



The current challenges of Color Physics & Chemistry



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OUTLINE



- **GVC-UA: team**
- **Color: human visual system – matter – light interaction**
 - **Physic-chemical causes of color**
 - **CIE system (measurement and color encoding)**
- **Multi-scale approach (*top – down vs. bottom – up*)**
 - **Impact of the color science & technology**
- **Inter and multi-disciplinary prospective of color**
- **Challenges for the Faculty and UA**
- **Conclusions**

TEAM



- Website: <http://web.ua.es/en/gvc>

GRUPO VISIÓN Y COLOR

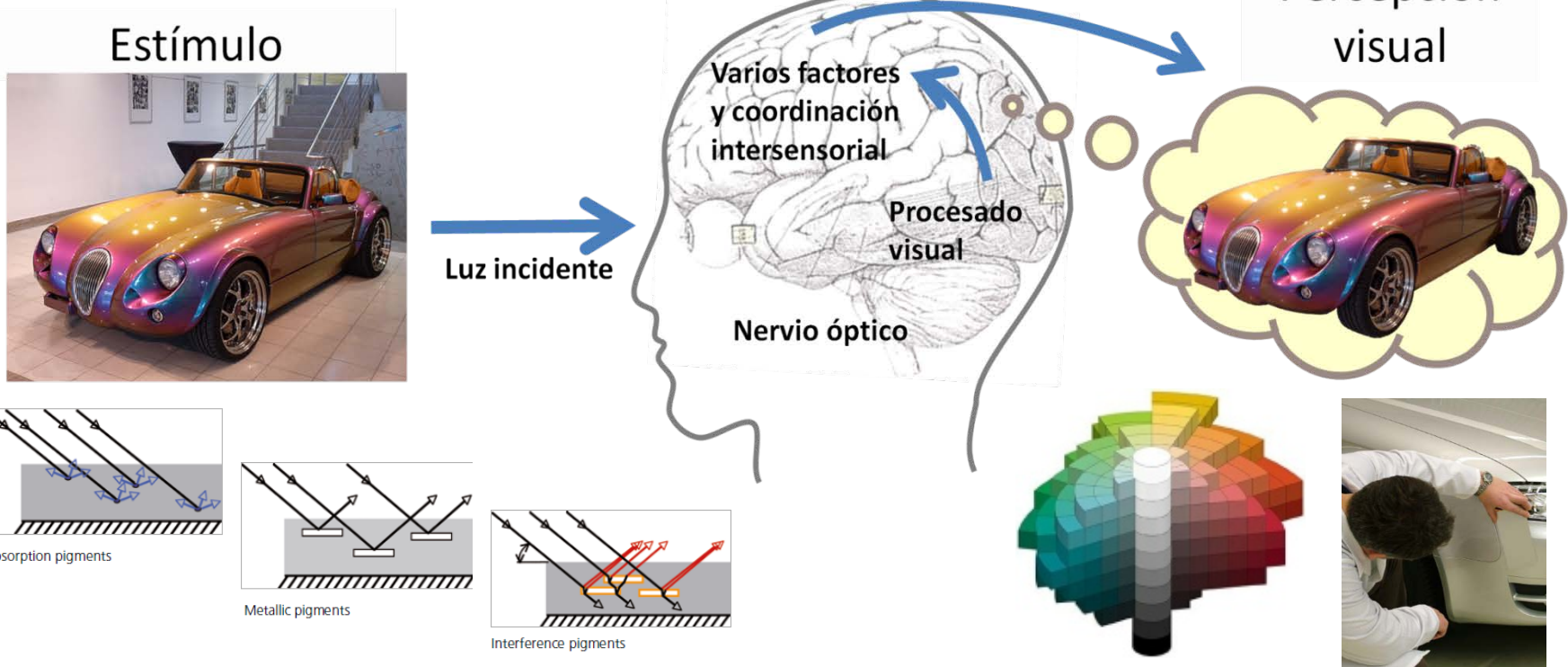
Universitat d'Alacant
Universidad de Alicante
Dpto. de Óptica, Farmacología y Anatomía

Internet | Modo protegido: activado 125%

- 5 Doctors
 - 4 Physics
 - 1 Industrial Eng.
- 3 PhD students
 - 1 Textile Eng. (UPV)
 - 1 Materials Eng. (UdA-Colombia)
 - 1 Materials Eng.



- **Visual System – Matter – Matter interaction**
 - (structural) nano/micro scales \Rightarrow macroscopic
 - It is a brain **“invention”**



15 PHYSIC-CHEMICAL CAUSES



ATOMIC EXCITATIONS AND VIBRATIONS

1. **Incandescence:** Sun, lamps, C-arc, fireworks*
2. **Gaseous excitations:** lighting, fireworks*, aurora borealis, lasers*
3. **Vibrations & rotations:** water, ice, iodine, chlorine

CRYSTALLINE NET TRANSITIONS

4. **Metal compounds:** pigments, lasers*
5. **Metal impurities:** ruby, emerald, colorants

TRANSITIONS AMONG MOLECULAR ORBITALS

6. **Organic compounds:** dyes, biological coloration*
7. **Charge transfer:** sapphire, magnetite, lapis

TRANSITIONS AMONG ENERGY BANDS

8. **Metals:** copper, gold, iron, silver
9. **Pure semiconductors:** silica, galena, diamond, cadmium
10. **Doped semiconductors:** diamond, LED, TV phosphors
11. **Color centers:** amethyst, smoky quartz

PHYSICAL / GEOMETRIC OPTICS

12. **Refraction & polarization:** rainbow, halo
13. **Scattering:** sky-blue, sunrise/set, bluish feathers*, bluish eyes in neonates
14. **Interferences:** oil-water, soap bubbles, butterfly wings
15. **Diffraction:** opal, LCD, diffraction grid

15 PHYSIC-CHEMICAL CAUSES



www.webexhibits.org/causesofcolor/index.html

Causes of Color

Why are things colored?

Read about the blue morpho butterfly »

Explore the three causes.
Repeated over and over, three causes create our colorful world.

Light is made in the yellow glow of a candle.
Light is lost when sunlight filters through stained glass.
Light is moved when sky turns crimson sunset.

[CONTINUE »](#)

webexhibits.org/causesofcolor — Bibliography — About — Contact

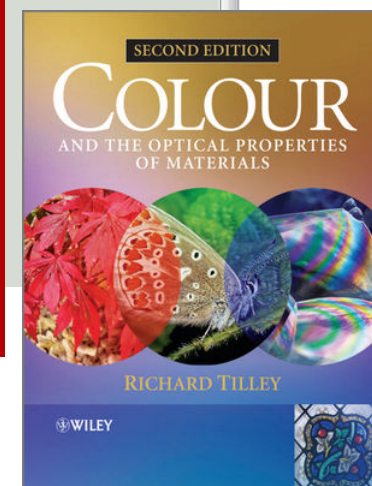
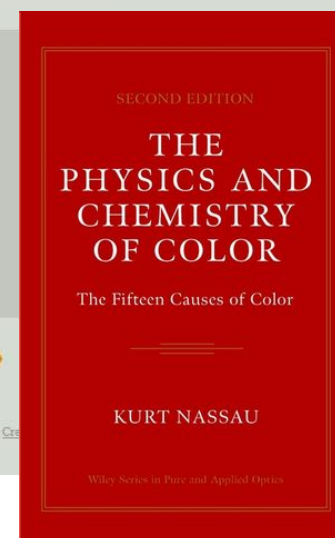
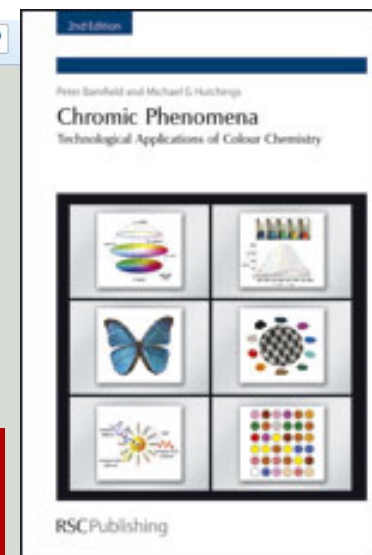
MADE: Lightbulbs
Fire & stars
Lightning & aurora
Glowing

LOST: Water
Plants & animals
Gemstones
Gold & diamonds

MOVED: Rainbows
Sky & sunset
Butterflies & peacocks
Holograms

VISION: Eye & mind
Color theory
Colorblind
Animal

Books



Color Science – OCW – UA (2009)

15 PHYSIC-CHEMICAL CAUSES



Light manipulation
refraction, laser, non-linear optics, etc.

Absorption & energy transfer
Photo-thermal, electric, etc.

Stimulated color change
Thermo-chromism, ion-, etc.

Color phenomena

Absorption & emission
luminiscence, etc.

Absorption & reflection
dyes & pigments



■ Color Science & Technology:

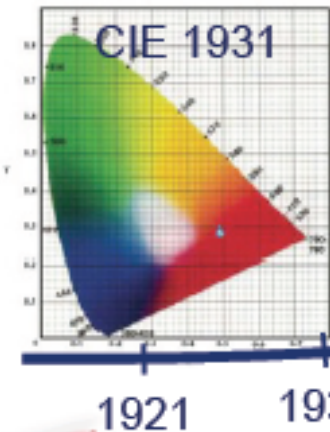
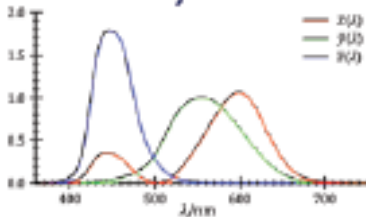
- Study of theories and techniques used for **design**, produce and **measure** colored objects
- Can we describe numerically a color? **Yes**
 - There are maths in Color Science
 - There are some color languages and dictionaries among them
 - Colors can be ordered, compared, ...
- If 2 colors are not exactly equal, how we can match them?
- Which colorant type (primary colors) and how amount of them we should mix for obtaining a concrete color applied on many substrates or materials?



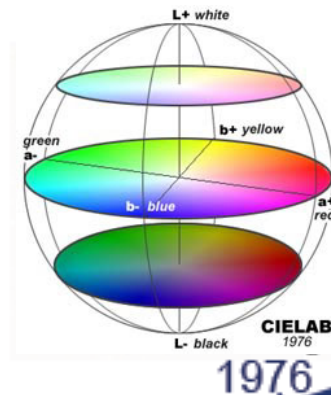
COLOR SCIENCE EVOLUTION



BLE
Div 1, Div2



Past and future



Translucency

Gloss

Texture

MApNet

Total appearance measurement

2013



2006

2002 CIE CAM02

2000 AUDI2000

1997 CIE CAM97s

1964

Visual appearance of materials

$\Delta T = f(\Delta E, \Delta G, \Delta S, \dots)$ is the **“GOAL”**

MATERIALS APPEARANCE: IMPACT



- **Growing demand nowadays for managing the visual appearance of materials**

- **\$700 B (in 1999) is the estimated value of shipments in industries for which unacceptable appearance may result in “**NO SALE**”**

- **Update from last decade?**
- **Prospect for next 10 years?**
 - **Automotive sector? Others?**

Sporting & Boats	\$18 B
Appliances	\$20 B
Carpet	\$20 B
Photographic	\$20 B
Paper	\$20 B
Furniture, office	\$22 B
Paints/Inks	\$25 B
Furniture, home	\$33 B
Apparel	\$62 B
Plastic Prod.	\$70 B
Printing	\$80 B
Automotive	\$330 B

From 1999 Annual Survey of
Manufacturers, U.S. Census
Bureau, 2001

MSc Color Technology - Automotive



GENERAL INFORMATION AND REGISTRATION

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 E-mail: escuela.negocios@ua.es, dofag@ua.es

For any general information regarding registration, legalisation of documents, foreign students, scholarships, insurance and issuance of degree certificates it is convenient to contact with the Continuing Education Centre (CEC-UA: <http://web.ua.es/en/continua/continuous.html>).

Pre-registration and fees:

Anyone interested in registering should complete a pre-registration form before 30th June 2014. This form is available from the course Secretary and must be handed in with a photocopy of the student's National Identity card or passport, as well as any academic transcripts and degree certificate/s. During the first half of July 2014, the Head of Studies will publish the list of admissions, which will be formalized once payment of the course deposit fee (€420, equating to 10% of the total course fee) has been confirmed in the CEDIP's Sabadell Bank account. This payment constitutes part of the first installment of the fee and will be deducted from the first installment in September.

Generally, those accepted onto the course will be required to pay course fees to the CEC-UA in three installments, the first in September 2014 (50%), the second in November 2014 (25%) and the final installment in April 2015 (25%).

Management and coordination:

Prof. Dr. Francisco Miguel Martínez Verdú,
verdu@ua.es, <http://web.ua.es/gvc>

Studies Coordinator:

Prof. Dr. Valentín Viqueira Pérez, valentin.viqueira@ua.es



Logos of partner companies and institutions:

- Universidad de Alicante Fundación General / Escola de Negocis / Escuela de Negocios
- BYK Additives & Instruments
- BASF The Chemical Company
- Mercedes-Benz
- AkzoNobel Tomorrow's Answers Today
- AXALTA
- nubiola our passion your colors
- PPG Industries Bringing innovation to the surface™
- valspar
- MERCK
- ISOCOLOR
- Naber INNOVATION & BUSINESS S.L.
- GONIO-VISION
- Office Color Science
- GAÏKER
- PLASTIC OMNIUM
- AUDI TOYOTA SEAT RENAULT VOLVO OPEL GRUPO ANTOLÍN
- Department of Optics – University of Granada
- Sensors, Instrumentation and Systems Development Center – Technical University of Catalonia
- Department of Paper and Textile Chemistry – Technical University of Valencia
- Institute of Optics – High Council of Scientific Research (CSIC)

(logos constantly updated)

Universitat d'Alacant / Universidad de Alicante

MASTER in COLOR TECHNOLOGY for the AUTOMOTIVE SECTOR

UNIVERSITY OF ALICANTE

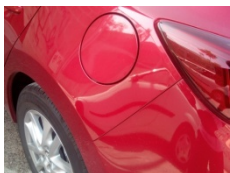
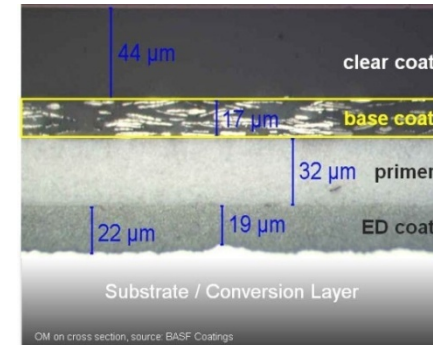
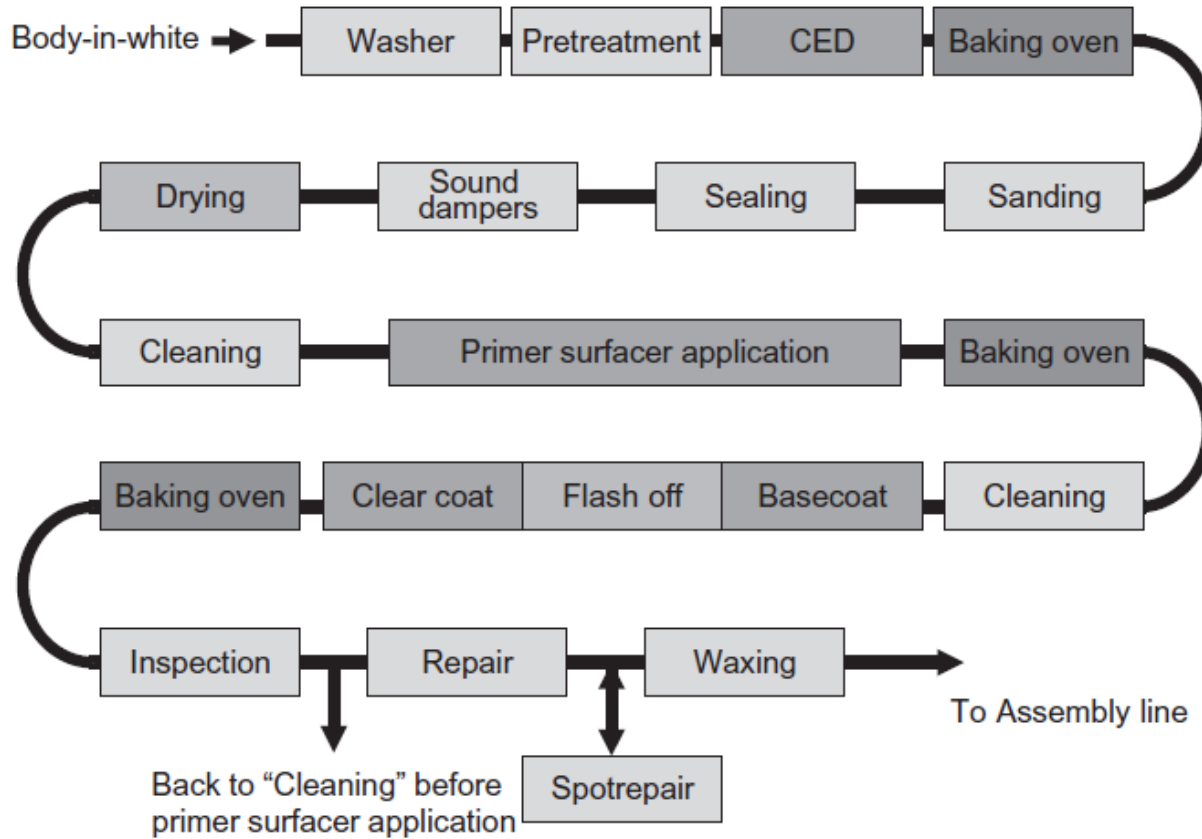
Color Technology: study of theories and techniques used to design, manufacture and measure colored objects

Academic year 2014-15

Logos of partner institutions:

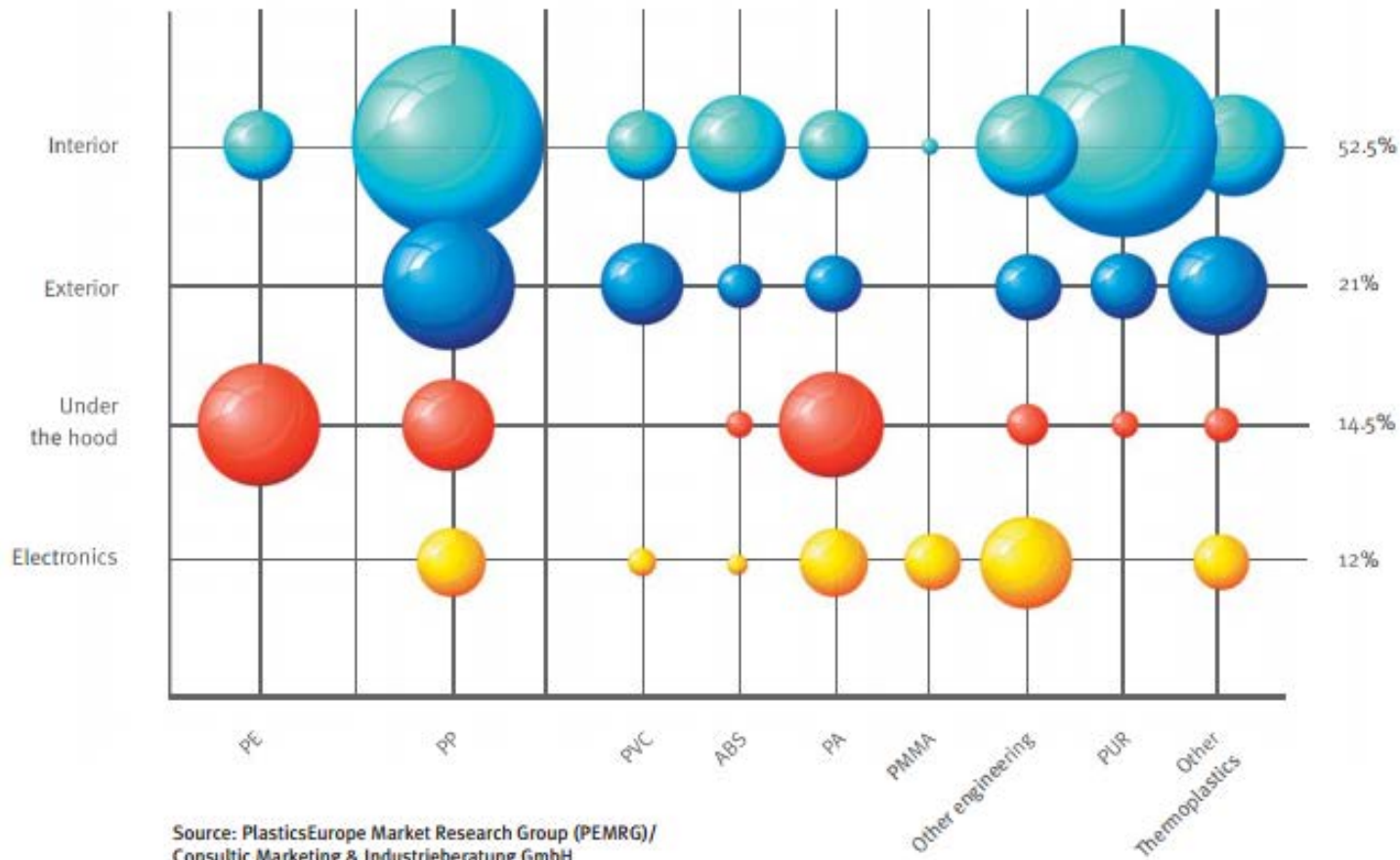
- Universidad de Alicante Fundación General / Escola de Negocis / Escuela de Negocios
- UA UNIVERSITAT D'ALACANT
- Color and Vision Group
- Department of Optics, Pharmacology and Anatomy
- Faculty of Science

MSc Color Technology - Automotive



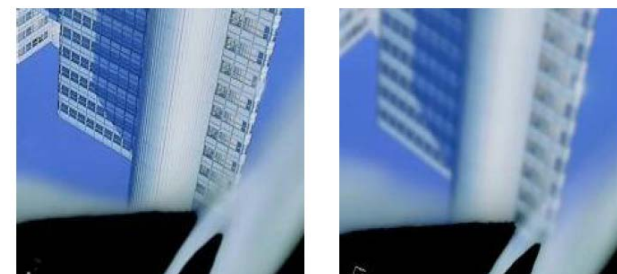
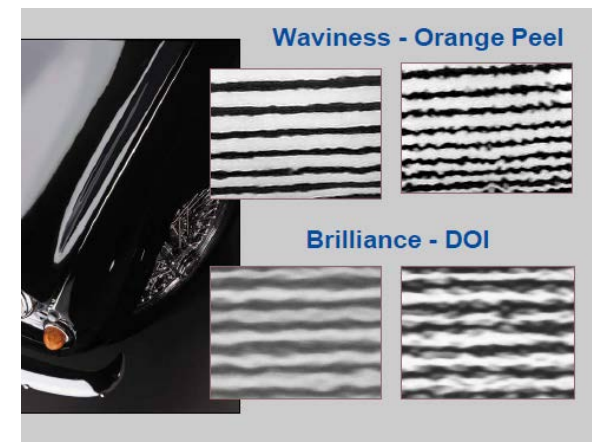
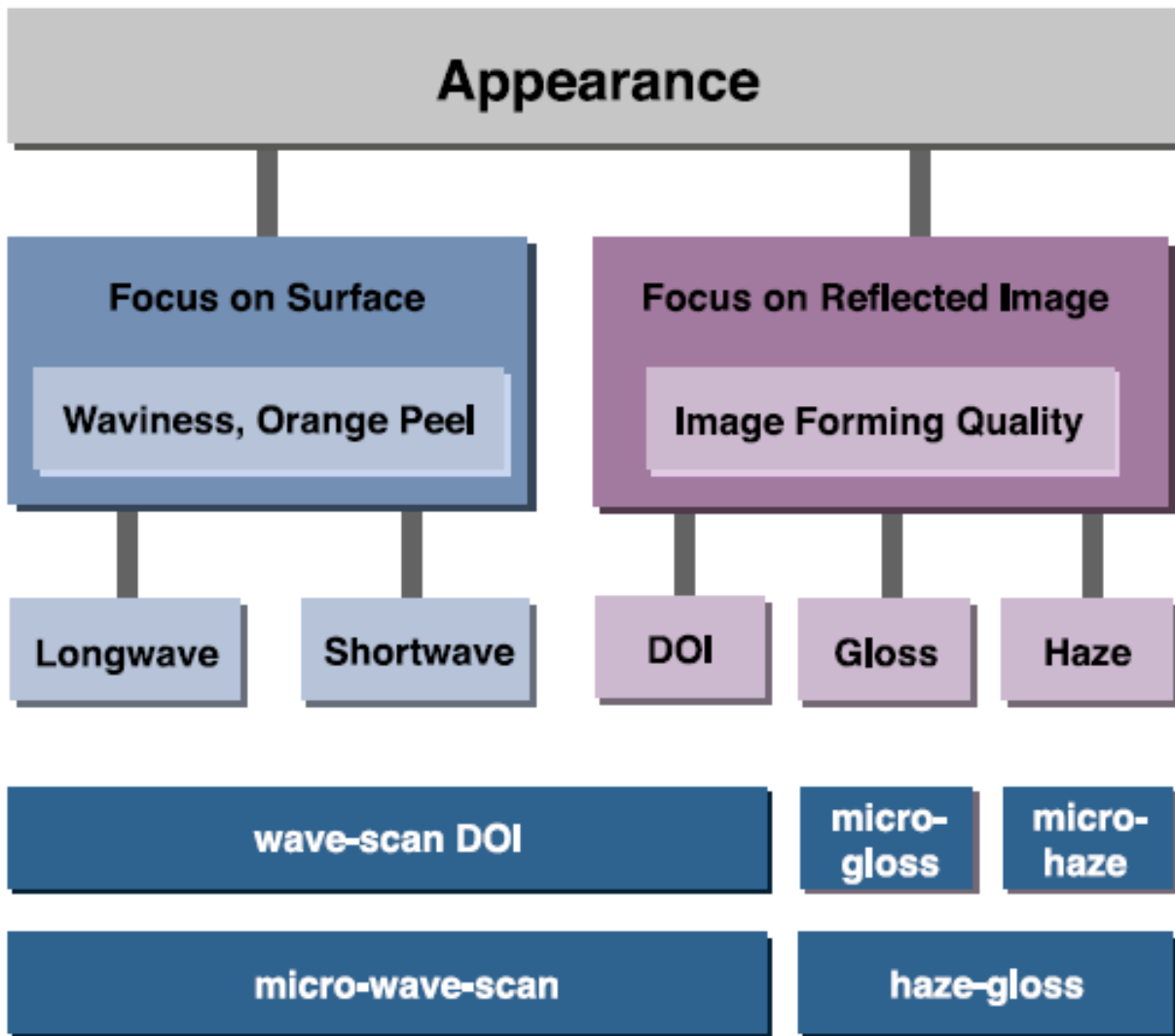


Use of plastics in the automotive industry by products/applications, Europe, 2012



Source: PlasticsEurope Market Research Group (PEMRG)/
 Consultic Marketing & Industrieberatung GmbH

MSc Color Technology - Automotive



Good Poor
 Contrast - Sharpness - Distinctness

BOTTOM-UP vs. TOP-DOWN APPROACHES



↑
THEORETICAL APPROACH

Light sources tech.,
geometries,
pigments,
color, gloss,
sparkle, haze, etc.

**Visual
appearance**

Emission SPD(λ)
Reflection $\rho(\lambda)$
Transmission $\tau(\lambda)$

Coefficients:
Absorption K
Scattering S

**Multi-flux
matter-light**

**Particles
interaction**

Cross
sections:
 $Q_A(D, \lambda)$
 $Q_S(D, \lambda)$
D size

Phys. + Chem. particles:
size (D), shape,
refraction index,
extinction index,
polarizability, etc.

**Light – matter
interaction
particle models**

↓
EXPERIMENTAL APPROACH



- **Nobel Physics Prize 2014: white LEDs (wLED)**
 - Isamu Akasaki, Hiroshi Amano & Shuji Nakamura

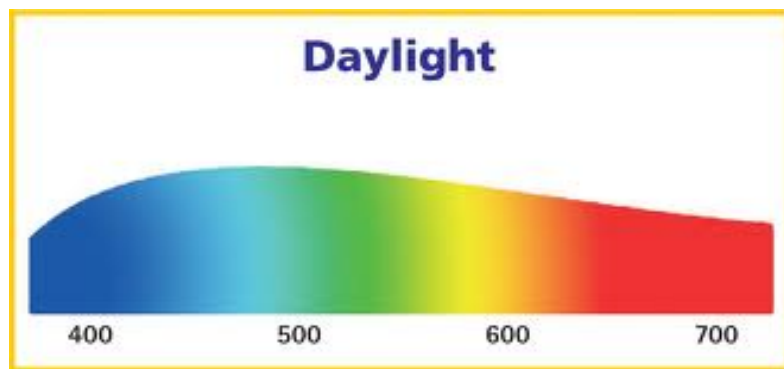
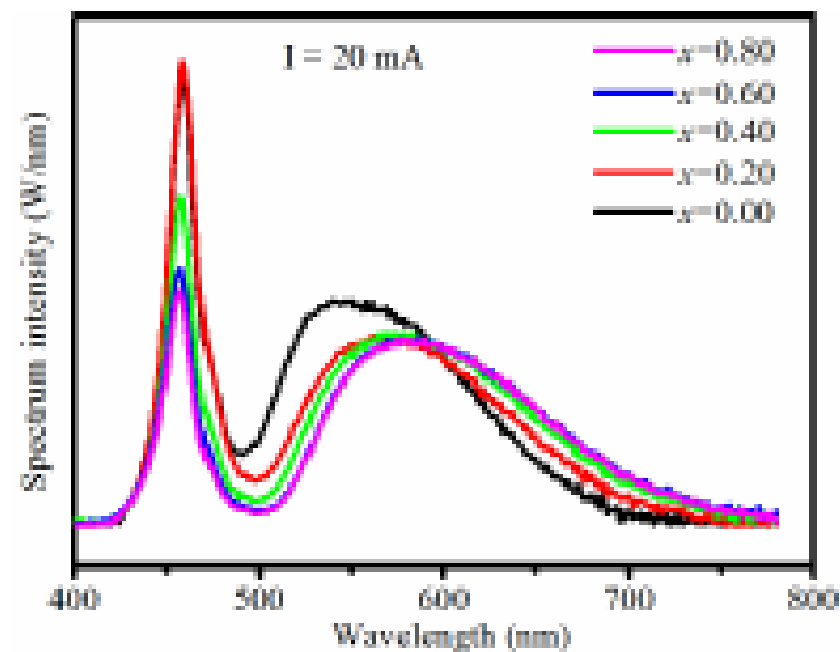


Table 1. Optical properties of white LEDs using modified $(Y_{0.98-x}Gd_x)_3Al_5O_{12}:Ce_{0.06}$ phosphors

Gd ³⁺ content <i>x</i> (mol)	CIE color coordinates		Luminous efficiency (lm/W)	R _a	CCT(K)
	X	Y			
0.00	0.3177	0.3373	134	73	6112
0.20	0.3293	0.3173	109	82	5656
0.40	0.3734	0.3470	106	76	3966
0.60	0.3973	0.3524	96	72	3338
0.80	0.4055	0.3613	95	70	3231



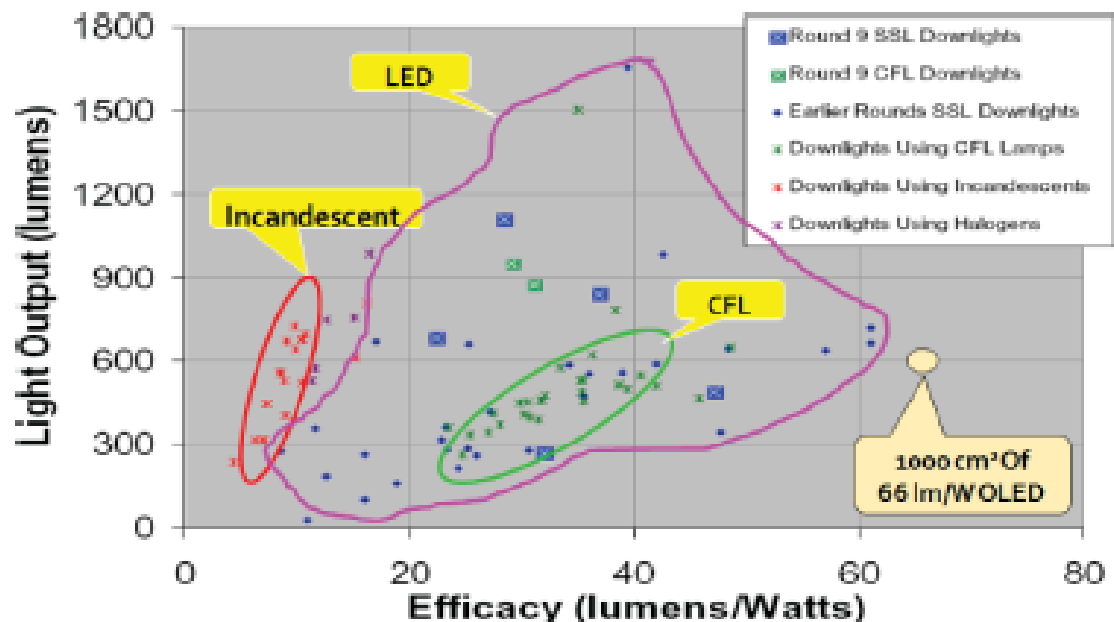
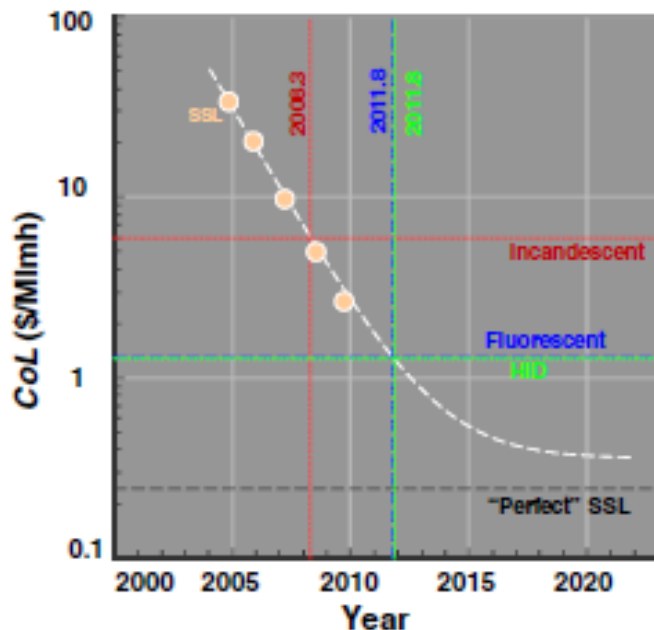
RECENT IMPACT: 2014 NOBEL



■ New technologies for light production

- Solid State Lighting (SSL):
- Pulsed OLEDs, free-phosphors, flexible, etc.
- 3D nano-structures, etc.
- **BASF campaign**: “invisible contribution, **visible** effect/success”

ENG62 MESaIL



Mid-term Balance 1



- **GVC-UA: synergies**
 - develops applied & theoretical projects where **human vision**, coming from the **eye-matter-light interaction**, performs an important role in metrology control and visual quality of some industries
 - **Inter-disciplinary:**
 - Needs **cooperation** from other disciplines
 - Physics (Optics), Chemistry, Biology, Materials, etc.
 - **Multi-disciplinary:**
 - Applicable to some technological-scientific fields



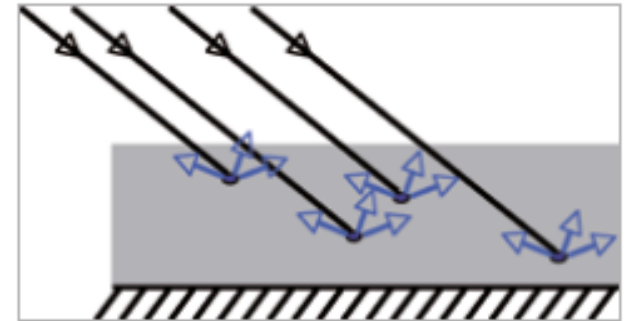
- **Structural colors**
 - synthetic vs. natural
- **Nanostructured hybrid pigments**
- **Functional pigments**
 - thermochromic, electrochromic, etc.
- **Colored metamaterials**

Structural colors



- **Solid:**

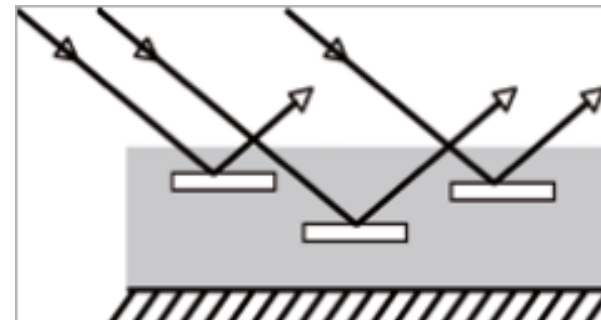
- light absorption and reflection in all directions (scattering)



Absorption pigments

- **Metallic:**

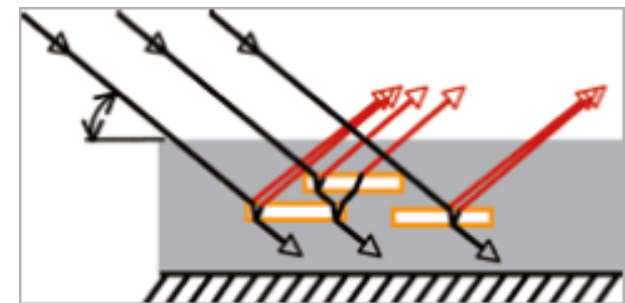
- micro-mirrors with adjusted reflection



Metallic pigments

- **Interference (pearlescent):**

- selective refraction and reflection

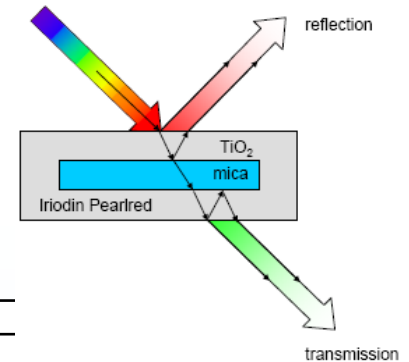
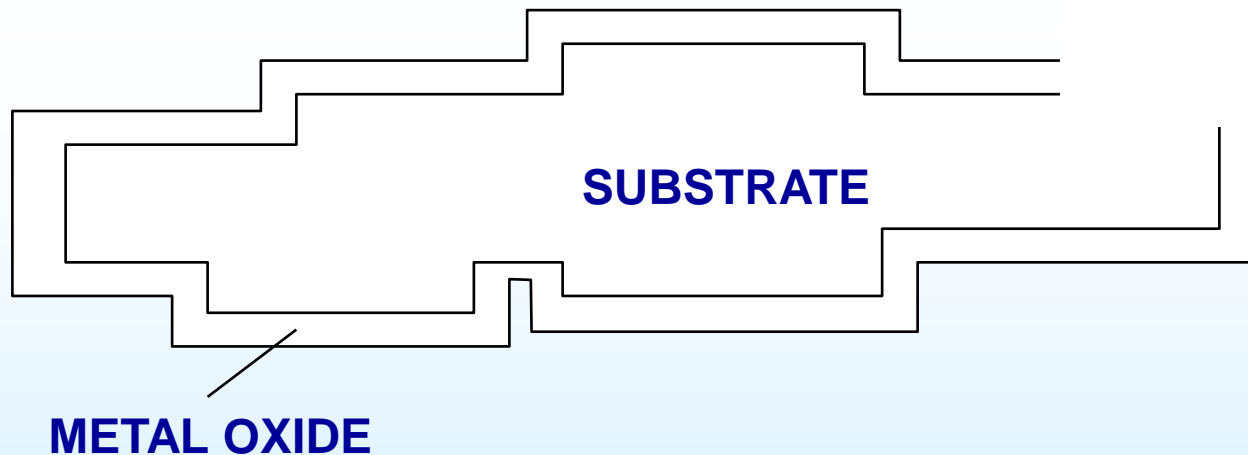


Interference pigments

Structural colors



Special-effect pigments



SUBSTRATE

Mica

Silicium Oxide (synthetic)

Aluminium

Aluminium Oxide (synthetic)

plated Iron Oxide (synthetic)

METAL OXIDE

TiO₂ (Rutil)

FeTiO₃

CoTiO₃

Fe₂O₃

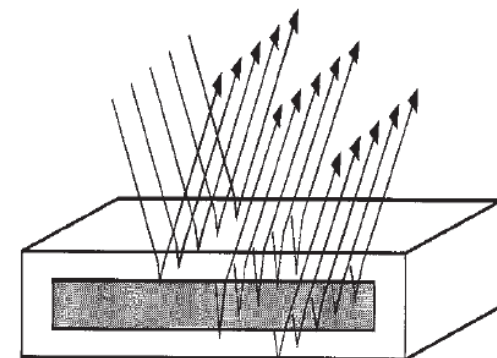
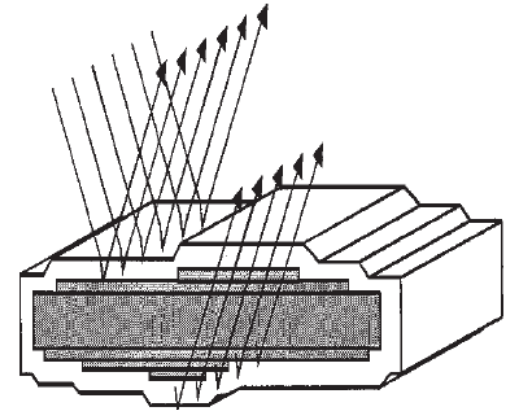
Cr₂O₃

multiple layer

Structural colors



- ***Iriodin/Afflair Merck:***
 - natural mica coated with high refractive metal oxide like TiO_2 or Fe_2O_3
- ***Xirallic Merck:***
 - Al_2O_3 -platelets coated with high refractive metal oxide
- ***Colorstream Merck:***
 - SiO_2 -platelets coated with high refractive metal oxide
- ***Pyrisma Merck:***
 - special mica coated with high refractive metal oxide

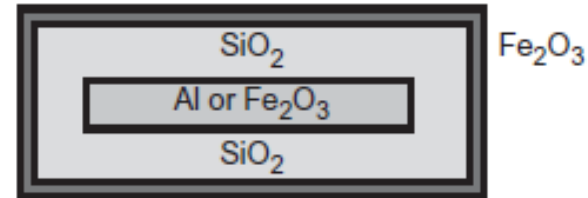


Structural colors



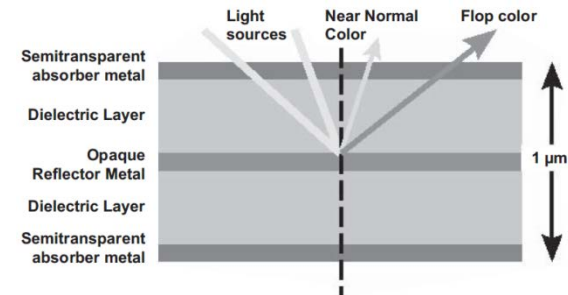
- **Variocrom BASF:**

- Optical Variable Pigments (OVP) chemical vapor deposition



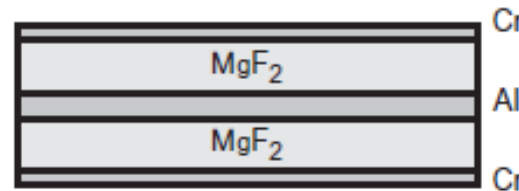
- **ChromaFlair Flex:**

- 5-layers with opaque reflector, dielectrical and semi-transparent layers

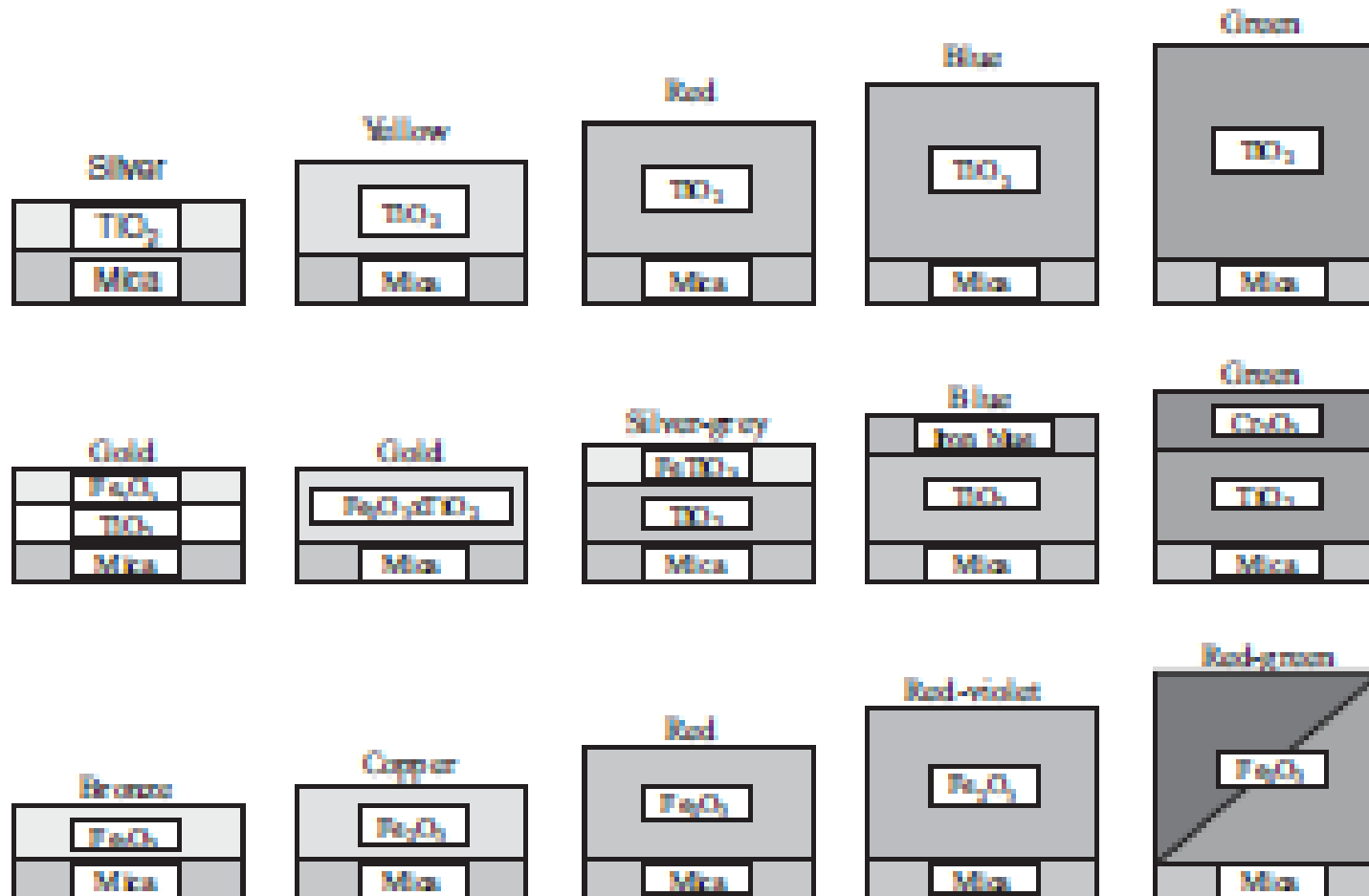


- **SpectraFlair Flex:**

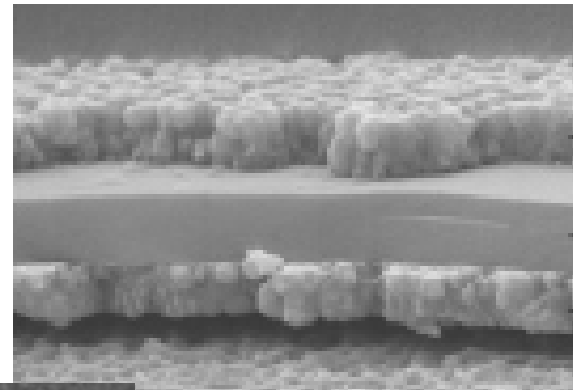
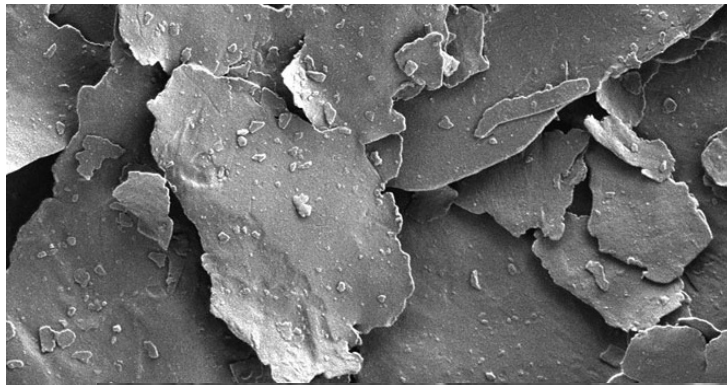
- microstructure surface and opaque reflector layer



Structural colors



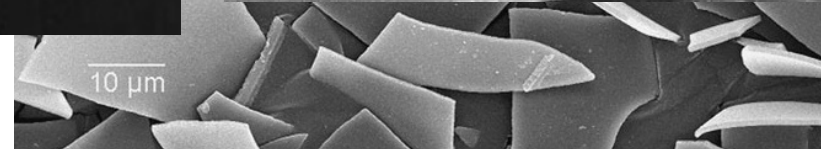
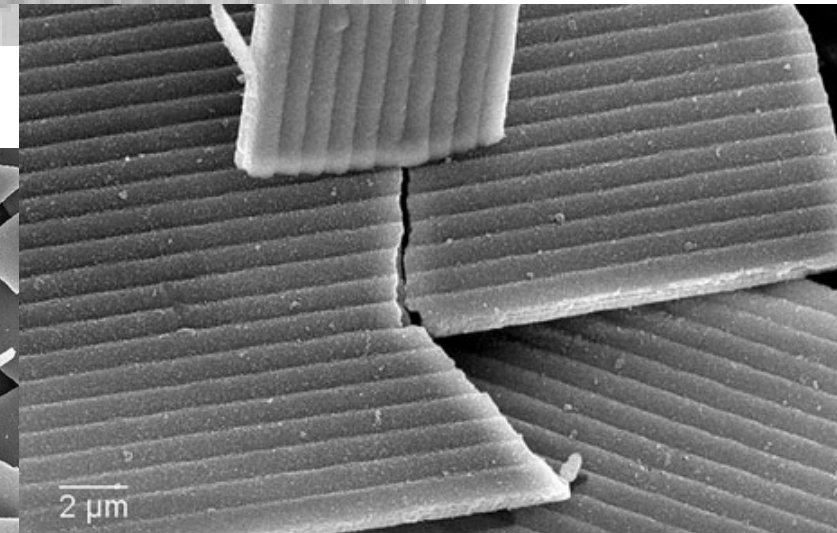
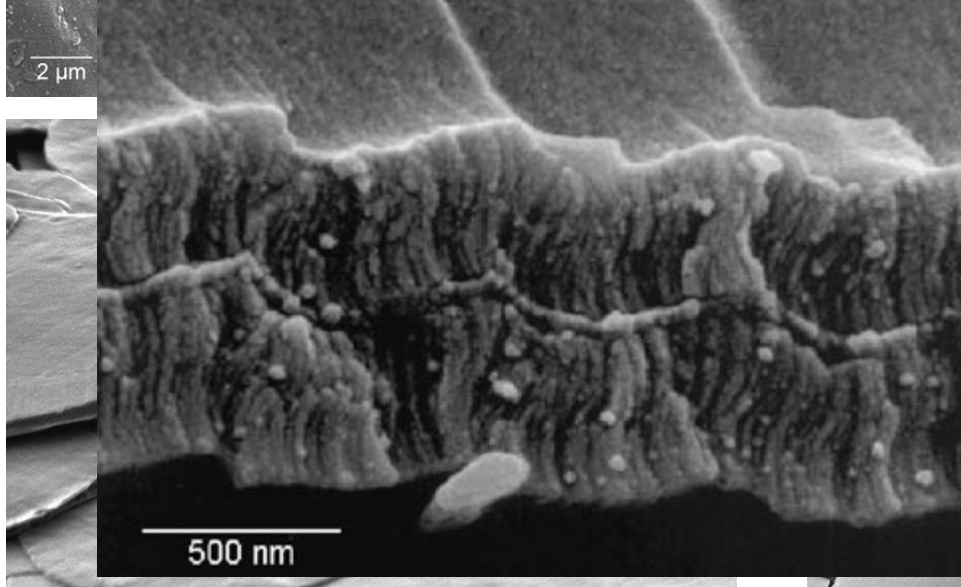
Structural colors



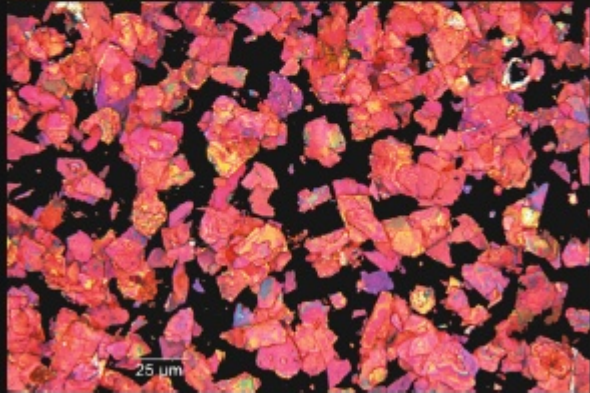
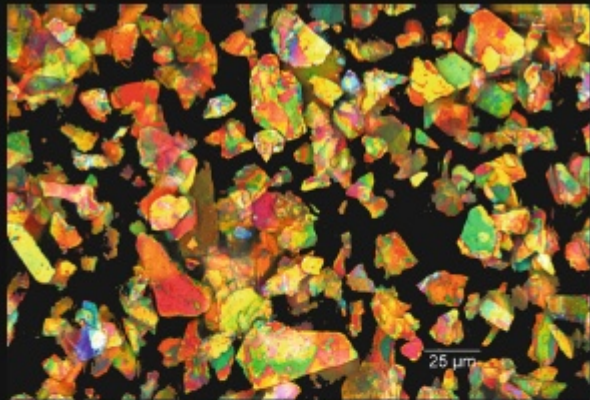
TiO₂ layer

Mica

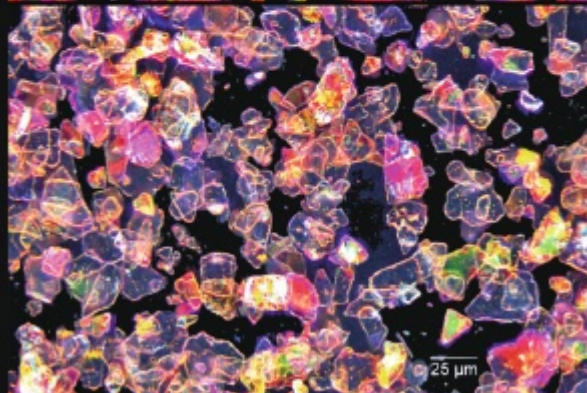
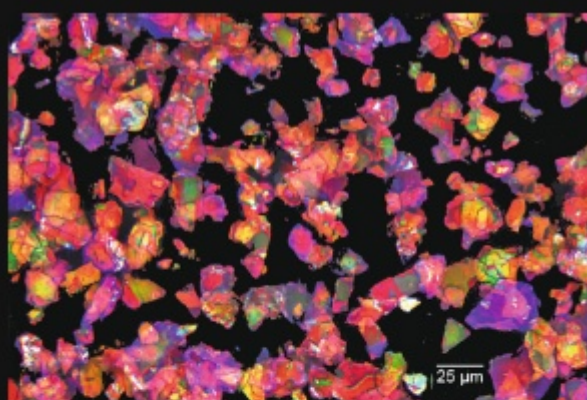
TiO₂ layer



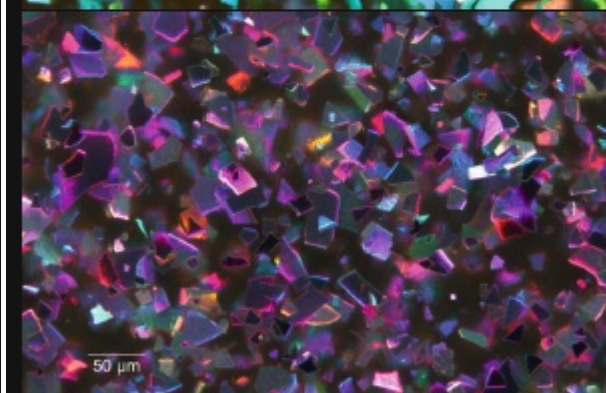
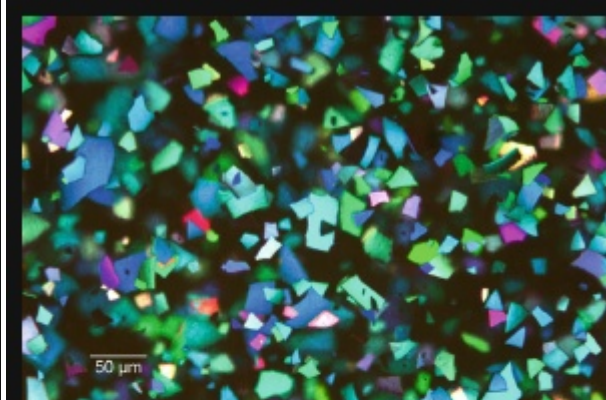
Structural colors



Color plate 7. Light microscopic images of pearlescent pigments with mica substrate in bright-field illumination: *top*: coated with titanium-dioxide (rutile), the particles appear yellow from the top view; *bottom*: coated with iron-III-oxide (α -hematite), the particles appear deep red from the top view (source: Clariant Produkte GmbH, Frankfurt am Main, Germany)



Color plate 8. Light microscopic images of a red pearl luster pigment with mica substrate coated with titanium-dioxide (rutile) of greater thickness than those in color plate 7; *top*: in bright-field, *bottom*: in dark-field illumination of the same frame (source: Clariant Produkte GmbH, Frankfurt am Main, Germany)



Color plate 9. Light microscopic images of an optically variable green/purple interference pigment of aluminum substrate coated with chromium and magnesium-fluoride; *top*: bright-field, *bottom*: dark-field of the same frame (source: Clariant Produkte GmbH, Frankfurt am Main, Germany)

Cortex effect

Thickness effect

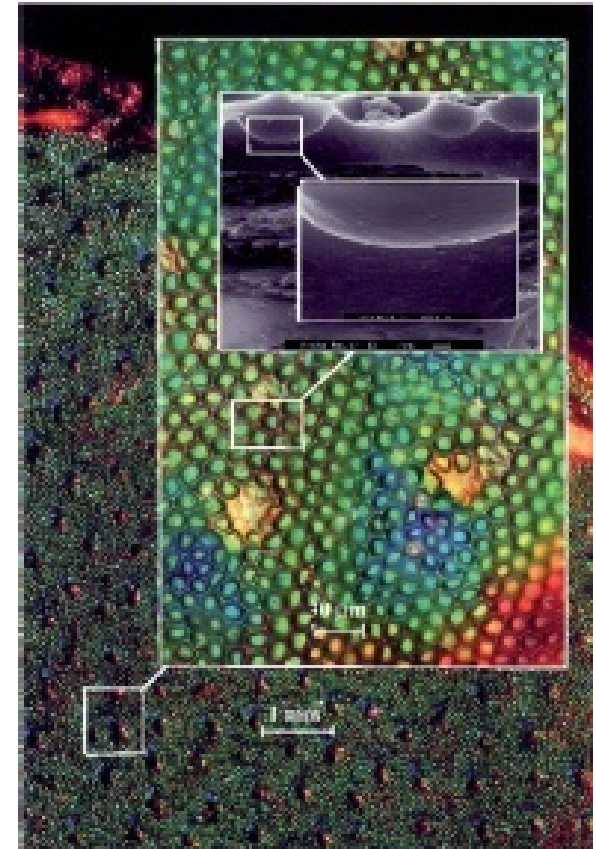
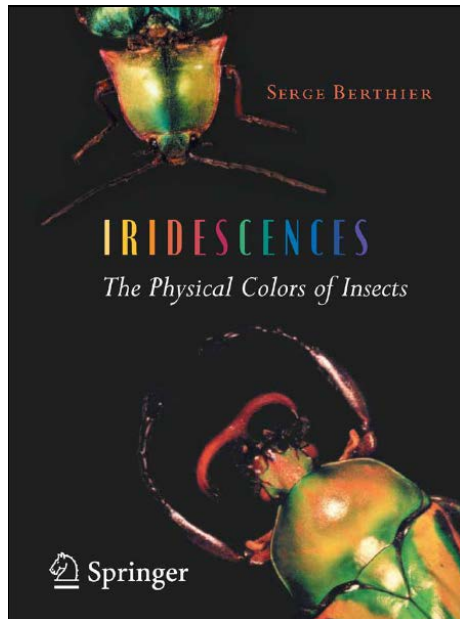
Absorp. vs. Scatt.



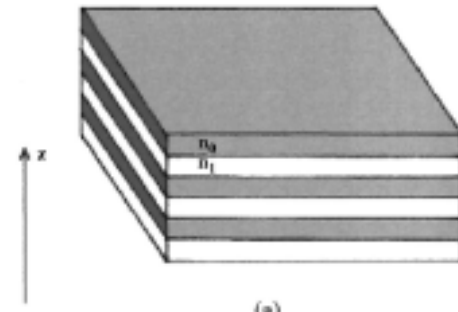
NATURAL STRUCTURAL COLOR



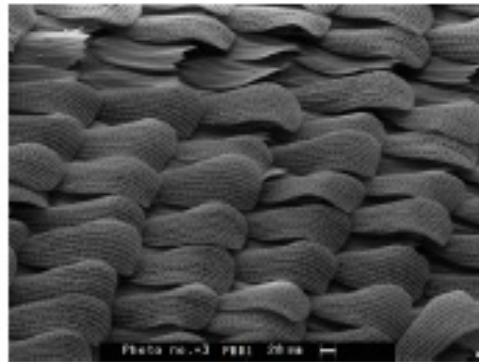
- 1-D structure: interference
- 2-D structure: interference + diffraction
- 3-D structure: crystalline diffraction
- Amorphous structures: scattering



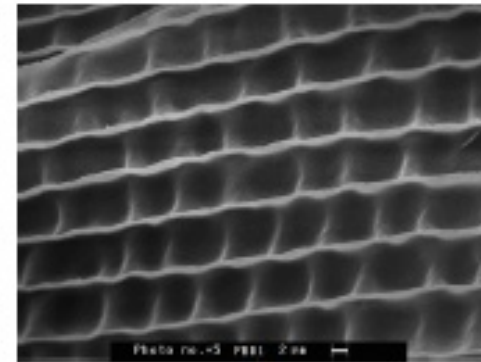
NATURAL STRUCTURAL COLOR



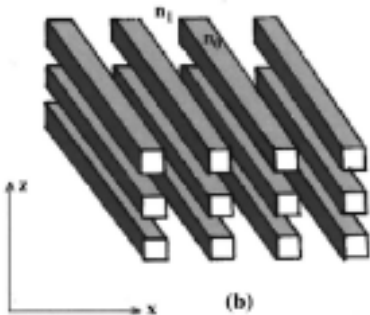
(a)



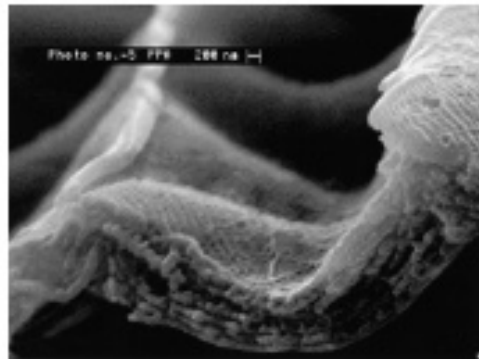
(a)



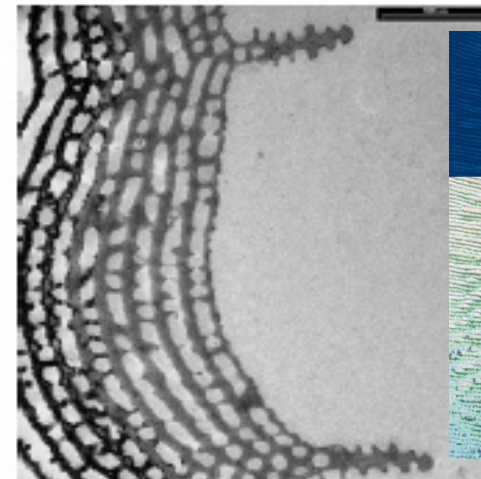
(b)



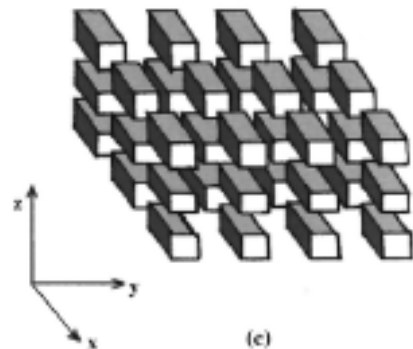
(b)



(c)



(d)



(c)

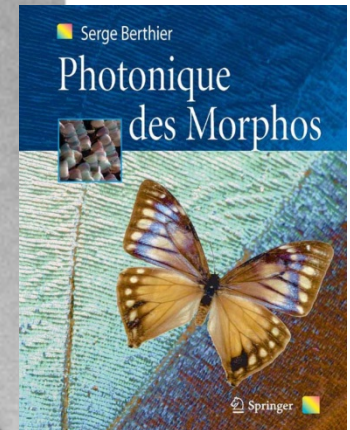
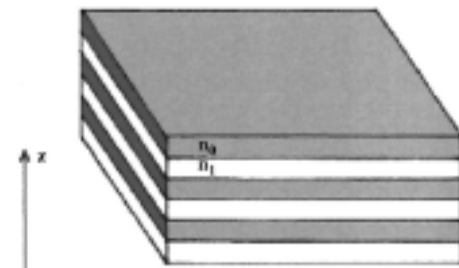
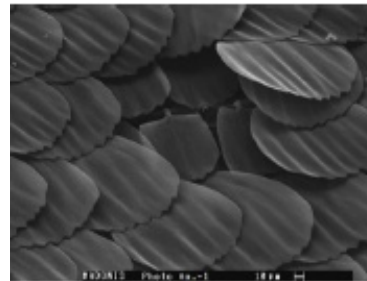


Figure 7.20. Structural organization of *Papilio—Papilio myles*. (a) cover structural scales. (b) a striated network and undulations forming a counter-striae network. Below, a section performed perpendicularly to striae next to the center of a bastin and showing the (c): SEM, (d): TEM.

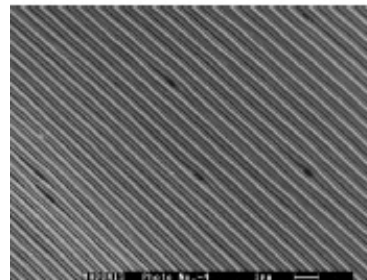
NATURAL STRUCTURAL COLOR



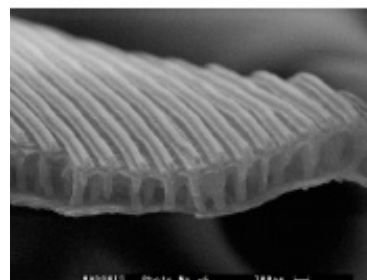
(a)



(a)

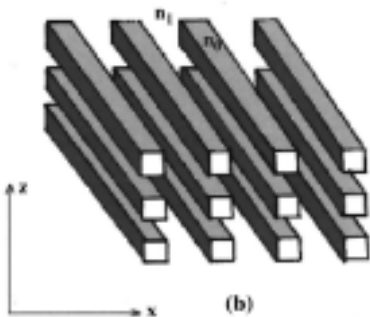


(b)

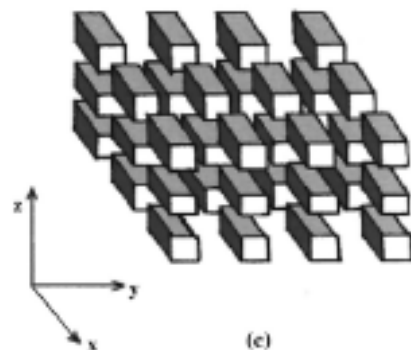


(c)

Figure 8.36. SEM image of *Morpho adonis*. (a) some large cover scales have been removed in order to expose ground scales. In the (b) picture, the very regular striated network of cover scales. (c) a lateral image showing the single-lamella structure.



(b)

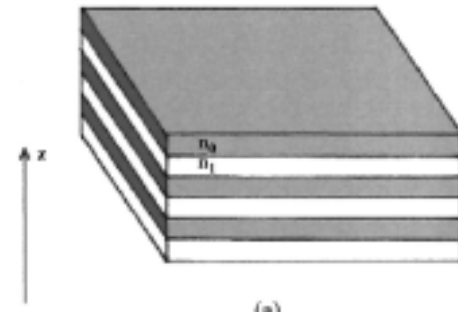


(c)

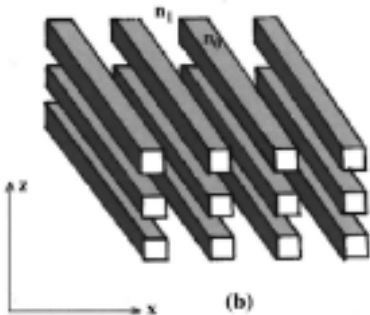


Figure 8.37. The bright *Morpho cypris* and *Morpho rhetenor* and the very mat *Morpho anaxibia*. The reflecting structures of the former are inclined to a large extent on the wing plane and the specular component of the reflection is significant, so that under collimated light, one cannot see color on both wings at the same time. *M. anaxibia* presents convex and very numerous cover scales, whereas the former are deprived of them.

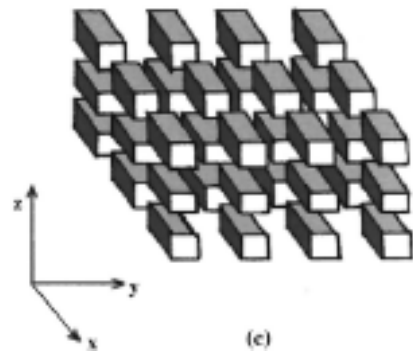
NATURAL STRUCTURAL COLOR



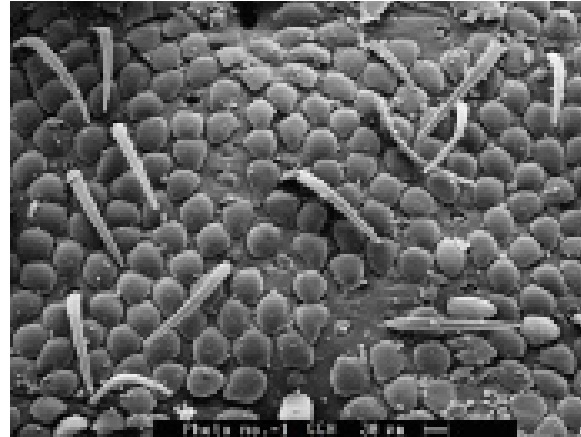
(a)



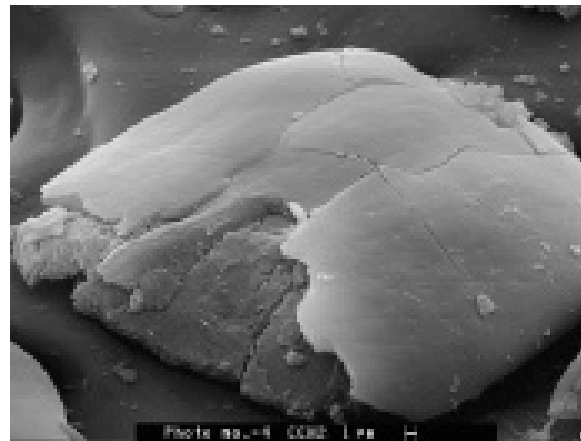
(b)



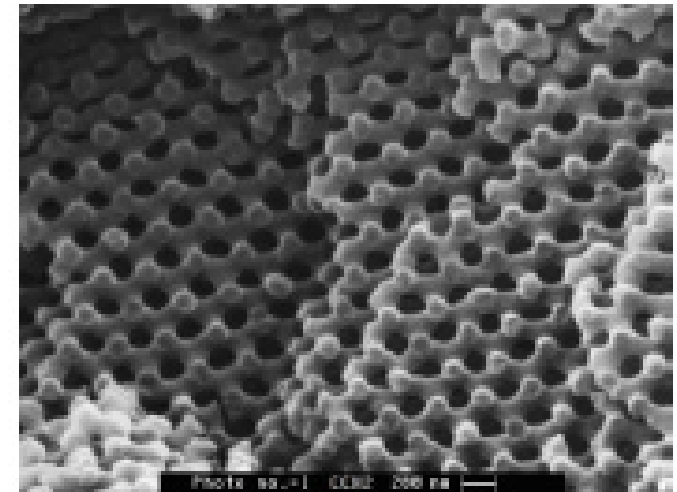
(c)



(a)

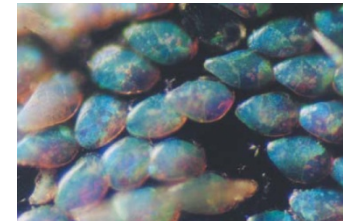


(b)



(c)

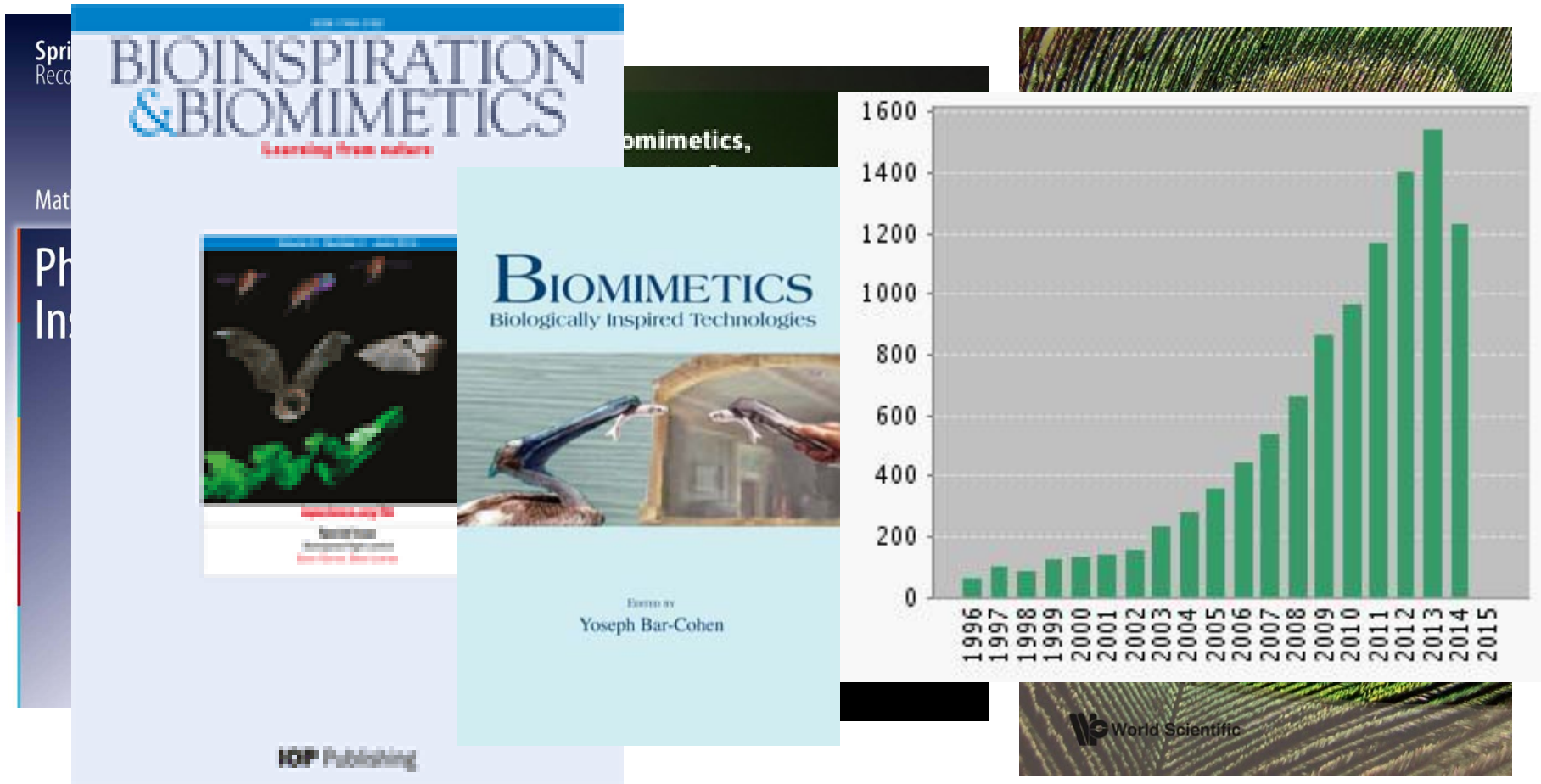
Figure 9.6. Organization and structure of *Carcharias* *Cypris lamcocki* scales. Like in butterflies, one can distinguish two types of scales that unevenly cover the elytron surface (a). A broken scale exposes the internal structure. One can very clearly distinguish reticular planes (b). The grating is tetrahedral (c).



NATURAL STRUCTURAL COLOR



- **Biomimetics using nanophotonic structures**





- **Biomimetics using nanophotonic structures**

Physical methods for investigating structural colours in biological systems

The original colours of fossil beetles

JOURNAL
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SOCIETY
Interface

The structure–function relationships of a natural nanoscale photonic device in cuttlefish chromatophores

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Reconfigurable Infrared Camouflage Coatings from a Cephalopod Protein





- **Biomimetics using nanophotonic structures**

Detaille Insect Colours and Visual Appearance in the Eyes of Their Predators

Marc Théry^{*,1} and Doris Gomez^{*,1}

**Département d'Ecologie et de Gestion de la Biodiversité, CNRS UMR 7179, Muséum National d'Histoire Naturelle, Brunoy, France*

icle

Iridesc grassquit feather barbules: the role of keratin and melanin

ie-black

Molecular and Physiological Basis of Colour Pattern Formation

L Structural colour in animals—simple to complex optics

SA

Andrew R. Parker^{*}, Natalia Martini

Department of Zoology, University of Oxford, South Parks Road, Oxford OX1 3PS

Available online 6 September 2005





- **Biomimetics using nanophotonic structures**

164 J. Opt. Soc. Am. B / Vol. 31, No. 1 / January 2014

Andkjær *et al.*

**Inverse design of nanostructured surfaces
for color effects**

**Perspective on synthesis, device structures, and
printing processes for quantum dot displays**



**Nanoplasmonics: past, present, and
glimpse into future**

Lee,⁵ and

OPEN ACCESS

materials

ISSN 1996-1944

www.mdpi.com/journal/materials

Ligh *Review*

Review of Plasmonic Nanocomposite Metamaterial Absorber



- **Biomimetics using nanophotonic structures**

UNIVERSITY OF SOUTHAMPTON, SCHOOL OF ELECTRONICS AND COMPUTER SCIENCE, MAY 2007

INTEGR. COMP. BIOL., 43:591–602 (2003)

A Fourier Tool for the Analysis of Coherent Light Scattering by Bio-Optical Nanostructures¹

*L **Antireflection and Light Trapping Scheme
Development with Biomimetic
Metamaterials**

DRRES†³
*v Museum, University of Kansas,
e, Kansas 66045-7561*

by Sean E. Nuzum

light harvesting
COMMUNICATION

www.rsc.org/chemcomm

Inorganic chiral 3-D photonic crystals with bicontinuous gyroid structure replicated from butterfly wing scales†





• Biomimetics using nanophotonic structures

nature
nanotechnology

LETTERS

PUBLISHED ONLINE 12 AUGUST 2012 | DOI: 10.1038/NANO.2012.128

Printing colour at the optical diffraction limit

Karthik Kumar^{1†}, Huigao Duan^{1†}, Ravi S. Hegde², Samuel C. W. Koh¹, Jennifer N. Wei¹
and Joel K. W. Yang^{1*}

vol. 30, No. 8

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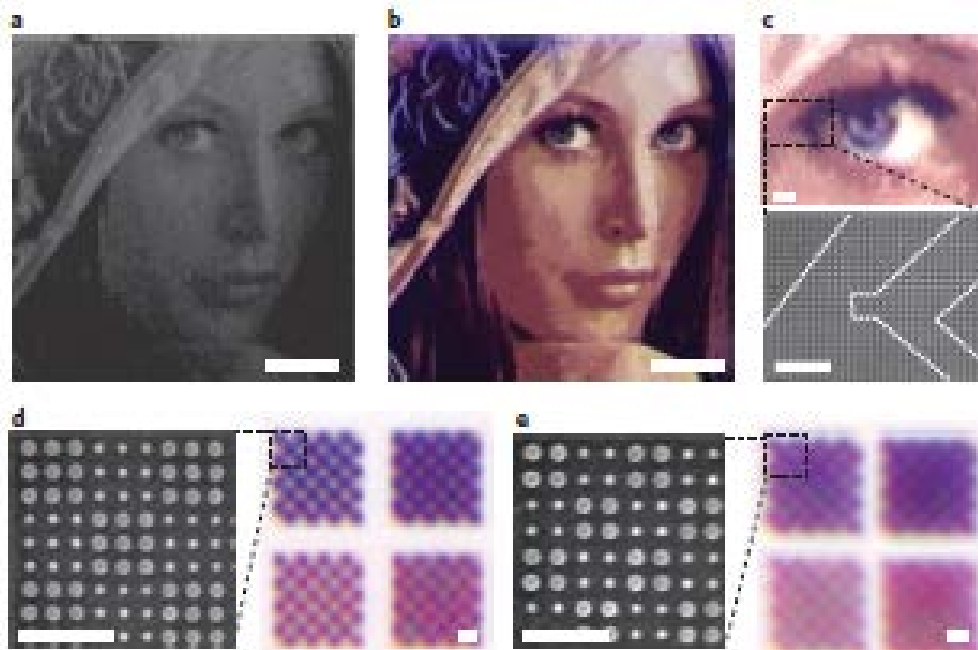
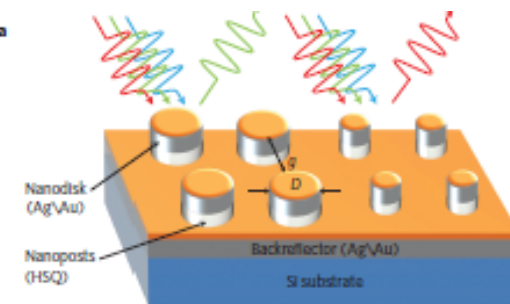
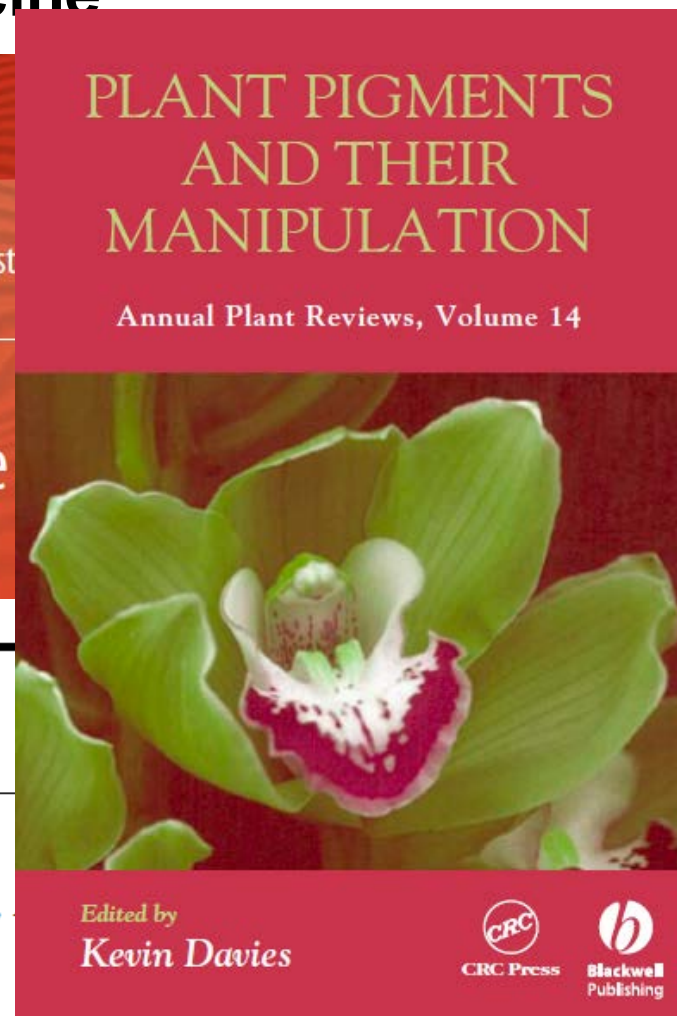
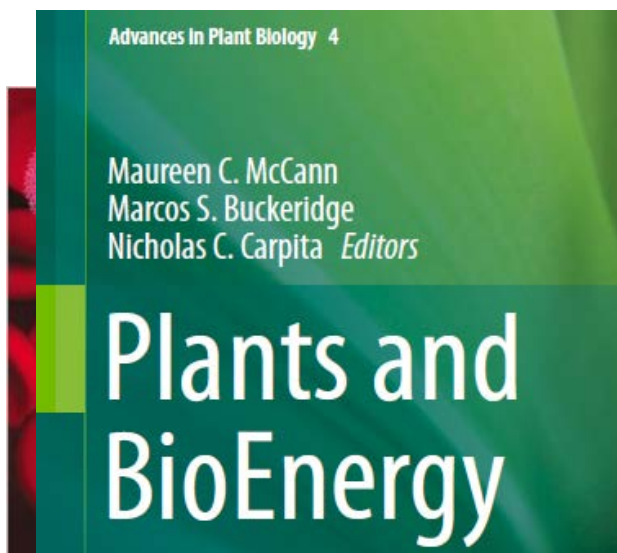


Figure 1 | Working principle and fabrication process for high-resolution plasmonic colour printing. **a** Interaction of white light with two closely spaced pixels, each consisting of four nanodisks. As a result of the different diameters (D) and separations (g) of the nanodisks within each pixel, different wavelengths of light are preferentially reflected back. **b**, Method of fabrication of nanostructures. (i) A 95-nm-thick layer of HSQ is spin-coated onto a silicon wafer piece and patterned using EBL. (ii) The unexposed portions of the HSQ are developed away using a salty developer (see Methods), leaving HSQ nanoposts. (iii) The nanoposts and backreflector are coated using a single metal evaporation step. (iv) A 70° side-angle SEM image of nanostructures after metal deposition. Colour information is encoded in the nanopost diameter and spacing of the resist structure.



- **Nanobiotechnology and nanomedicine**



Pigments of fungi (Macromycetes)

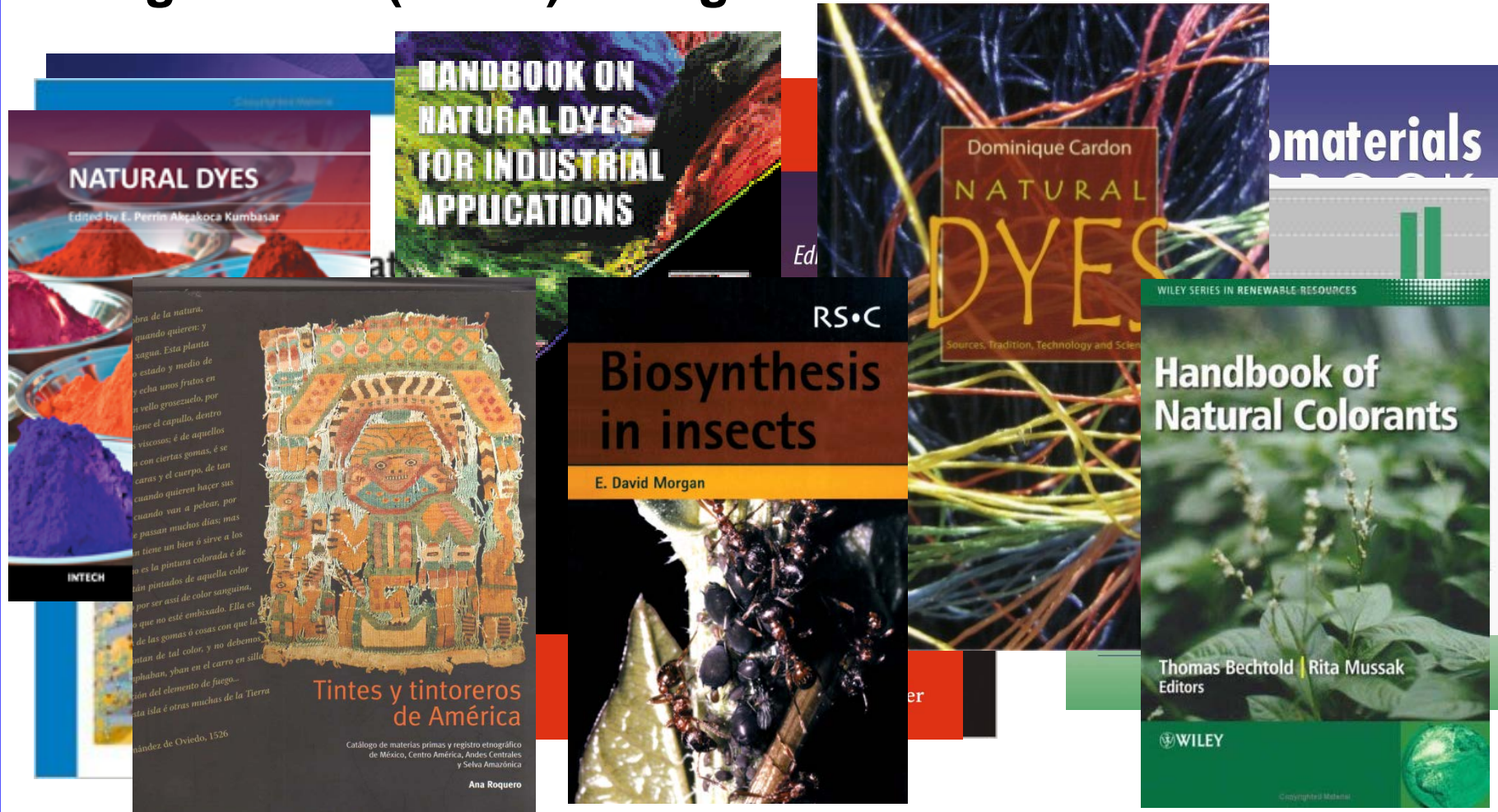
Melvyn Gill

School of Chemistry, The University of Melbourne, Parkville, Victoria 3052,

HYBRID NANOMATERIALS

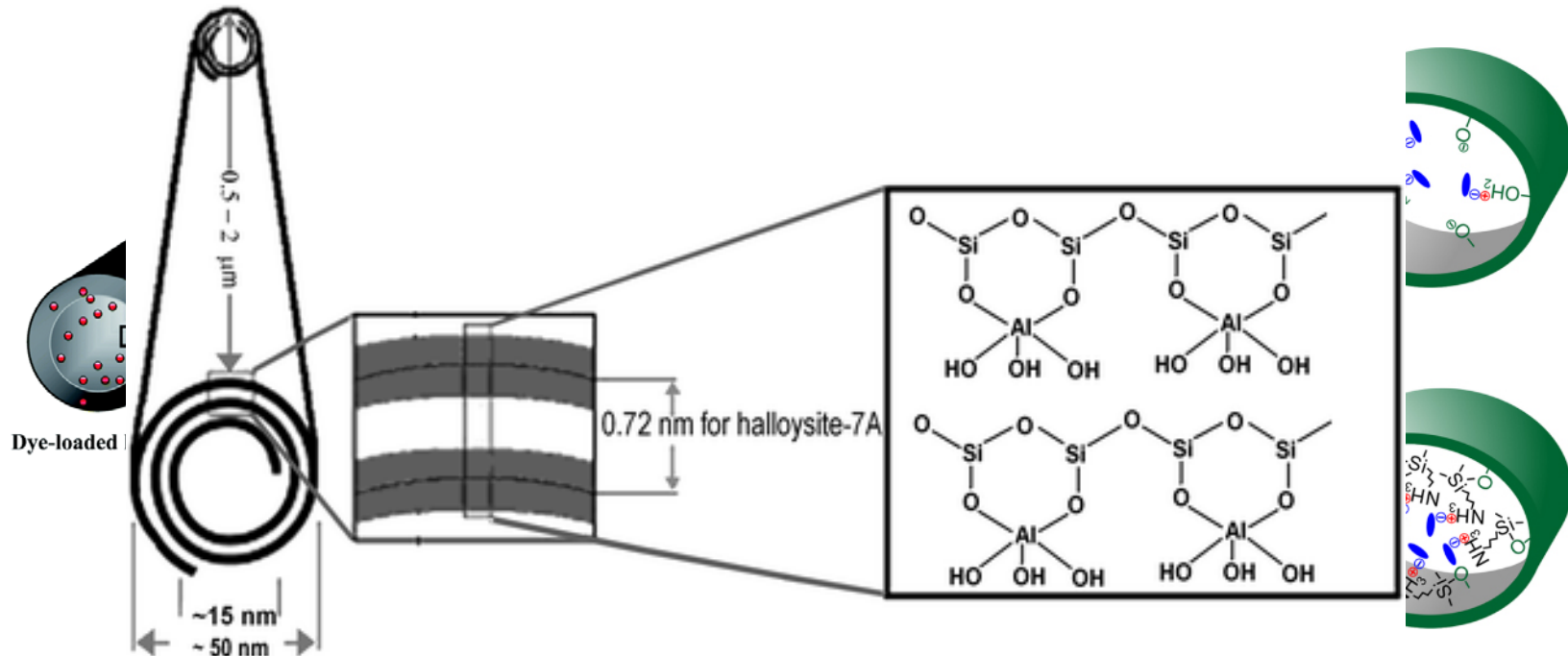


- Inorganic 1 + (inor 2) or organic 2

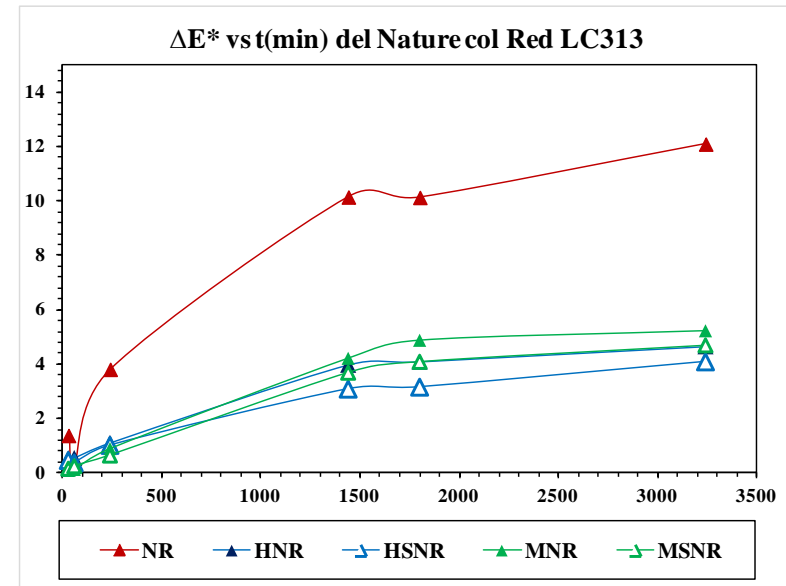
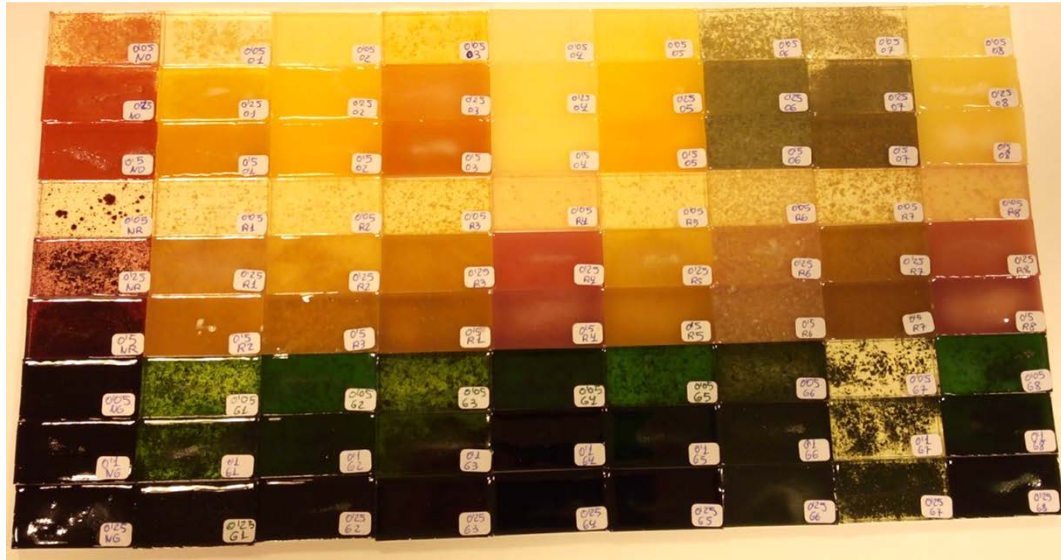




- Nanostructured hybrid pigments in the GVC-UA
 - natural dye + hydrotalcite / montmorillonite / laponite
 - natural dye + **halloysite**
 - **metal salt** (inorganic 1) + nanoclay (inorganic 2)



HYBRID NANOMATERIALS



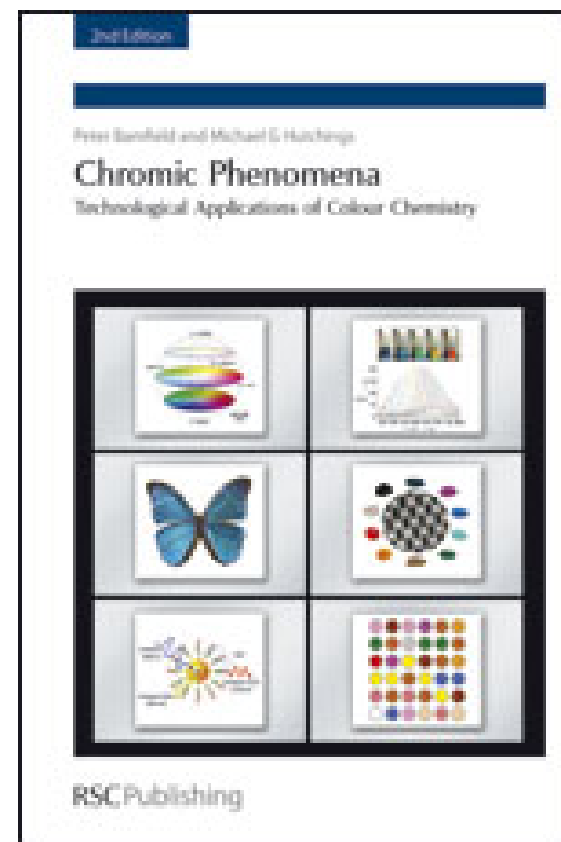
- Colored nano-bio-composites with bioresin and natural nanopigments varying synthesis factors with fixed concentration
- UV-VIS lightfastness of the Natural Red dye as nanopigment
- Nano-bio-composite based on bioresin and beetroot natural dye with two different nanoclays and mordant modifier (bottom)





▪ **Chemical substance (colorant) suffering a color change when an **external stimulus** is activated:**

- reversible vs. irreversible change
- contactless measurement
- stimulation phenomena:
 - UV radiation \Rightarrow VIS, Temperature,
 - electricity, pressure,
 - by aggregation (excitons, etc.),
 - plasmonic coupling,
 - chronochromism,
 - biochromism,
 - etc.



FUNCTIONAL PIGMENTS



Light manipulation
refraction, laser, non-linear optics, etc.

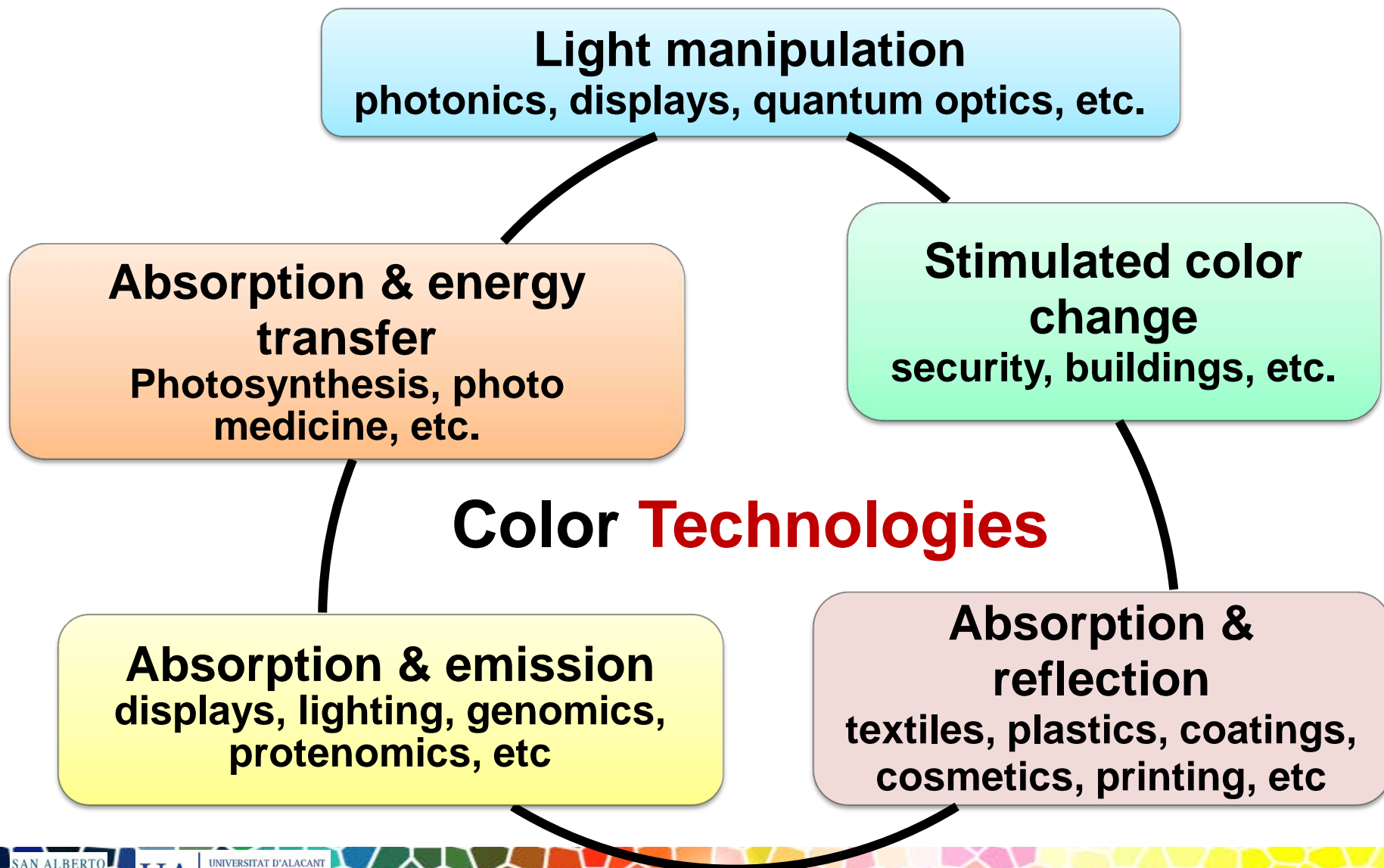
Absorption & energy transfer
Photo-thermal, electric, etc.

Stimulated color change
Thermo-chromism, ion-, etc.

Color phenomena

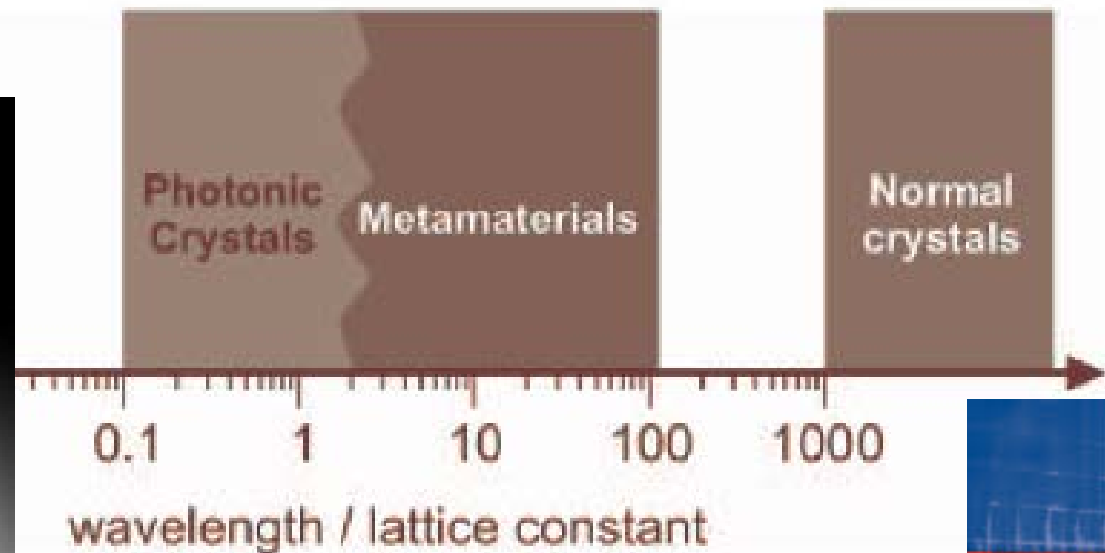
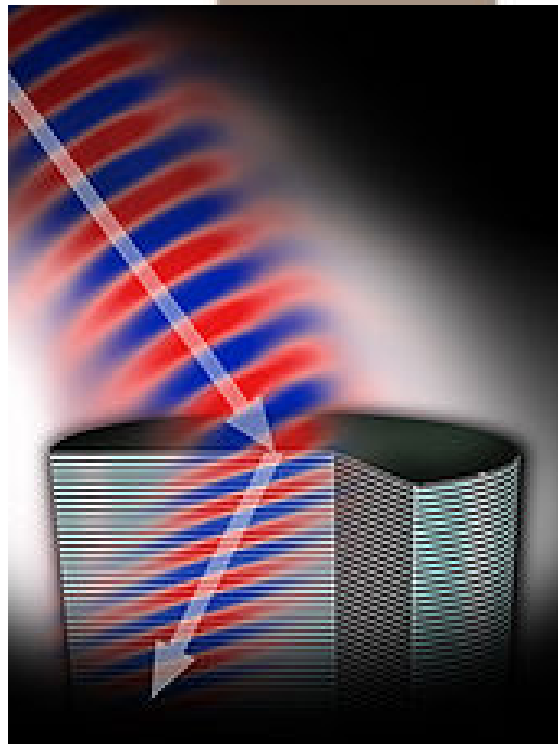
Absorption & emission
luminiscence, etc.

Absorption & reflection
dyes & pigments



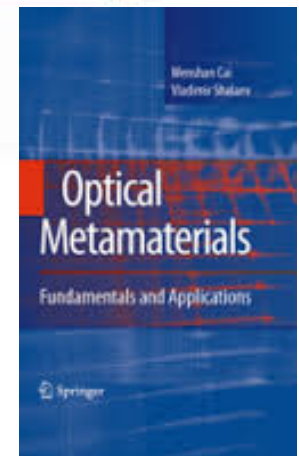


- **Metamaterials with negative refraction index:**
 - very few in Nature



Photonic crystals $a \approx \lambda$

Metamaterials $a < \lambda$

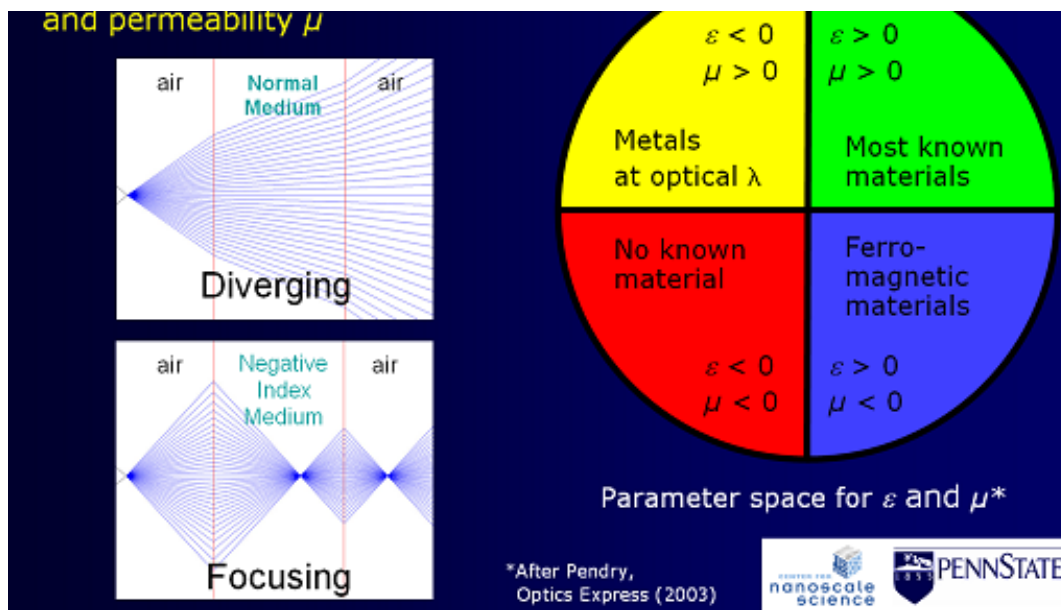
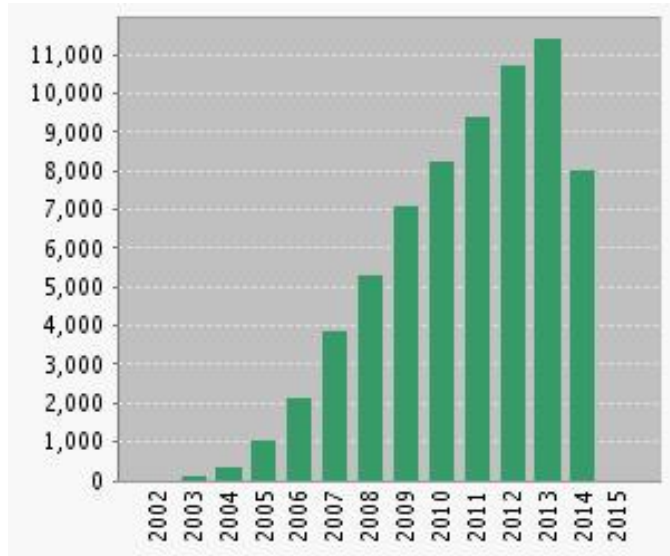




Metamaterials with negative refraction index:

A Broadband Negative Index Metamaterial at Optical Frequencies

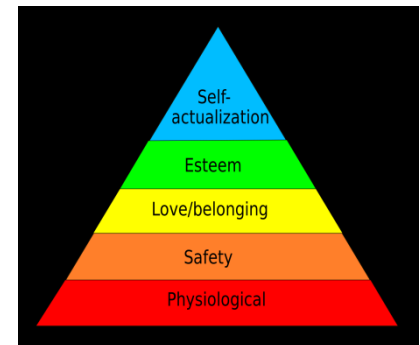
Ashwin C. Atre,* Aitzol García-Etxarri, Hadiseh Alaeian, and Jennifer A. Dionne



MID-TERM BALANCE 2



- Limit down? Far?
- Frontiers up (macro-perceptual)?
 - Visual neuroscience:
 - color – hearing, color – smell, etc.
- **FOR WHAT?**
 - Health, sustainability (energy, food, etc.), security, economical and ethic value, etc.
 - Taleb: black vs. gray swan
 - Taleb: anti-fragile
- Disruptive innovation? GVC-UA?





Pionero en universidades

Reflexiones de alguien que realiza múltiples actividades docentes, investigadoras y directivas

Análisis prospectivo de la Universidad de Alicante

noviembre 7th, 2014 by verduset70

Ayer jueves 6 tuvo lugar una mesa redonda en el museo UA a cargo de los 5 rectores más recientes de la Universidad de Alicante. El tema del debate era: "La Universidad de Alicante: nuevos escenarios científico, educativo y empresarial".

Categorías

- » [About](#)
- » [Ciencia del Color](#)
- » [Ergonomía Visual](#)
- » [Estudiantes](#)
- » [Familia vs. Trabajo](#)





- **Disruptive** innovations from UA?
- From the Faculty of Sciences?
- University rankings
 - CALTECH no. 1
- Ranking < 200 for Chemistry-UA
- How we can keep or improve?
- Are we ready? **how** we do it?



Universitat d'Alacant
Universidad de Alicante
Facultat de Ciències
Facultad de Ciencias



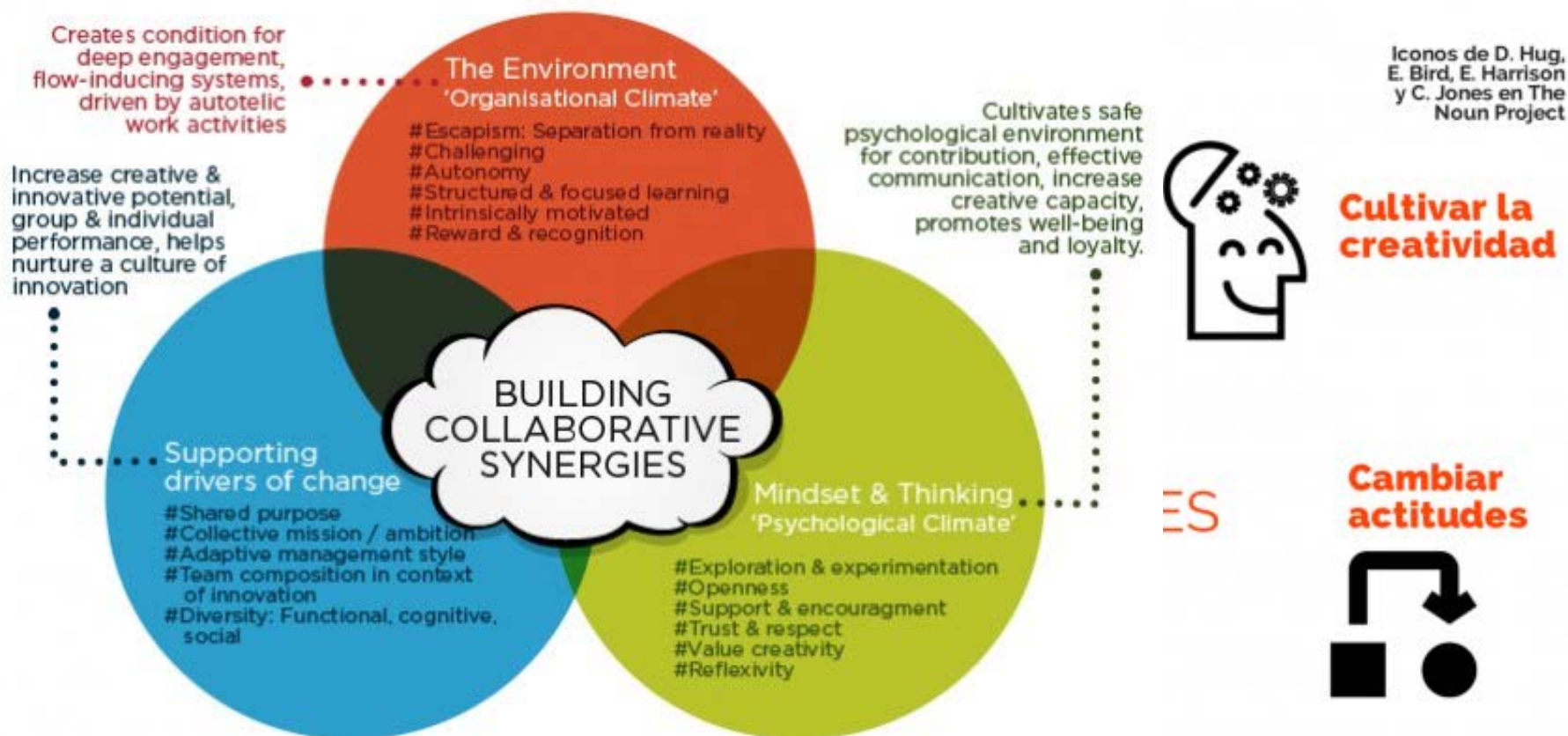
- **Research Technical Services:**
 - XPS, WDX, FRX, SEM, FT-IR, ATR, Raman, etc.
- **Pending advanced instrumentation**
 - multi-angle spectroscopic ellipsometry
 - spectral constants of absorption (K) and scattering to different measurement geometries (irradiation / observation)
 - multi-angle micro-spectrophotometer
 - X-CT (tomography)
 - (3D) transversal scanning of nanomaterials, etc.
 - interferometric microscopy using white light
 - 3D surface contactless profilometer



HUMAN RESOURCES



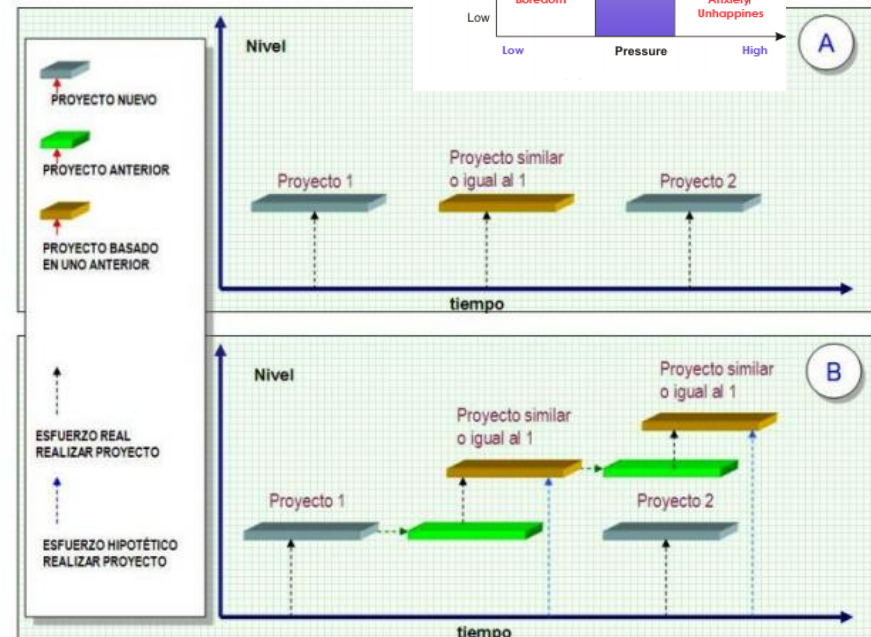
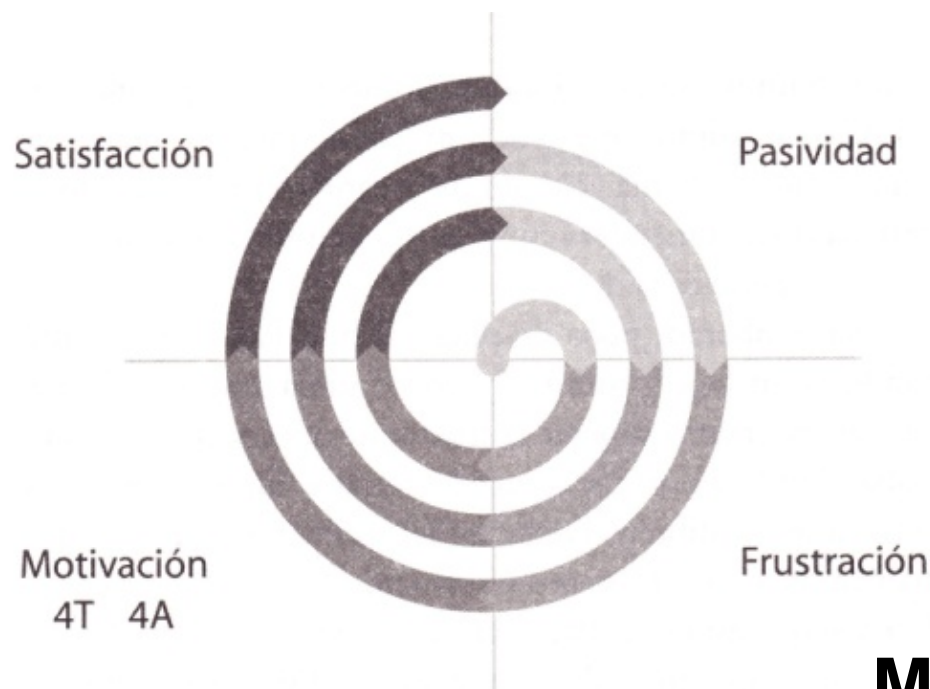
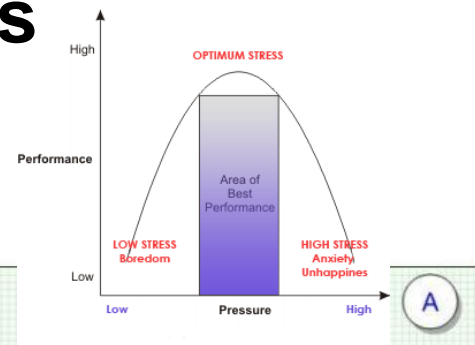
- Hybridization (knowledge exchange) in organizations stimulates **disruptive** innovation



HUMAN RESOURCES

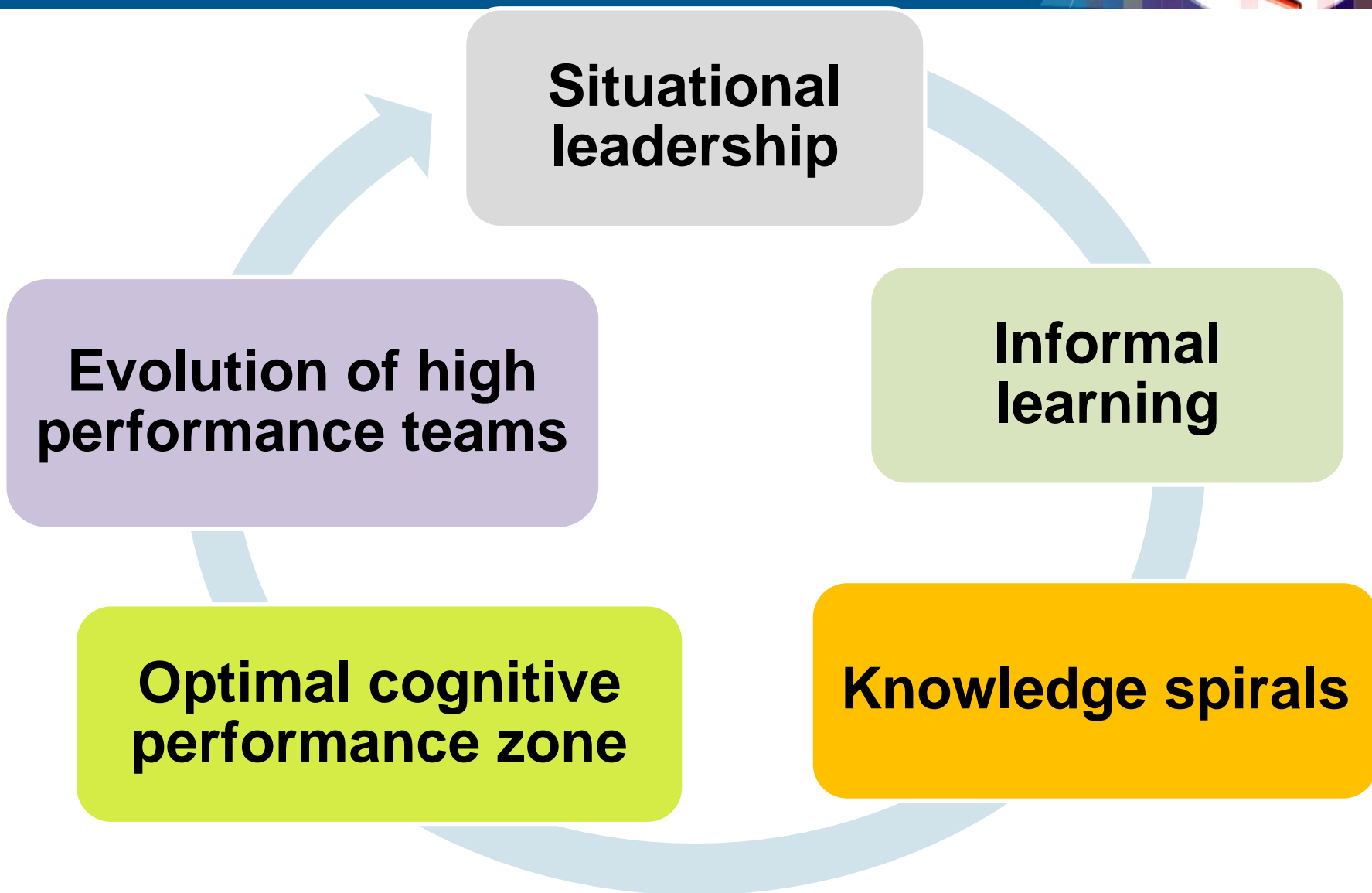


- **Motivation circle + knowledge spirals**
 - **Time** to reflect, talent to find out, etc.
 - Optimal cognitive **performance zone**



Fuente: Elaboración Propia.

MSc Thesis, PhD, projects



HUMAN RESOURCES



PI

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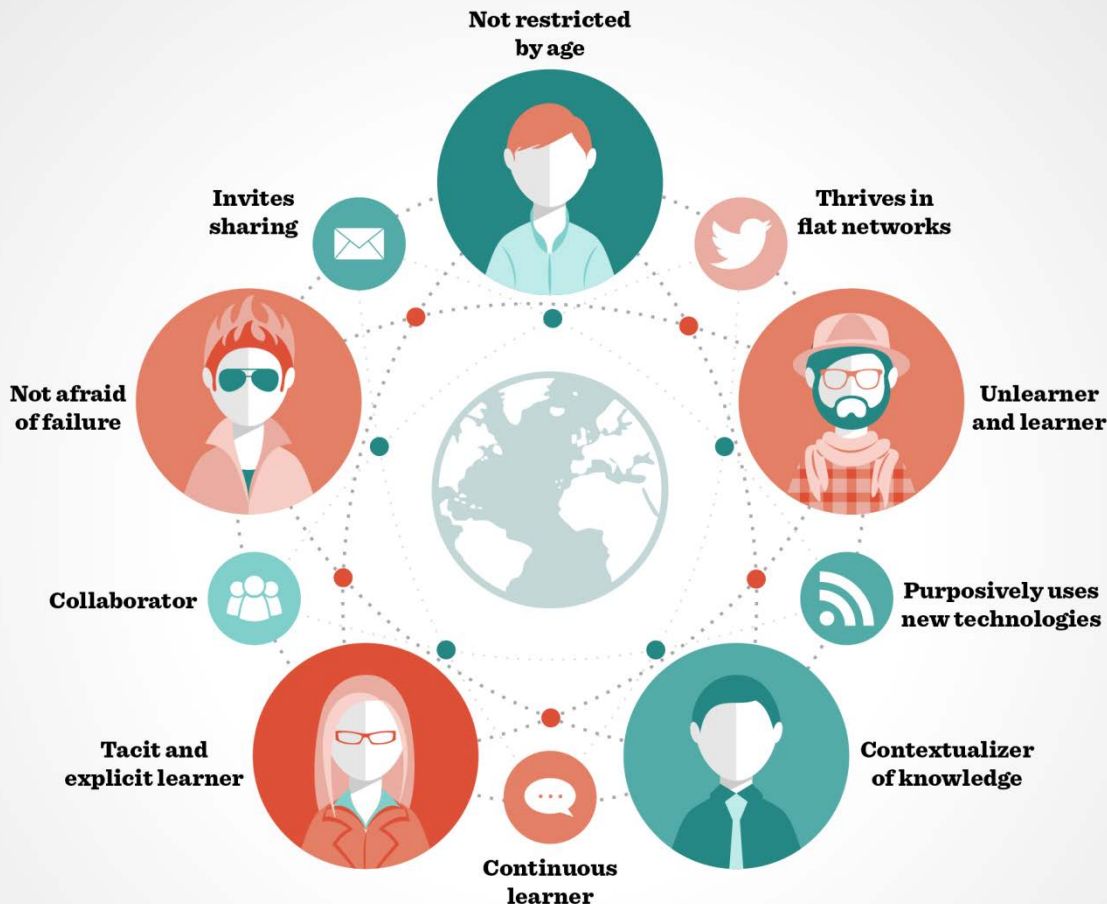
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l fracaso

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ersonas, ideas,
, etc.

CONCLUSIONS



- **UA: company of knowledge & talent training / education**
 - leaders, entrepreneurs, future of work, etc.
- **Science vs. Technol. vs. Challenges**
 - Relative value of the challenges (finan., etc.)
 - **Multi-scale** approach (color phys. & chem.)
- **New HR management: hybridization**
 - **Flexible** normative framework and necessary for adaptation to the new XXI age challenges
- **The **Time** is against us**

CONCLUSIONS



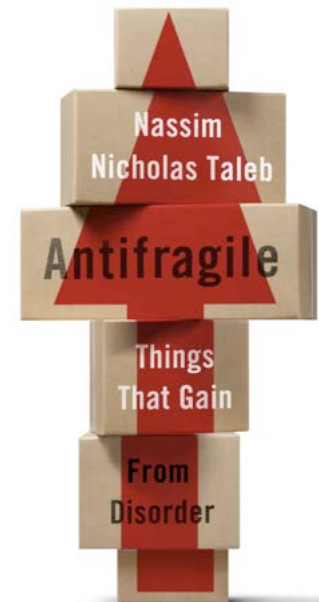
Knowledge

Talent

entrepreneurship



HR
hybridization, knowma
team work, etc.




R+D+i
challenges &
priorities

Multi
approaches
welfare, sustainability

CONCLUSIONS



WOODEN ON LEADERSHIP™



THE ART OF
SUCCESS

ACHIEVEMENT

True success comes only to an individual by self-satisfaction in knowing that you gave everything to become the very best that you are capable of.

PYRAMID OF SUCCESS

COMPETITIVE GREATNESS
"Perform at your best when your best is required. Your best is required each day."

POISE
"Be yourself. Don't be thrown off by events whether good or bad."

CONFIDENCE
"The strongest steel is well-founded self-belief. It is earned, not given."

CONDITION
"Ability may get you to the top, but character keeps you there – mental, moral, and physical."

SKILL
"What a leader learns after you've learned it all counts most of all."

TEAM SPIRIT
"The star of the team is the team. 'We' supercedes 'me.'"

SELF-CONTROL
"Control of your organization begins with control of yourself. Be disciplined."

ALERTNESS
"Constantly be aware and observing. Always seek to improve yourself and the team."

INITIATIVE
"Make a decision! Failure to act is often the biggest failure of all."

INTENTNESS
"Stay the course. When thwarted try again; harder; smarter. Persevere relentlessly."

INDUSTRIOUSNESS
"Success travels in the company of very hard work. There is no trick, no easy way."

FRIENDSHIP
"Strive to build a team filled with camaraderie and respect: comrades-in-arms."

LOYALTY
"Be true to yourself. Be true to those you lead."

COOPERATION
"Have utmost concern for what's right rather than who's right."

ENTHUSIASM
"Your energy and enjoyment, drive and dedication will stimulate and greatly inspire others."

"Success is peace of mind which is a direct result of self-satisfaction in knowing you made the effort to become the best of which you are capable."

John Wooden, Head Coach

SUCCESS

Success is not a destination, it is a journey.

12 LESSONS IN LEADERSHIP

1. Good Values Attract Good People
2. Love Is The Most Powerful Four-Letter Word
3. Call Yourself A Teacher
4. Emotion Is Your Enemy
5. It Takes 10 Hands To Make A Basket
6. Little Things Make Big Things Happen
7. Make Each Day Your Masterpiece
8. The Carrot Is Mightier Than A Stick
9. Make Greatness Attainable By All
10. Seek Significant Change
11. Don't Look At The Scoreboard
12. Adversity Is Your Asset

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in Moria
(2 times)**

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Francisco Miguel Martínez Verdú

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