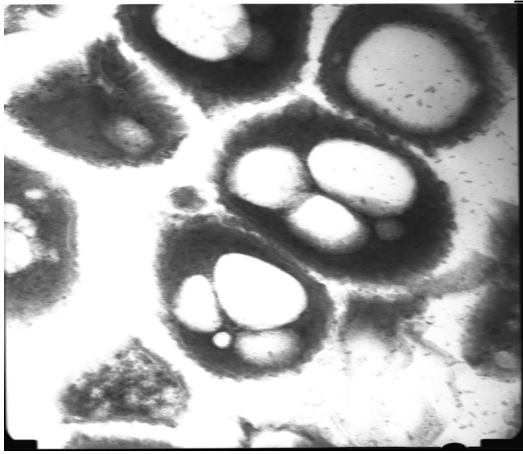

Wastewater Treatment Facilities: Biorefinery for Biofuels

T. French, R. Hernandez, A. Mondala, J. Hall, G. Zhang, M. White, E. Alley, B. Holmes

Dave C. Swalm School of Chemical Engineering

Mississippi State University

Objectives

- **Transform the daily disposal of industrial and domestic sewage into large quantities of lipids using microorganisms**

- **Integrate the lipid, sugar, and thermochemical platforms for producing JP-Fuels, gasoline, biodiesel and chemicals**

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Evaluation of BioDiesel Production Costs

Soybean Oil

Note: Feedstock represent ~90% of total processing costs →

$4.38/gal feedstock cost
$0.35/gal processing cost
$0.10/gal transportation cost

= $4.83/gal total cost

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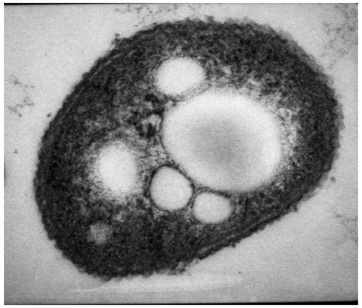
Sustainability and Logistical Barriers to Biofuels

- The US Consumes approximately 300,000,000,000 gal/yr
  - 165,000,000,000 gal/yr gasoline
  - 75,000,000,000 gal/yr diesel
- Ethanol would account for 2%
- Soy Bean oil accounts for 0.33%
- When populations need that for food fuel will lose
- Not Sustainable.
- Single-cell oil produced in a wastewater treatment facility will not have a food market
- Wastewater treatment will always occur and scales with population.



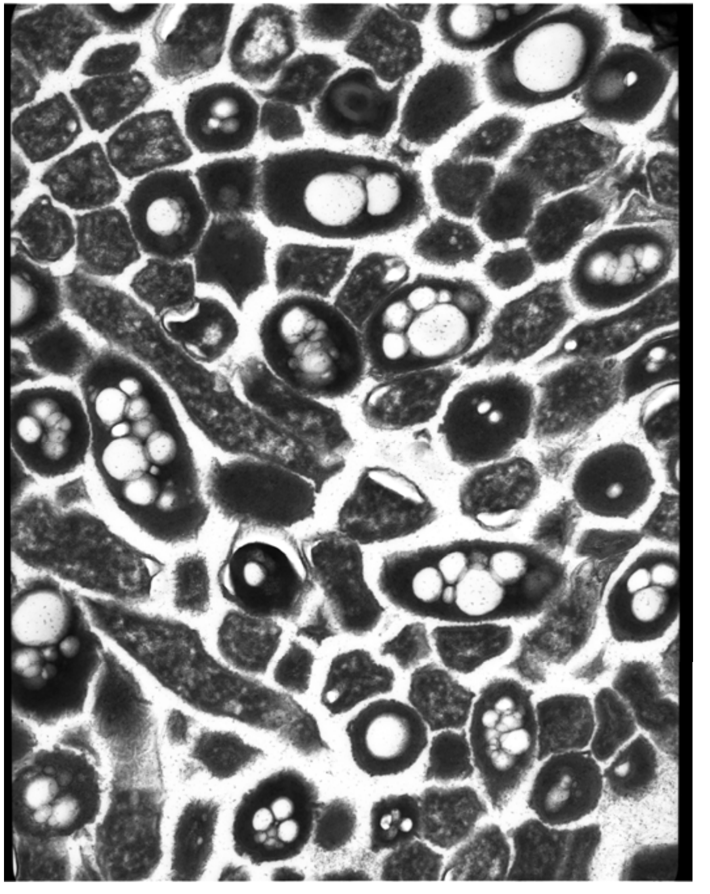
The Oleaginous Microorganisms

Candida bobicola, Yarrowia lipolytica, Lipomyces lipofer, Lipomyces starkeyi, Trichosporon pullulans, Rhodotorula graminis, Mortierella alpina, Cryptococcus terricolus, Rhodococcus fascians, Rhodococcus erythropolis, Nocardia corallina, Nocardia asteroids, Nocardia globerula, Norardia restricta, Dietzia maris, Acinetobacter lwoffi, Acinetobacter sp. strain HO1-N, Acinetobacter sp. strain 211, Psuedomonas aeruginosa strain 44T1, Gordonia amarae, Rhodococcus opacus, etc

1. Granger, L-M; et al. Biotech. & Bioengineering, 1993, 42, 1151-1156
2. Zheng, S; et al. Bioresource Tech., 2005, 96, 1522-1524
3. Xue, F; et al. Process Biochem., 2006, 41, 1699-1702

COMPARISON OF OIL PRODUCTION FROM FEEDSTOCKS

Sample	% Oil	Time (D)
Soybean	19	105
Canola	33	255
Camelina	36	255
Turnip	36	255
Flax	39	240
Tallow	46	365
Castor	55	195
H. matrinalis	23	2.5
R. glutinis	16-60	2.5
R. opacus	60-80	2.0

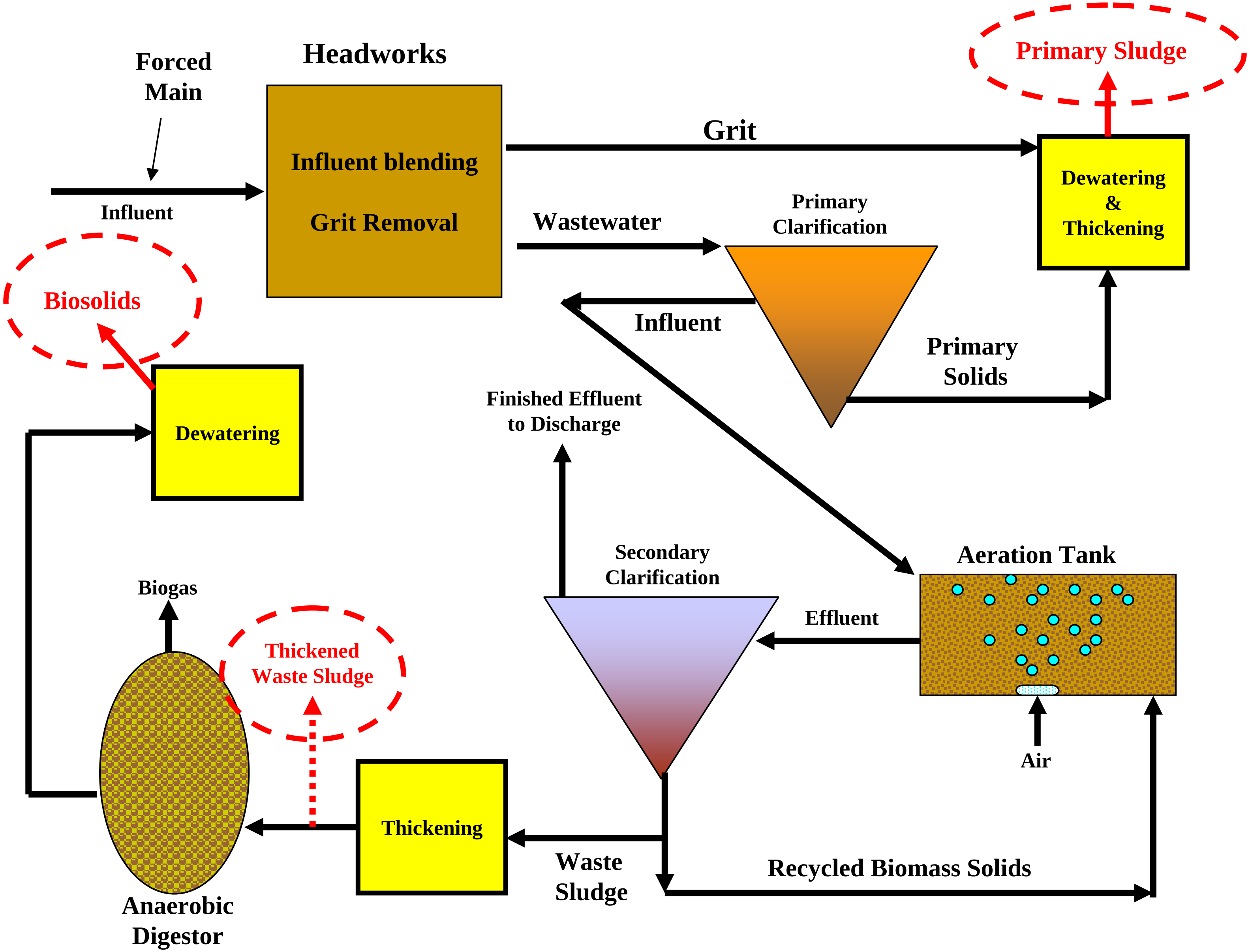


WASTEWATER AS CARBON SOURCE

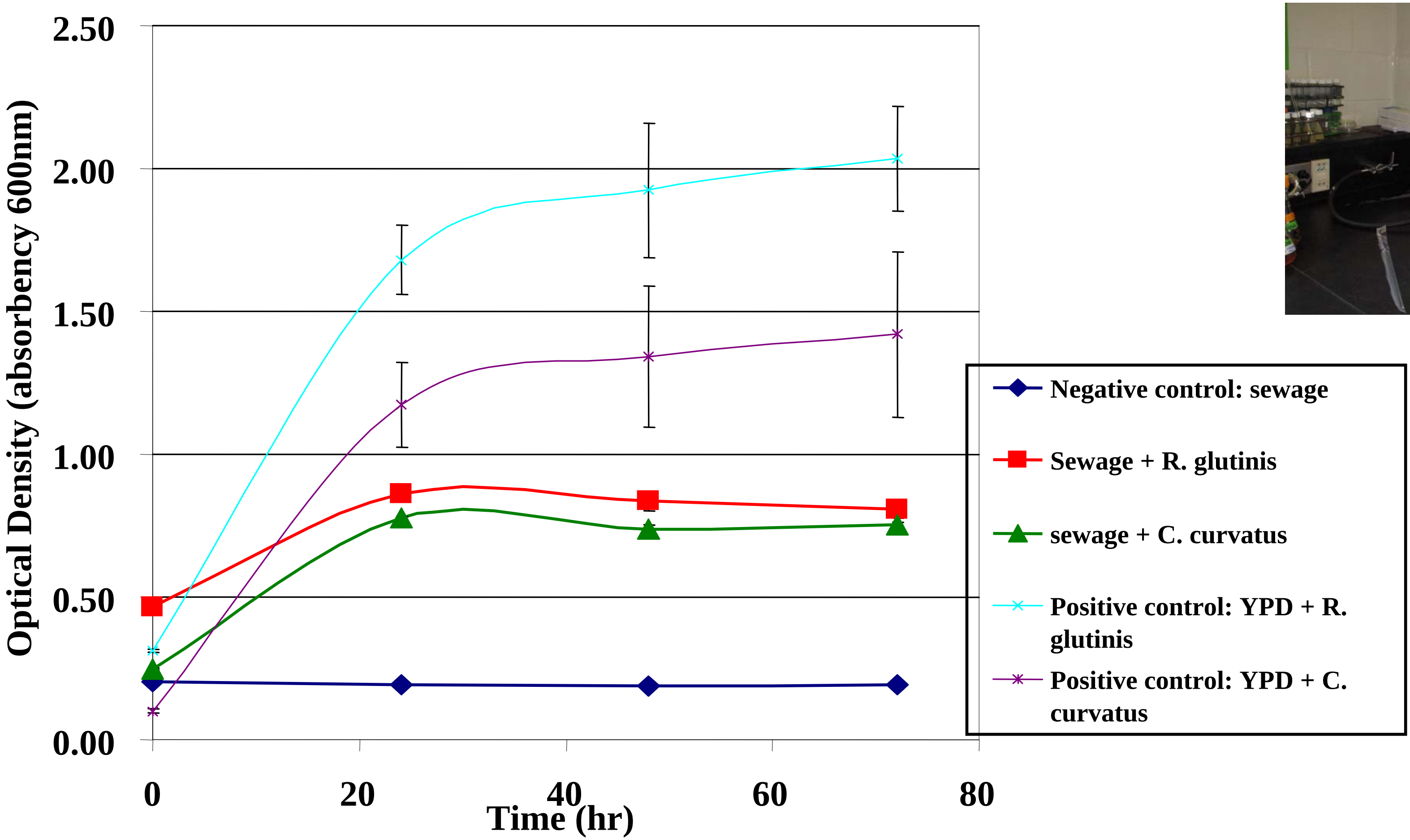
- **Wastewater contains:**
  - Carbon
  - Nitrogen
  - Phosphorous
  - Water
  - Micronutrients

- **Approximately 30 million gallons* of wastewater are produced daily in Tuscaloosa**
  - Residential waste
  - Industrial waste

35 Billion Gallons of Municipal Wastewater Generated Daily


Forced Main
Headworks
Influent blending
Grit Removal
Influent
Grit
Primary Sludge
Dewatering & Thickening
Wastewater
Primary Clarification
Biosolids
Influent
Primary Solids
Dewatering
Finished Effluent to Discharge
Secondary Clarification
Aeration Tank
Biogas
Effluent
Thickened Waste Sludge
Air
Thickening
Waste Sludge
Recycled Biomass Solids
Anaerobic Digestor

Growth of *R. glutinis* and *C. curvatus* on Sewage from YPD



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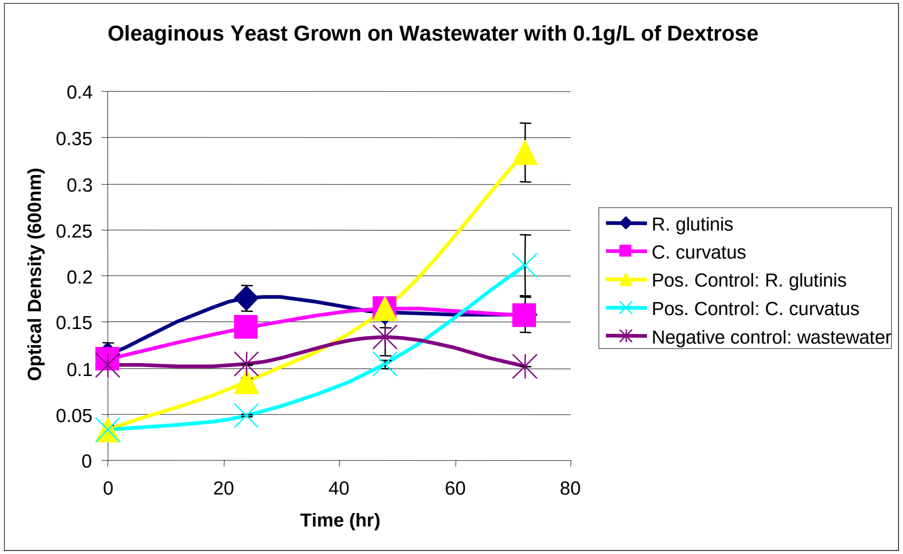
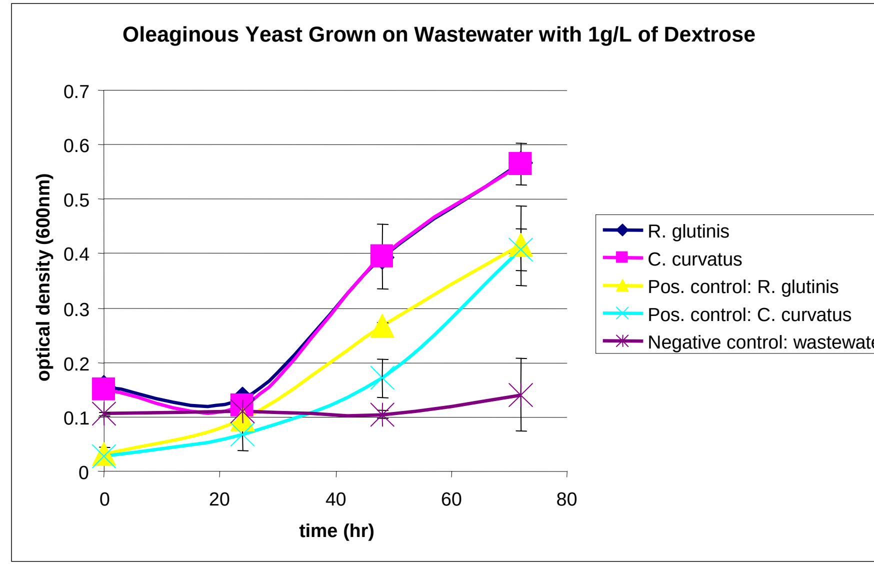
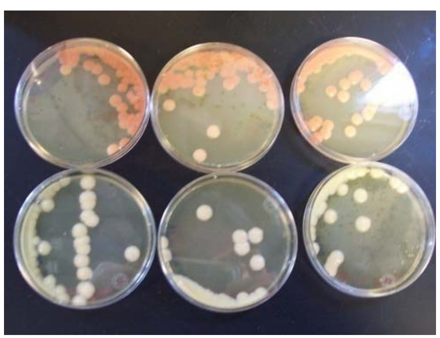
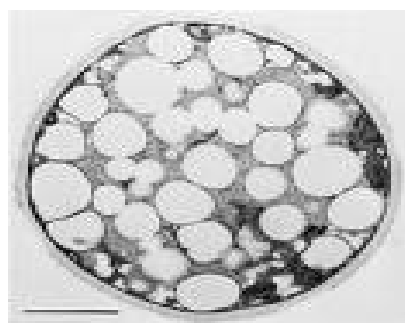
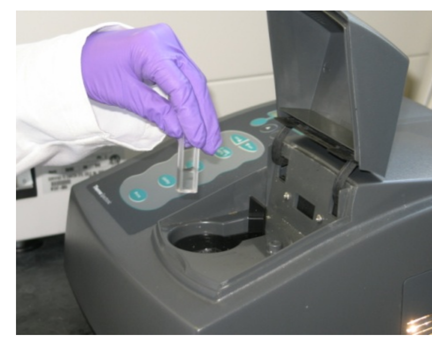
COMPARISON OF GROWTH CURVES











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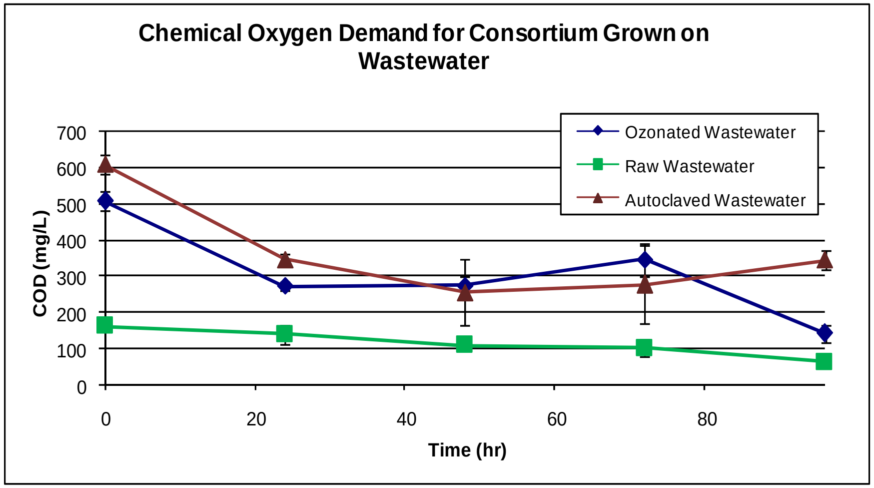
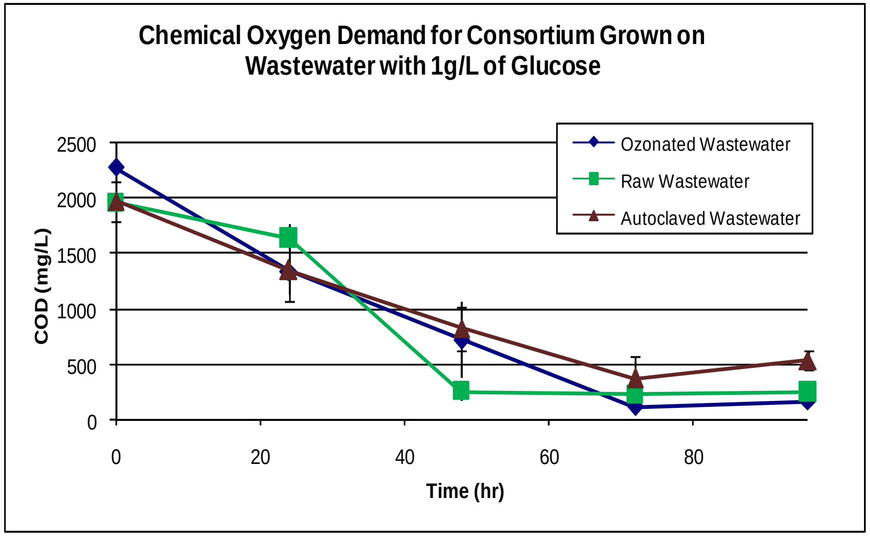
CHEMICAL OXYGEN DEMAND



Sugar	Sample	% Reduction
0	CO	72.26
	RW	61.25
	CA	43.49

10% Oil Content



Sugar	Sample	% Reduction
1g/L	CO	92.70
	RW	87.27
	CA	72.83

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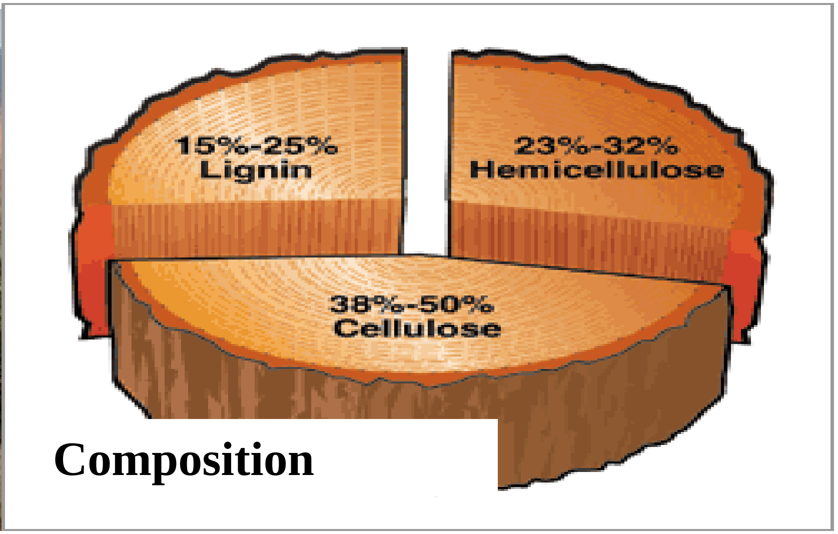
Carbon Sources Supporting Growth of Oleaginous Microorganisms

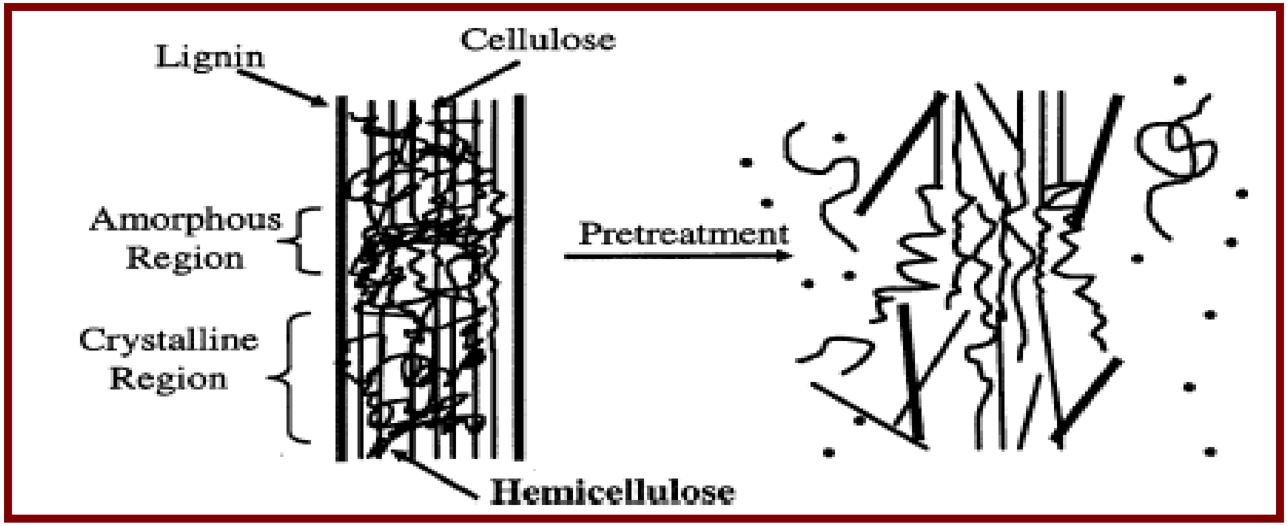
- **Sugars**
  - Glucose
  - Xylose
  - Ribose
  - N-acetyl glucosamine
- **Glycerol**
- **Flour**



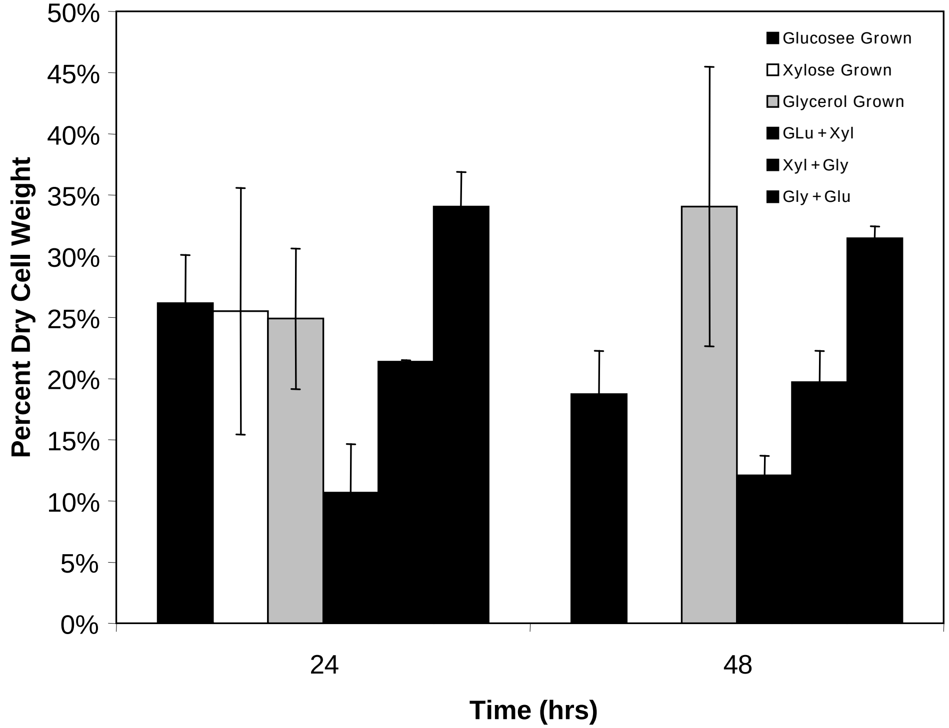


Lignocellulosic Biomass





Conversion of Lignocellulosic Biomass to Microbial Oil



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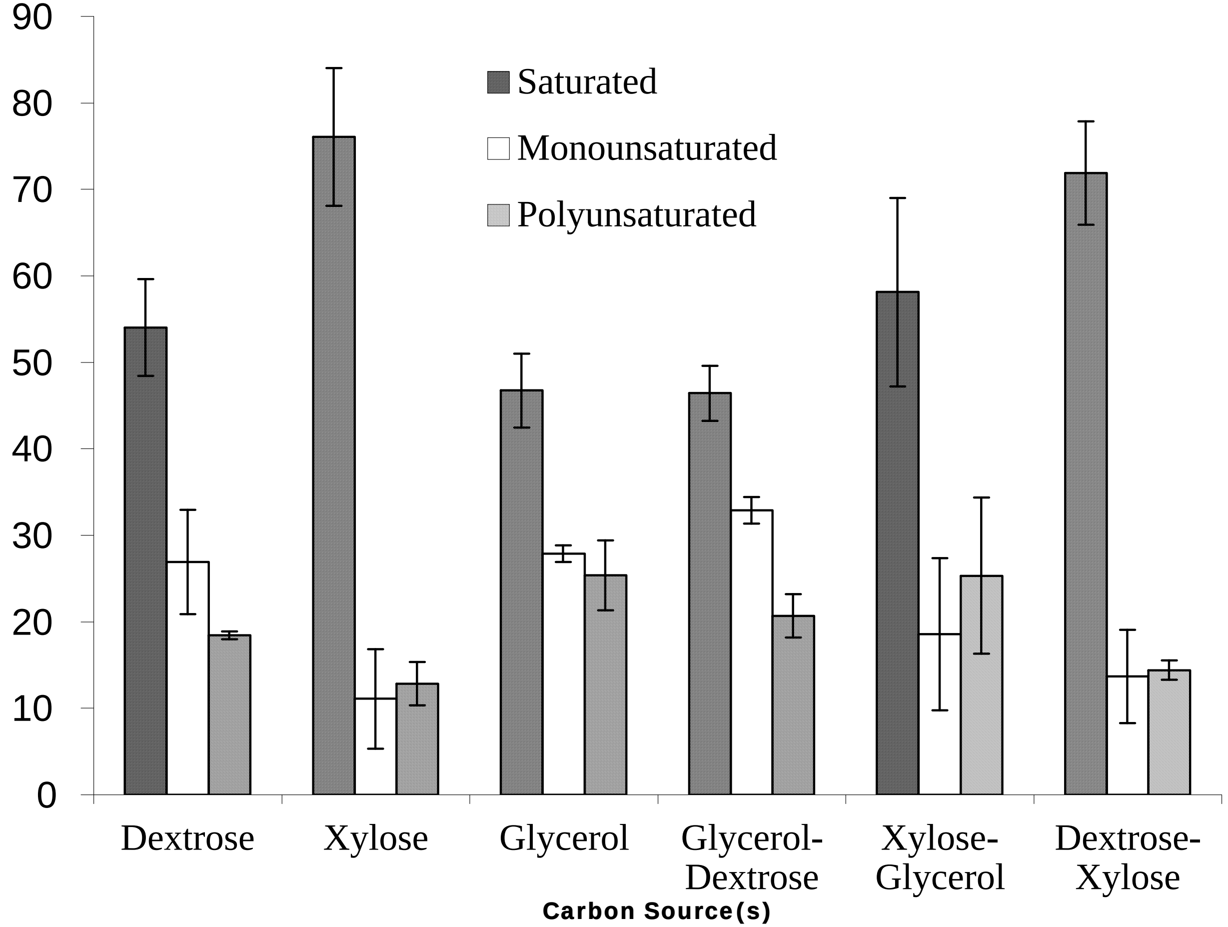
The Effect of Carbon Source on the Saturation of Fatty Acids Produced by *R. glutinis* 48 h



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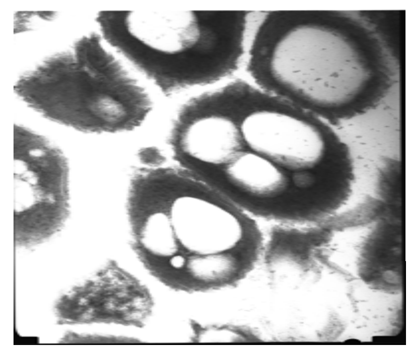
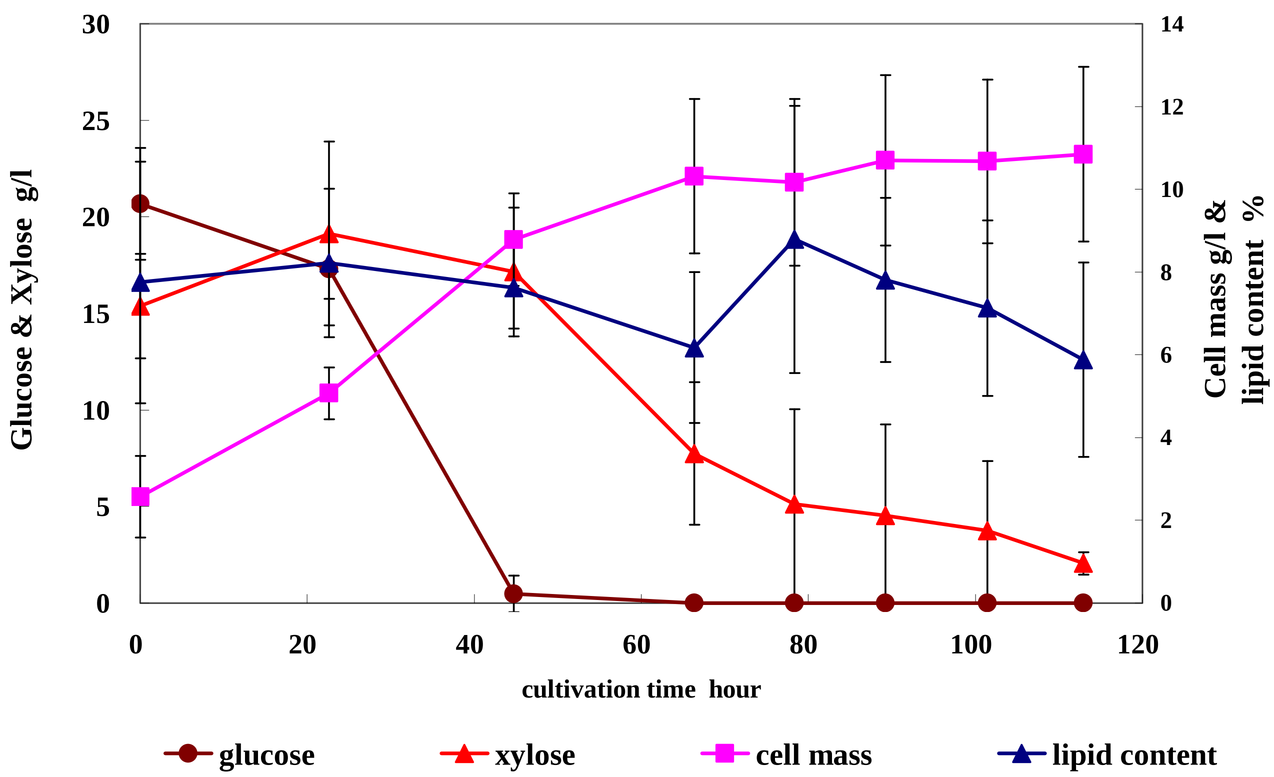
Conversion of Lignocellulosic Biomass to Microbial Oil

Sugar	Cell mass concentration in culture mg/ml	Total Lipid production. % dry wt.
Xylose	4.14	30
Dextrose	3.99	35
Artificial acid hydrolysate	4.12	22
Switch Grass Hydrolysates	2.63	26



Conversion of 30 g/L Acid Hydrolysate by Oleaginous Microbes



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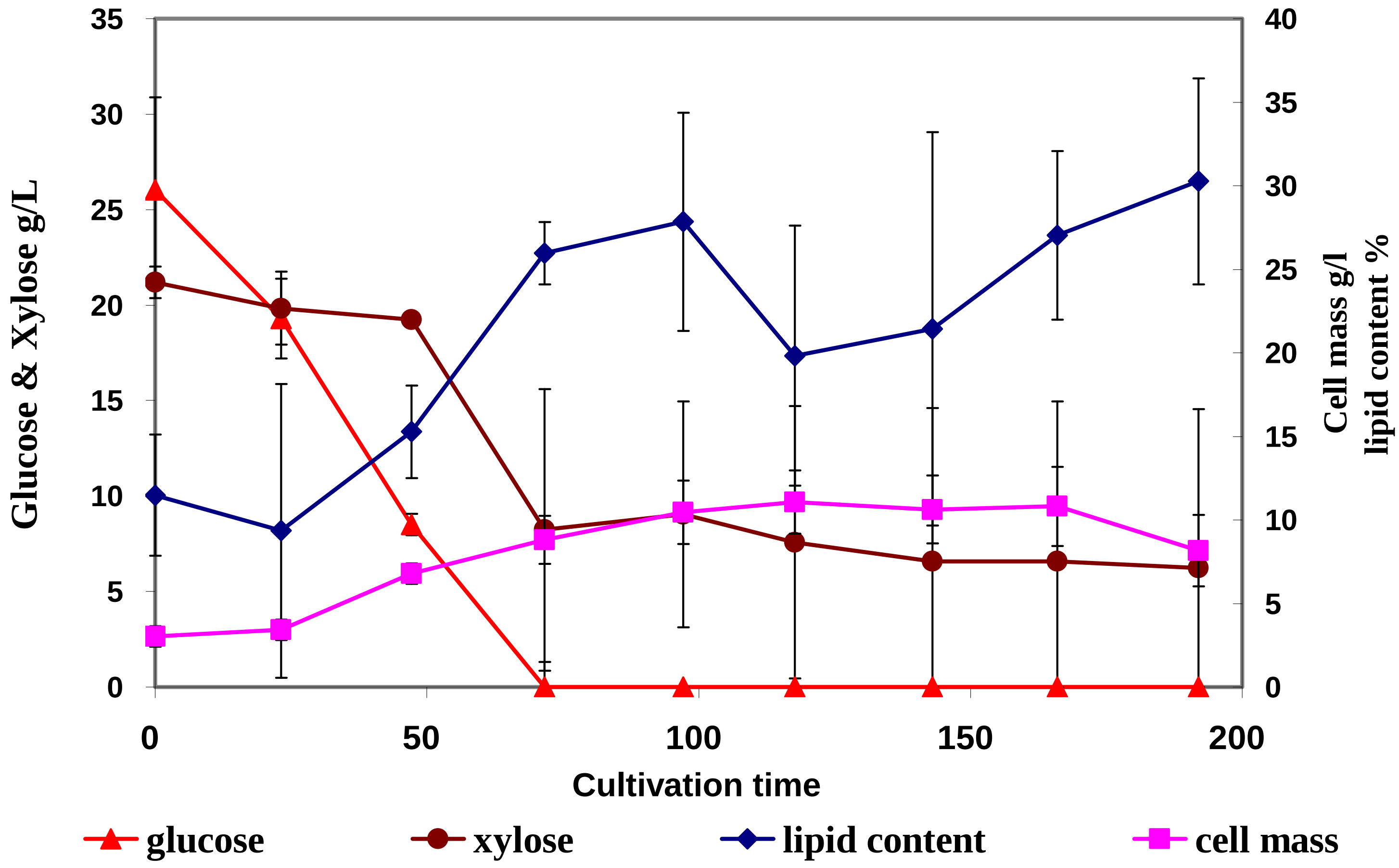
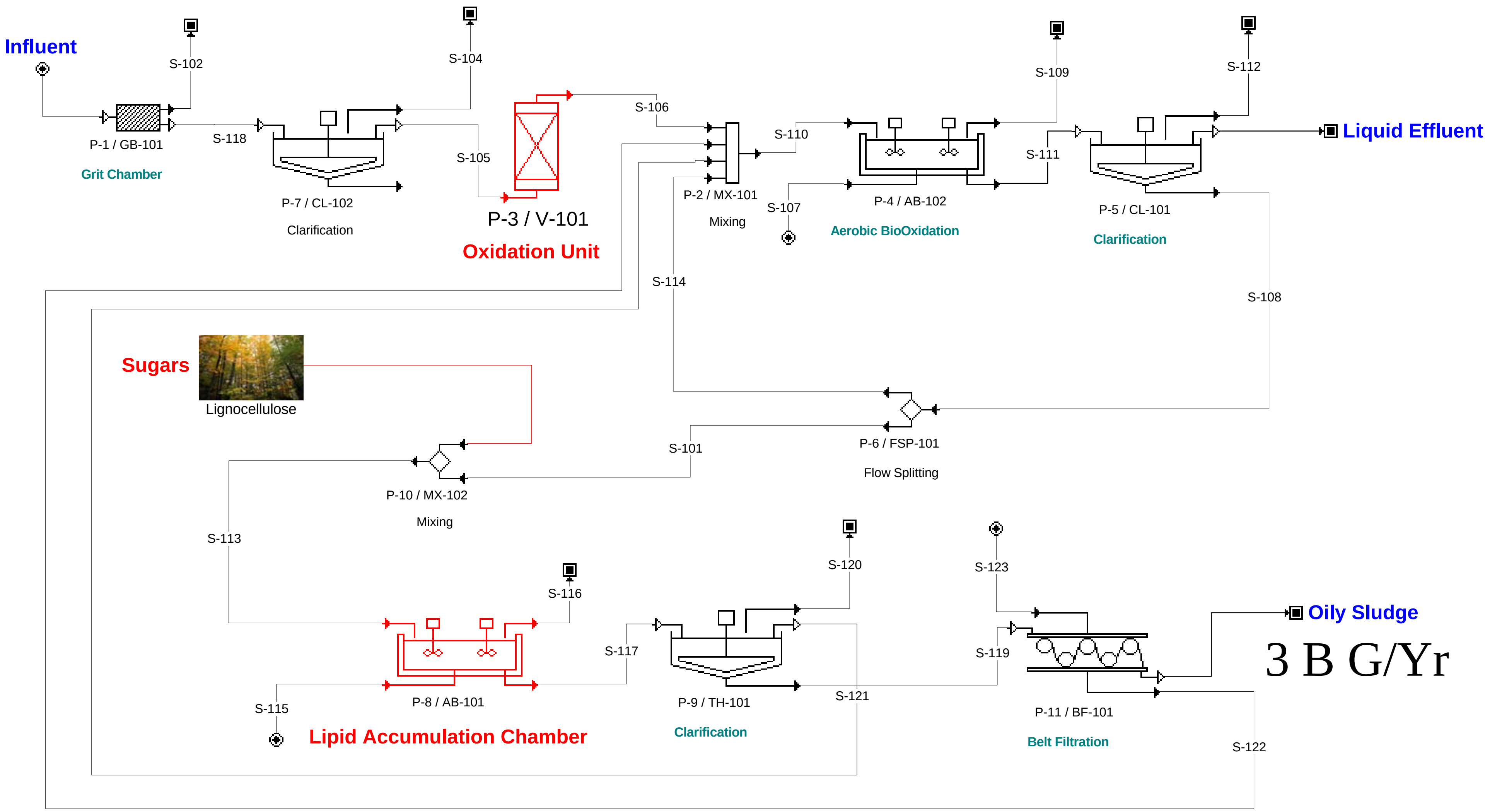
Conversion of 45 g/L Acid Hydrolysate by Oleaginous Microbes



Fatty Acid Composition

Fatty Acid	Yeast	Rape	Canola	Tallow	Soy
Caproic (6:0)	0.0	0.0	0.0	0.0	0.0
Myristic (14:0)	0.0	0.0	0.0	3.0	0.0
Palmitic (16:0)	14.0	2.2	4.0	23.3	9.9
Stearic (18:0)	7.0	0.9	2.4	17.9	3.6
Oleic (18:1)	32.0	12.6	65.0	38.0	19.1
Linoleic (18:2)	20.0	12.1	17.3	0.0	55.6
Linolenic (18:3)	3.0	8.0	7.8	0.0	10.2
Eicosatrienoic (20:3)	8.0	7.4	1.3	0.0	0.2
Behenic (22:0)	0.0	0.7	0.4	0.0	0.3
Erucic (22:1)	0.0	49.9	0.1	0.0	0.0

Envisioned Process: The New Biorefineries



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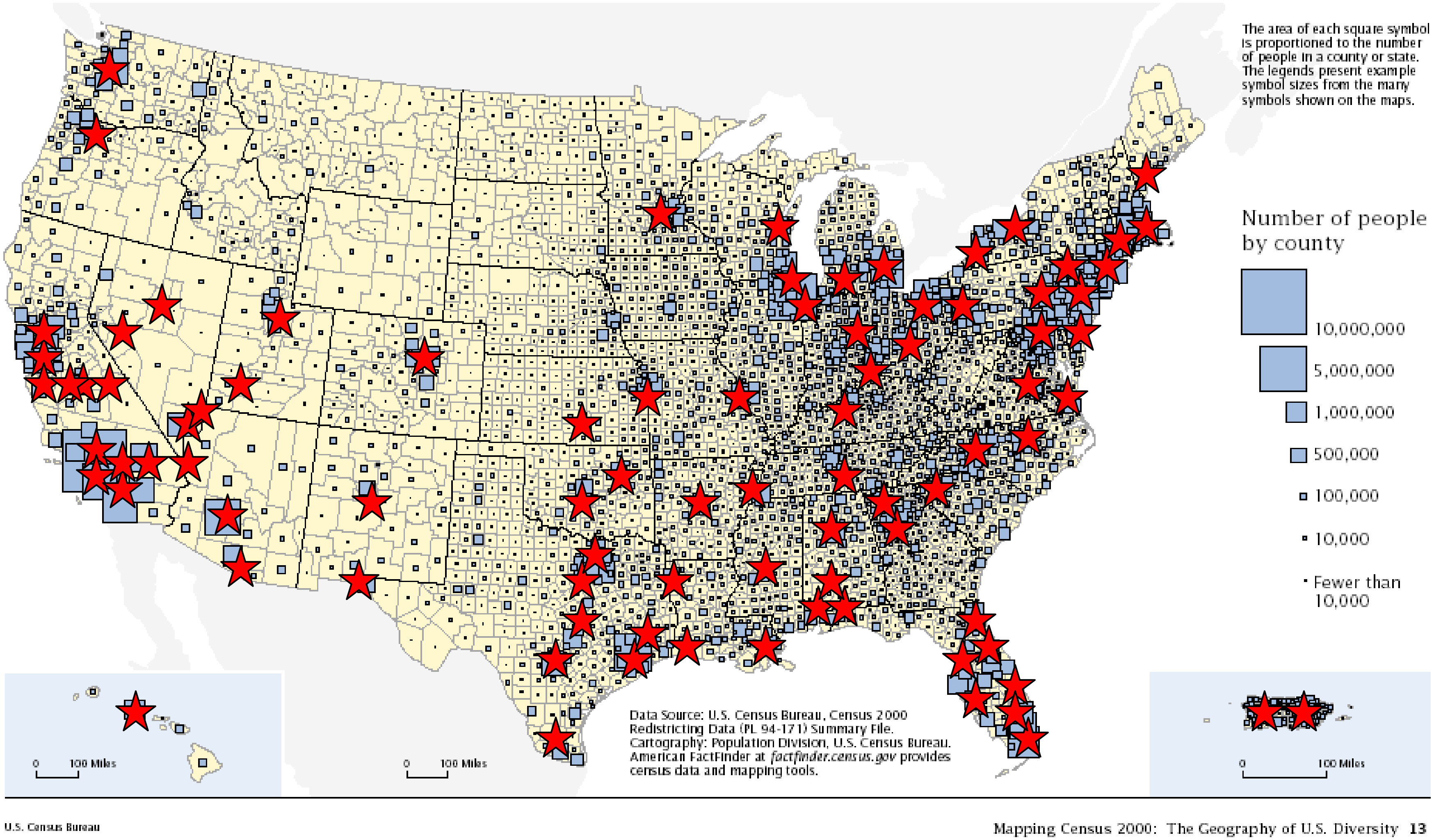
Biorefinery Locations



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- Department of Energy
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Thank You