Metabolic theory for holometabolic insects

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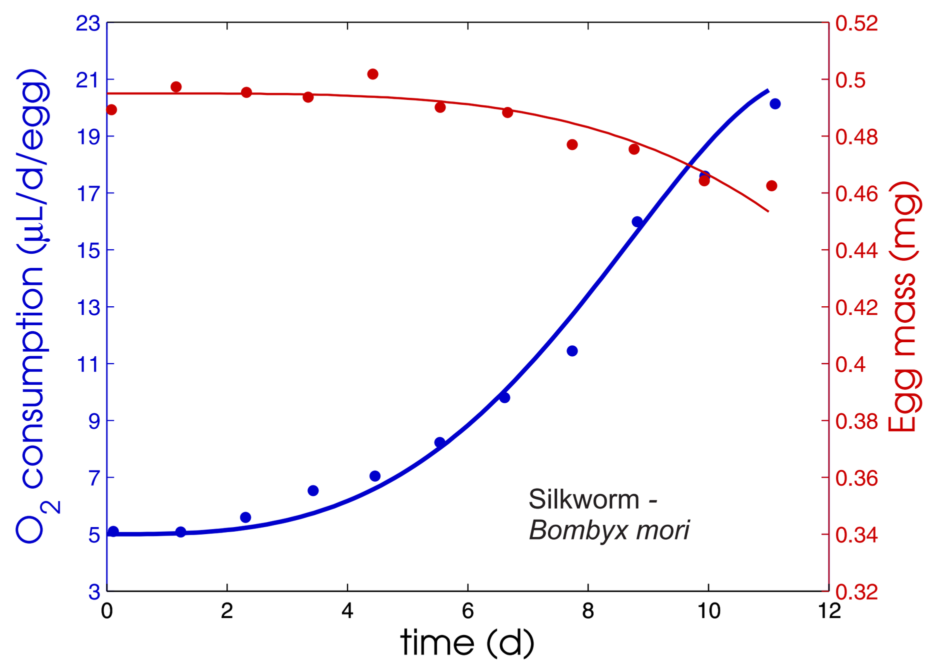
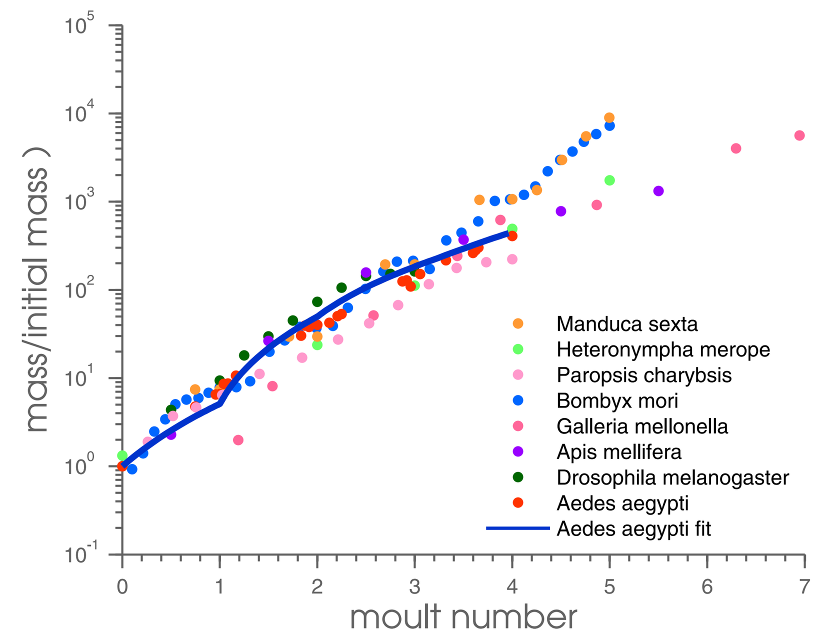
EMBRYO



Typical of insects, the oxygen consumption of a silkworm egg increases until hatching, while mass decreases.

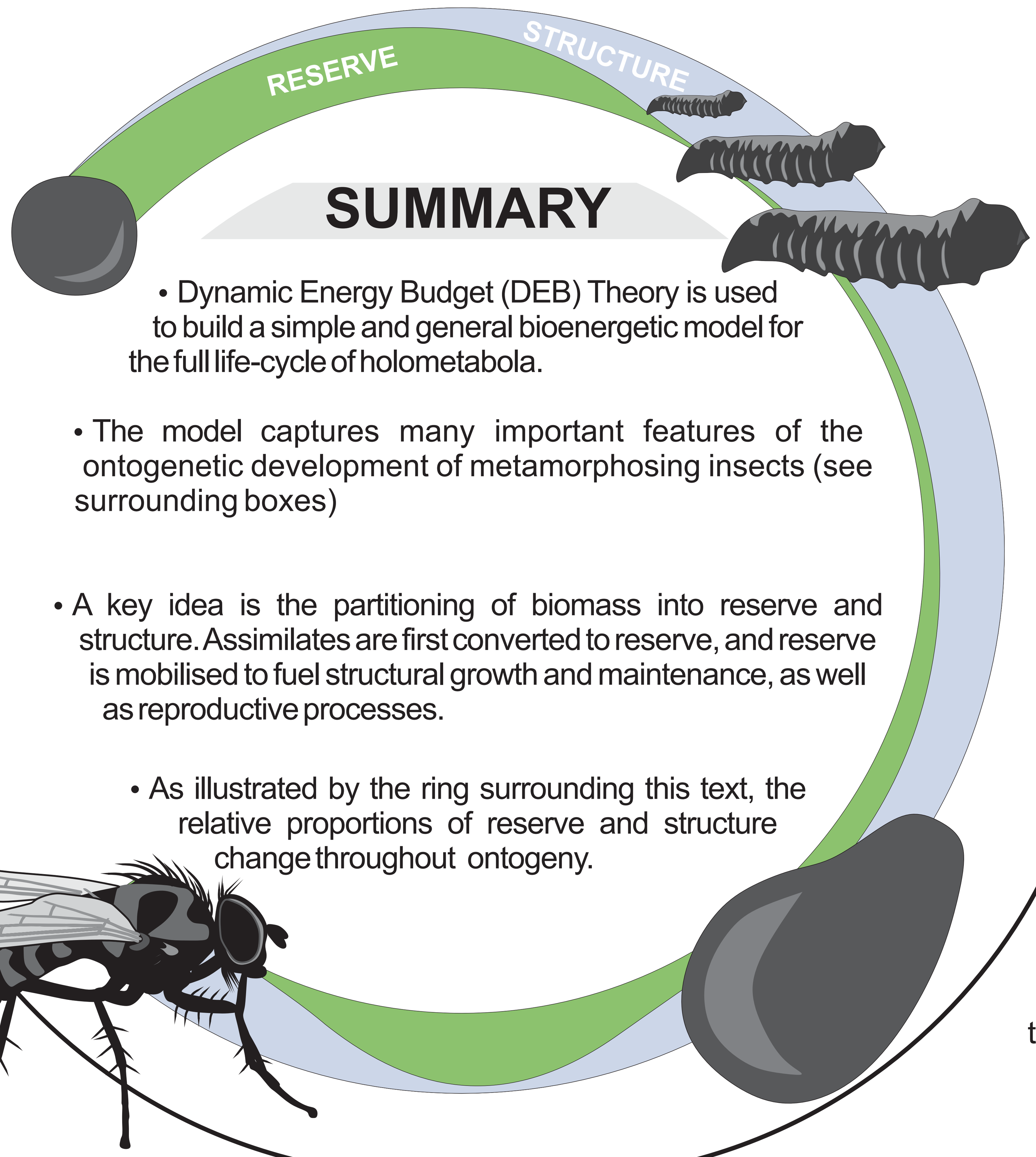
Oxygen consumption increases as a result of the growth and maintenance of larval structure, while egg mass decreases due to heat dissipation.

LARVA



The increase in scaled mass between moults broadly follows the same pattern for a wide range of holometabolic insect larvae.

The two compartment DEB model captures this general pattern of near exponential growth, as well as the changes in the energetic density of biomass as the larvae approach pupation.



SUMMARY

• Dynamic Energy Budget (DEB) Theory is used to build a simple and general bioenergetic model for the full life-cycle of holometabola.

• The model captures many important features of the ontogenetic development of metamorphosing insects (see surrounding boxes)

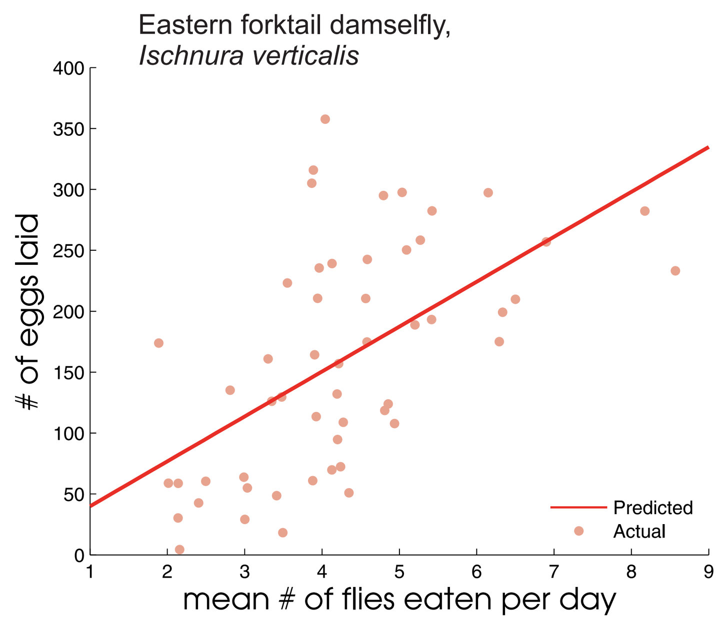
• A key idea is the partitioning of biomass into reserve and structure. Assimilates are first converted to reserve, and reserve is mobilised to fuel structural growth and maintenance, as well as reproductive processes.

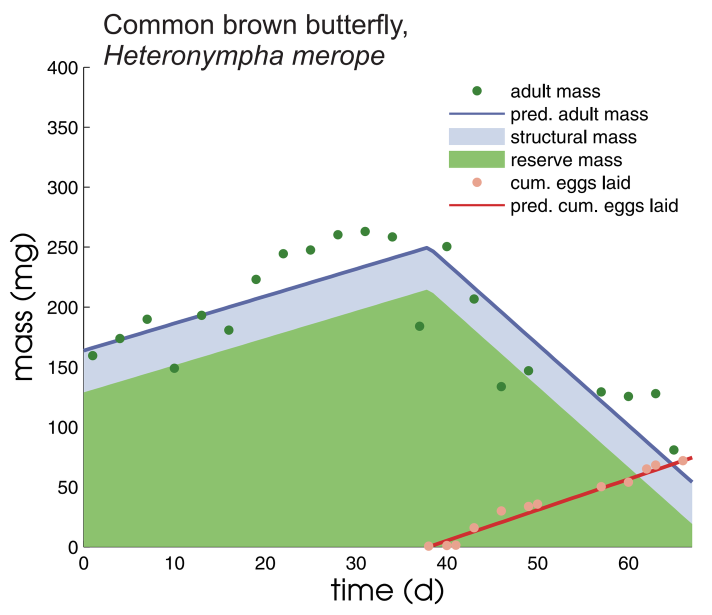
• As illustrated by the ring surrounding this text, the relative proportions of reserve and structure change throughout ontogeny.

ADULT

Higher food uptake in larval stages results in more adult reserve, increasing the number of eggs able to be produced (left fig.).

For holometabola that feed after pupation, adult mass can increase from resource uptake (right fig.). The cessation of egg laying coincides approximately with depletion of adult reserve.

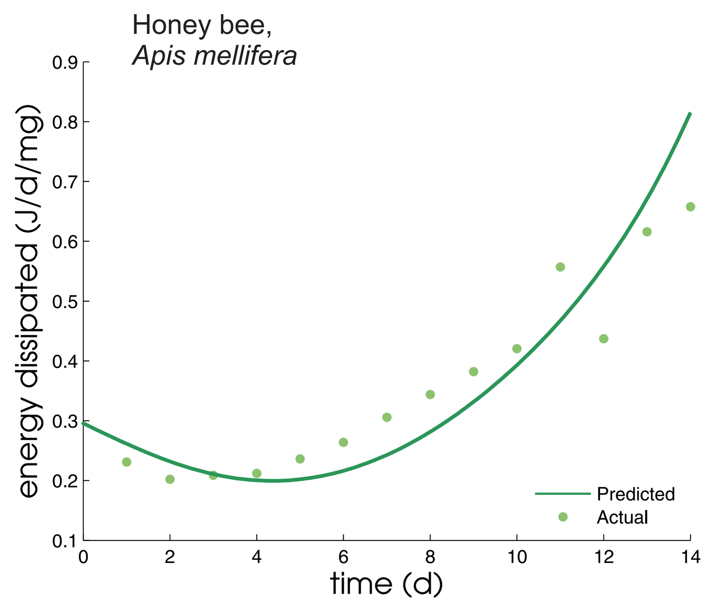


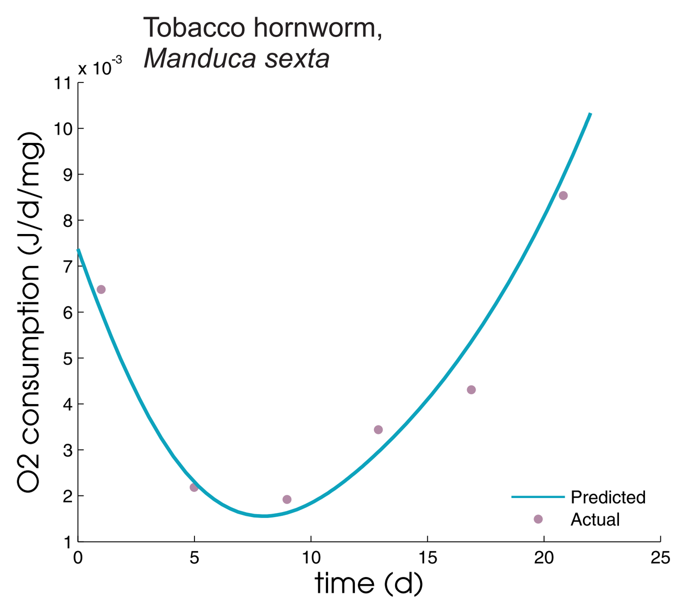


PUPA

The U-shaped pattern of pupal respiration is explained by the conversion of unnecessary larval structure to reserve followed by the development of adult structure.

Sedentary honey bee larvae (left fig.) have less larval structure to degrade than mobile tobacco hornworm larvae (right fig.), which accounts for the different shape of pupal respiration.





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James' research explores how constraints on the metabolic architecture of organisms can be utilised to build predictive models for full-lifecycle insect bioenergetics. In combination with biophysical approaches these models have applications in agricultural pest management and disease vector control.