Reaping the benefits of liquid handlers for high-throughput gene expression profiling in a marine model invertebrate.

Background: Modern high-throughput technologies enable the processing of a large number of samples simultaneously, while also providing rapid and accurate procedures. In recent years, automated liquid handling workstations have emerged as an established technology for reproducible sample preparation. They offer flexibility, making them suitable for an expanding range of applications. Commonly, such approaches are well-developed for experimental procedures primarily designed for cell-line processing and xenobiotics testing. Conversely, little attention is focused on the application of automated liquid handlers in the analysis of whole organisms, which often involves time-consuming laboratory procedures.

Results: Here, Annona et al present a fully automated workflow for all steps, from RNA extraction to real-time PCR processing, for gene expression quantification in the ascidian marine model Ciona robusta. For procedure validation, the authors compared the results obtained with the liquid handler with those of the classical manual procedure. The outcome revealed comparable results, demonstrating a remarkable time saving particularly in the initial steps of sample processing.

Conclusions: This work expands the possible application fields of this technology to whole-body organisms, mitigating issues that can arise from manual procedures. By minimizing errors, avoiding cross-contamination, decreasing hands-on time and streamlining the procedure, it could be employed for large-scale screening investigations.

Keywords: Automated protocols; Ciona robusta; Immune system; Laboratory automation; Large-scale screening; Marine organisms; Molecular biology protocols (Annona, G. et al., BMC Biotechnol, 2024, 24(1), 4).

AutonoMS: Automated Ion Mobility Metabolomic Fingerprinting. Automation is dramatically changing the nature of laboratory life science. Robotic lab hardware that can perform manual operations with greater speed, endurance, and reproducibility opens an avenue for faster scientific discovery with less time spent on laborious repetitive tasks. A major bottleneck remains in integrating cutting-edge laboratory equipment into automated workflows, notably specialized analytical equipment, which is designed for human usage. Here Reder et al present AutonoMS, a platform for automatically running, processing, and analyzing high-throughput mass spectrometry experiments. AutonoMS is currently written around an ion mobility mass spectrometry (IM-MS) platform and can be adapted to additional
analytical instruments and data processing flows. AutonoMS enables automated software agent-controlled end-to-end measurement and analysis runs from experimental specification files that can be produced by human users or upstream software processes. The authors demonstrate the use and abilities of AutonoMS in a high-throughput flow-injection ion mobility configuration with 5 s sample analysis time, processing robotically prepared chemical standards and cultured yeast samples in targeted and untargeted metabolomics applications. The platform exhibited consistency, reliability, and ease of use while eliminating the need for human intervention in the process of sample injection, data processing, and analysis. The platform paves the way toward a more fully automated mass spectrometry analysis and ultimately closed-loop laboratory workflows involving automated experimentation and analysis coupled to AI-driven experimentation utilizing cutting-edge analytical instrumentation.


Replacing manual operation with bio-automation: A high-throughput evolution strategy to construct an integrated whole-cell biosensor for the simultaneous detection of methylmercury and mercury ions without manual sample digestion. Methylmercury is primarily responsible for most food mercury pollution cases. However, most biosensors developed for mercury pollution analysis can only detect mercury ions. Although oxidative strong-acid digestion or microwave-assisted digestion can convert methylmercury into mercury ions, it is unsuitable for on-site detection. This study designed a bio-digestion gene circuit and integrated it into a mercury ion whole-cell biosensor creating a novel on-site methylmercury detection method. Five alkyl mercury lyases from different bacterial genomes were screened via bioinformatics analysis, of which goMerB from Gordonia otitis showed the highest catalytic biological digestion efficiency. The goMerB site-specific saturation and random mutation libraries were constructed. After two rounds of high-throughput visualization screening, the catalytic activity of the mutant increased 2.5-fold. The distance between the three crucial amino acid sites and methylmercury changed in the mutant, which likely contributed to the enhanced catalytic efficiency. The optimized whole-cell biosensor showed a linear dynamic concentration range of 100 nM to 100 μM (R² =0.991), satisfactory specificity, and interference resistance. The detection limit of the goMerBt6-MerR-RFP biosensor was 0.015 μM, while the limit of quantitation was 0.049 μM. This study demonstrated the application of synthetic biology for food safety detection and highlighted the future potential of "Lab in a Cell" for hazard analysis (Guo, M. et al, J Hazard Mater, 2024, 465, 133492).

Advances in high-throughput screening approaches for biosurfactants: current trends, bottlenecks and perspectives. The market size of biosurfactants (BSs) has been expanding at an extremely fast pace due to their broad application scope. Therefore, the re-construction of cell factories with modified genomic and metabolic profiles for desired industrial performance has been an intriguing aspect. Typical mutagenesis approaches generate huge mutant libraries, whereas a battery of specific, robust, and cost-effective high-throughput screening (HTS) methods is requisite to screen target strains for desired phenotypes. So far, only a few specialized HTS assays have been developed for BSs that were successfully applied to obtain anticipated mutants. The most important milestones to reach, however, continue to be: specificity, sensitivity, throughput, and the potential for automation. Here, Qazi et al discuss important colorimetric and fluorometric HTS approaches for possible intervention on automated HTS platforms. Moreover, the authors explain current bottlenecks in developing specialized HTS platforms for screening high-yielding producers and discuss possible perspectives for addressing such challenges (Qazi, M. A. et al, Crit Rev Biotechnol, 2024, 1-19. doi: 10.1080/07388551.2023.2290981).
Microfluidics for personalized drug delivery. This review highlights the transformative impact of microfluidic technology on personalized drug delivery. Microfluidics addresses issues in traditional drug synthesis, providing precise control and scalability in nanoparticle fabrication, and microfluidic platforms show high potential for versatility, offering patient-specific dosing and real-time monitoring capabilities, all integrated into wearable technology. Covalent conjugation of antibodies to nanoparticles improves bioactivity, driving innovations in drug targeting. The integration of microfluidics with sensor technologies and artificial intelligence facilitates real-time feedback and autonomous adaptation in drug delivery systems. Key challenges, such as droplet polydispersity and fluidic handling, along with future directions focusing on scalability and reliability, are essential considerations in advancing microfluidics for personalized drug delivery (Alavi, S. E. et al, Drug Discov Today, 2024, 29(4), 103936).

Microfluidics as diagnostic tools. The challenges in the management of human diseases are largely determined by the precision, speed and ease of diagnostic procedures available. Developments in biomedical engineering technologies have greatly helped in transforming human health care, especially for disease diagnosis which in turn lead to better patient outcomes. One such development is in the form of microfluidic chip technology which has transformed various aspects of human health care. The authors present in this review, a comprehensive account on the utility of microfluidic chip technologies for the diagnosis of autoimmune disorders, cardiovascular diseases (CVDs), infectious diseases, and neurodegenerative conditions. Kumar et al have included the diseases posing global threat such as rheumatoid arthritis, diabetes, pernicious anemia, tuberculosis, COVID-19, influenza, alzheimer’s, multiple sclerosis, and epilepsy. Apart from discussing the ways of microfluidic chip in diagnosis, the authors included a section presenting electrochemical, electrical, optical, and acoustic detection technologies for the precise diagnosis of CVDs. Microfluidics platforms have thus revolutionized novel capabilities in addressing the requirements of point-of-care diagnostics enabling miniaturization by integrating multiple laboratory functions into a single chip resulting in “one flow - one solution” systems. Hence, the precision and early diagnoses of diseases are now possible due to the advancements of microfluidics-based technology (Kumar, A. S. et al, Clin Chim Acta, 2024, 556, 117841).

XPORT ENTRAP: A droplet microfluidic platform for enhanced DNA transfer between microbial species. A significant hurdle for the widespread implementation and use of synthetic biology is the challenge of highly efficient introduction of DNA into microorganisms. This is especially a barrier for the utilization of non-model organisms and/or novel chassis species for a variety of applications, ranging from molecular biology to biotechnology and biomanufacturing applications. Common approaches to episomal and chromosomal gene editing, which employ techniques such as chemical competence and electroporation, are typically only amenable to a small subset of microbial species while leaving the vast majority of microorganisms in nature genetically inaccessible. To address this challenge, the authors have employed the previously described B. subtilis broad-host conjugation strain, XPORT, which was modularly designed for loading DNA cargo and conjugating such DNA into recalcitrant microbes. In this current work, Wippold et al have leveraged and adapted the XPORT strain for use in a droplet microfluidic platform to enable increased efficiency of conjugation-based DNA transfer. The system named DNA ENTRAP (DNA ENhanced TRAnsfier Platform) utilizes cell-encapsulated water-in-oil emulsion droplets as pico-liter-volume bioreactors that allows controlled contacts between the donor and receiver cells within the emulsion bioreactor. This allowed enhanced XPORT-mediated genetic transfer over the current benchtop XPORT process, demonstrated using two different Bacillus subtilis strains (donor and receiver), as well as increased throughput (e.g., number of successfully conjugated cells) due
to the automated assay steps inherent to microfluidic lab-on-a-chip systems. DNA ENTRAP paves the way for a streamlined automation of culturing and XPORT-mediated genetic transfer processes as well as future high-throughput cell engineering and screening applications (Wippold, J. A. et al, N. Biotechnol, 2024, 81, 10-19).

**High-throughput microfluidic systems accelerated by artificial intelligence for biomedical applications.** High-throughput microfluidic systems are widely used in biomedical fields for tasks like disease detection, drug testing, and material discovery. Despite the great advances in automation and throughput, the large amounts of data generated by the high-throughput microfluidic systems generally outpace the abilities of manual analysis. Recently, the convergence of microfluidic systems and artificial intelligence (AI) has been promising in solving the issue by significantly accelerating the process of data analysis as well as improving the capability of intelligent decision. This review offers a comprehensive introduction on AI methods and outlines the current advances of high-throughput microfluidic systems accelerated by AI, covering biomedical detection, drug screening, and automated system control and design. Furthermore, the challenges and opportunities in this field are critically discussed as well (Zhou, J. et al, Lab Chip, 2024, 24(5), 1307-1326).

**Advances in Artificial Intelligence in surgery**

Artificial intelligence in surgery. Artificial intelligence (AI) is rapidly emerging in healthcare, yet applications in surgery remain relatively nascent. Here Varghese et al review the integration of AI in the field of surgery, centering their discussion on multifaceted improvements in surgical care in the preoperative, intraoperative and postoperative space. The emergence of foundation model architectures, wearable technologies and improving surgical data infrastructures is enabling rapid advances in AI interventions and utility. The authors discuss how maturing AI methods hold the potential to improve patient outcomes, facilitate surgical education and optimize surgical care. The authors review the current applications of deep learning approaches and outline a vision for future advances through multimodal foundation models (Varghese, C. et al, Nat Med, 2024, 30(5), 1257-1268).

**Artificial Intelligence in Operating Room Management.** This systematic review examines the recent use of artificial intelligence, particularly machine learning, in the management of operating rooms. A total of 22 selected studies from February 2019 to September 2023 are analyzed. The review emphasizes the significant impact of AI on predicting surgical case durations, optimizing post-anesthesia care unit resource allocation, and detecting surgical case cancellations. Machine learning algorithms such as XGBoost, random forest, and neural networks have demonstrated their effectiveness in improving prediction accuracy and resource utilization. However, challenges such as data access and privacy concerns are acknowledged. The review highlights the evolving nature of artificial intelligence in perioperative medicine research and the need for continued innovation to harness artificial intelligence’s transformative potential for healthcare administrators, practitioners, and patients. Ultimately, artificial intelligence integration in operative room management promises to enhance healthcare efficiency and patient outcomes (Bellini, V. et al, J Med Syst, 2024, 48(1), 19).

**Artificial Intelligence in Spine Surgery.** The amount and quality of data being used in our everyday lives continue to advance in an unprecedented pace. This digital revolution has permeated healthcare, specifically spine surgery, allowing for very advanced and complex computational analytics, such as
artificial intelligence (AI) and machine learning (ML). The integration of these methods into clinical practice has just begun, and the following review article will describe AI/ML, demonstrate how it has been applied in adult spinal deformity surgery, and show its potential to improve patient care touching on future directions (Scheer, J. and Ames, C.P. Neurosurg Clin N Am, 2024, 35(2), 253-262).

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