FY2018 Annual Report (April 2018-March 2019)

Molecular Genetics Unit
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Abstract

Genomic perspective on the evolution of plants and animals

The comparative study of genomes provides a window into the origin and evolution of plant and animal diversity. Contemporary genomes evolved by descent with modification from earlier sequences, accumulating both neutral and adaptive mutations, with varying genomic impact ranging from small changes in sequence to radical changes in chromosome number and gene content. We apply the general comparative principle: features that are shared by two or more genomes were either present in their common ancestor, or evolved convergently.
This principle allows us, for example, to infer the gene content and even genome structure of early vertebrate by comparing genomes of appropriately chosen living species, and to discern macro-evolutionary trends. Similarly, analysis of genetic variation within individual species or between closely related populations sheds light on the evolutionary mechanisms underlying the origin and diversification of new species. The dynamic nature of genomes, including the waxing and waning of transposable elements that generate complex repetitive patterns, also provide opportunities for inferring past events that shaped the diversity of life.

1. Staff

- Dr. Ferdinand Marletaz, postdoctoral researcher
- Dr. Daria Gavriouchkina, postdoctoral researcher
- Dr. Chikatoshi Sugimoto, postdoctoral researcher
- Mr. Jeff Jolly, technician
- Dr. Yuko Hasegawa, technician
- Ms. Chika Azama, research unit administrator

2. Collaborations

2.1 Theme: Origins of Japanese Citrus
- Type of collaboration: Collaboration
- Researchers
  - Prof. Fred Gmitter (University of Florida, USA)
  - Dr. Albert Wu (DOE Joint Genome Institute, USA)

2.2 Theme: Amphioxus genome and the evolution of vertebrate chromosomes
- Type of collaboration: Collaboration
- Researchers
  - Prof. Oleg Simakov (University of Vienna, Austria)
  - Prof. Richard E. Green (University of California, Santa Cruz, USA)
  - Prof. Nori Satoh (OIST)

3. Activities and Findings

3.1 Amphioxus genome and the evolution of vertebrate chromosomes

We have assembled the chromosome of the Florida lancelet, *Branchiostoma floridae*, and developed new methods for comparing the chromosomal organization of this species with the organization of other invertebrates and vertebrates. This analysis conclusively answers several puzzles about early vertebrate evolution. We provide conclusive proof that (1) all vertebrates (including jawless lampreys and the jawed fishes and land-dwelling vertebrates) share one common whole genome duplication ("1R"), (2) jawed vertebrates share a second whole genome duplication ("2Rjv") that not found in lampreys, and (3) the jawed-vertebrate specific duplication occurred via allotetraploidy, a process that occurs via hybridization of distinct progenitors. Dr. Marletaz in our unit also led a functional study of the European amphioxus, shedding light on the origins of vertebrate gene regulation.

3.2 Evolution of citrus

The species diversity of the genus *Citrus*, which includes some of the most widely cultivated fruit crops worldwide, is poorly understood. Using genomic, phylogenetic and biogeographic analyses of 60 accessions representing diverse citrus germplasms, we describe ten natural citrus species. Further identification and analyses of hybrids and admixed genomes provides insights into the genealogy of major commercial cultivars of citrus. Among mandarins and sweet orange, we find an extensive network of relatedness that illuminates the domestication of these groups. Widespread pummelo admixture among these mandarins and its correlation with fruit size and acidity suggests a plausible role of pummelo introgression in the selection of palatable mandarins. We propose that citrus diversified during the late Miocene epoch through a rapid southeast Asian radiation that correlates with a marked weakening of the monsoons. A second radiation enabled by migration across the Wallace line gave rise to the Australian limes in the early Pliocene epoch. This work provides a new evolutionary framework for the genus *Citrus*.

4. Publications

4.1 Journals

1. Belcaid M, Casaburi G, McAnulty SJ, Schmidbaur H, Suria AM, Moriano-Gutierrez S, Pankey MS, Oakley TH, Kremer N, Koch EJ, Collins AJ, Nguyen H, Lek S, Goncharenko-Foster I, Minx P, Sodergren E, Weinstock G, **Rokhsar DS**, McFall-Ngai M, Simakov O, Foster JS, and Nyholm SV. (2019). "Symbiotic organs shaped by distinct modes of genome evolution in cephalopods" *PNAS*. 116 (8) 3030-3035. (2019 January 11) doi: https://doi.org/10.1073/pnas.1817322116
2. Lukoseviciute M, **Gavriouchkina D**, Williams RM, Hochgreb-Hagele T, Senanayake U, Chong-Morrison V, Thongjuea S, Repapi E, Mead A, Sauka-Spengler T (2018). "From Pioneer to Repressor: Bimodal foxd3 Activity Dynamically Remodels Neural Crest Regulatory Landscape *in vivo*." *Dev Cell*. 47(5):608-628.e6. (2018 Dec 3) doi: 10.1016/j.devcel.2018.11.009.
3. **Marlétaz F**, Firbas PN, Maeso I, Tena JJ, Bogdanovic O, Perry M, Wyatt CDR, de la Calle-Mustienes E, Bertrand S, Burguera D, Acemel RD, van Heeringen SJ, Naranjo S, Herrera-Ubeda C, Skvortsova K, Jimenez-Gancedo S, Aldea D, Marquez Y, Buono L, Kozmikova I, Permanyer J, Louis A, Albuixech-Crespo B, Le Petillon Y, Leon A, Subirana L, Balwierz PJ, Duckett PE, Farahani

E, Aury JM, Mangenot S, Wincker P, Albalat R, Benito-Gutiérrez È, Cañestro C, Castro F, D'Aniello S, Ferrier DEK, Huang S, Laudet V, Marais GAB, Pontarotti P, Schubert M, Seitz H, Somorjai I, Takahashi T, Mirabeau O, Xu A, Yu JK, Carninci P, Martinez-Morales JR, Crollius HR, Kozmik Z, Weirauch MT, Garcia-Fernàndez J, Lister R, Lenhard B, Holland PWH, Escriva H, Gómez-Skarmeta JL, Irimia M (2018). "Amphioxus functional genomics and the origins of vertebrate gene regulation." Nature. 564(7734):64-70. doi: 10.1038/s41586-018-0734-6.

4. Kenyon A, **Gavriouchkina D**, Zorman J, Chong-Morrison V, Napolitani G, Cerundolo V, Sauka-Spengler T (2018). "Generation of a double binary transgenic zebrafish model to study myeloid gene regulation in response to oncogene activation in melanocytes." *Dis Model Mech.* 11(4). pii: dmm030056. (2018 Apr 6) doi: 10.1242/dmm.030056.

4.2 Books and other one-time publications

Nothing to report

4.3 Oral and Poster Presentations

1. Sugimoto, Chikatoshi. *A story of cephalopod as a treasure of ocean,* Hakodate International Science Festival 2018, Hakodate, Japan, August 21 (2018)

2. Sugimoto, Chikatoshi. *Investigation for intelligence evolution of cephalopod,* Joint meeting with Keio, Nagoya, Ryukyu university, Nishihara, Japan, September 19 (2018)

3. Sugimoto, Chikatoshi., Ikeda, Yuzuru., Kanagawa Nobuhide. *Development of optimal live animal transportation for local branded squid,* The Hyper-interdisciplinary Conference Okinawa 2018, Nishihara, Japan, November 3 (2018)

4. Jolly, Jeffrey. *Bobtail Squids: What they are, where they are, and what they can teach us,* University of West Florida, Pensacola, USA, November 6 (2018)

5. Jolly, Jeffrey., Sugimoto, Chikatoshi., Sanchez, Gustavo., Hasegawa, Yuko., Zhang, Lin., Kawamura, Risa., Simakov, Oleg., Rokhsar, Daniel. *Towards a Laboratory Suited Cephalopod: Laboratory Culture of Indo-Pacific Bobtail Squids,* Cephalopod International Advisory Council Conference, St. Petersburg, USA. November 14 (2018)

6. Sugimoto, Chikatoshi. *How to take advantage of squid, how to be happy with octopus,* Okinawa biology educational conference, Onna, Japan, November 23 (2018)

5. Intellectual Property Rights and Other Specific Achievements

Nothing to report

6. Meetings and Events

Nothing to report

7. Other

Nothing to report