Photography

Depth of Field

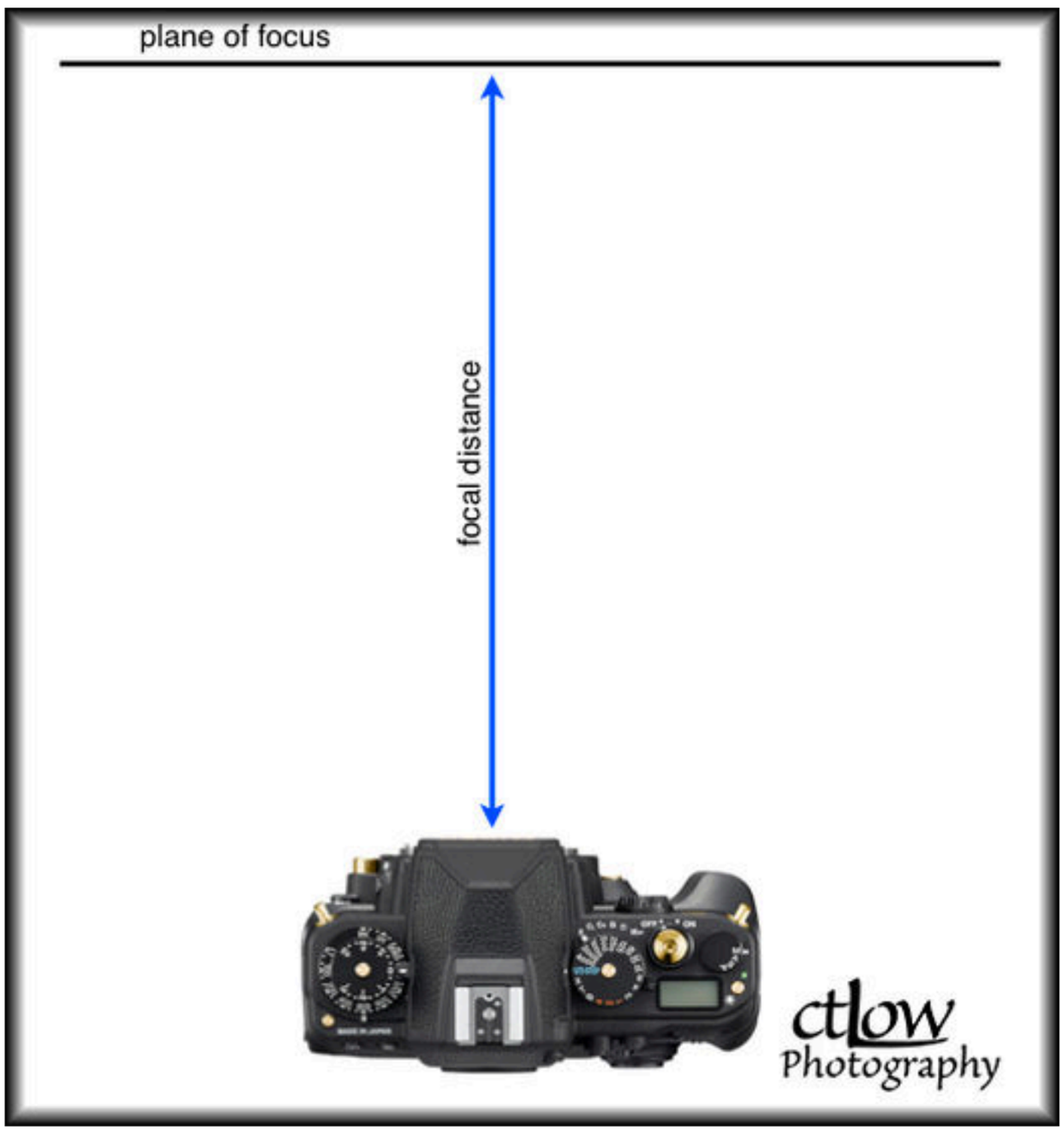
March 10, 2018 | Charles T. Low, Photographer

Better Photographs with Aperture Control

The concept here relates to how much of a photograph we wish to have in focus. It sounds obvious to say "as much as possible", but I will illustrate why not, and I aim to explain this in a way which beginners will understand but in which experts will also find a few new nuggets.

First, let me clear up a potential source of confusion, between "depth" and "sharpness". They don't mean at all the same thing, although of course they have a relation to each other.

By **sharp**, we mean how clear and in-focus the image appears ... *only at a specific distance from the lens*. We will hear the term "point of focus", although technically we would more accurately call it a "plane of focus" - the distance at which we have so carefully focussed our lens (or which we hope the auto-focus has done for us).



plane of focus

By **depth-of-field** we rather mean how much of the image appears acceptably sharp *ahead of and behind* the plane of focus. This varies with aperture, meaning the size of the adjustable iris opening: a smaller aperture provides more depth-of-field, and a larger aperture provides less.

As the aperture gets smaller, the f-number rises, because it derives from an inverse-ratio calculation.

(f-number ∝ 1/aperture-diameter)

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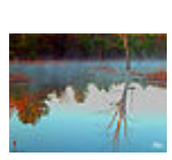

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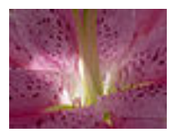

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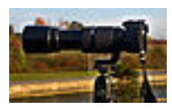

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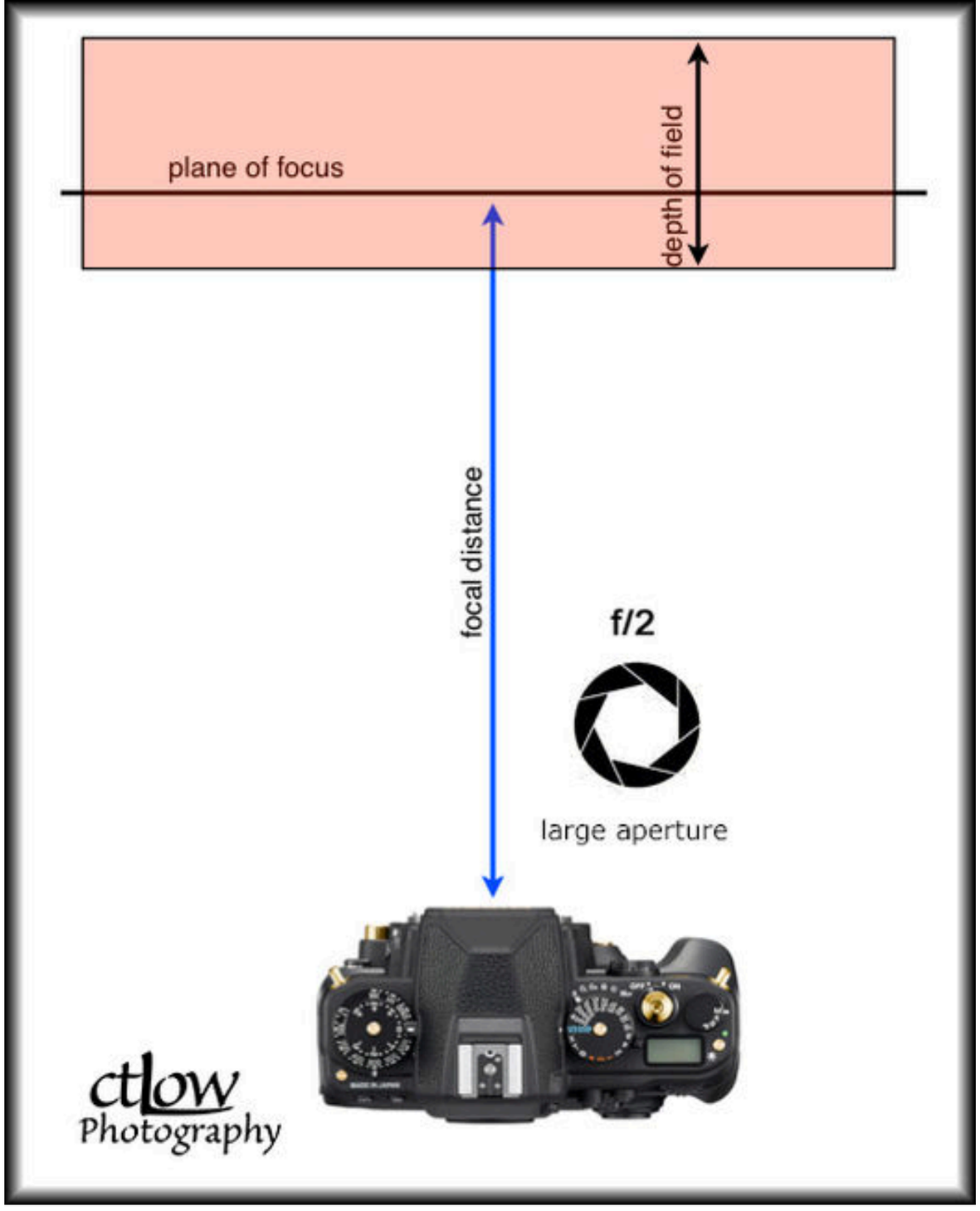

Shallow depth of field, large aperture (small f-number)

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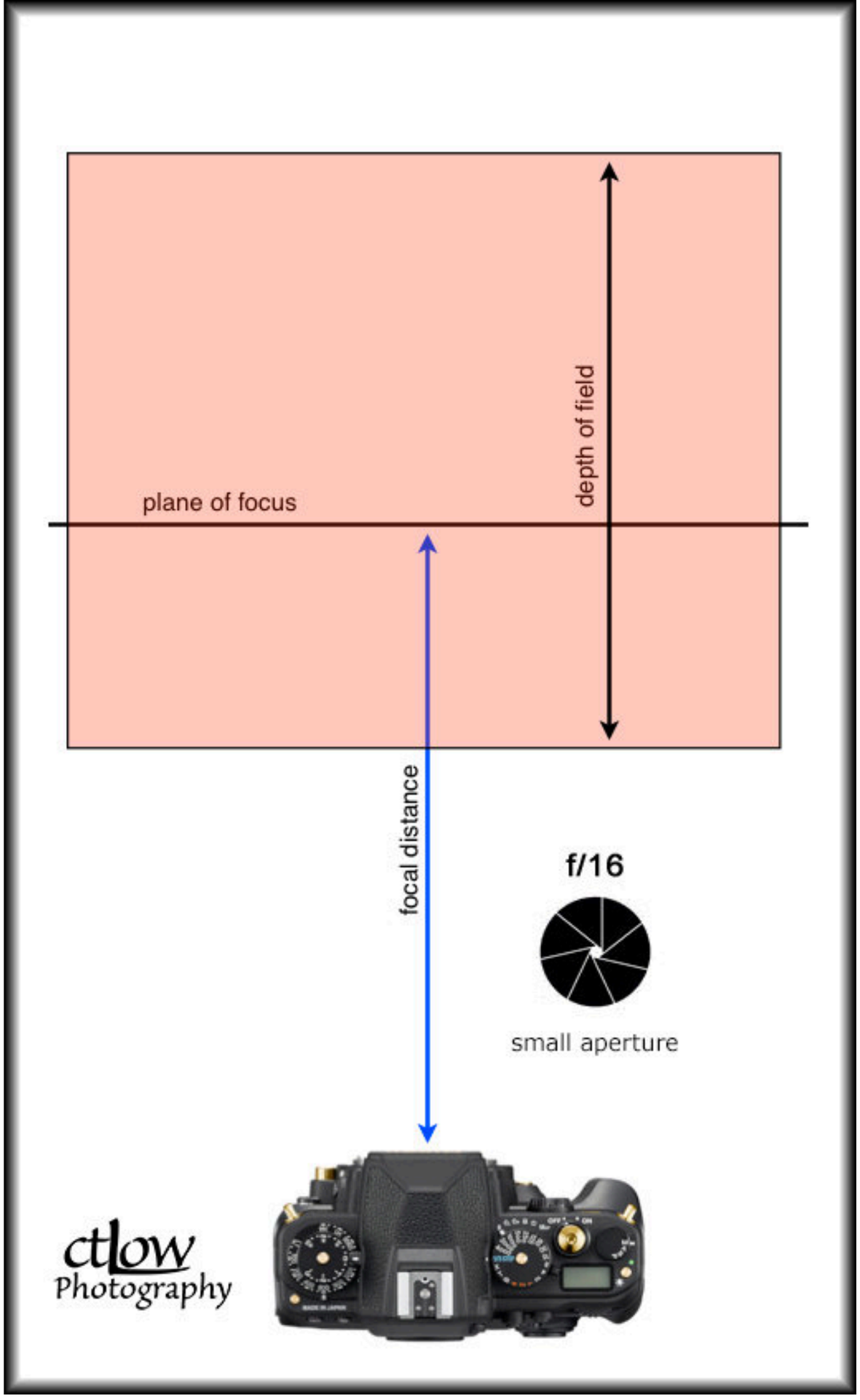


Large depth of field, small aperture

Let's get technical
(or skip this section)

We can make several other basic adjustments on our cameras:

- shutter speed;
- ISO;
- lens focal length.

For the present purposes, I will confine myself to aperture.

Incidentally, the f-number doesn't represent a *size*, but rather a *ratio*, so that f/8, for example, always means f/8. In theory, and almost in practice, you can change lenses, for example to a different focal length, and if everything else stays the same, f/8 will always let in the same amount of light. With a telephoto lens, which gathers light from a restricted field of view, f/8 requires a larger *physical* aperture than with a wide-angle lens, which gathers light from a generous field of view. But that doesn't matter, and the photographer doesn't have to think about it, knowing that if you have figured out a shutter speed and ISO setting for f/8 with one lens, it should stay the same (as long as the light doesn't change) with another lens.

We measure changes in f-numbers in **stops**. One full stop gives twice or half as much light as the one next to it. The sequence goes like this:

f/1.4, f/2, f/2.8, f/4, f/5.6, f/8, f/11, f/16, f/22

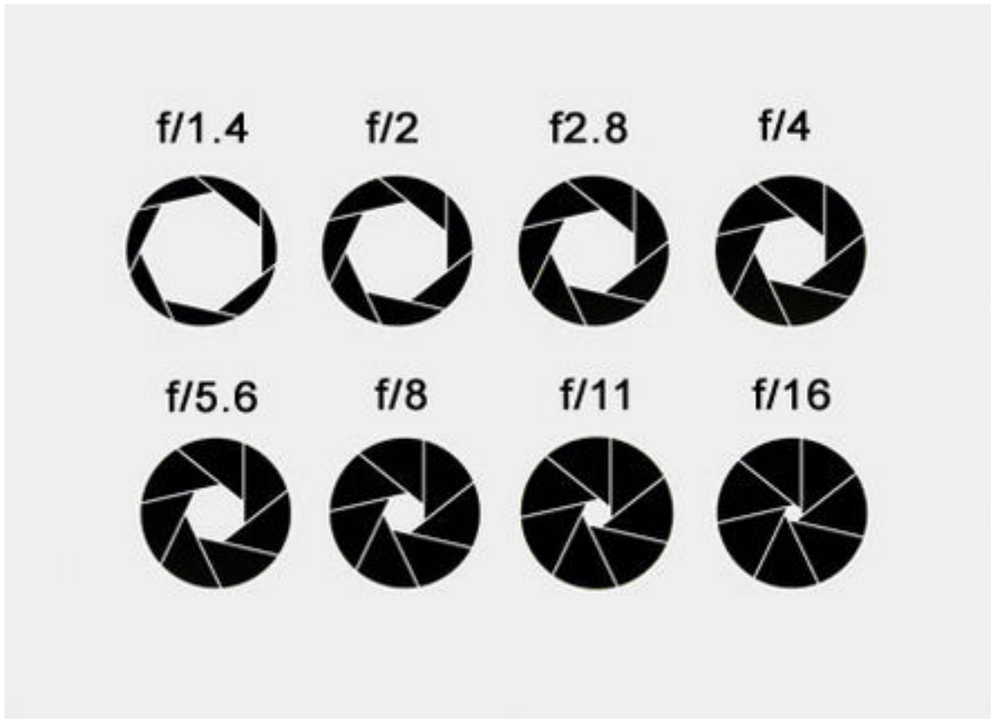
Those f-numbers, by the way, go from larger apertures to smaller. More below.

Most lenses allow setting half-stops, in between those numbers.

Conversely, depth of field *does* change with sensor size. The famed Group f/64, from almost a hundred years, ago only got the equivalent depth of field at f/64 as a modern full-frame sensor at f/8.

Their very large photographic plates account for this. By contrast, a micro-Four-Thirds camera, with a sensor essentially one quarter the area of a full-frame camera, gets that depth of field at f/4. This effect can work for or against us, depending on circumstances, but we cannot dispute the effect (for reasons, as always, simply of optical physics).

As an aside: we know intuitively what we mean by terms such as "sharp" (or "in-focus", or "resolution"). I could get into technicalities such as "circles of confusion", but I don't think that talking about confusion will provide any more clarity! I could get into an analysis of the smallest subtended angle which the human eye can perceive. Allow me to leave those alone for the purposes of the present discussion. Optical physicists might define "sharp" more rigorously, but again, that doesn't help us here. And for you purists: I will intentionally omit a discussion of hyperfocal distance.



aperture sizes and f-numbers

Deep Is Not Sharp

It might seem obvious that a larger depth of field would provide more sharpness, but it doesn't work like that. Think of sharpness only on the precise plane-of-focus. At that exact distance, which of course depends on where we focussed the lens, *the most sharpness comes usually from somewhere in the middle range of apertures*. The exact optimal f-number varies from lens to lens.

So, again thinking only of the plane of focus, we will get the sharpest image on a full-frame sensor camera at something close to f/8, and on a micro-Four-Thirds camera at around f/5.6. I assume that for the common APS-C sensor, an in-between size, we could use f/6.7.

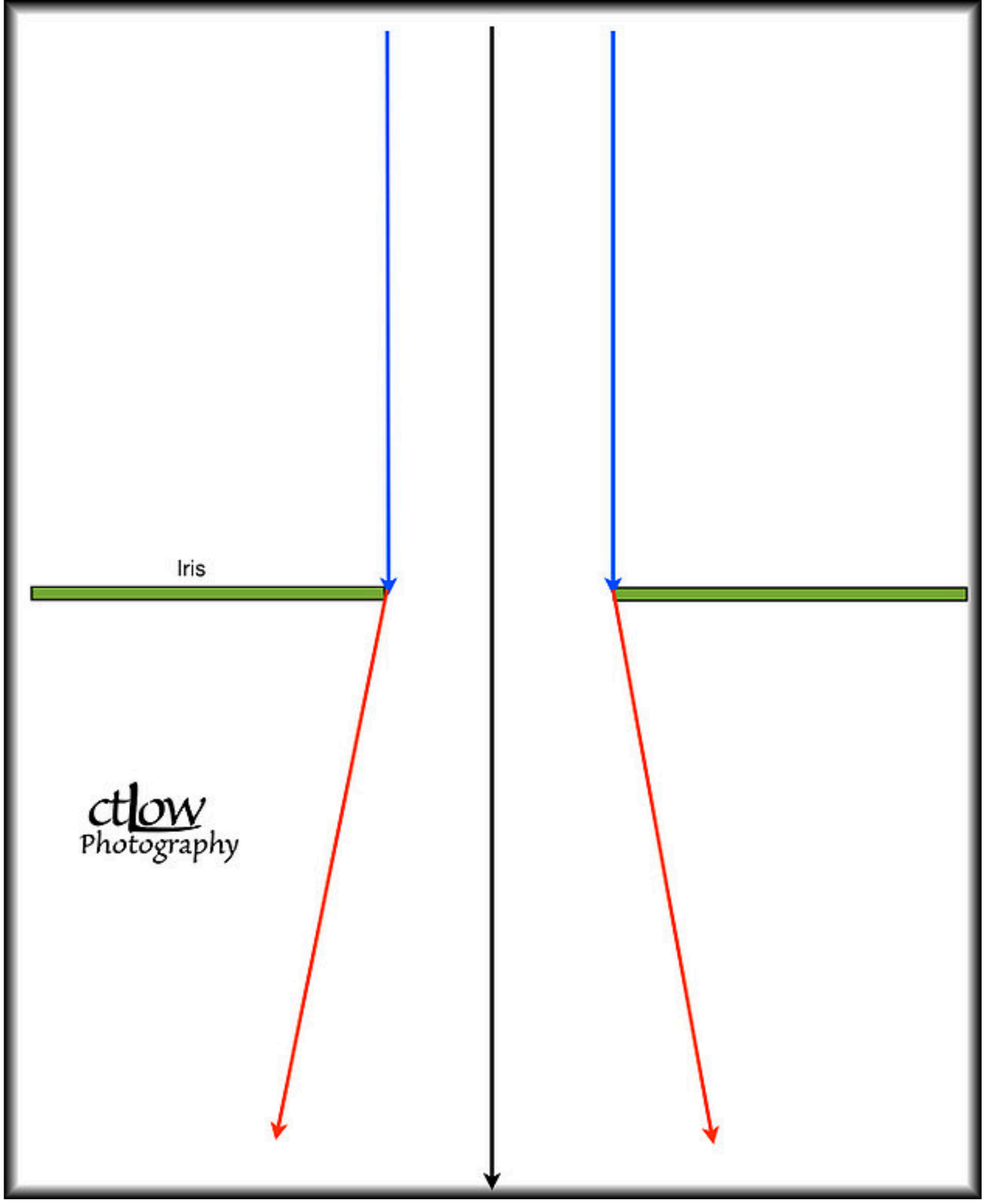
If you don't know if your camera uses a full-frame, APS-C, micro-Four-Thirds, or other sensor, then don't worry about it. The general principle will satisfy your needs. (Or ... find out about your sensor.)

Note that depth of field extends further *behind* the plane of focus than it does *in front of* the plane of focus. The physics of optics explains all of this, but let's stick with photography here, not math.

Large apertures: what happens at *larger* apertures to diminish sharpness - thinking still very specifically about only the plane of focus - relates to the difficulty of making lenses in the first place. The outer edge of a lens often doesn't provide quite the same resolution as the more central parts, so opening the iris, i.e. using a wide aperture (a lower f-number), uses more of the whole diameter of the lens, not just the central portions. This will not only provide less depth of field, but also will not provide quite as crisp, sharp an image at the actual plane of focus.

Higher-quality lenses will, in general, have better wide-open sharpness than lower-quality lenses. Furthermore, a cheaper lens might only open to f/5.6, and require f/11 to produce a really sharp image. An upper-end lens might open to f/2, and work well by f/2.8. See Equipment.

Small apertures: what happens at *smaller* apertures, however, relates to edge-diffraction. The edges of the iris scatter light, and the smaller the opening, the relatively more of the image suffers from this effect. The ratio of iris edge-length to aperture-area varies by the square (if you must know!), so that explains why the effect occurs more strongly at smaller apertures than at larger.



Light rays should remain parallel, but edge diffraction causes some blurring of the image, although not usually enough of the light to make a material difference. At smaller apertures, the proportional amount of diffracted light will increase, relative to undiffracted light, more than at larger apertures, because of a squared relationship between length (iris-edge) and area (aperture).

(length^2 ∝ area).

So, if you have something very specific on which you wish to focus, and you need it, and only it, as tack-sharp as possible, it might help to bear in mind to use a medium aperture.

Other considerations however often outweigh this. Among other things, the factor of aperture size does affect sharpness, but not always a lot, and certainly not always noticeably.

The other considerations include:

- shutter speed;
- focal length;
- compositional considerations.

If other things remain equal, then a smaller aperture will require a slower **shutter speed**. But you may decide that you need a *faster* shutter speed, for example to freeze action, or to allow hand-holding the camera - *vice versa* if you wish a long shutter speed. So, shutter speed might over-ride aperture/depth-of-field considerations.

Focal length affects depth of field very noticeably, and longer lengths, i.e. more telephoto lenses, provide less depth of field than shorter, i.e. wide-angle, lenses. This can hinder or abet your art, but like anything else pertaining to physics, it won't go away. It can absolutely number among the many factors which influence you to choose one lens over another for a particular photograph.

That leads in nicely to the topic of **composition** - how you put the elements together in your photograph.

Depth of Field and Composition

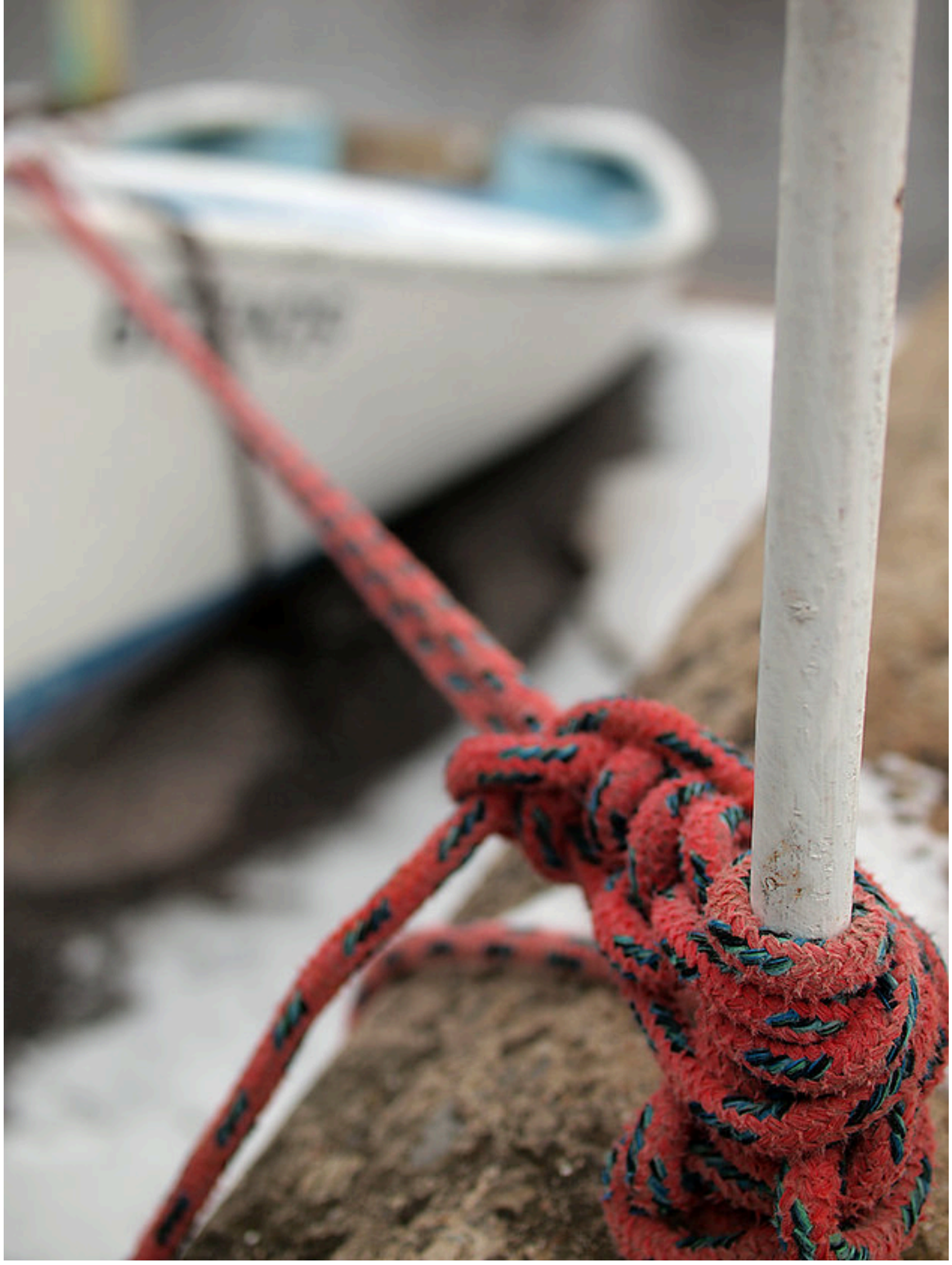
I noted in a recent blog that the way a camera looks at a scene - with a plane of focus, everything nearer and further from that plane becoming progressively more blurry - differs considerably from the way the eye/brain complex sees, scanning around, bringing various parts of the field of view into focus as required, and building some sort of composite mental image of the scene.

Beginning photographers soon learn that this does *not* necessarily mean that we want a maximal depth of field. It *does* mean that we need to recognize that a camera sees differently from the eye, and so we will use depth of field as one of the elements we choose and control in our photographs.

For example, we may want objects near and far to remain in focus, so will decrease the aperture (i.e. increase the f-number, such as f/22) until we get the effect we desire.

I chose f/6.7 to prevent the foreground and background from appearing as very blurry. Using a wider aperture would have isolated the tree trunk more, which I could have chosen as a completely valid option as well ... but I didn't. Aperture and therefore depth of field did what I wanted it to do.

Often, however, we wish to separate the subject visually from the background, and we can do that, among other methods, by using a shallow depth of field (i.e. decrease the f-number, such as f/2).



f/2.8 - large aperture, small depth of field (plus the scene encompasses a large distance-from-lens, relatively, front to back, which might exceed the depth of field no matter what we do)

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the further trees perfectly sharp (not that I wished to), because i) they were quite a bit farther away than the near trees, and ii) snow in the air acted as haze, and iii) the telephoto lens which I used (almost 6x magnification) provides less depth of field than a wider-angle lens.

My friend, the infamous Pirate King, Sandy Hay, in a pensive mood, isolated from the background because I let it go out of focus, using a large aperture (f/2.8).

I would like to add that small changes in f-number do not make much difference. Unlike small changes in exposure, where half stops can alter the photograph significantly, you won't see much difference in depth of field with half-stop increments. If you want very fine control, then you might make 1-stop adjustments, but often I do depth-of-field bracketing in 2-stop increments, if not more.

Prioritize your aperture!

Because of all of the above, I have always and almost only ever used "A" mode on my cameras, going back to 1983, when I received as a gift a Minolta X-700. (Man - the fun I had with that camera!) "A" indicates "aperture-priority", meaning that I set the aperture (f-number), and the camera chooses a suitable shutter speed, depending on the amount of light. Certainly, I can over-ride the shutter speed, and frequently do so, should I judge the scene as requiring more or less light than does the camera's automated process.

Well, at the *very* beginning, for a brief while, I used "P", "programmed" mode, in which the camera chooses both aperture and shutter speed for me. I never use "Auto" mode (nothing wrong with it ... I'm just stubborn), and personally rarely use "S", "shutter-priority" mode, in which I choose the shutter speed and the camera adjusts the aperture, which might however be handy for fast-moving subjects such as children or athletes. I almost never use specialty modes like "Portrait" or "Beach", although some photographers report highly satisfactory results with them.

In A-mode, I still have to remain aware of the shutter speed, for reasons discussed above. In lower-light situations, I will need a tripod, or some other stabilizing mechanism, but that remains my choice.

Controlling depth of field by aperture size has always felt important to me, as an essential aspect of artistic composition. I find myself much more often using apertures at the wide end, eg. f/4 on an f/2.8 lens, preferring a softer background against the in-focus subject, but that will always remain individualized for each photograph, and will always remain the artistic choice of each individual photographer.

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Thank you so much for reading.

Charles T. Low

Photographer

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