

OriginOil™

Second-Generation Dewatering & Extraction Technologies

AMSTERDAM, THE NETHERLANDS 9-12 NOVEMBER 2010



5TH ANNUAL MEETING

BIOFUELS 2010

Capitalise on the global biofuels opportunity

A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

Safe Harbor Statement



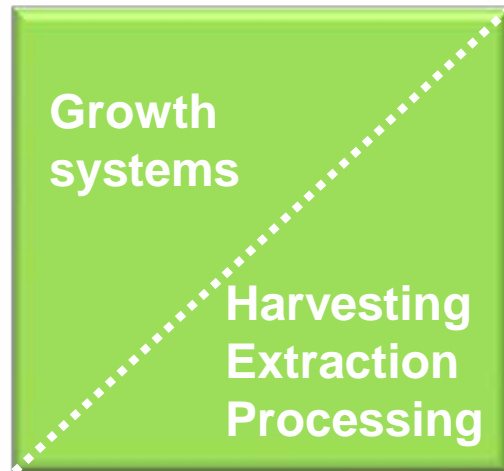
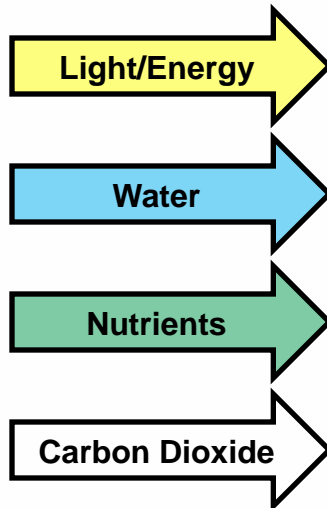
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ALGAE EXTRACTION TODAY

Techniques and Challenges

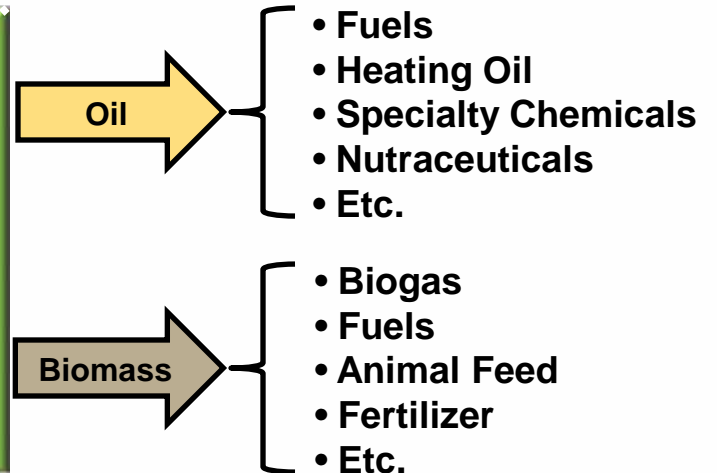
Algae Production Model

UPSTREAM



**Technology
&
Process Knowledge**

DOWNSTREAM



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A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

What is Algae Oil?



Levels of:
Chlorophyll?
Phospholipids?
FFA's?
Metals?
Residual solvent?



A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

What is Algae Oil?

Total Lipids \neq Oil

Total Lipids: Substances that dissolve in organic solvents but not in water (e.g., phospholipids, glycolipids, triacylglycerol, sterols, wax, chlorophyll, carotenoids)

'Oil'/storage neutral lipids: Triacylglycerol, hydrocarbons

- Neutral lipids (i.e., triacylglycerol)
- Neutral lipids to total lipids Ratio



Algae biomass



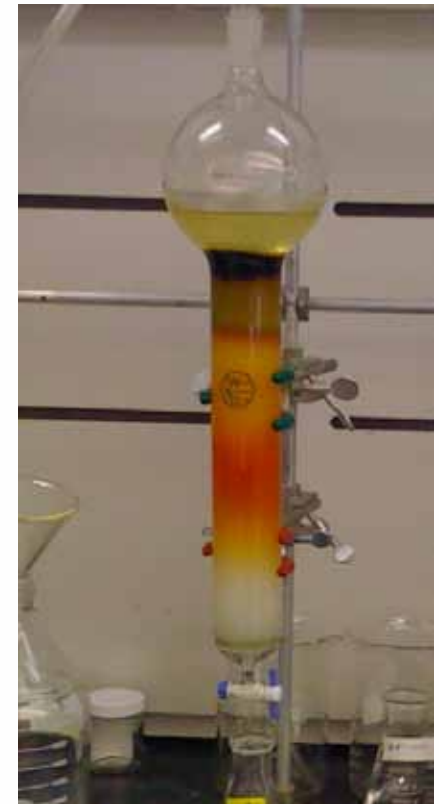
Algae oil?



Pretreated & refined oils



Gums



Source in part: Hu and Sommerfeld: NREL-AFOSR Workshop, January 30, 2008)

A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

Recovering Oil: A Twofold Challenge

§ Algae Grow Suspended in Large Amounts of Water

- § Cells have similar specific gravity to water
- § Algae in suspension neither sink nor float
- § Wet biomass retains interstitial water, which acts as a lubricant
- § Harvesting oil requires solids separation
- § Dewatering is energy and capital intensive

§ Cell Walls are Difficult to “Crack”

- § Algae have a tough exterior to protect internal lipids
- § Cell wall has a high elasticity modulus
- § Cell rupture through mechanical friction and steam explosion requires dry biomass
- § Mechanical extraction is energy and capital intensive
- § Chemical extraction requires toxic, hazardous solvents

Conventional Approach

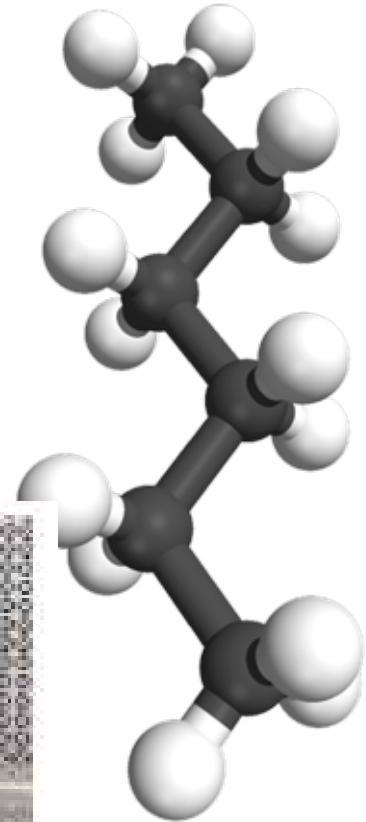
§ Current State of the Art is a 3-Stage Process:



Conventional Systems Feature a Combination of Technologies

Extraction: Solvents

- § Chemicals including benzene, ether and hexane are used to degrade cell walls
- § Oil dissolves into solvent and is recovered through distillation
- § Can be used in conjunction with mechanical extraction
- § Advantages
 - § Relatively inexpensive
 - § Effective at releasing up to 95% oil
- § Limitations
 - § Requires the use of hazardous chemical solvents
 - § **Not selective – extracts unwanted components into oil**
 - § Contamination of meal (extracted biomass)
 - § Hexane requires two year permitting process (U.S.)



Algae oil?

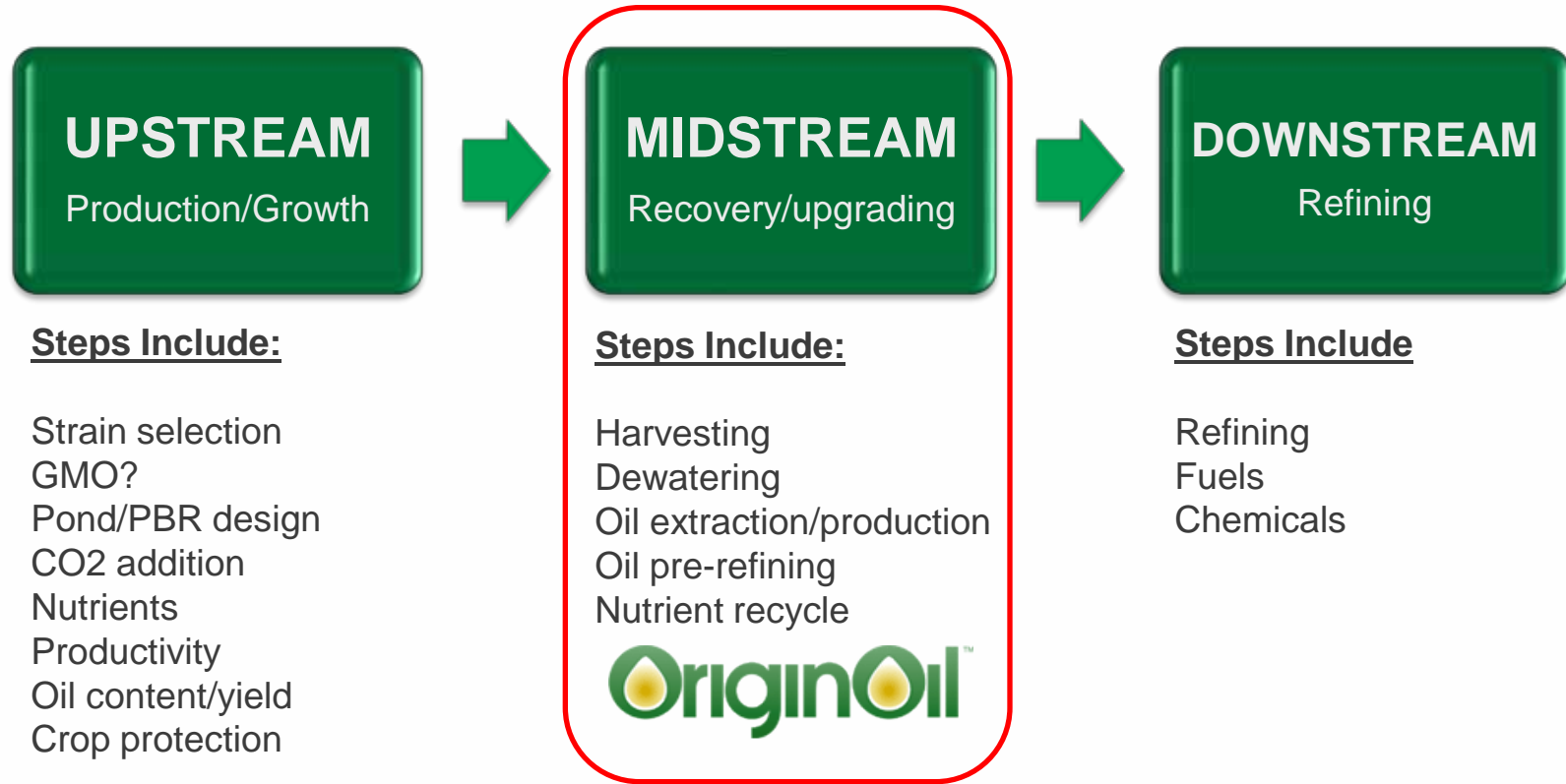
ALGAE TO FUELS

The Two Key Routes

Algae to Liquid Transportation Fuels

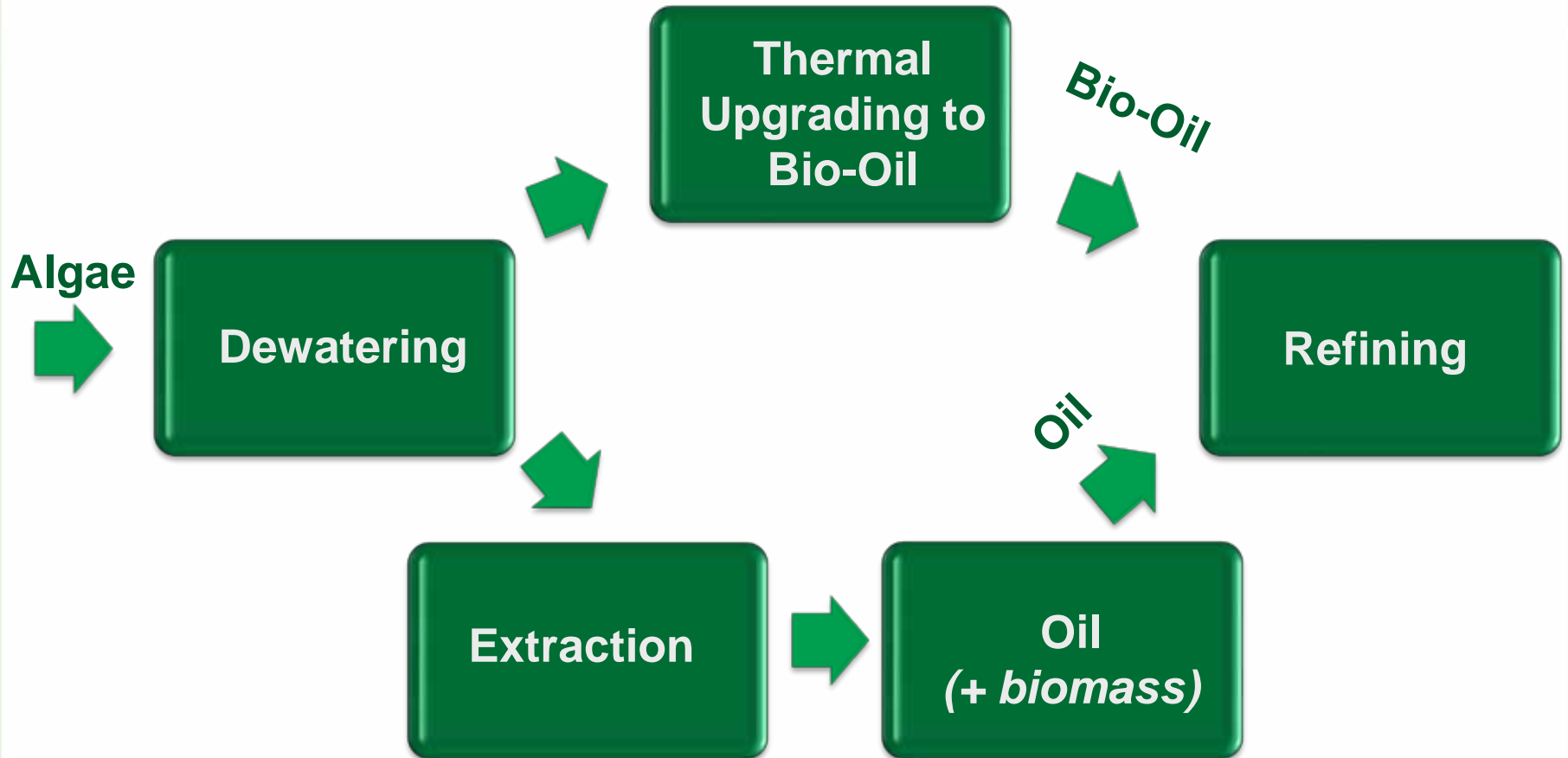


§ Essentially a 3-Stage Process:



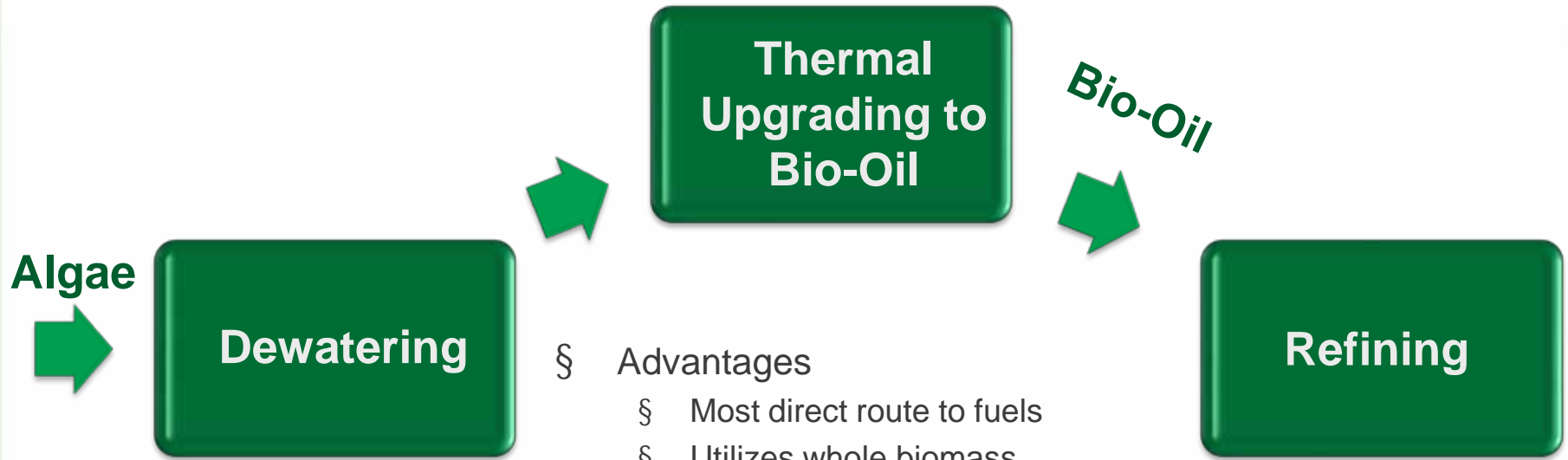
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Algae to Fuels



A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

Whole Biomass to Fuels



§ Advantages

- § Most direct route to fuels
- § Utilizes whole biomass
- § Obviates need for high oil strains, gives grower more options

§ Limitations

- § Capital and energy intensive
- § Typically requires drying algae
- § Recycling of nutrients problematic
- § Pure fuels and chemicals process – no food/feed/pharma

A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

Options for Thermal Upgrading to Bio-Oil

§ Flash Pyrolysis

§ Gasification

§ Thermochemical Liquefaction

§ Catalytic Hydrothermal Gasification to Methane

§ Hydrothermal Upgrading

Algae Oil Extraction

§ Advantages

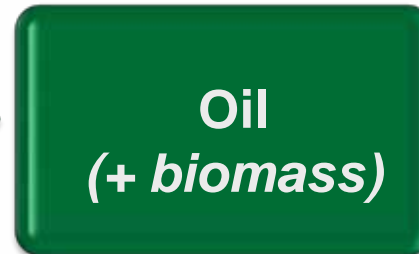
- § Potentially maximizes value of algal oils
- § Potentially delivers high value co-products (nutrition etc)
- § Parallels current industry practices for high value products

§ Limitations

- § Commercial scale of co-products

“Nothing scales with energy”

Algae



Oil



A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

The OriginOil Difference

Conventional Approach



OriginOil Approach



Radical Shift vs. Incremental Gains

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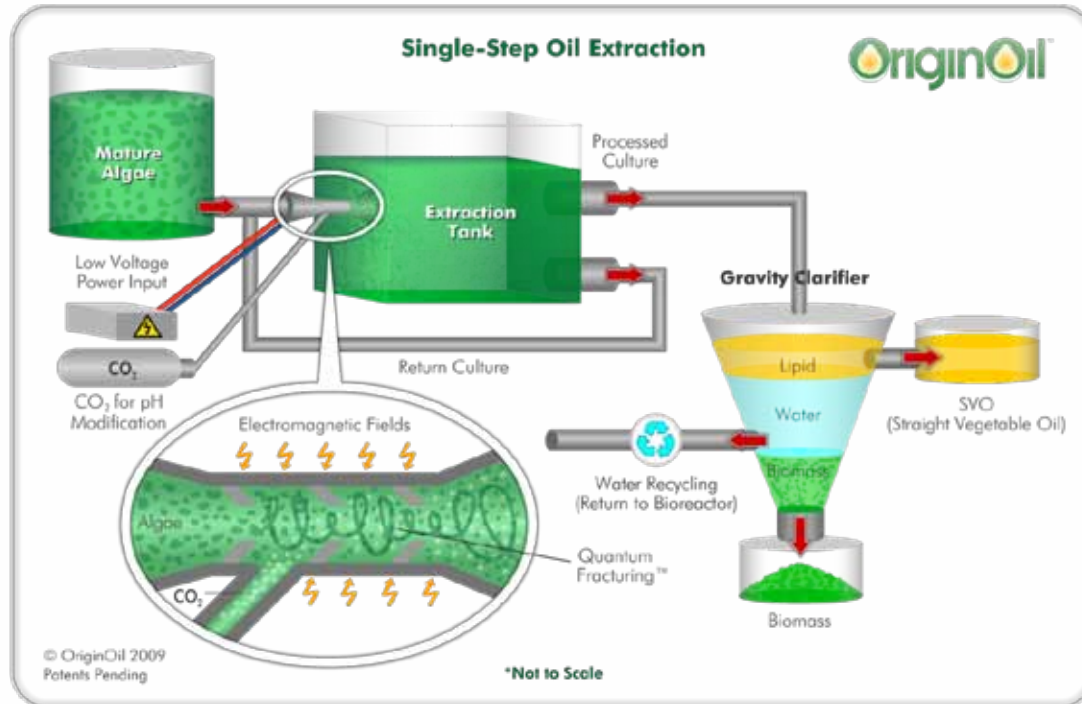


ORIGIN OIL TECHNOLOGY

Dewatering and Single Step Extraction

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OriginOil Single-Step Extraction™



- § In one step, Quantum Fracturing™ combines with electromagnetism and pH modification to break down cell walls.
- § Algae oil rises to the top for skimming and refining, while the remaining biomass settles to the bottom for further processing as fuel and other valuable products.

A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

Single-Step Extraction Process Details

§ CO₂ Injection

- § Lowers pH to optimize electromagnetic delivery
- § Chemically assists in cell degradation

§ Quantum Fracturing

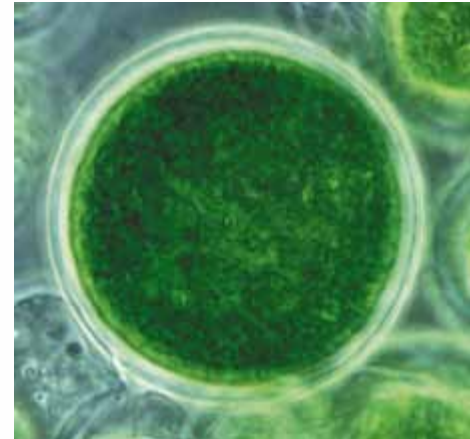
- § Creates fluid fracturing effect
- § Mechanically distresses algae cells

§ Electromagnetic Field

- § Highly tuned EMP ruptures algae cells
- § Causes cells to release internal lipids

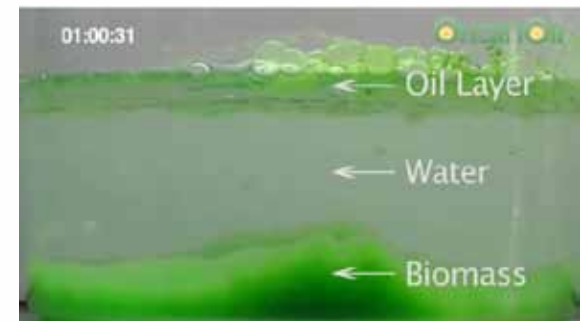
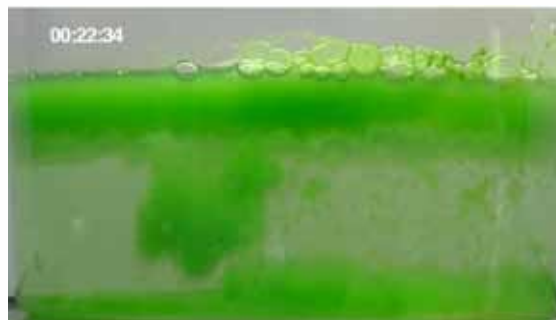
§ Additional Key Process Innovations

- § Multiple patents pending



Gravity Settling

- § Single Step Extraction separates oil from biomass
- § Processed culture is transferred to a gravity clarifier
 - § Oil rises to the top
 - § Biomass sinks to the bottom
- § Oil is skimmed for downstream polishing
- § Biomass is drained for further drying (if necessary)
- § Water is recycled to the bioreactor or pond



A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

Single Step Extraction Benefits

- § No initial dewatering required
- § Significant energy savings
- § No caustic chemicals
- § Tunable to a wide range of feedstock
- § Small footprint
- § Easy installation
- § Applicable to all growth platforms
- § Fast throughput – highly scalable
- § Greatly-reduced Capital Expenditure
- § **Oil quality**



Max ONE - (Mobile Algae eXtraction lab)

On the road in New Mexico



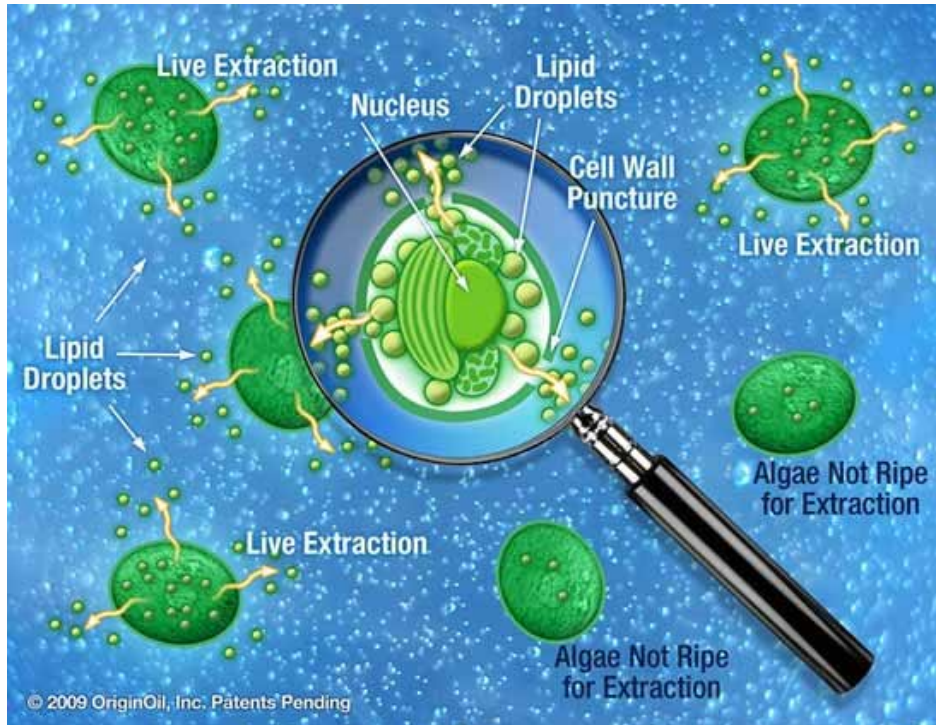
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MBD Energy Bio-Capture (Australia)



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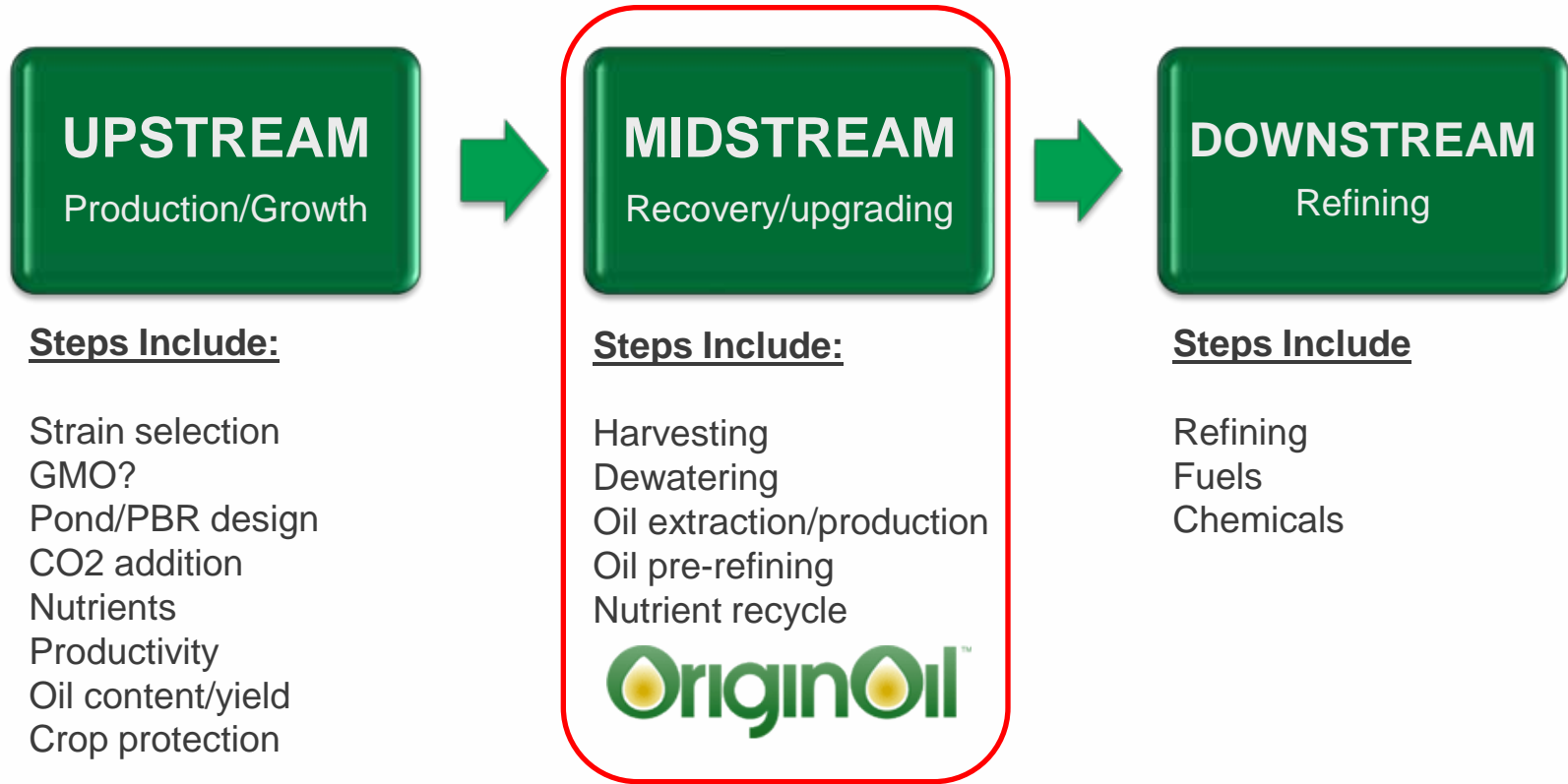
Live Extraction™



- § Continuous 'milking' process works by stimulating the algae cells electrically.
- § Algae oil is extracted continuously, algae remains alive.
- § Combines with daily harvest for improved productivity, refreshed cell cultures.
- § Does not use expensive consumables, not limited to one strain.
- § Now being scaled up to OriginOil's intermediate 200-gallon tank size.

A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

Position in the Value Chain



A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL



OriginOil Achieves Hydrogen Production Comparable to Photovoltaics

Los Angeles, CA, November 8, 2010

- Demonstrated reproducibly hydrogen energy corresponding to a solar energy conversion efficiency of about 12% continuously for several hours on a partially clouded day
- The sole energy input was the Sun
- By comparison, commercial solar cells achieve conversion efficiencies between 6 and 20% but the Hydrogen Harvester™ is still embryonic – and hydrogen can be readily stored
- The research breakthrough points to a highly scalable and renewable source of hydrogen that can be deployed as an additional system output in algae production settings

Hydrogen has often been called the perfect fuel. Its major reserve on earth (water) is inexhaustible, meaning that we will never run out of hydrogen. If produced cleanly, efficiently and affordably from renewable resources, hydrogen is the ultimate green energy solution: it produces no air pollutants or greenhouse gases when used in fuel cells and the only pollutants generated when burned in internal combustion engines are nitrogen oxides (NOx).

In one hour, enough sunlight strikes the Earth to provide the entire planet's energy needs for one year.

A BREAKTHROUGH TECHNOLOGY TO TRANSFORM ALGAE INTO OIL

Status and Next Steps

§ Single-Step Extraction:

- § Early 2010, launched pilot scale lab system (3-5gpm algae culture)
- § Mid-2010, launched mobile algae extraction system (ALGAEMAX) – on-site demos to interested algae companies.
- § First commercial sale to MBD Energy, Australia: Installation underway, completion expected by end November 2010.
- § Larger-scale deployments anticipated in 2011.
- § Ongoing discussions with OEMs.

§ Live Extraction:

- § Currently scaling up to 200-gallon tank system.
- § Testing productivity singly and in tandem with daily harvest and Single-Step Extraction.

§ Bio-Oil (Thermal Upgrading):

- § Of interest for long term direct-to-fuel applications.
- § OriginOil electro-flocculation process is a key enabler.
- § Ongoing techno-economic evaluations of selected technologies.



THANK YOU!

QUESTIONS?

INTEREST?

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