

Review

Status of medical mycology education

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The number of immunocompromised patients and subsequent invasive fungal infections continues to rise. However, the education of future medical mycologists to engage this growing problem is diminishing. While there are an increasing number of publications and grants awarded in mycology, the time and detail devoted to teaching medical mycology in United States medical schools are inadequate. Here we review the history in medical mycology education and the current educational opportunities. To accurately gauge contemporary teaching we also conducted a prospective survey of microbiology and immunology departmental chairpersons in United States medical schools to determine the amount and content of contemporary education in medical mycology.

Keywords mycology education, mycology teaching

Introduction

Medical advances in the treatment of life-threatening diseases, such as new and aggressive chemotherapeutic regimens, the increasing frequency of bone marrow and solid organ transplantations, and the AIDS pandemic have contributed to the growing number of immunocompromised patients and the steady rise in the incidence of fungal diseases [1]. There have been steady increases in both the number of opportunistic fungal infections [2], and the range of implicated fungal agents. Indeed, for the immunocompromised host, the concept of a non-pathogenic fungus is more difficult to define [3]. The available armamentarium of newer antifungal agents and cytokine therapies has also increased and may offer new options for the treatment of infections with both established and emerging fungal

pathogens. The number and types of treatments for fungal pathogens have increased so markedly in the last few years and so permeated all clinical fields that present and future clinicians and researchers require a heightened awareness and depth of knowledge of medical mycology.

Unfortunately, despite the plethora of evidence that the mortality from invasive mycoses is increasing [4], there is also a perception that training and research programs in medical mycology are decreasing in structure and scope, creating a lack of adequately trained individuals [5]. Although the consensus is that future clinicians are receiving less and less exposure to these increasingly mortal infectious diseases, there are scant data on United States medical school training in mycology. We compiled and analyzed the available data on mycology-related grants, publications, and educational opportunities. We also surveyed medical school microbiology and immunology departmental chairpersons about the extent and characteristics of formal instruction in medical mycology at their institutions.

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History of medical mycology education

Dr. Ana Espinel-Ingroff traced the development of medical mycology training and research in the USA from the late 1800s to the 1990s [6]. The early leaders in medical mycology were often botanists who were familiar with fungal plant pathogens (Fig. 1). These general mycologists subsequently learned about human disease from clinical descriptions rather than direct experience [7]. The pioneering clinical mycologists were pathologists or dermatologists who knew little of medically important fungi, failed to appreciate the mycologist's emphasis on taxonomy, and were frustrated by the renaming and reclassifying of fungi [7]. The pathologists first reported *Cryptococcus neoformans*, *Histoplasma capsulatum*, *Blastomyces dermatitidis*, and *Coccidioides immitis*, while dermatologists provided the first descriptions of *Candida* and the dermatophytes. Most early publications were illustrated with numerous drawings and photographs and consisted of lengthy, detailed descriptions of lesions, tissue reactions, culture results, and experimental infections [6]. In the early era, the lack of knowledge of medically important fungi was a major reason that the etiologies and clinical entities were often misunderstood and erroneously named. In addition, the prevalence and importance of medical mycotic infections was unknown and unappreciated [7].

As modern medical schools evolved in the United States, the transition from general to medical mycology as a distinct branch of microbiology resulted from the seminal efforts of the pioneering medical mycologists – Norman F. Conant, Charles E. Smith, Lorraine Friedman, Howard Larsh, Rhoda Benham, Libero Ajello, and Chester Emmons.

Medical mycology education crisis

After the 1970s, the increased incidence of fungal diseases in immunocompromised hosts stimulated awareness and growth in medical mycology. In the 1950s and 1960s, antifungal therapy was generally limited to amphotericin B, nystatin, and 5-fluorocytosine. With recognition of the increasing prevalence of opportunistic mycoses, antifungal drugs were resurrected from the status of orphan drugs. Industry responded by developing new antifungals, sponsoring conferences on antifungal chemotherapy, and raising public awareness of medical mycology as an important and distinctive discipline. Recent advances in molecular biology, cellular immunology, and genetics have promoted research to combat the increased virulence and resistance of fungi to antifungal therapies [6]. Research in medical mycology accelerated in industry, government, and academia, but medical student teaching continued to be neglected. Indeed, for modern clinical and basic scientists, teaching is a disincentive as it

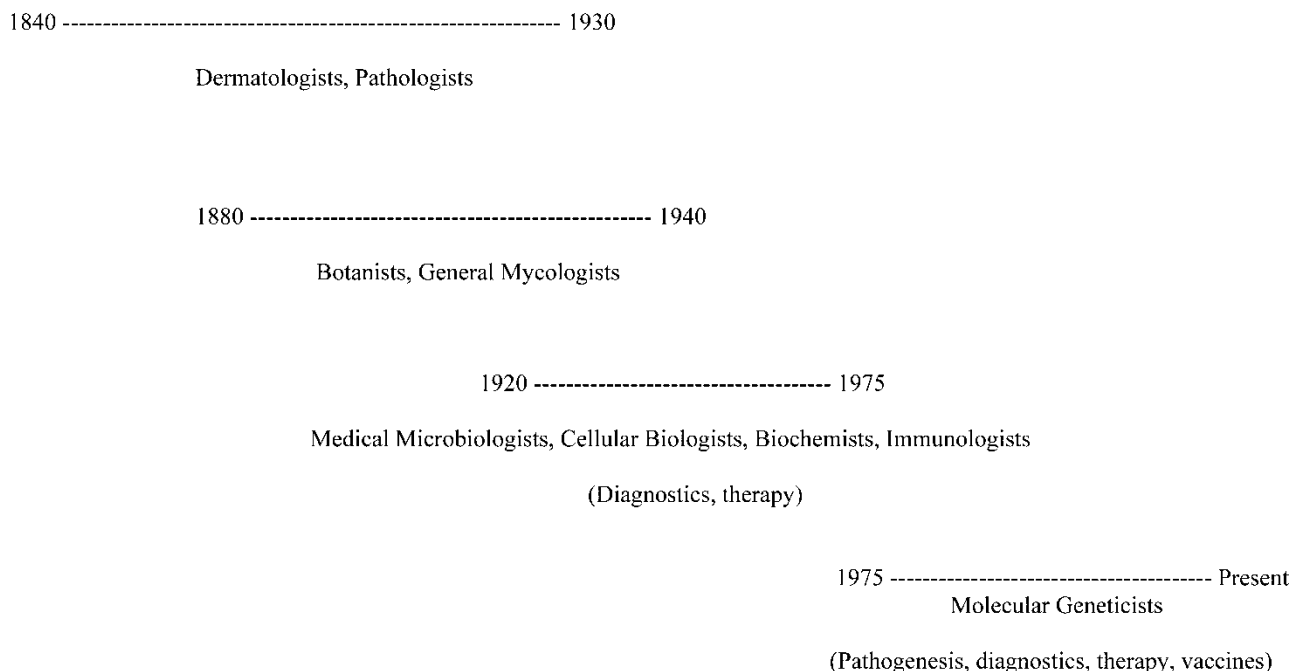


Fig. 1 Timeline of medical mycologists.

detracts from the time that is needed to secure grants and maintain research programs [7]. Reflecting this priority, most research-oriented medical schools do not consider teaching among the criteria for promotion.

In 1994 an open-ended informal 23-question questionnaire was distributed to 275 US members of the Medical Mycology Society of the Americas (MMSA) and 36 members of the National Institute of Allergy and Infectious Diseases – Mycoses Study Group (NIAID-MSG). The questionnaire's purpose was to assess the historical development of medical mycology in the US. There were 109 (35%) respondents [5]. One question addressed the current state of medical mycology in the US, including education and training. Most respondents felt there was a "training crisis", primarily because of the lack of adequate training programs, courses, and seminars at all levels. They noted that education and training in medical mycology was underemphasized and there was a decline in the number and quality of diagnostic laboratories with trained personnel [5].

This survey also revealed that 90.5% of medical mycologists spent some of their professional time engaged in medical mycological research. Although 84.8% were involved in teaching, most (74.3%) spent less than 25% of their time on formal teaching. Additionally, 10.5% of mycologists spent 26–75% of their time on informal teaching. A total of 38.1% spent some time in patient care, but most spent less than 25% of their time with patients [5].

Medical mycology education in other countries

Little is known about the mycological education of medical students in other countries. Dr. Graybill [8] distributed a mycology education questionnaire to 15 colleagues and received 13 responses, from the USA (4), Italy (3), and Argentina, Colombia, Israel, Japan, the Philippines, and Thailand. Eight respondents indicated that they had PhD students engaged in mycology research projects, and 10 supervised medical students conducting similar research. All programs had pre-clinical training in medical mycology, and seven apportioned some time in the clinical courses to mycology. Clinical manifestations, diagnostics, systemic mycoses, and dermatomycoses were heavily emphasized. Only half the respondents (6/13) felt there was sufficient mycology teaching, and just one indicated that the level of mycology teaching was appropriate for the clinical years.

Medical mycology education and training in developing countries was explored in a survey of MBBS students [9]. In most medical colleges in India, mycol-

ogy generally comprised one or two lectures and two to three hours of practical demonstrations. However, some institutions offered 5–10 hours of lectures and demonstrations. A few medical schools undertook 15–30 hours of teaching or offered a month-long course for medical students. In medical schools with active diagnostic mycology laboratories, the students had supervised postings in clinical mycology for one or two months to learn basic techniques. In West Africa, the survey revealed that most medical schools devoted very little time to medical mycology. Even postgraduate medical students generally received only a few hours [9]. In Argentina, mycology was included within microbiology [10], and most medical schools emphasized bacteriology and virology. Although there are no uniform or mandated standards for curricula in Argentinian medical schools, teaching has recently improved and currently an average of 20–40 hours is devoted to mycology, which is evenly divided between lectures and practical demonstrations.

Past medical mycology educational opportunities

The emphasis accorded medical mycology education is often influenced by political, economic and social factors. In the US, fiscal priorities of the health insurance industry have resulted in the elimination of PhD-trained clinical mycologists and expert diagnostic reference laboratories. Indeed, most hospital laboratories now typically cede fungal diagnostics to rotating medical technologists with a few years of technical training, a mycology laboratory manual, and commercially-available identification products. Unlike some areas of laboratory medicine, with present technology mycology simply cannot be automated or given to instrumentation because skill and expertise remain essential.

While the need for mycological expertise has increased, the number of students enrolled in clinical laboratory programs has decreased [11]. According to a 1998 survey of 605 laboratories registered to perform mycology testing, only about half sent staff members to any mycology training programs during the four-year survey period [12], possibly because training budgets are limited and allocated preferentially for microbiological areas with higher volumes of service [13]. We found only two other surveys of mycology education in US medical schools, and they were embedded in a larger effort to investigate microbiology and immunology curricula and included no substantial data about mycology [14].

The Association of Medical School Microbiology and Immunology Chairs (AMSMIC) has biennial

educational strategy meetings that routinely include sessions on curriculum and content in all areas of microbiology and immunology. A survey in 1992 by AMSMIC found an average of 4.9 hours devoted to lectures and conferences and 1.4 hours to laboratory instruction on mycology in medical school curricula [15] [16]. The two largest subcategories were “cutaneous mycoses” and “systemic mycoses,” each garnering 1.4 hours, while “antifungal agents” averaged 38 minutes of instructional time. Similar to AMSMIC, the International Association of Medical Science Educators (IAMSE) promotes and provides resources for medical education, but it has never addressed medical mycology.

Mycological societies have long been interested in medical mycology education, but they have evinced limited resources and modest accomplishments. In 1997, the International Society for Human and Animal Mycology (ISHAM) proposed to create a committee on mycology education, but that group never generated any recommendations. Unfortunately the lack of an educational template is probably a question of time and resources. Furthermore, ISHAM is international in scope, and it would be difficult to develop a universal model. Rather, ISHAM promotes medical mycology education by supporting periodical workshops around the world. For about ten years, the Medical Mycological Society of the Americas had sponsored an educational program in conjunction with the annual national meeting of the American Society for Microbiology (ASM). Similarly, the ASM in the past offered several traveling workshops per year on fungal topics, each lasting one to two days, but these were eliminated in the early 1990s and have been replaced with regional meetings. For example, every year or so, organizations such as the Southeastern Association of Clinical

Microbiology will include a talk on mycology at the annual meeting.

For in-depth training in the past, the Duke Summer Mycology Course was a premier, comprehensive four-week course in clinical mycology. It existed from 1948–1973 and 1975–1992, and consisted of a daily mixture of lecture and laboratory training. During its last 15 years, the course was attended by an average of 21 students each year (Table 1). Although most of the students were from North Carolina, 15.2% came from other parts of the United States, and 6% traveled from other countries. A highlight of the course was the participation every year of several guest faculty from other institutions. The course was discontinued in 1992 due to financial constraints, a reduction in institutional support and teaching space, and the lack of academic recognition for time and effort devoted to teaching. In addition, attendance waned as clinical laboratories began to decrease their staffing, identification of yeasts and moulds, and budgets for training.

Current educational opportunities

A few CME-accredited mycology training sessions and mini-courses are available. One-day workshops are presented at the annual meetings of the Interscience Conference on Antimicrobial Agents and Chemotherapy and ASM. These workshops usually cover laboratory aspects of mycology (identification, susceptibility testing, etc.). Since 1991, yearly educational conferences entitled “Focus on Fungal Infections” have been sponsored by the pharmaceutical industry. These didactic programs address clinical issues such as antifungal susceptibility testing, epidemiology, and strategies to treat and prevent fungal infections. Every conference includes a two-hour workshop on the

Table 1 Duke Summer mycology course, 1975–1992

Students	Total No.	Average No./Yr
Duke	163	10.9
Other North Carolina	80	5.3
Other United States	47	3.1
Foreign	19	1.3
	309	20.6
Students	Total No.	Percent
Medical Students	36	11.7
Graduate Students	28	9.1
Medical Technologists, Research Technicians, Laboratory Supervisors	75	24.3
Medical Residents and Clinical Fellows (Pathology = 49, Dermatology = 79, Infectious Diseases/Allergy, etc = 12)	140	45.3
Laboratory Directors (MD/PhD)	13	4.2
Academic Faculty (MD/PhD)	17	5.5

identification of rarer fungi (Annette Fothergill, personal communication). These venues will often include a pharmaceutical company-sponsored symposium on clinical mycology with a panel of experts speaking about other antifungal treatment issues.

Since the summer of 2000 the Centers for Disease Control and Prevention (CDC) has offered two-day introductory and advanced training courses on the identification of pathogenic moulds. They have an average of 40 participants, and the courses consist of lectures and laboratory sessions in which the participants examine cultures and slides of approximately 50 different fungi. Beginning in 2003 they will offer a new course, provisionally entitled "Medical Mycology: Quality, Cost-effectiveness, and Clinical Relevance", which will focus on specimen collection, processing and reporting, identification and typing, antifungal susceptibility testing, and other topics. The target audience will be clinical microbiology laboratory directors and supervisors (Dr. David Warnock, personal communication).

The National Laboratory Training Network, formed in 1989, and sponsored by the Association of Public Health Laboratories and the CDC, will offer nine mycology workshops in 2003. These two-day conferences are clinical, environmental, and public health laboratory teaching courses (http://www.phppo.cdc.gov/nltn/nltn_cal.asp).

A research-oriented summer course "Molecular Mycology: Current Approaches to Fungal Pathogenesis" has been conducted annually since 1997 at the Marine Biology Laboratory in Woods Hole, MA. This 15-day course accommodates 16–18 students and consists of laboratory experiments and lectures by the resident instructors and guest speakers (Table 2). The course focuses on applying methods of molecular biology and genetics to medical fungi. The course has been supported predominantly by the Burroughs Wellcome Fund and pharmaceutical companies.

The internet holds a future for dissemination of educational material, and a superb educational web site, Doctorfungus.org, was created in 2001 to provide a

wide range of topical information for consumers and professionals. The content is prepared and peer-reviewed by expert mycologists. Additionally, there are numerous other smaller websites that offer images or slides for educational use.

Several pharmaceutical companies offer medical mycology research grants for young investigators. These awards are generally targeted for fellows or young faculty members early in their research careers as a method to obtain preliminary data or establish a research program for subsequent funding. Previous grants included the Burroughs Wellcome Fund New Investigator Award in Molecular Pathogenic Mycology which ended in 2001, as well as the Merck Young Investigator Award in Medical Mycology which ended in 2002. The existing programs are the National Foundation for Infectious Diseases and Pfizer, Inc. John P. Utz Postdoctoral Fellowship in Medical Mycology and the Pfizer, U.S Pharmaceuticals Fellowship in Medical Mycology, both designed for physicians. The Burroughs Wellcome Fund has modified their award to now include investigators in diverse areas of microbial pathogenesis, eliminating a mycology focus. Unfortunately, the number of all such grants is waning due to financial constraints of the individual sponsors.

Current literature and grants in mycology

To assess the contribution of fungal infections to the literature, we performed a MEDLINE search (Fig. 2) using search terms "bacterial infection", "viral infection", "fungal infection", and "antifungal". The MEDLINE search revealed significant increases in the number of publications on bacterial, viral, and fungal infections. From 1966 to 2002, the publications on bacterial infections increased 211%, publications on fungal infections increased 263%, and publications concerning antifungals rose 629%.

We also searched the Computer Retrieval of Information on Scientific Projects (CRISP) database of federally-funded biomedical research projects (<http://crisp.cit.nih.gov>), which is maintained by the Office of Extramural Research at the National Institutes of Health (NIH). This database provided the number of new mycology-related NIH grants awarded over the past decade (Fig. 3). These mycology-related grants were also compared to the number of grants awarded for study of other pathogens (Fig. 4). Results from the CRISP database from 1991–2002, revealed a slight increase in the number of R01 awards for mycology-related projects. However, there was an obvious dearth of K-series awards for mycological research training, as

Table 2 Molecular mycology: current approaches to fungal pathogenesis course

Year	No. of Applicants	No. of Students	No. of Faculty
1997	31	16	22
1998	23	16	15
1999	29	16	8
2000	36	16	6
2001	45	18	13
2002	42	18	11

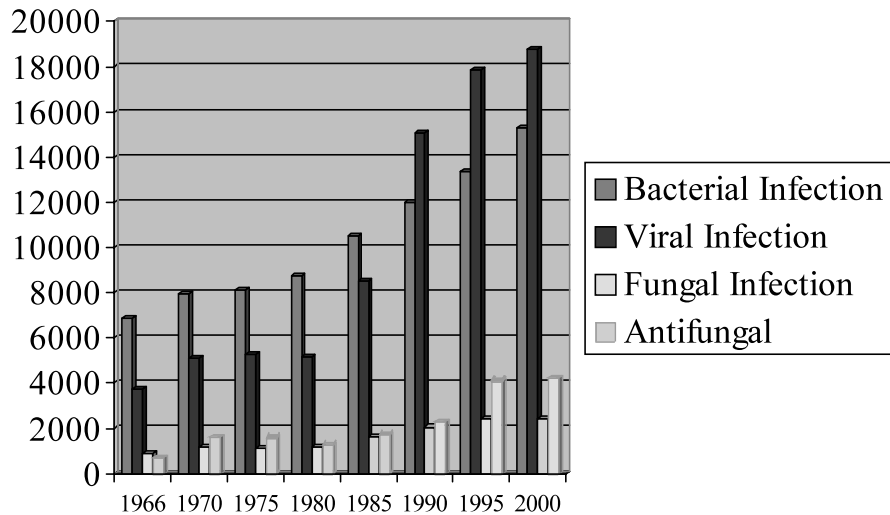


Fig. 2 Number of publications listed in MEDLINE according to search term.

only three K08 (basic science) and one K23 (clinical science) awards were funded. The substantial remainder of the total mycology grants aside from R01 grants were P01 (program) grants or Z01 (intramural) grants. Furthermore, only three institutional T-32 training grants in mycology were awarded during this period: pre-doctoral training programs at Montana State University (1994–2004) and the University of Georgia (1990–2001) and a postdoctoral training program at Georgetown University (1997–2002). Despite the concern that fungal infections are rising in incidence with continued dismal mortality, there remains a great

disparity in the number of NIH grants awarded for mycology study compared to the other infectious disease disciplines.

Additionally, we searched the Proquest Information and Learning (<http://www.umi.com/proquest>) database (Table 3) to determine the number of completed theses and dissertations on mycology-related topics. Despite the lack of institutional training grants, many trainees have been supported by research grants, and the number of theses or dissertations related to *Candida*, *Aspergillus*, or *Cryptococcus* has increased over the years.

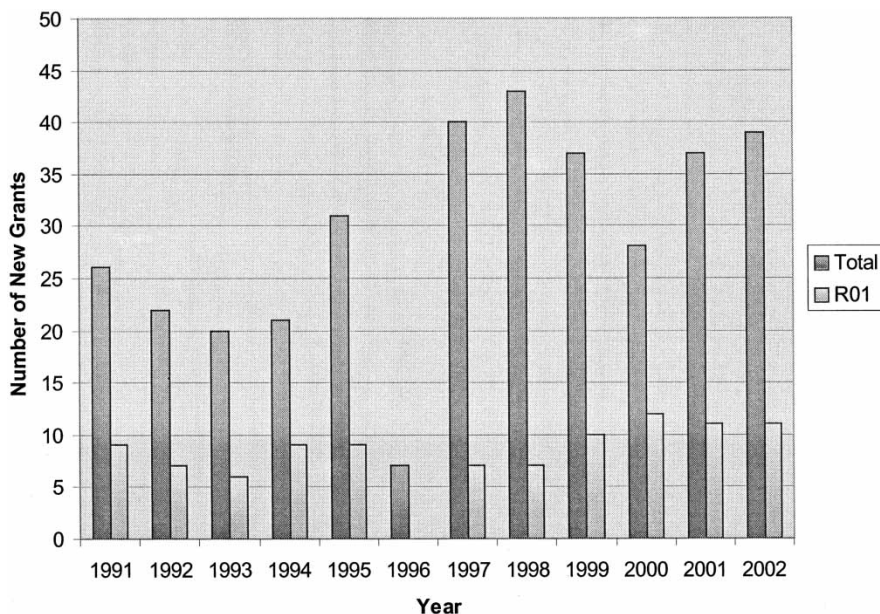


Fig. 3 New mycology NIH grants (1991–2002) from CRISP database.

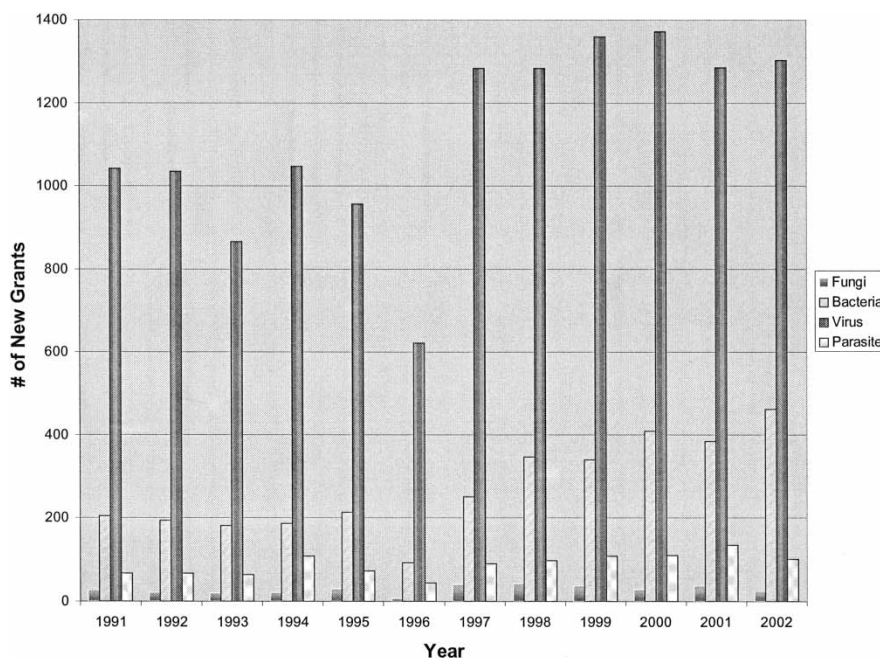


Fig. 4 New NIH grants by pathogen-type (1991–2002) from CRISP database.

Table 3 Completed Dissertations and Theses with Mycology Topics

Year	<i>Candida</i>	<i>Aspergillus</i>	<i>Cryptococcus</i>
1960	1	2	0
1965	3	8	2
1970	2	9	0
1975	3	1	1
1980	11	13	5
1985	15	10	2
1990	25	38	2
1995	30	41	3
2000	27	32	10

Keyword searching on Dissertation Abstracts Online. Ann Arbor, MI.

Proquest Information and Learning; 2003. Accessed 1/7/03.

Prospective survey of US medical schools

We sent electronic surveys to all members of AMSMIC listed in the 2002 directory. Members of AMSMIC include 125 chairpersons of Departments of Microbiology and Immunology or equivalent organizational units responsible for teaching medical students in accredited schools of the Association of American Medical Colleges. Each transmission included a cover letter explaining the purpose of the survey and a direct internet link to the web-based survey. The survey elicited information describing the coverage of medical mycology as part of the content of pre-clinical medical

school courses of microbiology and infectious diseases (Appendix A). Chairpersons were also queried regarding the amount of time allotted to medical mycology education over the last five years, as well as any future planned changes. The website survey consisted of twelve questions that were answered electronically by selecting from a choice of responses and included space to add comments. Chairpersons who did not respond to the survey were sent a second, and if necessary, a final third electronic mailing.

The survey yielded a 49% (61/125) response rate from the AMSMIC members, and therefore approximately half of the LCME-accredited medical schools in the United States were represented. The response rate increased to 87% (61/70) if only the active AMSMIC members were included. Responses to individual survey questions are shown in Appendix A. Most (80%) medical schools taught a microbiology course in the second year, and 21% (13/61) also taught a separate course of infectious diseases. Average totals of 94.4 hours and 35.8 hours were allocated for the microbiology and infectious diseases courses, respectively. Within the microbiology courses, the coverage of medical mycology was divided between lectures (mean 4.3 hours), laboratory studies (mean 1.0 hours), and problem-based learning or small group discussions (mean 1.7 hours). The data for the infectious diseases courses were similar for mycology lectures (mean 3.0 hours), laboratory sessions (mean 0.5 hours), and small

groups (mean 1.2 hours). Thus, the microbiology courses dedicated an average of 7.4% of their time to medical mycology, while the coverage of mycology within the infectious diseases courses was 13.1%.

Over the past five years, the total amount of time in the medical school curriculum devoted to the microbiology course remained the same (44%) or decreased (49%); similarly, the time allocated for the infectious diseases course remained the same (77%) or decreased (23%). During this time, the time dedicated to teaching medical mycology in the microbiology courses remained the same (59%) or decreased (30%), and in the infectious diseases courses, mycological coverage remained the same (77%) or decreased (15%).

Most instruction in medical mycology in either course was provided by Ph.D.-trained faculty members, who conducted 75–100% of the teaching at 55% of schools. However, only about half of those faculty were actively engaged in basic or clinical mycology research, and only 44% were considered specialists in medical mycology by training or research interests.

Almost every mycological topic received less than one hour of instruction. Only *Candida* species and dermatophytes generally received more than one hour of dedicated instructional time. Numerous clinically-relevant fungal pathogens were completely omitted at many medical schools (e.g. *Scedosporium*, *Fusarium*, dematiaceous moulds). Approximately one-third (38%) of schools spent 25 to 50% of their time on the basic identification or pathophysiology of fungi. The majority (86%) of courses used less than 50% of the allotted time for clinically-based education, and in most centers (67%), antifungal therapy was only briefly mentioned for each pathogen. Most institutions (75%) have no plans to change their medical mycology education in the near future.

Medical mycology education solutions

The need for expertise in basic and clinical mycology has never been more acute. Due to the improved survival of oncology and transplant patients, they are more susceptible to opportunistic invasive mycoses. Despite promising new therapies, the mortality from invasive fungal infections continues to be dismal. This situation has accelerated research on fungal pathogenesis and better patient management [5]. Although the growing need for formal and informal training in medical mycology is obvious, medical mycology courses as complete units have nearly vanished, and mycology education is generally limited to small sections of microbiology courses within medical school curricula [5]. Thus, it is unfortunate and deplorable that

in an era when the necessity for education in medical mycology has never been greater, the coverage of medical mycology in US medical schools is inadequate and stagnant. There are two critical concerns in formal medical mycology training: the urgent need for broader training to meet the newer challenges and replacement of the diminishing number of aging medical mycologists [5].

With the advent of the immunocompromised host, fungi have become preeminent pathogens and the field of medical mycology has garnered new respect and importance. Furthermore, there are new therapeutic agents to counter this growing fungal epidemic. The ironic difficulty is that most practicing clinicians are poorly educated in the diagnosis and management of invasive mycoses. The previously mentioned 1994 survey asked NIAID-MSG members what was needed to advance medical mycology, and they responded, more training at all levels and greater emphasis on mycology in medical school curricula. To implement changes, they suggested increased funding and visibility to attract more students, as well as educating deans and other leaders on the importance of medical mycology [5].

Aside from the inadequate teaching time for medical mycology [17], there is the issue of what type of education is appropriate. There have been several proposals to redesign medical mycology education [18]. To excite students, a multi-faceted approach is recommended, recruiting specialized experts to teach together [9], which is practical because many basic mycologists are too preoccupied by the competitive research environment to develop broad expertise in medical aspects [7]. A short-sighted remedy would be to limit mycology education to the years of clinical specialty training, as this plan erroneously assumes that mycotic diseases will always be confined to certain medical specialties. Other proposals to improve mycology education in medical schools include the separation of teaching into basic and clinical components, with the basic portion taught in the first or second year and relegating clinical coverage to the last year when students are better able to understand the pathogenesis of fungal diseases and therapeutic problems [8,9]. For example, one school in Argentina divided the mycology course into two stages, a basic first-year course and a final-year course on mycological diagnosis [9]. However, the aim should be to integrate and apply basic information and concepts to understand the diagnosis, clinical manifestations and treatment of mycoses.

Others have proposed to supplement the core coverage of essential topics and laboratory sessions with

optional short modules suited to particular medical specialties. These modules would ideally be presented in problem-based small group discussions, journal clubs, and case presentations to create a realistic active learning experience. Since fungal diseases cross multiple boundaries, the teachers and content would be multidisciplinary and include clinical, diagnostic, and therapeutic aspects [8].

One innovative educator, Glenn Bulmer, Ph.D., has trained physicians in Asia through banquet presentations and small group presentations. With sponsorship from pharmaceutical companies, he has designed continuing education programs that attract both local and academic physicians [9]. He has concluded that these presentations should be clinical in nature and relevant to the resources and medicine practices of the region.

For the laboratorian and the physician, workshops and short training courses raise awareness of medical mycological diagnostic and clinical issues. However, only experience yields expertise. Mycological laboratory technologists need to examine hundreds of moulds to become proficient at their identification. Similarly, the physician who has attended to hundreds of patients with invasive mycoses will acquire superior acumen in this area. Focused two- to four-week courses are the best solution to expedient proficiency, but they are costly, impractical for most laboratorians and clinicians, and they require qualified instructors and resources. There are more recently the genesis of smaller regional mycology meetings which do help alleviate the current lack of opportunities, but these ventures need increased support and attendance to maintain the future needs.

An interdependent tripartite approach to modern mycology comprises (1) clinical diagnosis, which is often the domain of infectious diseases specialists, (2) pathological findings, and (3) laboratory testing, which is performed by medical technologists. It is unfortunate that these components seem to have grown distant from each other, because a more rapid and accurate diagnosis and selection of optimal therapy are possible with closer collaboration. One solution may lie in incorporating instruction by mycologists into pathology training programs [19,20].

Funding for medical mycology education is a major concern. While philanthropy and foundation support for training and research in medical mycology have declined, governmental funding has gradually increased, but not in proportion to the increase in fungal pathogens. The future of medical mycology, similar to other medical sciences, is becoming increasingly dependent on pharmaceutical companies [5] to sponsor

medical mycology fellowships, conferences, basic science developments, and clinical trials.

Conclusion

Very few medical schools have full-time medical mycologists, and most teaching is done by microbiologists, biochemists, or immunologists with an interest in pathogenic fungi. It is clear that at the present rates, the incidence of fungal disease will far outpace the increase in new clinicians, educators, and researchers dedicated to medical mycology. In this new millennium, medical mycology has two imperatives – to combat the increasing number of fungal infections by training more mycologists, and to provide the high quality of medical mycology education demanded by a climate of newer and rarer pathogens. Additionally, the remaining mycology groups need to rejuvenate the field with the attraction of qualified, young mycologists determined to meet the next generation of challenges.

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Appendix A: Medical mycology education survey and responses

1) What year of medical school is the Microbiology course taught at your institution? (n = 61)

MS-1	11	(18%)
MS-2	49	(80%)
MS-3	0	(0%)
MS-4	1	(2%)

2) If there is a separate Infectious Diseases course, what year is it taught? (n = 13)

MS-1	3	(23%)
MS-2	8	(62%)
MS-3	1	(7.5%)
MS-4	1	(7.5%)

3a) How many total hours long is the Microbiology course at your medical school?

Mean: 94.4 hours (Range: 0–188 hours)

3b) How many total hours long is the Infectious Diseases course at your medical school?

Mean: 35.8 hours (Range: 0–100 hours)

4a) Over the last 5 years, has this total number of hours in your Microbiology course: (n = 61)

Remained the same	27	(44%)
Decreased	30	(49%)
Increased	4	(7%)

4b) How many total hours of the Microbiology course are devoted to **mycology**?

Lecture	Mean: 4.3	(Range: 0–12)
Lab	Mean: 1.0	(Range: 0–4)
Problem-based learning/ small discussion group	Mean: 1.7	(Range: 0–30)

4c) Over the last 5 years, has this devoted mycology time:

Remained the same	36	(59%)
Decreased	18	(29.5%)
Increased	7	(11.5%)

5a) If you also have an Infectious Diseases course, over the last 5 years has the total number of hours:

Remained the same	10	(77%)
Decreased	3	(23%)
Increased	0	

5b) How many total hours are devoted to mycology?

Lecture	Mean: 3.0	(Range: 0–12)
Lab	Mean: 0.5	(Range: 0–3)
Problem-based learning/ small discussion group	Mean: 1.2	(Range: 0–6)

5c) Over the last 5 years, has this devoted mycology time:

Remained the same	10	(77%)
Decreased	2	(15%)
Increased	1	(8%)

6) In your microbiology or Infectious Diseases course, who teaches (include lectures, lab instructors, small-group leaders), and what percentage of the time? (n = 61)

(MD PhD is considered as “MD”)

MD	0–10%	10–25%	25–50%	50–75%	75–100%
	19	19	11	5	7
PhD	0–10%	10–25%	25–50%	50–75%	75–100%
	5	0	10	12	34
MS or other	0–10%	10–25%	25–50%	50–75%	75–100%
	55	4	0	1	1

7a) Is (are) the person(s) who cover mycology actively engaged in basic or clinical mycology research?

No research	30 (49%)
Basic research	15 (25%)
Clinical research, including laboratory diagnostics	9 (15%)
Both basic and clinical research	7 (11%)

7b) Are the faculty who teach mycology considered specialist(s) in medical mycology by training or research interests?

Yes	27 (44%)
No	26 (43%)
Some are, some are not	8 (13%)

8) Which mycology topics are covered and approx. how many total hours are devoted to each?

Number of school curricula (n = 61) with the time devoted to each subject

	None	< 1 hour	1 hour	2-3 hours
<i>Candida</i>	0	46	14	1
<i>Aspergillus</i>	1	54	6	0
<i>Blastomyces</i>	3	55	3	0
<i>Histoplasma</i>	1	54	6	0
<i>Coccidioides</i>	1	58	2	0
<i>Paracoccidioides</i>	22	38	1	0
<i>Cryptococcus</i>	1	54	6	0
<i>Scedosporium</i>	53	7	1	0
<i>Fusarium</i>	37	23	1	0
<i>Sporothrix</i>	8	51	2	0
Dematiaceous moulds	25	31	5	0
Zygomycetes	12	47	2	0
Dermatophytes	4	43	13	1

Other Opportunistic mycoses	11	46	4	0
Other mycoses	21	37	3	0

9) What percentage of time of the lectures (or other didactic sessions) cover fungal basic science/identification/pathophysiology?

10-25%	10	(16%)
25-50%	23	(38%)
50-75%	5	(8%)
75-100%	3	(5%)

10) What percentage of time of lectures (or other didactic sessions) are clinically-based (i.e. vignettes, X-rays, lab results in cases, etc.)?

0-10%	12	(20%)
10-25%	17	(28%)
25-50%	23	(38%)
50-75%	7	(11%)
75-100%	2	(3%)

11) Do you cover antifungal therapy in your course(s)?

No antifungal therapy covered in the course	3	(5%)
Antifungal therapy mentioned briefly for each pathogen	41	(67%)
Antifungal therapy mentioned in detail for each pathogen	6	(10%)
Devoted lecture(s) to antifungal therapy	11	(18%)

12) Do you have any planned changes in the next 5 years for your mycology lectures/labs?

No	46	(75%)
Yes	15	(25%)