

Pan American Aerobiology Certification Board

Certification Program for Spore Analysts

Guidance Documents

These guidance documents are intended to give an indication of the topics that should be known by anyone claiming competency in spore identification or interpretation of airborne spore concentrations. The guidance documents should be used as one of many possible resources for gaining competency. Specific references within each of the documents are given to point you in the right direction for learning more in a particular area. The references are a starting point and by no means represent the sole authority on a particular topic nor do they represent an exhaustive list of all possible resources. Independent research and study is needed to acquire the technical knowledge expected for competency in spore counting and aerobiology in general. The guidance documents should be used for training and educational purposes, as well as preparing for the PAACB Certification Program for Spore Analysts. Questions pertaining to any of the areas included in the guidance documents, plus others, may be included on PAACB qualifying or certification exams. Please consult the summary of important guidance document topics for PAACB Spore Analyst Level 1 exams.

For questions or comments please contact the PAACB administrator at administrator@paacb.org

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Guidance Document #1: Basic background knowledge

Spore counters need the following knowledge:

Note: Numbers in parentheses refer to the PAACB reference book list at the end of this document. Recommended books for each topic represent a selection, only. Other books on the list may treat the topic as well.

- I. Basic and specific knowledge in the field of mycology
 - A. Basic taxonomy (7) (11) (24) (29) (45)
 1. Understand basic relationships between classes of fungi.
 2. Recognize the major taxonomic groups to which spores belong.
 3. Be able to locate and use literature to identify a spore.
 4. Understand principles of fungal nomenclature, including naming life cycle stages, authorities, synonyms.
 - B. Mechanisms of spore production and release (9) (11) (22) (27) (29) (45)
 1. Spore production processes as they relate to morphological features of the spores in:
 - basidiomycetes
 - ascomycetes
 - zygomycetes
 - the groups of mitosporic fungi
 2. Spore prevalence as related to spore discharge mechanisms and weather/climate conditions.
 - C. Spore morphology as it relates to spore formation and to taxonomic groupings (8) (9) (10) (12) (15) (16) (17) (19) (20) (21) (27) (34) (36) (39) (42) (43)
 - D. The use of schematic and synoptic identification keys (8) (9) (10) (12) (15) (16) (17) (19) (20) (21) (27) (34) (36) (39) (42) (43)
 - E. Ecology (11) (24) (37) (45)
 1. Natural habitats for common airborne fungi
 2. Habitats of various fungi as related to their ability or inability to amplify in a building:
 - obligate plant parasites
 - soil/litter/dung fungi
 - phylloplane fungi
 - mushrooms
 - wood rot fungi
- II. Basic knowledge about the field of bioaerosols (7) (15) (34) (36) (39)
 - A. Aerosol production processes
 - B. Particle deposition: basic aerodynamic principles
 1. Settling
 2. Impaction
 3. Filtration

- C. Principles of extrapolating count data to volumetric data
 - 1. Counts: raw (proportion counted) to total/sample
 - 2. Counts: volume sampled to counts/m³
- D. Characteristics and patterns of prevalence
- III. General principles of statistical variability of aerosols, sampling, & counting.
- IV. Familiarity with basic knowledge regarding why and how people sample the air (4) (7) (8) (36) (39)
 - A. Sampling strategies
 - B. Designing sampling plans
 - C. Realities of field investigations
- V. Familiarity with air sampling methods (4) (7) (14) (33) (36) (39)
 - A. Working knowledge of non-culture based methods, including preparation of samples, adhesives used, compatible mounting media and stains.
 - 1. Burkard
 - 2. Allergenco
 - 3. Zefon Air-O-Cell
 - 4. Biosis
 - 5. Others (new)
 - B. Familiarity with culture based methods and how they differ from non-cultural methods

Guidance Document #2: Bioaerosol Sampling: Theory, Methods, & Equipment

Spore counters need the following knowledge:

- I. Basic knowledge of aerosol behavior and collection strategies (4:Ch.14) (26:Ch.11) (28)
 - A. Settle/Gravitational
 1. Settling rates
 - B. Inertial Impaction (4:Ch.14) (13) (26:Ch.11)
 1. Physics
 - a. Aerodynamic diameter
 - b. Collection efficiency, cut-point, air streamlines
 - c. Adhesives, particle bounce
 2. Sampling
 - a. Sieve
 - b. Slit
 - c. Centrifugation
 - C. Impingement (4:Ch.14) (26:Ch.11) (28)
 - D. Filtration (4:Ch.13)
 3. Filter types, filter selection
 4. Particle capture mechanisms, collection efficiency
- II. Sampler descriptions: grouped by analytical method (4:Ch.23) (14:Ch.4) (23:Ch.8) (26:Ch.11) (28) (37:2nd section, pp. 245ff)
 - A. Non-cultural, direct examination samplers: Burkard (portable and recording), Allergenco, Zefon Air-O-Cell, BioSis
 - B. Culture based: Andersen (cascade and N6, copies of same), Burkard culture plate sampler, Merck, Reuter centrifugal sampler (RCS), SAS
- III. Microscopy (1)(2)(3)(32)(38)
 - A. Familiarity with all parts of the microscope
 - B. Ability to set-up and adjust a light microscope for Kohler or even illumination
 - C. Measurement of the Field of View for each objective
 - D. Calibration of an ocular micrometer
- IV. Data
 - A. Calculations (26:Ch.13)
 1. Converting raw counts (proportion counted) to total/sample
 2. Converting counts per total/sample to counts/m³
 - B. Variability (14:Ch.3)
 1. Limits of detection
- V. Air Sampling Investigations (4:Ch.7) (4:Ch.23) (11:Ch.1) (26:Ch.2,5) (37:2nd section, pp. 245ff)
 - A. When, where, and why is sampling appropriate
 - B. Developing an air sampling plan
 - C. Sampler selection
 - D. Sampler calibration; rotometers, etc.

Guidance Document #3: Specific Protocols

Spore counters need the following:

- I. The ability to formulate counting protocols, including the ability to calculate spores/m³ from counting data and the volumetric data provided
 - I. Acceptable samples
Example: Policy regarding broken or overloaded samples.
 - A. Labeling
 - B. Damaged samples
 - C. Appropriate collection (appropriate amount of deposit, appropriate grease, etc.)
 - II. Instructions re: how to prepare the sample for counting.
Example: Treatment of Air-O-Cell cassettes, Burkard slides, Allergenco slides, BioSis slides. This would include information regarding the use of various mounting media versus the varieties of sticky media.
 - III. Sample worksheets
 - A. The array of spores/pollen/particles to be counted
 - B. Sampling/labeling data
 - C. Counter data/signature
 - D. Data
 - E. A method for recording the general appearance of the sample as it relates to the accuracy of the count. Example: How much interfering material is present?
 - IV. Instructions re: performing the count
 - A. Instructions re: performing the count, including methods for accurately proportioning the trace into countable portions.
Example: How much of the trace is to be counted?
 - B. Methods for dealing with excessive background debris and other anomalies
 - C. A method for determining the levels of detection
Example: What constitutes an acceptable count?
 - V. Reporting
 - A. Protocols for performing calculations, including the method for converting counts per area counted to counts per trace, and the method for converting counts per trace to counts per m³.
Note: Rote 'plug-in' formulas should be avoided, but a spreadsheet that calculates is ideal.
 - VI. Data storage and retrieval
 - VII. Quality Control
 - VIII. Interaction with clients
 - A. Written educational material
 - B. Phone discussions
 - IX. Final reports

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RECOMMENDED BOOKS FOR MYCOLOGY/AEROBIOLOGY REFERENCE:

- 1) Abramowitz, M. MICROSCOPE BASICS AND BEYOND, 1987. Olympus America, New York 26p.
- 2) Abramowitz, M. OPTICS: A PRIMER, 1994. Olympus America, New York 22p
- 3) Abramowitz, Keller, Spring, Flynn, Long, Parry-Hill, Tchourioukanov, Davidson. BASIC CONCEPTS IN OPTICAL MICROSCOPY, 2002. <http://micro.magnet.fsu.edu/primer/anatomy/anatomy.html>
- 4) ACGIH. 1995. AIR SAMPLING INSTRUMENTS FOR EVALUATION OF ATMOSPHERIC CONTAMINANTS, 8th edition., Cincinnati, Ohio, American Conference of Governmental Industrial Hygienists
- 5) Ainsworth, Hawksworth, Kirk, Sutton & Pegler, AINSWORTH & BISBY'S DICTIONARY OF THE FUNGI, 1994. 8th Edition. Commonwealth Mycological Institute, Kew, Surrey, England. 1971. Also available from Lubrecht & Cramer, Ltd., P.O. Box 3110, Port Jervis, NY 12771. Phone/fax 1 800 920-9334
- 6) Al-doory, Yousef & Joanne Domson, editors, MOULD ALLERGY, 1984. Lea & Febiger, Philadelphia, PA. ISBN 0-8121-0897-3
- 7) Alexopoulos, Mims, and Blackwell, INTRODUCTORY MYCOLOGY, 1996. (4th Edition.) John Wiley and Sons, N.Y.
- 8) Barnett H.L. & Barry B. Hunter, ILLUSTRATED GENERA OF IMPERFECT FUNGI, 1987. Published by The American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, Minnesota 55121-2097 To order: (800) 328-7560
- 9) Barron, George, THE GENERA OF HYPHOMYCETES FROM SOIL, 1972. Publisher: Robert E. Krieger Publishing Co., Box 542, Huntington, NY 11743
- 10) Booth C, THE GENUS FUSARIUM, Commonwealth Mycological Institute, Kew, Surrey, England. 1971. U.S. DISTRIBUTORS: Call Pam Sherman (212) 481-7018. See note under Coelomycetes, by Brian Sutton.
- 11) Burge, Harriet, BIOAEROSOLS, 1995. Lewis Publishers, 2000 Corporate Blvd., N.W., Boca Raton, FL 33431-9868. Order toll free: 800-272-7737
- 12) Carmichael, Kendrick, Connors, and Sigler, GENERA OF HYPHOMYCETES, 1980. Publisher: The University Of Alberta Press, Edmonton, Alberta. Out of print. May be available from Lubrecht & Cramer, Ltd., P.O. Box 3110, Port Jervis, NY 12771. Phone/fax 1 800 920-9334.
- 13) Cox CS, 1987, THE AEROBIOLOGICAL PATHWAY OF MICROORGANISMS. New York, John Wiley & Sons
- 14) Dillon, H.K., Heinsohn, P.A. and Miller, J.D. eds., 1996. FIELD GUIDE FOR THE DETERMINATION OF BIOLOGICAL CONTAMINANTS IN ENVIRONMENTAL SAMPLES. Fairfax, Virginia, American Industrial Hygiene Association ISBN 0-932627-76-5.
- 15) Domsch K., W. Gams, and T.H. Anderson, THE COMPENDIUM OF SOIL FUNGI, Vol. I and Vol. II., Reprint 1993. IHW-Verlag, Bert-Brecht-Str. 18, D – 85386 Eching. Fax #: (International) +49 89 3192257 (Dial 011 for the international operator.)

- 16) Ellis M.B, DEMATIACEOUS HYPHOMYCETES, 1971. Commonwealth Mycological Institute, Kew, Surrey, England. U.S. DISTRIBUTORS: Call Pam Sherman (212) 481-7018. See note under Coelomycetes, by Brian Sutton.
Also available from Lubrecht & Cramer, Ltd., P.O. Box 3110, Port Jervis, NY 12771. Phone/fax 1 800 920-9334
- 17) Ellis MB, MORE DEMATIACEOUS HYPHOMYCETES, 1976. Common-wealth Mycological Institute, Kew, Surrey, England U.S. DISTRIBUTORS: Call Pam Sherman (212) 481-7018. See note under Coelomycetes, by Brian Sutton.
Also available from Lubrecht & Cramer, Ltd., P.O. Box 3110, Port Jervis, NY 12771. Phone/fax 1 800 920-9334
- 18) Gregory PH, MICROBIOLOGY OF THE ATMOSPHERE, 1973. Published by Leonard Hill Books, a division of International Textbook Company Limited, 24 Market Square, Aylesbury, Bucks. ISBN 0 249-44110-1.
- 19) Hanlin, Richard, ILLUSTRATED GENERA OF ASCOMYCETES, 1990. Published by The American Phytopathological Society, 3340 Pilot Knob Rd, St. Paul, Minnesota 55121-2097 To order: (800) 328-7560
- 20) Hanlin, Richard ,ILLUSTRATED GENERA OF ASCOMYCETES, Vol. II, 1990. Published by The American Phytopathological Society, 3340 Pilot Knob Rd, St. Paul, Minnesota 55121-2097 To order: (800) 328-7560
- 21) Hoog, G S. & J. Guarro, editors, ATLAS OF CLINICAL FUNGI, 1995. Centraalbureau voor Schimmelcultures, P.O. Box 273, 3740 AG Baarn, The Netherlands. Telephone + 31 (0) 2154-81211, Telefax +31 (0) 2154-16142. Note: Second edition now available.
- 22) Ingold TC, FUNGAL SPORES, THEIR LIBERATION AND DISPERSAL, 1971. Oxford University Press, Ely House, London W. 1. ISBN 0 19-854115-5.
- 23) Jensen PA, Lighthart B, Mohr AJ, editors. ATMOSPHERIC MICROBIAL AEROSOLS. New York, Chapman and Hall.
- 24) Kendrick, Bryce, THE FIFTH KINGDOM, Second Edition 1992. Focus Texts, Focus Information Group, Inc., PO Box 369, Newburyport, MA 01950. ISBN 0-941051-28-5.
- 25) Klich, Maren, & John Pitt, LABORATORY GUIDE TO COMMON ASPERGILLUS SPECIES AND THEIR TELEOMORPHS, 1988. CSIRO Food Research Laboratory, P.O. Box 52, North Ryde, N.S.W. 2113, Australia. ISBN 0-643-04837-5.
- 26) Macher Janet, Editor, BIOAEROSOLS, ASSESSMENT AND CONTROL, 1999. ACGIH, Kemper Woods Center, Cincinnati, OH. www.acgih.org. ISBN: 882417-29-1.
- 27) Malloch, David, MOULDS, THEIR ISOLATION, CULTIVATION, AND IDENTIFICATION, 1981. University of Toronto Press, Toronto, Canada. ISBN 0-8020-2418-1
- 28) Mandrioli P, Comtois P, Levizzani V., 1998. METHODS IN AEROBIOLOGY. Bologna, Italy, Pitagora Editrice
- 29) Moore-Landecker, Elizabeth, FUNDAMENTALS OF THE FUNGI, 4th Edition. 1996. Prentice Hall. <http://microscopy-uk.org.uk/mag/articles/bookr6.html> Available through Barnes & Noble
- 30) O'Donnell, Kerry, ZYGOMYCETES IN CULTURE, 1979. Published by Department of Botany, University of Georgia, Athens, Georgia, 30602. ISBN 0-935460-01-2.
- 31) Ogden, Eugene, Gilbert Raynor, Janet Hayes, Donald Lewis, & John Haines, MANUAL FOR SAMPLING AIRBORNE POLLEN, 1974. Published by Hafner Press, New York, NY. ISBN 0-02-849820-8.

- 32) Oldfield, Ron, LIGHT MICROSCOPY, AN ILLUSTRATED GUIDE, 1994. Wolfe Publishing, UK 160p.
- 33) Pitt, John, LABORATORY GUIDE TO COMMON PENICILLIUM SPECIES, 1991. CSIRO Food Research Laboratory, P.O. Box 52, North Ryde, N.S.W. 2113, Australia. ISBN 0-643-04837-5.
- 34) St-Germain, Guy, & Richard Summerbell, IDENTIFYING FILAMENTOUS FUNGI, A CLINICAL LABORATORY HANDBOOK, 1996. Star Publishing Company, P.O. Box 68, Belmont, CA 94002. ISBN 0-89863-177-7. Fax order to: (415) 591-3898.
- 35) Samson RA, Ellen Hoekstra, Jens Frisvad, Ole Filtenborg, INTRODUCTION TO FOOD-BORNE FUNGI, 1995. Centraalbureau voor Schimmelcultures, P.O. Box 273, 3740 AG Baarn, The Netherlands. Telephone + 31 (0) 2154-81211, Telefax +31 (0) 2154-16142.
- 36) Smith, E. Grant, SAMPLING AND IDENTIFYING ALLERGENIC POLLENS AND MOLDS, BLEWSTONE PRESS, San Antonio, Texas To order: (210) 822-4116
- 37) Solomon, William, Guest Editor. AIRBORNE ALLERGENS, Immunology & Allergy Clinics of North America, Volume 9, Number 2, August 1989. W. B. Saunders Company, Publishers, The Curtis Center, Independence Square West, Philadelphia, PA 19106-3399 This book may be out of print
- 38) Spring, Davidson. CONCEPTS AND FORMULAS IN MICROSCOPY, 2002.
<http://www.microscopyu.com/articles/formulas/formulasindex.html>
- 39) Sutton, Brian, THE COELOMYCETES, 1980. Commonwealth Mycological Institute, Kew, Surrey, England. 1971. U.S. DISTRIBUTORS: Oxford Press, 1 800 334-4249: Seek out Pam Sherman at extension 6490. Pam handles CAB International book orders, through which you can order CMI books. Other people at Oxford Press may not know what you are talking about. Note: Pam has a new number as of 7/2001: (212) 481-7018.
Also available from Lubrecht & Cramer, Ltd., P.O. Box 3110, Port Jervis, NY 12771. Phone/fax 1 800 920-9334
- 40) Sutton, Deanna, Annette Fothergill, and Michael Rinaldi, GUIDE TO CLINICALLY SIGNIFICANT FUNGI, 1998. Williams & Wilkins Publishers, Baltimore To order: (800) 638-0672
- 41) Ulloa, Miguel & Richard Hanlin, ILLUSTRATED DICTIONARY OF MYCOLOGY, 2000. Published by The American Phytopathological Society, 3340 Pilot Knob Road, St. Paul, Minnesota 55121-2097 To order: (800) 328-7560
- 42) Von Arx JA, THE GENERA OF FUNGI SPORULATING IN PURE CULTURE, 1981. Publisher: J. Cramer, Verlag, Germany. Available from Lubrecht & Cramer, Ltd., P.O. Box 3110, Port Jervis, NY 12771. Phone/fax 1 800 920-9334
- 43) Wang CJK, & R.A. Zabel, FUNGI FROM UTILITY POLES IN THE EASTERN UNITED STATES, editors, 1990. Published by American Type Culture Collection, 12301 Parklawn Drive, Rockville, Maryland 20852. ISBN 0-93-0009-31-2.
- 44) Watanabe, Tsuneo, PICTORAL ATLAS OF SOIL AND SEED FUNGI, 1994. Lewis (CRC) Press, 2000 Corporate Blvd., N.W., Boca Raton, FL 33431-9868. (800) 272-7737
- 45) Webster, John, INTRODUCTION TO FUNGI, 1970. Cambridge University Press, NY Branch, 32 East 57th St., New York, NY 10022.

Note: Some of these books may be out of print, which can be very frustrating. Other than consulting an out of print search service, the only recourse may be having your local library find the book for you, and then photocopying it.

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