Cell Culture Engineering XVIII

Workshop 8

Actionable 'omics in Cell Culture and Bioprocessing: Best Practices and Opportunities

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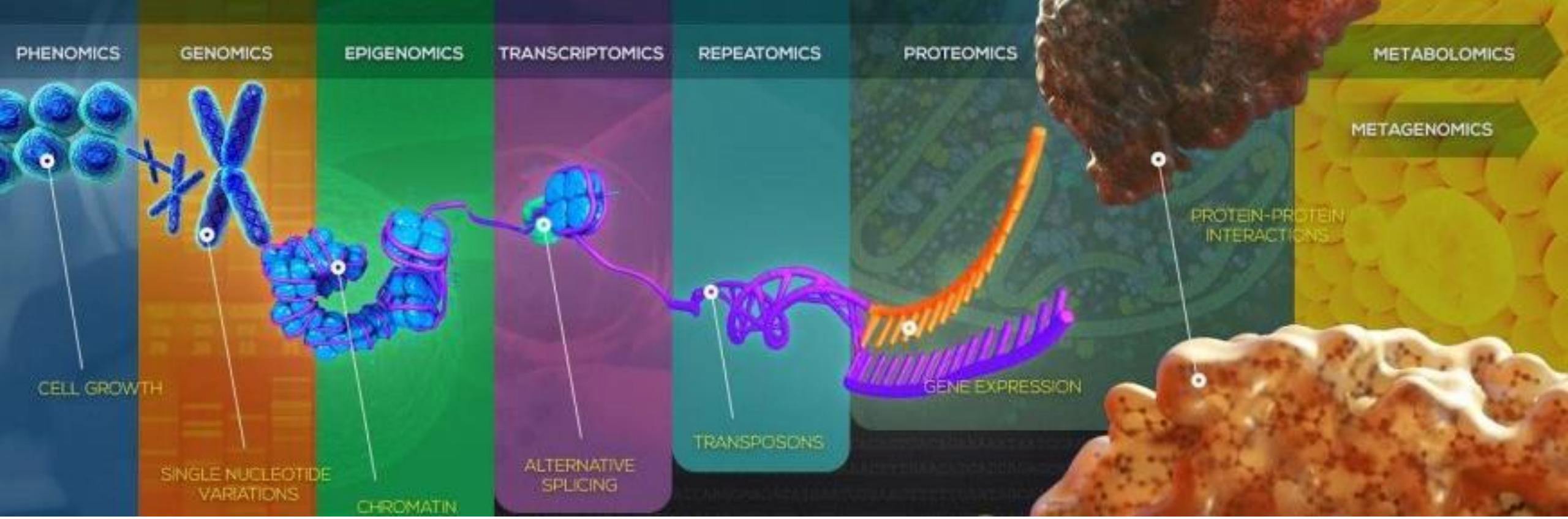


Actionable ‘omics in cell culture and bioprocessing: best practices and opportunities

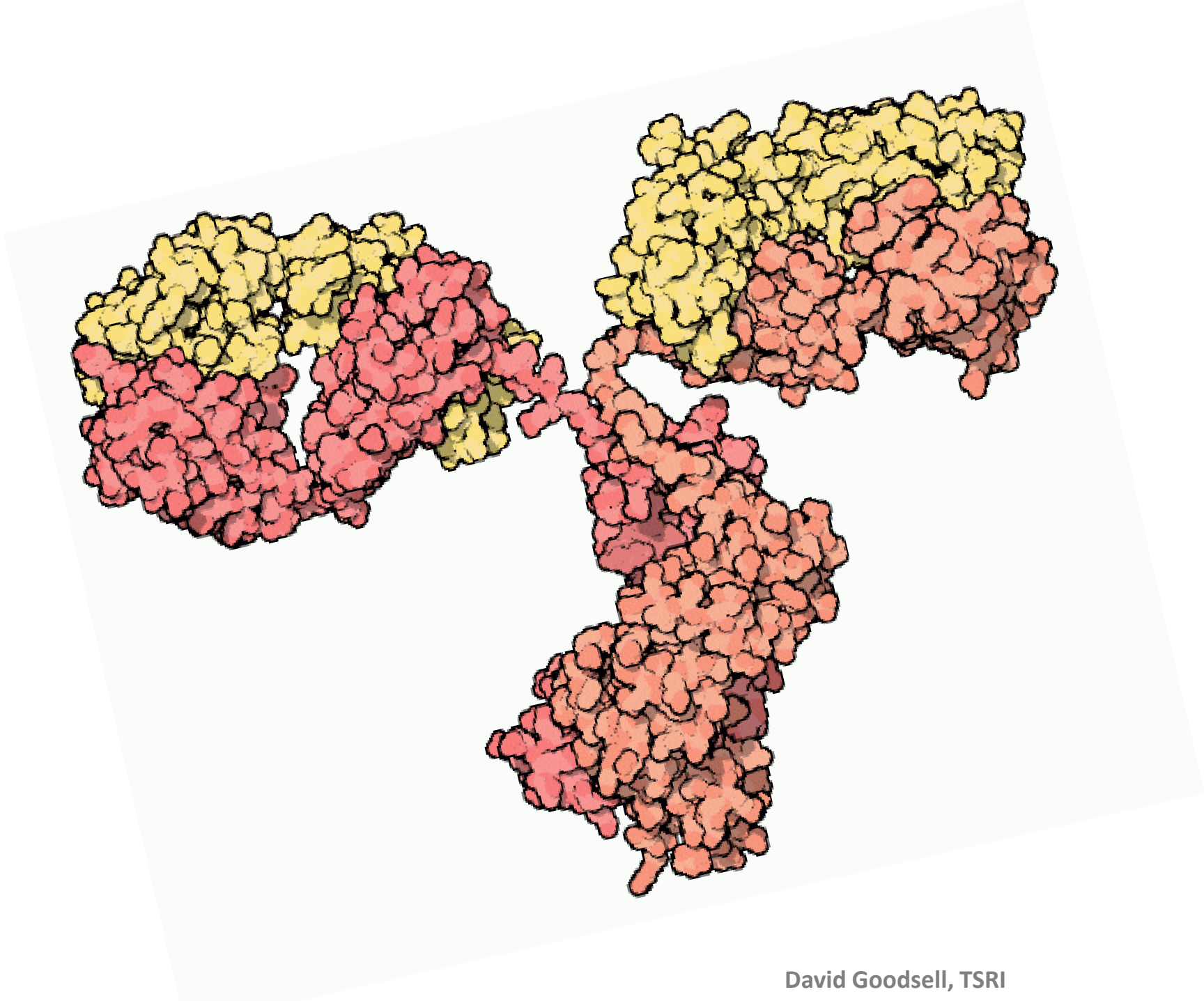
Chairs: Nathan Lewis (UCSD), Henry Lin (Sanofi), Paula Meleady (Dublin City University)

Workshop objectives:

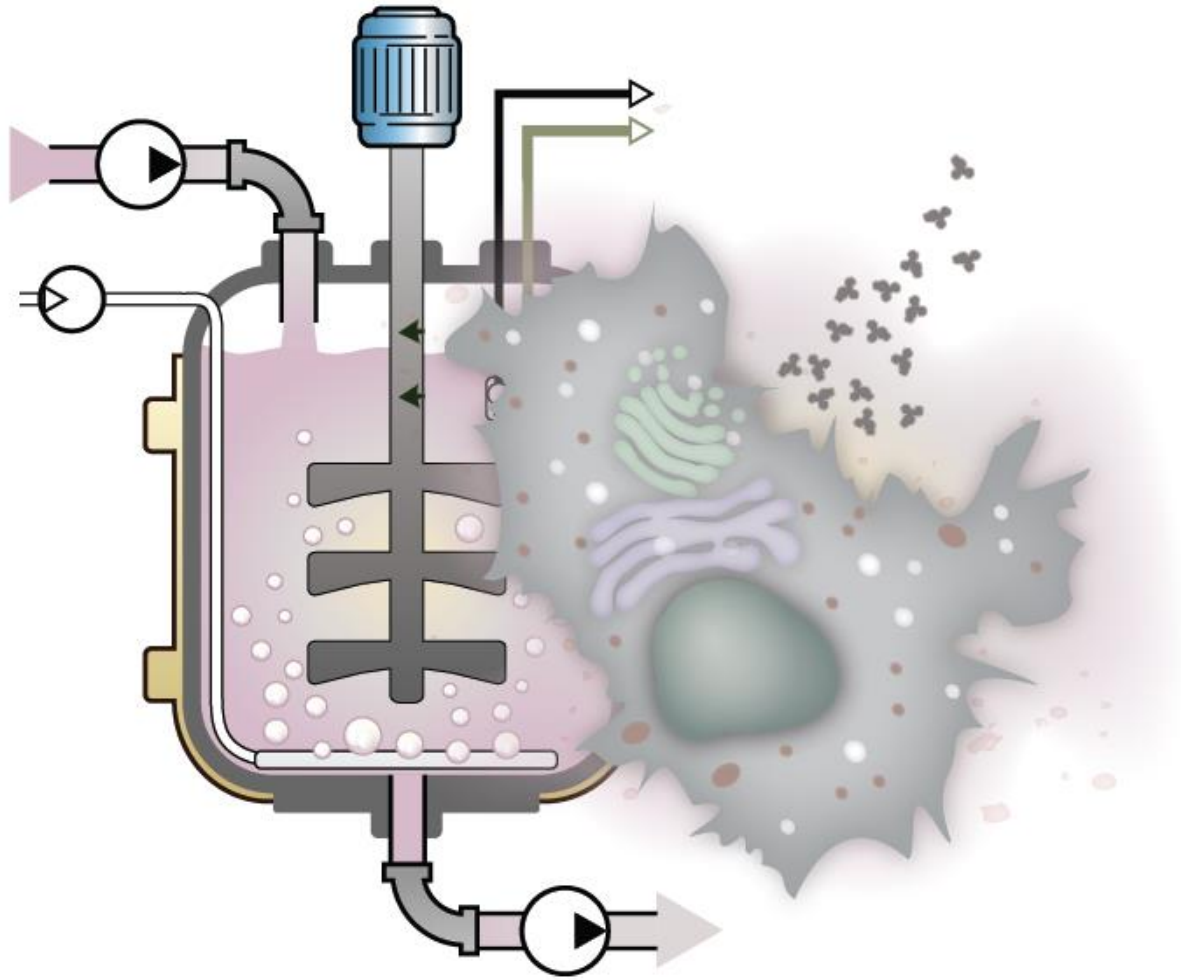
1. Better understanding of what one can do with omics, and a mindset of using omics for identifying actionable items
2. Idea of best practices for study design with omics and necessary resources for effective studies
3. Ideas on how omics can be applied to their specific challenges.

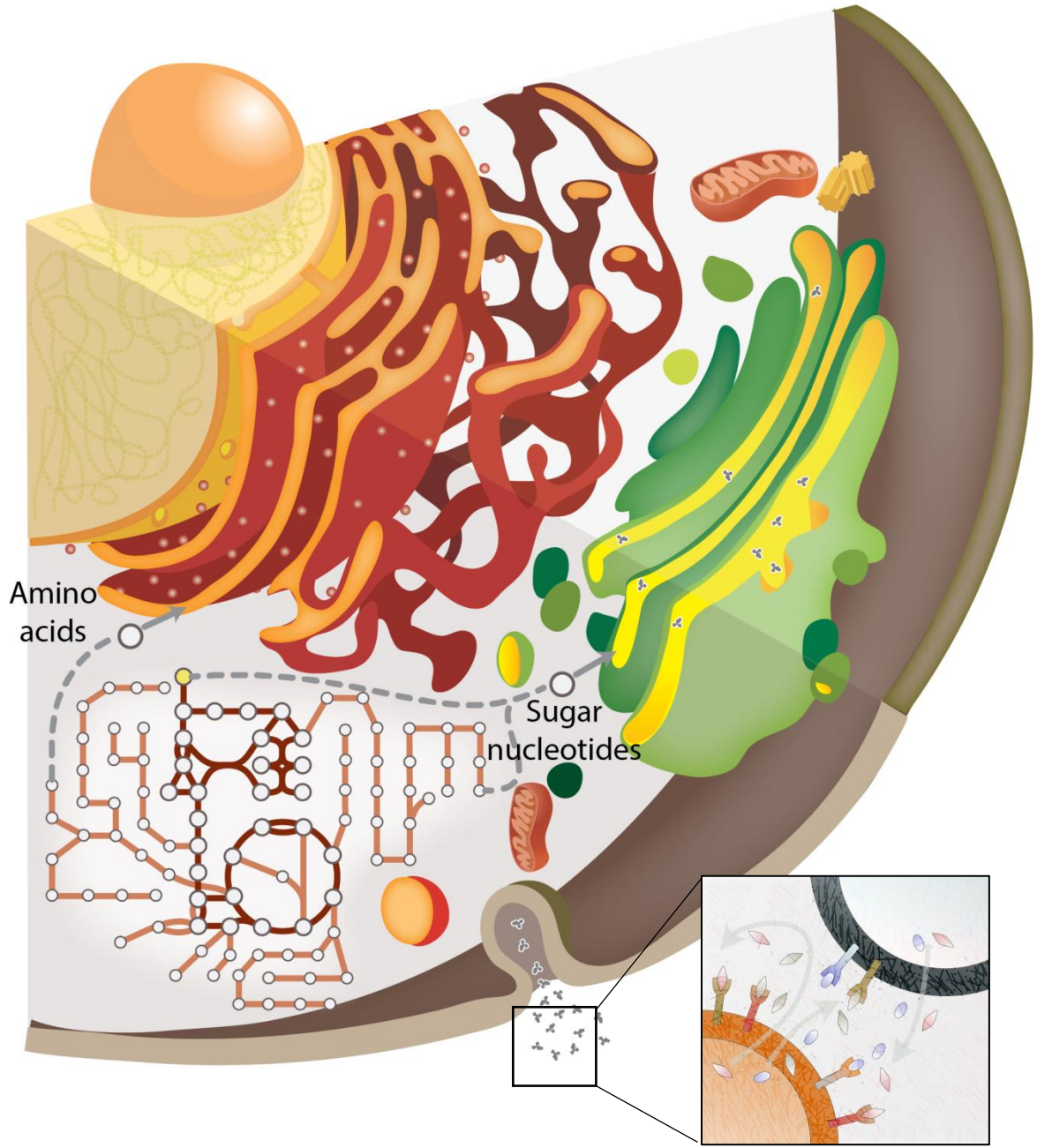
Agenda outline:

1. Expert background and experience on the successful use of omics tools for cell culture optimization
2. Survey results on challenges and hurdles in using ‘omics tools
3. Breakout groups to work on examples of research challenges that may be solved with omics strategies
    - Choice of omics
    - Study design
    - Data analysis techniques
    - Follow-up action plan



David Goodsell, TSRI




Amino
acids
Sugar
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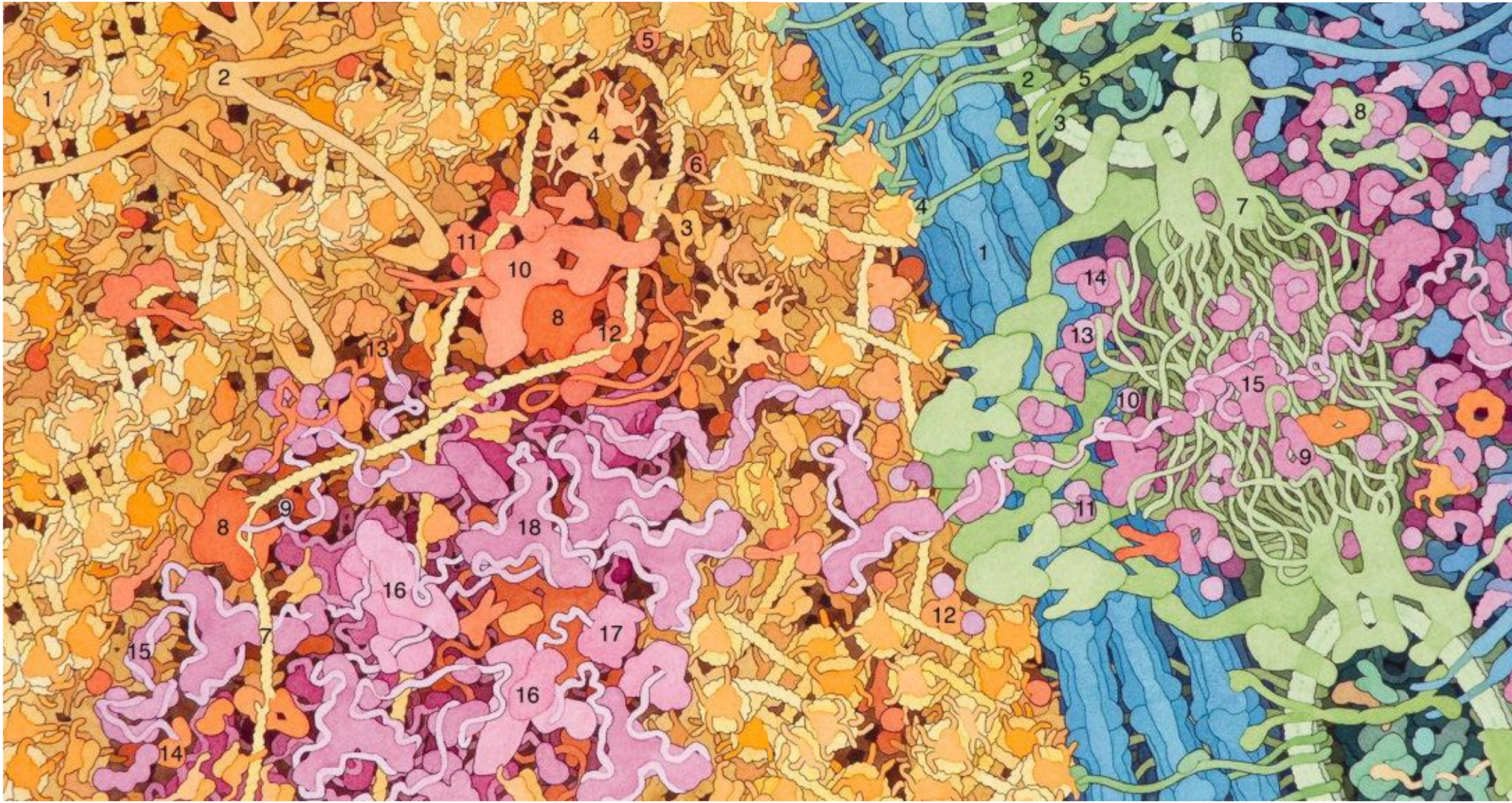
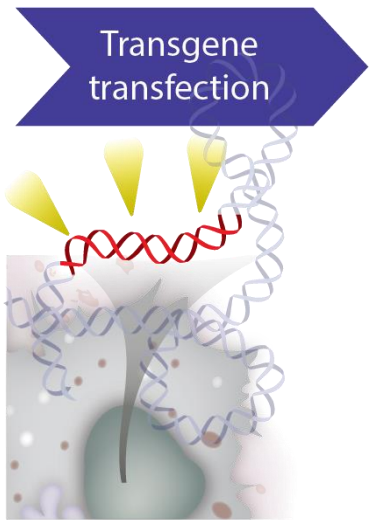
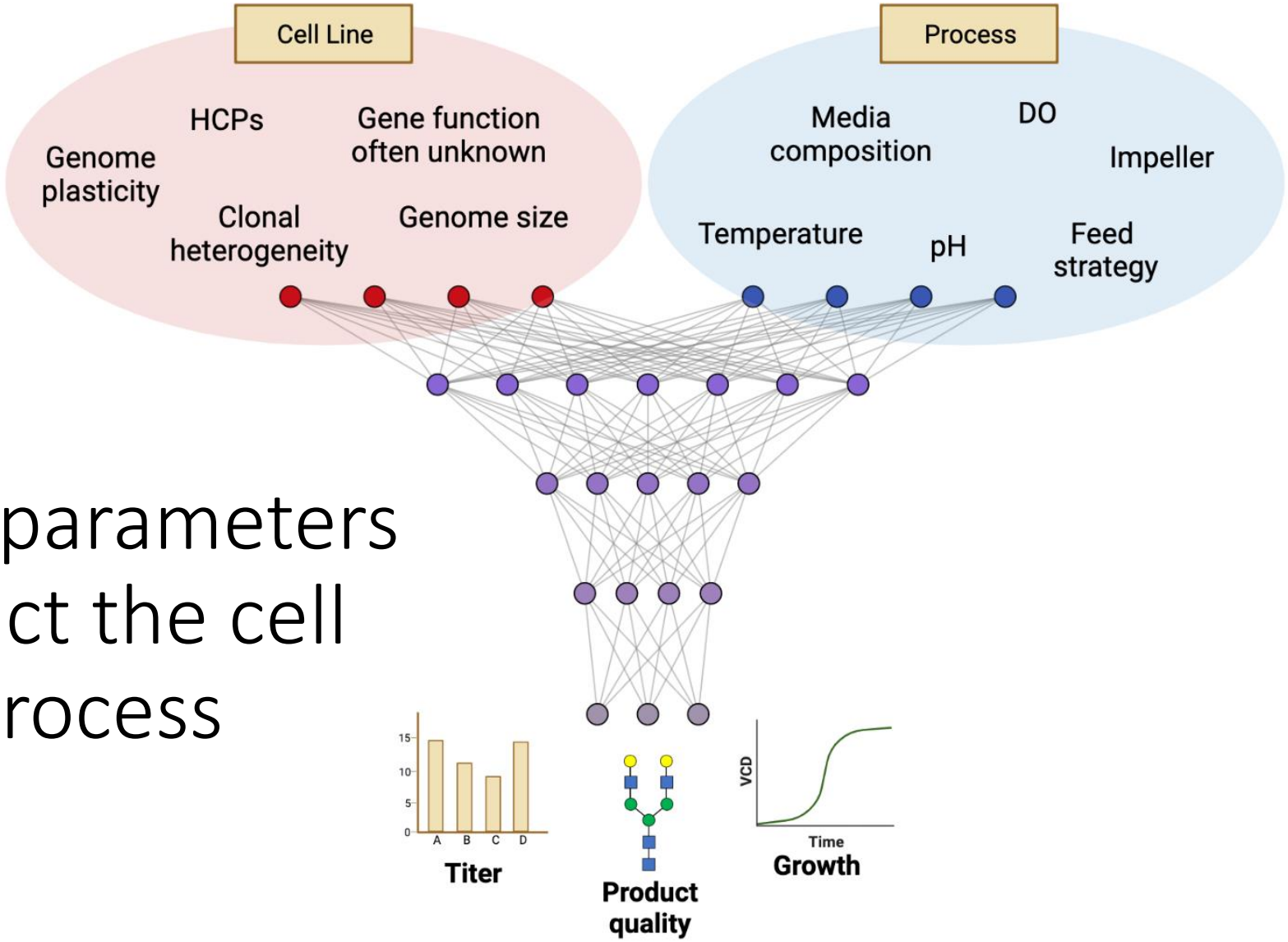


David Goodsell, TSRI

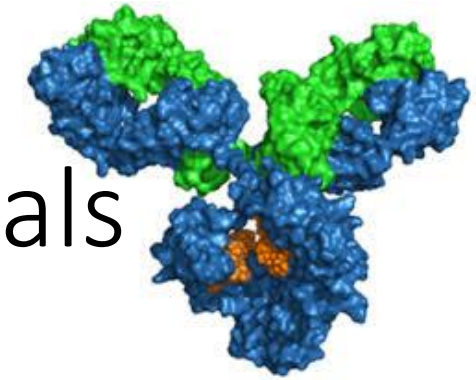
1 week



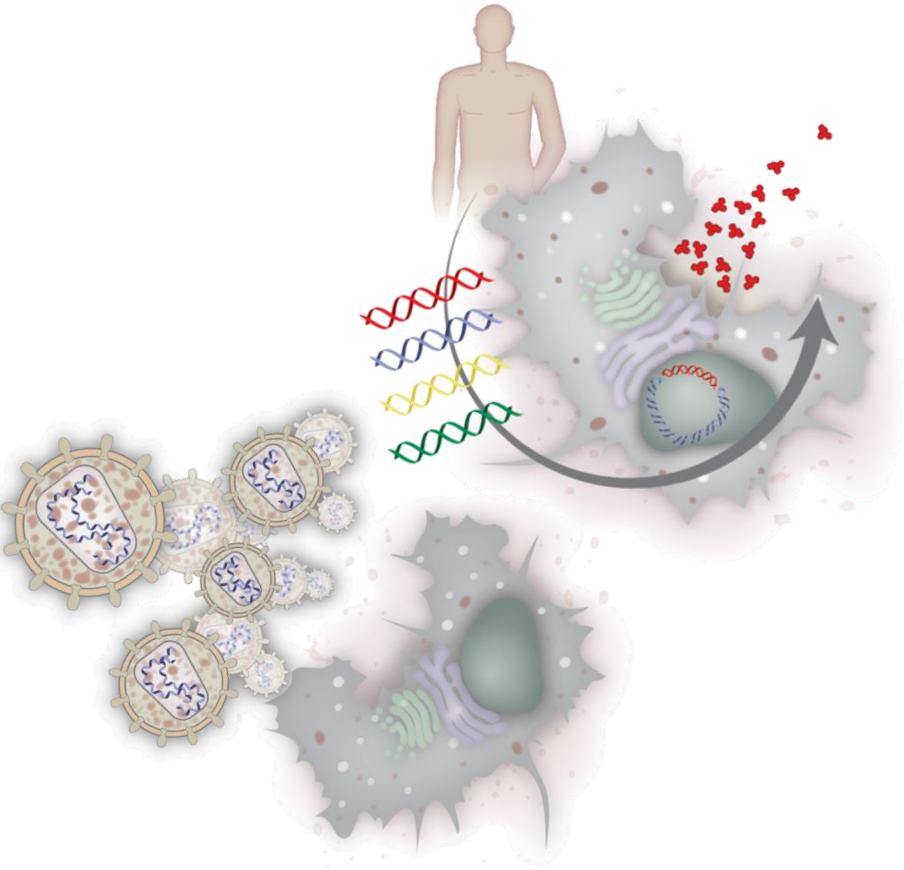
multiple parameters can impact the cell culture process outcome



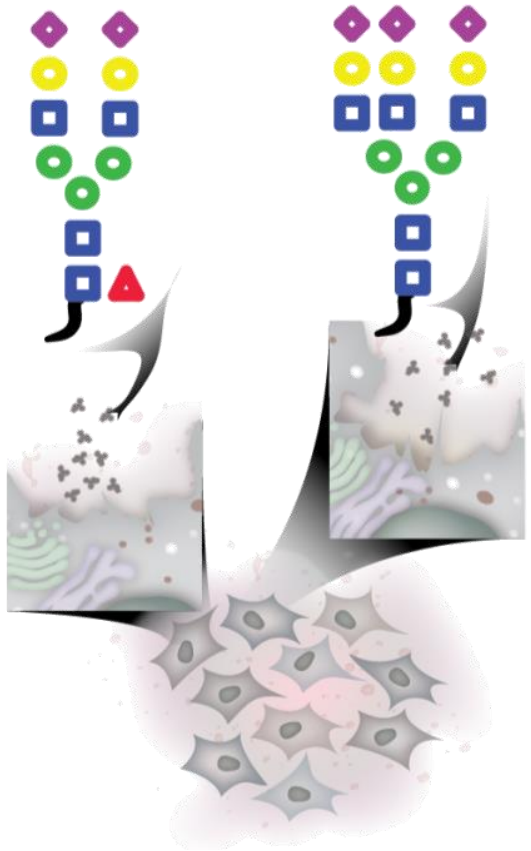
Unique challenges for biopharmaceuticals



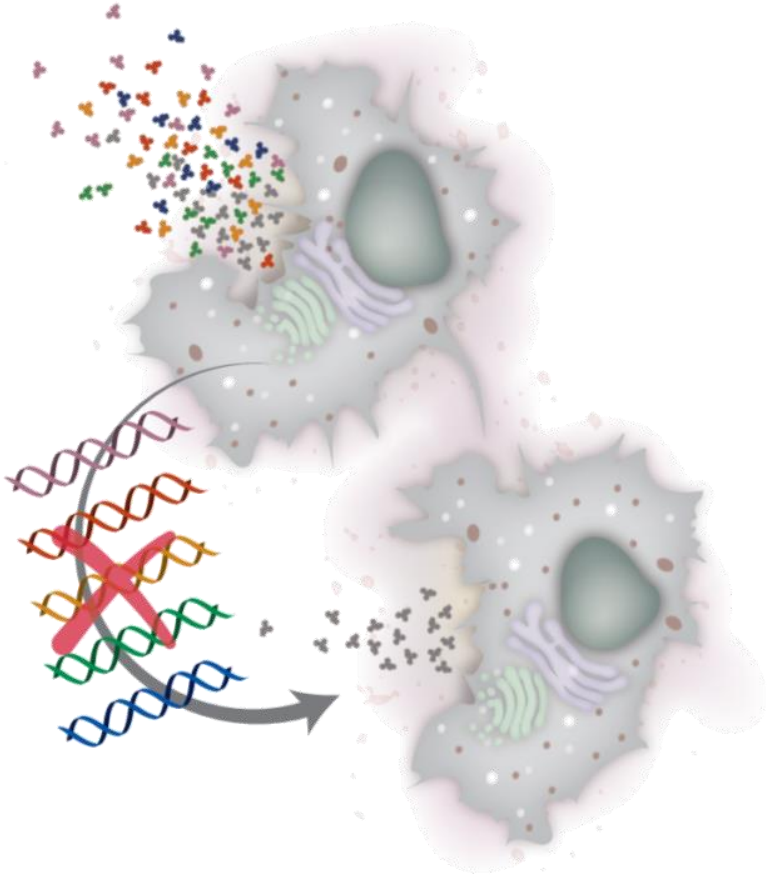
High yield



Controlled Quality Attributes



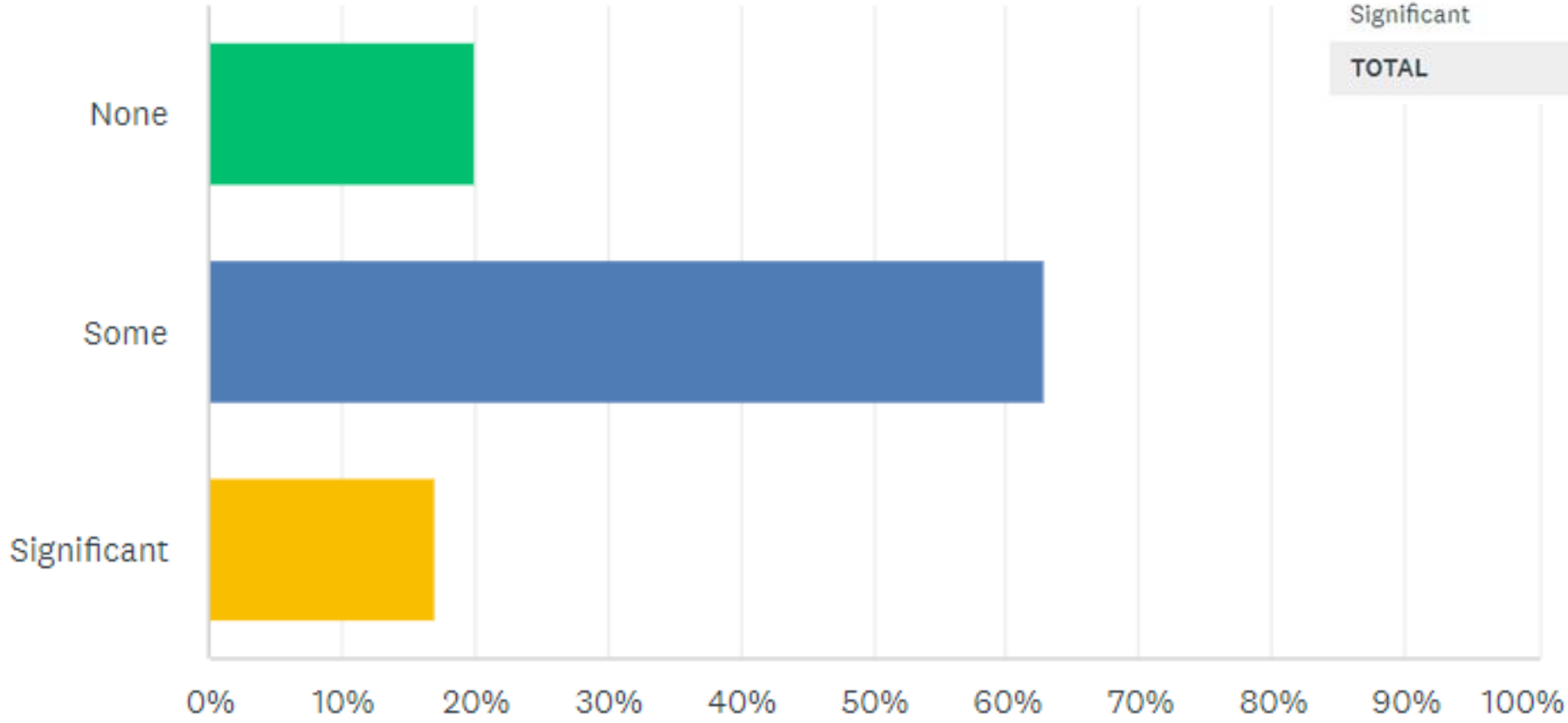
Purity



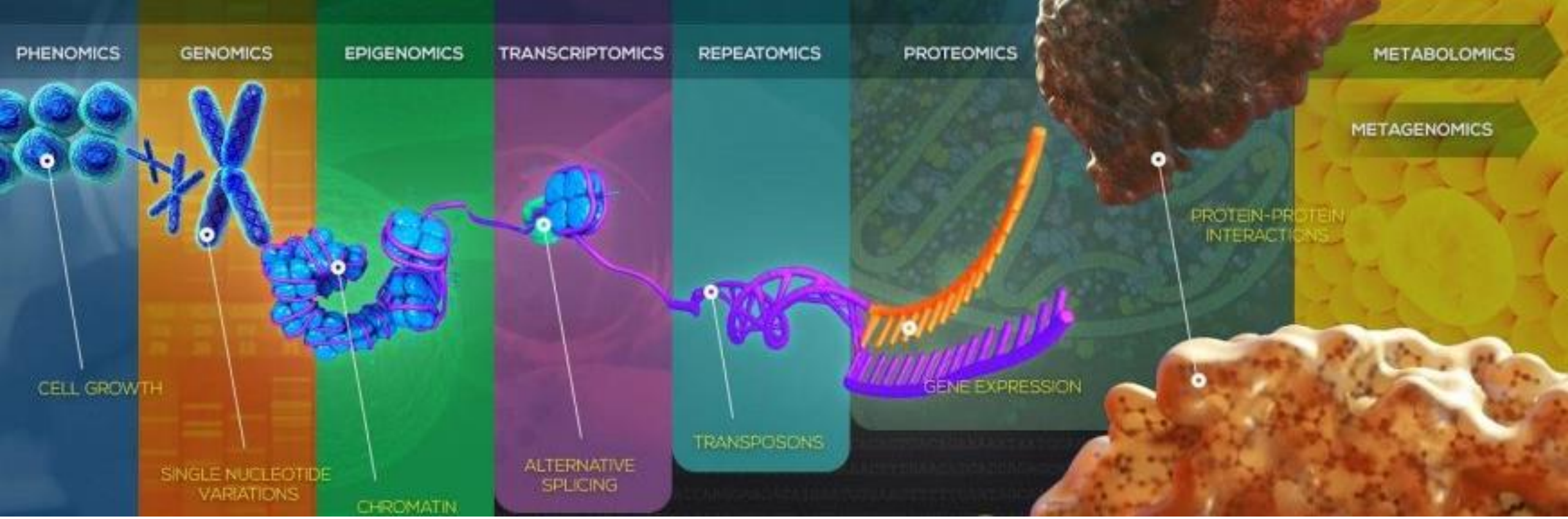
Do you use omics methods in your development work in any form?

Answered: 35 Skipped: 166

ANSWER CHOICES	RESPONSES	
None	20.00%	7
Some	62.86%	22
Significant	17.14%	6
TOTAL		35



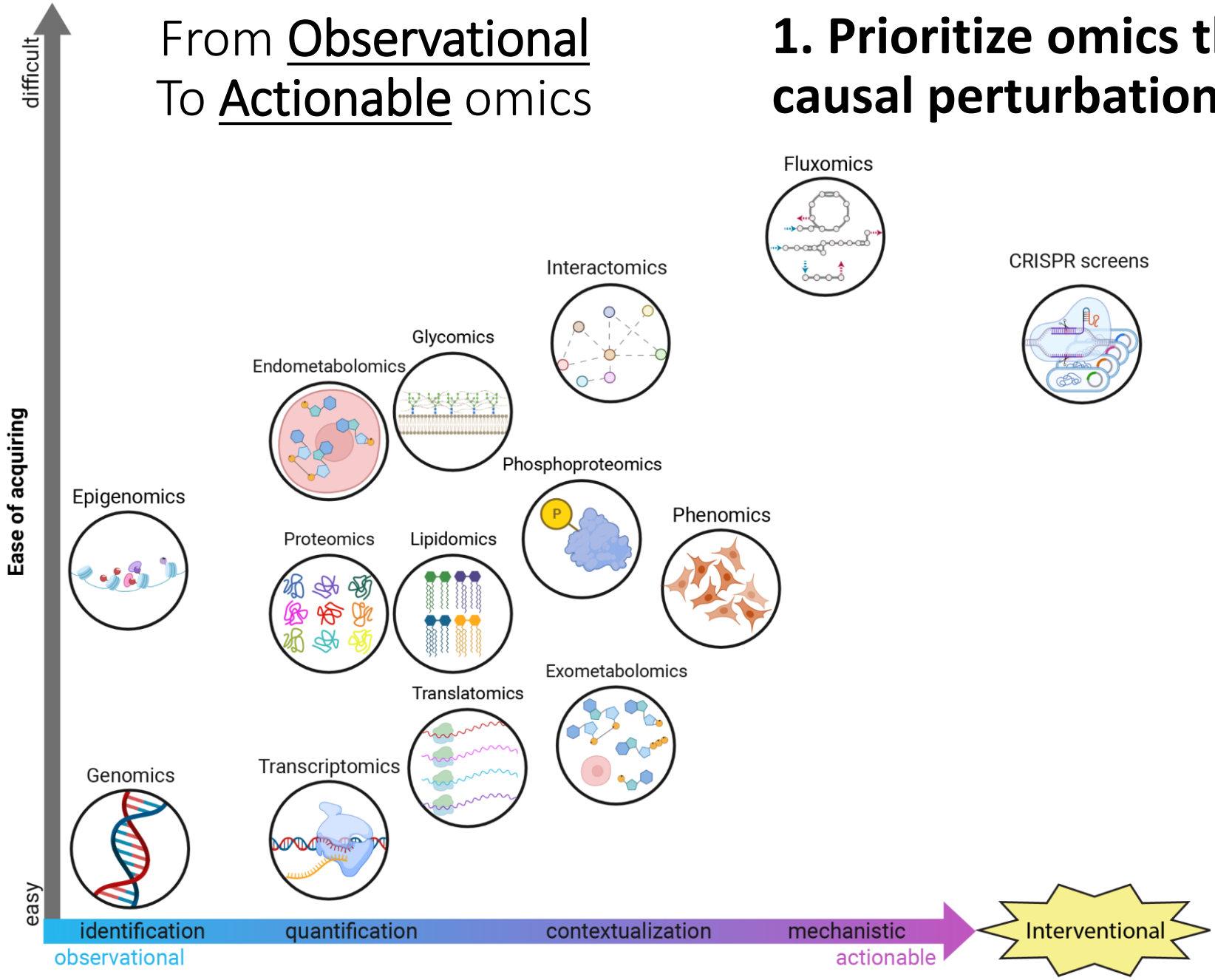
Cellular demands of secreted protein products – systems and synthetic biology improve quality and titer, Johan Rockberg
Newly-established Chinese hamster-derived cell line for protein production, Takeshi Omasa
Engineering of Chinese hamster ovary cell lipid metabolism results in an expanded ER and enhanced recombinant biotherapeutic protein production, James Budge
What's in a Phenotype? Nicole Borth
Systems and synthetic biology approaches towards optimization of N-glycan Sialylation, Jack Scarcelli
What does a cell need for efficient protein secretion: Deciphering, modeling, and augmenting the CHO machinery, Nathan Lewis
The microRNA landscape of the extracellular vesicles generated by Chinese hamster ovary cells under normal and stressed conditions, Eleftherios Papoutsakis
Metabolic engineering of high-productivity CHO host lines for biomanufacturing, Jamey Young
Biologics 4.0: Emergence of the CHO Biofoundry, Lars Nielsen
Transcriptomics guided mechanistic metabolic model for perfusion culture process, Veronique Chotteau
Rescue protein production with effector gene determination in CHO cells, Ece Cagdas
Designing a CHO protein production platform using multi-omics technology, Chengjian Tu
Engineering Chinese Hamster Ovary cells for enhanced protein secretion, Mauro Torres
A novel system for glycosylation engineering by natural and artificial microRNAs, Kerstin Otte
Omics-based characterization of random transgene integration sites from CHO production cell lines, Sofie O'Brien
Characterization of extrachromosomal circular DNA (eccDNA) structure, function, and dynamics in a CHO K-1 clone, Dylan Chitwood
Identification of transgene integration sites, their structure and epigenetic status with Cas9-targeted nanopore sequencing in CHO cells, Nicolas Marx
Genome-wide CRISPR-Cas9 screen identifies hyperosmotic stress responsive genes in Chinese hamster ovary cells, Su Hyun Kim
NextGen Sequencing (NGS) platform and applications in cell line development, Ying Shen
Enhancing recombinant protein and viral vector production in mammalian cells by targeting the YTHDF readers of N6–methyladenosine in mRNA, Niall Barron
CRISPR activation screening of dormant genes to improve secretory capacity in CHO cells, Johan Blatt Rojek
Dynamic regulation of mitochondrial metabolism as a strategy to maximize mAb production in industrial CHO cell cultures, Kevin Ruiz-Marquez
Development of a high throughput CHO cell glycosylation enzyme mRNA expression profiler, Shivani Gupta
Transcriptional response to recombinant protein production in isogenic multi-copy CHO cells, Giulia Scapin
A microplate-based assay for analyzing purity and mispairing of bispecifics and other complex molecules in cell culture samples, Sebastian Giehring
Prediction of CHO cell line stability using expression of DNA repair genes, Lauren Cordova
Subcellular fractionation coupled to shotgun proteomics allows the identification of novel targets of the classical secretion pathway associated with increased productivity in recombinant CHO cells, Norma A. Valdez-Cruz
Profiling lnc-RNA in CHO cells using NGS technologies, Caterina Ruggeri
Slowly co-fluctuating gene expression patterns are heritable and associated with stress resistance and improved productivity in CHO cell line development, Mark Blenner
Blueprint from nature: Multi-omics comparison of CHO and plasma cells unveils novel cell engineering targets to improve productivity, Linus Weiss
From observational to actionable: Rethinking omic studies in biopharmaceutical protein production, Hooman Hefzi
Investigation of the role of ubiquitination in ER stress mechanisms in recombinant CHO cells, Paula Meleady
Workflow for mining process relevant knowledge from transcriptomics, Meeri Mäkinen
Leveraging single-cell and bulk transcriptomics towards improved insect cell factories for biopharmaceuticals, Filipa Moura
Comprehensive meta-analysis of the CHO coding transcriptome, Markus Riedl
Establishment and application of a multiomics systems biology approach for cell culture process development and optimization, Chris Lowe
Enhancing CHO cell productivity through a novel dual selection system using Aspg and Gs in glutamine free medium, Julie la Cour Karottki
Mechanistic insights into the metabolization of S-Sulfocysteine by CHO cells using a multi-omics approach, Melanie Nguyen
Using next-generation sequencing technology, RNA-Seq, to understand the Chinese Hamster Ovary (CHO) cell transcriptome under industrially relevant conditions, Benjamin Synoground
A user-friendly tool using systems biology models to infer cell functions from omics, Helen Masson
Multi-Omics strategy for cell culture medium optimization in Fed-Bach CHO cell cultivation, Chengjian Tu
Transcriptional and metabolic response of CHO cells to different carbon dioxide Concentrations, Jorge Campano
Tracking amino acid metabolism in CHO cell cultures using stable isotope labeling assisted metabolomics, Maciek Antoniewicz



OMICs are largely <u>observational</u> and correlational

From Observational
To Actionable omics

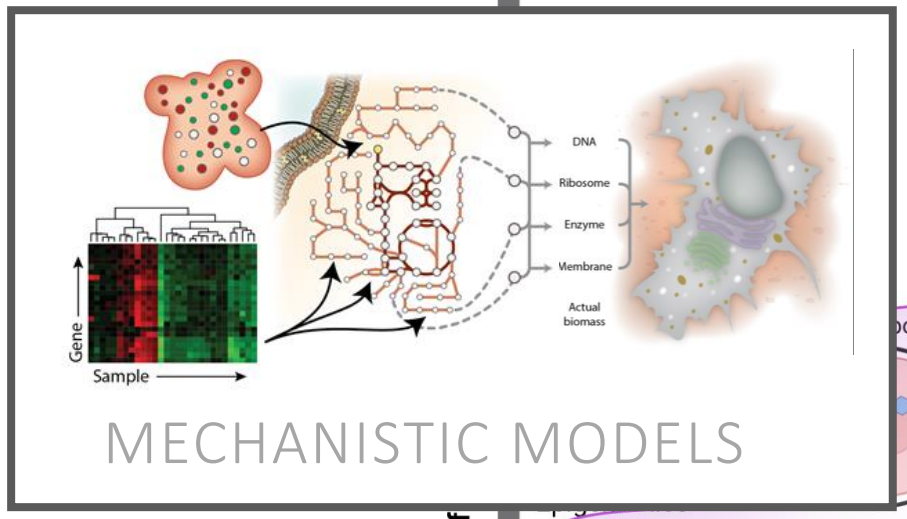
1. Prioritize omics that include causal perturbations



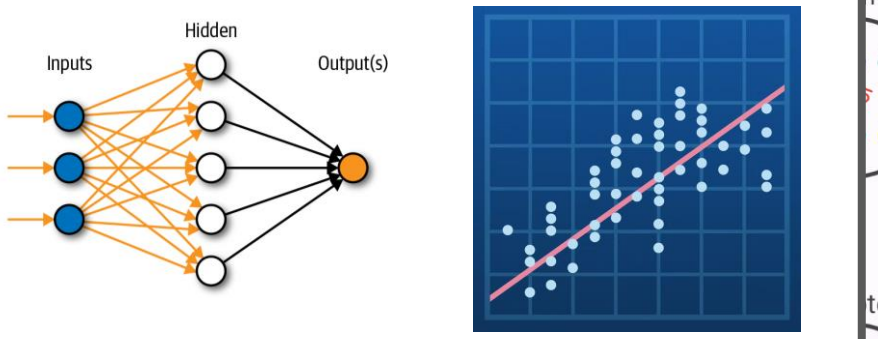
Adapted from Masson et al. Trends Biotech, 2023

From Observational
To Actionable omics

2. Deploy tools that analyze omics with mechanistic networks / M.L./A.I.



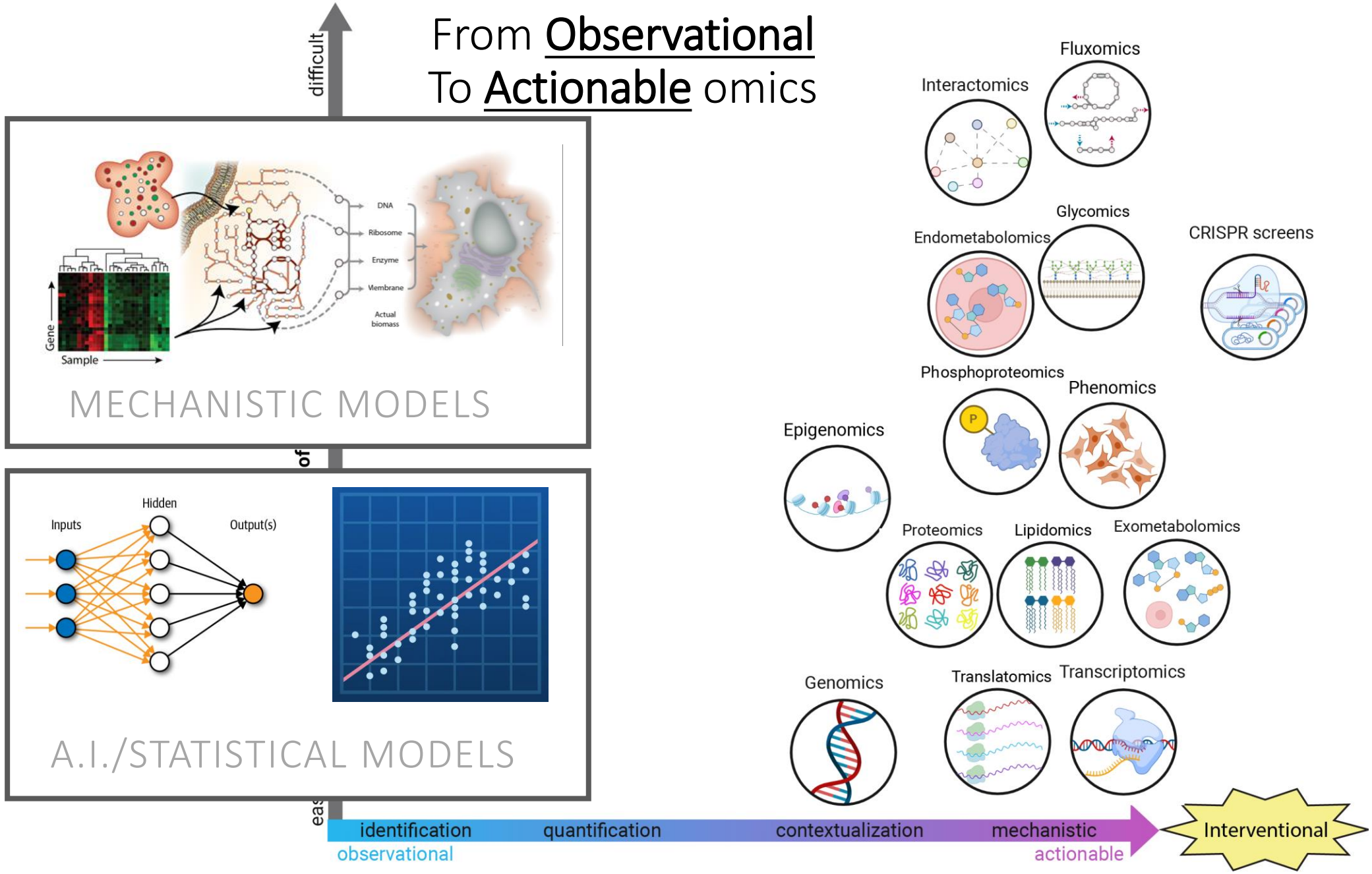
MECHANISTIC MODELS



A.I./STATISTICAL MODELS

Adapted from Masson et al. Trends Biotech, 2023

From **Observational** To **Actionable** omics

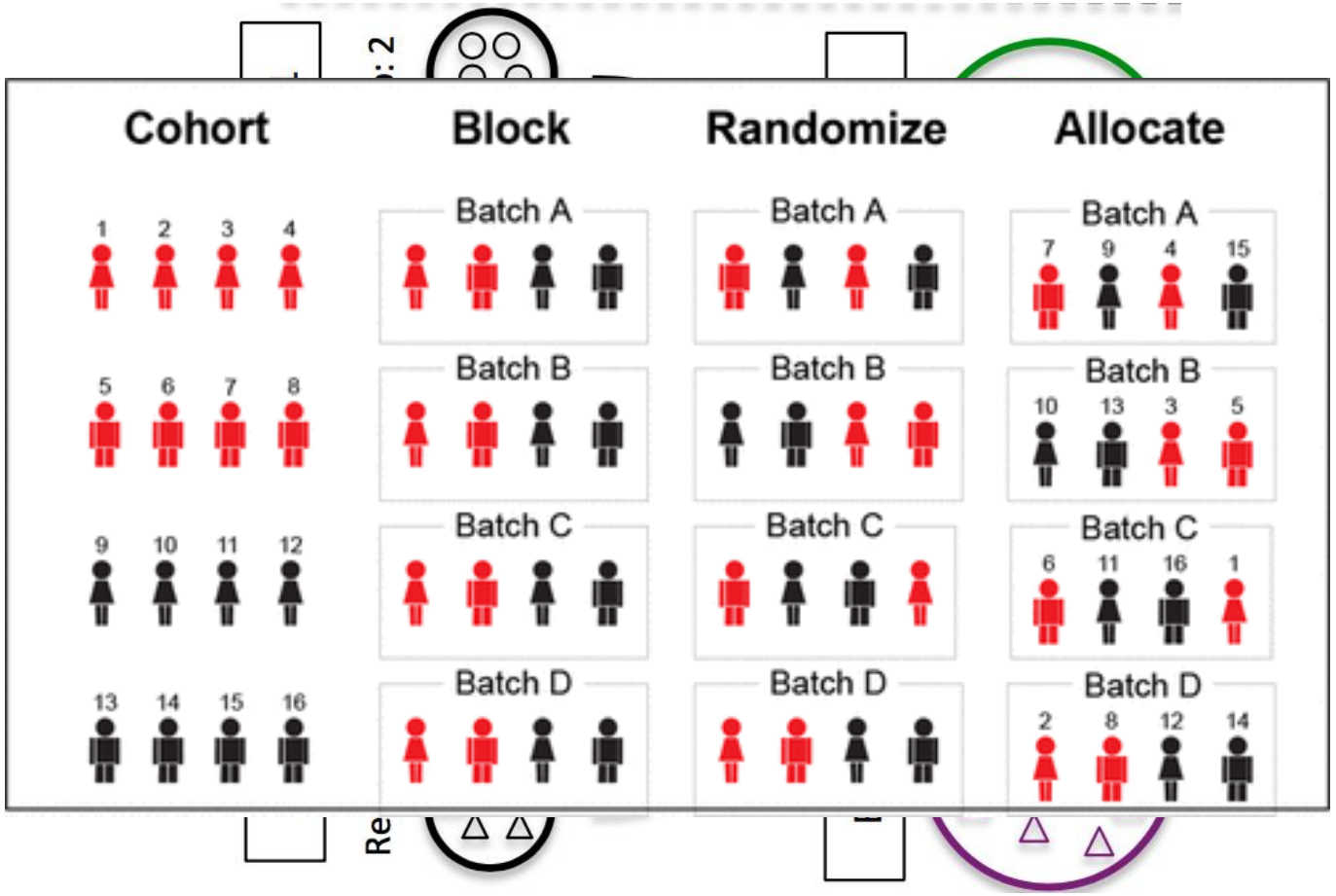


Adapted from Masson et al. Trends Biotech, 2023

FROM OBSERVATIONAL
TO ACTIONABLE OMICS

3. Carefully design your study for your immediate question and future scalability

- Enable for large numbers of samples over time
- Diversity in the parameters you'd like to study
- Careful control of study design parameters, covariates, and how you group and organize samples (batches)



Adapted from Masson et al. Trends Biotech, 2023

Chiang, bioRxiv, 2021
Burger, J. Prot Res, 2021

Proteomics of Recombinant Chinese Hamster Ovary Cells

Dr. Paula Meleady
Principal Investigator, School of Biotechnology,
National Institute for Cellular Biotechnology,
Dublin City University,
Ireland

Overview

- Proteomics Study Design
- Proteome complexity, e.g. cellular PTMs

Study Design

- Bryan et al. *Mapping the molecular basis for **growth** related phenotypes in industrial producer CHO cell lines using differential proteomic analysis.* BMC Biotechnology, 2021, 21:43

- Make sure to have comprehensive characterisation of the cell lines used in the study, in order to get **meaningful** phenotypic proteomics data
  - Growth rate differences – aim of study
  - Qp similar for all cell lines used
  - Waste products and metabolites of the cells were measured throughout culture with no significant difference in lactate or ammonia
  - Study controlled for cell size, cell volume, transgene copy number or transcript copy number.

Proteome Complexity: Dynamic nature of the proteome

- The dynamic nature of the changing proteome during growth of rCHO cells in bioprocess relevant conditions.
- Added layer of complexity with the inclusion of analysis of cellular post-translational modifications; e.g. phosphoproteomic & ubiquitinated proteomic data
- Genomic/transcriptomics studies ‘blind’ to these PTMs

Example: Manipulation of phosphoprotein targets to improve bioprocessing phenotypes?

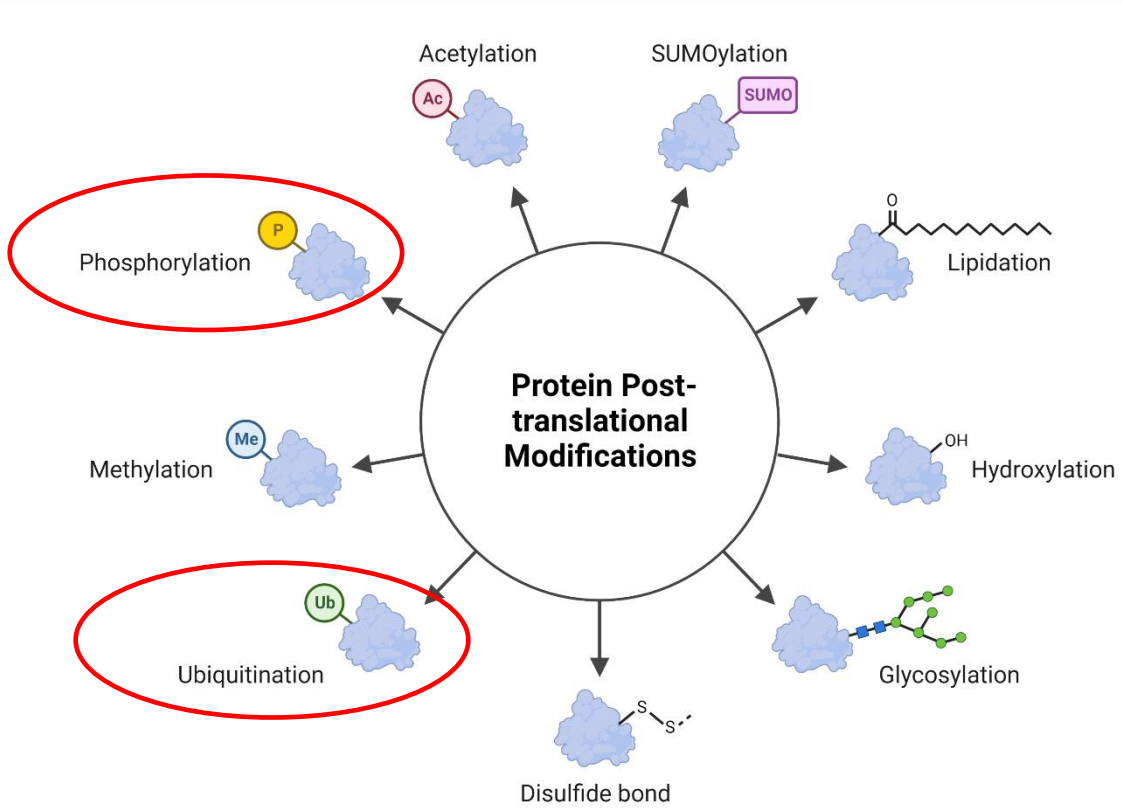
- Cell line engineering approaches
- Use of Chemical Inhibitors – e.g. kinase inhibitors
- Rational media/process design

Why study cellular PTMs?

- Genomic and transcriptomic approaches are blind to PTMs, making proteomics the only way to study these on a large scale

- PTMs can be static or dynamic, altering the chemical state of a protein in subtle ways that are not easily detected using standard profiling techniques.

- They increase chemical diversity and **complexity** of the proteome.



KEGG Pathway Analysis

	Proteome			***Phosphoproteome***
Day 2 v Day 3	Spliceosome		Day 2 v Day 3	Spliceosome
	RNA transport			ErbB signaling pathway
	Metabolic pathways			RNA transport
	Carbon metabolism			Thyroid hormone signaling pathway
	Protein processing in endoplasmic reticulum			Insulin signaling pathway
				Autophagy - animal
				mTOR signaling pathway
Day 3 vs Day 4	Carbon metabolism		Day 3 vs Day 4	AMPK signaling pathway
	Metabolic pathways			Autophagy - animal
	Spliceosome			Cell cycle
	Citrate cycle (TCA cycle)			mTOR signaling pathway
	RNA transport			Insulin signaling pathway
	Citrate cycle (TCA cycle, Krebs cycle)			Spliceosome
Day 4 vs Day 5	Carbon metabolism		Day 4 vs Day 5	RNA transport
	Metabolic pathways			Adherens junction
	Citrate cycle (TCA cycle)			AMPK signaling pathway
	Citrate cycle (TCA cycle, Krebs cycle)			Tight junction
	RNA transport			
	Proteasome			

Metabolism related proteins

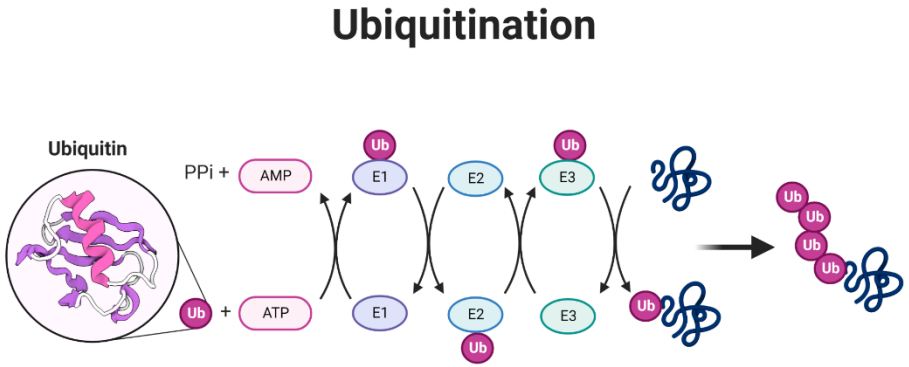
Signalling pathway related proteins

Kaushik et al. Biotech J. 13(10):e1700221.

Another PTM - Ubiquitination

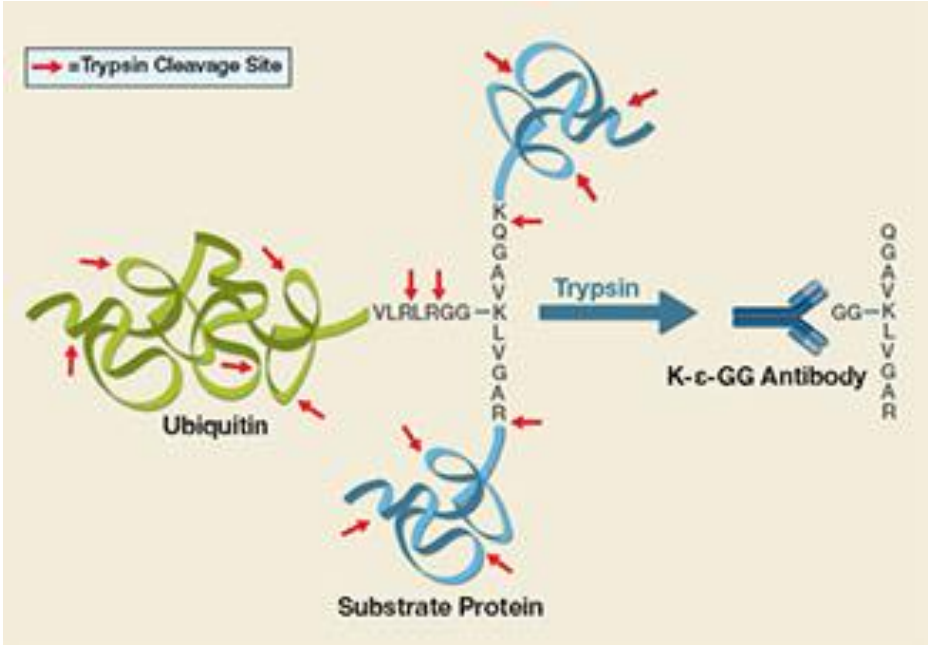
- Conjugation of the 8.5kD protein ubiquitin to target proteins marking them for **proteasomal degradation**

- Also has important **regulatory** functions similar to phosphorylation,
  - cell cycle regulation, gene expression, apoptosis, signal transduction, cellular localisation of proteins, modulating protein-protein interactions



Analytical Challenges

- Analysis of ubiquitination events is now possible with advancements in LC-MS/MS instrumentation
- Lys-ε-diglycine **(diGly)** mark on peptides after tryptic digestion of proteins indicates a site of ubiquitination.
- Immunoaffinity-based **enrichment** of diGly remnant-containing peptides (using an anti-K-ε-GG antibody) of ubiquitinated peptides for LC-MS/MS



https://www.cellsignal.co.uk/services/proteomics-analytical-services/ubiscan-ubiquitination-proteomics

DCU
Ollscoil Chathair
Bhaile Átha Cliath
Dublin City University

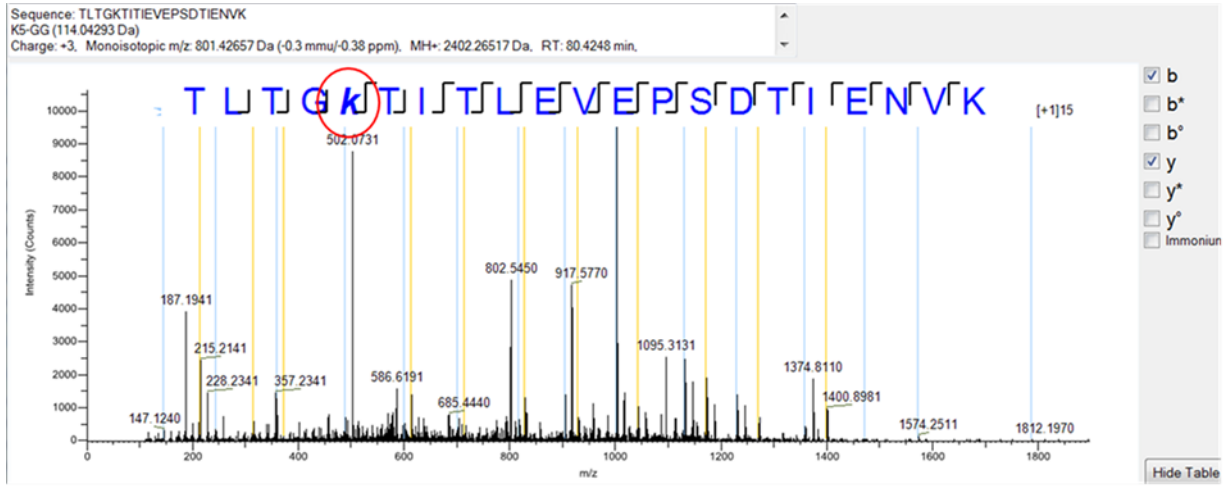
Why would we study ubiquitination events in rCHO cells?

- Production of recombinant proteins is a coordinated process of transcription, translation, folding, post-translational modification, and secretion.
  - Each of these steps may act as a bottleneck in the production of correctly assembled proteins
- Known link between protein productivity and ER stress mechanisms in CHO cell
- ER stress mechanisms are poorly understood in rCHO cells,
  - major bottleneck in improving the efficiency of production of high cost recombinant biopharmaceuticals.
  - Fine balance between UPR and ERAD

Industry Relevant Data

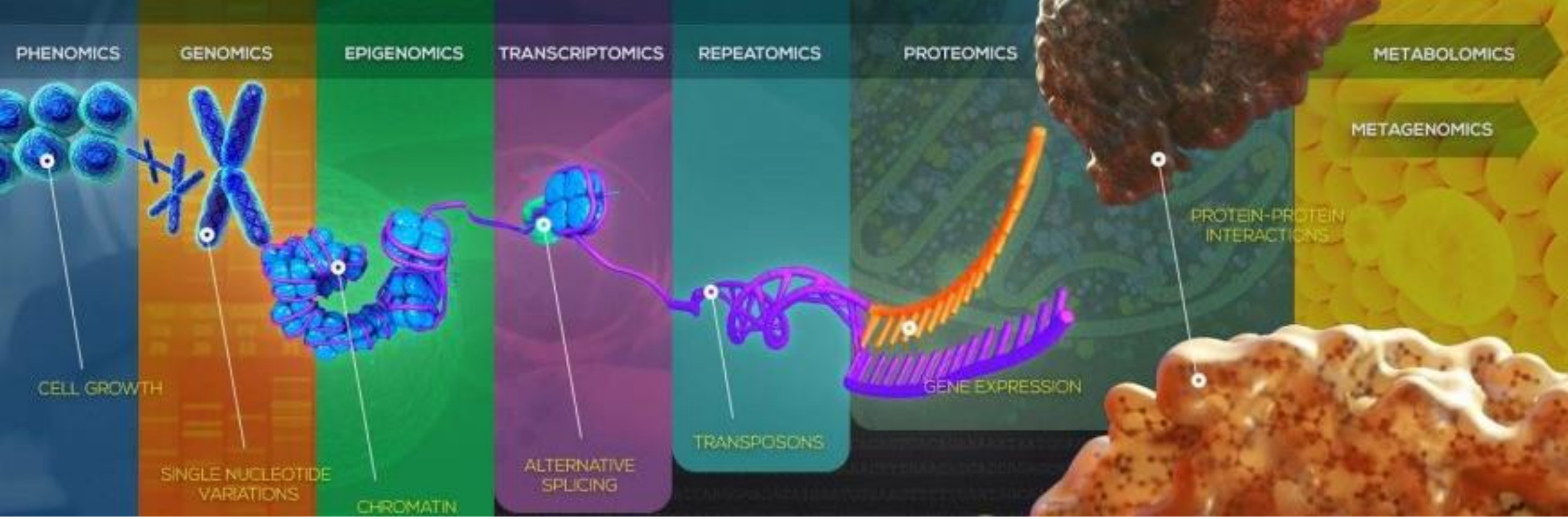
- High v low productivity rCHO cells (mAb producers) – industry-relevant cell lines
  - Many examples in literature of ‘proteomic’ studies to study such phenotypes

- In our lab, we have identified ~ 4,500 ubiquitinated CHO peptides
- > 75 ubiquitinated peptides showing differential expression (high v low producer)



An example of a fragment spectrum from ribosomal protein s27a, a ubiquitinated peptide identified from CHO-DP12 cells

Ollscoil Chathair Bhaile Átha Cliath
Dublin City University

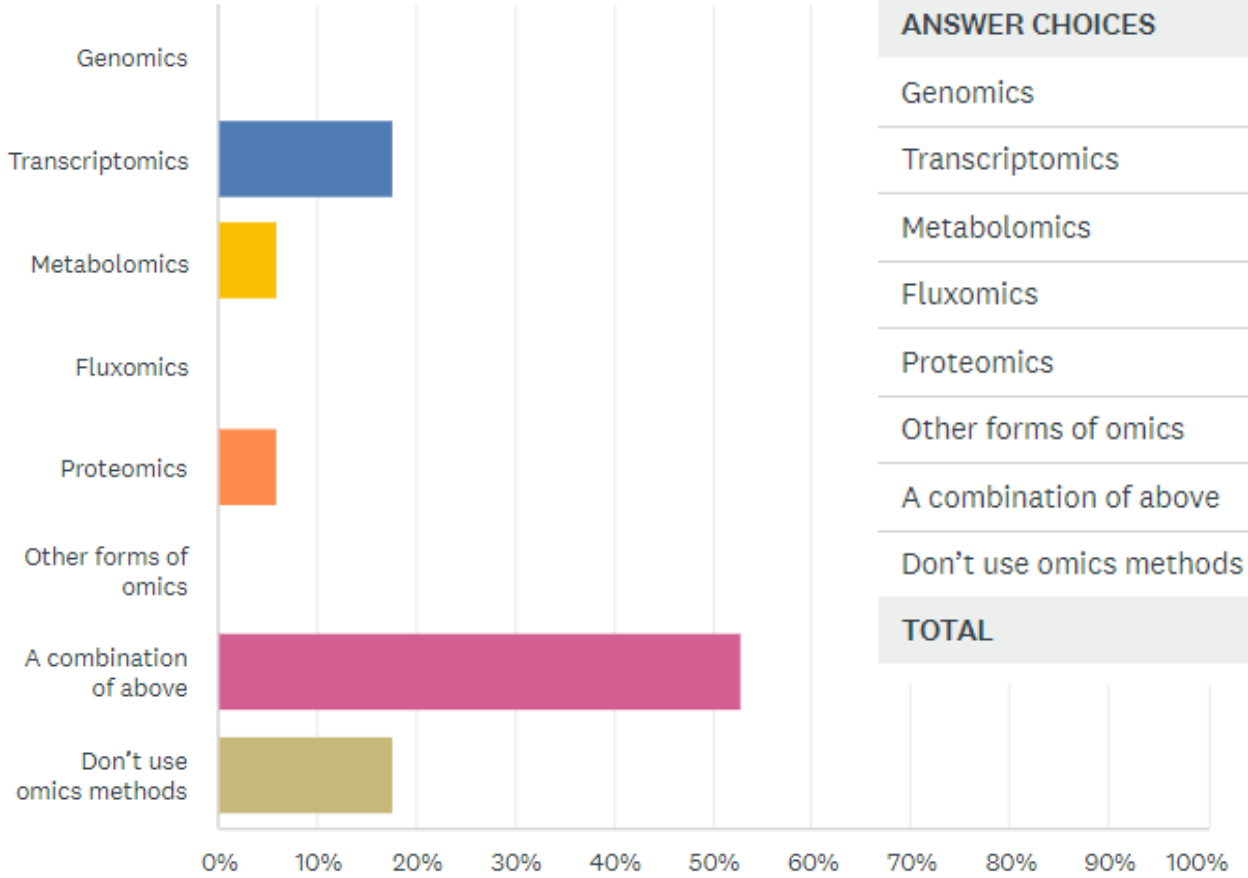


Your candid thoughts on omics in biomanufacturing

A survey review

What type of omics methods do you use in your work?

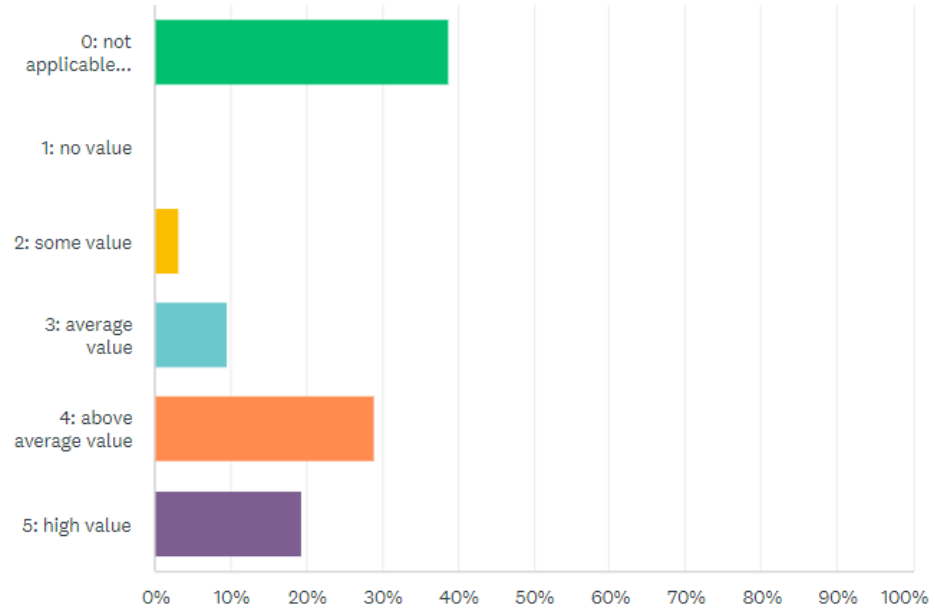
Answered: 34 Skipped: 167



ANSWER CHOICES	RESPONSES	
Genomics	0.00%	0
Transcriptomics	17.65%	6
Metabolomics	5.88%	2
Fluxomics	0.00%	0
Proteomics	5.88%	2
Other forms of omics	0.00%	0
A combination of above	52.94%	18
Don't use omics methods	17.65%	6
TOTAL		**34**

If you are from academia, do you think there is value in employing omics methods in cell culture or cell line development research work? Rate on a scale of 0-5:

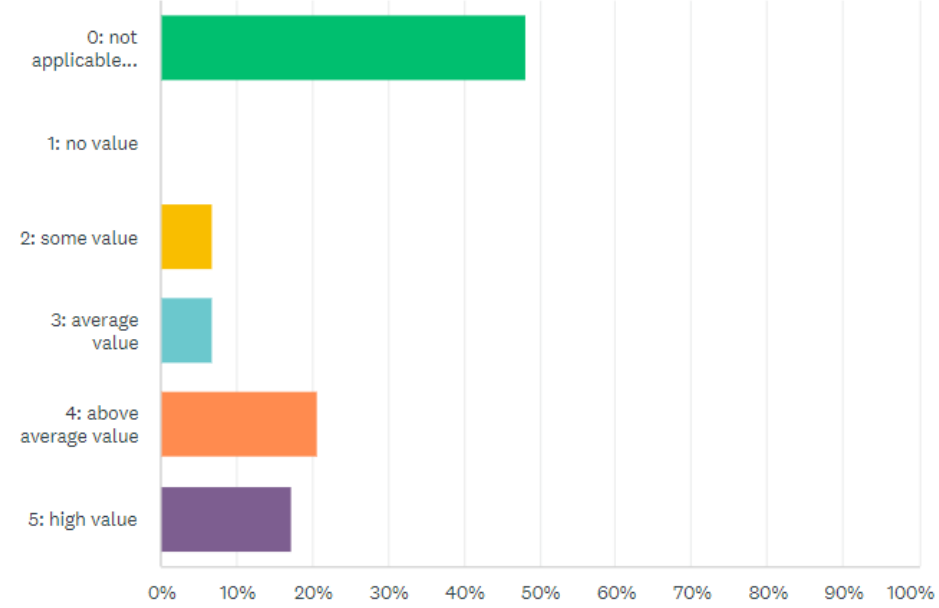
Answered: 31 Skipped: 170



ANSWER CHOICES	RESPONSES	
0: not applicable (those who are from industry)	38.71%	12
1: no value	0.00%	0
2: some value	3.23%	1
3: average value	9.68%	3
4: above average value	29.03%	9
5: high value	19.35%	6
TOTAL		31

If you are from industry, do you think there is value in employing omics techniques in cell culture or cell line development research work? Rate on a scale of 0-5:

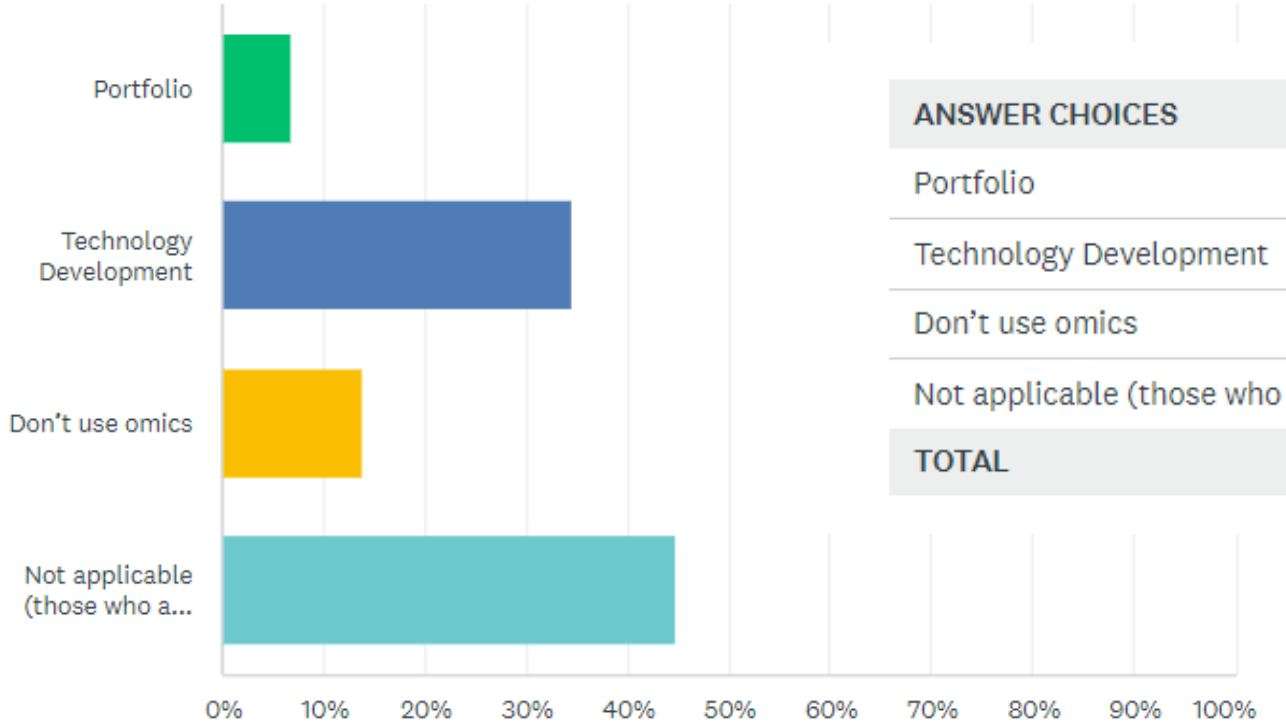
Answered: 29 Skipped: 172



ANSWER CHOICES	RESPONSES	
0: not applicable (those who are from academia)	48.28%	14
1: no value	0.00%	0
2: some value	6.90%	2
3: average value	6.90%	2
4: above average value	20.69%	6
5: high value	17.24%	5
TOTAL		29

If you are from industry, do you use omics in the portfolio space or technology development space?

Answered: 29 Skipped: 172



ANSWER CHOICES	RESPONSES	
Portfolio	6.90%	2
Technology Development	34.48%	10
Don't use omics	13.79%	4
Not applicable (those who are from academia)	44.83%	13
TOTAL		**29**

What are the perceived hurdles in applying omics routinely in industry?

- High cost, slow turnaround time, slow and complex data analytics and interpretations
- Making sense of the big data and getting practical benefits from implementation.
- specialized lab equipment needed; in depth knowledge required, large scale data sets and challenging to interpret
- Finding relevant actionable knowledge
- Cost of omics study in both data generation and analysis. Lack of skill sets design omic studies and perform analysis.
- New for many people.
- Turnaround time. Accessible analysis tools
- sufficiently "power" the experiments under relevant culture conditions - challenging with bioreactor work and heterogeneity in CHO - better separate the noise/variation vs biologically-meaningful signal
- Knowing where they can be applied
- Difficulties associated with measuring many parameters and data management/interpretations
- IP issues with big data, data security issues, finding out more than we're looking for, how much of the data is liable to be searched for from regulatory agencies, how to best use the data, bringing the company as a whole up to speed omics and seeing benefits over risks
- Relatively high cost; Data interpretation can be challenging considering the plasticity of CHO genome
- Deciphering what the data means and how to use it
- FTO
- The omics findings are not easily nor quickly translated to applicable actions to improve cell lines/process.
- Cumbersome
- Actionability in the data sets.
- Getting useful information out of bulk data
- the prices, the large amount of data and analysis
- data analysis/interpretation
- ROI unclear
- Implementation (sample processing and analysis, extra work for manufacturing issue), developing and verifying models at different scales.

Where do you feel the most important advancement is needed to make omics a mainstream analytical tool for biotech research?

- streamlined experimental and data analysis workflows including interpreation of results
- Data handling, interpretation, and management
- Demonstration of high value novel application
- The technology is ready to be utilized. FDA guidance in using omics for filing purpose is lacking in some areas
- Cell line development, cell culture process development.
- Speed. Data analysis tools for the non-expert/upskilling bioprocess scientists
- integration of omics anlyses; effective prioritization and follow-up of "targets"; systems modeling; training; appropriately scaled experiments and timelines;
- Lower costs, standardized and uniform sequencing procedures, and user-friendly analysis tools.
- Simplify the analyses, make it doable also for non-programmers
- Full automation, proper bioinfo dedicated teams, paradigm shift in industry culture
- New technology to further lower omics cost
- New technology to further lower omics cost
- simple use based on software and apps that can be easily integrated and applied without substantial bioinformatics training
- User-friendly correlations for data to function - effective biomarker identification Cell host/processs-agnostic predictive power
- reduce costs
- Data analysis tools
- simplification needed
- Standardized workflows for analysis; task specific data interpretation (e.g., how to use specific types of omics data to improve qp, or product quality).
- Analysis pipelines
- have more connected databases, More advances are needed in single cell proteomics, for example, and lower prices to make techniques quantifiable, whose application can be simple.
- More published case studies would help to justify implementation. More examples of how to implement models (metabolomics used to develop online models with Raman or continue with offline sample and analysis. More real time data is better)

For those who have used omics methods in the past, how did omics help you in your work? What type of issues did you try to solve using omics?

How omics helped

- process understanding/optimization, process and media development; cell characterization
- Suggestions for fed batch feed improvement, explanation for mechanism behind effect of process parameters
- sequence identity, impurity, and host/clone multi-omics characterization to correlate gene expression and phenotype
- Deselection of cell lines with product sequence variants. Integration site analysis to help with clonality assurance
- Expression vector design
- To have high-level understanding of CHO biology; to understand the fundamental differences between CHO host lineages.
- understanding complex regulatory pathways that impact production or product quality objective: to find ways of supporting cells to solve the problem
- We learned a tremendous amount from our omics studies of cell lines of varying productivities. The challenge is going through all the data.
- Confidential
- Evaluating expression levels under certain conditions.
- Identified targets for cell and process engineering
- ID potential targets for knock down to improve qp; ID leading drivers of phenotypic change in response to cell culture stress.
- Understanding cell reprogramming after restimulation
- It has helped me draw a line of research, it has allowed us to have targets that can be modified to improve bioprocesses.

Issues

- Data analysis is always a challenge, particularly in combining multi-omic measurements.
- Have run into too many hurdles to have success

Challenge questions for the tables

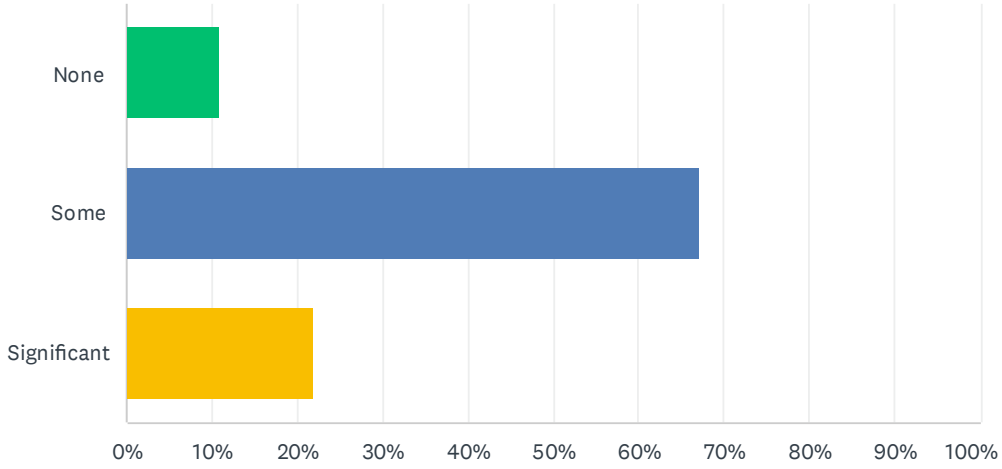
1. I am getting <50% product purity for a multi-specific mAb when expressed in my production CHO system. I want to know why and what options to increase the purity of the expression.
2. I have a robust CHO GS system that grows well but achieves only a q_p of 10 pcd for a particular product. How do I achieve 2-3x increase in q_p?
3. My cell line has titer stability issue which decreases with increasing generations. I know it's innate to this cell line developed. However, I think I am seeing possible positive effect when placed in different seed train media. How do understand why if this real?
4. I have intensified my perfusion cell culture achieving 150 x 10^6 cells/mL, but I like to still achieve much higher than this. However, my cell line has a relatively high cell specific OUR and my bioreactor OTR capacity can no longer support. How do I understand and mitigate from a cell line and/or cell culture point of view?
5. I developed a robust cell culture process with good lactate reconsumption by the end of the culture. However, when I scaled up to large-scale stainless-steel bioreactor, there is a high lactate spike by the end of the culture. Furthermore, my glycan profile has shifted to more high mannose species. I know I have added sufficient copper to mitigate lactate when I developed the process. How do I go about figuring out what's going on?
6. An elevated specific HCP level was identified in my harvested cell culture fluid at the large scale. The integrated viable cell concentration hasn't changed. Clearance at this level may be a challenge for downstream. How do I figure out the origin of this increase?

Open topics for further discussion and debate

- Omics studies of individual cell lines may help fine tune the process to achieve better productivity / quality. Omics studies generate lots of data, but it's very often difficult to interpret these data and the results are not applicable to other cell lines.
- Data overload coupled with lack of uniform understanding of predictability
- The community could have established omics reference database and tools to enable more users to use omics without needing significant bioinformatics resource and support.
- Tradeoffs in effort, cost, and actionability in omics data.
- Which omics approach deserves more awareness/use
- Discuss new techniques or strategies that improve the depth that allow the understanding of recombinant cells.

Q65 Do you use omics methods in your development work in any form?

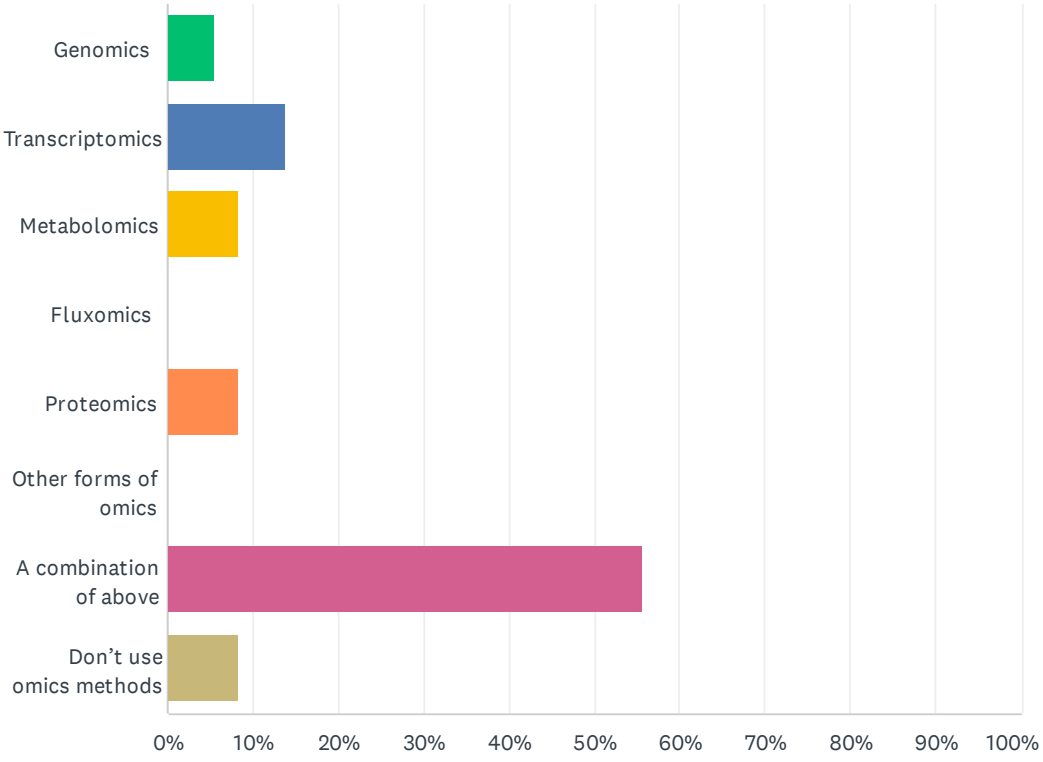
Answered: 73 Skipped: 256



ANSWER CHOICES	RESPONSES	
None	10.96%	8
Some	67.12%	49
Significant	21.92%	16
TOTAL		73

Q66 What type of omics methods do you use in your work?

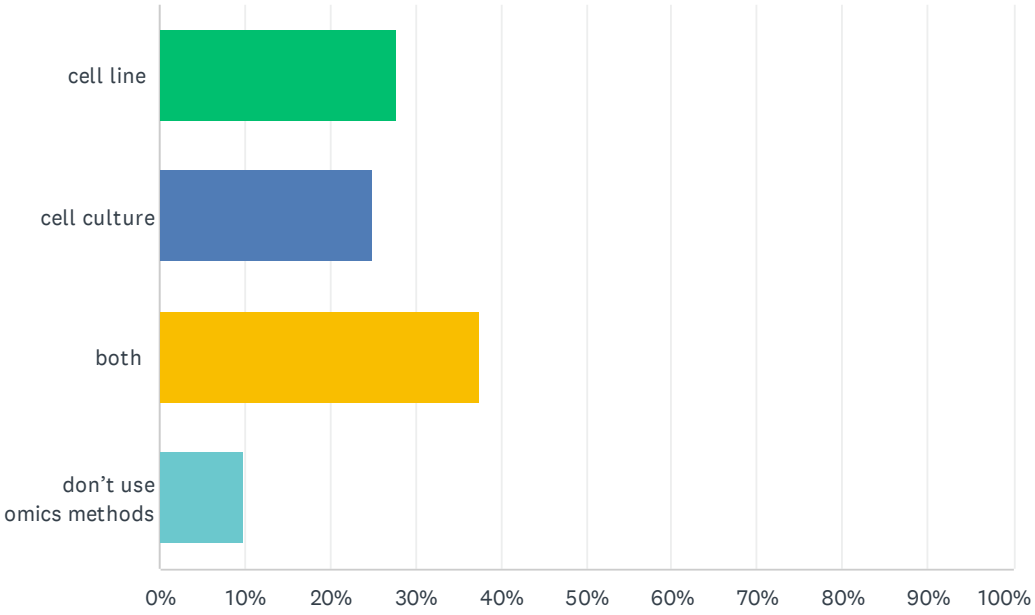
Answered: 72 Skipped: 257



ANSWER CHOICES	RESPONSES	
Genomics	5.56%	4
Transcriptomics	13.89%	10
Metabolomics	8.33%	6
Fluxomics	0.00%	0
Proteomics	8.33%	6
Other forms of omics	0.00%	0
A combination of above	55.56%	40
Don't use omics methods	8.33%	6
TOTAL		72

Q67 Do you use omics methods in cell line development research or cell culture development research?

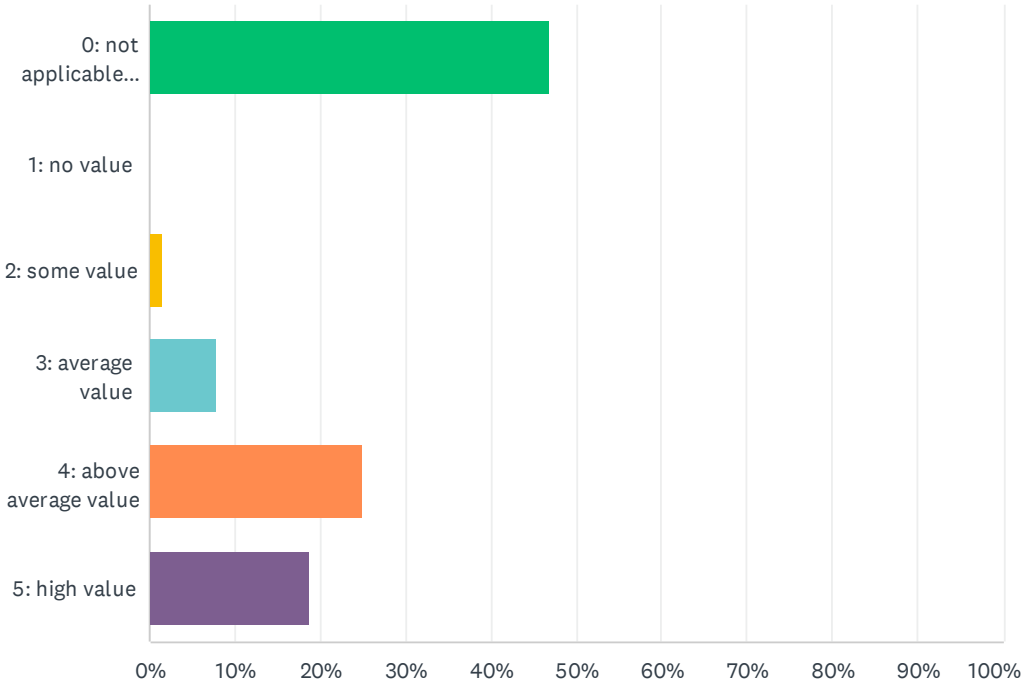
Answered: 72 Skipped: 257



ANSWER CHOICES	RESPONSES	
cell line	27.78%	20
cell culture	25.00%	18
both	37.50%	27
don't use omics methods	9.72%	7
TOTAL		72

Q68 If you are from academia, do you think there is value in employing omics methods in cell culture or cell line development research work? Rate on a scale of 0-5:

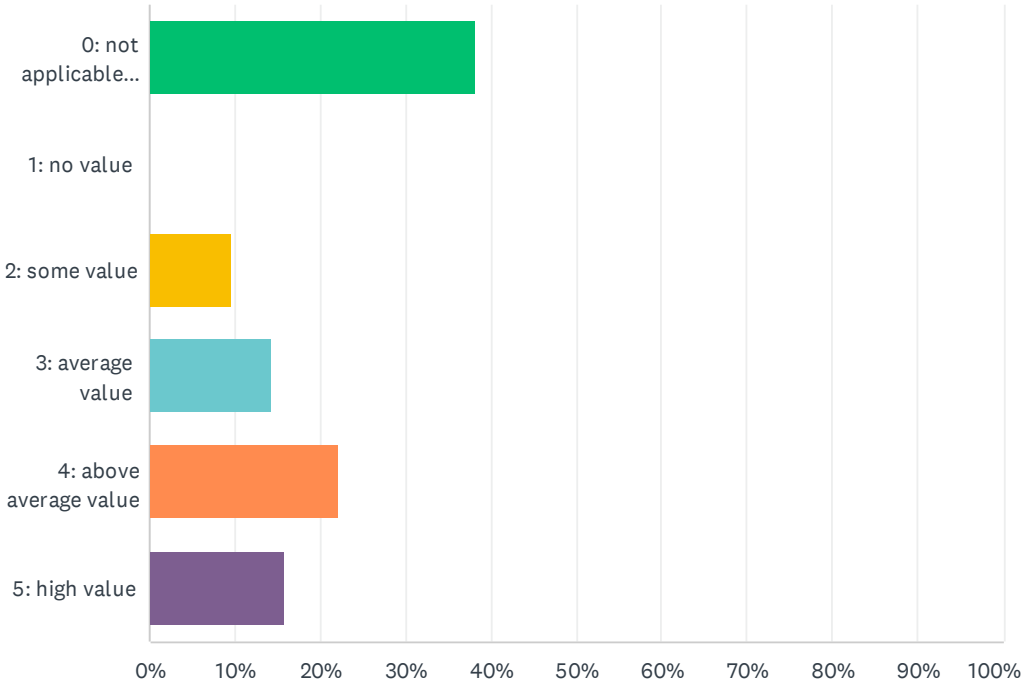
Answered: 64 Skipped: 265



ANSWER CHOICES	RESPONSES	
0: not applicable (those who are from industry)	46.88%	30
1: no value	0.00%	0
2: some value	1.56%	1
3: average value	7.81%	5
4: above average value	25.00%	16
5: high value	18.75%	12
TOTAL		64

Q69 If you are from industry, do you think there is value in employing omics techniques in cell culture or cell line development research work? Rate on a scale of 0-5:

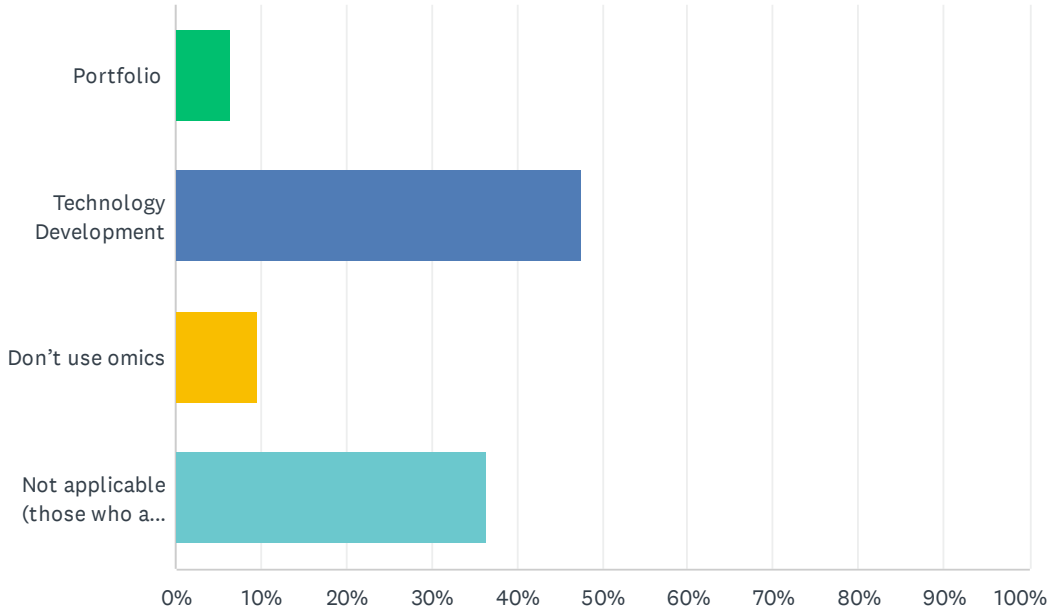
Answered: 63 Skipped: 266



ANSWER CHOICES	RESPONSES	
0: not applicable (those who are from academia)	38.10%	24
1: no value	0.00%	0
2: some value	9.52%	6
3: average value	14.29%	9
4: above average value	22.22%	14
5: high value	15.87%	10
TOTAL		63

Q70 If you are from industry, do you use omics in the portfolio space or technology development space?

Answered: 63 Skipped: 266



ANSWER CHOICES	RESPONSES	
Portfolio	6.35%	4
Technology Development	47.62%	30
Don’t use omics	9.52%	6
Not applicable (those who are from academia)	36.51%	23
TOTAL		63

Q71 What are the perceived hurdles in applying omics routinely in industry?

Answered: 47 Skipped: 282

#	RESPONSES	DATE
1	Translating omics to a program-related application	4/14/2023 6:36 PM
2	Consistency of results through various software platforms/pipelines. Applicability from often overwhelmingly large datasets.	4/14/2023 5:12 PM
3	Cost and data analysis	4/14/2023 1:34 PM
4	Time spent on data analysis and interpretation	4/14/2023 1:12 PM
5	Speed of data interpretation	4/14/2023 11:07 AM
6	Turnaround time, cost, data analysis & interpretation	4/14/2023 9:25 AM
7	You tend to generate very large data sets that can be difficult to draw meaningful and ACTIONABLE conclusions from.	4/14/2023 9:07 AM
8	Large amounts of data, difficult to apply findings	4/14/2023 8:10 AM
9	* Cost/benefit ratio for the average process * Value added vs traditional approaches (saving time& resources or better process for the buck)	4/14/2023 5:16 AM
10	Lack of people with the skillset, and limited training available in the field.	4/14/2023 12:37 AM
11	bandwidth to validate methods, lack of specific training, disconnect between dev scientists and data scientist	4/13/2023 8:47 PM
12	Accessibility of user-friendly tools/pipelines	4/13/2023 4:45 PM
13	That it is faster / easier to do the standard process development experiments with a DoE design versus the time investment for the omics route (do the omics experiment + analysis + doing the same experiments anyway)	4/13/2023 4:31 PM
14	Cost, big data analytics	4/13/2023 4:18 PM
15	Cost, dedicated personnel, time	4/13/2023 4:12 PM
16	Interpretation of results Typically hypothesis generating, not testing	4/13/2023 4:02 PM
17	lots of data, harder to interpret and winnow down to an actual causational effect	4/13/2023 4:01 PM
18	Inability to determine concrete actions to take based on 'omics data	4/13/2023 4:00 PM
19	Upfront resource commitment Lack of clear questions to answer with this technology	4/13/2023 3:52 PM
20	Time consuming and alot of data to analyze. No clear approach and not easy to explain the application	4/13/2023 3:51 PM
21	Extremely large data sets need to be analyzed	4/13/2023 3:54 AM
22	Timelines and probability of success	4/12/2023 3:46 PM
23	Data management	4/12/2023 11:10 AM
24	Business case, access to capability for sample and data analysis, gaps in CHO genome/metabolome annotation	4/10/2023 2:21 PM
25	High cost, slow turnaround time, slow and complex data analytics and interpretations	4/7/2023 7:36 PM
26	Making sense of the big data and getting practical benefits from implementation.	4/7/2023 5:34 PM
27	specialized lab equipment needed; in depth knowledge required, large scale data sets and	4/6/2023 6:11 AM

	challenging to interpret	
28	Finding relevant actionable knowledge	4/5/2023 3:41 AM
29	Cost of omics study in both data generation and analysis. Lack of skill sets design omic studies and perform analysis.	4/4/2023 7:11 PM
30	New for many people.	4/4/2023 2:16 PM
31	Turnaround time. Accessible analysis tools	4/4/2023 1:25 PM
32	sufficiently "power" the experiments under relevant culture conditions - challenging with bioreactor work and heterogeneity in CHO - better separate the noise/variation vs biologically-meaningful signal	4/3/2023 7:54 PM
33	Knowing where they can be applied	4/3/2023 6:51 AM
34	Difficulties associated with measuring many parameters and data management/interpretations	4/3/2023 4:27 AM
35	IP issues with big data, data security issues, finding out more than we're looking for, how much of the data is liable to be searched for from regulatory agencies, how to best use the data, bringing the company as a whole up to speed omics and seeing benefits over risks	4/2/2023 6:57 PM
36	Relatively high cost; Data interpretation can be challenging considering the plasticity of CHO genome	4/2/2023 10:46 AM
37	Deciphering what the data means and how to use it	4/1/2023 10:15 PM
38	FTO	4/1/2023 8:19 PM
39	The omics findings are not easily nor quickly translated to applicable actions to improve cell lines/process.	4/1/2023 5:55 PM
40	Cumbersome	4/1/2023 10:28 AM
41	-	4/1/2023 4:39 AM
42	Actionability in the data sets.	4/1/2023 4:29 AM
43	Getting useful information out of bulk data	3/31/2023 11:17 PM
44	the prices, the large amount of data and analysis	3/31/2023 8:44 PM
45	data analysis/interpretation	3/31/2023 7:58 PM
46	ROI unclear	3/31/2023 5:56 PM
47	Implementation (sample processing and analysis, extra work for manufacturing issue), developing and verifying models at different scales.	3/31/2023 5:05 PM

Q72 Where do you feel the most important advancement is needed to make omics a mainstream analytical tool for biotech research?

Answered: 44 Skipped: 285

#	RESPONSES	DATE
1	Simplified pipelines with GUIs	4/14/2023 5:12 PM
2	Data analysis tools that are easily deployed	4/14/2023 1:34 PM
3	Share omics expertise - Training people from start (sample preparation) to end (analysis & interpretation), adjusting omics workflow to desired needs and focus on common challenges	4/14/2023 1:12 PM
4	AI interpretation of data	4/14/2023 11:07 AM
5	There needs to be very easy to use tools/programs to upload data sets (metabolomics, proteomics, transcriptomics) and guide users through how to find actionable results.	4/14/2023 9:07 AM
6	Data interpretation	4/14/2023 8:10 AM
7	* Demonstrate reproducibly superior results and/or same results in shorter timeframe * Streamlining data acquisition, data analysis, and translation into actions so non-experts can use it * Timelines/Cost for omics-technologies if not established inhouse	4/14/2023 5:16 AM
8	Highlighting the utility and importance of 'omics; emphasizing the role of 'omics-based research and how it can streamline experimentation.	4/14/2023 12:37 AM
9	additional examples of clear value and necessity in a workflow or platform	4/13/2023 8:47 PM
10	Developing user-friendly tools and associated best practices so that people with little to no computational background can "correctly" extract value from omics.	4/13/2023 4:45 PM
11	Data analytics and workflow	4/13/2023 4:18 PM
12	Time	4/13/2023 4:12 PM
13	Quick and accessible data analysis tools	4/13/2023 4:02 PM
14	simplified user interfaces to interpretation tools (that aren't incredibly expensive)	4/13/2023 4:01 PM
15	Routine access to data Data analysis and interpretation - separation of drivers vs passengers and then determining subsequent actions based on understanding	4/13/2023 4:00 PM
16	An efficient data processing and analysis tool for an easier biological interpretation	4/13/2023 3:55 PM
17	As a wet lab person who used to work in an academic lab I still struggle with the visualization and need to rely on someone to help with this. Additionally, I feel once people see revolutionary improvements in productivity, it could become a more attractive tool for cell culture.	4/13/2023 3:52 PM
18	Some type of automation that standardizes the approach for each cell line or cell culture process	4/13/2023 3:51 PM
19	Better tools for analysis of large data sets	4/13/2023 3:54 AM
20	Which technology yields significant results to be translated into process improvement	4/12/2023 11:10 AM
21	Standardized methods that allow data interpretation across studies	4/10/2023 2:21 PM
22	Simple and easy to use by everyone	4/7/2023 7:36 PM
23	Translation to big improvements in titers and product quality.	4/7/2023 5:34 PM
24	streamlined experimental and data analysis workflows including interpreation of results	4/6/2023 6:11 AM
25	Demonstration of high value novel application	4/5/2023 3:41 AM

26	The technology is ready to be utilized. FDA guidance in using omics for filing purpose is lacking in some areas	4/4/2023 7:11 PM
27	Cell line development, cell culture process development.	4/4/2023 2:16 PM
28	Speed. Data analysis tools for the non-expert/upskilling bioprocess scientists	4/4/2023 1:25 PM
29	integration of omics anlyses; effective prioritization and follow-up of "targets"; systems modeling; training; appropriately scaled experiments and timelines;	4/3/2023 7:54 PM
30	Lower costs, standardized and uniform sequencing procedures, and user-friendly analysis tools.	4/3/2023 2:53 AM
31	Simplify the analyses, make it doable also for non-programmers	4/3/2023 2:41 AM
32	Full automation, proper bioinfo dedicated teams, paradigm shift in industry culture	4/2/2023 6:57 PM
33	New technology to further lower omics cost	4/2/2023 10:46 AM
34	simple use based on software and apps that can be easily integrated and applied without substantial bioinformatics training	4/2/2023 7:34 AM
35	User-friendly correlations for data to function - effective biomarker identification Cell host/processs-agnostic predictive power	4/2/2023 6:04 AM
36	reduce costs	4/1/2023 8:19 PM
37	Data analysis tools	4/1/2023 5:55 PM
38	Data handling, interpretation, and management	4/1/2023 10:28 AM
39	simplification needed	4/1/2023 4:39 AM
40	Standardized workflows for analysis; task specific data interpretation (e.g., how to use specific types of omics data to improve qp, or product quality).	4/1/2023 4:29 AM
41	Analysis pipelines	3/31/2023 11:17 PM
42	have more connected databases, More advances are needed in single cell proteomics, for example, and lower prices to make techniques quantifiable, whose application can be simple.	3/31/2023 8:44 PM
43	Not sure.	3/31/2023 5:56 PM
44	More published case studies would help to justify implementation. More examples of how to implement models (metabolomics used to develop online models with Raman or continue with offline sample and analysis. More real time data is better)	3/31/2023 5:05 PM

Q73 If you are from industry, does your company make budget allocation for omics expense?

Answered: 35 Skipped: 294

#	RESPONSES	DATE
1	Not specifically, part of technology development	4/14/2023 6:36 PM
2	Yes	4/14/2023 1:34 PM
3	Yes	4/14/2023 1:12 PM
4	some	4/14/2023 11:07 AM
5	No	4/14/2023 9:25 AM
6	CMC program dependent	4/14/2023 9:07 AM
7	Yes, historically.	4/14/2023 8:10 AM
8	Yes, limited	4/14/2023 5:16 AM
9	NA	4/14/2023 12:37 AM
10	yes	4/13/2023 8:47 PM
11	Yes	4/13/2023 4:31 PM
12	Somewhat	4/13/2023 4:18 PM
13	Not routinely	4/13/2023 4:12 PM
14	yes, but not necessarily for my line function outside of technology development	4/13/2023 4:01 PM
15	We do have some resources dedicated to omics, but these resources are generally only available for specific projects. Mostly I beg, lie, cheat and steal to get resources.	4/13/2023 4:00 PM
16	yes	4/13/2023 3:51 PM
17	Not applicable (those who are from academia)	4/13/2023 3:54 AM
18	Yes	4/12/2023 3:46 PM
19	no	4/12/2023 11:10 AM
20	Not specifically	4/10/2023 2:21 PM
21	Yes	4/7/2023 7:36 PM
22	minor	4/6/2023 6:11 AM
23	from academia	4/5/2023 3:41 AM
24	yes	4/4/2023 7:11 PM
25	No	4/4/2023 2:16 PM
26	Yes	4/3/2023 7:54 PM
27	No	4/3/2023 4:27 AM
28	No	4/2/2023 6:57 PM
29	Yes	4/2/2023 10:46 AM
30	yes	4/1/2023 8:19 PM
31	Some	4/1/2023 10:28 AM

32	-	4/1/2023 4:39 AM
33	NA	3/31/2023 8:44 PM
34	No.	3/31/2023 5:56 PM
35	Small allocation	3/31/2023 5:05 PM

Q74 If you are from industry, does your company perform omics analytics in-house or outsource? If in-house, for which types of omics?

Answered: 36 Skipped: 293

#	RESPONSES	DATE
1	Analytics in house for transcriptomics and genomics.	4/14/2023 6:36 PM
2	In-house, mostly transciptomics	4/14/2023 1:34 PM
3	In-house omics analytics (transcriptomics, proteomics, metabolomics)	4/14/2023 1:12 PM
4	both	4/14/2023 11:07 AM
5	Outsource	4/14/2023 9:25 AM
6	Some in-house, some out-sourced	4/14/2023 9:07 AM
7	Outsource at present. Mostly Metabolomics.	4/14/2023 8:10 AM
8	Partly internal (metabolites), mostly outsourced (esp. genomics/transcriptomics)	4/14/2023 5:16 AM
9	NA	4/14/2023 12:37 AM
10	outsource, genomics and proteomics	4/13/2023 8:47 PM
11	In house	4/13/2023 4:31 PM
12	Outsource, depends	4/13/2023 4:18 PM
13	A mix for all, mostly outsource	4/13/2023 4:12 PM
14	outsource most, has some metabolomics capabilities inhouse	4/13/2023 4:01 PM
15	In-house - genomics and transcriptomics Proteomics and metabolomics some in house augmented by outsourcing	4/13/2023 4:00 PM
16	inhouse, genomics, proteomics and metabolomics	4/13/2023 3:51 PM
17	Not applicable (those who are from academia)	4/13/2023 3:54 AM
18	in-house: all sequencing	4/12/2023 3:46 PM
19	in-house proteomics	4/12/2023 11:10 AM
20	Both. Generally, targeted omics approaches are performed in-house whereas more extensive untargeted/global analyses are outsourced.	4/10/2023 2:21 PM
21	Outsourced	4/7/2023 7:36 PM
22	mixture, tendency to outsource. Inhouse genomics and transcriptomics	4/6/2023 6:11 AM
23	from academia	4/5/2023 3:41 AM
24	Sequencing is done both internally and by vendors. In house sequencing includes short-read sequencing, LC/MS/MS proteomics.	4/4/2023 7:11 PM
25	No.	4/4/2023 2:16 PM
26	Transcriptomics in-house for quick turnaround	4/4/2023 1:25 PM
27	Both Outsource & inhouse	4/3/2023 7:54 PM
28	No	4/3/2023 4:27 AM
29	Mix of both for metabolomics	4/2/2023 6:57 PM
30	Outsource	4/2/2023 10:46 AM

31	in-house	4/1/2023 8:19 PM
32	In-house, RNA seq.	4/1/2023 10:28 AM
33	-	4/1/2023 4:39 AM
34	NA	3/31/2023 8:44 PM
35	NA	3/31/2023 5:56 PM
36	Outsource metabolomics	3/31/2023 5:05 PM

Q75 If you are from industry, would you consider collaborating with academic groups to deliver on 'omics' projects?

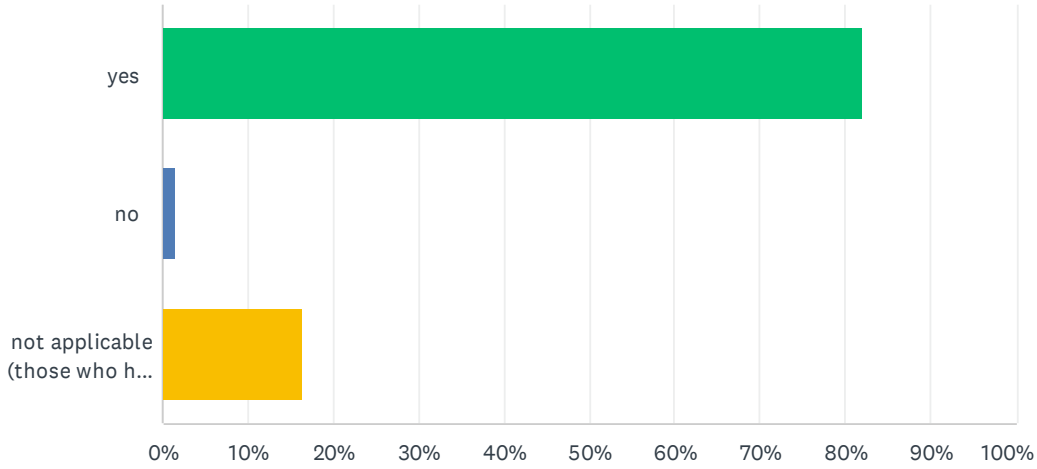
Answered: 34 Skipped: 295

#	RESPONSES	DATE
1	Yes	4/14/2023 1:34 PM
2	No.	4/14/2023 1:12 PM
3	depends on terms	4/14/2023 11:07 AM
4	Yes	4/14/2023 9:07 AM
5	Yes. I this has been done.	4/14/2023 8:10 AM
6	Depends on application: yes, in principle, but often long timelines to solution, little control over results	4/14/2023 5:16 AM
7	NA	4/14/2023 12:37 AM
8	yes	4/13/2023 8:47 PM
9	Yes	4/13/2023 4:31 PM
10	Open to.	4/13/2023 4:18 PM
11	Yes	4/13/2023 4:12 PM
12	yes where allowed	4/13/2023 4:01 PM
13	For certain types of projects, yes. Generally this is slow and you need to spend a lot of time teaching academics what it is that we care about in industry. These types of collaborations rarely take into account all of the follow up work that is required.	4/13/2023 4:00 PM
14	Yes, provided data is of high quality. When I was in academia I was concerned about bias, seeing irrelevant genes or not being able to parse out true differences (too noisy or statistical significance is too low so unsure if the data is truly accurate)	4/13/2023 3:52 PM
15	yes	4/13/2023 3:51 PM
16	Not applicable (those who are from academia)	4/13/2023 3:54 AM
17	yes	4/12/2023 3:46 PM
18	sure, in case IP issues are manageable	4/12/2023 11:10 AM
19	Yes	4/10/2023 2:21 PM
20	Depends on business value	4/7/2023 7:36 PM
21	rather not or dedicated questions. Seek for "commerical" solutions	4/6/2023 6:11 AM
22	from academia	4/5/2023 3:41 AM
23	Yes	4/4/2023 7:11 PM
24	Yes.	4/4/2023 2:16 PM
25	Yes	4/4/2023 1:25 PM
26	Yes. IP considerations on findings are challenging. Difficult to get the timeline and $ for more complex/integrated projects.	4/3/2023 7:54 PM
27	Yes	4/3/2023 4:27 AM
28	Yes	4/2/2023 6:57 PM

29	Yes	4/2/2023 10:46 AM
30	no	4/1/2023 8:19 PM
31	Yes	4/1/2023 10:28 AM
32	-	4/1/2023 4:39 AM
33	Maybe.	3/31/2023 5:56 PM
34	Yes, if they have capabilities to run small scale verification	3/31/2023 5:05 PM

Q76 For those who have used omics methods in the past (both academia and industry), would you prefer to use omics methods in any form in your research/development work in the future?

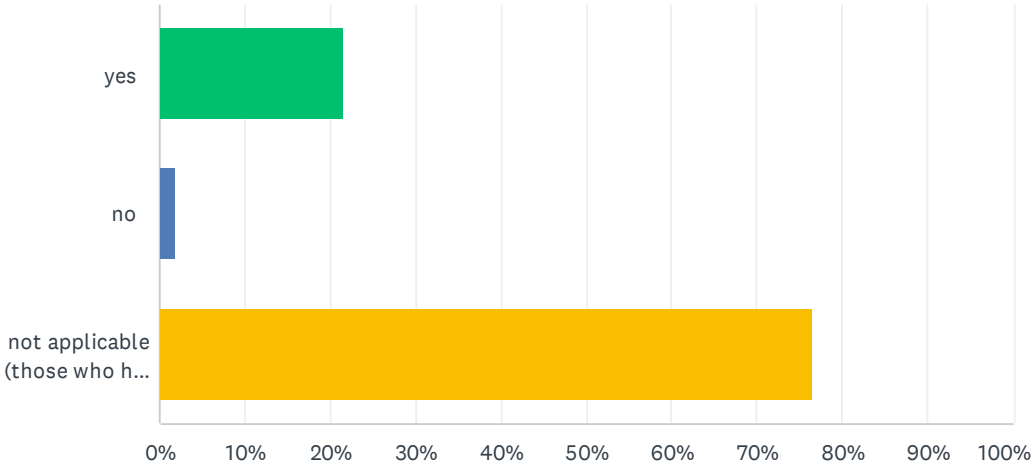
Answered: 67 Skipped: 262



ANSWER CHOICES	RESPONSES	
yes	82.09%	55
no	1.49%	1
not applicable (those who have not used omics in their work in the past)	16.42%	11
TOTAL		67

Q77 For those who haven't used omics (both academia and industry), would you prefer to use omics methods in any form in your research/development work in the future?

Answered: 51 Skipped: 278



ANSWER CHOICES	RESPONSES	
yes	21.57%	11
no	1.96%	1
not applicable (those who have used omics in their work)	76.47%	39
TOTAL		51

Q78 For those who have used omics methods in the past, how did omics help you in your work? What type of issues did you try to solve using omics?

Answered: 40 Skipped: 289

#	RESPONSES	DATE
1	Cell line stability, integration site analysis, understanding process differences	4/14/2023 6:36 PM
2	I have experience with transcriptomics, glycomics, and metabolomics. I found metabolomics to be the most useful and was able to attribute changes in amino acid metabolism to ammonia stress through this method.	4/14/2023 5:12 PM
3	Evolution of desired cell phenotypes in CAR-T process development	4/14/2023 1:34 PM
4	Investigation of the impact of a cell culture media / feed raw material on CHO cells, including the uptake of the raw material into the cell interior, metabolization / mechanism of action etc.	4/14/2023 1:12 PM
5	Medium design	4/14/2023 11:07 AM
6	Typically used to try and develop a mechanistic understanding of why something is happening.	4/14/2023 9:07 AM
7	Metabolomics on the cell pellet was helpful to see if extracellular changes were resulting in intercellular differences which could be connected to process outcomes.	4/14/2023 8:10 AM
8	* Applied to media optimization -> speed up media tuning * Target identification for cell line development	4/14/2023 5:16 AM
9	Using global metabolomics to identify and screen for possible secreted by-products in spent cell culture media.	4/14/2023 12:37 AM
10	hypothesis generation and discovery novel targets and pathways for screening and cell engineering	4/13/2023 8:47 PM
11	not used	4/13/2023 8:29 PM
12	I'm currently testing them now	4/13/2023 6:29 PM
13	Identifying the molecular mechanisms driving phenotype (disease state, high vs low producers, etc)	4/13/2023 4:45 PM
14	Used for troubleshooting	4/13/2023 4:31 PM
15	understanding changes to host metabolism	4/13/2023 4:01 PM
16	The simplest application of omics is proteomics for HCP characterization which mostly applies to downstream processing The next most valuable is to guide cell line engineering Occasionally useful for troubleshooting of cell culture manufacturing processes, but usually this is too slow and is mostly useful for getting a detailed post-mortem The most difficult application is to guide cell culture media and process development, not a lot of good examples here.	4/13/2023 4:00 PM
17	Determine expression level at transcript and protein level to identify potential limiting factors Identify host response to virus replication for enhancing productivity	4/13/2023 3:55 PM
18	Increase productivity from a cell line or develop media that meets the need of a cell line	4/13/2023 3:51 PM
19	Omics data helped to characterize cell lines to explain certain phenotypes and find potential targets for engineering	4/13/2023 3:54 AM
20	proteomics was used to identify new disease targets	4/12/2023 11:10 AM
21	Omics provided broader insight into CHO metabolism under different production conditions.	4/10/2023 2:21 PM
22	Mechanistic understanding of quality attribute levels	4/7/2023 7:36 PM

23	Data analysis is always a challenge, particularly in combining multi-omic measurements.	4/6/2023 3:28 PM
24	process understanding, process and media development; cell characterization	4/6/2023 6:11 AM
25	Suggestions for fed batch feed improvement, explanation for mechanism behind effect of process parameters	4/5/2023 3:41 AM
26	sequence identity, impurity, and host/clone multi-omics characterization to correlate gene expression and phenotype	4/4/2023 7:11 PM
27	Deselection of cell lines with product sequence variants. Integration site analysis to help with clonality assurance	4/4/2023 1:25 PM
28	Expression vector design	4/3/2023 6:51 AM
29	To have high-level understanding of CHO biology; to understand the fundamental differences between CHO host lineages.	4/2/2023 10:46 AM
30	understanding complex regulatory pathways that impact production or product quality objective: to find ways of supporting cells to solve the problem	4/2/2023 7:34 AM
31	Process optimisation Cell line functional characterisation	4/2/2023 6:04 AM
32	We learned a tremendous amount from our omics studies of cell lines of varying productivities. The challenge is going through all the data.	4/1/2023 10:15 PM
33	confidential	4/1/2023 8:19 PM
34	Evaluating expression levels under certain conditions.	4/1/2023 10:28 AM
35	identified targets for cell and process engineering	4/1/2023 4:39 AM
36	ID potential targets for knock down to improve qp; ID leading drivers of phenotypic change in response to cell culture stress.	4/1/2023 4:29 AM
37	Understanding cell reprogramming after restimulation	3/31/2023 11:17 PM
38	It has helped me draw a line of research, it has allowed us to have targets that can be modified to improve bioprocesses.	3/31/2023 8:44 PM
39	NA	3/31/2023 5:56 PM
40	Have run into too many hurdles to have success	3/31/2023 5:05 PM

Q79 If you haven’t used omics in the past, what prevented you from using omics techniques in your work?

Answered: 16 Skipped: 313

#	RESPONSES	DATE
1	Cost	4/14/2023 3:09 PM
2	N/A. I have used Omics.	4/14/2023 8:10 AM
3	NA	4/14/2023 12:37 AM
4	My project content did't require omics data.	4/13/2023 8:29 PM
5	-	4/13/2023 3:54 AM
6	N/A	4/10/2023 2:21 PM
7	have used	4/5/2023 3:41 AM
8	Didn't have a chance yet.	4/4/2023 2:16 PM
9	Costs, non-accessible protocols, little expertise in the subject	4/3/2023 7:52 AM
10	Novel process that needs resources for implementation	4/3/2023 4:27 AM
11	Expensive, no expertise, so far no need	4/3/2023 2:41 AM
12	Ip concerns	4/2/2023 6:57 PM
13	N/A	4/1/2023 10:28 AM
14	NA	3/31/2023 8:44 PM
15	expertise/infrastructure did not exist	3/31/2023 7:58 PM
16	Unclear how to best leverage a pilot for success and the costs/benefits involved.	3/31/2023 5:56 PM

Q80 What would help promote use of omics techniques in bioprocessing community?

Answered: 33 Skipped: 296

#	RESPONSES	DATE
1	Distilling information dense data into easily understood relationship/responses	4/14/2023 1:34 PM
2	Share expertise	4/14/2023 1:12 PM
3	Easier tools for process scientists that don't use omics datasets on a routine basis.	4/14/2023 9:07 AM
4	Open source data analysis tools, cheaper access to 'Omics analysis (outsourcing can be expensive.)	4/14/2023 8:10 AM
5	Success stories where you solved non-obvious problems and can time/resources reproducibly also for the next clone in the pipeline	4/14/2023 5:16 AM
6	Availability of training resources.	4/14/2023 12:37 AM
7	thoughtful experiment design using omic tools in mind vs. just throwing cells/conditions managing expectations and defining success better	4/13/2023 8:47 PM
8	The relevance of their output	4/13/2023 6:29 PM
9	Successful prospective use of omics within process development	4/13/2023 4:31 PM
10	Strong case studies demonstrating impact on titer, product quality	4/13/2023 4:02 PM
11	ease of use	4/13/2023 4:01 PM
12	Realistic expectations of where these techniques would be most useful and estimation of time and commitment. Original problem statements tend to be very flawed and/or complex (e.g. why is this cell line produce more mAb) with experimental conditions and samples not being best to answer specific questions.	4/13/2023 4:00 PM
13	A well-established pipeline for data processing, analysis and interpretation	4/13/2023 3:55 PM
14	A very clear approach of the methods and how it's performed.	4/13/2023 3:51 PM
15	Better tools for analysis of large data sets	4/13/2023 3:54 AM
16	Case studies of how omics analyses have been used to solve challenges that are relevant to the biopharm industry. Robust "best practices" for collection, analysis, and interpretation of omics data.	4/10/2023 2:21 PM
17	Lower cost and streamlined, universal methods	4/7/2023 7:36 PM
18	Better process analytic technologies	4/6/2023 3:28 PM
19	standardized workflows and solutions	4/6/2023 6:11 AM
20	lower price (in academia), clearer workflows for obtaining relevant knowledge (in industry)	4/5/2023 3:41 AM
21	Success stories	4/4/2023 7:11 PM
22	More knowledge of how to apply it.	4/4/2023 2:16 PM
23	More expertise-building	4/3/2023 7:52 AM
24	Standardized methods/tools to analize and compare data	4/3/2023 6:55 AM
25	Tailor-made, easy-to-use software	4/3/2023 2:41 AM
26	Case studies with real results	4/2/2023 10:59 AM
27	Lower the cost; Find an alternative host (not CHO) with less plasticity	4/2/2023 10:46 AM

28	Case studies presenting uniform advantages/routes to enhanced product yield/quality and range of potential product classes	4/2/2023 6:04 AM
29	Maybe better analysis tools?	4/1/2023 10:15 PM
30	Case studies	4/1/2023 10:28 AM
31	Training/east to use analysis tools	3/31/2023 11:17 PM
32	the intensification of production, the prevention of abnormal responses by cells, having longer lasting cultures and with better productivities even with difficult-to-express proteins	3/31/2023 8:44 PM
33	Not sure.	3/31/2023 5:56 PM

Q81 This workshop session is designed to be conducted in a debate format. Which points would you like to be debated as part of this session?

Answered: 29 Skipped: 300

#	RESPONSES	DATE
1	Benefits and challenges of omics analytics, research questions that can be addressed using omics, ways of integrating multiple omics technologies to better address research questions	4/14/2023 1:12 PM
2	Omics data analysis	4/14/2023 11:06 AM
3	1. "Is the juice worth the squeeze"? (i.e., is what you get from 'omics really worth all the effort that needs to be invested) 2. How often do omics data sets provide insights that can't be learned for easier to collect data? (process data, PQ data, peptide mapping data)	4/14/2023 9:07 AM
4	What can 'Omics do that our current approaches cannot? How quickly can one expect to see an 'Omics benefit? For those who have had success with 'Omics, how do you design your studies?	4/14/2023 8:10 AM
5	* Hear from other industrial people what best practices could lead to robust benefita. Am a great fan of these technologies, but have to acknowledge it has not been easy to show reproducible benefits faster/cheaper than existing technologies	4/14/2023 5:16 AM
6	Comparison of different 'omics platforms (e.g., genomics, transcriptomics), the importance of one over another.	4/14/2023 12:37 AM
7	best value applications for cell line development	4/13/2023 8:47 PM
8	Define common pipelines and ways to guarantee that the analysis is reproducible	4/13/2023 6:29 PM
9	Benefits to omics applications beyond retrospective troubleshooting	4/13/2023 4:31 PM
10	Open to all.	4/13/2023 4:18 PM
11	After omics analysis, what are practical or efficient experiments to prove that the interpretation of omics data is correct and to evaluate whether such insight can be actually applied to current processes.	4/13/2023 3:55 PM
12	OMICs is effective in creating a more productive cell line or process	4/13/2023 3:51 PM
13	How to take results from 'omics studies and translate them into tangible engineering solutions.	4/13/2023 3:34 PM
14	-	4/13/2023 3:54 AM
15	(1) Omics studies can often be criticized as "fishing expeditions," especially if the problem statement isn't clear. Is this a fair criticism? Why or why not? (2) Can the same insights be gained from less comprehensive methods like amino acid / vitamin analysis rather than running metabolomics studies?	4/10/2023 2:21 PM
16	Value proposition for investing in omics in the industry	4/7/2023 7:36 PM
17	Have omics generated a significanlty better CHO host?	4/7/2023 5:34 PM
18	How to get it more easy and accessible for daily development work in industry setting	4/6/2023 6:11 AM
19	how can academia serve the industry, where do the interests of these two differ what are the requirements/needs/wants for omics analysis from the industry side	4/5/2023 3:41 AM
20	What critical needs that could only be addressed by omics?	4/4/2023 7:11 PM
21	I want to learn about the basics of omics	4/3/2023 4:27 AM
22	Risks outweighing benefits	4/2/2023 6:57 PM
23	Omics studies of individual cell lines may help fine tune the process to achieve better productivity / quality. Omics studies generate lots of data, but it's very often difficult to	4/2/2023 10:46 AM

	interpret these data and the results are not applicable to other cell lines.	
24	Data overload coupled with lack of uniform understanding of predictability	4/2/2023 6:04 AM
25	The community could have established omics reference database and tools to enable more users to use omincs without needing significant bioinformatics resource and support.	4/1/2023 5:55 PM
26	Tradeoffs in effort, cost, and actionability in omics data.	4/1/2023 4:29 AM
27	Which omics approach deserves more awareness/use	3/31/2023 11:17 PM
28	Discuss new techniques or strategies that improve the depth that allow the understanding of recombinant cells.	3/31/2023 8:44 PM
29	NA	3/31/2023 5:56 PM