An Integrated Infectious Disease Course For An Entry-Level Doctor of Pharmacy Curriculum

J. Warren Beach, James W. Cooper, George E. Francisco and R. Alan Langford
College of Pharmacy, The University of Georgia, Athens, GA 30602-2351

An integrated introductory infectious disease course that incorporates pertinent clinical microbiology, anti-infective medicinal chemistry and drug treatment of common infectious disease entities, along with an applied microbiology skills laboratory was developed and begun in Fall semester 1996. The course is taught by four faculty members with medical, pharmacy practice, and medicinal chemistry training. There are 40 lectures and five exams. The course is divided into four weeks of microbiology, six weeks of medicinal chemistry, and five weeks of disease therapeutics. This course is part of an integrated year long sequence of medicinal chemistry, pharmacology, pharmaceutics, and therapeutic applications. The course content and delivery were assessed using an instrument made up of course objectives and topic headings.

INTRODUCTION

The entry-level Doctor of Pharmacy curriculum of the University of Georgia College of Pharmacy was begun in Fall 1995. The majority of courses are coordinated in such a way that the same or similar topics are covered from different perspectives. For example, in the first professional year, biochemistry, physiology, and pathophysiology are topic-coordinated. In the second professional year, the pharmacodynamic agents are covered in medicinal chemistry, pharmacology, and disease management (therapeutics) in this same topic-coordinated fashion.

However the agents used to treat infectious diseases

Table I. Microbiology section topics

Introduction/nomenclature/classification
Prokaryotic vs. Eukaryotic organisms
Normal Flora vs. Colonization vs. Pathogenic organisms
Microscopic Exam/Stains (esp. Gram stain)
Bacterial cell walls Microscopic
Appearance of Bacteria (cocci, bacilli, etc.)
Bacterial Structures
Culture media
Microbial Mechanisms of Pathogenicity
Gram. Pos. Cocci (Staph, Strep, etc.)
Endospore - forming Gram Pos. Rods
Non-Sporing Gram Pos. Rods
Mycobacteria
Actinomyces
Spirochetes
Helical Bacteria
Gram Negative - Coccobacilli
Gram Negative - Aerobic Rods
Facultatively Anaerobic Gram Neg. Rods
Rickettsiae/Chlamydiae
Mycoplasma
Fungi, yeasts
Protozoa
Helminths/Nematodes
Arthropods
Viruses
Mechanisms of Bacterial Resistance to Antibiotics

Table II. Antibacterial, antibiotic, antifungal and antiviral agents

I Antibacterial
A. Sulfonamides
B. Dihydrofolate Reductase inhibitors
C. Nitrofurans
D. Quinolones and Fluoroquinolones
E. Metronidazole
II Antibiotics
A. Penicillins
B. Cephalosporins
C. Carbapenems
D. Monobactams
E. Aminoglycosides
F. Macrolides
G. Clindamycin
H. Tetracyclines
I. Vancomycin
J. Antimycobacterium Agents
III Antifungal
A. Amphotericin B
B. Flucytosine
C. Azoles and Triazole
D. Griseofulvin
E. Allylamines
IV Antiviral Chemotherapy
A. Anti-AIDS
1. Nucleoside Reverse Transcriptase Inhibitors
2. Non-Nuclcoside Reverse Transcriptase Inhibitors
3. HIV Protease Inhibitors
B. Anti-herpetic Agents
C. Miscellaneous Antiviral Agents

cannot be approached in this horizontal manner. In order to make an appropriate drug selection for the treatment of an infectious disease one must have an understanding of the organisms that cause disease and the mechanism of action, spectrum of activity, distribution, and toxicities of all available therapeutic choices. In addition, the selection of an anti-infective agent is also based on a number of criteria including patient specific factors, organism specific factors, and infection site factors.

The present infectious disease course is designed to give the student the necessary information and knowledge to make therapeutic assessments and decisions related to the treatment of infectious diseases. In addition, this course builds on 16 hours of lecture material presented in the physiology and pathophysiology courses of the first professional year. It also serves to prepare students for the third professional year in which they will begin to formulate therapeutic plans.

The infectious disease course is divided into four parts: (*i*) Microbiology Section: (*ii*) Drug Section; (*iii*) Disease Section; and (*iv*) Skills Laboratory. Each of the first three sections acts as a foundation for the next and uses information imparted in the previous section. The skills laboratory gives the student a hands-on integration and application of all three areas. We are not aware of other published papers on this integrated approach to teaching infectious diseases.

THE MICROBIOLOGY SECTION

Prior to the adoption of our new entry-level PharmD curriculum in 1995 students were required to take a five quarter-hour microbiology course offered by the Department of Microbiology at this University. This course was offered three times a year and approximately one-third of the class enrolled in the course at each offering. The course content varied during these offerings from introductory medical microbiology to the microbiology of noninfectious organisms. Due to these inconsistencies in the microbiology course content, this section was incorporated into the infectious disease course within the College of Pharmacy. This section is four weeks (11 lectures and one exam) in length and covers the fundamentals of basic microbiology as it applies to pharmacy practitioners. The material was first presented by a pharmacist infectious disease specialist from an area hospital who moved to another job and could not continue these lectures. Subsequently, a physician educator who is board-certified in dermatology and based part-time within the College, offered these lectures (RAL). This transition from microbiology outside to inside the College gave the students a more consistent knowledge base and an better understanding of subsequent sections of the course. The microbiology material was not just a collection of facts to be memorized but information that had applicability. Four primary areas were emphasized: (*i*) bacterial cellular morphology and function; (*ii*) bacterial taxonomy; (*iii*) microbial resistance mechanisms; and (*iv*) common microbial pathogens implicated in human disease. An outline of this section is shown in Table I.

The first part of this section is used to present bacterial features used to identify and classify bacteria such as shape, size, arrangement, chemical activities, nutritional needs, physical conditions needed for growth, staining behavior, and laboratory tests used to determine these traits and antibiotic susceptibility. In addition, the types of cultures (sputum, throat, etc.) used to isolate the suspected organisms and problems associated with them are also presented. The next part presents information about bacterial charac-

Table III. Disease section, goal, objectives and topics

Goal: to orient the student to the most common infectious diseases assessment, treatment and outcomes.

Objectives:

1. Learn the most common microbes found on or within the body.
2. List the most common pathogens by site(s) and type of infection.
3. Describe the common presenting signs, symptoms, and lab tests used to assess ID entities covered. Physical and laboratory assessment and disease states and conditions that predispose, as well as mimic and mask infections. Incubation periods for common infectious diseases.
4. Differentiate the preferred and alternative antimicrobial agents for the ID entities covered.; differentiate time vs. concentration dependent killing of microbes by anti-infective class; postantibiotic effect.
5. Recognize most common infectious disease appropriate antimicrobial usage and effect and undesirable effects of agents covered.
   a. Anti-infective to include beta lactams, macrolides and lincomycin, tetracyclines, aminoglycosides, vancomycin, teicoplanin, Syncercid, antifungals, antituberculars and PPD, chloramphenicol, fluoroquinolones, UTI anti-infectives, metronidazole, antivirals, AIDS primary and secondary drugs
   b. Upper respiratory tract and Eye infections. Colds, flu, pharyngitis, sinusitis, otitis extena and media (and allergies); bacterial vs. viral vs. allergic conjunctivitis, bacterial blepharitis
   c. Lower respiratory tract infections. Bronchitis in COPD and healthy patients. Typical and atypical pneumonias, community-acquired, nosocomial-hospital-nursing facility; epiglottitis and bronchitises in children, tuberculosis
   d. Urinary tract infections. Upper vs. lower, Acute vs. chronic, host factors, age and sex, prostatitis, uncomplicated vs. complicated, symptomatic vs. asymptomatic, (catheter-associated problems), laboratory findings to rule-out colonization vs. active infection.
   e. Sexually transmitted diseases. Gonorrhea, syphilis, pelvic inflammatory disease, chlamydia, chancroid, bacterial vaginosis, trichomoniasis, genital herpes and warts.
   f. AIDS, detection, stages, markers, therapy by stages and treatment of infectious complications, and prognosis. Virion loads and three vs. four-drug regimens.
   g. Skin and soft tissue infections. Cellulitis, folliculitis, furunculosis and carbuncles, erythrasma, erysipelas, impetigo, lymphangiitis, infected pressure sores, venous stasis and diabetic ulcers, IV drug abuse-associated exanthems, infected bite wounds, cat scratch fever, burn wound infections, fungal skin infections, and scabies
   h. Infectious gastroenteritis, bacterial, viral, food poisoning, Travelers diarrhea, rehydration and treatment, pseudomembranous colitis, E-coli, salmonella and shigella.
   i. Bone and joint infections, osteomyelitis, septic arthritis and infections associated with prosthetic devices.
   j. Fungal infections. Antimycotics, superficial and cutaneous mycoses, systemic mycoses to include Candida, Blastomycosis, Histoplasmosis, Coccidiomycosis, Aspergillosis and Cryptococcoses.
   k. Viral infections. Antivirals and Herpes viruses, Influenza, Varicella zoster, cytomegalovirus, respiratory syncytial virus and Hantavirus.
   m. Parasitic infections. Malaria, Amebiasis, Giardiasis, Enterobiasis, Cestodiasis, Pediculosis and Scabies.
   n. Vaccines, Toxoids, and other immunobiologics. CDC recommendations by age, travel, occupation and current immunization status.
   o. Immunotherapy and infectious disease. Immune modulation of response to infectious disease in the immune-competent and immune-incompetent host. Sepsis an>‘ anti-endotoxin monoclonal antibodies, anti-cytokine antibodies, circulating inhibitors, receptor-bradykinin and nitric oxide inhibitors, hematopoietic growth factors (G-CSF, GM-CSF), M-CSF) and interferons.
   p. Central nervous system (CNS) Infections- meningitides by age groups and brain abscess,
   q. Cardiovascular infections. Valvular infections, endocarditis, and prophylaxis.
6. State basic patient education needed for anti-infective usage. Timing of anti-infective with meals assessing compliance and preventing the most common adverse reactions and interactions.

teristics that promote the development of infection or pathogenicity such as adherence to host cells, invasiveness, production of toxins, and enzymes and the ability to evade the host immune system. This is followed by mechanisms of bacterial resistance to antibiotics. These include alterations in antibiotic uptake and efflux, which may lead to reduced antibiotic accumulation and the production of inactivating enzymes such as beta lactamases and alterations in the target site of the antibiotics such as the penicillin binding proteins or the ribosomes. The ability of bacteria to transfer resistance from one organism to another through the exchange of genetic information (plasmid) is also presented.

To conclude the introductory microbiology section the most common causative organisms are covered. For each organism the morphology and laboratory tests used to differentiate organisms are presented as well as their usual site(s) of infection. In addition common microbial resistance patterns and the antibiotics most often used in resistant strains were presented.

THE DRUG SECTION

This section is taught by a medicinal chemist who is also a pharmacist (JWB), and is six weeks (16 lectures and two exams) in length. This section covers the antibacterial agents, antibiotics, antifungal agents, and antiviral agents. The topic outline is shown in Table II. For each class of agents, general attributes of the class such as the mechanism of action, chemical basis of the compounds resistance to inactivation by bacterial produced enzymes, structural features which influence chemical stability, absorption, metabolism and elimination, and structure-activity relationships are covered. General anti-infective spectrum of the class, such as mostly Gram positive mostly Gram negative or mixed broad spectrum, and class-specific information on stability, drug interactions, and toxicities are presented. This is followed by compound-specific information for the individual agents such as absorption, distribution, metabolism, elimination, stability, and significant drug interactions and toxicities. This material along with patient specific information allows the student to begin to make rational therapeutic choices

Table IV. Objectives for the microbiology skills lab

At the conclusion of this two-week lab, the student should be able to:

1. Describe the processing of a specimen in the clinical microbiology lab with respect to:
   a. Receiving the specimen
   b. Handling the specimen
   c. Working up the specimen
      - selecting appropriate media
      - culturing
      - staining
      - incubating
   d. Identifying organisms
   e. Performing sensitivities
2. Interpret clinical microbiology lab reports verbally and in writing.
   a. Differentiate between a preliminary and final report.
   b. Determine the significance of the culture results based on the patient's age, gender, type of specimen, site from which the specimen was obtained, number of organisms identified, type of organism identified, and pathogenicity of the organism.
   c. Interpret the significance of the growth of the organism as stated on the report.
   d. Interpret the sensitivity of organisms to various antibiotics against which they are tested
   e. State the reason for using different antibiotic panels for testing various organisms.
   f. Interpret mean inhibitory concentration (MIC) data and relate this to antibiotic concentrations.
   g. Select appropriate antibiotic(s) based on the organism, location of infection, and the MIC.
3. Describe situations in which the pharmacist interacts with the clinical microbiology lab.

when they are formulating a pharmaceutical care plan in the final part of the course.

THE DISEASE SECTION

The disease section consists of five weeks (14 lectures and two exams) and is taught by a pharmacy practice faculty member (JWC). This section integrates the anti-infective microorganisms by body site, and common infections by organ system. Table III lists the goal and objectives for this section as well as topics by objective. An additional optional assignment for the use of the text, Cases in Medical Microbiology and Infectious Disease(1) to compliment the reading assignments in Applied Therapeutics(2) is encouraged. The case studies book by Gilligan *et al.* was also used as an elective offering after course completion. Students in this elective course were required to write an acceptable therapeutic plan for each of the 66 cases presented.

The disease section attempts to give the student the best approach to recognizing and treating the most common infections that might present to them for assessment in community settings as prescriptions, or institutional settings as therapeutic selections. The basic philosophy is that pharmacists should be able to assess and treat the most common infections of the respiratory, genitourinary, gastrointestinal, musculoskeletal, cardiovascular, and central nervous as well as integumentary systems. Students should also recognize both appropriate and inappropriate anti-infective and immunologic prophylaxis and treatment of all common infections. The students are given cases of therapeutic problems with the usage of anti-infective agents.

This disease section is intended as an introduction to infectious disease treatment as part of an integrated drug and disease state management emphasis of the second year curriculum. Students within their third professional year will receive an additional 22 lecture hours in infectious disease assessment and pharmacotherapeutic planning using the text, *Pharmacotherapy: A Basic Pathophysiologic Approach(3)* before their clerkship year.

THE SKILLS LABORATORY

In tandem with the classroom instruction is a laboratory experience taught by another pharmacy practice faculty member (GEF). This section contains basic microbiology and pharmaceutical care components. Many pharmacy curricula require a basic course in microbiology as part of the pre-professional or professional course work. While the laboratory portion of these courses reinforce some of the concepts taught in class it is usually time-consuming and is not applicable to most pharmacy practice settings. Moreover, few microbiology courses or labs teach students practical information about how to process a patient's specimen or how to interpret culture and sensitivity reports. It was therefore decided to design a microbiology laboratory experience whereby students would be taught basic microbiological techniques via videotape and would be taught to interpret laboratory results through active interpretation and discussion of actual patients' culture and sensitivity reports.

The specific goals for the microbiology portion of the skills lab are listed in Table IV. During the first week students watch a video of how biologic specimens are collected and processed. This "home video" was made by the medical technologists at one of the local hospitals and was filmed on-site in the hospital's microbiology lab. The students are introduced to concepts of collecting specimens, selecting appropriate media in which to inoculate the bacteria, gramstaining, incubating, and interpreting preliminary and final results. The video also demonstrates manual and automated methods for bacterial sensitivity testing. In addition students are introduced to various means of identifying viruses and other non-bacterial microorganisms.

At the end of the first lab session each student is given a copy of an actual patient's final microbiology culture and sensitivity report. The students' homework assignment before the next lab is to interpret the report and be prepared to discuss the organism(s) identified, specific patient characteristics that may be of importance in determining the etiology of the infection, how commonly the organism causes this type of infection, and which antibiotic regimen would be suitable to treat the infection. The student should also be able to answer verbal questions regarding the media selected for inoculation, why certain antibiotics were or were not tested for susceptibility, and the parameters utilized to determine whether the antibiotic regimen is effective. During the next laboratory session each student gives a five-minute presentation on his/her patient s report and answers questions from classmates or the instructor. Each student has a copy of all the laboratory reports and makes notes on the reports during their peers presentations. At the conclusion of the lab period, everyone is given another case to interpret and can use the information presented during the discussion to answer questions about the case. Students are

Table V. Infectious disease course objectives survey

A. This was not taught and I cannot perform this task/operation
B. This was taught but I cannot perform this task/operation
C. This was not taught but I can perform this task/operation
D. This was taught and I can perform this task/operation

Objectives Related to the Microbiology and Skills Lab Section

Describe characteristics/methods used to identify and classify bacteria

2nd Y n=62	A	B 8.1	C	D 9
3rd Y n=27	A 18.5	B 40.7	C	D 40.7

Describe characteristics/methods used to identify and classify fungi

2ndY	A 12.9	B 23	C 1.6	D 45.2
3rdY	A 48.1	B 48.1	C	D 3.8

Describe the processing of a specimen in a clinical microbiology lab.

2ndY	A 1.6	B 17.7	C 3.2	D 74.2
3rdY	A 7.4	B 37.0	C 3.7	D 51.9

Describe the types of associated with specimens usually obtained from patients.. to identity an organism causing an infection and problems associated with each

2ndY	A	B 8.1	C 1.6	D 83
3rdY	A 7.4	B 18.5	C	D 74.1

Describe bacterial characteristics that promote pathogenicity or development of infection

2ndY	A 1.6	B 14.5	C 1.6	D 7'9
3rdY	A	B 29.6	C 3.7	D 55.6

Describe mechanisms of the development of resistance to antibiotics

2ndY	A 1.6	B 1.6	C	D '93.5
3rdY	A 7.4	B 11.1	C 3.7	D 66.7

Describe the morphology and laboratory tests used to differentiate common infection causing organisms

2ndY	A 8.1	B 27.4	C 1.6	D 56.5
3rdY	A 25.9	B 40.7	C 3.7	D 33.3

Objectives Related to the Medicinal Chemistry Section

Describe the mechanism of action of an antibiotic or antibiotic class.

2ndY	A	B 9.7	C	D 87.1
3rdY	A	B 44.4	C	D 55.6

Describe common side effects associated with an antibiotic or antibiotic class.

2ndY	A	B 3.2	C	D 93.5
3rdY	A	B 14.8	C 3.7	D 81.5

Describe the spectrum of activity of an antibiotic or antibiotic class.

2ndY	A	B 30.6	C	D 66.1
3rdY	A	B 59.3	C	D 40.7

Describe common drug-drug, drug-food interactions associated with an antibiotic or antibiotic class.

2ndY	A	B 3.2	C	D 93.5
3rdY	A	B 7.4	C	D 81.5

Describe structural features of an antibiotic or antibiotic class that impart resistance to bacterial inactivation.

2ndY	A	B 17.7	C	D 79.0
3rdY	A 3.7	B 63.0	C	D 33.3

Objectives Related to the Disease Section

Identify bacteria that are normal flora.

2ndY	A 1.6	B 17.7	C	D 77.4
3rdY	A	B 14.8	C	D 85.2

List the most common pathogens given the site of infection and/or type of infection.

2ndY	A 1.6	B 25.8	C	D 69.3
3rdY	A 7.4	B 14.8	C	D 59.3

Select the appropriate antibiotic(s) based on organism and site of infection.

2ndY	A	B 32.3	C	D 64.5
3rdY	A	B 63.0	C	D 37.0

Select an alternate antibiotic based of patient specific factors.

2ndY	A 3.2	B 24.2	C	D 69.3
3rdY	A 11.1	B 48.1	C	D 37.0

Describe appropriate prophylactic therapy for a given situation.

2ndY	A 4.8	B 27.2	C 1.6	D 62.9
3rdY	A 11.1	B 48.1	C 3.7	D 33.3

Determine the appropriateness of an antibiotic regimen based on organism specific, disease or infection site specific and patient specific information.

2ndY	A 8.1	B 21.0	C 1.6	D 66.1
3rdY	A 11.1	B 48.1	C 3.7	D 40.7

given one week to complete this assignment.

Other laboratory sessions during the semester focus on OBRA '90 requirements as they pertain to antibiotic drug use evaluation and patient counseling. Using simulated patient profiles, students are expected to detect drug interactions (*e.g.*, those associated with rifampin or erythromycin) and to determine an appropriate course of action to resolve the problem. Students are also given various other situations which require recognition of potential drug-related problems and intervention by the pharmacist. These include the need for pyridoxine with INH, an oral or topical decongestant for acute sinusitis, and the recommendation of an alternative birth control method for patients taking oral contraceptives and certain antibiotics.

Students also focus on skills to prepare and dispense antimicrobial agents. Examples include preparation of parenteral dosage forms and oral liquids and suspensions. Finally, students must be able to counsel patients on each drug product as outlined in the OBRA 90 requirements.

EVALUATION OF COURSE CONTENT AND DELIVERY

In order to evaluate the method of delivery and content of the infectious disease course a survey was administered to the third year PharmD students(N = 27) who took the course in Fall semester, 1996, and the second-year students (N = 62) who took the class in the Fall semester, 1997. This survey was administered to both classes during the Winter/Spring semester 1998 and contained items derived from the course objectives and topic headings. These items are shown in Table V and are divided into three groups: (*i*) those related to the microbiology/skills lab section; (*ii*) those related to the medicinal chemistry of antibiotics section; and (*iii*) those related to the disease section.

In the microbiology section, an average to 94.2 percent of the respondents in the second year class and 59.3 percent in the third year class said that they were taught these objectives with an average of 77.3 percent (2nd Y) and 47.8 percent (3rd Y) saying that they could perform these tasks/ operations. One hundred percent of the respondents in the second year class and 97.7 percent in the third year class said that they were taught the medicinal chemistry related objectives with 86.7 percent (2nd Y) and 59.3 percent (3rd Y) saying that they could perform these items. In the disease section, an average of 91.9 percent of the respondents in the second year class and 92.9 percent in the third year class said that they were taught these objectives with an average of 88.7 percent (2nd Y) and 48.4 percent(3rd Y) saying that they could perform them. The lower percentage of third year students who felt that they could perform these tasks may be related to the fact that when the survey was given, it had been more than a year since they had finished the infectious disease course and they had not started the infectious disease section of pharmacotherapy which would reinforce the information taught in the previous year. Thus, this may be not so much a lack of knowledge base as it is a lack of confidence in their knowledge of the material. This may be due to a lack of repetition of the material in other classes. For example, the side effects, drug interactions, and the appropriateness of the dose are covered in dispensing laboratory exercises but not the spectrum of activity of the antibiotic or its appropriateness for the infection being treated.

The students were also given a chance to offer comments concerning their overall impression of the course. The following are a few selected responses:

- "The manner in which the course was organized made learning the information easier."
- "I learned a lot from the way the course was designed. It was helpful having the bugs, then the drugs and then putting them together."
- "I felt this course was one of the most important in my pharmacy career. Antibiotics and antimicrobials are among the most prescribed drugs today, and pharmacists are increasingly on the front line of therapy with these drugs. I feel as though I can converse knowledge - ably with physician, patients and other health care workers. I also feel I can make recommendations to physicians when an alternative agent is needed."

CONCLUSION

This paper describes the design of an infectious disease course which incorporates medical microbiology as it applies to the pharmacy practitioners, the medicinal chemistry of the agents used to treat infectious disease and the therapeutic use of the agents. Each section of the course builds on the next allowing the student to see the relevance of the material being covered.

The survey which was used to evaluate the course has identified some potential problem areas, which will be addressed in future offerings of the course. Additional drill and outside class assignments should increase the student confidence in these areas.

Acknowledgments. The authors wish to thank the second and third year classes for their help with the survey.

Am. J. Pharm. Educ., **62**, 296-301 (1998);received 2/28/98, accepted 6/9/98.

Reference

(1) Gilligan, P.H., Smiley, M.L. and Shapiro, D.A., *Case Studies in Medical Microbiology, 2nd ed.* American Society for Microbiology, Washington DC (1997).

(2) Applied Therapeutics, *The Clinical Use of Drugs, 6th ed.,* (edit., Young, L.Y. and Koda-Kimble, M.A.), Applied Therapeutic, Inc. Vancouver WA (1995).

(3) *Pharmacotherapy, A Basic Pathophysiologic Approach. 3rd ed.* (edit., DiPiro, J. *et al),* Appleton and Lange, Stamford CT (1997).

This course is relevant for infectious diseases specialists, infectious diseases trainees, internists, pharmacists, hospitalists, and clinical infectious diseases researchers. The content will also benefit physician assistants, nurse practitioners, nurses, family physicians and clinical microbiologists with interest in managing patients with infections. Learning Objectives. Explain the diagnosis and management of tick-borne diseases.Â AMA Mayo Clinic College of Medicine and Science designates this live activity for a maximum of 29.50 AMA PRA Category 1 Creditsâ„¢. Physicians should claim only the credit commensurate with the extent of their participation in the activity. Session Breakdown. AMA Credits.