

**NATIONAL COORDINATION COUNCIL ON NANOTECHNOLOGY  
BULGARIAN ACADEMY OF SCIENCES**



**7<sup>th</sup> NATIONAL WORKSHOP on NANOSCIENCE & NANOTECHNOLOGY  
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# **Bioinspired Concepts and Medical Applications**

**Elena Mileva**

**Institute of Physical Chemistry**



# **BIOINSPIRED CONCEPTS AND MEDICAL APPLICATIONS**

**Key research topics are related to nanoscale  
phenomena in fluid media and  
at liquid and solid interfaces**

**Two major trends:**

- model studies**
- new pharmaceutical materials, medical  
applications**

# MODEL STUDIES:

- **liquid nanofilms**
- **amphiphilic bilayers, models of biological membranes**
- **nanostructures in solutions of surfactants, microbial surfactants, phospholipids and amphiphilic polymers**
- **nanoparticles in bulk solutions and at liquid interfaces**
- **self-assembled multilayer films from biopolymers on colloid particles**
  - **biocrystallization, protein crystallization**
    - **conducting polymers**
    - **metal/polymer sensors for bioactive substances**
- **nanostructured metal and metal/polymer materials for electrocatalytic applications**

# **MODEL STUDIES:**

- 1. Institute of Physical Chemistry, Department of Interface and Colloid Science  
(Exerowa, Stoylov, Radeva, Petkanchin, Mileva)**
- 2. Institute of Physical Chemistry, Department of Phase Formation and  
Crystal Growth  
(Nanev, Tsakova)**
- 3. Central Laboratory of Photoprocesses, Department of Laser-induced  
Processes in Solid State  
(Stabov, Starbova)**
- 4. Institute of Polymers, Laboratory of Bioactive Polymers  
(Rashkov)**
- 5. Institute of Biophysics, Department of Physical Chemistry of Biosurfaces  
(Petrov)**
- 6. Sofia University, Department of Physical Chemistry  
(Panaiotov, Radoev, Vassiliev)**
- 7. Sofia University, Department of Biochemistry  
(Lalchev)**

# **NEW PHARMACEUTICAL MATERIALS, MEDICAL APPLICATIONS**

- **new physicochemical diagnostic methods**
- **new knowledge-based pharmaceutical nanomaterials,  
incl. hybrid matrices and catalytic systems**
- **new biocompatible and bioactive nanostructured materials for  
implants and bone recovery**
- **drug delivery nanoparticles (mixed polymer/surfactant systems, etc.)**

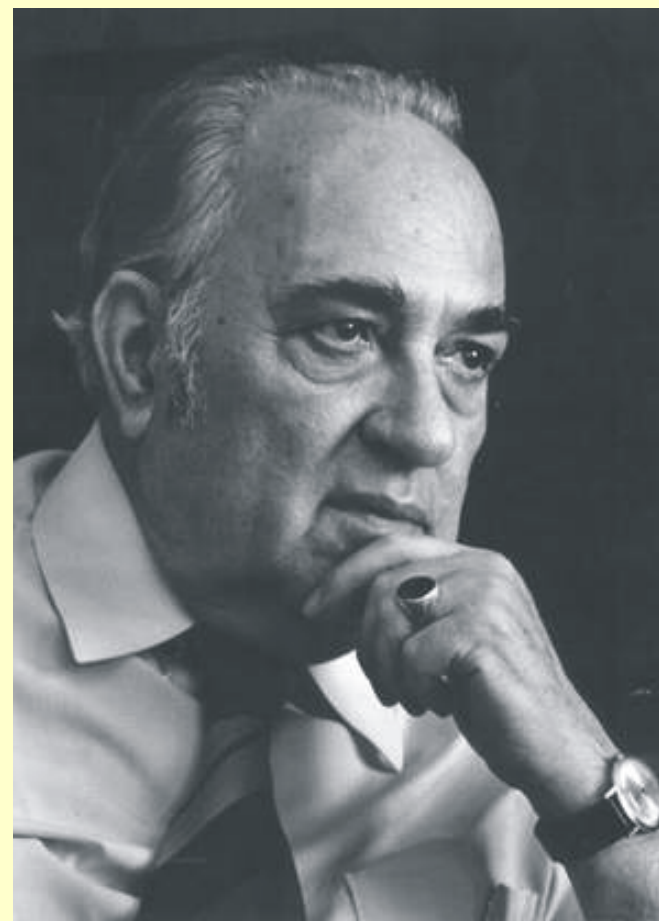
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(Panaiotov, Lalchev)**
- 6. Institute of Microbiology  
(Kabaivanova)**
- 7. Institute of Solid State Physics  
(Pramatarova)**
- 8. University of Chemical Technology and Metallurgy  
(Samuneva)**
- 9. Varna University, Department of Preclinical and Clinical Pharmacology and Biochemistry  
(Galunska)**

The founders of the Bulgarian School of Physical Chemistry



Professor Ivan Stranski  
(1896 - 1979)



Professor Rostislav Kaischew  
(1908 - 2002)

# **Institute of Physical Chemistry**

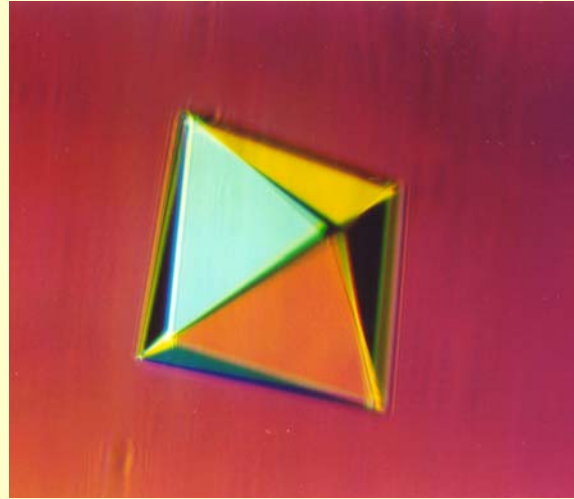
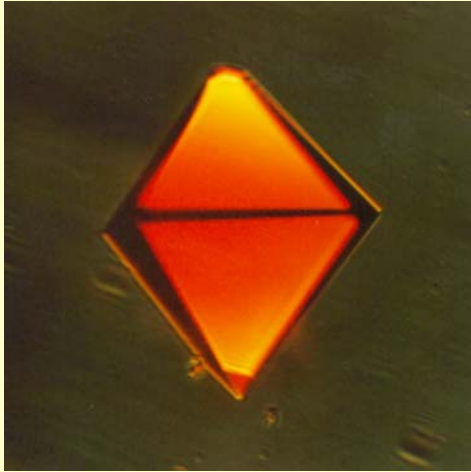


**The basic activity of the Institute is fundamental and applied research in the field of:**

- **phase transitions**
  - **crystal growth**
- **interfaces and colloids**
  - **amorphous phases**
- **applied electrochemistry for synthesis of new materials**
  - **thin solid films**
  - **protective coatings**



# Protein crystallization

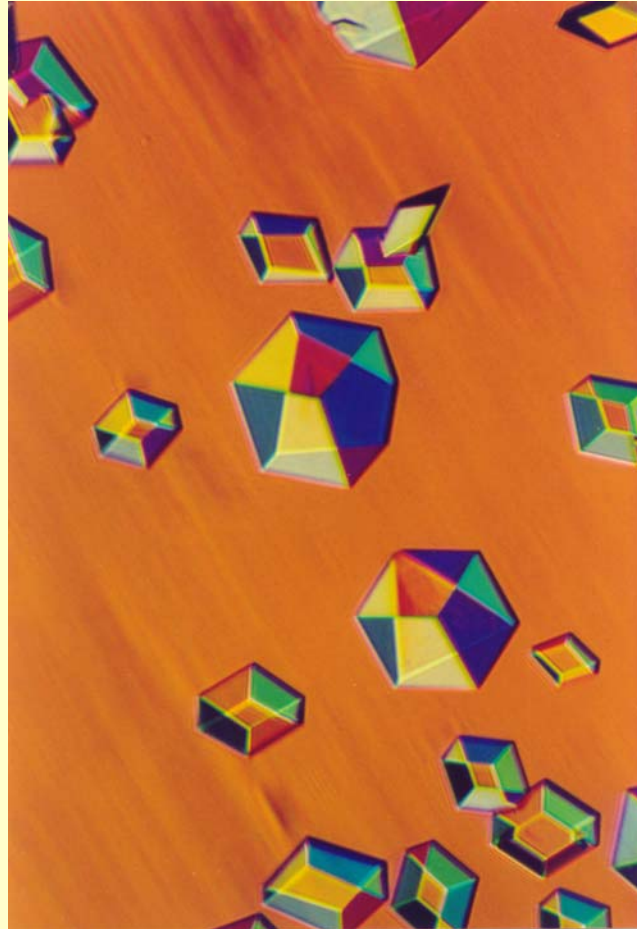


Ferritin (left-hand side) and apo-ferritin (right-hand side) crystals

**0.2 mm**



# Protein crystallization

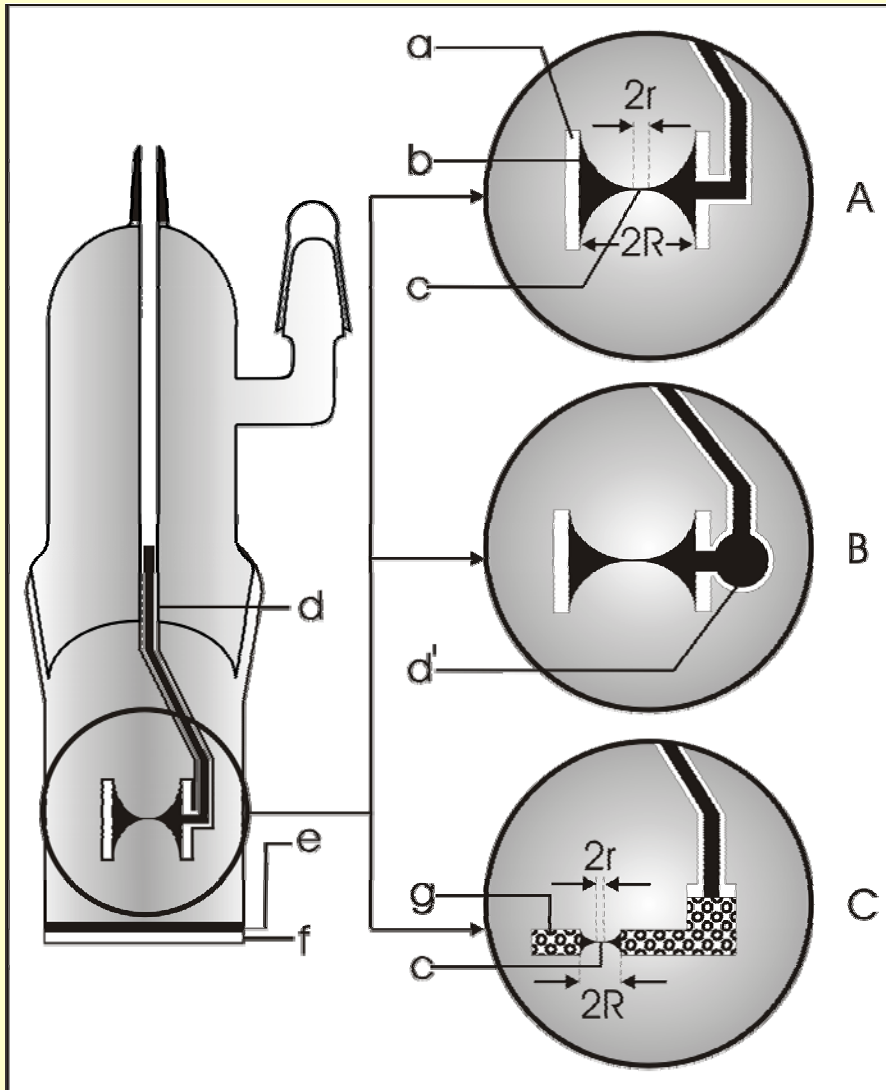


Crystals of hormone Insulin

# Thin liquid films (liquid nanofilms)



Professor Alexei Scheludko  
(1920 - 1995)



Scheme of **Scheludko-Exerowa measuring cell** for the study of microscopic foam films;

**A:** in a glass tube;

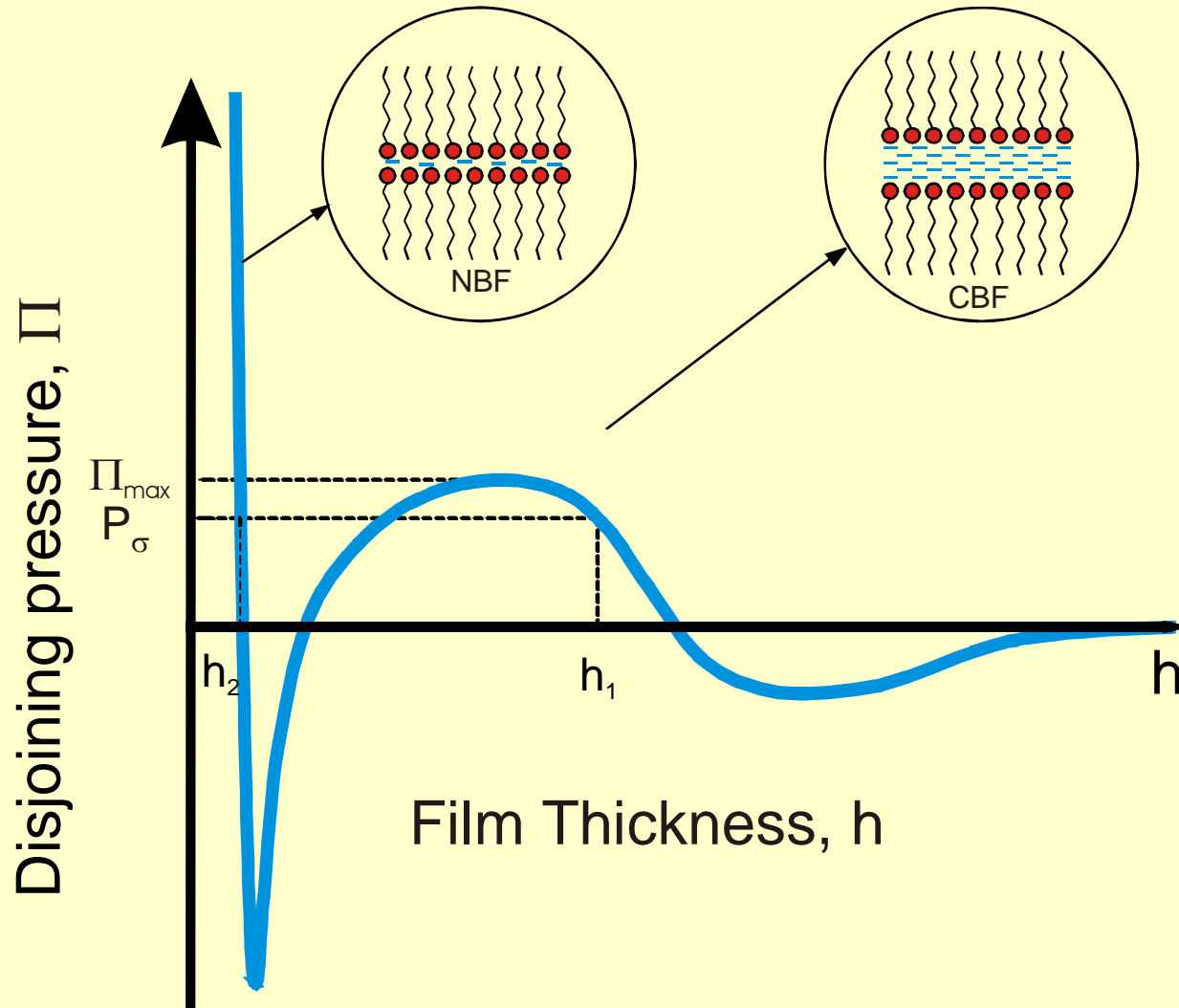
**B:** with a reservoir of surfactant solution **d'**;

**C:** in a porous plate;

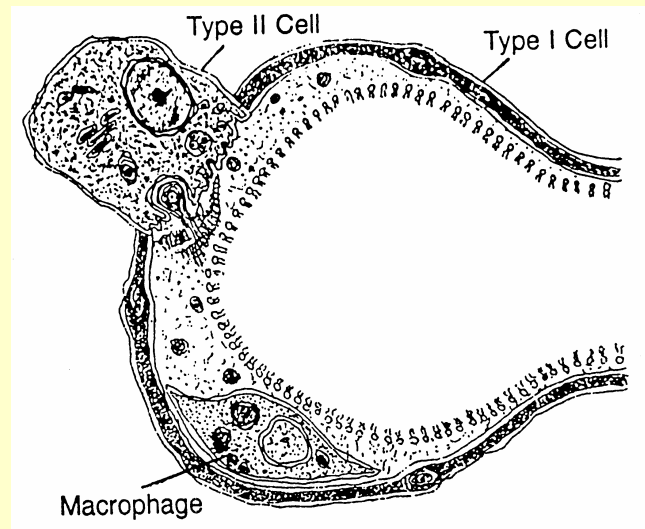
**a** - glass tube film holder; **b** - biconcave drop;  
**c** - microscopic foam film; **d** – glass capillary;  
**e** - surfactant solution; **f** - optically flat glass;  
**g** - porous plate.

# Liquid nanofilms

## Disjoining pressure isotherm



# Lung surfactant system



**MODEL (*in vitro*)**

**Alveolar Surface**

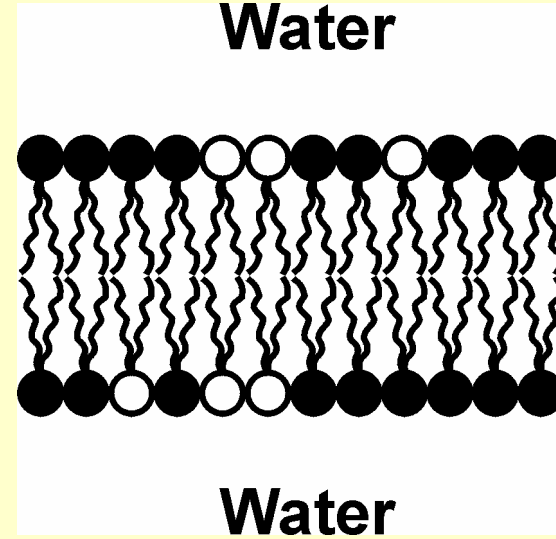
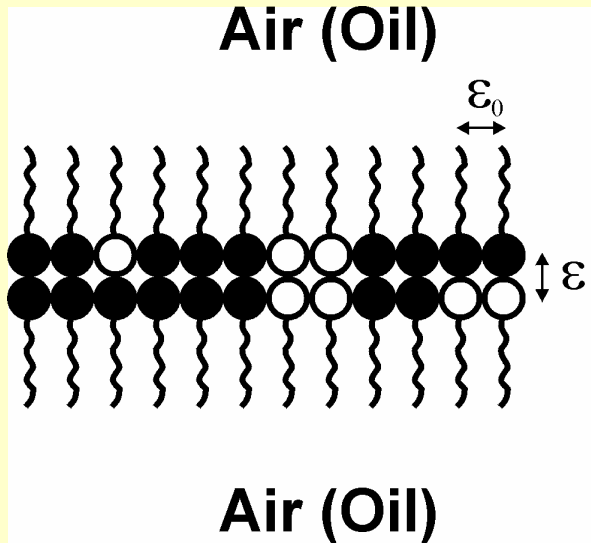
**MODEL (*in vivo*)**

Microscopic Foam Film  
Conditions in Lung Alveoli  
( $P_C$ ,  $r$ ,  $C_{el}$ ,  $t^\circ$ )

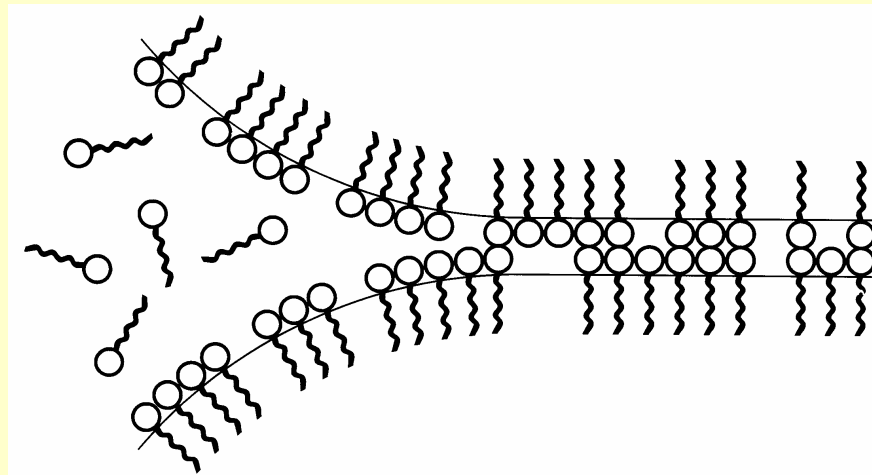
New Hypothesis for the  
Structure of the Alveola  
(Amphiphile Bilayer/Multilayer)

**New Physicochemical Clinical Methods for Assessment of  
Lung Maturity and Respiratory Disturbances**

# Formation and stability of amphiphile bilayers



## Amphiphile bilayers from soluble surfactants

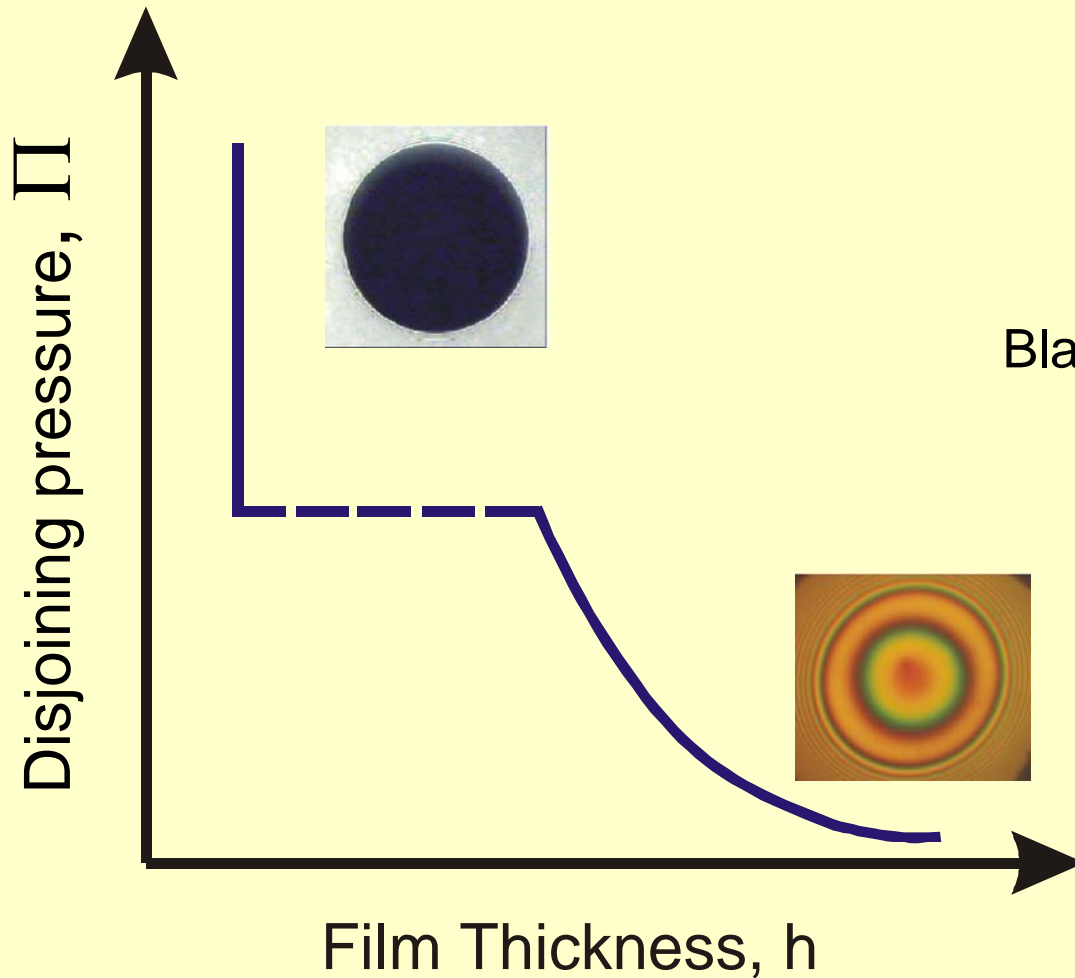
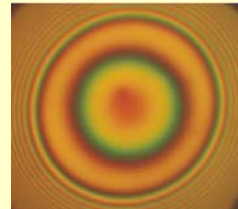


# Bilayer film (NBF) transition

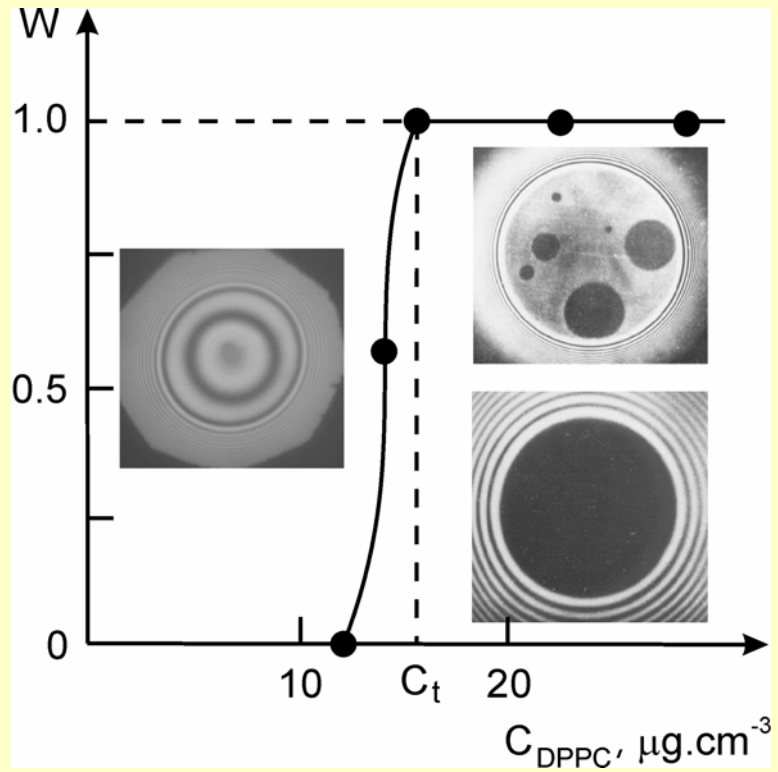
Thin Liquid Film: thickness  $100 \div 30$  nm



Black Film: thickness  $20 \div 5$  nm

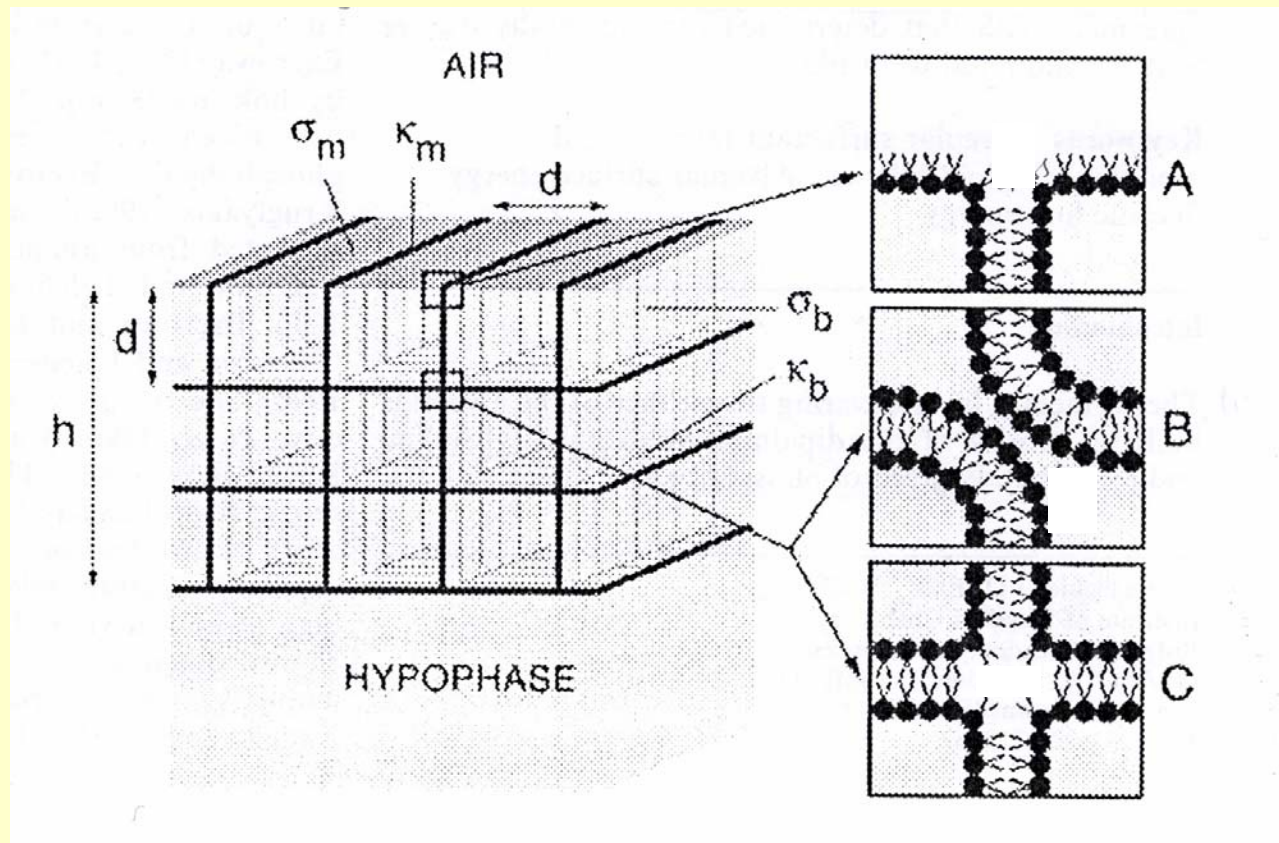


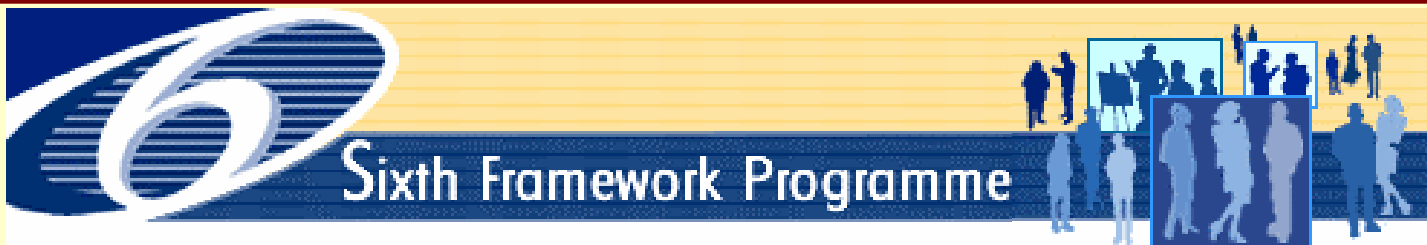




$C_t \implies \text{RDS}$

# Structure of surfactant layer on the alveolar surface





# NANOSCALE PHENOMENA AND STRUCTURES IN BULK AND SURFACE PHASES

# NANOPHEN

# NANOPHEN

**WP1**  
Collaboration  
with Member  
States

**T 1 1** Exchange of  
personnel and  
results  
**T 1 2** Participation  
in FP6  
**T 1 3** VIRT  
**T 1 4** New networks  
**T 1 5** Participation  
in NCNT

**WP2**  
Upgrade of  
S&T equipment

**T 2 1** Upgrade of  
equipment  
**T 2 2** Upgrade of  
electronic  
communication

**WP3**  
Carrier prospects  
for young  
scientists

**T 3 1** New jobs  
**T 3 2** New skills  
**T 3 3** Training abroad

**WP4**  
Dissemination of  
knowledge

**T 4 1** Workshops  
and conference  
**T 4 2** International  
scientific  
events  
**T 4 3** Scientific  
literature  
**T 4 4** Relation with  
public

**WP5**  
Management

**T 5 1** Monitoring  
and progress  
**T 5 2** Financial  
management  
**T 5 3** Organizational  
management  
**T 5 4** Women in  
Science

## **Strategic objective:**

**The basic objective of the NANOPHEN project is to improve and reinforce the research capacity of the Institute of Physical Chemistry at the Bulgarian Academy of Sciences in the field of nanoscale phenomena in bulk and surface phases so as to foster the impact of nanotechnologies on national scientific and economic development.**

# Main goals:

The NANOPHEN project aims at:

- **enhanced collaboration** with similar MS institutions and formation of stable networks
- improving the **participation in ERA**
- formation of a **critical mass of highly qualified young researchers** with multidisciplinary scientific skills
- improving the **technical level of key scientific equipment in IPC-BAS**

# Expected results:

The proposed support actions will result in:

- increasing the quality and scope of IPC-BAS research activities in the field of NMP
- adding new value to the national scientific potential in the thematic priority of the NANOPHEN project
- opposing the negative trend of age-misbalance in science and “brain-drain” of Bulgarian young researchers
- elaborating a new concept for coupling multidisciplinary practical training and fundamental knowledge in the field of nanoscale phenomena and structures
- **converting IPC-BAS into a high-level European research institution**