Bridging Academia and Industry: Shaping the Future of Bioprocessing Together

Suzanne Farid
Professor & Head of Department
UCL Biochemical Engineering

#bioProcessUK

BIA
UK BioIndustry Association

Bridging Academia and Industry: Shaping the Future of Bioprocessing Together

Peter Dunnill Award Lecture, bioProcessUK 2024

Professor Suzy Farid FREng FIChemE CEng PhD

UCL Biochemical Engineering

"Science is brilliant, but unless it delivers outcomes people can benefit from, it's just curiosity" – Peter Dunnill

Part 1:
Influence of Peter Dunnill and Mentorship

UCL Biochemical Engineering

Peter Dunnill:

A Visionary Leader in Biochemical Engineering

Peter Dunnill OBE DSc FREng FIChemE FRSC
1938-2009

Key Contributions

- **Pioneer of biochemical engineering in the UK**
- **Co-authored seminal textbook *Fermentation and Enzyme Tech***
- **Pioneered many of the unit ops used today for large-scale processing of semi-synthetic penicillin, mAbs, cell therapies**
- **Founded UCL's Advanced Centre for Biochemical Engineering (ACBE) with its pilot plant facilities in 1990s**

Peter Dunnill's Enduring Legacy

Peter Dunnill
1938-2009

"Peter turned ideas into impact, shaping policy and inspiring those around him" Sir Derek Roberts

"Peter was passionate about delivering the future. His vision always moved faster than the rest of us" Mike Hoare

"Without Peter, biochemical engineering wouldn't be as prominent in the UK as it is today" Nigel Titchener-Hooker

Key contributions:

- **Influenced UK bioscience strategy through roles on major government inquiries.**
- **Advocated for informed policy during pandemic flu crises, working with journalists**
- **Led research on pDNA vaccines for pandemics and integrated into UG/MSc projects**
- **Passionate about mentoring and supporting early career researchers.**

Peter's Influence on My Journey

Decisional tools: Inspired focus on mAbs, continuous processing, and cell therapies.

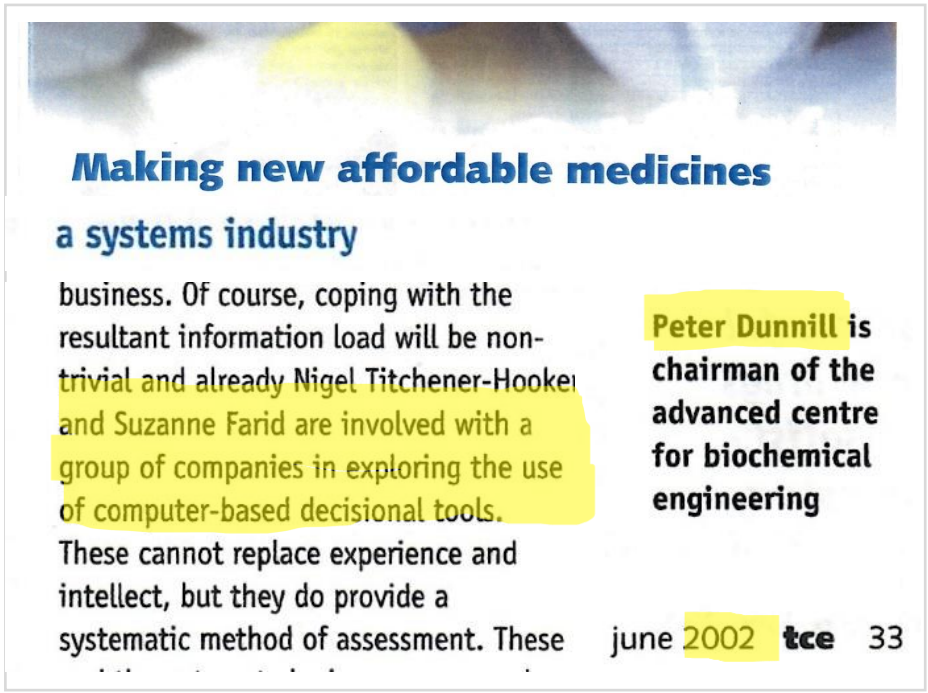
Biotech innovation: Encouraged insights through books like *The Development Factory.*

Science with outcomes: Shaped my research philosophy.

Research centres: Nurtured talent for large-scale leadership.

Mentorship: Legacy extended through Mike Hoare and Nigel Titchener-Hooker.

Skills gap: Stressed attracting talent during my admissions role.



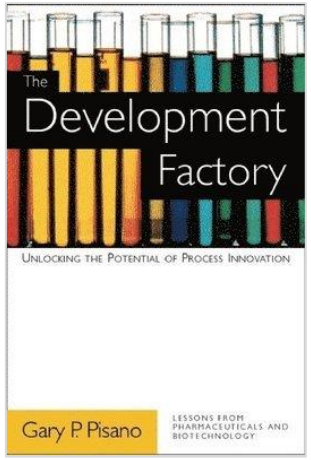
Making new affordable medicines

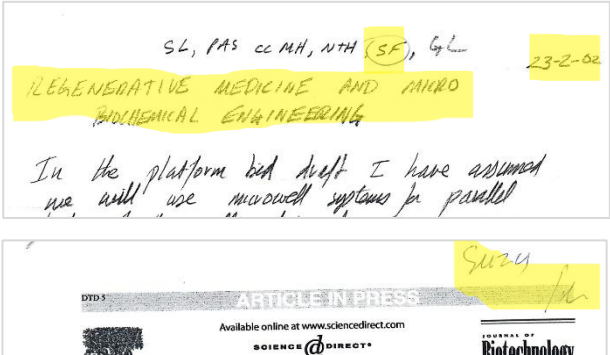
a systems industry

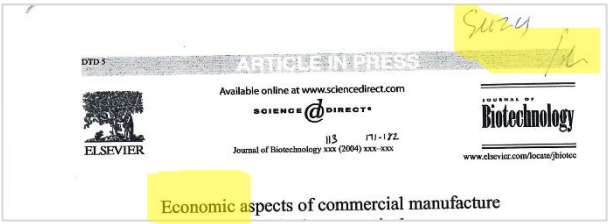
business. Of course, coping with the resultant information load will be non-trivial and already Nigel Titchener-Hooker and Suzanne Farid are involved with a group of companies in exploring the use of computer-based decisional tools. These cannot replace experience and intellect, but they do provide a systematic method of assessment. These

Peter Dunnill is chairman of the advanced centre for biochemical engineering

june 2002 **tce** 33





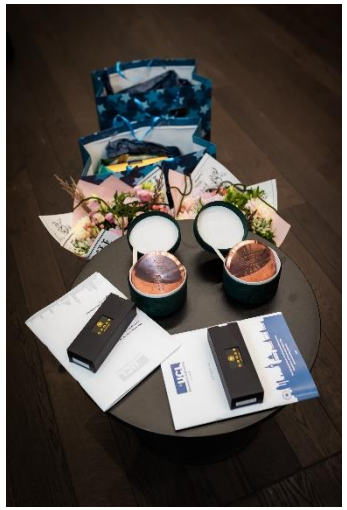


UCL Biochemical Engineering

Honouring Mike Hoare & Nigel Titchener-Hooker

1st & 2nd Heads of UCL BE. Retired from UCL Sep 2024

- Built on Peter Dunnill's vision of impactful science and talent development.
- Created a culture of collaboration, innovation, and global leadership.
- Profoundly shaped my research, leadership, and career trajectory.



UCL Biochemical Engineering

mbi

UCL LIFE LEARNING
ENTERPRISE AWARD FOR CPD AND SHORT COURSES
2014

EPSRC Life Sciences IMRC Bioprocessing

EPSRC CENTRE for Innovative Manufacturing in Emergent Macromolecular Therapi

A Royal Recognition: Queen's Anniversary Prize 2014

THE QUEEN'S ANNIVERSARY PRIZES
FOR HIGHER AND FURTHER EDUCATION
2013

- Led by Nigel, this award celebrated the department's lasting impact
- Memorable and unexpected exchange with Prince Philip!

UCL Biochemical Engineering

Part 2:
Collaboration at the Heart of Bioprocess Innovation
Strategic Research Leadership

The greatest advances occur when diverse expertise comes together

UCL-AstraZeneca Centre of Excellence

Over a Decade of Successful Collaboration (£6.75m)

Shared vision for advancing collaborative research and training next generation of leaders.

Industrial Leads: CoE: Richard Turner, Diane Hatton, Matthew Cheeks. Pre-CoE: Brendan Fish, Ray Field, Paul Varley. Plus > 20 AZ supervisors: D Gruber, C Spencer, K Klottrup-Rees

Goal

Generate integrated set of predictive decision-support tools for enhanced bioprocess design, operation and economics

2008
AstraZeneca & UCL joint TSB grant

2011
AstraZeneca-sponsored doctoral projects

2014
UCL-AstraZeneca Centre of Excellence launch

2019
UCL-AstraZeneca Centre of Excellence Phase 2

2024
UCL-AstraZeneca Centre of Excellence Phase 3

Pre-CoE | **Pre-CoE** | **CoE PHASE 1** | **CoE PHASE 2** | **CoE PHASE 3**

22
Trained Researchers

Delivering Impact: UCL-AstraZeneca Centre of Excellence

Key impact:

- 50+ knowledge transfer projects, tools and peer-reviewed papers, driving adoption of next-gen processes and cost-saving strategies at AstraZeneca

23 Knowledge Transfer on Live AZ Projects

27 Journal Publications

68 Conference Presentations

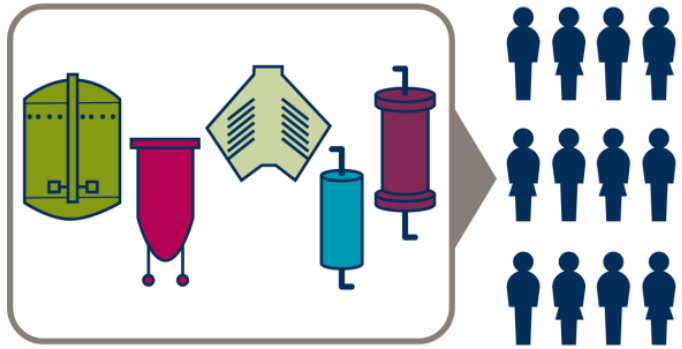
Economic and Sustainability Insights:

- Economic & environmental insights to focus continuous processing efforts
- AAV manufacturing cost analysis influencing AstraZeneca's strategy

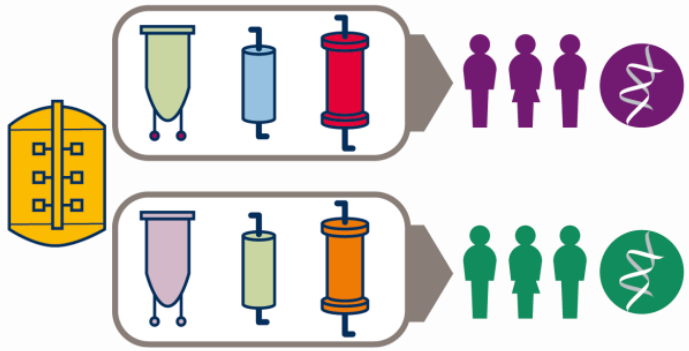
Advanced Data Analytics:

- Data integrity tools for Industry 4.0 - integrated into industrial practice
- Raman spectroscopy application improving process monitoring for mAbs

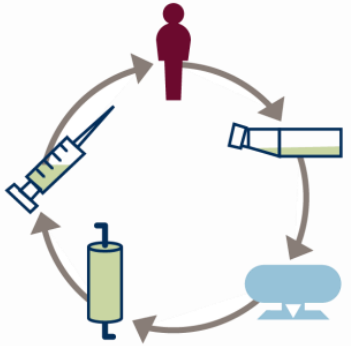
Future Targeted Healthcare Manufacturing Hub



Traditional One-Size-Fits-All Medicines



Targeted: Stratified Medicines



Targeted: Personalised Medicines

Number of patients per group

Number of drug products

Moving from "one-size-fits-all" to "targeted" medicines…
How can targeted biological therapies achieve success in manufacturing and business?

Hub Co-Directors Profs Suzy Farid & Paul Dalby **Strategy Director** Prof Nigel Titchener-Hooker **Grant** £10m, 2017-2024

Hub UCL **Spokes** Imperial College London, Loughborough University, The University of Manchester, University of Nottingham, Warwick **Funder** UKRI Engineering and Physical Sciences Research Council

Users

3M, accenture, Adaptimmune, aglaris Ltd, Albumedix, Applied Materials, AstraZeneca, Autolus, biopharm, BioLogicBus, CSL Behring, cytiva, deltaDOT, FUJIFILM Diosynth biotechnologies, GETINGE, GSK, IPSEN, KCT Kuopio Center for Gene and Cell Therapy, kymab, Lilly, Lonza, Orchard therapeutics, Oxford Biomedica, PALL, 康龙化成 PHARMARON, Purolite, ReNeuron, REPLIGEN, SARTORIUS, SSCBIO LTD, SUTRO BIOPHARMA, tillingbourne consulting, TrakCel, UNIVERCELLS, virica, West, WYATT TECHNOLOGY, abpi, BIA, CANCER RESEARCH UK, ktn, LGC, Medicines Manufacturing Industry Partnership, NIBSC, CATAPULT, cpi

THE FTHM HUB IN NUMBERS

28
Academic Researchers Across 6 Leading Universities

46
Industry & Sector Partners

160
Conference Presentations

201
Publications

103
Meetings, Workshops & Networking Events

162
Aligned PhDs & EngDs

>40
Feasibility Studies

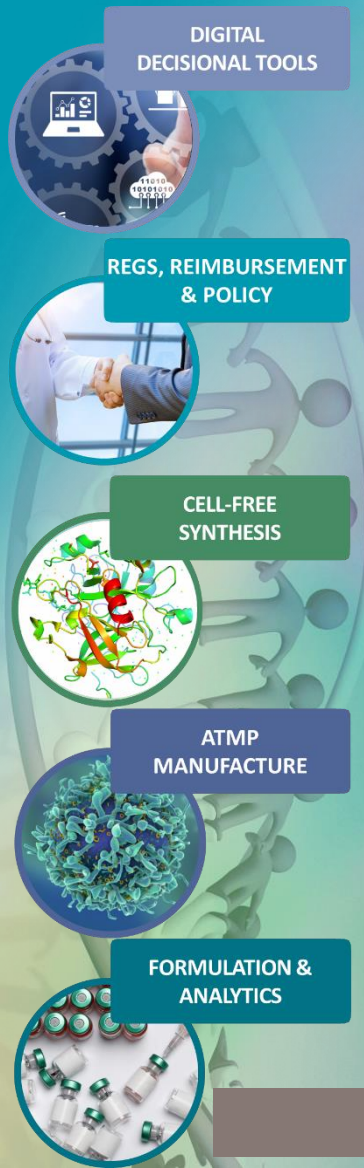
£84m
Leveraged Funding

9-12
Talent Pipeline New Posts: Industry/Policy – Academia

3
Company Sponsored Centres of Excellence

40
Hub Contributions to Policy

4
Start-Ups Leveraging Hub Research

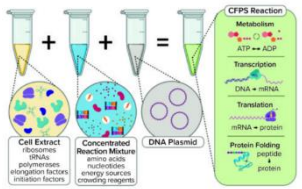


Delivering Industrial Insights and Solutions: >40 Feasibility Studies

IPSEN

Hub decisional tools from UCL identified cell-free synthesis strategies with significant manufacturing cost and process development time savings.

Published in BioProcess Int.



> **Informing priority shifts in investment decisions:** The UCL-Ipsen user feasibility study provided critical data to feed into a business case for cell-free synthesis that led to Ipsen committing to additional investment to further develop the cell-free platform.

Director of BioProcess Sciences, Ipsen

BIA MAC

Hub decisional tools identified the economic benefits of selecting scalable technologies for viral vectors from early stage development considering drug development effort and profitability.

> **Business case for investing in scalable manufacturing platforms in the UK:** Insights from the study were used as part of the business case to the Government for the UK Manufacture of GMP Viral Vectors. This resulted in the MRC / LifeArc / BBSRC £18M fund for Gene Therapy Innovation Hubs.

CTO, Oxford Biomedica & BIA MAC

Acting as a National Hub – Shaping Policy

HM Treasury

NICE
National Institute for Health and Care Excellence

Medicines & Healthcare products Regulatory Agency

UK Parliament

NHS England

BIA
UK BioIndustry Association

Economics

- **100 Days Mission** Roundtable input on costs for pandemic mAbs
- **HM Treasury** meeting on COG of CAR-T cell therapies
- **NHS Consultations:** Innovative Medicines, Future Cancer Care

Regulation

- **APPG Industry 4.0**: Future of personalised medicine manufacture
- **MHRA Consultation & Workshop:** Point-of-care (POC) mfg
- **Policy brief** on point-of-care manufacture of advanced therapies

Sustainability

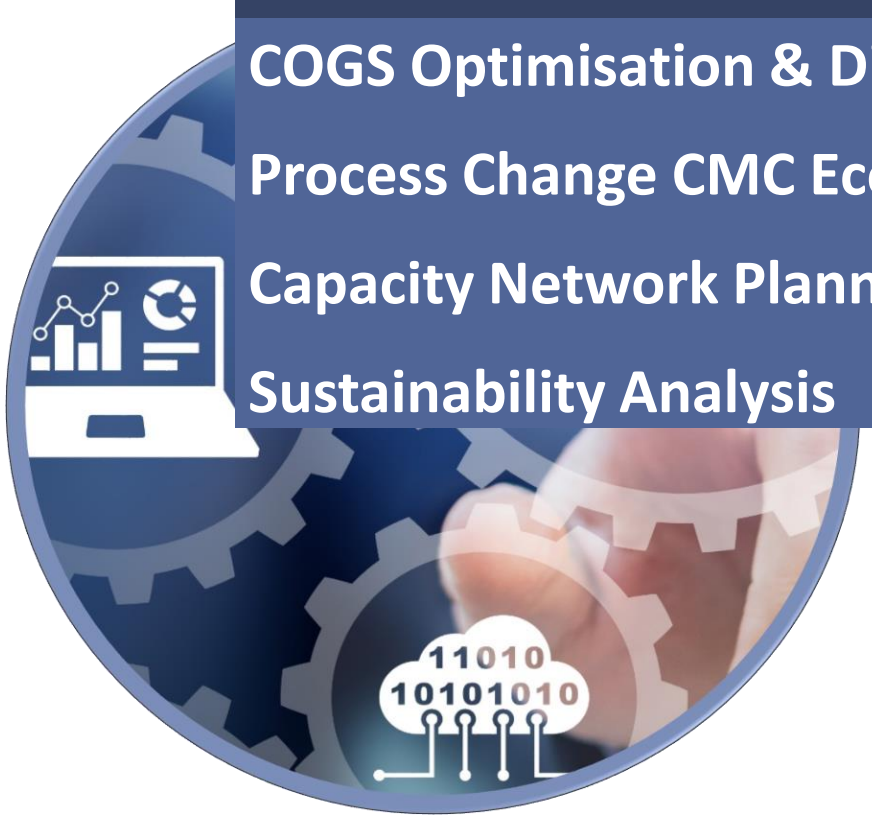
- **Policy sandpit** on sustainability challenges for biotherapeutics
- **Policy brief** on policy needs for sustainability actions
- **Call to action** on research priorities: Measure, Intensify, Recycle

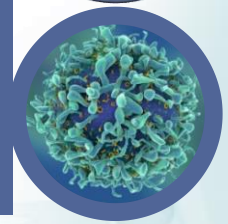
Evolution of UCL Decisional Tools – Suzy Farid

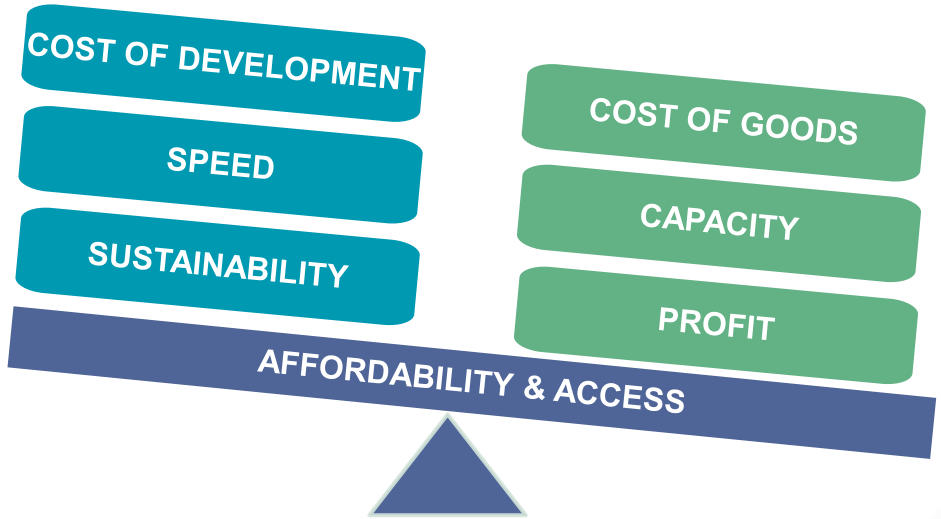
From Peter Dunnill's Vision to Today's Tools

Business Case for Process Intensification & Capacity Network Strategies

UCL DECISIONAL TOOLS	mAbs | CGTs | vaccines
COGS Optimisation & Digital Twins	Batch v Continuous, CHO v CFS
Process Change CMC Economics	Transient v Stable, Scale-out v Scale-up
Capacity Network Planning	Build v Buy, Centralised v Bedside
Sustainability Analysis	PMI & Carbon Footprint Reduction







UCL Decisional Tools in Action: Impact Suzy Farid

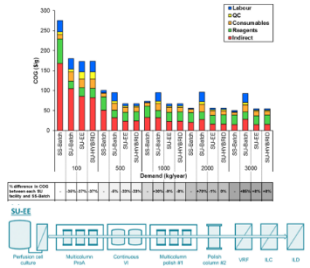
Business Case for Process Intensification & Capacity Network Strategies

mAbs

mAb Continuous Process Economics: Batch v End-to-End Conti

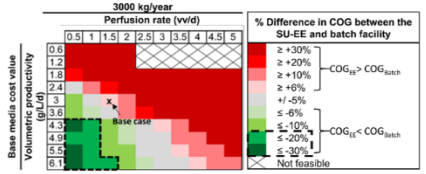
Do end-to-end continuous facilities provide COG savings over batch facilities?

At scales ≤ 1 ton: SU End-to-End Conti facilities offer 10-40% COG savings over SS Batch



Target perfusion parameters to meet a 20% COG saving?

To meet COG threshold, achieve 4 g/L/d and 0.5-1 vv/d



Are potential COG savings outweighed by the additional development costs for continuous processes?

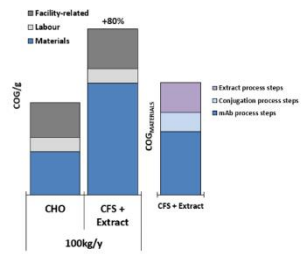
Depends on stakeholder perspective, company size, scale, % difference in COG and COD

CMC: Cost of Devt (COD)	+	Commercial: COGS	→	Lifecycle: COD + COGS
Batch wins		Conti wins		Conti wins

Mahal, Branton, Farid (2021) Biotech Bioeng

Cell-Free Synthesis Economics for ADCs: Target COG Analysis

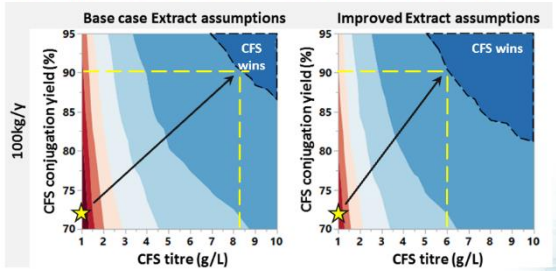
COG/g for ADCs using CFS compared to traditional CHO platforms?



Take-home messages:

- CFS is more costly than CHO (e.g. 80%)
- Key cost driver for CFS is materials.

Target process improvements required for CFS to become more cost-competitive with traditional CHO platforms for ADCs?



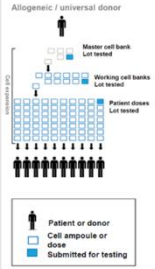
Take-home messages:

- Targets identified for CFS to break-even with CHO for ADCs.
- Process improvements in CFS titre, conjugation yield and extract can make CFS more cost-competitive with CHO

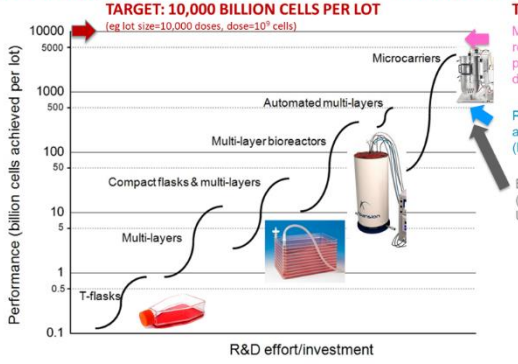
Stamatis, Farid (2021) Biotech J

CGTs

Allogeneic MSC Cell Therapies: Technology S-curve



Technology S-curve indicates performance limits of each technology



Technology Gap:

Microcarrier-SUBs require x2 increase in performance for high demand scenarios

Planar capacity capped at ~500B cells/lot (MSCs)

Bottleneck hits DSP (TFF / kSep) before USP

Allogeneic Cell Therapy Bioprocess Economics and Optimization: Single-Use Cell Expansion Technologies

Allogeneic cell therapy bioprocess economics and optimization: downstream processing decisions

Process change evaluation framework for allogeneic cell therapies: impact on drug development and commercialization

Viral Vector Process Change Economics: Cost of Development v Profitability

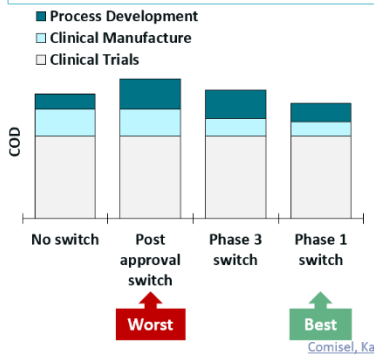
What is the impact of switching from a scale-out to a scale-up OR transient to stable viral vector process at different time points on the cost of development and the profitability?

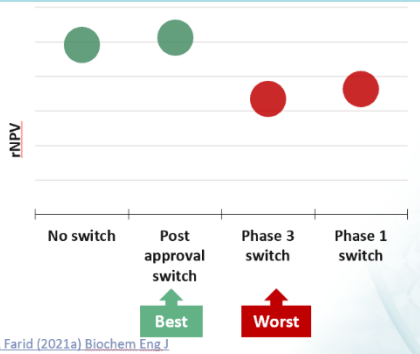
COST OF DEVELOPMENT (COD) PERSPECTIVE:

- Best: Phase 1 switch
- Worst: Post approval switch

PROFITABILITY PERSPECTIVE:

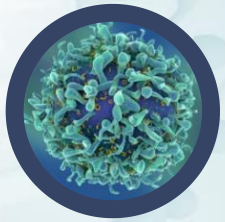
- Best: With Delay: Post approval switch
- Worst: With Delay: Phase 1/3 switch





Comisel, Kara, Fiesser, Farid (2021a) Biochem Eng J

Comisel, Kara, Fiesser, Farid (2021b) Biochem Eng J



RECOVERY OF BIOLOGICAL PRODUCTS XIX

PAST PRESENT FUTURE

ROME CAVALIERI | ROME ITALY | 10-15 JULY 2022

BIOTECHNOLOGY and BIOENGINEERING
VOLUME 121 NUMBER 8 AUGUST, 2024

Special Issue: Recovery of Biological Products: Past, Present, Future
Guest Editors: Suzanne S. Farid, Nihal Tugcu, and Arne Staby

RXIX

RXIX Conference Chairs

Suzy Farid	UCL
Nihal Tugcu	Sanofi
Arne Staby	Novo Nordisk

RECOVERY OF BIOLOGICAL PRODUCTS
RXIX
ROME
PAST PRESENT FUTURE

WILEY

Created by SS Farid (2020)

Education & Enterprise highlights

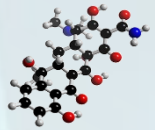
Leading the Design Project for 15 y with opportunities for students to get feedback from industry panels and experts

Running our CPD MBI module on Validation/QbD for 10 y

Translating our research into new teaching workshops

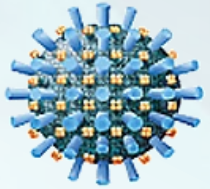
Innovating Design Teaching Through Industry Collaboration

Antibiotics

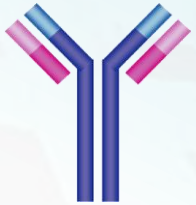


Proteins

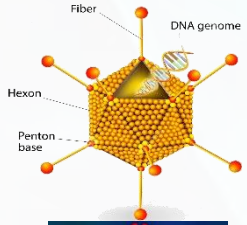
Pandemic flu vaccine



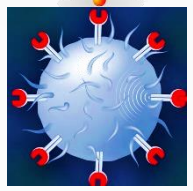
Cancer antibodies



COVID antibodies



COVID viral vector vaccines



Cell and gene therapies

- Changes in society's needs
  - e.g. emergency healthcare for pandemics
  - e.g. low cost vaccines for developing world
  - e.g. green sustainable bioprocesses
- New industrial sectors
  - e.g. cell and gene therapy
- New technological advances
  - e.g. cell-free expression
  - e.g. continuous bioprocesses
  - e.g. modular construction

Enriching the Student Experience with Industry Engagement

UG & MSc DESIGN PROJECT

Industry experts provide expert lectures and join the poster industrial panel where they are consulted for feedback by interdisciplinary teams in UCL Biochemical Engineering on their Design Project

Student point of view:

"I really enjoyed the poster session with all the industrial experts as it was great to see what our work was worth and debate how we can further optimize the process from multiple points of view (economic, risk, safety, scheduling, sustainability, etc...)"

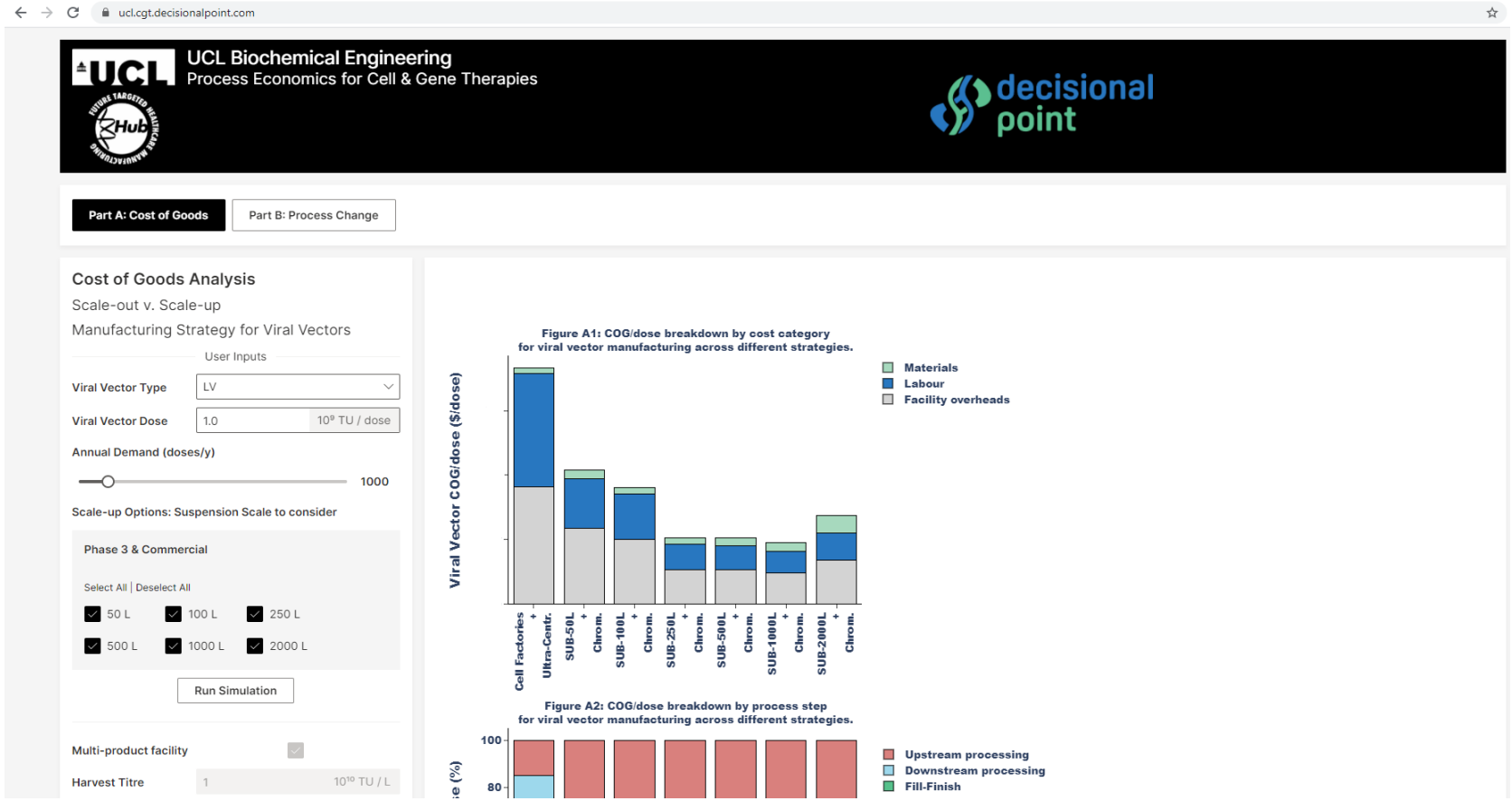
Translating Research into Educational & Enterprise Ventures

Education: Designed new teaching workshops to apply decisional tools methods to CGT commercialisation

Enterprise: **Decisional Point Ltd** spin-out form Hub established as a UK based bioprocess consultancy

Co-founders: Chris Stamatis (ex-Hub PDRA), Suzy Farid, Stephen Goldrick, Kostas Anastasiou

Mission: To create digital bioprocess solutions that empower you with the data and insights to make smart, cost-effective and sustainable decisions about your bioprocess strategy across the value chain



UCL Biochemical Engineering

Innovative Research & Education for Health and Climate

We are the largest academic bioprocessing group globally
33 academic/teaching staff | > 400 UG/MSc/MRes students | > 100 PhD/EngD/PDRA/RFs

Our founding spirit is very much alive
We pride ourselves on our distinctive team-based ethos

Our research is world-leading with extensive academic and industry collaboration
>100 via 4 Research Hubs | >40 via industry PhD/EngD | 5 Strategic Partnerships

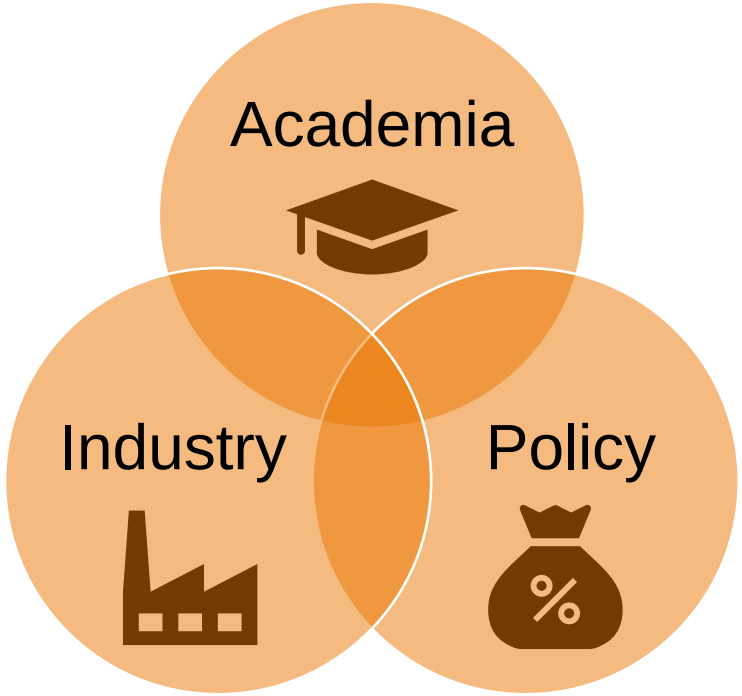
Our exceptional global links to industry and alumni support our teaching and students
> 30 industry experts feed into teaching activities

We have a long history of research-based teaching, CPD provision and enterprise activity
CPD: MBI and VISION programmes | Start-ups: x9

We have state-of-the-art facilities in the ACBE and MFL at UCL East
£35m pilot plant facilities in Bloomsbury | £4.5m Manufacturing Futures Lab in UCL East

Future of Bioprocessing
- A Collaborative Journey

Together, we innovate for health, sustainability, and impact.



UCL Biochemical Engineering

UCL
BIOCHEMICAL ENGINEERING
EST 1998

UCL Biochemical Engineering

Thank you…

Suzy Farid
Head of Department
s.farid@ucl.ac.uk