

# CV: Dr Marwa Mamdouh Tawfik

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**About me:** I recently completed my PhD studies in the molecular basis of nutritional programming within the Scottish Fish Immunology Research Centre under the supervision of Profs Sam Martin and Alex Douglas. My PhD focused on investigating both microbiome and transcriptome mechanisms of nutritional programming of carnivorous fish (Atlantic salmon) using plant-based diets during first feeding. I was funded by the prestigious Newton scholarship and my PhD project namely [NUTRIPROG](#), was funded by BBSRC; a collaborative project between the Universities of Stirling and Aberdeen, working together with BioMar, Norway as industrial partner. I am also an associate teaching fellow of [AdvanceHE](#), UK. I am very keen to pursue a career in -omics research to depict the gut microbiome and metabolome after feeding different diets.

## EDUCATION AND TRAINING

2019 - 2023 Aberdeen, Scotland, United Kingdom

PhD in Zoology ([Nutrigenomics](#)), University of Aberdeen, UK

**Title:** Impact of early nutritional programming strategy on gut microbiome and transcriptome of Atlantic salmon (*Salmo salar*).

2014 - 2017 Giza, Giza Governorate, Egypt

Master's degree (by research) in Veterinary Medical Sciences, Cairo University, Egypt

**Title:** Evaluation of nano zinc oxide feed additive on tilapia growth and immunity.

2015 - 2017 Beni-Suef city, Beni Suef Governorate, Egypt

Postgraduate Diploma (by research) in Material Science and Nanotechnology, Beni-

Suef University, Egypt

**Title:** Facile synthesis of osage-orange like TiO<sub>2</sub> mesospheres using titanate nanotubes.

2005 - 2010 Zagazig city, Sharkia Governorate, Egypt

Bachelor's degree in Veterinary Medical Sciences, Zagazig University, Egypt

## WORK EXPERIENCE

04/2024 - present La Jolla, CA, USA

Visiting Scholar, University of California, San Diego, USA

**PI:** Prof. Pieter C Dorrestein

**Overview:** I am currently involved in several multi-omics aquatic projects leading and/or helping in data analysis of metabolomics big datasets in collaboration with Prof. [Bolnick's Lab](#) at University of Connecticut, Scripps Institution of Oceanography ([SIO](#)) at UCSD and with different industrial partners mainly Ocean Era, [KRuMBS project](#).

10/2024 - 03/2024 Stirling, Scotland, UK

Visiting Researcher, Institute of Aquaculture, University of Stirling, UK

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**PIs:** Prof. (Associate) Mónica Betancor, Prof. Trevor Telfer

**Overview:** I was involved in nutrition ([NOSIFISH](#)) and aquatic toxicology projects at the University of Stirling where I helped in transcriptome data analysis. We are currently preparing manuscripts.

05/2023 - 08/2023 Storrs, CT, USA

Visiting Researcher, Department of Ecology & Evolutionary Biology, University of

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Connecticut

**PI:** Prof. Daniel I. Bolnick

**Overview:** We collaborated on microbiome and transcriptome work in salmon and stickleback. I got some training in the co-expression network analysis in addition to organoid cell culture on the ongoing [gut-on-chip project](#) in stickleback.

2019 - 2023 Aberdeen, Scotland, UK

Newton-funded PhD Scholar, Scottish Fish Immunology Research Centre,

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University of Aberdeen

**Supervisors:** Profs. Sam Martin and Alex Douglas

**PhD title:** Impact of early nutritional programming strategy on gut microbiome and transcriptome of Atlantic salmon (*Salmo salar*).

**Fund:** Newton fund and BBSRC.

**Overview:** My PhD thesis focused on nutritional programming (NP) in Atlantic salmon to program fish (nutritionally and immunologically) from early-stage (first feeding) on a plant-based diet while maintaining the fish performance. Mechanisms behind NP were investigated via gut microbiome and transcriptome. I was mainly involved in a feeding trial as part of a BBSRC-funded [NUTRIPROG](#) project in collaboration with the Institute of Aquaculture, University of Stirling, Scotland, UK, in addition to BioMar, Norway as industrial partner. I examined both the intestinal microbiome using 16S amplicon sequencing and the transcriptome using RNA-seq in a 22-week feeding trial. perMANOVA general effects revealed gut microbiota dissimilarity by fish group and time points. However, no interaction effect of groups and time points was demonstrated, suggesting a sustained impact during NP. At 2 weeks post-first feeding on nutritional stimuli, enriched pathways include epigenetic adaptation and lipid metabolism in the programmed fish. After the challenge at 22 weeks post-first feeding, the middle intestine showed lipid and energy metabolism in programmed fish whilst the middle intestine showed enrichment of acute adaptive immune response in the nonprogrammed fish. The distal intestine showed an enrichment of immune response that potentially suggests immune tolerance in programmed fish. Conversely, the distal intestine in nonprogrammed fish, revealed upregulation of lipid metabolic pathways, and tissue degeneration/apoptosis. The gut transcriptome is changed during NP with genes involved with both immune function and different metabolic processes being altered. This project shows microbial and transcriptional differences suggesting a programming response, although the mechanism of this response still requires more investigation. For this analysis I gained many bioinformatic and statistical skills and generated a pipeline to run my analysis using bash on HPC, bioconda (Ubuntu), and R. I was also a member of University and College Union (UCU) and the Health, Safety, and Wellbeing Committee (student rep). I was a teaching assistant for fish biology and biostatistics/bioinformatics courses).

2017 - 2019 Giza, Giza Governorate, Egypt

Assistant Researcher, National Research Centre (NRC)

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**Supervisors:** Profs. Iman M. K. Abumourad and Taghreed B. Ibrahim

**Project title:** Evaluation of greenly synthesized nano selenium feed additive on tilapia growth, immunity and DNA degradation.

**Funded by:** NRC and Faculty of Postgraduate Studies of Advanced Sciences

**Overview:** As a visiting researcher at Beni-Suef University, I was responsible for the green synthesis of Selenium nanoparticles to enhance the immunity of fish. During this project, I fed Tilapia (*Oreochromis niloticus*) with novel selenium nano-mineral and investigated growth performance, immune gene expression, and DNA degradation (COMET assay) in response to nano-selenium compared to conventional selenium source. I was involved in the practical demonstration of nanomaterials synthesis and fabrication at the Faculty of Postgraduate Studies of Advanced Sciences (PSAS), Beni-Suef University for graduate students. I was invited as a trainer in the "Molecular Biology and Biotechnology" summer course for Faculty of Science (Biology Minor) students. Seminars on "Molecular Biology and Nano-Biotechnology" at the Veterinary Research Institute, National Research Centre were delivered.

02/2016 - 10/2019 Giza, Giza Governorate, Egypt

Assistant Lab Manager, National Research Centre

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**Line manager:** Prof. Mona S. Mahmoud

**Overview:** I was in charge of managing different equipment and reporting directly to the institute Head. I helped with scheduling the time for researchers to carry on their experiments in the lab, arranging instrument company specialists' visits for technical training, and ensuring the maintenance of equipment. I helped in training on DNA isolation, RNA Extraction, cDNA Synthesis, qPCR, Thermocycler, UV Transilluminator, Nanodrop Spectrophotometry, and UV-Vis Spectrophotometry, for Postdoctoral, PhD, and Master students.

12/2014 - 06/2017 Giza, Giza Governorate, Egypt

Researcher Assistant, National Research Centre

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**Supervisors:** Profs. Wafaa Tawfik Abbas and Iman M. K. Abumourad

**Masters title:** Evaluation of nano zinc oxide feed additive on tilapia growth and immunity.

**Funded by:** National Research Centre

**Overview:** My master's thesis is focused on learning how to synthesize Zinc oxide nanomineral to evaluate its impacts on growth performance and immune response in Nile Tilapia and responsible for taking care of the fish throughout the experiment. Wet lab skillset included RNA isolation, cDNA synthesis, probe and primer design, and qPCR.

02/2012 - 12/2014 Giza, Giza Governorate, Egypt

Veterinary Lab Technician, National Research Centre

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**Line manager:** Prof. Iman M. K. Abumourad

**Overview:** I was entitled to take care of the aquarium fish and run periodic health checks for different experiments in addition to maintaining good records/data. I was involved in sampling from different fish farms in Egyptian governorates (mainly Fayoum and Beheira).

## PUBLICATIONS

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1. **Tawfik, Marwa Mamdouh**, et al. "Modulation of gut microbiota composition and predicted metabolic capacity after nutritional programming with a plant-rich diet in Atlantic salmon (*Salmo salar*): insights across developmental stages." *Animal Microbiome* 6.1 (2024): 38. [10.1186/s42523-024-00321-8](https://doi.org/10.1186/s42523-024-00321-8)
2. **Tawfik, Marwa Mamdouh**, et al. "Modulation of metabolic and immunoregulatory pathways in the gut transcriptome of Atlantic salmon (*Salmo salar* L.) after early nutritional programming during first feeding with plant-based diet." *Frontiers in Immunology* 15 (2024): 1412821. [10.3389/fimmu.2024.1412821](https://doi.org/10.3389/fimmu.2024.1412821)
3. McMillan, Stuart, et al. "Can nutritional programming in Atlantic salmon (*Salmo salar*) be optimised with a reduced stimulus period?" *Aquaculture* 585 (2024): 740686. [10.1016/j.aquaculture.2024.740686](https://doi.org/10.1016/j.aquaculture.2024.740686)
4. **Tawfik, Marwa Mamdouh**, et al. "The impact of nutritional programming on

the microbiota of different gut regions in Atlantic Salmon (*Salmo salar*) from first feeding in a 22-week feeding trial." (2024). Preprint: [10.21203/rs.3.rs-4243329/v1](https://doi.org/10.21203/rs.3.rs-4243329/v1)

5. **Tawfik, Marwa**. "Impact of Early Nutritional Programming Strategy on Gut Microbiome and Transcriptome of Atlantic Salmon (*Salmo salar*)". (2023). University of Aberdeen, [PhD dissertation](#).
6. Zaki, A. H., et al. "Morphology transformation from titanate nanotubes to TiO<sub>2</sub> microspheres." *Materials Science in Semiconductor Processing* 75 (2018): 10-17. [10.1016/j.mssp.2017.09.030](https://doi.org/10.1016/j.mssp.2017.09.030)
7. **Tawfik, M.**, et al. "Evaluation of nano zinc oxide feed additive on tilapia growth and immunity." *15th international conference on environmental science and technology, Rhodes, Greece*. Vol. 1342. No. 1. 2017.

## ORAL OR POSTER PRESENTATIONS

1. **Marwa Mamdouh Tawfik**, Mónica B. Betancor, Stuart McMillan, Alex Douglas and Samuel A. M. Martin. Impact of early nutritional stimulus for 3 weeks on the intestinal microbiome of Atlantic Salmon (*Salmo salar*) in a year-long feeding trial, University of California (UCSD), La Jolla, CA, USA, June 17<sup>th</sup>, 2024.
2. **Marwa Mamdouh Tawfik**, Wesley J. Sparagon, Emily C. Gentry, Jeremiah J. Minich, Lisa Vollbrecht, Lieve M. L. Laurens, Eric E. Allen, Neil A. Sims, Pieter C. Dorrestein, Linda Wegley Kelly, and Craig E. Nelson. Multi-omic analyses of gut sections microbiota and metabolome of Kyphosus fish species fed different seaweeds, UCSD, La Jolla, CA, USA, April 15<sup>th</sup>, 2024.
3. **Marwa Mamdouh Tawfik**, Mónica B. Betancor, Stuart McMillan, Alex Douglas and Samuel A. M. Martin. Impact of nutritional programming on the intestinal transcriptome of Atlantic Salmon (*Salmo salar*), ICISB 2024, Seattle, WA, USA, March 11-14<sup>th</sup>, 2024.
4. **Marwa Mamdouh Tawfik**, Marlene Lorgen-Ritchie, Elżbieta Król, Stuart McMillan, Fernando Norambuena, Daniel I. Bolnick, Alex Douglas, Douglas R Tocher, Mónica B. Betancor, Samuel A. M. Martin. The impact of nutritional programming on the gut microbiome and transcriptome in Atlantic Salmon (*Salmo Salar*), NoWPaS, Inverness, UK, February 26<sup>th</sup> - March 1<sup>st</sup>, 2024.
5. **Marwa Mamdouh Tawfik**, Marlene Lorgen-Ritchie, Elżbieta Król, Stuart McMillan, Fernando Norambuena, Daniel I. Bolnick, Alex Douglas, Douglas R Tocher, Mónica B. Betancor, Samuel A. M. Martin., Marlene Lorgen-Ritchie, Elżbieta Król, Stuart McMillan, Fernando Norambuena, Daniel I. Bolnick, Alex Douglas, Douglas R Tocher, Mónica B. Betancor, Samuel A. M. Martin. Impact of early nutritional programming strategy on gut microbiome and transcriptome of Atlantic salmon (*Salmo salar*), School of Biological Sciences, University of Aberdeen, UK, February 9<sup>th</sup>, 2024.
6. Invited: **Marwa Mamdouh Tawfik**, Mónica B. Betancor, Stuart McMillan, Alex Douglas and Samuel A. M. Martin. Impact of nutritional programming on the gut transcriptome of Atlantic salmon analysed by a user-friendly RNA-seq toolkit, Science Teaching Hub, University of Aberdeen, UK, December 6<sup>th</sup>, 2024.
7. **Marwa Mamdouh Tawfik**, Marlene Lorgen-Ritchie, Elżbieta Król, Stuart McMillan, Fernando Norambuena, Daniel I. Bolnick, Alex Douglas, Douglas R Tocher, Mónica B. Betancor, Samuel A. M. Martin. Gut microbiota in Atlantic salmon after nutritional programming with a vegetable-based diet across developmental stages and intestinal regions. Bolnick's Lab, Ecology and Evolutionary Biology Department, University of Connecticut, Storrs, CT, USA, May 2, 2023.
8. **Marwa Mamdouh Tawfik**, Marlene Lorgen-Ritchie, Monica Betancor, Stuart McMillan, Elżbieta Król, Alex Douglas, and Samuel A. M. Martin. Gut transcriptome in Atlantic salmon (*Salmo salar*) after nutritional programming with a plant-rich diet, 4<sup>th</sup> International Conference of Fish & Shellfish Immunology conference (ISFSI), Bodø, Norway, December 12-15, 2022.
9. **Mamdouh Tawfik, M. M.**, Lorgen-Ritchie, M., Betancor, M., McMillan, S., Król, E., Douglas, S. A. M. and Martin, S. A. M. Differentially expressed genes and enriched pathways after nutritional programming in Atlantic salmon (*Salmo salar*L.) with plant-rich diet, Fish Nutrition Workshop, Wageningen University and Research, Wageningen, Netherlands, October 17-20, 2022.
10. Invited: **Mamdouh Tawfik, M. M.**, Lorgen-Ritchie, M., Betancor, M., McMillan, S., Król,

- E., Douglas, A., and Martin, S. A. M. Gut microbiota in Atlantic salmon after nutritional programming with a vegetable-based diet, Mucosal Health in Aquaculture 2022 conference (MHA2022), Madrid, Spain, October 3-6, 2022.
11. **Mamdouh Tawfik, M. M.**, Lorgen-Ritchie, M., Betancor, M., McMillan, S., Król, E., Douglas, A., and Martin, S. A. M. Differences between intestinal regions in microbial profiles of Atlantic salmon parr (*Salmo salar* L.), Mucosal Health in Aquaculture 2022 conference (MHA2022), Madrid, Spain, October 3-6, 2022.
  12. **Marwa Mamdouh Tawfik**, Marlene Lorgen-Ritchie, Monica Betancor, Stuart McMillan, Elżbieta Król, Alex Douglas, and Samuel A. M. Martin. Gut microbiota in Atlantic salmon after nutritional programming with a vegetable-based diet, Aquaculture Europe 2022 Conference, European Aquaculture Society (EAS), Rimini, Italy, September 27 - 30, 2022.
  13. **Marwa Mamdouh Tawfik**, Marlene Lorgen-Ritchie, Monica Betancor, Stuart McMillan, Elżbieta Król, Alex Douglas, and Samuel A. M. Martin. Characterization of microbial profile of marine-based diet fed Atlantic salmon at first feeding: does plant-based diet cause dysbiosis at this critical period?, 4th European Association of Fish Pathologists (EAFP) UK and Ireland branch meeting, Centre for Environment, Fisheries and Aquaculture Science (Cefas), Weymouth, Dorset, UK, September 14 - 15, 2022.
  14. **Marwa Mamdouh Tawfik**, Marlene Lorgen-Ritchie, Monica Betancor, Stuart McMillan, Elżbieta Król, Alex Douglas, and Samuel A. M. Martin. Gut microbiota in Atlantic salmon (*Salmo salar*) at different developmental stages, Aquaculture Canada and World Aquaculture Society (WAS) North America 2022 conference, St Johns, Newfoundland, Canada, August 15-18, 2022.
  15. **Tawfik, M.**, Douglas, A., Tocher, D.R. & Martin, S.A.M. Evaluation of early nutritional programming effect on fish performance, intestinal transcriptome and microbiome in Atlantic salmon fry (*Salmo salar*), 20th (Zebra)Fish Immunology/Vaccination Workshop, Wageningen University and Research, Wageningen, Netherlands, April 28 - May 2, 2019.
  16. Invited: **Marwa M. Tawfik**. Cell Cycle Lecture, Nano-Biotechnology Course, Faculty of Postgraduate Studies of Advanced Sciences (PSAS), Beni-Suef University, spring semester, 2017.
  17. Invited: **Marwa M. Tawfik**. Molecular Biology & Gene Therapy Lecture, Biomedical Applications of Nanomaterials Course, Faculty of Postgraduate Studies of Advanced Sciences, Beni-Suef University, fall semester, 2015.

#### Other conferences and networking events:

- UCR Post-ASMS Symposium 2024, University of California, Riverside (UCR), Riverside, CA, June 7, 2024.
- Aquaculture UK, Aviemore, Scotland, UK, May 3-5, 2022.
- A3 Scotland, a conference for the Animal Health, Agritech, and Aquaculture (AAA) sectors, Edinburgh & Highlands, Scotland, UK, April 25-29, 2022.
- The 4th Annual Bioinformatics Networking Event, online, Cranfield University, England, UK, June 17, 2021.
- European Aquaculture 2020 (EAS), Virtual Meeting, April 12-15, 2021.
- 4th International Conference on Integrative Salmonid Biology, Edinburgh, Scotland, UK, November 17- 20, 2019.
- 2nd Egyptian Bioinformatics Workshop, Nile University, Egypt, December 26, 2017.
- BioKMT Masterclass in "OMICS and Bioinformatics", Academy of Scientific Research and Technology (ASRT), Egypt, December 23, 2017
- Development of Animal Wealth: Challenges and Solutions, National Research Centre, Cairo, Egypt, December 5-7, 2017.
- Applications of Proteomics in Animal Sciences and Dairy Food Workshop, NRC, Egypt, December 13, 2017.
- The Fourth International Conference on Advanced Sciences (ICAS4), Hurghada, Egypt, November 7-10, 2017.
- International Conference of Nanotechnology, Biotechnology, and Spectroscopy by Naqaa Foundation for Research and Nanotech Network (NNN), Cairo, Egypt, March 27-29, 2015.
- 4<sup>th</sup> International Workshop & Conference: Nanomaterial and Nanodevices, National Research Centre, December 8-9, 2014.

- BioVisionAlexandria 2014 Conference, Bibliotheca Alexandria, April 7-9, 2014, Alexandria, Egypt
- Transfer of Biomaterials' Knowledge into Technology by Egyptian Society for Science & Technology of Biomaterials (ESSTB), NRC, March 1-2, 2015.
- Common Aquaculture Systems in Egypt Course, The Fish Research Unit and Fish Diseases & Management Department, Faculty of Veterinary Medicine, Zagazig University, April 22, 2014.
- Practical Pharmaceutical Nanotechnology Workshop, Faculty of Pharmacy, Cairo University, April 28, 2012.
- Applications of Nanotechnology Science in Medicine Workshop, Animal Health Research Institute and Material Science Lab, Physics Department, Faculty of Science, Cairo University, March 4-8, 2012.

## HONOURS AND AWARDS

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### Academic awards/grants

- Shortlisted in the 4 semifinals for the best presentation award (the committee selected 3 out of the 4), ICISB, Seattle, WA, 2024.
- Fully funded award to present my work at NoWPaS, Scotland, 2024.
- Turing Scheme Fund (£2,897.5) - to visit the University of Connecticut, Storrs, CT, USA, 2023.
- Santander Mobility Award (£1000), to visit the US (award not utilized), 2023.
- 3-month internship (January-March 2023), Matis Aquaculture Research Station (MARS), Iceland (not utilized), 2023.
- "The most active participant award", Fish Nutrition Workshop, Wageningen University and Research, Wageningen, Netherlands, October 17-20, 2022.
- Sustainable Aquaculture Innovation Centre (SAIC) travel award (£800) - conference award, 2022.
- Charles Sutherland Scholarship fund (£1150) - conference award, 2022.
- Abdo Samy travel grant (emonovo co-founder) (\$500) - conference award, 2022.
- Biotechnology and Biological Sciences Research Council (BBSRC) PhD monthly stipend at BBSRC rate for 2 months, 2021.
- "Second best poster presentation", 20 (Zebra)Fish Immunology/ Vaccination Workshop, Wageningen University and Research, Wageningen, Netherlands, April 28 - May 2, 2019.
- Fully funded course "Genomic Data Science Specialization", Coursera, online, 2019.
- Newton-Mosharafa PhD Programme Scholarship, Fully Funded PhD in the UK for 2019 intake, 2018.
- 6-month Erasmus+ visiting student from the University of Vigo, Spain, and Beni-Suef University partnership (not utilized), 2018.
- Fully funded (by Ministry of Higher Education & Scientific Research, Egypt) 6-month visiting student researcher, USA (not utilized), 2018.
- Best Master's Thesis in 2017, Recognition from National Research Centre, Egypt, 2018.
- First Cohort, Data Analysis Track, One Million Arab Coders Program Scholarship, Udacity (Online Platform), Online, 2018.
- Masters Student Recognition from Veterinaries Syndicate, Egypt, 2017.
- Nominee for "USAID; The Cairo Initiative" 4-month training in the USA by National Research Centre, Egypt, 2017.
- Al Ghurair Open Learning Scholars Program Award, Al Ghurair Foundation for Education (AGFE), UAE, 2016
- Misr Elkheir (MEK) Qualifying Program Award, Misr Elkheir Foundation (MEK), Egypt, 2015
- BVM with Honors, Veterinary Medical Sciences, Faculty of Veterinary Medicine, Zagazig University, Egypt, 2010
- "Top Student" Recognition Award (4<sup>th</sup> academic year), Social Committee, Faculty of Veterinary Medicine, Zagazig University, 2009
- Honor and Appreciation Award, Pharmacology Department, Faculty of Veterinary Medicine, Zagazig University, 2008

## NETWORKS AND MEMBERSHIPS

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03/2023 - 12/2023 Aberdeen, UK

Aberdeen Computational Biology Forum

Talks and networking hub for interdisciplinary researchers across the University of Aberdeen using computational algorithms and statistics in their research to solve biological and medical problems.

02/2022 - 08/2022 Scotland, UK (Aberdeen and Edinburgh)

The Data Lab

Mentor: Brian Hills (CEO, The Data Lab)

As part of being accepted into the "Career Mentoring Programme" by the University of Aberdeen, I was mentored by an industry leader in data science and bioinformatics. It was helpful for networking and being informed about funding opportunities for academia and industry. I hosted and organized a session that was delivered by Brian Hills as part of the "Datafest" event across Scotland.

2021 - 2022 Europe (UK and Italy)

European Aquaculture Society (EAS)

I helped in organising Aquaculture Europe 2022 in Rimini, Italy and was member of EAS meetings.

01/2012 - 01/2016 Egypt

Nakaa Nanotechnology Network (NNN)

I mainly helped in practical demonstration of nanomaterials synthesis and fabrication and organising NNN conferences.

02/2016 - 01/2017 Cairo and Luxor

INTEL ISEF Egypt

I was accepted as a volunteer for helping in judging molecular biology and biotechnology projects of high school students in Luxor and Cairo.

## REFEREES

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- Prof. Samuel Martin ([sam.martin@abdn.ac.uk](mailto:sam.martin@abdn.ac.uk)), Director, Scottish Fish Immunology Research Centre, University of Aberdeen, Aberdeen, UK.
- Prof. Daniel Bolnick ([daniel.bolnick@uconn.edu](mailto:daniel.bolnick@uconn.edu)), Ecology and Evolutionary Biology & Institute for Systems Genomics, University of Connecticut, USA.
- Prof. Pieter Dorrestein ([pdorrestein@health.ucsd.edu](mailto:pdorrestein@health.ucsd.edu)), Director, Collaborative Mass Spectrometry Innovation Center, Skaggs School of Pharmacy & Pharmaceutical Sciences.