Development of Contextual E-Learning Modules for Analytical Chemistry

Thomas Wenzel and Cynthia Larive

6/28/2011

Global Society: Suppose We Set Out to Understand The World

- They work hard, these people. They roll up incredible mileages on their odometers, rack up state after state in two-week transcontinental motor marathons, knock off one national park after another, take millions of square yards of photographs …, Edward Abbey, *Desert Solitaire*
- *If It's Tuesday, This Must Be Belgium*
- Trophy Hunter – Aldo Leopold, *Sand County Almanac*

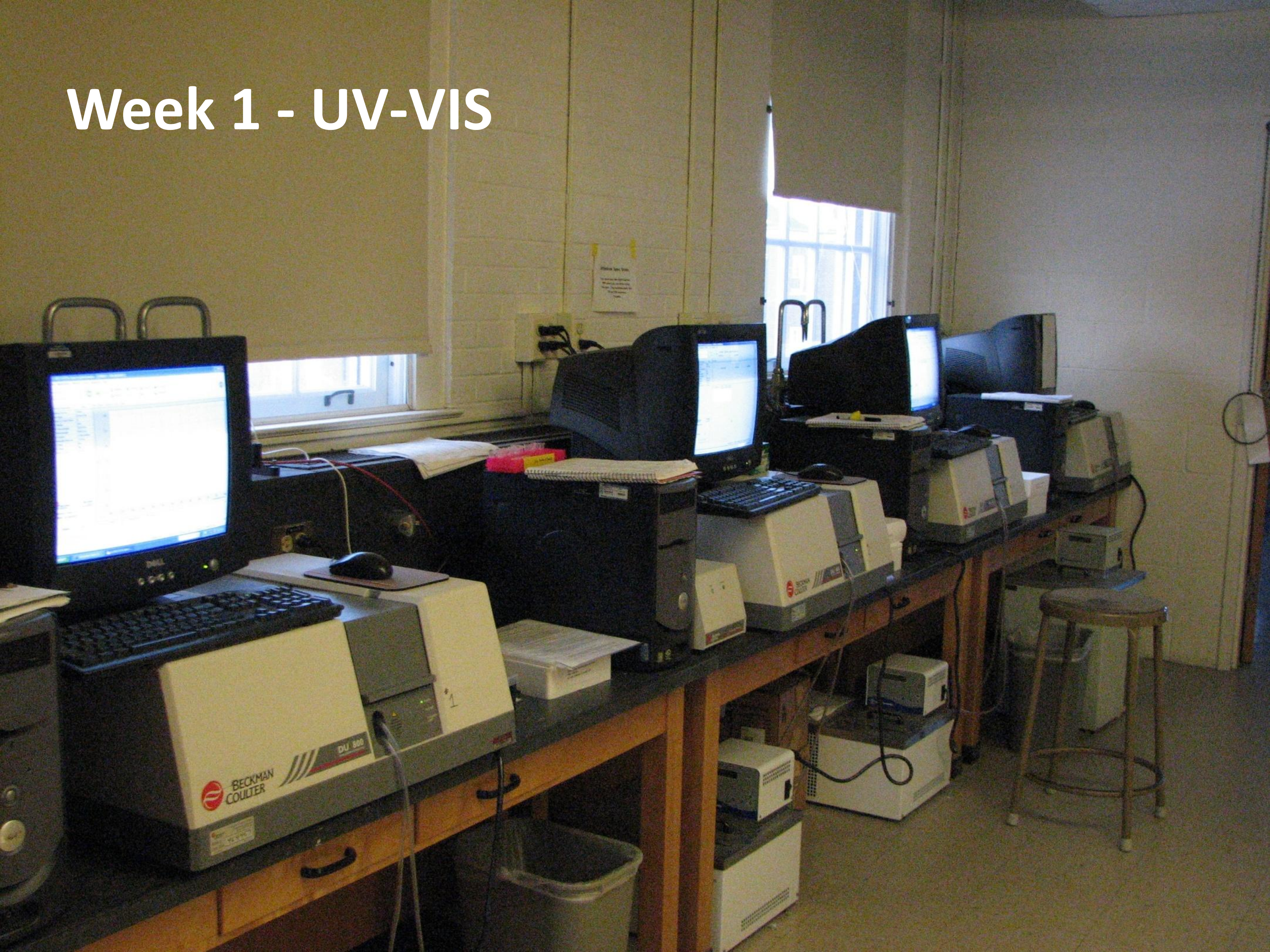
I think we would agree that this provides a superficial understanding of the world

Suppose We Set Out to Understand Analytical Chemistry

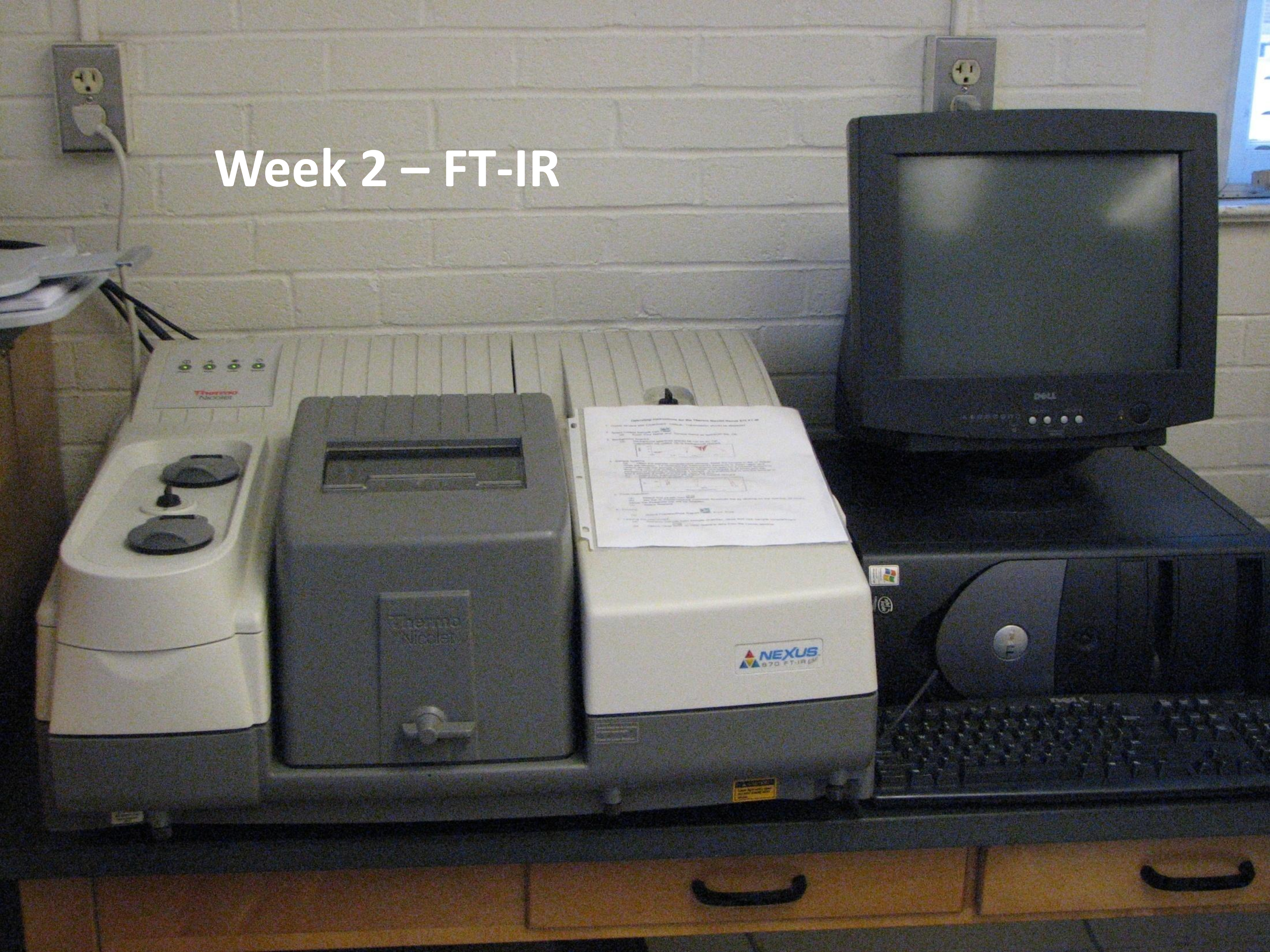
Where would we be most likely to develop this understanding?

- Lecture (classroom)?
- Laboratory?

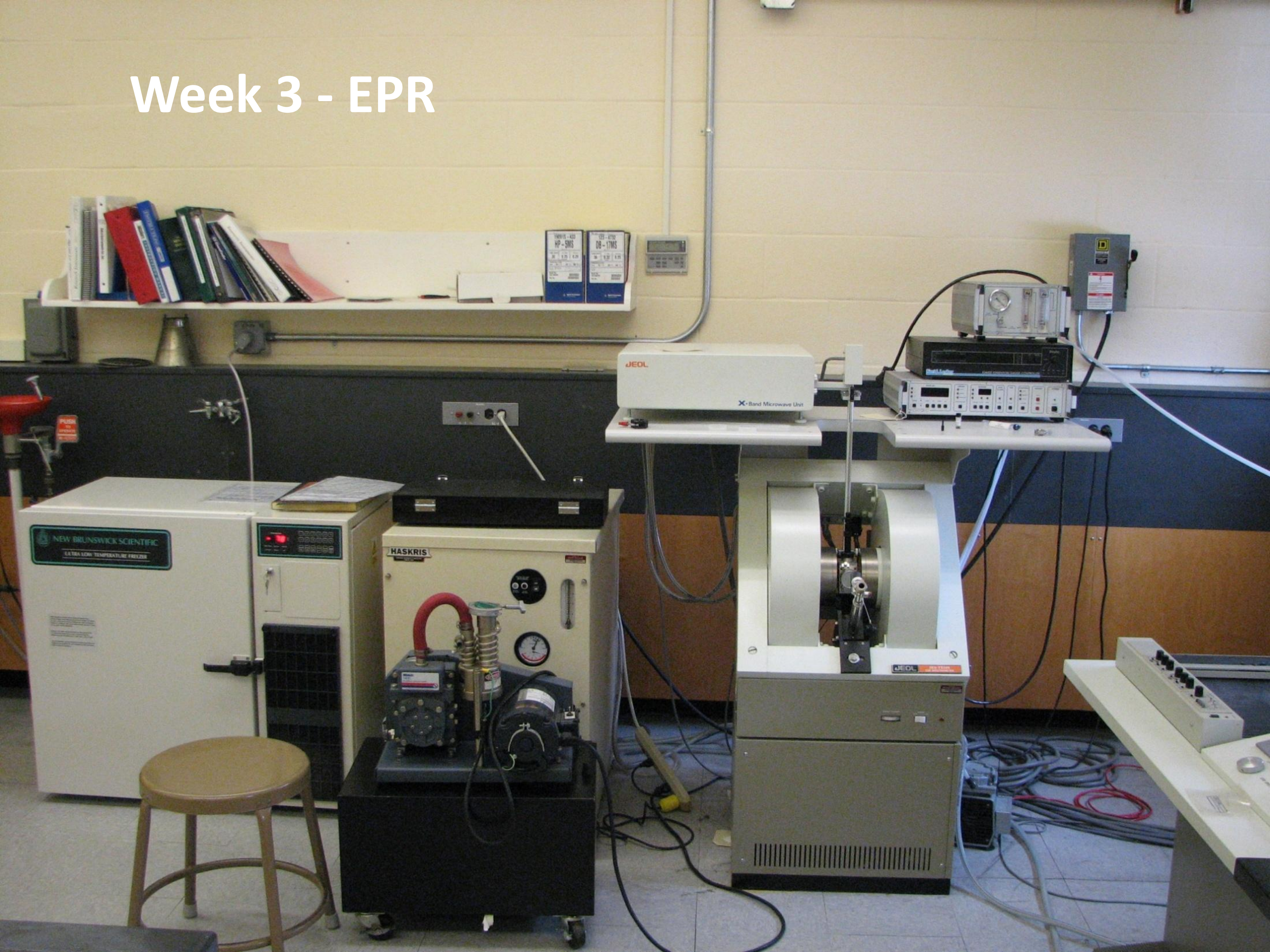
Week 1 - UV-VIS



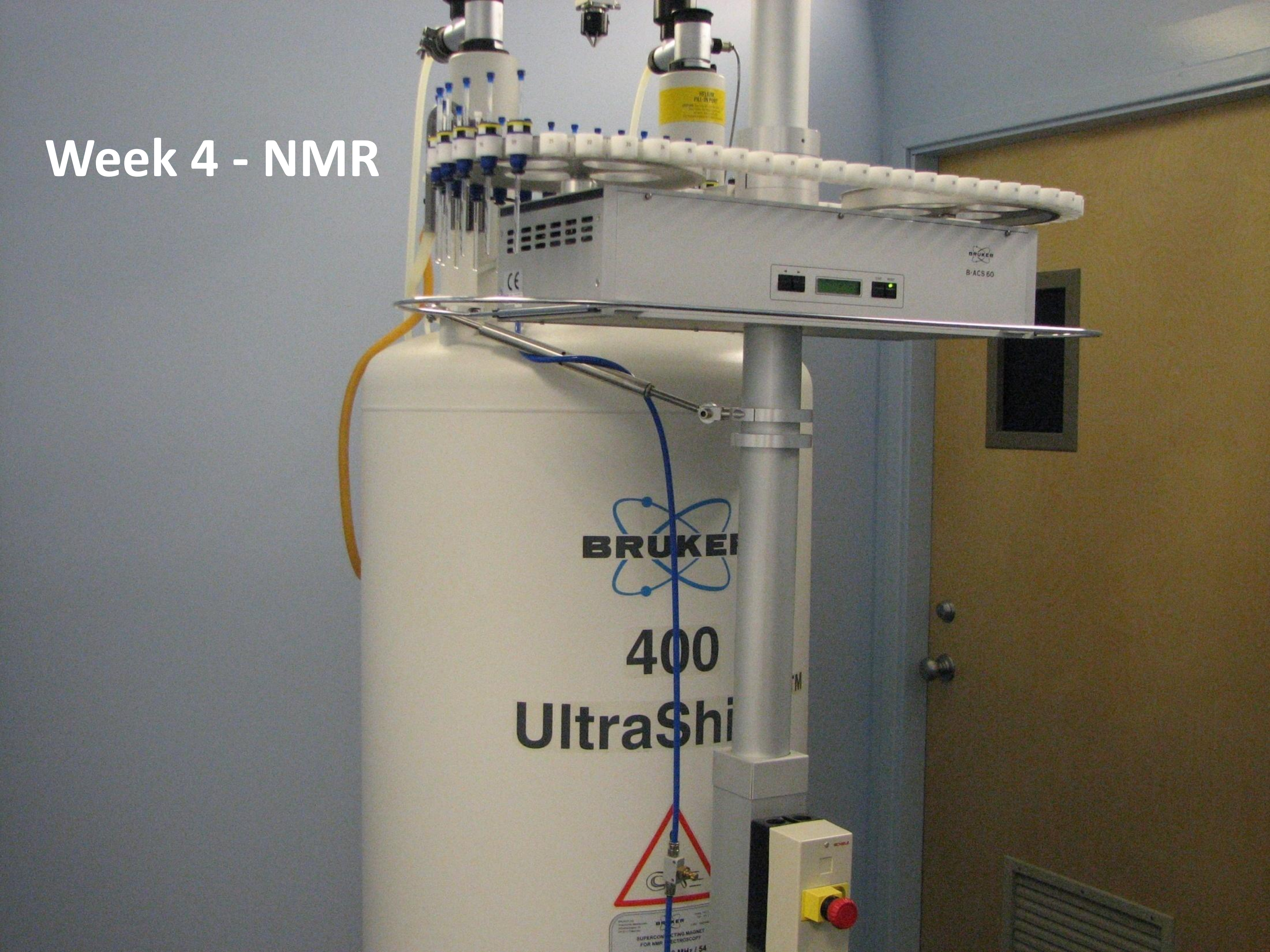
Week 2 – FT-IR



Week 3 - EPR

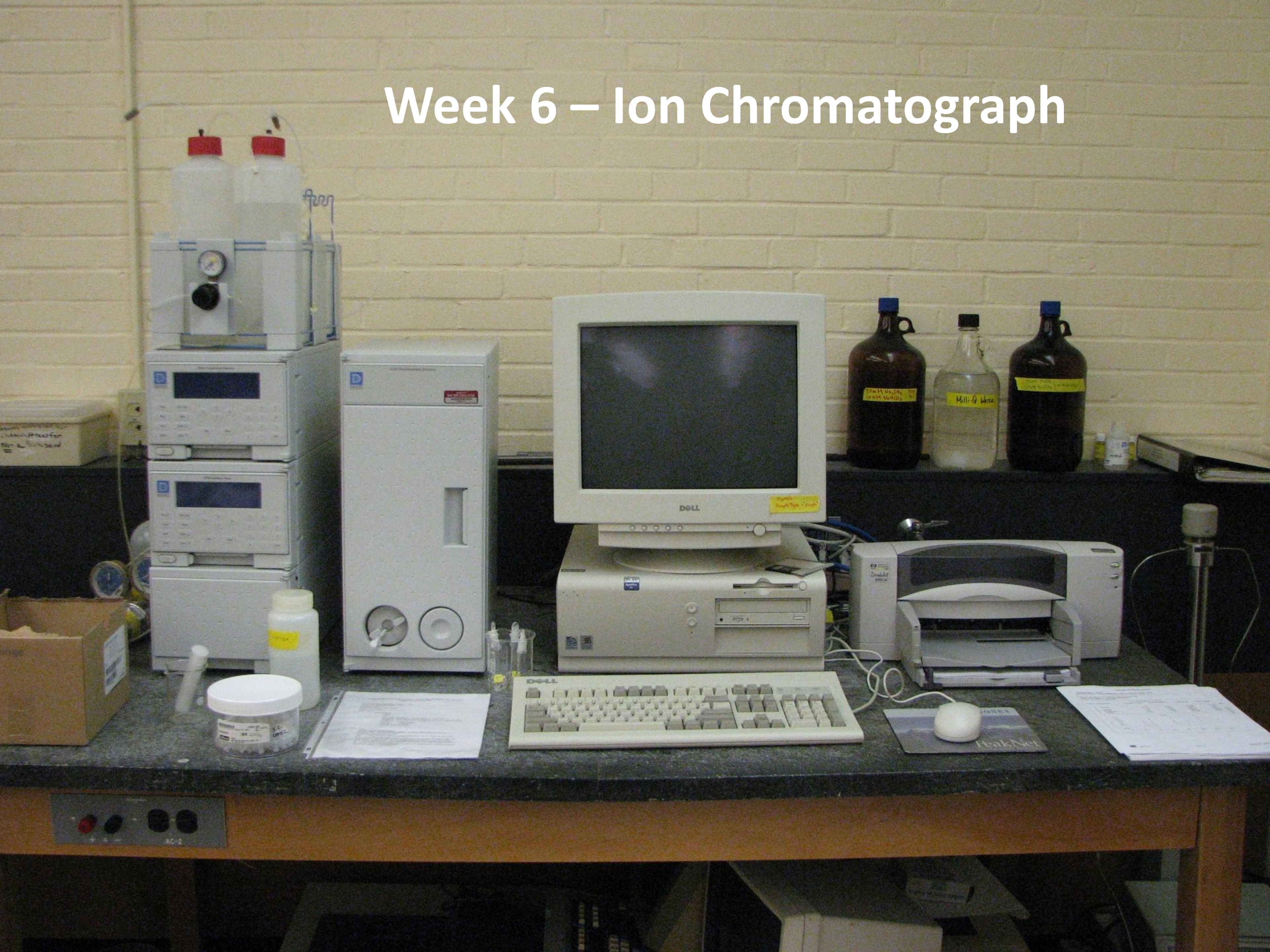

JEOL
X-Band Microwave Unit
NEW BRUNSWICK SCIENTIFIC
ULTRA LOW TEMPERATURE FREEZER
HASKRIS
JEOL

Week 4 - NMR

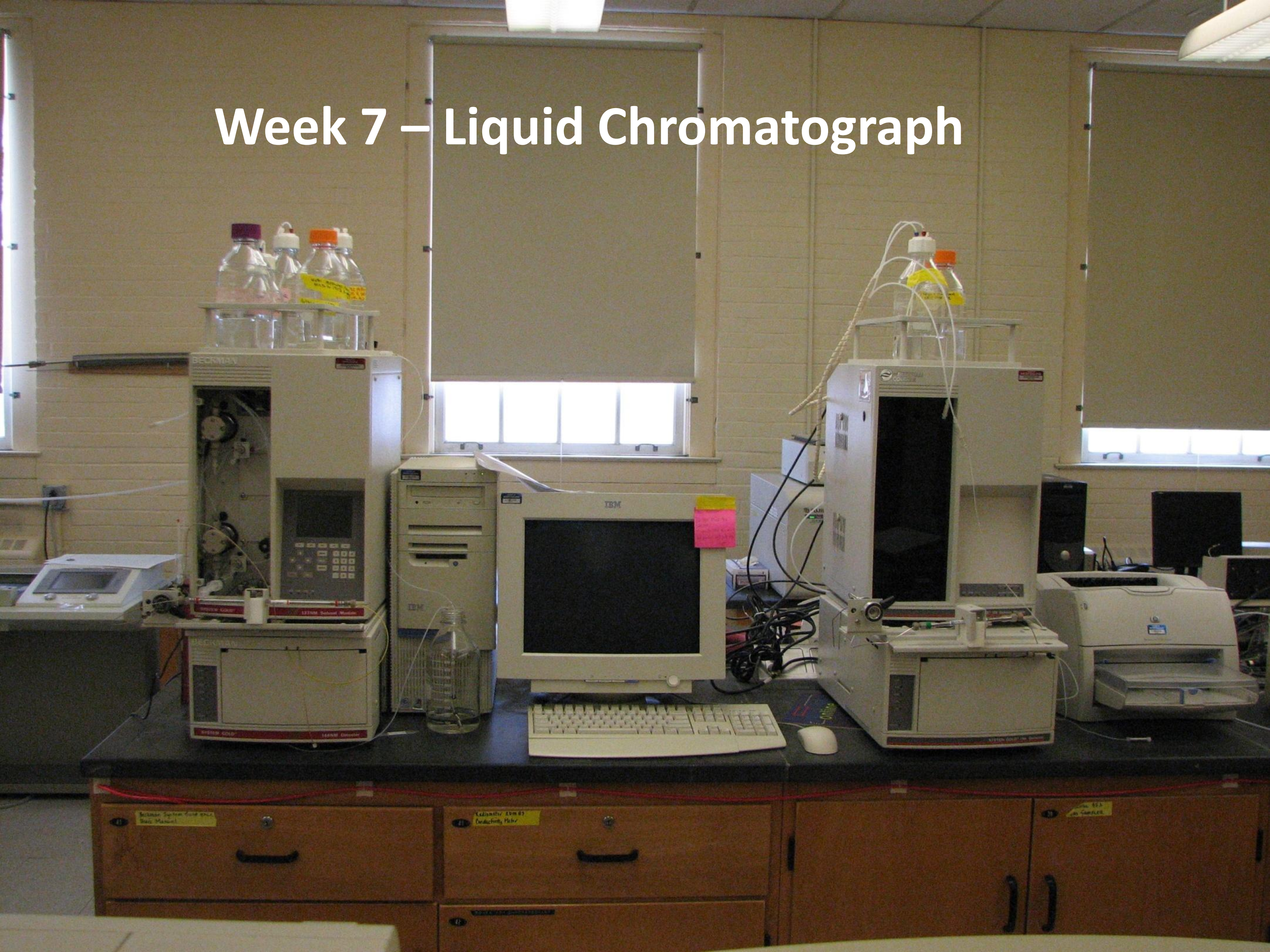


Week 5 – Gel Electrophoresis/Phospho-imager

Week 6 – Ion Chromatograph

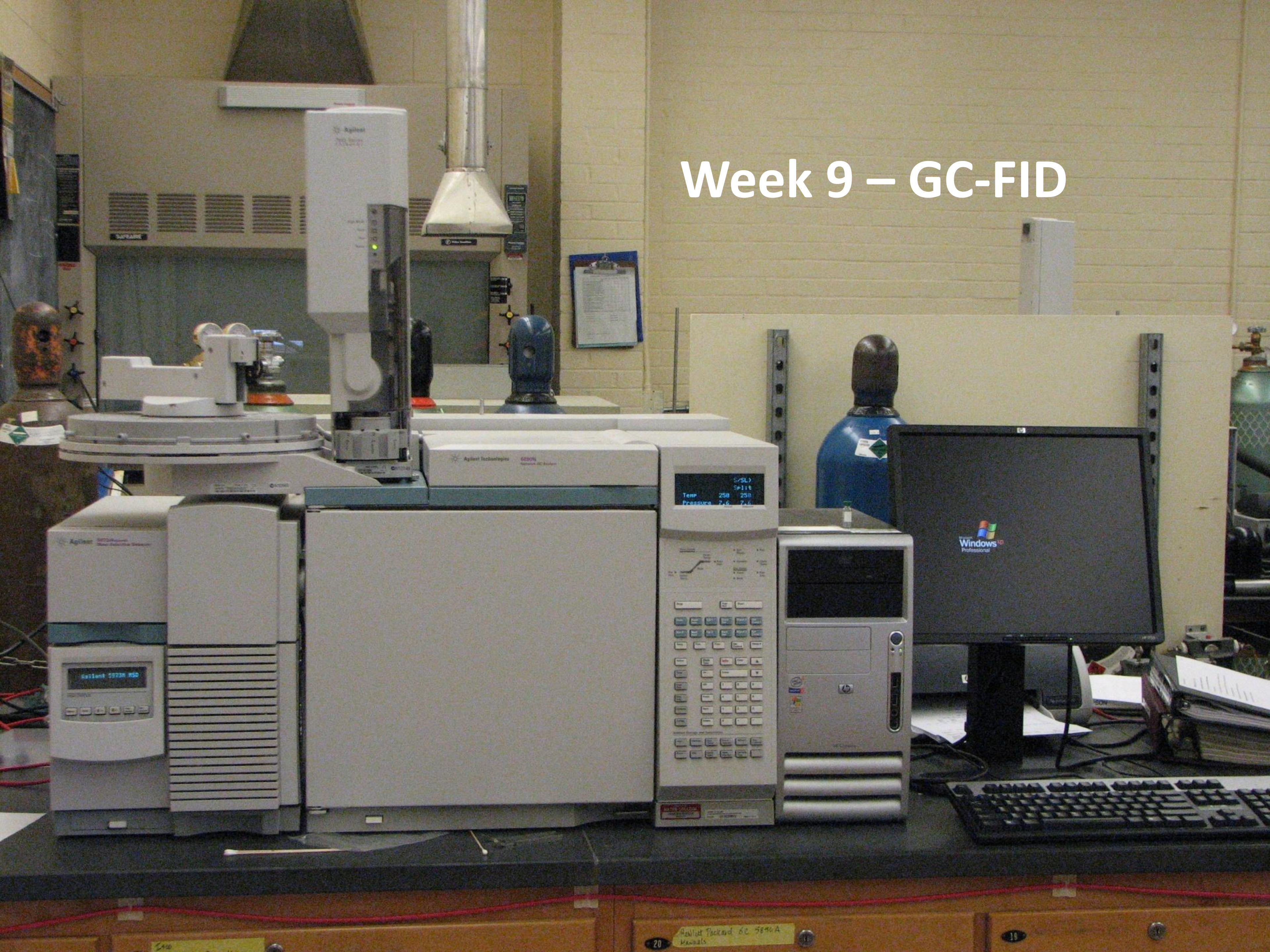


Week 7 – Liquid Chromatograph

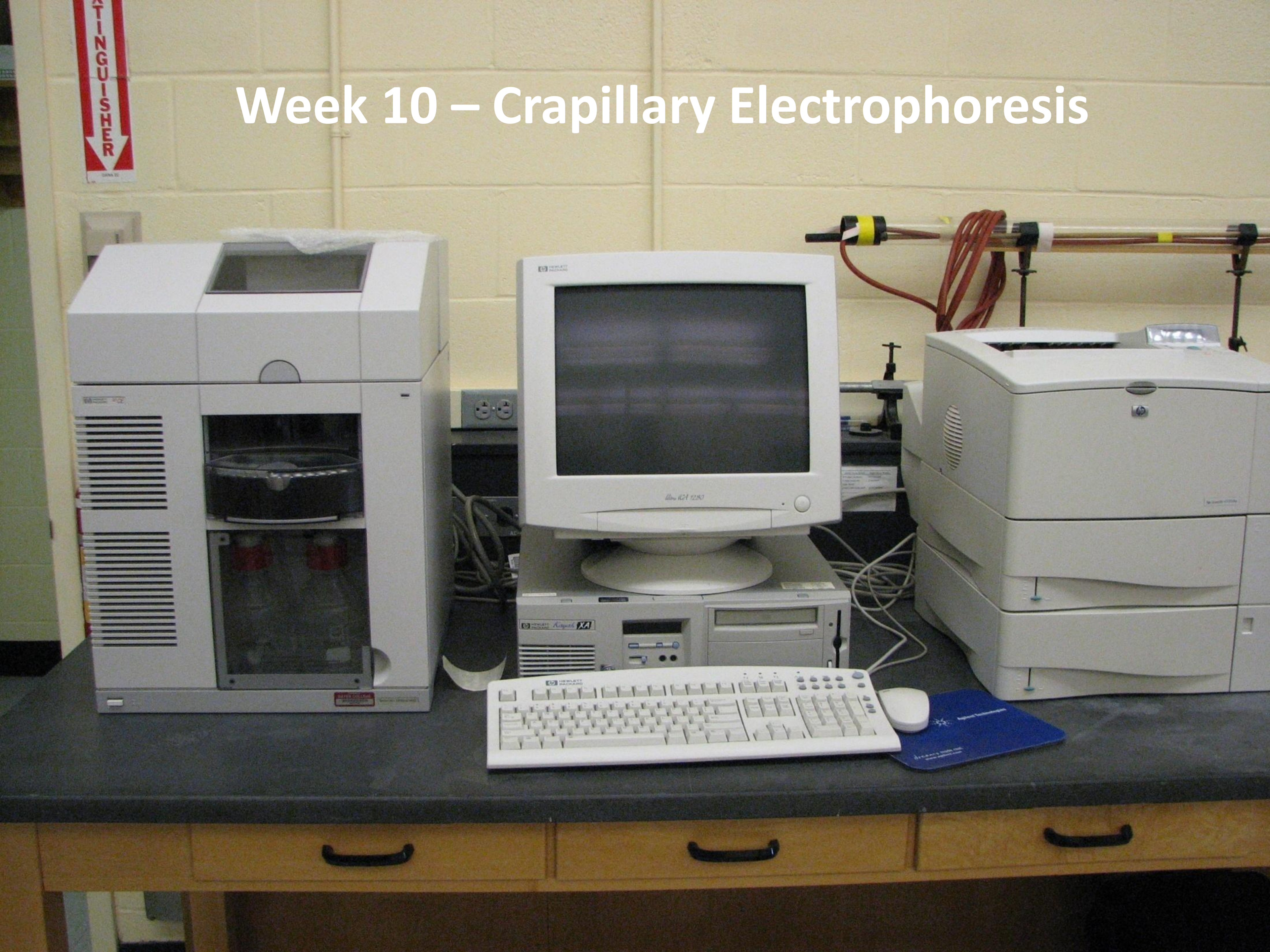


Week 8 – GC-MS

Week 9 – GC-FID


S/SL)
Split
Temp 250 250
Pressure 7.6 7.6
Agilent 5973N MSD
Windows
Professional

Week 10 – Crapillary Electrophoresis



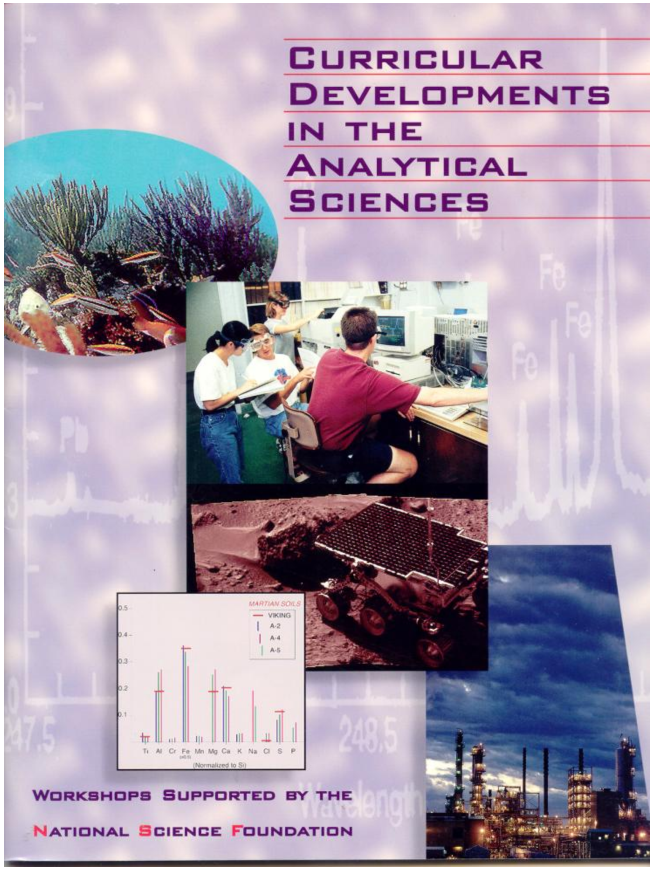
Week 11 – Isotope Ratio MS

Week 12 – Microwave Digester

Week 12 – ICP

I hope we would agree that this *Translaboratory Instrument Marathon* provides a superficial understanding of analytical chemistry

NSF-sponsored Workshops on Curricular Reform in the Analytical Sciences



Workshops brought together stakeholders to examine the current practice of analytical chemistry instruction and explore ways to improve the practice.

http://www.asdlib.org/files/curricularDevelopment_report.pdf/

Selected Workshop Recommendations

- ✓ That the academic community develop context-based analytical science curricula that incorporate problem-based learning.
- ✓ That more students be offered hands-on learning opportunities.
- ✓ That the analytical community develop a list of appropriate and well-developed technologies that faculty may consider for classes and labs.
- ✓ That faculty strive to incorporate today's technology into classrooms and laboratories and to use technology as an access to real-world learning.
- ✓ That analytical faculty drive the revisions to undergraduate analytical curricula and help spread the word about the need for these revisions.
- ✓ That the community of analytical educators take an active role in the design, assessment, and purchase of technology as it applies to education and in their own continuing education.
- ✓ That everyone involved in undergraduate education look for ways to share information about curricular reform.

Challenges to Implementing Workshop Recommendations

- PBL and active learning introduces new challenges to instructors and students
  - How does one identify good problems?
  - Problem-solving typically requires
  - Information not available in textbooks
- Need for the Analytical Chemistry community to interact and share teaching resources and educational strategies

Analytical Sciences Digital Library (ASDL)

Analytical Sciences Digital Library

ASDL *Analytical Sciences Digital Library*

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The Analytical Sciences Digital Library collects, catalogs, annotates and links peer-reviewed web-based educational resources and publishes the online journal, JASDL.

Techniques		Applications		Resources by Format		Teaching Resources	JASDL
chemometrics electrochemistry instrumentation mass spectrometry NMR and EPR	separations spectroscopy surfaces/nanomaterials	application databases bioanalytical environmental forensic quantitative analysis	lab manuals research practices	animations e-texts exercises lab experiments tutorials	videos virtual labs powerpoints	active learning case studies cooperative learning problem/inquiry-based learning reference links/databases	Courseware Labware Educational Practices Undergraduate Research

ASDL posters Posters are accepted anytime. Posters will be online at ASDL for one year and archived afterward. Authors retain copyright.

Congratulations to Christa Snyder, Wittenberg University, the winner of the 2010 ASDL-ALA Young Scientist Poster Award. Christina received $500 and travel costs to attend LabAutomation 2011 conference in Palm Springs, CA, January 29-February 2, 2011.

Analytical Chemistry 2.0 is now available through JASDL. This free electronic analytical chemistry textbook authored by David Harvey, DePauw University, can be accessed as a JASDL courseware item. The book is a completely updated revision of Harvey's text *Analytical Chemistry*, originally published by McGraw-Hill in 1999. The downloadable PDF files are extensively hyperlinked both within the text and to external sites.

ASDL Active Learning Materials . These materials have been developed with funding from the NSF-CCLI program and are currently under review for eventual inclusion in JASDL.

ASDL is proud to be partnered with the **Analytical Chemistry Division** of ACS. By joining forces we work to create enthusiasm for the ASDL collection, online articles, and student poster sessions while encouraging analytical scientists to become active in the Analytical Chemistry Division of ACS.

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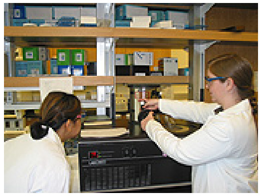
The Society for Laboratory Automation and Screening (SLAS)-LabAutopedia



News
Ted Kuwana wins Distinguished Service Award
Innovations in Education at Fall ACS Meeting

ASDL Professionals Directory
Meet colleagues and add your entry.

Photo gallery
Meet the ASDL People!
ALA 2010
Pittcon 2010
Pittcon 2009

Other Links
NSDL
Chemical Education Digital Library

http:/www.asdlib.org

The ASDL Project

- NSF DUE 0121518, 0531941, 0816649, 0817595, 0937751
- UC-Riverside, KU, UIUC, Bates College, DePauw
- Members of the ASDL Advisory Board

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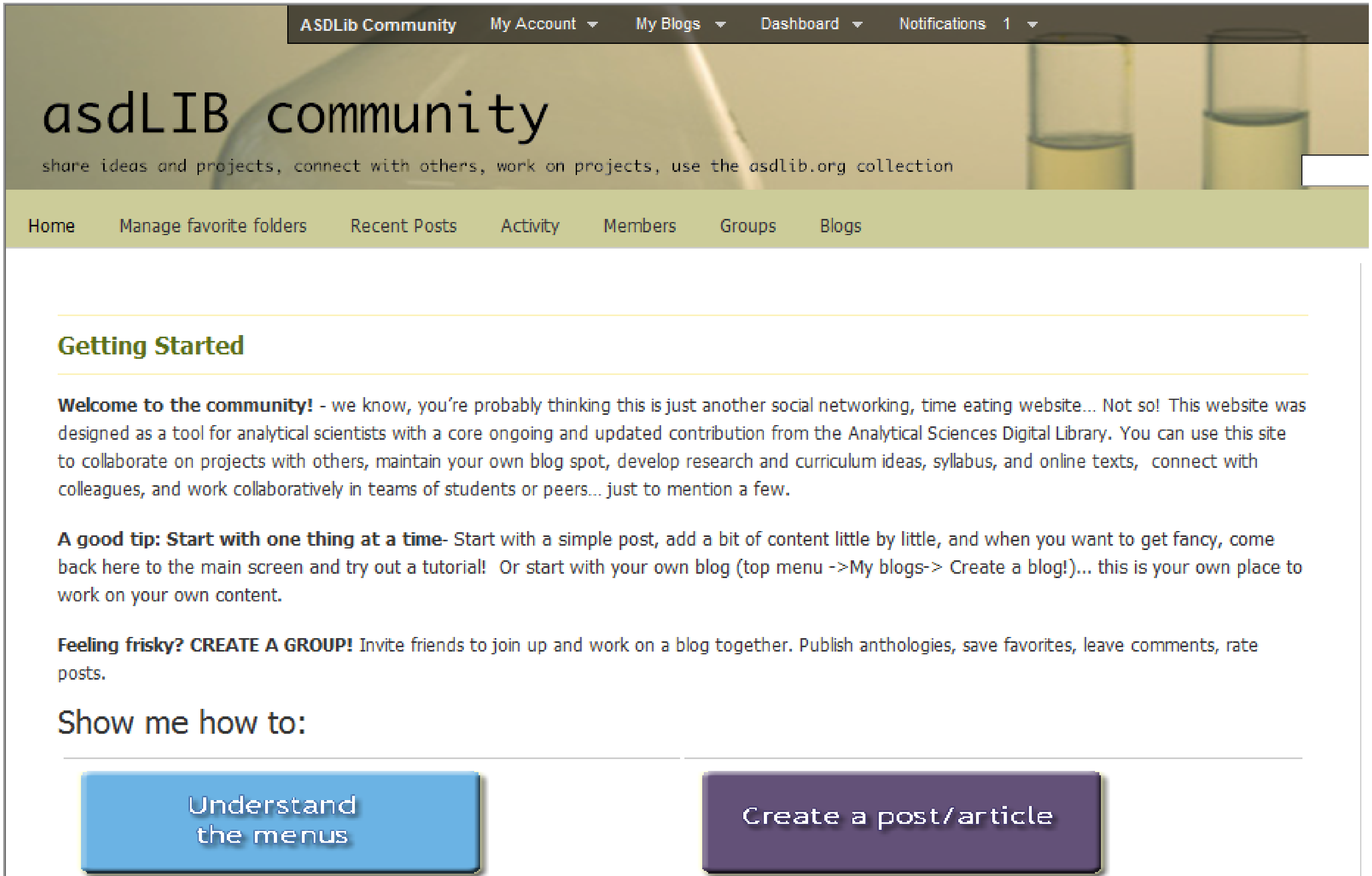
www.asdlib.org/community



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asdLIB community

share ideas and projects, connect with others, work on projects, use the asdlib.org collection

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Getting Started

Welcome to the community! - we know, you're probably thinking this is just another social networking, time eating website... Not so! This website was designed as a tool for analytical scientists with a core ongoing and updated contribution from the Analytical Sciences Digital Library. You can use this site to collaborate on projects with others, maintain your own blog spot, develop research and curriculum ideas, syllabus, and online texts, connect with colleagues, and work collaboratively in teams of students or peers... just to mention a few.

A good tip: Start with one thing at a time- Start with a simple post, add a bit of content little by little, and when you want to get fancy, come back here to the main screen and try out a tutorial! Or start with your own blog (top menu ->My blogs-> Create a blog!)... this is your own place to work on your own content.

Feeling frisky? CREATE A GROUP! Invite friends to join up and work on a blog together. Publish anthologies, save favorites, leave comments, rate posts.

Show me how to:

Understand the menus

Create a post/article

The Analytical Toolbox

- ✓ JASDL modules oriented around specific topics
- ✓ Toolbox can help students find answers
- ✓ Open-access publication of curricular innovations

Analytical Toolbox
Statistics
Sample Preparation
Equilibrium Chemistry
Kinetic Methods
Electrochemistry
NMR
Mass Spectrometry
Separations
Hyphenated Methods
Spectroscopy
Surface Methods

Types of Material in the ASDL Collection

- ✓ Web-based content: textbooks, tutorials, quizzes, lecture notes, experiments
- ✓ Resources/Databases: NIST, SCUBA, TOXNET
- ✓ Simulations, virtual experiments and real-time remote instrument access
- ✓ Videos and animations
- ✓ Innovative pedagogical approaches
- ✓ Learning modules on specific *Analytical Toolbox* topics

Using the ASDL Toolbox

- ✓ Flexible for use in a variety of educational environments
- ✓ In-class activities
- ✓ Out-of-class assignments
- ✓ Introduction to new techniques (or Pre-lab)
- ✓ Supporting theory
- ✓ Wet and Dry labs

Conventional to Inquiry Based Learning

Annual ASDL Curriculum Development Workshops

ASDL Active Learning Initiative

Development of Contextual E-Learning Modules for Analytical Chemistry

Inquiry-based undergraduate curricular materials

Learning Outcomes for Undergraduates
Knowledge Outcomes
Skills Outcomes
Affective Outcomes
Learned Abilities

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.**

ASDL CCLI Phase I Grant

- Long-term goal:
  - Put entire undergraduate analytical chemistry curriculum on-line
  - Materials that are readily adopted and adaptable (designed to be modified)

- Inquiry-based, collaborative learning activities
- Textual material
- Contextual problems
- Problem- and project-based classroom and/or laboratory experiences
  - Wet or dry lab
- Instructor’s manuals

Builds on work in progress at ASDL, and takes advantage of peer reviewed resources in the digital library

Separation Science

In-class Problems
Text
Learning Objectives
Instructor's Manual
Out-of-class Problems

Laboratory Projects
Peer/Self Evaluation for Laboratory Project
Final Lab Report for the Laboratory Project

Specialty Topics
- **Affinity Chromatography (Sapna Deo)**
- **Ion-exchange Chromatography (William Otto)**
- **Size Exclusion Chromatography (Sandra Barnes)**
- **Ultracentrifugation (David Thompson)**

Vignettes

Example Questions in the Equilibrium/Separations Unit

- Calculate the pH of a solution that is 0.155 M in ammonia.

- What would be the order of retention for the ions Li(I), Na(I), and K(I) on a cation exchange resin? Justify your answer.

Learning Objectives

Problem #1 (17 learning objectives)

After completing this problem, the student will be able to:

1. **Write the reaction of a weak base with water**
2. **Identify a chemical that is a weak base**
3. **Write the equilibrium constant expression for reaction of a weak base with water**
4. **Use the expression $K_aK_b = K_w$ to solve for K_a if given K_b (or vice versa)**
5. **Prove that $K_aK_b = K_w$ by writing out and multiplying the appropriate equilibrium constant expressions**

Instructor’s Manual

The problem sets on chemical equilibrium can be used in at least two different manners. The primary intent is to use these as a set of in-class, collaborative learning exercises. Groups of 3-4 students work together in discussing and working through the problems. When using the problem sets in this manner, the instructor must actively facilitate and guide students through the material. This manual will guide instructors through each of the problem sets, identifying possible student responses to the questions and the response and activities of the instructor during the progression of the problem.

An alternative to the use of the problems in class is to assign them as out-of-class activities, preferably done as a group activity among students or as a peer-led learning activity.

Instructor’s Manual

As students begin to ponder this question, and as the instructor begins to circulate among the groups, some things to ask are:

What is ammonia? Is it an acid or a base? Is it strong or weak?

After about five minutes, everyone should have identified ammonia as a weak base and have the correct chemical formula. I write the correct chemical formula on the board and that it is a weak base. With this information, they can next be asked:

What does ammonia react with? Can you write the correct chemical equation representing this reaction?

Text (Four pages on Problem 1)

1. Calculate the pH of a solution that is 0.155 M in ammonia.

The first step in any equilibrium problem is an assessment of the relevant chemical reactions that occur in the solution. To determine the relevant reactions, one must examine the specie(s) given in the problem and determine which types of reactions might apply. In particular, we want to consider the possibility of acid-base reactions, solubility of sparingly soluble solids, or formation of water-soluble metal complexes.

When given the name of a compound (e.g., ammonia), it is essential that we know or find out the molecular formula for the compound, and often times we have to look this up in a book or table. The molecular formula for ammonia is NH_3. Ammonia can be viewed as the building block for a large family of similar compounds called amines in which one or more of the hydrogen atoms are replaced with other functional groups (a functional group is essentially a cluster of atoms - most of these are carbon-containing clusters). For example, the three compounds below result from replacing the hydrogen atoms of ammonia with methyl (CH_3) groups.

INSTRUCTOR'S MANUAL FOR LABORATORY PROJECTS USING CHROMATOGRAPHY

Chromatography Projects

- Caffeine, theobromine and theophylline in chocolate – HPLC-UV
- Catechins (polyphenols) in green tea, wine and chocolate – HPLC-UV
- Amino acid analysis – HPLC-Fluorescence
- Volatiles in coffee – GC-MS
- Trihalomethanes in drinking water – GC-MS
- Methylbenzenes from car exhaust in air – GC-MS
- Nitrate and nitrite in hot dogs/cured meats – Ion Chromatography
- PAHs in charred meats or creosote – GC-MS
- Chloride content of frozen foods – Ion Chromatography
- DNA restriction fragment analysis – Capillary Electrophoresis
- Additives in soft drinks – Capillary Electrophoresis

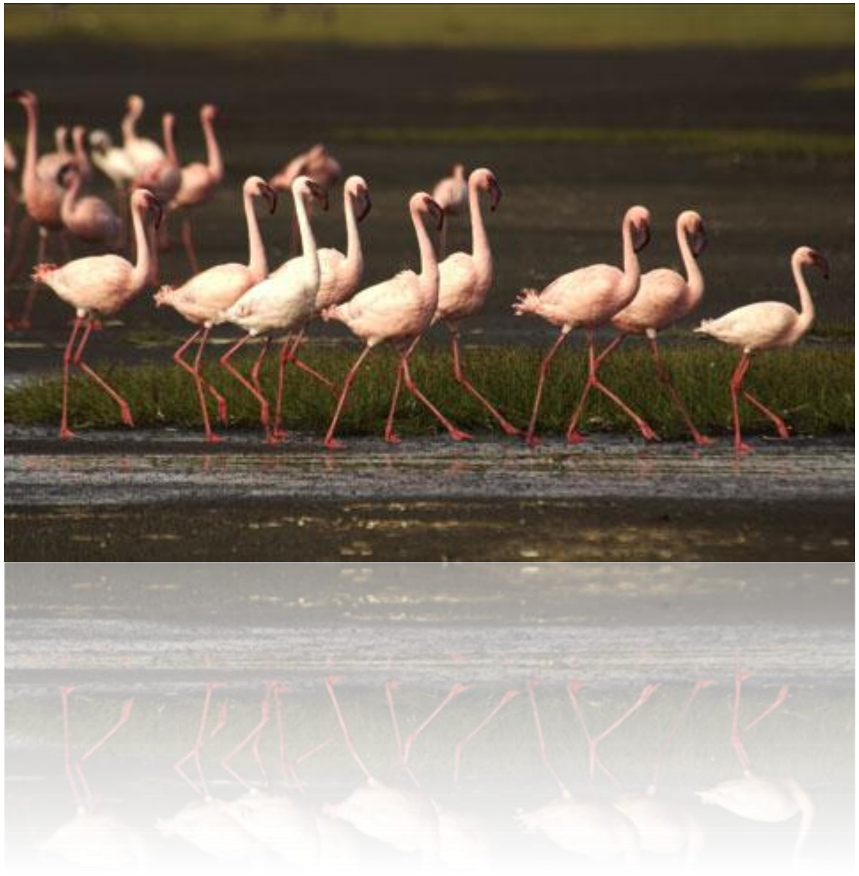
Contextual Problem Approach: Lake Nakuru, Kenya

Interdisciplinary Context-based Module

Beginning in 1993, and occurring in multiple years since, flamingos at Lake Nakuru have been dying by the tens of thousands (40,000 in 2000 alone)

Module Components

1. *Identifying the Problem*
2. *Sampling*
3. *Sample Preparation*
4. *Gas Chromatography*
5. *Pesticide Analysis by MS*
6. *Method Validation*
7. *Instructor's Guide*



Identifying the Problem

What is killing the flamingos at Lake Nakuru?

Heavy metals?

Algal toxins?

Organochlorine pesticides?

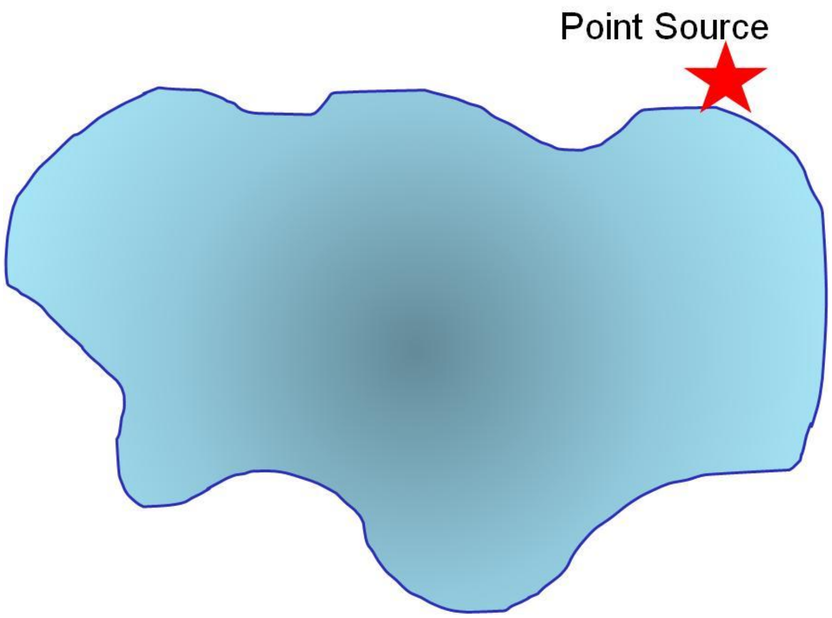
Sampling unit

At the end of this assignment students will be able to:

- ✓ Define various sampling strategies
- ✓ Assess the benefits and limitations of different sampling strategies
- ✓ Determine an appropriate sampling plan for an analysis

Sampling units: Example questions

- ✓ Assume you have chosen a judgmental sampling plan to evaluate pollution from a point source into a lake.
- ✓ Use the diagram at right and words to describe your sampling plan.



Designing a Sampling Plan

Key questions to consider:

1. From where within the target population should we collect samples?
2. What type of samples should we collect?
3. What is the minimum amount of sample for each analysis?
4. How many samples should we analyze?
5. How can we minimize the overall variance for the analysis?

Pesticide Analysis by Mass Spectrometry

- ✓ Explain the processes involved in the ionization of compounds in GC-MS.
- ✓ Predict isotopic distributions and identify chlorinated compounds by their MS isotopic signature and fragmentation patterns.
- ✓ Identify and use unique ions for MS quantitation in complex samples.
- ✓ Using a sampling scheme for Lake Nakuru, determine the concentrations of DDT from GC-MS results and draw some conclusions as to whether the levels of DDT detected in Lake Nakuru water play a role in flamingos' death.

Instructor's Manual - Vignettes

Heather Bullen, Northern Kentucky University

Anna Cavinato, Eastern Oregon University

Alanah Fitch, Loyola University – Chicago

Cynthia Larive, University of California – Riverside

Richard Kelly, East Stroudsburg University

David Thompson, Sam Houston State University

Thomas Wenzel, Bates College

Anna Cavinato Eastern Oregon University

- ✓ Used Nakuru sampling module
- ✓ Challenged students to design a sampling plan for a local lake
- ✓ Collected water samples and analyzed for pesticides by GC-MS

Eastern Oregon University Analytical Chemistry – Fall 2010

What Have We Learned?

- ✓ Evaluation
  - Improved student learning?
  - Useable in a wide variety of environments?
- ✓ Benefits
  - Student centered learning
  - Electronic, free of charge
  - Adaptable
  - Problems inter-dispersed with learning material
- ✓ Challenges
  - Time
  - Tailoring materials for individual classroom environments

Student Survey Results for CHEM125

- ✓ 76% active learning assignments are *helpful or very helpful* for learning the material
- ✓ 62% would enjoy using this approach to learn about a new technique

"helped to understand why such techniques and other instruments are used in real life situations"

"I really liked when the question dealt with what you would do with a real sample"

NSF TUES Type 2 Grant: Finish Materials Development

- Fill in textual material for remainder of analytical curriculum (about 85% already available on web)
- Inquiry-based collaborative learning exercises
- Develop additional contextual modules
- Develop project- and problem-based laboratory exercises (wet or dry lab)
- Instructor’s guides

New Contextual Modules

- Extension of Lake Nakuru project
  - Toxic metals – atomic spectroscopy
  - Salinity – multiple instrumental methods
- Analysis of explosives on IEDs
  - Gold nanoparticles/Surface-enhanced Raman
- Effect of acid rain on salmonid populations
  - Typical “quant” measurements
- Performance enhancing drug testing
  - Multiple instrumental methods

Participants (Type 2 Request)

- Olujide Akinbo – Butler
- Sandra Barnes – Alcorn State
- Chris Bauer – U. New Hampshire
- Heather Bullen –N. Kentucky
- Anna Cavinato – Eastern Oregon
- John Dimandja – Spelman
- Alanah Fitch – Loyola – Chicago
- Erin Gross – Creighton
- Grady Hanrahan – Cal Lutheran
- Chris Harrison – San Diego State
- David Harvey – Depauw
- Charles Hosten – Howard
- Richard Kelly – East Stroudsburg
- Albert Korir – Drury
- Cindy Larive – Cal Riverside
- Suzanne Lunsford – Wright State
- William Otto – Maine Machias
- Steve Petrovic – Southern Oregon
- Mike Samide – Butler
- Alex Scheeline – Illinois Urbana
- Tom Spudich – Military Academy
- David Thompson – Sam Houston
- Philip Voegel – SE Louisiana
- Tom Wenzel – Bates College

Goals for the Future

- ✓ Expand the Nakuru project to examine the possible role of heavy metals and salinity/algal toxins
- ✓ Expand analytical toolbox
- ✓ Modify existing content to be more inquiry-based
- ✓ Testing/sharing materials
- ✓ Assessment
- ✓ Development of additional context-based materials

Acknowledgements

NSF DUE

ASDL Editors

and

Collaborators