Metaphor matters: Interdependence through a western lens as applied to teaching biology at TCUs

Melanie Lenart, Ph.D.
Tohono O’odham Community College

FALCON
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Background on Gaia theory

- James Lovelock was working on identifying life from space during the 1960s at NASA (alongside Carl Sagan).
- He needed to be able to detect life from afar—on other planets in space.
- He used the evidence of some elements he could detect to build his case.

<table>
<thead>
<tr>
<th>Planet</th>
<th>Carbon Dioxide (CO₂)</th>
<th>Oxygen (O₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Venus</td>
<td>98%</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Earth</td>
<td>&lt;1%</td>
<td>21%</td>
</tr>
<tr>
<td>Mars</td>
<td>98%</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>
Gaia theory: The world is alive

“Life ... manages the planet in ways that continue to sustain life in more or less optimum circumstances. That is why it may be a mistake to call Earth the Goldilocks planet: not too hot, not too cold, but just right. In fact, Earth's average temperature may be just right because life, by unconsciously manipulating the planet's oceanic and atmospheric chemistry, sets the thermostat that keeps its Earthly home within a temperature range that is comfortable for life.’

James Lovelock, Gaia theory originator

'Weak’ Gaia, ‘Strong’ Gaia

1. **Influential Gaia** notes that the biosphere has a “substantial influence” over certain aspects of its environment, such as the temperature and composition of the atmosphere.

2. **Co-evolutionary Gaia** indicates that the biosphere and the environment evolve as a coupled system.

3. **Homeostasis Gaia** suggests that the Earth operates as a “self-regulating system.”

4. **Teleological Gaia** implies some intention by the biosphere in balancing the atmosphere.

5. **Optimizing Gaia** holds that the biosphere’s manipulations are efforts to create or maintain favorable conditions for existing life forms.
Indigenous scholars embraced Gaia

“The Gaia Hypothesis, among other new theories, suggests that we should begin to look at things organically and that we might indeed be a minor episode in a larger scheme of life. ... The issue today is that we are no longer bound to use mechanistic models exclusively to tell us how to think about the world.”

Vine Deloria, Jr., in *Power and Place* (2001)
Gaia as a modern take on Mother Earth

“Today these ancient concepts are being reintroduced in the theories and philosophies guiding curricula on ecology and environmental systems, from kindergarten to university level instruction. The Earth is being perceived as a living, breathing entity—a megabeing if you will.”

Gregory Cajete, author of Native Science
Debate, discussion continues

- In Anthropocene era of human influence and satellite imagery, humans can be seen as giving the planet potential for deliberate self-regulation.
- Humans as a bacteria-scale influence on this megabeing?

**SUSTAINABILITY**

**Gaia 2.0**

Could humans add some level of self-awareness to Earth’s self-regulation?

*By Timothy M. Lenton¹ and Bruno Latour²*

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Assignment for Biology 100: Consider ‘Gaia’ in context of life characteristics

• Life is organized.
• Life requires materials and energy.
• Living organisms maintain an internal environment.
• Living organisms respond.
• Living organisms reproduce and develop.
• Living organisms have adaptations.

Resource: https://www.youtube.com/watch?v=sCxlqgZA7ag
Daisyworld animation on how a planet can regulate temperature:
Symbiosis at the cellular level


• Dr. Margolis also provided convincing evidence in support of long-discarded theory of serial endosymbiosis.
Margolis 1998, Symbiotic Planet
Serial endosymbiosis

- Dr. Margulis refined the theory of “serial endosymbiosis”:
  - Independent bacteria evolved into some of the organelles of eukaryotic cells, namely
    - **Chloroplasts** and
    - **Mitochondria**.
  - Her theory also described cilia of cells as originating from independent flagellates, but that aspect of her theory is not as well accepted.
Some prokaryotic cells became mitochondria in eukaryotic cells

Prokaryotic cells are those lacking nucleus, such as bacteria (left). Margulis proposed in 1965 dissertation that some of these evolved into mitochondria (above).
Cyanobacteria and chloroplasts

• **Blue-green algae** (top right), also known as cyanobacteria, are one of the earliest life forms known.

• Their structure is similar to the chloroplasts in eukaryotic cells.

• **Chloroplasts** in plant cells (bottom right) use solar energy to synthesize carbohydrates through the process of photosynthesis.
Chloroplasts store energy, mitochondria free it for use

- **Chloroplasts** have their own DNA and ribosomes that differ from the host cells.
- Chloroplasts are found only in plant cells.
- **Mitochondria** also have their own DNA and ribosomes that differ from hosts.
- Mitochondria are found in both plants and animal cells.
Other forms of mutualism

- Lichens are a combination of algae and fungi.
- Coral (as in coral reef) are a combination of algae (zooxanthellae) and coral.
- Bacteria living in root nodules help “fix” nitrogen, converting airborne nitrogen into forms plants can use.
- Even humans have helpful bacteria inside our guts.
Bacteria in root nodules of nitrogen-fixing plants
Lichens

A symbiosis between fungi and algae (cyanobacteria)
Corals

Zooxanthellae cells provide corals with pigmentation. On the left is a healthy stony coral. On the right is a stony coral that has lost its zooxanthellae cells and has taken on a bleached appearance. If a coral polyp is without zooxanthellae cells for a long period of time, it will most likely die.
Humans & their inner bacteria

• Humans contain at least as many inner bacteria as human cells
  (Sender et al., 2016, PLoS Biology, 14(8))

• That’s without counting mitochondria (former bacteria) that cooperate with the other organelles in every human cell.

• “Bacteriotherapy” delivers a sample of intestinal bacteria to those suffering from *Clostridium difficile*; the recolonization of healthy bacteria can often turn this around (John Hopkins Medicine, 2013, Fecal Transplantation).
Thanks for your interest!

Melanie Lenart, Ph.D.
Author of Life in the Hothouse: How a Living Planet Survives Climate Change

mlenart@tocc.edu
520-465-6877