

# Right-handed Sugar Doughnuts: Nutritional Food for Undergraduates and Their Faculty

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# ENHANCING RESEARCH

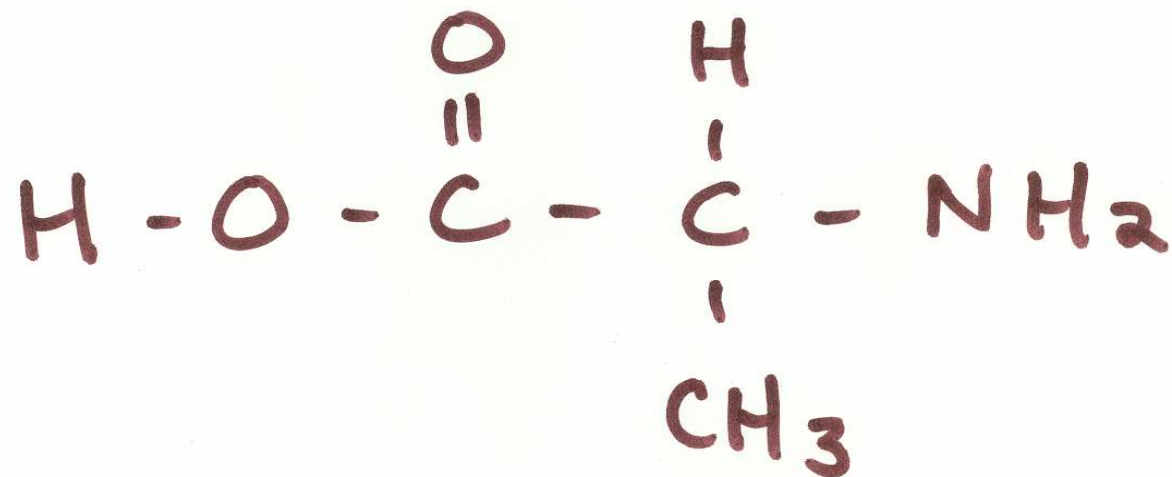
in the Chemical Sciences at Predominantly  
Undergraduate Institutions

A Report from the Undergraduate Research Summit  
Bates College, Lewiston, Maine  
August 2-4, 2003

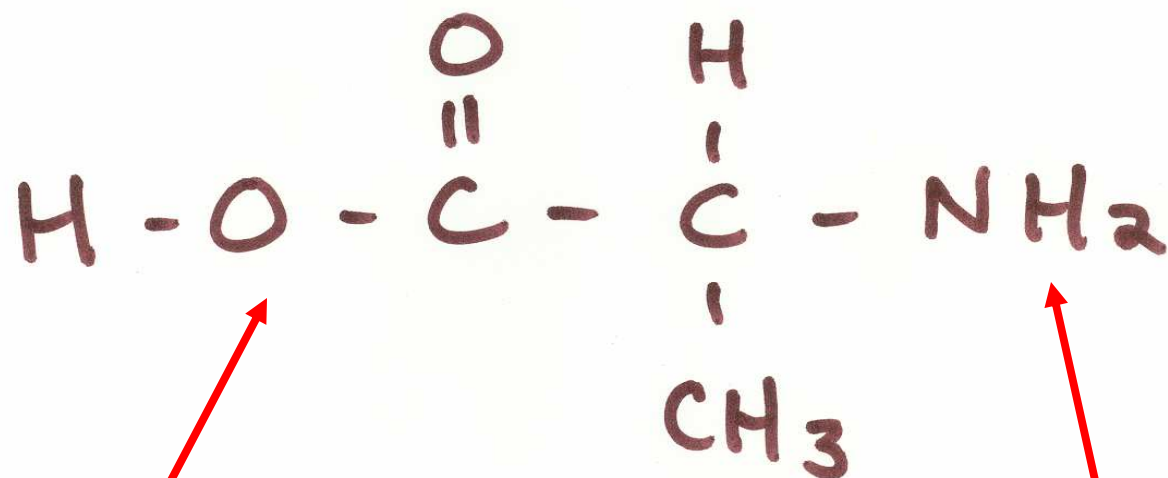
Supported by the National Science Foundation

Undergraduate research is an inquiry or investigation conducted by an undergraduate that makes an original or creative contribution to the discipline.

# Alanine







Carboxylic Acid

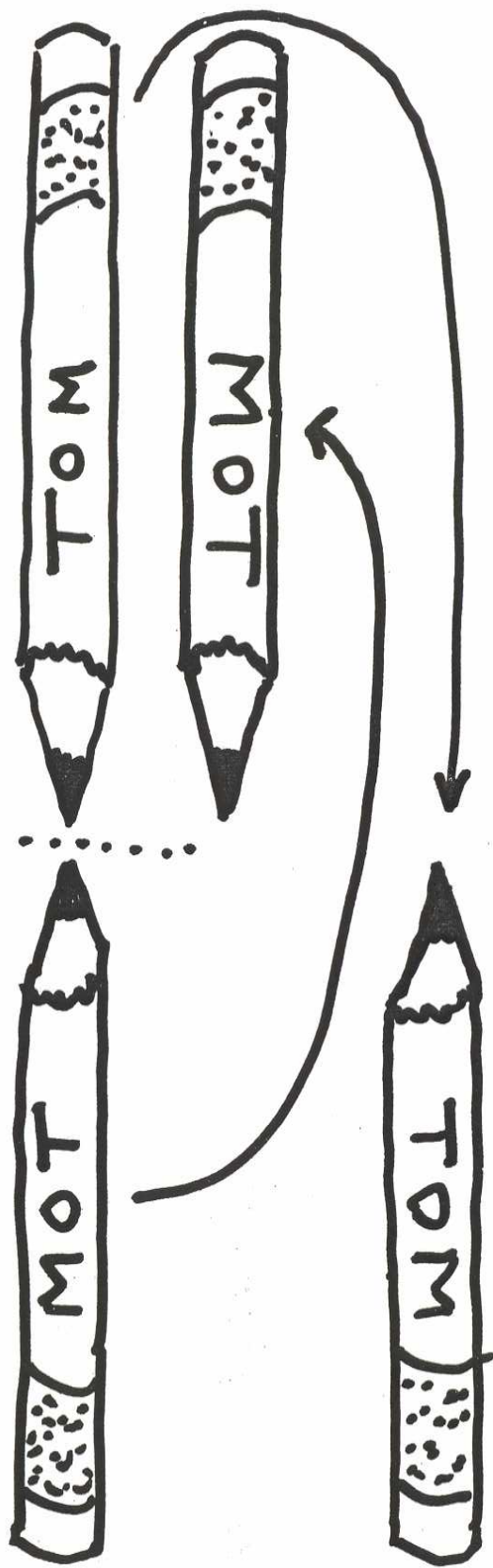
Amine

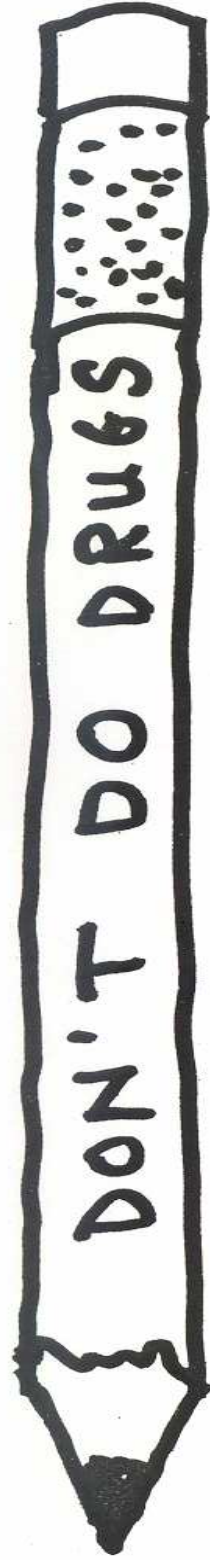
Amino Acid

# Non-superimposable mirror images

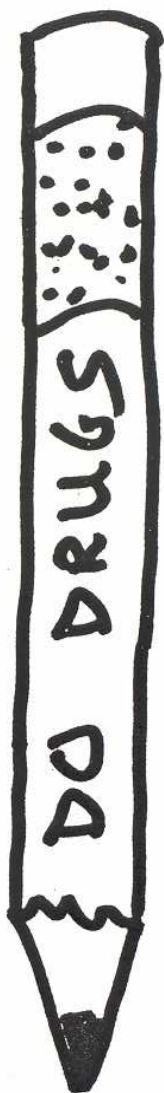
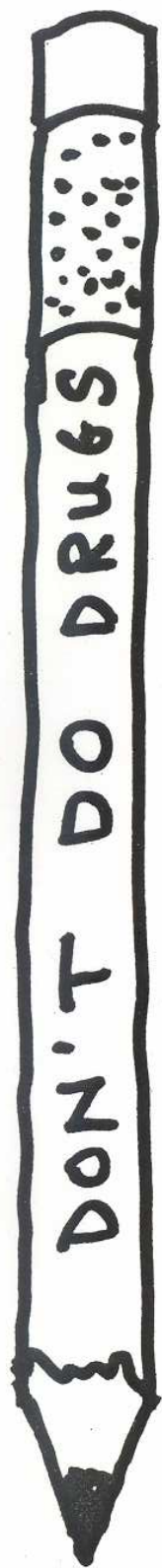
- Enantiomers
- Optical Isomers
- Chirality

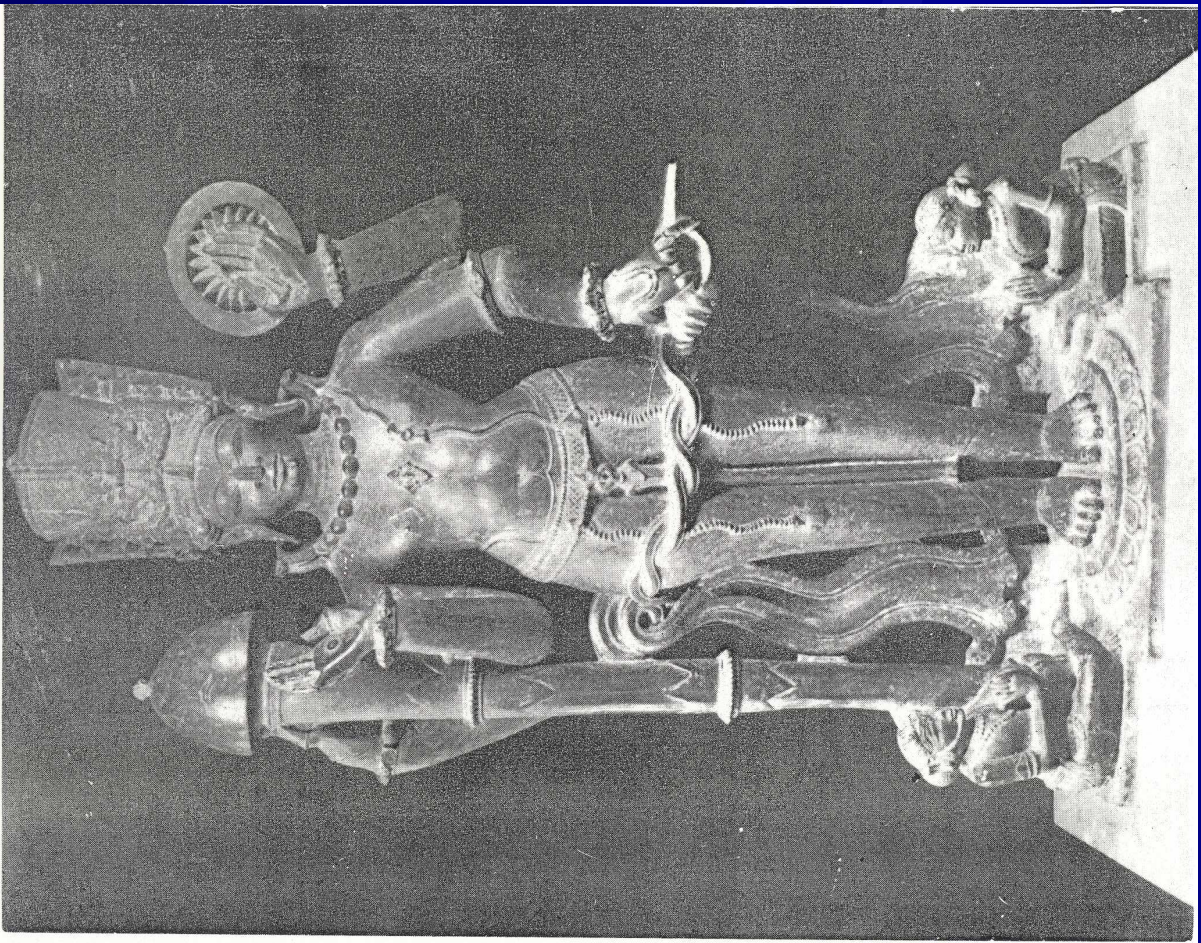
MIRROR



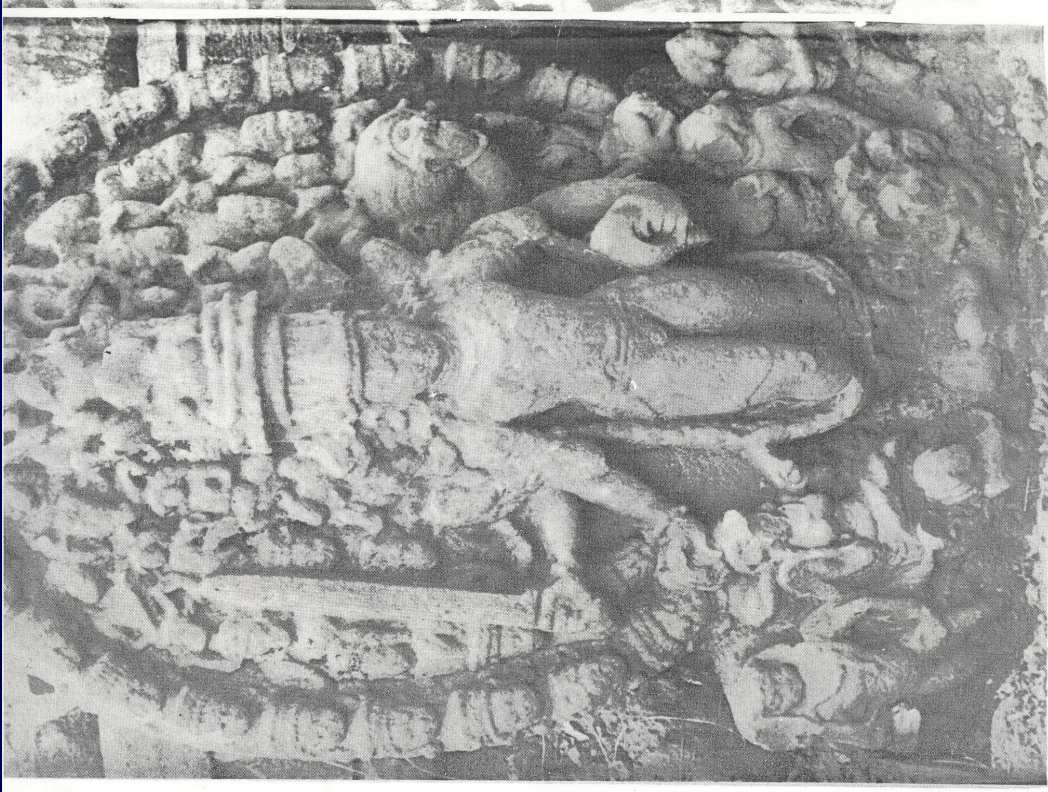












63 Post-classical Developments. The experimental image of Viṣṇu Viśvarūpa at Deogarh, U.P.  
*Courtesy: Odette Viennot*





16. (ミスロイマイ) *Euhadra peliomphala* (Purpurea)  
関東地方に最も普通なるカマムリで、色帯が完全に現われるとミ  
スロイとなるが加齢型もある。次のような色彩も山地帯では現わ  
れ、山地の黒色の夾のような色彩の美しい個体をミサマイマイ 或  
*A. melanota* (Clausen) という、個上にすむ。

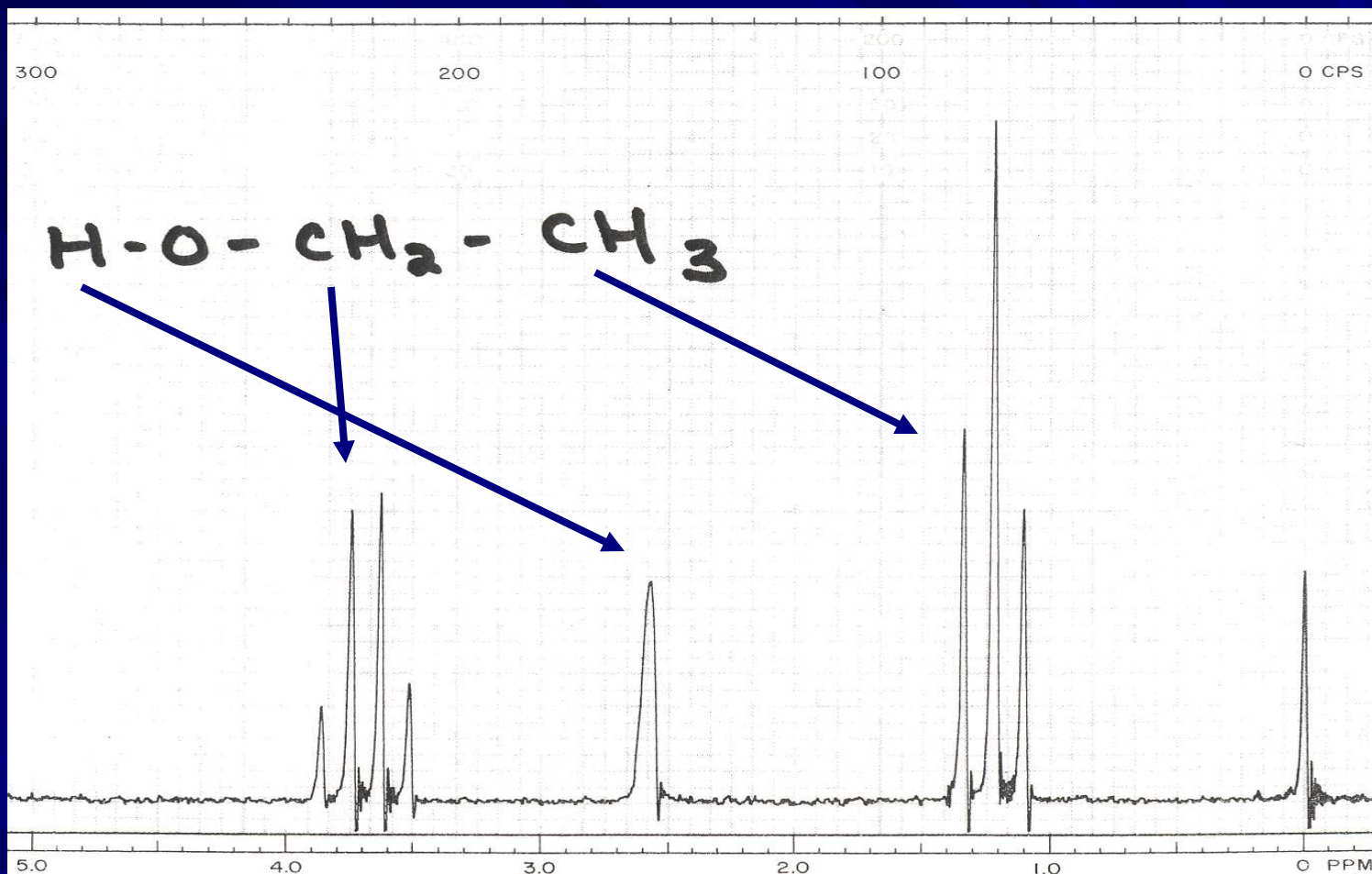


# Random Bit of Chemical Trivia

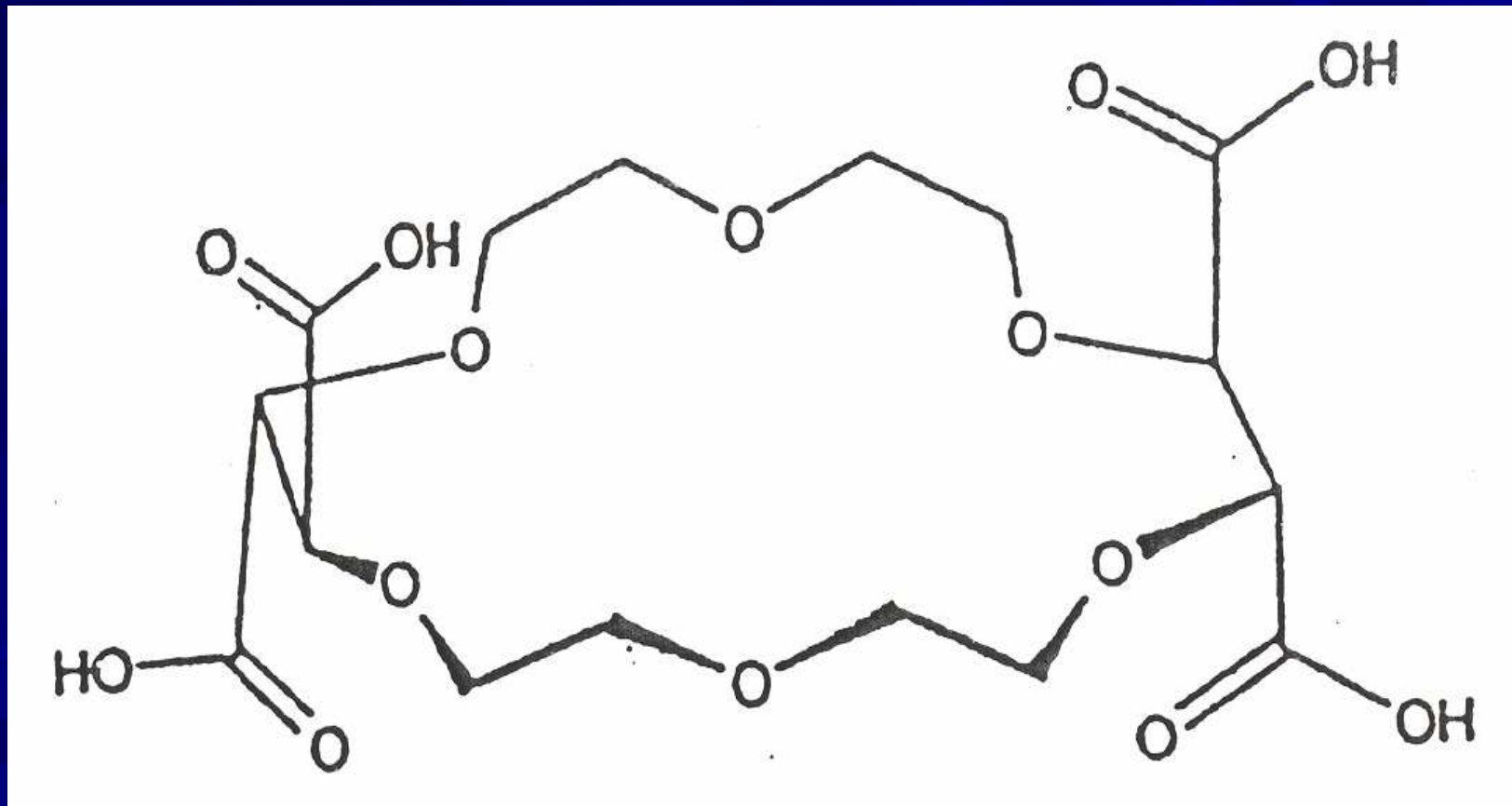
$$\text{Organic} = (\text{RBCT})^n$$

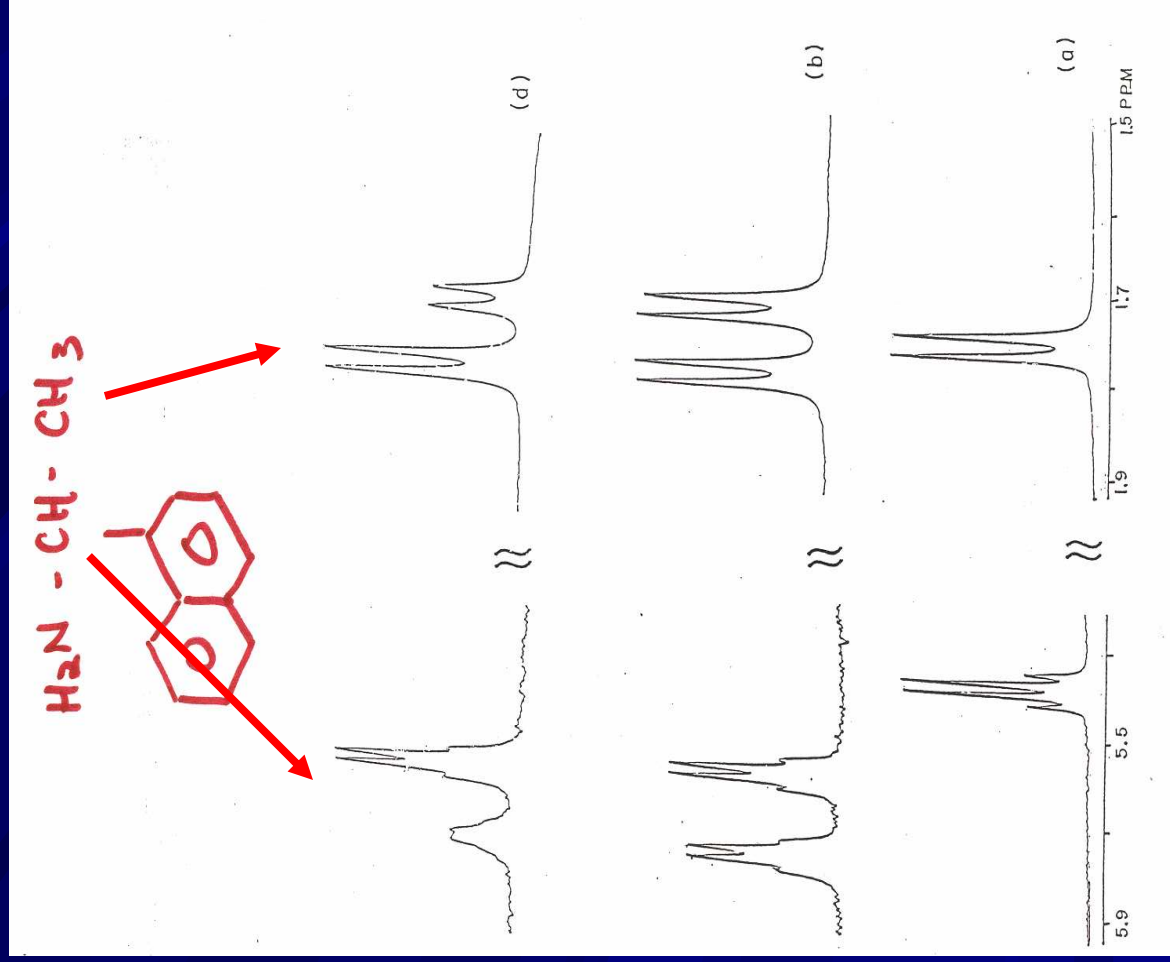
Where n is a very large number

# Ethanol



# Crown Ether

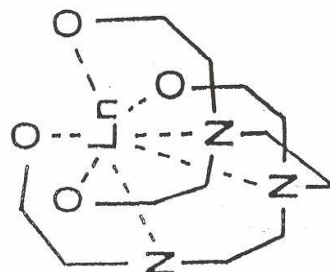
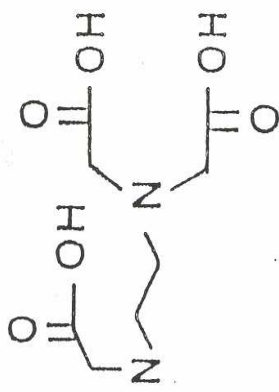




# $\beta$ -Cyclodextrin





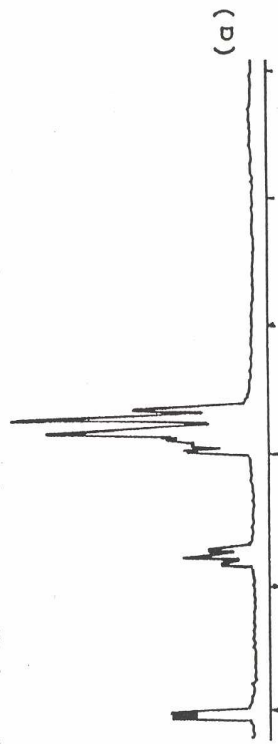
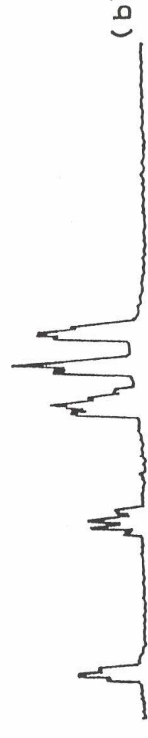
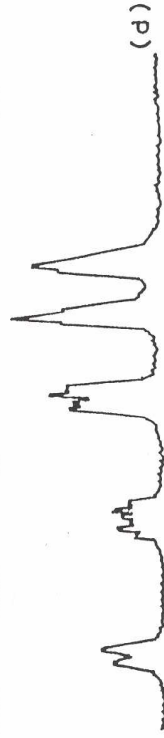
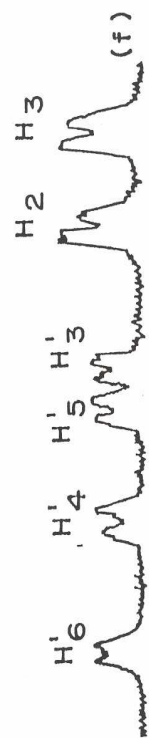
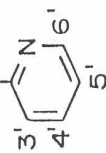
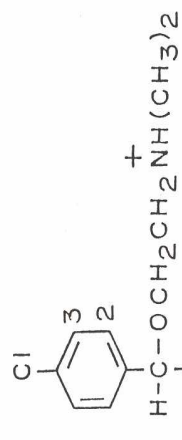


# PERIODIC CHART OF THE ELEMENTS

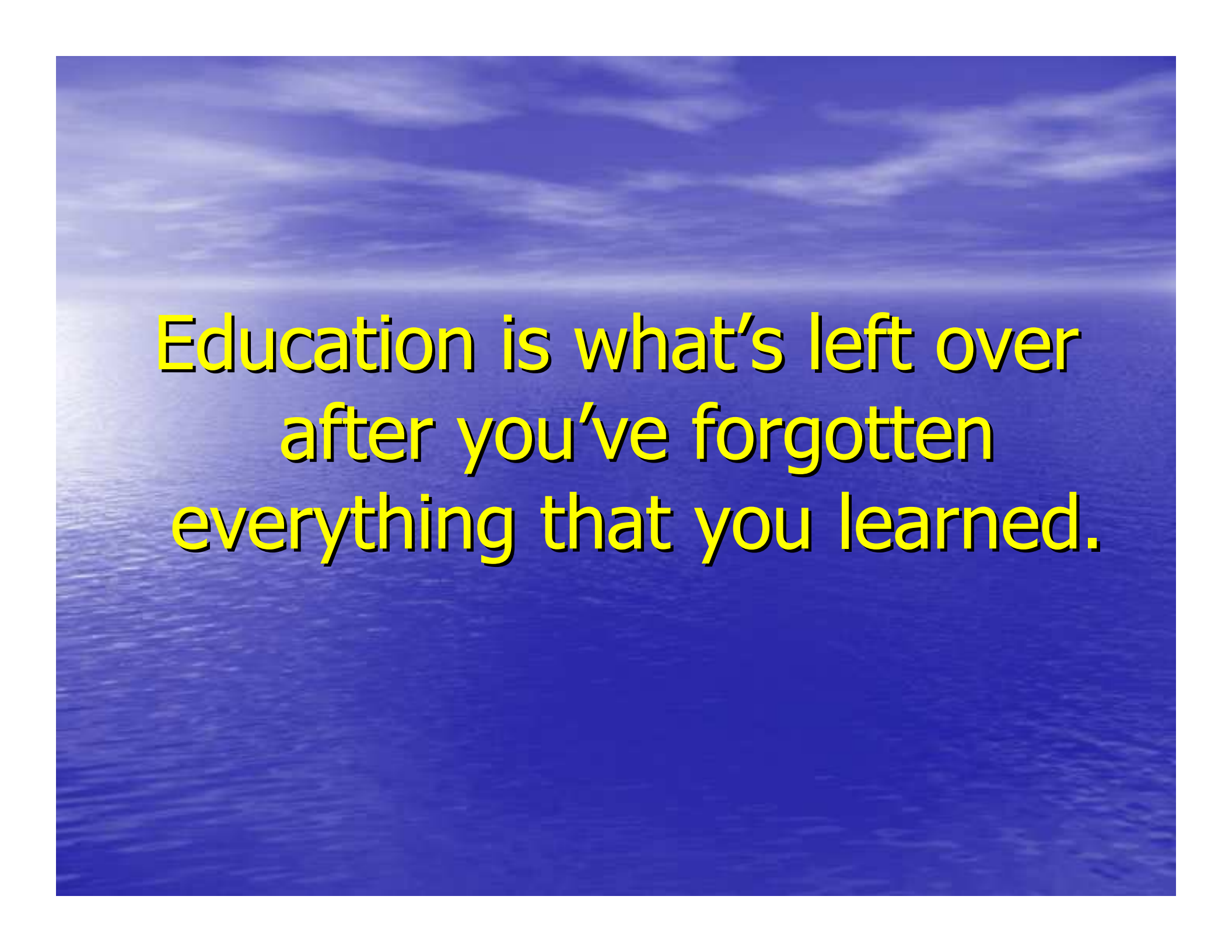
PERIODIC CHART OF THE ELEMENTS																		INERT GASES	
IA	IIA	IIIB	IVB	VB	VIB	VII B	VIII	IB	IIB	IIIA	IVA	VA	VIA	VIIA					
1 <b>H</b> 1.00797 ± 0.00001														1 <b>H</b> 1.00797 ± 0.00001	2 <b>He</b> 4.0026 ± 0.00005				
3 <b>Li</b> 6.939 ± 0.0005	4 <b>Be</b> 9.0122 ± 0.00005									5 <b>B</b> 10.811 ± 0.003	6 <b>C</b> 12.0115 ± 0.00005	7 <b>N</b> 14.0067 ± 0.00005	8 <b>O</b> 15.9994 ± 0.0001	9 <b>F</b> 18.9984 ± 0.00005	10 <b>Ne</b> 20.183 ± 0.0005				
11 <b>Na</b> 22.9898 ± 0.0005	12 <b>Mg</b> 24.312 ± 0.0005									13 <b>Al</b> 26.9815 ± 0.00005	14 <b>Si</b> 28.086 ± 0.001	15 <b>P</b> 30.9738 ± 0.00005	16 <b>S</b> 32.064 ± 0.003	17 <b>Cl</b> 35.453 ± 0.001	18 <b>Ar</b> 39.948 ± 0.0005				
19 <b>K</b> 39.102 ± 0.0005	20 <b>Ca</b> 40.08 ± 0.005	21 <b>Sc</b> 44.956 ± 0.0005	22 <b>Ti</b> 47.90 ± 0.005	23 <b>V</b> 50.942 ± 0.0005	24 <b>Cr</b> 51.996 ± 0.001	25 <b>Mn</b> 54.9380 ± 0.00005	26 <b>Fe</b> 55.847 ± 0.003	27 <b>Co</b> 58.9332 ± 0.00005	28 <b>Ni</b> 58.71 ± 0.005	29 <b>Cu</b> 63.54 ± 0.005	30 <b>Zn</b> 65.37 ± 0.005	31 <b>Ga</b> 69.72 ± 0.005	32 <b>Ge</b> 72.59 ± 0.005	33 <b>As</b> 74.9216 ± 0.00005	34 <b>Se</b> 78.96 ± 0.005	35 <b>Br</b> 79.909 ± 0.002	36 <b>Kr</b> 83.80 ± 0.005		
37 <b>Rb</b> 85.47 ± 0.005	38 <b>Sr</b> 87.62 ± 0.005	39 <b>Y</b> 88.905 ± 0.0005	40 <b>Zr</b> 91.22 ± 0.005	41 <b>Nb</b> 92.906 ± 0.0005	42 <b>Mo</b> 95.94 ± 0.005	43 <b>Tc</b> (99)	44 <b>Ru</b> 101.07 ± 0.005	45 <b>Rh</b> 102.905 ± 0.0005	46 <b>Pd</b> 106.4 ± 0.05	47 <b>Ag</b> 107.870 ± 0.003	48 <b>Cd</b> 112.40 ± 0.005	49 <b>In</b> 114.82 ± 0.005	50 <b>Sn</b> 118.69 ± 0.005	51 <b>Sb</b> 121.75 ± 0.005	52 <b>Te</b> 127.60 ± 0.005	53 <b>I</b> 126.9044 ± 0.00005	54 <b>Xe</b> 131.30 ± 0.005		
55 <b>Cs</b> 132.905 ± 0.0005	56 <b>Ba</b> 137.34 ± 0.005	57 <b>*La</b> 138.91 ± 0.005	72 <b>Hf</b> 178.49 ± 0.005	73 <b>Ta</b> 180.948 ± 0.0005	74 <b>W</b> 183.85 ± 0.005	75 <b>Re</b> 186.2 ± 0.05	76 <b>Os</b> 190.2 ± 0.05	77 <b>Ir</b> 192.2 ± 0.05	78 <b>Pt</b> 195.09 ± 0.005	79 <b>Au</b> 196.967 ± 0.0005	80 <b>Hg</b> 200.59 ± 0.005	81 <b>Tl</b> 204.37 ± 0.005	82 <b>Pb</b> 207.19 ± 0.005	83 <b>Bi</b> 208.980 ± 0.0005	84 <b>Po</b> (210)	85 <b>At</b> (210)	86 <b>Rn</b> (222)		
87 <b>Fr</b> (223)	88 <b>Ra</b> (226)	89 <b>*Ac</b> (227)	<b>*Lanthanum Series</b>																
			58 <b>Ce</b> 140.12 ± 0.005	59 <b>Pr</b> 140.907 ± 0.00005	60 <b>Nd</b> 144.24 ± 0.005	61 <b>Pm</b> (147)	62 <b>Sm</b> 150.35 ± 0.005	63 <b>Eu</b> 151.96 ± 0.005	64 <b>Gd</b> 157.25 ± 0.005	65 <b>Tb</b> 158.924 ± 0.00005	66 <b>Dy</b> 162.50 ± 0.005	67 <b>Ho</b> 164.930 ± 0.00005	68 <b>Er</b> 167.26 ± 0.005	69 <b>Tm</b> 168.934 ± 0.00005	70 <b>Yb</b> 173.04 ± 0.005	71 <b>Lu</b> 174.97 ± 0.005			
			<b>*Actinium Series</b>																
			90 <b>Th</b> 232.038 ± 0.00005	91 <b>Pa</b> (231)	92 <b>U</b> 238.03 ± 0.005	93 <b>Np</b> (237)	94 <b>Pu</b> (242)	95 <b>Am</b> (243)	96 <b>Cm</b> (247)	97 <b>Bk</b> (247)	98 <b>Cf</b> (249)	99 <b>Es</b> (254)	100 <b>Fm</b> (253)	101 <b>Md</b> (256)	102 <b>No</b> (253)	103 <b>Lr</b> (257)			
( ) Numbers in parentheses are mass numbers of most stable or most common isotope.																			
Atomic weights corrected to conform to the 1961																			

( ) Numbers in parentheses are mass numbers of most stable or most common isotope.  
Atomic weights corrected to conform to the 1961 values of the Commission on Atomic Weights.

## Lanthanides



8.0 7.0 6.0 ppm

The background of the slide is a photograph of a blue sky with wispy white clouds, transitioning into a blue ocean with gentle ripples. The text is centered in the upper half of the image.

Education is what's left over  
after you've forgotten  
everything that you learned.



## Traditional Science Courses

*Knowledge outcomes* – “..particular areas of disciplinary or professional content that students can recall, relate, and appropriately deploy.”

## Research Experience

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## Traditional Science Courses

*Skills outcomes* – “the learned capacity to do something – for example, think critically, communicate effectively, productively collaborate, or **perform particular technical procedures** – as either an end in itself or as a prerequisite for further development

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## Traditional Science Courses

Affective Outcomes – “..usually involve changes in beliefs or in the development of particular values, for example, empathy, ethical behavior, self respect, or respect for others.”

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## Traditional Science Courses

Learned abilities – “..typically involve the integration of knowledge, skills, and attitudes in complex ways that require multiple elements of learning. Examples embrace leadership, teamwork, effective problem-solving, and reflective practice”

## Research Experience

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From:

Ewell, P.T., *Accreditation and Student Learning Outcomes: A Proposed Point of Departure*, Council for Higher Education Accreditation (CHEA) Occasional Paper, Washington, DC, September 2001

# Analytical Chemistry Course

- Analysis of benzene and toluene in air
- Analysis of trihalomethanes in drinking water
- Amino acid content of foods (popcorn and beer)
- Caffeine, theophylline, and theobromine levels in chocolate
- Analysis of nitrate and nitrite in hot dogs
- PAHs in burgers, oysters, diesel exhaust and wood smoke
- Toxic metals in sludges from waste-water treatment plants



# Cooperative Learning

- Class divided into small groups (3-5)
- Presented with a problem or question
  - I serve as a facilitator
  - If one student sees the point, she or he is to explain it to the others
  - When the groups appreciate the point, I call timeout and highlight the concept

# Advantages of Cooperative Learning

- More “teacher” resources because the students are teachers as well
- Less formal
- Active learning – I know what they do/don’t understand – they know what they do/don’t understand
- Students spend more time on class material
- Cooperation, not competition
- Students learn more

# Outcomes of Cooperative Learning from Prior Research Studies

- Statistically significant improvements in academic achievement
- Better reasoning and critical thinking skills
- Proposed more new ideas when presented with problems
- Transferred more of what was learned in prior situations to new problems
- Reduced levels of stress



- Promotes more positive attitudes toward subject and instructional experience – faculty get to know students better
- Decreased absenteeism
- Improved student commitment
- Greater motivation toward learning
- Better student retention (especially for women and minorities)
  - Socially involved
  - Academically involved



# Introductory Course

- Thematic version of general chemistry – fundamentals of chemistry related to the study of the environment
- Counts for the chemistry major
- Pre-requisite for all upper-level chemistry courses
- 60 students in class (20/lab)

# Course Goals

- Learn fundamental concepts of chemistry
- Learn that science does not know all the answers
- Participate in and learn about the process through which scientists undertake investigations and create knowledge
- Learn in interaction with, rather than in isolation from, other students
- Appreciate that science occurs in a social context

# Laboratory Project

- Do plants grown in soil contaminated with lead take up more lead?
- Does the uptake of lead vary with the acidity of the rain water?



# Some questions the students need to answer:

- What to grow?
- What soil to use?
- How to mimic acid rain?
- How much lead to add?
- What watering schedule?
- What to use as a control?



# Some advantages of the project:

- Conduct a real investigation
- Ask/answer questions
- Design experiments
- Unanticipated problems
- Teamwork
- Communication – Informal/formal
- Opportunity for leadership

# Uncertainty

- 26 of 29 contaminated samples had higher lead  
-other three?
- Acidity trend is inconclusive

# Summary Comments

- We need to design an undergraduate curriculum in which students begin scholarly-like activities in their first year and progress through to an original project by their senior year
- We need to encourage cooperation and collaboration among our students







