



**HAL**  
open science

## Convergent evolution: concepts, database, roadmap and case studies

Isabelle Hue, Justine Dardaillon, Pierre Pontarotti, George Mc Ghee

### ► To cite this version:

Isabelle Hue, Justine Dardaillon, Pierre Pontarotti, George Mc Ghee. Convergent evolution: concepts, database, roadmap and case studies. AEEB: Evolutionary Biology Meeting, Sep 2017, Marseille, France. pp.189, 2017, 21st Evolutionary Biology Meeting. hal-02734433

**HAL Id: hal-02734433**

**<https://hal.inrae.fr/hal-02734433v1>**

Submitted on 2 Jun 2020

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

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

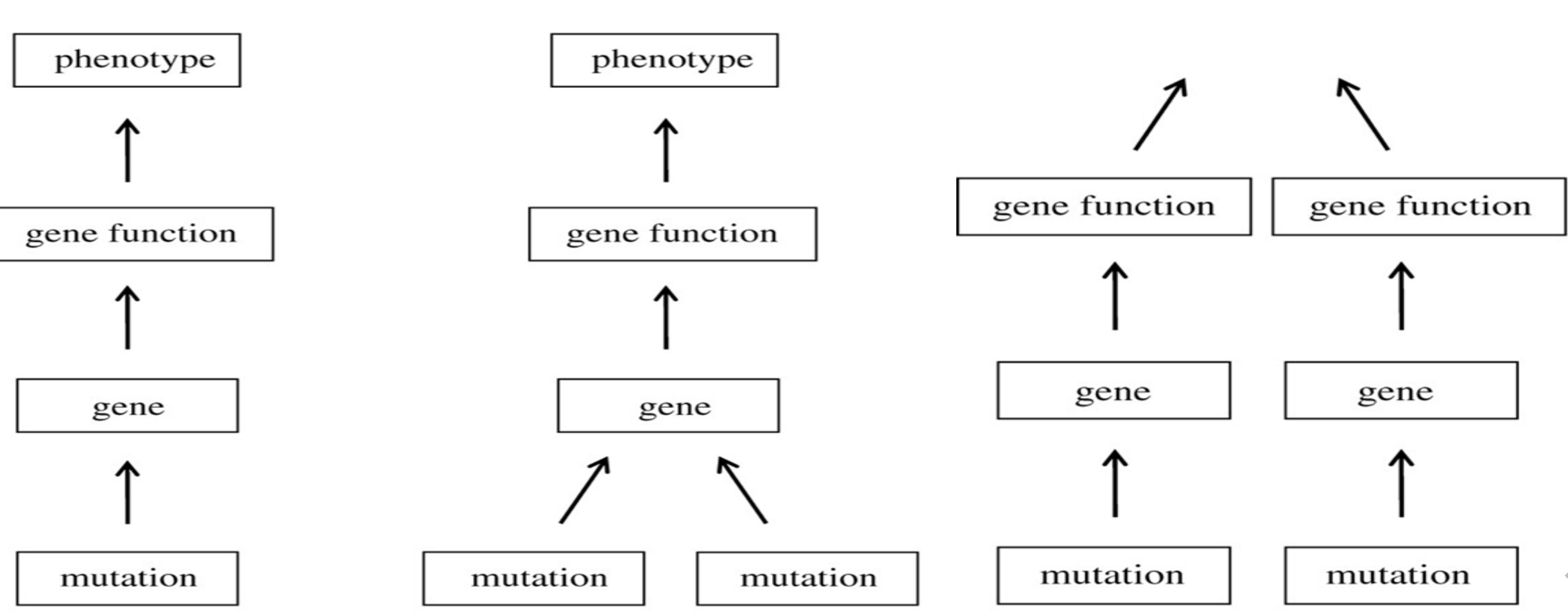
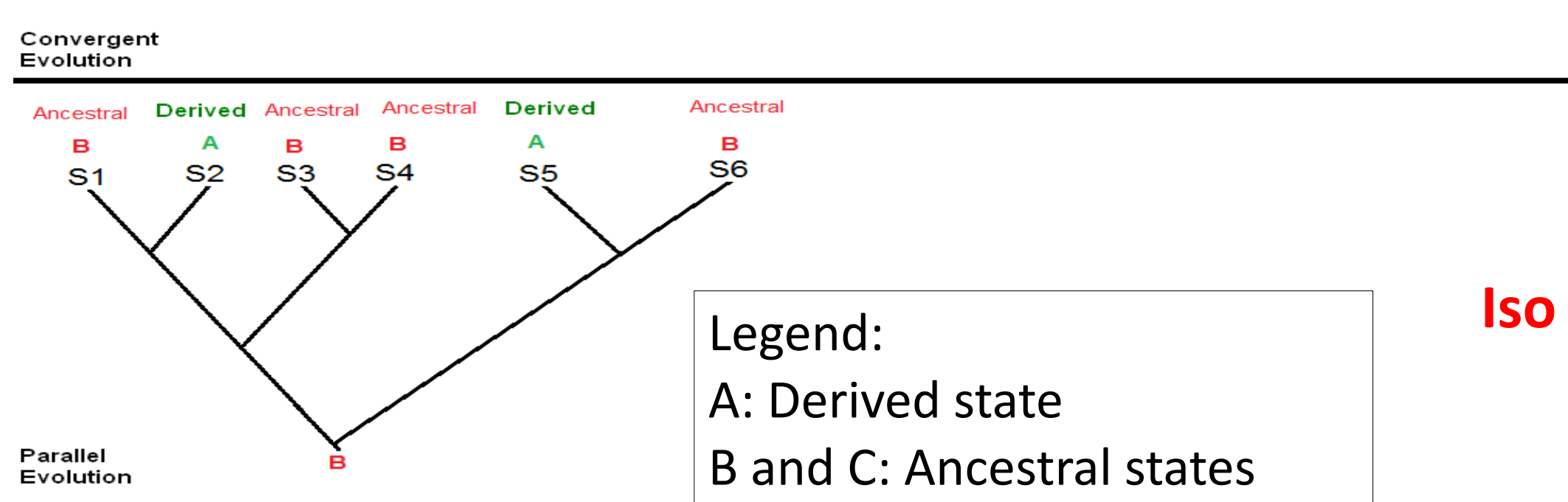
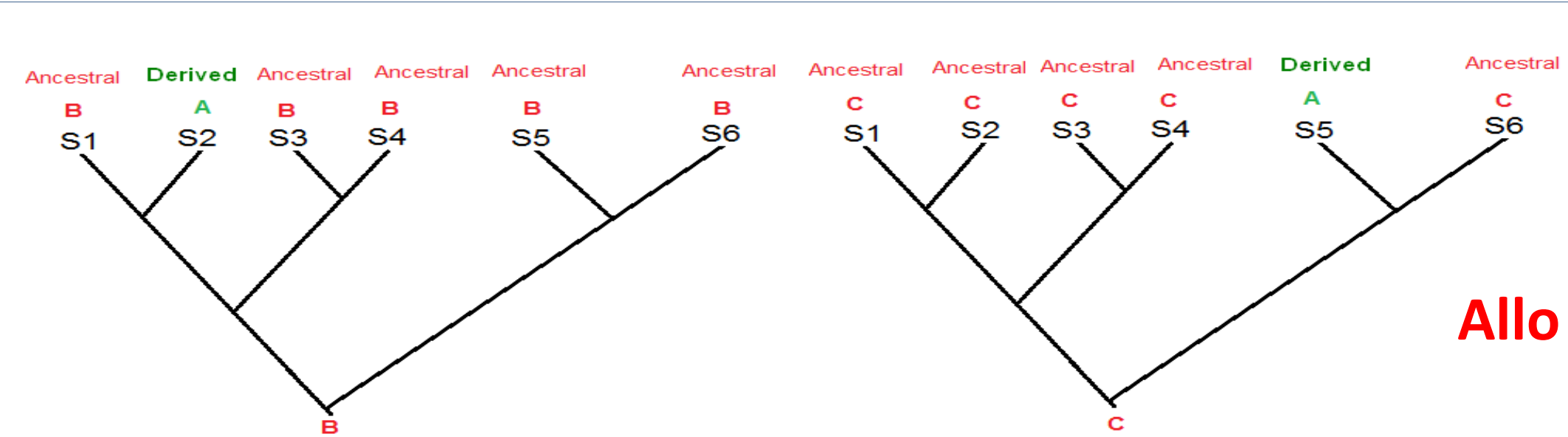
Isabelle Hue, Justine Dardaillon, Pierre Pontarotti & George McGhee

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). 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).



## 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

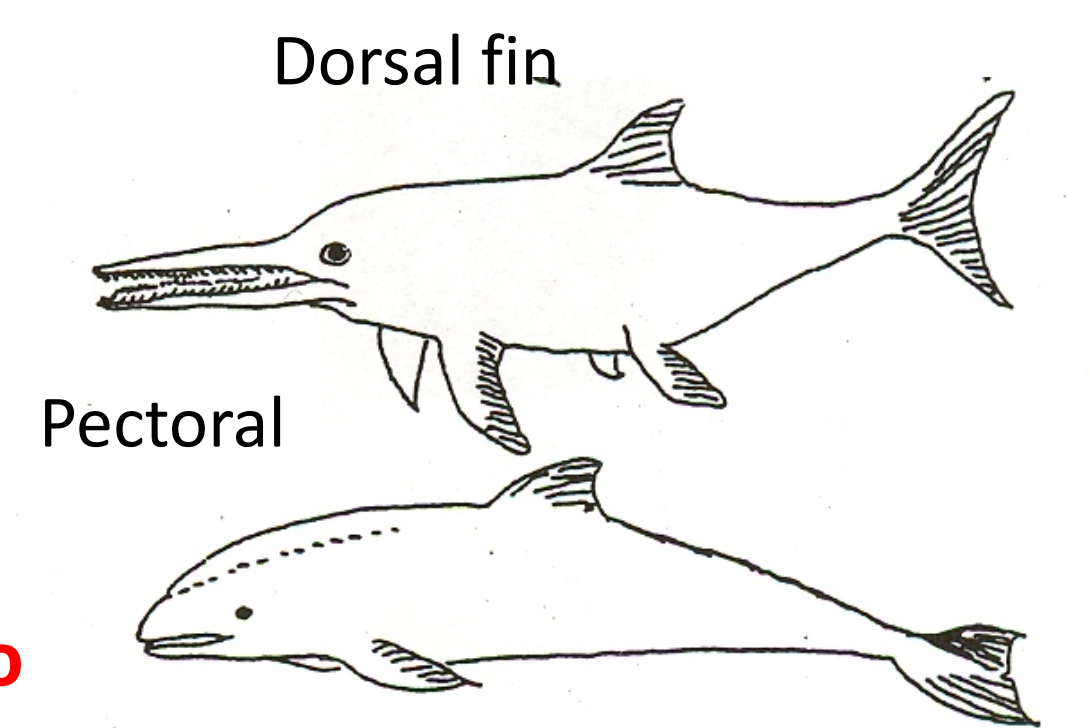
### Retro- Convergence

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 penta-dactylus 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 :

### Levelled 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

Scope Name (optional): Arthropoda  
Keyword (optional): cuticle

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.

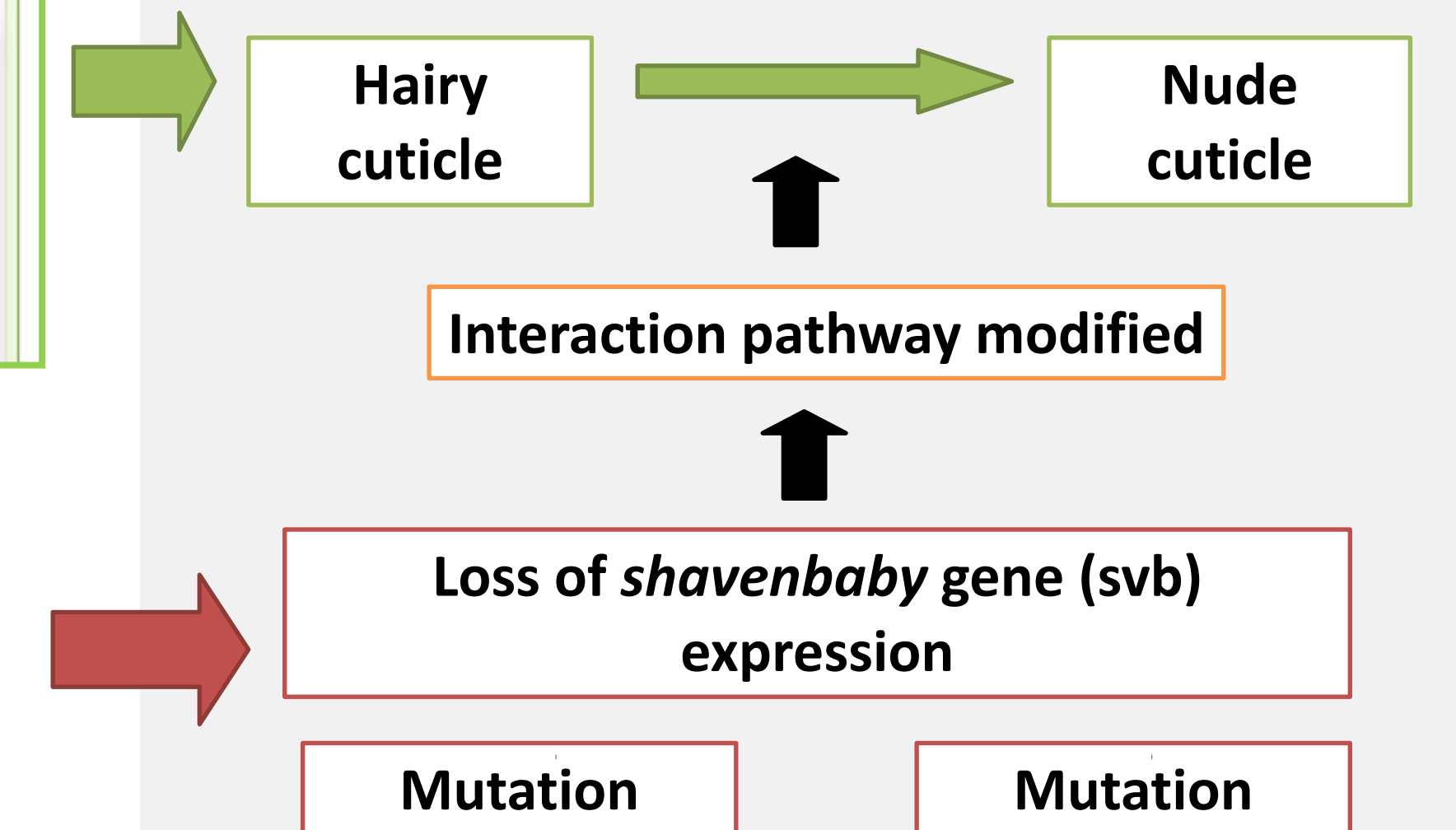
LEIA WebSite Results Page

Ancestral State: Hairy cuticle  
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.

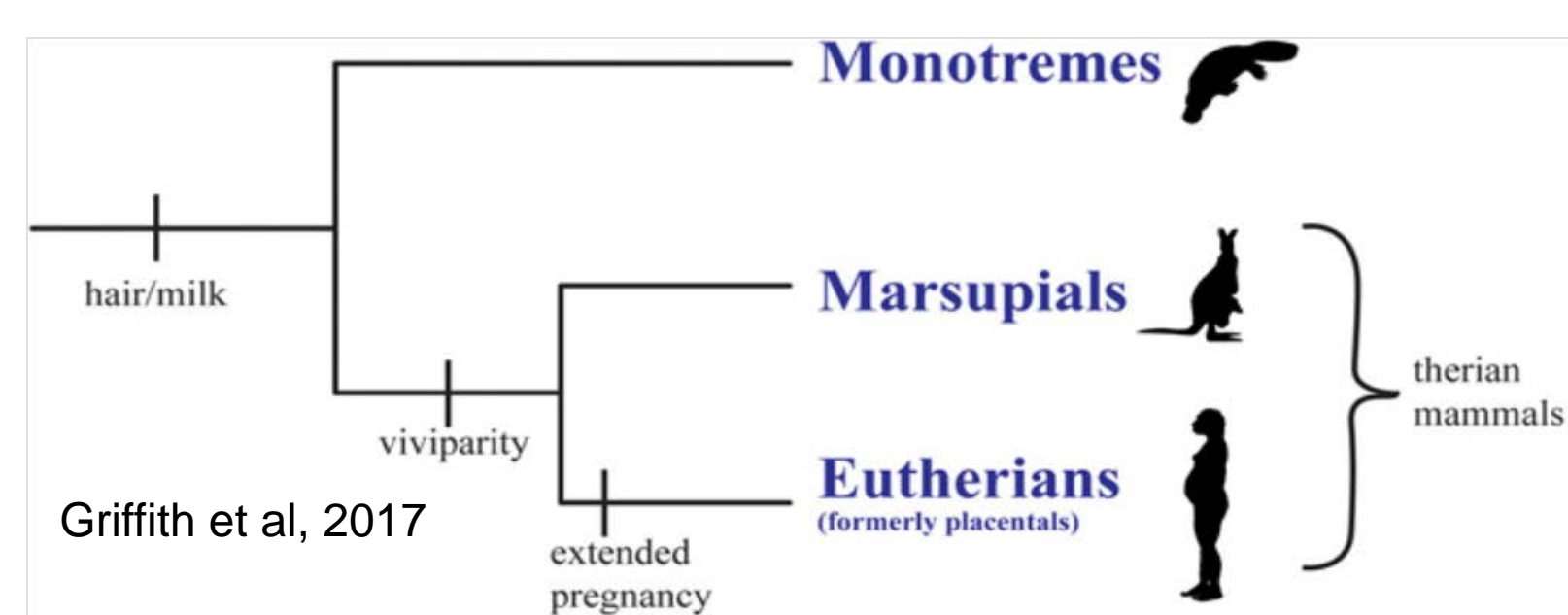
no rank (Number of results: 3)  
Get the csv of the following table here  
SCOPE used in the studies: Arthropoda (Number of results: 3)

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

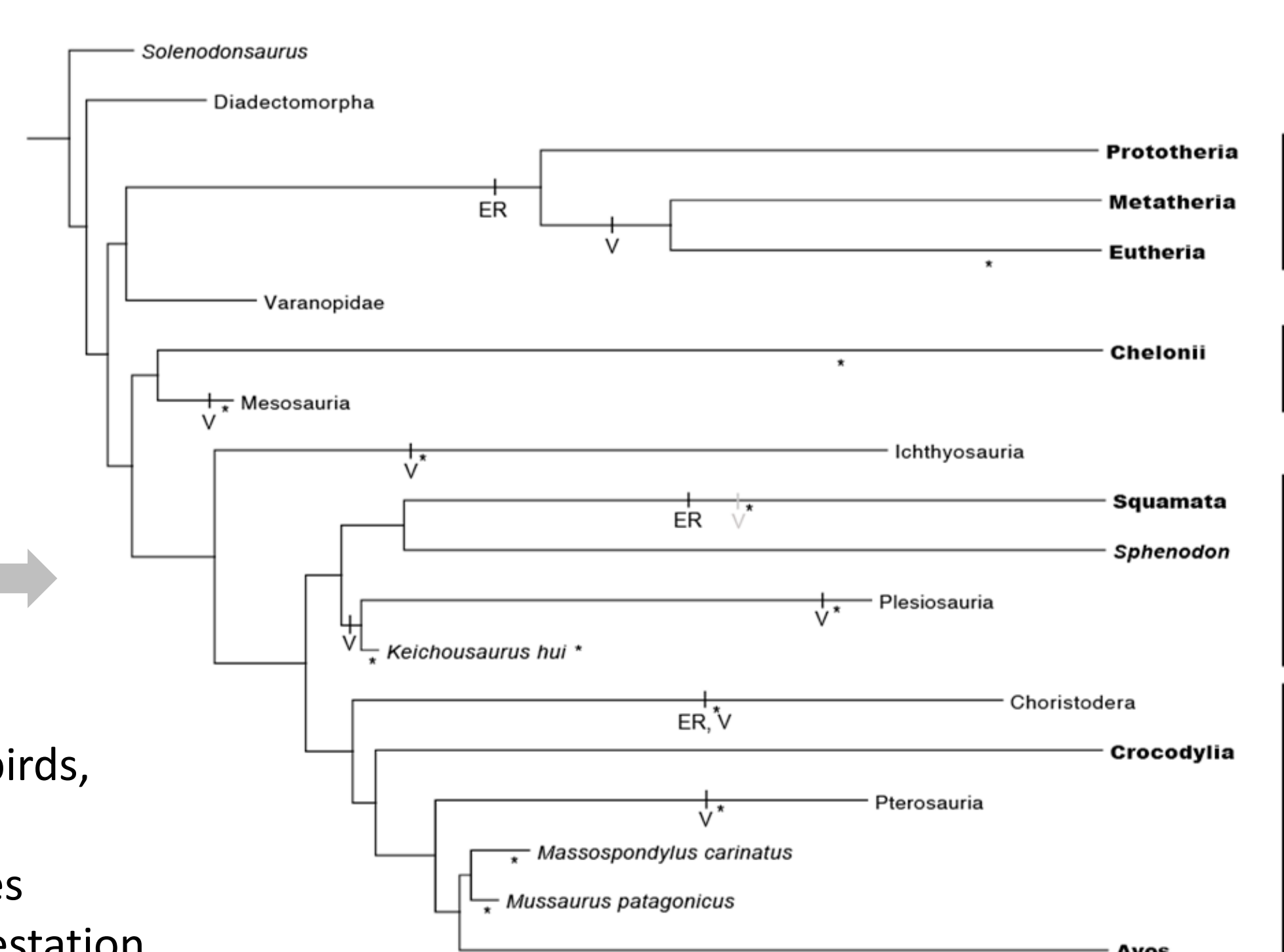
Genetic changes in *shavenbaby*'s **promoter** lead to the apparition of **nude cuticle** in two different phyla of *Drosophila* (*D. melanogaster* and *D. littoralis*; Frankel et al., 2011)



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



Mammals  
Ovi- /Vivi- parity  
Amniotes

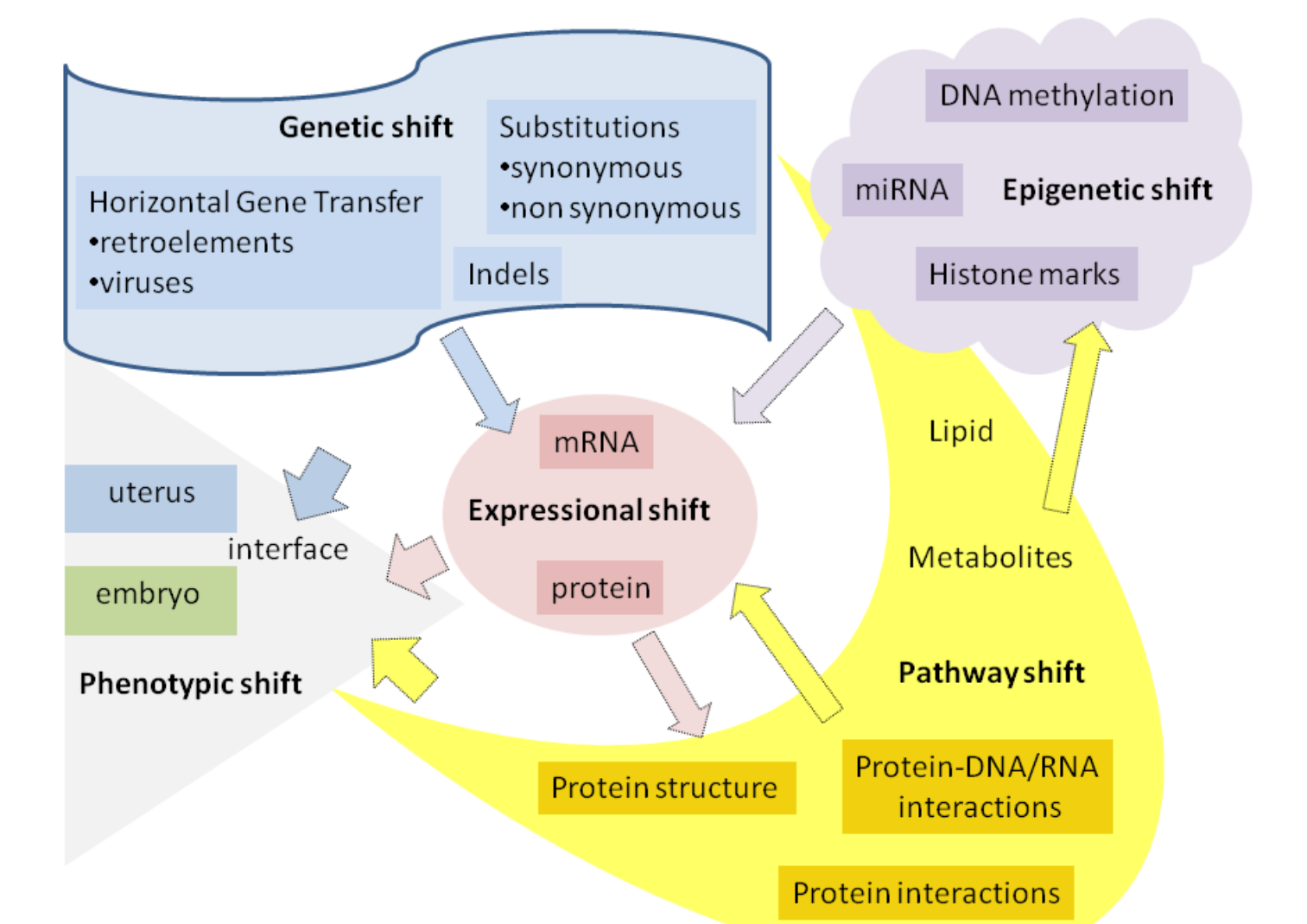


The ancestor was **oviparous** and laid **eggs** with a **solid shell** (still evidenced by birds, crocodiles, chelonians)  
The **same evolutionary events** occurred repetitively in the evolution of Amniotes (**Morphological Iso** convergence): the **eggs** became **retained** until around mid-gestation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



Conway Morris, Life's Solution: Inevitable Humans in a Lonely Universe, Martin, The Loci of repeated evolution: a catalog of genetic hotspots of phenotypic variation. Evolution. 2013,67:1235-50.

McGhee, Convergent Evolution: Limited Forms Most Beautiful. The MIT Press, Cambridge, 2011.

Parker, Genome-wide signatures of convergent evolution in echolocating mammals, Nature. 2013,502(7470):22831

Stern, The loci of evolution: how predictable is genetic evolution? Evolution. 2008, 62:2155-77

Frankel N. et al, Morphological evolution caused by many subtle-effect substitutions in a transcriptional enhancer. Nature, 2011, vol.474, p598-603.

Foote, Convergent evolution of the genomes of marine mammals, Nat Genet. 2015, 47:272-5

Gordon, Can systems biology help to separate evolutionary analogies (convergent homoplasies) from homologies? Prog Biophys Mol Biol. 2015, 117:19-29.

Griffith, Embryo implantation evolved from an ancestral inflammatory attachment reaction, PNAS July 2017

Losos, Convergence, adaptation, and constraint. Evolution. 2011, 65:1827-40

Krassilov, VA, *Scytophyllum* and the origin of angiosperm leaf characters. Paleontological 1995, 29: 63

Zhong Q et al, An inter-species protein-protein interaction network across vast evolutionary distance, Mol Syst Biol 2016, 12:865

Choate LA et al, Poised for development, Nat Genet, 2016, 48:222