Société Canadienne de
Zoologie

63e rencontre annuelle
6 au 10 mai 2024 • Moncton, N.-B.

Canadian Society of
Zoologists

63rd Annual Meeting
May 6-10, 2024 • Moncton, NB

PROGRAM
PROGRAMME

LOCAL ORGANIZING COMMITTEE/COMITÉ ORGANISATEUR LOCAL

Alex Zimmer (University of New Brunswick)

Andrea Morash (Mount Allison University)

Anne Dalziel (Saint Mary's University)

Kevin Duclos (University of Calgary)

Co-chairs/Co-présidents:

Nicolas Pichaud (Université de Moncton)

Simon Lamarre (Université de Moncton)

Université de Moncton Students/Étudiant(e)s :

Adèle Léger, Anna-Belle Pitre, Annie Sarah Lavoie-Rochon, Chloé Guignard, Florence Hunter-Manseau, Léa Herpe, Loïck Ducros, Mélanie Aminot, Samuel Robichaud

VOLONTEERS/BÉNÉVOLES

Denis Boudreau, Isabelle perron, Pascale Ouellette, Yann Baussan

ACKNOWLEDGEMENTS/REMERCIEMENTS

The local organizing committee would like to thank all of our sponsors for their generous financial contributions and for supporting our conference. We would also like to thank Katie Marshall (UBC) for setting up registration and abstract submission website, as well as the student/PDF councillors (Allanah Grant, Serita Fudlosid, Jacqueline Lebenzon) and CSZ executives (President, VPs, treasurer, secretary, section chairs and everyone else!) for help with the organization.

Le comité d'organisation local souhaite remercier tous nos commanditaires pour leurs généreuses contributions financières et pour leur soutien à notre conférence. Nous aimerions également remercier Katie Marshall (UBC) pour avoir organisé le site web pour l'inscription et la soumission des résumés, ainsi que les conseillers étudiants/PDF (Allanah Grant, Serita Fudlosid, Jacqueline Lebenzon) et les cadres de la SCZ (Présidente, VPs, trésorière, secrétaire, responsables des sections et tous les autres!) pour leur aide dans l'organisation.

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Welcome from the Local Organizing Committee

The LOC welcomes you to the Maritimes for the 63rd Annual Meeting of the Canadian Society of Zoologists! This annual meeting is four years in the making, as we first hosted CSZ virtually in 2022; we are excited to finally have the CSZ community 'in person' here in Moncton, NB. So here we go again!

First, we would like to acknowledge that Moncton is on the traditional unceded territory of the Wolastoqiyik (Maliseet) and Mi'kmaq peoples. This territory is covered by the "Treaties of Peace and Friendship" which Wolastoqiyik (Maliseet) and Mi'kmaq peoples first signed with the British Crown in 1725. The treaties did not deal with surrender of lands and resources but in fact recognized Mi'kmaq and Wolastoqiyik (Maliseet) title and established the rules for what was to be an ongoing relationship between nations. This year's conference is held at the Delta Hotel Beauséjour in downtown Moncton, and our city offers a plethora of options for food and drink enthusiasts (the vast majority of CSZ members!).

We believe that this year's edition of the annual meeting features the excellent programming you have come to expect from a CSZ, including our 2024 Society lectures (ZET, Cameron, Fry medal, Boutillier), students' and postdocs' award competitions (Hoar and President's award). We are also trying something new this year, as major events will be available to members virtually to make the CSZ conference more sustainable and accessible. This is largely funded by the Company of Biologists' Sustainable Conferencing support grant.

CSZ 2024 includes four symposia (Comparative Physiology and Biochemistry, Parasitism Immunity & Environment, Comparative Morphology, Development & Biomechanics, and Integrative Ecology & Evolution), section meetings, workshops (Caregiver lunch, NSERC faculty and student, Education, EDI, and Early Career Researcher 'Positive peer review') as well as networking events and will conclude with the banquet and awards ceremony on Thursday evening. We are proud to have more than 170 contributed oral and 75 poster presentations from students, postdocs and faculty members from across Canada, USA and Europe! For those who booked to trip to Hopewell rocks, prepare to be awed by this iconic Canadian scenic (and be sure to have warm clothes, the Fundy Bay is always colder than the city!); the coach will depart on Friday 8h30 in front of the Hotel.

Our members continue to face significant challenges to equity, diversity, inclusion, and accessibility (EDIA). As a society, the CSZ strives to be a diverse and inclusive community

that commits to welcoming all scientists and removing barriers to participation. In a nutshell, we hope you will treat others as you wish to be treated and act in accordance with the Canadian Society of Zoologists Code of Conduct. A respectful and supportive environment is crucial for doing good science and supporting science practitioners. Our EDI committee members (Alex Quijada-Rodriguez and Florence Hunter-Manseau) and LOC co-chairs (Simon Lamarre and Nicolas Pichaud) will be clearly identified and available during the meeting. Do not hesitate to reach out if you have any concerns.

Code of conduct

We hope you enjoy this year's CSZ conference and the city of Moncton!

Nicolas Pichaud and Simon Lamarre

Co-Chairs, Virtual Organizing Committee of CSZ 2024

Mot de bienvenue du Comité Organisateur Local

Le comité organisateur local aimerait vous souhaiter la bienvenue dans les Maritimes pour cette 63e assemblée annuelle de la Société Canadienne de Zoologie ! Cette conférence annuelle est en préparation depuis près de quatre ans, et même si nous avons organisé une assemblée virtuelle en 2022, nous voulions vraiment que la communauté de la SCZ vienne nous rendre visite à Moncton, au Nouveau-Brunswick. C'est donc reparti ! Tout d'abord, nous aimerions reconnaître que Moncton se trouve sur le territoire traditionnel non cédé des Wolastoqiyik (Maliseet) et des Mi'kmaq. Ce territoire est couvert par les "Traités de paix et d'amitié" que les Wolastoqiyik (Maliseet) et les Mi'kmaq ont signé pour la première fois avec la Couronne britannique en 1725. Ces traités ne portaient pas sur la cession de terres et de ressources, mais reconnaissaient les titres des Mi'kmaq et des Wolastoqiyik (Maliseet) et établissaient les règles de ce qui devait être une relation permanente entre les nations. Cette année, la conférence annuelle a lieu à l'hôtel Delta Beauséjour, au centre-ville de Moncton, avec de nombreuses options pour les amateurs de nourriture et de boissons (donc la grande majorité des membres de la SCZ!).

Nous croyons que l'édition de cette année de la réunion annuelle présente l'excellente programmation à laquelle vous vous attendez de la SCZ, y compris les conférences de la Société 2024 (ZET, Cameron, médaille Fry, Boutillier), les concours de prix pour étudiants et postdocs (Hoar et prix du Président). Nous essayons également quelque chose de nouveau cette année, puisque les événements majeurs seront disponibles pour les membres de manière virtuelle afin de rendre la conférence CSZ plus durable et accessible. Cette initiative est en grande partie financée par la subvention de soutien aux conférences durables de la Company of Biologists. Le programme comprend également quatre symposiums (Comparative Physiology and Biochemistry, Parasitism Immunity & Environment, Comparative Morphology, Development & Biomechanics, and Integrative Ecology & Evolution), des réunions des sections, des ateliers (déjeuner des aidants, professeurs et étudiants du CRSNG, éducation, EDI, et ECR 'Positive peer review') ainsi que des événements de réseautage et se terminera par le banquet et la cérémonie de remise des prix le jeudi soir. Nous avons également environ 160 présentations orales et 75 présentations d'affiches (le mercredi après-midi, qui sera suivi de l'évènement réseautage pour les étudiants au pub irlandais Old Triangle de l'autre côté de la rue) d'étudiants, de postdocs et de membres du corps facultaire de tout le Canada, des États-Unis et même d'Europe! Nous sommes très reconnaissants de cette formidable participation et nous vous remercions de vous être joints à nous à Moncton! Pour ceux qui ont réservé l'excursion aux rochers Hopewell, préparez-vous à être éblouis par ce paysage canadien emblématique (et assurez-vous d'avoir des vêtements chauds, la baie de Fundy est toujours plus froide que la ville): l'autocar partira le vendredi à 8h45 devant l'hôtel.

Nos membres continuent de faire face à des défis importants en matière d'équité, de diversité, d'inclusion et d'accessibilité (EDIA). En tant que société, la SCZ s'efforce d'être une communauté diversifiée et inclusive qui s'engage à accueillir tous les scientifiques et à éliminer les obstacles à la participation. En bref, nous espérons que vous traiterez les autres comme vous souhaitez être traité et que vous agirez conformément au Code de conduite de la Société canadienne de zoologie. Un environnement respectueux et favorable est essentiel pour faire de la bonne science et soutenir les praticiens de la science. Les membres de notre comité EDI (Alex Quijada-Rodriguez et Florence Hunter-Manseau) et les coprésidents du COL (Simon Lamarre et Nicolas Pichaud) seront clairement identifiés et disponibles pendant la réunion. N'hésitez pas à nous contacter si vous avez des questions.

Code of conduct

Nous espérons que vous apprécierez la conférence de la CSZ de cette année et la ville de Moncton !

Nicolas Pichaud et Simon Lamarre

Coprésidents, Comité d'organisation virtuel de la CSZ 2024

Welcome from the CSZ president

Hello everyone,

On behalf of the Local Organizing Committee and the Society, it's my sincere pleasure to welcome you to the vibrant city of Moncton for the eagerly awaited Annual Meeting of the Canadian Society of Zoologists. This gathering marks a special occasion for our community to share, learn, and foster collaborations across the diverse and vibrant spectrum of zoological disciplines and dynamic fields of study featured in our sections.

I'm particularly excited about the diverse and engaging program the LOC has put together and I look forward to the many exciting sessions. In particular, I know many are looking forward to the education workshop focused on the "Threats and Opportunities of Using AI in Teaching". This timely session promises to spark insightful discussions and equip us with strategies to harness the potential of AI responsibly. Additionally, the Caregiver workshop, the NSERC sessions, and the EDI workshop offer enriching opportunities for us all in the evolving landscape of education and research. They are poised to provide valuable learning experiences and reflect our commitment to fostering growth and inclusivity in our educational and research endeavors.

The program is rich with opportunities for participants to present their latest research findings and engage in stimulating exchanges in the numerous contributed sessions and section symposia. Here, we will hear and see the innovative ideas that are the cornerstones of our society. These moments are where the heart of our society beats the strongest, highlighting the innovative research that defines Canadian zoology. Additional highlights include several prestigious award talks, such as the Fry Lecture, which showcases distinguished contributions to zoology.

Finally, every year I look forward to the competitions that celebrate early career excellence in our community: the Hoar Award Talks for the best student presentation and the President's Award for the outstanding postdoctoral fellow talk. These competitions underscore our commitment to nurturing the next generation of zoologists who will lead us into the future of zoology in Canada.

As we gather in Moncton, let's seize this chance to expand our knowledge, challenge our perspectives, and strengthen our connections within the zoological community. Together, we will explore the latest advancements and tackle the pressing challenges facing our discipline.

Let's extend our collective appreciation to the local organizers and all those who have dedicated their time and efforts to orchestrating this exceptional meeting. Together with

them, I am delighted to welcome you to Moncton. I am confident that this year's annual meeting will be a landmark event for the Canadian Society of Zoologists!

Best wishes,

Carol Bucking

President, Canadian Society of Zoologists

Mot de bienvenue de la présidente de la SCZ

Bonjour à toutes et à tous,

Au nom du Comité d'Organisation Local et de la Société, c'est avec un plaisir sincère que je vous souhaite la bienvenue dans la ville dynamique de Moncton pour la réunion annuelle tant attendue de la Société Canadienne de Zoologie. Ce rassemblement marque une occasion spéciale pour notre communauté de partager, d'apprendre et de favoriser des collaborations à travers le spectre diversifié et vibrant des disciplines zoologiques et des domaines d'étude présentés dans nos sections.

Je suis particulièrement enthousiaste à propos du programme diversifié et engageant que le COL a préparé et j'attends avec impatience les nombreuses sessions excitantes. En particulier, je sais que beaucoup attendent avec impatience l'atelier éducatif axé sur les "Menaces et Opportunités de l'Utilisation de l'IA dans l'Enseignement". Cette session opportune promet de susciter des discussions pertinentes et de nous équiper de stratégies pour exploiter le potentiel de l'IA de manière responsable. De plus, l'atelier pour les aidants, les sessions du CRSNG et l'atelier sur l'EDI offrent des opportunités enrichissantes pour nous tous dans le paysage évolutif de l'éducation et de la recherche. Tout cela mettra en avant des expériences d'apprentissage précieuses qui reflètent notre engagement à favoriser la croissance et l'inclusivité dans nos efforts éducatifs et de recherche.

Le programme est riche en opportunités pour les participant(e)s de présenter leurs dernières découvertes de recherche et de s'engager dans des échanges stimulants lors des nombreuses sessions contributives et des symposiums de section. Ici, nous entendrons et verrons les idées innovantes qui sont les pierres angulaires de notre société. Ce sont ces moments où le cœur de notre société bat le plus fort, mettant en lumière la recherche innovante qui définit la zoologie canadienne. Parmi les autres points forts, citons plusieurs conférences de prix prestigieux, comme la Conférence Fry, qui présente des contributions distinguées à la zoologie.

Enfin, chaque année, j'attends avec impatience les compétitions qui célèbrent l'excellence en début de carrière dans notre communauté : les Conférences Hoar pour la meilleure présentation étudiante et le Prix du Président pour l'excellence de la présentation de post-doctorant. Ces compétitions soulignent notre engagement à nourrir la prochaine génération de zoologistes qui nous mènera dans l'avenir de la zoologie au Canada.

Alors que nous nous réunissons à Moncton, saisissons cette chance d'élargir nos connaissances, de remettre en question nos perspectives et de renforcer nos liens au

sein de la communauté zoologique. Ensemble, nous explorerons les dernières avancées et relèverons les défis pressants auxquels notre discipline est confrontée.

Exprimons notre appréciation collective aux organisateurs locaux et à tous ceux qui ont consacré leur temps et leurs efforts à orchestrer cette réunion exceptionnelle. Avec eux, je suis ravi de vous accueillir à Moncton. Je suis confiant que la réunion annuelle de cette année sera un événement marquant pour la Société Canadienne de Zoologie!

Meilleurs vœux,

Carol Bucking

Présidente, Société Canadienne de Zoologie

Welcome to Moncton!

Moncton (https://www.moncton.ca/fr), with its 79,470 inhabitants, is New Brunswick's most populous city. Officially bilingual, Moncton sits on the border of New Brunswick's two linguistic regions, between the predominantly French-speaking counties (Acadia) to the northwest and the predominantly English-speaking counties to the south. Located in the Petitcodiac River Valley, Moncton is at the center of the Maritime Provinces. Thanks to its central location and history of rail and land transportation, Moncton is often referred to as the Hub City. The Delta Beauséjour Hotel, where the CSZ annual meeting will be held, is ideally located downtown Moncton (see map below). The Greater Moncton International Airport is 7 km from the hotel. Parking is also available at the hotel for guests with one bedroom, at a rate of $15 per day. Downtown is within easy walking distance, and a trail by the Petit-Codiac River is just a stone's throw from the hotel, allowing you to easily observe the famous tidal bore. Weather-wise, anything's possible in May! We hope to have mild temperatures for the duration of the conference, but daily temperatures can vary between 2 and 22°C, so be prepared for any situation!

Taxi to and from the airport:

Taxi Moncton: (506) 989-0800, https://supertaxi.ca/

White Cab Company Limited: (506) 857-3000, https://whitecabrocks.ca/

Air Cab Taxi: (506) 857-2000, https://aircab.ca/

Bienvenue à Moncton!

Moncton (https://www.moncton.ca/fr), avec ses 79 470 habitants, est la ville la plus peuplée du Nouveau Brunswick. Ville officiellement bilingue, Moncton est située à la frontière des deux régions linguistiques du Nouveau-Brunswick, entre le regroupement des comtés majoritairement francophones (l'Acadie) au nord-ouest et le regroupement des comtés majoritairement anglophones au sud. Située dans la vallée de la rivière Petitcodiac, Moncton se trouve au centre des provinces maritimes Due à sa location centrale et son histoire dans le transport ferroviaire et terrestre, Moncton est souvent surnommée 'Hub City'. L'hôtel Delta Beauséjour dans lequel aura lieu la réunion annuelle de la SCZ est idéalement situé au centre-ville de Moncton (voir carte ci-dessous). L'aéroport international du Grand Moncton se trouve à 7 km de l'hôtel. Un parking est aussi disponible à l'hôtel pour les clients disposant d'une chambre à coucher au tarif de 15 $ par jour. Le centre-ville est facilement accessible à pied et un sentier près de la rivière Petit-Codiac est à un pas de l'hôtel, vous permettant d'observer facilement le célèbre mascaret. Au niveau du climat, tout est possible en Mai! Nous espérons avoir des températures clémentes pour la durée de la conférence, mais les températures quotidiennes peuvent varier entre 2 et 22 °C, soyez équipés pour toutes situations!

Services de Taxis depuis et vers l'aéroport :

Taxi Moncton: (506) 989-0800, https://supertaxi.ca/

White Cab Company Limited: (506) 857-3000, https://whitecabrocks.ca/

Air Cab Taxi: (506) 857-2000, https://aircab.ca/

General Information/Informations Générales

Conference/Conférence wifi:

We have arranged for delegates to have internet access. Please log in with the information on the back of your badge/ Nous avons pris des dispositions pour que les délégués aient accès à l'internet. Veuillez-vous connecter avec les informations en arrière de votre badge.

Social Media Information/Informations sur les Médias Sociaux:

Please follow the CSZ official social media accounts on Twitter and Instagram:

@cszscz_2024

@scz_csz_2024

CSZ SCZ Moncton

Please use #CSZ2024 hashtag when posting photos on social media.

Emergency Contact Numbers and information/Contacts d'Urgence et informations:

Call 911 for general emergency (police, fire, and ambulance)

Hospitals/Hôpitaux:

Centre hospitalier universitaire Dr-Georges-L.-Dumont (francophone): 330, avenue Université de Moncton, 506-862-4000

The Moncton Hospital (english speaking): 135, MacBeath Ave., 506-857-5111

Registration desk/Kiosque d'inscription:

In the mezzanine of the Delta Hotel Beauséjour (see map of the hotel): every morning from 8:30 to 10:30 and afternoon from 16:30 to 18:00.

Dans la mezzanine de l'Hôtel Delta Beauséjour (voir carte de l'hôtel) : tous les matins de 8:30 à 10:30 et tous les après-midis de 16:30 à 18:00.

Note: Credit card is preferred for payments for any conference registration fees or other purchases. The Hotel takes debit, credit cards, or cash for the cash bars/ La carte de crédit est préférable pour le paiement des frais d'inscription à la conférence ou d'autres achats. L'hôtel accepte les cartes de débit, les cartes de crédit ou les espèces pour les caisses.

Conference guidelines/Consignes pour la conférence:

Talks:

- Talks will be held in several rooms at the Delta Hotel Beauséjour, downtown Moncton: 'Petit Codiac', 'Shediac A', 'Shediac B', 'Shediac C', 'Ballroom A and B', 'Ballroom C' and 'Mezzanine'. Please refer to schedules and the map below. Rooms will be equipped with PC computers running Microsoft PowerPoint.

- No other media formats (e.g. slides) or software will be available, and participants will not be able to connect their personal computers to the projectors.

- You should arrive in the session room at 8 AM on the day of your presentation to upload your presentation file on the computer. An on-site volunteer will assist you in uploading your presentation.

- Please be in your session room at least 15 minutes before the beginning of your session and introduce yourself to the session chair(s).

Posters:

Poster orientation should be portrait, NOT landscape and the maximum size should be: 90 cm [35 in.] wide by 110 cm [43 in.] high.

- The poster session runs from 4:30 to 6:30, May 8th in Ballroom C.

- Presenters are expected to attend their poster for their assigned hour during the poster session to discuss their work with attendees visiting your poster.

• You will be assigned a **poster number**, which can be found at the end of this program.

• You must set up your poster on the poster board displaying the assigned poster number.

• **Your number will determine your presentation time: 4:30 to 5:30 PM for even-numbered posters, 5:30 to 6:30 PM for odd numbered posters.**

- Presenters are responsible for the setup and take-down of the poster.

• Poster set-up time: 1 to 3 PM

• Poster take-down time: 6:30 to 7.00 PM

• Double-sided Velcro will be provided in the exhibition hall, so you can hang your poster.

• **Posters that are not removed by the end of the day will be removed and destroyed.**

- The LOC cannot guarantee access to any on-site printing facilities, and we have not partnered with any local printing vendors in Moncton.

Présentations orales:

- Les conférences se tiendront dans plusieurs salles de l'hôtel Delta Beauséjour, au centre-ville de Moncton : "Petit Codiac", "Shediac A", "Shediac B", "Shediac C", "Salle de Bal A et B", "Salle de Bal C" et "Mezzanine". Veuillez-vous référer aux horaires et au plan ci-dessous. Les salles seront équipées d'ordinateurs PC fonctionnant avec Microsoft PowerPoint.

- Aucun autre format de média (e.g. diapositives) ou logiciel ne sera disponible, et les participant(e)s ne pourront pas connecter leurs ordinateurs personnels aux projecteurs.

- Vous devez vous présenter dans la salle de session à 8 heures du matin le jour de votre présentation pour télécharger votre fichier sur l'ordinateur. Un bénévole sur place vous aidera à télécharger votre présentation.

- Veuillez-vous rendre dans votre salle de session au moins 15 minutes avant le début de votre session et vous présenter au(x) animateur(s)/animatrice(s) de session.

Affiches :

Les affiches doivent être orientées en mode portrait, et NON en mode paysage, et leur taille maximale doit être de 90 cm [35 in.] de large par 110 cm [43 in.] de haut.

- La session de posters se déroulera de 16:30 à 18:30, le 8 mai dans la salle de Bal C.

- Les présentateurs/présentatrices sont tenu(e)s d'être présent(e)s à leur poster pendant l'heure qui leur est attribuée au cours de la session d'affichage afin de discuter de leur travail avec les participant(e)s qui visitent leur poster.

  • Un **numéro d'affiche** vous sera attribué, que vous trouverez à la fin de ce programme.

  • Vous devez installer votre poster sur le panneau d'affichage portant le numéro qui vous a été attribué.

  • **Votre numéro déterminera l'heure de votre présentation: 16:30 à 17:30 pour les affiches portant un numéro pair, 17:30 à 18:30 pour les affiches portant un numéro impair.**

- Les présentateurs/présentatrices sont responsables de l'installation et du démontage de leur affiche.

  • Heure de montage des affiches : de 13 à 15 heures

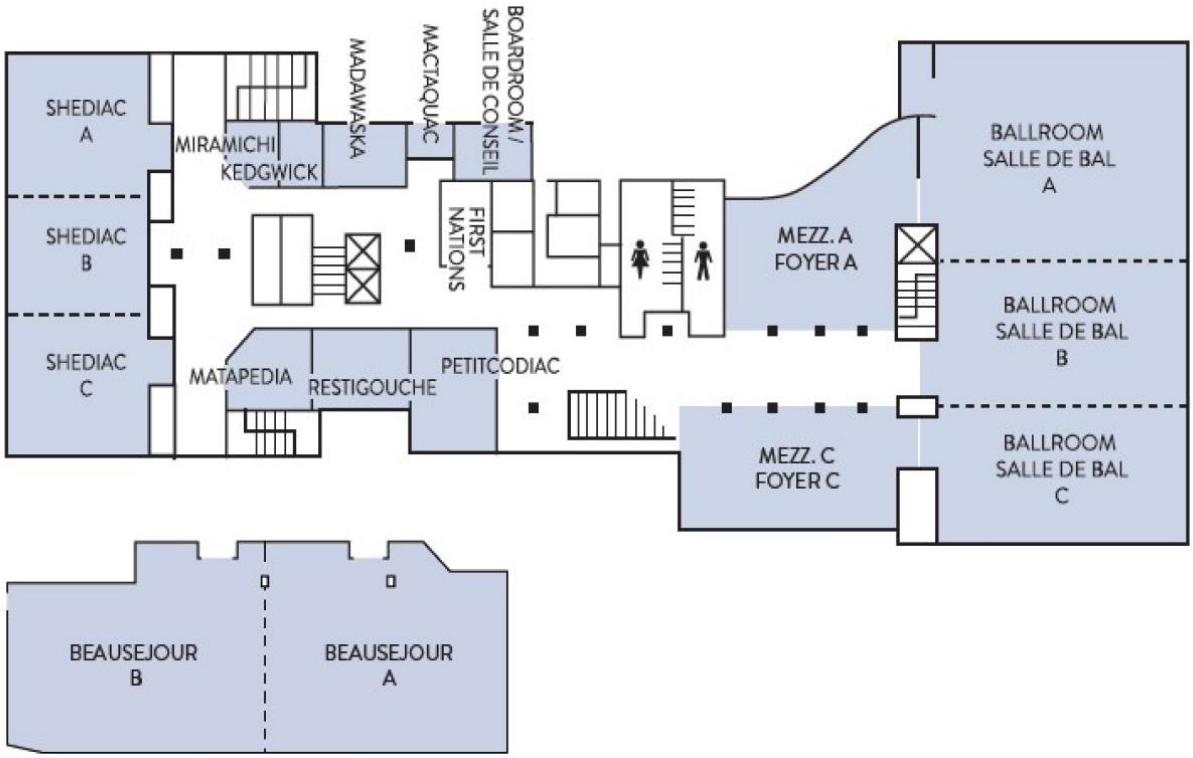
  • Démontage des affiches : de 18:30 à 19:00

  • Du velcro double face sera fourni dans le hall d'exposition afin que vous puissiez accrocher votre affiche.

  • Les affiches qui n'auront pas été retirées à la fin de la journée seront enlevées et détruites.

- Le COL ne peut garantir l'accès à des installations d'impression sur place, et nous n'avons pas établi de partenariat avec des fournisseurs locaux de services d'impression à Moncton.

Hotel Map/Carte de l'Hôtel



The Hotel is downtown with many services (including restaurants, banks, etc.) available close by.

L'hôtel est situé au centre-ville et de nombreux services (restaurants, banques, etc.) sont disponibles à proximité.

Program at a glance/Programme en un coup d'œil

Time	Monday May 6, 2024		Tuesday May 7, 2024		Wednesday May 8, 2024		Thursday May 9, 2024		Friday May 10, 2024
08:30-9:00	CSZ Council meeting (Ballroom C)		CPB symposium (Ballroom AB)	Contributed sessions (Shediac A, B and C)	PIE symposium (Shediac A)	Contributed sessions (Shediac B, C and Ballroom AB)	IEE symposium (Shediac A)	Contributed sessions (Shediac B, C and Ballroom AB)	Field Trip to Hopewell Rocks
09:00-9:30									
09:30-10:00									
10:00-10:30									
10:30-11:00			Coffee Break (Mezzanine)		Coffee Break, sponsored by Sable Systems International		Coffee Break (Mezzanine)		
11:00-11:30		Caregiver lunch (Petit Codiac)	Hoar Award (Ballroom AB)		President's Award (Ballroom AB)		Boutillier New Faculty Award (Ballroom AB)		
11:30-12:00									
12:00-12:30							Section lunch: PIE (Shediac A), CMDB (Shediac B), IEE (Shediac C)		
12:30-13:00									
13:00-13:30	Student NSERC Session (Shediac A)	Faculty NSERC Session (Petit Codiac)	AGM Lunch (Mezzanine, Ballroom AB)		CPB Section Lunch (Ballroom AB)				
13:30-14:00							Contributed session (Ballroom AB, Shediac A, B, C)		
14:00-14:30									
14:30-15:00					Contributed Sessions (Ballroom AB, Shediac B, C)	CMDB symposium (Shediac A)			
15:00-15:30	Coffee Break (Mezzanine)		Contributed sessions (Ballroom AB, Shediac A, B, C)						
15:30-16:00	Education Workshop (Shediac A)						Workshop 'Positive peer review' (Shediac A)		
16:00-16:30									
16:30-17:00	EDI Workshop (Shediac A)				Poster session (Mezzanine, Ballroom C)				
17:00-17:30			Break						
17:30-18:00	Welcome Reception (Mezzanine)		Cameron Lecture (Ballroom AB)				Open		
18:00-18:30									
18:30-19:00			Fry Medal Lecture (Ballroom AB)		Trainee Network Mixer (Old Triangle Irish Pub)		Banquet (Ballroom AB)		
19:00-19:30	ZET Lecture (Ballroom AB)								
19:30-20:00			Post-Fry Reception (Mezzanine)						
20:00-20:30									
20:30-21:00									

Breakout rooms
Main auditorium

Monday/Lundi, May/Mai 6

8 :30-13:00	Council Meeting/Réunion du conseil	Ballroom C
11:00-13:00	Caregiver Lunch/Dîner des aidants	Petit Codiac
13:00-15:00	Student NSERC Workshop/Atelier du CRSNG pour les personnes étudiantes	Shediac A
	Faculty NSERC Workshop/Atelier du CRSNG pour les prof.	Petit Codiac
15:00-15:30	Break/Pause	Mezzanine
15:30-16:30	Education Workshop/Atelier d'éducation: Toni Roberts	Shediac A
16:30-17:30	EDI Workshop/Atelier EDI	Shediac A
17:30-19:00	Welcome Reception/Réception de bienvenue (catered with cash bar)	Mezzanine
19:00-20:30	ZET Lecture/Conférence ZET : Allen Curry	Ballroom A and B

11:00-13:00

Caregiver Lunch/Dîner des aidants

From Surviving to Thriving as a caregiver in STEM

Location/Lieu: **Petit Codiac**

Chair/Animé par: **Sandra Fehsenfeld**

13:00-15:00

Student NSERC Workshop/Atelier du CRSNG pour les personnes étudiantes

Location/Lieu: **Shediac A**

Chair/Animé par: **Jackie Lebenzon**, CSZ Postdoc Councillor (University of California Berkeley)

Panelists/Panéliste: **Julien Landry**, NSERC Program Officer

Julien Landry, Program Officers from NSERC, will provide advice and tips for writing a successful scholarship or fellowship application. Julien Landry has been a Program Officer at NSERC since autumn 2021. Prior to joining NSERC he was postdoctoral researcher (SSHRC) at the University of Ottawa. He has also carried out postdoctoral research at the University of Alberta and at the University of Texas at Austin. His research subjects included the institutions of modern science and the relationships between politics and expertise. He holds a PhD in Science, Technology, and Society (STS) from l'Université du Québec à Montréal. Julien will be joined by Kari Saumur, Programme Officer with 5 ½ years of experience at NSERC.

This will be followed by a Q&A to provide students and postdocs with an opportunity to ask questions about NSERC scholarship and postdoctoral fellowship programs. Previous NSERC awardees and faculty who have been on the review panels will also be present to answer questions.

Julien Landry, administrateur de programme au CRSNG, fournira des conseils et des astuces pour rédiger avec succès une demande de bourse. Julien Landry est administrateur de programme au CRSNG depuis l'automne 2021. Avant de se joindre au

CRSNG, il était chercheur postdoctoral (CRSH) à l'Université d'Ottawa. Il a également effectué des recherches postdoctorales à l'Université de l'Alberta et à l'Université du Texas à Austin. Ses sujets de recherche comprenaient les institutions de la science moderne et les relations entre la politique et l'expertise. Il est titulaire d'un doctorat en science, technologie et société (STS) de l'Université du Québec à Montréal. Julien sera accompagné de Kari Saumur, chargée de programme ayant 5 ½ ans d'expérience au CRSNG.

Cette présentation sera suivie d'une séance de questions et réponses qui permettra aux étudiants et aux postdoctorants de poser des questions sur les programmes de bourses du CRSNG et de bourses postdoctorales. Des boursiers précédents du CRSNG et des professeurs qui ont fait partie des comités d'évaluation seront également présents pour répondre aux questions.

13:00-15:00

Faculty NSERC Workshop/Atelier du CRSNG pour les prof.

Location/Lieu: **Petit Codiac**

Chair/Animé par: **Simon Lamarre** (Université de Moncton), **Suzie Currie** (Acadia University)

The faculty workshop will be attended by representatives from NSERC EG 1502 – Biological Systems and Functions as well as past and current EG 1502 members. The workshop will provide information from NSERC and there will be a mock Discovery Grant evaluation.

L'atelier du corps professoral réunira des représentants du CRSNG EG 1502 - Systèmes et fonctions biologiques ainsi que des membres passés et actuels du cours EG 1502. L'atelier fournira de l'information du CRSNG et il y aura une simulation d'évaluation de la subvention à la découverte.

15:30-16:30

Education Workshop / Atelier d'éducation

Threats and opportunities of using AI in teaching

Location: **Shediac A**

Toni Roberts, Mount Allison University

Generative AI in teaching has resulted in a need for a re-evaluation of pedagogies and assessment in courses within post-secondary education and beyond. In this session, we will discuss the development and tensions between GAI and certain assessment approaches. We then discuss how we can develop assessment items that are resistant to GAI, while focusing more on authentic assessment. This will also include ways to leverage GAI in your classroom assessment.

Toni Roberts is the Purdy Crawford Teaching Centre director at Mount Allison University. The Purdy Crawford Teaching Centre advances teaching excellence at Mount Allison through research, development, and promotion of instructional technologies and progressive approaches to teaching and learning. Toni Roberts currently chairs the Maple League's Teaching and Learning Committee, bringing together educators from across the four member universities (Mount Allison, Acadia, Bishop's, and St. FX) to discuss and share ideas around teaching in higher education.

16:30-17:30

Equity, Diversity, and Inclusion (EDI) Workshop/Atelier sur l"équité, la diversité et l'inclusion

Looking back and moving forward: a workshop to define the future of EDI at CSZ

Location/Lieu: **Shediac A**

Chair/Animé par: **Alex Quijada-Rodriguez** (Wilfrid Laurier University, chair of the EDI committee)

17:30-19:00

Welcome Reception/Réception de bienvenue

Location/Lieu: **Mezzanine** (with cash bar)

19:00-20:30

Zoological Education Trust (ZET)/Fond pour l'éducation à la Zoologie Symposium

Location: **Ballroom A and B**

Introduction: **Simon Lamarre and Nicolas Pichaud**, LOC co-chairs (Université de Moncton)

Carol Bucking, CSZ President (York University)

Alex Zimmer, ZET Lecture Committee (University of New Brunswick)

Allen Curry, Professor of Biology, University of New Brunswick

Allen Curry is a professor of Biology, Forestry and Environmental Management at the University of New Brunswick (UNB) in Fredericton, NB, Canada. He was a founding member (2001) then Director of the Canadian Rivers Institute (CRI) from 2004-13 when he stepped down to become the Principal Investigator for the multi-million dollar Mactaquac

Aquatic Ecosystem Study. He is a Fellow of the CRI, the NB Department of Natural Resources/Cloverleaf Foundation Professor of Recreational Fisheries Research, and Assistant Director-NB Cooperative Fish and Wildlife Research Unit. He has >100 peer-reviewed publications, reports, books, and book chapters in the fields of fish ecology, fisheries, freshwater/estuarine/reef ecology, ecohydrology, and various fields within hydrology from environmental flows to forest hydrology processes. He sustains a suite of research associates, post-doctoral researchers, technicians, and graduate and undergraduate students, and teaches courses on statistics for the environmental sciences, ecohydrology, and the impacts of humans on the coral reefs.

The Weaving Waters Expedition: The beginning – "So Long and Thanks for All the Fish"

After 30+ years as a natural historian of all things watery, especially fish, I was exploring ideas about how to close the book on my professional career as a university professor and researcher. I found myself at Woods Hole, MA one morning where I had the pleasure of enjoying coffee with Rachel Carson. Inspired by her impactful contributions that advanced environmental awareness and conservation, I made a plan to traverse the waters of eastern North America to collect local water stories and share my own water experiences and science in a project to weave this collection of stories into a message of reconciliation and hope for our beleaguered water worlds. While I will write more science articles, Rachel's contribution reminded me that real change starts with the people in our community and that is where my expedition began. In July 2023, I set off on a boat journey through the Great Lakes, down the Mississippi River watershed, along the Gulf of Mexico into the Florida Keys, across into the Bahama Cays, and now my path north along the Atlantic seaboard to the St. Lawrence River and back to New Brunswick. Today I will present a travelogue about traversing big lakes and rivers, intercoastal waterways, and crossing the Gulf Stream, combined with a taste of local stories about aquatic invaders, persistent pollution, and our changing climate I have collected along my journey so far.

Tuesday/Mardi, May/Mai 7

8:30-10:30	CPB symposium: Tribute to Pat Wright	Ballroom A and B
	Contributed sessions	- Shediac A (Toxicology 1) - Shediac B (CMDB1) - Shediac C (Ecology 1)
10:30-11:00	Coffee Break	Mezzanine
11:00-13:00	Hoar Award	Ballroom A and B
13:00-15:00	AGM lunch	Mezzanine and Ballroom A and B
15:00-17:00	Contributed sessions	- Shediac A (Performance) - Shediac B (Osmoregulation) - Shediac C (Invertebrate parasitology) - Ballroom A and B (Thermal Physiology of fish 1)
17:00-17:30	Break	
17:30-18:30	Cameron Lecture: Hang Cheng (University of Ottawa)	Ballroom A and B
18:30-19:30	Fry Medal Lecture : Rudy Boonstra (University of Toronto)	Ballroom A and B
19:30-21:00	Post-Fry reception (catered with cash bar)	Mezzanine

8:30-10:30

CPB symposium

Tribute to Pat Wright

Location/Lieu: **Ballroom A and B**

Chair/Animé par: **Tamzin Blewett** (University of Alberta), **Suzie Currie** (Acadia University)

8:30-8:40

Introduction and Welcome

8:40-9:00

Cosima S. Porteus, Deep Soor, Liam R. Tigert, Gwangseok Yoon, Elissa Khodikian, Arsheen Bozai

Department of Biological Sciences, University of Toronto Scarborough, Toronto, ON, Canada

The effects of hypoxia and simulated ocean acidification on oxygen sensing and gill morphology of threespine stickleback (*Gasterosteus aculeatus*)

Dr Pat Wright has been an important mentor to me since the very beginning of my career. During my talk I will reflect on her guidance and the impact she has had on me as a scientist. I will also present some new research from my lab on neuroepithelial cells (NECs), which are the putative oxygen and CO_2 chemoreceptors in fish. Responses to conditions such as hypoxia or elevated CO_2 have been observed to increase NEC size and/or density in freshwater fish due to an increase cellular activity, but less is known about these cells in marine fish. The NECs of marine threespine sticklebacks (*Gasterosteus aculeatus*) were characterized using immunohistochemistry. Sticklebacks were exposed to mild (10kPa) or moderate (6.8kPa) hypoxia and two levels of simulated ocean acidification (1,500 and 3,000µatm) to determine if there were changes in NEC size and density, and gill morphology in response to these stressors. The NECs of stickleback contained synaptic vesicles, were innervated, but were larger and more abundant than in other similar sized freshwater fishes. NEC size and density were unaffected by exposure to hypoxia, but there was a significant decrease in interlamellar cell mass (ILCM) in response to hypoxia. NECs increased in size, but not abundance in response to simulated ocean acidification and had larger ILCMs compared to control fish. Our results demonstrated that NECs in adult marine sticklebacks can respond to both hypoxia and

CO_2 at environmentally relevant levels, which highlights the importance of NECs in marine fishes living in coastal areas.

9:00-9:20

Erin Leonard

Department of Biology, Wilfrid Laurier Biology, Waterloo, Canada

Chemosensing and Pat Wright: both required for success in life

For the CPB Symposium, I aim to honour the profound influence of my mentor, Dr. Pat Wright, in the field of science and beyond. With a focus on chemosensing, I will demonstrate how Pat's pioneering work on *Kryptolebias marmoratus* provides fundamental principles essential for success in both scientific pursuits and personal development. Pat's mentorship has taught me that asking thought-provoking scientific questions and formulating clear and testable hypotheses are the cornerstone of great science. I will highlight how her mentorship influenced some of my work expanding the role of neuroepithelial cells (NECs) involved with chemosensing. Arguably, one of the most important downstream responses to changes in chemostimuli is the hypoxic ventilatory response (HVR) which is ubiquitous across fishes and constitutes an increase in ventilation of the respiratory organs. The most well-studied chemoreceptors involved in the HVR are NECs, the putative oxygen sensors of the fish gill. Although the respiratory gases such as oxygen and carbon dioxide have received the most attention, it is becoming clear that other novel, "non-respiratory" stimuli including hydrogen sulfide, nitrogenous wastes such as ammonia, and tissue metabolites such as lactate can also stimulate ventilation in fishes. I will highlight the parallels between the ability to perceive and respond to chemical signals in the environment and the guidance provided by mentors, like Pat, in shaping our paths in life. As we celebrate Pat's contributions to science and mentorship, we recognize the legacy she leaves for future generations of young scientists.

9:20-9:40

Tammy Rodela

St. Francis Xavier University

Fish Tales: Unraveling biological narratives through environmental challenges

Every animal has a biological story to tell: Pat Wright's influence on generations of comparative physiologists has instilled a profound curiosity to understand how animals thrive and survive through a myriad of environmental challenges. My experience as a graduate student in the Wright lab influenced my research interests in the underlying

mechanisms used by fish to tolerate multiple environmental stressors. Natural shallow water habitats and slow-flowing streams are susceptible to decreases in ambient oxygen (hypoxia) and the accumulation of environmental ammonia (HEA). Zebrafish (*Danio rerio*) can tolerate these environments with ease, however, their mechanisms of resiliency to the combined exposures are understudied. We have collected evidence of a mechanistic link underlying tolerance to both hypoxia and HEA exposure in zebrafish. At the whole animal level, sequential exposure to either hypoxia or ammonia resulted in zebrafish being far more tolerant of the other stressor, suggesting the involvement of cross-protective mechanisms. Brain transcriptomic analyses identified convergent gene expression patterns in the oxidative stress response and metabolic pathways. Whole-cell proteomics of the zebrafish brain highlighted significant deacetylation of mitochondrial complex III and hyper-acetylation of complex V following hypoxia and HEA exposures, indicating that post-translational modifications may alter mitochondrial activity. Mitochondrial oxygen binding affinity and emission of reactive oxygen species changed in response to acclimation to individual and combined stressors. These data provide evidence for one facet of cross-protection in zebrafish. From the perspective of a curious comparative physiologist, many questions remain in the zebrafish's biological narrative and their ability to tolerate multiple stressors.

9:40-10:00

Andy Turko

Department of Integrative Biology, University of Guelph, Guelph, ON, Canada

Physiology of amphibious fishes in the lab and the field

The invasion of land by tetrapods is generally considered to be one of the most dramatic transitions in vertebrate evolution, but we now know that extant amphibious fishes have independently made this transition almost 100 times! I will briefly discuss some of the most exciting discoveries that Pat and I made during a decade of working together studying the physiology of amphibious fishes. In particular, I will discuss our field work in Belize to demonstrate the physiological insights that can be gained by studying animals in their natural environments. For example, we recently found that both aquatic and terrestrial athletic performance strongly depend on local environmental conditions. Finally, I will share some insights into my current research exploring the behaviour and physiology of newly-identified species of amphibious fishes. Overall, I hope to show how my work with Pat has improved our understanding of the physiological adaptations underlying the repeated transition from aquatic to terrestrial life in vertebrates, while also highlighting the many remaining knowledge gaps.

Oral contributed presentations/Présentations orales

8:30-10:30

Toxicology 1

Location/Lieu: **Shediac A**

Chair/Animé par: **Ken Jeffries** (University of Manitoba)

8:30-8:45	**Sensitivity of brown flatworms (*Dugesia dorotocephala*) to the lampricide TFM** Zajdlik, M., Sivarajah, R., Nunoo, R., Birceanu, O. *Department of Physiology and Pharmacology, Schulich School of Medicine and Dentistry, University of Western Ontario, London, ON, Canada*
8:45-9:00	**Multigenerational toxicity and metabolomics of lead from fishing gear to the freshwater snail, *Planorbella pilsbryi*** St-Hilaire, S.[1,2], Gilroy, È.[2] , Tétreault, G. [2], Frank, R. [2], McNabney, D.[2], Ravary, S.[2], Kim, J. [2], Leonard, E. M.[1] *[1]Department of Biology, Wilfrid Laurier University, Waterloo, ON, Canada; [2]Aquatic Contaminants Research Division, Environment and Climate Change Canada, Burlington, ON, Canada*
9:00-9:15	**Use of a juvenile mummichog (*Fundulus heteroclitus*) bioassay to assess the effects of ammonia exposure on fish growth and the GH-IGF1 pathway** Kuntyj, O., Lister, A., MacLatchy, D. *Department of Biology and Canadian Rivers Institute, Wilfrid Laurier University, Waterloo, Ontario, Canada*
9:15-9:30	**It doesn't pay to have a big mouth: how microplastic ingestion scales with insect body size** Ritchie, M.W., Provencher, J.F., MacMillan, H.A. *Department of Biology, Carleton University, Ottawa, ON, Canada*
9:30-9:45	**Climate change and urban growth are contributing to increased contaminant impacts on Arctic marine invertebrates** Jeffries, K.M. *Department of Biological Sciences, University of Manitoba, Winnipeg, Canada*
9:45-10:00	**CRISPR-Cas9 Knockout of Divalent Metal Transporter and its Implications for Metal Homeostasis in Zebrafish** Chandrapalan, T[1], Kwong, R. W. M.[1] *[1]Department of Biology, York University, Toronto, Canada*
10:00-10:15	**Neural Regeneration of Zebrafish in Response to Neurotoxin-Induced Degradation of Dopaminergic Neurons** Nhi, TMN, Raymond, RWM *Biology Department, Science Faculty, York University, ON, Canada*
10:15-10:30	**Interactive effects of hypoxia-reoxygenation and trace metals mixtures on heart mitochondrial bioenergetics during fatty acid and pyruvate oxidation** Pius Tetteh[1] , Zahra Kalvani[1], Don stevens[1], Ravinder Sappal [1,2] and Collins Kamunde[1] *[1]Department of Biomedical Sciences, Atlantic Veterinary College, University of Prince Edward Island, PE, Canada; [2]Department of Veterinary Biomedical Sciences, College of Veterinary Medicine, Long Island University, New York, USA*

8:30-10:30

CMDB 1

Location/Lieu: **Shediac B**

Chair/Animé par: **Robert Cieri** (University of British Columbia)

8:30-8:45	**Exploring the Social Brain: Uncovering the Genetic Mechanisms Regulating the Expression of the Social Neuropeptide, Pth2** Butland, S., Erickson, T. *Department of Biology, University of New Brunswick, NB, Canada*
8:45-9:00	**Osteohistology accurately estimates growth in the lion (*Panthera leo*)** Reynolds, A.R. [1,2], Evans, D.C. [3,4] *[1]Palaeobiology, Canadian Museum of Nature, Gatineau, QC, Canada; [2]Department of Biology, University of Ottawa, Ottawa, ON, Canada; [3]Vertebrate Palaeontology, Royal Ontario Museum, Toronto, ON, Canada;[4]Department of Ecology and Evolutionary Biology, University of Toronto, Toronto, ON, Canada*
9:00-9:15	**Ecomechanics in contemporary evolution: a case study in Threespine Stickleback (*Gasterosteus aculeatus L.*)** Kozak, A. M[1], Chung, M.[1], Lucas, K. N.[2], Rogers, S. M.[2], Jamniczky, H. A.[1] *[1]Cumming School of Medicine, University of Calgary, Calgary, Canada; [2]Department of Biological Sciences, University of Calgary, Calgary, Canada*
9:15-9:30	**Gustation in the sea lamprey.** Zielinski, B.S. Aurangzeb, Z., Grande G., Polat, H., Zhang, H., Daghfous, G., Dubuc, R. *Dept. of Integrative Biology, University of Windsor; Département des Sciences de l'Activité Physique, Université du Québec à Montréal*
9:30-9:45	**Simple physical models of chimaera pectoral fins swim like a bluegill sunfish** Kennedy, D. [1], Wong, J.G. [2], and Lucas, K.N. [1] *[1]Biological Sciences, University of Calgary, Calgary, AB, Canada; [2]Mechanical Engineering, University of Alberta, Edmonton, AB, Canada*
9:45-10:00	**Investigation of two different PACAP-38 (Pituitary Adenylate Cyclase-Activating Polypeptide) formulated feeds on Atlantic salmon (*Salmo salar*) with Enteric Red mouth disease (*Yersinia ruckeri*)** Fajei E[1], Whyte SK[1], Rivera L[2], Velazquez J[3], Dantagnan P[4], Soto Davila M[1], Rodríguez-Ramos T[2], Dixon, B[2], Carpio Y[3], Estrada M[3], Fast MD[1] *[1]Department of Pathology and Microbiology, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown, PEI; [2]University of Waterloo, Waterloo, ON; [3]Veterinary Immunology Project, Animal Biotechnology Division, Center for Genetic Engineering and Biotechnology, Havana, Cuba; [4]Department of Agricultural Sciences and Aquaculture, Faculty of Natural Resources, Catholic University of Temuco, Temuco, Chile*
10:00-10:15	**Piezo1-mediated detection of mechanical force regulates post-translational activation of matrix metalloproteinase-2 in growing zebrafish embryos** Hickey, J. E. and Crawford, B. D. *Department of Biology, University of New Brunswick, Fredericton, NB, Canada*
10:15-10:30	**Comparative phylogenetics of early ray-finned fishes** Miyashita, T. *Palaeobiology Section, Canadian Museum of Nature, Ottawa, Canada*

8:30-10:30

Ecology 1

Location/Lieu: **Shediac C**

Chair/Animé par: **Ken Lukowiak** (University of Calgary)

8:30-8:45	**Pond-side learning is no different than lab-learning** Lukowiak, K., and Hollings J. *Hotchkiss Brain Institute, Cumming School of Medicine, University of Calgary*
8:45-9:00	**Subhabitat usage by juvenile fish and the overall fish community in two New Brunswick salt marshes** Reyes Guevara, A., Barbeau, M.B., Endresz, K.C., and Linihan, J.T. *[1]Department of Biology, University of New Brunswick, Fredericton, NB, Canada*
9:00-9:15	**Applications and limitations of environmental nucleic acids in salmonid distribution and population health** Misutka, M.D.[1], Glover, C.N.[1,2], Goss, G.G.[1], Veilleux, H.D.[3] *[1]Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada; [2]Faculty of Science and Technology and Athabasca River Basin Research Institute, Athabasca University, Athabasca, Alberta, Canada; [3]Present address: Ecometrix Incorporated, Mississauga, Ontario, Canada*
9:15-9:30	**Effects of severe weather on staging juvenile semipalmated plovers: evidence of disrupted refueling and delayed departures in the Western Atlantic Flyway** Sophia M. Fraser[1], Hilary A.R. Mann[2], Julie Paquet[3], Devin R. de Zwaan[1,2], Diana J. Hamilton[1] *[1]Department of Biology, Mount Allison University, Sackville, New Brunswick, Canada; [2]Department of Biology, Acadia University, Wolfville, Nova Scotia, Canada; [3]Canadian Wildlife Service, Environment and Climate Change Canada, Sackville, NB, Canada*
9:30-9:45	**Can Corticosterone Predict Double Brooding in Savannah Sparrows (*Passerculus Sandwichensis*)?** Hayley A. Spina[1], D. Ryan Norris[1], Linda Nong[1], Sarah L. Dobney[2], Sarah Mueller[1], Stéphanie M. Doucet[2], Daniel Mennill[2], Amy E.M. Newman[1] *[1]Department of Integrative Biology, University of Guelph, Guelph, Ontario Canada; [2]Department of, Windsor University, Windsor, Ontario Canada*
9:45-10:00	**Under pressure – exploring partner changes, physiological responses and telomere dynamics in northern gannets across varying breeding conditions** Pelletier, D.[1,2], Blier, P.U.[2], Vézina, F.[2], Dufresne, F.[2], Paquin, F.[2], Christen, F.[2], Guillemette, M.[2] *[1]Département de biologie, Cégep de Rimouski, Rimouski, QC, Canada; [2]Département de biologie, Université du Québec à Rimouski, Rimouski, QC, Canada*
10:00-10:15	**Biodiversity Monitoring in Marine Conservation Areas within the southern Gulf of St. Lawrence** Dinn, C. *Department of Fisheries and Oceans Canada – Gulf Fisheries Centre*
10:15-10:30	**A role for gene editing towards understanding the ecological impacts of gene variation on adaptive potential** Galts, B. [1], Josephson, M. [1], Stanford, B. [1], Jamniczky, H. [2], Rogers, S. [1] *[1]Department of Biological Sciences, University of Calgary, Calgary, Canada; [2]Cumming School of Medicine, University of Calgary, Calgary, Canada*

11:00-13:00

William S. Hoar Award/Prix

Student Talks/Présentations étudiantes

Location/Lieu: **Ballroom A and B**

Chair/Animé par: **Tamara Franz-Odendaal** (Mount Saint Vincent University, CSZ-SCZ first vice-president)

11:00-11:10

Introduction and Welcome

11:10-11:30

Cadonic, I. G.[1], Heath, J. W.[2], Dixon, B.[1], Craig, P. M.[1]

[1]Department of Biology, University of Waterloo, Waterloo, Canada; [2]Yellow Island Aquaculture, Heriot Bay, Canada

Reduced cardiac performance in triploid chinook salmon (*Oncorhynchus tshawytscha*) during an extreme temperature exposure

Pressures associated with climate change will negatively impact wild fish populations; therefore, preserving genetic diversity in these populations will increase the potential for their successful adaptation to an altered environment. Farming of sterile triploid fish is more sustainable since any aquaculture escapees are unable to breed, preventing reduction of wild stock genetic diversity. However, triploid fishes respond poorly to stressful conditions and will be negatively affected by climate change as well. The objective of this study is to characterize cardiac performance of diploid and triploid Chinook salmon (*Oncorhynchus tshawytscha*) during and after recovery from an acute temperature challenge. Diploid and triploid fish were surgically implanted with heart rate loggers (Star-Oddi) to assess how both ploidies responded during a critical thermal maximum (Ct_{max}) experiment. Fish were then allowed to recover for one hour after reaching Ct_{max} to assess whether increased ploidy influences cardiac recovery at a molecular level. Although both ploidies had similar Ct_{max} temperatures, triploids became agitated ~1°C earlier than diploids. Additionally, triploids had an earlier onset of cardiac arrhythmia, indicating that their hearts fail at lower temperatures. Both ploidies had similar heat shock protein expression during recovery; however, triploids had elevated myoglobin expression in both the ventricle and atrium. Furthermore, in the ventricle, carbonic anhydrase 4 had lower expression in triploids while having higher expression of the

miRNA (*miR-24a-5p*) that is predicted to regulate it. Overall, this data indicates that triploids have altered cardiorespiratory gene expression in the heart which could explain their poor temperature tolerance.

11:30-11:50

Boyd, A., Blewett, T.A.

University of Alberta Department of Biological Sciences, Edmonton T6G 2E9, Canada

Bridging the gap between standardized laboratory tests and environmental outcomes: investigating organic ultraviolet filter toxicity to freshwater invertebrates *Daphnia magna* and *Daphnia pulex*

To accommodate the growing need for physiology research due to continued anthropogenic change of natural environments, standardized test guidelines have been developed that use simplified models to simulate complex real-world environments. These methods require that test organisms are reared in stable conditions to control life history traits such as genetic ancestry and prior exposure to chemical or biological stressors to minimize the effects of biological variation across research groups. By using data generated from these highly specific tests, critical assumptions are made that testing organisms raised in stable laboratory environments for a set duration of time produces data representative of real-world outcomes. These assumptions were tested by exposing Daphnia to organic ultraviolet filters (UVFs), contaminants of concern that have been demonstrated to cause toxicity at environmental concentrations. Daphnids exposed to UVFs experienced 60% mortality and 40% decreased reproduction over the standard first generation of exposure but were capable of gradual acclimation to continuous exposure across subsequent generations until no impairment was evident by the 4th generation. Additional studies comparing the responses of the laboratory lineage of *D. pulex* to a wild population revealed that each population differs in sensitivity to UVFs on a case-by case basis, as each tested chemical severely impacted one population type but not the other, highlighting fundamental differences in each population's physiology. This research identifies several shortcomings of applying standardized research to real-world environments and highlights the necessity to understand how the methods used to conduct biological research impact the conclusions drawn from resulting data.

11:50-12:10

Rowsey, L.E., Speers-Roesch, B.

Department of Biological Sciences, University of New Brunswick, Saint John, Canada

Do thermal constraints on physiological performance explain the use of winter dormancy among fishes?

During winter, certain fish species remain active while others become dormant, which is characterized by low metabolic rate, fasting, and negligible or negative growth. We hypothesized that winter dormancy is a survival strategy that arises in poleward species that tolerate severe, uncompensated constraints of cold on physiological performance. To date, we have measured the metabolic, exercise, and digestive performance of cunner (*Tautogolabrus adspersus*), a model winter-dormant fish, acclimated or acutely exposed to a wide range of temperatures (2-26°C). Contrary to our hypothesis, we found partial cold compensation of nearly all metabolic and exercise performance metrics studied, similar to winter-active species. Further, after bypassing the behavioural fasting response during dormancy using repeated force-feeding during cold acclimation, cunner were able to digest food and subsequently exhibit positive growth compared to negative growth of the voluntarily fasting fish. Only responsiveness to stimuli during the C-start escape response was greatly constrained in the cold even after acclimation, suggesting a thermal sensory limitation that may help explain the need to become dormant. To further explore this idea, we measured the C-start escape performance of six phylogenetically-diverse species along the spectrum of overwintering strategies from winter-dormant to winter-lethargic to winter-active. As we predicted, responsiveness was greater and more plastic in the winter-lethargic and -active species compared to -dormant species. While most physiological performance traits in cold dormant fish remain robust, impaired responsiveness to C-start stimuli may be a weak thermal link driving dormancy as an overwintering strategy among fishes.

12:10-12:30

Léger, A.[1,2], Aminot, M.[1,2], Jorissen, S.[4], Hébert-Chatelain, E.[2,3], Pichaud, N.[1,2]

[1]Department of Chemistry and Biochemistry, Université de Moncton, Moncton, NB, Canada; [2]New Brunswick Centre for Precision Medicine, Moncton, NB, Canada; 3Department of Biology, Université de Moncton, Moncton, NB, Canada; [4]Department of Biology, KU Leuven, Leuven, Belgium

The powerhouse of the hive: Seasonal differences in mitochondrial uncoupling, ATP and ROS production in honey bees

Because of their different roles within the hive, summer and winter honey bees (*Apis mellifera*) exhibit distinct phenotypes. We have recently demonstrated that honey bees'

mitochondria undergo drastic changes between seasons. More specifically, winter bees have lower CI-linked respiration but increased mtG3PDH- and CII-linked respiration. We hypothesize that this would lead to a decreased ATP production because mtG3PDH and CII do not directly contribute to proton pumping. Given the high energy requirements of winter bees, which shiver their thoracic muscles to keep the queen warm, we explored mechanisms allowing non-shivering thermogenesis that do not require ATP, specifically uncoupling proteins (UCP). Thus, in this study we investigated the seasonal differences in mitochondrial oxygen consumption, ATP production, site-specific reactive oxygen species (ROS) production and UCP activity in honey bees. Our results demonstrate that even though CI-linked respiration is diminished in winter bees, ATP production with CI substrates increased, suggesting that CI is more efficient in winter bees, likely to sustain shivering thermogenesis. On the other hand, succinate and G3P did not contribute to ATP production. Differences were also detected in terms of ROS production; overall, summer bees produced less ROS than all other seasons. Important UCP activity was detected in summer bees whereas winter bees displayed very little, or no UCP activity, suggesting that UCPs are not involved in thermogenesis in honey bees. However, increased UCP activity in the summer could help minimise ROS production, which might explain the low rates obtained in summer.

12:30-12:50

Van Wert, J. C.[1], Birnie-Gauvin, K.[2], Robinson, K. A.[3], Patterson, D. A.[3], Eliason, E. J.[1]

[1]Department of Ecology, Evolution & Marine Biology, University of California, Santa Barbara, CA 93106, USA; [2]Section for Freshwater Fisheries and Ecology, National Institute of Aquatic Resources, Technical University of Denmark, Silkeborg, Denmark; [3]Fisheries and Oceans Canada, Cooperative Resource Management Institute, School of Resource and Environmental Management, Simon Fraser University, Burnaby, BC V5A 1S6, Canada.

Heart function and pathology are linked to the migration success of Pacific salmon

The upstream spawning migration is a demanding feat for Pacific salmon (*Oncorhynchus spp.*). Relying on endogenous energy reserves, salmon often swim in warm water for weeks against strong currents and complex hydraulic conditions (e.g. rapids) to reach natal spawning grounds. Cardiac structure and function may determine migration outcomes. During migration, the heart's excessive beating can damage the coronary artery, causing lesions that reduce oxygen supply to the compact myocardium (i.e., coronary arteriosclerosis). We sampled sockeye salmon (O. nerka) across various stages of their migration, including in the ocean, at the river entry, in a subset that failed part-way through migration, and at their spawning grounds, for signs of coronary arteriosclerosis

and health status through blood chemistry. Coronary arteriosclerosis was most severe in fish that strayed and in fish sampled at the spawning grounds, occluding up to 25% of blood flow. We identified a suite of cardiorespiratory metrics associated with an unsuccessful migration. Fish that strayed showed signs of hyperkalemia (high plasma potassium levels, impairs heart contractility), advanced sexual maturity (relatively low plasma estradiol and testosterone concentrations), elevated plasma cardiac troponin C (indicative of O_2 limitation to the heart), and less relative compact myocardium (reduced reliable oxygen supply to the heart). Our results underpin the importance of heart function in migration success. Its pathology, chemistry, and potential for a plastic morphological response may serve as an indicator of how hard the fish have worked and help describe and predict migration success.

Oral contributed presentations/Présentations orales

15:00-17:00

Performance

Location/Lieu: **Shediac A**

Chair/Animé par: **Léa Herpe** (Université de Moncton)

15:00-15:15	**ATP and glutamate coordinate contractions in the freshwater sponge *Ephydatia muelleri*** Ho, V.R., Goss, G.G., Leys, S.P. *[1]Department of Biological Sciences, University of Alberta, Edmonton, AB, Canada*
15:15-15:30	**Protein turnover kinetics in the freshwater snail *Planorbella duryi*.** Wang, C.[1], Lamarre, S.G.[2], Treberg, J.R. [1] *[1]Department of biology, University of Manitoba, Winnipeg, Canada; [2]Département de biologie, Université de Moncton, Moncton, Canada*
15:30-15:45	**The Effects of Diet Quality on Developmental Plasticity of Size and Flight Energetics in the Hawk Moth, *Manduca sexta*** Ellison, E, Darveau, C. -A *Department of Biology, University of Ottawa, Ottawa, Canada*
15:45-16:00	**Adaptations to extreme hydrostatic pressure in the world's deepest freely diving insect (*Chaoborus edulis*) in Lake Malawi** McKenzie, E. K. G.[1], Ames, T. [1], Chombo, J.[2], Ngochera, M.[2], Matthews, P. G. D.[1] *[1]Department of Zoology, University of British Columbia, BC, Canada; [2]Department of Fisheries, Ministry of Natural Resources and Climate Change, Malawi*
16:00-16:15	**Effects Of Migratory Strategy On Flight Muscle Mitochondrial Physiology In Songbirds** Coulson, S. Z.[1,2], Staples, J. F.[1], Guglielmo, C. G.[1,2] *[1]Department of Biology, Western University, London, Canada; [2]Centre for Animals on the Move, Western University, London, Canada*
16:15-16:30	**Endogenous Antioxidant Response in Muscle Tissue of the Cownose Ray (*Rhinoptera bonasus*)** Bailey, B., Lewis, J.M. *Department of Biology, Georgia Southern University, Statesboro, GA, USA*
16:30-16:45	**Amino Acids at the Races: Vampire Bats Rapidly Fuel Running with Blood Meal Protein** Rossi, G.S. and Welch Jr, K.C. *Department of Biological Sciences, University of Toronto Scarborough, Toronto, ON, Canada*
16:45-17:00	**Exploring the broader systems-level consequences of ocean acidification in the bigfin reef squid, *Sepioteuthis lessoniana*** Allen, G.J.P. [1], Kuan P.-L. [1], Yan, J.-J. [1], Hayasaka, O. [2], Nash, M.T. [1], Chen, Y.-W. [3], Hwang, D.W. [3,4], Tseng, Y.-C.[1] *[1]Marine Research Station, ICOB, Academia Sinica, Jiaoxi, Taiwan; [2]Kanazawa University College of Science and Engineering, Isikawa, Japan; [3]Biomedical Translation Research Center, Academia Sinica, Taipei, Taiwan; [4]Institute of Biomedical Sciences, Academia Sinica, Taipei, Taiwan*

15:00-17:00

Osmoregulation

Location/Lieu: **Shediac B**

Chair/Animé par: **Alex Zimmer** (University of New Brunswick)

15:00-15:15	**The interactive effects of Copper and Phenanthrene on ionoregulation in mummichog** Senathirajah, E[1]., Zimmer, A[1]., Philibert, D[2]., De Jourdan B[2]., and Cremazy, A[3] *[1]Department of Biological Science, University of New Brunswick, New Brunswick, Canada; [2]Huntsman Marine Science Center, New Brunswick, Canada; [3]Institut national de la recherche scientifique, Québec City, Québec*
15:15-15:30	**Exploring the role of tachykinins on fluid and ion transport by the excretory system of *Drosophila melanogaster*** Agard, M.[1], Zandawala, M.[2], Donini, A.[1], Paluzzi, J.P.[1] *[1]Department of Biology, York University Toronto, ON, Canada; [2]Department of Biochemistry and Molecular Biology, University of Nevada, Reno, NV, USA*
15:30-15:45	**Effects of salinity exposure and broad-range antibiotic treatment on oxalate production, transport, degradation, and handling in *Poecilia latipinna*** Rajan, F.V., Bucking, C. *Department of Biology, York University, Toronto, ON, Canada*
15:45-16:00	**Effects of food limitation on ocean acidification tolerance in Chum salmon** Andrea Y. Frommel[1], Virginie Chalifoux[1], Arash Akbarzadeh[2], Tobi Ming[2], Kristi Miller[2], Brenna Collicutt[3], Kate Rolheiser[3], Colin J. Brauner[1], Brian P. V. Hunt[1,3] *[1] University of British Columbia; [2] Department of Fisheries and Oceans Canada; [3]Hakai Institute*
16:00-16:15	**Do white sturgeon smolt? Assessing physiological and molecular mechanisms associated with salinity preparedness.** Nowlan, J.[1,2], Margarethe, M.[1,3], Russell, S.[1,3], and Baker, D[3] *[1]Centre for Innovation in Fish Health, Vancouver Island University, B.C., Canada; [2]Department of Pathobiology, University of Guelph, O.N., Canada; [3]Department of Fisheries and Aquaculture, Faculty of Science and Technology, Vancouver Island University*
16:15-16:30	**Alterations in transepithelial potential following exposure of fish to differentially degraded microplastics suggests even brief pulse exposures to plastics has ionoregulatory consequences** Zink, L., Morris, C., Wood, C.M. *Department of Zoology, University of British Columbia, BC, Canada*
16:30-16:45	**The acute osmoregulatory effects of copper on the Amazonian fish, *Apistogramma agassizii*, in black and white waters at circumneutral and acidic pH.** Carolyn Morris[1], Anne Crémazy[2], Jhonatan Mota[3], Ora E. Johannsson[1], Colin J. Brauner[1], Chris M. Wood and Adalberto Luis Val[3] *[1]University of British Columbia, Vancouver, Canada; [2]Institut National de la Recherche Scientifique, Quebec City, Canada; [3]Instituto Nacional de Pesquisas da Amazônia, Manaus, Brazil*
16:45-17:00	**Effects of fluctuating and static ocean acidification on the behaviour and physiology of coastal crabs.** Khodikian, E., Porteus, C.S. *Department of Biological Sciences, University of Toronto, Scarborough, ON, Canada*

15:00-17:00

Invertebrate parasitology

Location/Lieu: **Shediac C**

Chair/Animé par: **Jillian Detwiler** (University of Manitoba)

15:00-15:15	**Snail microhabitat preference as a potential driver of trematode parasite exposure risk in the Bay of Fundy** Goldberg, R.M., Tay, A., Koprivnikar, J. *Department of Chemistry and Biology, Toronto Metropolitan University, Toronto, Canada*
15:15-15:30	**Avoidance of fungal and nematode parasitic threats by red flour beetles (*Tribolium castaneum*)** Smith, T.R., Koprivnikar, J. *Department of Chemistry and Biology, Toronto Metropolitan University, Toronto, ON, Canada*
15:30-15:45	**Mosquitoes cause of life threatening disease vectors.** Imran Ahmed, Shabab Nasir, Farhat Jabeen, Awais Ali Chatha *Department of Zoology, Government College University, Faisalabad, Pakistan*
15:45-16:00	**Mosquito-borne arboviruses in the Maritimes: Using ecological niche modelling as a tool for targeted arbovirus surveillance** Rawson, G.M.[1], Boyd, N.H.[1], Peach, D.A.H.[2], Ferguson, L.V.[1] *[1]Department of Biology, Acadia University, Wolfville, NS, Canada; [2]Department of Infectious Disease, University of Georgia, Athens, U.S.A.*
16:00-16:15	**Mosquito surveillance in the Maritime provinces under the lens of climate change** Boyd, N. H.[1], Bacon, E.[1], Rawson, G.[1], Rutherford, A.[1], Heard, S. B.[2], Badcock, J.[3], Carr, J.[4], Hillier, K.[1], Easy, R. H.[1], Smith, T. G.[1], Ferguson, L. V.[1] *[1]Acadia University; [2]University of New Brunswick; [3]New Brunswick Department of Health; [4]New Brunswick Department of Agriculture and Fisheries*
16:15-16:30	**Hemolymph metabolite, peptide, and protein changes in caterpillars experiencing parasite-induced feeding suppression** Miller, D.W.[1], Barker, A.[2], Zbarsky, J.[1], Adamo, D.[2], Adamo, S.A.[1] *[1]Department of Psychology & Neuroscience, Dalhousie University, Halifax, Canada; [2]Medical Sciences Program, Dalhousie University, Halifax, Canada*
16:30-16:45	**Parasitic manipulation via gene transfer and neuroinflammation: How the parasitic wasp, *Cotesia congregata* alters host neural function and behaviour.** Adamo, SA *Department of Psychology and Neuroscience*
16:45-17:00	**Assessing Whether Climbing Behaviour Explains Low Prevalence of Brainworm (*Parelaphostrongylus tenuis*) Infection in Gastropod Hosts** Mann, S. C. and Detwiler, J. T. *Department of Biological Science, University of Manitoba, Winnipeg, Canada*

15:00-17:00

Thermal physiology of fish 1

Location/Lieu: **Ballroom A and B**

Chair/Animé par: **Loïc Teulier** (Université Lyon 1)

15:00-15:15	**The cortisol response to acute temperature stress in rainbow trout (*Oncorhynchus mykiss*)** Gilmour, K.M.[1], Bard, B.[1], Cooke, S.J.[2] *[1]Department of Biology, University of Ottawa, Ottawa, ON, Canada; [2]Department of Biology, Carleton University, Ottawa, ON, Canada*
15:15-15:30	**Mitochondrial functions and fatty acid profiles in fish heart: an insight into physiological limitations linked with thermal tolerance and age.** Simon Chouinard-Boisvert[1], Léopold Ghinter[1,2], Amélie St-Pierre[1], Mathieu Mortz[1], Véronique Desrosiers[1], France Dufresne[1], Jean-Claude Tardif[3], Johnny Huard[4], Pascal Sirois[5], Samuel Fortin[1], Pierre U. Blier[1] *[1]Department of Biology, University of Quebec at Rimouski, Rimouski, Quebec, Canada; [2]Department of Biology of Exploited Marine Species, French Research Institute for Exploitation of the Sea (IFREMER), Plouzané, Brittany, France; [3]Research center of the Montreal Heart Institute, Montreal Health Innovations Coordinating Center, Montreal, Quebec, Canada; [4]Center for Regenerative Sports Medicine at the Steadman Philippon Research Institute (SPRI), Vail, Colorado, USA; [5]Department of Fundamental Sciences, University of Quebec at Chicoutimi, Chicoutimi, Quebec, Canada*
15:30-15:45	**Transcriptomic response to acute thermal stress in developing lake sturgeon.** Haghighi, H.[1], Bugg, W. S.[2], Madden, K.[3], Bernier, N. J.[3], Jeffries, K. M.[1] *[1]Department of Biological Science, University of Manitoba, Winnipeg, Canada; [2]Department of Forest and Conservation, University of British Columbia, Canada;[3]Department of Integrative Biology, University of Guelph, Guelph, Canada*
15:45-16:00	**Characterization of darter (*Etheostoma* spp.) interspecific energetic responses to climate-induced temperature change** Weber, A. V.[1], Craig, P. M.[1] *[1]Department of Biology, University of Waterloo, Waterloo, ON, Canada*
16:00-16:15	**Embryonic Thermal Stress and its Effect on the Stress Response during Embryogenesis and Early Life Stages in Yellow Perch (*Perca flavescens*)** Hartenstein, P.D.[1], Fraz, S.[2], Thompson, W A.[2], Laframboise, L.[2], Wilson, J. Y.[2], Somers, C.[1], Manzon, R. G.[1] *[1]Department of Biology, University of Regina, Regina, Canada; [2]Department of Biology, McMaster University, Hamilton, Canada*
16:15-16:30	**Elevated and variable thermal environments during embryogenesis lead to more notable plastic responses in Lake Whitefish than in Yellow perch.** Manzon, R.G. *Department of Biology, University of Regina, Regina, SK, Canada*
16:30-16:45	**Transcriptional responses as early indicators of thermal stress in bull trout (*Salvelinus confluentus*)** Lazaro-Côté, A.[1], Durhack, T. C.[2], Chapelsky, A. J.[2], Jeffries, K. M.[1], Mochnacz, N. J.[2] *[1]Department of Biological Sciences, University of Manitoba, Winnipeg, MB, Canada; [2]Fisheries and Oceans Canada, Freshwater Institute, Winnipeg, MB, Canada*
16:45-17:00	**Investigating Mechanisms of Thermal Stress Recovery in Lake Sturgeon (*Acipenser fulvescens*)** Thorstensen, M. T.[1], Edwards, T.[1], Weinrauch, A. M.[1], Bouyoucos, I. A.[1,2], Lazaro-Côté, A.[1], Schulte, P. M.[2], Treberg, J. R.[1], Jeffries, K. M.[1], Anderson. W. G. A.[1] *[1]Department of Biological Sciences, University of Manitoba, Winnipeg, Canada; [2] Department of Zoology, University of British Columbia, Vancouver, Canada*

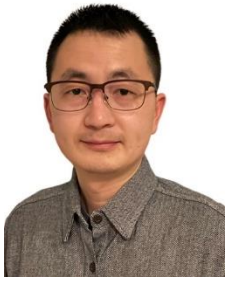
17:30-18:30

T. W. M Cameron Award/Prix

Outstanding PhD Thesis/Excellence de Thèse de PhD

Location/Lieu: **Ballroom A and B**

Chair/Animé par: **Carol Bucking** (York University, CSZ-SCZ president)



Hang Cheng, Faculty of Medicine, University of Ottawa

Hang Cheng gained extensive mitochondrial biology experience in the Pamenter Lab at the University of Ottawa where he completed his PhD. Following a year of postdoctoral training at Yale Med School studying the role of reactive oxygen species in epigenetic regulation, he returned to Ottawa to work with Stephen Ferguson on neurodegenerative disorders.

Mitochondria: Hubs of hypoxia-tolerance in naked mole-rats

Most adult mammals are highly sensitive to reduced oxygen availability; however, some species have evolved to live in hypoxic environments. Naked mole-rats (NMRs, *Heterocephalus glaber*) are among the most hypoxia-tolerant mammals and rapidly reduce whole animal oxygen consumption during hypoxia. Mitochondria are cellular oxygen sensors, major consumers of oxygen, and regulators of numerous cellular signalling pathways, and thus play key roles in cellular responses to hypoxia. However, little is known about the specific mechanisms and pathways that mitochondria regulate in NMRs, nor about how these roles vary between tissues with divergent metabolic demands in hypoxia. Hang's theses uncovered mechanisms via which mitochondria regulate oxidative phosphorylation (OXPHOS), reactive oxygen species (ROS), and calcium, and the impact of these mechanisms on hypoxia/ischemia tolerance in NMR interscapular brown adipose tissue (iBAT), brain, and skeletal muscle. Specifically: 1) In hypoxia, iBAT mitochondria significantly suppress respiration (by 45-70%) and rate of calcium uptake. These functional changes were accompanied by rapid reductions in the expression of OXPHOS and UCP1 proteins, which was likely mediated by mitochondrial membrane remodeling, including the activation of mitochondrial fission and inhibition of apoptosis. 2) NMR brain mitochondria have a very high capacity to buffer calcium. Elevated mitochondrial calcium suppresses the oxygen consumption rate without compromising membrane integrity in NMRs but not in mice. The mechanism underlying this enhanced capacity likely involves the occurrence of larger and more interconnected mitochondrial networks in NMR brain. As a result, NMR brain is better able to regulate redox state, minimize excitotoxity (i.e., glutamate, calcium), and retain OXPHOS function under *in vitro* ischemia than mouse brain. 3) Skeletal muscle mitochondria exhibit a mild decrease in OXPHOS function but reduce mitochondrial superoxide ($O_2^{\cdot -}$) emission in acute and chronic hypoxia, which may support continuous exercise in intermittent hypoxic burrow

systems in nature. Overall, these results suggested that NMR mitochondria play key roles in maintaining essential functions (e.g., brain function, physical activity), and also suppressing non-essential functions (e.g., thermogenesis) in a tissue-specific fashion to minimize the oxygen consumption and hypoxia-induced cell damage.

18:30-19:30

F. E. J Fry Medal/Médaille

Outstanding contribution to knowledge and understanding of an area in zoology/ Contribution exceptionnelle à la connaissance et à la compréhension d'un domaine de la zoologie

Location/Lieu: **Ballroom A and B**

Chair/Animé par: **Carol Bucking** (York University, CSZ-SCZ president)

Rudy Boonstra, Department of Biological Sciences, University of Toronto

I was born in the Netherlands but came to Alberta as a youngster and lived for the first 16 years on the western outskirts of Calgary. I spent summers and winters roaming the hills and fishing in the Bow River. The innate curiosity about the natural world was always there and early on, realized I wanted to be a biologist. I went to the University of Calgary for my Honours B.Sc. and my professors there were absolutely crucial in nurturing my curiosity and ability (Drs. Nancy Henderson, Robert Ogilvie, Charles Bird). Every summer of those years was spent working in north central Alberta (Alberta Forest Service, National Parks Service and 2 summers with the Canadian Wildlife Service on wolves in the wilds of Jasper National Park). I did my Ph.D. on the population ecology of cyclic small mammals at the University of British Columbia (1972-77) with Drs. Dennis Chitty and Charles Krebs. Charley has been a critical mentor, collaborator, and friend my whole research life. I then became an assistant professor at the University of Toronto Scarborough, finally retiring after 42 years, but still remaining active in research and now still having a lab and supervising students. My first sabbatical (1983-84) as a Senior Research Scientist with CSIRO in Canberra Australia was a career changer for me. There I learned how to rigorously quantify stress hormone using radioimmunoassay on wildlife.

My research has made fundamental contributions to the understanding of classic systems in ecology (boreal and arctic populations of cycling snowshoe hares, lemmings,

and voles, and the communities and ecosystems within which they occur, as well as in temperate ecosystem) and shown that these natural populations are also ideal models for studies of physiological and epigenetic mechanisms by which animals (including humans) respond to stress and senescence. I have pioneered studies of wild populations mammals and birds as models for the evolution and regulation of stress. My current research work is at the interdisciplinary junction of population and community ecology, endocrinology, neuroscience, and epigenetics and has led to the establishment of a new discipline focusing on the ecology of stress. Thus far, either directly, with graduate students or collaborators, have worked on ~35 different species of mammals (from bats to bison). I am now extending this through stress research collaborations on marine mammals (polar bear, dolphins, and seals) and sub-Antarctic birds (King penguins). I am a passionate advocate of the broader role for science in public discourse and the responsibilities of academics to address real-world problems, especially climate change.

The Pursuit of Generality in Nature: the Role of the Stress Axis

I will discuss two key problems have intrigued me since my undergraduate years: what is the role of the stress axis in life and why am I (and all other organisms) going to get old and die? In mammals, a key response to life's difficulties is the activation of the stress axis. The study of this axis is one of the best windows we have to 'see' under the surface of the animal into the functional mechanisms it uses to cope and adapt. At the individual level, the stress axis plays a key role in allowing animals to respond daily to change and challenge in the face of both environmental certainty and uncertainty. At the population and species level, the stress axis plays a central role in evolutionary adaptations to particular ecological pressures (e.g. the physical environment, intra- and interspecific competition, predators, etc.). Understanding how the axis functions among species is essential to understanding life history adaptations and ultimately species-specific aging patterns. My research and that of my students marries intense field work with laboratory research. I will review stress axis functioning and then apply it to 3 broad questions. First, predators may be a major force regulating prey populations. Are prey chronically stressed by their predators and is their demography affected? Second, in placental mammals, are the changes in maternal stress axis hormones over pregnancy the same in all mammals and what it the role of maternal effects? Third, the life history of mammals varies from those that breed once followed by death (they are semelparous) to those that breed multiple times over their life time (they are iteroparous). Is stress axis functioning traded off for reproduction (i.e. it deteriorates with age), resulting in death or is it a constraint (i.e. no change in functioning occurs over the lifespan)? Much of our understanding of the axis comes from intense biomedical research into it and our laboratory animal models, with the

ultimate objective being human health. Here my goal will be to discuss its role the real world of mammals found in nature.

Wednesday/Mercredi, May/Mai 8

8:30-10:30	PIE symposium: A slice of PIE in the Maritimes	Shediac A
	Contributed sessions	- Shediac B (Thermal Physiology: mammals, inverts, and more!) - Shediac C (Ecology 2) - Ballroom A and B (Oxygen availability)
10:30-11:00	Coffee Break **sponsored by Sable Systems**	Mezzanine
11:00-13:00	President's Award	Ballroom A and B
13:00-14:30	CPB section lunch	Mezzanine and Ballroom A and B
14:30-16:30	CMDB symposium: Developmental and Functional Biophysics in living systems	Shediac A
	Contributed sessions	- Shediac B (Toxicology 2) - Shediac C (Gut Physiology) - Ballroom A and B (Thermal Physiology of fish 2)
16:30-18:30	Poster session (catered with cash bar)	Mezzanine and Ballroom C
18:30-21:00	Trainee Network Mixer	Old Triangle Irish Pub (downtown Moncton)

8:30-10:30

PIE symposium

A slice of PIE in the Maritimes

Location/Lieu: **Shediac A**

Chair/Animé par: **Laura Ferguson** (Acadia University)

8:30-9:10

Lloyd V.K.

Department of Biology, Mount Allison University, Sackville, NB, Canada

The trouble with tick tourism – ticks and tick-borne pathogens in the Canadian Maritimes

Ticks are ectoparasites that transmit a greater variety of zoonotic pathogens than any other arthropod vector. Under the influence of climate change and other factors, the species composition of ticks in Canada has been changing. Expansion of generalist tick species, *Ixodes scapularis*, the black legged tick, and *Dermacentor variabilis*, the wood or American dog tick, being the most notable. We have documented both increasing tick presence, and pathogen presence in the Canadian Maritime Provinces. This pattern of tick range expansion is likely to include further invasive tick species such as *Amblyomma americanum*, the lone star tick. In addition to importing pathogens, invasive tick species have the potential to hybridize with local tick species, which may enhance pathogen transfer and population establishment. Another factor potentially driving pathogen prevalence is increased survival and questing of infected ticks. Investigation of epigenetic drivers of altered gene expression in Borrelia-infected ticks has revealed no DNA methylation changes but changes in the expression of a euchromatic histone methyl transferase. These findings offer a pathway to better understand the impact of pathogens on tick gene regulation and physiology, and ultimately a means to better understand the risk posed by ticks and the zoonotic pathogens that they vector.

9:10-9:50

Riley, J.L.

Mount Allison University, Sackville, NB, Canada

Disease Monitoring in Canadian Amphibians and Reptiles

One major threat to biodiversity is disease, and amphibians are one taxonomic group that has been severely impacted. Since discovery of the amphibian chytrid fungus, *Batrachochytrium dendrobatidis* (Bd), in 1998, it has driven extinction of 90 species and declines of ~500 others. Today novel pathogens continue to impact amphibians, as well as reptiles, and both groups are of conservation concern with 41% and 38% of species, respectively, at risk of extinction. In 2013, a new chytrid fungus, *Batrachochytrium salamandrivorans* (Bsal), was described after it resulted in a devastating decline of Fire Salamanders in the Netherlands. Its presence has yet to be documented in North America but is likely due to the pet trade with Europe. So, a surveillance program for Bsal called the Student Network of Amphibian Pathogen Surveillance (SNAPS) was established. In Canada, SNAPS is coordinated by the Canadian Wildlife Health Cooperative and, to date, Bsal has not been detected. I will summarise our surveillance efforts since 2022. In reptiles, the fungus that causes ophidiomycosis or snake fungal disease (SFD), *Ophidiomyces ophiodiicola*, was described in 2009 and has been reported across most of the USA and Great Lakes region of Ontario and Québec. In 2022, my lab investigated whether *O. ophiodiicola* is present in New Brunswick and Nova Scotia. I will present and interpret our findings and discuss on-going plans for a national monitoring program. Further research on amphibian and reptile disease will advance their conservation and ensure continuation of the services they provide for ecosystem and human health.

9:50-10:30

Shutler D.

Department of Biology, Acadia University, Wolfville, Nova Scotia, Canada

On parasites in food webs

Parasites are important participants in food webs, and despite repeated pleas for considering them, there has been limited attention to quantifying their contribution. Those studies that have been published tend to have a restricted taxonomic focus, and there has been virtually no consideration of the participation of viruses or bacteria. Moreover, research has been restricted largely to quantifying biomass as a proxy of energy use within food webs, but parasites also divert energy by selecting hosts to maintain and upregulate immune function and by requiring hosts to invest in tissue repair. An often overlooked effect of parasites is energy investment in sexually selected ornaments that honestly reflect a bearer's health. Finally, parasites may provoke extended phenotypes, as for example in gigantism in snails. Understandably, research in this area is hampered by the complexity of these processes and of the difficulty in quantifying entire parasite communities. As additional caveats, there can be considerable spatiotemporal variability

in both host and parasite communities. Nonetheless, against this backdrop, progress will be limited until dedicated investments are made.

Oral contributed presentations/Présentations orales

8:30-10:30

Thermal Physiology: mammals, inverts and more!

Location/Lieu: **Shediac B**

Chair/Animé par: **Anne Dalziel** (Saint Mary's University)

8:30-8:45	**Tropical endothermy in a changing world: predicting the energetics of small mammals using mechanistic models** Levesque, D.L.[1], Grunwald, A.[1], Breit,A[1,2], Brown, E.[1,2] *[1] School of Biology and Ecology, University of Maine, Orono, ME, USA; [2] School of Life Sciences, University of Nevada Las Vegas, Las Vegas, NV, USA*
8:45-9:00	**Ontogenetic Changes in Metabolic Scaling and Thermogenesis in the Thirteen-lined Ground Squirrel (*Ictidomys tridecemlineatus*)** Li, J. L., Marshall, K.E., Milsom, W. K. *Department of Zoology, University of British Columbia, Vancouver, BC, Canada*
9:00-9:15	**Estuarine crocodiles are heating up** Barham, K.[1], Dwyer, R.[2], Frere, C.[1], Baker, C.[3], Campbell, H.[3], and Irwin, T.[4], Franklin, C.E.[1] *[1] School of the Environment, The University of Queensland, Brisbane, Australia; [2] School of Science, Technology and Engineering, University of the Sunshine Coast, Sippy Downs, Australia; [3] Research Institute for Environment & Livelihoods, Charles Darwin University, Darwin, Northern Territory, Australia; [4]Australia Zoo, Beerwah, Australia*
9:15-9:30	**Effects of temperature and food availability on feeding behaviour and metabolism in the sea cucumber *Cucumaria frondose*** Kabanova, K., Filgueira, R. *Department of Biology, Dalhousie University, Halifax, NS, Canada*
9:30-9:45	**Exploring mechanisms of acclimation responses to thermal and saline stress in the cnidarian, *Nematostella vectensis*** Venkatesh, S., Little, A.G. *[1] Department of Biology, McMaster University, Hamilton, ON, Canada*
9:45-10:00	**The Heat is On: Investigating the impact of heat waves on the apple pest *Choristoneura rosaceana*** McMillan, L.E.[1], Adamo, S.A.[1], Blatt, S.[2] *[1] Department of Psychology and Neuroscience, Dalhousie University, Halifax, NS, Canada; [2] Agriculture and Agri-Food Canada, 32 Main St, Kentville, NS, Canada*
10:00-10:15	**Cell size and fatty acids as modulators of temperature tolerance in Daphnia** Dufresne, F., Pecl, I, Bernier, S.-B, Blier P. *Département de biologie, Université du Québec à Rimouski, Québec, Canada*
10:15-10:30	

8:30-10:30

Ecology 2

Location/Lieu: **Shediac C**

Chair/Animé par: **Tammy Rodela** (St Francis-Xavier University)

8:30-8:45	**Using benthic recruitment densities to forecast fisheries recruitment of American lobster in Atlantic Canada** White, L.M.[1], Sainte-Marie, B.[2], Lawton, P.[3], Rochette R.[1] *[1] Department of Biological Sceinces, University of New Brunswick, Saint John, New Brunswick, Canada; [2] Institut Maurice-Lamontagne, Pêches et Océans Canada, Mont-Joli, Québec, Canada; [3] St. Andrews Biological Station, Fisheries and Oceans Canada, St. Andrews, New Brunwick, Canada*
8:45-9:00	**Investigating the "hairy snail" holobiont of Alviniconcha from hydrothermal vents in the western Pacific and Indian oceans** Hanson, N. B.[1], Dufour, S. C.[2], Bates, A. E.[1,3] *[1] Department of Ocean Sciences, Memorial University of Newfoundland, St. John's, NL, Canada [2]Department of Biology, Memorial University of Newfoundland, St. John's, NL, Canada; [3] Department of Biology, University of Victoria, Victoria, BC, Canada*
9:00-9:15	**Freshwater Mussel Parental Care: the evolution of host-specificity and its relationship to brooding time** Penney, H.D.[1], Rodela, T.M.[2] *[1] Aquatic Resources Program; [2] Department of Biology; St Francis Xavier University*
9:15-9:30	**Honey Bee Majors and Minors: Multitasking in Foraging Behaviour** Van Nest, B. N. [1], Wagner, A. E. [2], Aniagu, M. [1], Moore, D. [2] *[1] Department of Biological Sciences, University of Manitoba, Winnipeg, Canada; [2] Department of Biological Sciences, East Tennessee State University, Johnson City, USA*
9:30-9:45	**More than a meal – gut yeasts make flies grow faster** Jiménez-Padilla, Y., Adewusi, B., Lachance M.-A., Sinclair B. J. *Department of Biology, Western University, London, ON, Canada*
9:45-10:00	**Complex biofouling effects of minimal ultraviolet light application for anti-fouling purposes** Murtaugh, M.P. and Wyeth, R.C. *Department of Biology, St. Francis Xavier University, Antigonish, Canada*
10:00-10:15	**Salt marsh-mudflat linkage inferred from stable isotope analysis in mega- and microtidal systems** Stack Mills, A., Hayden, B. , Barbeau, M. *Department of Biology, Univertsity of New Brunswick*
10:15-10:30	**Anthropogenic Impacts on Freshwater Mussels: Case Studies from New Brunswick, Canada** Dobbs, K.D.R. [1, 2], Jayawardane, A. [3], Bruce, M.R. [1, 2], Duffy, M.S. [1, 2] *[1] Canadian Rivers Institute, University of New Brunswick, Fredericton, NB, Canada; [2] Department of Biology, University of New Brunswick, Fredericton, NB, Canada; [3] Maliseet Nation Conservation Council, Saint Mary's First Nation, Fredericton, NB, Canada*

8:30-10:30

Oxygen availability

Location/Lieu: **Ballroom A and B**

Chair/Animé par: **Loïck Ducros** (Université de Moncton)

8:30-8:45	**The functional and structural response of the zebrafish (*Danio rerio*) cardiovascular system to chronic hypoxia.** Manchester, E.M. & Gillis, T.E. *Department of Integrative Biology, University of Guelph, Guelph, ON, Canada*
8:45-9:00	**Influence of hemoglobin-O_2 affinity on aerobic capacity in deer mice** Garvey, Kayla M.[1], Scott, Graham R.[1] *[1]Department of Biology, McMaster University, Hamilton, ON, Canada*
9:00-9:15	**The single chambered decapod crustacean heart may function as a "multi-chambered" organ.** Ebrahim, R. A.[1], Cahill, L. S.[2], Smith, G. R.[3], van Breukelen, F.[3], McGaw, I. J.[1] *[1] Department of Ocean Science, Memorial University of Newfoundland, Newfoundland, Canada; [2]Department of Chemistry, Memorial University of Newfoundland, Newfoundland, Canada; [3] Department of Life Sciences, University of Nevada Las Vegas, Nevada, United States of America.*
9:15-9:30	**Frozen-shut: Cold and hypoxia stress tolerance in winter-active pond insects** Burton, L.S., Rodela, T.M., Toxopeus, J. *Department of Biology, Saint Francis Xavier University, Antigonish, Canada*
9:30-9:45	**The Effects of Hypoxia on the Olfactory System of Marine Threespine Stickleback (*Gasterosteus aculeatus*)** Tigert, L.R.[1], Porteus, C.S.[1] *[1] Cells and Systems Biology, University of Toronto Scarborough, Scarborough, ON, Canada*
9:45-10:00	**Wild fish holobiont response to abiotic gradients in the Elbe estuary** Koll, R[1]., Theilen, R[2]., Hauten, E[3]., Woodhouse, J.[1,4], Fabrizius, A.[1] *[1] University of Hamburg; Institute of Cell- and Systems Biology of Animals, Molecular Animal Physiology; [2] Leibniz Institute for the Analysis of Biodiversity Change - Hamburg site; Centre for Taxonomy & Morphology; Zoological Museum; [3] University of Hamburg; Institute of Marine Ecosystem and Fishery Science, Marine ecosystem dynamicsp; [4] Leibniz-Institute of Freshwater Ecology and Inland Fisheries (IGB)*
10:00-10:15	**Naked Truths: Hypoxia Downregulates the Inflammasome of Naked Mole-Rats Following LPS Treatment** Kadamani, K. L.[1], Pamenter, M. E.[1] *[1]Department of Biology, University of Ottawa, Ottawa, ON, Canada*
10:15-10:30	**Turtle Hepatocytes Oxy-Conform to Extremely Low O_2 Tensions and Require Cyanide to Elicit Ion Channel Arrest.** Lari, E., Saganthan, H., Di Stefano, D., Myrka, A.. Buck, L. *Department of Cell and Systems Biology, Toronto, ON and Department of Ecology and Evolutionary Biology, Toronto, ON.*

11:00-13:00

President's Award/Prix du Président

Postdoc Talks/Présentations postdocs

Location/Lieu: **Ballroom A and B**

Chair/Animé par: **Tamara Franz-Odendaal** (Mount Saint Vincent University, CSZ-SCZ first vice-president)

11:00-11:10

Introduction and Welcome

11:10-11:30

Lebenzon, J.E., Diaz, T., Williams, C.M.

Department of Integrative Biology, University of California Berkeley, Berkeley, CA, USA

Break it 'til you make it: Selective flight muscle histolysis in the California variable field cricket

Many animals have evolved the capacity to remodel their muscle to match varying energetic demands of their life cycle. Skeletal muscles are key to locomotor performance and dispersal, making the ability to grow and maintain this muscle crucial for increasing organismal fitness. However, maintaining, and using skeletal muscle is energetically expensive. In insects, the energetic costs of their skeletal-like flight muscles lead to resource-based trade-offs that limit early life reproductive investment. When the costs of using and maintaining flight muscle outweigh the potential dispersal benefits, many insects can selectively break down (histolyse) their flight muscle to reallocate those resources towards reproduction. California variable field crickets (*Gryllus lineaticeps*) histolyse their flight muscle in this flight for reproduction trade-off, which results in the selective breakdown of one set of flight muscles (dorsolongitudinal; DLM) and maintenance of the neighbouring dorsoventral muscle (DVM). Despite the importance of flight muscle histolysis on cricket reproduction, we have a limited understanding of the mechanisms underlying the massive cellular re-organization required for this histolysis. Here, our objectives were to understand the structural and functional changes associated with muscle histolysis, explore how crickets integrate upstream signals into downstream selective remodeling of DLM and maintenance of DVM, and use RNAi to establish causal links between candidate regulatory pathways and selective flight muscle histolysis. The ability to selectively degrade a single muscle type is unique to insects, thus understanding

the mechanisms underlying flight muscle histolysis can contribute to a broader understanding of how muscle plasticity has evolved to combat energetic challenges.

11:30-11:50

Weinrauch, A.M., Bouyoucos, I.A., Anderson, W.G.

Department of Biology, University of Manitoba, Winnipeg, MB, Canada

Identification of alternate stress hormone production in elasmobranchs

The stress response is highly conserved across vertebrates with the corticosteroids cortisol and corticosterone mediating this response. Elasmobranchs have a unique corticosteroid, 1α-hydroxycorticosterone (1α-OH-B) and were previously not thought to produce cortisol. The complete biosynthetic pathway for 1α-OH-B is unknown but is hypothesized to involve symbiotic bacteria in the steroidogenic interrenal tissue, that are known to metabolize steroids including cortisol. Thus, we predicted that reducing the microbial population could elicit increased circulation of cortisol. First, sequencing the Pacific spiny dogfish (*Squalus suckleyi*) interrenal transcriptome verified the presence of 17α-hydroxylase (cyp17a), an enzyme necessary to produce steroid precursors of cortisol. Next, dogfish were exposed to either low salinity (21 ppt) or antibiotics, both of which have been shown to reduce microbial activity in *S. suckleyi*. Cortisol was not detected in plasma prior to low salinity exposure; however, following exposure, cortisol reached detectable levels in every dogfish. Further, transcripts of some steroidogenic enzymes upregulated during low salinity. Antibiotic exposure increased the number of dogfish with detectable cortisol (81%) compared to gavaged controls (38%). To investigate physiological actions of cortisol, cortisol was implanted and blood was collected over 72h. Cortisol implantation decreased corticosterone (indicative of negative feedback) and glucose concentrations, suggestive of a putative glucocorticoid effect. Overall, we demonstrate that despite the decades-long belief of an absence of cortisol, *S. suckleyi* do produce cortisol in a context-dependent manner, and that cortisol has putative glucocorticoid actions in this elasmobranch. These data have implications for understanding endocrine control of mineral and energy balance in elasmobranchs.

11:50-12:10

Thompson A.[1], Masood N.[1], Easwaramoorthy M.[1], Hartenstein P.[2], Laframboise L.[1], Chow E.[3], Choh V.[3], McCulloch D.[3], Manzon R.[2], Somers C.[2], and Wilson J.Y.[1]

[1]Department of Biology, McMaster University, Hamilton, Canada; [2]Department of Biology, University of Regina, Regina, Canada; [3]School of Optometry and Vision Science, University of Waterloo, Waterloo, Canada

Increased rearing temperature delays the development of the thyroid, alters eye development and impairs its function, and perturbs ecologically relevant behaviours of the yellow perch (*Perca flavescens*)

Due to anthropogenic impacts, water temperatures are projected to rise by nearly 3°C over the coming decades. Elevations in temperature may be of concern for the yellow perch (*Perca flavescens*), a cool-water fish of great cultural and economic importance. We have previously determined that small elevations in temperature can alter growth rates, morphology, and the metabolism of larval yellow perch. Suspecting endocrine disruption, we tested the hypothesis that elevations in temperature dysregulate the thyroid system in developing perch. We reared yellow perch at 12, 15 (optimal), and 18°C during embryogenesis, with hatched fish raised at common garden conditions (18°C). Antibody staining revealed that thyroid follicles first appear 1 day post-hatch (DPH) in fish reared at 12 and 15°C but are only first seen at 4 DPH in fish reared at 18°C, with molecular investigations into genes such as *slc5a5* (iodide transporter), and *dio3* (thyroid hormone inactivating enzyme) supporting these observations. As the thyroid system has been linked to the development of the eye, we investigated eye growth, discovering that the eyes of 18°C fish are larger. Using electroretinograms, we show that increased rearing temperature leads to higher responses of the eye to light. A novel light behavioural test demonstrated that yellow perch larvae reared at elevated temperatures (18°C) cannot discern differences in low levels of light. When presented with a foraging challenge, increased temperature during rearing leads to reductions in prey consumption of larval yellow perch (12°C=15°C>18°C). Together, the results generated in this study suggest that yellow perch are sensitive to increases in temperature, a concern for a species that has experienced significant population declines.

12:10-12:30

Cieri, R.L.

Department of Zoology, University of British Columbia

Adaptations for huge body size and extreme ventilatory mechanics in cetacean pulmonary airway morphology and flow patterns

The pulmonary systems of Cetaceans are the largest in evolutionary history and tell a fascinating story about adaptation to marine life. Biomechanical challenges to lung design

in cetaceans include not only extreme body size, but the repeated collapse and reinflation of lungs due to external pressure during diving, and extreme ventilatory dynamics due to exceptionally short breaths and high tidal volumes - approaching 90% of total lung capacity during short surface bouts. Using morphological analysis of pulmonary airways segmented from computed tomography (CT) scans of inflated lungs from 13 species, we show that airway morphology differs substantially from terrestrial mammals and varies substantially among cetacean species.

One main finding is that the conducting airways in deep-diving, slow-ventilating beaked whales (Ziphiidae) are relatively larger than those in shallow-diving, fast-ventilating dolphins (Delphinidae), suggesting that the need to store lung gas in the primary airways during lung collapse during diving may be a more important driving factor in airway design than maximizing pulmonary flow rates. By using computational fluid dynamics simulations built using one-dimensional tree-growing algorithms to extend the pulmonary tree down to the pulmonary acini, we show that branching angles and diameter ratios evolved to enable extremely fast and short ventilation in cetaceans. By combining our airway sophisticated models with traditional measurements and LiDAR/photogrammetry models of lung anatomy from species which are too large to CT scan, we can perform an allometric analysis of airway shape and size in cetaceans and simulate how breathing works in the largest lungs of all time.

12:30-12:50

Kong, J.D., Muzzatti, M.J., Vadboncoeur, É., Bertram, S. M., MacMillan, H.A.

Department of Biology, Carleton University, Ottawa, Canada

Effects of diet and temperature on cricket performance

Insects are reared en masse for releases related to conservation or pest management, for food and feed production and waste processing, as well as important services like pollination, decomposition, and disease control. Physiological performance fundamentally underpins the quantities and qualities of insects necessary for success in mass rearing programs. Such characteristics include growth, development and survival that, in turn, are modulated by extrinsic factors such as temperature and diet. However the relationships between these factors and how they modulate performance deficits and gains at the scale of a mass rearing operation are poorly understood. Here, I showcase how rearing temperature and diet affects the performance of farmed crickets (*Gryllodes sigillatus*) through trade offs in growth, development and survival. Higher rearing temperatures (30-38°C) resulted in rapidly maturing and larger crickets at the expense of lower survival and shorter lifespans compared with lower rearing temperatures (20-28°C). Group reared

crickets reared on higher protein diets did not differ in growth and development metrics but had lower survival than control diets, and these patterns contrasted with individually reared crickets. I discuss how manipulating insect physiology through rearing conditions and context can ensure the continued success and optimisation of mass rearing programs and the services they provide.

14:30-16:00

CMDB symposium

Developmental and Functional Biophysics in living systems

Location/Lieu: **Shediac A**

Chair/Animé par: **Natasha Mhatre** (University of Ottawa)

14:30-15:10

Standen E.

Department of Biology, University of Ottawa, Ottawa, ON, Canada

How body and armour act as passive constraints on locomotor output

The control of locomotion is a complex interaction of neural signals from the brain, the spinal column and sensory inputs. How the resultant motor outputs contribute to effective kinematics depends upon the material properties of body tissues, as well as the mechanical properties of the environment surrounding the animal. This talk will highlight two different experiments that use very different approaches to quantify the passive mechanical components involved in elongate fish locomotion. The first experiment will focus on American eel and measures the active and passive kinematic output of spinally transected eels. The second experiment looks at how body armour contributes to mechanical performance and how this contribution changes over ontogeny. Together these projects reveal that mechanical constraint and coupling between body parts is a critical influence in the complex kinematic output resulting from neural-motor signals.

15:10-15:50

Simsek M.

Department of Biology, McMaster University, Hamilton, ON, Canada

Molecular oscillators and gradients: How to make repetitive segments of the vertebrate

Diverse species across metazoa display metameric structures segmenting the major body axis for modularity, organisation, and guiding organ formation. Vertebrate embryos sequentially form repetitive sets of somites alongside the midline, with well-controlled species specific periodicity, sizes, and total counts. Fgf/Erk signalling establishes a tail-to-somite 'morphogen' gradient to instruct precise positional information to cell neighbourhoods. Recently we showed that the cell-autonomous molecular 'segmentation clock' reciprocates its oscillatory dynamics onto Fgf/Erk gradient. Oscillating Erk gradient

is necessary and sufficient to instruct tail mesoderm cells to commit into somite patterning. My current lab focuses on the space and time mechanisms of Erk gradient control in the vertebrate embryo. We combine quantitative microscopy, single-cell level analysis of signal dynamics, and data-informed predictive modeling. Zebrafish with its translucent, accessible, and multiplexed embryonic development as well as tractable genetics is our favorite organism. We aim to discover the conserved mechanisms of sequential segmentation across species and design principles of morphogen positional information in embryos.

Oral contributed presentations/Présentations orales

14:30-16:30

Toxicology 2

Location/Lieu: **Shediac B**

Chair/Animé par: **Erin Leonard** (Wilfried Laurier University)

14:30-14:45	**The Scale of Road Salt Contamination in Urban Freshwater Streams of Vancouver's Lower Mainland: Effects of Repeated Salt Pulses on Developing Coho *Salmon (Oncorhynchus kisutch)*** Kilgour, C. L.[1], Winter, C.[1], Brauner, C. J.[1], Wood, C. M.[1], Schulte, P. M.[1] *[1]Department of Zoology, University of British Columbia, Vancouver, BC, Canada*
14:45-15:00	**Road Salt Creating A Slippery Slope for Pacific Salmon: Unraveling the Impact of Road Salt on the Development and Physiology of Coho Salmon (*Oncorhynchus kisutch*)** Winter, C., Kilgour, C., Brauner, C.J., Schulte, P.M., & Wood, C.M. *Department of Zoology, University of British Columbia, Vancouver, BC, Canada*
15:00-15:15	**Accumulation of waterborne selenite and its toxic effects in Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*)** Klaczek, C. E.[1], Glover, C. N.[1,2], Goss, G. G.[1] *[1]Department of Biological Sciences, University of Alberta, Edmonton, Canada; [2]Faculty of Science and Technology and Athabasca River Basin Research Institute, Athabasca University, Athabasca, Canada*
15:15-15:30	**The effects of temperature on lampricide tolerance in juvenile lake sturgeon** Bouffard, E. N. [1]*, Koledin, M. [1], Mitrovic, D. [1], Quijada-Rodriguez, A. R. [1], Jeffries, K.M. [2], Wilkie, M. P. [1] *[1]Department of Biology, Wilfrid Laurier University, Waterloo, Ontario, Canada; [2]Department of Biological Sciences, University of Manitoba, Winnipeg, Manitoba*
15:30-15:45	**The ecotoxicological risks of recycling aquaculture wastewater: a transcriptomic approach using the fathead minnow EcoToxChip** Robertson, K.[1], Blandford, N.[1], Dickenson, L.[1], Jeffries, K.[1] , Hecker, M.[2] , Hardy, B.[3] & Palace, V.[4] *[1]Department of Biological Sciences, University of Manitoba, Winnipeg, Canada; [2]University of Saskatchewan, Saskatoon, Canada; [3] Myera Group, Manitoba, Canada; [4] IISD – Experimental Lakes Area, Canada*
15:45-16:00	**Fishes in murky waters: Effects of TSS on fish gills and swimming performance** Montoya, X.C.[1], Smith, C.[2], Thompson, W.A.[2] Wilson, J.M.[1], Vijayan, M.M.[2] *[1]Department of Biology, Wilfrid Laurier University, Waterloo, Canada; [2]Department of Biological Sciences, University of Calgary, Calgary, Canada*
16:00-16:15	**Assessing the Toxicity of Metals to Fathead Minnows by Observing Ventilation and Behavioural Endpoints in Response to Hypoxia** Nykamp, N. M. [1]; Leonard, E. M. [1] *[1] Department of Biology, Wilfrid Laurier University, Waterloo, Ontario, Canada*
16:15-16:30	**How the Hypercarnivorous Ancestry of Parasitic Lampreys May Have Made Them Vulnerable to Lampricides.** Wilkie, M.P.[1], Lawrence, M.J.[2], Mitrovic, D.[1,3], Bragg, L.M.[3], Servos, M.R.[3], Docker, M.F.[2], and Jeffries, K.M.[2] *[1]Department of Biology, Wilfrid Laurier University; [2] Department of Biological Sciences, University of Manitoba; [3] Department of Biology, University of Waterloo*

14:30-16:30

Gut Physiology

Location/Lieu: **Shediac C**

Chair/Animé par: **Marishia Agard** (York University)

14:30-14:45	**Unveiling the role of gastric acid secretion in post-prandial energetics and assimilation in *Astyanax mexicanus*** Ferreira, P.G., Wilson, J.M. *Department of Biology, Wilfrid Laurier University, Waterloo, Canada*
14:45-15:00	**Butyrate Supplementation and Temperature: Host vs Resident Impacts on Growth, Metabolism, and Gut Microbiome Composition in Sailfin Molly (*Poecilia latipinna*)** Trovato J., Bucking C. *Department of Biology, York University, Toronto, Canada*
15:00-15:15	**Hibernators salvage urea carbon during resource-limited winter to facilitate gut microbial acetogenesis** Regan, M.D.[1], Chiang, E.[2], Grahn, M[3]., Assadi-Porter, F.M.[4], Suen, G.[2], Carey, H.V.[3] *[1] Department of Biology, University of Montréal, Montreal, Canada; [2]Department of Bacteriology, University of Wisconsin-Madison, Madison, WI, USA; [3] Department of Comparative Biosciences, University of Wisconsin-Madison, Madison, WI, USA; [4] IsoMark Health LLC, Madison, WI, USA.*
15:15-15:30	**Functional characterization RYamides and deorphanization of their receptors in the yellow fever mosquito, *Aedes aegypti*** Tan, J.[1]* and Paluzzi, J.P.[1] *[1]Department of Biology, York University, Toronto, ON, Canada*
15:30-15:45	**Environmental influence on microbiome structure and function in the starlet sea anemone (*Nematostella vectensis*) across wild and laboratory conditions.** MacPherson, J. [1], Koçyiğit, S. [1], Little, A.G. [2], and Bucking, C. [1] *[1] Department of Biology, York University, Toronto, ON, Canada; [2] Department of Biology, McMaster University, Hamilton, ON, Canada*
15:45-16:00	**Effects of Swim Bladder Non-Inflation on the Gut of Larval Zebrafish (*Danio rerio*)** Caroline Blakely, Timothy Erickson, Kadri Lawrence, Benjamin Perrett *Department of Biology, University of New Brunswick, Fredericton, NB, Canada*
16:00-16:15	**Nitrogenous waste and acid-base dynamics in the gut of rainbow trout after a single meal. I. Physiology** Wood, C.M.[1], Wilson. J.M.[2] *[1] Department of Zoology, University of British Columbia, Vancouver, B.C., Canada; [2] Department of Biology, Wilfrid Laurier University, Waterloo, Canada*
16:15-16:30	**Nitrogenous waste and acid-base dynamics in the gut of rainbow trout after a single meal. II. Gene Expression.** Wilson. J.M.[1], Wood, C. M.[2] *[1] Department of Biology, Wilfrid Laurier University, Waterloo, Canada* *[2]Department of Zoology, University of British Columbia, Vancouver, Canada*

14:30-16:30

Thermal Physiology of fish 2

Location/Lieu: **Ballroom AB**

Chair/Animé par: **Ian Bouyoucos** (University of Manitoba)

14:30-14:45	**Taurine efflux supports cardiac output under acute thermal stress by protecting cell volume** MacCormack, T. J.[1], El, N.[1], Haché, C. M.[1], LaHay, M. E.[1], Smallwood, E. C.[1], Christjansen, M.[1], Pabody, C. M.[1], Lamarre, S. G.[2] *[1] Department of Chemistry and Biochemistry, Mount Allison University, Sackville, NB, Canada; [2] Department of Biologie, Université de Moncton, Moncton, NB, Canada*
14:45-15:00	**Seasonal changes in the thermal tolerance, sensitivity, and regulation of cardiac function in fishes with different overwintering strategies** Williams, E.P.[1], Gilbert, M.J.H.[1,2], Kieffer, J.[1], and Speers-Roesch, B.[1] *[1] Department of Biological Sciences, University of New Brunswick, Saint John, Canada; [2]Institute of Arctic Biology and Department of Biology and Wildlife, University of Alaska, Fairbanks, United States*
15:00-15:15	**Rapid Thermal Acclimation of Cardiac and Whole Animal Heat Tolerance in Lab and Field Populations of a Eurythermal Fish, the Mummichog (*Fundulus heteroclitus*)** Rivard, G., Gilbert, M.J.H., and Speers-Roesch, B. *Department of Biological Sciences, University of New Brunswick, Saint John, Canada*
15:15-15:30	**Dogfish heart rate peaks in warm water before they get agitated** Bouyoucos, I. A.[1 2], Weinrauch, A. M.[1 2], Jeffries, K. M. [1], Anderson, W. G.[1 2] *[1]Department of Biological Sciences, University of Manitoba, Winnipeg, Canada; [2]Bamfield Marine Sciences Centre, Bamfield, Canada*
15:30-15:45	**Facing an increasingly variable world : metabolic responses throughout an heatwave event in an endangered freshwater fish (*Zingel asper*)** Chloé Souques[1], Julia Watson[1], Julie Le Guyader[1], Ludovic Guillard[1], Laetitia Averty[2], Candice Bastianini[2], Angeline Clair[2], Lilian Redon[1], Yann Voituron[1], François-Xavier Dechaume-Moncharmont[1], Elisa Thoral [3], Loïc Teulier[1] *[1]Université Claude Bernard Lyon 1 , CNRS, ENTPE, UMR 5023 LEHNA, F-69622, Villeurbanne, France; [2]Plateforme Animalerie Conventionnelle et Sauvage Expérimentale de la Doua (ACSED), Fédération de Recherche 3728, Univ Lyon, Université Claude Bernard Lyon 1 , CNRS, ENS-Lyon, INRAE, INSA, VetAgroSup, F-69622, Villeurbanne, France; [3] - Lund University, Department of Biology, Section for Evolutionary Ecology, Sölvegatan 37, SE-223 62, Lund, Sweden*
15:45-16:00	**Seasonal temperature induced heart-collagen remodeling response in the rainbow darter (*Etheostoma caeruleum*)** Hamel, M. S. [1], Craig, P. M. [1] *[1] Department of Biology, University of Waterloo, Waterloo, Canada*
16:00-16:15	**Effects of a heatwave on cardiac mitochondrial respiration of a freshwater fish: the Rhône apron** Julia Watson[1], Chloé Souques[1], Julie Leguyader[1], Damien Roussel[1], Rémi Lassus[2], Ludovic Guillard[1], Angeline Clair[3], Laëtitia Averty[3], Candice Bastianini[3], Lilian Redon[1], Yann Voituron[1], Martin Daufresne[2], François-Xavier Dechaume-Montcharmont[1], Elisa Thoral[4], Loïc Teulier[1] *[1] - Université Claude Bernard Lyon 1 , CNRS, ENTPE, UMR 5023 LEHNA, F-69622, Villeurbanne, France; [2] - INRAE, Aix Marseille Univ., RECOVER, Aix-en-Provence, France; [3] - Plateforme Animalerie Conventionnelle et Sauvage Expérimentale de la Doua (ACSED), Fédération de Recherche 3728, Univ Lyon, Université Claude Bernard Lyon 1 , CNRS, ENS-Lyon, INRAE, INSA, VetAgroSup, F-69622, Villeurbanne, France; [4] - Lund University, Department of Biology, Section for Evolutionary Ecology, Sölvegatan 37, SE-223 62, Lund, Sweden*

Poster Session

16:30-18:30

Location/Lieu: **Mezzanine and/et Ballroom C**

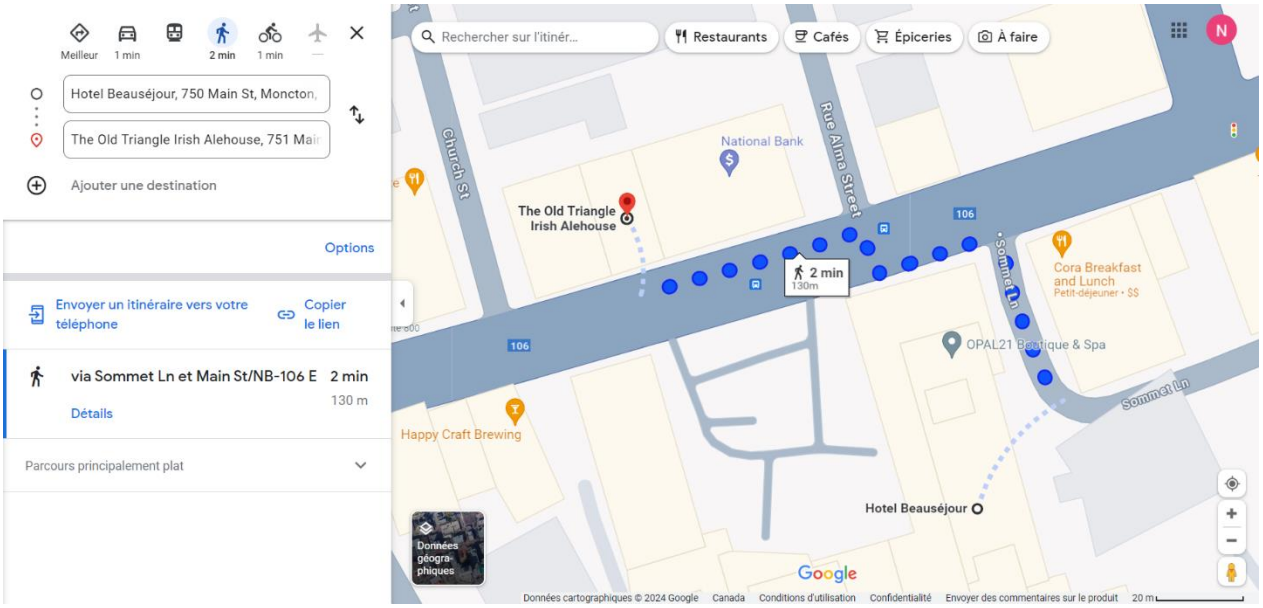
The number assigned to your poster (see 'poster abstracts') determine your presentation time: 4:30 to 5:30 PM for even-numbered posters, 5:30 to 6:30 PM for odd numbered posters.

Le numéro assigné à votre poster (voir 'résumé des posters') détermine l'heure de votre présentation: 16:30 à 17:30 pour les affiches portant un numéro pair, 17:30 à 18:30 pour les affiches portant un numéro impair.

Trainee Network Mixer

18:30-21:00

Location/Lieu: **Old Triangle Irish Pub**



Thursday/Jeudi, May/Mai 9

8:30-10:30	IIE symposium: The Evolution of Adaptive Plasticity	Shediac A
	Contributed sessions	- Shediac B (CMDB2) - Shediac C (Parasitology) - Ballroom A and B (Molecular and physiological thermal responses)
10:30-11:00	Coffee Break	Mezzanine
11:00-12:00	Boutillier New Faculty Award: Katie Marshall	Ballroom A and B
12:00-13:30	PIE, CMDB and IEE section lunch	Shediac A **(PIE)**, Shediac B **(CMDB)**, Shediac C **(IEE)**
13:30-15:30	Contributed sessions	- Shediac A (Cold invertebrates) - Shediac B (Mitochondria) - Shediac C (Stress and hormones) - Ballroom A and B (Fish hypoxia)
15:30-17:30	Workshop/Atelier 'Positive Peer Review'	Shediac A
19:00-	**Banquet**	Mezzanine, Ballroom A and B

8:30-10:30

IIE symposium

The Evolution of Adaptive Plasticity

Location/Lieu: **Shediac A**

Chair/Animé par: **Alexander Little** (McMaster University)

8:30-9:10

Draghi, J.A., Miller, C.M.

Department of Biological Sciences, Virginia Tech, Blacksburg, VA, USA

Ecological constraints and promoters shaping the evolution of plasticity

Adaptive plasticity is a potent but relatively rare strategy by which organisms can deal with heterogeneous environments. While theory can predict when plasticity is favorable, to understand its distribution in nature we must also understand the selection pressures acting on the initial mutational steps toward plasticity. In this talk I discuss a series of models designed to reveal how the evolution of plasticity may be constrained by pleiotropy or incomplete information, and how dispersal can sometimes alleviate these constraints. These models emphasize the multiple roles of spatial heterogeneity across scales. Spatial heterogeneity not only shapes selection on plasticity but also can impede and guide dispersal, creating ecological opportunities that may catalyze the evolution of innovative changes like plasticity. Together, these models point to underappreciated ways in which complex environments can help elicit complex adaptations.

9:10-9:50

Dworkin, I.

Department of Biology, McMaster University

A significant Genotype-by-interaction term in an ANOVA tells you nothing about the evolution of phenotypic plasticity: Towards a measurement-informed approach to the study of the evolution of phenotypic plasticity

Evolutionary causes and consequences of phenotypic plasticity have long been, and continue to remain, an area of active research. In part, this is due to the observation that trait expression - from gene expression, through cellular architecture, physiology, morphology, behaviour and ultimately organismal performance - depend to varying degrees, on environmental factors. This is generally coupled with the observation that the

degree of environmental sensitivity of trait expression, depends not only on the agent of plasticity (the environmental variables), or the target phenotype, but on genetic variation in the degree of plasticity. Evaluating Genotype-by-Environment (GxE) interactions has played a prominent role in the phenotypic plasticity literature for decades. Despite this, and the evidence that GxE is almost as common as plasticity itself, our understanding of the relative contributions of GxE (along with genetic and environmental effects per se) to phenotypic variation is inadequate to answering broader questions regarding plasticity. In this talk I argue that this is in large part due to how biologists frame results of statistical modeling of experimental work including GxE, and in particular how focusing on ANOVA tables (and p-value centric approaches) is limited in value. I will describe how developing biologically meaningful measures and directly assessing magnitudes of effects enhances interpretation, and utility to all researchers. I will discuss these issues through examples from our own work on the evolution of sexual size and shape dimorphism within and among species of Drosophila.

Oral contributed presentations/Présentations orales

8:30-10:30

CMDB2

Location/Lieu: **Shediac B**

Chair/Animé par: **Kevin Duclos** (University of Calgary)

8:30-8:45	**Walking on sand: Kinematic and behavioural response to sand fouling in the purple sea urchin** Lutek, K.[1], Drummond, M.S.[1], Baker, Z.[1], Stark, A.Y.[1] *[1] Department of Biology, Villanova University, Villanova, PA, USA*
8:45-9:00	**Neural specification in partial embryos of the annelids Capitella teleta and *Platynereis dumerilii*** Webster, N.B.[1], Carrillo Baltodano, A.[2], Davila Sandoval, J.[3], Özpolat, B.D.[4], Meyer, N.P.[3] *[1] Department of Biology, University of Saskatchewan, Saskatoon, Canada; [2] School of Biological and Behavioural Sciences, Queen Mary University of London, London, UK; [3] Department of Biology, Clark University, Worcester, USA; [4] Department of Biology, Washington University, St. Louis, USA*
9:00-9:15	**The effect of developmental phenotypic plasticity on morphological and metabolic traits associated with flight in the hawk moth, *Manduca sexta*** Facina, E.[1], Darveau, C.-A[1] *[1] Department of Biology, University of Ottawa, Ottawa, Canada*
9:15-9:30	**How spider bodies set the communication frequency** Reese Gartly[1], Lachlan Fisher[1], Mouad Elganga[1], Benjamin D. Rubin[1], Andrew Mason[2], and Natasha Mhatre[1] *[1] University of Western Ontario, Department of Biology, London, Ontario, Canada; [2] University of Toronto at Scarborough, Department of Biology, Scarborough, Ontario, Canada*
9:30-9:45	**Evolution of sensory systems: extreme adaptation to low food by deep sea glass sponges** Matveev, E.[1], Kahn, A.S.[1,2], Eerkes-Medrano, D.[1],[3], Ludeman, D.A.[1], Aragonés Suárez, P.[1], Yahel, G.[4], Leys, S.P.[1] *[1] Department of Biological Sciences, University of Alberta, Edmonton, AB, Canada; [2] Moss Landing Marine Laboratories, San Jose State University, CA, USA; [3] Ecology and Conservation Group, Marine Scotland Science, Aberdeen, Scotland; [4] Faculty of Marine Science, Ruppin Academic Center, Israel*
9:45-10:00	**Neuroanatomy of the biogenic amines octopamine and norepinephrine in the central nervous systems of freshwater pulmonate snails** Wyeth, R.C[1], Imai, J.[2], Tweedie-Pitre, V.[1], Beach, G..[2], Reunova, Y.[1], Croll, R.P.[2] *[1] St. Francis Xavier University; [2] Dalhousie University*
10:00-10:15	**More Than a Feeling: The importance of sensorimotor experience in postembryonic brain development** Hall, Z.J., Tropepe, V. *Department of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada; Department of Cell & Systems Biology, University of Toronto, Toronto, Ontario, Canada*
10:15-10:30	**Always a bigger fish: Developmental mechanisms and phenotypic divergence of a giant threespine stickleback population** Perry, S.[1], Duclos, K.[2], Jamniczky, H.[2] *[1] Department of Biological Sciences, University of Calgary, Calgary, AB, Canada; [2] Cumming School of Medicine, University of Calgary, Calgary, AB, Canada*

8:30-10:30

Parasitology

Location/Lieu: **Shediac C**

Chair/Animé par: **Luis Anholeto** (Acadia University)

8:30-8:45	**Investigating parasite densities for the detection of oxylipin signaling molecules** Sehgal, J.[1], Aukema, H. M.[2], Detwiler, J. T.[1] *[1]Department of Biological Sciences, University of Manitoba, Winnipeg, Canada; [2]Department of Food and Human Nutritional Sciences, University of Manitoba, Winnipeg, Canada*
8:45-9:00	**Transcriptome Responses of Atlantic Salmon of Different Families to Sea Lice Infection Under Different Temperature Conditions** Ghanei-Motlagh, R.[1], Cai, W.[2] , Whyte, S. K.[1], Garber, A. F.[3], Fast, M. D.[1] *[1] Department of Pathology and Microbiology, Atlantic Veterinary College, University of Prince Edward Island, Charlottetown, PEI, Canada; [2] Department of Infectious Diseases and Public Health and State Key Lab of Marine Pollution, Jockey Club College of Veterinary Medicine and Life Sciences, City University of Hong Kong, Kowloon Tong, Hong Kong; [3] Huntsman Marine Science Centre, St. Andrews, New Brunswick, Canada*
9:00-9:15	**Parasitic Castration by the Cestode *Ligula intestinalis*: Elucidating Mechanisms that Alter Fertility of Host Fishes** Fraser, M.L. [1,2], MacLellan, S.R. [1], Duffy, M.S. [1,2] *[1] Department of Biology, University of New Brunswick, Fredericton, NB, Canada; [2] Canadian Rivers Institute*
9:15-9:30	**Developing an in vitro Infection Model for the Microsporidian Parasite *Spraguea americanus* in Rainbow Trout Cells.** Noah Rogozynski[1], Brian Dixon[1] *[1] Department of Biology, University of Waterloo, Waterloo, ON, Canada*
9:30-9:45	**One Health at the top of the world: *Toxoplasma gondii* in wildlife in the Canadian North** Jenkins, E. J.[1], Bouchard, E. [1,2], Gouin, G. [3], and Hernandez-Ortiz, A.[1] *[1] Department of Veterinary Microbiology, University of Saskatchewan, Saskatoon, SK; [2] Environment and Climate Change Canada, St-Hyacinthe, QC; [3] Nunavik Research Centre, Makivik Corporation, Kuujjuaq, QC*
9:45-10:00	**Gastrointestinal parasite communities overlap among sympatric humans, vervet monkeys, livestock, and dogs.** Upadhayay, P.[1], Červená, B.[2], Kváč, M.[3,4], Noskova, E.[2,5], Ilik, V.[2, 5], Schoof, V. A. M.[1, 6] *[1] Department of Biology, Faculty of Graduate Studies, York University, Toronto, Ontario, Canada; [2] Institute of Vertebrate Biology, Czech Academy of Sciences, Brno, Czech Republic; [3] Institute of Parasitology, Biology Centre, Czech Academy of Sciences, České Budějovice, Czech Republic; [4] Faculty of Agriculture and Technology, University of South Bohemia in České Budějovice, České Budějovice, Czech Republic; [5] Department of Botany and Zoology, Faculty of Science, Masaryk University, Brno, Czech Republic; [6] Bilingual Biology Program, Department of Multidisciplinary Studies, Glendon College, York University, Toronto, Ontario, Canada*

8:30-10:30

Molecular and physiological thermal responses

Location/Lieu: **Ballroom A and B**

Chair/Animé par : **Analisa Lazaro-Côté** (University of Manitoba)

8:30-8:45	**Osmorespiratory Compromise in Triploid Rainbow Trout (*Oncorhynchus mykiss*)** Concannon, A. V.[1], Garber, A. F.[2], Robertson, W. D.[3] Benfey, T. J.[1] *[1] Department of Biology, University of New Brunswick, Fredericton, Canada; [2] Huntsman Marine Science Centre, St. Andrew's, Canada; [3] Ocean Trout Canada, Bedford, Canada*
8:45-9:00	**A coastal fish can be vulnerable to the intensification of heat waves with ocean acidification.** Gwangseok R. Yoon, Gary J. Ren, Elissa Khodikian and Cosima S. Porteus *Department of Biological Sciences, University of Toronto Scarborough*
9:00-9:15	**Interactive effects of elevated temperature and venlafaxine on mitochondrial respiration and enzyme capacity in Nile tilapia (*Oreochromis niloticus*)** Borowiec, B.G.[1], Robichaud, K.B.[1], Craig, P.M. *[1]Department of Biology, University of Waterloo, Waterloo, ON, Canada*
9:15-9:30	**Inter-individual variation and repeatability of critical thermal maximum (CTmax) across acclimation temperatures in killifish** Rost-Komiya, B., Schulte, P.M. *Department of Zoology, University of British Columbia, BC, Canada*
9:30-9:45	**Does early life freshwater tolerance or adult tolerance of combined stressors limit freshwater colonization in stickleback fishes?** Young-Veenstra, S.J., Dalziel, A.C. *Biology Department, Saint Mary's University*
9:45-10:00	**You're hot then you're cold: Early life exposure to diel thermal variation alters microRNA expression and performance in zebrafish.** Gavarikar, S. M.[1], Craig, P. M.[1] *[1] Department of Biology, University of Waterloo, Waterloo, Canada.*
10:00-10:15	**Characterizing behavioral and physiological changes in fish with changing thermal regimes** Hajji, A.L. [1], Rogers, S.M. [1], Lucas, K.N. [1] *[1] Biological Sciences, University of Calgary, Calgary, AB, Canada*
10:15-10:30	**Testing traditions: Validating mitochondrial density markers in ectothermic species** Aminot, M.[1], Lamarre, S.G.[2], Pichaud, N.[1] *[1] Département de chimie et biochimie, Université de Moncton, Moncton, NB, Canada; [2] Département de biologie, Université de Moncton, Moncton, Canada*

11:00-12:00

Boutillier Award Lecture/Conférence du Prix Boutillier

New Investigator award/Prix Nouveau Chercheur

Location/Lieu: **Ballroom A and B**

Chair/Animé par: **Carol Bucking** (York University, CSZ president)

Katie Marshall, Department of Zoology, University of British Columbia

Dr. Marshall grew up in the small town of Elmira, Ontario. She attended Acadia University for her undergraduate, then began graduate studies with Brent Sinclair at Western University. She completed her PhD in 2013, had a short post-doc with Jennifer Baltzer at Wilfrid Laurier University, then received a Killam postdoctoral fellowship to work at UBC with Chris Harley. She then began a faculty position at the University of Oklahoma in 2016, then headed to the comparative physiology group at UBC in 2018 where she is now an associate professor.

Hot topics in "cool" adaptations: how Canada's invertebrates survive the winter

While the effects of climate change on heat exposures are well-documented, on the opposite end of the scale--the cold--there are also significant shifts. Cold tolerance more directly sets range limits than heat tolerance, and winters are shifting in temperature much more rapidly than summer. Yet we still know relatively little about the mechanisms of cold tolerance in many organisms, and even less about the potential for poleward range expansions in invertebrates under climate change. The work in my laboratory has focused on two main models systems for exploring these ideas: the eastern spruce budworm *Choristoneura fumiferana*, and the many freeze tolerant animals of the West Coast intertidal zone. The eastern spruce budworm is Canada's most destructive forest insect pests, and is on the move with climate change. Over the past six years, our lab group has explored how plasticity in cold tolerance has evolved in spruce budworm, finding that populations vary in their ability to modulate glycolysis to increase glycerol production. In the intertidal zone, where freezing is unavoidable, we have explored how cold tolerance can evolve when osmolarity cannot be increased to improve tolerance. We found that ice binding protein activity is ubiquitous, and small compatible solutes like TMAO can be

upregulated to improve freeze tolerance. Taken together, our work has shown that by looking at the cold end of the temperature scale can yield new insights into adaptive evolution.

Oral contributed presentations/Présentations orales

13:30-15:30

Cold Invertebrates

Location/Lieu: **Shediac A**

Chair/Animé par: **Jackie Lebenzon** (University of California Berkeley)

13:30-13:45	**Does Borrelia burgdorferi, the bacterium causing Lyme Disease, improve the cold tolerance of black-legged ticks?** Lauzon, M.C.[1], van Oirschot, M.L.[2], Gough, A.L.[2], Toxopeus, J.[2], Ferguson, L.V.[1] *[1]Department of Biology, Acadia University, Wolfville, Canada; [2]Department of Biology, St. Francis Xavier University, Antigonish, Canada*
13:45-14:00	**Renal transcriptional plasticity during cold acclimation allows Drosophila melanogaster to prevent chill injury.** Dean, R. A.[1], DeNicola, E. H. M.[1], MacMillan, H. A.[1] *[1] Department of biology, Institute of Biochemistry, Carleton University, Ottawa, Canada*
14:00-14:15	**Harlequin ladybird, *Harmonia axyridis*, physiology is largely unaffected by fungal infection (*Hesperomyces virescens*), except for cold tolerance** Awde, D.A.[1], Žabová, B.[2], Vaněčková, K.[2], Řeřicha, M.[2], Knapp, M.[2] *[1] Department of Biology, Mount Saint Vincent University, Halifax, NS, Canada; [2] Department of Ecology, Faculty of Environmental Sciences, Czech University of Life Science Prague, Prague-Suchdol, Czechia*
14:15-14:30	**Latent chilling injuries and their link to the immune system in *Drosophila melanogaster*** El-Saadi, M. I., Allen, M. C., MacMillan, H. A. *Department of Biology, Carleton University, Ottawa, ON, Canada*
14:30-14:45	**Freeze frame: Cytoskeletal restructuring (or lack thereof) in freeze-tolerant crickets** van Oirschot, M, L.[1], Toxopeus, J.[1] *[1] Department of Biology, St. Francis Xavier University, Antigonish, Canada*
14:45-15:00	**Surviving the Chill: Unraveling the Mysteries of *Ambigolimax valentianus*' Slug Freeze Tolerance** Gill, L. T.[1], Udaka, H.[2], Marshall, K. E.[1] [1] Department of Zoology, University of British Columbia, Vancouver, Canada; [2] Division of Biological Sciences, University of Kyoto, Kyoto, Japan
15:00-15:15	**Bioprospecting Vancouver's Intertidal Zone for Novel Ice Binding Proteins** Moyes, N.H.W. [1], Bertram, A.K.[2], Marshall, K.E.[1] *[1]Department of Zoology, University of British Columbia, Vancouver, BC, Canada; [2]Department of Chemistry, University of British Columbia, Vancouver, BC, Canada*
15:15-15:30	**The mighty mito membrane: How do frozen crickets maintain mitochondrial function?** Saruhashi, S., Coulson, S.Z., Staples, J.F., Sinclair, B.J. *Department of Biology, Western University, London, Ontario, Canada*

14:00-15:30

Mitochondria

Location/Lieu: **Shediac B**

Chair/Animé par: **Fouzia Hader** (Carleton University)

13:30-13:45	
13:45-14:00	
14:00-14:15	**Mitochondrial microRNAs differ during hibernation in thirteen-lined ground squirrels (*Ictidomys tridecemlineatus*)** Robichaud, K. [1], Duffy, B.[2], Staples, J. F.[2], and Craig, P. M.[1] *[1] Department of Biology, University of Waterloo, Waterloo, Ontario, Canada; [2] Department of Biology, University of Western Ontario, London, Ontario, Canada*
14:15-14:30	**Cellular and Mitochondrial Response to Fluctuating Thermal Stress in *Drosophila melanogaster*** Hunter-Manseau, F.[1,2] , Cormier, J.[1,2] and Pichaud, N.[1,2] *[1] Department of Chemistry and Biochemistry, Université de Moncton, Moncton, NB, Canada; [2] New Brunswick Centre for Precision Medicine, Moncton*
14:30-14:45	**Long live the king: exploring the metabolomic signature of extreme longevities in bivalves.** Bertrand P.[1], Lemieux, H.[2,3], Derosiers, V.[1], Blier P.U.[1] *[1]Department of Biologie, Université du Québec à Rimouski, Rimouski, Qc, Canada; [2]Faculty Saint-Jean, University of Alberta, Edmonton, AB, Canada; [3]Department of Medicine, University of Alberta, Edmonton, AB, Canada*
14:45-15:00	**Plasticity of mitochondrial coupling efficiency: the last chance to survive in adverse environment?** Roussel, D.[1], Thoral, E.[2], Voituron, Y.[1], Teulier, L.[1] *[1] Université Claude Bernard Lyon 1 , CNRS, ENTPE, UMR5023 , LEHNA, Villeurbanne, France; [2] Lund University, Department of Biology, Lund, Sweden*
15:00-15:15	**ROS in Hibernation: Dynamics and Implications** Duffy, B. M., Staples, J. F. *Department of Biology, Western University, London, ON, Canada*
15:15-15:30	**Investigating a link between hydrogen sulfide biogenesis and aging in vertebrates using evolutionary analysis and molecular dockings** Gary J Ren, Frances Hauser, Nathan Lovejoy, Cosima Porteus *Deaprtment of Cell and System Biology, University of Toronto*

13:30-15:30

Stress and Hormones

Location/Lieu: **Shediac C**

Chair/Animé par: **Alex Quijada-Rodriguez** (Wilfried Laurier University)

13:30-13:45	**Characterization of glucose/glycogen metabolism during stress in larval sea lamprey, *Petromyzon marinus*** Quijada-Rodriguez A.R.[1], Doughty, N[1], Hall, D.J.[1], Wilkie, M.P.[1] *[1] Department of Biology, Wilfrid Laurier University, Waterloo, ON, Canada*
13:45-14:00	**Chronic Cortisol suppress Feeding by enhancing Hypothalamus-Specific Metabolite enrichment in Rainbow Trout Brain** Antomagesh, F.[1], Blanco, A.M.[2], Comesaña, S.[2], Soengas, J.L.[2], and Vijayan, M.M.[1] *[1] Department of Biological Sciences, University of Calgary, Calgary, Alberta, Canada; [2] Centro de Investigación Mariña, Laboratorio de Fisioloxía Animal, Departamento de Bioloxía Funcional e Ciencias da Saúde, Facultade de Bioloxía, Universidade de Vigo, Vigo, Spain*
14:00-14:15	**CRHR1 signalling modulates acute stress-related behaviour in larval zebrafish** Rajeswari, J. J, Gilbert, G. N. Y., Vijayan, M. M. *Department of Biological Sciences, University of Calgary, Calgary, Alberta*
14:15-14:30	**Investigating the Behavioural Consequences of Stress-Induced Inhibition to Forebrain Neurogenesis in Adult Zebrafish (*Danio rerio*)** Amanda Wiseman[1], Faith Young[1], Sarah Alderman[1] *[1] Department of Integrative Biology, University of Guelph, Guelph, Canada*
14:30-14:45	**Ultraviolet radiation - the neglected pervasive diurnal stressor** Franklin, C.E.[1], Cramp R.C.[1], Hird, C.[1], and Lundsgaard, N.[1] *[1] School of the Environment, The University of Queensland, Brisbane, 4072 , AUSTRALIA*
14:45-15:00	**Restricting pee is key: neuroendocrine inhibition of primary urine secretion in a major vector of human diseases** Sajadi, F.[1], Di Scipio, C.[1], Snan, L.[1], Vergara-Martínez, M.F.[1,2] and Paluzzi, J.P.[1] *[1]Department of Biology, York University, 4700 Keele Street, Toronto, ON, Canada; [2]Departamento de Biología Celular y Fisiología, Instituto de Investigaciones Biomédicas, Universidad Nacional Autónoma de México, Mexico City, Mexico.*
15:00-15:15	**Behavioural and transcriptional profiling of larval zebrafish exposed to environmentally relevant ammonia levels** Bernier, N.J.[1], Kwant, P.[2], de Jong, G.H.R.[1], Gorissen, M.[2] *[1] Department of Integrative Biology, University of Guelph, Guelph, Canada; [2] Department of Plant & Animal Biology, Radboud Institute for Biological and Environmental Sciences, Radboud University, Nijmegen, The Netherlands*
15:15-15:30	**Characterization of neuroepithelial cells across life stages of sea lamprey (*Petromyzon marinus*)** Sevova, R.L [1], Tigert, L.R [2], Singh, D. [3], Porteus C.S. *Department of Cells and Systems Biology, The University of Toronto Scarborough Campus, Scarborough, Canada*

13:30-15:30

Fish hypoxia

Location/Lieu: **Ballroom A and B**

Chair/Animé par: **Brittney Borowiec** (University of Waterloo)

13:30-13:45	**Tissue O_2 Supply as a Potential Trigger for Hypoxic Metabolic Depression in Fishes** Goudreau, A., Regan, M.D. *Department of Biology, University of Montréal, Montreal, QC, Canada*
13:45-14:00	**Does Chronic Hypoxia Elicit a Whole-animal Ketogenic Response in the Pacific Spiny Dogfish (*Squalus suckleyi*)?** Wahl, R. C., Morash, A. J. *Department of Biology, Mount Allison University, Sackville, NB*
14:00-14:15	**Goldfish (*Carassius auratus*) Exhibit a More Robust Response to Anoxia and Re-oxygenation at Colder Temperatures** Trzcinski, M.E.[1], Borowiec, B.[2], Wilkie, M.P.[1] *[1] Department of Biology, Wilfrid Laurier University, Waterloo, ON, Canada; [2] Department of Biology, University of Waterloo, Waterloo, ON, Canada*
14:15-14:30	**Adapting to low oxygen: enhancing hypoxia tolerance in brook trout (*Salvelinus fontinalis*) through acclimation and repeated exposure** Stairs, C. and Sacobie, C.F.D. *Department of Biology, University of New Brunswick, Fredericton, NB, Canada*
14:30-14:45	**Breathability versus Barricade: Gill morphology of *Kryptolebias marmoratus* in response to individual and combined exposures to hypoxia and high environmental ammonia?** Clow, T. M.[1], Rodela, T. M.[1] *[1] Department of Biology, Saint Francis Xavier University, Antigonish, Canada*
14:45-15:00	**Arctic char and cyclic hypoxia: a story that comes to an end…** Ducros, L.[1,2], Lavoie-Rochon, A.S.[1], Cohen, A.M.[3], Touaibia M.[2], Pichaud, N.[2], Lamarre, S. G.[1] *[1] Département de Biologie, Université de Moncton, Moncton, Canada; [2] Département de Chimie et Biochimie, Université de Moncton, Moncton, Canada; [3] Biological Mass Spectrometry Core Facility, Dalhousie University, Halifax, Canada*
15:00-15:15	**Evaluating The Toxicity Of Silver Nanoparticles On The Behaviour And Physiology Of Bristlenose Catfish** (*Ancistrus Cirrhosis*) Hache, C. M.[1], MacCormack, T. J.[1] *[1] Department of Chemistry and Biochemistry, Mount Allison University, Sackville, NB*
15:15-15:30	**Anaerobic swim performance and recovery of Pacific salmon during their spawning migration** Pleizier, N.,[1] Kusack, K. [1], Stambolian, S. [1], Robinson, K.[2], Patterson, D. [2], Venditti, J. [1], Eliason, E.[3] *[1]School of Environmental Science, Simon Fraser University, Burnaby, Canada; [2]Fisheries and Oceans Canada, Science Branch, Cooperative Resource Management Institute, School of Resource and Environmental Management, Simon Fraser University, Burnaby, Canada; [3]University of California, Santa Barbara, Department of Ecology, Evolution and Marine Biology, University of California, Santa Barbara, USA*

Workshop/Atelier: Positive Peer Review

15:30-17:30

Location/Lieu: **Shediac A**

Chair/Animé par: **Katie Gilmour** (University of ottawa), **Patricia Schulte** (University of British Columbia) and **Pat Wright** (University of Guelph)

Sponsored by:

Journal of Experimental Biology

BANQUET

From/À partir de 19:00

Location/Lieu: **Ballroom A and B**

With Award ceremony/ Avec Remise des prix

Friday/Vendredi, May/Mai 10

8:30-10:30

Field trip to Hopewell Rock/Sortie au Parc des Rochers Hopewell

Meet at 8:15 in front of the Hotel, coach departure at 8:30.

Rencontre à 8:15 devant l'Hôtel, départ de l'autobus à 8:30.

The tide will be at its lowest at 7:30 and at its highest at 13:30.

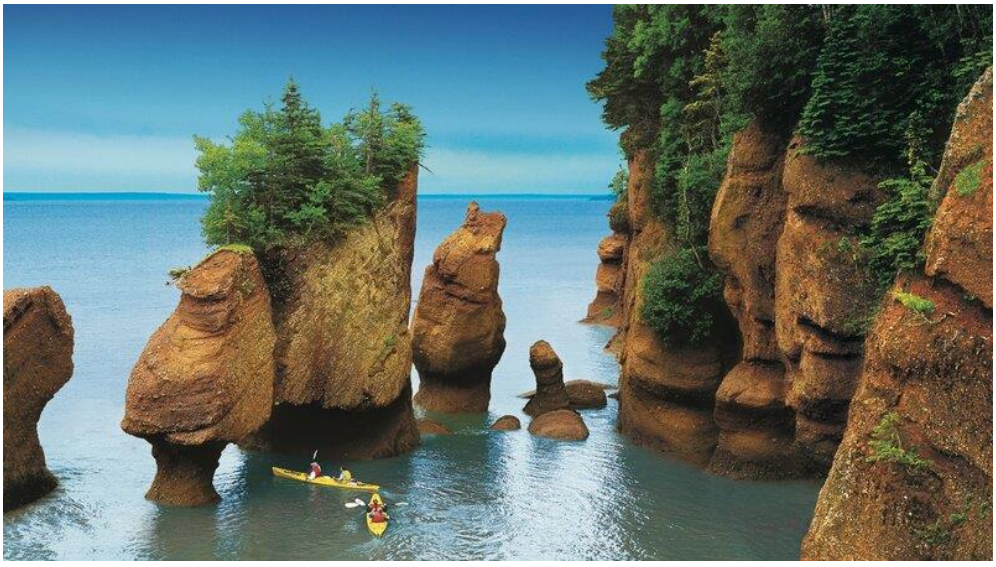
La marée sera la plus basse à 7h30 et la plus haute à 13h30.

Be sure to have warm clothes, the Fundy Bay is always colder than the city! You can also bring an extra pair of shoes if you want to walk on the muddy ocean floor!

Prévoyez des vêtements chauds, car la baie de Fundy est toujours plus froide que la ville! Vous pouvez également apporter une paire de chaussures supplémentaire si vous voulez marcher sur le fond boueux de l'océan !

Departure at around 14:30, back at the Hotel at 15:30.

Départ vers 14h30, retour à l'hôtel vers 15h30.



Abstracts for Oral Presentations

Tuesday/Mardi, May/Mai 7

Sensitivity of brown flatworms (*Dugesia dorotocephala*) to the lampricide TFM

Zajdlik, M.*, Sivarajah, R., Nunoo, R., Birceanu, O.

Department of Physiology and Pharmacology, Schulich School of Medicine and Dentistry, University of Western Ontario, London, ON, Canada

The lampricide, 3-trifluormomethyl-4-nitrophenol (TFM) is used to control invasive sea lamprey (*Petromyzon marinus*) populations in the Great Lakes. TFM uncouples mitochondria oxidative phosphorylation, leading to a mismatch between energy supply and demand, which eventually kills the animal. Recent studies have raised concern about risks of TFM resistance developing in the sea lampreys due to longstanding use, but studying multigenerational effects of TFM in fishes is time consuming and resource draining. The brown flatworms (*Dugesia dorotocephala*) could be used as a model for testing resistance, due to its ability to multiply by fission, with a short regeneration time. However, before modelling resistance, we need to have a better understanding of the effects of TFM on brown flatworm physiology. The current study is the first to determine how TFM affects behaviour, metabolites and energy reserves in brown flatworms. To this end, we exposed worms to increasing concentrations of TFM in soft water (alkalinity 100mg/L CaCO3, pH 7.59, temperature 20.2°C) and determined the 2h LC50 to be 2.79 mg/L. Locomotion was reduced within 5 min of exposure to TFM, in a dose-dependent manner, suggesting that the lampricide impacts motility. Next, animals were exposed to the 2h LC50 and samples were collected to measure whole-body lactate, glucose and glycogen at 0.5, 1.0, 1.5, 2.0 h of exposure. Our work to date has shown that flatworms are highly sensitive to TFM at environmentally relevant concentrations, leading to decreased locomotion and mortality that could be due to impaired ATP production

Multigenerational toxicity and metabolomics of lead from fishing gear to the freshwater snail, *Planorbella pilsbryi*

St-Hilaire, S.[1,2]*, Gilroy, È.[2] , Tétreault, G. [2], Frank, R. [2], McNabney, D.[2], Ravary, S.[2], Kim, J. [2], Leonard, E. M.[1]

[1]*Department of Biology, Wilfrid Laurier University, Waterloo, ON, Canada*

[2] *Aquatic Contaminants Research Division, Environment and Climate Change Canada, Burlington, ON, Canada*

Lead is a highly toxic element with no known biological function. It is estimated that over 460 tonnes of lead fishing gear is lost in Canada's waterways annually, posing a health risk to aquatic organisms. Lower trophic-level organisms, such as invertebrates, are an important food source within aquatic food-webs and are highly sensitive to metals in the ecosystem. Despite their importance and abundance in aquatic environments, freshwater snails (*Planorbella pilsbryi*) lack representation in environmental risk assessments. There is an ongoing debate in the fishing community on the impact of lost lead fishing gear to the aquatic environment. Although the toxicity of lead is well known, the toxicity of lead from fishing gear remains unknown. In order to address these gaps in the research, this project has two main objectives: (i) determine the toxicity

of lead from fishing gear to *P. pilsbryi* through multigenerational exposures; (ii) use metabolomics to investigate the mechanisms of lead toxicity to *P. pilsbryi*. It is hypothesized that lead from recreational fishing gear will hinder the growth and reproduction of freshwater snails. Metabolomic analysis will provide insight on the mechanistic toxicity of lead and the physiological pathways disrupted. This work will provide fundamental knowledge for metabolomics in freshwater snails, contributing relevant data to risk assessors on the risk of lead fishing gear and provide baseline data for future efforts restricting the use of lead fishing gear in Canada.

Use of a juvenile mummichog (*Fundulus heteroclitus*) bioassay to assess the effects of ammonia exposure on fish growth and the GH-IGF1 pathway

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Ammonia is known to inhibit fish growth; however, the mechanism(s) remain unclear. Mummichog (*Fundulus heteroclitus*), a small-bodied estuarine teleost inhabiting the east coast of North America, were used in these studies. Flow-through exposures were conducted, with weight measurements taken every three days as the apical growth endpoint. Liver gene expression was examined by qPCR for genes known to regulate growth, including growth hormone (*gh*), insulin-like growth factor 1 (*igf1*), and their respective receptors. Six-month-old mummichog exposed to 0, 125, or 200 mg/L ammonium chloride (NH_4Cl) for 21 days showed no growth differences; however, 200 mg/L NH_4Cl-exposed fish exhibited lower liver *ghra* and *ghrb* mRNA expression compared to control, suggesting a state of reduced sensitivity to liver GH. After 33 days, NH_4Cl-exposed fish weighed less but expressed higher liver *igf1* and *ghrb* mRNA expression, suggesting a compensatory mechanism for reduced growth. Three-month-old mummichog exposed to 250 mg/L NH_4Cl at 20 and 25°C for 21 days weighed less than controls, starting on Day 3 and Day 9 for fish at 20 and 25°C, respectively. NH_4Cl-exposed fish at 25°C exhibited higher liver *igf1ra* and *igf1rb* mRNA expression. These studies, along with previous literature, demonstrate that mummichog can tolerate high NH_4Cl concentrations relative to other fish and younger stages might be more susceptible to growth inhibition. Variability in molecular endpoints indicates the need for further studies and to consider alternate mechanisms, including other hormonal pathways, as the GH-IGF1 pathway may not be the primary mechanism involved in decreasing fish growth when exposed to ammonia.

It doesn't pay to have a big mouth: how microplastic ingestion scales with insect body size

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Microplastics (MPs; plastics <5 mm in size) have been silently accumulating worldwide over the last century, and the environmental consequences of this pollution remain largely unknown. The potential interactions terrestrial organisms (e.g., insects) have with MPs have been particularly understudied, especially with an estimated 6800 megatons of plastics being directed to terrestrial systems so far. We used a generalist insect (a cricket; *Gryllodes sigillatus*) to examine how growth allows for the ingestion of MPs of different sizes throughout development and in what form MPs are deposited back into the environment. We fed crickets fluorescent MPs (28-500 µm; 1% w/w) mixed into a standard diet and tracked changes in cricket morphology throughout development while examining the frass for MPs. By comparing ingested plastic size to body size,

we sought to identify at what point insects could likely ingest MPs of different size classes. We also investigated whether differently sized plastics affected survival and growth differently and if the degree of plastic breakdown that occurs in the gut changed as crickets grew. We predicted that larger-size plastics would only be ingested later in development, and larger crickets would exert greater grinding forces such that plastics would be more degraded during gut passage. These findings reveal how insects are likely contributing to increasing the number and decreasing the size of present MPs, and can help inform policy regulation surrounding MP production and disposal.

Climate change and urban growth are contributing to increased contaminant impacts on Arctic marine invertebrates

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Climate change-related temperature increases in the Arctic are occurring at a rate that is 3-4 times higher than the global average leading to many direct impacts on marine ecosystems. An unexpected consequence of climate change has been the increased impact of municipal wastewater effluent on coastal ecosystems in Northern Canada. Longer ice-free periods have facilitated increased tourism and shipping traffic, while also contributing to more people moving to major northern communities. This influx of people has the potential to exceed the capacity of wastewater treatment facilities in larger communities. Iqaluit is the largest city and has grown rapidly since being named the capital of Nunavut in 1999. Because of the movement of people into and through Iqaluit, there are often challenges in properly processing the municipal wastewater before it is released into Frobisher Bay and potentially impacts water quality. We have been working to understand the effects of wastewater effluent on the truncate softshell clam (*Mya truncata*) since 2018. This is a popular subsistence food species for communities on Baffin Island and therefore there are concerns about whether the clams are safe to eat from areas surrounding Iqaluit. We have established that clams nearest the wastewater effluent source have markers of contaminant exposure in their shells and tissues leading to physiological responses. This talk will provide an overview of the effects of wastewater effluent on this important bivalve species and how we try to differentiate between local and long-range sources of contaminants in Arctic Canada.

CRISPR-Cas9 Knockout of Divalent Metal Transporter and its Implications for Metal Homeostasis in Zebrafish

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The divalent metal transporter 1 (DMT1) is a major transporter for iron and has also been implicated in the transport of other essential metals such as zinc and manganese in fish. The absorption of essential metals from freshwater environments can vary drastically due to bioavailability and is influenced by metal-metal interactions and competition among metals for uptake. In the present study, we utilized CRISPR-Cas9 technology to generate a knockout of DMT1 and create a valuable in vivo model to examine the importance of this transport pathway in metal homeostasis as well as identify potential compensatory mechanisms that may be in effect. To answer these questions, the development and whole-body metal homeostasis of the mutants have been characterized. We observed that whole body contents of iron, zinc, cobalt,

and manganese were significantly decreased in the knockout mutants at early developmental stages, and subsequently became comparable to those in wild-type fish by the juvenile stage. The DMT1 mutants also exhibit a prominent lack of pigment in circulating red blood cells and in organs like the gills. The underlying mechanisms that enable the maintenance of metal homeostasis in the mutants are being assessed with proteomics. The results of this study will deepen our foundational understanding of the functional involvement of the iron transport pathway in fish function and in metal homeostasis.

Neural Regeneration of Zebrafish in Response to Neurotoxin-Induced Degradation of Dopaminergic Neurons

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Parkinson's disease (PD), one of the most common neurodegenerative diseases characterized by the degradation of Dopaminergic (DAergic) neurons, remains without a cure. This study employs zebrafish as a model to investigate neuronal regeneration processes aiming to inform the design of regenerative therapies for PD. To do that, the regenerative responses of MPTP-treated zebrafish were studied in terms of i) locomotory behaviours, ii) mRNA expression profile of regenerative and DAergic marker genes, iii) protein level of proliferating cell nuclear antigen (PCNA), and finally iv) the number of PCNA-positive neurons in different brain sections. Post-MPTP treatment, zebrafish larvae manifest altered behaviour, indicating the impact of the neurotoxin. Notably, an initial increase in proliferative activities occurred in the frontal Optic Tectum, followed by a reduction in proliferative cell density in the ventral Diencephalon and Telencephalon, regions housing the majority of DAergic neurons. This suggested a potential impact on the local regenerative ability. Additionally, a diminished number of mature astroglia across the entire head indicates a shift toward neuronal differentiation rather than astrogenesis, contributing to the regeneration of ablated brain areas. The elucidation of zebrafish regenerative dynamics provides crucial insights into neural regeneration timelines and underscores the potential of zebrafish larvae as a valuable model for PD research, offering promise for the development of more effective PD treatments.

Interactive effects of hypoxia-reoxygenation and trace metals mixtures on heart mitochondrial bioenergetics during fatty acid and pyruvate oxidation

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Metals and oxygen depletion are common stressors in the aquatic environment that impair mitochondrial physiology in fish. However, there is limited understanding of how fuel selection modulates the effects of combinations of stressors on mitochondrial function. Our work investigated the interactive effects of trace metals (copper, Cu; cadmium, Cd; zinc, Zn), individually and as binary mixtures, with oxygen depletion on rainbow trout (Oncorhynchus mykiss) heart mitochondria. Isolated heart mitochondria were energized with pyruvate + malate (PYM) or palmitoylcarnitine + malate (PCM) and exposed to Cu, Cd, or Zn and their binary mixtures with and without a bout of hypoxia (0.3-0.5 mg O_2/L) followed by re-oxygenation (HRO).

Heart mitochondria were highly sensitive to HRO combined with the metals, limiting the hypoxia exposure duration to 5 min and test metals concentrations to 10 µM. Only Zn during PYM oxidation and Cu singly and as a mixture with Cd during PCM oxidation significantly altered state 3 respiration. The metals and their binary mixtures acted synergistically with HRO to markedly inhibit state 3 respiration irrespective of substrate. Cd, the binary mixtures of the trace metals, and HRO increased state 4 respiration during PYM oxidation but no treatment significantly altered state 4 respiration during PCM oxidation. HRO reduced the respiratory control ratio (RCR) irrespective of substrate and either augmented the reduction and reversed the increase in RCR evoked by the metals and their binary mixtures during oxidation of PYM and PCM, respectively. Overall, our study indicates that HRO combined with metals singly or their binary mixtures alter mitochondrial bioenergetics differently depending on substrate. Notably, the interactions of metals singly or as binary mixtures with HRO enhanced, reduced, or had no added effect depending on the substrate, type of metal and binary mixture, and mitochondrial bioenergetic endpoint

Exploring the Social Brain: Uncovering the Genetic Mechanisms Regulating the Expression of the Social Neuropeptide, Pth2

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Social interactions have a profound impact on our emotions and brain chemistry. However, mechanisms that regulate the “social brain” are not well understood. Recent studies show that social context regulates production of a pro-social neuropeptide called parathyroid hormone 2 (Pth2). In rodents and zebrafish, *pth2* expression increases with socialization but decreases with isolation. In zebrafish, changes in *pth2* expression occur rapidly, within hours. My project will use *pth2* expression in zebrafish as a powerful new model to uncover the genetic mechanisms regulating how the brain responds to social context.
Gene expression dynamics are influenced by two key regulatory regions: the 5’ promotor and the 3’ regulatory element (3’ RE). However, the contribution of these regions to the socially-regulated expression of *pth2* is remains unexplored. My research aims to evaluate the role of the *pth2* 3’ RE in post-transcriptional mRNA stability. I hypothesize that the 3’ RE acts to negatively regulates *pth2* mRNA abundance. To test this hypothesis, I have created two lines of transgenic zebrafish. Both lines express destabilized GFP under control of a 2000 base pair fragment of the *pth2* promoter. However, one line includes the *pth2* 3’ RE while the other utilizes a generic polyadenylation signal. I expect that the 3’ RE transgene will be more sensitive to isolation events, indicating that *pth2* expression is negatively regulated by this genetic element. My work will develop a sensitive transgenic zebrafish model that accurately reflects *pth2* mRNA dynamics and will provide new insights into regulation of the social brain.

Osteohistology accurately estimates growth in the lion (*Panthera leo*)

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Life history is a fundamental aspect of any organism's ecology. Some species alter their life history in response to environmental variation, but studies of this phenomenon are scarce. This is partly because long-term studies on life history are costly and difficult to conduct. Osteohistology may offer a means to use museum collections to study historic changes in vertebrate life history. The growth record of vertebrates is preserved in bone as lines of arrested growth, which have been used to reconstruct growth patterns. However, this work has predominantly focused on herpetofauna and there is comparatively little work done to investigate the suitability of these methods for mammals. This study investigated whether osteohistologically-derived growth curves reflect true growth patterns in a large carnivoran, the lion (*Panthera leo*). Observational growth data were used to compute growth curves and a femur from a wild male lion from Kenya was thin sectioned. Lines of arrested growth were measured and a growth curve for this individual was computed. The osteohistologically-derived growth curve falls well within the range of variation seen in observational growth data for male lions from eastern Africa, suggesting that osteohistology can work well to estimate growth patterns in felid skeletons sourced from museum collections. This suggests that museum collections can be used to learn how mammals responded to increasing anthropogenic pressures in the historic record, as well as how they responded to environmental change in deep time. Osteohistology could also be a valuable tool to assess life history in rare or cryptic species.

Ecomechanics in contemporary evolution: a case study in Threespine Stickleback (*Gasterosteus aculeatus L.*)

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Understanding how organisms adapt to rapidly changing environments requires linking ecological performance on a population scale to environmental context. We investigated the relationship between performance and adaptation in a population of threespine stickleback, recently isolated to fresh water, containing individuals exhibiting all three common lateral plate morphs. Lateral plate variation is driven by Ectodysplasin (Eda) genotype, and all three Eda genotypes are present at relatively high frequency in this population, allowing us to control for habitat variation and genetic background. We tested the hypothesis that fish with low-plated Eda alleles exhibit an increased C-start escape response to avoid capture and therefore reduce predation in the absence of body armour, resulting in increased fitness that drives selection for the low-plated Eda allele in freshwater. We measured escape performance in a wild sample from this locality, and in an F1 cross from these fish, raised in fresh and saltwater contexts, at juvenile and adult timepoints. No significant differences were found in escape response among Eda genotypes in the wild sample, although we did observe a trend, driven by females, where individuals carrying one or more low-plated alleles traveled a greater total distance during their escape responses. Among adult F1 fish, Eda genotype was significantly correlated with greater total distance traveled in fish raised in fresh water, but not in fish raised in salt water. Our results suggest that Eda genotype is indeed beneficial in fresh water by facilitating a more effective C-start escape response in low-plated individuals to avoid predation.

Gustation in the sea lamprey.

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The chemosensation of taste is associated solely with feeding in various vertebrates and invertebrates. Taste buds are in the pharynx of sea lampreys - basal jawless vertebrates that feed voraciously on live prey during the parasitic juvenile stage of the life cycle. This location on the lateral surface of the pharynx, between adjacent gill pores is maintained throughout the life cycle, despite changes in the digestive and respiratory systems during metamorphosis. We have tested for neural chemosensory activity in larval, metamorphic, parasitic juvenile and adult stages. Chemosensory responses to sweet, bitter and sour compounds as well as to amino acids and to bile acids were observed. This organization and function of sensory gustatory structures in lampreys are indicators of the importance of the sense of taste to sea lamprey survival and evolution.

Simple physical models of chimaera pectoral fins swim like a bluegill sunfish

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Chimaeras are an ancient group of cartilaginous fishes that are principally found in deep-sea environments and are characterized by their soft, tapered bodies and flexible pectoral fins. These pectoral fins are used in a unique mode of swimming called flapping flight, where the pectoral fin is oscillated dorsoventrally, inducing bending in both the chordwise and spanwise directions. How this motion and induced bending leads to swimming forces and whether swimming dynamics varies among chimaera species is unknown. We constructed simple physical model fins based on the pectoral fins of three chimaera species (*Chimaera jordani*, *Callorhinchus callorynchus*, and *Rhinochimaera pacifica*) with a silicone rubber polymer and “swam” these fins in a standing tank using a robotic controller that mimicked the motions observed from freely swimming chimaeras. Digital particle image velocimetry was used to visualize and quantify flow around the mid-span of each fin. We find that fin shape influences the spacing of vortices in the fin’s wake, leading to differences in swimming force production. Notably, the pattern of vortex shedding strongly resembles that of a bluegill sunfish (*Lepomis macrochirus*), a teleostean separated from chimaeras by more than 400 million years and which differs from our models in internal structure and actuation mode (bluegill actively deform their fins, our models bend passively). Our findings add to a growing body of evidence that many combinations of material properties, external morphologies, and actuation patterns among fishes tend to converge on specific fluid dynamics in support of swimming force production.

Investigation of two different PACAP-38 (Pituitary Adenylate Cyclase-Activating Polypeptide) formulated feeds on Atlantic salmon (*Salmo salar*) with Enteric Red mouth disease (*Yersinia ruckeri*)

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In salmonids and other vertebrates, pituitary adenylate cyclase-activating polypeptide (PACAP) has been demonstrated to have anti-inflammatory activity, anti-oxidative stress, and cytoprotective impacts against several aquatic pathogens, including *Yersinia ruckeri*, which is the causative agent of enteric red mouth (ERM) disease. Our aim in this study was to evaluate the impacts of two forms of feed formulated with PACAP variants on subsequent infection with *Y. ruckeri* in Atlantic salmon (*Salmo salar*) responses. Approximately 106 Atlantic salmon were randomly assigned (45±5.6 g) to three replicate tanks per diet, with a base diet (Ctrl), an amidated form of PACAP added to the diet (C-PAC), or a non-amidated form of PACAP (N-PAC) added to the diet. After 28 days on experimental feed, two tanks per diet underwent bath exposure (80 L tank for 60 min with 72 fish; water temperature was 16.6 ± 0.2 °C) to *Y. ruckeri* (isolate U27451-11; at 7.8 x 108 CFU/ml) and one tank per diet was unexposed. Fish were sampled prior to exposure, 24 h, 72 h, 7 days, and 14 days post-infection. Infected salmon that received the amidated form of PACAP, unlike the control diet, showed a significantly higher survival rate from ERM (25%), and bacteriological samples that were collected from the kidney and intestine after analysis led to identifying *Y. ruckeri* as a primary agent of the symptoms. *Yersinia ruckeri* infection induced strong inflammatory responses in the kidneys of exposed fish within 1-3 dpi; however, differences in the host responses were observed across different diets. The impacts of these responses on the control of inflammation and tissue repair will be discussed.

Piezo1-mediated detection of mechanical force regulates post-translational activation of matrix metalloproteinase-2 in growing zebrafish embryos

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To grow and change shape during development, wound healing and regeneration, multicellular tissues must remodel their extracellular matrix (ECM). The matrix metalloproteinases (MMPs) are the primary effectors of ECM remodeling, making their proper regulation central to normal development, and their mis-regulation central to many diseases. All MMPs are synthesized as inactive pro-enzymes that are activated post-translationally by the proteolytic removal of an auto-inhibitory N-terminal domain. Using a novel transgenic zebrafish, we can visualize and quantify the proteolytic activation of matrix metalloproteinase 2 (Mmp2) in intact embryos. Interestingly, in the epidermis of growing embryos Mmp2 is activated in a patchwork-like pattern, suggesting that the mechanical stretching of this tissue as the embryo grows may stimulate ECM remodeling. Piezo1 is a stretch-sensitive calcium channel that we observe by immunofluorescence is abundant in the epidermis of zebrafish embryos; we hypothesize that mechanical activation of Piezo1 by stretching of the epidermis due to growth of the underlying tissue triggers expression of membrane type 1 MMP (Mmp14), resulting in patches of Mmp2 activation in the epidermis. Consistent with this, we see similar patches of mmp14b expression in the epidermis using hybridization chain reaction, increased abundance of Mmp2 activation

patches following treatment with the Piezo1 agonist Yoda-1, and reduction of Mmp2 activation following treatment with GsTMx4, an inhibitor of mechanosensitive cation channels. These findings provide a new link between mechanical stretching of epithelial tissues and the biochemical mechanisms of ECM remodeling in vivo, shedding light on the feedback mechanisms regulating tissue morphogenesis in vertebrates.

Comparative phylogenetics of early ray-finned fishes

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One out of every two living vertebrate species is an actinopterygian (ray-finned fish). Despite this massive success, interrelationships of early actinopterygians remain unstable and controversial. Actinopterygians from the Devonian and Carboniferous times may fall outside or sit within the crown group, and may form their own clusters or nest with the living lineages. In what combination and what context do the factors of phylogenetic uncertainty contribute to this problem?
To identify the causes of the instability, I compared phylogenetic datasets that generated radically different trees. I found that relative branch lengths vary predictably over the trees regardless of phylogenetic hypotheses. Unevenness of branch length distribution is mainly driven by the long living branches such as bichirs and sturgeons. However, the core group of early actinopterygians tends to have relatively longer terminal branches in the earlier analyses. In the recent analyses, increased character and taxon sampling contributed disproportionately to younger lineages. Next, comparison of phylogenetic and morphological distances reveals that these recently added character variations drive overall homoplasies in the datasets, perhaps to the point of diminishing returns. This is mainly because the positive relationship between phylogenetic and morphological distances weakens with increasing sampling. However, the character space is never entirely exhausted in any actinopterygian dataset I examined. These results suggest that: 1) increased sampling has outpaced improvement in data quality; and 2) sampling focused on a particular type of characters and a particular part of the tree can recover robust signals.

Pond-side learning is no different than lab-learning

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In 1973 the Nobel Prize for Physiology or Medicine was awarded to Karl von Frisch, Konrad Lorenz, and Nikolaas Tinbergen for pioneering the development of Ethology. This branch of science, which involves the study of animal behaviour, differs from others due to its emphasis on the behaviour of animals in their natural environment. An earlier Nobel Prize to A. Krough (1929) suggested to us that the animal of choice to explore whether 'what we see in the lab' is what we see in the 'wild' is the pond snail, *Lymnaea stagnalis*. Here we demonstrate for the first time the learning and memory capabilities of the pond snail *Lymnaea stagnalis* in both their natural environment and in the lab. We hypothesised that freshly collected wild snails will be capable of demonstrating learning in both artificial lab pond water and lake water. We further hypothesised that the snails are capable of demonstrating similar configural learning and memory formation both in laboratory and lake-side environmental conditions. The results show

that freshly collected *Lymnaea stagnalis* are capable of undergoing higher-order learning, configural learning, in both laboratory and natural conditions.

Subhabitat usage by juvenile fish and the overall fish community in two New Brunswick salt marshes

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Salt marshes, characterized by their rich nutrient content and ecological productivity, provide essential habitat for diverse biotic communities. These ecosystems, which include creeks and salt pools, play a vital role as nurseries for various fish species. Our study examined subhabitat usage by the fish community, focusing on juvenile fish, in two New Brunswick sites: Aulac (in macrotidal Bay of Fundy) and Baie Verte (in microtidal Northumberland Strait). We quantified density of fish species, vegetative cover, and water quality of three subhabitats, namely salt pools, creek edges, and creek bottoms. We also assessed the population structure of Mummichog (*Fundulus heteroclitus*), a resident salt marsh species, focusing on size class densities. Results revealed site-specific differences in fish usage of salt marsh subhabitats. Baie Verte exhibited notably higher abundance of Mummichog in salt pools compared to Aulac. Additionally, juvenile fish, particularly Mummichog and Sticklebacks (*Gasterosteidae*), were more prevalent in salt pools than other size classes. This exploratory research lays the groundwork for future studies, promoting a comprehensive understanding of salt marsh ecosystems and guiding targeted conservation strategies tailored to specific environmental conditions.

Applications and limitations of environmental nucleic acids in salmonid distribution and population health

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Environmental nucleic acids (eDNA & eRNA) are a non-invasive tool for the biomonitoring of aquatic species. To detect a species of interest, water samples are collected and filtered, and nucleic acids are extracted and analyzed in downstream applications such as qPCR and Next-Generation Sequencing. While eDNA barcoding is a relatively well-established approach, representing a highly sensitive and specific method for determining species distribution, spawning, or migration patterns, the utility of eRNA is less well known. We designed and optimized an eDNA and eRNA detection assay for a Species of Special Concern in Alberta, Arctic grayling. This freshwater fish is an iconic species, believed to be in decline, but our understanding of its distribution and factors affecting it, is poor. Improved tools for monitoring current and future species distribution are required. To this end, we developed assays, tested their specificity and sensitivity, and determined best practices for achieving maximum yield from field samples. Our assays were successfully applied in the field to 2 watersheds across Alberta: Athabasca and Peace/Slave River Basins and subsequently applied in a laboratory setting to

determine shedding and decay rates. Our eRNA assay is under further development with the goal of understanding fish population health in both Arctic grayling and Westslope cutthroat trout. We aim to determine whether eRNA can be an effective tool for monitoring salmonid responses to an environmental stressor of heat stress.

Effects of severe weather on staging juvenile semipalmated plovers: evidence of disrupted refueling and delayed departures in the Western Atlantic Flyway

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Severe weather events causing ecological disturbance in coastal habitats greatly impact species reliant on their structure and ecological processes. Atlantic Canada coastlines provide numerous critical staging sites for Arctic-breeding shorebirds to re-accumulate energy reserves (mainly fat) which fuels their remaining migration through the Western Atlantic Flyway. Juvenile refueling efficiency and migration success may be disproportionatly impacted by storms as inexperiance, coupled with unfamiliar habitat, may limit their capacity to respond to storm-related alterations of habitat structure and resource availability. Juvenile shorebird migration timing also coincides with late-season storms, making them more likely to encounter them. Effects of severe weather on staging juvenile birds and their capacity to respond to or recover from acute disturbances is largley understudied. We assessed effects of Hurricane Fiona on on fat stores, bivalve prey availability, and length of stay of juvenile semipalmated plovers (*Charadrius semipalmatus*) during fall staging in Atlantic Canada by combining morphometric analyses, automated radiotelemetry tracking, and invertebrate sampling. Birds captured post-storm lost approximately 78% of their fat mass relative to pre-storm birds, alongside an estimated 68% decline in bivalve availability. Individuals that experienced the storm approximately doubled their length of stay. This single hurricane event had profound impacts on refueling efficiency, prey availability, and departure decisions for a staging juvenile shorebird, with likely implications for migration success and future population trends. Given the projected increase in the frequency and severity of storms, this research highlights that storm-related disruption will become an increasingly important threat to shorebird populations.

Can Corticosterone Predict Double Brooding in Savannah Sparrows (*Passerculus Sandwichensis*)?

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Given that double-brooding can increase annual fecundity, it is unclear why some females in multi-brooded populations rear only one brood per season. The Quality Hypothesis proposes that double-brooded females are high quality and, therefore, have sufficient energetic resources available to rear two broods per season. Using 12 years of reproductive data on Savannah sparrows (*Passerculus sandwichensis*) from Kent Island, NB, we explored whether baseline corticosterone concentrations in females could reflect a measure of quality (i.e., capacity to

mobilize energetic resources) and the probability they would double brood. We tested whether corticosterone concentrations were correlated with measures of female quality (body condition and fat score), and whether a female's baseline corticosterone concentrations during her first brood would predict whether she would attempt a second brood (n = 81 single-brooded and n = 45 double-brooded females). Recognizing that an individual's capacity to mobilize energy can change across breeding stages, we sampled females during either the incubation or nestling feeding stage of the first brood and included the interaction between corticosterone concentrations and breeding stage in the double-brooding model. Baseline corticosterone concentrations were negatively correlated with body condition and fat score. Double-brooding was negatively related to baseline corticosterone during the first brood nestling phase, but not significantly related to baseline corticosterone during the first brood incubation phase. These findings support the Quality Hypothesis and demonstrate the importance of considering parental breeding stage when assessing corticosterone concentrations in songbirds.

Under pressure – exploring partner changes, physiological responses and telomere dynamics in northern gannets across varying breeding conditions

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Life history theory suggests a trade-off between reproduction and survival Threrefore, breeding challenges such as the expansion of foraging ranges, diet diversification, and partner changes of northern gannet (*Morus bassanus*) — key forms of behavioral flexibility — potentially jeopardize reproductive success of this species. To explore physiological costs associated with reproduction and partner changes, we analyzed 21 biomarkers relating to telomere dynamics, oxidative stress, and more, in 38 gannets over three years (2017-2019) at Parc national de l'Île-Bonaventure-et-du-Rocher-Percé (Québec, Canada). Our findings reveal that annual breeding conditions exert a more significant impact on physiological states than does partnership status. Gannets undergoing partner changes exhibited increased short-term stress, marked by higher oxidative lipid damage, decreased antioxidant capacity, inflammation, and notable weight loss compared to those in stable partnerships. Under favorable breeding conditions, these birds showed stabilized telomere lengths and reduced muscle damage, while adverse conditions led to the opposite, irrespective of mate retention. Physiological responses varied among individuals with consistent partners, yet telomere dynamics were not influenced by partnership status. Favorable years saw enhancements in unsaturated fatty acids and oxygen transport, contrasting with years of increased oxidative DNA damage and antioxidant capacity, reflecting similar changes in gannets that changed partners. These results underscore the dominant role of breeding conditions over partner changes in affecting seabird health, highlighting the intricate interplay between behavioral flexibility, environmental challenges, and physiological repercussions.

Biodiversity Monitoring in Marine Conservation Areas within the southern Gulf of St. Lawrence

Dinn, C.

Department of Fisheries and Oceans Canada – Gulf Fisheries Centre

Area-based conservation measures restrict human activities in Canada's oceans to protect sensitive habitats and species. The Department of Fisheries and Oceans has implemented Marine Protected Areas (MPAs) and marine refuges which contribute to Canada's goal to protect 30% of our oceans by 2030. In the Southern Gulf of St. Lawrence, Basin Head MPA (9 km^2) was established to protect a unique population of Irish Moss (*Chondrus crispus*). The Scallop Buffer Zones marine refuge (5,835 km^2) was implemented to protect juvenile lobster habitat from scallop dredging, as well as offering protections for Winter Flounder (*Pseudopleuronectes americanus*), Atlantic Herring (*Clupea harengus*), an endangered breeding population of Winter Skate (*Leucoraja ocellata*), and a population of Lady Crab (*Ovalipes ocellatus*). Two offshore coral conservation areas (758 km^2) prohibit all bottom contact fishing to protect four species of sea pens (Superfamily *Pennatuloidea*). Monitoring of conservation objectives is paramount to ensure effectiveness of these areas, and ecological monitoring plans are currently being developed through researching suitable indicators and knowledge gaps. Biodiversity monitoring inside and outside of conservation areas using longstanding surveys and newer minimally invasive tools will contribute to ongoing monitoring plans. Recent work in the region has included a preliminary population genetics study on C. crispus, and the creation of a field guide of sponge species, which have largely gone unidentified in benthic surveys in the region. This work has led to the naming of four new sponge species*: Haliclona* (*Flagellia*) *xenomorpha*, *Crella* (*Pytheas*) *cutis*, *Crellomima mehqisinpekonuta*, and *Mycale* (*Mycale*) *lorea*.

A role for gene editing towards understanding the ecological impacts of gene variation on adaptive potential

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For adaptation to occur, selection must act on existing functional genetic variation within a population. To understand how candidate genes are associated with adaptive response, genomic techniques can be employed to link genotype and phenotype for potential genes of interest. One such candidate gene, the transcription factor peroxisome proliferator-activated receptor alpha (*PPARα*), has exhibited associations to temperature response across multiple fish species, including threespine stickleback (*Gasterosteus aculeatus*). In this study we aimed to introduce variation via gene editing in threespine stickleback to gain a better understanding of the role of *PPARα* in the thermal response of fishes, as well as how gene editing techniques can be applied to test adaptive evolution hypotheses. Non-Homologous End Joining CRISPR was used on four families of laboratory stickleback, which were then crossed to create an F1 generation. Using a combination of DNA sequencing techniques, we confirmed the transmission of 27% edited alleles to the F1 individuals. All F1 individuals were reared in the same environment and tested for thermal tolerance performance and measured body size, testing the hypothesis that edited alleles would alter performance. Our results showed no phenotypic differences between edited and wild-type individuals, highlighting the importance of understanding adaptive genetic variation and the potential of gene editing techniques to aid in our understanding of functional genetic variation within populations, and subsequently their potential for adaptation under environmental change.

ATP and glutamate coordinate contractions in the freshwater sponge *Ephydatia muelleri*

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Sponges (phylum *Porifera*) are an early diverging animal lineage that lacks both conventional nervous and muscular systems, and yet they are able to produce coordinated whole-body contractions in response to disturbances. Little is known about the underlying signaling mechanisms in coordinating such responses. Previous studies demonstrated that sponges respond specifically to neuroactive chemicals such as L-glutamate and γ-amino-butyric acid (GABA), which trigger and prevent contractions respectively. Genes for purinergic P2X-like receptors are present in several sponge genomes, leading us to ask whether ATP works with glutamate to coordinate contractions in sponges as it does in other animal nervous systems. Using pharmacological approaches on the freshwater sponge *Ephydatia muelleri*, we show that ATP is involved in coordinating contractions. Bath applications of ATP cause a rapid, sustained expansion of the excurrent canals in a dose-dependent manner. Complete contractions occur when ATP is added in the presence of apyrase, an enzyme that hydrolyzes ATP. Applying ADP, the first metabolic product of ATP hydrolysis, triggers complete contractions, whereas AMP, the subsequent metabolite, does not trigger a response. Blocking ATP from binding P2X receptors with pyridoxalphosphate-6-azophenyl-2',4'-disulfonic acid (PPADS) prevents both glutamate- and ATP-triggered contractions, suggesting that ATP works downstream of glutamate. Bioinformatic analysis revealed two P2X receptor sequences, one which groups with other animal P2X receptors. Altogether, our results confirm that purinergic signaling by ATP is involved in coordinating contractions in the freshwater sponge suggesting a role of ATP-mediated signaling that predates the evolution of the nervous system and multicellularity in animals.

Protein turnover kinetics in the freshwater snail *Planorbella duryi*.

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Protein metabolism is a major contributor to resting energetic costs in ectotherms and protein accretion is a central component of growth. Hence, a thorough understanding of protein turnover can provide insights to how energy metabolism interacts with growth dynamics. Using isotopically-labelled phenylalanine to flood internal phenylalanine pools, we are measuring protein metabolism in the freshwater snail *Planorbella duryi*. Adding the labelled tracer to the water bathing the snails allows for a sufficiently longer period of exposure to the isotope as well as its maintenance in the free amino acid pool, compared to injections, to determine stabilization in the protein-bound pool via protein production, which should provide estimates of both synthesis and degradation kinetics.

The enrichment of phenylalanine in the free amino acid pool needs 12hrs to stabilize using our approach and can be maintained long enough for equilibration with the protein pool which takes approximately 2 weeks. We tested separately the fractional synthesis rates of protein in muscle, visceral mass, and gonad to investigate the tissue-specific differences on protein synthesis and the rates for tissues respectively are 6.6±1.3, 7.7±1.1, 10.5±1.8%/day. The highest protein synthetic rate being found in gonads indicates a strong prioritization of reproductive investment during growth in these snails. This method also offers opportunity to measure the rate of protein degradation following the removal of the isotopes from the bathing water.

The Effects of Diet Quality on Developmental Plasticity of Size and Flight Energetics in the Hawk Moth, *Manduca sexta*

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Animals vary tremendously in body size which has profound impacts on most of their function. Not only does size vary across species, but environmental conditions experienced during development induce substantial variation in adult size. In holometabolous insects, the larval stage of development is crucial in determining the final size of adults but also various body proportions. Here we assess how developmental plasticity impacts the effect of size on animal function through manipulation of nutrient intake in the larval diet of the hawk moth, *Manduca sexta*. It is hypothesized that changes in body size due to developmental plasticity will impact flight energetics and flight muscle metabolic phenotype, ultimately predicting that small size impose high wingbeat frequency, high mass-specific metabolic rate, and higher metabolic capacity of the flight muscle. Through this, we successfully induced a change in size variation showing a significant decrease in body size among treatment groups, also showing sexual dimorphism of body proportion in females. Females show increased body proportions in legs, wings, and thorax while decreasing proportions in the abdomen. Individuals in starved groups showed a significant decrease in wing loading compared to the controls. The next steps in our process are to explore the flight muscle metabolic capacity by measuring enzymatic activity of six key enzymes involved in carbohydrate and lipid metabolism. These metabolic measurements will provide insight on how the influence of size effects metabolic capacity, allowing assessments on the effects of developmental plasticity through nutrient manipulation on flight energetics of the hawk moth.

Adaptations to extreme hydrostatic pressure in the world's deepest freely diving insect (*Chaoborus edulis*) in Lake Malawi

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Aquatic larvae of the *Chaoborus* midge are the only truly pelagic insects, controlling their buoyancy using unique hydrostatic organs: gas-permeable air-filled sacs that reversibly expand when pH is altered. As the gas within the air-sacs is unpressurized, the sac wall must both withstand hydrostatic pressure and generate enough force to expand. *Chaoborus edulis* larvae in Lake Malawi routinely dive >200 m, experiencing the highest hydrostatic pressures of any *Chaoborus* species. What mechanical and physiological adaptations allow *C. edulis* air-sacs to resist implosion and generate the forces necessary to regulate air-sac volume during such deep dives? We compared the pressure (depth) of air-sac collapse, as well as stress-strain characteristics in *Chaoborus* species from lakes of varying depth, including Lake Malawi. Recording air-sac compression along with applied pressure revealed the response to pressure as a stress-strain curve. We found that *C. edulis* air-sacs have a higher compressive modulus than other species we measured, they transition to higher stiffness as pressure increases, and also implode at far higher pressure than other species. We used hydrostatic pressure to counteract pH mediated swelling, measuring the mechanical work involved in expanding against hydrostatic pressure. Work performed per pH unit and normalized to air-sac length at pH 6 was

greatest for C. edulis air-sacs, being 0.91 mJ • m^{-1} • pH^{-1}. This is approximately 3× the value found for shallow dwelling C. americanus (0.26 mJ • m^{-1} • pH^{-1}) and *C. trivittatus* (0.36 mJ • m^{-1} • pH^{-1}). Our work reveals how this unique system has adapted to function even under extreme pressure.

Effects Of Migratory Strategy On Flight Muscle Mitochondrial Physiology In Songbirds

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Avian migration is energetically challenging, so variation in migratory strategy may have selected for variation in flight muscle oxidative capacity. Mitochondria supply most of the energy used for migration, so we hypothesized that flight muscle mitochondrial abundance and function vary with migratory strategy. We predicted that long-distance migrants would have greater pectoralis size, mitochondrial abundance, phosphorylating respiration, but lower reactive oxygen species (ROS) emission than short-distance migrants and resident species. We assessed mitochondrial physiology in 19 songbird species, including resident, short-distance and long-distance migrants. We measured pectoralis wet mass, citrate synthase activity (as a proxy for mitochondrial abundance) and used isolated mitochondria to assess respiration and ROS emission during palmitoyl-carnitine oxidation. We found that, after adjusting for body size, pectoralis mass correlated negatively with migration distance, but citrate synthase activity did not vary among migratory strategies. We found that migration distance correlated negatively with OXPHOS respiration, leak respiration, and flux capacities through electron transport system complexes I-IV, II-IV and IV. Migration distance correlated positively with state 4 ROS emission but did not correlate with state 3 ROS emission. Together, our data provide little support for our hypothesis and suggest that mitochondrial function varies with migratory strategy in songbirds, but not to support an elevated oxidative pectoralis oxidative capacity. Instead, long-distance migrants may have evolved a lower pectoralis oxidative capacity with lower pectoralis size and mitochondrial respiratory capacity. However, this phenotype may be beneficial to long-distance migrants by reducing overall costs of migration by reducing tissue maintenance costs.

Endogenous Antioxidant Response in Muscle Tissue of the Cownose Ray (*Rhinoptera bonasus*)

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The cownose ray, a benthopelagic batoid species, has a unique distribution of muscle fiber types compared to other fishes. These rays have wing muscle with relatively equal proportions of red and white fibers (supporting their continuous, oscillatory mode of swimming) and hyper-developed masses of red and pink fibers in the jaw musculature, hypothesized to be connected to its durophagous feeding style. These muscle fiber proportions provide an excellent model system to investigate the relationship between the biochemical and metabolic aspects of muscle fibers to their specialized function. The aim of this study was to quantify and compare activities of endogenous antioxidants (CAT, GPx, and SOD) between the white (wing), red (upper jaw), pink (lower jaw), and cardiac muscle fibers of the cownose ray. Muscle tissue samples were collected from cownose rays caught within the Manatee River in Tampa Bay, Florida. The enzymatic activities of catalase (CAT), glutathione peroxidase (GPx), and superoxide dismutase (SOD) were determined via colorimetric assays. The activity of all three antioxidants (CAT, GPx,

and SOD) significantly differed by tissue location and metabolism ($p<0.0001$). As hypothesized, CAT and GPx activities were highest in the tissues with continuous, lower force contractions that are supported by aerobic metabolism and lowest in the glycolytic tissues (cardiac > upper jaw > lower jaw = wing). Whereas activity of SOD showed the inverse trend (wing = lower jaw > upper jaw > cardiac) which is atypical compared to mammals, but has been observed in a few teleost species.

Amino Acids at the Races: Vampire Bats Rapidly Fuel Running with Blood Meal Protein

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Running mammals support this exercise primarily by oxidizing endogenous carbohydrates (glycogen). Amino acid oxidation accounts for a very small proportion (5-10%) of energy production during exercise. Vampire bats (*Desmodus rotundus*), however, specialize on a uniquely protein-rich blood diet and are, unlike other bats, capable runners. Given these natural history features, we hypothesized that these bats would rapidly begin utilizing dietary amino acids to support a majority of their running metabolism, in contrast to other mammals. We performed breath stable isotope tracking on running bats, first by feeding each bat cow's blood enriched with isotopically labeled glycine (non-essential amino acid) or leucine (essential amino acid). Bats were run at speeds of 10, 20, and 30 m min^{-1} on a respirometry treadmill, allowing us to assess metabolic rate and track the oxidation of labeled amino acids in exhaled CO_2. During exercise, vampire bats oxidized amino acids as their primary fuel as indicated by a consistent respiratory exchange ratio (RER = ratio of CO_2 production to O_2 consumption rates) of approximately 0.9 at all speeds, with the labeled meal accounting for > 50% of oxidized fuels at peak usage. Bats did not discriminate between essential and non-essential amino acid use during exercise; peak apparent oxidation rates for both glycine and leucine were similar. Given nectar bats show an unusual ability to rely on recently ingested sugars to fuel flight, the reliance of vampire bats on blood-meal amino acids to fuel running highlights how strongly metabolism can be shaped by a specialized diet.

Exploring the broader systems-level consequences of ocean acidification in the bigfin reef squid, *Sepioteuthis lessoniana*

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Ocean acidification imposes a chronic respiratory acidosis on marine invertebrates, causing the partial pressure of carbon dioxide and the acidity of their extracellular fluids to increase. While coleoid cephalopods have been found to readily counteract this challenge by accumulating bicarbonate ions within their hemolymph, there is little understanding of how their broader physiology may be impacted by ocean acidification. Lab-reared bigfin reef squid (*Sepioteuthis lessoniana*) were found to be 41% less likely to attack prey when reared year 2100-like conditions (pH 7.8, 1160 µatm PCO_2) for 7 days. Individuals that did attack prey always succeeded but

required nearly 2.5-fold longer to capture prey items. This behavioral impairment coincided with a significant 32% reduction in the routine metabolic rate of squid as well as a broad-spectrum impairment of energy transforming processes within the optic lobes of their central nervous system at the transcriptomic level. Squid that were developed under acidified conditions for 90-days exhibited similar behavioral impairments despite their ability to restore their metabolic profile and an overall lack of clear changes to their gut physiochemistry and microbial communities. The insensitivity of the gut to acidification may relate to its relatively acidic (pH 5.4 – 5.6) and low carbon (0.25 – 0.5 mmol T CO_2 l^{-1}) nature and its relatively simple microbial diversity. Long-term changes were found to rather be associated with changes in the state of their central nervous system, suggesting that although short-term metabolic impairments caused by ocean acidification are transient, they can result in long-term damage to neural systems of cephalopods.

The interactive effects of Copper and Phenanthrene on ionoregulation in mummichog

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Metals and polycyclic aromatic hydrocarbons (PAHs) are pervasive pollutants in aquatic environments, but there is a limited understanding of their potential synergistic effects on aquatic organisms. Limited studies to date suggest the potential occurrence of more-than-additive effects in specific scenarios, yet current water quality guidelines are based on individual toxicity of metals and PAHs, therefore underscoring a significant knowledge gap. The current study conducted 48-h seawater toxicity tests to evaluate the individual toxic effects of copper (Cu) and phenanthrene (PHE) on iono-and osmo-regulation in mummichog (*Fundulus heteroclitus*). Two different experiments employed different methods of PHE dosing: passive dosing and single spiking with 0.01% dimethyl sulfoxide (DMSO) as a co-solvent. In the Cu experiment (nominal 0, 0.5, 1.0, 2.0 mg/L) a decrease in muscle moisture and an increase in tissue sodium and chloride concentration were observed. Conversely, both PHE exposures (nominal 0, 0.25, 0.5, 0.75 mg/L) exhibited no discernible differences in muscle moisture, or tissue sodium and chloride concentrations. These preliminary findings suggest that the likelihood of more-than-additive ionoregulatory toxicity is low, given the absence of PHE-induced effects on these parameters. Subsequent experiments will delve into the potential of PHE to enhance the iono-disruptive effects of Cu in mummichogs across seawater and freshwater environments. Log-logistic modelling will be used to estimate EC_{50} and maximal response to Cu exposure under varying concentrations of PHE for ionoregulatory and oxidative stress endpoints. The overarching objective is to build a deeper understanding of the interaction between metals and PAHs, unravelling their potential synergistic effects in contaminated environments.

Exploring the role of tachykinins on fluid and ion transport by the excretory system of *Drosophila melanogaster*

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The excretory system of insects like *Drosophila melanogaster* consists of the hindgut and Malpighian tubules (MTs), which are essential in maintaining ionic and osmotic homeostasis.

The MTs are composed of two main epithelial cell types, the principal and stellate cells, that are targets of circulating hormones that regulate primary urine formation. One group of neuropeptides that may function as blood borne messengers are Drosophila tachykinins (DTKs) by binding to their cognate G-protein-coupled receptor, the DTK receptor (DTKR). However, there are no studies confirming the role of DTKs on the excretory organs in the fruit fly. Therefore, the objective of this study was to determine whether DTK signaling regulates fluid and ion secretion by the adult fly MTs. To examine this, RNA interference was utilized to knockdown DTKR expression in a cell-specific manner in the MTs. To establish the physiological role of DTKs, in vitro assays were conducted on isolated MTs along with whole animal stress assays using DTKR knockdown flies. Our findings indicate that DTKs are diuretic hormones that targets DTKR expressed in stellate cells as DTKR knockdown in the MTs disrupts fluid secretion and ion transport. Furthermore, DTKR knockdown increased lifespan during desiccation stress likely due to their ability to conserve water. Ongoing work will determine the source of DTKs responsible for driving fluid transport in the MTs by measuring DTK levels stored in midgut enteroendocrine cells. Overall, this research advances our knowledge of DTKs, which are bona fide diuretic hormones influencing hydromineral balance in this important model organism.

Effects of salinity exposure and broad-range antibiotic treatment on oxalate production, transport, degradation, and handling in *Poecilia latipinna*

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Oxalate is an anion, produced through metabolic pathways and/or ingested in the diet, that can readily bind to cations like calcium and is believed to play a role in osmoregulation. As such, the influence of saltwater on oxalate homeostasis within euryhaline sailfin mollies (*Poecilia latipinna*) constitutes a complex interplay between physiological adaptations and microbial partnerships. This study aimed to elucidate the effects of a saltwater environment on oxalate balance within this species, focusing on the liver, intestine, and kidney — organs critically involved in oxalate processing. By quantitatively measuring oxalate concentrations within these organs, our research offers new insights into the osmoregulatory challenges faced by sailfin mollies in saline conditions. The employment of antibiotics and subsequent microbiome analyses were pivotal in deciphering the role of gut bacteria in oxalate metabolism, highlighting the potential for microbial modulation of host oxalate levels. Furthermore, this study investigated the expression of oxalate transporters *SLC26A3* (solute carrier family 26, member 3) and *SLC26A6* (solute carrier family 26, member 6) through quantitative PCR techniques, revealing organ-specific responses to saltwater exposure that suggest differential regulation of oxalate absorption and excretion mechanisms. Collectively, our findings contribute to the broader understanding of how environmental salinity influences oxalate homeostasis in aquatic organisms, underscoring the importance of both host and microbial factors in navigating the physiological challenges posed by saltwater environments.

Effects of food limitation on ocean acidification tolerance in Chum salmon

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Salmon populations are declining in the Pacific Northwest, with high mortality rates during juvenile seaward migration presenting a bottleneck to recruitment. The ocean conditions in a main migratory route of juvenile salmon in British Columbia are characterized by high variability in CO_2 with the amplitude, duration and frequency of ocean acidification events exacerbated by climate change. This is causing a change in the abundance and diversity of plankton, leading to areas of food paucity for juvenile salmon. We tested the combined effects of ocean acidification and food limitation on the survival, condition and gene expression profiles of juvenile Chum salmon, trialling "fitchips" as predictive markers for CO_2 and food deprivation stress.

Do white sturgeon smolt? Assessing physiological and molecular mechanisms associated with salinity preparedness.

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Historically classified as anadromous, white sturgeon can exhibit migratory forays into the ocean as they age; this is not, however, associated with a clear physical change akin to smoltification in salmonids. As an endangered species with significant management needs in the Fraser River, understanding the timing of seawater readiness may help with predicting vulnerabilities related to climate change. Insight into this timing may be gained through an examination of the physiological and molecular mechanisms relevant to the reversal of ion gradients associated with seawater entry. However, whether these mechanisms are responsive to seawater exposure or precede it is still unknown in white sturgeon. To investigate seawater preparedness in white sturgeon, 2- and 3-year-old white sturgeon were exposed to gradually increasing salinity over 20 days (1 ppt/day), and then held for another 20 days at 20 ppt. Physiological and molecular markers relevant to seawater tolerance, such as hematocrit, NKA activity and branchial expression of genes such as NKCC and NKA were investigated at day 10 (10ppt), 20 (20ppt) and 40 (20ppt). Hematocrit in 2-year-old fish decreased ($p>0.05$) at day 40, but was unchanged in 3-year-old fish. NKA activity changed little during this exposure but was generally higher in 3-year-old than 2-year-old fish. The responses of a suite of genes will be presented within this context. Overall, our findings suggest that a level of seawater preparedness is occurring as these fish age, but whether a true "smoltification" is occurring prior to reaching 2 or 3 years of age is still unclear.

Alterations in transepithelial potential following exposure of fish to differentially degraded microplastics suggests even brief pulse exposures to plastics has ionoregulatory consequences

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Microplastics (MPs) are constantly degrading while moving through aquatic systems as a result of mechanical abrasion, thermal fluctuations, UV light, and chemical exposure. As such, fish may experience pulse exposures to differentially degraded MPs. MPs have been observed to interact

with the fish gill during extended exposures (hours – days), causing increased mucus production, damage to secondary lamellae, and oxidative stress, suggesting disturbances to ionoregulation but there have been few direct measurements. Nothing is known about immediate effects (minutes) on ionoregulation. We used transepithelial potential (TEP) across the gills, a diffusion potential resulting from the differential permeability of cations versus anions, as a sensitive indicator of potential ionoregulatory effects. Freshwater fish normally maintain a negative TEP (extracellular fluid relative to water), which favours Na^+ uptake and retards Na^+ efflux. In initial studies we found that virgin (non-degraded) MPs immediately depolarize the gills, reflected in a less negative TEP. In such short pulse exposures (< 5 minutes), there is negligible opportunity for the uptake of MPs into the gill, this suggests immediate physicochemical interaction between the gill surface and the MP surface. As each mode of degradation – that is, mechanical, chemical, UV, and thermal – alter the surface of MPs differently, we isolated the role that each mode of degradation plays in altering the TEP (NSERC).

The acute osmoregulatory effects of copper on the Amazonian fish, *Apistogramma agassizii*, in black and white waters at circumneutral and acidic pH.

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Dissolved organic carbon (DOC) is often the most abundant dissolved component in freshwater, and is central to the structure, function, and diversity of aquatic ecosystems. DOC has been shown to protect against metal toxicity and ionoregulatory disturbances, particularly at low pH. However, little is known about the effects of DOC and trace metals, such as copper, on the water transport pathways. Water moves across the gills of fish through two distinct pathways, paracellularly through tight junctions and by diffusion, via the transcellular pathway through aquaporins. In the present study, the effects of copper (200 µg/L) on diffusive water flux rate (a proxy for transcellular water movement), paracellular permeability (measured by [3H]-polyethylene glycol-4000 clearance), ion transport (net sodium, potassium and chloride fluxes) and nitrogenous waste (ammonia and urea) excretion rates were evaluated in the dwarf cichlid, Apistogramma agassizii, in two DOC sources (Rio Negro black water and Rio Solimoes whitewater) at two pHs (4, 7). Our results show, for the first time, that copper tends to inhibit urea-N excretion rates, as well as ammonia excretion rates. It provides the first measurements of both water transport pathways in Amazonian fish, demonstrating that copper decreases water transport both transcellularly and through tight junctions. The protective effects of DOC against the disturbances caused by copper were dependent on the source of the DOC and the water pH. Overall, this work describes the damaging effects of copper on osmoregulation at the gill as a function of DOC source and water chemistry (NSERC, ADAPTA, CNPQ).

Effects of fluctuating and static ocean acidification on the behaviour and physiology of coastal crabs.

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Coastal regions are currently experiencing carbon dioxide (CO_2) levels greater than end-of-century predicted levels. Upwelling events, that bring deeper high CO_2 waters to the surface, and the high productivity of the coasts contribute to both daily and seasonal fluctuations in CO_2. Ocean acidification has been shown to alter olfactory behaviours such as foraging and predator sensing in both fish and crustaceans. With coastal regions experiencing natural fluctuations, it is unknown whether fluctuating levels of CO_2 could similarly impair olfaction. Yellow shore crabs, *Hemigrapsus oregonensis*, were exposed for 7-days to control (~700µatm, pH=8.0), static low (~1500µatm pH=7.7 ± 0.1), and fluctuating (~3000 – 600µatm, pH=7.7 ± 0.4) CO_2 levels. Olfactory behaviour to an attractive food cue, putrescine (butane-1,4-diamine), was then analyzed. Crabs exposed to static high CO_2 levels took nearly three times longer to locate the odorant source and longer to indicate preference to the odorant side. Crabs exposed to fluctuating CO_2 levels had intermediate behavioural responses between both control and static high CO_2 levels. This indicates possible acclimation to fluctuating CO_2 that mimics their natural environment. This behavioural response is consistent with changes in protein expression of IR25a, an olfactory receptor, and proliferation of sensory neurons as visualized with the use of bromodeoxyuridine (BrdU), a marker for cell proliferation. Responses in fluctuating CO_2 conditions illustrate potential adaptation to natural environments but with impairment during exposure to static high CO_2 as experienced during upwelling events. With these events predicted to increase in length and severity, this impairment will likely worsen.

Snail microhabitat preference as a potential driver of trematode parasite exposure risk in the Bay of Fundy

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Understanding where potential hosts are most likely to encounter parasite infectious stages in their environment is crucial for explaining disease transmission in natural ecosystems, and this should also be considered at different spatial scales. This study investigates microhabitat preferences of two common intertidal mudflat snails (*Littorina littorea* and *Ilyanassa obsoleta*) known to host various trematode species. Snail movement could drive their distribution and density within mudflats, and thus their potential exposure to trematode eggs or miracidia if the latter are not homogeneously distributed. Field experiments were conducted in Kingsport Beach in the Bay of Fundy in June and August 2023 to assess snail movement over a 48-hour period in two distinct microhabitats: (A) a grassy region near the high tide zone and (B) a muddy region further from the high tide zone. A mark and recapture method was employed to record the movement of 795 and 206 snails among 10 1m^2 quadrats in zone A and B respectively. Results indicate differences in movement between the two snail species and sampling times. Further investigation is needed to see if these results are linked to patterns of trematode infection in these snails within the two zones. This study underscores the importance of considering host behaviour at small spatial scales to better understand host-parasite dynamics and infectious disease risk in coastal environments.

Avoidance of fungal and nematode parasitic threats by red flour beetles (*Tribolium castaneum*)

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Hosts have developed effective defences, both physiological and behavioural, to counter the ubiquitous threat of parasitism. Avoidance is one defensive strategy whereby potential hosts modify their behaviour to reduce their risk of encountering parasite infectious stages, and thus becoming infected. Avoidance should be a common first-line defence given its reduced resource costs relative to post-contact responses like those involving the immune system. However, avoidance requires that hosts can assess their environment for potential risk of infection based on cues involving sight, olfaction, or chemosensory perception. Various studies have established parasite avoidance in a range of animals, but this is poorly understood for insect hosts. More research is also needed to comprehensively understand how potential hosts assess infection risk and exhibit avoidance behaviours that correspond to the level of threat. In this study, we investigated how red flour beetles (*Tribolium castaneum*) exhibited behavioural avoidance in response to a series of choices involving two different parasites, the fungal pathogen *Beauveria bassiana* (BB) and nematode *Steinernema carpocapsae* (SC). Beetles were placed in arenas with two chambers, allowing them to choose between two options represented by: 1) BB vs. no threat (NT), 2) SC vs. NT, 3) BB vs. SC, 4) BB vs. BB+SC, and 5) SC vs. BB+SC. The choices made by red flour beetles when facing these different parasite threat conditions will be discussed. This work has implications for understanding avoidance as an anti-parasite behaviour across different host taxa.

Mosquitoes cause of life threatening disease vectors.

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Mosquitoes cause of life threatening disease vectors. Due to non-availability of vaccine and treatment for most of these diseases, the only solution is to control the mosquito population. The excess use of synthetic insecticides causes development of resistance (in vector species), biological magnification (of toxic substances through the food chain) and adverse effects (on environmental quality and non-target organisms including human health). So, under the biological control of mosquito by the use of different plant extracts, such as *Citrullus colocynthis*, *Datura stramonium* and *Azadirachta indica* emphasis is given on the application of plant extracts through petroleum either. During the current study, plant sample were collected for oil extractions. Mosquito larvae were collected from different habitats. After identification, Aedes mosquitoes were reared and treated with *Citrullus colocynthis*, *Datura stramonium* and *Azadirachta indica* plant extracts. Six concentrations of each treatment were applied against 2nd and 3rd instars larvae. The data was collected to check knock down affect after 2, 4, 8 and 10 hours respectively. The data was analyzed through ANOVA to find significant factors (plant extracts,) contributing for mortality. Different significant oil to test their efficacy against *Aedes* larvae. Again mortality data was collected and subjected to probit analysis to calculate LC50. The least value of LC50 (1.5-40 ppm) and LT50 (0.4-0.8hrs) was observed with solution of *Citrullus colocynthis*, *Datura stramonium* and *Azadirachta indica* extracts through ether, for *Aedes* larvae. By adopting these techniques we should able to manage the populations of *Aedes* in the environment.

Mosquito-borne arboviruses in the Maritimes: Using ecological niche modelling as a tool for targeted arbovirus surveillance

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Mosquito-borne arboviruses such as West Nile virus (WNV), eastern equine encephalitis virus (EEEV), and the California serogroup viruses (CSV) are endemic to Canada and are a risk to humans, livestock and wildlife. Historically, the presence of arboviruses has been low in the Maritime provinces; however, warming and increased precipitation are reducing barriers to mosquito and arbovirus distributions and abundance. To help prepare for this future, we can use ecological niche modelling (ENM) to determine areas at risk for increased arbovirus prevalence. Maximum entropy niche modelling (MaxEnt) is a machine-learning tool that develops detailed species distribution maps that predict the ecological suitability for a specific species of interest. Through intensive mosquito surveillance, we aim to provide a baseline for arbovirus prevalence in the Maritimes, while also developing targeted arbovirus surveillance plans for *Culex pipiens* and *Culiseta melanura*, the primary amplification vectors for WNV and EEEV. We collected and pooled adult female mosquitoes by date and location over six months in 290 locations in New Brunswick, Nova Scotia and P.E.I. and sent the samples for arbovirus testing using RT-PCR. I used species presence-only data from surveillance in New Brunswick, P.E.I., and Nova Scotia, and 19 bioclimatic variables from Worldclim, ENMTools and MaxEnt to produce species distribution maps. These maps will outline the areas where *Cx. pipiens* and *Cs. melanura* are likely to be prevalent, and consequently, where we can expect arbovirus amplification. Through arbovirus testing and ENMs, we will provide a baseline for arbovirus prevalence and tools for efficient, future arbovirus surveillance.

Mosquito surveillance in the Maritime provinces under the lens of climate change

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Climate change is creating warmer and wetter conditions in the Maritimes, which will support the survival and reproduction of mosquitoes. Increased abundance of endemic species, and range expansion of exotic species, may thus increase the risk of mosquito-borne diseases to humans, livestock, and wildlife. However, the Maritime provinces do not conduct regular mosquito surveillance and thus our database of species richness and distributions is outdated. To update our baseline of mosquito presence and 'get ahead of the spread' of invasive species, we are conducting proactive mosquito surveillance in New Brunswick, P.E.I., and Nova Scotia. In 2023, we sampled over 250 sites in these provinces through collecting larvae from stagnant water sources (i.e. ephemeral ponds, roadside ditches, bogs, and artificial containers), and collecting adult mosquitoes using light traps baited with CO_2 or as they land on our bodies. Currently, we have identified over 12,000 individual mosquitoes that comprise 45 species, increasing the total species richness in the Maritimes by 3 species. We have found four new species records for New Brunswick (i.e. *Aedes mercurator*, *Aedes rempeli*, *Aedes spencerii*, *Uranotaenia sapphirina*) and six new species records for P.E.I (i.e. *Aedes atropalpus*, *Aedes hendersoni*, *Aedes japonicus*, *Anopheles walkeri*, *Culex salinarius*, *Culiseta minnesotae*). We have also observed the expansion of the invasive species, *Aedes japonicus*, throughout all three provinces.

Surveillance will continue in spring and summer of 2024, and we will ultimately create an up-to-date catalogue of mosquito species for the Maritimes that will inform the extent of climate impact on vector range expansion.

Hemolymph metabolite, peptide, and protein changes in caterpillars experiencing parasite-induced feeding suppression

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Cotesia congregata, a parasitic wasp, injects eggs into its host caterpillar, *Manduca sexta*. Via unknown mechanisms, wasp larvae permanently suppress host feeding upon exiting from the caterpillar, preventing caterpillars from eating the wasp cocoons, but staying as a bodyguard. This study investigated caterpillar hemolymph changes after wasp emergence that could help explain the feeding behaviour loss. Cell-free plasma was collected from healthy unparasitized caterpillars, as well as food deprived caterpillars-to mimic non-feeding post-emergent caterpillars. These were compared to groups of parasitized caterpillars: prior to wasp emergence, during wasp emergence, 1, and 3 days after wasp emergence. Plasma metabolomics, peptides, and small proteins were analyzed via liquid chromatography with tandem mass spectrometry, identifying significant differences between groups in nearly 200 metabolites ($n=10$/group, $p<0.001$), peptides ($n=9$/group, $p<0.001$) and small proteins ($n=9$/group, $p<0.001$). After the wasps emerge, there are distinct hemolymph changes, including a dramatic decline in nutrients and their metabolism, an increase in oxidative stress and immune signaling, and a decrease in waste elimination. Previous work has demonstrated a substantial immune response in the caterpillar as the wasps emerge, and all assays suggested a sustained immune activation starting at emergence and for at least 3 days after. Activation of the immune response can also temporarily reduce or suppress feeding behaviour in caterpillars. We found that injection of immune modulators, such as adenosine, that are highly elevated in parasitized caterpillars, also reduce feeding in controls. These results suggest that activation of an immune-neural connection plays a role in the suppression of host feeding.

Parasitic manipulation via gene transfer and neuroinflammation: How the parasitic wasp, *Cotesia congregata* alters host neural function and behaviour.

Adamo, SA

Department of Psychology and Neuroscience

The parasitic wasp, *Cotesia congregata*, uses multiple prongs of attack to alter the brain and behaviour of its caterpillar host, *Manduca sexta*. The wasp injects eggs and a domesticated virus (CcBV) into the body of the caterpillar. The host's behaviour remains normal during wasp larval development within the host's blood space. Once the wasps are ready to pupate, they exit through the caterpillar's body wall and form cocoons on its cuticle. The caterpillar loses all self-generated behaviours (i.e. feeding and spontaneous locomotion). Defensive behaviours remain intact, allowing the host to act as a bodyguard for the wasp cocoons. During wasp emergence, the wasps trigger a massive immune response in the host, both systemically, and within the CNS, as shown by proteomic and transcriptomic studies. The bodyguard behaviour is similar to the 'sickness behaviours' adopted by the caterpillar during an infection. Augmenting immune-neural connections may help produce the bodyguard phenotype.

Both viral (CcBV) RNA transcription and the production of viral proteins occurs within the CNS of the host. There is novel viral gene expression and viral protein production during and after wasp emergence, and may be involved in triggering the host's neuroimmune response. Although neural activity continues within the brain, descending output is reduced. This decline is consistent with a reduction in synaptic transmission in parasitized hosts. Our studies support our hypothesis that *C. congregata* uses multiple small effects (i.e. many nudges) to control the host, as opposed to overwhelming a single neuroanatomical or neuropharmacological target.

Assessing Whether Climbing Behaviour Explains Low Prevalence of Brainworm (*Parelaphostrongylus tenuis*) Infection in Gastropod Hosts

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Due to the rare occurrence of gastropods infected with brainworm (*Parelaphostrongylus tenuis*) in nature, it has been hypothesized that the standard survey method is biased against them. Cardboard traps capture non-climbing gastropods, so if infection increases climbing, then parasitized gastropods will be undetected. Knowing whether infected gastropods are being underestimated is important when creating interventions that would reduce brainworm transmission to ungulate populations of conservation concern, because ungulates are infected by the consumption of gastropods containing the L3 stage of brainworm. If brainworm infection alters climbing behaviour, then infected gastropods may be under sampled with cardboard traps (collects only non-climbing gastropods), compared to visual searches (collects climbing and non-climbing gastropods). To compare these approaches, we surveyed gastropods at six forested sites within brainworm range bimonthly from June-October 2023. Gastropods were estimated from 10-minute visual searches of quadrats performed alongside five similarly sized cardboard traps. Although L3 prevalence in gastropods was similar between the cardboard traps and visual searches (0.5% (1/194) and 0.4% (1/223), respectively), cardboard traps were more likely to yield individuals of brainworm host species. During visual searches, 3.6% of gastropods were climbing vegetation, and none were infected. Results from field sampling suggest that the use of cardboard traps does not underestimate gastropod prevalence, and that brainworm does not affect climbing behaviour. However, since so few individuals were found climbing and infected in nature, lab-exposures could help determine whether gastropod behaviour is influenced by infection. Results of ongoing lab experiments with the meadow slug, *Deroceras laeve*, will be discussed.

The cortisol response to acute temperature stress in rainbow trout (*Oncorhynchus mykiss*)

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Although there is abundant evidence that fishes exposed to high water temperatures have elevated levels of the stress hormone cortisol, the mechanisms responsible for this relationship have received little attention to date. Cortisol is the end-product of activation of the hypothalamic-pituitary-interrenal (HPI) axis. We tested the hypothesis that exposure to high temperature activates the HPI axis in rainbow trout, and that this response is mediated at least in part by

activation of the thermosensitive membrane channel TRPV1. Circulating cortisol levels in trout exposed to 23 or 25°C did not differ from those in fish held at 13°C. However, a significant rise in cortisol was observed in trout exposed to 27°C. This cortisol response was accompanied by increased transcript abundance of crf, which initiates HPI axis activation. Treatment of trout with the TRPV1 agonist capsaicin appeared to potentiate the cortisol response to temperature, in that cortisol levels were elevated at 25°, a temperature that, on its own, did not elicit a cortisol response. Correspondingly, treatment of trout with the TRPV1 antagonist capsazepine appeared to blunt the cortisol response to 27°C. Collectively, these data support the hypothesis that high temperature serves as a stressor in rainbow trout, with a role for TRPV1 in mediating activation of the HPI axis.

Mitochondrial functions and fatty acid profiles in fish heart: an insight into physiological limitations linked with thermal tolerance and age.

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Heart failure is among the first major consequences of heat stress in aquatic ectotherms. Mitochondria produce most of the ATP the heart uses, representing almost half of the volume in cardiac cells. It has, therefore, been hypothesized that mitochondrial dysfunctions may be highly involved in heart failure associated with heat stress. The present study aims to investigate if CTmax is linked to the thermal sensitivity of their cardiac mitochondria in diverging three-spined sticklebacks (*G. aculeatus*) ecotypes and if it is influenced by heart fatty acid composition and age. To do so, cardiac mitochondrial oxygen consumption was measured by high-resolution respirometry at three temperatures, and heart lipid profiles were obtained by Gas chromatography (GC) coupled with a Flame Ionization Detector (FID). Fish age was estimated via otolith readings. Sticklebacks from the estuarine environment performed better during CTmax tests than lacustrine fish, but this difference generally did not reflect at the level of cardiac mitochondrial oxygen consumption. Fatty acid profiles significantly varied between ecotypes, but CTmax only showed a weak positive correlation with Eicosapentaenoic acid. Mitochondrial respiration was strongly affected by temperature and a drastic drop in OXPHOS respiration fed by Complex I and II while uncoupled respiration plateaued was observed at CTmax temperature. Our results suggest that Complex I is an important modulator of mitochondrial respiration at high temperatures but is not the main limiting factor in physiological conditions (maximal OXPHOS). Mitochondrial respiration was also affected by fish age, showing a general decrease in older individuals.

Transcriptomic response to acute thermal stress in developing lake sturgeon.

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Through evolution, fishes have adapted to the temperature of their habitat and its natural fluctuations. Any changes beyond this natural range can affect the metabolism, growth, and physiology of the animal. However, fishes can acclimate to higher or lower temperatures, but potentially not without consequences. In this study, we investigated the influences of genetic differences and acclimation temperature on the molecular response of juvenile lake sturgeon, *Acipenser fulvescens*, to acute thermal stress. To conduct this experiment, two groups of juvenile *A. fulvescens* from two genetically distinct populations from northern and southern Manitoba were acclimated to 16, 20, and 24 °C for 30 days, and then underwent a critical thermal maximum (CTmax) trial. The expression of 52 genes involved in detoxification, apoptosis, hypoxia, immune system, endocrine system, growth and metabolism, and heat shock response was measured in gill through qPCR using OpenArray™ technology. Overall, acute thermal stress downregulated the expression of most of the genes involved in the immune system, apoptosis, detoxification, growth and metabolism, osmoregulation, and hypoxia in both populations. Of nine genes involved in molecular response to thermal stress, *hspa4a*, *hsp70a*, and *hsp90a* were highly upregulated in both populations. In some genes, such as *bcl2l1-xl* and *cyp1a*, fish that were acclimated to higher temperatures showed a greater upregulation after CTmax compared to those acclimated to lower temperatures. In contrast, acclimating to higher temperatures reduced the expression of some genes, such as *hsp70a* and *hsp90a*, in response to acute thermal stress.

Characterization of darter (*Etheostoma* spp.) interspecific energetic responses to climate-induced temperature change

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Aquatic environments are predicted to experience increases in temperature variability as the occurrence and severity of heat waves continues to rise. Here, we characterized the thermal tolerance limits and metabolic function of three closely related darter species: Fantail (*Etheostoma flabellare*; FTD), Rainbow (*Etheostoma caeruleum*: RBD), and Johnny darter (*Etheostoma nigrum*; JD) native to the Grand River of Southern Ontario. Brain and heart enzymatic activity were characterized for each species at 15C baseline and following CTmax thermal challenge. Additionally, metabolic rates were determined for each species while undergoing five heat ramp exposures designed to mimic previously recorded heat waves. Significant differences were observed in the thermal tolerance limits of each species. For brain tissue, FTD appeared to have higher baseline enzymatic activity compared to JD and RBD, however at CTmax, this difference was lost. Heart tissue exhibited no interspecific differences in activity levels at baseline. At CTmax, however, JD had increased activity than RBD for all enzymes, although neither JD or RBD were different from FTD. Metabolically, FTD aerobic scope was significantly higher than JD and RBD at both 25C and 30C, however no differences were observed at 15 or 20C. These results suggest that FTD may be the best equipped at responding to temperature-induced increased metabolic demands due to their higher baseline enzymatic activity and broader aerobic scope. Collectively, these findings provide insight to predict how

climate change will affect local species, and may have conservation applications for determining which species may be most at risk.

Embryonic Thermal Stress and its Effect on the Stress Response during Embryogenesis and Early Life Stages in Yellow Perch (*Perca flavescens*)

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The global effects of climate change and industrial thermal effluents are causing a rise in water temperatures. As ectotherms, temperature can influence all aspects of fish biology, particularly during key developmental stages. Yellow perch (*Perca flavescens*) are cool water fish with economic, recreational, and ecological importance in North America that spawn in the near shore environment and may experience warmer than average embryonic incubation temperature. We examined how chronic non-optimal embryo incubation temperatures alter the characteristics of the heat shock response in embryos and post-hatch fish. We reared embryos at 12, 15, and 18° and then acclimated larvae to 18° after hatch. Embryonic and larval yellow perch were subjected to acute heat shock (HS) treatments, 3, 6, or 9° above their incubation temperature at various points throughout development. We used CTmax as a proxy for thermal tolerance. HSP transcript levels changed in response to the acute HS treatment with embryonic stage and post-hatch fish age. Embryos incubated at 12 and 18° had significantly higher *hsp70-1*, *hsp70-2*, and *hsp47* transcript levels than the 15° group in response to most HS treatments. Incubation temperature also influenced CTmax, further supporting our claim that the early thermal environment can have lasting effects on fish thermal tolerance. Overall, this study shows that the early thermal environment can have cascading effects on the HSR that persist well after embryogenesis.

Elevated and variable thermal environments during embryogenesis lead to more notable plastic responses in Lake Whitefish than in Yellow perch.

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Anthropogenic activities that affect fishes include, but are not limited to urbanization, agricultural activities, chemical and thermal pollution, and rising temperatures associated with global climate change. Fish are ectotherms with a large gill surface area; thus, they are particularly susceptible to thermal and chemical stressors. Our group along with collaborators have been studying the short- and long-term effects of thermal and hypoxia stressors during the embryonic period on the embryonic and juvenile stress responses, metabolism, and swim performance in the winter and spring spawning Lake whitefish and Yellow perch, respectively. Elevated embryonic incubation temperatures altered both species' heat shock response (HSR). Lake whitefish showed a more pronounced response that differed with age. Lake whitefish embryos attenuated their HSR when exposed to elevated temperature (5°C vs 2°C) and repeated thermal stress (RTS), but juveniles responded more robustly with greater increases in *hsp 70* mRNA. Yellow perch embryos had attenuated responses to a median embryonic temperature of 15°C, relative to those at 12 and 18°C. In both species, we observed an altered HSR in juveniles following stressor exposures as embryos, suggesting that these responses are plastic and the embryonic environment can

have lasting effects. Elevated incubation temperature also affected performance in Lake whitefish (~1.5 yrs). The most notable difference was a reduction in critical swimming speed at 15°C and a reduced routine metabolic rate at a higher acclimation temperature of 21°C. By comparison, these plastic responses to embryonic incubation temperatures were absent in Yellow perch (~ 1 yr). Our data show that embryonic rearing temperatures have lasting effects on fishes, with the relatively stenothermal Lake whitefish being more robust than that of the eurythermal Yellow perch.

Transcriptional responses as early indicators of thermal stress in bull trout (*Salvelinus confluentus*)

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Climate-induced increases in water temperature can push fish to their physiological limits and decrease the spatial extent of suitable thermal habitat. A species resilience to shifts in thermal regimes will therefore hinge on their thermal tolerance and plasticity. One mechanism underlying phenotypic flexibility is changes in gene expression estimated through increases or decreases in mRNA transcript abundance. Therefore, we tested whether thermal tolerance at the organismal level corresponds to shifts in tissue-specific transcriptional profiles using bull trout (*Salvelinus confluentus*), a coldwater stenothermic fish of conservation concern. Eggs were collected from wild bull trout in Smith-Dorrien Creek, Alberta, and reared at 4C in vertical incubators. One year post-hatch, fish were acclimated to one of six temperatures (6, 9, 12, 15, 18, and 21C) within the thermal range that bull trout experience in Alberta. We measured metabolic rate and temperature preference, as well as growth, and mRNA abundance of 56 genes related to thermal stress and overall health in salmonids using a high-throughput stress-response transcriptional profiling chip. Absolute aerobic scope and standard metabolic rate were highest at temperatures greater than 15C. Juveniles showed a preference for temperatures <15C and beyond this temperature growth was lower. These whole-organism effects coincided with a marked increase in the transcript abundance of heat shock proteins and a decrease in growth-related genes as temperature increased. Our results suggest that occupying temperatures >15C is energetically costly for juvenile bull trout and elicits a cellular stress response that may provide an early warning of population-level effects.

Investigating Mechanisms of Thermal Stress Recovery in Lake Sturgeon (*Acipenser fulvescens*)

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The thermal stress response in vertebrates is a well-studied, largely conserved set of mechanisms. Less well-understood are mechanisms of recovery from thermal stress, which may be critical for wild organisms that survive rapid environmental perturbations. We studied these mechanisms in the lake sturgeon (*Acipenser fulvescens*). Fish were acclimated to 15°C or 20°C for 21 days prior to sampling, then a subset underwent a CTmax trial to establish upper limits of

thermal tolerance (mean 30.8°C ± 1.5°C std. dev. for the 15°C group; mean 33.1°C ± 1.1°C std. dev. for the 20°C group). An 8-hour heat exposure at 28°C was thus chosen as an extended thermal stressor, followed by recovery at acclimation temperatures. Fish were sampled before, during, and at the end of the exposure (0, 4, and 8 hours into it), and 4, 24, 72, and 168 hours after the exposure ended to investigate recovery from thermal stress. Messenger RNA sequencing from liver, cortisol, glucose, and lactate assays were used to study stress response recovery mechanisms (n=6 to 8 fish in each group and timepoint, N=126 total). Cortisol rose slightly in the group acclimated to 15°C, but not the group acclimated to 20°C. Overall, the group acclimated to 20°C had a dampened transcriptional response, while the 15°C group exhibited prominent signals of mitochondrial synthesis and potentially energy mobilization in the week following the heat exposure. These results emphasize the key roles of energy mobilization in both thermal stress responses and recovery.

Wednesday/Mercredi, May/Mai 8

Tropical endothermy in a changing world: predicting the energetics of small mammals using mechanistic models

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Small endotherms (<5kg) are often assumed to live predominantly at temperatures below thermoneutrality therefore necessitating high thermoregulatory costs to maintain their elevated and relatively constant body temperatures. Yet endothermy evolved in mammals when the environment was closer to that found in modern day tropics: warm and relatively constant. Therefore, unlike temperate species that must consistently generate heat to maintain an elevated body temperature, low latitude species spend more time at thermoneutrality and therefore can spend the energy elsewhere. We will discuss the costs and benefits of the different types of thermoregulatory phenotypes observed in tropical mammals from the Malaysian province of Sarawak on the island on Borneo, the viability of mechanistic biophysical models for these species, and how knowledge of these factors can help predict which species will be the most vulnerable to climate change.

Ontogenetic Changes in Metabolic Scaling and Thermogenesis in the Thirteen-lined Ground Squirrel (*Ictidomys tridecemlineatus*)

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Metabolic scaling describes the relationship between metabolic rate and body size, and can be calculated using the equation Metabolic Rate = a(Body Mass)B. Juvenile mammals are predicted to have high scaling exponents (B) ≥1 until reaching adult body size. Following this, B decreases and scaling becomes hypometric. Preliminary data from altricial thirteen-lined ground squirrels (*Ictidomys tridecemlineatus*) show their B falls around the same time they start to develop greater endogenous thermogenic capability. This study tracked ontogenetic changes in metabolic scaling, and their correlation to the development of endogenous thermogenesis. *I. tridecemlineatus*' masses, body temperatures, and metabolic rates were measured over a wide range of developmental stages under resting conditions and in response to a cooling challenge. Significant changes in B and growth rate were found via breakpoint analyses. An earlier increase in B was measured prior to the metabolic critical switch which has not been previously described: at postnatal days 18-23 (P18-P23), B more than doubles from 1.01±0.03 to 2.64±0.17. This high B is sustained until P35-P43, when it decreases to -0.27±0.20. Notably, the period of most rapid growth does not begin until P29. At this age, growth rate increases from 1.18±0.02 to 4.87±0.03 grams/day. This is sustained until adult body size is reached at P79, long after B decreases. Data were also compiled into a series of curves visualizing the development of cold-induced thermogenic responses, which will be discussed further. Results indicate factors other than growth and body size underly ontogenetic changes in metabolic scaling. Funded by the NSERC of Canada.

Estuarine crocodiles are heating up

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Tropical ectotherms are at particular risk from anthropogenic climate change as they are already living in environments matching their thermal tolerance range and may have limited ability to thermoregulate or physiologically compensate for elevated temperatures. In 2008, we embarked on a long-term monitoring program studying the movement ecology and thermal physiology of estuarine crocodiles, *Crocodylus porosus*, ranging in size to over 4.5 m body length. From 2008-2023, we have recorded the body temperature (Tb) of 203 estuarine crocodiles, *Crocodylus porosus*, in northern Australia using implanted acoustic transmitters to observe long-term trends in Tb. More than 6.5 million individual recordings of body temperature were collected. We found that the body temperature of *C. porosus* has increased since 2008, and changes in Tb reflected climatic shifts caused by the El Niño-Southern Oscillation. Since 2008, we found that crocodiles experienced more days close to critical thermal limits, temperatures at which their diving performance was reduced. There were also increases in active cooling behaviour when Tb was high. These results indicate that estuarine crocodiles are experiencing temperatures that influence their thermoregulatory behaviour and experience temperatures that may result in decreases in performance, building upon 20 years of experimental research on the thermal sensitivity of physiological processes in crocodiles. The importance of collecting long term physiological data will be discussed.

Effects of temperature and food availability on feeding behaviour and metabolism in the sea cucumber *Cucumaria frondose*

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Cucumaria frondosa are the largest and most abundant species of sea cucumber in the North Atlantic and Arctic oceans, and are commercially exploited in Maine and Atlantic Canada; however, knowledge gaps in their bioenergetics and growth compromise a reliable stock assessment. While temperature is commonly assumed to be the principal factor affecting the metabolic rates of ectotherms, food availability determines the feeding ecology and, ultimately, the energy budget of suspension feeders such as *C. frondosa*. Effects of temperature and food availability on individual feeding and metabolic rates, and population-level feeding activity were investigated in *C. frondosa* held in mesocosms. In the first experiment, temperature was increased from 5 to 16°C by 1°C every 3 days. Maximum tentacle insertion rates (TIRmax; a proxy for food intake) and cloacal opening rates (COR; a proxy for metabolic rate) increased with temperature, while the total proportion of feeding individuals generally decreased. Beyond 12°C, novel abnormal behaviors – rhythmic openings of the mouth and incomplete TIR – emerged, and became increasingly common at higher temperatures, suggesting thermal stress. In the second experiment, phytoplankton concentration was increased from 2,000 to 50,000 cells ml^{-1} by ~10,000 cells ml^{-1} every 3 days. TIRmax increased until ~ 30,000 cells ml^{-1}, then plateaued. The proportion of feeding individuals increased with food availability, with all individuals feeding at 40,000 cells ml^{-1}. These findings provide insight into the physiological performance of *C.*

frondosa under different environmental conditions and can aid in the development of bioenergetic models for this species and, ultimately, inform fisheries management.

Exploring mechanisms of acclimation responses to thermal and saline stress in the cnidarian, *Nematostella vectensis*

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Starlet sea anemones (*Nematostella vectensis*) are cnidarians endemic to estuarine environments along the Atlantic coast of North America. Across this broad latitudinal range, natural growth habitats vary drastically between populations, particularly in terms of temperature, salinity, reactive oxidative species (ROS), and pollution. This variation, coupled with reduced gene flow and dispersal ability results in populations that appear to be locally adapted. Using anemones collected from coastlines along New Hampshire, USA, we aim to explore interactions between thermal and saline stress, to determine their capacity for plasticity, and identify underlying signaling pathways. We acclimated anemones using a two-factor design — warm and cold treatments at 16°C or 26°C, and high and low salinity treatments at 30‰ or 15‰ ASW. Leveraging the clonal nature of these anemones, 4 clones from 8 different genotypes were used for the 4 treatment groups (i.e., genotype represents a random effect). After an acclimation period of 3 weeks, routine metabolic rates (RMRs), metabolic and osmoregulatory enzyme activities of citrate synthase (CS), lactate dehydrogenase (LDH), cytochrome C oxidase (CCO), and Na^+-K^+ ATPase (NKA), along with ROS and behavioural assays were measured acutely - both at their acclimation temperature, and at the orthogonal temperature. We also investigate mRNA expression levels of hepatocyte-nuclear factor 4a (*HNF4a*) as a potential regulator of the acclimation responses alongside with other nuclear receptors identified in Nematostella. Preliminary results indicated an interaction between temperature and salinity that affected acclimation responses to either stressor in isolation. Nematostella represent an important, convenient model to study the effects of interacting stressors in different cnidarians, including corals. Studying acclimation response mechanisms in these anemones can help us further understand processes underlying bleaching events and the effects of pollution in marine invertebrates.

The Heat is On: Investigating the impact of heat waves on the apple pest *Choristoneura rosaceana*

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Currently, Canada is experiencing an increase in extreme weather events, including heat waves, as a consequence of climate change. Investigating the impacts of such events on agricultural pest species is critical in order to advise Canadian growers on what pest management strategies will be most effective. The current work investigates the potential consequences, both beneficial and detrimental, of heat waves on the pest species *Choristoneura rosaceana* (OBLR), which is a prevalent apple pest in Canada. Using incubators to simulate five-day heat waves, we examined their effects on OBLR development and susceptibility to different agricultural control agents. Neonate caterpillars that had been exposed to heat waves exhibited negligible survival rates, which contrasts dramatically with 2nd and 3rd instar caterpillars who actually received growth benefits from experiencing a heat wave. Older caterpillars who underwent heat waves gained mass faster, and developed through their instars faster, even after the heat wave had

ended, compared to controls reared without heat waves. Interestingly, when pesticide is applied prior to, or during a heat wave, these benefits do not increase the probability of survival. In fact, heat waves increase the lethality of the pesticides Altacor, DiPel and Confirm compared to caterpillars of a similar life stage experiencing normal temperature conditions. These results highlight the complex interplay between heat extremes and pest dynamics, emphasizing the need for tailored pest management strategies.

Cell size and fatty acids as modulators of temperature tolerance in Daphnia

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Cell size has recently been recognized as an important trait in understanding temperature tolerance in ectotherms. As small bodies are often composed of small cells with a bigger membrane surface area relative to volume than larger cells, they may support a greater capacity for oxygen transport which could explain the greater temperature tolerance of small ectotherms. By contrast, larger cells could provide metabolic advantages in the cold. In addition to cell size, fatty acid profiles can also be modified to maintain an optimal membrane fluidity under changing temperatures. In this study, we examined the contribution of cell size, body size, and fatty acid profiles on temperature tolerance in the freshwater microcrustacean Daphnia. Diamond-shaped prints on the carapace were used as proxy of epidermal cell size. CTmin and CTmax were measured in 17 diploid and triploid *Daphnia pulex* clones acclimated to 16°C and 24°C for several generations. Lower temperature acclimation decreased CTmin and CTmax. Clones raised under higher temperatures had smaller cells. Polyploid clones had larger cells than diploid clones under both rearing temperatures. CTmax was negatively correlated with cell size and body size. A strong negative relationship was found between EPA and CTmax. Polyploid clones had lower CTmax and lower CTmin than diploid clones. Our results suggest that the larger cells of polyploid clones may be disadvantageous under higher temperatures thus explaining their differential distribution at high latitudes.

Using benthic recruitment densities to forecast fisheries recruitment of American lobster in Atlantic Canada

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Landings of American lobster (*Homarus americanus*) in Canada have increased by ~500% since the mid 1980's, although trends have varied geographically. There is incomplete understanding of the mechanisms underlying these temporal and spatial trends, and little ability to forecast future changes. We built an individual-based model for three Lobster Fishing Areas (LFAs) in Canada that uses the annual density of benthic recruits in nursery grounds to generate an index of fisheries recruitment and exploited biomass up to six years in the future, using latitude-based von Bertalanffy growth equations complemented with inter-individual variability in growth. We found significant positive relationships between the modelled recruitment index and fisheries landings in all three LFAs. Out-of-sample validation in two LFAs (longer time series) using 1-year and 6-year reduced data sets revealed mean annual model errors of 11.4% and 11.2%, and 23.7% and 51.7%, respectively. Our findings strongly suggest benthic recruitment indices could

help make strategic decisions concerning lobster fishing activities, and they argue for the continued and expanded monitoring of lobster benthic recruitment in Canada.

Investigating the "hairy snail" holobiont of Alviniconcha from hydrothermal vents in the western Pacific and Indian oceans

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Symbiotic relationships at deep-sea hydrothermal vents are of key interest because these habitats occur across geologically distinct settings, with hydrothermal fluid chemistries varying substantially in temperature, pH, and reduced chemical concentrations. Therefore, animals that both feed on external sources and rely on internal symbionts may exhibit different levels of mixotrophy depending on the fluid chemistry. We assessed host feeding and gill endosymbiont characteristics in the genus of hairy snails, Alviniconcha, which dominate hydrothermal vent communities in the southwestern Pacific and Indian oceans. We used Scanning Electron Microscopy (SEM) imaging to assess radular tooth wear and found evidence supporting variable mixotrophy: radular wear differed within and between vent sites and species. To determine whether differences in feeding might reflect differences in symbiont type and population density, Transmission Electron Microscopy (TEM) was used to examine the gill epithelial cells harbouring symbionts. We observed dense gill endosymbiont populations, but with site differences in symbiont morphotype. Notably, evidence of episymbiosis was found in *A. boucheti*, the only species within the genus to host thiotrophic Sulfurimonas belonging to Campylobacteria rather than Gammaproteobacteria. All species within Alviniconcha are currently listed on the IUCN Red List of Threatened Species as Vulnerable or Endangered, based on their extremely restricted habitat and lack of protection against deep-sea mining. Without the immediate implementation of protection, there is a future risk of extinction of these and other vent endemic species.

Freshwater Mussel Parental Care: the evolution of host-specificity and its relationship to brooding time

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Freshwater mussels are ecosystem engineers that provide key functions such as water filtration, habitat creation, and pelagic-benthic coupling for the rivers and lakes they inhabit. North America is a hotspot for freshwater mussel diversity. There are over 300 species of freshwater mussels endemic to North America. However, within the Canadian Maritimes there are ten extant species from two families. One species was recently extirpated, and two of the remaining species are currently considered 'special concern' under the Canadian Species at Risk Act and 'threatened' under the province of Nova Scotia. Unfortunately, due to the impingement of anthropogenic effects on aquatic ecosystems and their complex life history, freshwater mussels are among the most imperiled aquatic taxa globally. The development of Unionid mussels relies heavily on parental care (brooding) and the success of an obligate parasitic life history stage (larvae called glochidia) in fishes. For the latter, some species produce lures to improve the odds of successful transmission into their piscine hosts. We are conducting an updated literature review on the life history characteristics of unionid mussels. We will be mapping evolutionary characters for unionid mussels such as brooding time and host specificity, onto a pre-existing phylogeny. We

hypothesize that brooding time and host-specificity will be correlated. Understanding the evolution and ecology of host-specificity for an important group of at-risk species can help with the management and implementation of recovery plans due to the inherent reliance on their host fish species.

Honey Bee Majors and Minors: Multitasking in Foraging Behaviour

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Flower constancy is the phenomenon whereby a pollinator will fly past potentially profitable foraging sources in search of the flower species from which it had previously collected. The adaptive benefits to the plant are clear: flower constancy reduces pollen waste and avoids clogging stigmas with foreign pollen. The adaptive benefits to foraging insects, however, are not well understood. They are usually attributed to balancing (a) energy expenditure while searching for a known source and (b) the challenges in a small brain of learning to manipulate multiple sources. In bumble bees (*Bombus spp.*), which are generally less flower constant than honey bees (*Apis mellifera*), foragers often exploit a “major” and a “minor” flower species. This is advantageous in social insects that cannot communicate foraging opportunities to one another. The minor flower species serves as a “backup” in case the major source becomes unavailable. It had long been thought that due to their waggle dance foraging recruitment language, honey bees need not maintain a memory of a backup flower species; if the source a honey bee has been exploiting becomes unavailable, the forager can learn of an alternative source on the dance floor. However, while many studies have shown that flower constancy in honey bees is not absolute, any deviations are usually explained as errors. Here, we demonstrate that such deviations are a common feature of honey bee foraging behaviour, and we propose that honey bees also exhibit majoring- and minoring-like foraging behaviour.

More than a meal – gut yeasts make flies grow faster

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Insect guts contain a community of microbes composed of bacteria, fungi, protists, and archaea that affects host metabolism, digestion, immunity, and even behaviour. Most research has focused on the effects of bacteria but other taxa, such as yeasts, remain understudied. The *Drosophila melanogaster* gut microbiota is comprised mainly of bacteria and yeasts; I am exploring the role of yeasts as gut symbionts. I reared axenic (free of microbes) and gnotobiotic (with a known yeast species) *D. melanogaster* to determine the effect of yeasts on host development time. Axenic flies take 15 % longer from egg to adult compared to flies reared with their native gut microbiota. Flies reared with a single yeast species, either *Saccharomyces cerevisiae* (baker’s yeast used in lab diets) or *Lachancea kluyveri* (first isolated from Drosophila spp.), develop as fast as native microbiota flies. This effect of yeasts is not just because yeasts contain macro- or micro-nutrients. Heat-killed yeasts or vitamin and amino acid supplements partially accelerate fly development. Live yeasts accelerate larval development by reducing the length of the third instar (final larval stage) but do not affect pupation time or development in the first two instars, and the yeasts must be present at the moult from 2nd to 3rd instar to have their effect. Thus, yeasts provide both a passive nutrient supply (food) and active metabolites (by live yeast), and likely play an important role in the biology of wild flies.

Complex biofouling effects of minimal ultraviolet light application for anti-fouling purposes

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Marine biofouling is the unwanted growth of organisms on submerged surfaces which creates problems for human activities. This natural process has driven the development of numerous antifouling technologies, many of which can harm the environment substantially. A new and promising anti-fouling technology is the use of ultraviolet (UV) light, as it can successfully prevent biofouling while not accumulating in the environment. However, its effectiveness depends widely on various factors, such as light intensity, distance from a light source, and time between treatments. Importantly, for any UV light source there will always be a region of minimal exposure. We deployed UV protected and unprotected glass surfaces in the marine environment, to test the effect of minimal UV on biofouling composition. After a 16-week submersion period at two Nova Scotian harbors, the application of a minimal treatment of UV had different effects. At one harbor, UV light simply reduced the total abundance of biofouling organisms, while at the second, some species were affected more than others, creating a change in dominant species and an increase in diversity. These findings reinforce past findings that, antifouling effectiveness of UV light depends on the biofouling community at a given location. Furthermore, the possibility that UV can increase biofouling diversity raises the risk of transporting potential invasive species. In conclusion, any UV treatment intended to prevent biofouling will likely need to be adjusted according to location (and biofouling community) and to minimize areas receiving minimal illumination.

Salt marsh-mudflat linkage inferred from stable isotope analysis in mega- and microtidal systems

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Neighbouring ecosystems are not typically isolated from each other, rather they interact and exchange matter, nutrients, and energy. In Maritime Canada, salt marshes and mudflats are neighbouring soft-sediment ecosystems that are highly productive habitat for a variety of fauna, particularly invertebrates. We investigated linkages between salt marsh and mudflat ecosystems in megatidal (> 12m amplitudes; Bay of Fundy) and microtidal (< 2m; Northumberland Strait) regions in Maritime Canada, using 13C and 15N isotope signatures of primary producers and invertebrate consumers. Over 2 years and three sampling rounds, we observed consistent stable isotope values. Certain mudflat infauna appear to be feeding on exported salt marsh grass detritus. The trophic relationships showed regional differences, including elevated 15N isotope values in the megatidal region and a wider 13C isotopic range in the microtidal region, the latter partly reflecting linkage with subtidal eelgrass beds. Overall, the degree of linkage and the number of ecosystem types that are linked varied with hydrodynamic regime. Salt marshes and mudflats elsewhere in the world have been reported to supplement adjacent coastal systems, including offshore fisheries, and we are starting to find evidence of this at north temperate latitudes.

Anthropogenic Impacts on Freshwater Mussels: Case Studies from New Brunswick, Canada

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Freshwater mussels (Bivalvia, Unionida) are ecosystem engineers, playing essential roles in freshwater ecosystems, however, they are among the most imperilled organisms in North America due to many influences including anthropogenic interventions. As larvae (glochidia), freshwater mussels are obligate parasites to fish, so any river alterations impairing fish passage can prevent their ability to survive. Historically there were 11 different mussel species found in New Brunswick but one species (Dwarf Wedgemussel; *Alasmidonta heterodon*) has since been extirpated. The extirpation of Dwarf Wedgemussel was due to the construction of a causeway without fish passage mechanisms in the Petitcodiac River. Restricted fish passage is a common occurrence in New Brunswick causing a lot of issues for mussels. The Mactaquac Generating Station in the Wolastoq | Saint John River intentionally passes three species of anadromous fishes upstream, none of which are thought to be hosts for Yellow Lampmussel (*Lampsilis cariosa*) potentially causing them to disappear from upstream habitats. A newer threat to Yellow Lampmussel, a species of special concern, is the invasion of Zebra Mussels (*Dreissena polymorpha*). Although Zebra Mussel distribution does not overlap with Yellow Lampmussel yet, it is just a matter of time before they outcompete Yellow Lampmussel causing their populations to decrease. Unlike the Yellow Lampmussel, Eastern Pearlshell (*Margaritifera margaritifera*) has a conservation status of secure in New Brunswick and are found all over the province. However, Eastern Pearlshell rely on Atlantic salmon (*Salmo salar*) to complete their life cycle and Salmon populations in the province are dwindling.

The functional and structural response of the zebrafish (*Danio rerio*) cardiovascular system to chronic hypoxia.

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The functional capacity of the cardiorespiratory system depends on oxygen availability to the myocardium. However, there are fish species, including the zebrafish (Danio rerio), that maintain aerobic function in their natural habitats where exposure to hypoxia is a common occurrence. Previous work in our lab has focused on the ability of fish to modify the structure and function of the heart in response to a sustained environmental challenge, for example, cold acclimation. In the current study, we investigate the response of zebrafish to chronic hypoxia, and the adaptations they use to compensate for the physiological challenges caused by hypoxia. We exposed zebrafish to 30% dissolved oxygen (DO) for 7 weeks, measured cardiorespiratory capacity via loss of equilibrium (LOE) trials, and then characterized heart function using high frequency cardiac ultrasound. We also investigated heart morphology and composition using histological approaches and explored the expression of a variety of gene transcripts related to the hypoxia response, anaerobic metabolism, and angiogenesis. Our results suggest that exposure to chronic hypoxia enhances cardiorespiratory function, as indicated by improved performance in LOE trials, and a lack of a bradycardic response when subjected to both acute hypoxia and acute cold exposure. These functional responses could be explained by the observed increase in hematocrit, and/or by the predicted modifications to myocardial structure. These results provide novel insight into the physiological response of fish to hypoxia, which is becoming a challenge in aquatic ecosystems worldwide. This work was supported by NSERC.

Influence of hemoglobin-O_2 affinity on aerobic capacity in deer mice

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High-altitude hypoxia constrains tissue O_2 supply, but several high-altitude populations have evolved adaptations to overcome this challenge. Evolved increases in hemoglobin- O_2 (Hb- O_2) affinity are pervasive across high-altitude taxa, but the influence of such increases on aerobic capacity in hypoxia remains contentious. The influence of Hb- O_2 affinity on aerobic capacity in hypoxia could vary depending on other traits in the O_2 transport pathway, but this possibility is poorly understood. We examined this issue in deer mice (*Peromyscus maniculatus*), which is found from sea level to >4300m altitude in the Rocky Mountains. Mice from populations native to high-altitude and low-altitude were born and raised to adulthood in captivity. Low-altitude mice (n=14) were acclimated to warm normoxia, and high-altitude mice (n=14) were acclimated to cold hypoxia for 6 weeks, creating two groups with distinct capacities for O_2 transport in hypoxia. Aerobic capacity for thermogenesis (VO_2 max) was measured in hypoxia after each of three pharmacological treatments to manipulate Hb- O_2 affinity: saline (control); efaproxiral, which decreases Hb- O_2 affinity; and sodium cyanate, which increases Hb- O_2 affinity. In control conditions, high-altitude mice had higher VO_2 max and arterial O_2 saturations (Sa O_2) than low-altitude mice. Efaproxiral reduced Sa O_2 and decreased VO_2 max in both populations. Sodium cyanate increased Sa O_2 in hypoxia in both populations. However, this was only associated with an increase in VO_2 max in 7 of 14 high-altitude mice and 4 of 14 low-altitude mice. Our results suggest that Hb- O_2 affinity may be optimal for aerobic capacity in hypoxia in high-altitude mice, and reductions in Hb- O_2 affinity reduce performance.

The single chambered decapod crustacean heart may function as a "multi-chambered" organ.

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The open circulatory system of decapod crustaceans is described as highly complex; a single chambered ventricle delivers haemolymph into seven arterial systems that further divide into "capillary-like" vessels. Regional haemolymph flow is controlled via cardioarterial valves at the base of each artery. Recently published research using *Cancer pagurus* shows that the internal structure of the crab heart is not a simple open ventricle, but rather is divided by longitudinal myocardial folds. We used the American lobster, *Homarus americanus*, to investigate the functional morphology of the decapod heart to determine if these myocardial folds may aid in regional haemolymph flow. Lobsters were scanned in situ using Micro Computed Tomography (Micro CT), and Echocardiography (ECG), allowing us to reconstruct the internal structure of the heart in 3D and investigate the effects of hypoxia on regional contraction of the heart. We found that like the crab heart, the internal structure of the lobster heart is divided into a series of "pseudo chambers." A typical bradycardia was observed during hypoxic exposure, our preliminary results showed the "pseudo chambers" may be differentially contracting during a single cardiac event. We are currently analysing the data to determine if this aids in differential/regional haemolymph flow. These findings could not only further our knowledge of the field of crustacean physiology, but drastically change our understanding of the control mechanisms in open circulatory systems.

Frozen-shut: Cold and hypoxia stress tolerance in winter-active pond insects

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Winter presents harsh physiological challenges for insects living in temperate ponds, in the form of low temperature and low oxygen (hypoxia). Despite these stressors, water boatmen (*Hesperocorixa sp.*), backswimmers (*Notonecta sp.*) and diving beetles (*Laccophillus sp.*) remain active year-round in eastern Nova Scotia, including when ice forms on top of these ponds. However, the stress physiology of overwintering pond insects has not been widely studied. We tested whether whole-animal and physiological correlates of cold and hypoxia tolerance changed during fall and winter in insects from the three genera mentioned above. We stocked two outdoor mesocosms with water boatmen, backswimmers, and diving beetles in late summer and early fall 2023. We sampled insects from these mesocosms every two months between September, 2023 and April 2024 to conduct in-lab measurement of stress tolerance. To assess cold tolerance, we measured the low temperatures at which voluntary movement ceased and at which internal body fluids froze. To measure hypoxia tolerance, we quantified surface respiration and dive duration of these air-breathing insects under low oxygen conditions. Additionally, we used biochemical assays to determine concentrations of metabolites and enzymes important for cold tolerance and hypoxia tolerance. We found several seasonal trends in whole-animal and biochemical measure of cold tolerance that expand on the highly limited stress physiology literature of aquatic pond insects.

The Effects of Hypoxia on the Olfactory System of Marine Threespine Stickleback (*Gasterosteus aculeatus*)

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Due to both changes in climate and changes in land use practices, many aquatic habitats in coastal regions around the world are becoming increasingly hypoxic. Globally, there are many hypoxic regions now present, where the oxygen concentration in water approaches 2 mg/L. There are no studies that examine the extent of effects hypoxia may have on the olfactory system. Olfaction is crucial for many species to find food, suitable habitats, mates, and to avoid predators. Therefore, if hypoxia can affect olfaction in any way, it could have lasting repercussions on species within hypoxic zones. To investigate this, a coastal species, the threespine stickleback was exposed to hypoxic conditions (4 mg/L O_2 or 2.7 mg/L O_2) for seven days. After the exposure, the behavioural responses to a predator associated odorant (dogfish bile) was investigated. There notable changes observed in the amount of time fish spent avoiding the odorant after hypoxia exposure, with hypoxia exposed fish initially avoiding the odorant less than control fish. Following hypoxia exposure, the olfactory epithelium of these threespine stickleback had less cellular proliferation occurring, as indicated by less prominent cellular division markers (PCNA). Additionally, there was a lower density of olfactory receptor cells being present within the epithelium. This evidence suggests that after this length of exposure to hypoxia, morphological changes can occur within the olfactory epithelium, with some effect on olfactory related behaviour occurring. However, whether longer acclimations would have a more detrimental effects is not known, and requires further study.

Wild fish holobiont response to abiotic gradients in the Elbe estuary

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Biotic interaction with complex communities of microbiota inhabiting every mucosal surface of teleost fish strongly influence the host metabolism, growth and health. The gill mucosal surface constitutes a special habitat for host-associated microbes due to its unique functions in waste excretion, gas exchange and local immune activity. The gill associated lymphoid tissue (GIALT) enables fish to discriminate between beneficial and pathogenic bacteria keeping microbiome homeostasis. Changes in the environment however, including water conditions, seasonal changes and physiological stress can lead to compositional disturbances that turn commensals into pathogens. This sensitivity to environmental parameters provides the opportunity to use the microbiome composition of the external mucus as a biomarker for the health of the fish. Here we compare the microbial gill mucus communities of the two teleost species *Osmerus eperlanus* and *Gymnocephalus cernua* from different life-history guilds and the bacterioplankton in the Elbe estuary. Over the course of one year, we collected 220 fish along the main channel of the estuary and generated matching *16S* rRNA metabarcoding and host transcriptome libraries. The aim is to characterize the physiological response along spatio-temporal gradients, extract bacterial indicator species and determine driving factors for fish health.

Naked Truths: Hypoxia Downregulates the Inflammasome of Naked Mole-Rats Following LPS Treatment

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The formation of NLRP3 inflammasomes is induced in response to immune (i.e., lipopolysaccharide; LPS) or other endogenous (i.e., hypoxia) stressors. Such immune activation is energetically costly, but hypoxia impairs aerobic cellular energy production. Thus, hypoxia-tolerant organisms, which often minimize energy demand in hypoxia, likely make trade-offs between hypometabolism and inflammasome activation. Various NLRP3 inflammasome proteins, such as caspase-1, are formed during inflammasome assembly; caspase-1 plays a role in the activation of pro-inflammatory cytokines, which subsequently induce sickness behaviours. We asked how the immune response of hypoxia-tolerant naked mole-rats (NMRs) is impacted by hypoxia at the cellular and behavioural levels. We treated NMRs with phosphate-buffered saline (sham) or LPS (1.5 mg/kg, a bacterial immune stimulant) injections in either hypoxia (11% O_2) or normoxia (21% O_2). We then assessed the expression of various NLRP3 inflammasome proteins and monitored sickness behaviours in treated animals. Our preliminary results suggest that lung NLRP3 expression is unchanged following LPS or hypoxia exposure but decreased 2-fold in animals exposed to a combination of hypoxia and LPS. However, pro-caspase-1 expression decreased following LPS or hypoxia exposure, yet remained unchanged in the double treatment. Furthermore, NMRs exhibited sickness behaviours following LPS or hypoxia exposure but with a longer latency in hypoxia, and with no additive effects in the double treatment

group. These results suggest that hypoxia activates an immune response in NMRs without impairing immune responsiveness to a bacterial challenge.

Turtle Hepatocytes Oxy-Conform to Extremely Low O_2 Tensions and Require Cyanide to Elicit Ion Channel Arrest.

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Pyramidal neurons in painted turtle brain sheets begin to initiate a characteristic anoxia tolerance response at an O_2 tension below 35 torr. This response includes depolarization of mitochondrial membrane potential, release of mitochondrial calcium, increased release of GABA, increase in GABA-A receptor currents, an increase in whole cell conductance, reduction in action potential frequency and a positive shift in threshold potential. Painted turtle hepatocytes appear to oxy-conform down to extremely low oxygen levels, hepatocyte mitochondria remain polarized during a N_2 gassed saline perfusion down to below 0.08 torr and retain calcium. The application of cyanide to the N_2 gassed saline depolarize hepatocyte mitochondrial potential and effectively reduced whole-cell conductance by 75% over a 30 min exposure. This is the first direct measure of ion channel arrest in a non-excitable cell model and offers the potential to explore cell level oxygen sensing mechanisms. Furthermore, we have developed cell culture techniques that allowed us to effectively patch-clamp these cells.

The Scale of Road Salt Contamination in Urban Freshwater Streams of Vancouver's Lower Mainland: Effects of Repeated Salt Pulses on Developing Coho *Salmon (Oncorhynchus kisutch)*

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The use of road salt (NaCl) is increasing across Canada, with an average of 5,500 tonnes applied in the City of Vancouver alone every year. Road salt enters nearby freshwater streams through stormwater runoff, leading to the salinization of these systems. In order to monitor road salt inputs to streams across Vancouver's Lower Mainland (VLM), a network of 29 Solinst conductivity/temperature loggers were installed and maintained through collaborative efforts between 13 local stewardship groups, government, and three academic institutions. These loggers have been tracking conductivity (a proxy for salinity) since as early as 2021 in some creeks, allowing us to describe the scale of road salt contamination in the VLM. Based on data from these loggers and targeted field sampling, we have confirmed that acute inputs of road salt result in brief (~24-h) peaks in stream chloride concentrations, as high as 14x the provincial acute water quality guideline. These pulses are highly seasonal, with the highest frequency and magnitude of peaks typically occurring at the end of December/early January, coinciding with spawning and early development of local Pacific salmon species, including coho salmon. Although acute salt exposures are known to be toxic to juvenile salmonids, the consequences of repeated pulsed exposures are not well understood. In this study, we exposed coho salmon (Oncorhynchus kisutch) to up to three repeated 24-h salt pulses at an environmentally relevant concentration at either 1-hr post-fertilization or 50% hatch. Test organisms were assessed for both lethal and sub-lethal endpoints (NSERC Alliance).

Road Salt Creating A Slippery Slope for Pacific Salmon: Unraveling the Impact of Road Salt on the Development and Physiology of Coho Salmon (*Oncorhynchus kisutch*)

Winter, C.*, Kilgour, C., Brauner, C.J., Schulte, P.M., & Wood, C.M.

In the Vancouver Lower Mainland, Pacific salmon spawn in freshwater streams that traverse highly urbanized areas. With an increase in impervious surfaces, runoff threatens the water quality of freshwater spawning habitats. Each year, road salt is heavily dispensed, leading to its contamination of local waterways, with pulses exceeding provincial guidelines by more than 14-fold. These pulses coincided with critical developmental stages for salmonids. Collaboratively with citizen scientists, government, and three academic institutions, we are exploring the impact that road salt contamination may have on the development and physiology of Pacific salmon. Building on a preliminary experiment on early life stages of rainbow trout (*Oncorhynchus mykiss*), we aimed to identify the lethal and sublethal effects of a 24-h NaCl pulse on coho salmon (*Oncorhynchus kisutch*) at six environmentally relevant salt concentrations and three developmental time points: fertilization, <1hr post-fertilization, and 50% hatch. Lethal effects were observed depending on the concentration and the developmental time point of the salt exposure. Our research aims to raise public awareness among those who distribute road salt and to advocate for stricter regulations of its use. (NSERC Alliance).

Accumulation of waterborne selenite and its toxic effects in Westslope cutthroat trout (*Oncorhynchus clarkii lewisi*)

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Selenium is an essential nutrient to all life, playing a role in many physiological processes. However, it possesses a narrow margin between essentiality and toxicity. Anthropogenic activities such as mining and agriculture have led to selenium being detected at levels exceeding regulatory guidelines in aquatic systems. Thus, it is commonly identified as a trace element of major concern, where selenium exposure to aquatic biota is documented to lead to multiple adverse effects. Although the diet is the main route of exposure to higher trophic levels, like fish, previous studies have demonstrated that aqueous exposures can still contribute to accumulation and toxicity. However, there is little mechanistic understanding of how waterborne selenium is accumulating in tissues and its toxicity in non-model, local species. We utilized radiolabeled selenite (Se75) to characterize how and if water chemistry can affect selenium accumulation in Westslope cutthroat trout (WCT). Lethality and biochemical endpoints were also examined after a 96-h exposure to waterborne selenite (0-32 mg L^{-1}). Anionic water chemistry affected selenite accumulation in WCT, where water phosphate concentration and/or phosphate transport inhibitors significantly affected selenite accumulation in some WCT tissues. Furthermore, the sensitivity of WCT was aligned with other salmonid species. However, protein carbonylation, Na^+/K^+-ATPase and H^+-ATPase activity were still altered indicating that waterborne selenite exerts effects on WCT physiology. These findings suggest that specific water chemistries may provide protection against selenium toxicity in impacted waterways and provides a better understanding of the sensitivity of a previously unstudied fish species providing insight into potential protective measures.

The effects of temperature on lampricide tolerance in juvenile lake sturgeon

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In the Laurentian Great Lakes, invasive sea lamprey are controlled using applications of the lampricide, 3-trifluoromethyl-4-nitrophenol (TFM), in infested waterways. The relative inability of larval sea lamprey to detoxify TFM compared to other fishes makes this pesticide a highly effective means of sea lamprey control. However, recent studies show that as water temperature rises, TFM tolerance in larval sea lamprey also increases. How water temperature alters TFM sensitivity in non-target species is not known, however. Lake sturgeon (*Acipenser fulvescens*) are endangered in the Great Lakes basin, and they are susceptible to lampricide treatments in early life when their habitat overlaps with larval lamprey. To examine the physiological implications of rising temperatures on young lake sturgeon, oxygen consumption ($\dot{M}O_2$) of young-of-the-year (YOY) was measured across a wide range of temperatures to estimate their thermal optima (Topt) and thermal breadth. Lake sturgeon had a Topt of 22.8 ℃ and a thermal breadth if 15.8-27.5 ℃. Subsequently, age 1-year-plus (1+) lake sturgeon were acclimated to 8, 16, or 20 ℃ and then exposed to a field-relevant concentration of TFM (4 mg/L). Survival tests indicated that TFM tolerance was lowest at 16 ℃ compared to cooler (8 ℃) and warmer (20 ℃) waters, which lie nearer their Topt. In conclusion, lake sturgeon tolerance to the lampricide TFM is influenced by temperature, with temperatures nearing their Topt resulting in greater TFM tolerance.

The ecotoxicological risks of recycling aquaculture wastewater: a transcriptomic approach using the fathead minnow EcoToxChip

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The rising demand for nutritious and low-fat foods has led aquaculture and wild rice industries to be among the fastest growing in the world. Northern wild rice (*Zizania palustris*) benefits from large quantities of phosphorus and ammonia-based nitrogen, while inland finfish aquaculture operations produce wastewater high in phosphorus from uneaten feed, and ammonia from nitrogenous excretions. Therefore, using aquaculture wastewater as a fertilizer for wetland wild rice paddies presents a sustainable system for the recycling of nutrient rich wastewater while supporting optimal plant growth. Yet, introducing uncharacterized wastewater to an ecosystem presents substantial ecological risks. This includes the addition of ammonia, which is toxic at low concentrations. Additionally, phosphorus loadings can contribute to eutrophication, resulting in oxygen depletion within aquatic ecosystems upon the decay of algae and aquatic macrophytes. Furthermore, the absence of regulatory oversight on chemical usage in aquaculture raises concerns surrounding a suite of contaminants of emerging concern (e.g. antibiotics, antifoulants, metals and disinfectants). We assessed the ecotoxicological effects of adding aquaculture wastewater to an aquatic ecosystem by measuring gene expression in the liver of adult fathead

minnows (*Pimephales promelas*) chronically exposed to incremental additions of aquaculture wastewater in simulated wild rice paddy mesocosms (n = 18). Transcriptomic analyses were completed using liver tissues with the EcoToxChip, a qPCR tool designed specifically for environmental and chemical risk assessments. The objective was to determine adequate nutrient loadings for maximizing wild rice production without adversely impacting fishes in the ecosystem. This study may aid in understanding the ecotoxicity of aquaculture wastewater effluents, and the risks associated with recycling or discharging effluents into natural systems.

Fishes in murky waters: Effects of TSS on fish gills and swimming performance

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Total suspended solids (TSS) naturally occur in aquatic habitats, but climate change and other anthropogenic disturbances can lead to increased levels. Exposure to high levels of TSS has the potential to damage fish gills through abrasion, leading to impairments to gill function and fish physiology. However, little work has been done exploring the linkages between TSS-induced gill damage and animal performance. Therefore, we tested the hypothesis that TSS damages gill structure, causing gill dysfunction and reducing swimming performance. We exposed salmonids (rainbow trout, brook trout and cutthroat trout) and non-salmonids (fathead minnow and longnose dace) to different TSS concentrations (0-1000 mg/L) for four days in a static exposure system. We assessed gill morphometrics [filament thickness (FT), oxygen-water diffusion (O-WD), lamellae thickness (LT), lamellae height (LH), interlamellar distance (ID), and epithelial lifting (EL)], expression of genes and proteins involved in ion regulation [Na^+/K^+-ATPase and vacuolar-type proton pump], and markers of animal swimming performance [critical swimming speed (Ucrit), oxygen consumption rate ($\dot{M}O_2$) and aerobic capacity [standard metabolic rate (SMR), maximum metabolic rate (MMR) and aerobic scope (AS)]]. At 100 mg/L and higher, TSS increased gill FT, LT and OW-D and decreased ILD. These changes corresponded with a reduced respiratory surface area in rainbow trout, leading to a reduction in $\dot{M}O_2$ and Ucrit. While $\dot{M}O_2$did not change in fathead minnows, the MMR was reduced, and they also showed a reduction in Ucrit. TSS did not affect the gene and protein markers in the gills. Overall, elevated TSS damages gill structure, leading to impaired aerobic metabolism and swimming performance of fish.

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Assessing the Toxicity of Metals to Fathead Minnows by Observing Ventilation and Behavioural Endpoints in Response to Hypoxia

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Eutrophication from nutrient pollution can result in hypoxic waters leading to overall stress of aquatic ecosystems. Fish have adapted strategies to cope with hypoxia, such as increasing their ventilation rate and changing their behaviour. However, fish are often exposed to more than one stressor in the wild. Nickel (Ni) has been included on Canada's critical mineral list because of its importance in clean technology and the significant reserves that are being mined in Canada. Lead (Pb) is also mined in Canada and has great economic value due to large scale mining and manufacturing operations. This study examines the effects of Pb and Ni on the oxygen regulation in fathead minnows (*Pimephales promelas*). Fish are exposed to the metal for 48 hours prior to observation, and the ventilation rates and behaviours of the fish are assessed under normoxia

and hypoxia. Results show that Ni (150 ug/L) exposure causes a significant decrease in activity and inhibits the increase in ventilation under hypoxic conditions. Pb (100 ug/L) on its own causes a significant increase in activity which is abolished in hypoxia with no effect on breathing frequency. These results will be correlated to time to loss of equilibrium as a metric of ecological health. Pb and hypoxia cause a significant increase of metal accumulation in the gills. Emphasizing a multiple stressor approach, this research is essential for developing Canadian Water Quality guidelines that can be used to effectively protect our aquatic species, as it reflects environmentally relevant challenges faced by Canadian aquatic ecosystems.

How the Hypercarnivorous Ancestry of Parasitic Lampreys May Have Made Them Vulnerable to Lampricides.

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Sea lamprey (*Petromyzon marinus*) invaded the Laurentian Great Lakes in the late 19th and early 20th century, where they devastated native fisheries. Populations were subsequently brought under control using the “lampricide” 3-trifluoromethyl-4-nitrophenonl (TFM), a phenolic compound applied to streams infested with larval sea lamprey. Lampreys are vulnerable to TFM due to a limited ability to detoxify it using the enzyme UDP-glucuronylsyltransferase (UGT). UGTs likely evolved in herbivorous animals to detoxify phenols produced by plants as phytochemical defenses. However, hypercarnivorous animals that feed exclusively on flesh, such as felines, hyenas, and sea lions, also have low capacity to detoxify phenolic compounds compared to omnivorous mammals due to fewer functional UGT isoforms in their liver. Due to the exclusive blood diet of parasitic sea lamprey, we hypothesized that they would have a lower diversity and abundance of UGT genes. We therefore exposed larval sea lamprey and omnivorous bluegill (*Lepomis macrochirus*) to TFM and used whole transcriptome sequencing to compare their UGT gene expression patterns in liver and gill. TFM detoxification capacity was greater in bluegill, which experienced limited TFM accumulation in muscle compared to sea lamprey, even when exposed to 10-fold higher [TFM]. Bluegill expressed 17 transcripts from 3 UGT families, representing 7 different UGT isoforms in liver and gill. In contrast, sea lamprey expressed 6 transcripts from one UGT family, with 4 isoforms. We conclude that the hypercarnivorous lifestyle of sea lamprey may have resulted in lower selective pressure to evolve defenses against phenolic compounds, explaining their greater sensitivity to TFM.

Unveiling the role of gastric acid secretion in post-prandial energetics and assimilation in *Astyanax mexicanus*

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Over the past decades, great interest and effort have been put towards dissecting the components of meal digestion and nutrient assimilation in vertebrates. Particular attention has been given to the influence of gastric acid in the postprandial energy mobilization and absorption. The luminal secretion of acid by the stomach is dependent on the heterodimeric gastric proton pump (HKA), encoded by the *atp4a* and *atp4b* genes. Traditional approaches have focused on the use of pharmacological knockdowns of gastric acidity and diet modulation. To overcome potential confounding factors that can be linked to these methods, we generated the first teleost

knockout model for the gastric proton pump (*atp4a* -/-) and set out to elucidate the energetic costs linked to digestion and nutrient assimilation. Here, we show a reduction of the energetic costs of digestion in both heterozygous and homozygous mutants and a reduction in post-prandial ammonia excretion, with no apparent changes in growth. qPCR data on heterozygous fish indicate a downregulation of *cholecystokinin* and *pept1* genes in the intestine, suggesting an accelerated gastric emptying rate, and a reduction of proton coupled peptide absorption resultant from lower intestinal acid levels. Furthermore, we used RNAseq to characterise the impact of the loss of gastric acidification on the modulation of genes linked to gastrointestinal transit time, peptide absorption, satiation, and growth. Taken together, our results shed light on the precise involvement of the stomach in the downstream processes of nutrient assimilation and open the door to further analyses in diverse areas using this genetic line.

Butyrate Supplementation and Temperature: Host vs Resident Impacts on Growth, Metabolism, and Gut Microbiome Composition in Sailfin Molly (*Poecilia latipinna*)

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Antibiotic use in aquaculture poses significant challenges, prompting a shift towards exploring alternative strategies such as the supplementation of prebiotics and probiotics in fish diets. This study investigated the effects of incorporating butyrate, a probiotic, into the diet of Sailfin molly (*Poecilia latipinna*) on growth, metabolism, gut microbiome composition, and host transcriptional responses. In addition, we tested the impact of temperature variation (23°C vs 30°C) as well as the role of the gut bacteria by employing broad-spectrum antibiotic over a six-week period. Growth was determined by measuring animal mass, while metabolic rates were assessed through intermittent respirometry, and bacterial communities in the gut microbiome were characterized through next generation sequencing. Finally, mRNA transcription of genes related to intestinal integrity was quantified using qPCR. Results revealed significant impacts of butyrate supplementation, temperature, and antibiotic use on the growth and metabolism of Sailfin molly. Furthermore, analysis of the gut microbiome and mRNA abundance revealed differences across treatments indicating a role for both host and bacteria responses. Overall, this research reveals the potential physiology behind the impact of butyrate in fish farming. By interpreting butyrate's effects on growth, metabolism, gut microbiome composition, and host transcriptional machinery this study contributes valuable insights for optimizing aquaculture practices towards sustainable and environmentally friendly strategies.

Hibernators salvage urea carbon during resource-limited winter to facilitate gut microbial acetogenesis

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The hallmark trait of mammalian hibernation is torpor, a metabolically depressed state that slows rates of fuel use and facilitates long-term fasting during winter, when food is scarce. While torpor solves the food scarcity problem, it deprives the animals of exogenous nutrients, including biomolecular building blocks such as nitrogen and carbon. Recently, we showed that 13-lined ground squirrels compensate for their lack of dietary nitrogen by harnessing the ureolytic capacity of their gut microbiota to salvage nitrogen from urea, and then use the urea nitrogen to

facilitate tissue protein synthesis during the winter fast. As urea also contains carbon, we wondered if perhaps they salvaged urea carbon as well. We explored this possibility in squirrels with naturally intact and antibiotic-depleted gut microbiotas, treating each with ^{13}C-labeled urea and then using ^{13}C-specific techniques to track the fate of urea carbon at three points of the year. We found that a significant quantity of urea carbon was incorporated into gut content acetate, a microbially derived short chain fatty acid that plays multiple metabolic roles during hibernation. We also found that urea carbon incorporation into acetate, a process involving microbial urea hydrolysis, carbon fixation and acetogenesis, was more efficient during hibernation than summer, and that a large proportion of the winter acetate pool appears to include urea nitrogen. This work suggests that urea is an important endogenous nutrient source during hibernation, supplying both host and potentially microbes with carbon and nitrogen when dietary sources of these atoms is lacking.

Functional characterization RYamides and deorphanization of their receptors in the yellow fever mosquito, *Aedes aegypti*

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Neuropeptides are chemical messengers synthesized and released by neurons that influence various physiological processes and behaviours. Examining neuropeptides in the mosquito *Aedes aegypti* helps better comprehend the regulatory networks governing their physiology. The RYamide neuropeptides and their associated G protein-coupled receptor were identified in a few insect species over a decade ago. However, there are limited studies on expression profiles, localization, and physiological roles of RYamides and their cognate receptors in many other insects, including *A. aegypti*. This research aimed to bridge this knowledge gap by immunolocalizing RYamides within the nervous system and peripherally, quantifying transcript expression and identifying ligands for putative RYamide receptors, all of which would help establish functional roles of this signaling system in this important insect pest. Interestingly, RYamide transcript abundance was stable over developmental stages, whereas enriched RYamide transcript expression was observed in tissues/organs of adult mosquitoes including the nervous system. These observations corroborate the RYamide immunolocalization observed within neurons in the optic lobes of the brain and in the abdominal ganglia of the ventral nerve cord. Further, RYamide immunoreactive axonal processes were observed extending from the pyloric valve region and continued over the entire ileum towards the posterior hindgut, with extensive staining over the rectal pads of both male and female mosquitoes. A heterologous functional assay was used to confirm the specificity and sensitivity of two putative mosquito RYamide receptors by assessing their activity in response to diverse peptidergic ligands, revealing that RYamides exhibited the strongest response by both receptors with low nanomolar activities.

Environmental influence on microbiome structure and function in the starlet sea anemone (*Nematostella vectensis*) across wild and laboratory conditions.

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Host-associated microbiomes are widely known to influence host physiology, with different environments eliciting unique host-microbiome interactions. Here, we examined how changing

environments alter the microbiome of the starlet sea anemone (*Nematostella vectensis*), an emerging clonal model organism. Using targeted *16s rRNA* gene sequencing we first characterized the microbiome associated with two populations of wild-collected anemones before and after laboratory acclimation. Our results revealed significant differences in the diversity and composition of wild and lab-acclimated microbiomes, highlighting the influence of captivity on microbial communities. Interestingly, anemone populations sourced from salt marsh ponds located within 50 feet of one another exhibited discernible microbial communities, which persisted even after laboratory acclimation. Laboratory animals were subsequently exposed to various salinity conditions (5 ppt, 20 ppt, 40 ppt) using either autoclaved water or autoclaved water seeded with water from the wild collection site. After four weeks in these conditions, a subset of the animals were used to characterize the microbiome while another group underwent a regeneration challenge or a thermal tolerance experiment. Changes in host responses were observed as a result of salinity and in the anemones raised in autoclaved water compared to those with wild-seeded water. This observation suggests a crucial role of the microbiome in supporting physiological processes, particularly related to wound healing and tissue regeneration. Understanding how environmental conditions influence the microbiome and, in turn, how the environment influences hosts in the absence of a functional microbiome is essential for disentangling the potential effects of environment-microbe interactions on host physiology.

Effects of Swim Bladder Non-Inflation on the Gut of Larval Zebrafish (*Danio rerio*)

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The swim bladder is a gas-filled organ needed for neutral buoyancy and energy conservation in many fish, including zebrafish (*Danio rerio*). Failure to inflate their swim bladders within the first 5-6 days of life results in 100% mortality of larval zebrafish by the time they reach 11-12 days old. Surprisingly, the cause of death for larvae that fail to inflate is unknown. To further understand the cause(s) of death, larval zebrafish are placed in an experimental air-restriction apparatus, where they cannot inflate their swim bladders. Forced non-inflation allows for the observation of swim bladder and gut morphologies, development, and inflammatory responses. Even though uninflated zebrafish are dying, and a common assumption for their death is starvation, research conducted in a lab setting reveals that they have the same amount of food in their gut as their inflated counterparts. This similarity in gut content raises concerns about potential issues in the development of the gut and its ability to intake nutrients. There is a significant amount of leakage of the gut barrier at increasing days-post-fertilization, which caused interest in the degradation of gut cells. Based on ongoing testing, non-inflation manifests in the degradation of smooth muscle and vasculature, fewer enterocytes, and an increased number of macrophages and neutrophils that contribute to the mortality of the uninflated larval zebrafish. The results of this study can help further understand the mechanisms behind why non-inflation causes death in larval teleost fish, therefore learning more about the pathologies associated with non-inflation.

Nitrogenous waste and acid-base dynamics in the gut of rainbow trout after a single meal. I. Physiology

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While the roles of the gills in ammonia, urea-N, and acid-base homeostasis in freshwater fish have been well-studied, much less is known about the comparable roles of the digestive tract in these processes. We have addressed this issue by sampling blood, chyme, and gut tissues in juvenile rainbow trout (10 °C) after 10 days fasting (control), and at 4h, 10h, 30h, 54h, 80h, and 175h after a single satiation meal (4.94% body weight) of commercial trout pellets. Marked, long-lasting elevations of ammonia, urea-N, and total CO_2 concentrations occurred in the blood plasma, the latter indicative of an alkaline tide. After feeding, total ammonia levels in chyme increased in the stomach, but decreased progressively in all sections of the intestine (anterior, mid, and posterior). Changes in chyme urea-N were modest. Stomach pH rose greatly immediately after feeding, and long-lasting elevations in pH were seen in all intestinal sections, coincident with large increases in chyme [HCO_3^-]. Clearly, gut-mediated fluxes play important roles in disturbances of systemic homeostasis after feeding. Possible involvement of specific transporters in these fluxes at the molecular level will be considered in the companion presentation (NSERC Discovery).

Nitrogenous waste and acid-base dynamics in the gut of rainbow trout after a single meal. II. Gene Expression.

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The gills have a well described role in nitrogenous waste and acid-base homeostasis in freshwater fishes, but less is known about the comparable roles of the digestive tract in these processes. We have addressed this issue by sampling blood, chyme, and gut tissues in juvenile rainbow trout (10 °C) after 10d fasting and at 4h, 10h, 30h, 54h, 80h, and 175h after a single satiation meal (4.94% body mass) of trout pellets. To complement the physiological data presented in Wood and Wilson, we report here the corresponding changes in ion [NKA: *atp1a1c*, *atp1a3*, VHA: *atp6v1b*, *slc12a2*], acid-base [HKA: *atp4a* (ST only), *slc9a3*, *slc4a1a*,*-b*, *slc4a4/nbc*, *ca*], Rhesus ammonia (*rhag*, *rhbg*, *rhcg1* and *2*, *rh30-like3*) and urea (*ut*) transporters in the stomach, and the anterior and posterior regions of the intestine using quantitative PCR (qPCR). In stomach, there were few changes in gene expression except for transient drops in *rhag* and *rh30like3* that correspond to high luminal levels of ammonia. Significantly these changes did not correlate with the erythrocyte marker *hbaa2* since both these transporters are also known to be expressed in erythrocytes. In the anterior intestine, which is the most important site for digestion and absorption, *rhag*, *atp1a1c*, *atp1a3*, *slc4a4*, *slc4a1a* and *2b* increased while *rh30like3* decreased transiently. Both *atp6v1b* and *ca* showed delayed increases (80h). In the posterior intestine, there was an early increase in ca and delayed increases in *rh30like3* and *slc4a2b*. The significance of these changes in gut gene expression will be discussed. (NSERC Discovery).

Taurine efflux supports cardiac output under acute thermal stress by protecting cell volume

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Maximum cardiac function is a critical determinant of upper thermal tolerance in fish but the mechanisms constraining it remain unresolved. Taurine is an important osmolyte in fish that is

acquired largely via the diet. It is required to support maximum heart rate under thermal stress, but its importance to blood flow and associated mechanisms of action are unclear. To address this gap in knowledge, we assessed in vivo cardiac function, routine rates of O_2 consumption (MO_2), and a variety of biochemical parameters in control and taurine-deficient (TD) brook char (*Salvelinus fontinalis*) during an acute thermal stress. Resting heart rate was lower in TD fish, but thermal sensitivity was similar to controls. Control fish increased stroke volume with temperature more than TD fish so that maximum cardiac output was 30% lower in the latter. The thermal sensitivity of MO_2 was lower in TD fish, as was plasma lactate following acute thermal stress. Cardiac intracellular pH (pHi), plasma cortisol, and taurine synthesis pathways were similar between treatment groups. Cardiac taurine efflux was absent in TD brook char, which caused heart tissue osmolality to increase by >40 mosmol/kg following acute thermal stress. Collectively, these data demonstrate that intracellular taurine constrains maximum cardiac function under thermal stress through its role in regulating cardiomyocyte volume. Life stage, species, or climate change-related shifts in dietary taurine availability may therefore significantly impact cardiac and whole animal sensitivity to acute thermal stressors.

Seasonal changes in the thermal tolerance, sensitivity, and regulation of cardiac function in fishes with different overwintering strategies

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Fishes can experience large temperature variation over both rapid (i.e. daily) and prolonged (i.e. seasons) time scales that can challenge critical physiological functions. During acute warming or summer highs, fish can increase their heart rate to support increased tissue oxygen demands but only until a maximum temperature where a concomitant peak heart rate is reached. Conversely, at cold winter temperatures, life processes such as heart rate will be slowed markedly. Through acclimation, fishes will commonly adjust their cardiac thermal performance to compensate for warming or cooling. However, the degree to which this compensation varies among species with different thermal habitats and strategies is not well defined. Additionally, the extent to which any thermal acclimation of cardiac thermal sensitivity and heat tolerance are driven by changes in adrenaline regulation (a key controller of cardiac function) among fishes requires further exploration. Using an electrocardiogram method, we investigated seasonal changes in cardiac temperature tolerance and adrenergic regulation in winter-dormant cunner (*Tautogolabrus adpsersus*) and winter-active brook char (*Salvelinus fontinalis*). We found that seasonal temperature acclimation includes partial compensation of cardiac thermal tolerance and sensitivity in both cunner and brook char, supporting thermal compensation as a conserved response among temperate fishes. Adrenergic stimulation was necessary for cardiac function at high acute temperatures regardless of acclimation temperature in cunner but not in brook char, indicating species-specific roles for adrenaline in sustaining cardiac thermal performance.

Rapid Thermal Acclimation of Cardiac and Whole Animal Heat Tolerance in Lab and Field Populations of a Eurythermal Fish, the Mummichog (*Fundulus heteroclitus*)

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Temperature can vary greatly in aquatic habitats over time scales from hours to months. In fishes, the heart is an important mediator of thermal tolerance and performance. During acute

warming, fishes can sustain higher oxygen demands by accelerating heart rate, but only until a maximum temperature/heart rate is reached. If warming continues, the heart can become arrhythmic, in association with the whole-animal upper thermal tolerance limit. Warm acclimation in fishes can involve cardiac thermal acclimation including an increase in the temperatures where peak maximum heart rate and cardiac arrythmia occur. This improvement of cardiac heat tolerance is known to be remarkably rapid in salmonids (within 24-72 hrs). We do not know whether rapid cardiac thermal acclimation is found widely among fishes or to what degree the acclimation speed or magnitude depends on species' thermal niche. Using ECG and CTmax assays, we investigated the time scale/scope of cardiac and whole animal thermal acclimation in the eurythermal mummichog (*Fundulus heteroclitus*). After 30°C warm lab acclimation for ≤ 4-weeks, we found the fastest cardiac thermal acclimation yet known in fishes, with significant improvements in cardiac metrics within 6hrs alongside enhanced CTmax. We then investigated whether this rapid plasticity is used by wild mummichog to cope with the substantial rapid and seasonal temperature fluctuation in their estuarine habitat. Wild mummichog responded primarily to the maximum temperatures across short timescales (24-168 hrs) including as waters cool in autumn. Rapid plasticity of cardiac and whole-animal heat tolerance is an important component of eurythermality in mummichog.

Dogfish heart rate peaks in warm water before they get agitated

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When the body temperature of a fish is acutely increased to its critical thermal maximum (CTMax), fish exhibit a marked shift in behaviour that is attributed to attempts to find cooler water. This behavioural response occurs at the 'agitation temperature', which is a sub-lethal thermal tolerance metric first described in fishes in 2015 that has since received little mechanistic evaluation. Previous studies have demonstrated that the agitation temperature occurs at cooler temperatures than CTMax, is reversibly plastic with temperature and oxygen, and denotes the onset of the cellular stress response. Cardiorespiratory performance often declines in fishes approaching their CTMax, marked by the onset of arrhythmias; therefore, the present study tested the hypothesis that cardiorespiratory performance declines at the agitation temperature. Pacific spiny dogfish (*Squalus suckleyi*) were screened for the agitation temperature, CTMax, and cardiorespiratory thermal limits (Arrhenius breakpoint temperature and temperature of peak heartrate [Tpeak]). Secondary stress markers associated with poor cardiac performance were measured at CTMax, and molecular markers of thermal and hypoxemic cellular stress and biochemical markers of aerobic and anaerobic metabolism were measured at the agitation temperature. Contrary to our hypothesis, Tpeak occurred at the agitation temperature, suggesting that cardiorespiratory performance was maximized and not impaired. Further, thermal cellular stress, but not hypoxemic cellular stress, was evident at the agitation temperature, and lactate accumulation was only evident at CTMax. Together, these data demonstrate that the agitation temperature is associated with the onset of thermal cellular stress and not oxygen limitation.

Effects of a heatwave on cardiac mitochondrial respiration of a freshwater fish: the Rhône apron

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We studied the effects of an environmental heatwave in an endangered species in France: the Rhône apron. We chose to study cardiac mitochondria as the heart plays a central role in metabolism and is solicited during acute thermal stress. The heatwave was characterised by an increase of temperature from 13°C to 18°C (1°C/hour) for 5 days, followed by a decrease from 18°C to 13°C (1°C/hour) for 5 days and measures were made at different timelines; 1h, 24h and 96h during the heatwave and at the same times during the decrease. Mitochondrial respiration rates associated to phosphorylating state (OXPHOS), basal state (LEAK) and uncoupled state (FCCP) were measured at 13°C and 18°C in heart homogenates for each individual using high-resolution oxygraphs. Fluxes were divided by COX respiration as a proxy of mitochondrial content in the homogenates. We found that OXPHOS in complexes I+II, LEAK and uncoupled respiration were decreased 24 hours into the heatwave but returned to baseline levels 1 hour into the decrease. This could be considered as the fish's adaptive response to acute stress and once they are acclimated to the stress, mitochondrial respiration returns to its original level. There was also an effect of assay temperature; OXPHOS and LEAK respiration of complexes I+II and uncoupled respiration tended to be higher at 13°C than at 18°C, excluding the possibility of a Q10 effect and suggesting that the mitochondria of these fish are less efficient at higher temperatures, which could partly explain their status as an endangered species.

Seasonal temperature induced heart-collagen remodeling response in the rainbow darter (*Etheostoma caeruleum*)

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Acclimation to temperature changes in fish has been shown to prompt a cardiac remodeling response, with collagen protein playing a key role, although the mechanism of this response remains unclear. Currently, it is believed to be a seasonal adaptation to shifting temperatures, with studies indicating that *microRNA-29b*, an epigenetic non-coding RNA, targets collagen mRNA in the heart. To further explore these questions, this study characterizes the remodeling response in a wild population of rainbow darters (*Etheostoma caeruleum*) to examine seasonal effects in a natural environment, which moves beyond the current lab-only studies. Rainbow darter heart tissue was collected on-site at three season timepoints (Spring, Summer, Fall 2023) from the Grand River, Grand Valley, ON. Water temperature loggers were deployed to monitor the fluctuating river temperatures throughout the study. Hearts were used to measure gene expression of *microRNA-29b*, and the three collagen type I protein monomer transcripts (*col1a1*, *col1a2*, & *col1a3*) through qPCR. Additionally, hearts were embedded for histological analysis to

visualize and quantify the collagen protein content through picrosirius red staining. Results from qPCR revealed seasonal and sex-specific differences in expression of *microRNA-29b*, *col1a1*, and *col1a2*, suggesting the presence of this remodeling response in a non-model species. Understanding the impacts of temperature fluctuations and extreme weather events on local fish populations is increasingly crucial. This study contributes to a more comprehensive understanding of seasonal effects in a natural environment.

Facing an increasingly variable world : metabolic responses throughout an heatwave event in an endangered freshwater fish (*Zingel asper*)

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Climate change is often conceived merely as a gradual rise in average temperatures, yet it also manifests through increased thermal variability. Heatwaves are notably predicted to expand in frequency and amplitude, exposing organisms to recurrent and acute thermal stresses. In ectotherms, body temperature – and so energy expenditure – are directly shaped by environmental temperature and an increased vulnerability to the anticipated escalation of extreme climatic events, has recently been highlighted. Freshwater fish are particularly threatened due to reduced water volumes that do not act as buffers against temperature variations, as efficiently as marine hydrosystems. In this context, we investigated whole-organism energetic expenditure in an endangered freshwater fish species, Rhône apron (*Zingel asper*), throughout a simulated heatwave event. Aprons (n=16) were randomly divided into three groups. Controls were acclimated to 13°C or 18°C and followed a constant treatment. The third group (HW) was initially acclimated to 13°C and experienced a five-day heatwave exposure at 18°C before returning to 13°C. Both Standard (SMR) and Routine (RMR) metabolic rates, and spontaneous activity (area under the curve), were individually measured before, during (1h, 24h, 72h, 96h) and after (at the same intervals) the heatwave. Control groups exhibited high repeatability of SMR during all the experiment. HW fish showed an additional metabolic cost during the heatwave episode, after which they returned to their previous baseline level. These results point out integrative consequences of acute and chronic exposure to heatwaves on the acclimation process of organisms and encourage further exploration of the mechanistic underpinnings through mitochondrial bioenergetics.

Thursday/Jeudi, May/Mai 9

Walking on sand: Kinematic and behavioural response to sand fouling in the purple sea urchin

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Habitat shifts in the marine intertidal and subtidal zones between algal turf, barrens, and kelp forest can result from interactions between herbivory, productivity, predation, and water temperature. Positive feedback loops perpetuate two stable ecological states: the historical kelp forest, and a disturbed algal turf. This is because algal turf colonizes barrens faster than kelp forest and hampers kelp forest recovery. Previous work hypothesized that sediment accumulation in algal turfs helps maintain this ecosystem by inhibiting both kelp recruitment and herbivore browsing. In the lab, sea urchins feed on algal turf (and display species-specific preferences), but in natural environments they are restricted to gaps in algal turf. This distribution may reflect sediment interfering with the sea urchin adhesive system, a system essential for locomotion and adhesion on unfouled substrates. To test whether accumulated sediment physically prevents sea urchins from reaching and browsing on algal turf we measured behaviour (use of tube feet/spines, patterns of movement, exploration behaviour) and locomotor performance (maximum speed, distance travelled) across a glass substrate covered by progressively higher levels of sand. We used the purple sea urchin, *Strongylocentrotus purpuratus*, because it feeds primarily on kelp and so may be subject to physical limitations contributing to dietary preference. We hypothesized that sediment inhibits sea urchin locomotion by precluding the use of tube feet in sufficiently deep sand. Our results clarify both the ecological consequences of access to the algal turf for this important herbivore, and the mechanics of locomotion using tube feet and spines across different substrates.

Neural specification in partial embryos of the annelids Capitella teleta and *Platynereis dumerilii*

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Cell fate acquisition requires a complex mix of inherited and external signaling cues. An ideal framework to examine fate acquisition is spiral cleavage, the ancestral form of cleavage for Spiralia (~Lophotrochozoa). Animals with spiral cleavage undergo stereotypic cell divisions, and each cell (blastomere) reproducibly produces a specific set of tissues. By removing potential signaling cells via blastomere isolation we can determine if external signals are necessary for a specific developmental fate (conditional specification). If the specific end fate is still produced, this suggests that inherited signals are sufficient (autonomous specification). To better understand these processes in Spiralia, we isolated blastomeres in the annelid *Capitella teleta* (Sedentaria) and assayed for whether certain fates were possible. In both annelids, the isolated cells responsible for neural formation were capable of creating neural tissue in isolation, suggesting that inherited factors may promote brain and ventral nerve cord fate in both species. Further evidence suggests that both mesoderm and endoderm require cells fated to produce those tissues, with no evidence of compensation in partial embryos. Thus far our results suggest that CNS evolution may have been more complicated than a single centralization event at the

base of Bilateria or that significant changes occurred within Spiralia. Future experiments to identify the genes involved in neural specification in annelids will ultimately provide insight into CNS evolution. This research was supported an MBL Whitman Early Career Investigator Fellowship to NBW and an NSF grant to NPM.

The effect of developmental phenotypic plasticity on morphological and metabolic traits associated with flight in the hawk moth, *Manduca sexta*

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In flying insects, intraspecific variation in body size and wing proportions impacts flight energetics. Larger individuals tend to have lower wingbeat frequencies, and at a given size, wingbeat frequency is inversely proportional to wing size. Within a geometrically similar species, metabolic rate, expressed on a mass-specific basis, is expected to decrease to the same extent as wingbeat frequency with an increase in size because less frequent flight muscle contractions reduce the required muscle power output for flight. Temperature is an overarching cause of intraspecific variation that can expand the range of size and wing proportions, but how this affects flight energetics is unknown. To examine this, we reared *Manduca sexta* larvae at various temperatures. We found that on average, a 10°C decrease in temperature led to an increase in body mass of 53%, while wing size only grew by 20%. I will present evidence that flight energetics in a disproportional species deviates from trends observed within geometrically similar species. Notably, an extreme large size caused some individuals to have severe difficulties with flight, indicating that sometimes developmental plasticity can be detrimental to flying insect function. To complement whole animal measurements, experiments currently underway are examining muscle metabolic phenotype through quantification of activity of key enzymes involved in *Manduca sexta*'s metabolism. This next step will be presented and will further shed light on whether there is a trade-off associated with plasticity in response to temperature on flight energetics.

How spider bodies set the communication frequency

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Spider leg joints are multi-functional and are important both in vibration sensing and locomotion. We expect that the biomechanics of leg joints are tuned to enable them to support the spider's mass but will also set the vibration frequency range. We studied 11 spider species and measured the rotational stiffness of two joints on two legs. Using mixed effects models we examined the scaling relationships between joint stiffness and spider mass, and whether the joint and species identity affect this relationship. We found that heavier spiders had stiffer joints, and the relationship between mass and stiffness was nearly allometric. These data when incorporated into experimentally validated multibody models of spiders, suggests that spiders of different body masses will nonetheless be mechanically stimulated by very similar vibration frequency ranges. Thus, our data suggest that using the whole body as a sensor prevents spiders from niche partitioning the vibrational signal space.

Evolution of sensory systems: extreme adaptation to low food by deep sea glass sponges

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**Presenter*

Sponges are porous filter feeding animals that lack both nervous and muscular systems. Yet one group – Hexactinellida (glass sponges) – uses electrical signals to arrest their feeding current. Action potentials travel unimpeded through syncytial tissues, whose cobweb-like strands line the very open canal system. We asked whether such thin-walled tissues, and the associated electrical conduction system, were adaptations to reduce the costs of filtration in the food-poor deep-sea. Although sponges have specialized cells that function as biological pumps, their porous bodies are proposed to take advantage of ambient currents via 'induced flow'. To test the hypothesis that ambient currents can induce passive flow through living glass sponges and reduce the metabolic cost of pumping we developed custom flow and oxygen sensors to record flow over and out of glass sponges at a 175m deep glass sponge reef. We found that few individuals processed more water during periods of higher ambient current, but surprisingly, at higher ambient currents the sponges removed 30% less oxygen from water processed. Nevertheless, in all individuals, flow stopped independently of ambient currents, demonstrating their ability to control pumping using their electrical conduction system. These experiments suggest that deep-sea glass sponges can take advantage of ambient flow to reduce their costs of feeding, but nevertheless control water movement with their complex physiology. The mechanism underlying how costs are reduced at higher ambient flows remains unknown, but may involve feedback via primary cilia that have been shown to sense flow in other sponges.

Neuroanatomy of the biogenic amines octopamine and norepinephrine in the central nervous systems of freshwater pulmonate snails

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Biogenic amines, including dopamine, octopamine, and norepinephrine, are neurotransmitters with deep origins in the metazoa. In arthropods, octopamine has been shown to have a similar role to adrenaline in vertebrates. However, it is not clear where this function arose in the protostome lineage. For example, less is known about functions of octopamine in molluscs. With some discrepancies amongst past reports, our goal was to characterize the neuroanatomy of putative octopaminergic cells in the pulmonate snails *Lymnaea stagnalis* and *Biomphalaria alexandrina*. In addition, because of overlapping enzymatic pathways, we also investigated the neuroanatomy of norepinephrine. We used both immunohistochemistry (with antibodies targeting the neurotransmitters themselves, as well as their synthetic enzymes, tyrosine hydroxylase and tyramine beta hydroxylase) and in situ hybridization chain reaction (HCR) labelling of those same enzymes. Consensus maps were generated from confocal images, with putative octopaminergic cells sparsely scattered through several ganglia of the central nervous system. The neuroanatomy was broadly similar to a past study, but with many discrepancies in the details, and was also consistent with the known effects of octopamine on feeding and locomotion. In addition, HCR (but not immunohistochemistry) revealed the novel finding of a few

scattered putatively octopaminergic neurons in in the periphery. As expected, no evidence was found for cells with norepinephrine, nor the combination of enzymes required for its synthesis. Overall, these results lay the groundwork for further exploration of the role octopamine plays in the molluscan nervous system, and insight into the evolutionary origins and diversification of biogenic amine neurotransmission.

More Than a Feeling: The importance of sensorimotor experience in postembryonic brain development

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During postembryonic development, the nervous system becomes sufficiently developed to begin processing sensory input from the environment while the brain continues to grow. This combination of sensory processing and ongoing growth makes postembryonic development sensitive to sensory experience. Whereas traditionally focus falls on nervous growth via structural and functional changes in pre-existing neurons, we chose to monitor the birth of new neurons via neurogenesis. We found that an understudied source of early sensory experience, movement, is critical to maintain a large pool of neural precursors, the source of new neurons, in the larval zebrafish forebrain. We found that movement regulates neurogenesis via both treatments that made larvae swim less (less cells) and swim more (more cells). To better understand how movement contributes to new brain cells, we carried out experiments that altered sensory sources that accompanied movement. We found that the somatosensory feedback detected by peripherical sensory cells, the body dorsal root ganglion (DRG), were at least part of movement-dependent forebrain growth. Reducing DRGs significantly reduced new forebrain cells and electrically activating DRGs in larvae that couldn't physically move generated more forebrain cells. As I became an assistant professor at the University of Alberta, my lab continues to investigate this finding with new experiments, further unravelling the body-brain relationship of movement-dependent early in vertebrate development.

Always a bigger fish: Developmental mechanisms and phenotypic divergence of a giant threespine stickleback population

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The threespine stickleback, *Gasterosteus aculeatus*, is known to exhibit extensive habitat-specific phenotypic variation across its range. While marine-freshwater and benthic-limnetic transitions have been extensively studied, extreme phenotypes and allometric relationships remain understudied in sticklebacks. For instance, gigantism, while rare in sticklebacks, has significant evolutionary and ecological implications.

Here we explore phenotypic variation and variability in stickleback populations. We compare sticklebacks from Sarita Lake, BC, which are exceptionally large, bordering on gigantism, with "normal-sized" populations from lacustrine and marine habitats. We further assess the role of allometry and morphological integration in inter-population phenotypic divergence. Geometric morphometrics was used to analyze shape, allometric trajectories, and morphological integration across the cranium, pectoral girdle, and pelvic girdle of four lacustrine and two marine stickleback populations.

Sarita Lake fish displayed unique cranial, pelvic, and pectoral phenotypes, both in shape and

size and were consistently larger than other lacustrine populations. Distinct allometries were also observed in the cranial and pelvic regions. Sarita Lake stickleback differed from other populations in their patterns of morphological integration. While all populations displayed different phenotypes, Sarita Lake displayed distinctly stronger integration between the pelvis and the cranium. Cranial phenotypes are associated with a wide range of ecological factors, but the unique integration patterns with the pelvis in Sarita Lake may produce a morphological change in the cranium through the influence of predation pressure on pelvic morphology. These results are consistent with common hypotheses regarding gigantism in stickleback.

Investigating parasite densities for the detection of oxylipin signaling molecules

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Signaling molecules are a potential mechanism mediating host-parasite interactions, but much remains to be discovered, including the origin and function of specific molecules. To elucidate these aspects, methods must be developed that can adequately detect and quantify oxylipins emitted from hosts or parasites. Differences in body size between hosts and parasites suggests hosts may emit more oxylipins than parasites. As a result, a greater number of parasites relative to hosts may be required for oxylipin profiling. To determine the density of cercarial parasites (larvae produced within snail hosts) required for oxylipin detection, we exposed ~150 freshwater snails (*Stagnicola elodes*) to 5-10 miracidia (larvae produced within eggs) of *Echinostoma trivolvis* lineage c and induced cercariae emergence by placing them under lights after 6 weeks, pooling parasites from 13 infected snails. Subsequently, we conditioned 6 water samples with different densities of cercariae (91-158 cercariae/mL) for 4 hours, and 2 negative controls, and performed lipid extraction followed by high-performance liquid chromatography/tandem mass spectrometry from each sample. Interestingly, cercarial density did not affect the diversity and amount of oxylipins emitted. In total, cercariae emitted 25 oxylipins with varying amounts (0.0049-0.57 ng). These results will guide our selection of an optimal density for future sampling of cercarial oxylipins. Comparing cercariae profiles to profiles from infected snails will clarify the respective contributions of parasites and hosts to oxylipin emissions from infected hosts. Ultimately, determining the source of oxylipins will inform our selection of oxylipins for assays aimed at elucidating their influence on parasite-modified host behaviour.

Transcriptome Responses of Atlantic Salmon of Different Families to Sea Lice Infection Under Different Temperature Conditions

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Lepeophtheirus salmonis, the salmon louse, is a naturally occurring copepod that parasitizes anadromous salmonids and causes significant economic losses in salmon aquaculture. The objective of this study was to determine the transcriptome response of the skin and head kidney of Atlantic salmon infected with sea lice under normal and elevated temperature conditions, and

whether family background influenced the outcome. With this objective in mind, Atlantic salmon smolts from different family groups were infected with sea lice in the copepodid stage (50-100 copepodids/fish) under controlled temperature regimes [10 (±2) and 20 (±2) °C]. The lice were allowed to reach the chalimus II (C, 12 days post exposure) and adult (A, 35 days post exposure) stages. In each developmental stage of lice (C or A), fish were subjected to biometric assessment, deformity/abnormality scoring and lice counting followed by collecting skin and head kidney samples. We found 9,667 and 11,447 differentially expressed genes (DEGs) in the skin of Atlantic salmon following pairwise comparisons within specific families in two developmental stages of lice at 10 and 20 °C, respectively. Of the 9,667 DEGs identified (T10A vs. T10C), there were 299 shared DEGs among all families which were found to be involved mostly in metabolic pathways, collagen trimer (complex), extracellular matrix (network) and oxidoreduction reactions. In addition, 203 and 406 shared DEGs were respectively identified in the skin and head kidney after pairwise comparisons between all families at two different temperatures. Gene ontology term enrichment analyses revealed the association of these DEGS with oxidoreductase activity, chemokine/cytokine activity and protein folding chaperones. Our findings highlighted that induced temperature stress and various developmental stages of sea lice significantly impact transcriptome profiles of the skin and/or head kidney of Atlantic salmon.

Parasitic Castration by the Cestode *Ligula intestinalis*: Elucidating Mechanisms that Alter Fertility of Host Fishes

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Ligula intestinalis, a tapeworm that infects freshwater fishes during its plerocercoid (i.e., larval) life stage was identified in New Brunswick for the first time in 2021. Species level identifications were made using morphological characteristics and by sequencing COX1 mitochondrial DNA. Plerocercoids of *L. intestinalis* occupy the peritoneal cavity of their fish host and promote consumption by a piscivorous bird, where the parasites mature in the intestine. Adult parasites reproduce and pass eggs to the water column with feces of the bird host, where they hatch and are eaten by freshwater copepods. Fish become infected by eating infected copepods. Heavily infected fish are easily identified by the severe abdominal distention caused by the parasite. Plerocercoids of *L. intestinalis* induce sterility of their host fishes, however the mechanisms behind this are poorly understood. We are developing an in vitro culture system to complete the parasite's life cycle and acquire eggs. Eggs will be used to for experimental infections in lab-reared copepods and zebrafish to investigate this parasitic castration effect. Additionally, in vitro culture systems are being utilized to collect plerocercoid secretions for the identification of compounds which may have endocrine disrupting effects. Such compounds represent novel biologicals that could be used in commercial aquaculture to disrupt gonad development, divert resources to muscle production, and decrease time to market for farm-raised fish.

Developing an in vitro Infection Model for the Microsporidian Parasite *Spraguea americanus* in Rainbow Trout Cells.

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For over a century microsporidian parasites of the genus Spraguea have fascinated the scientific community with their striking host-cell manipulations. Upon infection, Spraguea species convert neurons into massive, spore-filled cysts called xenomas which can often be observed by the

naked eye. However, due to the high host and tissue specificity of this genus, effective in vivo and in vitro models for the propagation of these organisms have yet to be developed. Consequently, the biology and life histories of *Spraguea lophii* and *Spraguea americanus* (a.k.a. *Glugea americanus*) remain largely undescribed. This study establishes the first in vitro model for the propagation of *Spraguea americanus* in rainbow trout cell lines with the goal of characterizing immune responses against microsporidia in cold water fishes. As part of this study, a novel pretreatment strategy was used to induce Spraguea infection in a variety of cell lines of a non-host species. Specifically, sustained replication of *Spraguea americanus* was observed in RTgut, RTbrain and RTgill cell lines. Moreover, expression of various immune transcripts was analyzed in infected cells to elucidate the host response and/or immune evasion mechanisms of *Spraguea americanus*. Finally, the life cycle of *Spraguea americanus* was examined via transmission electron microscopy of host cells over the course of infection. Through facilitating an improved understanding of teleost immune responses against microsporidia and the development of an in vitro model, this study will both improve fish health and support the development of novel strategies to mitigate the impacts of microsporidia in both fisheries and aquaculture.

One Health at the top of the world: *Toxoplasma gondii* in wildlife in the Canadian North

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The coccidian *Toxoplasma gondii* is arguably the most ubiquitous parasite, infecting many vertebrate hosts and ranging from the equator to the poles. The ultimate source of *T. gondii* is the intestines of wild and domestic felids, whereas the pathogenicity of *T. gondii* lies primarily in vertebrate intermediate hosts, where it can cross the placenta and affect mammalian fetuses (sometimes triggering abortion), and reactivate in immunocompromised hosts. Unique among coccidians, *T. gondii* can transmit from intermediate host to intermediate host through carnivory. Therefore, while cats are the ultimate source of environmental contamination, the importance of food borne routes of exposure is increasingly recognized. This is almost certainly the case in the Canadian Arctic, where there is high seroexposure to *T. gondii* in wildlife and people, but felids are few and far between above treeline. Over a decade of research in the Canadian Arctic reveals that lynx are a potential source of environmental contamination with *T. gondii*, but are far more commonly infected as intermediate hosts; terrestrial carnivores are good sentinels of circulating levels of *T. gondii*, which are higher in the eastern vs western Canadian Arctic; and exposure to *T. gondii* in the eastern Canadian Arctic is primarily linked to consumption of migratory and aquatic wildlife, rather than terrestrial herbivores like caribou. These findings in wildlife are congruent with human seroepidemiological studies and have significance for Indigenous harvesters, emphasizing the utility of One Health approaches to the complex transmission and ecology of this globally successful, but enigmatic, parasite in the Arctic.

Gastrointestinal parasite communities overlap among sympatric humans, vervet monkeys, livestock, and dogs.

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Overlap in wildlife habitat and human settlements can lead to interspecific disease transmission. We examined parasitism in sympatric hosts, including vervet monkeys (N=75), humans (N=25 household latrines), dogs (N=25), and livestock (Ncows=9, Ngoats=7, Npigs=9) in the human-modified landscape at Lake Nabugabo, Uganda. We used the sedimentation technique for coproscopic analysis, and molecular techniques for the identification of Strongyloides and protists. We identified 19 unique parasite taxa with vervets, dogs, and livestock each harbouring nine taxa and humans harbouring six parasite taxa. The coproscopic analysis of fecal samples showed that there was a significant difference (χ^2 = 92.03, df=3, $p<0.05$) in the overall parasite prevalence between vervet monkeys (89%), humans (24%), dogs (40%), and livestock (48%). We did not find any Strongyloides infections in humans, and only limited overlap between vervets and other hosts (i.e., dog, pig). *Giardia intestinalis* assemblage A was found in vervets (1.3%), humans (12%), and dogs (16%), and Enterocytozoon bieneusi occurred in vervets (5.3%) and humans (12%). Among protists, we identified species-specific Cryptosporidium taxa in dogs, goats, and pigs, and *C. andersoni* was found in both dogs (4%) and cows (22%). Our results indicate parasite community overlap (*G. intestinalis* and *E. bieneusi*) between humans and animals. Although we did not find evidence of human-animal overlap for Cryptosporidium, there is the potential for anthropozoonotic disease transmission given that *C. ubiquit*um has previously been found in humans. We are extending our examination of human-animal parasite species community overlap by conducting molecular analyses of strongylid nematodes.

Osmorespiratory Compromise in Triploid Rainbow Trout (*Oncorhynchus mykiss*)

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This study examines the effects of family, sex ratio, and ploidy on salinity tolerance of rainbow trout (*Oncorhynchus mykiss*). Triploidy renders fish sterile and offers advantages in net-pen production, but triploids have lower thermal tolerance than diploids. Conducted at the Huntsman Marine Science Centre (Saint Andrews, NB), the live-fish component of the experiment utilized fish from 48 diploid mixed-sex families, 15 diploid all-female families, and 12 triploid all-female families, with each fish individually PIT-tagged for tracking purposes. After a two-month freshwater acclimation period, fish were transitioned to salt water at ambient temperature (13°C). Temperature was then gradually increased to 18°C, maintained for 10 days, and then decreased back to ambient levels. Survival and growth were monitored at three time points: PIT-tagging, 30 days after saltwater transfer, and at the end of the experiment or at mortality. A parallel experiment, which will be the focus of this presentation, examined salinity tolerance of sibling female diploids and triploids from eight of the families, analyzing gill morphology and plasma osmolality and ion levels under the same conditions. Gill morphology will focus on interlamellar

cell mass size as an indicator of osmorespiratory function. This study will characterize the physiological responses of sterile triploids to temperature and salinity challenges encountered under typical aquaculture conditions and the potential to breed for improved performance based on among-family variation.

A coastal fish can be vulnerable to the intensification of heat waves with ocean acidification.

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Heat waves are becoming more intense and frequent in recent years, potentially imposing stress on aquatic animals. Coastal species are especially affected with additional presence of elevated PCO_2 from upwelling events. It is well documented that temperature and PCO_2 could exert strong influence on energy metabolism and swimming performance in fish, which can significantly alter ecological fitness. In the present study, we tested a hypothesis that temperature and PCO_2 will have antagonistic effects on aerobic metabolism and swimming performance in marine stickleback (*Gasterosteus aculeatus*). Fish were exposed to one of four treatments for a week: control (12 °C, 750 µatm), high CO_2 (12 °C, 1500 µatm), high temperature (20 °C, 750 µatm), and a combination of the two (20 °C, 1500 µatm). Baseline activity, group behaviour, escape response, and metabolic rate were measured post-exposure. Elevated PCO_2 significantly reduced baseline activity and escape response were observed only when fish were at the higher temperature ($p<0.05$), indicating a potential antagonistic effect. Elevated PCO_2 also significantly reduced the group size but only at the lower temperature ($p<0.05$). Both elevated temperature and CO_2 increased the metabolic costs for basal maintenance and reduced aerobic capacity ($p<0.01$). Our results suggested that coastal fish could be susceptible to combined stressors of temperature and CO_2. Future studies are warranted to understand how multiple stressors may influence predator-prey interactions and biodiversity in the rapid climate change.

Interactive effects of elevated temperature and venlafaxine on mitochondrial respiration and enzyme capacity in Nile tilapia (*Oreochromis niloticus*)

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Warming events are becoming more frequent and extreme in aquatic environments worldwide. Concurrently, many environments are polluted with biologically active compounds such as pharmaceuticals. Understanding how these challenges interact is critical for understanding the climate crisis, as contaminants may modulate how ectotherms respond to heat stress or vice versa. One potential site for this interaction is mitochondria, which are central to metabolism, implicated in thermal tolerance, and evolutionarily conserved. Using high-resolution respirometry, we investigated how acute warming (35°C, 40°C, and 45°C from 25°C) impacted the respiration, respiratory control ratio, and maximum enzymatic capacity of mitochondria isolated from Nile tilapia, and how exposure to environmentally-relevant levels of the ubiquitous antidepressant venlafaxine modulated those effects. As expected, warmer mitochondria had higher respiration rates and decreased respiratory control ratio compared to mitochondria exposed to cooler temperatures. The depressive effects of venlafaxine on respiration rates through Complex I&II or Complex II only (State 3 and State 4), as well as Complex IV-linked respiration, were mild except in mitochondria exposed to high temperatures, suggesting a strong interactive effect of warming and contaminant exposure. Finally, we found that the metabolic capacity of intact mitochondria (represented by respiration data) showed a different pattern of

response to warming and venlafaxine compared to its underlying components (as reflected by the activity of succinate dehydrogenase [Complex II] and cytochrome c oxidase [Complex IV]), demonstrating the value of incorporating both interactive and reductive approaches in understanding how mitochondria cope with the complex environmental challenges of the Anthropocene.

Inter-individual variation and repeatability of critical thermal maximum (CTmax) across acclimation temperatures in killifish

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Assessing the extent of inter-individual variation and plasticity in thermal tolerance likely to be important for predicting the resilience of fishes to climate change. Here, we used Atlantic killifish, *Fundulus heteroclitus*, to assess levels of inter-individual variation in critical thermal maximum (CTmax) and to determine whether it is a repeatable trait across multiple acclimation temperatures. There was significant inter-individual variation in CTmax, and in accordance with other studies of repeatability in CTmax, there was high repeatability of this trait within a given acclimation temperature. Although thermal acclimation had consistent effects on CTmax, the rank order of CTmax was not repeatable across acclimation temperatures, such that fish that performed well at one acclimation temperature were not necessarily the individuals that performed well at other acclimation temperatures. This suggests that there is substantial inter-individual variation in the plasticity of thermal tolerance. Taken together, this study demonstrates that it is difficult to make predictions about resilience to climate change based on laboratory data collected for fish acclimated to a single temperature.

Does early life freshwater tolerance or adult tolerance of combined stressors limit freshwater colonization in stickleback fishes?

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Freshwater tolerance has evolved multiple times among stickleback fishes (*Gasterosteidae*), such that several closely related species differ in freshwater tolerance. The threespine and fourspine sticklebacks (*Gasterosteus aculeatus* and *Apeltes quadracus*) inhabit both freshwater and saltwater, while the blackspotted stickleback (*Gasterosteus wheatlandi*) and white threespine ecotype (*Gasterosteus aculeatus*) are largely restricted to saltwater habitats, despite being able to survive acute freshwater exposure as adults. We investigated whether the distribution of blackspotted and white threespine sticklebacks might be limited by a) their capacity to tolerate freshwater during vulnerable early life stages and/ or b) the winter-induced combined stressors of freshwater and cold temperature. The blackspotted stickleback's fertilization success decreased by 75% in freshwater relative to saltwater, while the threespine and white threespine sticklebacks maintained similar fertilization success in both salinities. Once fertilized, all four species had high survivorship rates (~100%), similar development rates, and comparable metabolic rates (150-250umolO_2/um) in freshwater. Overall, our results suggest that reproduction may limit freshwater colonization in this clade, but early life freshwater tolerance does not. In addition, overwintering of adults in freshwater environments may necessitate energetic expenditure that is unsustainable for non-freshwater-colonizing species. Indeed, a cold-induced decrease to their aerobic scope has been shown to occur in the threespine stickleback. To test whether such energetic limitation might restrict non-freshwater-colonizing species' distributions, we are currently measuring aerobic scopes of threespine and blackspotted

sticklebacks who experienced freshwater and saltwater, under winter (4°C) and summer (18°C) temperatures.

You're hot then you're cold: Early life exposure to diel thermal variation alters microRNA expression and performance in zebrafish.

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Fish are exposed to diel thermal fluctuations in their natural environments, and with the increase in frequency of heat waves, the range of these fluctuations is expected to increase dramatically. Recently, it has been posited that epigenetic modulators like microRNAs (miRNAs) could buffer fish populations against such rapid changes as they act on a more rapid timeframe than genetic adaptation. To investigate this, we exposed zebrafish (*Danio rerio*) embryos to either constant control (CTRL; 28°C) or fluctuating (FLUX; 23-33°C) conditions until 30 days post fertilisation (dpf). The expression of 7 miRNAs was quantified using qPCR during the larval (5 dpf) and juvenile (30 dpf) stages, and performance metrics such as survival and oxygen consumption rate were measured at 30 dpf. To understand whether their ontogenetic history influenced their response to elevated temperatures, we moved the remaining juveniles from both treatments to CTRL conditions until adulthood (6 months post fertilization; mpf) and measured thermal tolerance along with miRNA expression in the brain and gonads. While survival was not significantly different at 30 dpf, FLUX fish had a lower oxygen consumption rate and elevated expression of miR-181a. Similarly, while there were no differences in thermal tolerance between the groups at 6 mpf, miR-181a and let-7d were elevated in the brains of male FLUX fish at their thermal maximum point (CTMax). This study highlights the need to incorporate ecologically realistic conditions into experimental designs to understand the physiology of fish under natural conditions and predict how they will respond to climate change.

Characterizing behavioral and physiological changes in fish with changing thermal regimes

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Understanding the impacts of sea temperature changes on marine fishes' physiology and behavior (neurology/endocrinology) is critical for marine ecosystem management. Around Vancouver Island, threespine stickleback (*Gasterosteus aculeatus*) populations thrive in areas that differ by 10°C. To understand the acclimatory potential of stickleback, fish were exposed to cold (10°C), control (15°C), or warm (20°C) water treatments for 4 weeks. Their acclimation response was tested using the novel tank test (NTT), black-white test (BWT), measuring growth, and determining critical thermal maxima (CTmax). We found that CTmax differed significantly between treatments. However, the increase in acclimation temperature was not proportional to the increase in CTmax. In the BWT, the average number of crosses and duration that fish spent in the white zone was lower in the cold treatment than the control, while these metrics were higher in the warm treatment. A similar trend was observed in the NTT test, with warm treatment having the highest number of crosses and duration in the top third of the tank, and the cold treatment having the lowest. Surprisingly, fish reared in the cold treatment had a significantly greater change in weight than fish kept in the other treatments, which may be associated with energy expenditure and trade-offs for activity. Given these results, greater trade-offs in fish energy usage are anticipated in changing climates due to the acclimation limits of their bodies which would starkly affect ecosystem dynamics.

Testing traditions: Validating mitochondrial density markers in ectothermic species

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In ectothermic species, changes in environmental conditions can be reflected in mitochondria, which are known for their high level of sensitivity and plasticity. These can result in either a functional change within the mitochondrion itself, a variation in total density within a tissue, or even a combination of the two. Therefore, experimental data must be presented with an adequate measure of mitochondrial density to be interpretable and scientifically backed. One of the most effective ways to quantify mitochondrial density (MD) is through transmission electron microscopy (TEM). However, proxies of mitochondrial density are often used in lieu. Commonly, quantifications of mitochondrial protein content, enzyme activity, and mitochondrial DNA copy numbers are employed as estimates of MD. The most frequently used estimates include measurements of citrate synthase (CS), complex I, and complex IV activity, but results vary greatly between studies. Indeed, mitochondrial plasticity, especially in ectotherms, may partly explain these discrepancies. This ongoing project therefore embodies a comprehensive approach evaluating if the use of mitochondrial density markers can be generalized in ectothermic animals. We show that despite cold-acclimated Drosophila (*D. melanogaster*) having higher complexes I and IV activity, and a tendency for increased CS activity, these commonly employed mitochondrial density markers were poor predictors of differences in various measurements of MD (i.e. number of mitochondria, fractional area, and surface density) evaluated by TEM. Conversely, neither differences were observed between enzymatic activities nor MD measurements between differentially acclimated beetles (*Leptinotarsa decemlineata*). The analysis of further density markers is ongoing.

Does Borrelia burgdorferi, the bacterium causing Lyme Disease, improve the cold tolerance of black-legged ticks?

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The ability for the invasive black-legged tick, *Ixodes scapularis*, to survive the winter in Canada determines, in part, their range and population size, and tick-borne disease prevalence. Thus, our understanding of the future of tick-borne disease relies on characterizing cold tolerance in these ticks. Further, the ability for ticks to tolerate low temperatures may be modified by the presence of pathogens such as the bacterium that causes Lyme disease, *Borrelia burgdorferi*. Infection with *B. burgdorferi* correlates with improved overwintering survival in adult, female *I. scapularis*; however, we do not yet know the mechanism underlying this improved survival, which could be linked to an increased ability to withstand or recover from exposure to low temperatures. The objectives of this research are to describe the physiological responses to cold exposure of adult *I. scapularis* and determine if *B. burgdorferi* infection correlates with enhanced cold tolerance. Using adult female and male *I. scapularis* field-collected in Nova Scotia, we characterized the supercooling point, lower lethal temperature (LT_{50}), and cold tolerance strategy both before and after overwintering. After conducting cold tolerance experiments, we preserved the ticks for DNA extractions and nested PCR to test for infection with *B. burgdorferi*. We will assess whether infection with *B. burgdorferi* changes aspects of the cold tolerance of *I. scapularis*, and whether cold tolerance varies between sex and season. Overall, this research

will help to determine why infection may enhance overwintering survival, ultimately improving our ability to predict the prevalence and infection risk associated with ticks in Canada.

Renal transcriptional plasticity during cold acclimation allows Drosophila melanogaster to prevent chill injury.

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Most insects, including *Drosophila melanogaster*, suffer from chilling injury in the cold, in part because of a progressive loss of ion and water balance that causes cell, and ultimately organismal, death. This ionoregulatory collapse has been linked to temperature-induced reductions in membrane-bound transporter activity (e.g. Na^+/K^+ ATPase, H^+-ATPase) in the renal system. Cold acclimation can improve low temperature tolerance and is associated with an increase in water and ion transport rates in the Malpighian tubules of cold acclimated flies, but a paradoxical reduction in the activity of ATPases in the same tissues. These findings raise questions about whether the current models of ion transport apply to cold-acclimated insects, or if modulation of other transporters allow for improved renal function in the cold. Here, we report the results of transcriptomic sequencing of the anterior Malpighian tubules of warm and cold-acclimated flies before, during, and after a cold stress. In this talk, we will explore how differential expression of genes may be responsible for adaptive thermal plasticity in renal function, narrowing down the broader mechanisms responsible for the mitigation of chill injury in insects.

Harlequin ladybird, *Harmonia axyridis*, physiology is largely unaffected by fungal infection (*Hesperomyces virescens*), except for cold tolerance

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In some regions of Europe, nearly 50% of the globally invasive harlequin ladybird, *Harmonia axyridis*, are infected with the fungal ectoparasite *Hesperomyces virecens*. Despite the prevalence of both host and parasite, few studies have explored the impact of *He. virecens* on the immune response and other traits important for the continued geographic range expansion of this invasive species. Infected ladybirds have reduced survivorship compared to uninfected ladybirds. Therefore, we predicted that infected ladybirds would show an increased immune response and an overall decrease in phenotypic performance compared to uninfected ladybirds. Furthermore, since *Ha. axyridis* phenotypes such as thermal tolerance vary with environmental temperature, we predicted that infection status would impact these traits if *Ha. axyridis* adjusted its thermal preference as a behavioural immune response. To test these predictions, we collected *He. virescens* infected and uninfected *Ha. axyridis* adults from the field (Central Bohemian Region, Czechia) during summer and autumn. We assessed the impact that season and infection status had on thermal tolerance, thermal preference, activity level, and immune function. In general, season had the largest effect on *Ha. axyridis* phenotypes: summer ladybirds were more heat tolerant, less cold tolerant, preferred warm temperatures, were less active, and had stronger immune function when compared to autumn ladybirds. On the other hand, only cold tolerance significantly differed between infected and uninfected ladybirds – uninfected ladybirds were more cold tolerant. Moreover, since infection status had very little effect on ladybird phenotypes, we did not detect a season by infection interaction effect for any measured phenotype.

Latent chilling injuries and their link to the immune system in *Drosophila melanogaster*

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Chill-susceptible insects suffer negative effects of chilling at low temperatures above the freezing point of their body fluids. Cold-induced suppression of renal ionoregulation leads to a collapse of ion gradients in the cold that drives cell membrane depolarization and cell death. At the organismal level, chilling injuries manifest as a loss of neuromuscular function that affects an insect's ability to stand, walk, or fly. These injury phenotypes can manifest quickly, or with some delay, following removal of the insect from the cold. Recently, we have characterized how and when sex-dependent "latent" chilling injuries appear in *Drosophila melanogaster* following a cold stress. Following exposure to an acute or chronic cold stress, female flies show a decrease in overall mobility and survival over a 24 h period. These latent injuries are significantly mitigated in flies that are cold-acclimated, but what causes latent injury and how acclimation prevents it remain unknown. Cold stress also causes upregulation of genes in insect immune pathways, and activation of the same pathways leads to the release of antimicrobial peptides (AMPs) that normally serve to fight foreign pathogens. Using CRISPR-Cas9 engineered lines, we investigated the roles that AMPs play in cold tolerance by exposing *D. melanogaster* to a cold stress and quantifying post-chilling survival on a point-based scale over a 24 h period. This work will allow us to better understand the relationship between cold-induced immune activation and observable chilling injuries in insects.

Freeze frame: Cytoskeletal restructuring (or lack thereof) in freeze-tolerant crickets

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Animals that survive cold stress are hypothesized to protect cytoskeletal structure during cold stress or repair cytoskeletal structure after cold stress. The spring field cricket, *Gryllus veletis*, is freeze-tolerant if acclimated to fall-like conditions. Previous transcriptomic work showed that these crickets modify expression of key cytoskeletal genes when exposed to fall-like conditions. We tested whether these crickets modify cytoskeletal structure during fall-like acclimation, as well as whether the cytoskeletal structure was damaged by freezing in both acclimated (freeze-tolerant) and unacclimated (freeze-intolerant) crickets. To visualize the cytoskeleton, we dissected fat body, Malpighian tubules and femur muscle followed by staining them with fluorescent markers for F-actin (microfilaments) and β-tubulin (microtubules) and imaging with confocal microscopy. Following acclimation, tissue specific increases were exhibited by F-actin abundance but not β-tubulin abundance. Therefore, there is evidence that freeze-tolerant crickets "reinforce" their actin (microfilament) cytoskeleton. Freezing only significantly decreased F-actin intensity in the fat body of freeze-intolerant crickets. Thus, both freeze-tolerant and freeze-intolerant crickets showed maintenance of cytoskeletal structure after freezing in most tissues, challenging the idea that freezing tends to damage the cytoskeleton. This study increases our understanding of how *G. veletis* modify their cytoskeletal structure to potentially protect cells against freezing, improving our understanding of mechanisms that underlie insect freeze tolerance.

Surviving the Chill: Unraveling the Mysteries of *Ambigolimax valentianus*' Slug Freeze Tolerance

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Terrestrial molluscs facing sub-zero temperatures can employ one of two strategies 1) partial freeze-tolerance or 2) behavioural thermoregulation (moving to a warmer habitat). Partially freeze-tolerant molluscs can survive limited internal ice formation, and potentially accumulate low molecular weight cryoprotectants to balance osmolarity and protect against ice damage. *Ambigolimax valentianus* is a widely distributed invasive slug species that detrimentally affects agricultural crops. Although they can survive cold temperatures, their ability to survive internal ice formation is unknown. Understanding their lower temperature tolerances is necessary for effective management, especially since winters often dictate the possibility of an invasive species establishing. We predicted that exposing *A. valentianus* to winter conditions (short photoperiods, lower temperatures), would increase its freeze tolerance and increase the quantity of low molecular weight cryoprotectants. Individual *A. valentianus* slugs were collected from Kyoto, Japan and exposed to four different acclimation conditions with differing photoperiods (long day/short day) and temperatures (15 °C/ 20 °C). After acclimation, slugs were briefly freeze exposed and survival was assessed. Some acclimated slugs were sacrificed for 1H NMR spectroscopy to measure low weight cryoprotectants. We found that *A. valentianus* is not meaningfully freeze tolerant, but slugs acclimated to short day photoperiods and cooler temperatures had significantly higher survival rates following cold exposure. We found little evidence of well-known cryoprotectants, but that formate and glutamine, two small molecules involved in metabolism, were both significantly depressed in winter acclimated slugs. Overall, *A. valentianus* may suppress its metabolism to prepare for winter and can survive cold but not freezing.

Bioprospecting Vancouver's Intertidal Zone for Novel Ice Binding Proteins

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Intertidal invertebrates are exposed to the high and low extremes of both air and water conditions throughout the year. During the winter, low tides often occur in the middle of the night, resulting in rapid declines in temperature over a short period of time. Being exposed to these temperatures leaves animals at risk of freezing. Many intertidal invertebrates are freeze tolerant, meaning they can survive either full or partial freezing of their body's tissues. There is evidence that intertidal animals possess proteins that can manipulate ice growth, known as ice binding proteins. These proteins function in a variety of ways to alter ice growth, and allow for survival freezing events. Nine invertebrate species spanning three phyla were collected from the intertidal zone in Vancouver, British Columbia with the goal of categorizing ice binding protein activity in each animal, in addition to investigating macroevolutionary variation of ice binding proteins. Ice nucleation protein activity was found in every animal tested, and ice recrystallization inhibition activity was common, but not as prevalent. Interestingly, ice recrystallization inhibition activity was found in some animals, but not attributable to protein, suggesting non-protein sources of this activity. In addition, live animals were tested in an ecologically relevant freeze-exposure, and survival results were compared to the ice binding protein activity findings. This study highlights how ubiquitous ice binding proteins are in the intertidal environment, in addition to shedding light on how many unstudied animals survive sub-zero temperatures.

The mighty mito membrane: How do frozen crickets maintain mitochondrial function?

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Freeze-tolerant insects can withstand internal ice formation, which is lethal to most animals. Freezing normally causes a range of injuries, but the spring field cricket, *Gryllus veletis* maintains or even increases its whole-organism metabolic rate after thawing, suggesting that they must either prevent freezing damage to mitochondria, or quickly repair that damage after thawing. We used mitochondria from Malpighian tubules of the freeze-tolerant cricket *G. veletis* to determine the effects of freezing and thawing on mitochondrial structure and function. We compared freeze-intolerant (i.e. control) and freeze-tolerant crickets to identify how mitochondria change when acquiring freeze tolerance; and unfrozen with frozen crickets to disentangle the effects of cold from ice formation. We measured mitochondrial respiration using high-resolution respirometry and mitochondrial ultrastructure using transmission electron microscopy. We show that freeze-tolerant and -intolerant mitochondria have similar oxidative capacity freeze-tolerant mitochondria are rounder and bigger. After thawing, freeze-intolerant crickets have reduced capacity to produce ATP, damaged inner mitochondrial membrane, and swollen mitochondria. Curiously, freeze-tolerant mitochondria swelled when exposed to both cold and freezing, but maintained metabolic function and inner membrane integrity after freezing. We conclude that freeze-tolerant insects protect their mitochondria from damage caused by freezing and thawing. This implies that the mitochondria fundamentally change when the crickets acquire freeze tolerance, and that this change alters their response to chilling and freezing.

Cellular and Mitochondrial Response to Fluctuating Thermal Stress in *Drosophila melanogaster*

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Temperature is a significant environmental stress factor that impacts organisms across various levels, from cellular responses to physiological adjustments of the organism. Ectotherms subjected to prolonged low temperature can experience physiological damages, potentially compromising their survival. However, studies have shown that exposure to fluctuating thermal regimes (FTR) can enhance *Drosophila melanogaster* longevity. The cellular mechanisms allowing this increased longevity remain however unknown. In this study, we aimed to understanding the role of mitochondria in the cellular response of Drosophila exposed to fluctuating thermal stress. Drosophila raised for five days at a constant temperature of 24 °C were either maintained at this temperature (controls) or subjected to a FTR of 24 °C/15 °C day/night for another five days. We assessed transcriptional pathways linked to mitochondrial quality control via mitophagy and chaperone proteins, as well as genes involved in mitochondrial biogenesis and the nutrient sensing pathways. Our results indicate a rapid molecular response, characterized by changes in transcript abundance after only one night of cold exposure, accompanied by mitochondrial respiration adjustments. These responses are further reflected at the physiological level (thermal tolerance), with acclimation potentially completed by the fifth day following FTR. Importantly, these adjustments seem to have a beneficial long-term effect on the organism, as flies exposed to the FTR treatment exhibited a 44% increase of their longevity compared to controls (or a 17% increase for temperature-adjusted longevity). This project offers insights into adaptative responses enhancing mitochondrial metabolism and contribute to a better understanding of stress resilience in Drosophila.

Mitochondrial microRNAs differ during hibernation in thirteen-lined ground squirrels (*Ictidomys tridecemlineatus*)

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During the hibernation season, thirteen-lined ground squirrels (TLGS) cycle between torpor (hypometabolism) and interbout euthermia (IBE; typical euthermic metabolism). This metabolic suppression is observed in TLGS liver, where mitochondrial respiration is suppressed by up to 70% during torpor and returns to typical levels during arousal to IBE. Nuclear-encoded microRNA (small, non-coding RNA that post-transcriptionally regulate RNA) differ in abundance throughout hibernation in TLGS, and have been shown to regulate mitochondrial gene expression in mammalian cell culture (where they are referred to as mitomiRs). The objective of this study was to compare mitomiR profiles from TLGS liver mitochondria isolated from squirrels during summer, IBE, and torpor, then predict their function in regulating mitochondrial gene expression. Small RNA sequencing revealed that 38 mitomiRs were differentially abundant (up to 8 times greater) between hibernation states. Most of these differences were seasonal (i.e. between summer and winter) and only one mitomiR differed between IBE and torpor. Nine of these differentially abundant mitomiRs had predicted mitochondrial RNA targets, including subunits of electron transfer system complexes I and IV, 12S rRNA and two tRNAs. We found that expression of selected mitochondrial targets (*COX1*, *COX3*) may be suppressed by these mitomiR differences. Overall, mitomiRs were present in TLGS in vivo, and were predicted to suppress expression of their mitochondrial RNA targets. This study found differences in mitomiR abundances between seasons and hibernation states of TLGS and suggests potential mechanisms in regulating the mitochondrial electron transfer system.

Long live the king: exploring the metabolomic signature of extreme longevities in bivalves.

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Longevity in the animal kingdom is unfair. Within the bivalve class, the ocean quahog *Arctica islandica* can live more than 500 years, while its cousin the freshwater clam *Corbicula fluminea* only lives 4 years. What physiological processes are at the origin of these inequalities among species? Over the past decades, there has been a growing focus on the role of mitochondrial structure and function in determining the pace of aging. Comparative studies on bivalves have elucidated variations in mitochondrial metabolism regulation linked to lifespan. In my current study, we delve into mitochondrial function at the metabolite level. We compare six distinct bivalve species spanning a lifespan range from 4 to over 500 years, aiming to elucidate whether differences in flux control across species correlate with metabolite concentrations. Furthermore, we aim to explore whether these differences could account for reduced ROS production and alter mitochondrial signaling observed in long-lived species. Our findings highlight a higher concentration of succinate in longer-lived species. Additionally, as evidenced by a lower ATP/(ADP+AMP) ratio in *Arctica islandica*, there appear to be variations in cellular energy status that correlate with longevity. These observations hint at a potential metabolomic signature associated with lifespan.

Plasticity of mitochondrial coupling efficiency: the last chance to survive in adverse environment?

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Converting food to cellular energy (ATP) is a fundamental requirement to sustain life. In aerobic organisms, mitochondria are the major source of ATP, becoming a strong physiological link between environmental resources and organism's performances. The mitochondrial rate of ATP synthesis is dependent on both the oxidative capacity of the electron transport chain and the coupling efficiency of the oxidative phosphorylation process, i.e. the amount of ATP generated per molecule of oxygen consumed by mitochondria. Environmental fluctuations in abiotic (temperature and oxygen) and biotic (food resources) parameters have the potential to alter mitochondrial oxidative ATP production at different temporal levels. For instance, it is well described that thermal acclimation induces compensatory adjustments triggering mitochondrial fluxes resilience across large shifts in temperature.
Using several experimental studies, we will explore the idea that changes in energy coupling efficiency would be the ultimate mitochondrial adjustment to sustain life on "the razor blade".

ROS in Hibernation: Dynamics and Implications

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During hibernation 13-lined ground squirrels (TLGS) cycle through torpor (characterized by low body temperature and suppressed metabolism for ~12 days) and spontaneous arousals to interbout euthermia (IBE; characterized by high body temperature and increased metabolism). Active metabolic suppression of mitochondria likely drives these physiological changes between torpor and IBE. During arousal TLGS experience a 2-fold increase in oxygen availability. We also determined that succinate concentration, a metabolite that suggests hypoxic stress, is high in torpor and low in IBE. We hypothesize that changes in mitochondrial metabolism help reduce reactive oxygen species (ROS) production and help remove succinate in a variable internal environment. Using high-resolution respirometry and Amplex UltraRed fluorimetry, we determined that isolated liver mitochondria produce two-fold less ROS during torpor and IBE than in summer. Post-translational modifications (PTMs) of mitochondrial proteins may contribute to metabolic control. Previous work in our lab shows that succinate dehydrogenase is phosphorylated during IBE and dephosphorylated during torpor. Low levels of ROS production likely contribute to cell signalling, and we hypothesize that low levels of ROS during hibernation affect PTMs of mitochondrial proteins by increasing Fgr Kinase activity, which phosphorylates succinate dehydrogenase. Incubation in a ten mM H_2O_2 solution increased torpid oxidative phosphorylation rates by 50% to levels similar to IBE mitochondria. However, we did not see this increase when PP2, a kinase inhibitor, was added to the incubation. Together this suggests that phosphorylation is a mechanism of metabolic control in TLGS which is indirectly manipulated by ROS concentrations.

Investigating a link between hydrogen sulfide biogenesis and aging in vertebrates using evolutionary analysis and molecular dockings

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Hydrogen sulfide (H_2S) is a toxic gaseous molecule at high doses, but at the physiological levels, endogenous H_2S plays important physiological functions, including limiting oxidative stress in the mitochondria, maintaining mitochondrial function, and inhibiting cellular senescence. H_2S can also play an integral role in extending longevity. For example, H_2S at physiological levels has been shown to directly extend both lifespan and health span in *C. elegans* through enhancing mitochondrial function. However, no studies to date have been done on H_2S effects on aging in vertebrates. H_2S is produced endogenously through the evolutionarily conserved trans-sulfuration pathway, involving the enzymes cystathionine beta-synthase (CBS), cystathionine gamma-lyase (CSE), and 3-mercaptopyruvate (MST). As such, I investigated the potential link between longevity and variations in the enzymes that endogenously produce H_2S. To address this gap, I used maximum likelihood methods to infer mutations under specific selection pressure in long-lived vertebrates and determined the functional implications of these mutations through molecular docking analysis. I constructed phylogenetic trees for mammals and bony fishes using CSE coding sequence and identified mutations under positive selection in long-lived mammals and bony fishes when compared to other mammals/fishes, implying a connection between these mutations and longevity. Further, I identified mutations in the long-lived naked mole-rat (*Heterocephalus glaber*) CSE sequence that have potential functional implications, as molecular docking analysis showed these mutations are affecting the protein-ligand affinity of CSE as well as its structural stability. Future research will focus on testing these mutations in vivo using gene editing techniques.

Characterization of glucose/glycogen metabolism during stress in larval sea lamprey, *Petromyzon marinus*

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The hypothalamus-pituitary-adrenal/interrenal axis is vital in regulating the vertebrate stress response. During stress, vertebrates release glucocorticoids which regulate the mobilization of energy stores. Agnathans, the most basal vertebrate taxa, are known to elicit a glucocorticoid response following stress. However, unlike teleost fishes, cortisol does not stimulate a glucocorticoid response in agnathans. In sea lamprey, 11-deoxycortisol increases following stress and stimulates an increase in plasma glucose. The metabolic changes in sea lamprey following a stressor and the subsequent increase in 11-deoxycortisol are not well characterized. In this study we characterized the changes in glucose/glycogen metabolism in larval sea lamprey following a standard stress protocol comprised of 1 minute netting followed by 5 minutes of chasing, which has previously been shown to increase 11-deoxycortisol. Lamprey were sampled at several post-stress time points over 24 hours for measurement of plasma glucose, lactate, and 11-deoxycortisol. Muscle, liver, and brain were also collected for measurement of glucose/glycogen stores and molecular characterization of key genes involved in glucose/glycogen metabolism. Our initial results revealed an increase in plasma glucose and lactate peaking at 3 hours post-stress. This increase in post-stress plasma glucose coincided with a decline in liver but not muscle glycogen stores. Our initial findings provide evidence that the glucocorticoid response in lamprey following stress is linked to metabolic changes in hepatic metabolism much like that observed in teleost fishes despite differences in glucocorticoid hormone.

Chronic Cortisol suppress Feeding by enhancing Hypothalamus-Specific Metabolite enrichment in Rainbow Trout Brain

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Energy homeostasis is counterbalanced by food intake and expenditure. During stress, this homeostasis is disrupted by the increased energy demand and reduced feed intake. Corticosteroids, released in response to stress axis activation, mobilize energy substrates to meet the energy demand and suppress feeding. However, the role of corticosteroids in regulating the central control of feeding during stress is unclear. Here, we tested the hypothesis that hypothalamus-specific metabolite changes due to cortisol stimulation modulates feeding during stress. Rainbow trout (*Oncorhynchus mykiss*) were given a slow-release cortisol implant for 3 days and the metabolite profile in the plasma, hypothalamus, and the rest of the brain were investigated using metabolomics. Also, the acute glucose turnover in the brain during stress was investigated by injecting U-^{13}C-glucose into the hypothalamus by intracerebrovascular (ICV) route. Chronic cortisol stimulation reduced feed intake, and this corresponded with a downregulation of the hypothalamic orexigenic gene *agrp*, and an upregulation of the anorexigenic cart. The ^{13}C-labelled metabolite from glucose indicated an enhanced oxidative capacity in the rest of the brain compared to the hypothalamus. The endogenous metabolites profile showed a hypothalamus-specific enrichment, including an abundance of leucine and citrate content compared to the rest of the brain. Also, there was an upregulation of gene encoding the enzyme acetyl CoA carboxylase (*acc*), the rate-limiting enzyme for de novo fatty acid synthesis. Altogether, hypothalamus-specific enrichment of leucine and the generation of fatty acid intermediates may play a role in the cortisol-mediated feeding suppression in fish. This study was supported by the Natural Sciences and Engineering Research Council of Canada Discovery Grant to Dr. Vijayan.

CRHR1 signalling modulates acute stress-related behaviour in larval zebrafish

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Corticotropin-releasing hormone (CRH) is the primary step in the stressor-induced activation of the hypothalamus-pituitary-interrenal (HPI) axis, leading to the production of cortisol. The HPI axis activity is mediated by the CRH receptor 1 (CRHR1), as fish lacking this receptor fails to elicit an elevated cortisol response to stress. We recently showed that CRHR1 activation is also essential for the acute stress-related behaviour, and this precedes the cortisol-mediated behavioural effects post-stress. Here we investigated whether multiple acute stressors may modulate the CRHR1-mediated behavioural response to tease out if there was a stress-mediated desensitization of this receptor activity. To this end WT and CRHR1 knockout zebrafish larvae were subjected to repeated acute stressors. The stressor paradigm included subjecting 4 dpf zebrafish larvae to either one acute stressor (consisting of 1 min @ 250 rpm) or two, three or four acute stressors with a 10 min recovery period between each stress episode. The larvae were then subjected to a light/dark behavioural assessment and thigmotaxis to assess whether CRHR1 was involved in the stressor-mediated anxiety behaviour. Overall, increasing the number of acute stressor episodes eliminated the stress-related behaviour suggesting a possible desensitization of the CRHR1 signalling. Also, the stress mediated CRHR1 activation has an

anxiolytic effect, as zebrafish larvae lacking CRHR1 showed higher thigmotaxis (anxiogenic), but this was absent with four repeated stressors. Altogether, CRHR1 activation play a critical role in the behavioural response that is essential for stress coping, but this receptor responsiveness may be altered by multiple stressors.
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Investigating the Behavioural Consequences of Stress-Induced Inhibition to Forebrain Neurogenesis in Adult Zebrafish (*Danio rerio*)

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Zebrafish (*Danio rerio*) have the greatest capacity for adult neurogenesis yet described in vertebrates, particularly in the telencephalon. Adult neurogenesis is inhibited by chronic stress, like social subordination, but the functional outcomes of this response are unknown. We tested the hypothesis that reduced neurogenesis in the forebrain of subordinate zebrafish promotes an adaptive shift in behavioural phenotype. Specifically, we predicted that, alongside reduced forebrain neurogenesis, subordinate zebrafish would demonstrate increased anxiety-like behaviours and decreased aggressive behaviours following social interaction with a dominant fish. To test this hypothesis, baseline behaviours of zebrafish were assessed using a novel tank test (anxiety) and a mirror test (aggression). Pairs of zebrafish were size-matched and cohoused for 96 hr, establishing a dominant/subordinate hierarchy, and mitotic cells were labelled using BrdU at the end of the interaction. The behaviours of each fish were then twice re-assessed during the 14 days after experiencing social stress; all fish were euthanized following the last behavioural assessment to quantify forebrain neurogenesis via immunohistochemistry. Results to date indicate that time spent in the lower half of the tank, frequency of transitions to the upper half of the tank, and time spent immobile for subordinate fish were similar to baseline behaviours, suggesting that anxiety-like behaviours were not developed or reinforced by social subordination. Analysis of mirror test data and immunohistochemistry are ongoing. This research will help to understand the functional significance of the stress-induced decrease in neurogenesis and may be further used as a model for the neurobehavioral effects of social stress.

Ultraviolet radiation - the neglected pervasive diurnal stressor

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UVR is a ubiquitous and pervasive daytime stressor. Although UVR provides some benefits for organisms, UVR is mostly detrimental as a powerful cytotoxin and mutagen. UVR causes carryover effects and interacts with a range of abiotic and biotic factors, such as temperature and disease, to influence organismal performance and health. Despite this, UVR is mostly neglected in experimental biology research, rarely is it considered and measured. However, we know that relatively small UVR doses from artificial lights are capable of causing lethal and detrimental sub-lethal effects in some taxa, yet UVR exposure regimes are usually not offered or quantified in experiments (laboratory and mesocosm) even when the lack of UVR can have significant effects on physiology. Furthermore, UVR is rarely considered when interpreting findings, particularly within the ecological context. As a result, many gaps remain in our understanding of UVR effects on organisms. We wish to encourage and promote a renewed consideration of UVR in research programmes concerned with understanding the effects of global change on organisms.

Restricting pee is key: neuroendocrine inhibition of primary urine secretion in a major vector of human diseases

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Insect excretory systems are comprised of the Malpighian 'renal' tubules (MTs) and hindgut, whose functions are regulated by diverse diuretic and antidiuretic hormones acting to preserve hydromineral balance. Unlike ultrafiltration in the vertebrate kidney, primary urine formation by the MTs involves secretion energized by the apical membrane-localized V-type H+-ATPase (VA), whose activity has been shown to increase in response to various diuretic hormones. However, haematophagous insects, like female mosquitoes, must fine-tune their excretory system to survive desiccating terrestrial environments while searching for vertebrate hosts on which they feed, but must also quickly clear excess fluid and ions associated with the bloodmeal they imbibe. Therefore, this presentation highlights recent progress characterizing hormonal inhibitors of primary urine secretion by the adult female mosquito MTs, including identification of receptors, effects on ion transport processes and mediators along with second messenger signaling cascades. VA activity increases in diuretic-treated MTs, whereas anti-diuretic hormone reduces its activity via the NOS/cGMP/PKG signaling pathway. Notably, VA complexes are strictly localized apically in the MTs shortly after blood-feeding while, a few hours after blood-feeding, VA is dispersed in the MTs with reduced apical membrane localization. Finally, evidence demonstrating the timing of release and activity of circulating diuretic and antidiuretic neurohormones in association with blood-feeding by female Aedes aegypti mosquitoes is discussed, providing insight on the integration of hormone activities necessary for maintaining the osmolarity and volume of their haemolymph. Collectively, these findings reveal neuroendocrine fine-tuning of the MTs matching the physiological demands essential for preserving organismal homeostasis.

Behavioural and transcriptional profiling of larval zebrafish exposed to environmentally relevant ammonia levels

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Exposure to high environmental ammonia can be neurotoxic in fish, but the concentrations associated with the pathophysiological effects of ammonia are rarely observed in nature. Using behavioural assays, this study assessed whether 5 dpf larval zebrafish acutely exposed to environmentally relevant concentrations of ammonia (250-1,000 µM or 4.25-17.0 mg/l; total ammonia levels) display abnormalities in locomotion, thigmotaxis, the response to light/dark transitions, and the startle and habituation responses to vibrational stimuli. Ammonia exposure did not affect thigmotaxis, the response to light/dark transitions, and only the 1,000 µM concentration increased locomotion. In contrast, all ammonia concentrations sharply increased the initial startle response to a sequence of 30 vibrational stimuli with a 1 s interstimulus interval, and the 500 and 1,000 µM ammonia concentrations accelerated habituation to this behavioural protocol. Subsequent assessment of locomotion during a 15-min rest period and a second set of stimuli demonstrated that the tapping sequences caused physical exhaustion in all ammonia-

exposed larvae. Expression profiling of target genes revealed that acute ammonia exposure increases neural activity, stimulates serotonin synthesis, reduces serotonin degradation, and alters glutamatergic and GABAergic systems. However, most transcriptional effects were only observed at the 1,000 µM ammonia concentration. Overall, our results demonstrate that acute exposure to environmentally relevant ammonia concentrations specifically affects the startle reflex in zebrafish larvae and suggest that alterations in several neurotransmitter systems contribute to this neurobehavioural impairment. More broadly, our findings highlight the potential benefits of using behavioural profiling for chemical risk assessment and identifying the impacts of sub-lethal pollutant exposures.

Characterization of neuroepithelial cells across life stages of sea lamprey (*Petromyzon marinus*)

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In aquatic environments, accurately sensing oxygen levels is a complex but critical process, complicated further by anthropogenic stressors that contribute to widespread hypoxia. Neuroepithelial cells (NECs) are crucial in detecting O_2 and CO_2 levels, and are prominently found within the gills of aquatic species. The sea lamprey, *Petromyzon marinus,* undergoes significant respiratory mode and environmental shifts between the larval and juvenile stage, presenting a unique model for investigating NECs during development. Therefore, we hypothesize that these environmental and/or physiological functions of the gills will influence distribution of NECs in lamprey. Utilizing immunohistochemistry and confocal microscopy imaging, we examined serotonergic NECs in gill arches, using antibodies to label serotonin, innervation, and synaptic vesicles. Preliminary results indicate a greater cell density of NECs in the first gill arch of juveniles and similar NEC surface area across gill arches, aligning with findings in most other fish species but contrasting with the related hagfish , which lack serotonergic NECs in their gills. These observations suggest an evolutionary adaptation in lampreys, possibly linked to their unique method of ventilation and oxygen sensing needs, that varies across their life stages due to morphological gill changes during metamorphosis and a change in O_2 levels across their environment. This research furthers our understanding of NEC functions within an ancient vertebrate lineage, contributing to our knowledge of respiratory and sensory evolution. Further analysis will aim to quantify NEC density and distribution more comprehensively contributing to our understanding of how aquatic vertebrates navigate environments with fluctuating oxygen levels.

Tissue O_2 Supply as a Potential Trigger for Hypoxic Metabolic Depression in Fishes

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Hypoxic metabolic depression (MD) is a regulated and reversible depression of metabolic rate below standard metabolic rate. It is used by specialized animals to prolong their survival when little to no O_2 is available. Although some cellular processes underlying hypoxic MD are known, the upstream signal that induces these processes is not. We hypothesized that the hemoglobin-mediated supply of O_2 per se to the cells acts as this signal. One prediction made by this hypothesis is that hypoxic MD will be induced and reversed at the same PO_2. We tested for this using calorespirometry to measure the water PO_2s at which goldfish (*Carassius auratus*) induce and reverse states of hypoxic MD. Calorespirometry enabled simultaneous measurements of O_2

uptake rate and metabolic heat, and we performed this technique under both flow-through and intermittent flow conditions. This talk will present these results. Next steps will involve calorespirometry-based tests of two other predictions made by this hypothesis, including a correlation between hypoxic MD induction PO_2 and hemoglobin-O_2 binding affinity, and a shifted MD induction PO_2 concordant with a pharmacologically manipulated hemoglobin-O_2 binding affinity.

Does Chronic Hypoxia Elicit a Whole-animal Ketogenic Response in the Pacific Spiny Dogfish (*Squalus suckleyi*)?

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Hypoxic events are becoming increasingly common and longer lasting, due to climate change. Hypoxic exposure can result in poor ATP production as oxygen is the final electron acceptor in the ETS. Lipids and glucose are the preferred substrate of most vertebrates during normoxia and hypoxia, however, elasmobranchs rely on heavily on ketone bodies as mitochondrial fuel. It is currently unclear why elasmobranchs evolved to rely on ketone bodies over other substrates, but it may be related to their evolution through periods oceanic hypoxia and anoxia. Ketone bodies have recently been shown to be beneficial during periods of hypoxia in mammals, but we know considerably less about their metabolism in other species. To test if ketone body metabolism is beneficial during chronic hypoxia in elasmobranchs, we exposed Pacific spiny dogfish (*Squalus suckleyi*) to 20% dissolved oxygen for 7 days and investigated the effects of hypoxia on ketone body metabolism. We predicted that chronic hypoxic exposure would elicit a ketogenic response and that ketone bodies would impact mitochondrial function. We investigated key enzymes involved in ketosis and the efficiency and function of the electron transport system in both red muscle and heart. Our results indicate that our hypoxic exposure did not elicit a ketogenic response and that ketone bodies did not impact the efficiency and function of the mitochondria when compared to pyruvate. However, these fish were likely able to balance oxygen supply and demand through behavioural mechanisms such that a physiological change in substrate oxidation was not required.

Goldfish (*Carassius auratus*) Exhibit a More Robust Response to Anoxia and Re-oxygenation at Colder Temperatures

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Goldfish can survive anoxia for weeks under the ice of ponds and lakes by mobilizing liver glycogen stores and generating ethanol to minimize acid-base disturbances. Yet most studies on goldfish anoxia tolerance have been conducted in warmer (~ 20°C), rather than colder waters. In the present study, goldfish acclimated to 4°C or 14°C were exposed to anoxia for 96h or 24h, respectively, followed by re-oxygenation for 1, 4, or 12h. Normoxic muscle glycogen concentrations were 2-fold greater in 4°C vs 14°C fish, suggesting cold water facilitates glycogen storage. There were also greater reductions in total glycogen in liver during anoxia at 4°C compared to 14°C. Muscle lactate accumulation during anoxia was also greater at 4°C than at 14°C, and lactate remained elevated through the entire re-oxygenation period at the colder temperature. Muscle ethanol increased 7-fold from normoxic levels during anoxic exposure at both temperatures. However, ethanol was more slowly eliminated from muscle during the 12h re-oxygenation period at 4°C compared to 14°C. Lipid peroxidation was 2-fold greater in the cold-

water compared to warm-water goldfish, which may have been related to both homeoviscous changes in membrane composition and decreases in glutathione peroxidase activity. Overall antioxidant enzyme activity responses to anoxia and re-oxygenation were greater at 4°C, with enzymes such as superoxide dismutase having greater activities in the muscle at colder temperatures. We conclude that goldfish have a more robust response to anoxia and re-oxygenation at 4°C compared to 14°C, which may better reflect their physiological responses to these stressors in nature.

Adapting to low oxygen: enhancing hypoxia tolerance in brook trout (*Salvelinus fontinalis*) through acclimation and repeated exposure

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The frequency and severity of aquatic hypoxia are increasing as anthropogenic pressure on aquatic systems continues to increase. Fishes experience physiological and behavioural changes in response to hypoxic events. Most previous literature has focused on variation in hypoxia tolerance among fish species, while little information focuses on intraspecific differences in hypoxia tolerance following repeated exposure. This study used the loss of equilibrium (LOE) to indicate hypoxia tolerance of individual brook trout (*Salvelinus fontinalis*) following their acclimation to lower oxygen levels and repeated exposures to hypoxic stress over five weeks. Fish reared in hypoxic conditions displayed a higher hypoxia threshold (i.e., lower PO_2 at LOE) during the first and second exposures to severe hypoxia. This indicates that brook trout's hypoxia tolerance can be increased through acclimation to low oxygen levels. This study also revealed that frequent exposure to extreme hypoxic conditions can improve brook trout's tolerance to hypoxia.

Breathability versus Barricade: Gill morphology of *Kryptolebias marmoratus* in response to individual and combined exposures to hypoxia and high environmental ammonia?

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The gills act as a physical boundary between fish and their environment. Some species, including the amphibious mangrove rivulus (*Kryptolebias marmoratus*) can modify the structure of their gills in response to environmental changes. These morphological alterations change the surface area of the gills through modifications of interlamellar cell masses (ILCMs). In their natural habitat, these fish are often exposed to low oxygen (hypoxia) and high environmental ammonia (HEA). While an increase in gill surface area (reduction in ILCM) improves oxygen uptake, the thinner barrier may lead to an influx of ammonia that can be lethal. Little is known how these two environmental stressors, with opposing physical pressures, impact gill morphology. We hypothesized that *K. marmoratus* would remodel their gills to prioritize oxygen uptake during combined hypoxia and HEA exposure. To test this hypothesis, lineages from Belize and Honduras were acclimated to control, hypoxia (3.7 kPa), HEA (0.75 mM NH_4Cl), or combined stressors for 7 days. Fish were euthanized, processed for paraffin sectioning, and stained using H&E. Lamellar length, lamellar width, and ILCM were quantified. In response to the combined exposure, both lineages reduced their ILCM. However, the lineages displayed different responses to the individual stressors. The Belize fish decreased their ILCM during both hypoxia and HEA exposures. Whereas the Honduras lineage only responded to HEA by lengthening their lamellae. These findings suggest that the lineages may employ additional mechanisms to

withstand combinations of these stressors. Emersion behaviour and ammonia transporter (Rh glycoprotein) expression will be the focus of future experiments.

Arctic char and cyclic hypoxia: a story that comes to an end…

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A consequence of eutrophication is the exacerbation of the diurnal fluctuations between normoxic (oxygen-rich) and hypoxic (low-oxygen) conditions. At the metabolic level, both hypoxia and reoxygenation have serious consequences on fish and result in altered ATP balance and an elevated risk of oxidative damages. Although cyclic hypoxia is a major concern for ecosystems around the world, our knowledge of how fish respond to it is limited. Our main objective was to characterize how Arctic char (*Salvelinus alpinus*) are affected by and respond to cyclic hypoxia. We hypothesized that, when exposed to multiple cycles of hypoxia, Arctic char can modulate their physiology through metabolic alterations due to the pressure on their aerobic metabolism. Fish were exposed to up to 15 days of cyclic hypoxia and their hepatic DNA methylation, proteome, and metabolome were analyzed. We also monitored their metabolic rate, mitochondrial respiration and in vivo ROS generation. DNA methylation, proteome and metabolome profiles in the liver of Arctic char revealed their impressive capacity to alter their phenotype, including adjustments of their metabolic rate and mitochondrial physiology. These results are consistent with their overall capacity to maintain their growth rate and energy reserves that we previously observed. Surprisingly, no mitochondrial ROS upsurge was detected. This raises questions about the origin of the oxidative stress observed in a context of hypoxia and reoxygenation.

Evaluating The Toxicity Of Silver Nanoparticles On The Behaviour And Physiology Of Bristlenose Catfish (*Ancistrus Cirrhosis*)

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Silver nanoparticles (AgNPs) are currently being found in increasingly higher concentrations in our water supply, where they aggregate and fall to the bottom, affecting benthic creatures. In this study, the benthic Bristlenose Catfish (*Ancistrus Cirrhosis*) was used for their ability to air breathe using their highly vascularized stomachs. By analyzing air breathing frequency (seen only in times of stress), we can better understand what role AgNPs play in a catfish's ability to tolerate environmental stress. Catfish were isolated for seven days with or without the presence of AgNPs. On the eighth day, these fish were exposed to either optimal conditions, hypoxia, or high temperature where their movement was tracked and quantified for 6 hours. In addition to this, fish were placed in a respirometer to measure oxygen consumption, gills were analyzed via SEM imaging, and gut samples were used to determine malondialdehyde (MDA) concentration. It was found that, regardless of environmental stressor or AgNP presence, the total distance a fish moved did not change. However, hypoxic fish exposed to AgNPs were found to increase air breathing frequency, indicating that any movement the catfish is doing is focused on air breathing, increasing their exposure to aerial predators. Respirometry analysis showed an increase in oxygen consumption only when AgNPs are present, which agrees with the behavioral

data. MDA levels varied between environmental stressors in AgNP exposed fish, and qualitative gill analysis indicated that the gills were not damaged from nanoparticles.

Anaerobic swim performance and recovery of Pacific salmon during their spawning migration

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Many Pacific salmon populations must use anaerobic burst swimming to cross high velocity flows to reach their spawning grounds. Although burst swimming is necessary for these fish, there is also evidence that those that expend the greatest anaerobic effort are more likely to die before spawning (Burnett et al. 2014). Whereas the maximum sustained swimming speeds (Ucrit) and recovery of adult salmon have been described in detail, anaerobic swimming speeds and recovery have not (Kraskura et al. 2024). Our purpose was to quantify maximum burst swimming speeds of migrating Pacific salmon and to characterize their recovery. We predicted that individuals that swam anaerobically for greater durations would experience longer recoveries. To study this, we swam wild, migrating adult sockeye (Oncorhynchus nerka), pink (*Oncorhychus gorbuscha*), and coho salmon (*Oncorhynchus kisutch*) in a 10 m-long flume at a water velocity of 2.7 m/s until they reached fatigue. We then conducted respirometry on these fish for one hour. Afterwards, we collected morphometric measurements and tissue samples for biochemical analysis. We describe the velocity and duration of burst swimming as well as metrics of recovery. We explore how factors such as sex, species, size, and condition are related to these outcomes. Thus, we demonstrate the anaerobic burst swimming performance and recovery of three salmon species during their spawning migration.

Abstracts for Poster Presentations

Wednesday/Mercredi, May/Mai 8

1. Exploring the Spatial-Temporal Expression of Shell Matrix Proteins in the Intertidal Gastropod, *Crepidula atrasolea*

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As the principal organ involved in shell formation, the mantle plays a fundamental role in the biomineralization of the gastropod (snail) shell. Notably, the mantle secretes a suite of shell matrix proteins (SMPs) whose diverse spatial and temporal patterns of expression are thought to be the driving force behind novel shell morphologies. The objective of this study was to use a novel technique: in situ hybridization chain reaction (HCR) to comparatively map the expression of three SMPs (*CaSMP1*, *CaSMP20*, *Ca94322*) in the mantle of *Crepidula atrasolea*, a marine gastropod with year-round reproduction and a simple unpigmented shell, throughout larval development. This work highlights the potential to develop *C. atrasolea* as a molluscan model. Despite advances in modelling shell secretion by the mantle, the exact mechanisms controlling shell secretion have not been confirmed, though some evidence suggests that shell deposition is under neural control. The optimization of an HCR protocol for the early stages of *C. atrasolea* provides a precise means of explicitly testing the neural control hypothesis. Further work will determine the expression of neural genes in correlation with biomineralization genes in the mantle throughout the early developmental stages of *C. atrasolea* to determine if the formation of the neural mantle tissue precedes the expression of biomineralization genes.

2. Neural Specific-Gene Expression in the Great Pond Snail, *Lymnaea stagnalis*

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Studies of gastropods have enhanced our understanding of how the nervous system controls animal behaviour. Immunohistochemical labelling has traditionally been the primary method used to investigate gastropod neuroanatomy, however, challenges persist regarding antibody availability and specificity. To address this, we explored a novel technique, in situ hybridization chain reaction (HCR), to label mRNA expression of neural-specific genes. This method offers higher versatility, as genetic sequence data allows for labelling a wider array of potential targets. Moreover, HCR inherently provides increased specificity by relying on genetic base-pairing, rather than the lock-and-key mechanism seen with antibodies. We conducted a comparative analysis of the techniques by parallel investigations of two enzymes associated with the synthesis of neurotransmitters in the nervous system of *Lymnaea stagnalis*. Tyrosine hydroxylase (involved in the production of catecholamines; e.g. dopamine) labelling with HCR was consistent with current and past immunohistochemical findings. However, discrepancies emerged with Tyramine Beta Hydroxylase (involved in the production of octopamine) expression in the central nervous system, suggesting possible differences in the sensitivity of the two methods and the need for further investigation. Despite the potential of HCR to offer enhanced versatility and specificity, it failed to label neural fibers (axons and dendrites) with both enzymes, limiting anatomical detail compared to immunohistochemical labelling. This highlights complementary advantages of both techniques: while HCR offers stronger evidence of specificity

and greater target range, immunohistochemistry appears to provide superior visualization. Overall, the integration of both approaches could synergistically advance neuroanatomical exploration and facilitate future studies of neuron functions.

3. Wish for a fish: whole-mount in situ hybridization of mRNA in Threespine Stickleback

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In the era of phenomics, methods such as whole mount in situ hybridization (WISH) permit detection and mapping of relative timing and positioning of gene expression throughout ontogeny. While crucial for studying the genotype-phenotype map, this technique is mostly used with laboratory organisms such as zebrafish. This is owing in part to the complexity and specificity of this method and the challenges inherent in adapting the technique for non-model organisms. We describe an approach to WISH applied for the first time to the threespine stickleback fish, *Gasterosteus aculeatus*, an emerging model organism in ecology and evolutionary developmental biology. This methodology was adapted with the goal of being applicable both to wild and laboratory-housed individuals across ontogeny. We successfully applied this technique to visualize *BMP4* expression in individuals ranging from 5 to 90 days post fertilization (dpf), with staining being most efficient for individuals around 13 dpf. At this stage of development individuals were small enough to allow for thorough clearing and imaging while being large enough to manipulate. Gene expression was observed in the craniofacial region, the hypaxial and epaxial muscle blocks, and along the spinal cord. While genes involved in morphological patterning and body plans tend to be conserved in their timing and location of expression, subtle differences in regulatory genes and morphogens can produce different phenotypes in response to epistatic and environmental variation. The development of WISH for emerging model organisms serves to broaden the scope of evolutionary developmental biological inquiry.

4. Expression of *mmp25b* and its Inhibitor clu in the Developing Zebrafish Nervous System – A Novel Axon Guidance System?

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Matrix metalloproteinases (MMPs) are secreted or membrane-bound proteases best known for their roles in extracellular matrix (ECM) remodelling during development, regeneration, tissue homeostasis and in pathological contexts such as inflammation and tumour metastasis. Membrane type MMPs (MT-MMPs) also play central roles in the regulation of other MMPs, converting latent 'proMMP' into their active forms. Matrix metalloproteinase 25 (a.k.a MT6-MMP, leukolysin, or Mmp25) is a membrane-tethered MMP studied primarily in the context of leukocyte extravasation and the pathology of colon cancer, but limited research done in developmental contexts suggests Mmp25 is necessary for pathfinding/elongation of sensory axons of the trigeminal ganglion and Rohon-Beard cells. Here we replicate and refine our understanding of the expression of *mmp25b* during zebrafish development using hybridization chain reaction (HCR) and analysis of single cell RNA sequence databases. Consistent with older data, we see

strong expression of *mmp25b* in peripheral sensory ganglia, including trigeminal, anterior and posterior lateral line, vagal, and glossopharyngeal ganglia; Rohon-Beard sensory neurons in the spinal cord; and leukocytes. Intriguingly, we also detect expression of clusterin, a poorly studied extracellular inhibitor of Mmp25, in the floor plate of the spinal cord, dorsal midbrain, the epiphysis in the forebrain, and generally throughout the epidermis. These findings suggest that gradients of Clusterin, specifically around the spinal cord and midbrain, may function as axon pathfinding cues by antagonizing Mmp25-mediated ECM-clearance and/or activation of latent MMPs, and further underscore the overlap between molecular mechanisms involved in inflammation and neural development.

5. Neural Role in Biomineralization: The Ontogeny of Mantle Neural Tissue in *Crepidula atrasolea* (Calyptraeidae, Gastropoda)

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While we have a good understanding of biomineralization as a chemical process, we have very little understanding of how organisms like molluscs (e.g., snails, nautilus, clams, etc.) control mineral deposition. Several studies suggest that biomineralization in molluscs is under neuronal control, however, there is currently no direct evidence to support this hypothesis. Specifically, the neural control hypothesis (NCH) proposes that neurosecretory networks signal to the mantle, the organ that secretes the shell, to control biomineralization. Our goal was to test the NCH by determining if nerves are present throughout all stages of shell formation in *Crepidula atrasolea*. The ontogeny of mantle neural anatomy was observed across shell developmental stages using the neural antibodies serotonin, FMRF-amide, and anti-tyrosinated α-tubulin. We created a spatiotemporal map of the presence and location of each neural marker in the mantle tissue. This image map determined if neural tissue is present throughout development in the shell-secreting tissue, as well as where it connects to shell-secreting cells in the mantle. This research is the first step in understanding how molluscs control shell secretion, how the process can be modified based on environmental changes, and how that process has evolved to create the vast diversity of shells.

6. The effect of movement on the development of the peripheral nervous system in zebrafish

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During development, the nervous system grows and starts to gather sensory inputs that can stimulate neurogenesis. For example, the sensory feedback generated by movement has been shown to stimulate zebrafish larvae brain development, with larvae that swim more generating more new neurons in the forebrain than those swimming less. Dorsal root ganglia (DRG) are a type of peripheral sensory cells present in most vertebrates, including zebrafish. During swimming, DRG detect movement and convey the sensory inputs to the brain. Cell populations of DRG grow during postembryonic development through neurogenesis like the brain, so it's possible that movement directly impacts the generation of DRG. I hypothesize that movement during postembryonic development affects the production of DRG. To test this, I used three different approaches: (1) I raised fish under restraint using smaller wells that reduce larval swimming; (2) I raised the fish in 6% methylcellulose, a thick media that reduces swimming; and

(3) I used chrna1 fish, mutants that can't move due to the lack of synaptic transmission at the neuromuscular junction. For all approaches, I used transgenic zebrafish (*Isl2b*:*gfp*) that produce a green fluorescent protein in their DRG allowing for in vivo visualization and resampling over development to count DRG cells. All treatments reduced larval swimming compared to controls and consequently reduced the number of DRG generated. Therefore, I conclude that the amount of postembryonic movement that a zebrafish larvae experience affects DRG growth.

7. Stay grounded: hydrodynamic interactions between the ground and river stingrays

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The ocellate river stingray (*Potamotrygon motoro*) is a foil-shaped stingray that migrates along the ground throughout South American river basins. In this study, we measured lift and drag forces, and the posterior flow field using particle image velocimetry (PIV), to characterize the hydrodynamic performance of the form of river rays as a function of flow speed and distance from the ground. The experiments were conducted in a recirculating flume where a deceased ray (14cm width, W) was attached to load cell at an angle of attack of 0°, to measure forces and flow at different heights from the substrate (0.001-0.85W) at a range of speeds (0-1.33W/s). The ray generated negative lift when positioned furthest away from the ground (>0.5W). However, lift changed to positive and increased in value as the ray was positioned closer to the ground. Furthermore, as expected, drag decreased as the ray was positioned closer to the ground. From the lift-drag ratios (L/D) we observed three distinctive regions: weak ground interaction with negative L/D due to negative lift (>0.5W), intermediate ground interaction with slightly positive and constant L/D (0.07-0.5W), and strong ground interaction with high L/D (<0.07W). Hence, river rays may benefit from hydrodynamic interactions with the substrate that inherently stabilizes the fish near the ground when swimming or station holding in flowing rivers.

8. Losing a sense of our surroundings: Assessing how the loss of social senses like touch and vision can modulate neuropeptide activity in the brain of zebrafish

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Social interactions, which rely on sensory information, are important for the well-being of social animals like humans. Chronic loss of our senses can change how we experience social interactions and can leave us feel lonelier. In zebrafish, parathyroid hormone 2 (Pth2) is an excitatory neuropeptide associated with social interactions, with pth2 levels decreasing in the brain during social isolation. Mechanical detection of conspecifics via the lateral line system contributes to the majority of pth2 levels in zebrafish, with nonfunctional lateral lines leading to decreased pth2 levels. However, pth2 levels are not completely reduced, suggesting that an additional sense contributes to social detection. With my research, I explore vision as a social sense, and if/how lateral line and visual inputs interact in the brain to affect pth2 levels in zebrafish. Furthermore, thalamic pth2 expression overlaps with the thalamic expression of an

inhibitory neuropeptide called somatostatin 7 (Sst7). Excitatory and inhibitory transmitters in the brain tend to have dynamic relationships and can induce a phenomenon called neurotransmitter switching. Exploring the excitatory Pth2 and inhibitory Sst7 in tandem may uncover a dynamic switching relationship that can further illustrate the molecular consequences of sensory loss on the social brain. In my experiments, I will use both environmental and genetic approaches, along with hybridization chain reaction, to explore the relationship between social senses, pth2 and sst7. Through my research, I hope to use the zebrafish model to understand the molecular basis of how sensory loss affects social perception and brain chemistry.

9. Cold Temperature Regimes and Morphometrics through Ontogeny in the Threespine Stickleback (*Gasterosteus aculeatus*)

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The Threespine Stickleback (*Gasterosteus aculeatus*) is a model organism for parallel evolution that occupies marine habitats across North America. Temperature has been proposed as an important selective pressure in this process, but the mechanism remains unclear. In particular, the effects of temperature on morphology or the possibility of growth advantages under differing temperature regimes are unknown. We used 2D geometric morphometrics to study how cold temperatures affect shape and size from hatching to adulthood in marine stickleback obtained from the Bamfield Marine Sciences Centre. A 'control' group was held at a steady 15°C throughout the experiment. A 'cold' treatment group had their water temperature gradually dropped from 15°C to an ecologically relevant temperature of 8.5°C for 20 days at 140 days post-fertilization (dpf), simulating a shortened winter, after which temperatures were gradually raised back to 15°C. Morphometric analyses were conducted before and after this simulated winter (190 dpf), and at a third, adult timepoint (240 dpf). We found that temperature did not significantly affect either shape or size through development. Developmental time was the only significant factor contributing to shape and size change. There were allometric changes in mouth positioning, operculum size and pelvic spine length. Together, these findings suggest that juvenile G. aculeatus are resilient to ecologically relevant cold temperatures and that such temperatures do not appear to confer a notable growth advantage. Further work is required to understand the complex relationship between temperature and adaptive evolution in this species.

10. The Effects of Chronic Hypoxia on the Lipid Metabolism of Brook Trout (*Salvelinus fontinalis*)

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Aquatic hypoxic events are becoming far more frequent, severe, and long lasting. To cope with periods of hypoxia, fish can decrease their oxygen requirements by reducing energetically costly activities such as locomotion, growth and feeding. During normal oxygen conditions fasting will typically upregulate fat metabolism, as fats can be stored in large quantities, and yield high levels of ATP per molecule. However, during periods of acute hypoxia, fat metabolism is typically downregulated as this process requires large amounts of oxygen and can produce harmful levels of reactive oxygen species. Instead, cells typically breakdown carbohydrates which use

considerably less oxygen, but have limited stores. However, it is unclear how periods of chronic hypoxia may impact fat metabolism in fish when carbohydrate stores are exhausted. To determine the effects of chronic hypoxia and fasting we exposed brook trout (*Salvelinus fontinalis*) to 14 days of fasting and normoxia, or fasting and hypoxia at 45% dissolved oxygen. We measured mitochondrial respiration using both short-chain (sodium butyrate) and long-chain (palmitoyl-CoA) fatty acid,s as well as the activity of various other enzymes important in lipid metabolism in cardiac muscle tissue. We found that fish exposed to chronic hypoxia had an increased capacity for long-chain fatty acid uptake and higher oxygen consumption in the heart than control groups. This suggests that chronic hypoxia may induce fat oxidation to support cardiac function despite the potential negative side effects.

11. Taurine efflux: a novel mechanism constraining maximum cardiac function under thermal stress

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Stressors that activate anaerobic metabolism in mammalian hearts increase intracellular osmotic strength via the breakdown of glycogen and glucose and the accumulation of lactate, protons, and inorganic phosphate. This is rarely acknowledged in mammalian research and, to our knowledge, has not been studied in fish. In the face of any osmotic disturbance, regulatory volume increase and decrease mechanisms protect cardiomyocyte volume via the active and passive movement of ions and organic osmolytes, with taurine being the most important of the latter. Anaerobic stressors stimulate cardiac taurine efflux in healthy, but not taurine deficient (TD) fish, and that efflux is critical for maintaining cardiac function. Taurine efflux occurs in the absence of changes in extracellular (plasma) osmolality, suggesting it is driven by intracellular changes. We developed and validated a rapid method to assess changes in tissue osmolality and studied the effects of acute thermal stress on plasma and heart osmolality, and heart taurine and lactate content in control and TD brook char (*Salvelinus fontinalis*). Acute thermal stress caused equivalent lactate accumulation in control and TD fish. Plasma osmolality did not differ between groups, but heart osmolality was >40 mosmol/kg higher in TD fish following thermal stress. These data confirm that taurine efflux occurs in response to increases in intracellular osmolality and is required to maintain cardiac osmotic homeostasis, and thus mechanical function, during thermal stress. This represents a novel mechanism constraining maximum cardiac function under thermal stress that has important implications for our understanding of thermal tolerance across fish species.

12. Taurine supports the cardiovascular response to hypoxia in marine fish

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Climate change is altering aquatic environments through processes like eutrophication. This is generating hypoxic conditions which may have adverse consequences for aquatic species. This may be exacerbated by taurine-deficiencies occurring due to a loss of taurine-rich prey. Taurine is a non-proteogenic β-amino acid that exhibits cardioprotective properties through osmoregulation and calcium homeostasis. Taurine is necessary for supporting cardiac function under hypoxic conditions in freshwater fish but analogous studies in marine fish are lacking. The present study investigates this knowledge gap by determining the effect of taurine-deficiency on

cardiac function in marine fish. Saltwater acclimated brook char (*Salvelinus fontinalis*) were used as a model marine fish to facilitate comparisons with existing data on freshwater brook char. Taurine deficiency was generated through a 5% β-alanine feed, which acts as a competitive inhibitor of tissue taurine transport. Heart rate (fh) was quantified using electrocardiograms (ECG) under normoxic or hypoxic conditions. Plasma osmolality and tissue taurine concentrations were determined to confirm taurine deficiency and understand the dynamics of taurine flux under hypoxic conditions. Results showed that control brook char exhibit a typical bradycardia in response to hypoxia with an average decrease in fh of 55%. Taurine deficient fish showed high interindividual variability and a blunted bradycardia. Additionally, control fish maintained plasma osmolality following hypoxia, while it increased by 57 mosmol/kg in taurine-deficient fish. Overall, taurine is important for the normal cardiac response to hypoxia through the maintenance of osmotic homeostasis in the heart.

13. Parental environmental and embryonic thermal history can alter thermal tolerance and the heat shock protein threshold of induction in embryos and post-hatch Lake whitefish (*Coregonus clupeaformis*)

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A warming environment and increased temperature fluctuations associated with climate change or other anthropogenic processes can detrimentally affect fish development and survival; however, protective cellular responses can attenuate the effects of these stressors. We investigated how parental environmental history (lake type) and embryonic thermal history influenced thermal tolerance and the heat shock response (HSR) in early-stage Lake whitefish (*Coregonus clupeaformis*). Embryos derived from parents of a warm shallow lake, Blackstrap Lake, were 6ºC more thermally tolerant than embryos from Lake Diefenbaker and Doré Lake, which are deep cool lakes. Post-hatch fish from Blackstrap Lake were also more thermally tolerant than fish from the deep, cool lakes. Daily thermal stress (1 hour at 3ºC above incubation temperature) for 50 days during embryogenesis reduced thermal tolerance by 2ºC in embryos from all three lakes. The minimum temperature for heat shock protein production (HSR induction threshold) in embryos at 80 days post-fertilization did not change with parental thermal history. However, embryonic thermal history resulted in a more variable HSR, with those exposed to daily thermal stress tending to have a higher HSR threshold induction temperature than embryos held at constant temperatures. Our data show that parental and embryonic environmental/thermal history can have lasting effects on thermal tolerance and the HSR in Lake whitefish.

14. Determining the relationship between cryoprotectants and Lyme disease infection status in *Ixodes scapularis*

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The black legged tick, *Ixodes scapularis*, is the primary carrier of *Borrelia burgdorferi* - the bacterium that causes Lyme disease. Previous research has shown that black legged ticks infected with *B. burgdorferi* exhibit higher survival after winter conditions. This research aims to determine which mechanisms are underlying this enhanced ability of infected I. scapularis to

survive winter. Many organisms survive winter due to enhanced cold tolerance, which can be supported by the accumulation of small molecules known as cryoprotectants. Cryoprotectants include polyols (e.g., glycerol), small sugars (e.g., trehalose), and some amino acids (e.g., proline). We hypothesized that cryoprotectant concentrations would be higher in infected ticks compared to noninfected ticks. To test this hypothesis, we collected *I. scapularis* in spring 2023 and fall 2023 in Nova Scotia, tested for infection by *B. burgdorferi*, and used biochemical assays to measure concentrations of glycerol, trehalose, proline, and myo-inositol. By determining whether infected *I. scapularis* have higher cryoprotectant concentrations than uninfected I. scapularis, we will improve our understanding of the ticks' overwintering mechanisms, with implications for the spread of Lyme disease in Atlantic Canada.

15. Shocking worms!

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In the Anthropocene era, living organisms are confronted with numerous environmental changes that threaten their survival. The adenylate energy charge (AEC), which represents the energy status of an organism, may be a good indicator of stress due to these factors. It is therefore crucial to develop a fast and efficient method for measuring adenylates and therefore AEC. To achieve this, the muscle contraction of earthworms was electrically stimulated to generate stress. Several solvents and homogenization methods were tested in order to select those most effective in extracting ATP, ADP and AMP. Adenylates and lactate, another stress marker, were quantified by HPLC-MS/MS and AEC was calculated. The results showed that electrical stimulation did not affect AEC, but did reduce total adenylate concentration in stimulated earthworms. The experimental method developed now makes it possible to measure adenylates and AEC in a variety of organisms exposed to stressful environmental factors.

16. The Ecotoxicity of a N-Heterocyclic Carbene Species on *Dugesia dorotocephala*

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Anticorrosion materials often contain chemicals such as metals, organic solvents, or corrosive substances. When these materials are applied to surfaces exposed to water, such as bridges and pipelines, there's a risk of chemicals leaching into aquatic environments, which can lead to adverse effects, depending on the concentration and nature of the chemicals involved. Current research shows that the unique properties of N-heterocyclic carbenes (NHC) make them attractive candidates for the development of advanced anticorrosion materials; however, their effects on the toxicology of organisms found in freshwater systems remains understudied. Using brown flatworms (*Dugessia dorotocephala*) as a model, the relationship between NHC concentrations and planarian toxicity were investigated under various pH and temperature conditions over a 96-hour exposure. The greatest mortality in both experiments was found in the

highest concentration of NHC. However, the percentage and rate of mortality differed for each pH and temperature experiment. Results indicate that higher NHC concentrations lead to increased mortality rates, with abiotic factors playing a significant role in modulating toxicity. Further research into the accumulation and distribution of NHCs in aquatic organisms is required to fully assess their environmental impact and inform the development of safer anticorrosion materials. Ultimately, this study contributes valuable insights into the complex interactions between NHCs and freshwater ecosystems, highlighting the importance of considering abiotic factors in toxicity assessments and environmental risk evaluations.

17. Temperature differences in the molecular physiology of the poeciliid gill epithelium TJ complex

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Poeciliids are livebearing fishes, known for their adaptability to diverse environmental conditions, including varying temperatures. This study considered the molecular physiology of the gill epithelium tight junction (TJ) complex of the guppy (*Poecilia reticulata*), in response to water temperature. Claudin (Cldn) TJ proteins known to be abundant in the gill and responsive to environmental change were targeted. Fish were acclimated to either high (35°C), medium (control) (25°C) or low (15°C) temperature conditions for two weeks. Gill samples were collected for analysis of cldn mRNA abundance by qPCR. Data indicate that many cldns exhibit differences in mRNA abundance in response to elevated or lowered water temperature, but in all cases, a decrease in mRNA abundance was observed. In terms of trends, transcript abundance of genes encoding Cldn-8 proteins typically decreased irrespective of temperature change (i.e. elevated or reduced water temperature typically saw a decrease in *cldn-8* gene family mRNA abundance) while *cldn-3* gene family mRNA abundance only significantly decrease in low temperature conditions. In contrast, *cldn-28b* and *-30b* mRNA decreased only in high temperatures. Data suggest that temperature-induced differences in the molecular physiology of the gill TJ complex occur in fishes. By inference, alterations in mRNA abundance indicate that the gill epithelium TJ complex becomes leakier in high and low temperature conditions. But this study considered a limited number of Cldn family members at the transcriptional level only. Therefore further study will be required to tease out the TJ complex role in gill epithelium permeability following temperature change.

18. Does the parasitic wasp, *Cotesia congregata*, produce leaky brains and sticky synapses in its host?

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The parasitic wasp, *Cotesia congregata*, injects its eggs into the body of the caterpillar. The host's behaviour remains normal during wasp larval development within the host's body cavity. Once the wasps are ready to pupate, they exit through the caterpillar's body wall and form cocoons on its cuticle. After the wasps have exited the host, the caterpillar loses all self-generated behaviours (i.e. feeding and spontaneous locomotion). However, defensive behaviours remain intact, allowing the host to act as a bodyguard for the wasp cocoons. One hypothesis for the change in host behaviour is that the wasps induce neuroinflammation, resulting in heightened immune-neural signaling. We tested whether the blood-brain-barrier

becomes leaky concomitant with the host's behavioural changes. Such leakiness would produce neuroinflammation. Trypan blue injections were used to assess brain permeability. Penetrance of the dye into the supraesophageal ganglion was measured using histological images and absorbance spectroscopy. However, we found no evidence for a leaky brain barrier. The bodyguard phenotype could also be created by reducing synaptic transmission. We increased neural activity in 'bodyguard' caterpillars by using electroshock and stressful handling. Although there was no significant difference across stressed groups, preliminary data suggests all forms of stress triggered feeding. These results suggest that a stress response can produce partial recovery.

19. Field Testing and Validation of Clearflow Coal Mine Water Treatment Technologies

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Mining activities often lead to high levels of suspended particles (TSS) as well as other exceedances in a number of water quality guidelines for aquatic life. Clearflow Group has developed coagulating/flocculating polymers that produce rapid clarification of mine waters due to the cationic polymers binding to the mainly negatively charged TSS. However, following the clarification of mine waters, residual cationic polymers are still toxic to aquatic life, especially fish. Clearflow's neutralizing polymer ameliorates the toxicity of residual cationic polymers rendering the process of mine water treatment environmentally friendly. In addition, the polymer treatments reduce the concentrations of a number of other chemicals that typically exceed the guidelines for aquatic life in mine water effluents. This field study examines the effects of treating mine water with both cationic and neutralizing polymers on nutrient and metal contaminant removal, invertebrate communities impacts, and toxicity to fish. The first season of study demonstrated that the use of neutralizing polymers in combination with cationic polymer clarification of the mine water had no acute toxicity to trout fingerlings. Water chemistry overall was substantially improved by the polymer treatments. The invertebrate community compositions in the polymer treated mine effluent stream vs the receiving river appears to promote the abundance of mollusk species.

20. Seasonal acclimation of cardiac heat tolerance and adrenergic sensitivity in Greenland cod (Gadus ogac) in the Central Canadian Arctic

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Northern climates are characterized by extreme seasonality which can challenge critical physiological processes, including cardiac function. During warming, heart rate in fish generally

increases, which supports increased tissue oxygen demands but only up to a critical temperature at which a peak heart rate is reached. Conversely, at cold winter temperatures, heart rate is slowed. Available single-species studies have revealed considerable diversity in the responses of heart rate to temperature change among fishes, but the mechanistic basis and significance of this diversity is unclear. For example, adrenaline can be critical for maintaining heart function at thermal extremes, but the extent to which thermal acclimation of cardiac temperature sensitivity is driven by changes in adrenergic regulation requires exploration. Using an electrocardiogram approach, we investigated seasonal changes in cardiac heat tolerance and adrenergic sensitivity in winter-and summer-acclimated Greenland cod in the Central Canadian Arctic. Fish were anaesthetized, fitted with subdermal electrodes, and given a drug injection to elicit either maximum or intrinsic heart rate, with the difference being indicative of adrenergic sensitivity. Fish were then acutely warmed until heart rate peaked, and cardiac arrythmia began, indicating heart failure (an upper cardiac thermal limit). We found that cardiac heat tolerance is markedly compromised in winter relative to summer-acclimated cod with only slight effects of adrenaline. The magnitude of thermal plasticity is likely a result of the significant acclimatory changes (e.g. membrane fluidity) beyond adrenergic control of heart rate that are required to allow cod to remain functional at winter temperatures as low as -1.8°C.

21. The disruption of gastrointestinal hormonal control of digestion in Nile tilapia (*Oreochromis niloticus*) by omeprazole

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Stomach acidity is a critical aspect of the digestive system, facilitating the breakdown of protein through the activation of the protease pepsin. Gastric acid is enabled by H^+/K^+ ATPase, the gastric proton pump. Our earlier study on Nile tilapia showed that inhibiting the production of stomach acid using omeprazole, reduced growth in the species that correlated with an acceleration of the rate of gastric emptying. This contrasts with studies in mammals in which there is a delay in gastric emptying and no impacts on growth. To address the question of the mechanism behind the effects on gastric emptying in tilapia, we examined the role of cholecystokinin (CCK). CCK is secreted by enteroendocrine cells in the anterior intestine in response to acidic chyme from the stomach and acts as a brake to stomach emptying. CCK controls the rate of gastric motility as it contracts the most anterior part of the intestine to delay gastric emptying, holding food so that it can properly go through the digestive process. Post-prandial changes in tilapia fed a fixed ration of 2%BM/day of pellets either with (25mg/kg/d) or without omeprazole. Our results show lower circulating plasma CCK concentrations and lower *cck* gene expression in anterior intestine. Which together suggest a reduced release of CCK that would explain the accelerated rate of stomach emptying seen in tilapia. My study will observe the interactions of gastric acidification and its relationship to the endocrine system on a molecular level not only with CCK but other hormones that are influenced by gastric acidification, bridging the gap in knowledge towards the endocrine systems interaction with the stomach in the teleost species.

22. Cold acclimation and its impact on the protein metabolism of *Drosophila suzukii*

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Drosophila suzukii, (a major threat to agricultural productivity which was localized to tropical regions) is now found in all Canadian provinces due to its ability to survive the cold characterized by a clear phenotypic distinction between "summer morph" and "winter morph". The biological mechanisms that confer this cold hardiness to *D. suzukii* have been studied at the transcriptome level but remain poorly studied at the proteome level. Maintenance of protein conformation or degradation is an energetically costly process and might thus be a key process to understand this phenotypic switch. This project therefore aims to explore the impact of cold development and acclimation on the protein metabolism of *D. suzukii*. For this purpose, two cohorts of *D. suzukii* will be used, one control with larvae and adults developing at 25°C (summer morphs), and the other with larvae and adults developing at 10°C (winter morphs). We will first measure protein synthesis, adenylic energy charge (ATP, ADP and AMP concentrations) and mitochondrial ROS in vivo (with the ratiometric probe MitoB) by mass spectrometry (MS). The activation of regulatory proteins, such as AMPK, a kinase responsible for activating catabolic pathways and inhibiting anabolic ones to maintain the energy balance, will also be evaluated to understand the regulation of protein metabolism between morphs. Finally, the expression of genes linked to antioxidant defences and protein folding will be evaluated to understand how protein damage is controlled by the organism.

23. Simulating Season: The effects of photoperiod and temperature on thermogenesis in deer mice

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Ambient temperature is known to drive changes in the thermal physiology of mammals, such as an increase in the capacity for thermogenesis in winter. Our previous work has shown that acclimation to chronic cold increases the capacity for non-shivering thermogenesis (NST) and thermogenic capacity (cold-induced VO_2max) in deer mice (*Peromyscus maniculatus*). Daylight, or photoperiod, is an important driver of seasonal changes in physiology. In the wild, animals are attuned to seasonal changes in temperature and photoperiod. However, few studies have examined the combined effect of photoperiod and temperature on the capacity for NST in small mammals, such as the deer mouse. To address this, we acclimated deer mice to long or short photoperiods (12h or 8h light), in either thermoneutral or cold conditions (30°C vs 5°C). To simulate the fall conditions in their natural habitat (Nebraska) we gradually reduced either daylength, temperature, or both over 4 weeks and acclimated mice an additional 4 weeks at those conditions. After 8 weeks of acclimation, we determined NST and VO_2max for each mouse. Thus far, we found that the capacity for NST increases with acclimation to short photoperiod and cold conditions but cold-induced VO_2max does not significantly change.

24. Induction of sodium uptake recovery mechanisms in adult zebrafish during low-pH exposure

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Sodium homeostasis in fish gill cells is integral for maintaining proper cellular and bodily function. Sodium uptake in most freshwater fish species is conducted by electroneutral transporters, however, electroneutral transporters in fish ionocytes are thermodynamically unfavoured for forward function at reduced environmental pH (< pH 6) and low environmental ion concentrations (freshwater). Many fish species like cyprinids are known to live in these environments without ionoregulatory issues, which has created interest in the overall function and molecular mechanisms of ion transporters in these fishes. One novel transport model of sodium uptake that has been shown in zebrafish (*Danio rerio*) that uses an as yet undetermined potassium-driven sodium transporter that theoretically circumvents the thermodynamic constraints of low environmental pH and has shown to recover sodium uptake to nominal rates after chronic exposure to low pH conditions. This current study has used radiotracer-based ion flux technologies to measure sodium uptake in zebrafish over acute (<2 hours) and chronic (8 hours) exposures to pH 4, which has shown increased sodium uptake and net potassium efflux between 6-8 hours of pH 4 exposure. We are currently investigating ion flux profiles similarly in other species of known acid-tolerant fish species like cardinal tetras (*Paracheirodon axelrodi*) and fathead minnows (*Pimephales promelas*) and conducting differential gene expression analyses to find candidate genes for the unknown potassium-driven sodium transporter.

25. Total suspended solids impact on the stress response in fish

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Total suspended solids (TSS) are present in our waterways, and they are subject to daily fluctuations caused by both natural and anthropogenic events. The increases in TSS can negatively impact water quality, and also affect aquatic life. However, whether the TSS impacts the stress performance of fish is far from clear. In this study, we investigated whether 4-day exposure to TSS would compromise the stress response and alter the liver and muscle metabolism in fish. To this end, we carried out a multi-species comparison, including rainbow trout (Oncorhynchus mykiss), cutthroat trout (*Oncorhynchus clarkii*), brook trout (*Salvelinus fontinalis*), fathead minnow (*Pimephales promelas*), and longnose dace (*Rhinichthys cataractae*) exposed to TSS concentrations ranging from 0-1000mg/L for 96 hours. We measured cortisol as a marker of the primary stress response, while glucose, glycogen, and lactate concentrations were measured to assess the metabolic consequences. Furthermore, to test their stress performance, fish in the 100 mg/L group were subjected to an additional acute stressor, which consisted of a 3-minute air exposure and sampled at 0, 60, and 120 min later. All species tested showed no significant effect of 4-day TSS exposure on the cortisol and metabolic stress response. Also, they were all able to elicit a cortisol and metabolic stress response to a secondary acute stressor despite the TSS exposure. Altogether, 4-day exposure to TSS did not affect either the steady-state cortisol and metabolite levels or the dynamic stress response, suggesting that the stress performance of fish was not compromised in the present study. Acknowledgments: This study was supported by funding from the City of Calgary, the Alberta Conservation Association, and the Natural Sciences and Engineering Research Council of Canada, Alliance, and Discovery grants.

26. If looks could chill: Characterizing visual response in freeze-tolerant crickets

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Freeze-tolerant insects can withstand internal ice formation, during which their cells experience osmotic, ionic, metabolic, and mechanical stress. Insects process visual information via modulation of ions in precisely structured, integrated sensory and nervous tissues in the compound eye, which is therefore likely vulnerable to the stresses of freeze-thaw. I aim to determine how freezing and thawing affect the eyes of the freeze-tolerant spring field cricket, *Gryllus veletis*. I use electroretinograms to measure photoreceptor potential, time-to-peak response, and critical flicker fusion frequency, which describe photoreceptor activity, laminar neuron activity, and temporal resolution, respectively. I compare acclimated freeze-tolerant crickets to non-acclimated freeze-intolerant crickets to identify how becoming freeze-tolerant changes visual performance. I also compare the effects of freezing and cold exposure on freeze-tolerant and -intolerant crickets to control for the effects of cold verses ice formation. This is the first study of eye function in freeze-tolerant insects, and will generate hypotheses about how freeze-tolerant insects protect and/or repair sensory epithelia and neurons in winter.

27. Temperature tolerance and regulation of cardiac function in lumpfish (*Cyclopterus lumpus*)

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At poleward latitudes, water temperature can fluctuate greatly over days to seasons, which can challenge the physiology and whole animal performance of ectothermic fish. Acute and acclimatory adjustments of the cardiovascular system are thought to be key to coping with thermal challenges among fishes. Heart rate will increase with warming water to meet high tissue oxygen demand up until a peak temperature at which point heart rate peaks and then becomes arrhythmic and fails with further warming. Conversely, when faced with colder water, the heart rate and metabolism is slowed. We are exploring the extent to which different species with different thermal niches and strategies can adjust their heart rate, cardiac thermal sensitivity, and cardiac temperature tolerance to compensate for thermal change. In particular, we are assessing the role of adrenergic regulation of the heart in contributing to cardiac thermal plasticity among fish species. Using a well-established electrocardiogram (ECG) method, I am investigating the temperature tolerance and adrenergic regulation of cardiac function in lumpfish, a cold- and winter-active species that is also of aquaculture interest. My study will provide insight into the interaction between adrenaline, cardiac function and thermal limitations in cold temperate fishes.

28. Drivers of Metabolic Consequences of Freezing in the Intertidal Mussel, *Mytilus trossulus*

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The bay mussel, *Mytilus trossulus*, is an intertidal bivalve found along the west coast of North America which risks freezing during low tides in the winter. Despite being freeze tolerant, the energetic costs required to survive freezing are unknown and may affect its role as an ecosystem engineer. Using a closed respirometry system, we measured their oxygen consumption as a proxy for metabolic rate before and after single and repeated freezing events. We compared these responses to hypoxia exposures as tissues are not perfused when frozen which largely inhibits gas exchange. In general, we observed that mussels' oxygen consumption rates decreased immediately after a single freeze. This initial metabolic decrease after freezing may relate to the damage to the oxygen cascade and limit the capacity for oxygen uptake (e.g. damage to the gill). Alternatively, it may be representative of a deliberate metabolic suppression to limit oxidative damage. However, after 24 hours of recovery from a single freeze, metabolic rates were generally elevated. Additionally, repeated freeze-thaws did not cause the same decrease in oxygen consumption, and generally showed an elevation in metabolic rates. Combined, this suggests that periods of repair may be crucial to survive freezing, and that the elevated metabolism may be fueling post-freeze repair. Further work will elucidate the mechanisms underlying the main driver of this response and the broader ecological implications to the intertidal zone following cold spells.

29. Posttranslational modifications of mitochondrial proteins in hibernating thirteen-lined ground squirrels, *Ictidomys tridecemlineatus*

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Thirteen-lined ground squirrels (TLGS), *Ictidomys tridecemlineatus*, are obligate hibernators native to central North America. TLGS inhabit regions where seasonal changes result in harsh environmental conditions, and hibernation maximizes a ground squirrel's likelihood of survival. When TLGS hibernate, they experience two distinct physiological states: torpor and interbout euthermia (IBE). When entering torpor, whole-animal metabolism and mitochondrial respiration decrease dramatically over a short period. The mechanism underlying this rapid change in mitochondrial respiration between torpor and IBE is not fully understood, however past research suggests posttranslational modifications (PTMs) to mitochondrial proteins contribute. PTMs modify proteins at a similar timescale of the quick entrance into torpor. Additionally, enzymes function slower at low temperatures and faster at high temperatures, which is consistent with mitochondrial metabolism increasing slower when body temperature is cold in torpor, and decreasing faster when body temperature is high in IBE. My project compares the abundance of several PTMs to TLGS liver mitochondrial proteins in torpor, IBE, and summer euthermia. Using isolated liver mitochondria from TLGS in these three states, I performed western blotting to quantify the abundance of protein acetylation, hydroxylation, methylation, phosphorylation, S-nitrosylation, succinylation, sulfhydration, and SUMOylation. Of particular interest, acetylation, hydroxylation, S-Nitrosylation, and SUMOylation were significantly higher in torpor in comparison to IBE and summer euthermia. Conversely, phosphorylation and sulfhydration were significantly higher in IBE than in torpor, while succinylation was highest in summer euthermia. Differential PTMs between torpor and IBE correspond with changes in mitochondrial function suggesting a mechanism underlying this extreme example of mitochondrial plasticity.

30. The Influence of an Energy Deficit on Neurogenesis in Zebrafish (*Danio rerio*)

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Neurogenesis is the process through which new neurons are formed in the brain, and this process continues throughout the lifespan of zebrafish in all major brain regions. Neurogenesis is modulated by a variety of factors, but the reason for individual variation in the rate of neurogenesis remains unknown. Given that the maintenance and generation of neural tissue is energetically expensive, we tested the hypothesis that individual rates of neurogenesis are modified to maintain energy balance. Under acute energy deficits, we predicted that neurogenesis will be prioritized to sustain neural function. We exposed adult zebrafish to either increased temperature (33°C) and/or starvation for 3 days in a fully factorial experiment. Cell proliferation in the brain was quantified in individuals from each group using the mitotic marker 5-bromo-2'-deoxyuridine (BrdU) and tallying the number of BrdU+ cells in cross-sections of the telencephalon and cerebellum. Gastrointestinal tract (GIT) and body weight measurements were recorded and compared between all experimental groups. Although the acute energy deficit did not impact body weight, the GIT weights of fish in the Starved and Starved+Heated groups were significantly less than those of fish in the Control and Heated groups. If the number of BrdU+ cells are similar across treatment groups, this would support a trade-off between neurogenesis and the GIT under acute energy deficits.

31. Prevention of cold-induced ionoregulatory collapse via cryoprotectant accumulation in a freeze tolerant insect: Asian longhorn beetle (*Anoplophora glabripennis*)

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Temperature is a key environmental constraint on insect population size and distribution, and a crucial factor limiting establishment and spread of invasive species. For insects, cold exposure results in progressive loss of ion balance, which is dependent on both exposure duration and intensity. Ionoregulatory collapse is characterized by extracellular hyperkalemia, which causes tissue damage and eventually death. Preliminary data suggests mountain pine beetle larvae (*Dendroctonus ponderosae*; MPB), which are freeze-avoidant, only partially lose ion balance during chilling and maintain extracellular [K^+] just below lethal cellular limits – unlike less cold-tolerant species. Similar to MPB, freeze-tolerant, Asian longhorn beetle larvae (*Anoplophora glabripennis*; ALB), suppresses their supercooling point in winter partially by accumulating cryoprotectants (mainly glycerol). Whether cold-hardy species other than MPB can mitigate cold-disrupted ion balance is unknown, as are the mechanisms behind this phenomenon. This research will examine whether cryoprotectants, in addition to preventing freezing, increase cold tolerance by acting as osmoprotectants that mitigate cold-induced ionoregulatory collapse. Using ALB as a model system, we will characterize their cold tolerance and explore the relationship of hemolymph ion concentrations (Na^+/K^+), cryoprotectant accumulation, and their hypothesized interaction with cold. ALB larvae lab-reared on artificial diet will undergo cold exposures at temperatures approaching their lower thermal limit, hemolymph concentrations of cryoprotectants and ions will then be measured. Understanding the mechanisms underlying winter survival of cold-tolerant species will improve our ability to predict their capacity to survive

in novel habitats outside their native ranges and forecast potential impact of future climate conditions on these species' distributions.

32. Investigating the relationship between ionoregulatory mechanisms and salinity tolerance in early life stages of mummichog (*Fundulus heteroclitus*)

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Maintenance of ion homeostasis via active ion transport is crucial for the survival of virtually all organisms. Euryhaline fishes can acclimate to both seawater and freshwater environments, and therefore must modify their ionoregulatory mechanisms in response to changes in environmental salinity. Freshwater-acclimated fish must actively absorb ions to mitigate passive ion diffusion to the environment, whereas seawater-acclimated fish must actively secrete ions to compensate for passive ion influx. In adult fishes, the active component of ionoregulation is coordinated by ionocytes, specialized cells localized to the gill epithelium, and in some species the opercular membrane. Mummichog (*Fundulus heteroclitus*) has served as an ecologically relevant model organism for many physiology studies, yet we lack an understanding of the ionoregulatory mechanisms used in its early life stages of this species. Furthermore, larvae of this species appear to be less euryhaline relative to adults, yet the mechanisms underlying this discrepancy have not been investigated. This study will investigate the mechanisms underlying early-life salinity tolerance of this species. We will use immunofluorescence to assess the expression of specific ionocyte transport proteins in response to environmental salinity during early-life development and further assess the expression of transporter genes. We predict that late larval developmental stages will be salinity tolerant as a function of ionocyte plasticity in response to environmental salinity, whereas salinity-susceptible individuals in early developmental stages will not exhibit plasticity nor changes in transporter expression. This research will address the long-standing question of how these organisms in early developmental stages acclimate to environmental salinities.

33. Characterizing the Structure and Post-Translational Regulation of the Alternative Oxidase (AOX) Protein of Animals, Plants, Fungi, and Protists Using a Yeast Expression System

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The alternative oxidase (AOX) in the electron transport system directly reduces oxygen to water and enables electrons to bypass complexes III and IV. AOX is important for cellular respiration and providing metabolic flexibility by modulating electron flow and reactive oxygen species (ROS) levels to mitigate oxidative stress and support redox homeostasis. AOX has a broad taxonomic distribution, but research gaps persist, such as the limited knowledge about AOX structural differences, their functional implications, and how the enzyme is post-translationally regulated across kingdoms. This study focuses on analyzing and comparing AOX protein sequences and structures in plants, animals, fungi, and protists using bioinformatics tools, and developing a yeast expression system to express AOX proteins from a variety of eukaryotic

kingdoms for further analysis. In this study, initial analysis using predictive modelling software, such as AlphaFold and SwissModel, found that all AOX proteins examined exist as a monomer. In parallel to bioinformatic analysis, AOX cDNA sequences from various organisms were synthesized and inserted into the pYES2.1 protein expression vector designed for *Saccharomyces cerevisiae*. Future work will explore the post-translational modifications of AOX proteins across these kingdoms using biochemistry and respirometry. Research on AOX will continue to deepen our understanding of cellular respiration and organism adaptation strategies. Understanding AOX structure and post-translational regulation can lead to technologies for developing stress-resistant crops, treating mitochondrial diseases, and combating fungal and protistan pathogens.

34. Acid-Base Regulatory Mechanisms in the West African Lungfish, *Protopterus annectens*: An Investigation into the Role of the Sodium Proton Exchangers (NHE)

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The lungfish possesses a primitive lung and underdeveloped gills, making use of bimodal respiration. Like other freshwater fishes they must regulate ion- and acid-base equilibrium through active ion uptake (driven by pumps and ion transporters), albeit with challenges due to possessing reduced gills. This study aimed to elucidate the role of the sodium proton exchangers (NHE), encoded by the genes *slc9a1/nhe1*, *slc9a2/nhe2* and *slc9a3/nhe3*, which we hypothesized to play a role in acid-base regulation. Pharmacologically we observed that amiloride, a sodium-transport inhibitor, and 5-(N-Ethyl-N-isopropyl)-Amiloride (EIPA), an NHE specific inhibitor, affected titratable acidity and ammonia fluxes supporting a physiological function of the NHE. Next, a PCR based approach was used to identify the paralogues in the gill and kidney. The function of NHE (and associated acid-base transporters) was assessed by challenging lungfish under acidic and basic extremes (of pH 4.0 and 9.0, respectively). After pH 9 acclimation, ammonia excretion transiently decreased and recovered. Gill *nhe3* expression was upregulated , while kidney expression was unchanged. Rhesus glycoprotein C (*rhcg*), an ammonia channel, was downregulated in the gill suggesting an alternative method to nitrogenous waste excretion. Our results suggest that *nhe3* may be functioning as an Na^+/NH_4^+ exchanger under high pH conditions. The NHEs likely do not function under the low pH conditions, and changes in expression were not observed. Research into the physiological function of the NHEs in the lungfish serves as a crucial link into understanding the evolutionary transition from the aquatic to terrestrial environment and provides insight into relatively understudied processes.

35. Investigating the contribution of the gut microbiome to thermogenesis at high altitudes.

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High-altitude environments present significant challenges for endothermic animals, as they require high metabolic rates to generate heat at low temperatures (thermogenesis) but also have reduced oxygen levels (hypoxia). High-altitude natives have adapted to these conditions by

enhancing thermogenesis in hypoxia. An underexplored contributor to thermogenesis in high-altitude taxa is the gut microbiome, the composition and function of which can be influenced by both host genetics and environment. The gut microbiome could contribute to heat production by communicating with the host's thermogenic tissues and by generating heat itself, primarily through anaerobic processes. Two series of experiments are examining this issue. First, deer mice (*Peromyscus maniculatus*) native to high and low altitudes are acclimated to warm (25°C) normoxia or cold (5°C) hypoxia (12 kPa O_2) for 6 weeks, and a subset of the latter are treated with broad spectrum antibiotics to disrupt the gut microbiome. Second, caecum contents from high and low altitude deer mice were transferred to domestic germ free mice via oral gavage. Thermogenic performance was then assessed in all mice by measuring cold induced VO_2max and cold endurance. Preliminary results thus far indicate that cold hypoxia acclimation enhances thermogenic performance in deer mice. Antibiotic treatment reduces cold endurance, with greatest effects seen in highland deer mice. Ongoing work will thus elucidate the role of the gut microbiome in thermogenesis at high altitude.

36. Unearthing the adaptive value of soil chambers built by an insect prior to winter dormancy

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Many insects construct chambers from soil prior to winter dormancy or metamorphosis. However, the adaptive value of these structures during dormancy is unclear. We used prepupae of the western bean cutworm, *Striacosta albicosta* (Lepidoptera: Noctuidae) to test three potential roles for soil chambers: that chambers confer space necessary for life stage transitions, protect against natural enemies in soil, or beneficially modify the soil microclimate. Here, we experimentally manipulated the integrity of chambers, by either manually breaching or leaving chambers intact, and measured the survival of prepupae exposed to soils that were either compacted, pathogen-inoculated, or flooded. We show that intact chambers (1) reduce mortality within soils inoculated with an entomopathogenic fungus (*Beauveria bassiana*) and (2) are necessary for prepupae to survive prolonged soil flooding. We discuss possible mechanisms by which chambers might reduce the severity of hypoxia in flooded soils.

37. A microscopic examination of the life cycle of *Tigriopus californicus*

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The marine copepod *Trigriopus californicus* has been used in science for toxicology and genetics experiments. Commercially, they are used as a nutritious food source for various animals in salt-water aquariums. As a first step towards conducting CRISPR via injection in this species, we wanted to better characterize their mating behaviors, development, and the timing of key life cycle events. Our preliminary observations suggest the following: 1) what has been previously termed an egg sac is in fact a sac containing developing embryos, not eggs; 2) once the embryo sac is evident, it detaches from the pregnant female 10-14 days later; 3) dropping of the embryo sac results in the immediate hatching of the nauplii offspring; 4) copepods prefer different locations in the water column of the cell culture container habitat depending on their life stage (e.g. nauplii prefer the bottom, pregnant females prefer the upper 25%, while mating pairs hover near the very top of the habitat. Our results suggest that injection of the embryo sac will not be

effective for CRISPR as too much cell division has already taken place. A better strategy may be injection of pregnant females prior to the formation of the sac. Our current research is therefore focusing on the timing of mating pair separation and characterizing the development of the embryo sac.

38. Functional Characterization of Tyramine Receptors in the Yellow Fever Mosquito, *Aedes aegypti*

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The adult mosquito *Aedes aegypti* is an important organism to study due to its role as a chief vector of various human arboviral diseases such as yellow fever, dengue, and Zika virus. Tyramine (TA) and octopamine (OA) are two biogenic amines that, along with their corresponding receptors, are involved in regulating several physiological and behavioural processes in insects including metabolism, reproduction, homeostasis, and smell perception. TA and OA are thought to function analogously to epinephrine and norepinephrine in vertebrates. Moreover, TA and OA receptors are targets for antiparasitic agents and insecticides. However, our understanding of the specific roles of TA and OA and their receptors in *A. aegypti* mosquitoes remains limited. While there are several predicted TA and OA receptors in the *A. aegypti* genome, it is essential to confirm the functional relevance of different receptor subtypes by confirming their ligand-specific activation. In this study, three TA receptors (TAR1-3) were successfully cloned and functionally characterized using a heterologous system. The results highlight the pronounced specificity of three distinct TA receptors for TA since comparatively, OA was orders of magnitude less active while serotonin and dopamine yielded no activity. With this new evidence, three putative TA receptors can be considered bona fide functional TA receptors in the adult mosquito, *A. aegypti*. Future research will aim to unravel the functional role of TA signaling in reproductive biology, particularly involving TAR2 which is highly enriched in *A. aegypti* ovary and thus may have broader implications in overall mosquito biology.

39. The Mitochondrial Physiology of Torpor in Ruby-Throated Hummingbirds (*Archilochus colubris*)

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Ruby-throated hummingbirds (*Archilochus colubris*) are seasonal long-distant migrants found in eastern North America. Hummingbirds have a small body size (2.5-5 g) and high surface-area-to-volume ratio, so maintaining their typical day-time body temperature (Tb) of ~40℃ is energetically costly. To survive cold nights, hummingbirds use torpor, a state of inactivity characterized by low Tb and metabolic rate (MR) that can be spontaneously reversed using endogenously produced heat. In mammalian models of hibernation and daily torpor, mitochondria have been implicated as a major site of metabolic suppression. Much less is known about mitochondrial function in avian daily torpor. The goal of my PhD is to determine how whole-animal and mitochondrial physiology change to facilitate metabolic suppression in hummingbirds experiencing daily torpor. I used flow-through respirometry to measure the metabolic rate of torpid and normothermic birds. When torpid, MR dropped by ~90%, Tb dropped to ~10℃ and the RER changed from ~1 (carbohydrate metabolism) to ~0.7 (lipid metabolism). Next, I used

high-resolution respirometry to measure respiration in isolated pectoralis mitochondria. The fuel-use shift I observed on the whole-animal level was not mirrored at the level of the mitochondria: oxidative phosphorylation (OXPHOS) was only suppressed by ~20% (complex I-supported respiration), but not when fueled with a lipid-based substrate. I also measured the activities of several rate-limiting enzymes and found no differences in metabolic flux between torpid and normothermic birds, although pyruvate dehydrogenase activity correlated with OXPHOS. These findings highlight interesting contrasts between birds and mammals and provide insight into their evolutionary paths to heterothermy.

40. Why do spring field crickets, *Gryllus veletis*, require three environmental cues to elicit a seasonal response?

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Gryllus veletis, becomes freeze tolerant when exposed to three simultaneous environmental cues: Decreasing and fluctuating temperature with decreasing photoperiod. However, we do not yet understand why these specific cues are required nor their roles in eliciting this response. Our goal is to untangle the molecular underpinnings responsible for freeze tolerance acclimation. We are exposing crickets to a full-factorial combination of decreasing, fluctuating temperature, and decreasing or constant photoperiod. Following acclimation, freeze tolerance will be tested by exposing crickets to -8°C for 90min. After 48-hours freeze tolerance will be determined by gently prodding the crickets and observing their response. Additionally, crickets from each treatment will be dissected to collect their fat body, Malpighian tubules, midgut, and hindgut for RNA sequencing. We hypothesize that the combination of environmental cues over a six-week period is required to induce a molecular response that does not arise from each cue individually. We also predict that if the removal of specific environmental cues results in the same transcriptomic expression, then the combination of environmental cues over a six-week period of acclimation triggers individual molecular responses that collectively express an induction of freeze tolerance. We have a limited understanding of how multiple environmental cues interact to produce physiological shifts. By using a mechanistic approach, we will generate additional hypothesis and questions that will explore more specific molecular pathways under varying environmental cues. Ultimately, this will serve as the framework for identifying the molecular underpinnings of freeze tolerance acclimation.

41. Naked Truths: Unveiling Microglia Activation Patterns During Hypoxia and/or Immune Stimulation in Naked Mole-Rat Brain

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Mounting an immune response is an energetically expensive process. Immune activation is primarily fueled by aerobic energy production in most mammals but hypoxia throttles aerobic metabolism, which may inhibit immune activation. Hypoxia-tolerant organisms, which often minimize energy demand in hypoxia, must therefore make trade-offs between hypometabolism and immune competency when oxygen availability is limited. Microglia are macrophages located in the brain and change shape when activated (i.e., retracted processes and a more ameboid shape) by triggers such as lipopolysaccharide (LPS, a bacterial challenge) or hypoxia in hypoxia-intolerant species. We hypothesized that the microglia of hypoxia-tolerant naked mole-rats

(NMRs) will not be activated by hypoxia or by LPS during hypoxia. To test this, we treated male NMRs with phosphate-buffered saline (sham) or LPS (1.5 mg/kg) injections in either hypoxic (11% O_2) or normoxic (21% O_2) conditions. We then sacrificed animals to evaluate microglia activation using immunohistochemistry. LPS and hypoxia exposures both induced microglia proliferation after 24h, but without an additive effect, whereas these changes were reversed at 48h. Interestingly, cell counts remained unchanged in breeding males across all groups. However, LPS combined with hypoxia led to more activated microglia with fewer and shorter projections, which were more pronounced by 48h. As such, morphological activation was still present, but proliferation did not increase. These results suggest that hypoxia activates an immune response in subordinate NMRs only but does not impair immune responsiveness to a bacterial challenge.

42. Is thermal plasticity in *Aedes aegypt*i sensitive to photoperiod?

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Environmental conditions serve as important cues for the regulation of seasonal plasticity in insects. Changes to photoperiod, the duration of darkness and daylight in a 24-hour cycle, can influence insect physiological responses, affecting their circadian rhythm and thermal plasticity. *Aedes aegypti*, a mosquito historically confined to tropical regions, has recently been found in more poleward climates, including southern Ontario, suggesting the thermal plasticity of this species may be more complex than previously believed. We have been working to characterize how different thermal environments affect adult performance in the laboratory and have confirmed adults are capable of cold acclimation under a standard tropical photoperiod of 12h:12h (light:dark). Cold acclimation reduces injury and enables survival at otherwise lethal low temperatures. To assess the impact of disrupting the mosquito internal clock, cold acclimation was attempted under an extreme photoperiod outside of their typical range (20h:4h). This photoperiod was introduced at three different life stages: during egg development, adult acclimation and at the parental generation, as mosquitos are known to be photosensitive at these life stages. Using a chill coma onset assay, we confirmed cold acclimation in all treatment groups except offspring receiving the light cue from the parental generation, suggesting a heritable factor influences this response. To investigate the possible molecular mechanisms underlying this response to the extreme photoperiod, we are now measuring expression of circadian clock genes using RT-qPCR data. This approach will help us gain a deeper understanding of the complex relationship between photoperiod cues and cold acclimation in *Ae. aegypti*.

43. Venlafaxine exposure alters mitochondrial respiration and mitomiR abundance in zebrafish brains

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Pharmaceuticals like venlafaxine (an antidepressant) are released into freshwater ecosystems from wastewater effluent and have many behavioral and metabolic effects on fish. Changes to metabolism can be regulated by epigenetic mechanisms like microRNA (small RNA molecules that regulate mRNA translation) including regulating mitochondrial mRNAs. Nuclear encoded microRNA regulates mitochondrial gene expression in mammals, and we previously demonstrated that they may play a role in silencing mitochondrial gene expression in darters, a

freshwater benthic fish. This study sought to identify if venlafaxine exposure changes mitochondrial respiration in zebrafish brains and determine if mitochondrial microRNA (mitomiRs) were differentially abundant with venlafaxine exposure. We found that in vitro exposure of zebrafish brain homogenate to below environmentally relevant concentrations of venlafaxine (< 1 µg/L) resulted in a decrease in mitochondrial respiration. To identify whether these effects also occur in vivo, zebrafish were exposed to 1 µg/L venlafaxine for 0, 1, 6, 12, 24, and 96 hours. Acutely in vivo, venlafaxine exposure had no significant effects to brain mitochondrial respiration, however select mitomiRs (*dre-miR-301a-5p*, *dre-miR-301b-3p*, and *dre-miR-301c-3p*) were also measured, as they were bioinformatically predicted to regulate mitochondrial cytochrome c oxidase subunit I (COI) abundance. These mitomiRs were differentially abundant based on exposure to venlafaxine, and with respect to sex and circadian rhythm. Overall, venlafaxine had demonstrated effects in vitro, which may have been attenuated during in vivo exposure due to the ability of the fish to mitigate effects through mechanisms including mitomiR regulation.

44. Investigating the importance of mtG3PDH in mitochondrial flexibility during environmental and physiological changes

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Maintaining cellular homeostasis is crucial to survival, and organisms must be able to adjust their physiology and metabolism to environmental and cellular constraints. Mitochondria are at the core of these adjustments, as they integrate multiple pathways and perform one of life's most important biological functions, the production of ATP via the oxidative phosphorylation process (OXPHOS). When confronted to stressful conditions such as reduced macronutrient availability and/or impairment of cellular signaling, these organelles can lose their ability to modulate substrate oxidation switching from NADH-bound to $FADH_2$-bound substrates, a process known as mitochondrial inflexibility. Recently, it was shown that feeding fruit flies (*Drosophila melanogaster*) with high-fat or high-sugar diets for prolonged periods induces mitochondrial inflexibility, characterized by complex I dysfunction which is however offset by an increased contribution of alternative mitochondrial complexes such as mitochondrial glycerol-3-phosphate dehydrogenase (mtG3PDH). As a result, mtG3PDH seems to be involved in metabolic adjustments and would therefore be a protein playing an important role in insect adaptation to environmental and cellular stress. The aim of this work is to generate D. melanogaster lines with reduced activity for mtG3PDH. Among a panel of modified lines obtained by Crispr-Cas9 method, we confirmed the reduction of mtG3PDH activity by spectrophotometry and selected multiple candidates. The lines selected will be used to study the importance of this enzyme in metabolic flexibility and inflexibility during environmental and physiological changes.

45. Effect of nutritional status and Zn on liver mitochondrial respiration and H_2O_2 metabolism in rainbow trout, *Oncorhynchus mykiss*

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Starvation is a common phenomenon in fishes under natural and aquaculture settings that may moderate effects of chemical contaminants such as metals. The key features of starvation include reduced oxidative metabolism with redirection of energy resources towards maintenance and survival. Because mitochondria comprise the cellular oxidative energy conversion hubs and target for metals, we investigated the effects of zinc (Zn) on mitochondrial respiration and reactive oxygen species (hydrogen peroxide, H_2O_2) emission following starvation and refeeding in rainbow trout (*Oncorhynchus mykiss*). Fish were maintained under three levels of feed availability: satiation feeding (control), 7-day food withdrawal (starved), and one-time satiation feeding following 7-day food withdrawal (re-fed). Liver mitochondria were isolated, and the rates of respiration and H_2O_2 emission driven by glutamate-malate (complex I, CxI) and succinate (complex II, CxII) were measured without and with Zn exposure. Starvation and Zn exposure inhibited CxI state 3 respiration rate, with refeeding and low Zn concentration partially reversing the effect of starvation. While feeding regime and Zn exposure did not alter CxI state 4 respiration rate, they reduced CxI respiratory control ratio (RCR), with the low Zn concentration partially reversing the effect of starvation. CxII state 3 and 4 respiration rates were not altered by feeding regime but were inhibited by Zn. Both starvation and Zn exposure reduced CxII RCR, with refeeding reversing the effect of starvation. The rate of H_2O_2 emission was markedly increased by starvation but was not altered by Zn exposure during glutamate-malate oxidation. In contrast, starvation/refeeding did not alter the H_2O_2 emission rate, but Zn greatly stimulated it during succinate oxidation. Overall, our study indicates that effects of nutritional status and Zn exposure on mitochondrial respiration and H_2O_2 emission depend on substrate and that refeeding and exposure to low levels of Zn may reverse the effects of starvation.

46. Effects of acclimation and developmental plasticity on thermal and hypoxia tolerance in killifish

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With climate change, coastal aquatic ecosystems are experiencing dramatic increases in the duration and frequency of warming and hypoxic events. Although thermal acclimation is known to improve thermal and hypoxia tolerance, the potential for developmental plasticity has seldom been explored. Using Atlantic killifish (*Fundulus heteroclitus*), we investigated the relative roles of developmental plasticity and acclimation on these phenotypes. Killifish (*Fundulus heteroclitus*) embryos were incubated at 26°C with a diel fluctuation of + 0, 3, 5, or 7°C from fertilization to hatch, and were then reared at a common, constant, temperature of 18°C for 1.5 years. We acclimated these fish to 26, 18, or 10°C and assessed critical thermal maximum (CTMax) and time to loss of equilibrium under hypoxia (TLOE; 2% O_2 sat). 26°C-acclimated fish were more thermally tolerant (40.2+0.06°C) but had a lower thermal safety margin (13.5+0.08°C) than 18 (36.0+0.08; 16.2+0.1°C) and 10°C (32.1+0.09°C; 19.8+0.17°C) acclimated fish. Hypoxia tolerance was also affected by acclimation temperature, with TLOE's for 26, 18, and 10°C-acclimated fish of 8.2+1.0, 104.0+7.5, and 229.7+21.7 minutes respectively. By contrast, developmental temperature treatment had little effect on these traits, except in 26°C-acclimated fish. Those that experienced 26+3°C during incubation had statistically significant higher CTMax (40.3±0.1°C) than fish incubated at 26+0 or 7°C (40.0±0.1°C), although this difference in contrast to differences between acclimation temperatures is extremely small. Similarly, there were few significant differences in hypoxia tolerance between developmental groups. These data suggest

that acclimation temperature has a stronger effect on thermal and hypoxia tolerance than does developmental temperature.

47. Exploring Sex-Specific Molecular Adaptations in Gill Tight Junctions of *Limia nigrofasciata* Across a Salinities: From Freshwater to Hypersalinity

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Poecilid teleost fishses distinguished by sexual dimorphism and physiological adaptability, serves as the focal species for this investigation into gill epithelium adaptation under varying salinity. Using Limia nigrofasciata we examined tight junction (TJ) proteins, particularly Claudin (Cldn) proteins, for sex-specific molecular responses to different saline environments. By acclimating fish to fresh (FW), salt (SW, 35‰), and hypersaline water (HSW, 58‰) for two weeks, and separating males from females with a clear partition, we assessed changes in *cldn* mRNA via quantitative PCR. The analysis was two-pronged: (1) as a collapsed data set (i.e. combined results for male and female fish) or (2) separately (i.e. male and female fish independently). The findings revealed several cldns responded to salinity shifts (e.g. upregulation of *cldn-8a*, *-10d*, *-30c*, and downregulation of *cldn-3b*). Notably, some *cldn* expressions were predominantly sex-specific, such as the *cldn-8a* increase in females. We also explored heat shock proteins (HSP) 70 and 90 to gauge stress responses to salinity. Conclusively, this research presents evidence of sex-specific differences in the molecular physiology of fish gill TJ complexes. These variations are inherent regardless of salinity levels but can be accentuated under environmental stress, underscoring the complexity of physiological adaptation in sexually dimorphic species.

48. Plasticity and Evolved Changes in Mitochondrial Physiology Across Skeletal Muscles in Deer Mice Native to High Altitude

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High-altitude is amongst the harshest terrestrial environments inhabited by animals, characterized by cold temperatures and low O_2 levels (hypoxia). Small mammals at high altitude thus face the metabolic challenge of maintaining thermogenesis to cope with cold in a hypoxic environment that can constrain mitochondrial respiration. While skeletal muscles play an essential role in both shivering and non-shivering thermogenesis, the pervasiveness of mitochondrial adjustments in high-altitude mammals remains unclear, with studies limited to a small number of muscles. We examined this issue in deer mice (*Peromyscus maniculatus*). Mice from populations native to high altitude and low altitude were born and raised in captivity, and adults were acclimated to warm (25°C) normoxia or cold (5°C) hypoxia (~12 kPa O_2 for 8-10 weeks) in a full-factorial design. Mitochondrial function was investigated in permeabilized fibers extracted from diaphragm, gluteus maximus, vastus medialis, and vastus lateralis using a comprehensive substrate titration protocol by high-resolution respirometry and fluorometry. Preliminary results suggest that acclimation to cold hypoxia increases leak respiration across muscles, which could increase mitochondrial heat generation. Mitochondrial ROS emission was lower in highlanders than in lowlanders for some muscles. Overall, this study will provide important insight into the roles of plastic and evolved changes in the function of muscle mitochondria in small mammals at high altitude.

49. Characterization of regional current densities on cardiomyocyte electrophysiological properties in Lake Sturgeon

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Understanding the coordinated processes contributing to an integrated cellular response - like an action potential - is essential for understanding the basic and applied electrophysiology of a cell in an electrically excitable tissue/organ. Cardiomyocyte electrophysiological properties in fish have been extensively studied, yet unlike in non-fish model species electrogenic cells, their spatial distribution of channels and corresponding currents have not yet been investigated. Further, general cardiomyocyte electrophysiological properties, including channel activity and current dynamics tied to cellular electrogenic events, in more classically considered 'basal' vertebrates are understudied. To address these disparities, we aim to investigate the regional distribution of numerous ionic currents along the bodies of atrial and ventricular cardiomyocytes isolated from Lake Sturgeon, *Acipenser fulvescens*. Using whole-cell patch clamp techniques, channel-specific current type, ionic current densities, and current-voltage relationships will be characterized along the lengths of cells split into three distinct regions: 0 - 25 µm, between 25 – 50 µm, and between 50 – 75+ µm of cell ends. The main ion currents (and channel-specific currents of each ion type) recorded within each cardiomyocyte zone will be Na^+ (INa), Ca^{2+} (ICa; L-type and T-type), and K^+ (IK; both delayed-rectifying and inwardly rectifying). These analyses will crucially address the question of equal versus unequal spatial distribution of cardiomyocyte channel activity (a novel and previously never determined metric in fish) and provide key comparative information on INa, ICa, and IK properties. Our analyses will additionally contribute cardiac electrophysiological information on an ancient species with clear evolutionary importance.

50. A comparison of macromolecule extraction and quantification methods in the house cricket, Gryllodes sigillatus

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Bioenergetics is an essential component linking the physiology of any organism to its ecology. Understanding the metabolism of stored energy in organisms is a fundamental aspect of bioenergetics. Organisms store energy in the form of macromolecules (carbohydrate, lipid, and protein). The metabolism of these macromolecules is crucial for growth, reproduction, and survival. Studies on fruit flies and mosquitoes show that macromolecule reserves are a key regulating factor in life-history decisions (e.g., growth, reproduction, and metamorphosis). Linking changes in macromolecule content with changes in critical life stages can provide ecologically relevant information about the impact of biotic and abiotic environmental stressors. Accurate quantification of macromolecules is a key first step in this process, and several different methods are used for macromolecule extraction and quantification. In this study, we have extracted macromolecules from the common house cricket, *Gryllodes sigillatus* using two different extraction methods and quantified each macromolecule using different methods. Each cricket was bisected longitudinally; extraction of one-half was done with Na_2SO_4 and 75% methanol and the other half was extracted in 0.1M Tris buffer. Protein was quantified using Bradford reagent and Bicinchoninic acid (BCA) assay. For glycogen, we compared the sulfuric

acid-anthrone method and the sulfuric acid-phenol method. Total lipids for both extraction methods were measured using the sulpho-phospho-vanillin method. The goal of this study is to identify a reliable, time- and cost-effective quantification method of the macromolecules in small organisms to use bioenergetics as a marker to understand the effects of environmental stressors.

51. Can aquatic acidification impair olfactory imprinting in Pacific salmonids?

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Pacific salmon (*Oncorhynchus spp.*) undergo fantastical life history events, culminating in a return from the sea to natal freshwater habitat where salmon spawn and then die. The remarkable fidelity Pacific salmon have for their natal habitat is partially driven by their ability to remember chemical cues that they detect through their sense of smell. This process is called olfactory imprinting and is hypothesized to occur during early development before juveniles migrate to the sea. Improper, incomplete, or impaired imprinting is thought to lead to salmon straying from their natal grounds to new habitats and is a phenomenon of conservation concern. While Pacific salmon stocks have been enhanced by the activities of conservation hatcheries for decades, the chemical cues in waters that salmon imprint on in hatcheries can exacerbate straying. Here, we propose that another phenomenon, aquatic acidification by carbon dioxide (CO_2), might contribute to straying by impairing olfaction during critical developmental windows when imprinting occurs. Pink salmon (*Oncorhynchus gorbuscha*) have been the subject of separate studies on imprinting and aquatic acidification, demonstrating that olfactory imprinting occurs at the yolk-sac absorption (YSA) stage, and that olfaction is also impaired by CO_2 acidification at YSA. However, there is an overall lack of understanding of molecular mechanisms underlying imprinting and whether those mechanisms are plastic to acidification. Thus, we present a preliminary investigation into a putative molecular marker of imprinting, salmon olfactory imprinting gene, across five ecologically and economically important Pacific salmon species in preparation for larger-scale studies on CO_2 acidification and olfaction.

52. The dynamic transcriptomic response of the goldfish brain under chronic hypoxia

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Oxygen is essential to fuel aerobic metabolism. Some species evolved mechanisms to tolerate periods of severe hypoxia and even anoxia in their environment. Among them, goldfish (*Carassius auratus*) are unique, in that they do not enter a comatose state under severely hypoxic conditions. There is thus significant interest in the field of comparative physiology to uncover the mechanistic basis underlying hypoxia tolerance in goldfish, with a particular focus on the brain. Taking advantage of the recently published and annotated goldfish genome, we profile the transcriptomic response of the goldfish brain under normoxic (21 kPa oxygen saturation) and, following gradual reduction, constant hypoxic conditions after 1 and 4 weeks (2.1 kPa oxygen saturation). In addition to analyzing differentially expressed protein coding genes and enriched pathways, we also profile differentially expressed microRNAs (miRs). Using in silico approaches, we identify possible miR-mRNA relationships. Differentially expressed transcripts compared to normoxia were either common to both timepoints of hypoxia exposure

(n=174 mRNAs; n=6 miRs), or exclusive to 1-week (n=441 mRNAs; n=23 miRs) or 4-week hypoxia exposure (n=491 mRNAs; n=34 miRs). Under chronic hypoxia, an increasing number of transcripts, including those of paralogous genes, was downregulated over time, suggesting a decrease in transcription. GO-terms related to the vascular system, oxidative stress, stress signaling, oxidoreductase activity, nucleotide- and intermediary metabolism, and mRNA posttranscriptional regulation were found to be enriched under chronic hypoxia. Known 'hypoxamiRs', such as *miR-210-3p/5p*, and miRs such as *miR-29b-3p* likely contribute to posttranscriptional regulation of these pathways under chronic hypoxia in the goldfish brain.

53. Unlock in progress: Physiology tools in an ecological context

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To disentangle molecular and cellular mechanisms, physiologists can rely on specific tools, designed to be mainly used on few model organisms and in very controlled conditions. However, studying how organisms can respond physiologically to environmental stressors in an ecological context (i.e. Ecophysiology), could represent a great challenge. Indeed, wild animals exhibit a huge inter-individual variability due to specific life-history trajectories, ages, sex… that could not be avoid in natural population sampling. It is also noteworthy to add that counteracting this issue by working with very large sample size is impossible, because of the invasiveness of physiological technics. This variability has therefore to be considered within data analysis, to eventually give trustful conclusion.
To answer this methodological weakness, it is now necessary to think of different manners to fill this gap by first a better use statistical tools (i.e PGLS analysis, Bayesian approach), and by the fine-tuning development of different physiological tools that could be adapted for ecological studies. For example, muscle micro biopsy technic was recently validated on small fish, allowing to study longitudinally mitochondrial function without killing animals. Moreover, a series of DIY-low-tech systems to precisely control temperature in several aquaria is currently developed in the lab to better mimic stochastic small thermal variations that could be met by fish in natural environment. This growing interest in improving techniques to perform physiological measurements in ecologically relevant conditions should allow a better understanding of how animals respond to climate changes in the wild.

54. Effects of experimental parasite infection on aerobic scope and hypoxia tolerance in freshwater sunfish

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Water temperatures in freshwater ecosystems are rising concurrent with rising atmospheric temperatures, elevating the oxygen demands of resident fishes while simultaneously reducing dissolved oxygen levels in the water. These phenomena constrain the fishes' aerobic scopes (AS) for activity and render them more susceptible to hypoxia. Compounding this challenge is the risk of parasite infection, which, although common in fishes, is projected to increase as rising temperatures enhance the metabolic and reproductive rates of many parasites and their intermediate hosts. Because parasite infection can trigger an energetically costly and time-dependent immune response in the host, this could further impact AS and hypoxia tolerance. We hypothesized that parasite infection reduces the AS and hypoxia tolerance of fishes in a time-dependent manner. To test this, we experimentally infected pumpkinseed sunfish (*Lepomis gibbosus*) with a trematode parasite (*Uvulifer sp.*) causing blackspot disease, a common infection among centrarchid fishes. Then, at five time points over 56 post-infection days, we made respirometry-based measurements of metabolism and hypoxia tolerance, namely standard and maximal metabolic rates, AS, critical oxygen tension and PO_2 of loss-of-equilibrium, as well as underlying hypoxia-related variables including plasma lactate and hematocrit. This poster will detail the results of this project and speculate on its implications.

55. The Madagascar Hissing Cockroach: A New Neuroethological Model Species

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Due to the relatively large brains of cockroaches, American (*Periplaneta americana*) and German (*Blatella germanica*) cockroaches are common invertebrate species in neuroethology research. While valuable models, these species have drawbacks: they are fast and difficult to handle, and they are major infestation risks. Madagascar hissing cockroaches (MHCs) (*Gromphadorhina portentosa*) provide many benefits over traditional cockroach models: they are large, slow, and easy to handle, they cannot fly, they live up to five years in captivity, and they are not an infestation risk. Additionally, MHCs exhibit cognitive behaviours not seen in many insects: they are semi-social and maintain a dominance hierarchy, and they communicate by their hiss. Yet, despite MHCs being charismatic insects commonly kept as pets, relatively little is known of their biology. Copious anecdotal information is available from MHC enthusiasts, but few controlled studies have been performed. To start, we explored gustatory preference using common foods of varying nutrients, separately for adult males, adult females, and late-instar (unsexed) nymphs. Considering reproductive investment needs, we hypothesized that females prefer more protein-rich foods than do males. Similarly, due to growth needs, we hypothesized that nymphs prefer more protein-rich foods than do adults. We performed two experiments. First, foods were individually placed in the colony enclosure for 24 hours. Consumption was measured (by weight), and time-lapse recordings were used to compare food interactions between adults and nymphs. Second, 24-hour consumption was measured in separate cohort cages for each food. Preliminary results will guide future studies involving carefully controlled nutritional choice-based experiments.

56. Developmental and behavioural responses of the obliquebanded leafroller (*Choristoneura rosaceana*) to heatwaves and insecticide

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Climate change-fueled heatwaves are expected to become longer, hotter, and more frequent over the next 20 years. Temperature plays a significant role in both the development and growth of insects, and could alter their susceptibility to pest control agents. We investigated how heatwaves and insecticide may interact to affect the growth, development, and foraging behaviour of the caterpillar *Choristoneura rosaceana* (Obliquebanded Leafroller, OBLR). OBLR are a common apple pest across North America (including Nova Scotia), and their impact on orchards will likely increase with climate change. Using third instar OBLR, we simulated a 5 day heatwave using temperatures expected in Kentville, NS within the next 20 years. During, or after, the heatwave, each caterpillar was placed on artificial OBLR diet. Half the food dish was covered with the insecticide DiPel, which is derived from Bacillus thuringiensis and damages the caterpillar's midgut wall. There were 4 groups per timepoint: heatwave exposure only, DiPel exposure only, exposure to both, and exposure to neither. Caterpillar location (on the food), weight, instar, and mortality were measured daily. Heatwave exposure accelerated growth and development, but this trend was absent when DiPel was applied early. Mortality was highest when DiPel exposure occurred early in the heatwave, suggesting a cost to accelerated development in younger OBLR. Regardless of treatment, there were no differences in foraging behaviour, suggesting OBLR do not actively avoid ingesting DiPel. These data could help guide the timing of pesticide use for greatest efficiency in the future.

57. A Study in Fur: Pine martens, fur trappers, and their joint future under rising temperatures in Maine

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Increasing temperatures from climate change are predicted to alter and constrain species distribution in unpredictable ways over time. For cold-adapted species, such as American martens (*Martes americana*), we have a limited understanding of what temperature ranges might have physiological impacts significant enough to affect their distribution. This project will develop a mechanistic model of martens' heat balance and exchange with their environment, integrating functional trait and microclimate data to develop a model specific to conditions in Maine. This project will also incorporate a social analysis of fur trapper perceptions and practices related to our species of interest. We will conduct semi-structured interviews and analyze the collected data through a phenomenological theoretical lens. By combining biophysical and social research, we hope to produce a more complete understanding of the ways in which increased temperatures affect American martens' physiology and distribution at the southern end of their geographic range.

58. A New Approach to Evaluating Honey Bee Learning in Free Moving Associative Learning Tasks

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Learning is an adaptive process that allows for experiential modification of behaviour. An organism's ability to learn is partially dependent on its sensory systems, neural architecture, and its evolutionary and ecological context. Studying learning capacities in a species allows for better understanding of the environmental demands placed on that species, and its potential resiliency to environmental changes. However, learning is a complex process that can be difficult to quantify. Traditionally, honey bee (*Apis mellifera*) studies quantified learning by examining cumulative performance for an entire cohort rather than individuals. This method is flawed because it assumes learning is a homogeneous process among individuals within a population. Thus, it can hide variability in learning capacity, diminishing our understanding of behavioural adaptability of a population. Psychophysics is a field dedicated to developing mathematical models for evaluating cognitive processes in humans and other species, but psychophysical methods have seldom been used with bees. Binary data present a special challenge for evaluating performance over time at the individual level. Here, we conducted colour-learning experiments to develop models of binary-choice associative learning in honey bees. Bees were trained to associate escape from a y-maze with going towards either a blue or green LED. Performance for each bee was found to follow one of four patterns: learning the correct colour, bias towards the correct colour, bias towards the incorrect colour, or no learning. For bees that learned the association, the model allowed behaviour to be quantified in terms of learning strength, learning time, and learning rate.

59. Decoding the Dance: Exploring Honey Bee Responses to Modulated Electric Fields in the Waggle Dance Recruitment Language

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Although honey bees (*Apis mellifera*) they do not possess an electroreceptive organ, per se, they are capable of detecting small antennal movements induced by changing electric fields in the immediate environment via the Johnston's organ. To investigate the role of electric fields emanating from foragers performing the waggle dance on the behaviour of nearby recruits, we developed an artificial waggle dance generator that produces electric fields mimicking those of a waggle dancing bee, including both the high-frequency (~200 Hz) modulation associated with wing beats and the low-frequency (~15 Hz) modulation associated with the waggling abdomen. Honey bee foragers were then captured for two series of experiments. First, harnessed bees were placed in front of the generator electrode, and a camera recorded antennal movement. We then compared antennal velocity between signal-on and signal-off conditions. Second, harnessed bees were placed on an air-suspended ball treadmill in front of the generator electrode to record locomotor activity. We then compared locomotion between signal-on and signal-off conditions. Preliminary results suggest activity decreases in the presence of the artificial waggle dance signal. Future directions involve installing the generator electrode on the dance floor of an observation beehive to determine if modulated electric fields affect observers' behaviour in a functioning hive. These findings contribute to our understanding of the complex interplay between electric fields and honey bee behaviour, shedding light on the mechanisms underlying communication and navigation in these important pollinators.

60. The Metropolitan Wasp: Understanding Behavioural Responses to Urbanization in Yellowjackets

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Urban environments provide unique challenges for many animals, often leading to population reduction and diversity loss. Vespid wasps (commonly known as yellowjackets), however, display a high degree of behavioural plasticity and thrive in urban environments. For this reason, they are a good system for studying behavioural adaptation to urbanization and human-wildlife conflict. Despite this, yellowjackets are usually studied only as pests and invasive species; relatively little is known of their behavioural ecology or neurobiology. In the present study, we examined changes in defensive behaviour between urban and rural yellowjacket colonies, along with the neural correlates of these changes. Colony-level aggression was measured using an automated decoy that recorded strikes after a disturbance was provoked at the nest entrance. Response duration and total number of strikes per response were compared between urban and rural colonies. Additionally, because serotonin is implicated in aggression in insects, we measured serotonin levels in the brains of individual yellowjacket specimens from each nest. Brains were sliced, immunolabelled for serotonin, and imaged on a confocal microscope. Serotonin levels in sensory and cognitive brain centres were then compared between urban and rural colonies. Here we present validation of these methods and the results of a small pilot study.

61. Examining Bitter Detection and Gustatory Preference in Honey Bees

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Honey bees (*Apis mellifera*) generally need not discern the safety of foods they collect, as their foods are “gifts” from plants. This is likely why bees have far fewer gustatory receptors compared to other insects. However, exactly which receptors bees possess and what tastants they can detect is unclear. Their genome appears to contain many gustatory pseudogenes. Specifically, it is unclear if bees possess bitter receptors, despite quinine (typically a bitter tastant) frequently being used as a gustatory punishment in bee training experiments. While bees clearly prefer sucrose over sucrose+quinine, the preference is possibly due to quinine acting as a sweet receptor antagonist rather than a bitter receptor agonist. We performed two series of gustatory preference experiments. First, we placed individual fasted bees in cages with pairs of coloured wells containing two different solutions. Bees learned to associate well colour with the preferred solution, and we measured the quantities of the solutions consumed. Second, we placed individual fasted bees in a y-maze, where they learned to associate the colour in one arm of the maze with the preferred solution. We then calculated preference scores for each bee. In both series, we tested sucrose vs sucrose+quinine, sucrose vs water, water vs quinine, and as a control, sucrose vs sucrose+NaCl. Bees demonstrated a preference for sucrose over water, quinine, and NaCl, but no preference between quinine and water. This work is part of a larger study investigating sensory systems and phytochemicals, in particular allyl isothiocyanate (the “wasabi compound”) in canola nectar.

62. Naphthenic acids contribute to oxidative stress by eliciting the emission of reactive oxygen species in mitochondria

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Oxidative stress is a major cellular mechanism of toxicity elicited by a plethora of toxicants. The mitochondrial oxidative phosphorylation pathway is a major cellular source of reactive oxygen species contributing to oxidative stress. Recent research shows that 3,5-dimethyladamantane-1-carboxylic acid, a model quaternary naphthenic acid, increased ROS emissions in isolated mitochondria. The purpose of this study was to determine if a primary carboxylic acid, the moderately hydrophobic naphthenic acid, 3,5-dimethyladamantane-1-acetic acid, would cause the hydrogen peroxide (H_2O_2) production by mitochondria in multiple bioenergetic states. It was hypothesized specific mitochondrial electron transport complexes are the site of ROS emission. Mitochondria isolated from rainbow trout (*Oncorhynchus mykiss*) liver were exposed to commercially available 3,5-dimethyladamantane-1-acetic acid. The emission of ROS during States 3 and 4 respirations was quantified using a respirometer. Subsequently, each ROS emission site in the mitochondrial complexes was isolated using inhibitors, and the ROS emission of each site was measured in multiwell plates using the AUR-HRP system. The compound 3,5-dimethyladamantane-1-acetic acid caused ROS emission in state 3 and state 4 with EC_{50} of 0.77 mM. The test compound increase ROS emission in a dose-dependent manner at all ROS production sites, OF, IF, IQ, IIF, IIIQo. However, some sites were more responsive to the production of ROS than others with IQ > IIIQo > IF > IIF > OF. Overall, the research shows that the mitochondrial H_2O_2 metabolism in rainbow trout liver is a possible source of oxidative stress in response to naphthenic acids.

63. Towards a Baseline Behavioural Survey of Juvenile Lobsters (*Homarus americanus*) in the Southern Gulf of St. Lawrence Scallop Buffer Zone

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Scallop Buffer Zones (SBZ) were created in the southern Gulf of St. Lawrence by the Department of Fisheries and Oceans to protect juvenile lobster habitat by restricting scallop dragging. As the SBZ are newly established and encompass almost all of the available juvenile habitat in the region, gathering baseline and monitoring data will be important for evidence-based management decisions for lobster populations. We conducted a pilot survey of juvenile lobster abundances and behaviours at one site in the SBZ to collect baseline behavioural data of juvenile lobsters across environmental factors of food availability, depth, and substrate. We hypothesized that juvenile lobster behaviour will change across all three factors. We recorded continuous top-down underwater video from the shallow subtidal habitat of juvenile lobster. For analysis, we determined abundances of lobsters in the videos and constructed a time budget for six broad behavioural categories. Variations in sheltering and digging behaviour were observed, corresponding with either food availability or depth (or both), as well as across substrate types. Increased sheltering on cobble is expected because lobster shelters are typically available amongst the cobble, while burrows cannot be typically constructed in unconsolidated sand.

Despite this, we found increased digging behaviour on sand, either as a futile effort at shelter construction, or more likely a foraging strategy. This pilot study will contribute to the development of the full baseline survey methods as well as later monitoring efforts to document the status of juvenile lobsters in the southern Gulf of St. Lawrence.

64. Hybridization along a salinity gradient between two species of Killifish

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A species can be defined as a group of individuals capable of reproducing with each other and producing viable, fertile offspring. Nevertheless, some species can reproduce with each other and produce viable, fertile offspring. This is the case for *Fundulus diaphanus* and *Fundulus heteroclitus*, two fish species found in New Brunswick. In 2022, a hybridization zone was identified in the Richibouctou River. Mitochondrial DNA (mtDNA) analyses revealed that all individuals sampled were of the *F. heteroclitus* type, although their phenotype was not always concordant. The 2023 results seem to confirm this finding, suggesting the presence of *F. heteroclitus* mtDNA in *F. diaphanus* populations. This suggests that New Brunswick hybrids have the ability to reproduce sexually with individuals of the parental species, and that the maternal species of the individuals is *F. heteroclitus*.

65. Preliminary Exploration of Fjord Wall and Sea Floor Epibenthic Invertebrate Communities in the Saguenay-St. Lawrence Marine Park

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The Saguenay-St. Lawrence Marine Park of Tadoussac, Quebec was the first park established in Canada for the protection of solely marine habitat. Its boundary contains highly productive waters in both fjord and estuarine environments, with well known and abundant populations of marine mammals such as the southernmost beluga whales on Earth. Invertebrate communities play an integral role in the local food web supporting these populations. The diversity, abundance, and distribution of epibenthic invertebrate communities along the 80km long Saguenay Fjord was largely unknown. In Fall 2023 as part of a wider research initiative and with the support of the marine park and the Trebek Initiative, a combination of underwater ROV and drop camera quadrats were used to begin to address this research gap. Seven randomized vertical fjord wall surveys were conducted with an ROV to a depth of 100 metres. Survey video and photographs were collected at pre-identified depth intervals along with accomanying CTD data. A 50 cm² drop camera quadrat was dropped at 45 randomized locations along the fjord floor. Extensive and diverse populations of invertebrates were observed. Preliminary results indicate that the walls of the fjord are critical habitats for local epibenthic invertebrate populations when compared against the fjord floor, and observed species diversity and abundance decreased further upstream in the fjord. Further data analysis and collection is needed to understand the state and composition of invertebrate communities within the Saguenay-St. Lawrence Marine Park.

66. Quantifying post-larval American lobster (*Homarus americanus*) benthic recruitment in relation to depth and temperature in southwest Bay of Fundy

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Benthic recruitment of American lobster, which provides an index of future fisheries recruitment, has historically been monitored in shallow waters (5-15m) due to an assumed avoidance of colder (i.e. deeper) waters by settling post-larvae. However, climate-driven warming and strong tidal mixing could be expanding the depth and total area of seafloor over which lobster post-larvae are recruiting in the Bay of Fundy. The main objective of this study is to test this hypothesis. Bio-collectors will be deployed in 2024 to quantify temperature and benthic recruitment of lobster between 5-95m within three study regions in southwest Bay of Fundy. Although we expect greater recruitment in shallow waters, we predict benthic recruitment to occur at greater depths than historically monitored. Furthermore, using bathymetric maps and our recruitment at depth data, we will estimate the proportion of benthic recruitment that occurred at different depths in our study domain. We will also explore the relationship between recruitment density and temperature over different time periods in our study year and will create a model that can hopefully be used to hindcast changes in the extent of suitable habitat for lobster based on historical records of water temperature. Quantifying American lobster post-larval benthic recruitment at depths greater than historically sampled in a region where climate change is changing habitat suitability is crucial in understanding how fisheries recruitment may be affected down the line.

67. Fish master: Foraging behaviour of northern gannets (*Morus bassanus*) feeding on five main prey species in the Gulf of St. Lawrence

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Northern gannets (*Morus bassanus*) are piscivorous predators that feed on a wide range of prey species and sizes. Notably, gannets from the colony at Parc national de l'Île-Bonaventure-et-du-Rocher-Percé (Québec, Canada) typically consume five pelagic fish species during the breeding season: Atlantic mackerel (*Scomber scombrus*), capelin (*Mallotus villosus*), sand lance (*Ammodytes sp.*), Atlantic herring (*Clupea harengus*) and rockfish (*Sebastes sp.*). Their broad diet implicates gannets' flexible foraging behaviour regarding search and capture techniques for prey. Indeed, studies have shown that gannets utilize a variety of diving strategies to capture prey of different sizes, including variation in terms of dive shape, depth reached and duration. Another peculiar feature of their foraging habits is that gannets regurgitate food to their chicks or when they are slightly disturbed by researchers. In this study, we used the fact that birds handled upon their return from a foraging trip were regurgitating the last prey captured. Our primary goal is to characterise the foraging behavior of adult northern gannets in the Gulf of St. Lawrence during the breeding season, focusing on the five main pelagic fish species they consume. Using GPS and diving loggers deployed from 2020 to 2023, we aim to identify key elements of travel, diving, and resting throughout foraging trips where the bird regurgitated a single prey species upon returning to the colony. Furthermore, we aim to quantify and compare the profitability, in

terms of energy gained per unit of foraging time, of the five main prey species. Here, we present our preliminary findings.

68. A New Invasive Exotic Slug in Québec: *Arion vulgaris*

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Species monitoring is required to quickly identify new introductions. Early detection of invasive exotic species generally increases the success of control methods, thus limiting the species impacts. However, cryptic species, which are by definition hard to identify, require additional identification work and can remain undetected for years. This is the case of the exotic slugs of the genus Arion, known for their significant ecological and economic impacts worldwide. Despite the challenges associated with their identification (e.g. externally similar species or hybridizations), it is essential to know their identity as different slug species have their own invasion specificities. Here we present the first record of the European slug *Arion vulgaris* in Québec, a slug classified among the 100 most invasive species in Europe. A combination of genital apparatus morphological analyses and 16SrDNA gene sequencing were used to confirm the identity of the species. As this species has a high invasive potential, it should be carefully monitored in Québec to limit its spread and evaluate its impacts.

69. The effect of turbidity on nasal and olfactory epithelia in the Redside Dace

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Anthropogenic activities and natural disasters increased water turbidity and endanger aquatic species. In fish, turbidity damages gills impairs vision, alters ventilation, disrupts reproduction, impacts growth, hampers movement and elevates mortality. Turbidity may also impact olfactory sensory neurons and other nasal cells, including crypt cells which are associated with chemosensation for predator/prey interactions, reproduction, and migration. This study investigated the effect of water turbidity on the olfactory rosette of Redside dace, a species challenged due to urbanization-induced effects. Bentonite clay was added to increase water turbidity and olfactory sensory neurons in the nasal cavity were examined. Immunohistochemistry was utilized to label olfactory crypt cells with anti-S100 protein, microvillous olfactory sensory neurons with anti-calretinin and anti-acetylated tubulin to label ciliated olfactory sensory neurons. Exposure to bentonite was followed by an increased crypt cell abundance in the nasal epithelium, but not in the olfactory epithelium. Variations were observed in calretinin-immuno-labeled microvillous cells, with some rosette regions not labelling in bentonite-treated samples. This study highlights the sensitivity of Redside dace to environmental changes, particularly to water turbidity. These implications for the olfactory system may impact the survival and reproduction of this species. Understanding these impacts is crucial for conserving and managing Redside dace populations in their natural habitat and emphasizes the broader importance of environmental factors in shaping fish physiology and ecology

70. HemaP injection may rescue feeding motivation in the parasitized caterpillar *Manduca sexta*

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The parasitic wasp *Cotesia congregata* employs a multifaceted approach to manipulate the brain and behavior of its caterpillar host, *Manduca sexta*. The wasp injects her eggs, along with venom and a virus, into the caterpillar. During wasp larval development there are no changes in host behaviour. However, once the wasps emerge from their hosts, the hosts lose self-generated behaviors such as feeding and locomotion, while retaining defensive responses, effectively acting as bodyguards for the developing wasp cocoons. Proteomic and peptidomic analysis of host hemolymph has revealed profound changes, including a reduction in the peptide HemaP. The elevation of HemaP increases feeding motivation and foraging behaviour in healthy caterpillars of other species. We attempted to rescue feeding behaviour by injecting HemaP into parasitized caterpillars. Preliminary data suggests that both movement and feeding increase following HemaP injection. This study suggests that one method wasps may use to suppress host feeding is by preventing the release of a key feeding neuropeptide – HemaP.

71. Are Lungworms Emerging in Prince Edward Island Coyotes?

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Crenosoma vulpis, *Capillaria aerophila*, and *Angiostrongylus vasorum* are metastrongyloid nematodes of domestic and wild canids. *Crenosoma vulpis* and *C. aerophila* reside in the trachea and bronchi, and *A. vasorum* is found within the pulmonary arteries and right ventricle. All three lungworms can cause dyspnea and respiratory issues in infected hosts. *Crenosoma vulpis* and *C. aerophila* are common in canids worldwide, while *A. vasorum* is prevalent throughout Europe, Newfoundland, and recently was detected in PEI foxes for the first time. The aim of this study is to determine the prevalence of *A. vasorum*, *C. vulpis*, and *C. aerophila* in the coyote population of PEI. Coyotes were hunted or trapped for other purposes and their carcasses made available for this study. So far, 16 coyote lungs and hearts collected between 2020 and 2024 were dissected to recover lungworms. Parasites were identified, sexed, and counted. For coyotes collected in winter 2020-2021, the *A. vasorum* prevalence was 12.5% (1/8), the *C. vulpis* prevalence 62.5% (5/8), and the *C. aerophila* prevalence 12.5% (1/8). Comparatively, in coyotes collected in winter 2023-2024, the prevalence was 62.5% for *A. vasorum* (5/8), 25% for *C. vulpis* (2/8), and 12.5% for *C. aerophila* (1/8). This is the first study to report the presence of *A. vasorum* in PEI coyotes. Our preliminary results suggest an increasing *A. vasorum* prevalence and a decreasing *C. vulpis* prevalence over a three-year period, while the *C. aerophila* prevalence remained stable. Research is ongoing and further samples will be analyzed.

72. Isolation and identification of Clonostachys rosea (*Ascomycota: Hypocreales*) from deceased ticks, revealing a novel natural tick pathogen

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The American dog tick (*Dermacentor variabilis*) and the black-legged tick (*Ixodes scapularis*) are vectors of pathogens that cause harmful diseases to humans and animals. Entomopathogenic fungi can replace the use of chemical acaricides for tick management, reducing risks to the environment, and human and animal health. We identified a fungus in wild ticks collected in Coldbrook, NS, Canada that could be used as a biocontrol agent against them. Carcasses of *D. variabilis* ticks with visual evidence of infection were suspended in sterile water containing 0.05% (v/v) Tween 80 to collect spores and mycelium fragments. The suspension was plated on PDA and incubated at 25±1 °C and 12 h:12 h [L:D] photoperiod for 10 days. For molecular identification, the ITS region of ribosomal DNA was targeted for PCR amplification. Lab-reared *D. variabilis* and I. scapularis unfed females were sprayed with 1 x 108 conidia/mL and monitored for mortality over 15 days. The fungus species *Clonostachys rosea* (Ascomycota: Hypocreales) was identified through molecular characterization, with a 100% GenBank match. After 72h of treatment with the conidial suspension, fungal growth was observed on the tick cuticle, mainly on the anal plate, joints, and hypostome. *D. variabilis* showed more fungal colonization than *I. scapularis*. The concentration of spores applied on ticks exerted acaricidal activity on *D. variabilis*, causing 80% mortality after 10 days, while 20% of infected I. scapularis died after being exposed to the fungus. These preliminary results indicate that *C. rosea* has potential entomopathogenic activity against ticks, particularly towards American dog ticks.

73. Modulation of Immune-inflammatory Responses in the Intestine of Atlantic Salmon Upon Sea Lice Infestation

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The salmon louse, *Lepeophtheirus salmonis*, is an ectoparasitic crustacean that has threatened the sustainability of salmonid mariculture. In this study, the effects of sea lice infestation on gene expression responses in the intestine of Atlantic salmon were studied using real-time quantitative PCR. Atlantic salmon (120 g) were distributed into two tanks (control and lice) prior to exposure to sea lice. Fish in the first tank (control group) were not exposed to sea lice, whereas fish in the second tank (lice-infected group) were infected with copepodids of L. salmonis (50-100 infectious copepodids/fish). The water temperature was maintained at 10 (±2) °C in both tanks before and after the challenge. Sea lice counting occurred 240-degree days postinfestation at which point the lice had reached the pre-adult stage. The posterior intestine samples were collected from 25 fish per group for further processing and gene expression analyses. Based on the results, the expression of several genes involved in immune responses/inflammation (*CD8*, *IFN-α*, *IFN-γ*, *IL-4/13a*, *IL-6*, *IL-8*, *IL-12*, *IL-17*, *SAA*, *TLR-9*) and cell growth (*TGF-β*) were significantly down-regulated in the intestine of fish infected with sea lice. In contrast, the expression of matrix metalloproteinase-9 (*mmp9*), which plays a key role in the remodeling and destruction of extracellular matrix (ECM), significantly increased in lice-infected fish. The transcription levels of

other genes examined (*CATH1b*, *CATH2*, *COX-2*, *GAL9*, *IL-1β*, *IL-10*, *MHC-II*, *SOD2*, *TRIM25* and *TRX*) were not remarkably altered postinfection with sea lice. Our findings are similar to those found in the other mucosal surfaces affected by lice infection such as the skin and suggest that infection with sea lice results in reduced inflammation and disturbed anti-viral responses both systemically and in multiple mucosal tissues, which may impact the integrity and immune protection of these mucosal surfaces to other infections. Further studies are required to investigate whether infection with lice may lead to the imbalance of microbial community in the intestine of Atlantic salmon.