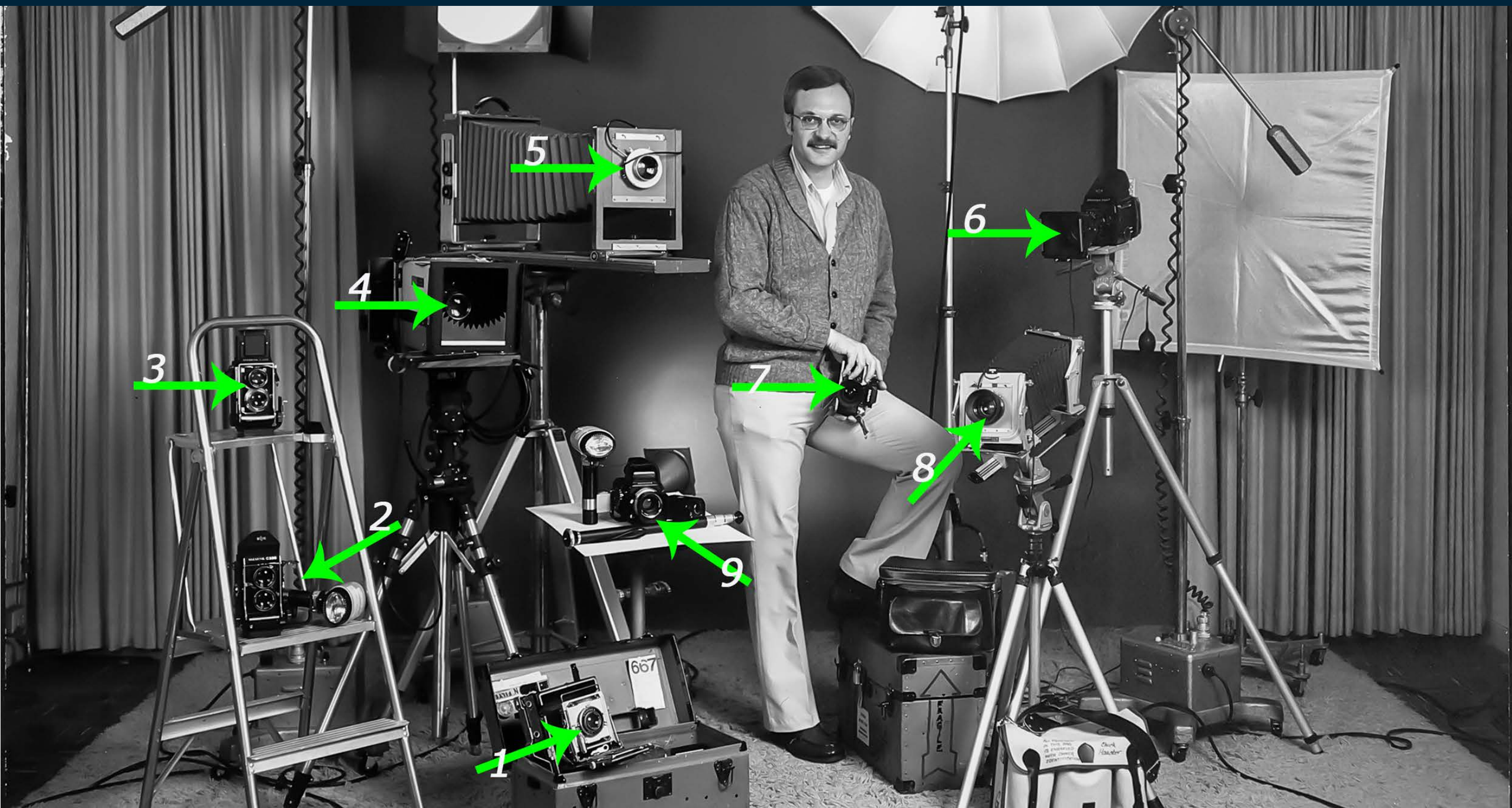
Photzy

FACTS REGARDING LARGE CAMERA SENSORS

Quick Guide
Written by Chuck Haacker



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When I began researching for this guide, I was somewhat conflicted. My career started long ago with “BIG” cameras and worked downward.

I went to school for commercial photography in the early 1970s. For our first two semesters we were required to shoot all assignments with bigger-than-your-head six-pound 4x5” “press” cameras, and to turn in our negatives to prove we hadn’t cheated with any “miniature” camera, what our instructors termed anything smaller than 4x5”.

Despite our whining, they insisted that there were excellent reasons why the big cameras were the industry standard for more than half a century: **resolution and flexibility in cropping and enlarging.**

> **Key Lesson:** Working in film, larger negatives permitted greater enlargements with less or no visible grain, plus bigger negatives allowed for more cropping than smaller ones. When you think of sensor size, can you see the correlation?

The rationale was that the relatively huge 4x5” (10.1cm x 12.7cm) negative, with its area of 20” sq. (~128cm), allowed for cropping quite small sections out of the big negative. Size mattered. The area of a full-frame 35mm negative is 8.64cm sq., or only about 1.34” sq. A 4x5” negative has FIFTEEN TIMES the area of a full-frame 35mm negative.

When I had my studio, I used many different cameras in all sizes. My *smallest* were full-frame SLRs (film, of course) and got bigger from there.

Photograph by Charles Haacker

My camera room ca. 1978.

The camera in my hand is a 35mm Nikon F2AS, a top-of-the-line professional camera for the time. The camera on the floor (sitting on the camera case) is my 4x5" Pacemaker Speed Graphic that I used all through school. The camera over my right shoulder is an 8x10" Burke and James. You get the idea. BIG!

All black and white portraits were made in 4x5", so I could hand-retouch them directly on the negatives.

All color portraits were made, at minimum, with 6x6cm (2-¼" x 2-¼") cameras on roll film.

My 35mm cameras were used mostly for events, like conventions and meetings where it was unlikely that we'd need to enlarge greater than 8x10". I was thoroughly indoctrinated: bigger = better. And in film, that was mostly true.

Key Lesson: Digital has turned the old conventional wisdom on its head. The industry was now thinking smaller is better… at first.

I entered the fray after the close of the press camera era. The man that I bought my studio from had shot hundreds of weddings in black and white with 4x5" press cameras. He had recently "downsized" to 3-¼" x 4-¼" and had even transitioned to roll film and color.

I shot all my weddings with 6x6cm cameras. It horrified the previous owner; it would have horrified my mentors, but at least I didn't do what some contemporaries were doing: shooting weddings with (oh the humanity!) 35mm film. *Subminiature!* Omigosh, we cried; *you can't make big enlargements!*

But time marched on.

When I went digital (2007), I was so abysmally ignorant that I did not even know the sensor size of my first tiny camera (it was 1/2.5), but I felt that the quality was so good – especially the sharpness – that it did not matter to me.

So, does size still matter in this miraculous digital age? Researching this piece was an eye-opener for me. I learned that bigger is still generally better, and why, and I hope I can help you see it too.

Here is what we will discuss:

- How do we define "large" in a digital sensor?
- Is "bigger" better?
- Resolution
- Low light
- Greater dynamic range (latitude)
- Less visible noise (digital "grain")
- Tolerating more cropping
- Handling higher ISOs with less loss of resolution and less noise
- Does "bigger" have any drawbacks?
- Physical size and weight
- Depth of field
- Easier bokeh (blur), and harder to control
- You need a full-frame sensor camera, right?

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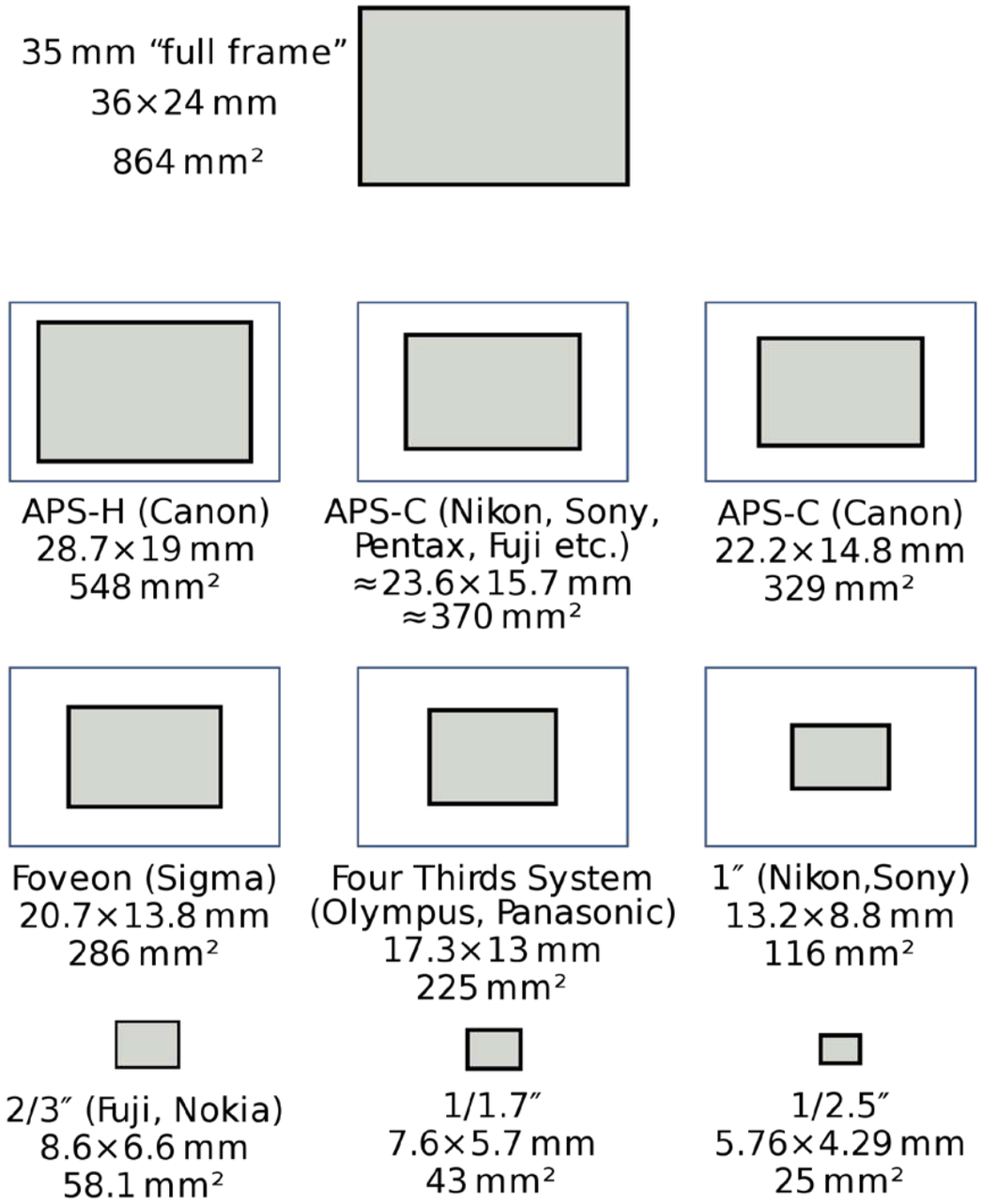
Photograph by Charles Haacker

Madison, Wisconsin skyline, hand-held, Sony RX10, 1” sensor.

DEFINING ‘LARGE’ IN A DIGITAL SENSOR

Generally, sensors from 1” up are considered large, while from 1” down are considered small. One inch is the break point, which is odd since it isn’t even an inch. Paraphrasing Ken Rockwell, *“There is no such thing as a 1” digital image sensor. What are marketed as 1” sensors are actually only about 9 x 12mm (0.35” x 0.47”) — nowhere near 1”. They have about a 3x crop factor. Fifty years ago, video cameras used vacuum tubes as their image sensors. They were described by the outside diameter of their overall glass tube, like 1” or 2/3” tubes. The active image sensing areas were always much smaller than the tube’s outside diameters, but engineers all understood; it was jargon.”*



Subsequently reworked extensively by user: Moxfyre for correct, exact sensor size dimensions and accurate captions. Image: SensorSizes.png, Public Domain, https://commons.wikimedia.org/w/index.php?curid=3163749

For reasons not well understood, camera manufacturers glommed onto this, apparently for no other reason than to make their sensors sound bigger than they actually are. Rockwell thinks it’s fraudulent, but I think we can all read the charts. One inch is either the largest of the small sensors, or the smallest of the large. I’ve used a 1” Sony RX10 and was absolutely thrilled with it.

The entire tech industry advances by leapfrogging itself. For most photographers, today’s benchmark default is the 36x24mm so-called “full frame” of the 35mm, created by Oskar Barnack in 1913 (Leica). Today there are even larger sensors available, medium format and even adapters for big view cameras, but for you and me the full frame is classified as “large,” and downsizes from there.

> **Key Lesson:** Where once a full-frame 35mm negative was considered “miniature” owing to it showing more grain and lower resolution, the exact opposite is true of the digital full-frame sensor.

Photograph by Charles Haacker

This JPEG at Jackson Lake in the Grand Tetons was made with a Nikon L12 in 2007, a tiny point and shoot with a 1/2.5" sensor barely bigger than a cell phone's.

IS BIG BETTER?

That's the $64 question. If you're fairly new to digital, especially if you have been shooting with a smartphone or pocket point and shoot, you have probably been astounded by the apparent quality of the output. I sure was when I got my first digital in 2007. I still am, actually.

At the time, I thought this JPEG, from a polo-shirt-pocket camera, was every bit as good as I could have made in film with a 35mm camera. It appears sharp and richly detailed. What's not to like? Eventually I understood that tiny cameras meant tiny sensors needing only very short focal lengths. Given that the output was so incredibly amazing, for quite a while I did not care. I was getting what I thought were great results. Who cared what size the sensor was?

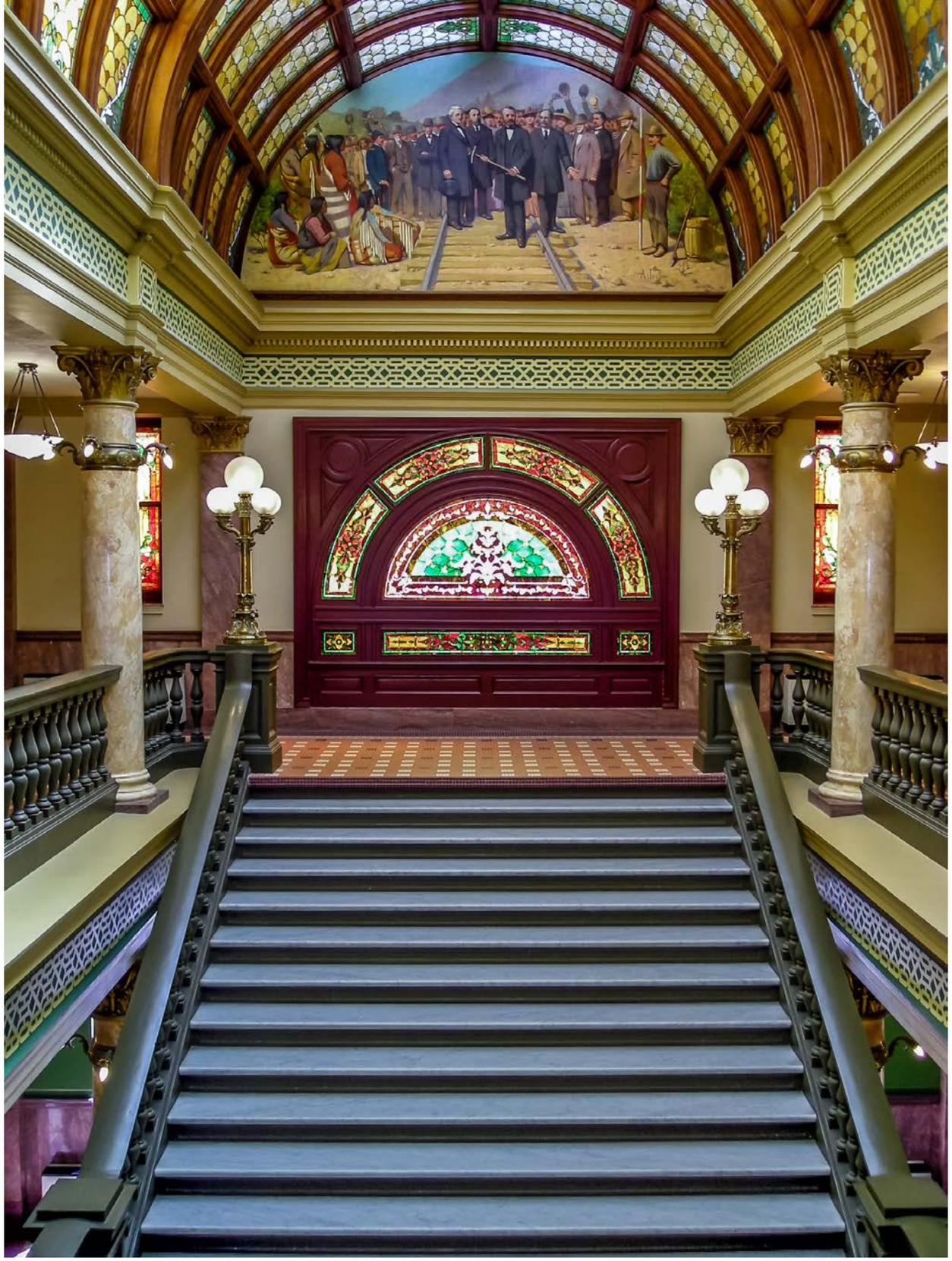
 **Key Lesson:** Modern digital sensors are so good that we can be fooled into thinking that size is irrelevant; it isn't.

Photograph by Charles Haacker

RESOLUTION

A sensor with more surface area includes more pixels. Assuming pixels of equal size, a digital sensor that is 50% larger means that there can be 50% more pixels. That translates to higher resolution, which in turn means more detail so you can enlarge with no discernible loss of quality. We are getting back to the old principle: size matters, and bigger is demonstrably better.

I enlarged an approximate 100% section out of the Jackson Lake picture to show how, at high magnification, it begins to fall apart – goes to mush. You can see artifacts, haloing, and increased noise. In its defense, the original is a JPEG, plus I have no identical picture made with a larger format for true comparison. Moreover, that was a 2007 CCD sensor, nowhere near as good as what was already in the pipeline.



Photograph by Charles Haacker

Existing-light interior, un-cropped JPEG made with that same 1/2.5” Nikon L12 of the Montana State Capitol at Helena.

Key Lesson: In good light, small sensors deliver excellent results.

Photograph by Charles Haacker

NOISE!

But what about not-so-good light? Maybe you're forced to boost the ISO. This shot was made with a 2007 Nikon P5000 1/1.7-in CCD sensor inside a greenhouse. This JPEG-only camera was capable of ISO 1600. The shot was made at ISO 800. Un-cropped it doesn't look bad.

Photograph by Charles Haacker

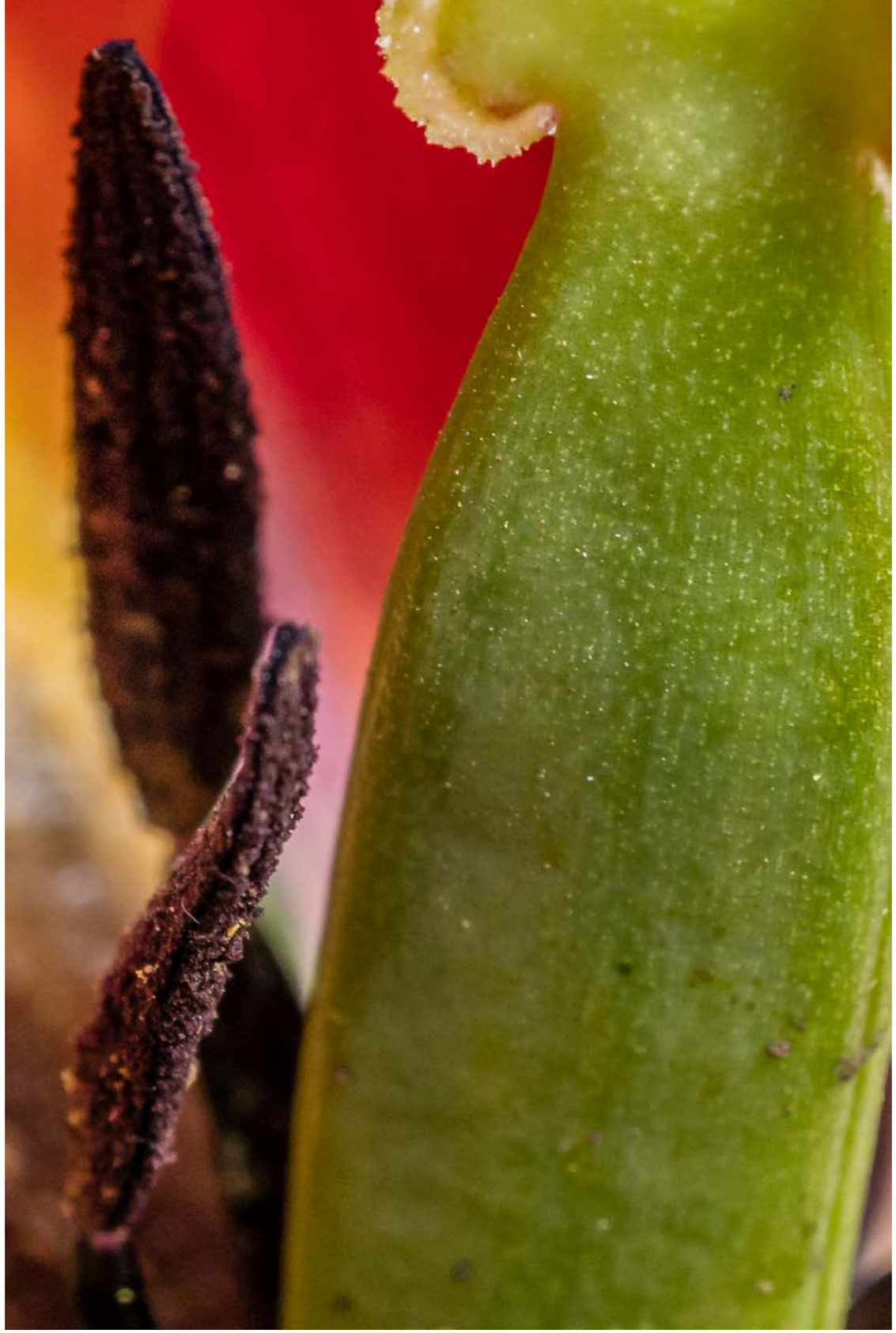
Whoa! Pretty ugly!

But what if we wanted to crop and enlarge? Might we expect a little noise in a JPEG from a tiny (admittedly obsolete) sensor, even if it was twice the size of the L12s?

> 💎 **Key Lesson:** Small sensors in low light will show more noise (grain) and lower resolution than a larger sensor under the same conditions.

For comparison I found something shot under similar conditions of light and ISO, but with a Sony A6300 with its APS-C "half frame" or "crop" sensor.

Photograph by Charles Haacker



Photograph by Charles Haacker

Photograph by Charles Haacker

It's not a fair comparison owing not just to it being a bigger sensor, but also to the nine-year gap in sensor technology. I chose the picture because it was also made at an ISO of 800, like the one made with the 1/1.7" Nikon P5000. The APS-C sensor has nearly *nine times* the area of the 1/1.7", and that's easily seen in the relative increase in sharpness plus lack of discernible noise (grain).

Even reverting to a small 1/1.7" Nikon – a P7800 – you can see the tech galloping onward. In good light the tiny sensors seem to do excellently.

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Photograph by Charles Haacker

Photograph by Charles Haacker

Inside Carlsbad Cavern by the existing light alone

SMALL SENSOR PERFORMANCE IN LOW OR POOR LIGHT

I have never hesitated to make any camera do things far outside its design parameters. This is inside Carlsbad Cavern (NM) by the “available dark” with that 1/1.7” Nikon Coolpix P7800, wide open at *ƒ*/2.0, 6.0 mm, 1/8-second @ ISO 1600. The original is a JPEG because I was still not shooting raw (for shame). It was reprocessed in Lightroom because I never show anything unprocessed.

The conventional wisdom is that this can’t be done. So? I’m unconventional.

Photograph by Charles Haacker

The cropped section is a dead giveaway that this was a small sensor in poor light.

But even if it looks pretty good un-cropped, what happens if I enlarge a section around 100%? Bear in mind that this is a 2013 1/1.7" sensor, JPEG. Here is the roughly 100% enlargement of a section of this picture. It looks like French Impressionism.

GREATER DYNAMIC RANGE (LATITUDE)

I think raw vs. JPEG figures more into this than sensor size, but everything I read implies that bigger sensors have more latitude than smaller ones. I don't have a way to test it, but I am skeptical; I absolutely know raw beats JPEG irrespective of sensor size.

BIGGER CAN TOLERATE MORE CROPPING

At some stage available-dark freaks must face reality: bigger sensors just better handle worsening conditions. A good simile for any sensor is that it's like a bucket; a larger sensor (larger bucket) can collect more light (more rain) than a smaller sensor in the same circumstances. I remain very impressed with what smartphones can do with near-microscopic sensors, but bigger sensors collect more light, such as at a mostly candlelit birthday.

💎 **Key Lesson:** Digital sensors are analogous to buckets catching rainwater; the bigger the bucket, the more volume it can hold.

Photographs by Charles Haacker

BIGGER SENSOR CAN HANDLE HIGHER ISOS WITH LESS DISCERNIBLE NOISE

These were made with my “big” APS-C “half frame” Sony A6300, 1/125 @ f/4, ISO 5000. Yes—ISO *five thousand*.

The top image on the left is un-cropped. What happens if we enlarge sections out of it? Keep your eye on her eyes (bottom image).

Photograph by Charles Haacker

In the last one we can discern some noise, but it would be easily mitigated in any good post-processing app, and I don’t feel it’s that objectionable anyway. (We maybe could have wiped off the chocolate first but...)

Photograph by Charles Haacker

Un-cropped, shot with hardly any available "light," gelled, ISO 12,800.
The relatively big APS-C sensor performed like a champ.

Over time I have made thousands of pictures in low light with cameras never intended for that purpose, but I also knew I was pushing boundaries off the edge of the cliff. I just didn't want to schlep around BIG cameras and BIG bags full of gear.

💎 **Key Lesson:** The larger the sensor, the greater the overall quality under any conditions, good light to bad. Any increase in area over a smaller sensor results in a discernible increase in image quality (IQ). **Greater sensitivity, with little to no visible noise.**

ARE THERE DRAWBACKS TO BIGGER SENSORS?

Probably the biggest drawback (if it is one) is that bigger sensors generally require physically bigger bodies and bigger lenses, usually meaning more weight, especially if they are DSLRs. At the time of writing, Canon and Nikon are competing head to head with Sony's full-frame, pro-grade mirrorless Alpha series. Mirrorless cameras are roughly a quarter to a third smaller and lighter than the equivalent DSLRs, full or crop frame.

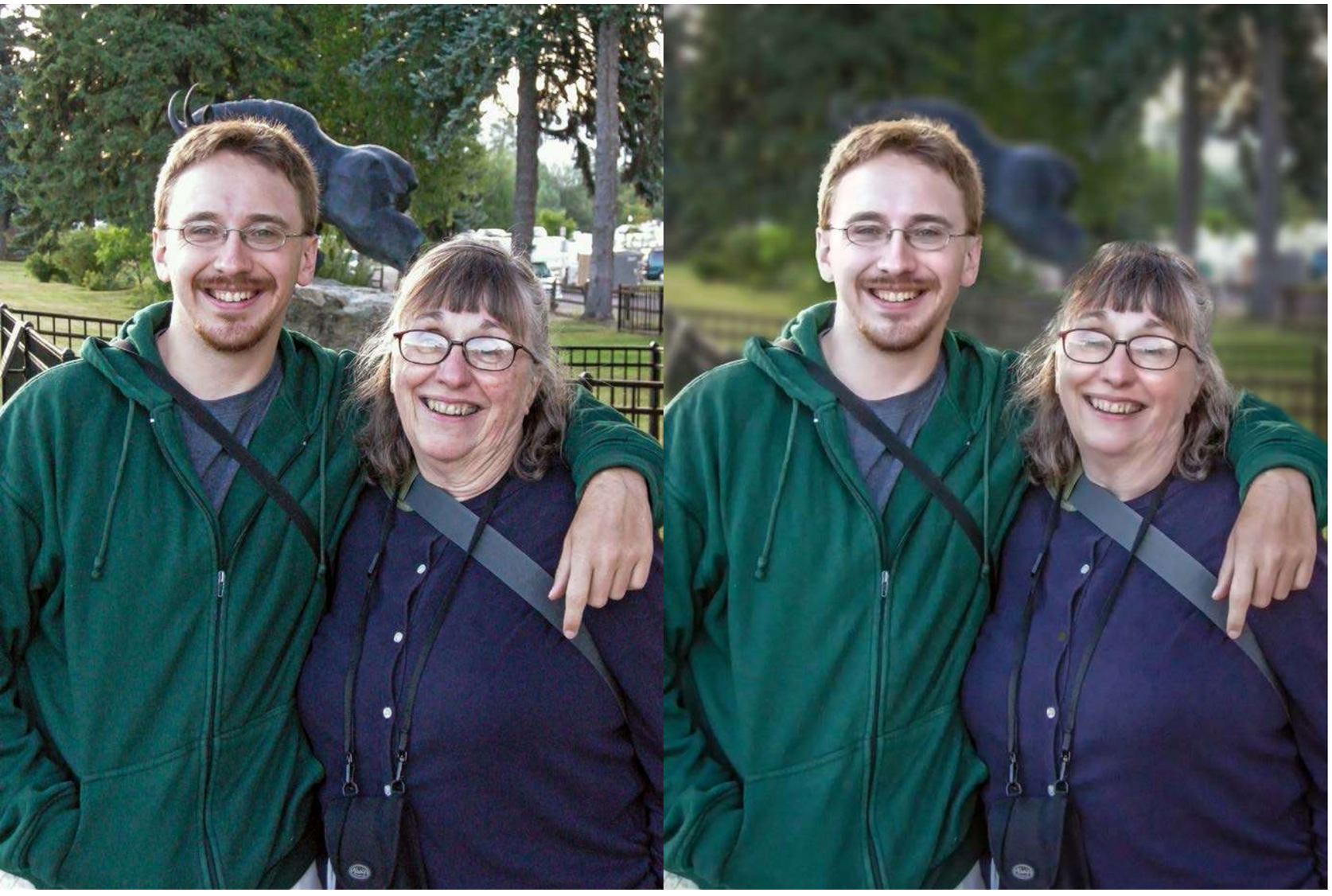
My Sony A6XXXs bodies are actually physically just a hair *smaller* than the Nikon A900 hi-end point and shoot. Nikon has reverted to a microscopic 1/2.5" sensor; at least it's a CMOS, but it won't deliver raw. The sensors in my Sony cameras are *15 times* the area of the Nikon A900, yet the bodies are the same size. (Weight is another matter. I have one lens that weighs two pounds on a one-pound body.)

DEPTH OF FIELD (AND BOKEH)

Bokeh (blur, especially background) is easier to achieve and control with bigger sensors, but the physical size or format has nothing to do with it. I hear someone in the back saying, "Yeah, it's about focal length, right?!" Pretty much.

Simply stated, the shorter the focal length of the lens, the deeper the *apparent* depth of field at any given *f*/stop. We say "apparent" because it is actually an illusion. Depth of field is defined as the area before and behind the plane of critical focus – the subject focused upon. "DOF" is influenced by several things starting with the focal length, the distance focused upon, and the aperture (*f*/number).

You've heard of "normal" lenses. The focal length of any lens is defined as the distance from the lens to the image sensor when focused at infinity, usually stated in millimeters (e.g., 28mm, 50mm, or 100mm). The accepted focal length of a "normal" lens is about equal to the diagonal of the frame. Full frame 35mm has a diagonal of ~43mm, so its "normal" focal length is around 40 to 50mm (i.e., "Nifty Fifty").



Photographs by Charles Haacker

A 1/2.5” sensor (cell phone) has a diagonal of ~7mm. Most cell phones have lenses in the 4 to 6mm range, slightly wide angle. A sensor that tiny, with a focal length that short, has a perceived depth of field that seems to go from zero to infinity. That’s why it’s so hard to get anything like bokeh with them, or any camera with a small sensor.

A common complaint about compacts is the near impossibility of getting blur. Compacts’ small sensors mean short focal lengths, which means greater apparent depth of field, especially at normal distances. Depending on what you are after, this can be either a feature, or a bug.

I made the left image with my P5000 point and shoot with its 1/1.7” sensor and (ahem) wasn’t watching the background. Had I made the picture with one of my APS-C cameras I could have gotten the bokeh I craved in the camera instead of in Photoshop (right image).

The exposure was 1/125 @ f/4, “wide open.” The focal length was zoomed to 16mm, which on my half-frames is a wide angle, but the normal for the 1/1.7” format is only 8mm. 16mm was double normal, equivalent to about 100mm on a full frame, a mild telephoto and common portrait focal length. Yet, despite being wide open and zoomed out, the background is almost as sharp as the subjects. It’s frustrating for compact-camera enthusiasts.

The reverse of the coin, however, is that it can be challenging to get *enough* DOF with a bigger sensor, owing their requiring longer focal lengths. Here’s an extreme example, made with a 30mm macro lens on my APS-C “half frame” sensor. A 30mm lens on a crop sensor is equivalent to 45mm on a full frame; it’s a normal lens, but it’s still nearly 4x as long as an 8mm normal on a tiny sensor. There is very little DOF, even stopped down when focused this close (just inches away).

Photographs by Charles Haacker

DOF is not only affected by f/stop and focal length; it is also affected by magnification. When in very close, your DOF becomes very thin even at small apertures. The top picture is focused on the edges of the front hole in the bowl. The bottom picture is focused on the object seen through the holes. The aperture used was f/16, but when this close, it doesn't help much at all.

Photograph by Charles Haacker

The picture I wanted could only be made with “focus stacking,” using several planes of critical focus and virtually stacking them in Photoshop. Had I made the picture with my old P7800 with its 1/1.7” sensor (9mm diagonal), I could have gotten it much sharper within just a single frame. But I’d still much rather work around the limitations of the bigger sensors; I sold my runty-sensor cameras because I would never use them again.

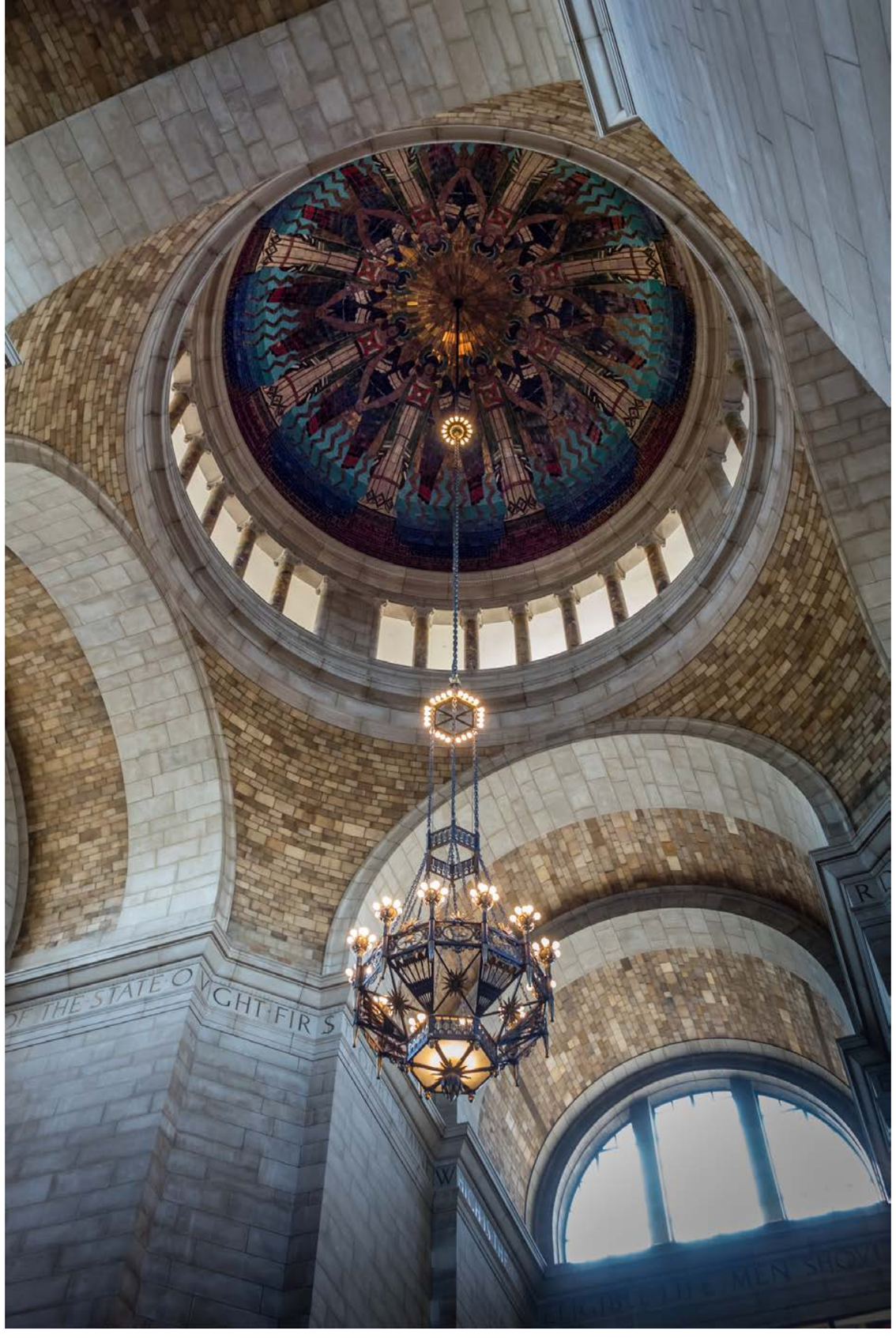
Photograph by Charles Haacker

But if it's bokeh you want, larger sensors deliver. This amaryllis was made at *f*/8 with that same 30-macro, focused critically on the anthers, allowing everything else to fall well out of focus (bokeh). It's easy to do with a big sensor, but if I wanted to keep everything sharp, I would need either to focus-stack or use a much shorter focal length. Stopping down would help, but not as much this close. Sometimes smaller sensors seem to have an advantage, sometimes bigger ones do.

Photograph by Charles Haacker

SO, YOU NEED A FULL-FRAME, RIGHT?

Not at all. My first “large sensor” was a 1” Sony RX10, still considered to be in the “compact” class. That camera and I were inseparable for most of two years. I made these with it.



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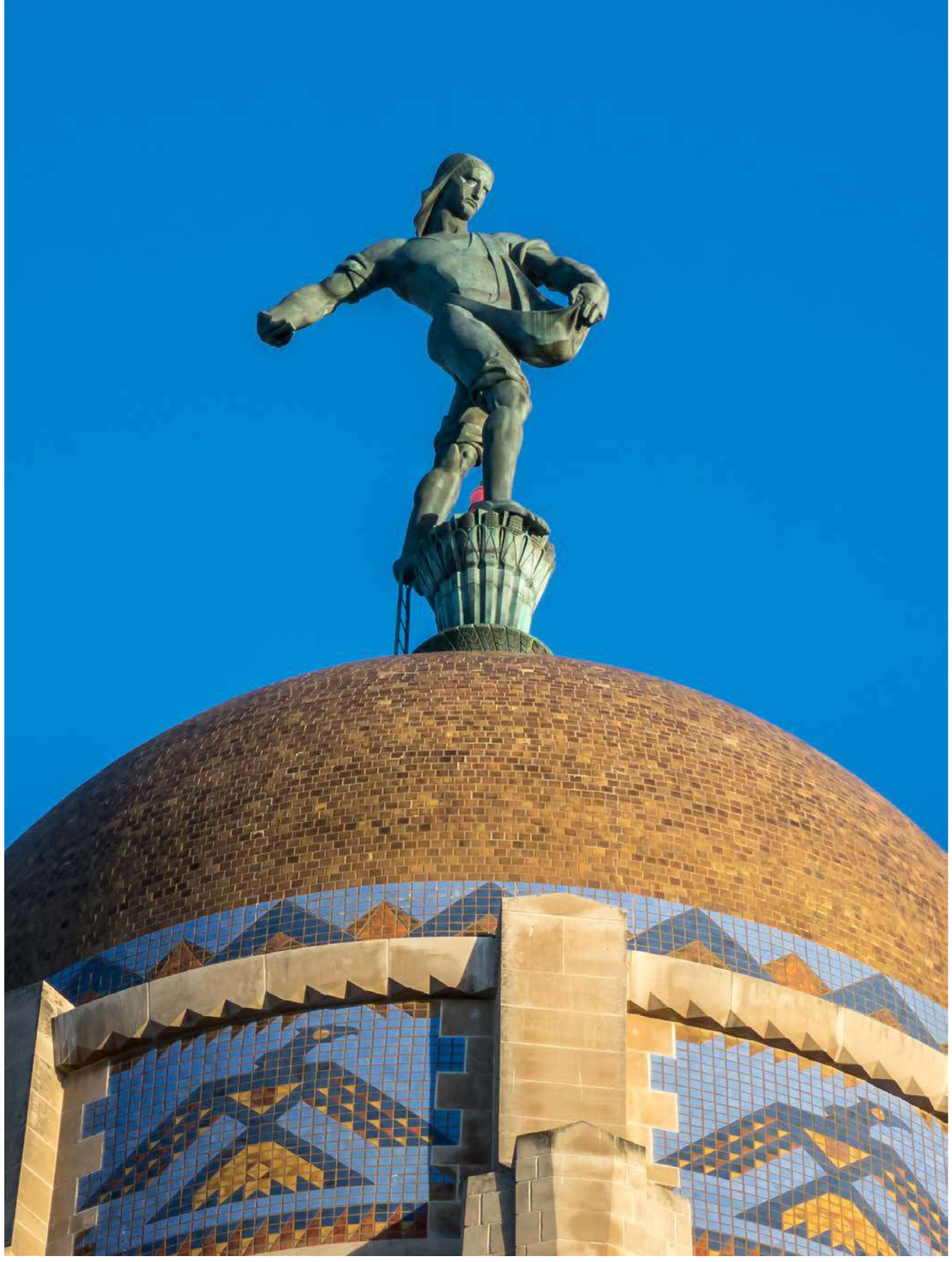

Photograph by Charles Haacker

I see no need for a full frame in my own work. I think professionals need full-frame pro bodies, and if I was working for money I would think hard about it, but I keep my hand in shooting events for nonprofits and am very pleased with the sterling performance of my APS-C Sony cameras. My benchmark is my stock question: *Would I shoot a wedding with it?* Yes. Absolutely. I would.

CONCLUSION

I am satisfied that bigger sensors make the most sense overall. The bigger the sensor, the higher the overall resolution, superior low-light performance, greater dynamic range (especially if you shoot raw), lower discernible noise, and the files can tolerate more cropping under all conditions, much like the big 4x5 negatives I started with. You don't need a full frame. I don't have one. I almost didn't have the half-frames as I was content with the 1" Sony RX10 (killed by lens fungus, RIP). It's a journey for all of us. I am not sorry I got into MILCs, but I could have happily continued as I was.

But doing this project convinced me that absolutely, bigger is, on balance, better.

If I didn't know it before, I do now.

Self-Check Quiz:

1) Explain to someone using a tiny compact why a larger sensor will deliver better quality.

2) True or False: You can crop a little section out of a small-sensor picture without visible loss of quality.

3) True or False: On balance, digital sensors of all sizes seem to produce superior quality to film.

4) True or False: In very low light, larger sensors always outperform smaller ones.

5) True or False: In excellent light, larger sensors always outperform smaller ones.

6) True or False: In film, we could make equally sharp, low-grain enlargements with any size negative.

7) If you take the same scene with a 35mm film camera and an equal digital full-frame camera and make identical prints, will you be able to tell the difference?

Assignment:

If you have access to a larger format digital camera, defined as anything over 1”, and you have a smaller format (your phone is fine), then try taking some identical pictures with each so you can compare. Try good light and low light. Try enlarging both. See if you can see a difference.

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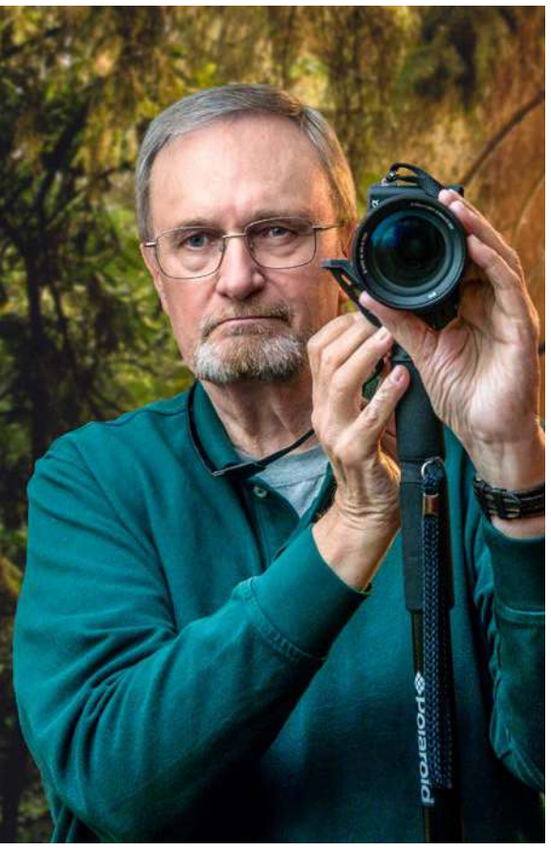

Charles Haacker graduated Summa cum Laude from Laney College in Oakland, California. He holds a degree, “Associate of Science in Commercial Photography”. He worked as a professional photographer specializing in weddings, children, family, and business portraiture from 1968 until 1994. He also handled assignments in the corporate and industrial arenas. After retiring from his studio, he stays busy by donating his talents to pro bono work for charities that cannot afford the rates of a professional photographer. He is a proud member of the Lincoln, Nebraska Camera Club.

You can reach him on Quora or view his work at: https://flic.kr/s/aHsjoEW9oR.

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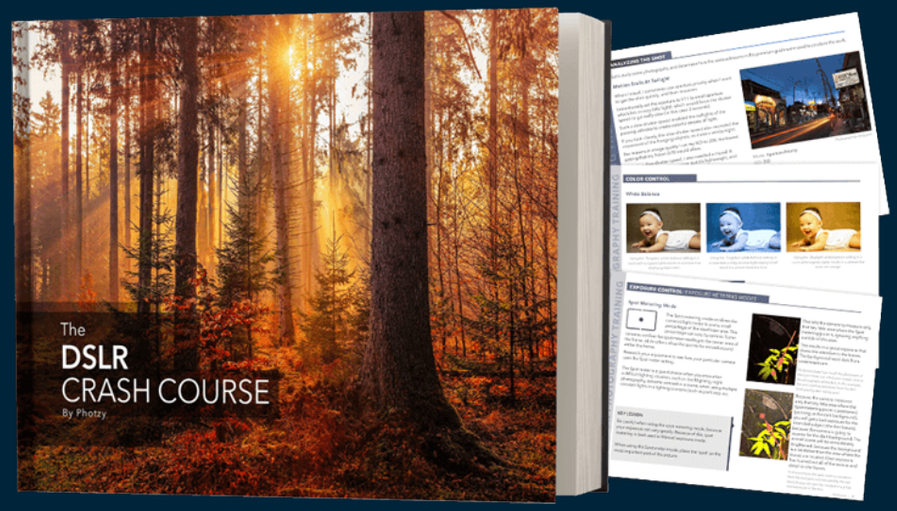

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