SUSTAINABLE WORLD

International Conference 14-15 July 2005 Westminster London

Mae-Wan Ho

Sustainable Food Systems For Sustainable Development

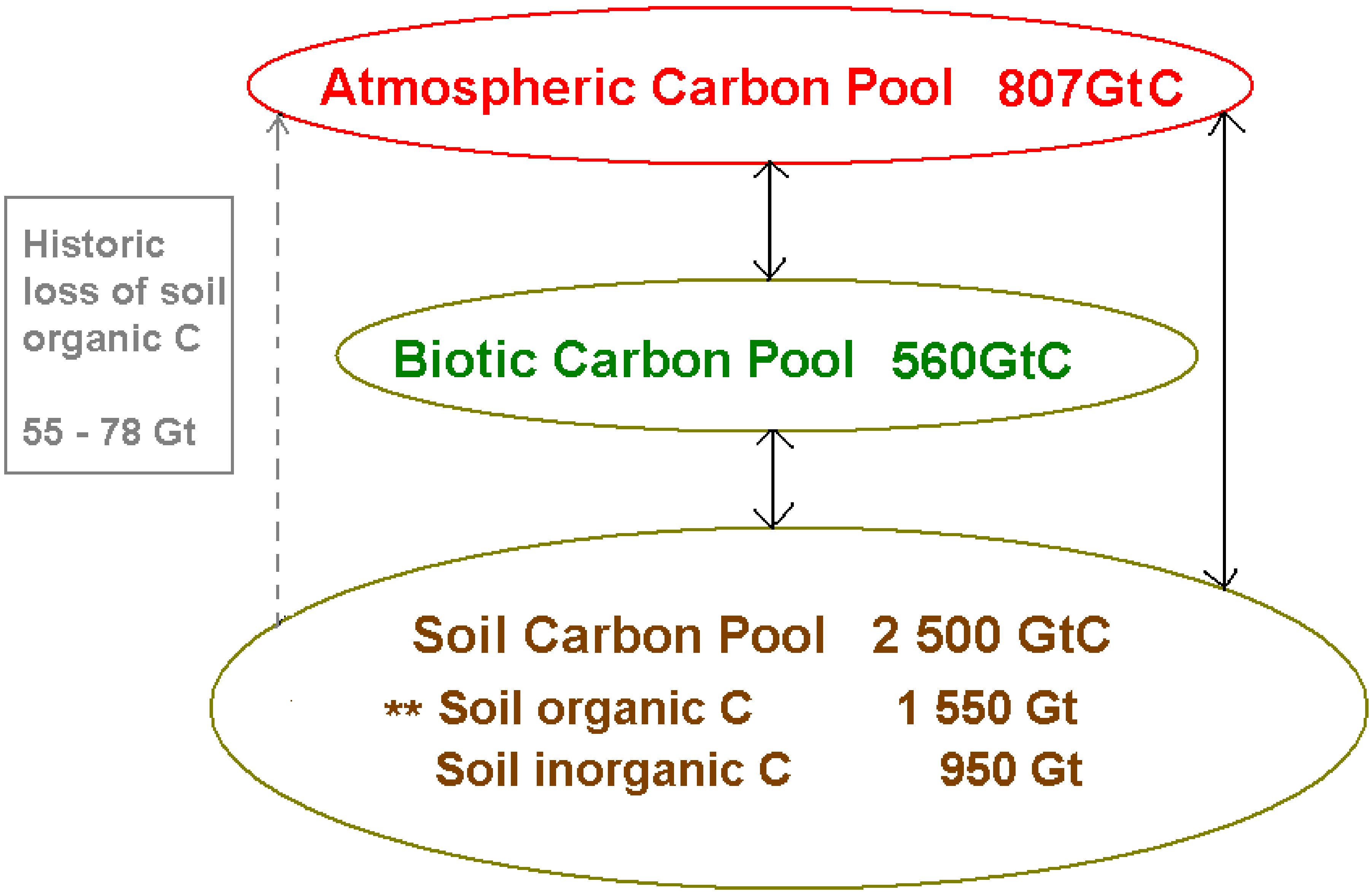
ISP ISIS

Current Food System Contributes 30.4% of GHGs

Agriculture direct emissions	42.0Mt
Fertilizer	
(French fertilizer industry only, more than half imported)	0.8Mt
Road transport	
(goods, French share only, not counting import/export)	4.0Mt
Road transport (people)	1.0Mt
Truck manufacture & diesel	0.8Mt
Store heating (20% national total)	0.4Mt
Electricity	
(nuclear in France, x5 elsewhere)	0.7Mt
Packaging	1.5Mt
End of life packaging	
(waste disposal, one-quarter total)	1.0Mt
Total	52.0Mt
National French emission	171.0Mt
Share from food system	30.4%

Jean-Marc Jancovici. March 2004
http://www.manicore.com/anglais/documentation_a/greenhouse/plate.htı

The Earth's Carbon Pools



Potentials for Sequestering C in Soils

Total: 0.4-1.2GtC/y

Croplands (1.35 bha) - maximise soil fertility with organic inputs, cover crops, conservation tillage, mixed farming 0.4-0.8GtC/y

Degraded land (1.1bha) – prevent water/wind erosion, harvest/conserve water, plant forests 0.2-0.4GtC/y

Rangelands and grasslands (3.7bha) - prevent overgrazing, fire and loss of nutrients 0.01-0.3GtC/y

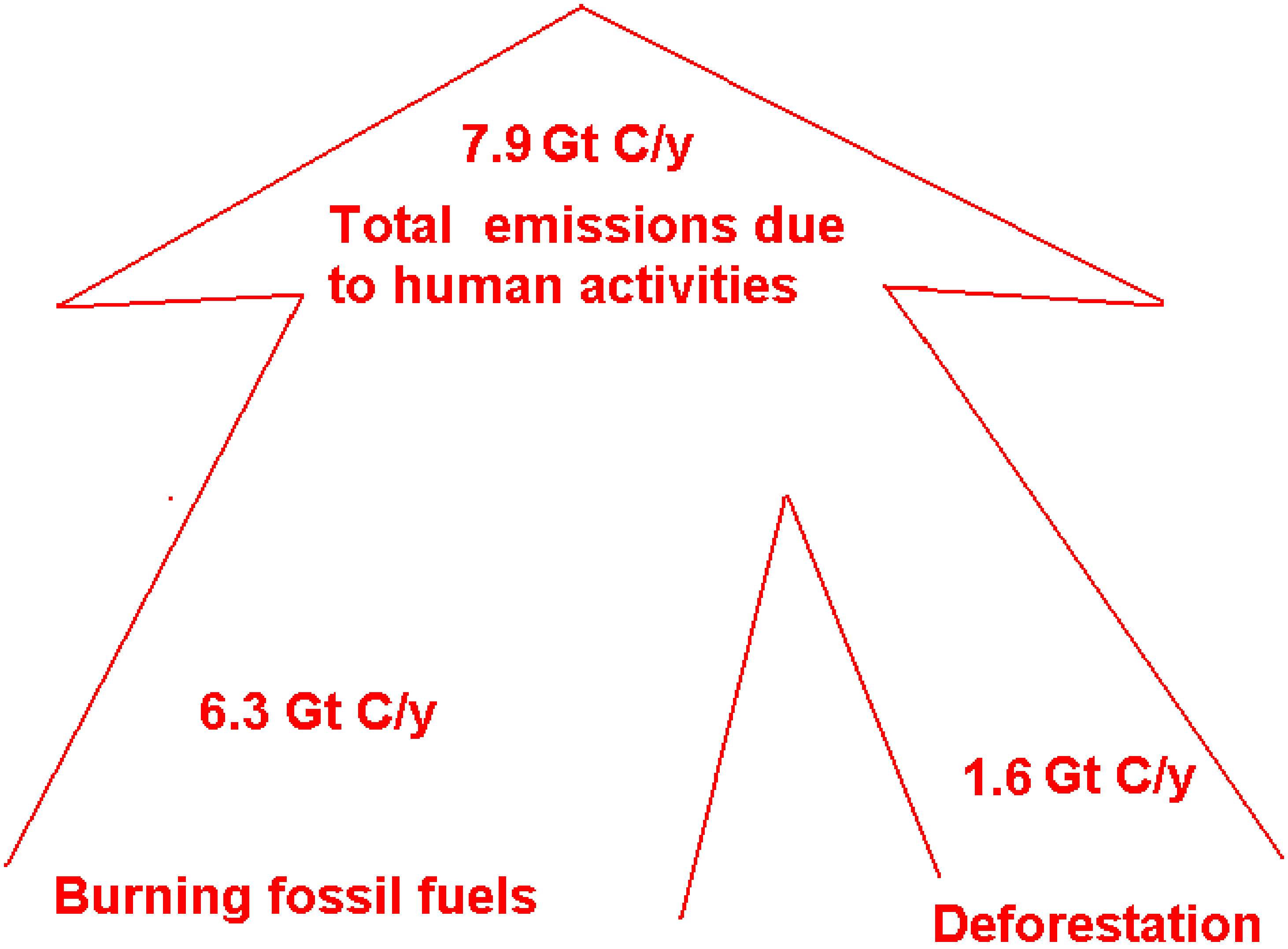
Irrigated land (0.275bha) – control salinity, drip/sub-irrigation, provide drainage, enhance water efficiency and conservation 0.01-0.03GtC/y

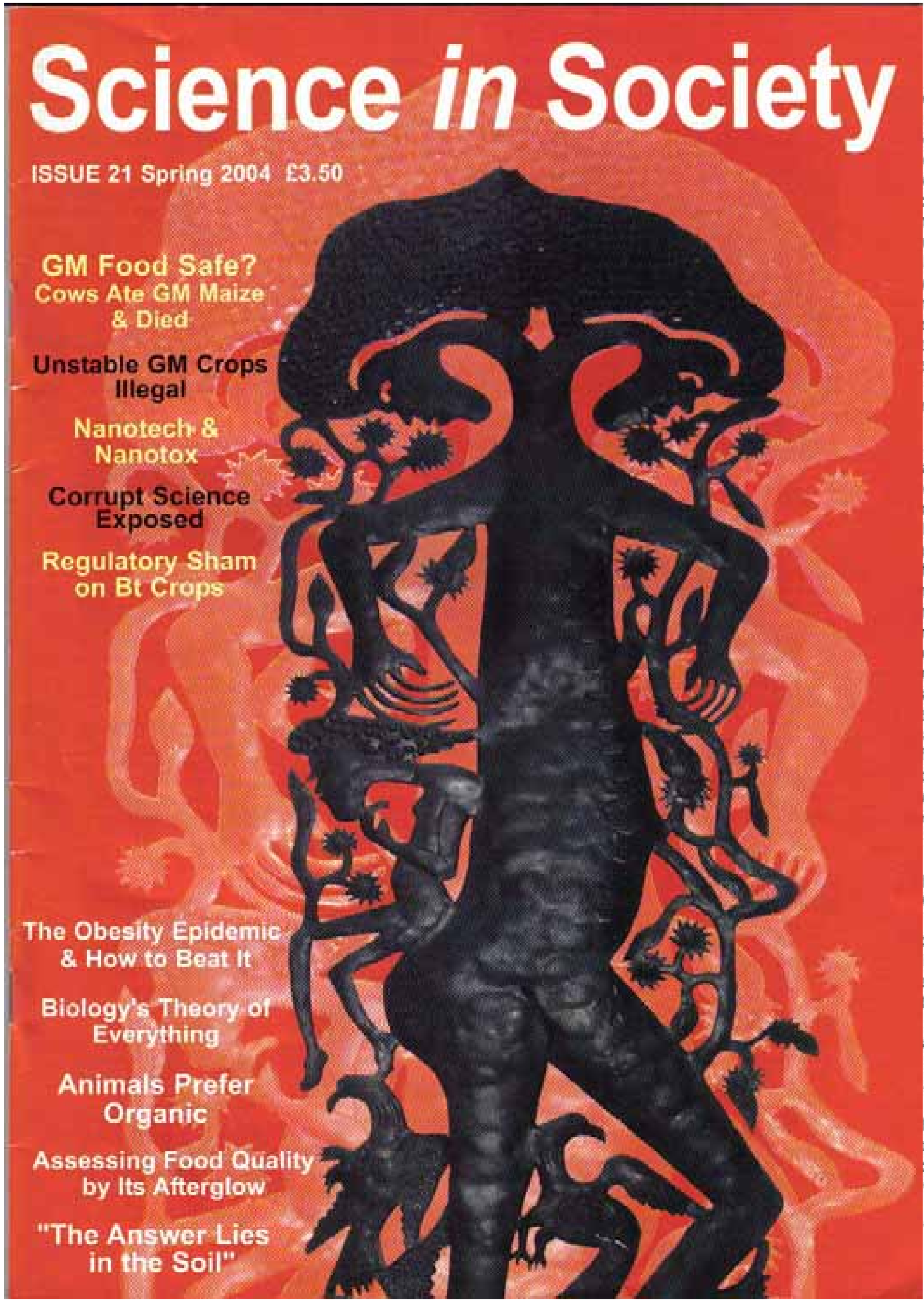
R. Lal, Carbon sequestration impacts on global climate change and food security. *Science* 2004, 304, 1623-7

“Soil C sequestration is a strategy to achieve food security through improvement in soil quality.”

And as a bonus, it offsets 0.4 to 1.2Gt C/year, or 5 to 15% of the global emissions of 7.9Gt C of greenhouse gas due to human activities each year.

Lal R. Soil carbon sequestration impacts on global climate change and food security. *Science* 2004, 304,1623-7


7.9 Gt C/y
Total emissions due to human activities
6.3 Gt C/y
Burning fossil fuels
1.6 Gt C/y
Deforestation



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Indigenous BriBri woman and her daughter holding a cacao fruit in Talamanca, Costa Rica. Photo Miguel Altieri

Why Gaia Needs Rainforests

Losing the earth's largest remaining tropical rainforests will greatly accelerate global warming. ***Peter Bunyard*** *reports.*

Get critically informed to challenge and influence cutting edge science

Reclaim science for the public good

What you need to know about GM crops, nanotechnology, also climate change, human cloning, mobile phones, the quantum revolution, obesity, AIDS, food quality, and more…

Get critically informed to challenge and influence cutting edge science, to reclaim science for the public good

Science *in* Society

" By far and away the most

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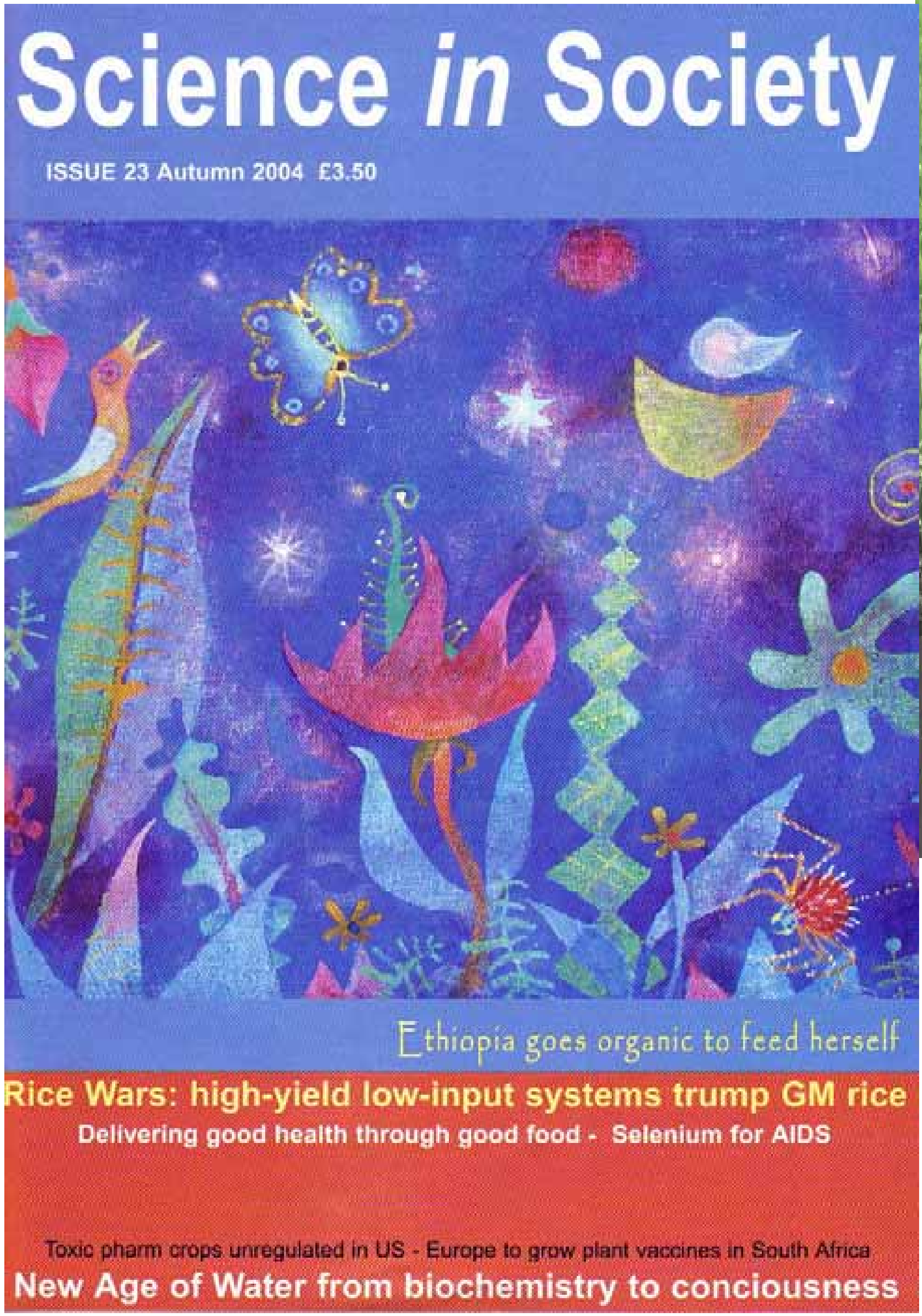
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ISSUE 23 Autumn 2004 £3.50
Ethiopia goes organic to feed herself
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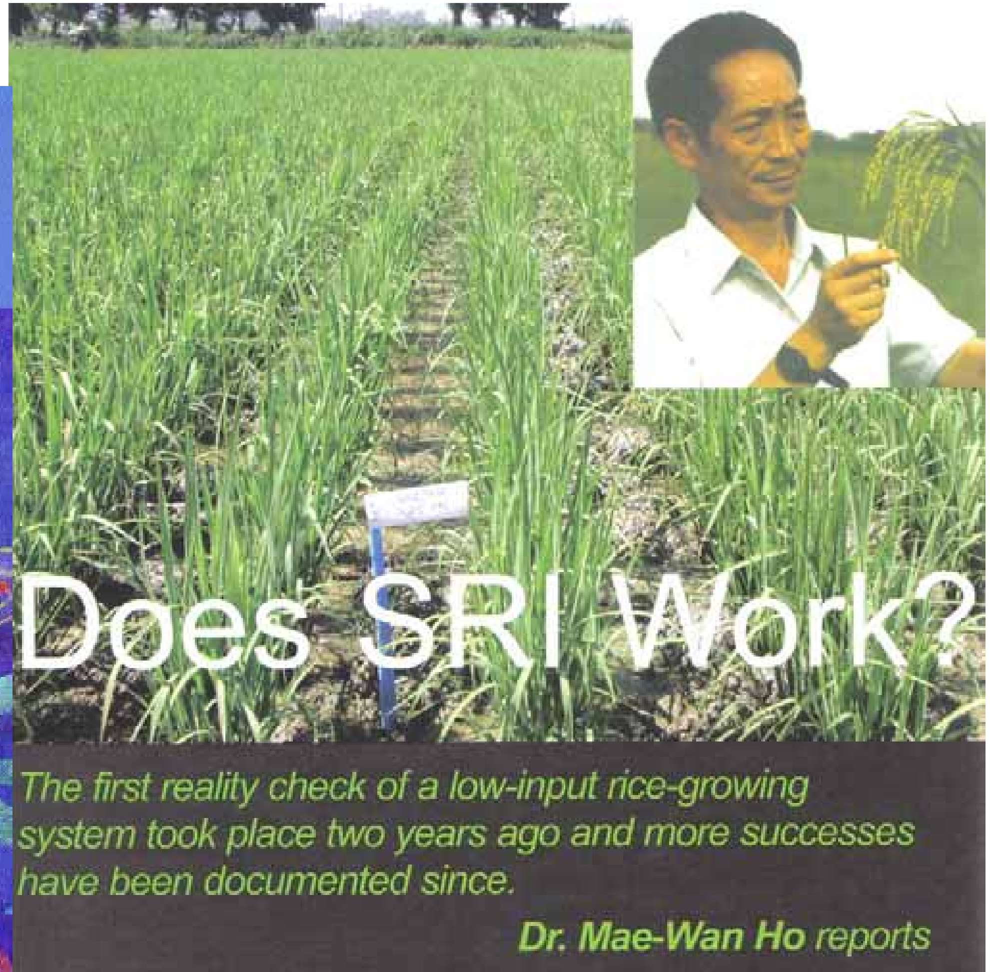
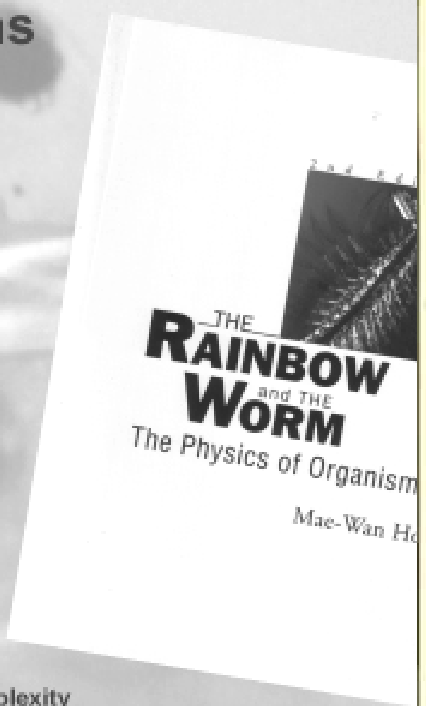
Delivering good health through good food - Selenium for AIDS
Toxic pharm crops unregulated in US - Europe to grow plant vaccines in South Africa
New Age of Water from biochemistry to conciousness

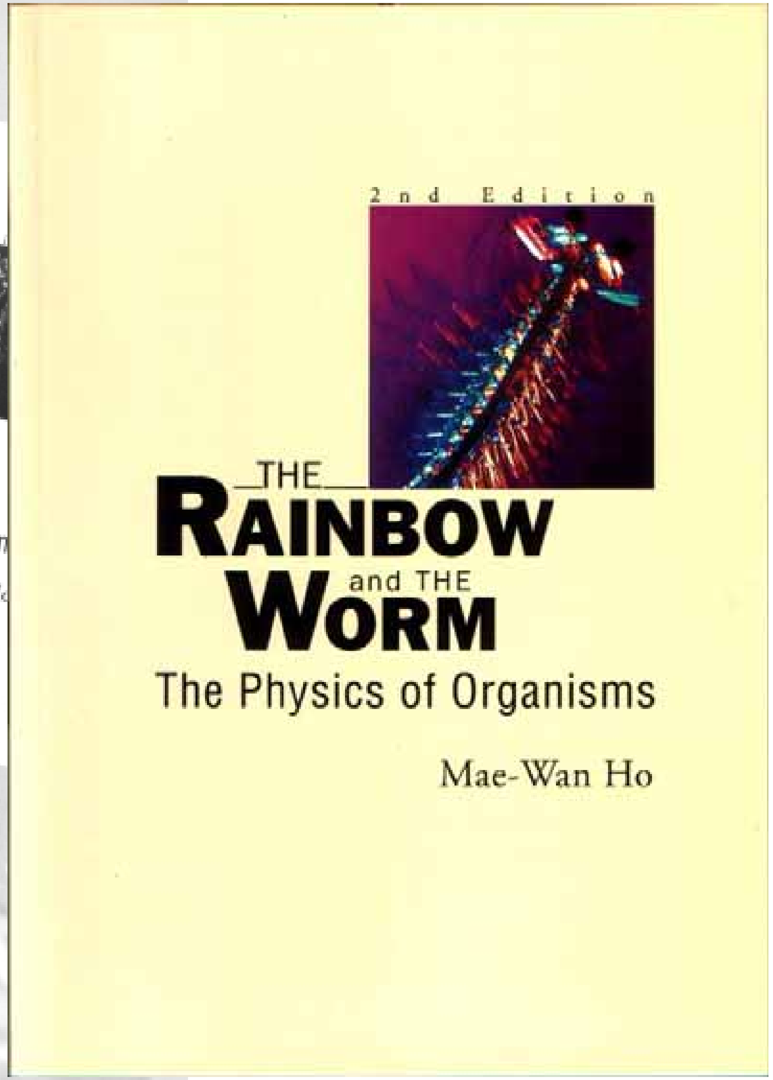

Does SRI Work?
The first reality check of a low-input rice-growing system took place two years ago and more successes have been documented since.
Dr. Mae-Wan Ho reports

The **Rainbow** and The **Worm**

The Physics of Organisms

by **Mae-Wan Ho**
Institute of Science in Society





Readership: General

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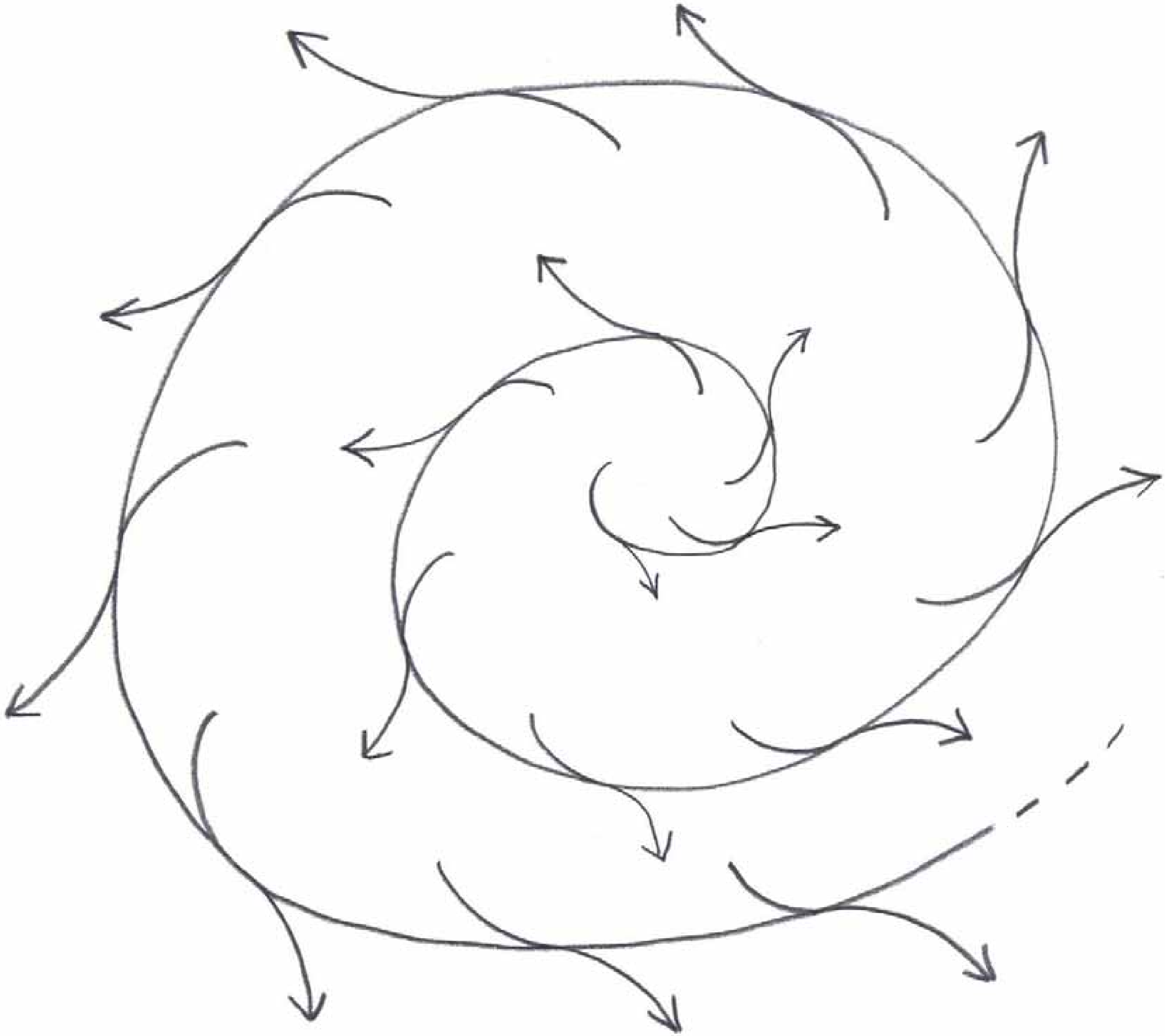
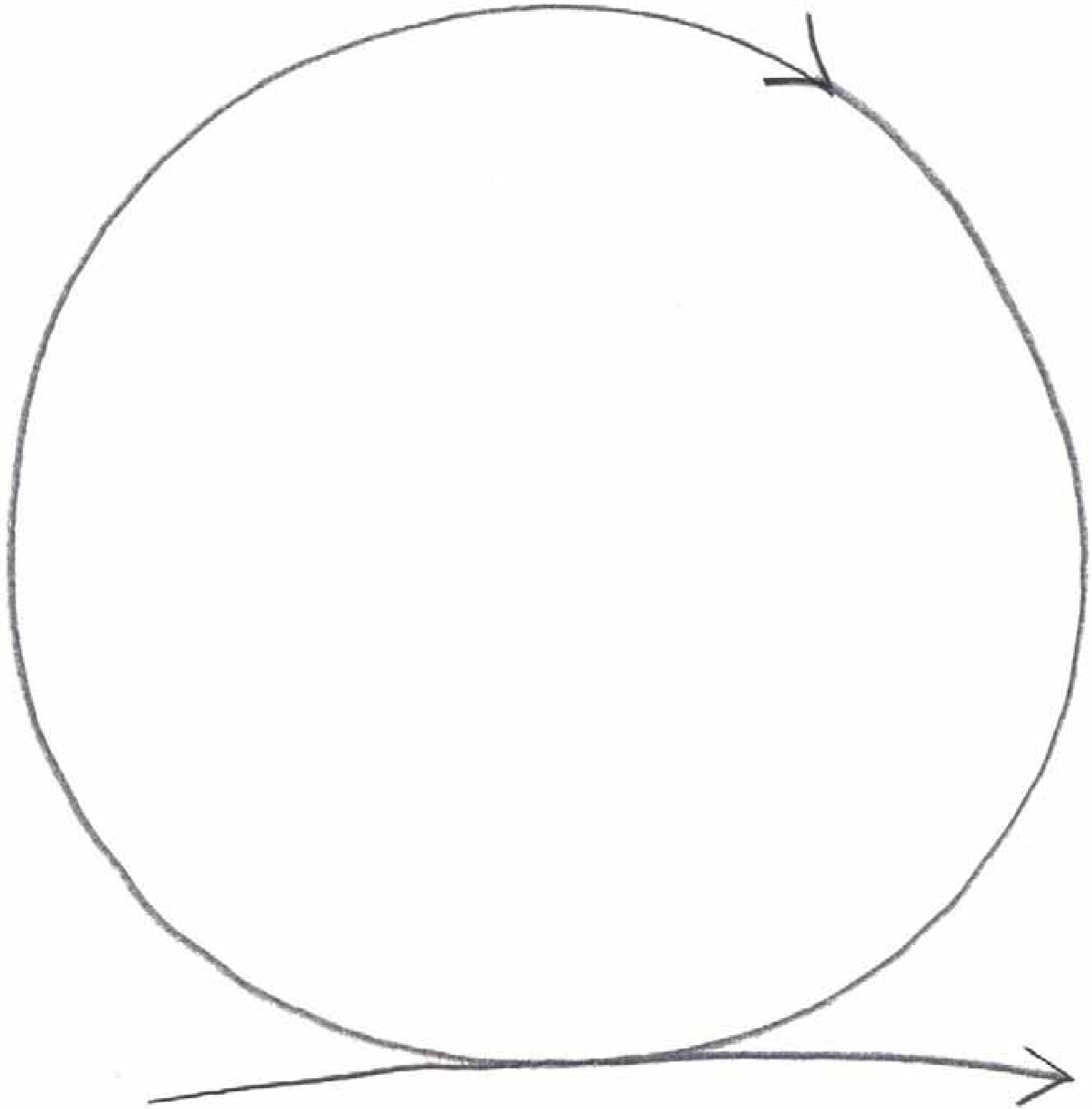
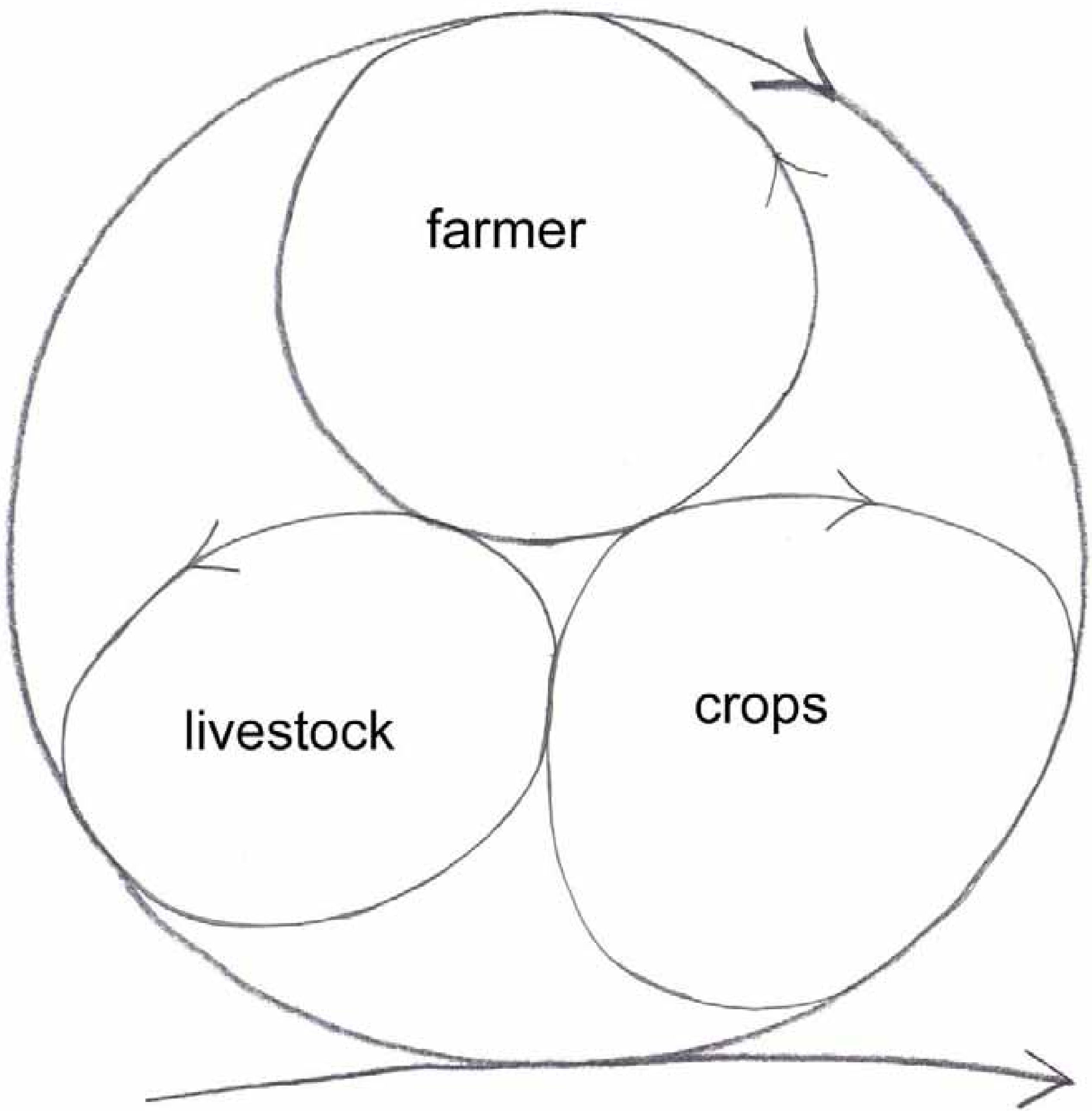
A serious, in-depth enquiry into Schrödinger's question, "What is Life?" and at the same time, a celebration of life itself



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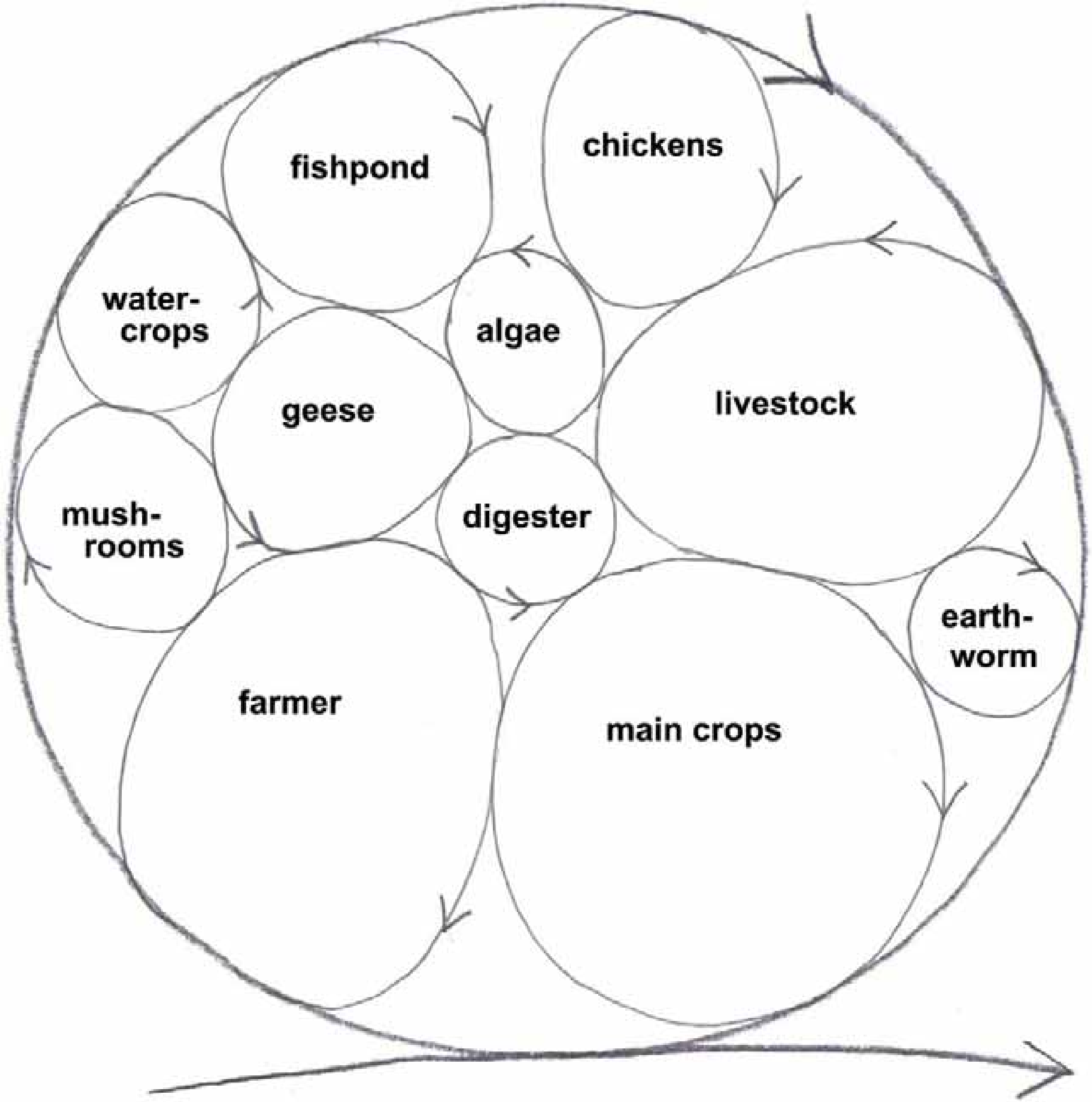
fishpond
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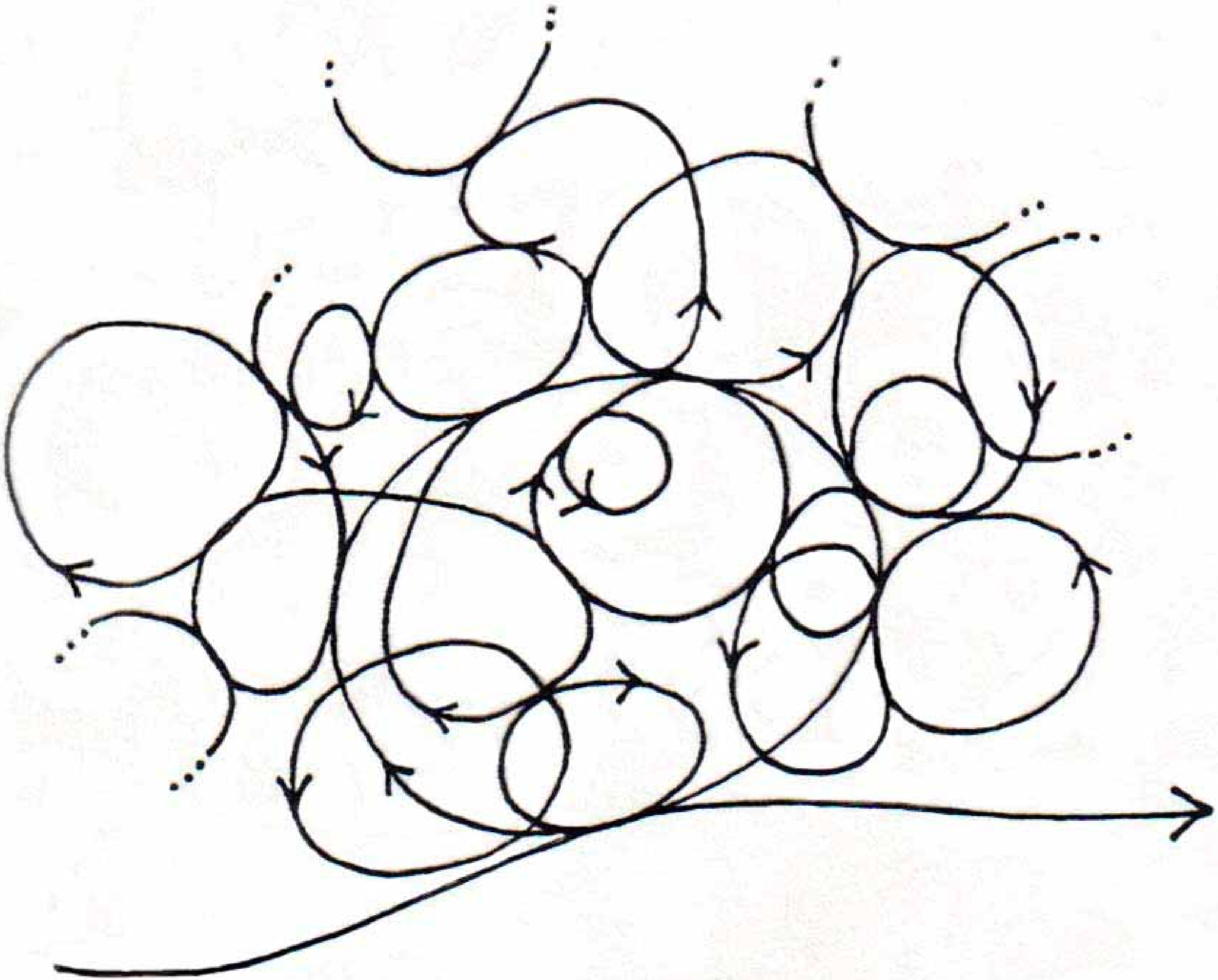
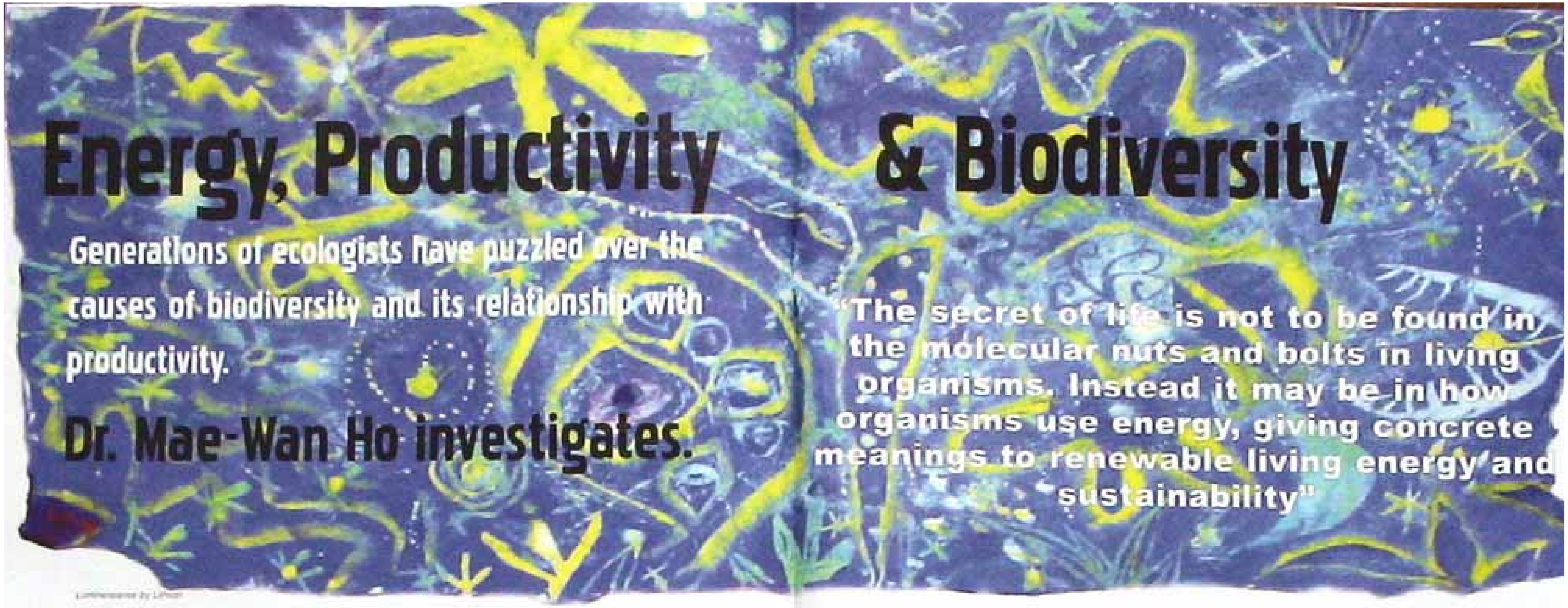




Energy, Productivity & Biodiversity

Generations of ecologists have puzzled over the causes of biodiversity and its relationship with productivity.

Dr. Mae-Wan Ho investigates.

> "The secret of life is not to be found in the molecular nuts and bolts in living organisms. Instead it may be in how organisms use energy, giving concrete meanings to renewable living energy and sustainability"

Commissioned by Lifeart

"Why are there so many kinds of animals?"

This was the question asked by distinguished ecologist Evelyn Hutchinson in 1959, the centenary of Darwin's Origin of Species, a question that has remained as enigmatic today as it was then.

There are about a million described species of animals, three-quarters of them being insects, of which disproportionately large numbers belong to the order Coleoptera, or beetles. In contrast to land animals, there are far fewer species in the sea.

Hutchinson considered a number of possible explanations. Could food chains or feeding relationships suffice? If one supposes an energy conversion efficiency of 20% at every link of the chain, and each predator being twice as big as its prey, the fifth animal link will have a population of one ten thousandth (10^{-4}) of the first, which is about as long as it would get. Food chains could hardly generate a great deal of biodiversity.

Natural selection isn't going to help; an overly efficient predator will simply eat itself out of prey, thus breaking the link and making itself extinct in the process. While lengthening the chain is difficult, shortening the chain is not; the most dramatic example is the whale-bone whale, which can feed largely on plankton.

What about the diversity of terrestrial plants which provide a variety of different structures - bark, leaves, flowers and fruits - for different animals to feed on? A major source of biodiversity of land animals was indeed introduced by the evolution of almost 200 000 species of flowering plants, and the three-quarters of a million species of insects are a product of that diversity. But then, why are there so many different kinds of plants?

Part of the answer is that instead of linear food chains, nature is replete with food webs. Most predators eat more than one species of prey, which reduces the danger that it will eat its prey and itself extinct. So, at least part of the answer to why there are so many kinds of animals and plants is that biodiverse communities are better able to persist than less diverse communities. And that was the origin of the idea that complex ecosystems are more stable, which has been hotly debated to this day. While it may be intuitively obvious that the more flexible the links in the food web, the less likely they will break, mathematicians find it extraordinarily difficult to represent such flexibility, and more so, to agree on what constitutes stability let alone complexity.

Energy available?

Going back to biodiversity, ecologists have long noticed that while a hectare of tropical rainforest contains an estimated 200 to 300 species of trees, the same area of temperate forest contains only 20-30 species. One hypothesis is that diversity is ultimately determined by the amount of energy available to an ecosystem. Support for this idea came from measures of productivity and biodiversity in different ecological communities. Productivity is the rate of production of biomass by an ecosystem, and is in general determined by the rate of energy supply.

High proportions of land and freshwater species on earth do occur in the tropics, which receive the highest amount of the sun's radiant energy. Average species richness increases from high to low latitudes and this has been documented for a wide spectrum of taxonomic groups, including protists (single-celled organisms), trees, ants, woodpeckers and primates, and for data across a range of spatial resolutions. Species richness also appears to increase with energy, measured as mean annual temperature, and evapotranspiration.

But that doesn't seem to be the whole story. The relationship between diversity and productivity was found to vary at different spatial scales. At large geographical scales, such as across continents in the same latitude, diversity generally increases with productivity. At smaller local scales (metres to kilometres), several different patterns emerge.

Early studies found biodiversity peaking at intermediate levels of productivity in a unimodal curve (a curve with a single hump). More recent reviews came up with a variety of relationships, with diversity increasing, decreasing or remaining unchanged as productivity increases. Although some of these patterns suggest that energy is causally involved, other factors may also be important, such as environmental heterogeneity: spatial or temporal variation in the physical, chemical or biological features of the environment.

Complexity of the environment?

In a simple lab experiment, the bacterium *Pseudomonas fluorescens* was used to test the relationship between environmental heterogeneity and diversity. This bacterium is known to rapidly differentiate into distinct "morphs" in different microhabitats in unmixed culture vessels. One major morph flourishes at the interface between air and the liquid growth medium, another does best in the centre of the culture vessel and a third occupies the bottom of the vessel. The researchers found that there are further variations within each major morph, so that a total of ten types can be distinguished. Shaking the vessel eliminated environmental heterogeneity and, with it, diversity. With a gradient of productivity, a unimodal diversity curve was obtained. In other words, diversity increased with energy available up to a peak, and then decreased as available energy increased further.

Ecosystems typically consist of plant and animal species of vastly different sizes, from big mammals to birds, insects and microbes in the soil, which would use resource that matches their size. Thus, the more finely the species can divide up space and resources, the more species can coexist in the same habitat. But how best to represent this environmental heterogeneity?

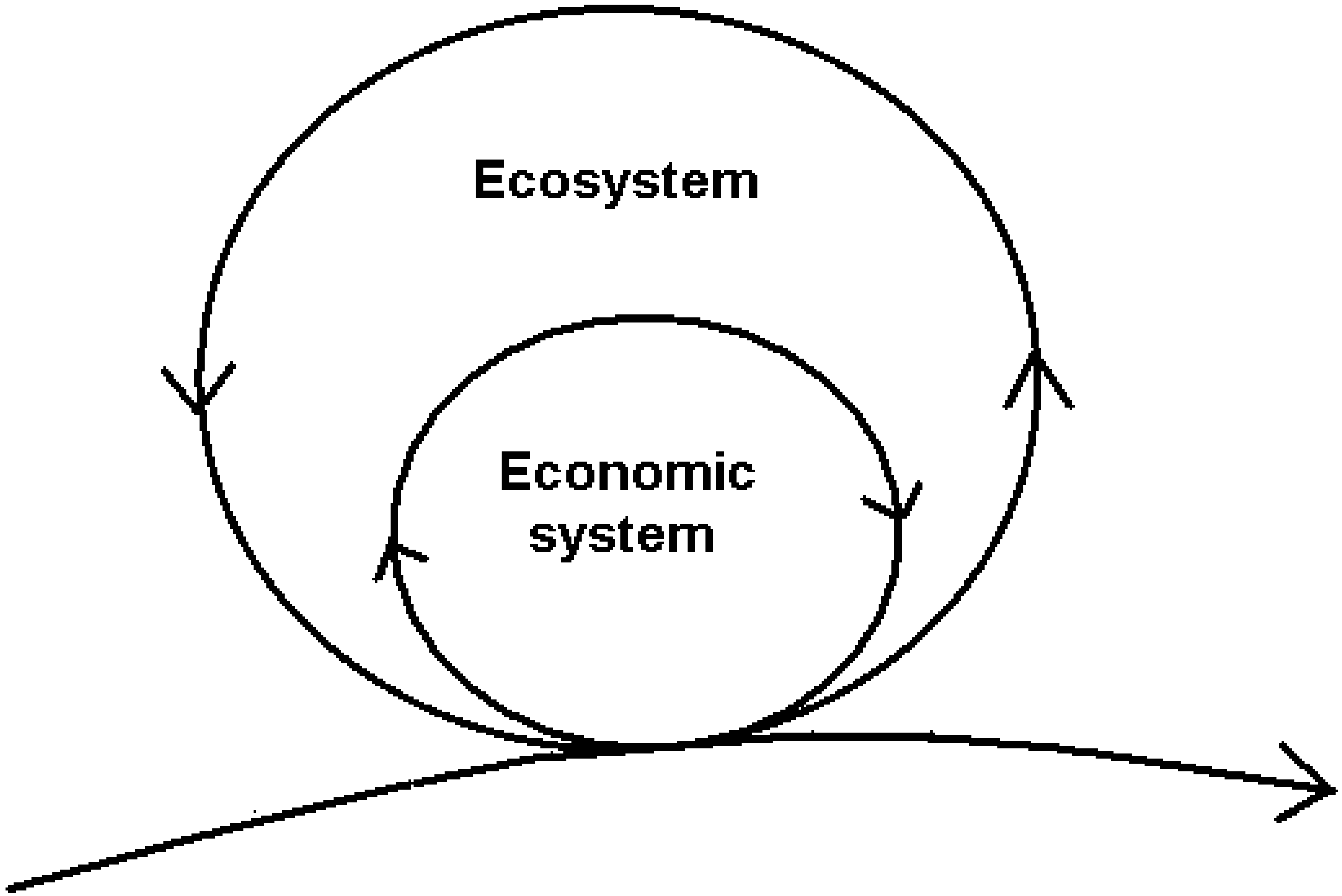
Mark Ritchie from the University of Utah, Logan, in the United States, and Han Olff in Wageningen Agricultural University, in the Netherlands, reasoned that the distributions of habitat, food and resources often appear to be statistically 'self-similar' over three to four orders of magnitude. If so, their volume or area can be described with fractal geometry.

A fractal is a structure that has dimensions in between the usual 1, 2 or 3, and 'self-similar' refers to the property that the structure appears the same over many scales. Typical examples are fern leaves, branching blood vessels and the coastline.

In a fractal environment, body size determines the abundance of food and resources that a species perceives, and it sets limits to the similarity in body size between any two species. Ritchie and Olff derived a body size ratio between species of adjacent sizes that declines with increasing organism size. That in turn predicts how diverse the community can be.

Thus, energy, productivity and environmental heterogeneity all appear to play a role in creating biodiversity.

In the next article ("Why are organisms so complex?" this series), I shall show how biodiversity and productivity are intimately linked through energy capture and storage in a sustainable system.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