Just Trace Evidence from Classroom to Courtroom

Introduction [00:00:05] Now this is recording RTI International Center for Forensic Science Presents Just Science.

Voiceover [00:00:18] Welcome to Just Science, the podcast for justice professionals and anyone interested in learning more about forensic science, innovative technology, current research, and actionable strategies to improve the criminal justice system. In Episode six of our Strengthening the Forensic Workforce Season, Just Science sat down with Dr. Brooke Kammrath, a Professor of Forensic Science at the University of New Haven, and Dr. Tatiana Trejos, an Assistant Professor in the Department of Forensic and Investigative Science at West Virginia University to discuss career paths for individuals trained in trace evidence analytical methods. Trace evidence analysts are tasked with extracting information from small quantity samples like glass, paint fibers and gunshot residue to shed light on what possibly occurred at a crime scene. These analysts utilize chemical, microscopic and physical comparisons of evidence to make conclusions and provide investigative leads. Listen along is Dr. Kammrath and Dr. Trejos discuss available collegiate courses such as microscopy and testimony practices for those interested in trace evidence analysis and what it takes to succeed. This episode is funded by the National Institute of Justice's Forensic Technology Center of Excellence. Here's your host, Gabby DiEmma.

Gabby DiEmma [00:01:23] Hello and welcome to Just Science. I'm your host, Gabby DiEmma, with the Forensic Technology Center of Excellence, a program of the National Institute of Justice. Throughout this season, Just Science has been discussing forensic science programs and NIJ funded research at universities accredited by the Forensic Science Education Programs Accreditation Commission or FEPAC. Here to guide us in our discussion is Dr. Brooke Kammrath, a Professor of Forensic Science at the University of New Haven and Assistant Director of the Henry C. Lee Institute of Forensic Science and Dr. Tatiana Trejos, an assistant professor in the Department of Forensic and Investigative Science at West Virginia University. Brooke, Tatiana, welcome to the podcast. It's great to have you on the show.

Brooke Kammrath [00:02:06] Thank you so much.

Tatiana Trejos [00:02:07] Thank you, Gabby.

Gabby DiEmma [00:02:08] Brooke, I'd like to hear a little bit more about your professional background and your current roles.

Brooke Kammrath [00:02:13] I'm a Professor of Forensic Science at the University of New Haven and the Assistant Director of the Henry C. Lee Institute. So at the University of New Haven, I teach courses in Criminalistics and Trace and Chemical Analysis. I teach both undergraduate and graduate classes. And then at the Henry C. Lee Institute, we do a range of different activities from presenting webinars and trainings for police officers, as well as forensic scientists, and give courses for all ages from high school students through professionals in the field on a range of different forensic science topics and areas.

Gabby DiEmma [00:02:55] Excellent. And Tatiana, tell us a little bit more about your professional background and current role at West Virginia University.

Tatiana Trejos [00:03:01] So I was a forensic practitioner for various years before joining academia. I had a Master of Science in Forensic Science and I ended up teaching chemistry. So being able to join academia really put together my two passions in chemistry and forensics. And I have been teaching forensic chemistry in the last six years near West Virginia University. I teach at the undergraduate, master and Ph.D. programs in various courses that deals with instrumentation that we use in forensic chemistry for the undergraduate students. In trace evidence, I teach a class at the undergraduate and also a class at the graduate level in trace evidence that has also a heavy practical component on laboratories so we do everything from crime scene and breaking things at the crime scene to study the transfer of trace evidence to analysis in the laboratory and then presentation in the courtroom. In the Ph.D. level, I teach a class on research design that teaches students on how to apply the different experimental designs in statistical analysis for doing interpretation in various disciplines of forensic science.

Gabby DiEmma [00:04:19] My background is chemistry. I was chemistry first and then kind of discovered that love of forensic science as a way to apply that chemistry education.

Brooke Kammrath [00:04:29] You know, the draw for me was the application of chemistry, but it does have such unique problems that are different from analytical chemistry or any other scientific discipline. So the fact that it's analytical chemistry plus some really challenging problems that, you know, not even just the small size of the sample, but the degradation and where it could have come from, it just makes it just the most fascinating form of problem solving that I think we can do.

Tatiana Trejos [00:04:55] I agree with Brooke. I think one of the things that I really love of what I do is that we are forensic chemists, but we have to deal with so many other disciplines in a daily basis so that we have that continuous feedback from many other disciplines, from computer science, from statistics, from medicine, from physics and because there's something that we have learned over the years is that forensic science problems are not solved with one person or one discipline. The more multi-disciplinary we become, the better we can address those challenges.

Gabby DiEmma [00:05:32] So diving a little bit into today's discussion, I wanted to see if one or both of you would like to briefly define for our listeners what is trace evidence analysis and what types of evidence do trace analysts typically work with?

Brooke Kammrath [00:05:47] So it's interesting because the term trace has been used historically for a very long time in terms of the use of the word trace as a noun. So in forensic science, we use trace mainly as an adjective. So trace evidence, and usually it describes material evidence that has a small size to it or is in a small concentration. However, when you think about traces in their original intent from Locard or Kirk or some of the original pioneers in our field, it's more a vestige of a past event. So something that was left behind, like no trace was left, or it vanished without a trace. So when I think about traces, and I teach about traces, I generally talk about it and teach in that vein, as fingerprints are traces, DNA is traces. And you'll see that more and more people are using that term of DNA traces or finger mark traces. Especially in Europe it's becoming a little bit of a thing called trace-ology that's happening. But when we really talk about trace evidence, we're talking about smaller sized evidence that gets transferred. So another common term would be transfer evidence.

Gabby DiEmma [00:06:55] So as trace analysts or forensic chemists, what types of skills or quote unquote tools in the toolbox do you need that might be less prevalent in other forensic disciplines?

Tatiana Trejos [00:07:08] So I think trace analysts must have, an outstanding attention to detail and critical thinking. There are many, many different skills but I think those two are very important in that being the area of trace evidence that should be the kind of person that is okay without routines because every case is different and require special consideration during the daily decision-making process. And also we often have to apply a multitude of analytical tools, beginning with microscopic examinations and continuing with various instrumental techniques to combine all the relevant physical and chemical information from the material to make often inferences about their origin. So in my opinion, trace examiners need to have excellent analytical and instrumental skills as well in the laboratory because of the type of nature of cases that we deal with.

Brooke Kammrath [00:08:04] I agree 100%.

Gabby DiEmma [00:08:07] Both of your universities have amazing FEPAC accredited forensic science programs, and I would love to hear more about them and the sorts of courses and things that they offer.

Brooke Kammrath [00:08:18] So University of New Haven has longstanding FEPAC accreditation and I think ultimately what that provides for our students is confidence that they're getting coursework and content that will lead them to success. Success in forensic science or other careers. And then classes that they take are your biology, chemistry. So they take organic chemistry, physics, calculus. I mean, it's -forensic science is a science and so all FEPAC accredited programs require hard sciences as the fundamental basis for understanding this and being able to evaluate any part of forensic evidence. And then we have courses in physical methods. That's the first laboratory class our students have where they're learning microscopy and fingerprints and question documents, firearms, so more of the pattern evidence is but microscopy is thrown in there as well because it is so fundamental. And so it's - we teach it first. The students in our university, then go on to a forensic biology class which covers the body fluid and forensic serology all through DNA. And then the third required class in the series would be forensic chemistry and that will involve both the chemical analysis of traces such as fibers and paint, as well as drugs and toxicology. We also have required crime scene investigation class. We have a really nice crime scene house. So the students are educated in a variety of different skills from photography and note taking, and then they also have the opportunity to take restricted electives, which are higher level forensic science courses and things such as forensic microscopy, toxicology, drug chemistry. But we also have some real specialists at our university. So we have a class in animal cruelty taught by Professor Virginia Maxwell, who is using trace evidence and a variety of other forensic tools and applying it to the area of animal cruelty cases. We have a really nice program in forensic genetic genealogy that Dr. Claire Glynn has developed, and so students get to take courses in that. We have anthropology and taphonomy, we have a range of different electives on a variety of specialties that the students get to take. And then the last thing is there's a required capstone class for our undergraduates, and so that they get some experiential education. And so that will either include an internship or a research project. And usually it's about a 50-50 split. Although during the pandemic, it definitely shifted more towards research because of the lack of availability of internships during the pandemic.

Gabby DiEmma [00:11:07] So Tatiana, tell us a little bit about the program at West Virginia University.

Tatiana Trejos [00:11:13] Sure. So again, our programs are FEPAC accredited. So I agree with Brooke, that really brings a seal of quality to our programs and following the standards that we can meet the demands for the workloads. So they have a lot of rigorous science courses in the first year at the undergrad level, math, statistics. And then in the last year, they get a lot of heavy hands-on courses in forensic chemistry, forensic biology and forensic examiners, which are the three major of our undergrad programs. So forensic chemistry, they take classes about fundamentals of instrumental analysis as applied to forensic laboratories forensic analysis. We have a course on explosives and fire debris and a course dedicated to drugs. We also have a course in forensic toxicology. I teach the classes in forensic trace evidence. At the biology area, they have a lot of courses focus on DNA. They also have some fun electives like entomology and chemistry of the grave, in which they get to experience all sorts of things related to death investigations. And in the forensic examiner major they developed a lot of courses in the areas of fingerprints, firearms examination. We have a large ballistics laboratory, including a shooting range. So we get a lot of experiential learning as well. Pattern evidence with wear impressions. And something that also is unique in our programs is the heavy hands-on experience. So for every class that they take, they have a practical component. And so one of them is the crime scene investigations they had to take at the undergraduate level at least two courses of crime scene in which we have like a crime scene complex. So we have four crime scene houses, each one with several levels or like basements and different floors. So they really get to experience real life situations. So our professors have the experience in crime scene for many, many years, so they get really tough on them and the crime scene final exams are done in a day where they know that they might have been called that week, but they don't know what time of what day so they have to be attentive and often they will be called at 1:00am, 3:00am in the morning and spend the whole night processing a crime scene in the rain or snow in real life situations. So they really get to experience how it's like to make decisions when you are tired and cold and under pressure. We also have a photography laboratory where the students learn how to process the different evidence that they collect at the crime scene. And also court testimony is one of the most important classes that they receive at the undergraduate and also at the graduate level in different courses in which they get to experience what it's like to be presenting your opinion in front of actual judges and lawyers that will make your life difficult. So you have to be able to stand and to process that correctly. And we also have capstone and internships. There is a mandatory internship. The last two years of the undergrad program in which they have to do about 270 hours, and this year we have placed about 78 students in different crime laboratories and different agencies. And some of the students that want to pursue grad school, they often do their internship as research program over the summer in order to gain those skills for research and really learn whether or not they have that research bug that will be very important for grad school.

Gabby DiEmma [00:15:08] I love the idea of the on-call crime scene exam. Real life conditions. It's a great way to prepare students for the workforce. I'd like to switch gears now and talk a little bit more about research and any research that you and your students have been doing with NIJ funding and focused on trace evidence topics.

Brooke Kammrath [00:15:29] So I have NIJ funded research. It's a project on using particle correlated Raman spectroscopy for soil analysis. So Raman spectroscopy is a technique where you're measuring the molecular chemistry. You're identifying the material based on the bonds that the molecules have and with particle correlated Raman

spectroscopy, it combines image analysis so we can take a image of the particle and measure its morphology so things such as its color or transparency as well as its size and circularity and pair that with a targeted Raman spectroscopy analysis. And then that combines both the morphological features with the chemical identification, which potentially will provide more information about a soil sample or any sample than would be obtained from either method individually. For example, instead of just getting an overall particle size distribution, we can now with this tool get a particle size distribution by each mineral individually without having to do a physical separation. So my research is evaluating the use of particle correlated Raman spectroscopy for forensic soil analysis. I have a number of students working on this project. My first two graduate students graduated a year ago. One is in law school. She found a different passion in the criminal justice system. And so she's doing great in law school. And my other student is actually now at a company that uses particle identification for pharmaceutical identification. So kind of a forensic investigation in the pharmaceutical industry. But for most of my students, they are going to stay in the forensic sciences.

Tatiana Trejos [00:17:16] Well, our program has been also very fortunate to receive funding from NIJ in various areas of forensic science, which are great benefits to our students and collaborators across the state and federal agencies and private sectors and the criminal justice system as a whole. In my particular area of trace evidence, we are working on three major projects. One of them has to do with gunshot residue. So those are residues left behind when a firearm is fired. And often we can collect those residues from different areas and surfaces. But the most common is the hands of the person of interest, the person that is suspected to have been handling the firearm. So the methods that we have developed are screening tools that are not available in the field. We have excellent consensus base with a lot of scientific foundation methods called SEM/EDX and it's a long name but really what is great about that methodology is that it has the capability to look at particles that are as small as less than one micron in size. So the morphology of that particle and the chemical composition can really provide a good confirmation that those particles originated from a firearm rather than other environmental residue and traces. But it's the only method that is used in the forensic laboratory and even though it's great, it is time consuming per sample and sometimes we have multiple samples in a case, so turnaround times are a little bit complex in that area. So what we have been working in the past years is developing methods that can be used in the front end at the crime scene. Portable instrumentation that can provide very quick response time. So we have developed methods that use a laser beam that is very small. So these are called LIBS or laser induced breakdown spectroscopy, and those allow us to detect in 60 seconds or less the elemental profiles of gunshot residues collected from a hand and what we do to complement leads because it's not as confirmatory as SEM/EDX because we cannot see the morphology components is that we have coupled it with another technology that is called electrochemistry, that uses disposable sensors that are about a centimeter long, and they can be attached to an apparatus that is as small as an iPhone. And so with electrochemistry, we can detect inorganic and organic compounds that are present in the residues. So when we combine LIBS with electrochemistry, we can do the analysis in a single sample in less than 3 minutes, and we can achieve accuracies over 90%, which is great for a screening tool. So you can put this one in the front end of your workflow to make better decisions at the crime scene and what's needed at the laboratory. And you can use them at the laboratory also to make more informed decisions and kind of triage the number of samples that are going to be included in your case and only confirm those that are necessary. So our hope is that this technology can really bring down the time or response in these types of investigations. Another of the projects that we are being working on is what we call fracture rates. So there are many materials that fracture or

separate in a crime. Let's take the example of duct tape, right? That is used a lot for gagging or binding victims or explosives, improvised explosive devices. So when a piece of tape is broken from the roll, there are possibilities that the edges you can find the roll and you can find the piece that was broken in the victim or in the suspect and you can kind of compare them together. You can think about it like putting a puzzle together. So physical fits can become very valuable in an investigation because they have a high probative value, because there is a common belief that it is very unlikely that two pieces will fit back together with distinctive characteristics just by chance. However, regardless of the probative value that these have, there are very few scientific foundations that demonstrate these principles. So one of our research has to do with that. We are doing empirical experiments and very, very large databases of thousands of these type of materials, tapes, textiles, plastics that are often found in crime scenes, of physical fits. And we are developing first methods that are systematic for doing that quantification and providing not only the opinion here they look like they fit, but we are also providing a method that kind of quantified the quality of the fit. Is it 90%? Is it 80%? Is 60%? And if so what that means. So we are helping in building up that scientific validity. And the last project that we are working with has to do with microscopic amounts of glass in trace that can be glass and paint that can be transferred during different types of scenarios like hit and runs, break and entries, and we're working on the interpretation aspect. So one of the things that are very necessary to use quantitative likelihood ratios and interpretations in this type of evidence is having background knowledge of how common it is to find these traces in the regular population. And there has been a large body of knowledge that is what we use in our field but has been done mainly outside of the United States, in Europe, in Australia, in other countries and continents that do not necessarily reflect the reality and socioeconomical aspects of the United States. So we're building those background databases in the United States in that collaborative project with Sam Houston State University. So we are evaluating those backgrounds, in small cities, big cities with different geographical and socio economic realities here in the United States.

Gabby DiEmma [00:23:33] Very cool. You guys are working on a lot of different really cool projects. In your experience, do you find that students that participate in these research projects with you, are they more likely to pursue graduate studies or go on to continue with research? What do their career trajectories look like for students that are engaged in this research from the get-go?

Brooke Kammrath [00:23:55] Generally, when a student, an undergraduate student does research with me, it does generally lead to graduate education. So - and it might not be in forensic science, so I have students who are going to medical school next year because they want to be pathologists. I try to teach students good research and problem solving and skills that will make them good scientists, be it if they're going to be in research labs or in in practitioner labs or becoming lawyers you know, having a good forensic education, I think is useful there as well. But most of my students do - undergraduate students do continue on for master's or Ph.D. programs. And if they're lucky, they get to learn from someone like Tatiana.

Tatiana Trejos [00:24:36] Thank you. Yes, in my case, I agree with you, Brooke. Research is fostering that creative problem solving. So I definitely think that students that do research, whether or not they decide to stay later on for grad school, they leave the program with a different set of skills that prepared them better to do that problem solving or to get like even those soft skills that you learn when you do research like teamwork and leadership and sometimes learning how to take orders and sometimes learning how to speak up and how to do documentation and research and what to do when you don't get

what you want, right? They learn a lot of skills that are analytical and important for their workplace in the laboratory or later on in research. They also learn the day to day skills and how to solve problems and how do you think outside the box, how do you know when you've hit a wall and you need to take another direction.

Brooke Kammrath [00:25:37] William Barrett wrote this book called The Illusion of Technique and in it he describes the difference between a technician and a scientist. And he says the technician is someone who knows how to follow a method, whereas the scientist is someone who knows what to do when the method doesn't work. So they know how to problem solve and develop new methods. So I really pride myself in teaching my students to become forensic scientists and not forensic technicians. And I think research is really the ideal place to make that happen.

Gabby DiEmma [00:26:07] You both and your students are involved in all of these amazing projects, and I'm sure it takes a lot of time, what are the outcomes of those? Are your students going to conferences, becoming parts of professional organizations? Are you working with your local, state and federal agencies to transition these technologies into practice?

Brooke Kammrath [00:26:31] The ultimate outcome for me, University of New Haven, is a teaching institute, so it's not an research focused university, so really my number one outcome is my students leaving better scientists. So that's the most important thing to me. Second to that is publications. This would be, right? It's adding to the body of knowledge of forensic science, and that is incredibly rewarding. So through professional presentations or publications, I encourage all of my students to present and I'm very involved at Eastern Analytical Symposium and with the Society for Applied Spectroscopy. So through those organizations in the analytical chemistry community, but as well as with my regional organizations, so Northeastern Association of Forensic Scientists and the American Academy, the students generally present their research. I really encourage them to do that. So I work very closely with collaborators in a variety of different agencies, from state crime labs to federal agencies. I feel as an academic, I haven't worked in a crime lab. I have done consulting with Dr. Peter De Forest, but I haven't worked in a crime lab and I think not having that practical day to day experience, I try to supplement that with partnering with practitioners as much as possible. A lot of my research not involving trace evidence but involving portable instruments. So I'm very involved with the portable instrumentation and that has been very exciting to see various libraries my students and I have built or applications being utilized and that's very exciting. So I have a project now where we're building a fentanyl analog library on a portable GC-MS instrument, and we are going to be deploying to the Marines this summer. So it's very exciting that something my students are building is going to be actually used in military forensics.

Gabby DiEmma [00:28:26] That's excellent. And Tatiana, what about the research that you guys are doing?

Tatiana Trejos [00:28:30] So I agree. Like, I think one of the most important things is making sure our students get exposed as much as possible, that they build their own career and networking is quite important. So I think the forensic practitioner inside of me is always dragging this project to actual applications, things that eventually can be applied. And I understand that being part of the system that doesn't take a year or two, it might take five years, six years or seven years to get there. But there's nothing more rewarding to see that final stage when an idea becomes that research and that research became an application that is useful and is helping that services our criminal justice system. So that's

something that I try to do in every project, is to have very early on, even in the design of the experiments, to have feedback with practitioners, crime laboratories and different agencies and have the students be involved in that process. And I think that changes completely their perspective on why they are doing things, what are the relevant things and what are they competing against instead of what are the challenges, what are the technologies that if used instead of what is needed out there. So trying to keep them very away all the time of research is something I encourage them is don't let two or three weeks pass by without you reading a new paper in your field so that you are aware of what is going on, what are the challenges, what are new technologies that have been proposed to make our science better? And in that process of collaboration with the different laboratories and agencies, they learn a lot. Learning from that feedback and critical process that takes into account when you propose an idea and you know that most of the time you find resistance from the community, but then how you can demonstrate and provide and minimize that resistance by letting them know the value. Because otherwise, if you don't do that early in the process of the research, it's going to be more difficult to adopt the technology later on. So in terms of outcomes for our grad students, publications is very important, being exposed to rigorous peer review processes. So understanding that when they publish they have gone through that consensus based on the quality of what they are publishing is worth to being sharing with the rest of the community and building that sense of responsibility when you publish something. And of course, networking and presentation at scientific meetings. I think that's a great way of learning from other colleagues and a rewarding experience for them to be able to share what they have been doing to share and, you know, be proud of what they have been working very hard during the preparation of a poster or presentation.

Gabby DiEmma [00:31:35] That is a perfect note to end on. And so I'd like to thank you both, Brooke and Tatiana, for taking the time to chat with me and for joining us on the podcast to talk about forensic science and research and all the fun things that we do.

Tatiana Trejos [00:31:48] Thank you, Gabby.

Brooke Kammrath [00:31:49] Thank you so much.

Gabby DiEmma [00:31:51] If you enjoyed today's episode, be sure to like and follow Just Science on your podcast platform of choice. For more information on today's topic and resources in the forensics field, visit ForensicCOE.org. I'm Gabby DiEmma and this has been another episode of Just Science.

Voiceover [00:32:09] Next week, Just Science sits down with Dr. Karen Scott and Dr. Jarrad Wagner to discuss forensic toxicology education and careers. Opinions or points of views expressed in this podcast represent a consensus of the authors and do not necessarily represent the official position or policies of its funding.