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PCR vs. Culture: Rethinking traditional microbiological methods.

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Introduction

Clinical microbiology has long relied on culture-based techniques to identify pathogens and guide treatment decisions. These methods, while foundational, are increasingly being challenged by molecular diagnostics—particularly polymerase chain reaction (PCR)—which offer speed, sensitivity, and specificity that traditional culture often cannot match. As infectious disease management evolves in the age of precision medicine, it is time to rethink the role of culture and PCR in modern microbiological practice. Culture remains the cornerstone of microbiological diagnostics. It involves growing microorganisms on selective media under controlled conditions, allowing for identification, antimicrobial susceptibility testing (AST), and epidemiological typing. Cultures are essential for detecting viable organisms and remain indispensable for certain pathogens, such as *Mycobacterium tuberculosis* and *Neisseria gonorrhoeae*. Bacterial cultures typically require 24–72 hours, while fungal and mycobacterial cultures may take weeks [1].

Nonviable organisms or those suppressed by prior antibiotic use may not grow. Requires skilled personnel and laboratory infrastructure. Fastidious or slow-growing organisms may be missed. Despite these drawbacks, cultures provide critical information, especially for antimicrobial resistance profiling and outbreak investigations. Polymerase chain reaction (PCR) amplifies specific DNA or RNA sequences, enabling rapid detection of pathogens directly from clinical specimens. Since its development in the 1980s, PCR has transformed diagnostics across virology, bacteriology, and parasitology [2].

Results can be obtained within hours. Detects low levels of pathogen DNA, even in partially treated infections. Useful for bacteria, viruses, fungi, and parasites. Simultaneous detection of multiple pathogens in a single assay. PCR is particularly valuable in diagnosing infections where culture is slow or unreliable, such as viral respiratory infections, sexually transmitted diseases, and central nervous system infections. Blood culture is the traditional method for diagnosing sepsis, but it may take days and often yields negative results due to prior antibiotic use. PCR-based assays like the BioFire FilmArray Blood Culture Identification Panel detect over 20 pathogens and resistance genes in under an hour, enabling timely and targeted therapy [3].

Culture of *M. tuberculosis* is slow, taking up to 8 weeks. The GeneXpert MTB/RIF PCR assay detects the pathogen and rifampicin resistance in less than two hours, revolutionizing TB diagnosis in high-burden settings. Culture for *Chlamydia trachomatis* and *Neisseria gonorrhoeae* is technically demanding and less sensitive. PCR offers superior detection and is now the preferred method in most clinical laboratories. During the COVID-19 pandemic, PCR became the gold standard for SARS-CoV-2 detection, highlighting its role in outbreak response and public health surveillance [4].

PCR assays and equipment are expensive, limiting access in low-resource settings. Detection of nonviable organisms or contamination can lead to overdiagnosis. PCR cannot distinguish between live and dead organisms. While some resistance genes can be detected, comprehensive AST still requires culture. Therefore, PCR should complement—not replace—culture in clinical microbiology. Modern laboratories increasingly

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adopt a hybrid approach, using PCR for rapid screening and culture for confirmation and susceptibility testing. This integration enhances diagnostic accuracy and supports antimicrobial stewardship. For example, in urinary tract infections, PCR can quickly identify uropathogens and resistance markers, while culture confirms viability and guides therapy. In meningitis, PCR detects pathogens in CSF within hours, while culture provides additional data for treatment and epidemiology [5].

Conclusion

PCR and culture are not competing technologies but complementary tools in the microbiologist's arsenal. While culture remains essential for resistance profiling and viability assessment, PCR offers unmatched speed and sensitivity. Rethinking traditional methods means embracing molecular diagnostics while preserving the strengths of culture. Together, they form a robust framework for accurate, timely, and personalized infectious disease management.

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