N1: Hi listeners! Welcome back to another episode of Carry The One Radio. My name is Isaac

N2: And I am Marilyn.

N1: Today, we are venturing to the dark side and diving deep into the murky world of scientific fraud - Buckle up folks, because we are going to talk about some spicy scientific scandals and we are not afraid to spill the beans.

N2: Ohhhhh. Exciting! I love gossip and tea, especially in the scientific world. But before we start, I think it's important that we define what scientific fraud is. First, imagine a recipe for scientific success: You start with an observation, add a pinch of hypothesis, a dash of experimentation, and a sprinkle of statistical analyses, and out comes a finely-measured, precisely-brewed piece of scientific finding that is ready to be shared with the whole world.

N1: However, the scientific process can be extremely tedious and frustrating. Experiments don't always go according to plan and the results are often perplexing and contradict expectations. At that point, there really is nothing you can do but go back to the drawing board. But, today we're going to talk about people who choose "alternative" routes of making science easier for themselves.

N2: In this two-part series on scientific fraud, we will be speaking with three experts who specialize in cracking down on scientific fraud and misconduct. Our first expert is Dr. Elizabeth Bik, an image forensic scientist with a super sharp eye for image manipulation. Our second expert is Dr. Leonid Schneider, a scientific journalist who reports on matters related to research integrity and ethics on his website- "For Better Science". Our final expert for the episode is Dr. Leif Nelson, a Professor at UC Berkeley, who specializes in using mathematical and statistical methods to spot anomalies in data.

N1: We are super excited to have Dr. Bik, Dr. Schenider, and Dr. Nelson here to take us through what scientific fraud is and why people do it. So Let's get right to it!

[CTOR jingle]

N1: Hi Dr. Bik! We are super excited to have you. Could you briefly introduce yourself to our audience?

Elizabeth: Hi, I'm Elizabeth Bik. I am born and raised in Netherlands, and I did my PhD in the Netherlands I moved to the United States about 21 years ago. I worked 15 years as a microbiologist at Stanford University as a staff scientist. Then I worked two years in industry. And in 2019, I quit my job because I found out I have this talent to find image duplications in scientific papers. And so now I do this full-time.

N2: Wow so you're kind of a scientific fraud-finding guru. What would you say are the legal definitions of scientific fraud?

Elizabeth: Scientific fraud, misconduct, is defined in the US as one of three things. so it's a very narrow definition. It's plagiarism, falsification and fabrication. Falsification is when you obtain results and you change them a little bit, so that would not necessarily reflect interpretation of results. And fabrication is where you just make up results. You don't do an experiment, you just make some numbers up and or, you know, or, or you, yeah, you, type in some, some numbers in a spreadsheet and make a nice graph.

N1: To explain why fraud exists in the scientific community, let's pull back and take a look at the scientific review and publishing process. When a scientist makes an exciting discovery on a lab bench, the results aren't released to the world immediately. The scientist has to first write a manuscript, which summarizes the results, methods, and interpretation of their data. The manuscript is then submitted to a scientific journal for publication but before that, it has to undergo a process called peer review.

Elizabeth: Peer review is a process where the editor of the journal will look and try to find other people working in the same field, trying to get them to review the paper. They will look at the paper, the manuscript, give feedback, scientific feedback like, you know, I feel this, this, um, conclusion does, is not supported by the experiments or, or, I, I didn't understand this particular part, or I feel you, you've left out this hypothesis and you should add that. So that can take a long time. Sometimes the paper gets rejected because the editor doesn't like it.

N2: Peer review is an integral part of the scientific publishing process. It is like a quality check for scientists to ensure that scientific papers are reliable, accurate, and worthy of publication. If the reviewers spot any inconsistencies, errors, or signs of misconduct, they will raise these concerns to the journal editor. In some cases, if the errors are particularly egregious, they would recommend the paper be rejected. In this way, peer review is the first line of defense against scientific fraud.

N1: So if peer review acts as a safeguard against scientific fraud, why do some papers still slip under the radar?

Elizabeth: Because peer reviewers are not looking at a paper with the idea that it could be fraud. At least maybe my work has made them a little bit more alert. But I think scientists tend to really trust each other. We tend to trust if we see a manuscript that we need to peer review and for example, it says, oh, we looked at 70 patients and we, you know, draw some blood and we did some analysis that these 70 patients really existed. We assume, okay, this is the paper, these are the results. And most peer reviewers will just look at the results assuming that the whole paper is true.

Another thing is that peer reviewers are not paid; it's a volunteer job. I feel when you do a volunteer job, you are not expected to do your job as well as if you are a paid person. If I was a paid misconduct detector at a journal, I would do my best to look at the paper from all angles. But most peer reviewers, they are professors or postdocs and they have a busy schedule and they sort of do it on the side, maybe on a Saturday evening, while they really wanted to watch something on television or, doing something else. But yeah, they have to peer review this paper. And so you cannot really expect people to, to dive in these papers and look at that from that angle.

N2: Yeah, totally. I've even been asked to peer review papers before, and I'm excited and honored to be a part of this system, but I also recognize it's not a foolproof system. Like if there's a type of experiment that they conducted that I personally have never done, I am not 100% sure what to look for.

In some ways there has to be some trust in the researcher to have presented me with reliable raw data, or data that hasn't been analyzed or altered in any way.

N1: For example, a friend asks you to taste test a dish they just made. But it is a Turkish dish and you've never made or really had Turkish food before. So you aren't really sure if this tastes good or not. Should it be this sweet? Should it be cold? Are the colors right? Is there supposed to be that much coriander? So you have a limited scope of what to critique here. But if a friend comes to you with Mexican food and you happen to make a lot of Mexican food then you can really offer more nuanced feedback because you know what to look for, what it should taste like, and you know what spices should be there to make it better.

N2: So… Is there a good way to judge whether something is trustworthy? Let's say it is coming from a really reputable journal?

Elizabeth: In general, yes. But there are some famous exceptions. So, I think the famous exception, for example, would be a paper published in the Lancet that claimed that autism was correlated to MMR vaccinations.

N1: For those who are not aware, Lancet is THE most frequently cited general medical journal. In 1998 the Lancet published a paper by Dr. Andrew Wakefield and his colleagues in which they suggested a potential link between the measles, mumps, and rubella (MMR) vaccine and the development of autism in children.

Elizabeth: And that paper got retracted. it was fabricated and falsified, and still has a huge influence on the anti-vax movement in the US and people still believe that, even though it was retracted and it was in the Lancet, so it has to be good. So yes and no.

[Music break]

N1: So now you might be wondering… Why do scientists commit fraud? I mean… Scientists want to understand nature and how the world works. Faking data and making up stories go against every principle that a scientist should uphold. So why do people still do it? Why did Dr. Wakefield publish fake data?

N2: We talked to Dr. Nelson to find out…

Leif: I'm a professor at UC Berkeley, in the school of business , but my background and training is in experimental psychology, social psychology in particular, within that domain. And where I am currently

in my career I spend a lot of time thinking about research methods and the best practices or rules or guidelines that we might have in a field that would encourage scientists to produce the highest quality of work.

N1: So why do you think scientists commit fraud?

Leif: I can only speculate. People commit fraud because it is a very inexpensive way to help themselves potentially a very great deal. The incentives currently all point towards there being tremendous professional value for publishing new and interesting findings, right? So if you knew that if you could just get the result of some study to look good, that you could publish a paper in Cell, you would say to yourself, that is pretty good to me.

Well, aren't people gonna be in this self-correcting world of science that it's all gonna be found out and someone's going to notice? And I would say, no way, no there's no way that anything close to the majority of fraud is being found out. Most published papers go unread and uncited. So if there's fraud in there, it's definitely not being fixed because it's definitely not even being read. When you get to the stuff that is being read, most of it is read just for the conclusions.

Like, oh, what do they say that they found? Right? Write it down, next paper. For some small minority of that, of that set, there's people who don't just read it for the conclusions, they read it for the methods or the, the style of analysis or the approach to answering questions. In order to identify fraud, one has to read, read a paper or a study well enough to understand what's going on, to take in account all of the methods and all of the data, and then look at it in some way that is very idiosyncratic and say, I don't, I don't actually think that's possible. I think a fraudster could quite comfortably fabricate data and publish that data knowing that in most journals, most of the time they'll be protected forever. No one will ever notice it.

N2: Because detecting fraud in papers is so difficult and requires so much effort, it is really easy for some scientists to give in to the temptation to fudge the data ever so slightly to fit their own narratives. Picture this, you can put countless hours, pouring your blood, sweat, and tears into an experiment, and have the results be not so perfect. Or, you can press a few keyboard strokes, open up Photoshop and get the perfect image every time. And you probably won’t get caught. Which one would you choose?

[Music break]

N1: Dr. Schneider has been actively following and reporting cases of scientific fraud and misconduct and documenting them on his website for over 15 years. He has a bit to say on why NOT to commit fraud.

Leonid: What motivates scientists not to commit fraud? Because the environment, the scientific merit is just, it's so conducive to fraud that you have to have a strong motivation not to commit it. It's very easy. Um, the pressure is huge. You need to publish papers, you need to deliver results, you need to please your boss. Foreign students in the US need to their visa, which depends, again, on their result performance. So, um, yeah, it's, it is a strange of character to not to commit fraud

The scientific journals, they operate, well, like, editorial offices for fiction books. They want a story. So they tell you your story is not good, uh, go away or your story is kind of ok. You have to improve it and add a bit of plot twist, and then we will probably take it and publish it or whatever.

N1: yeah, there is always this talk about " good storytelling" when it comes to paper writing which…is good when you're trying to make sure your research gets noticed, and is not just a giant wall of unintelligible data for the rest of the world to sift through….

N2: totally, but taken to the extreme, this emphasis on "storytelling" might create an environment that rewards scifi more than sci-fact.

N1: Do you notice more fraud being committed by junior professors versus more senior professors?

Leonid: Once a fraudster stays over the fraudster, and so the big professors, there used to be PhD students, so already they started feeding already back then. But the difference is, um, once you become a pi, you don't work at the lab anymore. Sometimes they still continue to fudge data. Uh, there were cases like this where PIs actually taught, uh, the lab members how to falsify data. Generally, you don't have to fake data yourself as a pi. You just have to apply enough pressure on your people, and they will fake you anything you want.

N2: Is there a difference between pressuring students to fake data and faking data yourself? Who should be responsible in that case?

Leonid: I don't think there's a difference between if the PI him or herself sits down and falsifies the figure in Photoshop, or if the PI terrorizes a student so much that they falsify the figure, it comes with fake data doesn't matter anymore because this person is a, this PI has no place in science either way. Either because they are a fraudster or because they're a bully. Bullying and bad science always go hand to hand. In labs where that is a lot of bullying, there will be a lot of fraud because people are just afraid to, to, to, to anger the boss.

And that's why it's also connected to bad science because when you, when you achieve this power, I mean, you run your lab like a little, like a dictator. You bully your people into faking data and humiliate people who don't produce the right results.

N1: What would your advice be for trainees that are in a situation where they are experiencing this type of bullying?

Leonid: Well, I can say the only way is to leave the lab and, uh, ideally is to report the PI for bullying. Uh, because if they stay it will get worse, you know, in any case, and they shouldn't trust that, that they will change the PI or the PI will, uh, see how hard they work. definitely, they should leave.

Yeah. So my advice for people, if you want to stay in science, you need a good mentor. People who support you. If you don't have them, you will never make it in science. Um, so this is very important. If

they are end up in a bullying lab, it means you have no mentor. You, you have a sadist who will torture you. So leave, find a better lab or leave science. But you can't stay.

N2: Many institutions come with their own Office of Ethics and Compliance, which is a governing body that handles alleged reports of improper research activities. Whistleblowers who uncover evidence of fraud can file a complaint anonymously which leads to an investigation into the alleged misconduct. Unfortunately, these policies are by no means perfect and sometimes, junior researchers will face retaliation.

OK so it sounds like there are a lot of different motivations hanging in the balance which lead to scientific fraud.

N1: Yeah, and it seems that there is a lot of gray area when it comes to what's considered fraud and what's not.

N2: So, is there any example that's like ~super~ egregious, black and white, totally blatant fraud?

N1: Have you heard of paper mills?

[Music break]

Leonid: So paper mill is basically this, it's a couple of people who fabricate papers out of thin air, out of nothing. So some pictures they have stolen somewhere or whatever, write some nonsense text more, which looks like science, and sell these papers completely. Or they sell individual authorships on the paper. Uh, you can buy it on Internet. And, uh, then they, the paper mill publishes it in journals. They submit it to journals, run the peer review and take the money and run.

So paper mills, this discovery which my colleagues made. So, Smut Clyde in particular, but also Elizabeth Bik and several others they worked on this. Our original investigation from January 2020 into this, uh, Chinese paper mill, which has over 600 papers - all fabricated and sold to orders in China.

My colleagues, and one of them, started to, analyze some papers from China, and then he noticed that they all have the same, similar-looking Western blots and said, this is probably a paper mill. And then others came in and said a look. And then they found more and more and more

So these papers are, they look like science, but they look like the journal editors expect science to look,. So the paper mills make it look like, it's like, it's a classical science paper with all this story of a molecular mechanism and what disease it can be treated with it.

N2: But who is buying these fake papers? And why?

Leonid: We initially thought, well, initially we started just doctors in Chinese hospitals, which for some - the Communist Party just said, if you want a promotion in China as a doctor, you must publish papers. Well, imagine you're a doctor in the hospital, you have no access to lab at all, but you will like to get a promotion. So where you get your papers, you buy them.

So now they, they, they, they created this monster industry, and now they're trying to fight it, but it was because they made this requirement. Uh, so in China it got particularly bad. Exactly. Because of this. In other countries, but also in Iran, they have labs, but they don't have much resources. But they can cheaply buy a paper and submit it.

There's a intrinsic problem in science that they like to evaluate scientists, and they need a metrics for that. Because basically nobody is reading papers, especially not the Bureaucrats. They need numbers. So they can put it in the Excel sheet and say, this, per this scientist is a good, prefer well performing this scientist, will we fire? Because, because they're not good enough. And so the metrics are, uh, number of papers is a popular metrics.

N1: What Leonid referring to here is the h-index. The h-index, named after Jorge Hirsch, is used to measure the productivity and impact of a scientist's research based on their citation count. If a scientist has an h-index of 10, it means they have published 10 papers, and each of those papers has received at least 10 citations.

N2: But here's the catch: it's not a perfect measure of true scientific prowess. There are many ways to artificially inflate your h-index. Like Leonid said, you can buy fake papers from a paper mill and boost your paper count. Another way is to affiliate yourself with papers that you are never involved in. Although rare, an academic colleague can sometimes offer a free authorship to another colleague, in the hopes of getting the same offer in the future. Everyone walks away with an extra publication under their belt. It's a win-win! H-index and other similar metrics can be kind of deceiving. But institutions continue to use these metrics to evaluate scientists in performance reviews and hiring processes.

[Music break]

N1: jeez it's so scary to know that some of the papers I read might be totally blatant like this.

N2: I wonder if AI will make this problem even more common, as it's easier and easier to generate these types of fake articles.

N1: Yeah, something to…look forward to…ugh

N2: So, that was the black-and-white example. What about a more gray-area example of scientific fraud? Like something harder to spot or less intentional.

N1: Just as journals may manipulate citations to boost their impact factor, researchers sometimes engage in a statistical sleight of hand called p-hacking where they adjust their data ever-so-slightly to get a more statistically significant result.

Imagine you're conducting a study to investigate whether a new medication is effective in treating a certain condition. You have the control group which are patients who receive a placebo and the experimental group that receives the experimental medication. Lucky for you, patients receiving the

medication show much more improvement than the patients receiving placebo. Now you want to know whether this difference is truly "real" or is just due to random chance. That is when p-value comes in.

The p-value is the probability that the difference you are seeing occurs purely by chance. So, as a scientist, you want really small p-values, for example, a p-value of 5%, to show that there is only a 5% chance that the difference you observe occurs by chance.

N2: Researchers, for some reason, are really obsessed with that 5% p-value. If you get a p-value less than 5%, you'd say that the result is statistically significant. If it is not, well, time to move on because that means your experimental group has no effect. This 5% cutoff is totally arbitrary but many researchers will try to manipulate and analyze data in different ways to get that 5% p-value to show that their results are significant.

N1: The term p-hacking describes exactly that. Lucky for us, Leif and his colleagues were the first to come up with the term p-hacking. So let's talk to the man himself!

Leif: So p hacking was this term that we coined to contain a large category of behaviors that researchers might have. And they're essentially situations where the researchers have many decisions they can make in analysis, typically, all of which are kind of tied for being reasonable. So in my domain of work, we collect multiple measures of something. So you might say, oh, we're gonna ask people how much they like the object, how much they're willing to pay for the object, how likely they are to give it to someone else. And they're all measures of liking in some way. Well, the researcher on the other side could choose to report any of those three. The researcher could figure out how to combine them into a central index of liking. They could take two and drop a third one and say that the third one was not representative, right? And so those are small decisions and sort of apriori you could argue for, for any of them. But if you do it after the fact, it means you have now instead of just a 0.05 chance of getting a significant effect by chance, you would have something higher, a little bit higher maybe.

N1: Okay think of P-hacking as trying to find the best restaurant in your city. You love the pizza parlor downtown and you have your pick already. But the scientist in you tells you to be unbiased so you conduct a totally objective survey and ask your friends for their ratings. You collect the results but then you decide to throw out the ratings of 4 people because you just don't agree with them. And you end up with 5 peoples ratings and they all happen to really love pizza… So guess what you decide is the best restaurant in the city? the pizza parlor in downtown…Surprise surprise. Well you kind of did your own p-hacking here because you cherry picked the results.

Leif: Similarly, you could choose to add control variables. You control for the gender of the participants And all of those are just plausible things that one could do. But when you combine them all, it means that now you have a researcher who can specify and respecify the data each time, get a new P value until they say, oh, I like this specification because it has given me a p value less than 0.05, and it is shown to have a significant effect

And so, p-hacking in that regard is exploiting these undisclosed researcher degrees of freedom, and many, many published findings to be false.

N2: So if they're honest about how they process these data, are these practices acceptable in some cases?

Leif: okay, well, acceptable is tricky. So we start by saying that undisclosed is bad, and in fact, that disclosure is really good. But that's only because when they're undisclosed, we have no idea of all of the other things that a researcher could have done when they're disclosed. It's good because it allows other people to, after the fact, be critical and informed.

N2: Hmm, yeah so definitely disclosing your practices is a step in the right direction. And fortunately, there seems to be a push from grant agencies right now for scientists to be way better about data reporting and methods reporting, so maybe that'll help avoid p-hacking in the future.

N1: This ~is~ a tricky one, though. P-hacking seems like it could occur maliciously or non-maliciously. Like, it could happen because a scientist just doesn't know their stats all that well, and what's acceptable and not acceptable

N2: Totally, so would you define p-hacking as fraud?

Leif: Absolutely not. I mean, I define it not as fraud. Most of it isn't researchers who are trying to do some sinister manipulation. They are well-meaning individuals who aren't really sure the best way to specify their data and their analysis. There is no sinister agent in that model. There are just people who are wandering blindly and like certain outcomes more than others. Fraud, like true academic fraud, someone typing in numbers that they were making up or something like that, that person probably has trouble convincing themselves that what they're doing is totally fine.

[Music Break]

N2: Scientists are human. There are flaws embedded in our methodologies, human biases that can slip through the cracks, and perhaps for some, an ever-present temptation to cut corners. It is important for us to acknowledge these issues in science and confront them head-on to try our best to minimize their impact. This, I think, is the best way for science to improve and adapt.

N1: So what's next for us? What can we do about all this fraud and deception?

N2: Good segue! Stay tuned for our next episode, where we talk about the tools we have at our disposal to detect and deter scientific fraud. Until then, keep your minds open and think critically!

N1: This episode is produced by yours truly, Isaac Chang, along with Marilyn Steyert, Camila Benitez, and Cindy Liu. Thank you to Dr Elizabeth Bik, Dr. Leonid Schneider, and Dr. Leif Nelson for their time and insightful input. You will hear more from them in our next episode too.

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Catch you all in our next episode!