A Review of Cellulosic Hydrocarbon, Drop-in Replacement and Infrastructure Compatible Fuel Technologies

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College of Agriculture
Auburn University, Alabama, USA

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Objectives

1) Establish personal credibility
2) Indicate current status of biofuels in the US
3) Define Cellulosic Hydrocarbon, Drop-in Replacement and Infrastructure Compatible Fuel Technologies
4) Describe different cellulosic hydrocarbon fuel technologies

Personal Background

- Raised on a small dairy farm in South Africa
- BSc & PhD, University of Natal, South Africa
- MSc, University of Missouri – Columbia
- Visiting Scientist, Texas Tech University, 1984
- Immigrated in 1987
- Became naturalized US citizen in 1992

Credibility

- 24 years in the bioenergy field
- Research and development in all aspects of energy crops, mainly switchgrass: production, harvesting, storage, pre-processing and transport.
- Considerable knowledge of conversion technologies and who has them.
- Briefed President Bush twice on the emerging cellulosic biofuels industry.


POLICE
CITY OF HOOVER
ALABAMA
DEPT
85% Eth
GALLONS
ONOR
PRIDE

Switchgrass

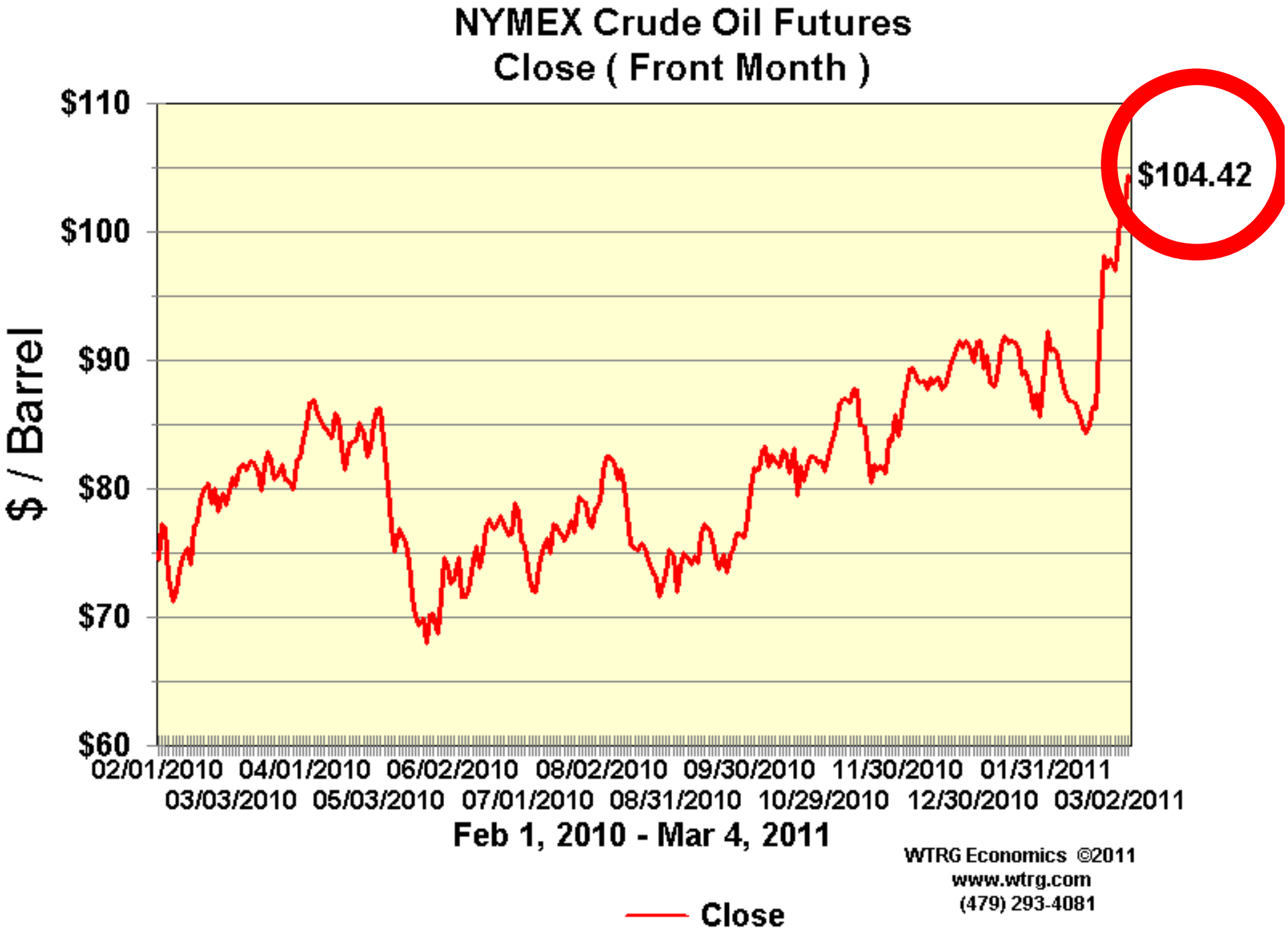
1989

Switchgrass

1989

2008

Current Status of Biofuels in the US


NYMEX Crude Oil Futures
Close (Front Month)
$110
$100
$90
$80
$70
$60
$ / Barrel
$104.42
02/01/2010
03/03/2010
04/01/2010
05/03/2010
06/02/2010
07/01/2010
08/02/2010
08/31/2010
09/30/2010
10/29/2010
11/30/2010
12/30/2010
01/31/2011
03/02/2011
Feb 1, 2010 - Mar 4, 2011
WTRG Economics ©2011
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Photographer unknown

BIOMASS

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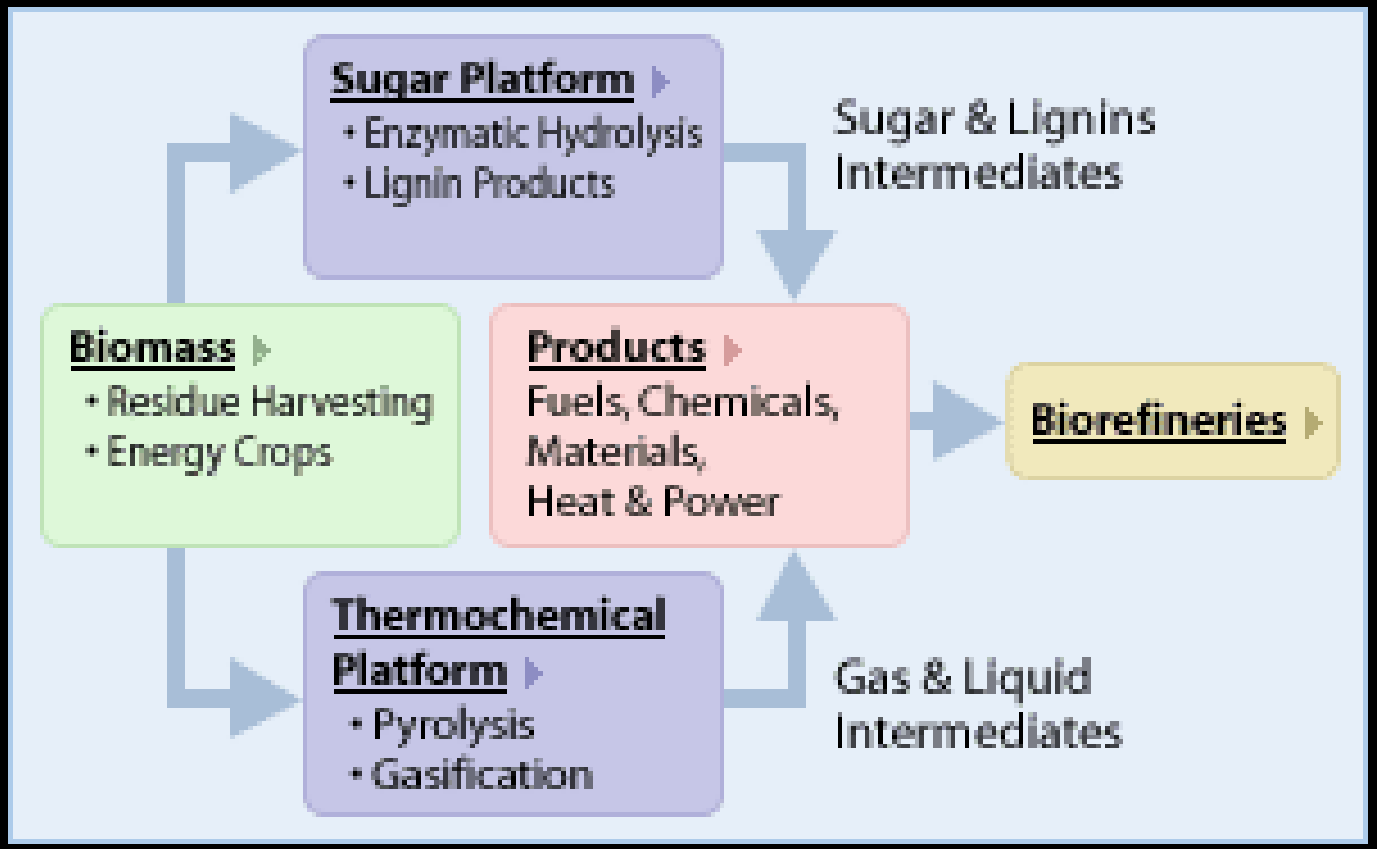
Cellulosic Ethanol Technologies



Problems with Ethanol

- Only 66% of the energy content of gasoline
- Only 66% of the mileage of gasoline
- Therefore, only worth 66% of the price of gasoline
- Need E-85 cars
- Need E-85 pumps

Problems with Ethanol

- Can’t transport by pipeline
- Need to transport by truck or train
- Difficulty in attaining “Advanced Biofuel” status (60% GHG reduction compared to petroleum fuels) because fossil fuels needed to harvest and haul

Drop-in Replacement Fuels

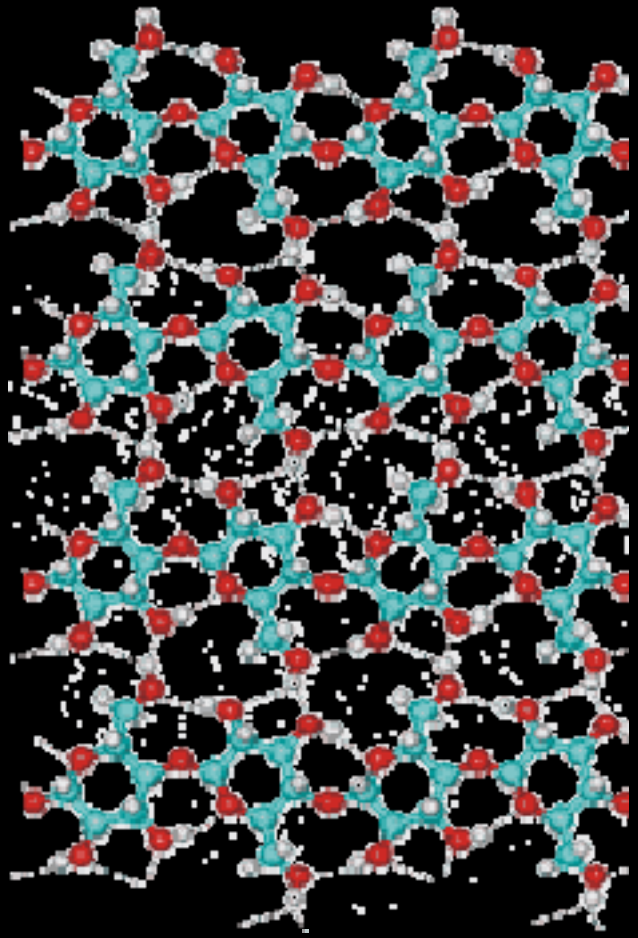
- Cellulosic hydrocarbon fuels?
- Gasoline, Diesel &Aviation fuel

-- - - made from cellulosic biomass instead of oil

- Have no problems in qualifying as "Advanced Biofuels" because they can be used in diesel trucks and equipment

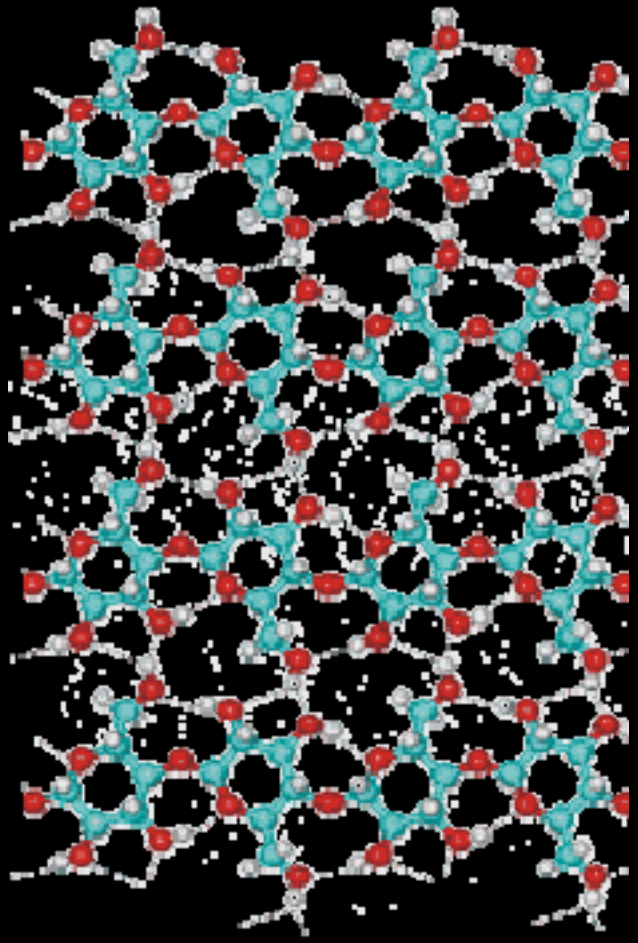
SASOL South Africa

Depolymerization



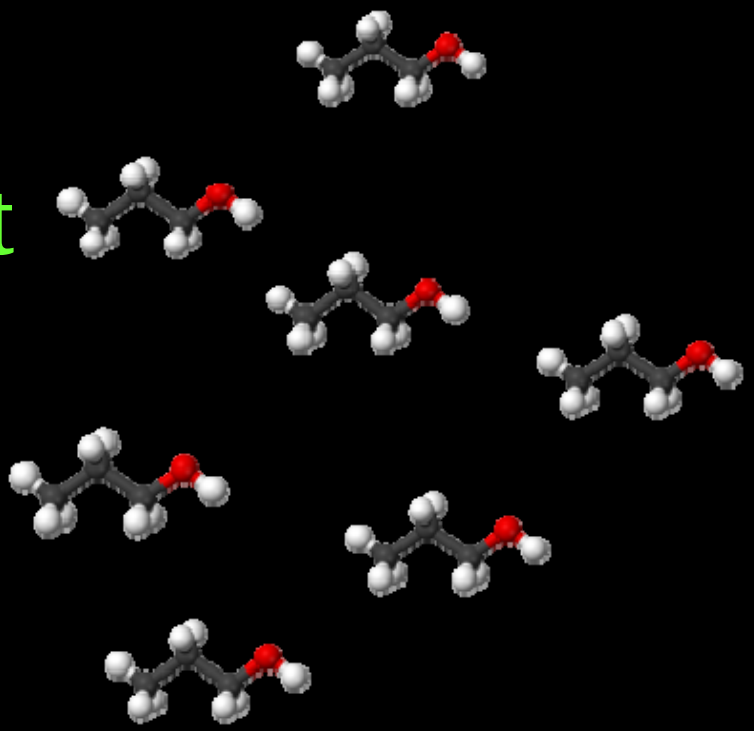
Cellulose

Depolymerization



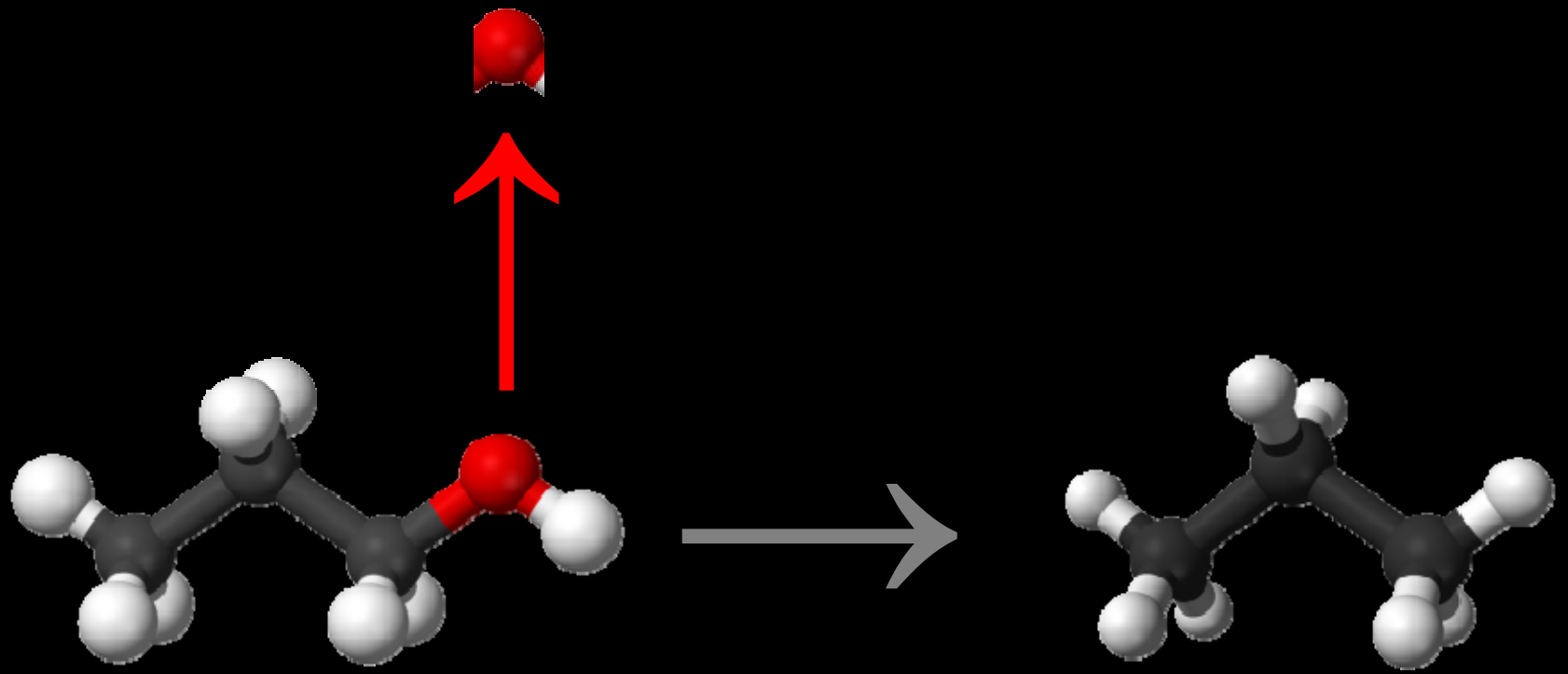
Cellulose

Catalyst

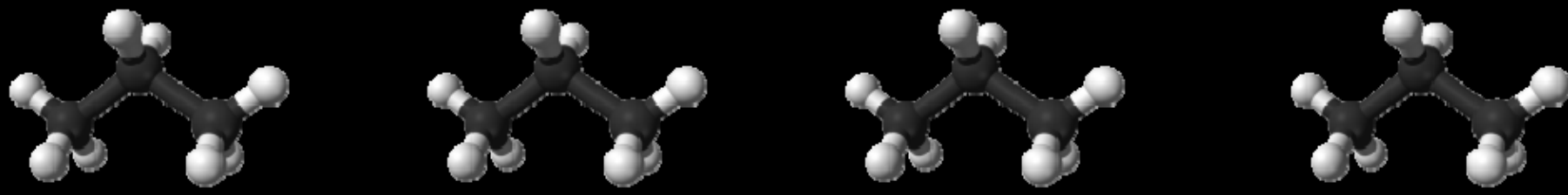


Carbon-based fragments

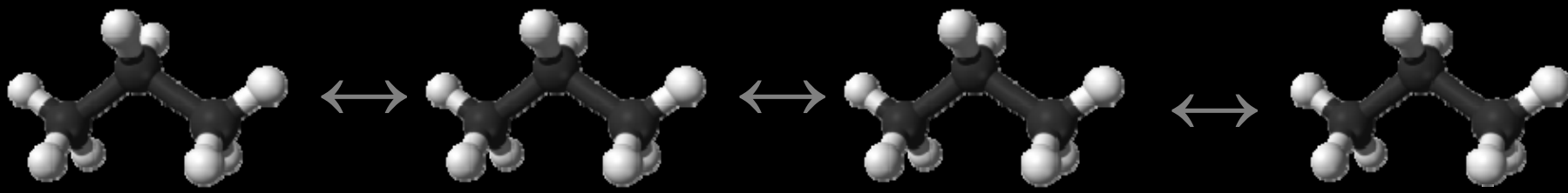
Removal of Oxygen



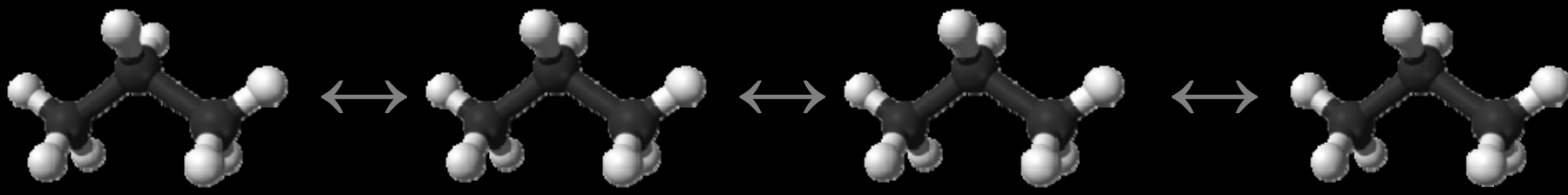
Repolymerization

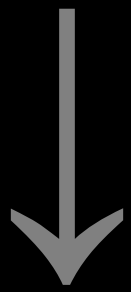


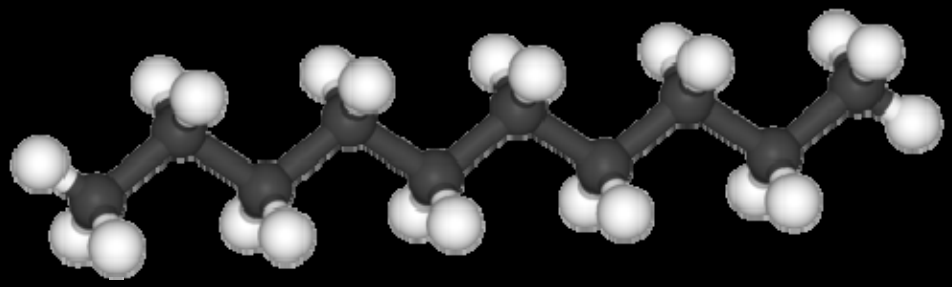
Repolymerization



Repolymerization



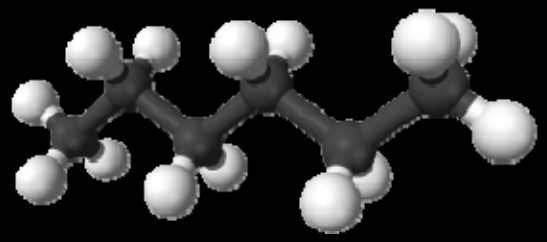




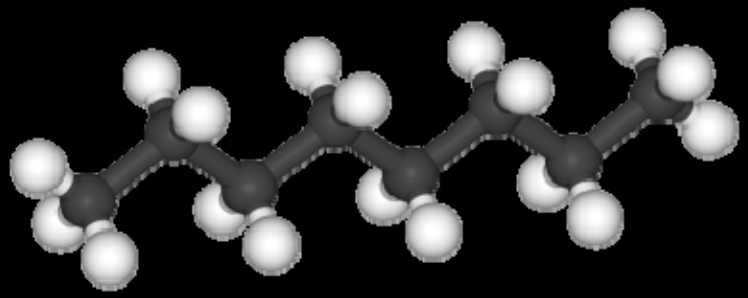
Alkanes/ Hydrocarbons

Gasoline: 6-12C

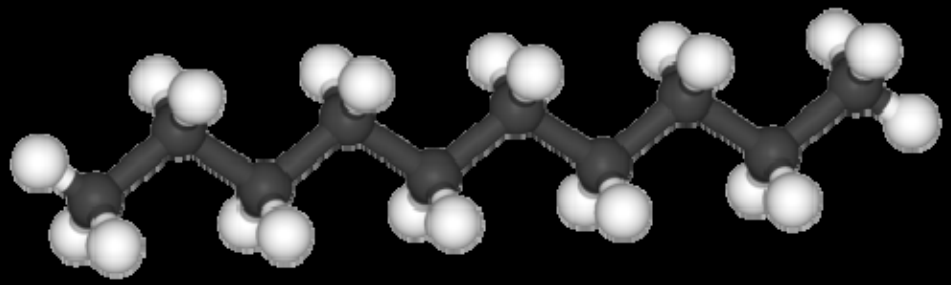
Hexane



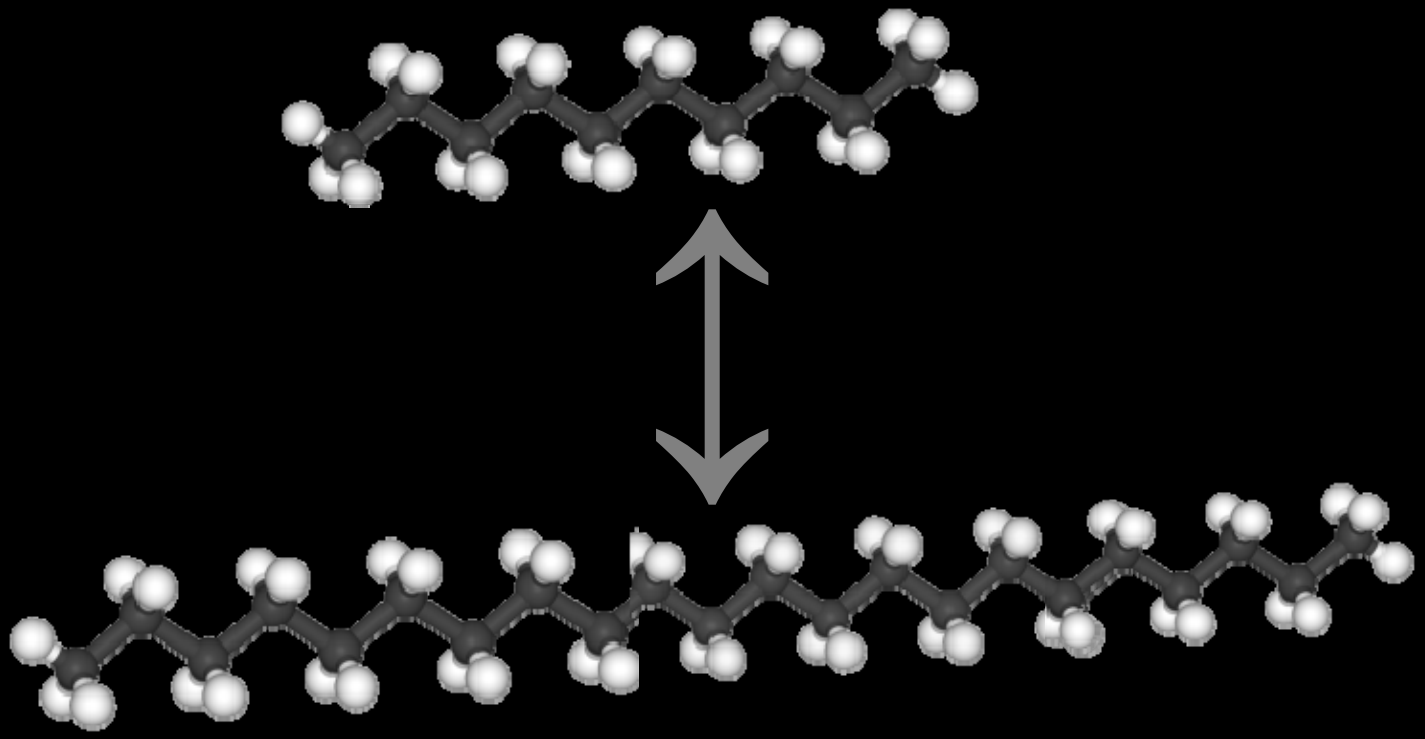
Octane



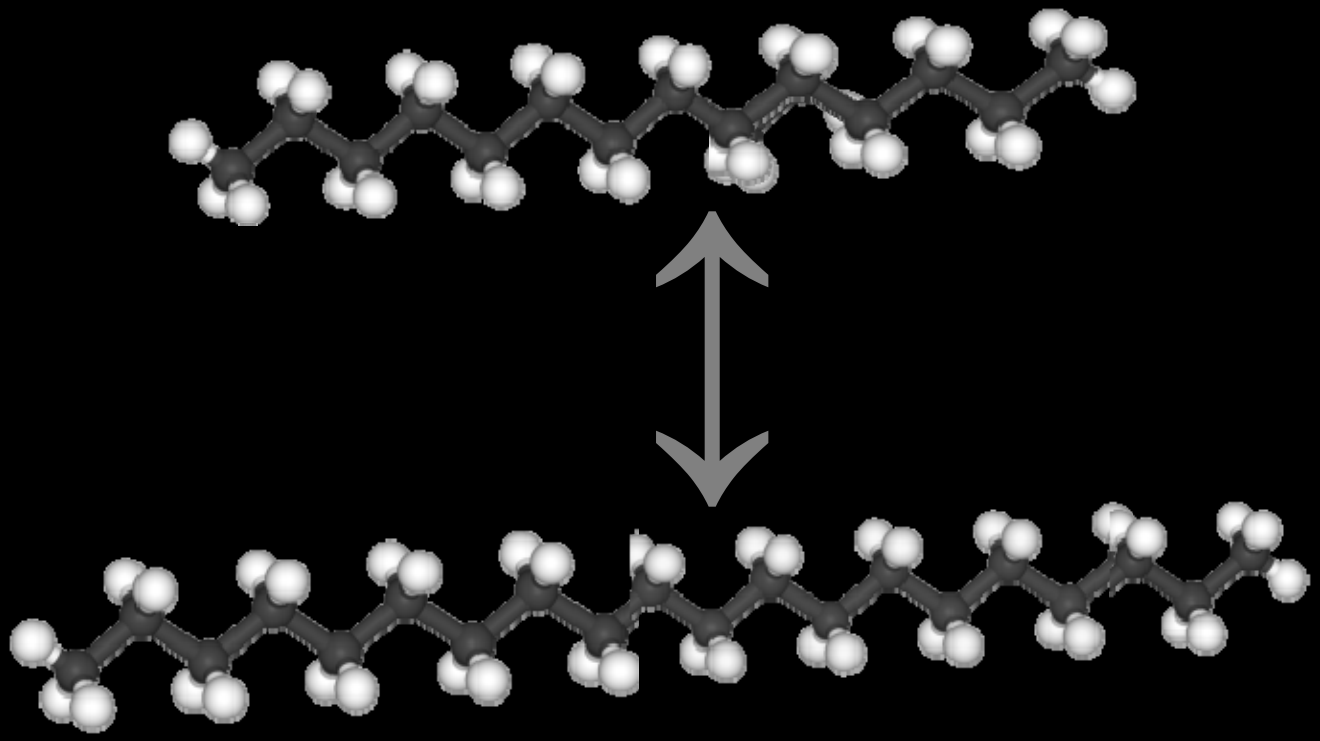
Decane



Diesel: 12-21C



Aviation Fuel: 14-19C



Some Companies Involved in Alkane/Hydrocarbon Production

- KiOR – www.kior.com
- Virent – www.virent.com
- Amyris – www.amyrisbiotech.com
- LS9 – www.ls9.com
- ClearFuels/Rentech www.clearfuels.com
- MME – www.mmeag.de
- Organic Fuel Technology www.organicfueltechnology.com

KiOR – www.kior.com

- Appears to be leading in the race to commercialize
- Just announced a $1 billion DOE loan guarantee term sheet for multiple plants in the Southeast
- Broken ground for first 500 tpd plant in Columbus MS
- Expect to start production 1st Qtr, 2012

February 3, 2011

Media contact:
Matthew Hargarten
(312) 377-4136
media@kior.com

KIOR RECEIVES LOAN GUARANTEE TERM SHEET FOR OVER $1 BILLION PROJECT FROM U.S. DEPARTMENT OF ENERGY

Project would produce drop-in fuels from wood biomass at four facilities across three states

KiOR – www.kior.com

- Catalytic process that produces a bio-oil which requires further refining.
- Flexible with regard to feedstock, but starting with wood

Virent – www.virent.com

A catalyst-based process that can produce the standard hydrocarbon fuels produced from petroleum

Amyris – www.amyrisbiotech.com

LS9 – www.ls9.com

Biological conversion of sugars to hydrocarbon fuels

Sugars need to be produced from biomass first

ClearFuels/Rentech

www.clearfuels,com

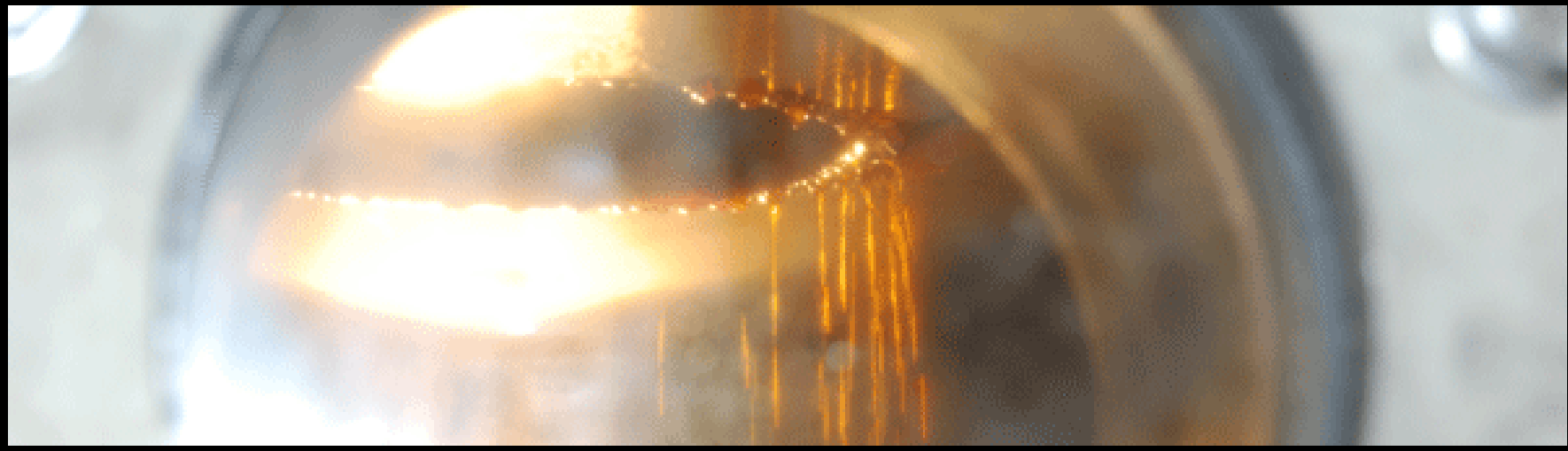
- Gasification followed by catalytic conversion to jet fuel and diesel.
- First commercial plant scheduled for west Tennessee

MMEAG
Plant in Germany

MMEAG
Plant in Germany

MMEAG
Plant in Germany

MMEAG
Plant in Germany



MMEAG Plant Specifications

- 1.3 million gal/yr capacity
- $6 million capital
- Regular drop-in replacement diesel, from any biomass material
- Production costs of less than $2.00/gal

Concluding on a Personal Note

- Innovation at the local level
- Do not underestimate the ingenuity of farmers
- Do not underestimate the future energy demand of Asia

An Alabama farmer's (Wayne Keith) idea of a true drop-in replacement fuel


BIOfueled


F250


DODGE

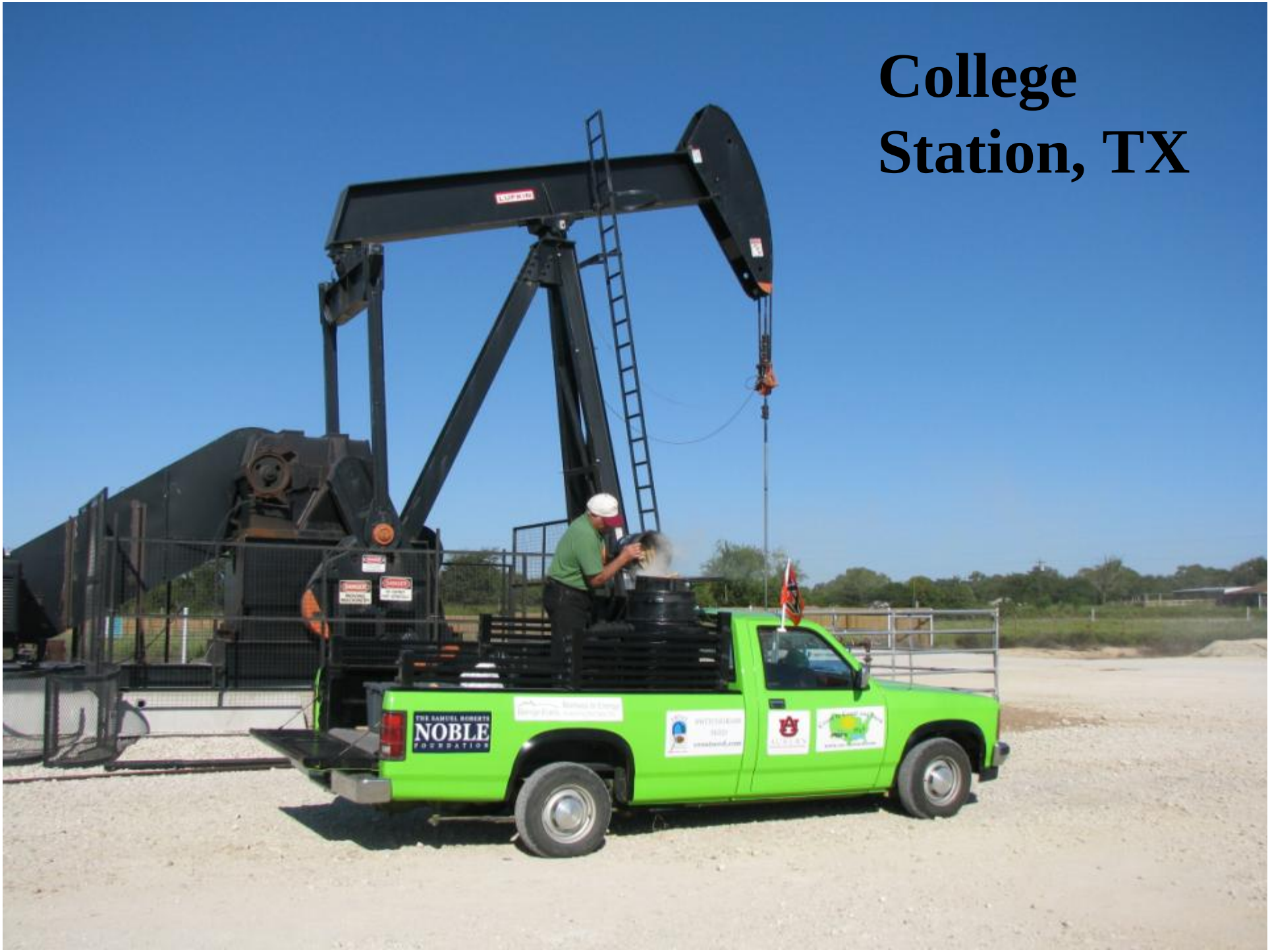
Auburn University and RES Renewable Energy Tour: Coast-to-Coast on Wood and other biomass

...and Back!

October '08

Charleston, SC

College Station, TX


College
Station, TX
NOBLE

Ardmore, Oklahoma

Grand Canyon


NEVADA JOE'S
OPEN 4 HRS.
BUD LIGHT
OPEN
LATHROP
WELLS
NEVADA


ADULT
ENTERTAINMENT
AIR
WATER


CHERRY PATCH RANCH 2
HOUSE OF
PROSTITUTION
OPEN 24 HOURS
MASTERCARD
VISA

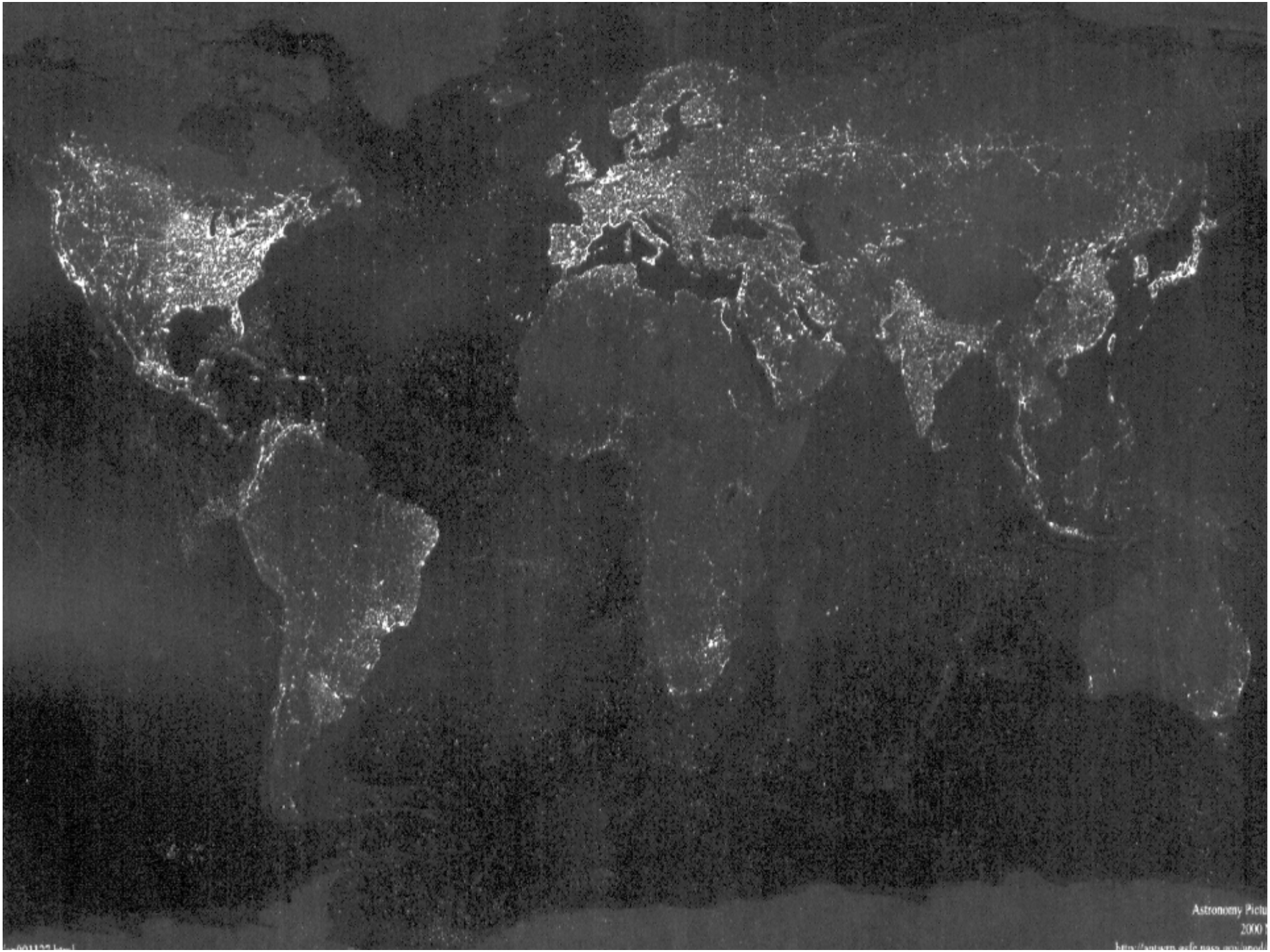

Death Valley
National Park
Homeland of th
RACE
VEHICLE

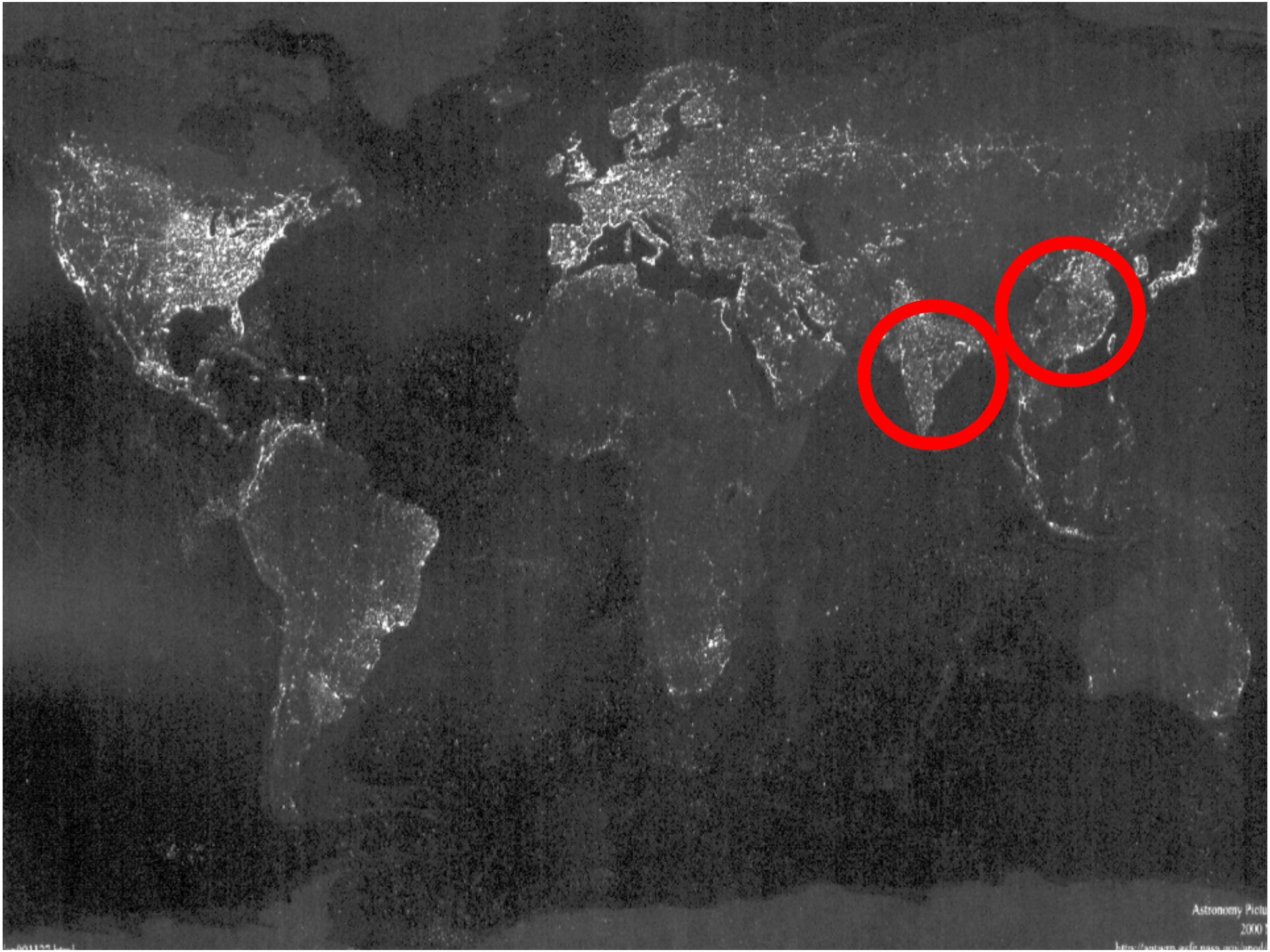

ELEVATION
SEA LEVEL


YOSEMITE NATIONAL PARK


10,000 ft

Golden Gate, San Francisco


Astronomy Pictu
2000


Astronomy Pictu

Key Conclusions

1. **Until recently, farmers have possibly been the main driving force behind biofuel development in the US.**
2. **Cheap fossil energy has been a disencentive for biofuel development.**
3. **War in Iraq, hurricane damage to refineries and oil price hikes have changed the attitude to biofuels.**

Key Conclusions

4. The oil companies are getting involved

5. Due to weaknesses related to ethanol, research is expanding into cellulosic hydrocarbon fuels.

6. The US has enormous capability and resources for cellulosic biofuel production

We can do it!

Thank you!