

Total Laboratory Automation in Clinical Bacteriology

1

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1 CLINICAL BACTERIOLOGY AND AUTOMATION: BACKGROUND

The primary mission of the clinical bacteriology laboratory is to assist the health care provider in the diagnosis of infectious diseases. Due to the variety of specimens submitted to the bacteriology laboratory, many of the steps related to the processing and workup of a specimen have remained manual. The specimen is inoculated onto an agar medium (with plating protocols typically driven by the source of the specimen), the plates transferred manually to an incubator, the plates removed after a defined period of time and the culture examined by a technologist to look for potential pathogens. The cost of healthcare in many countries and the Affordable Care Act in the United States are collectively driving institutions to explore new and novel ways to provide continuous, quality care in a more affordable, efficient fashion. One of those options to enhance efficiency and affordability is automation.

Notwithstanding the pressure to maintain affordability and quality, there are many other pressures health care institutions face. It is a fact that fewer clinical laboratorians are entering the workplace and this parallels the decline in medical technology training programmes in the United States ([Microbiology, 2008](#)). The American Society for Clinical Pathology (ASCP) vacancy survey indicated that in 2012, 9% of the microbiology staff will most likely retire in the next 2 years ([Garcia, Ali, & Choudhry, 2013](#)). In the state of California alone, the average age of a medical technologist is approximately 55 years of age. Again, with fewer programmes producing licenced, trained technologists and the anticipation of the growing need for laboratory services, automation is a potential solution to mitigate the decreased staffing situation ([Garcia et al., 2013](#)). In addition to automation, some institutions are investigating the training and implementation of lean within the laboratory section. Although other industries have seen the adoption of lean impact efficiency and bottom line, the healthcare setting has been slow to adopt the lean philosophy. Seminars are now being offered in the context of the laboratory and lean management. Some health care institutions have published on lean in the laboratory space and offer

training to laboratorians interested in adoption of these principles in their own laboratory (<http://www.henryford.com/body.cfm?id=50135>).

Automation is available in many shapes and sizes and does not fit in all laboratories equally. Thoughtful analysis should be performed by each laboratory to determine if they are a candidate for automation in the bacteriology space (Ledeboer & Dallas, 2014). Capital dollars, physical space in the lab, testing volumes, information technology (IT support for interfacing) and staff adoption, are all factors that should to be considered and will dictate the type of automation that might be an option. Laboratories are finding that placing automation in areas where processes are inefficient does not result in the best use of that automation, so the lean approach is perhaps an initial stepping stone to implementing future automation.

Until fairly recently, there have been relatively limited number of innovations in microbiology automation. Examples of automation include continuous monitoring blood culture instruments and automated identification and susceptibility testing such as the Vitek (bioMerieux, Marcy l'Etoile, France), MicroScan Walk Away (Beckman Coulter, Brea, CA) or Phoenix Automated Microbiology System (Becton, Dickinson and Company, Franklin Lakes, NJ) (BD) which have been adopted by most bacteriology laboratories. Nevertheless, even with the aforementioned automation, bacteriology has typically lagged behind many of the other clinical laboratory departments such as chemistry and haematology in the ability to fully automate, improve turnaround time (TAT) to results for patients and minimise manual steps that can lead to inefficiencies and ergonomic concerns (Ellison & Jensen, 2011). Faster TAT can lead to improved clinical outcomes as documented in the literature (Barenfanger, Drake, & Kacich, 1999). More recently, there have been improvements in the area of bacteriology automation that will have significant impact on workflow, quality and time to result. MALDI-TOF (Matrix-Assisted Laser Desorption Ionisation-Time of Flight) systems employ protein mass spectrometry for the identification of bacteria, yeast, moulds and Mycobacteria (many to genus and species level) in minutes compared to hours or days using conventional methods. In addition, Total Laboratory Automation (TLA) for bacteriology has been developed (Bourbeau & Ledeboer, 2013; Buchan & Ledeboer, 2014; Burnham, Dunne, Greub, Novak, & Patel, 2013; Mutters et al., 2014; Novak & Marlowe, 2013). TLA encompasses a suite of instruments which includes a pre-analytical plating instrument, track systems that can transport inoculated Petri dishes to “smart incubators” and a digital camera to image inoculated plates for the presence of growth. There are other standalone instruments (that would be incorporated into the TLA line) that should enter the market very soon which will automatically inoculate a mass spectrometry target slide and prepare McFarland Standards for additional identification or susceptibility tests. Culture analysis is performed by visualising the plated media from a computer screen instead of manipulating and holding the plates as is done today in most laboratories. This chapter will focus on the pre-analytical plating instruments and the newer TLA systems on the market today and discuss some of the features associated with them. It is important for the reader to note that this area of microbiology is dynamic and rapidly changing and that the most current information can be obtained from the manufacturer.

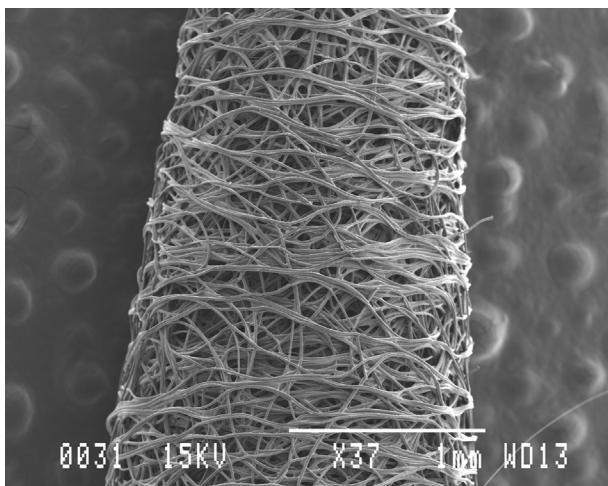
To set the background for this discussion, bacteriology automation has many advantages that are important to mention in the context of this chapter. Automation of the inoculation and culture analysis process can have a significant impact on the bacteriology laboratory, but more comparative studies between manual and automated methods are still required. Some benefits of automation can range from efficiency related to labour savings, better time to result if cultures are read in a timely fashion versus being batched and traceability of patient samples since plates are labelled during the inoculation process. When the inoculation process is performed using an automated plating instrument, the streaking is standardised and bacterial isolation is comparable or superior to the manual plating method. This has been our experience within our own laboratory at Kaiser Permanente since we began using pre-analytical plating instrumentation in 2004. When manual inoculation is used, there are often differences between individuals plating the specimens which can present challenges overall to the technologists reading the plates. Standardisation of inoculation allows for better control over the streaking quality, pattern and isolation of microorganisms. Though there are advantages to pre-analytical plating instruments, a thorough validation must take place in the laboratory setting to assure that there is equivalency to the current manual plating process ([Ledeboer & Dallas, 2014](#)). Many laboratories that receive high volumes of specimens are often plagued with ergonomic and repetitive motion injuries to the staff if manual processes are used to perform tedious but simple tasks such as de-capping and re-capping specimen tubes. Injury to an employee is not only a quality of life issue for the staff member but also can cost an organisation money paid for workers compensation claims and time off of staff due to injury and/or surgery and rehabilitation. Some employees return to work with temporary or permanent restrictions due to injuries which present challenges to the laboratory in terms of placing them back to work. Automation minimises or eliminates repetitive tasks, such as capping of specimens as described above, sparing the employee from having to perform that specific task every day. The instrument performing this task also saves time so that employees can be placed on other tasks within the laboratory. Taking advantage of automation can also impact workplace safety relative to reducing the exposure to potentially dangerous pathogens since the plates are opened within the “smart incubators” (described below). This process reduces the exposure to pathogens such as *Coccidioides immitis*, *Brucella* spp. and *Neisseria meningitidis* to name a few ([Prevention, 2003](#); [Sayin-Kutlu et al., 2012](#); [Traxler, Lehman, Bosserman, Guerra, & Smith, 2013](#)). *C. immitis* is endemic in the southwest region of the United States and can grow on routine cultures in the bacteriology setting where exposures can and have occurred in the lab. It is anticipated that once these instruments are more widespread within the laboratory space that some of the assumptions above will be additionally confirmed in the literature. Incorporation of the automation means the instrument performs many tasks that have historically been manual and removes or minimises the concern that accompanies repeating a task. This is especially true in the clinical laboratory that processes thousands of samples in a 24-h period.

In addition to the pre-analytical plating instruments, there are “smart incubators” which include not only the incubator to incubate the culture plates at the appropriate temperature but also a sophisticated digital camera to take images of the culture plates. The digital camera can detect colonies that are not able to be visualised by the human eye, therefore potentially allowing a specimen to be worked on much earlier than if the plates were examined manually with the naked eye. Digital imaging has the potential to impact in the areas of competency, training and quality assurance. Images of organisms on culture plates can be stored and subsequently retrieved if there is a quality problem in the laboratory or for training or competency testing. Digital plate reading (DPR) allows the technologist to work up the cultures without handling the plates. This impacts on the ergonomics of opening and closing plates in addition to decreasing unnecessary pathogen exposure as mentioned above.

To date, there is limited literature on TLA and the components that make up these systems (Bourbeau & Swartz, 2009; Mutters et al., 2014; Novak & Marlowe, 2013). Once these types of instruments are placed in more clinical laboratories additional performance data will be forthcoming. This chapter will summarise the currently available automation systems from a modular and TLA perspective.

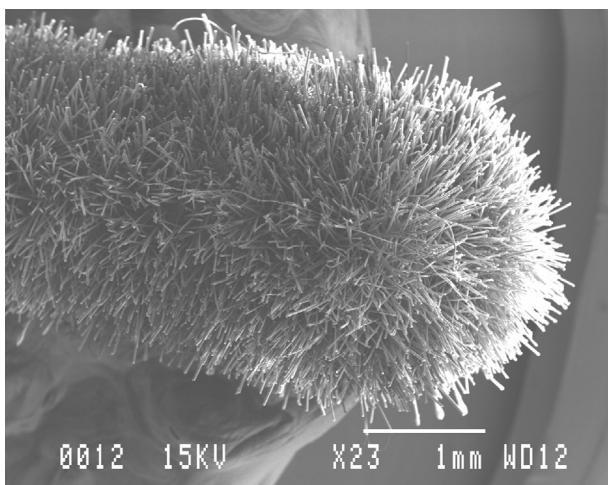
2 SPECIMEN COLLECTION: LIQUID MICROBIOLOGY

A wide variety of specimen types are submitted to the bacteriology department for processing. In order to fully automate the plating of samples for microbiology the specimen (for several of the instruments mentioned below) must be in a liquid form. There is one pre-analytical plating instrument that can process the liquid from a transport swab or inoculate the media using the swab in semi-solid transport medium. Regardless of the specimen collection device, the importance of adequate specimen collection is always paramount when submitting microbiology samples for laboratory analysis. For many years, rayon swabs have been used for routine microbiology specimen collection. The rayon swab contains tightly round rayon fibres placed on the end of the collection shaft (Figure 1). To improve on specimen collection, Copan Diagnostics (Brescia, Italy) developed the flocked swab or ESwab™ which allows for better collection and subsequently more homogenous dispersal of the specimen into a liquid Amies transport medium within the transport tube (Buchan, Olson, Mackey, & Leedeboer, 2014; Trotman-Grant, Raney, & Dien Bard, 2012; Van Horn, Audette, Sebeck, & Tucker, 2008). The flocked swab is unique in the design with nylon fibres arranged perpendicular to the head of the swab thus increasing the surface area for collection and trapping of the specimen and associated organisms (Figure 2). Figure 3 shows various types of ESwabs from Copan Diagnostics available today on the market. In the case of the nylon swab, the net that is created traps the sample preventing release of the specimen during plating. After the sample is collected with the ESwab, approximately 90% of the specimen is released into the liquid Amies transport medium present in the transport tube. This liquid Amies transport medium is suitable for plating using an automated instrument such as those

**FIGURE 1**

Electron micrograph image of the tip of a rayon specimen collection swab.

Image courtesy of Copan Diagnostics.

**FIGURE 2**

Electron micrograph image of the tip of a flocked swab showing the increased surface area.

Image courtesy of Copan Diagnostics.

described in this chapter. Several studies have demonstrated equivalent or superior performance of the ESwab compared to conventional swabs. In one study, there was a 3.6-fold increase in the recovery of viable methicillin-resistant *Staphylococcus aureus* with the ESwab versus the Venturi swab ([Smismans, Verhaegen,](#)



FIGURE 3

Various ESwab™ vials. Each tube contains a different size swab, which correlates to the colour cap of the tube.

Image courtesy of Copan Diagnostics.

Schuermans, & Frans, 2009). In another study, the ESwab was equivalent or better than (respectively) to other swabs tested (BD CultureSwab MaxV and the Remel BactiSwab (Lenexa, KS)) when using Clinical Laboratory Standards Institute (CLSI) criteria for the evaluation of swab systems (Van Horn et al., 2008). The liquid specimen is a more homogenous specimen than a swab in semi-solid media which should result in all plates receiving the same amount of specimen. This is advantageous when multiple plates are inoculated for specific specimen types. There are other manufacturers of flocked swabs in addition to Copan Diagnostics such as Puritan (Guilford, ME) and Millipore (Billerica, MA) (Buchan & Ledeboer, 2014).

3 PRE-ANALYTICAL AUTOMATION

In regards to specimen processing and inoculation of media, there are several instruments that can fully automate the pre-analytical processing of the majority of clinical samples submitted for routine bacteriology testing. It is important to note that because laboratories are very different in terms of the volume and types of specimens processed there will seldom be a “one size fits all” solution for automation in the clinical bacteriology laboratory. Many of the systems described below have features that are complimentary to one another yet differences do exist. Briefly, all fully automated pre-analytical plating instruments will read the barcoded specimen and can query the Laboratory Information System (LIS) to determine the type of specimen and the plating protocol. This is a very important feature because it allows for less intervention from the personnel that are managing the upfront processing of the specimens and in addition allows for traceability and positive identification throughout the pre-analytical process. After the barcode is read, the systems will then apply a barcode label to each plate linking that plate to a specific patient specimen. Specimen

tracking and traceability are paramount in today's clinical laboratory where staff are continuously being challenged to work very efficiently yet maintain excellent quality. Enhanced procedures should be put in place to minimise labelling errors and specimen mix-up (Wagar, Stankovic, Raab, Nakhleh, & Walsh, 2008). Plating automation can significantly reduce or mitigate these errors from occurring in the context of pre-analytical specimen processing.

The following sections will describe the automated plating systems available today, but it is important to note that the functionality of these systems and associated software is constantly evolving (Bourbeau & Ledeboer, 2013; Buchan & Ledeboer, 2014; Novak & Marlowe, 2013). If a laboratory is interested in pursuing automation, due to the dynamic nature of the software and functionality of the instrumentation, it is important to obtain up to date information from the manufacturer.

4 PRE-ANALYTICAL BACTERIOLOGY SPECIMEN PLATING INSTRUMENTS

4.1 ISOPLATER

One of the first semi-automated plating instruments on the market for use in the clinical laboratory was the Isoplater (Vista Technology Inc., Edmonton, Alberta, Canada; www.vistatechnology.com). The initial version of the instrument was developed almost 24 years ago and continues to be used in clinical laboratories today. Unlike newer instrumentation, the Isoplater is a semi-automated plating instrument which means the sample must be manually inoculated onto the agar media prior to the placement of the plate on the instrument for streaking. A newer version of the instrument on the market today is the Isoplater 180i ([Figure 4](#)). The specimen must be inoculated over the standard $\frac{1}{4}$ " Frosted Mark found on most Petri dishes, so the Isoplater can properly orient the plates before streaking. A carousel can hold up to four stacks of 20 Petri dishes with a total of 80 plates resulting in a 30-min walk-away cycle. The instrument has dimensions of 30" (width) \times 25" (depth) \times 30" (height) and can fit on the table or bench top within the laboratory. The Isoplater streaking pattern is the standard four quadrant overlapping pattern (the streak lines are curved for maximum dish usage) which is very standardised and can easily be quantitated by the technologist. By using four wire loops in succession, the throughput is 180 plates per hour producing isolated colonies ([Figure 5](#)). The manufacturer states that the life span of the wire loop is approximately 20,000 inoculated plates. Four "S"-shaped loops ([Figure 6](#)), designed for maximum streak coverage and improved isolation are used to streak a single plate. The instrument can streak one plate in 18 s with a total of 180 plates per hour. The newer instrument offers a touch screen interactive control panel as shown in ([Figure 4](#)). Streaking of an inoculated plate occurs in a negative pressure area within the instrument that is HEPA filtered to provide safety to the laboratorians using the instrument and those personnel in the surrounding laboratory space. The negative pressure and HEPA filter also remove smoke when heating the

**FIGURE 4**

Isoplater 180i pre-analytical specimen processor, Vista Technology.

Image courtesy of Vista Technology.

**FIGURE 5**

Isoplater 180i streaking pattern.

Image courtesy of Vista Technology.

**FIGURE 6**

Inside view of Isoplater 180i instrument loop mechanism.

Image courtesy of Vista Technology.

loops and reduces the risk when a hazardous specimen containing potential pathogenic organisms is being processed. The HEPA filter is a feature present in all of the instruments described below as well. The Isoplater 180i cannot be interfaced with the LIS, and patient labels must be applied to the plates manually when the Petri dish is inoculated. The four individual S-shaped streaking loops the Isoplater allow effective streaking of sputum, stool and other thick specimens without any special specimen pre-treatment.

Generally, prepping, labelling and inoculating represent about 50% of the labour of set up, and streaking takes the other 50%. Therefore, while there are some manual steps associated with preparing the media for placement on the Isoplater, this instrument may be an ideal solution for those laboratories that process a lower volume of samples but want to enhance the quality of plating and remove the manual task of streaking the plates which can free up staff for other essential departmental tasks.

4.2 INNOVA

The number of manufacturers developing bacteriology pre-analytical automation have been limited to date. Dynacon, manufactured one of the first fully automated liquid plating instruments in 2002, called the Inoculab ([Novak & Marlowe, 2013](#)). This instrument set the stage for newer fully automated pre-analytical plating instruments and is still used in many laboratories today although as of 2015 this instrument

will no longer be manufactured. The next-generation instrument from Dynacon was the Innova, and at the time of introduction to the clinical market, Dynacon was acquired by Becton Dickinson in 2010.

The Innova (Figure 7) was introduced around 2010 and had enhanced features compared to the Inoculab and could accommodate various sizes and shapes of specimen containers. The instrument can be interfaced to the LIS, has a capacity to hold up to 200 specimens and contains six plate silos that can hold six different types of media with a total plate capacity of 270. The instrument measures 60" (width) × 49.5" (depth) × 71" (height) and access to the instrument is through the front. As shown in Table 1, the Innova is similar to other plating instruments in that a re-useable loop is used for inoculation. Loop sizes can vary depending on the need and range from 1, 10 and 30 µl. To increase the homogeneity of the specimen plated, the Innova has an agitator/shaker so that the specimen is mixed prior to plating. An internal camera takes a picture of the loop to ensure loop alignment since a misaligned loop (on any system) can impact the quality of plating and the isolation and recovery of important organisms. To ensure an adequate volume is present in the original specimen, an ultrasonic level sensor is present and if adequate volume is not available for plating, the specimen will not be processed, and the instrument



FIGURE 7

Innova™ pre-analytical specimen processor, Becton, Dickinson and Company.

Image courtesy of BD.

Table 1 Comparison of the Fully Automated Plating Instruments Currently on the Market

	PREVI Isola	Innova	WASP	Inoqua+	PreLUD
De-cap/cap containers	No	Yes	Yes	Yes	Yes
Number of different media at once	5	6	9	12	8
Number of samples at once (max)	114	200	72	288	300
Number of plates streaked at once	1	1	1	Up to 5 at once	1
Streak only mode	No	Yes	Yes	Yes—MI module	Yes
Inoculate Gram Slide	No	No	Yes	Yes	Future
Inoculate broth tube	No	No	Yes	Yes	Future
Detect Eswab presence	No	Yes	No	No	Yes
Method of inoculation	Pipette	Re-useable loop	Re-useable loop	Pipette	Pipette, re-useable loop, primary swab
Throughput ^a	~180 inoculations/h	~130 inoculations/h	~180 inoculations/h	~220 inoculations/h	~120 inoculations/h
Integrate into track system	No	No	Yes	Yes	Future
Sample vortex/agitation	No	Yes	Yes	Yes	Yes
Streaking method	Spiral-plastic comb	Custom loop	Custom loop	Custom-rolling bead	Custom loop, primary swab, custom bead
Sort plates by incubator	Yes	Yes	Yes	Yes	Yes—Custom—8 stacks
Consumables/waste	Streaking comb, pipette tip, extra cap	Re-useable loop	Re-useable loop	Re-useable bead, pipette tip	Re-useable loop, pipette tip, re-useable bead

^aVaries depending on streak pattern.

flag will notify the operator that the specimen was not plated. The Innova was the first next-generation plating instrument to have a universal specimen de-capper/capper which can adjust to the container type when the instrument scans the barcode on the individual specimen prior to plating the specimen. After the specimen is de-capped and plated, the instrument re-caps the specimen so the sample can be stored depending on the departmental protocols. This de-capping and re-capping feature is integral for all the newer plating instruments. Specimens are placed in metal racks or “canoes” within the Innova that are located in five individual drawers, with a total of 40 specimens in each drawer. The metal racks are flexible in that the rack can accommodate different size specimen containers such as a boric acid tube or a stool Culture & Sensitivity vial (C&S, Meridian Bioscience, Inc., Cincinnati, OH). An advanced feature of this instrument, again similar to the others that will be described below, is that the Innova can be programmed to inoculate media using various plating protocols that can be configured based on the specimen source or laboratory procedures. The instrument can obtain this information from the LIS which is a very important feature for small- to medium-size laboratories that might need to place a variety of specimens on the plating run. The Innova does not have a track for constant feeding of specimens into the unit nor does it have a track system exiting the system as do many of the other instruments described below. Consequently, this instrument would not be part of a TLA suite of instruments but could be used as a standalone instrument to automate the pre-analytical plating process. If necessary, certain specimens can be plated on the media within a biological safety cabinet (BSC) and a streak only mode used on the Innova similar to the Isoplater. Positive identification of the sample is ensured throughout the plating process since the instrument queries the LIS for instructions as to the patient information, type of media to plate (based on the specimen source or protocol) and attaches the correct patient label to the plate. In an era of increased awareness in terms of patient safety, positive patient identification throughout the journey of the specimen as it travels through the laboratory is critical for most laboratories in today’s healthcare environment.

In 2012, BD acquired KIESTRA Lab Automation (Drachten, the Netherlands) which had designed and developed another specimen processing system—the InoquA. The InoquA, which will be described in more detail below, offers several enhanced features. As the InoquA is the latest specimen-processing platform offered by BD, the Innova will eventually no longer be marketed for sale but will be serviced and supported for those that are currently using this technology.

4.3 BD KIESTRA™ InoquA+™

As mentioned above in 2012, BD acquired Kiestra™, a Dutch company that specialises in microbiology automation. Kiestra has been in the microbiology domain for 17 years and installed the first automated instrumentation in 2006 in Europe. The InoquA™ pre-analytical automated plating instrument has been in the laboratory setting since 2011 in Western Europe. In 2013, BD Kiestra introduced the InoquA+ (Figure 8) which is the first system on the market to include an optional

**FIGURE 8**

InoculaA+™ pre-analytical specimen processor, Becton, Dickinson and Company.

Image courtesy of BD.

BSC, which was designed with the intent to assist the laboratorian in processing samples that cannot otherwise be processed with the full laboratory automation. This would include specimens such as tissues, catheter tips and sputum, for example, and may obviate the need for a standalone BSC in the laboratory. The previous configuration of the Inoqua did not have the BSC feature. The Inoqua+ is interfaceable and has a dimension of 174" (width) × 37" (depth). The instrument has a fully loaded plate capacity of 612 plates and can be loaded with 12 different media types depending on the protocols of the individual laboratory. Compared with the other instruments described in this chapter, this system has the largest plating capacity and is well suited for higher-volume clinical laboratories. The system has customisable container racks and a universal de-capper (as described with previous instrumentation) which enables the de-capping of different-sized sample containers. A calibrated pipette which samples the liquid specimen is used to inoculate plates, broth tubes and slides according to the sample protocol set by the end user. The pipetting mechanism is unique to the Inoqua+; however, the instrument has a unique streaking technology that uses a magnetic rolling bead (shown in Figure 9) to streak the plate using customisable patterns (zig zag, four quadrants, bi-plate, antimicrobial susceptibility testing (AST) lawn and semi-quantitative patterns) based on operator need. When comparing the magnetic bead streak pattern and colony isolation, it appears that the number of single or discrete colonies is enhanced compared to manual methods. From a capacity perspective, the instrument can streak up to five plates at once using the rolling bead technology. From a throughput perspective if a sample requires seven plates to be inoculated, the Inoqua+ can streak 220 plates per hour. The instrument has similar features already mentioned in that the specimen is vortex-mixed prior to inoculation and a picture is taken of the pipette tip prior to inoculation to ensure adequate specimen delivery. The Inoqua+ also has a barcode-

**FIGURE 9**

Petri dish streaked with magnetic bead technology using the InoquIA+™, Becton, Dickinson and Company.

Image courtesy of BD.

driven semi-automated mode that is designed for continuous processing of specimens that are not suitable for fully automated plating, such as tissues, catheter tips and other non-liquid samples types. In this mode, even though the specimen is not liquid, plates can be selected by the instrument and barcoded. Other plating instruments do not have the BSC feature, though laboratories are likely to have a stand-alone BSC in the laboratory. The attached BSC might be advantageous to those labs that do not have a BSC or the additional space for both plating automation and a BSC. This also places all necessary components for specimen processing in a line which compliments a lean process flow for pre-analytical specimen processing. The InoquIA+ contains a module that will label a slide with patient identifier information and prepares the slide for a Gram stain offline. It is important to note that consumables are needed in the form of pipette tips and magnetic beads for specimen inoculation with the InoquIA+. The bead and tip will be biological waste and must be disposed of accordingly. These costs should be figured into the overall cost analysis if this instrument is introduced into the clinical laboratory.

4.4 PREVI® ISOLA

The Previ® Isola (Figure 10) is bioMerieux's solution for pre-analytical microbiology specimen processing. The instrument is interfaceable, has footprint of 66.5" (width) × 35.7" (depth) × 58.7" (height) and can be loaded with five different types of media at once with a total of 150 plates. The Previ Isola is similar to the Isoplater in that the streak pattern is spiral. Each plate is inoculated using a single-use disposable specimen applicator (comb). The spiral applicator comb is unique in that it mimics

**FIGURE 10**

PREVI™ Isola pre-analytical specimen processor, bioMerieux.

Image courtesy of bioMerieux.

16 loops streaking simultaneously which covers more surface area on the plate versus conventional quadrant streaking patterns. The applicator can be changed with every plate or can be used for each specimen regardless of the number of plates inoculated. This feature is defined by the end user. One additional feature of the Previ Isola is the ability to streak a bi-plate, in the case of a urine culture, with the comb applicator. The throughput of the instrument is approximately 180 plates per hour streaking the full plate in a spiral configuration.

To date, the Previ Isola does not have the capability of de-capping and re-capping specimens which is a feature present in some of the other plating instrumentation described in this chapter. The impact of the lack of de-capping/capping within the instrument may be varied depending on the size of the laboratory and the number of specimens processed per day. This impact might be minimal in a low- to medium-volume lab but may be more significant in a higher-volume lab where thousands of specimens are being processed throughout the day. Having to move the specimens back and forth between the de-capper/capper and the plating instrument will be an added step adding labour and reducing the overall efficiency. As with other instruments, the Previ Isola can query the LIS and can be programmed to separate plates into individual canisters based on the atmospheric environment the plates will be incubated in. One study compared the Previ Isola to manual methods and demonstrated decreased hands-on time and improved efficiency in the laboratory space with integration of the instrumentation ([Mischnik, Mieth, Busch, Hofer, &](#)

Zimmermann, 2012). The same study demonstrated that the Previ Isola reduced the need for re-incubation in regard to obtaining isolated colonies compared to a manual plating method (0.8–1.1% with Previ Isola compared to 5–15% with manual streaking) (Mischnik et al., 2012).

It is important to note that after sometime in 2016, the Previ Isola is likely to be discontinued as a product by bioMerieux. bioMerieux will be partnering with Copan Diagnostics in the future to enhance the TLA solutions offered by Copan Diagnostics using the strengths of both companies to enhance the features of the WASP and WASPLab™ TLA.

4.5 COPAN WASP®

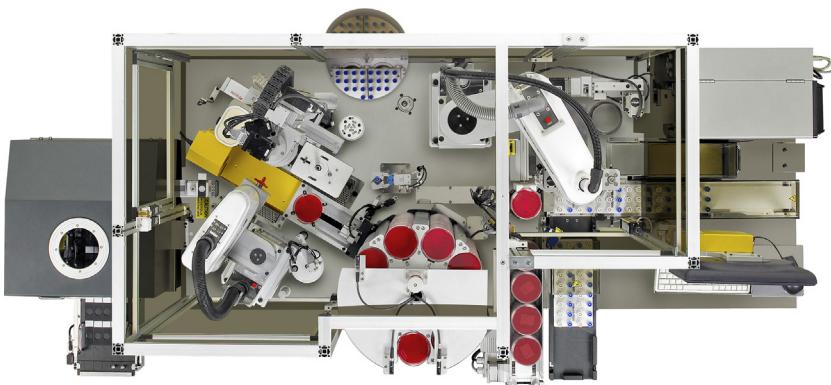
Early on as described above, Copan Diagnostics recognised the value of liquid microbiology and flocked swabs from both a pathogen recovery perspective and from the ability to automate swab specimens using plating instrumentation. Complementary to the flocked swab, Copan Diagnostics has developed the WASP® (Walk Away Specimen Processor) for the automation of bacteriology plating (Figures 11 and 12; Bourbeau & Swartz, 2009). As described with the other systems, the WASP comes



FIGURE 11

Copan WASP® pre-analytical specimen processor. Front view.

Image courtesy of Copan Diagnostics.

**FIGURE 12**

Copan WASP® pre-analytical specimen processor. Top view.

Image courtesy of Copan Diagnostics.

equipped with HEPA filtration to mitigate exposure of staff to potential pathogens in the specimen. The footprint of the WASP is 43.5" (depth) × 81.5" (width) × 76" (height) and can accommodate tracking both to load specimens onto the system and to move the plates to a smart incubator which will be discussed below in more detail (WASPLab™). The agar plates are inoculated using custom loops (Table 1) that are available in sizes of 1, 10 and 30 µl. The universal de-capper/capper can accommodate various specimen containers while relying on the LIS to direct the plating protocol. The WASP tool belt can carry five loop devices, and each loop device is comprised of two individual loops, each of which can inoculate approximately 15,000 plates. Two loops allows for faster plating since one loop can be cooling post sterilisation, while the other loop is plating a specimen. A dual streaking tool is also available which comprises two double-loop heads. Therefore, both sides of a bi-plate can be streaked simultaneously. The throughput of the WASP varies depending on the specimen type and plating protocol that is being used. When streaking a bi-plate, for example, 180 plates/h can be inoculated. With the LIS-driven process, the WASP can select the appropriate protocol based on the specimen type. This will drive which loop is automatically selected for plating and which streak pattern is used. Similar to other plating systems, the specimen is vortex mixed, and a camera takes a picture of the loop prior to each inoculation ensuring ample specimen is present on the loop. This is a very important quality control feature of the WASP system.

An additional feature on the WASP is a module which prepares a slide for subsequent Gram staining. The Gram SlidePrep Module is a barcode-driven process as well, which prepares the smear using the liquid sample while automatically labelling the slide with the patient information via permanent inkjet printing, again facilitating traceability with the specimen. Adding to the functionality of the WASP is an additional area within the system called the warehouse carousel. The warehouse carousel (Figure 13) can hold supplies for Kirby–Bauer susceptibility testing in addition to

**FIGURE 13**

Copan WASP® warehouse carousel.

Image courtesy of Copan Diagnostics.

other disks such as bacitracin or optochin since some laboratories might apply these disks directly to the primary plate to aid in initial organism identification. Lastly, within the warehouse carousel, there is a Broth Inoculation Module which automatically applies a barcode to sterile tubes and can prepare up to four different broth tubes per specimen. The WASP has what is termed the Sort Out Stacker module that automatically sorts inoculated plates into four different categories depending on the incubation protocol of the culture plates. This facilitates placement of the inoculated media into the appropriate incubator without adding steps in sorting the plates. There are limited studies comparing automated plating instruments to manual processes. One study found the WASP to be comparable to manual methods in the clinical laboratory setting ([Bourbeau & Swartz, 2009](#)).

Since liquid microbiology is a prerequisite for many plating instruments, Copan Diagnostics has also developed other products to facilitate the plating of specimens such as sputa. Since these specimens are not in a completely fluid form and often not homogenous in nature (for optimal plating), they are incompatible with most plating systems on the market today. Copan Diagnostics has developed the Snot Buster™ which is a sputum-liquefying agent. The Snot Buster consists of dithiothreitol

(DTT) premeasured in instrument (WASP) ready tubes. The laboratorian uses a small plastic disposable sampling tool (Sputum Dipper) to collect approximately 0.5 g or 0.5 ml of sputum which facilitates manual specimen placement into the Snot Buster™. The shaft of the dipper is broken off and the cap placed on the tube (capturing the swab in the cap head). The sputum to DTT is at a 1:1 ratio which is optimal for liquefying the sample. The tube can be labelled and after mixing and standing for 15 min the sample is ready to be placed on the WASP instrument for plating. The liquid sample is inoculated to the designated media as is described above for other liquid samples.

Because mass spectrometry is rapidly being integrated into most laboratories, Copan has recognised the need for accurate inoculum application on the mass spectrometry slide. This can be a tedious task, and in addition, the technologist has to remember which MALDI spot the specific patient organism needs to be applied to, based on the corresponding mass spec slide map set up for patient tracking. Copan has developed a standalone instrument called the C-Tracer™ that can assist the technologist in identifying the precise colony and the location on the mass spec plate where the colony needs to be placed (Figure 14). This is a stand alone piece of equipment separate from the WASP.

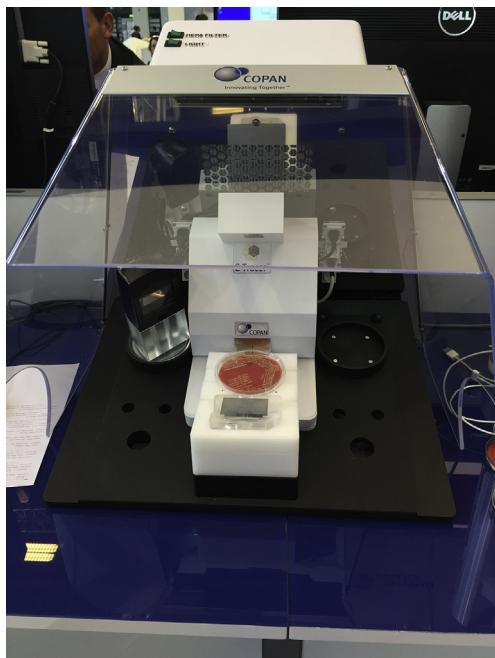


FIGURE 14

Copan Diagnostics MALDI C-Tracer™.

Image courtesy of Copan Diagnostics.

4.6 PreLUDE: i2a

i2a (Montpellier, France) is a French company with its own unique solution for pre-analytical automation for the microbiology laboratory. The pre-analytical specimen processor is called the PreLUD™ (Pre-Analytical Laboratory Universal Device) **Figure 15**. The PreLUD™ has a capacity of 480 plates with 60 plates in eight individual stacks. The throughput depends on the plating protocol, but the instrument can process up to 120 plates/hour. The PreLUD™ has a footprint of 90" × 40" × 75" and can be placed up against the wall unlike other instruments that need access from behind. When loading the instrument, the plates are loaded upside down to avoid condensation if they are just removed from the refrigerator (other systems the Petri dishes are loaded top-side up). Plates are front loaded into the instrument into the stacking unit. The instrument has the ability to track the specimen automatically with an integrated reader or by a barcode scanner, while the instrument is being loaded. Lot numbers of the media can be tracked based on expiration date of the media. What is unique about the PreLUD™ is that the instrument will process for inoculation a wide variety of tubes, even a swab in a gel or semi-solid medium. This is different than the other processors that need the sample in the form of a liquid. The PreLUD™ therefore has the ability to use the primary swab for direct streaking, without needing a pipette or loop to perform the initial plate inoculation. The instrument contains a vortex for liquid specimen mixing and a camera to take pictures of the inoculum preparation before and after the plating occurs. The system will alert the user if the specimen was not inoculated onto the media. The instrument can handle tubes with or without caps and also has the ability to recognise the sample



FIGURE 15

i2a PreLUD™, pre-analytical specimen processor.

Image courtesy of i2a.

rack which is barcoded. Information on a rack barcode can be read which will direct the plating protocol.

Another unique feature of the PreLUD™ is that there are three different methods for streaking or inoculating plates; (1) via an inoculating loop, (2) with a pipette and the Trigalski bead and (3) with a primary swab. The Trigalski bead is used to streak the plate after the pipette has released the inoculum. The process is similar to the rolling bead used by the Inoqua+ except the Trigalski bead is maintained by the robot arm. The loop and the bead are sterilised between each plate. Streaking methods are customisable and can be spiral or quadrant. After inoculation, the plates are stacked and stored upside down. To enhance traceability, the plates are labelled with the barcode imprinted directly on the side (or anywhere else) of the Petri dish, which eliminates the expense of labels. Since there are no paper labels being used, this eliminates label jamming that does occur with other systems that utilise paper labels. All printing on the plate can be customisable by the end user which adds to the flexibility of this feature.

Integrated into the instrument is a module that automates the preparation of the Kirby–Bauer disk susceptibility test. The proprietary middleware SIRweb™ linked with the LIS can determine the susceptibility testing set up for a customisable panel of antibiotic disks; each disk is dispensed by the instrument onto the agar plate ([Figure 16](#)). The plate can then be placed in the AST incubator/reader SIRscan™ and then automatically read after the appropriate incubation protocol. The instrument comes equipped with HEPA filtration similar to other pre-analytical plating instruments to mitigate any exposure to the staff working with the equipment.

4.7 deltalab AUTOPLAK

The deltalab AUTOPLAK (NTE Healthcare, Barcelona, Spain) ([Figure 17](#)) is a newer instrument to the market that is similar to other pre-analytical plating instruments described above. The instrument has a footprint of 72" (width) × 33" (depth) × 78" (height) and can be interfaced with the LIS. The instrument can process liquid samples and accommodates a wide range of tube sizes. Similar to the other instrumentation described, there is a mechanism to remove and re-cap tubes. Two independent drawers allow continuous loading of samples, and each rack can accommodate 10 specimen tubes. The loading capacity is 120 samples. Inoculation is performed with re-usable loops, and no extra consumables are required. Streak patterns are customisable by the end user, and both solid and liquid media can be inoculated. The instrument can streak 90 mm plates and up to 240 plates can be loaded with the ability to extend to 480 plates. This translates into six media silos, extendable to 12. The plates can be sorted by incubation atmosphere, and on average, 140 plates can be streaked per hour. Inoculated media are labelled by the instrument for traceability, and the user interaction is performed via a touch screen and pop-up keyboard. There is a HEPA filter within the instrument and a station to prepare a smear for a Gram stain that is labelled with the patient information directly on the slide. As this

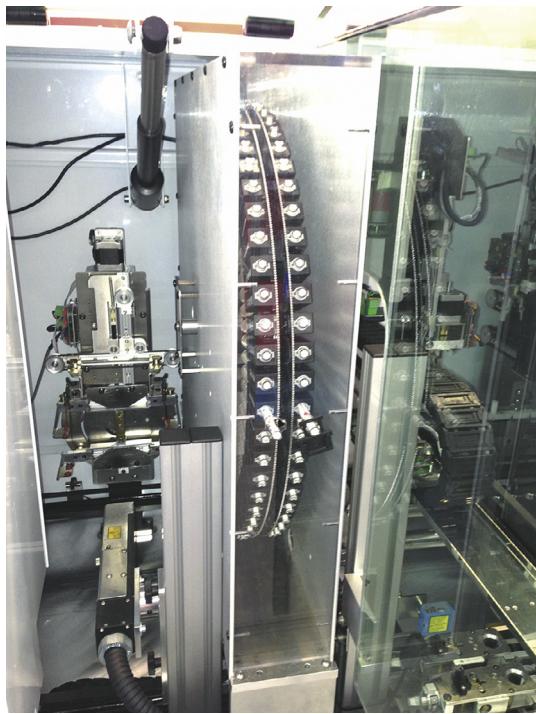


FIGURE 16

i2a PreLUD Kirby–Bauer susceptibility test preparation module.

Image courtesy of i2a.

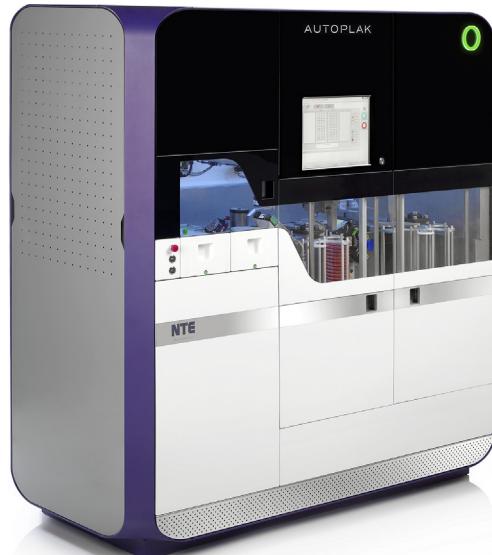


FIGURE 17

AUTOPLAK pre-analytical plating processor, deltalab.

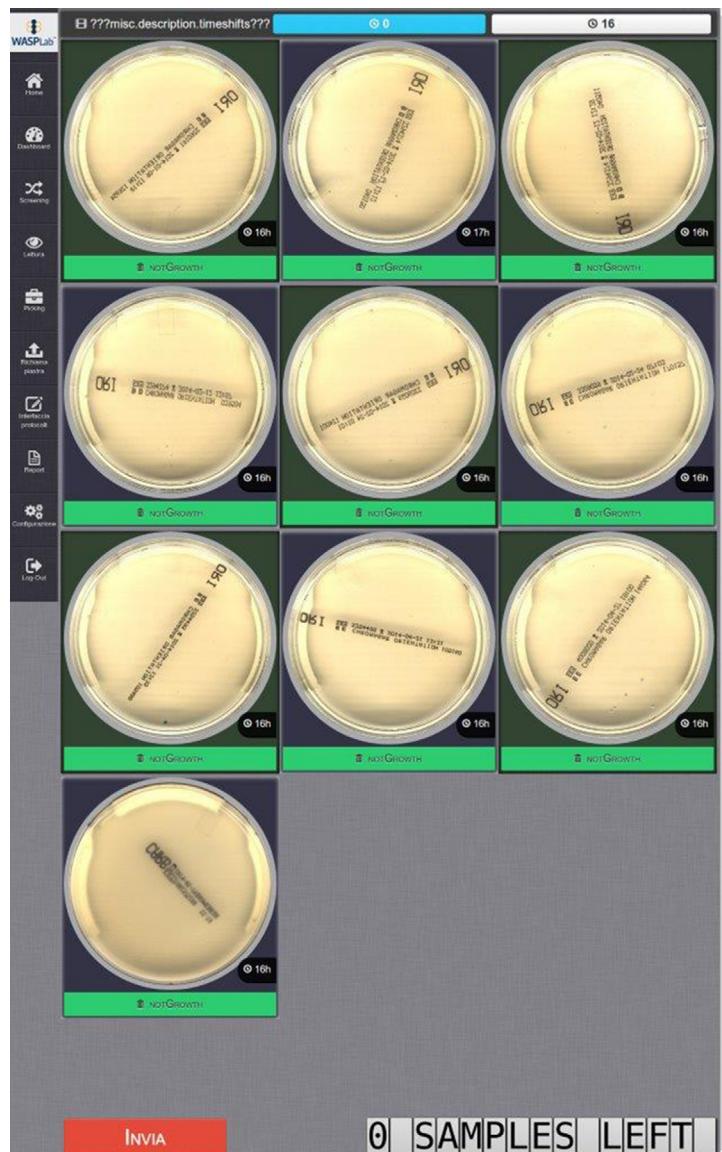
Image courtesy of deltalab.

instrument is introduced into the clinical laboratory market, more information on performance and functional characteristics will be forthcoming.

5 DIGITAL PLATE READING

The manual reading and workup of bacterial cultures is a process that all clinical microbiologists are familiar with. To date, there is little in the literature regarding DPR as it relates to microbiology (Rhoads, Novak, & Pantanowitz, 2015). With the advent of the “smart incubator” as part of the TLA suite of instruments, DPR can now become a reality. The smart incubator (a term used generically to describe an incubator with a camera) consists of an incubator, and a sophisticated digital camera juxtaposed to the instrument that can take an image of the growth on an agar Petri dish over the course of a defined incubation period for a specimen or specimen type. Several manufacturers are incorporating this technology into their TLA systems. The digital camera works collectively with the middleware or software solution, depending on the vendor, so that images can be presented to the technologist for reading (Figures 18–20). Figures 18–20 are an example of COPAN screen displays showing how plates are visualised using the Synapse Pro (Copan Diagnostics middleware software). As mentioned previously, bioMerieux and Copan will be partnering collectively to enhance the middleware system for the Copan WASPLab. Gone are the days where the technologist handles the plates directly, digital microbiology allows for culture workup by observing the plates and the associated bacterial growth on the computer screen. Digital cameras are part of the newer incubator systems, and user-defined protocols can be set as to when the individual plates should be observed and at what intervals. DPR allows the plates to be kept under the appropriate incubation conditions compared to the process currently where technologists take out stacks of plates to be read and left on the bench top. This decreases the growth time associated with the culture because plates are held under the appropriate conditions at all times.

Incubators that are available in combination with TLA consist of a compartment for each individual plate, a robotic mechanism to move the plates in and out of the incubator or to the camera for image analysis and a camera. The sophistication of the camera is increasing with a range of 9–27 megapixels present today in the variety of systems on the market. Various images are presented to the laboratory technologist using different lighting conditions. Backlighting can be used to enhance haemolysis or tangential lighting to enhance colony texture. Composite images are used within DPR to render the best image possible for presentation to the technologist. Composite images consist of several images within one image. The time required to photograph an individual plate is seconds, but protocols will need to be developed so that imaging of all plates within an incubator can occur within a defined period of time. Depending on the types of cultures, images can be taken (and stored) more frequently (e.g. sterile site cultures), or less frequently (Chromagar that requires a defined incubation time prior to reading). These individual configurations for plate reading can be incorporated into the software. These user-defined capabilities allow

**FIGURE 18**

COPAN WASPLab middleware screen shot shows an example of digital plate image. This screen shot elucidates how negative or no growth plates can be grouped together on the computer screen. Technologists can screen multiple no growth plates at one time for release to the LIS.

Image courtesy of bioMerieux.

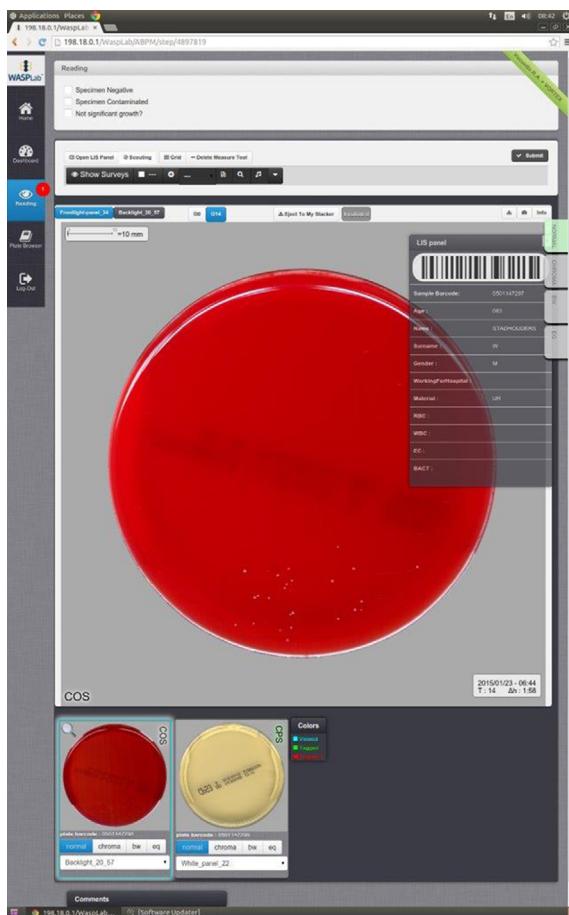
**FIGURE 19**

Screen shot of the technologist view when working up culture plates within the Copan Middleware solution for Digital Plate Reading.

Image courtesy of bioMerieux.

the individual laboratory to keep the protocols that they are comfortable with in terms of cultures analysis. Protocols can vary by source depending on the needs of a laboratory, and digital images that are captured can be stored within the system for viewing at a later time by the technologist.

Middleware systems today can assess the biomass of growth on a plate, as in the case of a urine culture, and convert the biomass to a colony-forming unit. In the case of a urine specimen, cultures with similar growth quantities can be grouped together within the middleware system for more expeditious review and release to the hospital information system (HIS) by the technologist (Figure 18). This will save needed time on cultures that are negative or that contain insignificant growth so that more time can be spent on critical tasks in the laboratory. Software systems also allow the grouping of multiple cultures from one patient visually on one computer screen, allowing a more comprehensive assessment of all specimens from one individual patient.

**FIGURE 20**

COPAN WASPLab middleware screen shot shows an example of digital plate image.

Image courtesy of Copan Diagnostics.

As mentioned previously, DPR and archiving routine cultures can allow laboratories to manage quality assurance issues that arise. There are instances where an organism is missed on culture workup or misidentified, and in these cases, the laboratory can go back to the archived picture of the plate to determine where the problem may have arisen. From a competency or educational perspective, pictures of unique or rare organisms could be saved to the server for access at a future time. Sharing unique results and organisms isolated in the clinical laboratory is a powerful way to train and keep technologists competent at the bench level. Libraries of unique and rare or hard to identify organisms can be used for plate rounds and case studies. There are advantages and perhaps challenges associated with DPR ([Novak & Marlowe, 2013](#)) since the technology is very new to the bacteriology space. Studies

are lacking due to the infancy of DPR within microbiology, and there are no professional guidelines for implementation or quality management to date.

6 TLA SYSTEMS

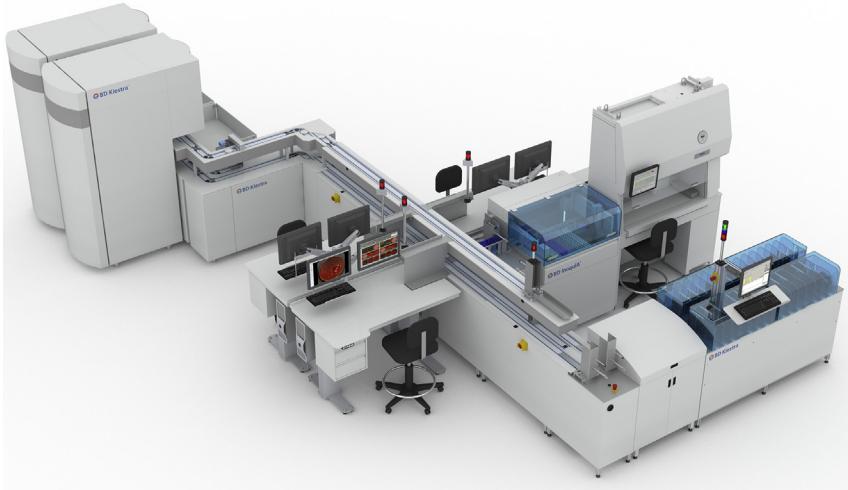
There are many drivers towards automation in the clinical microbiology laboratory as there are in other clinical laboratory testing areas. Automation can result in increased efficiency and personnel cost savings, can reduce repetitive motion injuries and even mitigate pathogen exposure in the workplace in the case of the smart incubators described above. Automation allows for positive patient identification since the barcode on the initial patient specimen is read prior to plating, and then all of the subsequent plates that are inoculated are tied to the original patient barcode. Quality and reproducibility can be enhanced by the automation as well. Many of the above pre-analytical systems mentioned above are meant to be part of a suite of instrumentation called TLA for microbiology. To refresh, these systems can include a number of modular components, but the full suite would consist of a plating system, a track leading from the plating instrument to the “smart incubator” which contains the digital camera for the imaging of all culture and Kirby–Bauer susceptibility plates. Some systems come complete with track systems emanating from the smart incubators and are connected to ergonomic workstations where the technologist will reside to analyse the cultures. The incubators can either be configured as an O₂ or CO₂ incubator no different than today. When a specimen is inoculated, the system delivers the plate directly to a defined spot within the incubator via a track system. When a plate is called up by a technologist, retrieval of the plate can usually occur within less than a minute. This is accomplished via sophisticated software that tracks the location of the plated media and a robotic arm that will manipulate the plates inside the incubator cabinet.

Depending on the size of a laboratory, the complete needs for a full TLA system will vary. Some laboratories might need more than one complete system due to the high volume nature of their laboratory. The reader is encouraged to reach out to the manufacturer of all the systems described in this chapter since the instruments and functionality are changing at a very fast rate. Middleware systems are constantly being adapted to provide more information and functionality to enhance what TLA can offer the clinical microbiology laboratory.

Given the flexibility of digital microbiology, technologists would in theory not have to be physically present within the lab to work up specimens. Future technologists might be working up cultures from a reading room, away from the busy, active laboratory, so they could concentrate on reading the cultures. As TLA is adopted in the microbiology laboratory, we will see the unique ways the systems can be used to enhance the care that we provide the patient.

6.1 BD KIESTRA

The BD Kiestra TLA offers total microbiology lab automation that maximises throughput and staff efficiency to reduce TAT and improve workflow in the microbiology laboratory ([Figure 21](#)). Modular and flexible with integrated workbenches,

**FIGURE 21**

BD/Kiestra Total Laboratory Automation. Consists of Inocula plating system, track system, BSC and incubator with digital camera.

Image courtesy of BD.

the TLA can be configured to meet the unique space and capacity requirements in each laboratory. This system includes automated specimen processing, plate transportation, incubation and digital imaging systems as well as integrated work benches designed to improve workflow and the efficiency of the laboratory technologist. The modules that make up the Kiestra TLA consist of the module for the loading and sorting of the plates (SorterA), barcoding (BarcodeA), and as discussed above the InoquaL+ for automated plating of liquid specimens.

The BD Kiestra incubation and digital imaging system is the ReadA Compact ([Figures 22 and 23](#)). This second generation system has a capacity of 1150 plates and requires a floor space of about four square feet. The unit can operate in either O₂ or CO₂ conditions and is designed to optimise the growth conditions with a stable and measured temperature and humidity control. The track-based solutions of the BD Kiestra WCA work cell automation (WCA) and TLA Systems allow for plates to move in and out of the ReadA Compact incubator based on request or protocol. Each ReadA Compact includes four output stackers. In the WCA configuration, these stackers are used to facilitate follow-up work, waste handling and request for visual inspection of plates. The TLA configuration will present plates to the user at the work bench (ErgonomicA) needed for follow-up inspection or work. The ReadA Compact automatically takes plates into the incubation section and places them in designated racks. Each plate will have a unique location enabling direct access, ensuring fast retrieval and short delivery times. When a plate is requested by a user or finished its protocol and is assigned to go to the waste, the system will move that plate to

**FIGURE 22**

BD Kiestra ReadA Compact Incubator.

Image courtesy of BD.

**FIGURE 23**

BD Kiestra ReadA Compact Incubator—inside close up view.

Image courtesy of BD.

the output lane. The ReadA Compact has the unique capability of parallel processing plates that come into the incubator, plates that go out of the incubator and plates that need to be imaged, due to the three different plate tracks/lanes designed for this purpose. The incubator uses a laboratory-defined protocol to image plates at set intervals allowing for the monitoring of growth. The HD industrial camera creates a realistic image of the plates using different light sources to create multiple image scenarios. The system is capable of imaging 300 plates per hour (approximately 4 h to image a full incubator). Once all plates of a sample have been imaged, the sample will be flagged as ready for reading and updated on the BD Kiestra dashboard and in the ReadA Browser work list.

The ReadA Browser software enables plate reading and follow-up work selection. The software will indicate plates that are ready for reading. The user will access these files and imaged plates. Users can see and compare growth over time and have a complete patient overview over multiple samples. Per plate the software can show various scenarios and light conditions. When growth is detected and follow-up work is required, the user will mark a colony and select a specific follow-up task. This sets up a follow-up action in the system which is again visible on the dashboard.

One study showed that for pathogen detection, the Kiestra TLA combined with mass spectrometry resulted in approximately 30 h time gained per isolate compared to conventional methods used in this laboratory ([Mutters et al., 2014](#)). Most TLA systems are equipped with a “dashboard” (which is a large display screen) that can be positioned in the laboratory which shows the cultures that are ready to be analysed by the technologist. This dashboard allows timely workup of cultures and movement away from reading cultures in a batch mode. This is a paradigm shift from how bacteriology laboratories are operated today where batches of specimens are usually read which consists of a number of cultures. Some of those cultures might not be ready for analysis and culture workup due to the level or amount of growth being insufficient. The images taken by the camera and corresponding middleware display the cultures that are ready for analysis on the dashboard in the laboratory.

6.2 COPAN WASPLab™

The TLA solution for Copan Diagnostics is the WASPLab ([Figures 24 and 25](#)). Inoculated media are transferred from the WASP to the WASPLab smart incubator via a track or conveyor system so that the inoculated plate can be incubated and imaged with the digital camera. The WASPLab Image Acquisition technology uses sophisticated lighting associated with a camera. The camera has a sensor that acquires the image as the plate sweeps laterally beneath the camera. The WASPLab camera produces a 27 megapixel image. The camera and WASPLab software can detect and differentiate colonies as small as 0.1 m in diameter. The WASPLab Image Acquisition technology uses a variety of different types of lighting which varies depending on the media colour or opacity. Top light with background can be used for transparent agar simulating viewing the plate at the bench. Top light without background can be used for opaque agar simulating viewing the plate at the bench. Bottom light can

**FIGURE 24**

WASPLab™. Consists of WASP® plating system, track and incubator with digital camera.

Image courtesy of Copan Diagnostics.

**FIGURE 25**

WASPLab™ smart incubator, inside close up view.

Image courtesy of Copan Diagnostics.

be used without background to see haemolysis. The WASPLab features telecentric camera optics and software which aids in visualising three-dimensional objects. A telecentric lens uses constant magnification so that the image on the screen is not distorted to the user. The depth of field on the camera is 9 mm which ensures that all colonies (regardless of height, shape, colour or texture) are captured for visualisation. As with most digital imagers and associated software, an image of the plate will be taken at “time 0”, so all subsequent images can be compared back to the original plate. WASPLab unique discriminative image analysis software uses the plate image taken at time 0 and compares it to the images taken after incubation. WASPLab software is able to discriminate artifacts present on the plate at time 0, focus on the growth and even recognise small colonies. The software then groups the plates according to the estimated number of colonies. The system then sorts the plates from the most estimated colonies to the least estimated colonies and presents it to the technologist for interpretation and analysis. The technologist can then decide which plates represent significant growth and choose to work those up first. This new technology helps speed up the workup of positive cultures, by presenting them to the technologist first, leaving no growth cultures for last. In the case of no growth cultures, the technologist, after reviewing the plates, can batch result them in groups.

The WASPLab solution is flexible in that large specimen managers can be used for higher-volume laboratories that process thousands of specimens per day and can be used to feed samples into the WASP system. These specimen manager type systems are manufactured by other automation companies such as Inpeco (Lugano, Switzerland) and are being configured to work with WASPLab systems being placed today. As shown [Figure 18](#), the technologist will analyse and work up the culture by visualising the images on the computer screen. If the technologist needs to identify a colony on the plate, the plate can be called up and sent to the colony picking station (in development) which will inoculate the mass spectrometry template and prepare a McFarland standard for susceptibility testing. If plates need to be manually visualised or handled by the technologist, the plates can be called from the incubator into silos along the track system for manual retrieval.

6.3 i2a: ECITALS™

i2a offers a TLA solution for the clinical laboratory illustrated in [Figure 26](#). The suite of instrument is called RECITALS™ and contains a number of modular instruments that are part of the fully automated solution. RECITALS is defined as number of analysers that can be used as standalone pieces of equipment or with a conveyor track system depending on the needs and size of the laboratory. As mentioned above, the PreLUD™ system is the pre-analytical analyser including automatic culture plates streaking, as well as automatic preparation of AST (Mueller Hinton agar plate streaking and antibiotic disks dispensing). The MAESTRO™ is the smart incubator-reader module (with a throughput of up to 240 plates/h) where the digital plating reading station is housed and all plate reading occurs. MAESTRO™ includes incubation of culture plates and Mueller Hinton plates for AST under different conditions

**FIGURE 26**

i2a Recitals, Total Laboratory Automation.

Image courtesy of i2a.

(atmosphere, temperature and hygrometry), automatic reading of plates, results interpretation that are customisable (with interpretation rules set by the user) and sorting. MAESTRO includes integrated software, a microbiology safety cabinet and a remote validation workstation. The SIRSCAN™ is a unique solution for automatic incubation/reading of AST (disk diffusion on round or square plates that holds up to 16 antibiotic disks each) that allows for rapid results for many microorganisms (5–7 h when used with i2a's Rapid Mueller Hinton media). The middleware is called SIRWEB™ which is a proprietary middleware that enables the complete management and centralisation in one single database of all bacteriology results. This is an open system which can be bi-directionally interfaced with other analysers as well as having full compatibility with various LIS and HIS. The system has an expert system for customised results according to CLSI guidelines. There is a data management component as well which contains features for generating epidemiology reports, detecting and following multi-resistant bacteria and managing hospital-associated infections. This system is relatively new to the market with no placements in the United States to date but the manufacturer is partnering with one of the mass spectrometry vendors to integrate that technology into the TLA solution as well.

7 CHANGE MANAGEMENT: A HOLISTIC APPROACH TO AUTOMATION IN BACTERIOLOGY

The landscape within the microbiology laboratory is changing due to automation. Automation will standardise processes, improve quality and TAT and reduce workplace injury due to repetitive motion associated with tasks that are currently performed manually. The anticipated gain from a clinical perspective is that inoculated media can be imaged based on custom protocols, and software programs can alert the end user to when the cultures are ready to be analysed. This will reduce TAT to result for many cultures. As most of the microbiology laboratory are aware,

automating culture workup is new and will require adoption from the staff. This change management is important to recognises and includes not only training staff members but also includes a robust vendor/laboratory partnership that can help the laboratory make the most of the new automation. Technologists in the clinical laboratory have been used to working up cultures using conventional methods for years and need to be given the support to understand and adopt the newer automation at a pace that is comfortable for them. Technicians in reality might be able to process specimens in a more timely fashion than the pre-analytical automation can, but it is important to recognise that automating the plating function will allow those staff members to be freed up to perform other important laboratory tasks, with subsequent efficiency gain in the laboratory overall.

As mentioned at the beginning of this chapter, automation is here but a one size fits all solution does not exist for all laboratories. There will be a significant investment in workflow analysis with the vendor to understand each laboratories individual needs, given the diversity of available automation. Each facility will have to investigate space constraints, and monetary investment may be necessary for remodelling, in addition to the dollars needed for capital equipment expenditure. In today's competitive market, a business case is often necessary to engage upper administration about new technology and the placement of that new technology in the laboratory setting. The reader can refer to other published articles that illustrate how to formulate a robust business case for TLA (Novak & Marlowe, 2013).

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