# Biology 412.3.1, Limnology

**Instructor:**

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**Lectures:** Biology Bldg. Rm. 123, Mon., Wed., & Fri., 12:30 - 1:20 pm

**Lab:** Rm 307, Friday 1:30 - 5:20 pm (except on Sept 23, proceed to Biol Room 213)

**Day Field Trips:** Friday Afternoon (Sept 16) to Sunday afternoon (Sept 18)

**Course Description**
Limnology is a multidisciplinary field that is broadly defined as the study of inland waters. Limnology lectures provide an introduction to the biological, physical and chemical properties of lakes. The course is taught at an ecosystem level, i.e., processes and concepts are emphasized. Human impacts will also be studied. Afternoon labs and the Field trips are designed to train students in field and laboratory techniques. This includes the use of sampling equipment and procedures to identify and quantify aquatic organisms, and for characterizing the physical and chemical properties of a lake (e.g., water quality). Laboratories will also emphasize experimental design. On completion of the course students will be prepared for advanced study in limnology (graduate level). In addition, students will be better prepared for careers in the environment (e.g., water quality assessment, habitat assessment, lake and fisheries management).

**Learning Outcomes**
Through lectures, assigned readings, and laboratory exercises students will develop an understanding of:

- The diversity of biological, physical and chemical characteristics of lakes
- The influence of watershed characteristics on lake properties
- Lake ecosystem function (energy flow and biogeochemical cycling)
- The diversity and ecology of organisms in lakes
- Experimental design and the interpretation of scientific data.
- Human impacts on lakes (e.g., water quality) and remediation strategies
- The use of limnological equipment to characterize the biological, physical and chemical characteristics of lakes
- Current and emerging scientific thinking in limnology
- The role of ecosystem science in society

**Course website includes:** lecture notes, laboratory data and guidelines, outlines, relevant references for each assignment, and Emma field trip photos (http://www.usask.ca/biology/hudson/bio412/) **Username:** bio412, **password**: perch412

**Prerequisites:** Biol 121, Biol 228 and CHEM 112; or permission of the instructor. A course in statistics is recommended.

**Note:** the weekend field trip (Sept. 16-18) is mandatory. Students collect samples during this field trip for use throughout the lab sessions in Sept., Oct., and Nov. The fee for this weekend trip is has been waived for 2016.

**Course e-Text:** Kalff, J. (2002). Limnology: Inland Water Ecosystems. Link for e-text: https://www.amazon.com/Limnology-Inland-Ecosystems-Jacob-Kalff-ebook/dp/B01GFEPZT0/ref=mt_kindle?_encoding=UTF8&me

**Course Outline as of Sept 7, 2016***

| Week Of | Lecture Topic (Biol Rm 125, M, W, & F, 12:30 to 1:20 pm) | Laboratory (Fridays 1:30 - 5:30 pm) | Lab Report Due Dates | Readings |
|---|---|---|---|---|
| Sept. 6 | -Course introduction<br>-Properties of water | | | -Running Dry News Article |
| Sept. 12 | -Lake ontogeny<br>-Lake morphometry<br>-**Fridays lecture merged into field trip** | **-Weekend Field Trip (Sept 16-18)** | | -Aquatic Hotspots article |
| Sept. 19 | -Lake morphometry<br>-Assignment: lake trophic status as affected by morphometry | **Computer Laboratory, Sept 23, Rm 213**<br>-Start algal fertilization experiment | Lake profile assignment due on **Sept 30.** | -Measuring Chl a (Bev Clark)<br>-Chl a protocol<br>-Lab, Wetzel page 75 for thermocline definition |
| Sept. 26 | -Light and the lake ecosystem<br>-Assignment: $k_d$ calculations<br>-Temperature, Heat, and Stratification | **Limno lab (Rm 307)**<br>-Terminate algal fertilization experiment (pending Chl a conc.)<br>-Sample for Chlorophyll 'a', dry matter, total phosphorus (TP) | -Algal fertilization Experiment due **Nov 4** | -Schindler et al. 1996, UV radiation & DOC |
| Oct. 3 | -Lake types: monomictic, polymictic etc.<br>-Meromictic lakes and paleolimnology<br>-Water movement, surface waves, seiches and circulation patterns | **Limno lab (Rm 305)**<br>-Sample for Chlorophyll 'a', dry matter, total phosphorus (TP) | | -Zhang et al. 2010, UV radiation & DOC<br>-Acidification of the Oceans (DIC issue) |
| Oct. 11 | -Dissolved inorganic carbon<br>-Lake whitings and biota<br>-Oxygen in lakes, profiles, seasonal effects, primary production, effect of DOC, BOD, winter & summer kill | **Limno lab (Rm 305)**<br>-Analyze TP, Chl a and dry matter | | - Nürnberg 2001. Eutrophication |
| Oct. 17 | -Redox reactions in the water column and sediment<br>-Nutrients in lakes: P<br>**Midterm EXAM, October 21** | **Limno lab (Rm 305)**<br>-Analyze TP, Chl a and dry matter | | -Hudson et al. 2000. phosphate determination |
| Oct. 24 | -Nutrients in lakes: P<br>-P management in lakes: successful and unsuccessful attempts<br>-Nutrients in lakes: N | **Plankton (Rm 307)** algal and zooplankton identification and biomass determination. Lake comparison | Algal & Zooplankton assignment: hand in at end of lab | -Lawrence et al. 2007. Microbial loop |
| Oct. 31 | -Size spectrum of planktonic organisms<br>-Fish of Saskatchewan (Guest Lecture) | **Benthos Lab (Rm 307)** | Benthos and Macrophyte | -Watson and McCauley article (Chl. *a* along trophic gradient) |

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|---|---|---|---|---|
| | -Viruses, bacteria, bacterial production | | assignment: hand in at end of lab | |
| Nov. 7 | **Fall Mid-Term Break** | **No Lab** | | -Cyr and Pace 1993. Grazing patterns in terrestrial vs aquatic ecosystems |
| Nov. 14 | -Algae, Algal succession and productivity<br>-Microbial loop<br>-Benthic Invertebrates | **Talking Science Lab** | | -Rhode et al. 2001. Impact of UV on Daphnia migrations<br>-Wilhelm et al. 1999 Benthic - pelagic coupling |
| Nov. 21 | -Zooplankton communities<br>-Zooplankton migration<br>-Size efficiency hypothesis<br>-Food webs: benthic-pelagic coupling | **Student presentations** (Nov 25, Rm 307)**<br>Environmental topics concerning lake limnology | | Brooks and Dodson 1965: size efficiency hypothesis |
| Nov. 28 | -Size efficiency hypothesis<br>-Food webs: benthic-pelagic coupling<br>-Resources vs. predation control of food webs: Top-down bottom-up control, trophic cascade hypothesis | **No Lab** | | -McQueen et al. 1986; Carpenter et al. 1985: Top-down and Bottom-up Food Web Dynamics<br>-Mazumder and Taylor 1990: algal particle size and heat |
| Dec. 5 | -Humans and Angling<br>-Review & Questions | **No Lab**<br>Last day of Limnology class is Dec 7 | | -Schindler 1976. The impact statement Boondoggle |
| **Final Exam** | Rm ??? & Time ??? | | | |

* There will be minor changes to the schedule. I will provide advanced consultation with the class about such changes.
**See list of topics below. These topics are oriented to address human impacts on lakes and should not overlap extensively with lecture content.

## Potential Seminar Topics for Student Presentations:

- Watershed protection/maintenance for urban use (e.g., Vancouver, Victoria, Toronto, New York examples).
- Aquatic endocrine disruptors: source, persistence, and impact
- Biogeochemistry of lake acidification
- Biological impact of lake acidification: phytoplankton, invertebrates or fish
- Cyanobacterial production of toxins and effects
- Logging impacts on inland waters
- Mining impacts on inland waters
- Nanoparticle impacts on inland waters
- Angling impacts on lakes (commercial and sport)
- Biogeochemistry of metals (e.g., mercury, or copper, or nickel etc.)

- Metal effects on biota (e.g., mercury, or copper, or nickel etc.)
- Organic contaminant cycling
- Organic contaminant effects on biota
- Effect of climate change on lake biogeochemistry
- Effect of climate change on lake biota
- Effect of forest fires on inland waters
- Exotic species effects: zebra mussels, Bythotrephes, fish (e.g., carp)
- Shoreline development and impact on littoral habitats
- Lake or river restoration
- Pulp mill impacts
- Introduction to the environmental applications of paleolimnology
- Antibiotics and other pharmaceuticals in water
- Aquatic pathogens and parasites (e.g., *Giardia, Cryptosporidium, Escherichia coli*)
- Impact of intensive livestock operations on surface waters
- Agricultural impacts on surface waters (Irrigation, biocides, fertilizers, erosion)
- Human use and the future outlook for water resources
- Water as a commodity and the international pressure for Canada's water resources
- Biodiversity issues in inland waters
- Effect of ultraviolet radiation on inland water biogeochemistry
- Effect of ultraviolet radiation on the biota of inland waters
- Impact of sewage and sewage treatment on surface waters
- Impact of tourism on inland waters
- Impact of road salt on inland waters

**Notes for oral presentations**

1) Only one topic per student please
2) You may consider other topics, but get my approval beforehand
3) Topics must not duplicate material already presented in class (e.g., the trophic theme of the course)

## Relevant Library Resources

**Example of Journals:**

- Canadian Journal of Fisheries and Aquatic Sciences
- Limnology and Oceanography
- Freshwater Biology
- Lake & Reservoir Management, and colloquial journal "Lakeline"
- Water Research

- Ecology
- Hydrobiologia

**Texts Resources:**

- Lampert, W. and U. Sommer. 2007. Limnoecology. 2nd Edition. Oxford University Press.
- Bronmark, C. and L.A. Hansson. 2005. The biology of lakes and ponds. 2nd Edition. New York, Oxford University Press.
- Wetzel, R. G. (2001). Limnology: lake and river ecosystems. San Diego, Academic Press.
- Dodson, S. 2005. Introduction to Limnology. New York. McGraw-Hill.
- Moss, B. (1998). Ecology of fresh waters: man and medium, past to future. Oxford, Blackwell Science.
- Wilderer, P. 2011. Treatise on water science. Volumes 1-4. Amsterdam, Elsevier.
- Likens, G. 2009. Encyclopedia of inland waters. Volumes 1-3. Boston, Elsevier.
- Lynn, K and Cech, T. (2010). Introduction to Water Resources and Environmental Issues. Cambridge, Cambridge University Press.
- Carpenter, S. R. and J. F. Kitchell (1993). The trophic cascade in lakes. Cambridge, Cambridge University Press.
- O'Sullivan and C. Reynolds. 2004. The Lakes Handbook. Volumes 1-2. Malden, MA, Blackwell.
- Fassett, N. C. (1957). A manual of aquatic plants. Madison, University of Wisconsin Press.
- Cooke, G., E. Welch, S. Peterson, and S. Nichols. 2005. Restoration & management of lakes & reservoirs, 3rd Ed. Boca Raton. Taylor and Francis,
- Kerr, S. R. and L. M. Dickie (2001). The biomass spectrum: a predator-prey theory of aquatic production. New York, Columbia University Press.
- Smol, J. P. (2002). Pollution of lakes and rivers: a paleoenvironmental perspective. London, Arnold.
- North American Lake Management Society and the Terrene Institute. (2001). Managing lakes and reservoirs. Madison, WI
- Lehmkuhl, D. M. 1979. How to know the aquatic insects. Dubuque, Iowa, W.C. Brown Co.
- Thorp, J. H. and Covich, A. P. 2001. Ecology and classification of North American freshwater invertebrates. San Diego, Academic Press.
- Dillard, G. E. (1999). Common freshwater algae of the United States. Berlin, Gebr. Borntraeger

| **Course Evaluation** | **Mark** | **Lab Assignments: Mark Breakdown** | **Mark** |
|---|---|---|---|
| Final exam | 35% | Lake profiles | 5% |
| Mid-term exam | 15% | Algal fertilization | 20% |
| Lab assignments | 30% | Plankton | 2.5% |
| Oral presentation | 15% | Benthos | 2.5% |
| Class Participation | 5% | | |

**Note:** the field trip (Sept. 16-18) must be attended in order to pass this course

**Late assignment policy:** 3% deduction per day. Late assignments may not be returned to a student until the end of term.

**Regulations on Academic Student Misconduct**

The University of Saskatchewan is committed to the highest standards of academic integrity and honesty. Students are expected to be familiar with these standards regarding academic honesty and to uphold the policies of the University in this respect. Students are particularly urged to familiarize themselves with the provisions of the Student Conduct & Appeals section of the University Secretary Website and avoid any behavior that could potentially result in suspicions of cheating, plagiarism, misrepresentation of facts and/or participation in an offence. Academic dishonesty is a serious offence and can result in suspension or expulsion from the University.

All students should read and be familiar with the Regulations on Academic Student Misconduct (http://www.usask.ca/university_secretary/honesty/StudentAcademicMisconduct.pdf) as well as the Standard of Student Conduct in Non-Academic Matters and Procedures for Resolution of Complaints and Appeals (http://www.usask.ca/university_secretary/honesty/StudentNon-AcademicMisconduct2012.pdf)

For more information on what academic integrity means for students see the Student Conduct & Appeals section of the University Secretary Website at: http://www.usask.ca/university_secretary/pdf/dishonesty_info_sheet.pdf