

# *Gas Fermentation at Calysta*

**Intro for REMEDY workshop  
October 20, 2020**

**CALYSTA**

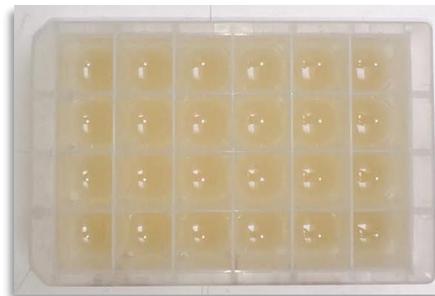
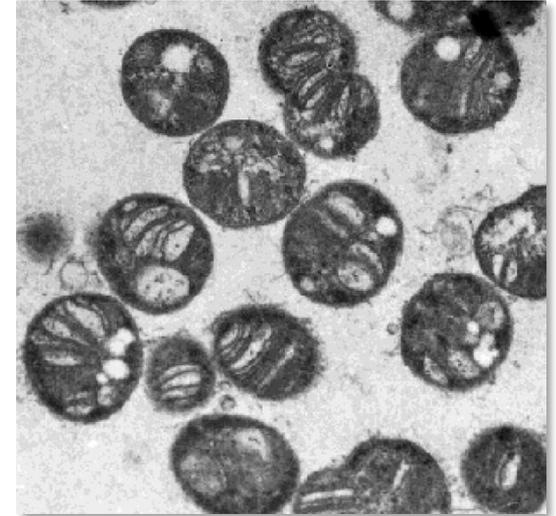
# Gas Fermentation is the Next Step in Industrial Biotech

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- Lower cost feedstocks are needed for biological products to compete with petroleum derivatives
- C1 feedstocks ( $\text{CH}_4$ ,  $\text{CO}$ ,  $\text{CO}_2$ ) are accepted to be among the cheapest sources of carbon
- C1 feedstocks are generally pollutants, with significant safety and solubility issues compared to traditional biofeedstocks
- Calysta owns the world's only commercially-validated gas fermentation technology allowing use of C1 feedstocks

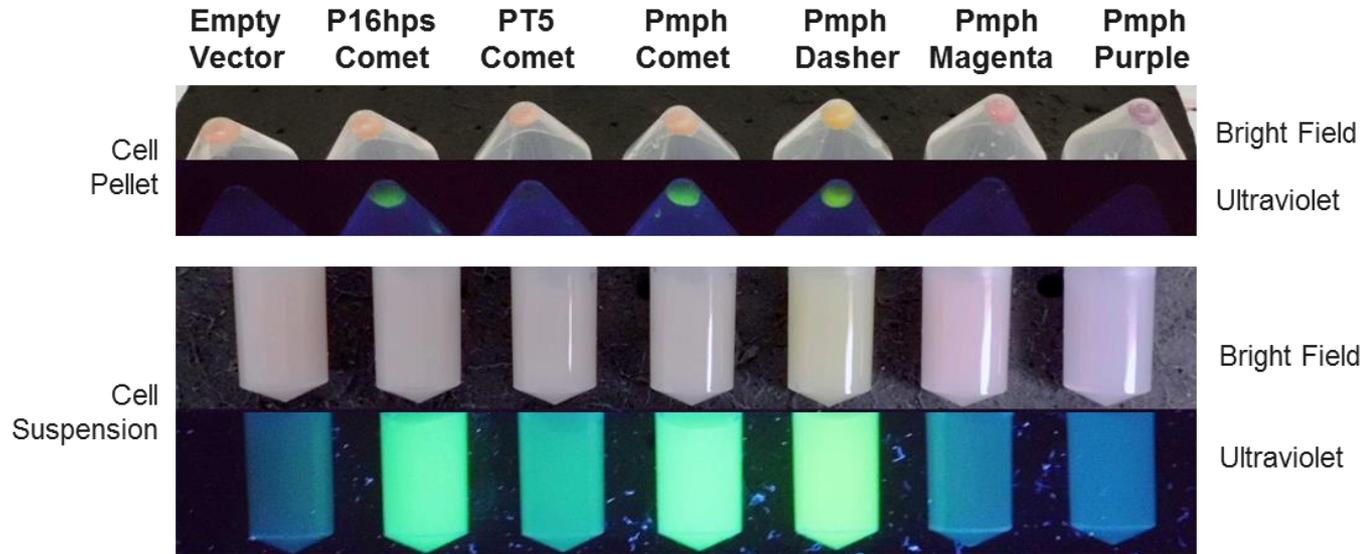
## *Methylococcus capsulatus* Bath

- Gammaproteobacteria, type I methanotroph
- Relatively fast growth rate (methane:oxygen mix)
- Genome sequence available
- Amenable to genetic manipulation
- Only methanotroph proven at commercial scale
- Variety of formats for strain testing: well plates, pressure bottles, 2L fermenters
- Amended media and optimized feeding strategies produce high cell densities in small scale.



## Calysta has developed a set of novel engineering tools for methanotrophs:

- Reporter genes

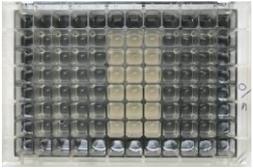


Different promoter gene-fusions with synthetic fluorescent and chromogenic proteins (non-*Aequorea*) expressed in *M. capsulatus*

- Plasmids that replicate both in methanotrophs and in *E. coli*
- Constitutive and inducible (low/med/high) promoters
- Techniques for chromosomal knockin and knockouts

# Calysta Performs Methanotrophic Fermentation at All Scales

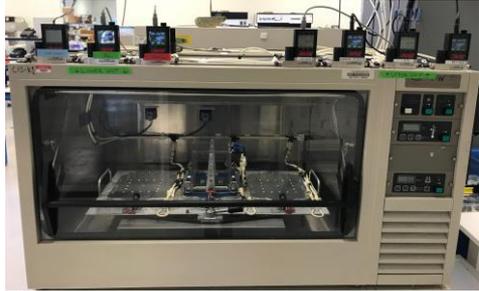
**CALYSTA**



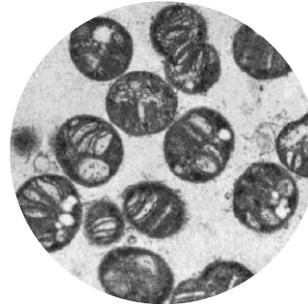
Fermentors



TPP



High Throughput



Nanjing Demo Lab



China Plant



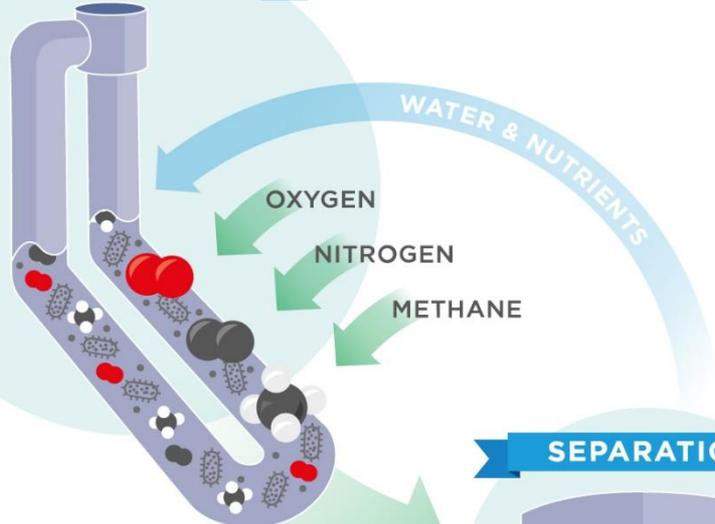
NorFerm Commercial Plant



# Calysta FeedKind Production Process

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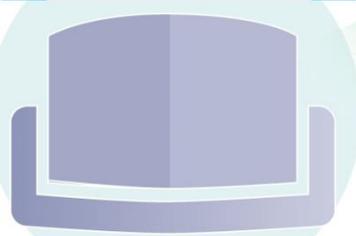
## FERMENTATION



### STEP 1

Gases are mixed in a proprietary fermenter where they are consumed by Calysta's natural microorganisms, which form the basis of **FeedKind** protein

## SEPARATION



### STEP 2

**FeedKind** protein is separated from the aqueous media in which it is grown, with water and nutrients returned back to the fermenter

## DRYING AND PACKAGING



### STEP 3

**FeedKind** protein is dried and packaged per customer specifications

## DISTRIBUTION



### STEP 4

Products are shipped to be fed to fish and livestock worldwide

# FeedKind Protein Commercial Samples Shipping Worldwide from Teesside UK Plant

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- Production of ~50 tons/year
- Shipping commercial samples to customer and partners worldwide
- Facility is a “scale-down” of the original Tjeldbergodden, Norway reactor, demonstrated to produce at a rate of 10,000 mtpa
- Successful maintenance of 12+ weeks of continuous fermentation, exceeding design parameters for key commercial metrics such as yield and productivity
- Partnered with Center for Process Innovation (“CPI”) to provide on site services and well trained staff



*Fermenter in Teesside, England.*

# FeedKind® is a Natural, Non-GMO Protein Source

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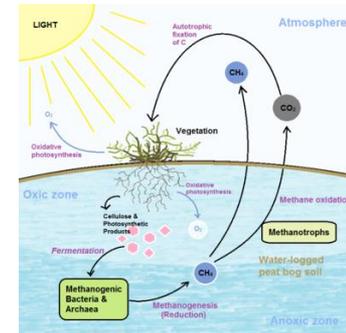
FeedKind Protein is composed of naturally occurring microorganisms that metabolize methane as their sole source of carbon and energy, producing a nutritious, high-protein biomass

- ✓ *FeedKind is a non-GMO source of protein obtained by natural fermentation*

## EU Register of Feed Ingredients, 2017

12.1.2	Product from <i>Methylococcus capsulatus</i> (Bath), <i>Alca ligenes acidovorans</i> , <i>Bacillus brevis</i> and <i>Bacillus firmus</i> rich in protein (1) (2)	Fermentation product obtained by culture of <i>Methylococcus capsulatus</i> (Bath) (NCIMB strain 11132), <i>Alcaligenes acidovorans</i> (NCIMB strain 13287), <i>Bacillus brevis</i> (NCIMB strain 13288) and <i>Bacillus firmus</i> (NCIMB strain 13289) on natural gas (approx. 91 % methane, 5 % ethane, 2 % propane, 0,5 % isobutane, 0,5 % n-butane), ammonia, and mineral salts, the crude protein is at least 65 %.	Crude protein Crude ash Crude fat Propionic acid if > 0,5 %
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- ✓ *Approved in the EU, Japan and Australia*
- ✓ *Can be used in Canada and in the Philippines*
- ✓ *On-going regulatory process in the USA*
- ✓ *Additional countries in process*



# Calysta Commands a Leading IP Position, Creating Significant Barriers-to-entry

**CALYSTA**

- **>50 granted** patents with **over 100 pending** applications covering more than **22 patent families**
- Strong claims covering proprietary reactor design that have already invalidated one potential competitor's patent
- Broad claims granted in 2016 covering biological production of any chemical from natural gas
- Aggressively filing on new gas fermentation reactor designs and improvements with 4 new issued patents and 15 applications in the area
- 38 pending applications in the area of animal feed