

Convergent Evolution: concepts, database, road map and case studies

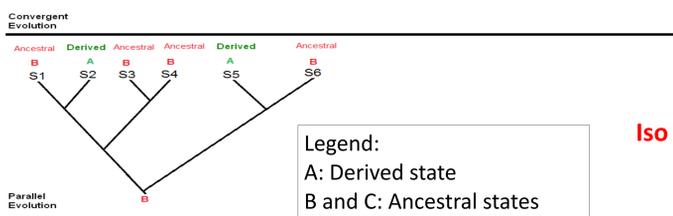
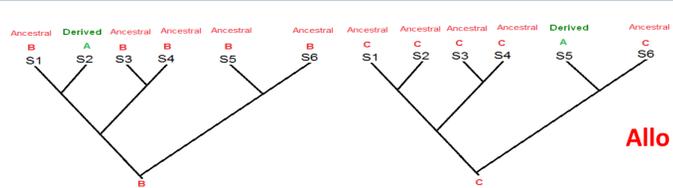
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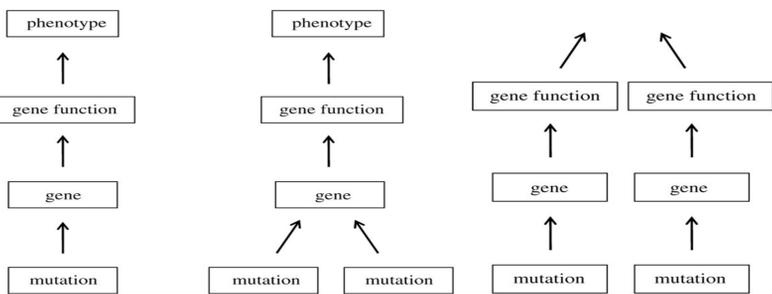
Abstract

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). From this broad definition authors focused on case studies: echolocation (Parker et al 2013) or repetitive adaptations of marine mammals (Foote 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 Orgozozo 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 , cuticle evolution and ovi-/vivi- parity transition (in mammals or amniotes).



Legend:
A: Derived state
B and C: Ancestral states



Allo- and Iso- convergence at the phenotypic level

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**

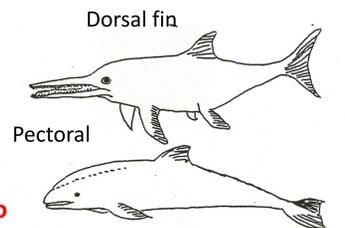
Iso: from the same ancestral state
Allo: from a different ancestral state

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

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

Retro-Allo



Retro-Iso

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

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 alloconvergences at morphological and/or genetic level and see the potential link between these two levels.

Morphological Iso convergence research

LEIA WebSite Research Page

Genetic Iso convergence research

Ancestral State: Hairy cuticle
Derived State: Nude cuticle
Description: Multiple mutations in the cis regulatory in enhancer region of svb gene result in modifications of morphological traits with the suppress of dorsal trichome pattern. It's a typical example of cis-regulatory modifications that cause morphological modifications.

Tissue event (Number of results: 4)
Get the csv of the following table here
SCOPE used in the studies: Arthropoda (Number of results: 4)

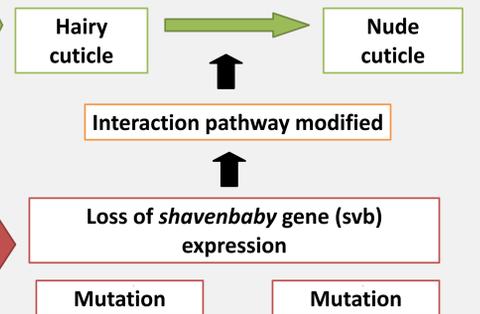
#	NCBI taxid	species name	methods and references
1	7238	Drosophila sechellia	Morphological evolution caused by many subtle-effect substitutions in a transcriptional enhancer. Frankel N. et al., Nature, 2011, vol.474, p598-603.

LEIA WebSite Results Page

Ancestral State: Hairy cuticle
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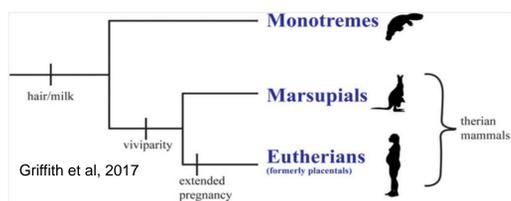
no rank (Number of results: 3)
Get the csv of the following table here
SCOPE used in the studies: Arthropoda (Number of results: 3)

Genetic changes in *shavenbaby*'s **promoter** lead to the apparition of **nude cuticle** in two different phyla of *Drosophila* (*D. melanogaster* and *D. littoralis*; Frankel et al., 2011)



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

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

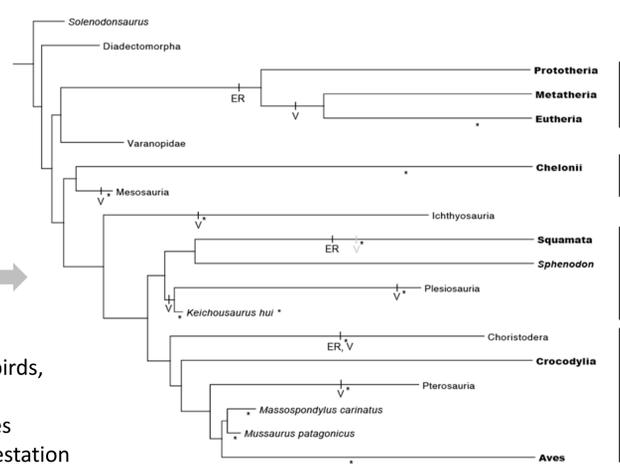


Mammals
Ovi- /Vivi- parity

Amniotes

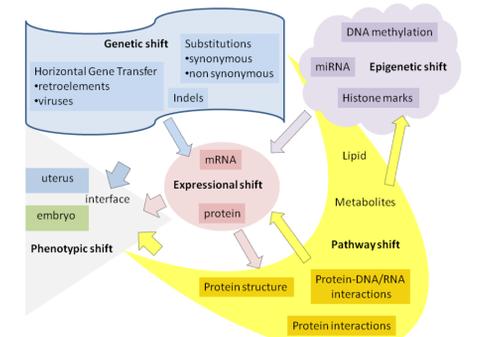
The ancestor was **oviparous** and laid **eggs** with a **solid shell** (still evidenced by birds, crocodiles, chelonians)
The **same evolutionary events** occurred repetitively in the evolution of Amniotes (**Morphological Iso** convergence): the **eggs** became **retained** until around mid-gestation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

* earliest fossilized embryos along each branch of the tree



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

Another evolutionary **novelty** occurred **once** in the common ancestor of eutherians and metatherians, **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) angiogenesis
iv) immunosuppression (to prevent the immune response of the mother and the rejection of the embryo)



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