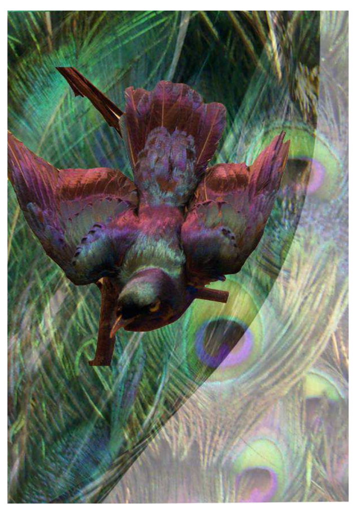

# Bionic-Art
# Structure.makes.Colors

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**ABSTRACT**

**Bionic-Art stands for a new kind of investigation field in interdisciplinary cooperation between nanotechnology, biology and art via highly developed material techniques. The project structure.makes.colors deals with structural colors (i.e., physical colors based on nanostructured materials) that have a long history in science and art. Already the Old Romans put their glasses beneath the earth to obtain shiny marvellous colors via the decomposition of the surface through metal salts. Organisms exhibit a wide choice of iridescent colors: examples comprise the wings of the Morpho butterfly species, the feathers of the peacock Pavo cristatus or the outer cell wall of the beetle Cetonia aurata. Structural coloration is due to the interaction of visible light on sophisticated nanostructures caused by five physical phenomena (and not by pigments, as in the generally known colors). Most of the structural colors change with the viewing angle – this is a phenomenon known as iridescence. The aim of the project is to develop a new tool respectively a novel technique to implement the nanostructures directly on the surface of the artwork to obtain multiple illusions from different viewing angles, awaking people from their every day illusion to improve the artist-public interaction. The project also serves as a start up to establish Bionic-Art as a new science field connecting different science subjects in the name of art to enforce creativeness and knowledge exchange for their own benefits. By finding suitable materials and corresponding nanostructures we aim at developing a revolutionizing nanoprint tool with possible bonus properties such as colors reacting to variations in humidity, radiation or even music (slight air pressure variations). Imagine we color our lives with nanostructures yielding colors that change with their ecological environment, are never fading and may have high sustainability potential (depending on the material and the structures we choose). This would be a revolution compared to the potentially toxic chemical pigments currently used in so many instances. Bionic-Art is going to pave this way in an artistic way that causes joy to the audience and the artists!For more information contact: info.bionic.art@gmx.net**

## Bionic

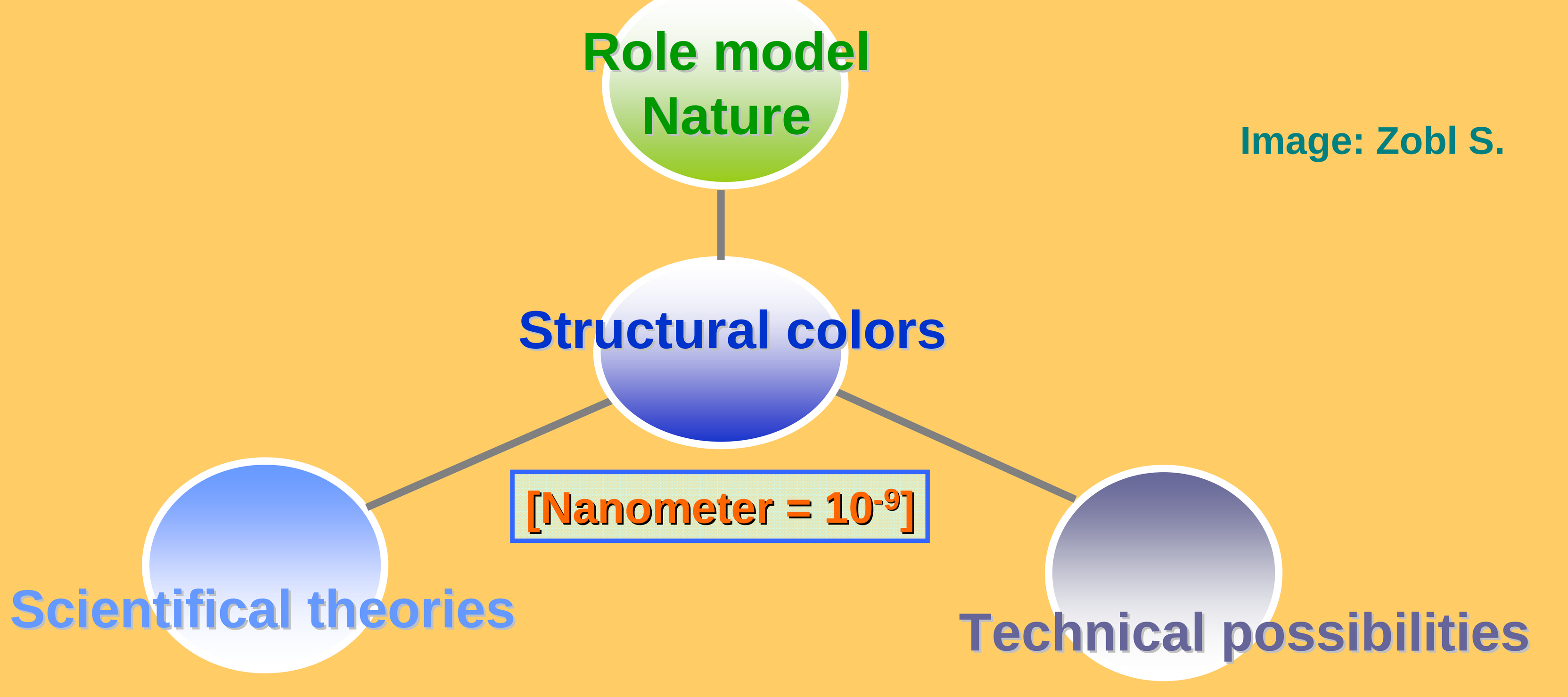


Image: Zobl S.

LIMITLESS APPLICATION DUE TO PROGRESSIVE STATE OF THE ART DEVELOPEMENTS SCIENTIFICAL STAFF TAKE RESPONSIBILITY OF THE DIRECTION!?

## Bionic-Art

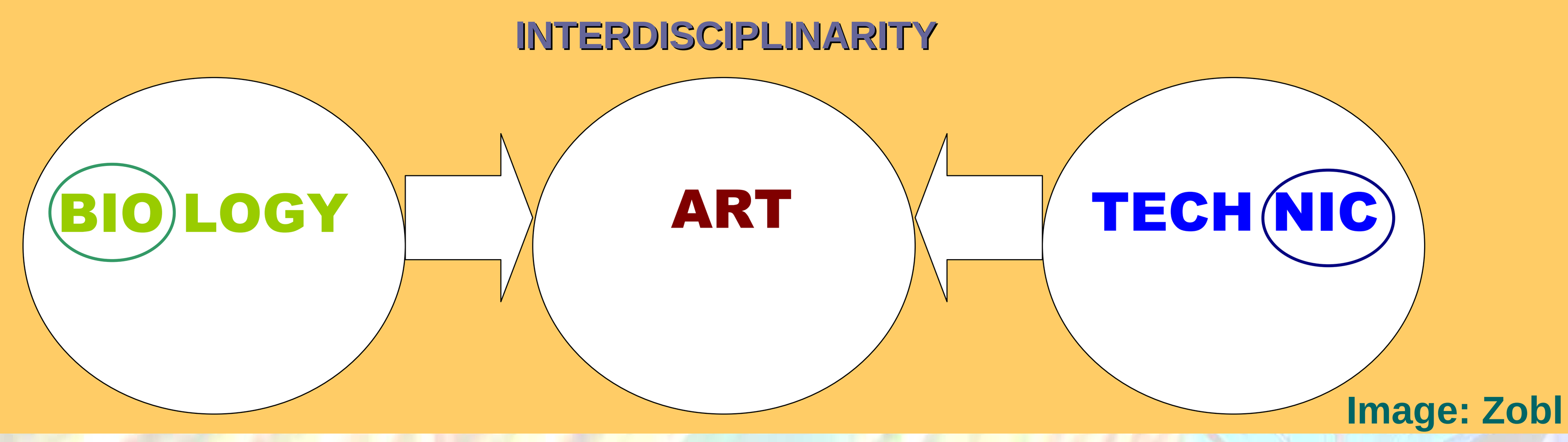


Image: Zobl S.

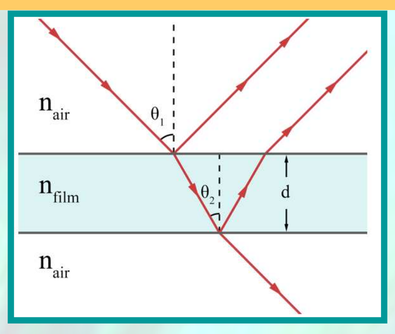
## Physics of Structural Colors

**STRUCTURAL COLORS → LIGHT + Nano-STRUCTURE**

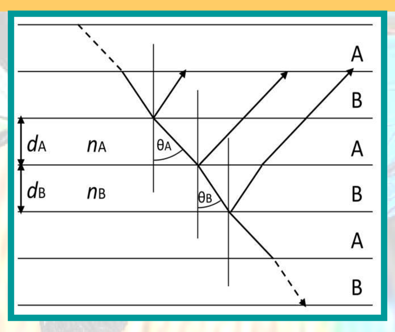
3 important parameters:
- REFRACTION INDEX
- THICKNESS IN THE RANGE OF THE VISIBLE LIGHT
- ANGLE OF INCIDENT LIGHT AND ANGLE OF VIEW

5 physical phenomena::

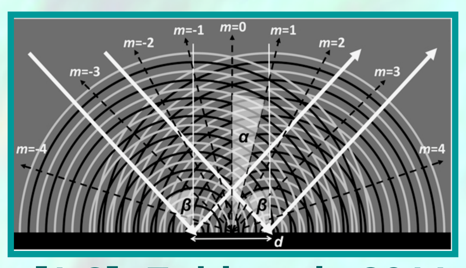
THIN FILM INTERFERENCE
*e.g. Soap bubble*



MULTILAYER INTERFERENCE
*e.g. Mother of pearl*



DIFFRACTION GRATING
*e.g. Compact Disc*



Images [1-3]: Zobl et al., 2011.

SCATTERING
*e.g. blue Sky*

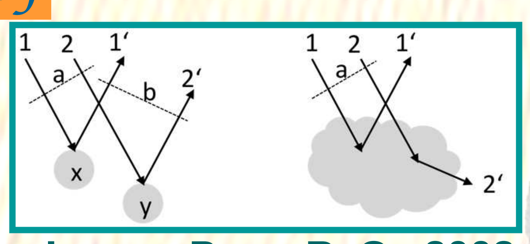


Image: Prum R. O., 2003.

PHOTONIC CRYSTALS
*e.g. Opal*

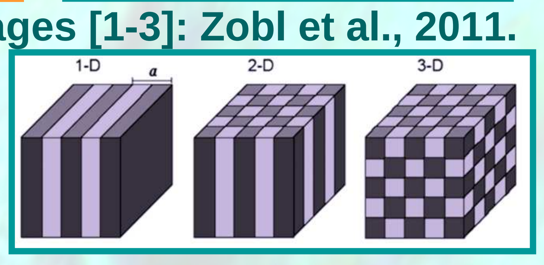



Image: Joannopoulos J. D. et al., 1995.

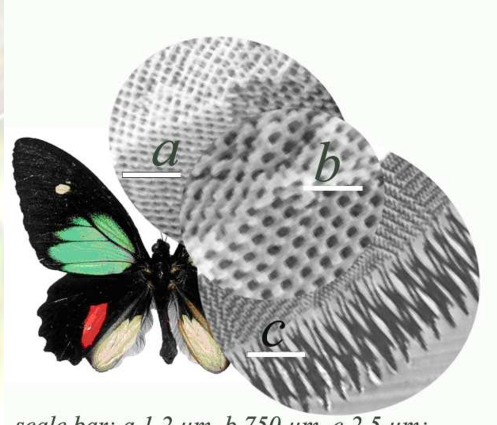
## Structural colors in Nature

| FAUNA | FLORA | MINERALOGY |
|---|---|---|
| Arthropoda | understory Plants | Opal |
| Aves | in Rainforests | Labradorit |
| Teleostei | marine Algae | Mountain Crystal |
| Mollusca | Leaves, Fruits, Petals | |

& more


Image above shows a composition of selected structural colors in nature and of some the Nanostructure is shown with a Scanning electron microscope or Transmissionelectronmicroscope view.

*Parides sesostris - Photonic crystals*




*scale bar: a 1.2 µm, b 750 µm, c 2.5 µm;*

Image above left side: *Parides sesostris*, Davis. On the right side: Detail of a Scale a) b) SEM images show photonic crystals. c) TEM image of a 50 nm section of a scale from a). Dark section is cuticle. Vukusic et al., Nature Publ. Group, 2003.

*Morpho sp. - Shelf Structure*

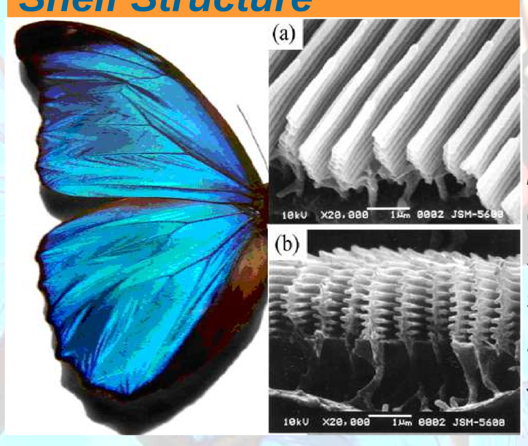



Image left side: *Morpho menelaus* Gnu free documentation License. Right side show SEM images of the structered groundscales of a) *Morpho didius* b) *M. sulkowsky*. Kinoshita et al., 2008.

## Replication techniques of structural colors

- Sol gel technique
- PVD (Physical vapour deposition) e.g. CEFR (conformal evaporated film by rotation)
- ALD (Atomic Layer deposition)
- Imprint Lithographie and Casting

(Pulsifer et al., IOP, 2011.)

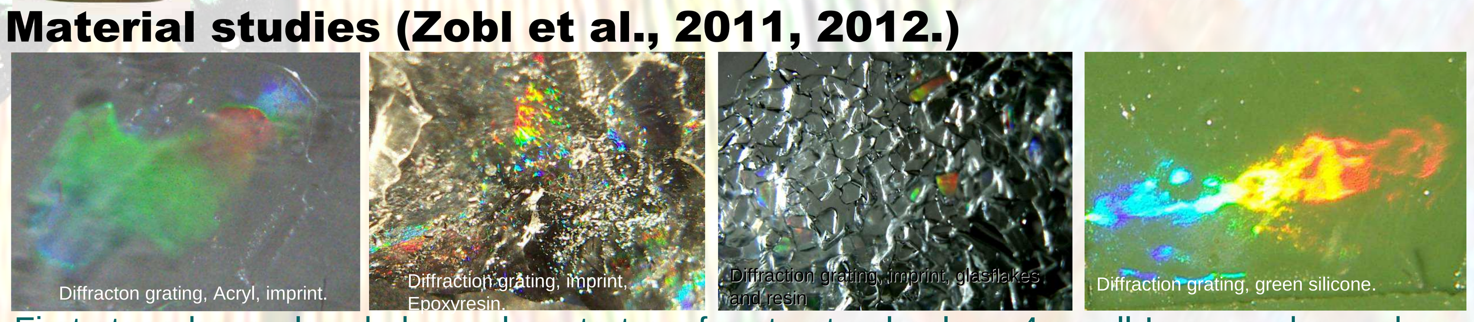
## Structural coloration techniques in Art

**„Effect pigments“** – effect structural colors used for coatings of e. g. cars, packaging, additives in cosmetics, security prints and for artwork. These are multilayer systems generating thin film interference with „flip-flop“ effects. They consist of flakes with alternating layers of low and high refractive index made of different basic materials like: Aluminum oxide, Borosilicate, Silicon dioxide or others coated with Oxides of Iron, Titanium, Silicon, Chromium, Copper etc. Metal oxide mica flakes are possible to equip with functional properties like corrosion limitation, magnetism, electrical conductivity, dielectric properties. Especially ones are obtainable for artwork called Pearl essence pigments or metal effect pigments. (Pfaff, 2007.)


**Imagecollage: Zobl S.**

The Artcraft is made by the enterprise LÖTZ, Witwe Lötz, Vienna (~ 1900). The iridescent colors are due to fumes of metal salts in high tempereture or wet in combination with muriatic acid. The decomposition of the glass surfaces through compounds of chlorine generates the luster (Randau, 1905). The green iridescent glass left with branch structured body, Ref.: Ricke – Ploil, Lötz, vol. 1, p.102, comp. no. 65, vol. 2, pp.88, 331, 420, 557. Image: August Lechner, für bel etage, 2004.

### Material studies (Zobl et al., 2011, 2012.)




First steps have already been done to transfer structural colors: 4 small Images above show artificial synthesised structural colors by the Imprint Lithography and Casting Replication Technique. Common materials used for artworks have been investigated (Zobl et al. 2011.).

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**in cooperation with:** imen, TU Wien, BIONIK Biomimetics, universität innsbruck

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