

# THE TEXT

## Daisyworld Misunderstood: Gaian Homeostasis is Inevitable

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The streamlined tuna is fit for purpose, needs a selective explanation.

The boulder rolling to the bottom of a hill doesn't.

Too many misunderstand Daisyworld-style explanations [1] of Gaian regulation as the former type. But Daisyworld is the latter: from some initial conditions a pattern of Daisyworld-homeostasis is inevitable, no selection needed.

Misunderstanding follows failure to distinguish between *Viability* and *Feasibility* [2]. Define  $Viability_D(T)$  as the steady-state quantity of D-daisies at T-temperature. In turn, daisies have *effect(D)* on T (e.g. black daisies are warmer). The  $D \leftrightarrow T$  interactions are parameterised by some perturbation L (e.g. solar Luminosity). Define *Feasibility-Range*  $FR(D, effect())$  as the range of L-values supporting stable equilibrium with  $D > 0$ : '*feasible* Luminosities supporting steady  $Viability > 0$ '.

Using physically plausible equations [2] we prove  $FR(D, effect()) \supseteq FR(D, null-effect)$ . Any (+/-) effect that D has on T can only increase (never decrease) *Feasibility-Range*. This agrees with classical Daisyworld-homeostasis [1] (that used 'anecdotal' examples open to accusations of cherry-picking); but is now fully generalisable [2] (including to any number of  $D_i$  or of  $T_j$  without selection).

A change in *effect()* may increase *Feasibility-Range* whilst decreasing *Viability*. They are different, indeed orthogonal, though commonly confused: even Gaian advocates [3] misleadingly claim "Daisyworld is a special case in that traits selected at an individual scale also lead to global regulation". Actually interactions with Darwinian evolution are very different than this implies, and even random unselected trait-effects support such global regulation. Advances in Gaia theory are essential for understanding past, present and future homeostasis of this planet; but are hindered by such misunderstandings and misplaced appeals to selection.

References: [1] Watson AJ and Lovelock JE (1983). Biological homeostasis of the global environment: the parable of Daisyworld. *Tellus* 35B:284-289.  
[2] Harvey I (2018). Robustness and contingent history: from Prisoner's Dilemma to Gaia theory. *Artificial Life* 24(1):29-48.  
[3] Lenton, TM et al. (2018). Selection for Gaia across multiple scales. *Trends Ecol Evol* 33(8):633-645.

See ref [2] via my webpage

# THE SUBTEXT



1982/83: Classic Daisyworld "Parable"  
No selection/evolution

...sounds adaptive, must have evolved, we can show you some anecdotal examples

we'll just use terms like 'selection' a bit vaguely, and hope we are not challenged



We've got no theory



sounds adaptive, but how could it have evolved?



don't you know all the problems with 'group selection'?



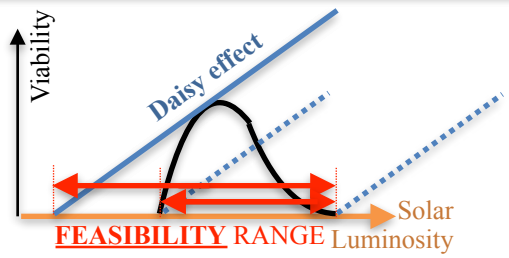
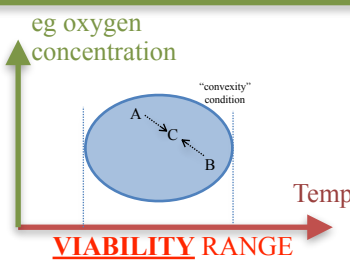
your examples are cherry-picked, we can surely find counter-examples



They've got no theory



It's just Physics, stupid!  
No selection needed!  
Rigorous theory needed!



## THE BET

Find a single counter-example  
Terms and conditions apply!  
Win a case of champagne!



## Feasibility Range, under DW effect

Decreased	Stays Same	Increased
 Sceptics wrongly suspect this. But provably impossible.	 If unconstrained evolution, or effect size too small.	 If effect size is big enough, evolution is constrained or absent.