

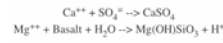
The Sulfur Cycle



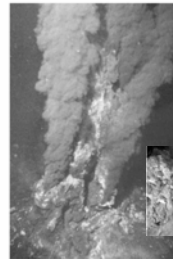
Mt. St Helens is about to Blow its top again!



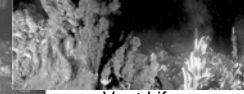
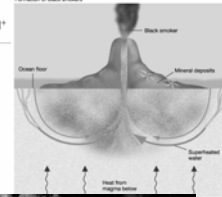
The Sulfur Cycle



Formation of black smokers



Black Smoker



Vent Life



Sulfur Biogases

Hydrogen sulfide - H_2S
 Carbon disulfide - CS_2
 Carbonyl Sulfide - COS
 Methyl mercaptan - CH_3SH
 Dimethyl Sulfide - CH_3SCH_3
 Dimethyl Disulfide - CH_3SSCH_3



Sulfate in Rain: Sources

Sea-salt sulfate
 Anthropogenic SO_2 - industrial and automobiles
 Biogenic reduced S gases
 Volcanic emissions
 Forest Burning
 Soil dust
 Plant aerosols



The Sulfur Cycle



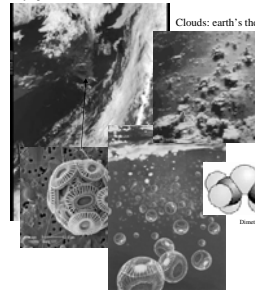
Luke Howard



<http://www.inclouds.com/>

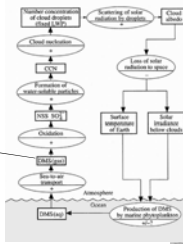
The Sulfur Cycle

Phytoplankton bloom

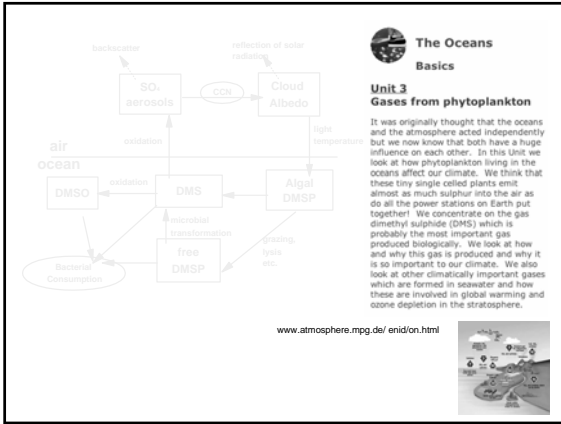


Coccolithic phytoplankton

Clouds: earth's thermostat



Cloud Formation



Sources of Oil Contamination of the Ocean

The title of this case study has been carefully chosen to make the point that whilst oil spills at sea make 'good news stories', they contribute only a tiny amount of the oil that gets into our seas and oceans each year.

Source	Oil (barrels)
Big Spills	37
Routine Maintenance	137
Down the Drain	343
Up in Smoke	82
Offshore Drilling	15
Natural Seepage	62

343 million gallons of used oil end up in the sea. It comes from people pouring engine oil down the drain, from industrial waste pipes and from the oil that spills on our city roads. (In a city of 5 million people, the only road runoff that gets washed by the rain into the drains, could contain as much oil as one large tanker spill).

137 million gallons of oil is washed into the sea each year by ships carrying out routine maintenance. Cleaning out the bilges and other ship operations releases only a few gallons each time but many thousands of ships carry out this maintenance procedure each year.

92 million gallons of oil results from air pollution. Air pollution, mainly from cars and industry, places hundreds of tons of hydrocarbons into the air and rain washes these hydrocarbons from the air into the oceans.

62 million gallons of oil comes from natural seepage from the ocean bottom and from eroding sedimentary rocks which release oil.

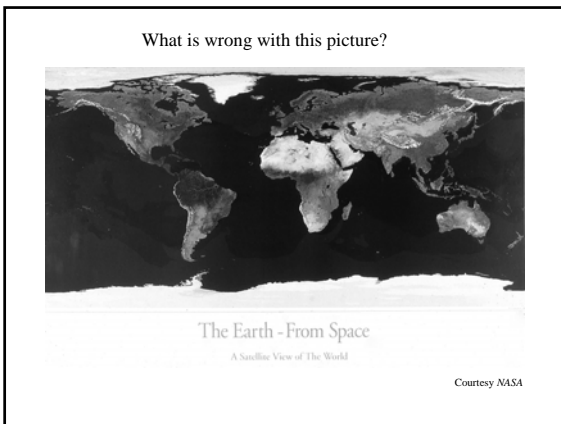
15 million gallons of oil comes from offshore oil production and results from spills and operational discharges.

37 million gallons of oil end up in the sea from tanker accidents. These spills contribute only about 5 percent of oil pollution in oceans but the oil is released suddenly and in large quantities so one big spill can disrupt sea and shore life for miles around.

History of Ocean Oil Spills

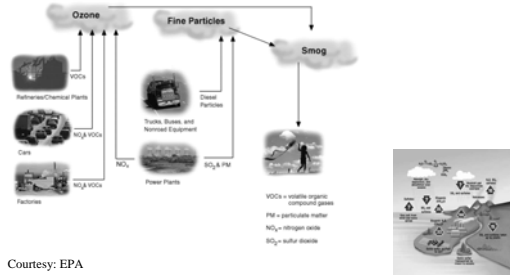
Ship	Year	Location	Oil lost (tonnes)
1	Atlantic Empress	1979 off Tobago, West India	280,000
2	Agulha	1991 700 nautical miles off Angola	260,000
3	Castillo de Bellver	1963 off Saldanha Bay, South Africa	257,000
4	Amoco Cadiz	1976 off Brittany	227,000
5	Yara	1991 Genoa, Italy	140,000
6	Colony	1966 700 nautical miles off Nova Scotia	132,000
7	Taney Canyon	1967 Sicily, Italy	118,000
8	Ungula	1974 La Coruna, Spain	108,000
9	Iraklian Patrol	1977 300 nautical miles off Honolulu	96,000
10	Independencia	1979 Bosphorus, Turkey	93,000
11	Brera	1983 Shetland Islands	85,000
12	Khark 5	1969 120 nautical miles off Atlantic coast of Morocco	80,000
13	Jahk Mersak	1975 Oporto, Portugal	80,000
14	Aragon Sea	1982 La Coruna, Spain	72,000
15	Katira P	1992 off Maputo, Mozambique	72,000
16	Nova	1969 The Gulf, 20 nautical miles off Iran	70,000
17	Matina	1971 off Cape Agulhas, South Africa	65,000
18	Assara	1963 55 nautical miles off Muscat, Oman	63,000
19	Melita	1974 Magellan Straits, Chile	63,000
20	Exxon Valdez	1989 Prince William Sound, Alaska	37,000

Source: International Tanker Owners Pollution Federation



No clouds!

The Sulfur Cycle



The Sulfur Cycle

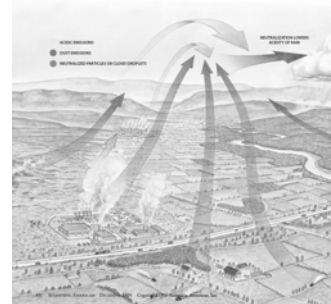


The Earth At Night



Most energy generating systems that utilize fossil fuels put significant amounts of SO₂ into the atmosphere.

Acid Rain And Deposition



Deforestation-Reforestation

The George Washington National Forest, now a national treasure, was once "the land nobody wanted". It was formed as a result of the Weeks Law of 1911, which authorized the purchase or exchange of private lands, primarily in the east. Its original intent was to protect water and water supplies that had been damaged by abuse during the earlier settlement and industrial period.

SHENANDOAH
NATIONAL PARK



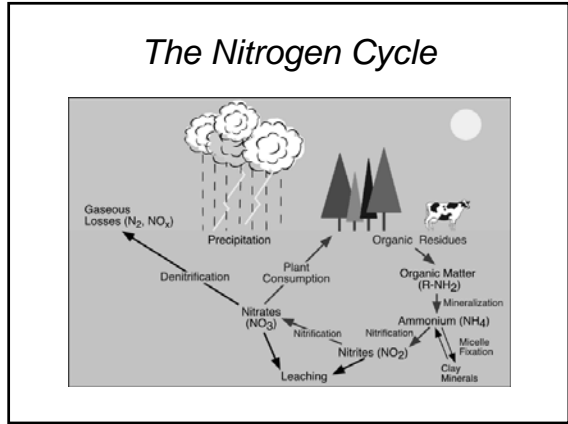
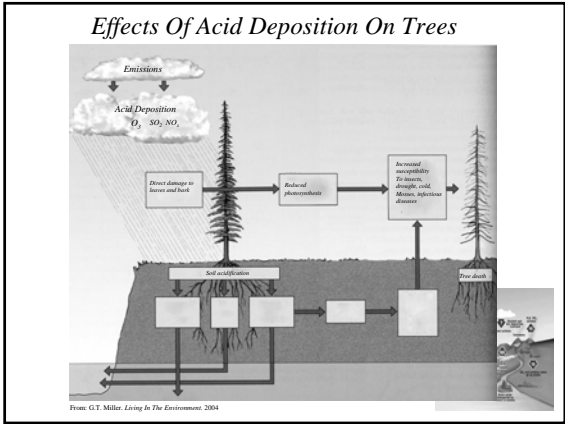
Forest Damage Due To Acid Rain



Germany



New York



The Nitrogen Cycle*

Ultrastructure of root nodule bacteria

Root nodules

Nitrogen Fixation by Symbiotic and Free-Living Spirochetes
 T. G. Lilburn,^{1,2} K. S. Kim,³ N. E. Ostrom,⁴ K. R. Nyank,⁵
 J. R. Leadbetter,¹ J. A. Branan^{1,2*}

*what is wrong with this picture?

Corn is not a legume

