DEB 2025

Acceleration and its evolution

Bas Kooijman

salm.kooijman@gmail.com

A-Life, VU University Amsterdam

VU VRIJE UNIVERSITEIT AMSTERDAM

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University of Crete, Heraklion, Greece

deb2025.sciencesconf.org

Metabolic acceleration

Def: long-term increase of respiration relative to standard DEB expectation

Types of acceleration

- R: maturation
- X: food
- A: assimilation
- M: morph
- T: temperature

Short-term increase in respiration (no metabolic acceleration)

- heat increment of feeding
- boosts of activity
- migration
- pregnancy/ lactation

Kooijman 2014
J Sea Res **94**: 128-137

Type R acceleration

Def: Change in allocation to boost maturation

- Increase in respiration
- Decrease in growth
- Hit maturity threshold earlier
  at smaller size

Mueller et al 2012,
Comp. Biochem. Physiol. A
163: 103-110

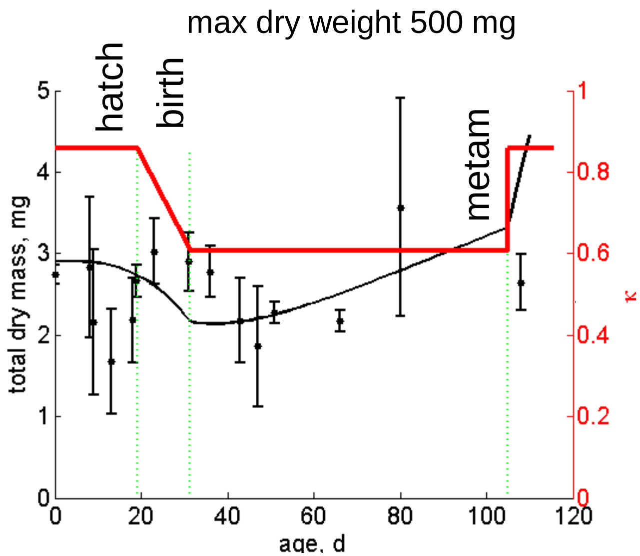
Type R acceleration

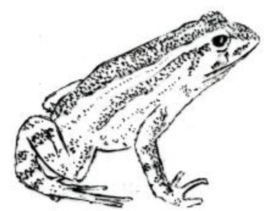
acceleration	no	yes
development		
indirect	 *Pseudophryne bibronii*	 *Crinia georgiana*
direct	 *Geocrinia vitellina*	 *Crinia nimbus*

Type R acceleration

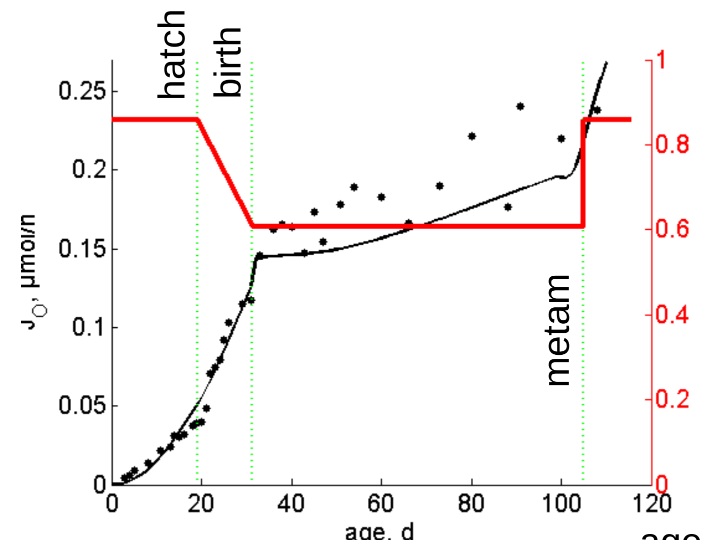
Mueller et al 2012,
Comp. Physiol. Biochem. A,
163:103-110

Crinia georgiana



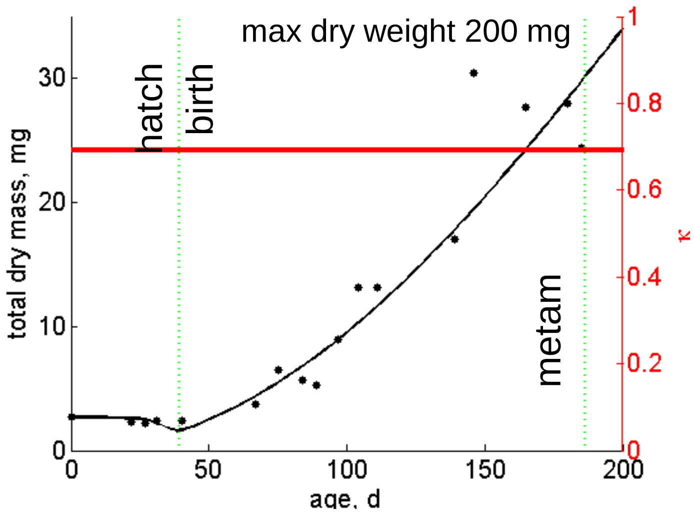


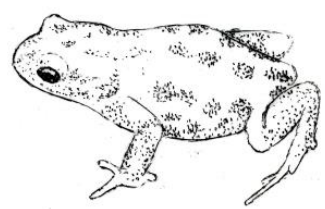
12 °C

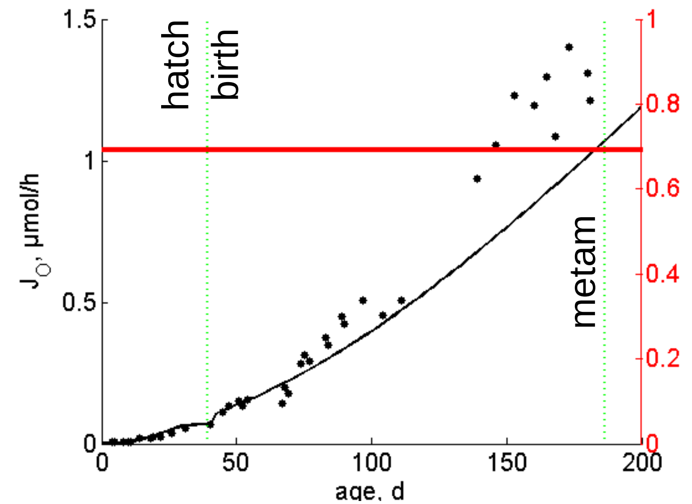


age, d

Pseudophryne bibronii







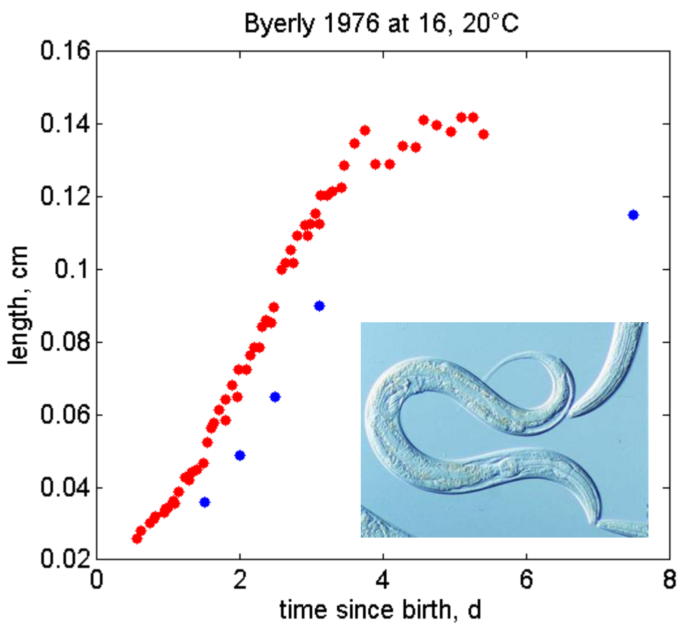
Type X acceleration

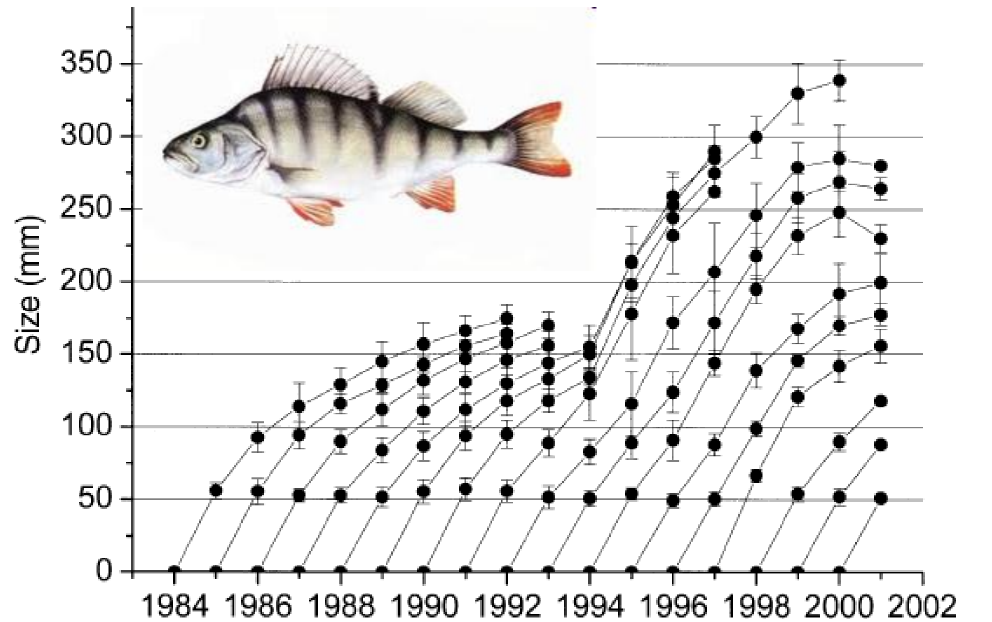
Def: increase of food intake during ontogeny,
but no change in potential food intake

Known examples concern change in food type

Young (=growing) individuals need lots of protein,
older ones mostly energy.

Type X acceleration





Caenorhabditis elegans
Byerly et al 1976
Developmental Biol. **51**: 23-33**.**

Perca fluviatilis
Persson et al 2004
Ecol. Mon. 74: 135–157

organic compounds
→ bacteria

zooplankton
→ fish

Type A acceleration

Def: increase of potential food intake during ontogeny,
but no change in mobilisation

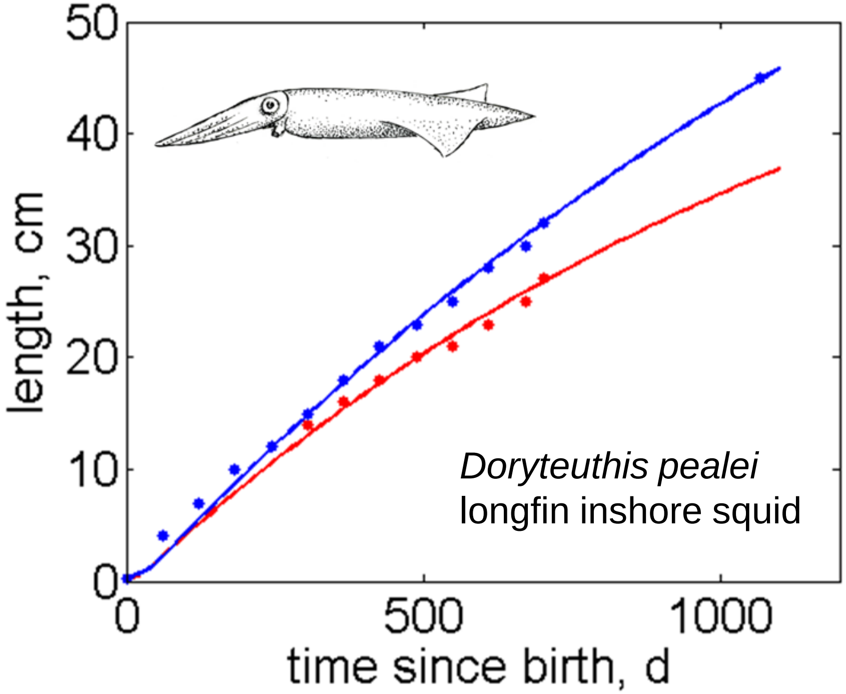
Known examples concern sex dimorphy
Increase in reserve capacity

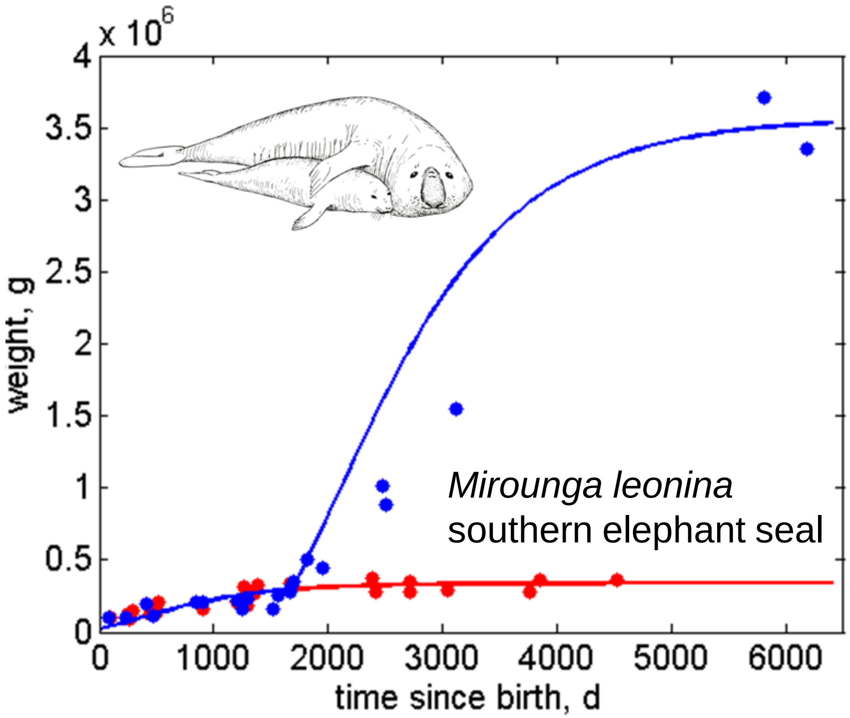
Acceleration is confined to period bj

Quantifier: acceleration factor $s_M = l_j/l_b$

Siblings can be born equal, visit areas of different food availability and remain unequal for the rest of their lives.

Type A acceleration





Incubation time

temperature (°C)	measured (d)	predicted (d)
22	10.71	11.14
18	18.54	17.35
15	26.75	25.83

Type M acceleration

Def: increase of potential food intake during ontogeny,
combined with increase in potential mobilisation

Increase of specific assimilation $\{p_{Am}\}$ and energy conductance v
with length from birth to metamorphosis
no change in reserve capacity

One-parameter extension of standard DEB model:
maturity level at metamorphosis
DEB theory does not assumes isomorphy

Applies to most species with morphological metamorphosis,
but also to some taxa without
amphibians have metamorphosis, but no acceleration

Recognize M acceleration by upcurving of L(t) at constant food

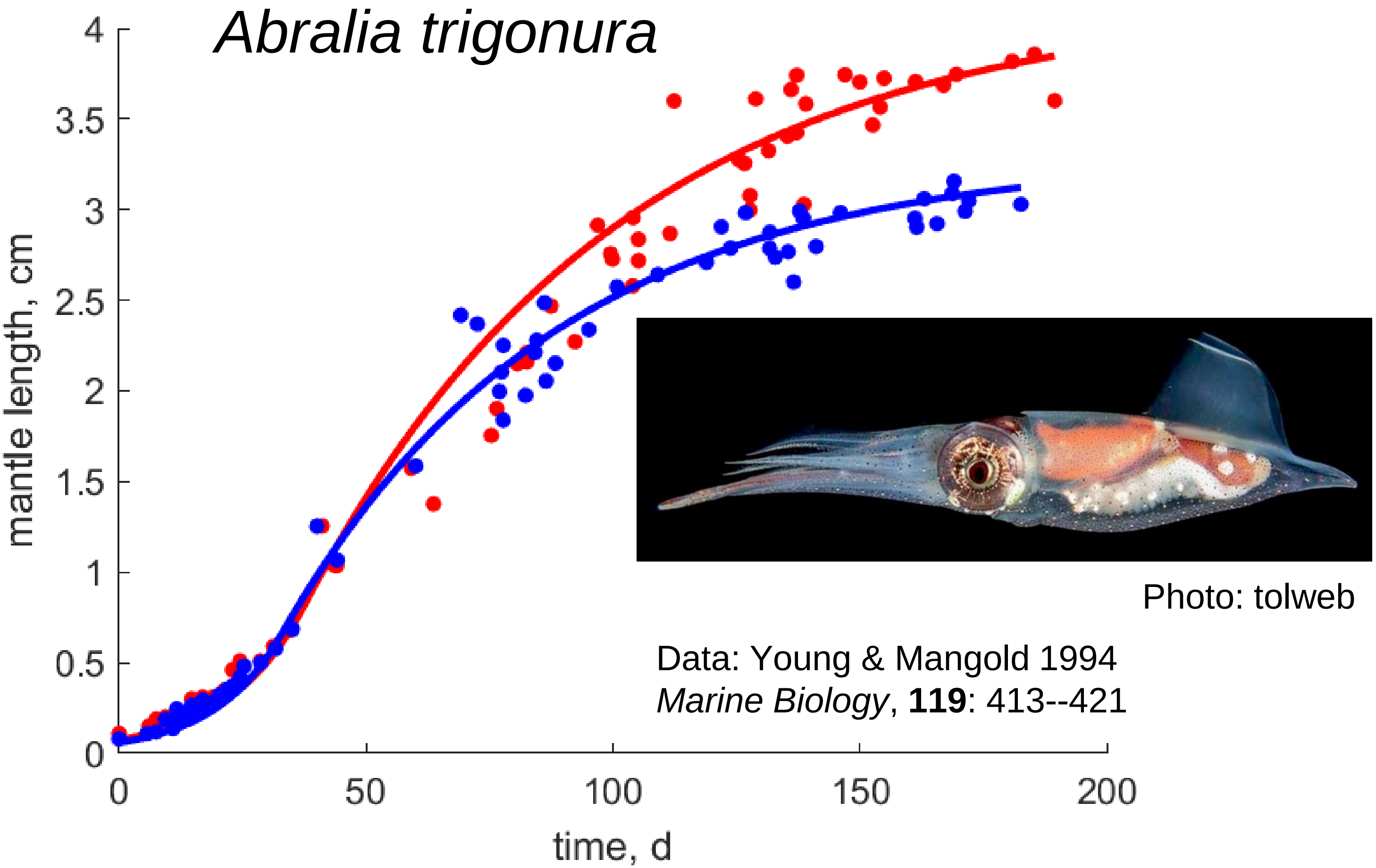


Photo: tolweb

Data: Young & Mangold 1994
Marine Biology, **119**: 413--421

Many cephalopods accelerate till puberty; shelled species do not accelerate (*Nautilus, Argonauta*)

Life history might affect acceleration

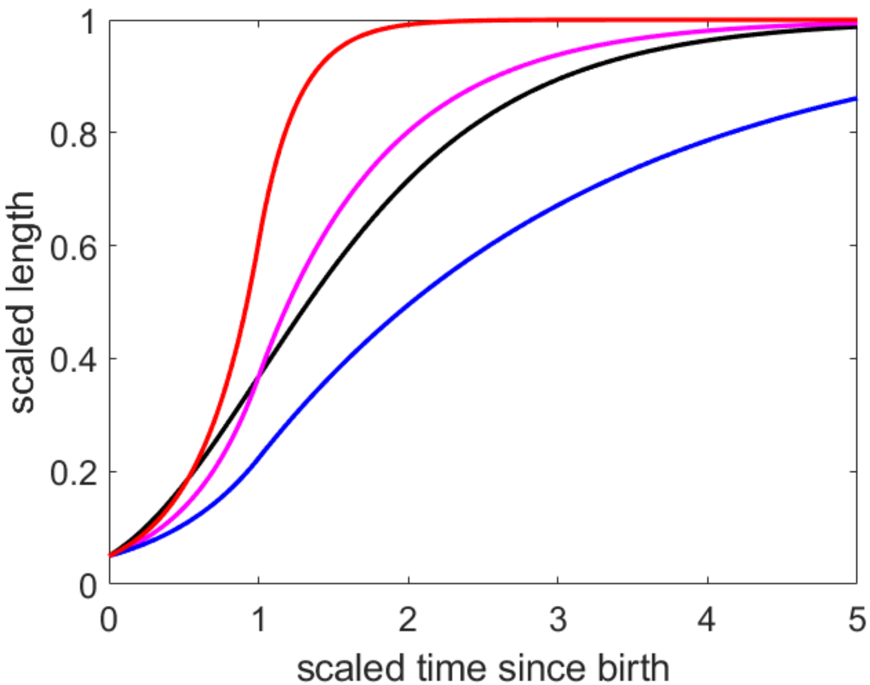
Demersal Eupercaria members in Mediterranean waters

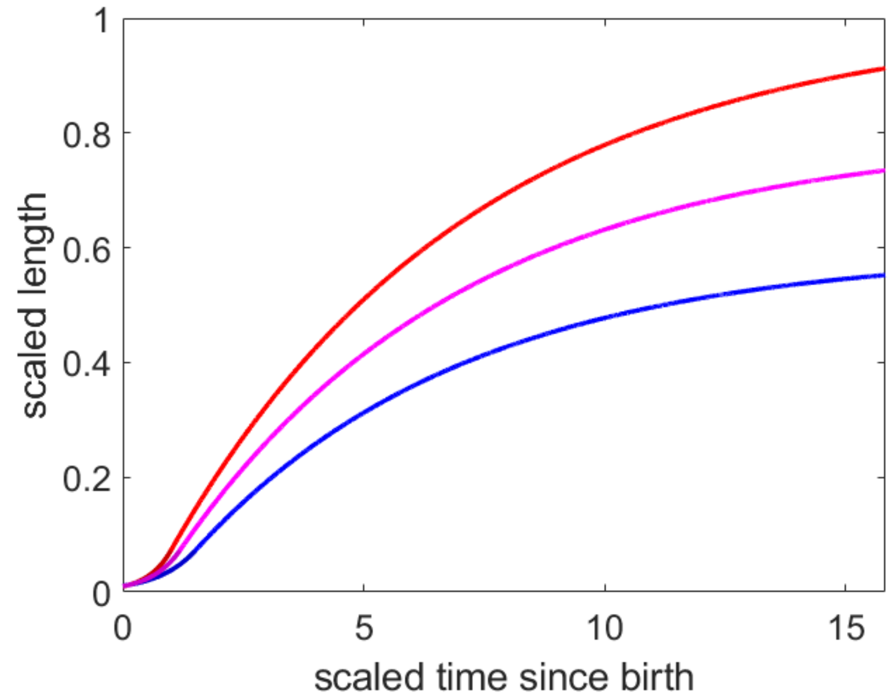
Species	Family	s_M	Spawning	Mean temp, °C
Dentex dentex	Sparidae	5.3	Apr–May	16.5 (16.9–19.2)
Sparus aurata	Sparidae	6.7	Oct–Dec	19.2 (16.5–22.7)
Diplodus puntazzo	Sparidae	10.9	Sep–Oct	23.9 (22.7–25.1)
Pagellus erythrinus	Sparidae	22.7	May–Sep	24.0 (19.2–27.2)
Argyrosomus regius	Sciaenidae	7.6	Mar–May	17.1 (15.2–19.2)
Sciaena umbra	Sciaenidae	3.7	Mar–May	17.1 (15.2–19.2)
Dicentrarchus labrax	Moronidae	8.2	Jan–Mar	15.3 (14.7–16.0)

Energetics is rather similar after acceleration, so large acceleration factor means slow start
Acceleration might be linked to life history pattern: slow start in warm waters, when food is scars

Lika et al 2014
J Sea Res **94**: 37-46

Gompertz expo-von Bertalanffy curves





Gompertz growth curve (1779–1865)

$$L(t) = L_\infty (L_0/L_\infty)^{\exp(-\dot{r}_G t)}$$

Expo-von Bertalanffy (= Pütter) growth curve

$$\begin{aligned} L(t) &= L_0 \exp(\dot{r}_j t/3) \quad \text{for } t < t_j \\ L(t) &= L_\infty - (L_\infty - L_j)\exp(-\dot{r}_B(t - t_j)) \quad \text{for } t > t_j \\ L_j &= 3(L_\infty - L_j)\dot{r}_B/\dot{r}_j \quad \text{for } L(t_j) = L_j \end{aligned}$$

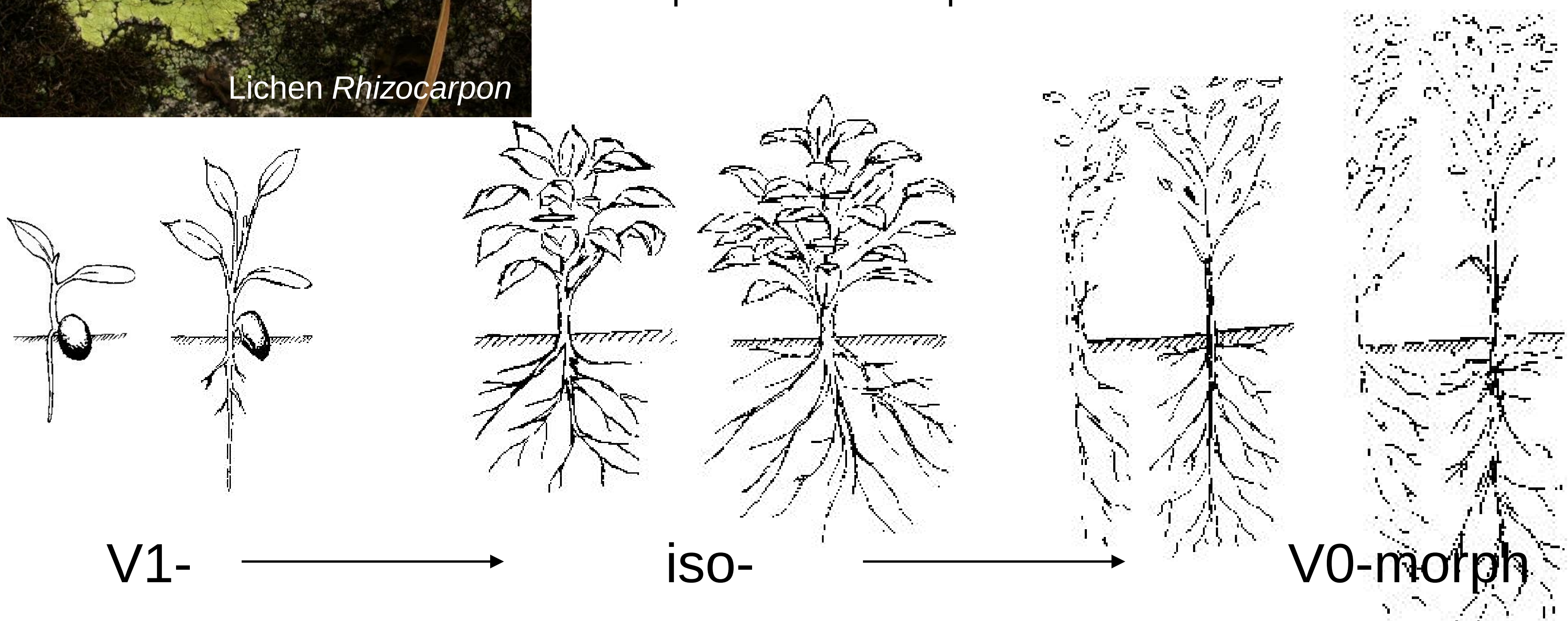
Mixtures of changes in shape

Lichen *Rhizocarpon*

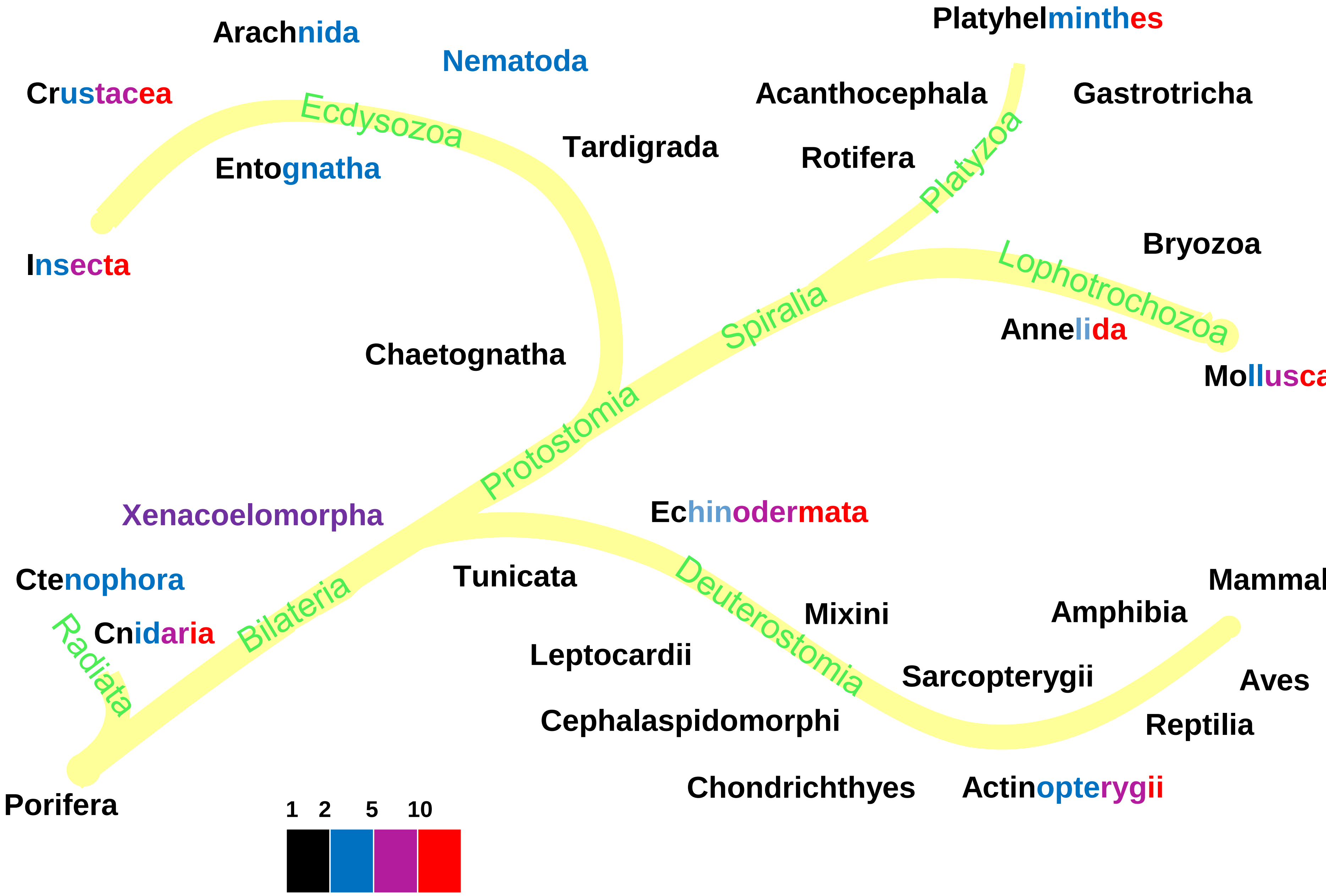
Dynamic mixtures between morphs

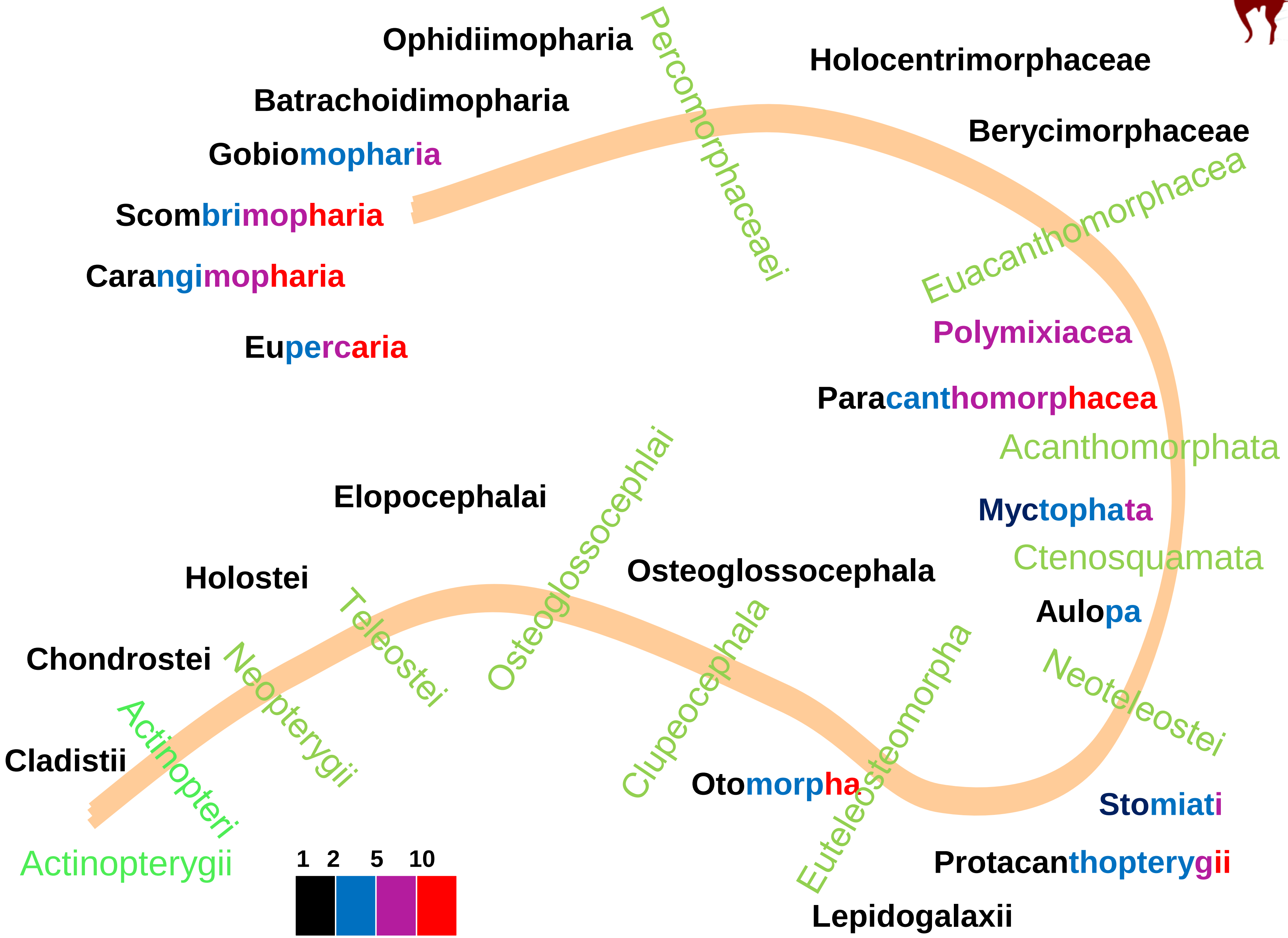
V1- ⟶ V0-morph

outer annulus behaves as a V1-morph,
inner part as a V0-morph. Result: diameter increases $\propto$ time

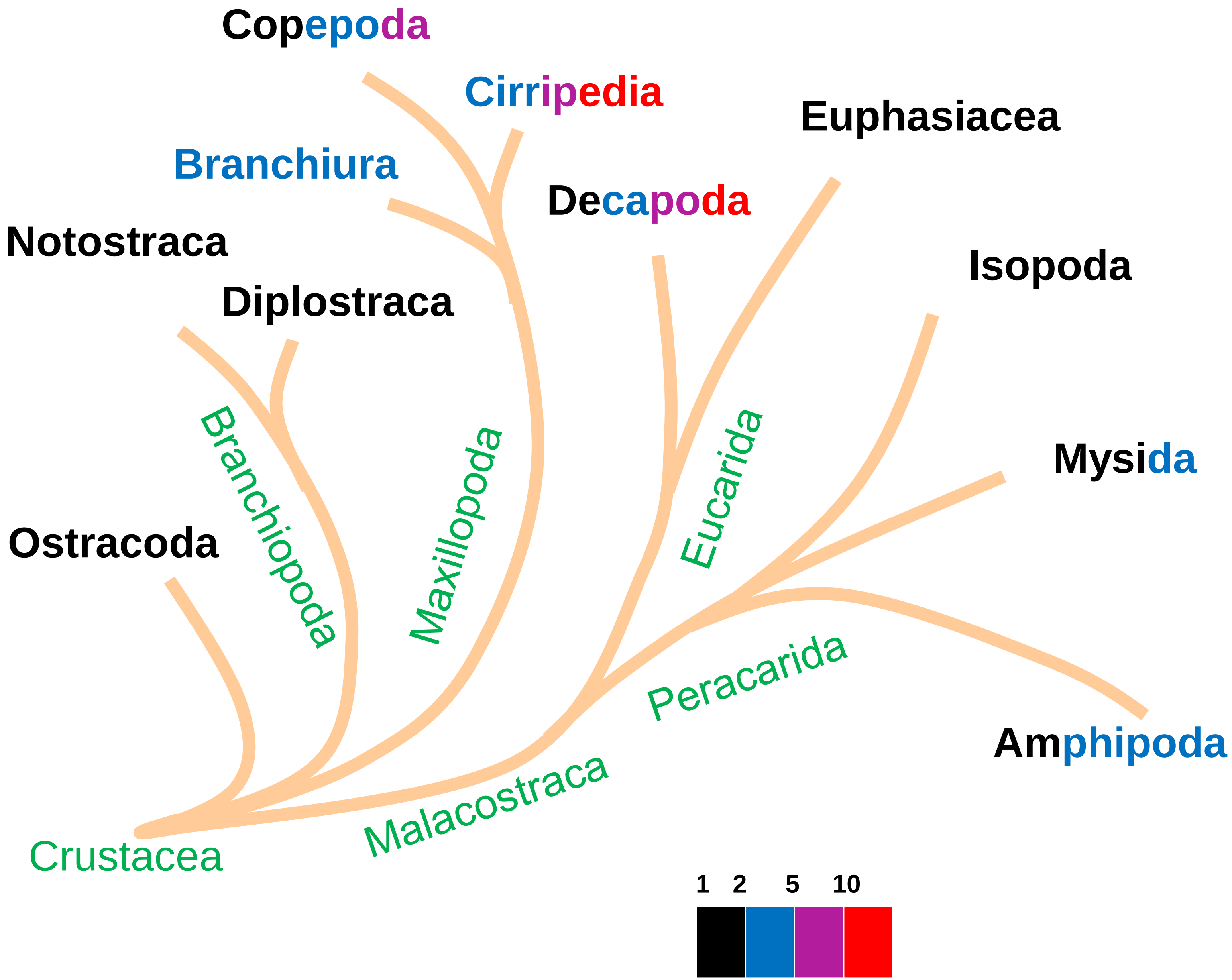


V1- ⟶ iso- ⟶ V0-morph

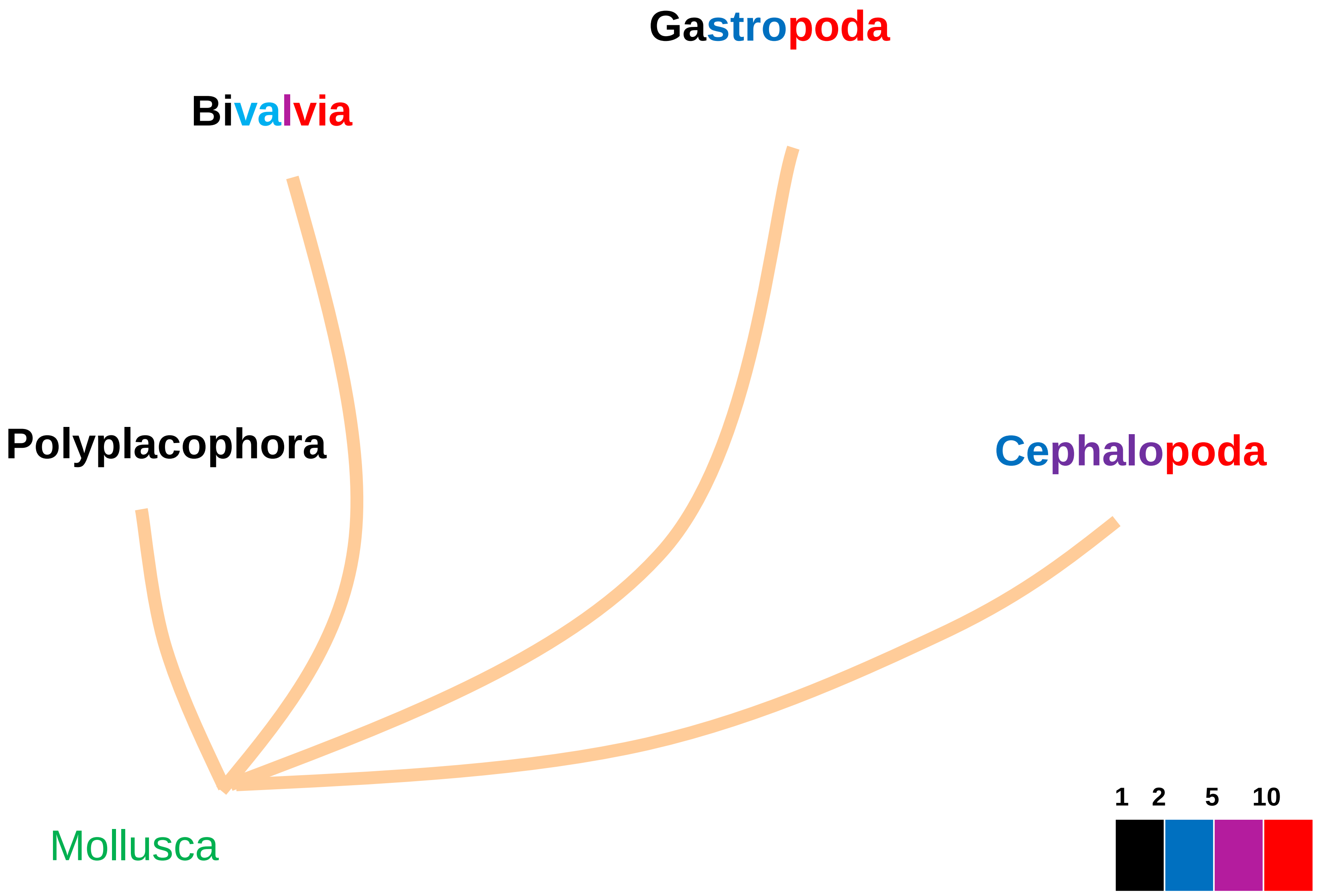

Arachnida
Nematoda
Platyhelminthes
Crustacea
Ecdysozoa
Acanthocephala
Gastrotricha
Tardigrada
Rotifera
Entognatha
Platyzoa
Insecta
Bryozoa
Lophotrochozoa
Spiralia
Annelida
Chaetognatha
Mollusca
Protostomia
Xenacoelomorpha
Echinodermata
Ctenophora
Tunicata
Deuterostomia
Mammal
Radiata
Cnidaria
Bilateria
Mixini
Amphibia
Leptocardii
Sarcopterygii
Aves
Cephalaspidomorphi
Reptilia
Porifera
Chondrichthyes
Actinopterygii
1
2
5
10



Ophidiimopharia
Batrachoidimopharia
Gobiomopharia
Scombrimopharia
Carangimopharia
Eupercaria
Percomorphaceaei
Holocentrimorphaceae
Berycimorphaceae
Euacanthomorphacea
Polymixiacea
Paracanthomorphacea
Acanthomorphata
Myctophata
Ctenosquamata
Aulopa
Neoteleostei
Stomiati
Protacanthopterygii
Lepidogalaxii
Euteleosteomorpha
Otomorpha
Clupeocephala
Osteoglossocephala
Osteoglossocephlai
Elopocephalai
Teleostei
Holostei
Neopterygii
Chondrostei
Actinopteri
Cladistii
Actinopterygii
1
2
5
10



Copepoda
Cirripedia
Euphasiacea
Branchiura
Decapoda
Notostraca
Isopoda
Diplostraca
Branchiopoda
Maxillopoda
Eucarida
Mysida
Ostracoda
Peracarida
Amphipoda
Malacostraca
Crustacea
1 2 5 10

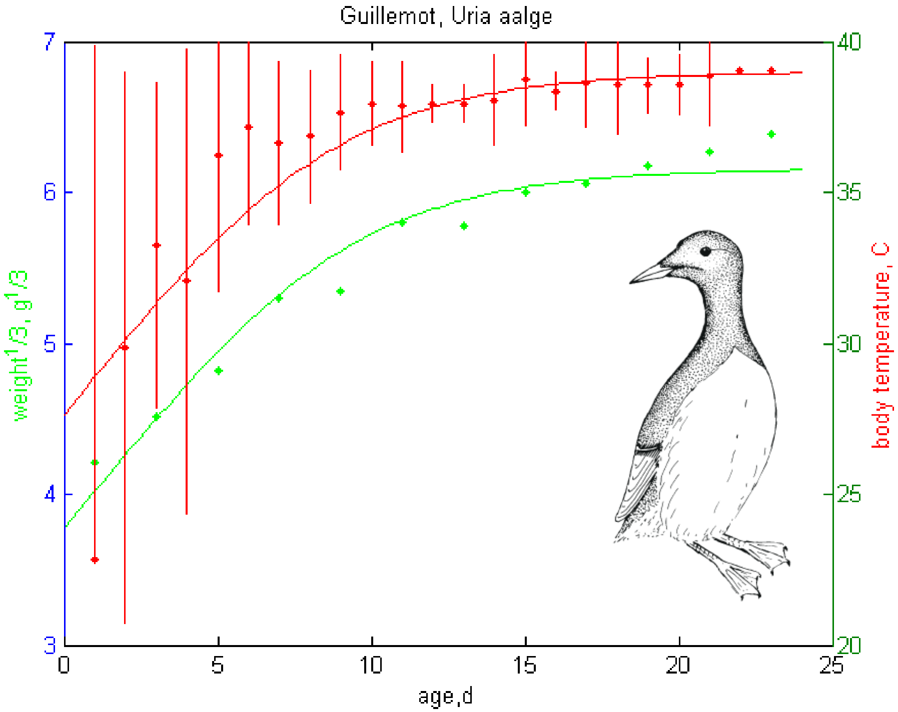

Gastropoda
Bivalvia
Polyplacophora
Cephalopoda
Mollusca
1 2 5 10

Type T acceleration

Def: increase of all rates
due to ontogenetic increase in body temperature

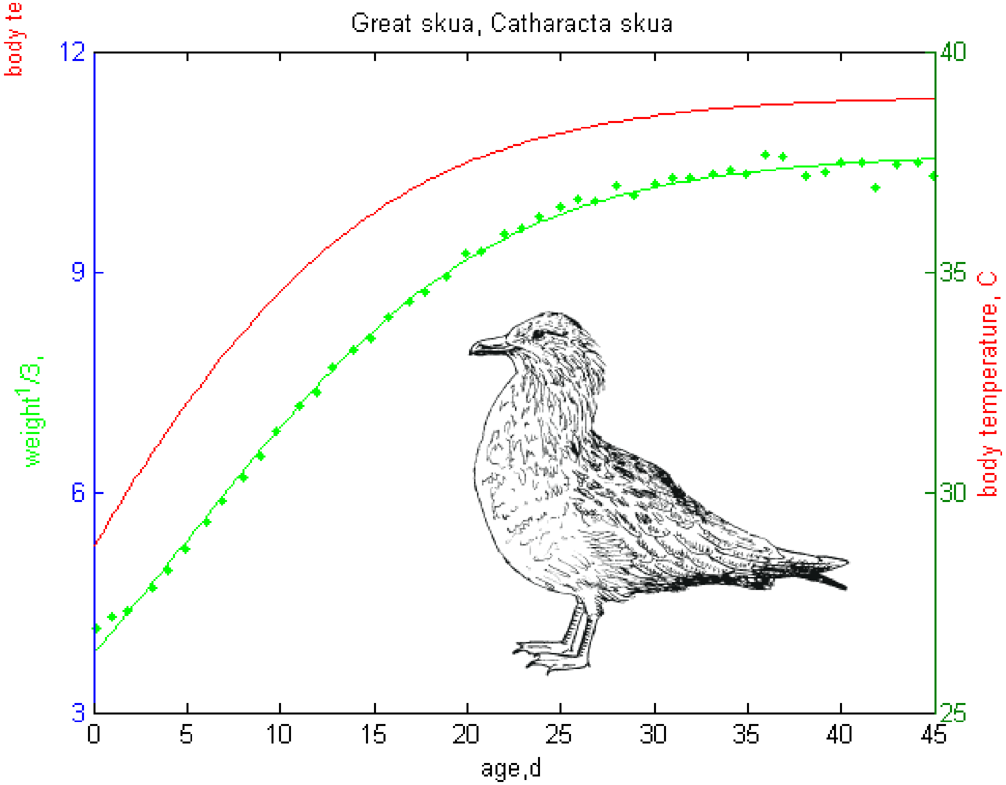
Mostly confined to birds.
Embryos are ectothermic
Neonate heating capacity
not sufficient to maintain target temperature

Type T acceleration

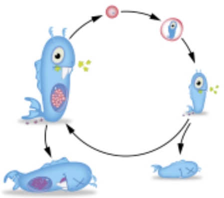


t-T and t-L curves
fitted simultaneously

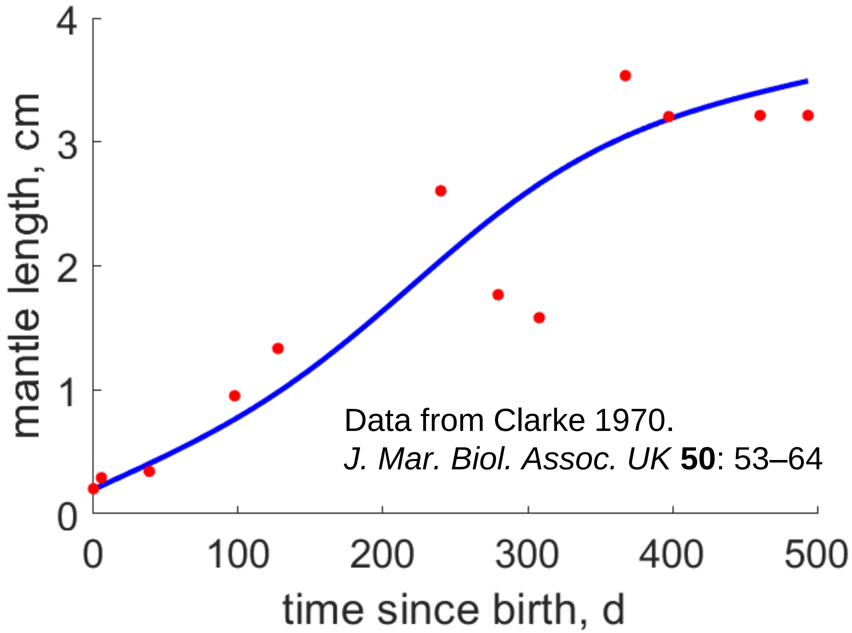
t-T inferred from t-L curve



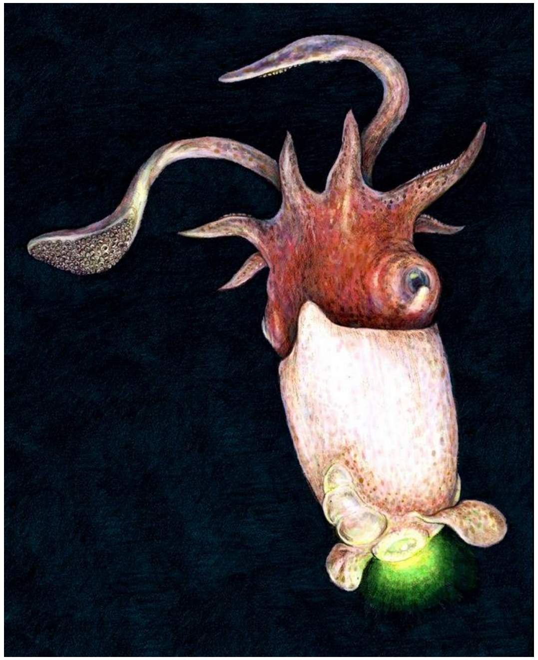
Type T acceleration



Ram’s horn squid, *Spirula spirula*



Born at the bottom of deep water: 4–6 ºC,
Migrates to mid ocean waters: 12–14 ºC,
Then back again bottom to spawn & die.



Photophore points downwards

Internal shell 2.1 cm

Final slide

Thank you for your attention

Download slides

https://www.bio.vu.nl/thb/users/bas/lectures/

Questions/remarks are very welcome

Also later during breaks