Technoeconomic analysis of single-cell food protein production from probiotic bacteria

Overview

1. Introduction
2. Background
3. Protein Synthesizers
4. Protein of Interest
5. Process Outline
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   - Downstream
6. Cost Analysis
7. INEST Experience

THE UNIVERSITY OF TENNESSEE CHATTANOOGA
College of Engineering and Computer Science

Introduction

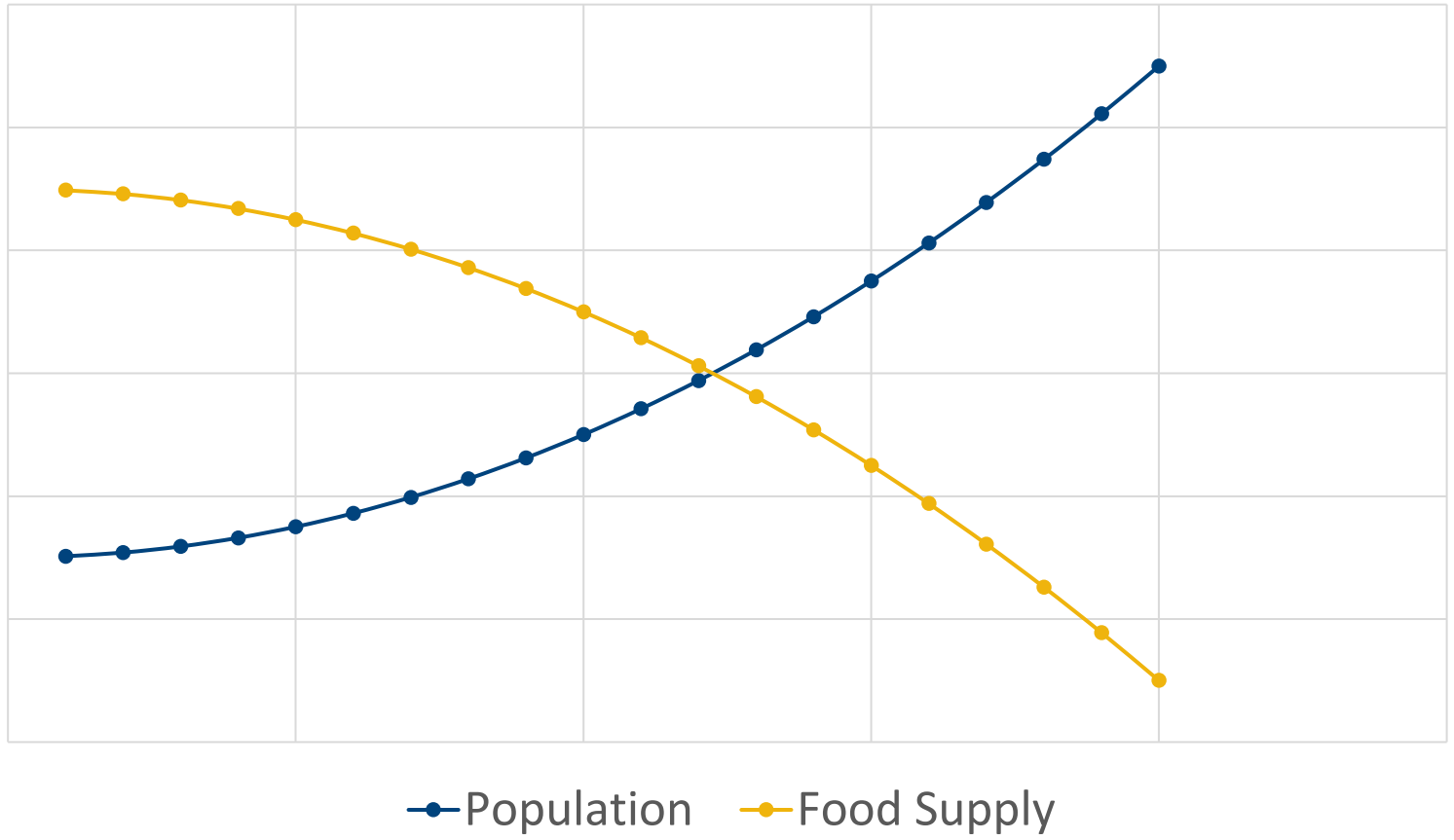
iNEST A USDA-NIFA FUNDED PROJECT AT UTC | USDA | NIFA

Food Sustainability

- Population vs Food Supply
- The Current Global Economy
- Indirect Effect On Land
- Developed vs Underdeveloped

Methods of Action

- Indirect vs Direct
- Manipulation of Food Supply
- Enhance Food Supply
- Global Impact



[1] Mason, A., Lee, R., Six Ways Population Change Will Affect the Global Economy. Population and Development Review, 2022, 48: 51-73.

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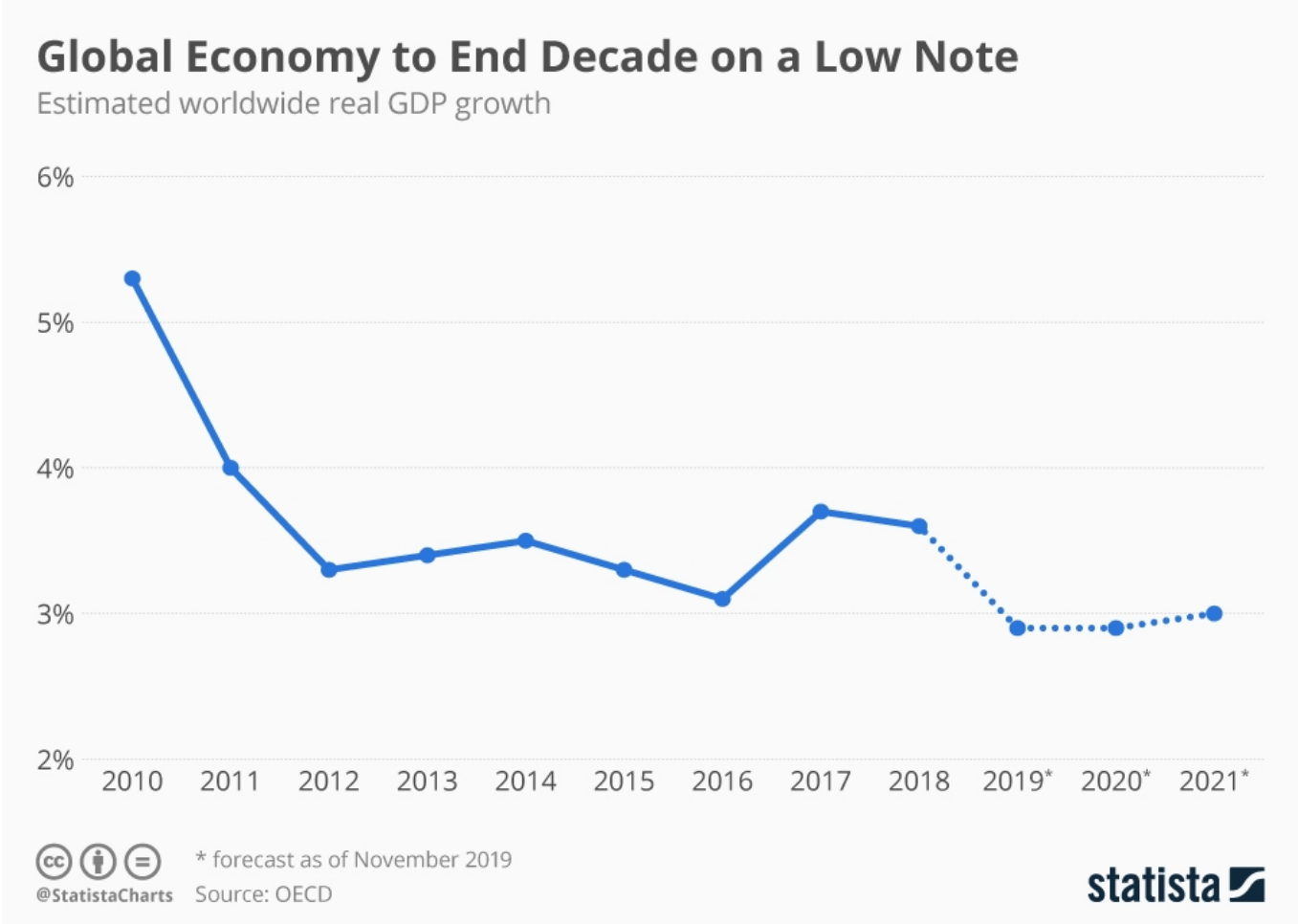

Figure 1

[2] https://cdn.statcdn.com/Infographic/images/normal/20078

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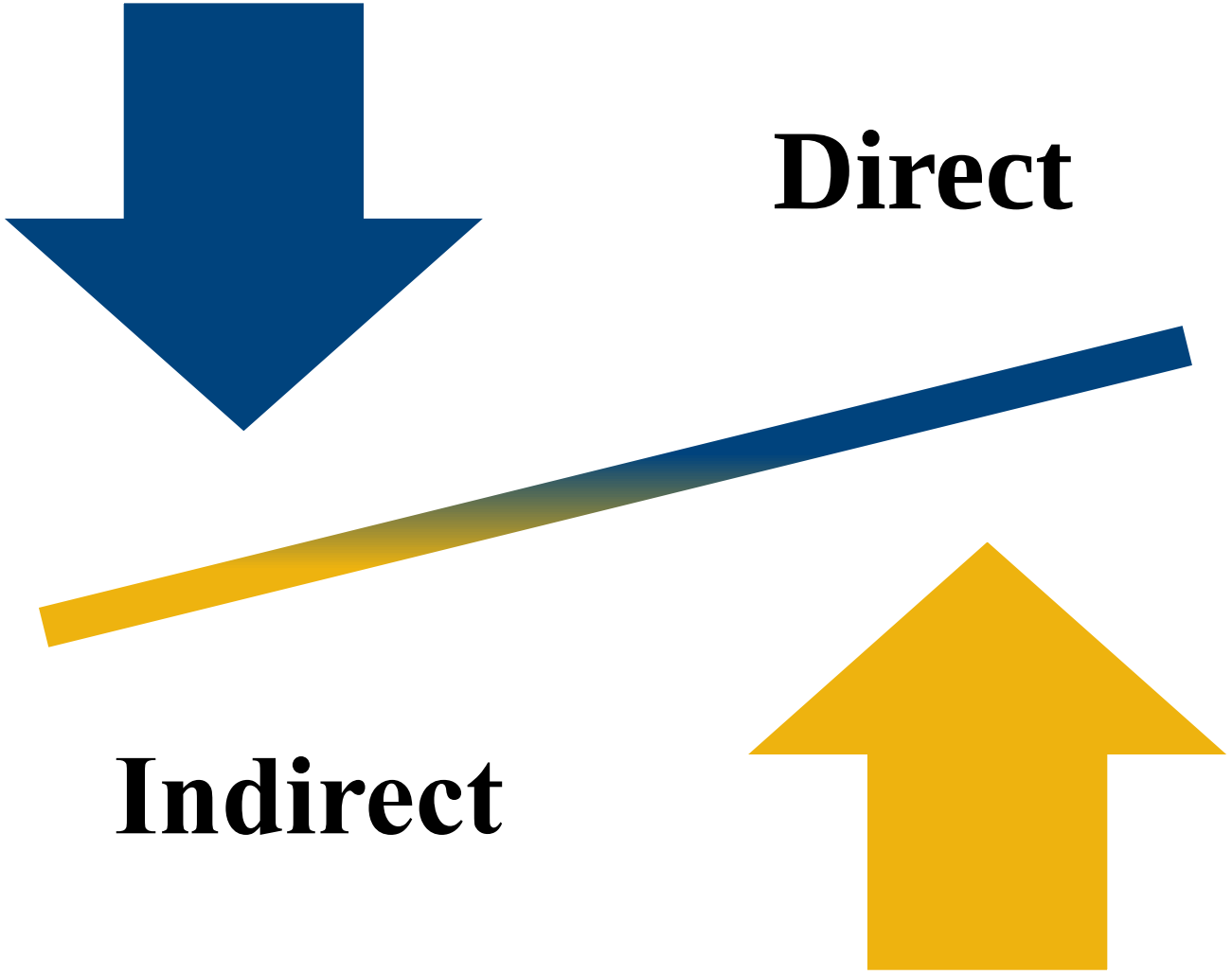


Background

Proteins

- Components of Life
- Inability to Synthesize
- Exterior Source

Protein Synthesizers

- Intracellular vs Extracellular
- Production Approach
- Microorganisms

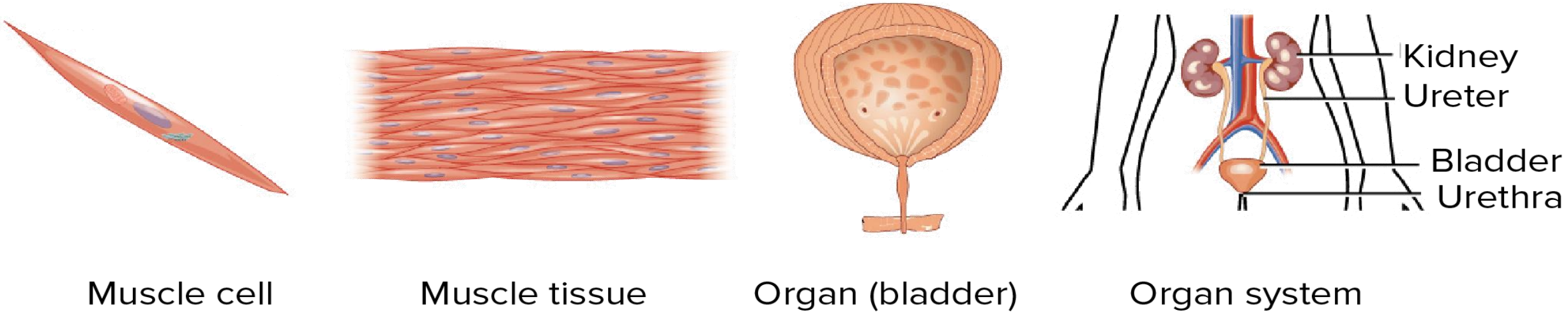
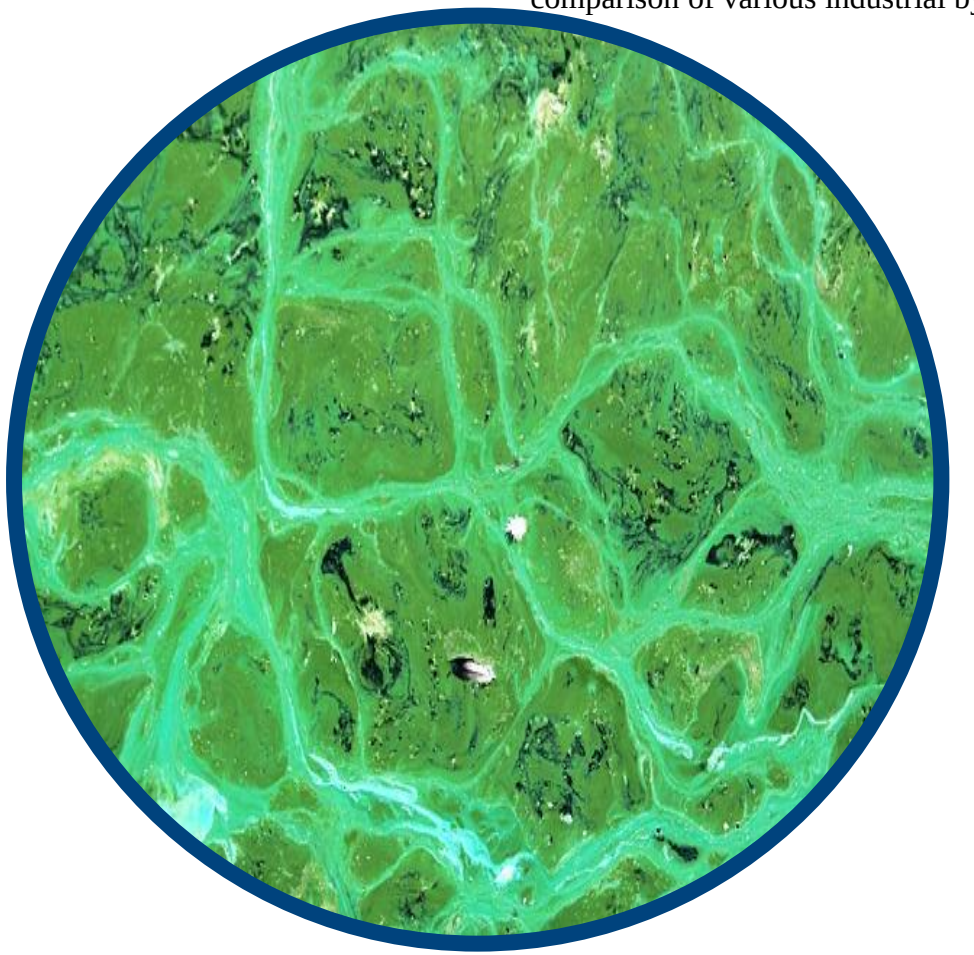


Figure 2

[3] https://cdn.kastatic.org/ka-perseus-images/

Protein Synthesizers

[4] Spalvins, K.; Zihare, L.; Blumberga, D.; Single cell protein production from waste biomass: comparison of various industrial by-products. *Energy Procedia.* **2018**, 147, pp. 409-418.



Photosynthetic

Protein Synthesizers

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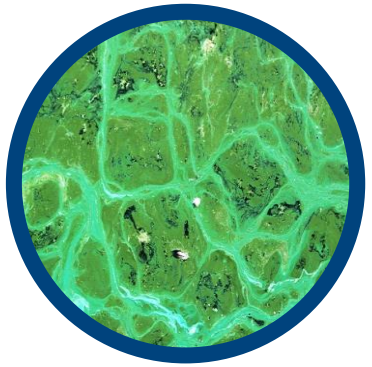

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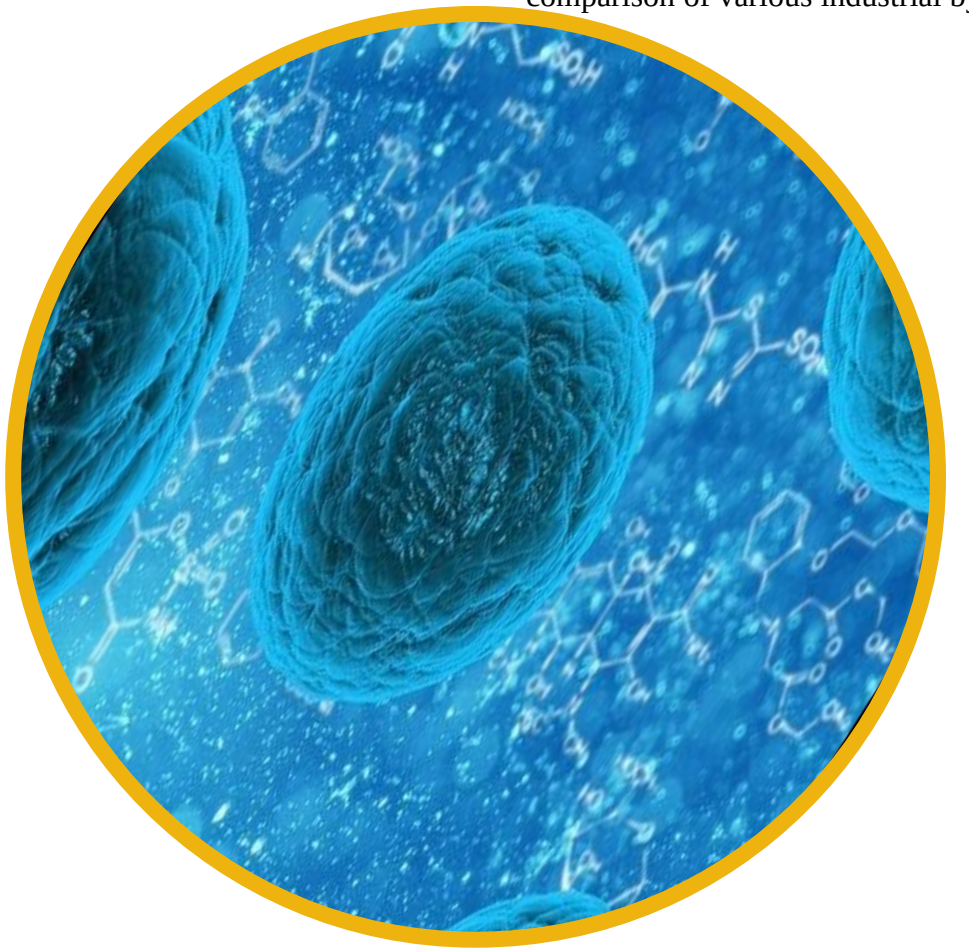
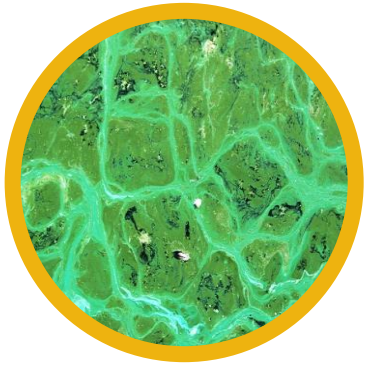


Polymer Source

Protein Synthesizers

[5]Vrati S. Single cell protein production by photosynthetic bacteria grown on the clarified effluents of biogas plant. Appl Microbiol Biotechnol 1984;19:199–202.



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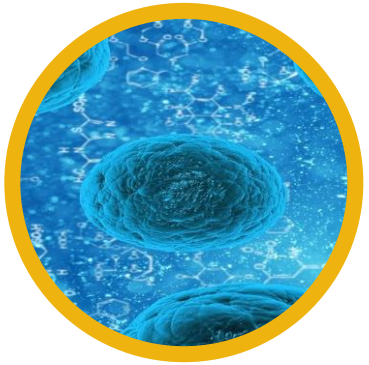


Polymer Source

Carbon Source

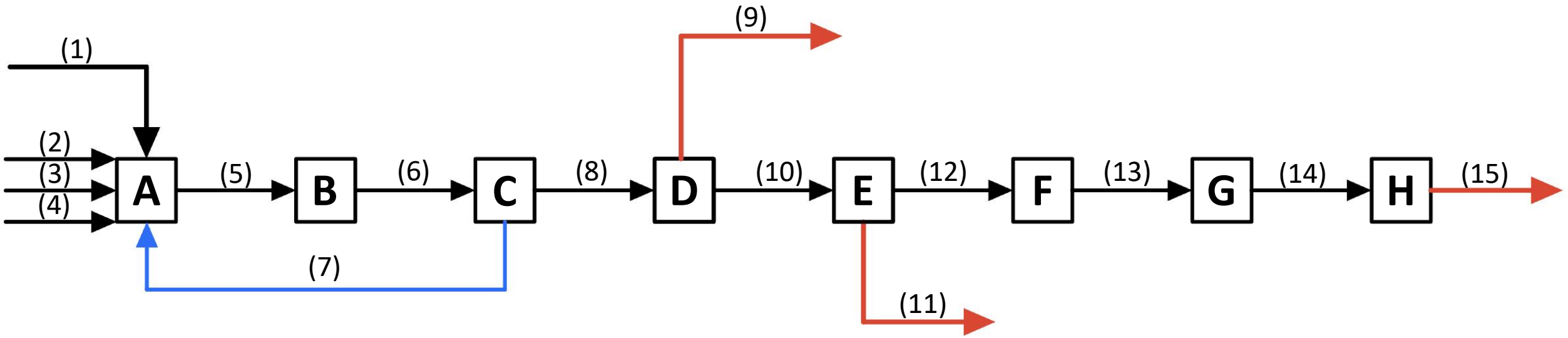
Protein of Interest

Methylophylus Methylotrophus

- Obligate Methylotroph
- Widely Available Carbon Source
  - Selectivity
  - Low Toxicity
  - Volatility
- High Growth Rate
- Production of Lysine

[6] Gunji, Y., Tsujimoto, N., Shimaoka, M., Ogawa-Miyata, Y., Sugimoto, S., and Yasueda, H.: Characterization of the L-lysine biosynthetic pathway in an obligate methylotroph, Methylophilus methylotrophus. Biosci. Biotechnol. Biochem., 68, 1449–1460 (2004).

Process Outline



A Bioreactor

B Flocculation

C Filtration

D Cell Lysis

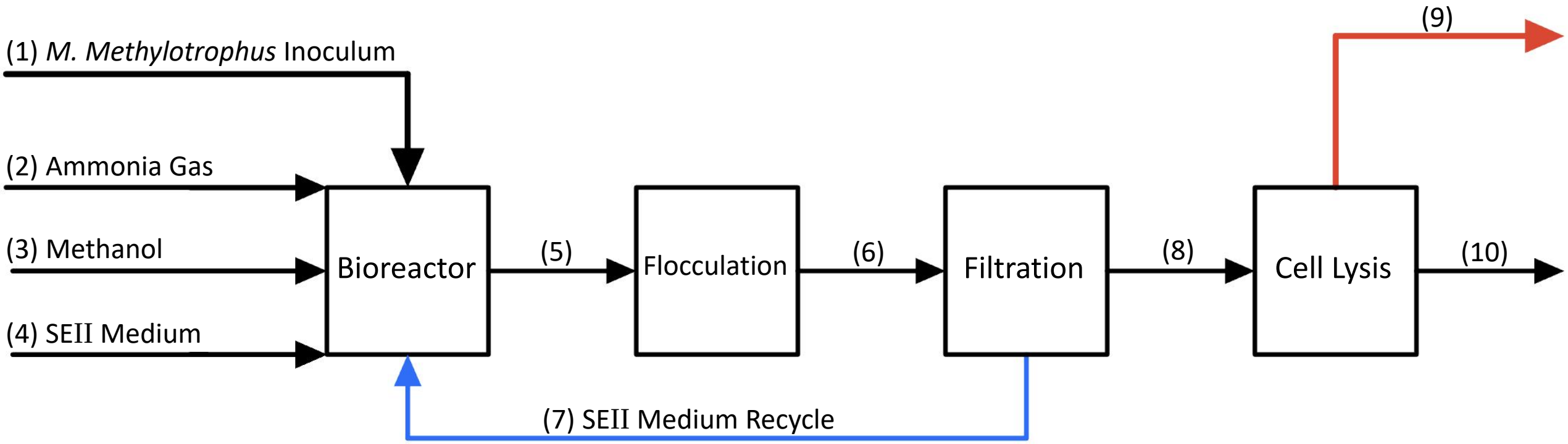
E Ultrafiltration

F Ion Exchange Separation

G Macro porous Resin Colum

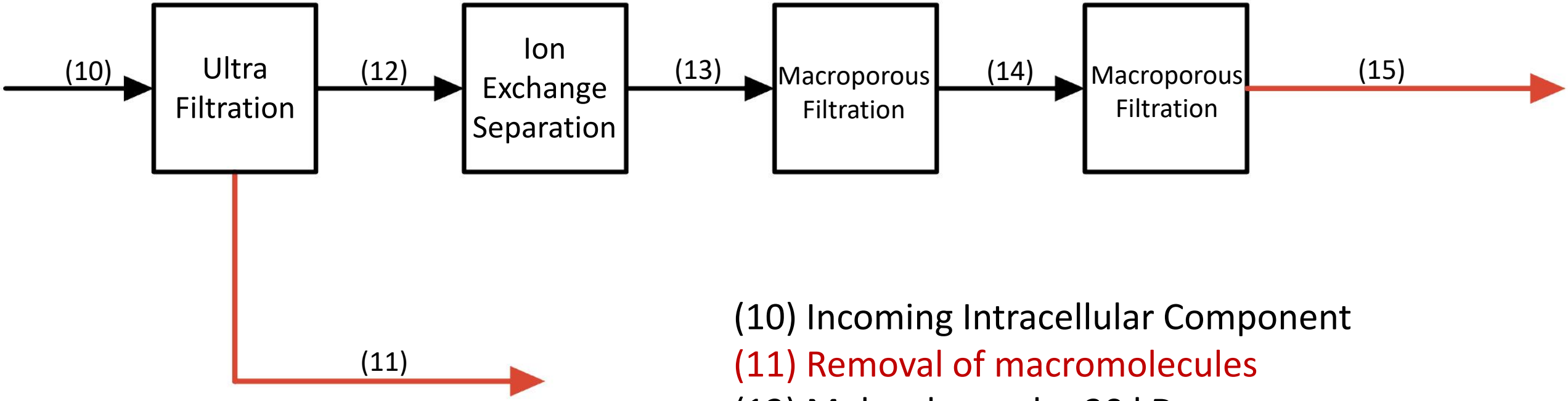
H Macro porous Resin Colum

Upstream Processes



(1) *M. Methylotrophus* Inoculum
(2) Ammonia Gas
(3) Methanol
(4) SEII Medium
(5) Reactor Fluid Translation
(6) Flocculation of Bacteria
(7) Recovered Medium for Recycle
(8) Bacterial Cell Translation
(9) Extracellular Components Removed
(10) Intracellular Component Translation

Downstream Processes



(10) Incoming Intracellular Component
(11) Removal of macromolecules
(12) Molecules under 30 kDa
(13) Separation by Charge
(14) Refinement of Lysine
(15) Further Refinement of Lysine

Cost Analysis

- Daily Requirement of 235 $\frac{\text{kg}}{\text{batch}}$
- Lab Scale Estimate of $21 per kg
- Cost of Materials is estimated as $4935 per batch
- Current Market of $4.88 per 100g
- Theoretical maximum profit of $11468 per batch
- Distribution of Profit
  - 45% Cost of Materials
  - 25% Labor
  - 20% Packaging and Distribution
  - 10% Gain

INEST Experience

- Nutritional Value
- Metabolic Pathways
- Food Processing
- Method of Sanitation
- Comparison to Cosmetic Processing

- Pharmaceutical Career Path
- Exploration of clean energy production modeled after the symbiotic relationship between the biochemical pathways of photosynthetic organisms and heterotrophs

Any Questions?