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Convergent Evolution: concepts, database, road map and case studies
Isabelle Hue, Justine Dardaillon, Pierre Pontarotti & George McGhee
UMR 1198, BDR, INRA; I2M, UMR AMU, CNRS 7373; Rutgers University, USA

Abstract
Most of the authors studying convergent evolution think about the apparition of a similar phenotype in two evolutionary independent lineages (Conway Morris 2003, McGhee 2011, Losos 2011, Gordon et al 2015). However, cases of “repetitive similarities” should be defined in a better way.

We so far: 1) proposed neologisms that can apply to any biological level: allo-convergent, iso-convergent and retro-convergent evolution (both retro-iso and retro-allo). This is important since, in the case of iso-convergent evolution, one can suspect that the underlying molecular mechanism(s) could be similar (Stern and Orgozo 2008). Such cases could then be used as meta-models (Kopp 2009) to decipher biological mechanisms at genetic, epigenetic, transcriptional or any biological level, 2) initiated the development of the LEIA database to store reported cases of convergent evolution at the phenotypic level and sort out cases of iso-convergence, 3) developed a road map to study these cases at different biological levels, and 4) illustrate cases of: dorsal or pectoral fin re-evolution, cuticule evolution and ovi-/vivi-parity transition (in mammals or amniotes).

LEIA Database:
Leveled Events of Iso and Alloconvergence evolution Database

The LEIA database is a multi-level database, its different levels spread from the genotype to the phenotype, each one can be linked to one another.

With an interactive and easy-to-use visual interface, the user can search for iso- and allomorphologies at morphological and/or genetic level and see the potential link between these two levels.

Downloadable CSV files: indel/substitution event of candidates/known genes linked to the event

Another evolutionary novelty occurred once in the common ancestor of eutheriens and metatheriens, three times in the squamates: the complex viviparity (V). This corresponds to:

i) loss of the the egg shell,
ii) interaction between the uterus and the embryo (attachment/implantation; see Griffith et al, 2017)
iii) angiogenis
iv) immunosuppression (to prevent the immune response of the mother and the rejection of the embryo)

The ancestor was oviparous and laid eggs with a solid shell (still evidenced by birds, crocodiles, chelonians)
The same evolutionary events occurred repetitively in the evolution of Amniotes (Morphological Iso convergence): the eggs became retained until mid-gestation and the egg shell became softer (ER: Egg Retention).

* earliest fossilized embryos along each branch of the tree

Pre-attachment, attachment, parturition (Opossum)
Pre-attachment, implantation, extended pregnancy, parturition (Human)

Mammals
Ovi-/Vivi-parity
Amniotes

Different biological levels and/ or mechanisms possibly involved: Iso- / Allo- convergence?

Retro-Isoconvergence (pectoral fins of ichthyosaur and dolphin, re-evolved by modifying tetrapod forelimbs with pentalogy bone arrangements in both species
Ichthyosaur: reptile, extinct
Porpoise: mammal

Retro-Alloconvergence (dorsal fins of ichthyosaur and dolphin: i) in ichthyosaurs, re-evolution of rope-like structure of fine filaments, ii) in dolphins, of soft tissue with core placements of the blood vessels

Iso- Convergence at multiple biological levels

Retro- Convergence
For the re-evolution of a lost character in two (or several ) sister species

Retro-Iso: from the same ancestral character

Retro-Allo: from a different character

The current use of the parallel and convergent evolution is confusing
This came from the fact that: most authors gave sub-definitions based on the genetic mechanisms involved in the evolution of the convergent evolving character, while others used a phylogenetic-based definition

We proposed instead the use of
Iso- & Allo-Convergence
Iso: from the same ancestral state
Allo: from a different ancestral state

Pectoral Fins: Retroparallel Case

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