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Enzyme activity in microgravity: a problem of catalysis at the water–lipid interface?

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The gravitational effects on molecule–molecule interactions are largely unknown, though well-defined physico-chemical systems have demonstrated that diffusion processes, mass transfer and density fluctuations are targets for gravity [1]. In this line we have interpreted our recent observation that microgravity increases the affinity of lipoxygenases for free fatty acids [2]. However, an interesting report has shown that neither direction of the isocitrate lyase reaction is affected by microgravity [3], raising the question of which critical factors might control the sensitivity of enzymes to the gravitational field. We have been asked to comment on this.

While it is not surprising that enzymes so different as lipoxygenase (which adds molecular oxygen to polyunsaturated fatty acids) and isocitrate lyase (which cleaves isocitrate into succinate+glyoxylate) react differently to the gravistimulus, the two studies [2,3] seem to give clues to possible factors responsible for the observed differences. Firstly, microgravity is likely to favour the dispersion in water of less dense molecules such as lipids (including fatty acids), just the opposite to what is observed in hypergravity [1]. This effect, schematically represented in Fig. 1, should facilitate the formation of the enzyme–substrate complex, thus leading to an apparently increased enzyme affinity for the fatty acids [2]. Secondly, the substrate reaches the active site of lipoxygenase by passing through a relatively long hydrophobic channel, termed 'cavity II' [4], and the weak chemical bonds formed during this passage might be affected by the force of gravity, as suggested by preliminary theoretical calculations [5]. Taken together, it can be suggested that enzymes working at the water–lipid interface might be more sensitive to gravity than enzymes having hydrophilic substrates. At any rate, the two studies [2,3] clearly show that further experiments are needed to clarify the gravitational effects on enzyme catalysis, which might be particularly important for enzymes involved in lipid metabolism and membrane remodelling and homeostasis.

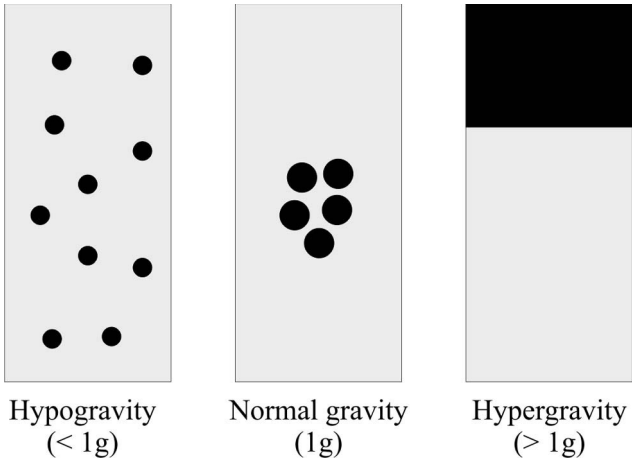

Fig. 1. Schematic representation of the possible effect of the gravitational field on the dispersion of lipid droplets in water.

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