

Organic Science

Plant Nutrition and Soil Conditioning

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Treatise: “Do Green Products Make Us Better People?”



**Dr. Nina Mazar, U of Toronto
Asst. Prof of Marketing**

**Research in March 2010, issue of
Journal of Psychological Science**

- **Exposure creates “halo effect”**
- **Purchase gives “moral capital”**

Master Gardener Program

- **Mission:** Disseminate horticultural and related technical information to the public



Focus Groups: Northeast,
Southwest and Central
Ohio

- **Conclusion:** Economic downturn is excellent time to introduce **scientific organics** that are:
 - 1) effective
 - 2) cost-effective
 - 3) sustainable in the environment

Webster Dictionary Definitions of Organic

- ***Biol.*** – Relating to, or derived from living organisms
- ***Chem.*** – Relating to, or containing carbon compounds

Government Definitions of Organic Fertilizer



USDA – National Organic Program (NOP)

All organic fertilizers allowed in the Program are naturally derived; that is, of plant or animal origin. Sewage sludge and synthetic organic fertilizers are not included on the allowed list.



Canada Organic

Follows the same standards as NOP



Association of American Plant Food Control Officials (AAPFCO)

“A material containing carbon and one or more elements other than hydrogen and oxygen essential for plant growth.”

Original Plant Nutrition Research

Dr. Daniel Arnon (1910- 1994)



Leading Expert in Plant Nutrition

- Essential Elements
- Hoagland's Solution

Concerns about Organic Movement

- Plants don't absorb organic nutrients intact
- Plants are organic regardless of nutrient source

Organics: “Changing His Mind Intelligently”

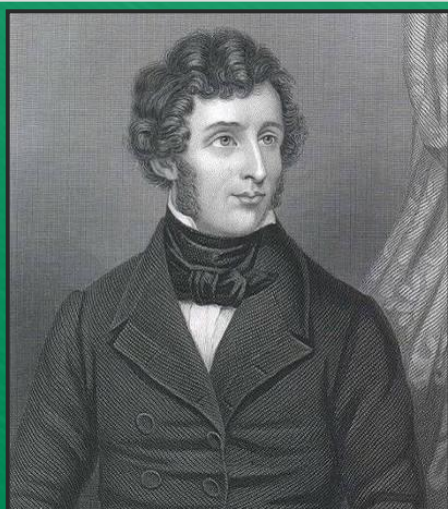
- ***Environmentalism Who Helped Inspire The Foundation of Earth Day April 22, 1970***
- ***Whole Earth Discipline: An Ecopragmatist Manifesto. 2009***
- ***Organics Are A Nostalgic Market For The Wealthy***



Stewart Brand

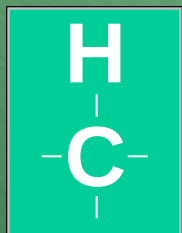
Historical Source of Confusion

- Prior to 1828, scientists were unable to bond carbon to carbon and there was a common belief that a “life essence” was necessary. This philosophy was known as **Vitalism**.
- The carbon compounds were called “**organic**” to denote their origin.

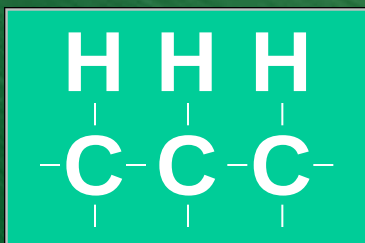


IN 1828, FRIEDRICH WOHLER'S RESEARCH INITIATED **ORGANIC SCIENCE**, WHICH DISPELLED THE THEORY THAT ORGANIC COMPOUNDS WERE FUNDAMENTALLY DIFFERENT FROM INORGANIC.

Scientific Definition of Organic



Organic is the chemistry of carbon, and more specifically, the chemistry of the carbon-hydrogen linkage.



Catenation is the formation of carbon chains or polymers, the basis for organic chemistry and life on Earth.

Unique Characteristics of Organic Compounds

- *Of the nearly 100 natural elements, only carbon can catenate and form stable, multiple covalent bonds at ordinary temperatures and pressures on Earth.*
- *The energy stored in the covalent bonds of carbon polymers is released by cellular respiration, a form of “chemical burning”.*
- *Organisms (microorganisms, plants, animals) use this energy for cellular activity.*

Carbon-Containing, But Not Organic

Carbon (C)

Carbon Oxides (CO_x)

Carbonates (CaCO_3)

Urea ($(\text{NH}_2)_2\text{CO}$)

Biological, But Not Chemically Organic

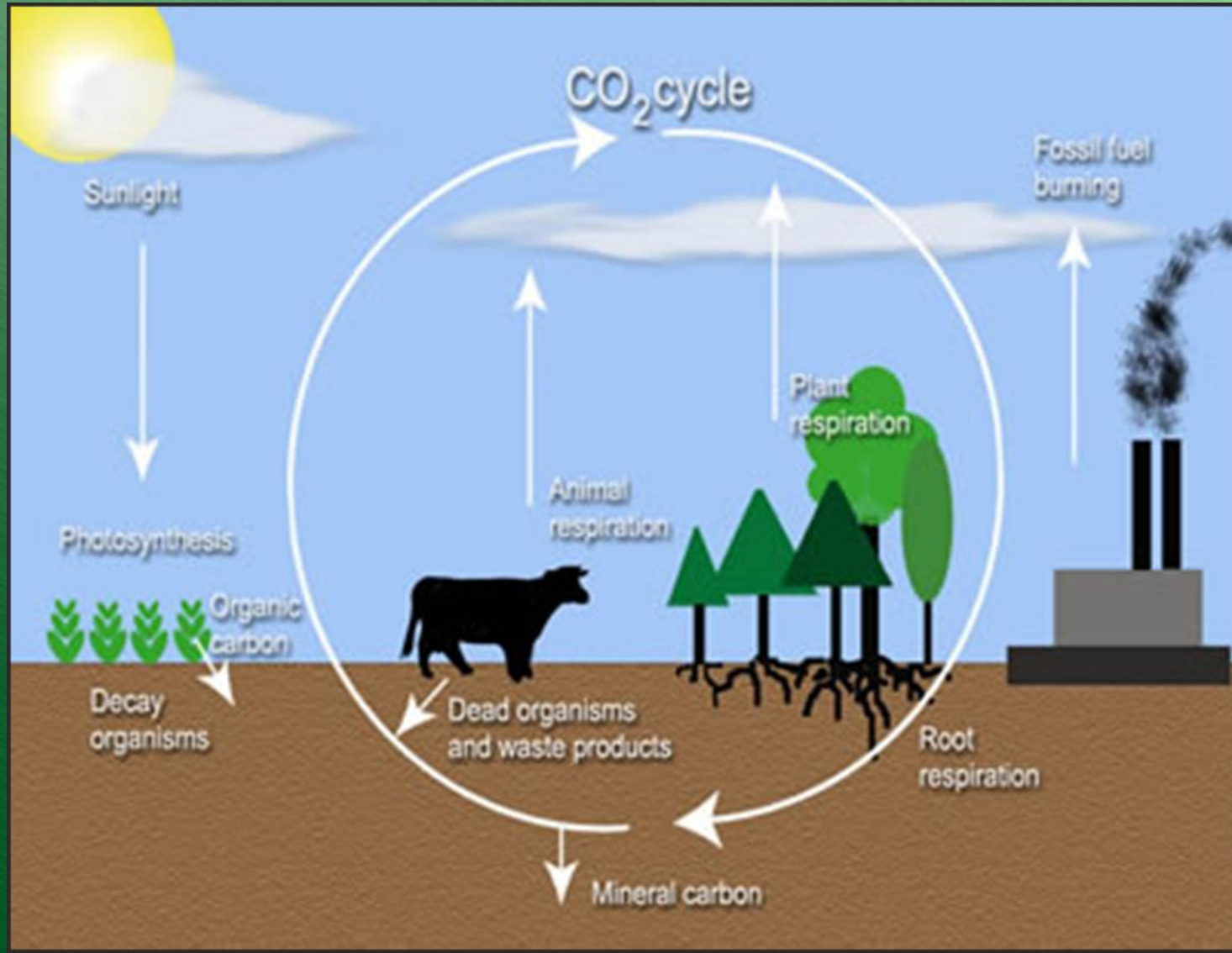
- Urea, produced by terrestrial animals and also synthesized as a fertilizer, contains carbon but does not react chemically as organic.
 $(\text{NH}_2)_2\text{CO}$
- Our bones and teeth are primarily a form of calcium phosphate
 $\text{Ca}_5(\text{PO}_4)_3\text{OH}$

6
C

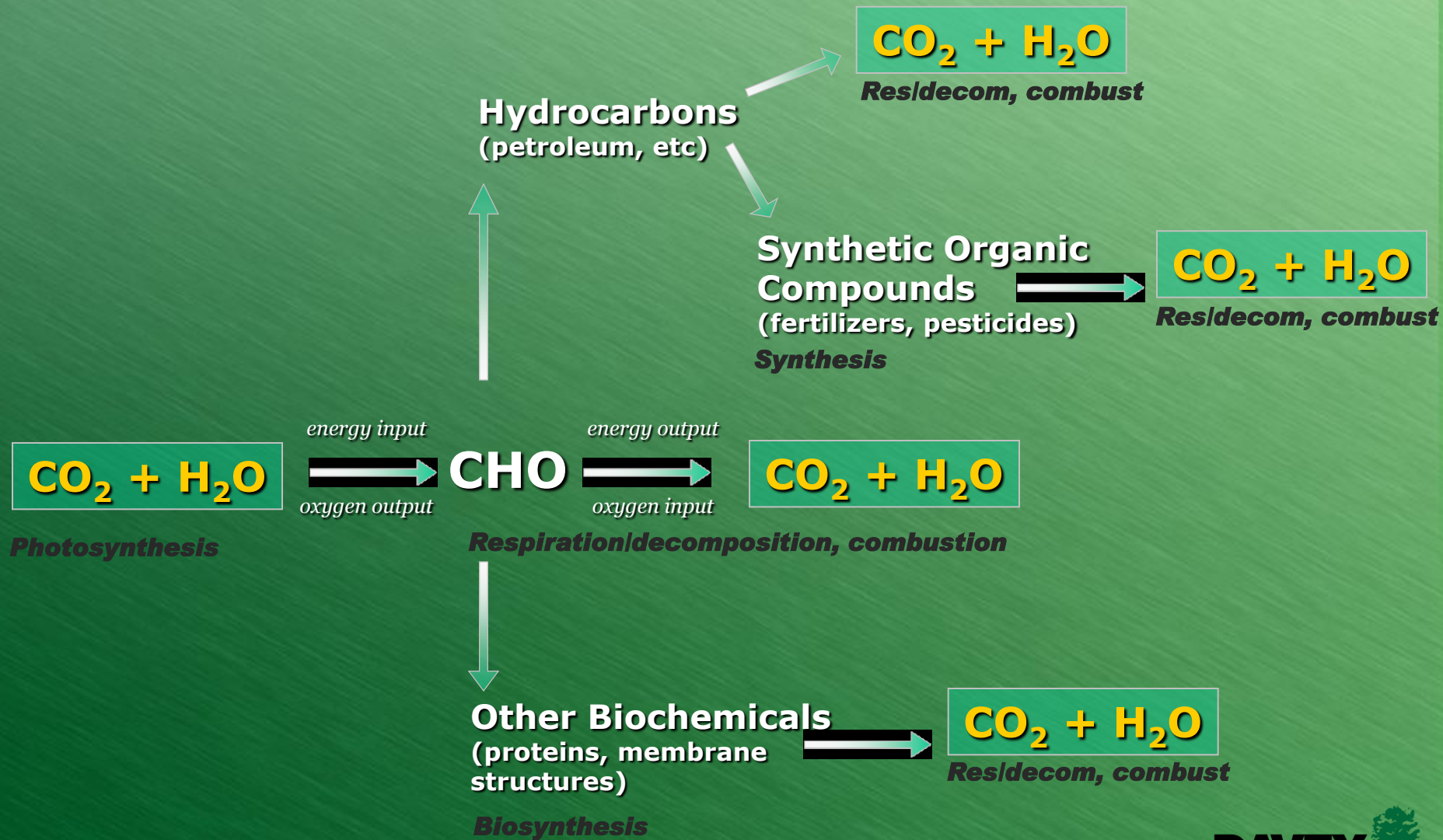
* Lanthanide Series	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
+ Actinide Series	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

 Inert Elements

Carbon Cycling: An Overview



Carbon Cycling: Detail



Plant Nutrient Overview

Inorganic

- Natural
- Engineered

Ionization
Water

Mineralization

Hydrolysis and/or Microbial
Decomposition

Nutrient Ions
i.e. NH_4^+ , NO_3^-

} Uptake
Burn
Leach

Organic

- Natural
- Engineered

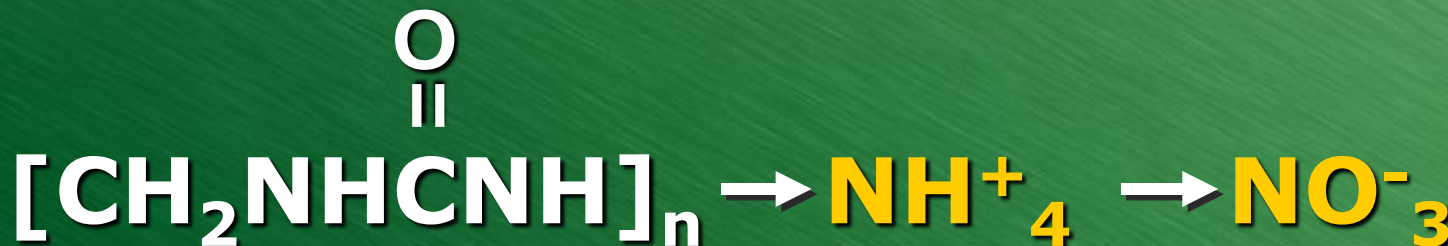
What is the difference between organic and inorganic fertilizers?

	Natural	Engineered
Organic	Natural Organic $[\text{NH}_2\text{CHR}^*\text{COOH}]_x \rightarrow \text{NH}_4^+ \rightarrow \text{NO}_3^-$ Protein → Ammonium → Nitrate	Engineered Organic $[\text{CH}_2\text{NHC(=O)NH}]_x \rightarrow \text{NH}_4^+ \rightarrow \text{NO}_3^-$ Methylene Urea Polymer → Ammonium → Nitrate
Inorganic	Natural Inorganic $\text{NaNO}_3 \rightarrow \text{Na}^+ + \text{NO}_3^-$ Sodium Nitrate → Sodium + Nitrate	Engineered Inorganic $\text{NH}_4\text{NO}_3 \rightarrow \text{NH}_4^+ + \text{NO}_3^-$ └─→ NO₃⁻ Ammonium Nitrate → Ammonium → Nitrate

* Varying functional groups.

Organic Fertilizers

- Carbon-hydrogen linkages
- Covalent bonding 
- May be used as energy source by microorganisms
- Requires microbial or hydrolytic action
- Nutrients attached to carbon



Inorganic Fertilizers

- No carbon-hydrogen linkage
- Ionic bonding $\oplus \ominus$
- Not used as energy source by microorganisms
- Water alone can separate
- Nutrient ions attached to each other



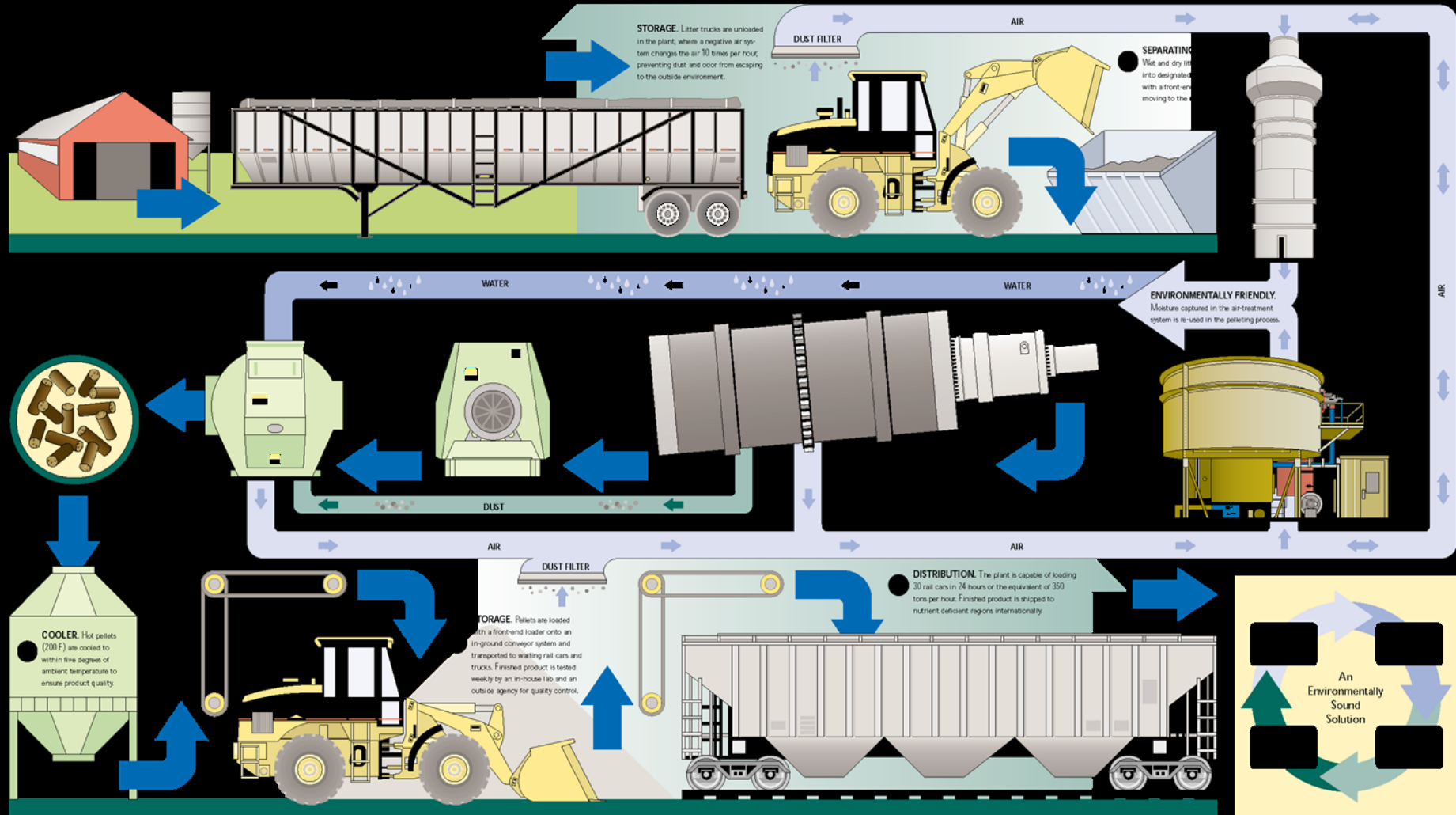
Comparison of Organic and Inorganic Fertilizers

Characteristic	Fertilizer				
	Organic		Urea	Inorganic	Coated
	Natural	Synthetic			
Nutrient Release	Slow	Slow	Quick	Quick	Slow
Burn Potential	Low	Low	High	High	Low
Leach Potential	Low	Low	High	High	Low
Cost / Nutrient	High	Intermediate	Low	Low	Intermediate
Microorganism Energy Source	May	May	No	No	No

Comparison of Synthetic and Natural Organic Fertilizers

Characteristic	Natural				Synthetic			Urea
	Alfalfa	Turkey Litter	Blood Meal	Urine	Methylene Urea	Urea-form	IBDU	
Nutrient Analysis	2-1-2	4-2-3	13-1-.5	15-2-3	40-0-0	38-0-0	31-0-0	45-0-0
CiN Ratio	15:1	16:1	3:1	1:1	1:1	1:1	1.5:1	1:2
Micro-nutrient Energy Source	Yes	Yes	Some	No	Some	Yes	No	No

Processing Turkey Litter as Fertilizer



Carbon Footprint: Kg C equivalent/1 lb N

Fertilizer

Kg C/lb N

Organic Science

Lawn Care (25-0-7) 1.33

Tree Care (30-10-7) 0.92

Natural Organic

Turkey Litter (4-2-3) 1.63

Yvon Chouinard, Founder of Patagonia



- 1% of gross income to environmental charities since 1985
- Synthetic organic fabrics can be better for the environment than organic cotton

Organic Science: Carbon:Nitrogen Ratio

Managing Soil and Plant Growth is Basically Managing the Carbon:Nitrogen Ratio

- *Too much carbon (relative to nitrogen) results in a nitrogen deficiency for plants*
- *Too little carbon (relative to nitrogen) results in accelerated carbon loss from the soil with resultant loss in soil structure*

How Organic Matter Improves Soil and Plant Growth



Microbial Decomposition

Raw Organic Material



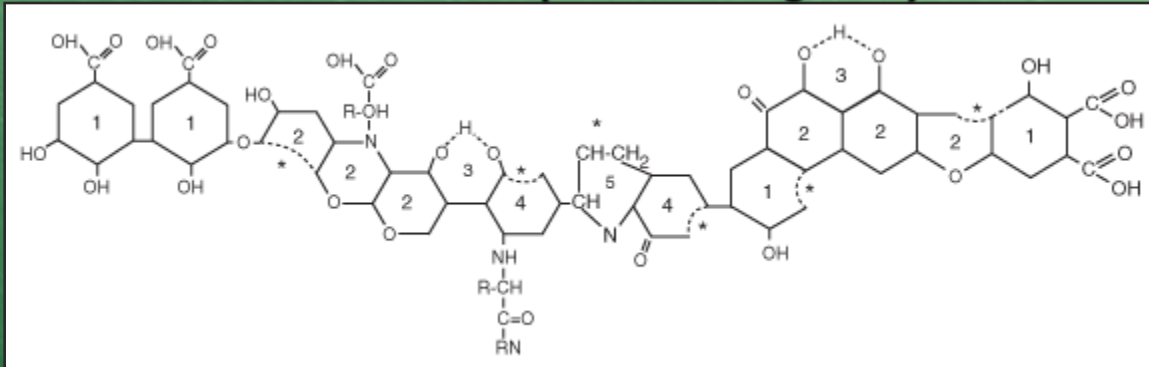
Stable Humic Material

- Secretions
 - Soil aggregation
 - Plant defense
- Filamentous growth extends root influence
- Nutrient release

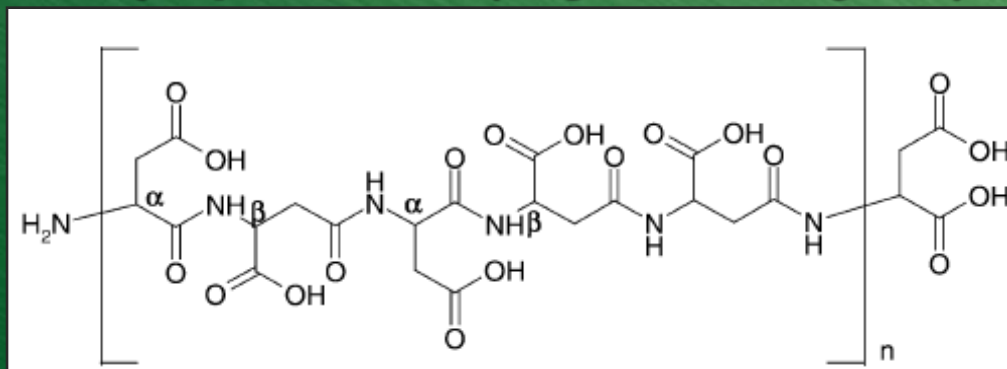
- Soil aggregation
- Nutrient retention
- Moisture retention

Active Sites in Stable Organic Matter

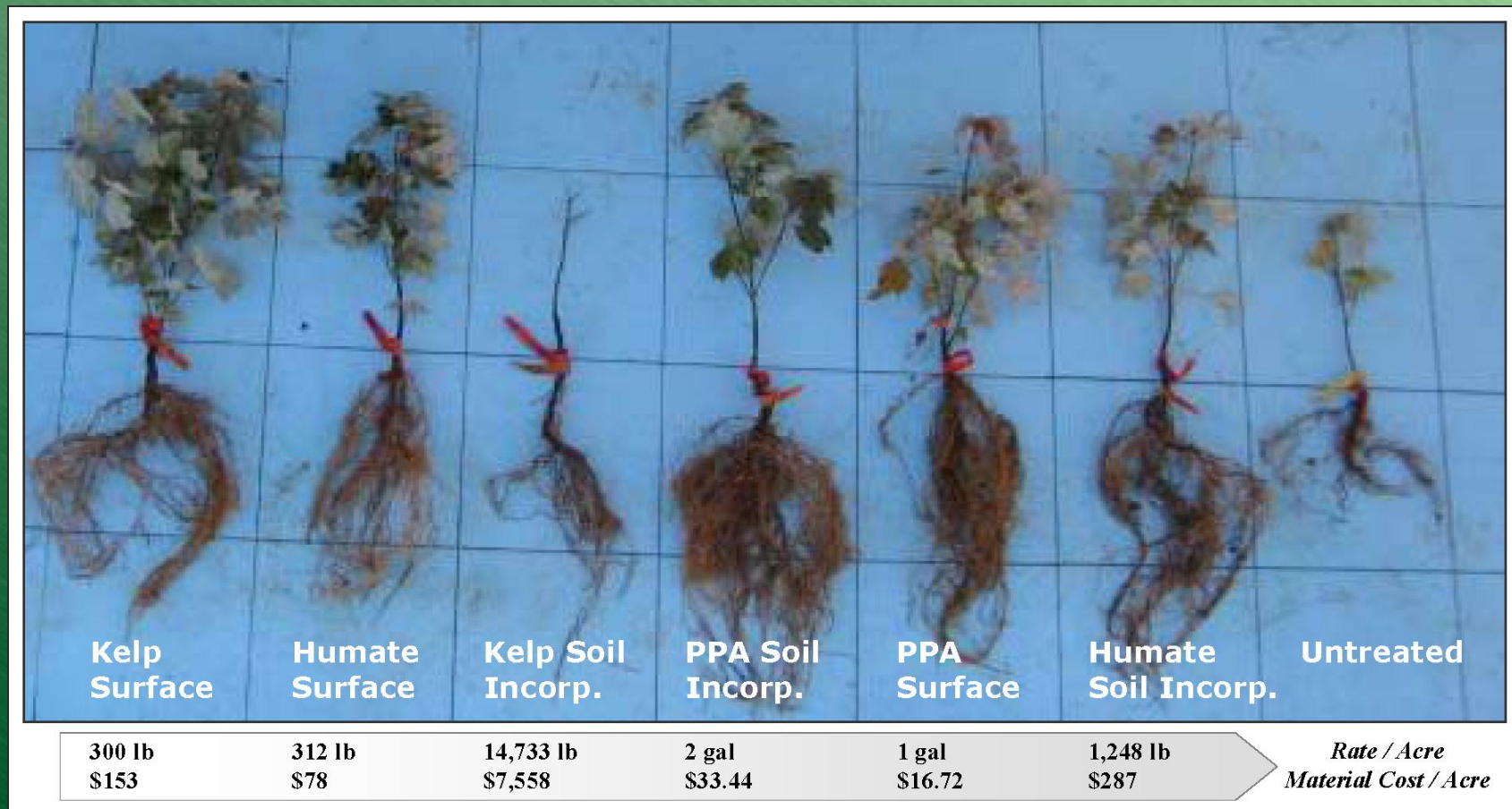
Humic Acid (natural organic)



Polyaspartic Acid (engineered organic)



Root Response to Natural and Synthetic Organic Amendments



Organic Science: Summary

“Feed the Plant *and* Feed the Soil”

- **Inorganics** - Carbon either not present or not used as an energy source for microorganisms; thus promote plant growth but not soil structure
- **Natural Organics** - Improve soil structure but the C:N ratio is too high for optimal plant growth
- **Synthesized Organics** – Can be used alone or in combination with natural organics to provide the optimum C:N ratio to improve soil structure and plant growth

Organic Science: Summary

- Synthesized organics have the same chemistry as their natural counterparts and often are **more effective**, **more cost-effective** and **more environmentally sustainable**