Essai about DEB theory

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The goal of DEB theory is the study of the organization of metabolism described by the mass and energy flows inside the organisms. This theory aims to capture the quantitative aspects of the organization of metabolism at the organism level with implications for the sub and supra organismic levels. This theory is compatible with physics and evolution. This is traduced by the consideration of several physical principles:

1. mass and energy are conserved quantities;
2. any energy conversion process leads to dissipation;
3. mass and energy flows depend only on intensive properties;
4. mass and energy transport are proportional to surface areas because they occur across surfaces.

Some evolutionary principles taken into account:

1. organisms have increased their control over their metabolism during evolution allowing for some adaptation to environmental changes in short periods;
2. organisms inherit parent's characteristics in a sloppy way allowing for some adaptation to environmental changes across generations.

Deb theory partitions biomass into one or more reserves and one or more structures. It consider individual as the basic level of metabolic organization. The theory highlights 'Homeostasis' which is the ability to run metabolism independent from environmental conditions. This can obviously not be perfect, all organisms require food and/or nutrients. Homeostasis can be strong or weak : the difference between them is that strong homeostasis applies to possibly varying conditions, weak homeostasis to constant conditions only. DEB theory assumes that the chemical composition of reserve and structure is constant.

The standard DEB model is the simplest one. It considers an isomorphic organism, with one reserve and one structure. This model is assumed to be appropriate for heterotrophic unicellular organisms and animals.

Metabolism can be characterized by the following processes:

- Feeding : The intake of substrates from the environment.
- Assimilation : Generation of reserves from substrates.
- Catabolism : The use of reserves for metabolism (Reserve dynamics, Somatic and maturity maintenances, Reproduction).

The κ-rule assumes that food is transformed into reserve and faeces. The reserve, after the assimilation phase, is allocated with some fraction κ to growth and somatic maintenance, and with a fraction $1-\kappa$ to reproduction, maturation and maturity maintenance. The κ function is independent of reserve. In the standard DEB model, κ function is independent of volume.

DEB implementation is motivated by 4 observations :

1. Contrary to age, volume at birth or puberty hardly depends on food density. So stage transitions cannot be linked to age.
2. Some species continue growing after puberty. Other species, such as birds, only reproduce well after the growth period. So stage transitions cannot be linked to size.
3. Total cumulative energy investment in development at any given size of the individual depends on food density; this can be removed by allowing for maturity maintenance.
4. No reproduction occurs at very low food densities. This demonstrates the existence of maturity maintenance

To describe the energetic behaviour of an isomorph that feeds on a single type of food and has a single reserve and a single structure, the standard model has three state variables: structural volume V , reserve energy E and maturity, expressed in terms of cumulative energy investment, E_H.