



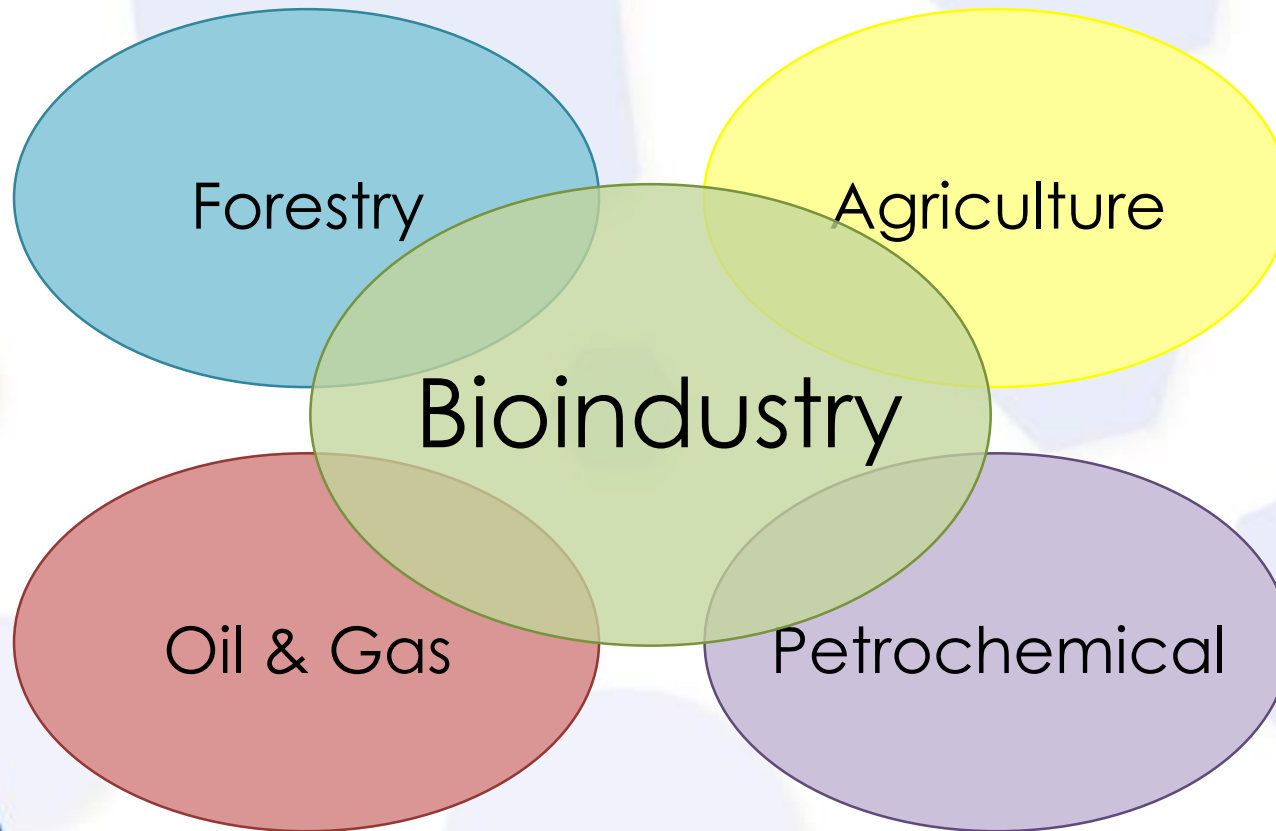
# **Commercializing New Biofuel Technologies in Canada: Opportunities for Collaboration with the Oil Industry**

**David C. Bressler**

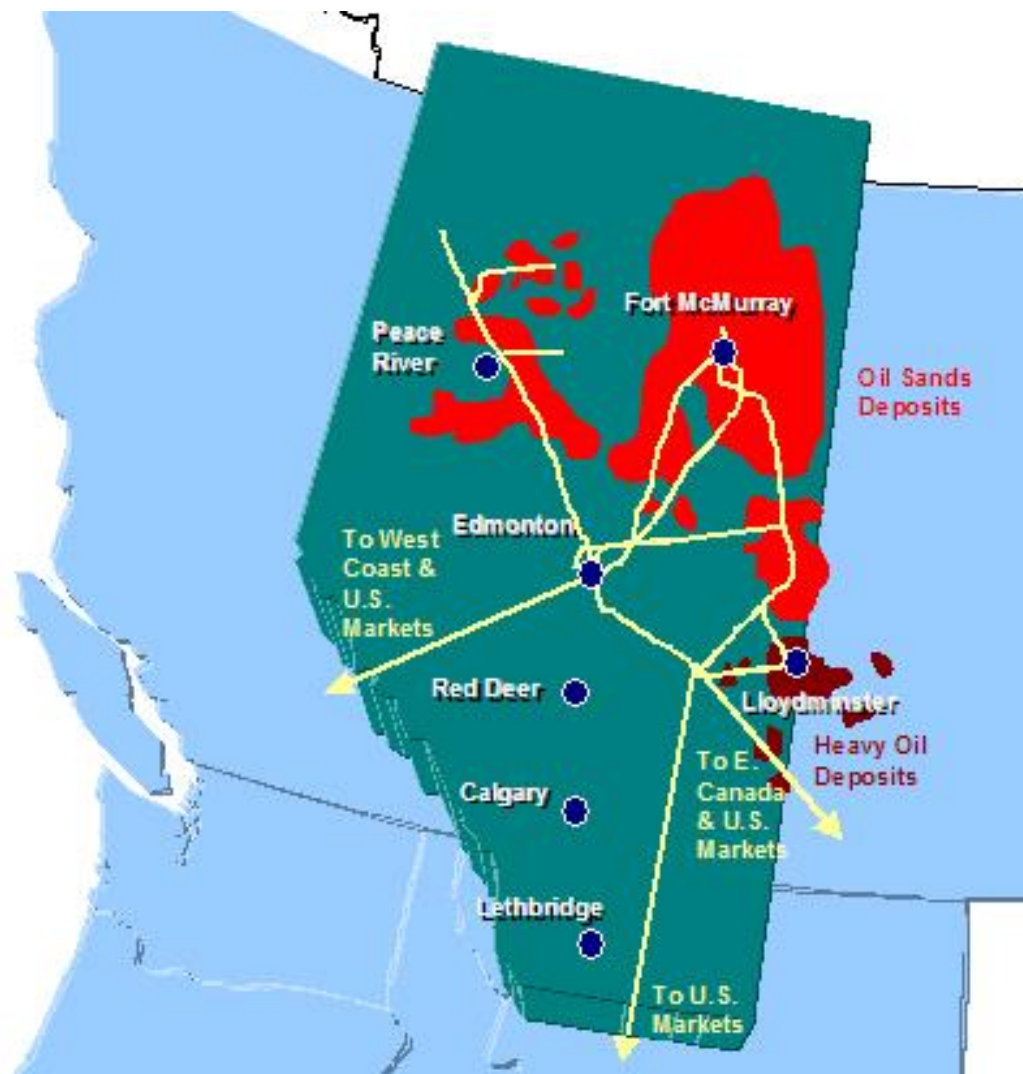
**Department of Agricultural, Food & Nutritional Science  
Biorefining Conversions Network**

**BIOCLEANTECH**  
FORUM

# Canada's BioIndustry



**Integrating the traditionally separate sectors to create a unified bioeconomy**



Alberta's oil sands deposits total >2.4 trillion barrels of oil, and established reserves are only second to Saudi Arabia's 263 billion barrels at 175 billion barrels.



**Syncrude**





# ***Biorefining Conversions Laboratory projects focus on 3 themes:***

***Byproducts  
Utilization***



***Value-add  
Opportunities***

***Biological  
Platforms  
(Synthetic Biology)***



***Biocatalysis &  
Fermentation***

***Chemical  
Platforms***



***Advanced  
Bioproducts***

# *Hydrocarbon industry drivers for new biofuels*

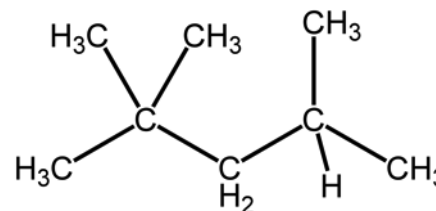
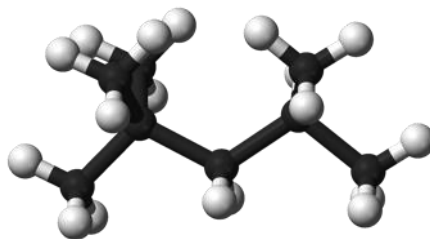


- *Compatible molecules*
- *Zero process Interruption*
- *Low to zero emissions*
- *Increasingly lower carbon intensity*
- *Greenhouse gas reduction*

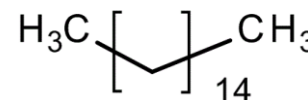
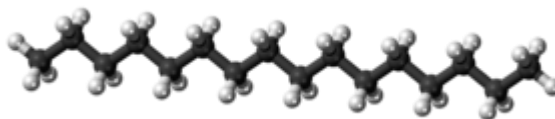
# What is a Fuel?

## To blend or integrate prior to refining?

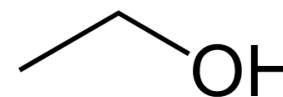
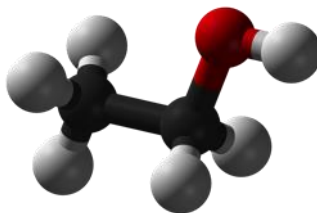
Isooctane  
(C<sub>8</sub>H<sub>18</sub>)



Hexadecane  
or Cetane  
(C<sub>16</sub>H<sub>34</sub>)



Ethanol  
(C<sub>2</sub>H<sub>5</sub>OH)



# ***Obstacles to overcome for new biofuels***



- ***Enhanced Lifecycle Analysis***
- ***Century of technical optimization (Emissions)***
- ***Incumbent regulatory regime***
- ***Social License***  
***(Food vs Fuel, GMO etc.)***
- ***Evangelism of early efforts***



# BioFuelNet: About the network

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**BioFuelNet Canada** is a Network of Centres of Excellence (NCE) that brings together the Canadian biofuels research community.

Operates under a \$25 million grant over 5 years (2012 to 2017) through the NCE program.

- **10 project containing 59 work packages**
- **Facilitates collaboration**
- **Supports commercialization**
- **Government interaction**
- **Represents Canada**
- **Trains students and postdocs**



# Task Forces Integrate Themes



INTEGRATED  
THERMAL BIOREFINERY  
BIOFUELNET



INTEGRATED  
BIOLOGICAL BIOREFINERY  
BIOFUELNET



FORESTRY  
BIOFUELNET



AVIATION  
BIOFUELNET



LOW COST  
SUSTAINABLE FEEDSTOCKS  
BIOFUELNET



POLICY  
BIOFUELNET

## FEEDSTOCK

1. Purpose-grown feedstock
2. Residues & waste

## CONVERSION

3. Bioconversion
4. Pyrolysis
5. Gasification
6. Emerging conversion technologies

## UTILIZATION

7. Combustion & engine operations

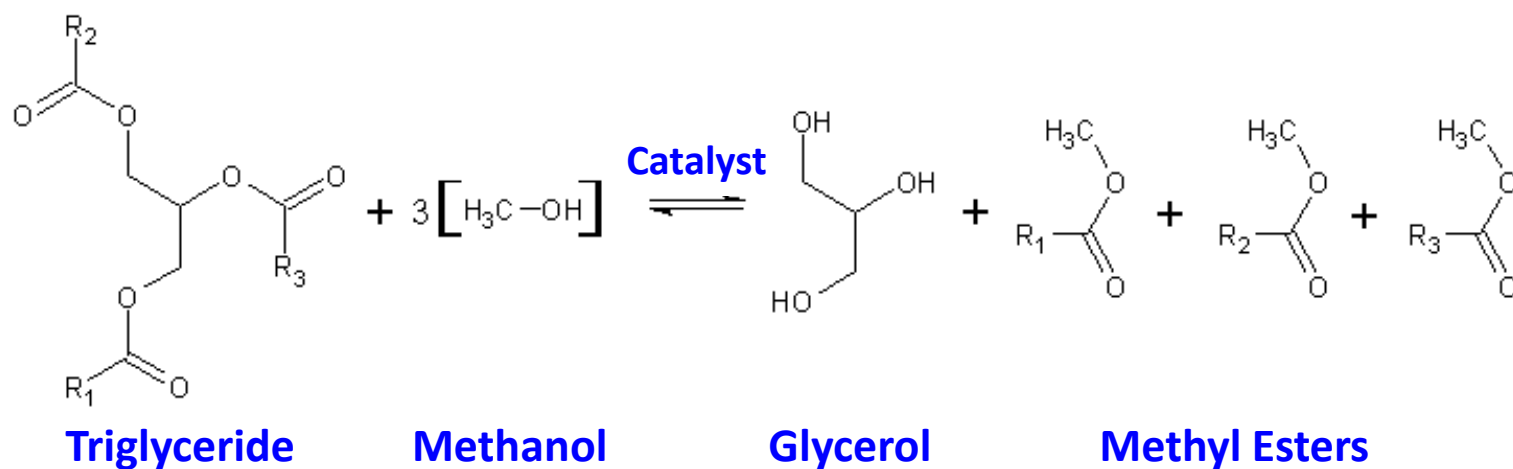
## SEES

8. Life cycle analysis & microeconomics
9. Domestic & international policy
10. Supply-chain logistics

# Vegetable Oils



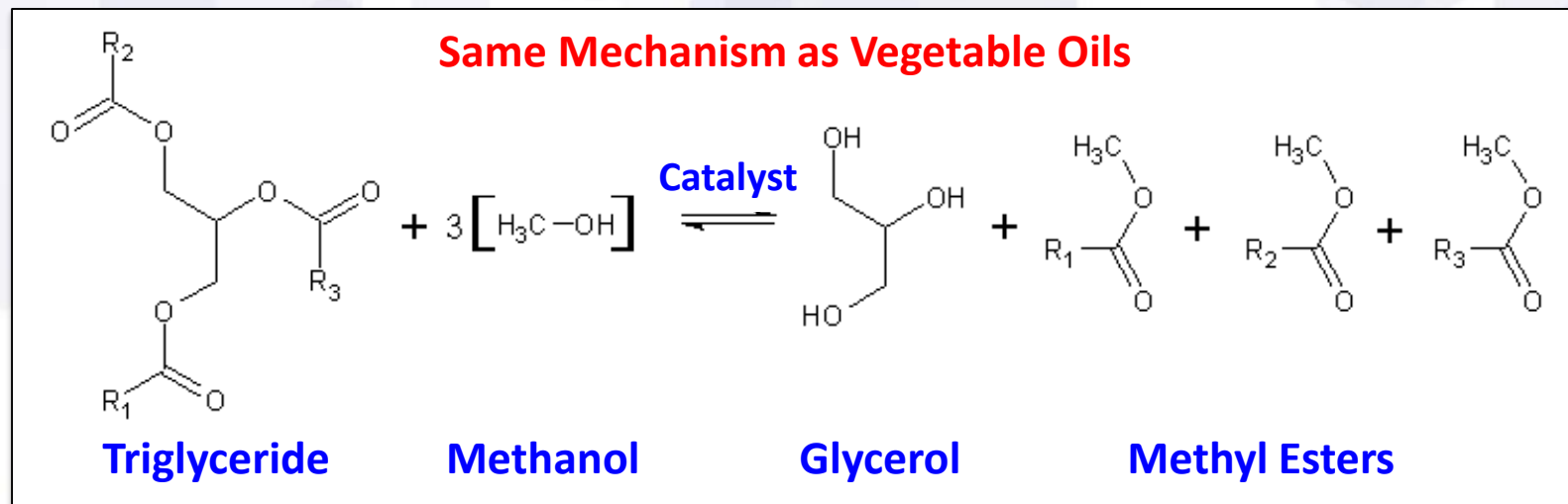
- Corn oil
- Sunflower oil
- Canola
- Palm oil
- Coconut oil



# Animal Fats



- Lard (Pigs)
- Tallow (Cows/Mutton)
- Poultry fat



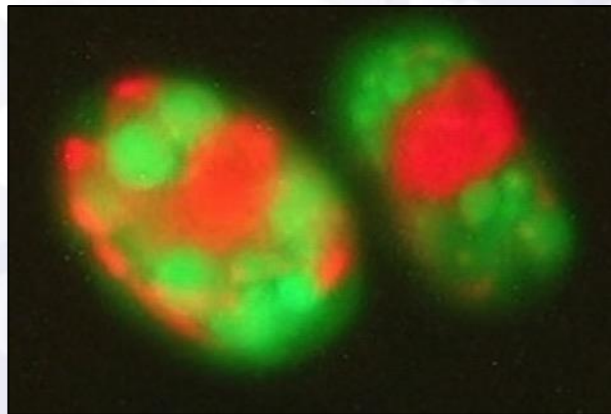


# Waste Oil and Fats



# Oleaginous Microorganisms

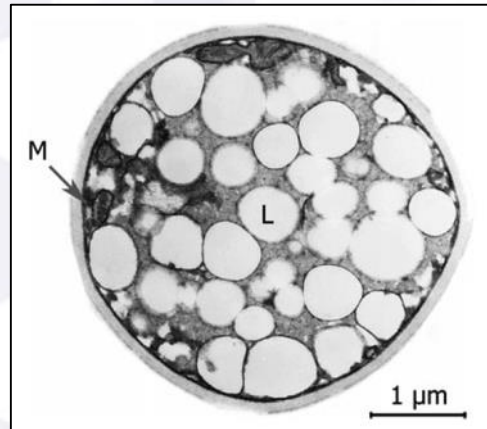
Algae



*Chlorella  
vulgaris*

40 - 70% lipids

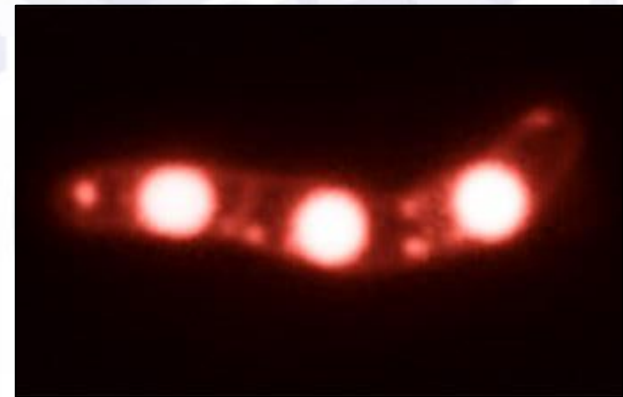
Yeast



*Cryptococcus  
curvatus*

20 - 70% lipids

Bacteria



*Rhodococcus  
opacus*

Up to 87% lipids

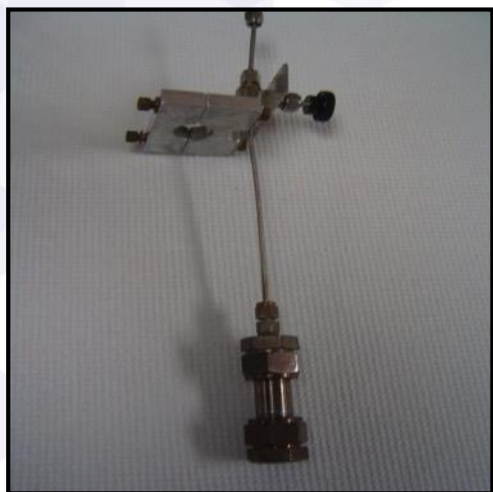


# **Lipid Program**

# NSERC Funded Discovery Research

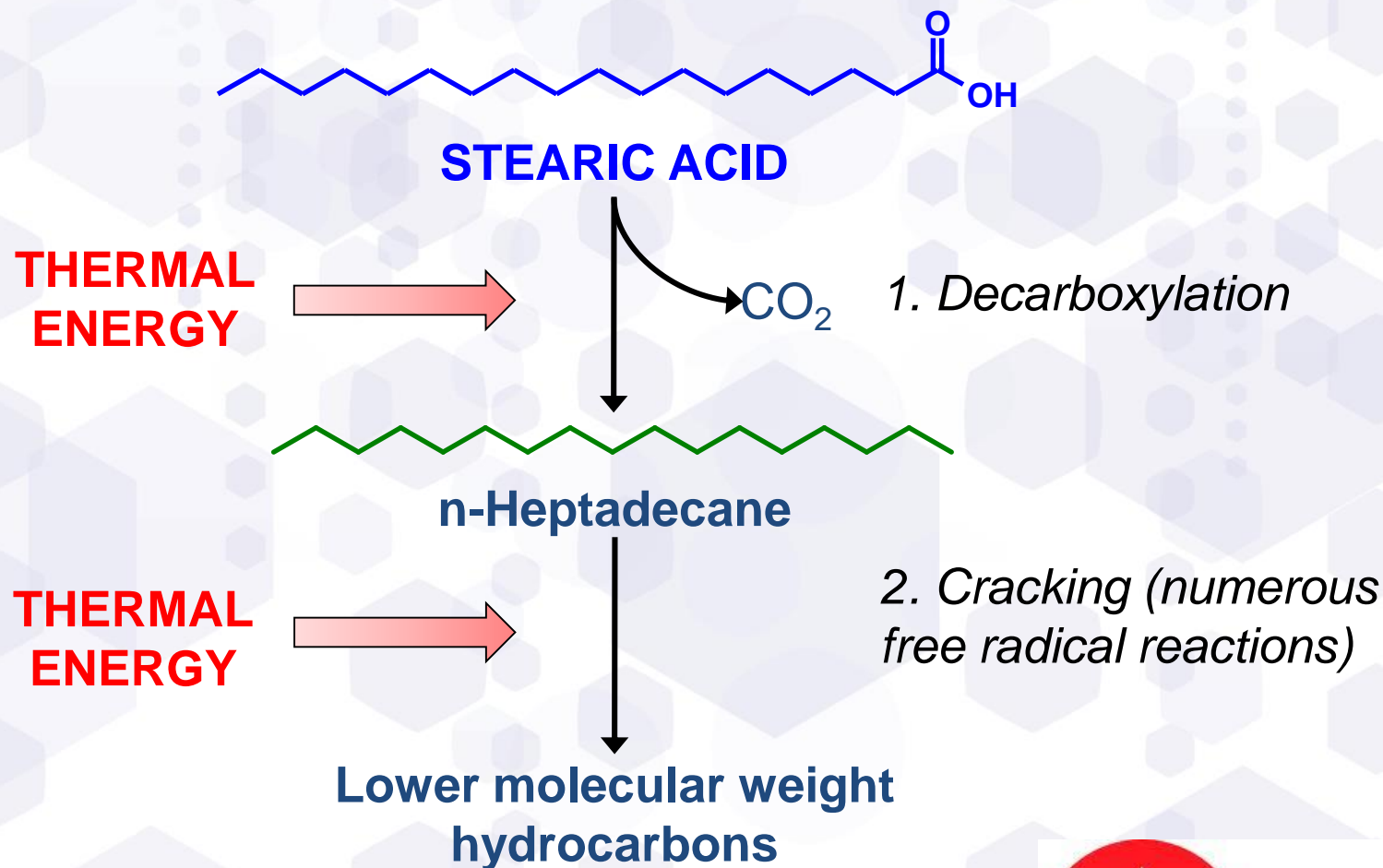
## Micro Batch Reactions

- 15 ml stainless steel microreactors heated in a fluidized sand bath





# Pyrolysis → Hydrocarbons

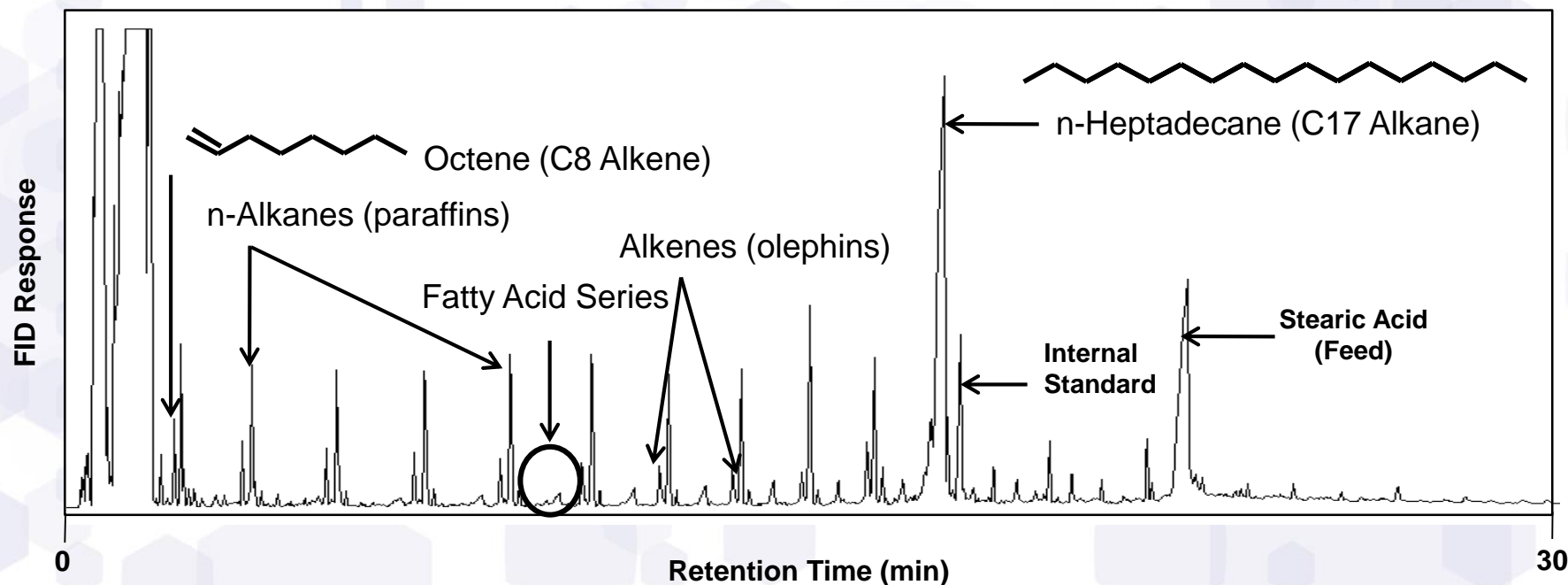


**NSERC  
CRSNG**

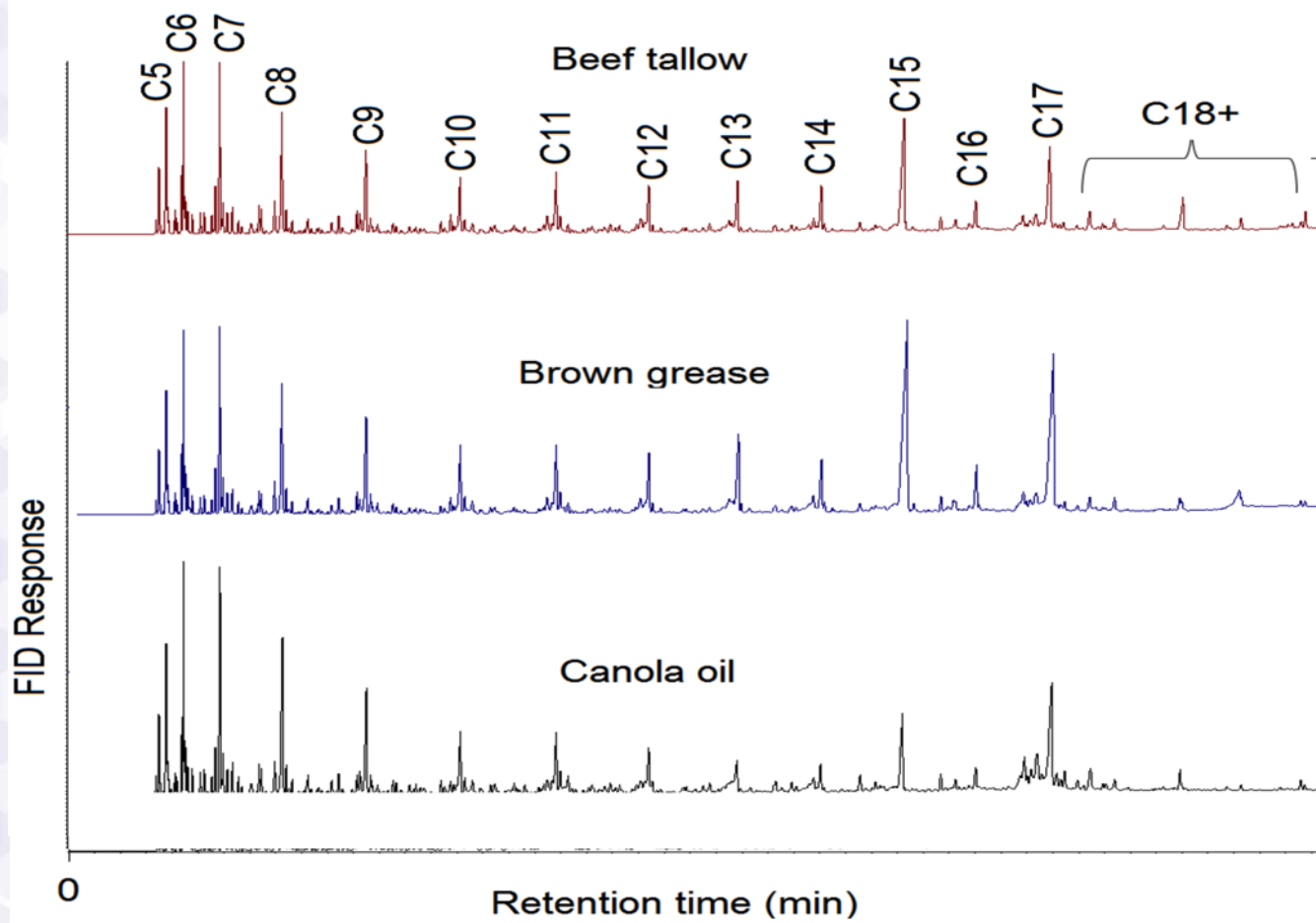
# Proof-of-Concept

## Stearic Acid Pyrolysis Products

- Model stearic acid feed resulted in alkane/alkene series
- Smaller concentration of fatty acids in series
- C<sub>17</sub> alkane indicates decarboxylation of stearic acid



**GC-FID chromatogram showing stearic acid pyrolysis products  
after reaction at 410°C and 1 hr**



# Process Development – Scale-Up

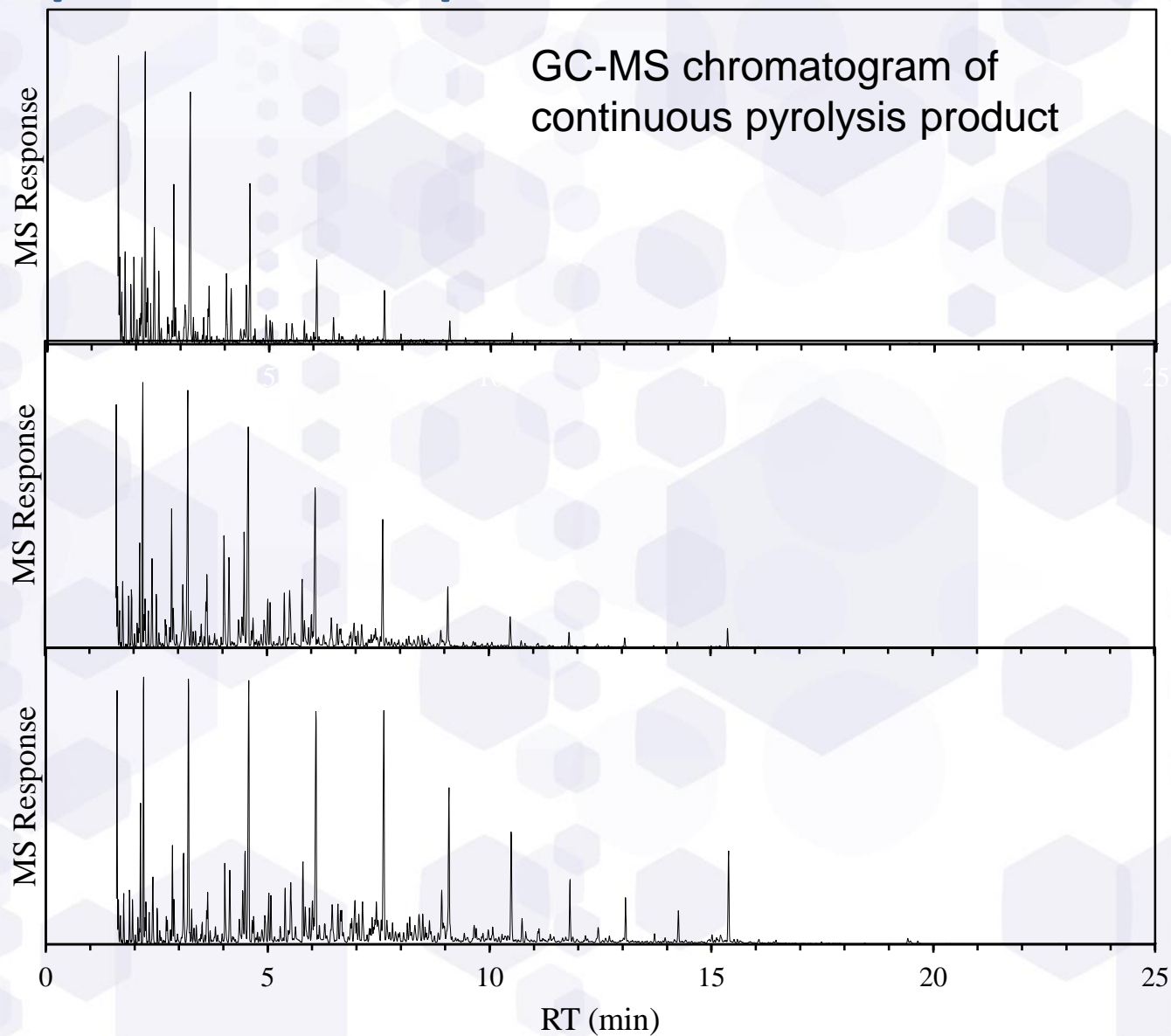
- Scale-up, design and optimization of a 1L CSTR
  - heated feed tank and pumping system
  - rated 500° C and 5000 PSIG

*Alberta*  
Freedom To Create. Spirit To Achieve.





# Liquid Product Optimization





Western Economic  
Diversification Canada

Diversification de l'économie  
de l'Ouest Canada

# FORGE

## HYDROCARBONS

**feedstock**  
[\$2/gallon]

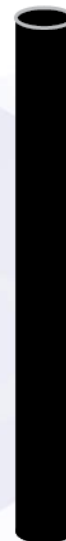


**FORGE proprietary process**



no hydrogen,  
catalysts or  
co-solvents

**distillation**



**55% diesel**  
[>\$5.00/gal]



**25% gasoline**  
[>\$4.00/gal]



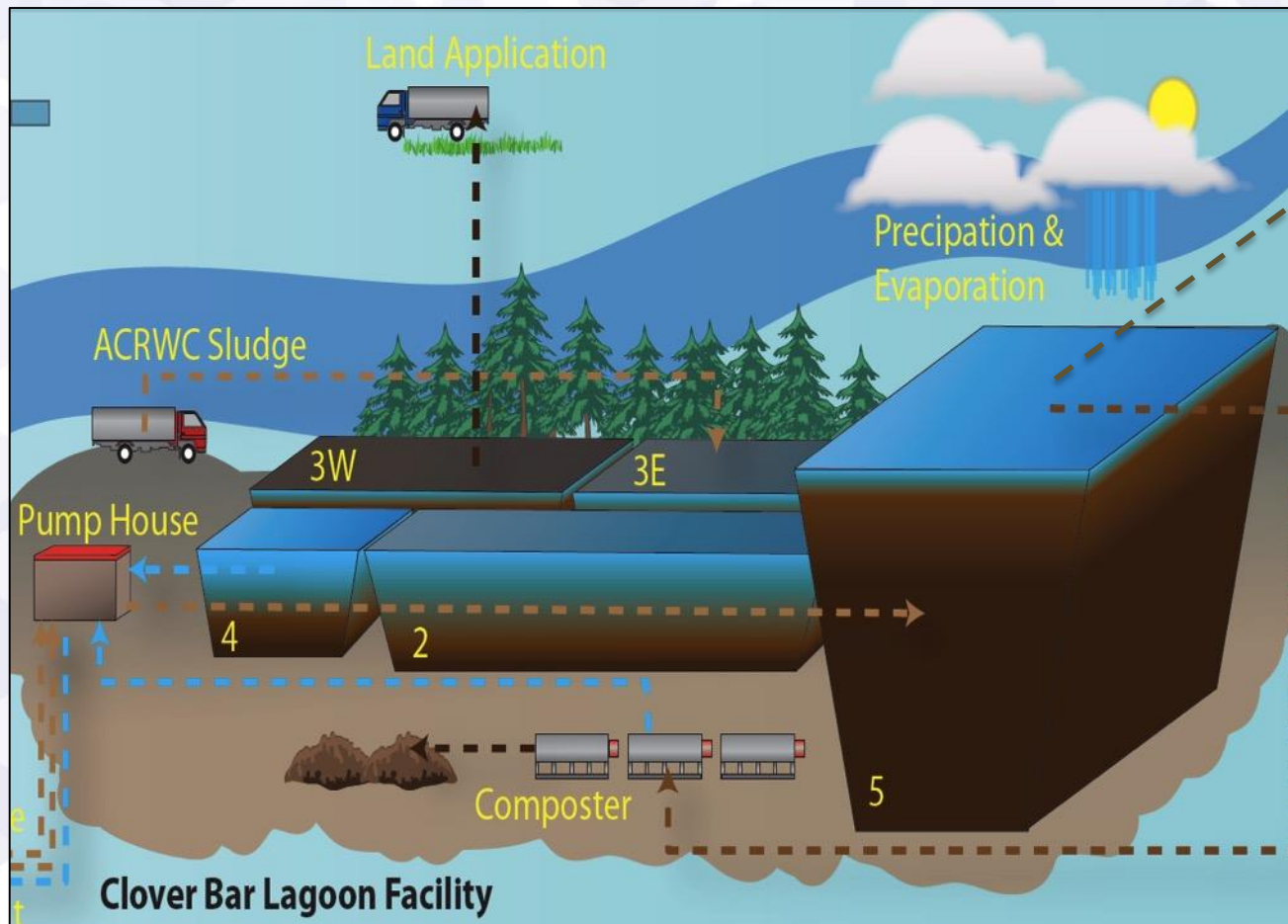
**5% light ends**  
[>\$3.00/GJ]



**15% CO<sub>2</sub>**  
[>\$0.00/gal]



# Using Biosolids to Produce Biofuels



About 180,000 dry tonnes of biosolids stored in Clover Bar lagoons (Edmonton, AB)

Use as a water substitute for in the Lipid-to-Hydrocarbon process to produce drop-in fuels

From: CLOVER BAR BIOSOLIDS LAGOONS RISK AND OPERATION STUDY



# Pathway to Commercialization

- 2003-2006 Basic Research
- 2006-2010 Applied Research
- 2010 1L scale online
- 2006 First Patents Filed
- Initial License 2007
- 2011 Full Patents Awarded
- 3 more patent families filed
- 2012 Recovered IP and Re-Licensed
- Tim Haig (Forge Hydrocarbons)



- 2013 WED & ALMA Pilot Funding
- 2013 Company Launch
- 2013 \$5M Strategic Investment
- 2014 2<sup>nd</sup> US patents awarded
- April 2014 200K L/y Online
- 2015 SDTC Funding
- 2017? First Commercial Groundbreaking...



# Acknowledgements



Western Economic  
Diversification Canada

Diversification de l'économie  
de l'Ouest Canada



# Thank-You Questions?

For further info, please contact:

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