

WONDERFUL PHOTONICS IN NATURE

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1 - A RESEARCH LAB CALLED NATURE

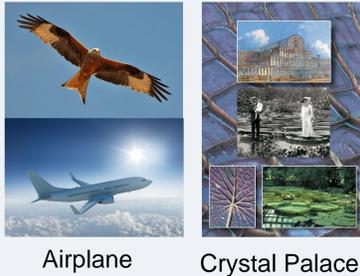
Nature is the best inspiration source for scientists, engineers, and designers who want improve human activities and technologies

Biomimetic:

Science that studies and mimics living systems

➤ XV – XVI century - Leonardo da Vinci studied **bird flight**, anticipating many principles of **aerodynamics**

➤ 1851 - The botanist Joseph Paxton designed “**The Crystal Palace**” inspired by the structure of the **Victoria Amazonica leaf**



➤ 1957 - The engineer George de Mestral inspired by the minute hooks on the seeds of the burdock **plant**, produced the **velcro** closure

➤ 2011 – Researchers of ENEA institute developed **self-cleaning surfaces** inspired by lotus **flowers**

Optical biomimetics:

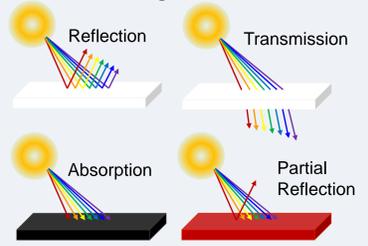
Science inspired by colours and brightness of natural optical systems

2 - WHAT IS THE COLOUR?

Colour is a property of both the coloured object and the human visual perception

An object can **reflect**, **transmit** or **absorb** light

- **White** – total reflectance/transmittance of incidence light
- **Black** – total light absorption
- **Colour** – selected colours reflection (e.g. red)

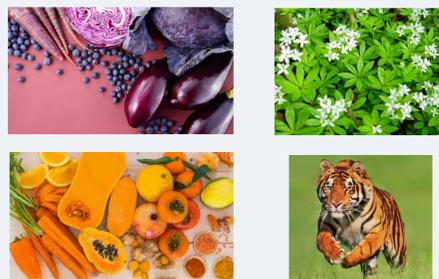


Colouration in nature:

Pigments

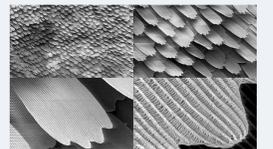


Chemical compounds which absorb light and transmit or reflect a specific colour

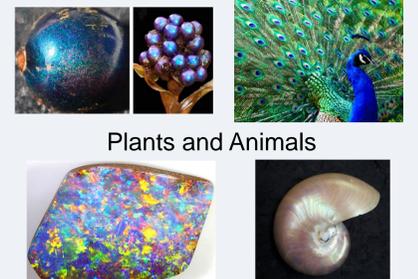


Fruit and Vegetables Plants and Animals

Structural colour



The colour is produced by high ordered structures able to interfere with visible light



Gem and Mother of Pearl

3 – PHOTONICS IN NATURE

Natural **Photonic Crystals (PCs)** are structures capable of producing structural colours

Depending on the orientation of the biological components within the structure, the PCs can be classified as:

➤ 1D frameworks



Brilliant blue wings → alternated cuticle-air lamellar structure

➤ 2D frameworks

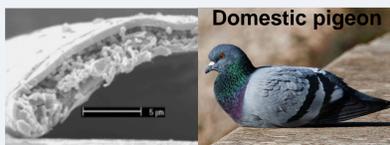


Iridescent setae → periodic voids along fibers

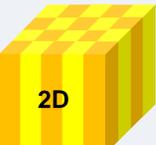
➤ 3D frameworks



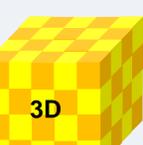
Brilliant green wings → air-filled voids based 3D-cuticles network



Iridescent green and purple neck → light interference with the feather keratin layers



Colored feathers → melanin rods periodicity variation on size and number



Intense green exoskeleton → periodic arrays of holes into staircase-like cuticular matrix

Typical iridescence and brightness of natural PCs play an important role in sexual attraction, social behavior and environmental camouflage

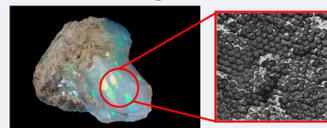


Mature male chameleons shift skin colour by tuning its structure periodicity leading to different light-structure interaction

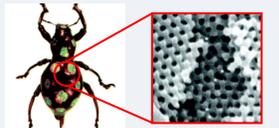
4 – INSPIRED BY NATURAL PHOTONICS

Typical natural 3D photonic structures are:

Opals

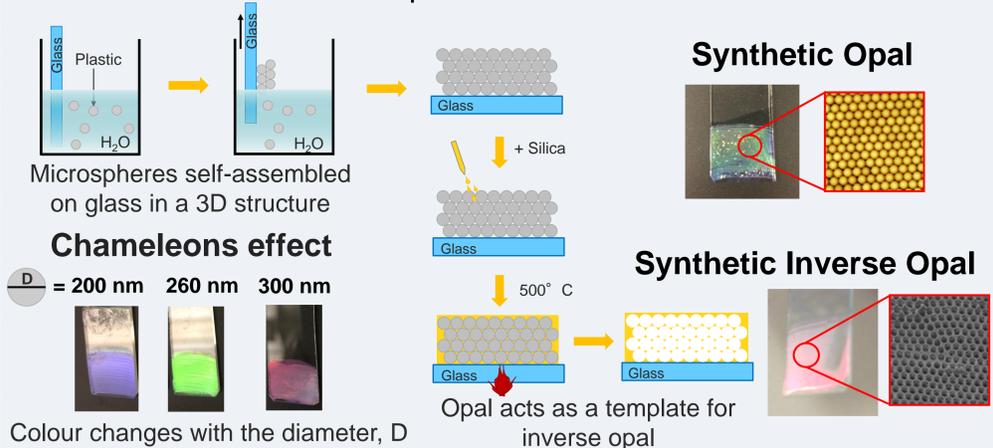


Inverse Opals

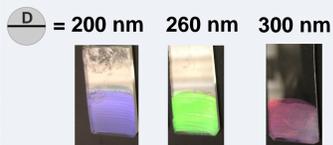


Characteristics: Chameleons effect and Iridescence

How to replicate 3D PCs in lab?

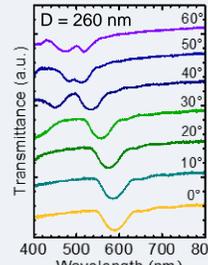


Chameleons effect



Colour changes with the diameter, D

Iridescence



... and with the incidence angle

Bio-inspired optical technologies are everywhere around us:

- Morpho Butterfly in **cosmetic** and **fashion** industry
- Housefly eyes for **antireflective surface**
- 3D PCs in **medicine** and **agriculture** (e.g. sensors)
- 1D and 2D PCs in **technology** (e.g. solar cells)



Nature provides a wonderful database of perfect systems
All we need is to borrow ideas from Nature

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