

**COURSE TITLE: PHRD 402. Principles of Drug Action and Therapeutics I****I. Contact Information**

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**II. Course Prerequisites/Corequisites**

Acceptance into the COP and enrollment or credit in PHRD 420  
Graduate Students: permission of the instructor.

**III. Course Description**

This course focuses on the molecular-level composition of living organisms in relationship to the biochemical and molecular biopharmaceutical bases of therapeutic intervention with medicinal substances, and associated foundational concepts of medicinal and pharmaceutical chemistry, pharmacology, and toxicology.

**IV. Curricular Objectives and Outcomes**

See Appendix B.

**V. Course-Specific Objectives and Outcomes**

The overarching objective for the course is to introduce the student to basic principles underlying the actions of medicinal substances in the human body. **For further elaboration, please refer to Appendix A.** In general, *memorization of material will not be emphasized*; rather, evaluation will largely be based on assessing your understanding of concepts and principles, your ability to apply this

understanding in intelligent and reasonable ways, and—when practical—higher-order abilities: analysis, evaluation, and synthesis. The content of this course varies widely in nature, ranging from conceptual to applied mathematical; the expectations and corresponding nature of the assessments will vary accordingly. Additional detailed information concerning study and learning objectives, beyond what is given in Appendix A, will be provided in class, typically within the context of grappling with particular types of content, or on the Moodle site as we go, addressing questions such as...

- How should I study?
- On what aspects should I particularly focus?
- What will be expected of me on the quizzes and exams?

Question and Answer (Q&A) sessions will be offered at specially scheduled times (not during regular class time) immediately prior to the exams, and on other selected occasions during the semester. These may prove useful in guiding your study techniques and emphases.

## VI. Course Topics

See Course Schedule (Section X below).

## VII. Instructional Methods and Activities

Instructional methods will include: traditional and technology-based lectures with in-class discussion, and various formative exercises designed to invoke active learning.

## VIII. Evaluation and Grade Assignment

Test I	50 points	(Jois/Hill)
Test II	50 points	(Jois)
Test III	50 points	(Jois/Hill/Amal)
Test IV	50 points	(Jois/Hill)
Quizzes	50 points	(Hill 20, Jois 25, Amal 5 points)
Final Exam	100 points	(Jois/Hill/Amal)
Total	350 points	

According to university guidelines (as given in *The University of Louisiana at Monroe 2008–2009 Graduate Catalog*, wherein the Pharm.D. program is currently listed as a professional degree program), grades should reflect the following:

A - EXCELLENT                      B - AVERAGE                      C - BELOW AVERAGE

D & F - Failing

Grading will be straight scale: >89.9% = A, 80.0%–89.9% = B, 70.0%–79.9% = C,  
60.0%–69.9% = D, <60.0% = F

Mid-term grades will be posted on-line for students to view via the Arrow system. *Mid-term grades indicate a student's status at mid-semester only.*

## IX. Class Policies and Procedures

General policies stated in the current ULM *Student Policy Manual & Organizational Handbook* will be followed (see <http://www.ulm.edu/studentpolicy/>). Additional class policies include:

- **Preparation for class.** For each class period, you are held responsible for **prior preparation**, involving: (1) viewing any e-presentations as may be assigned in advance; (2) reading over notes or handouts, if provided in advance; (3) completing a reading if assigned for a particular class; (4) answering or attempting to answer pre-class study questions, if given. Reading assignments will be kept to a modest length, and study questions and homework problems, when provided, will serve to emphasize and illustrate key concepts presented in notes, handouts, or readings. **You should plan for a minimum of 9-10 hours per week of outside study time in support of your learning in this class; some students may find that they need more time than this.** Assignments and any needed materials (notes, handouts, study questions) will be posted on Moodle several days in advance. You should, however, habitually check the Moodle page the evening before class for any possible corrections or clarifications.
- **Exams.** Five examinations will be administered during the course. The four hourly exams (Exams 1, 2, 3, & 4) will emphasize topics as mentioned in the class schedule, but beginning with Exam 2 will have some degree of comprehensive coverage, concerning the nature of which you will be advised soon enough for any needed review. The final exam will include a significant comprehensive component; more details will be forthcoming.

### A. Textbook(s) and Materials:

Access to computer with internet; various materials will be provided online via the Moodle portal.

*Required textbook: Biochemistry, 6<sup>th</sup> Edition.* Mary K. Campbell and Shawn O. Farrell.  
Thompson/Brooks-Cole; ISBN-10: 0495390410; ISBN-13: 9780495390411

*Required textbook: Graham L. Patrick. An Introduction to Medicinal Chemistry, 4<sup>th</sup> edition (2009)*  
Oxford University Press;. ISBN: 978-0-19-923447-9 (paperback)

### B. Attendance:

The College of Pharmacy attendance policy will be followed.

### C. Make-up Policy:

Exams, Graded In-class Exercises, and Assignment Deadlines: The university requires that you are given a fair opportunity to complete missed grade opportunities when circumstances warrant. For examinations (and in most other instances) such circumstances must be **compelling**, including: (1) you are sick enough to require medical attention and be confined to bed; (2) there is a death in the immediate family (including grandparents); (3) there is a personal or family emergency. If the absence is predictable (e.g. scheduled surgery), a prior approval must be obtained from Dr. Hill (as the Instructor of Record). In most instances, *physical proof will be needed or you will not be provided the opportunity to make up the grade!!!* **If you miss an examination or assignment deadline, and intend to request a makeup under the above policy, Dr. Hill MUST be informed BY PHONE OR IN-PERSON no later than the day following the missed event unless circumstances are prohibitive.** Excuses will be validated. If a makeup is allowed under these guidelines, it will be arranged on an individual basis.

**D. Academic Integrity:**

University policies against cheating and plagiarism, as given in the *ULM Graduate Catalog*, *ULM Student Policy Documents* (<http://www.ulm.edu/studentpolicy/>), and *ULM College of Pharmacy Student Policy Handbook* will be strictly enforced. **CHEATING WILL NOT BE TOLERATED, AS ANY ACADEMIC ADVANCEMENT THEREBY GAINED IS CONSIDERED A POTENTIAL THREAT TO THE PUBLIC.** Any instances of cheating will be dealt with vigorously and doggedly, and to the fullest extent possible.

**E. Course Evaluation Policy:**

At a minimum, students are expected to complete the on-line course evaluation.

**F. Student Services:**

Information concerning student services in the College of Pharmacy can be found in the *College of Pharmacy Student Handbook*. In particular, students should pay special attention to the College's technical standards and policies concerning students with special needs (<http://www.ulm.edu/studentpolicy/studentpolicy.pdf>, pages 21-22). Information concerning ULM student services and resources, such as the Student Success Center (<http://ulm.edu/cass/>), Counseling Center (<http://ulm.edu/counselingcenter/>), and Student Health Services, is available at the following Student Services web site <http://ulm.edu/studentaffairs/>.

**G. Emergency Procedures:**

Please review the emergency escape plan in the classrooms and hallways of the Bienville building. Procedures for evacuating the room under emergency circumstances will be discussed on the first day of class. Please ask about our procedures at any time, however! For emergencies, to contact University Police, call 1-911 from landlines and **342-5350 from cell phones.**

**X. Course Schedule**

Topic	Class Hours	Days	Instructor
Drug Discovery and Drug Creation, Round 1	5	M 8/24 W 8/26 F 8/28	Hill
Molecular structure as it relates to acidity and basicity of organic molecules; solution ionization; review of ionic equilibria of biochemically common functional groups	3	M 8/31 W 9/02 h1 *	Hill
Stereochemistry review	1	W 9/02 h2	Hill
Proteins: Brief review/overview of their various biological functions	2	F 9/04 W 9/09 h1	Jois
Molecular recognition: weak (noncovalent) intramolecular interactions, the hydrophobic effect, and the nature of molecular recognition (basic thermodynamics and kinetics; conformational equilibria);	3	W 9/09 h2 F 9/11** M 9/14 h1	Jois
Myoglobin and hemoglobin function as prototypical systems for illustrating... <ul style="list-style-type: none"> <li>• ligand-protein interaction;</li> <li>• protein structure vs. function;</li> <li>• multimeric protein assemblies;</li> <li>• allosteric cooperativity and regulation</li> </ul>	3	M 9/14 h2 W 9/16	Jois
Test 1	1	F 9/18	Hill/Jois

Enzymology, with particular emphases as pertains to drug action: <ul style="list-style-type: none"> <li>• enzyme kinetics and effects of inhibitors</li> <li>• allosteric enzymes; allosteric activators and inhibitors</li> <li>• enzyme catalysis: molecular mechanisms of biocatalysis overview, including vitamin-derived cofactors as applicable</li> </ul>	4 2 6	M 9/21 W 9/23 F 9/25 M 9/28 W 9/30*** F 10/02 M 10/05	Jois
Enzyme inhibition strategies for drug design (overview)	2	W 10/07	Hill
Test 2	1	F 10/09	Jois
Receptors and associated concepts, Round 1 <ul style="list-style-type: none"> <li>• affinity; association, dissociation, and other molecular-level processes</li> <li>• efficacy: agonists, antagonists, partial agonists, inverse agonists</li> <li>• target-level dose-response relationships</li> </ul>	1 2 2	M 10/12 W 10/14 F 10/16 #	Hill
Molecular-level membrane structure and functions, with a review of lipids	1	M 10/19 h1	Jois
Membrane transport basics	1	M 10/19 h2	Amal
Membrane transporters, Round 1	2	W 10/21	Amal
Molecular determinants of drug absorption	1	M 10/26 ##	Amal
Molecular determinants of drug distribution	1	M 10/26	Amal
Molecular determinants drug excretion	1	W 10/28 h1	Amal
Cellular energetics (thermodynamics and energy “currency”)	2	W 10/28 h2	Hill
Test 3	1	F 10/30	Hill/Jois/ Amal
Cellular energetics (thermodynamics and energy “currency”), contd		M 11/02 h1	Hill
Metabolic pathways: overview, characteristics of multi-enzyme pathways, and pathway regulation; the following topics will serve for introductory exemplification: <ul style="list-style-type: none"> <li>• glycolysis, tricarboxylic acid cycle;</li> <li>• lipid metabolism: fatty acid catabolism and ketone bodies, lipids biosynthesis</li> <li>• glycogen metabolism; gluconeogenesis; glycogen synthesis</li> </ul>	2 7	M 11/02 h2 W 11/04 h1 W 11/04 h2 F 11/06 M 11/09 W 11/11 @ F 11/13	Hill Jois Jois Jois
Electron transport and oxidative phosphorylation	1	M 11/16 h1	Jois
Metabolic integration; hormonal regulation of primary metabolism (Round 1–general/broad principles)	2	M 11/16 h2 W 11/18 h1	Hill
Biotransformation of xenobiotics (including drugs) <ul style="list-style-type: none"> <li>• Overview</li> <li>• Phase I metabolism, including some enzymology</li> </ul>	1 3	W 11/18 h2 F 11/20 M 11/23	Hill
Test 4		W 11/25	Hill/Jois

Biotransformation of xenobiotics, contd <ul style="list-style-type: none"> <li>• Phase I metabolism, including some enzymology, contd</li> <li>• Phase II metabolism, including some enzymology</li> </ul> Significance of drug biotransformation, and brief introduction to “pharmacogenomics”	1	M 11/30	Hill
	2	W 12/02	
	1	@@	
Prodrugs and soft drugs—an introduction	1	F 12/04	Hill

\* Quiz 1 (Hill) - 7 pts      \*\* Quiz 2 (Jois) - 5 pts      \*\*\* Quiz 3 (Jois) - 10 pts  
# Class Exercise (Hill) - 7 pts      ## Quiz 4 (Amal) - 5 pts  
@ Quiz 5 (Jois) - 10 pts      @@ Class Exercise (Hill) - 6 pts

**KEY DATES:**

*Labor Day Holiday: 01 SEP 2009 (Monday)*

**Test I: 18 SEP 2009 (Friday)**

**Test II: 09 OCT 2009 (Friday)**

*Fall Break 23 OCT 2009 (Friday)*

**Test III: 30 OCT 2009 (Friday)**

**Test IV: 25 NOV 2009 (Wednesday)**

**Final Exam: TBA**

## APPENDIX A: Course Objectives and Outcomes, Elaborated

As written in Section V. above, the overarching objective for the course is to introduce the student to basic principles underlying the actions of medicinal substances in the human body. More particularly, this course aims to guide students in gaining foundational understandings of the chemical/biochemical logic underlying the actions of medicinal substances, which together with corresponding theoretical frameworks encompasses the molecular-level aspects of pharmacology. (Systems-level aspects are only begun in this course, but this will be the major focus of the Part 2 followup course.) The molecular structures and corresponding physical and functional characteristics of the medicinal substances (pharmacotherapeutic agents, or in the vernacular, “drugs”) and also of the biological substrates (enzymes, receptors, and other molecular-level drug targets; binding proteins; membrane transporters) will be considered, focusing on relationships (“correlates”) between molecular structure and (1) biopharmaceutical properties, including routes of administration, bioavailability, and biodistribution; (2) target-level pharmacological actions and off-target-mediated side-effects; (3) excretion and biotransformation (“drug metabolism”).

Specific Outcomes Objectives and Competencies: Upon completion of this course, besides progressing on the general curricular outcomes and competencies provided in Appendix B, students should be equipped with knowledge and abilities as follows.

- Describe structural and functional characteristics of important molecular targets of drug action: (1) receptors, (2) enzymes, and (3) nucleic acids.
- Describe structural and functional characteristics of important molecular macromolecular assemblages and tissue microstructures as affects drug absorption, distribution, biotransformation, and excretion: (1) cellular and intracellular lipid membranes, (2) transporters, (3) enzymes catalyzing biotransformation.
- Given a molecular structure of a drug molecule...
  - be able to make reasonable structure-based predictions concerning aqueous solubility and relative hydrophilicity/lipophilicity;
  - be able to make structure-based predictions concerning useful routes of administration;
  - demonstrate an ability to rationalize or predict ease of access to various tissues.
- With respect to acidic and basic properties of structural moieties incorporated within drug molecules and macromolecular drug targets, demonstrate a knowledge of approximate  $pK_a$ s for common ionizable functional groups, and the corresponding molecular species distribution as a function of pH (i.e., approximate proportions of ionized, unionized, and—if applicable—amphoteric forms).
- With respect to acidic and basic properties, be able to write equations for salt formation.
- Given a molecular structure of a drug molecule, describe its stereochemical attributes and the potential pharmacological significances thereof.
- Describe the types and bonding strengths of intermolecular forces that occur between a ligand and its macromolecular binding site, and the nature of hydrophobic interactions.
- Define the basic mathematical terms commonly encountered in descriptions of the kinetic characteristics of enzymes, and their meaning from a biochemical and drug action perspective.
- Demonstrate an understanding of the distinct types of enzyme inhibitors, and the consequences of these differences in terms of the biochemical pharmacology of drugs that modulate enzymes.
- Define allosteric cooperativity, and describe the significance of such cooperativity to molecular cellular physiology and the biochemical pharmacology of drug action.
- Define and differentiate affinity and efficacy, describe how these concepts relate to the associated concepts of agonism, antagonism, partial agonism, and inverse agonism, and further describe in general how these concepts are related to the patient-level actions (observed clinical pharmacology) of drugs.
- Define the concept of pharmacological selectivity, describe the molecular bases for selectivity from both the drug and target aspects, and describe the general clinical significance of selectivity.
- Provide a list of drug-associated and tissue-associated factors affecting access by drugs to particular organs of the body, including access *to* the body (i.e., bioavailability).

- As regards biochemical pathways...
  - Define the concept of equilibrium, and how equilibria are affected by Gibbs free energy changes for biochemical transformations;
  - Identify and describe in general factors affecting the rates of individual biochemical transformations and of a biochemical pathway;
  - Define the concepts (1) rate-limiting step, (2) homeostasis (as pertains to biochemical pathways), and (3) feedback inhibition/modulation/regulation.
- Outline, with broad brushstrokes, the major biochemical pathways involved in nutrient sugar and lipid utilization, storage, and biosynthesis, and the means by which energy required for various cellular processes is produced from these nutrients.
- Describe the general physiological purposes of drug biotransformation (“drug metabolism”), and define and differentiate Phase I and Phase II biotransformation, including the nature of the chemical transformations involved with each.
- Given a molecular structure of a drug molecule, be able to predict likely routes of biotransformation.
- Describe, in general terms, the significance of drug biotransformation with respect to pharmacokinetics.
- List major sources of individual variation and drug-drug interactions that may arise as a result of effects on drug biotransformation, and outline the practical significance of each of these sources.
- Define, in very general and basic terms, the concept “pharmacogenomics,” and the related concepts (1) genotype, (2) phenotype, (3) single nucleotide polymorphism, (4) amino acid homology, (5) isoform, (6) isozyme.

## APPENDIX B: Curricular Objectives and Outcomes Addressed by this Course

Upon successful completion of this course, the student will gain competencies that are consistent with the educational outcomes adopted by the ULM College of Pharmacy in August 2006, which are based on CAPE 2004\* and ACPE Standards 2006, and also the Medicinal Chemistry Supplemental Outcomes to CAPE 2004 (see below). [\*CAPE = Center for the Advancement of Pharmaceutical Education Advisory Panel Outcomes, as adopted by the American Association of Colleges of Pharmacy (AACCP) and the American Council on Pharmacy Education (ACPE).] A listing of applicable outcomes is provided starting on p. 2 of this appendix.

The course will, in complement with other pharmacy coursework, endeavor to provide students with as broad and deep an answer as time permits to the questions, (1) “How do drugs work?” and (2) “Why do drugs have the molecular structures that they do?” and (3) “How is the information that is ‘coded’ into the molecular structure of a drug molecule ‘translated’ by the human organism to provide the observed biological effects/responses?”

The American Association of Colleges of Pharmacy Section of Teachers of Chemistry has proposed the following chemistry-based practice outcomes to supplement the new (2004) CAPE outcomes and newest (adopted 2006) ACPE accreditation standards concerning curriculum. This class is designed in part so as to help you make important progress on achieving these outcomes by the time you graduate:

1. General outcomes based on chemistry and chemical properties:
  - a. Describe important molecular targets of drug action: (1) messenger receptors, (2) enzymes, (3) nucleic acids, (4) excitable membranes, and (5) transporters and other biomolecules.
  - b. Relate drug pharmacophores and structure-activity relationships to drug : molecular target interactions and mechanism(s) of action.
  - c. Recognize and predict ionization, solubility properties, absorption, excretion, and the [biotransformation chemistry] of a drug molecule according to the structure.
  - d. Describe factors that can affect the stability or shelf-life of a drug: (1) protein structure, (2) molecular structure, and (3) functional groups that are vulnerable to chemical degradation pathways such as hydrolysis, oxidation, and reduction.
2. Appropriate choice of pharmacotherapy based on structural properties:
  - a. Evaluate possible choices of pharmacotherapy based on mechanisms of action and target specificity.
  - b. Evaluate potencies of pharmacotherapy choices based on structure-activity relationships (SAR) and metabolism.
  - c. Evaluate possible drug-drug interactions based on chemical incompatibilities, and solubility concerns when drugs are admixed for oral or intravenous administration.
  - d. Evaluate possible drug-drug interactions based on mechanisms of action.
  - e. Evaluate possible drug-drug interactions based on routes of metabolism and induction or inhibition of metabolism.
  - f. Evaluate the appropriate use of OTC products, and herbal supplements using label information to establish the active ingredient(s). [*R.A.H. note: This competency relates in particular to chemical nomenclature.*]

**Pertinent curricular outcomes addressed by this course among those adopted by the ULM College of Pharmacy in August 2006:**

PROFESSIONAL-PRACTICE-BASED OUTCOMES DIRECTLY IMPACTED (\*; concepts and principles directly applicable) or INDIRECTLY IMPACTED (F; crucial foundational skills)

1. Provide Comprehensive Patient Specific Pharmaceutical Care.
  - A. Evaluate the appropriateness of a given prescription or medication order based on patient and disease-specific factors.
    - i. Analyze the prescription regarding the medication, dose, delivery form, and duration of use as being appropriate for the patient and disease state.
      - a. Collect patient-specific data regarding demographics, medical history, diagnosis, physical assessment, and medication history.
        - 2) Identify and collect pertinent information from the medical chart, database, and/or the patient/caregiver interview.
          - c) \*Recognize appropriate patient- and drug-specific factors that will impact the drug regimen.
        - 4) <sup>F</sup> Collaborate with other healthcare providers.
      - b. Analyze and interpret information gathered to identify any drug-related problem.
        - 1) \*Assess the prescription for interaction potential, including interactions with other medications (both prescription and non-prescription), disease states, foods, and herbals.
        - 2) \*Determine availability and appropriateness of medications and dosage form.
  - B. Evaluate each patient for self-treatment or referral.
    - i. <sup>F</sup> Identify patient signs and symptoms amenable to self-treatment and identify contraindications to self-treatment.
  - C. Develop and implement an evidence-based care plan.
    - i. <sup>F</sup> Identify goals of therapy that are individualized to the patient.
    - ii. <sup>F</sup> Develop a plan of care that includes interventions to resolve drug therapy problems, achieve the goals of therapy, and prevent drug therapy problems.
    - iii. <sup>F</sup> Develop a schedule to follow up and evaluate the effectiveness of outcomes from drug therapies and assess any adverse events experienced by the patient.
    - iv. <sup>F</sup> Evaluate patient outcomes with respect to the achievement of goals of therapy, patient adherence, patient safety, and the development of new drug therapy problems.
  - D. Compound and/or dispense the most optimal formulation for drug delivery consistent with the patient needs and in harmony with the law.
    - ii. \*Identify pertinent patient and drug specific biopharmaceutic issues and select the most appropriate dosage form, route, method of administration, and formulation.
    - iii. \*Identify chemical stability and incompatibility issues (IV sets/fluids).
    - vi. <sup>F</sup> Apply good compounding practices.
    - viii. <sup>F</sup> Administer medications when appropriate.
  - E. <sup>F</sup> Document all activities involved with the provision of comprehensive patient-specific pharmaceutical care.

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## Educational Outcomes, contd

### 2. Communicate Effectively.

- A. Counsel and educate patients regarding medication use, disease-state management, and health maintenance.
  - iv. \*Provide information that empowers patients to effectively manage their medication-related health care.
- B. Develop population-based patient education programs.
  - i. \*Develop disease state educational programs.
- C. Collaborate with other healthcare professionals using appropriate effective communication in both written and oral forms.
  - i. \*Demonstrate fluency in medical terminology.
  - v. \*Present and defend pharmacotherapy recommendations.
- D. Read, write, speak, listen, and use data, media, and computers to send and respond effectively to communications for varied audiences and purposes.
  - i. Construct appropriate and professional presentations to support communication.
    - b. <sup>F</sup> Prepare appropriate and relevant graphical support from available data.
    - e. \*Present and defend ideas in a logical and effective order.

### 3. Appropriately Manage and Use Resources of the Health Care System.

- A. Plan, organize, direct, and control pharmaceutical care systems and human, material, and financial resources utilizing management theories and practices.
  - i. \*Use and evaluate acquisition, inventory control,<sup>#</sup> and distribution systems with appropriate documentation. [<sup>#</sup>i.e., chemistry aspects of stability issues]
  - v. <sup>F</sup> Determine and implement appropriate inventory control methods.<sup>#-see above</sup>
  - viii. <sup>F</sup> Describe humanistic and technological factors involved in the distribution processes.<sup>#-see above</sup>
- B. Apply patient and population specific data, quality assurance strategies, and research processes to:
  - i. Assure that medication use systems minimize drug misadventures and optimize patient outcomes.
    - d. \*Distinguish between patient and population specific data.
    - e. \*Collect, analyze, and interpret patient and population specific data.
    - f. <sup>F</sup> Make appropriate recommendations based on data interpretation.
  - ii. Develop drug use and health policy to manage pharmacy benefits.
    - i. <sup>F</sup> Develop disease-specific treatment algorithms/pathways for a health care system.
- C. Ensure efficient, cost-effective utilization of human, physical, medical, informational, and technological resources in patient care.
  - iv. \*Identify and manage risks associated with the practice of pharmacy.
  - v. <sup>F</sup> Apply CQI principles to the pharmaceutical care practice.

*(contd next page)*

## Educational Outcomes, contd

4. Identify, Interpret, and Evaluate Literature Needed for the Provision of Drug Information and Pharmaceutical Care.
  - A. \*Define the question that needs to be answered.
  - B. \*Distinguish among lay, professional, and scientific literature.
  - D. <sup>F</sup> Explain the method to construct an appropriate search strategy for various literature types.
  - E. <sup>F</sup> Evaluate literature source validity.
  - G. <sup>F</sup> Evaluate the appropriateness of research methodologies and statistical methods.
  - H. \*Draw appropriate conclusions from research results.
  - I. <sup>F</sup> Assess the potential impact and implication of published information on current practices.
  
6. Think Critically.
  - A. Identify, retrieve, understand, analyze, synthesize, and evaluate information needed to make informed, rational, and ethical decisions.
    - i. \*Systematically gather, organize, and extract relevant information using a variety of methods and research tools.
    - ii. Analyze information within appropriate scientific, social, and clinical contexts.
      - a. \*Identify principles of organization and the logic of arguments.
      - b. \*Identify and test assumptions, biases, and prejudices implicit in arguments.
      - d. \*Assess accuracy, soundness, fairness, significance, relevance, completeness, and persuasiveness of information, arguments, and sources.
    - iii. \*Synthesize information in order to draw conclusions, hypothesize, conjecture alternatives, or plan a course of action.
    - iv. \*Evaluate conclusions and solutions according to appropriate criteria, and revise as necessary.
    - v. \*Provide support for rationale, solutions, and results.
  - B. Solve complex problems that require an integration of one's ideas and values within a context of scientific, social, cultural, legal, clinical, and ethical issues.
    - i. \*Interpret problems within appropriate contexts.
    - ii. \*Prioritize problems based on identifiable criteria and standards.
    - iii. \*Apply systematic problem-solving strategies.
    - iv. <sup>F</sup> Articulate and implement a defensible solution and apply appropriate criteria to monitor outcomes.
    - v. <sup>F</sup> Implement modifications based on monitoring data.
  - C. Display habits, attitudes, and values associated with mature critical thinking.
    - i. \*Evaluate personal assumptions, biases, prejudices, and opinions.
    - ii. \*Display an openness to new ideas and a tolerance for ambiguity.
    - iii. \*Display inquisitiveness and commitment to the pursuit of truth.