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Enzymatic Regulation of Zooplankton Respiration

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Metabolic Theory of Ecology

by Brown et al. *Ecology (*2004) ;85:1771-1789.

- Based on metabolism (Klieber's Law), but applied to growth, to development time, to the ocean, & to many other biological phenomenon.
- Philosophy: Supply-side Economics*
- R = F(Metabolic Distribution Networks)
- R = Delivery rate of these fractal networks

Metabolic Theory of Ecology

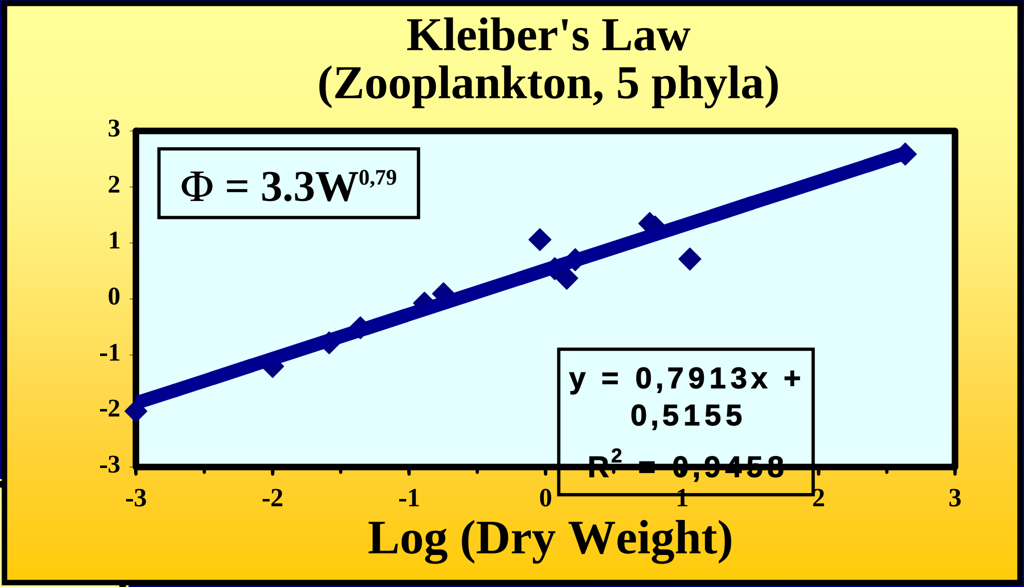
by Brown et al. *Ecology (*2004) ;85:1771-1789.

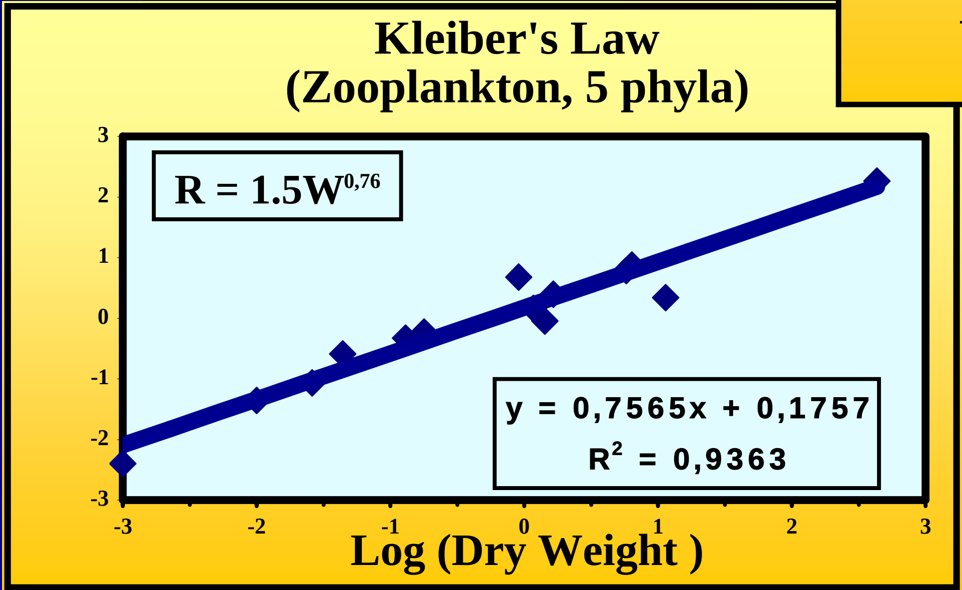
- $R = K_o M^{3/4} e^{-Ea/kT}$

- Part A: Nutrient dependency [reactants]
- Part B: Biomass dependency (Kleiber's Law) [reactant fluxes, reaction rates]
- Part C: Temperature dependency (Boltzmann Factor) [system kinetic energy]

Why Kleiber's Law is correct.

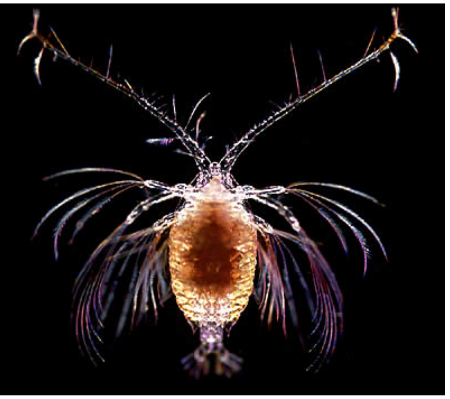
Zooplankton R & Φ obey Kleiber's Law

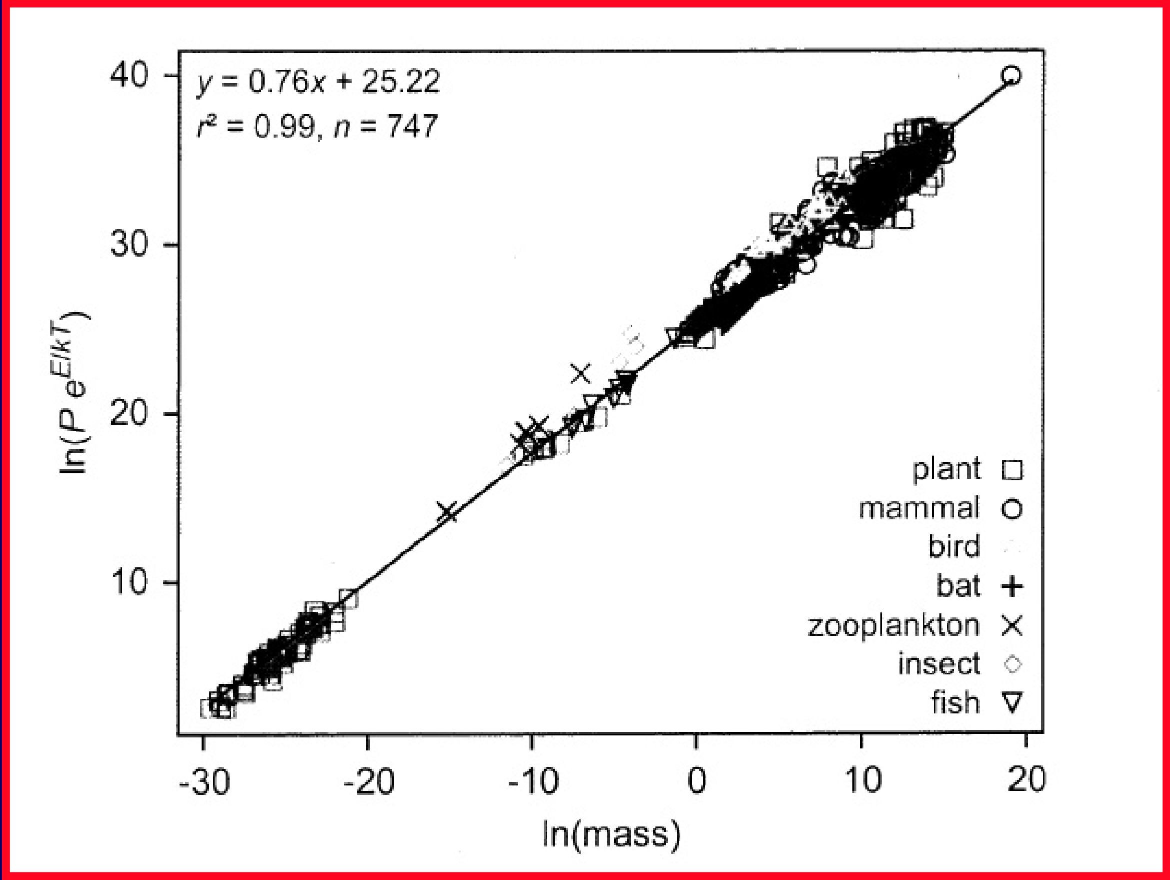




Why the MTE is right.

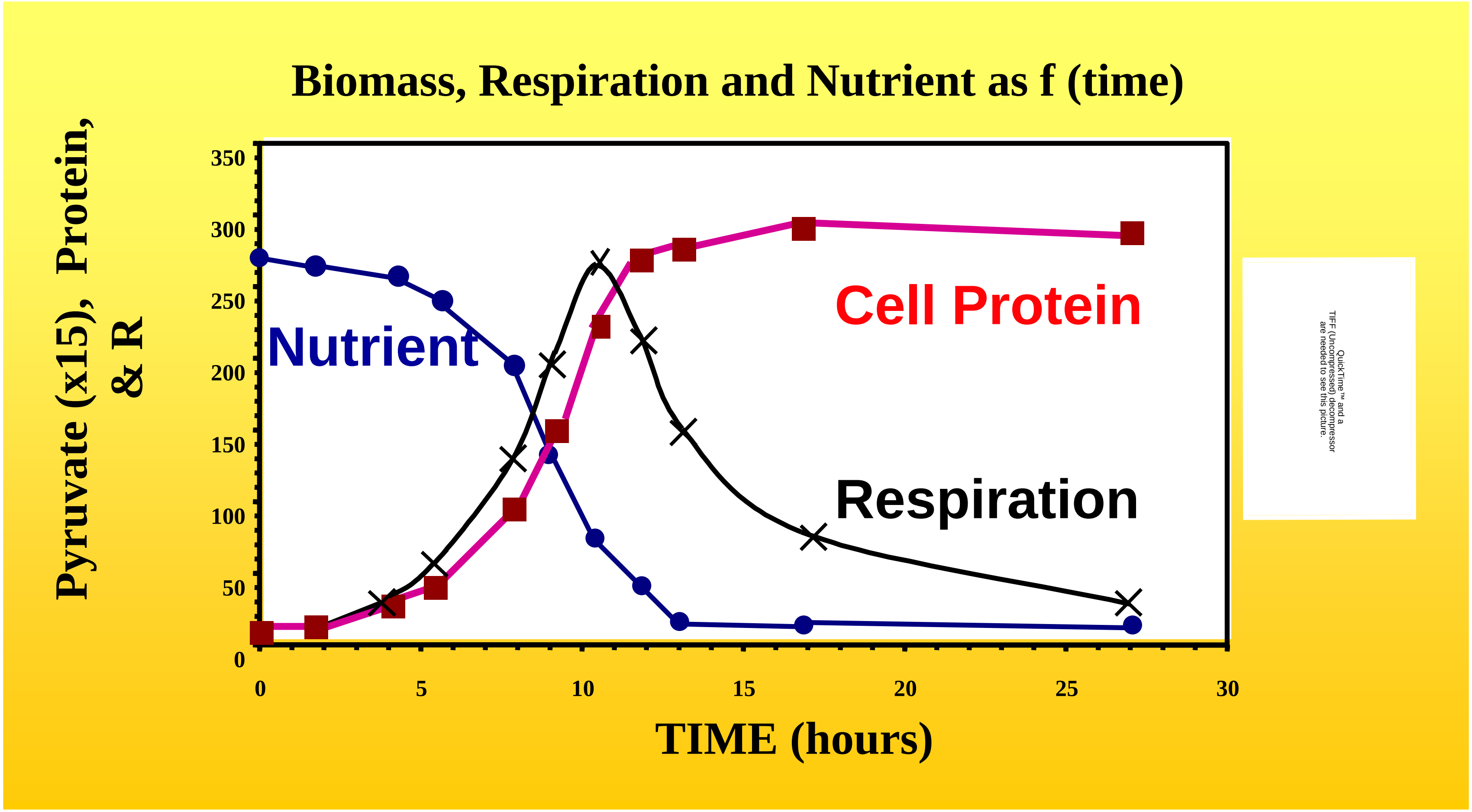
R = f(M + T)

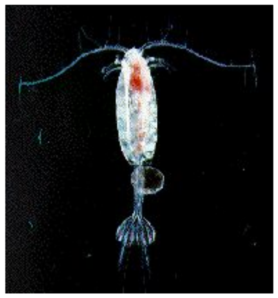




Why Kleiber's Law and the MTE are wrong.

The MTE & Kleiber's Law can't predict respiration under nutrient limitating Conditions.





$$R = K_o M^{3/4} e^{-Ea/kT}$$

$$R = S\Phi A\,(e^{-Ea/RT})/(K_\beta + S)$$

Our alternative is based on the recognition:

1. That the electron transport system (ETS) controls respiration and is a measure of potential respiration (Φ).

2. that mitochondrial NADH (and NADPH) control the activity of the ETS.

3. and that Michaelis-Menten kinetics describes the impact of substrate (reactant) limitation on reaction rates.

$Ae^{-Ea/RT}$

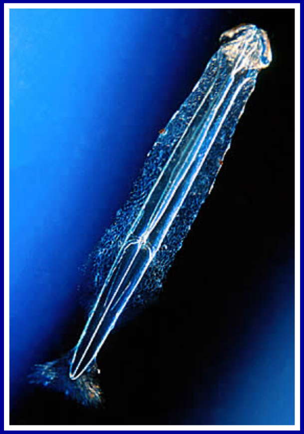
$$R = S\Phi A\,(e^{-Ea/RT})/(K_\beta + S)$$

In addition, we can build on 100 years of research by recognizing the Arrhenius equation's efficiency in describing the temperature dependence of biological as well as chemical rate processes. Note! A is necessary!

A counter proposal: A First Principle Respiration Model*

$$R = S\Phi A\,(e^{-Ea/RT})/(K_\beta + S)$$

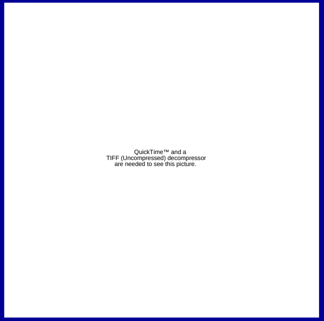
- Based on: respiratory potential (Φ) as set by the respiratory electron transport system.
- Philosophy: Demand-side *Economics**
- R = f(Cellular Demand for ATP)
- R = Delivery rate of e^- to Cyt a-a_3



A counter proposal: A First Principle Respiration Model*

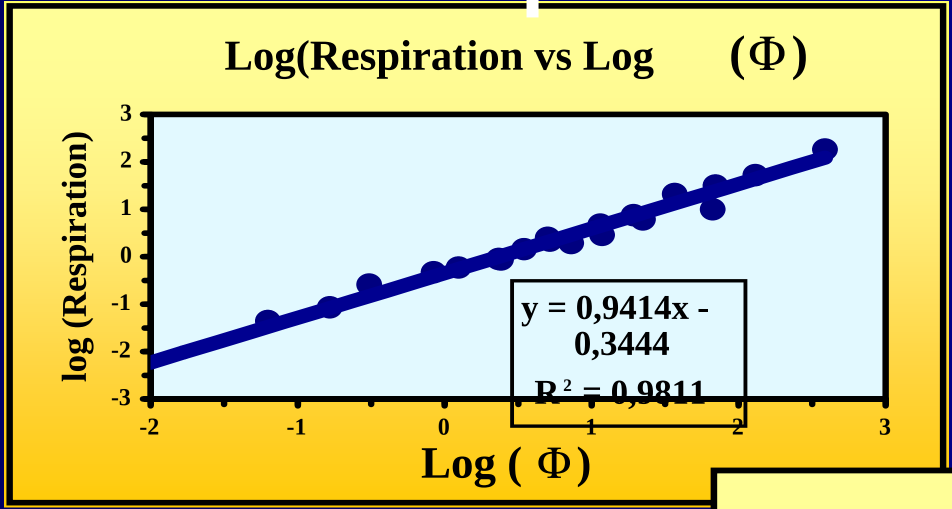
$$R = S\Phi A\,(e^{-Ea/RT})/(K_\beta + S)$$

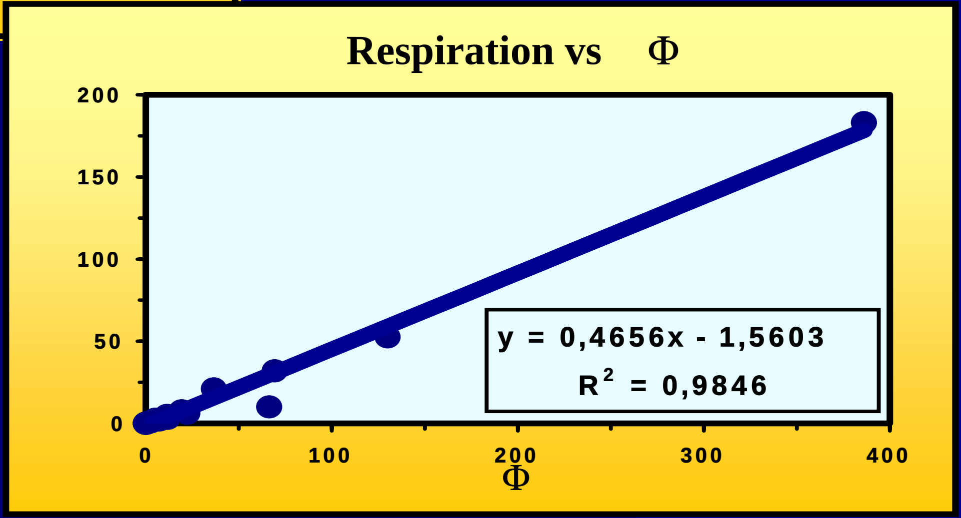
- Part A: Michaelis-Menten Nutrient dependency (NADH + NADPH)°
- Part B: Respiratory potential dependency (Φ from ETS activity).
- Part C: Temperature dependency (Arrhenius Reaction Rate Theory).

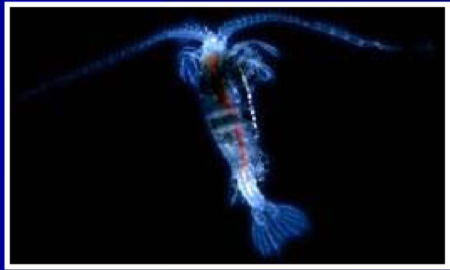


Biomass replacable by Potential Respiration (Φ)!

$$R = S\Phi A\,(e^{-Ea/RT})/(K_\beta + S)$$

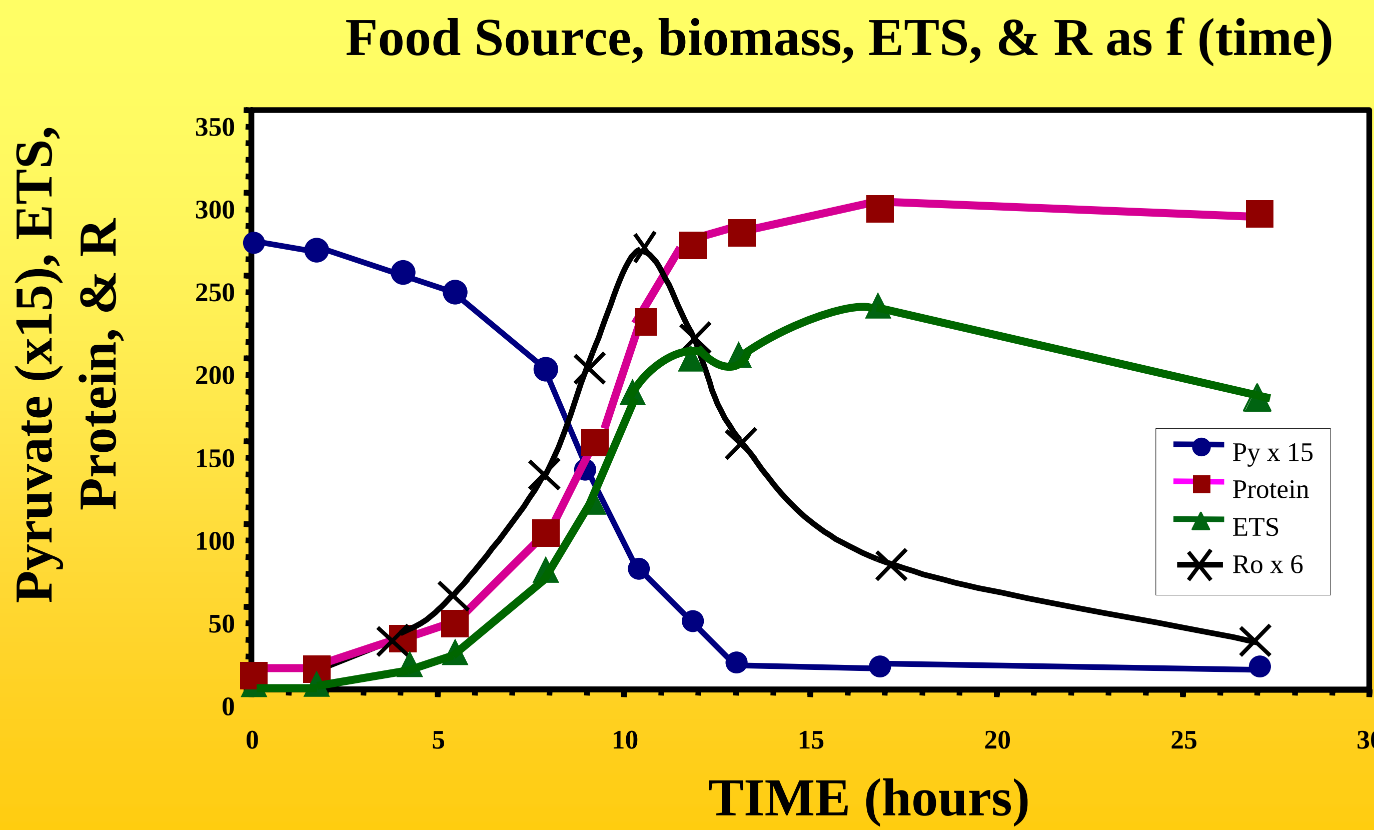


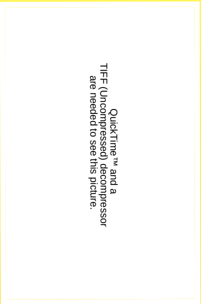




A First Principle Model for Respiration

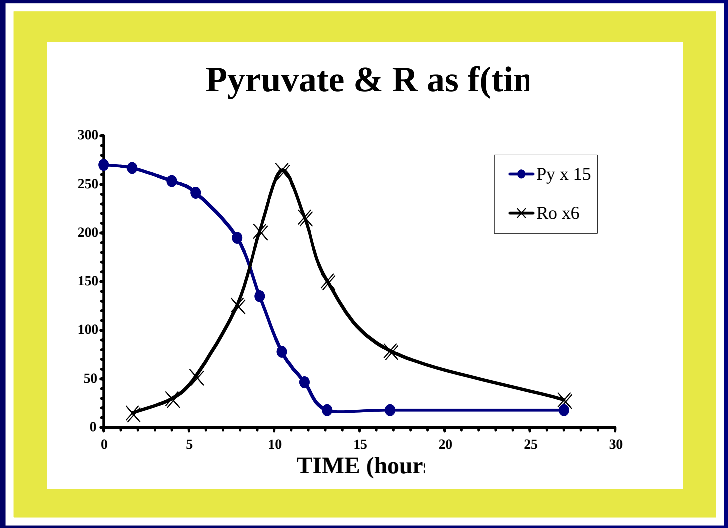
$$R = S\Phi A(e^{-Ea/RT})/(K_\beta + S)$$





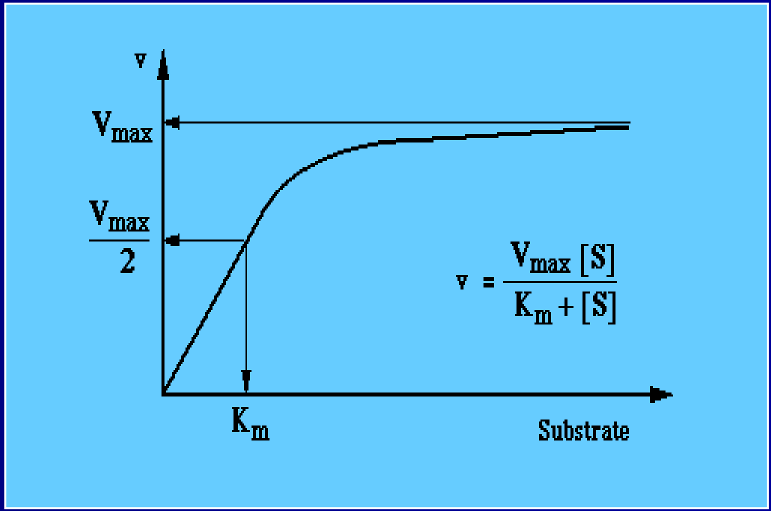
A First Principle Model for Respiration

$$R = S\Phi A(e^{-Ea/RT})/(K_\beta + S)$$



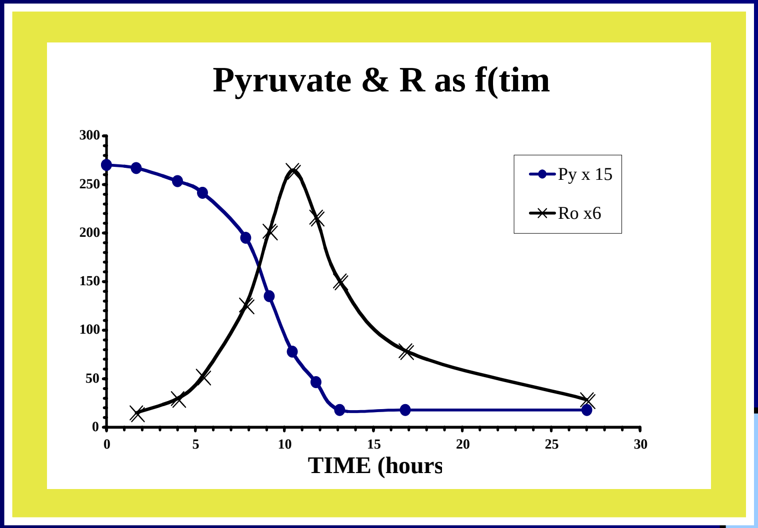
As falls the pyruvate in the culture medium, so falls the ETS reactants. And thus falls the respiration rate!

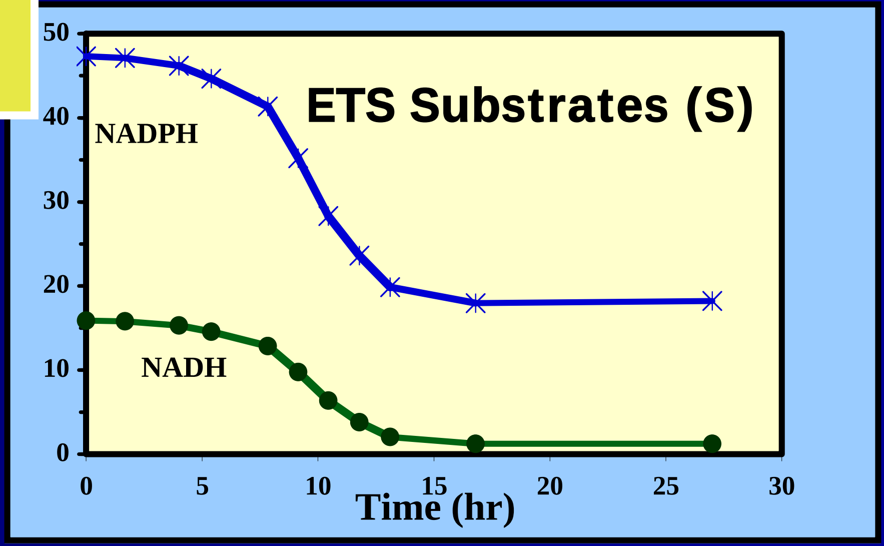
As falls the substrate in an enzyme reaction, so falls the activity of the enzyme!



A First Principle Model for Respiration

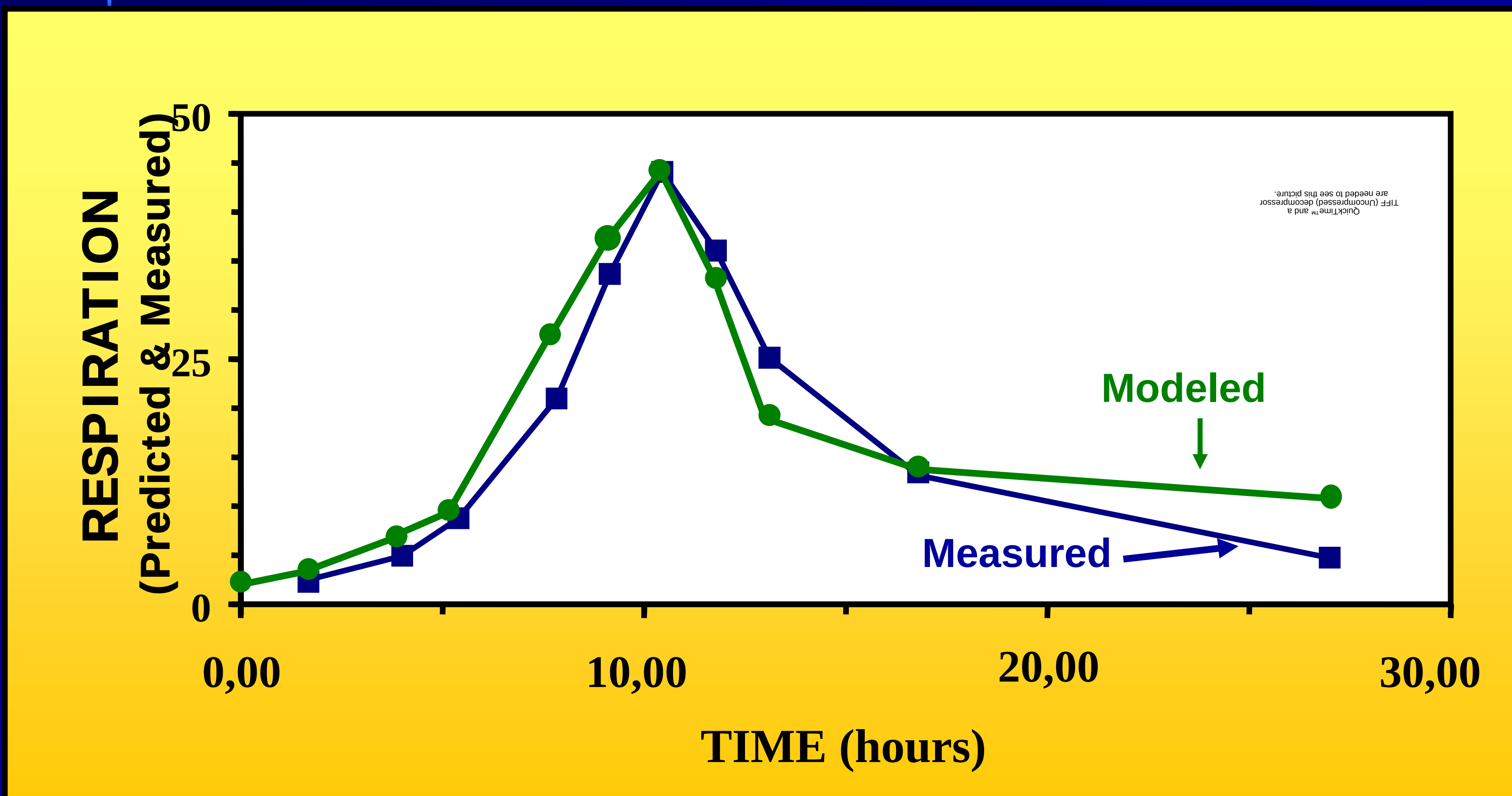
S (t) = f([DOC] + [Cell Protein])





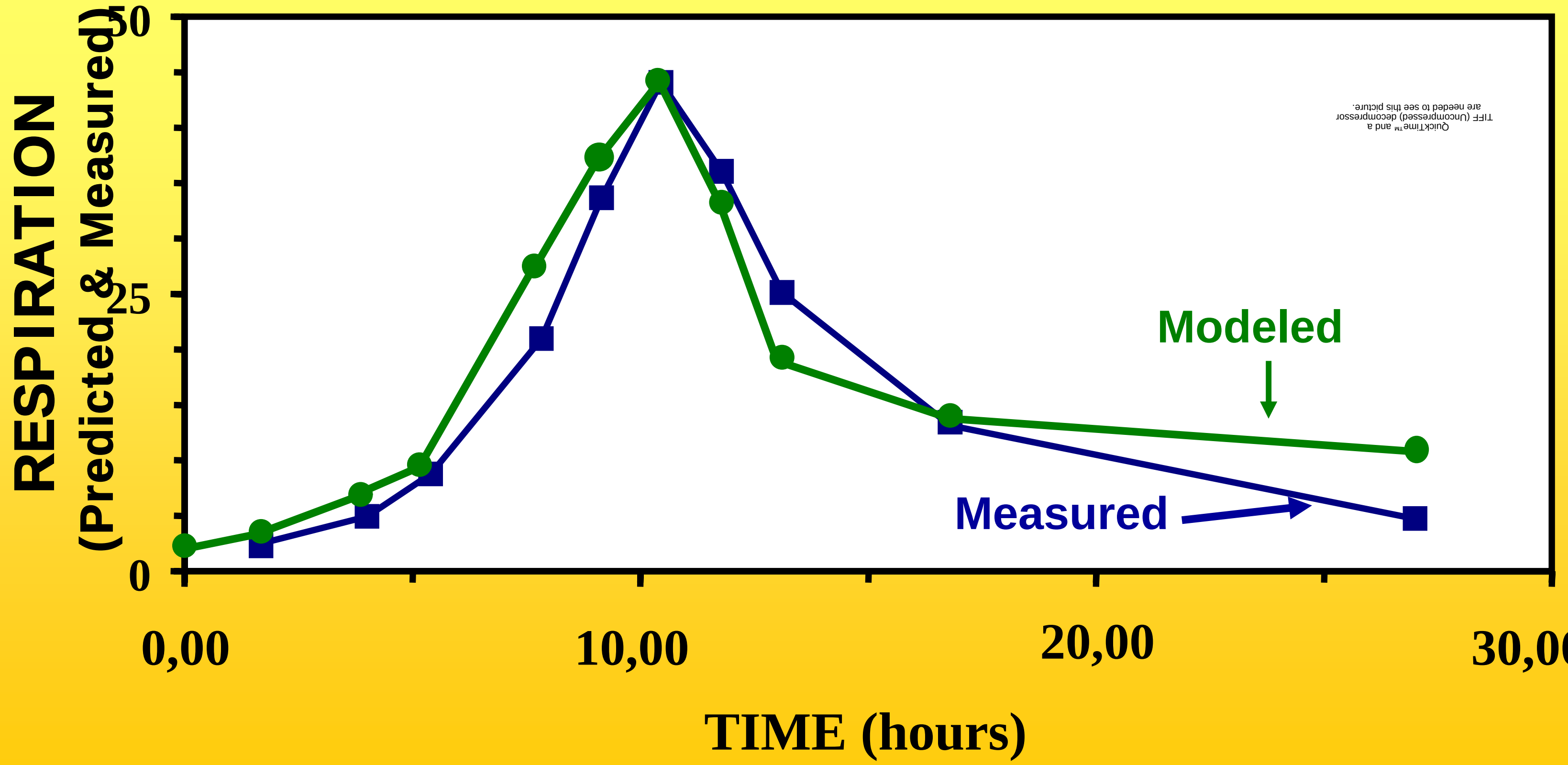
A First Principle Model for Respiration

$$R = S\Phi A(e^{-Ea/RT})/(K_{\beta} + S)$$



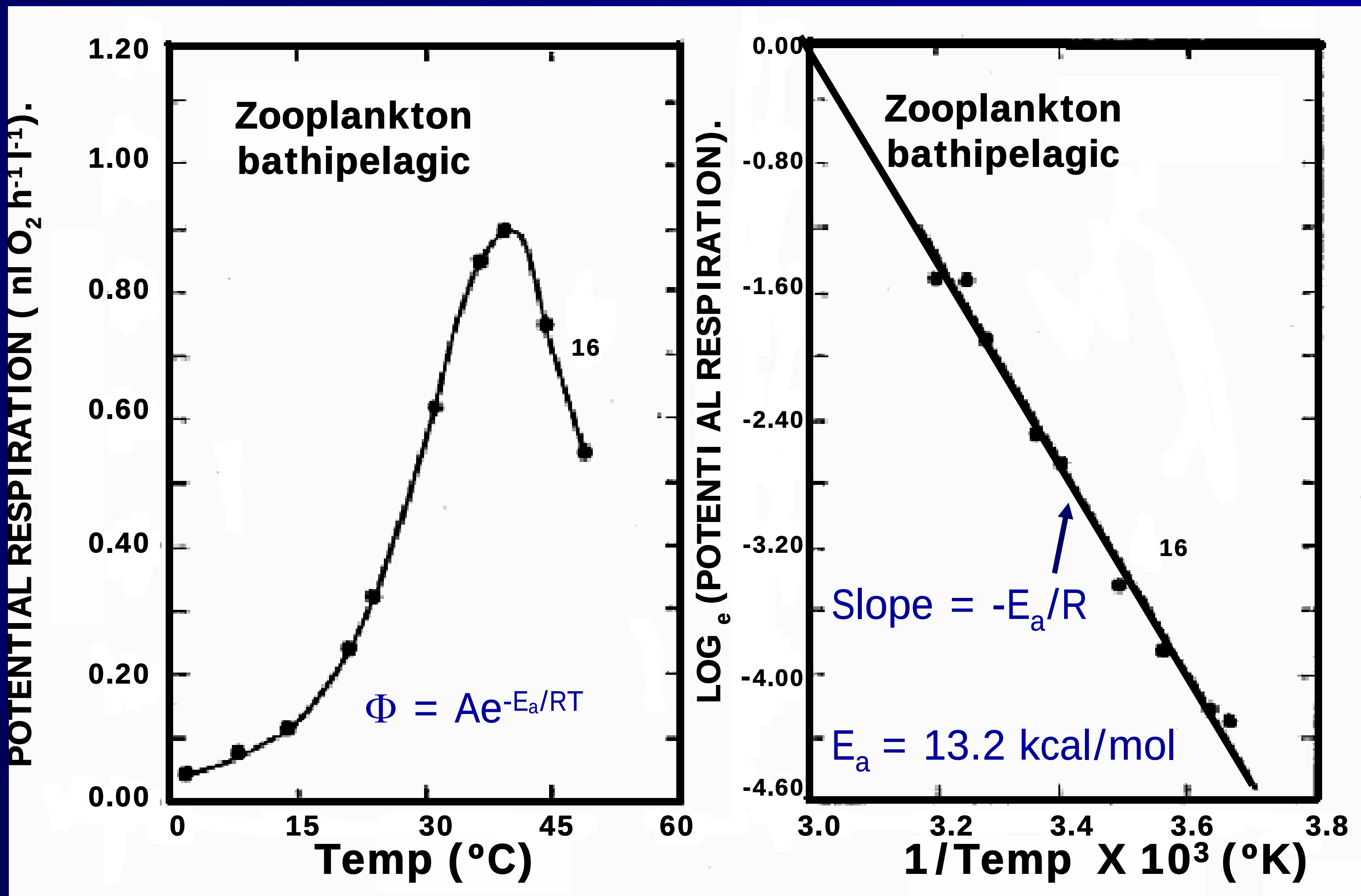
A First Principle Model for Respiration

$$R = S\Phi A(e^{-Ea/RT})/(K_\beta + S)$$



R = f (T). Use the Arrhenius Equation, it incorporates the Boltzmann Factor!

$$R = S\Phi A(e^{-Ea/RT})/(K_\beta + S)$$



CONCLUSION

- The MTE and Kleiber's Law alone can not predict or explain respiration on the small scale.

- Potential respiration, substrate depletion, and Michaelis-Menten kinetics can explain and predict respiration on the small scale.

ACKNOWLEDGEMENTS

For all their help, support, and encouragement we thank

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