Les Insectes et la Lumière

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Innover pour sauver le climat – Grenoble -16-06-2014

Sommaire

La démarche bio-inspirée
Principe

La lumière et la vie
Les leçons de la nature

2 exemples liés au énergies lumineuses

Lumière entrante :
Les insectes « capteurs solaires »

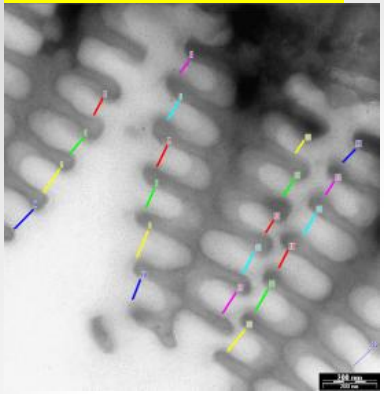
Lumière sortante :
Les insectes LED »

Démarche générale

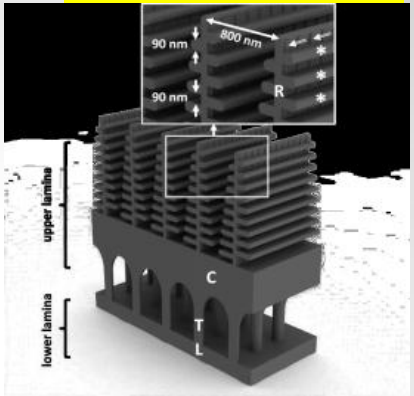
Identification
Pb communs

Recherche et compréhension des fonctions des structures

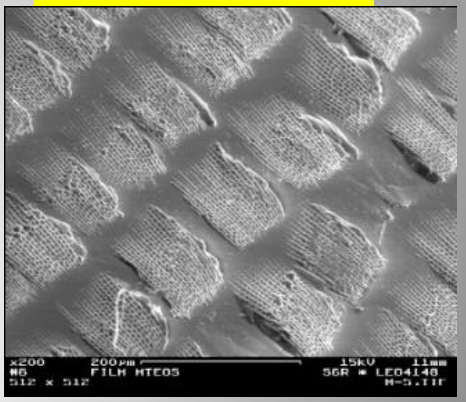
Caractérisation morphologique et physiques



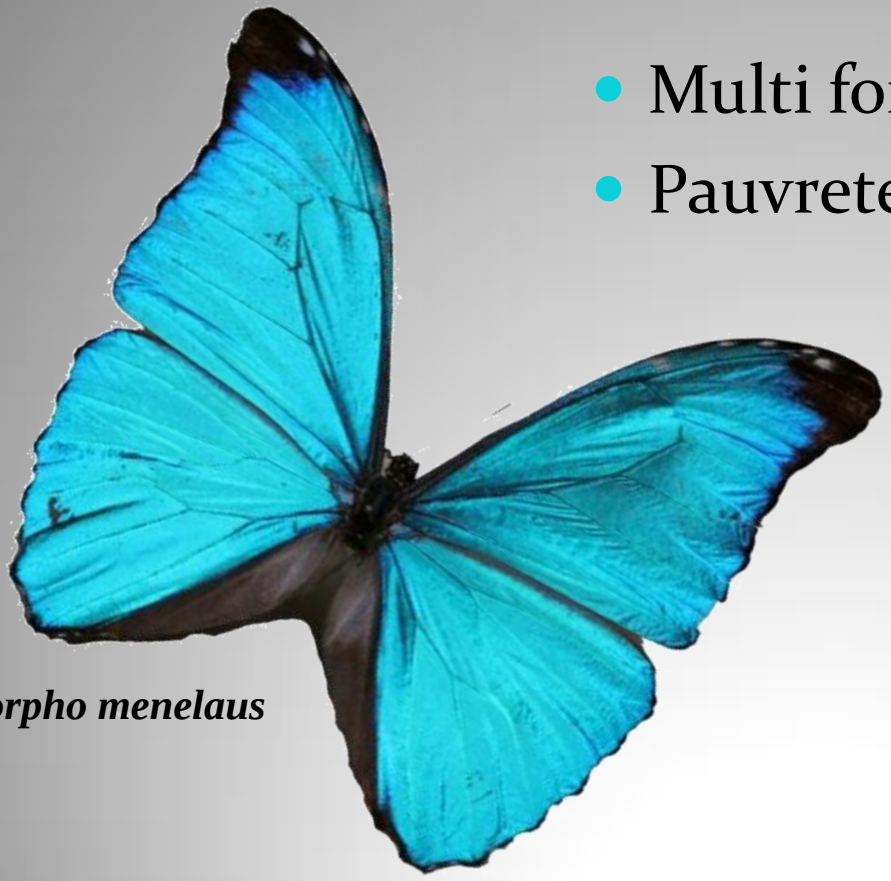
Modélisation
Extrapolation



Transfert
bio-inspiré



Les leçons de la nature



Morpho menelaus

- Multi fonctionnalité
- Pauvreté en matériaux

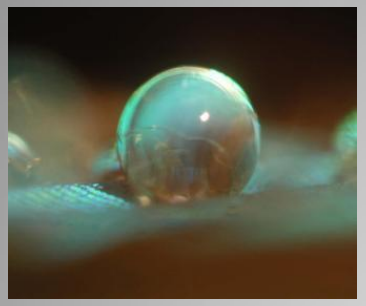
Solutions :

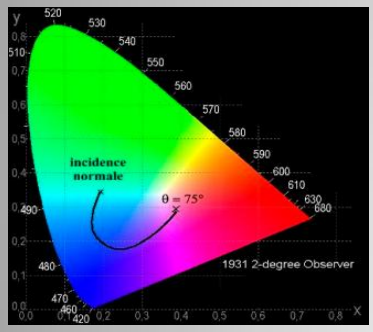
Désordre et Complexité

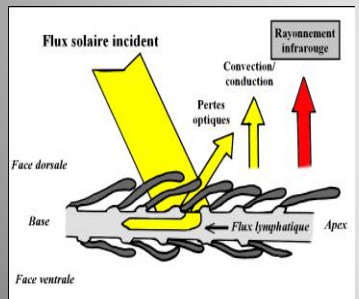
Caractéristiques des nano-structures naturelles:

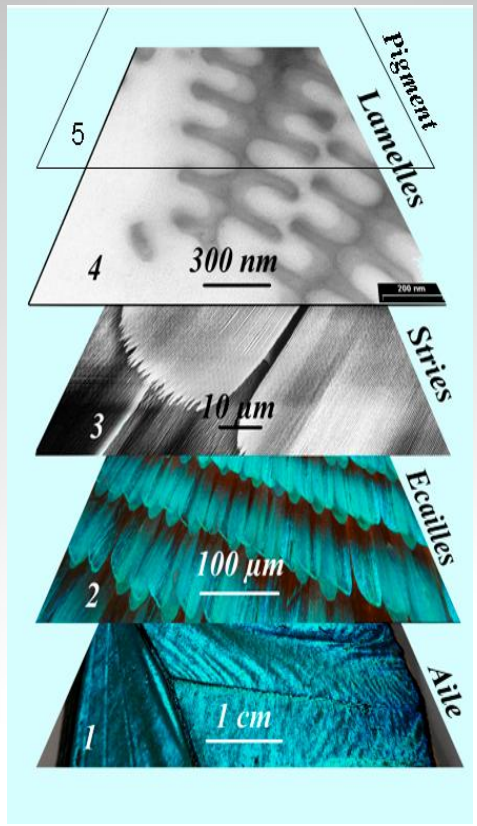
2 règles
1 prix

Multi-fonctionnelles – ***Complexes*** – ***Economes en éléments***









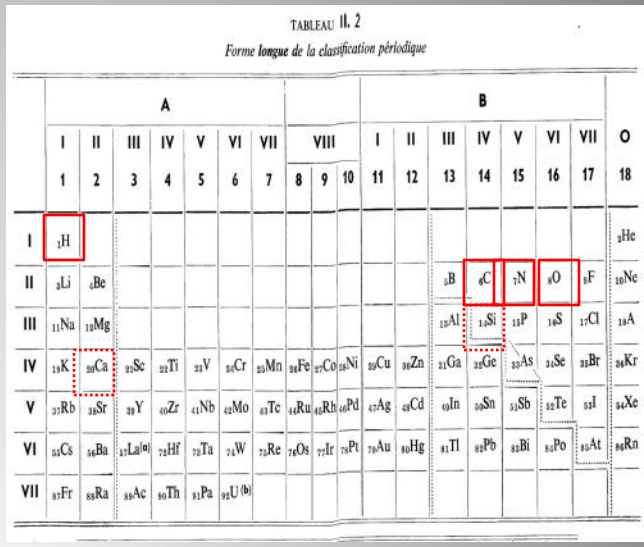


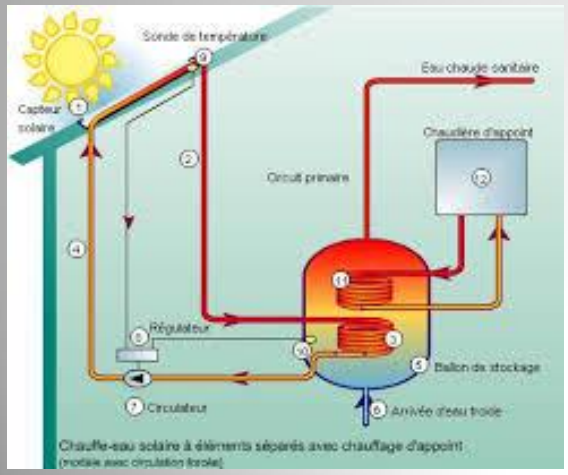
TABLEAU II. 2

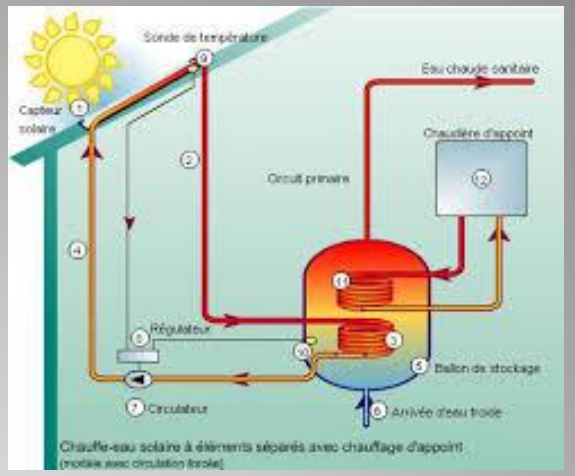
Forme longue de la classification périodique

	A							VIII			B							O
	I	II	III	IV	V	VI	VII				I	II	III	IV	V	VI	VII	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
I	1H																	2He
II	3Li	4Be											5B	6C	7N	8O	9F	10Ne
III	11Na	12Mg											13Al	14Si	15P	16S	17Cl	18A
IV	19K	20Ca	21Sc	22Ti	23V	24Cr	25Mn	26Fe	27Co	28Ni	29Cu	30Zn	31Ga	32Ge	33As	34Se	35Br	36Kr
V	37Rb	38Sr	39Y	40Zr	41Nb	42Mo	43Tc	44Ru	45Rh	46Pd	47Ag	48Cd	49In	50Sn	51Sb	52Te	53I	54Xe
VI	55Cs	56Ba	57La(a)	72Hf	73Ta	74W	75Re	76Os	77Ir	78Pt	79Au	80Hg	81Tl	82Pb	83Bi	84Po	85At	86Rn
VII	87Fr	88Ra	89Ac	90Th	91Pa	92U (b)												

Lumière absorbée – Lumière émise

Pb communs ?



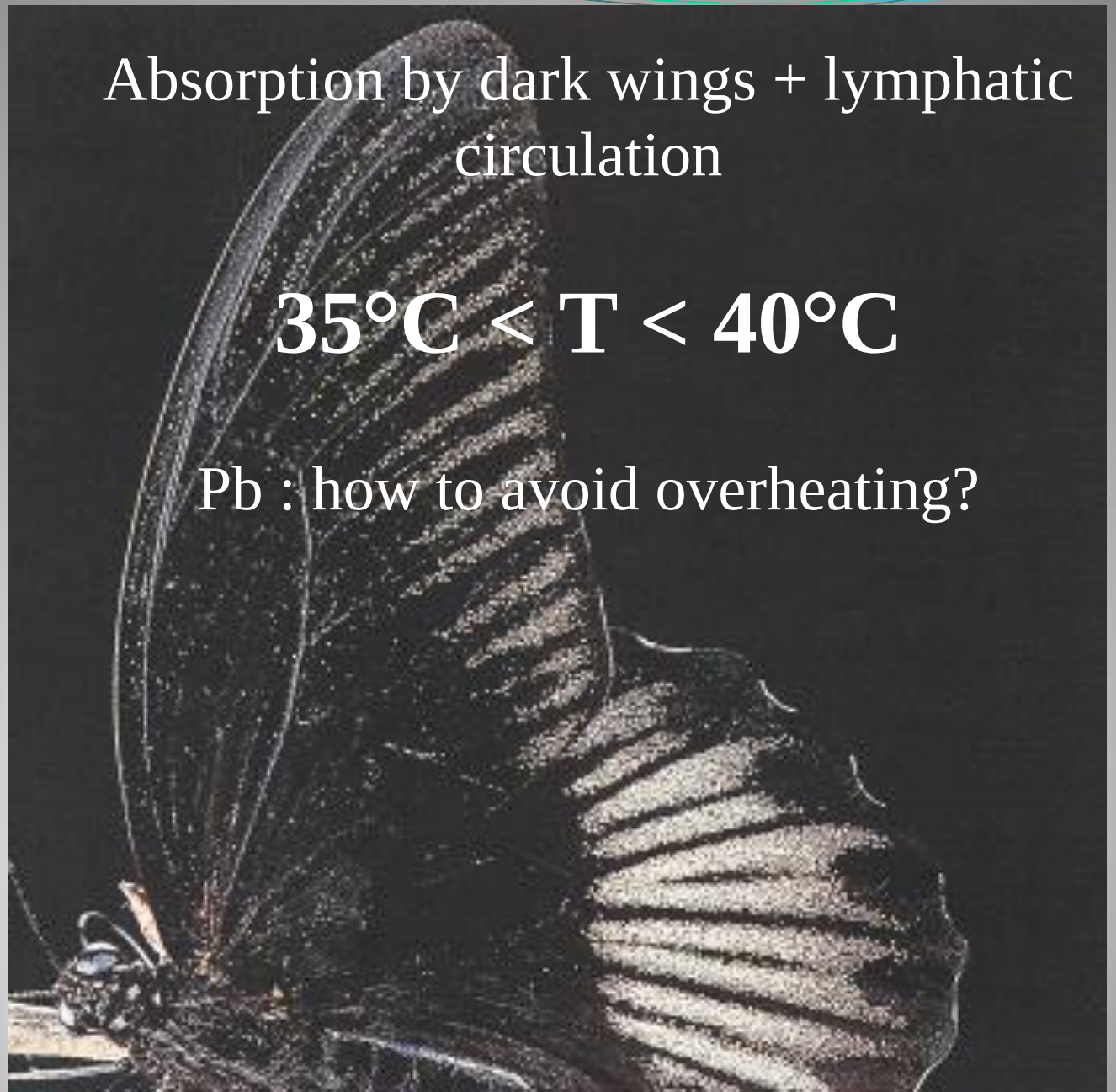


Se chauffer au soleil mais éviter la surchauffe (Fatale pour le papillon) (T max 40 – 45°)

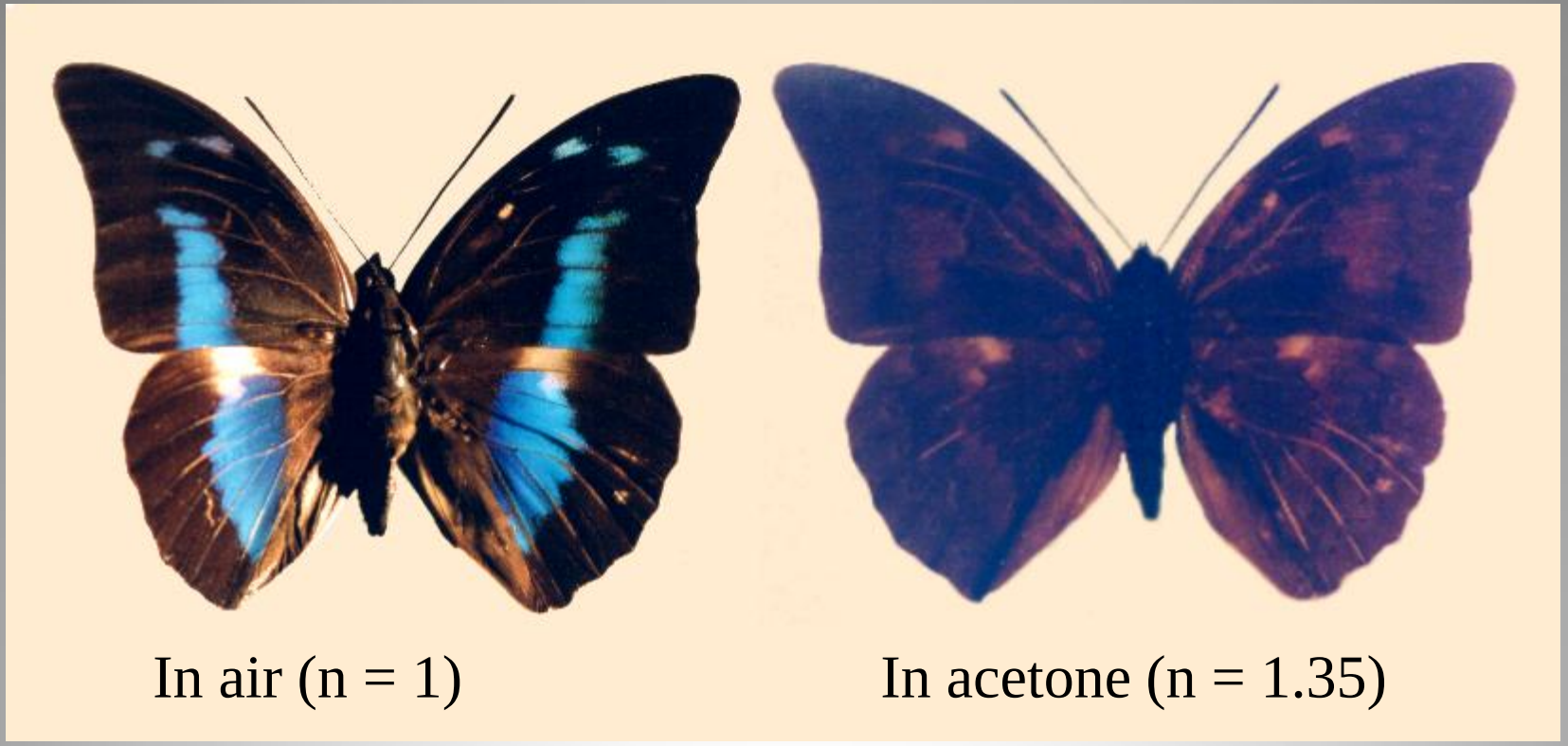
Produire de la lumière et l'extraire
(Contourner la réflexion totale)

Part 1 – Solar absorption by Insects

The constraints


Absorption by dark wings + lymphatic circulation
35°C < T < 40°C
Pb : how to avoid overheating?

Black : A combination of structure and pigments (melanin)

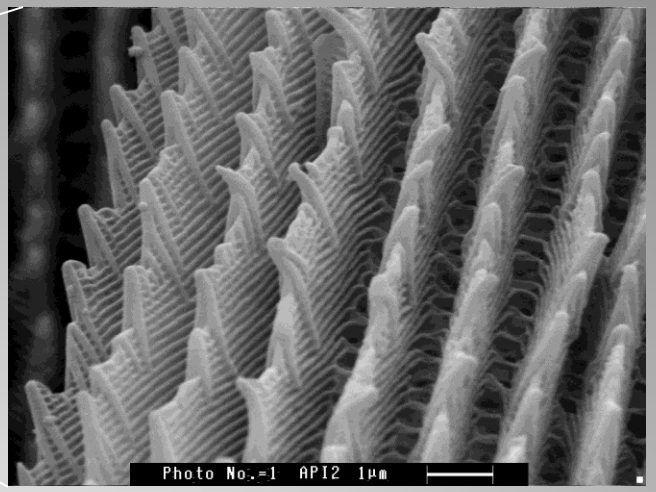


In air (n = 1)

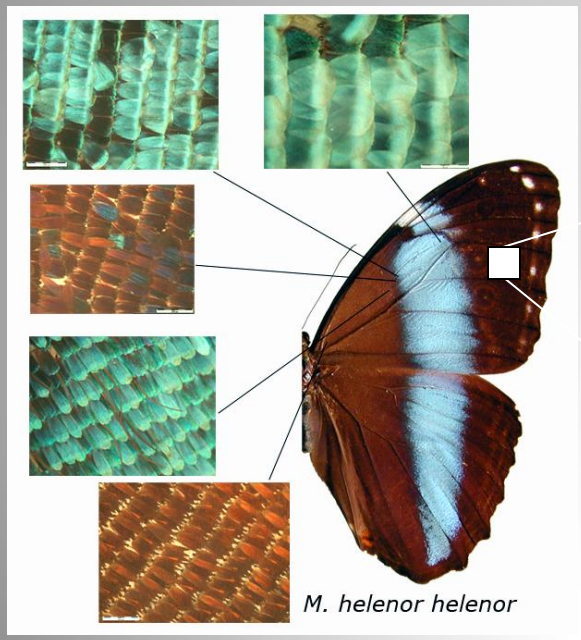
In acetone (n = 1.35)

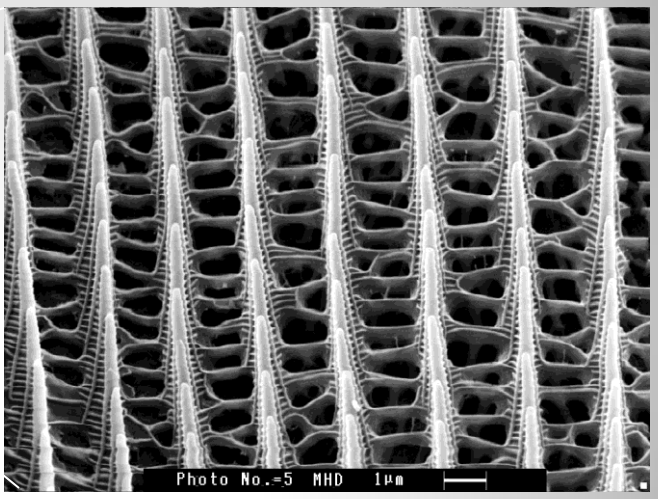
Prépona meeander in air and acetone.

Absorbing structures



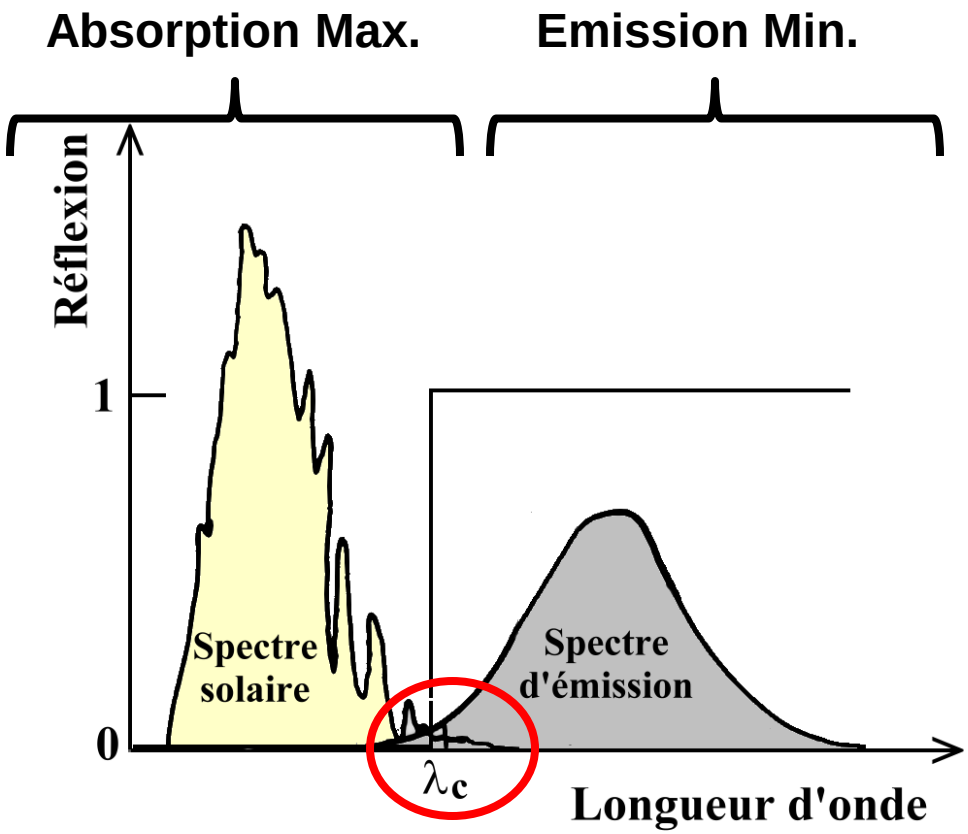
Dendrite structures





pping structures

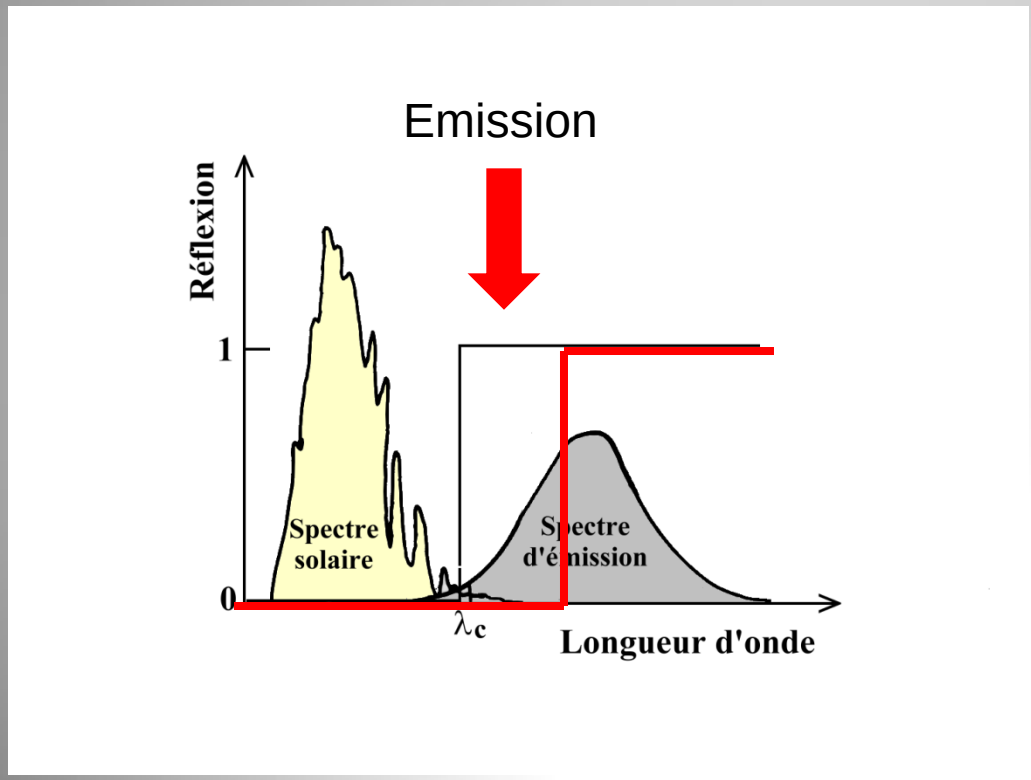
Ideal selective absorber

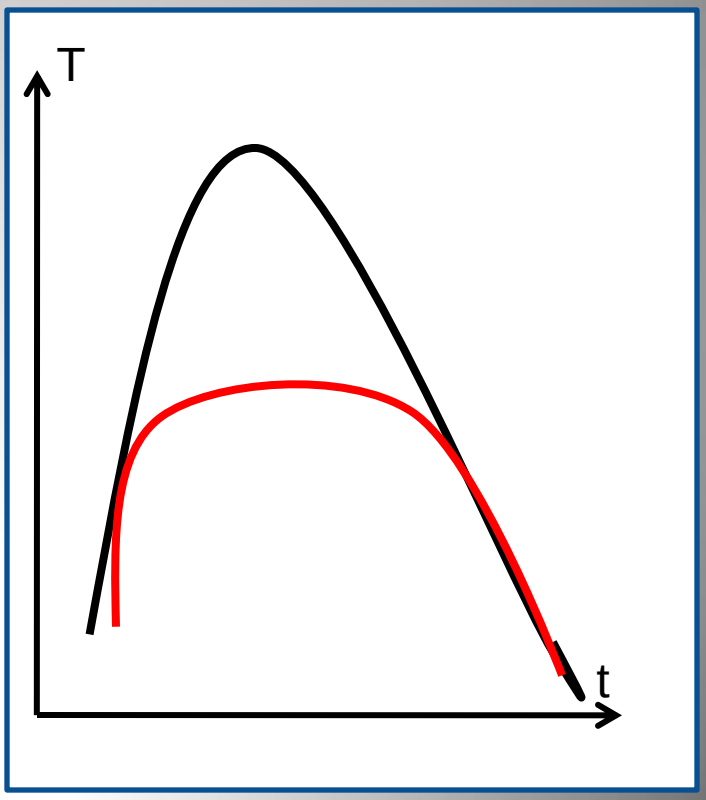


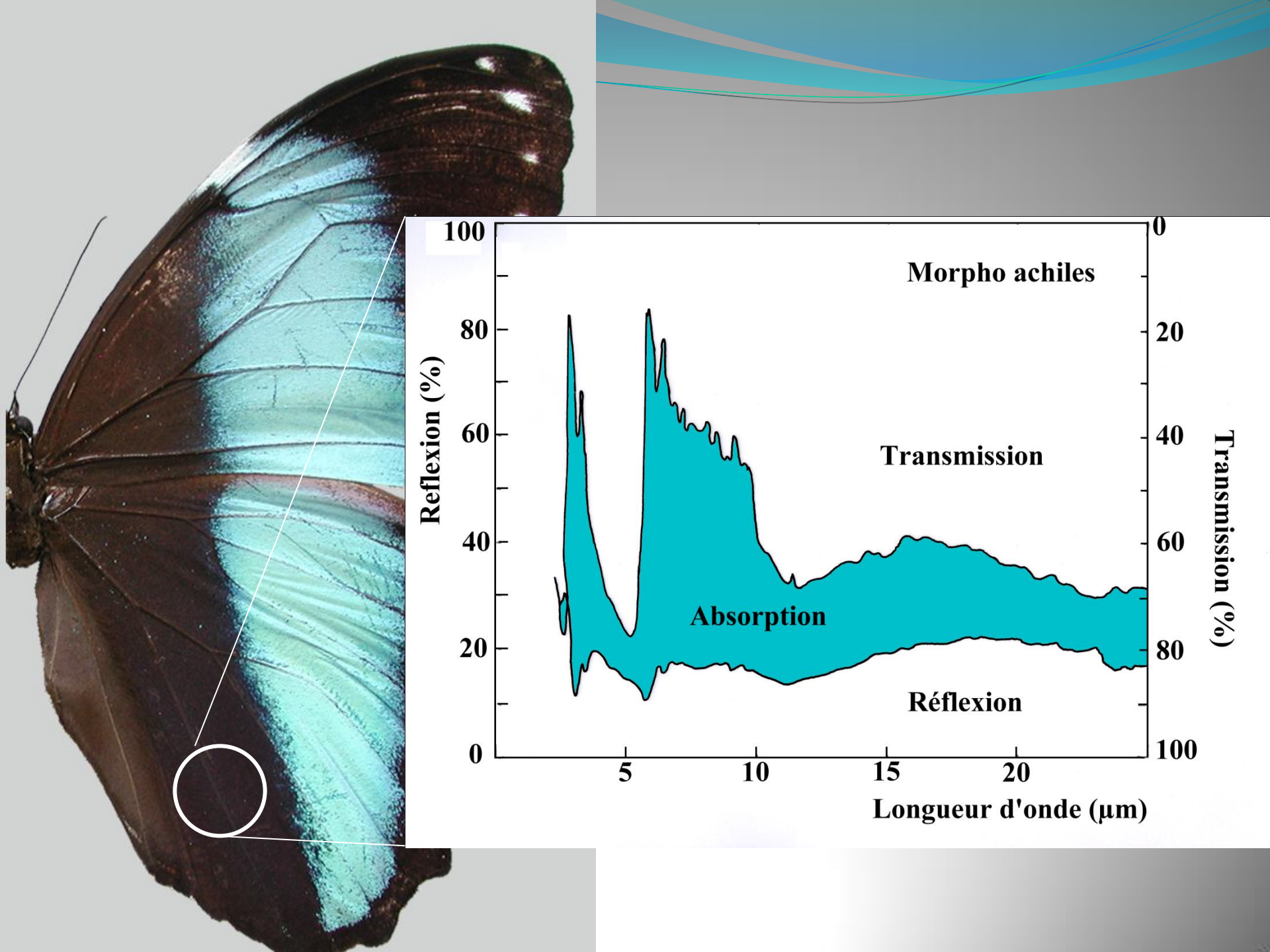
Cut of wavelength

Thermique Régulation :

A shift of λc, modifies α / ε, and the balance



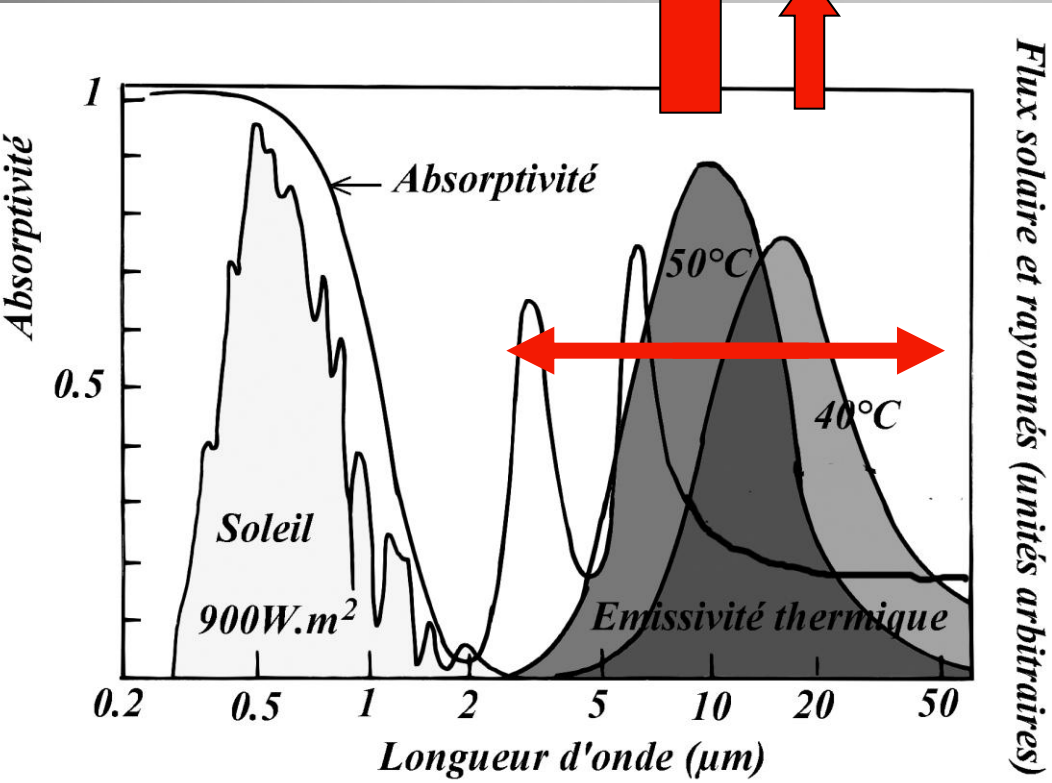


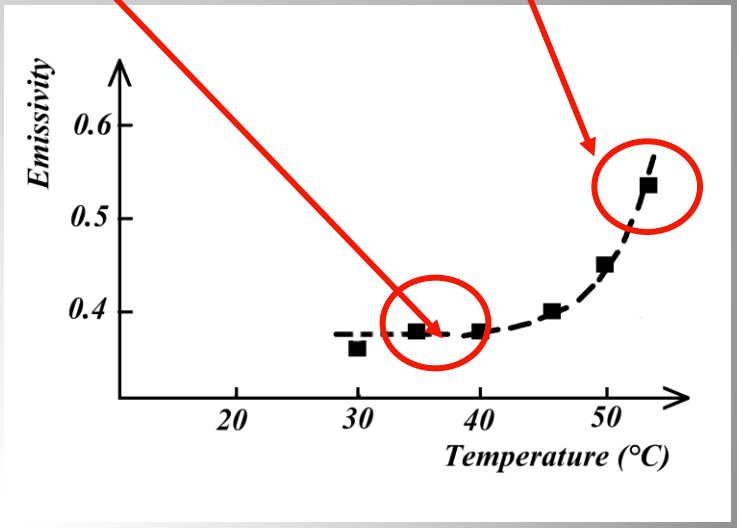

Morpho achiles
Transmission
Absorption
Réflexion
Reflexion (%)
Transmission (%)
Longueur d'onde (µm)
100
80
60
40
20
0
0
20
40
60
80
100
5
10
15
20

Faible émissivité: Augmentation de la température

Augmentation de l'émissivitée émissivité: Baisse de la température

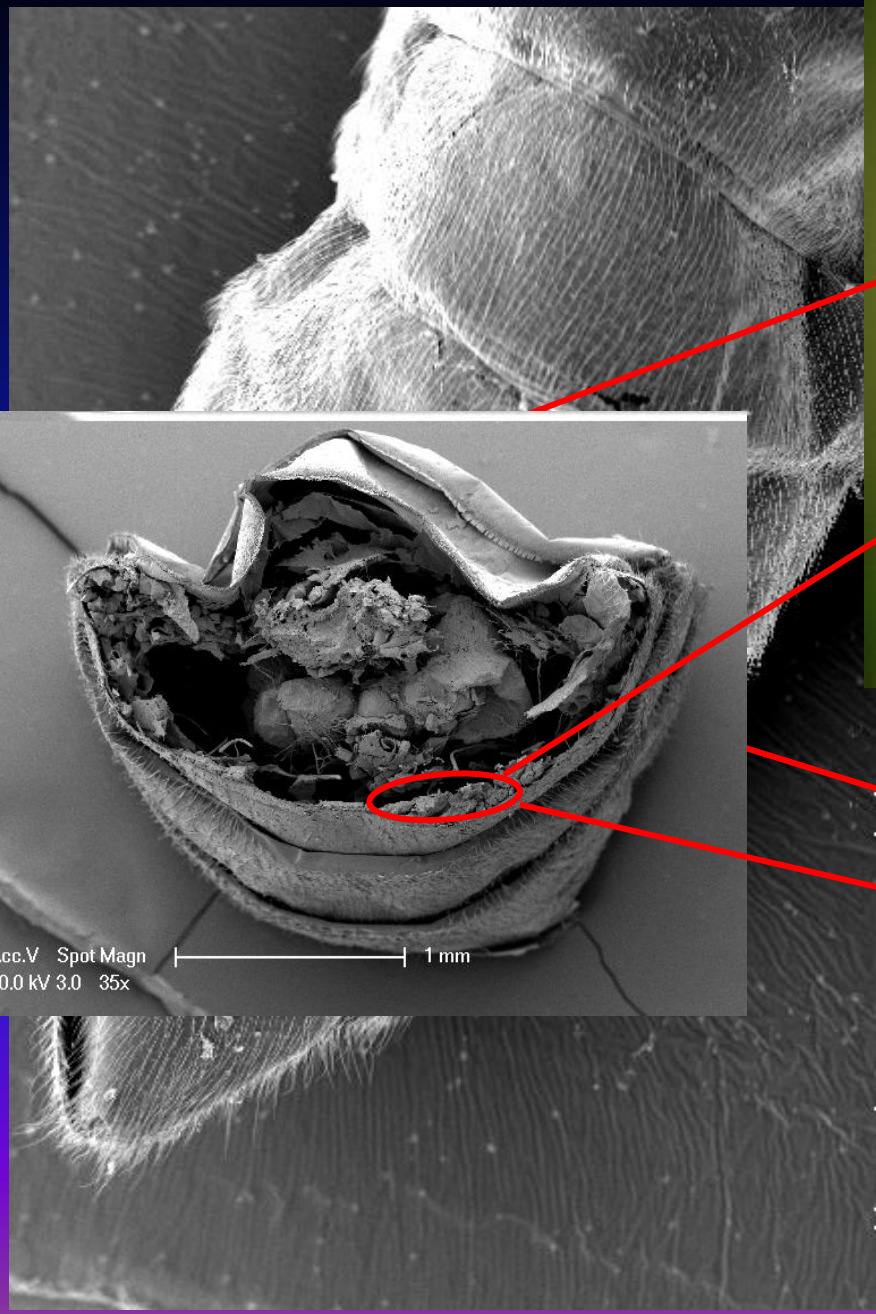
$\alpha = 0.85$

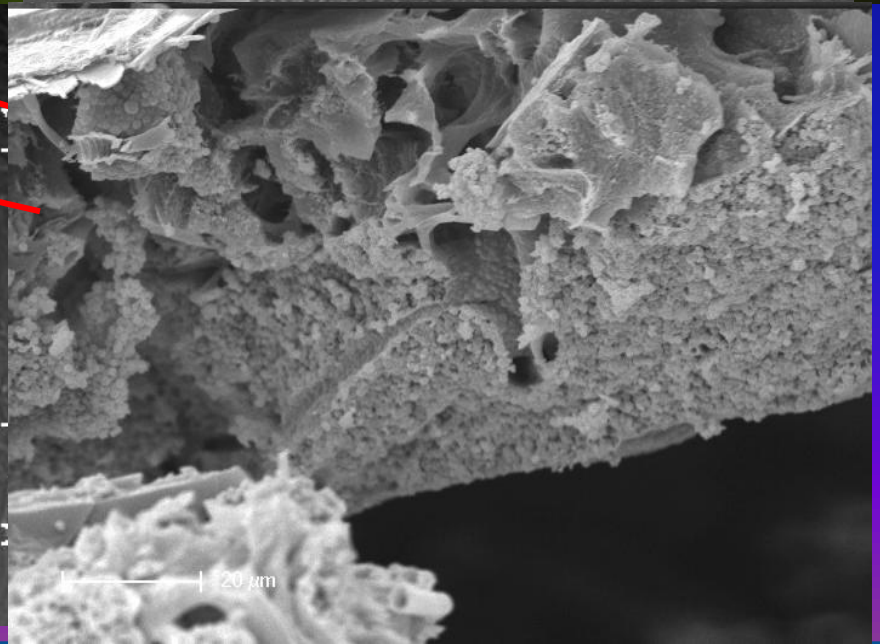




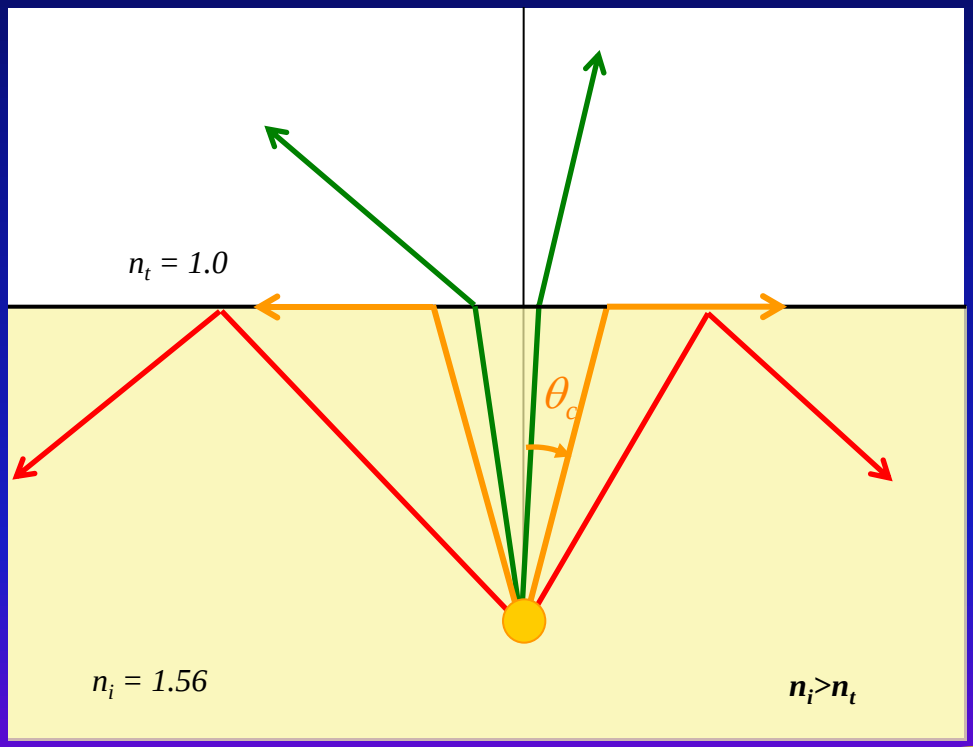
xtraction de la lumière : Solution “Luciole”

Photo: J.P. Vigneron, A. Bay)





Problème : Extraction de la lumière



Lois de Descartes $i = r$

$$n_i \sin i = n_t \sin t$$

$n_i > n_t$

Réflexion totale

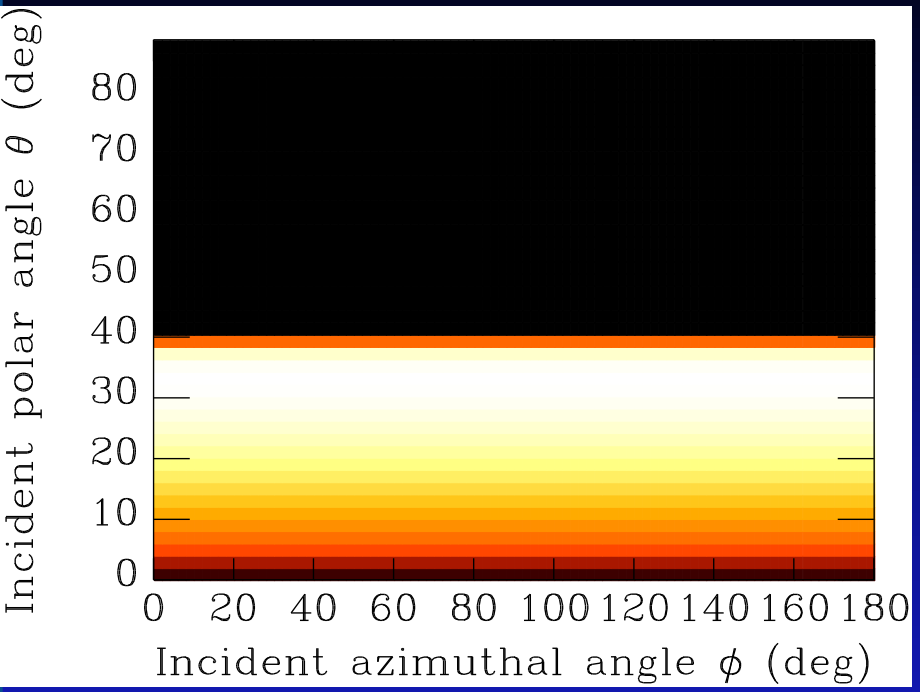
$$t = 90°$$

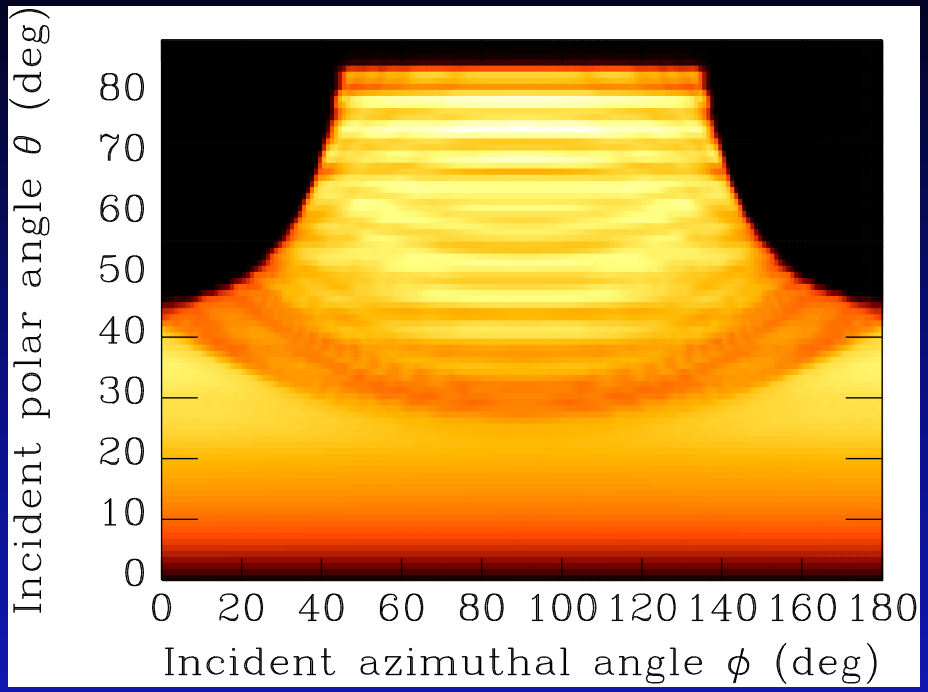
$$\sin c = \frac{n_t}{n_i} < 1$$

$$\frac{n_t}{n_i} = \frac{1.0}{1.56}$$

Dans le cas de la luciole: $c = 40°$

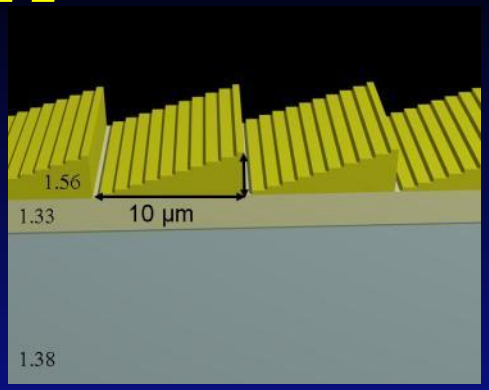
Lumière extraite par …

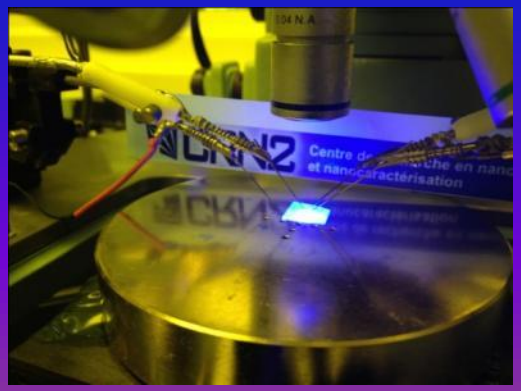


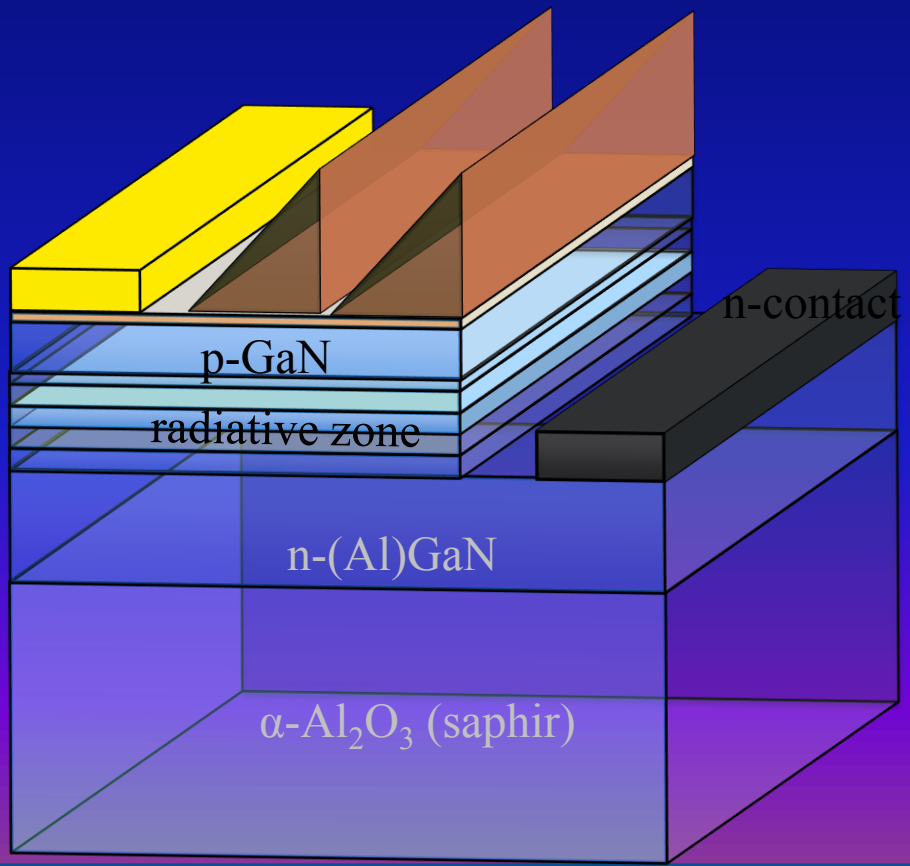


Une première réalisation

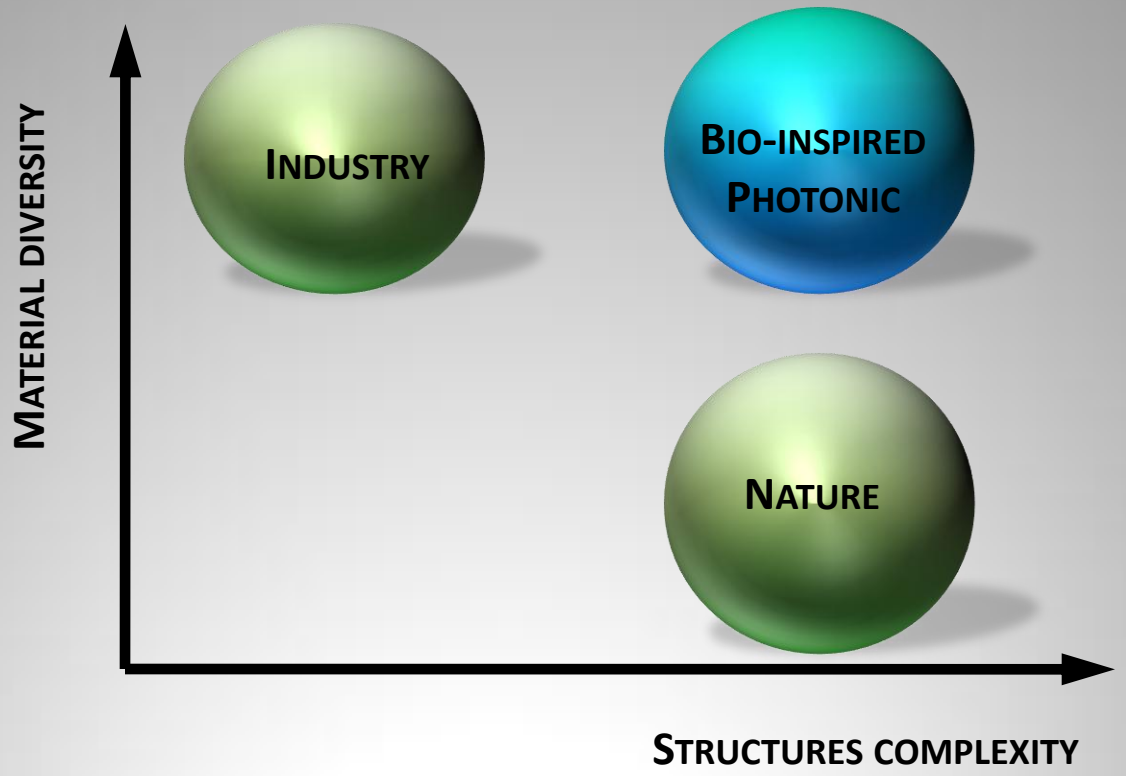
Gain : 20%



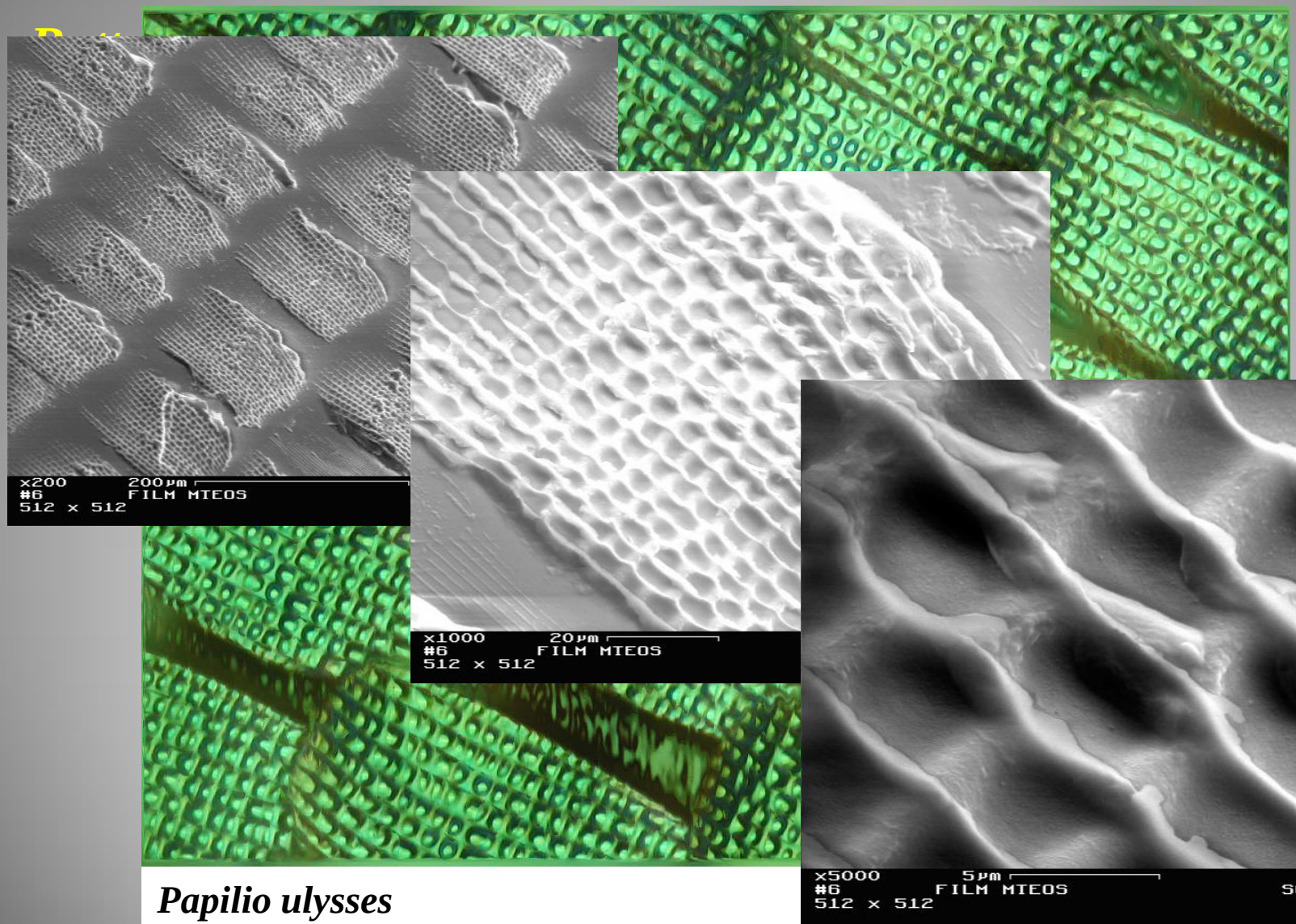




Retours à la bio-inspiration



Comment : La réplication



Papilio ulysses

Conclusion

"On est encore à cette époque (1914) où la nature n'est pas encore cette viellarde fragile qu'il faut protéger mais un redoutable ennemi qu'il faut vaincre." (Patrick Deville, 2012)

De nombreux problèmes viennent de la nature…
…mais elle donne souvent la solution

1 – Nous devons préserver la nature

La comprendre ← ***L'observer***

**** ~100 espèes (animales and vegetalle) disparaissent chaque jour***

2 – Nous devons préserver les peuples qui y vivent

Indian Amazonian population decreases of ~99% in 2 centuries