Osorb:
A Novel Water Remediation Technique

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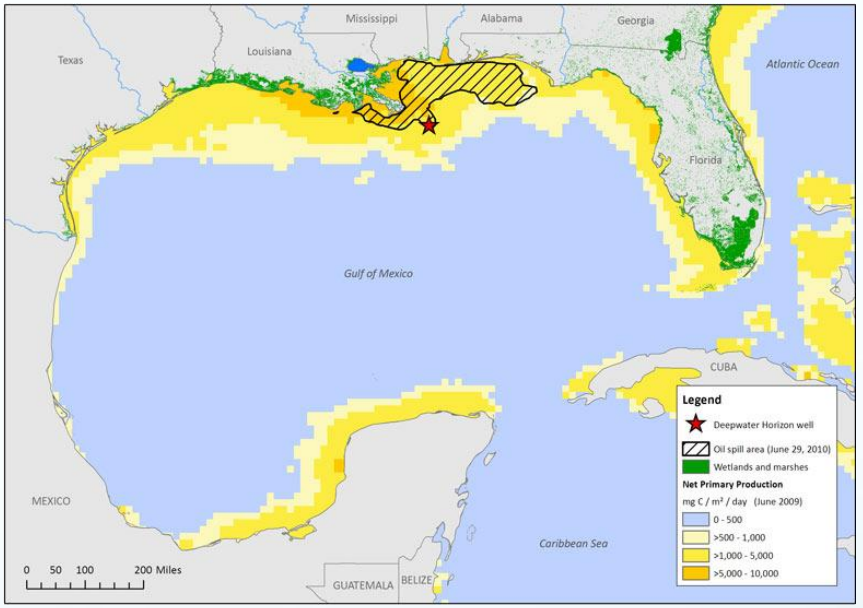
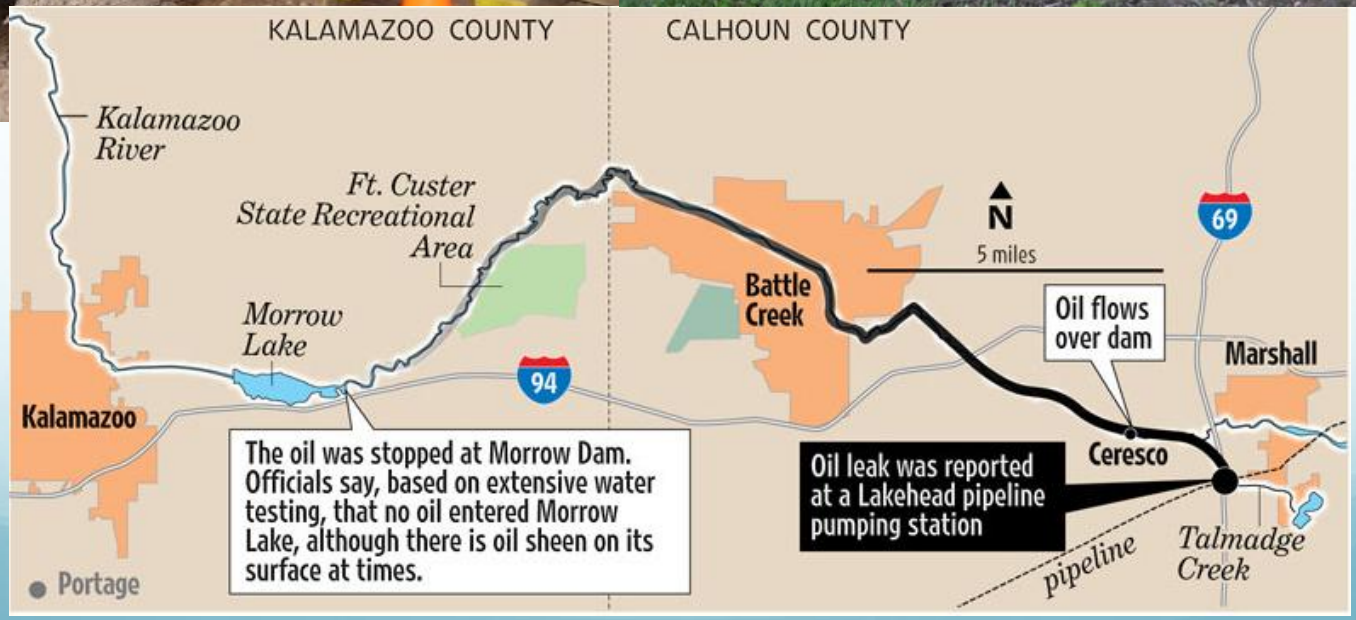
Outline

- Applications
- Background of Oil Spill Cleanup
- Absorbent Material
- Osorb Synthesis
- Swelling Capabilities
- Green Application
- Conclusion

Deepwater Horizon Oil Spill



Talmadge Creek Oil Spill



Cleanup Methods

Containment and Diversion

Mechanical removal

Cleanup Methods

Dispersants/ Chemical Treating Agents

In Situ Burning

Characteristics of a good absorbent

- Hydrophobicity
- Oleophilicity
- High uptake capacity
- High rate of uptake
- Retention over time
- Oil recovery from absorbents
- Reusability and Biodegradability of absorbents

Types of Absorbents

Synthetic Organic Products

- Polypropylene
- Polyurethane

Natural Products

- Rice straw
- Wool Fiber
- Peat moss wood
- Milkweed Floss

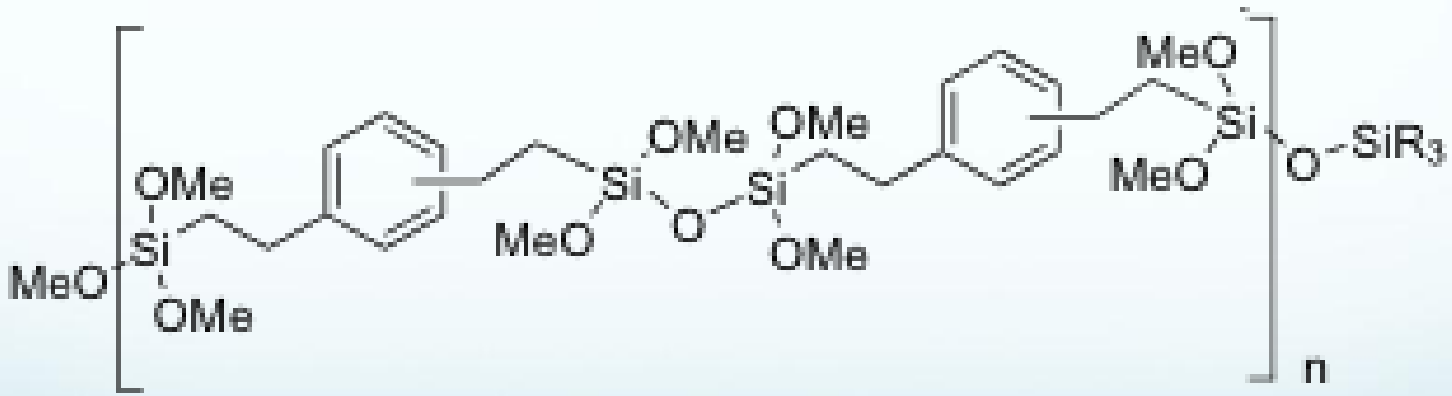
Types of Absorbents

Mineral Products

- Silica Aerogels
- Zeolites
- Organophilic Clays
- Osorb

What is Osorb?

- Swellable Organically Modified Silica (SOMS)
- A sol-gel that after drying can swell in a few seconds when placed in an organic solvent



Attributes

- Rate of swelling is mass transport limited
- Uptake of absorbates generates forces >100N/g
- The swelling is completely reversible
- Absorption is non-selective
- Material is Hydrophobic
- Swelling and absorption is driven by the release of stored tensile force

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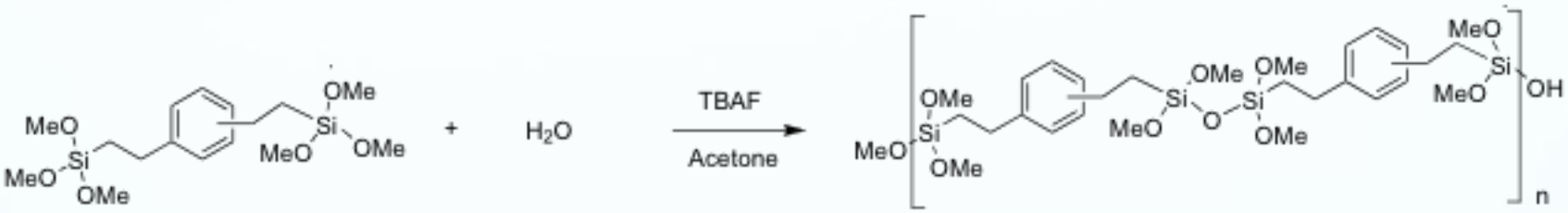
Synthesis of a Sol-Gel

Step 1: Mixing /Gelation

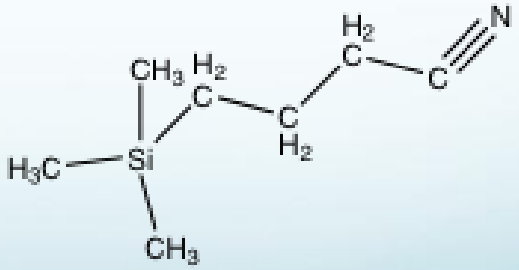


0.144 mol bis(trimethoxysilyethyl)benzene added to 220ml Acetone

1.5 mL of 1.0M tetrabutylammonium fluoride in 7.8 mL water

Step 2: Aging and Rinsing

Step 3: Derivatization



5% v/v cyanopropyltrimethylsilane in Acetonitrile

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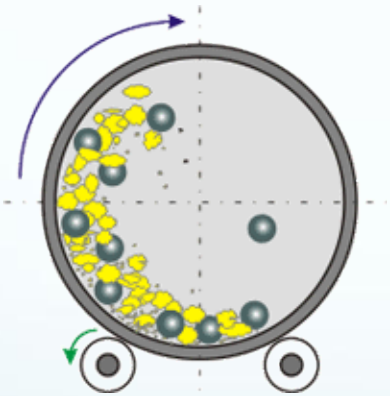
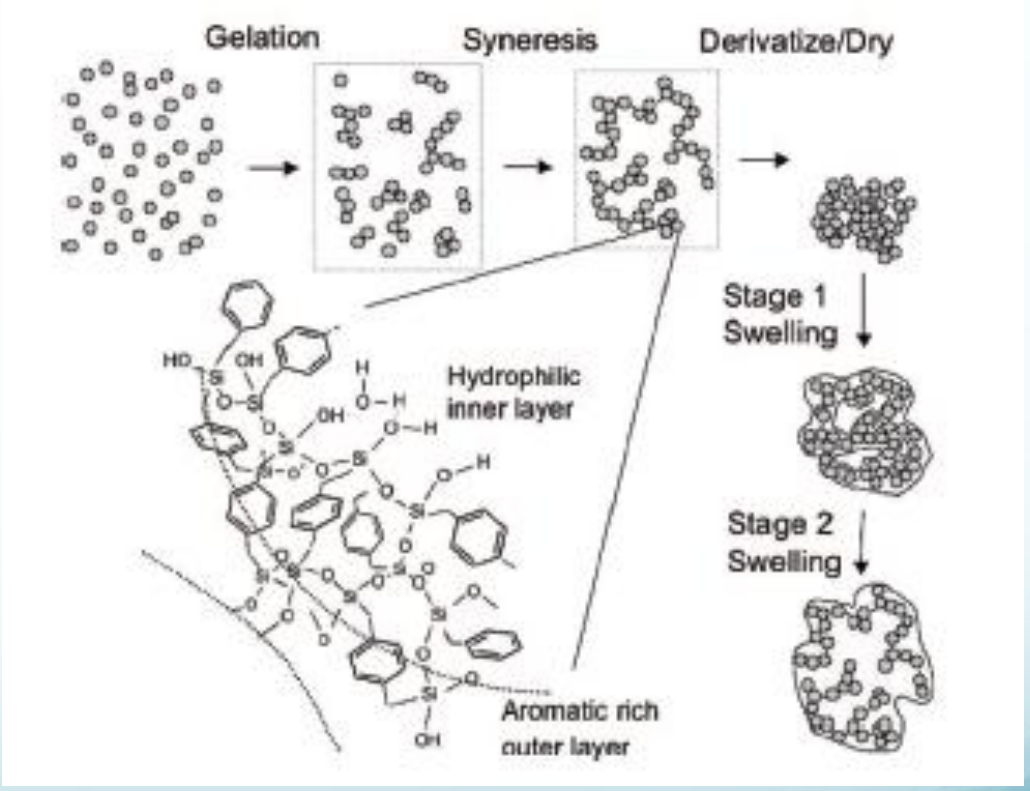
Synthesis of a Sol-Gel

Step 4: Rinse and Dry

Step 5: Grind





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Swelling Capability

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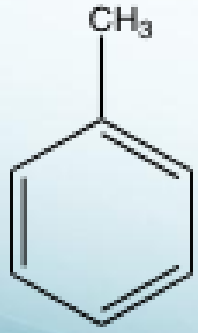
Absorption of Toluene

Concentration (ppm)	Percent extraction**	Partition coefficient***/10^3
25	99.8	285
55	98.2	21.8
100	95.9	9.4
210	96.1	9.8
320	94.4	6.7
420	91.9	4.5
530	89.6	3.4



µg TCE abs/mg SOMS
11
21
40
82
120
156
190

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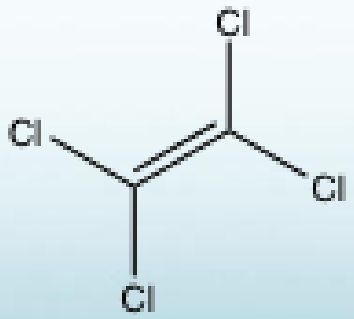
Absorption of Perchloroethylene

Concentration (ppm)	Partition coefficient/10^3	µg PCE abs/mg SOMS
1.0	4.0 ± 0.8	0.2
8.0	6.3 ± 0.8	1.7
30	21 ± 1	6.2
70	19 ± 4	13.6
145	16 ± 2	28.3



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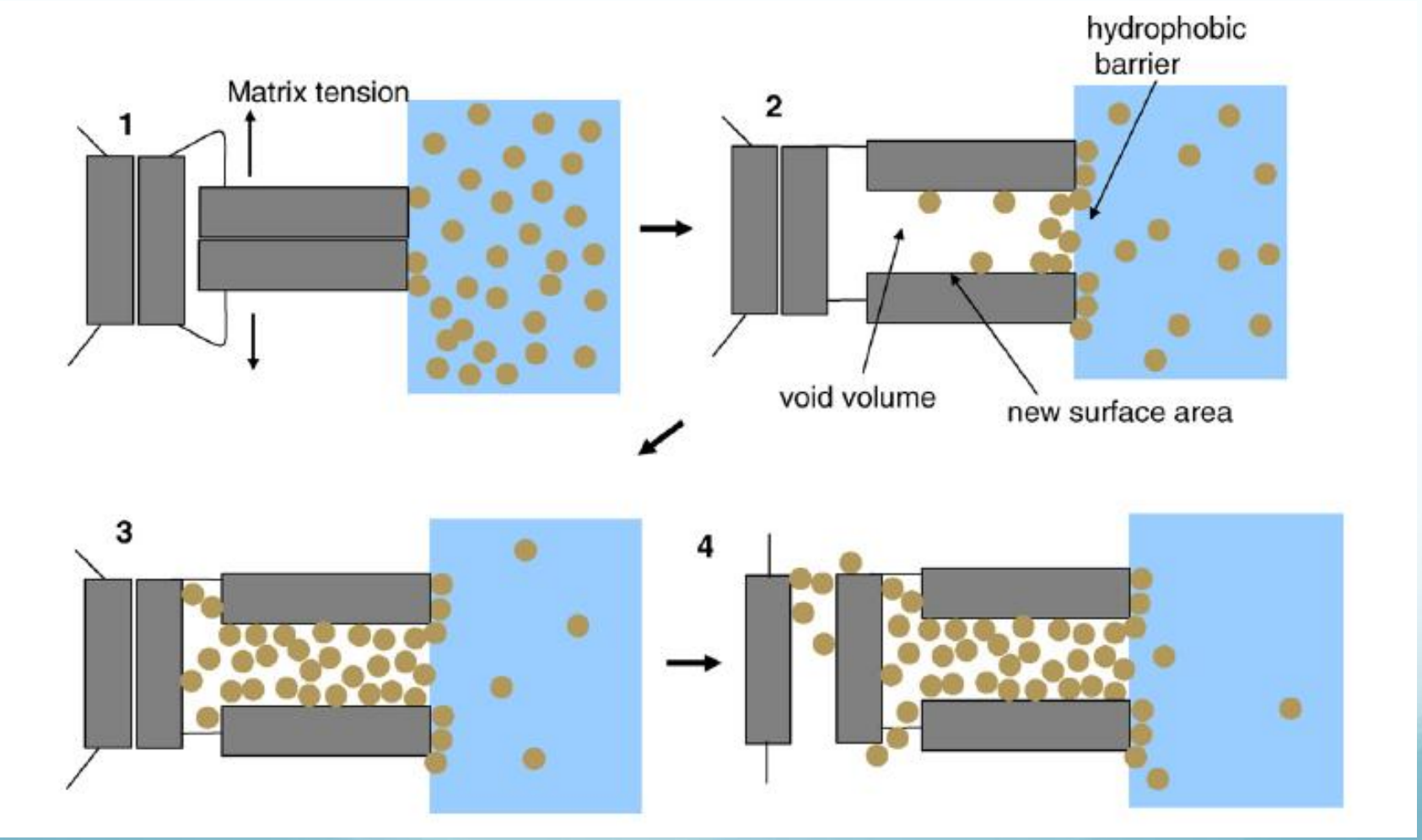
Triggered Matrix Expansion



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Absorption of Polar Organics

Absorption data for polar organics in water*.

Concentration (ppm)	Percent extraction**			
	MTBE	1-Butanol	1,4-Dioxane	Acetone
50	48	21	33	23
100	52	21	33	15
200	53		30	25
500	56	43	18	5
1000	46		24	5
2000	32	25		
10,000	33	26	33	17
20,000	38	18	49***	13***
50,000	34***	24***		

* Mass SOMS/volume solution = 0.5% (w/v). Temperature = 25 °C.

** Error < 10% ($n = 3$).

*** Visible swelling noted.

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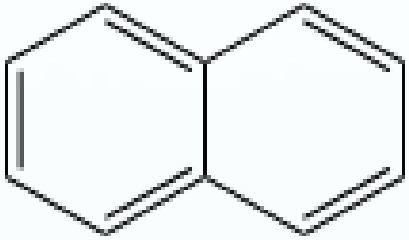
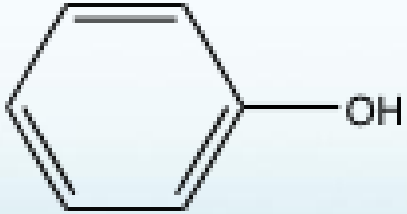
Absorption of Other Organic Species

- Naphthalene – Solid at standard state



- Phenol – exists in a deprotonated anionic form at environmental pH



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Regeneration

- Tested by heating the SOMS that had absorbed either TCE or PCE
- Results: - Swelling capacity remained consistent (3.1mL)

TCE and PCE binding affinity after thermal regeneration*.

Number of times used	Dissolved contaminant**	Regeneration temperature (°C)	Partition coefficient***/10^3
0	TCE	n/a*	1.7 ± 0.7
1	TCE	60	0.8 ± 0.2
2	TCE	60	0.9 ± 0.4
1	TCE	110	2.2 ± 0.5
2	TCE	110	1.1 ± 0.2
0	PCE	n/a	11 ± 2
2	PCE	110	9 ± 3

* Mass SOMS/volume H_2O = 0.5% (w/v). Temperature = 25 °C.

** TCE concentration = 1200 ppm; PCE concentration = 15 ppm.

*** n = 3 for all measurements.

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Absorption from Natural Waters

- Salt does not inhibit absorption
- Water/Topsoil mixture does not absorb as well as pure water mixture
- Leaves behind water, proteins, genetic material, and inorganic salts

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How is this green?

1. Waste Prevention
2. Atom Economy
3. Less Hazardous Chemical Process
4. Designing Safer Chemicals
5. Safer Solvents and Auxiliaries
6. Energy Efficiency
7. Renewable Feedstocks
8. Reduce Derivatives
9. Catalysis
10. Design for Degradation
11. Real-time Analysis for Pollution Prevention
12. Safer Chemistry for Accident Prevention

Conclusion

- SOMS are highly effective in absorbing organic species from water
- SOMS can be tailored to target specific contaminants
- Work is being done to explore more uses of Osorb

References

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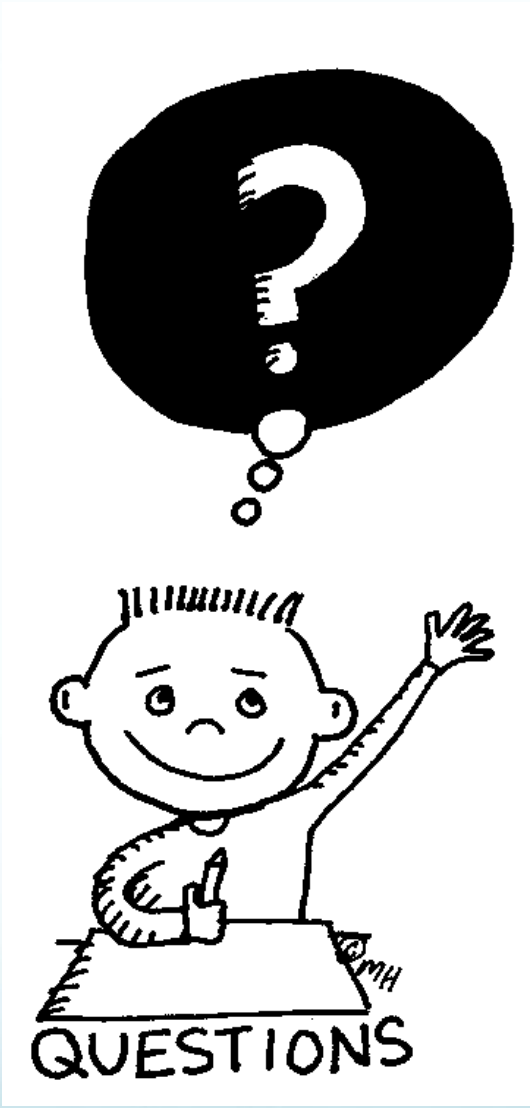
QUESTIONS