BIODIESEL FROM ALGAE

Jackie Huynh (ABE), John Mason (ABE), Yixi Kennedy (ABE), Blake Tutterow (ABE)

Introduction:

Going from algae to bio-fuel has the potential of removing our dependence on oil to a more renewable resource. This will allow us to have a cleaner and more sustainable environment. There is an abundance of research on different procedures for obtaining biodiesel from algae, from cultivation to extraction. Our objective is to develop a procedure for maximizing biodiesel production and to adapt this plan to a plant design.

Growth Kinetics:

Model:

$$\frac{dC}{dt} = \cdot - \cdot + \cdot - \cdot$$

$$\frac{dL}{dt} = \cdot \cdot + \cdot \cdot$$

$$\frac{dG}{dt} = -$$

$$r_{\bar{e}} = \frac{V}{K_{m,\bar{e}} +} \cdot$$

$$r_G = \frac{V}{K_{m,G} +} \cdot$$

$$f_{L/\bar{e}} = \cdot \left(\right)$$

$$f_{L/G} = \cdot \left(\right)$$

Variables and Parameters:

- C : cell concentration [g/L]
- L : lipid concentration [g/L]
- G : glucose concentration [g/L]
- $\bar{e}$: average light exposure [mol photon/L]
- $r_{\bar{e}}$: rate of light absorbtion [mol photon/L-h]
- r_G : rate of glucose uptake [g/L-h]
- $f_{L/\bar{e}}$: fraction of light energy used to produce lipids
- $f_{L/G}$: fraction of glucose energy used to produce lipids
- $Y_{C/\bar{e}}$: yield of new cells for a given amount of light [g cells/mol photon]
- $Y_{C/G}$: yield of new cells for a given amount of glucose [g cells/g glucose]
- $Y_{L/\bar{e}}$: yield of lipids for a given amount of light [g lipids/mol photon]
- $Y_{L/G}$: yield of lipids for a given amount of glucose [g lipids/g glucose]
- $V_{max,\bar{e}}$: max rate of light absorbtion [mol photon/g cells-h]
- $K_{m,\bar{e}}$: light absorbtion saturation constant [mol photon/L]
- $V_{max,G}$: max rate of glucose uptake [g glucose/g cell-h]
- $K_{m,G}$: glucose uptake saturation constant [g/L]
- $f_{L/\bar{e},0}$: uninhibited fraction of light energy used to produce lipids
- $L_{max,\bar{e}}$: maximum lipid levels for total inhibition, light as energy source [g/L]
- $n_{\bar{e}}$: order of lipid inhibition, light as energy source
- $f_{L/G,0}$: uninhibited fraction of glucose energy used to produce lipids
- $L_{max,G}$: maximum lipid levels for total inhibition, glucose as energy source [g/L]
- n_G : order of lipid inhibition, glucose as energy source

Key assumptions:

- Growth is in the "exponential" phase
- All cells are in the same "state"
- Cells do not die or consume lipids

Design Parameters:

Cultivation:

- Strain selection for lipid content and growth characteristics
- Light exposure
- Media content
- Reactor type

Separation:

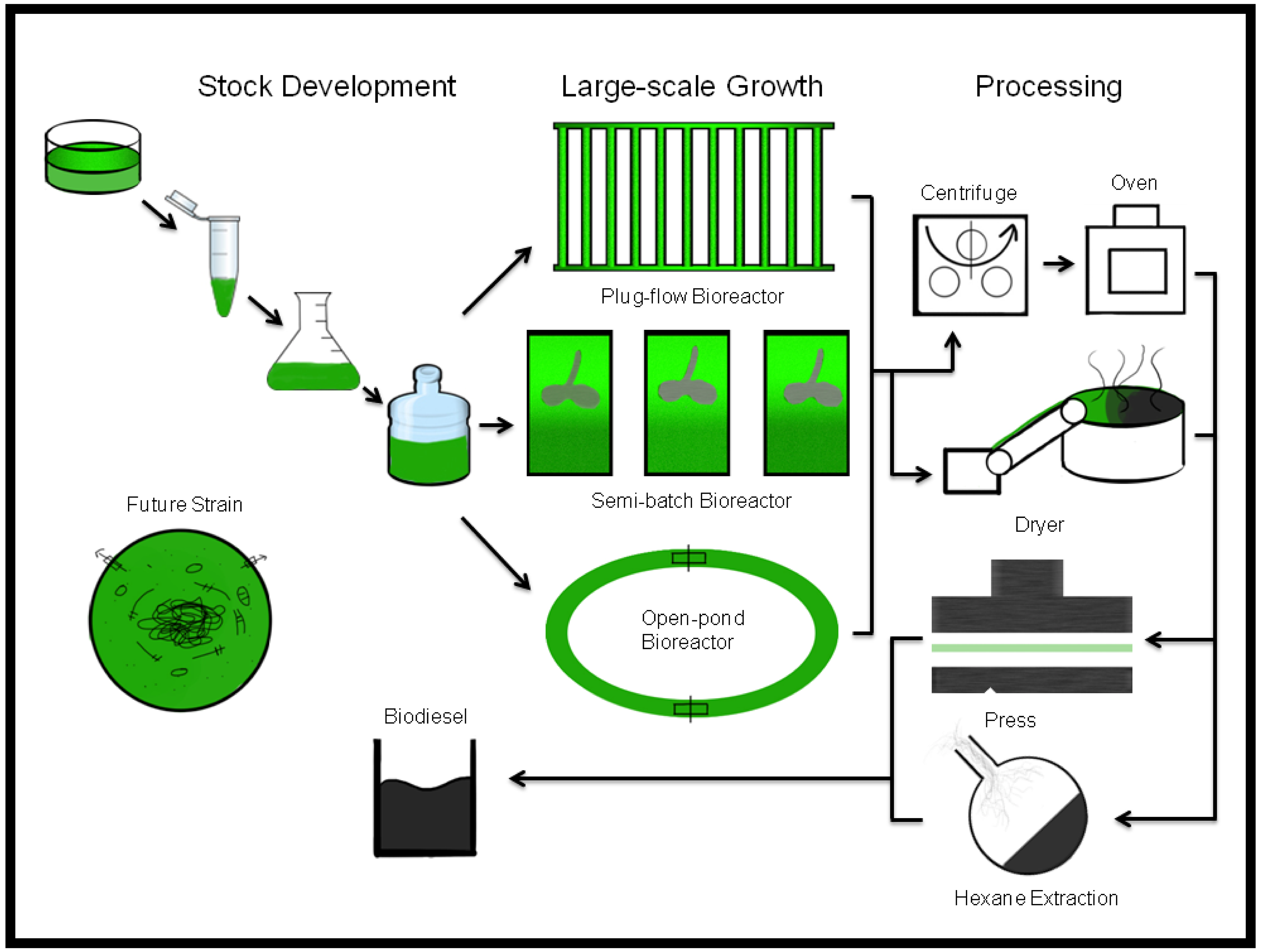
- Centrifugation or membrane separation

Drying:

- Batch (oven) or continuous (belt)

Extraction:

- Mechanical (press) or hexane extraction



Mass and Energy:

For this design we intend to match 5% of the total biodiesel production. This would require us to grow 375 tons of algae which would require 10 million gallons of media. Afterwards we could produce 16 thousand gallons of biodiesel, enough to take you from Purdue to San Francisco about 260 times in a Jetta TDI. The amount of energy place into making biodiesel yields a theoretical efficiency of 3.5 to 1. In terms of energy return is great, but on the other hand mass (water usage) efficiency is 0.9%. Thus, a significant consideration in the production of biodiesel is the impact and cost of the water utilized.

Budget:

The cost of the media alone is $3M/annum. Conservative production cost estimates are currently $30/gal, which would return $380k/annum. In comparison, diesel currently costs approximately $4/gal, one-sixth the cost of biodiesel production. Given current technology and the market value of diesel, it is not profitable to produce biodiesel from algae.

Future:

Through the use of genetic and metabolic engineering, it may be possible to modify algae to grow faster and to yield a higher lipid content. It may also be possible to engineer algae in such a way that it excretes excess lipids, or to modify another organism's metabolism to produce lipids that may be converted to diesel.

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