JULY 20, 2022 / FYI those telescope photos are kinda fake

[HALF SECOND OF SILENCE]

[BILLBOARD]

SCORING IN – NETWORK BUILDING

SEAN RAMESWARAM (host): if I was actually shootin’ by the Carina Nebula in a spaceship, would it actually look like that?

JOSHUA SOKOL (science reporter): No, it would not actually look like this. I have to confess, it would not.

SEAN: Whoa.

JOSHUA: It would still look really cool.

SCORING BUMP

SEAN: Coming up on Today, Explained: Photos from the James Webb telescope broke the internet last week. And we’re just getting started.

DR. AMBER STRAUGHN (NASA astrophysicist): We're starting to get a hint, to, to learn what these distant galaxies are made of, because we've never been able to see that before.

SEAN: But they’re also a digital representation of something no human could ever see with their own eyes.

JOSHUA: Yeah! Well, the raw data is black and white. Or I challenge you to imagine something even more abstract.   
  
SEAN: Earth is hot and stressful so we’re going deep on deep space today.

SCORING TAIL

[THEME]

*<TAPE> NASA HYPE LADY: Good morning, good morning everyone! We are live, and this is it, today is the day we have all been waiting for. So let’s get excited!*

*APPLAUSE*

AMBER STRAUGHN (Astrophysicist, NASA): I am Amber Straughn, an astrophysicist at NASA's Goddard Space Flight Center.

SEAN RAMESWARAM: And I am Sean Rameswaram, one of two hosts at *Today, Explained*. Dr. Amber Straughn is on a first name basis with the James Webb space telescope.

AMBER: I am a scientist on the team at NASA for JWST.

SEAN: James Webb space telescope’s friends just call it JWST.

AMBER: And I’ve been in this role for eleven, twelve years now officially. And I’ve been working on it before then as a postdoc and grad student, so it’s been a while! <laughs>

SEAN: Which means she saw those mind-expanding images before they were cool.

AMBER: I mean, I don't think you have to be an astronomer to appreciate the beauty of these images. And I think, you know, the past 30 years of Hubble has demonstrated that.

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AMBER: The public loves Hubble because of these beautiful images. And I don't know exactly why that is. It's a little strange that they're just sort of it's a universal human experience to, to be sort of awed by the beauty of the universe.

SEAN: And I think that was the exact reaction, although I don't think people actually know in most cases exactly what they're looking at. So we were wondering if you could help us with that part of it?

AMBER: So broadly speaking, these first five images that were released sort of spanned a breadth of different science topics ranging from exoplanets.

*<TAPE> NASA BROADCAST: It’s about the size of Jupiter, about half the mass of Jupiter, it orbits around a sun like star but it does it about every, about three and a half days. So…*

AMBER: To looking at the detailed chemical signatures of a planet orbiting other stars to looking at regions of star birth and star death.

*<TAPE> NASA BROADCAST: There are galaxies here in which you’re seeing individual clusters of stars forming, popping up, forming just like popcorn.*

AMBER: To other galaxies. Light from some of the most distant galaxies in that image has been traveling over 13 billion years. So we are literally seeing galaxies as they were in the distant past, which is exactly what this telescope was designed to discover.

SEAN: So the James Webb telescope is essentially a time machine.

AMBER: That is literally true. And it sounds sort of, you know, sci fi,<laughs> but it's actually due to a very sort of basic principle of physics. And that is the fact that light takes time to travel. You're seeing a lamppost across the street? Light from that takes a tiny fraction of a second to reach your eye. The light from the sun takes about 8 minutes to get to the earth. So in essence, you're seeing the sun as it was 8 minutes ago. Putting these powerful telescopes in space allows us to see things as they were literally back in time.

SEAN: It's amazing. It's actually it's… it’s… the true definition of the word amazing.

AMBER: <<laughs>> I couldn't agree more.

SCORING OUT

SEAN: Which of the images have been the widest circulated, do you know?

AMBER: My sense is just from, like, looking at all the media reports and stuff that the people have fallen in love with the Deep Field image and also the Carina Nebula. Those two seem to be the ones that I've seen popping up, but all of them are spectacular for their own reasons.

SEAN: Let me pull up the Deep Field image first. There's a lot going on in this image. Where do you even begin to start talking about it? I guess. What are we seeing broadly? Where are we?

AMBER: It's so much to take in. But I guess the first sort of thing to know about this image is it is it's a teeny tiny piece of sky. If you held a grain of sand out at arm's length, that's the amount of sky we're seeing here, which is incredible right? And in this grain of sand, we're seeing thousands of galaxies. I mean, it's absolutely incredible. And to go a little bit more in detail the sort of fuzzy white galaxies we see near the center of the image, those are making up a galaxy cluster and those are further away. They're sort of in the background. And essentially what's happening in this image. And the reason you get those little arcs is that the combined mass of the the fuzzy white galaxies and also, crucially, their dark matter is serving as this giant cosmic lens. And so when light travels sort of through the universe from these distant galaxies and hits the mass of this galaxy cluster, it gets bent and stretched out. So that's what all these little arcs that you're seeing are sort of like, you know, looking through the bottom of like a glass and you see how light gets weird and distorted. So proving once again that Einstein was right.

SEAN: Uh, right about what?

AMBER: About the way the universe works in the way that mass can actually bend light.

*<TAPE> ALBERT EINSTEIN: The equation E is equal MC squared, in which energy is put equal to mass multiplied with the square of the velocity of light, showed that very small amount of mass may be converted into a very large amount of energy.*

SEAN: Is, like, anything we're seeing a star?

AMBER: Yes. The bright points of light that have spikes around them. So you can see several of those. Those are actually stars within our own Milky Way galaxy. So relatively nearby.   
  
SEAN: Okay.   
  
AMBER: So anything with a spike is a star. Everything else. Every other point of light is a galaxy.  
  
SEAN: Huh.   
  
AMBER: And of course, again, just to sort of go back to, you know, high school astronomy class <chortles>, a galaxy is a grouping of stars. Our own Milky Way galaxy has a couple hundred billion stars. And so each point of light you see in this image, aside from the individual stars with spikes, every other point of light is an individual galaxy itself, probably with hundreds of billions of stars.

SEAN: <chortles> Okay, so that's like, that is actually mind blowing because what you're saying is that the galaxies greatly, greatly outnumber the few spiky stars we're seeing in this photo, right?

AMBER: Absolutely. The data is brand new, so we haven't done an actual count yet. But just by looking at this, I mean there are thousands, right? There are thousands of galaxies here and just a few stars within the sort of foreground of the Milky Way.

SEAN: So there's thousands of galaxies here, which contain billions of stars. This photo is representative of holding a grain of sand up to the sky at arm's length.

AMBER: Yeah!

SEAN: Right?

AMBER: Right, right. It starts to give you a little tiny bit of a sense of just how big the universe is.

SEAN: And is the James Webb telescope going to sort of pivot on an axis and give us all the other grains of sand. What happens after this?

AMBER: Well, that would, of course, take a very long time. <laughs> But the good news is, is that taking these little teeny, tiny snapshots of the universe helps to give us a sense of what the rest of the universe is like. It's sort of just statistics <chortles>, because one of the fundamental assumptions and astrophysics is that the universe is sort of the same in all directions, roughly speaking. So you can imagine that, point anywhere in the sky and you would see roughly this many galaxies. Now, that's a little bit, maybe not quite true, because this is a galaxy cluster in the foreground. But of course, we have examples from Hubble and we will soon have examples from JWST of just sort of clear deep fields, like deep fields of galaxies without the intervening galaxy cluster here.

SEAN: Incredible as that is, let's pivot to another photo here, one that Marina Koren at *The Atlantic* called “the coolest space picture I've ever seen.” And this is, of course, the aforementioned nebula, Carina Nebula. Is that right?

AMBER: This was the image that made me cry when I first saw it.

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AMBER: <laughs>

SEAN: Hm.

AMBER: You know, it's just it's just so stunningly beautiful. And I love how it I mean, it sort of brings the universe to life, right? You can see texture and structure and depth. It's it's it's gorgeous.

SEAN: And what exactly is it? It looks like some sort of, like, cotton candy cloud out in deep space.

AMBER: Yeah, well, maybe not cotton candy, but it is sort of a cloud. <laughs> So the Carina Nebula, which the team sort of nicknamed “Cosmic Cliffs”, which I think is great, but the Carina Nebula is a relatively nearby star forming region within our Milky Way galaxy. It's about 7600 light years away, so, you know, relatively nearby, but it's basically a stellar nursery. So the orange stuff you see in this image is basically gas and dust.

SEAN: Hm.

AMBER: And then above the sort of ridge of the nebula here, up above, sort of out of the frame of view, are some really hot, young, gigantic stars. And these stars have immense amounts of radiation and stellar winds. And so you can imagine that radiation and wind is sort of pushing down on this region of gas and dust. And these processes are some of what help newborn stars to form.

SEAN: Hm.

AMBER: So it really is, you know, a stellar nursery.

SCORING OUT

SEAN: What does the information collected thus far by the telescope reveal about the universe that we didn't already know?

AMBER: The type of light this telescope sees – this is infrared light – which is light that's a little bit more red than what your eyes can see. And this is the first time we've ever gotten a spectrum of an exoplanet in these certain longer wavelengths of light, which is super exciting. But in terms of what we've learned, this is just a first look. And so scientists are already busy sort of digging into the data. But the most impressive thing to me, was this this chemical, you know, fingerprint of this extremely distant galaxy. What we're learning. We're starting to get a hint, too, to learn what these distant galaxies are made of, because we've never been able to see that before. And this was one of the the main drivers for building this telescope the way that we did. So, you know, over the course of the last 30 years with Hubble, we've been able to learn incredible things about galaxies, about how the universe works in the sense of how galaxies change over time. And with Hubble, we've been able to look back pretty far into the distant past. But Hubble was not able to see the very first epic of galaxies that were born after the Big Bang. So we're talking about looking back in time, oh about 13 and a half billion years into the past.

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AMBER: That's a part of space we have never seen before. And this telescope was designed to find those first galaxies. And this very first deep field image was a relatively short image. It's just like a snapshot. And what we see, what this image shows us is that we will be able to do that. We think we will be able to to learn what that first epic of galaxies was like, that set off the whole evolution of the universe.

SCORING BUMP

SEAN: That thing Dr. Amber Straughn from NASA said about this telescope seeing infrared light? That’s the reason all of these images have been painstakingly doctored.  
  
SEAN: More on that in a minute on Today, Explained.

[MIDROLL]

[BUMPER]

*<CLIP> MAD MEN:*

*DON DRAPER: This isn’t a spaceship, it’s a time machine.*

SEAN: Welcome back. *Today, Explained*. Joshua Sokol is a freelance science writer and he wrote recently in the *New York Times* about how NASA went about selecting James Webb images for public consumption. We got him on the show because I had this sorta burning question…

SEAN: So Joshua, I was reading lots of articles about these James Webb images because of course. They were mind blowing and I wanted to learn more. And then buried deep in one of them, not the headline, not in the first few graphs, but towards the end: “By the way, all of these images you're seeing have been doctored?!” Is that, is that true?

JOSHUA: I mean. Yes. Yes, it is true.

SEAN: Ahh! <laughs>

JOSHUA: There's they're all they're all mediated.

SEAN: *Mediated*. Is that a euphemism?

JOSHUA: Well, there's, there's technology interfering between what's out there in the universe and what you're seeing. And this is kind of something that we accept in other situations. You know, our phone cameras and our cameras in general, digital cameras all kind of are creating a vision of reality. They're they're trying to create something that mimics what our eyes do. But it's not exactly real, I guess.

SEAN: I see what you're saying there, because I've noticed I recently went from an iPhone five to an iPhone 13. And what I'm noticing now, especially when I take photos at night, is that my iPhone's rendering of events, this iPhone 13, is actually much better lit than what I actually see with my human eye. Which is the more accurate reality? Is that, like, an existential question?

JOSHUA: <laughs> Yeah, it gets philosophical really quick. I mean, if you think about the romantic notion of an astronomer as somebody who puts their eye up to the, the lens of a telescope and looks at the universe, and they perceive it all through their eyeballs, the reality hasn't been like that for a while.   
  
SEAN: Hm.

JOSHUA: And also, that's not the way our photography works. We're creating almost like a data visualization of your iPhone or the telescope. It creates an array of numbers, it takes in some data from the universe. And then there's this added step of like, how do we want to visualize that? Do we want to, Do we want to make it look it exactly mimicking how your eye might see it? Granted that people's eyes are different and lighting conditions are different, you know. Or are you trying to show other things?

SEAN: So what you're saying is the telescope’s up there capturing ones and zeroes and the question is, how do we want to represent those ones and zeroes?

JOSHUA: The telescope is not up there to make really, really cool pictures. It's up there to take data about what's in the universe. And what this kind of breaks down to is like in every pixel of this image, how much light do we see from the universe? And that's all that the telescope wants to do. Everything past that point of ‘How would it look to us and how can we visually communicate what it's seeing and what it's doing?’ That's all a little bit subjective, a little bit of interpretation. It is a data visualization.

SEAN: What's coming across their desks in its raw form. Is it black and white?

JOSHUA: Yeah. The well, the raw data is black and white. Or I challenge you to imagine something even more abstract.

SEAN: Huh.

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JOSHUA: What it really is, is an array of numbers. And the array of numbers is just like how bright was the universe in each pixel? Like this pixel saw 100 photons from this crazy galaxy, and this one saw a little bit less. And it's just an array of numbers. What astronomers do on their computers is like, immediately translate that into a black and white, like a grayscale image of like..”let's see it.”  
  
SEAN: Mm.  
  
JOSHUA: ‘And that will help me understand it, because I don't want to look at just a matrix code, you know, I want to see an image.’ So, you know, the really raw is the array of numbers, the kind of the way that an that's visualized is like let's translate this into an image, a digital image, black and white image for sure.

SEAN: Does that feel sort of distinct from the way, say, our smartphones, our Google pixels and our iPhone 13s are interpreting a landscape photo shot at night? Because here you're talking about actual black and white ones and zeros, numbers of photons. And then what you end up with is this sort of stunning image of of the Carina Nebula, which people actually look at and can't believe what they're seeing. And it sort of turns out, well, that isn't exactly what anyone saw.

JOSHUA: I think there's an analogy that holds up pretty well between the phone and the telescope, and then it breaks down towards the end. The way that our cameras, our regular cameras work, is they're also really creating arrays of numbers, black and white images. And then they're combining them and they're creating they're assigning colors to them, digitally combining them. They're showing us something that makes a visual sense. A lot of times their goal is to recreate kind of how our eyes work and do something that that looks like the kinds of things we see. But they might punch it up in certain ways because they're also trying to create something that's pleasing to us and contains the information about the scene that we want to see. The thing is, when your phone does this, you're not involved in the process at all. It's all like underneath the hood in a black box. And what's happened with these telescope images is there were people involved at every step, decisions made at every step, and it's just much more intentional about what is being communicated in the images.

SCORING OUT

SEAN: If I was actually shooting by the Carina Nebula in a spaceship, would it actually look like that?

JOSHUA: No, it would not actually look like this. I have to confess, it would not.

SEAN: Whoa.

JOSHUA: It would still look really cool.

SEAN: Bummer. <laughs> What would it look like?

JOSHUA: I mean, it would look cloudy and you would see a lot of these structures, and you would definitely see less color with your eyes. And you cheated a little bit in your example because you said you're there in a spaceship, like, at warp speed. So you're still implying there's this technological mediation going on…  
  
SEAN: Mm.  
  
JOSHUA: … to get you close to this thing that, like, I promise you, no human being in the next thousand years will ever be close to. Carina Nebula, visually, your eyes could see a lot of cloudiness, a lot of structure, a lot of color. It would not be this vivid. It's fake in the sense that <chortles> all images are sort of fake, but it's, it's hyper real. It's super humanly real. It's beyond what you could do. And that's what's cool about it, too.

SEAN: It seems like such an enormous responsibility because these images are essentially now the historical record. I mean, they have entered the public consciousness and that's how people will think about James Webb. How does NASA walk the line between getting the public excited about what this telescope is doing and representing fairly what it's actually seeing?

JOSHUA: These images are a conscious act of visual communication. Part of that is almost brand management. It's like communicating, Hey, here's this thing that we do that's very legible to the average person, this amazing image that you can appreciate and see. So it'll make the argument that the telescope that cost all this taxpayer money is is worthwhile, that it's functioning well, that it that it's capable of doing amazing things. That's kind of a cynical thing almost. You know, we want to inform public perception of what this large public project is doing. The other part is that NASA is required with its spending to explain itself, to do science communication. So you could also imagine the telescope is just taking all this really technical data, but it's not showing anything. Nobody benefits from the knowledge generated. So there is this very genuine, earnest desire in the people that work on this is how we see the universe is what we can learn about it. This is what you paid for. Let me explain how it works. The colors are not fake to convince people to fund NASA more. The colors are punched up and combined and made esthetically pleasing to communicate real information about just how precisely the telescope could see the universe. That it can really see this thing that looks red in the image that's this stuff out in space. And this blue in the image is a totally different physical process. And hey, look, isn't it amazing that we built this thing that can that can, like, tell that difference? I mean, it's better than what our eyes can see. It's more informative. And that's why they're doing it.

SEAN: And if they release some black and white, no one would care.

JOSHUA: If they release it in black and white, they'd be showing off less of what the things true capabilities are, and they would be less impactful on an audience. They would be, they would be boring.

SCORING IN QUIRKY SYMPHONY

SEAN: Joshua Sokol is a freelance science writer. Earlier in the show you heard from Dr. Amber Straughn. She’s with NASA.

Our program today was produced by Victoria Chamberlin. Matthew Collette edited. Laura Bullard fact checked. Paul Mounsey engineered. We had help from our friends at *Unexplainable*, especially Dr. Brian Resnick. They just re-released their two episode series on the James Webb space telescope. If you want to hear more about what exactly this telescope is looking for in outer space look for *Unexplainable* wherever you listen.

This is *Today, Explained*.

[10 SECONDS OF SILENCE]