REPLY

Reply to Comment on ‘The cancer Warburg effect may be a testable example of the minimum entropy production rate principle’

To cite this article: Bartolomé Sabater and Dolores Marín 2018 Phys. Biol. 15 028002

View the article online for updates and enhancements.
Concerning the first error claimed by Sadeghi [1] in our paper [2], we would like to point out that the minimum rate theorem [3] refers to internal entropy production ($\Delta S_i$), here applied to the chemical reaction in the open cell system: $\Delta S = (\Delta H - \Delta G)/T$. This is indicated in the last lines of the left column of page 2, and shown in table 1 for respiration and fermentation. Within the steady-state open cell system, the entropy does not vary and internal entropy production is compensated by exported entropy ($\Delta S_i + \Delta S_e = 0$) that includes the contribution of the heat of reaction ($\Delta H$). The cell is continuously exporting entropy ($\Delta S_e$) to compensate for the entropy produced inside ($\Delta S_i$). The whole system accomplishes the second principle ($\Delta S_{\text{universe}} > 0$) because it also includes the entropy production associated with the transport of substrates, products and heat between the cell and the external environment.

Concerning his second claim, we agree. Entropy production rate is usually expressed per unit of time ($dS/dt$). However, as we indicated [2]: ‘In a steady-state open system there is an essentially constant supply of the glucose precursor and the minimum rate of entropy production per unit of time is equivalent to the minimum rate of production of entropy per mole of glucose’ (first paragraph in section 5. Accomplishment of the Prigogine theorem (right column of page 3).

In our opinion, the questions raised by Sadeghi would be settled by the experimental approach that we propose to confirm the cancer Warburg effect as an example of the minimum entropy production rate theorem. In fact, Sadeghi recognises in the first two lines of the third paragraph [1] that ‘Glucose fermentation produces less entropy than mitochondrial respiration per mole of glucose consumed…’ and our hypothesis (according to which external CO₂ concentrations in the range 1000–1100 ppm could displace fermentative by respiratory cells and, eventually, decrease cancer cell proliferation) deserves an experimental approach.

ORCID iDs
Bartolomé Sabater https://orcid.org/0000-0002-8586-1226

References
[1] Sadeghi Ghuchani M 2018 Comment on: The cancer Warburg effect may be a testable example of the minimum entropy production rate principle Phys. Biol. 15 028001