

**SUSTAINABILITY INTEGRATION INTO BIOLOGY 321
(INTRODUCTION TO MORPHOLOGY AND EVOLUTION OF BRYOPHYTES)**

Big Ideas	Topics	Delivery (Activities, Discussions, Lectures, Assignments, Readings, etc)	Learning Objectives/ Attributes and Pillars	Unit(s) Topic Addressed
<p>Sustainability and the three pillars</p>	<p>Overview of bryophytes and their importance ecologically, economically, to society – link to global issues (overview)</p> <p>Ecological and Carbon Footprints</p>	<p>Class Discussion - What is sustainability? Include: viability of natural resources and ecosystems and maintenance of human living, three pillars. - Thinking toward the future Present other definitions (Brundtland, UBC, etc).</p> <p>Revisit at end of course to see how students have developed personal definitions and have them explain how sustainability relates to bryophytes and the world at large. Identify ways their actions impact sustainability (part of the final online quiz).</p>	<ol style="list-style-type: none"> 1. Define sustainability. 2. Explain how concepts such as carrying capacity and tipping points apply to sustainability. 3. Discuss how the concept of sustainability applies at local, regional, national, and global levels. 4. Speculate how the three pillars of sustainability apply to the course content. 5. Distinguish between ecological and carbon footprint. How big is yours? <p>Attribute(s): 2 Pillar(s): Sust (define all)</p>	<p>Units 1 (recurring)</p> <p>Revisit in final unit</p>
<p>Roles/Uses of Bryophytes</p>	<p>Bryophytes role in:</p>	<p>Have students brainstorm why we (humans) are interested in bryophytes (identify personal connections). Begin by discussing why they are taking the course and then the broader issues.</p>	<ol style="list-style-type: none"> 1. Identify five ways you have interacted with bryophytes. 2. Explain why bryophytes are studied. 3. Describe the ecological and economic roles of bryophytes. <p>Attribute(s): 1, 2, 3</p>	<p>Fieldtrip 1 Unit 1</p>

	Biodiversity	Overview of the levels of biodiversity (ecosystem, species, genetic). Discuss the importance of each and how bryophytes contribute to maintaining biodiversity in an ecosystem (habitat for other invertebrates, algae, etc).	Pillar(s): Sust 1. Define Biodiversity and explain how it applies at different levels of organization. 2. Propose how bryophytes enhance biodiversity in an ecosystem. Attribute(s): 2 Pillar(s): Envir	Fieldtrip 1 Lab activities
	Water and Nutrient Cycling	Discussion: water and nutrient retention in different ecosystems. - identify features that facilitate water and nutrient retention and the ecosystems in which this feature is most important. Prevention of run-off and erosion.	1. Discuss the role of bryophytes in water and nutrient retention in an ecosystem of your choice. 2. What structural features facilitate water and nutrient retention? Attribute(s): 2 Pillar(s): Envir	Unit 3 Lab 3
	Nutrient Cycling (Carbon)	Carbon sequestering (covered in detail in the peatland unit).	1. Draw a concept map that illustrates the flow of carbon through the environment. 2. Identify the ecosystems in which bryophytes serve as major carbon sinks. Attribute(s): 2 Pillar(s): 2, 3	Units 3 and 7 Lab Activities to identify fungi associated with bryophytes
	Nutrient Cycling (Nitrogen)	Significance of nitrogen fixers. Overview of symbioses that promotes nitrogen cycling through ecosystems.	1. Explain the importance of nitrogen to life. 2. Draw a concept map that illustrates the flow of nitrogen through the environment. 3. Identify fungal and bacterial	Lab Activities to identify fungi and bacteria in association with bryophytes

			<p>associations with bryophytes and how these interactions enhance nitrogen uptake by bryophytes and other organisms.</p> <p>4. Explain the symbiotic relationship between hornworts and <i>Nostoc</i>.</p> <p>Attribute(s): 2, 3 Pillar(s): Envir</p>	Unit 8 Identify <i>Nostoc</i> in hornwort specimens
	Temperature Regulation	As part of discussion in the fieldtrip	<p>1. Compare the role of bryophytes in regulation of temperature in a local coniferous forest and the far north.</p> <p>Attribute(s): 2, 3 Pillar(s): Envir</p>	Fieldtrips
	Economic uses	<p>Have students investigate the different uses of bryophytes (online). Students present findings.</p> <p>Emphasis: Horticulture industry; peat, <i>Sphagnum</i>, and harvest of other species for horticulture use (e.g. orchid cultivation)</p>	<p>1. Identify the primary economic uses of bryophytes and explain the qualities they impart that facilitate teach use.</p> <p>2. Explain the impacts of harvest to the ecosystems from which bryophytes are harvested.</p> <p>Attribute(s): 2, 3 Pillar(s): Sust, Econ</p>	Unit 5
	Research and Development	<p>Linking various lecture topics</p> <ul style="list-style-type: none"> - Research: model organisms, potential for crop development and other technological advances <p>Parts of world most affected by unproductive croplands</p>	<p>1. Evaluate the use of bryophytes as model organisms.</p> <p>2. Propose a potential application of research in bryology to solve a global problem.</p> <p>Attribute(s): 2, 3, 4 Pillar(s): Envir, Social</p>	Units 1 and 3
	Impacts to human health	Sporotrichosis (<i>Sphagnum</i>) and	<p>1. Explain how exposure to</p>	Units 5 and 6

	(minor)	Loggers' itch (<i>Frullania</i>)	bryophytes can impact human health (include species names and agents). Attribute(s): 2, 3 Pillar(s): Envir, Soc	
	Remediation	Role in remediation and re-vegetation of degraded sites (mines, etc).	1. Describe vegetative and reproductive features that make bryophytes good candidates for remediating degraded sites. Attribute(s): 2 Pillar(s): Envir	Unit 4
	Water Quality	Lesson: how water and nutrients are absorbed	1. Explain how bryophytes are used to monitor water quality. Attribute(s): 2, 3 Pillar(s): Envir, Soc	Unit 6
	Bryophytes as indicators	Discussion: Bryophytes as indicators of air quality, water quality (link above), forest integrity, climate change, etc	1. Identify different ways bryophytes are used as bioindicators and categorize techniques used in direct or indirect biomonitoring. 2. Explain how naturalness indices of bryophytes are used as biodiversity indicators. Attribute(s): 2 Pillar(s): Envir	Unit 3
Global Issues Many interconnecting topics	System Thinking (Systems theory)	Good way to present overview. Not all challenges will apply to this course, but good to identify them in the big picture. - systems approach: problems are addressed as part of a whole	1. Construct a concept map illustrating the interconnection between organisms and the environment in a bog (be sure to distinguish the bog ecosystem from a fen and other wetlands).	Unit 5

		<p>not in isolation</p> <p>Brainstorm/Lecture Start with connections within environment (ecosystem connections), then discuss economic and social consideration</p> <p>Degradation in all ecosystems of the world (www.worldwatch.org)</p>	<p>2. Predict the consequences of altering the abiotic conditions to the organisms in the bog.</p> <p>3. Assess the importance of a bog to the neighboring ecosystems. (likely a discussion for when we talk about the boreal forest)</p> <p>Attribute(s): 2, 3 Pillar(s): Envir</p>	
Habitat Loss		<p>Discussion on biodiversity hotspots and factors that contribute to habitat loss.</p>	<p>1. Identify the human activities that result in habitat degradation and loss.</p> <p>Attribute(s): 2, 3, 4 Pillar(s): Envir, Soc</p>	<p>Fieldtrips Units 5 and 6</p>
Ecological Footprint		<p>Assignment: How much of your ecological footprints stomps on bryophytes?</p>	<p>1. Identify your impact to local bryophyte distribution.</p> <p>Attribute(s): 3 Pillar(s): Envir, Soc</p>	<p>Pre-class reading and online reporting in discussion forum</p>
Loss of Biodiversity		<p>Discussion/Lecture: Consequence to habitat loss and other factors such as pollution, acid rain, climate change</p> <p>Lecture (Guest): Rare bryophytes and Canadian policy on Bryophyte monitoring and assessment (COSEWIC and SARA)</p>	<p>1. Discuss the value of biodiversity for ecosystem health.</p> <p>2. Predict the consequences of climate change to the bryophytes of Vancouver.</p> <p>3. Identify impacts of global warming to bryophyte distribution and biodiversity.</p> <p>4. Explain how organisms are assessed when determining the status of wildlife at risk in Canada.</p>	<p>Unit 6, Bryogeography Lecture</p> <p>Guest Lecture</p>

		Case Study Activity	<p>5. For three red listed bryophytes explain factors that contributed to their limited distribution.</p> <p>Attribute(s): 1, 2, 3, 4 Pillar(s): Envir, Soc</p>	
	Global Climate Change	<p>Focus on current research in bryophytes that focuses on mitigation of impacts of global warming. (e.g. research on desiccation tolerance: applications in crop development -</p>	<p>1. Predict the global and local impacts of climate change. 2. Explain the role of carbon and carbon cycling to global warming. 3. Predict the consequences of global warming to bryophyte distributions (also addressed in sustainability activity). 4. Identify current research in bryology associated with global climate change.</p> <p>Attribute(s): 1, 2, 3, 4 Pillar(s): Envir</p>	Units 5 and 6, carbon sink Bryogeography
	Poverty	- Burning peat for fuel	<p>1. Identify parts of the world peat is burned as a cheap form of fuel</p> <p>Attribute(s): 2, 3 Pillar(s): Soc, Envir</p>	Unit 6
	Energy	<p>- In many parts of the world (not North America peat is burned as fuel (household and electric plants)</p> <p>- impacts to habitats in oil acquisition (Canadian)</p>	<p>1. Identify the parts of the world that peat is used as a source of fuel and energy. 2. Identify the pros and cons of using peat as an energy source in terms of energy output and environmental impact. (also discussed in greater detail in sustainability activity).</p>	Unit 6

			<p>Attribute(s): 2, 3 Pillar(s): Sust</p>	
	Nutrient Cycles (N, C, S) and Acidification	<p>Impacts of acid rain, pollution, etc</p> <p>Tissue culture activity – spore and propagule growth on media treatments including acidified and nitrogen enriched substrate.</p> <p>Students compare growth patterns to control samples and predict what will happen in nature.</p>	<p>1. Explain why bryophytes are more susceptible to pollutants and acid rain than other plants. 2. Predict the impacts of acidification and nitrogen enrichment in nature on the growth of protonema and asexual reproduction in mosses.</p> <p>Attribute(s): 2, 3 Pillar(s): Envir</p>	Lab #2
	War and Conflict	Smoke bombs.....peat mining in Burns Bog		
	Population Growth	Habitat loss....also spread of non-native species		
	Gender Equality			
	Sustainable Agriculture/Forestry			
Sustainability Focused Activity	Peatlands locally and globally with economic, societal, and environmental lenses.	<p>Lecture: Present overview of peatlands and their use around the world.</p> <ul style="list-style-type: none"> - Harvest of peat and other products from Canadian peat lands. - Peatland destruction for agriculture, energy <p>Class Assignment: Class broken into groups.</p>	<p>1. Assess the pros and cons of harvests made from peatlands. 2. Identify alternative sources of horticultural materials. Are they ecologically friendlier than peatmoss?</p> <p>Attribute(s): 1, 2, 3, 4 (consensus building strategies, develop communication skills) Pillar(s): Sust</p>	Unit 6

		<p>Groups are assigned different aspects to research:</p> <ul style="list-style-type: none"> - economic considerations (importance to Canadian economy) – local to country - social (livelihood, tradition) - environmental impacts of peat and other forms of harvest - alternatives to peat (in horticulture business) - demand for non-peat products from bogs (berries, Labrador tea....) <p>Design townhall meeting style discussion where we consider how take into account all aspects of an issue</p>		
Regional/Local Issues	Deforestation (loss of habitat) for Campus Development - Historic	Fieldtrips to different regions of Pacific Spirit Park. Vegetation surveys to look for patterns in distribution and historic logging practices.	<ol style="list-style-type: none"> 1. Predict moss species that would colonize newly cut coniferous woodlands. 2. Explain how microhabitats determine distribution and species richness. 3. Identify different vegetation zones in Pacific Spirit Park and determine areas of high and low biodiversity. <p>Attribute(s): 2, 3, 4 Pillar(s): Envir, Soc</p>	Fieldtrips Units 5 and 6
	Natural Disturbance	Fieldtrip to Pacific Spirit Park, natural disturbances within a forest.	<ol style="list-style-type: none"> 1. Assess the impact of different types of ecological disturbances to local diversity. 	Fieldtrip to Stanley Park

		Fieldtrip to sites of blow down (2006) in Stanley Park.	Attribute(s): 2, 3 Pillar(s): Envir	
(opportunity for Community Service Learning Component) Loss of peatland in Vancouver Area. Efforts at ecosystem restoration.		Field Activity: - Interact with Restoration Group - Vegetation Survey of restored peatland - Historic Perspective - Local anchor - Community engagement Emphasis on the role of public participation in community decision-making. Looking at local issues in a global context.	1. Identify the human role in the deterioration of Camosun Bog. 2. Evaluate the restoration program (Camosun Bog Restoration Group, Stanley Park Ecological Society restoration project at Beaver Lake). 4. Assess the impact of the restoration projects to local biodiversity. 3. Contrast preservation and conservation. How do these terms apply to the Camosun (or Beaver Lake) Restoration project? Attribute(s): 1, 2, 3, 4 Pillar(s): Sust	Fieldtrip Activity
Green City		Bryophyte enhancement in the city..... Potential CSL project idea.	1. Identify existing use of bryophytes in the “greening” of Vancouver. 2. Suggest ways in which bryophytes can be used to green Vancouver. 3. Create a protocol for promoting moss growth on urban substrates. Attribute(s): 1, 2, 3,4 Pillar(s): Sust	Optional Fieldtrip to “greened” part of city
Local Bryophyte Biodiversity		15 specimen collection of local mosses and liverworts	1. Identify common local bryophyte species. 2. Record collection information. 3. Use keys for identification. 4. Prepare voucher specimens of	Collection Project

			local bryophytes specimens as for a scientific collection Attribute(s): 2, 3 Pillar(s): Envir	
Importance of Herbaria and Collections for Biodiversity	Using an Herbarium Beaty Museum - Research in Biodiversity	During a lab period we will visit Beaty Museum. For half the class students will do an herbarium-based project and for the other will do a discovery type activity in the museum based on research in biodiversity.	1. Explain why collections such as herbaria are important for conservation and research in biodiversity. 2. Explain how you would use the herbarium to assist you in completing your collection project. Attribute(s): 2, 3 Pillar(s): Environ	Fieldtrip to Beaty Herbarium and Museum Activities
Communicating Sustainability	Ecosystem Restoration	Write a one-page article about the Restoration project of either Beaver Lake or Stanley Park. The audience will be the general public (like something they would write for the Courier newspaper). One of each will be selected to be posted on the Public Bryology Website.	1. Write a one-page article about the Restoration project of either Beaver Lake or Stanley Park. Provide historical background, human impacts, and value to the community. Attribute(s): 1, 2, 3, 4 Pillar(s): Sust	Fieldtrip Activity

Attributes:

- 1 = Holistic Thinking
- 2 = Sustainability Knowledge
- 3 = Awareness and Integration
- 4 = Agent of Change

Pillar coverage:

- Envir = Environmental
- Econ = Economic
- Soc = Societal
- Sust = Sustainability Focus