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Biological Markets: A Catalyst for the Major Transitions?

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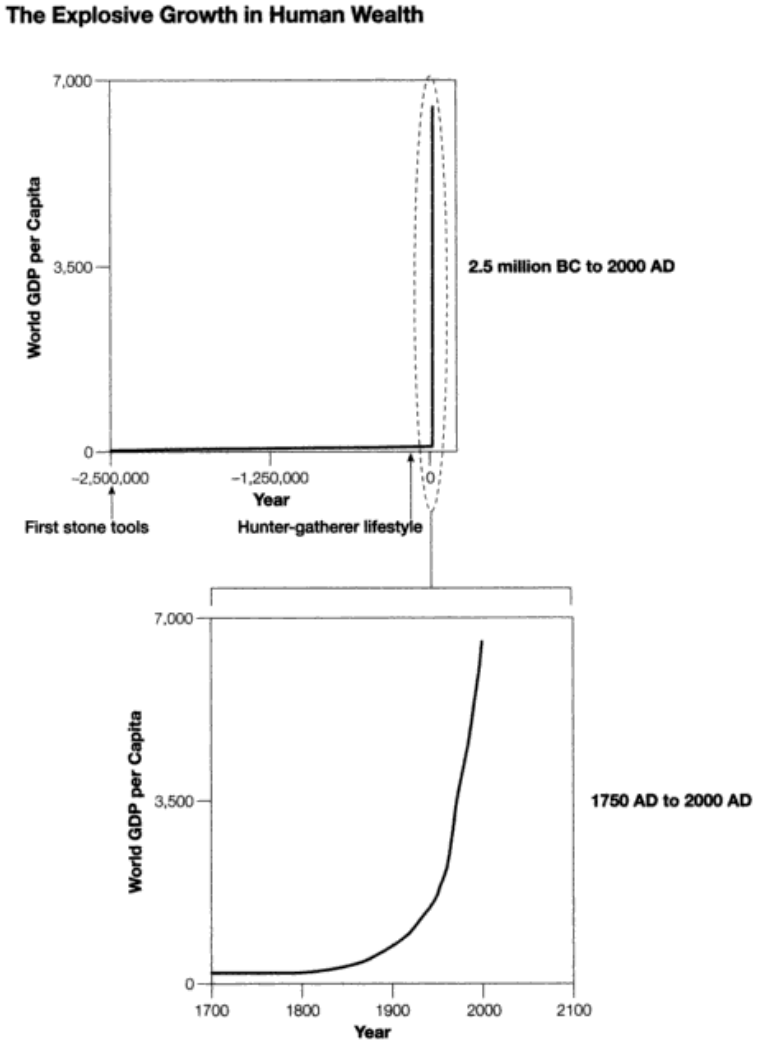
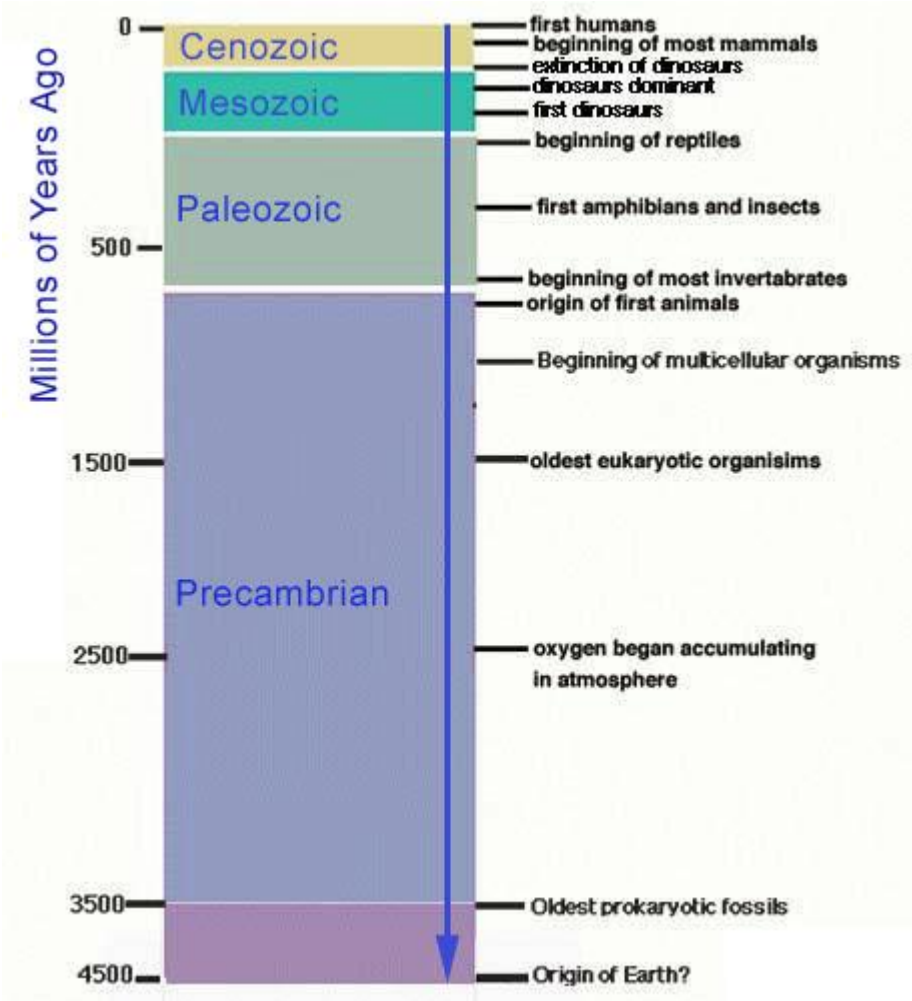
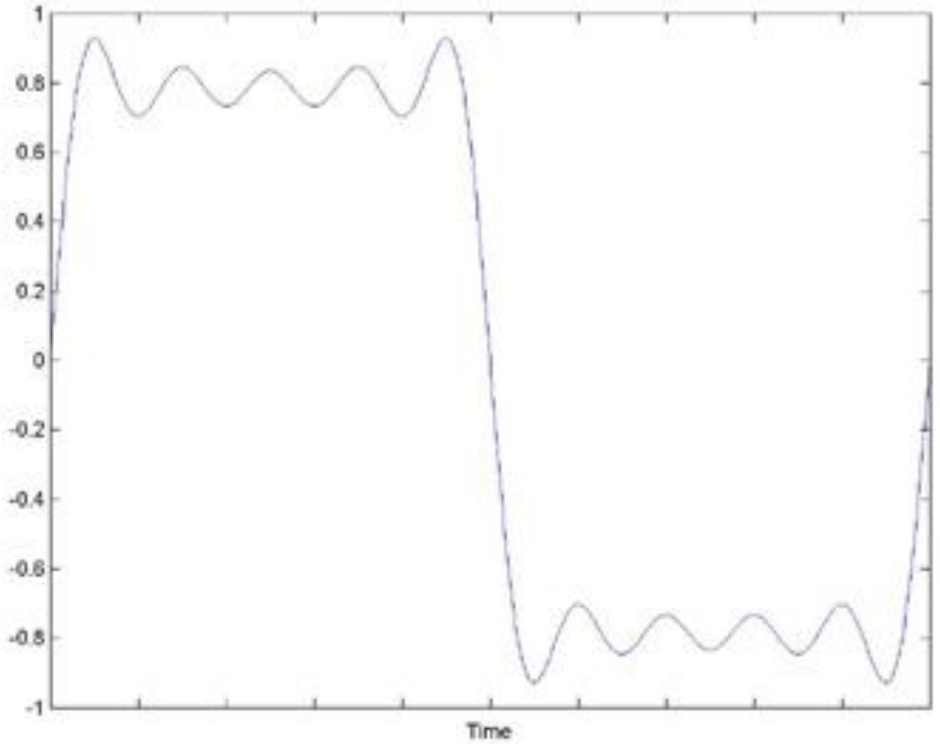
Evolution:
Economic verses Biological





Reproduced from *E. D. Beinhocker, 2007, "The Origin of Wealth" p. 10*

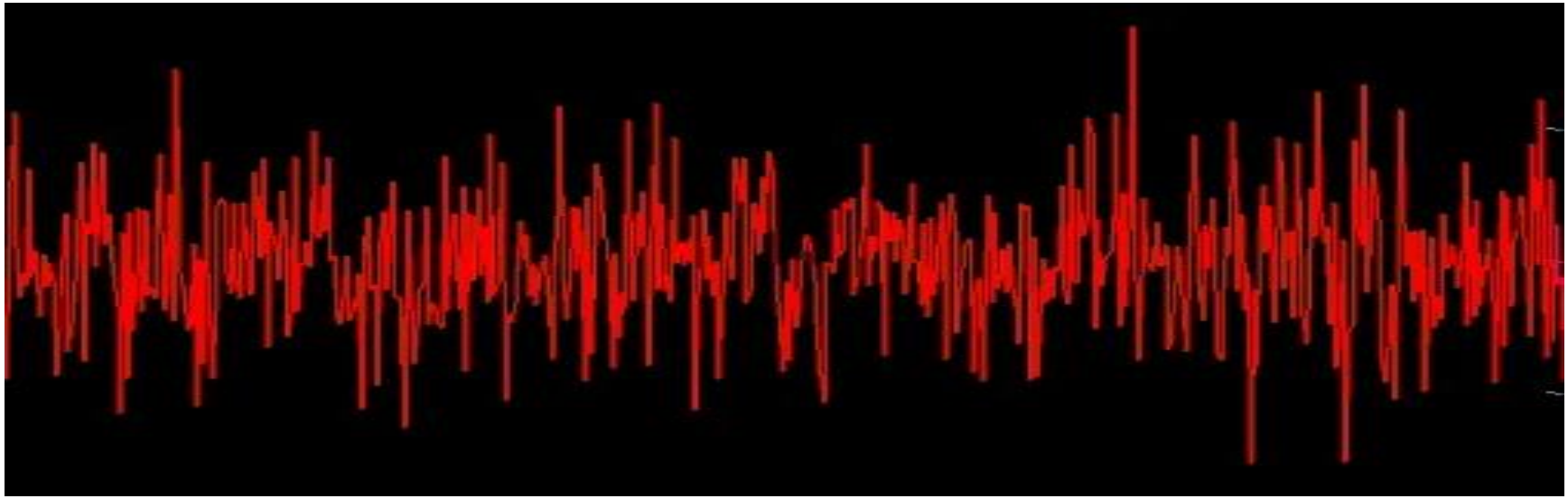
If markets were ordered



Efficient markets = Random Returns

If markets are efficient then returns are non-predictable (noise).

Therefore prices should follow a random walk:

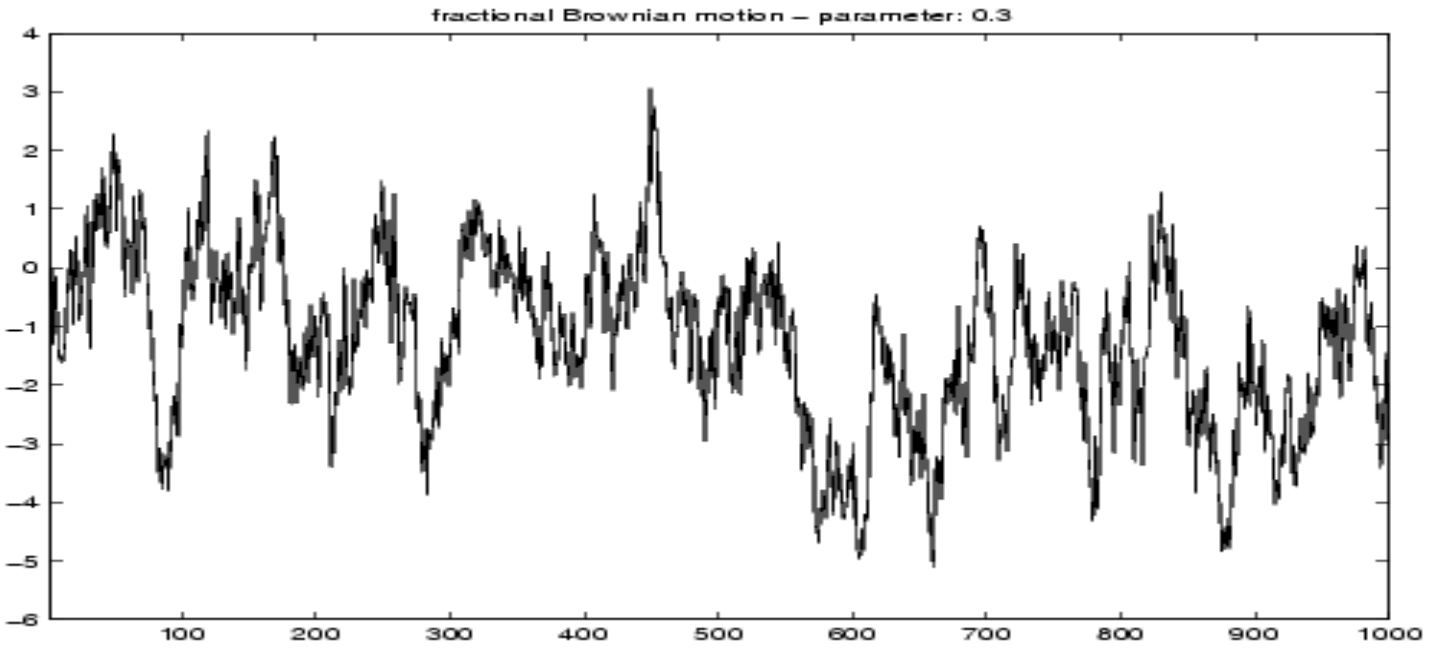


Real Markets

- In fact, Brownian motion is an idealisation
- Real markets are neither well-ordered
- Nor completely random
- Somewhere in between: complex

Markets are *complex*

Fractional Brownian Motion:



Economics & Biology

*"The solution, as I believe, is that the modified offspring of all dominant and increasing forms tend to become adapted to many and highly diversified places in the **economy** of nature"*

C. Darwin, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*, 6th ed. J. Murray, June 1872.

Comp-sci	Biology	Economics	Physics
multi-agent system	ecosystem	market	material
agent	gene/genome/ cell	person/household /firm	atom
goal	maximise (inclusive) fitness	maximise (expected) utility	minimise energy
action	phenotype behaviour	trading strategy	Brownian motion
interaction	symbiotic /parasitic	cooperate/ compete/trade	attract/repulse/ collide

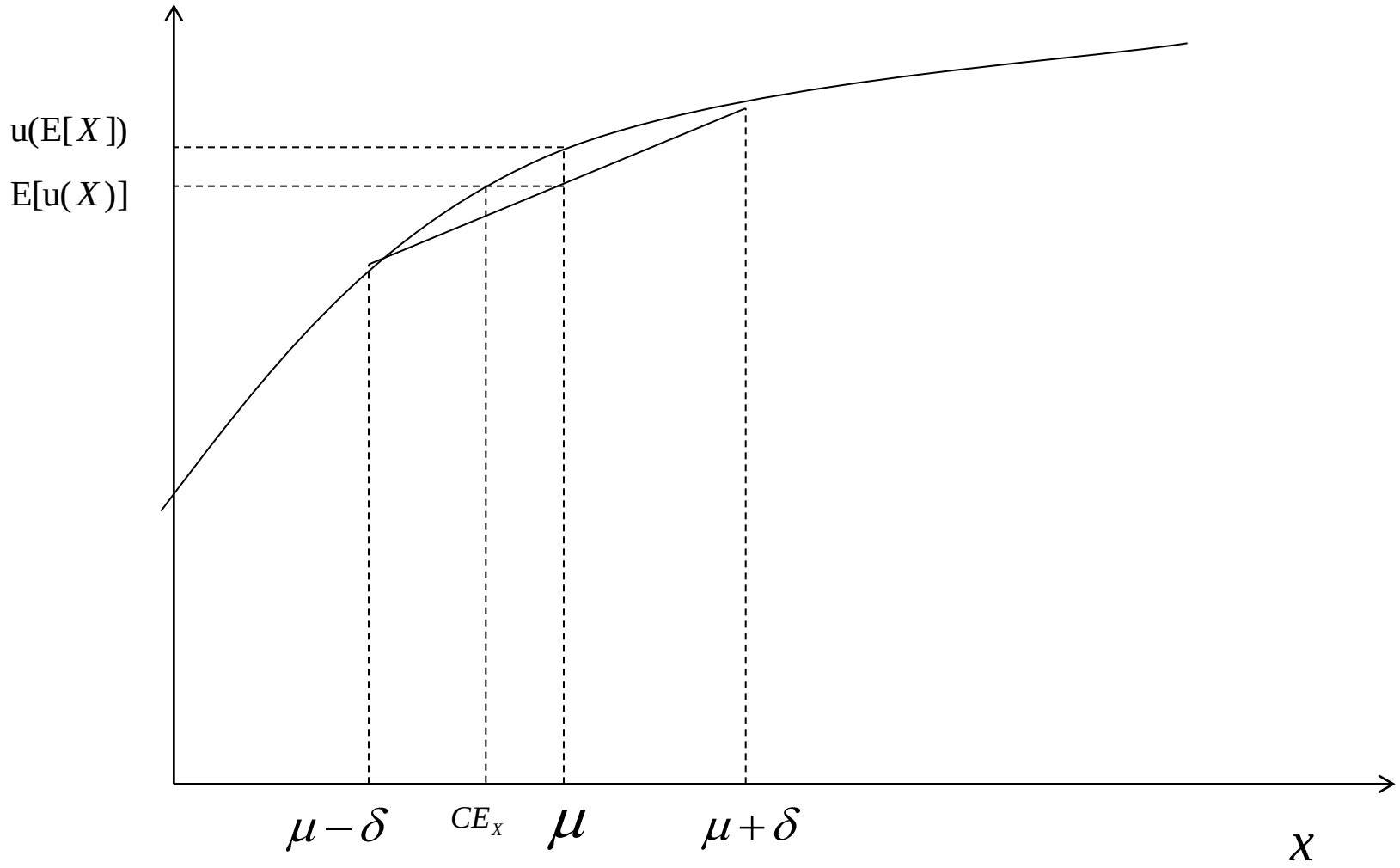
Economics	Biology
Maximise expected **utility** ("happiness")	Maximise expected **fitness**
Utility can be increased by acquiring **wealth**	Fitness can be increased by acquiring **energy**
Wealth can be **deposited** in *risk-free* assets	Energy can be **deposited** in fat reserves
Wealth can be **invested** in *risky* assets	Energy can be **invested** in the short-term for longer-term but uncertain energy gains (eg foraging or hunting)
Wealth can be misappropriated – illegally (stolen) or legally (rent-seeking)	Energy can be transferred in the form of food: possibly at the expense of the fitness of the donor (eg **predation**)
Money can be exchanged for goods/services	Food can be exchanged for beneficial services, eg seed dispersal
Money is "conserved" by the money supply	Energy is conserved by available solar energy
Money supply is variable	Available solar energy changes with climate

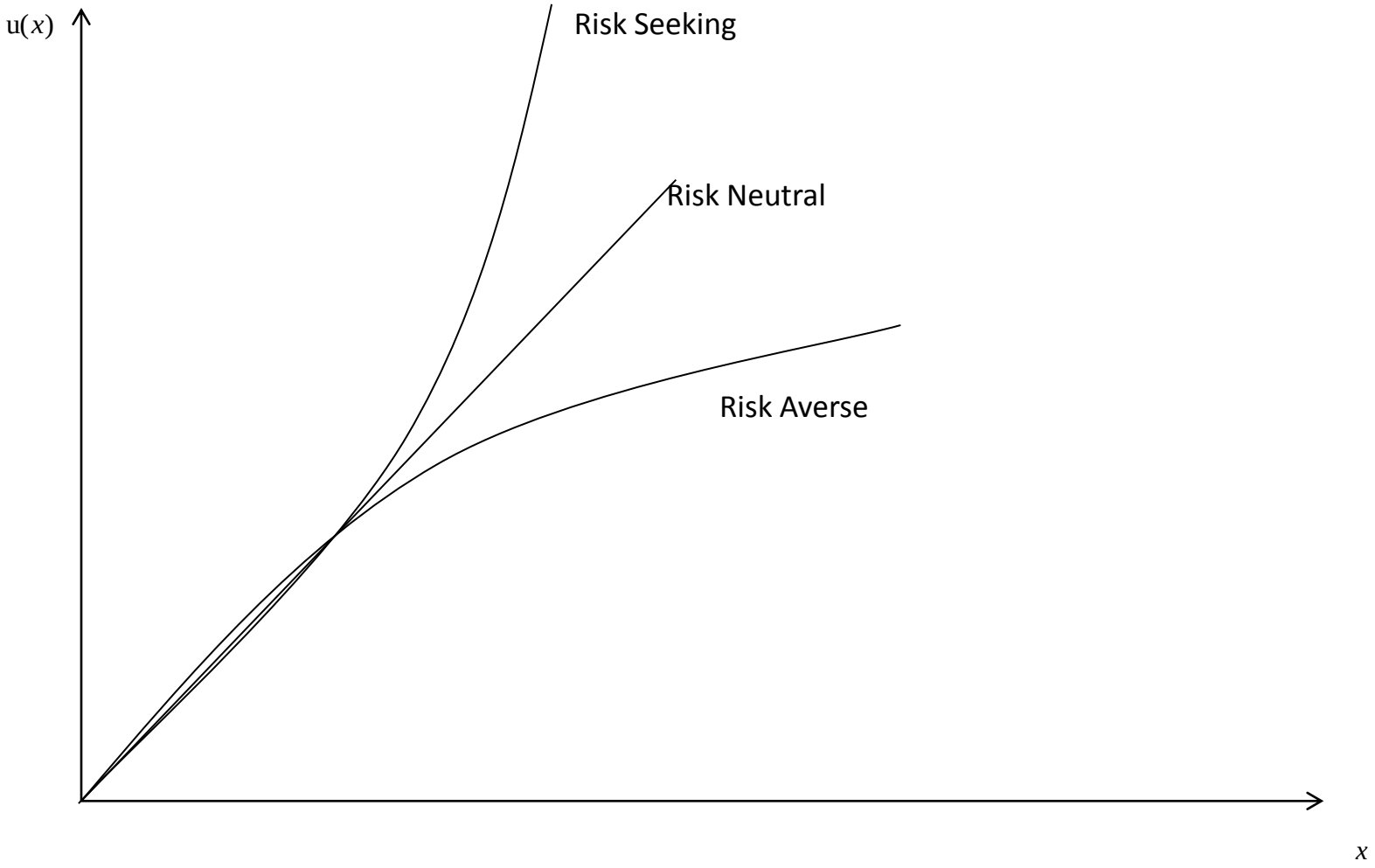
P. A. Corning, "Thermoeconomics: Beyond the second law," *Journal of Bioeconomics*, vol. 4, no. 1, pp. 57-88, January 2002.

Diversification in Markets & Nature

- Diversity in nature:
  - System-level
    - Biodiversity ⇔ Organisms **diversify** into species
  - Individual-level
    - Within a species individual organisms have a **diverse** range of behaviours
- Diversity in markets:
  - System-level
    - **Division** of labour and specialization
  - Individual-level
    - Hedging risk through **diversification** of investments

Expected utility of an **uncertain** investment compared with a certain investment




u(x)
Risk Seeking
Risk Neutral
Risk Averse
x

Risk management through **diversification**

The expected return to a portfolio is the weighted average of the expected returns of the assets composing the portfolio. The same result is not generally true for the variance: the variance of a portfolio is generally smaller than the weighted average of the variances of individual asset returns corresponding to this portfolio. Therein lies the gain from diversification.

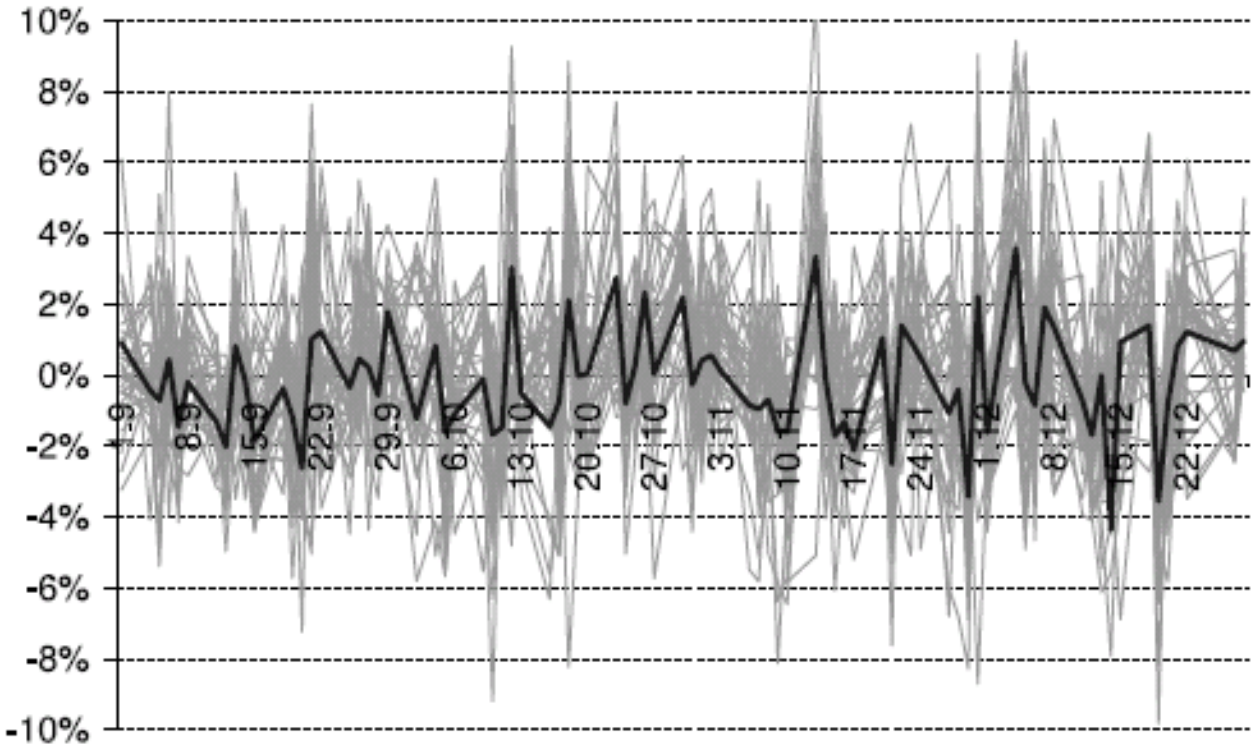


Fig. 1.1: Daily returns of the DAX (black line) and the stocks contained in it (gray lines) for the 4th quarter of the year 2000

(c) D. Maringer

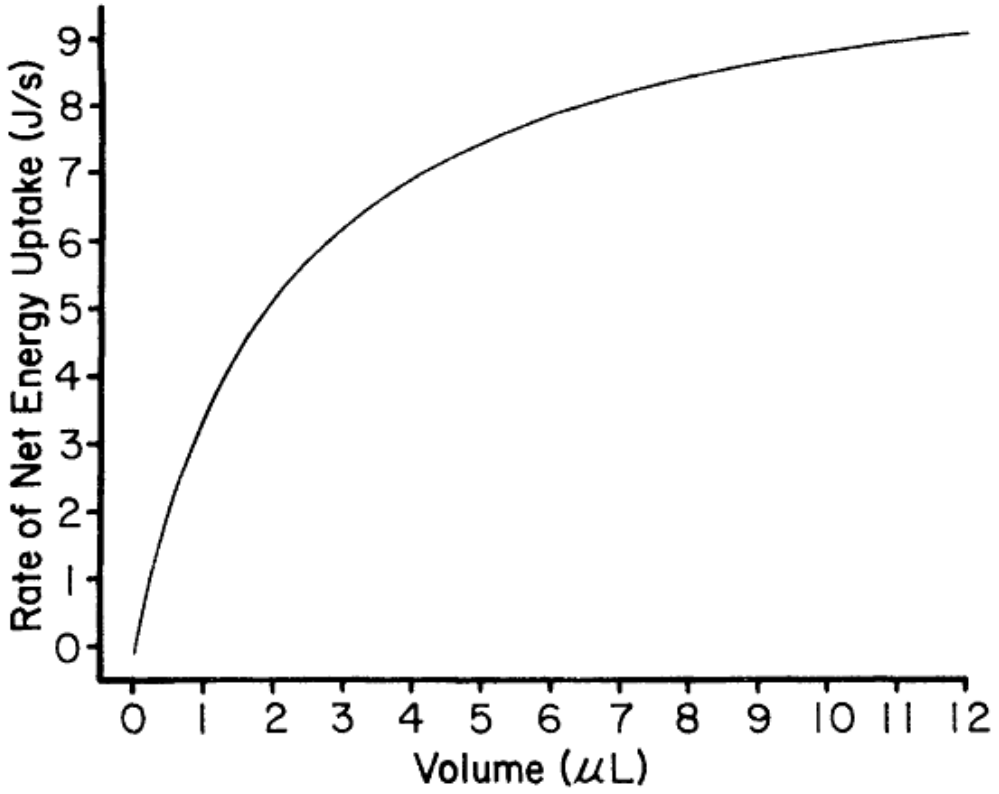


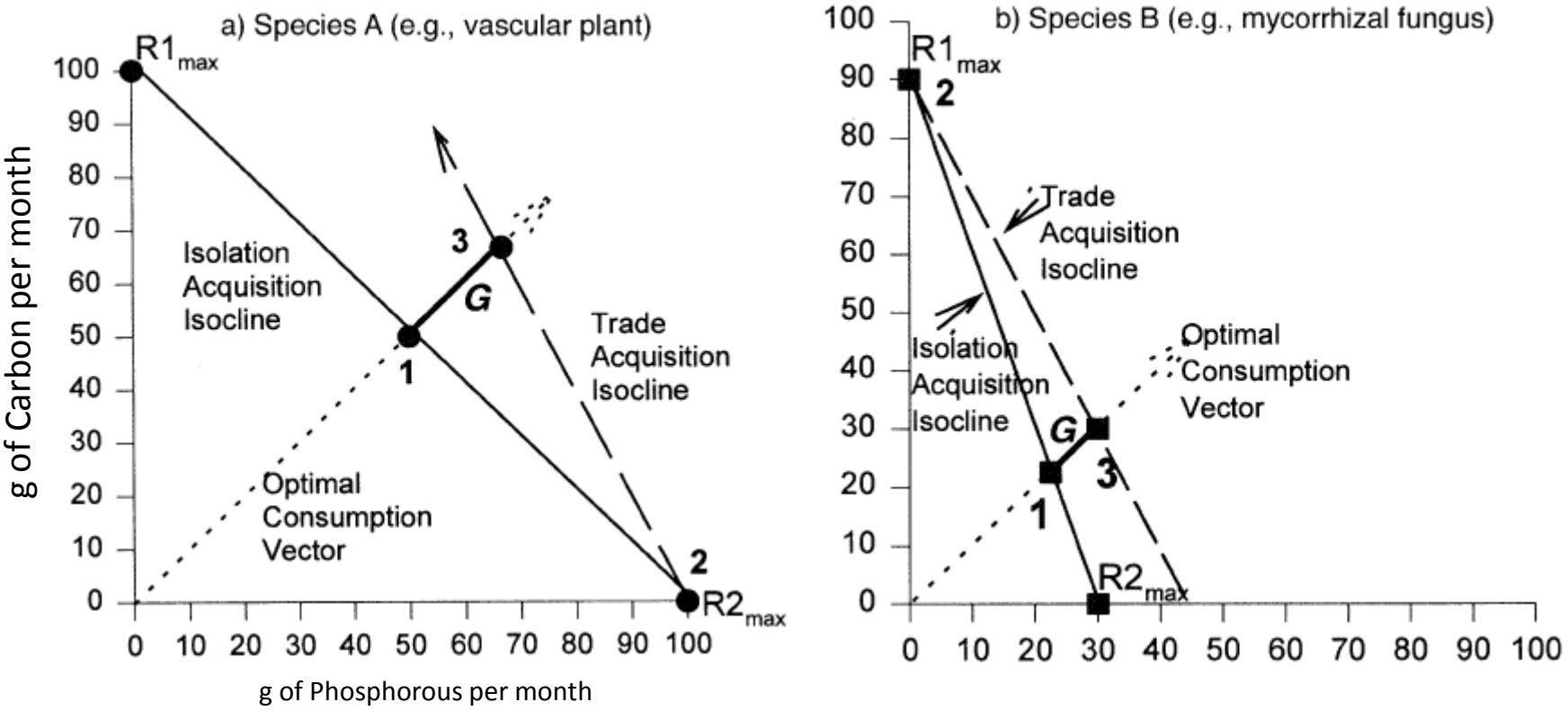
FIG. 1. Expected rate of net energy uptake as a function of nectar volume for an average *B. pennsylvanicus* worker feeding on flowers 3 mm deep, containing 30% sucrose solution, and distributed randomly, as described in Real et al. (1982). Based on Eqs. 1 and 2 and empirical descriptions of flight time (Harder 1985) and ingestion rate (Harder 1986).

Reproduced from L. D. Harder and L. A. Real, "Why are bumble bees risk averse?" *Ecology*, vol. 68, no. 4, pp. 1104-1108, 1987.

Division of labour and the "Invisible Hand"

- *"… could scarce, perhaps, with his utmost industry, make one pin in a day, and certainly could not make twenty. But in the way in which this business is now carried on, not only the whole work is a peculiar trade, but it is divided into a number of branches, of which the greater part are likewise peculiar trades. One man draws out the wire, another straights it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving the head."* A. Smith *An Inquiry into the Nature and Causes of the Wealth of Nations*.

Trading
Carbon for Phosphorous leads to specialisation



Reproduced from M. W. Schwartz and J. D. Hoeksema, "Specialization and resource trade: Biological markets as a model of mutualisms," *Ecology*, vol. 79, no. 3, pp. 1029-1038, 1998.

Payments in Nature

- No courts to enforce contracts
- How can trade get off the ground?
- Two possibilities:
  - A. Evolutionary secure payment systems:
    - Fructose in fruit is a payment for seed dispersal
    - Very hard for frugivores to break this contract
    - *Testable*: conditions of supply and demand should determine "price"; i.e. fructose to seed ratio
  - B. Incremental Trade

Trade in Artificial Emergence

- If the insights from the field of biological markets and Thermoeconomics are correct then trade will play an important role in emergent complexity
- Some existing work in this area:
  - P. T. Hraber, T. Jones, and S. Forrest, "The ecology of echo," *Artificial Life*, vol. 3, no. 3, pp. 165-190, 1997.
  - E. Pachepsky, T. Taylor, and S. Jones, "Mutualism promotes diversity and stability in a simple artificial ecosystem," *Artificial Life*, vol. 8, no. 1, pp. 5-24, January 2002.

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H. S. Houthakker, "Economics and biology: Specialization and speciation," *Kyklos*, vol. 9, no. 2, pp. 181-189, 1956.

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M. W. Schwartz and J. D. Hoeksema, "Specialization and resource trade: Biological markets as a model of mutualisms," *Ecology*, vol. 79, no. 3, pp. 1029-1038, 1998.

E. L. Simms and D. L. Taylor, "Partner choice in nitrogen-fixation mutualisms of legumes and rhizobia," *Integrative and Comparative Biology*, vol. 42, no. 2, pp. 369-380, April 2002.