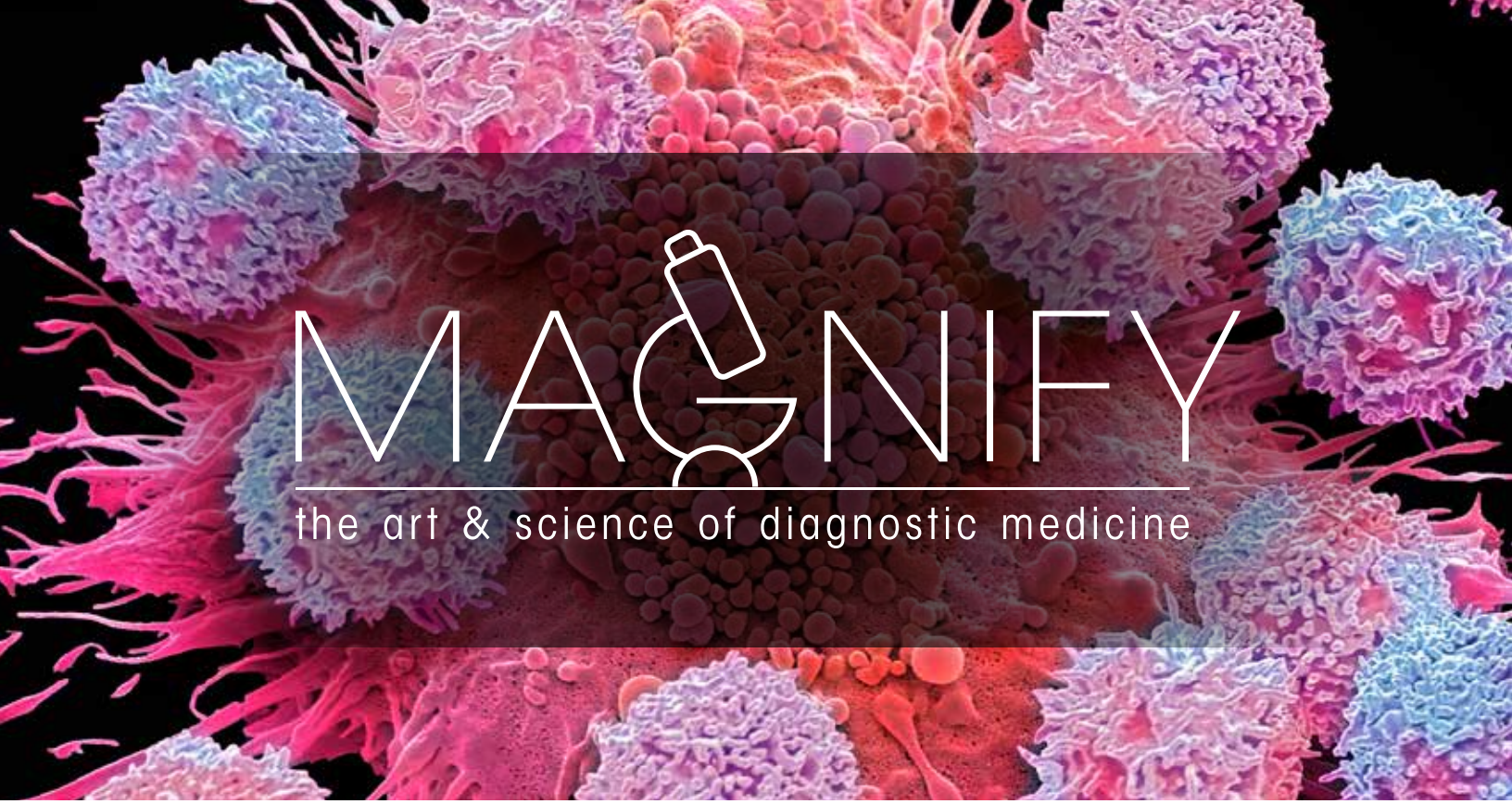

Fall 2022

Emerging Public Health Threats and the Laboratory

The past three years have laid a foundation for the new role laboratory medicine plays in preparing our communities, responding to new threats, and treating patients long after a public health crisis is over. We explore how this role is changing in this latest issue of Magnify: The Art and Science of Diagnostic Medicine.

ARUP® LABORATORIES

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MAGNIFY

the art & science of diagnostic medicine

In Magnify, we share stories that bring laboratory medicine to life.

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A Message From the CEO

Once the worst of a crisis has passed, we're inclined to reflect on what we learned and how we grew as a result of the challenges we faced.

Nearly three years in, we're slowly reaching the "reflection" stage of the COVID-19 pandemic, and I'm pleased to confirm that ARUP Laboratories has already applied much of what we learned during the pandemic to improve our operations and services and, ultimately, patient care.

In this edition of Magnify, you meet Marc Couturier, PhD, whom we named medical director of Emerging Public Health Crises as one outcome of our updated pandemic response plan. Dr. Couturier's experience and expertise enabled ARUP to respond quickly to provide our clients with high-capacity testing for orthopoxviruses, including monkeypox, within weeks of the virus's first appearance in the United States.

We also share stories about groundbreaking research at ARUP and the University of Utah that has advanced and will continue to advance our understanding of SARS-CoV-2. Notably, these discoveries hold promise for myriad other applications, as well.

In laboratory medicine, we learn from each other, and then we grow as a discipline. We appreciate this opportunity to share the results of our pandemic reflections at ARUP.

Andy Theurer, CEO

New Medical Director of Emerging Infectious Diseases Faces First Test, Succeeds in Monkeypox Outbreak Response

Marc Couturier, PhD, an infectious diseases expert with experience with almost a dozen outbreaks during his career, was appointed as the medical director of Emerging Public Health Crises in January 2022.

Marc Couturier, PhD, has always understood the potentially devastating consequences of an infection, whether it's an isolated case or a pandemic that affects millions.

In college, Couturier watched two of his friends experience protracted battles with chronic infections of *Helicobacter pylori,* bacteria that infects the stomach.

"I saw how much they struggled with their diagnosis and treatment, and I remember thinking that two 20-year-old, healthy young men shouldn't be that miserable. There's got to be something we can do—something we can understand better or get better at diagnosing and treating," Couturier said.

One of Couturier's friends made a full recovery; the other developed multiple complications that led to an even more prolonged course of treatment.

That college experience sparked Couturier's lifelong dedication to better understanding infections and improving diagnostic methods and fed his keen interest in helping communities respond to outbreaks.

Article by Kellie Carrigan

When leaders at ARUP Laboratories realized they needed an individual who would be responsible for responding to emerging infectious diseases, Couturier was a natural choice for the role.

"I made the decision to create a medical directorship for emerging public health crises so that going forward, we would have somebody who would track the progress of these infections and could direct Research and Development on which assays to develop, knowing that not everything becomes a public health epidemic," said Tracy George, MD, ARUP president and chief scientific officer. The new role grew out of the experience ARUP gained in bringing a new test online quickly and scaling up capacity rapidly during the COVID-19 pandemic.

Couturier became medical director of Emerging Public Health Crises in January 2022. Five months later, he faced his first test when monkeypox cases in the United States began to rise. Couturier tracked the progress of the outbreak and coordinated with his contacts in public health to ensure that ARUP responded efficiently and appropriately to the emerging disease.

In this new position, Couturier was able to raise the alarm on the developing monkeypox crisis and bring ARUP teams together to respond quickly to the public health emergency. ARUP's success in providing a testing solution with the capacity to support the needs of communities across the U.S. demonstrated the effectiveness of Couturier's new role.

"Marc was perfect for this role, given his medical expertise in infectious diseases as well as his innate curiosity, his enthusiasm for issues concerning public health, and his skill at building relationships that are key to success when these outbreaks occur," said Jonathan Genzen, MD, PhD, ARUP chief medical officer.

Expertise and Experience in Multiple Outbreaks

After receiving his doctorate degree in medical microbiology and immunology with specialization in bacteriology from the University of Alberta in Canada, Couturier worked as a postdoctoral fellow at the Alberta Provincial Laboratory for Public Health.

"That was my first introduction to pandemic response and seeing a laboratory develop a test quickly," he said. "I was exposed to many other pandemic response processes, infrastructure, and systems that were in place in the Canadian public health system."

Couturier was working at the Alberta laboratory during the first early wave of the 2009 H1N1 pandemic, where he experienced an outbreak from the perspective of both laboratory expert and patient. While he was participating in conversations with public and government officials on how to proceed with social mitigation efforts, his wife was expecting their first child. They spent time in the hospital, where they saw firsthand the segregated, makeshift hallways where those who had flu-like symptoms could be kept separate from other patients and visitors.

Shortly after his experience in Alberta, Couturier relocated to Utah to continue his work in infectious diseases. He completed a fellowship in medical microbiology at the University of Utah School of Medicine, where he now serves as a professor in the Department of Pathology. He is also the medical director of Parasitology/Fecal Testing and Infectious Disease Antigen Testing at ARUP Laboratories.

> "Since I entered the field, I've been involved with 10 different epidemics or pandemics of some kind that have required an immediate or urgent response from the laboratory."
>
> —Marc Couturier, PhD, ARUP Medical Director of Emerging Public Health Crises

"My recommendations in handling monkeypox have been informed by my experiences at ARUP for the past 11 to 12 years, including our experiences with the Zika virus and COVID-19," Couturier said. "Since I entered the field, I've been involved with 10 different epidemics or pandemics of some kind that have required an immediate or urgent response from the laboratory."

Article by Kellie Carrigan

Launching a State-of-the-Art Assay for Monkeypox Infections

Dot Grimes, Technician II in Molecular Infectious Disease Support, loads samples into the Roche cobas 6800.

As a result of Couturier's attentiveness and the efforts of many others, ARUP launched its test, Orthopoxvirus (includes monkeypox virus) by PCR, on July 25, 2022, within just a few weeks of initiating development. ARUP was also one of the first labs to implement a test that was designed for more modern processes and automated testing platforms.

"ARUP developed a state-of-the-art, automated test that has great turnaround times, is scalable to meet capacity, and meets the needs of patients in the United States," George said.

Experts at ARUP chose to design their own, modified assay rather than use the current CDC assay, which was designed in 2005. The CDC's assay was validated for dry lesion swabs that require a manual, labor-intensive extraction method that slows down the entire testing process and takes much longer to yield results. ARUP's test was instead validated for use with swabs in viral transport media (VTM), which can be processed without requiring a manual extraction process.

"It would have been disruptive to attempt to incorporate the CDC's test as it was into our existing workflows," Couturier said. "While it was difficult to turn away an assay that was already packaged, we chose to develop a test based on the CDC's assay but optimized to fit in the systems we already had in place. Because of that decision, we were able to support higher volumes right out of the gate."

That higher capacity proved invaluable once specimens began to arrive at ARUP for testing. Although there was not the dramatic explosion in test demand that the world witnessed during the COVID-19 pandemic, the testing volumes for monkeypox rose quickly, expanding from just a handful of tests per day to hundreds.

After the launch of its first test, ARUP immediately began working to validate an even higher-throughput testing platform, the Roche cobas 6800, that further increased ARUP's testing capacity.

"We quickly realized that we needed to develop a second assay because of all the supply chain issues that ARUP dealt with during COVID-19," George said. "The transition from validation in Research and Development to production in the laboratory went smoothly because each person understood their role."

ARUP launched the second version of its orthopoxvirus assay within three weeks of initiating the validation, completing an extensive process that normally takes several months.

"We've done a much better job of identifying key stakeholders—everyone from medical directors to lab to Purchasing to Safety to Communications teams. Everyone is in this, and there are no silos. This allows separate processes to move forward concurrently, creating significant efficiency in how quickly we can complete the necessary tasks," Couturier said.

Implementing a Comprehensive Pandemic Response Plan

Appointing Couturier to his new role is just one aspect of ARUP's new comprehensive pandemic response plan.

"We didn't have anyone at ARUP who was specifically tasked with monitoring emerging infections. We needed to identify an expert in the field who could not only pay attention to emerging diseases, but who could advise ARUP's executive emergency response team about when to enact the pandemic response plan, and about the right level

of response and timing," said Margaret Coppin, HT(ASCP), ARUP quality officer.

After COVID-19, ARUP leaders moved to capture the lessons learned during the pandemic to ensure ARUP could respond quickly and effectively to new infections.

Coppin and her team of quality professionals evaluated the events that occurred during COVID-19 to formulate a comprehensive pandemic response plan that is based on the same quality standards that form the foundation of all testing at ARUP.

"We already had a very robust disaster response plan, but there were some nuances with bringing a test online quickly that we learned from COVID-19," Coppin said. "The pandemic response plan acts as a checklist to ensure that everyone understands who is ultimately responsible for completion of certain tasks and to prevent team members from working at cross-purposes."

The pandemic response plan also provides a pathway for ARUP experts to complete the necessary steps that ensure the test operates as expected and to the highest quality standards.

"The quality systems essentially form the framework of our pandemic response plan and illustrate our focus on quality. The plan incorporates the quality indicators, metrics, and quality assurance checks that we build into any other test to ensure that we can carry out a rapid response to meet patient needs while also ensuring that we are not compromising on quality," Coppin said.

Now that the pandemic response plan has proven effective and helpful, Coppin and her team will investigate ways they can implement elements of the new plan into the existing emergency response plan as part of their commitment to continually improve ARUP's preparedness for unexpected events.

Collaboration Between ARUP and Other Labs Improves Community Outcomes

In addition to the new pandemic response plan, increased collaboration between ARUP and other laboratories has improved overall accessibility to testing during the monkeypox outbreak.

ARUP has worked closely with the Utah Public Health Laboratory. Its current Clinical Laboratory Improvement Amendments (CLIA) laboratory director, Alessandro Rossi, PhD, D(ABMM), is a former ARUP fellow.

"The Utah Public Health Lab was absolutely integral to ARUP's effort to develop a monkeypox assay. They were able to share known positive and known negative samples that they had tested early in the outbreak that enabled us to validate our assay," Couturier said.

In return, when the Utah public lab needed samples to validate another specimen type for its assay, ARUP was able to provide those samples.

"Marc has previous training in public health, so he understands the mindset and culture to work with us as a state lab. Marc realizes the importance

Collaboration between Alessandro Rossi, PhD, Clinical Laboratory Improvement Amendments (CLIA) laboratory director of the Utah Public Health Laboratory, and Marc Couturier, PhD, medical director of Emerging Public Health Crises at ARUP Laboratories, has ensured that efficient, accurate testing is available to communities in response to the monkeypox outbreak.

Article by Kellie Carrigan

of working closely with public health to help the entire community," Rossi said.

Rossi was a fellow at ARUP from 2015 to 2017 and continues to collaborate with ARUP on several research studies, in addition to working with ARUP on the COVID-19 and monkeypox outbreaks.

"The government has been more proactive in involving private laboratories in responding to this new pandemic threat to quickly build capacity. The CDC has shared protocols for reference labs such as ARUP to bring on a test for monkeypox infections," Rossi said.

At the time the CDC released protocols for monkeypox testing, the state labs were operating only at an average of 10% capacity. However, while many labs were well under capacity, some state laboratories were beyond 100% capacity in particularly heavy-hit areas. To prevent the state laboratories from becoming completely overwhelmed, the CDC moved much more quickly to involve private laboratories, in contrast to the delayed response during the COVID-19 pandemic.

In addition to sharing specimens for validation, the Utah public lab also meets monthly with clinical partners in the state, including ARUP and Intermountain Healthcare, to discuss emerging infections and the best approaches to minimize their impact on Utah communities. This type of collaboration is something that may not have been common before COVID-19 and is one silver lining to emerge from the pandemic.

"Having a good relationship with a reference or private lab means it can absorb capacity when the state lab becomes overwhelmed. This has not yet happened for monkeypox, but the state relied on ARUP several times during COVID-19, and ARUP has always been there for us," Rossi said.

Enthusiasm for Community, Innovation Beyond Infectious Disease

Since his college friends' battles, Couturier has become an expert in *H. pylori* infections, pushing the boundaries to understand its pathogenesis and antibiotic resistance and methods to diagnose it, and has investigated its prevalence in communities in Utah.

> "Seeing all these groups and individuals work cohesively toward the betterment of public and community health during times of need is a fundamental example of what brought me into this field from the beginning."
>
> —Marc Couturier, PhD, ARUP Medical Director of Emerging Public Health Crises

Couturier has also advanced the use of artificial intelligence (AI) solutions at ARUP, leading the development of the world's first AI-augmented ova and parasite assay. The AI-augmented tool uses a convolutional neural network to identify ova and parasites in scanned images of stool samples.

"He's a firm believer in pursuing the leading edge of new technologies and applications that will improve our testing and decrease turnaround time. Not only is he extraordinary in his technical expertise, but he has a public mindset and is intent on contributing to the health and welfare of people," said Lisa Skodack-Jones, an ARUP clinical product manager in areas of infectious disease and immunology who has continued as a consultant for ARUP after her retirement in late 2021.

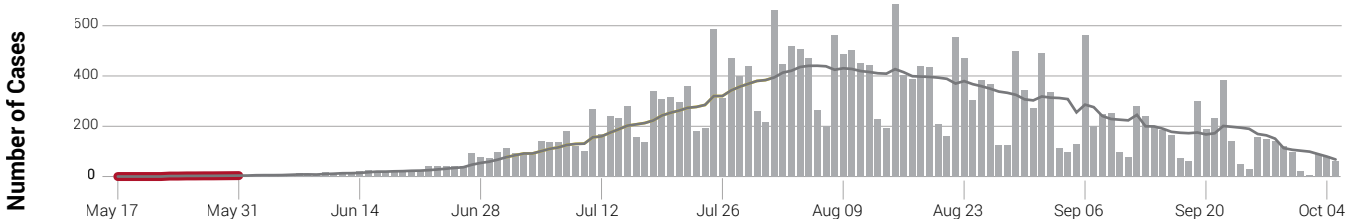
Couturier's community initiatives extend outside the realm of infectious diseases. He has also been heavily involved in helping build the hockey community in Salt Lake City, and he coaches the local teams of both his son and daughter.

"His heritage is French Canadian, so that's where the hockey comes from," Skodack-Jones added.

"This new position has been an absolute pleasure. It has allowed me to liaison with so many different groups within ARUP and others at the local and national levels," Couturier said. "Seeing all these groups and individuals work cohesively toward the betterment of public and community health during times of need is a fundamental example of what brought me into this field from the beginning."

The Evolution of Monkeypox

MAY



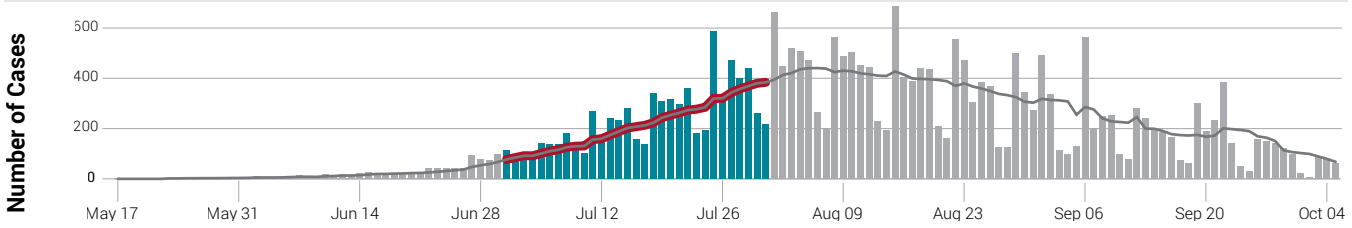
"Monkeypox was different from COVID-19 in that there was already an FDA-cleared test in existence. However, the assay was designed for older instruments. We chose an assay that would use a more automated process and allow us to use higher-throughput, modern instrumentation."

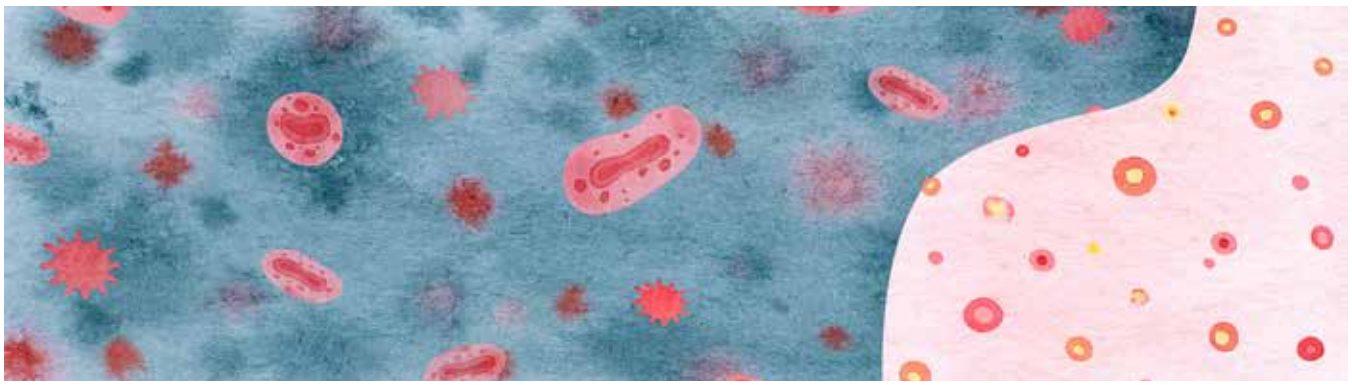
—Jonathan Genzen, MD, PhD, Chief Medical Officer

May 17, 2022: The first case of monkeypox is confirmed in the United States in Boston, Massachusetts.

May 30, 2022: The CDC releases a test procedure for labs interested in pursuing validation for a laboratory-developed test (LDT).

JULY





Article by Kellie Carrigan

Dot Grimes, a technician in Molecular Infectious Diseases Support, transports specimens to the Roche automated testing platform, where they will be evaluated for monkeypox infection.

July 18, 2022: ARUP approves the Orthopoxvirus by PCR (polymerase chain reaction) validation plan and begins validation in preparation to assist with testing needs during the monkeypox health crisis.

"We started a parallel development between R&D, the laboratory, Clinical Systems, Marketing, Sales, and other groups to go live with a test as fast as we could. We were setting up workflows, building the test in our laboratory information system, and building our IT resources all in parallel to the assay's development so that we could go live as soon as possible. That took many, many resources."

—Jeremy Klein, BS, MB(ASCP)^{CM},
Molecular Infectious Diseases Lab Supervisor

July 18, 2022: ARUP partners with Sonic to offer monkeypox testing while ARUP completes development of its LDT assay.

To validate the assay, ARUP's Research and Development (R&D) department conducts a series of experiments to ensure the assay is sound and operates as expected in terms of limit of detection, stability, specificity, and reproducibility.

July 20, 2022: ARUP receives a shipment of vaccines to begin vaccinating employees and a shipment of reagents to begin the validation run.

July 21, 2022: Kathryn Gibson, MD, FAAFP, medical director of Health and Wellness, who oversees the ARUP Family Health Clinic, educates ARUP employees on exposure risk, vaccines, preventive measures, and other safety procedures.

July 22, 2022: ARUP completes validation for its Orthopoxvirus (includes monkeypox virus) by PCR assay.

ARUP's Safety department completes its hazard assessment to ensure the appropriate safety measures are in place to protect ARUP employees.

"A typical validation on a molecular platform would normally take two to three months or perhaps more, depending on the complexity of the project. We validated ARUP's orthopoxvirus test for monkeypox infections within a period of about two weeks."

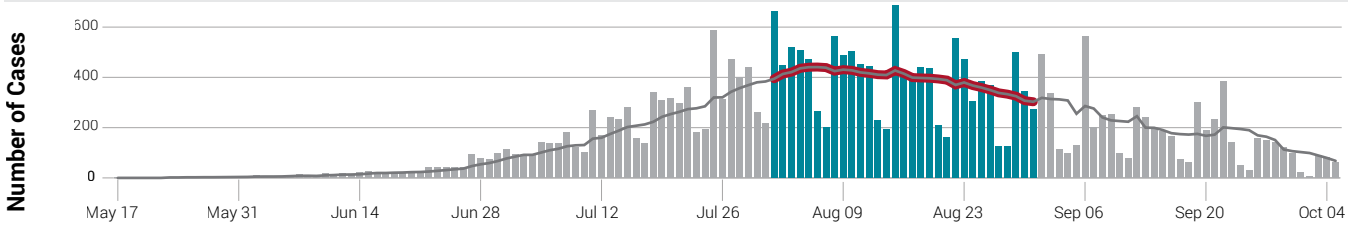
—Weston Hymas, Lead Scientist,
R&D Infectious Disease Group

July 23, 2022: ARUP approves its Orthopoxvirus (includes monkeypox virus) by PCR validation.

July 25, 2022: ARUP launches its state-of-the-art test for monkeypox infection. The test is designed for automated processes with the latest instrumentation and offers faster turnaround time and higher throughput.

ARUP begins vaccination clinics for employees at risk for monkeypox infection.

AUGUST



August 4, 2022: The White House declares monkeypox is a U.S. public health emergency.

"We knew early on that once the first test was online, we would need higher throughput to meet demand. We started right away on validating a more automated platform."

—Michael Pyne, R&D Scientist

Aaron Waiss, technical specialist in Infectious Disease Technical Operations, places specimens into the Roche cobas 6800 automated platform.

"What started with only a handful of samples rapidly increased to dozens and then hundreds per day."

—Jeremy Klein, BS, MB(ASCP)^{CM}, Molecular Infectious Diseases Lab Supervisor

August 5, 2022: ARUP approves the validation plan for its second orthopoxvirus assay on the Roche automated platform.

August 8, 2022: ARUP Orthopoxvirus (includes monkeypox virus) by PCR test receives New York State Department of Health approval for both dry swab and viral transport media (VTM).

August 17, 2022: The validation is approved for the second version of ARUP's orthopoxvirus assay, which is performed on the Roche cobas 6800 automated platform.

"We stick to the mantra that we've always had to bring online good tests. If there had been a problem, we would have stopped. We were fortunate that all the data looked good, and we were happy with the results,"

—Weston Hymas, Lead Scientist, R&D Infectious Disease Group

August 19, 2022: ARUP completes hazard assessment for the Roche platform.

Article by Kellie Carrigan

"When assessing the risk for an outbreak or pandemic, we have to look at the modes of transmission and how virulent it is. It's our responsibility to protect our people in receiving, prepping, and testing. We refer to a hierarchy of controls to determine how to mitigate or eliminate risks, such as engineering controls, procedural controls, and adequate personal protective equipment."

—Tom Wachter, MBA/HCM, SLS(ASCP), Director of Corporate Safety

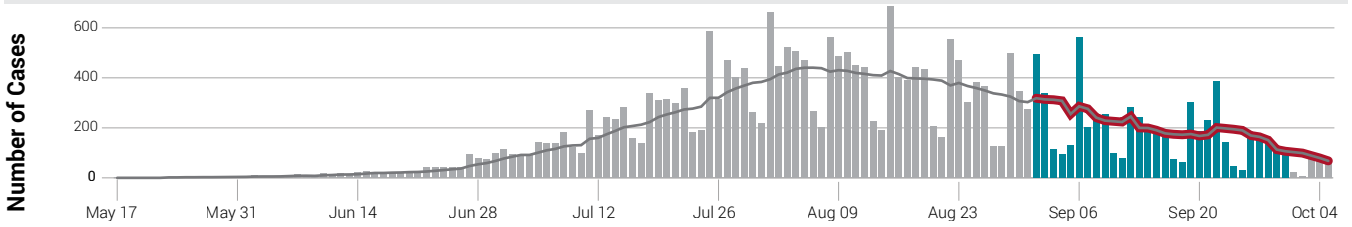
August 24, 2022: ARUP orthopoxvirus test on the Roche automated platform is live in the lab.

"We all work together to reach a common goal, but those who work in the lab carry the largest burden. There's so much that goes into putting together a new test, and it usually takes months. To complete all the necessary tasks—it's just incredible they were able to accomplish it so quickly."

—Kristin Case, Clinical Product Manager in Infectious Disease and Hemostasis/Thrombosis

August 29, 2022: The ARUP orthopoxvirus assay that uses the Roche automated platform receives approval from New York State Department of Health.

SEPTEMBER



Nathan Bodily, technical specialist in Molecular Infections Disease Rapid Testing, pipettes specimens or reagent in a biosafety cabinet (BSC).

"It's important to acknowledge the incredible work and dedication of the many individuals and departments at ARUP who are necessary to realize a project of this magnitude, from the laboratory staff who are completing the testing every day, to the Research and Development teams who validated the assay so quickly, to our Marketing and Business Development teams who are the primary source of information for our clients."

—Jonathan Genzen, MD, PhD, ARUP Chief Medical Officer

September 6, 2022: CDC sends out lab alert regarding dropout mutations; ARUP's assay is not affected.

September 7, 2022: FDA requires notification from any private laboratories that are performing LDTs for monkeypox infection.

September 13, 2022: ARUP submits the required notification to the FDA.

ARUP's Clinical Trials Group Assists in Multisite Study Aimed at Unravelling the Mysteries of Long COVID-19

According to the CDC, postacute sequelae of SARS-CoV-2 infection (PASC), commonly known as long COVID-19, can involve a spectrum of long-term symptoms that might be experienced weeks to months after SARS-CoV-2 infection has resolved.

Lisa O'Brien looked at her heart monitor in disbelief. During the past several weeks, she'd had erratic heart rates that varied tremendously from 30 beats per minute (bpm) to the dangerously high number that she stared at now: 220 bpm.

O'Brien had fallen ill in March 2020 after a trip to Hawaii that coincided with the nation's shutdown to contend with the encroaching COVID-19 pandemic. She wondered if her illness could be related, but at the time, COVID-19 tests were hard to come by. When she was finally tested, it had been more than two weeks since her symptoms began, and her test result came back negative.

But for some reason, O'Brien wasn't getting better. Her teenage son helped her to his car for yet another emergency room visit. The doctor asked her many questions, ranging from whether she suffered from anxiety to if she'd had an energy drink that day. O'Brien listened as the doctor explained that the strange symptoms she was experiencing were something that people with chronic illness deal with all the time.

"I hadn't had any experience with chronic illness until that point. I was very privileged. I had this great health. I hiked. I travelled. I had just started to learn Irish dancing. That just wasn't part of my life."

Lacking any clear answers about what was happening to her body, she turned to social media and found others suffering the same strange constellation of symptoms. She launched the Utah Long-Haulers Facebook group in June 2020. Today, the group includes nearly 5,000 members.

"The biggest reason that I wanted to grow this group was so that I could take this data to somebody and say, look how many people I have found. We have a problem. We need help," O'Brien said.

Patients connecting in online forums such as O'Brien's across the country helped to spur the creation of the National Institutes of Health (NIH) Researching COVID to Enhance Recovery (RECOVER) Initiative. According to the NIH RECOVER team, the initiative seeks to quickly improve our understanding of recovery after SARS-CoV-2 infection and to prevent and treat long-term health effects.

The NIH granted the parent award to New York University (NYU) Langone Health, which in turn has made multiple subawards to more than 100 investigators at 30 different institutions. ARUP Laboratories is contracted with NYU as a RECOVER Core, meaning that ARUP provides centralized laboratory testing for 150 partner sites.

Article by Kelly Killian; graphic by D'Arcy Monforte

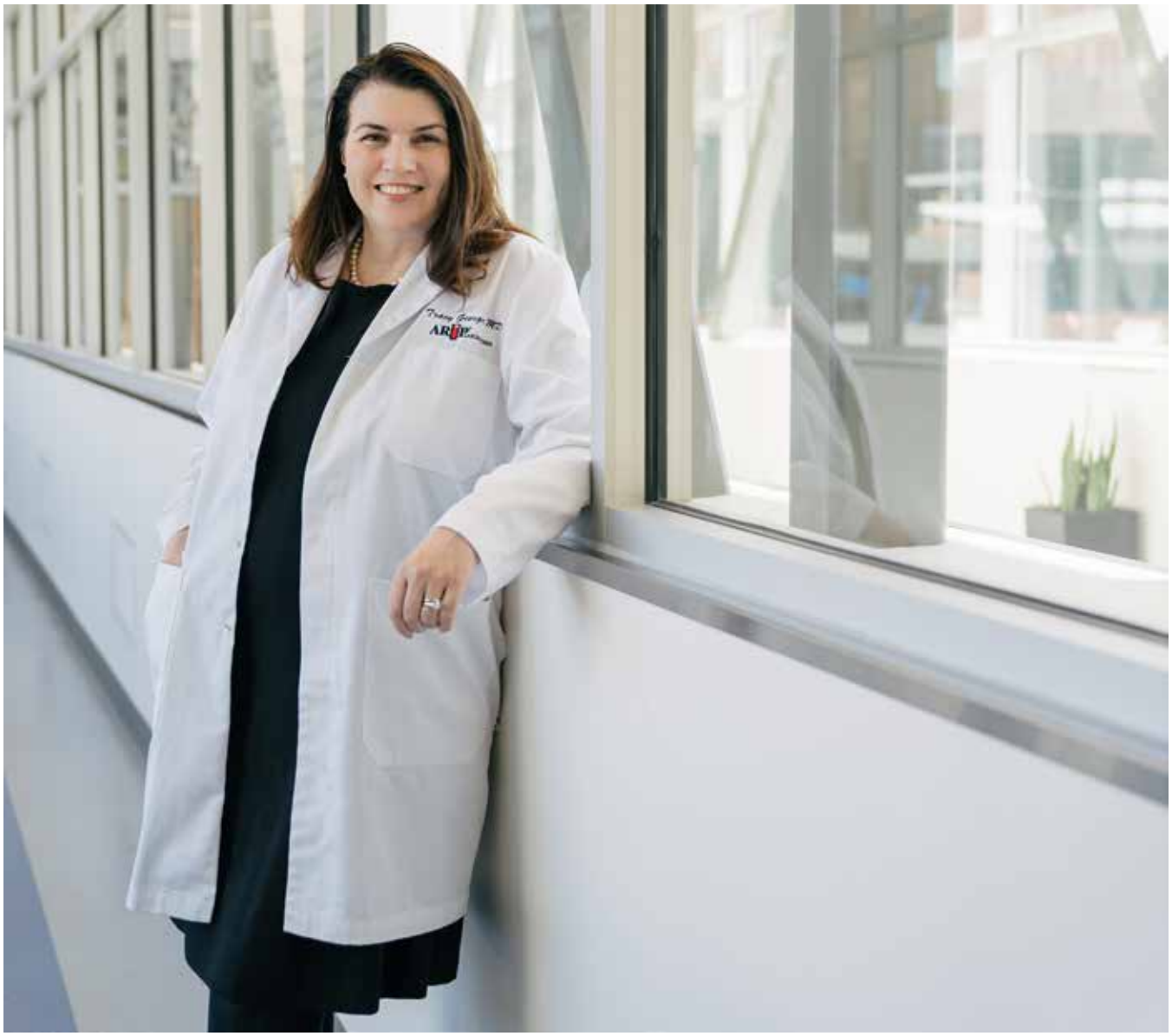
The NIH RECOVER team explained that the primary role of RECOVER Core centers is to build and support the RECOVER Initiative and its participant pool and team of investigators, and to ensure that data are standardized and effectively shared among researchers and with the public. By working in tandem with researchers across the country, ARUP plays an integral role in helping investigators understand why some people recover from COVID-19 while others, like O'Brien, do not. This work is expected to shed light on other postacute infection syndromes, such as myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS).

Erica Clyde, manager of the Clinical Trials group, appreciates the opportunity to work on the RECOVER study, particularly after being involved in COVID-19-related studies earlier in the pandemic. "COVID-19 is here for the long haul, and we're going to be seeing the ramifications of the pandemic for a long time. Being a part of the solution is gratifying for me."

According to the Infectious Diseases Society of America (IDSA), long COVID refers to new, recurring, or ongoing symptoms related to COVID-19 that occur several weeks after the acute phase of infection. This phenomenon is also referred to as long-haul COVID, postacute sequelae of SARS-CoV-2 infection (PASC), and the CDC-coined umbrella term, post-COVID conditions. Importantly, there is no definitive diagnostic test for PASC, which has contributed to the difficulty of creating a standardized case definition.

According to recent data collected by the Household Pulse Survey, an ongoing collaborative effort that involves the Census Bureau, the CDC, and other federal agencies, more than 40% of adults in the United States reported having had COVID-19, and nearly one in five of those (19%) are still having symptoms of long COVID.

"The complications that are affecting those we know and love—if not ourselves—are very, very real, and we have no idea why the symptoms vary so greatly from person to person," said Erica Clyde, manager of ARUP's Clinical Trials



Tracy George, ARUP president and chief scientific officer, sees the NIH-funded RECOVER Initiative as a natural fit for ARUP's academic focus. "We are always happy to help facilitate large multicentral trials."

team. Clyde worked alongside several others at ARUP, including Angela Aguilar, account executive, to partner with NYU as a RECOVER Core site. "As soon as Angela heard about this study, she knew that ARUP had the resources to carry out this work. Thanks to Angela and ARUP's relationship with NYU, we were in a position where we could seamlessly transition from reference to research work," Clyde said.

Clyde's Clinical Trials group supports clients in major research endeavors with its specialized project and sample management teams. The group has worked on several other COVID-19 studies at ARUP, but nothing of the magnitude of RECOVER. "This is the largest project that we have ever been involved with," Clyde said. "There are so many moving parts to RECOVER. Other COVID-19-related studies that we've been involved in, including HERO and COVERED, were much more centralized. In this study, we are partnering with 150 sites across the country."

The Utah Health and Economic Recovery Outreach Project (HERO) is a massive research undertaking aimed at studying the spread of COVID-19 in Utah. The COVID Evaluation of Risk for Emergency Departments (COVERED) project is a collaboration between the David Geffen School of Medicine at the University of California, Los Angeles, and the Carver College of Medicine at the University of Iowa to study the risk of infection in hospital emergency

Article by Kelly Killian; graphic by D'Arcy Monforte

department workers during the early days of the pandemic. ARUP provided laboratory test support for both studies.

Tracy George, MD, ARUP president and chief scientific officer, noted that RECOVER is an interesting opportunity to study the postacute sequelae stage of COVID-19 and is a natural complement to the studies ARUP was involved in earlier in the pandemic. Importantly, George said that ARUP's excellent work on these prior studies has helped to position the company to participate in larger-scale studies, such as RECOVER. "We wouldn't be a considered as a partner for studies like this one unless we'd done a good job with our previous studies. We're being contacted now by these larger consortiums that are academically interested and understand the value of quality and what ARUP can bring to the table."

> "ARUP is one of the few academically affiliated labs that can serve a national study such as RECOVER."
>
> —**Rachel Hess, MD, MS, General Internist and Chief of the U's Division of Health System Innovation and Research**

Although ARUP is always enthusiastic about supporting large multicenter trials, George sees RECOVER as a particularly good fit for ARUP because of the involvement of several U faculty members, including Rachel Hess, MD, MS, general internist and chief of the U's Division of Health System Innovation and Research. Hess leads the Mountain States PASC Consortium (MSPC), a coalition of five healthcare systems in Utah, Colorado, and New Mexico, and spearheaded its successful RECOVER Initiative application. The MSPC seeks to understand and compare patients who have or have had PASC with those who had COVID-19 but did not develop long-term symptoms.

Hess's consortium plans to recruit more than 900 adults, including a diverse set of volunteers from Hispanic, Native American, and rural populations within the Mountain West region, to study patients who have been newly diagnosed with COVID-19, as well as those who had COVID-19 earlier in the pandemic. Others who have not been infected with SARS-CoV-2 will be recruited as a control group.

"One of the goals of the RECOVER study is to really understand the development of PASC," Hess said. "We want to not just study people who have developed PASC, but also enroll people who are quite early in their COVID journey, before they have developed any long-term symptoms." The first cohort—those with PASC—has, fortunately or unfortunately, proven to be easier to recruit for, in part thanks to groups such as O'Brien's, Hess noted.

As for ARUP's role as a RECOVER Core site, Hess sees ARUP's academic affiliation and licensure in every state in the country as a major asset. "ARUP is one of the few academically affiliated labs that can serve a national study like RECOVER," she said.

"At the University of Utah, we benefit so greatly from our relationship with ARUP," she added. "We can literally run any test we need."

Enrollees in Hess's PASC study undergo a series of laboratory tests that researchers hope will provide clues to predict the development of PASC. These tests provide information about the body's autoimmune system, inflammatory processes, and microbiome, all of which have been hypothesized to be impacted by SARS-CoV-2 and were chosen by a diverse group of experts. "We are so early in our understanding of long COVID that we want to try and test everything and figure out what actually is impacted," Hess said. COVID-19 has been blamed for nearly everything, she said. "The question is, what of that is true and what of that is not?"

Jeanette Brown, MD, PhD, medical director of the U's COVID-19 Long-Hauler Clinic, confronts that question every day. The COVID-19 Long-Hauler Clinic serves two categories of patients: those with COVID-19 who were severely ill (i.e., were hospitalized or in an intensive care unit), and those with long COVID whose symptoms have persisted for months. According to Brown, the clinic has seen more than 1,000 patients since opening its doors in July 2021. Approximately 70% of those patients are women, and the average age is 47.

Brown described the clinic as a "one-stop shop" that helps to triage patients and brings together a diverse group of specialists, including doctors from the U's neurology, pulmonary, and cardiology clinics.

"Patients' symptoms are so extensively diverse. We had to work really hard to put a network of specialists together," Brown said. "We were struck right away by the variety of symptoms that we were seeing. One patient would come in and say, 'I can't taste and smell correctly, or at all.' Then the next person would say, 'I'm having blood pressure and heart dysregulation that is totally incapacitating.' And the next person is having pain issues."

Jeanette Brown, MD, PhD, medical director of the University of Utah's COVID-19 Long-Hauler Clinic, sees a variety of symptoms from patients. The most common complaint is sleep disturbance. Other symptoms include fatigue, postural orthostatic tachycardia syndrome (POTS), headaches, pain, and wide variations in blood pressure and heart rate.

Brown's clinic interfaces with Hess's RECOVER study in two important ways. First, many of the clinic's patients participate in the initiative. "Our patient population is very altruistic and they want to be involved in research studies, even if it doesn't necessarily benefit them," Brown said. Second, the clinic serves as a resource for patients whose study test results may necessitate follow-up.

Brown speaks fondly of her long relationship with ARUP. Her undergraduate degree was in medical laboratory science, and she completed her rotations at ARUP. "It becomes a small world here very quickly," said Brown, noting that she has frequently reached out to collaborate and consult with medical directors at ARUP, such as Lisa Peterson, PhD, medical director of Immunology. "You need a resource that you can trust, and there are a lot of really thoughtful people behind the lab testing at ARUP."

> "You need a resource that you can trust, and there are a lot of really thoughtful people behind the lab testing at ARUP."
>
> —**Jeanette Brown, MD, PhD, Medical Director of the University of Utah's COVID-19 Long-Hauler Clinic**

Other cohorts that U researchers are studying for RECOVER—and that ARUP provides lab testing for—include pregnant and pediatric populations. In sum, these studies are expected to provide insights over the coming months into many important considerations, including the incidence and prevalence of long-term effects from SARS-CoV-2 infection, the range of symptoms, underlying causes, risk factors, outcomes, and potential strategies for treatment and prevention.

Article by Kelly Killian; graphic by D'Arcy Monforte

Lisa O'Brien started her online support group to spread awareness about long COVID-19 after finding a scarcity of information that spoke to her experience. "All we heard about in the earlier days was the 99% survival rate. Not many were talking about how some people just weren't getting better." O'Brien is enjoying life again but remains vigilant about protecting herself—she masks in crowded, public places—and is concerned about contracting COVID-19 again. "Some people in my group who have been reinfected will have a resurgence of symptoms that had resolved. I don't know what it would look like if I got sick. It just varies so greatly from person to person."

> "RECOVER's advantage here is that it has the brute force numbers you really need to pick up on the signals through the noise."
>
> —Jeanette Brown, MD, PhD, Medical Director of the University of Utah's COVID-19 Long-Hauler Clinic

O'Brien finds hope in the ongoing efforts to understand long COVID. "If anything good comes from COVID-19, it's going to be that we develop a better understanding and awareness of chronic fatigue syndrome, postural orthostatic tachycardia syndrome [POTS], and mast cell activation syndrome, among so many others. These are conditions people have struggled with long before COVID. Studies like RECOVER give the OG long haulers hope."

COVID-19 has proven to be what Brown refers to as a "giant natural experiment" for a lot of conditions that haven't been well understood for years. "RECOVER's advantage here is that it has the brute force numbers you really need to pick up on the signals through the noise."

Today, O'Brien continues to focus on helping researchers learn more about the long-term consequences of the virus. She serves as a patient representative in Hess's PASC study and is also an enrolled participant, like many others from her online group.

"Any time I hear of a new clinical trial or study, I share it with my group so that we can learn more. What's the trigger? Why does this happen to certain people and not to others? Maybe if we can figure out the why, we can prevent others from ending up like this. Maybe we can at least give people back some of their quality of life, you know?" O'Brien said.

She added that she feels 95% better most days, and she feels fortunate, especially because many of her support group acquaintances have not been so lucky. "I have friends who are more than two years out who could end up having a chronic illness for the rest of their lives."

She is cautiously resuming activities that she only dreamt of a year ago. O'Brien has traveled a few times for work in recent months but is still cautious and wears a mask on airplanes. She does most of her grocery shopping early in the day when stores are less crowded. And she recently resumed Irish dance lessons.

"I went from being this person who had all of these high hopes and dreams and this life that I was planning to live. COVID took all of that from me for two years. It takes your health, but it also takes this life that you had planned and worked for and hoped to live," O'Brien said.

For her part, Clyde feels privileged to have a part in such an important study. "Long COVID is just this big unknown," she said. "We don't know what this is going to look like in our kids over the next several years and what the overall impact will be. And while that's scary, it feels very gratifying to be part of the solution."

Tests Developed to Characterize Immunity to COVID-19 Hold Promise for Myriad Future Applications

Researchers in the lab run by Shawn Owen, PhD, University of Utah associate professor in Molecular Pharmaceutics, worked with a team at the University of Toronto to develop a SARS-CoV-2 neutralizing antibody test that can be quickly adapted for new variants of the virus as they emerge.

At this point in the COVID-19 pandemic, regardless of which combination of vaccinated, boosted, and/or naturally infected we claim, all of us who have developed antibodies against SARS-CoV-2 have the same questions: Are we immune to infection, and if so, how long will that immunity last?

Scientists have been seeking answers to these questions since the first cases of COVID-19 were observed in December 2019, and they know far more than they did three years ago. Perhaps even more importantly, their pursuit of knowledge about immunity to SARS-CoV-2 has led to novel approaches to testing that promise to improve diagnosis and monitoring of not only COVID-19, but many other diseases in the future.

That's certainly true of research at ARUP Laboratories and the University of Utah, said Julio Delgado, MD, MS, an immunologist who is ARUP's executive vice president and chief of the Clinical Pathology Division at the U. "We see potential benefits beyond COVID-19 for every advancement born of the pandemic," he said. "That may be one upside of what we've all been through the past few years."

ARUP was among the first clinical laboratories in the nation to offer SARS-CoV-2 antibody testing when it launched a qualitative IgG antibody test in April 2020, and then a semiquantitative IgG antibody test a month later.

Immunoglobulin G (IgG) antibodies are proteins that bind to and neutralize the virus so that it cannot invade cells and enable the infection to spread. ARUP's COVID-19 IgG, Qualitative by CIA test detects IgG antibodies against the nucleocapsid protein of SARS-CoV-2 that develop in response to natural infection, and the COVID-19 IgG (Spike) Semi-Quantitative by CIA test detects IgG antibodies against the spike protein (S1) of SARS-CoV-2. These tests are considered standard for determining whether an individual has had COVID-19, but are not useful for determining immunity to the disease.

So how do we test for immunity?

There is no easy answer, but research at ARUP and the U has helped us get closer to understanding what constitutes protection against the disease.

Article by Lisa Carricaburu; illustration and graphics by Natalia Wilkins-Tyler

A Novel Test for SARS-CoV-2 Neutralizing Antibodies

Sun Jin Kim, PhD, a former University of Utah postdoctoral fellow, conceptualized the Neu-SATiN assay and is the primary author of an article published in Nature Communications.

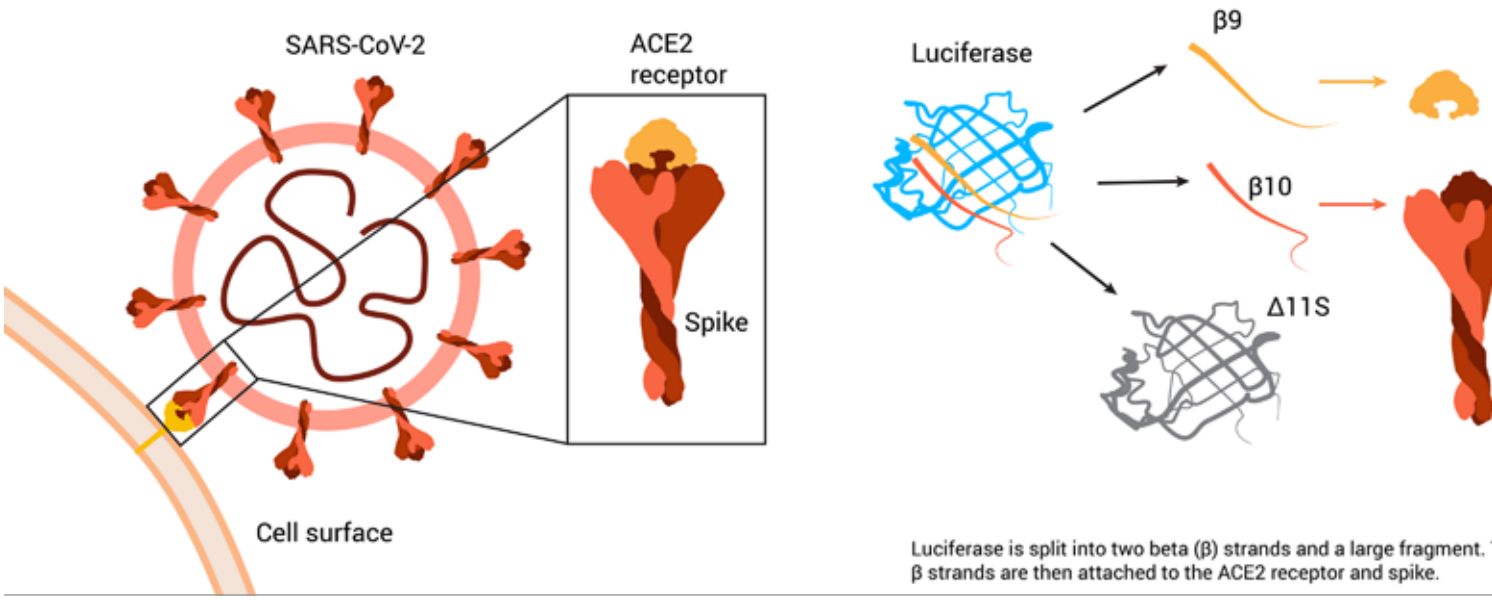
The lab run by Shawn Owen, PhD, an associate professor in Molecular Pharmaceutics at the U, may at first seem to be an unlikely source of a novel SARS-CoV-2 antibody test, but Owen says it made sense for him to work with former postdoctoral fellow Sun Jin Kim, PhD, who is now at the University of California, San Francisco, to apply a system they were developing to measure levels of therapeutics for use in the detection of SARS-CoV-2 neutralizing antibodies.

"When COVID-19 hit, the only people the U was allowing to be in person in labs were those who were working on COVID research, so we brainstormed an idea that would help get us back in our lab," Owen said.

> "Where our test is really empowering is that it is modular and can be easily adapted for new SARS-CoV-2 variants as they emerge."
>
> —**Shawn Owen, PhD, University of Utah Associate Professor in Molecular Pharmaceutics**

In essence, Owen's lab uses antibodies as tools, taking an approach that relies on what he refers to as a "protein switch." He and his colleagues saw a way to use the switch to detect the presence of SARS-CoV-2 neutralizing antibodies, which are correlated with protective immunity. Standard IgG antibody tests typically do not measure neutralization efficacy specifically.

University of Utah graduate students Morgan Marsh (left) and Annette Gerlund (right) work in the lab run by Shawn Owen, PhD. Marsh was involved in experiments and data analysis of Neu-SATiN test results and helped write the article published in Nature Communications.



Luciferase is split into two beta (β) strands and a large fragment. β strands are then attached to the ACE2 receptor and spike.

Owen said other neutralizing antibody tests exist, but he, Kim, and others in Owen's lab joined with a team of researchers at the University of Toronto led by Igor Stagljar, PhD, to develop a test that they say can be performed more quickly and inexpensively. An added boon is the test's versatility. "Where our test is really empowering is that it is modular and can be easily adapted for new SARS-CoV-2 variants as they emerge," he said.

Their test, Neu-SATiN, is performed on serum or plasma and is powered by a luciferase protein that is converted into a protein "switch."

An animation (available at aruplab.com/magnify-fall22-immunity) demonstrates how Neu-SATiN works to detect whether neutralizing antibodies are present by measuring the ability of the SARS-CoV-2 spike protein to associate with the angiotensin-converting enzyme 2 (ACE2) receptor to penetrate the wall of a healthy cell.

The commercially available luciferase NanoLuc is broken into fragments. One luciferase fragment is fused to the spike protein, and the other is fused to the ACE2 receptor. If no antibodies are present, when the spike protein and the receptor bind, the luciferase fragments are in proximity to one another, and the "switch" turns on, or rather, luminescence occurs that can be measured by an instrument.

When neutralizing antibodies are present, however, they bind to the spike protein and prevent it from associating with the ACE2 receptor, so the luciferase fragments remain separated, and the light signal measured by the instrument is weaker.

Owen said the assay's components can be easily modified and produced, so it can be adapted for differences in the spike protein of a new variant, for example.

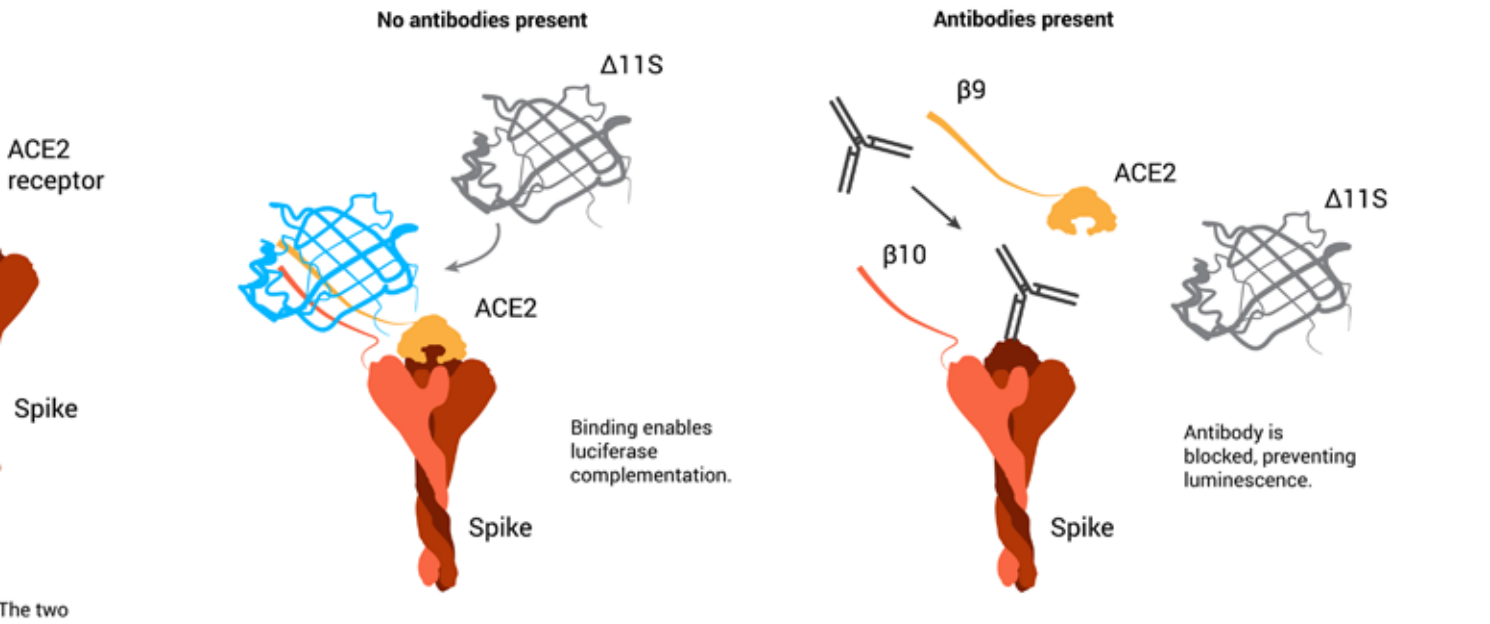
"For a test to be useful in helping to guide policy or individual decisions about whether to get another vaccine, it has to be able to measure neutralization of the newest variants," he said.

Owen and his colleagues relied on specimens provided by ARUP to develop and validate Neu-SATiN. Delgado and Marc Elgort, PhD, codirector of the ARUP Institute for Clinical and Experimental Pathology®, also shared feedback on various test design and development questions and are coauthors of a Nature Communications article that describes the development of the test and its results.

What Neu-SATiN Results Reveal About Immunity

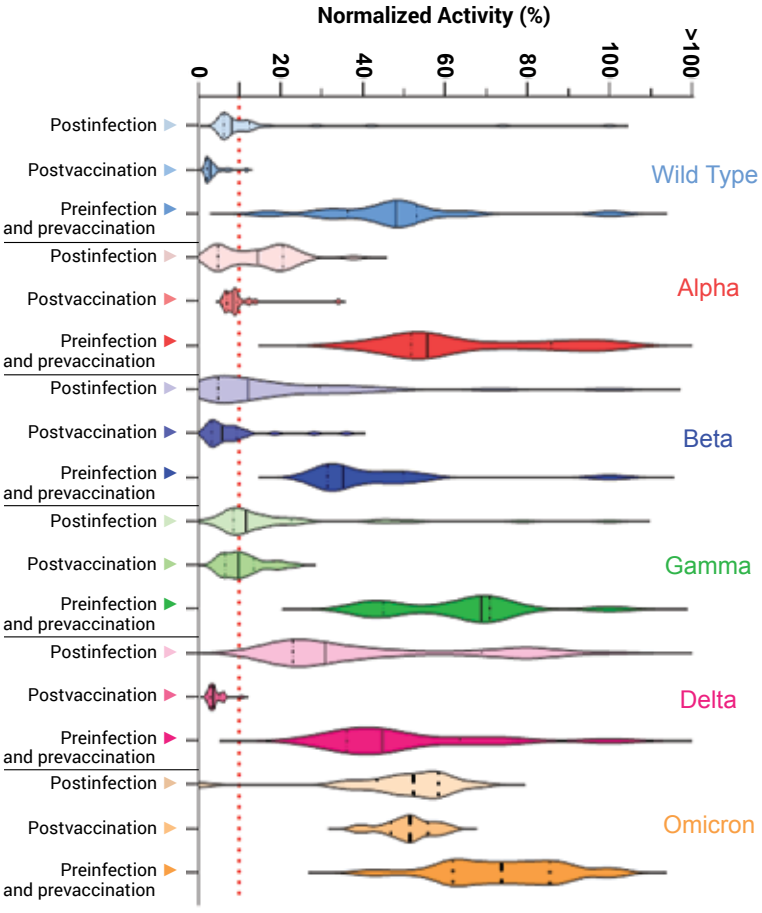
In all, 63 patients with different vaccination and natural infection histories were tested with Neu-SATiN, and testing concluded in November 2021, just as the Omicron variant of SARS-CoV-2 had begun to emerge. The researchers assessed the potency of patients' neutralizing antibodies against the original strain of SARS-CoV-2 and the Alpha, Beta, Gamma, Delta, and Omicron variants, and found that for the majority of the strains, the neutralizing antibodies provided protection for three to four months, after which time their levels dropped by about 70%, irrespective of infection or vaccination status.

Article by Lisa Carricaburu; illustration and graphics by Natalia Wilkins-Tyler



Neutralization differed somewhat by variant but was dramatically different for Omicron, Owen said. "Virtually no neutralization was seen for the Omicron variant," whether the patient had been vaccinated, naturally infected, or both.

"This does not mean Omicron is like starting over, though," he said. "The body does have a memory, and if you get reinfected, there's a better chance that you can recover and that the second infection won't be as serious. Vaccines are definitely helping with that."



Characterizing T-Cell Immunity to SARS-CoV-2

Owen was referring to another aspect of our complex and adaptive immune systems that helps protect against pathogens. Although neutralizing antibodies are key to understanding our immune response to SARS-CoV-2, our bodies over time also begin to call on T lymphocyte cells (T cells), a type of white blood cell, not to stop SARS-CoV-2 from infecting cells, as antibodies do, but to prevent propagation of the virus by essentially killing infected cells, according to Delgado.

He, along with Leo Lin, MD, PhD, ARUP medical director of Immunology and an assistant professor at the U, worked with former clinical immunology fellow Hemant Joshi, PhD, on Joshi's development of an activation-induced marker (AIM) assay to characterize T-cell-mediated immunity to SARS-CoV-2. A poster Joshi created along

with Delgado, Lin, and others about the test and his test results earned the Doctorate Award at the Association of Medical Laboratory Immunologists (AMLI) annual meeting held in Salt Lake City in August.

Currently, there isn't an assay to characterize T-cell response to SARS-CoV-2 that has been approved by the U.S. Food and Drug Administration (FDA), although T-SPOT.*COVID*, a test developed by the British company Oxford Immunotec, has earned approval for use in the European Union.

Lin said T-cell response to infection is harder to tease out than antibody response because researchers must work with live cells. Specimen stability is shorter and interrogating specimens is more difficult. "You've got to have a way of isolating T cells and then making sure they're alive and functional so you can test them," he said.

The AIM assay Joshi developed uses flow cytometry to evaluate surface expression of activation markers on live cells.

In his research, peripheral blood mononuclear cells first were isolated from whole blood specimens, then were cultured in the presence of SARS-CoV-2 spike protein peptides. The cells were then stained with T-cell markers (cluster of differentiation 3 [CD3], CD4, CD8) and activation markers (CD69, CD25, CD134 [OX40], and CD137) to determine which combination worked best to detect spike-specific T cells.

Joshi, who is now at Mount Sinai Hospital in New York City, found that coexpression of CD69 and CD134 on CD4 T cells, and coexpression of CD69 and CD137 (4-1 BB) on CD8 T cells, were the best combinations.

Julio Delgado, MD, MS (left), and Leo Lin, MD, PhD (center), worked with Hemant Joshi, PhD (right), on Joshi's development of an activation-induced marker (AIM) assay to characterize T-cell-mediated immunity to SARS-CoV-2.

He found that spike-specific CD4 T cells were detected in 93% of vaccinated specimen donors and 80% of unvaccinated but naturally infected donors. The test also detected spike-specific CD8 T cells in 93% of vaccinated donors and 100% of donors who were unvaccinated but had been naturally infected with the virus.

He performed the T.SPOT test on all specimens to correlate his results, and found "excellent concordance."

"Our findings demonstrate that SARS-CoV-2 spike protein peptides can be utilized to develop a technically feasible and clinically sensitive and specific assay for spike-specific CD4 and CD8 T cells," Joshi concluded.

Importantly, the AIM assay also offers a potential advantage over the T.SPOT test because it can be easily adapted to test T-cell response to different variants as they emerge by changing the proteins used to stimulate the T cells, Lin said. "You can tailor it to any new variants of SARS-COV-2 that might emerge and to other pathogens as well."

What's Comes Next for SARS-CoV-2 Tests?

Neither Neu-SATiN nor Joshi's AIM assay has a clear path to commercialization as of yet.

Owen said that his University of Toronto colleagues have taken the lead in pursuing partners who may be interested in commercializing Neu-SATiN. He added that he has had preliminary conversations with ARUP's New Technologies Group to gauge interest in the potential to use the test methodology for other applications.

Lin said a next step for the AIM assay is to get the test results published.

Both tests, however, especially when considered along with related work other researchers are doing around the globe, hold the promise that we may one day be able to go to a healthcare provider for a test that will tell us whether we are immune to COVID-19 or another infectious disease, or perhaps tell us whether it's time for another vaccination.

"COVID-19 has really accelerated so much research and discovery in immunology," Lin said. "It's led to the development of new testing and vaccine technologies that we can apply to future problems as well. The possibilities are really limitless."

Article by Lisa Carricaburu; illustration and graphics by Natalia Wilkins-Tyler

Ambitious SARS-CoV-2 Antibody Study Provided Real-Time Data to Benefit Patient Care

Preliminary data gleaned from a far-reaching study of immunity to SARS-CoV-2 showed that vaccine-induced antibodies persist longer than those induced by natural infection, a finding that proved useful in real time as the ARUP Family Health Clinic began offering vaccinations in early 2021.

In the early days of the COVID-19 pandemic, employees at ARUP Laboratories and the University of Utah were first responders to the emerging crisis as they raced to validate tests and build much-needed testing capacity.

The pressure and the workload they faced were unrelenting, yet a core group nonetheless recognized an opportunity for ARUP to do what it does best as an academic reference laboratory: learn from the crisis and apply what they learned to improve patient care as quickly as possible.

As the number of COVID-19 cases started to climb in the spring of 2020, Julio Delgado, MD, MS, an immunologist and ARUP's chief medical officer at the time, already was initiating a far-reaching study approved by the U's Institutional Review Board to understand what constitutes immunity to SARS-CoV-2. The study, for which Delgado was the principal investigator, also involved the validation of various specimen types for SARS-CoV-2 antibody testing.

In many ways, it was not unlike hundreds of other studies around the globe that sought answers to key questions about COVID-19. The investigation was unique, however, in that it enabled ARUP to understand how its own newly launched SARS-CoV-2 immunoglobulin G (IgG) antibody tests were working in real time and to use that information to provide immediate feedback to the company, which was not only providing testing to hospitals and health systems nationwide, but was also managing the health and safety of a large workforce through a pandemic and caring for employees' dependents through the ARUP Family Health Clinic.

"What we saw was truly amazing behavior throughout our organization," said Delgado, who is now ARUP executive vice president and chief of the Clinical Pathology Division at the U.

About 150 employees enrolled in the study without hesitation, he said. The Family Health Clinic, which provides free primary care to employees and their families, became the testing site, with Kathryn Gibson, MD, FAAFP, ARUP medical director of Health and Wellness, who oversees

Article by Lisa Carricaburu

> "We were able to see the science roll out while also watching the clinical picture develop, which afforded a full continuum of understanding from the basic science all the way through research and development to how to apply testing and results in the clinic, and then how to apply them in people's lives."
>
> —Kathryn Gibson, MD, ARUP Medical Director of Health and Wellness

the clinic, and nearly every member of her staff also enrolling at a time when the demands of their work had never been greater.

Jennifer (Jenna) Rychert, PhD, medical director of Operational Informatics and Microbial Immunology, implemented specimen collection schedules, worked to ensure the availability of supplies needed for the study, connected the research team with the clinical team led by Gibson, and created a REDCap database. Then Delgado, Gibson, Rychert, fellow medical directors, clinic staff, and Research and Development and laboratory employees got to work.

Multiple times over the nearly two years that followed, study participants submitted to blood draws, finger pricks, saliva collection, and early in the study, collection using a microcapillary device so that ARUP could perform different tests to monitor SARS-CoV-2 antibodies over time in patients who had been naturally infected, vaccinated, both, or neither.

"It was really fascinating because it enabled us to see lab results in real time before anyone really knew what they meant or how to apply them," Gibson said. "We were able to see the science roll out while also watching the clinical picture develop, which afforded a full continuum of understanding from the basic science all the way through research and development to how to apply testing and results in the clinic, and then how to apply them in people's lives."

Trends emerged. From preliminary data, researchers learned that SARS-CoV-2 antibodies begin to diminish three to six months after they're detected, and that nucleocapsid-specific antibodies decline faster than spike-specific antibodies, Delgado said. They learned that vaccine-induced antibodies persist longer than those induced by natural infection.

They also learned that SARS-CoV-2 antibodies can be detected in dried blood spots and saliva in addition to venous serum, and that these other specimen types are viable alternatives to serum in antibody testing.

In addition, Gibson said the study served as a stark reminder of something else that is essential for every ARUP employee to remember. Early on, patients eagerly awaited any information antibody tests could offer them because most did not meet criteria for SARS-CoV-2 molecular diagnostic tests that were still hard to come by.

"Participants in the study were very connected to their lab results because it gave them some semblance of control in a very uncontrolled environment," she said. "We talk a lot about how to connect what we do to the patients behind the tests. Moments like these help us remember what it's like for a patient awaiting a cancer diagnosis. Lab test results have so much power behind them."

The research team is still analyzing data and considering opportunities to publish results, particularly related to the efficacy of alternative specimen types in SARS-CoV-2 antibody testing, Delgado said.

Regardless, he and Gibson consider the investigation an important win for ARUP.

"There was such a sense of connection throughout the study, a sense that all of us at ARUP are here to contribute to progress in our world in a positive way," Gibson said. "For me, it encapsulated the goodness of our company—the hope we have for our patients and for ourselves."

Article by Lisa Carricaburu

Q&A With Former Fellow Alessandro Rossi

Alessandro Rossi, PhD, D(ABMM), is chief scientist and CLIA director at the Utah Public Health Laboratory.

Alessandro Rossi, PhD, D(ABMM), chief scientist of Infectious Disease and CLIA director at the Utah Public Health Laboratory, was a microbiology fellow at ARUP Laboratories from 2015 to 2017. Over the course of his career, his work and research projects have advanced the field of clinical microbiology and guided public health interventions.

Here, he offers a glimpse into his history at ARUP, his current work, and his plans for future research.

Why did you decide to complete your fellowship at ARUP?

I was already working at the University of Utah in the Department of Medicinal Chemistry. My background was originally in infectious disease, as I did my PhD in molecular parasitology. I wanted to move from basic research to a more clinical, applied career. With basic research, you tend to investigate things that are more far-fetched before you make an impact on people's lives. But with clinical research, you know that every day of your work, you are saving a life.

How has your fellowship experience prepared you for your career in public health?

It was essential. I could not do this work and direct a lab without the knowledge I acquired during the fellowship. I learned from everybody at ARUP, from faculty members to the medical laboratory scientists working in the lab. Everyone is very dedicated and knowledgeable.

One thing that's unique about ARUP is that it receives specimens from all over the country. For example, in our parasitology rotations, we saw so many unique parasites. It was like a gold mine of organisms! I'm very grateful for having had this opportunity.

At ARUP, I had the chance to get acquainted with next generation sequencing (NGS). I had never worked with that before the fellowship. NGS is the bread and butter of public health right now. With that information, you can assess the genetic relatedness of organisms to establish an epidemiological link. You can monitor evolution in circulating viral strains like we do with SARS-CoV-2 or

influenza. That information allows you to make changes in vaccines or monitor resistance to antivirals and other therapeutics. That's where public health is going.

How have you made an impact on patients' lives?

As the chief scientist of Infectious Disease at the state lab, I participate in outbreak investigations. For example, in one case we investigated, people were traveling to Tijuana, Mexico, for medical tourism for bariatric surgery procedures. Unfortunately, due to bad infection prevention practices at a local hospital, they would come back with nasty, drug-resistant infections. We provided laboratory evidence that most of the people affected were getting the infection at a specific clinic and after surgeries performed by a specific doctor.

Based on these findings, the clinic was closed, and public health reached out to scheduling services to alert people not to travel to Tijuana for bariatric surgery. The health departments of Utah and other affected states also disseminated this information in national and local media to make people aware of the risk. That saved hundreds of people from getting an infection.

We do cases like that on a regular basis.

What scientific and professional accomplishments are you proud of?

In the field of clinical microbiology, my biggest achievement has been the characterization of a new genus of bacteria, *Chimaeribacter*. This work was for my fellowship research project, which I did under the supervision of Mark Fisher, PhD, medical director of the Bacteriology lab at ARUP. I actually named one of the *Chimaeribacter* species I described, *C. arupi*, in honor of ARUP.

I'm proud of the work we do every day with drug resistance to help infection prevention efforts. In 2019, we were recognized as a regional lab of the Antimicrobial Resistance Laboratory Network, which is the CDC's surveillance system for antibiotic resistance. As a regional lab, we serve seven other states in the mountain region. That was a big professional achievement for me.

What goals do you have for your clinical research?

We are always thinking about new ways to protect the public. Right now, a new paradigm in public health is wastewater surveillance.

We have started to use the wastewater to look at concerning drug-resistance organisms like carbapenem-resistant *Enterobacterales* and *Candida auris*. With these data, we can draw an endemicity map of these bugs in Utah and possibly provide early detection of organisms not yet introduced in our state, such as *C. auris*. We are currently assessing whether monitoring wastewater at a community level could be used to infer transmission of drug-resistant organisms. That's one collaboration we have right now with ARUP. ARUP provides residual deidentified stool culture with ZIP code information. I'm very glad to continue working with the institution where I trained.

ARUP is seeking news about former fellows and residents to spotlight in a recurring Question and Answer (Q&A) feature.

Fill out the form found at the QR code above to share your news, and ARUP will follow up in an email.

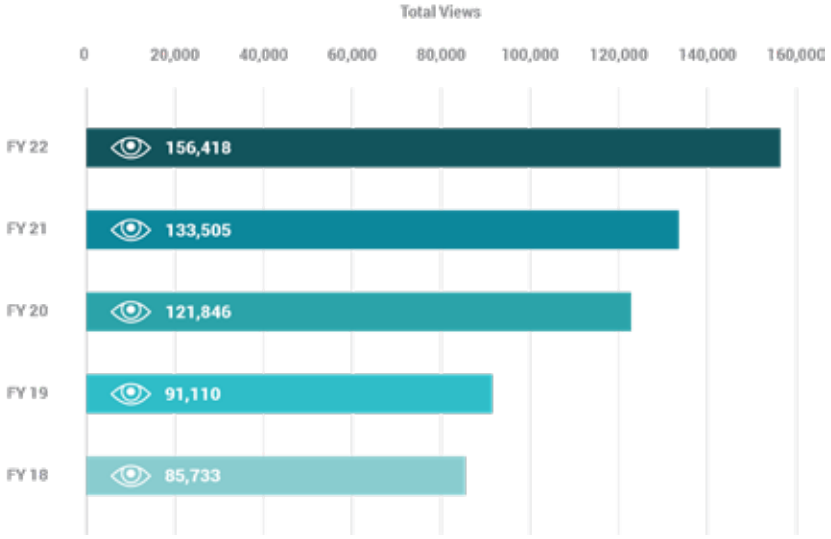
2022 ARUP fellows and residents

ARUP's Educational Offerings: A Roundup

ARUP's Institute for Learning (IFL) team works hard every day to create, refine, and publish quality, no-cost training materials for medical laboratory scientists (MLSs) and physicians, all available at arup.utah.edu. Each year, the IFL produces four live webinars, publishes an average of 35 CME and 40 P.A.C.E.® courses, creates 14 LabMind podcast episodes, and hosts a weeklong anatomic pathology medical conference in Park City, Utah. Here, we highlight the IFL's growth and achievements in recent years.

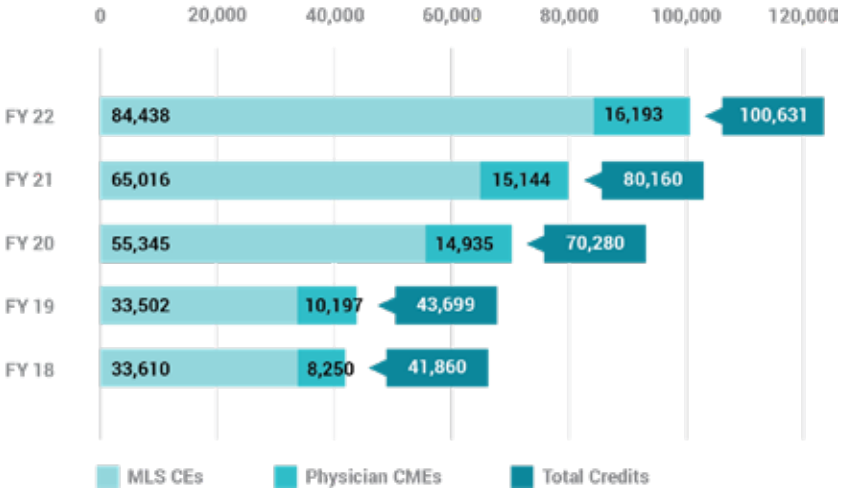
Video and Course Participation

In the past five fiscal years, the number of video views (shown in graph to the right) and course completions has grown significantly.



Continuing Education Credits Granted

Continuing education (CE) credits are granted to MLSs upon completion of P.A.C.E.® courses, whereas continuing medical education (CME) credits are granted to physicians. This fiscal year, more credits have been granted to MLSs and physicians than ever before.



Topics

The IFL covers a diverse range of relevant topics in its lectures, webinars, and LabMind podcast episodes. Here are some of the most critical topics covered in the past few years:

Award-Winning COVID-19 Content

Experts at ARUP produced materials on various topics related to COVID-19 to guide medical professionals and educate the public.

Update on the Laboratory Diagnosis of COVID-19

Kimberly E. Hanson, MD, MHS, presented updates on the diagnosis and surveillance of COVID-19 in December 2020, a time of rapid change in COVID-19 testing.

The Lab Must Go On

In March 2021, Jonathan R. Genzen, MD, PhD, presented on the shifting dynamics of laboratory medicine caused by the COVID-19 pandemic and provided insight into laboratories' adaptations to the crisis.

The COVID-19 Vaccines from Pfizer-BioNTech and Moderna: What's in Them and How Do They Work?

The COVID-19 Vaccines from Johnson & Johnson and AstraZeneca: What's in Them and How Do They Work?

In two short videos produced in December 2020 and March 2021, Genzen explained how each of the COVID-19 vaccines offered by Pfizer-BioNTech, Moderna, Johnson & Johnson, and AstraZeneca work, providing vital education about the vaccines. Each of the videos won a Golden Viddy award for excellent and timely content.

An Interview With Dr. Julio Delgado: Personal Insights on Leading a Laboratory During a Pandemic

Brian Jackson, MD, MS, and Julio Delgado, MD, MS, discussed the important role of laboratory leadership in the healthcare industry during the early months of the pandemic. This podcast episode received a Golden Viddy award.

Endocrine Testing in Transgender Individuals

Joely Straseski, PhD, MS, MT(ASCP), DABCC, led a project to adapt endocrine testing to fit the needs of transgender patients and patients receiving hormone therapy. Following her project, she shared her insights through ARUP's educational channels.

Inclusivity in Laboratory Medicine: Endocrine Testing in Transgender Individuals

Straseski explained the importance of choosing appropriate testing for transgender and nonbinary patients and highlighted ARUP's changes to endocrine testing to better suit transgender patients and patients receiving hormone therapy.

An Interview With Drs. Joely Straseski and Jenna Rychert: How Transgender Medicine Is Changing Laboratory Practices for the Better

In this LabMind podcast episode, Straseski and Jenna Rychert, PhD, discussed the importance of reexamining historical practices related to patient demographic information, reference intervals, and terminology to fit the needs of transgender patients.

Staffing Crisis

During the Great Resignation, ARUP staff members worked to recruit and retain laboratory employees and released educational materials to help other leaders in the healthcare industry with their staffing difficulties.

Addressing the Laboratory Staffing Crisis—Expert Strategies to Recruit and Retain a Stronger Workforce

In June 2022, Tyler Tinling, MBA, Misty Smith, MSOL, MSAP.IO, CSP, and Tony Smith, BS(HCM), MLT(ASCP), hosted a webinar to share their expertise in building and retaining a strong workforce.

An Interview With Stephanie Whitehead: Keys to Recruiting and Retention in a Tough Labor Market

Stephanie Whitehead, MBA, MPH, MLS(ASCP), discussed the ongoing healthcare recruiting crisis with Jackson on LabMind and offered recommendations for recruiting and retaining exceptional staff.

What do our viewers say?

Here's what users have to say about ARUP's CE and CME courses:

"Diversity in topics and rarity of some topics compared to most CE opportunities."

—Breland Hockman, PhD, Supervisor and Clinical Trials Prinicipal Investigator, LetsGetChecked

"Authoritative discussions of timely topics."

—John Steele, MD, PhD, Pathologist, Medical College of Georgia, Augusta University

"Top-quality lectures, relevant topics, ease of access. The topics are relevant to things we see as practicing pathologists every day."

—Mary Henry, MD, MBA, Adjunct Assistant Professor, Saint Louis University

"Free, innovative, current."

—Gayle May, Laboratory Manager/MLS, Daniels Memorial Healthcare Center

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