History of Norwegian Kveik Cultures and a Few Words on Cell Counts

Mark Schwarz

OMEGA YEAST

What does Omega Yeast do?

- Propagate and ship brewing yeast and bacterial cultures for microbreweries and home brewers all over the US (and some international).
- Basic differential plating-based contamination testing of beer samples.
- Advice on strain selection and fermentation parameters.
- Proprietary strain banking and propagation.

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History of the Company

- Founded in 2013 by Lance Shaner and myself
  - Lance received Ph.D. in Microbiology & Molecular Genetics from UT-Houston Graduate School of Biomedical Sciences
- First culture sold in June 2013
- First employee hired in May 2014
- Started in 1100 sq ft space, now occupy 10,000 sq ft building

What is Kveik?

- Norwegian dialect word for “yeast”
- Traditional Norwegian farmhouse cultures passed on for generations
- Brought to the attention of the brewing world by blogger Lars Marius Garshol (Larsblog)
- Generally speaking, the cultures are high temp tolerant, flocculent, non-phenolic and high alcohol tolerant.
- Norwegian brewers regularly push temps to 100F!

Hallmarks of Norwegian Farmhouse Brewing Tradition

- Juniper-infused mash water, long boils, little hop character
- Rapid fermentation (1-2 days) of high gravity (~19P) wort
- Yeast stored dry on kveikstokker (yeast logs)
- Kveikstokker used to inoculate next batch by dipping in 86-104F (30-40C) wort(!)
- In one region of Norway, they scream into the fermenter as yeast is being pitched

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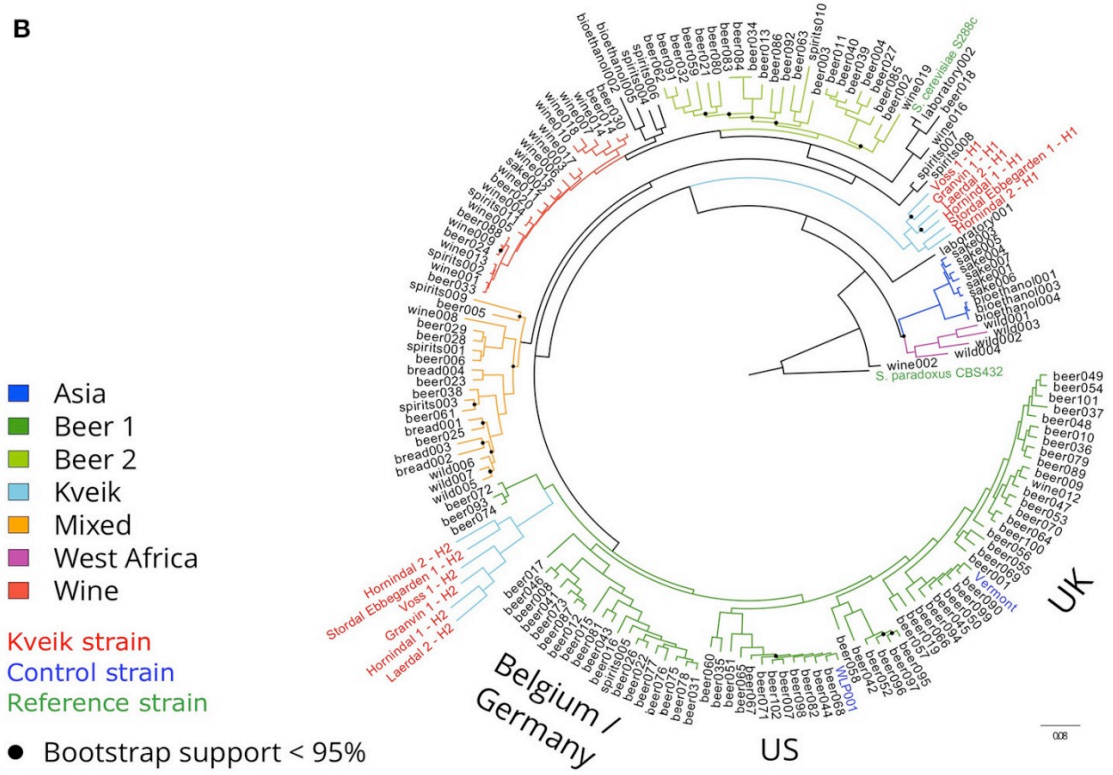
Where do Kveik fit in the world of brewing yeast?



Preiss et al, Frontiers in Microbiology, 2018

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TABLE 6 | Thermotolerance and ethanol tolerance in kveik yeasts.

	Temperature (°C)				Ethanol (% v/v)			
	30	**40**	**42**	**43**	**10**	**12**	**14**	**16**
WLP570	2.00	1.80	0.51	0.39	1.84	0.50	0.41	0.37
WLP001	1.93	0.14	0.13	0.12	0.80	0.48	0.34	0.14
WLP002	1.90	0.21	0.11	0.11	0.56	0.11	0.11	0.10
WLP029	1.96	0.17	0.11	0.11	0.50	0.40	0.10	0.10
Granvin 1	1.86	**1.53**	0.42	0.35	**1.18**	0.42	0.10	0.10
Granvin 2	1.92	**1.40**	**0.36**	**0.28**	**1.44**	0.55	0.45	0.25
Granvin 3	1.95	**1.53**	0.45	**0.31**	0.72	**0.27**	0.12	0.10
Granvin 4	1.87	**1.53**	0.23	**0.15**	0.70	0.38	**0.21**	0.10
Granvin 5	1.91	0.13	0.10	0.13	0.40	0.11	0.10	0.10
Granvin 6	1.84	1.74	0.41	0.40	**1.63**	0.46	0.42	0.19
Granvin 7	1.82	**0.70**	**0.31**	**0.25**	0.74	0.33	0.16	0.10
Granvin 8	1.84	0.14	0.13	0.13	0.62	0.21	0.10	0.10
Granvin 9	1.84	**0.84**	0.44	**0.22**	0.77	0.25	0.10	0.10
Hornindal 1	1.84	1.76	0.41	0.35	**1.39**	0.48	**0.30**	**0.27**
Hornindal 2	1.88	1.67	**0.33**	**0.26**	**1.12**	0.40	**0.32**	**0.22**
Hornindal 3	1.93	**1.49**	0.22	**0.19**	**1.47**	0.48	**0.27**	**0.29**
Joniskelis	1.88	**1.62**	0.56	**0.30**	1.70	0.62	**0.54**	0.37
Laerdal 1	1.83	**1.70**	0.48	0.44	1.79	0.50	0.40	0.33
Laerdal 2	1.86	**1.21**	0.45	0.33	**1.39**	0.47	0.39	**0.24**
Muri 1	1.96	**0.51**	**0.33**	0.30	0.93	0.47	0.49	**0.21**
Stordal Ebbegarden 1	1.81	**1.41**	**0.36**	**0.29**	0.73	0.47	0.47	0.34
Stordal Ebbegarden 2	1.91	**0.32**	**0.25**	**0.21**	0.72	0.39	0.27	0.10
Stordal Framgarden 1	1.97	1.64	**0.29**	**0.25**	**1.39**	0.60	0.41	0.32
Stordal Framgarden 2	1.84	1.72	**0.28**	**0.19**	**1.47**	0.61	0.44	0.33
Stranda	1.86	1.48	0.16	**0.18**	**1.14**	0.45	0.33	0.13
Sykkylven 1	1.87	1.78	0.46	**0.30**	1.70	0.51	**0.31**	**0.20**
Sykkylven 2	1.83	1.26	**0.26**	**0.26**	**1.01**	0.50	0.28	0.16
Voss 1	1.83	1.84	0.70	**0.30**	1.79	0.56	0.39	**0.22**
Voss 2	1.97	1.82	0.60	**0.24**	1.79	0.58	0.47	0.19

	Ethyl Acetate	Ethyl Caproate	Ethyl Caprylate	Ethyl Decanoate	Ethyl Nonanoate	Hexanoic Acid	Isoamyl Acetate	Isoamyl Alcohol	Isobutanol	Phenethyl Acetate	Phenethyl Alcohol	4-Vinyl Guaiacol
Granvin 1	1.715	0.156	2.512	0.494	0.161	0.023	0.674	6.79	1.324	1.052	19.694	0.058
Granvin 2	3.118	0.366	4.555	0.455	0.197	0.01	0.781	7.879	1.527	1.87	21.603	0.012
Granvin 3	1.492	0.122	1.159	0.013	0.143	0.002	0.744	7.506	2.282	0.36	17.216	0.014
Granvin 4	1.195	0.059	0.232	0.012	0.025	0.004	0.467	4.719	1.126	0.257	15.163	0.043
Granvin 5	2.231	0.116	1.666	0.08	0.149	0.008	0.933	9.432	2.175	0.749	28.262	0.016
Granvin 6	3.2	0.365	5.005	0.88	0.238	0.02	0.905	9.046	1.9	1.36	24.966	0.016
Granvin 7	1.564	0.128	1.712	0.056	0.155	0.001	0.7	7.049	2.022	0.424	20.577	0.012
Granvin 8	1.229	0.056	0.299	0.026	0.028	0.003	0.538	5.423	1.344	0.298	14.628	0.043
Granvin 9	1.537	0.085	1.188	0.076	0.109	0.003	0.467	4.704	1.065	0.474	13.653	0.037
Hornindal 1	3.408	0.193	3.58	1.39	0.164	0.074	0.539	5.436	0.945	2.074	14.128	0.043
Hornindal 2	2.257	0.084	1.271	0.247	0.091	0.002	0.635	6.421	1.184	0.906	15.291	0.043
Hornindal 3	2.505	0.236	4.151	1.412	0.155	0.203*	0.556	5.659	0.838*	1.498	13.504	0.042
Joniskelis	1.495	0.117	2.301	1.277	0.151	0.055	0.589	5.942	1.018	1.568	17.63	0.223
Laerdal 1	1.838	0.315	4.124	0.891	0.204	0.116	0.453	4.689	0.624*	0.687	13.535	0.069
Laerdal 2	1.849	0.102	1.8	0.554	0.159	0.022	0.672	6.927	1.005	1.04	15.838	0.044
Muri	2.713	0.224	2.005	1.078	0.188	0.011	0.53	5.354	0.892	2.276	14.804	0.31
Stordal Ebbegarden 1	2.103	0.083	0.811	0.272	0.053	0.097	0.475	4.783	0.947	0.794	13.974	0.039
Stordal Ebbegarden 2	2.542	0.089	0.619	0.341	0.041	0.217*	0.677	7.052	1.135	1.074	16.637	0.049
Stordal Framgarden 1	2.395	0.168	2.975	0.772	0.158	0.058	0.55	5.536	0.901	1.635	15.809	0.052
Stordal Framgarden 2	2.654	0.44	4.112	0.753	0.176	0.006	0.593	5.998	0.976	0.864	14.03	0.047
Stranda	2.393	0.168	2.818	1.035	0.157	0.027	0.602	6.086	0.857	1.018	16.056	0.049
Sykkylven 1	2.046	0.101	1.306	0.427	0.08	0.005	0.483	4.883	0.867	0.749	14.28	0.043
Sykkylven 2	1.668	0.102	1.392	0.675	0.079	0.133	0.422	4.257	0.619*	0.622	12.081	0.044
Voss 1	2.156	0.209	3.317	0.618	0.145	0.006	0.463	4.651	0.941	0.825	12.377	0.039
Voss 2	2.364	0.307	3.059	0.347	0.157	0.005	0.519	5.225	1.01	1.148	15.121	0.039
WLP001	2.064	0.192	0.241	0.105	0.196	0.03	0.66	6.654	2.46	1.004	25.918	0.072
WLP002	0.735	0.076	0.537	0.047	0.101	0	0.81	8.168	4.062	0.478	19.481	0.053
WLP029	3.22	0.348	4.142	0.99	0.292	0.002	0.655	6.601	1.962	1.601	21.047	0.013
WLP570	5.734	0.806	8.586	1.583	0.424	0.019	1.395	14.057	2.106	3.529	33.427	0.299
Threshold (ppm)	30	0.21	0.9	0.2	0.85	8	1.2	70	100	3.8	100	0.3

Ethyl caproate = pineapple, tropical

Ethyl caprylate = tropical, apple, cognac

Ethyl deconoate = apple

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Omega Yeast Kveik Offerings

- **HotHead® Ale (OYL-057)** - Highly flocculent strain with an astoundingly wide temperature range (62-98F) and little change in flavor across the range. Clean enough for both American and English styles. It has a unique honey-like aroma with overripe mango which is complementary to modern, fruity hops.
- **Voss Kveik (OYL-061)** – From the Gjernes farmstead, orange-citrus notes present throughout its wide temperature range (68-98F). Relatively clean across its fermentation temperature range and pairs well with citrusy, fruity hops.
- **Hornindal Kveik (OYL-091)** - From the farmstead of Terje Raftevold, Hornindal presents an intense tropical flavor and aroma of fresh pineapple, mango and tangerine, which complement fruit-forward hops. Add even more dimension to "C" hops with a high fermentation temperature, intensifying aroma and fermentation speed.

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Kveik FAQ

- Will kveik infect all of my equipment?
  - No. It's just Sacch yeast. Not diastatic.
- How do I make a kveik beer?
  - There's no such thing. "Kveik" means "yeast". That's like saying "How do I make a yeast beer?"
- What styles can I make using kveik?
  - Anything where you would use an English ale yeast – IPA, NEIPA, APA, porter, stout, barleywine, imperial stout, cream ale, etc.
- How do I pronounce "kveik"?
  - K (combination of w and v) ike
  - Ask a Norwegian.

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How do Kveik Cultures Fit Into Modern Brewing?

- Non-phenolic and fruity = IPAs, pale ales, English ales, stouts, imperial stouts, barleywines, porters, etc.
- High alcohol tolerance = Imperial stouts, barleywines, etc.
- Rapid, high temp fermentations mean lower tank residence time, faster product turnaround
- Rapid, high temp fermentations mean lower energy costs due to less chilling during KO, less glycol demand during fermentation
- Unique ester content can make products stand out while still being recognizable

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Real World Examples

- 5-Day Berliner Weisse
- Imperial Stout
- Barleywine

Berliner Weisse

Vitals

OG: 1.039

FG: 1.010

ABV: 3.8%

IBU: 0

pH: 3.34

Ingredients

- 40% Pilsner Malt
- 50% White Wheat Malt
- 10% Munich Malt
- No hops!

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Berliner Weisse

Process

- Mash at 148℉ for 60 minutes
- Boil for 30 minutes
- Knock out at 95℉

Fermentation

- Pitch OYL-605 and apply heat wrap to maintain 90℉
- After 24 hours, pitch OYL-057
- Terminal gravity and pH were reached after 96 hours.

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5 Day Berliner

- On day 4, cold crash beer for ~8 hours, then transfer to keg.
- Force carbonate at 30 psi with intermittent shaking.
- Ready to drink 5 days after brewing.
- Tart, bready, and clean.

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Imperial Stout

Vitals

OG: 1.114

FG: 1.040

ABV: 9.7%

IBU: 50

Ingredients

- Light DME - 38.9%
- 2 row - 22.2%
- Munich Malt - 11.1%
- Crystal 60L - 5.6%
- Special B - 5.6%
- Roasted Barley - 5.6%
- Black Malt - 5.6%
- Hopped with Warrior and EKG

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Imperial Stout

Process

- Mash at 150℉ for 60 min
- Boil for 150 min with hop additions at 60, 15, 10 and flameout
- Knockout at 90℉ and oxygenate generously

Fermentation

- Pitch 2x standard pitch rate of OYL-091 (~14 mil cells/mL)
- Ferment at 90℉+
- Reached terminal gravity on Day 4.

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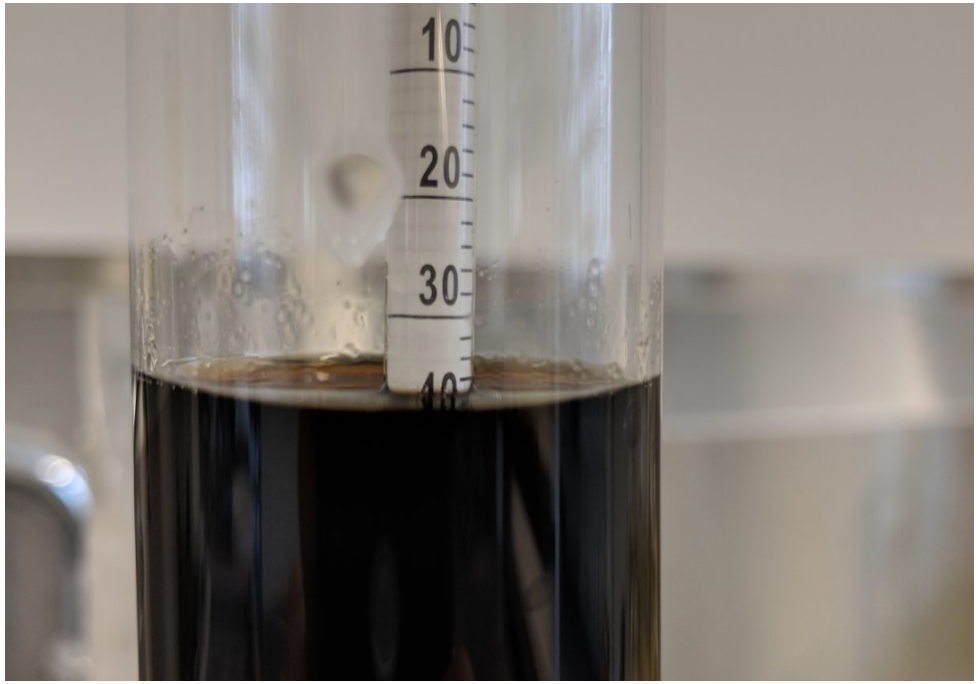
Imperial Stout

- Smooth, rich dark chocolate character.
- Stonefruit esters compliment dark malts.
- No fusels = dangerously drinkable



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Barleywine

Vitals

OG: 1.150

FG: 1.030

ABV: 16%

IBU: 45

Ingredients

- Dark Munich (30 SRM) -65 %
- Flaked Barley - 32%
- Pale 2-row - 3%
- Hopped with Columbus

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Barleywine

Process

- Mash at 154℉ for 60 min
- Boil for 240 min with hop addition at 60 min
- Knockout at 95℉ and oxygenate generously

Fermentation

- Pitch 2x standard pitch rate of OYL-091 (~14 mil cells/mL)
- Ferment at 90℉+
- Reached terminal gravity in 36 hours.

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Barleywine

- Small amount of acetaldehyde conditioned out at 72 hours.
- Rich maltiness + kveik esters = candied fruit
- Again, no fusels means no boozey burn.

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Future Projects

- Generational behavior
- Experiment with pitch rates
- HAZE!
- Brut Stout
- Kveik + Brett
- Cider, meads and beyond
- Explore the farmhouses of Lithuania

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A Brief Examination of Cell Counts

Conventional Wisdom:

- To achieve an optimal fermentation, yeast should be pitched a rate of 0.75-1.5 million cells/mL per degree Plato.

- Input your target pitch rate and batch size into a calculator and it will output the starter volume necessary to produce the total number of cells required.

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Our Experiment

1. Inoculate yeast scraped from petri plate into 100mL of 1.040 wort in small flask.
2. Incubate on stir plate until maximum cell density is achieved.
3. Count cells using microscope and hemocytometer.
4. Repeat with all the strains in our library.

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A Few Words on Cell Counts and Pitch Rates

Results: Final cell count varied wildly from strain to strain.

* Hefeweizen Ale (OYL-021): 98M cells/mL
* West Coast Ale I (OYL-004): 146M cells/mL
* French Saison (OYL-026): 465M cells/mL
* *Brettanomyces lambicus* (OYL-203): 885M cells/mL

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Results

OYL-021	OYL-004	OYL-203	OYL-026
98M cells/mL	146M cells/mL	885M cells/mL	465M cells/mL

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A Metaphor

- Remember that the goal of yeast is to produce more yeast, not make beer.
- Think of yeast cells like factories that make more identical factories.
  - Wort components are the raw materials.
  - Factories will continue to make more of themselves until one of the raw materials runs out.
  - Alcohol, carbon dioxide, and flavor compounds are the emissions.
- Some factories are bigger than others.
  - Bigger factories will produce fewer copies of themselves than smaller factories given the same amount of raw materials.
  - In most cases, the total amount of factory mass and emissions remains the same.

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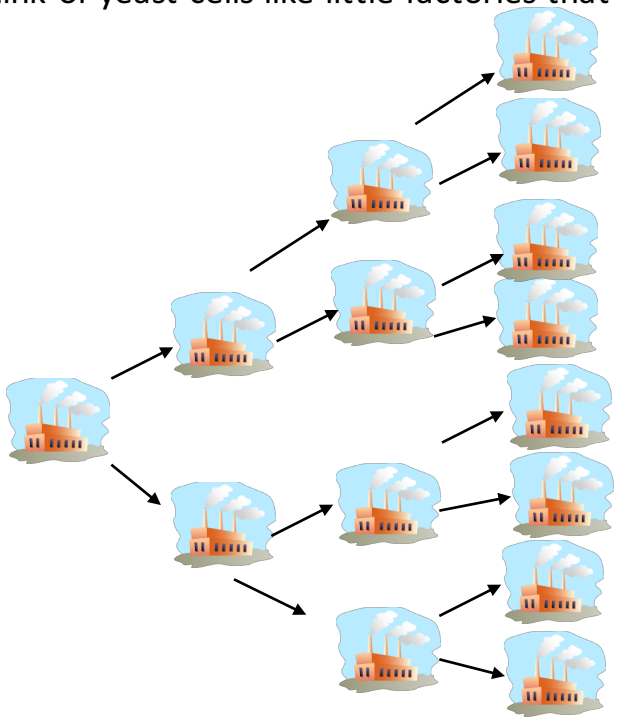
A Few Words on Cell Counts and Pitch Rates

Why?

Think of yeast cells like little factories that churn out more factories.



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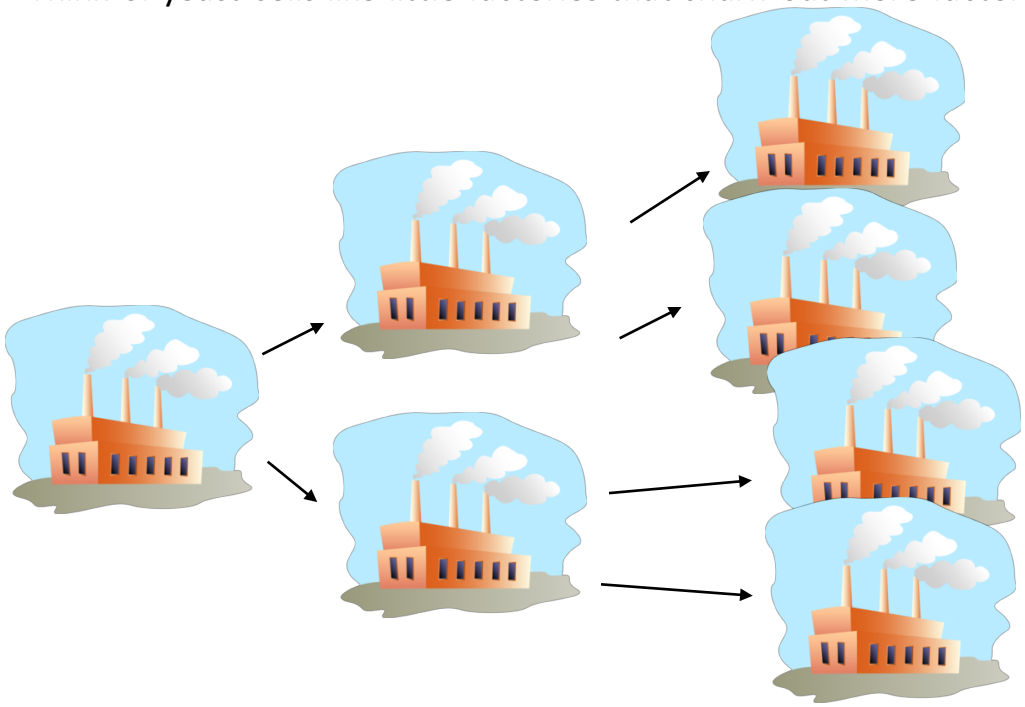

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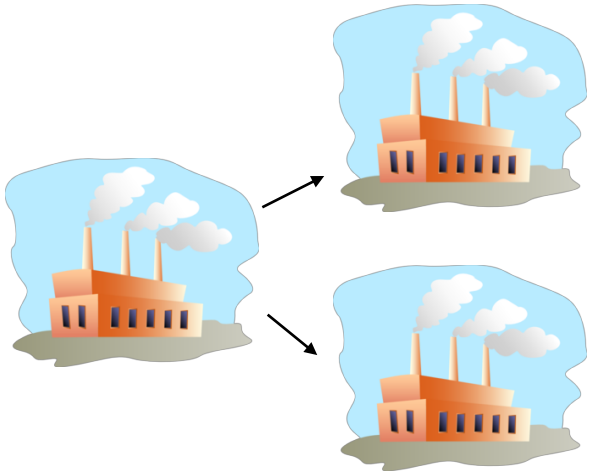

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A Few Words on Cell Counts and Pitch Rates

Practically speaking, what does this mean?

If you truly wanted a calculator that could estimate cell counts in a starter, it would have to take into account strain differences.

Should there be a strain-specific calculator?

Our opinion is that it's unnecessary.
Existing pitch rate calculators could more accurately be thought of as biomass calculators.
Strain-specific calculators could lead to underpitching or overpitching when applying pitch rate "rules."

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A Few Words on Cell Counts and Pitch Rates

Conclusion: Your pitch rate calculator is lying to you, but that's ok.

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