

# Revisiting oxygen supply and demand oxygen availability, metabolic rate and thermal limits in aquatic ectotherms



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# Outline

Oxygen defined thermal niches

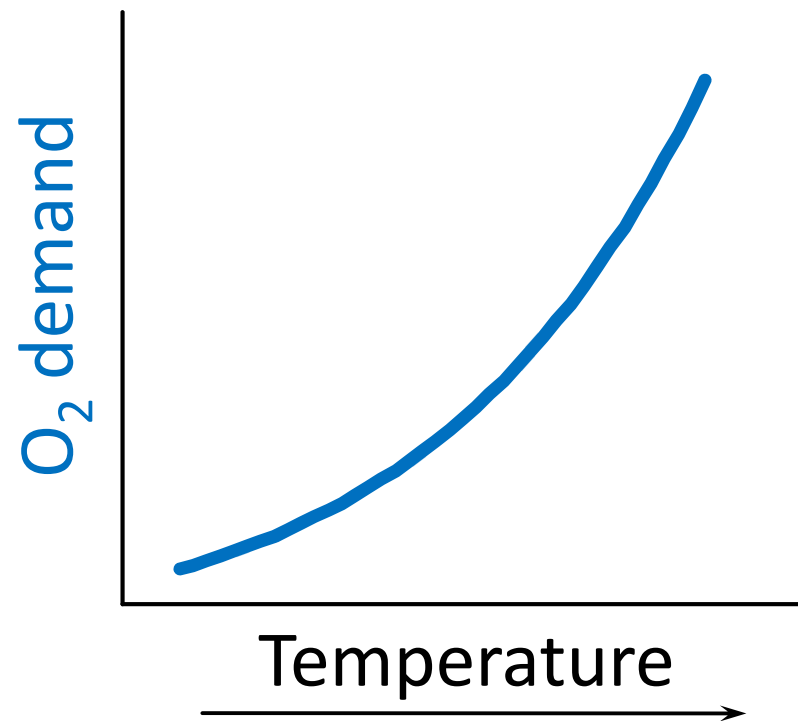
How much oxygen is available?

Oxygen and thermal limits in an insect

Conclusion

## Oxygen defined thermal niches?

Mismatch oxygen supply and demand  
- internal: circulation & ventilation



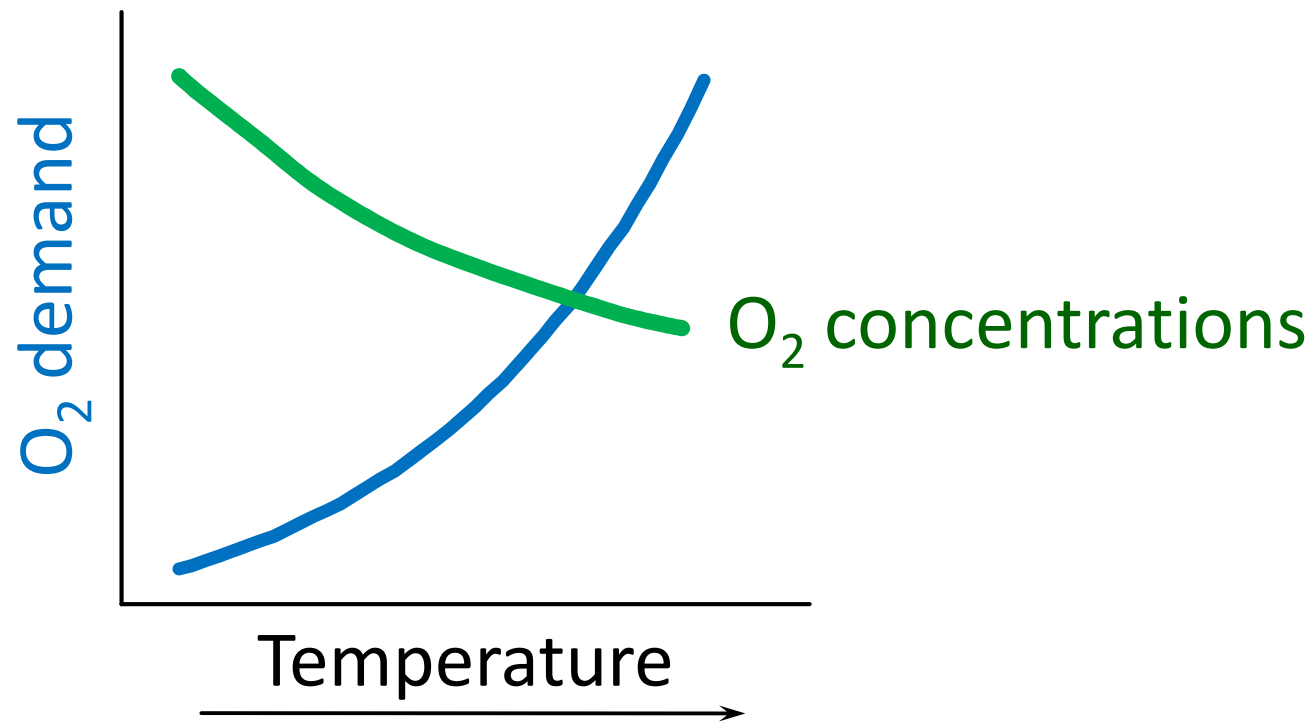
## Oxygen defined thermal niches?

Mismatch oxygen supply and demand

- internal: circulation & ventilation

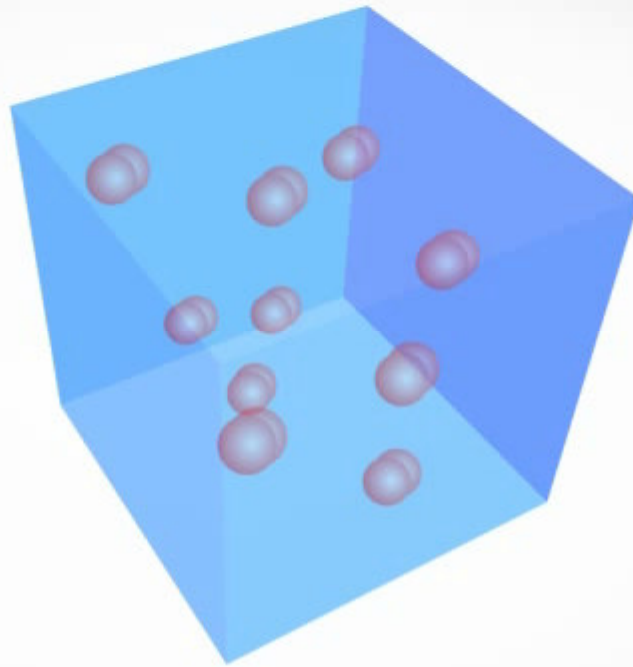
- **external: double jeopardy?**

# Oxygen defined thermal niches?

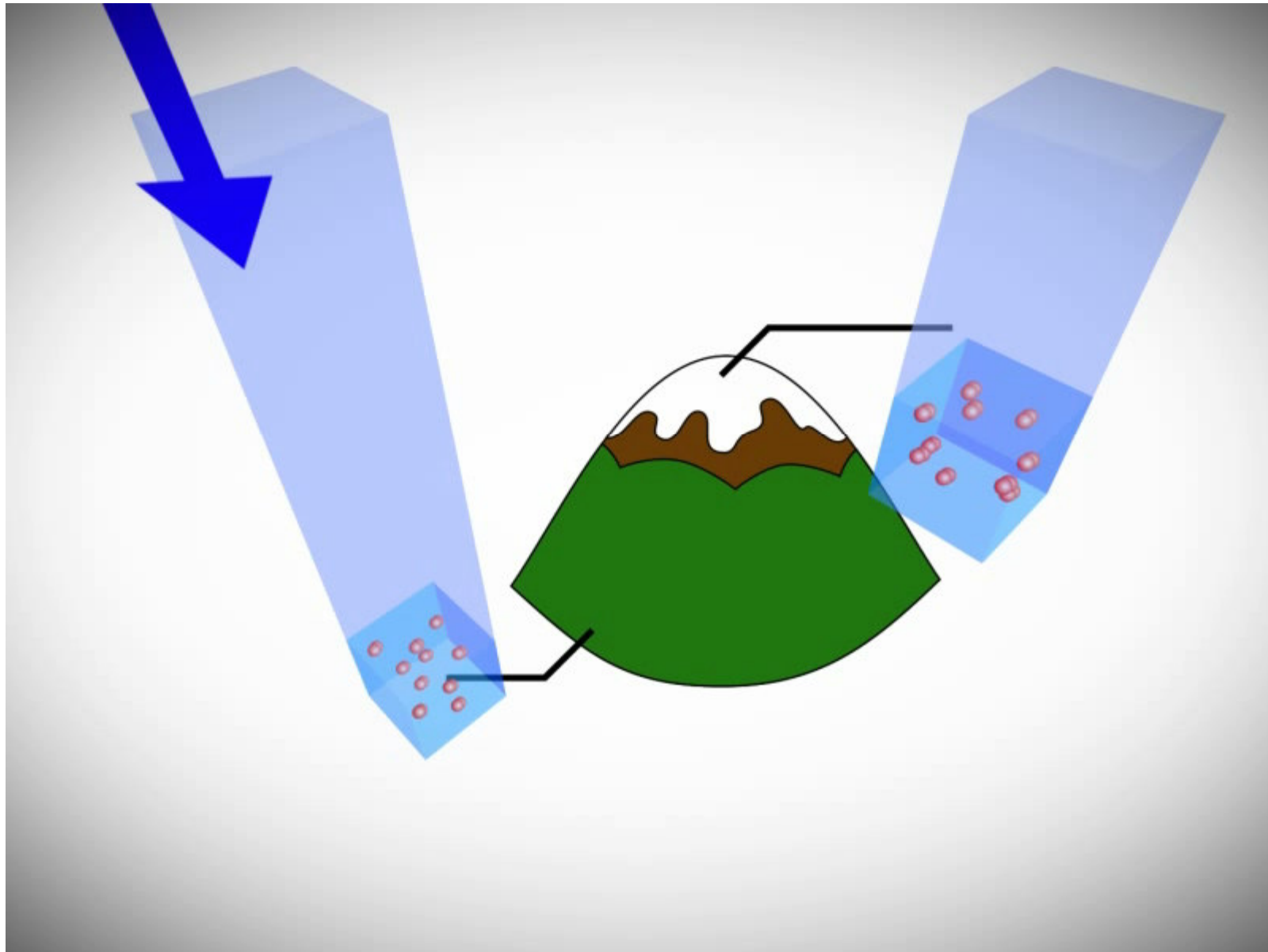


How much oxygen is available?

**Solubility**  $\alpha_{O_2}$  ( $\text{mol}\cdot\text{m}^{-3}\cdot\text{Pa}^{-1}$ )

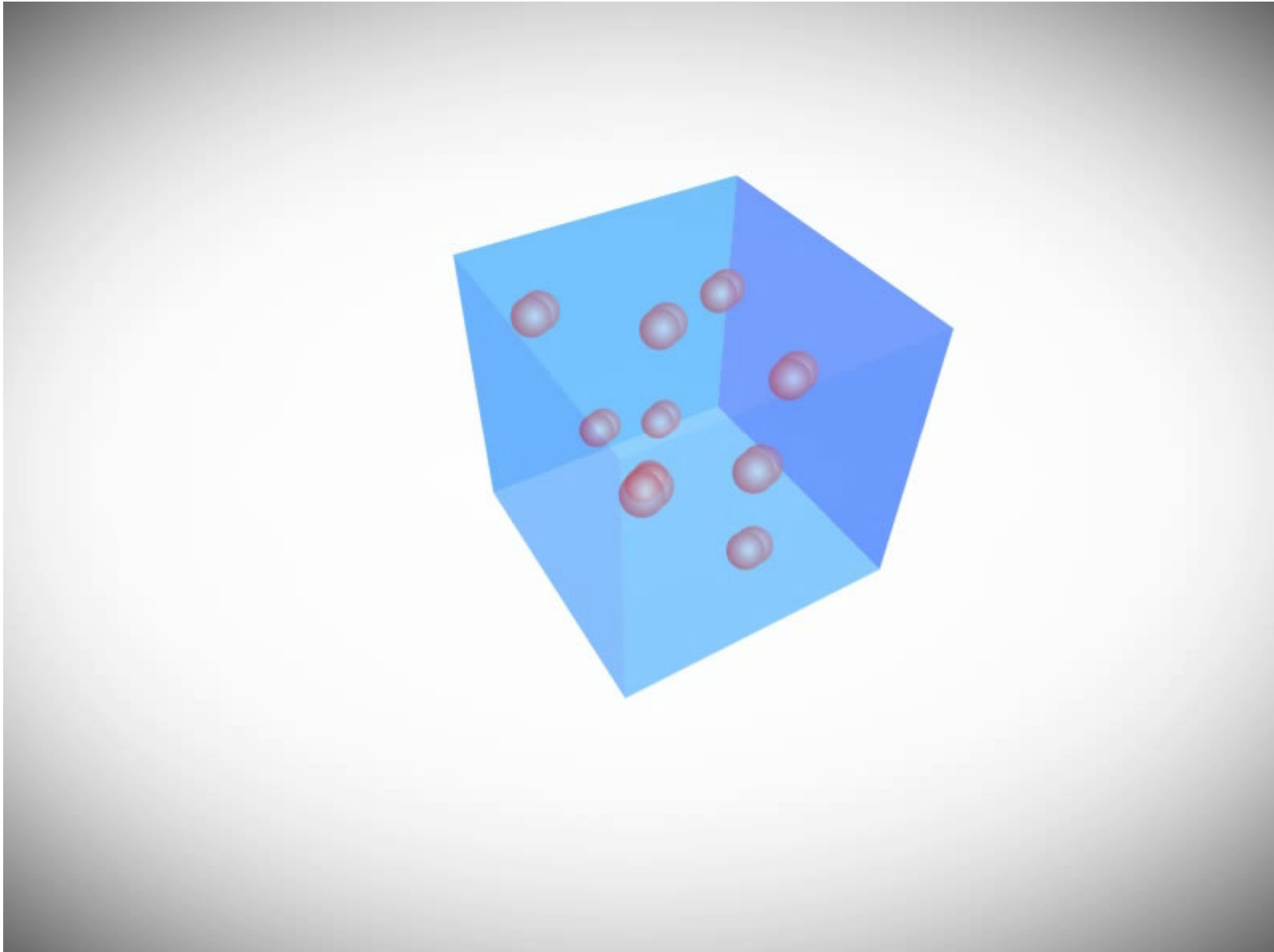


# Partial pressure $PO_2$ (Pa)

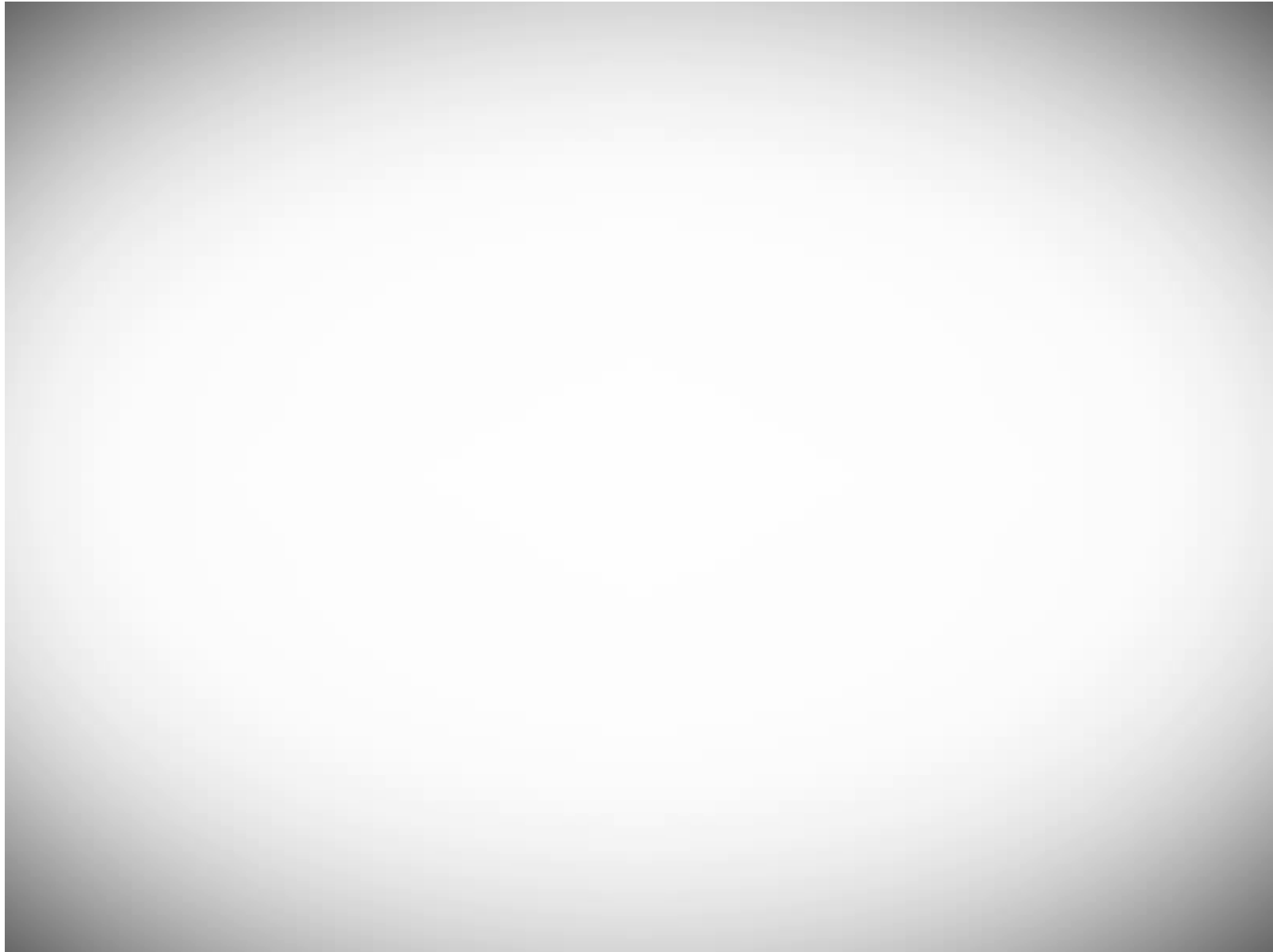




**Diffusivity**  $DO_2$  ( $m^2 \cdot s^{-1}$ )



**Oxygen Supply Index (OSI)** ( $\text{mol} \cdot \text{m}^{-1} \cdot \text{s}^{-1}$ )



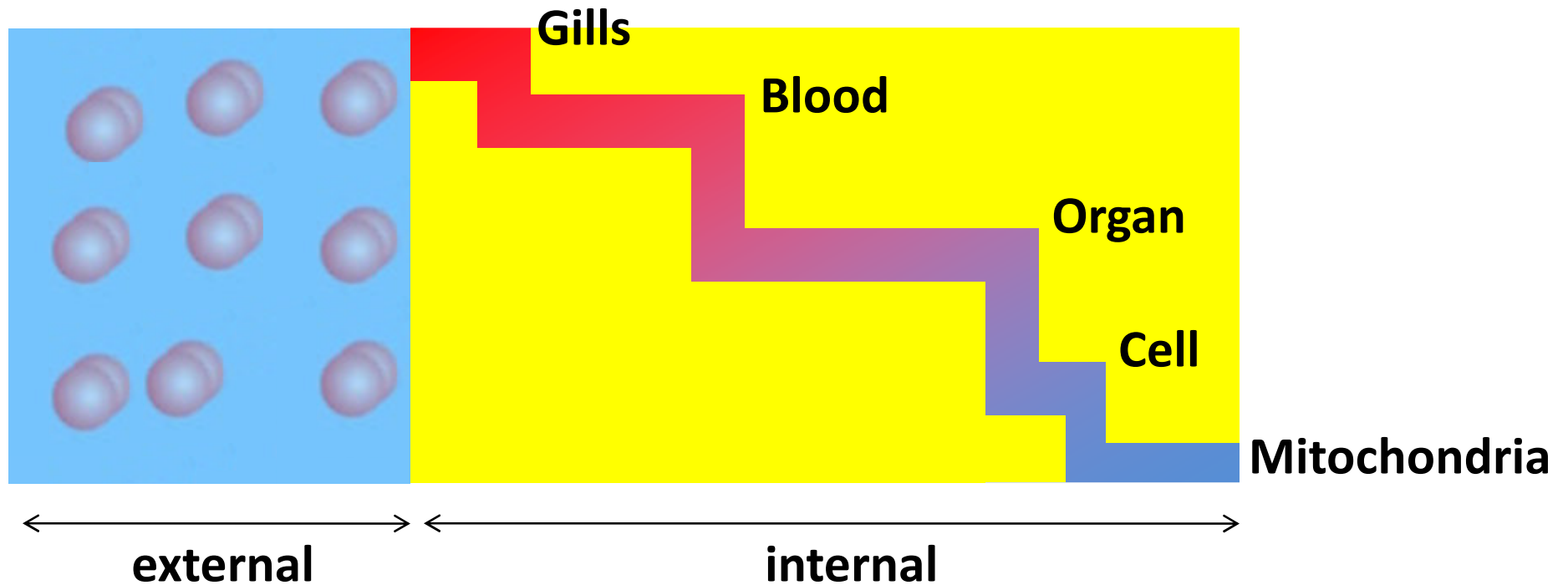
How much oxygen is available?

$$\dot{M} O_2 = D_{O_2} \cdot A \cdot \frac{\alpha_{O_2} \cdot \Delta p_{O_2}}{L}$$

Oxygen Supply Index (OSI)  $\propto D_{O_2} \cdot \alpha_{O_2} \cdot \Delta p_{O_2}$

# How much oxygen is available?

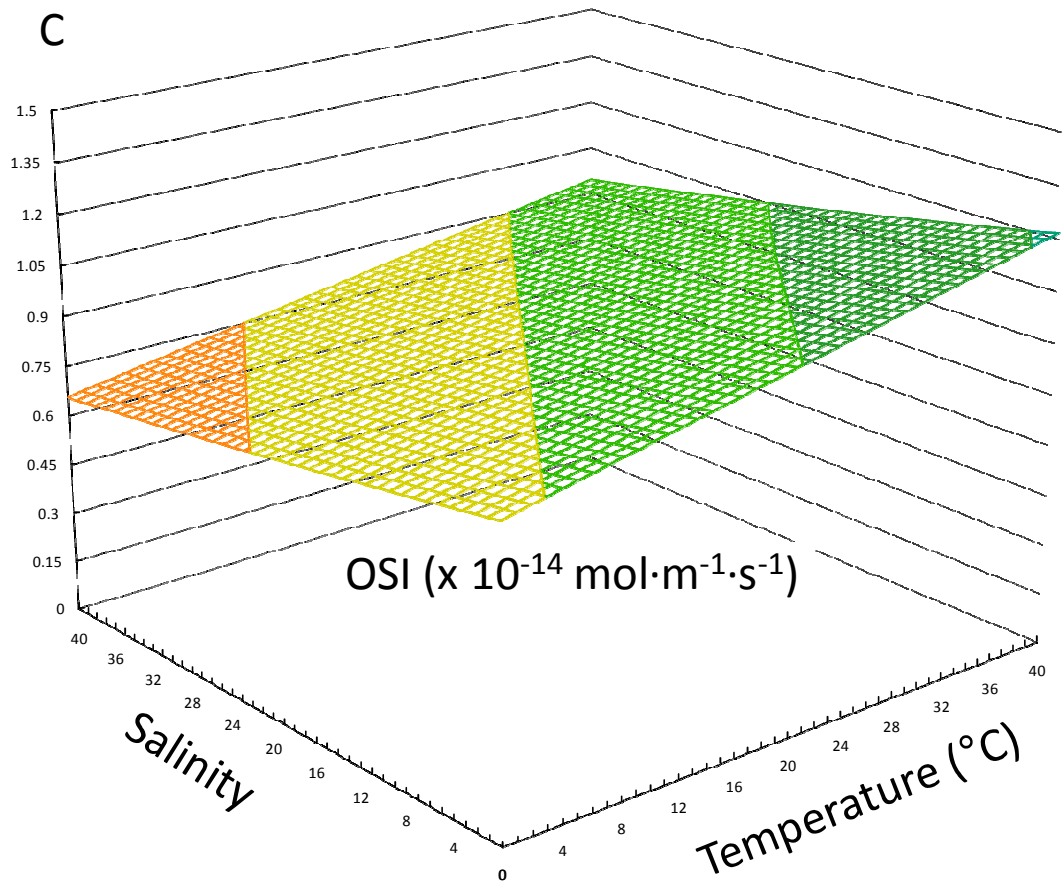
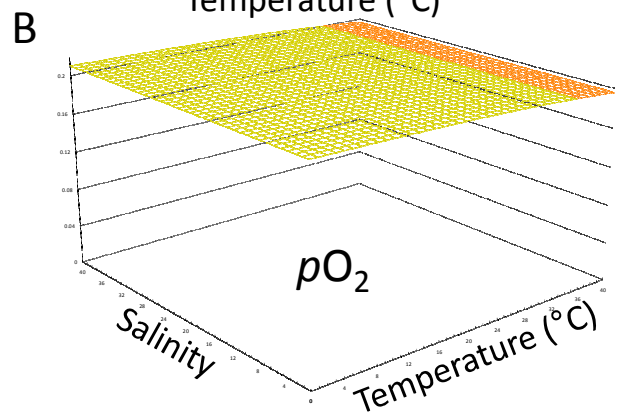
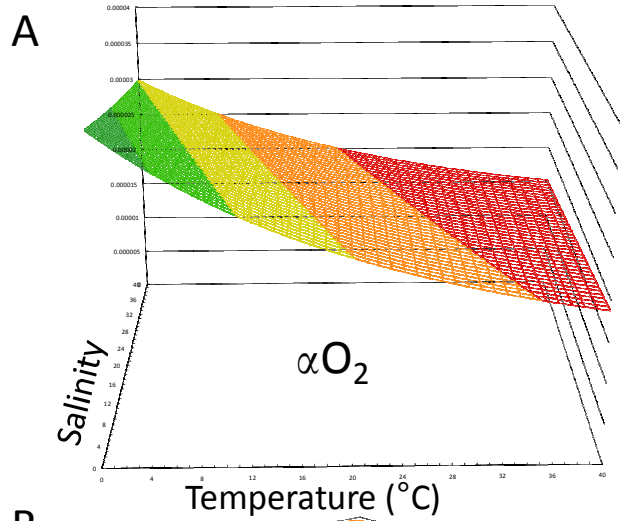
$$\text{Oxygen Supply Index (OSI)} \propto D_{O_2} \cdot \alpha_{O_2} \cdot \Delta p_{O_2}$$

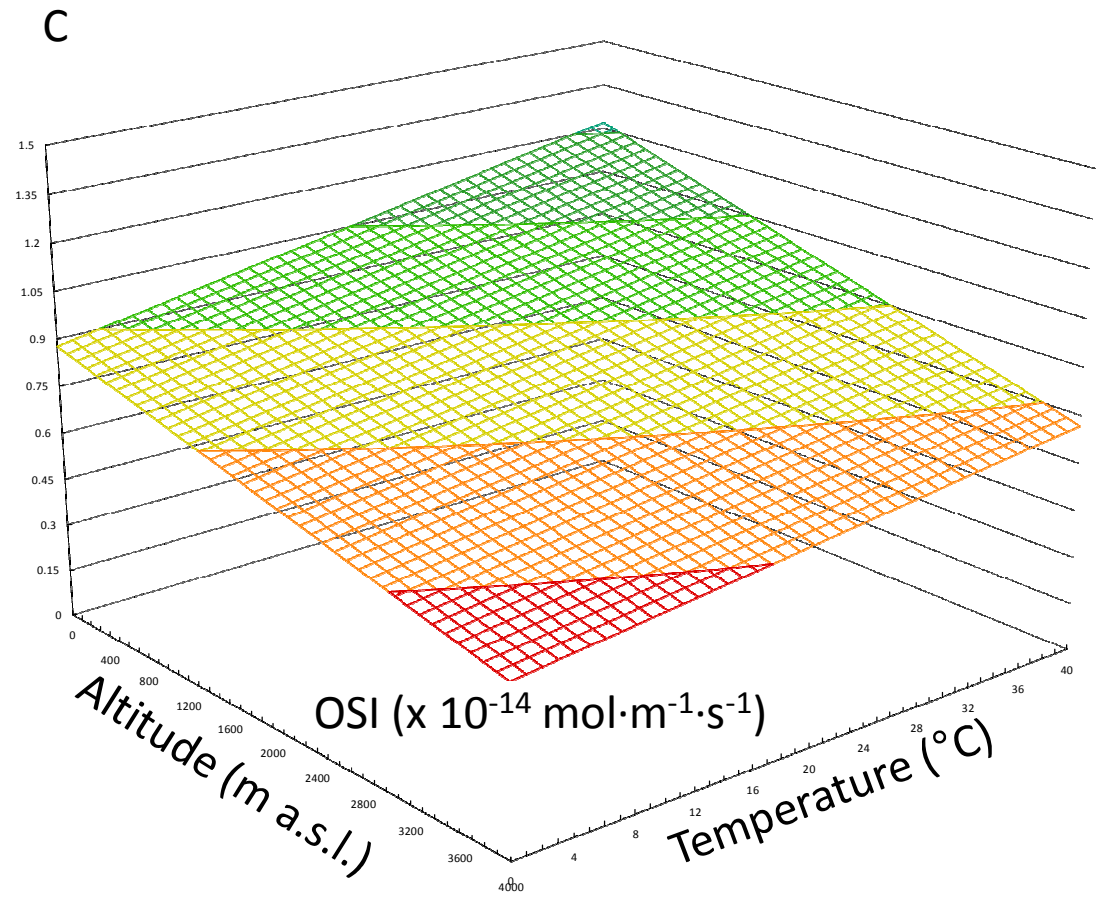
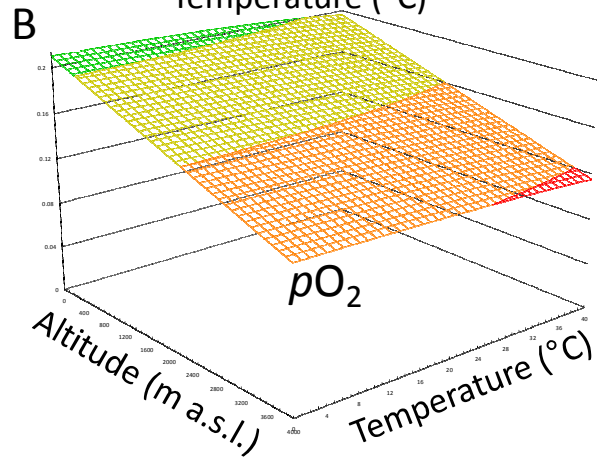
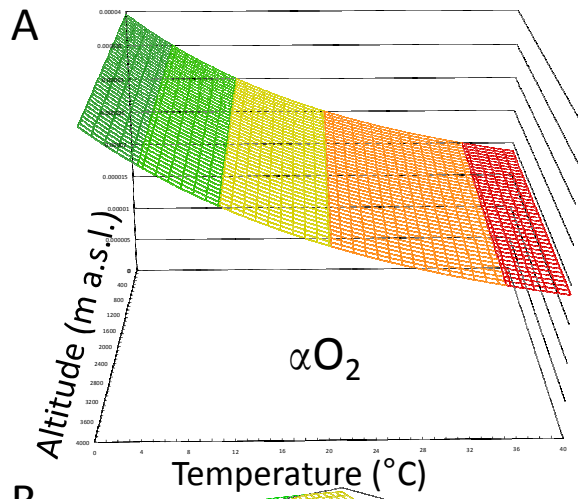


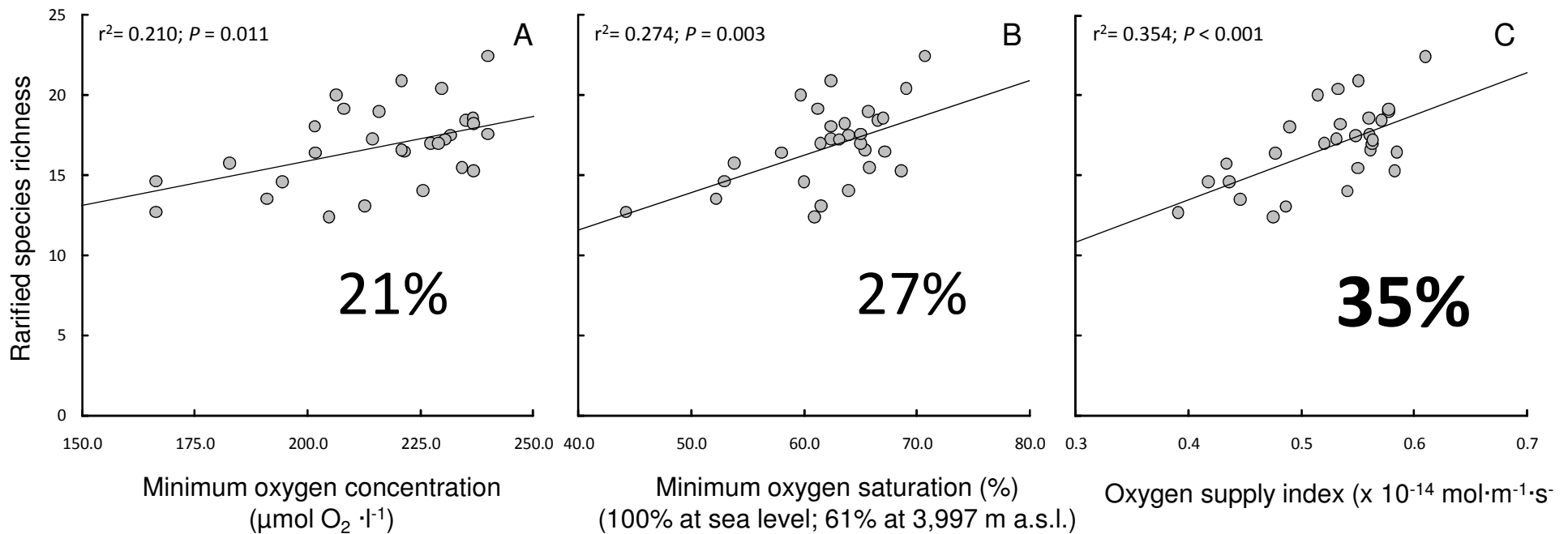
Micro-organisms

Eggs

Modular organisms (Bryozoans)







**Solubility**

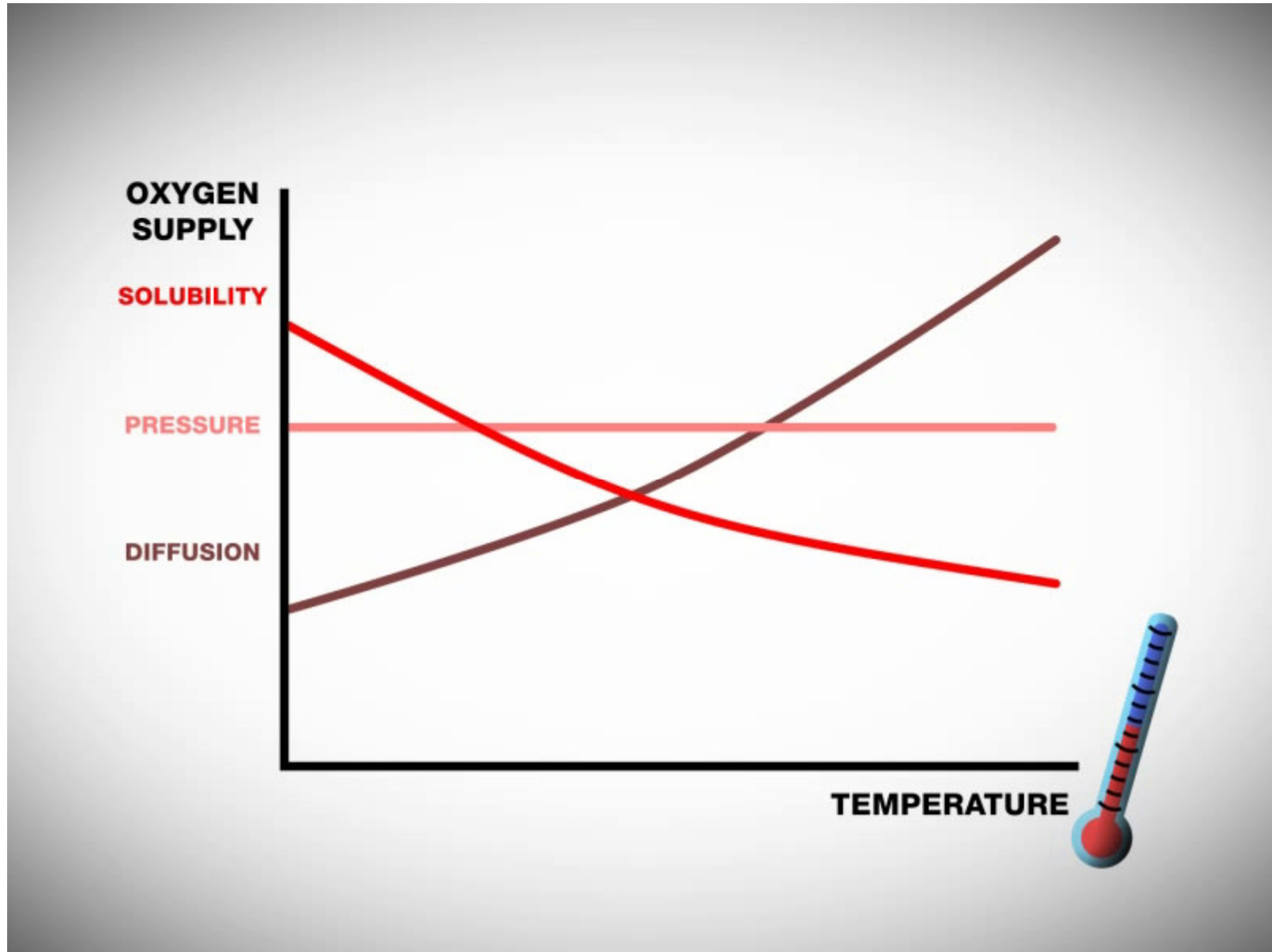
**Partial pressure**

**Oxygen Supply Index (OSI)**

**Verberk WCEP, Bilton DT, Calosi P & Spier JJ (2011)** Oxygen supply in aquatic ectotherms: Partial pressure and solubility together explain biodiversity and size patterns. *Ecology* 92:1562-1572.

You tube: 'ecology' + 'oxygen'

# Oxygen defined thermal niches?





# Oxygen and thermal limits in an insect



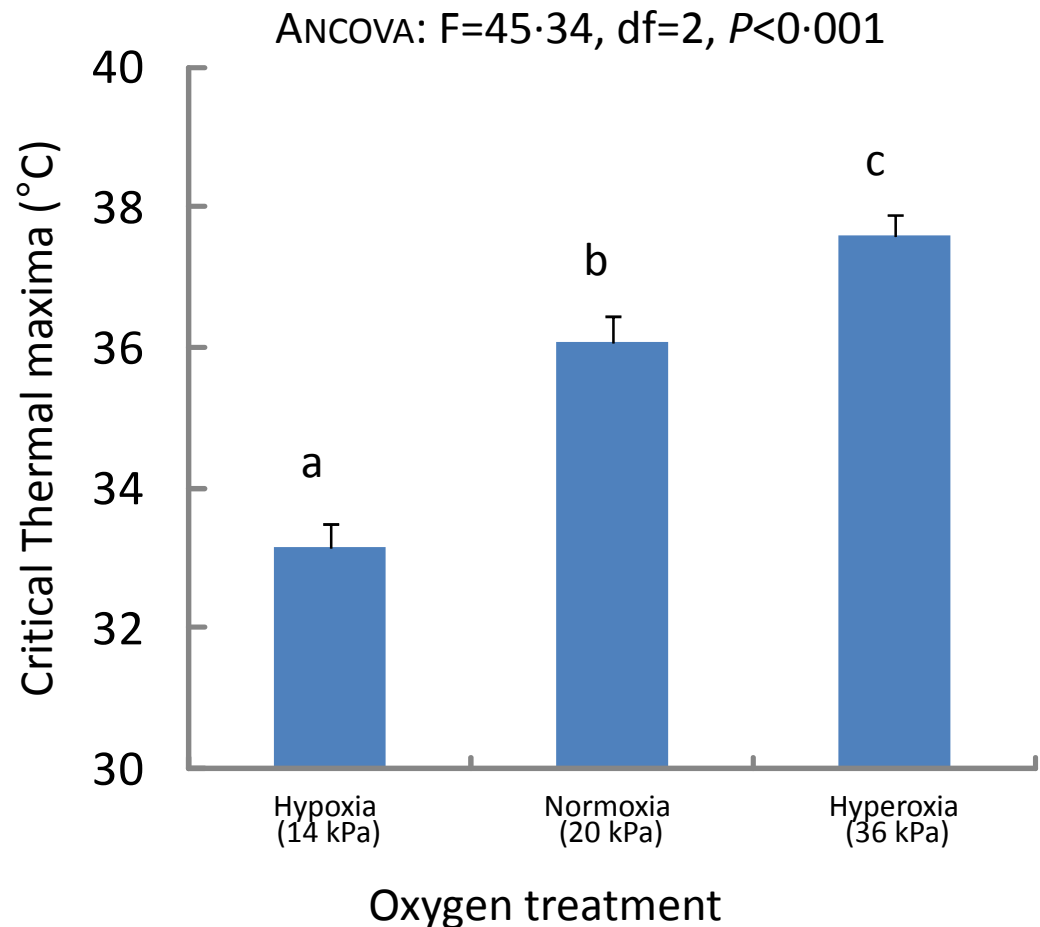




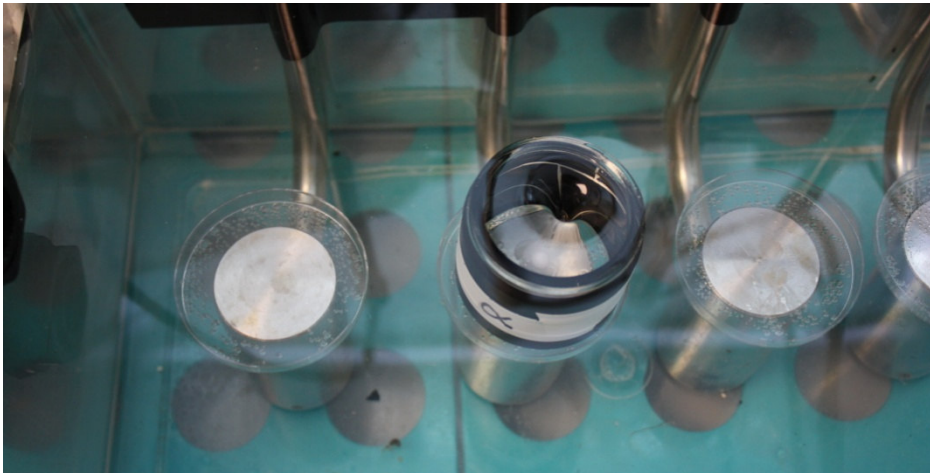
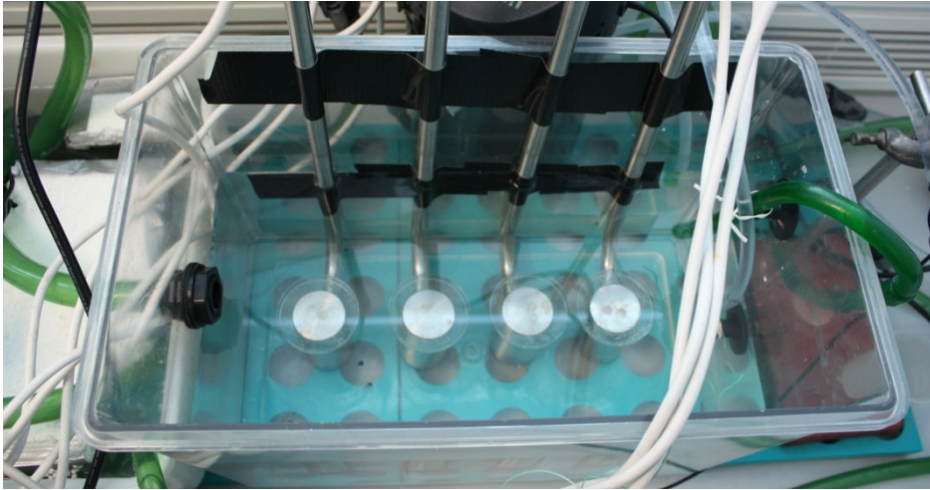
# Oxygen and thermal limits in an insect



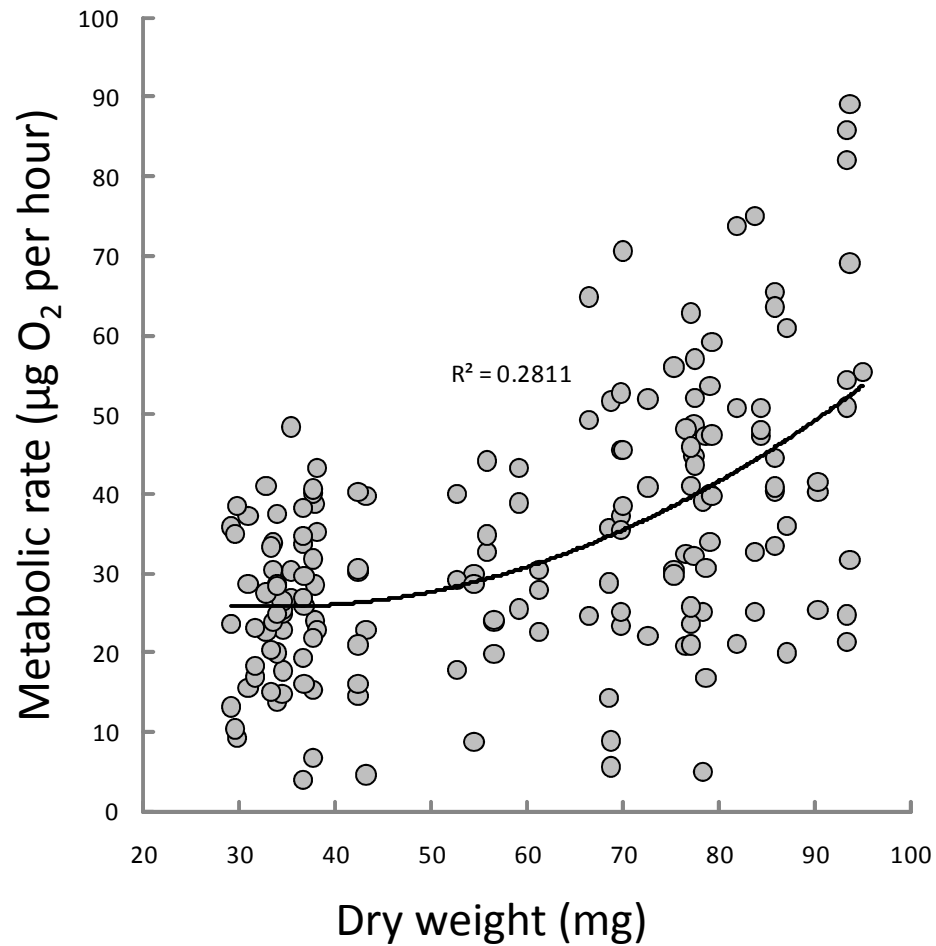
✓ oxygen supply



**Verberk WCEP & Bilton DT (2011)** Can oxygen set thermal limits and drive gigantism? PLoS One, in press. (doi: 10.1371/journal.pone.0022610)

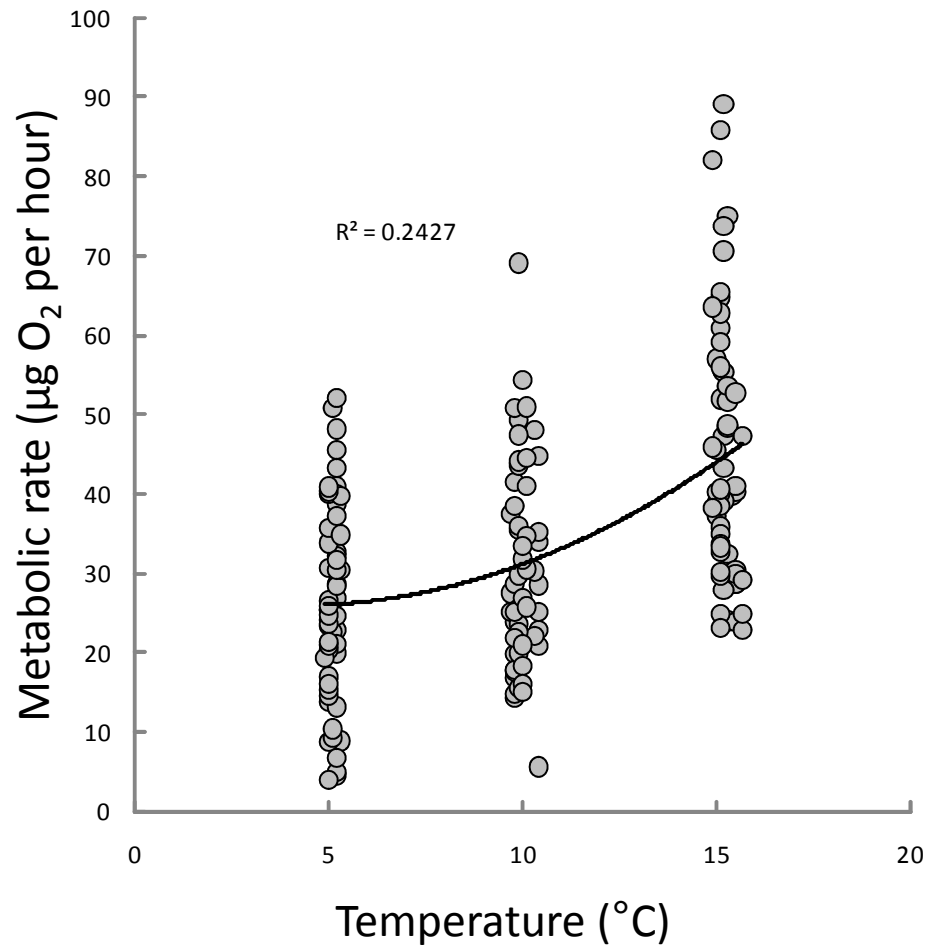


# Oxygen and thermal limits in an insect



324 measurements (before & after)  
167 data points  
52 individuals

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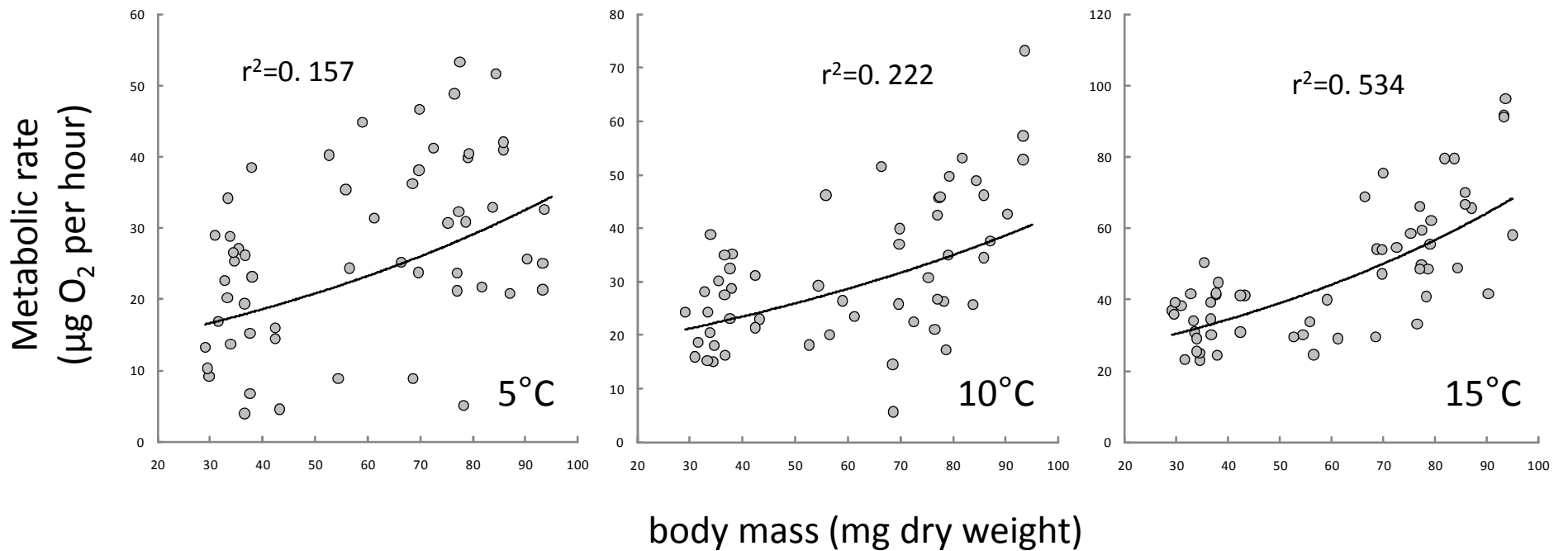


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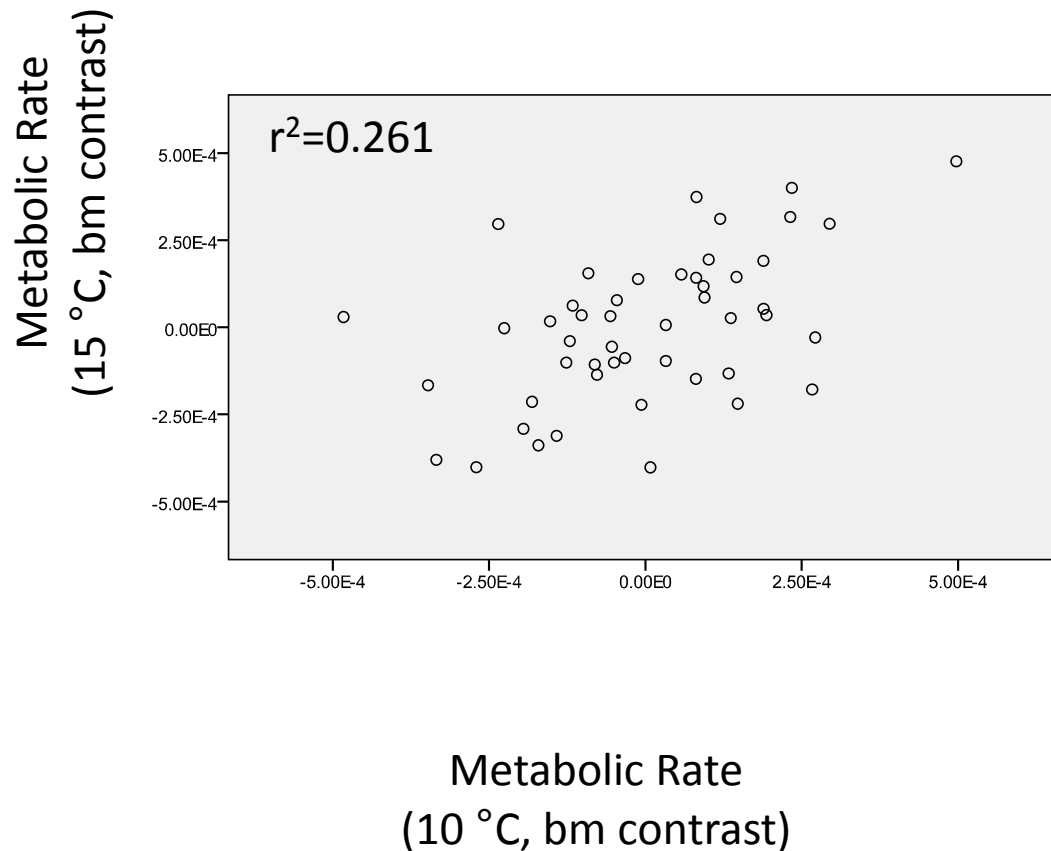
# Oxygen and thermal limits in an insect

Sources of variation:

- temperature & body mass  $Q_{10}(10-15)$



# Oxygen and thermal limits in an insect



Sources of variation:

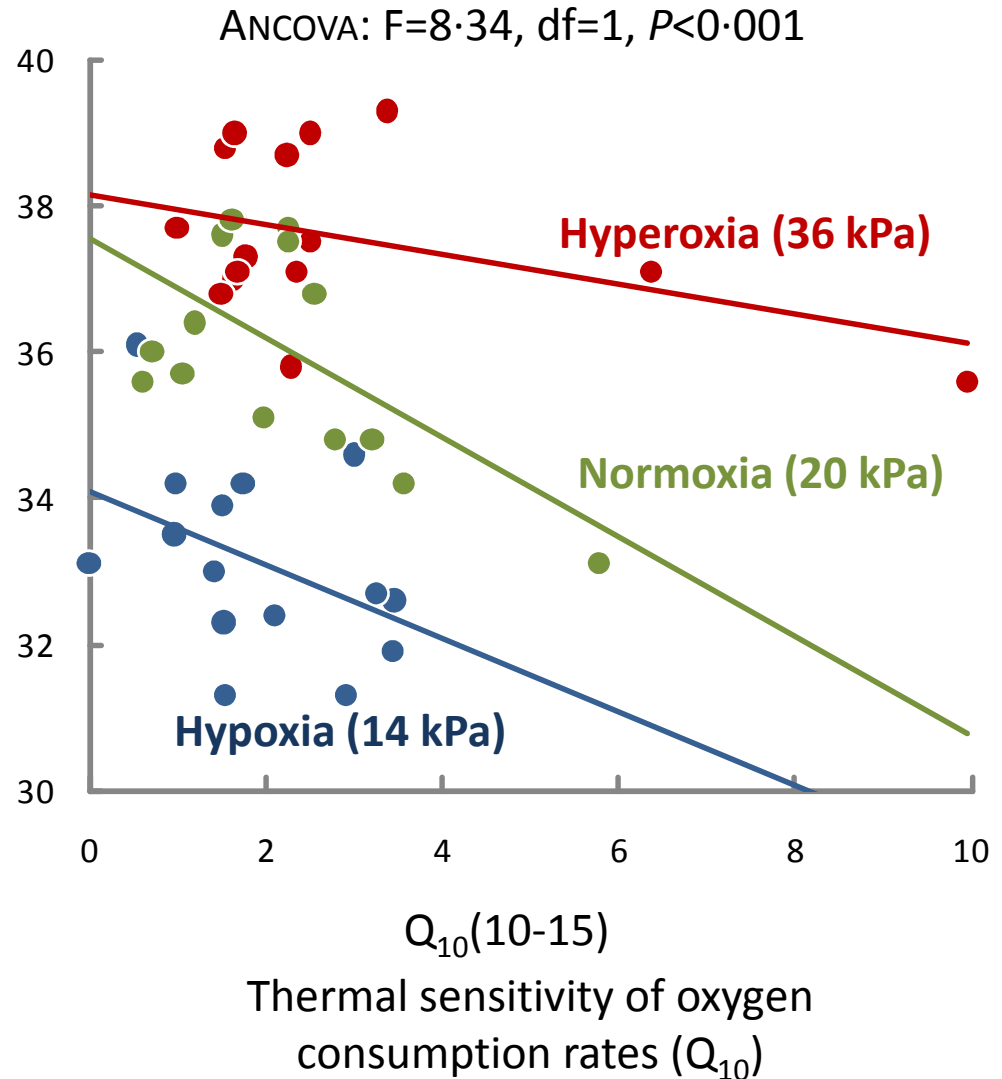
- differences in atmospheric pressure
- oxygen conformer
- individual



# Oxygen and thermal limits in an insect



✓ oxygen supply  
✓ oxygen demand



**Verberk WCEP & Bilton DT (2011)** Can oxygen set thermal limits and drive gigantism? PLoS One, in press. (doi: 10.1371/journal.pone.0022610)

# Oxygen and thermal limits in an insect

Aquatic medium

Closed trachea

Lower O<sub>2</sub>

Extra step

Uptake

Regulation

Thermal buffering

Limited adjustment



Verberk WCEP & Bilton DT (2011) Can oxygen set thermal limits and drive gigantism? PLoS One, in press. (doi: 10.1371/journal.pone.0022610)

# Conclusion

New perspective of aquatic (larval) stages

OSI reconciles viewpoints: **solubility** and **PO<sub>2</sub>**

More oxygen available in warmer waters

Implications:

- no double jeopardy
- solutions more feasible

