



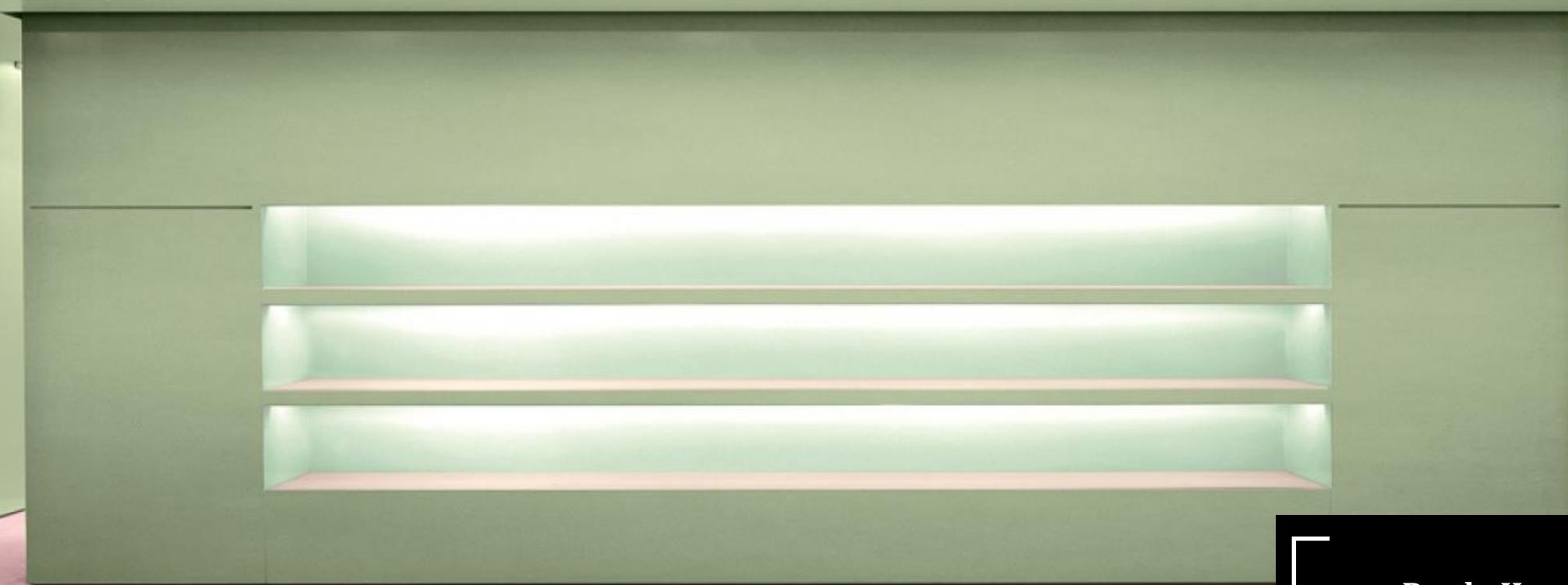
Amazon

Andreas Gursky, 2016



## F1 Boxenstopp I

Andreas Gursky, 2007



Prada II

Andreas Gursky, 1997



Tokyo

Andreas Gursky, 2017



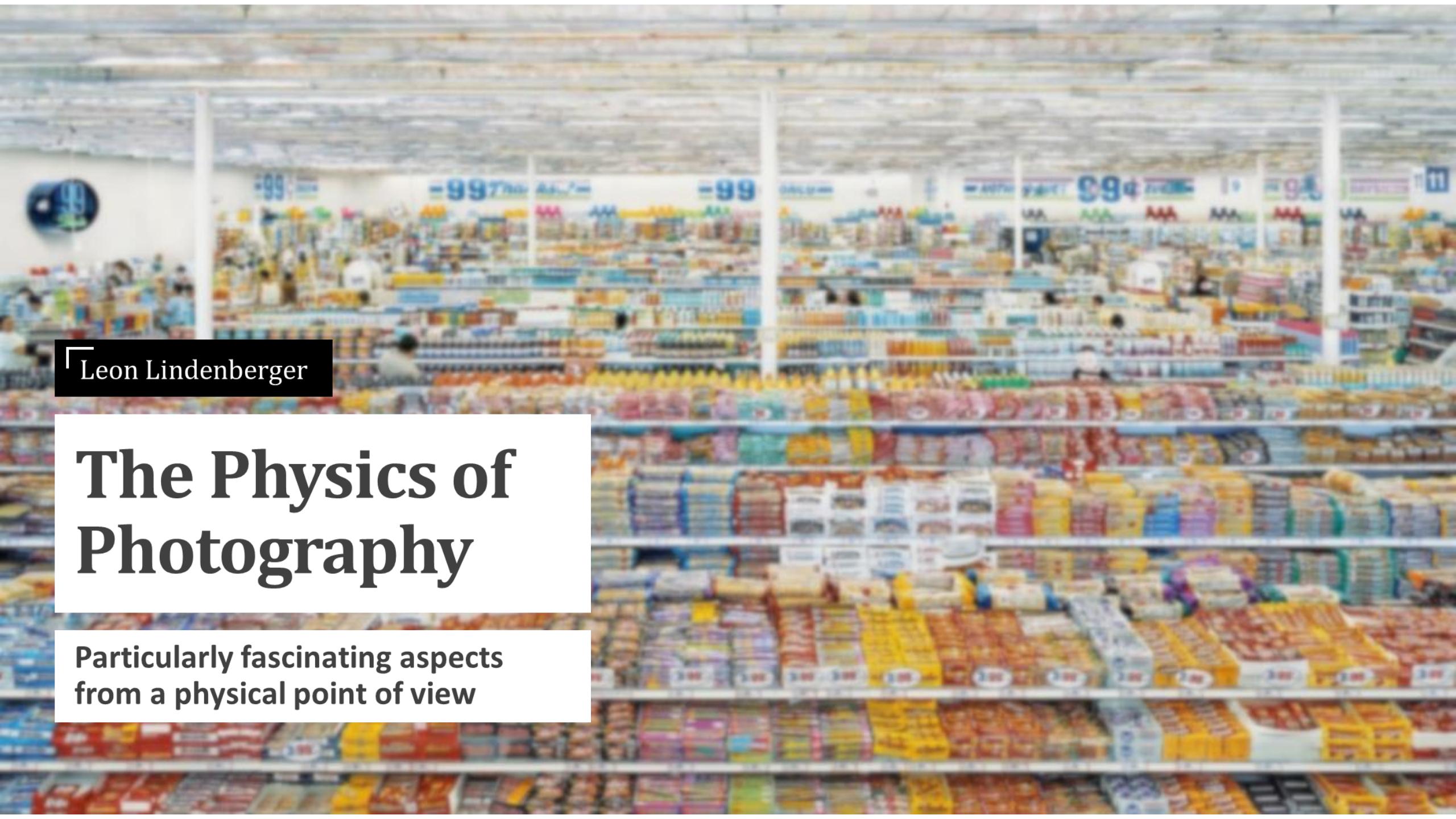
## Rhein II

Andreas Gursky, 1999



99 Cent

Andreas Gursky, 1999

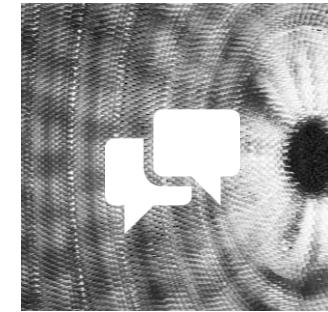
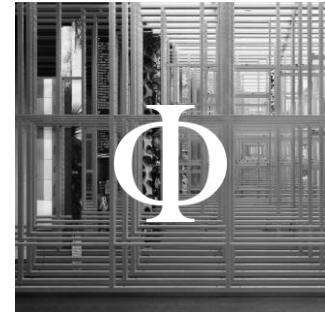
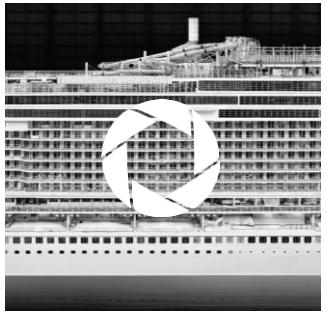


Leon Lindenberger

# The Physics of Photography

Particularly fascinating aspects  
from a physical point of view

# Structure



Camera lenses

CCD- and CMOS-  
sensors

Photo-flash

Golden ratio

Discussion



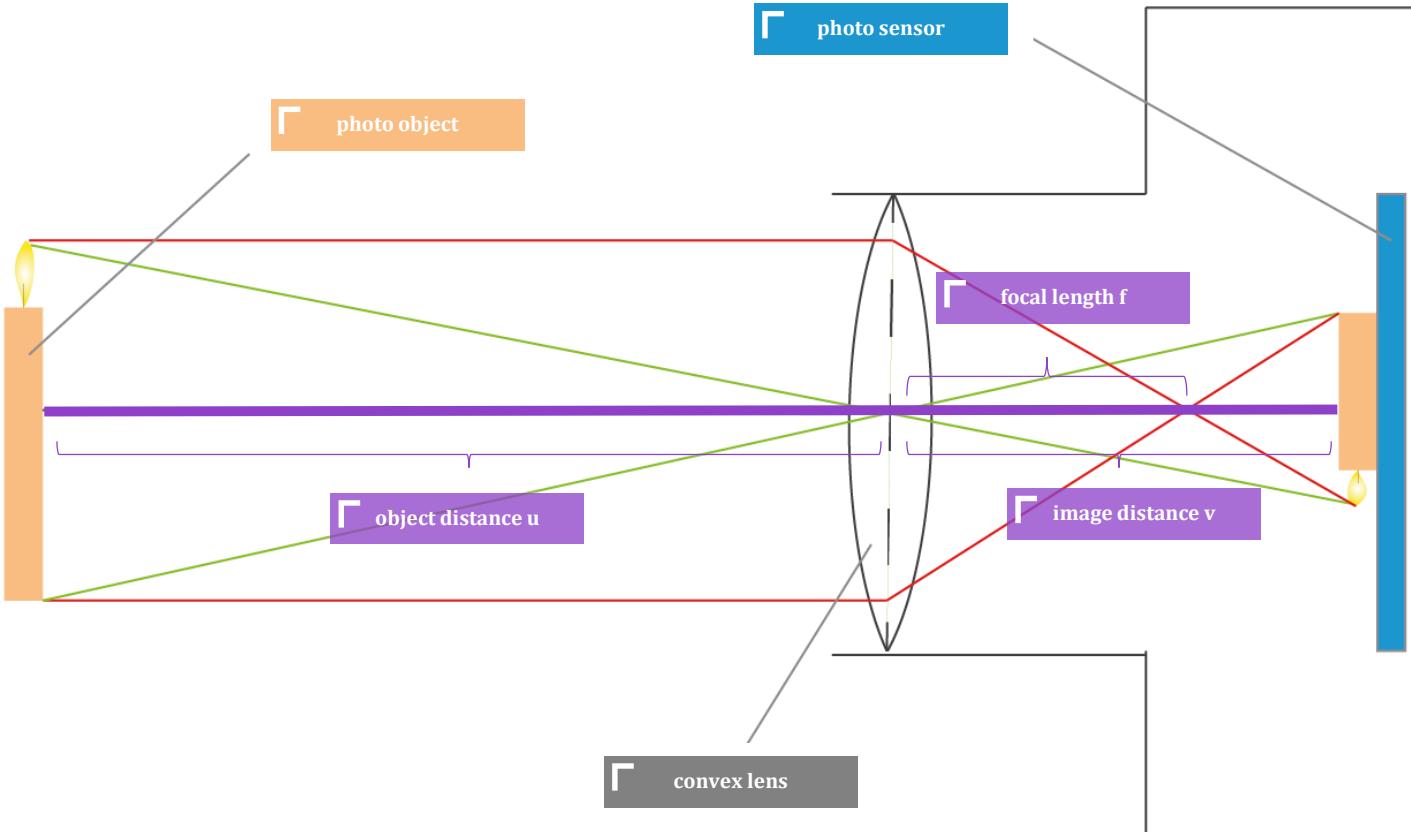
# Part 1: Camera Lenses

Kreuzfahrt

Andreas Gursky, 2020

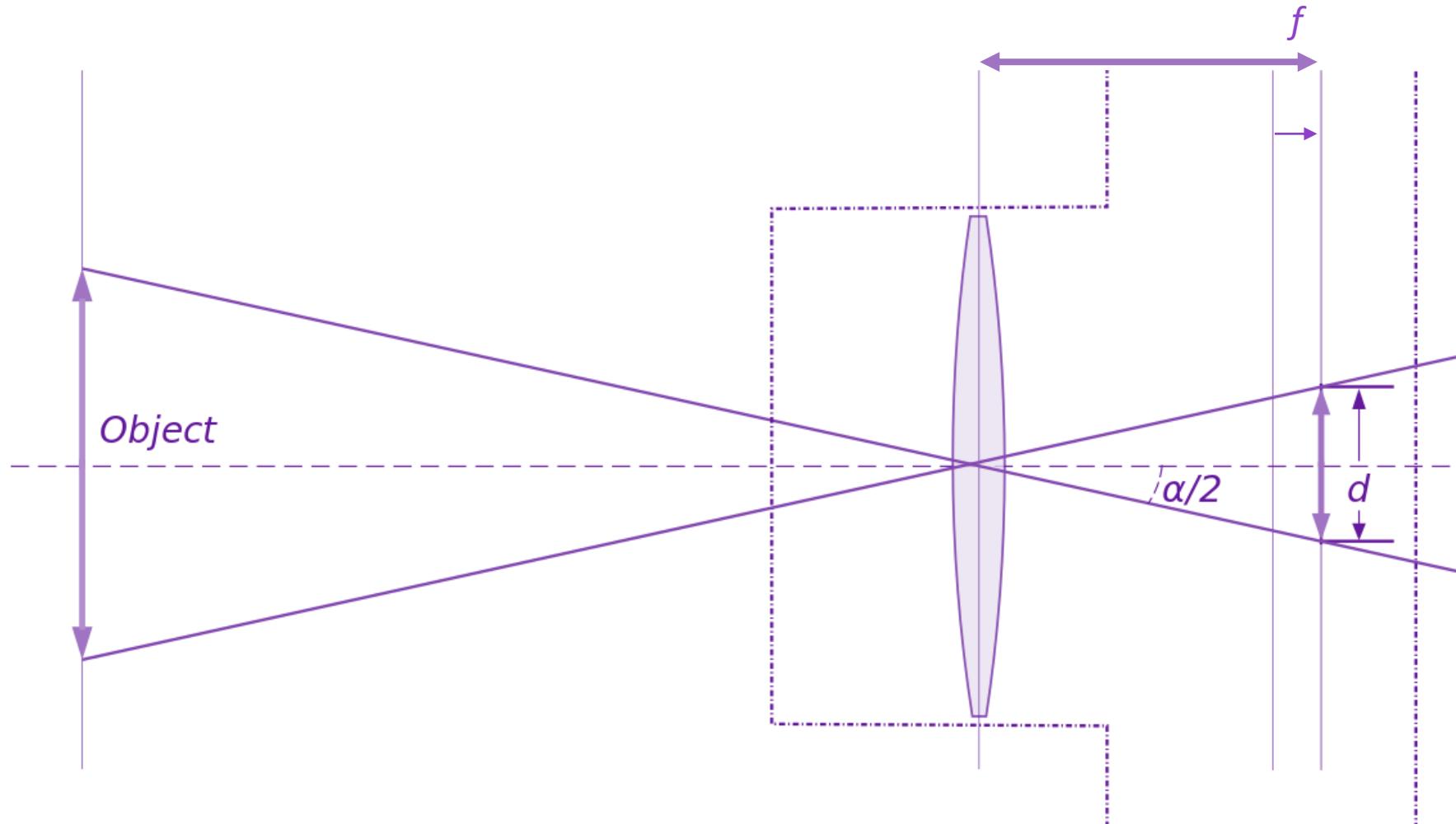


# One Lens System and Focal Length



$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

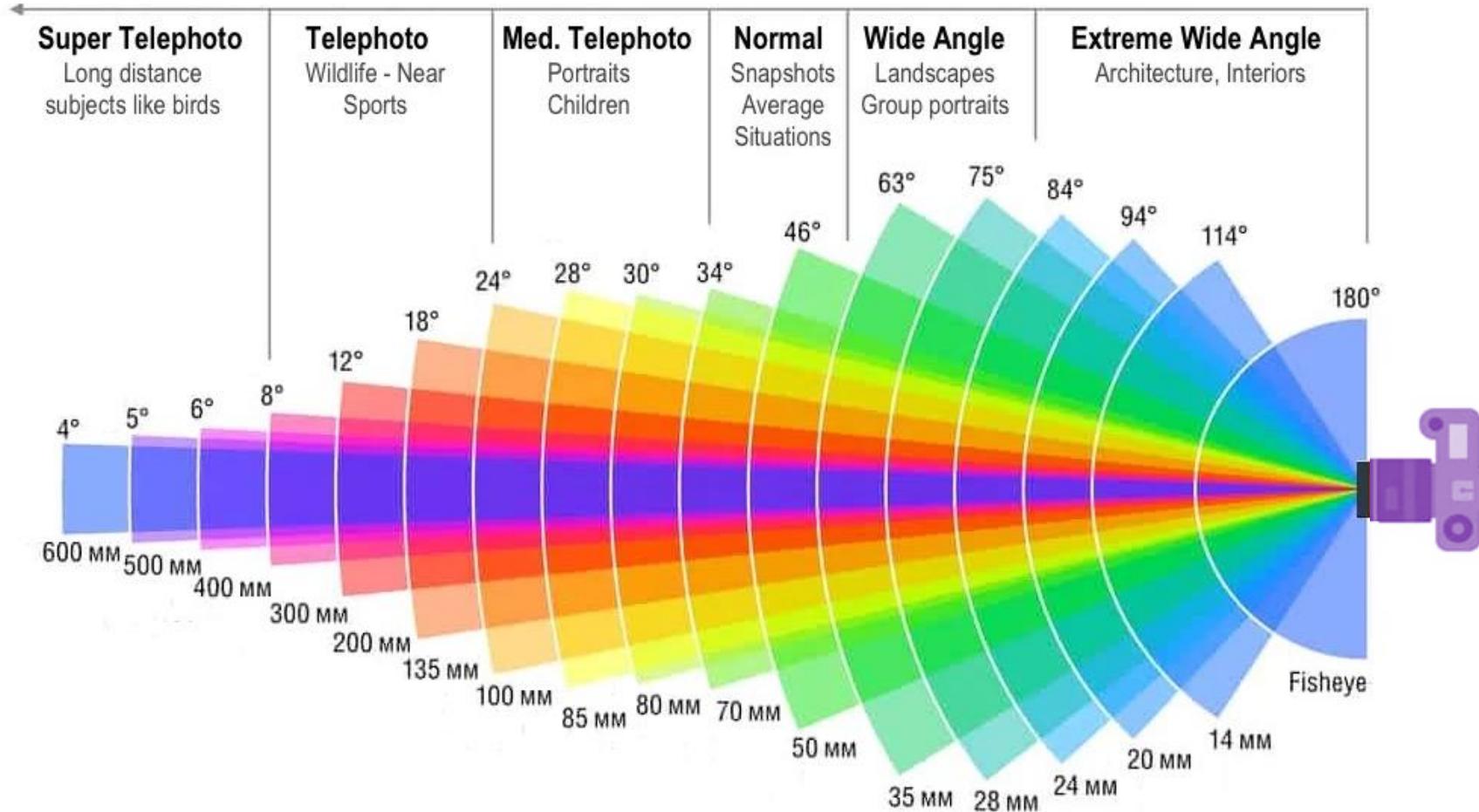
# One Lens System and Focal Length



$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$\alpha = 2 \arctan \frac{d}{2f}$$

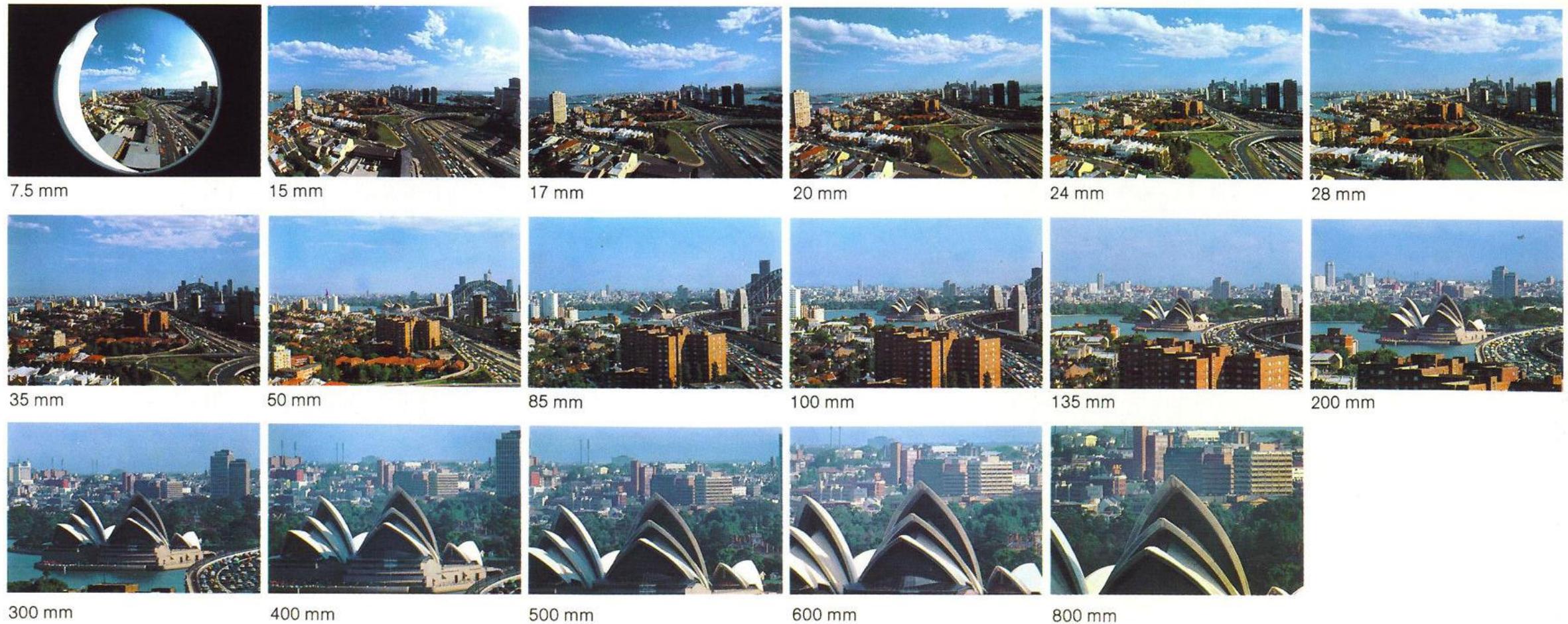
# One Lens System and Focal Length



$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

$$\alpha = 2 \arctan \frac{d}{2f}$$

# Examples of different Focal Lengths



# Examples of different Focal Lengths (Lenses)



Γ 8mm



Γ 100mm



180° (Fisheye)  
Four Thirds 8mm  
(Equivalent to 16mm of 35mm lenses)



114°  
Four Thirds 7mm  
(Equivalent to 14mm of 35mm lenses)



84°  
Four Thirds 12mm  
(Equivalent to 24mm of 35mm lenses)



75°  
Four Thirds 14mm  
(Equivalent to 28mm of 35mm lenses)



Γ 18mm



47°  
Four Thirds 25mm  
(Equivalent to 50mm of 35mm lenses)



34°  
Four Thirds 35mm  
(Equivalent to 70mm of 35mm lenses)



24°  
Four Thirds 50mm  
(Equivalent to 100mm of 35mm lenses)



12°  
Four Thirds 100mm  
(Equivalent to 200mm of 35mm lenses)



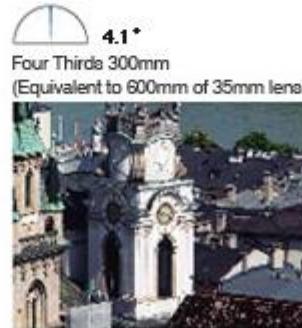
Γ 50mm



8.2°  
Four Thirds 150mm  
(Equivalent to 300mm of 35mm lenses)



6.2°  
Four Thirds 200mm  
(Equivalent to 400mm of 35mm lenses)



4.1°  
Four Thirds 300mm  
(Equivalent to 600mm of 35mm lenses)

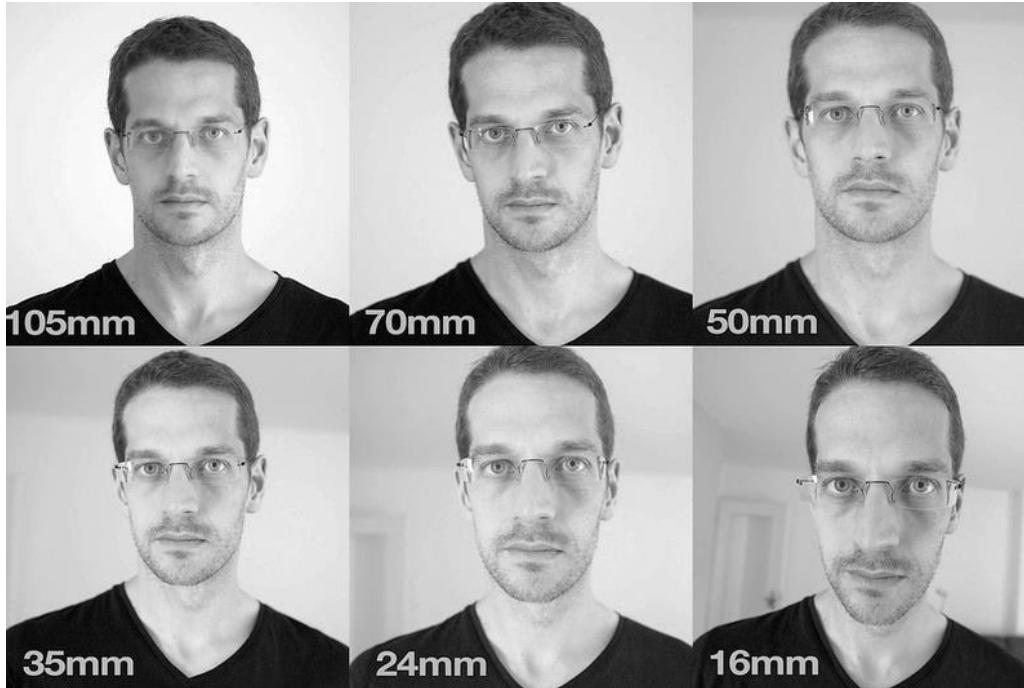


2.5°  
Four Thirds 500mm  
(Equivalent to 1000mm of 35mm lenses)

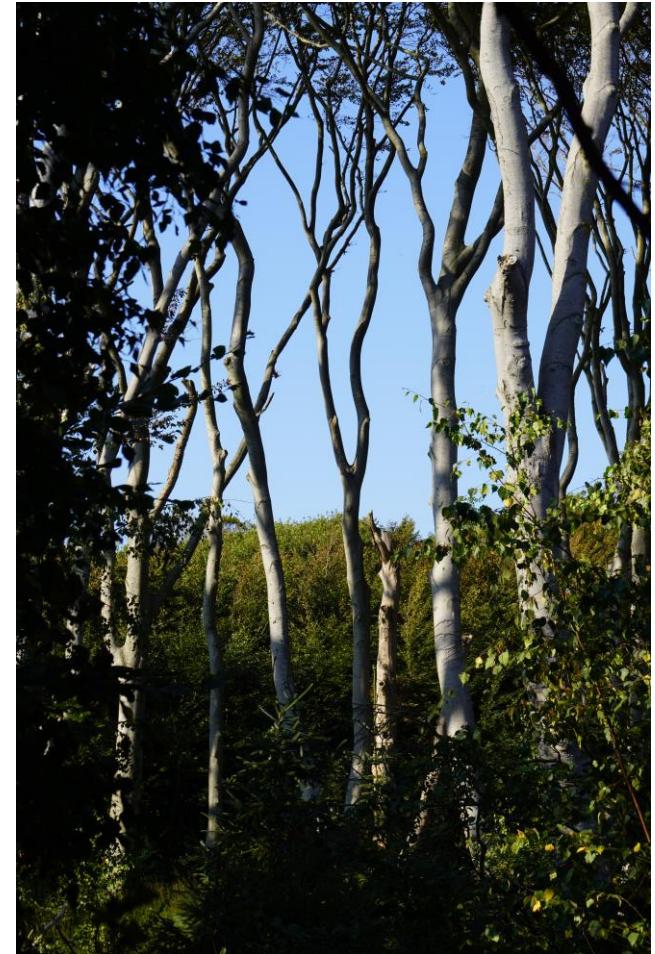
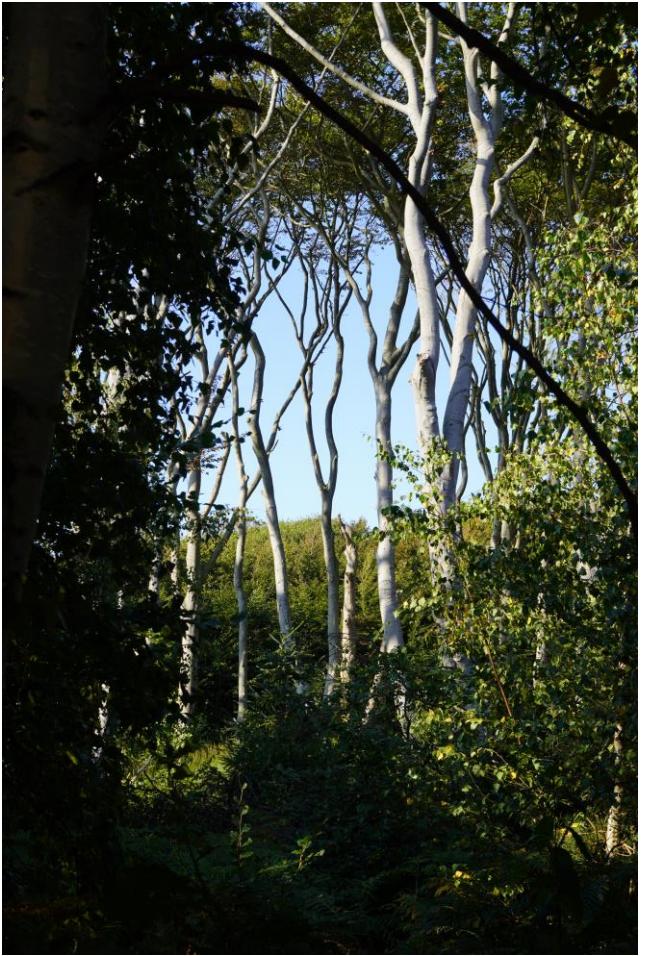


Γ 500mm

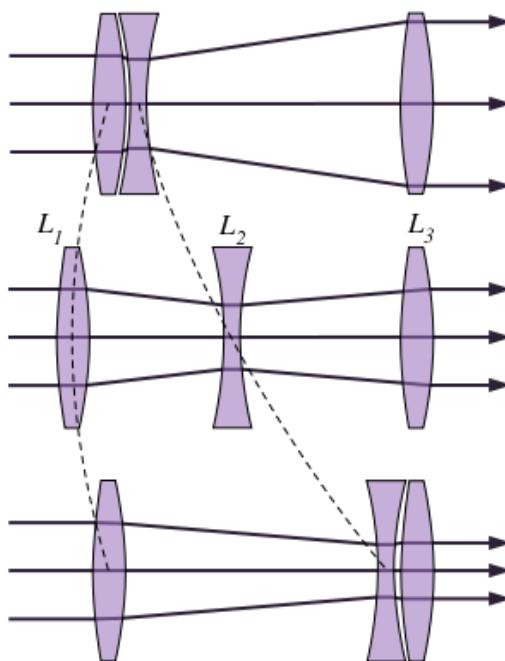
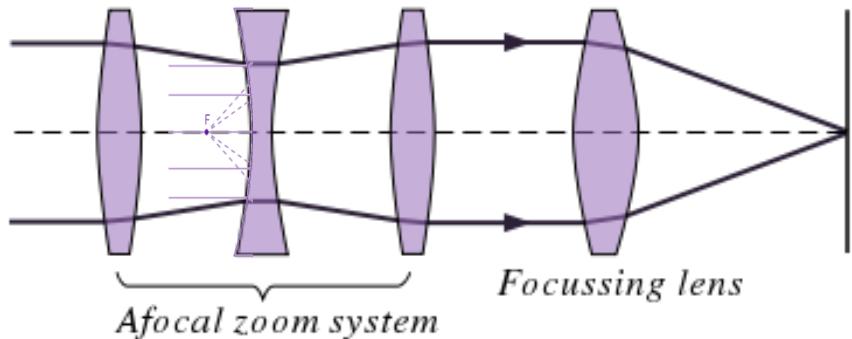
# Examples of different Focal Lengths (Depth)



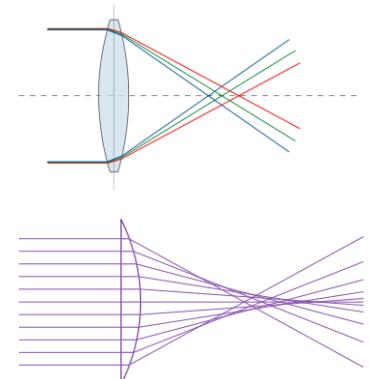
# Zoom Lenses



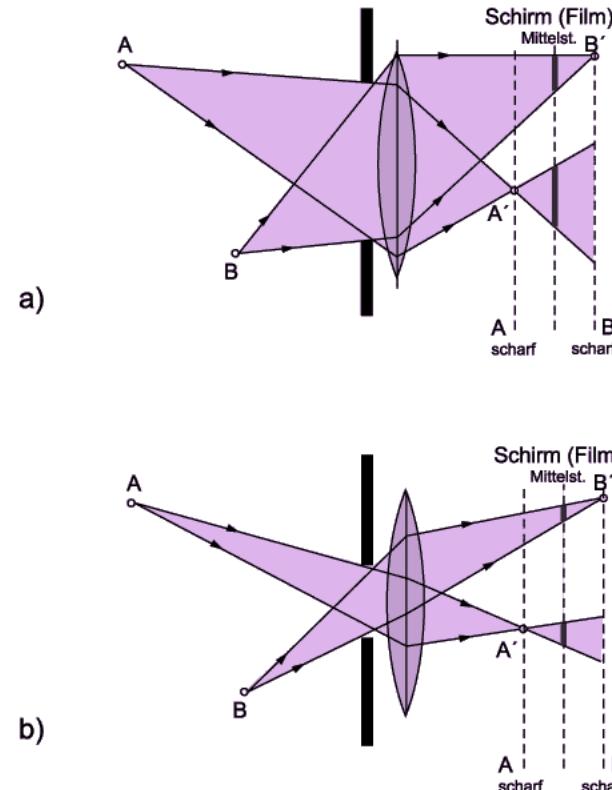
# Zoom Lenses



- simple zoom system:  
afocal part using two positive lenses  
and one negative, positive focussing  
lens
- complex engineering moves lenses  
in afocal system, thereby changing  
the overall focal length
- system needs to stay afocal
- more prone to aberrations:  
chromatic aberration: failure of a lens  
to focus all colors to the same point due  
to dispersion  
spherical aberration: light rays that  
strike a spherical surface off-centre are  
refracted more or less than those that  
strike close to the centre



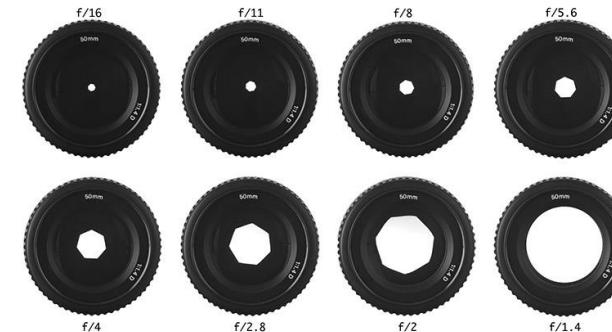
# Aperture



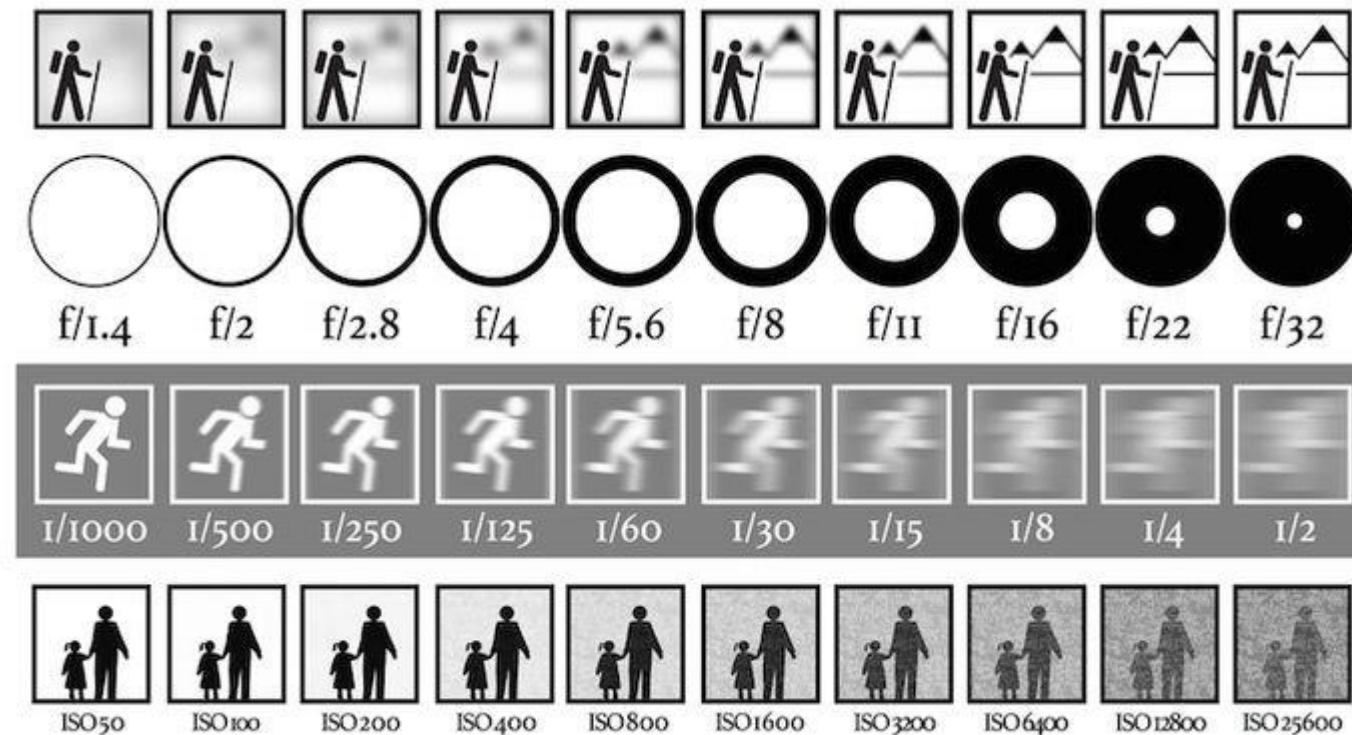
- iris diaphragm controls the amount of light coming in
- shutter-speed needs to be adjusted
- Lens speed: maximum aperture diameter / minimum f-number

$$k = \frac{f}{D}$$

- smaller opening reduces spherical aberration effects and increases depth of field (DOF)



# Aperture



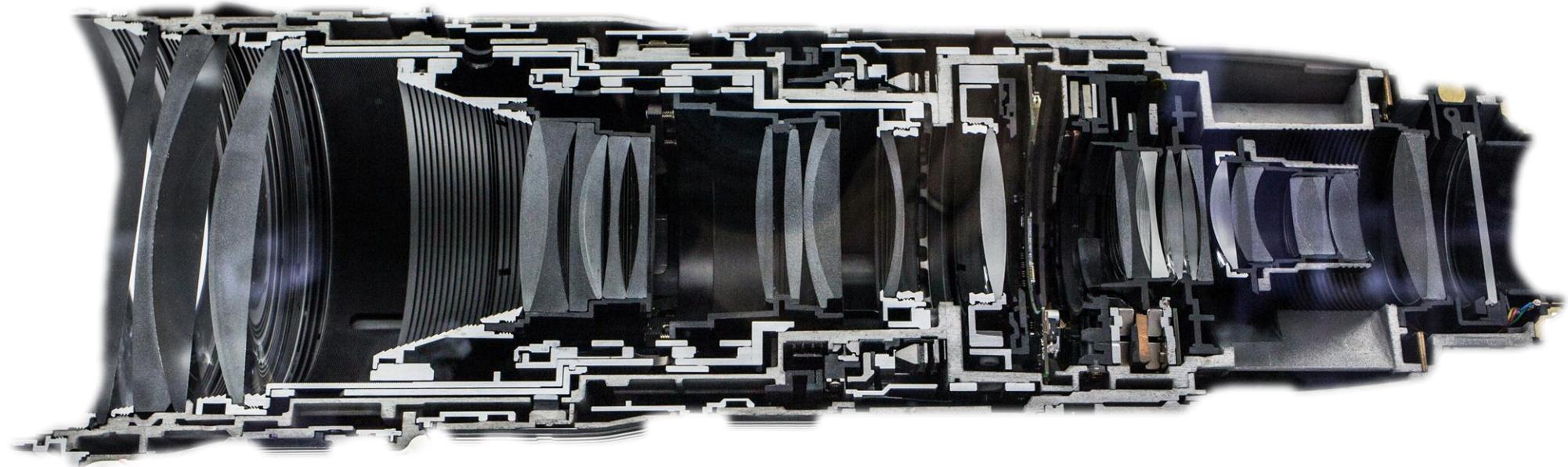
# Aperture



# Peter Lindbergh and Bokeh in Photography



# Complex Camera Lens



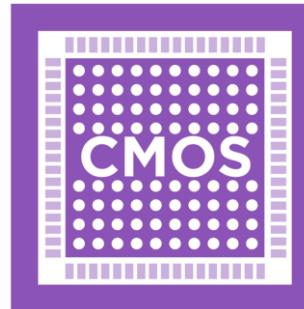
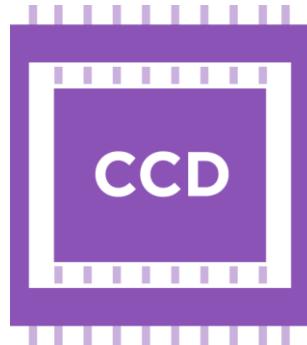


Part 2:  
**CCD- and CMOS-sensors**

Amsterdam, Arena

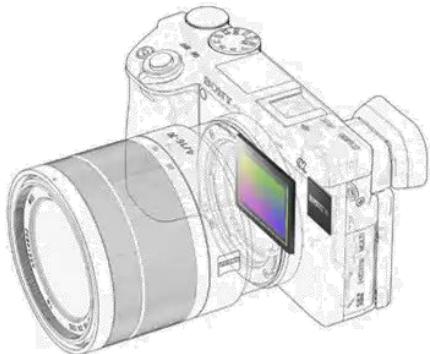
Andreas Gursky, 2003

# CCD- and CMOS-sensors



- used in most commercial cameras for a long time
- also: fax-devices, image-scanners, spectrometers
- array of photo-diodes used to charge corresponding capacitors
- voltage-information of capacitors collected for each line as a bundle
- color: filters used to create rgb-diodes (25%, 50%, 25%)
- can be found geometrically and converted into a golden angle
- used in better, more expensive cameras
- also: most phone cameras, barcode reader
- same principle as CCD, but: each diode/capacitor is read individually
- pros: cheaper, smaller, faster, higher resolution, some processing steps can be carried out in the pixel amplifier (e.g. white balance)
- cons: lower photosensitivity, more individual components, greater differences in sensitivity between the pixels (leads to more noise)

# CCD- and CMOS-Sensors



1/3"

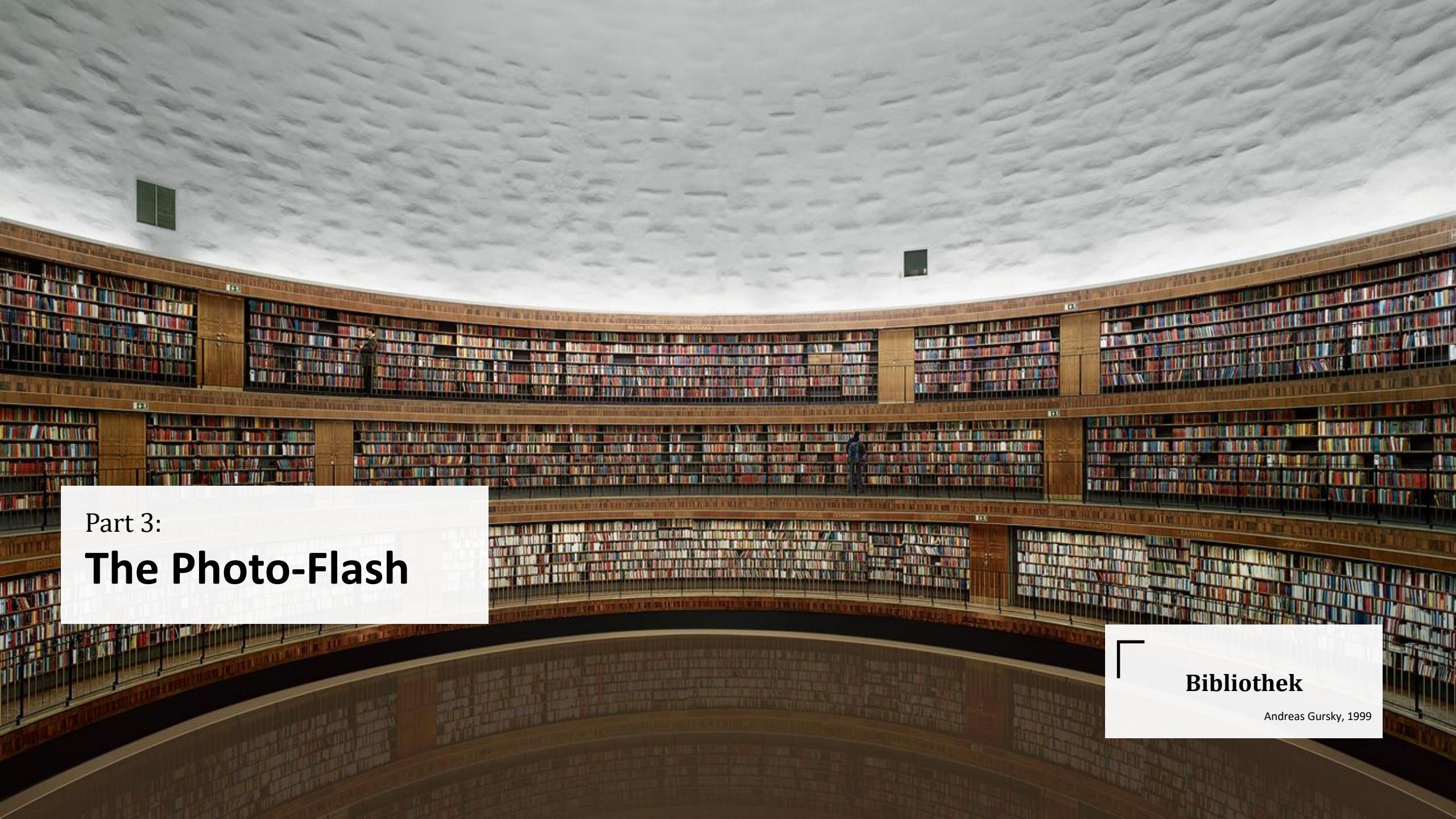
2/3"

1"

APS-C

Super 35mm

Full-Frame 35mm

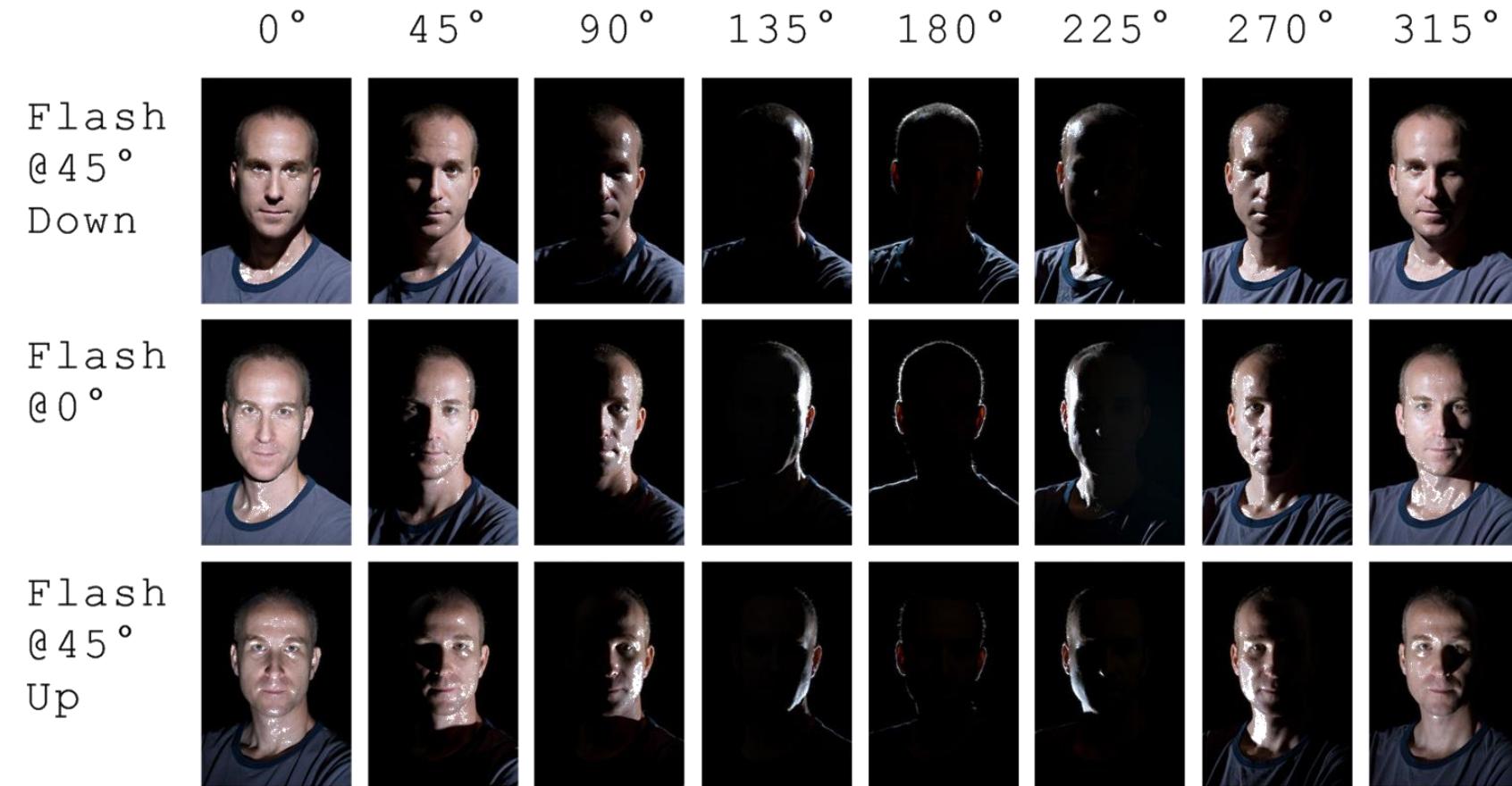


Part 3:  
**The Photo-Flash**

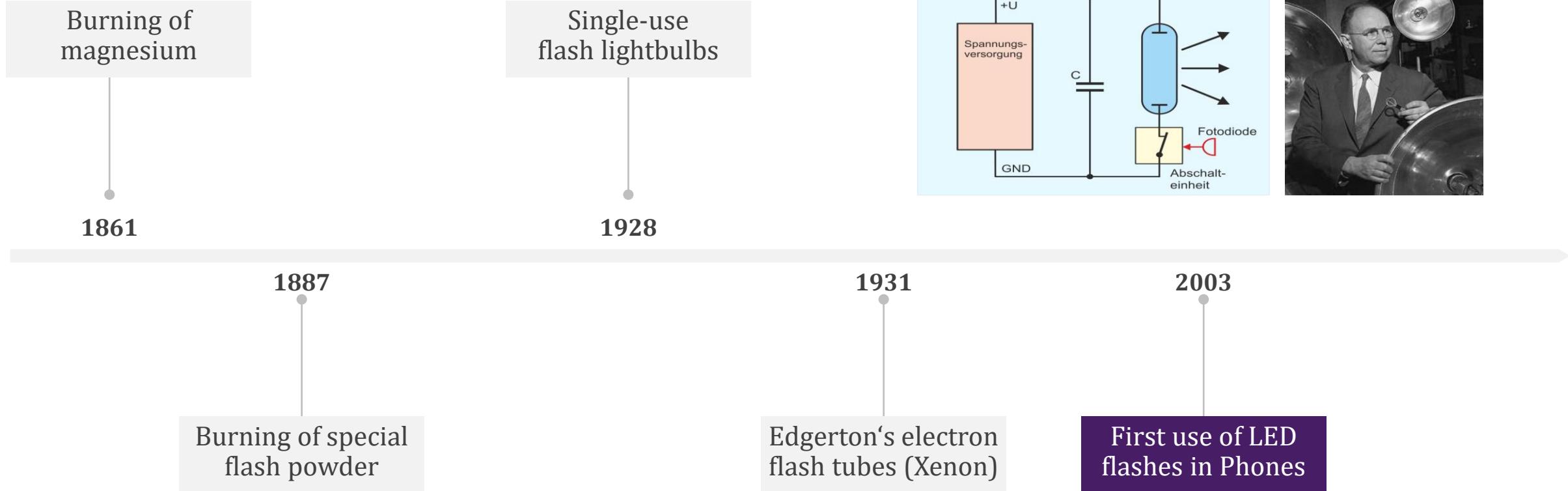
Bibliothek

Andreas Gursky, 1999

# Portrait Lighting Cheat-Sheet

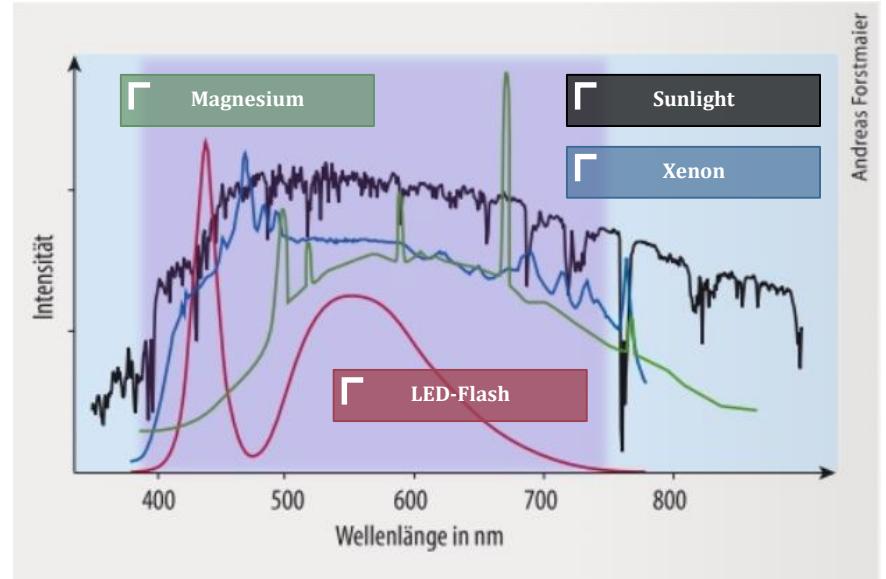


# The Photo-Flash over Time



# The Color Temperature and CRI

- for natural impression: 5500K-6000K
- technical way to solve the problem: white balance
- continuous spectral color mixing is perceived as natural (white) light
- Color Rendering Index:  
“Effect of an illuminant on the color appearance of objects by conscious or subconscious comparison with their color appearance under a reference illuminant.” – CIE
- 8 of the 14 DIN6169-colors are used as reference
- $R_a = \frac{R_1 + R_2 + \dots + R_7 + R_8}{8}$
- high value is desirable: xenon almost at 100
- but: not totally representative



in dem es unabhängige  
in einer groben ersten  
nschaften zuschreibt,  
ste wurde darin zum  
en, das Geschehende  
eschah, aber hindurch  
seiner Möglichkeiten,  
gedicht seines Daseins  
ichkeit und Charakter  
der Anschauung jeder  
Tugenden wie Laster  
allgemein, wenn auch  
werden, bewies ihm  
geschieht, daß jedes  
M

ng sehr oft sich auch  
nsicherheit ausdrückt  
as Ungenügen an den  
erf wohl daran erinnert  
wie es die Menschheit  
en handelt. Sie wider  
anderes an seine Stelle,  
brechen in Tugenden  
mmenhänge aller Ge  
henaltern wieder ein  
n einem einheitlichen  
lässt keine Steigerung  
laboratorium hatte in  
so wie eine große Ver  
in, durchgebrannt und  
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Gesamtlabora  
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att. Man kön  
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er ist es um ihre  
sere Gattung  
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als eine fram  
Große der Erde bei  
e zusammen, ganz  
sion, die nicht mit der

KIER-XB  
MUSCAT-D  
KTHEN-TH  
SX  
EASSE  
TANSA-AT  
NEW YORK  
LONDON-H  
KATORIEE  
STUTTGAR  
CHENNAI  
MUSCAT-B  
SALT-LAK  
BERL2N  
MADRID  
TASHKENT  
CHARLOTT  
HYDERABA  
LONDON-C  
ISTANBUL  
VERONA  
VARSHAG  
DUKARET  
MUNICH

WARSCHA  
TURIN  
TORONTO  
CHICAGO  
MOSCOW  
LUXEMBUR  
NEW YORK  
LINZ

Airbus Dornier

## Part 4: The Golden Ratio

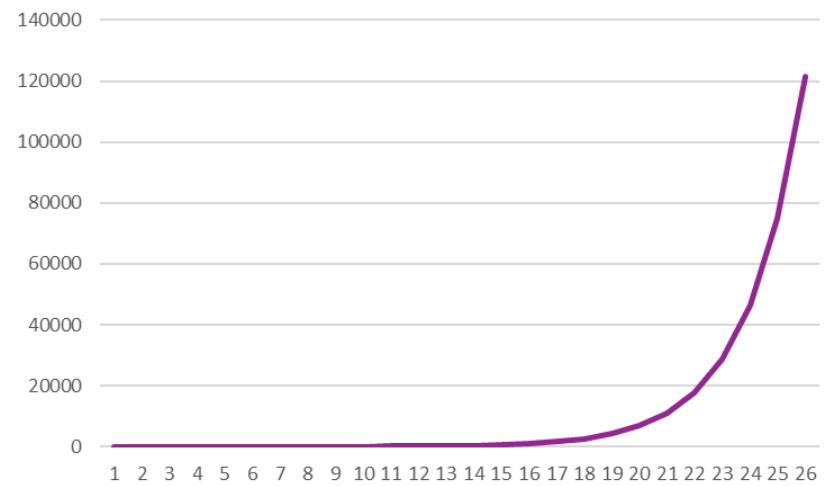
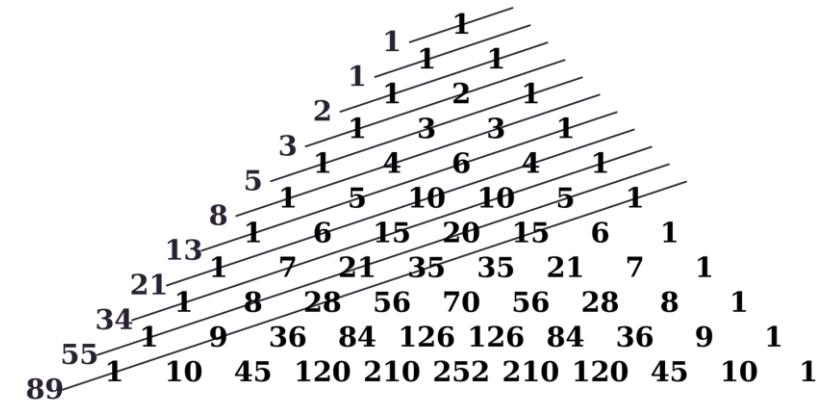
Lager

Andreas Gursky, 2014

# The Fibonacci Sequence

$$\text{fib}(n) = \begin{cases} 0, & n = 0, \\ 1, & n = 1, \\ \text{fib}(n - 2) + \text{fib}(n - 1), & n > 1. \end{cases}$$

- introduced by Italian mathematician Leonardo of Pisa
  - used to describe populations
  - finds many applications in science and art
  - closely related to the golden ratio



# The Fibonacci Sequence

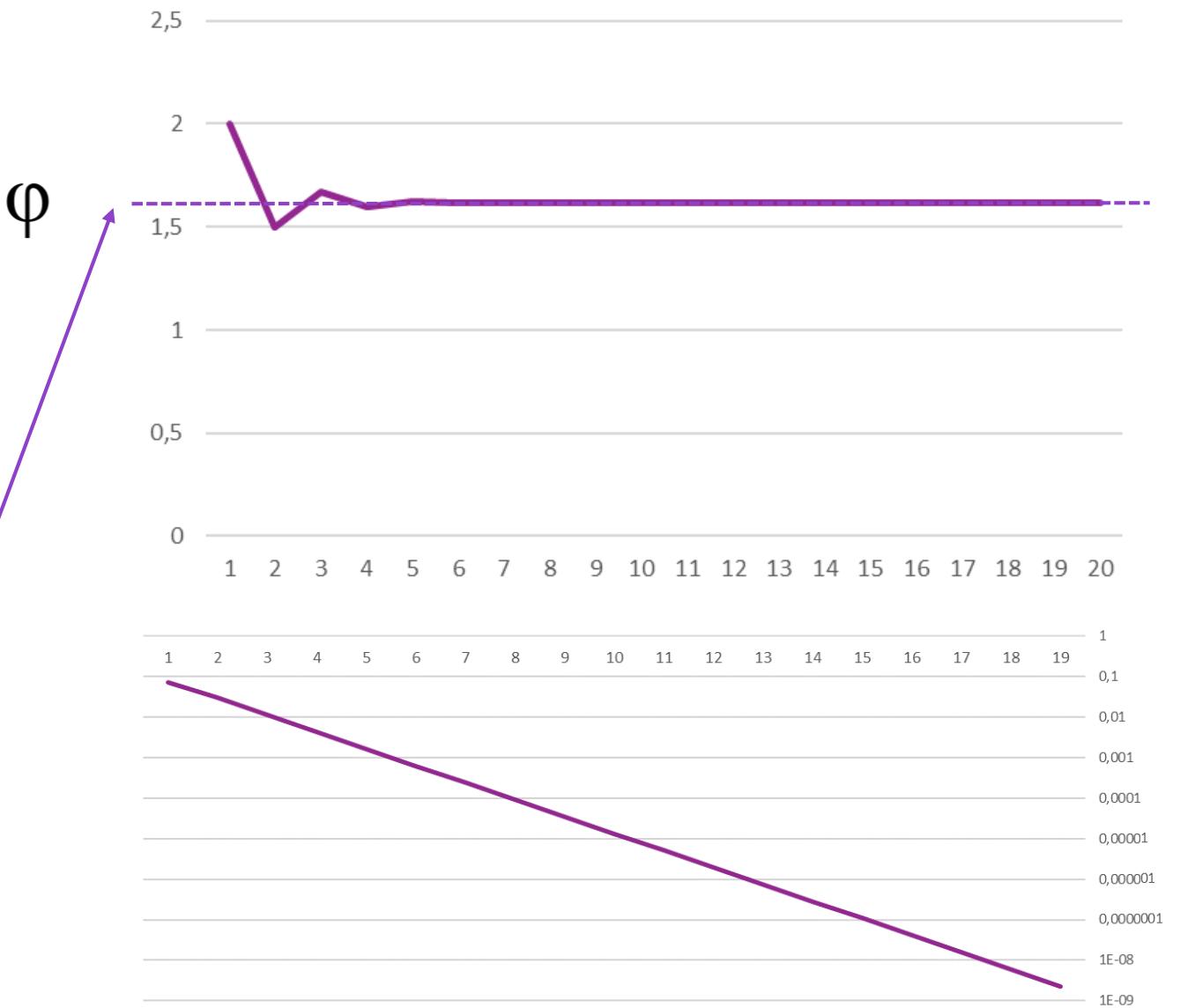
$$fib(n) =: b$$

$$\rightarrow fib(n+1) = b + fib(n-1) =: a$$

$$\rightarrow fib(n+2) = a + b$$

For large n:

$$\frac{fib(n+1)}{fib(n)} = \frac{a}{b} \approx \frac{fib(n+2)}{fib(n+1)} = \frac{a+b}{a}$$



# Calculation of $\varphi$

$$\frac{a+b}{a} = \frac{a}{b} = \varphi$$

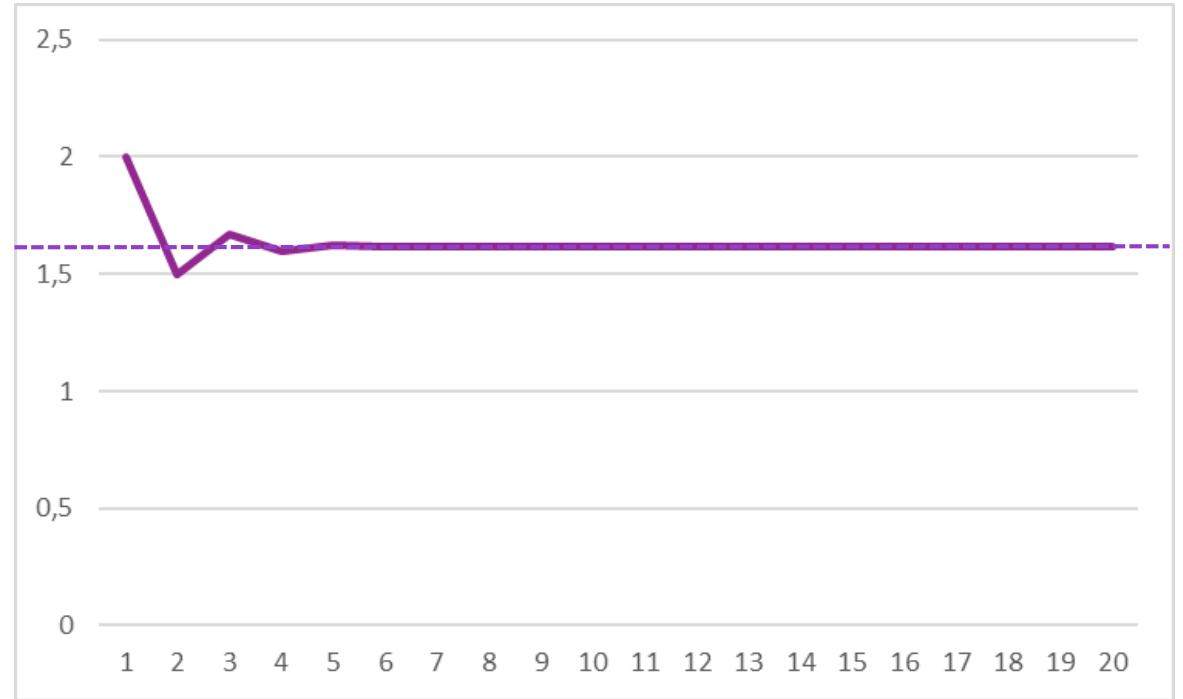
$$\frac{a+b}{a} = \frac{a}{a} + \frac{b}{a} = 1 + \frac{b}{a} = 1 + \frac{1}{\varphi}$$

$$1 + \frac{1}{\varphi} = \varphi$$

$$\varphi^2 - \varphi - 1 = 0$$



$\varphi$



$$\frac{1 + \sqrt{5}}{2} = 1.618\,033\,988 \dots = \varphi$$

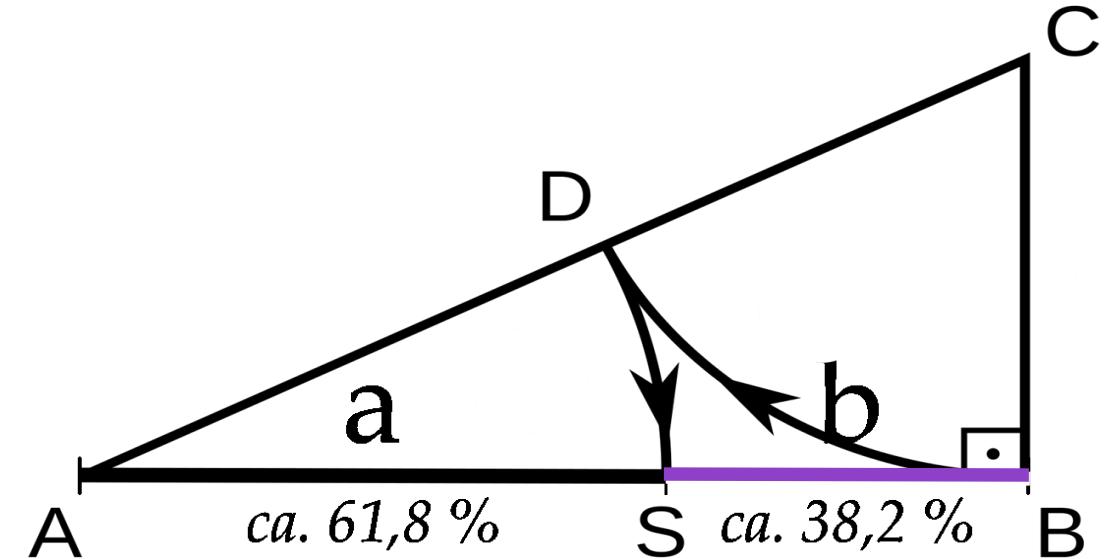
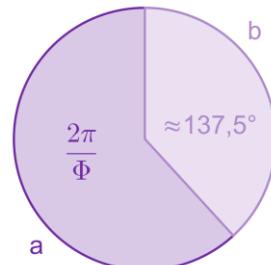
$$\left( \frac{1 - \sqrt{5}}{2} = -0.618\,033\,988 \dots \right)$$

$$\text{fib}(n) = \frac{1}{\sqrt{5}} \left( \frac{1 + \sqrt{5}}{2} \right)^n - \frac{1}{\sqrt{5}} \left( \frac{1 - \sqrt{5}}{2} \right)^n$$

# The Golden Ratio

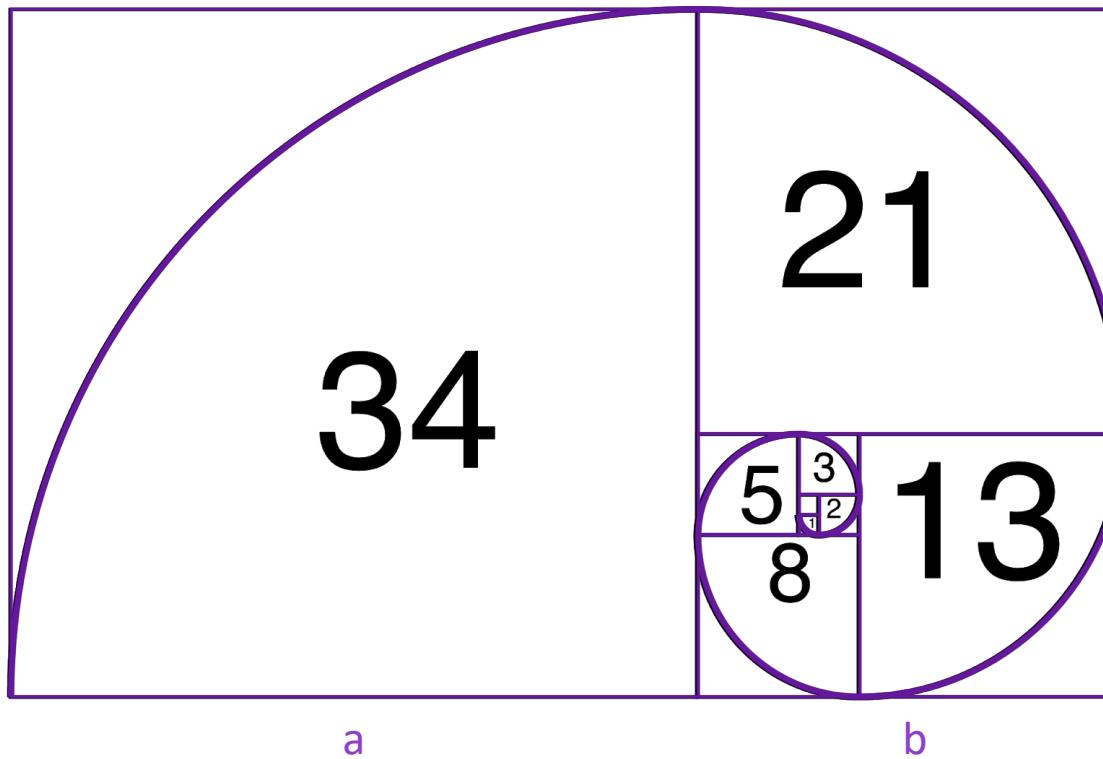
$$\varphi = \frac{a+b}{a} = \frac{a}{b} \approx 1.61803398874989484\dots$$

- relates to an irrational number
- first mentioned by Euclid, later: Binet and Kepler
- can be found geometrically and converted into a golden angle

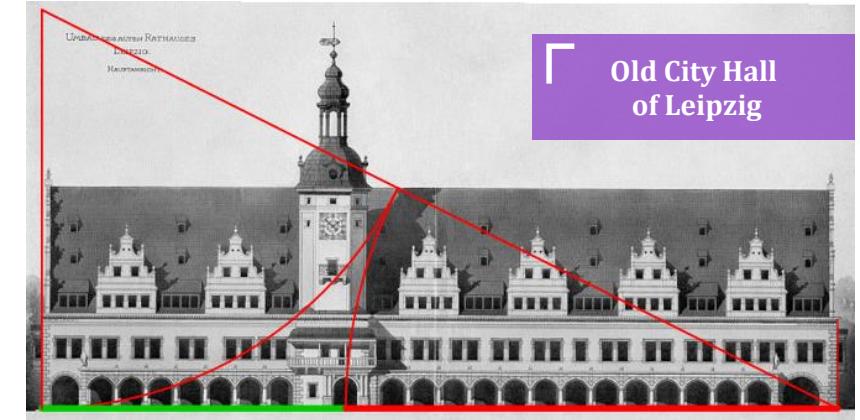


- other names: golden mean, divine proportion
- believed this to be aesthetically pleasing
- appears both in man-made art and in nature
- however: relevance for the perception of beauty controversial

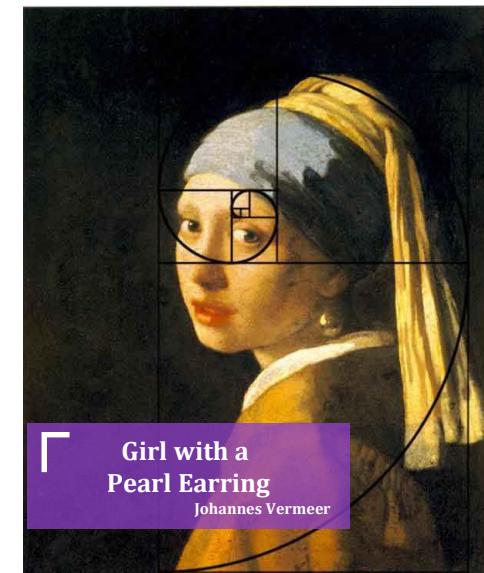
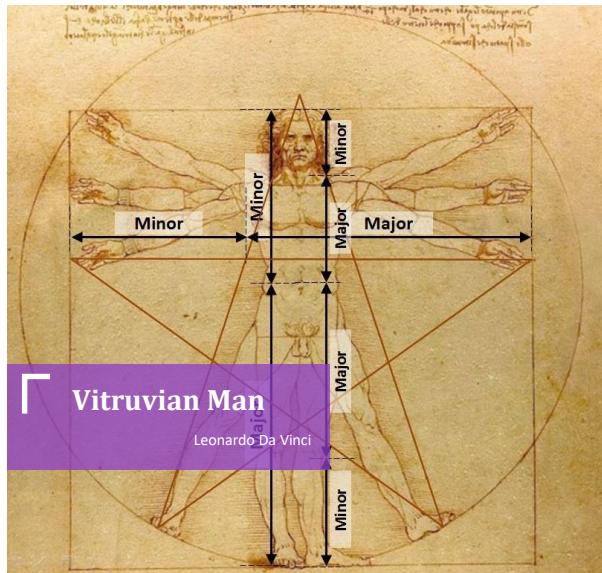
# The Golden Spiral



# Examples in Art

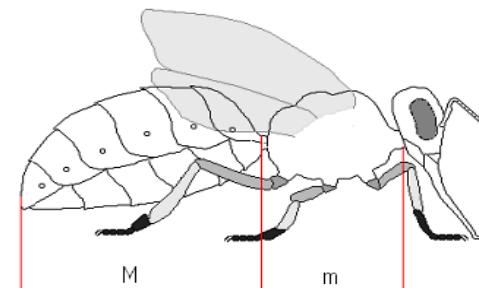
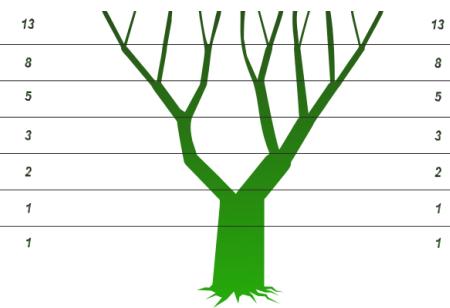
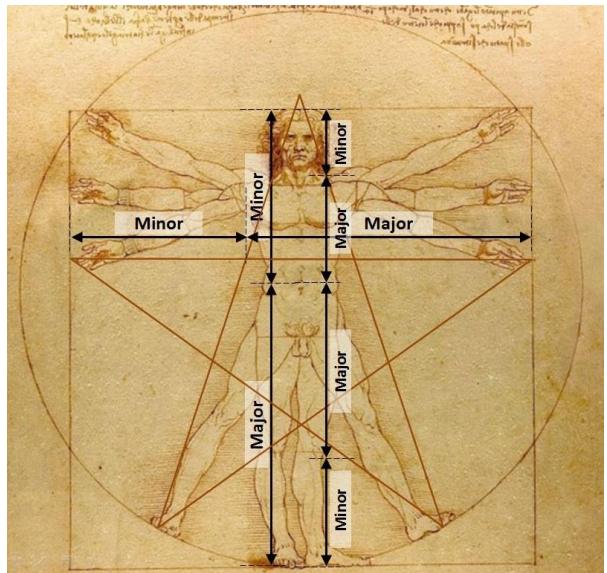
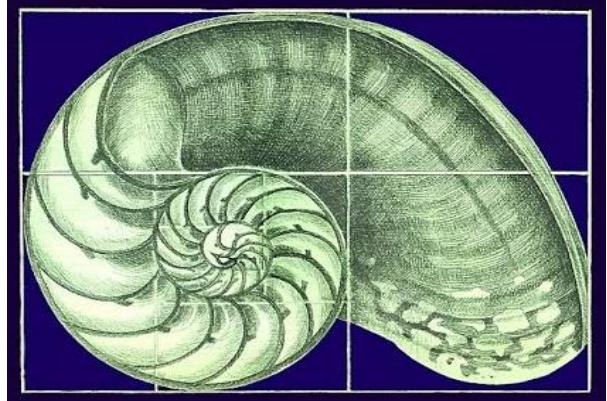


Old City Hall  
of Leipzig

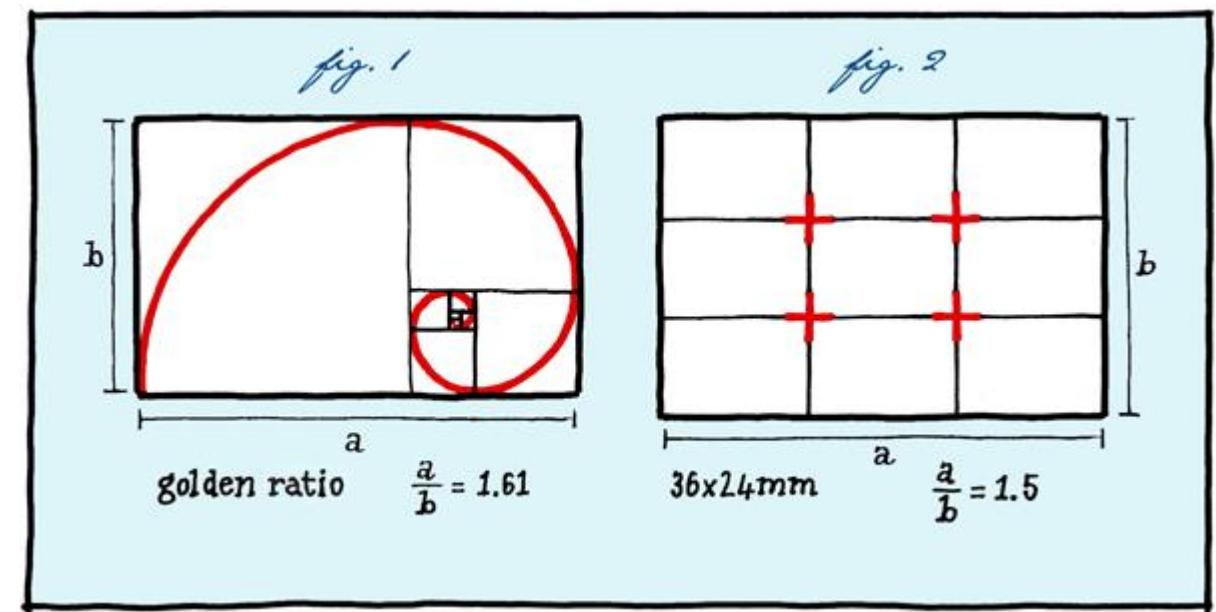
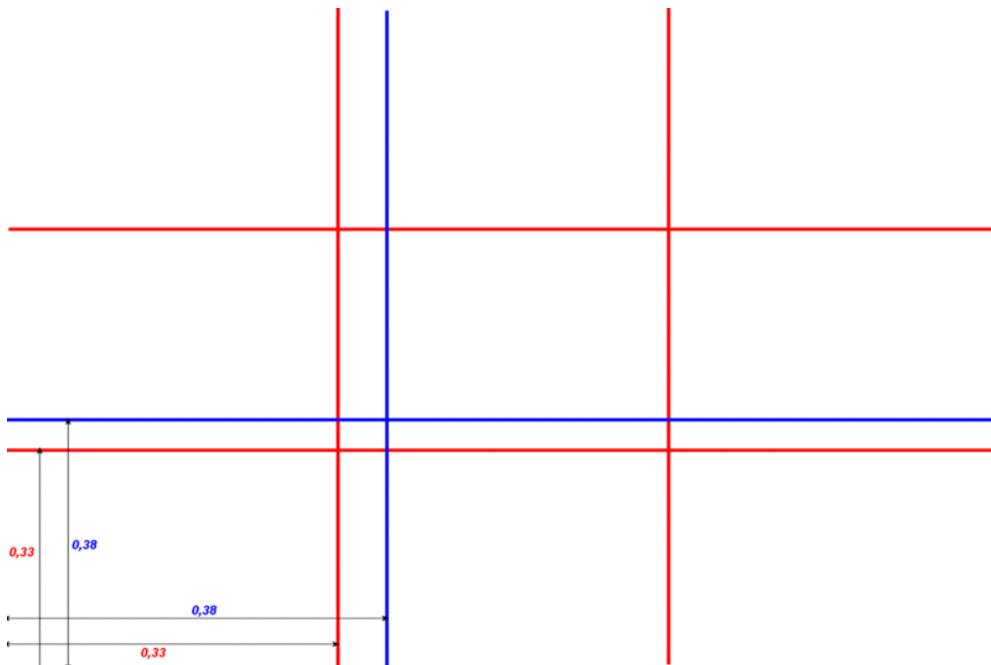


Mona Lisa  
Leonardo Da Vinci

# Examples in Nature



# Examples in Photography – The Rule of Thirds



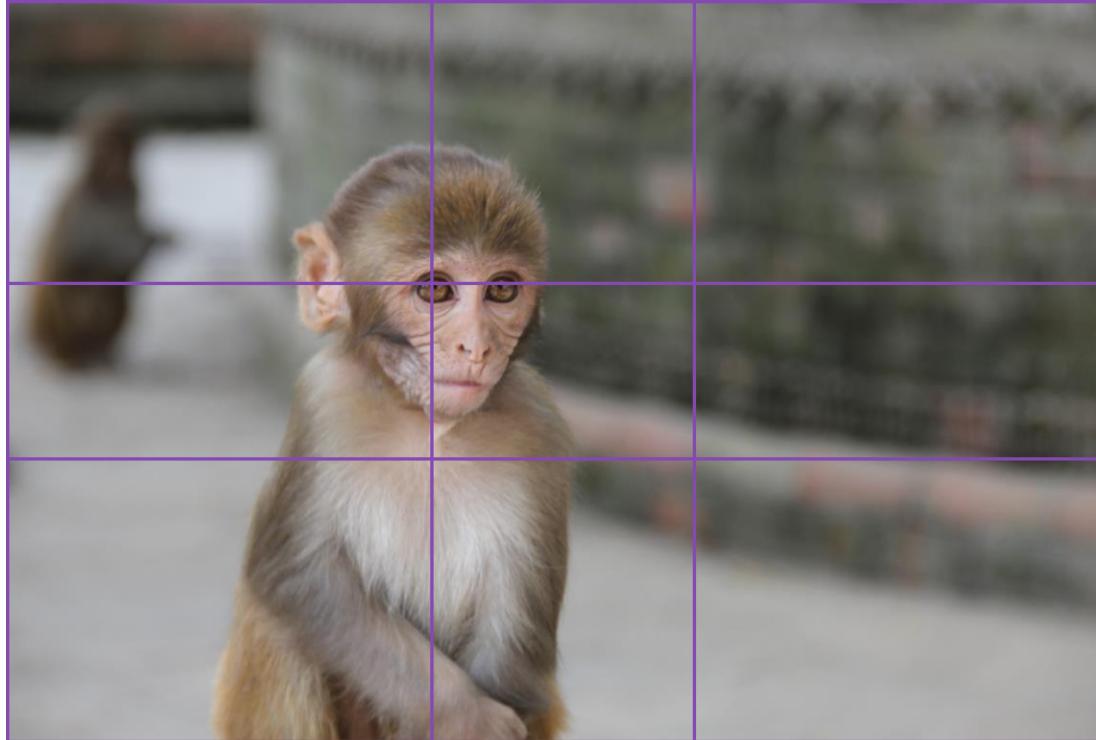
# Examples in Photography



# Examples in Photography



# Examples in Photography



# Examples in Photography



# Examples in Photography



Thank You:  
Any Questions?

Madonna 1

Andreas Gursky, 2001





# The Most Influential Images of All Time

EXPLORE THE STORIES BEHIND 100 IMAGES THAT CHANGED THE WORLD, SELECTED BY TIME AND AN INTERNATIONAL TEAM OF CURATORS

► ABOUT THE PROJECT

SHARE

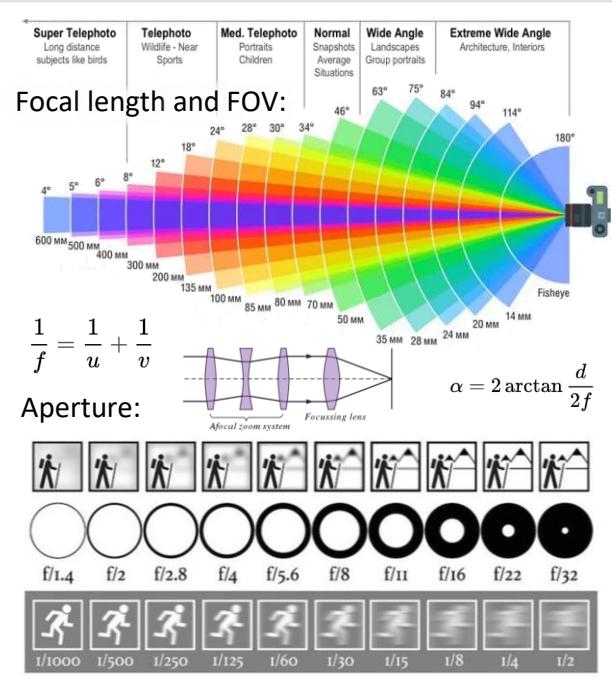


To take a look at Time's 100 Pictures: <http://100photos.time.com/>

# Synopsis

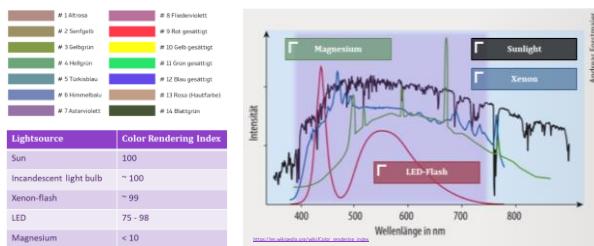


## Camera Lenses



## Photo Flash

- 1861: magnesium flash (dangerous)
- 1887: flash powder ( $Mg, KClO_3, Sb_2S_3$ )
- 1928: single-use flash bulbs ( $Mg, Al$ )
- 1931: Robert Edgerton's electron-flash tube (Xenon), high-speed photography
- 2003: LED flash in phones with worse color rendering index

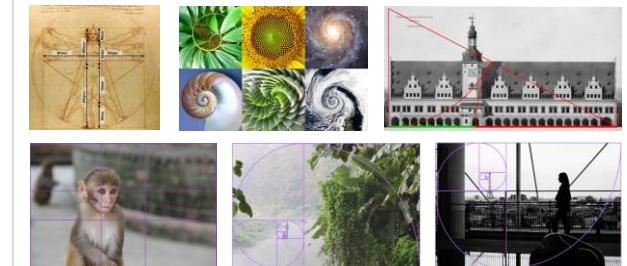
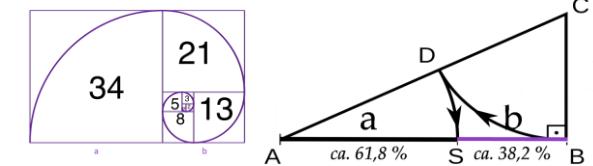


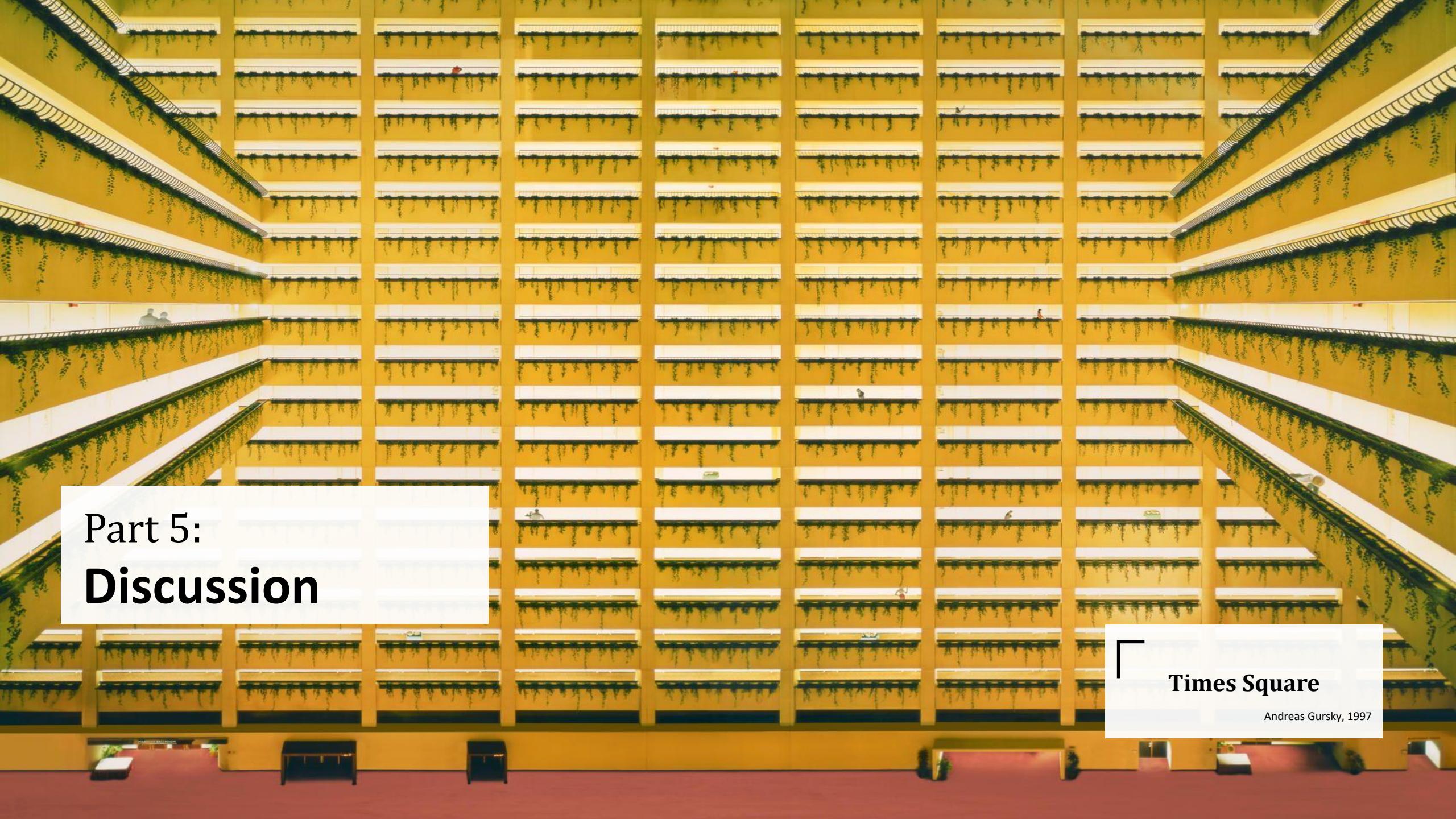
## Φ Golden Ratio

$$fib(n) = \begin{cases} 0, & n = 0, \\ 1, & n = 1, \\ fib(n-2) + fib(n-1), & n > 1. \end{cases}$$

For large n:

$$\frac{fib(n+1)}{fib(n)} = \frac{a}{b} \approx \frac{fib(n+2)}{fib(n+1)} = \frac{a+b}{a} \Rightarrow \frac{1+\sqrt{5}}{2} = 1.618\,033\,988 \dots = \varphi$$





## Part 5: Discussion

Times Square

Andreas Gursky, 1997

# Sources and Links

## ○ Pictures:

- Andreas Gursky: <https://www.andreasgursky.com/de/werke>
- Peter Lindbergh: "Untold Stories", Taschen 2019
- Part 1:
  - [https://praxistipps.chip.de/kamera-objektiv-kaufen-darauf-sollten-sie-achten\\_38731](https://praxistipps.chip.de/kamera-objektiv-kaufen-darauf-sollten-sie-achten_38731)
  - [https://www.four-thirds.org/en/common/img/c\\_ft\\_standard\\_know\\_vi\\_04.jpg](https://www.four-thirds.org/en/common/img/c_ft_standard_know_vi_04.jpg)
  - <https://www.dslr-forum.de/showthread.php?t=1594480>
  - <https://www.zeiss.de/corporate/home.html>
  - <https://www.taschen.com/pages/de/search/peter-lindbergh>
- Part 2:
  - <https://www.baslerweb.com/de/medical-life-sciences/wissenswertes/trends/wechsel-von-ccd-zu-cmos/>
  - <https://www.sony.de/electronics/wechselobjektivkameras/ilce-6400>
- Part 3:
  - <http://100photos.time.com/>
  - <https://fotoschule.fotocommunity.de/blitzlicht-weissabgleich-und-mischlicht-loest-du-das-problem/>
- Part 4
  - <https://www.mathnasium.com/examples-of-the-golden-ratio-in-nature>
  - <https://www.whitewall.com/at/mag/goldener-schnitt>
  - [https://en.wikipedia.org/wiki/Golden\\_ratio](https://en.wikipedia.org/wiki/Golden_ratio)
  - <https://golden-ratio.club/golden-ratio-in-nature>

## ○ Part 1

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- [https://en.wikipedia.org/wiki/Zoom\\_lens](https://en.wikipedia.org/wiki/Zoom_lens)

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- “CMOS/CCD sensors and camera systems” by Gerald C. Holst, Gerald, SPIE 2011
- <https://www.pcwelt.de/ratgeber/CMOS-vs-CCD-Bildsensoren-5794727.html>

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- <https://www.natur-foto-technik.de/LED-Blitz.html>
- “Physik Journal”, DPG, 11.2020, page 50: “Hell, schnell ... und farbecht”
- “Organic Electronics”, Elsevier, 5.2011, page 865: “Efficient very-high color rendering index organic light-emitting diode” by Jwo-Huei Jou
- To take a look at Time’s 100 Pictures: <http://100photos.time.com/>

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- “Die Fibonacci Zahlen und der goldene Schnitte” by Thomas Peters, 2003: <http://www.mathe-seiten.de/fibonacci.pdf>
- “The Golden Ratio”, Can Akdeniz, 2019
- To gain additional information one could research the work of Alexey Petrovich Stakhov

# Sources for Individual Images

In order of appearance

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- <https://www.businessfotograf-magdeburg.de/category/fotografie-tipps/>
- <http://www.kay-pehnke.de/blog>
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- [https://www.wikiwand.com/en/Canon\\_EF\\_200-400mm\\_lens](https://www.wikiwand.com/en/Canon_EF_200-400mm_lens)

## ○ Part 2

- <https://www.sony.de/electronics/wechselobjektivkameras/ilce-6400>
- [https://pro.sony/de\\_CH/technology/full-frame-sensor](https://pro.sony/de_CH/technology/full-frame-sensor)

## ○ Part 3

- <https://www.51vimeo.com/paipiangoongve/detail-99.html>
- [https://nl.wikipedia.org/wiki/Bestand:AHA\\_Blitzlichtpulverlampe.jpg](https://nl.wikipedia.org/wiki/Bestand:AHA_Blitzlichtpulverlampe.jpg)
- <https://www.physicsforums.com/threads/charges-in-a-gas-discharge.985025/#post-6305849>
- <http://www.nikodeco-design.com/led-flash>
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- [https://www.youtube.com/watch?v=gTY0\\_O6ExSY](https://www.youtube.com/watch?v=gTY0_O6ExSY)

## ○ Part 4

- [https://de.wikipedia.org/wiki/Goldener\\_Schnitt](https://de.wikipedia.org/wiki/Goldener_Schnitt)
- <http://www.sights-and-culture.com/Germany/Leipzig-1.html>
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- <https://blog.prototyp.io/golden-ratio-what-it-is-and-why-should-you-use-it-in-design-7c3f43bcf98?gi=8cb666246159>
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- <https://www.lifecoachcode.com/2018/09/26/divine-ratio-is-found-everywhere-nature/>
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# Examples of Analog Photography (Lockdown)



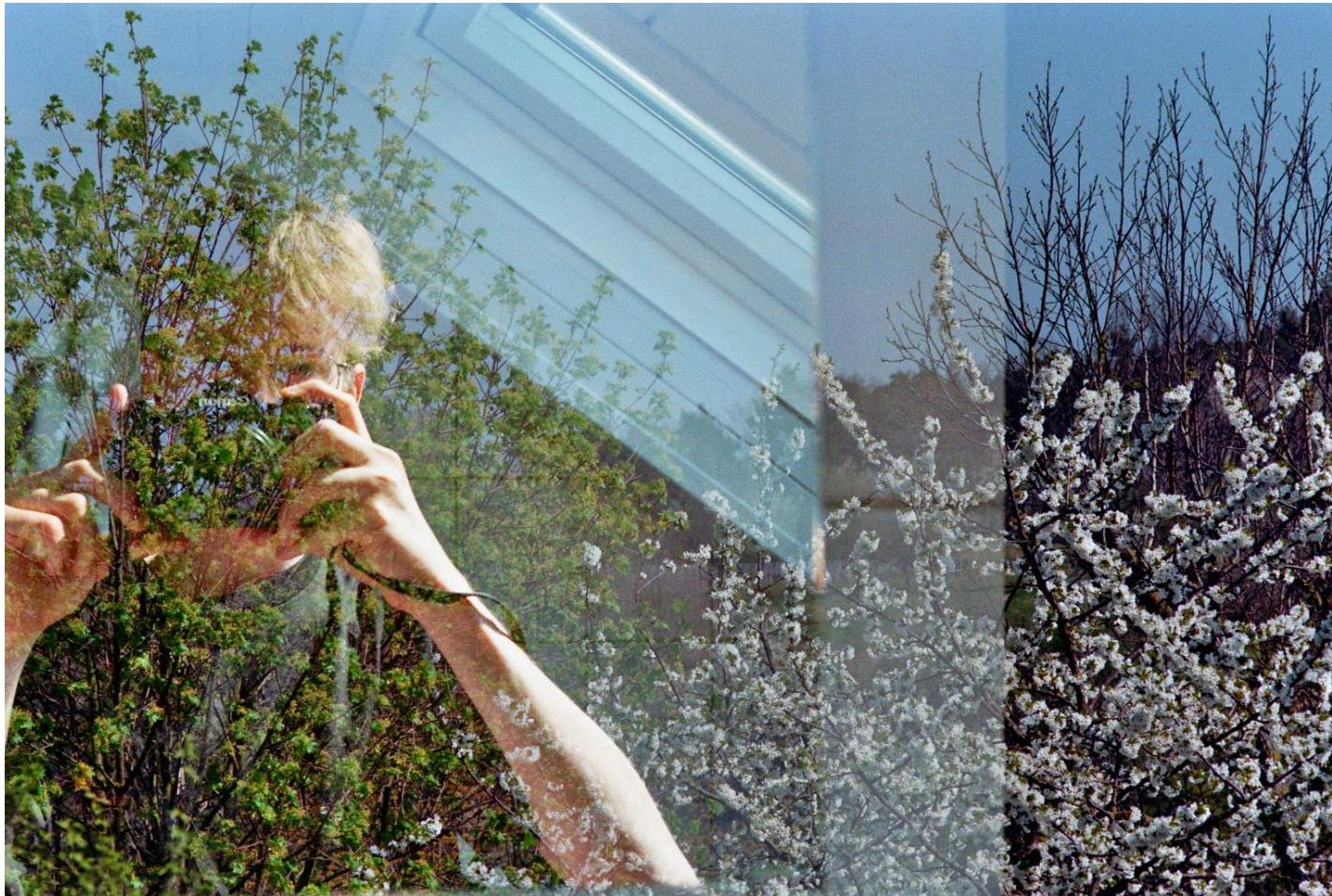
# Examples of Analog Photography (Lockdown)



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# Examples of Analog Photography (Lockdown)



# Examples of Analog Photography (Lockdown)

