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Thermal tolerance in the lugworm *Arenicola marina*: measures of climate dependent organismal performance

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AWI NMR

Deutsche Forschungsgemeinschaft DFG

AQUA SHIFT

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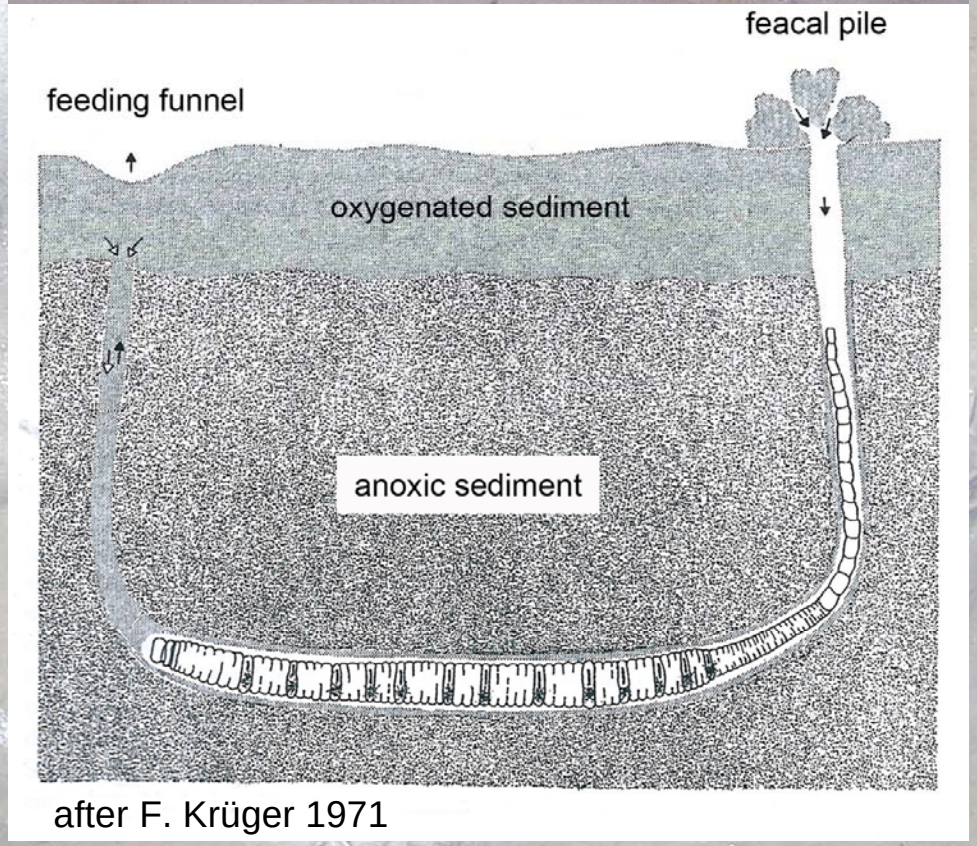
Model organism

The lugworm *Arenicola marina* beside it‘s burrow

Longitudinal section of the burrow



after F. Krüger 1971

Organismal performance

As seen in fishes (Pörtner and Knust 2007), long-term warming

=> reduced performance (growth, reproduction, muscle exercise,...)

=> ecological consequences:

- decreased abundance
- local extinction
- shift in distribution

Latitudinal adaptation

How do populations in a latitudinal cline differ in their temperature dependent performance?

Populations

Organismal performance

As seen in fishes (Pörtner and Knust 2007), long-term warming beyond pejus temperatures

=> reduced performance (growth, reproduction, muscle exercise,...)

=> ecological consequences:

- decreased abundance
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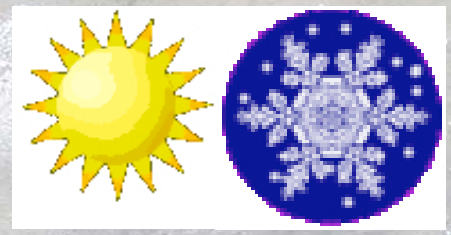
Latitudinal adaptation

How do populations in a latitudinal cline differ in their temperature dependent performance?



Seasonal acclimatisation

In which way does performance change with seasonal acclimatisation?

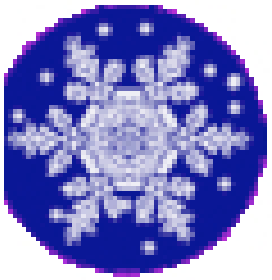
Seasonal comparisons in the same population

North Sea


Photo: V. Nießing

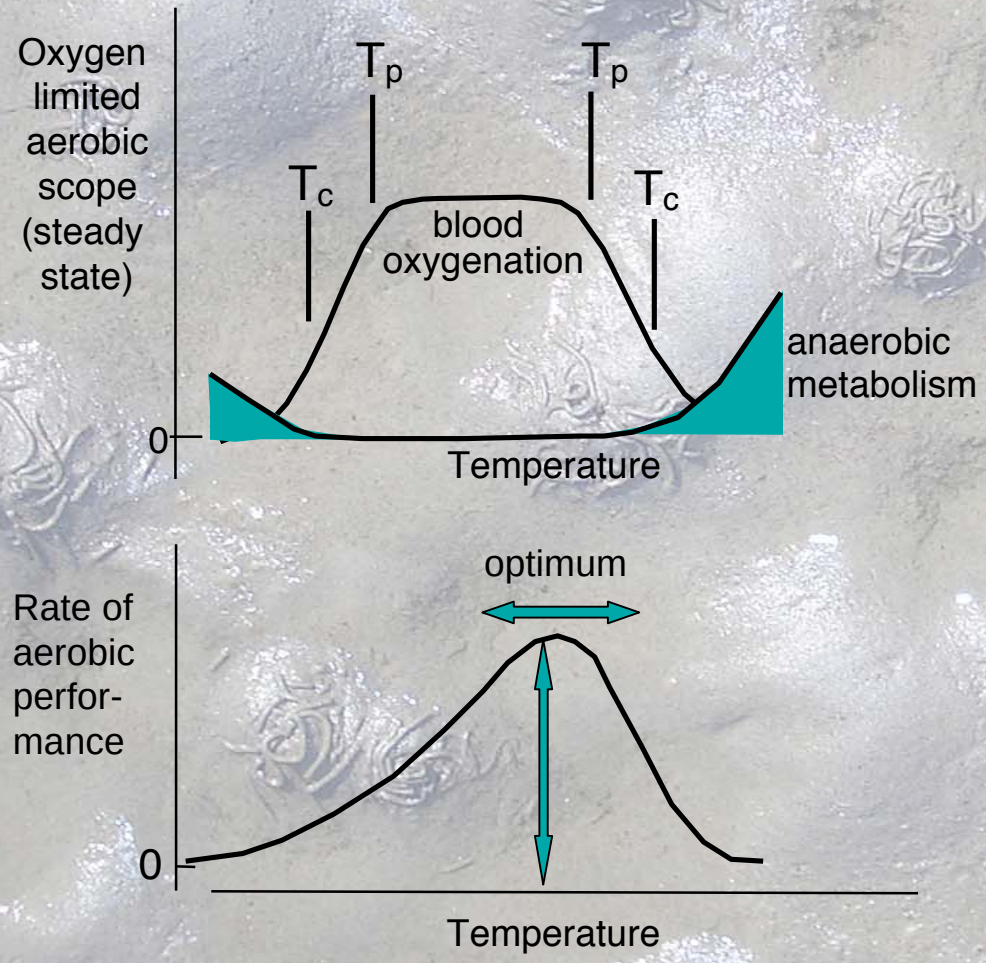

Photo: V. Nießing

summer



winter

Temperature thresholds and performance



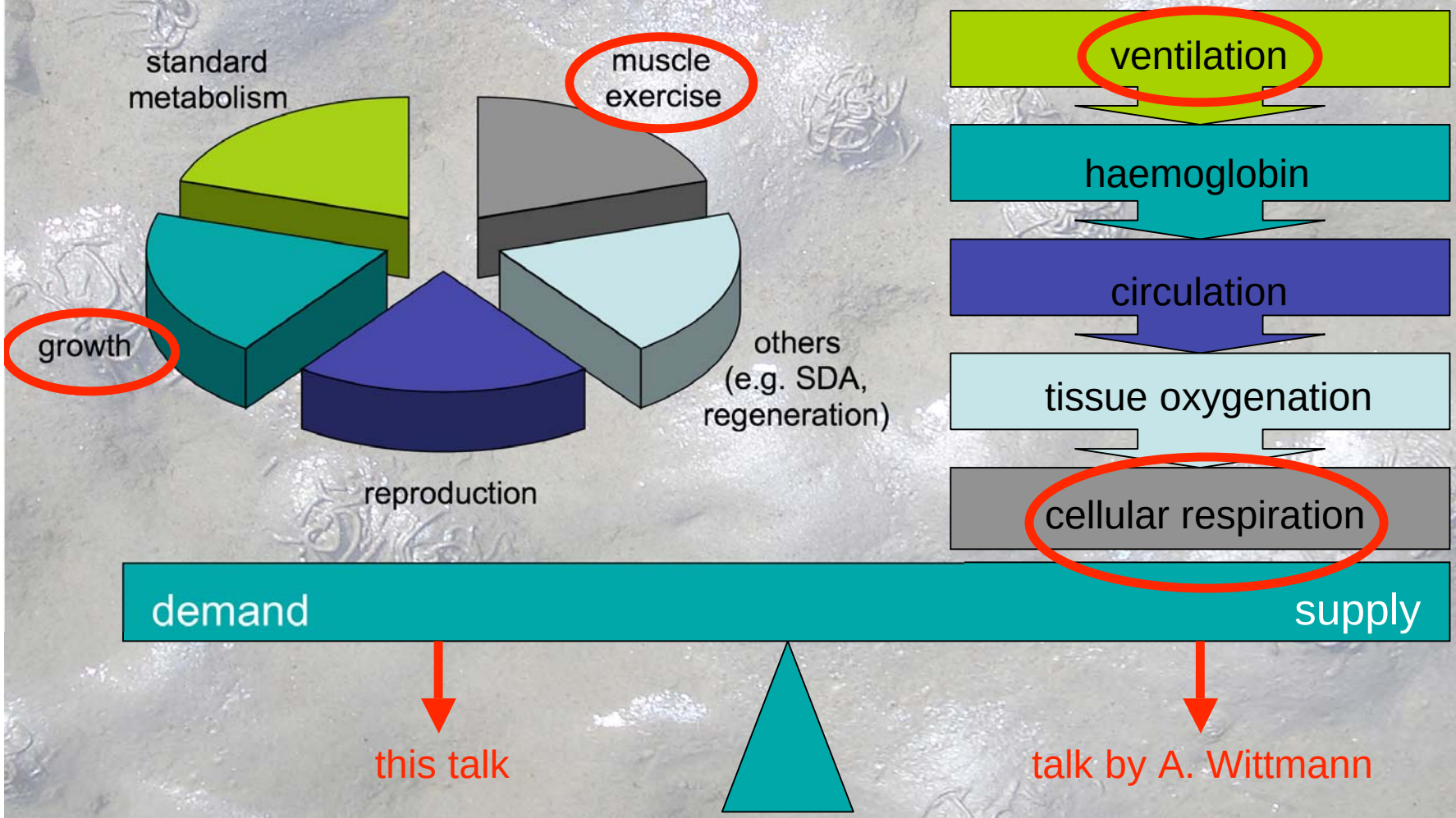
After: Pörtner et al. 2004

T_p: pejus temperatures
oxygen supply limit
decreasing blood oxygenation
loss of performance

T_c: critical temperatures
metabolism turns anaerobic
survival time limited unless
acclimatisation occurs

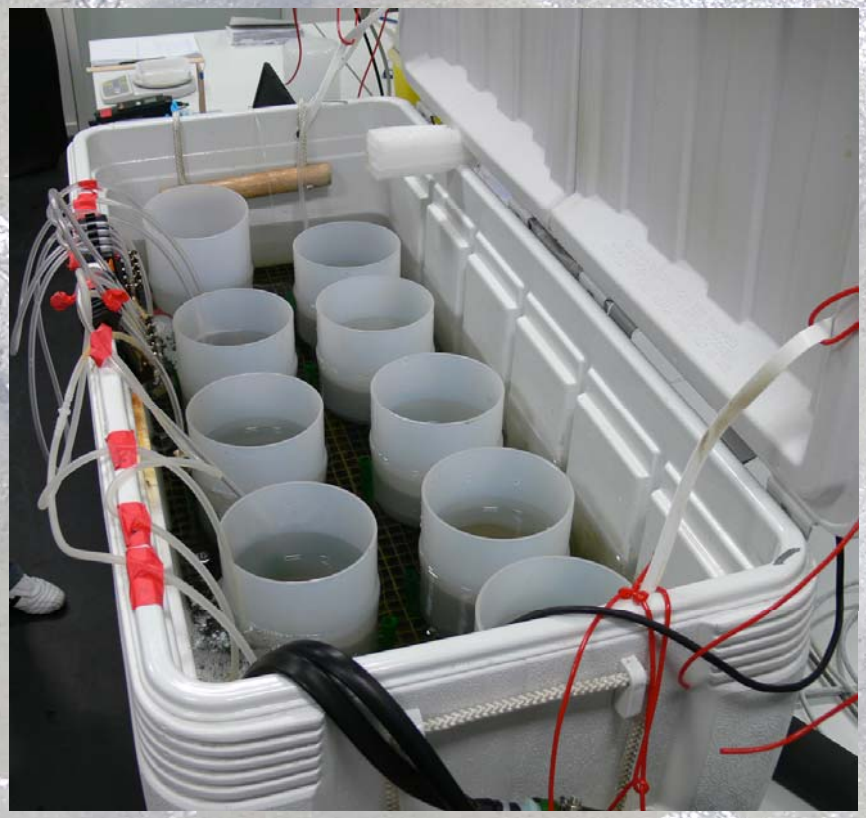
Performance curve: oxygen supply budget above basic metabolism

Balance of oxygen demand and supply



Muscle exercise: digging activity

Method:

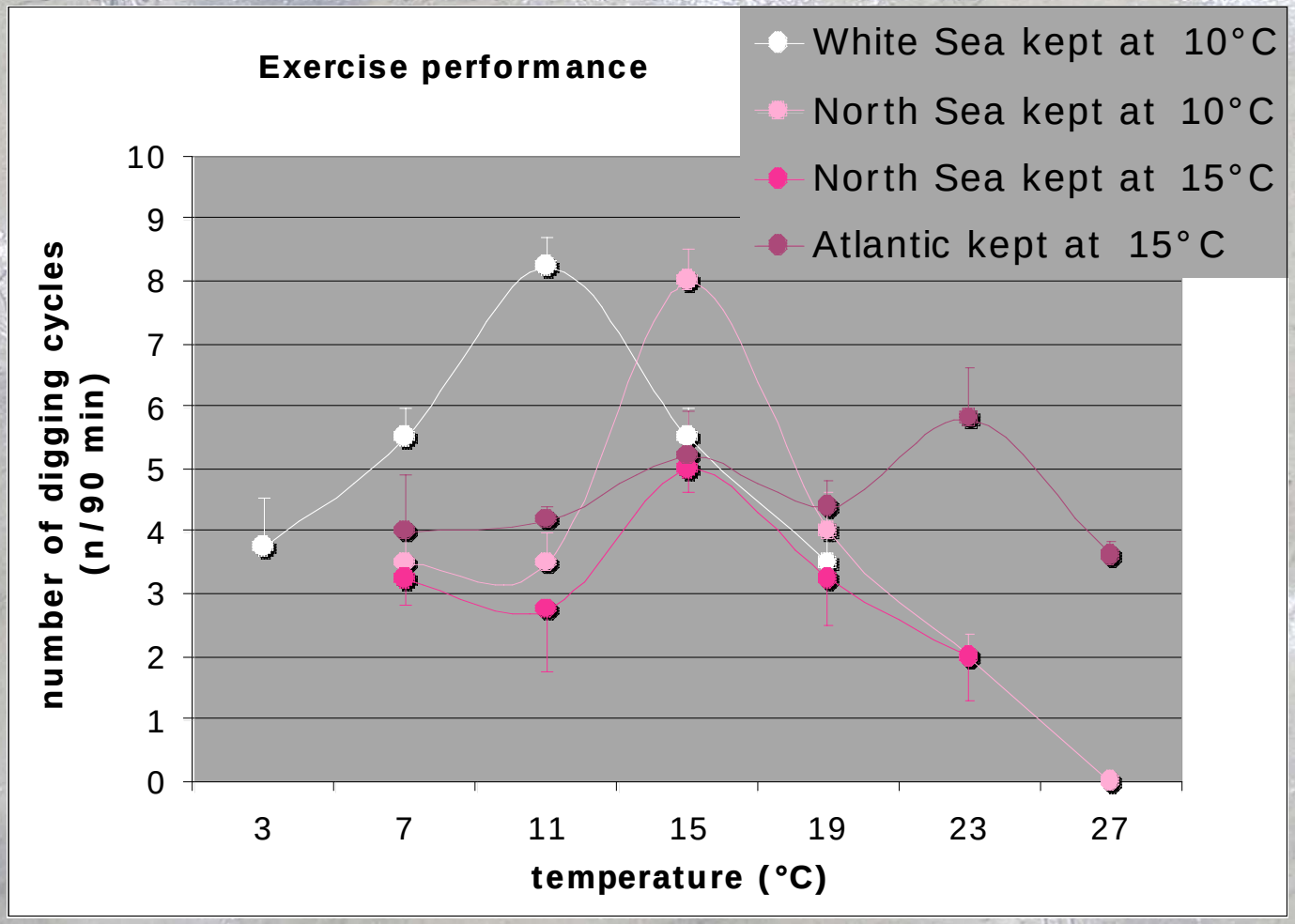


Experimental setup

Worm digging into sediment

Latitudinal adaptation

visible in summer animals from 3 populations:

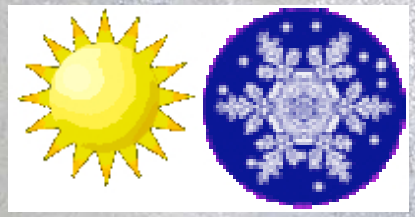


Performance optima:

White Sea 11ºC

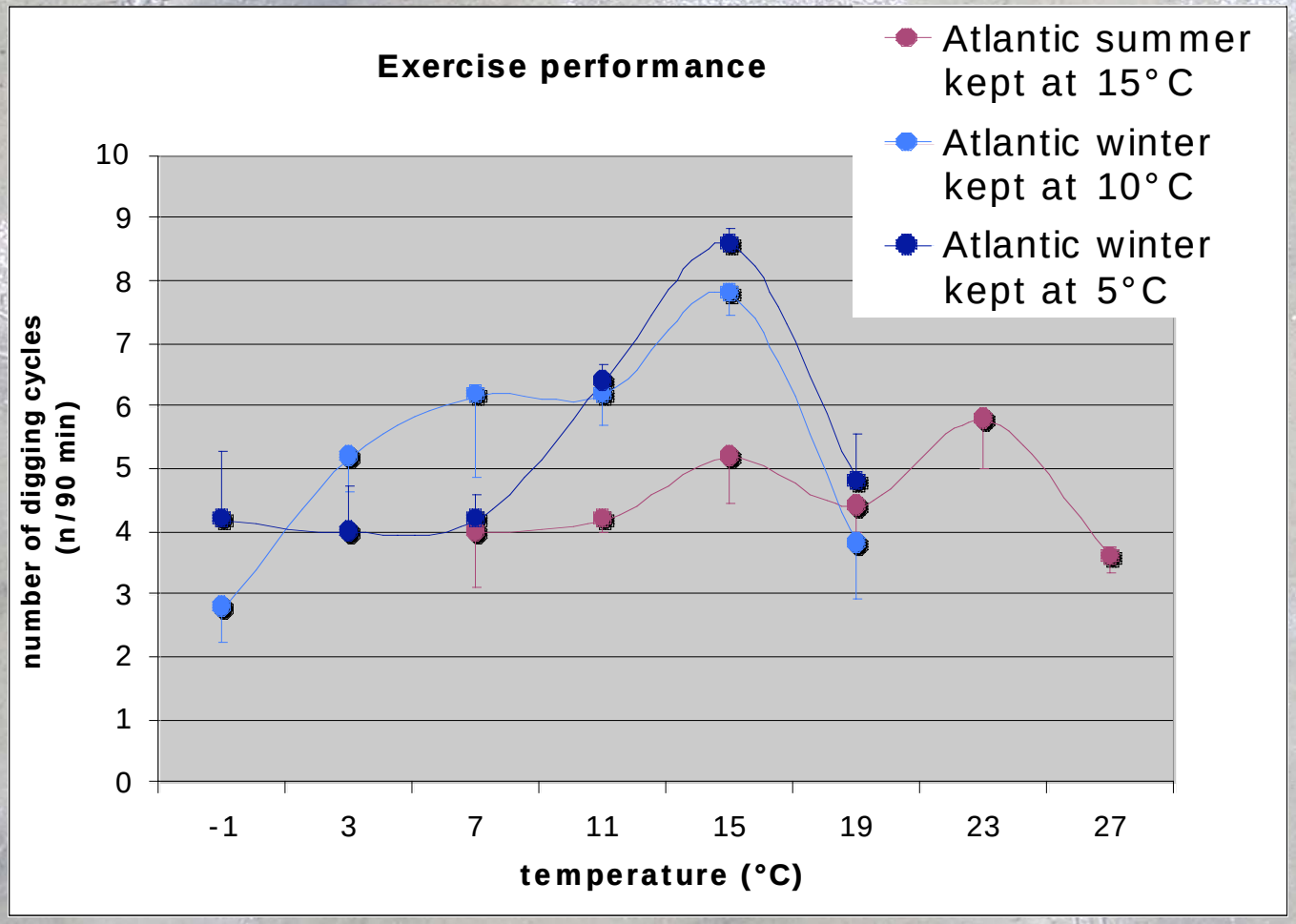
North Sea 15ºC

Atlantic 23°C



Seasonal acclimatisation

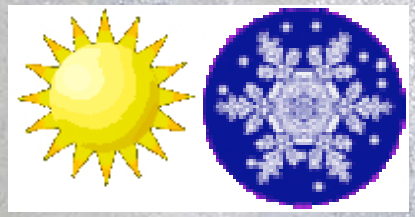
shown in summer and winter animals from the same population:



Performance optima:

Atlantic summer 23ºC

Atlantic winter 15ºC



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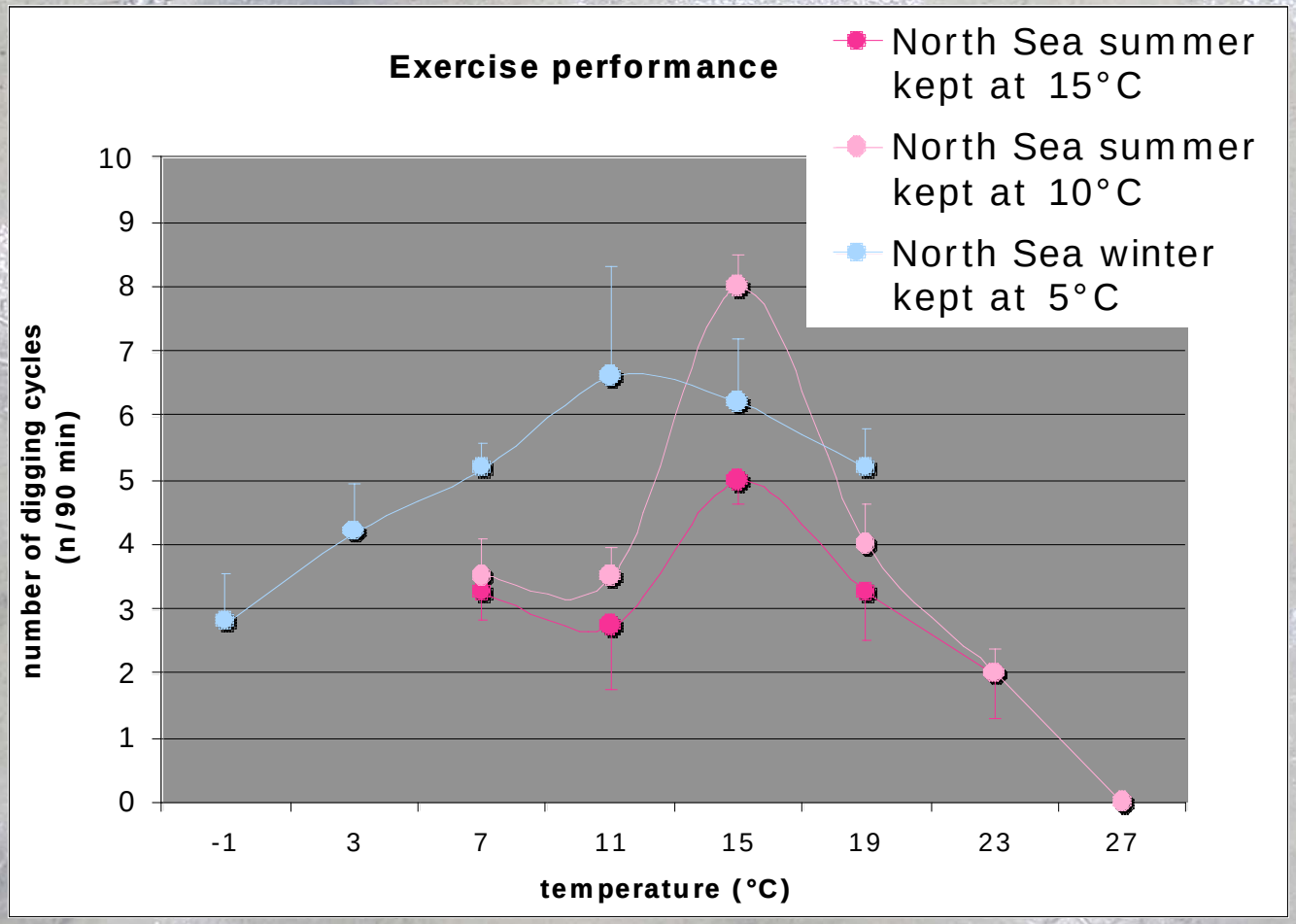


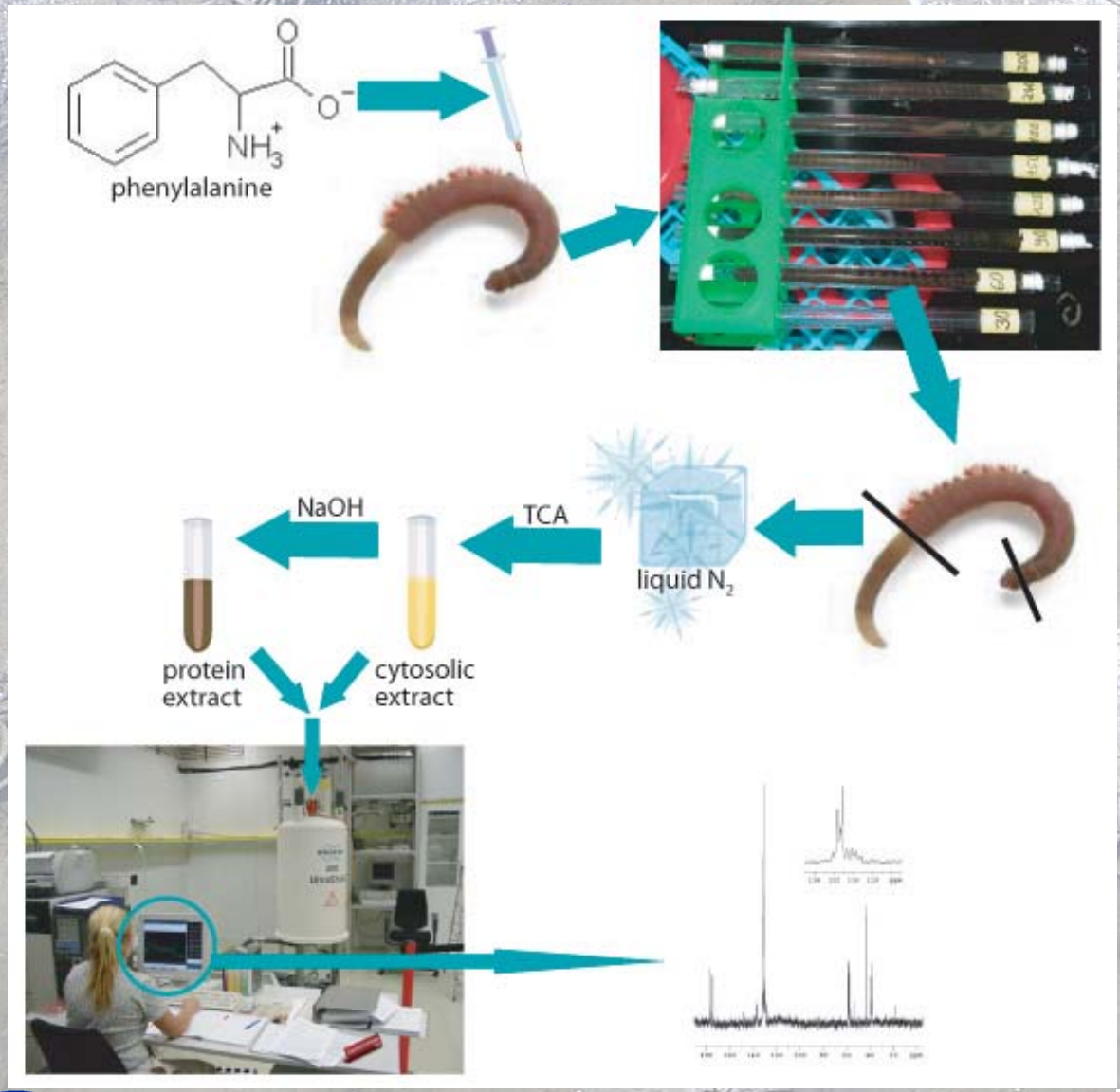
Performance optima:

North Sea summer 15ºC

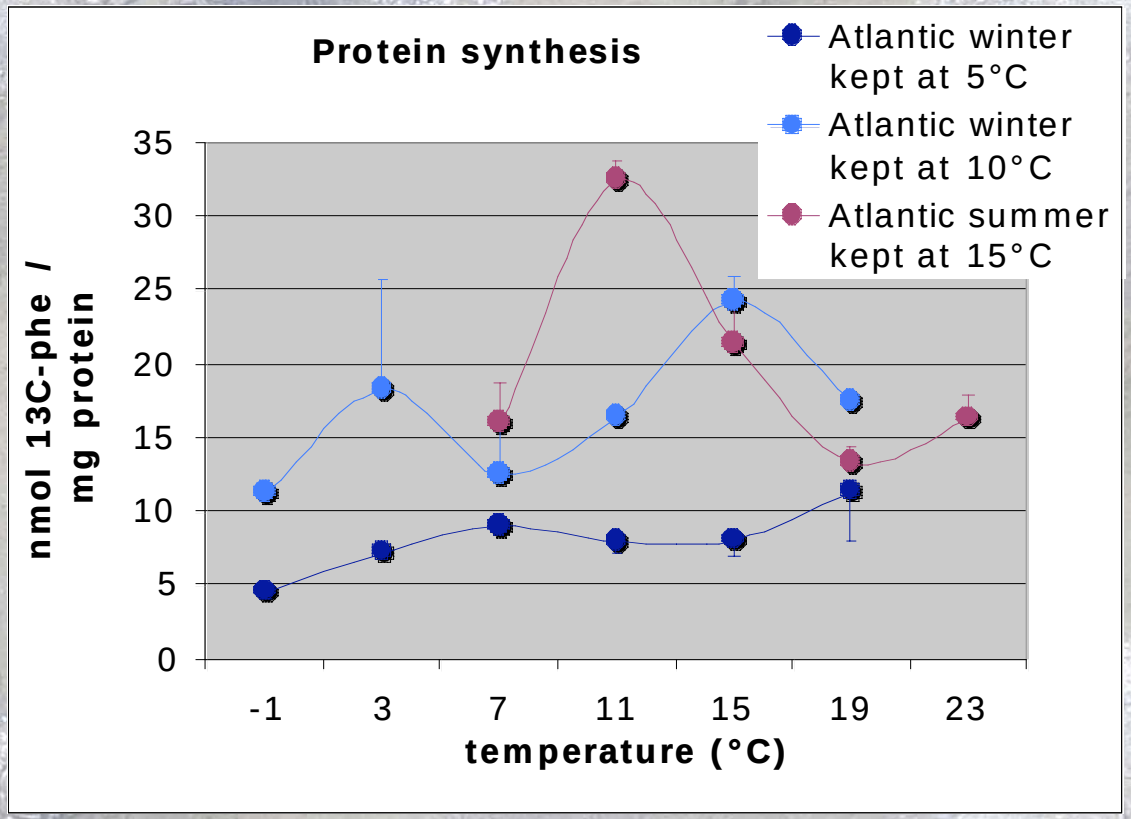
North Sea winter 11ºC

Protein biosynthesis (= growth?)

Method:



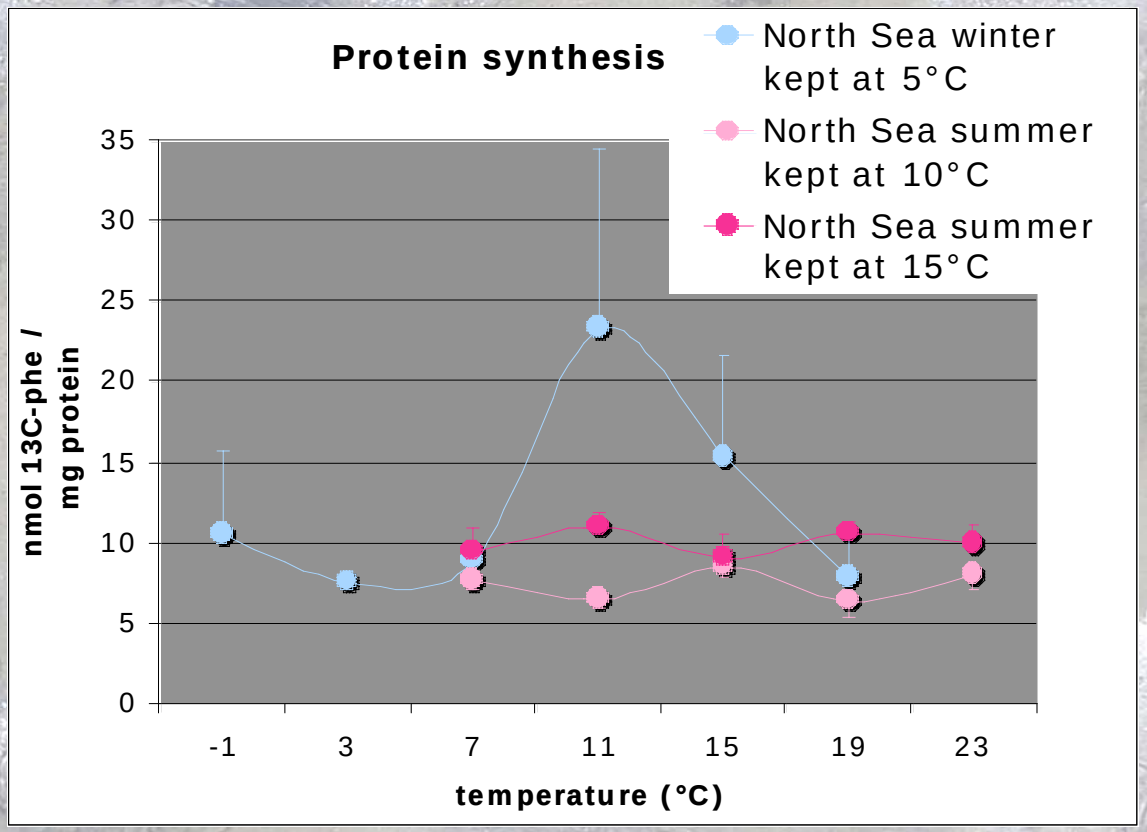
Protein biosynthesis



Atlantic:

- Highest synthesis performance in summer animals: performance optimum at 11ºC
- Protein synthesis detectable in winter animals kept at 10ºC: performance optimum at 15ºC

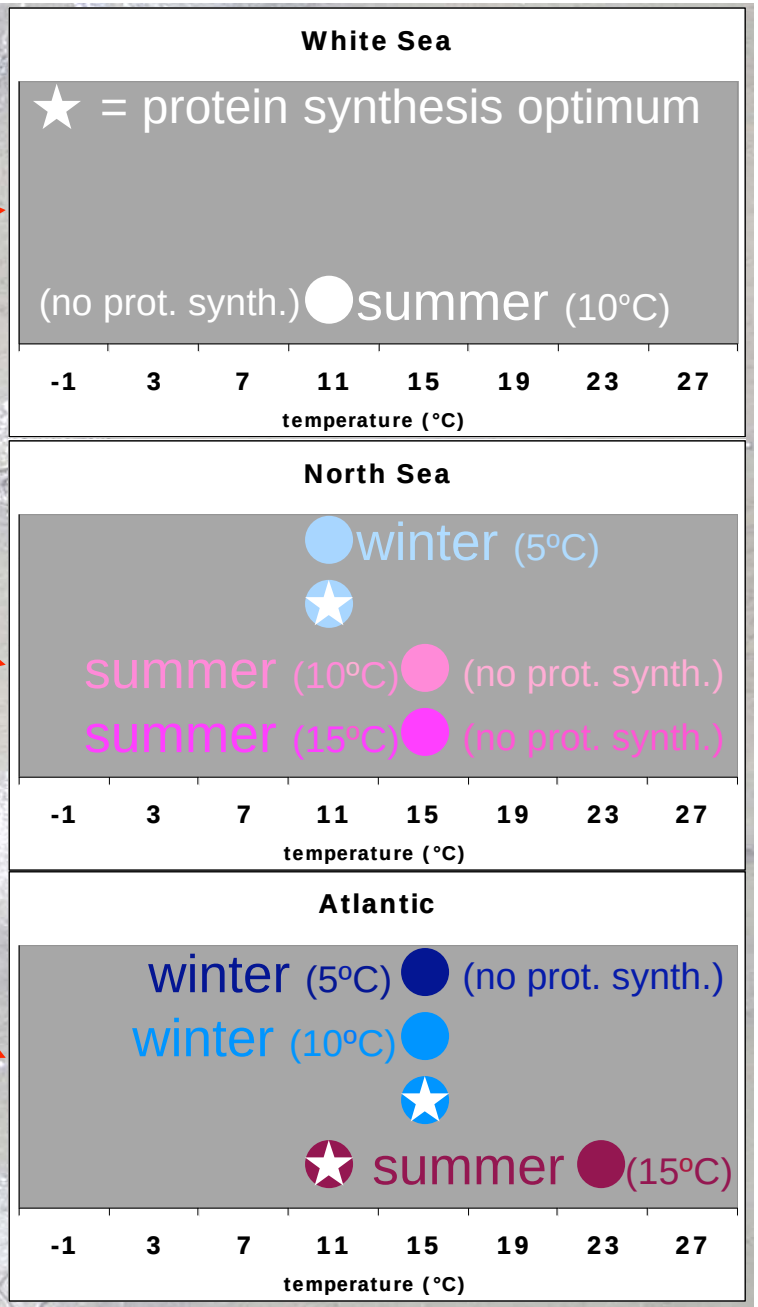
Protein biosynthesis



North Sea:

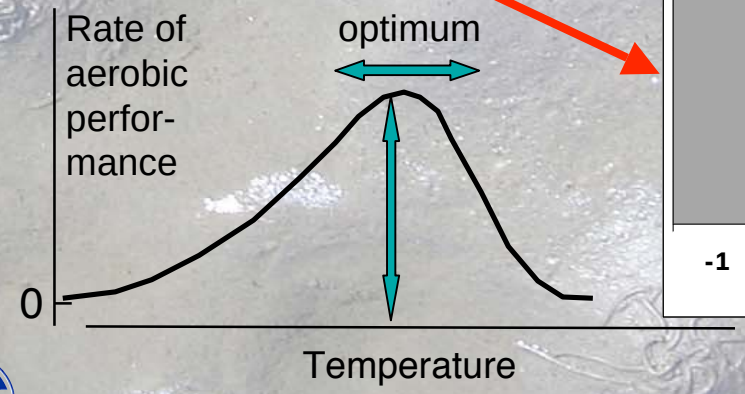
- Highest synthesis performance in winter animals: performance optimum at 11ºC
- No protein synthesis detectable in summer animals

Summary



Performance optima:

- latitudinal specialisation
- seasonal shifts

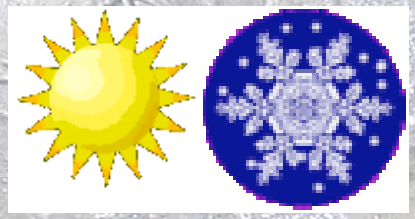


Conclusions

Latitudinal adaptation

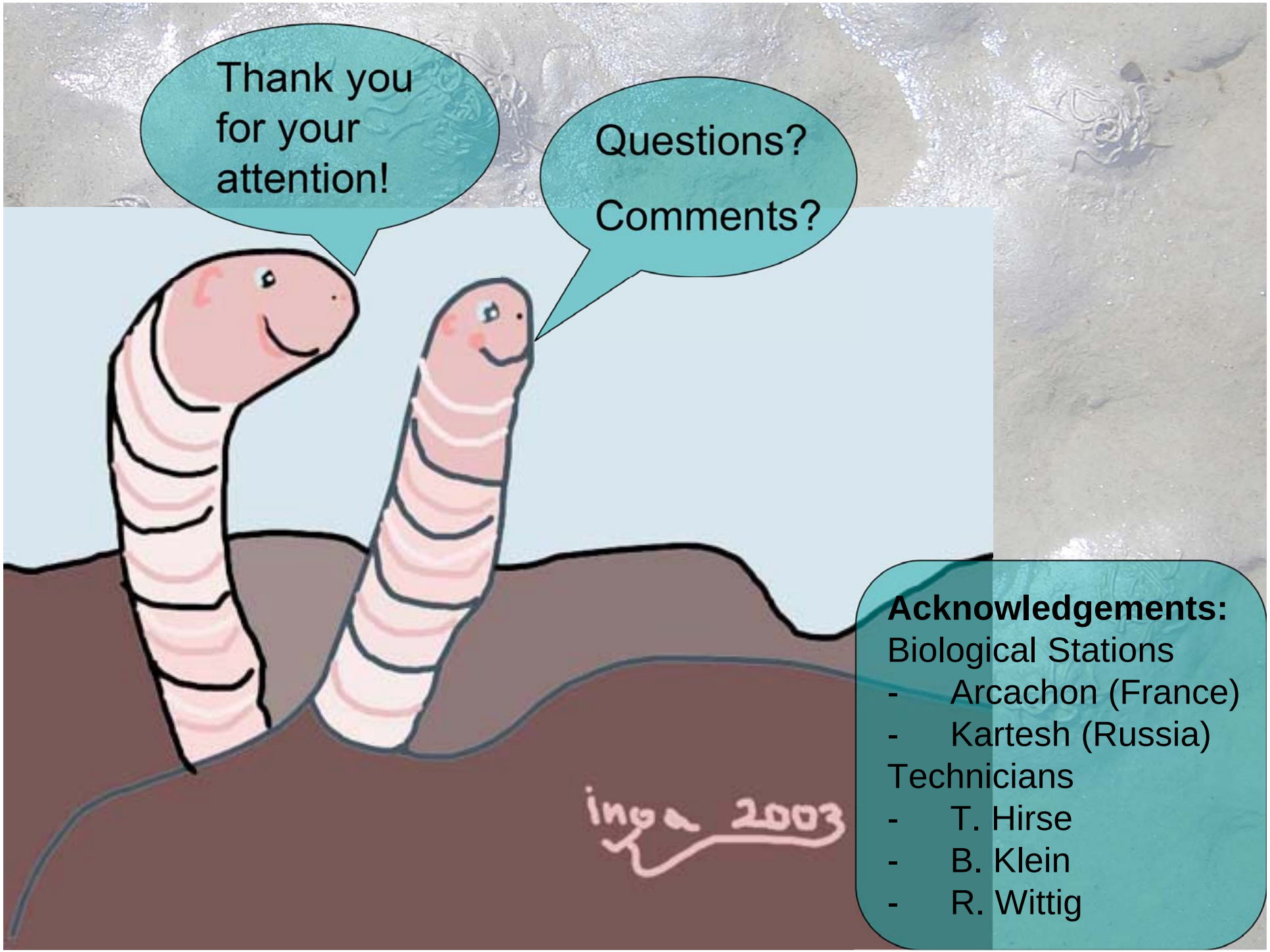
- Performance optima found at higher temperatures with decreasing latitude
- White Sea and North Sea summer animals: groups kept at 10°C show a similar maximum exercise performance amplitude
- North Sea and Atlantic summer animals: groups kept at 15ºC show a similar maximum exercise performance amplitude
- White Sea and North Sea summer animals: no protein synthesis detectable
- Atlantic summer animals: protein synthesis activity present, but performance optimum below habitat summer temperature range
- North Sea and Atlantic winter animals: protein synthesis optima agree with exercise performance optima

Conclusions



Seasonal acclimatisation

- Exercise performance optima shifted towards higher temperatures with summer acclimatisation
- Atlantic animals: shift by 8ºC; North Sea animals: shift by 4ºC
- Lower exercise performance amplitudes in summer than in winter
- protein synthesis performance optima located outside naturally experienced temperature range in winter and summer => maximum activity expected in spring



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