

# PLOS Science Wednesday: Hi Reddit, I'm Tom Kaye, here to talk about how my team uses laser fluorescence in our paleontology research, Ask Me Anything!

PLOSScienceWednesday<sup>1</sup> and r/Science AMAs<sup>1</sup>

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## Abstract

Hi Reddit! I am Tom Kaye, Associate Researcher with the Burke Museum in Seattle, Washington. My research uses lasers to make fossils and minerals fluoresce in ways never seen before. My team recently published a paper in PLOS ONE titled “Laser-Stimulated Fluorescence in Paleontology” where in one example we used our system to identify the origin of a bracelet that was placed around the arm of a 6,000 year old skeleton of a girl. We also demonstrated the use of laser fluorescence to automatically sort microfossils, its ability to “back light” feathers preserved as carbon films and light up micro-fossils that were normally invisible under the surface. We are also taking the laser underground and using it to fluoresce and photograph cave formations at great distances! I hope to answer lots of interesting questions at the PLOS AMA at 1pm ET (10 am PT, 5 pm UTC), and you can follow my science adventures on Facebook. See you all soon!

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PLOSSCIENCEWEDNESDAY [R/SCIENCE](#)

## ABSTRACT

Hi Reddit!

I am Tom Kaye, Associate Researcher with the [Burke Museum](#) in Seattle, Washington. My research uses lasers to make fossils and minerals fluoresce in ways never seen before. My team recently published a paper in [PLOS ONE](#) titled "[Laser-Stimulated Fluorescence in Paleontology](#)" where in one example we used our system to identify the origin of a bracelet that was placed around the arm of a 6,000 year old skeleton of a girl. We also demonstrated the use of laser fluorescence to automatically sort microfossils, its ability to "back light" feathers preserved as carbon films and light up micro-fossils that were normally invisible under the surface. We are also taking the laser underground and using it to fluoresce and photograph cave formations at great distances! I hope to answer lots of interesting questions at the PLOS AMA at 1pm ET (10 am PT, 5 pm UTC), and you can follow my science adventures on [Facebook](#). See you all soon!

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**How do you rule out the possibility of interference from fluorescent algae and bacteria without destroying or compromising the integrity of your specimens? What wavelength(s) are you using? As to the bracelet, are you identifying the origin of the artifact itself using laser fluorescence or actually identifying microfossils associated with it, i.e. pollen?**

**Btw, definitely going to give your paper a go when I get a chance. As a geologist, the notion of backlighting feathers intrigues me as to its possible application in dinosaurian studies.**

### [fossilreef](#)

Most of the specimens we deal with are minerals so bacteria and algae usually do not come into the picture. The bracelet example was used to demonstrate in in-situ solution. The laser fluoresced a crack pattern that matched a fossil hippo tooth from the same area. That was just ONE of the data points we used to make the hippo connection. We also took micro-samples for atomic analysis etc. You will be very pleased with the backlighting technique on the right specimens.

### **What is your favorite dinosaur?**

#### [bozoboza](#)

Anchiornis at the moment since we recently made some very exciting discoveries with the laser system when we went to China and looked at about 400 specimens.

**Tom Kaye? *The Tom Kaye?* Holy crap. I apologize for not having a proper question, but I would**

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**like to thank you for your role in the many fun Saturdays I've spent playing paintball over the years. AGD made good products and I dearly love my automags.**

**Do you still update [tomkaye.com](http://tomkaye.com)?**

[invertedwut](#)

Thanks to all my PB buddies! Any yes I update tomkaye.com but I am blogging more on my Facebook page.

**Can this fluorescent laser technique give us a better understanding of what different colours dinosaur skin and feathers had?**

[remco27](#)

I would have to say probably not at this time but one specimen could change everything!

**Would you mind explaining a bit more about how this process works? What kind of laser are you using? How exactly does it stimulate fluorescence?**

[FOR\\_PRUSSIA](#)

Currently we are using violet (405nm) diode lasers in the 1/2-1 watt range. When the laser is projected on a mineral such as calcite, impurities in the calcite absorb some of the photons at the atomic level. The atoms jump to a higher energy level, and then relax back down giving off a longer wavelength photon in return. The calcite itself does not fluoresce, only the contamination that was incorporated into the crystal structure when it formed. So by using fluorescence we are looking at color differences caused by the geochemistry of the mineral. Often the contaminants are at the parts per million level so this can be a very sensitive technique.

**What is the age range of the micro fossils you are sorting? Are they pollen and other plant materials or are you looking at stuff like they find in the Burgess shale?**

[grossguts](#)

Paleontologists for a hundred years have been collecting the surface gravel of anthills and then painstakingly going through each grain under the microscope looking for small teeth and other fossils. This can literally take years so I developed a machine to do it automatically. A narrow stream of gravel flows out of the machine and is illuminated by the laser. The stream is being monitored by a video system that detects the bright fluorescence of the bones and teeth and uses an air puff to move them off to the collection bin. We have used it on fine gravels from virtually all ages from the Triassic up to recent times.

**Is there a drawback to this technique? As an example, could it damage paint on an ancient piece of art?**

[Akesgeroth](#)

We use a laser line lens to spread the laser beam into vertical line. This reduces the point energy of the laser and makes the higher power ones safer to use. It is then scanned back and forth over the subject in the dark while the camera does a time exposure. The laser could cause bleaching but it has not been a problem we have run into yet. I recently did a full analysis on a suspected Rembrandt where the laser brought out a lot of detail that had darkened over time.

**I do flow cytometry and would love to understand more. (And now I'm going to have to take my rock collection to work.)**

**Do you know whether it's specific fossilized proteins that are being excited? (I have no idea how much of a protein's structure remains after fossilization.) Or is it a crap-shoot where it depends on which minerals fossilized a thing? Also, are you looking at other wavelengths? In my work, I find that there are a few endogenous proteins that are excited by 488 and 633.**

[FlowJock](#)

We are not doing anything with proteins.

**Becoming a paleontologist has been my dream since I was about 5 years old, now a sophomore in college pursuing a geology degree, what tips do you have for a budding researcher? Thank you!**

[5ee5](#)

Go volunteer at your local museum. Go to all the conferences you can and get a publication out early.

**What is the Holy Grail of this application? (Please say "the Holy Grail.") But seriously, is there a problem on the horizon that, with some more time or technical development, that you really hope to crack and has been intractable with other methods?**

[patricksaurus](#)

The Holy Grail would be an inexpensive, portable, UV laser. I have been working on this since the 90's and the hold back has been the lasers. A few years ago we only had green lasers in the 1/2 watt range that were affordable. To make them work you had to block out all the light from the green laser and below which meant no blue light. So a "full color" image meant just red and some green. Now with the 405nm violet lasers they are on the edge of the UV and we get full color RGB. We are now working with the science team at Kartchner Caverns State Park where we are doing long range panoramic fluorescent images of the inside of the cave. The pictures are absolutely stunning as this is the first time a cave has ever provided its own light for a picture! Still looking for that UV laser though...

**First, I have not yet read the paper so, if this has already been addressed, I apologize.**

**What is the possibility of using this technology to examine things such as pollen in older rocks (Cretaceous for example)?**

[themadskeptic](#)

The problem with pollen is concentrating it down so you can find it. There are better techniques already in place to do that.

**Can you go into a bit more detail on how the fluorescence works, and give some examples? Does it give off different colors for various minerals, and could you get a rough idea of what you're viewing from great distances?**

[The\\_FatOne](#)

It gives off different colors depending on the mineral and more specifically the contaminants in the crystal structure of the mineral. If the contaminants change, usually the color changes too and you can see this at great distances with a powerful enough laser. One of our plans is to take the system into a fossil quarry and scan the wall looking for bits of fossil sticking out that could lead to the whole specimen.

**How do you ensure that your laser excitation does not damage your sample? Biomedical imaging has well-defined laser fluence exposure limits that serve as illumination guidelines. Do**

**you ever have to risk damage to your sample in exchange for more florescent signal?**

**What's the most powerful laser in your arsenal?**

[shiruken](#)

We are usually shining on rocks so damage is not a problem. Our most powerful is a 1 watt violet from Visible Diode Lasers.

**Hey Tom! Thanks for doing this AMA! So my first question is: can anyone do this with a decently powered laser and a dissecting scope? And secondly, is this better at seeing silicate-containing or calcified diatoms or other microbes better than a cellulose or lipid membrane of modern microbes?**

[EColi452](#)

Yes you can do with with a decent laser and a stereo scope. I don't know how it will work on diatoms or microbes so you have to try!

**What do you think (in your opinion) is the most interesting, important or surprising result or conclusion you have discovered from your work?**

[NiceMonster64](#)

Our recent investigation into the Chinese feathered dinosaurs using LSF has revealed shocking details in the preservation never before seen. We are currently working on a paper that will show soft tissue patterns in unprecedented detail but that will have to wait until the next AMA!