thermo scientific

From Dish **to Digital**

Mapping a journey to the **lab of the future**

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Whether they work in food testing, pharmaceutical testing, or the clinical arena, microbiology laboratories of all stripes have a common aim – shortening the time to result.

Faster results keep the food supply lines open, ensure medication batches are released on time and on budget, and get the right treatments to the right patient at the right time.

Sectors from transportation to food delivery, banking to insurance have embraced the efficiency-boosting potential of digital transformation.

A similar opportunity exists in microbiology, where, to date, the challenge has been to find solutions that have proved they are able to cope with the complex and varied nature of the applications and matrices.

Now, with the evidence base building, is the time is right to embrace the potential of the digital laboratory? Because if not now - when?

Rising to the challenge

Innovative solutions, from digital record keeping to computer vision plate reading, could help, by aiding the faster, more efficient return of results, without compromising on quality.

This report will look at the main challenges and pain points across pharmaceutical, clinical, and food microbiology, and explore how similar challenges are being addressed with digital solutions in other sectors.

Shared **Challenges**

Differing sub-sectors of microbiology are united by common, interconnected challenges.

Technicians work with numerous workflows, all with varying culturing steps, incubation times, observation points, and validation processes, for example. This melting pot of standard operating procedures (SOPs) and manual tasks results in complicated workflows.

Workforce shortages are another common challenge in a sector dominated by highly skilled, yet manual work.

Countries around the world simply cannot recruit enough qualified technicians to keep up with the rising demand for microbiology services. Between 1990 and 2015, for example, the number of laboratory training programmes in the United States dropped by 15%, from 720 to 608.

Ensuring traceability to this backdrop of inefficiencies and shortages is a demanding task – and one that will only increase in complexity as the volume of data being collected throughout sector-wise ecosystems continues to grow.

Ultimately, overcoming these challenges is about one thing: shortening time to result.

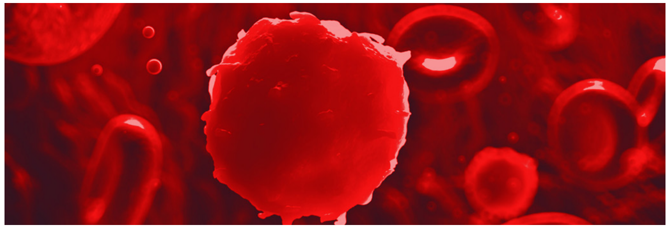
Shared **Challenges**

Clinical

Shortening the time to result provides superior patient outcomes, when they need it most.

Studies have shown that returning antibiotic susceptibility testing results 24 hours earlier than standard time frames could:

- save $2,500 to $20,000 per patient
- reduce mortality rates by around 40%



Pharma

Shortening time to result increases throughput of products, gets medicines to the people who need them when they need them, and increases return on investment (ROI).

- the sooner a pharmaceutical laboratory can identify a problem the sooner mitigation procedures can be put in place. Greater line "uptime" correlates directly with lower medication production costs
- budgets are built to reflect the typical batch release lead time of 20 to 28 days – delays can be costly
- the risk of pathogens to the end user is considerable. Companies need to know as soon as possible if patients are in danger

Food

Shortening time to result despite the challenges of working with such a diverse range of matrices reduces food chain interruptions, aids 'just in time' supply chains, and increases ROI.

- the sooner a food laboratory can identify a problem the sooner mitigation procedures can be put in place. Greater line "uptime" correlates directly with lower food production costs
- the risk of pathogens to the end user is considerable. Companies need to know as soon as possible if consumers are in danger

Laboratory Digitalisation:
The State Of Play

We are not starting with a blank sheet. Recent years have seen various digital initiatives, platforms and products make their way into the laboratory. Some are relatively simple, both in their scope and their implementation, while others are on the cutting-edge of what is scientifically possible.

What they all have in common is the ability to drive efficiencies and shorten time to result.

LIMS

One of the simplest, yet most effective, advances has been the shift from paper notes to electronic laboratory information management systems (LIMS).

Many laboratory operations are still paper-based, despite more modern approaches offering greater data integrity, compliance, and efficiencies. LIMS allow teams to manage test and study data flows and provide easy access to structured information.

While this productivity-boosting move was well underway before COVID-19 hit, the pandemic has certainly accelerated uptake.

Laboratories across the specialty divide have seen demand soar as clinicians rushed to diagnose patients, food production facilities mobilised to keep supply lines open, and pharmaceutical companies reorganised to ensure continuity of supply while also joining the global fight against SARS-CoV-2. In fact, the LIMS market is expected to be worth more than $2billion by 2026 – that's a 12% increase on 2020.

Aside from COVID, this growth is being driven by advances in the technology itself, which, in the past, may have been limited by its inability to structure large amounts of disparate information. Integrated electronic laboratory notebooks (ELN) now allow microbiologists to capture and share complex information, and scientific data management systems (SDMS) can manage vast volumes of data seamlessly.

2D Barcodes

Traditionally, microbiologists label samples by hand and manually track them through the various workflows.

Not only is this time consuming and inefficient, but it also leaves results vulnerable to human error – particularly in those laboratories which deal with large numbers of samples.

The automation of this routine work, by affixing 2D barcodes to test tubes and Petri dishes, is becoming common practice. In tandem with the increased popularity of LIMS, the method offers greater accuracy, and traceability, while also driving productivity.

It is a simple process that significantly simplifies documentation protocols. Technicians scan the label on their sample to create a digital record within the LIMS. At each subsequent step of the workflow, the label is scanned, the latest information entered, and a photograph of the sample attached.

The result is a full report of each sample, complete with audit trail, available on request to any member of the team.

Digital Plate Reading

Digital plate reading (DPR) is another efficiency driving approach that is being seen more and more in the modern laboratory setting. Much like the initiatives already mentioned, it can boost productivity while helping avoid errors and increase traceability.

A 2015 review of the technology perfectly outlined the challenges of traditional, open bench methods.

“At the beginning of each shift,” it said, “stacks of inverted plates are removed from incubators and set on the benchtop. Throughout the day, the technologist works through the stack of culture plates.”

This includes collecting plates from different incubators, inspecting media for bacterial growth, examining colony morphology, isolating pure cultures, performing biochemical testing on isolates, preparing media, interpreting results, and discarding or archiving old culture plates, for instance. The plates are eventually returned to their incubator, and the same process is repeated the following day. It is inefficient and it is prone to error.

DPR uses digital imaging, enabling microbiologists to read plates and record results virtually, without having to remove them from the incubator.

It allows for the continuous incubation of cultures, with the scheduling of image collection times, which increases staff productivity and decreases exposure to any cultivated pathogens. Crucially, it also cuts the all-important time to result.

Artificial Intelligence and Plate Reading

The role of artificial intelligence (AI) in microbiology is still in its infancy, but it stands ready to take workflow efficiencies to the next level.

One of the most pertinent AI-driven technologies to our field is computer vision, or the training of software algorithms to recognise and characterise patterns. The potential uses are as wide-ranging as they are transformative.

Computer vision technology exists, for example, to classify the morphology of white blood cells and to recognise bacterial colonies, while studies are underway to evaluate its ability to detect malarial parasites.

As these applications grow in volume, it is important to remember that the technology is used to augment, rather than replace, qualified microbiologists.

AI can be used to screen large numbers of samples, flagging those with concerning features for human review and validation. In this form, AI enables skilled staff to have the time to concentrate on what matters most - increasing throughput and reducing time to result.

A 2020 validation study published in the Journal of Clinical Microbiology, for example, describes a computer vision application for the detection of protozoa in trichrome-stained faecal smears.

Traditionally, it is a task that takes very many hours of manual light microscopy by highly skilled staff. By using AI and digital slide scanning to screen the samples and flag potential parasites for manual confirmation, this new approach was able to significantly reduce time to result. Importantly, it did so with around 98% accuracy and excellent reproducibility.

“Researchers, microbiologists, laboratorians, and diagnosticians are interested in AI-based testing because these solutions have the potential to improve a test’s turnaround time, quality, and cost,” said a 2020 article in the same journal, which described the technology as “the next frontier in laboratory diagnostics”.

“Computer vision in the year 2020 is analogous to PCR in the year 2000. A generation ago, PCR was a laboratory tool and an exciting technology, and today nucleic acid amplification tests are an essential component of the clinical diagnostic laboratory.

“Clinical microbiologists that train 20 years from now will recognize computer vision as an integrated and essential tool for many areas of the microbiology laboratory.”

Growing **Evidence Base**

Microbiology may have been slow to embrace digital transformation, but it is easy to see why. Move fast and break things may yield results for search engines and social media, but it is not the best mantra when people's health and safety are at stake.

In many ways, the sector has been holding back, waiting for the data to back up the claims. Yet today, with so many examples of how other fields and specialities have overcome similar challenges, many organisations believe it is time to go from dish to digital.

Acknowledging image recognition

Field

Echocardiography, or the use of ultrasound exams to diagnose and monitor heart conditions

Challenge

A growing shortage of qualified sonographers and increasing demand due to the growing prevalence of cardiovascular diseases have been compounded by the modality's essential role in the diagnosis of COVID-19 and the monitoring of long COVID.

Solution

Computer vision algorithms are increasingly being used to screen echocardiograms, and flag those of concern for human validation. They can automate basic, yet time-consuming tasks, such as ejection fraction and strain measurement, allowing skilled staff to focus on providing timely, accurate diagnosis.

The evidence

Studies have shown that AI can automate EF and Strain measures to levels of accuracy that are equal to or better than human experts.

Accelerating drug development

Field

Pharmaceutical development

Challenge

Drug development pathways are long and expensive. It takes an average of 12 years and £1.15billion to bring a new product from candidate selection to approval. For every one medicine that makes it to market, between 5,000 and 10,000 chemical compounds are made and disregarded. Shortening the pathway – or accelerating the time to result – is key to increasing ROI.

Solution

AI has been employed in numerous ways by drug developers. Machine learning algorithms can spot patterns in the characteristics of potential drug candidates and identify those most likely to succeed, for example.

The evidence

Last year, a partnership of Japan's Sumitomo Dainippon Pharma and Exscientia in the UK announced that the first drug molecule to be developed by AI had entered Phase I clinical trials. The potential obsessive-compulsive disorder treatment, DSP-1181, was developed in just 12 months, compared to the standard average of five years.

Ensuring traceability

Field

Food production and retail

Challenge

At the same time as consumers are demanding maximum sustainability and transparency on where their food comes from, supply chains are becoming ever longer, complex – and vulnerable.

Solution

Manufacturers and retailers in the agriculture space are utilising blockchain, which stores "blocks" of information in a way that makes it difficult to change or hack, to provide customers with farm-to-fork traceability. With the scan of a QR or barcode at each point of contact along the supply chain, companies can ensure and demonstrate full traceability and sustainability.

The evidence

Walmart's blockchain pilot slashed the time it took to trace a pack of sliced mangoes through its six-stage "farm to fork" journey from more than 18 hours to just two seconds. In Europe, Carrefour provides an app that allows customers to scan selected products and track their entire production journey.

Joining The **Dots**

What is clear from those technologies that are emerging and embedding themselves into routine workflows is that they, at least to some degree, rely on each other.

Laboratories are looking to technology to overcome the triple threat of complex and varied workflows and diverse matrices, industry-wide skills gaps, and the need for greater traceability as the volume and complexity of data being collected increases.

The digital transformation of clinical, food, and pharmaceutical laboratories necessitates the full-scale integrated adoption of the currently available technologies – and new infrastructures that are agile enough to allow future breakthroughs to fit seamlessly into workflows as and when they become available.

Making It **Happen**

Digital transformation is not all about the newest technology. It is about putting the processes, tools, and solutions that improve efficiency and enable agility in place.

It is a process of mapping out pathways, and identifying pain points, then applying and monitoring solutions. They might be as simple as keeping electronic records, or as "complex" as implementing AI.

Automation is probably one of the most well-known and embedded methods of increasing productivity. It can streamline inefficient workflows and free-up microbiologists to focus on more high-value tasks.

Applications such as automated plate reading and plate barcoding, for example, can also help to build robust traceability processes.

identify repetitive process > define goals > train team > design workflow

implement solution < measure progress < implement improvements

One of the most important things to remember is that digital transformation is not about replacing microbiology's hugely skilled workforce, it is about augmenting human input.

Success is designing processes that remove repetitive, manual tasks, and allow technicians to concentrate on what they do best – guiding meaningful decision-making.

Join The **Discussion**

Across microbiology subsectors, we face similar challenges, from inefficient workflows and skill gaps, to the need to increase traceability in line with the growing amount of data being collected every day. These challenges will only compound as microbiology itself advances.

Laboratories the world over are being asked to do more with less – and digital transformation is the key to doing just that.

We may be at the start of the dish to digital journey, but we can learn from other sectors, fields, and arenas that have faced similar challenges. And while we do not yet have all the answers, we can work together, as an industry, to find and implement the solutions.

Find out more at **thermofisher.com**

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