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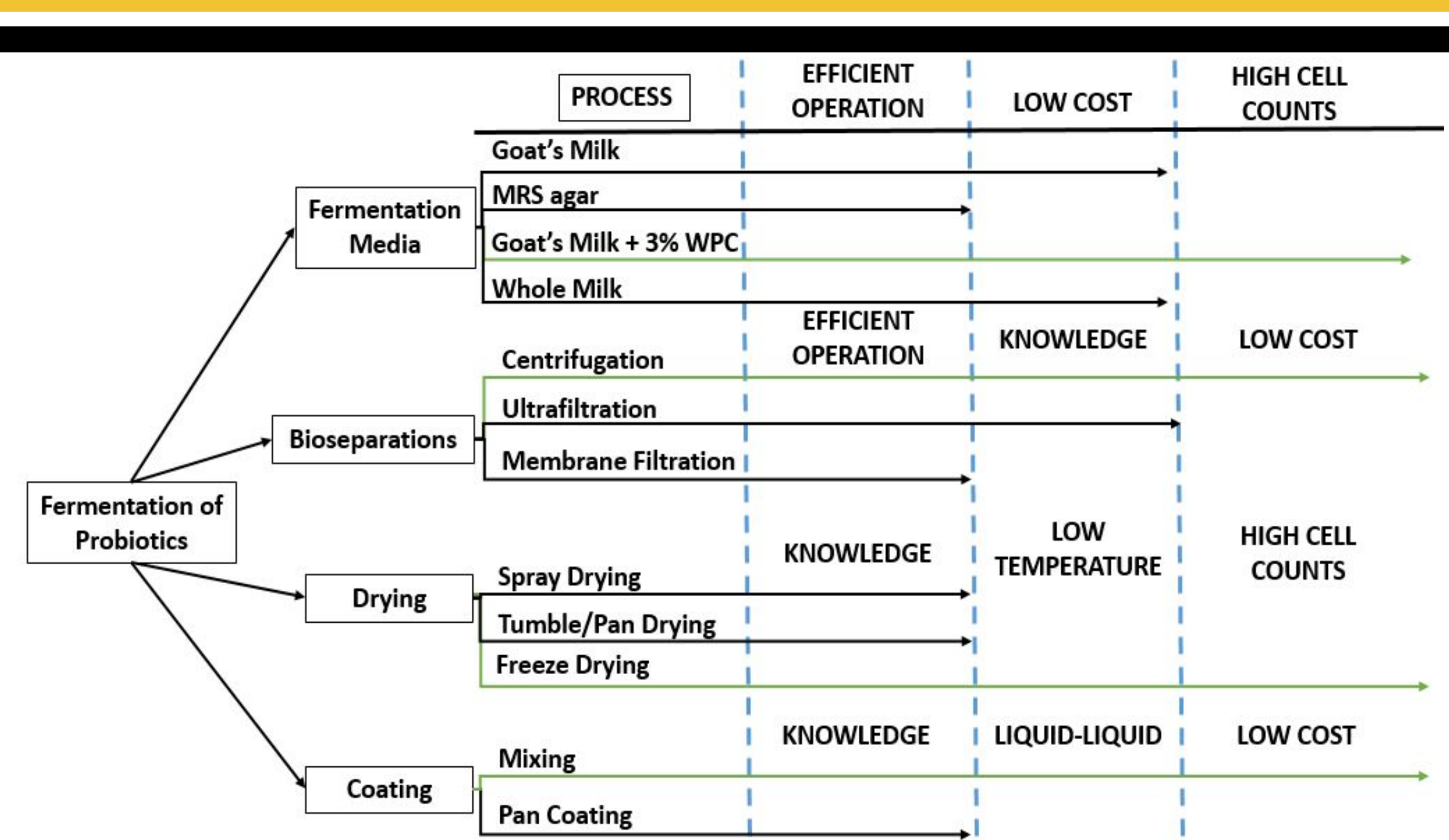
GOAL, OBJECTIVES, AND IMPACT

Goal: To create *L. rhamnosus* probiotic supplement with viability of 10^9 cfu/pill.
Objectives:
 - Grow *L. rhamnosus* with alternative media to 10^7 cfu/mL.
 - Concentrate and purify *L. rhamnosus* to 10^9 cfu/g.
 - Reduce fixed and variable cost of operation in order to develop and grow a profitable business.
Impact: Development of high viability, low price probiotic capsule as a nutritional and preventative dietary supplement.

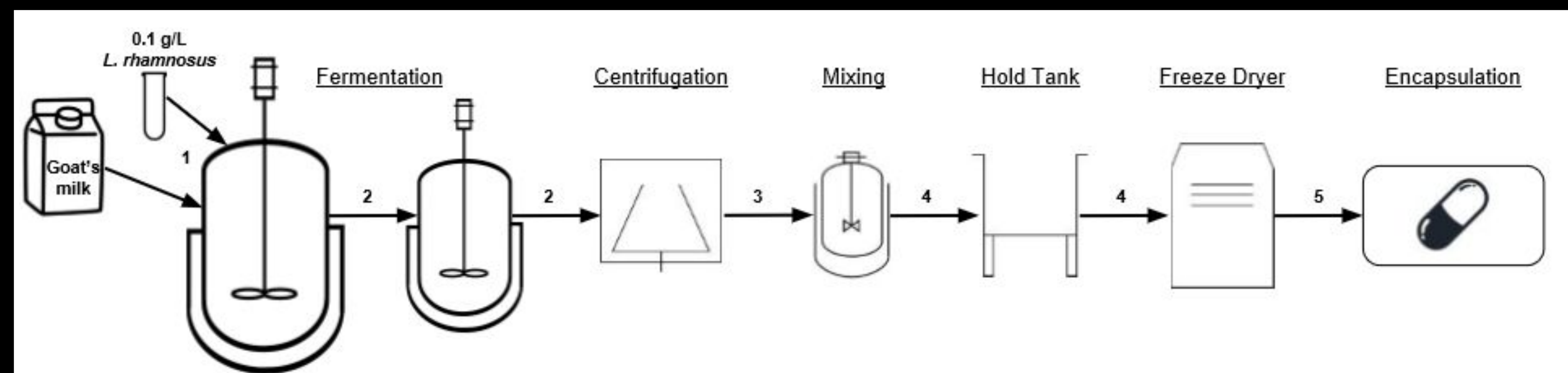
MARKET AND MARKET ANALYSIS

- Open global market, projected to grow at 7.4% CAGR through 2020
- The target demographics are millennials and generation X, 43% of population
- Fragmented market with top 5 competitors producing less than 40% revenue

MORPHOLOGICAL ANALYSIS

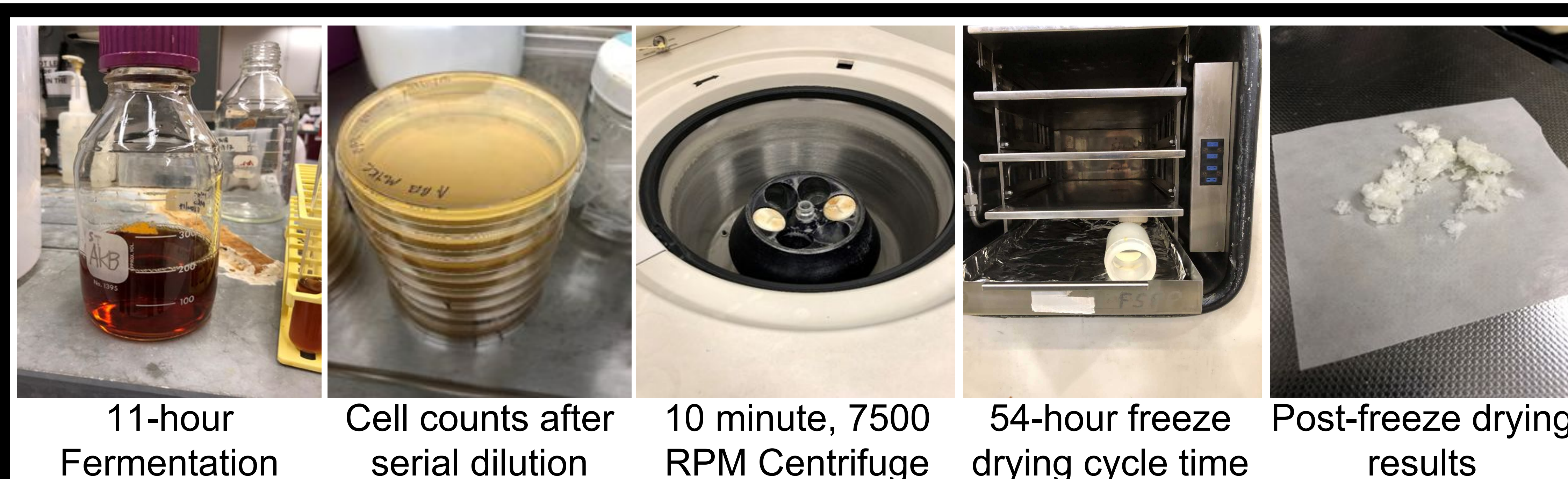


PROCESS FLOW DIAGRAM WITH COMPOSITIONS



Stream number	1	2	3	4	5
Mass flow (kg/hr)	1253.7	1253.7	166.3	228.5	2322.0 (kg/batch)
Protein (%)	3.39	3.0	22.5	16.4	32.3
Fats (%)	4.0	4.0	2.9	2.1	4.2
Ash (%)	0.8	0.8	6.0	4.4	8.6
Water (%)	87.0	87.0	32.7	50.2	2.0
Carbs (%)	4.8	4.4	30.1	22.7	44.6
Cells (%)	0.01	0.8	5.8	4.2	8.3

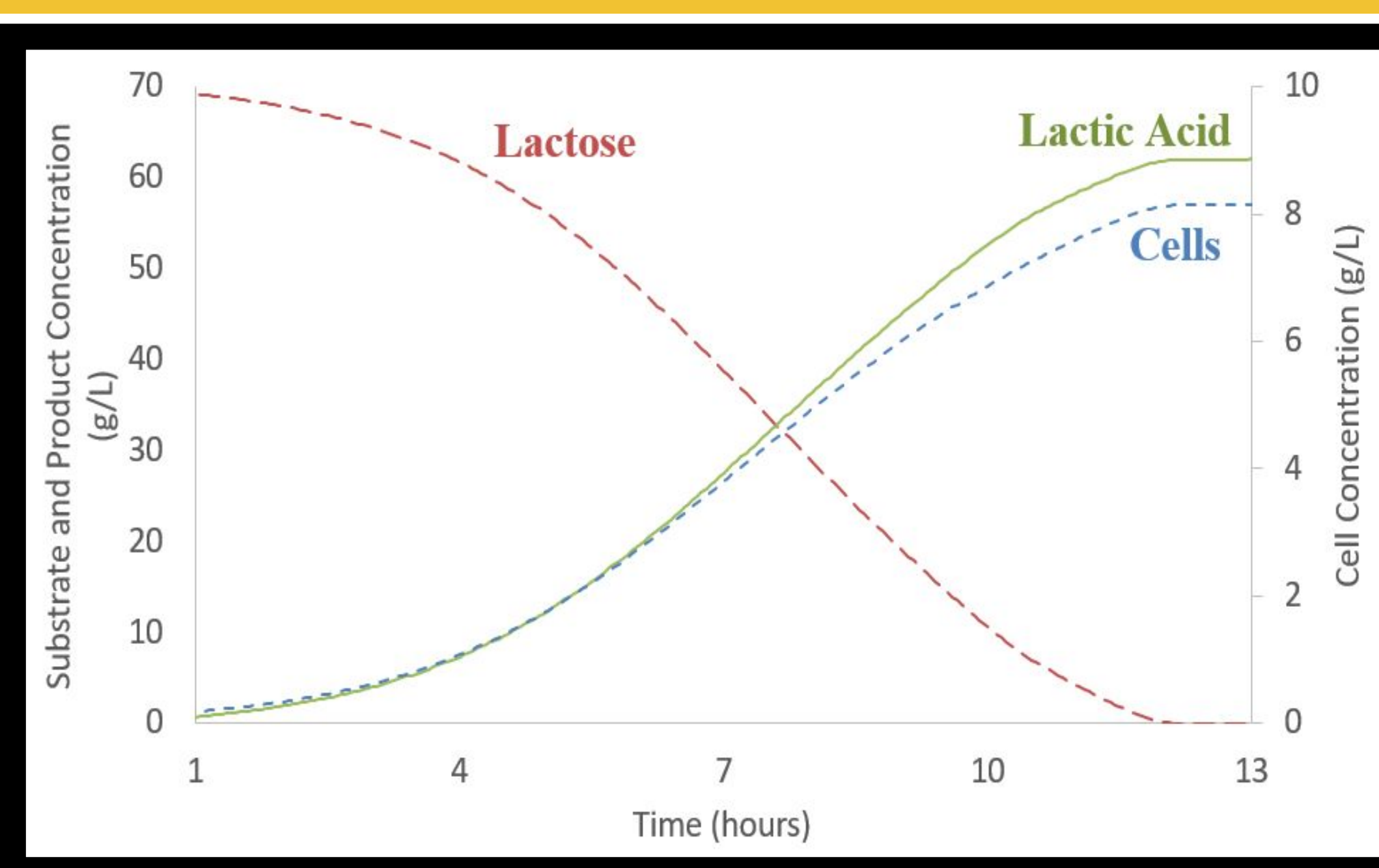
EXPERIMENTAL RESULTS



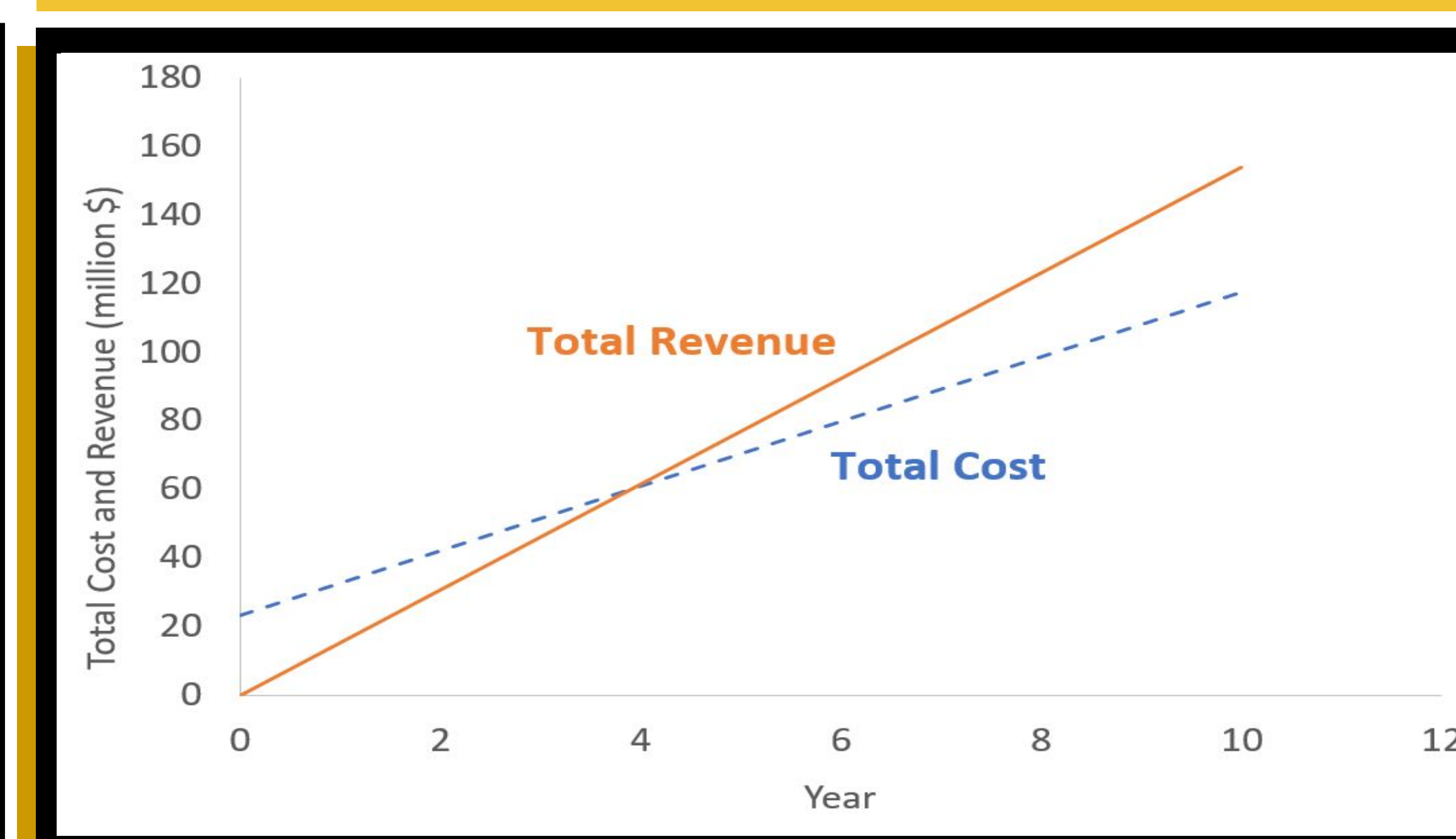
OPTIMIZATION

Unit Operation	Optimization Variable	Minimized Parameter
Heat Exchanger	Water Temp.	TAC
Centrifuge	Diameter	TAC
Mixer	Tank Diameter	TAC
Freeze Dryer	Drying Area	TAC

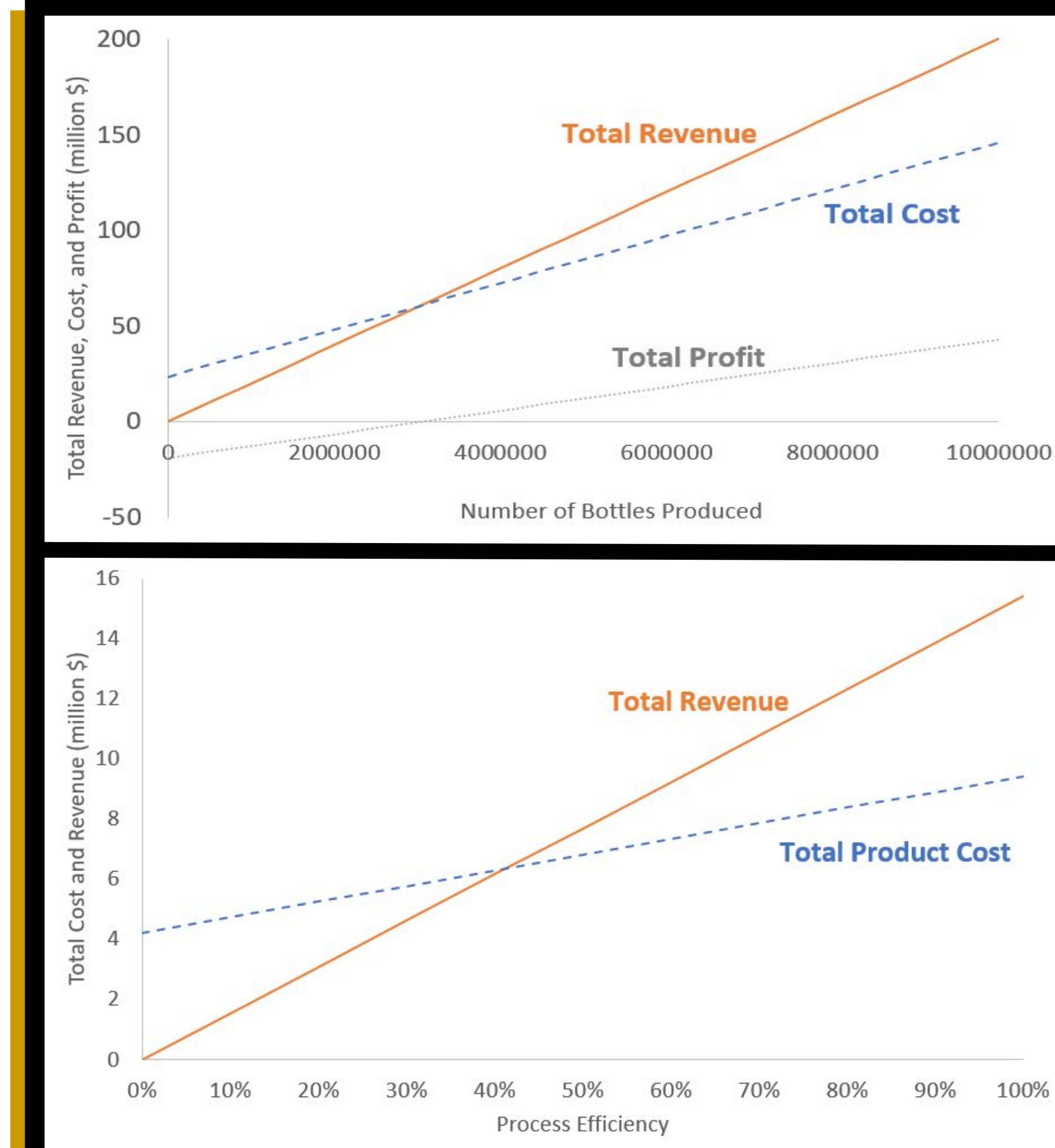
FERMENTATION TIME COURSE



BREAKEVEN CHART



ECONOMIC SUMMARY



TCI (million \$)	23.46
TPC (million \$/year)	9.42
Fixed Cost (% TPC)	11.3
Production (10 ⁵ bottles/year)	7.69
Product Cost (\$/bottle)	12.24
Product Price (\$/bottle)	20
Total Revenue (million \$/year)	15.39
Total Profit (million \$/year)	4.42
Breakeven Point (years)	3.93

SWOT ANALYSIS

Strengths	Weaknesses	Opportunities	Threats
<ul style="list-style-type: none"> - Limited FDA regulation in supplement industry (i.e. lower cost) - High profit margins relative to food industry 	<ul style="list-style-type: none"> - High cost of downstream processing (93% of total equipment cost) - Reliance on robustness of single strain <i>L. rhamnosus</i> 	<ul style="list-style-type: none"> - Expanding global probiotic market (\$46.6 billion in 2020) - Large future product pool, including other probiotic strains and prebiotics 	<ul style="list-style-type: none"> - Improvements in unit operations with lower cost (i.e. spray drying) - Subject to increased industry regulation in the future

ASSESSMENT AND FUTURE RECOMMENDATIONS

- Investigate enteric coating, encapsulation techniques, and excipients to elongate cell viability
- Vary fermentation media and times to maximize cell counts (while maintaining pH above 4.6)
- Experiment with *L. acidophilus* and *L. casei* to optimize fermentation results
- Incorporate alternative unit operations (i.e. spray drying and ultrafiltration)
- Determine optimal location based off manufacturing and distribution costs
- Investigate potential for future growth in the Food & Beverages and animal feed sectors

References:
 (1) Probiotics: In Depth. (2016, October). Retrieved November 15, 2017, from <https://nccih.nih.gov/health/probiotics/introduction.htm>.
 (2) Probiotics Market Size, Market Share & Forecast, 2017 – 2024. (2017, September). Retrieved April 12, 2018, from <https://www.gminsights.com/industry-analysis/probiotics-market>.
 (3) Regier, M., Knörzer, K., & Erle, U. (2004). Mikrowellen- und Mikrowellen-Vakuumtrocknung von Lebensmitteln. *Chemie Ingenieur Technik*, 76(4), 424-432. doi:10.1002/cite.200400066.

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