Back to Basics: DEPTH OF FIELD

Orléans Photo Club

February 8, 2020

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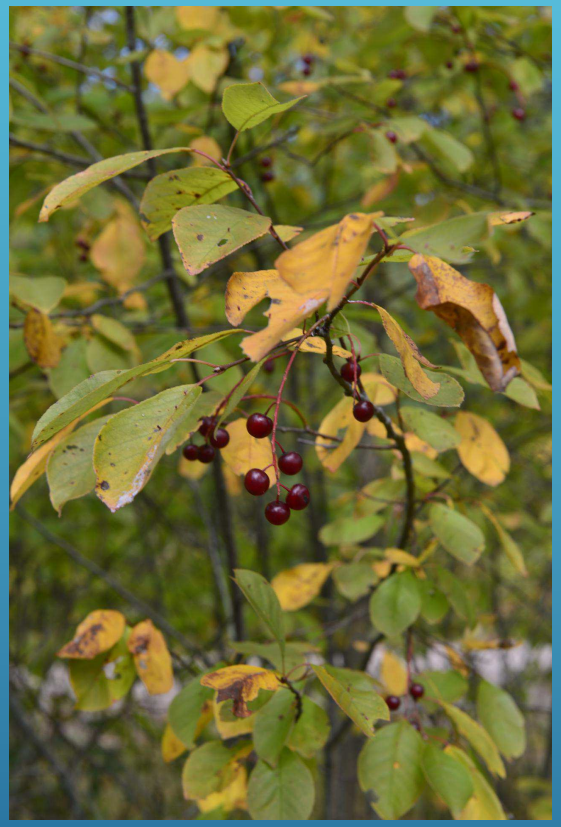
- What is depth of field?
- What controls it?
- How can it be used?
- How can we change it?

WHY DO WE CARE ABOUT DEPTH OF FIELD?

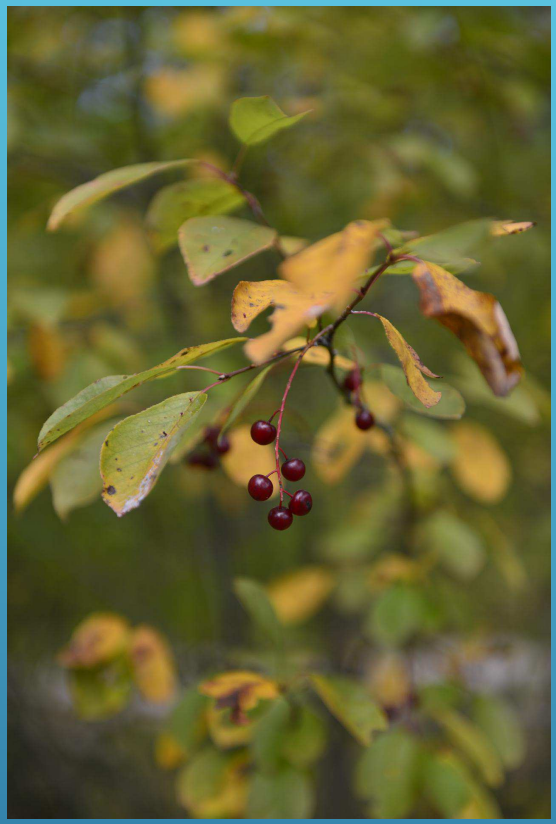
Photographers control depth of field to:

- Highlight an area
- Keep attention in one part of the image
- Allow the subject to be seen as we normally perceive it

TO SEPARATE THE SUBJECT FROM THE BACKGROUND



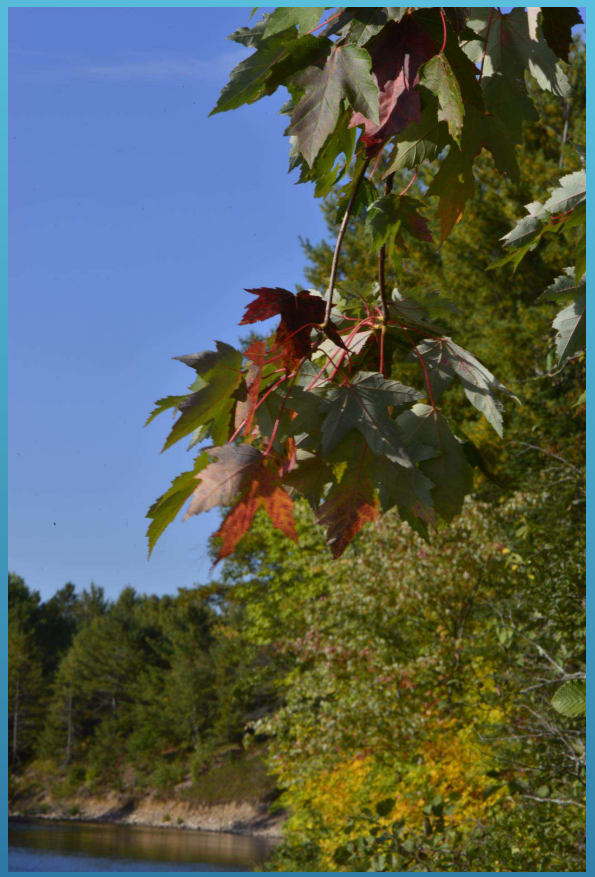
Deep



Shallow

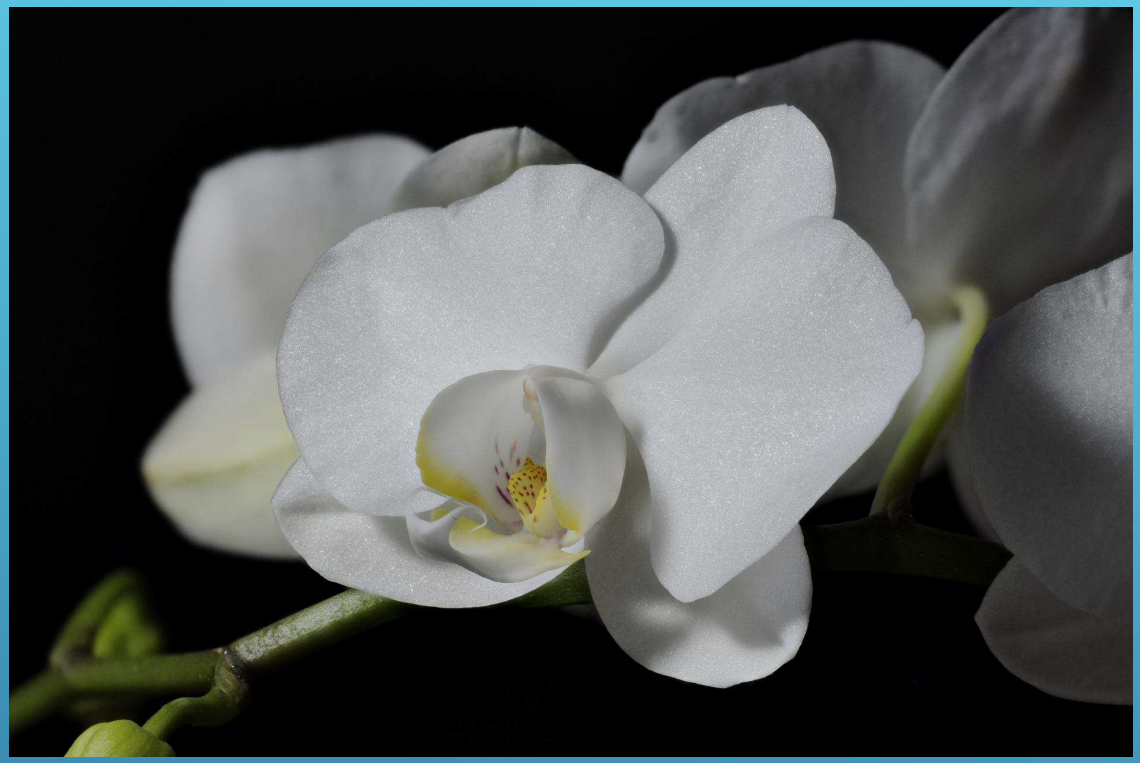
WE WANT THIS…

INSTEAD OF THIS…



BUT, SOMETIMES WE WANT A LOT OF DEPTH OF FIELD…

SOMETIMES WE NEED IT TO SHOW WHAT WE SEE…

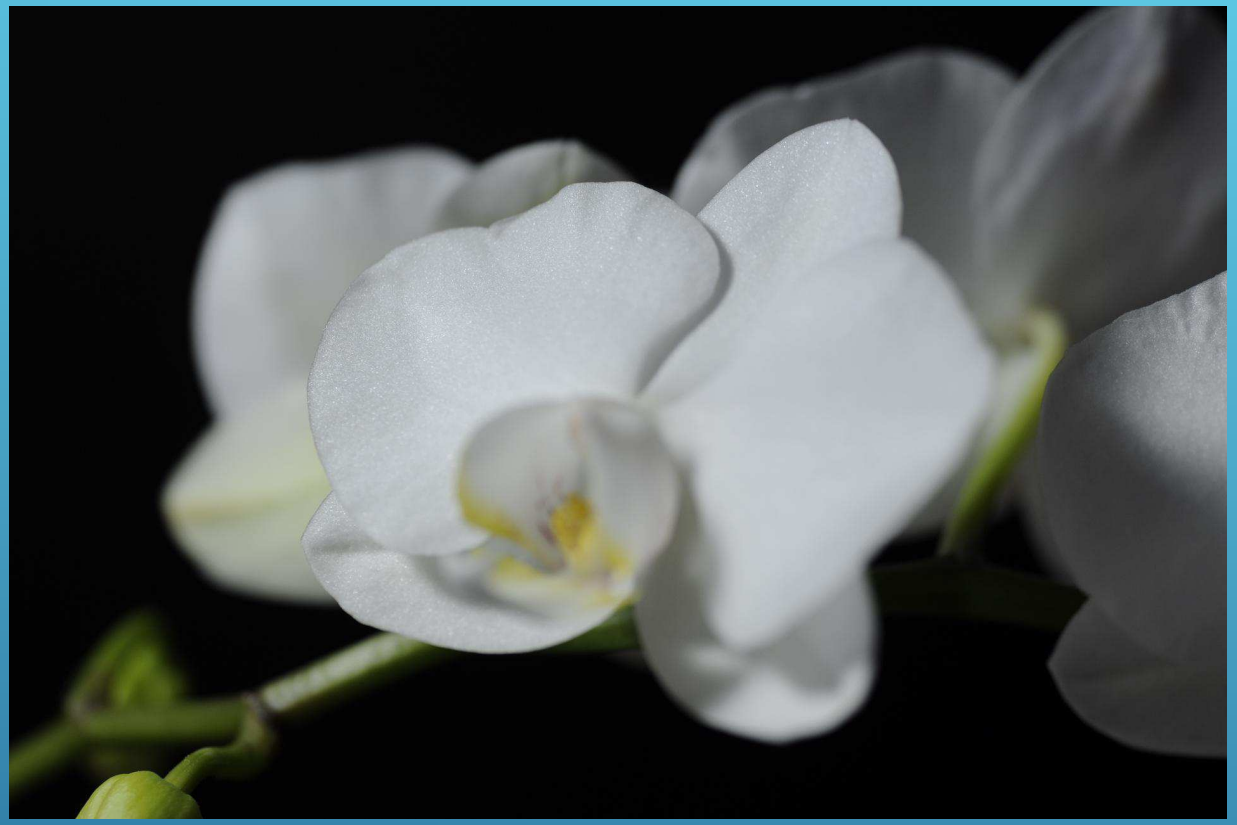


When we look at a subject up close, our eyes automatically focus on different parts and our brain blends them together so we see it all in focus

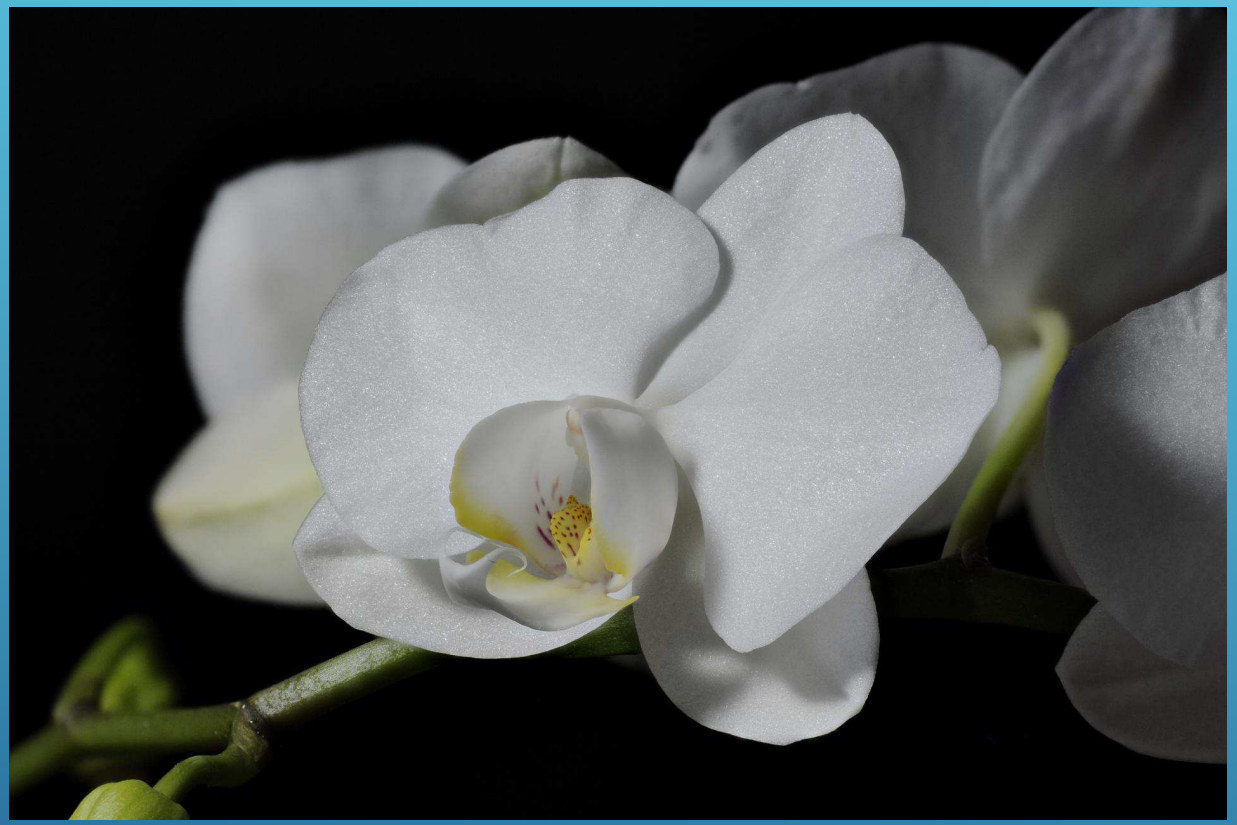
BUT WITH A CAMERA,
F YOU FOCUS ON THE FRONT OF THE FLOWER…

F YOU FOCUS IN THE MIDDLE…

AND IF YOU FOCUS AT THE BACK…



SO WE NEED TO MANIPULATE DEPTH OF FIELD TO SHOW WHAT WE SEE



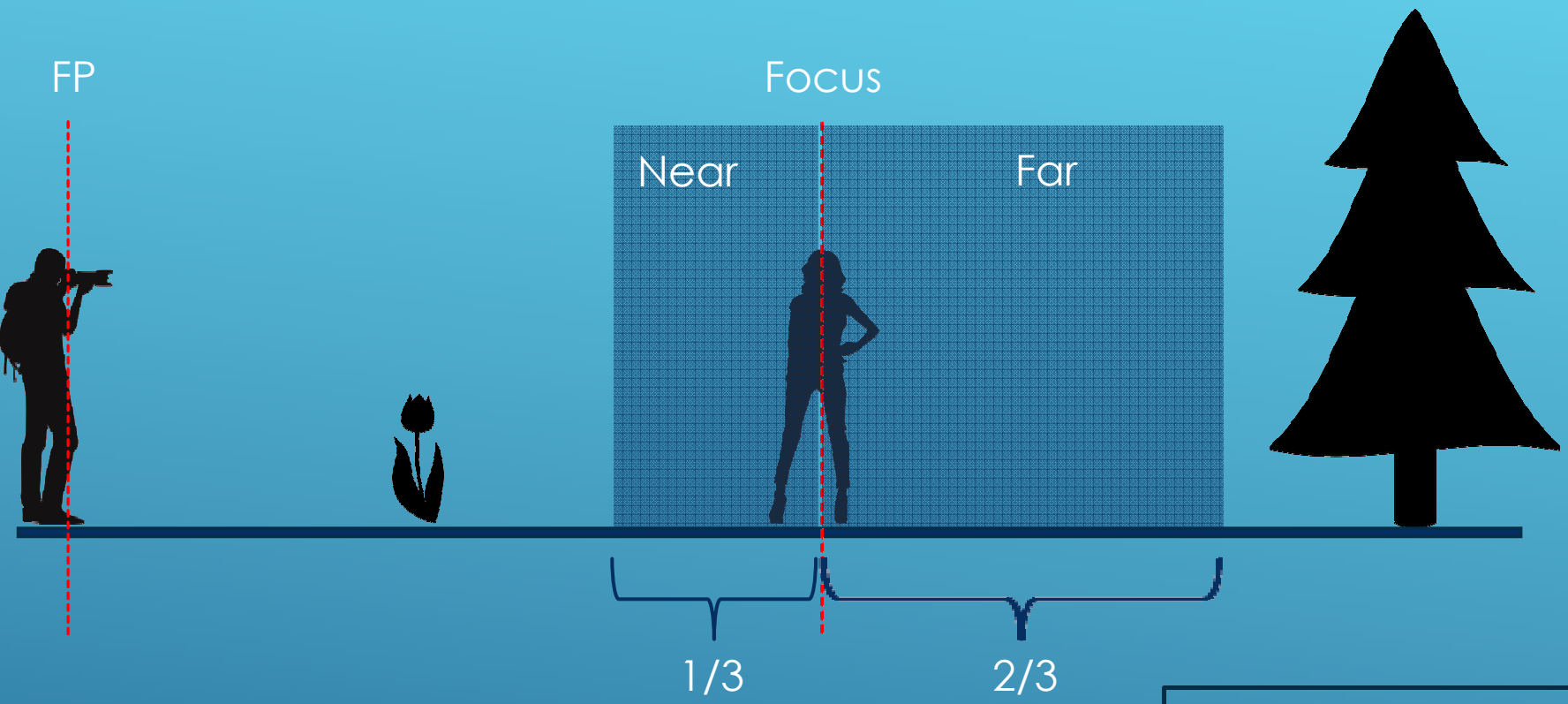
WHAT IS 'DEPTH OF FIELD'?

The distance between the nearest and furthest objects in an image that appear to be in focus

There is one **point of focus** in any photograph.

The zone of acceptably sharp image
in front of and behind this point of focus
is the depth of field.

WHERE IS THE 'DEPTH OF FIELD'?



Rule of Thumb:

The depth of field is:

- **One third in front of the subjec**
- **Two thirds behind the subject**

WHAT CONTROLS DEPTH OF FIELD?

There are several factors that control the depth of field for any image:

- Aperture (f/number)
- Lens focal length (mm)
- Distance from the lens to the subject
- Sensor Size

Remember:

The depth of field is split with one-third in front of the point of focus and two-thirds behind the point of focus

What **does not** control depth of field?

- Shutter speed
- Height from the ground
- ISO speed
- Number of megapixels
- Brand of camera or lens

APERTURE

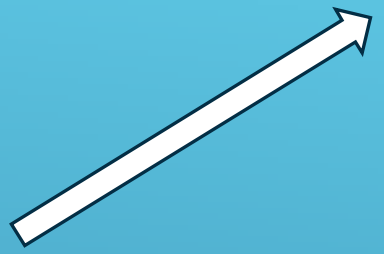
The aperture on a camera lens controls the amount of light passing through.

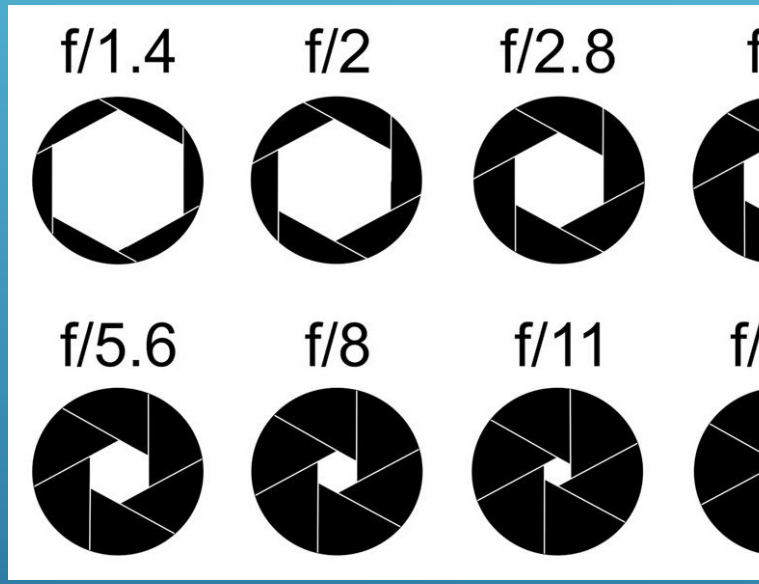
The diaphragm opens or closes, depending on the selected f/stop.

Selected either on the lens, by the camera or automatically.

Given in units such as f/2.8, f/5.6, f/16.

The **larger** the number,
the **smaller** the aperture.





APERTURE LIMITS

NO lens performs its best at either end of the aperture range

Wide open (f/2) – chromatic aberration, vignetting

Closed down (f/32) – diffraction limited

Most lenses have a “sweet spot” around f/8

APERTURE & DEPTH OF FIELD

The smaller the aperture (f/32 vs f/2.8), the deeper the depth of field

Focal Length (mm)	f/stop	Focus Distance (m)	Near Focus (m)	Far Focus (m)
50	2.8	33	15.6	Inf
	5.6		10.2	Inf
	8		7.9	Inf
	16		4.5	Inf
	32		2.4	Inf

But you can't just stop all the way down to get a large depth of field.

Remember the diffraction limit!

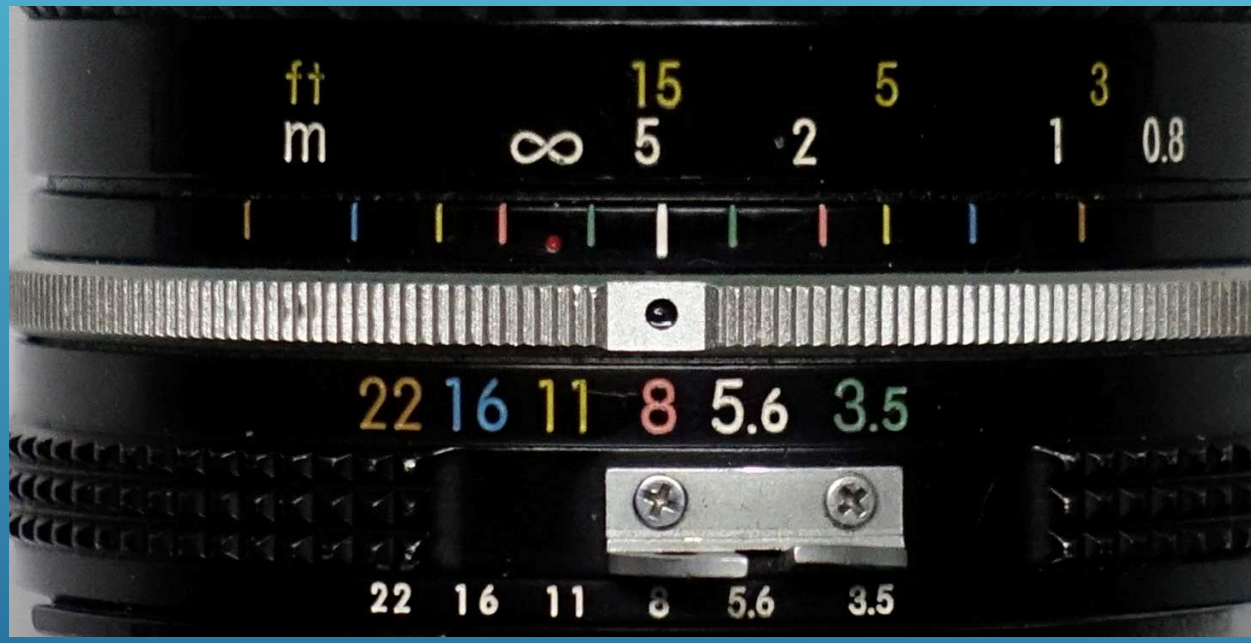
APERTURE & DEPTH OF FIELD

enses used to have a system for showing
ow the depth of field could be predicted.

Colour-coded aperture values correspond
with tick marks on distance scale

Not generally available
anymore

Automatic lenses where
aperture is set in the camera



LENS FOCAL LENGTH & DEPTH OF FIELD

The shorter the focal length (14 mm vs 200 mm), the deeper the depth of field

Focal Length (mm)	f/stop	Focus Distance (m)	Near Focus (m)	Far Focus (m)
14	8	33	0.8	**Inf**
50			7.9	**Inf**
200			27.6	41.1

A 1000 mm lens (super telephoto) will have a depth of field of 0.5 m when focussed at 33 meters (at f/8).

Accurate focussing becomes critical with longer focal lengths.

LENS FOCAL LENGTH & DEPTH OF FIELD

Compare two different focal lengths 50 mm vs 200 mm (same distance)

50 mm

f/stop	Near Focus (m)	Far Focus (m)
2.8	15.6	Inf
5.6	10.2	Inf
8	7.9	Inf
16	4.5	Inf
32	2.4	Inf

200 mm

f/stop	Near Focus (m)	Far Focus (m)
2.8	31.6	34.5
5.6	30.3	36.2
8	29.3	37.7
16	26.4	44
32	22	65.8

FOCUS DISTANCE & DEPTH OF FIELD

The farther from the lens to the object, the deeper the depth of field

Focal Length (mm)	f/stop	Distance (m)	Near Focus (m)	Far Focus (m)
50	8	333	10.1	Inf
		33	7.93	Inf
		3	2.34	4.19
		1	0.92	1.10
		0.5	0.48	0.52
		10 cm	9.95	10

Getting closer to the subject makes the depth of field shallower.

Macro (close up) photography depends on other factors as well.

The depth of field is only 0.5 mm

SENSOR SIZE & DEPTH OF FIELD

This can be deceiving as a calculator will initially show DOF to be deeper with larger sensor sizes

Focal length 100mm, f/5.6, Distance 10 meters				
Camera	**Sensor Factor**	**Near (m)**	**Far (m)**	**Total (m)**
Nikon D800	1.0	8.6	12	3.5
Nikon D300	1.6	8.9	11.3	2.3
Sony RX100	2.7	9.4	10.7	1.2

Is DOF Decreasing?

SENSOR SIZE & DEPTH OF FIELD...continued

But, we have to correct for sensor size!

Focal length 100mm, f/5.6, Distance 10 meters				
Camera	**Corrected Focal Length**	**Near (m)**	**Far (m)**	**Total (m)**
Nikon D800	100	8.6	12	3.5
Nikon D300	63	7.8	14	6.6
Sony RX100	37	6.9	18.3	11.4

DOF
Increasing

For the equivalent focal length, as the sensor size decreases, the depth of field increases!

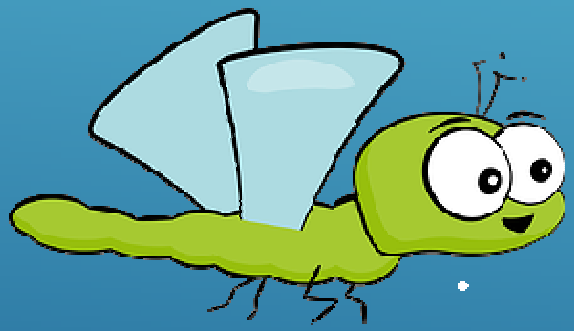
NCREASING THE DEPTH OF FIELD

Macro photography can be a challenge because the depth of field is so small.

Landscape and scenic photographs also require large depth of field

HOW CAN WE INCREASE THE DEPTH OF FIELD FOR MACRO PHOTOS?

Most photographers have seen an interesting insect and thought:



Then, when they take the photo they get...

This

Or this

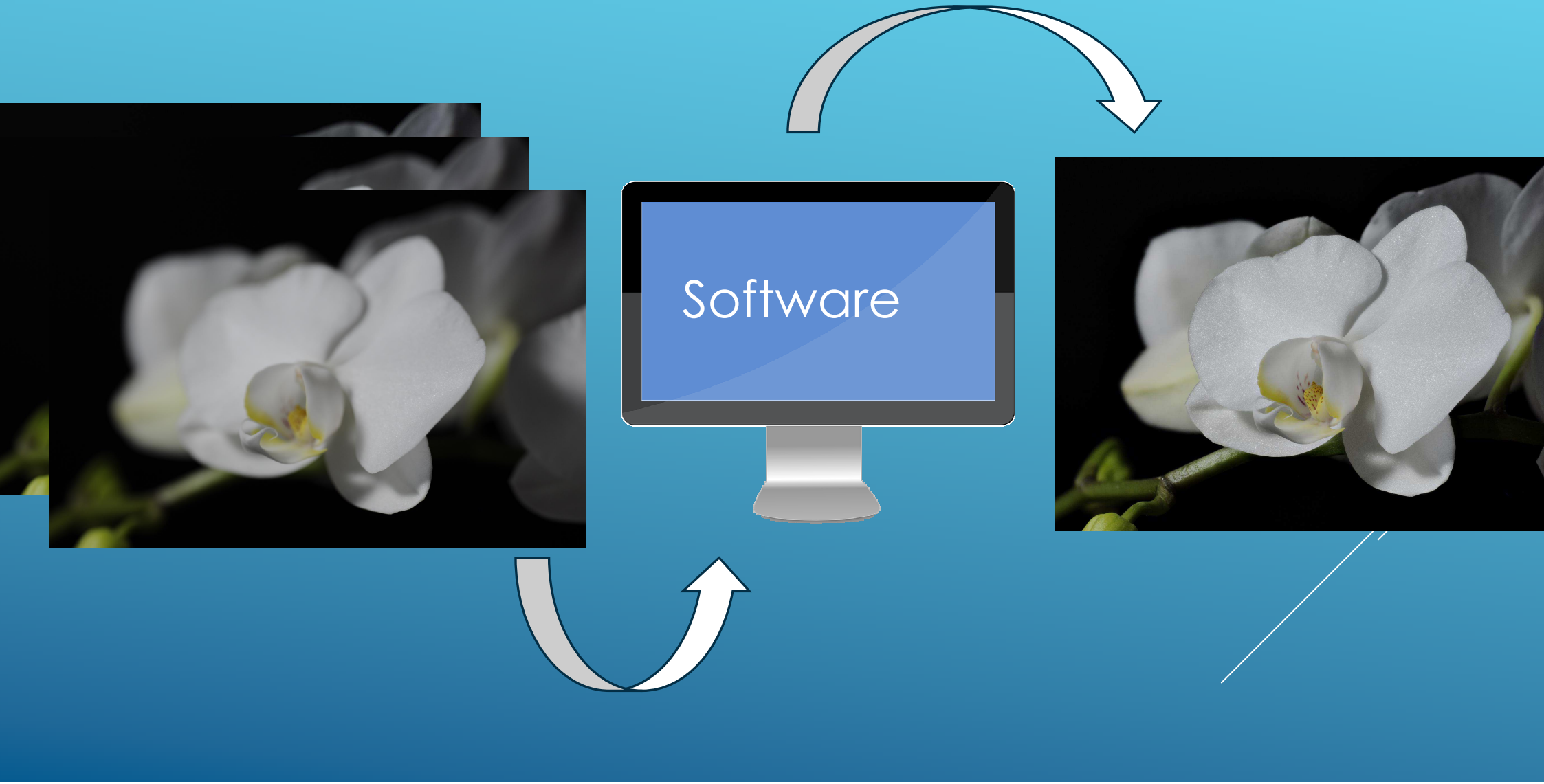
Unless the dragonfly is very patient a
then you can take time to stop down

What can the photographer do to increase the depth of field in macro photography?

- Change the plane of the subject
  - If most of the subject is in one plane, more will be in focus

- Minimize aperture (“stop down”)
  - Usable for most subjects but there are limits (diffraction)
  - Need more light
- Focus stacking
  - Usable for static subjects
  - Requires software

Focus Stacking



Focus Stacking - How is it done?

ither

- Focusing rail
  - incrementally move camera after each photo
- Software to control the camera lens
  - moving the point of focus with each photo

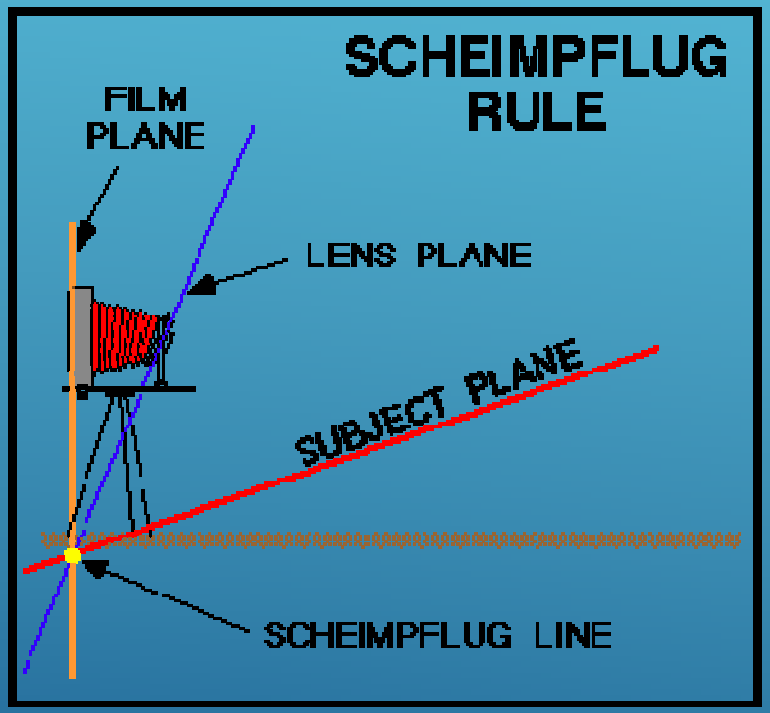
Then, use software to combine the images
•Manually (Photoshop)
•Automatically (Zerene, Helicon, etc.)

HOW CAN WE INCREASE THE DEPTH OF FIELD FOR LANDSCAPE PHOTOS?

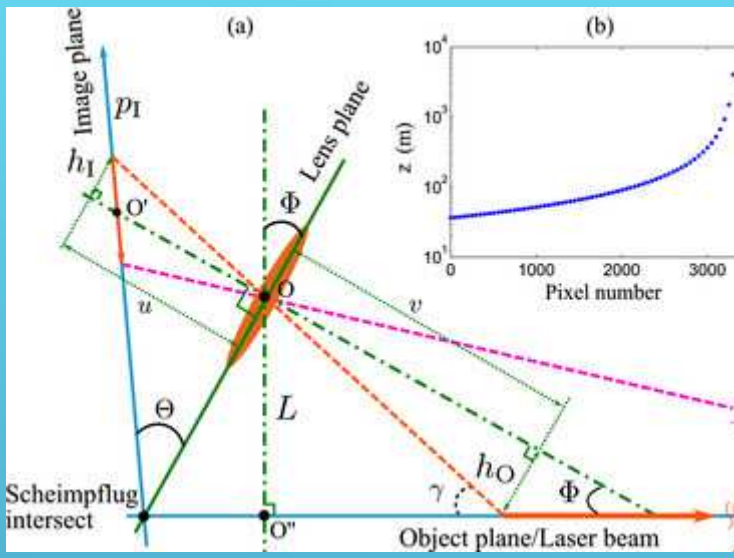
- Use smaller aperture ("stop down")
  - But remember, there are limits to how far we can stop down due to diffraction
- Use special tilt-shift lens

Using Tilt-Shift Lenses

Scheimpflug principle



If the plane of the lens can be aligned with the plane of the subject, then the DOF can be considerably increased



$$
\begin{aligned}
y_v &= m y_u \\
&= -\frac{v-f}{f}\left(a\frac{vf}{v-f}+b\right) \\
&= -\left(av+\frac{v}{f}b-b\right),
\end{aligned}
$$

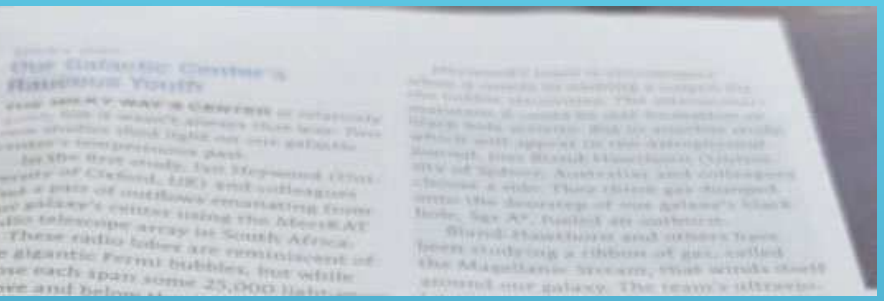
Using Tilt-Shift Lenses

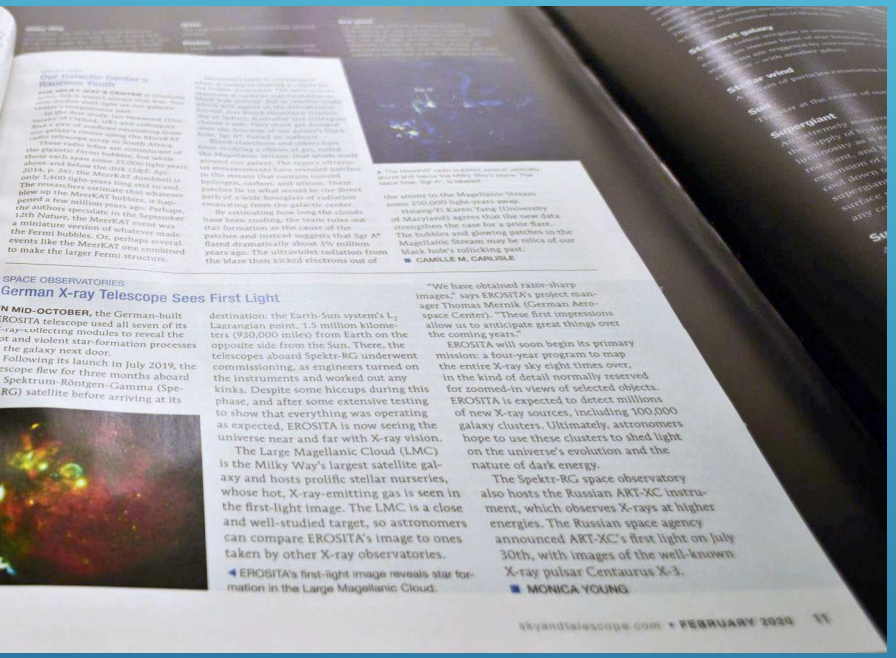
Keeps the camera back vertical

But the front of the lens is tilted to bring it more parallel to the subject line

However, these specialty lenses are very expensive

Non-Tilted





SPACE OBSERVATORIES

German X-ray Telescope Sees First Light

IN MID-OCTOBER, the German-built *EROSITA* telescope used all seven of its X-ray-collecting modules to reveal the hot and violent star-formation processes in the galaxy next door.

Following its launch in July 2019, the telescope flew for three months aboard the Spektrum-Röntgen-Gamma (*SRG*) satellite before arriving at its destination: the Earth-Sun system's L_2 Lagrangian point, 1.5 million kilometers (930,000 miles) from Earth on the opposite side from the Sun. There, the telescopes aboard Spektr-RG underwent commissioning, as engineers turned on the instruments and worked out any kinks. Despite some hiccups during this phase, and after some extensive testing to show that everything was operating as expected, EROSITA is now seeing the universe near and far with X-ray vision.

The Large Magellanic Cloud (LMC) is the Milky Way's largest satellite galaxy and hosts prolific stellar nurseries, whose hot, X-ray-emitting gas is seen in the first-light image. The LMC is a close and well-studied target, so astronomers can compare EROSITA's image to ones taken by other X-ray observatories.

"We have obtained razor-sharp images," says EROSITA's project manager Thomas Mernik (German Aerospace Center). "These first impressions allow us to anticipate great things over the coming years."

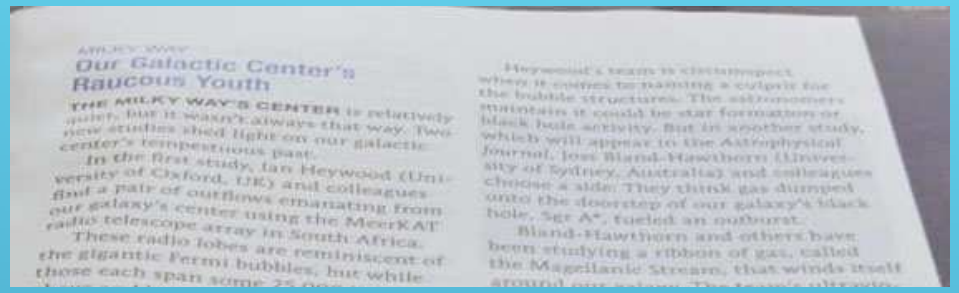
EROSITA will soon begin its primary mission: a four-year program to map the entire X-ray sky eight times over, in the kind of detail normally reserved for zoomed-in views of selected objects. EROSITA is expected to detect millions of new X-ray sources, including 100,000 galaxy clusters. Ultimately, astronomers hope to use these clusters to shed light on the universe's evolution and the nature of dark energy.

The Spektr-RG space observatory also hosts the Russian ART-XC instrument, which observes X-rays at higher energies. The Russian space agency announced ART-XC's first light on July 30th, with images of the well-known X-ray pulsar Centaurus X-3.

◀ EROSITA's first-light image reveals star formation in the Large Magellanic Cloud.

■ MONICA YOUNG

Tilted



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CONCLUSIONS

Depth of field can be used to bring parts of the subject into or out of focus

Helps the photographer highlight areas of interest in the subject

Allows the photographer to more accurately represent what the photographer saw

Rule of Thumb:

The depth of field is:

- **One third in front of the subje**
- **Two thirds behind the subject**

CONCLUSIONS

- **Depth of field is controlled by:**
  - **Aperture**
    - The **smaller** the aperture, the **greater** the depth of field
  - **Lens focal length**
    - **Longer** focal lengths give a **shallower** depth of field
  - **Distance to subject**
    - The **greater** the distance to the subject, the **deeper** the depth of field

CONCLUSIONS…

Depth of field is controlled by:

- **Sensor size**
  - For equivalent focal lengths, the **smaller** the sensor, the **greater** the depth of field

- **Magnification (macro)**
  - For macro photography, as the magnification **increases**, the depth of field becomes **shallower**

CONCLUSIONS…

Depth of field can be adjusted by:

- **Focus Stacking**
  - Taking multiple photos with different focal points and combining them into one image

- **Tilt-Shift Lenses**
  - Aligning the lens plane with the subject plane will increase the depth of field

QUESTIONS?

THANK YOU!