

SOIL BIOLOGY: THE ROOTS OF NUTRITION

*If the organic grower knows why, he or she will teach
himself or herself how! (modified from L. H. Bailey)*

Choices: A Fresh Focus

The Conference that Celebrates Food and Health!

Michigan State University

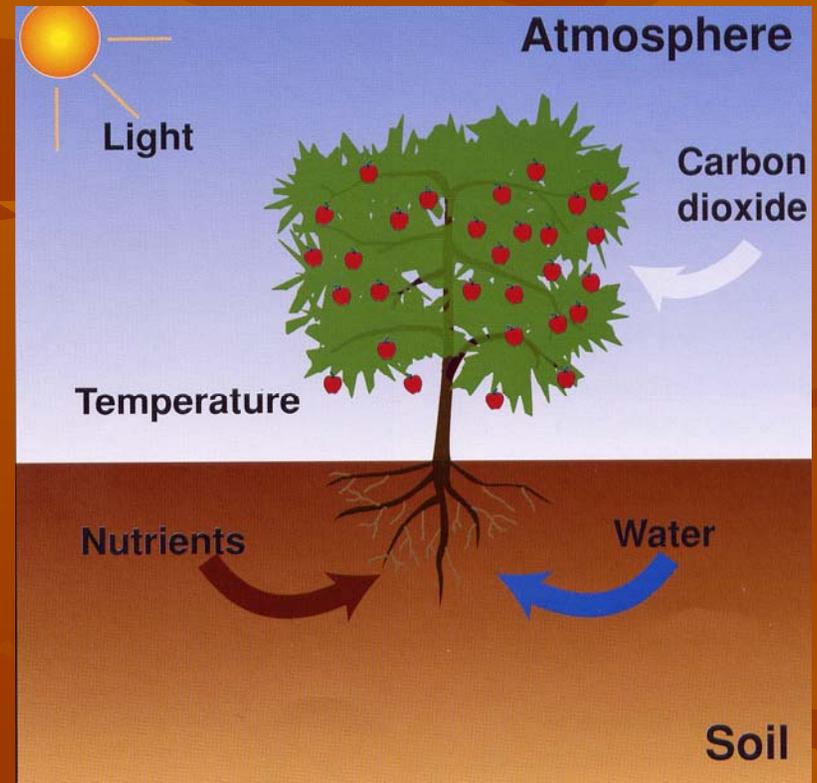
March 8, 2006

George W. Bird, Professor

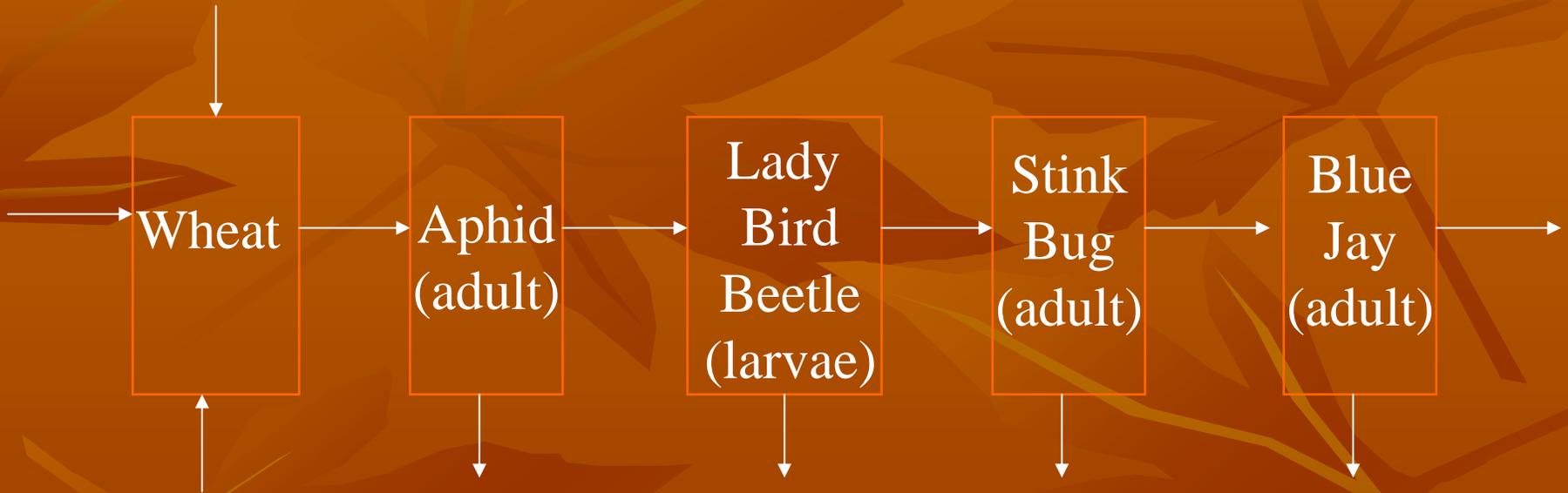
Introduction and Overview

1. Structure + Process = Pattern
2. The Language of Ecology
3. Human Nutrition and Body Composition
4. The Nature of Soil Biology
5. How it Works
6. An Organic Ethic

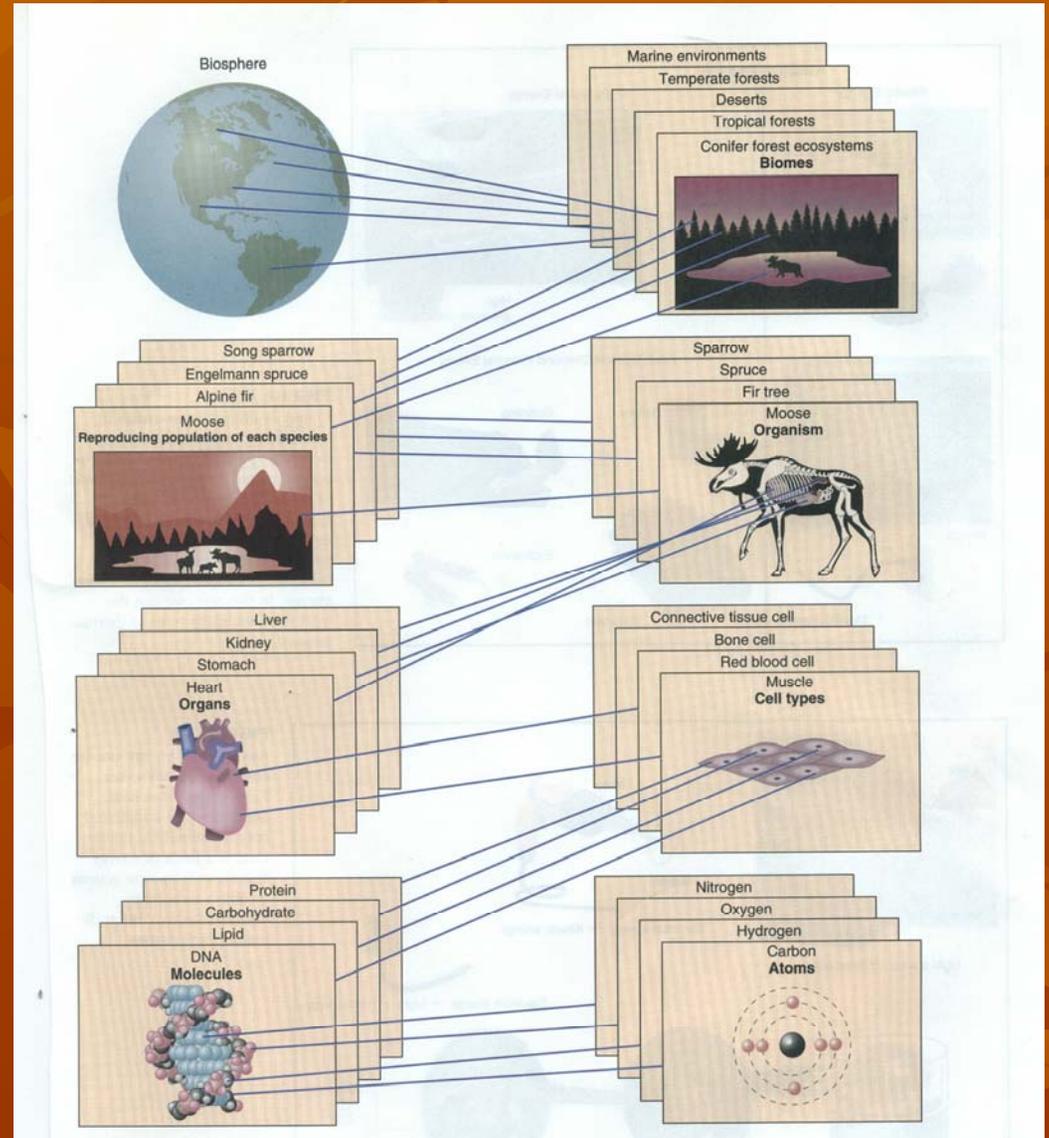
Structure + Process → Pattern



Trophic Level Food Chain



Life as a Hierarchy of Organisms



Mechanistic (Industrial) World View

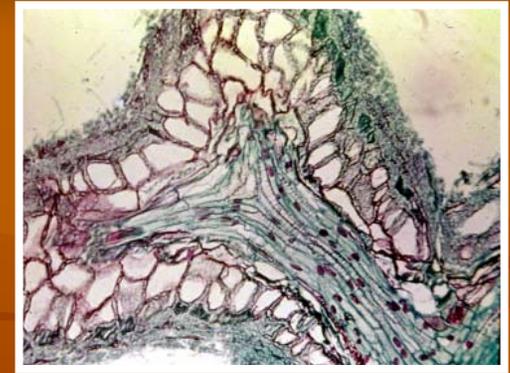
- **It is based on linear relationships.**
- **The assumption that the whole represents the sum of the parts.**
- **That resources are either infinite or replacement technologies will be continually available.**
- **There are relatively few direct feedback loops and only a small number of system components with overlapping functions.**
- **This world view does not mandate existence within a vibrant community of local ecological interdependence and partnerships.**
- **Growth (increase in size through assimilation of materials) is a fundamental attribute of the mechanistic world view.**
- **Through growth, there is an increasing flow or throughput of matter and energy resources for production of goods and services for an economy based on both population growth and increases in consumption.**

Ecological (Organic) World View

- **The Ecological World View is the foundation of Organic Agriculture.**
- **It is cyclic in nature and based on the assumptions that resources are finite and the whole is greater than the sum of its parts.**
- **It consists of local ecological interdependence-partnerships, cyclic patterns of organization, components with overlapping functions, multiple feedback loops and existence within a vibrant community.**
- **It requires development (realizing potential or bringing to an enhanced or better state) as a fundamental attribute of the ecological world view.**
- **Through development, the self organizing, interdependent and interconnected networks of living organisms interact to bring the overall system to a fuller or better state!**

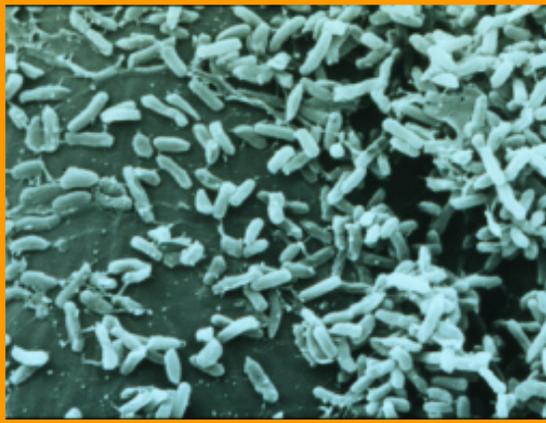


All of the 22 elements have the potential to come directly or indirectly from the soil.



- Outer most layer of our planet
- Regenerative living system (essential for organic agriculture)
- Ecosystem (Biotic, Abiotic, Boundaries)
- Place where **energy** and **matter** are transformed and transported.

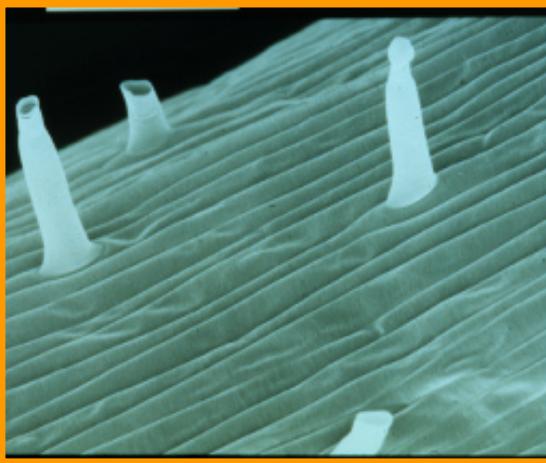
SOIL STRUCTURE



Gaseous (Air)
circa 25%

Liquid (Water)
circa 25%

Solid
(Mineral)
circa 45%
(Organic)
<1% to circa 10%



What Organisms Colonize Our Planet Oceana? (Misnamed Earth)

Three Domains and 23 Kingdoms of Life
(Science, Vol 275:1740)
(all but three are microscopic)

Domain No. 1

Bacteria
(6 Kingdoms)

Domain No. 2

Arachaeae
(6 Kingdoms)

Domain No. 3

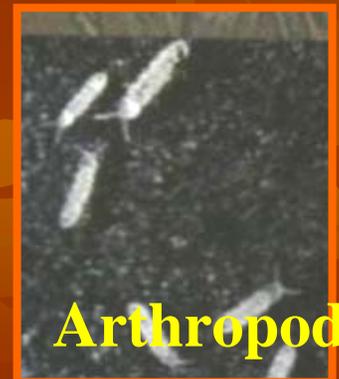
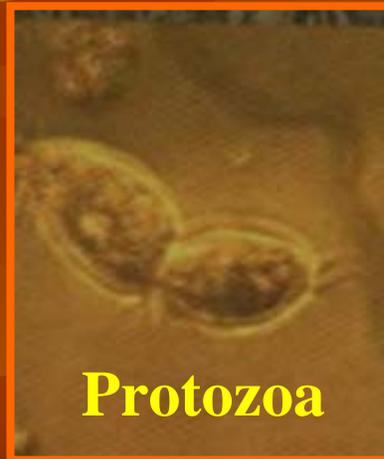
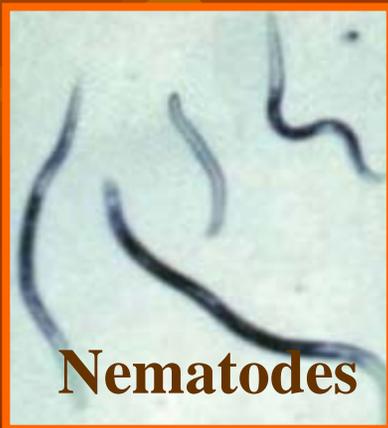
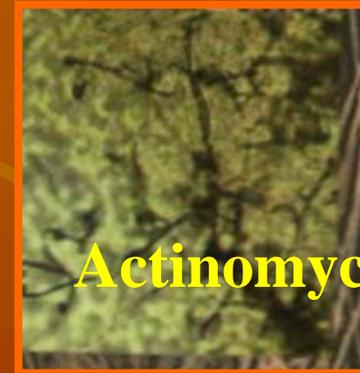
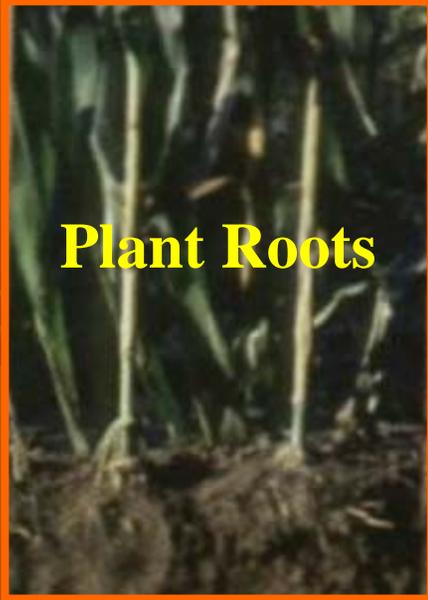
Eukarya
Animals
Plants
Fungi
(8 other Kingdoms)

Viruses (chemical messengers)
ssRNA ssDNA
dsRNA ssRNA multiple components

Prions
(Protein fragments)

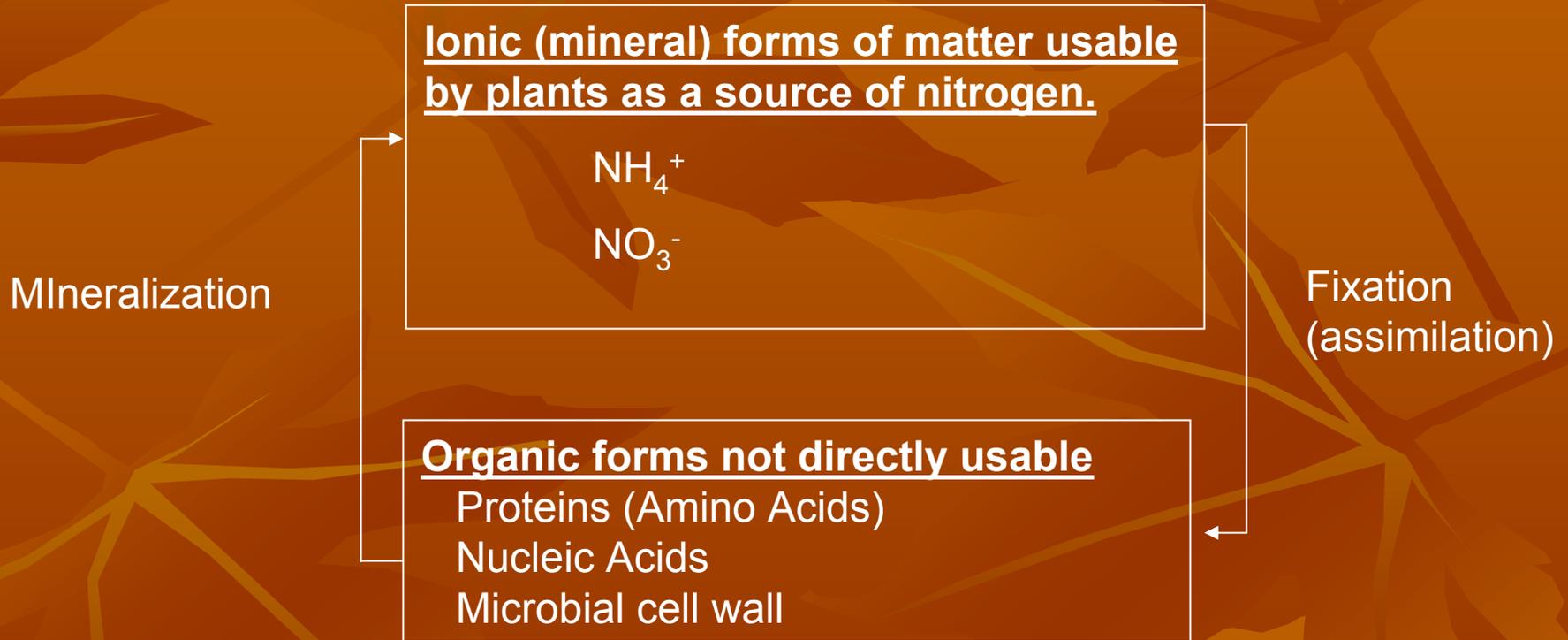
Soil-Borne Organisms

(The Things That Make It Work)



Nutrient Mineralization and Fixation

Essential Processes for the Growth and Development of Authtrophs



Nitrogen transport and transformation in soil and compost

What are bacteria and what do they do in the soil?

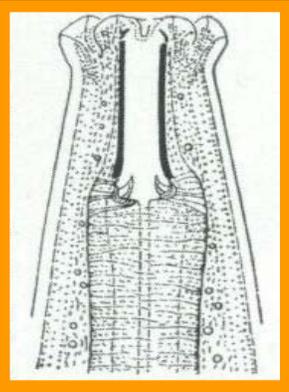
(Consumer/Decomposers)

- $\approx 5:1$ (C:N ratio)
- Feed/Metabolize
- Transport and Transform Nutrients
- Immobile C and N in soil and compost
- Mineralize C and N in soil and compost
- Replicate
- Hybernate
- Die (consumed)

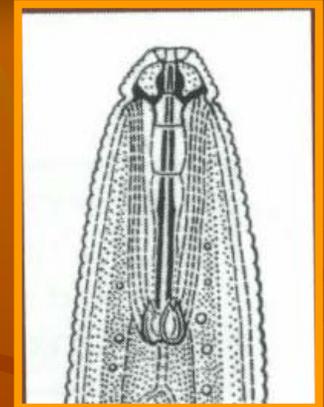


E. coli survived the Columbia Space Shuttle Crash of February 1, 2003.

What are the roles of nematodes in ecosystem function?

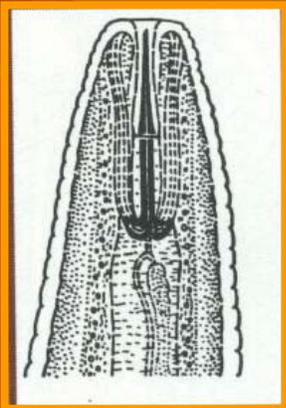


Bacterial Feeders

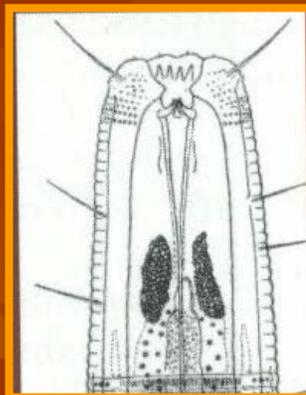


Plant Feeders

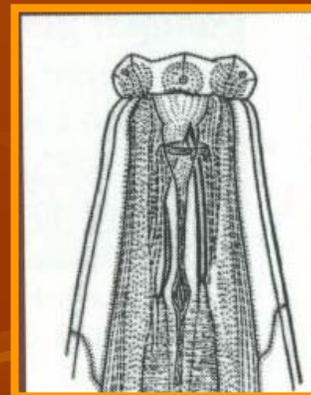
- N.A. Cobb (1915) ... if all the matter in the universe except the nematodes was swept away, our world would still be dimly recognizable – we would find mountaintops, valleys, rivers, lakes and oceans recognizable – by a thin film of nematodes.



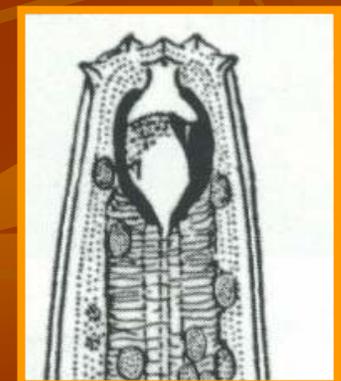
Fungal Feeders



Algal Feeders

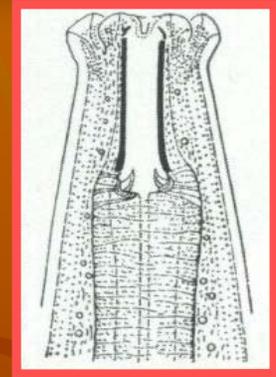


Omnivores



Carnivores

What do nematodes do in soil?

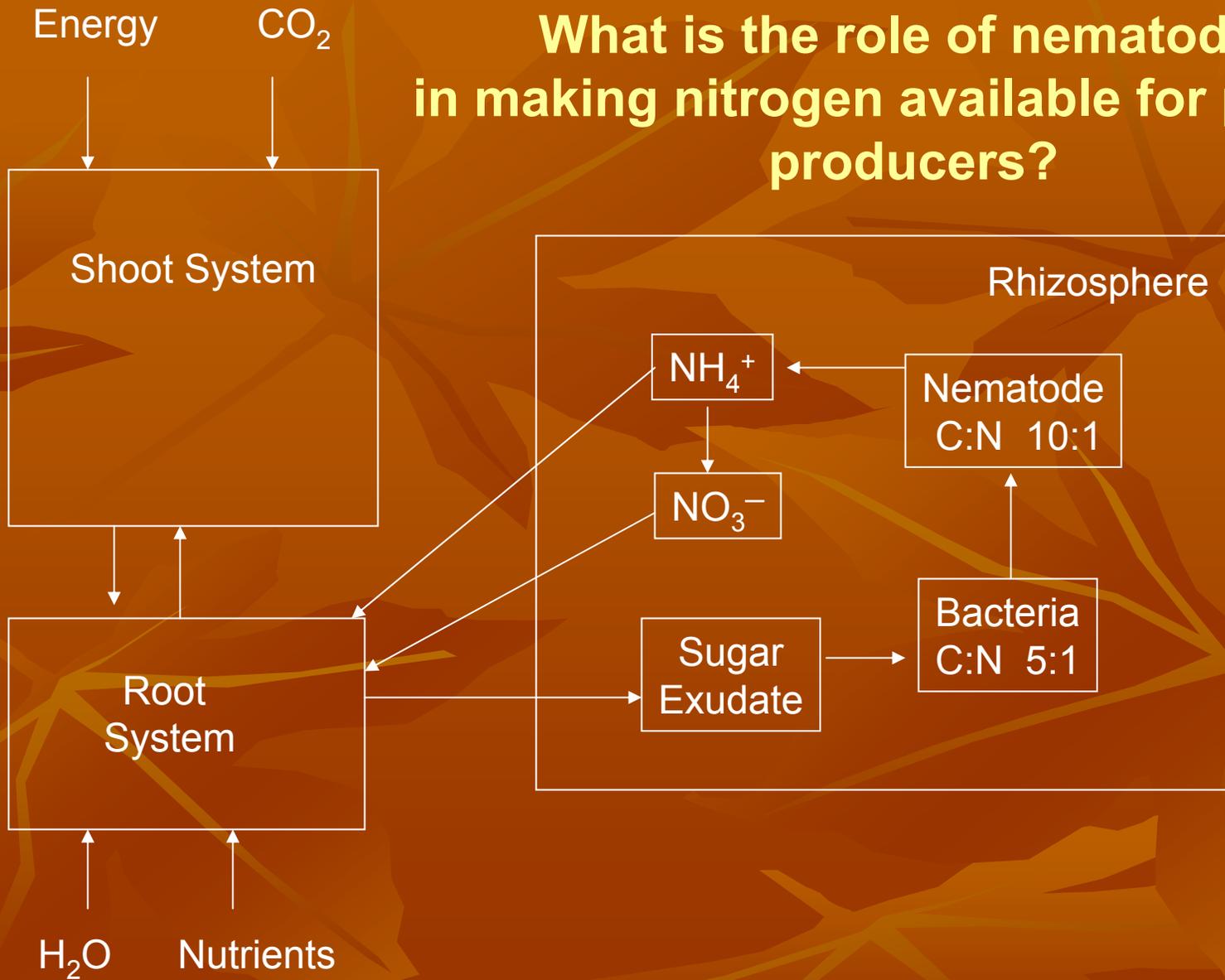


- 10:1 (C:N ratio)
- Feed (Bacterivores)
- Release NH_4^+
- Mobilize C and N
- A pulsing agent may be necessary for activation
- Reproduce
- Hybernate
- Die



The nematode *C. elegans* survived the Columbia Space Shuttle Crash of February 1, 2003.

What is the role of nematodes in making nitrogen available for primary producers?



There are more flagellates in organic soil than in conventionally managed soil. Why?

Flagellates

	Organic		Conventional
Surface litter	258,344	T-test 0.002	21,235
0 to 6" depth	6,991	T-test 0.445	4,524
6 to 12" depth	2,342	T-test 0.776	2,928



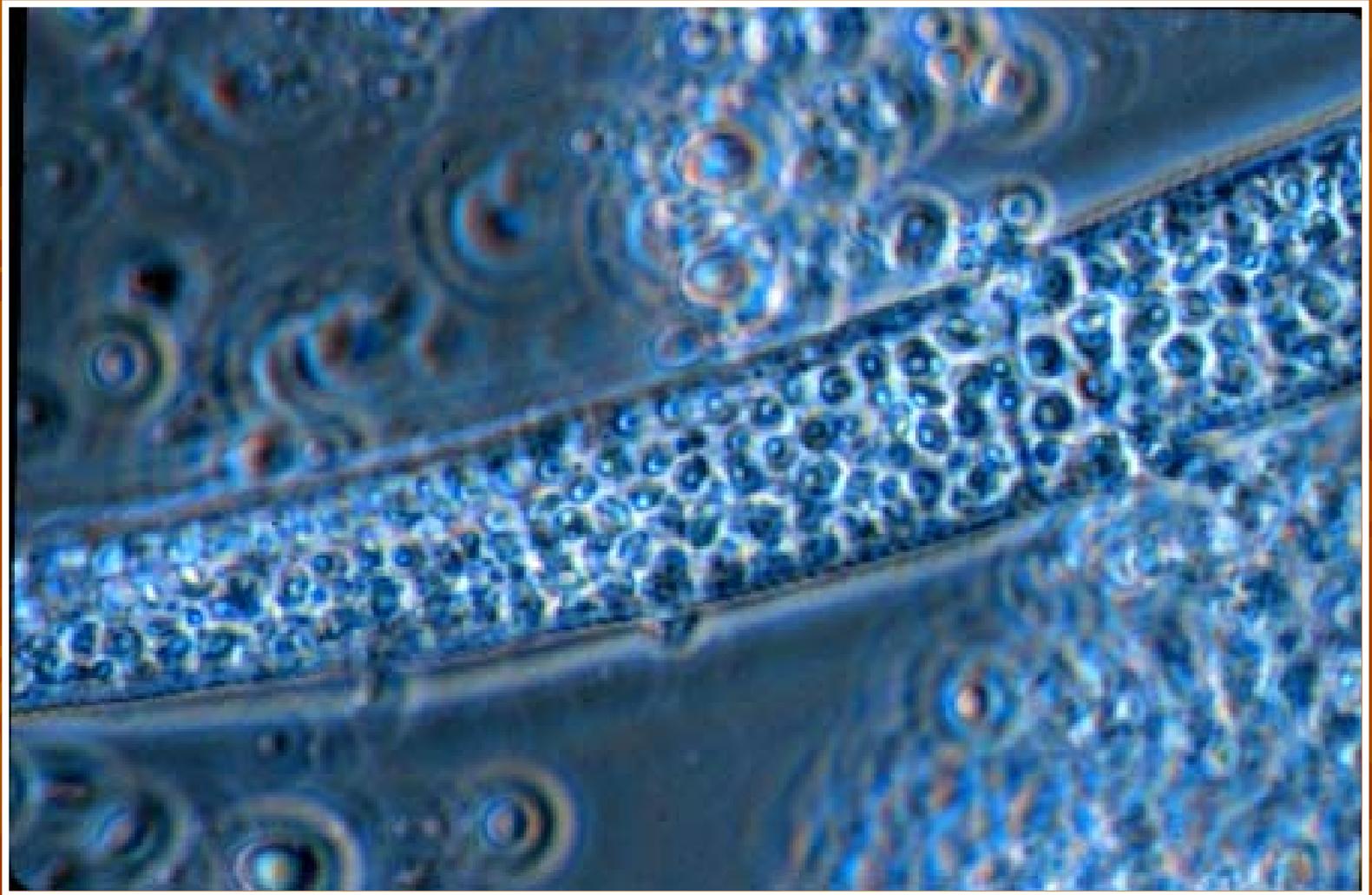
Bacteria endospore attachment



Fungal feeding nematode

Transport & transformation of matter and energy

Bacteria endospores in nematode cadaver



Matter and energy transformation

Influence of tart cherry ground cover and nutrient management on the active carbon and nitrogen pool sizes.

Management systems	Active carbon Pounds per acre	Active nitrogen
Conventional	1,054	59
Cover crop	1,350	96
Mulch	1,409	85
Compost	1,348	108
Biosystem	1,680	110

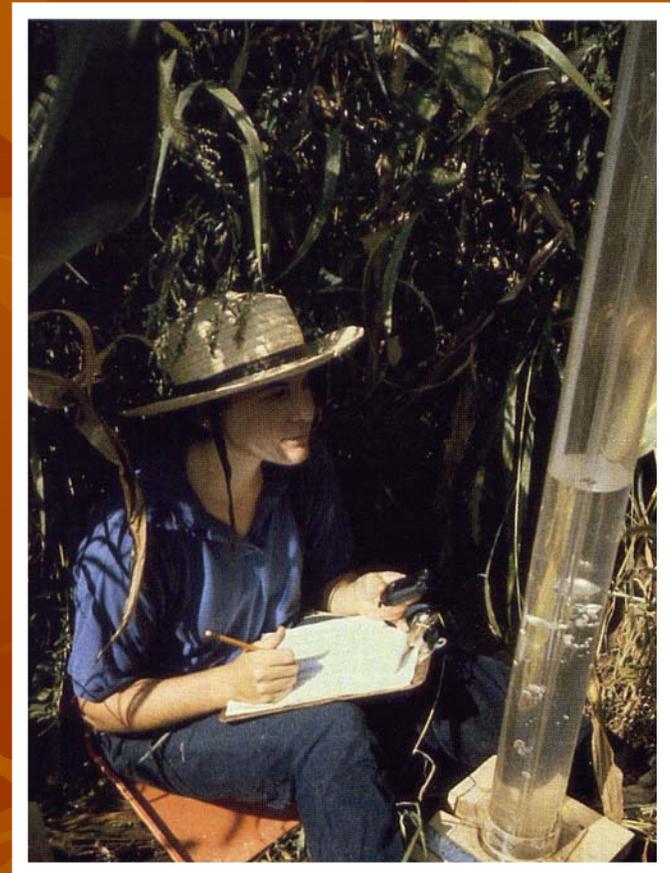
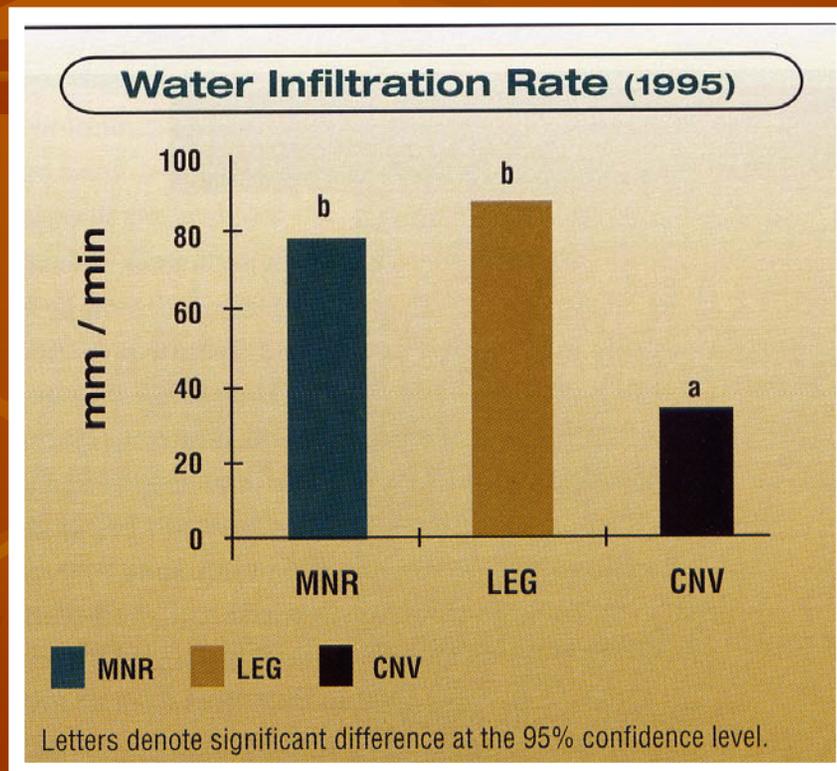
Data are a two-year average of samples taken in May 1999 and 2000. For detailed management information, refer to appendix at the end of this chapter. *Source: D.R. Mutch, C.E. Edson, T.C. Willson.*

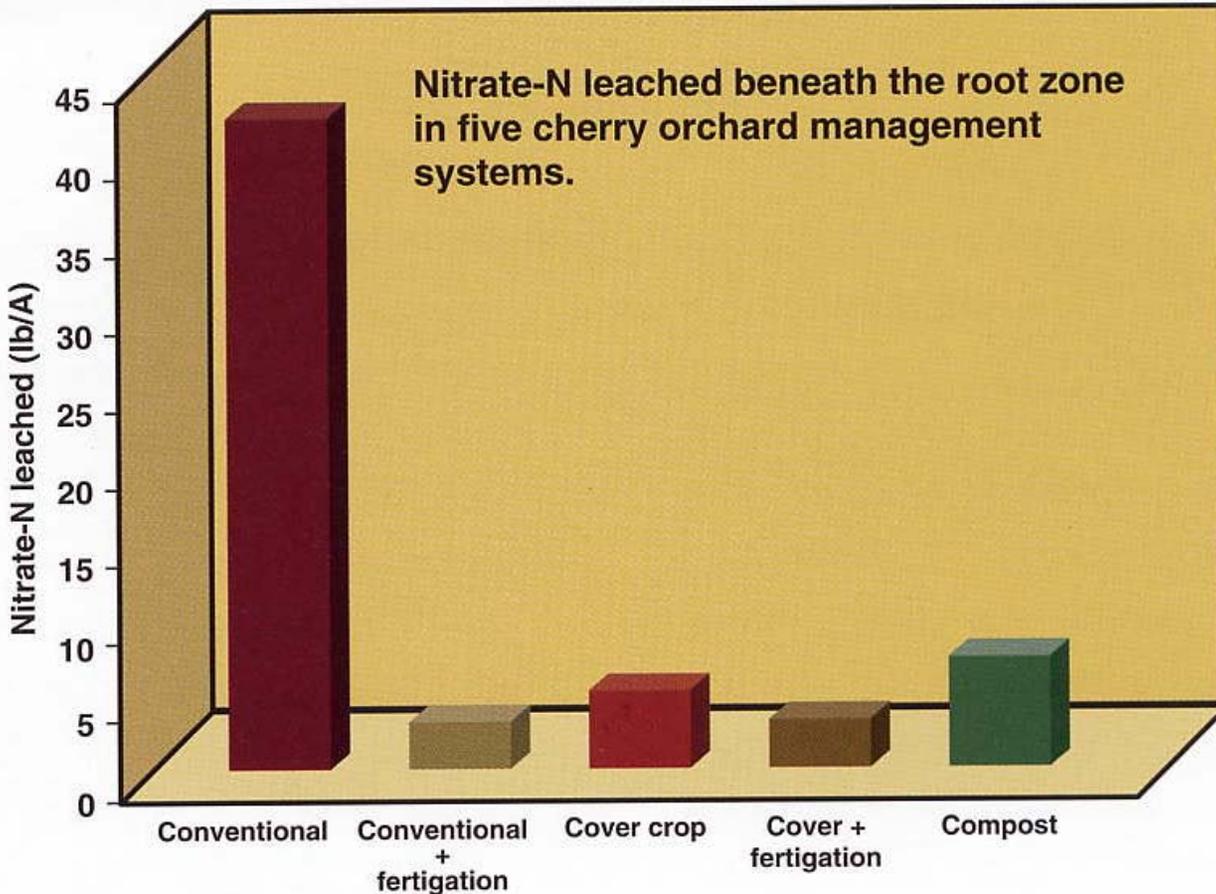
Cumulative Nitrogen Balance after 15 years under the 3 management regimes

Nitrogen Balance	MNR	LEG	CNV
	lb/A	lb/A	lb/A
Nitrogen inputs	1220	570	1170
Nitrogen exports*	735	660	705
Total inputs - Exports	485	-90	465
<i>Net change in soil nitrogen</i>	<i>365</i>	<i>100</i>	<i>-440</i>

*Non-leguminous grain, hay and silage

Water Infiltration Rate





Data are the average of four years (1996-99). For detailed management information, refer to appendix at the end of this chapter.

Do cover crops impact risks of ground water to chemical pollutants?

Organic Ethic¹

- Food and Farming Systems that:
 - Are regenerative in nature through ecological interdependence and partnerships ^{2,3}
 - Based on families, vibrant local communities and a philosophy of integrated equity ^{3,4}
 - Generate appropriate wealth through work ⁵
 - Foster a commerce with morality ⁵, and
 - Provide leadership for politics with principles ^{5,6}.

¹George W. Bird, Professor, MSU, 2001.

²Robert Rodale, Our Next Frontier, 1984.

³Fritjof Capra, The Web of Life: New Scientific Understanding of Living Systems, 1996

⁴Potter et al., 1970. Purpose and Function of the Univ. Science 167:1590-1593.

⁵Mahatma Gandhi.

⁶Thomas Jefferson.

Soil Biology: The Roots of Nutrition

Σ (Interdependence + Cycling +
Partnership + Flexibility + Diversity)

An Understanding of the Roots of Nutrition Requires

- Ecoliteracy
- Values of the Organic Ethic
- Meaningful Dialogue
- Hard Work
- Strong Commitment for a High Quality of Life for Current and Future generations