Syllabus
BIOL 4506 – Cactus Biology – Fall 2021

Professor: Root Gorelick — Thursdays at 2:35 pm
TA: Alec Medd

CONTACT INFORMATION

E-mail – Subject lines of your e-mails should include "Cactus Biology" or "BIOL 4506".
Phone – I do NOT have access to a phone during the pandemic, so please don't phone me.

NOTE: Your e-mails must be formal, polite, and proofread in order to guarantee a response from me. I reserve the right to ignore e-mails that are filled with spelling and grammatical errors. Use the automatic spelling and grammar checker, possibly cutting-and-pasting from a word processor. I reserve the right to ignore e-mails that address me only by my first name or otherwise appear overly colloquial. You are here to learn, which includes learning how to effectively communicate with those who evaluate your work.

PREREQUISITE

BIOL 2002 (Plant Form & Function)

COURSE OBJECTIVES

- Learn for the joy of it, with no obvious practical takeaways.
- Understand how much diversity exists, even in a narrow evolutionary slice of the world.
- Appreciate the importance of exceptions in biological theory.
- Detect when biologists are (usually unknowingly) telling adaptationist just-so-stories.
- Think, speak, and write for yourself, saying what you actually believe, questioning authority and eschewing conformity.
- Combine ecology, evolution, systematics, developmental biology, morphology, anatomy, physiology, geography, genetics, and anthropology to study a small taxon.
- Tackle questions for which nobody yet knows the answers and discern when questions are unanswerable.

CAVEATS

I reserve the right to alter this syllabus at any time, but promise to only do so for good cause. If I get hit by a bus or something akin to that, whoever takes over teaching the course also reserves the right to alter the syllabus when they step in. Other than during a pandemic – which itself seems like an extraordinary situation – the only time I previously altered a syllabus during middle of the term was due to a labour strike and consequent loss of a few weeks of labs in BIOL 2002.

OPTIONAL TEXTBOOK

If you are looking for an optional textbook to supplement the course material, I highly recommend the following superb book, which is easy to find both new and used copies for sale online. Given that it was first published 35 years ago, it is unfortunately no longer in print.

The Cactus Primer by Arthur C. Gibson and Park S. Nobel (1986) Harvard University Press.

MY PHILOSOPHY

You should know up front that I am a bit of an anarchist. There exists several classes in biology that foster group work, but this is NOT one of those. Instead, I want to hear your own personal voice. That seems more inclusive, more diverse, and a way for you to develop your own voice and persona. The practical (impractical?) side to that is that if two or more of you seem to mimic one another in written work, be it assignments or the questions each week, I reserve the right to send this to the associate dean for adjudication as a putative plagiarism case. So please remember in this class NOT to be collaborative. I would much prefer to hear has many different opinions as we have students and even for your opinions – if well-grounded – to differ from mine.

ACADEMIC INTEGRITY

Carleton University's Senate defines plagiarism as "presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one's own." This can include:

- reproducing or paraphrasing portions of someone else's published or unpublished material, regardless of the source, and presenting these as one's own without proper citation or reference to the original source;
- submitting a take-home examination, essay, laboratory report or other assignment written, in whole or in part, by someone else;
- using ideas or direct, verbatim quotations, or paraphrased material, concepts, or ideas without appropriate acknowledgment in any academic assignment;
- using another's data or research findings;
- failing to acknowledge sources through the use of proper citations when using another's works and/or failing to use quotation marks;
- handing in substantially the same piece of work for academic credit more than once without prior written permission of the course instructor in which the submission occurs.

Plagiarism is a serious offence that cannot be resolved directly by the course instructor. The Associate Dean of Science will conduct a rigorous investigation, including an interview with the student, if I suspect a piece of work has been plagiarized. Currently, minimum penalties for any violation of Carleton's *Policy on Academic Integrity* are:

- First offence (for anybody other than 1st year students): F in the course
- Second offence: One-year suspension from program
- Third offence: Expulsion from the university

More-severe penalties will be applied in cases of egregious offences, e.g. bribing a faculty member or TA for a better grade would be grounds for suspension from the university.

COURSE COPYRIGHT

Tentative Syllabus

ONLINE DETAILS

I will post on BrightSpace (with the dreadful acronym "BS") pre-recorded lectures as powerpoint recordings with my voice over the slides. Be warned that some of the files are big, up to 1.0 GB.

There will be two important times each week: (1) thursdays at 2:35 pm when we will all convene for discussions in which you will earn participation points and submit two questions regarding the readings for that day, one question per reading, and (2) mondays at 11:55 pm which will be the deadline for submitting assignments regarding the past thursdays' topics.

Weekly discussions, which include your verbal participation, will be conducted using zoom (https://zoom.us/j/94965600622). These online zoom discussions will start punctually at 2:35 pm each thursday, are scheduled for two-hours, but will often end sooner.

You will submit weekly written ASSIGNMENTS regarding the previous week's topic and readings via BrightSpace (BS) on or before 11:55 pm each monday night. I will deduct 10% per day for late assignments, with the penalty applied starting at 11:56 pm each monday. Assignments will be posted under "Assignments due each Monday at 11:55 pm" in BrightSpace (BS).

Weekly written QUESTIONS regarding the coming week's reading will also be due no later than the start of class, i.e. at 2:35 pm each thursday. Post your questions using the BrightSpace (BS) tab labeled "Questions on readings – due each thursday at 2:35 pm". Make these questions that you want to know the answer to and questions for which I have not provided the answers in the pre-recorded lectures. And, yes, I will try to answer your questions! I will NOT allow late submission of written questions.

The assignments and questions that you turn in must be your own work in your own words. If two or more people have effectively the same answers, I will send your papers to the dean for adjudication of possible plagiarism. Transcription of somebody else's written or spoken words without quotation marks or without citation to the original source constitutes plagiarism. Failure to include quotation marks (or other distinguishing marks) and a full citation constitutes a *prima facie* violation of the university's academic integrity policy, which will be immediately referred to the dean for adjudication. If two of more students submit qualitatively similar questions or similar assignments each week, I will also refer these to the dean. Copying of someone else's words but then substituting half of the words therein also constitutes a *prima facie* case of plagiarism. See the *Guardian*'s hilarious article about "sinister buttocks" (here) for what this might entail, and note that this still would be sent to the dean as a presumptive case of plagiarism.

Tentative Syllabus

GRADING

12 Assignments: due each monday just before midnight (only 10 highest scores will count)
12 Questions: due each thursday before the scheduled class (only 10 highest scores will count)
12 Participation marks: weekly (only 10 highest scores will count)
There are a maximum of 50 points you can earn for the term.

ASSIGNMENTS will count for 60% of your final course mark (maximum 3 points per week).
Written QUESTIONS will count for 20% of your final course mark (maximum 1 point per week).
PARTICIPATION will count for 20% of your final course mark (maximum 1 per week).

Your first weekly questions will be due at 2:35 pm on thursday 9 September 2021, just before our first class. Your last weekly assignment will be due at 11:55 pm on Monday 13 December 2021, which is the monday after our last class. There will be no final exam nor term paper.

Participation will be based on your responses during the synchronous portion of the class starting at 2:35 pm on thursdays. We will use talking circles for much of this, where we will go in order speaking. I will sometimes announce ahead of time whether you will speak in alphabetic or reverse alphabetic order, either alphabetized by first or last name. Sometimes I will randomize the speaking order. While your speaking order will be controlled, you are free at any time to chime in at any time using the "chat" function on zoom.

During two of the 13 weeks, in lieu of written questions and written assignments, every student will have to present part of the lecture. For each of these two weeks, you will receive a maximum of 4 points that will replace the maximum 4 points you would have received for that week's written questions (1 point) and assignment (3 points). If you do not present during this week, this will count as a zero for one written weekly question and one weekly assignment, remembering that only the ten highest weekly scores count for questions and assignments. During those two week in which students present, your participation mark (1 point) will still be based on the questions you ask and answer while others are presenting.

All course marks will be posted on BS (aka: BrightSpace), allowing you to monitor your marks as the course proceeds. Please understand that as the course instructor, I only advise the department chair and the dean about what final mark you will receive for the course. The dean makes the final decision on marks. Therefore, there is a chance, albeit a small chance, that the marks you calculate from BS may be different from the final course mark that you ultimately see from the registrar's office. I also will NOT post your marks for the final week of class until after the dean and the registrar release final course marks to you.

With one exception described below, you will NOT be allowed to make up any assignments, written questions, or participation marks. I effectively drop the lowest marks in order to account for an occasional absence. Those lowest marks could be zeroes. Plus, it is far less likely that any of us will have to miss class this term because of traveling, especially since you can connect to the internet from almost anywhere. I encourage you to hand in assignments and questions early because there are no make-ups of anything and because the thursday 2:35 pm and monday 11:55 pm deadlines are hard and fast. The only way I will extend those deadlines is if there is a BS outage just before your work is due.

Tentative Syllabus

The one exception alluded to above is that you will have the option of submitting an "un-essay" on or before tuesday 2 December, worth a maximum of 5 points to be used in lieu of any single week's 5 points of assignment-questions-participation. This is NOT extra credit, but must replace a week's worth of your scores, which could have been scores of zero. This substitution must be for one week of scores, e.g. cannot be divvied up to replace five separate participation marks nor can be be used to replace an assignment in week 2 plus questions-participation in week 8. An "un-essay" is a creative work of art related to the course material, such as a painting, sculptor, video, poetry, song, etc. Talk with me about various options. You also must be willing to share this "un-essay" with the rest of the class. The reason an "un-essay" is due on 2 December is to provide adequate time to integrate such things into the last day of class on 9 December.

If there are un-essays presented on 9 December, then I hope you will still listen to your peers and participate. You can therefore have a 13th participation mark, remembering that only the 10 highest participation marks will be used for your final course mark,, i.e. this is a way to improve your final course grade.

Tentative Syllabus

REQUESTS FOR ACADEMIC ACCOMMODATIONS

You may need special arrangements to meet your academic obligations during the term because of disability, pregnancy or religious obligations. Please review the course outline promptly and write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. See the Department of Equity and Inclusive Communities' website to view the policies and to obtain more detailed information on academic accommodation at https://carleton.ca/equity/.

For Students with Disabilities:

The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to have them send me your ***Letter of Accommodation*** at the beginning of the term, and no later than two weeks before the first scheduled assignment. **Requests made after this deadline will be reviewed on a case-by-case basis.** After requesting accommodation from PMC, please talk with me to ensure accommodation arrangements are made.

For Religious Obligations:

Students requesting academic accommodation on the basis of religious obligation should make a formal, written request to me for alternate dates and/or means of satisfying academic requirements. Such requests should be made during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist, but no later than two weeks before the compulsory event. Accommodation is to be worked out directly and on an individual basis. I will make accommodations in a way that avoids academic disadvantage to the student. For more details, see the Carleton Department of Equity and Inclusive Communities "Student Guide".

Students who have questions or want to confirm accommodation eligibility of a religious event or practice may refer to the Department of Equity and Inclusive Communities' website for a list of holy days and Carleton's Academic Accommodation policies, or may contact an Equity Services Advisor in the Department of Equity and Inclusive Communities for assistance.

For Pregnancy:

Pregnant students requiring academic accommodations are encouraged to contact an Equity Advisor in the Department of Equity and Inclusive Communities to complete a *letter of accommodation*. During the first two weeks of class or as soon as possible after the need for accommodation is known to exist, the student must write to me with any requests for academic accommodation.

Tentative Syllabus

FAVOURITE CACTUS HABITATS

I will post several optional lectures. These will NOT be used in grading and will not explicitly help with the weekly written questions, assignments, or participation…except to say that these optional lectures on my favourite cactus habitats will give you greater appreciation for cactus diversity. My hope is to post online optional lectures regarding the following half-dozen places:

- Anthony Gap, New Mexico (and barely into Texas), US
- Big Bend, Texas, US
- Cataviña boulder fields, Baja California, Mexico
- Grão Mogul, Minas Gerais, Brazil
- Morro do Chapéu, Bahia, Brazil
- my winter-hardy cactus garden in Ontario

FOUR KEYS TO SUCCESS IN CLASS

Read Mike Dorf's brilliant and still timely 23 August 2010 *FindLaw* column (here).
Although written about law school, Mike Dorf's article is applicable to any university course.
[http://writ.lp.findlaw.com/dorf/20100823.html]

SCIENCE STUDENT SUCCESS CENTER

The "Science Student Success Centre" offers help to all science students, from helping to secure summer jobs, to improving chances at getting accepted to medical school, to helping learn how to improve grades in Carleton science classes. Events include orientation workshops, mini-conferences, science-related events, and one-on-one mentoring.
Voice: 613- 520-2600 ext 3111 Email: sssc@carleton.ca URL: www.carleton.ca/sssc

APPEALS

If you wish to appeal any grade, please do so via an e-mail to both the professor and TA via e-mail with an appropriate subject line and submit this written appeal within one week of us posting the mark. Your e-mail should politely explain in detail how and/or why you think we erred. Note that Carleton e-mail is considered a secure platform for discussing grades if and only if you use your Carleton e-mail address.

SCHEDULE, TOPICS, AND READINGS

Each week we will read and discuss two (or occasionally three papers) on a given topic. Before the weekly discussion, you will have (1) read the papers for that week, (2) watch the pre-recorded lecture on the topic, (3) submitted online one question on the two designated papers that week – if there are three papers, the syllabus specifies which ones you are assigned to draft questions on, (4) be prepared to discuss that week's papers and pre-recorded lecture, and (5) submitted online an assignment before each monday evening related to the previous week's topic and papers. Below, you will find the list of topics and papers to be read.

Download the assigned readings early because some of them are somewhat difficult to find on the Carleton Library website. For example, the first week's reading can be found at *Scholars Portal Journals*. Many of my papers can be found at my website (https://rootgorelick.com/21-2/publications-by-topic/cacti-and-succulents/). The 2002 paper by Hugo Cota-Sánchez is only available from his personal website at University of Saskatchewan. Most other papers are available via the links on *Web of Science*.

Tentative Syllabus

Why is cactus classification so confounding?
23 September 2021

For this week, you and your peers will present the material, doing so on your own or in groups of two. Your job is to explain why classification within the cactus family, Cactaceae, keeps changing. I will randomly assign which students get which of ten topics for why cactus classification may be so difficult. Your job is to explain in 5 minutes (total time for each topic and pair of students, not necessarily 5 minutes per person) to everyone, possibly with slides, why or why not your subject area makes cactus classification difficult. You will also have to answer questions from your peers and me for another 5 minutes per topic.

Here are ten things that might make cactus classification so confounding:

- polyploidy
- genetic drift
- analogous and homologous traits
- chloroplast inheritance
- clonality
- human transport
- biological species concept
- fossil record
- Madrean sky islands
- phenotypic plasticity

My suggestion for your presentation is to (1) first define the topic you have been assigned, (2) next describe, in general, how this topic may affect classification of any taxon, maybe even including animals, and (3) finally, describe specifics about your topic and cacti. If you use slides, feel free to include pictures or even cartoons, but give full credit for any images or data that you have cut-and-pasted onto your slides. This will require that you find information in the library (library electronic resources will suffice) on the topic you have been assigned and for you to decide whether your topic is relevant to cacti. For example, does polyploidy affect classification? How? Do cacti have a little or a lot of polyploidy? For another example, should we use analogous traits or homologous traits to classify anything? Why? Which traits are used to classify cacti and are they analogous or homologous?

While pairs of students are assigned a topic, feel free to either work as a pair/team or to both present the same topic independently.

You are allowed to swap topics with other students if and only if (1) you have mutual consent of all parties and (2) you provide the TA and me with written notice at least three days before you present.

In terms of grading, this exercise will replace both the written questions and the written assignment for this week. Therefore, there will be no make-up exercises to replace this week if you are absent because you are allowed to drop your lowest mark for weekly questions and assignments.

Adaptations to Deserts
4 November 2021

For this week, you and your peers will present the material, doing so on your own or in groups of two. I will randomly determine which students get assigned which of twelve traits that may help cacti survive in deserts. Your job is to explain in 5 minutes (total time for each topic and pair of students, not necessarily 5 minutes per person) to everyone, possibly with slides, how your assigned trait helps cacti survive in deserts. You will also have to answer questions from your peers and me for another 5 minutes per topic.

Here are the 12 topics:

- massive cortex, pith, and SAM
- cortical bundles
- wide-band tracheids (primary & secondary?)
- lignification
- cork formation
- tylose formation and heartwood
- CAM photosynthesis
- leaf morphology
- root morphology
- stomatal number and location
- hypodermis
- medullary rays

One possible approach is to compare your assigned trait between various cacti, such as comparing cacti that live in deserts versus cacti that live in jungles (mostly epiphytic cacti) or comparing cacti between the four different subfamilies.

While sometimes pairs of students are assigned a topic, feel free to either work as a pair/team or to both present the same topic independently.

You are allowed to swap topics with other students if and only if (1) you have mutual consent of all parties and (2) you provide the TA and me with written notice at least three days before you present.

In terms of grading, this exercise will replace both the written questions and the written assignment for this week. Therefore, there will be no make-up exercises to replace this week if you are absent because you are allowed to drop your lowest mark for weekly questions and assignments.

What is a cactus? What are cacti related to?

9 September

Nyffeler R, Eggli U, Ogburn M, Edwards EJ (2008) Variations on a theme: repeated evolution of succulent life forms in the Portulacineae (Caryophyllales). *Haseltonia* 14: 26-36.

Metzing D, Kiesling R (2008) The study of cactus evolution: the pre-DNA era. *Haseltonia* 14: 6-25.

Gorelick R (2009) Odd Opuntias: *Quiabentia* and *Brasiliopuntia. Cactus and Succulent Journal* (2009) 81: 162. [no need for written questions on this very short paper]

16 September

Hernández-Hernández T, Hernández HM, De-Nova JA, Puente R, Eguiarte LE, Magallón S (2011) Phylogenetic relationships and evolution of growth form in Cactaceae (Caryophyllales, Eudicotyledoneae). *American Journal of Botany* 98: 44-61.

Mauseth JD (2017) An introduction to cactus areoles (part 1 **and** part 2). *Cactus and Succulent Journal* 89: 128-134, 219-229.

Gorelick R (2011) *Ariocarpus fissuratus* and other cacti at the Dog Canyon trailhead, Big Bend. *Cactus and Succulent Journal* 83: 146-149. [no need for written questions on this paper]

Why is cactus classification so confounding?

23 September

No readings – Students present the synchronous lecture today – no question nor assignment due

Canadian Cacti

30 September

Cota-Sánchez JH (2002) Taxonomy, distribution, rarity status and uses of Canadian cacti. *Haseltonia* 9: 17-25. [download this from the author's website at Univ. of Saskatchewan]

Gorelick R (2015) Northern range limit of *Opuntia fragilis* and the Cactaceae is 56°N, not 58°N. *Madroño* 62: 115-123.

Gorelick R (2017) *Opuntia fragilis* in the San Juan Islands. *Cactus and Succulent Journal* 89: 197-200. [no need for written questions on this paper]

7 October

Gorelick R, Drezner TD, Hancock K (2015) Freeze-tolerance of cacti (Cactaceae) in Ottawa, Ontario, Canada. *Madroño* 62: 32-44.

Frego KA, Staniforth RJ (1985) Factors determining the distribution of *Opuntia fragilis* in the boreal forest of southeastern Manitoba. *Canadian Journal of Botany – Revue canadienne de botanique* 63: 2377-2382.

Gorelick R, Gorelick R (2021) Cacti grow smaller in cold environments and larger in warm ones. *Cactus and Succulent Journal* 93: 197-199. [no need for written questions on this paper]

Culture and longevity – 14 October

Dyck E, Bradford T (2012) Peyote on the Prairies: religion, scientists, and Native-newcomer relations in western Canada. *Journal of Canadian Studies – Revue d'études canadiennes* 46: 28-52.

Bowers JE, Webb RH, Rondeau RJ (1995) Longevity, recruitment and mortality of desert plants in Grand Canyon, Arizona, USA. *Journal of Vegetation Science* 6: 551-564.

Adaptation to deserts

21 October [pick any 2 of 3 papers for your weekly questions]

Mauseth JD (2006) Wood in the cactus subfamily Opuntioideae has extremely diverse structure. *Bradleya* 24: 93-106.

Landrum JV (2006). Wide-band tracheids in genera of Portulacaceae: novel, non-xylary tracheids possibly evolved as an adaptation to water stress. *Journal of Plant Research* 119: 497-504.

Barthlott W, Porembski S (1996) Ecology and morphology of *Blossfeldia liliputana* (Cactaceae): a poikilohydric and almost astomate succulent. *Botanica Acta* 109: 161-166.

4 November – Students present the synchronous lecture today – no question nor assignment due

Mauseth JD (2006) Structure-function relationships in highly modified shoots of Cactaceae. *Annals of Botany* 98: 901-926. [this paper is difficult reading, but very worth the effort]

Reproductive structures and strategies

11 November

de Almeida OJG, de Souza LA, Paoli AAS, Davis AR, Cota-Sánchez JH (2018) Pericarp development in fruit of epiphytic cacti: implications for fruit classification and macro-morphology in the Cactaceae. *Botany* 96: 621-635.

Gorelick R (2016) What is a cephalium? *Bradleya* 34: 100-124.

18 November

Martorell C, Vega E, Ezcurra E (2006) Morphological consequences of the trade-off between growth and reproduction in a columnar cactus (*Lophocereus schottii*). *Plant Ecology* 183: 125-131.

Gorelick R (2016) Subdermal woody thorns with secondary growth may support shoots of senita, *Lophocereus schottii* (Cactaceae). *Haseltonia* 22: 18-21.

25 November

Zavala-Hurtado JA, Vite F, Ezcurra E (1998) Stem tilting and pseudocephalium orientation in *Cephalocereus columma-trajani* (Cactaceae): a functional interpretation. *Ecology* 79: 340-348.

Gorelick R, Machado M (2012) Axillary branching of lateral cephalia of *Coleocephalocereus* (Cactaceae). *Haseltonia* 17: 35-41.

2 December [pick any 2 of 3 papers for your weekly questions]

Eggli U, Giorgetta M (2015) Flowering phenology and observations of the pollination biology of South American cacti. I. *Denmoza rhodacantha*. *Haseltonia* 20: 3-12.

Drezner TD, Garrity CM (2003) Saguaro distribution under nurse plants in Arizona's Sonoran Desert: directional and microclimate influences. *Professional Geographer* 55: 505-512.

Bennett JP, Bomar CR, Harrington CA (2003) Lichens promote flowering o*f Opuntia fragilis* in west-central Wisconsin. *American Midland Naturalist* 150: 221-230.

Un-essays – 9 December

Presentation of un-essays by students (if there are any).

This will also be a chance for you to ask any other questions about cacti, so come prepared to stump me.

Tentative Syllabus