Detergency

A need for qualification

A necessary innovation

A proven efficacy

Why better detergents' performances?

- Techniques evolution
  - material
  - efficacy / time
- Biocide Directive
  - ecotoxicological data
- Biological data evolution
  - nv MCJ . . .

Definitions (1)

Detergent (Commission Recommendation 89/542/EEC)

- Products intended for washing and cleaning purposes or for use in connection with washing and cleaning process….

  (washing machines ; dish washers)
- The definition also applies to products used to prewash or whiten, fabric softeners or any product intended to be used for cleaning purposes...

Definitions (2)

Detergency

- **Process by which soil is removed from a surface and undergoes solubilization or dispersion.**

  Result of several physicochemical phenomenons taking place at the interface of three phases : surface/soil/detergent.
- **The phenomenons are :**
  - **Wetting of surface.**
  - **Removal of soil from surface.**
  - **Avoiding re-deposition of soil on surface.**

Basic principles

Detergency : 1 / wetting

The detergent must come into contact with the surface so that ... (F_a = adherence force)

- $F_{detergent/surface} > F_{soil\ /surface}$

- To lower the superficial tension of the detergent solution…
- …and the interfacial tensions between aqueous bath, soil and surface

Basic principles

Detergency : 2 / Removal of soil

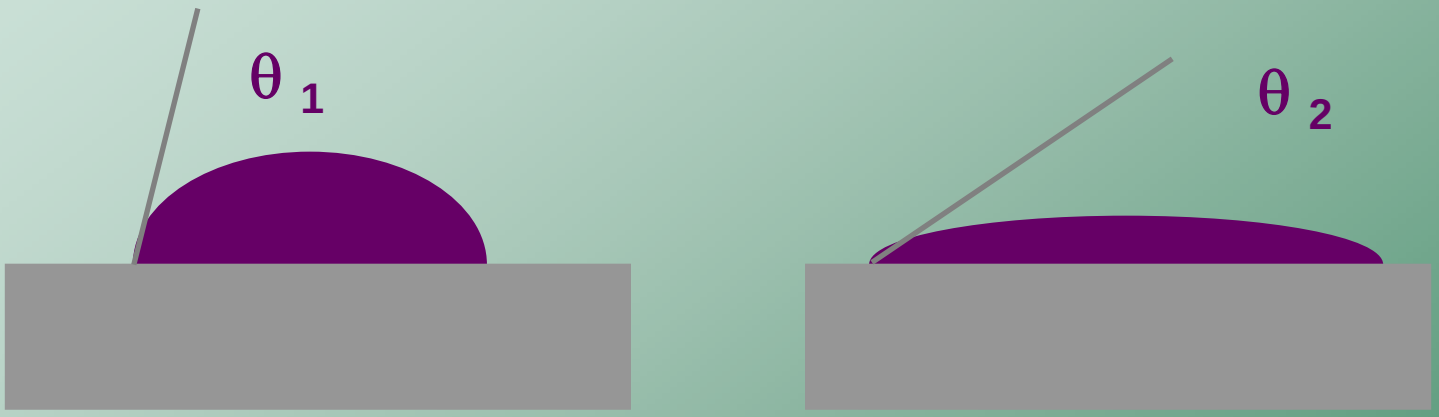
surface / soil + detergent

surface / detergent + soil / detergent

- The detergent solution wets the surface, is absorbed by it and lowers the surface's attraction to allow the soil to separate itself from the surface.

Basic principles

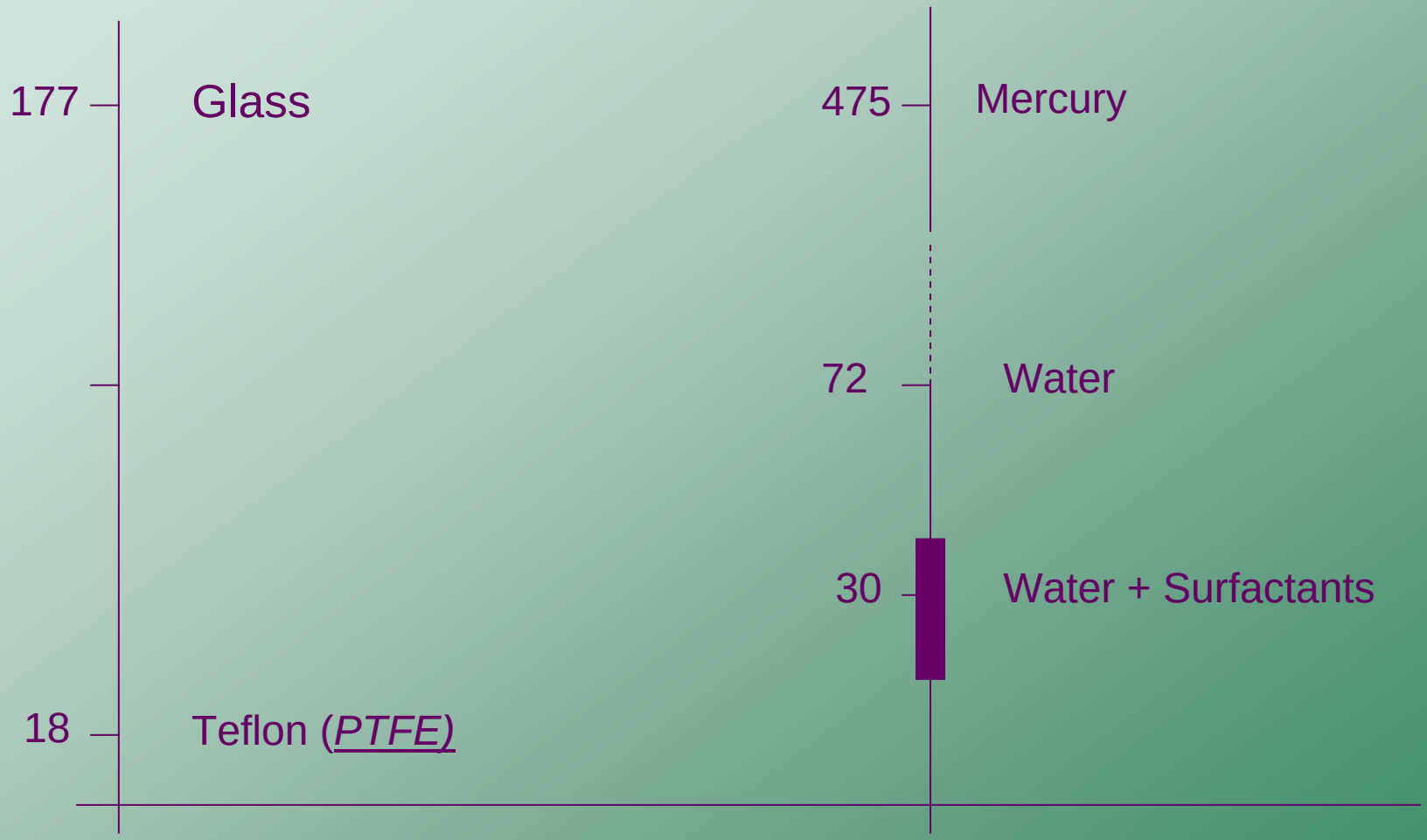
Wetting



θ = contact angle

Basic principles

Surface tensions



Basic principles

Detergency : 3 / avoiding re-deposition

- Chemical reactions
  - lipids undergo saponification
  - mineral soil undergoes solubilization
  - soil undergoes emulsification
    - Liquid soil = hydrophobic ; detergent solution = hydrophilic.

→ Surfactant potentials and *émulgateur des détergents*

How can we better detergents' performances ?

- By understanding the mechanisms of detergency
- By apprehending what a detergent is made off and how it works
- By comparing performances

How can we better detergents' performances ?

- By having evaluation methods
  - easy and fast
  - reproductible
  - closely related to field problems
    - soil
    - surface . . .

Problematics of Detergency

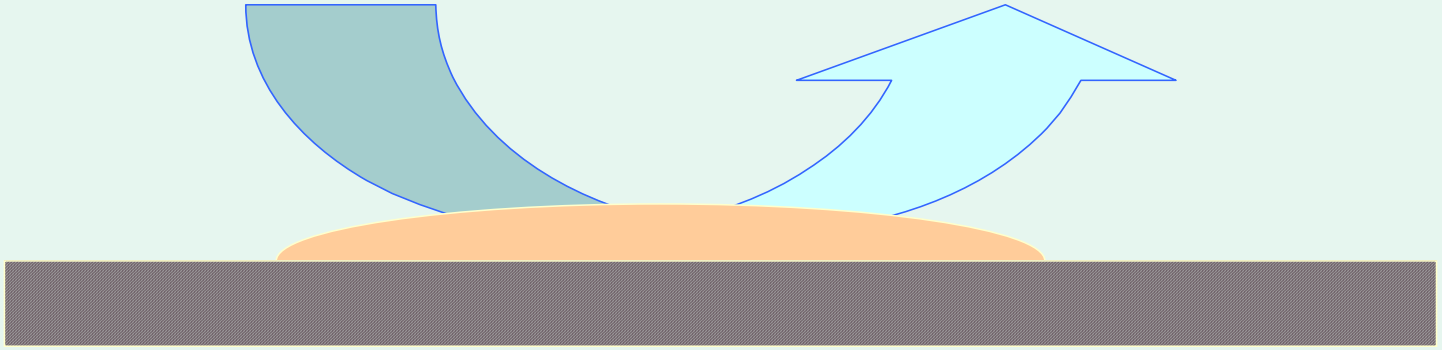
or

How can one eliminate

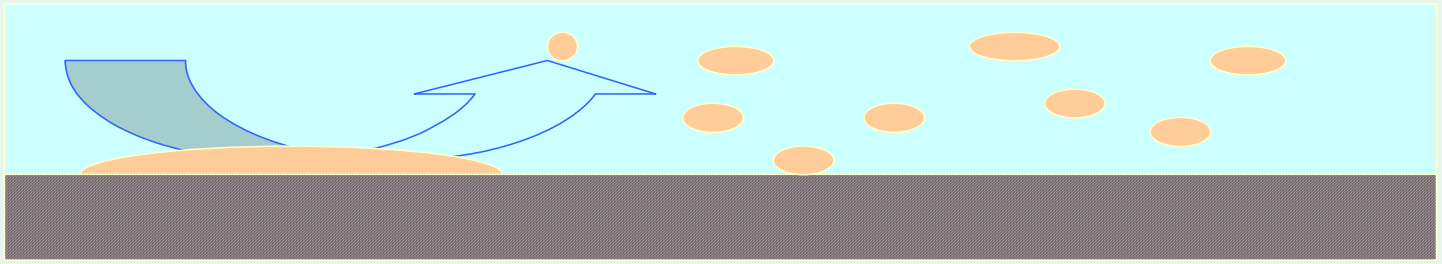
soil made of unidentified compounds

from an unspecified surface ?

A strategy ...



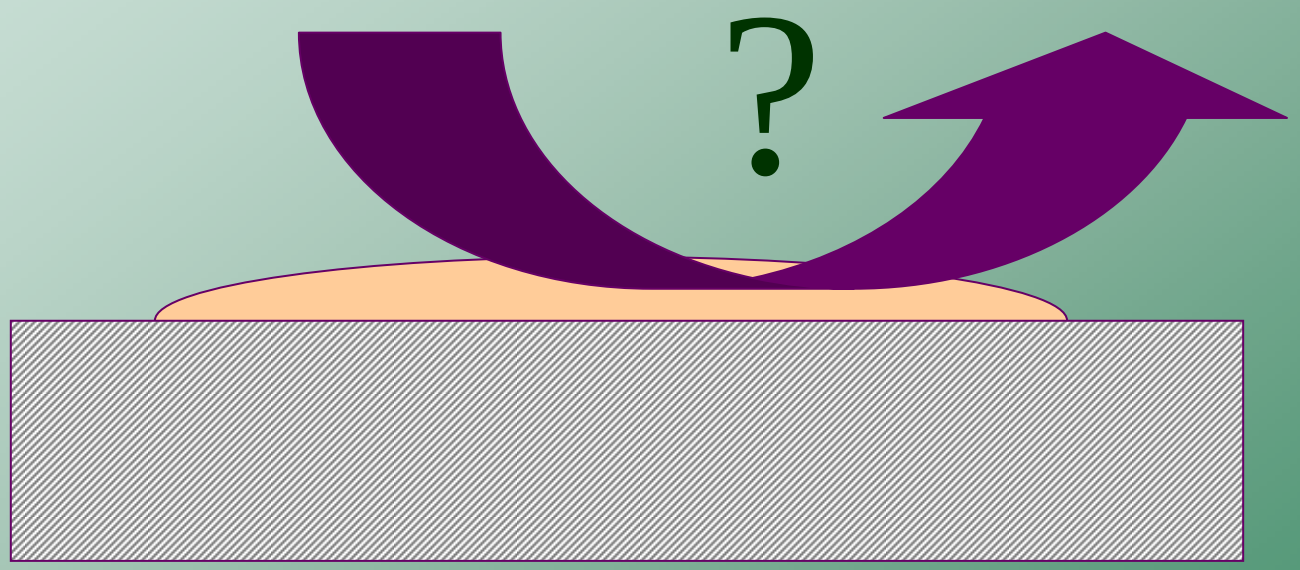
To make water-soluble a substance which is not (or slightly) water-soluble...



…to gain efficacy when rinsing off.

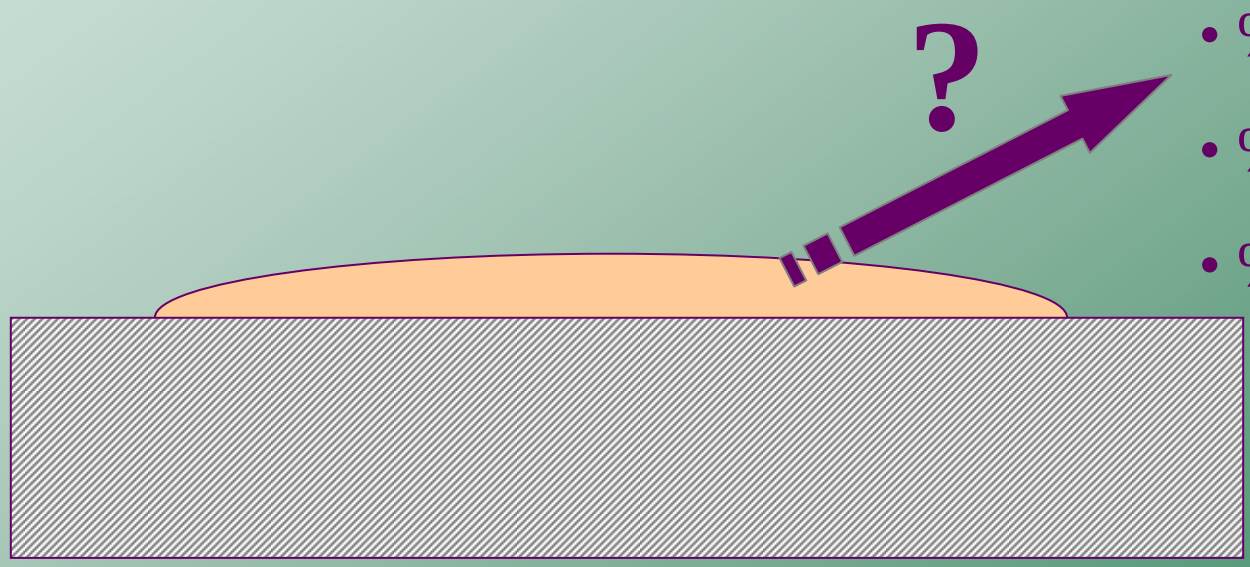
Detergency

- Detergent action parameters



Detergent action parameters

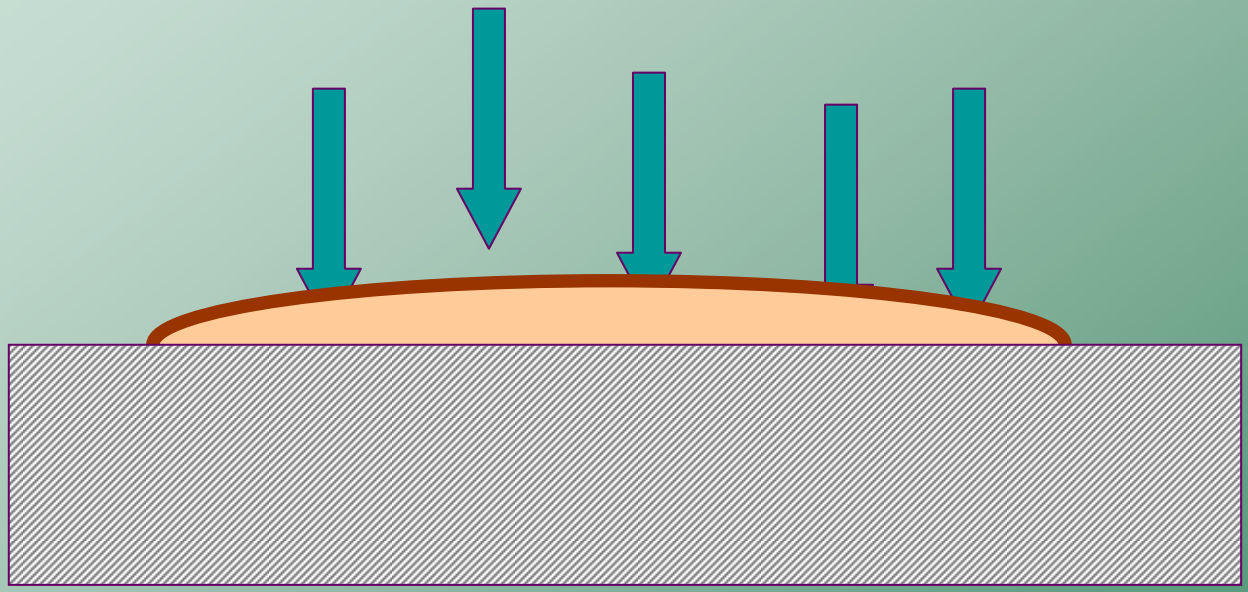
- Soil nature



- % Proteins
- % Lipids
- % Sugar
- % Mineral

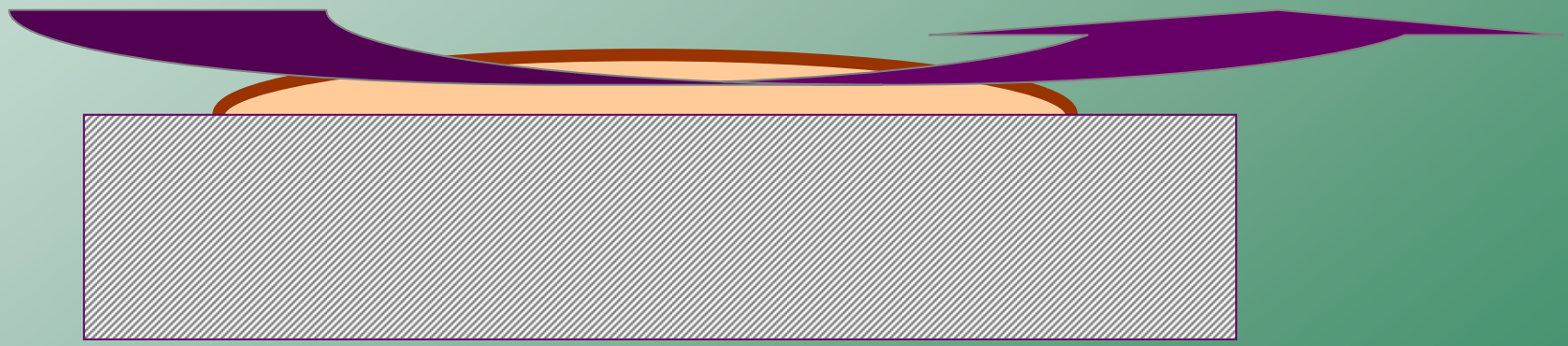
Detergent action parameters

- Soil state



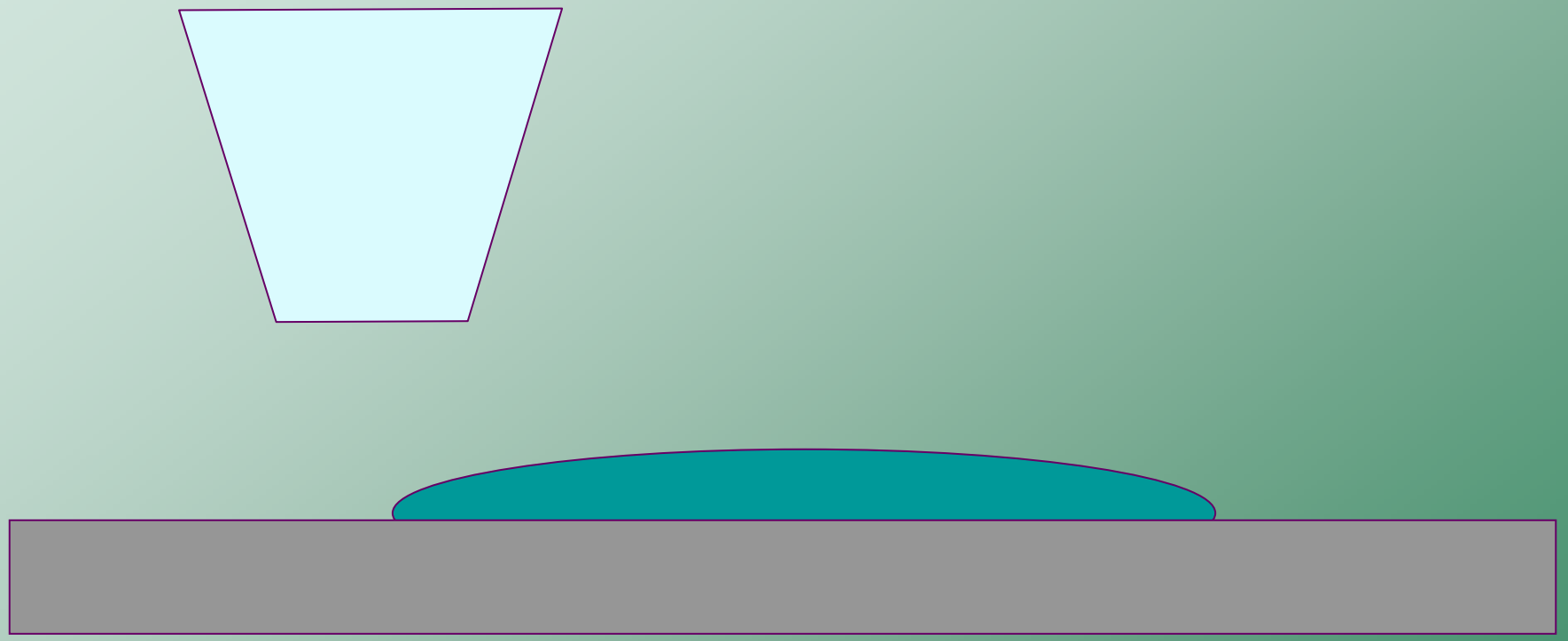
Detergent action parameters

- Mechanical action

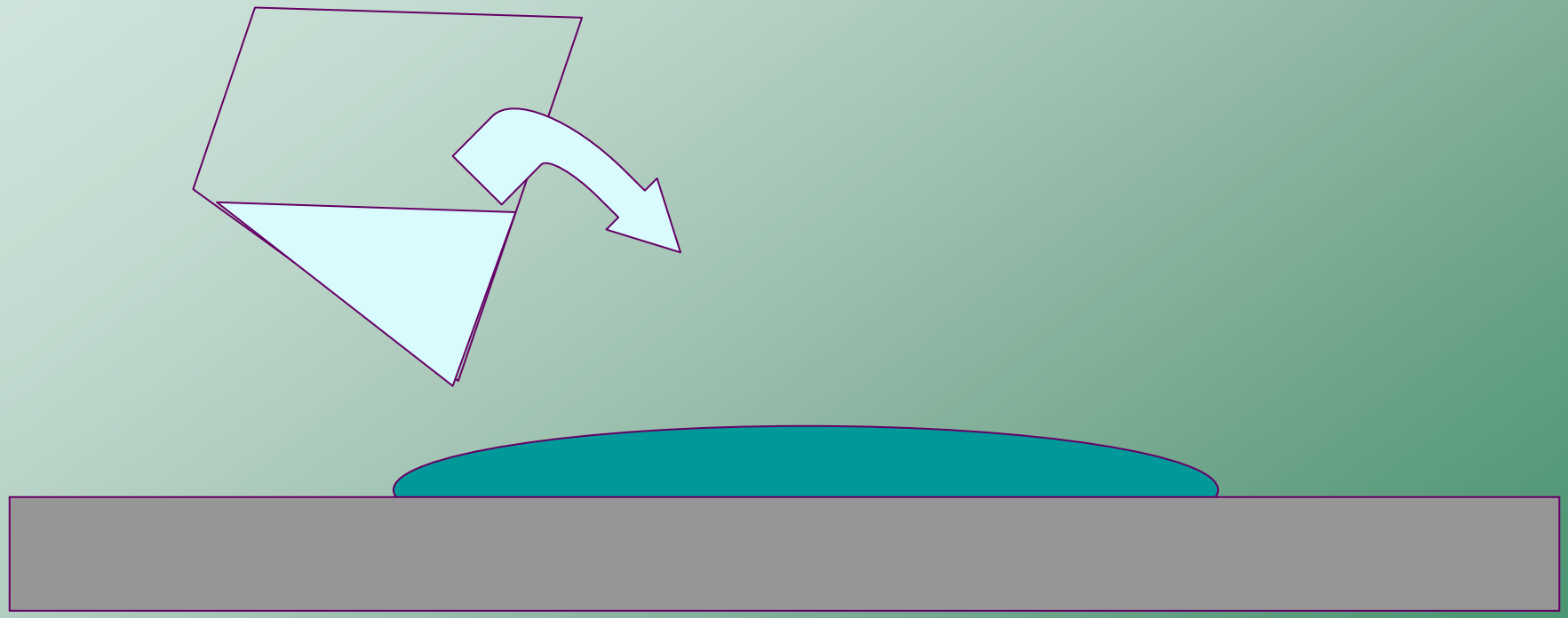


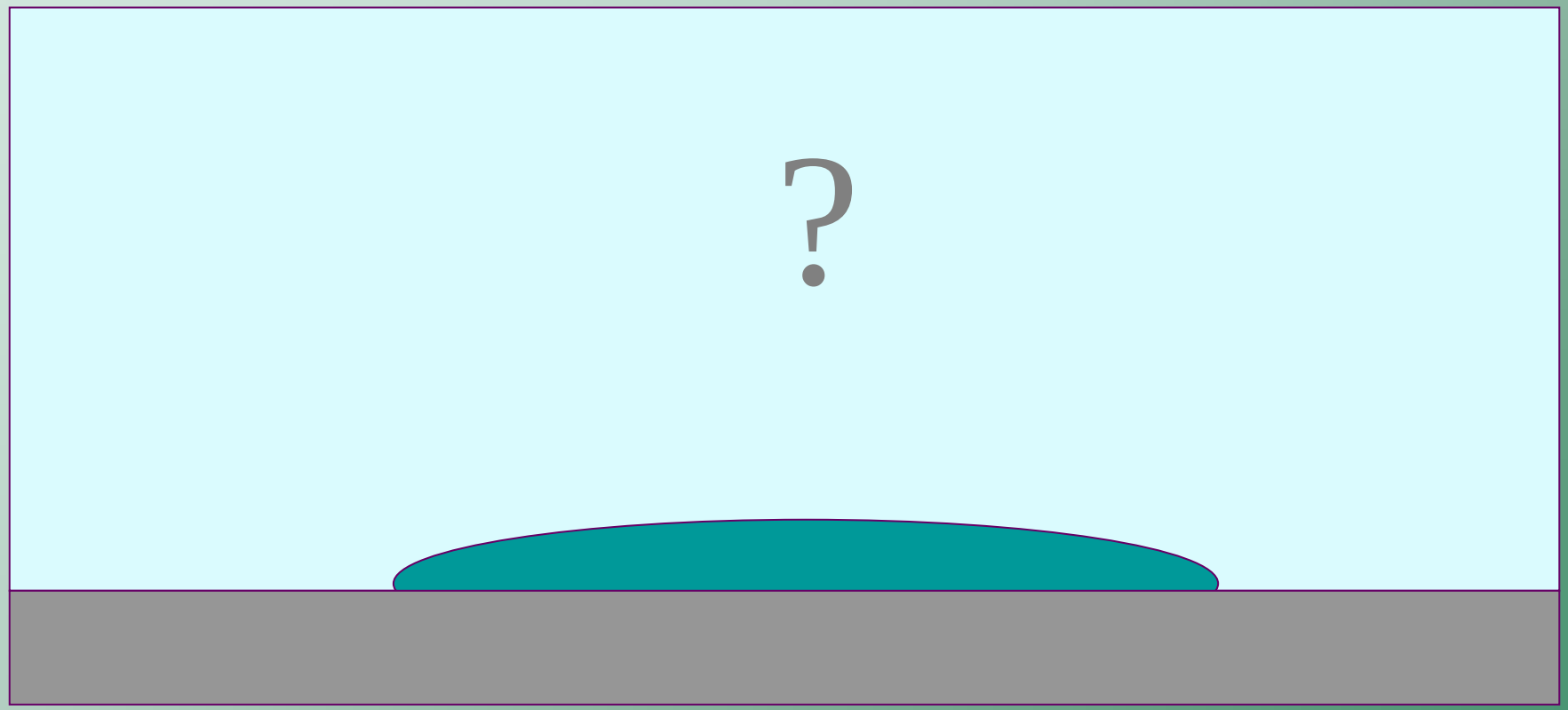
How can we eliminate soil ?

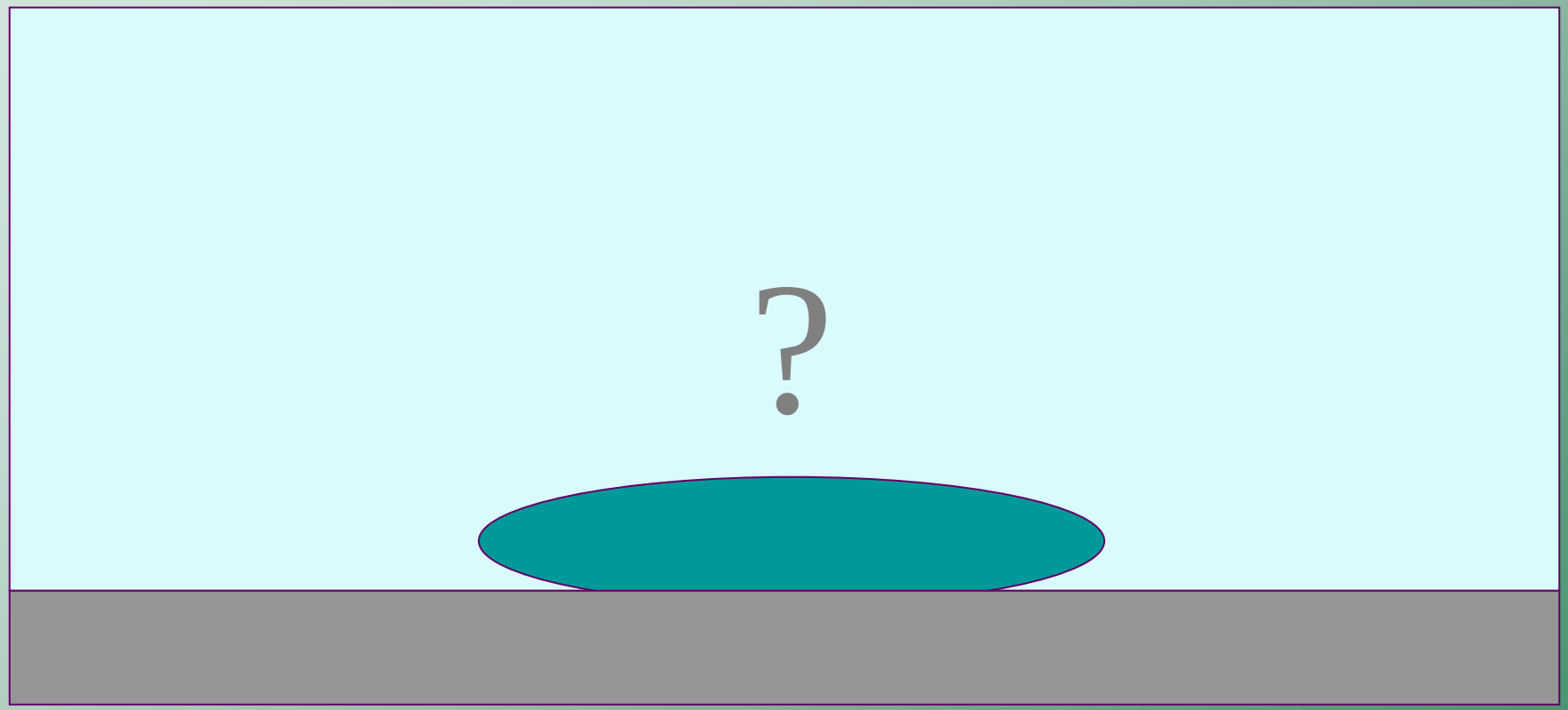
with water ?

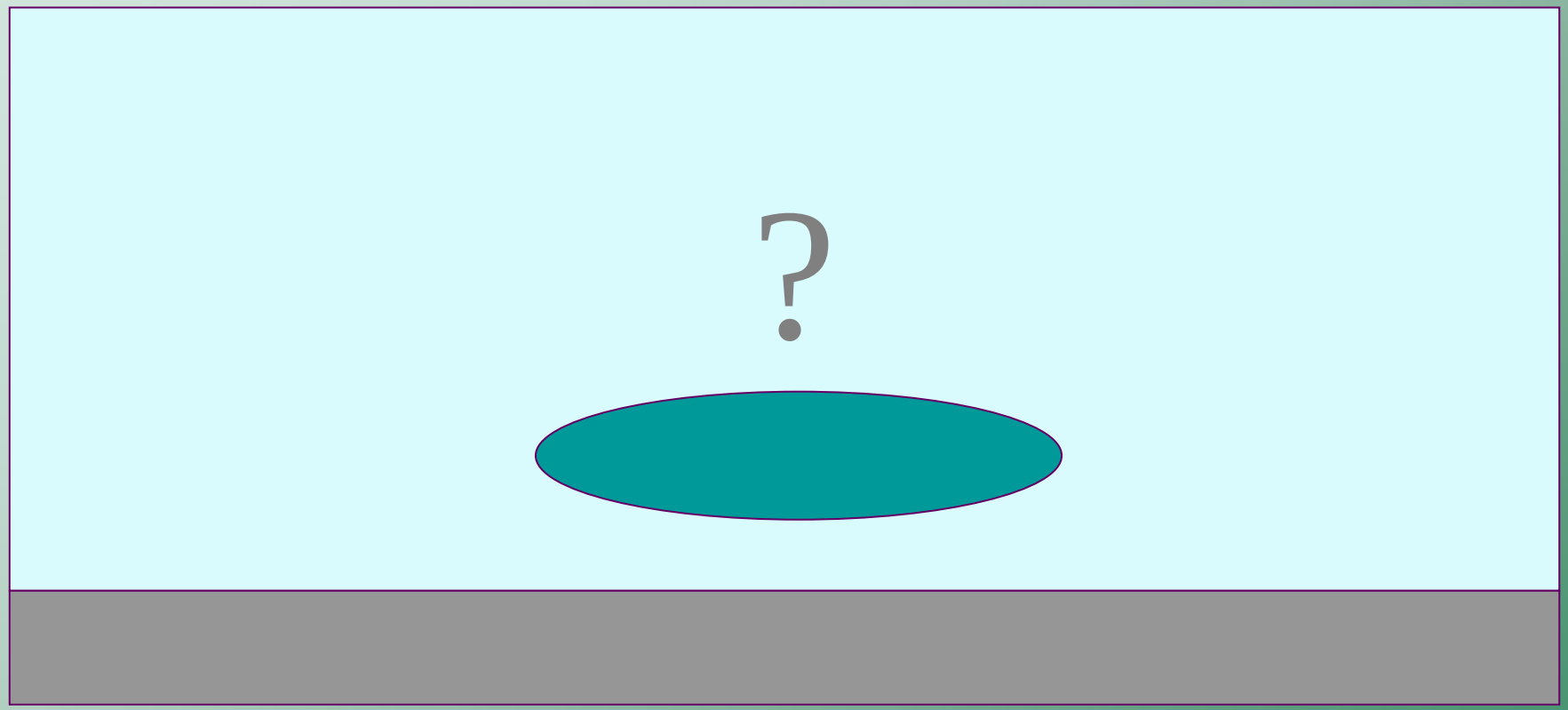


a lot of water . . . ?

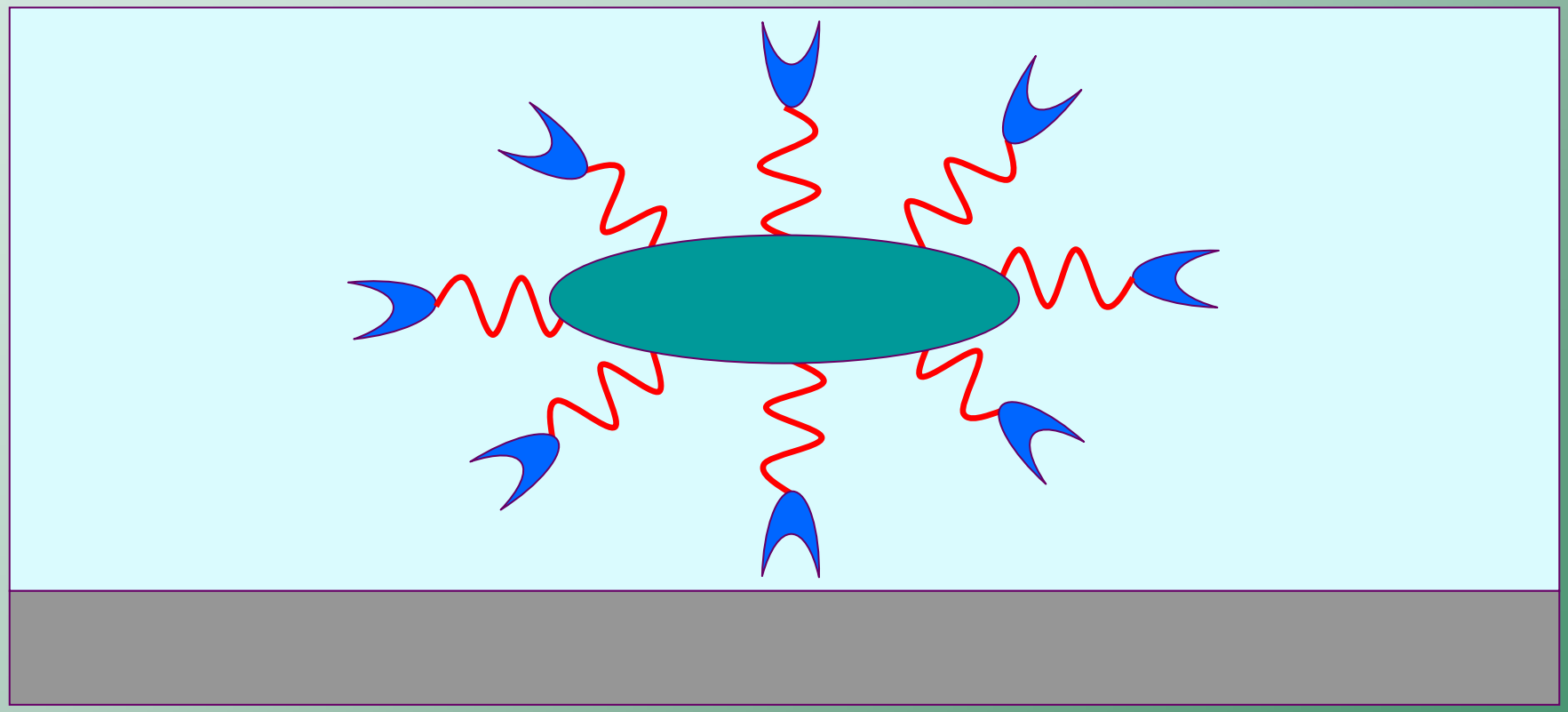






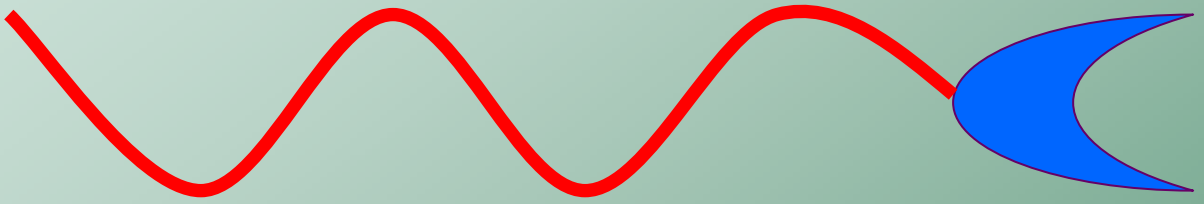


With detergent molecules. . .



which ones. . . ?

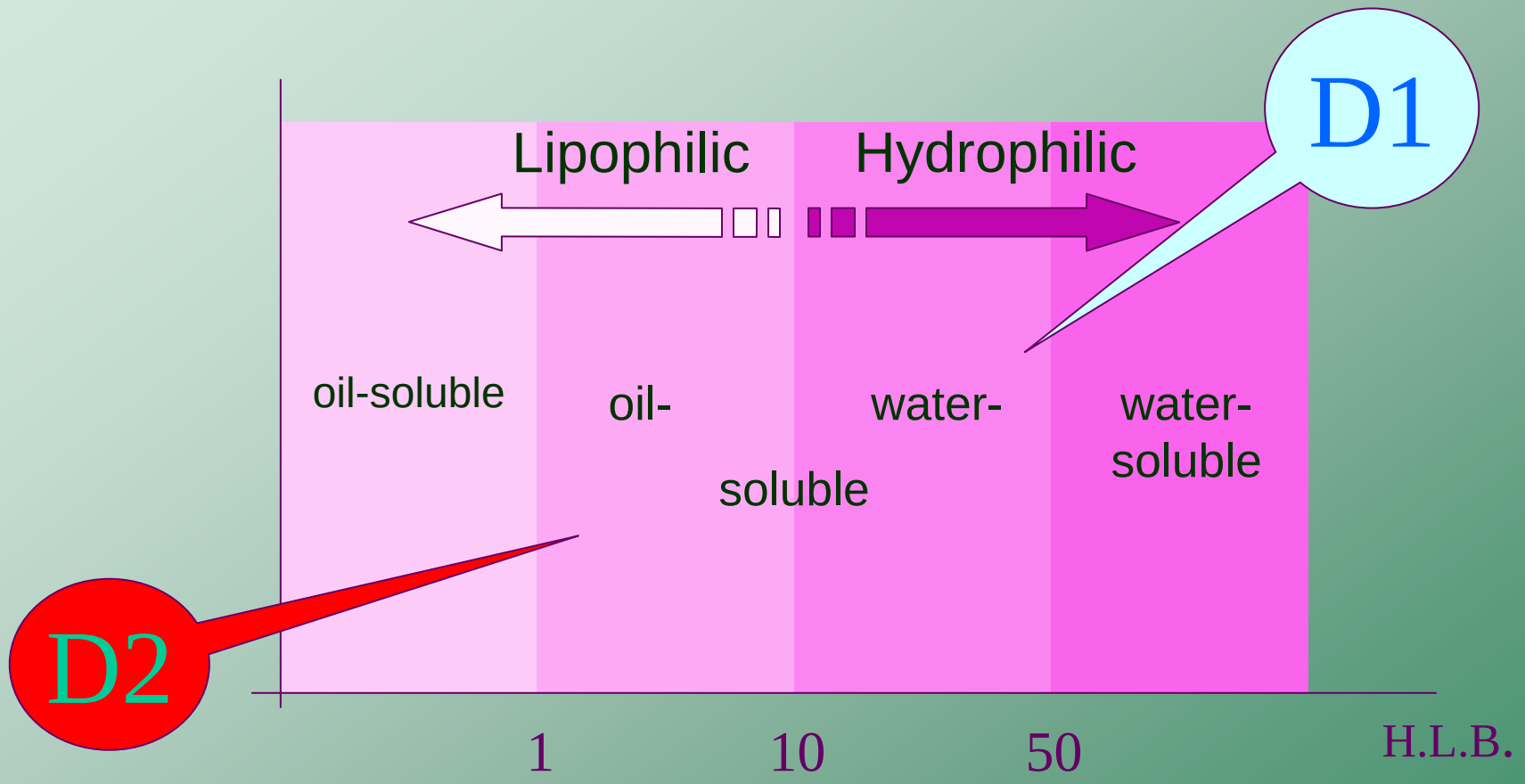
Which detergent molecule ?



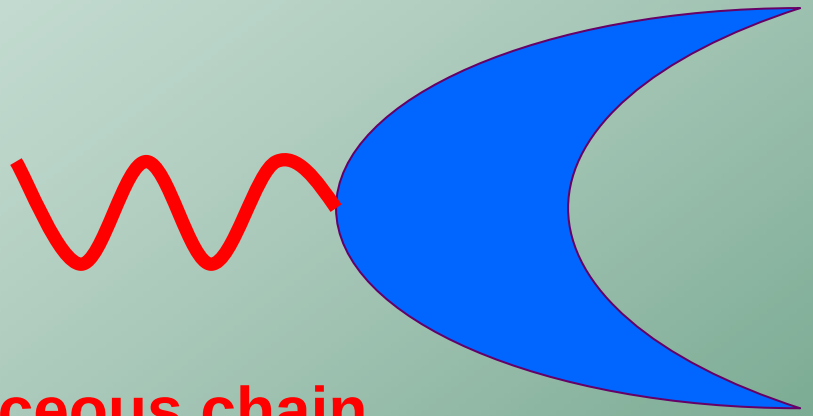
Hydrophobic carbonaceous chain **Hydrophilic part**

Example Lauric alcohol ethoxylated

H.L.B. definition



Detergent molecule (D1)



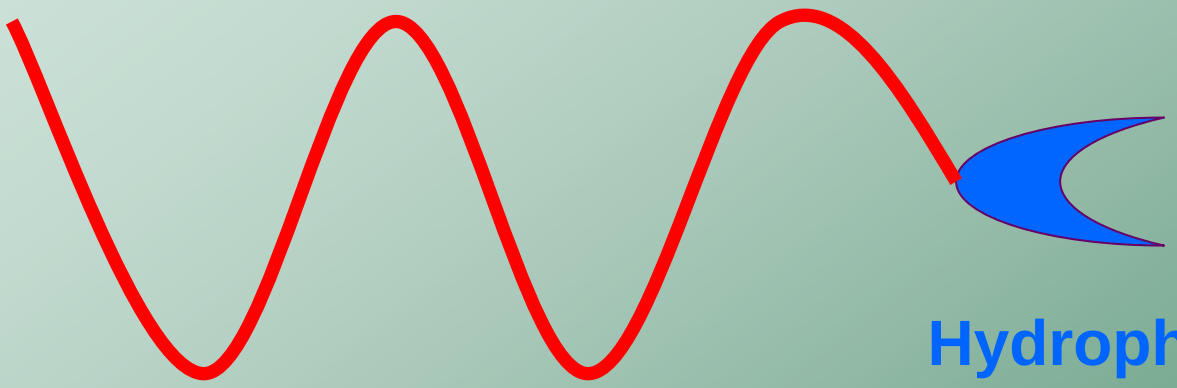
Hydrophobic carbonaceous chain

Hydrophilic part

High H.L.B. : lack of tropism for organic soil

H.L.B. :Hydrophilic Lipophilic Balance

Detergent molecule (D2)



Hydrophilic part

Hydrophobic carbonaceous chain

Low H.L.B. : lack of affinity for water

Choice of Detergent and H.L.B. value

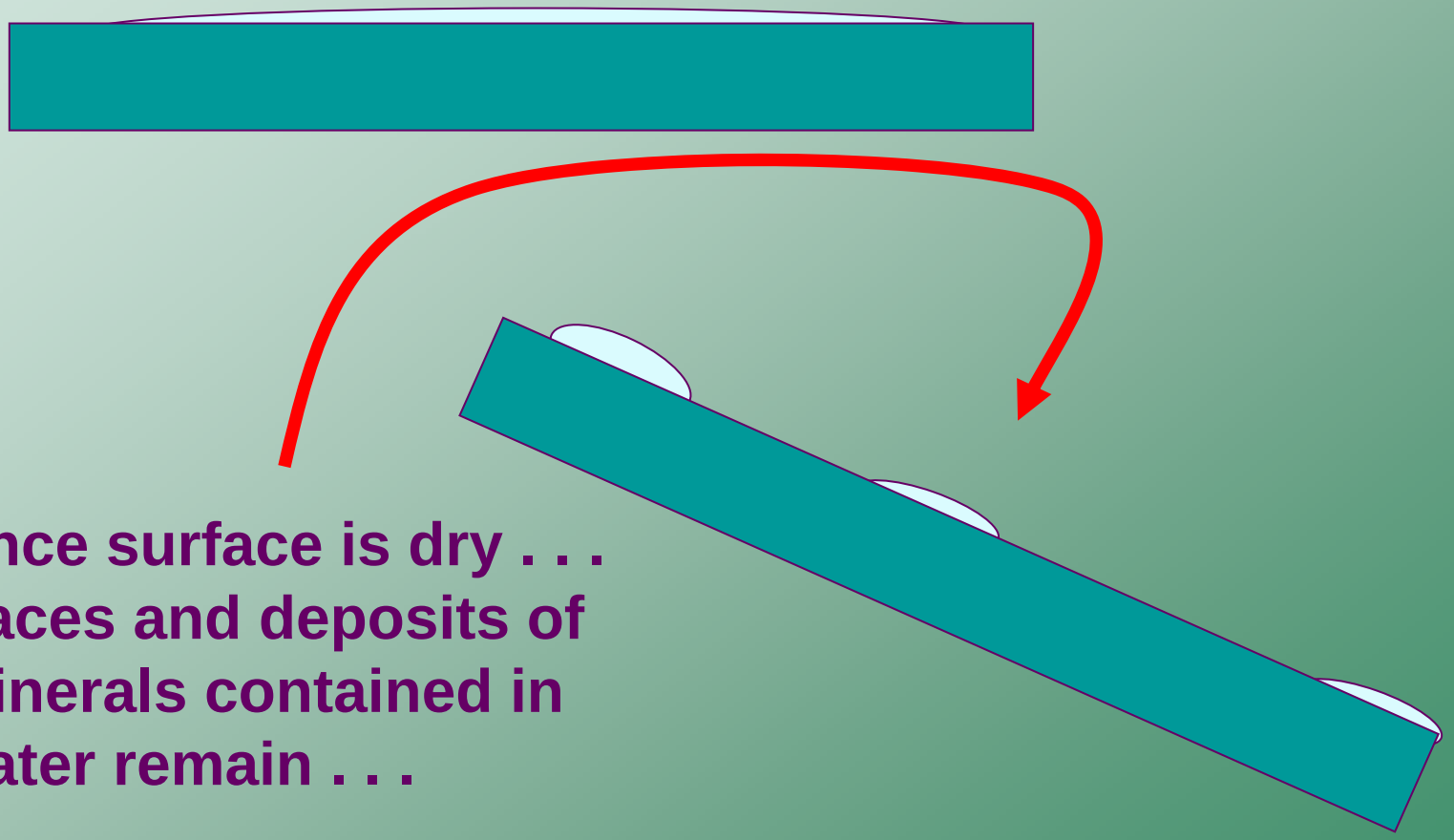
- A water-soluble protein can be masked by a lipidic matrix and therefore be non-water soluble.

  In the end, this protein is poorly eliminated by water.
- Protein solubilization is not the only paramount factor in choosing a detergent. One should also consider the hydrophilic/lipophilic nature of soil and surface.

Choice of Detergent

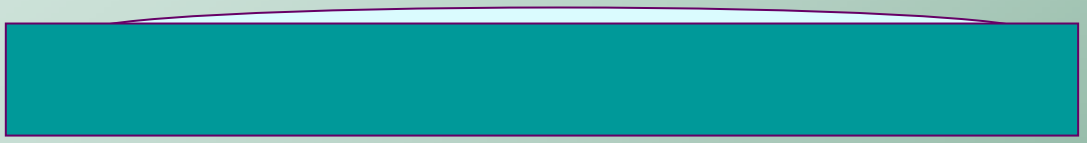
- Detergent's other properties:
  - wetting effect or surfactant effect
  - emulsifying effect
  - dispersive effect
  - solubilizing effect
- Complementary properties due to pH
  - saponifiying effect

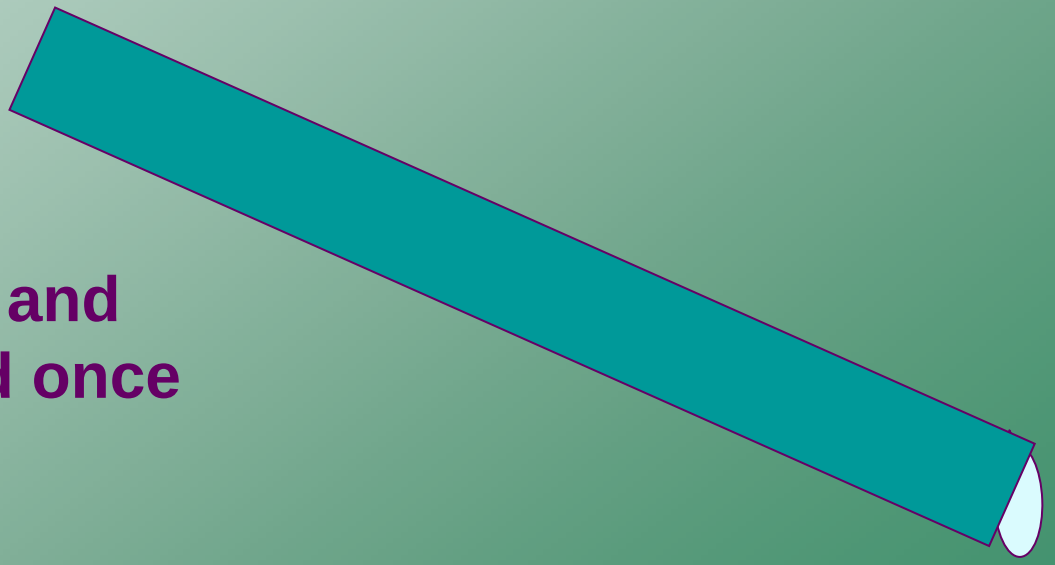
Optimized elimination of water ?



Once surface is dry . . . traces and deposits of minerals contained in water remain . . .

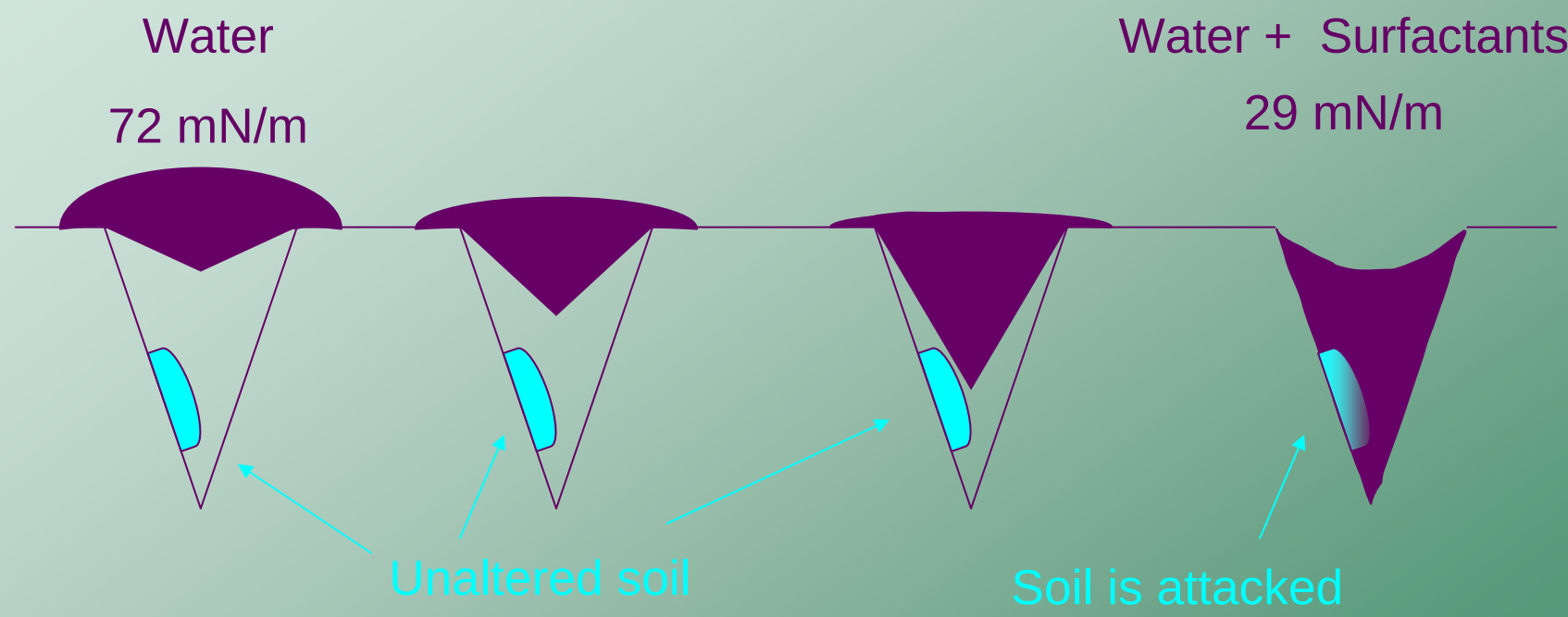
Elimination of water with wetting effect





Water is effectively eliminated. Traces and deposits are limited once surface is dry.

Wetting effect



Water, without the wetting effect or with a poor wetting effect, does not penetrate cracks properly.

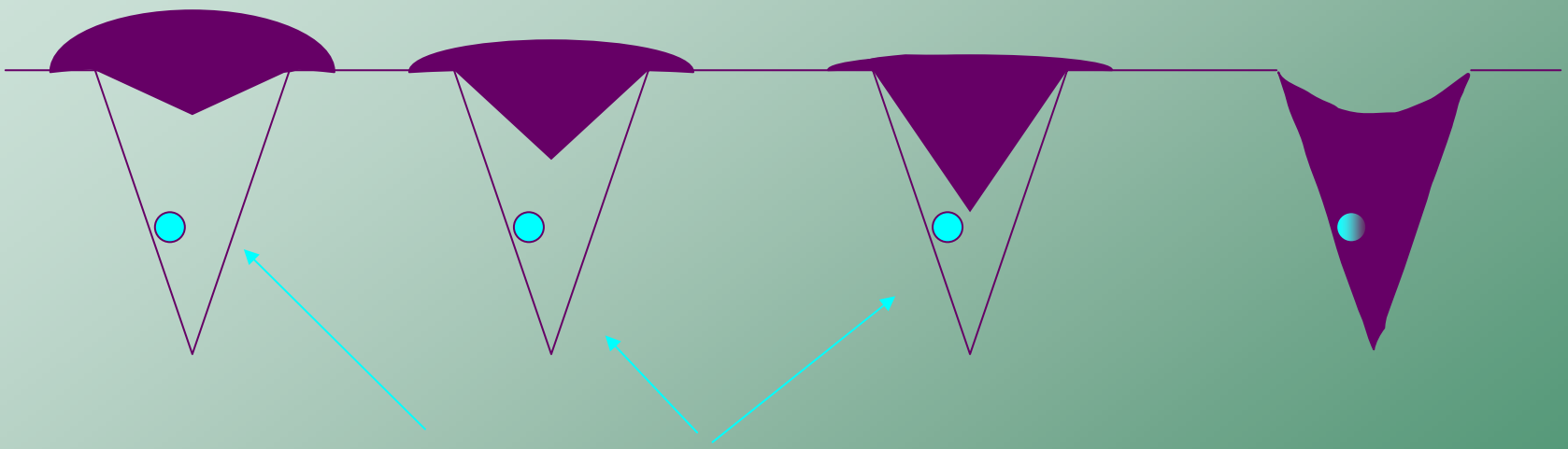
Wetting effect

Water

72 mN/m

Water + Surfactants

29 mN/m

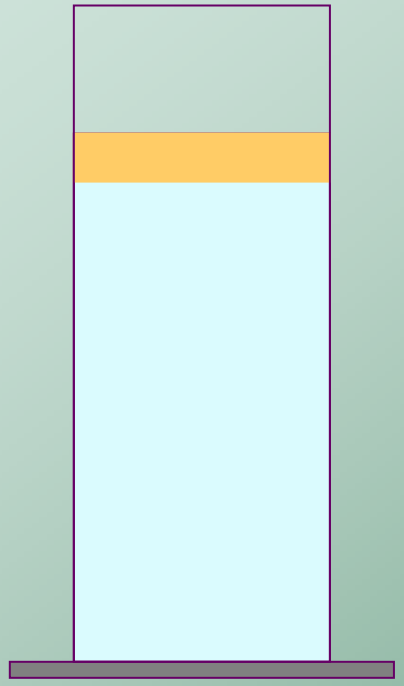


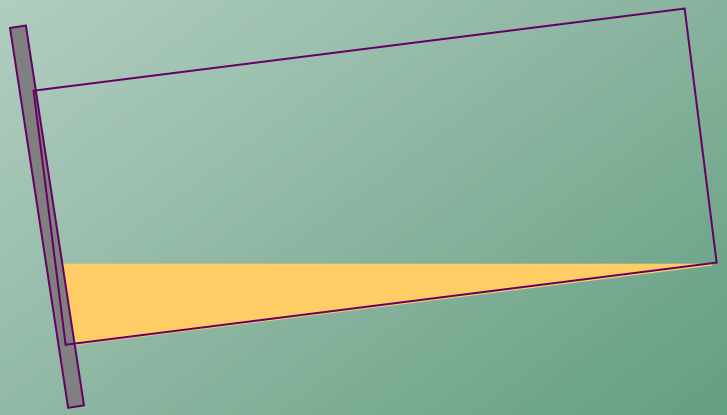
No contact with micro organism

Contact hence activity

mN/m : Milli Newton meter

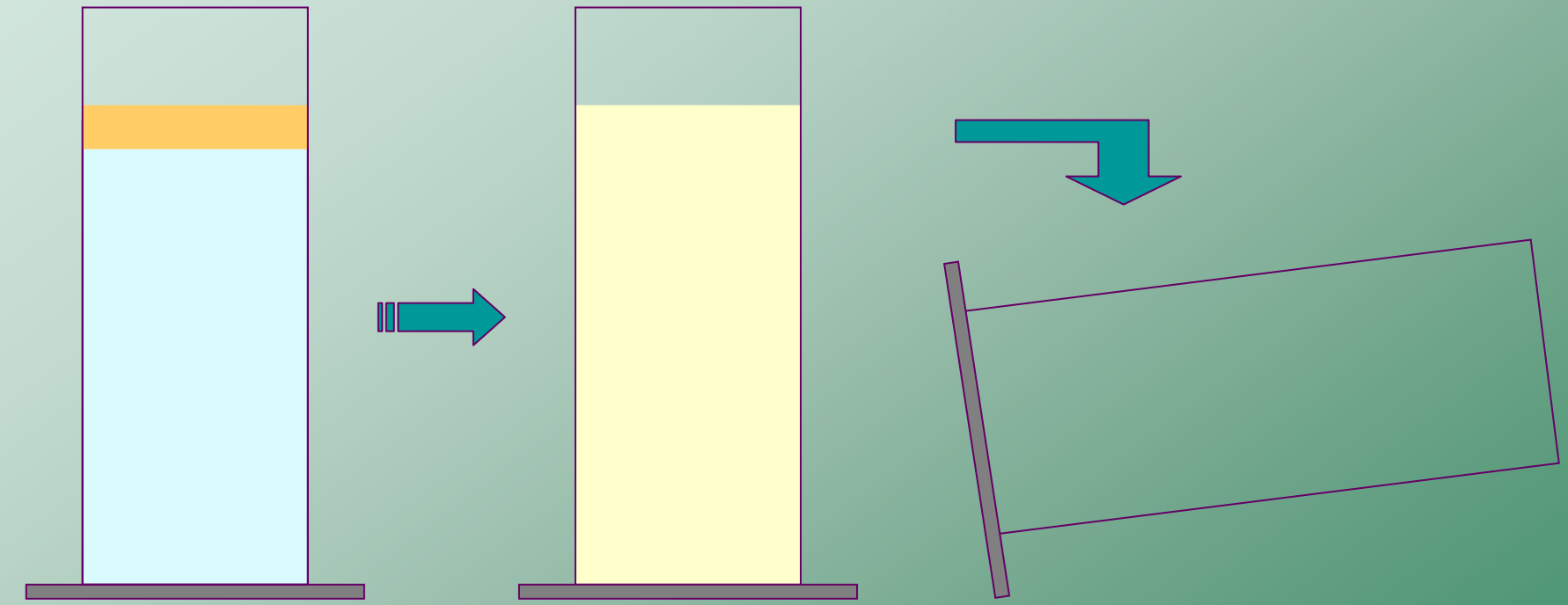
Elimination of fat





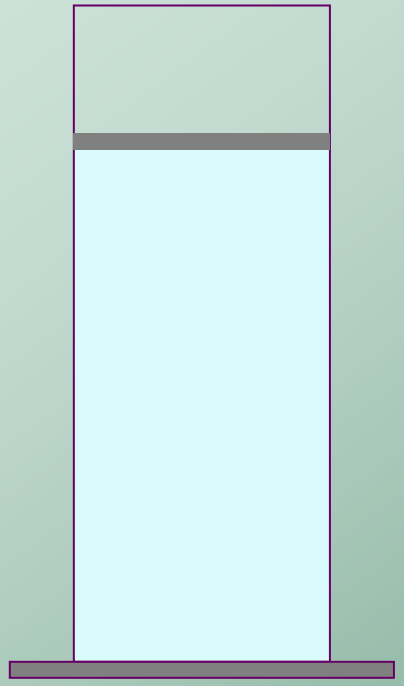
Water cannot eliminate fat fixed to surfaces.

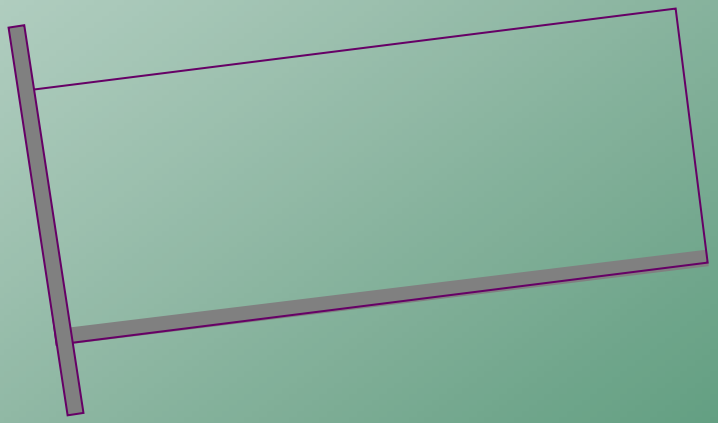
Elimination of fat
Emulsifying effect



Emulsified fat is eliminated with water.

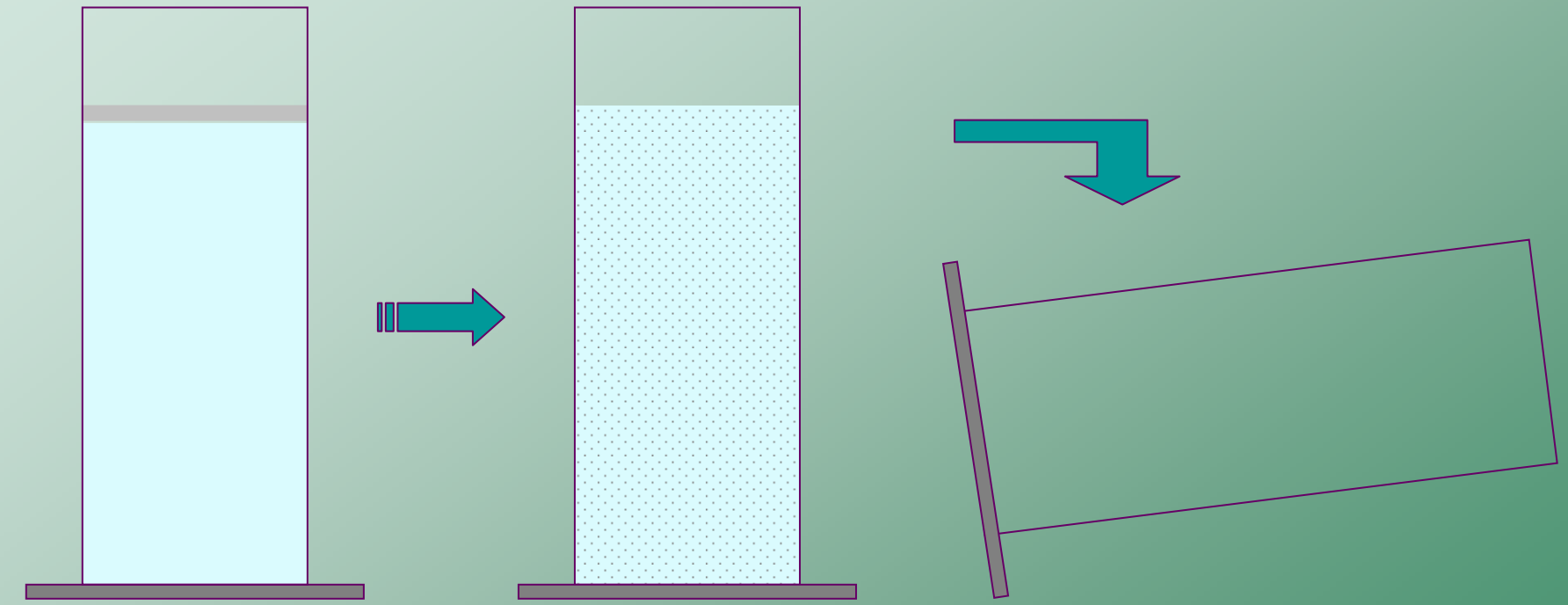
Elimination of matter in suspension





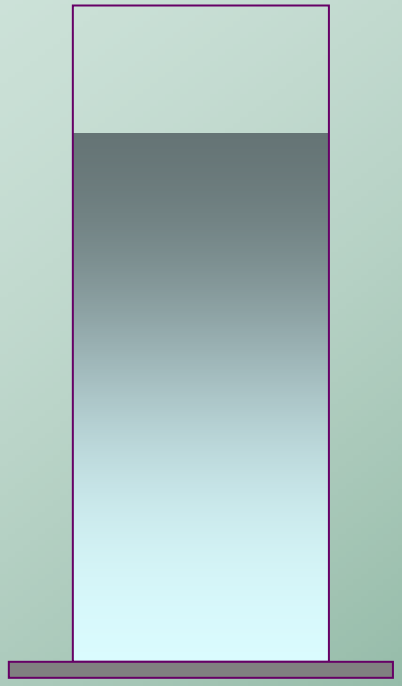
Matter in suspension settles on surfaces.

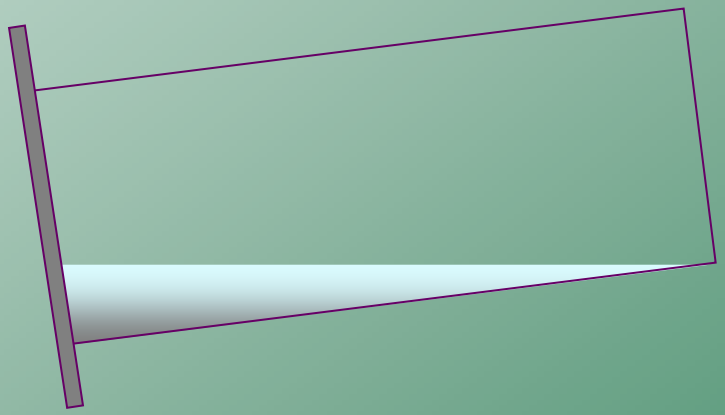
Elimination of matter in suspension
Dispersive effect



Matter is dispersed and eliminated with water.

Elimination of ± soluble matter

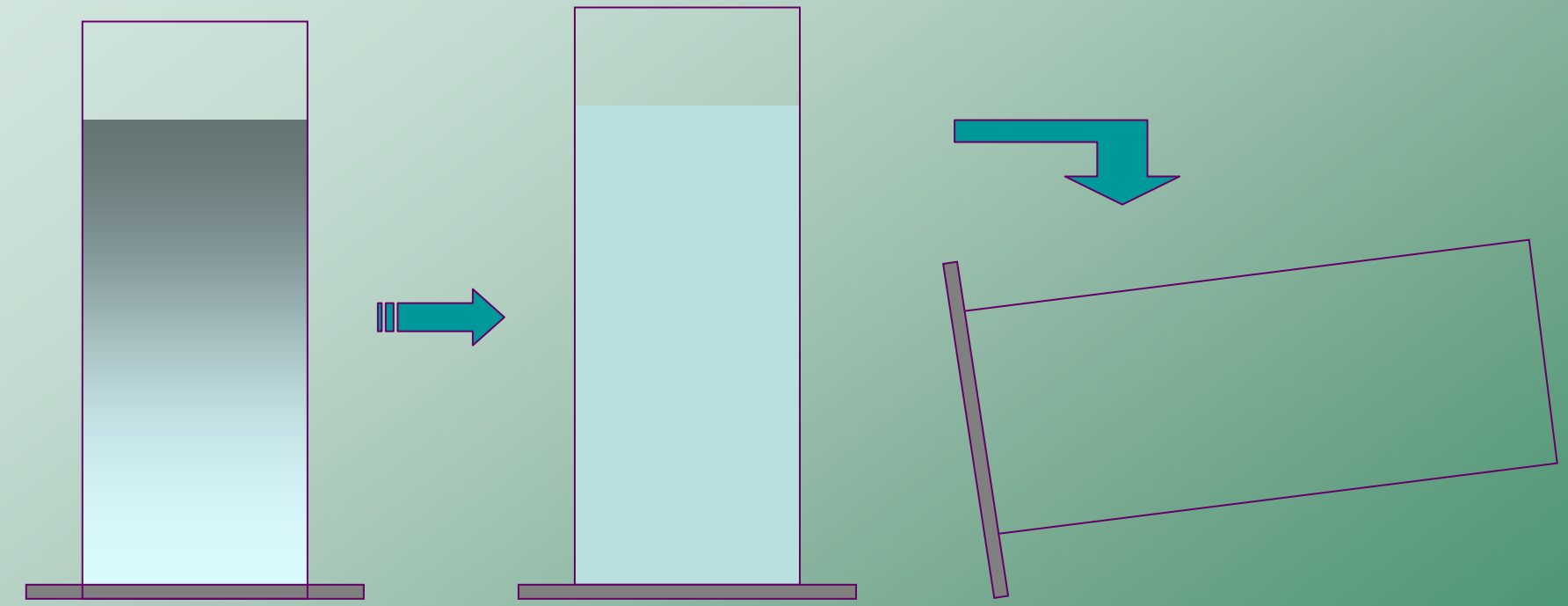




Matter which is not well solubilized creates a film on surfaces.

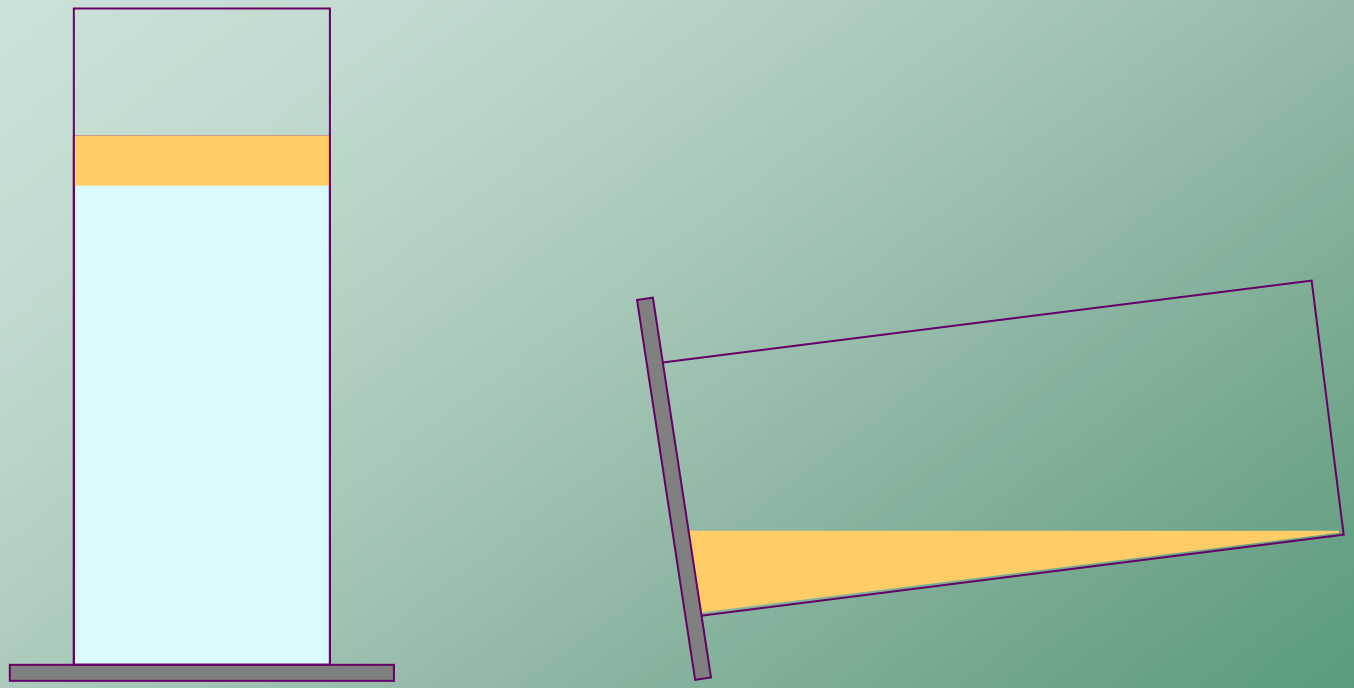
Elimination of ± soluble matter

Solubilizing effet



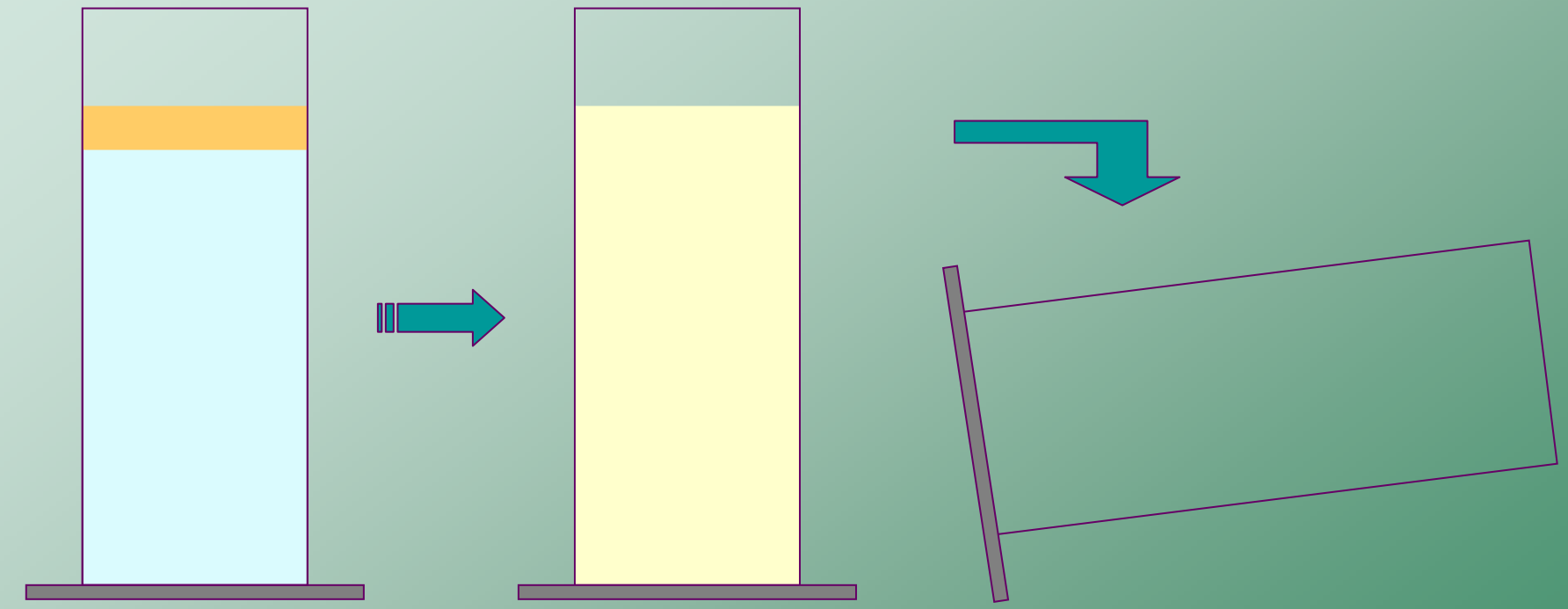
Solubilized matter is easily eliminated.

Elimination of fat



Water cannot eliminate fat fixed to surfaces.

Elimination of fats
Saponifying effect



Fat undergoes saponification in very alkaline medium (sodium hydroxide, potassium hydroxide …) : pH >11 and is eliminated with water.

In theory . . .

- Soil is made of :
  - Sugar
  - Lipids
  - Proteins
  - Limestone
  - Dust

Reality is more complex !!!

- Basic sugar + Exopolysaccharides + Glycoproteins + Lipopolysaccharides...
- Lipids + Lipopolysaccharides + Lipoproteins...
- Proteins + Glycoproteins + Lipoproteins...
- Limestone + « protected » limestone
- Dust and other particules (iron, copper…)

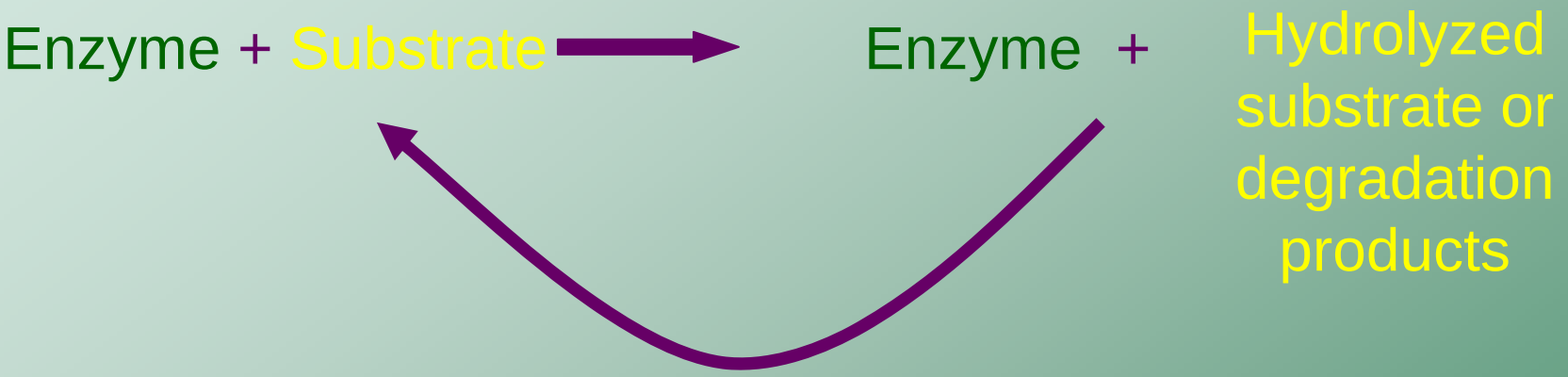
How can one stimulate the detergent power of surfactants ?

Enzymatic Power Assessment

Enzymology

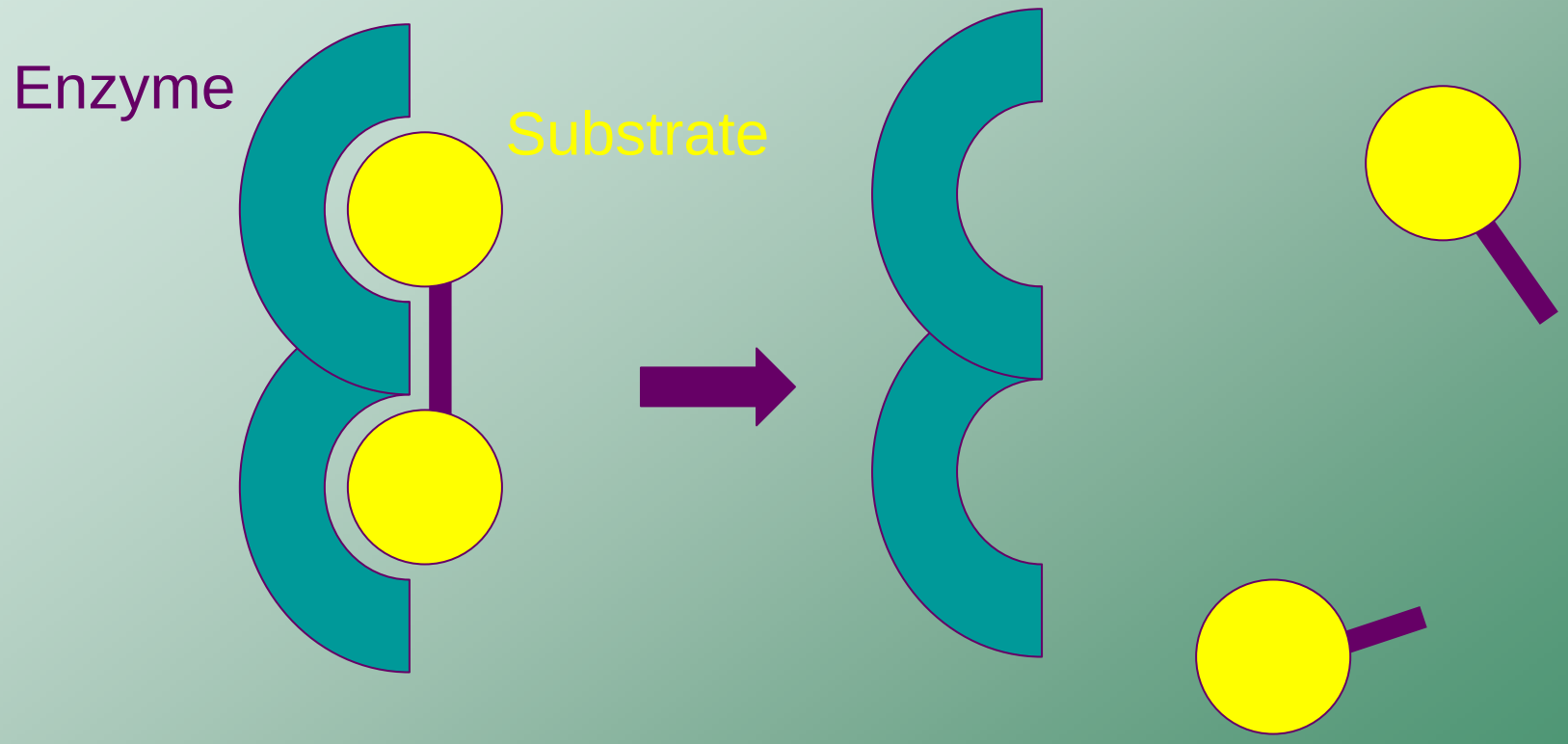
- To assess the role of enzymes in detergency in addition to surfactants :
  - Enzymes' ability to fraction slightly soluble matter into more water-soluble parts.
  - ! : The difficulty lies in choosing the enzyme. The enzyme should not be too substrate-specific.

Enzymatic activity



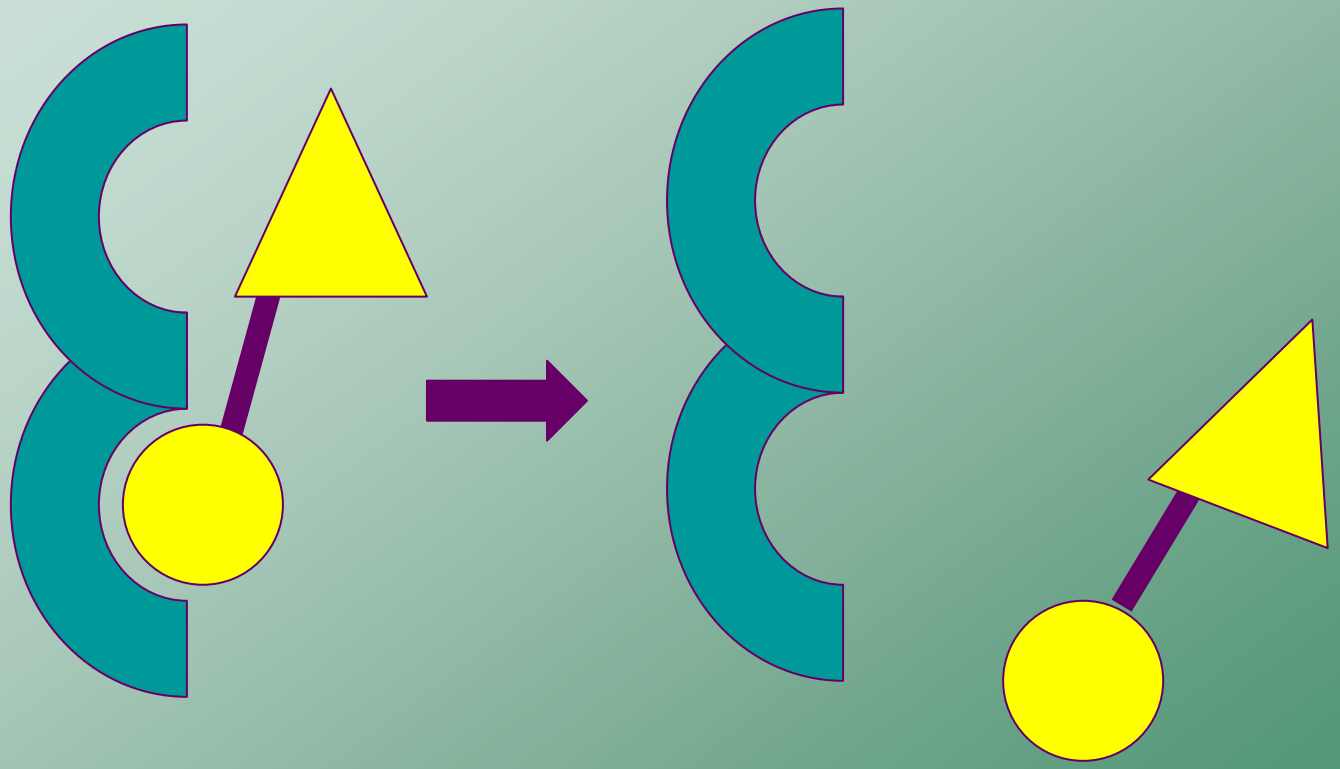
- The enzyme is not consumed in the reaction.
- Its action continues on the substrate as long as environmental conditions are respected (temperature, pH…)

Enzymatic activity



Enzyme recognizes substrate, hence enzymatic activity

Enzymatic activity (2)

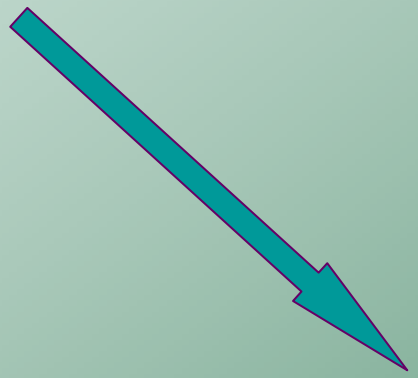


Enzyme does not recognize substrate. No enzymatic activity.

Protease action

Albumin + Protease

(only slightly soluble)



(Soluble)

Peptides of various weight

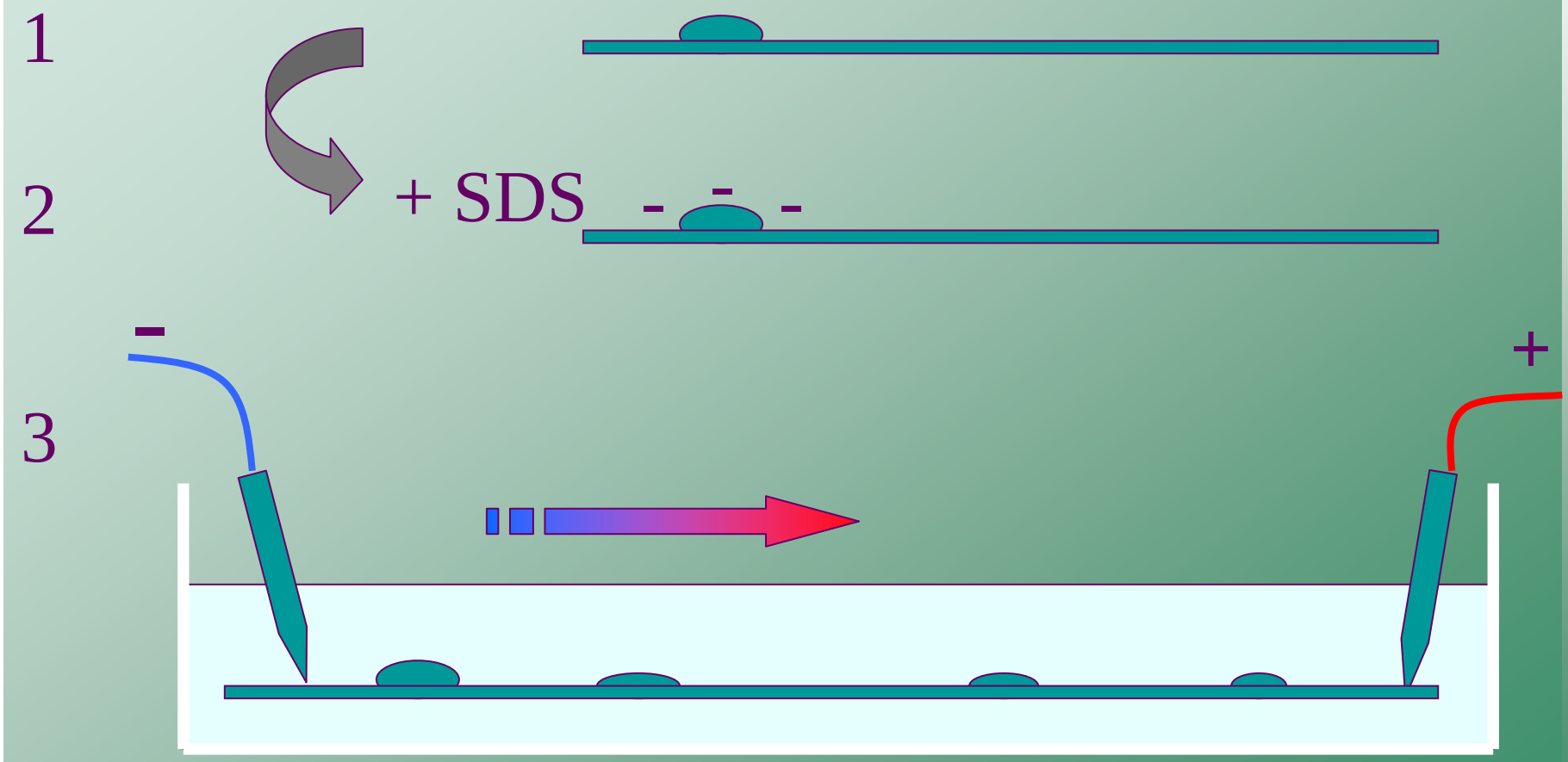
and in the end Amino acids

Control of the proteasic activity by electrophoresis

Electrophoresis principles (1)

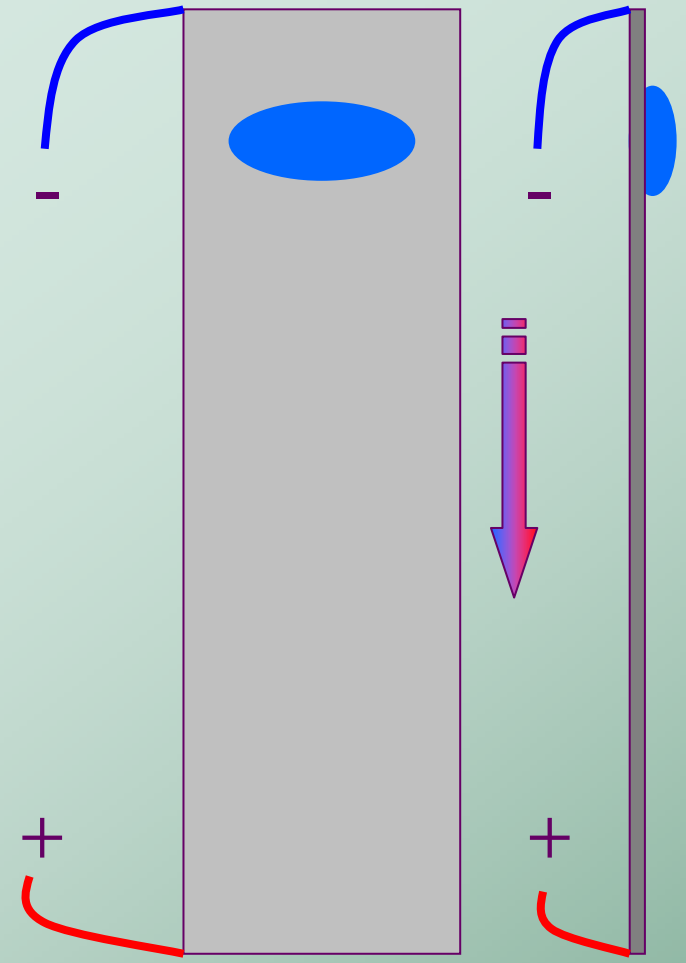
- Proteins to be analyzed are treated with S.D.S. (sodium dodecyl sulfate) which charges them negatively.
- The proteins are then set in an electrical field.
- The proteins move from the cathode (-) towards the anode (+).

Electrophoresis principles (2)

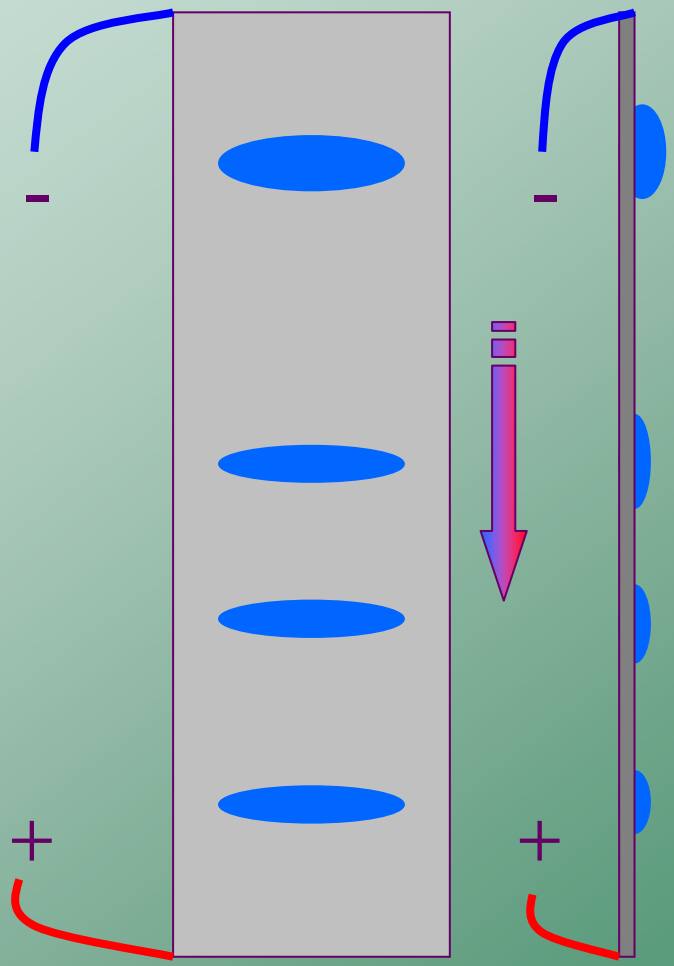


Electrophoresis principles (3)

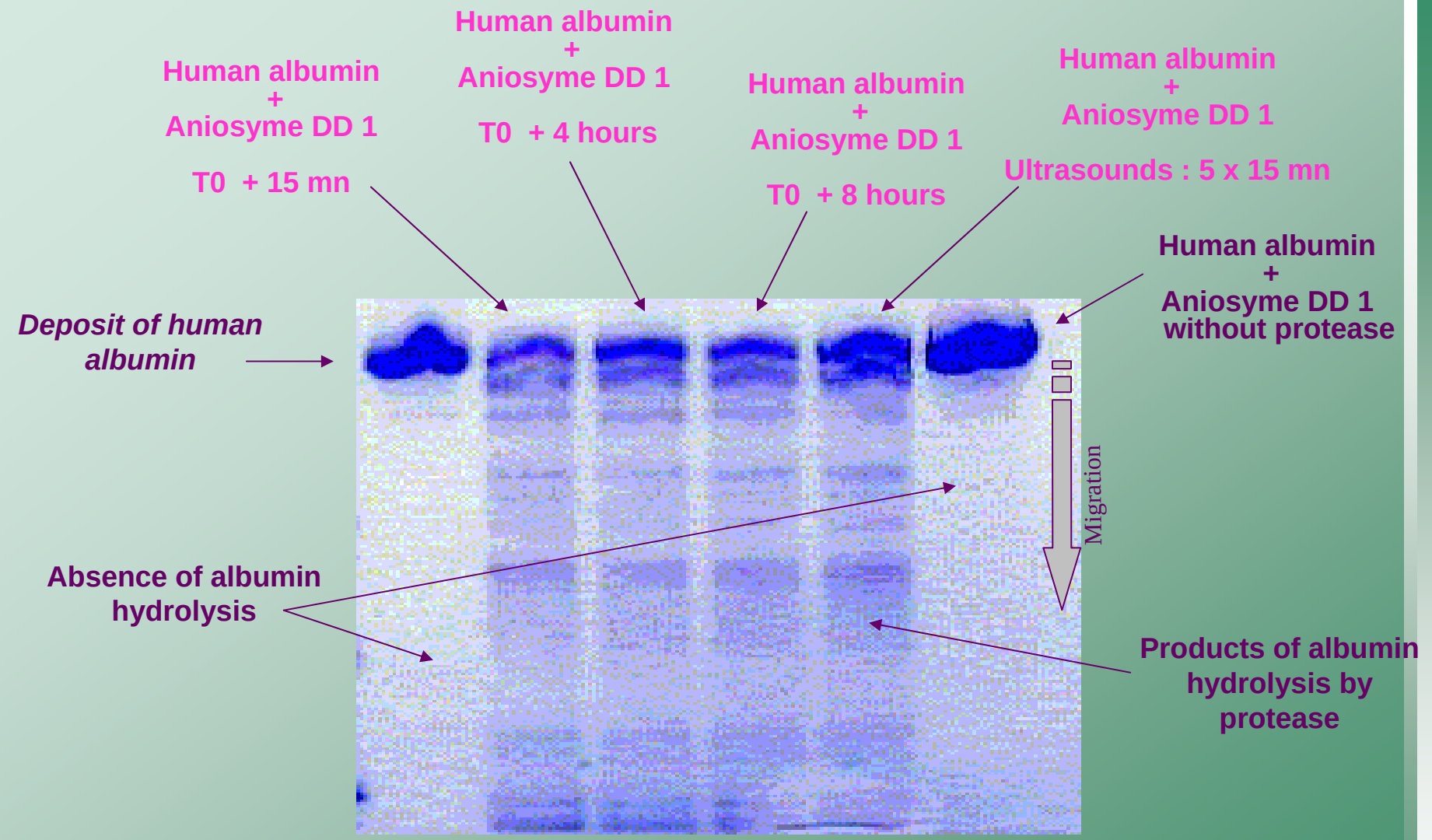
- Their movement is slowed down by their size and/or their weight
- The biggest molecules are retained and slowed down more by the polycrylamide gel (ex. : human albumin)
- The smallest molecules are less retained and slowed down by the polycrylamide gel (ex. : albumin hydrolysis products : peptides)



Albumin is not hydrolyzed because there is no enzymatic action



Albumin is hydrolyzed by protease and hydrolysis products are present



Proteasic activity of Aniosyme DD1 vis-a-vis human albumin

(Electrophoresis on gel)

Lipase action

Triglycerides + Lipase

(only slightly soluble)

Diglycerides + Lipase

Monoglycerides + Lipase

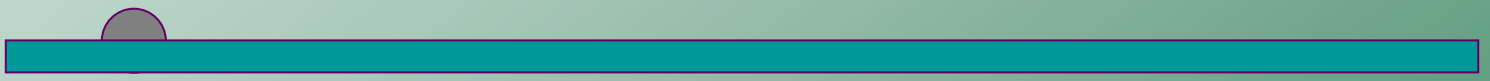
(Soluble)

Glycerol

Control of the lipasic activity by chromatography

Chromatography principles

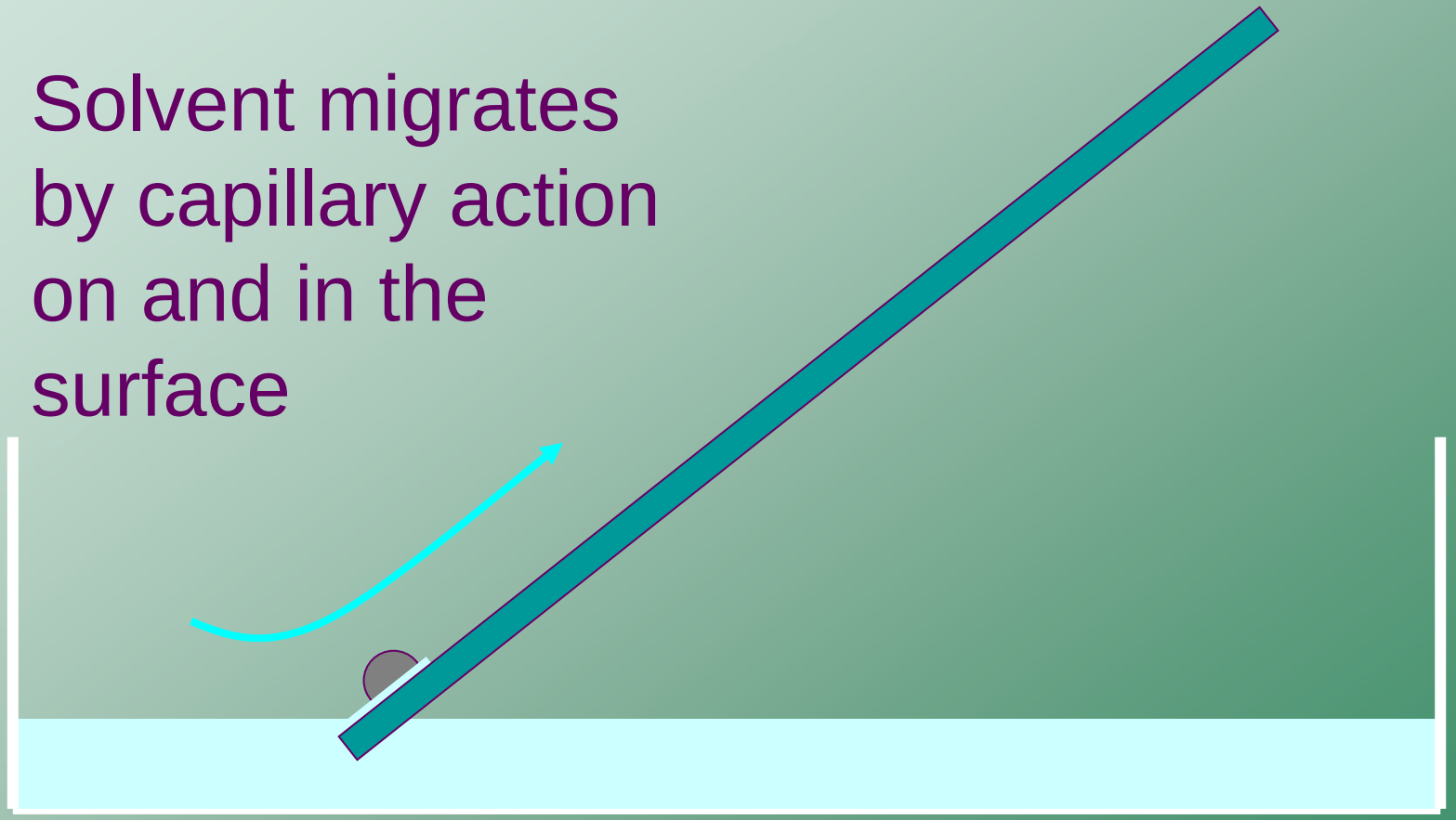
Raw material or a substance to be analyzed is put



on a surface (gel, paper . . .) which is then partially immersed in a tank of solvant

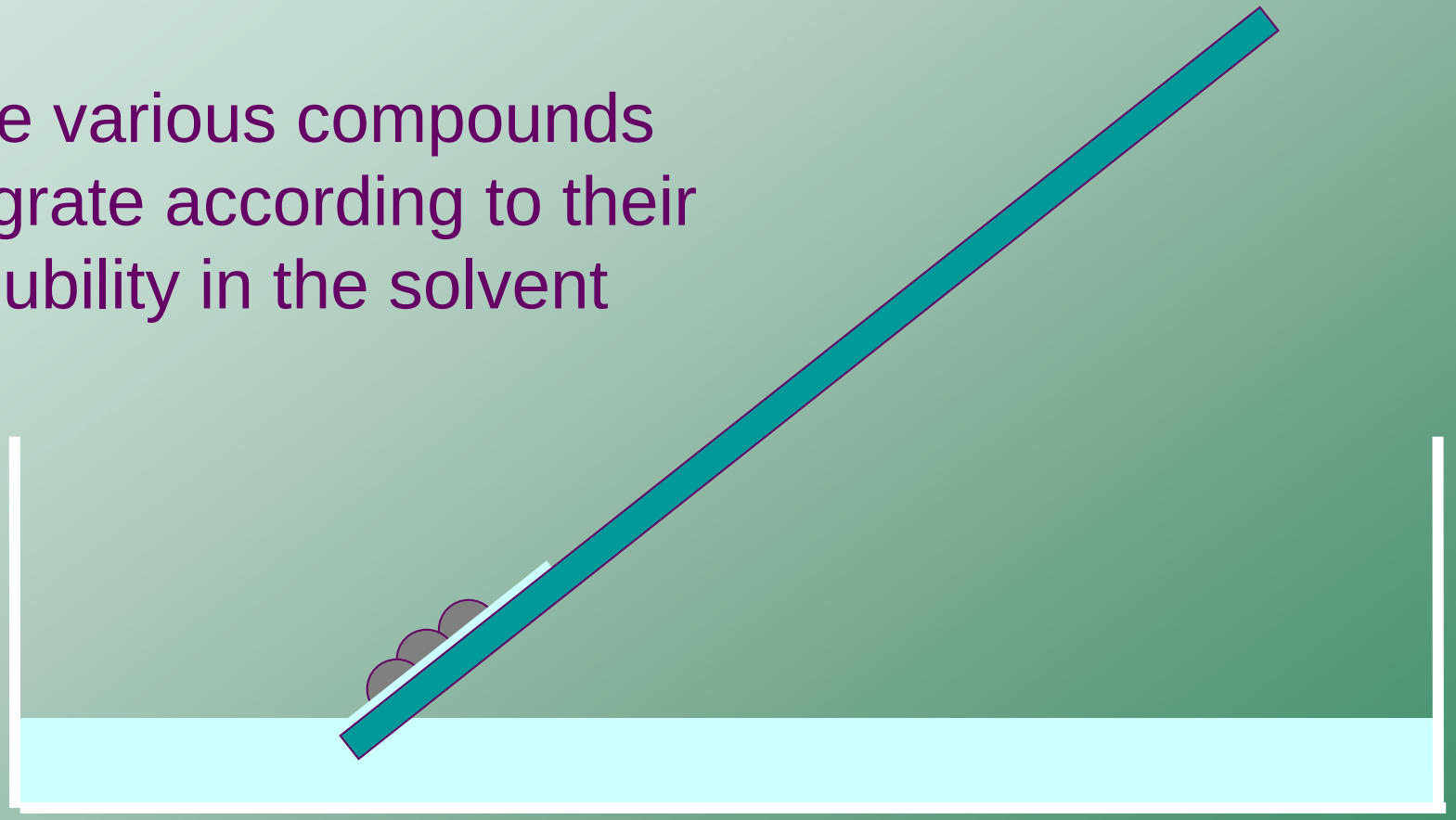
Chromatography principles (2)

Solvent migrates by capillary action on and in the surface

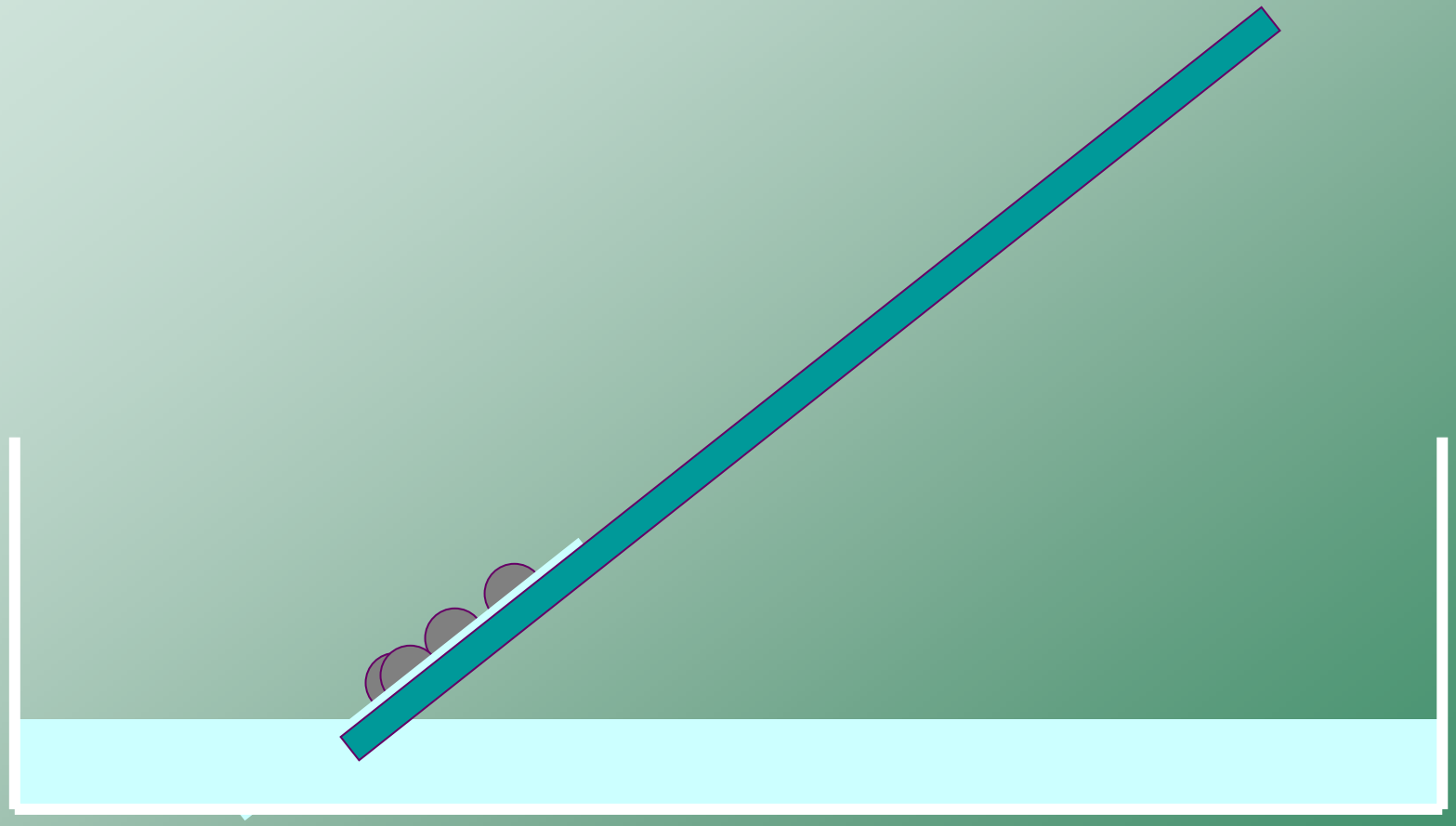


Chromatography principles (3)

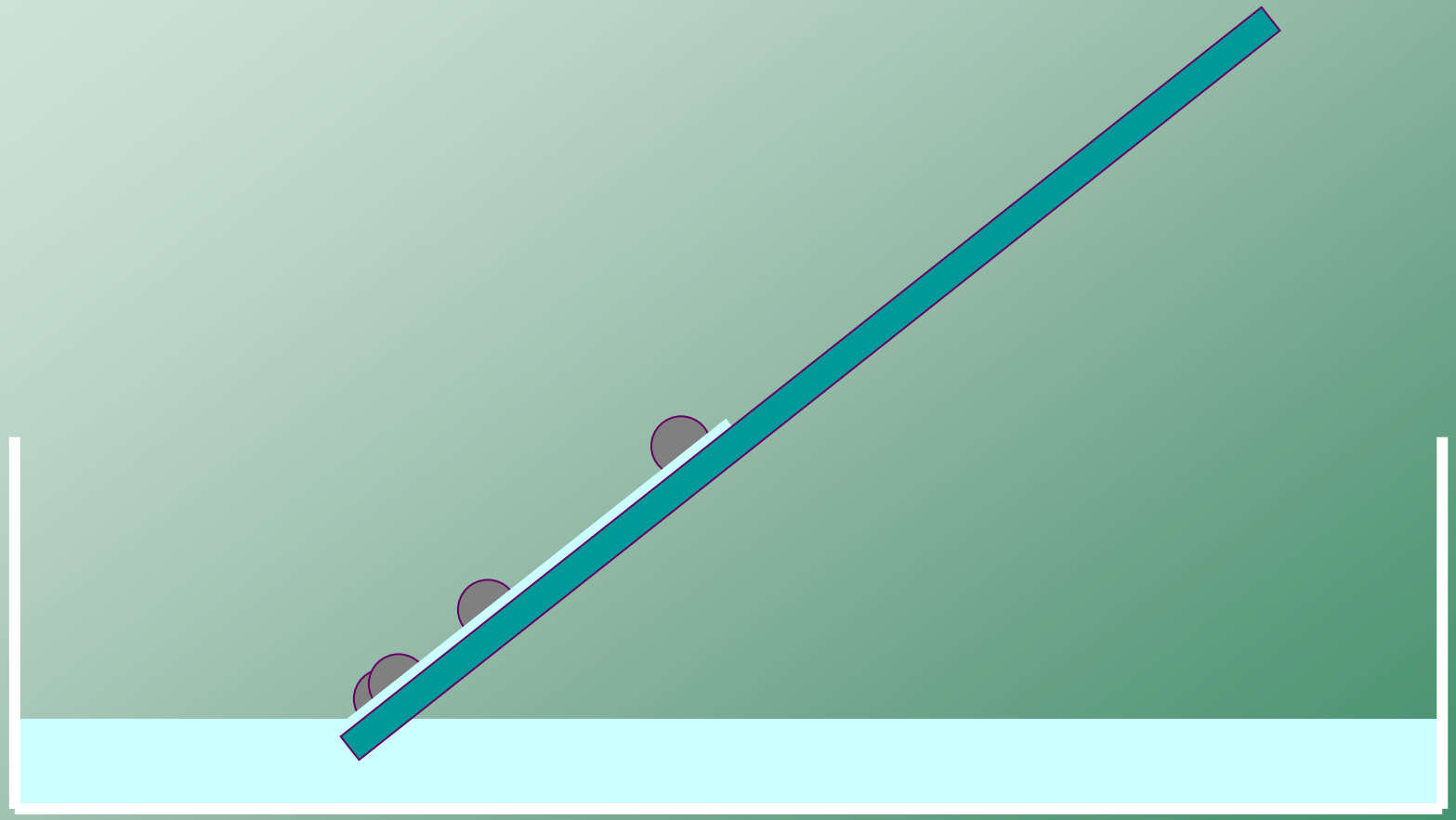
The various compounds migrate according to their solubility in the solvent



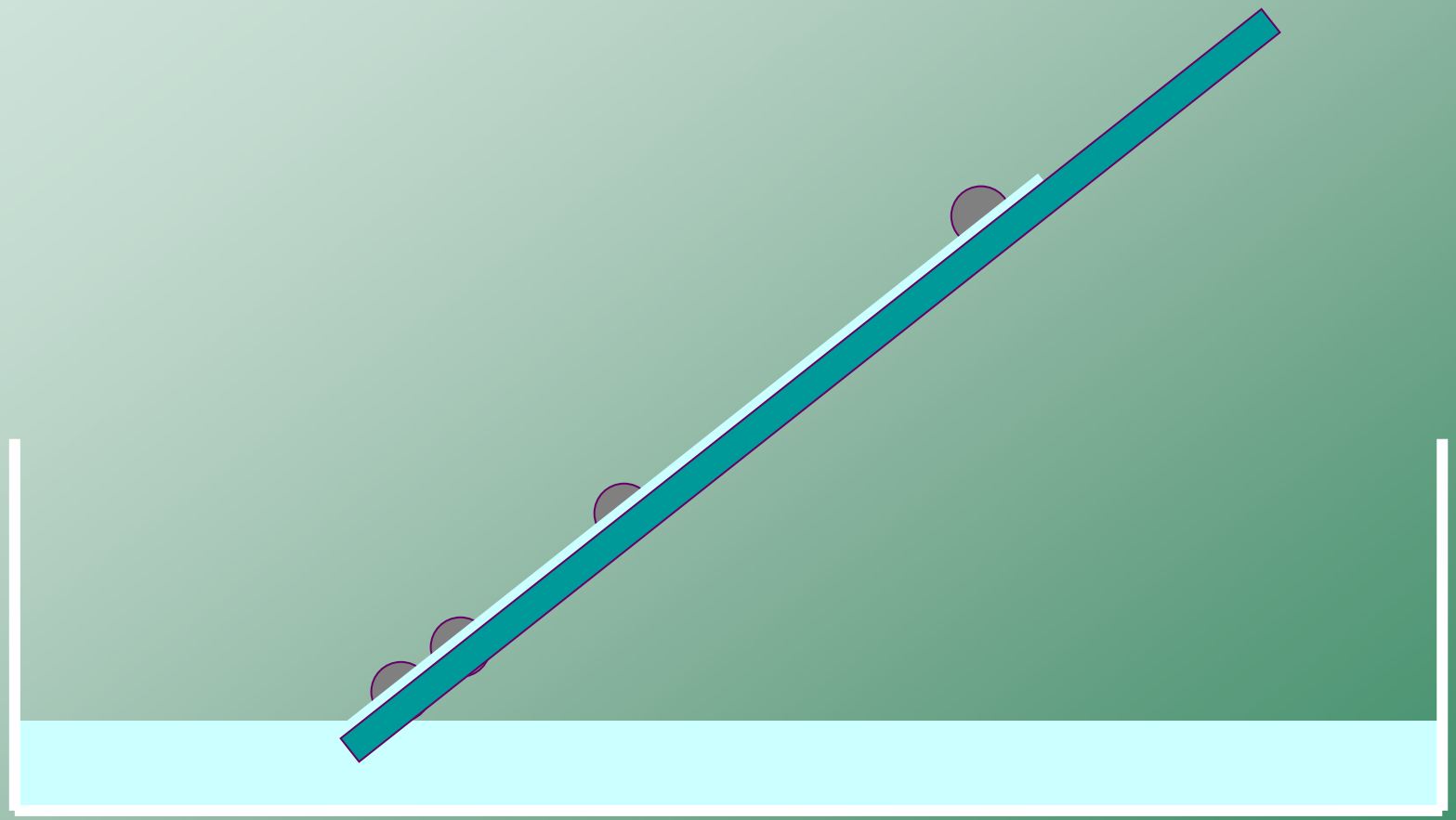
Chromatography principles (4)



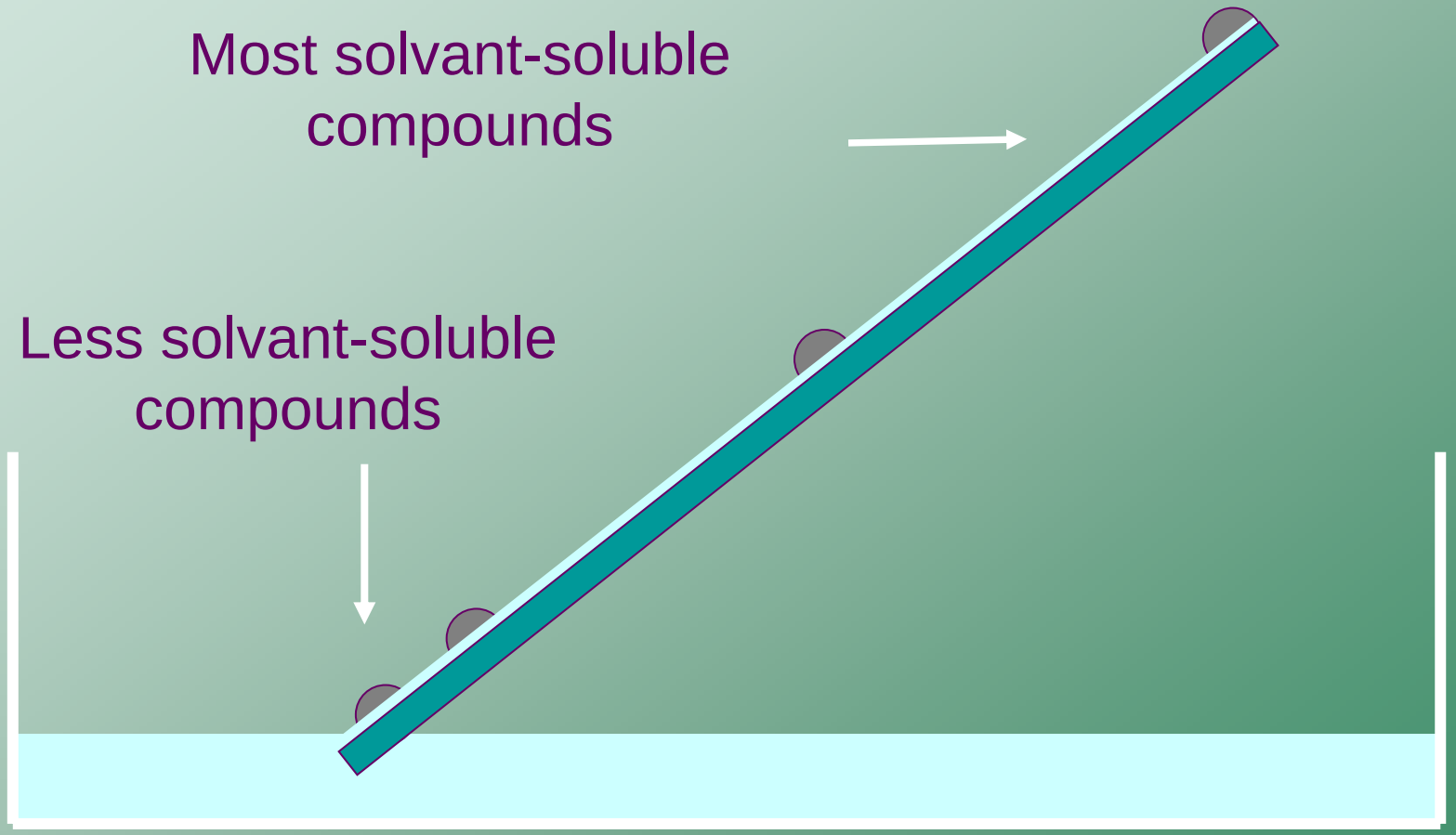
Chromatography principles (5)



Chromatography principles (6)



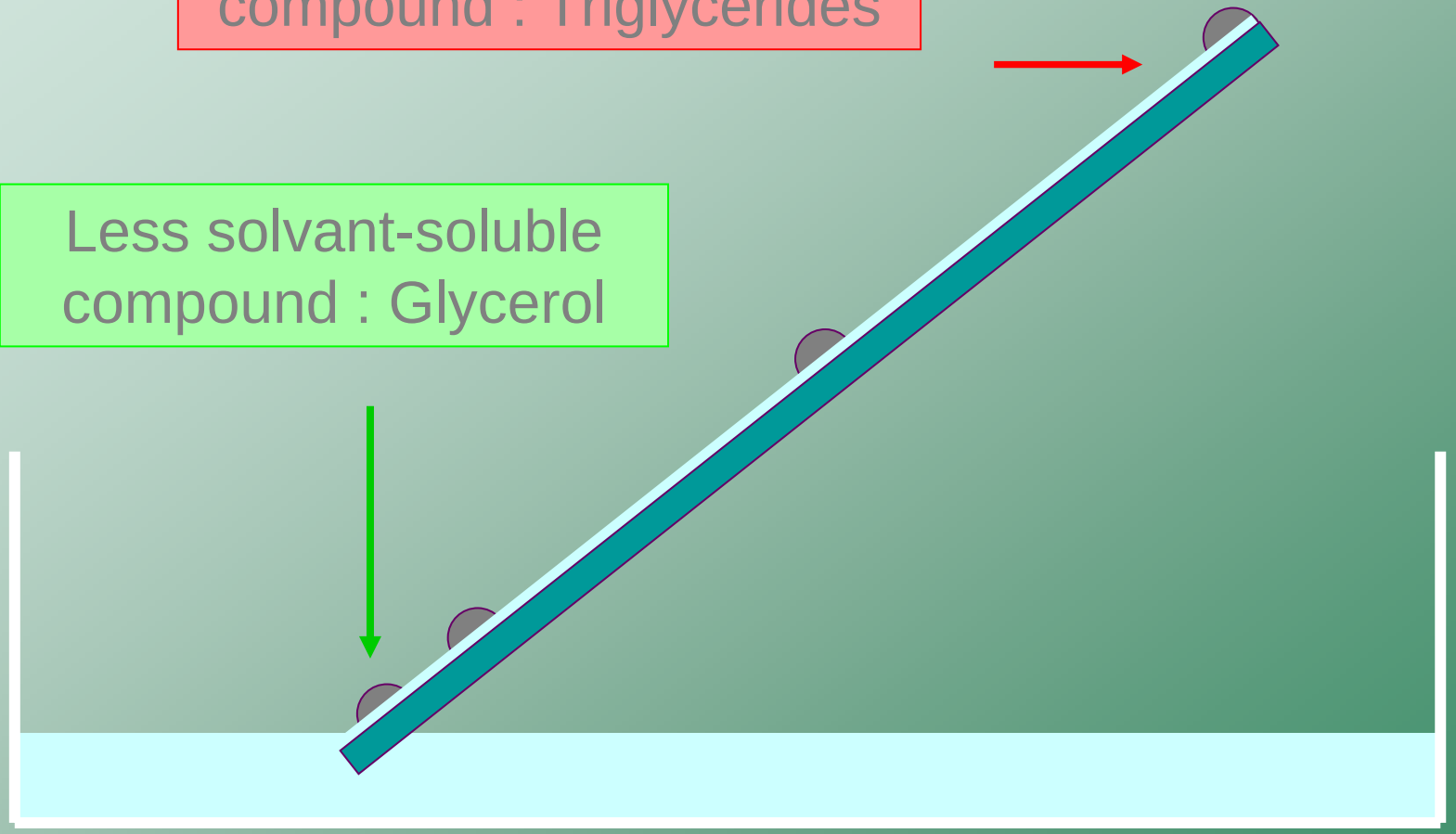
Chromatography principles (6)



Example N° 1 : A solvant efficient on lipids such as acetone or hexane is used

Most solvant-soluble compound : Triglycerides

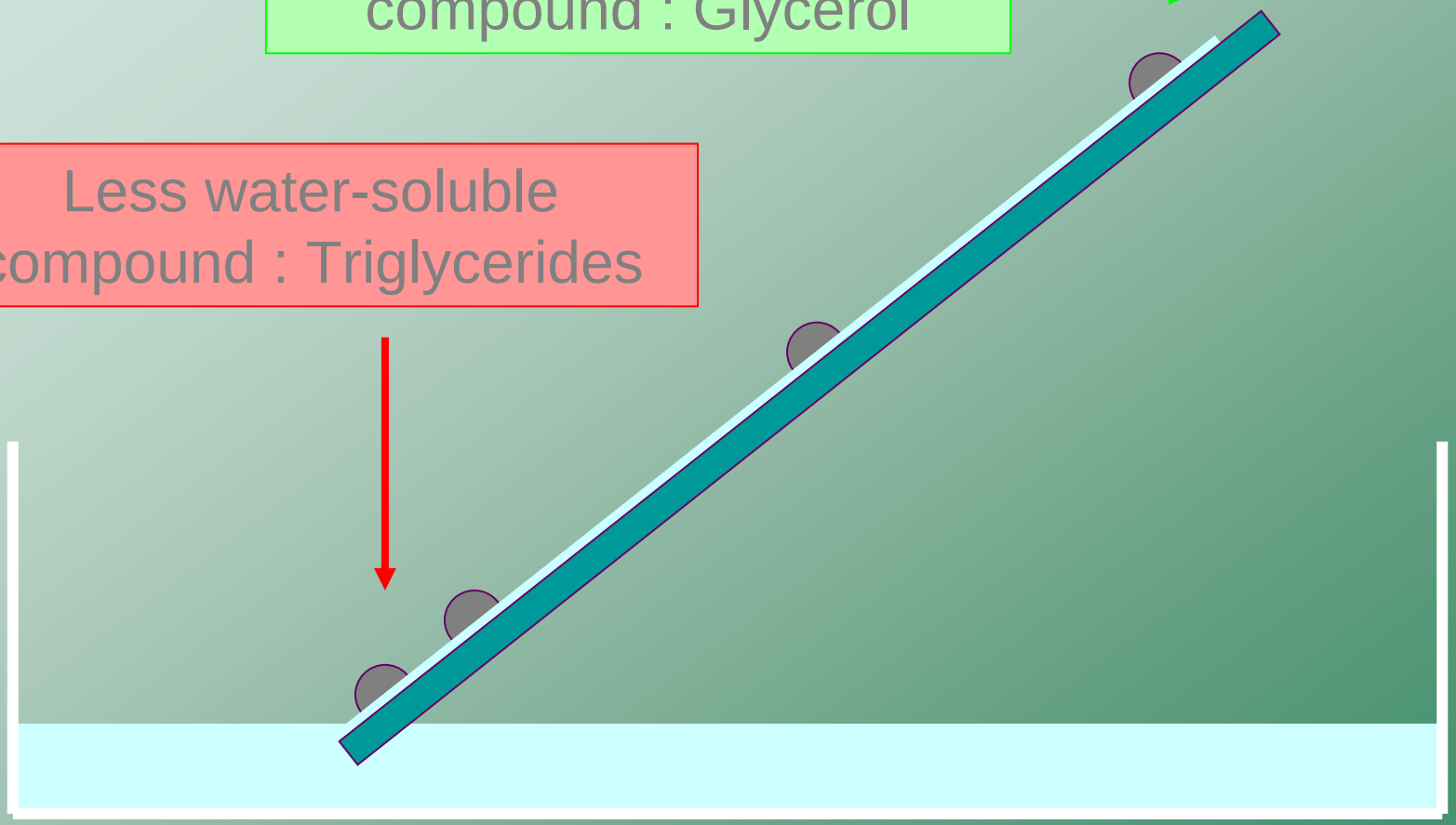
Less solvant-soluble compound : Glycerol



Example N° 2 : Water used as solvant

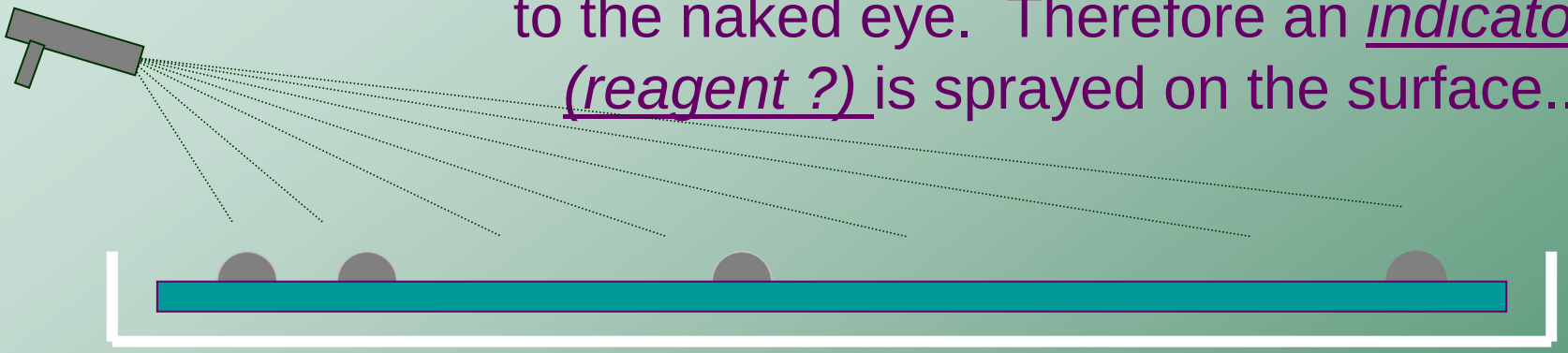
Most water-soluble compound : Glycerol

Less water-soluble compound : Triglycerides

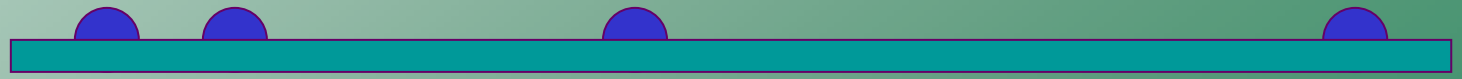


Stain identification

The analyzed compounds are often invisible to the naked eye. Therefore an *indicator (reagent ?)* is sprayed on the surface...

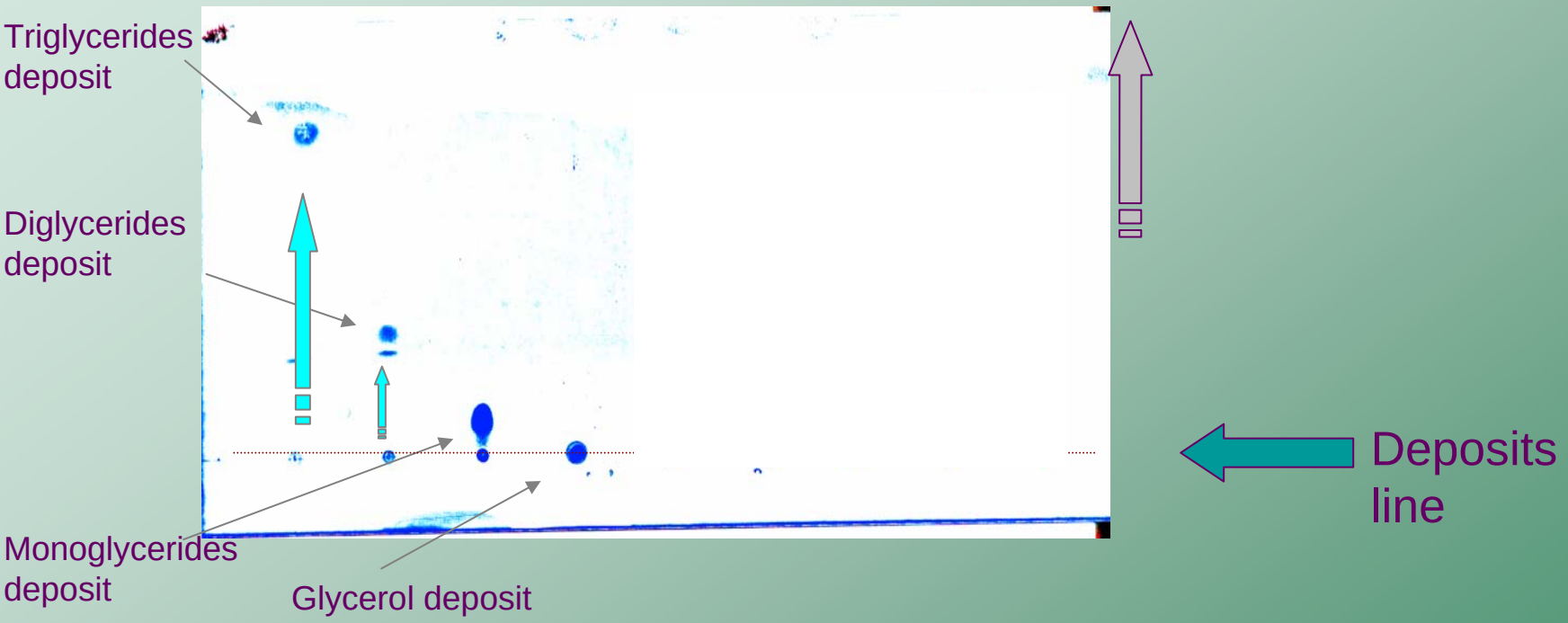


. . . to color and make them visible.



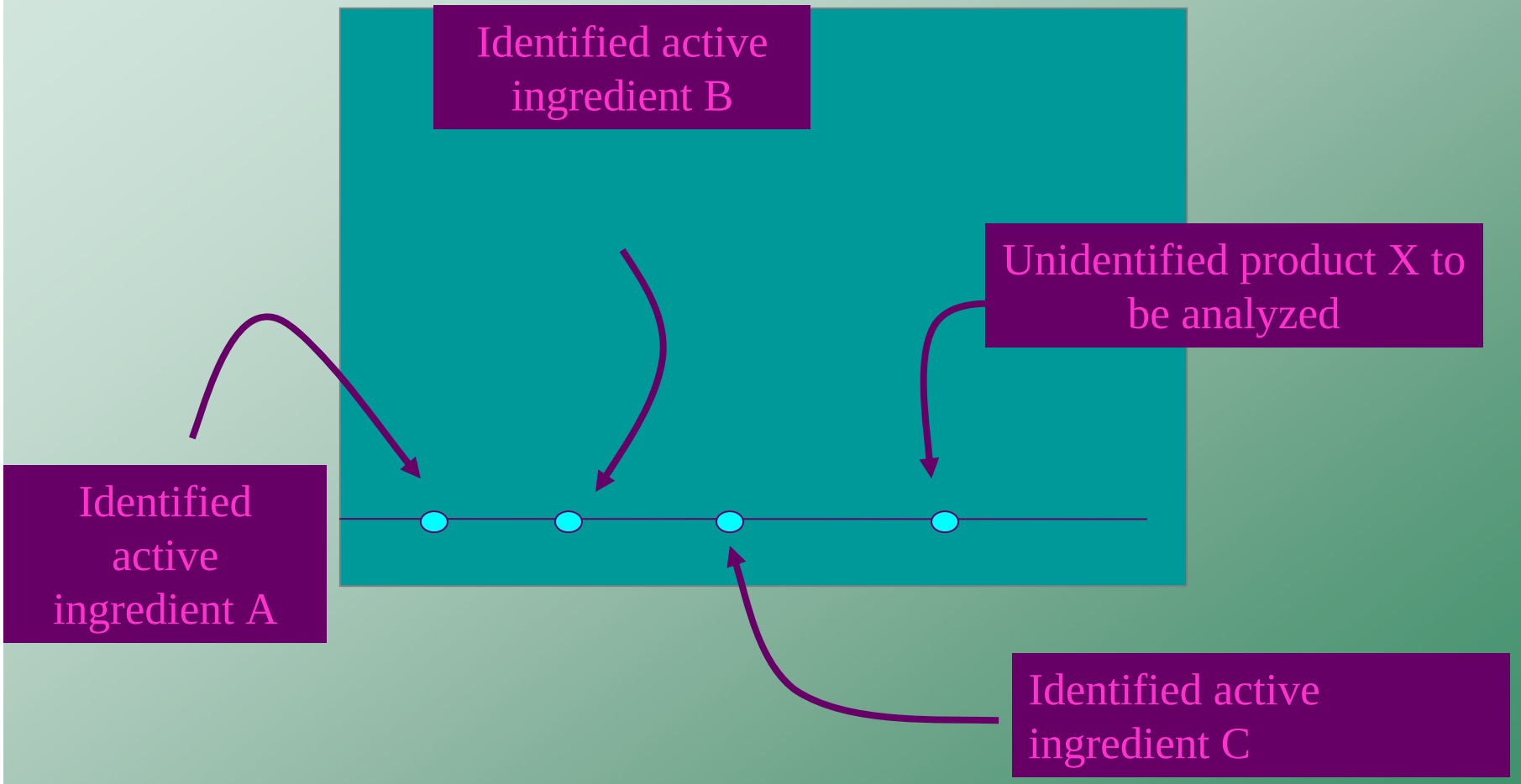
Lipasic activity of Aniosyme DD 1 vis-a-vis triglycerides

(Chromatography in thin layer on silica gel)

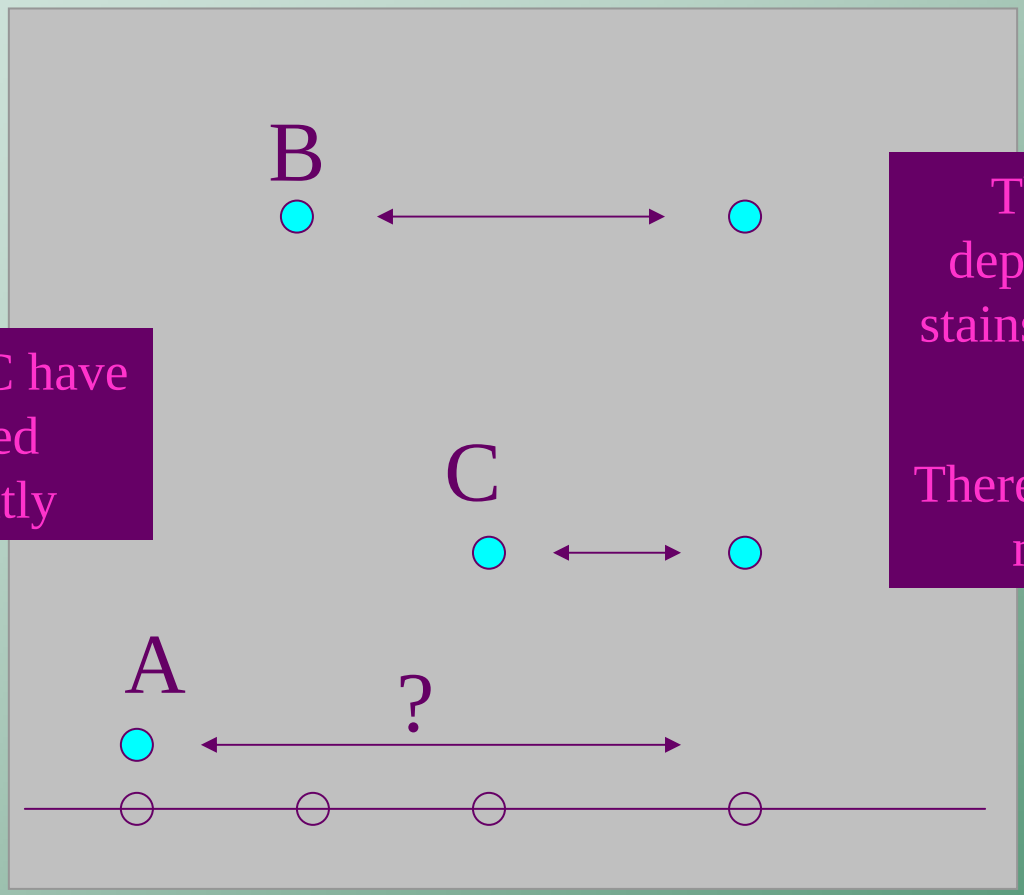


- **Under the solvent's influence (Hexane ...), triglycerides migrate heavily, diglycerides migrate moderately and monoglycerides migrate slightly. Glycerol does not migrate at all.**

Analysis of an unidentified compound by chromatography



After chromatography and *revelation*



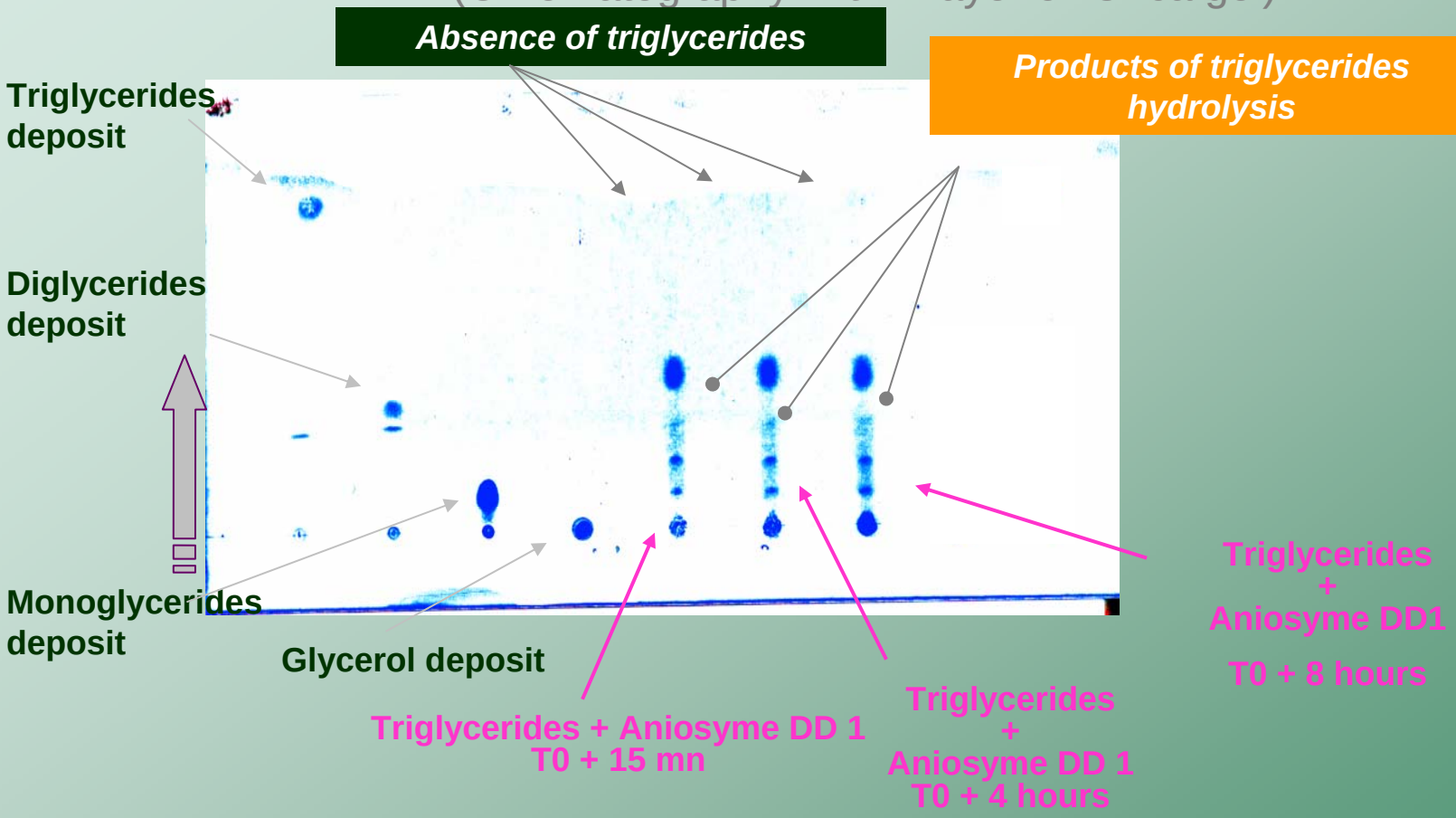
A , B and C have migrated differently

The unidentified X deposit has produced 2 stains which match B and C.

Therefore, X contains raw material B and C

Lipasic activity of Aniosyme DD 1 vis-a-vis triglycerides

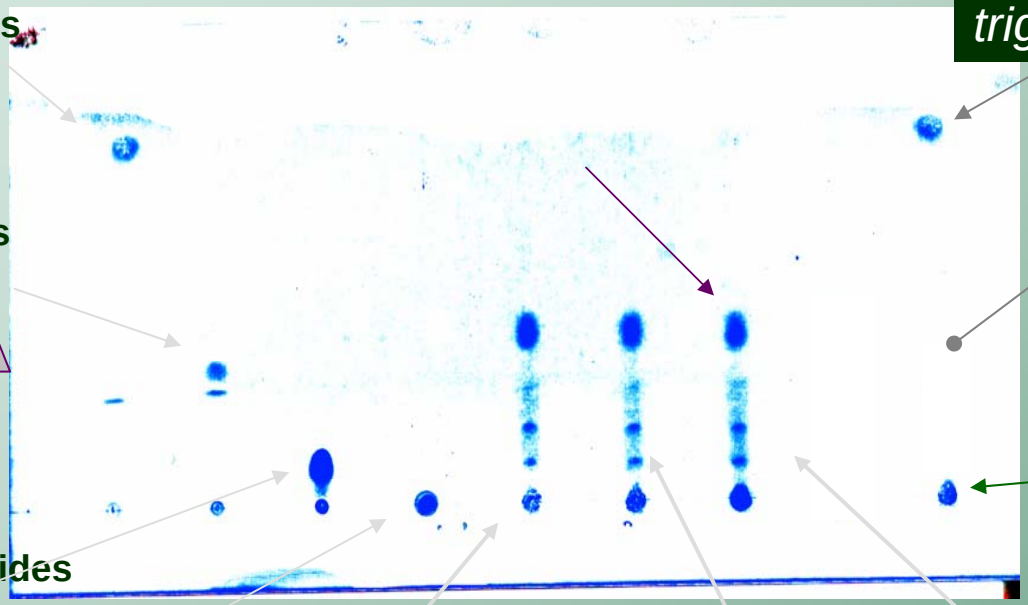
(Chromatography in thin layer on silica gel)



- Triglycerides are mixed with Aniosyme DD 1. **Lipase hydrolyzes the triglycerides in diglycerides, monoglycerides and glycerol.**
- Chromatography demonstrates that there are no triglycerides left but rather the products of degradation of triglycerides.

Lipasic activity of Aniosyme DD 1 vis-a-vis triglycerides

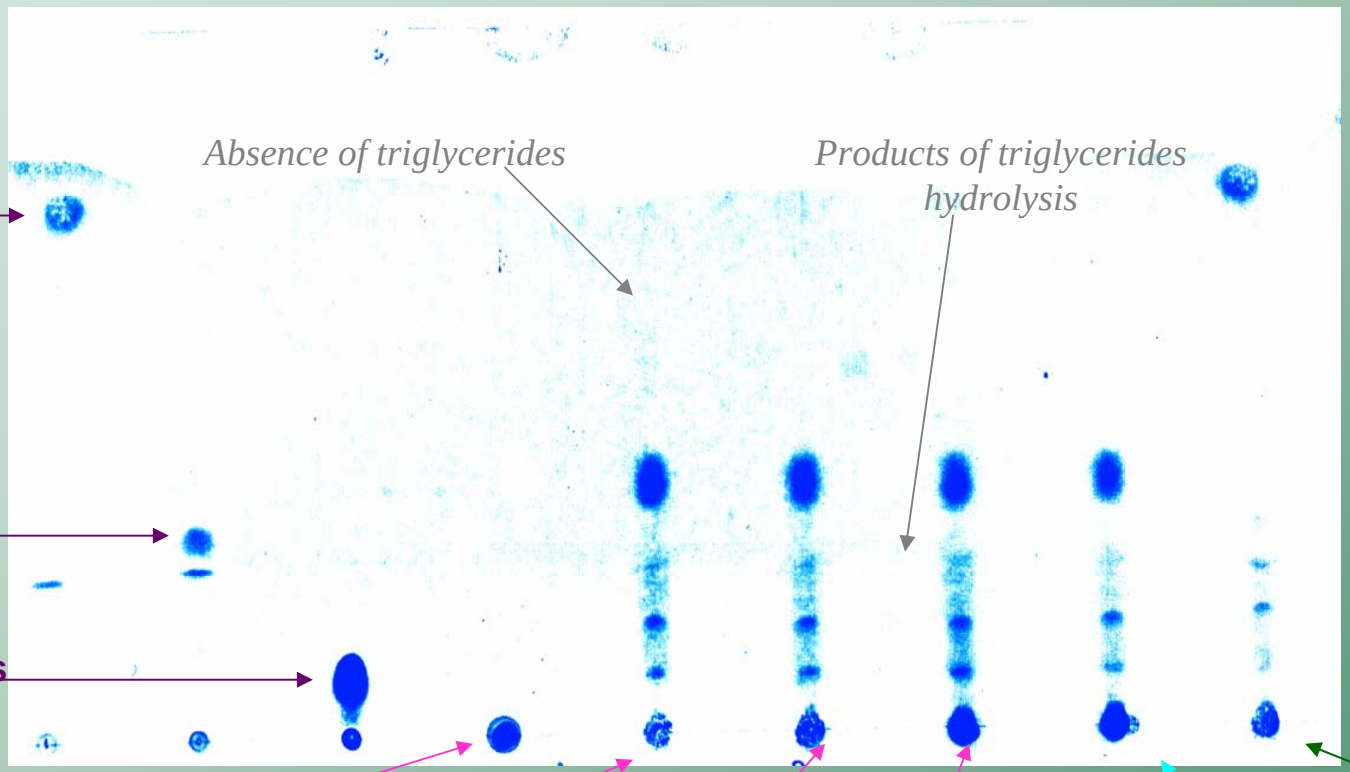
(Chromatography in thin layer on silica gel)



•**Aniosyme DD 1 without lipase cannot hydrolyze triglycerides**. Non-hydrolyzed triglycerides are found but hydrolysis products such as diglycerides, monoglycerides or glycerol are not.

Lipasic activity of Aniosyme DD 1 vis-a-vis triglycerides

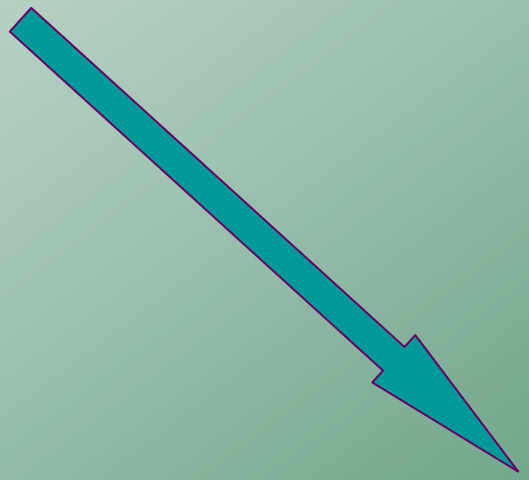
(Chromatography in thin layer on silica gel)



Amylase action

Glycogen + Amylase

(only slightly soluble)

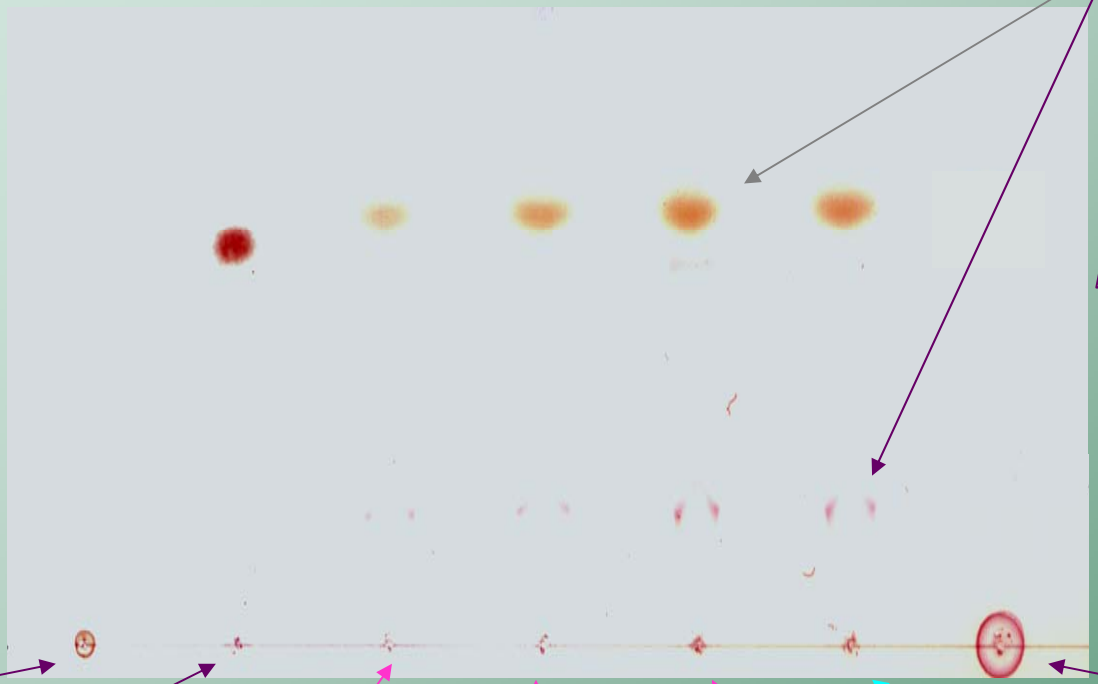


(Soluble)

Polyosides and in the end Glucose

Amylase activity of Aniosyme DD 1 vis-a-vis glycogen

(Chromatography in thin layer on silica gel)



Products of glycogen hydrolysis

Migration

Glycogen deposit

Glucose deposit

Glycogen + Aniosyme DD 1 T0 + 15 mn

Glycogen + Aniosyme DD 1 T0 + 4 hours

Glycogen + Aniosyme DD 1 T0 + 8 hours

Glycogen + Aniosyme DD 1 Ultrasounds : 5 x 15 mn

Glycogen + Aniosyme DD 1 without amylase

- We demonstrate :
  - The specific activity of the 3 enzymes
    - Protease on human Albumin
    - Lipase on triglycerides
    - Amylase on glycogen
  - Enzymes stability
    - In solution after 15 mn, 4 and 8 hours' preparation
  - Enzymatic non cannibalism
    - The lipases and amylases are active and are not destructed by the protease
  - The stability in ultrasound bath

ANIOSYME DLT Plus

ANIOSYME DD1

3enzyme Complex

ANIOSYME FIRST

ANIOSYME PLA II

A High Performance Detergency

- **by surfactants** : demonstrated on organic soil (brain + animal fats) and on artificial monobacterial biofilm

- **by enzymatic action** : demonstrated on organic substrates (Human albumin - Triglycerides -Glycogen)