Functional response of carbon absorption efficiency in the calanoid copepod *Acartia tonsa*

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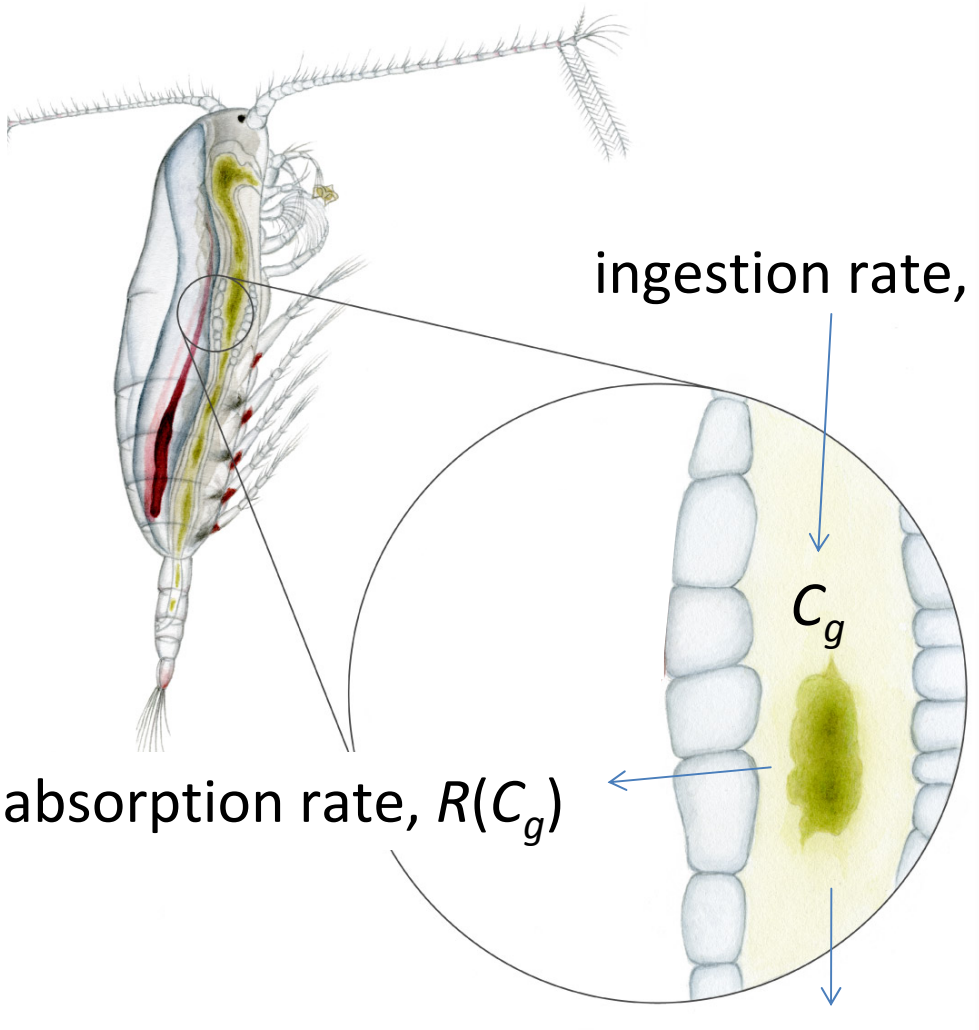
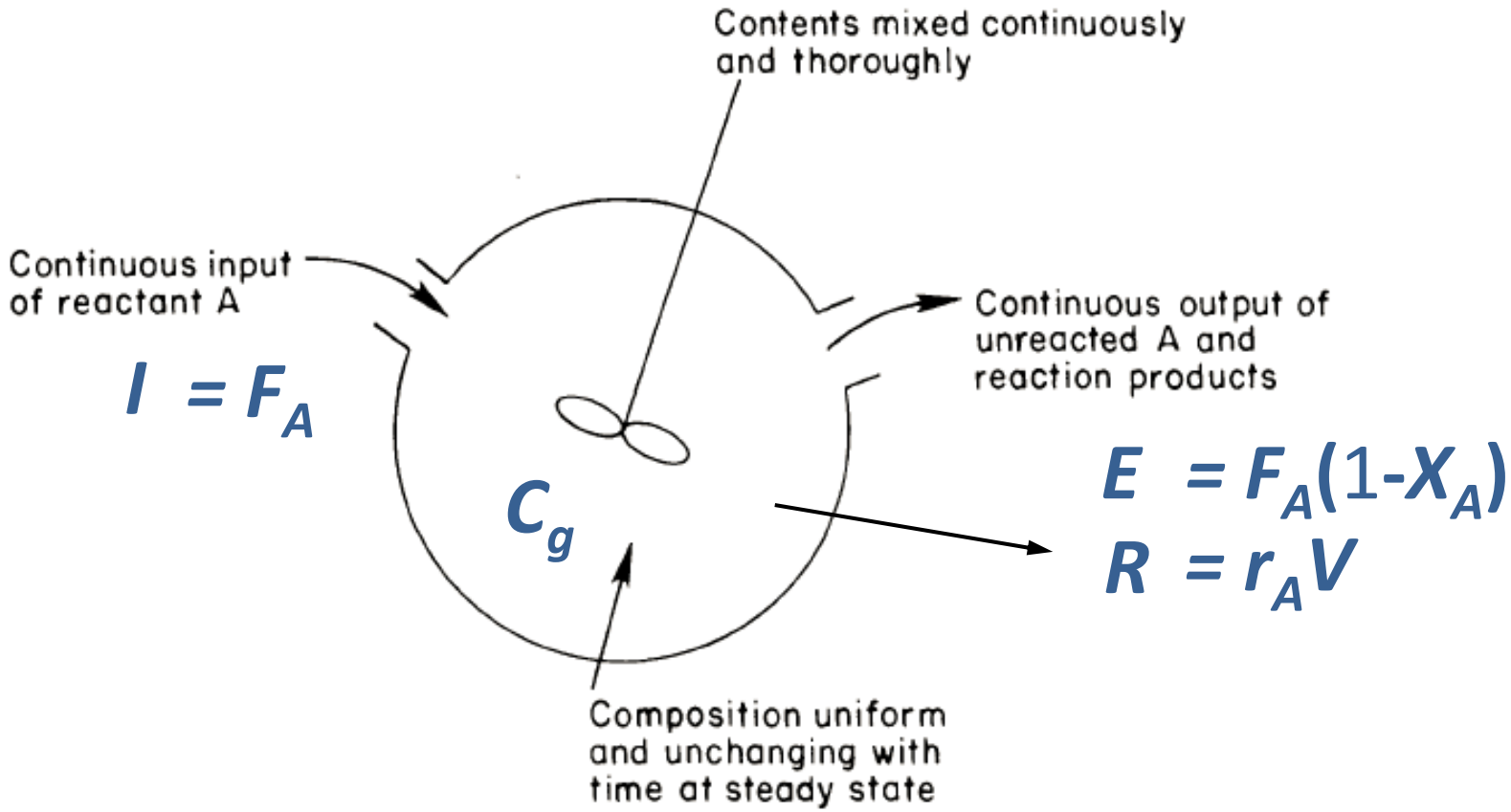
Functional response of carbon absorption efficiency in the calanoid copepod *Acartia tonsa*

- Create a functional response model for AE
  - useful for IBMs
  - model the balance between transport up through the food web and feacal carbon export to the microbial loop
- Explored the possibility to apply chemical reactor dynamics
  - AE as a direct function of prey concentration

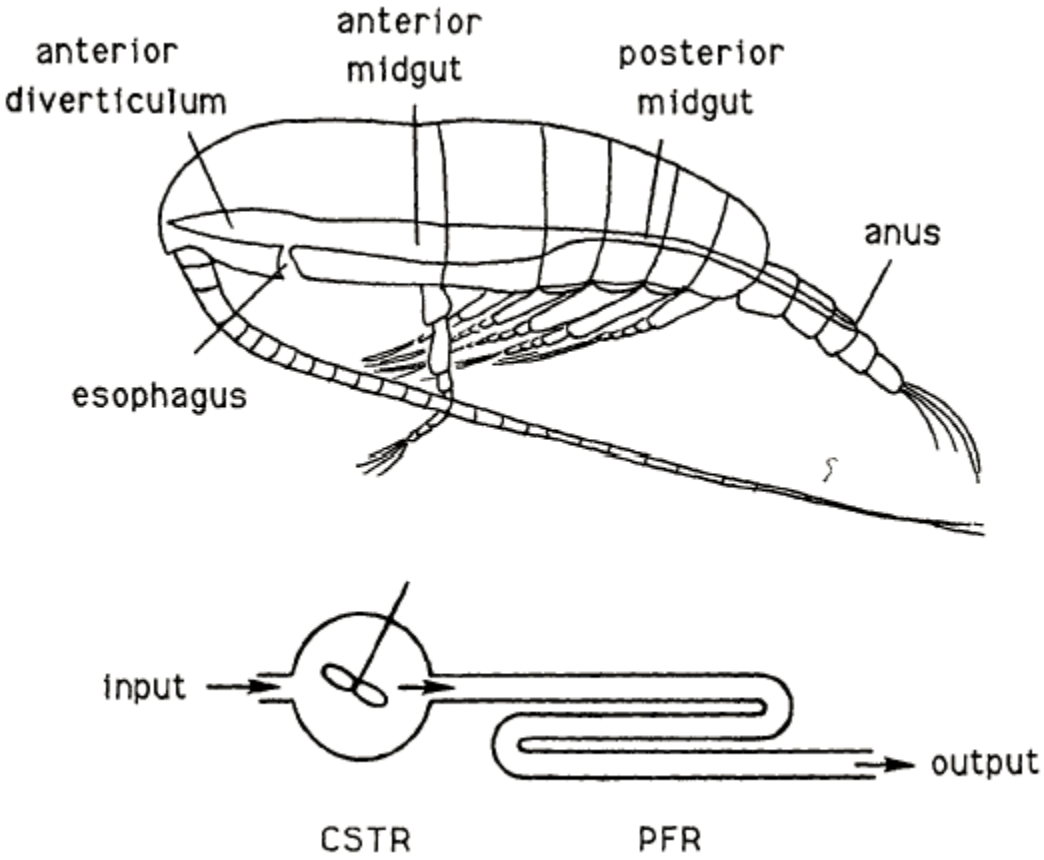


$$AE = 1 - \frac{E(C_g)}{I(C_p)}$$

Continuously stirred tank reactor, CSTR

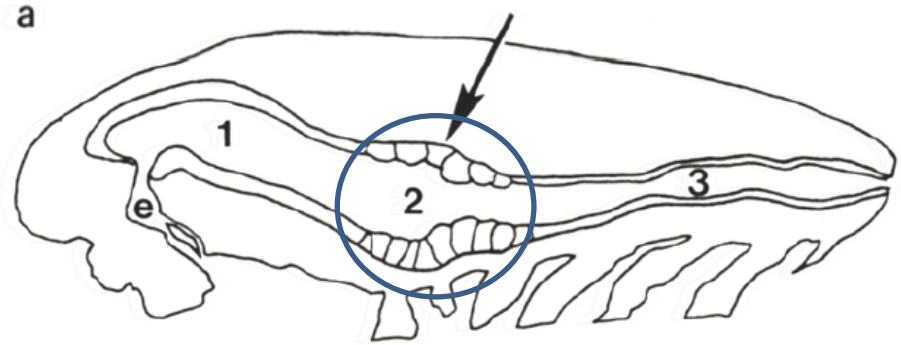


Penry and Jumars 1987



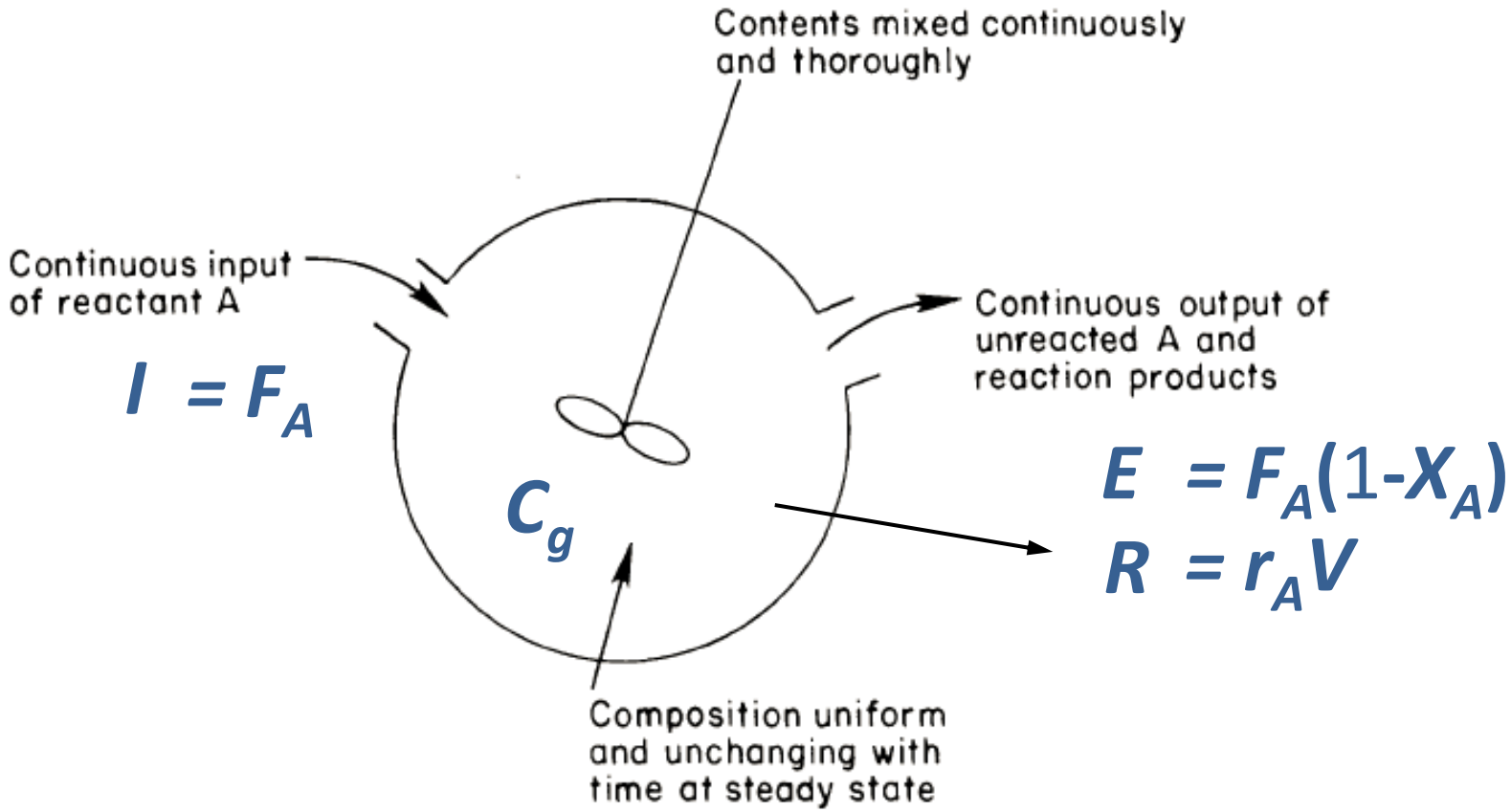
Penry and Frost 1990

Digestion in B-cells



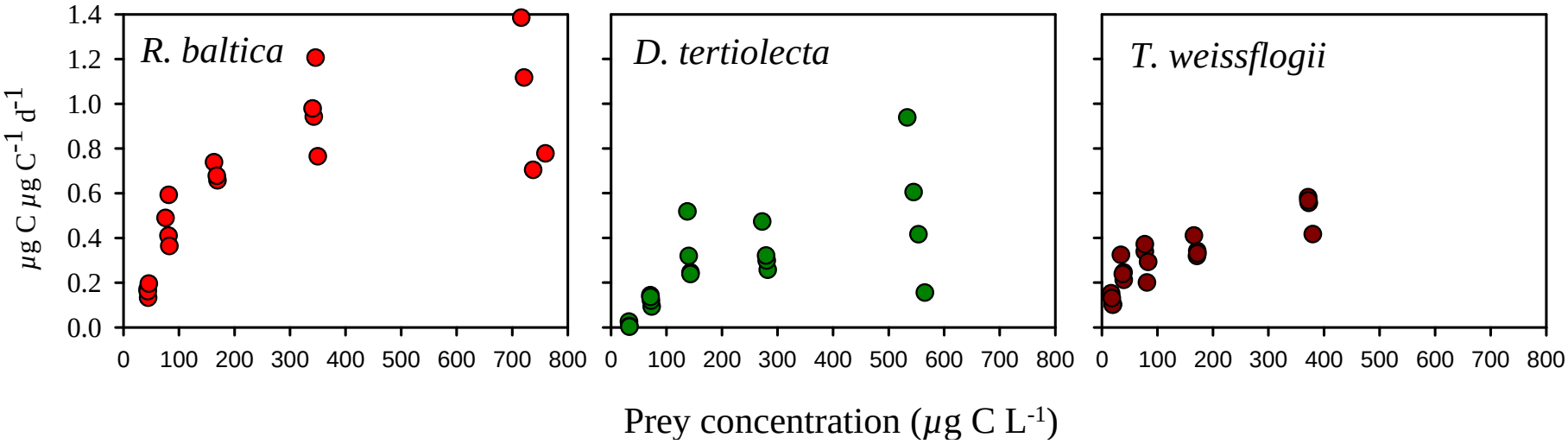
Hassett and Blades-Eckelbarger 1995

Continuously stirred tank reactor, CSTR



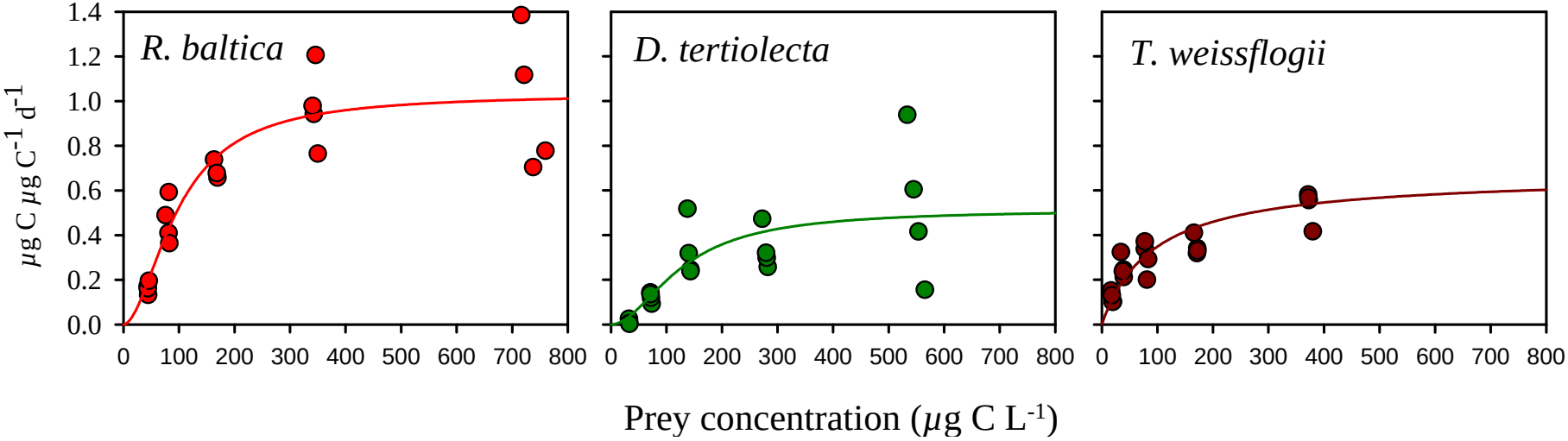
Penry and Jumars 1987

Ingestion rates

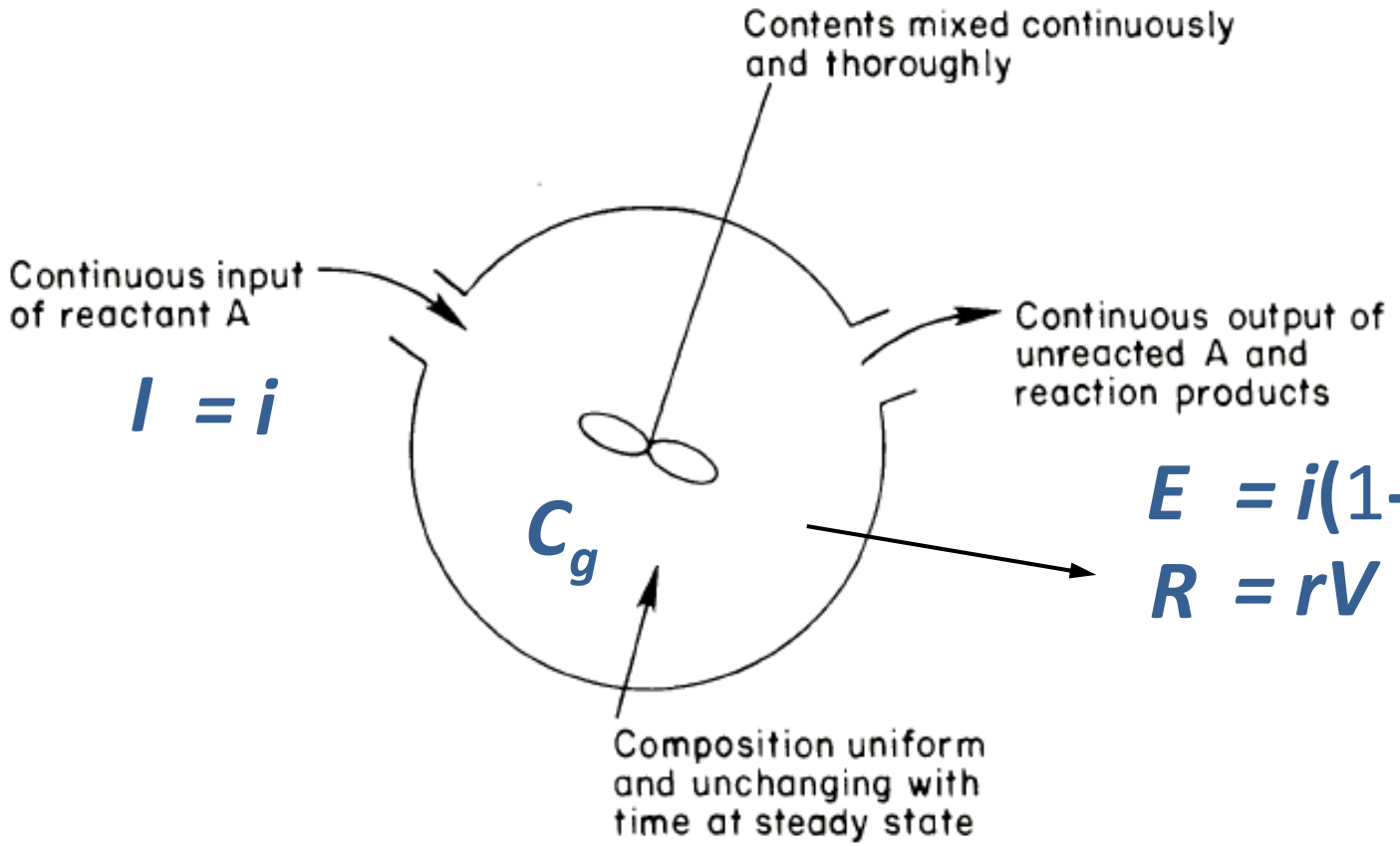


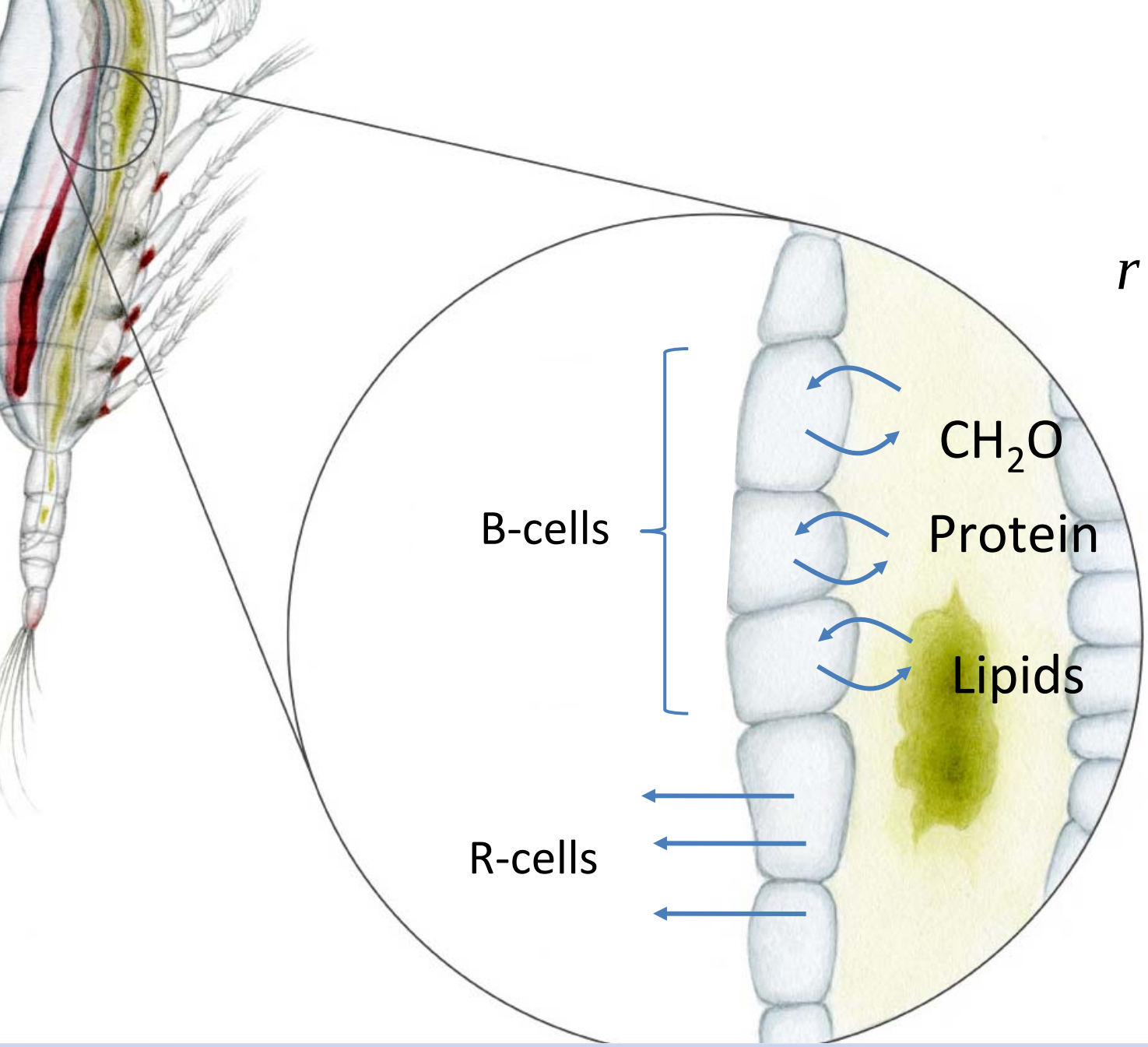
$$i = \frac{i_{\max} C_g^{\,h}}{K_m^{\,h} + C_g^{\,h}}$$

Ingestion rates

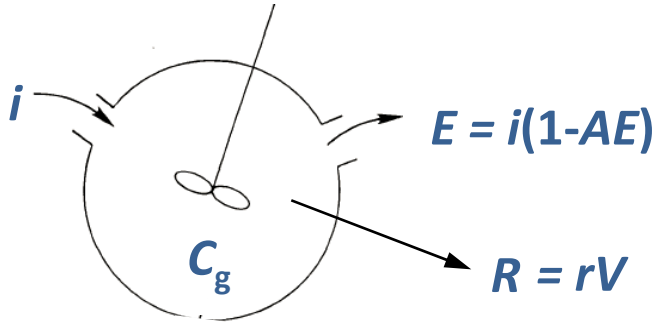


Continuously stirred tank reactor, CSTR



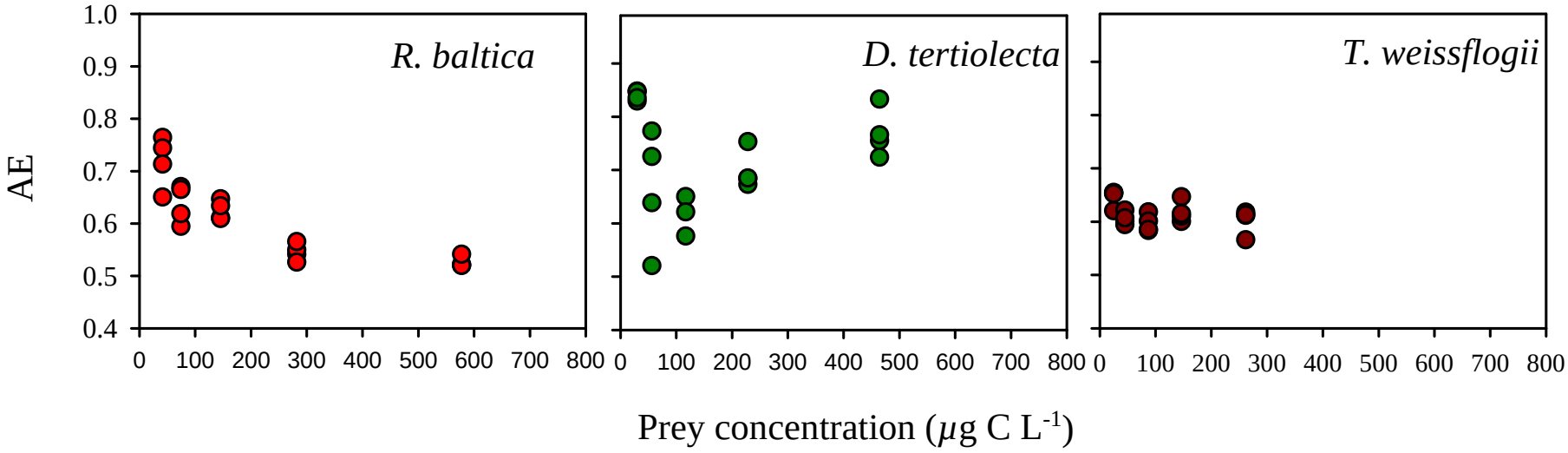


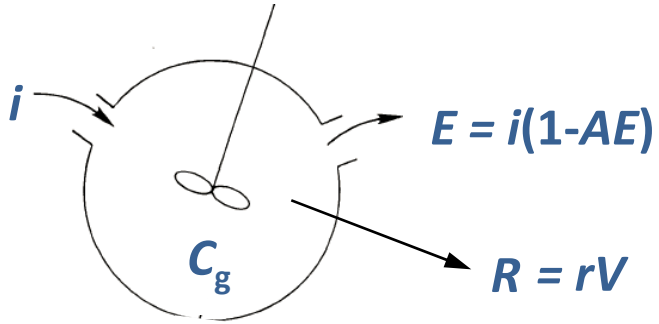
$$r = \frac{r_{\max} C_g}{K_m + C_g}$$



$$r = \frac{r_{max} C_g^{\ h}}{K_m^{\ h} + C_g^{\ h}}$$

Absorption efficiencies





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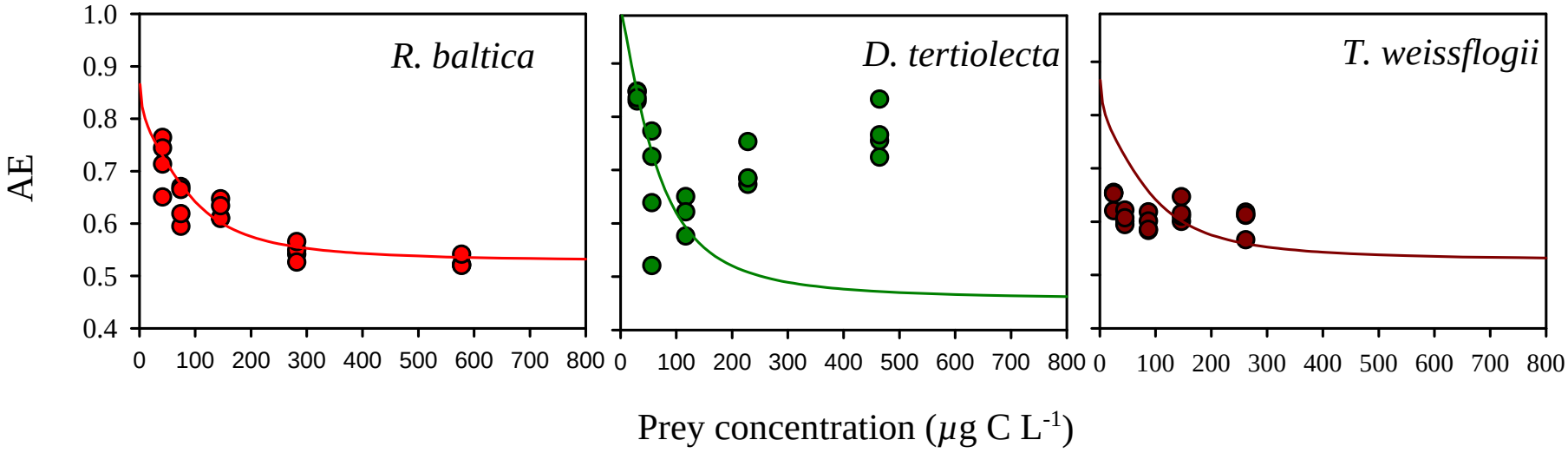
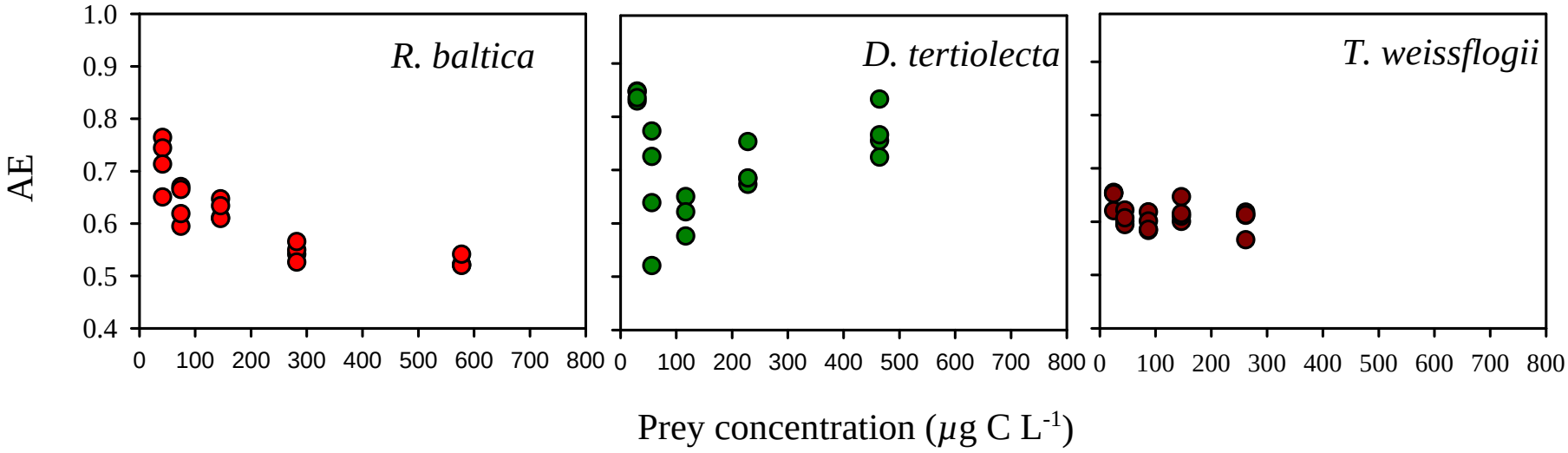
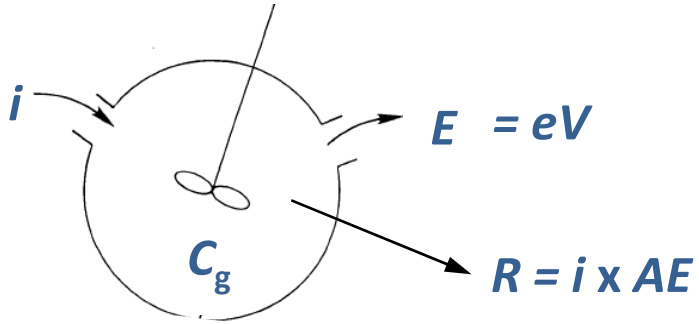
Absorption efficiencies

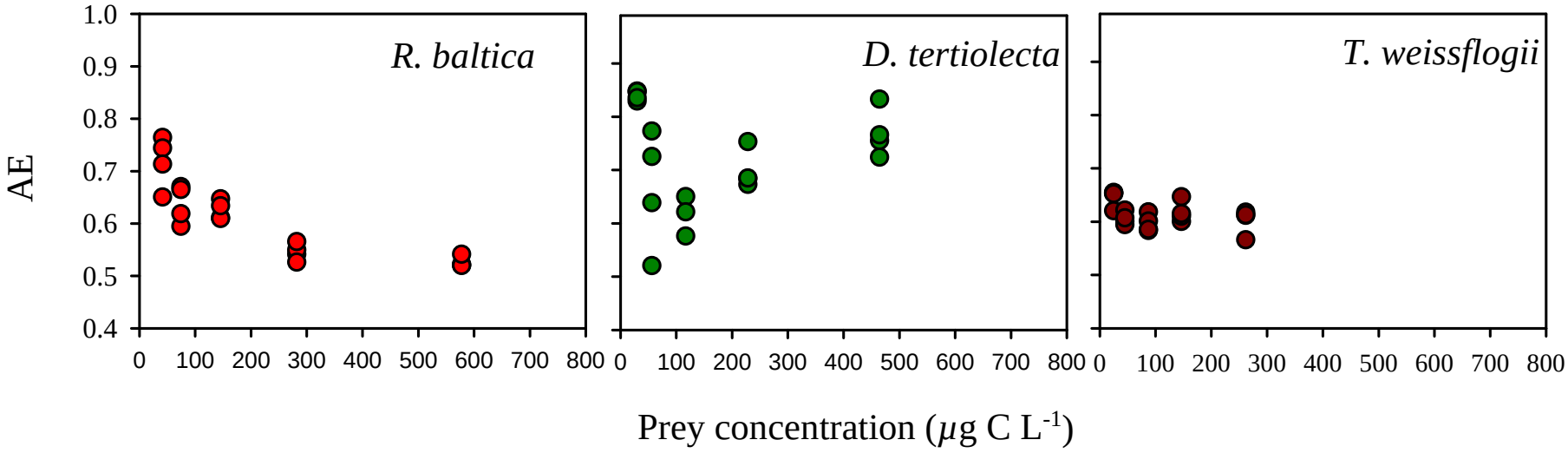


Absorption efficiencies

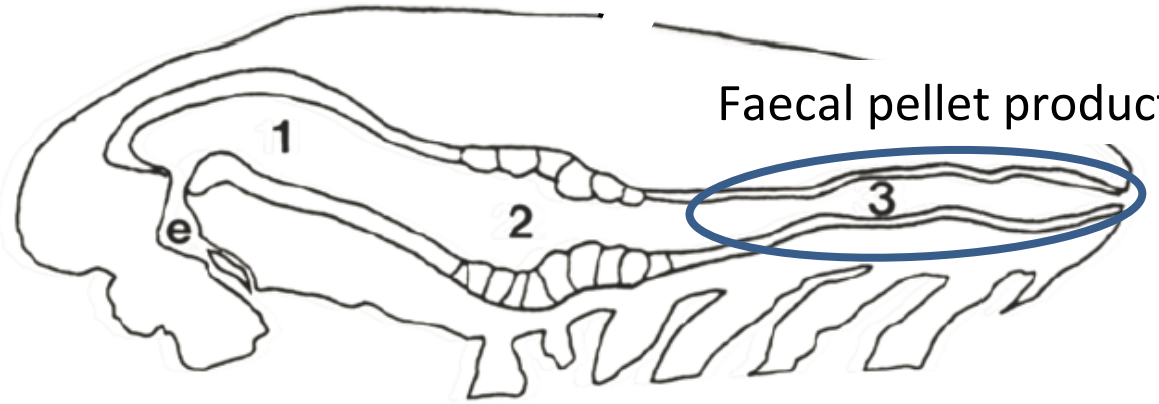




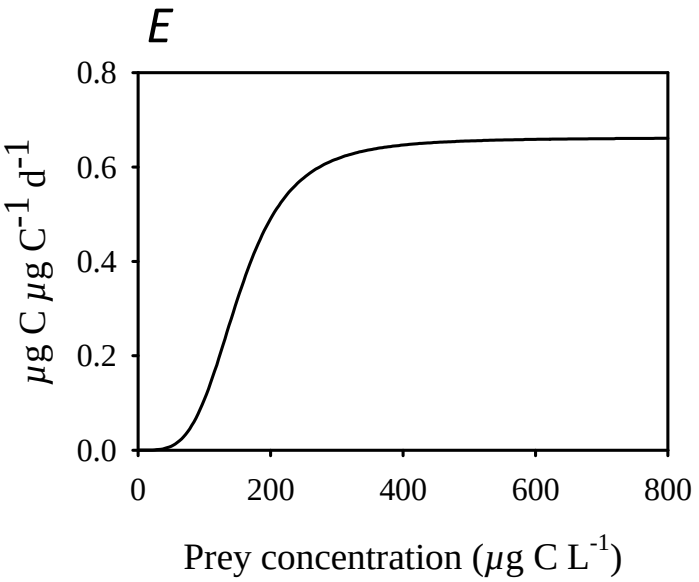
Absorption efficiencies

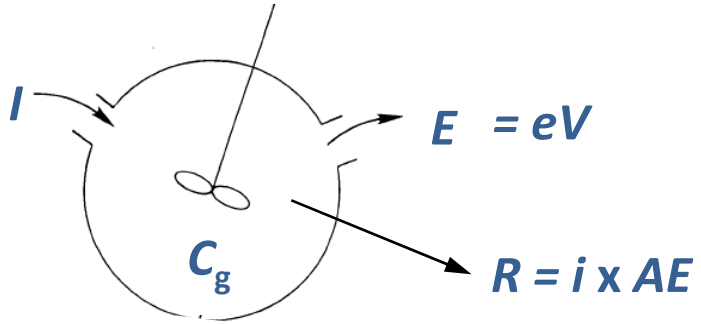


Egestion rate is controlled by the faecal pellet production rate



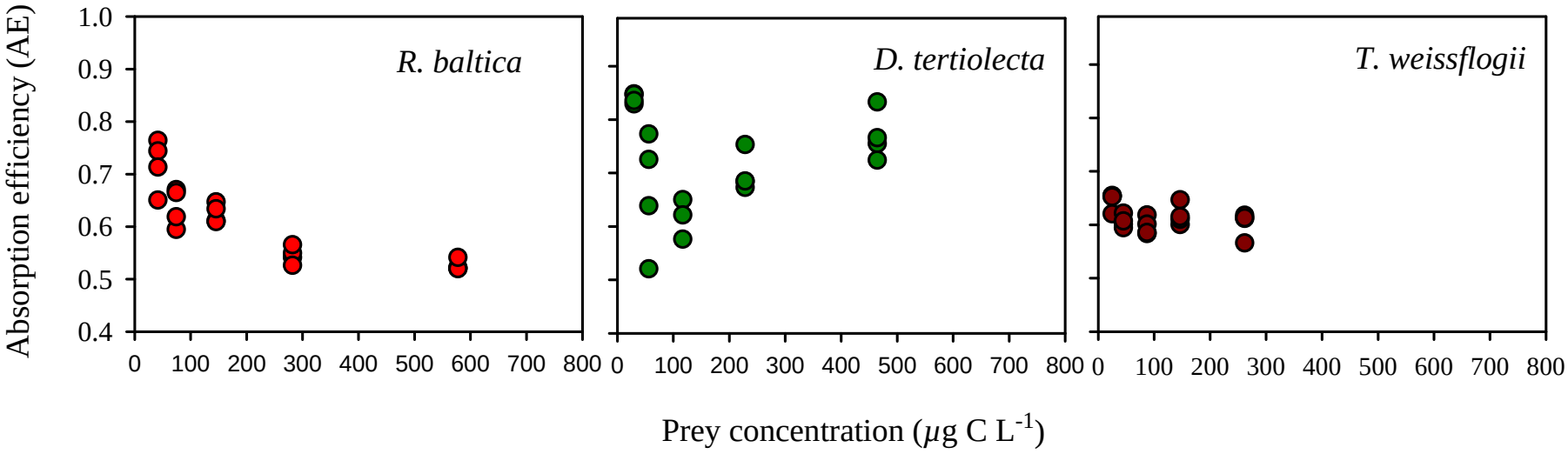
- chitin production rate (v_{env})
- compacting of gut material (z)
- peristaltic transport rate (v_{per})
- $$E = \frac{v_{env} v_{per}}{z}$$

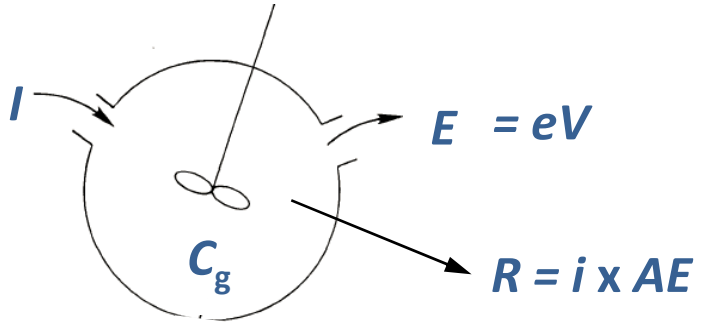




$$e = \frac{e_{\max} C_g^{\,h}}{K_m^{\,h} + C_g^{\,h}}$$

Absorption efficiencies





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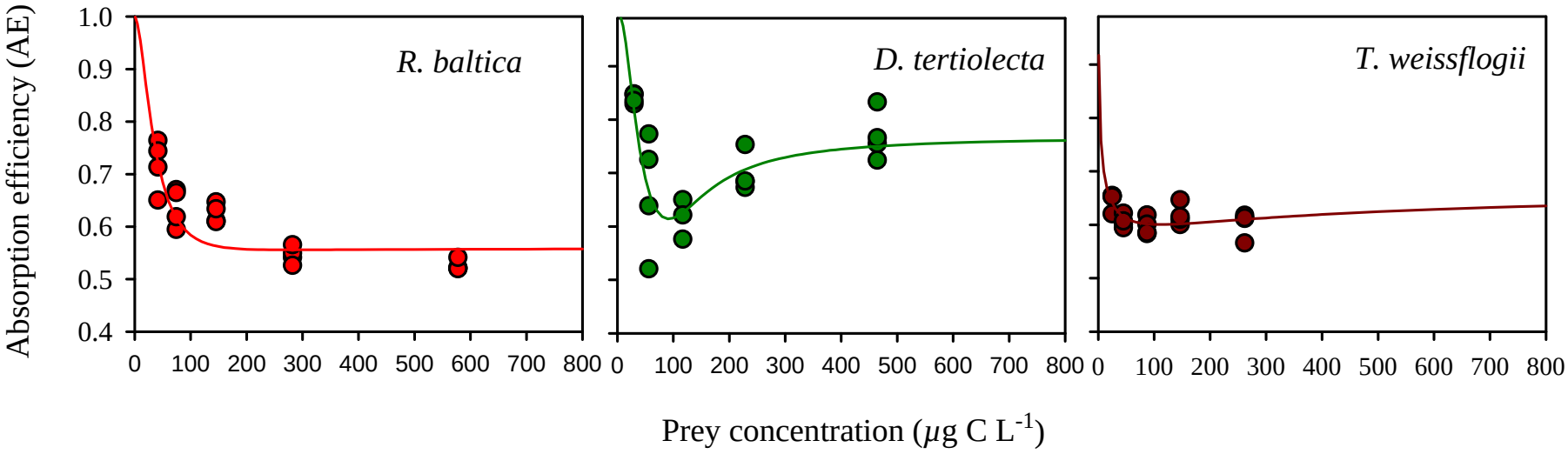
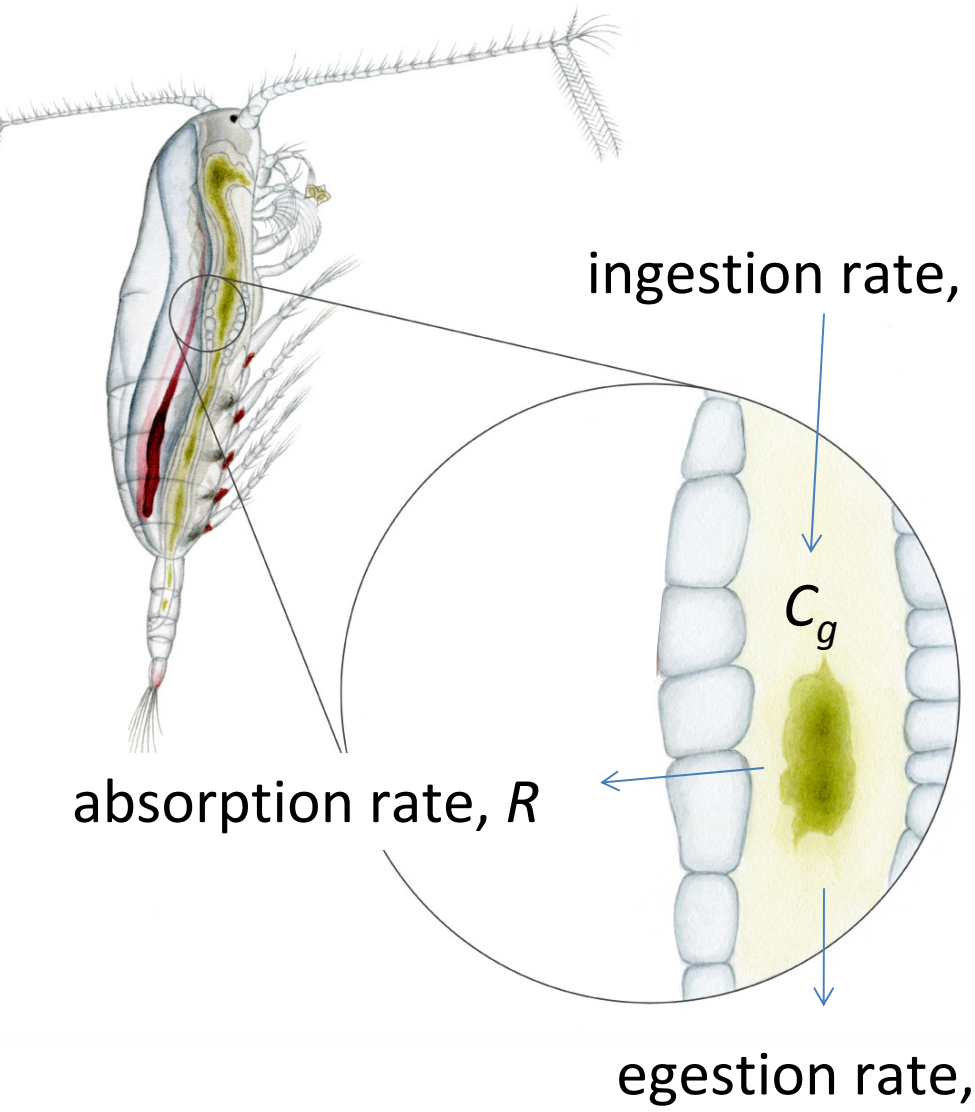
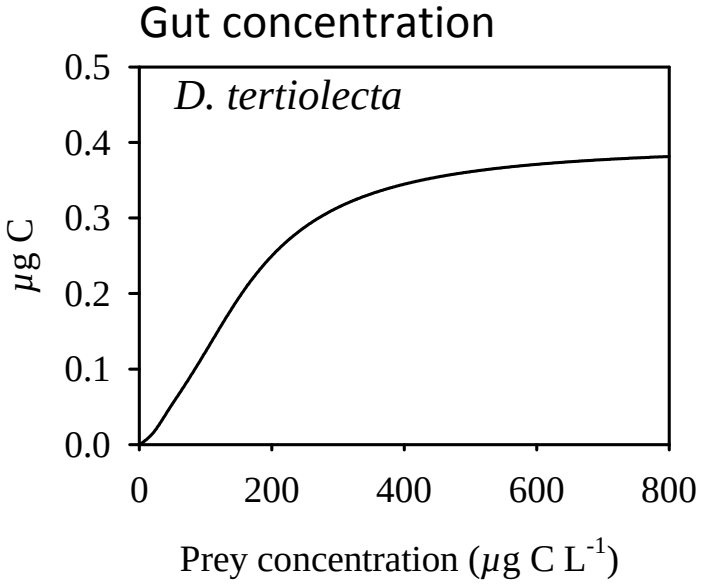
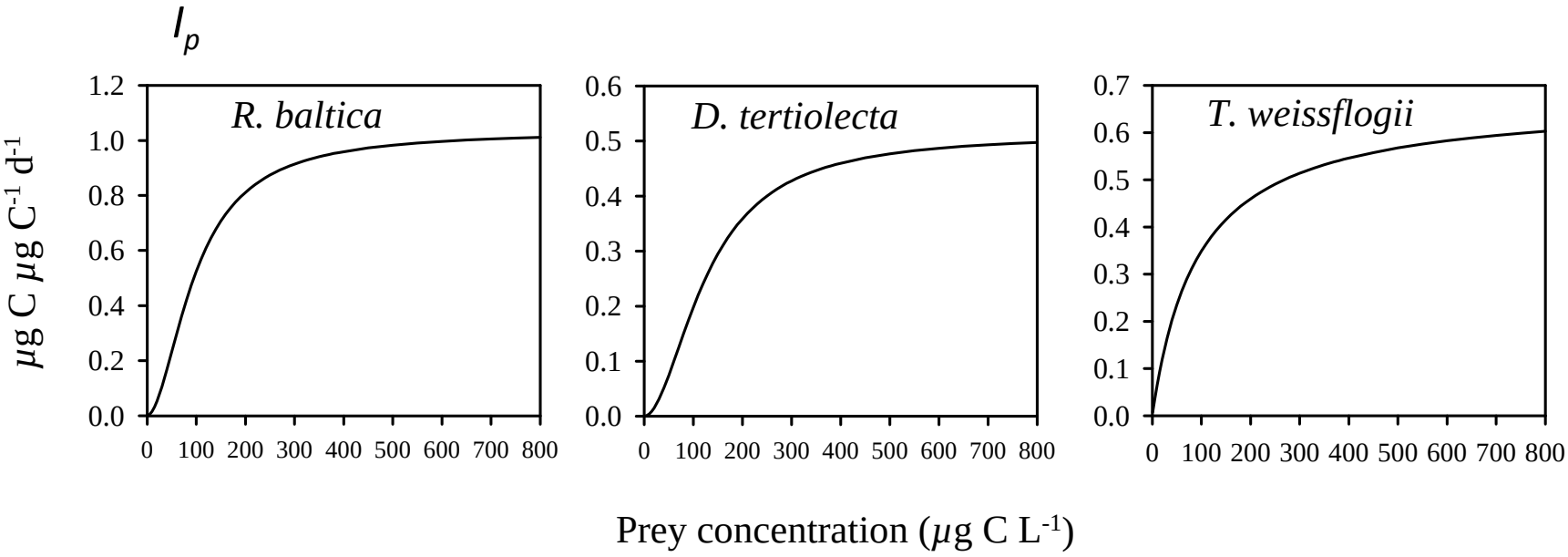


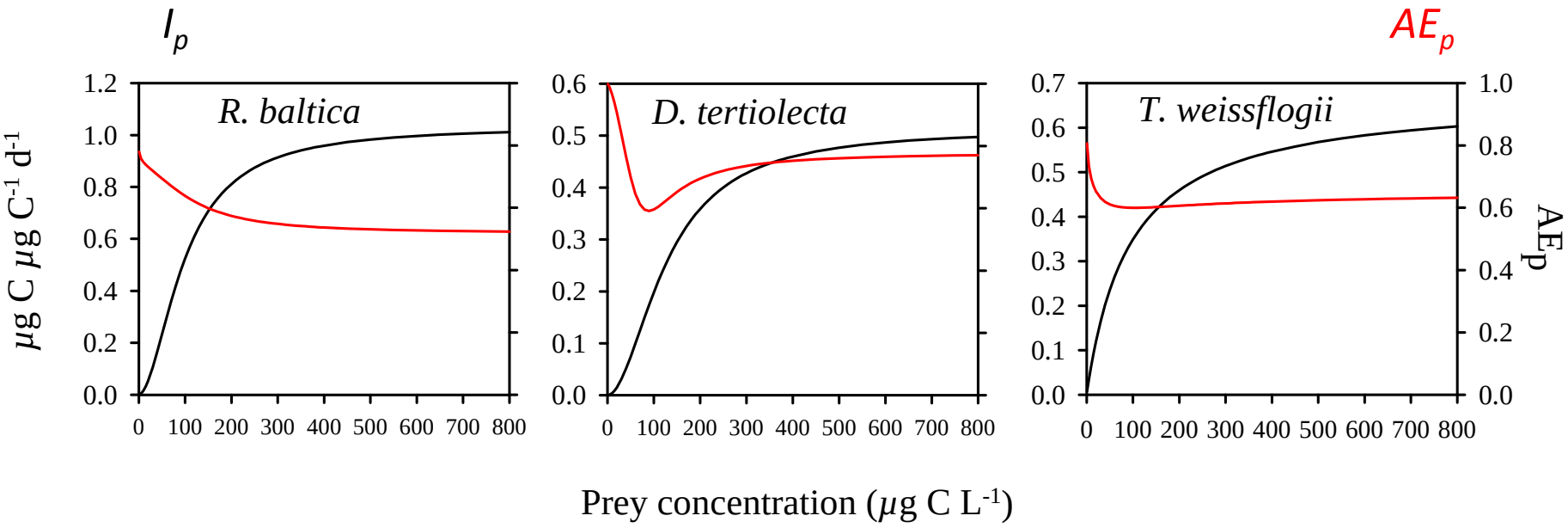
AE as a direct function of prey concentration

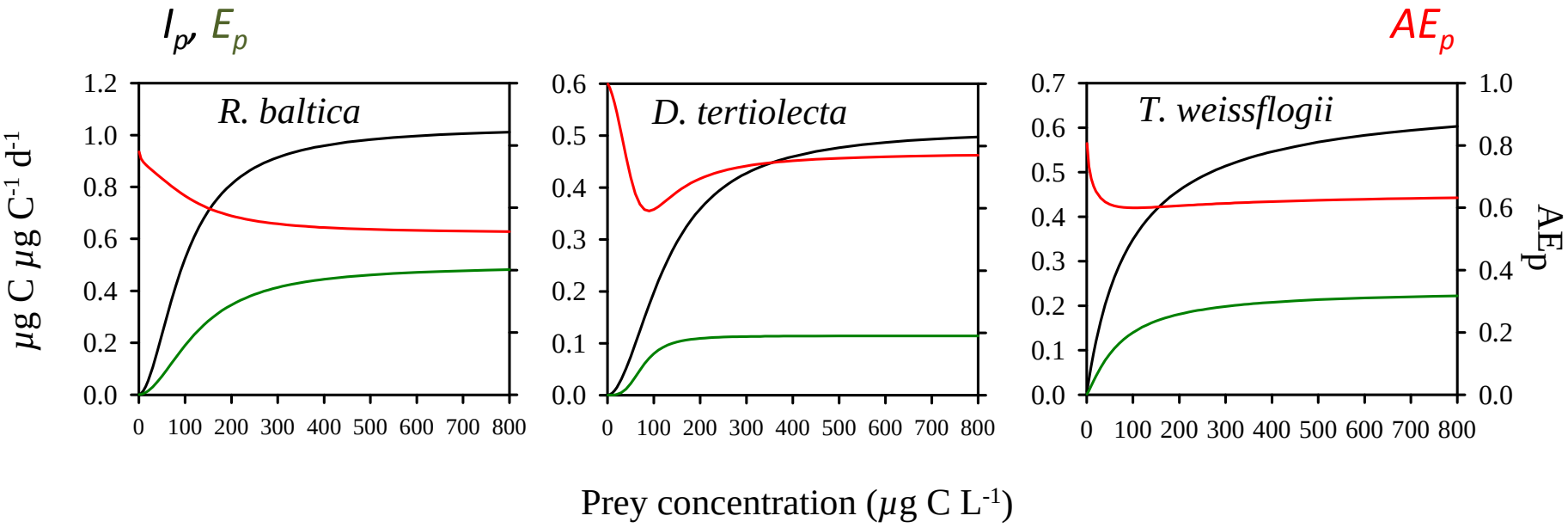


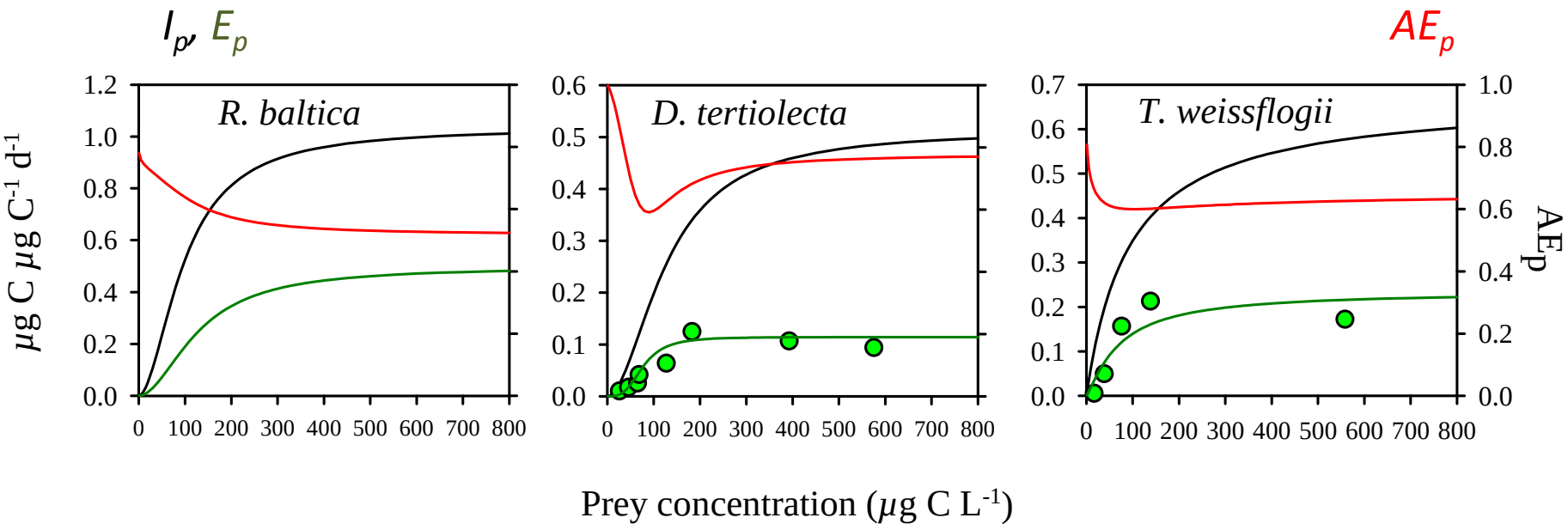
$$AE = 1 - \frac{E(C_p)}{I(C_p)}$$


Gut concentration
D. tertiolecta
0.5
0.4
0.3
0.2
0.1
0.0
µg C
0
200
400
600
800
Prey concentration (µg C L-1)


I_p
μg C μg C^{-1} d^{-1}
R. baltica
D. tertiolecta
T. weissflogii
0.0
0.2
0.4
0.6
0.8
1.0
1.2
0.1
0.3
0.5
0.7
0 100 200 300 400 500 600 700 800
Prey concentration (μg C L^{-1})


I_p
AE_p
R. baltica
D. tertiolecta
T. weissflogii
µg C µg C^{-1} d^{-1}
AE$_p$
Prey concentration (µg C L^{-1})


I_p, E_p
AE_p
R. baltica
D. tertiolecta
T. weissflogii
µg C µg C^{-1} d^{-1}
AE$_p$
Prey concentration (µg C L^{-1})



Butler and Dam 1994
Besiktepe and Dam 2002

Conclusions

- The CSTR model is able to explain gut absorption in copepods
- Variations in egestion rates control AE
- The model predicts AEs on very different algal diets, and is robust
- We were only able to model the observed AEs by de-coupling *I* and *E*
- AEs were around 60% for a wide range of concentrations for all 3 prey species (so 60% may be a useful standard AE for herbivorous copepods)