COLOR CONFORMANCE CONFERENCE '25

New Port Richey, FL (Tampa North)
January 28–30, 2025

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Unusual Printing Conditions

When an instrument does not seem to correspond to human perception

January 28, 2025

Presented by

Krzysztof Kućma

Agenda

- **Human vision - key aspects**

- **Object's surface properties**

- **How instruments see color?**

- **Inter-instrument disagreement**

- **Methodology to solve the issue**

- **Conclusions**

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Problem

**We observe a lack of correlation between how we perceive color
and how the instrument measures it.**

- Why do we really measure color?

- What are the reasons for this and have our instruments really become worthless?

- Why is there still no standard of color or ideal instrument?

- How can we turn an apparent problem into an effective method?

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What is Color?

It is a subjective impression that is caused in our brain by the relationship between:

- the **Object**,
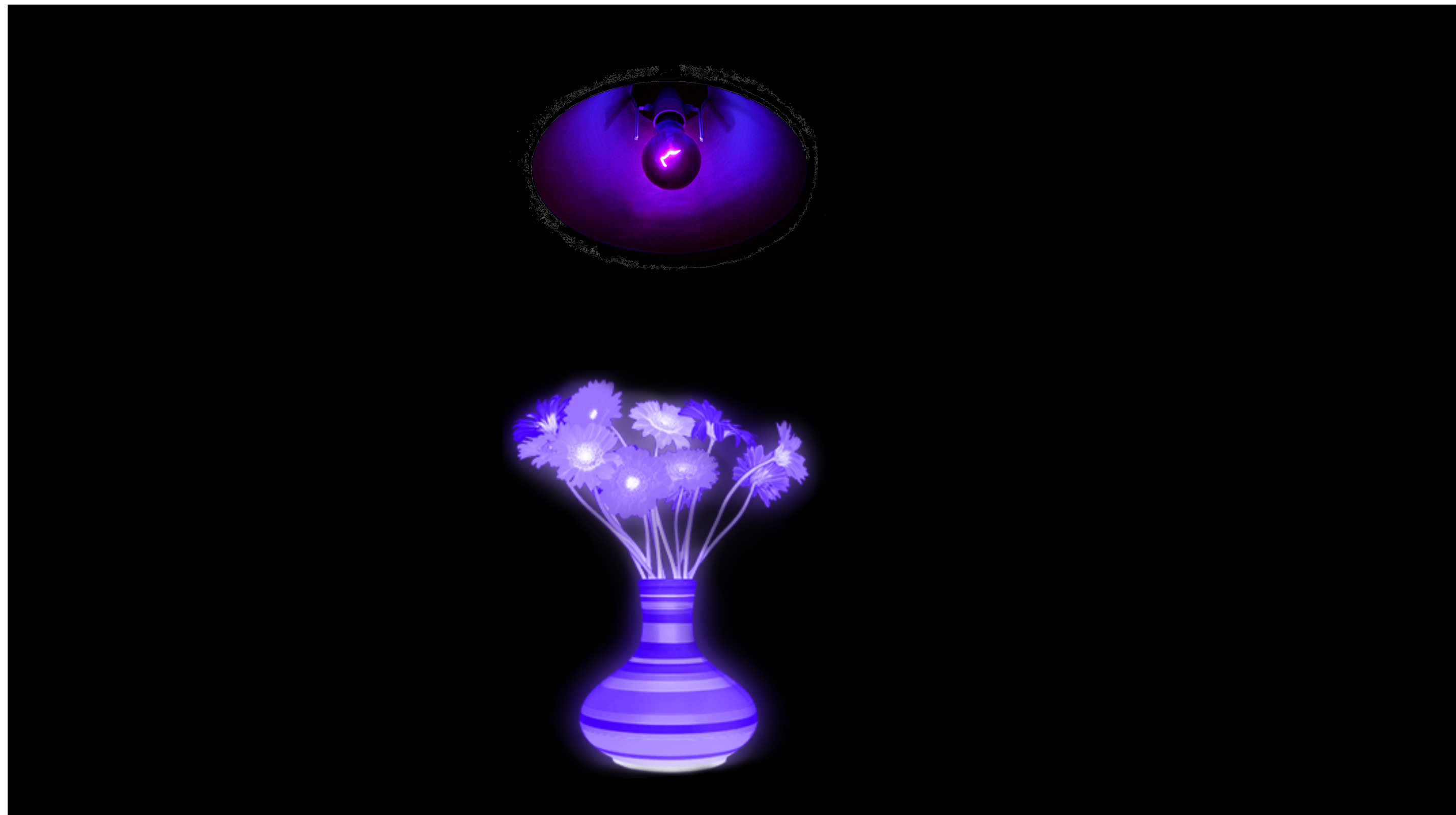- **Observer**
- and **Lighting**

Observer

Object

Illuminant

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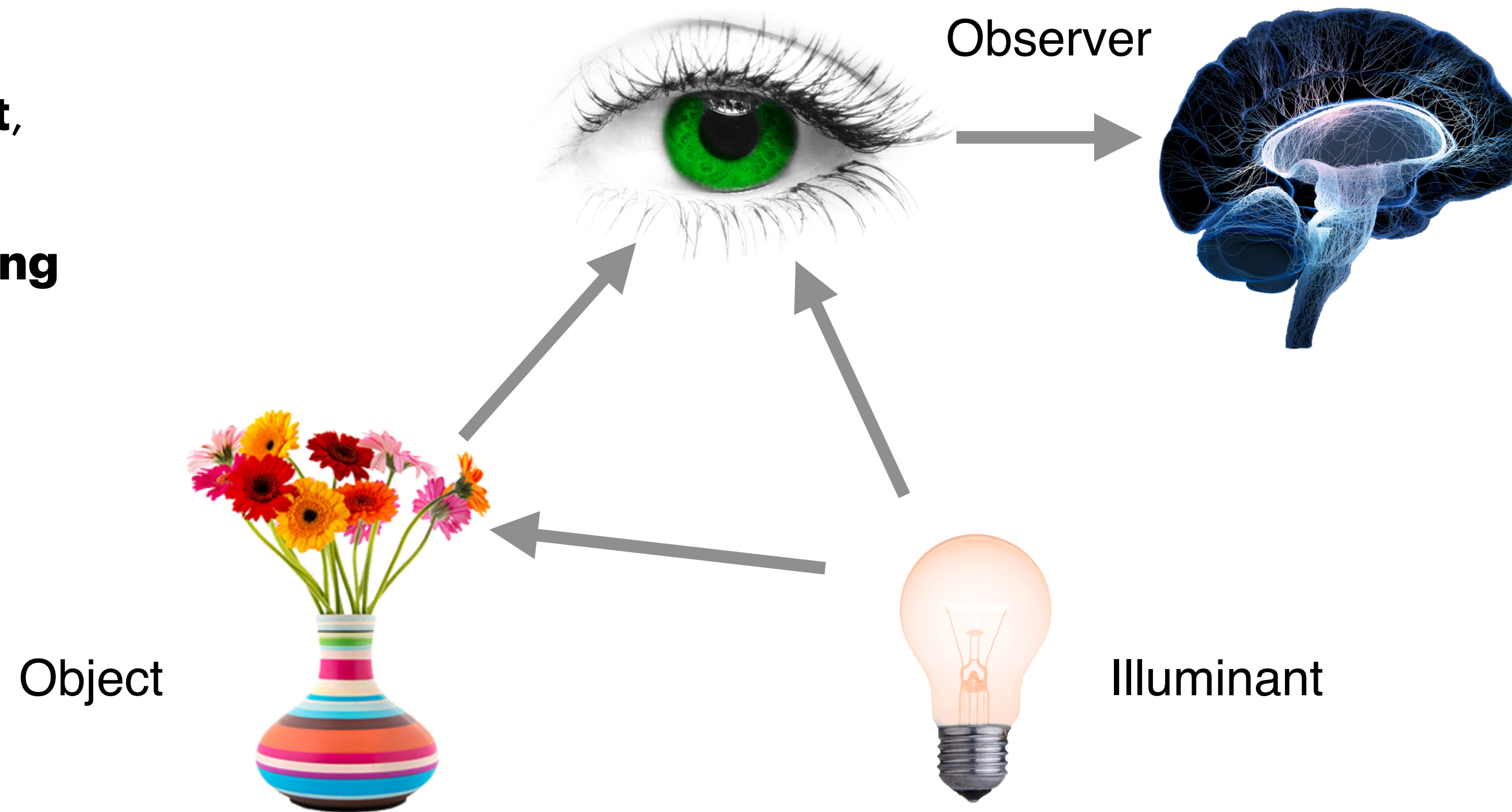
Role of Illuminant

In the photographic darkroom illuminated by red light, everything is just a shade of red.

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UV - invisible component

Some problems may be caused by a component invisible to humans.

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Color vision - how it happens?

The brain is responsible for vision, the eye is only a receptor. There are differences in the structure of the eye. Not everyone has the same number and type of rod and cone receptors. However, the brain is key, where an important role is played by:
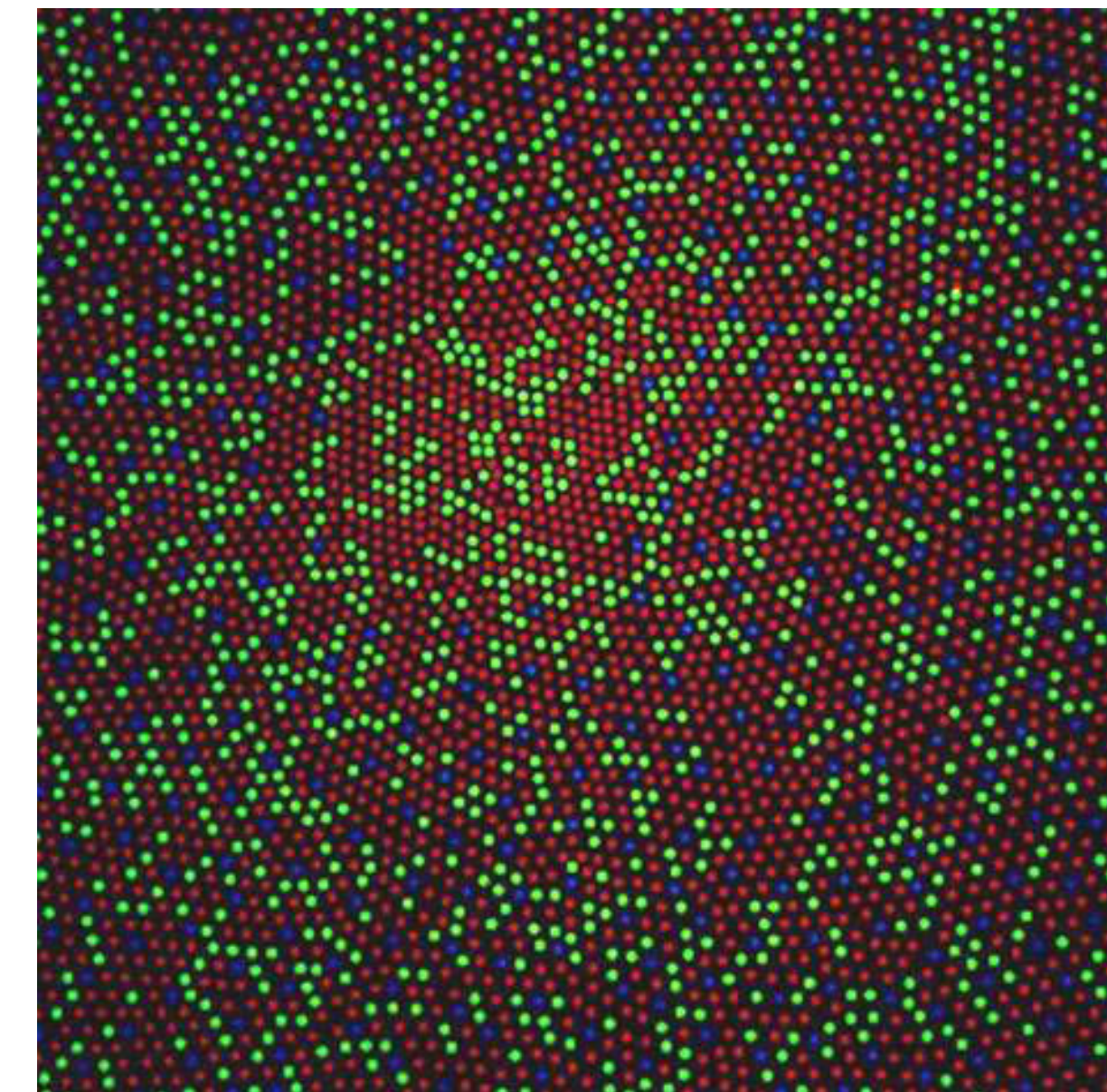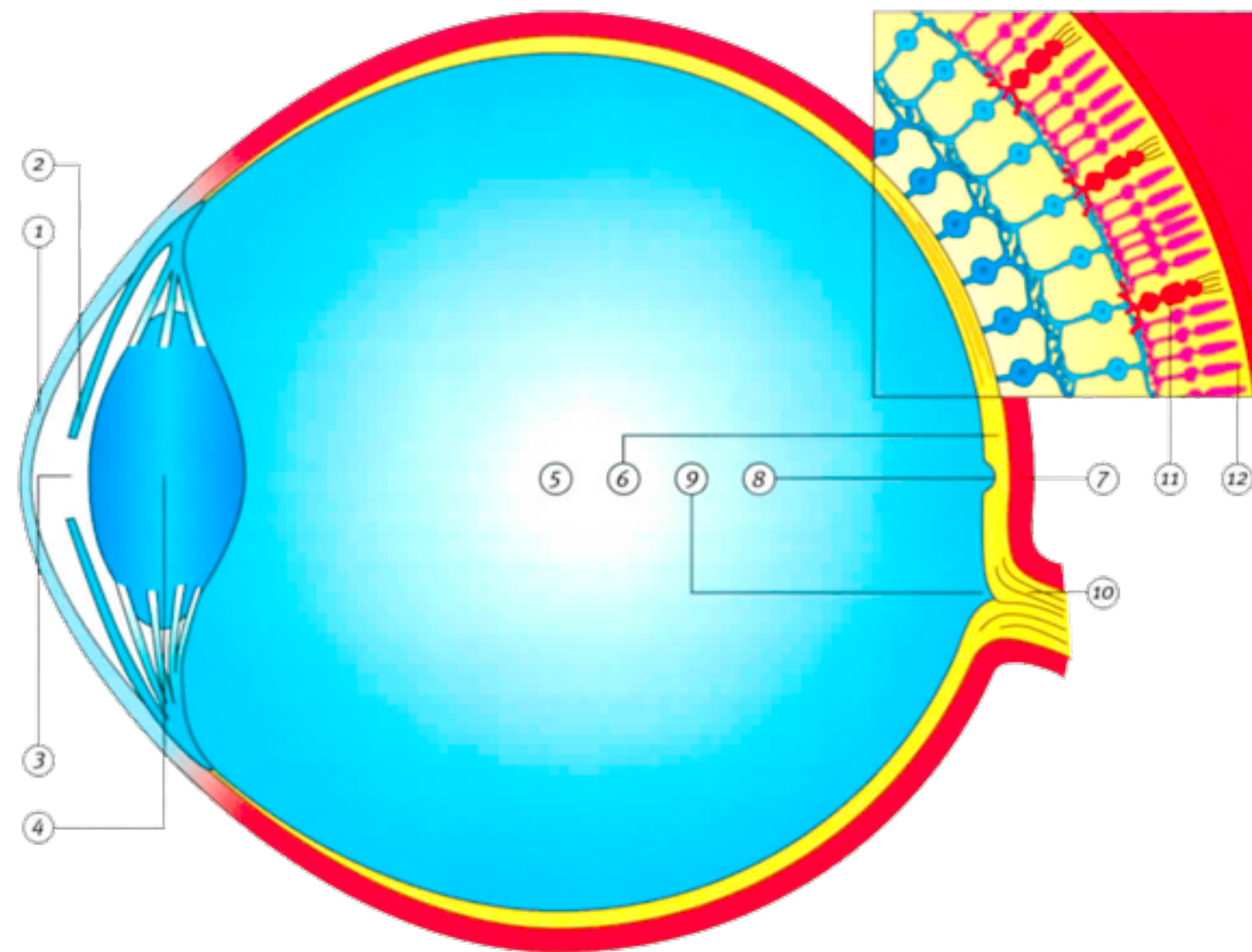
Color vision - how it happens?

The brain is responsible for vision, the eye is only a receptor. There are differences in the structure of the eye. Not everyone has the same number and type of rod and cone receptors. However, the brain is key, where an important role is played by:

- cultural background (we learn the colors of our surroundings from childhood)
- experience (color vision can be trained)
- observation conditions (geometry of vision, lighting conditions, state of mind)
- accommodative abilities (the white and black points work like the auto-levels in Photoshop)
- relativity of assessment (we do not remember everything so as not to overload the mind - instead of absolute values, we use references to our memory)

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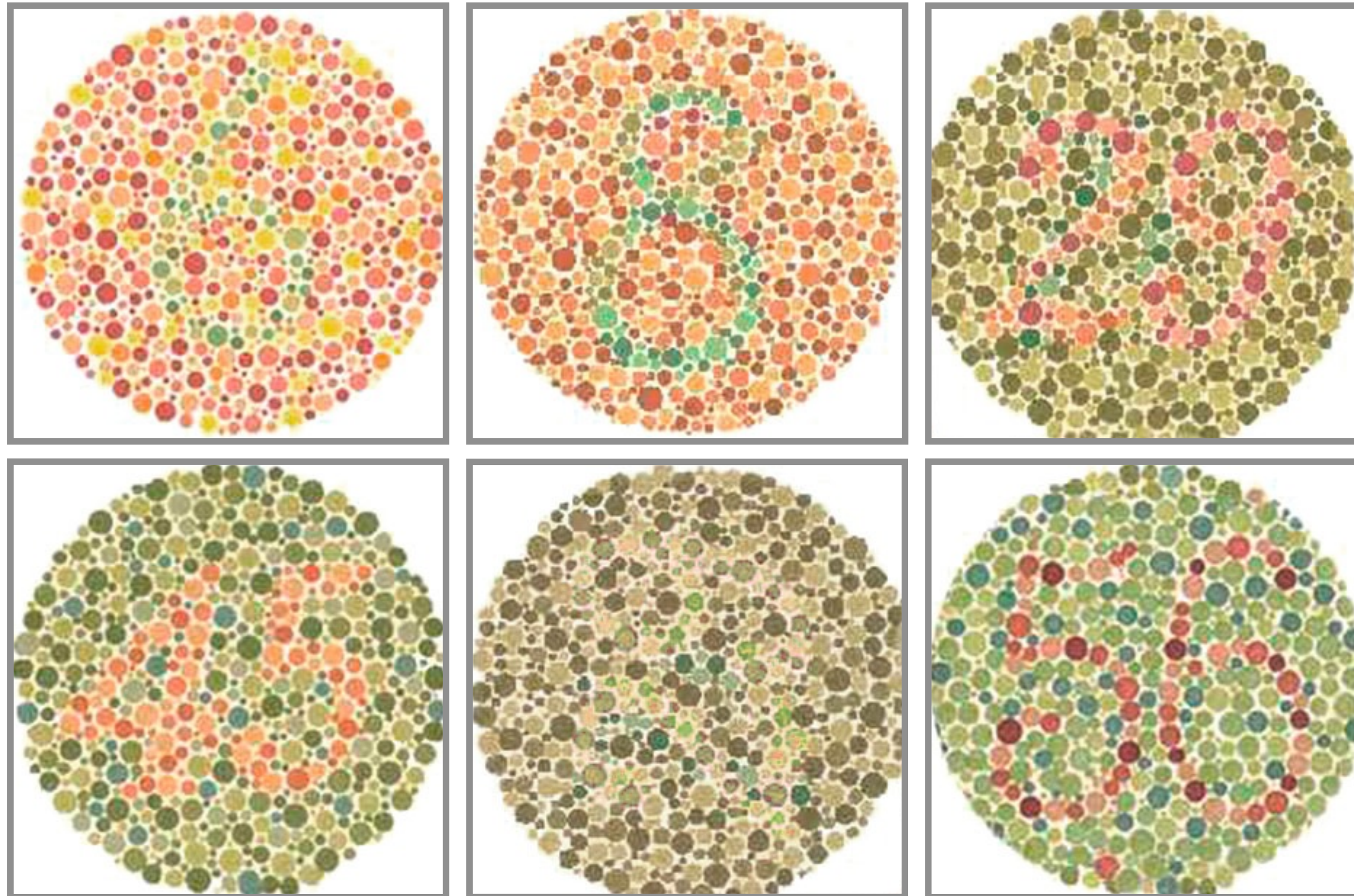
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Color blindness

Checker Shadow Illusion

The checker shadow illusion is an optical illusion published by Edward H. Adelson, professor of vision science at MIT, in 1995

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Checker Shadow Illusion

The checker shadow illusion is an optical illusion published by Edward H. Adelson, professor of vision science at MIT, in 1995

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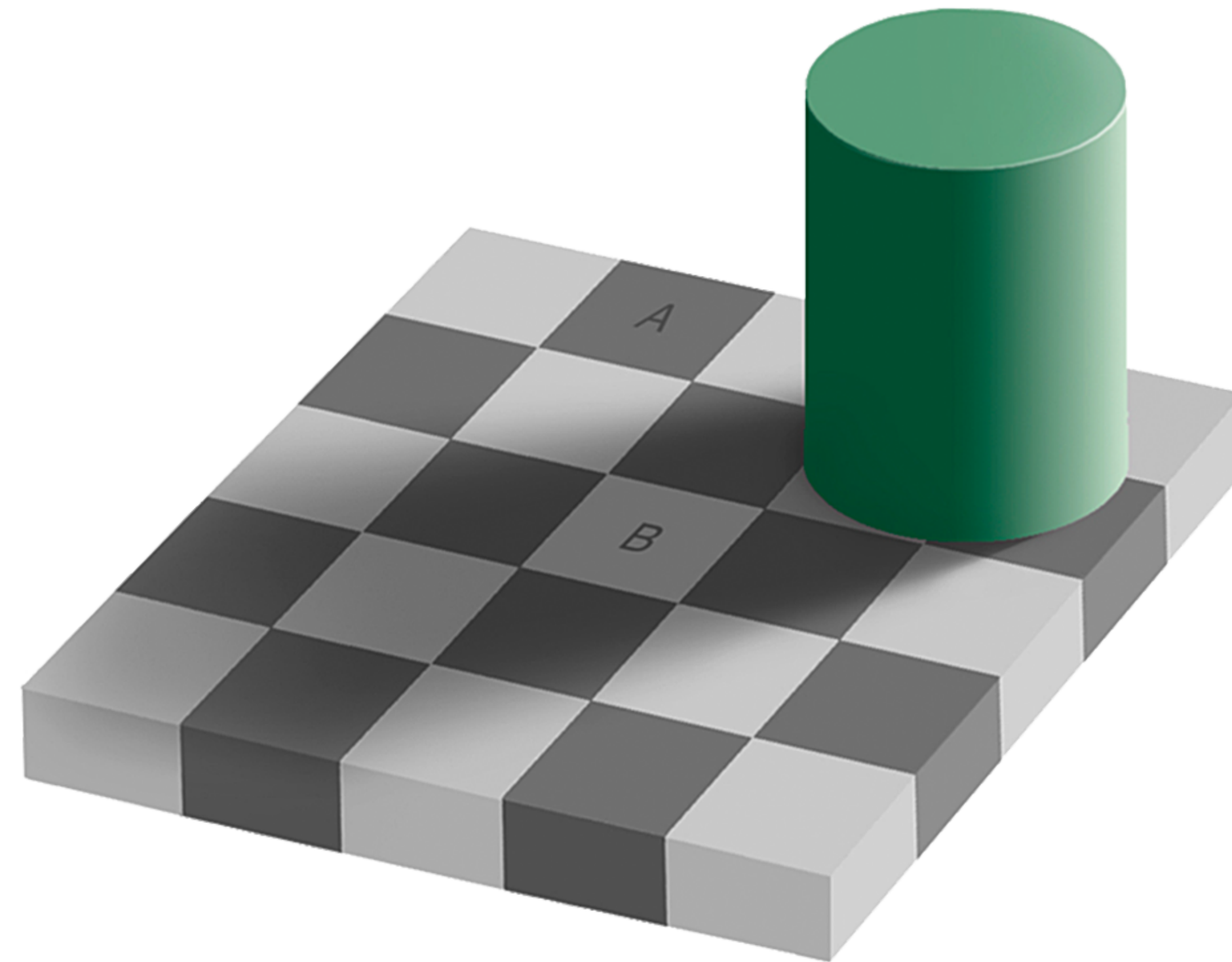
COLOR CONFORMANCE
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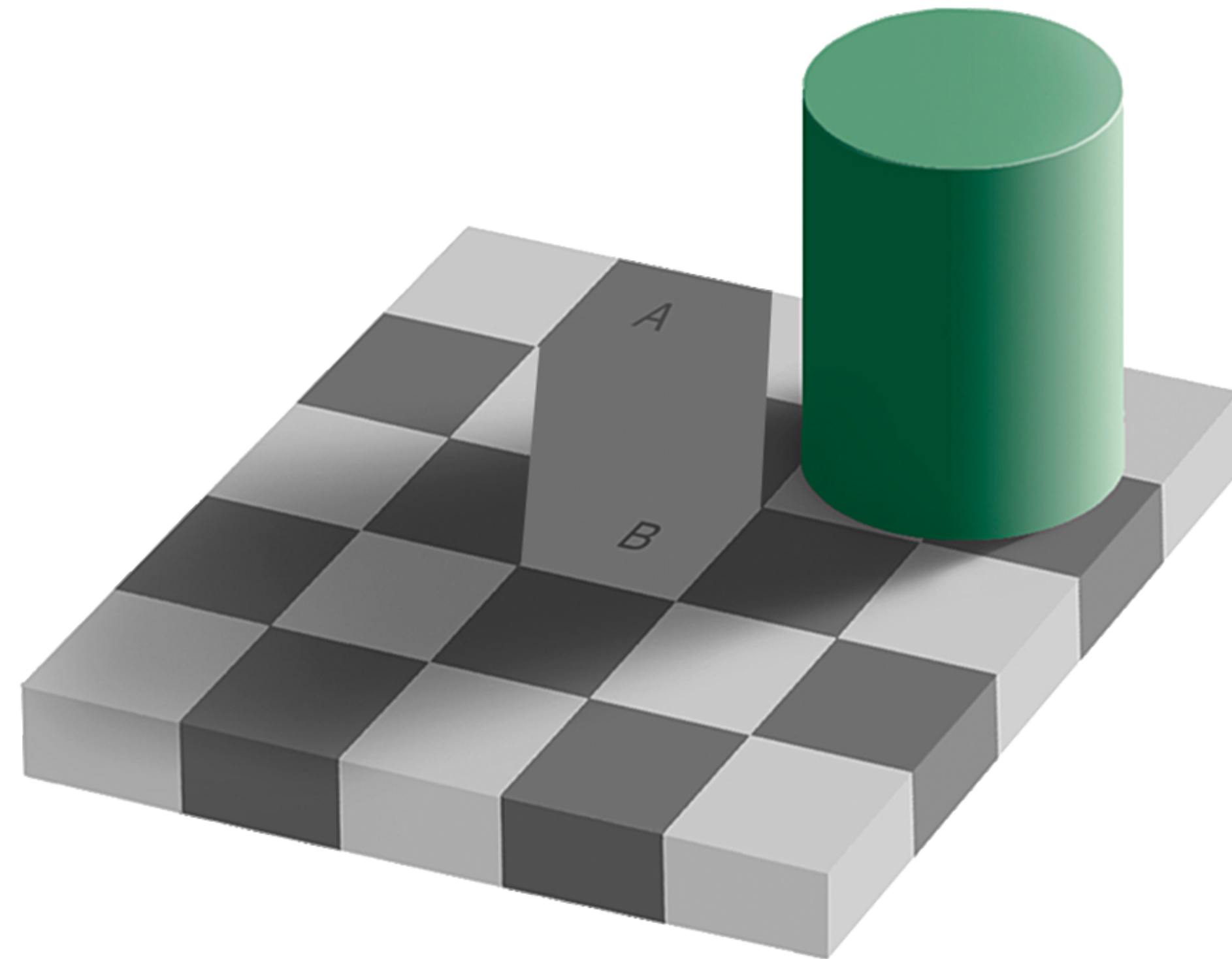
Key Determinants:

- **White point**
  - The color temperature of white changes a lot from sunrise to sunset - our mind compensates for the differences and it seems to us that objects look the same throughout the day, also using artificial lighting at night.

- **Black point**
  - Similarly, black - brightness but also color temperature change this point similarly to white.

- **Tone curve**
  - A grey object is often perceived similarly but sometimes we lose details when it is too dark or too light.

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Tone curve...
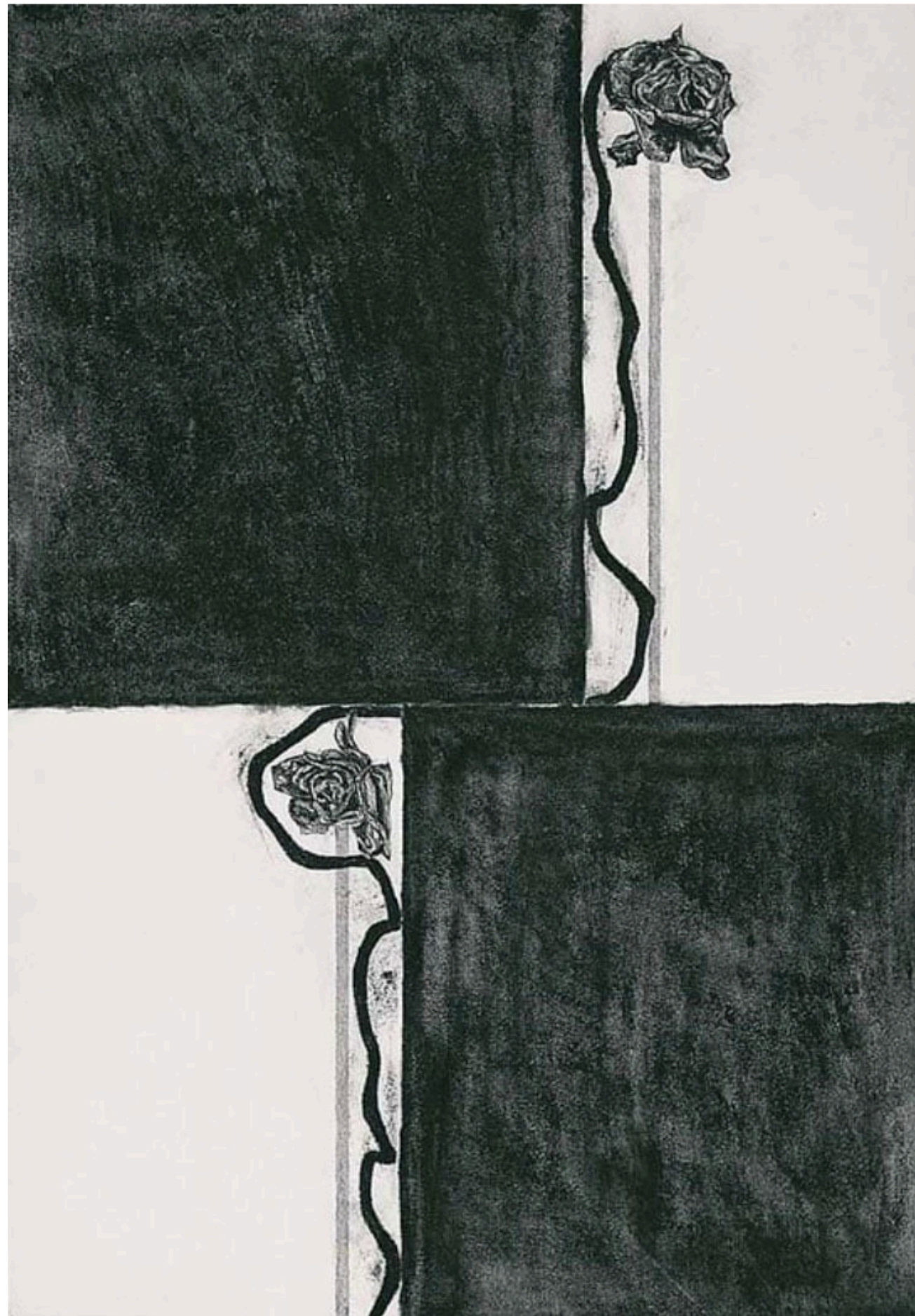
The work of Marek Chlanda.

Jerusalem has much more light than Krakow. A drawing made there and transported to an exhibition at a different latitude looks different, surprising the author himself.

computer simulation

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The Object

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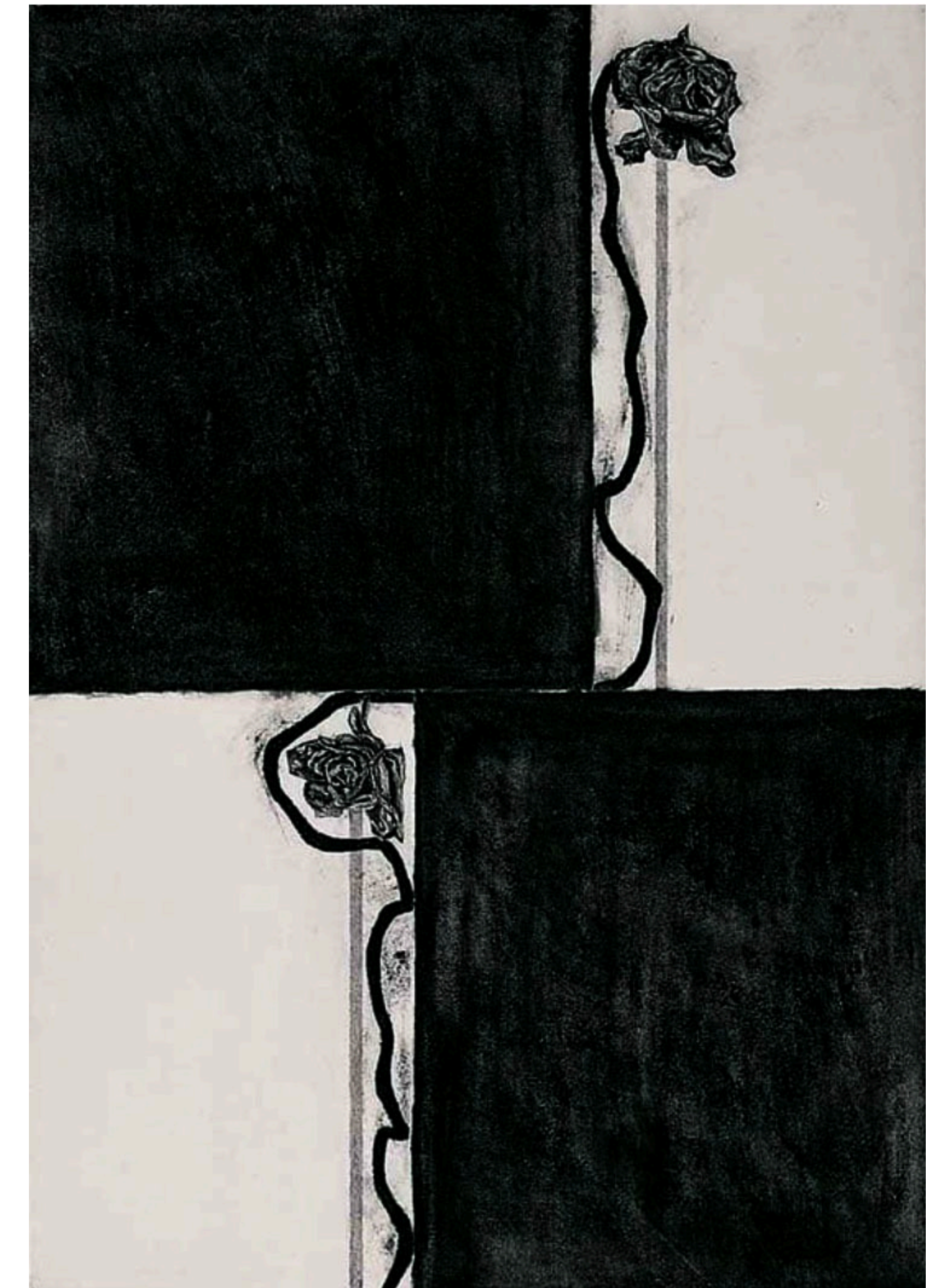
Reflection by various surfaces
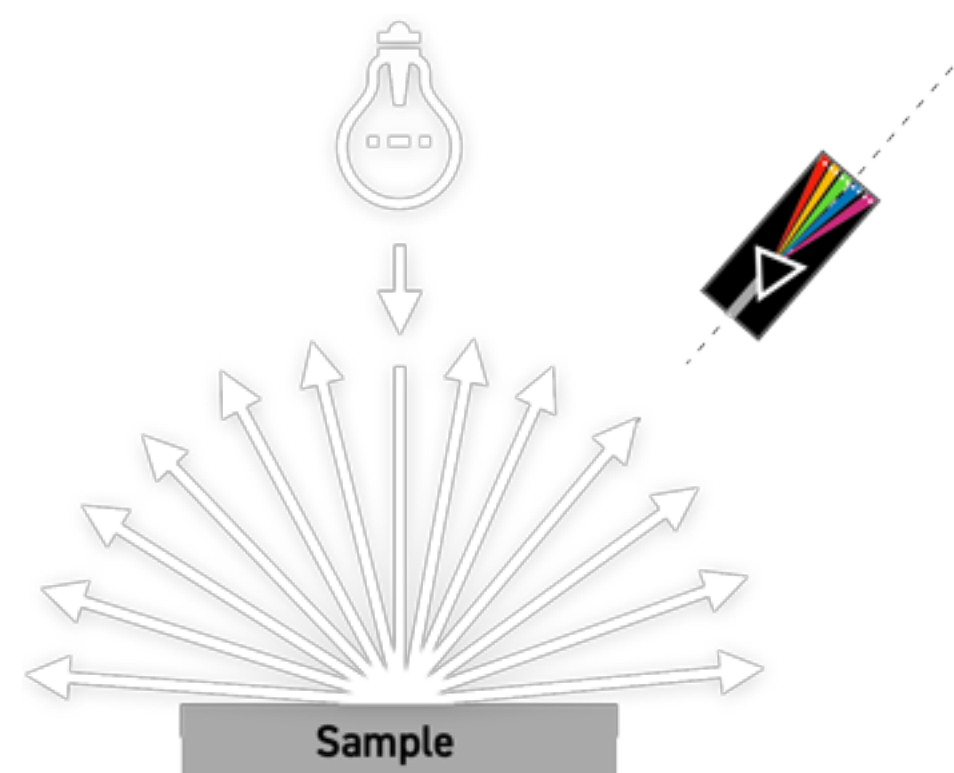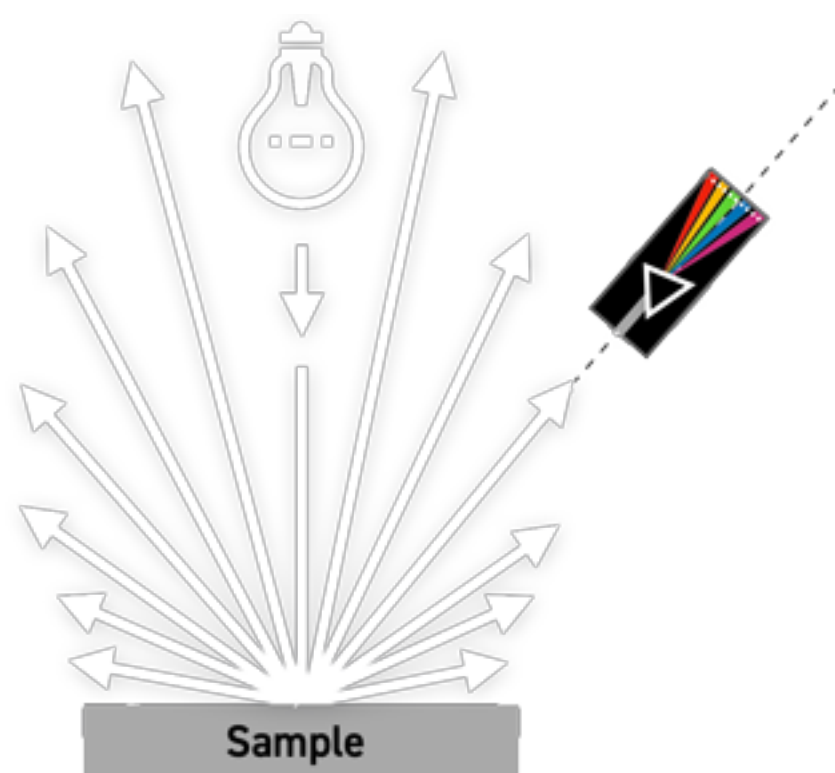
Matt surface **Glossy surface** **Irregular surface**
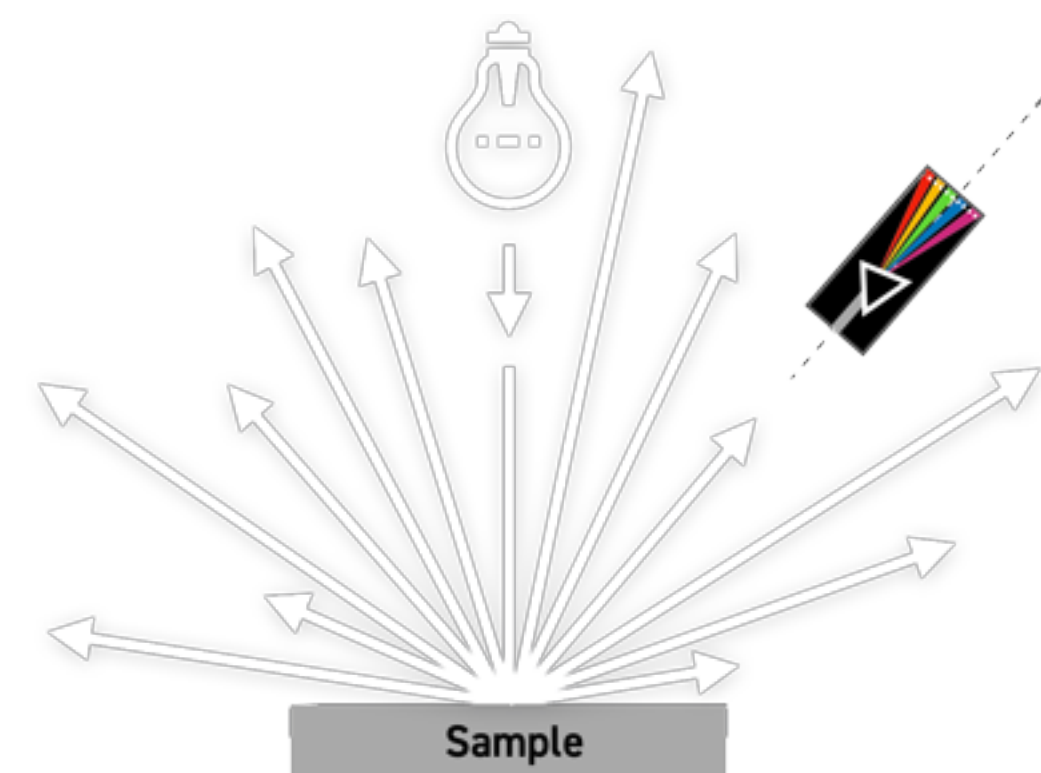
Whenever printing is performed on the metalised substrate, film, or final product has sophisticated finishing like structural varnish, or /and is calendared or/and as a result of postproduction, the final surface is not flat and matt finished — regular printing spectrophotometer may not work correctly.

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Reflection by various surfaces
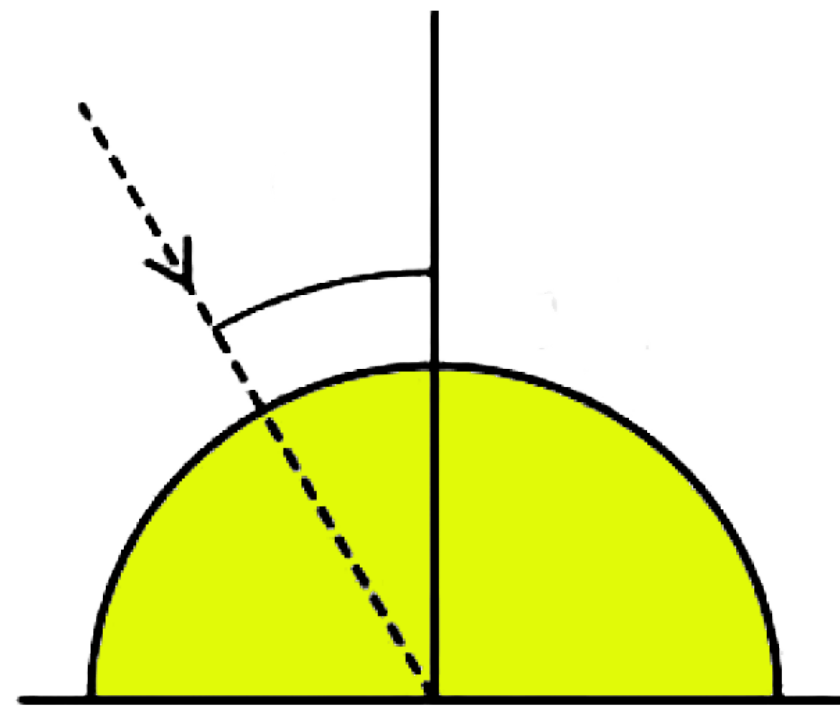
a Lambertian reflector

a smooth surface

a roughened aluminum

a glossy paper

Lambertian reflectance is the property that defines an ideal "matte" or diffusely reflecting surface. It is theoretical model.

mirror or perfect glossy finishing (coloured glass, piano varnish,...)
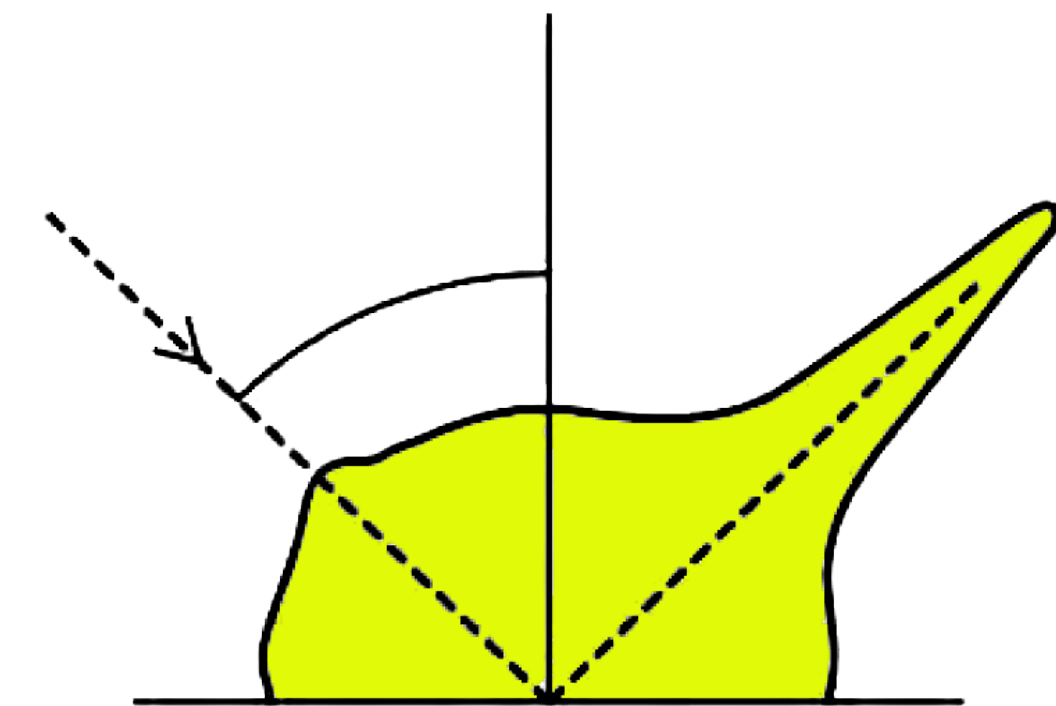
(based on: Fundamentals of Optics and Radiometry for Color Reproduction, Mathieu Hébert, Roger D. Hersch, Patrick Emmel, hal-01179588.)

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The Problem

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Instrument's Geometry Choices ...

0°/45°

45°/0°

45°/0° Annular

d/0°

di/8° SCI

de/8° SCE

Multi-Angle

0°/180°

Emission: irradiance measurement

Emission: radiance measurement

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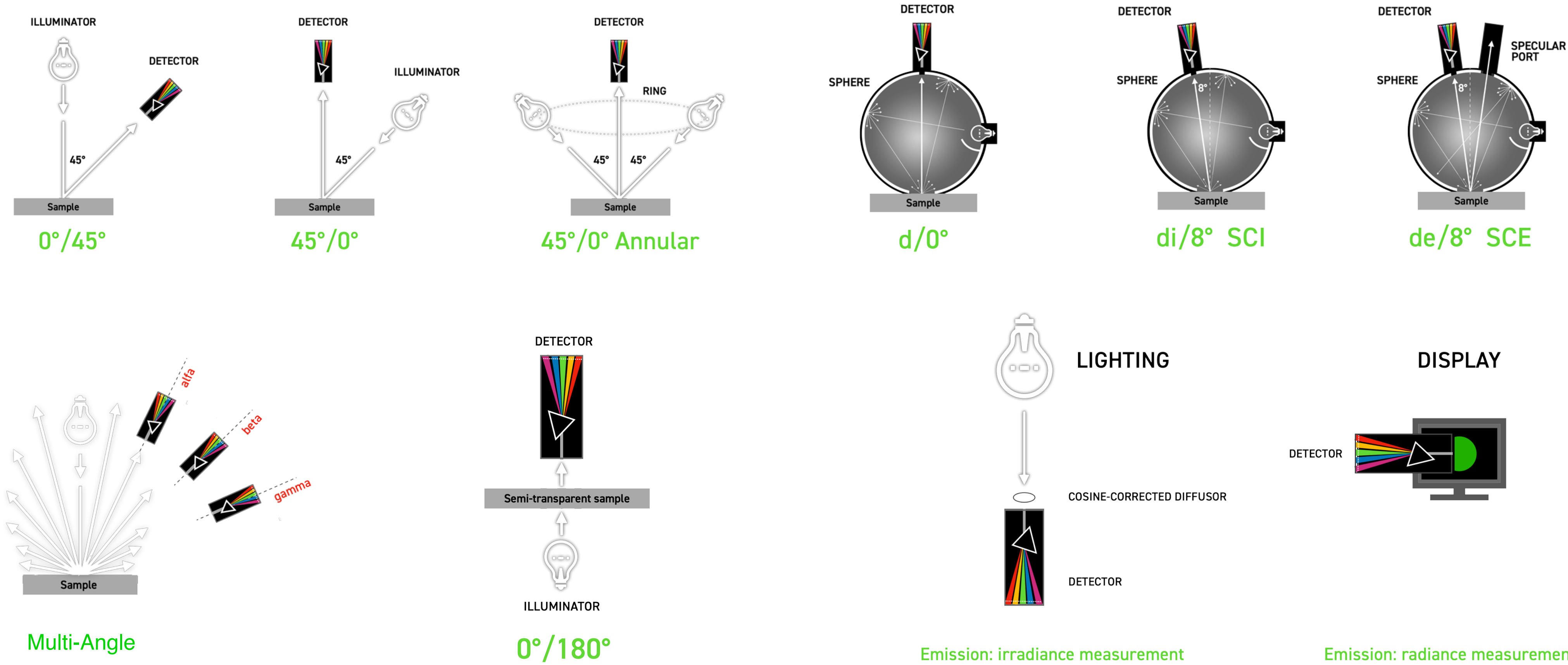
Human's Geometry is dynamic!

- We observe the object in different points, often change the angle of view and even move the object if possible to see how it reacts to different angles of lighting and observation.

- This is a series of "measurements" with subconscious adjustment of viewing conditions.

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Print on metalic foil

CMYK (CC224 target) printed on foil material.

The background is the same - your brain knows that but the camera is reporting a difference due to the reflection.

Printing is efficient but the substrate is slightly wrinkled and reflects light differently. Our brain understands this.

CC-224 CMYK

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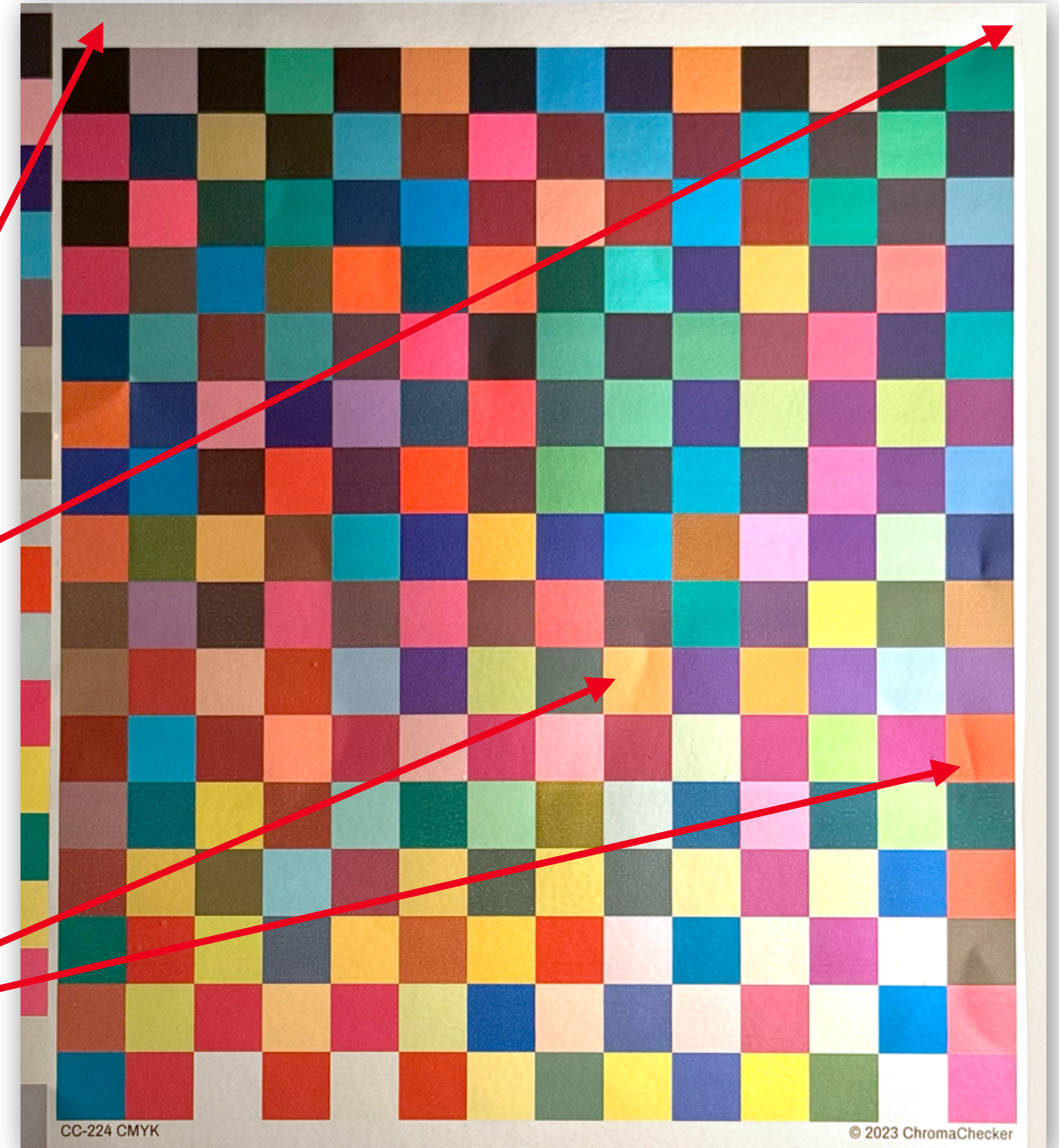
Print on metalic foil

CMYK (CC224 target) printed on foil material.

Sheet of paper with one black and one white side and a hole in the center.

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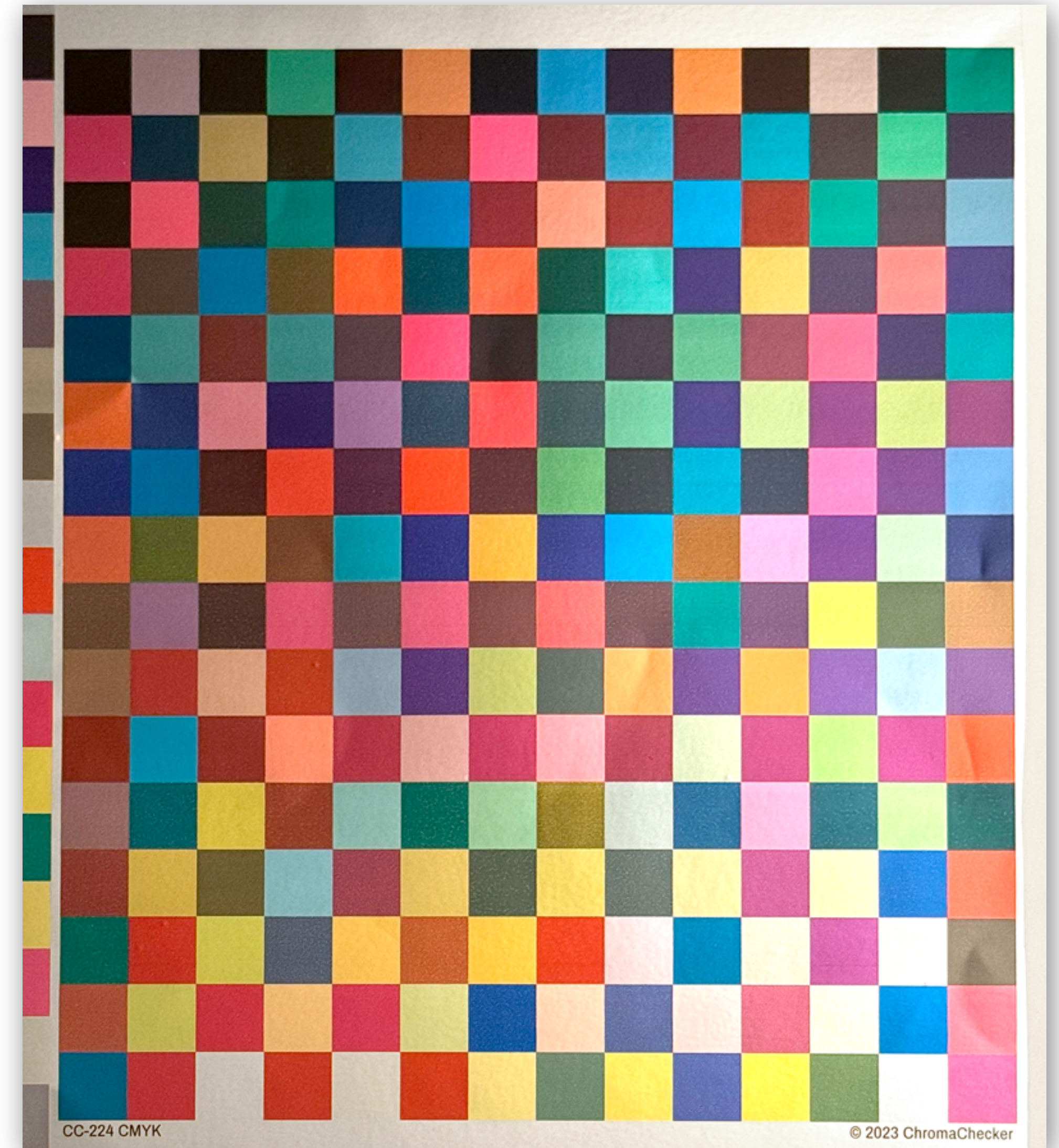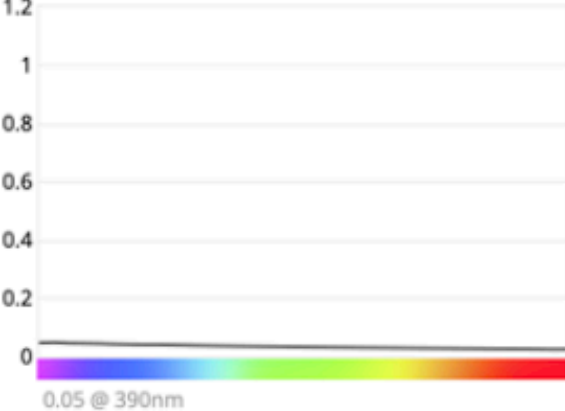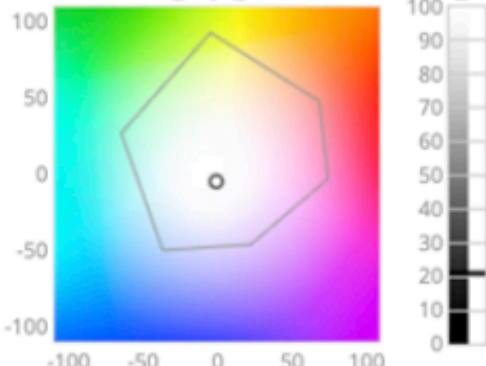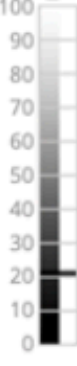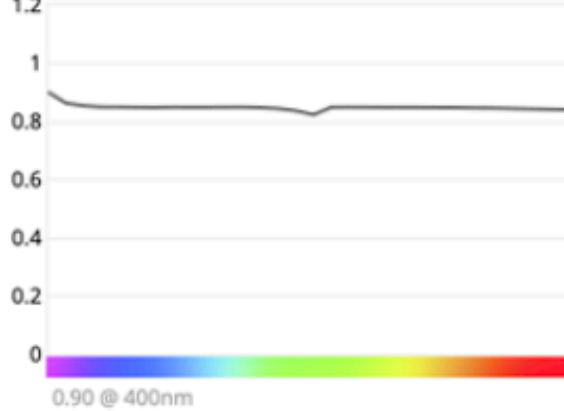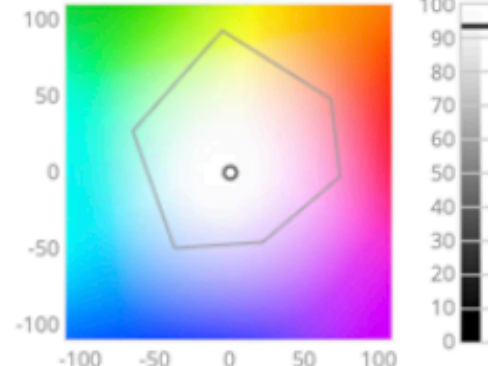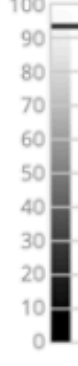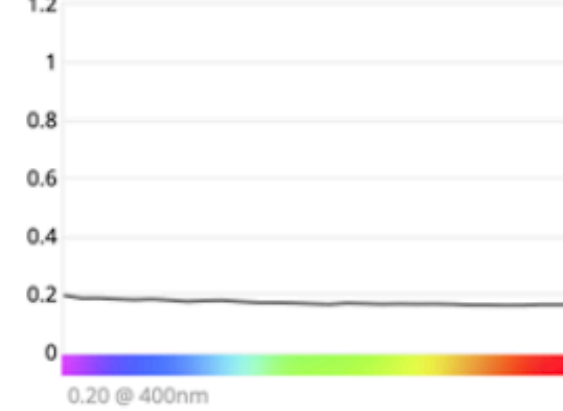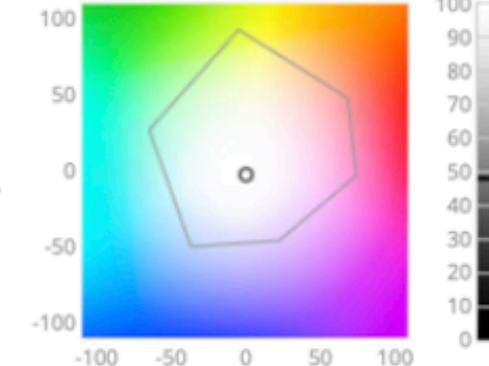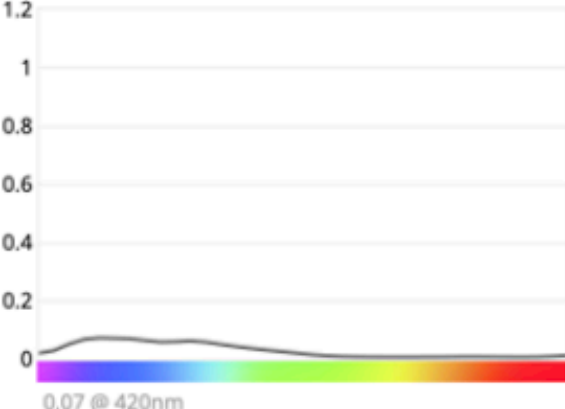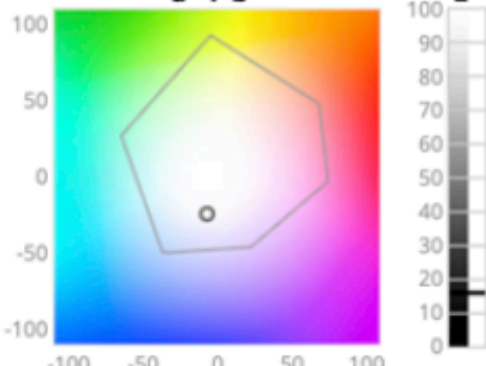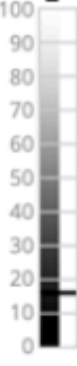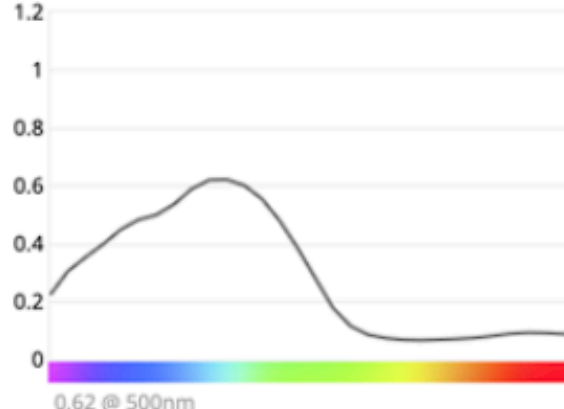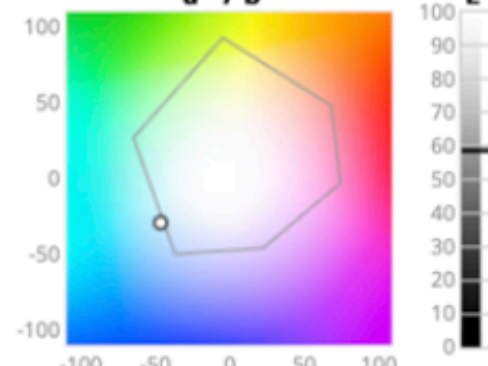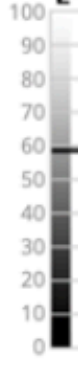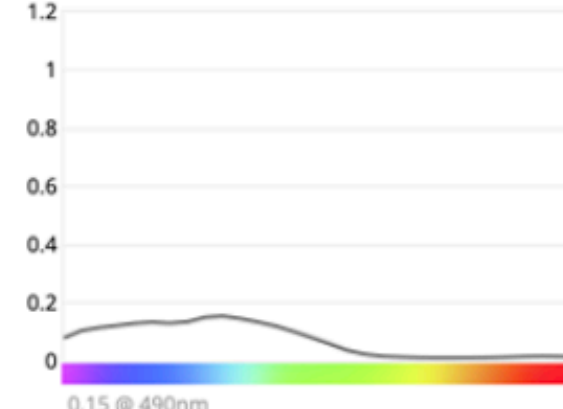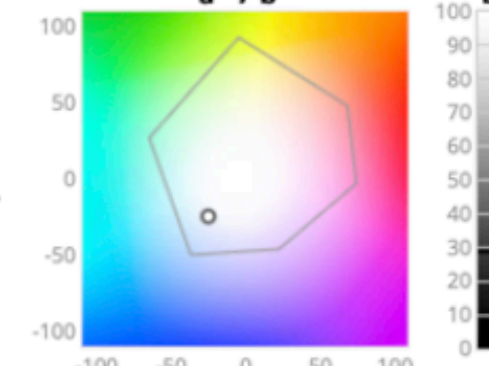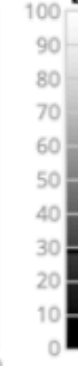
Print on metalic foil
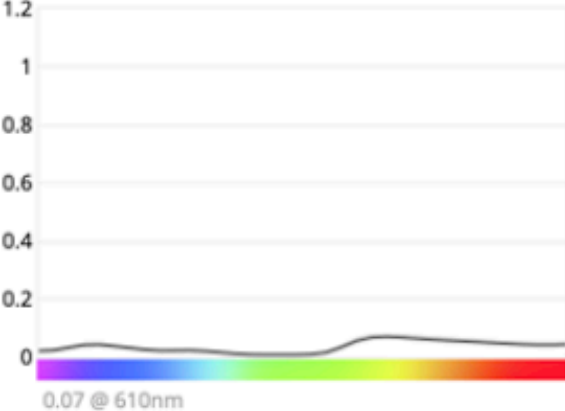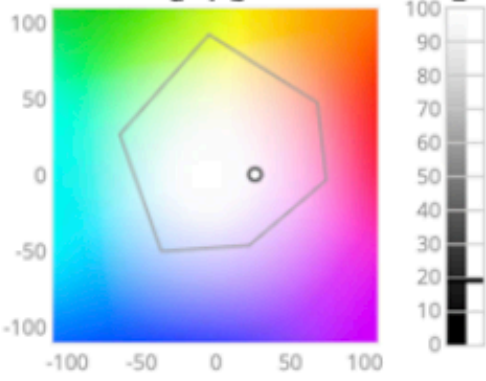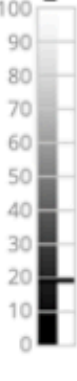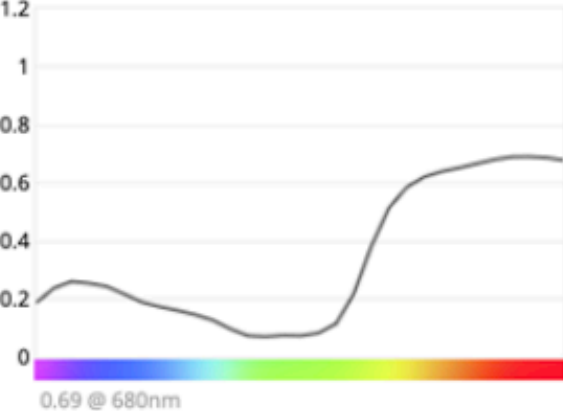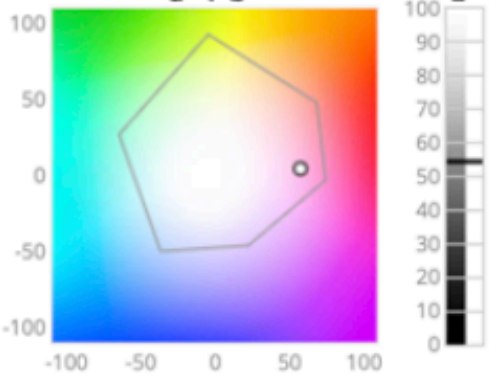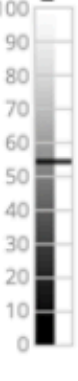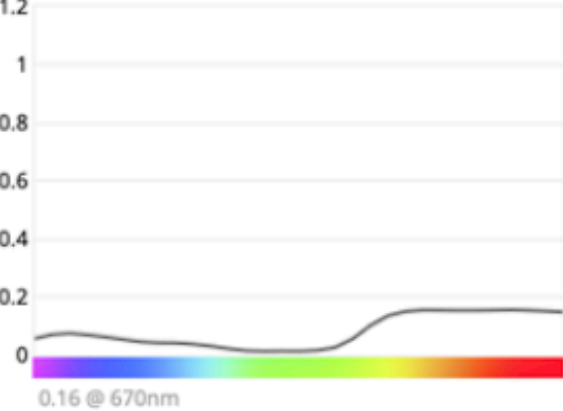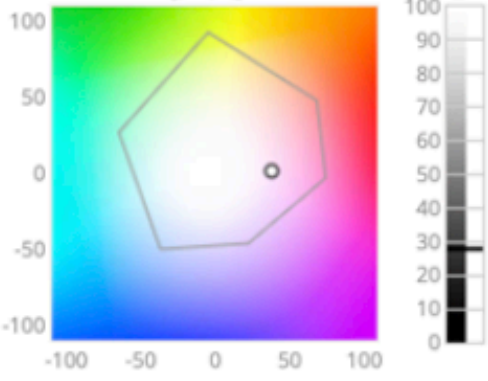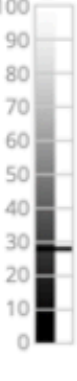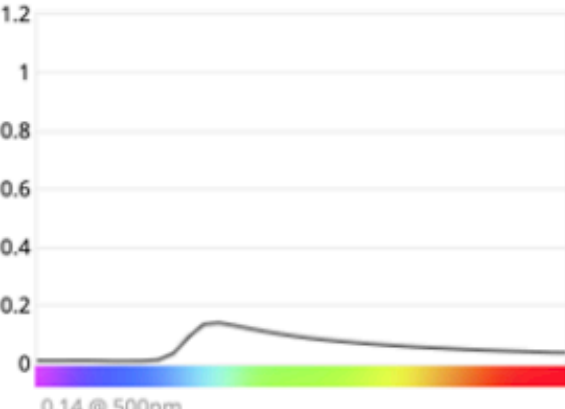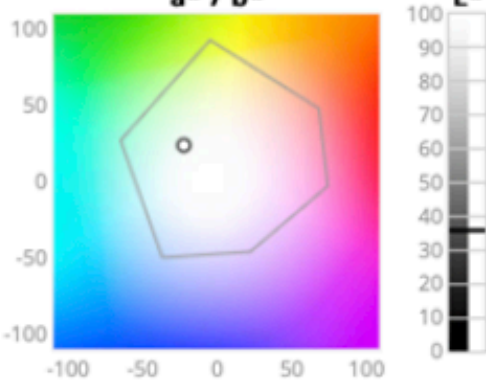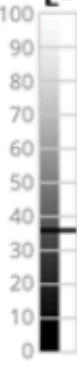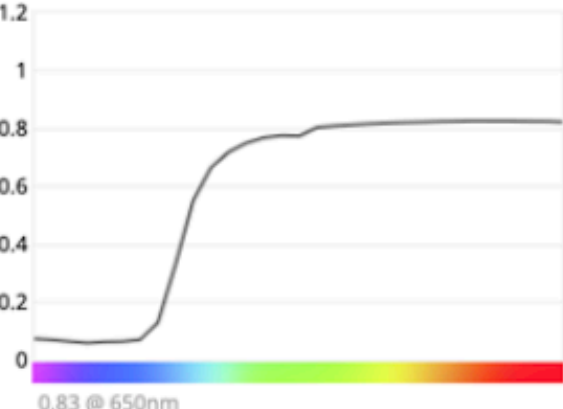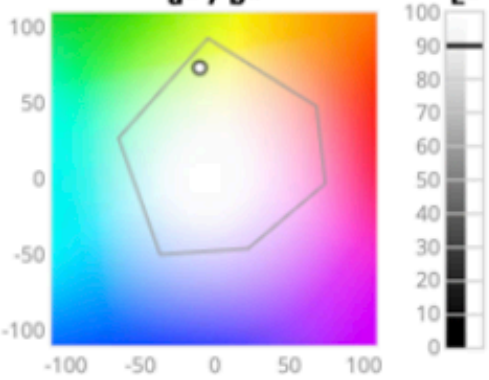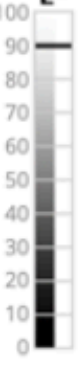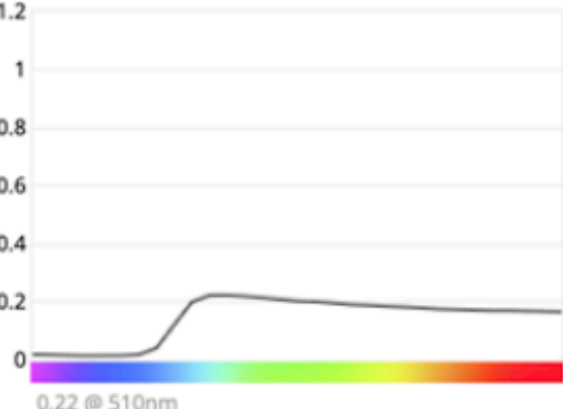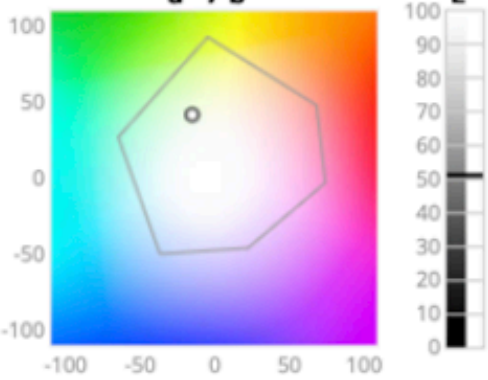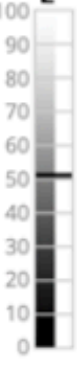
Real pictures taken through the hole - no manipulation!

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Measurments

	X-Rite i1Pro 3	CC Sphere SPIN	CC Spere SPEX

Substrate (16/3)

X-Rite i1Pro 3 — Substrate – col. 3 row 16, 2023-11-12 17:59:52
- Spectral Reflectance Graph: 0.05 @ 390nm
- CIELab: L* = 20.97, a* = -1.14, b* = -4.77, C = 4.90, h = 256.5°
- OBA Index: 0.0
- FI: 0.0

CC Sphere SPIN — White #297, 2023-11-12 18:16:17
- Spectral Reflectance Graph: 0.90 @ 400nm
- CIELab: L* = 93.63, a* = 0.41, b* = -0.35, C = 0.54, h = 319.1°
- OBA Index: -
- FI: -

CC Spere SPEX — White #297, 2023-11-12 18:16:17
- Spectral Reflectance Graph: 0.20 @ 400nm
- CIELab: L* = 48.08, a* = -0.03, b* = -2.54, C = 2.54, h = 269.4°
- OBA Index: -
- FI: -

Cyan (16/1)

X-Rite i1Pro 3 — Cyan – col. 1 row 16, 2023-11-12 17:57:18
- Spectral Reflectance Graph: 0.07 @ 420nm
- CIELab: L* = 15.88, a* = -7.36, b* = -24.36, C = 25.45, h = 253.2°
- OBA Index: 0.0
- FI: 0.0

CC Sphere SPIN — Cyan #295, 2023-11-12 18:15:21
- Spectral Reflectance Graph: 0.62 @ 500nm
- CIELab: L* = 58.69, a* = -46.71, b* = -29.25, C = 55.12, h = 212.1°
- OBA Index: -
- FI: -

CC Spere SPEX — Cyan #295, 2023-11-12 18:15:21
- Spectral Reflectance Graph: 0.15 @ 490nm
- CIELab: L* = 28.88, a* = -25.36, b* = -24.62, C = 35.35, h = 224.2°
- OBA Index: -
- FI: -

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Measurments

	X-Rite i1Pro 3	CC Sphere SPIN	CC Spere SPEX

Magenta (16/2)

X-Rite i1Pro 3 — Red – col. 2 row 16, 2023-11-12 17:58:58
Spectral Reflectance Graph
CIELab: L* = 19.03, a* = 26.08, b* = 0.73, C = 26.09, h = 1.6°
OBA Index 0.0
FI 0.0
0.07 @ 610nm

CC Sphere SPIN — Magenta #296, 2023-11-12 18:15:56
Spectral Reflectance Graph
CIELab: L* = 54.46, a* = 57.06, b* = 4.50, C = 57.24, h = 4.5°
OBA Index -
FI -
0.69 @ 680nm

CC Spere SPEX — Magenta #296, 2023-11-12 18:15:56
Spectral Reflectance Graph
CIELab: L* = 27.84, a* = 37.70, b* = 1.60, C = 37.74, h = 2.4°
OBA Index -
FI -
0.16 @ 670nm

Yellow (16/11)

X-Rite i1Pro 3 — Yellow – col. 11 row 16, 2023-11-12 18:00:38
Spectral Reflectance Graph
CIELab: L* = 35.82, a* = -22.55, b* = 23.84, C = 32.82, h = 133.4°
OBA Index 0.0
FI 0.0
0.14 @ 500nm

CC Sphere SPIN — Limone #298, 2023-11-12 18:16:43
Spectral Reflectance Graph
CIELab: L* = 90.11, a* = -10.42, b* = 73.51, C = 74.25, h = 98.1°
OBA Index -
FI -
0.83 @ 650nm

CC Spere SPEX — Limone #298, 2023-11-12 18:16:43
Spectral Reflectance Graph
CIELab: L* = 51.17, a* = -15.40, b* = 41.83, C = 44.57, h = 110.2°
OBA Index -
FI -
0.22 @ 510nm

ChromaChecker

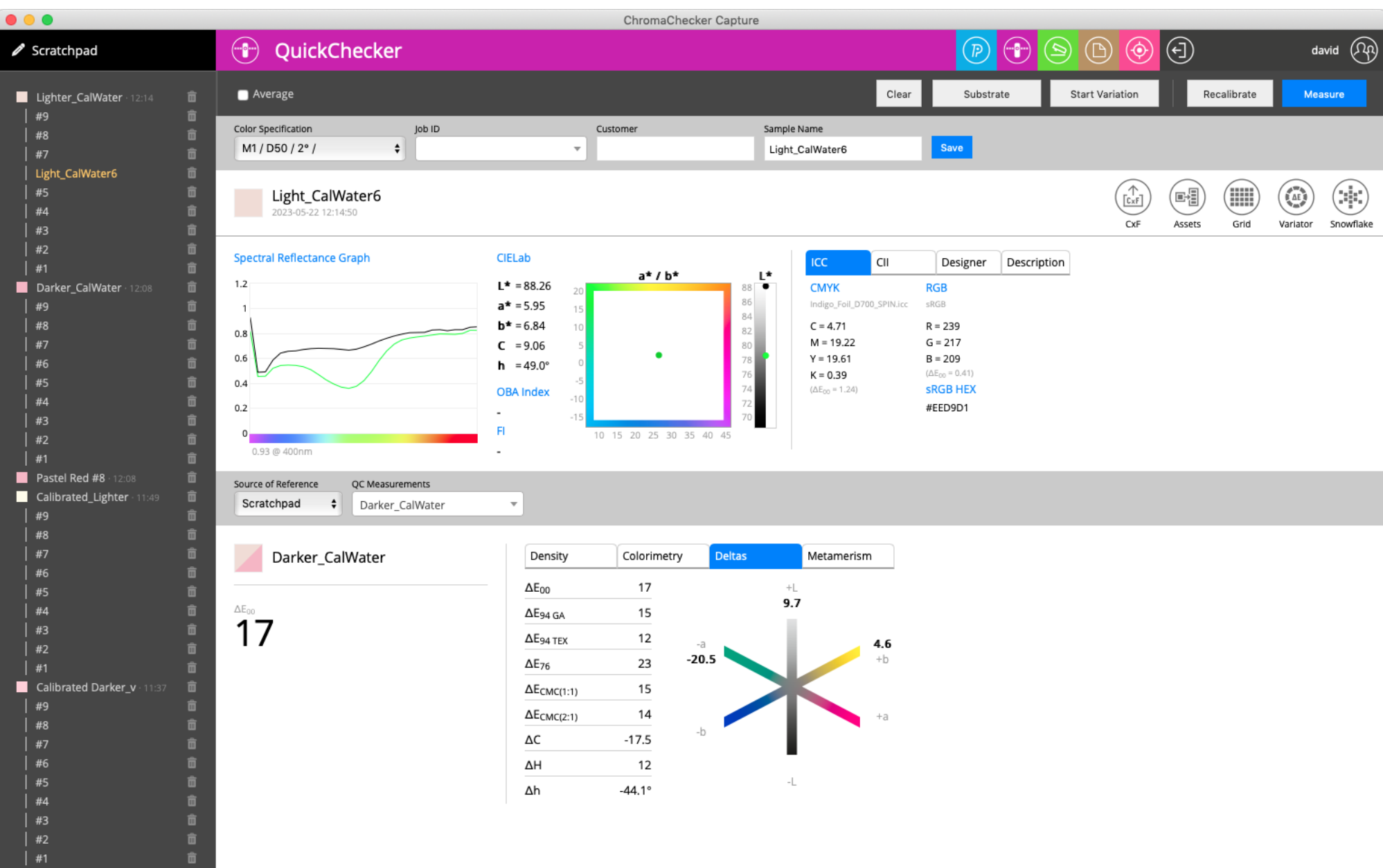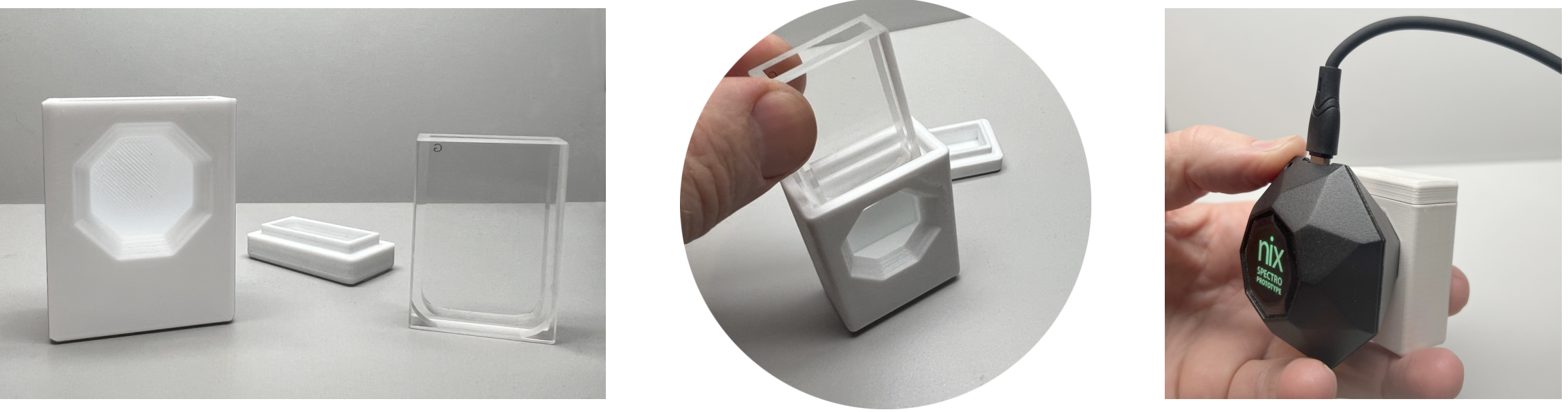COLOR CONFORMANCE CONFERENCE '25

Measurments of liquids.

What if you need to measure color of liquid?

Nix offers a dedicated adapter that enables liquid measurements.
This is unique **custom geometry 45°/180°**

Instrument require a custom calibration
on the cuvette filled with fresh water!

This is way to control unusual white point!

Nano Instrument

Unique Instrument: Measures Texture/Appearance

- It is not a Spectrophotometer, but a Camera with Colorimeter
- Color Match for Average and Dominant Color:
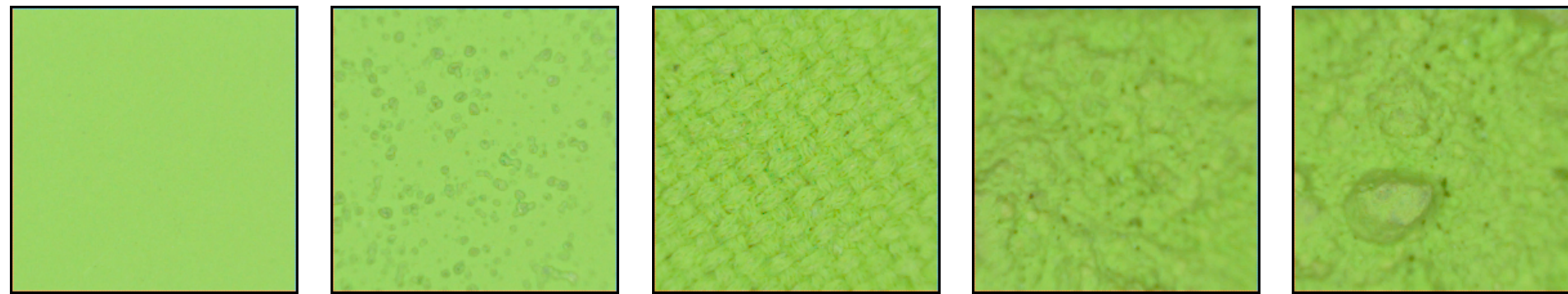
- Surface Match for texture/pattern:
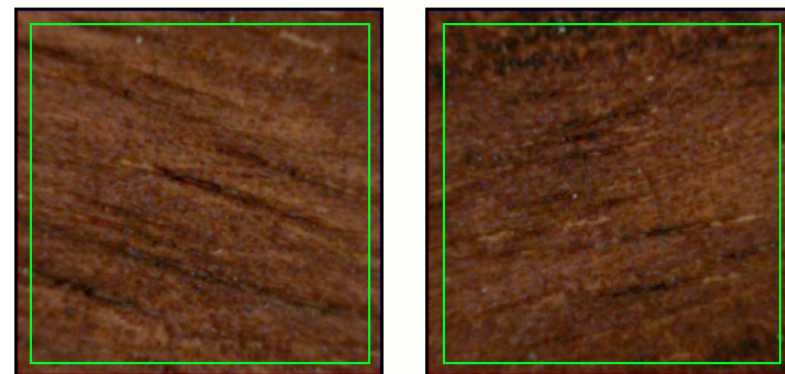
Wood 85%   **Marble 89%**   **Textile 92%**   **Aluminum 82%**

- Uniformity of patch values

U=0.6   **U=3.0**   **U=6.0**   **U=7.7**   **U=11.2**   **U=13.2**

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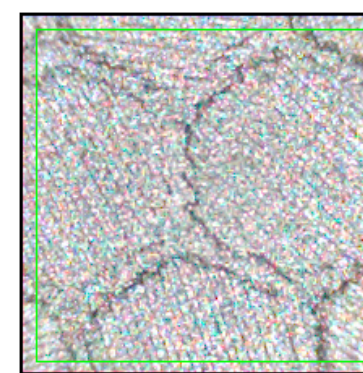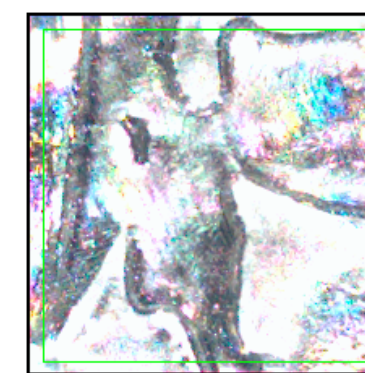
Summary

- In most non-standard cases, there is no single objective method or single reference instrument.

- There are no ideal standards of any color.

- There is no single ideal measurement.
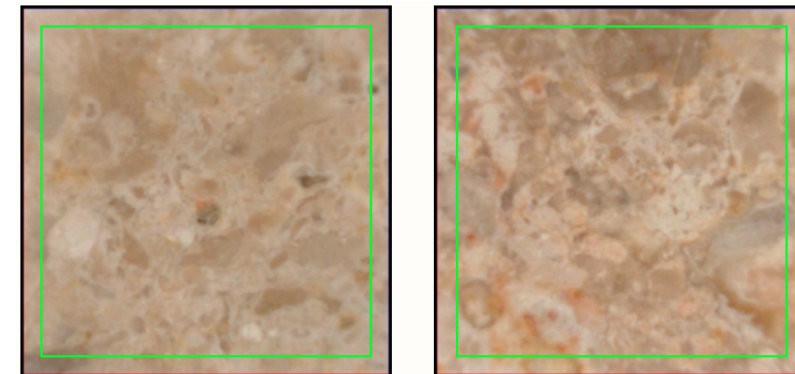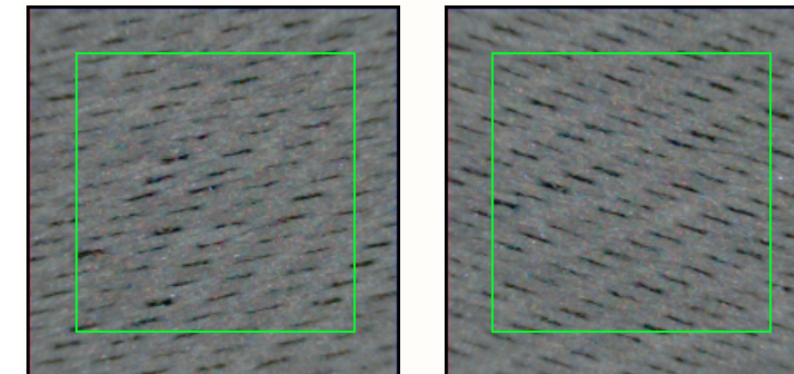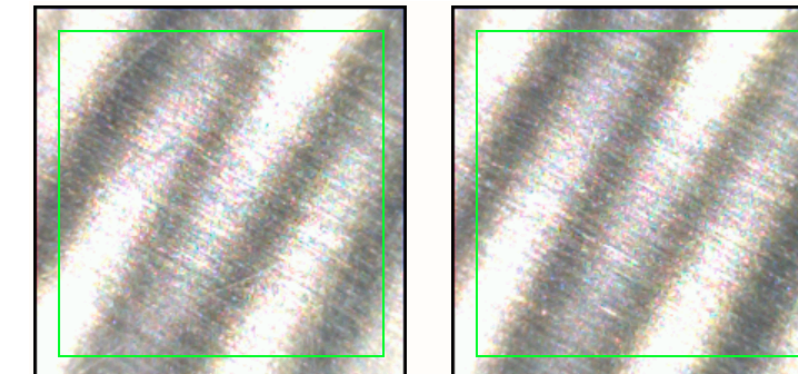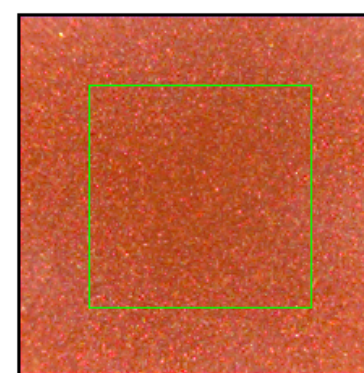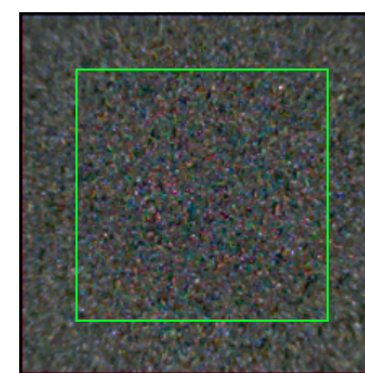
- In most non-standard cases we cannot exchange data from other instruments

- Today, measurement results are modified by manufacturers with machine learning programs imitating others with a strong position on the market.

- The correlation is always only partial, and many areas are not correlated (fluorescence, for example)

- If we want to measure to check compliance with the standard - with simple tests we can find such an instrument and its settings, which will describe in numbers what eliminates a good product from a bad one.

- The color itself does not describe the standard precisely - gloss, and special effects must complement the definition for its completeness.

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Solution

- Measure good and bad examples - those that are marketable and those that are not - using different methods and instruments.

- Find out which type of measurement works best with visual assessment

- Make your own standard specifically for this instrument/settings and evaluate the numerical values, not the color on the computer screen

- QuickChecker will allow you to make such an assessment very quickly.

- The instrument does not have to provide absolute values - if it detects anomalies in the relative mode then the goal is achieved.

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Conclusion

- Learning about objects through experiments with instruments and their settings opens the way to simple, effective solutions that do not have to involve large investments in expensive instruments.

- Science is supposed to help - for scientists it is a goal in itself, but in industry practical solutions count.

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Resources – Thank You

Helpful links

- PDF version of this presentation

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