BIOLOGY 323 COURSE OBJECTIVES AND EXAMINATION FORMAT (Oct 09, M. Berbee)

Be able to discuss fungal biology, answering questions about fungal diversity, about how fungi succeed or fail in the game of survival, and about how fungi alter the world around them. Find helpful background information in the Fungi chapter in Raven's Biology of Plants, on-line material, and in the lab manual and your lecture notes.

Be able to refer to characteristics of the fungal genera and other taxa, from the list of 'taxa to know' to illustrate your points.

You may bring a single-sided, letter sized page of notes to the lecture midterm and to the lab midterm. You may bring a double-sided page of notes to the lecture and to the laboratory final.

1. How do hyphae grow?
2. Where do representatives of different fungal groups grow in nature? How do different fungi get their nutrients?
3. What features of fungal species may be interpreted as adaptations to life as a saprobe, a pathogen, or a mutualistic symbiont? Which fungal features permit some fungal species and not others to be pathogenic on humans?
4. Be prepared to describe the ecological roles of different kinds of fungi.
5. How do different kinds of fungi, including lichenized fungi, reproduce asexually?
6. What is the functional significance of variations in sexual fruit body morphology in different classes in the Ascomycota (first part of course) and the other fungal phyla (2^{nd} part of course)? The lab manual and textbook will be helpful here.
7. Why are there several names for the same fungus or fungal group? Provide specific examples.
8. What are possible developmental fates for different parts of a fungus, for spores, hyphae, reproductive tissues etc.? For example, what happens to a conidium after it is released from a conidiophore?
9. How does sexual development take place? For representatives of the different taxonomic groups, be able to predict which tissues are 1N, 2N or N+N. Be able to predict which mating type genes would be found in each tissue type. Be able to predict which pheromones and receptors a fungus could make.
10. Be able to compare the different kinds of mycorrhizae; know which kinds of fungi and plants are involved and what kinds of structures are produced in the symbiosis. Raven's chapter is helpful.
11. Understand and be able to diagram PCR and DNA sequencing reactions. Understand the reasons for selecting DNA sequence regions for systematic studies, e.g. when and why use ribosomal genes or spacers, or, for that matter, protein-coding genes? Be able to interpret the output of a BLAST search.
12. Be able to discuss the basis for current estimates of fungal diversity, the limitations of the estimates, and the kinds of research that could yield improved estimates. Articles by Hawksworth may be useful.

In general, do spend a few minutes planning your answers before you begin to write an exam answer. Read questions carefully. Some questions will ask you to make comparisons. Please make the comparisons of features explicit by explaining how each feature is the same or different.

Laboratory examination expectations.
In the laboratory midterm and final examination, you will be given ~ four organisms on petri dishes or natural substrates such as leaves or wood. The laboratory examinations will consist of a series of questions about the four organisms.

1. Demonstrate your ability to make slides that clearly show the stages of fungal life history that you found. This usually involves careful examination of plates or host material with a dissecting microscope,

using visual clues and your lab experience to locate material that might be in the desired stage of development.

2. Through accurate, labeled drawings, demonstrate your ability to observe reproductive and vegetative characteristics of fungi using appropriate microscopy techniques and slides that you have prepared yourself.

3. Using your observations, notes, and knowledge of fungal life history, be able to predict the ploidy of fungal tissues that you observe.

4. Be able to predict the source of nutrients and to describe structures associated nutrient assimilation, with reference to structures that you can observe.

5. For each organism, be able to predict the next stage in development and the conditions necessary for that development to take place. Be able to do the same for the preceding stage of development.

6. Be able to predict how the fungus dispersed to location where it was growing and how it would disperse and colonize a new location if it continued to grow.

7. Be able to classify your specimen using its visible features. At each level in the classification, using your notes and observations, be able to rule out all other possible alternative classifications based on features that you actually see.

The next two pages serve as a guide to taxa that you are likely to need to know for Biol. 323 lecture and lab exams. Depending on the condition of material, the lists may change as exams approach. Be familiar with classification at and above the genus level for these organisms.

Rank	Taxon	Genus (teleomorph)	Genus (anamorph)
Kingdom	Fungi		
Phylum	Ascomycota		
Subphylum	Saccharomycotina	*Saccharomyces cerevisiae* *Dipodascopsis*	
Subphylum	Pezizomycotina		
Class	Eurotiomycetes		*Penicillium* *Aspergillus* *Trichophyton* *Microsporum*
		Emericella	
Class	Sordariomycetes	*Neurospora** *Chaetomium** *Sordaria** *Xylaria* *Claviceps*	
			*Fusarium** *Trichoderma**
Class	Leotiomycetes	*Rhytisma*	
			Botrytis
		*Microsphaera** *Sawadaea **	
Class	Lecanoromycetes	*Peltigera* *Platismatia* *Usnea*	
Class	Pezizomycetes	*Morchella* *Ascobolus* *Tuber*	
Class	Dothideomycetes	*Sporormia (=Sporormiella)* *Apiosporina* (black knot of cherry)	
			*Cladosporium** *Alternaria** *Epicoccum** *Bipolaris** *Phoma** *Septoria**

Rank	Taxon	Genus (teleomorph)	Common name
Phylum	Basidiomycota		
Subphylum	Agaricomycotina		
Class	Agaricomycetes		
Order	Agaricales	*Pleurotus*	Oyster mushroom
		Amanita	Fly agaric
		Agaricus	Mushroom, common grocery-store type
		Lycoperdon	Puff balls
			Bird's nest fungi
Order	Boletales	*Suillus*	Mushroom, slippery jack
		Scleroderma	Earth balls
Order	Polyporales	*Trametes*	Polypores, turkey tails
		Fomitopsis	Red-belted conk
Class	Dacrymycetes	*Dacrymyces*	Jelly fungus, witch's butter
Subphylum	Agaricomycotina		Orchidoid mycorrhizae and ectomycorrhizae
Subphylum	Pucciniomycotina	*Sporidiobolus*	Mirror yeast
		Gymnosporangium	Pear trellis rust
		Melampsora	rust on poplar
		Cronartium	White pine blister rust
		Puccinia	hollyhock rust
		Phragmidium	Rose rust
Subphylum	Ustilaginomycotina	*Ustilago*	Smut
Phylum	Zygomycota	*Phycomyces*	
		Rhizopus	
		*Thamnidium**	
		*Syncephalastrum**	
		*Cunninghamella**	
		*Dimargaris**	
		Pilobolus	
		Entomophthora Dimargaris	
Phylum	Glomeromycota		Vesicular arbuscular mycorrhizae
Phylum	Blastocladio-mycota	*Allomyces*	
Phylum	Chytridiomycota	*Rhizophlyctis rosea*	

Lecture exam (partial) from biology 323 from a previous year. Note that emphasis is a little different each year.

1. 30 pts, 20 min.

What happened to the fungi **before** the stage described below? Specify (1) **which fungal structure** would most likely have been **dispersed** to reach the substrate described below, (2) **how** dispersal might have occurred, and then (3) **How** did the fungus get the nutrients to grow to the stage described? Give nutrient source; fungal structures involved; how nutrients arrive at fungus. Do not draw life cycles.

	(1) Before this stage, _____ might have been dispersed to the substrate:	(2) How might dispersal have occurred?	(3) Nutrient source; fungal structures involved in uptake; how nutrients arrive at fungus.
a) Green powder from a mold on bread.			
b) Saccharomyces ascospore on a petri dish.			
c) White mold on the surface of a green leaf.			
d) A lichen thallus			
d) Ring worm	Take a guess...		

2. **25 marks**, 10 min. The fungus life cycle.
An outcrossing ascomycete has mating types A and a.
A. What would be the possible mating type (A or a; A only; a only; A/a (diploid) A+a (dikaryon) of the following tissues and structures. B. What would be possible mating types IF you know that the female was mating type A?

	A. Possible mating type, female not specified.	B. Possible mating type, female specified as 'A'
The wall of a perithecium		
The wall of a cleistothecium		
A conidium picked randomly from population		
A crozier's uppermost cell		
A paraphysis		
A nucleus in an ascogenous Cell		
A nucleus in the ascus at the time of free cell formation		

4. **15 marks, 10 min.** Under what conditions might you grow a fungus (or fungi) if you wanted it (or them) to:
A. Conidiate
B. Produce high yields of a secondary metabolite.
C. Reproduce sexually.
5. **15 marks, 10 min.** *Saccharomyces cerevisiae* and *Candida albicans* are fairly close relatives but *C. albicans* causes human disease and *S. cerevisiae* does not. Which of its biological characteristics may make *C. albicans*, but not *S. cerevisiae*, pathogenic on humans?

Example text from Lab exam Biology 323 Mycology. This lab exam consists a series of questions about the four organisms you'll find at your place. The exam will end officially at 5:00 PM, but you are welcome to leave as soon as you finish.

The exam is worth 100 marks; 10 marks are for the set of a semi-permanent slides your will hand in to support your conclusions. Use a drop of glycerol at the edge of the coverslip to make the slides semi-permanent.

Good luck!

Organism 1. Find on petri dish.

25 pts.

1a. Carefully draw the structures associated with reproduction (compound microscope view).
=>Provide a **diagrammatic overview** and separate **drawings showing the fine details**. Label the structures with **names** and **ploidy (1N, 2N, N+N)**. Make a semi-permanent slide to turn in.
You may wish to look at question #3, comparing this organism with organism #2.

Organism 1 cont.

1b. This organism is in Subphylum _____. Which character (s) visible in your slide, lead you to this conclusion?

1c. This organism is in **Class** _____. Which two characters, visible in your slide of this fungus lead you to your conclusion about its class? Explain how you can rule out other possible classes within the same subphylum.

1d. This organism is in genus _____.

Organism 2. 25 pts. For the slimy white organism in the culture dish:

2a. Diagram the structures involved in the sexual cycle VISIBLE in this culture. Label structures that you've diagrammed with their names and ploidy. Make a semi-permanent slide to turn in.

2b. Phylum of this organism? _____

Which character(s), visible in this specimen, lead you to rule out other possible phyla for this organism?

3. Comparison, 10 pts. With reference to your drawings and visible structural similarities and differences, compare and contrast sexual spore dispersal in Organism 1 and Organism 2.

4. Organism 3 10 pts.

Make a slide of this organism.
Diagram the asexual reproductive structures of the organism visible in this culture.
Turn in a semi-permanent slide.

5. Organism 4. **20 pts.**

Examine the organism under the dissecting and compound microscopes.

5a. This organism is in **Class** _____. Which two characters, visible in your slide of this fungus lead you to your conclusion about its class? Explain how you can rule out other possible classes within the same subphylum.

5b. Diagram and label the sexual reproductive structures you can observe in this organism (compound microscope view). Make a semi-permanent slide to turn in.

5c. How does this thallus reproduce itself, assuming it can only make the reproductive structures visible on the thallus? (Check thallus over, and then think...)

Lab exam continued:
The following three keys may help distinguish among closely related genera.

Key A

1a. Fruit body flask-like, ornamented with thick, brown hyphae	*Chaetomium*
1b. Fruit body flask-like, may be smooth or if covered with hyphae, the hyphae are not thick and brown	2
2a. Ascospores with nerve-like ridges	*Neurospora*
2b. Ascospores surrounded by gelatinous sheath	*Sordaria*

Key B:

1a. Fruit body closed, ornamented with simple hyphae	*Erysiphe*
1b. Fruit body closed, ornamented with branched hyphae	2
2a. Fruit body ornamented with hyphae with hooks at the ends	*Uncinula*
2b. Fruit body ornamented with hyphae with dichotomously branching tips that do not end in hooks	*Microsphaera*

Key C:
For **asexual ascomycetes**:

1a. Conidia always aseptate	*Trichoderma*
1b. Conidia, at least some conidia, septate	2
2. Conidia with both transverse and longitudinal septa	*Alternaria*
2b. Conidia with only transverse septa	3
3. Conidia long, clear, slender (canoe shaped).	*Fusarium*
3b. Conidia usually dark, ellipsoidal	*Bipolaris*

BIOLOGY 323: STRUCTURE AND REPRODUCTION OF FUNGI (3)

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TEXT:
None required

$30.00 lab manual fee

EVALUATION:
10% collection of two fungi in pure culture, 26% project involving DNA sequencing and critical identification of a fleshy fungus; 24% midterm (12% lab + 12% lecture); 40% final (20% lab + 20% lecture).

Participation in a weekend field trip is required.
This takes place October 24, Saturday, and October 25, Sunday.
=>Plan ahead!<=

SYNOPSIS:
This course is a laboratory- and field-centred introduction to the diversity of the Kingdom fungi. In labs, students culture and identify common molds and apply DNA sequencing to molecular identification of fleshy fungi. Labs offer an overview of fungal diversity through study of field-collected and cultured fungi. Lectures and readings support the laboratories by providing a phylogenetic and functional framework for the fungi.

OBJECTIVES:
Fungi cause plant and human diseases. In more beneficial roles, fungi provide food and drugs and serve as model systems in molecular genetics and as decomposers in the natural environment.

This course will provide students with the basis for working with fungi in these roles. Students will learn to culture and fungi and to interpret fungal morphology.
PREREQUISITES/COMPANION COURSES:

First year Biology is a prerequisite. BIOL 209 (Non-vascular Plants) is useful, but is not a prerequisite.

date	day	lecture topic	Reading Assignments	Tuesday Lab topic
8-Sep	Tue		http://herbarium.usu.edu/fungi/FunFacts/Kingfact.htm	
9-Sep	W	The body of a fungus Classification	Raven et al. (2005) *Biology of Plants* Ch. 14, p 260-266. OR Raven et al. (1999) Ch. 15, p 306-312. Lab Manual p. 13-18	[Note: If you don't have Raven et al., let Mary Berbee know. I'll photocopy the chapter for you.]
14,15-Sep	M/T		Ascomycota background; Raven ('05) 269-272; 282-283. Raven ('99) 317-320; 330-332.	Lab 1. Begin fungal isolations.
16-Sep	W	Molds in Subphylum Pezizomycotina, Class Eurotiomycetes	Raven ('05) 283-285. Raven ('99) 332-334. Kendrick Ch. Pp. 38-77 http://www.mycolog.com/CHAP4a.htm	
21,22-Sep	M/T	Molds and their toxins: examples from Class Eurotiomycetes	http://herbarium.usu.edu/fungi/FunFacts/penicillin.htm	Lab 2. Continue fungal isolations. Molds, *Aspergillus* and *Penicillium*
23-Sep	W	Sexual reproduction in Class Pezizomycotina.		
28,29-Sep	M/Te	Diversity in sexual structures in Pezizomycotina	Lab manual has descriptions of characteristeristics for each subphylum.	Lab 3. Begin fungal identification. Perithecial fungi and molds in the Sordariomycetes.
30-Sep	W	Mating and sexual development in the filamentous ascomcyetes	Casselton, LA BioEssays 2008 30:711 http://www3.interscience.wiley.com/cgi-bin/fulltext/120751739/PDFSTART	
5,6 OCT	M/T	Ascomycota: Yeasts in the Subphylum Saccharomycotina		Lab 4. Mold identification. Lichens and cup fungi. Powdery mildews
7-Oct	W	Hyphal cell biology	http://www.biology.ed.ac.uk/research/groups/jdeacon/microbes/apical.htm	
12,13-Oct	M/T	Monday is Thanksgiving		Lab 5. =>Two molds due. Dothideomycetes and more cup fungi. Yeast; Subphylum Saccharomycotina
14-Oct	W	Lecture exam		
19,20-Oct	M/T	Intro to Basidiomycota	Raven ('05) 272-282 Raven ('99) 320-330 http://www.biology.ed.ac.uk/research/groups/jdeacon/microbes/basidio.htm#Top	=>Lab Exam

date	day	lecture topic	Assignments	lab topic
21-Oct	W	Mushroom form and function. Mushroom walk if fungi are fruiting.		
24-Oct	Sat	**Weekend Field trip**		Set up sampes for spore prints. Dry part of sample for DNA. Put part in fridge.
25-Oct	Sun	**Mushroom identification** Sign up for DNA extraction slot!		Critical morphological study of specimen.
26,27-Oct	M/T	How PCR and DNA sequencing work	Lab manual contains Qiagen DNeasy kit protocols. http://www.dnalc.org/ddnalc/resources/pcr.html	This week: DNA extraction & PCR reactions, rm 1128. Read DNA extraction protocol before lab. Annotate flow chart diagram, noting what must be done at each step.
28-Oct	W	Basidiomycete diversity		
2,3-Nov	M/T	Forcible basidiospore discharge	http://www.jstor.org/stable/pdfplus/3761212.pdf	This week: Gel electrophoresis rm 1128. Lab 6. rm 3008/3009. Mycorrhizae and mushrooms, Other fleshy fungi; jelly fungi and polypores.
4-Nov	W	Mating systems in basidiomycetes	Kendrick, Pp. 168-170.	
9,10-Nov	M/T	Rusts	Raven ('05) 278-282 Raven ('99) 320-330	This week: check DNA sequence. BLAST search; simple phylogeny
11-Nov	W	Remembrance Day holiday		
16,17-Nov	M/T	Rusts		Lab 7. Rusts, smuts, rm 3008/3009.
18-Nov	W	Zygomycota	Raven ('05) 265, 268-269 Raven ('99) 313-317	
23,24-Nov	M/T	Chytridiomycota, water molds	Raven ('05) 266-268 Raven ('99) 312-314 http://www.biology.ed.ac.uk/research/groups/jdeacon/microbes/chytrid.htm	Lab 8 Chytridiomycota and Zygomycota Course evaluations
25-Nov	W	Mycorrhizae	http://www.mycolog.com/chapter17.htm	=>Mushroom DNA report due. See lab manual for details.
30 Nov-1 Dec	M/T	Slide review for lab final		=>Final lab exam
2 Dec	W	The fungal diversity problem	Hawksworth, D. L. (1990) *The Fungal dimension of biodiversity* Mycol. Res. 95:641-655	