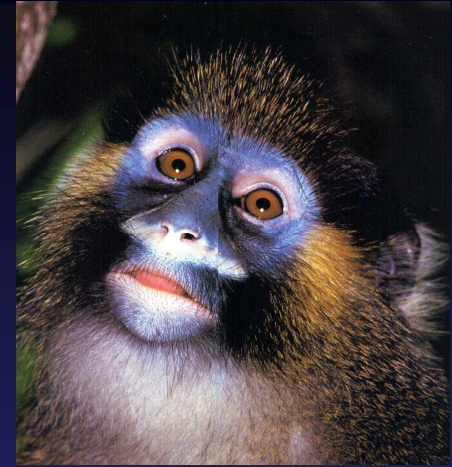


# Structures Photoniques Multiéchelles Naturelles



Serge Berthier\* - Stéphane Borensztein \*\*

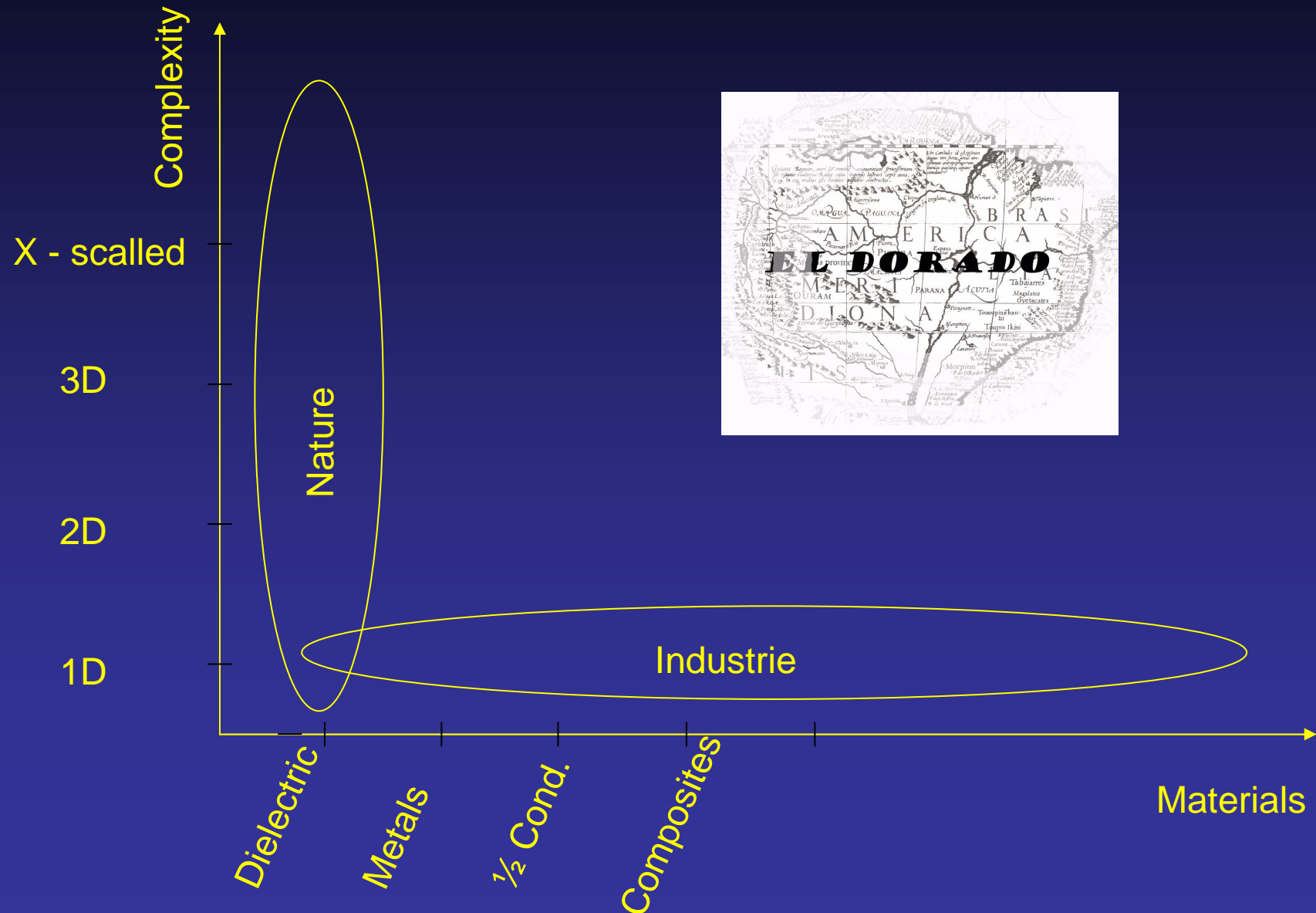


\* IUT Paris – Jussieu  
Université Denis Diderot

\*\* *Laboratoire de Physique des  
Liquides et Electrochimie*



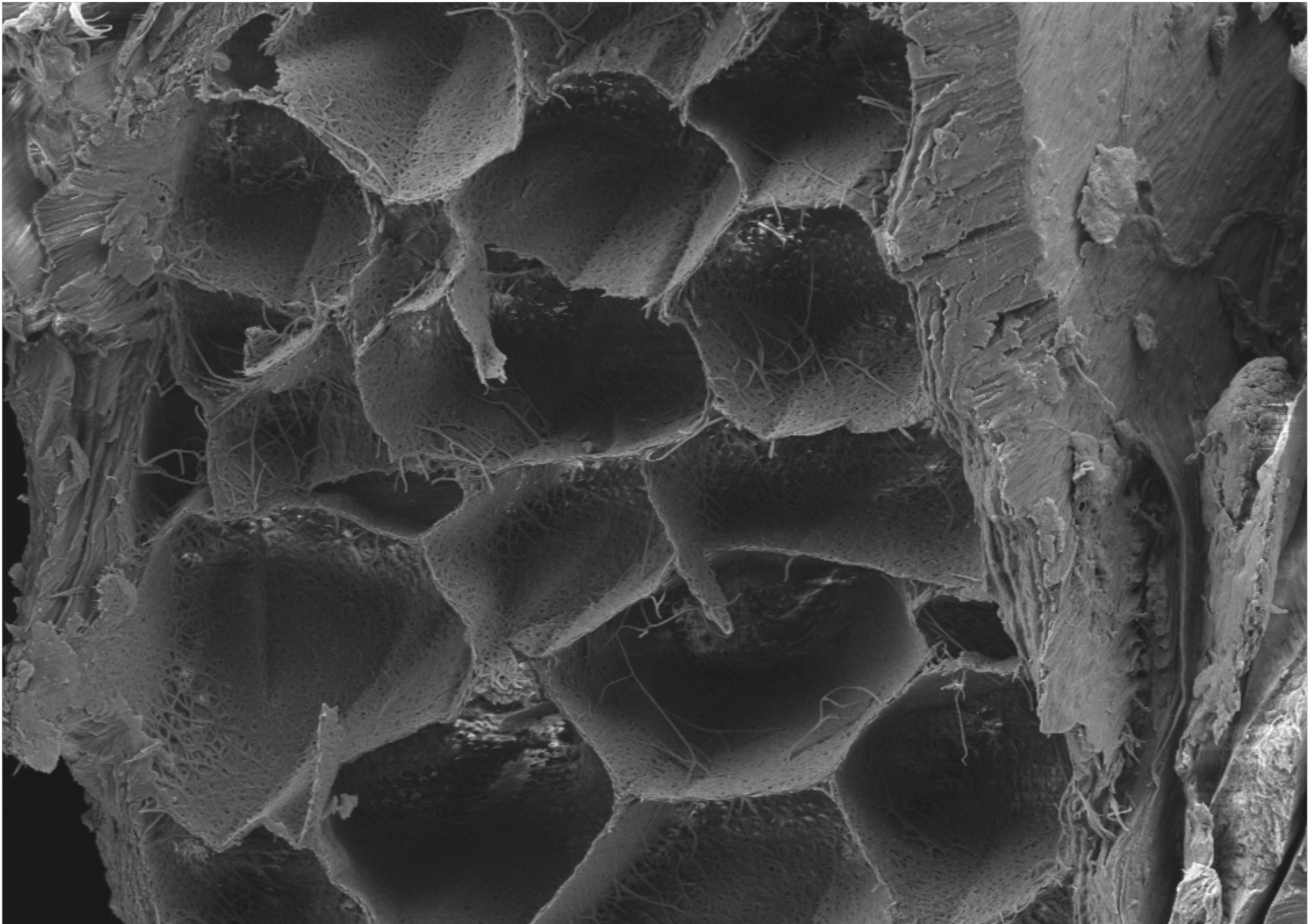
# Les structures photoniques au laboratoire et dans la nature



# Structures Multiéchelles

## Quelques exemples





EHT = 3.00 kV

Signal A = SE2

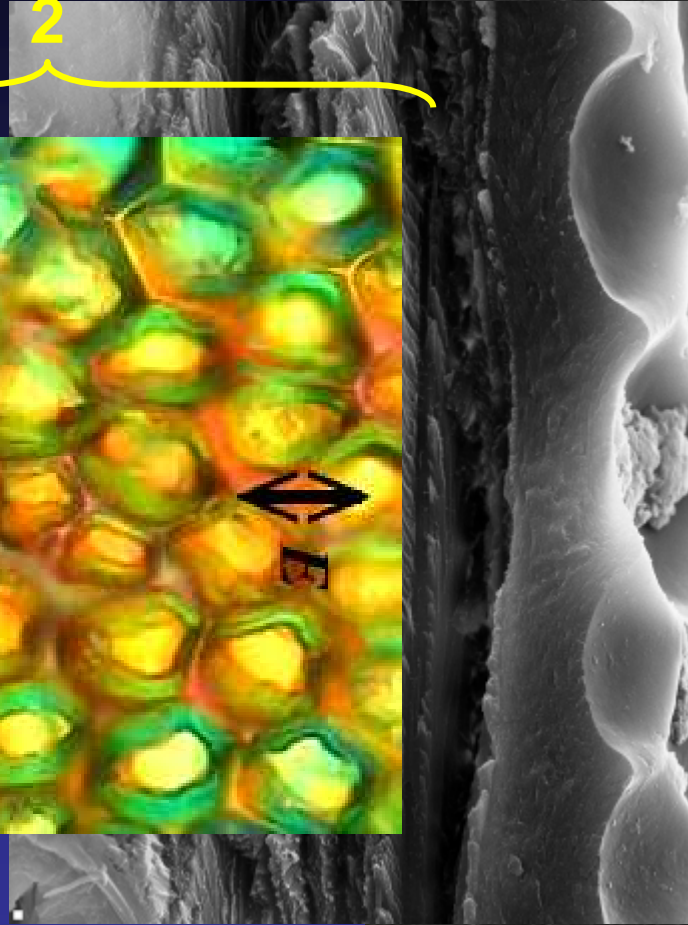
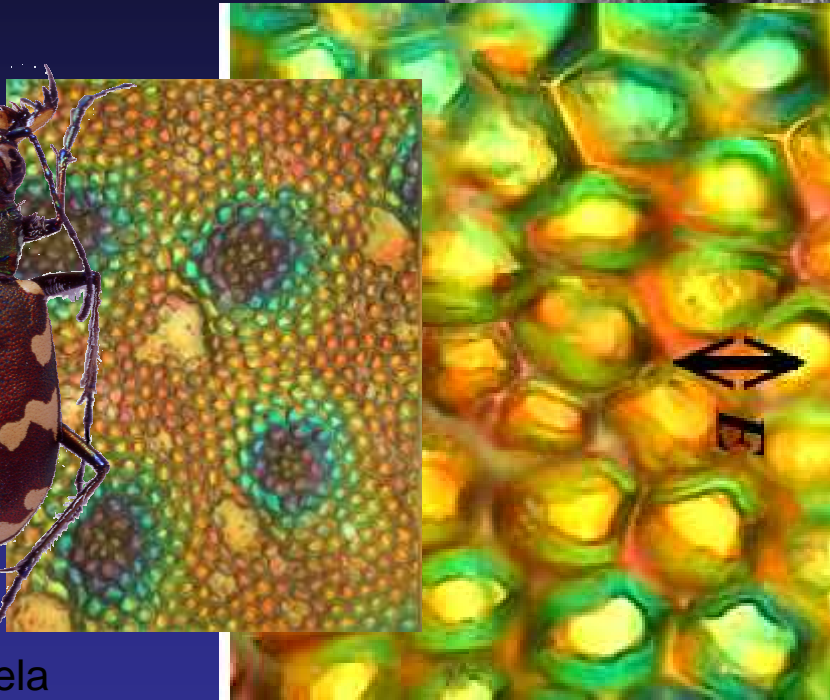
Date :26 Oct 2006

ARA

# Observation



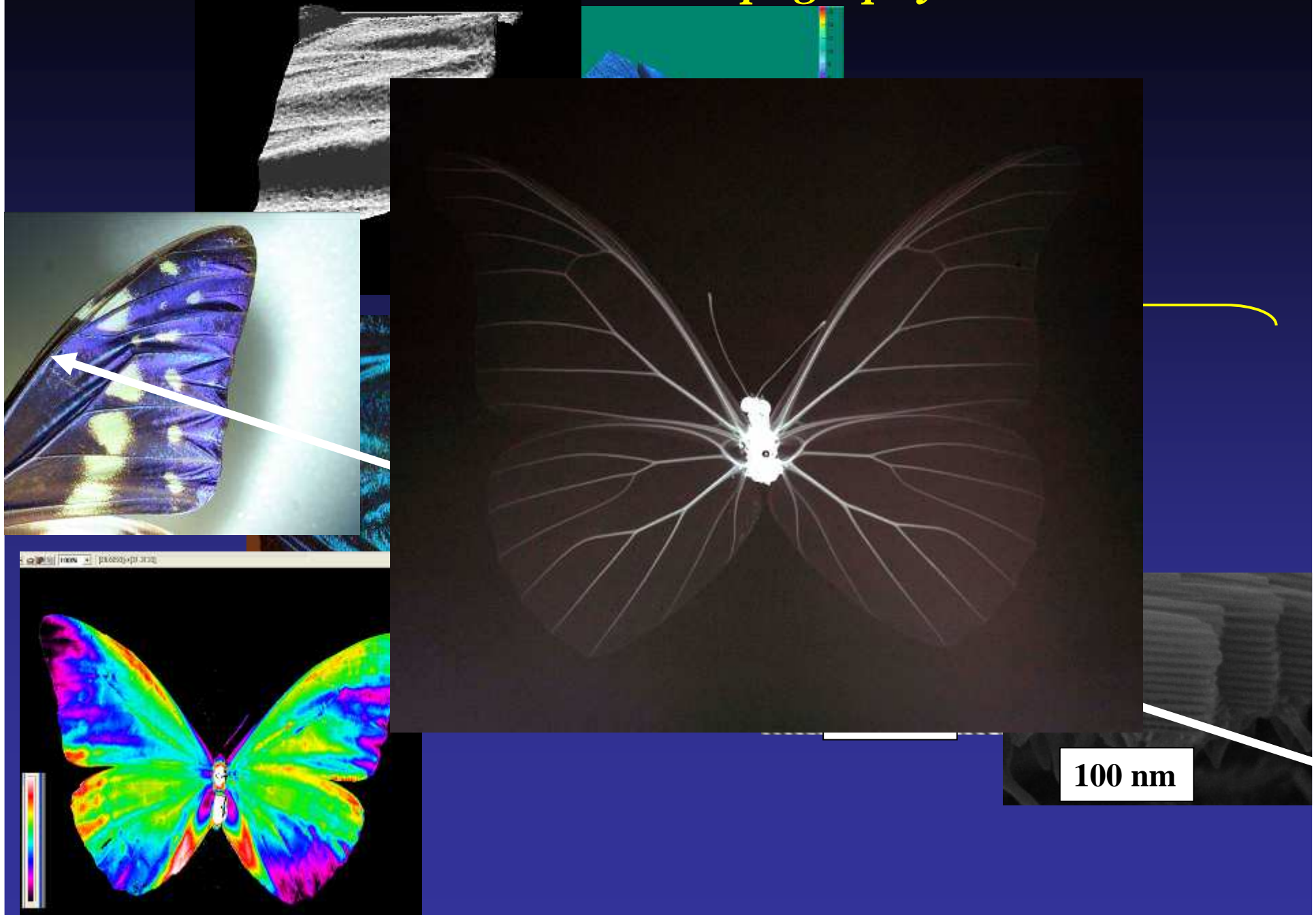
*Cicindela campestris*



# Modeling

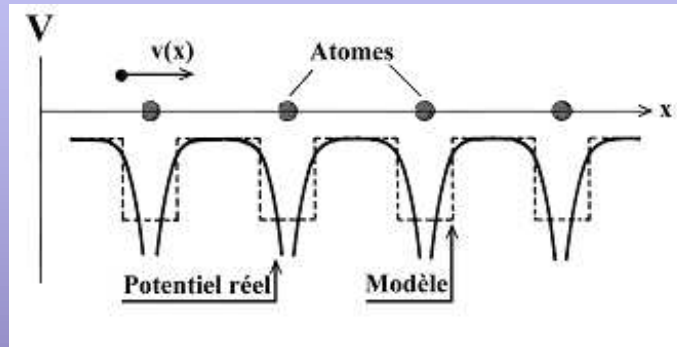


# Structure - topography

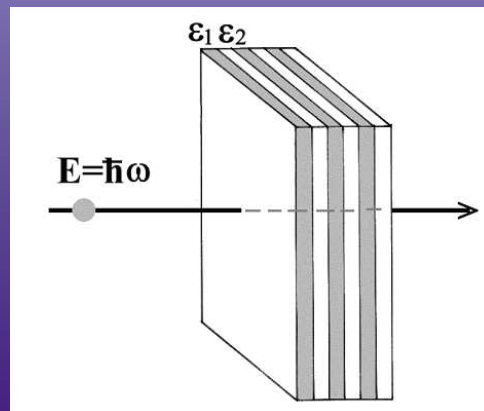


# Qu'est-ce qu'un cristal photonique ?

Cristal réel :



Cristal  
photonique



(Schrödinger)

$$\nabla^2 \psi = -\frac{2m}{\hbar^2} (E - V) \psi$$

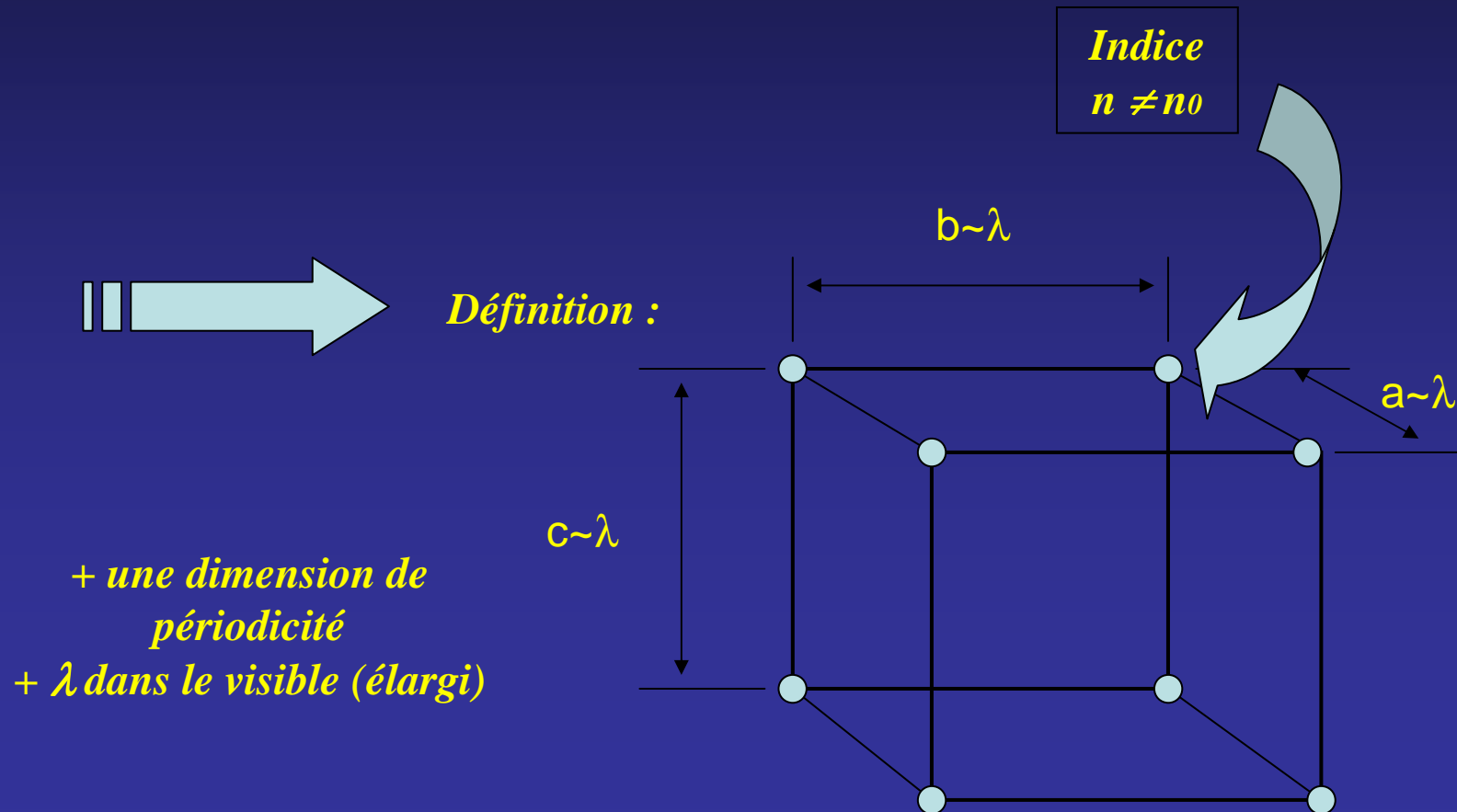


$$\nabla^2 \varepsilon = -\frac{n^2 \omega^2}{c^2} \varepsilon$$

(Helmholtz)

# Structures photoniques élémentaires

## Paramètres

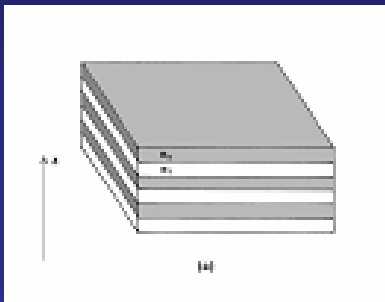


# Structures

*cristallines*

-

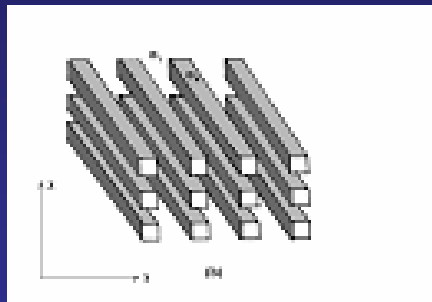
*amorphes*



1D

Interférences

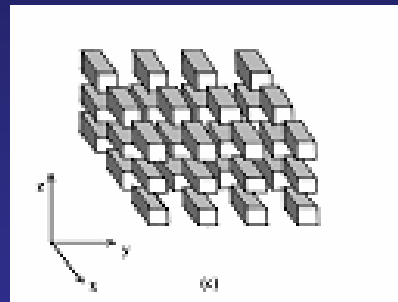
Couche  
mince



2D

Diffraction

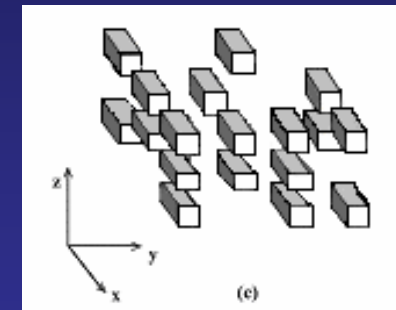
réseau



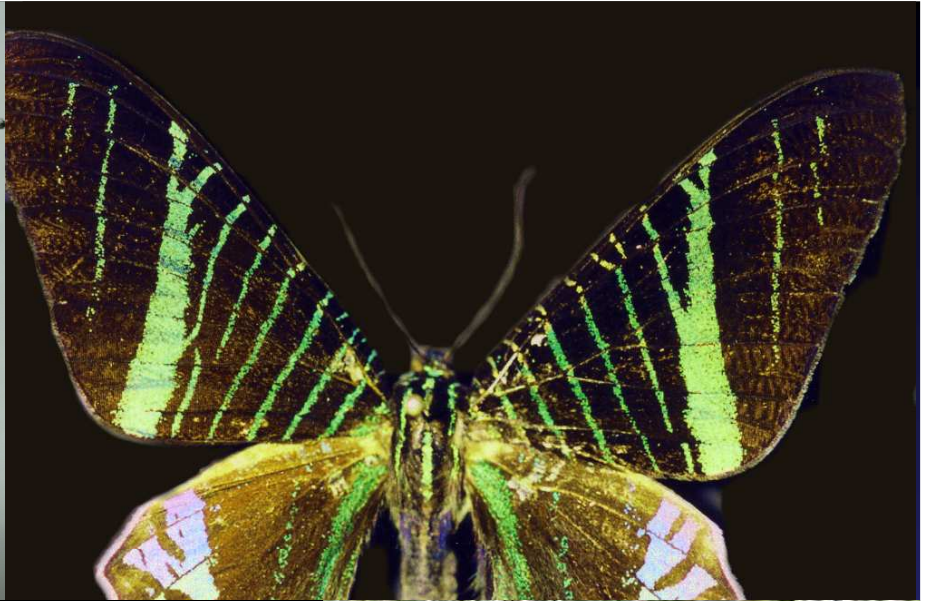
3D

Diffraction

Cristalline



Diffusion

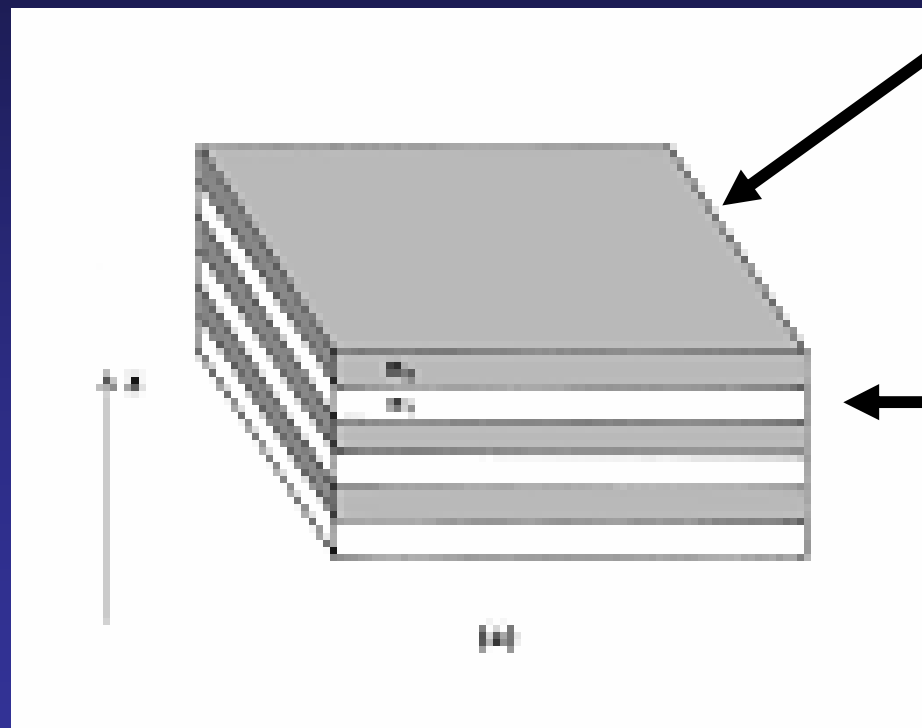


**Structures 1D**



# *“Cristaux photoniques” à une dimension (1D)*

- *Dans l'épaisseur: La multicouche*

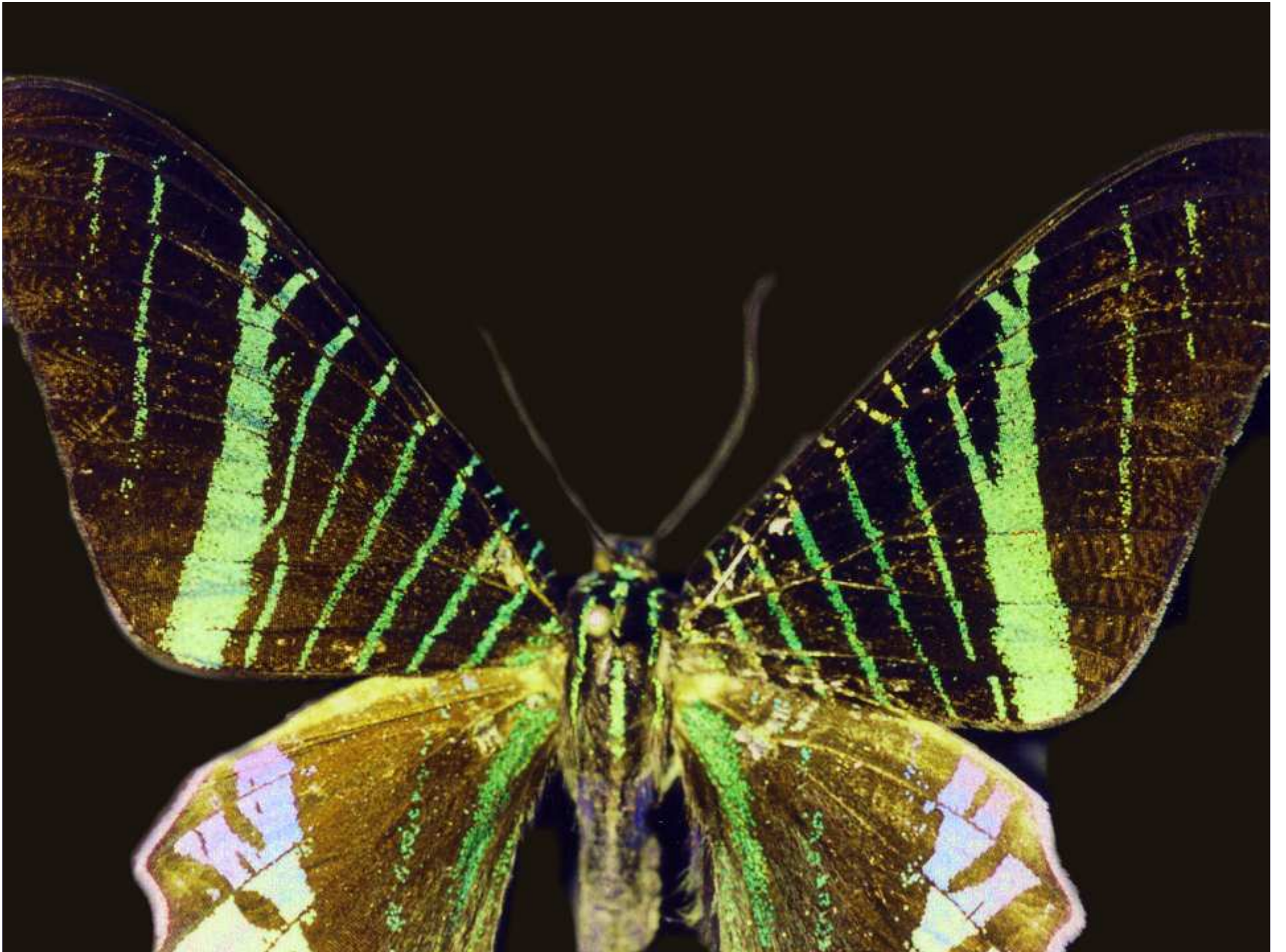


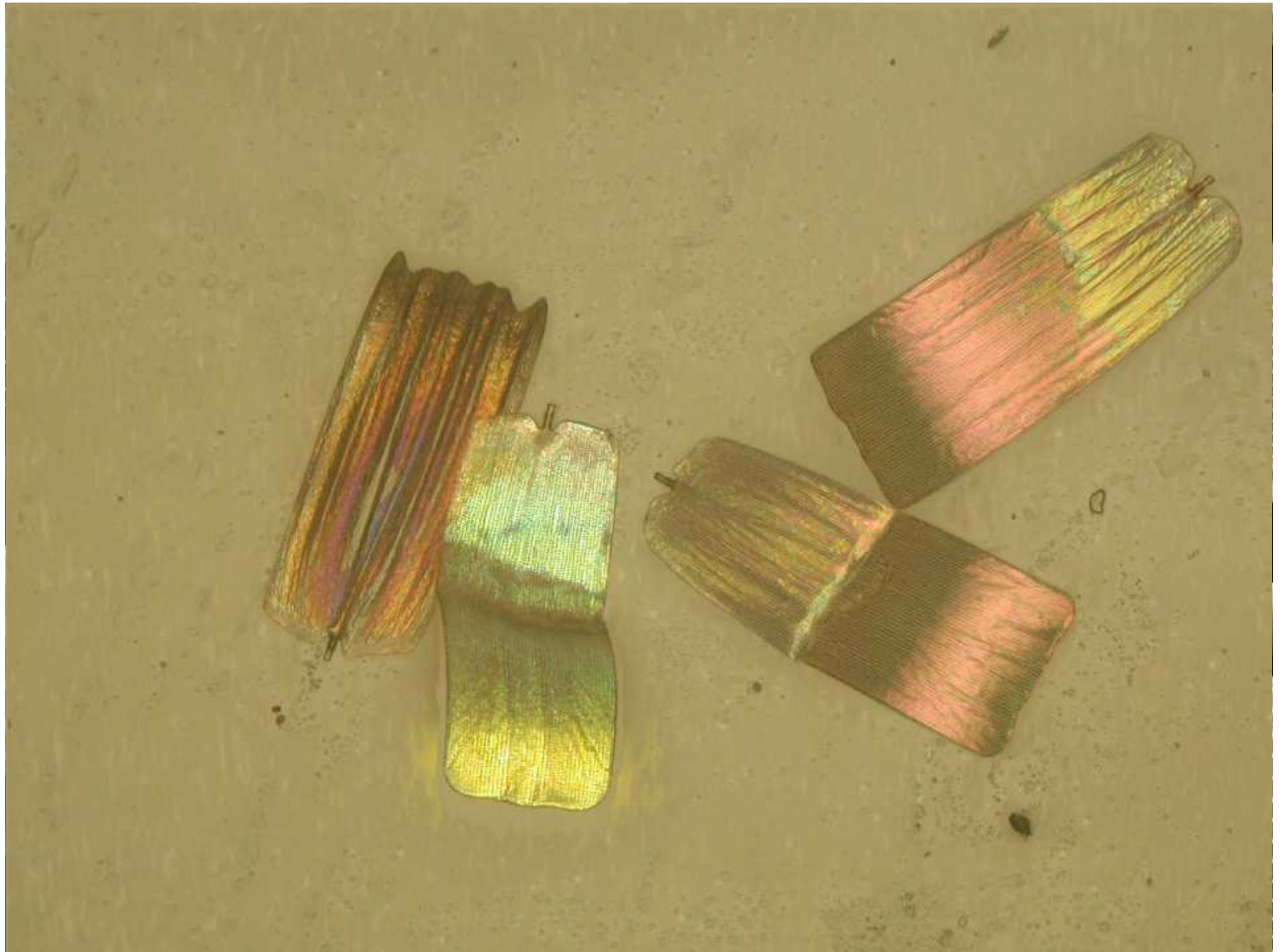
*Solide*

*Solide*

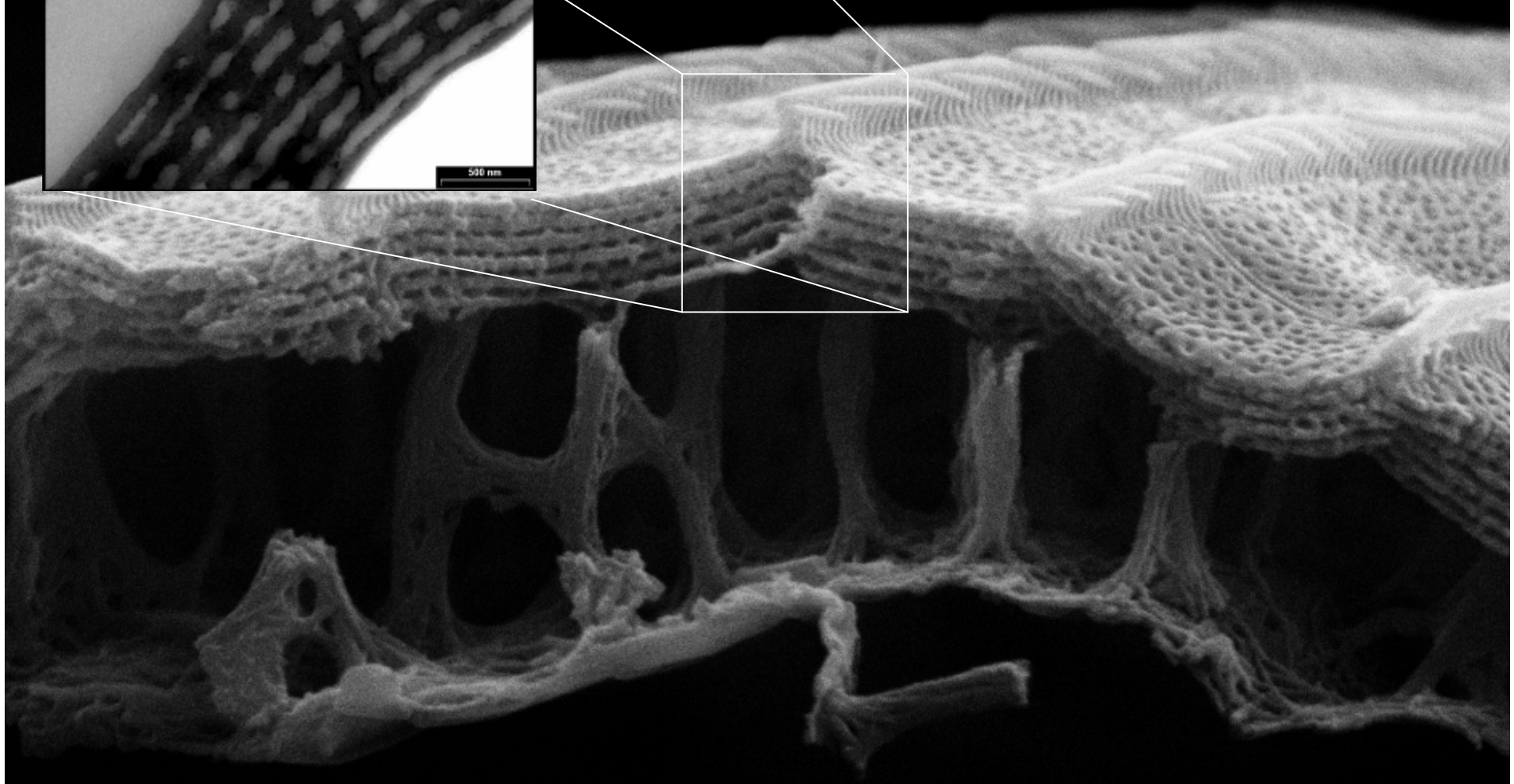
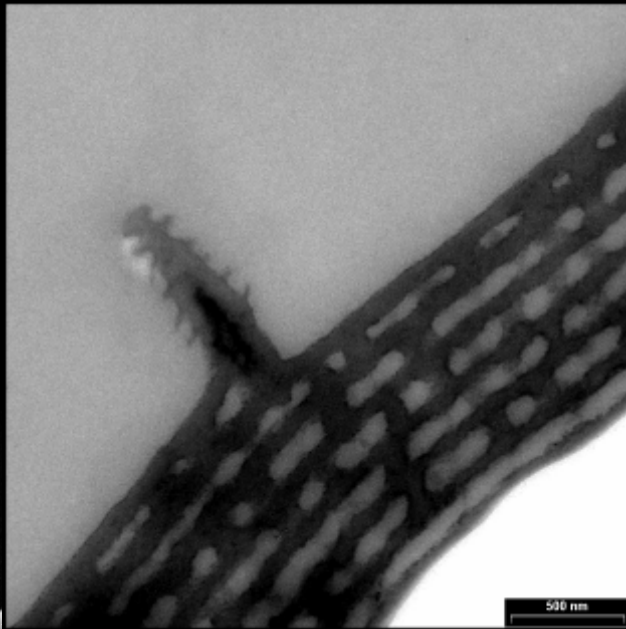
*Liquide*

*gaz*





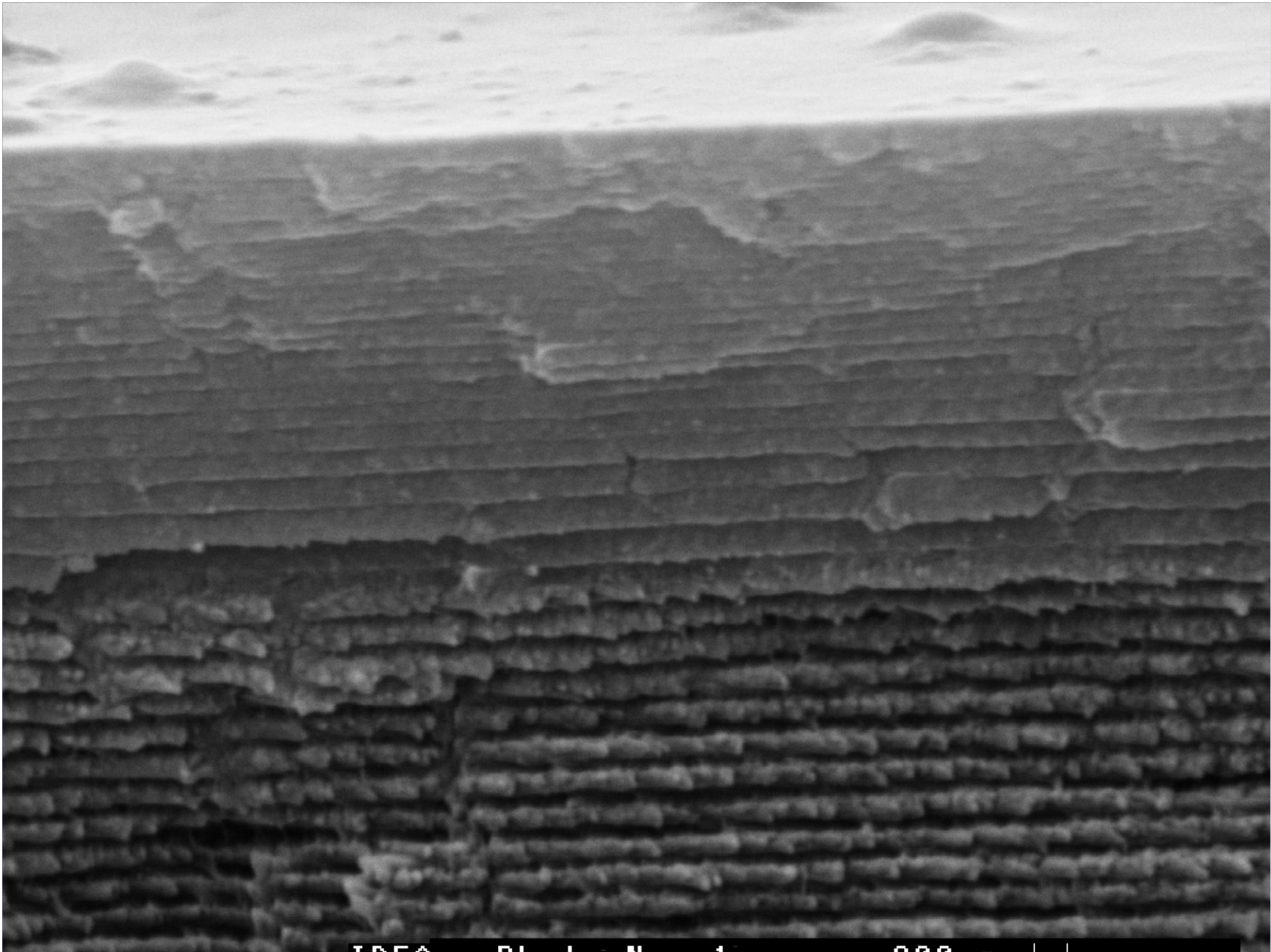
*Contraste fort: N = 6 - 12*



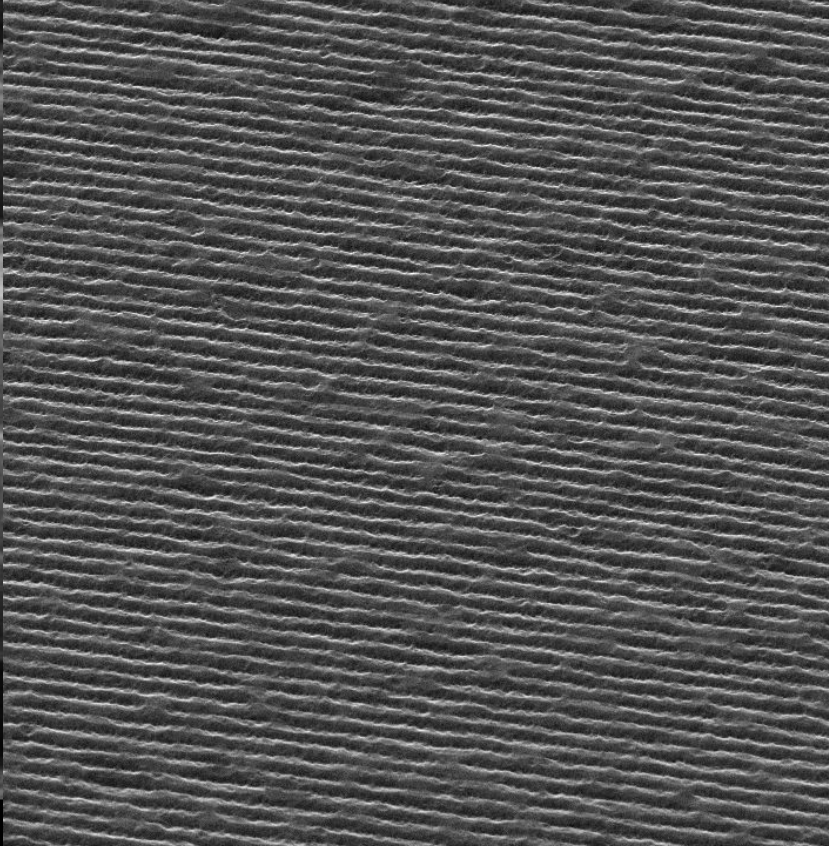
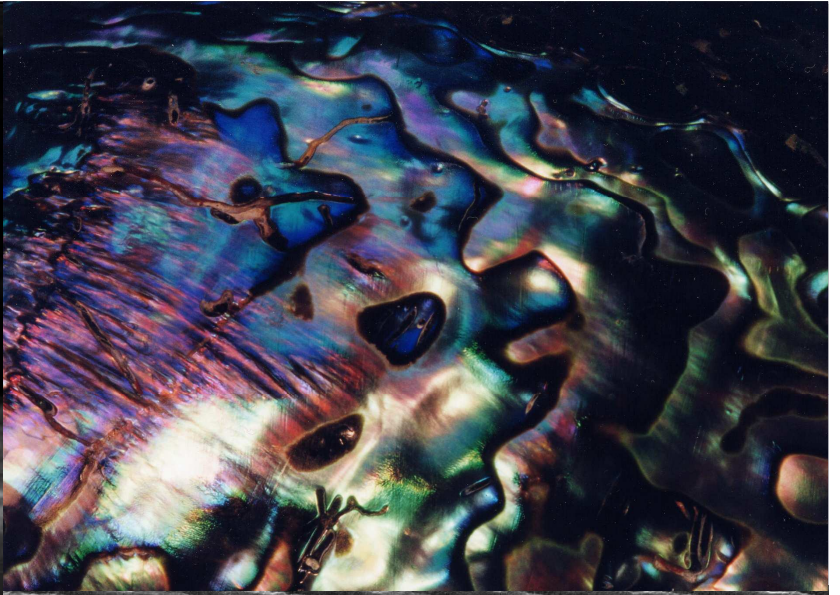
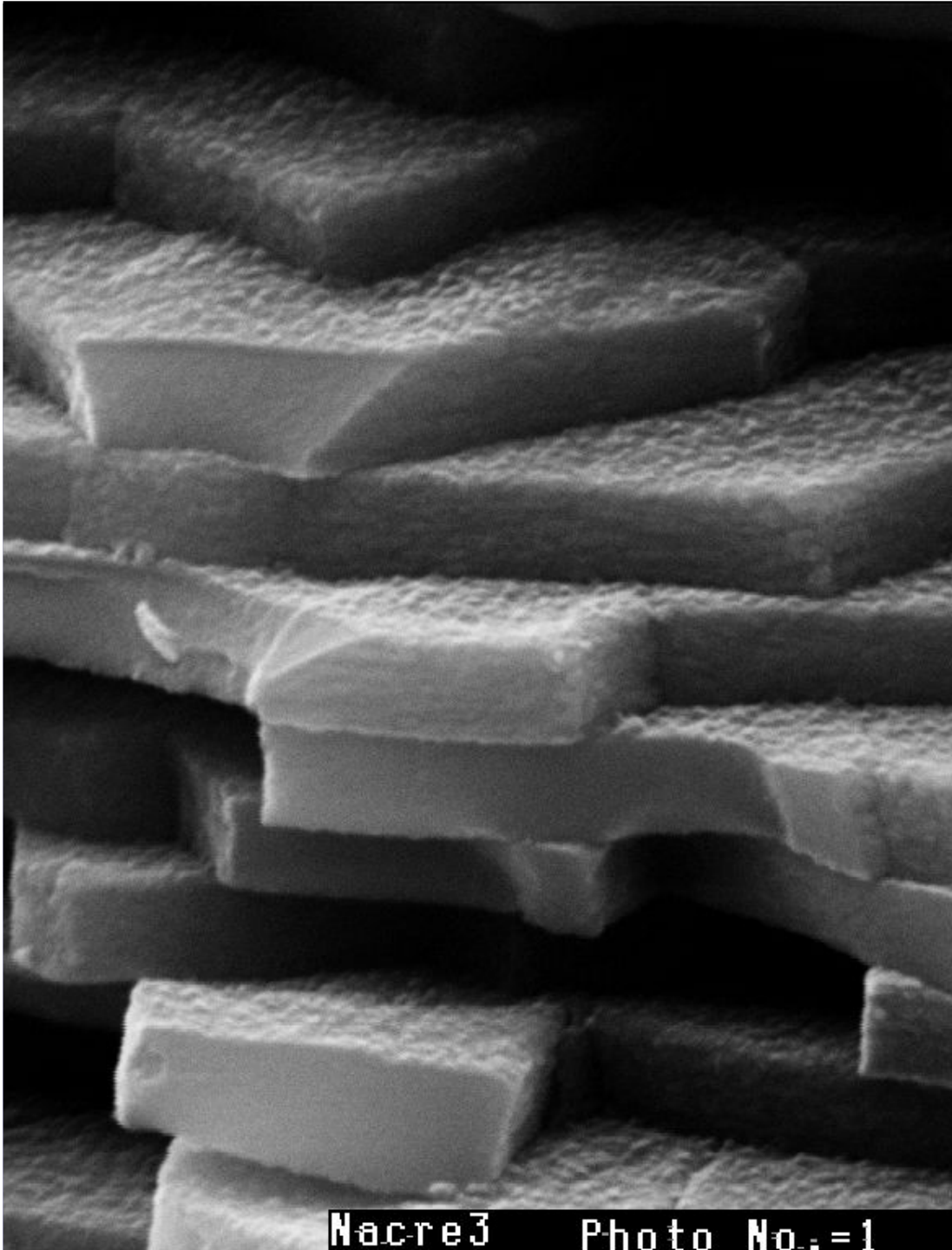
# Chrysalis

*Contraste faible: N = 50 - 100*





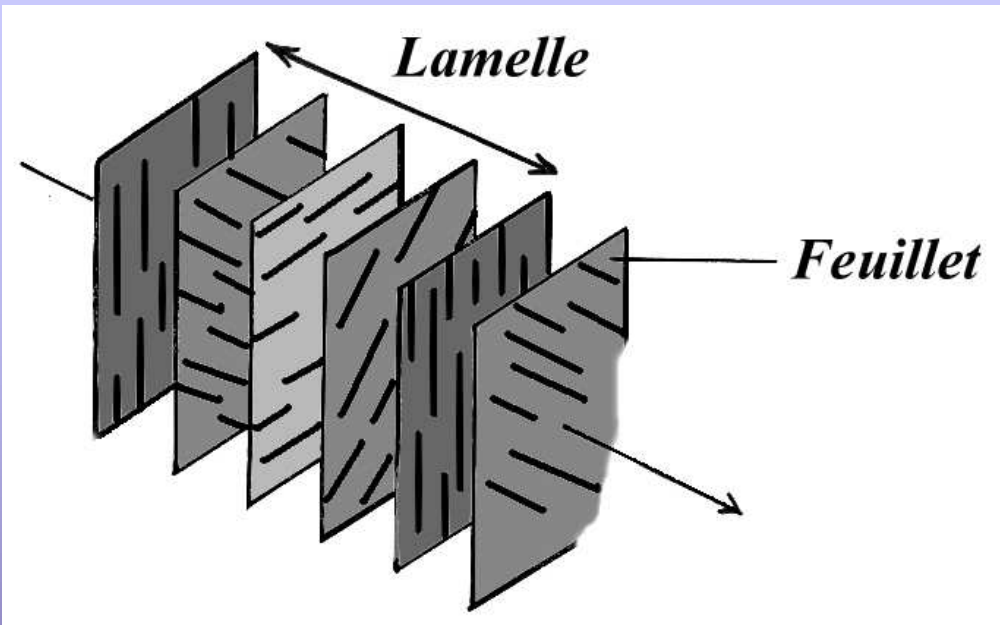
1950 01 1 N 1 000



Nacre3 Photo No.:1

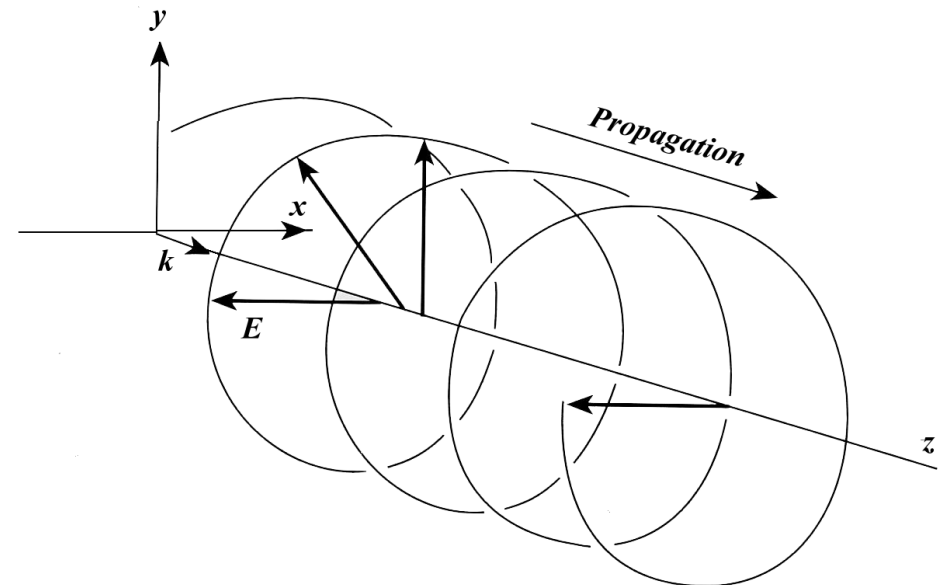
***Un cas particulier:  
Les structures cholestériques***



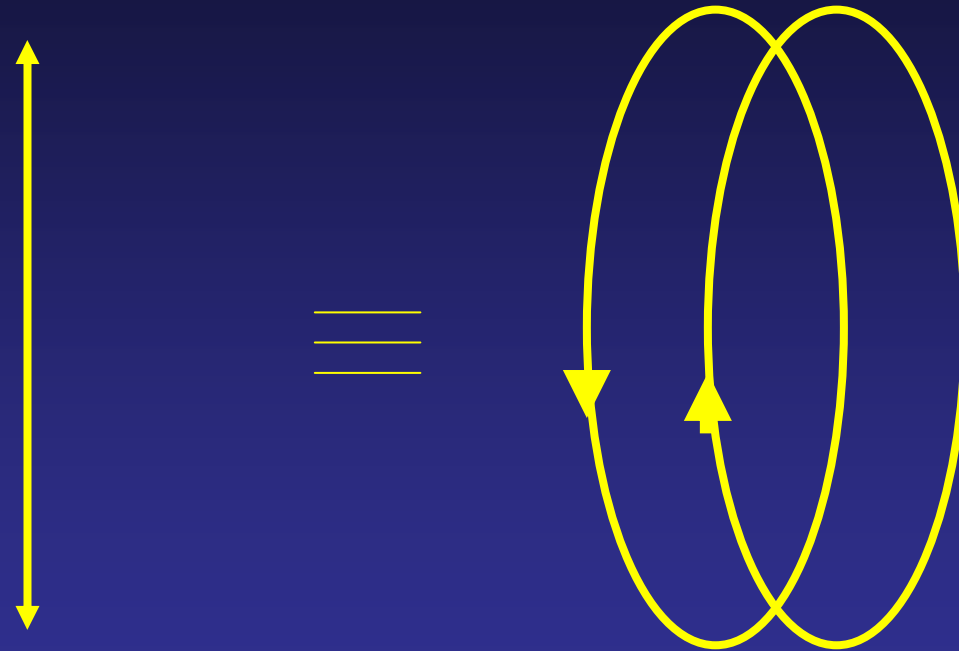


**L'épicuticule externe de certains scarabées présente un arrangement hélicoïdale...**

**...ce qui produit une polarisation circulaire**

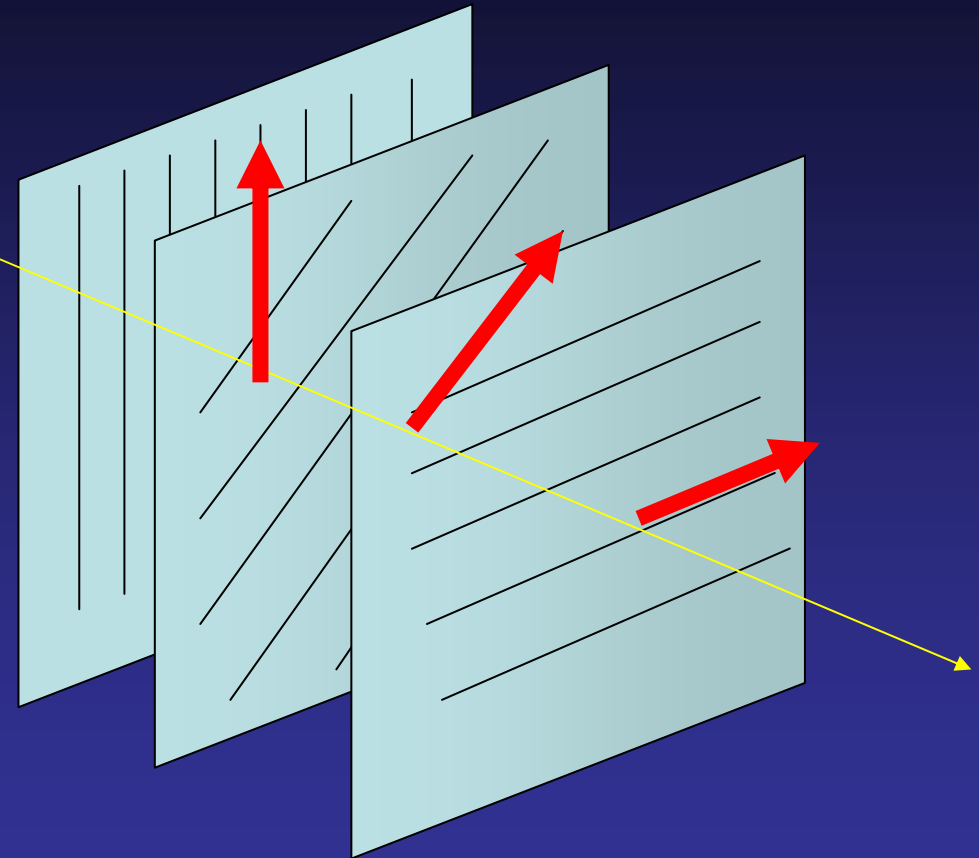
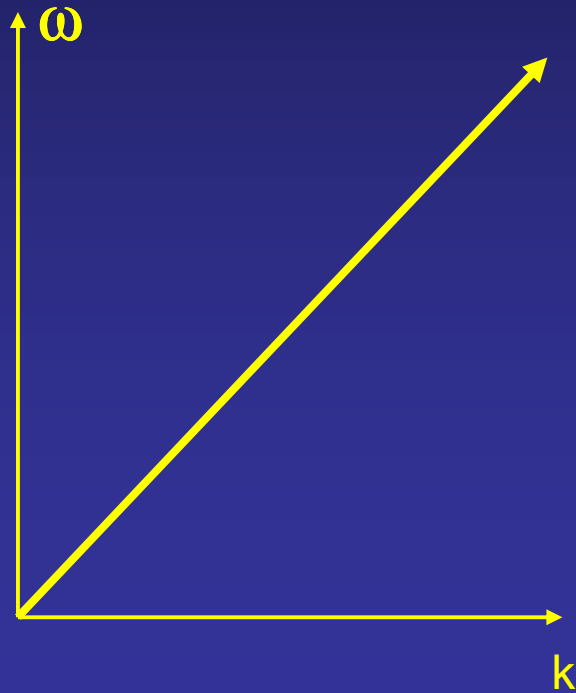


# Explication du phénomène

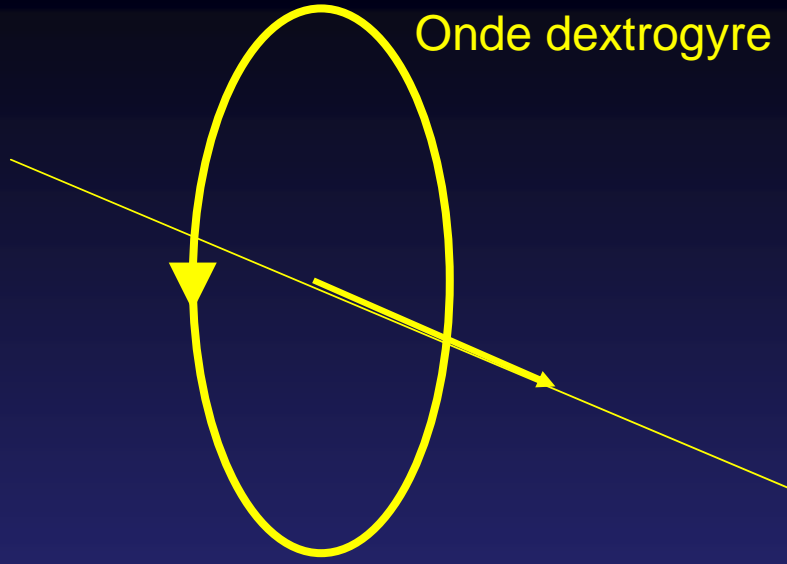


Onde levogyre

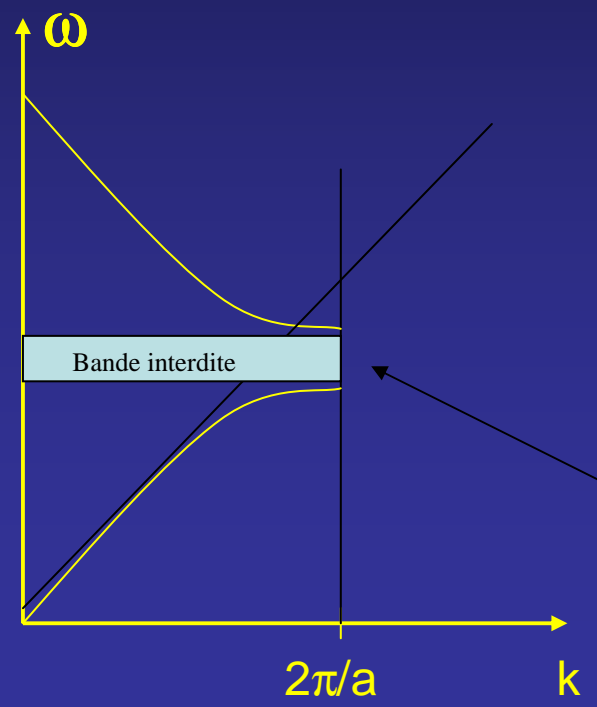
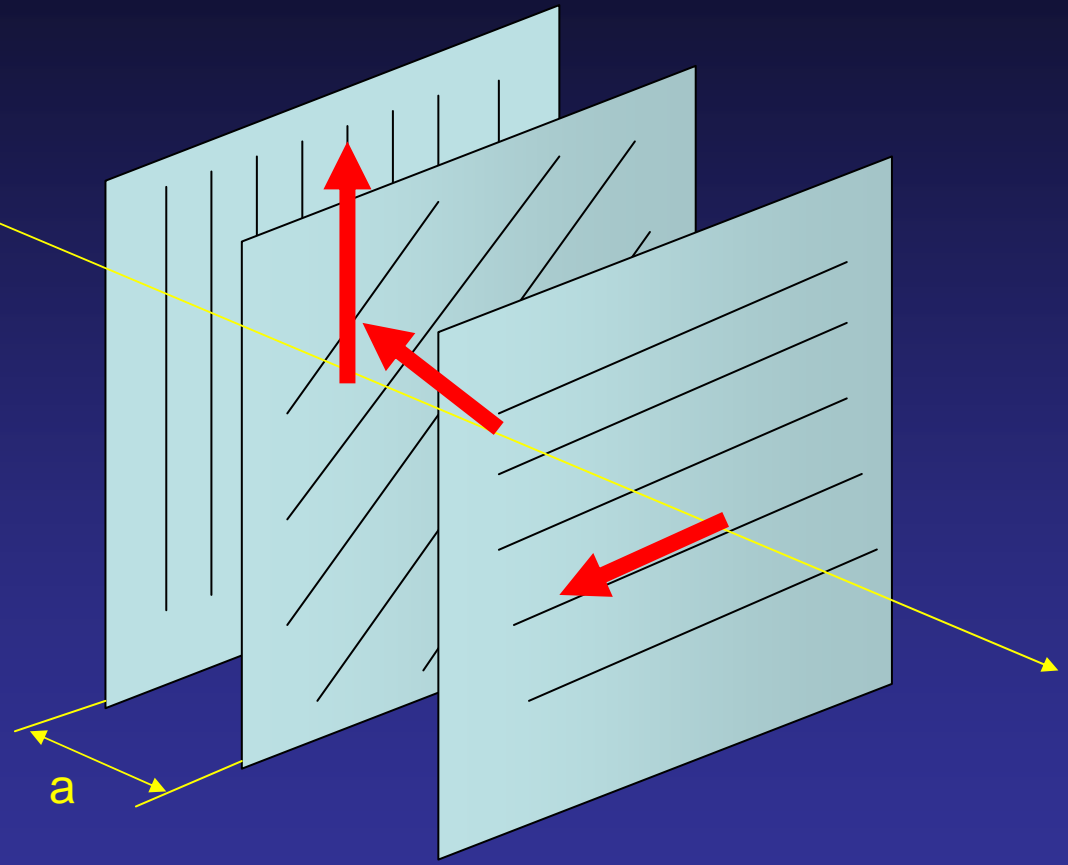
Structure levogyre



*Le champ "voit" toujours le même matériau*



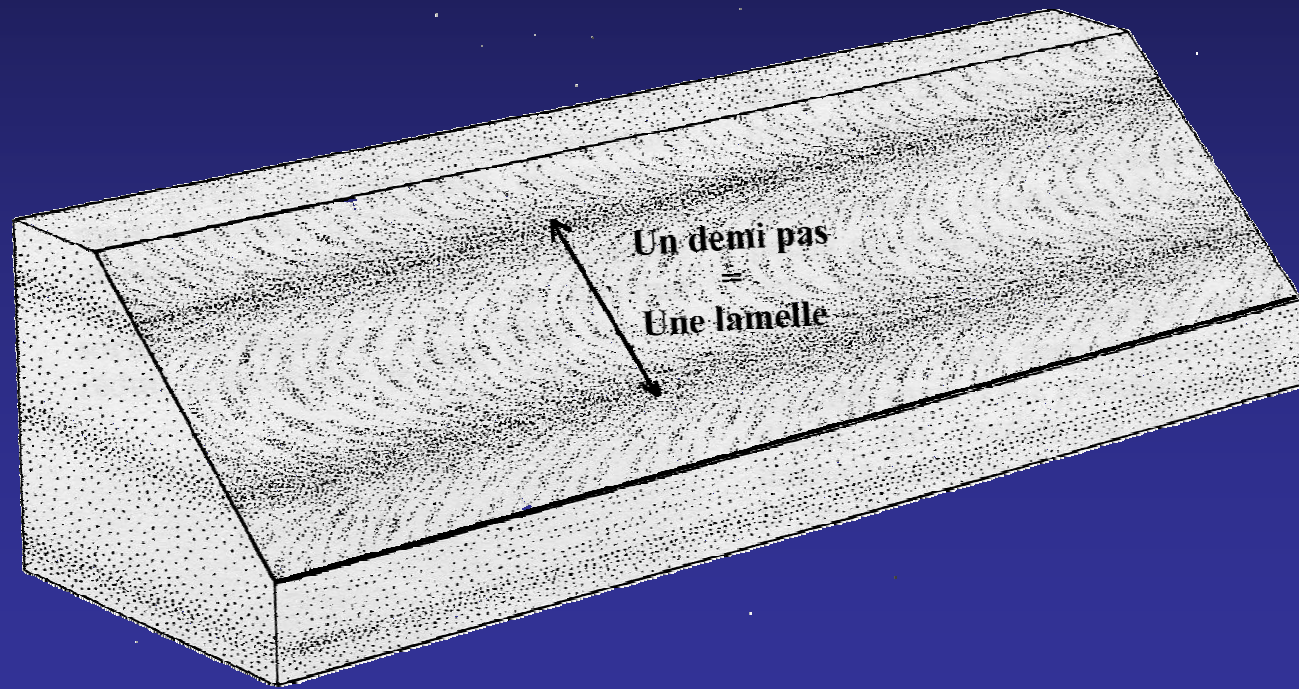
Structure levogyre



*Le champ "voit" une structure périodique*  
*Ouverture d'un gap: réflexion totale*

## Caractérisation d'une structure cholestérique ?

Méthode traditionnelle: coupe oblique et observation au TEM (Bouligand)



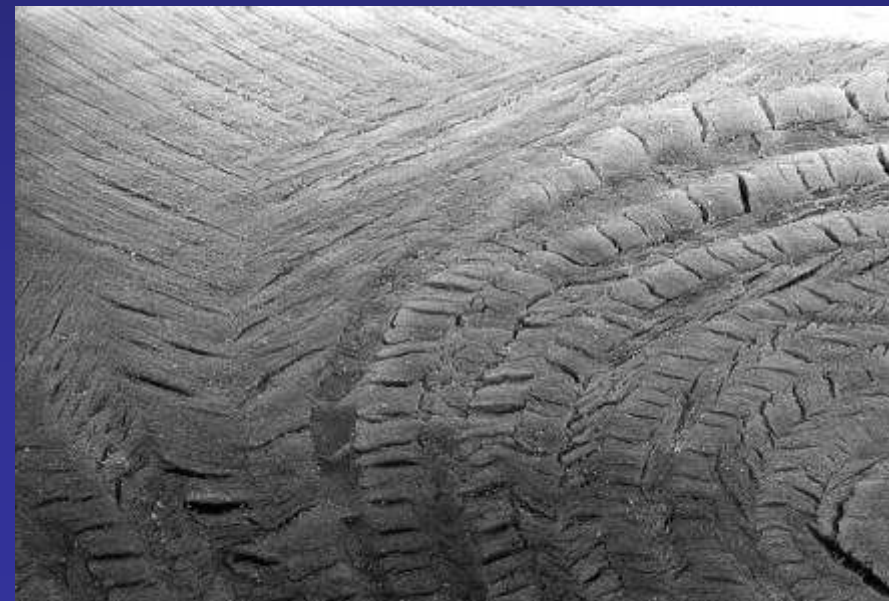
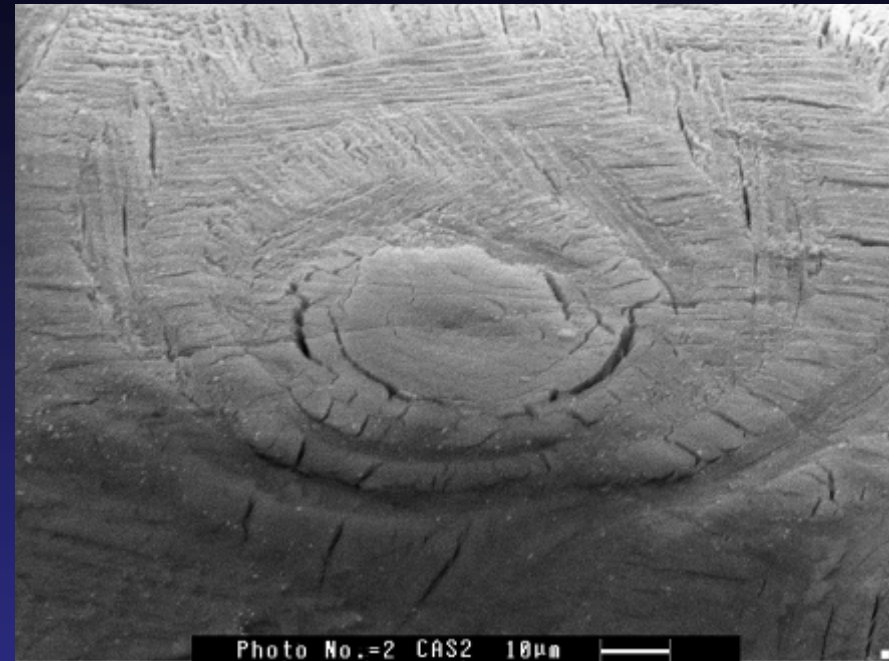
## Méthode "Berthier" (MEB)

### 3 – Mise en relief des baguettes de chitine

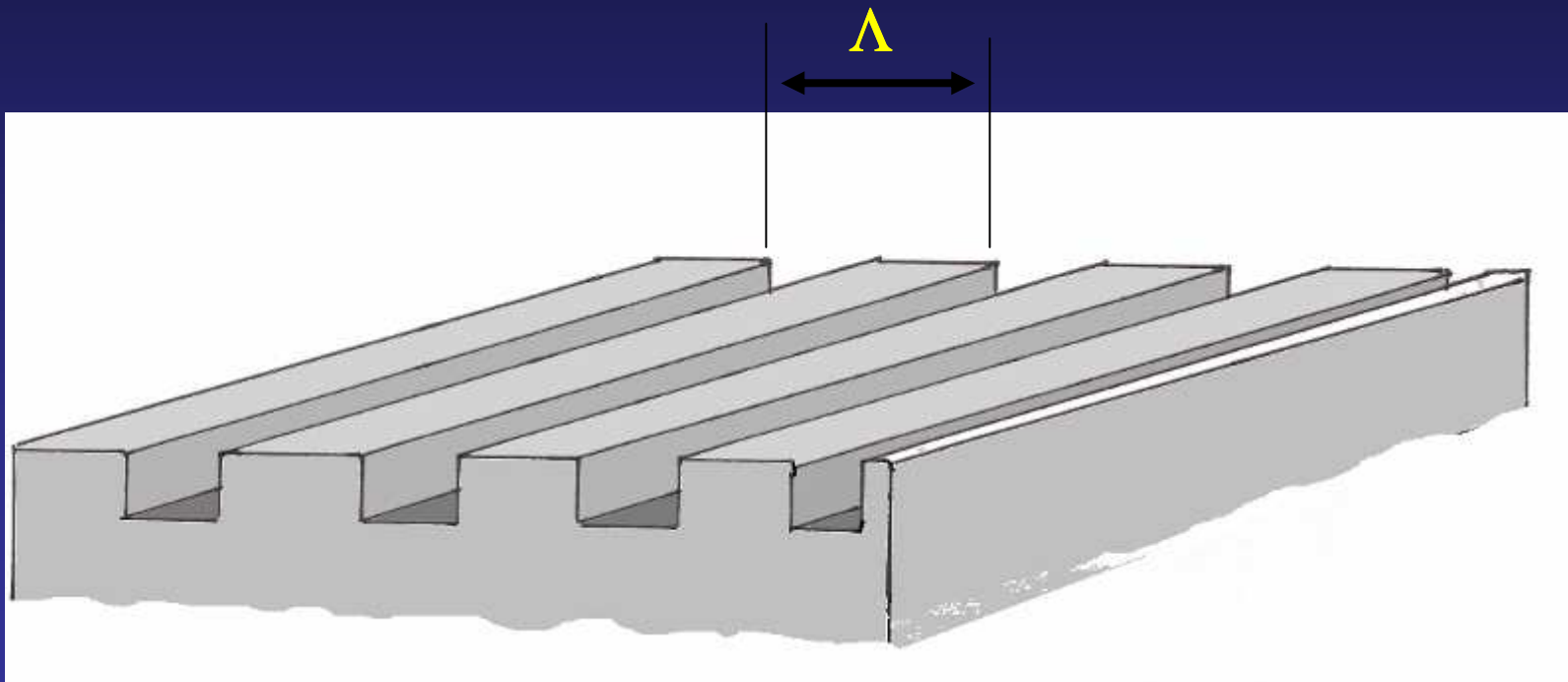


1 – Ponçage optique de l'élytre

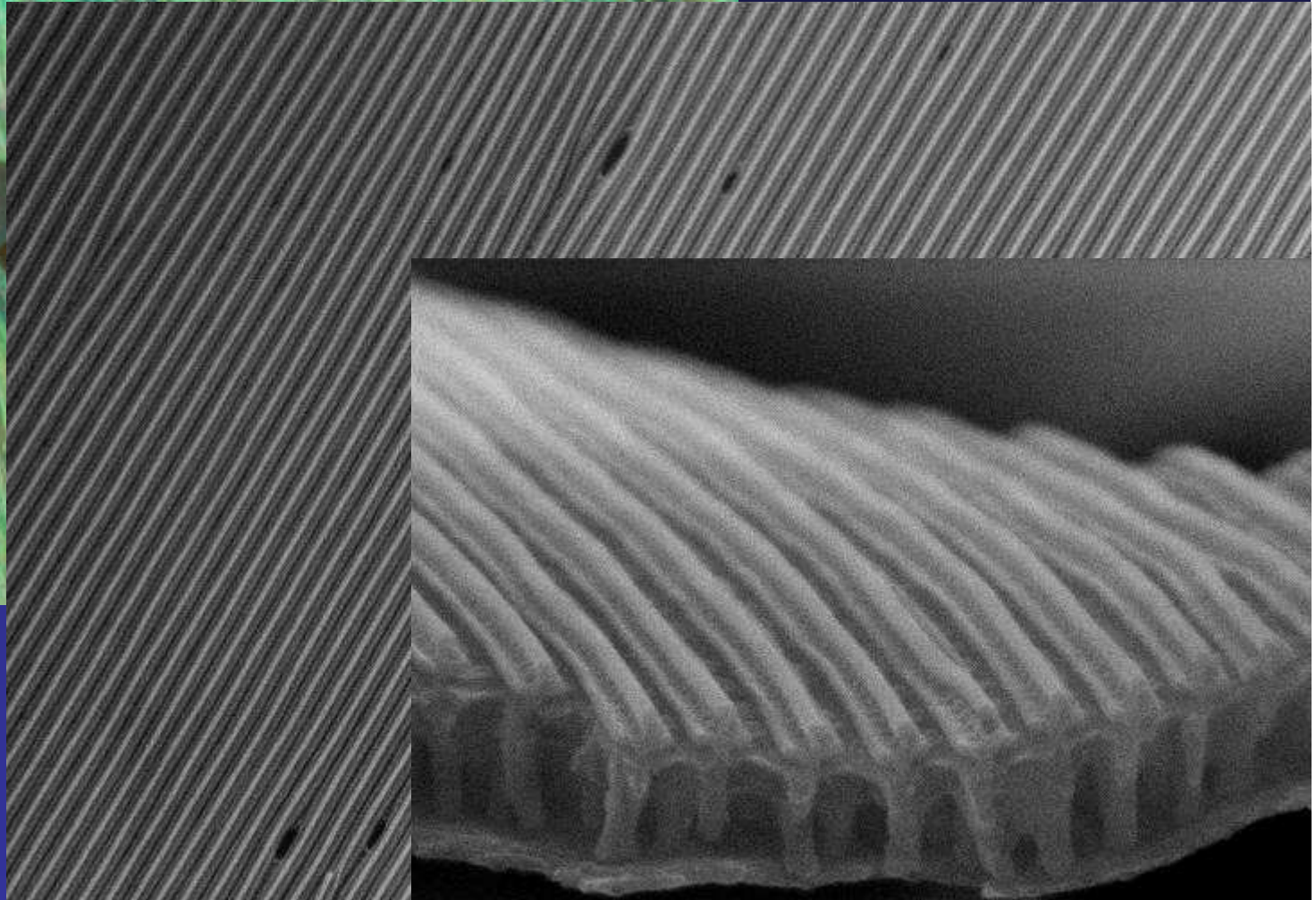
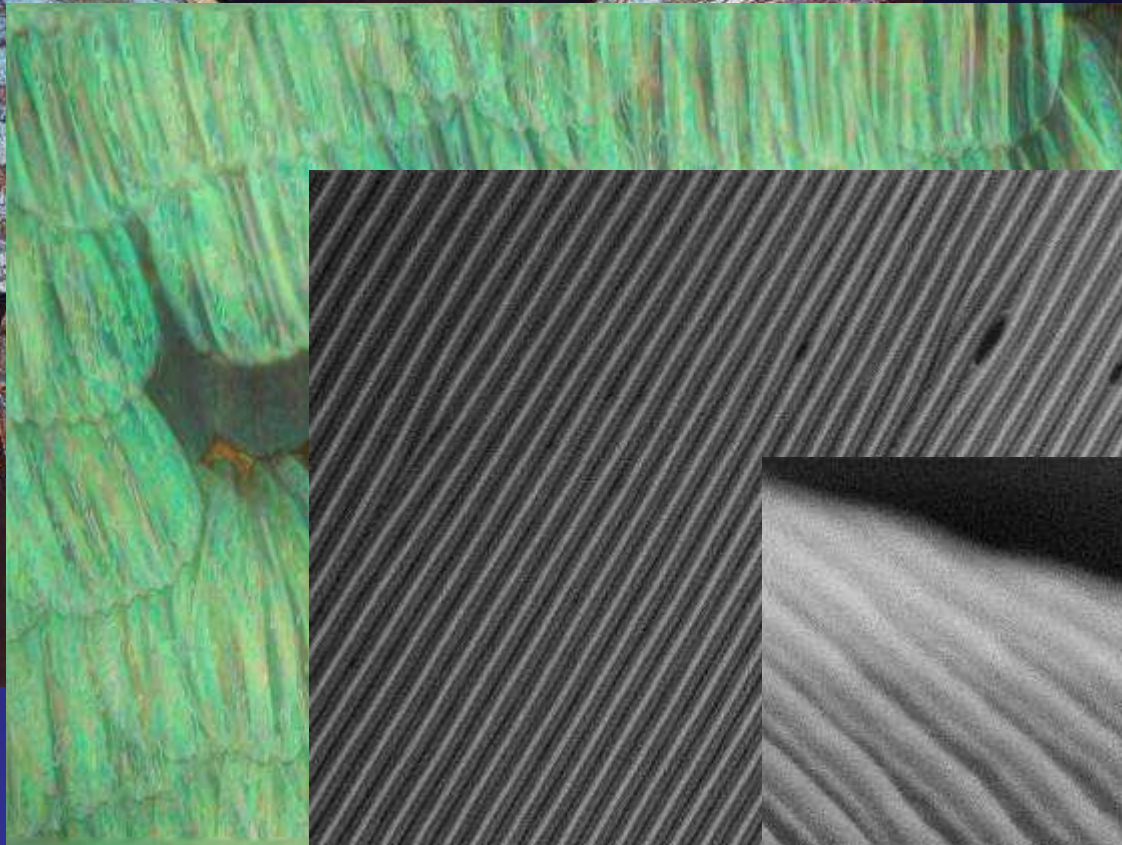
2 – Attaque ionique de la surface polie

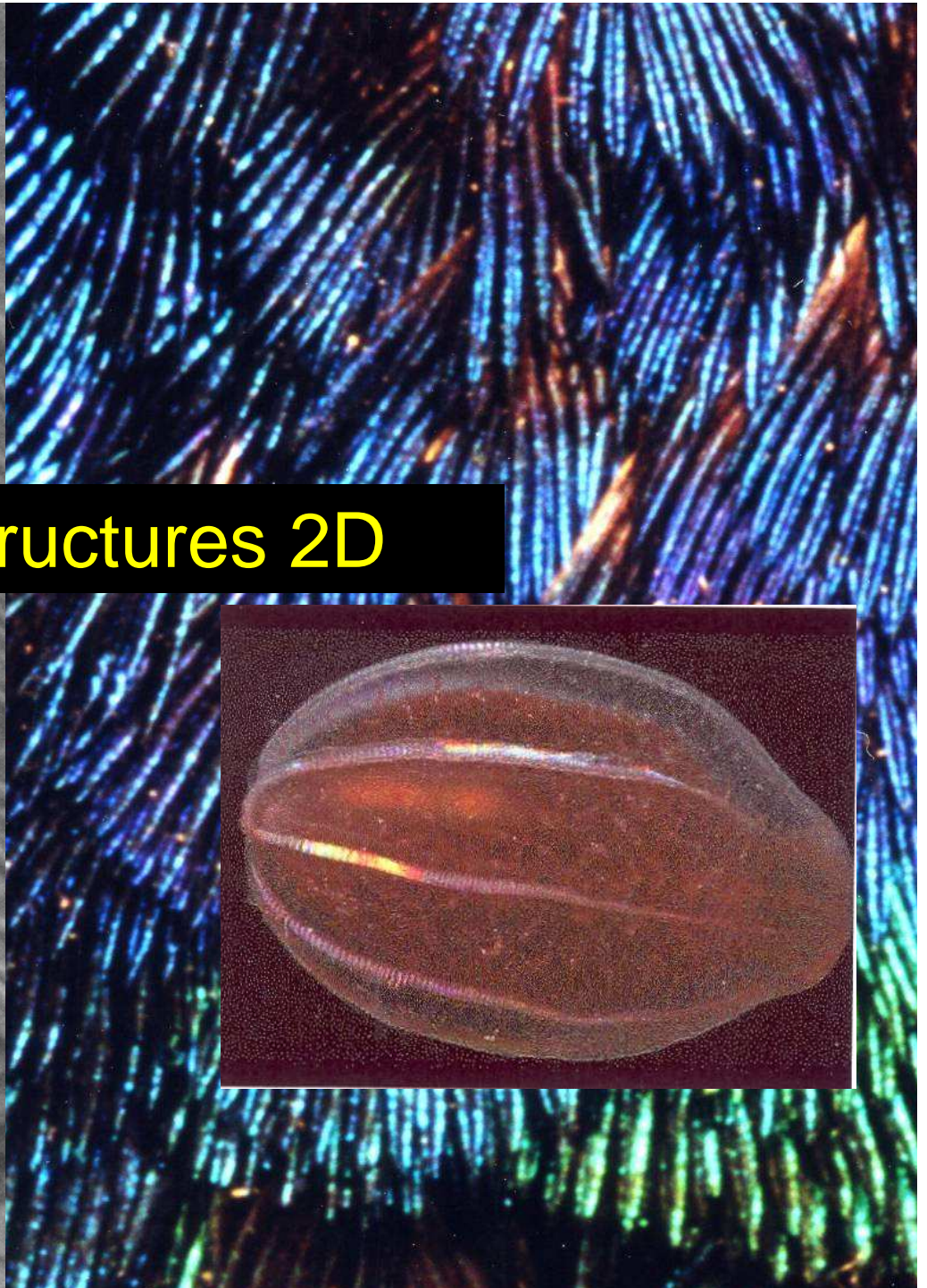


- *Dans le plan: Le réseau*



*o adonis*

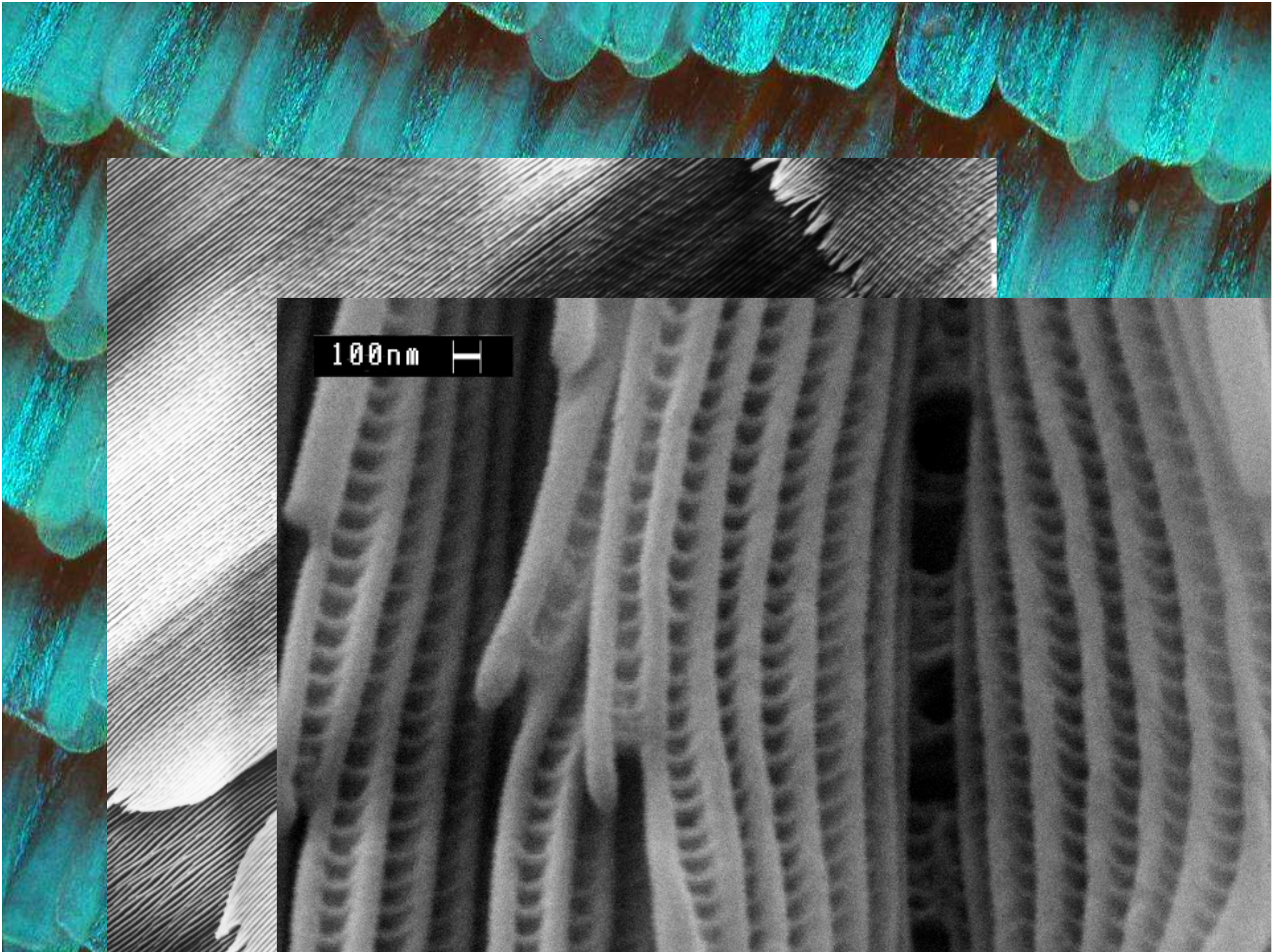


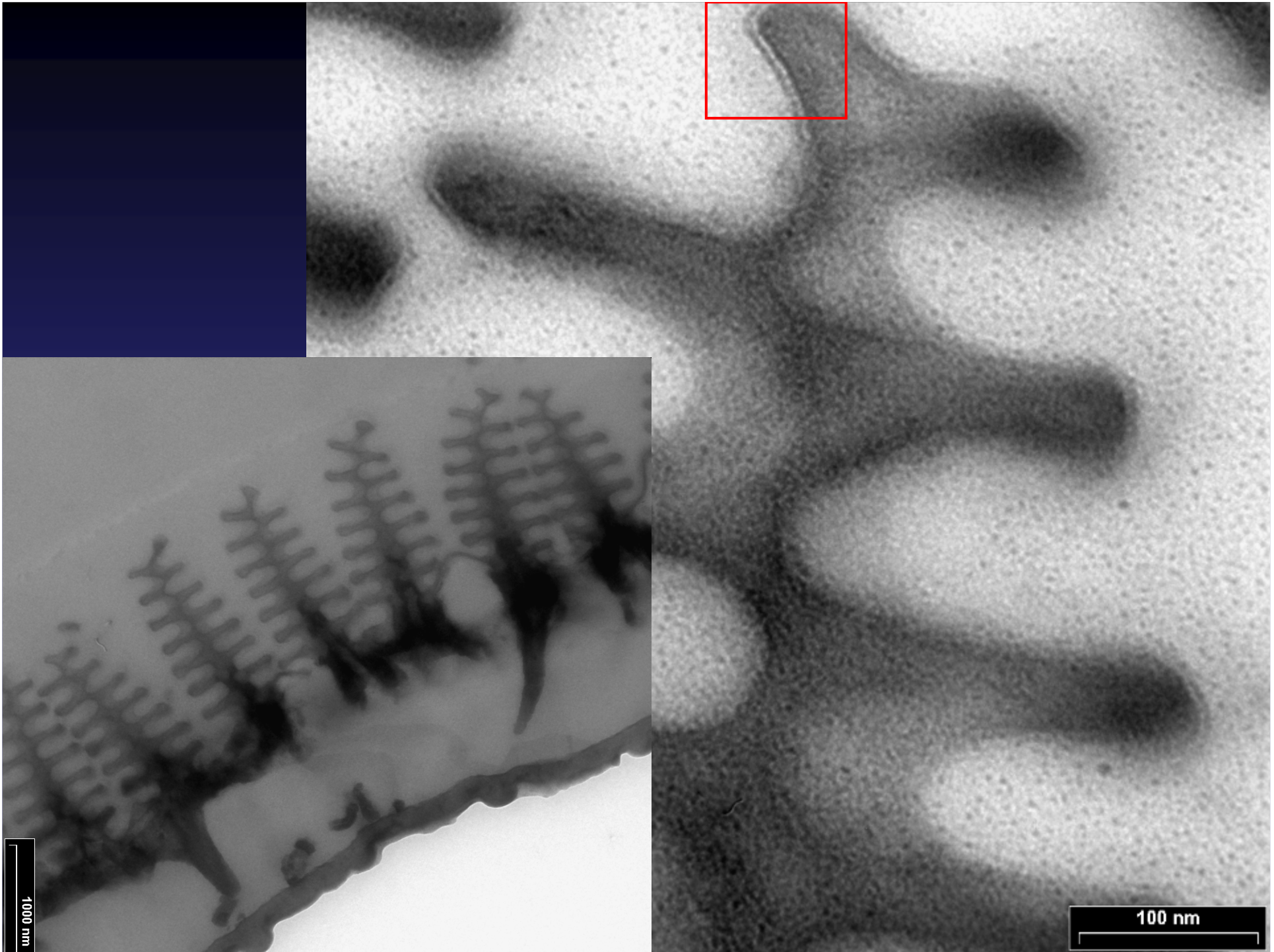


Structures 2D

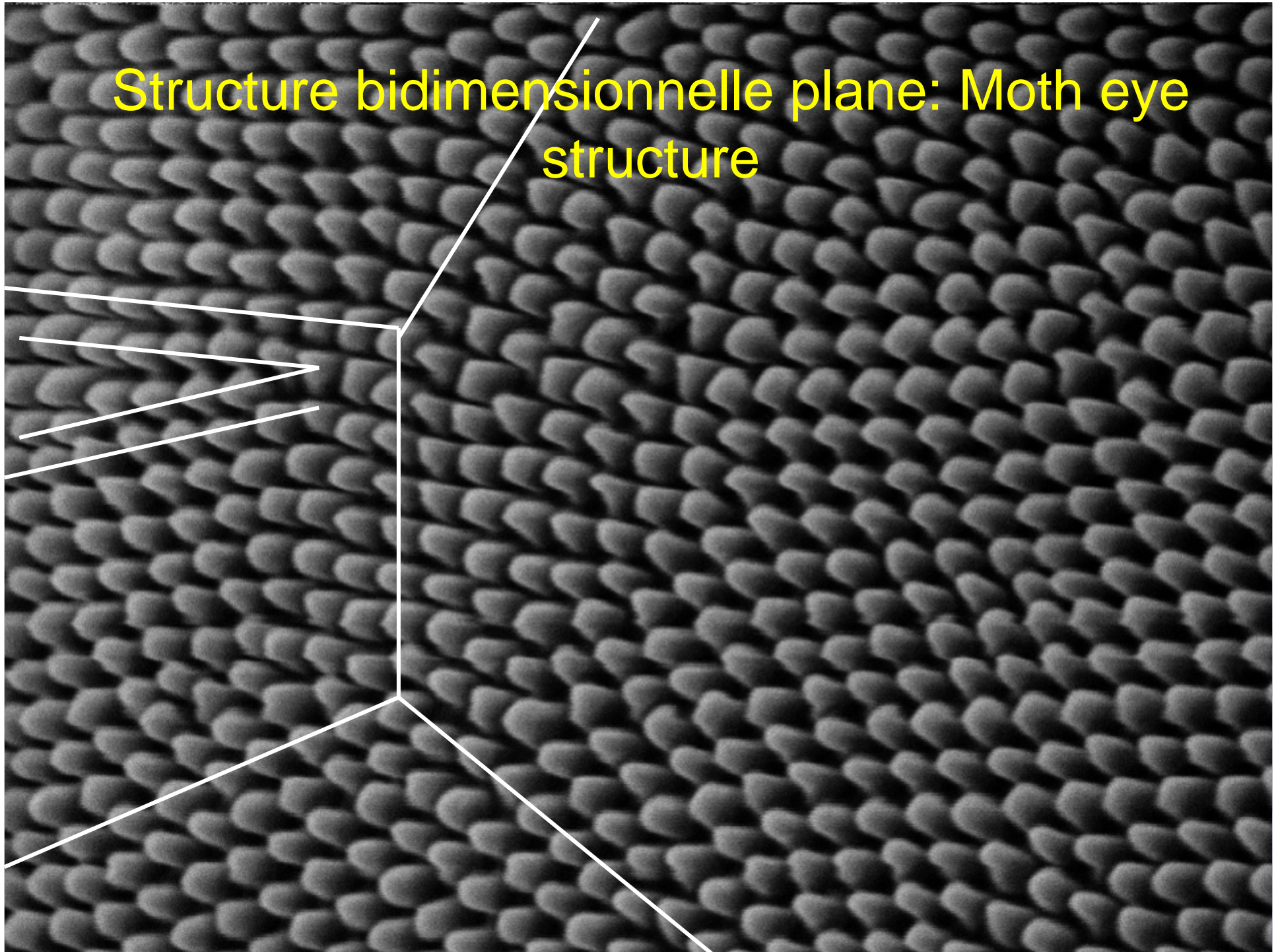


CB

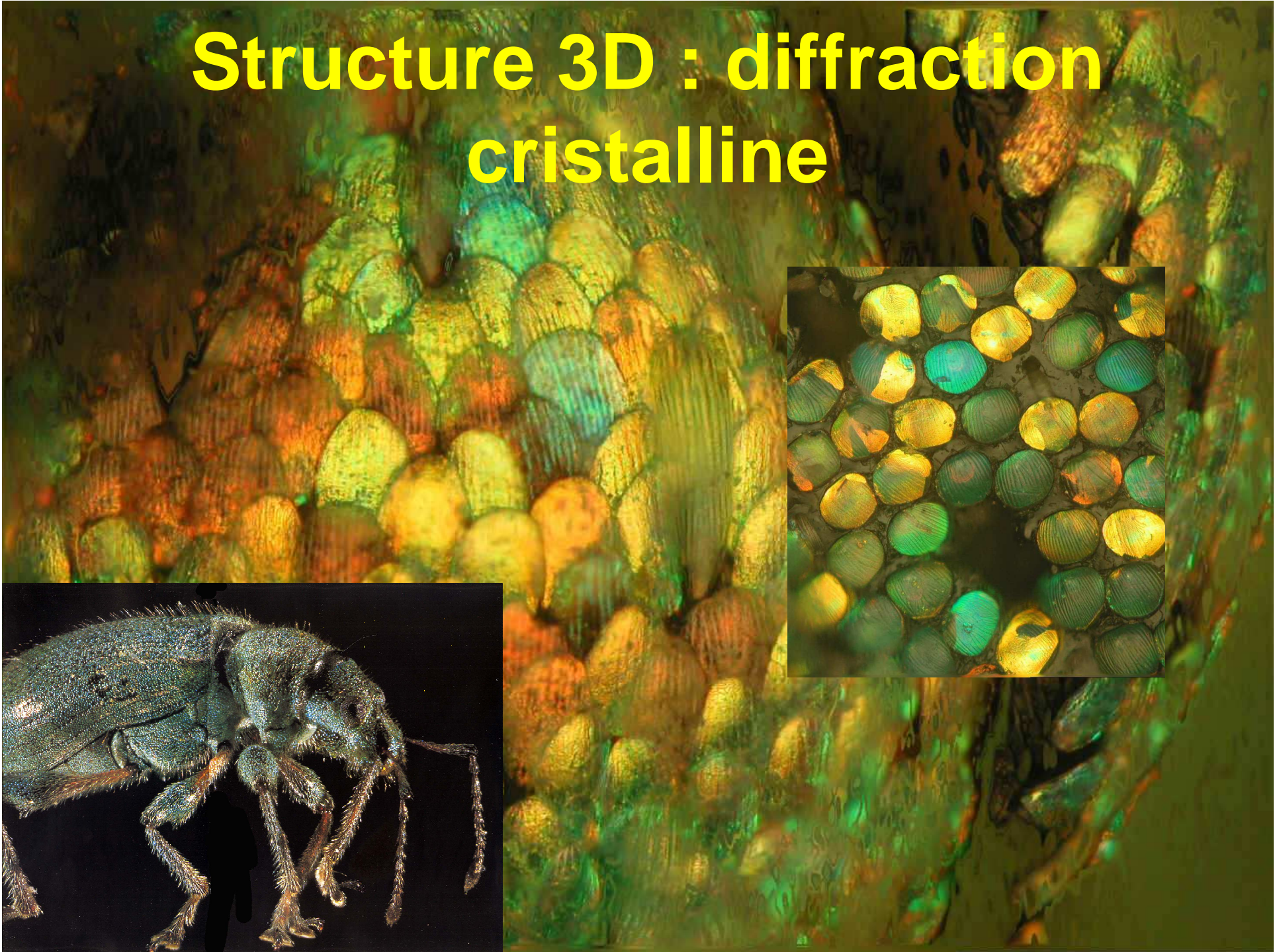




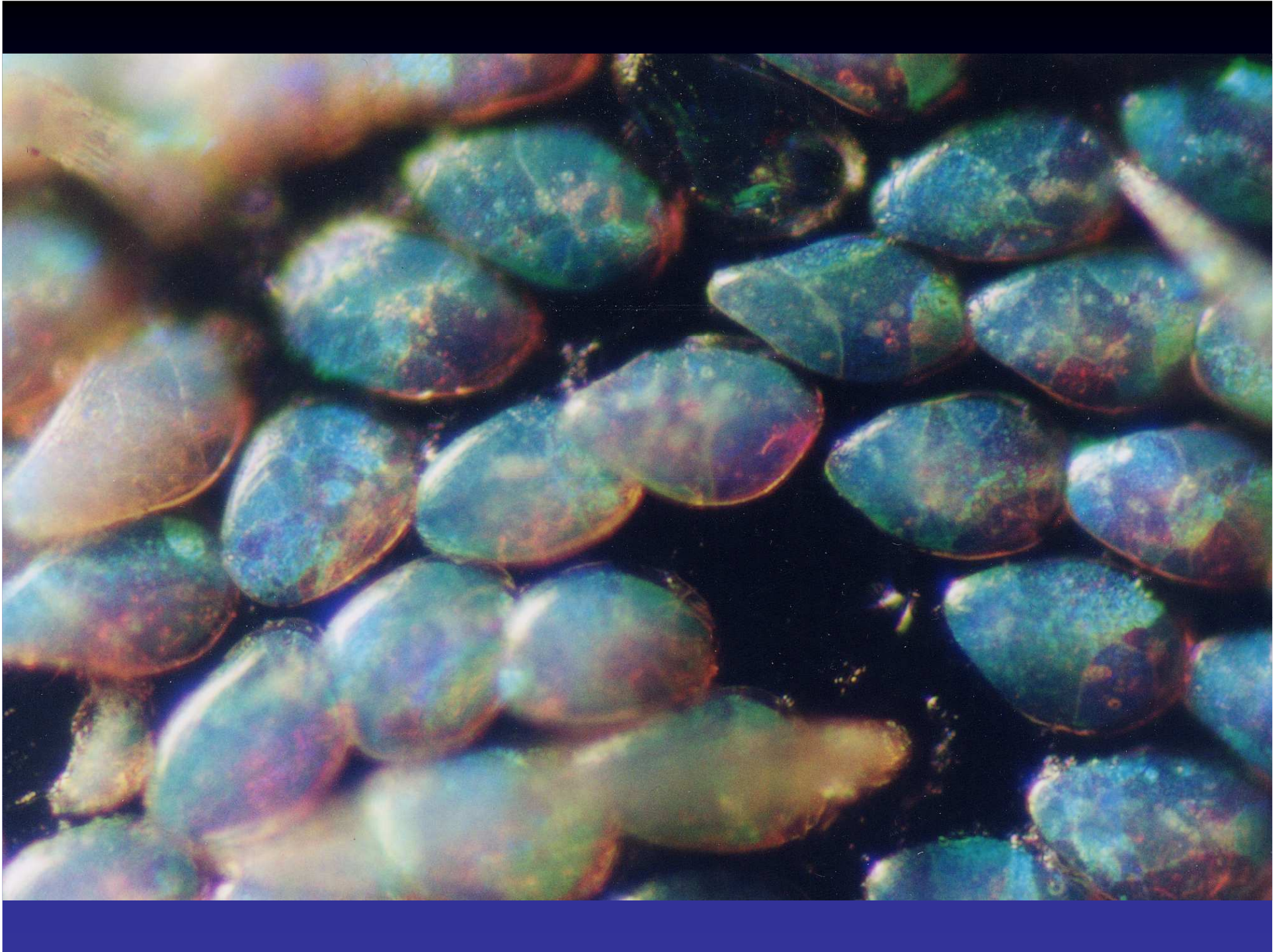
Structure bidimensionnelle plane: Moth eye structure

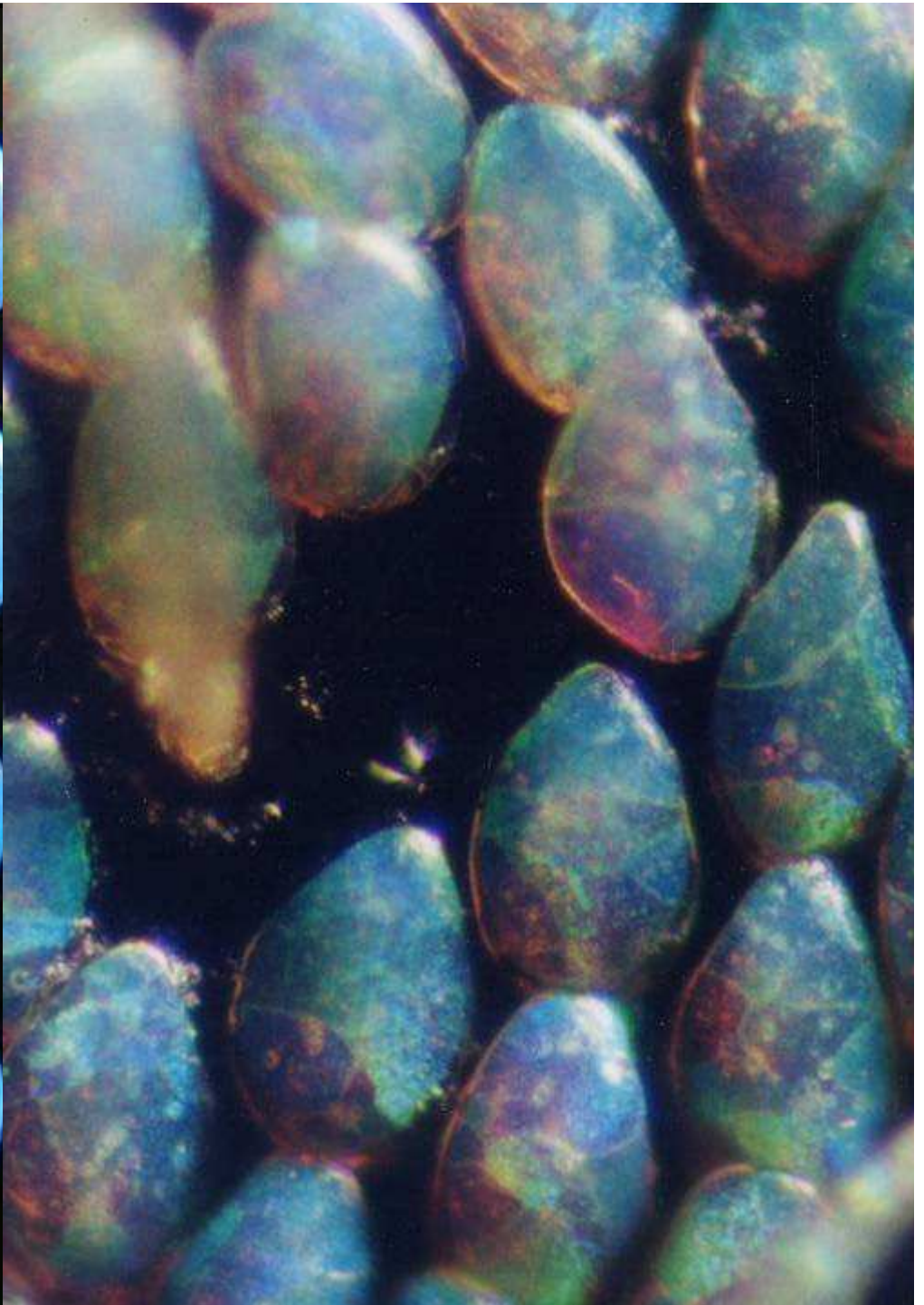
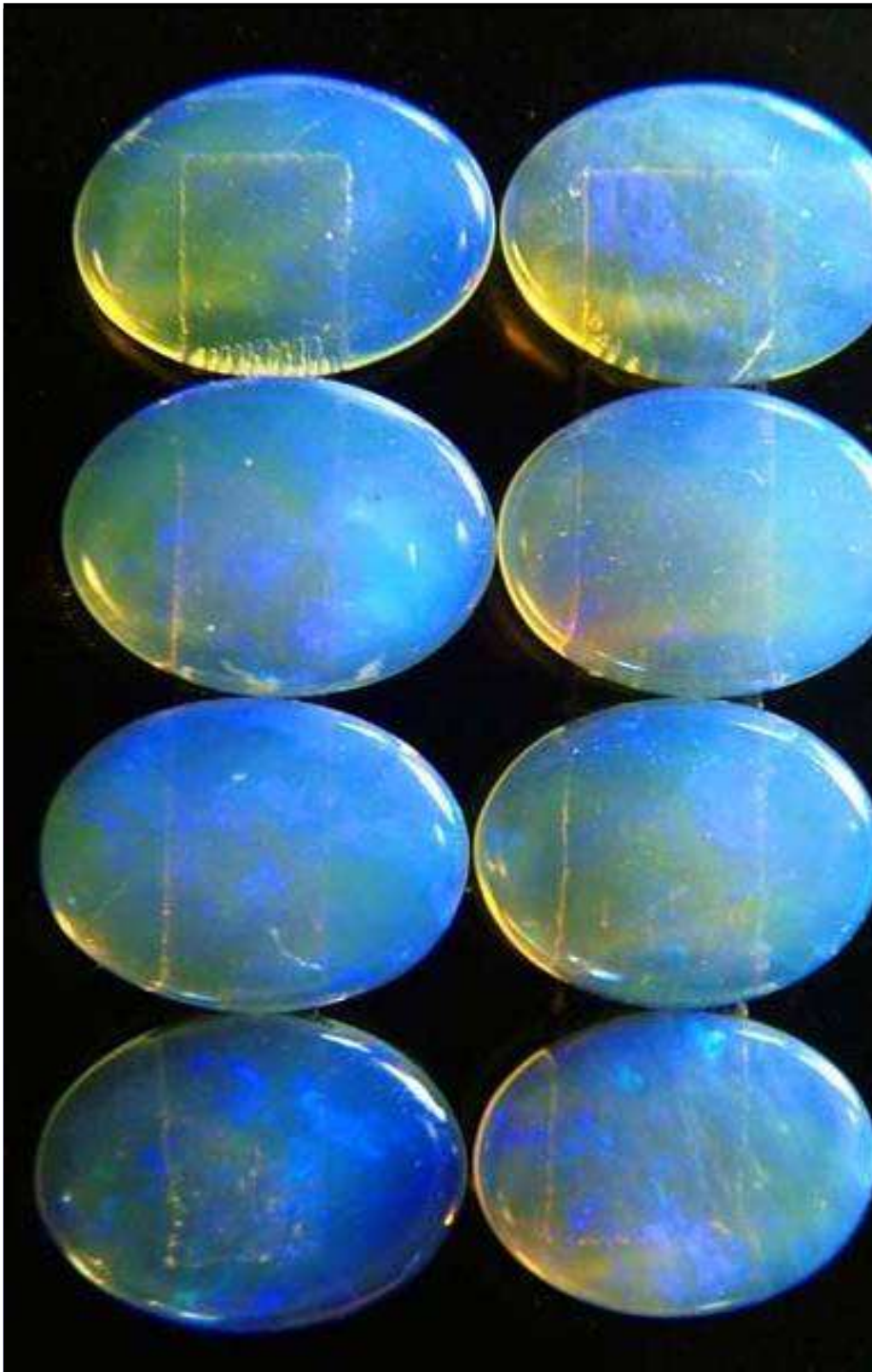


# Structure 3D : diffraction cristalline









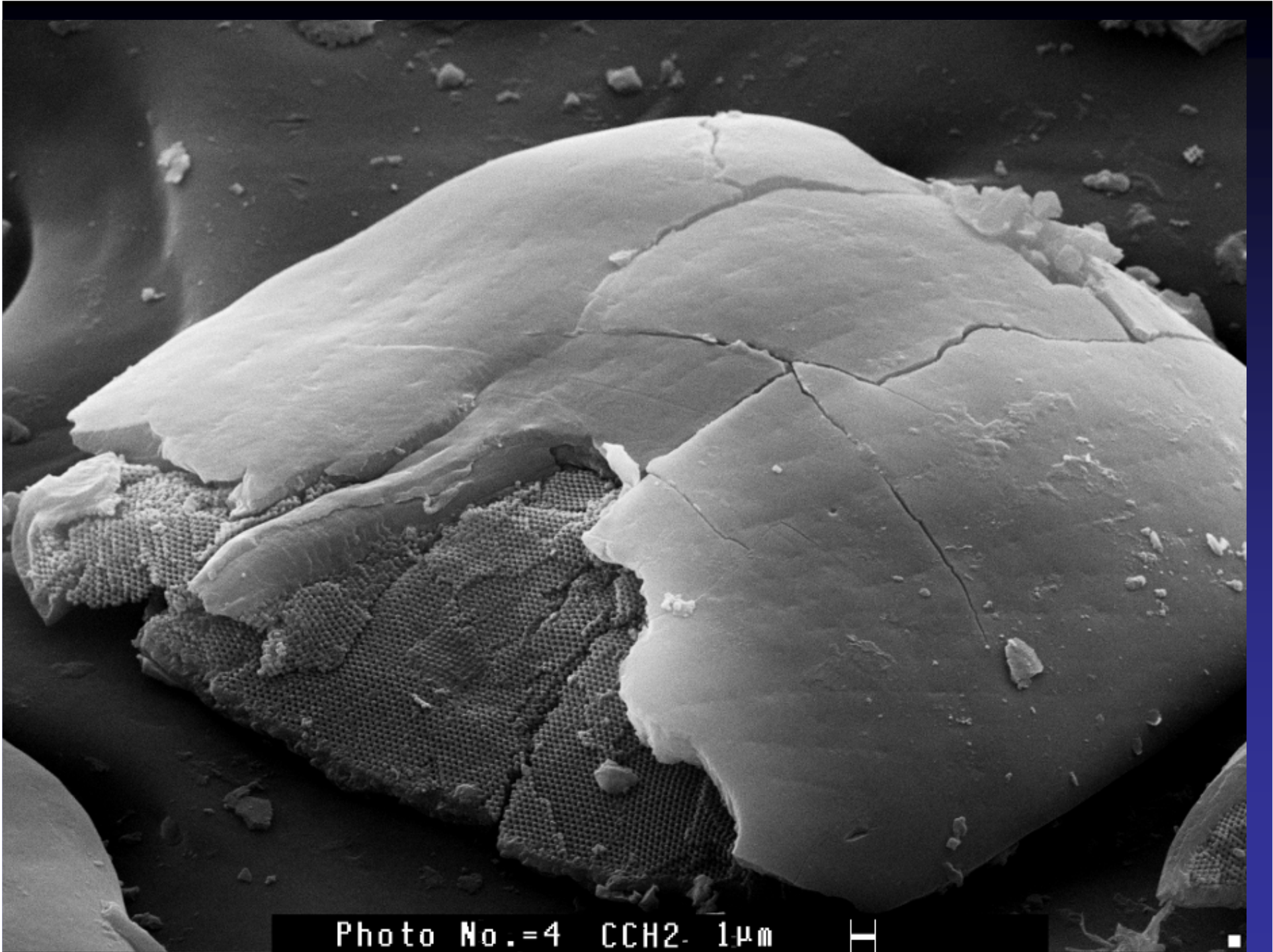


Photo No.=4 CCH2- 1 $\mu$ m



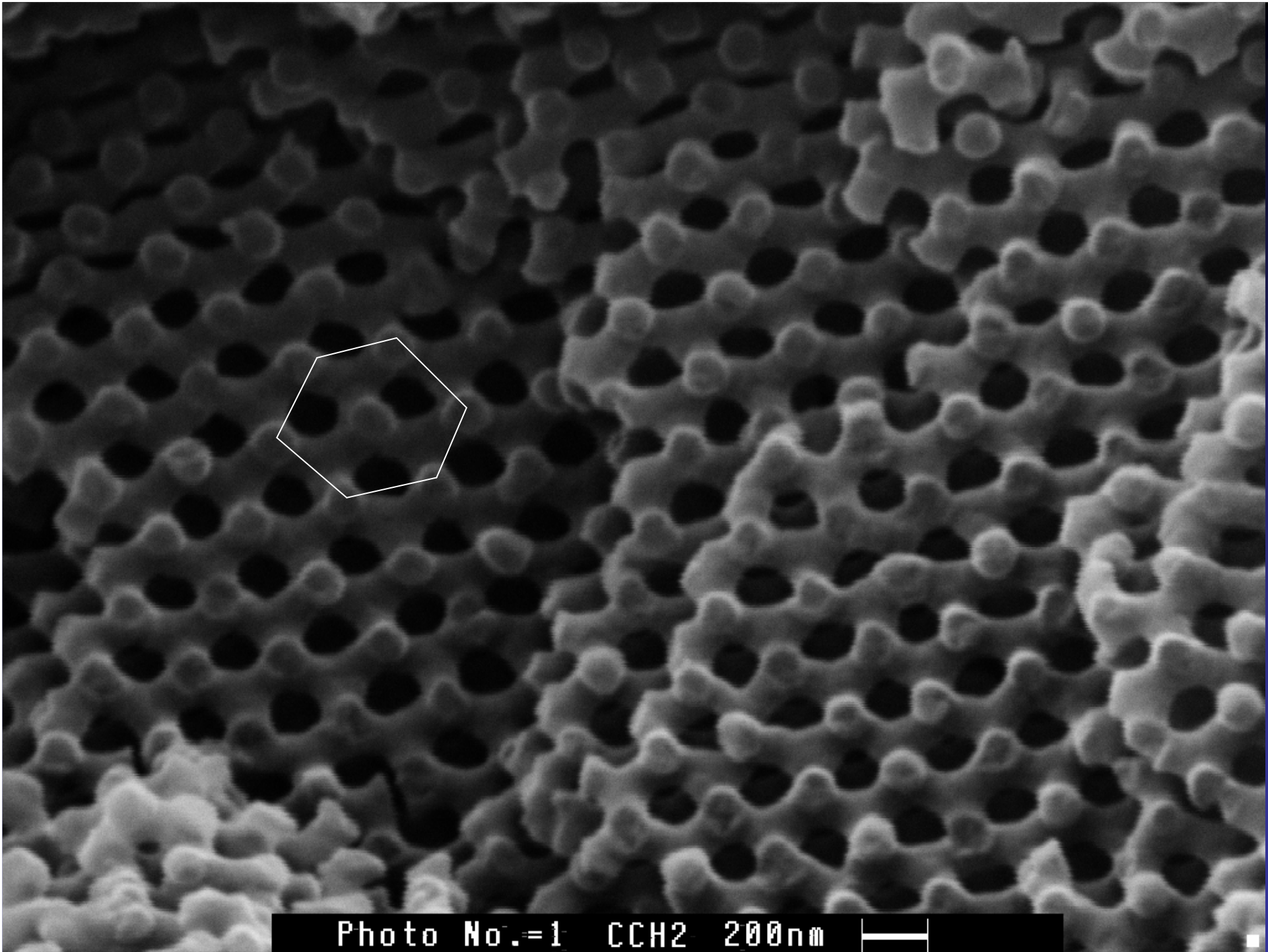
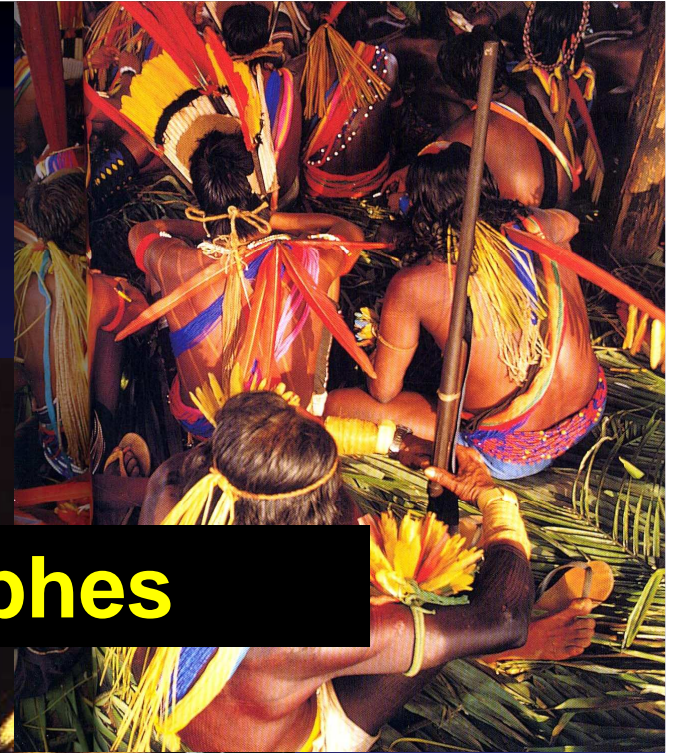
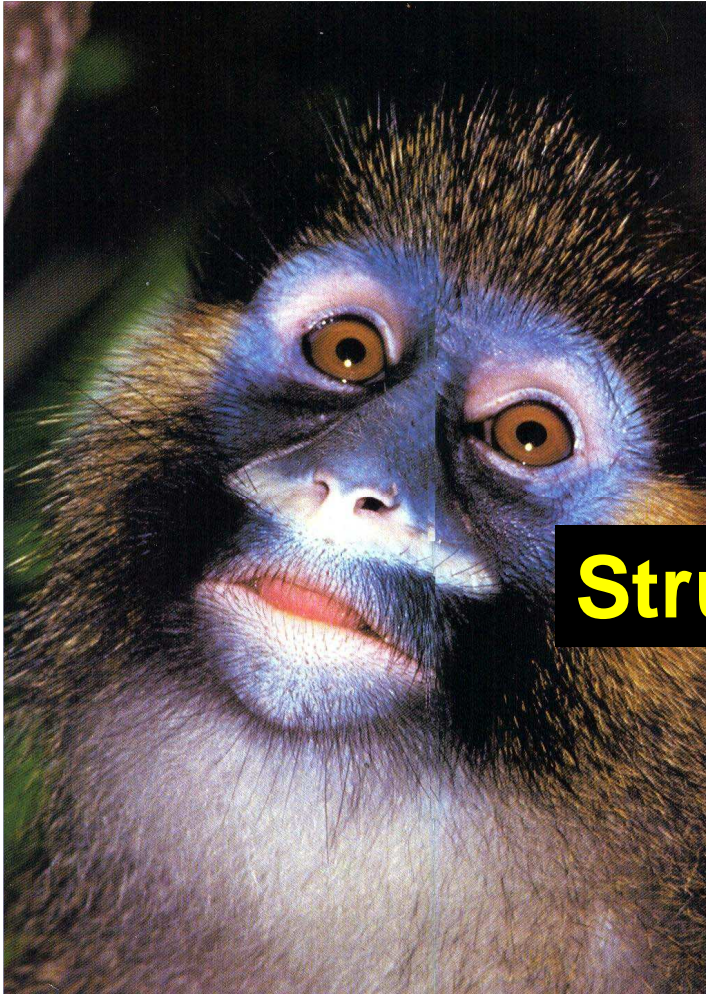


Photo No.=1 CCH2 200nm



**Structures amorphes**



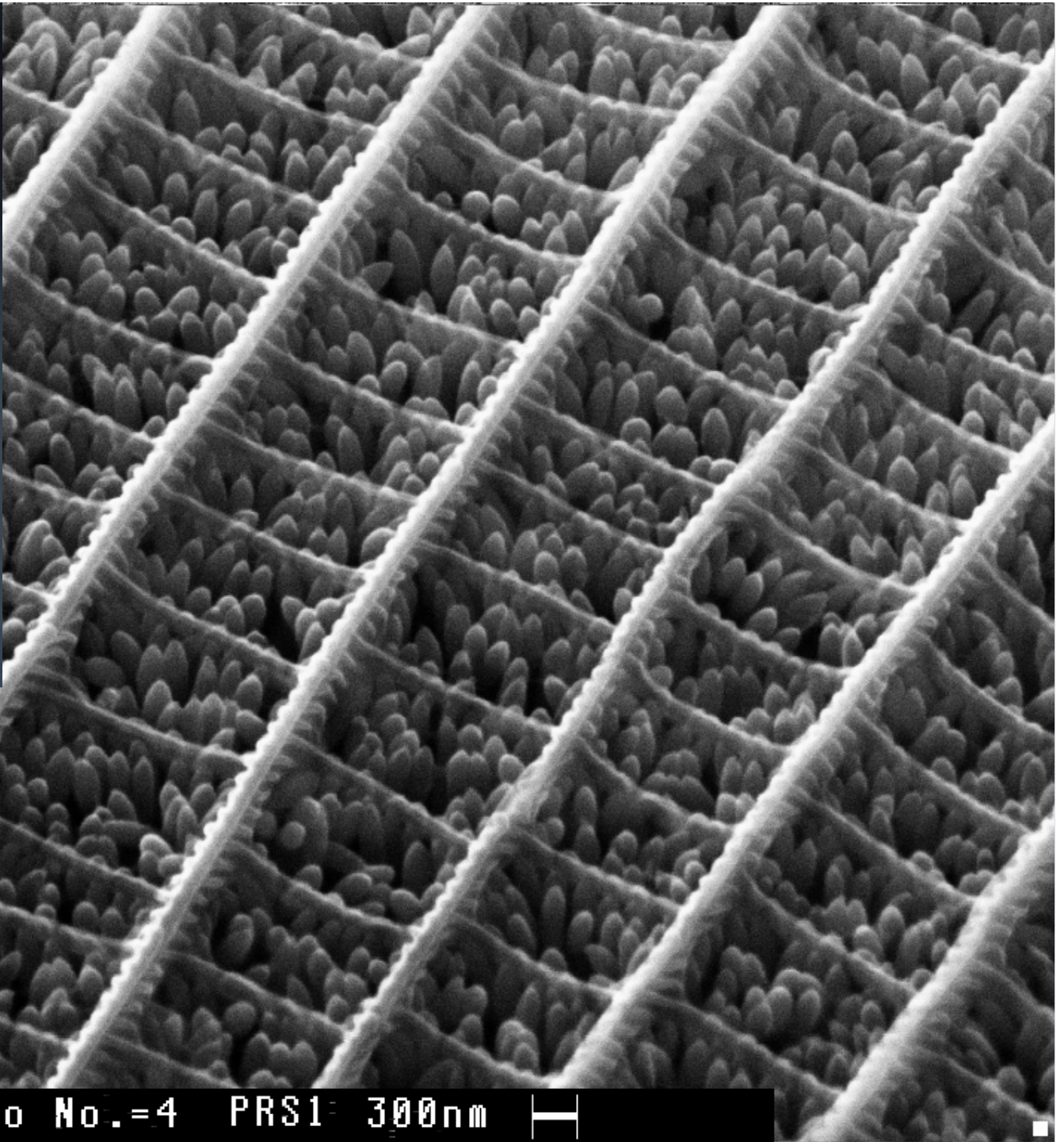

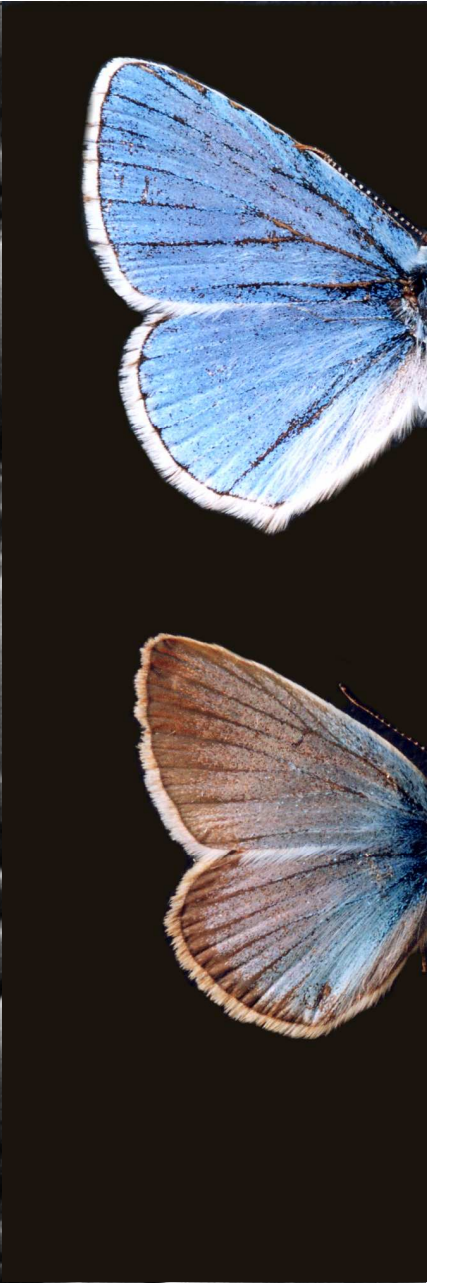
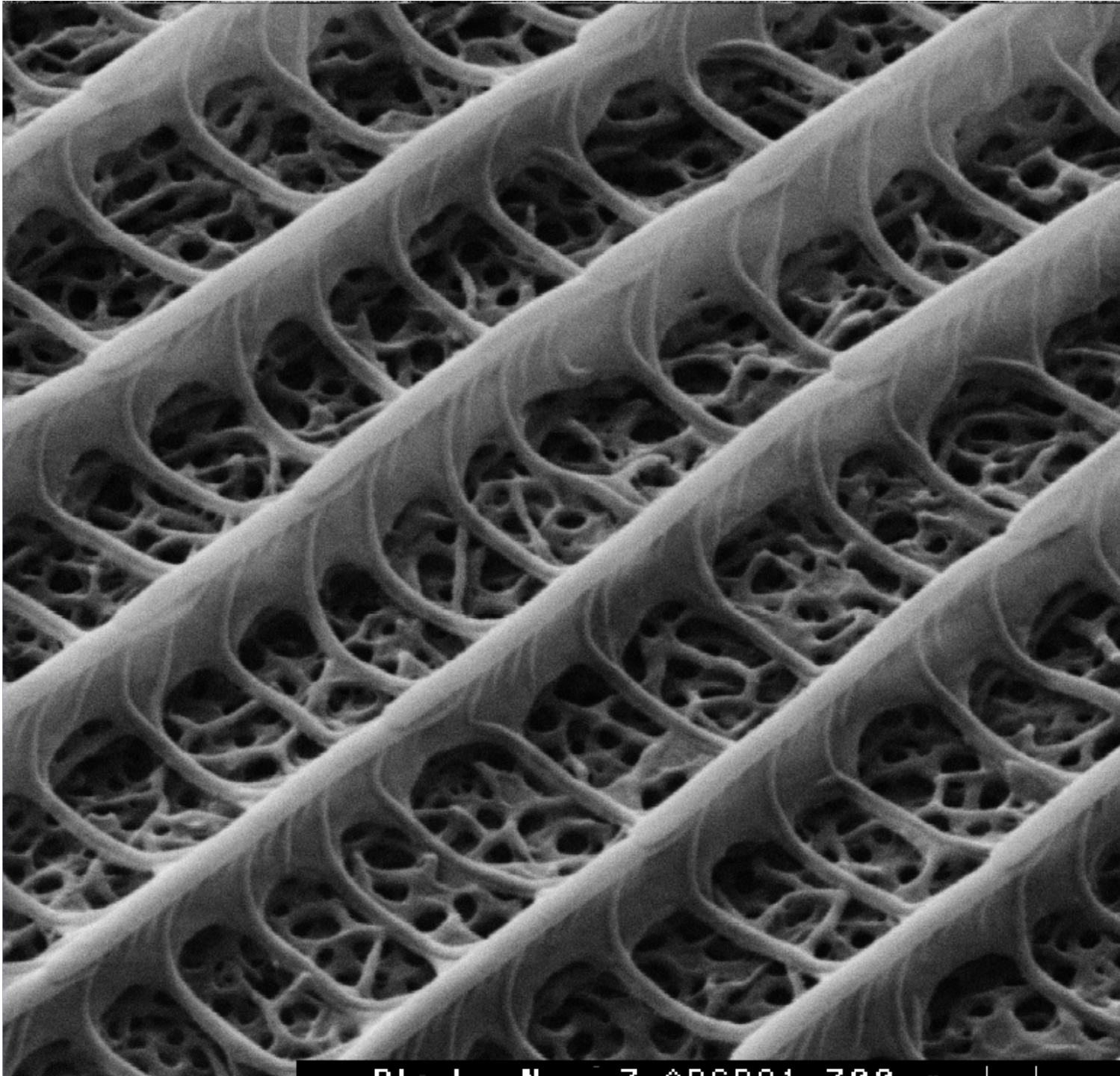


Photo No.=4 PRS1 300nm 



**Merci pour votre attention!**

