From custom solutions to continuous improvement—strategic directions towards Bioprocessing 3.0

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Introduction

A holistic approach for future bioprocessing must be centered around connectivity of data and people across unit operations and scales. Data is already generated in abundance, but many of the current systems create data silos. To get to a scalable approach, data needs to be digitally available, integrated between source systems, connected across the entire process, and contextualized such that knowledge can be accumulated across the product life cycle. All these aspects dictate dedicated life cycle management of data and models, emphasizing model scalability and evolution.

The following examples illustrate how such a common foundation for data aggregation and contextualization lays the ground for exponential productivity improvement beyond the productivity gained from automating data integration.

1. Get connected: Data must be integrated, contextualized, and made available

Data integration is a major problem for our industry, but why is that? We believe that it is largely because context is hard to track or gets lost due to the lack of structured workflows and in handovers between functions.

Therefore, a strategic consideration at this stage is the digitalization of lab workflows as a critical complement to connecting process and analytical data (Fig 1).

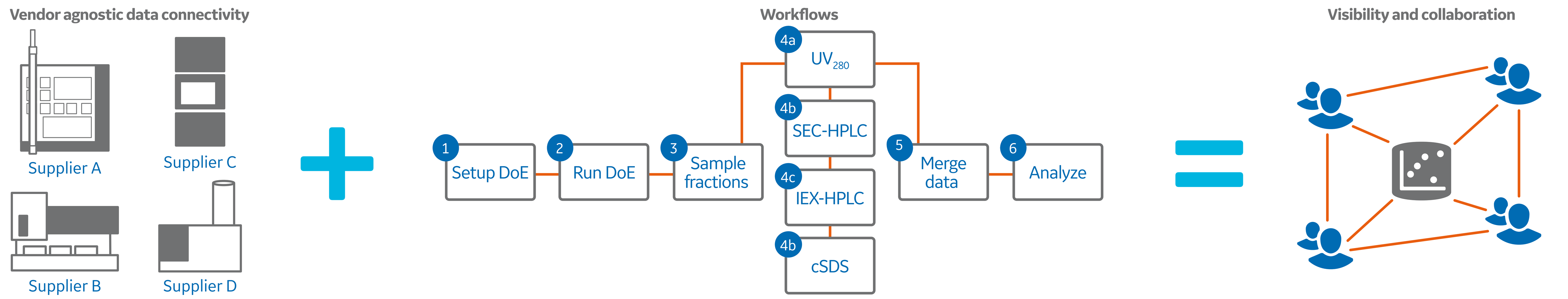

Fig 1. Connectivity is more than data aggregation. DoE = design of experiments, HPLC = high-pressure liquid chromatography, IEX = ion exchange SEC = size exclusion

2. Get insights: Standardized nomenclature provides consistency in context

Once data flows into a central location, we can use it more effectively. However, in order to drive efficiency, standardizing the contextualization of the data allows us to re-use the results of our investments the next time the same situation appears in a new process. There is also huge potential for innovation in analytics and other applications when data is aggregated, contextualized, and accessible (Fig 2 and 3).

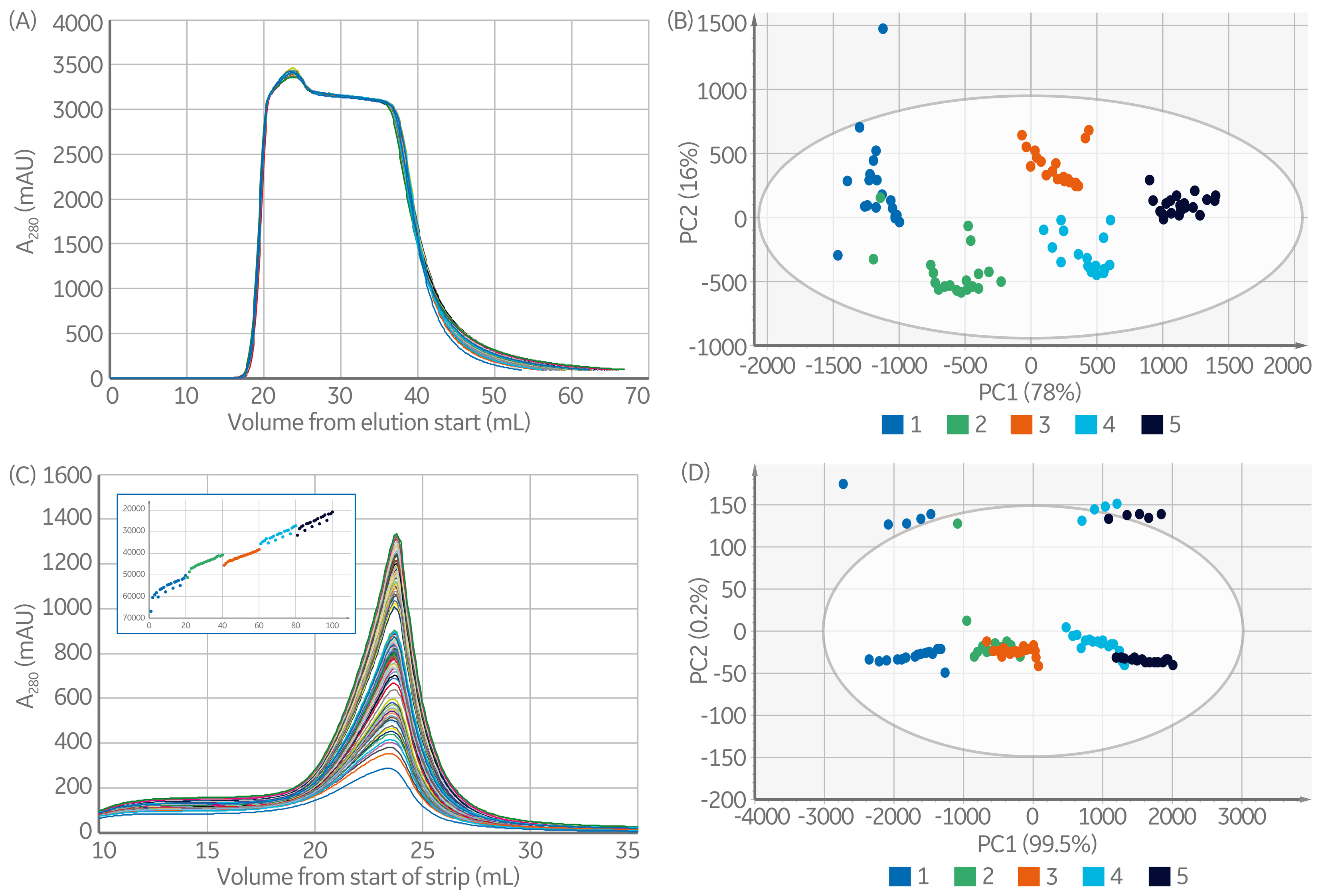

Fig 2. MabSelect SuRe™ chromatography resin lifetime study analyzed by principal component analysis (PCA). (A) Consistent performance with only a small increase in elution peak tailing across 100 cycles; (B) PCA of elution peaks together with contextualization allows identification of subgroups related to the thaw/filtration of a new harvest cell culture fluid vial (1–5). The PC1 scores increase monotonically within each subgroup; (C) Strip peak size increases with cycle number. The insert shows the increase in strip peak area with minor upsets every fourth cycle; (D) PCA of strip peaks shows the same subgroups related to thaw/filtration while the minute upsets are reflected in the second very small PC. Contextualization identifies a storage step performed every fourth cycle affecting the strip peak area and shape.

Therefore, the main strategic imperative at this stage is **openness**. Proprietary solutions will not enable the proliferation of productivity applications. New standards, such as the Allotrope Foundation, need to be established and get implemented widely. A collaborative ecosystem of peers, partners, suppliers, and other actors unlocks the innovation potential.

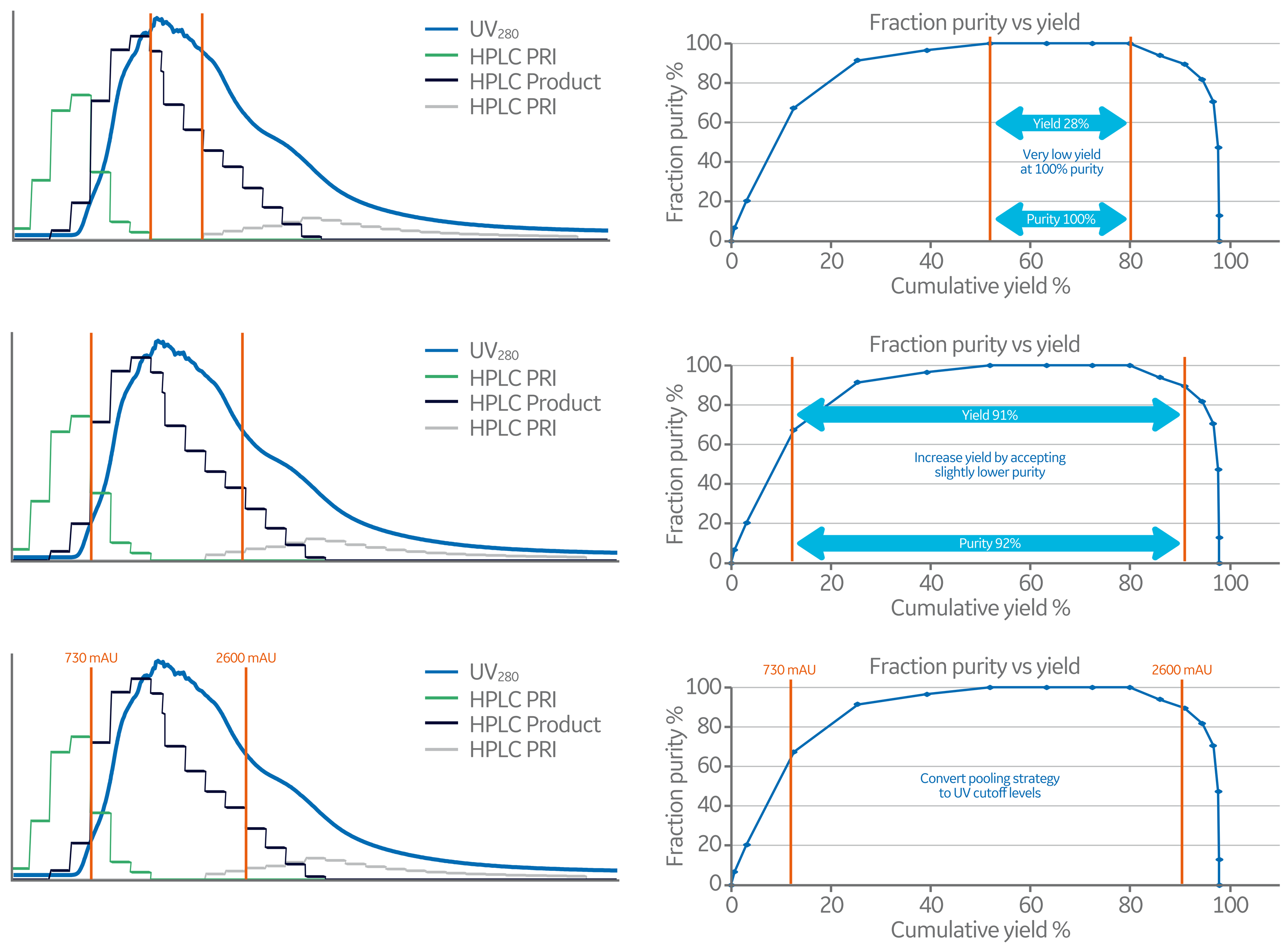

Fig 3. Process development support tool. Aggregation of process development chromatograms with offline analytics data allows development of dedicated apps for optimization, for example, addressing the trade off between purity and yield with respect to pooling criteria. Adding in mechanistic modeling and availability of resin variability samples will extend the scope to the impact of process parameters and raw material variability. PRI = product-related impurity.

3. Get optimized: Connect the control strategy across the process life cycle and drive continuous improvement

Ultimately, we want to get to a situation where we can drive continuous improvement. The continuous improvement cycle is about knowledge management across the enterprise and requires transferability of knowledge and models across scales, sites, and over time. For this to happen, multiple capabilities need to play in unison; quality risk management sets the agenda while process analytics and modeling are essential parts of the control strategy for risk mitigation and detection. The purpose of the modeling needs to be explicitly stated a priori to allow a conscious decision of the appropriate modeling approach for each situation (Fig 4).

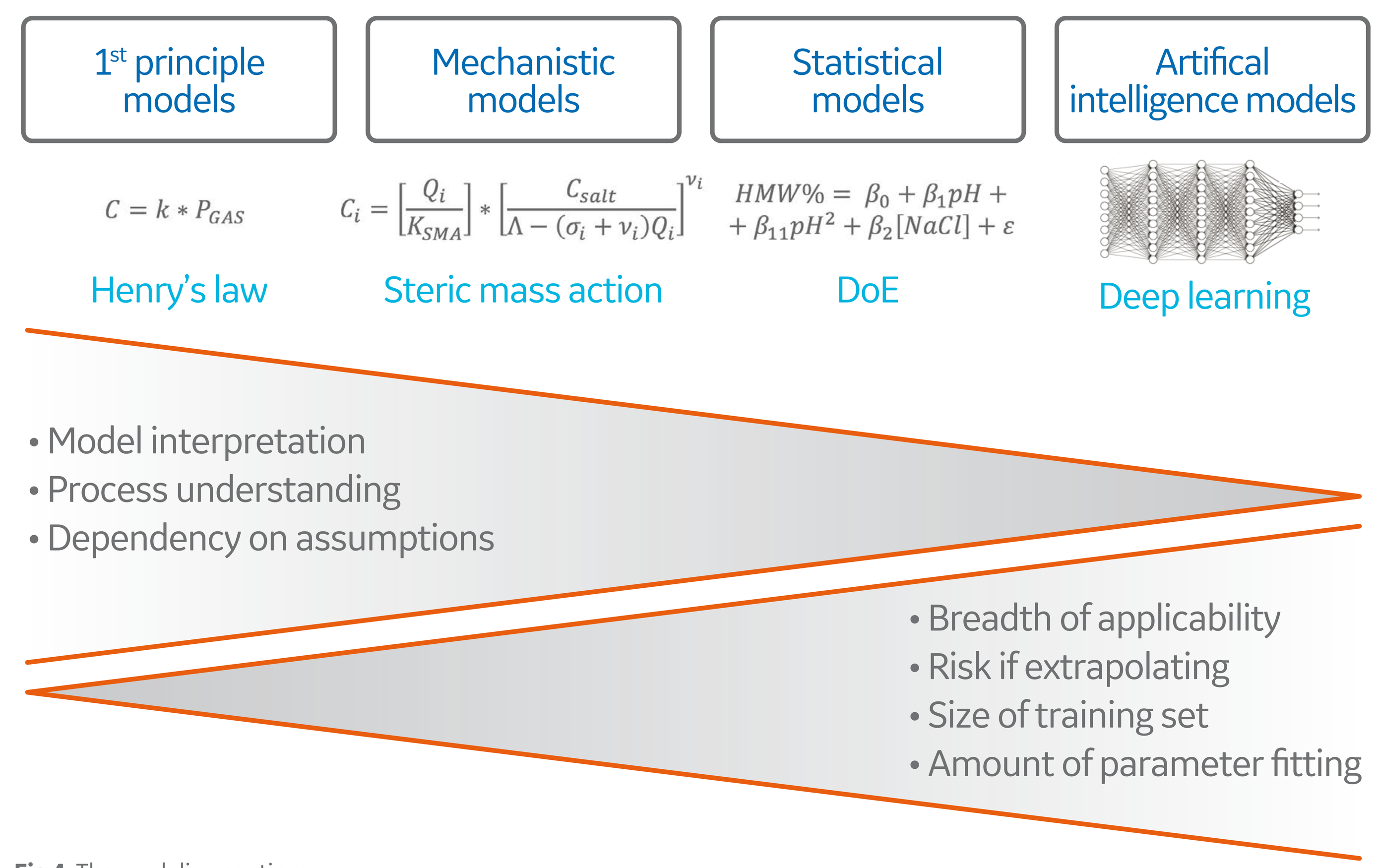

Fig 4. The modeling continuum.

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