoreactivity was also identified in reproductive tissues including the testes and ovaries, which suggests a role related to spermatogenesis and oogenesis in males and females, respectively. RNA interference techniques to downregulate LGR1 transcript expression have been successful in adult mosquitoes achieving over 90% knockdown. Ongoing studies implementing this knockdown approach will further investigate this putative reproductive function and will build upon the established osmoregulatory and ionoregulatory role by examining GPA2/GPB5 activity related to diet-specific challenges.

Sacchi, Federico, Joshua G. Pemberton, and John P. Chang
University of Alberta.
PI3K involvement in basal and ghrelin-stimulated LH and GH release from goldfish pituitary cells.
Recent studies have shown that, in goldfish pituitary cells, phosphoinositide 3-kinase (PI3K) signalling is involved in gonadotropin-releasing hormone-mediated growth hormone (GH) and luteinizing hormone (LH) release. Ghrelin, another stimulator of GH and LH secretion in goldfish, has also been shown to increase phosphorylation of substrates downstream of the PI3K signalling cascade in other vertebrate cells. In this study, we examined the involvement of PI3K signalling in synthetic goldfish ghrelin-induced GH and LH secretion in primary cultures of dispersed goldfish pituitary cells in cell column perifusion. Treatments with a broad-spectrum PI3K inhibitor (LY294002) and a selective class 1 PI3K inhibitor (GDC0941) abolished ghrelin-induced GH and LH release, which suggests that ghrelin positively regulates GH and LH secretion via class I PI3K signalling in goldfish pituitary cells. However, LY294002, but not GDC0941, enhanced basal GH and LH secretion, indicating that class I PI3K may modulate basal secretion in a manner different from class II and III PI3Ks. These findings improve our understanding of the intracellular mechanisms integrating neuroendocrine regulation of GH and LH secretion. (Supported by NSERC.)

Saibu, Yusuf, Ankur Jamwal, Renfei Feng and Som Niyogi
University of Saskatchewan
Distribution of zinc and its interactions with copper and cadmium in fish gills using X-ray fluorescence imaging.
X-ray fluorescence imaging (XFI) is a synchrotron-based technique, which can be used to investigate the distribution profile of elements in a biological tissue. We used XFI to examine: (i) the spatial distribution of Zn and its co-localization pattern with other essential elements (Ca, S and Fe), and (ii) the effect of competing metals (Cd and Cu) on the Zn distribution in the gills of rainbow trout. Fish were exposed to acute levels of waterborne Zn alone and in combination with waterborne Cd or Cu for 24h. Following exposure, gills were dissected out and 5 microns thick sections were prepared to map the distribution of different elements using the hard X-ray VESPERS beamline of the Canadian Light Source. The primary lamellae of the fish gill were found to be the primary area of Zn accumulation. Zn was also found to predominantly co-localize with Ca and S, but not with Fe, indicating the role of Ca and S in intracellular Zn handling. Zn distribution in the gill was markedly reduced during co-exposure to Cd, but not to Cu, suggesting a competitive interaction between Zn and Cd for uptake. The implications of these findings in understanding metal-mixture toxicity in fish will be discussed.

Schlater, Amber, Nicole Pranckevicius, and Grant McClelland.
McMaster University.
Skeletal muscle physiology and performance in low and high altitude deer mice (*Peromyscus maniculatus*).

The deer mouse (*Peromyscus maniculatus*) has the widest altitudinal distribution of any North American mammal, with resident populations ranging from sea level to altitudes greater than 4,300 meters. Regarding the latter, atmospheric hypoxia characteristic of high altitudes poses extreme physiological challenges for these small endotherms that their lowland counterparts never experience. Is the deer mouse capable of extreme phenotypic plasticity, or do highlander and lowlander populations exhibit hardwired, ancestral differences? To investigate, we characterized cellular and tissue-level metabolism and overall performance in F1 highlander and lowlander skeletal muscle, a tissue that utilizes aerobic metabolism in both work and heat production. Regarding performance, force production did not differ between populations in normoxia; however, in hypoxia, lowlanders were capable of greater force production than highlanders. Enzyme assays from primary cells cultured from leg muscles showed highlanders as having higher aerobic and lower anaerobic capacities versus lowlander cells; these cellular differences matched tissue-level enzyme differences. Moreover, tissue-level enzyme markers showed even greater population disparities in mice acclimated to cold and hypoxia. Collectively, while both populations demonstrate phenotypic plasticity in the presence of abiotic stressors, these cellular and tissue-level skeletal muscle data in unacclimated mice highlight ancestral differences between highlander and lowlander physiology.

Schorno, Sarah, Guylaine LaRochelle, Douglas Fudge and Andreas Heyland
University of Guelph.

Temporal and morphometric dynamics of slime gland refilling in hagfish.

Hagfishes are known for their unique defensive slime, which they use to ward off gill breathing predators. When attacked, the musculature around the slime glands contracts, forcing the slime cells out through a narrow pore where they quickly interact with the surrounding seawater. It is speculated that the two main cells types within slime glands, the gland mucus cells (GMCs) and gland thread cells (GTCs), likely originate from stem cells in the gland epithelium, and increase dramatically in size as they develop and mature. While much is known about the biochemistry and biophysics of the two slime components, the questions of how long slime glands take to refill and how they refill remain unanswered. The temporal and morphometric dynamics of how these two cell types are replenished within the slime glands was investigated using a mix of histology, immunofluorescence, and analysis of the slime exudate. This study aimed to establish a timeline for gland refilling, as well as determining a model of refilling and how the proportions of the GMCs and GTCs released in exudate changes during refilling.

Shaw, Laura, Craig Jurkiewicz, Sarah Alderman, Frederic Laberge and Todd Gillis.
University of Guelph.

The effects of hypoxia and exercise on relative brain size in juvenile rainbow trout (*Oncorhynchus mykiss*).

In mammals, exercise increases neurogenesis while postnatal hypoxia reduces brain size. How these stressors affect the fish brain is not known. This study tested the hypothesis that constant exercise (0.9 body lengths/s) would protect the brain from a negative influence of overnight hypoxia (8 h, 63% oxygen saturation) on brain size in juvenile rainbow trout fed a matched diet . Fish were maintained in either normoxia, normoxia + exercise, hypoxia, or hypoxia + exercise for 5 weeks. Total brain weight and regional brain volumes (olfactory bulbs, telencephalon, hypothalamus, optic tectum, cerebellum) were measured and standardized to body length. Both hypoxia and exercise reduced growth, but their effects did not interact. Relative brain weight was not affected by any treatment. There was a trend towards a decrease in relative volume for all brain regions due to exercise, but not hypoxia. Interestingly, this effect was statistically significant in the telencephalon and olfactory bulbs, two regions with a high capacity for neurogenesis in fish. The results did not support the hypothesized neuroprotective effect of exercise. On the contrary, exercise reduced brain volume while the hypoxic stressor had no effect. This might be due to conditions of energetic limitation under which the experiment was conducted.

Small, Christopher, Bryan Crawford, and Tillmann Benfey
University of New Brunswick – Fredericton

Exposure to hypoxia in early development increases the number of hematopoietic stem cells in zebrafish embryos.

Many organisms display a degree of developmental plasticity in which embryonic rearing conditions influence phenotype, thereby generating an organism better suited to its environment. For instance, exposing zebrafish embryos to short pulses of hypoxia 24 to 48 hours post-fertilization (hpf) increases larval hypoxia tolerance highlighting a critical window of plasticity during early development when physiological tolerances are being set; the mechanisms underlying this plasticity are unknown. Hypoxia inducible factor 1 (Hif-1a) regulates hypoxic signalling and blocking this signalling pathway in zebrafish causes 1) upregulation of hematopoietic genes, 2) more circulating red and white blood cells, and, intriguingly, 3) expanded populations of hematopoietic stem cells (HSCs). This plasticity in the number of HSCs seems limited to early development as adults respond to hypoxia using strategies 1 and 2, but not 3. To develop a better understanding of the mechanisms underlying this plasticity, embryos from transgenic zebrafish expressing HSC-specific green fluorescent protein were reared in hypoxia (5% DO) and

normoxia (95% DO) between 24 and 48 hpf, and HSCs quantified using confocal microscopy. This experiment will test the idea that early exposure to hypoxia 'primes' the fish for a hypoxic environment, thereby leading to faster growth rates.

Spong (presenter) - Hanna Grover, Kristin Spong and R Meldrum Robertson.
Queen's University.

Aging prolongs stress-induced coma in *Locusta migratoria*.

In response to metabolic stress, such as anoxia and hyperthermia, locusts enter a reversible coma that conserves energy during severe environmental conditions. The onset of a stress-induced coma occurs simultaneously with an abrupt increase in the extracellular potassium concentration ($[K^+]_o$) within the CNS and recovery of motor pattern generation relies on the restoration of ion levels. In semi-intact preparations, pharmacologically disrupting mechanisms of ionic homeostasis with ouabain (inhibition of the Na^+/K^+-ATPase) or sodium azide (ATP depletion) elicits similar disturbances. Using fully intact locusts we found that "young" individuals (~4 week old adults) took longer to enter an anoxic coma induced by submersion under water compared to "old" locusts (~9 week old adults). Furthermore, upon return to normoxia, young animals began ventilating and regained their ability to stand faster than older individuals. Electrophysiological experiments, using semi-intact preparations, did not reveal significant differences in the timing of onset or recovery from neural shutdown induced by sodium azide; however, in the presence of ouabain a greater disturbance in $[K^+]_o$ regulation was observed in "old" preparations compared to "young" preparations. We conclude that aging impairs mechanisms of ion homeostasis in the CNS of locusts making them more vulnerable to environmental stress.

Srithiphaphirom, Phinyaphat, Darius Soo Lum and Mel Robertson.
Queen's University.

Acclimation of chill coma mechanisms in the CNS of *Locusta migratoria*

When exposed to cold, migratory locusts enter chill coma (neuromuscular paralysis) and can resume normal body functions after returning to normal temperature. The mechanisms underlying chill coma and recovery are not well understood and the role of the CNS is unclear. With an implanted thermocouple in the thorax, we measured the low temperature that induced loss of coordination and responsiveness (CT_{min}) in intact male locusts. In parallel experiments, we also recorded DC potential in the metathoracic ganglion in dissected preparations to determine the low temperature that induced neural shutdown. Acclimation at 10 ˚C for 10 days or rapid cold hardening (RCH) at 4 ˚C for 4 hours reduced CT_{min} and chill coma recovery time. RCH also reduced the temperature at neural shutdown by an amount similar to the reduction of CT_{min}. These results suggest that the CNS has an important role in determining entry into and exit from chill coma.

Stephens, Robert, Wendy Guan , Omar Mourad, David Spafford.
University of Waterloo.

Domain II/IV Extracellular Turrets as Determinants of Ion Selectivity in LCa_v3, a T-type Channel from *Lymnaea stagnalis*.

Our research involves evaluating the structural determinants for calcium (Ca^{2+}) and sodium (Na^+) selectivity in Ca_v3 T-type calcium channels from the pond snail, *Lymnaea stagnalis*. T-type channels can have ion selectivity that resembles voltage-gated calcium channels, but many invertebrates also have splice isoforms which are sodium selective. The extracellular (S5P) turret, upstream of the selectivity filter in Domain II, is critically important for generating highly sodium-selective T-type channels. Native splicing of exon 12a generates a sodium selective channel. Exon 12b generates calcium selectivity. Another region contributing to ion selectivity is the extracellular turret of Domain IV. Like Domain II, the Domain IV turrets are different between sodium- and calcium-selective channels. We have swapped Domain II turrets between a sodium-selective invertebrate T-type channel from *L. stagnalis* (LCa_v3-12a) and a calcium-selective, mammalian $Ca_v3.2$ channel. Before the swap, LCa_v3 exhibits sodium selectivity reminiscent of Na_v1 channels. After the swap, the chimeric LCa_v3 exhibits selectivity that is more like calcium-selective $Ca_v3.2$ channels. We are attempting to resolve the molecular mechanisms involved in generating dramatic ion selectivity changes in invertebrate T-type channels; we were able to alter selectivity by swapping Domain II and IV turrets from a $Ca_v3.2$ channel into LCa_v3, the T-type from *L. stagnalis*.

Tait, Janet C., Evan W. Mercer and William S. Marshall.
St Francis Xavier University.

Osmotic regulation of ion transport outstrips hormonal regulation in cold acclimated fish.

The eurythermal and euryhaline teleost fish (*Fundulus heteroclitus*) survives 0-60‰ and 0-40°C extremes. NaCl secretion is under apparently redundant control, by a hormone-receptor mediated adrenergic pathway and a stretch-sensitive osmotic pathway. We hypothesized that in winter, the complex receptor-mediated adrenergic pathway would become less responsive, whereas the more direct osmotic pathway would retain sensitivity. We tested the two pathways by placing opercular epithelia

(OE) of both warm (20˚C) and cold (5˚C) acclimated fish in an Ussing chamber and measuring changes in short circuit current (*Isc*, Cl^- secretion rate) across the OE in response to transport inhibitors (clonidine, α_2-adrenergic agonist, and hypotonic saline) and stimulators (isoproterenol, a ß-adrenergic agonist and hypertonic saline). We found that change in *Isc* was significantly lower for cold acclimated fish in all treatments except hypertonicity. Osmotic decrease (hypotonic shock) was fully effective at inhibition of *Isc* in the cold but clonidine inhibition was blunted and had a significantly higher ED50, compared to warm acclimated controls ($P < 0.001$). We conclude that the α_2-adrenergic pathway is less responsive at low temperatures, whereas the parallel osmotic pathway becomes critical to survival of killifish in the cold. Supported by NSERC Discovery Grant (WSM) and UCR scholarship (JCT).

Taylor, Elias and Andreas Heyland.
University of Guelph.
The effect of thyroid hormones on skeletogenesis in larval sea urchins of *Strogylocentrotus purpuratus*.
Biomineralization provides the rigid material for many adaptations across diverse phyla. Skeletogenesis is the process by which biomineralized structures are formed during embryogenesis. In the sea urchin *S. purpuratus*, it is a well understood process of development and the gene regulatory network (GRN) controlling skeletogenesis in the larva has been described. Previous research shows that TH accelerates the development of the juvenile rudiment in Dendraster excentricus and other irregular urchins while slowing the growth of larval skeleton. Here we test the hypothesis that thyroid hormones (T_4 and T_3) are regulators of skeletogenesis in *S. purpuratus*, upstream of the skeletogenic GRN. Specifically we predict that the THs' regulatory mechanism antagonistically affects larval skeletogenesis, shifting resources towards the juvenile rudiment. Preliminary data show that thyroxine accelerates developmental timing of larval skeleton growth. Further work will focus on the effect of THs on transcription levels in the skeletogenic GRN. We expect that TH will regulate upstream initiators of skeletogenesis such as *Ets1* and *Alx1*, and cause the *Tgif-Hex-Erg* loop to be activated earlier in development while downstream skeletal matrix proteins will be downregulated.

Tea, Jonathan, Sarah L Alderman and Kathleen M Gilmour.
University of Ottawa.
Neurogenesis in adult zebrafish: how social stress affects the brain.
Zebrafish (*Danio rerio*), like many other vertebrates, form social hierarchies through agonistic interactions when faced with the constraints of limited resources. Social interactions appear to be a chronic stressor for subordinate fish because male subordinate zebrafish exhibited significantly higher trunk cortisol levels at 4 day of interaction; however no effect existed at 2 days of interaction. In developing mammals, glucocorticoids impede neurogenesis by stimulating neuron differentiation. In fish, unlike mammals, neurogenesis continues throughout life providing an opportunity to examine the effects of social stress, and particularly elevated cortisol levels, on neurogenesis in adult zebrafish. Neurogenesis will be characterized at 4 days of interaction in adult male zebrafish using BrdU.

Toxopeus, Jantina, Vladimír Koštál, Brent J Sinclair
Western University
Crickets on ice: dissecting the mechanisms underlying insect freeze tolerance.
Juveniles of the spring field cricket, *Gryllus veletis*, survive internal ice formation (i.e. are freeze-tolerant) when acclimated under fall-like conditions, while summer-acclimated juveniles do not survive freezing. We compare freeze-tolerant and freeze-sensitive *G. veletis* to identify tissues damaged by freezing, and potential mechanisms that protect against or repair this injury. All crickets exhibit fat body damage after a freeze-thaw cycle, but the damage is severe and irreparable in freeze-sensitive crickets, while freeze-tolerant crickets repair the damage within two days of recovery. We conduct metabolomic analysis to identify molecules that are potentially necessary for freeze tolerance in hemolymph and fat body tissue during acclimation, freezing, and recovery of freeze-tolerant and freeze-sensitive *G. veletis*. We use these results to generate hypotheses about the mechanisms by which these molecules contribute to surviving internal ice formation.

Turko, Andy J., Kelly D. Levesque, Tessa Blanchard, Andrew Leinonen, and Patricia A. Wright.
University of Guelph.
A low-cost, modular, and highly configurable 3D printed system for building metabolic rate chambers for air or water.
Accurately measuring the metabolic rate of animals is fundamental to answering many questions in biology. Oxygen consumption is often used as a proxy for metabolic rate, and recent breakthroughs in oxygen sensor spot technology have greatly improved our ability to make these measurements. Suitable animal holding chambers still pose challenges, however, as these need to be gas-impermeable and sized to the organism being studied. Custom glassware is often used, but this can be

prohibitively expensive when multiple chamber sizes are required. Additionally, long acclimation times in these chambers (e.g. overnight) are often required before accurate metabolic rate measurements are possible, limiting the rate at which data can be collected. We present a highly configurable system that overcomes these problems. Screw-top glass vials are readily available in many sizes, and are easily modified to hold water- or air-breathing animals. A modular 3D printed mounting rack securely holds the vials in place and ensures alignment between sensor spots and optical fibers. The low cost and modular design can also increase throughput, as multiple "rounds" of animals can be acclimated at the same time and then measured in rapid succession.

Turnbull, Kurtis F., Jeremy N McNeil and Brent J Sinclair.
Western University.
Does microhabitat, phenology and metabolic plasticity reduce overwintering energy use in the western bean cutworm?
Many temperate insects rely on finite energy stores to fuel metabolism across overwintering dormancy. Since metabolism is directly linked to temperature in ectotherms, relatively warm conditions can hasten energy use by overwintering insects, with potential consequences for survival and post-dormancy performance. Dormant insects may conserve energy through metabolic plasticity or by selecting a microhabitat that buffers against warm conditions. Alternatively, insects may avoid the energetic demands of warm autumnal conditions through later entry into dormancy. However, the extent to which these factors reduce energy use by overwintering insects in the field is unclear. We will explore the overwintering energetics of the western bean cutworm (WBC; *Striacosta albicosta*) to identify factors that influence energy use, and establish the links between overwintering energetics and post-dormancy performance. WBC larvae enter the soil in late summer and overwintering as dormant prepupae. We will sample prepupae from the field across the overwintering period to determine the effect of phenological variation and microhabitat selection on metabolic rate-temperature relationships, energy use, and mortality. We will then explore the potential consequences of energy drain on post-dormancy performance by measuring the lifetime fecundity of WBC recovered from the field.

Tward, Carly, Jaspreet Singh, and Allison McDonald.
Wilfrid Laurier University.
Alternative Oxidase in Copepods.
Alternative oxidase (AOX) is a ubiquinol oxidase present in the electron transport systems of many animal mitochondria. In other organisms, AOX plays a key role in the flexibility of bioenergetic systems, control of reactive oxygen species levels, and acclimation and adaptation to environmental stresses. Previous work indicated that AOX might be absent from Arthropods, but our recent bioinformatics investigations have revealed the presence of AOX in several copepod species. We decided to further investigate this enzyme in the intertidal marine copepod *Tigriopus californicus* as it is a model experimental system for investigating mitochondrial biology and it experiences a wide range of environmental perturbations on a daily basis in its natural habitat. Molecular biology techniques have confirmed the presence of the AOX gene and the expression of AOX mRNA in *T. californicus*. We are currently working to develop protein isolation and high-resolution respirometry protocols in order to investigate AOX enzyme activity and regulation in this species.

Valdez Domingos, Fabíola Xochilt and Chris Wood.
INPA - Instituto Nacional de Pesquisas da Amazônia and UBC - The University of British Columbia.
Do realistic concentrations of single and combined copper, nickel and cadmium affect sodium fluxes in zebrafish?
Metals are ubiquitous in the aquatic environment. Most studies on metal effects are focused on single exposures but they are usually present as mixtures in nature. Fish exposed to metals generally present ionoregulatory disturbances. Traditionally, sodium uptake was thought to be inhibited by copper. However Alsop and Wood (2011) recently reported that sodium uptake was increased during single copper exposure, whereas cadmium and nickel had minimal influence. They also observed that sodium efflux usually surpassed the uptake, resulting in net sodium losses. The effects of nickel and also of combinations of these three metals still need to be clarified. We will present and discuss the influence of environmentally realistic concentrations of single and combined copper, nickel and cadmium exposures on unidirectional and net sodium fluxes in the model fish species *Danio rerio* (CNPq, NSERC Discovery).

Vroom, Paige, Esther Peters and John Lumsden
University of Guelph.
Regeneration in Corallimorpharia.

Corallimorpharia species, in the phylum Cnidaria, regenerate after fragmentation in approximately 14 days. They are closely related to Scleractinia, but are easily maintained in the laboratory and possess the potential to be a model for aspects of coral physiology and immunity. Our goal is to choose a corallimorpharian species and the conditions that allow for the fastest regeneration to be used in future research. This project examined the impact of intrinsic and extrinsic factors on regeneration. Intrinsic factors included the comparison of 3 species, representing 3 different genera, as well as small (<5 cm^2) versus large (≥5 cm^2) initial polyp size. Extrinsic factors included light intensity (40-50, 90-100, and 140-150 µmol photons m−2s−1) and feeding (starved or fed every 5 days). Individuals were fragmented and the surface area was measured at days 2, 6, 10, and 14 using ImageJ to obtain a regeneration rate for each treatment. Zooxanthellae density was also measured with the use of a haemocytometer. As there is a lack of studies describing the cellular processes during coral regeneration, the process of regeneration using light microscopy was also described over a 2-week period following fragmentation. This work will create a basis for future research on experimental pathology and immunology of coral disease, effects of environmental impacts on regeneration and regeneration mechanisms.

Webber, Marissa and Dr. Russell C. Wyeth.
St. Francis Xavier University.
Consistent and inconsistent patterns of GABA-, histamine-, and FMRFamidergic neuroanatomy of *Hermissenda*.
The nudibranch *Hermissenda crassicornis* is a model system for studying the molecular and cellular basis for classical conditioning, based on an ability to associate light with vestibular stimulation. However, to date, there has been no basic survey of putative neurotransmitter content in the CNS and the associated sense organs involved in learning. We used immunohistochemistry and confocal microscopy to map GABA, FMRF-amide, and histamine-containing neuroanatomy and in the CNS, eyes, and statocysts. Throughout the CNS, we documented consistent patterns of histamine-immunoreactive and GABA-immunoreactive cells and fibers. We also found considerable inter-individual variation in some aspects of histamine immunoreactivity. Despite positive and negative controls confirming the specificity of GABA labeling, we found no evidence for GABA inside the photoreceptors or hair cells of the visual and vestibular systems. This surprising result is at odds with previous studies indicating hair cells should be GABAergic. We did find FMRFamide-immunoreactivity in the visual system and both FMRF-amide- and histamine-immunoreactivity in the vestibular system. Both inter-individual and inter-population variation in neuroanatomy must be considered as a possible explanation for the results.

Weihrauch, Dirk, Aida Adlimoghaddam, Andrew Donini, Stephanie Hans, Ashley Tripp
University of Manitoba
Ammonia transporters (AMTs) in invertebrates
Ammonia transporters (AMTs) are the key transporters for the uptake of ammonia from the soil in plants (AMTs), fungi (MEPs) and bacteria (amtBs). They are distantly related to the Rh-glycoproteins however, in contrast to the Rh-proteins, they are NOT expressed in vertebrate animals. Most interestingly, numerous genome and transcriptome projects revealed that AMTs are indeed expressed in invertebrates. Their actual role here needs to be examined. A study by the Zwiebel group (2014) suggested that the AMT from *Anopheles gambiae*, when expressed in oocytes, promotes a NH4+ transport. Moreover, most recent physiological studies by the Donini group on *Aedes agypti* larvae showed a strong decrease of the ammonia excretion rates in the excretory anal papillae when the AMT was knocked down. In the marine polychaete *Eurythoe complanata*, three AMTs were identified, all of them highly expressed in the gills. In fact, one of them exhibited higher transcript levels than the Na+/K+-ATPase (α-subunit). AMT function is however not clear-cut. For instance, out of four AMTs expressed in *C. elegans*, only one responded to elevated environmental ammonia levels. Furthermore studies in the horseshoe crab showed that all three identified AMTs exhibit rather negligible tissue expression levels.

Williams, Melanie, Vladimir Kodzhahinchev, Andrew Biancolin and Carol Bucking.
York University.
Quantifying Calcium and Magnesium Flux in the Pyloric Ceca of *Oncorhynchus mykiss* using the SIET.
The Scanning Ion-selective Electrode Technique (SIET) provides a novel approach to the study of ion movement across the epithelium of a variety of biological tissues. This method was used to investigate the flux of two important dietary ions, calcium and magnesium, across the epithelia of the pyloric ceca (PC) in *Oncorhynchus mykiss*. There is epithelial zonation within the PC correlated with their function in osmoregulation and absorption of nutrients such as lipids, in which calcium and magnesium play a significant role. We proposed that along the proximodistal axis of the PC epithelium a transition from calcium and magnesium efflux towards the serosa to an influx of these ions into the mucosa would be observed. We further proposed that these fluxes would correspond to the epithelial zonation of osmoregulatory and lipid absorption processes, respectively. The efficacy of SIET in measuring the flux of these ions in the PC was explored at various locations along the anterior intestine and

PC. Calcium and magnesium fluxes were also observed across both the serosal and mucosal epithelium through non-everted and everted PC tissue respectively. Funded by NSERC.

Wyeth (presenter) Veronica Ells and Russell Wyeth.
St. Francis Xavier University.
At least three shades of gray: a true test of colour effects on marine invertebrate biofouling.
Past tests of biofouling by marine invertebrates on different colours were not designed to distinguish between responses to substrate colour and substrate brightness. Using colour vision testing methods, we designed a true test for responses to colour by including both coloured and grayscale settlement plates. The dominant fouling taxa at our tests sites (the solitary ascidian, Ciona intestinalis; the colonial ascidians Botryllus schlosseri or Botrylloides violaceous; and a bryozoan Bugula sp.) showed no significant differences in settlement between blue, red or green plates. In contrast, the ascidians responded to substrate brightness with significantly lower settlement on lighter plates, while the bryozoans showed no significant preference relative to substrate brightness. The contrasting responses to brightness are at odds with previous laboratory experiments that showed larvae of both ascidians and bryozoans are negatively phototactic at settlement. Other cues presumably supersede any phototactic responses in the bryozoans in the field. In future studies, our methods serve as a model for testing responses to colour during invertebrate settlement. In addition, since novel antifouling coatings designed to reduce biofouling often have varying colour or brightness, our results indicate controls with appropriate brightness are needed if ascidians are part of taxa in the fouling community.

Xu, Xinjian, Huahui Lan, Xiangjie Zhu, Shujing Zhou, Bingfeng Zhou.
College of Bee Science, Fujian Agriculture and Forestry University.
Effects of Thermal Stress on Sealed Brood Development of Queen Honeybee, *Apis mellifera*.
The eusocial honeybees are stenothermic during the development from egg into adults. To better understand the effects of thermal stress on Honeybee (*Apis mellifera*) queen development, sealed broods were incubated at constant temperatures ranging from 28°C to 39°C (i.e. 12 thermal treatments). No queen emerged at temperatures lower than 30°C or higher than 37°C. The duration of sealed brood stage and eclosion rate of the queen reared at optimal thermal range (33-36°C) were 168.8-205.1 h and 92-98%, respectively, while the duration of sealed brood development significantly prolonged and the eclosion rate dramatically decreased at 31, 32, and 37°C. External morphological traits, such as fore wing length, longitudinal diameters of the tergite and sternite of adults at 33 -36°C were larger compared to those treated at lower or higher temperatures. Furthermore, a dozen categories of vein imperfections occurred from adult queens treated at 31, 32, and 37°C. Our results suggested that the optimum temperature zones for queen development ranged from 33-36°C, implying that there are fitness costs if brood is reared outside the normal nest temperatures.

Yap, Jeff Kang Nian, Karilyn C. Harris, Oh Run Kim, Tony D. Williams.
Simon Fraser University.
Physiological cost of training for increased foraging effort.
It has long been assumed that a key determinant of reproductive success in birds is the quality of parental care and, consequently, increased foraging effort associated with rearing chicks. Some, though not all, studies have shown that parental effort, as measured by provisioning rates, can influence reproductive output although individuals appear to have considerable plasticity regarding chick provisioning rate, suggesting that perhaps individuals vary in the cost they pay for provisioning chicks at a higher rate. However, little is known about the physiological basis of individual variation in workload associated with foraging effort in birds, or costs associated with high workload. To investigate physiological costs of increased workload, we experimentally manipulated foraging effort in captive zebra finches (*Taeniopygia guttata*) to examine how high workload affect oxidative stress. Birds are subjected to 2 conditions: high foraging cost (HF) and control foraging conditions (CTR). Birds were kept in the same condition for 90 days, at the end of which they were sacrificed to investigate long term changes in oxidative stress. Preliminary analysis showed that HF birds foraged at a higher rate than CTR birds (based on behavioural observation). We hypothesize that HF birds will show increased oxidative damage and decreased anti-oxidant capacity.

Yerushalmi, Gil, Heath MacMillan and Andrew Donini.
York University.
Salt stress confers cold tolerance in *Drosophila*.
At low temperatures, *Drosophila*, like most other insects, lose the ability to regulate water and ion homeostasis across the gut epithelia. A resulting hemolymph water loss leads to a hyperkalemic state that leads to onset of chilling injuries. To better understand the importance of diet in determining cold tolerance, we exposed adult *D. melanogaster* to 24-hours on diets

highly enriched in sucrose, K^+, or Na^+. Supplementation with K^+ improved chill coma recovery time and both Na^+ and K^+ enrichment improved survival rates following cold stress. No difference in critical thermal minimum was found among diets, suggesting that high salt intake is beneficial for survival and recovery but not for coma onset. Additionally, no change in chill tolerance was observed in flies on a high sucrose diet, suggesting this effect is not strictly osmotic in nature. Measurements of hemolymph [K^+] revealed that both the K^+, and Na^+ enriched diets led to an increase in baseline hemolymph [K^+] and that cold exposure similarly disrupted [K^+] balance in all but the sucrose-enriched diet. We thus propose that acute Na^+ and K^+ supplementation confers benefits to cold tolerance that are not clearly related to extracellular [K^+].

Zhang, Yangfan, Florian Mauduit, Denis Chabot, Guy Claireaux, Anthony P. Farrell.
University of British Columbia.

Chemically dispersed oil has chronic residual effects on hypoxia resistance in European sea bass (*Dicentrarchus labrax*).
Dispersants increase the bioavailability of water-soluble polycyclic aromatic hydrocarbons to fish. Thus, we evaluated the chronic residual effects of a 48-h exposure of European sea bass to chemically dispersed oil on standard metabolic rate (SMR), maximum metabolic rate (MMR), aerobic scope (AS), critical oxygen tension (P_{crit}) and incipient lethal oxygen saturation (ILOS) following a 188-day recovery. No residual effects of dispersed oil were evident for SMR, MMR and AS, suggesting full recovery of aerobic capacity. Instead, a sub-population of hypoxia-tolerant fish indicated by a low ILOS had an elevated P_{crit} in the hypoxia-tolerant fish that was exposed to dispersed oil ($p=0.002$) while the sub-population of contaminated hypoxia-sensitive fish presented a larger variation in P_{crit}, suggesting the ability extract oxygen in low ambient oxygen tension had not fully recovered, which could impact population fitness in a habitat that experiences seasonal hypoxia. Funded by ITOPF