DEB 2023

Welcome and Summary of the Tele-course

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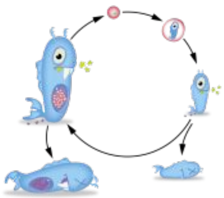
MARETEC
MARINE, ENVIRONMENT AND TECHNOLOGY CENTER
TÉCNICO LISBOA

A-LIFE Amsterdam Institute for Life and Environment

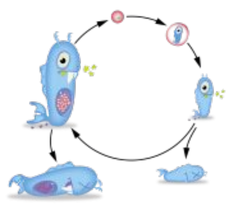
School: 4-13 June 2023
Baton Rouge, Louisiana, United States
deb2023.sciencesconf.org

Overview

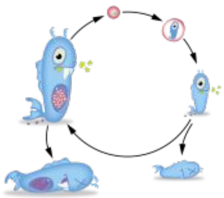


- Orientation
- How to receive and provide feedback
- Structure of the course, objectives
- Summary tele-course

Orientation>Websites



- Database
- Manuals
- Code repositories
- Frequent updates
- Short videos



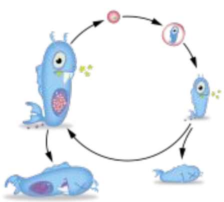
Questions

"There are no stupid questions, only stupid answers"

We welcome all questions. With a well formulated question one is 99% on the way to a solution.

We all come with a broad spectrum of experience - cross-disciplinary communication can be challenging, and should remain respectful.

Orientation



Chap 1 → Chap 2 → Chap 3 → Chap 4

Concepts

Homeostasis

Standard DEB model

Concepts

Body size and composition

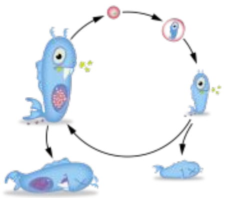
Classes of compounds

Macrochemical reaction equations

Uni-variate DEB model

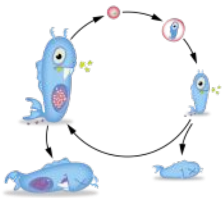
Changing shapes

Learning Objectives



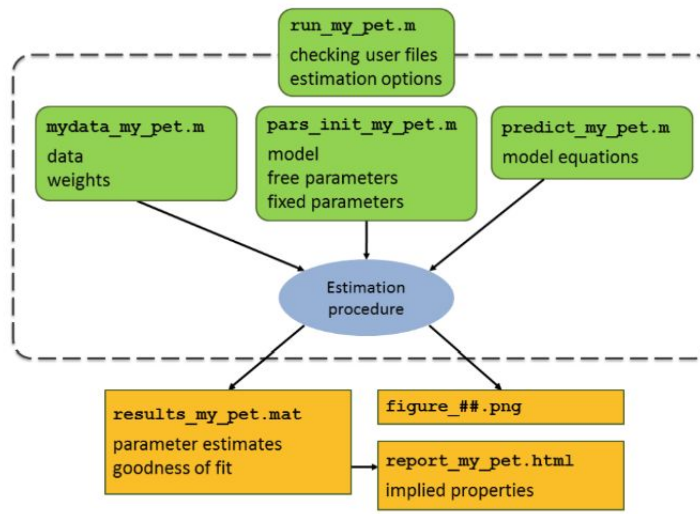
- Formulate a research question
- Know core DEB concepts and associated alternative concepts
- Acquire the skills necessary to estimate DEB parameters using real-world data.
- Critically evaluate and discuss the biological realism of DEB parameters
- Apply DEB (parameter estimation) techniques to support and enhance one's own research projects.
- Demonstrate the capacity to apply DEB theory to address contemporary issues in conservation, environmental impacts, and resource management.

Contents of 8-day practical workshop

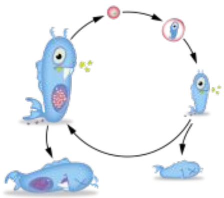


- "AmP workshop" - estimate parameters for your species (14.5H)
- "DEB in practice" - guided exercises on applications (11 H)
- Lectures (19H)
- "Group discussions" - present your discussion topic (6 H)
- "Plenary discussions" (2 H)
- "Pet presentations" (3 H)

AmP workshop (16.5 hrs)



Group discussion (6 hrs)

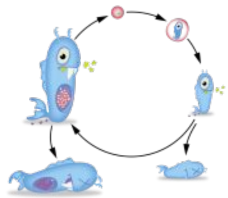


- Formulating research questions
- Sharpening research questions
- Group input and inspiration

TOPIC 1 (Jun 05, 06 & 07): “Metabolic scaling, life-history theory, and DEB”

TOPIC 2: (June 09,10 & 12) “From stylized facts to DEB model(s)”

Plenary Discussion (2H)



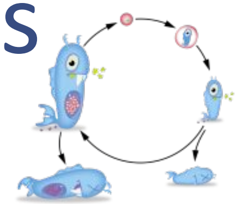
Thurs 08 & Tues 13

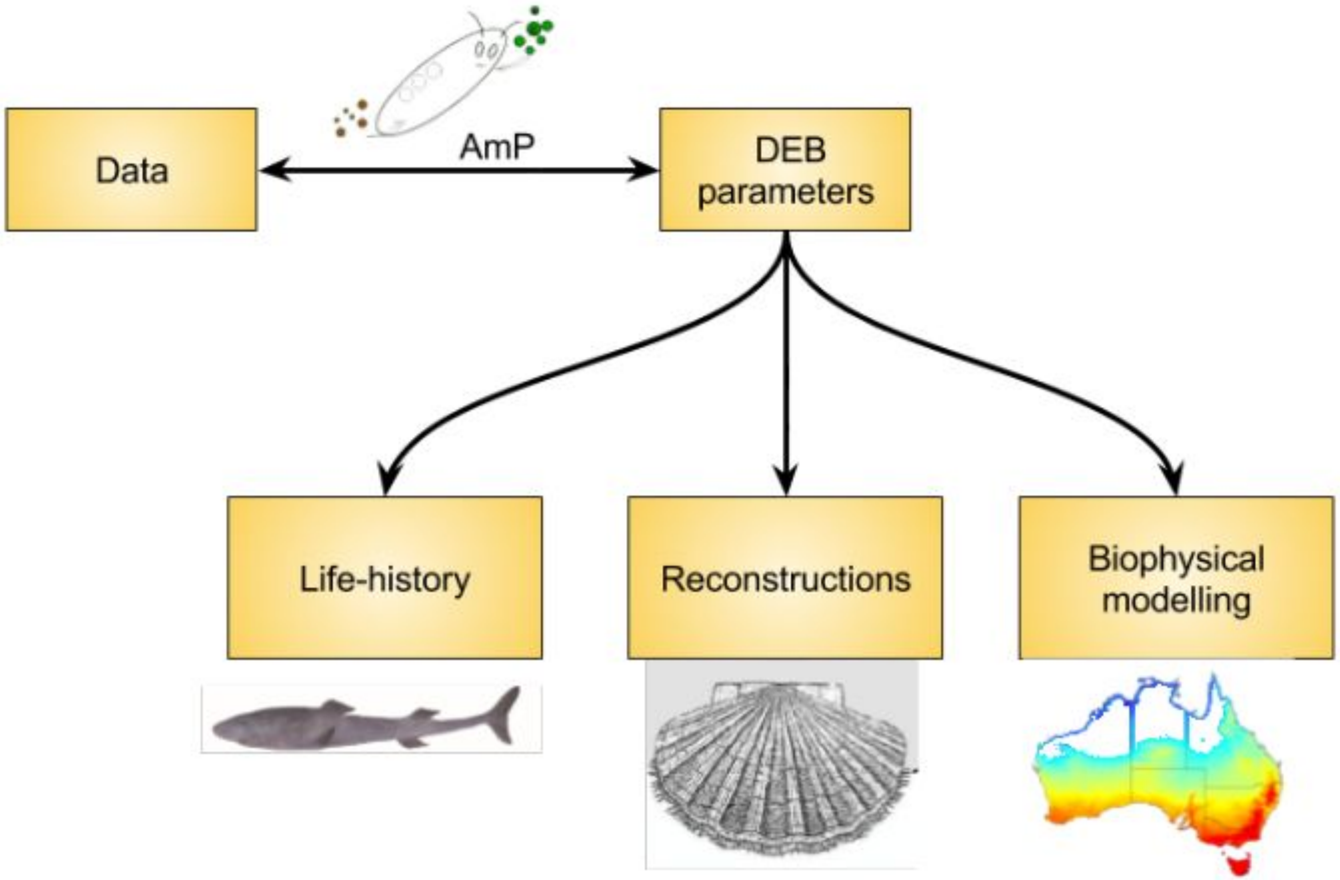
We switch groups around after the 1st prenary

Make you you have a reporter for each group to present general results to the group for the plenary

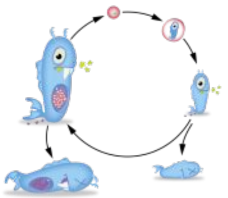
Moderated debate around the discussion topic

"DEB in practice" - guided exercises on applications (11 H)





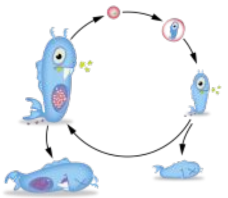
Summary of Tele-course



What are key concepts behind the DEB theory?

“cornerstones”

Life-cycles: creating maps

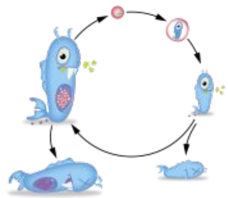


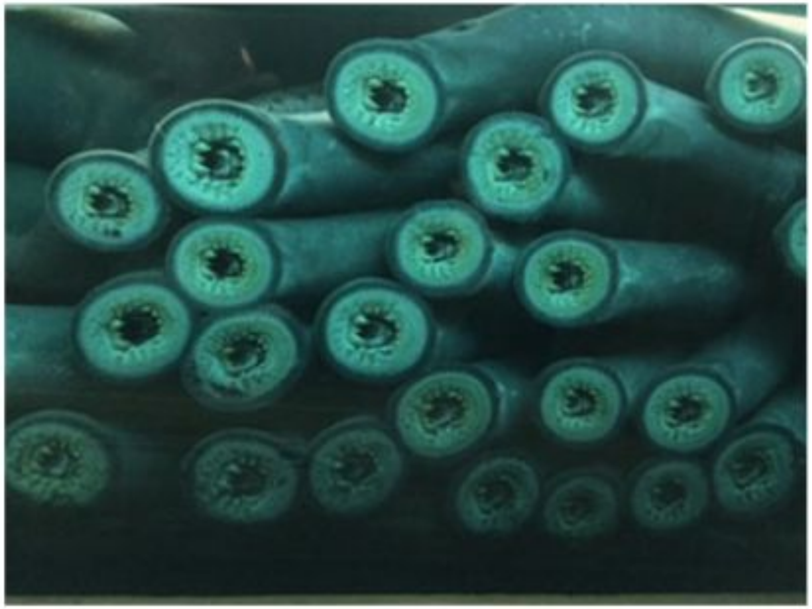
Why are DEB defined life-stages and not terminology used by specialists of each group?

How to model a complex life-cycle? Approach, Discussion

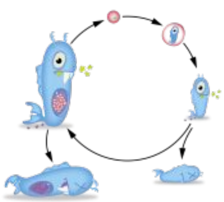
Complex life-cycles as variations of the Standard DEB model “std”

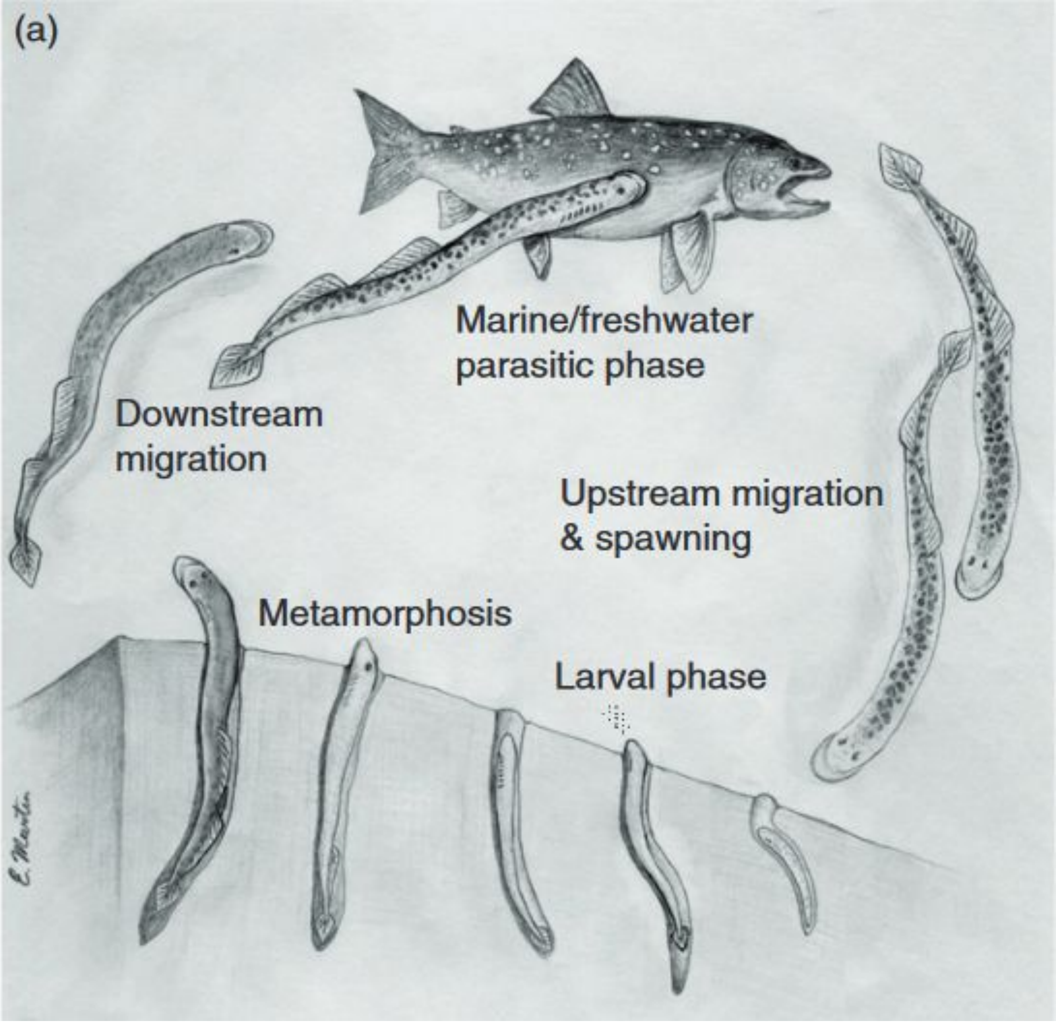
Example of complex life-cycles: the Lampreys



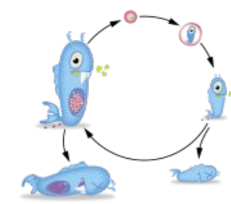


Lamprey life-cycle:





Lamprey life-cycle



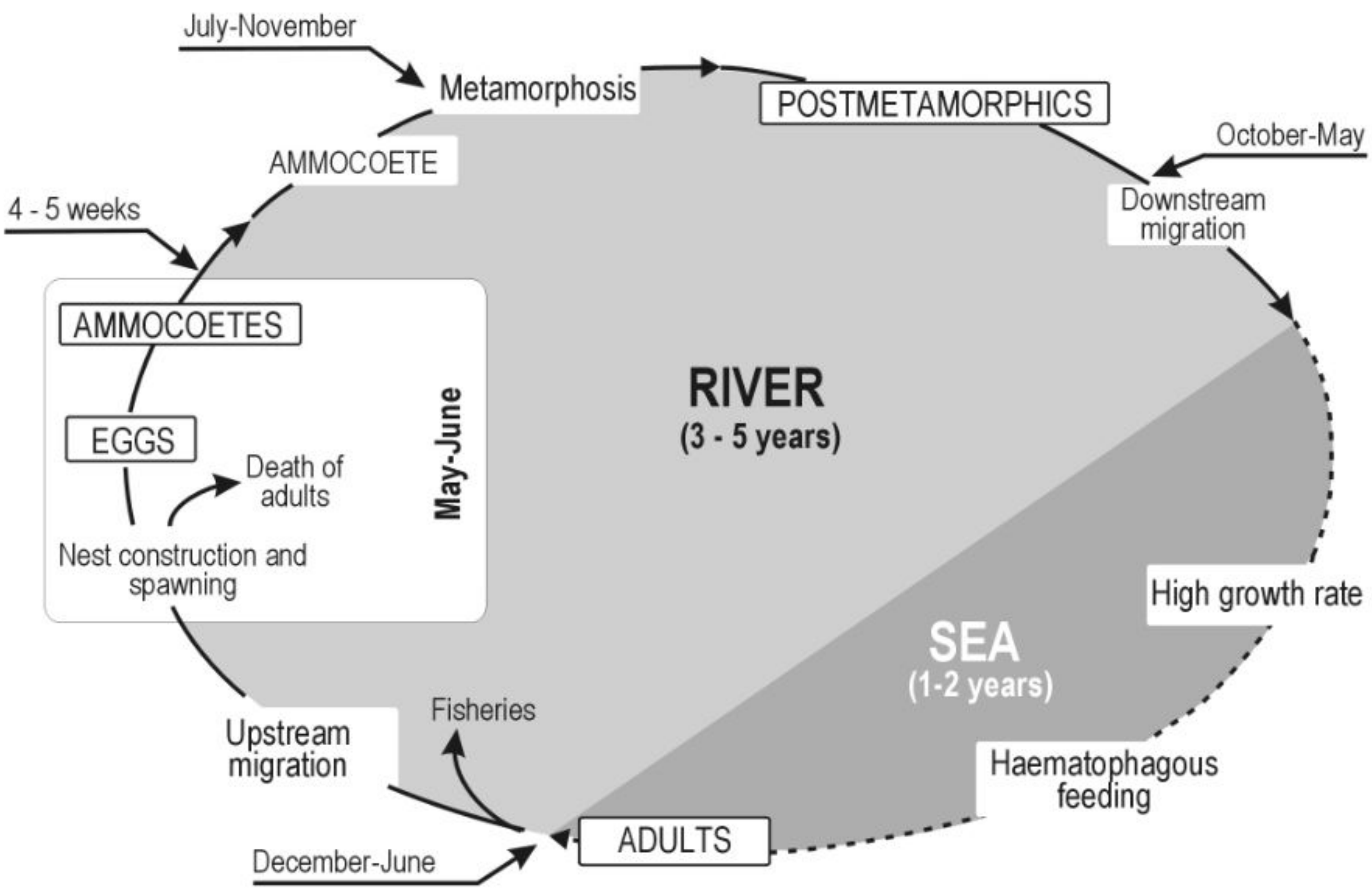
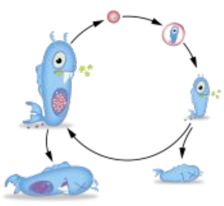
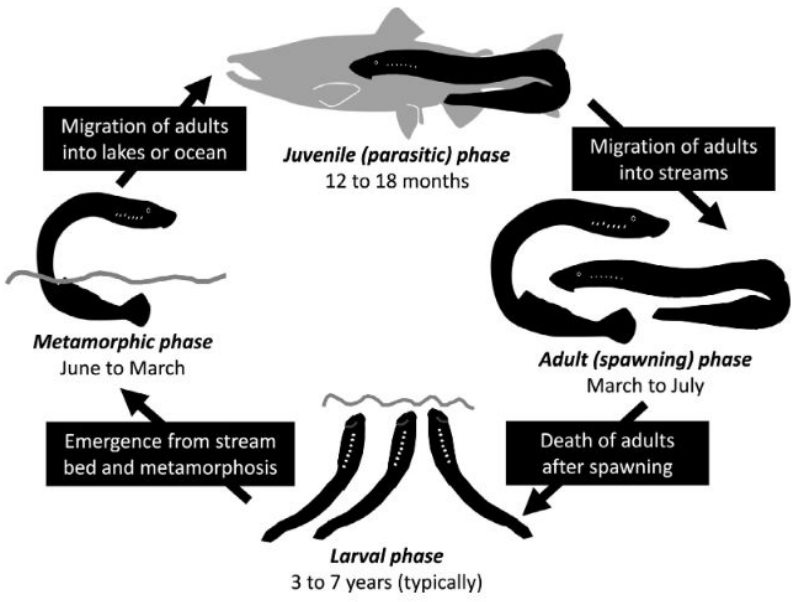


Figure 14-15. Life cycle of *P. marinus* in the NW of the Iberian Peninsula.

Lamprey life-cycle by species





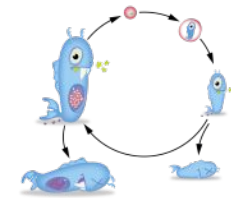
41-45 species

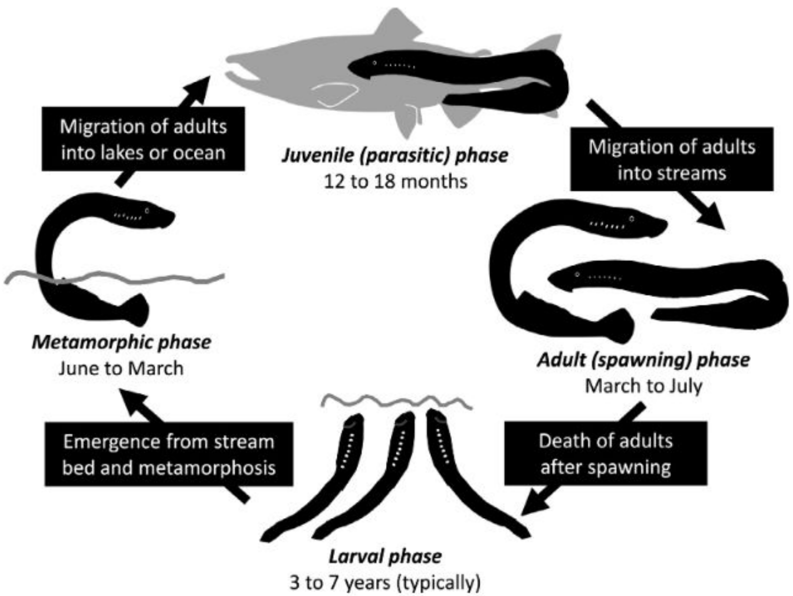
18 species have the “parasite” “juvenile” stage

23-27 are brook lampreys which:

- remain in their streams.
- have non-trophic periods of metamorphosis and sexual maturation are superimposed.
- are the only vertebrates known to have “non-trophic adults”

Lamprey life-cycle by species

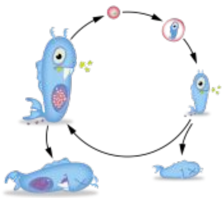




Important Questions:

- Where is feeding?
- Where is puberty?
- Where is allocation to reproduction happening?
- What is metamorphosis

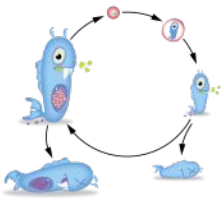
Life-cycles:
Life-stages and events



	event		life stage
0	start of development	**0b**	embryo (non-feeding)
b	birth (start feeding)	**bj**	larva (juvenile)
x	weaning/fledging	**bx**	baby (mammals), nestling (birds)
j	end of acceleration	**jp**	juvenile (post larval)
p	puberty	**pi**	adult
e	emergence (insects)	**je**	pupa (holometabolic insects)
i	death	**ei**	imago (egg-laying stage of insects)

What is a metabolic switch

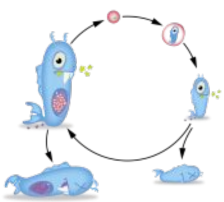
Life-cycles:
Morphological *vs* Functional



1 simple DEB model - complex life-cycles with many morphological life-stages and transformations

Morphological events and life-stages
metamorphosis, pupation
settlement of bivalves
emergence of dragonflies, midges
larvae
imagos

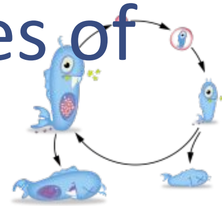
Metamorphosis: “Indirect development”



- Invertebrate taxa: insects, echinoderms
- Non-vertebrate chordates: cephalochordates and urochordates
- Vertebrate chordates: lampreys, eels, flatfishes, amphibians

Those who do not metamorphosis: direct-developers

All models can be extended with more stages of maturity: one for each stage:



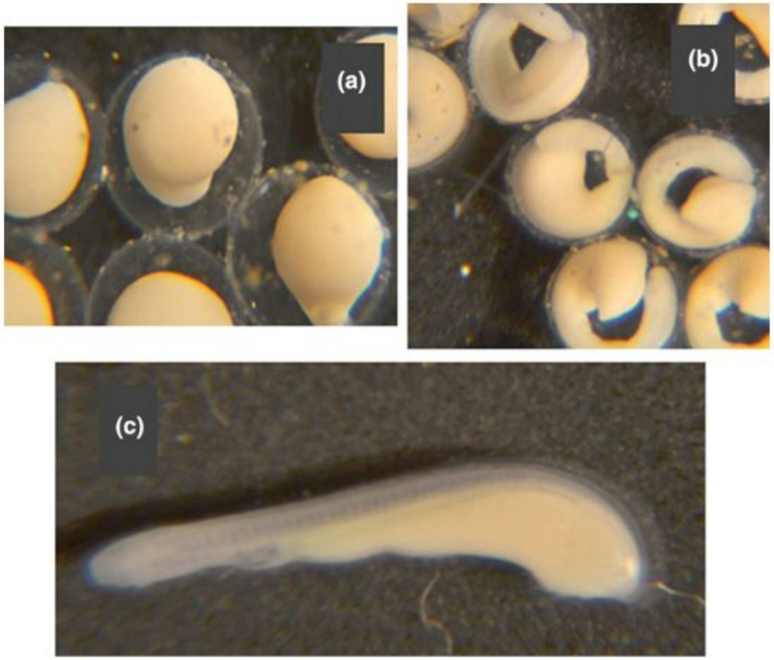
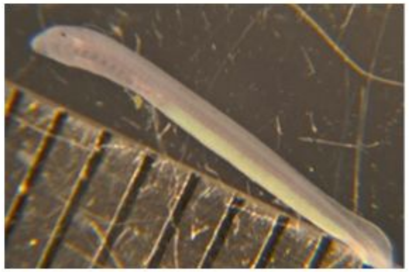


Fig. 2.1 Larval development of Pacific lamprey: **a** early neurula stage 11; **b** pre-hatching stage 13; and **c** hatching stage 14 (*Photo* © Mary L. Moser)

Fig. 2.2 Pacific lamprey prolarva (stage 15; see Sect. 2.1.2) (*Photo* © Mary L. Moser)



Embryo staging Atlas:

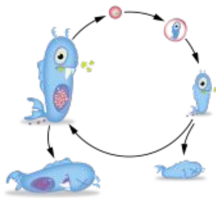
stage 1: zygote

stage 14: hatching

stage 17: prolarvae begins to burrow

stage 18: onset of exogenous feeding

Cornerstones



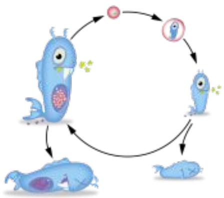
Conservation

Homeostasis

Reserves

Kappa

Conservation



C

H

Exploit conservation of energy and masses

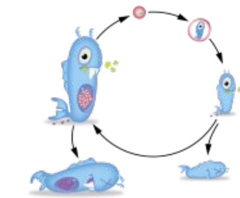
Energy conservation is straight forward.

R

Mass conservation is not because elements are trapped in molecules.

K

chemical indices & chemical potentials

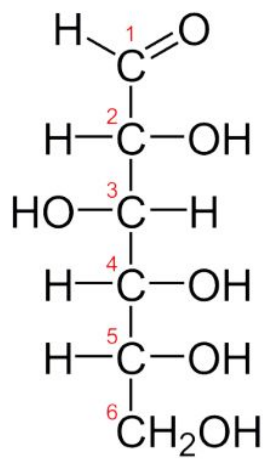


C

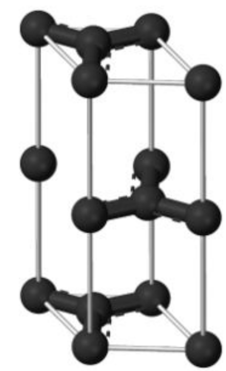
H

R

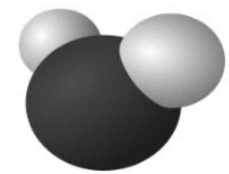
K



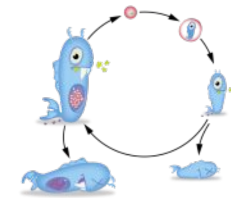
$C_6H_{12}O_6$



C



H_2O



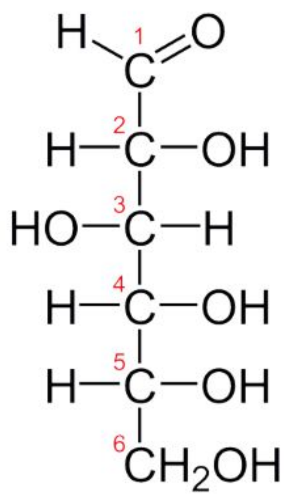
the c-mol

C

H

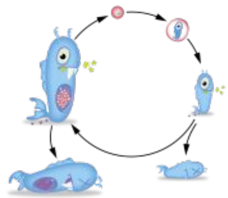
R

K



$C_6H_{12}O_6 \longrightarrow$ 6 C-moles of : CH_2O

macro-chemical reaction equations



C

Oxygenic photosynthesis:

H

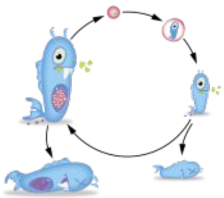
Respiration (mitrochondria)

R

K

Metabolism of the individual ?

macro-chemical reaction equations



C

H

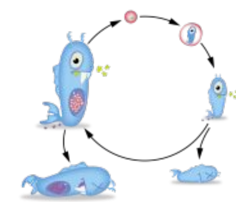
R

K

- Stoichiometry
- Anabolic and catabolic aspects to reactions

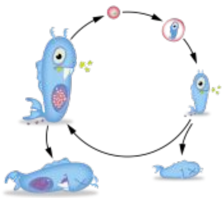
https://www.youtube.com/watch?v=wJyUtbn0O5Y

3 basic transformations:



compounds →		minerals, $\mathcal{M}$				org. comp. $\mathcal{O}$			
transformations ↓		carbon dioxide C	water H	dioxygen O	nitrogenous waste N	food X	structure V	reserves E	faeces P
assimilation	A	+	+	−	+	−		+	+
growth	G	+	+	−	+		+	−	
dissipation	D	+	+	−	+			−	

Homeostasis



C

H

R

K

strong

constant composition of pools (reserves/structures)

generalized compounds, stoichiometric contraints on synthesis

weak

constant composition of biomass during growth in constant environments

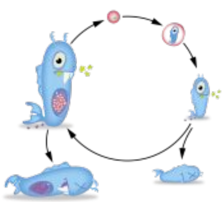
determines reserve dynamics (in combination with strong homeostasis)

structural

constant relative proportions during growth in constant environments

isomorphy

Delimitation of pools respecting strong homeostasis



C

H

Strong homeostasis : C-mol of material

We need to specify elemental frequencies

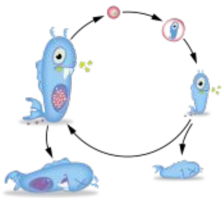
R

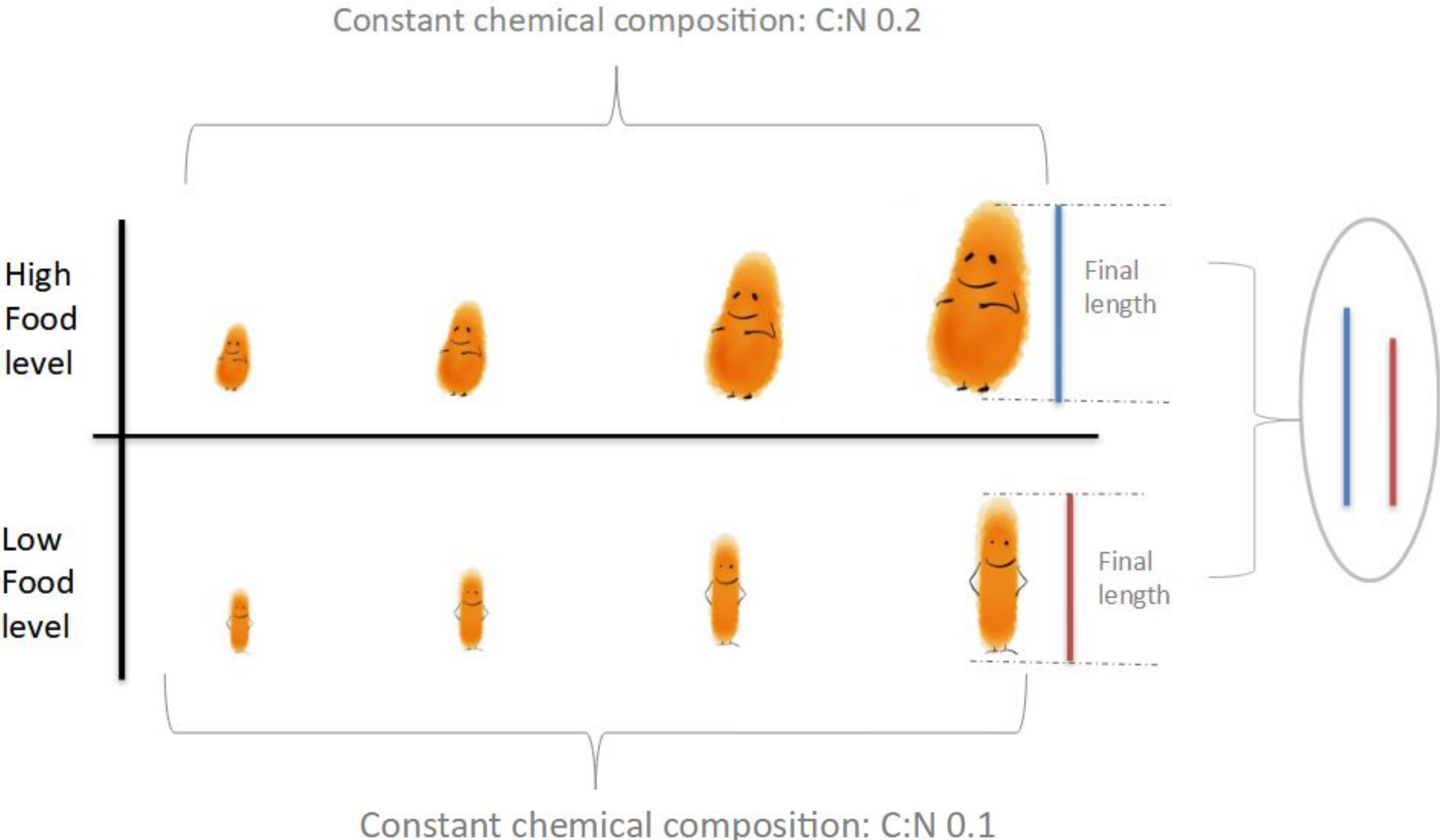
We need to specify chemical potential : Joules per C-mol

We need a way to convert volumes to mass

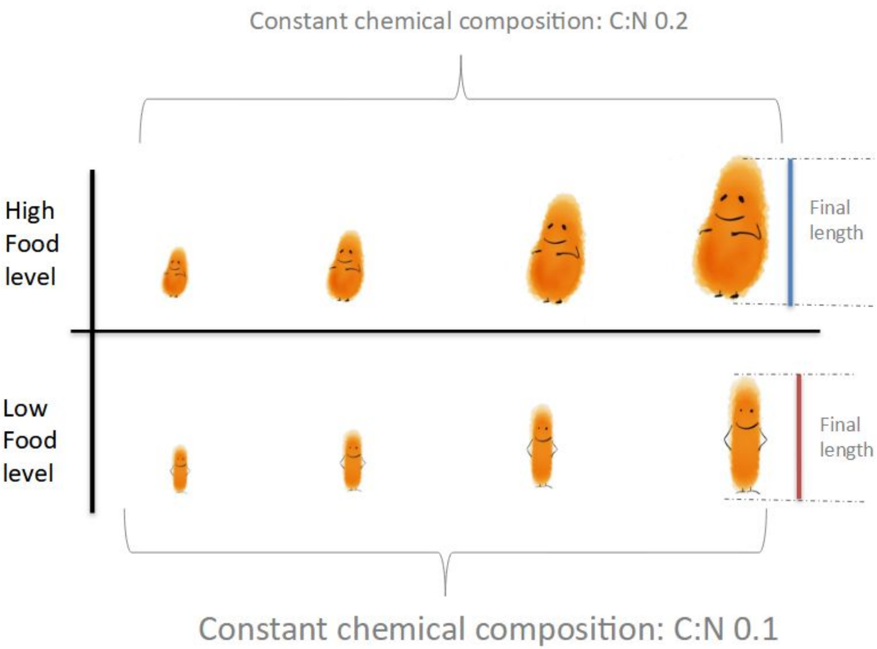
K

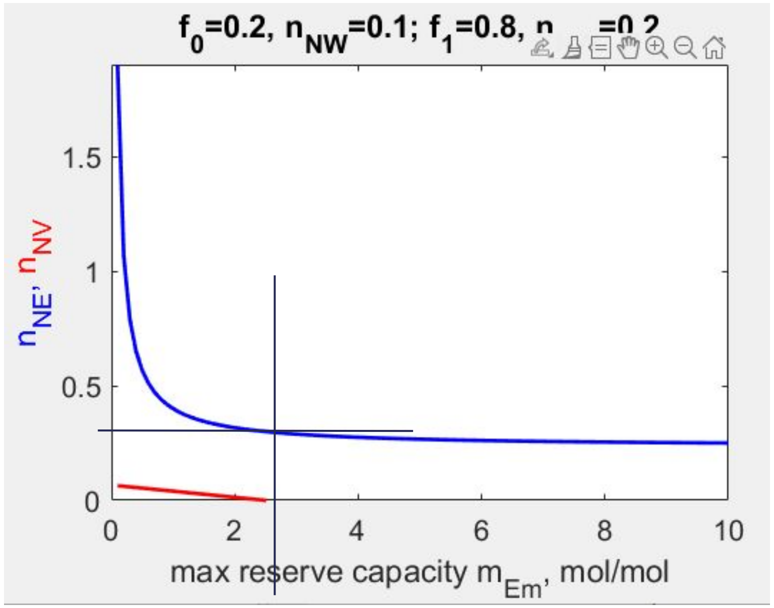
Weak homeostasis





Weak homeostasis





get_nNEV

Gets chemical indices for nitrogen of reserve and structure, from data for biomass

Contents

- Syntax
- Description
- Remarks
- Example of use:

Syntax

m_Em, n_NEV] = = **get_nNEV** (f, n_NW, m_Em)

Description

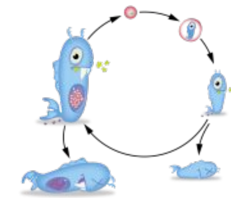
Gets chemical indices for nitrogen of reserve (E) and structure (V), from data for biomass (W) at 2 values for scaled functional response (f). A graph is produced for varying max reserve capacity m_Em.

C

H

R

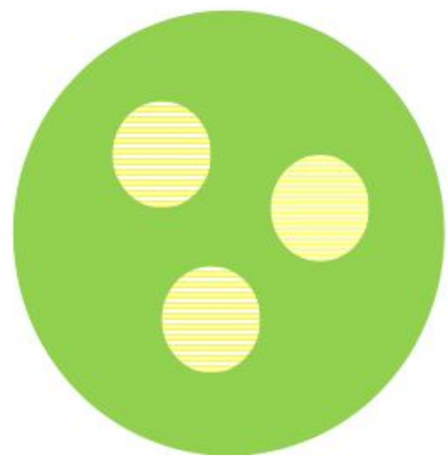
K



2 types of material → Reserve

2 types of material → Structure

Reserve and Structure are intermingled at the cellular level:



C

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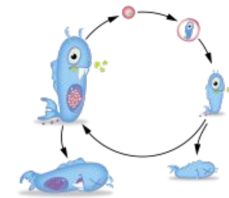
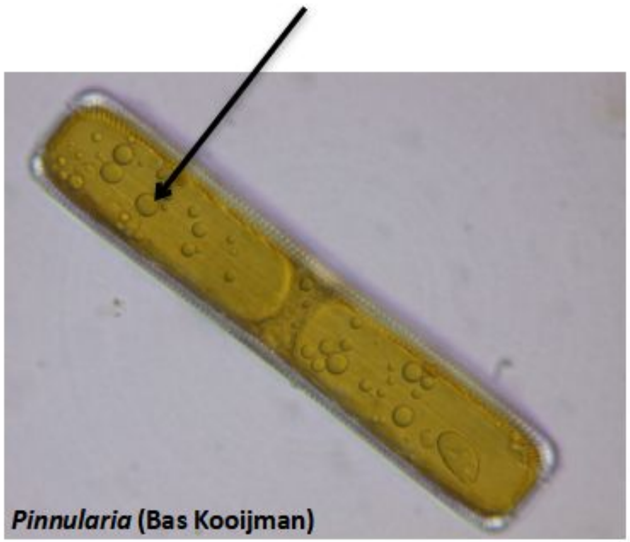
R

K

Reserve and Structure



Intermingled at the cellular level



Pinnularia (Bas Kooijman)

RESERVES: all compounds which are not maintained and which are used in reactions for e.g. growth or maintenance processes are reserve molecules

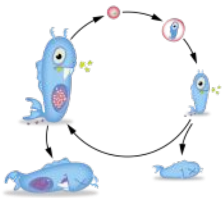
C

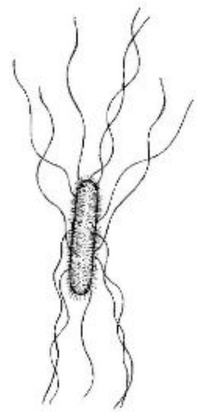
H

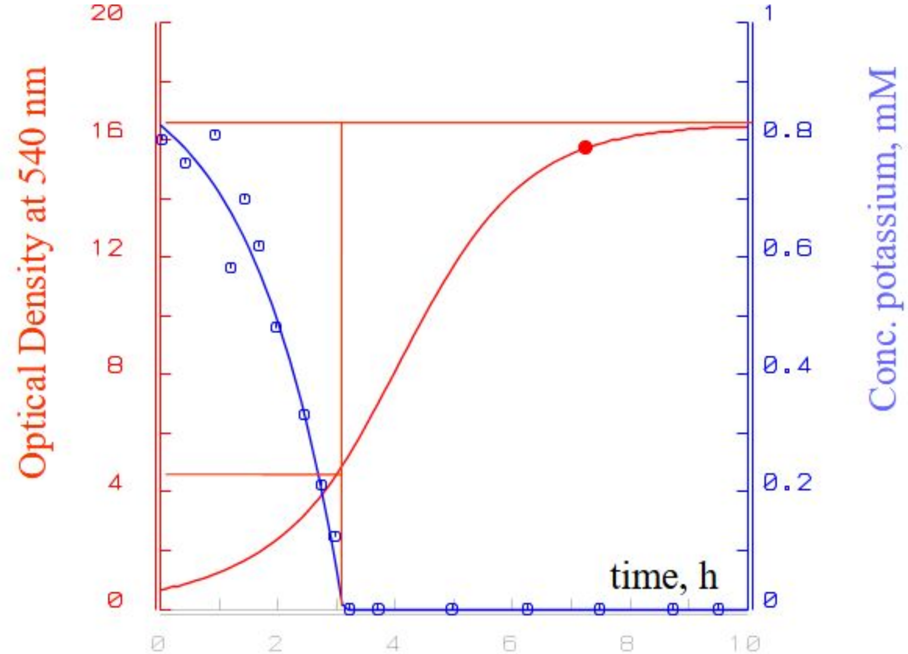
R

K

Growth on reserve







Potassium limited growth of *E. coli* at 30 °C
Data Mulder 1988; DEB model fitted
OD increases by factor 4 during nutrient starvation
internal reserve fuels 9 hours of growth

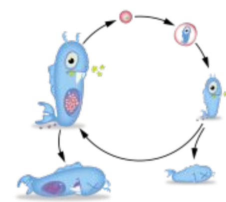
C

H

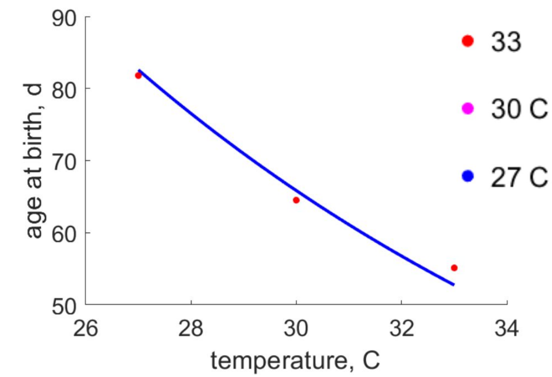
R

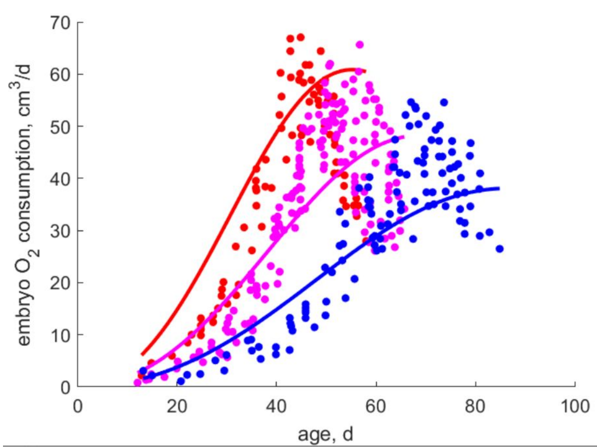
K

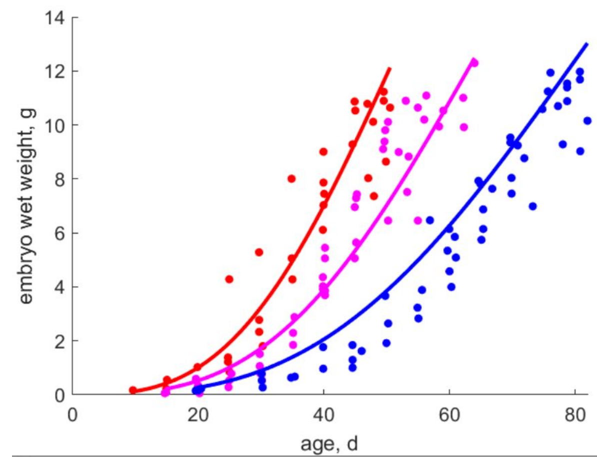
Embryonic development



Example: embryo development of African softshell turtle







Bas Kooijman. 2021. AmP *Trionyx triunguis*, version 2021/05/01.

Thank you

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Starrlight

Questions?