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Fundamental role of bistability in optimal homeostatic control
GUANYU WANG, George Washington University — Bistability is a fundamental phenomenon in nature and has a number of fine properties. However, these properties are consequences of bistability at the physiological level, which do not explain why it had to emerge during evolution. Using optimal homeostasis as the first principle and Pontryagin's Maximum Principle as the optimization approach, I find that bistability emerges as an indispensable control mechanism. Because the mathematical model is general and the result is independent of parameters, it is likely that most biological systems use bistability to control homeostasis. Glucose homeostasis represents a good example. It turns out that bistability is the only solution to a dilemma in glucose homeostasis: high insulin efficiency is required for rapid plasma glucose clearance, whereas an insulin sparing state is required to guarantee the brain's safety during fasting. This new perspective can illuminate studies on the twin epidemics of obesity and diabetes and the corresponding intervening strategies. For example, overnutrition and sedentary lifestyle may represent sudden environmental changes that cause the lose of optimality, which may contribute to the marked rise of obesity and diabetes in our generation.

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