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Mathematical modelling of the plasticity of energy stores at cellular scale

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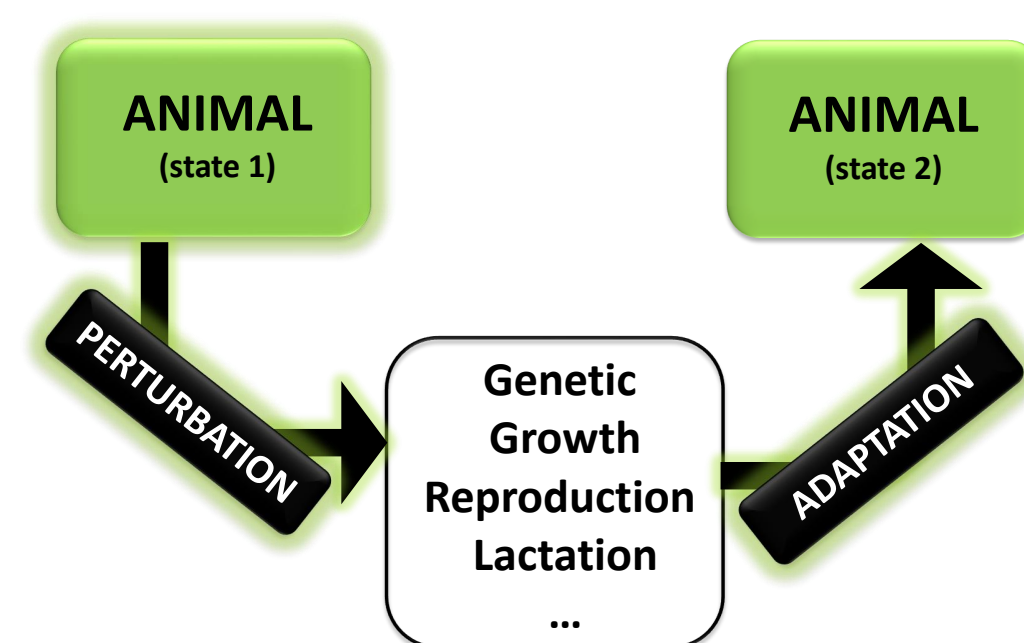
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INTRODUCTION

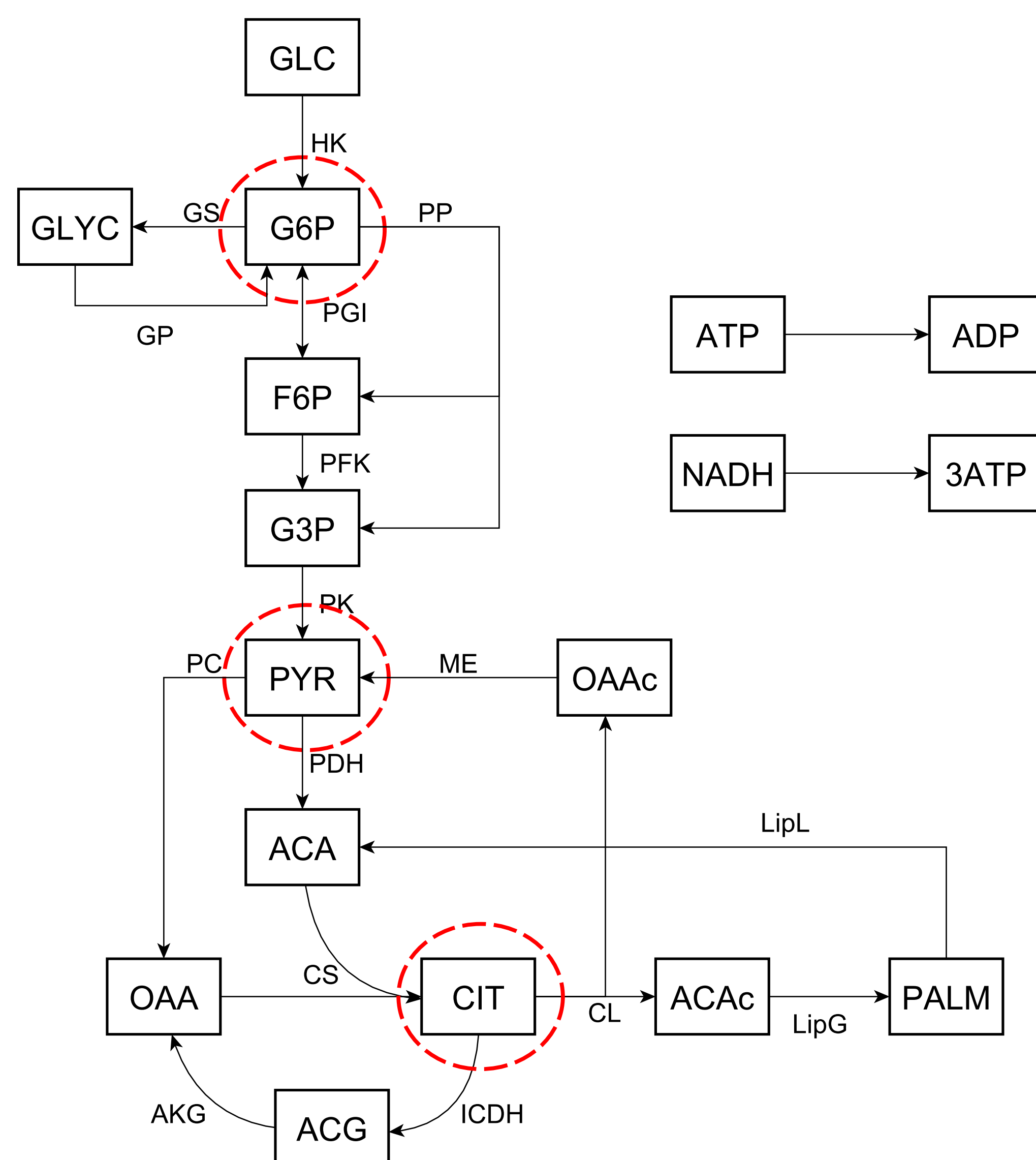
Faced with environmental constraints (nutritional, pathogens and disease, climate), animal modifies its energy metabolism at a cellular scale to guarantee its homeostasis. For example, in the case of nutritional challenges, the energy stocks are mobilized to produce the required energy for animal. In this study, we investigate the plasticity of the energy reserves

at cellular scale according to nutrient inputs and energy needs.



MATHEMATICAL MODELLING

A dynamic model has been developed to observe the evolution of energy stocks in a generic cell. Taking into account the main regulators of enzymes activities allows the model to describe the dynamics of storage and use of glycogen and lipids stores in a cell. The biochemical network of our model is represented in Figure below



$$\frac{dS}{dt} = N \cdot \nu(k, S)$$

$$S = (s_1, \dots, s_{15}), \nu = (\nu_1, \dots, \nu_{19})$$

$$N = [n_{ij}]_{1 \leq i \leq 15, 1 \leq j \leq 19}$$

Regulation of pentose phosphate pathway (ν_{PP}):

1. required energy for the cell is provided ($Energy = E_s$)
2. glycogen reserve is filled ($glycogen = G_m$)
3. the surplus of intake nutrients in $F6P$ is then deviated toward pentose phosphate pathway.

NUMERICAL SIMULATIONS

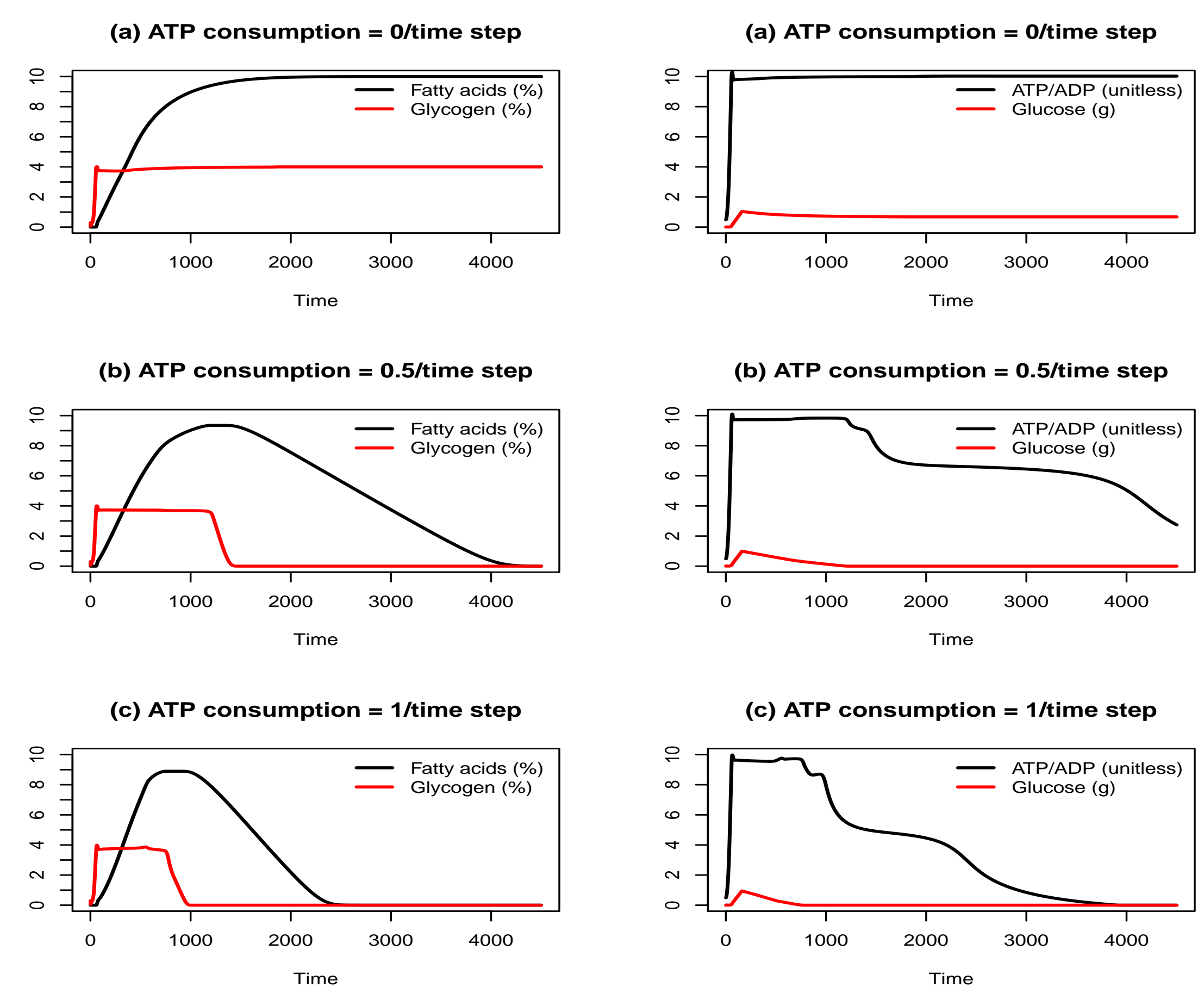


Figure 1: Three levels of ATP need have been compared: (a) no energy need, (b) 0.5 ATP per minute and (c) 1 ATP per minute for continuous entry of 160 glucose units.

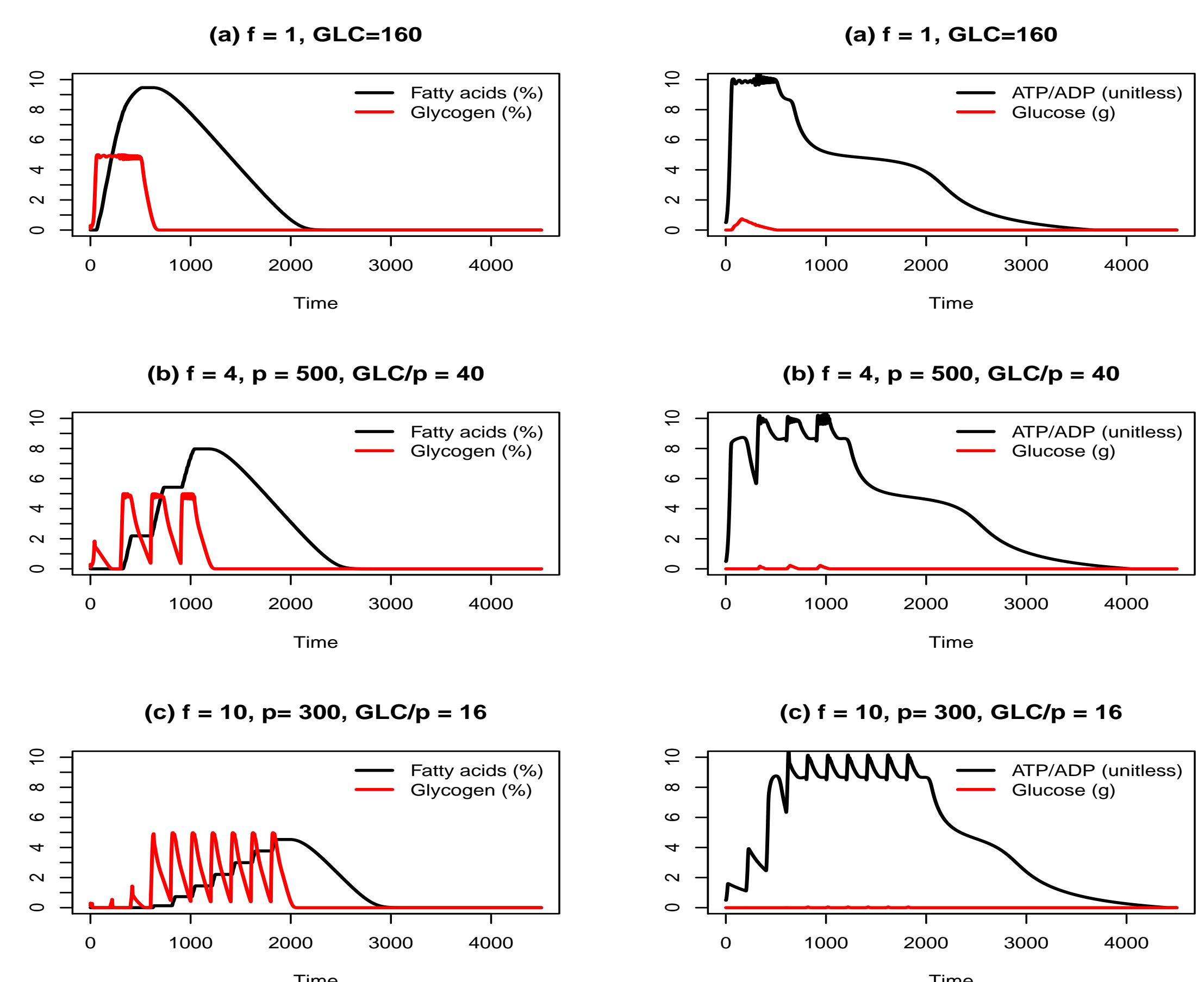


Figure 2: Three feeding frequencies have been compared, (a) one entry of 160 GLC, (b) 4 entries of 40 GLC et (c) 10 entries of 16 GLC.

CONCLUSION

The model is generic and phenomenological, and provides a basis to investigate various hypotheses in animal biology. It allows for example studying the postprandial metabolism (fast dynamics) and energy stock management in lactation/gestation (slow dynamics). Furthermore, it allows understanding and predicting the effects of diets containing contrasting sources of energy (carbohydrates / lipids) on the energy stocks in animal.

CONTACT INFORMATION

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