From Mimesis to Biomimetics: Towards "Smarter" Art

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Located at the interface of art and science, and drawing on relevant findings from material science, optical physics and evolutionary biology, this paper argues that the scientific field of **biomimetics** has the potential to lead to, and enable, ‘smarter’ art. It is argued that the origin of **biomimetics** can be traced back to the ancient artistic concept of **mimesis.** And that therefore many illuminating analogies can be drawn between the two concepts.

Prelude

What colour is this dress?

Or

The conundrum of representation

What color is that dress?

It's about an overexposed photograph of a dress, whose colors were as chameleon-like as the perceptions of its viewers. Is it gold and white? Was it black and blue?

A passionate debate exploded around the world with tens of millions of social media posts, in part fueled by A-list celebrities.

http://www.norwalkreflector.com/article/6502576

What color is that butterfly?

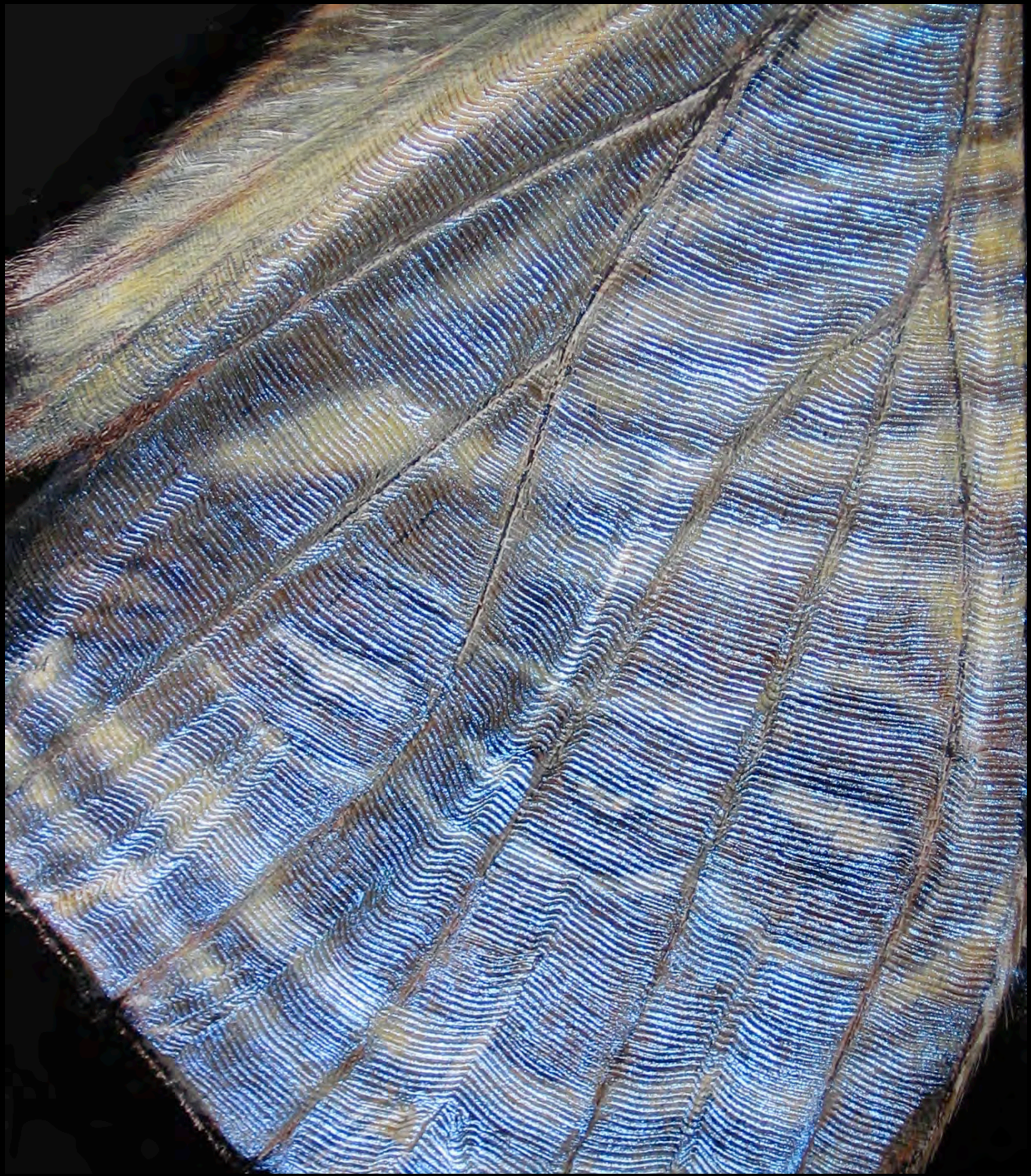
"Any account of colour in art must begin with the belief, which dominated Western culture for centuries, … that colours are of two distinct types:

- those that are stable attributes of material substances,

- and those, that are 'accidental', such as the evanescent colours of the rainbow and the colours of some birds' feathers, which change according to the viewpoint of the spectator."

Gage: Colour in Art, 2006

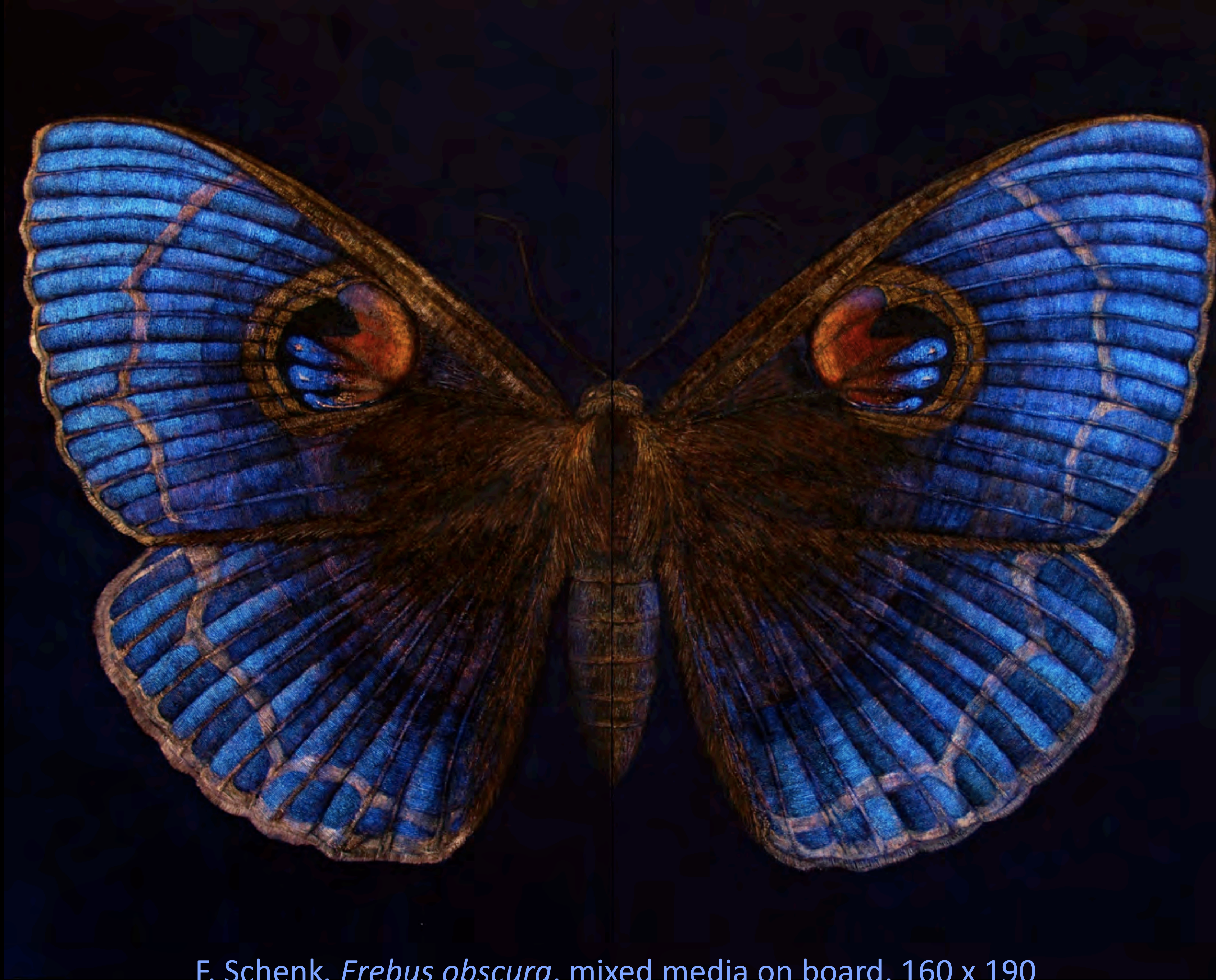
What color is this?



How to mimic nature in art?

The allegory of the butterfly:

Still life painting



F. Schenk, *Erebus obscura*, mixed media on board, 160 x 190

Adriaen Coorte
Still life with hanging bunch of grapes, two medlars and a butterfly
1687
33cm x 26,5cm

Still Life - (nature morte)

A still life is a work of art depicting mostly inanimate subject matter, typically commonplace objects which may be either natural (food, flowers, dead animals, plants, rocks, or shells) or man-made (e.g. vases, jewelry, coins) to contemplate the transitory nature of life.

Still Life - (nature morte)

Roman Xenia


Blue Art Photo

Mimesis

Mimesis (Anceint Greek: μίμησις (*mīmēsis*), from μιμεῖσθαι (*mīmeisthai*), "to imitate," from μῖμος (*mimos*), "imitator, actor") is a critical and philosophical term that carries a wide range of meanings, which include imitation, representation, mimicry.

The Great Leveler, Mosaic from Pompeii (House cum workshop I, 5, 2, triclinium).
30 BCE — 14 CE. Naples, National Archaeological Museum

Roman mosaic representing the Wheel of Fortune which, as it turns, can make the rich (symbolized by the purple cloth on the left) poor and the poor (symbolized by the goatskin at right) rich; in effect both states are very precarious, with death never far and life hanging by a thread: when it breaks, the soul (symbolized by the butterfly) flies off. And thus are all made equal.

"Sandwiched between skull and wheel is a butterfly with apparently iridescent wings patterned with blobs of blue and half-moons of yellow and white. Again the artist appears to have drawn his inspiration from a real butterfly; it seems to be his best shot at reproducing the pattern and purple iridescence of the Lesser Purple Emperor." (Marren, p. 159)

Apatura

Lesser Purple Emperor, *Apatura ilia* (Marren 2015, p. 159).

Fabricius, the Danish entomologist who named the species in the 18th century, apparently made up Apatura based on the Greek apatao, meaning to deceive. Possibly attempting a learned joke by hinting at, and employing, deception.

(Marren, 2015, pp. 140-141)

Arguably, it may be precisely this dual quality of alternately concealing and revealing the underlying darkness of things that makes the Emperor most pertinent to use as a symbol within the momento mori genre.

“Painted in colours more impressive than any robes’, they [butterflies] ‘pulled down’ sinful pride, whilst in the shortness of their lives they taught us to be mindful of our own failing condition. Butterflies both chide and warn.”

(Moffet, 1553-1604, pp. 974-5)

How to mimic butterfly blue/purple with chemical pigments?

Adriaen Coorte
Still life with hanging bunch of grapes, two medlars and a butterfly
1687
33cm x 26,5cm

Elias van den Broeck, Still Life with a Snake 1695

Karl Wilhelm de Hamilton, 1739, Forest Floor Still Life)

Alexander James, Distil Ennui Studio Vanitas, ‘The Great Leveler’, 2011, C-print mounted on polished aluminium

Alexander James, Distil Ennui Studio Vanitas, 2011, C-print mounted on polished aluminium

Blue Morpho, (1865),
Martin Johnson Heade

Sibylla Merian,
1647-1717

High Art or
Scientific Illustration?

How to mimic structural color in art?

- How to bring art to life?
- How to bring life to art?

The Blue Jewel

THE MORPHO

Klots: Living Insects of the World (1959):

"like jewels, the flashing blue of their wings is plainly visible from several hundred feet

… living color that changes with every tiny shift of the light or angle of view."

… almost three-dimensional colors "

Simon: The Splendor of Iridescence (1971):

"… the blue colour is, in the truest sense of the word, superficial, that is, a result of surface structure only.

… the living colour resides in scales consisting of "dead" tissues that do not change."

Iridescent colour glows for millions of years

Biomimetics –
towards "smarter" art

Biomimetic refers to human-made processes, substances, devices, or systems that imitate nature. The science of designing and building biomimetic apparatus is called biomimetics, and is of special interest to researchers in nanotechnology, robotics, artificial intelligence (AI), the medical industry, and the military.

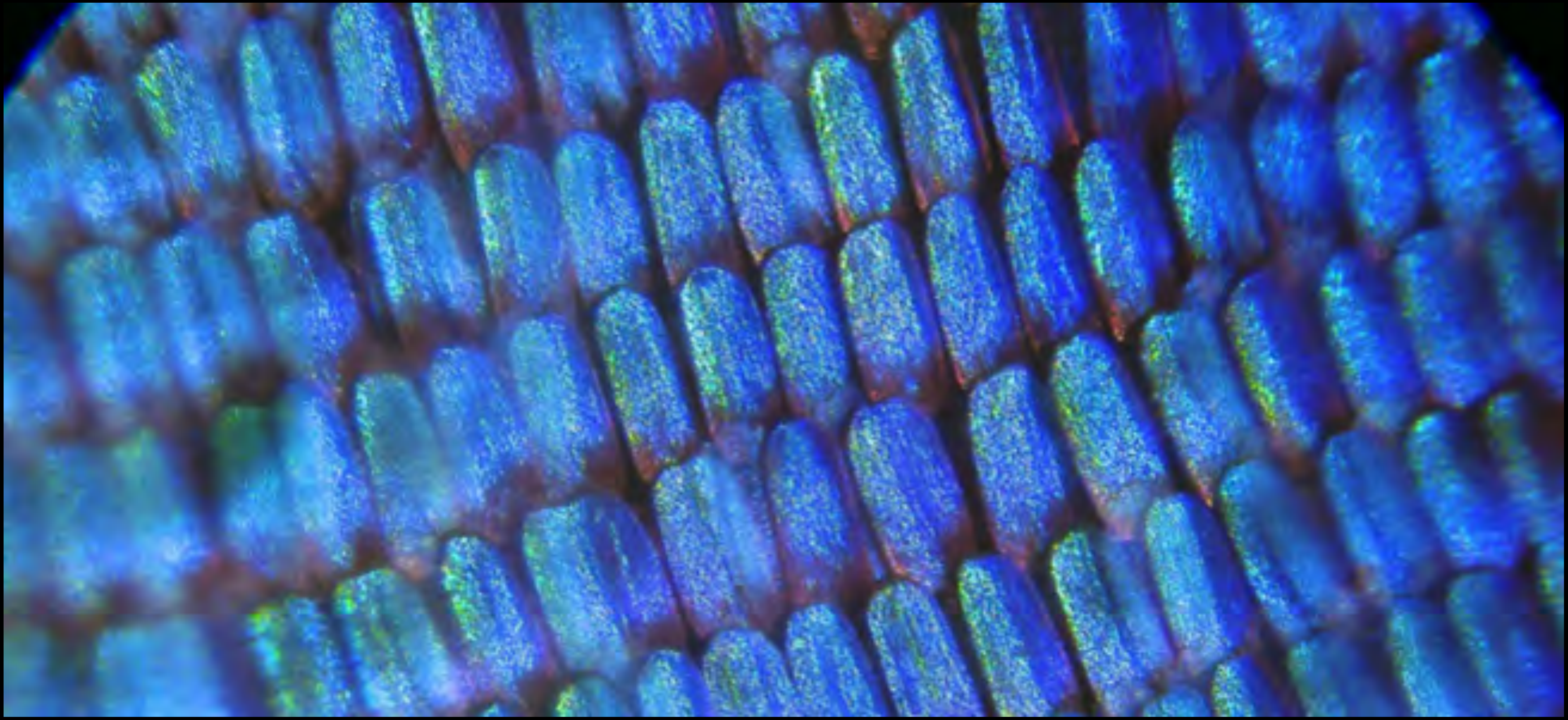
But can biomimetic methodology also innovate art?

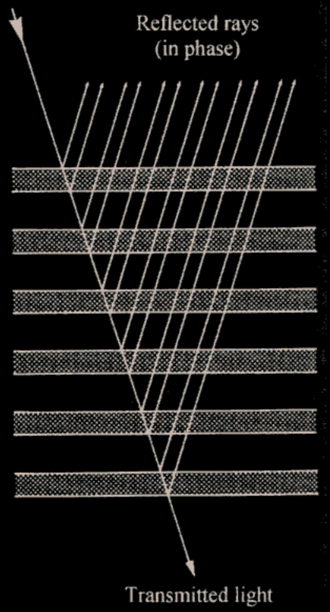
Aristotle

Aristotle defined artistic Mimesis as ‘imitation of nature’ both via …

- form and
- material

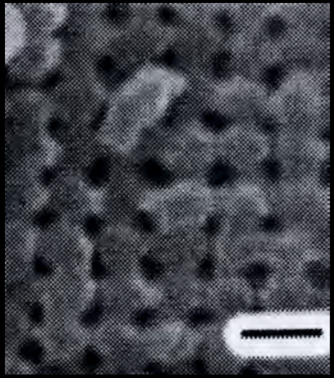
Butterfly scales

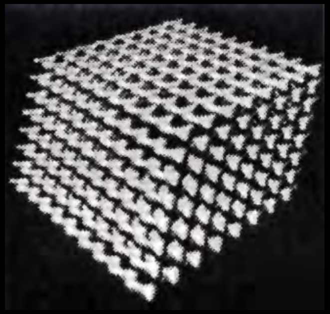




Multilayer reflectors

- alternating layers of materials each with a different refractive index
- ‘simple’ optics
- constructive interference
- each light wave is scattered only once within structure





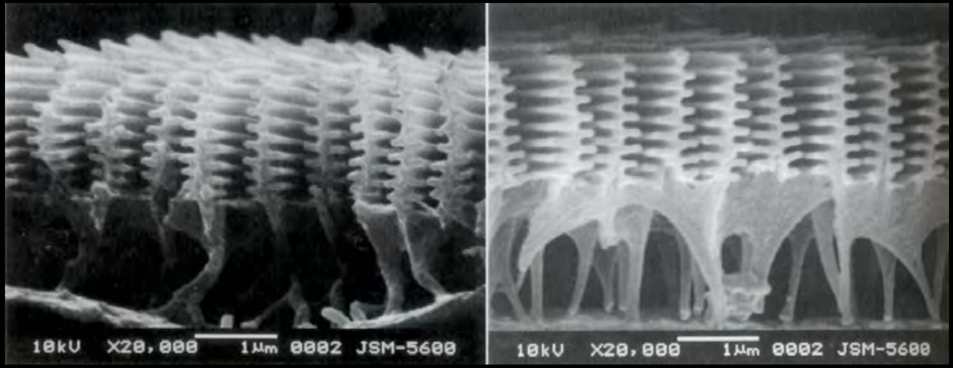
Photonic crystals

- ordered 2D and 3D lattices
-‘complex’ optics (quantum optics/photonics)
- each light wave is scattered more than once
- all the probabilities for wave paths need to be considered
- large computers are required for the calculations

In Pursuit of *Morpho* blue

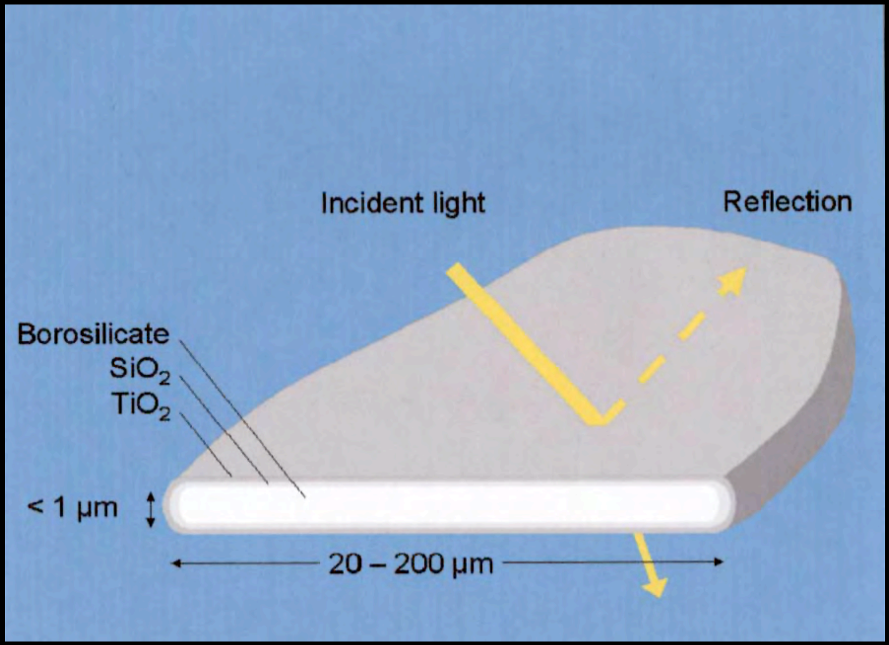
S. Kinoshita and S. Yoshioka:

M. didius M. sulkowskyi



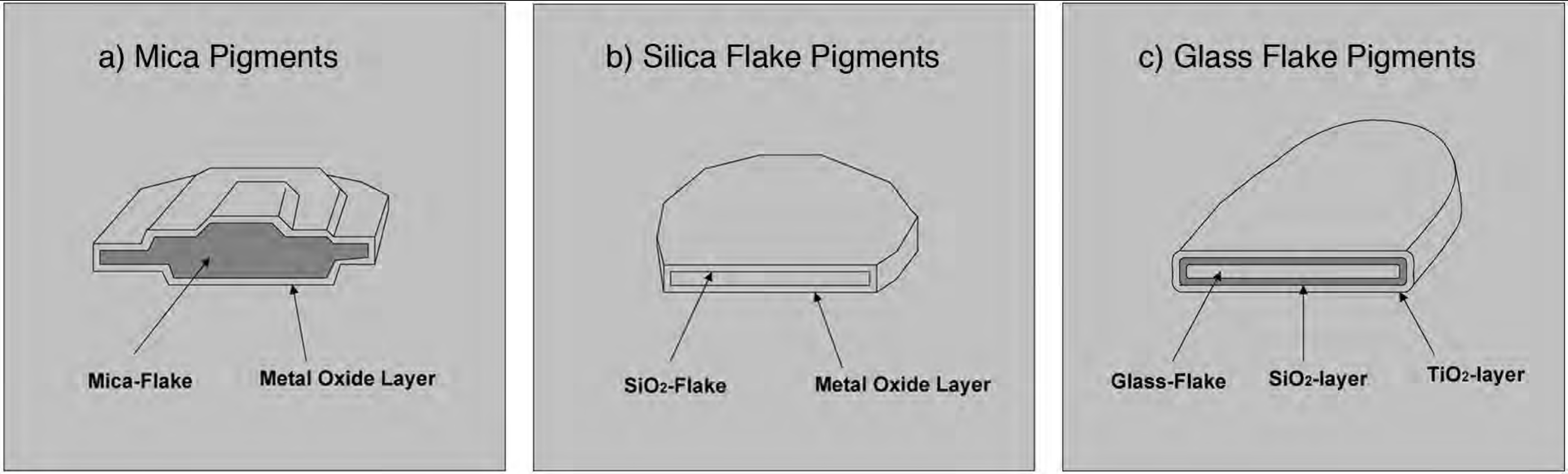
Ground scales of M. didius and M. sulkowskyi

Glass Flake Pigment



- Launched in 2004
- High transparency and gloss
- Pure, intense interference colour
- Smooth surface and rounded edges

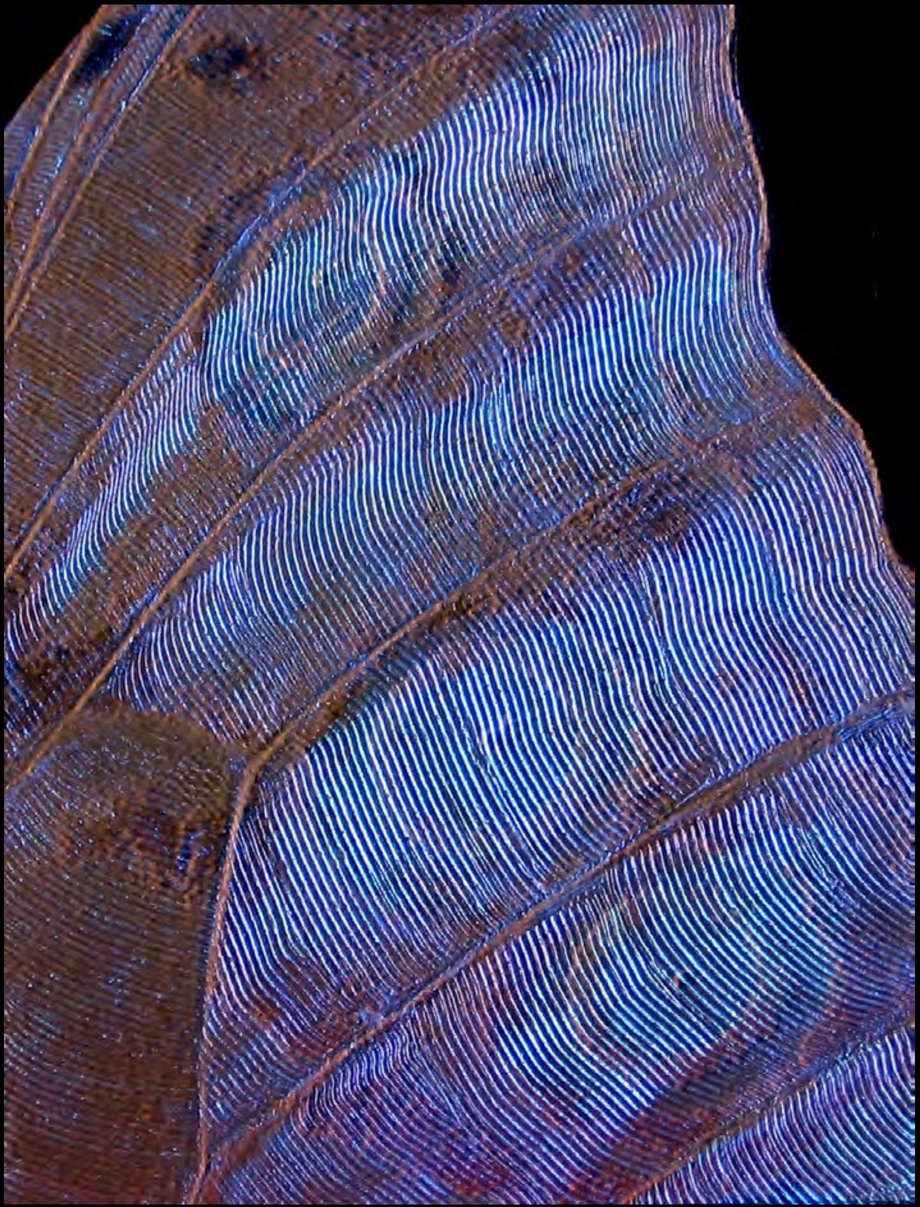
Special Effect Pigments



This innovative bio-mimetic colour-technology has the potential to, via novel colour-shift, introduce ‘the dynamic’ into painting - historically a decidedly static medium. Until now, iridescent hues such as those found on the wings of certain butterflies have never been encountered in the art world.

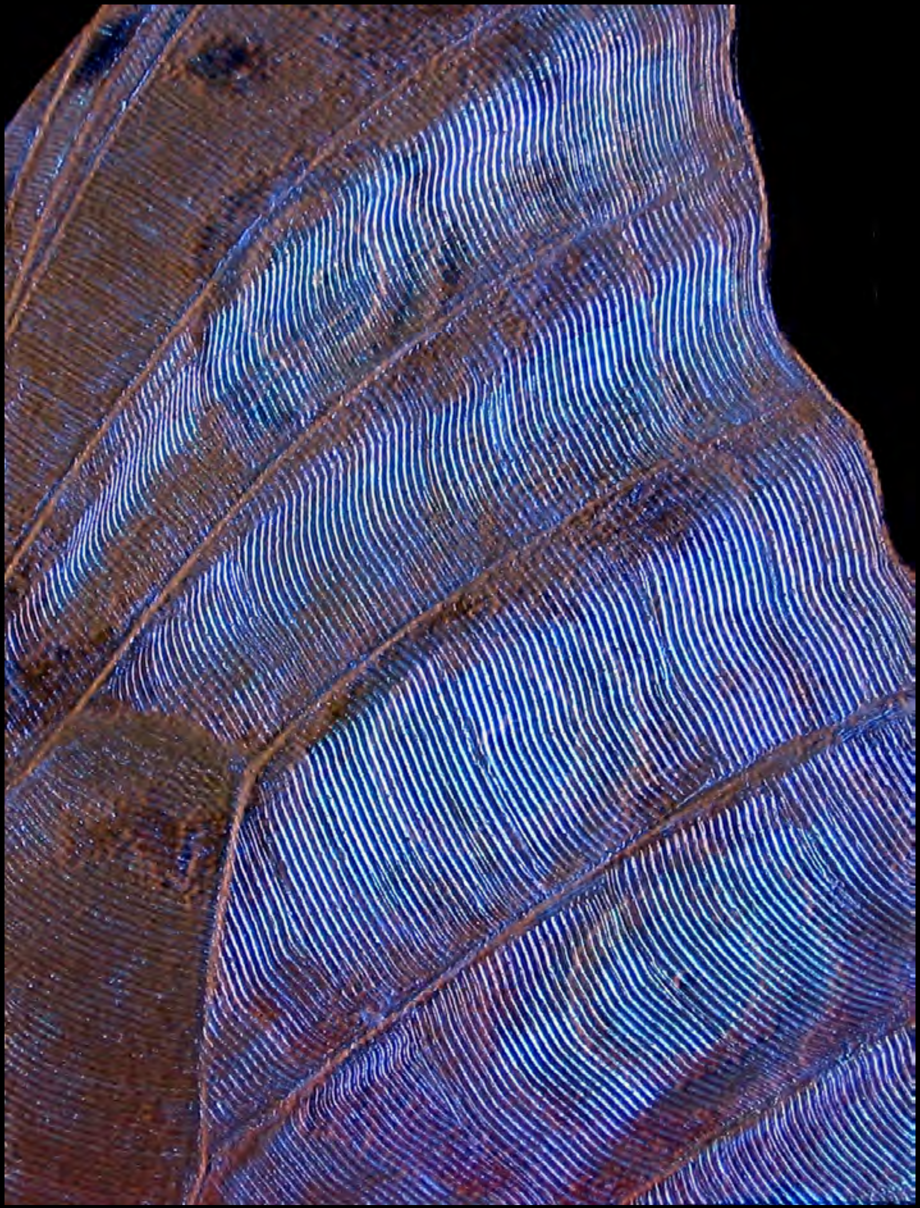
Photo of Morpho wing section

Morphp Painting I, iridescent paint on board, A4, 2007



Morpho Painting II, iridescent paint on board, A4, 2007

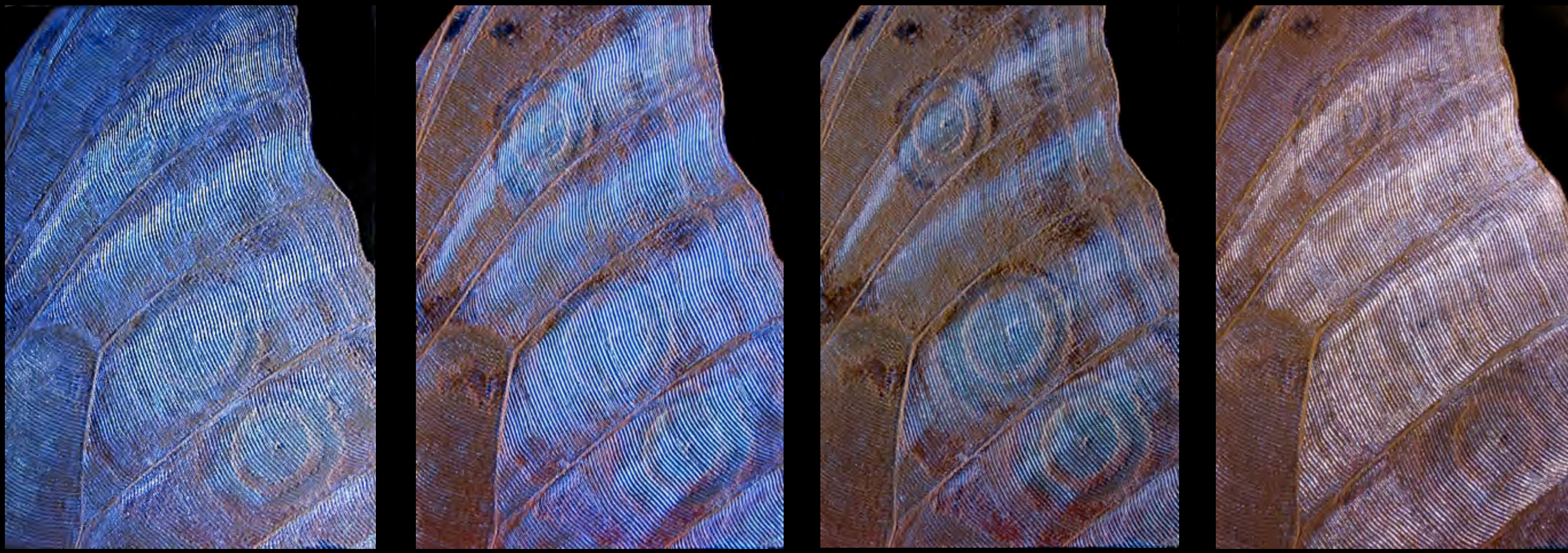
The same painting lit from a different angle

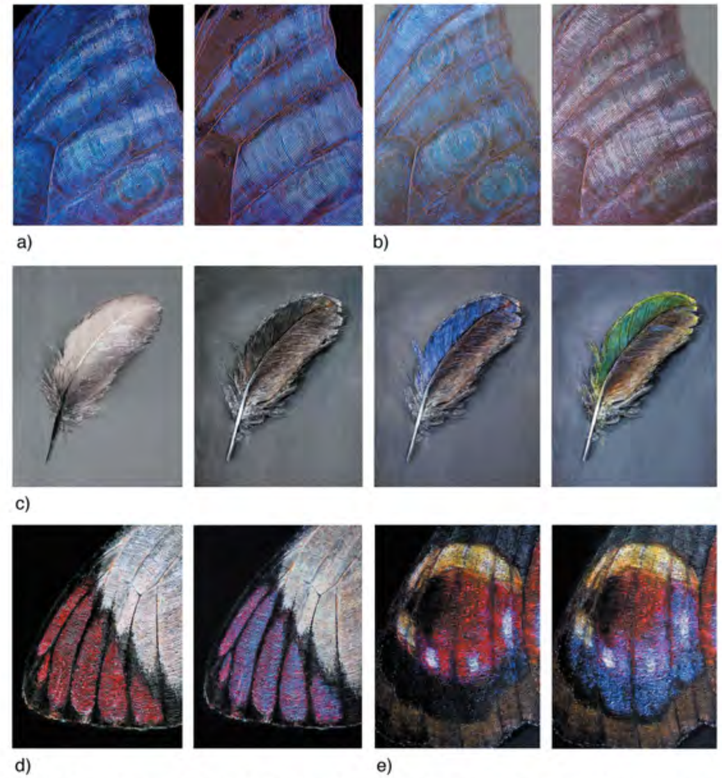


Morpho Painting II, iridescent paint on board, A4, 2007

The same painting lit from a different angle

Morpho rhetenor



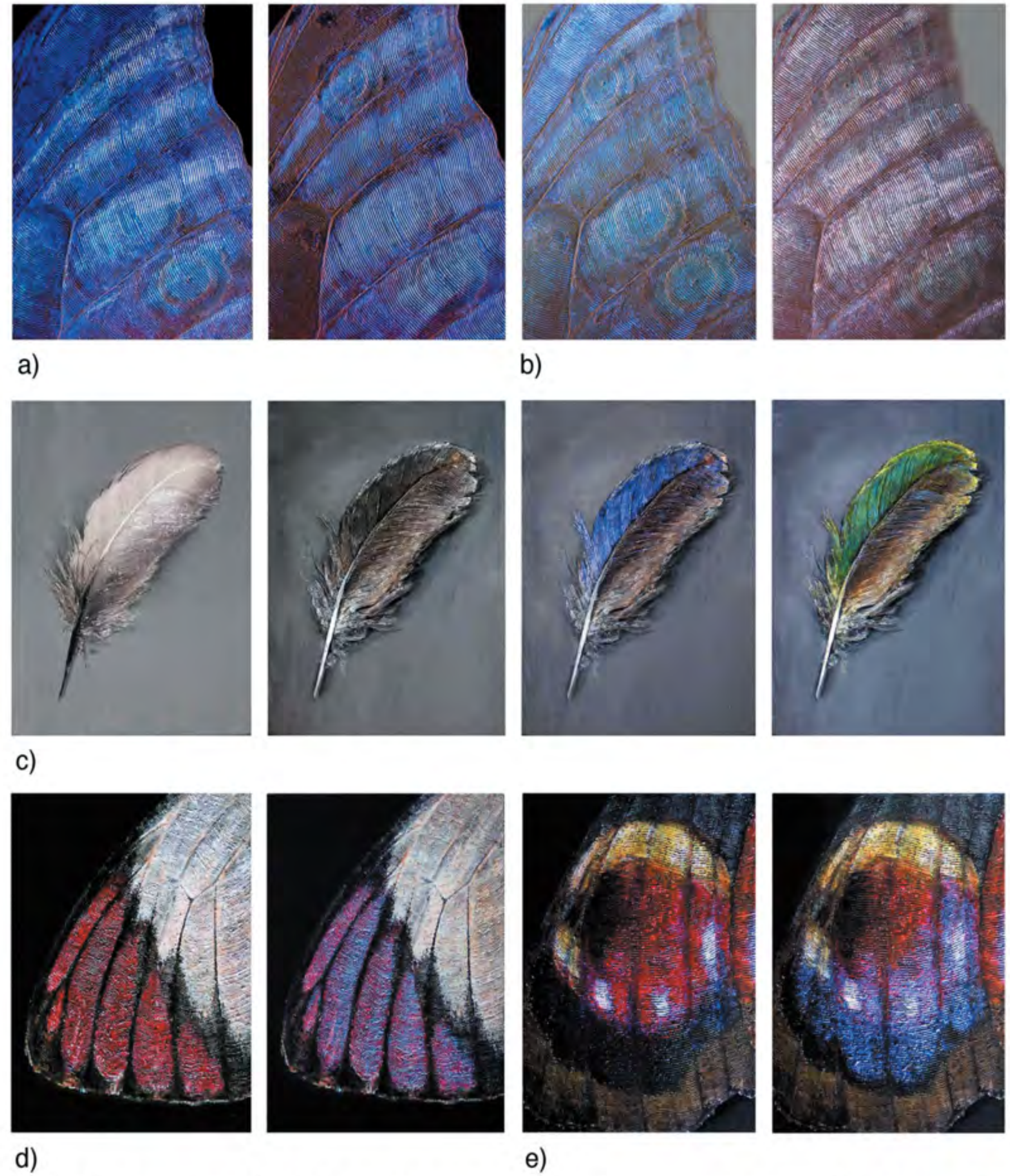


Franziska Schenk, paintings, A4 size, 2008–2009. Different stages of the painting process are represented. (a) Morpho didius: A dark ground is overlaid with interference blue, giving rise to metallic hues. (b) Morpho sulkowskyi: On a lighter ground the same blue generates two-color opalescence. (c) Poicephalus senegalus: A brown base is covered with interference blue which, in turn, is overlaid with a chemical yellow to arrive at green. (d) Colotis regina: Red pigment is overlaid with interference blue to generate purple. (e) Inachis io: Interference blue on red creates purple; on black a vivid blue results. (© F. Schenk)

Iridescent color: From nature to the painter’s palette, Leonardo, 2011

Interaction between chemical pigments and structural color

In collaboration with
Andrew Parker, Natural
History Museum, London



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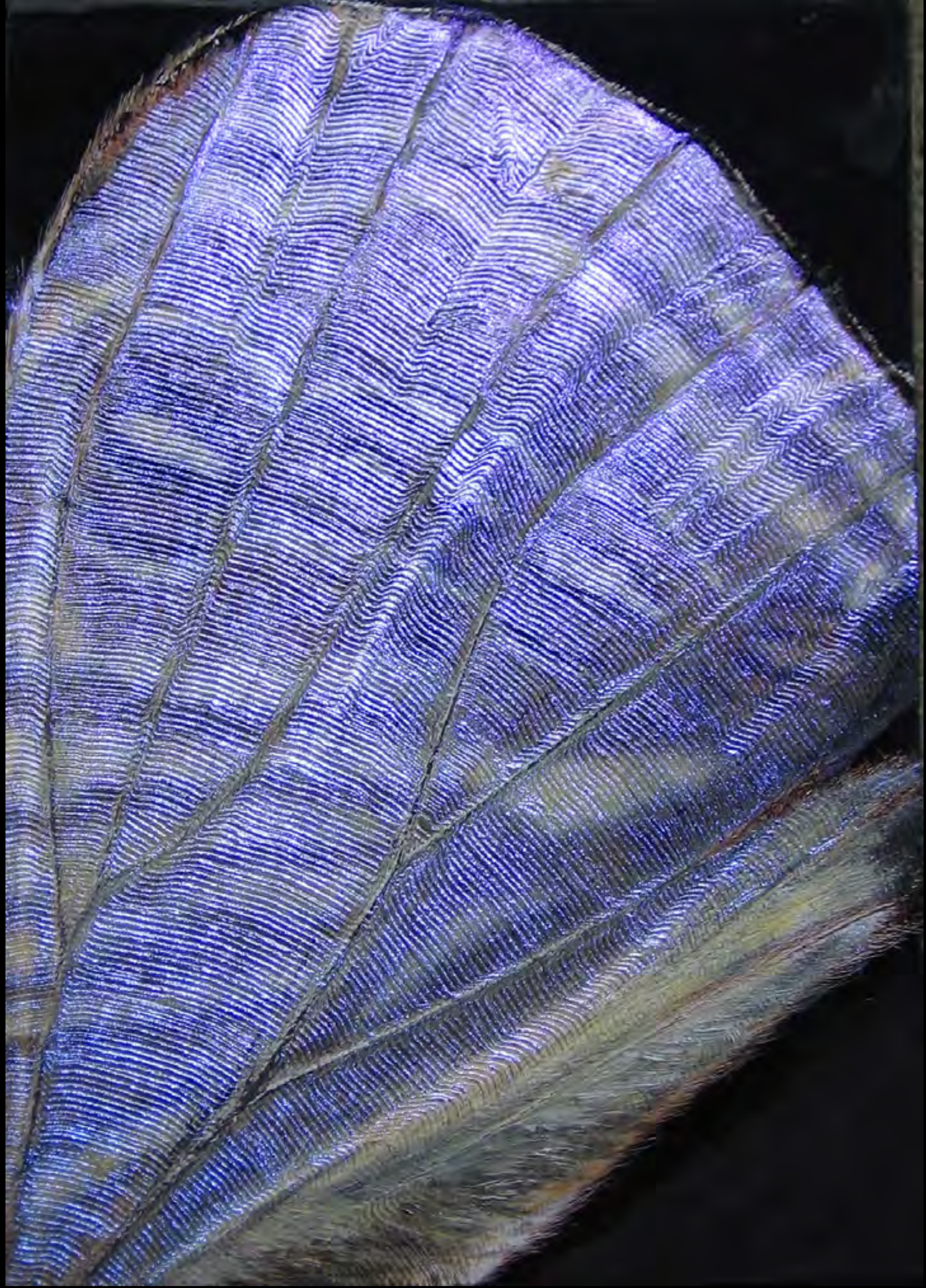
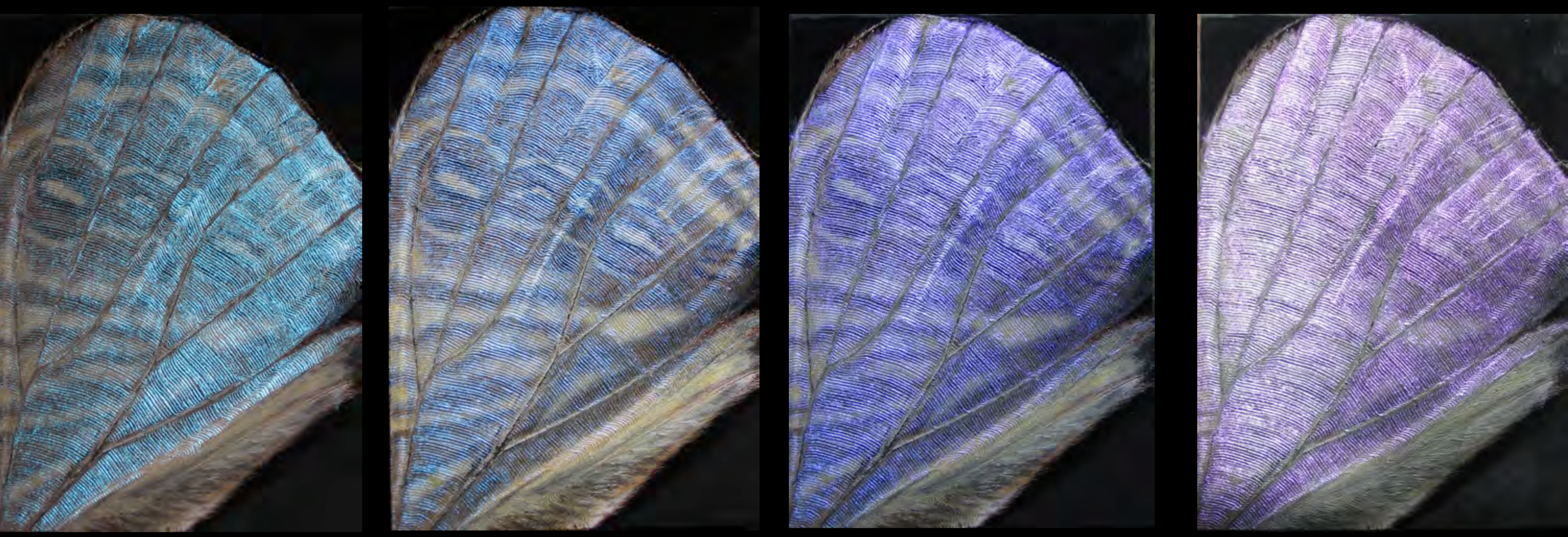
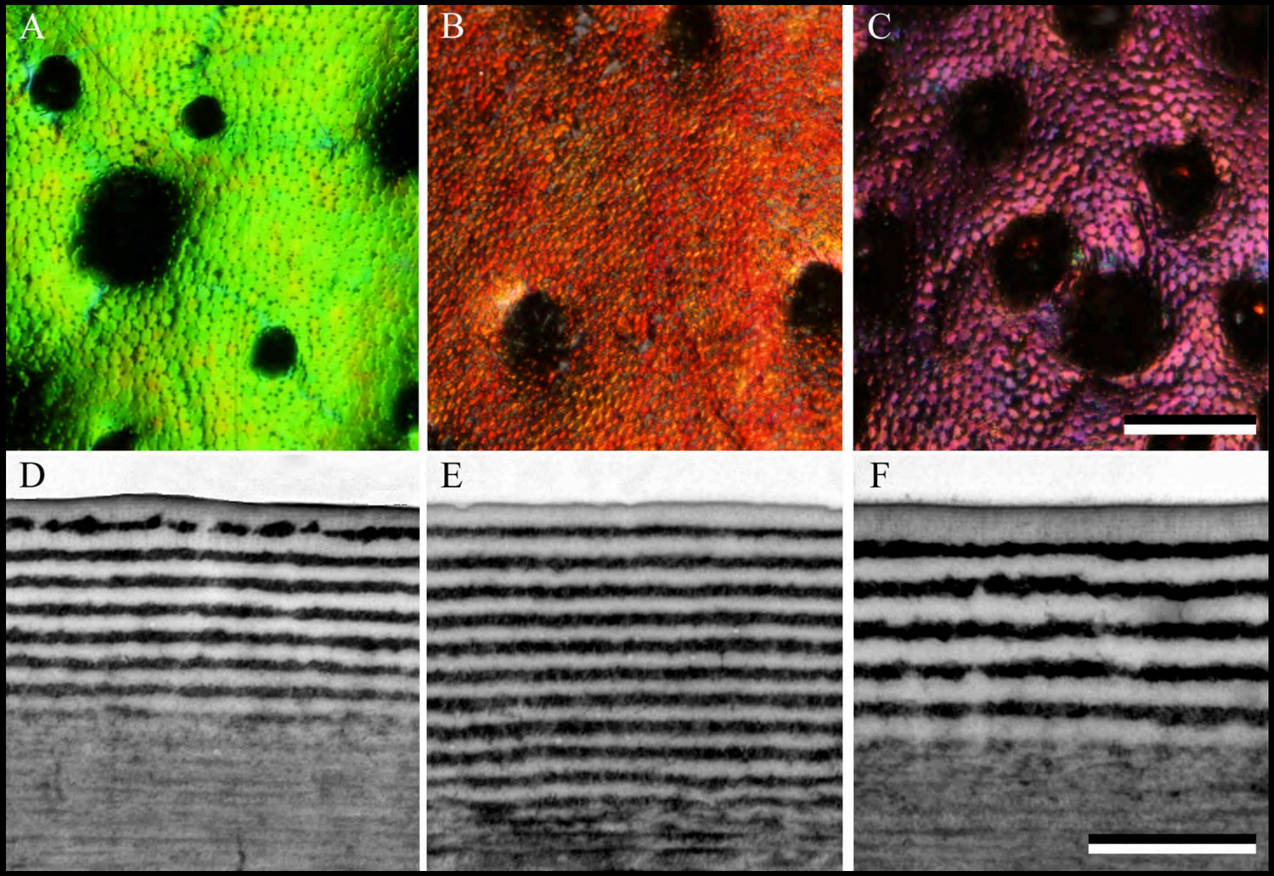



Morpho sulkowskyi

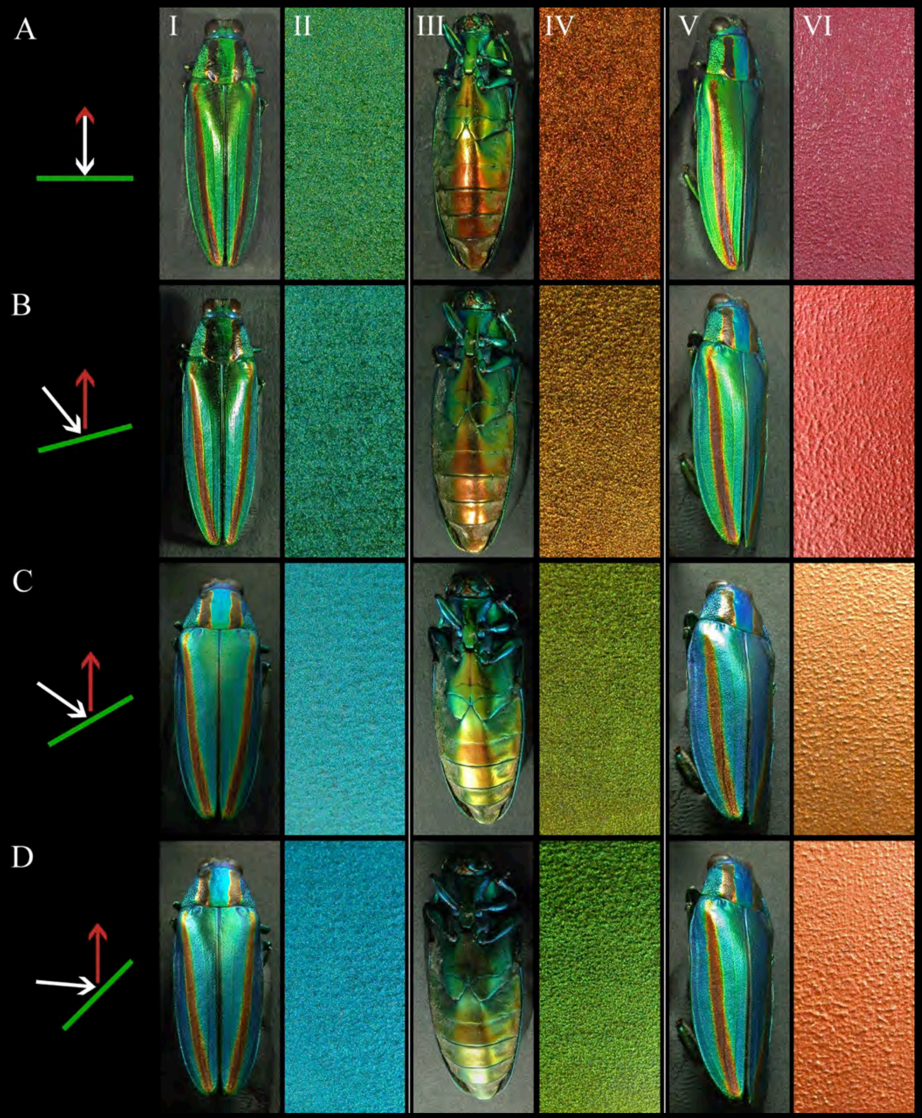


The Japanese jewel beetle: a painter's challenge

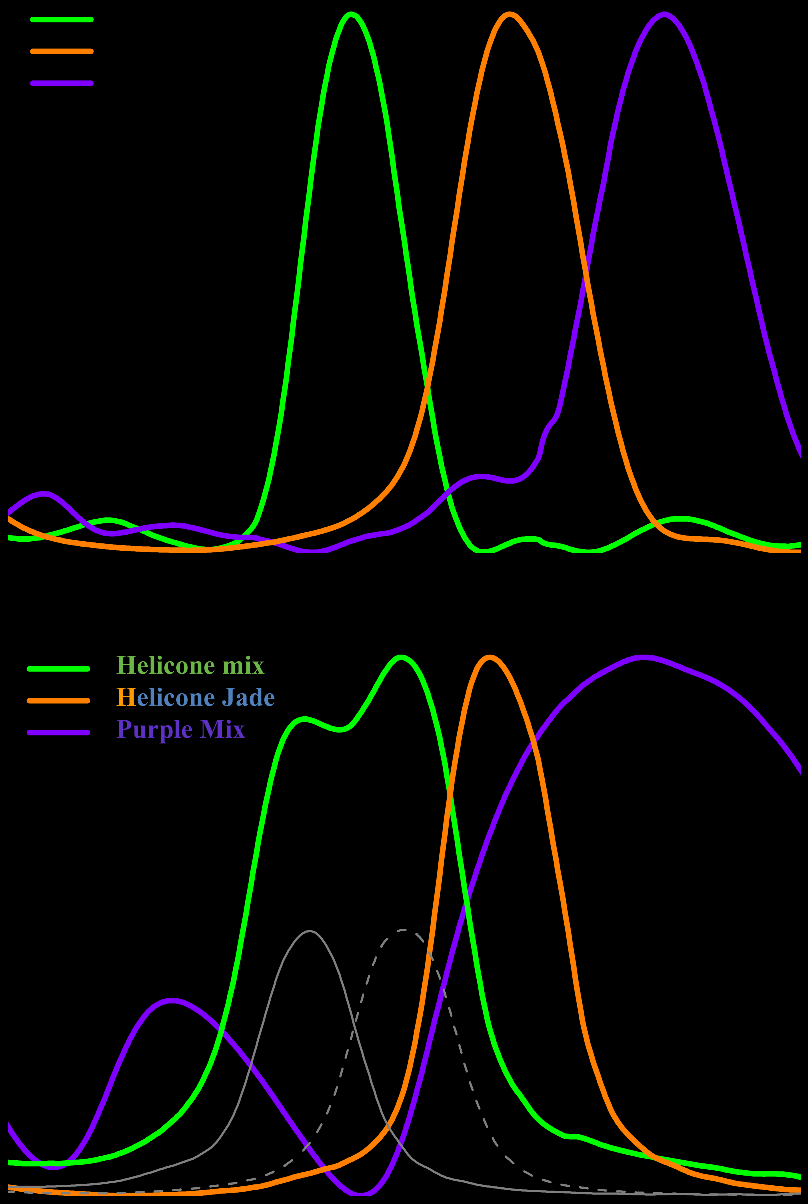
Published in: *Bioinspiration Biomimetics* and *Zetesis* (Nov 13)



Photographs and transmission electron microscopy (TEM) images of the cuticular surface of the Japanese Jewel Beetle, *Chrysochroa fulgidissima*. **A** Green part of the elytron. **B** Orange ventral area. **C** Purple stripe of the elytron; bar: 100 µm. **D**-**F** Transversal TEM sections of the cuticle of the three cases of **A**-**C**, showing the multi-layered structure; bar: 1 µm.



The three colour cases of the Jewel Beetle, the green part of the elytra (column I), the orange underside (column III) and the purple stripes of the elytra (column V), together with the mimicking effect paints (columns II, IV, VI) illuminated from various angles and observed from the mirror angle. From row **A** to row **D** the angle of light incidence increased in steps of about 10º. The animal and the colour samples were rotated around an axis perpendicular to the longitudinal (viewing) axis.



Normalized reflectance spectra with perpendicular illumination of the Japanese Jewel Beetle and effect paint. **A** The reflectance spectra of the green part of the elytra, the orange underside and the purple stripes of the elytra of the jewel beetle. **B** The spectra of the effect paints used in mimicking the beetle colours. The grey curves represent the reflectance spectra of the two components that together make up the green Helicone® mix spectrum.

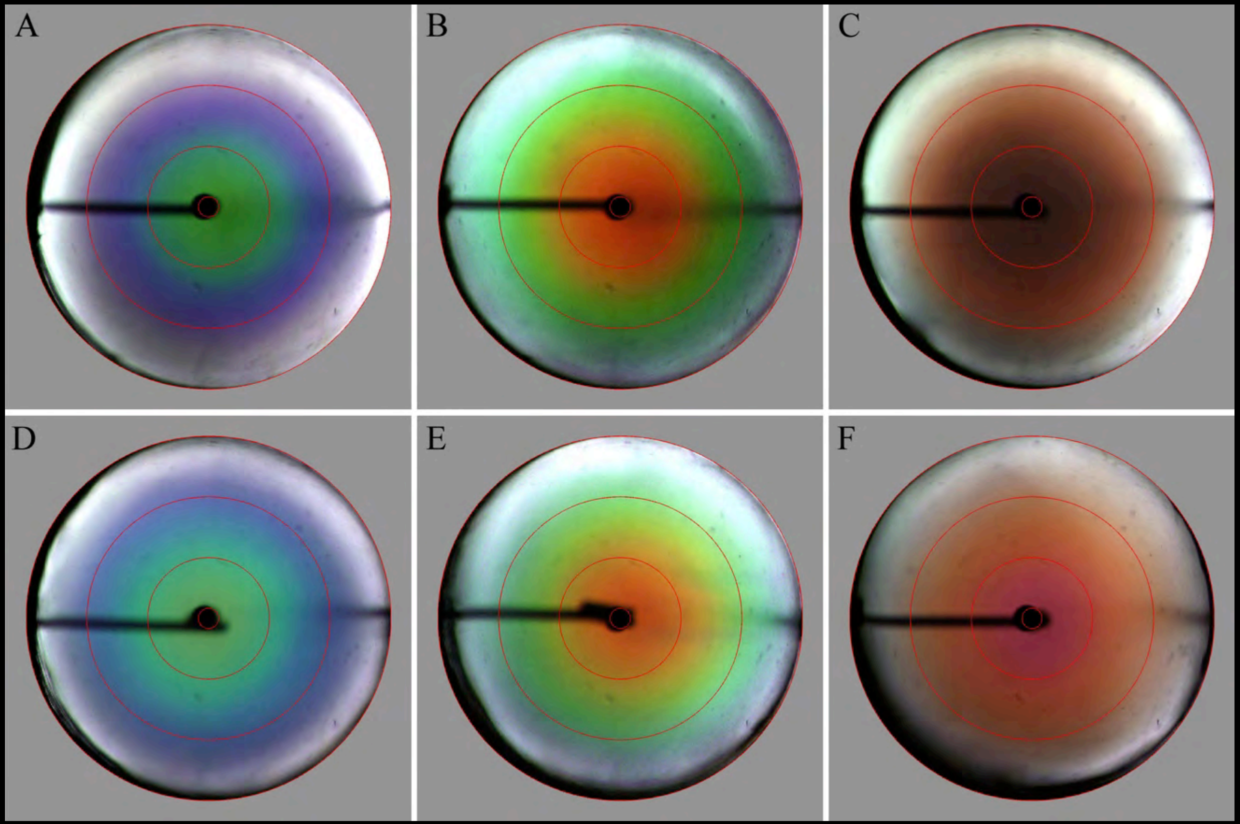
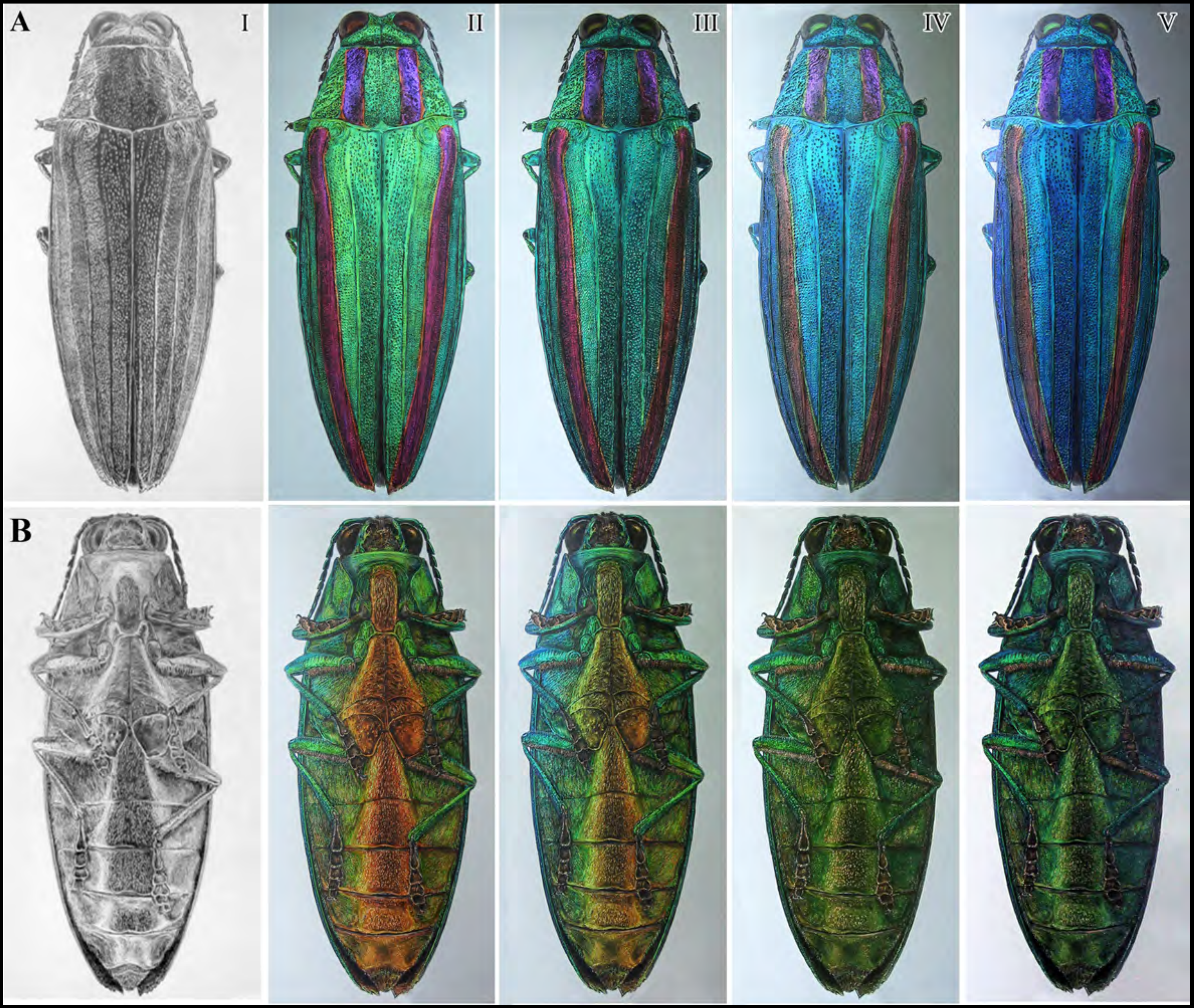


Figure 4. Scatterograms of the Japanese Jewel Beetle and effect paints. **A** Scatterograms of the green part of the elytra. **B** The orange underside. **C** The purple stripes of the elytra. **D-F** Scatterograms of the effect paints mimicking the three beetle cases. The red circles indicate angular reflection directions of 5º, 30º, 60º, and 90º. The black bars at 9 o'clock are due to a glass pipette holding a piece of cuticle (**A-C**) or a piece of effect paint (**D-F**). The central black circle is due to a small central hole in the scatterometer's ellipsoidal mirror (for details of the method of imaging scatterometry, see Stavenga *et al.* 2009, 2011).



A
I
II
III
IV
V
B

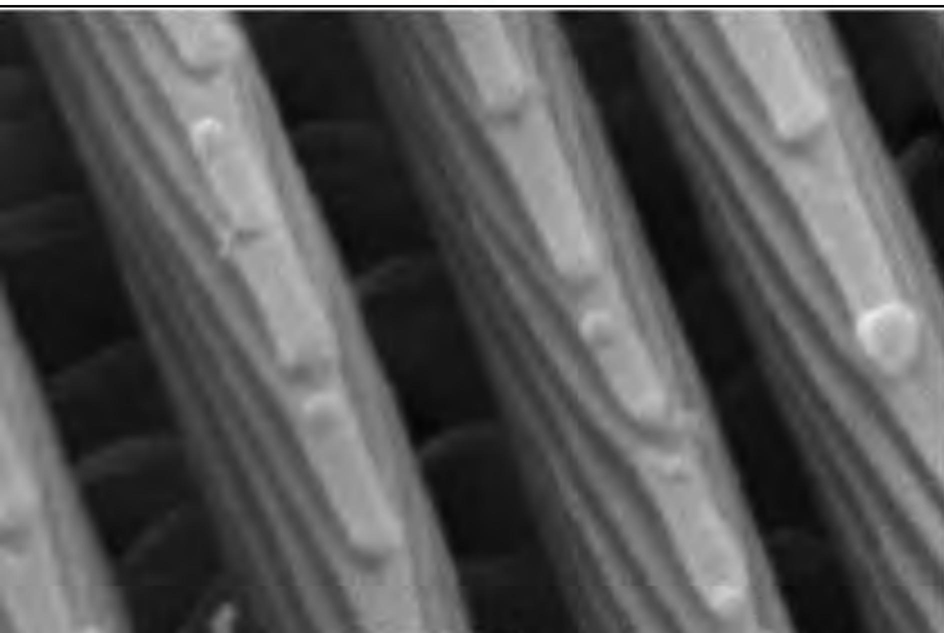
Apatura

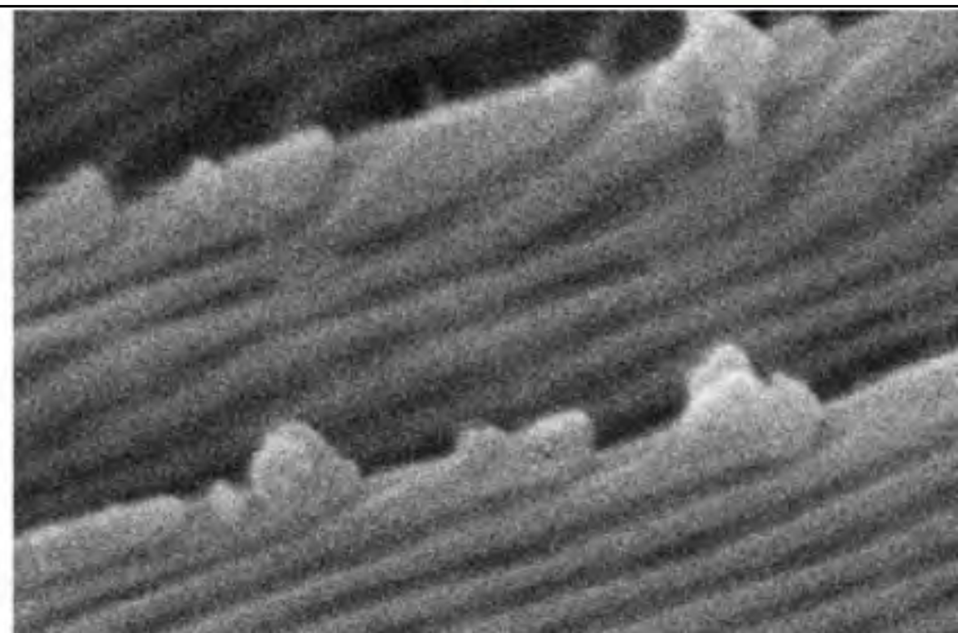
Now you see it, now you don’t

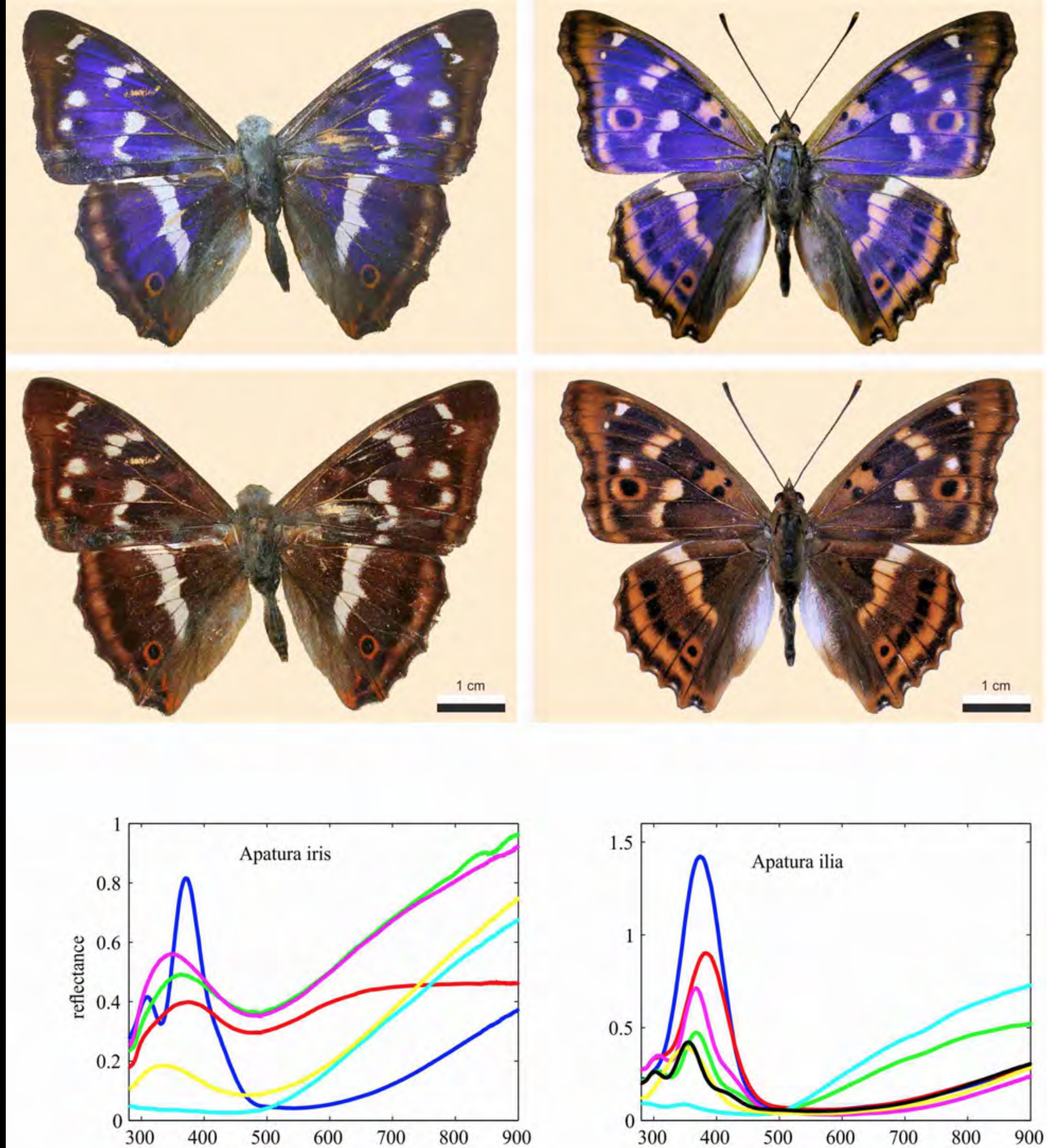
The angular selectivity is high and purple iridescent colour is observed within the angular range of only 18 degrees.

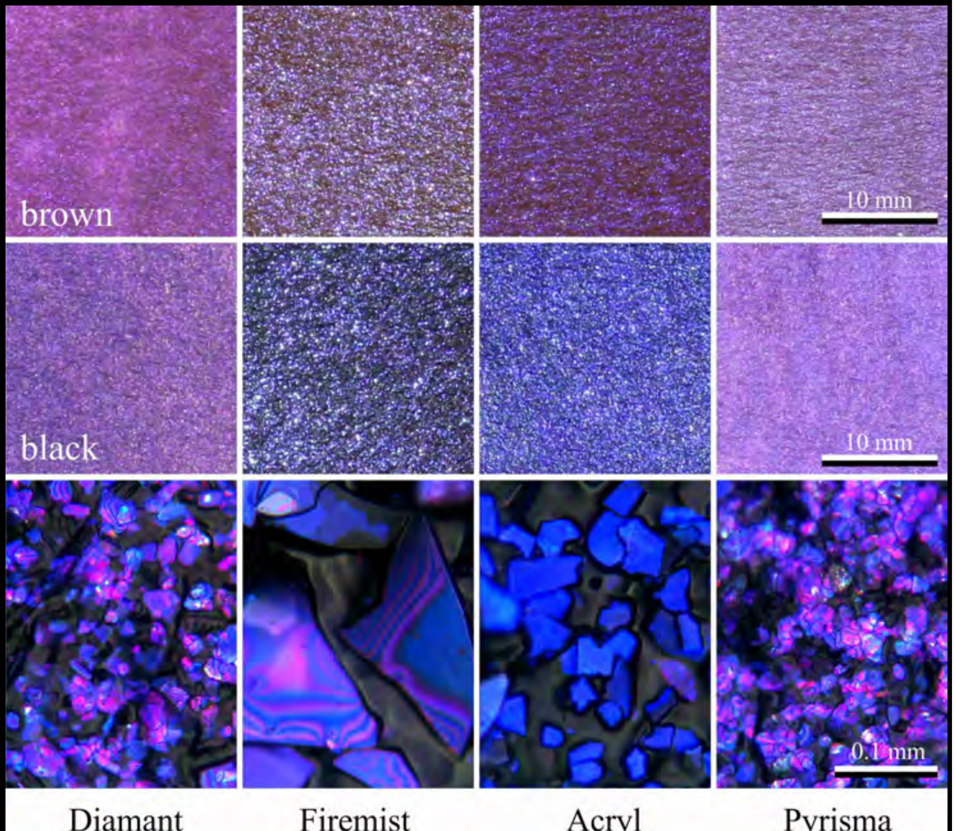
a)

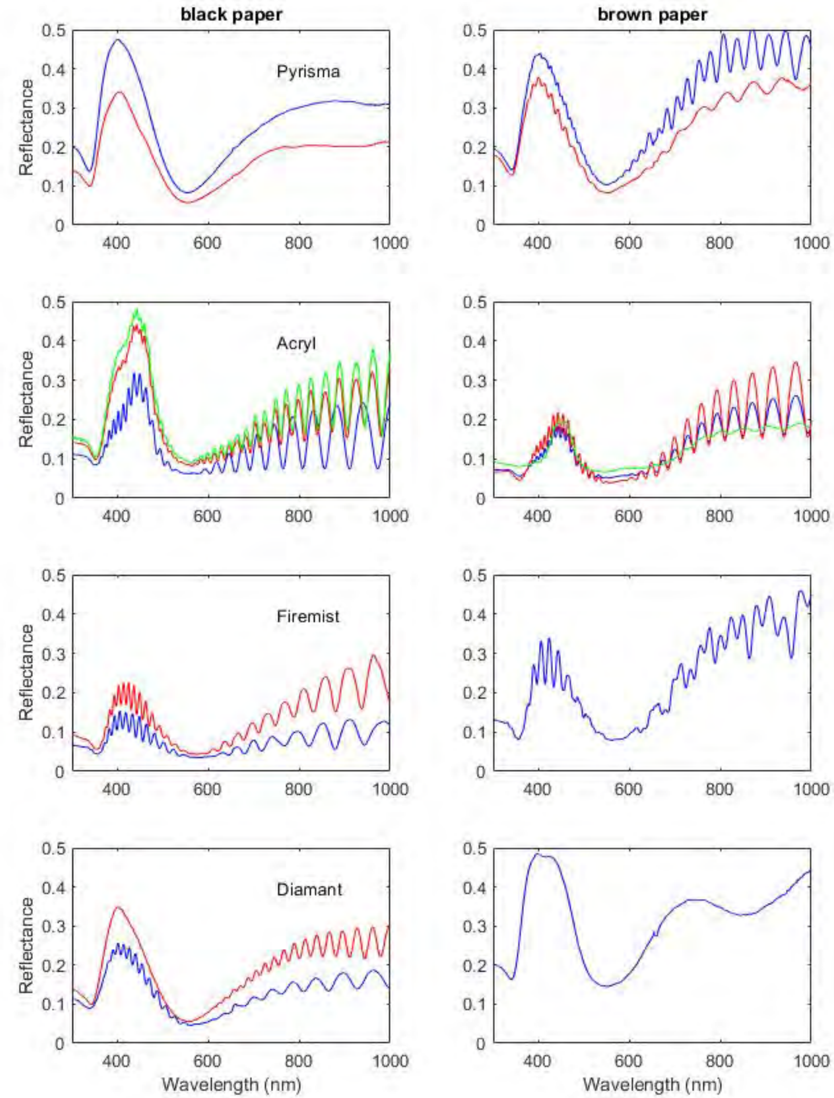
b)






1 cm
1 cm
Apatura iris
reflectance
0
0.2
0.4
0.6
0.8
1
300
400
500
600
700
800
900
Apatura ilia
0
0.5
1
1.5
300
400
500
600
700
800
900


brown
black
10 mm
10 mm
0.1 mm
Diamant
Firemist
Acryl
Pyrisma


black paper
brown paper
Pyrisma
Acryl
Firemist
Diamant
Reflectance
Wavelength (nm)

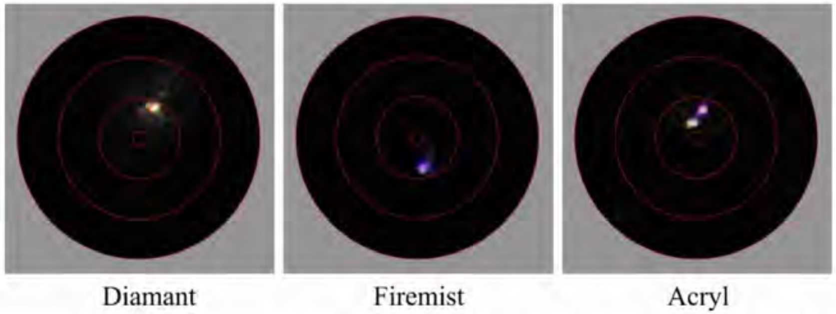


Fig. 5. Scatterograms of a few pieces cut out of the black papers with pigment showing directional reflections (in the case of Acryl two flakes are reflecting)

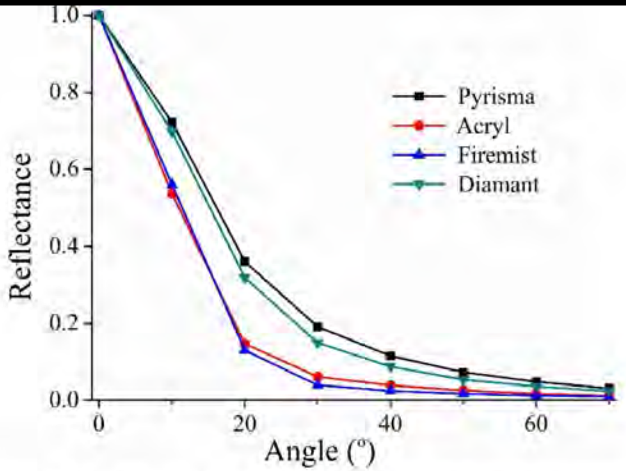
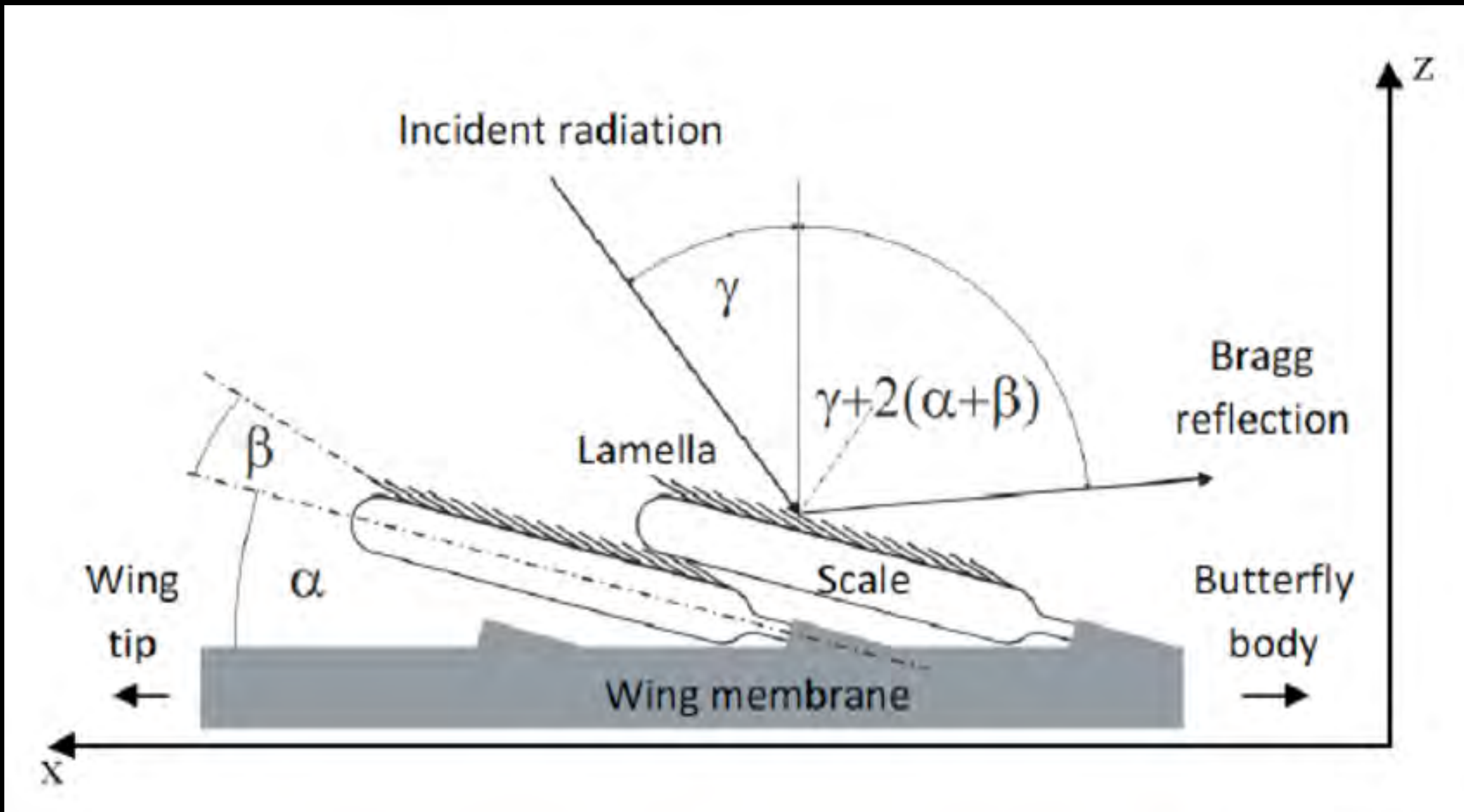


Fig. 6. Angle-dependence of the reflectance. One optical fiber delivered normal illumination, and a second fiber measured the reflectance at various angles.

High angular and spectral selectivity of purple emperor (Lepidoptera: *Apatura iris* and *A. ilia*) butterfly wings, Optical Express, March 2011.

Dejan Pantelić, Srećko Ćurčić, Svetlana Savić-Šević, Aleksandra Korać, Aleksander Kovačević, Božidar Ćurčić, and Bojana Bokić



The angular selectivity is high and purple iridescent colour is observed within the angular range of only 18 degrees.

Conclusion:

The work presented illustrates how, facilitated by concerted scientific study of nature's millennia-old colour optics, one can arrive at vital clues on how to adapt and adopt challenging new optical nano-materials for painting.

And indeed, the resulting artwork, like iridescent creatures, fluctuates in perceived colour and pattern, depending on the light and vantage.

Thereby extending the canon of art by adding new colour spectra, novel visual realms and modes of expression.

Thank you:

- Doekele Stavenga (Univeristy of Groningen)
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- Mark Colclough (University of Birmingham)
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- Max Planck Institute Dresden for hosting this event

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