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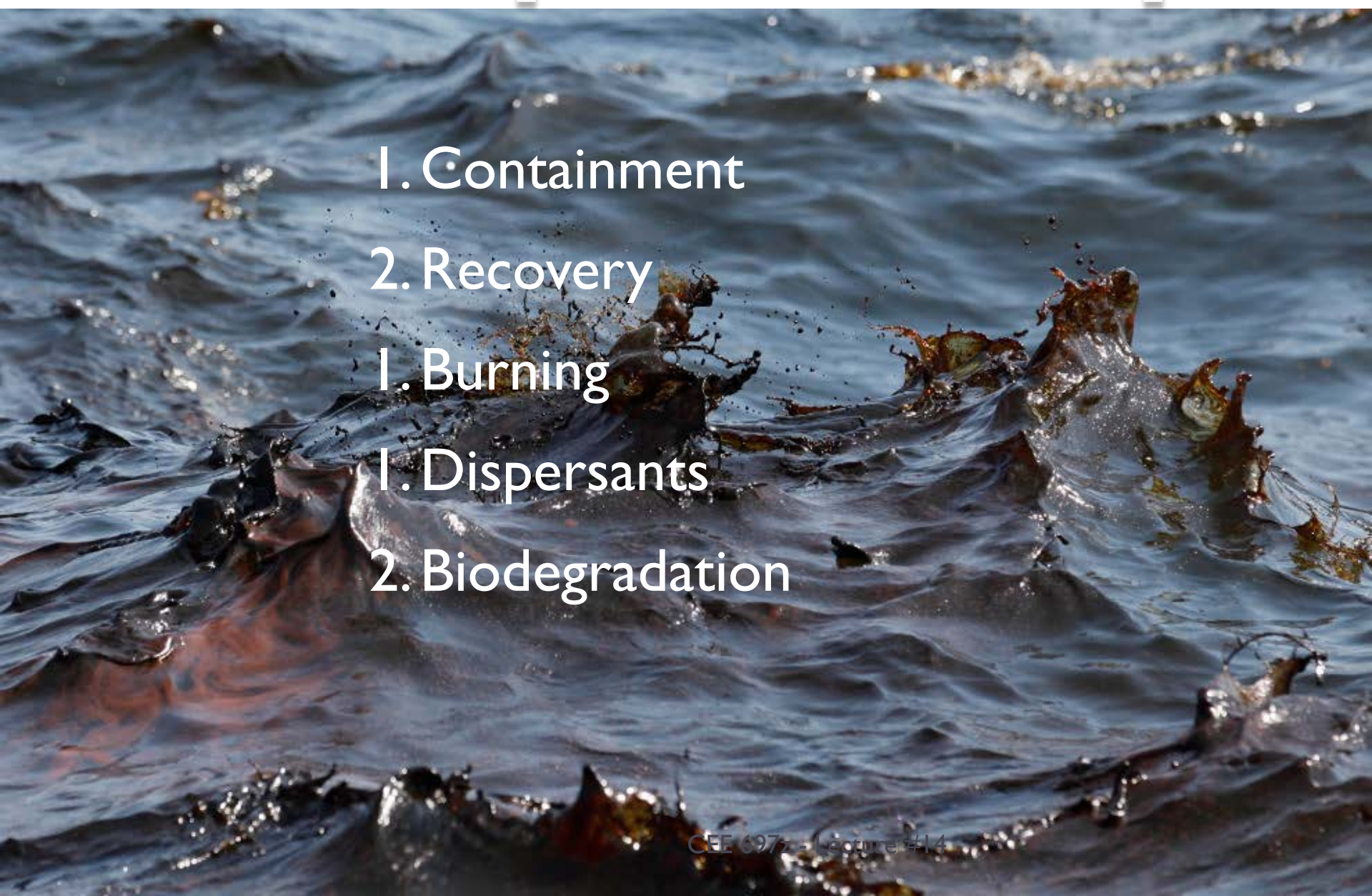
# CEE 697z

# *Organic Compounds in Water and Wastewater*

## Oil Spill Cleanup and Surfactant Use

Kristie Stauch-White: Lecture #14

# Oil Spill Clean Up



1. Containment
2. Recovery
1. Burning
1. Dispersants
2. Biodegradation

# CONTAINMENT:



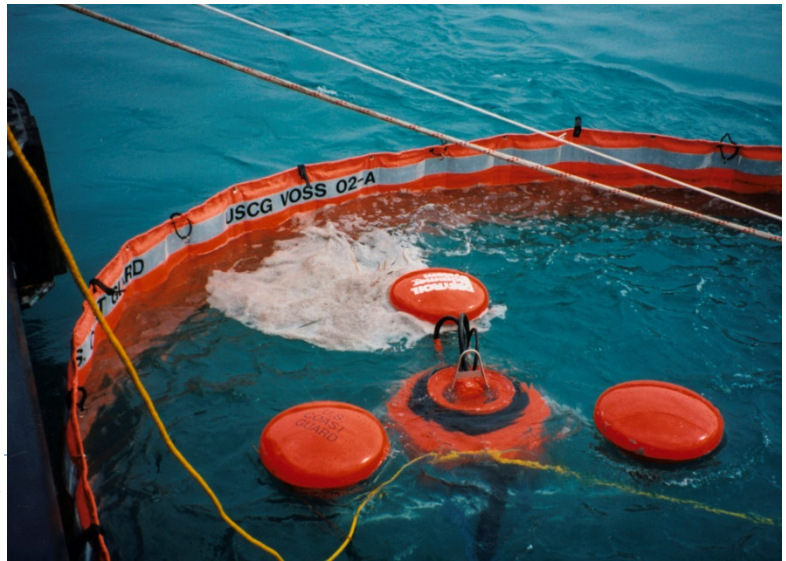

http://www.federallabs.org/flc/sandlg/state_profile/?state_id=127


conceptualized artist rendition
www.deepdowndesign.com

# Recovery

Skimmers and Sorbent materials:

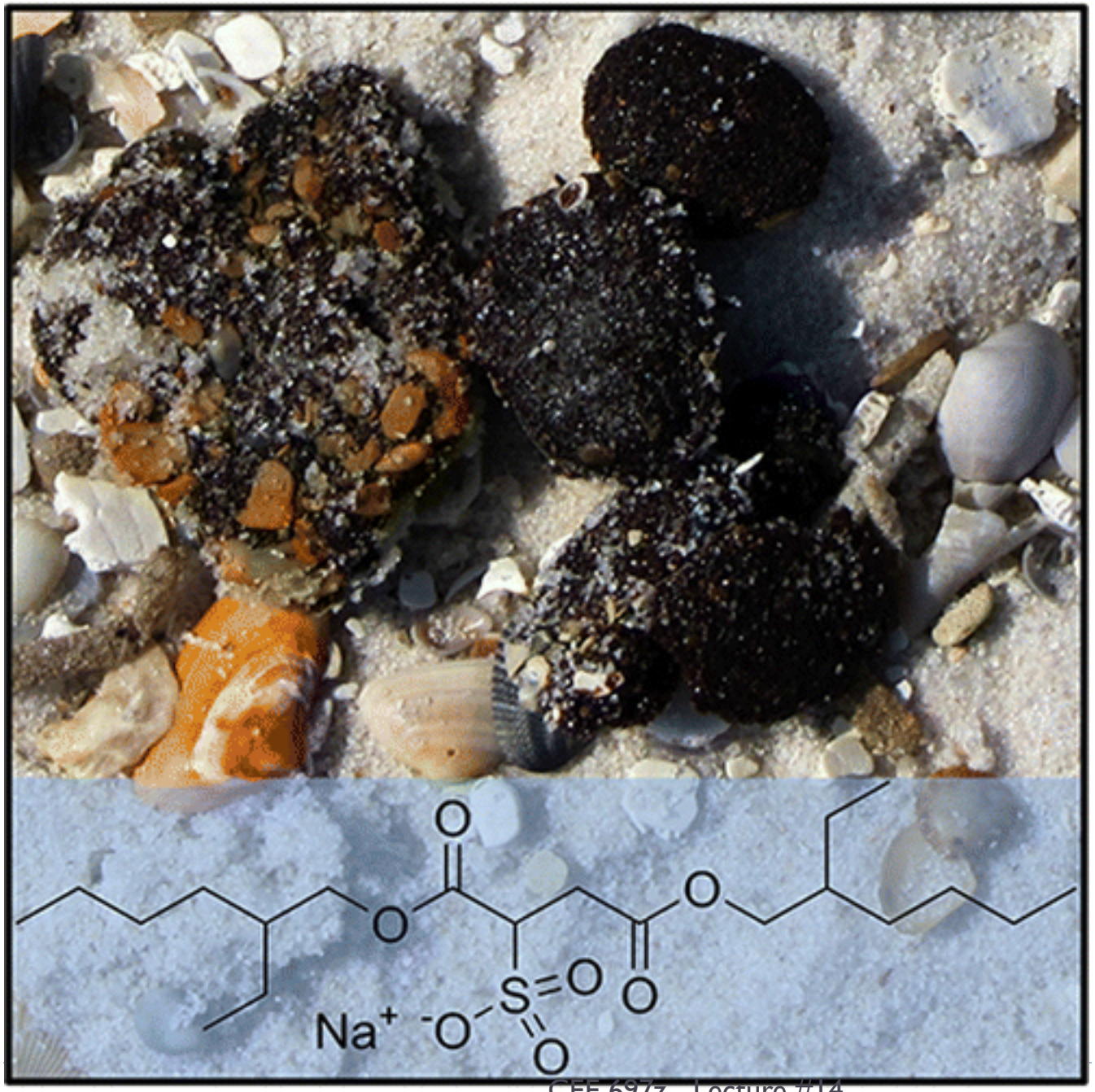
- polyester Fiber Mats
- Super-Hydrophobic Absorbents
  - polyethylene mop-like pads
- Hair Mats
- Hay
- Pine Shavings




# Burning



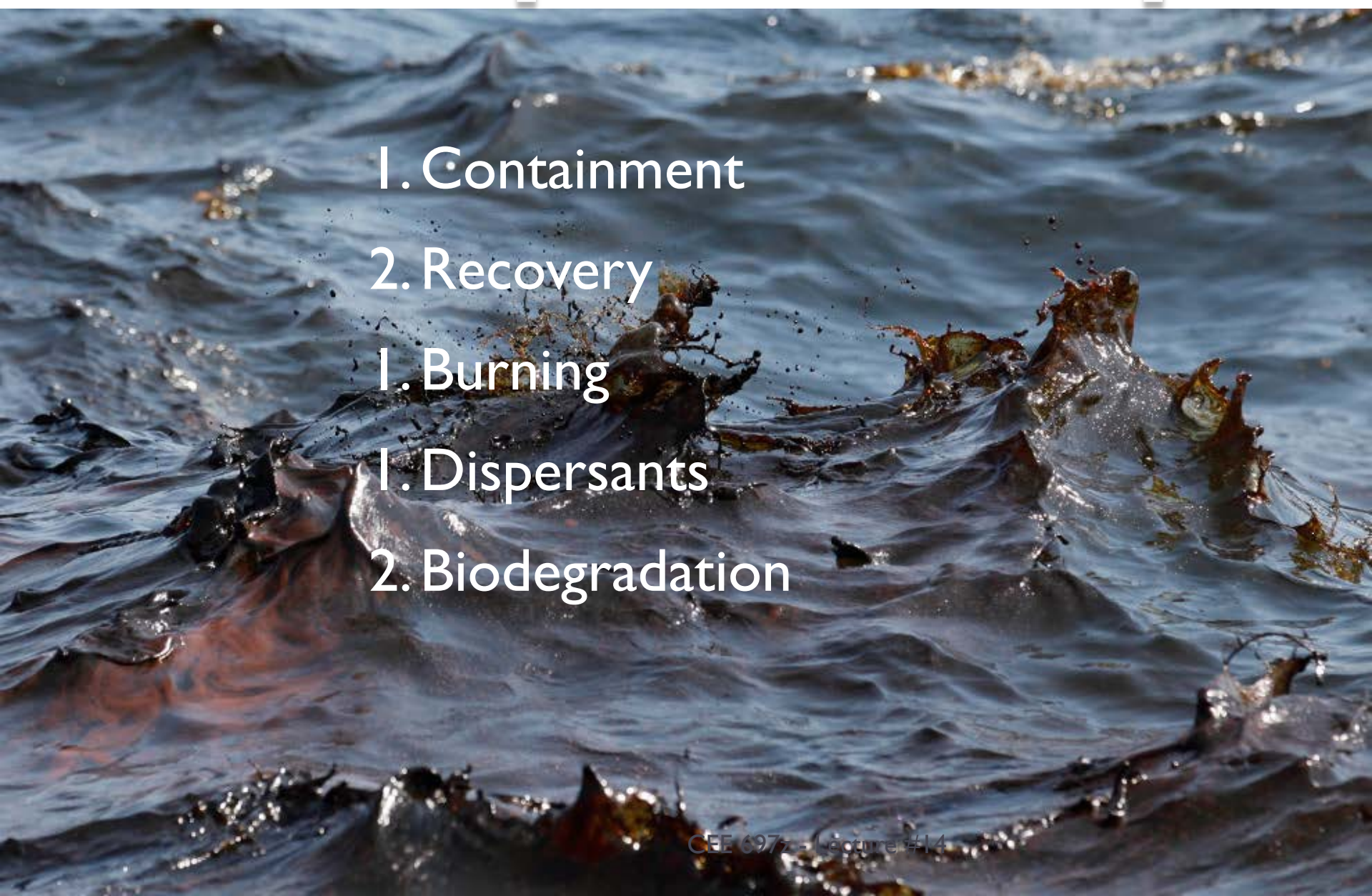
*Department of Defense*






Helen K. White, 2014, Dept. of Chemistry, Haverford College

# Oil Spill Clean Up



1. Containment
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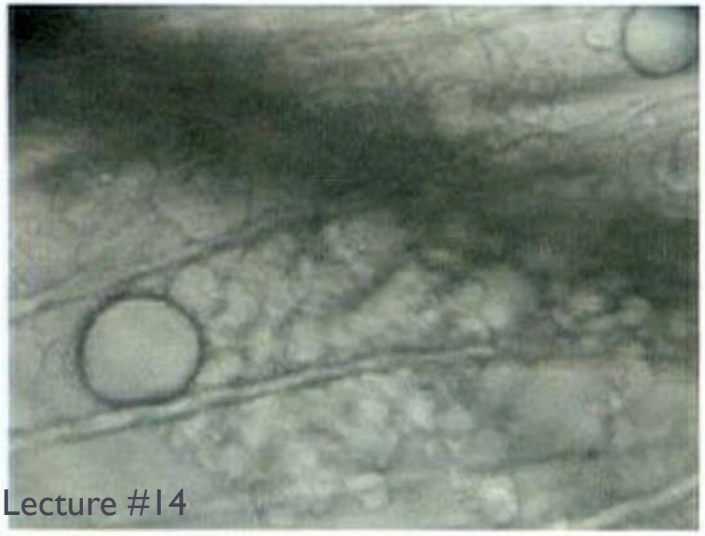
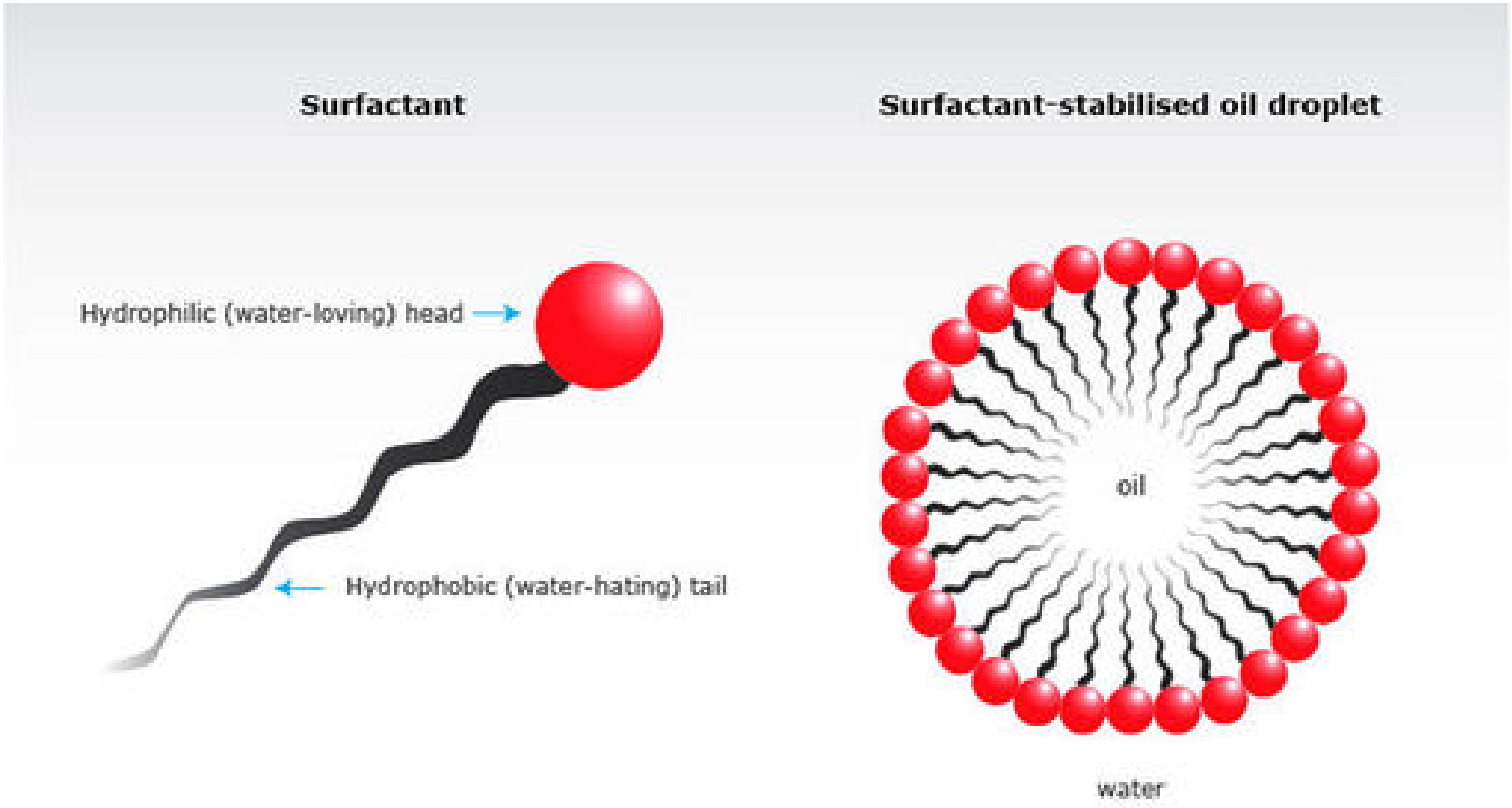
# Dispersants

- Solvents – decrease viscosity
- Surfactants – surround and emulsify oil
  - Encourages oil to sink and come into contact with bacteria in the water column
  - Also encourages oil droplets to spread into fur and feathers of marine animals

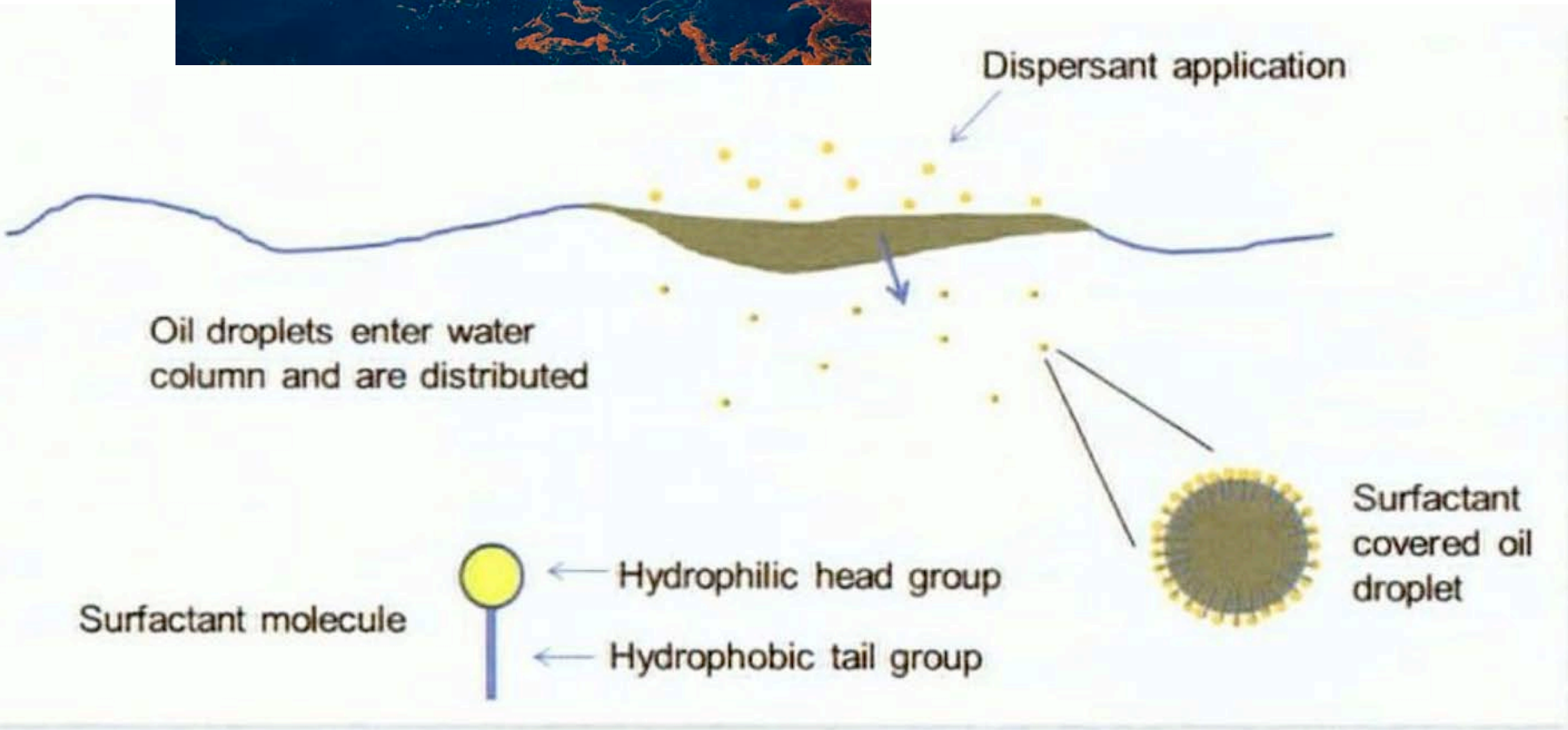


# Surfactants





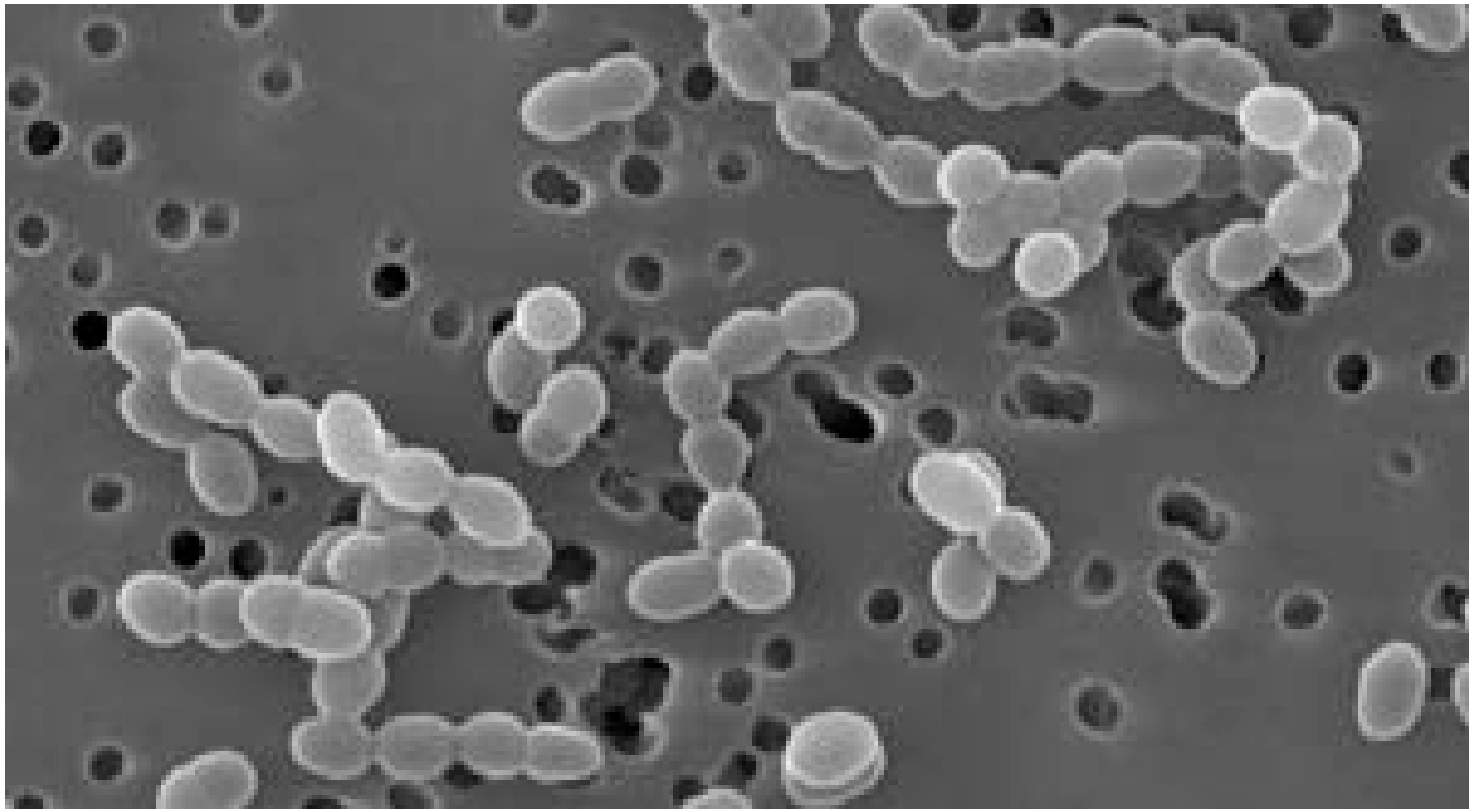

amphipathic




Tiny oil droplets suspended in the water column are more available for biodegradation

# odegradation

## Direct Interfacial Uptake of Oil/Surfactant Emulsion Droplets



**Oil Degrading Bacteria:**

- Alcanivorax borkumensis
- Pseudomonas

**Symbiotic Bacteria:**

- Azotobacter – provides fixed nitrogen
- Cyanobacteria – provides fixed nitrogen and oxygen

# ants

- 1.8 million gallons of Corexit 9500 applied at Deep Water Horizon Oil Spill in 2010

Active Ingredients:

dioctyl sodium sulfosuccinate (DOSS)

-Reported to be quickly biodegradable (>90% in 12-19 days)

-Found in Coral Beds 6 months after application

-Found on Coastline 4 years later

-Toxic to Marine Life

-Toxicity increased when mixed with Oil

# Clearly, more research is needed to find less toxic and more biodegradable surfactants for Oil Spill Remediation

- Commercial Lecithin & Cellulose Polymer based surfactant – mixture of natural phospholipids in oil

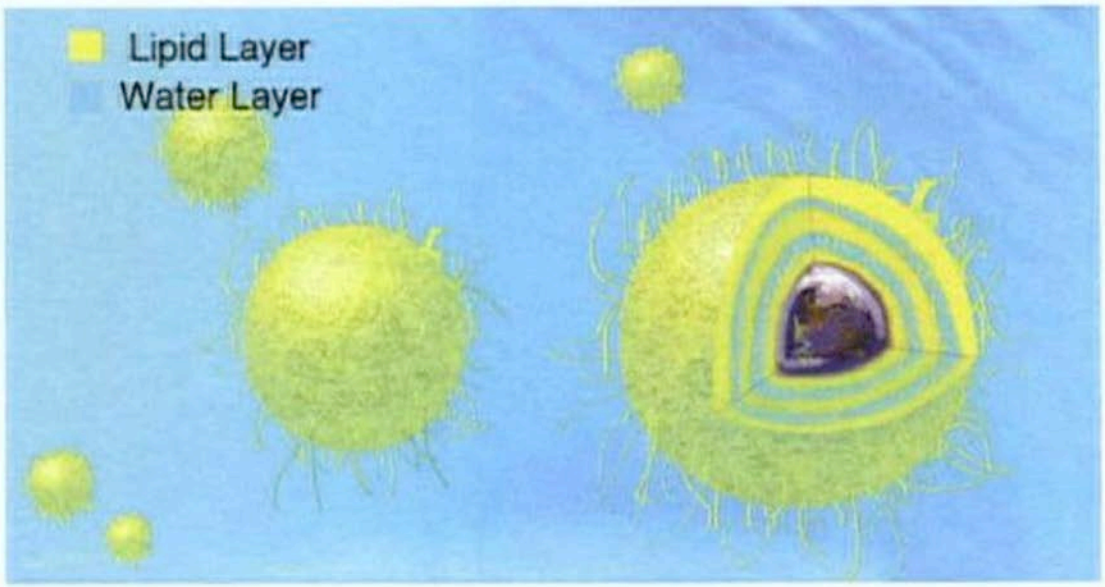
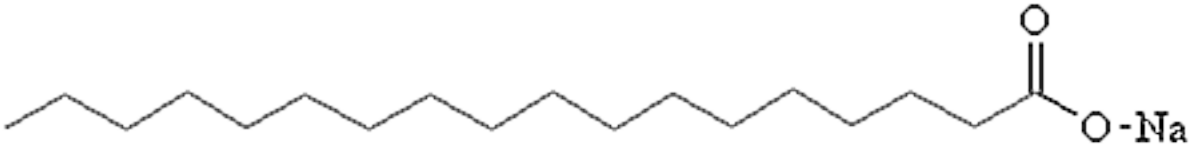



**Figure 15**—Illustration of the method of encapsulation for antideposition treatment of oil droplets. The lecithin bilayers form around the oil droplet and anchor the cellulosic polymer in the d-spacing of the bilayers. (Note: illustration not to scale)

# Commonly Used Surfactants

# Commonly Used Surfactants




Sodium Stearate

- Soaps
- Detergents
- Household Cleaners
- Foaming Agents
  (sodium lauryl sulfate in toothpaste and shampoo)

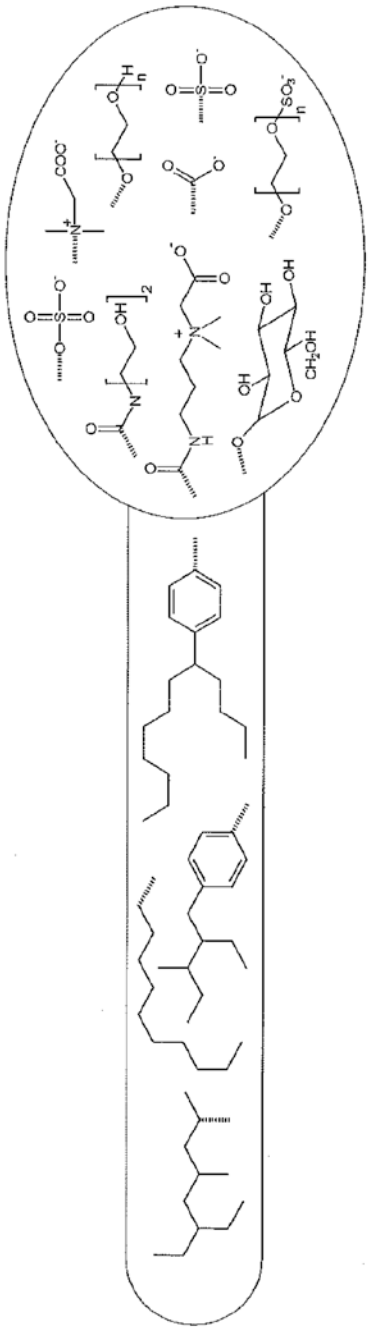
Soap – 1st Widely used Surfactant

ABS – Alkylbenzene sulfonates used in laundry products*

- left calcium and magnesium salt precipitates
- foaming in sewage water, treated sewage and river water
- led to ban in Germany and voluntary bans in the U.S.

LAS – Linear alkylbenzene sulfonates

- introduced in 1960s
- improved biodegradability
- less foaming
- levels of surfactants in aquatic environments

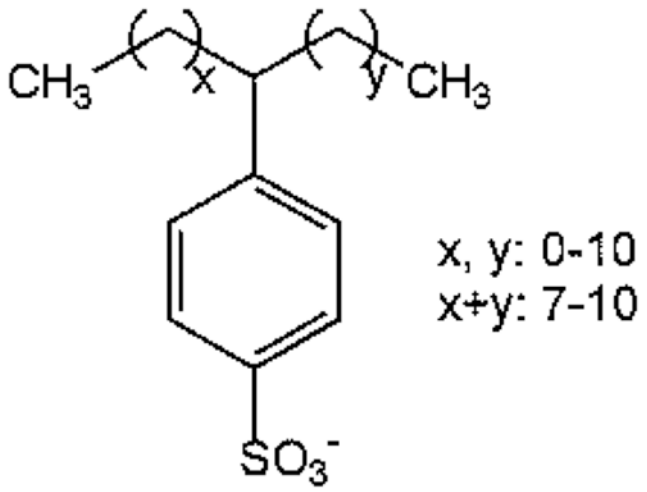




*Thomas P. Knepper and Peter Eichhorn*

# asses of Surfactants

- Anionic
- Cationic
- Non-ionic

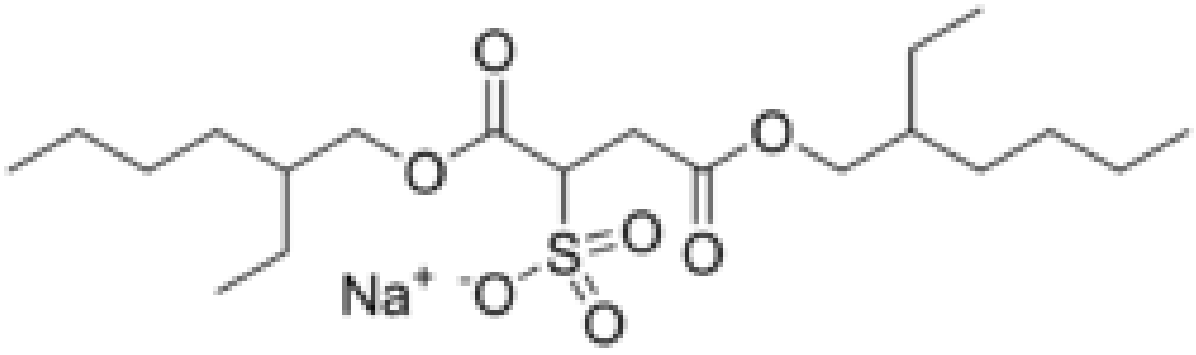



General Structure of LAS
(linear alkylbenzene sulfonate)



Knepper & Eichhorn, 2006

# Dioctyl Sodium Sulfosuccinate




## Anionic Surfactant

# Biodegradation of Surfactants

## Primary Biodegradation

– minor alterations in chemical structure of surfactant molecule

– may result in loss of surface-active properties, lowering toxicity



Knepper & Eichhorn, 2006

# esting for Surfactants

- Anionic Surfactants are methylene blue-active substances (MBAS)
- Non-ionic surfactants are bismuth iodide-active substances (BiAS)

Additional testing required to determine the fate of surfactant molecules after primary degradation

# Biodegradation of Surfactants

**Organization of Economic Co-Operation and Development (OECD)**

- developed International Standard Methodologies for testing the biodegradability of surfactants
  - **Ready Biodegradability** – real environmental conditions (60% CO2 formation or 70% DOC removal within 28 days) *likely to be degraded
  - **Inherent Biodegradability** – ideal conditions *potential to be degraded
  - **Simulation Biodegradability** – WWTP conditions

# What happens to Surfactants from household and industrial use?

The majority reach Wastewater Treatment Plants where they are effectively eliminated.

Some persistent compounds and their metabolites are found in raw water that is treated for drinking water.

Additional Research is needed to better understand the fate of these compounds and their metabolites.

Thank you

- To next lecture