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Bioenergy Research at BNL: Increasing Productivity Using Biological Interactions

Lee Newman

With D. van der Lelie, S. Taghavi, S. Monchy, N. Weyens, L. Odom, B. Temple, A. Hoffman, R. Ferrieri, A. Rogers, L. Miller, R. Tappero J. Schwender and J. Vangronsveld

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So who am I?

- Education
- Work
- And beyond

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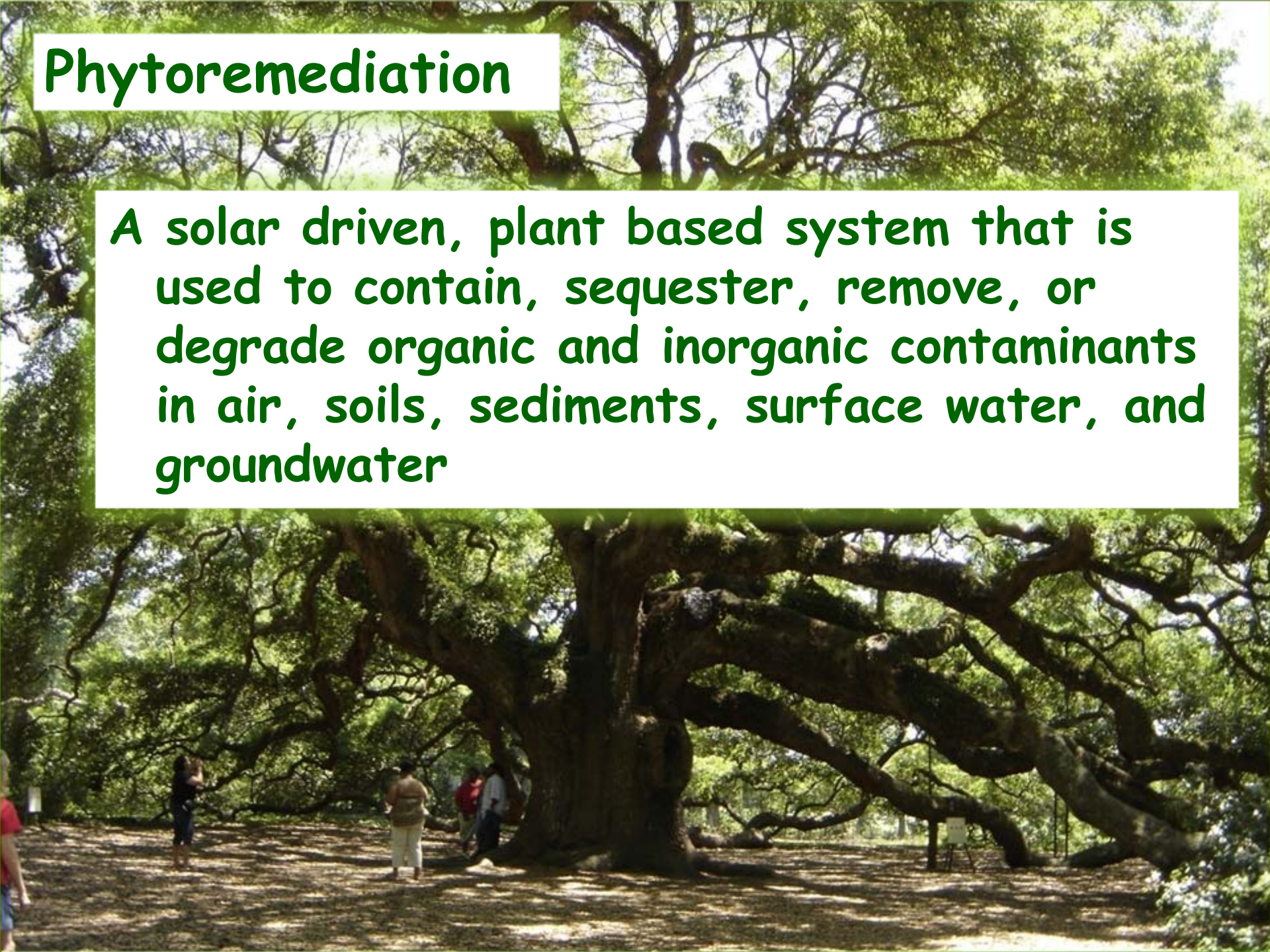
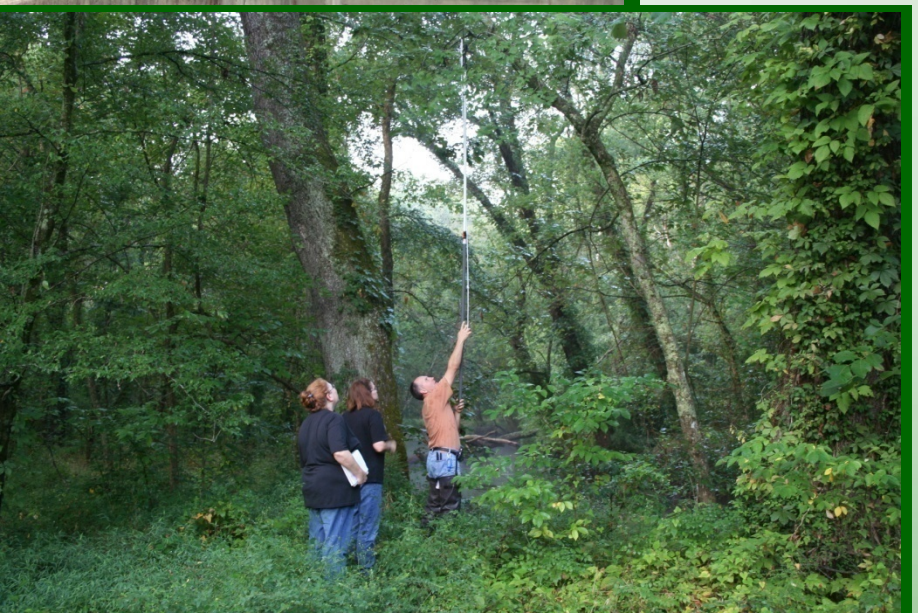
What Type of Research Do I Do?

Phytoremediation

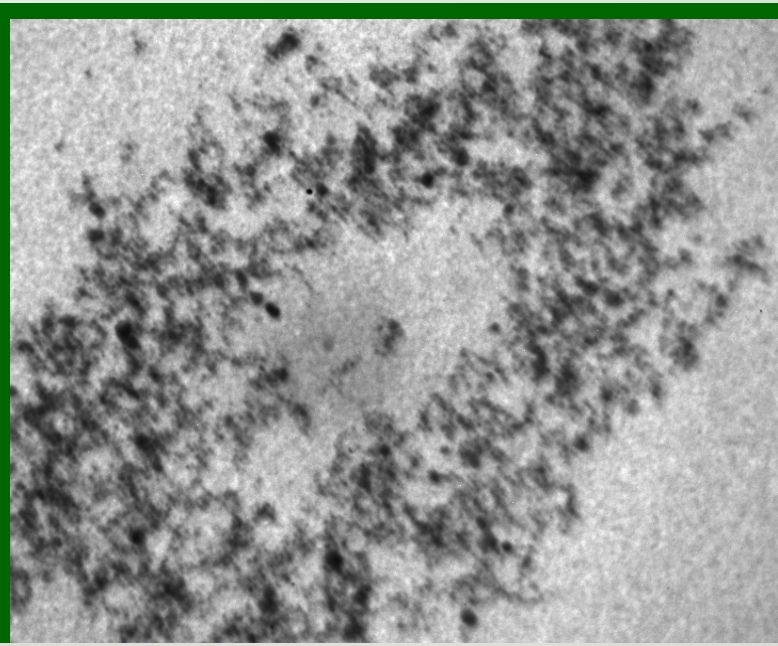
A solar driven, plant based system that is used to contain, sequester, remove, or degrade organic and inorganic contaminants in air, soils, sediments, surface water, and groundwater

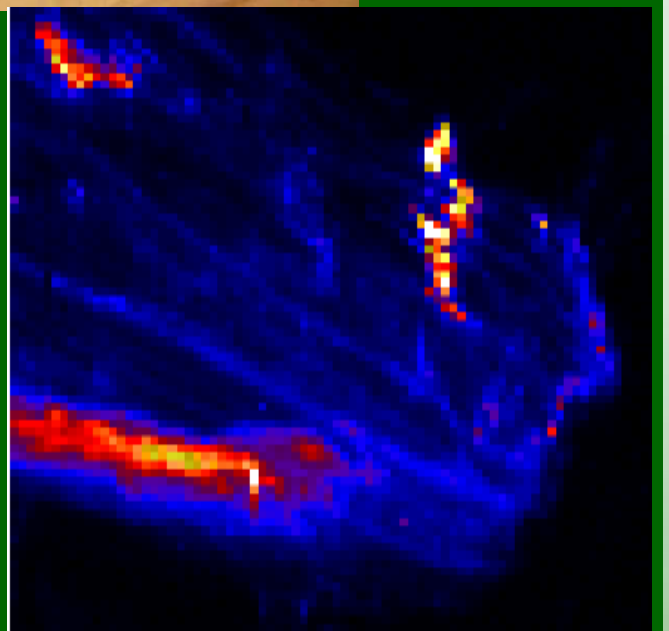


Monitoring



Plant/Nanoparticle Interactions





Biofuels

- What are Biofuels?
- Where do we get them from?
  - Sugars
  - Starch
  - Vegetable Oil
  - Animal fat
  - Wood
  - Charcoal
  - Dried excrement
- In order for the fuel to be considered a "biofuel" it must contain at least 80% renewable material

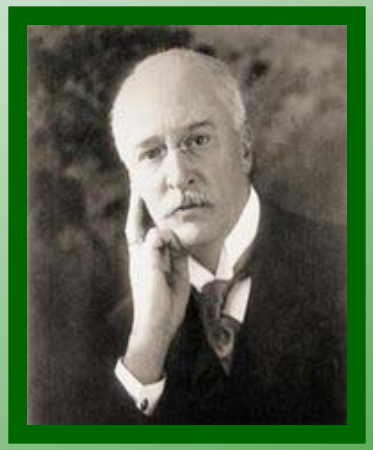
At the Most Basic

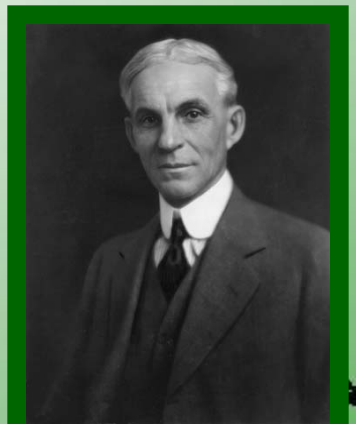
- Burning plant material for heating and cooking

Biofuels for Transportation

Biofuels for Transportation

- Nicolaus August Otto (1879)
  - Invented the internal combustion engine
- Rudolf Diesel (1898)
  - Invented the diesel engine
- Henry Ford (1903-1923)
  - Founded the Ford Motor Company





- "The fuel of the future is going to come from fruit like that sumach out by the road, or from apples, weeds, sawdust -- almost anything," Henry Ford said. "There is fuel in every bit of vegetable matter that can be fermented. There's enough alcohol in one year's yield of an acre of potatoes to drive the machinery necessary to cultivate the fields for a hundred years."

Arachis hypogaea L.
Image processed by Thomas Schoepke
www.plant-pictures.de

Biofuels: What happened to Them?

- Texas and Pennsylvania and the Roaring 20's

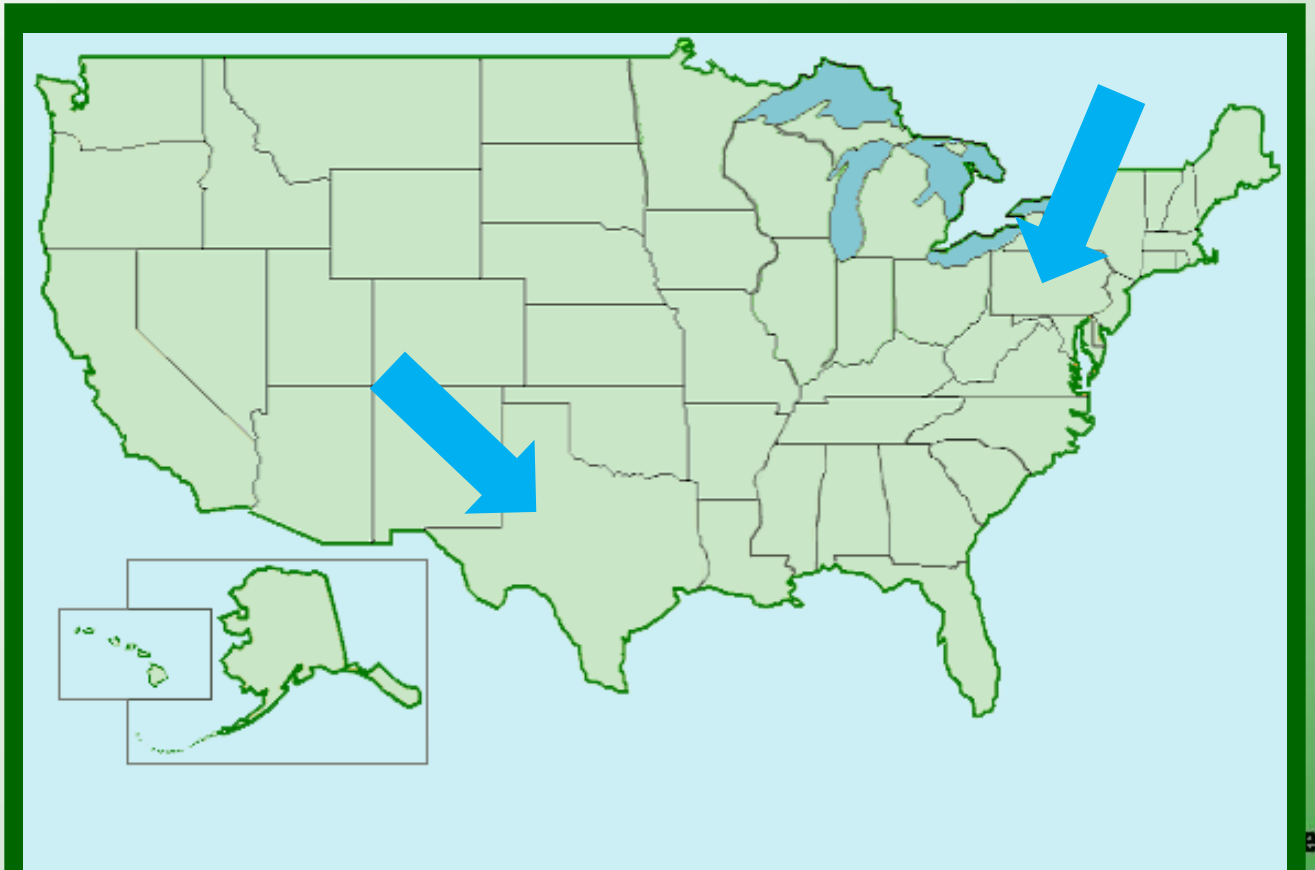
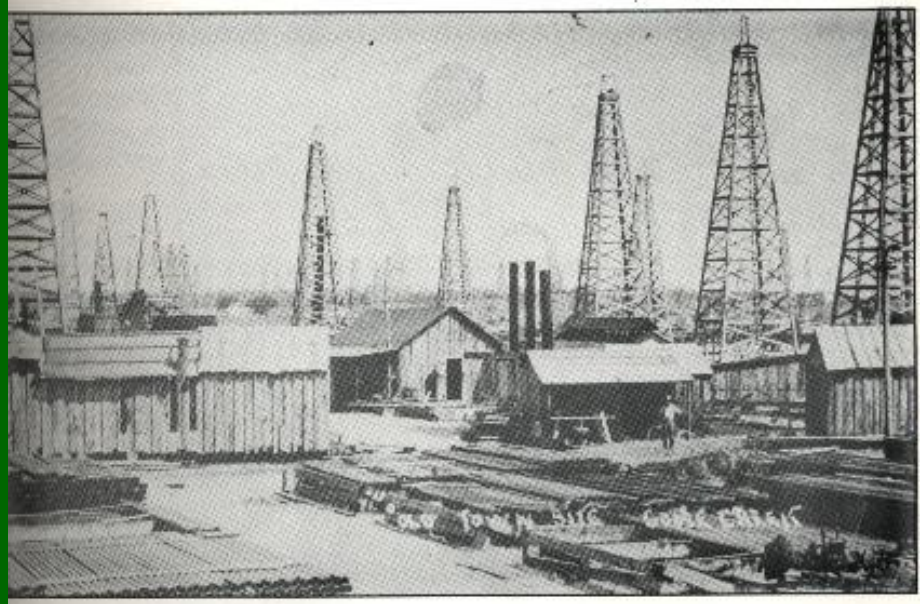


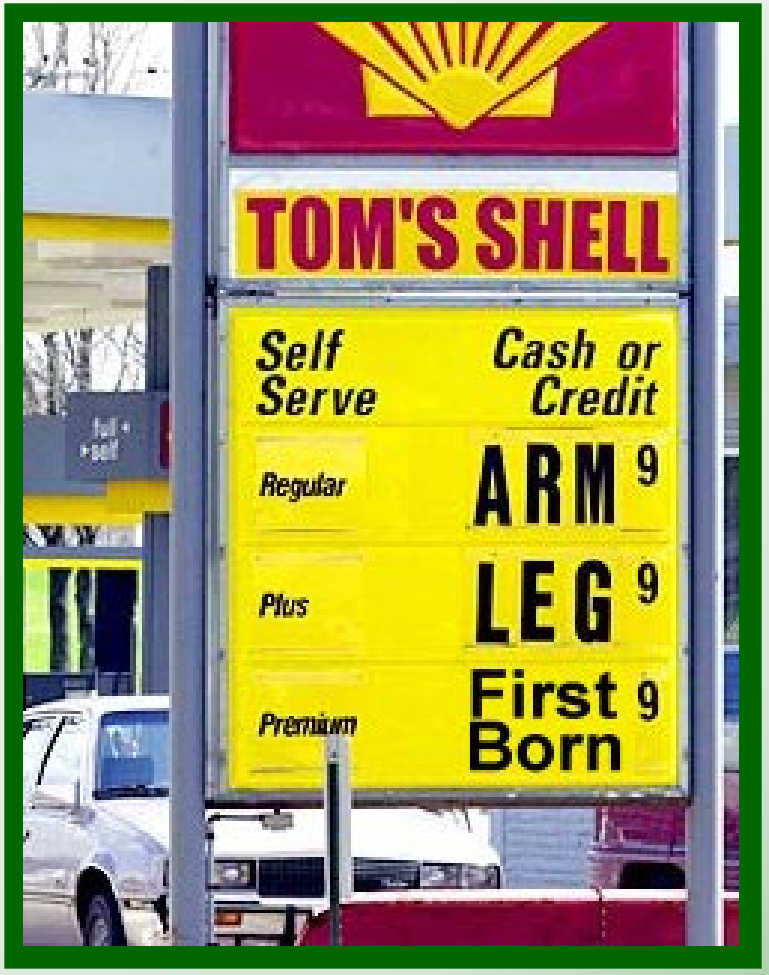
Photo courtesy Baytown Historical Museum

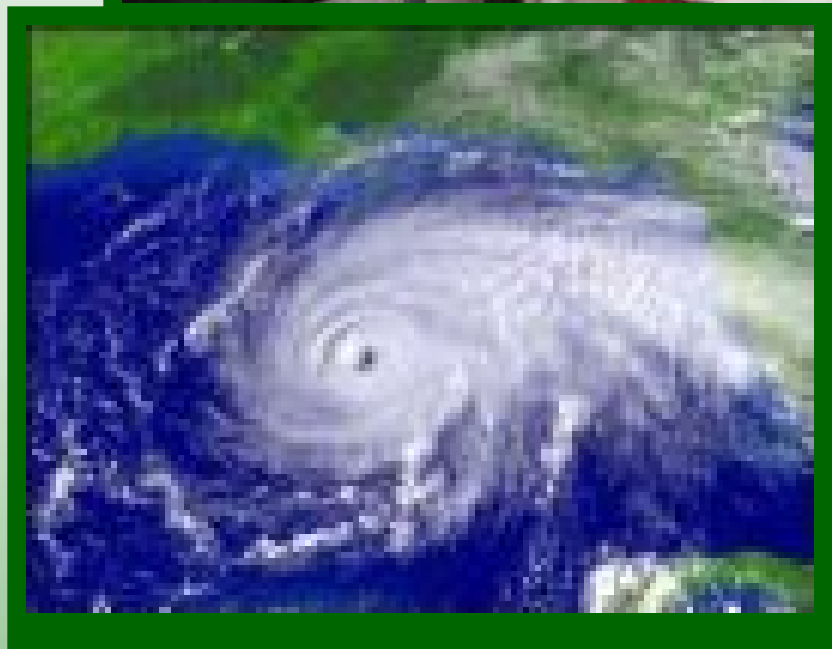


The Goose Creek oil boom at its height in the nineteen teens

Why do we need them now?

- 1973 to Present





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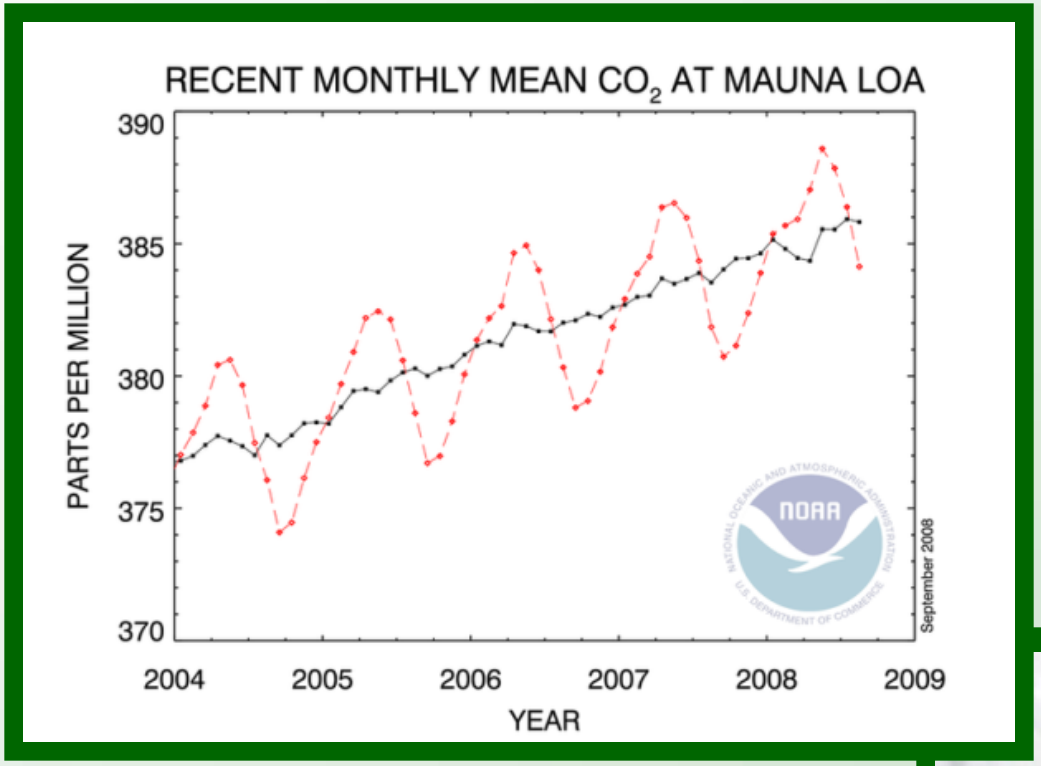
CO_2 and the Atmosphere



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"Enough" biomass for biofuel?

- 50B gallons of EtOH would require approximately 1B dry tons of biomass per year (DOE-USDA "Billion ton study").
- Corn based biofuel economy has major consequences:
  - Price of corn has doubled
  - Farmers are planting more corn for ethanol
- Increase alternative feedstock production without competition for food production or endangering our natural heritage:
  - More than one use per crop
  - Growth of lignocellulosic biomass on marginal soils.

http://feedstockreview.ornl.gov/pdf/billion_ton_vision.pdf

n Science Associates

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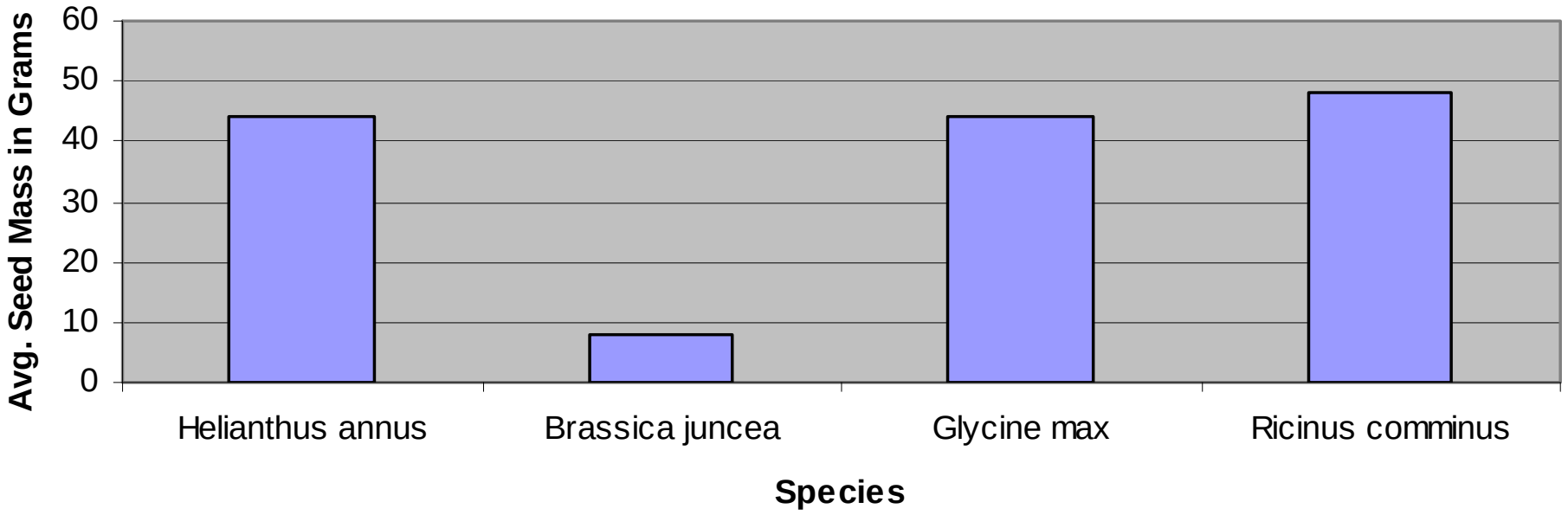
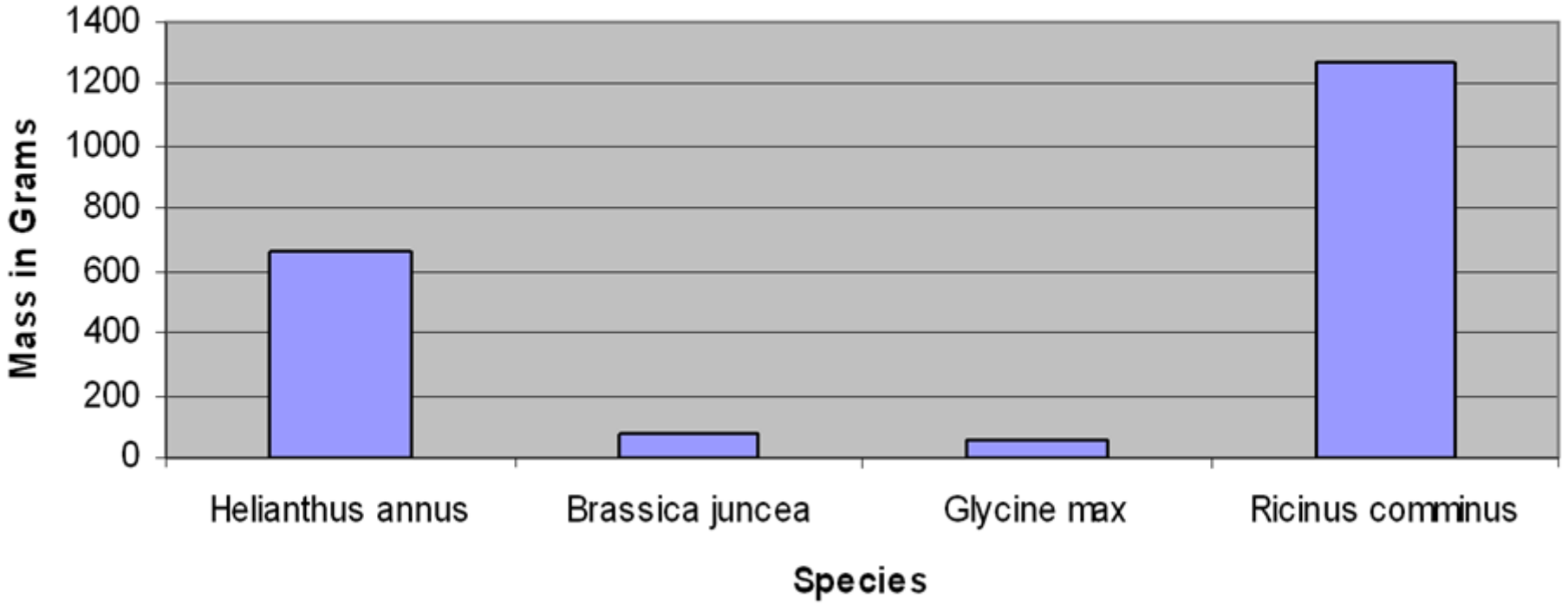
Multi-use Plants for Biofuel

Determining which plant species can be grown to produce both high biomass for energy production as well as oil for biodiesel

Seed mass per plant



Biomass per plant



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Poplar trees for biomass production and cleaning the environment

Poplar is one of the trees of choice for biomass production and phytoremediation of contaminated groundwater

- Impressive production of biomass on many soil types

Endophytes

- What are endophytes?

Previous work with endophytes showed improved phytoremediation

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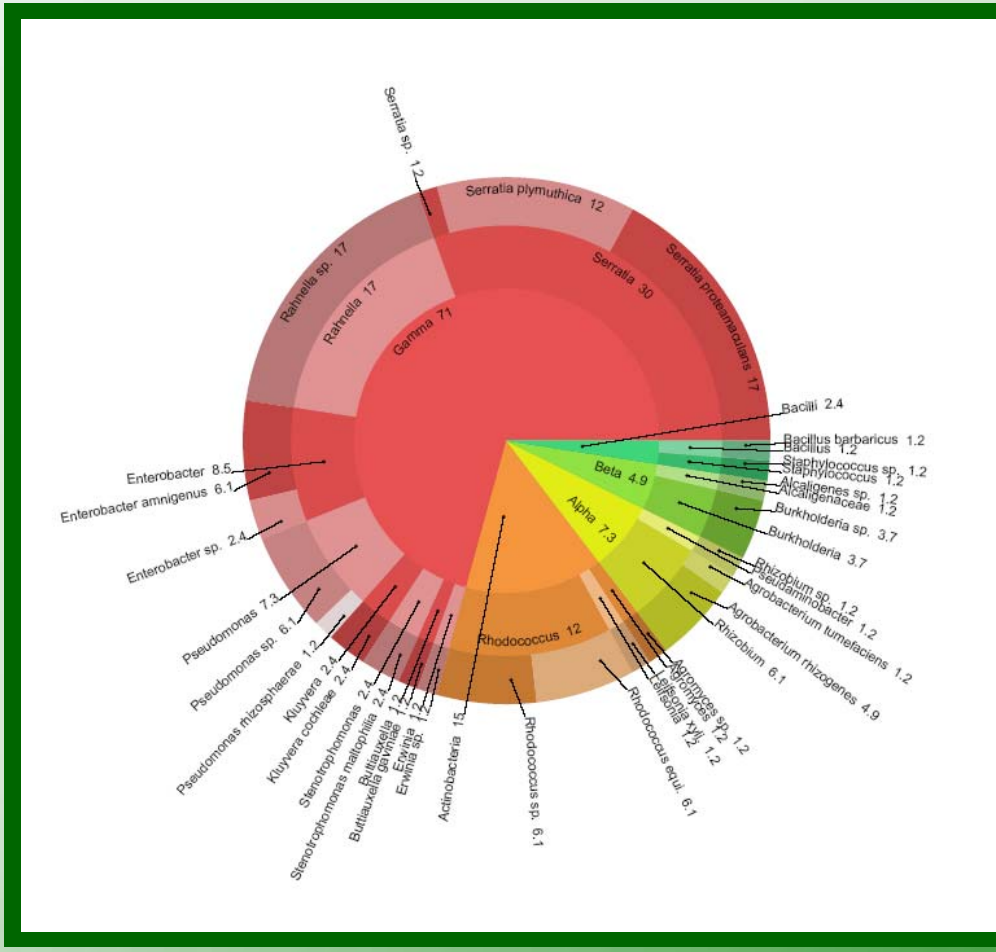
Improved poplar biomass production

- Can bacteria be used to improve biomass production of poplar on marginal soils?
  - Selection of bacterial strains
  - Greenhouse studies
  - Field experiments

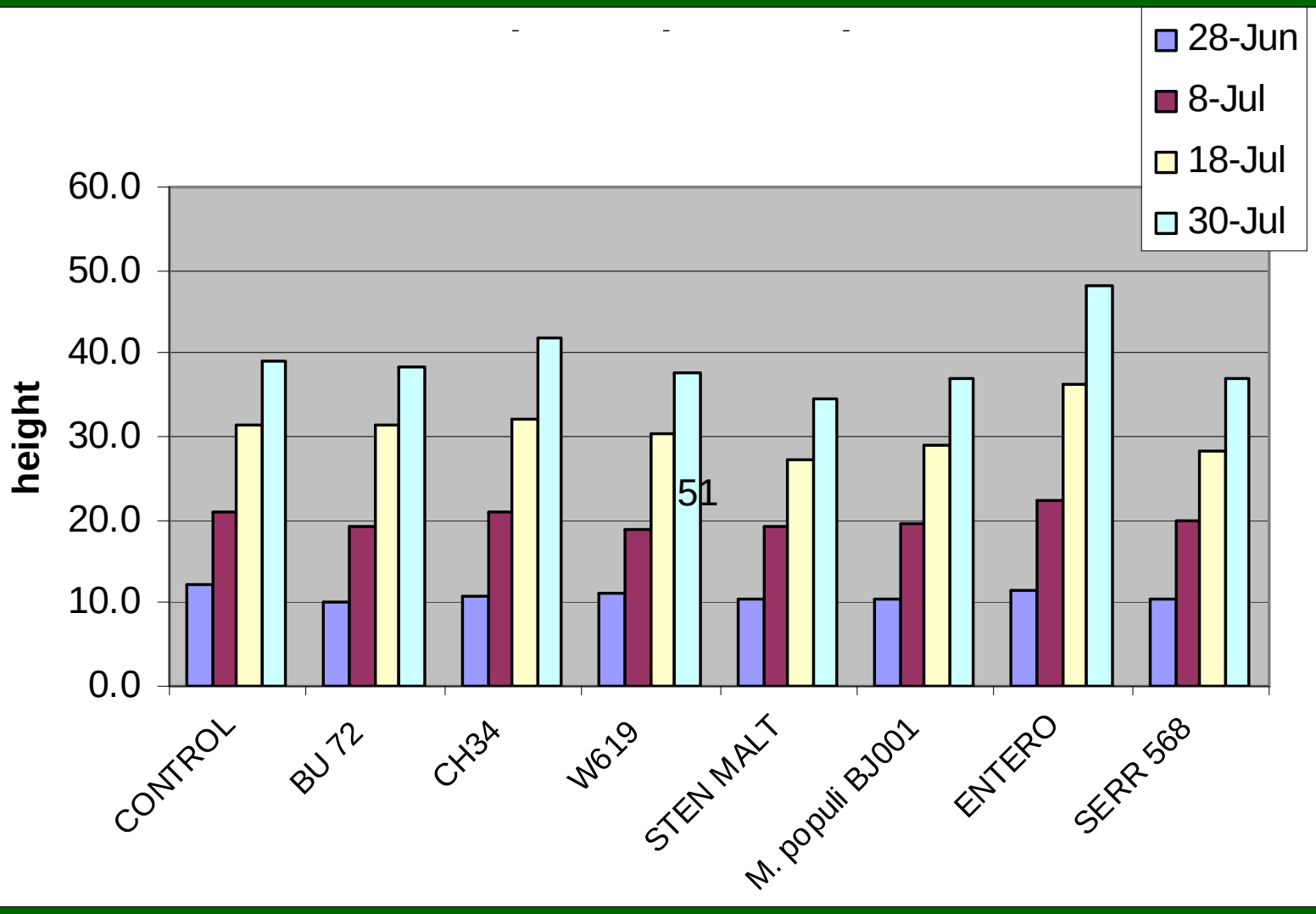


Distribution of cultivable root bacteria isolated from poplar

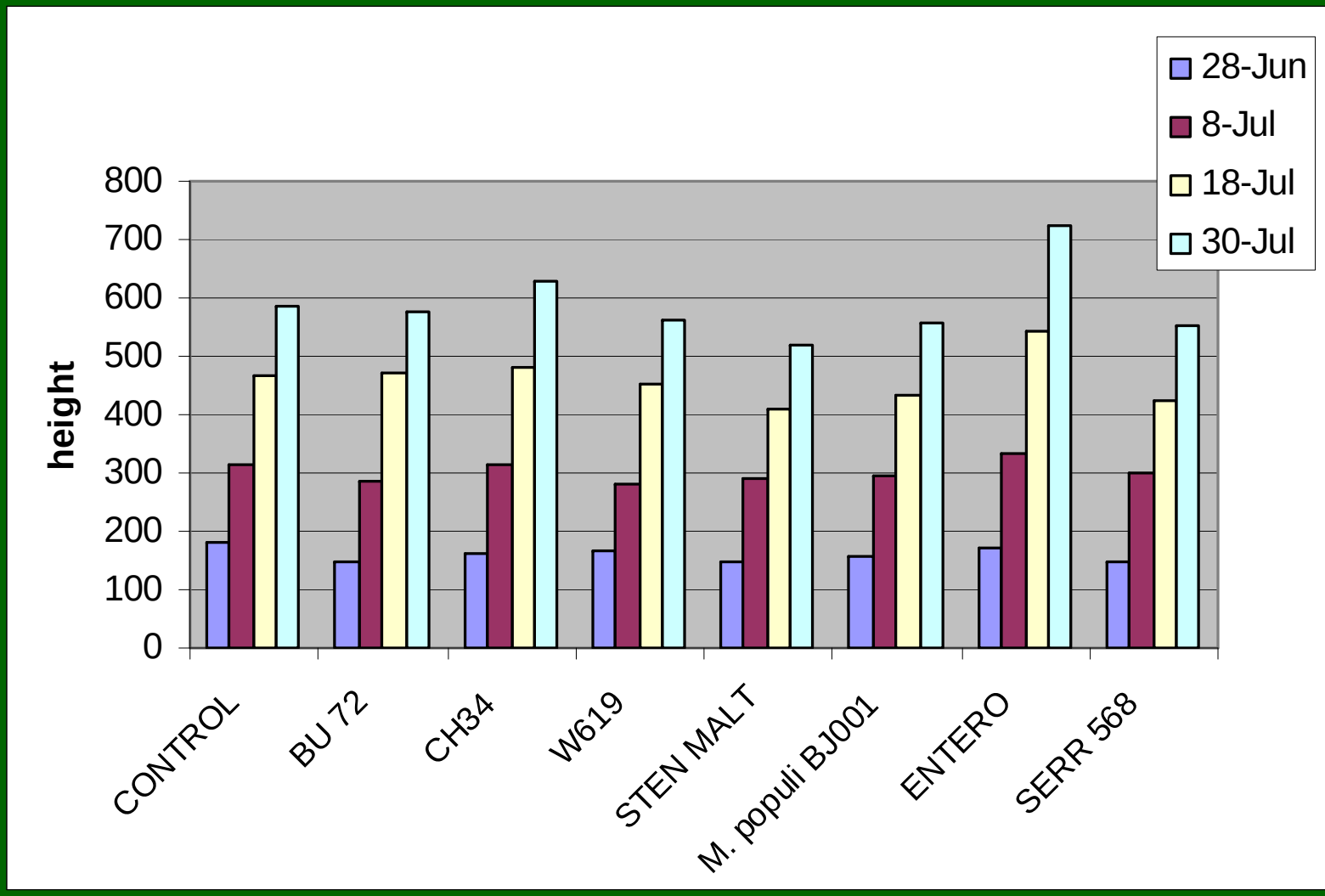
Beneficial effects of bacteria on their host plant

- Short term effects – improved plant establishment on marginal soils
  - Accelerated root development
  - Faster initial growth
- Long term effects – improved plant growth, health and survival, leading to economically sustainable feedstock production
  - Counteracting environmental stress
  - Protection against pathogens

Change in Growth



Total Growth

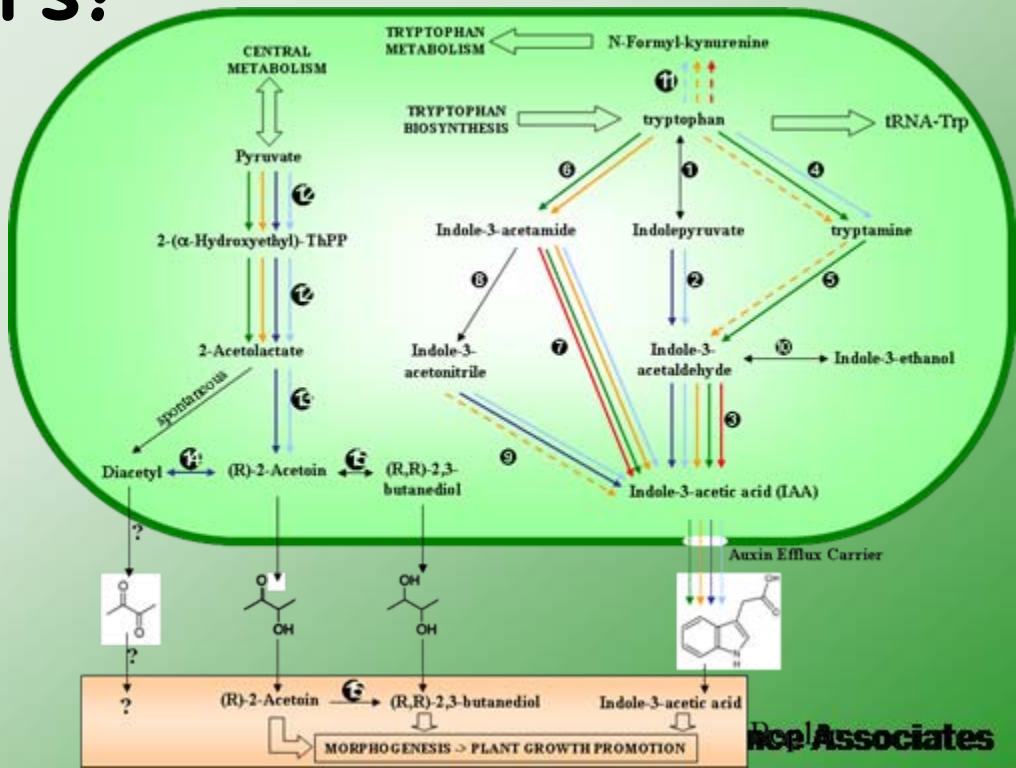


Production of plant growth promoting compounds

- Auxins influence root morphology, inhibit root elongation, increasing lateral root production and inducing adventitious roots
- Auxins include indole-3-acetic acid, phenylacetic acid, indole-3-butyric acid, acetoin

So how do they do that?

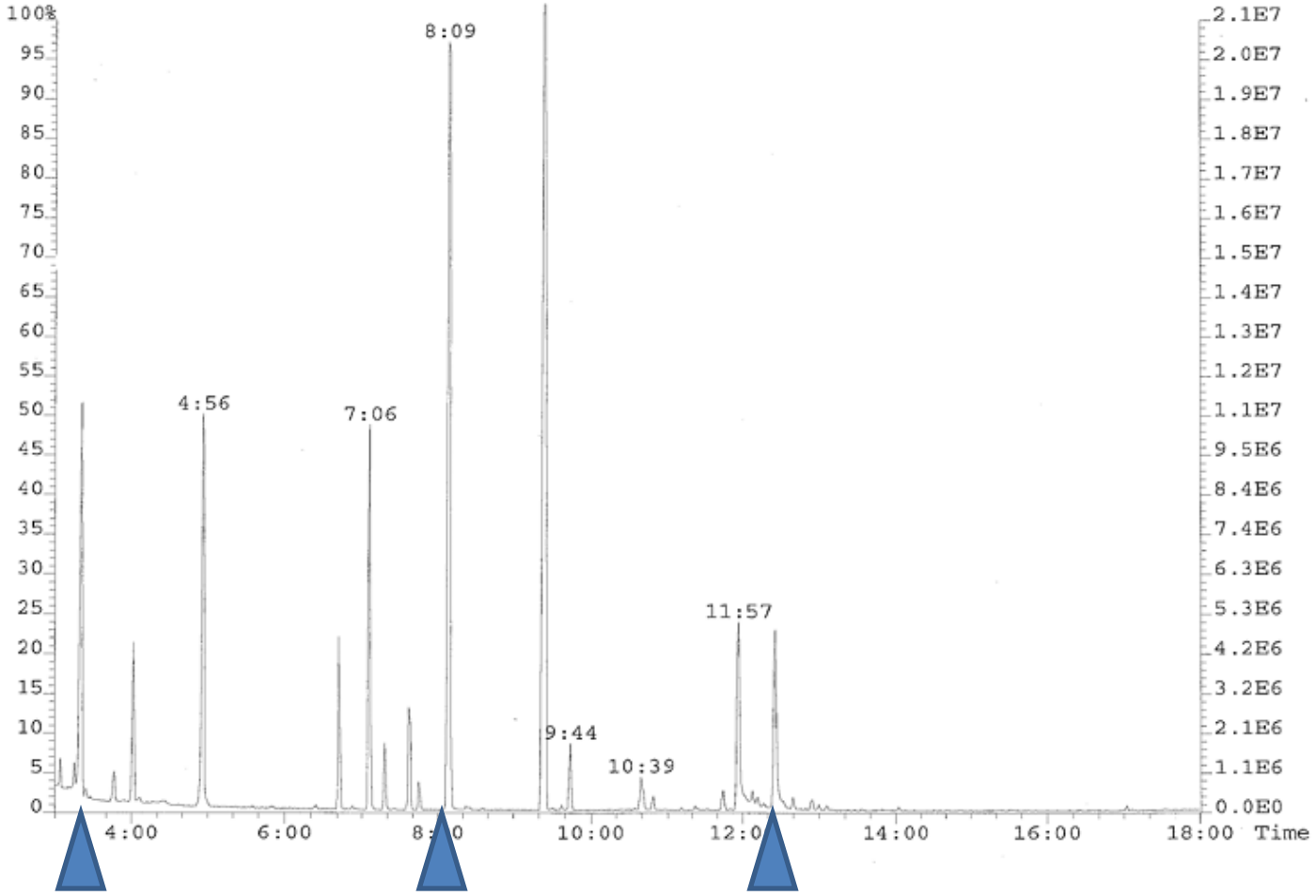
- Prior colorimetric methods showed low levels of IAA production (most common auxin
- But what of others?



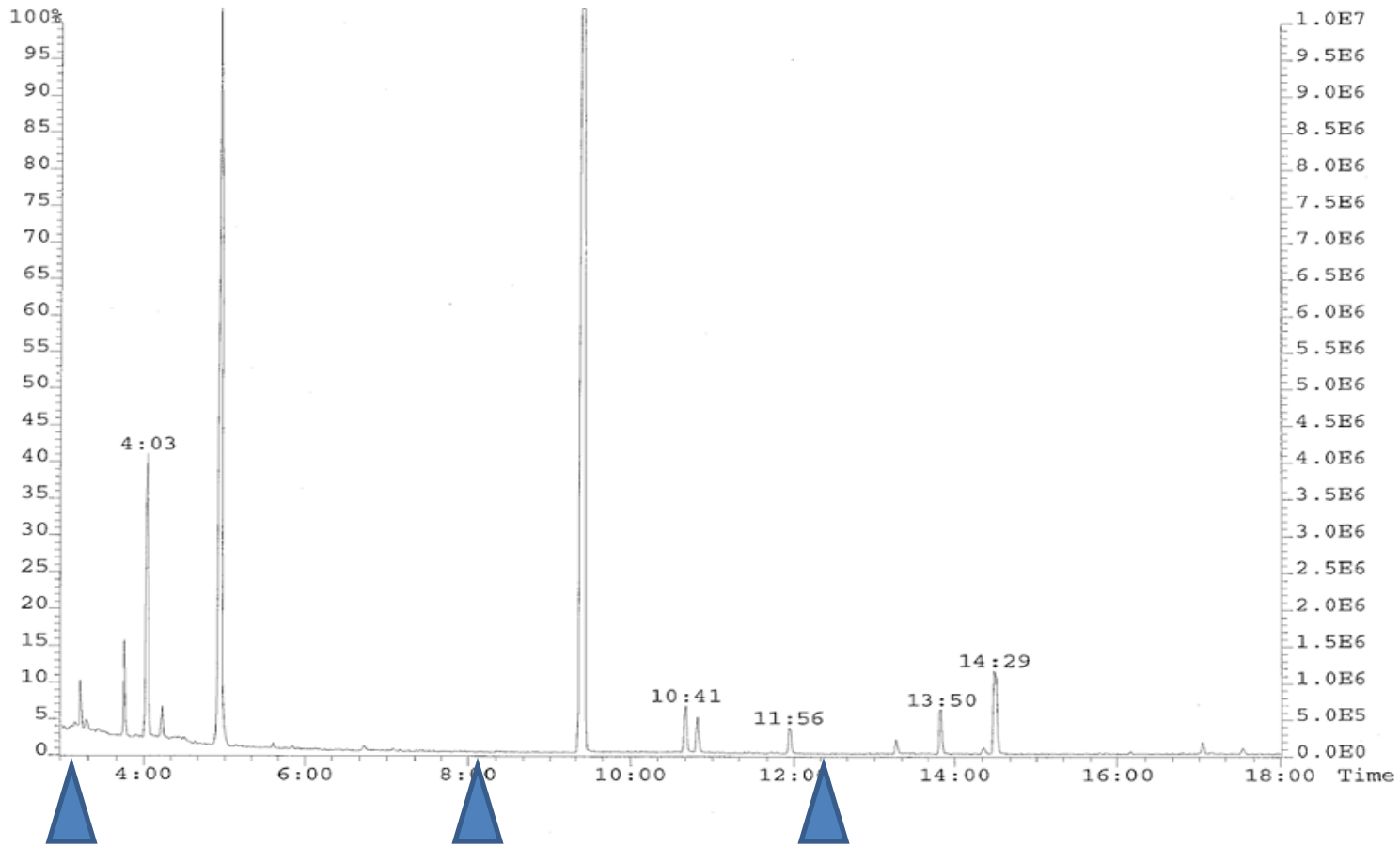
Growing conditions

- Grow bacteria in presence of plant extracts
  - Look for production of other plant-growth related compounds
- Grow bacteria in presence of plant sugars
  - Simpler to quantify reaction

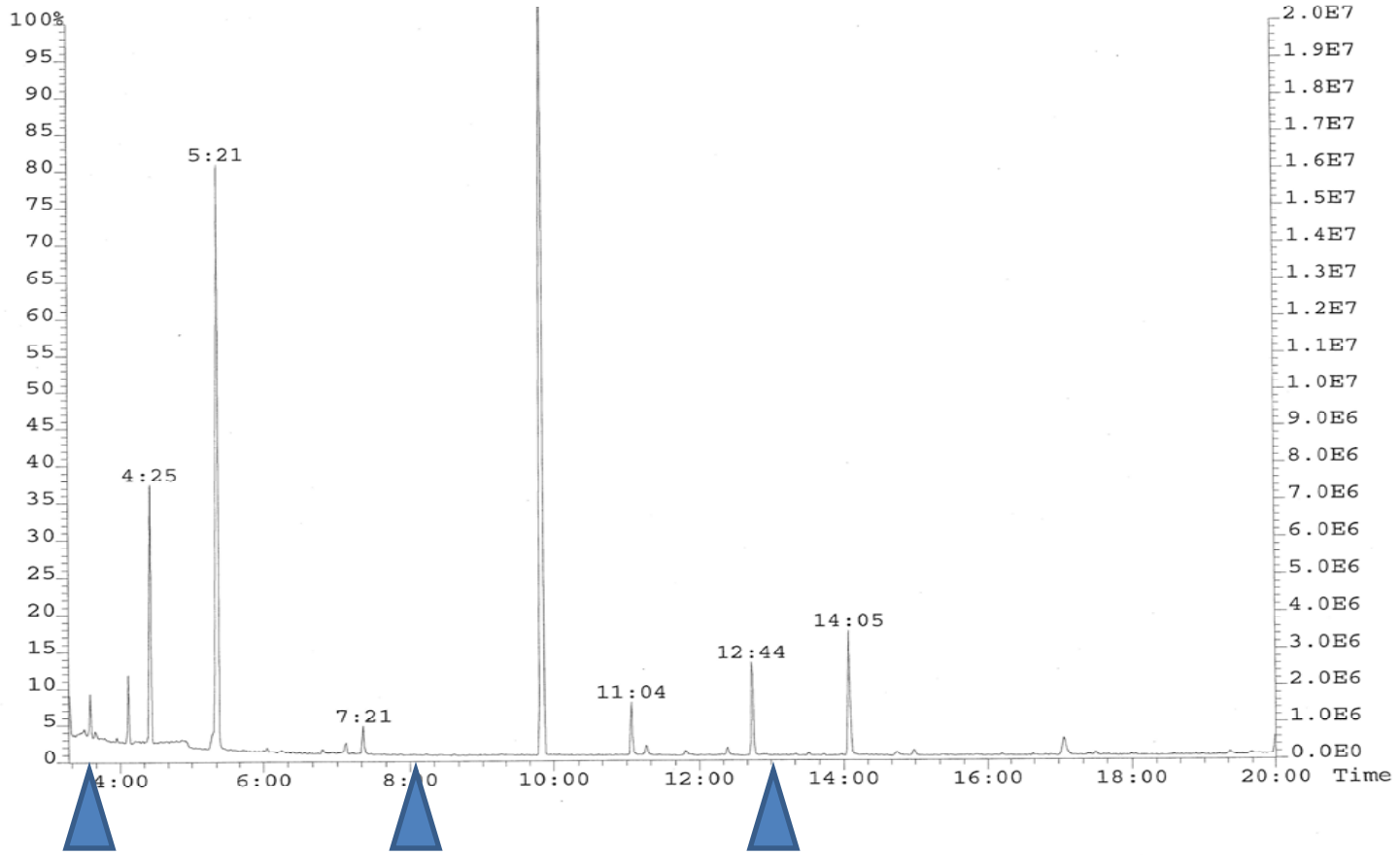
Compounds of interest



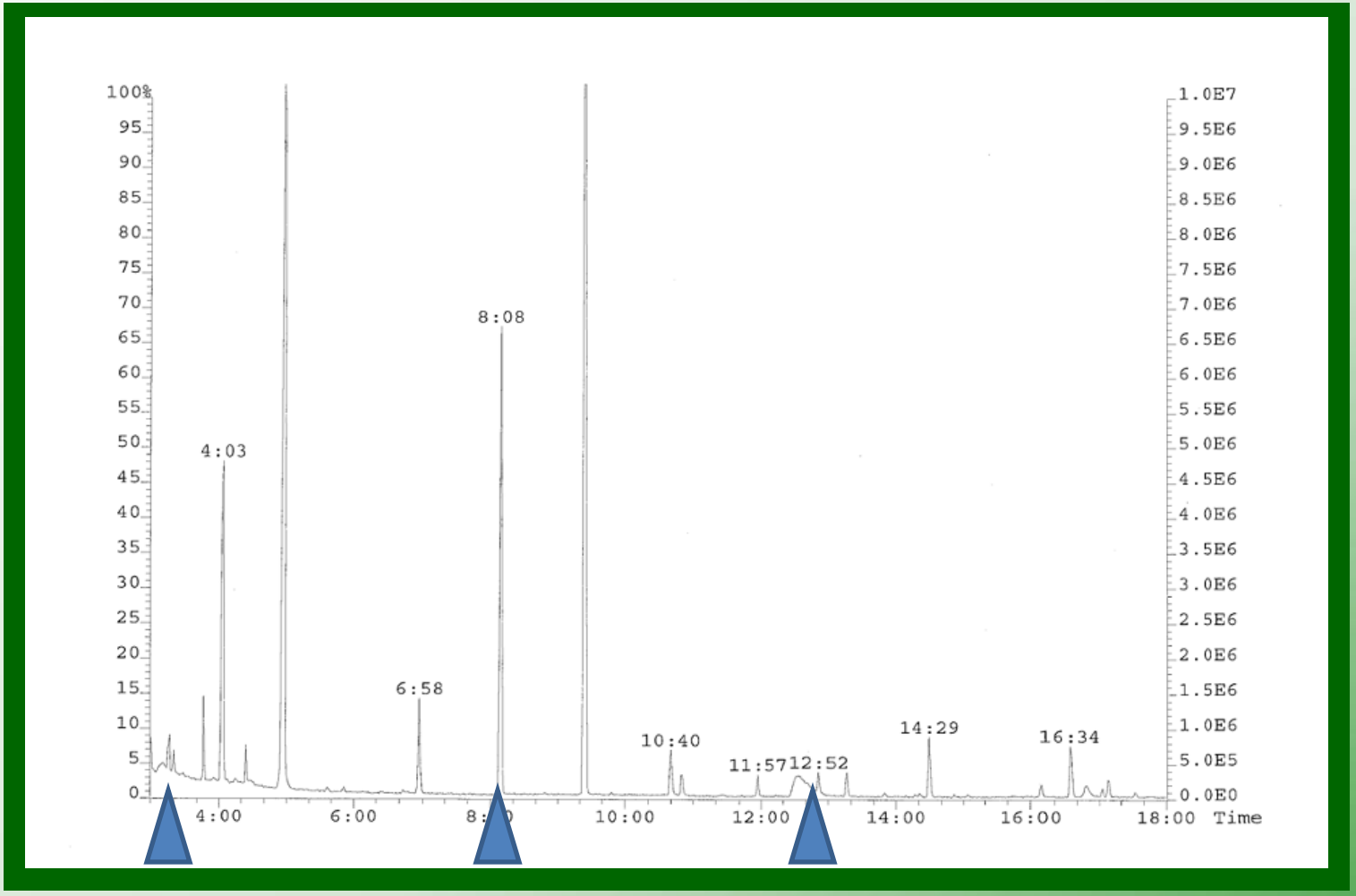
Poplar Extract



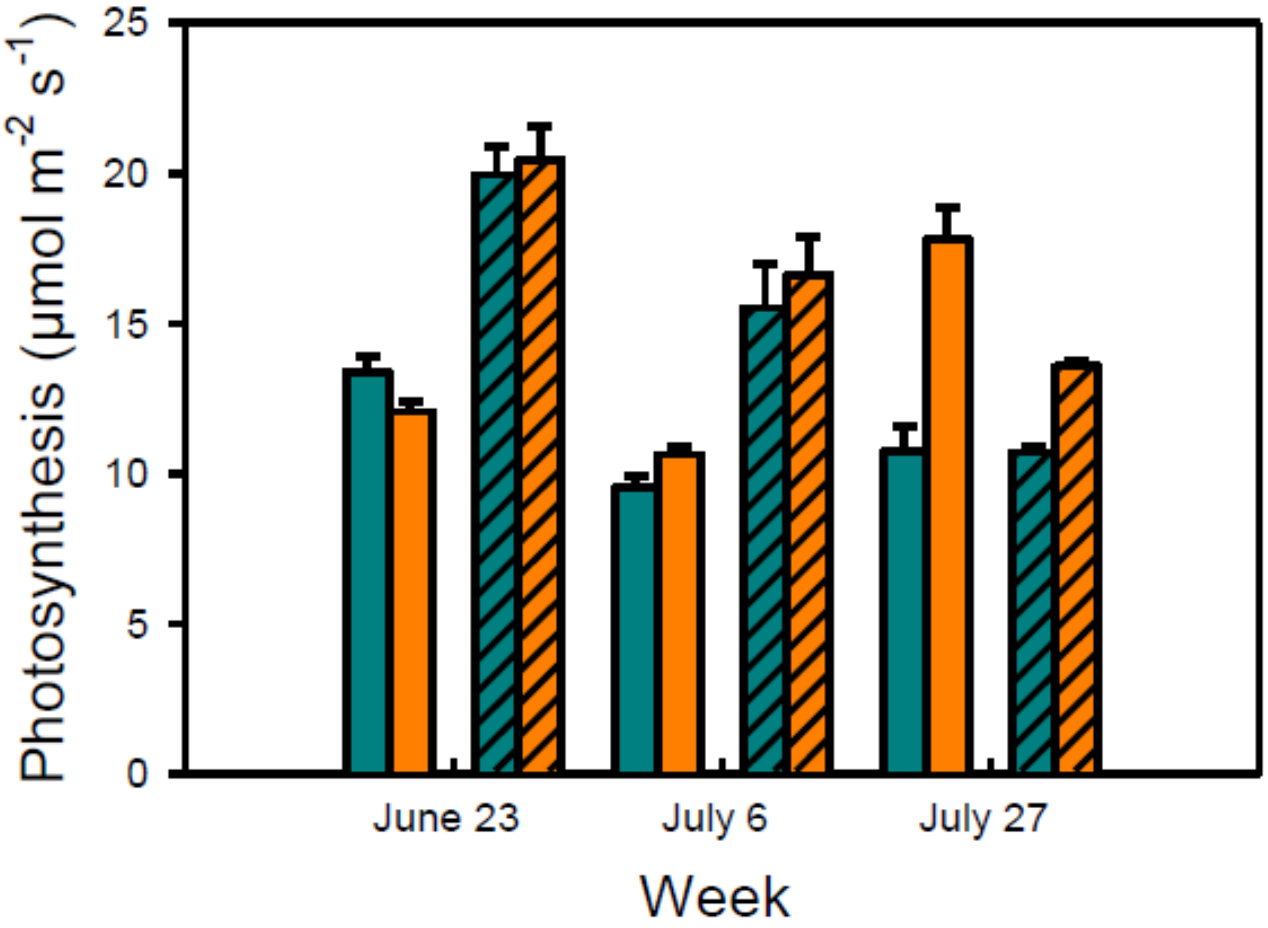
Enterobacter sp. 638 alone



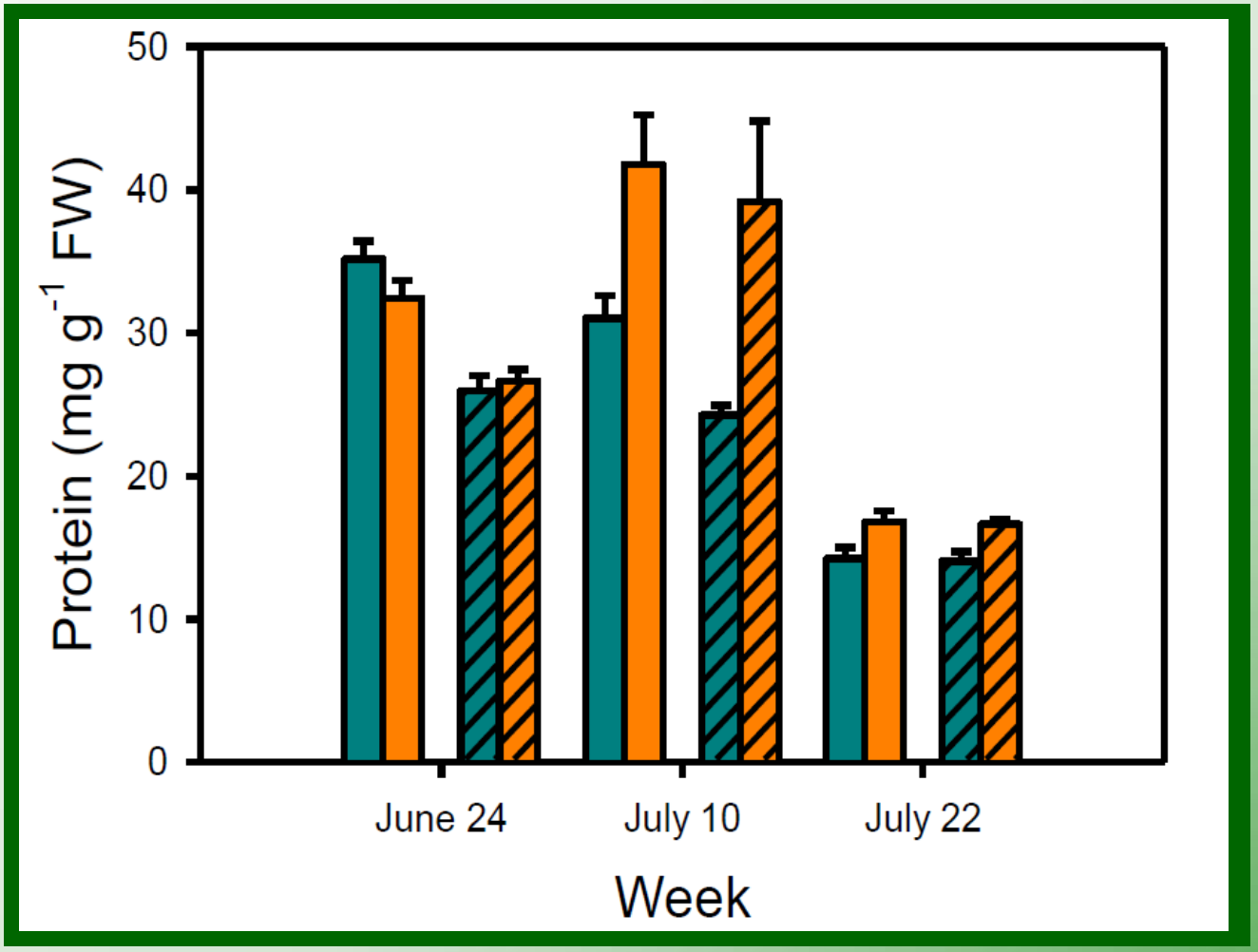
Enterobacter sp. 638 grown with poplar extract



How else do they affect the plant?



Protein levels



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Poplars and more poplars

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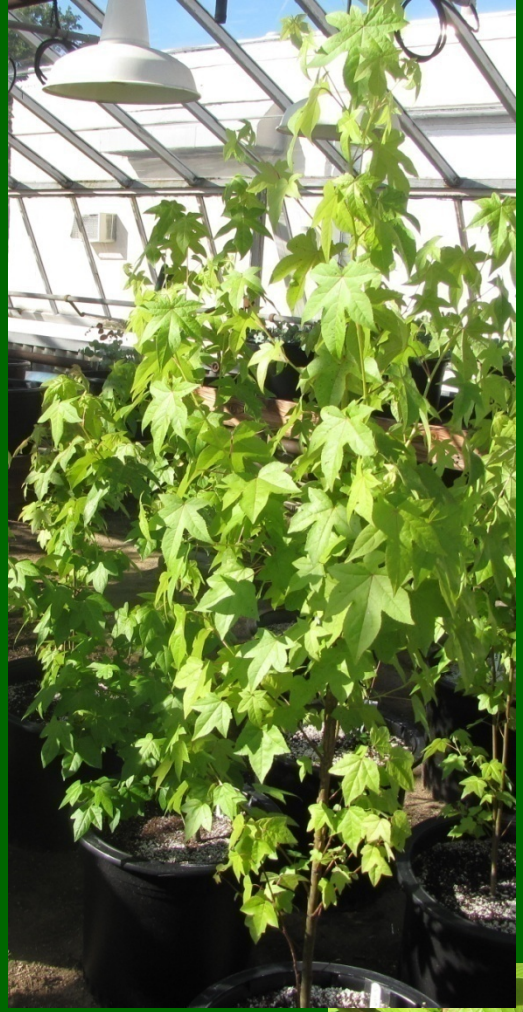
Hardwoods



And still more

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Where do we go from here?

- Genetic analysis of bacteria and plants
- Physiological responses of plants

Other areas

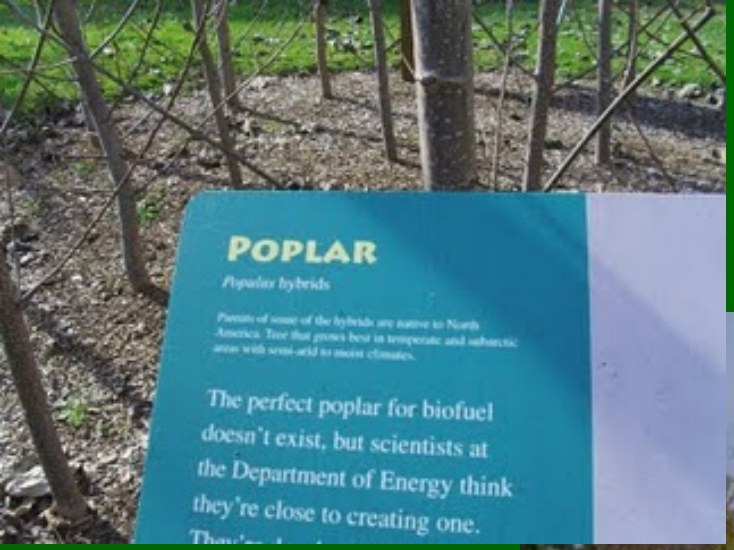
- PET imaging
- NSLS
- Field site
  - On BNL
  - SUNY-Environmental Science and Forestry at Syracuse
- Energy garden

Facilities

- Develop collaborations with local/state schools and Universities to train students
  - Dowling College
  - Stony Brook Southampton
  - Syracuse University
  - SUNY-Environmental Science and Forestry at Syracuse
  - City University of New York
  - Sachem Central School District at Holbrook

Field Site

- Grow a variety of plants on site with different growing conditions
  - Soil amendments
  - Endophytes
- Determine which plants/conditions are of optimal productivity here on Long Island
- Develop strategy for full-scale production of biofuel at BNL


POPLAR
Populus hybrids
The perfect poplar for biofuel doesn't exist, but scientists at the Department of Energy think they're close to creating one.


CASTOR BEAN
Ask your grandmother about castor oil, and she'll tell you that it used to be a common


POWER PLANTS
FARMING ENERGY


SUGARCANE


POWER PLANTS
Meadow Road
Eagle Nest Road
Info
Plants in the Garden
1. Castor bean
2. Barley
3. Mustard
4. Jatropha
5. Sugarcane
6. Corn
7. Sunflower
8. African oil palm
9. Soybean
10. Switchgrass
11. Poplar
12. Sorghum
13. Algae
14. Alfalfa
15. Sugar beet
16. Cuphea
17. Miscanthus
18. Camelina
19. Lesquerella
20. Peanut
21. Canola
Learn about the process:
Biodiesel Process
Grain Ethanol Process
Cellulosic Ethanol Process
Sugar Ethanol Process

Remember to Thank a Plant today!