

About the Book

For more than ten years I have been working on a book on bryophyte ecology and was joined by Heinjo During, who has been very helpful in critiquing multiple versions of the chapters. But as the book progressed, the field of bryophyte ecology progressed faster. No chapter ever seemed to stay finished, hence the decision to publish online. Furthermore, rather than being a textbook, it is evolving into an encyclopedia that would be at least three volumes.

Having reached the age when I could retire whenever I wanted to, I no longer needed be so concerned with the publish or perish paradigm. In keeping with the sharing nature of bryologists, and the need to educate the non-bryologists about the nature and role of bryophytes in the ecosystem, it seemed my personal goals could best be accomplished by publishing online. This has several advantages for me. I can choose the format I want, I can include lots of color images, and I can post chapters or parts of chapters as I complete them and update later if I find it important.

Throughout the book I have posed questions. I have even attempt to offer hypotheses for many of these. It is my hope that these questions and hypotheses will inspire students of all ages to attempt to answer these. Some are simple and could even be done by elementary school children. Others are suitable for undergraduate projects. And some will take lifelong work or a large team of researchers around the world. Have fun with them!

The Format

The decision to publish *Bryophyte Ecology* as an ebook occurred after I had a publisher, and I am sure I have not thought of all the complexities of publishing as I complete things, rather than in the order of the planned organization. But I wanted to reach a worldwide audience that included not only professional bryologists, but beginners, non-bryologist ecologists, teachers, naturalists, anyone who wanted to know something about bryophytes. Many of these people would never be willing or able to pay the cost of such a book in print copy. And the cost of the numerous color plates would be prohibitive.

Some chapters have been easier for me to do and some will simply need help from others. The "book" will actually be multiple volumes, with the first being physiological ecology, but including an introduction to the broad classification of phyla and classes, morphology, structures, and life cycles. Communities, habitats, roles, interactions, and methods, among others, are in various stages of completion. Large chapters and those with many images difficult to download, so chapters are broken into smaller segments that I shall call subchapters. Sections, chapters, and subchapters will not always be posted in order, so each begins new pagination. Where possible, I will try to number sections of a chapter continuously.

New chapters will be added as they are ready but may not cover all planned topics at the onset. Bryologists are encouraged to send me text or images for consideration, or to volunteer to write a chapter. I am considering making this like an online journal with reviewers, but that needs more planning and is likely to make style and nomenclature inconsistent. Your thoughts on the idea would be appreciated.

Acknowledgments

The contributors to this book are far too numerous to mention all of them by name. To my graduate students and students of bryology, I owe a debt of gratitude for their enthusiasm for this project and for helping me to write for a somewhat less than professional and experienced audience by critically reviewing early chapters. To the members of Bryonet, I thank you not only for your wonderful contributions through Bryonet, but for the promptness with which I receive help for my many requests for images, information, ideas, and publications, reminding me over and over what a wonderful group of people comprise bryology.

From Heinjo During I received numerous helpful suggestions and encouragement to keep going. As my co-author he obtained a contract with Cambridge, which we later abandoned. In the end, he modestly withdrew from authorship, claiming to have made no contribution, but his contributions in reading my chapters have been invaluable. Irene Bisang, as my co-author on the Sexual Strategies chapter update, kept me organized, and I still feel her presence and advice as I work on other chapters. To many persons I owe an immense debt of gratitude for permission to use their images. Without this wide array of choices, the book would have been of incredibly dull appearance on the web, and much less instructive. But most of all, I owe the beauty of the book to Michael Lüth, who gave me blanket permission to use as many of his wonderful images as I wished. They have provided more than half the bryophyte images used and put my own early photographic efforts to shame.

Finally, I acknowledge the support of the Botanical Society of America, the International Association of Bryologists, and most of all, the Department of Biological Sciences of Michigan Technological University for sponsorship of the web version of the book. To my department chair, John Adler, I appreciate his cooperation and support in publishing this as an online book instead of a printed one. To Emil (Tiger) Groth, I owe the web layout and all the web activity needed to place the book there in an accessible and searchable form. And to Annelise Doll and the E. R. Lauren Library staff, we all owe gratitude for selecting this book for Digital Commons and for doing her best to meet all my requests, assuring that this book will be preserved for posterity.

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This file will contain all the volumes, chapters, and headings within chapters to help you find what you want in the book. Once you enter a chapter, there will be a table of contents with clickable page numbers. **To search the list**, check the upper screen of your pdf reader for a search window or magnifying glass. If there is none, try **Ctrl G** to open one.

TABLE OF CONTENTS

BRYOPHYTE ECOLOGY

VOLUME 1: PHYSIOLOGICAL ECOLOGY

Chapter in Volume 1

1 INTRODUCTION

- Thinking on a New Scale
- Adaptations to Land
- Minimum Size
- Do Bryophytes Lack Diversity?
- The "Moss"
- What's in a Name?
 - Phyla/Divisions
- Role of Bryology

2 LIFE CYCLES AND MORPHOLOGY

2-1: Meet the Bryophytes

- Definition of Bryophyte
- Nomenclature
- What Makes Bryophytes Unique
- Who are the Relatives?
 - Two Branches
- Limitations of Scale
 - Limited by Scale – and No Lignin
 - Limited by Scale – Forced to Be Simple
 - Limited by Scale – Needing to Swim
 - Limited by Scale – and Housing an Embryo
- Higher Classifications and New Meanings
- New Meanings for the Term Bryophyte
- Differences within Bryobiotina

2-2: Life Cycles: Surviving Change

- The General Bryobiotina Life Cycle
- Dominant Generation
- The Life Cycle
- Life Cycle Controls
- Generation Time
 - Importance
 - Longevity and Totipotency

2-3: Marchantiophyta

- Distinguishing Marchantiophyta
 - Elaters
 - Leafy or Thallose?
- Class Marchantiopsida
 - Thallus Construction
 - Sexual Structures
 - Sperm Dispersal
- Class Jungermanniopsida

Chapter in Volume 1

Metzgeriidae
 Jungermanniidae

2-4: Bryophyta – Takakiopsida

Phylum Bryophyta
 Class Takakiopsida

2-5: Bryophyta – Sphagnopsida

Class Sphagnopsida – the peat mosses
 Sphagnaceae
 Flatbergiaceae
 Ambuchananiaceae

2-6: Bryophyta – Andreaeopsida, Andreaebryopsida, Polytrichopsida

Andreaeopsida – The Granite Mosses
 Andreaebryopsida
 Polytrichopsida
 Polytrichaceae
 Tetraphidaceae
 Buxbaumiaceae – Bug on a Stick
 Diphysciaceae

2-7: Bryophyta – Bryopsida

Bryopsida Definition
 Chromosome Numbers
 Spore Production and Protonemata
 Gametophore Bud
 Gametophores
 Location of Sex Organs
 Sperm Dispersal
 Release of Sperm from the Antheridium
 Dispersal to the Archegonium
 Embryo Development
 Capsule Development

2-8: Anthocerotophyta

Anthocerotophyta

3 SEXUAL STRATEGIES

3-1: Sexuality: Sexual Strategies

Expression of Sex
 Unisexual and Bisexual Taxa
 Sex Chromosomes
 An Unusual Y Chromosome
 Gametangial Arrangement
 Origin of Bisexuality in Bryophytes
 Monoicy as a Derived/Advanced Character
 Multiple Reversals
 The Monoicous Advantage
 Or the Dioicous Advantage?
 Origins of Polyploidy
 Sporophytes from Fragments
 Genome Doubling in Mosses
 Relationship of Polyploidy and Monoicy in *Atrichum*
 Pseudodioicy
 Polyploidy and Spore Size
 Cross Fertilization
 Sperm Dispersal by the Bryophyte
 Sperm Travel Distances
 Explosive Help in Thallose Liverworts

Chapter in Volume 1

- Sperm Dispersal Vectors – After Release
 - Splash Mechanisms
 - Invertebrate Dispersal
- Sperm Longevity
- Factors for Successful Fertilization

3-2: Sex Ratio and Sex Expression

- Sex Ratio
 - The Bryophyte Female Bias
 - Spore Sex Ratios
 - Genetic vs Expressed Adult Sex Ratio
 - Causes of Female Bias
 - Sex Expression and the Shy Male Hypothesis
 - Germination Patterns and Spore Mortality
 - Environmental and Geographic Differences
 - When Are Some Males More Stress Tolerant?
 - Other Differences between Populations
 - Frequency and Timing of Sex Expression
 - Branching Patterns and Gametangial Location
 - Protogyny and Protandry
 - Age-related Differences
 - Sexual Plasticity
 - Bisexual through Ramets and Rhizautoicy
 - Sex Reversal
 - Mechanisms of Labile Sex Expression
 - Plasticity vs Genetic Differentiation
 - Is There an Asexual Role for Males?
 - When Males Are Dominant
 - Maintaining Sexual Dimorphism in a Population
 - Season and Sex Expression
 - Role of Asexual Reproduction in Dioicy
 - Gemma-bearing Dioicous Taxa
 - Spores, Asexual Propagula, and Rarity
 - Why Are Liverworts Different?
 - Are Epiphytes a Special Case?

3-3: Size and Sex Differences

- Sex-related Differences in Gametophores
- Size and Sex Differences
 - Dwarf Males
 - Revisiting the Sex Ratio
 - Dwarf Males in *Homalothecium lutescens*
 - What Is the Role of Vegetative Propagules?
 - How Do Facultative Males Develop?
 - The Dwarf Male Advantage
 - Species Interactions
 - Spore Differences
 - Anisospory
 - False Anisospory – Spore Abortion
 - Evolution of Spore Differences
 - Advantages of Anisospory and False Anisospory in Bryophytes

3-4: Reproductive Barriers and Tradeoffs

- Reproductive Barriers: Selfing and Hybrids
 - Selfing and Inbreeding Depression
 - Reduced Fitness
 - Hybridization
 - Intergeneric Hybrids
 - Hybrid Success
 - When Barriers Are Needed – or Not
 - External Barriers

Chapter in Volume 1

- Spatial or Geographic Isolation
- Ecological Isolation
- Seasonal Isolation – Gametangial Timing
- Internal Barriers
 - Gametic Isolation
 - Genetic Incompatibility
 - Hybrid Sterility
- Apomixis?
 - Vegetative Apomixis
- Reproductive Tradeoffs
 - Cost of Sexual Reproduction
 - Spore Size and Number
 - Sexual vs Asexual Strategies
 - Bet Hedger
 - Growth vs Asexual Reproduction
 - Significance of a Dominant Haploid Cycle
 - Do Bryophyte Sexual Systems Affect Genetic Diversity?
- The Red Queen Hypothesis
- Surviving Unfavorable Conditions
- Bryophytes vs Seed Plants

4 ADAPTIVE STRATEGIES

4-1: Phenology, What does it mean?

- Developing Consistency in Reporting
- System of Naming

4-2: Phenology, It's all in the timing

- Timing the Stages – Environmental Cues
- Patterns
- Growth
- Asexual Reproduction
- Gametangia
 - Protandry and Protogyny
- Sporophyte Maturation
 - Energy Needs
 - Optimizing Dispersal Time
 - Spring and Autumn Dispersal
 - Development Time
 - Winter Dispersal
 - Elevation Effects
- Spores and Protonemata
- Duration of Stages
 - Gametangia
 - Sporophytes
 - Winter Effects
- Geographical Differences within Species
- Seasonal Differences among Habitats
 - Tropics
 - Deserts and Dry Habitats
 - Epiphytes
 - Savannah
 - Polar and Alpine
 - Disturbed Habitats – Ephemerals
 - Wetlands
 - Aquatic

4-3: Phenology, a *Sphagnum* case study

- Sphagnum*: A Case Study
 - Gametangia
 - Fertilization

Chapter in Volume 1

Embryogenesis (formation of embryo)
Spore Release and Germination

4-4: Phenology, Tradeoffs and Habitats

Tradeoffs
Tradeoffs with Spore Production
Geographic Differences
Longevity Tradeoffs
Control of Phenological Events

4-5: Growth and Life Forms

Growth Forms and Life Forms
Definitions
Jargon of Life History
Growth Forms
Life Forms
Environmental Influences on Life Form
Physical Effects on Growth Form
Moss Balls
Adaptive Significance
Habitat Relationships
Deciduous Woodlands
Pine Woods
Epiphytes
Peatlands
Aquatic
Deserts
Polar Regions
Alpine
Studies Needed

4-6: Life Cycles

Life Strategies
Clonal Growth
Foraging and Sharing
Implications for Reproduction
Density Effects
Tradeoffs
r & K Strategies
Bet Hedgers
Dedifferentiation Issues
The r Strategist
The K Strategist
Life Cycle Strategies
Diaspore Banks
Tradeoffs
Life Cycle Strategies based on Dunning (1979, 1992)
Fugitives
Fugitives – species that live in unpredictable environments
Colonists
Colonists (*sensu stricto*)
Colonists
Colonists (ephemerals) – species that live where habitat start is unpredictable
Colonists (pioneers) – species that live where habitat start is unpredictable and habitat lasts at least several years after disturbance; make habitat suitable for perennial stayers (Rabotnov 1975)
Shuttles
Annual Shuttle
Short-lived Shuttle
Perennial (long-lived) Shuttle
Perennial Stayers
Perennial stayers (competitive)

Chapter in Volume 1

Perennial stayers (stress-tolerant)
 Dominants – bogs
 Generation Time
 Habitat Studies

4-7: Adaptive Strategies: Spore Dispersal

Importance of Dispersal
 Diaspores
 Sampling Methods
 Diaspore Banks or New Arrivals?
 Species Differences
 Arable Fields
 Ponds and Lakes
 Forests
 Peatlands
 Delayed Germination – Dormancy
 Does Depth Matter?
 Benefits of Diaspore Banks
 Tradeoffs
 Spores vs Vegetative Dispersal
 Differences in Success
 Limits to Success
 Which Strategy Accomplishes More?
 Lost Energy
 Liverworts vs Mosses
 Habitat Differences
 Disturbed Habitats
 Epiphytes
 Peatlands
 The Antarctic
 Plasticity of Spore Size
 Seasons
 Are These Adaptations?
 Capsules and Setae
 Habitat Differences
 Anisospory
 Spores and Spore Walls
 Liverworts
 Monoicous vs Dioicous
 Ecological Adaptations
 Who Is Travelling?
 Spore Dispersal Mechanisms
 Sporophyte Adaptations for Dispersal
 Role of Peristome
 Cleistocarp

4-8: Adaptive Strategies: Vegetative Propagules

Diaspore Travel Distances
 Failure to Leave Home
 Polytrichaceae
 Evidence from a Road Cut
 Epiphytes
 Disturbed and Short-lived Substrata
 Long-Distance Dispersal (LDD)
 Lessons from Tracheophytes
 Everything Is Everywhere!
 Spore Size and Range
 Distribution Stories
 Island Colonization Stories
 Factors Contributing to Dispersal
 Distance from Source

Chapter in Volume 1

- Dispersal Pathway
- Air Currents
- Molecular Clocks
- Weather
- Fires
- Diaspore Characteristics
- Evidence from Geophysics
 - Diffusion Models
 - Dust Storms
 - Not All Storms Are Equal
 - Aloina* Example
- Size and Falling Velocity – Distance and Laws of Physics
- Evidence from Restoring Peatlands
- Disjunct Distributions
- Stepping Stones
- Gene Flow
- Spore Size and Number
 - Large Spores
 - Spore Weight
- Survival and Longevity
 - Atmospheric Conditions – UV and Desiccation
 - Drought Tolerance
 - Frost Resistance
 - UV Protection
 - Liverwort Spore Survival
 - Adaptations for Survival
 - Survival in Water
 - Survival of Spores vs Asexual Diaspores
 - Long-distance Survival
- Establishment Success
 - Adherence
 - Conditions Matter
 - Slow Establishment
 - Dispersal Limitation
- Recolonization
 - Forests

4-9: Adaptive Strategies: Spore Dispersal Vectors

- Dispersal Types
- Wind Dispersal
 - Splachnaceae
 - Liverworts
 - Invasive Species
- Decay Dispersal
- Animal Dispersal
 - Earthworms
 - Insects and Spiders
 - Ants
 - Aquatic Insects
 - Sticky Spores
 - Muscidae and Dung Mosses
 - Diversification of Spore Dispersal Strategies
- Molluscs
- Fish
- Birds
- Mammals
- Water Dispersal
 - Common Adaptations
 - Marine Dispersal?
 - Flood Plains and Dry Flats
 - Raindrops

Chapter in Volume 1

- Exploding Capsules?
 - Vortex Rings
 - Role of Stomata
 - Is This an explosion in *Sphagnum*?
 - Falling Rate
 - A *Sphagnum* Spore Mimic

4-10: Adaptive Strategies: Vegetative Propagules

- Vegetative Reproduction
- Adaptations
- Fragmentation
 - Leaves and Stems
 - Protonemata
 - Perianths
 - Calyptrae
 - Involucres
 - Paraphyses
 - Falling Epiphytes
 - Moss Balls
 - Animals – Breaking or Ingesting Bryophytes
 - Extreme Environments
 - Antarctic & Arctic
 - Alpine
- Vegetative Diaspores
 - Stem and Leaf Gemmae
 - Rhizoidal Gemmae
 - Rhizoidal Tubers
 - Protonemal Gemmae
- Liberation Mechanisms
 - Protonemal Gemmae
 - Tmema
- Diaspore Bank
- Propagule Dispersal Distances
- Propagule Survival/Longevity
- Propagule Establishment
 - Desiccation
 - Inhibitors
 - Establishment and Rarity
 - Reproductive Problems
 - Epiphytes
 - Symbionts Needed
- Tradeoffs

4-11: Vegetative Dispersal Vectors

- Dispersal
- Gravity
- Wind Dispersal
- Water Dispersal
 - Splash Cups
- Animal Dispersal
 - Earthworms
 - Arthropods
 - Isopods
 - Mites
 - Harvestmen
 - Insects
 - Weevil Gardens
 - Ants
 - Molluscs
 - Amphibians
 - Turtles

Chapter in Volume 1

- Birds
- Mammals
 - Rodents
 - Flying Fox
 - Lessons from a Dog
 - Hoofed Mammals
 - Bears
- Human Dispersal
- Mystery Dispersal
- Invasive Species

4-12: Speculation on Gametophyte Structures

- Prologue
 - Linked Genes
 - Evolutionary Drivers
- GAMETOPHYTE
 - Wetland vs Non-wetland Trends
 - Stem
 - Stem Structure
 - Paraphyllia
 - Leaf Margins
 - Borders or Not
 - Marginal Teeth
 - Liverworts
 - Hair Tips
 - Costae
 - Lamellae
 - Keels
 - Leaf Plications
 - Leaf Cells
 - Papillae
 - An Alternative to Papillae?
 - Fluorescence
 - Thallus
 - Pigmentation
 - Gender
 - Wound Response

4-13: Speculations on Sporophyte Structure

- SPOROPHYTE
 - Calyptra
 - Hairs
 - Capsules
 - Capsule Structure
 - Stomata
 - Location, Structure, and Number
 - Stomatal Functioning
 - Adaptive Significance
 - Hornwort Capsules
 - Are Bryophytes Slow to Evolve?

5 ECOPHYSIOLOGY OF DEVELOPMENT**5-1: Hormones**

- Introduction
- Developmental Adjustments
- Life Cycle Importance
- Growth Regulators
 - Auxins
 - Cytokinins
 - Factor H

Chapter in Volume 1

- Gibberellins
- Abscisic Acid
- Lunularic acid
- Ethylene
- Acetylcholine
- Cryptochromes

5-2: Spore Germination

- Spores Maturation
 - Maturation Seasons
- Does Dormancy Exist in Bryophytes?
- Definition of Spore Germination
- Germination Process
 - Water Needs
 - Energy Needs
 - Light Needs
- Environmental Control over Germination
 - pH
 - Nutrients
 - Temperature
 - Vernalization
- Germination Inhibitors
 - Hormonal Regulation
 - Inter- and Intraspecific Interactions
 - Interspecific Competition
- External Growth Promoters
- Pollutants
- Spore Size
 - Anisospory and False Anisospory
 - Tradeoffs
- Germination Success
- Germination Time
- Spore Resiliency and Longevity
- Adaptations to Moisture Extremes
 - Dry Habitats
 - Precocious Germination
 - Aquatic

5-3: Protonema

- The Protonema
- Water Relations
- Seasonal Light/Temperature Changes
- Light
 - Light Intensity
 - Light Quality
 - Photoperiod
- Hormonal Response
- Tropisms
 - Phototropism
 - Gravitropisms
- Nutation
- Interactions
- Nutrients
- Rhizoids
- Tmema
- Protonemal Gemmae and Tubers
- Liverworts
- Ecological Considerations

5-4: Gametophore Buds

- Establishment Success

Chapter in Volume 1

Light and Photoperiod
 Growth Regulators
 Cytokinins
 Auxin-Cytokinin Interaction
 Ethylene
 Interactions with Other Organisms
 Nutrients or Inhibitors?
 Temperature

5-5: Gametophores

Growth
 Stem Growth
 Water
 Light
 Tropisms
 Photoperiod
 Temperature
 Growth Regulators
 Branches and Apical Dominance
 Environmental Factors
 Growth regulators
 Pleurocarpous Mosses
 Thallose Liverworts
 Nutrients
 Leaves
 Light
 Water
 Nutrients
 Growth Regulators
 Liverwort Leaf Suppression
 Cuticle
 Rhizoids
 Temperature
 Light
 Tropisms
 Adhesion
 Growth Regulators
 Wounding
 Habitat Conditions
 Conduction
 Bryophyte Senescence
 Ecological Interaction

5-6: Fragments

Fragmentation
 Arctic and Alpine
 Streams and other Aquatic Habitats
 Dedifferentiation
 Secondary Protonemata from Fragments
 Gravity Effects
 Callose Formation
 Establishment
 Growth Regulators
 Animal Dispersal

5-7: Brood Bodies

Introduction
 Definitions
 Brood Bodies
 Tubers
 Development

Chapter in Volume 1

- Hormonal Effects
 - Auxins
 - Cytokinins
- Environmental Effects
 - Temperature
 - Light
 - Water Relations
 - Gender
 - Nutrients and Inhibitors
- Dormancy
- Germination Time
- Tradeoffs
- Ecological Function

5-8: Gametogenesis

- Definition
- Developmental Stages
- Environmental Factors
 - Water Availability
 - Gametangium Developmental Need for Water
 - Swimming Sperm
 - Paraphyses
 - Photoperiod and Light Intensity
 - Nutrients
 - pH
 - Temperature
 - Environmental Signalling Interactions
- Hormones
 - Environmental Hormone Interactions
- Sugars
- Overall Physiology
- Color Changes
- Delay of Gametogenesis
- Male vs. Female
 - Differential Survival
 - Bisexual Gametangial Differentiation
 - Hormonal Regulation of Gender
 - Dwarf Males
 - Different Controls
 - Numbers of Gametangia
- Gender Recognition
- Fertilization
 - Self-incompatibility
- Geographic and Habitat Relationships
- Tradeoffs – Cost of Reproduction

5-9: Sporophyte

- Sporophyte Structure
 - Sporophyte Nutrition
 - Seasonal Development
 - Why Does It Look Different
- Seta Structure and Function
 - Seta Elongation
 - Mosses
 - Liverworts
 - Tropisms
- Dispersal
- Capsule Development
 - Light
 - Nutrients
 - Water Needs

Chapter in Volume 1

- Stomata
- Control of Sporophyte Morphology
- Capsule Shape
 - Role of Calyptra
 - Neoteny
- Perichaetial Leaves
- Hormone Interactions
- Spore Production
- Dehiscence
- Tradeoffs
- Habitat Adaptations

6 LIMITING FACTORS AND LIMITS OF TOLERANCE

- Pushing the Limits
- C-S-R Triangle
- Severe Stress
- Genetic Adaptations
- Crystals – Adaptive?
- Do Nutrients Limit Bryophytes?

7 WATER RELATIONS**7-1: Conducting Structures**

- Bryophytes as Sponges
- Conducting Structure
 - Leptomes and Hydromes
 - Hydroids
 - Leptoids
- Rhizome
- Leaves
 - Costa
 - Sphagnum*
 - Leafy Liverworts
- Leaf Traces
- Sporophyte Conduction
- Adaptation and Evolution
 - Being Acrocarpous
 - Being Pleurocarpous
 - Aquatic
 - Using a Partner

7-2: Water Movement

- Water Movement
 - Ectohydric
 - Endohydric
 - Nocturnal
 - Mechanisms of Water Movement
 - Transport to Sporophyte

7-3: Water Strategies – Plant

- Water Strategies
- Water Cycle Role in Ecosystem
- Structural Adaptations
 - Thallose Liverworts
 - Scales
 - Ballooning of Epidermis
 - Rhizoids
 - Fungal Partners
 - Main Thallus Structure
 - Spongy Thallus
 - Cuticle

Chapter in Volume 1

- Pores
- Archegoniophores and Antheridiophores
- Dormancy
- Mosses and Leafy Liverworts
 - Growth Form
 - Stems and Branches
 - Central Strand
 - Waxes
 - Rhizoids and Tomentum
 - Mucilage
 - Capillary Spaces
 - Fungal Partners
 - Protonema
 - Leafy Liverwort Gemmae
- Sporophyte
 - Calyptra Protection
 - Cuticle
 - Guard Cells and Stomata

7-4a: Water Strategies – Leaf

- Overlapping Leaves
- Leaves Curving or Twisting upon Drying
- Thickened Leaf
- Concave Leaves
- Cucullate Leaves
- Plications
- Revolute and Involute Margins
- Borders
- Leaf Teeth
- Teniolae
- Costa
- Stereids
- Lamellae
- Lobules and Storage Organs
- Hair Points
- Nucleation
- Papillae
- Leaf Bases and Alar Cells
- Leaf Cell Shape
- Porose Cells
- Hyalocysts
- Cancellinae
- Cell Structure
 - Cell Walls
 - Oil Bodies
 - Vacuoles
 - Slime Papillae

7-4b: Water Strategies – Leaf Strategies – Cuticles and Waxes

- Bryophytes Do Have Cuticles
 - Sphagnum*
 - Leafy Liverworts
- Admissibility of Water
- Multiple Forms – Multiple Roles
 - Temperature
 - Light
 - Salt Stress
 - Contact Angles and Entry
 - Combined Role and Water Relations
 - Altitude Protection
 - Pollution Protection

Chapter in Volume 1

Ozone
CO₂
Repelling Water

7-5: Physiological Adaptations

Water Relations on Land
Drought Tolerance vs Avoidance
 Desiccation Tolerance
 Desiccation Avoidance
Life Cycle and Life Strategy Adaptations
Seasonal Changes
Physiological Adaptations
 Mode of Conduction
 Osmotic Potential and Turgor
 Water Content
 Water-logging
 Inducible vs Constitutive Desiccation Tolerance
 Hardening
 Desiccation-induced Changes
 Cell Contents
 Chloroplast Responses
 Photosynthesis
 Mitochondria
 Nuclei
 Vacuoles and Vesicles
 Membranes
 Plasmolysis
 Liverworts

7-6: Rehydration and Repair

Uniqueness of Bryophytes
Resumption of Activity
Protein Degradation
Photosynthesis
Membrane Repair
Photodamage
Architectural Changes
Chloroplast Recovery
Frequency of Dehydration/Rehydration
Implications

7-7: Biochemical Adaptations to Drying

Membrane Chemistry
ABA Role
Protection from Oxidation
 Oxidative Damage
 Glutathione
 Pathogen Danger
Shoot Tips – Variable Tolerance within Plants
The Genes

7-8: Habitats

Habitat Relations
Peatlands
Aquatic Habitats
Arid Habitats
 Sporophyte Damage
 Desiccation from Salt
Flood Plains
Arctic and Antarctic
Forest Floor

Chapter in Volume 1

- Temperate Epiphytes
- Tropics, Rain Forests, and Cloud forests
 - Epiphytes
 - Pendent Mosses
 - Altitude Differences in the Tropics

7-9: Winter Physiology

- Problems in Winter
 - Frost Damage
 - Ice Crystals
- Desiccating Conditions
- Desiccation Tolerance
- Ice-nucleating Proteins
 - Atmospheric Source
 - Nucleating Proteins in Lichens
 - Nucleating Proteins as a Source of Water
- Compounds for Winter?
 - Sugars
 - ABA
 - Arachidonic Acid
- Polyribosomes

8 NUTRIENT RELATIONS

8-1: Requirements

- What Do Bryophytes Require?
- Nutrient Requirements
 - Macronutrients
 - Nitrogen
 - Phosphorus
 - N:P Ratios
 - Calcium and Magnesium
 - Iron
 - Micronutrients
 - Boron
 - Copper
 - Heavy Metals
- Nutrient Content
 - Habitat Differences
 - Streams
 - Bogs and Fens
 - Forests
 - Arctic and Alpine
 - Species Differences
 - Adaptability and Acclimation
- Plant Nutrient Locations
 - Cell Wall Sites
 - Intracellular Sites
 - Vertical Distribution
- Nutrient Sources
 - Precipitation
 - Bogs
 - Atmospheric Dust
 - Soil
 - Micronutrients
 - Litter and the Role of Trees
 - Decomposition
 - Snow
 - The Salmon Story and Other Animals
 - Fungal Partners
- pH Relationships

Chapter in Volume 1

Protective Devices
Seasonal Nutrient Behavior
Effects on Species Composition

8-2: CO₂

CO₂ Sources and Limitations
 Early Carbon Relations
 Relationships Today
 Structural Adaptations
 Soil CO₂
CO₂-Concentrating Mechanisms
Aquatic CO₂
 Role of pH
Bogs
 Methane
CO₂ and Desiccation Tolerance
Translocation
Importance of Bryophytes in C Cycling

8-3: Nitrogen

N Forms
 Nitrate and Ammonium
 Physiology of Nitrate and Ammonium
 Morphological Anomalies
 Benefit or Detriment?
 Species Differences
 Long-term Effects
 Organic Nitrogen
Nitrogen Uptake
Nitrogen Fixation
 Arctic, Antarctic, and Alpine
 Arctic and Subarctic
 Antarctic and SubAntarctic
 Alpine and Subalpine
 Peatland Associations
 Boreal Forests
 Tropics
 Epiphylls
 Liverwort Symbiosis
 Hornwort Associations
 Lunar Rocks
 Other Stressful Habitats
Nitrogen Translocation
N Sequestering
N Deficiency Effects
N Enrichment
Habitat Relations
Nutrient Cycling

8-4: Uptake

Uptake
 General Considerations
 Sources
 Site of Uptake
 Rhizoids
 Growth Form
 Age
 Nutrient Concentration
 Water Source
 Cation Exchange
 Polyuronic Acids and CEC

Chapter in Volume 1

- The Mechanism
- Cation Competition
- Heavy Metal Relationships
- Differing Affinities
- Habitat Differences
- Uptake Rate
- Desiccation and Loss
- Anion Uptake
- Proton Pumps
- Cotransport
- Pinocytosis
- Nanoparticles
- Influence of Cellular Structures
- Location Is Important
- New Growth
- Specificity
- Seasons
- Glucose Uptake
- Fungal Connections – Mycorrhizae?
 - Cryptothallus mirabilis*
 - Underground and Other Partnerships
 - Arbuscular Mycorrhizae
 - Beneficial or Harmful?

8-5: Translocation and Transport

- Translocation and Transport
 - Movement from Older to Younger Tissues
 - Directional Differences
 - Species Differences
- Mechanisms of Transport
 - Source to Sink?
 - Enrichment Effects
 - Internal Transport
 - Structural Facilitation
 - Leptome Transport
 - Carbon Transport
 - Apoplastic Transport
 - Desiccation Effects
 - External Translocation
- Sporophyte Conduction

8-6: Deficiency

- Nutrient-deficient Habitats
- Nutrient Deficiency Symptoms
 - N and P Deficiency
 - K Deficiency
 - Ca Deficiency
 - Mg Deficiency
 - S Deficiency
 - Fe Deficiency
 - Micronutrient Deficiency
 - Oxygen Deficiency
- Community Effects of Deficiencies

8-7: Fertilization

- Fertilization Effects
 - N Additions
 - P Additions
 - Ca and Mg Additions
 - Fe Additions
 - CO₂ Additions

Chapter in Volume 1

Excess Nutrients
Fertilization and Community Structure

8-8: Cycling

Storage and Release
Storage Locations
 Mineral Nutrients
 What We Learned from Heavy Metals
 Oil and Lipid Bodies
 External Storage
 Bryophytes as Nutrient Sinks
 Luxury Nutrients
 Carbon Sinks
 The Vernal Dam
Release during Desiccation/Rehydration
 Canopy Releases
Bogs and Fens
pH Effects
Indicator Species
Needed Research

9 LIGHT**9-1: The Shade Plants**

Bryophytes Are Shade Plants
 Compensation Point
Light Quality
Light Measurement
Adaptations to Shade
Compensation Points
Sunflecks
Light Effects on Morphology

9-2: Adaptations for Shade

Structural Adaptations for Light Capture
 Lamellae
 Surface Reflectance
 Altering Wavelengths
 Papillae
 Leaf Area Index
Self-shading
 Bryophyte Canopy
 Growth and Branching
Chlorophyll Fluorescence
Morphological Responses
Physiological Adaptations to Low Light
 Chlorophyll
 Other Pigments
 Chloroplast Movement
 Light and Storage
Forest Gaps
Sunflecks
Litter Burial
The Partnership Choice

9-3: Effects of High Intensity

Effects of High Light Intensity
 Light and Moisture Relations
 Photoinhibition
Adaptations to High Light
 Structural Adaptations

Chapter in Volume 1

Pigmentation

- Sphagnorubin
- Chlorophyll Ratios in Aquatic Bryophytes
- UV Absorption
- Desiccation Effects and Light
- Avoidance – Hiding under Rocks

9-4: Seasonal Effects

- Bryophyte View of Light
- High Light and Low Temperatures
- Light Effects on Reproduction
- Seasonal Effects on Pigments
- Colors of Light
- Photoperiod Effects

9-5: Reflection and Fluorescence

- Cave Mosses
 - Schistostega pennata* – Luminous Moss
 - Cyathodium*
 - Wombat Holes
 - Cave Communities
 - Rockhouses
 - Responses to Low Light in Caves
- Reflectance in the Desert
- Fluorescence
- Pigments
- Leaf Canopy
- Leaf Angle

10 TEMPERATURE

10-1: Effects

- Temperature
- Bryophyte Alteration of Temperature
 - Soil Temperatures
 - Degree Days
 - Safe Sites
- Life Cycle Effects
- Normal and Extremes for Growth
- Compensation Point
- Antarctic and Arctic
- Acclimation
 - Cold vs Heat
 - Acclimation Triggers

10-2: Cold

- Low Temperature Limits
- Stress Protection
- Freezing
 - Desiccation Tolerance
 - Protection of Photosynthetic System from Light
 - Role of Calcium
 - Abscisic Acid
 - Transporter Proteins, ABA, and Ca
 - Sugars and Plasmolysis
 - Freezing Longevity
- Freezing Effects
 - Supercooling Intracellular Water
 - Ice Crystals Increase Solutes
 - Crystal Damage
 - Preventing Ice Crystals

Chapter in Volume 1

- Rate of Freezing
- Hydration State
- Lipids in Membranes and Protein Denaturation
- Unsaturated Lipids
- Fatty Acid Alterations
- Fatty Acids and N
- Triglycerides
- Polyribosomes
- Age Difference to Freezing
- Freezing Effect on Distribution and Niche
- Regulation of Mammal Reproduction?
- Overwintering under Snow
 - Snow Temperatures
 - Nutrients from Snow
 - Epiphytes
 - Light through Snow
- Late Snowbeds
- Acclimation and Adaptation
 - Winter Growth
 - Winter Warming Events
 - Pigments and Color Changes

10-3: Heat

- Heat Stress and Heat Resistance
- Heated Habitats
- Sporophyte Stress
- Plant and Cellular Responses
- Biochemical Responses
 - Isoprene
 - Sugars
 - Peroxidase
 - Heat Shock Proteins
 - Light vs Dark
- Acclimation
- Night Temperature
- Hydration State
- Duration
- Age and Structure
- Reversible Effects
- Decomposition

10-4: Species and Ecosystems

- Species and Distributions
 - Importance of Climate
 - Warming Studies
 - Seasonal Fluctuations
 - Species Differences
 - Cryptic Species
- Ecosystem Relationships
 - Altering Ecosystems
 - Disturbed Habitats
 - Grassland
 - Tropics
 - Polar and Alpine
 - Lakes
 - Streams
 - Peatlands

11 PHOTOSYNTHESIS**11-1: The Process**

Chapter in Volume 1

- Photosynthesis: The Productivity Engine
- Early Studies
- Structural Adaptations
- Photosynthetic apparatus – the Chloroplast
 - Chloroplast Structure
 - Associated Proteins
 - Fatty Acids
- Need for Light
 - Color Retention in the Dark
 - Chloroplast Replication
- Photosynthetic Capacity
 - Antenna Pigments
- Type of Photosynthetic Pathway
 - C₃ Evidence
 - CO₂-concentrating Mechanisms – Exceptions to C₃?
 - Bicarbonate Uptake
 - Pyrenoids
 - The Bottom Line
- Diurnal Patterns in Photosynthesis?
- Products of CO₂
- Dark CO₂ Fixation
- Transport of Photosynthate
- Storage of Photosynthate
- Sporophyte Photosynthesis
- Respiration

11-2: Photoinhibition

- Photoinhibition
 - Quenching
 - Zeaxanthin
- Chloroplast Position
- Sun and Shade Plants
 - Chlorophyll Concentration
 - Age Differences
 - Chlorophyll *a:b* Ratio
 - Seasonal Differences
 - Habitat Differences in Chlorophyll
 - Desert and Dry Areas
 - Aquatic
 - Antarctic

11-3: Limiting Factors

- Limiting Factors
- Compensation Point
- Water Availability
 - Water Excess
 - Seasonal Water Differences
 - Nighttime Absorption
- CO₂
 - Compensation Point
 - CO₂ Environment
- pH
 - Limits to Entry
 - Methane
- Light
 - Compensation and Saturation Points
 - Excess Light
 - Continuous Light
 - Bryophyte Canopy Structure
- Photoperiod Effects on Physiology
- Temperature

Chapter in Volume 1

Compensation Point
Acclimation
Aquatic Differences

12 PRODUCTIVITY

Productivity
Ecological Factors
 Ability to Invade
 Niche Differences
Growth
 Growth Measurements
 Annual Length Increase
 Uncoupling
 Seasonal Differences
 False Growth Markers
Growth Control
Growth Tradeoffs
Etiolation
Belowground Productivity
Sporophyte Productivity
Productivity and Aging
Life Span
Leaf Production and LAI
Energy Content
Fungal Partners
Recent History Effect
Mitotic Activity
Respiration
Habitat and Geographic Comparisons
Rates of Productivity
 Latitude Differences
 Antarctic
 Frigid Antarctic
 Arctic
 Wetlands
 Tundra
 Boreal Forest
 Temperate Forest
 Epiphytes
 Peatlands
 Desert
 Savannah
 Temperate Rainforest
 Tropical Rainforest
Problems in the Water
 Rivers and Streams
 Lakes and Ponds
Problems with Bryophyte Measurement

13 DECOMPOSITION

Decomposition
Decomposers
Phaeopigments
Influential Factors
Rate
Habitat Differences
 Forests
 Peatlands
 Arctic
 Tundra
 Antarctic

Chapter in Volume 1

Streams
Lakes
Epiphytes
Role

VOLUME 2: INTERACTION**Chapter in Volume 2****1 THE FAUNA: A PLACE TO CALL HOME**

Types of Interactions
Bryological Fauna
Dispersal
Limitations
The Inhabitants
Cover and Nesting Materials – Terrestrial
Bryophyte Individuality
Food Value of Bryophytes
Vitamins
Food Chain Effects
Seasonal Differences in Habitat and Diet
Habitat Differences in Nutrient Availability
Consumption Rates
New and Exciting Directions

2 PROTOZOA**2-1: Protozoa Diversity**

Moss-Dwelling Micro-organisms
Terminology
Abundance
Peatlands
Protozoa
Zoomastigophora and flagellated Chlorophyta
Euglenophyta
Pyrrophyta (=Dinophyta)
Ciliophora (Ciliates)
Symbionts

2-2: Protozoa: Ciliophora and Heliozoa Diversity

Other Ciliophora Known from Bryophytes
Heliozoa

2-3: Protozoa: Rhizopod Diversity

Rhizopoda (Amoebas)
Species Diversity

2-4: Protozoa: Rhizopod Ecology

Geographic Distribution
Communities
Moisture Relationships
Case Building
Food
Symbionts
Bryophyte Chemistry
Pollution – Heavy Metals

2-5: Protozoa: Peatland Rhizopods

Peatlands Taxa: *Sphagnum*
Medium and Rich Fens

Chapter in Volume 2

- Successional Stages
- Habitat Needs
- Food
- Vertical Distribution
- Horizontal Differences
- Seasonal Differences
- Pollution
 - Ozone Loss and UV-B Radiation
- Reconstruction of Past Climate
 - Geographic Differences
 - Problems in Using Rhizopods
 - Human Influence on Development
 - Use in Peatland Regeneration

2-6: Protozoa Ecology

- General Ecology
 - Epiphytes
 - Antarctic
- Nutrient Cycling
- Habitat effects
 - Moss Effects on Soil Habitat
 - Epizoites
 - Soil Crusts
- Vertical Zonation
- Zoophagy by Liverworts?
- Dispersal
- Cosmopolitan
- Communities as Biological Monitors
- Collecting and Sorting
 - Collecting
 - Storage and Preservation
 - Preservation
 - Long-term Storage of Cysts
 - Extraction
 - Testate Amoebae
 - Non-testate Taxa
 - Observation
 - Staining
 - Identification
 - Quantification

3 SLIME MOLDS**3-1: Biology and Diversity**

- What are Slime Molds?
- Identification Difficulties
- Reproduction and Colonization
 - General Life Cycle
 - Seasonal Changes
 - Environmental Stimuli
 - Light
 - pH and Volatile Substances
 - Water
 - Reproduction in Myxomycetes
- Dispersal
- Habitat Needs
 - Moisture
 - Latitude
 - Food and Light
- Role of Bryophytes as Slime Mold Habitats
- Slime Mold Effects on Bryophytes

Chapter in Volume 2

Bryophytes Known to Grow on Slime Molds
 Epizooites
 Potential for Symbiosis?
 Interactions with Invertebrates

3-2: Bryophyte Associations

Bryophyte Associations
 Bryophiles
 Commonly Associated Slime Molds
 Collection Records in Floras
 Photographic Indicators
 Generalists – Bryophytes are Okay
 Interactions Can Be Helpful or Hindering

3-3: Ecology and Habitats – Bark and Logs

Habitats
 Bark Associations
 Liverwort vs Moss Associations
 Limiting Factors
 Log and Stump Associations
 Comparison of Checklists
 Where Bryophyte and Slime Mold Meet
 What Do These Associations Offer?
 Life Cycle Relationships
 Algae and Cyanobacteria
 Decay Stages

3-4: Ecology and Habitats – Lesser Habitats

Epiphyllous Leafy Liverwort Associations
 Non-Epiphyllous Liverwort Associations
 Leaf Litter
 Soil Associations
 Rock Associations
 Sand Dunes
 Alpine and Polar
 Wet-Habitat Associations
 Ravines
 Wet Rocks
Sphagnum Dwellers

4 INVERTEBRATES

4-1: Invertebrates: Introduction

The Invertebrate Fauna
 Sampling
 Preservation of Specimens
 Community Patterns
 Terrestrial/Limnoterrestrial
 Lobules as Habitat
 Aquatic
 Altitudinal Gradients
 Food Webs
 Pollution
 Harvesting Dangers

4-2: Invertebrates: Sponges, Gastrotrichs, Nemerteans, and Flatworms

Cnidaria
 Porifera – Sponges
 Gastrotrichs
 Nemertea – Ribbon Worms
 Platyhelminthes – Flatworms

Chapter in Volume 2

- Bryophyte Habitat Constraints
- Food Sources
- Protection or Predation?
- Watch Out for Invasive Species
- Desiccation Tolerance
- Terrestrial (Limnoterrestrial)
- Epiphyte Dwellers
- Epilithic Dwellers
- Aquatic Bryophyte Habitats
- Extraction and Observation Techniques

4-3: Invertebrates: Nematodes

- Nematoda – Roundworms
- Densities and Richness
- Habitat Needs
 - Moisture Requirements
 - Food Supply
 - Quality of Food
 - Warming Effect among Bryophytes
 - Unusual Bryophyte Dwellings
 - Substrate Preferences
 - Motility Constraints
- Drought Strategies
- Succession
- Seasonal Changes
- Freeze Tolerance
- Gall-formers
- Terrestrial Moss Inhabitants
- Peatlands
 - Global Warming
 - Population Size
- Aquatic Nematodes
- The Antarctic
- Dangers Lurking among Bryophytes
 - Fungal Interactions
 - Safe Site from Predation
- Pollution

4-4: Invertebrates: Annelids

- Annelida – Segmented Worms
 - Water Relations
 - Temperature Tolerance
 - Reproduction
 - Food Relations
- Sampling
- Habitats
 - Aquatic
 - Peatlands
 - Prairie Worms
 - Antarctic
- Dispersal Agents?
- Earthworm Culture
- Polychaetes

4-5: Invertebrates: Rotifers

- Rotifera – Rotifers
- Reproduction
- Bryophytes as Habitat
- Adaptations
- Physiological Differences
 - Surviving Desiccation

Chapter in Volume 2

Food
 Specific Habitats
 Roofs
 Antarctic
 Peatland Habitats
 Aquatic Bryophytes
 Seasons
 Danger amidst the Bryophytes
 Ozone Hole Dangers?
 Extraction Techniques

4-6: Invertebrates: Rotifer Taxa – Bdelloidea

Taxa on Bryophytes

CLASS BDELLOIDEA

Adinetidae

Adineta

Bradyscela

Habrotrochidae

Habrotrocha

Otostephanos

Scepanotrocha

Philodinavidae

Philodinidae

Ceratotrocha and *Didymodactylos*

Dissotrocha

Macrotrachela

Mniobia

Pleuretra

Philodina

Rotaria

Desiccation Tolerance

4-7a: Invertebrates: Rotifer taxa – Monogononta

CLASS MONOGONONTA

Order Collothecacea

Collothecidae

Collotheca

Stephanoceros

Order Flosculariaceae

Conochilidae

Flosculariidae

Floscularia

Ptygura

Hexarthridae

Testudinellidae

Order Ploimida

Trochosphaeridae

Brachionidae

Anuraeopsis

Brachionus

Kellicottia

Keratella

Notholca

Dicranophoridae

Albertia

Aspelta

Dicranophorus

Dorria

Encentrum

Pedipartia

Streptognatha

Chapter in Volume 2

Wierzejskiella
 Epiphanidae
Cyrtonia
Epiphanes
Mikrocodides
 Euchlanidae
 Gastropodidae

4-7b: Rotifer Taxa – Monogononta

Lecanidae
 Ituridae
 Lepadellidae
Colurella
Lepadella
Paracolurella
Squatinella
 Lindiidae
 Microcodidae
 Mytilinidae

4-7c: Rotifer Taxa – Monogononta

Notommatidae
Cephalodella
Drilophaga
Enteroplea
Eosphora
Eothinia
Monommata
Notommata
Pleurata
Pleurotrocha
Pseudoploesoma
Resticula
Taphrocampa
 Proalidae
Bryceella
Proales
Proalinopsis
Wulfertia
 Scaridiidae
 Synchaetidae
Polyarthra
Synchaeta
 Tetrasiphonidae
 Trichocercidae
Elosa
Trichocerca
 Trichotriidae
Macrochaetus
Trichotria

4-8: Invertebrates: Molluscs

Gastropoda: Snails and Slugs
 Reproduction
 Mating and the Love Dart
 Egg and Larval Development
 Bryophyte Interactions
 Abundance
 Adaptations
 Confusing the Predator
 Jumping to Escape

Chapter in Volume 2

- Keeping It Small
- Conical Shape
- Avoiding Desiccation
- No Shell – Slugs
- In Search of Food
 - Low Palatability?
 - Low Nutritional Quality?
 - Food for Some
 - An Avoidance of Gametophores?
 - Deterrents to Herbivory
 - Digestibility
 - Role in Bryophyte Competition with Lichens
 - Palatable Gametophytes
 - Aquatic Grazing
- Bryophyte Antifeedants
- Dispersal Agents
- Bryophytes as Home
 - Epiphytic
 - Calcareous Areas
 - Bogs and Mires
 - Aquatic
- Plant Protectors
- Mussels (Bivalve Molluscs)
- ECHINODERMATA

5 TARDIGRADES

5-1: Tardigrade Survival

- Tardigrades – Water Bears
- Suitability of Bryophytes as Habitat
- Adaptations of Tardigrades
- Survival of Hazardous Conditions
 - Physical Adaptations
 - Pigments
 - Physiological Adaptations
 - Light Response
 - Cryptobiosis
 - Tun Formation
 - Dangers in a Tun
 - Effects of Size
 - Longevity
 - Dangers and Protective Mechanisms
 - Anhydrobiosis
 - Osmobiosis
 - Anoxybiosis
 - Cryobiosis
- Diapause (Encystment)
- Eggs
- Migration?

5-2: Tardigrade Reproduction and Food

- Life Cycle and Reproductive Strategies
- Reproductive Strategies and Habitat
- Eggs
- Molting
- Cyclomorphosis
- Bryophytes as Food Reservoirs
- Role in Food Web

5-3: Tardigrade Habitats

- Bryophyte Habitats

Chapter in Volume 2

- Specificity
- Habitat Differences
 - Acid or Alkaline?
 - Altitude
 - Polar Bryophytes
 - Forest Bryophytes
 - Epiphytes
 - Aquatic
 - Dry Habitats
 - Vertical and Horizontal Distribution

5-4: Tardigrades: Species Relationships

- Species Relationships
 - Growth Forms
 - Liverworts
- Substrate Comparisons
- Finding New Species

5-5: Tardigrade Densities and Richness

- Densities and Richness
 - Europe
 - North America
 - South America and Neotropics
 - Asia
 - Africa
 - Antarctic and Arctic
- Seasonal Variation
- Patchiness

5-6: Tardigrade Ecology

- Dispersal
 - Peninsula Effect
- Distribution
- Common Species
- Communities
- Unique Partnerships?
- Bryophyte Dangers
 - Role of Bryophytes in Fungal Interactions
- Pollution
 - Acid Rain, SO₂, and NO₂
 - Urban Environment
- Tardigrades in Space
- Evolutionary Similarities to Bryophytes
- Sampling and Extraction
- Checklist of Bryophyte Dwellers
 - Heterotardigrada (armored tardigrades)
 - Eutardigrada (unarmored/naked tardigrades)

6 ONYCHOPHORA

- Phylum Onychophora (Velvet Worms)
 - Feeding Habits
 - Moisture and Light Relations
 - Mating and Reproduction
 - Mimics?

7 ARTHROPODS**7-1: Habitat Relations**

- Arthropods (Phylum Arthropoda)
- Habitat Relations

Chapter in Volume 2

- Epiphytes
- Forest Floor
- Rock Zonation
- Cryptogamic Crusts
- Streams
- Peatlands
- Antarctic
- Altitude
- Temperature Protection for Arthropods
- Disturbance
- Role of Life Form
- Chemical Refuge
- Food Value
- Collection and Extraction Techniques
 - Collection
 - Extraction
 - Taxonomic Difficulties

7-2: Arachnida – Spider Biology

- Subphylum Chelicerata
 - Class Arachnida
 - Arachnid Trapping Limitations
 - Order Araneae – Spiders
 - Spider Biology
 - Growth Forms and Life Forms
 - Bryophytes as Cover
 - Trampling
 - Abundance, Richness, and Specificity
 - Moisture Relationships
 - Importance of Temperature
 - Food Sources
 - Reproduction
 - Nests and Webs
 - Dormant Stages
 - Overwintering
 - Spider Guilds
 - Adaptations to Bryophytes
 - Anapidae
 - Clubionidae (Sac or Tube Spiders)
 - Gnaphosidae (Ground Spiders)
 - Linyphiidae (Sheet Spiders)
 - Lycosidae (Wolf Spiders)
 - Symphytognathidae and Micropholcommatidae
 - Theridiidae (Tangle-web Spiders, Cobweb Spiders, and Comb-footed Spiders)

7-3: Arachnida – Spider Habitats

- Habitats
 - Forests, Heaths, and Meadows in Denmark
 - Forests and Woodlands
 - Atypidae
 - Clubionidae (Sac Spiders)
 - Gnaphosidae (Ground Spiders)
 - Hahniidae (Dwarf Sheet Spiders)
 - Linyphiidae
 - Neotropical and South American Forests
 - Lycosidae
 - Malkaridae
 - Salticidae
 - Theridiidae
 - Thomisidae
 - Rock Outcrops
 - Epiphytic Bryophytes
 - Heath and Heather

Chapter in Volume 2

- Clubionidae
- Linyphiidae
- Marshes and Moist Meadows
 - Linyphiidae
- Swampy Places
- Aquatic
- Sand Dunes
- Grasslands and Pastures
 - Clubionidae
 - Gnaphosidae
 - Linyphiidae
 - Lycosidae
 - Thomisidae
- Mountains and Altitudinal Relations
 - Araneidae
 - Clubionidae
 - Gnaphosidae
 - Hahniidae
 - Linyphiidae
 - Lycosidae
- Tundra and Arctic
 - Clubionidae
 - Gnaphosidae
 - Hahniidae
 - Linyphiidae
 - Faroe Islands
 - Yukon
 - Lycosidae
- Bryophytes vs Lichens
- Casual Users
- Invasive Bryophytes
- Known Associates

7-4: Spiders and Peatlands

- Bogs and Fens
- Bryophytic Accommodations
 - Moisture Relationships
 - Temperature Relationships
 - Spider Mobility
 - Abundance and Dominance
 - Tyrphobionts
 - Specialists and Rare Species
- Mosses as Spider Habitats in Bogs and Fens
 - Is *Sphagnum* Special?
 - The Bog and Fen Habitat
 - Hummocks and Hollows
 - Indirect Association with *Sphagnum*
 - Differences among Bogs and Fens
 - Niche Separation – Lycosidae
 - Bryophytes and Trap-door Spiders
 - Bryophytes Hide New Species
- Conservation Issues
- Peatland Fire Communities

7-5: Spiders of Peatlands in Denmark and Tundra

- Peatlands
- Two Acidic *Sphagnum* Fens
 - Dalhof Mire (observations by Lissner)
 - Naesgaard Mire (observations by Lissner)
- Raised Bogs
- Raised Bogs in Denmark (observations by Lissner)
- Two Spring-Fed Mires
 - Lake Bredsgård (observations by Lissner)
 - Lake Rosborg (observations by Lissner)

Chapter in Volume 2

Tundra Peatlands

7-6: Species List

8 ARTHROPODS: HARVESTMEN AND PSEUDOSCORPIONS

Order Opiliones – Harvestmen

Adaptations

The Harvestman Presence

Mating Sites

Seasons

Epizoid Liverworts on Harvestmen

Predators on Bryophyte Inhabitants

Peatlands

Order Pseudoscorpionida – Pseudoscorpions

Order Scorpiones

9 ARTHROPODS: MITES

9-1: Arthropods: Mites

Order Acari – Mites

Habitat Relations

Mite Adaptations to Bryophyte-Dwelling

The Inhabitants

The Role of Bryophytes

Bryophytes as Food

Community Food Sources

Importance of Bryophytes for Food

Reproductive Site

Parasitic Mites

Adaptations of Parasitengonina

Bryophytes or Lichens?

General

Cool Sites

Sphagnum

Arboreal

Coastal

9-2: Arthropods: Mite Habitats

Forest Bryophytes

Forest Floor

Arboreal Habitats

Epiphytes

Lobule Mites

Semiaquatic Habitats

Aquatic Habitats

Sphagnum peatlands

The Fauna

Trampling

Predation

Acidity Problems

Historical Indicators

Antarctic and Arctic

Temperature and Humidity Protection

Tropics

Epizootic

Vertical Distribution

Forest Habitat Strata

Within Bryophyte Clumps

Vertical Migration

Elevational Differences

Seasons

Chapter in Volume 2

Disturbance Effects
 Pollution Indicators
 Dispersal of Mites and Bryophytes
 No place for Generalists?
 Limitations of Methods
 Order Acari – Ticks
 SUBPHYLUM MYRIAPODA
 Class Chilopoda (Centipedes)
 Class Diplopoda (Millipedes)
 Epizootic Bryophytes
 Class Symphyla
 Class Pauropoda
 Class Symphyla

10 ARTHROPODS: CRUSTACEA**10-1: Arthropods: Crustacea – Copepoda and Cladocera**

SUBPHYLUM CRUSTACEA

Reproduction
 Dispersal
 Habitat Fragmentation
 Habitat Importance
 Terrestrial
 Peatlands
 Springs
 Streams
 Collection Methods

CLASS BRANCHIOPODA, ORDER CLADOCERA

Adaptations
 Structural
 Life Cycle Strategies
 Habitats
 Terrestrial
 Peat Bogs
 Aquatic
 Lakes
 Streams

CLASS MAXILLOPODA, SUBCLASS COPEPODA

Adaptations
 Structure
 Life Cycle Strategies
 Feeding
 Habitats
 Terrestrial
 Antarctic
 Peat Bogs and *Sphagnum*
 Aquatic
 Mossy Tarns
 Springs
 Rivulets
 Streams
 Splash Zones
 Cave Pool

10-2: Crustacea – Ostracoda and Amphipoda

CLASS OSTRACODA

Adaptations
 Swimming to Crawling
 Reproduction
 Habitats
 Terrestrial
 Peat Bogs

Chapter in Volume 2

- Aquatic
 - Streams
 - Springs
- CLASS MALACOSTRACA, ORDER AMPHIPODA
 - Adaptations to Land – and Bryophytes
 - Reproduction and Early Development
 - Food among the Bryophytes
 - Habitats
 - Terrestrial
 - Aquatic

10-3: Crustacea – Isopoda, Mysida, and Decapoda

- CLASS MALACOSTRACA, ORDER ISOPODA
 - External Anatomy
 - Adaptations to Terrestrial Life and to Bryophytes
 - Water Relations
 - Waste Elimination
 - Osmotic Balance
 - Respiration
 - Temperature Tolerance
 - Moisture and Temperature Interaction
 - Behavior
 - Congregating Behavior
 - Sheltering
 - Reproduction
 - Predators
 - Overwintering
 - Bryophytes as Food
 - Digestion
 - Terrestrial Consumers
 - Defenses and Apparency Theory
 - Aquatic Consumers
 - Apparency or UV Protection?
 - Habitat
 - Terrestrial
 - Peatlands
 - Springs
 - Waterfalls
 - Aquatic
 - Pollution
- CLASS MALACOSTRACA, ORDER MYSIDA
- CLASS MALACOSTRACA, ORDER DECAPODA

11 AQUATIC INSECTS**11-1: Biology**

- Aquatic Insects
- Life Cycle Stages
 - Collembola
 - Hemimetabolous Insects
 - Nymphs
 - Naiads
 - Holometabolous Insects
- Adaptations to Aquatic Bryophyte Life
 - Life Cycle Strategies
 - Life Cycle Cues
 - Temperature Relations
 - Overwintering
 - Structural
 - Attachment
 - Behavioral

Chapter in Volume 2

- Oxygen Conditions
- Obtaining Food
- Who Lives There?
- Specificity
- Seasons
- Sampling
- Preservative
- Extraction
- Flotation
- Artificial Mosses

11-2: Bryophyte Roles as Habitats

- Potential Roles
- Refuge
- Habitat Diversity and Substrate Variability
 - Nutrients
 - Substrate Size
 - Stability
 - pH Relationships
 - Bryophyte Structure
 - Scapania undulata*
 - Hygroamblystegium* spp.
 - Platyhypnidium riparioides*
 - Fissidens grandifrons*
 - Fontinalis* spp.
- Flow Regimes
 - Flow Rates
 - Overtured Rocks
 - Life History and Flow
- Water Level
- Stream Drift
- Safe Sites
- Biomass and Richness
- Food Sources
 - Bryophytes as Food
 - Nutritional and Antifeedant Properties
 - Tracing Bryophytes in the Food Chain
 - Food when Food Is Scarce
 - Epiphytes and Meiofauna of Bryophytes
 - Trapping Detritus
- Detrimental Effects?
- Bryophytes vs Tracheophytes

11-3: Bryophyte Habitats and Fauna

- Aquatic Bryophyte Habitat and Fauna
 - Streams
 - Streamside
 - Artificial Bryophytes
 - Preference Experiment
 - Torrents and waterfalls
 - Springs
 - Bogs and Fens
 - Collembola – Springtails
 - Coleoptera – Beetles
 - Odonata – Dragonflies and Damselflies
 - Diptera – Flies
 - Other Insects
 - Lakes and Ponds
 - Arctic and Alpine
- Disturbance
- Retention

Chapter in Volume 2

Colonization
 Pollution Effects
 Geographic Differences

11-4: Hemimetabola – Collembola and Ephemeroptera

COLLEMBOLA

Isotomidae
 Bog Springtails

HEMIMETABOLA

EPHEMEROPTERA – Mayflies

Suborder Furcatergalia

Leptophlebiidae – Prong-gilled Mayflies
 Caenidae – Small Squaregill Mayflies
 Neophemeridae
 Ephemerellidae – Spiny Crawlers

Seasons

Food

Ephemerella

Serratella

Teloganopsis

Cincticostella

Drunella

Caudatella

Attenella

Torleya

Leptohyphidae – Little Stout Crawler Mayflies

Suborder Pisciforma

Ameletidae – Combmouthed Minnow Mayflies
 Baetidae – Blue-winged Olives
 Siphonuridae – Primitive Minnow Mayfly
 Heptageniidae – Clinger Mayflies
 Isonychiidae
 Oligoneuriidae – Brushleg Mayflies

Suborder Carapacea

Baetiscidae – Armored Mayflies

11-5: Hemimetabola – Odonata

ODONATA – Dragonflies and Damselflies

Suborder Zygoptera – Damselflies

Suborder Anisoptera – Dragonflies

Life Cycle Considerations

Mating and Egg-laying

Emergence

Safety in Numbers

Bogs and Fens

11-6: Hemimetabola – Plecoptera

PLECOPTERA – Stoneflies

Predation Retreat or Restaurant?

Food Relationships

Typical Fauna

Reproductive Use

Capniidae – Small Winter Stoneflies

Leuctridae – Rolled-winged Stoneflies

Nemouridae – Spring Stoneflies

Notonemouridae

Chloroperlidae – Green Stoneflies

Taeniopterygidae – Winter Stoneflies

Perlidae – Common Stoneflies

Perlodidae – Springflies and Yellow Stones

Peltoperlidae – Roachflies

Chapter in Volume 2

Gripopterygidae
Pteronarcyidae – Giant Stoneflies

11-7: Hemimetabola – Hemiptera

HEMIPTERA – True Bugs
Cicadellidae – Leafhoppers
Ceratocombidae
Dipsocoridae – Jumping Ground Bugs
Gerridae – Water Striders
Hebridae – Sphagnum Bugs, Velvet Water Bugs
Mesoveliidae – Water Treaders
Veliidae – Small Water Striders, Riffle Bugs
Macroveliidae – Macroveliid Shore Bugs
Corixidae – Water Boatmen
Saldidae – Shore Bugs
Lygaeidae – Seed Bugs, Cinch Bugs
Rhyparochromidae – Dirt-colored Seed Bugs

11-8: Holometabola – Neuroptera and Megaloptera

HOLOMETABOLA
NEUROPTERA
Osmylidae
Chrysopidae
MEGALOPTERA
Sialidae – Alderflies
Corydalidae – Dobsonflies and Fishflies

11-9: Holometabola – Coleoptera, Suborder Adephaga

COLEOPTERA BACKGROUND
Suborder Adephaga
Carabidae – Ground Beetles
Gyrinidae – Whirligig Beetles
Haliplidae – Crawling Water Beetles
Hygrobiidae – Squeak Beetles
Dytiscidae – Predaceous Diving Beetles and Noteridae – Burrowing Water Beetles
Moors, Bogs, and Fens

11-10: Holometabola – Coleoptera, Suborder Polyphaga

Suborder Polyphaga
Helophoridae
Hydrochidae
Hydrophilidae – Water Scavenger Beetles
Hydraenidae – Minute Moss Beetles
Ptiliidae – Featherwing Beetles
Silphidae – Large Carrion Beetles
Staphylinidae – Rove Beetles
Scirtidae (=Helodidae) – Marsh Beetles
Elmidae – Riffle Beetles
Dryopidae – Long-toed Water Beetles
Chelonariidae – Turtle Beetles
Lampyridae – Lightning Bugs
Latridiidae – Minute Brown Scavenger Beetles
Curculionidae – Weevils
Lagriidae

11-11: Holometabola – Trichoptera, Suborder Annulipalpia

LEPIDOPTERA
TRICHOPTERA
Drift
Food
Case Building

Chapter in Volume 2**SUBORDER ANNULIPALPIA**

- Hydropsychoidea
 - Ecnomidae
 - Hydropsychidae – Net-spinning Caddisflies
 - Pupal Sites
 - Crowding and Niche Separation
 - Food
 - Role of Water Velocity
 - Role Below Impoundments
 - Polycentropodidae – Tube Maker Caddisflies
 - Psychomyiidae – Net Tube Caddisflies
- Philopotamoidea
 - Philopotamidae – Finger-net Caddisflies

11-12: Holometabola – Trichoptera, Suborders Integripalpia and Spicpalpia

- Suborder Integripalpia
 - Leptoceroidea
 - Odontoceridae – Mortarjoint Casemakers
 - Limnephiloidea
 - Goeridae
 - Limnephilidae – Northern Caddisflies
 - Lepidostomatidae – Bizarre Caddisflies
 - Oeconesidae
 - Uenoidea
 - Phryganeidea
 - Brachycentridae – Humpless Casemaker Caddisflies
 - Brachycentrus*
 - Micrasema*
 - Adicrophleps hitchcockii*
 - Phryganeidae – Giant Casemakers
 - Sericostomatoidea
 - Beraeidae
 - Conoesucidae
 - Helicophidae
 - Sericostomatidae – Bushtailed Caddisflies
- Suborder Spicpalpia
 - Glossosomatoidea
 - Glossosomatidae – Tortoise or Saddle-case Makers
 - Hydroptiloidea
 - Hydroptilidae – Microcaddisflies, Purse-case Caddisflies
 - Ptilocolepus*
 - Palaeagapetus*
 - Scelotrichia*
 - Rhyacophiloidea
 - Rhyacophilidae – Free-living Caddisflies
 - Food
 - Substrate Preference

11-13a: Holometabola – Diptera, Suborder Nematocera

- DIPTERA – Flies
 - Suborder Nematocera
 - Nymphomyiidae
 - Cylindrotomidae – Long-bodied Craneflies
 - Limoniidae – Limoniid Craneflies
 - Pediciidae – Hairy-eyed Craneflies
 - Tipulidae – Craneflies
 - Anisopodidae – Wood Gnats, Window Gnats
 - Axymyiidae
 - Cecidomyiidae – Gall Midges, Gall Gnats
 - Mycetophilidae – Fungus Gnats
 - Sciaridae – Dark-winged Fungus Gnats

Chapter in Volume 2

Ceratopogonidae – Biting Midges, No-see-ums, Sand Flies

11-13b: Holometabola – Diptera, Suborder Nematocera

Suborder Nematocera, continued

Chironomidae – Midges

Emergence

Seasons

Cold-water Species

Overwintering

Current Velocity

Diversity

Bryophyte Preferences?

What's for Dinner?

Parasite Protection?

Refuge in Bryophytes

Culicidae – Mosquitoes

Simuliidae – Blackflies

Simulium

Prosimulium

Cnephia/Metacnephia

Stegopterna

Thaumaleidae – Trickle Midges

Psychodidae – Moth Flies and Sand Flies

11-14: Holometabola – Diptera, Suborder Brachycera

Suborder Brachycera

Athericidae/Rhagionidae – Watersnipe Flies

Spaniidae/Rhagionidae

Dolichopodidae – Long-legged Flies

Empididae – Dance Flies

Fast-water Refuge

Where Shall We Go for Dinner

Empididae in the Cold

Oreogetonidae

Syrphidae – Hover Flies

Ephydriidae – Shore-flies

Sciomyzidae – Marsh Flies

Agromyzidae – Leaf-miner Flies

Muscidae – House Flies and Kin

12 TERRESTRIAL INSECTS**12-1: Habitat and Adaptations**

Bryophytes as Habitat

Temperature Relations

Preparation for Winter

Water Relations

Fragmentation and Corridors

Insect Adaptations to Bryophytes

Abundance

Food Sources

Bryophytes as Pesticides

Sampling Methods

Field Collection

Extraction

Habitats

Bogs and Wetlands

Forests

Montane Tropical Rainforests

Epiphytes

Cryptogamic Crusts

Chapter in Volume 2

- Altitude
- Tundra
- Antarctic
- Geothermal
- Pollution Effects
- Climate Change

12-2: Hemimetabola – Collembola

- Meet the Collembola
 - Moisture Needs
 - Reproduction
 - Dispersal
- Bryophytes as Habitat for Springtails
 - Species and Abundance
 - Food
 - Predators
- Adaptations
- Sampling Methods
- Temperature Survival
- Fertilizing Mosses
- Habitat Differences
 - Bogs and Wetlands
 - Forests
 - Forest Floor
 - Epiphytes
 - Boulders and Rock Canyons
 - Vertical Gradients
 - Mountains, Alpine, and Arctic
 - Altitudinal Gradients
 - Antarctic Bryophyte Communities
 - Who Dares to Live Here?
 - Geothermal Areas
 - Habitat Suitability and Collembolan Adaptations
 - Eat and Be Eaten
 - Glacier Mice – Moss Balls
- Pollution

12-3: Hemimetabola – Odonata

- ODONATA – DRAGONFLIES AND DAMSELFLIES
 - Biology
 - Terrestrial Naiads
 - Emergence
 - Perching and Mating
 - Oviposition
 - Sampling
 - Life in a Thallus

12-4: Hemimetabola – Orthopteroidea

- ORTHOPTERA – Grasshoppers and Crickets
 - Tetrigidae – Pygmy Grasshoppers
 - Tetrix*
 - Color Morphs – Thermoregulation or Camouflage?
 - Gause's Law and Bryophyte Dwellers
 - Discotettix*
 - Vibration Sites
 - Reproduction
 - Food Consumption
 - Age and Seasonal Differences
 - Mandibular Abrasion
 - Potua sabulosa*
 - Acrididae – Grasshoppers
 - Melanoplus*

Chapter in Volume 2

- Chorthippus*
 - Nicarchus*
 - Sciaphilacris* – Moss and Lichen Mimics
 - Myrmeleotettix maculatus*
 - Food
 - Oviposition
 - Gryllidae – Crickets
 - Rhaphidophoridae – Camel Crickets, Wetas
 - Tettigoniidae – Katydid
 - Camouflage
 - Paraphidnia*
 - Balboana tibialis*
 - Arachnacris tenuipes* – Emperor Bush Cricket
 - PHASMIDA – Walking Sticks
 - Antongilia laciniata* (Bacillidae)
 - Phanocles* (Diapheromeridae)
 - MANTODEA – Preying Mantids
 - Liturgusidae
 - Mating
 - BLATTODEA – Cockroaches and Termites
 - ISOPTERA – Termites
 - EMBIOPTERA – Webspinners
- 12-5: Hemimetabola – Notoptera and Psocoptera**
- NOTOPTERA
 - Grylloblattodea – Ice Crawlers
 - Grylloblattidae – Ice Crawlers
 - Galloisiana*
 - Grylloblatta*
 - Grylloblattella*
 - PSOCOPTERA – Booklice, Barklice, Barkflies
- 12-6: Hemimetabola – Hemiptera (Heteroptera)**
- ORDER HEMIPTERA – True Bugs
 - Adaptations
 - Nutrients
 - Habitats
 - Forests
 - Epiphytes
 - Sand Dunes
 - Streamside and Wet Habitats
 - Peatlands
 - SUBORDER HETEROPTERA
 - PENTATOMORPHA – STINK BUGS, FLAT BUGS, AND SEED BUGS
 - Thyreocoridae – Ebony Bugs
 - Cydnidae – Burrowing Bugs, Shield Bugs
 - Pentatomidae – Stink Bugs and Shield Bugs
 - Berytidae – Stilt Bugs
 - Lygaeidae – Seed Bugs and Milkweed Bugs
 - Piesmatidae – Ash-Grey Leaf Bugs
 - Rhyparochromidae – Seed Bugs
 - Scutelleridae
 - CICOMORPHA – BED BUGS, BAT BUGS, ASSASSIN BUGS, AND PIRATE BUGS
 - Anthocoridae – Minute Pirate Bugs or Flower Bugs
 - Microphysidae – Minute Bladder Bugs
 - Nabidae – Damsel Bugs
 - Miridae – Jumping Tree Bugs
 - Tingidae – Lace Bugs
 - Cantacaderidae
 - Reduviidae
 - DIPSOCOMORPHA

Chapter in Volume 2

Dipsocoridae
 Ceratocombidae
 Schizopteridae – Jumping Soil Bugs
 GERROMORPHA – SEMIAQUATIC BUGS OR SHORE BUGS
 Mesoveliidae – Water Treaders
 NEPOMORPHA
 Aphelocheiridae

12-7: Hemimetabola – Hemiptera (Non-Heteroptera) and Thysanoptera

SUBORDER AUCHENORRHYNCHA
 CICADOMORPHA
 Cicadellidae – Leaf Hoppers
 FULGOROMORPHA – PLANTHOPPERS
 Delphacidae – Delphacid Planthoppers
 Derbidae – Planthoppers
 Issidae – Planthoppers
 SUBORDER STERNORRHYNCHA
 Eriococcidae – Scale Insects
 Aphididae (including Pemphigidae) – Aphids
 Gall Aphids
Schlechtendalia
Kaburagia
Muscaphis
Myzodium
Melaphis
Clydesmithia (Pemphigidae)
Pemphigus (Pemphigidae)
 Other Aphididae that Live Among Mosses
 Attractants?
 Why Alternate Hosts?
 Adelgidae – Woolly Conifer Aphids
 SUBORDER COLEORRHYNCHA
 Peloridiidae – Moss Bugs
 Symbiotic Bacteria
 ORDER THYSANOPTERA – Thrips

12-8: Holometabola – Megaloptera and Neuroptera

MEGALOPTERA – Alderflies, Dobsonflies, and Fishflies
 NEUROPTERA - Lacewings
 Osmylidae
 Chrysopidae

12-9a: Holometabola – Coleoptera Biology and Ecology

COLEOPTERA – BEETLES
 Bryophagids – Eating and Being Eaten
 Sampling
 Habitat Relations
 Forests
 Hitch-hikers
 Forest Disturbance and Recovery
 Effects of Beetles on Forest Bryophytes
 Dunes
 Heathland
 Bogs and Wetlands
 Antarctica and Antarctic Islands
 Home for Rare Species
 Invasive Bryophytes

12-9b: Holometabola – Coleoptera Families

ADAPHAGA
 Carabidae – Soft-bodied Plant Beetles

Chapter in Volume 2

POLYPHAGA

Artematopoidea

Artematopidae – Soft-bodied Plant Beetles

Byrrhoidea

Byrrhidae – Pill Beetles

*Amphicyrta**Byrrhus**Chaetophora**Chalciosphaerium**Curimopsis**Cytilus**Epichorius**Exomella**Lioligus**Lioon**Listemus**Nothochaetes**Notolioon**Simplocaria*

Chelonariidae – Turtle Beetles

Limnichidae – Minute Marsh-loving Beetles

12-9c: Holometabola – Coleoptera Families

POLYPHAGA cont.

Chrysomeloidea

Chrysomelidae – Flea Beetles, Leaf Beetles

Cucujoidea

Latridiidae – Minute Brown Scavenger Beetles

Curculionoidea

Atelabidae – Leaf-rolling Weevils

Curculionidae – Weevils

Bryophagy and Evolution

Impacts on Ecosystems

Camouflage

Travelling Ecosystems

Elateroidea

Lampyridae – Fireflies

Lycidae – Net-winged Beetles

Bupestroidea

Bupestridae – Jewel Beetles

Hydrophiloidea

Helophoridae – Water Scavenger Beetles

Hydrophilidae – Water Scavenger Beetles

Scaraboidea

Scarabidae

Staphylinoidea

Leiodidae – Round Fungus Beetles

Pselaphidae – Short-winged Mold Beetles

Ptiliidae – Featherwing Beetles

Staphylinidae – Rove Beetles

Scydmaenidae – Ant-like Stone Beetles

Tenebrionoidea

Perimylopidae (=Promecheilidae)

Lagriidae – Long-jointed Beetles

Tetatomidae – Polypore Fungus Beetles

12-10: Holometabola – Hymenoptera

HYMENOPTERA

Ants

The Phenomenal Ants

Where Ants Are Absent

Chapter in Volume 2

- Food Source?
- Anthills
- Ants as Gardeners
- Forest Ants
 - Epiphyte Communities
 - Epiphylls as Defenders
- Dispersal
- Nesting
- Ants, *Sphagnum* Collars, and Aphids
- Bogs and Fens
- Bees
 - Apidae – Honey Bees, Bumblebees, Carder Bees, etc.
 - Honey Bees
 - Bumblebees
 - Carder Bees
 - Braconidae – Parasitic Wasps
 - Cynipidae and Mimicry
 - Diprionidae – Conifer Sawflies
 - Ichneumonidae
 - Pompilidae
 - Scelionidae
 - Sphicidae
 - Vespidae – Wasps
- A Calyptra Mimic

12-11: Holometabola – Trichoptera

- Larvae
- Oviposition
- Pupation
- Bogs

12-12: Holometabola – Lepidoptera Biology and Ecology

- Lepidoptera
- Life Cycle
 - Eggs
 - Larvae
 - Pupation
- Food Sources
 - Feeding on Leafy Gametophytes
 - Feeding on Capsules
 - Butterflies
 - Epiphylls as Food
 - Invertebrates on the Menu
- Antiherbivory
- Adaptations
- Habitats
 - Forests
 - Epiphytes
 - Bogs and Wetlands
- Disappearing Species

12-13: Holometabola – Lepidoptera: Micropterigoidea – Gelechioidea

- MICROPTERIGOIDEA
 - Micropterigidae – Mandibulate Archaid Moths
- MNESARCHAEOIDEA
 - Mnesarchaeidae – New Zealand Primitive Moths
- HEPIALOIDEA
 - Hepialidae – Ghost Moths
 - Paleaetosetidae – Miniature Ghost Moths
- TINEOIDEA
 - Psychidae – Bagworm Moths, Case Moths

Chapter in Volume 2

Tineidae – Fungus Moths
 GELECHIOIDEA
 Gelechiidae – Twirler Moths
 Oecophoridae – Concealer Moths

12-14: Holometabola – Lepidoptera: Tortricoidea – Papilionoidea

TORTRICOIDEA
 Tortricidae – Tortrix Moths, Lear-roller Moths
 PYRALOIDEA
 Crambidae – Grass Moth; Sod Worms
 Pyralidae – Snout Moths
 HESPERIOIDEA
 Hesperidae – Skippers
 PAPILIONOIDEA
 Lycaenidae – Blues, Coppers, Hairstreaks, Harvesters (Butterflies)
 Nymphalidae – Brush-footed Butterflies
 Rionidae – Tropical Butterflies

12-15: Holometabola – Lepidoptera: Geometroidea – Noctuoidea

GEOMETROIDEA
 Geometridae – Geometrid Moths (Inch Worms)
 LASIOCAMPOIDEA
 Lasiocampidae – Snout Moths
 NOCTUOIDEA
 Arctiidae – Tiger Moths, *etc.*
 Erebidae
 Lymantriidae – Tussock Moths
 Noctuidae – Owlet Moths

12-16: Holometabola – Mecoptera

MECOPTERA – SCORPIONFLIES
 Choristidae
 Boreidae
 Boreus
 Caurinus
 Hesperoboreus
 Nannochoristidae
 Panorpidae
 Apteropanorpidae
 Meropeidae
 Bittacidae

12-17: Holometabola – Diptera Biology and Habitats

Diptera Overview
 Role of Bryophytes
 Collection and Extraction Methods
 Fly Dispersal of Spores
 Habitats
 Wetlands
 Forests
 Epiphytes
 Harvesting Stowaways
 Altitude

12-18: Holometabola – Diptera Nematocera: Tipuloidea

NEMATOCERA
 Cylindrotomidae
 Triogma
 Diogma
 Cylindrotoma
 Phalacrocer

Chapter in Volume 2

Liogma
 Limoniidae
 Pediciidae
 Tipulidae – Craneflies
 Adaptations
 Tipula
 Prionocera
 Dolichopeza
 Dicranomyia
 Nephrotoma – Tiger Craneflies

12-19: Holometabola – Diptera Nematocera 2

Cecidomyiidae – Gall Midges
 Mycetophilidae – Fungus Gnats
 Sciaridae – Dark-winged Fungus Gnats
 Ceratopogonidae – Biting Midges
 Chironomidae – Midges
 Belgica
 Culicidae – Mosquitoes
 Simuliidae – Blackflies
 Psychodidae – Drain Flies, Sink Flies, Moth Flies, or Sewer Gnats
 Anisopodidae (=Rhyphidae) – Wood Gnats

12-20: Holometabola – Diptera Brachycera

BRACHYCERA
 Rhagionidae – Snipe Flies
 Spaniidae – Snipe Flies
 Dolichopodidae – Long-legged Flies
 Empididae – Dance Flies
 Hybotidae
 Syrphidae – Syrphid Flies
 Phoridae – Scuttle Flies
 Agromyzidae – Mine Flies
 Lauxaniidae
 Anthomyiidae – Root-maggot Flies
 Heleomyzidae
 Muscidae – House Flies
 Scathophagidae – Dung Flies
 Calliphoridae – Blow Flies

13 FISH

Fish Uses of Bryophytes
 Habitat
 Spawning
 Aquarium Fish
 Food
 Piscicidal Properties
 Cover
 Diversity
 Nutrient Relations
 pH and *Sphagnum*
 Pollution
 Global Warming
 Surrogate Species

14 AMPHIBIANS**14-1: Amphibians: Frogs**

Bryophytes and Amphibians Share Commonalities
 Anura – Frogs and Toads
 Role of Bryophytes for Anurans

Chapter in Volume 2

- Safe Sites
- Moisture and Temperature Conservation
- Calling Sites
- Nesting and Reproduction
- Overwintering
 - Undulating Mosses and *Lithobates* (= *Rana*) *sylvaticus* (Wood Frog, Ranidae)
 - Cold Water – *Rana temporaria* (Common Frog, Ranidae)
 - Freeze Tolerance – *Rana arvalis*
 - Under Woodland Bryophytes – *Pelophylax* (Ranidae)
- Bryophytes for Food and Food Locations
- Occasional Usage – A Place to Travel
- Adaptations to Bryophyte Habitats
 - An Altered Life Cycle
 - Food Capture
 - Escaping Predators and Flying Moss Frogs
 - Camouflage and Mimicry
 - Importance of Being Still
 - Disruptive Coloration – *Boophis*
 - Ceratophrys ornata*, a Bryophyte Mimic
 - Tubercles – *Theroderma corticale* (Vietnamese Mossy Frog, Rhacophoridae)
 - Green and Wet – *Centrolene geckoideum* (Pacific Giant Glass Frog, Centrolenidae)
 - Changing Colors – *Platymantis* spp. (Ground Frogs, Ceratobatrachidae)
 - Colors Matter
 - Does Size Matter?
 - The Frog or the Egg?
 - Enter the Bryophytes – and *Eleutherodactylus*

14-2: Amphibians: Toads, Treefrogs, and Cloud Forest Frogs

- Conservation Issues and Endangered Species
 - Red Leg: *Aeromonas hydrophila*
 - Peatland Conservation
 - Mining
 - Old-growth Forests
 - Tropics
 - Atelopus certus* (Darien Stubfoot Toad; Toad Mountain Harlequin Frog; Bufonidae)
 - Chytridiomycosis*
 - Diagnosis
 - A Cure?
- Moss Use in Captivity
 - Making a Home – *Scaphiopus holbrookii* (Eastern Spadefoot Toad, Scaphiopidae)
 - In the Aquarium – *Trachycephalus resinifictrix* (Amazon Milk Frog, Hylidae)

14-3: Ground-Dwelling Anurans

- Peatland Habitats
 - Effects of *Sphagnum* Acidity
 - Acid as a Refuge – *Rana arvalis* (Moor Frog, Ranidae)
 - Moisture Refuge
 - Burrows in the Bog Moss
 - Retreats – Mosses Instead of Sand
 - A Toxic Bog-dweller – *Bombina bombina* (European Fire-bellied Toad, Bombinatoridae)
- Ground-Dwellers: Bufonidae (Toads)
 - Anaxyrus americanus* (American Toad)
 - Anaxyrus boreas* (Western Toad)
 - Bufo bufo* (European Common Toad)
 - Incilius coniferus* (formerly *Bufo coniferus*, Evergreen Toad)
 - Pseudepidalea viridis* (Green Toad)
 - Epidalea calamita* (Natterjack Toad)
 - Leptophryne cruentata* (Indonesia Tree Toad, Bleeding Toad)
 - Atelopus zeteki* (Panamanian Golden Frog)
 - Atelopus loettersi*
- Toads in the Trees: Bufonidae

Chapter in Volume 2

- Rhinella tacana* (formerly *Chaunus tacana*)
Ansonia latidisca (Borneo Rainbow Toad, Sambas Stream Toad)
 Eastern Hemisphere Mossy Habitats
 Arthroleptidae
 Myobatrachidae
Pseudophryne
Pseudophryne corroboree & *P. pengilleyi* (Corroboree Frogs)
Pseudophryne semimarmorata (formerly *Pseudophryne bibroni*) (Southern Toadlet)
Crinia nimbus & *C. georgiana* (Australian Moss Froglet)
Crinia tasmaniensis (Tasmanian Froglet)
Geocrinia victoriana (Victoria Ground Froglet)

14-4: Anurans: Waterfalls, Treefrogs, and Mossy Habitats

- Waterfalls
Sachatamia ilex (formerly *Centrolene ilex*) (Limon Giant Glass Frog, Centrolenidae)
 Frogs in the Trees
Espadarana prosoblepon (*Centrolenella prosoblepon*) (Emerald Glass Frog, Centrolenidae)
 Hylidae: North Temperate Treefrogs
Hyla chrysoscelis (Cope's Gray Treefrog)
Hyla arborea (Common Treefrog)
Hyla gratiosa (Barking Treefrog)
 Hylidae: Tropical Treefrogs
Ptychohyla dendrophasma (formerly *Hyla dendrophasma*) and *Ecnomiohyla minera*
 (formerly *Hyla minera*) (Fringe-Limbed Treefrogs)
Isthmohyla lancasteri (formerly *Hyla lancasteri*) (Lancaster's Treefrog)
 – Why Have Tubercles?
Agalychnis saltator (Misfit Leaf frog)
Charadrahyla nephila (Oaxacan Cloud-forest Treefrog)
Anotheca spinosa (Spine-headed Tree Frog)
Litoria serrata (Green-eyed Treefrog)
Ecnomiohyla miliaria (Cope's Brown Treefrog)
Smilisca sila (Panama Cross-banded Treefrog)
 Mantellidae
Spinomantis aglavei (Anamalozoatra Madagascar Frog)
 Cloud Forests and Other Mossy Habitats
 Cape Horn, South America
 Microhylidae
Albericus valkuriarum (Microhylidae)
Cophixalus (Rainforest Frog, Microhylidae)
Choerophryne (Microhylidae)
Dyscophus guineti (Sambava Tomato Frog, Microhylidae)
Platypelis grandis (Boulenger's Giant Treefrog, Microhylidae)
Hypopachus barberi (Barber's Sheep Frog, Microhylidae)
Xenorhina (Snouted Frog, Microhylidae)
 Ceuthomantidae
Ceuthomantis duellmani
Ceuthomantis smaragdinus
 Hemiphractidae
Gastrotheca pacchamama (Ayacucho Marsupial Frog, Hemiphractidae)
Gastrotheca excubitor (Abra Acanacu Marsupial Frog, Hemiphractidae)
Stefania (Stefania Treefrogs, Hemiphractidae)
 Dendrobatidae
Oophaga pumilio (formerly *Dendrobates pumilio*)
Phyllobates (Poison-arrow Frog, Dendrobatidae)
Silverstoneia flotator (Rainforest Rocket Frog, Dendrobatidae)
 Leptodactylidae
 Eleutherodactylidae

14-5: Amphibians: Bryophyte-dwelling Salamander Checklist

- Strabomantidae
Bryophryne spp.

Chapter in Volume 2

Noblella pygmaea (Noble's Pygmy Frog)
Psychrophrynella spp.
Pristimantis (South American Rain Frogs)
Yunganastes ashkapara
 Craugastoridae
 Cycloramphidae
 Alsodes vittatus
 Eupsophus
 Rhinoderma darwini (Darwin's Frog)
 Ceratophryidae

14-6: Salamanders and Adaptations

Caudata (Urodela) – Salamanders
 Distribution
 Adaptations to Bryophytes
 Tail Autotomy
 Toxicity
 Predator Avoidance
 Warning Coloration and Mimicry
 Locomotion
 Life Cycle
 Role of Bryophytes
 Moisture
 Nesting Sites
 Food Sources
 Hibernation and Aestivation

14-7: Hynobiidae, Ambystomatidae, and Plethodontidae

Hynobiidae
 Hynobius tokyoensis (Tokyo Salamander)
 Salamandrella keyserlingii (Siberian Salamander, Hynobiidae)
 Ambystomatidae (Mole Salamanders)
 Ambystoma laterale (Blue-spotted Salamander)
 Ambystoma maculatum (Spotted Salamander)
 Ambystoma jeffersonianum (Jefferson Salamander)
 Plethodontidae (Lungless Salamanders)
 Plethodon teyahalee, formerly *Plethodon*
 Plethodon serratus (Southern Red-backed Salamander)
 Plethodon nettingi (Cheat Mountain Salamander)
 Plethodon cinereus (Eastern Red-backed Salamander)
 Plethodon dorsalis (Northern Zigzag Salamander)
 Plethodon welleri (Weller's Salamander)
 Plethodon elongatus (Del Norte Salamander)
 Plethodon idahoensis (Coeur d'Alene Salamander)
 Plethodon vandykei complex (Van Dyke's Salamander)
 Plethodon larselli (Larch Mountain Salamander)
 Plethodon glutinosus (Northern Slimy Salamander)
 Plethodon richmondi (Southern Ravine Salamander)
 Plethodon metcalfi, formerly *Plethodon jordani metcalfi* (Southern Gray-cheeked Salamander)
 Plethodon jordani (Red-cheeked Salamander; Jordan's Salamander)
 Plethodon stormi (Siskiyou Mountains Salamander)
 Plethodon asupak (Scott Bar Salamander)
 Gyrinophilus porphyriticus
 Hemidactylium scutatum (Four-toed Salamander)
 Habitat Characteristics
 Mating
 Nest Sites
 Stereochilus marginatus (Many-lined Salamander)
 Desmognathus fuscus (Northern Dusky Salamander)
 Desmognathus ochrophaeus (Allegheny Mountain Salamander)
 Desmognathus monticola (Seal Salamander)

Chapter in Volume 2

Desmognathus santeetlah (Santeetlah Dusky Salamander)
Desmognathus aeneus (Seepage Salamander)
Desmognathus wrighti (Pygmy Salamander)
Desmognathus quadramaculatus (Black-bellied Salamander)
Desmognathus ocoee (Ocoee Salamander)
Phaeognathus hubrichti (Red Hills Salamander)
Ensatina eschscholtzii (Monterey Ensatina)
Hydromantes brunus (Limestone Salamander)
Hydromantes shastae (Shasta Salamander)
Hydromantes ambrosii

14-8: Salamander Mossy Habitats

Tropical Mossy Habitats – Plethodontidae

Terrestrial and Arboreal Adaptations

Bolitoglossa (Tropical Climbing Salamanders)
Bolitoglossa diaphora
Bolitoglossa diminuta (Quebrada Valverde Salamander)
Bolitoglossa hartwegi (Hartweg's Mushroomtongue Salamander)
Bolitoglossa helmrichi
Bolitoglossa jugivagans
Bolitoglossa lincolni (Lincoln's Mushroomtongue Salamander)
Bolitoglossa longissima
Bolitoglossa marmorea (Crater Salamander)
Bolitoglossa mexicana (Mexican Mushroomtongue Salamander)
Bolitoglossa obscura (Tapanti Giant Salamander)
Bolitoglossa robusta (Robust Mushroomtongue)
Bolitoglossa rostrata (Longnose Mushroomtongue Salamander)
Bolitoglossa rufescens (Northern Banana Salamander)
Bolitoglossa sombra (Shadowy Web-footed Salamander)
Bolitoglossa subpalmato (La Palma Salamander)
Bolitoglossa suchitanensis
Bolitoglossa xibalba
Chiropterotriton (Splayfoot Salamanders)
Chiropterotriton chiropterus (Common Splayfoot Salamander)
Cryptotriton alvarezdeltoroi (Alvarez del Toro's Salamander)
Cryptotriton monzoni (Monzon's Hidden Salamander)
Dendrotriton cuchumantus (Forest Bromeliad Salamander)
Nototriton (Moss Salamanders, Plethodontidae)
Nototriton abscondens
Nototriton barbouri (Yoro Salamander)
Nototriton gamezi (Monteverde Moss Salamander)
Nototriton guanacaste (Guanacaste Moss Salamander)
Nototriton picadoi (Picado's Moss Salamander)
Nototriton richardi (Richard's Salamander)
Nototriton saslaya (Plethodontidae)
Nototriton tapanti (Tapanti Moss Salamander)
Nyctanolis permix (Nimble Long-limbed Salamander)
Oedipina (Plethodontidae)
Oedipina carablanca (Los Diamantes Worm Salamander)
Oedipina elongata (Central American Worm Salamander)
Oedipina gracilis (Long-tailed Worm Salamander)
Oedipina pacificensis
Oedipina poelzi (Quarry Worm Salamander)
Oedipina pseudouniformis
Oedipina uniformis (Cienga Colorado Worm Salamander)
Pseudoeurycea juarezi (Juarez Salamander)
Pseudoeurycea rex (Royal False Brook Salamander)
Pseudoeurycea scandens (Tamaulipan False Brook Salamander)
Pseudoeurycea werleri (False Brook Salamander)
Lineatriton (Plethodontidae)
Thorius (Mexican Pigmy Salamanders; Plethodontidae)

Chapter in Volume 2

- Thorius dubitus* (Acultzingo Pigmy Salamander)
- Old-growth Temperate Habitats
 - Aneides aeneus* (Green Salamander, Plethodontidae)
 - Aneides vagrans* (Wandering Salamander, Plethodontidae)
 - Batrachoseps wrighti* (Plethodontidae)
 - Rhyacotriton cascadae* (Cascade Torrent Salamander, Rhyacotritonidae)
 - Rhyacotriton olympicus* (Olympic Torrent Salamander, Rhyacotritonidae)
 - Rhyacotriton variegatus* (Southern Torrent Salamander, Rhyacotritonidae)
- Asia – One Plethodontid!
 - Karsenia koreana* (Korean Crevice Salamander, Plethodontidae)
- Europe – One Plethodontid Genus
 - Speleomantes supramontis* (Supramonte Cave Salamander, Plethodontidae)
- Peatlands and Wetlands
 - Eurycea wilderae* (Blue Ridge Two-lined Salamander, Plethodontidae)
 - Eurycea guttolineata* (Three-lined Salamander, Plethodontidae)
- Streams and Springs
 - Eurycea bislineata* (Northern Two-lined Salamander, Plethodontidae)
 - Eurycea lucifuga* (Cave Salamander, Plethodontidae)
 - Eurycea multiplicata* (Many-ribbed Salamander, Plethodontidae)
 - Eurycea tynnerensis*, formerly *Eurycea griseogaster* (Oklahoma Salamander, Plethodontidae)
- Proteidae
 - Necturus punctatus* (Dwarf Waterdog, Proteidae)
- Salamandridae
 - Calotriton asper*, formerly *Euproctus asper* (Pyrenean Brook Salamander, Salamandridae)
 - Chioglossa lusitanica* (Golden-striped Salamander, Salamandridae)
 - Euproctus platycephalus* (Sardinian Mountain Newt, Salamandridae)
 - Lissotriton boscai* (Bosca's Newt)
 - Lissotriton helveticus*, formerly *Triturus helveticus* (Palmate Newt, Salamandridae)
 - Lissotriton montandoni*, formerly *Triturus montandoni* (Carpathian Newt, Salamandridae)
 - Lissotriton vulgaris*, formerly *Triturus vulgaris* (Smooth Newt, Salamandridae)
 - Notophthalmus viridescens* (Eastern Newt, Salamandridae)
 - Salamandra salamandra* (European Fire Salamander Salamandridae)
 - Triturus cristatus* (Great Crested Newt, Salamandridae)
- Importance of the Bryophyte Amphibian Community

14-9: Bryophyte-dwelling Salamander Checklist**15 REPTILES**

- Vertebrates
 - Order Testudines – Turtles
 - Clemmys guttata* (Spotted Turtle, Emydidae)
 - Chrysemys picta* (Painted Turtle, Emydidae)
 - Glyptemys* spp. (Emydidae)
 - Emydoidea blandingii* (Blanding's Turtle, Emydidae)
 - Chelyra serpentina* (Snapping Turtle, Chelydridae)
 - Marine Turtles
 - Testudo* (Spur-thighed Tortoise, Testudinidae)
 - Dispersers
 - Winter
 - Order Squamata – Lizards
 - Adaptations
 - Anolis* (Anole, Polychrotidae)
 - Brookesia vadoni* (Mossy Pygmy Leaf Chamaeleon, Chamaeleoniae)
 - Rhampholeon spectrum* (Spectral Pygmy Chamaeleon, Chamaeleoniae)
 - Corytophanes cristatus* (Helmeted Iguana, Chorytophanidae)
 - Ceratophora karu* (Agamidae)
 - Zootoca* (formerly *Lacerta*) *vivipara* (Viviparous Lizard, Lacertidae)
 - Plestiodon* (formerly *Eumeces*) *anthracinus* (Coal Skink, Scincidae)
 - Lobulia* (Scincidae)
 - Cnemaspis spinicollis* (Geckonidae)
 - Order Squamata – Snakes

Chapter in Volume 2

Diadophis punctatus punctatus (Ringneck Snake, Colubridae)
Pseustes poecilonotus (Dos Cocorite, Colubridae)
Sibon longifrenis (Stejneger's Snail Sucker, Colubridae)
Virginia valeriae (Smooth Earth Snake, Colubridae)
Sistrurus catenatus catenatus (Eastern Massasauga Rattlesnake, Viperidae)
Vipera berus (European Viper, Viperidae)
Bothriechis schlegelii (Eyelash Viper, Viperidae)
 Visitors

Order Crocodylia – Crocodiles (Family Crocodylidae)
 Reptiles in Captivity

16 BIRDS

16-1: Birds and Bryophytes Intersect

Where Birds and Bryophytes Intersect
 Watch Towers and Sentinels
 Bathing
 Thirsty Birds
 Fertilizer Effects of Birds on Bryophytes
 Guano
 Penguins
 Peatland Habitats
 Effects on Bryophyte Community Structure
 Conservation Issues
 Dispersal Agents
 Soft Landings

16-2: Birds and Bryophytic Food Sources

Capsules
 Ptarmigans
 Grouse
 Titmice
 Kōkako
 Fruit Mimicry by Capsules?
 Bird Color Vision
 Leafy Plants
 Ducks and Food Availability
 Geese
 Blood Pheasant
 Kakapo
 Turkeys?
 Dispersal
 Nutritional Value of Bryophytes
 Palatability
 Foraging
 Ground Foragers
 Arctic Foraging Effects
 Foraging on Epiphytes
 Juncos
 Weaver Birds
 Tropical Birds
 Jamaican Blackbird

16-3: Bird Nests

Nests
 Types of Nests
 Bryophyte Advantages in Bird Nests
 Insulation
 Humidity Control
 Elasticity
 Antibacterial, Antiparasitic?

Chapter in Volume 2

Cavity Nest Elevation
 Selection of Nest Materials
 Who Uses Mosses in Nests?

16-4: Bird Nests – Non-Passeriformes, Part 1

Anseriformes: Screamers, Ducks, *etc.*
 Anatidae – Swans, Geese, & Ducks
 Pink-footed Goose (*Anser brachyrhynchus*)
 Long-tailed Duck (*Clangula hyemalis*)
 Snow Goose (*Chen caerulescens*)
 Phasianidae – Quail, Pheasants, *etc.*
 Gaviiformes: Loons
 Gaviidae – Loons
 Podicipediformes: Grebes
 Podicipedidae - Grebes
 Pelecaniformes: Tropicbirds, Pelicans, *etc.*
 Phalacrocoracidae – Cormorants
 Falconiformes: Vultures, Hawks, & Falcons
 Accipitridae – Hawks, Old World Vultures, & Harriers
 Rough-legged Buzzard/Hawk (*Buteo lagopus*)
 American Bald Eagle (*Haliaeetus leucocephalus*)
 Gruiformes: Cranes, Rails, *etc.*
 Gruidae – Cranes
 Rallidae
 Chestnut Forest-Rail (*Rallina rubra*)
 Charadriiformes
 Charadriidae – Plovers, *etc.*
 Dotterel (*Charadrius morinellus*)
 Scolopacidae – Sandpipers *etc.*
 Broad-billed Sandpiper (*Limicola falcinellus*)
 Laridae – Skuas, Gulls, Terns, & Skimmers
 Herring/Glaucous Gull Hybrid (*Larus argentatus/hyperboreus*)
 Kelp Gull (*Larus dominicus*)
 Lesser Black-Backed Gull (*Larus fuscus*)
 Alcidae – Auks, Murres, & Puffins
 Marbled Murrelet (*Brachyramphus marmoratus*)

16-5: Bird Nests – Non-Passeriformes, Part 2

Columbiformes: Pigeons & Doves
 Columbidae – Pigeons & Doves
 Cuculiformes: Cuckoos, *etc.*
 Cuculidae – Typical Cuckoos
 Strigiformes: Owls
 Strigidae – Typical Owls
 Snowy Owl (*Bubo scandiacus*)
 Burrowing Owls (*Athene cunicularia*)
 Caprimulgiformes: Goatsuckers & Relatives
 Caprimulgidae – Goatsuckers
 Apodiformes: Swifts & Hummingbirds
 Apodidae – Swifts
 Glossy Swiftlets (*Collocalia*)
 Mossy-nest Swiftlet (*Aerodramus salangana*)
 Mascarene Swiftlet (*Aeroramus francicus*)
 Philippine Swiftlet (*Aeroramus francicus*)
 Trochilidae – Hummingbirds
 Ruby-throated Hummingbird (*Archilochus colubris*)
 Rufous Hummingbird (*Selasphorus rufus*)
 Picaflor Rubí (*Sephanoides sephaniodes*)
 Trogoniformes
 Trogonidae – Trogons

Chapter in Volume 2

16-6: Bird Nests – Passeriformes, Part 1

Passeriformes: Perching Birds

Tyrannidae – Tyrant Flycatchers

- Olive-sided Flycatcher (*Contopus cooperi*)
- Yellow-bellied Flycatcher (*Empidonax flaviventris*)
- Pacific-slope Flycatcher (*Empidonax difficilis*)
- Hammond's Flycatcher (*Empidonax hammondi*)
- Eastern Phoebe (*Sayornis phoebe*)
- Eastern Kingbird (*Tyrannus tyrannus*)
- Yellow-bellied Chat-tyrant (*Ochthoeca diadema*)
- Crowned Chat-tyrant (*Ochthoeca frontalis*)

Laniidae – Shrikes

Vireonidae – Typical Vireos

Rhipiduridae

Monarchidae

Corvidae – Jays, Magpies, and Crows

- Common Raven (*Corvus corax*)

Hirundinidae – Swallows

- Tree Swallow (*Trachycieta bicolor*)

Paridae – True Tits

- Black-capped Chickadee (*Poecile atricapillus*)
- Carolina Chickadee (*Poecile carolinensis*)
- Varied Tit (*Sittiparus varius*)
- Blue Tit (*Cyanistes caeruleus*), Great Tit (*Parus major*), and Japanese Tit (*Parus minor*)
- Ground Tit (*Pseudopodoces humilis*)

Pipridae – Manakins, Piprites

- Black-capped Piprites (*Piprites pileata*)

Aegithalidae – Long-tailed Tits

- Long-Tailed Tit (*Aegithalos caudatus*)

Sittidae – Nuthatches

- Red-Breasted Nuthatch (*Sitta canadensis*)

Certhiidae – Holarctic Treecreepers

Troglodytidae – Wrens

- Carolina Wren (*Thryothorus ludovicianus*)
- Pacific Wren (*Troglodytes pacificus*) and Winter Wren (*T. hiemalis*)
- Eastern Winter Wren (*Troglodytes hiemalis*)
- Eurasian Wren (*Troglodytes troglodytes*)

Cinclidae – Dippers

- Brown Dipper (*Cinclus pallasii*)

16-7: Bird Nests – Passeriformes, Part 2

Passeriformes (cont.)

Grallariidae

Regulidae – Kinglets

Sylviidae – Old-World Warblers and Gnatcatchers

Turdidae – Thrushes

Muscicapidae – Old World Flycatchers

Petroicidae – Australian Robins

Sturnidae – Starlings *etc.*

Motacillidae – Wagtails and Pipits

Bombycillidae – Waxwings

Peucedramidae – Olive Warbler

Parulidae – Wood Warblers *etc.*

Furnariidae – Neotropical Ovenbirds

Thraupidae – Tanagers and Honeycreepers

Emberizidae – Emberizines

Icteridae – Blackbirds, Orioles, *etc.*

Fringillidae – Fringilline Finches

Leiothrichidae – Laughing Thrushes

Ptilonorhynchidae – Bower Birds

Acanthizidae – Scrubwrens, Thornbills, and Gerygones

Chapter in Volume 2

Rhinocryptidae – Tapaculos
 Callaeatidae – New Zealand Wattlebirds
 Zosteropidae – White-eyes
 Effect of Cavity-nesting Birds on Bryophyte Communities
 Edible Nests

17 RODENTS

17-1: Muroidea: Muridae

Mammals
 Rodentia – Rodents
 Bryophytes as Food
 Impact on Bryophytes
 Grazing
 Runways, Burrows, and Nests
 Rodent Cycles
 Dispersal
 Muroidea – Hamsters, Voles, Lemmings, and New World Rats and Mice
 Muridae – Mice, *etc.*
Micromys minutus – Eurasian Harvest Mouse
Myodes = Clethrionomys – Red-backed Voles
Myodes rufocanus – Grey Red-backed Vole
Myodes rutilus – Red-backed Vole
Myodes gapperi – Southern Red-backed Vole
Myodes glareolus – Bank Vole
Apodemus sylvaticus – Wood Mouse
Pseudohydromys and *Mirzamys* – Moss Mice
Otomys sloggetti – Sloggett's Vlei Rat
Rattus rattus – Rats
Leptomys – Water Rats
 Shrew Rats
Paucidentomys vermidax
Hyorhinomys stuempkei
Gracillimus radix
Bunomys

17-2: Rodents – Muroidea: Non-Muridae

Cricetidae – Hamsters, Voles, Lemmings, and New World Rats and Mice
Chionomys nivalis – Snow Vole
Microtus agrestis – Field Vole
Microtus pennsylvanicus – Gull Island Vole
Microtus oeconomus – Tundra Vole
Microtus pinetorum – Pine Vole
Microtus xanthognathus – Taiga Vole
Microtus chrotorrhinus – Rock Vole
Phenacomys intermedius – Heather Vole
Phenacomys ungava – Eastern Heather Vole
Arborimus albipes – White-footed Vole
Arborimus longicaudus – Red Tree Vole
Peromyscus maniculatus – Deer Mouse
Neotoma cinerea – Bushy-tailed Woodrat
Neotoma fuscipes – Dusky-footed Woodrat
Neotoma magister – Allegheny Woodrat
 Lemmus – Lemmings
Lemmus lemmus – Norwegian Lemming
Lemmus sibiricus/trimucronatus – Brown Lemmings
Synaptomys borealis – Northern Bog Lemming
Synaptomys cooperi – Southern Bog Lemming
Dicrostonyx – Collared Lemming
Dicrostonyx groenlandicus – Northern Collared Lemming
Myopus schisticolor – Wood Lemming
 Bathyergidae – Blesmoles and Mole Rats
Cryptomys hottentotus – Hottentot Mole-rat
 Myoxidae – Dormice and Hazel Mice
Muscardinus avellanarius – Hazel Dormouse
 Gliridae – Dormouse
Glirulus japonicus – Japanese Dormouse

Chapter in Volume 2

Myoxus glis – Fat Dormouse

Dryomys nitedula – Forest Dormouse

17-3: Rodents and Bats – Non-Muroidea

Soricomorpha

Soricidae – Shrews

Sorex cinereus – Long-tailed Shrew

Sciuromorpha

Sciuridae

Tamias merriami – Merriam Chipmunk

Tamiasciurus hudsonicus – American Red Squirrel

Sciurus vulgaris – Eurasian Red Squirrel

Sciurus carolinensis – Grey Squirrel

Spermophilus parryi – Arctic Ground Squirrel

Glaucomys – Flying Squirrels

Glaucomys sabrinus – Northern Flying Squirrel

Glaucomys volans – Southern Flying Squirrel

Lagomorpha – Hares, Rabbits, and Pikas

Leporidae – Rabbits and Hares

Lepus arcticus – Arctic Hare

Oryctolagus cuniculus – European Rabbit

Ochotonidae – Pikas

Ochotona princeps – American Pika

Ochotona collaris – Collared Pika

Erinaceidae – Hedgehogs

Chiroptera – Bats

Pteropidae – Flying Foxes

Pteropus conspicillatus – Spectacled Flying Fox

18 LARGE MAMMALS

18-1: Large Mammals: Ruminants – Cervidae

Ruminantia – Ruminants

Impact of Ruminants on Bryophytes

Grazing

Trampling

Manuring

Life on Manure – Splachnaceae

Cervidae – Deer, Elk, Moose, and Caribou

White-tailed Deer – *Odocoileus virginianus*

Black-tailed Deer – *Odocoileus hemionus*

Reindeer/Caribou – *Rangifer tarandus*

Importance of Mosses in Diet

Digestibility

Effects on Soil Temperature

Microbial Responses to Grazing

Temporal Differences

Site Differences

Grazing Effects on Bryophytes and Vegetation

Roe Deer – *Capreolus capreolus*

Hog Deer – *Axis porcinus*

18-2: Large Mammals: Ruminants – Non-Cervidae

Moschidae – Musk Deer – *Moschus*

Bovidae – Antelopes, Cattle, Gazelles, Goats, Sheep, and Relatives

Sheep – *Bovis*

Goats – *Capra*

Cattle – *Bos*

Bison – *Bison*

18-3: Large Mammals – Non-Ruminants

Canidae – Dogs

Macropodidae – Wallabies and Kangaroos

Dendrolagus – Tree Kangaroo

Macropus – Australian Wallabies (and others)

Chapter in Volume 2

Vombatidae – Wombats
 Phalangeridae
 Common Brushtail Possum – *Trichosurus vulpecula*
 Elephantidae – Elephants, Mammoths
 Elephants – *Elaphas maximus*
 Mammoths – *Mammuthus*
 Ursidae – Bears
 Hominidae – Primates
 Chimpanzees

19 BACTERIA	coming later
20 ALGAE	coming later
21 BRYOPHYTE – BRYOPHYTE INTERACTIONS	coming later
22 TRACHEOPHYTES	coming later
23 FUNGI	coming later
24 ALLELOPATHY	coming later
25 ANTIHERBIVORY	coming later

VOLUME 3: METHODS**Chapter in Volume 3****1 FIELD TAXONOMY AND COLLECTION METHODS**

Collection
 Obtaining the Sample
 The Sposs
 Chisel
 Masking Tape Sampler
 Seasons
 What to Sample
 Sample Size
 Mixed Collections
 Epiphytes and Epiphylls
 Aquatic Samples
 Collecting Permits
 Bryological Collector Arrested
 Record-keeping
 Data Sheets
 Permanent Ink
 GPS Coordinates
 Voucher Specimens
 Field Preservation
 Liverworts and other Flat Plants
 Tiny Bryophytes
 Aquatic Species
 Drying Specimens
 Field Stains
 Field Gear – Collecting Equipment
 Attire
 Collecting Apron
 Collection Bags
 Hand Lenses (Loupes)
 Field Microscopes

Chapter in Volume 3

Return at the End of the Day
Getting your Specimens Home – Customs and Inspection

2 LABORATORY TECHNIQUES

2-1: Equipment

Lab Bench Setup

Microscopes

Parfocal Adjustment

Procedure

Microscope Use

Adjusting Light and Learning to Focus

Adjusting the Focus and Ocular Distance

Adjustments for Glasses

Dissecting Microscope

Self-focusing Foam Stage for a Dissecting Microscope

Microscope Light Sources

Differential Interference

Ha'penny Optics

Polarized Light

Leaf Borders and Costae

Fluorescence

Dark Field Microscopy

Phase Contrast Microscopy

Small Equipment

Microforceps

Forceps Repair

Microdissecting Needles

Dropper Bottles

Needle Dropper Bottle

Slides

Coverslips

Housing for Coverslips

Coverslips and Slides in Box

Other Useful Tools

Photomicrography

Scanners

Cameras

Scalebar

Inserting Scales into Images Using Photoshop

Stacking

Standardizing Focus Increments for Image Stacking Photomicrography

Culture and Viewing Chamber

2-2: Slide Preparation and Stains

Preparing the Specimen

Cleaning Bryophytes

Washing Machine

Embroidery Hoop

Wash Bottle

HCl

Aquatic Bryophytes

Sorting the Plants

Wetting Agents

Soap

Agral 600

Clearing Leaves

Lactic Acid

KOH or NaOH

Chloral Hydrate

Dehydration

Chapter in Volume 3

- Stains
 - Staining Stems
 - Triple Stains
 - Kawai Stem Staining Techniques
 - Acid Fuchsin
 - Aniline Blue
 - Congo Red
 - Eosin
 - Fast Green
 - Fuchsin
 - Gentian Violet (=Crystal Violet)
 - Janus Green
 - Methyl Green
 - Leaves
 - I₂KI
 - KOH or NaOH
 - Safranin O / Fast Green
 - Sphagnum* Stains
 - Methylene Blue
 - Crystal Violet/Gentian Violet
 - Toluidine Blue O
 - Reproductive Structures
 - Iron Haematoxylon / Fast Green
 - Bulbils and Spores
 - Fluorescence and Fluorescent Dyes
 - Staining Liverwort Capsules
- pH Testing
- Weak Alkali
- Cleaning Up Stains
- Leaf Removal and Making Slides
- Sectioning
 - Razor Blades
 - Cutting Techniques
 - Wax Mounts
 - Cutting Block
 - Pith Sandwich Cutting Tool
 - Chopping Method
 - Roll and Chop
 - Modified Roll and Chop
 - Dissecting Microscope Hand Sections
 - Double Slide Sectioning Technique
 - Cryostat Sections
 - Stems and Small Leaves
 - Lamellae
- Mounting
- Techniques for Special Structures
- Clearing Spores
 - Gum Chloral Recipe
 - SEM
 - Vacuoles
 - Liverworts and Oil Bodies
 - Peristome Teeth

2-3: Making Observations

- Sporophytes
 - Stomata
 - Opening Immature Capsules (Lauridsen 1972)
 - Peristomes
 - Anchoring Specimens in Clay
- Spores
- Spore Dispersal

Chapter in Volume 3

- Sperm
- Leaf Movement
- Water Movement
- Tropisms
- Etiolation
- Splash Cup Dispersal
- Brownian Movement
- Plasmolysis
- Nutrient Cycling
- Measuring
 - Calibrate
 - Leaf Angles

2-4: Preservation and Permanent Mounts

- Permanent Slides – Mounting Media
- Semipermanent Slides – Mounting Media (Mountants)
 - Glycerine to Gum Arabic
 - Hoyer's Solution
 - Water Glass Alternative (WGG) for Hoyer's Solution plus Glycerin
 - Modified Hoyer's for Chromosomes (Bowers 1964)
 - Gum Chloral Solution
 - Glycerine, Glycerol, and Glycerine Jelly
 - Glycerine Jelly Preparation (Zander 2003)
 - Using Glycerine Jelly
 - To Make Semipermanent Mount
 - Clearing
 - DMHF (5,5-dimethyl Hydantoin Formaldehyde)
 - PVA
 - Karo Syrup
 - Polyvinyl Lactophenol
 - Aquamount Improved
 - Kleermount, Xylene Solution #2
 - Fluoromount-G
 - Gray-Wess Mountant
 - Double-Coverslip Method
- Sealing Slides
- Reviving Dried Slides
- Cleaning Slides
- Labels
- Slide Storage
- Preserving Bryophyte Plants for Dioramas
 - Field Collections
 - Preservation Protocol
- Preserving Liverworts

3 HERBARIUM METHODS AND EXCHANGES

- Folding Packets
 - Packet Machine
 - Followers
 - Herbarium Sheets
- Herbarium Labels
 - Multiple Species
 - Annotations
 - Multiple Access
- Storage
 - Cabinets
 - Packet storage
 - Type Specimens
 - Storage Containers
 - Palm Folders
 - Storage Boxes from Genus Covers

Chapter in Volume 3

	Specially Made Storage Boxes	
	Preservation	
	Cool Preservation	
	Minute Species and Special Structures	
	Herbarium Arrangement	
	Guide Cards	
	Herbarium Care	
	Pest Control	
	Agral 600	
	Moth Balls (Naphthalene)	
	Microwave Oven	
	Bromomethane (Methyl Bromide)	
	Freezing	
	Insect Traps	
	Drowning	
	Steam Sterilization	
	Moisture Control	
	Dehumidifier	
	Silica Gel	
	Herbarium Materials	
	Sending Specimens for Identification	
	References	
	Current Names	
	Indexing	
	Herbarium Programs	
	Shipping Live Bryophytes	
	Sharing Images	
	Herbaria	
	Herbarium Specimen Mapping	
	Live Collections	
	Cryopreservation	
	When You Leave – Willing Your Herbarium	
	Exchange Programs	
	Borrowing Specimens	
	Type Specimens	
4	SAMPLING AND FIELD METHODS	coming later
5	CULTURING	coming later
6	PHOTOGRAPHY	coming later
7	MEASUREMENTS	
	Growth Measurements	coming later
	Physiological Measurements	coming later
8	TEACHING EXPERIMENTS AND DEMONSTRATIONS	coming later

VOLUME 4: HABITAT AND ROLE**Chapter in Volume 4****1 AQUATIC AND WETLAND****1-1: Anthocerotophyta**

Anthocerotaceae

*Anthoceros**Anthoceros agrestis**Anthoceros caucasicus**Anthoceros punctatus**Aspiromitus*

Chapter in Volume 4

- Aspiromitus asper*
- Aspiromitus bulbosus*
- Aspiromitus lobatus*
- Aspiromitus squamulosus*
- Folioceros*
- Folioceros fuciformis*
- Folioceros glandulosus*
- Dendrocerotaceae
- Megaceros*
- Megaceros flagellaris*
- Megaceros tjibodensis*
- Phymatocerotaceae
- Phymatoceros*
- Phymatoceros bulbiculosus*
- Notothyladaceae
- Phaeoceros*
- Phaeoceros carolinianus*
- Phaeoceros laevis*

1-2: Marchantiophyta, Class Jungermanniopsida, Order Jungermanniales – Cephaloziineae 1

- Adelanthaceae
- Cuspidatula flexicaulis*
- Syzygiella sonderi*
- Anastrophyllaceae
- Anastrophyllum assimile*
- Anastrophyllum michauxii*
- Barbilophozia barbata*
- Barbilophozia sudetica*
- Gymnocolea inflata*
- Isopaches bicrenatus*
- Rivulariella gemmipara*
- Schljakovia kunzeana*
- Sphenolobus minutus*
- Tetralophozia filiformis*
- Cephaloziaceae
- Cephalozia*
- Cephalozia ambigua*
- Cephalozia austrigena*
- Cephalozia bicuspidata*
- Fuscocephaloziopsis albescens*
- Fuscocephaloziopsis connivens*
- Fuscocephaloziopsis lumulifolia*
- Odontoschisma elongatum*
- Odontoschisma fluitans*
- Odontoschisma sphagni*
- Cephaloziellaceae
- Cephaloziella*
- Cephaloziella hampeana*
- Cephaloziella rubella*
- Kymatocalyx*
- Kymatocalyx africanus*
- Kymatocalyx cubensis*
- Kymatocalyx dominicensis*
- Kymatocalyx madagascariensis*
- Kymatocalyx rhizomatica*
- Lophoziaceae
- Lophozia*
- Lophozia ventricosa*
- Lophozia wenzelii*
- Lophoziopsis excisa*
- Trilophozia quinqueidentata*
- Tritomaria exsecta*
- Tritomaria exsectiformis*

1-3: Marchantiophyta, Order Jungermanniales – Cephaloziineae 2

- Scapaniaceae

Chapter in Volume 4

Diplophyllum
Diplophyllum albicans
Diplophyllum taxifolium
Douinia ovata
Saccobasis polita
Scapania
Scapania aspera
Scapania crassiretis
Scapania cuspiduligera
Scapania hyperborea
Scapania irrigua
Scapania microdonta
Scapania nemorea
Scapania paludicola
Scapania paludosa
Scapania ridiga
Scapania rufidula
Scapania subalpina
Scapania uliginosa
Scapania umbrosa
Scapania undulata
 Streams
 Lakes
 Associations
 pH
 Water Relations
 Temperature
 Photosynthetic Products
 Reproduction
 Secondary Compounds
 Pigments
 Nutrient Relations
 Heavy Metals
 Other Pollutants
 Disturbance
 Role
 Habitat Summary

1-4: Marchantiophyta, Order Jungermanniales – Jungermanniineae

Antheliaceae
 Anthelia julacea
 Anthelia juratzkana
 Balantiopsidaceae
 Balantiopsis convesiuscula
 Calypogeiaceae
 Calypogeia
 Calypogeia arguta
 Calypogeia azurea
 Calypogeia fissa
 Calypogeia goebelii
 Calypogeia muelleriana
 Calypogeia sphagnicola
 Calypogeia sullivanii
 Geocalycaceae
 Geocalyx graveolens
 Gymnomitriaceae
 Gymnomitrium commutatum
 Gymnomitrium crenulatum
 Marsupella
 Marsupella aquatica
 Marsupella boeckii
 Marsupella emarginata
 Marsupella emarginata subsp. *tubulosa*
 Marsupella sparsifolia

Chapter in Volume 4

Marsupella sphacelata
Nardia assamica
Nardia compressa
Nardia geoscyphus
Nardia scalaris

Harpanthaceae

Harpanthus flotovianus

Hygrobiellaceae

Hygrobiella laxifolia

Jungermanniaceae

Eremontus myriocarpus

Jungermannia

Jungermannia atrovirens

Jungermannia borealis

Jungermannia callithrix

Jungermannia exsertifolia

Jungermannia exsertifolia subsp. *cordifolia*

Jungermannia pumila

Jungermannia quadridigitata

Mesoptychia badensis

Mesoptychia bantriensis

Mesoptychia collaris

Mesoptychia gillmanii

Mesoptychia turbinata

Notoscyphaceae

Notoscyphus lutescens

Saccogynaceae

Saccogyna viticulosa

Solenostomataceae

Solenostoma

Solenostoma ariadne

Solenostoma gracillimum

Solenostoma hyalinum

Solenostoma javanicum

Solenostoma obovatum

Solenostoma sphaerocarpum

Solenostoma stephanii

Solenostoma tetragonum

Solenostoma truncatum

Solenostoma vulcanicola

1-5: Marchantiophyta, Order Jungermanniales – Lophocoleineae, Myliineae, Perssoniellineaecoming soon

1-6: Marchantiophyta, Aquatic Metzgeriidaecoming soon

1-7: Marchantiophyta, Porelloides and Ptilidioidescoming soon

1-8: Marchantiophyta, Class Marchantiopsidacoming soon

Bryophytacoming soon

2 STREAMS

2-1: Stream Physical Factors Affecting Bryophyte Distribution

Factors Affecting Bryophyte Presence

Stability and Stream Order

Substrate

Substrate Type

Rock Size

Substrate Stability

Erosion

Stability, Bryophytes, and Macroinvertebrates

Step Pools

Disturbance Factors

Flow

Chapter in Volume 4

- Abrasion and Scouring
- Drag Coefficients
- Flooding
- Bankfull Discharge
- Regulated Rivers
- Drought and Desiccation
- Depth
- Siltation
- Pasture and Plantations
- Clear-cutting
 - Forest Buffers
 - Effects on Streams and Riparian Zones
 - Time Lags
- Ice and Snow
- Anchor Ice

2-2: Stream Factors Affecting Bryophyte Physiology and Growth

- pH and Alkalinity
- CO₂ Relationships
 - pH
 - CO₂ and Boundary Layer Resistance
 - Microbial CO₂
 - Diving Bell
- Nutrient Availability
- Temperature Effects
- Light
- Seasonal Changes

2-3: Structural Modifications – Leaves and Stems

- Structural Modifications
 - Evolutionary Drivers
 - Bryophytes vs Tracheophytes
- Modified Leaves
 - Multistratose Leaves
 - Costa
 - Borders
 - Falcate Leaves
 - Alar Cells
 - Structural Protection from Desiccation
- Leaf Arrangement
- Stem Characters
 - Stem Length
 - Stem Rigidity and Drag Force
 - Drag Reduction
 - Central Strand
 - Stolons
 - Ethylene Response?

2-4: Structural Modifications – Rhizoids, Sporophytes, and Plasticity

- Rhizoids and Attachment
 - Effects of Submersion
 - Effects of Flow on Rhizoid Production
 - Finding and Recognizing the Substrate
 - Growing the Right Direction
 - Rate of Attachment
- Reductions and Other Modifications
- Sporophyte Characters
- Spores
- Character Plasticity
 - Resultant Identification Problems
 - Plastic Characters

Chapter in Volume 4

Alterations of Terrestrial and Wetland Species
 Genetic Variation
 Mechanisms Facilitating Differences
 Dimorphic Forms?

2-5: Life and Growth Forms and Life Strategies

Life and Growth Forms
 Definitions and Habitats
 Functional Groups
 Factors Influencing Life Forms
 Morphological Plasticity of Life Form
 Life Strategies and Reproduction
 Sexual Strategies and Gametangia
 Fertilization
 Sporophytes
 Dispersal
 Hydrochory
 Adaptations for Hydrochory
 Dispersal Vectors
 Changes in Distribution
 Small Dispersal Units and Long-distance Dispersal
 Spore Germination and Protonema Development
 Asexual Reproduction
 Regeneration
 Gemmae and Bulbils
 Longevity
 Life Cycle Strategy

2-6: Physiological Adaptations – Water, Light, and Temperature

Moisture Relations
 Drying Effects
 Membrane Leakage
 Rate of Drying
 Recovery
 Photoinhibition
 Sucrose Accumulation
 More Leakage Problems
 Invaders in the Mix
 Polyribosomes and Protein Synthesis
 Non-autotrophic CO₂ Fixation
 Temperature Effects
 Pigment Responses
 Fatty Acid Responses
 ABA Mediation
 Allocation Changes
 Light
 Habitat Differences
 Chlorophyll and Accessory Pigments
 Seasons
 UV-B
 Sun and Shade Plants
 Photoprotective Pigments
 Cell Wall vs Soluble Compounds
 UV Interactions
 Photoinhibition
 Effects of Nutritional Status
 Temperature
 High Temperatures
 Low Temperatures
 Optimum Temperatures
 Bryophyte Antifreeze

Chapter in Volume 4

Temperature Effects on Absorption

2-7: Physiological Adaptations – Nutrients, Photosynthesis, and Others

Nutrient Relations

Nitrogen

Phosphorus

Locations in Plant

Pollution Effects

Heavy Metals

pH

Photosynthesis and Growth

Patterns of Allocation

Water Content

Respiration

Winter Temperatures

CO₂

CO₂ or Bicarbonate Use – or Not

pH

Boundary-layer Resistance

Diving Bell

Ecotypes

Seasons and Phenology

Reproductive Signals

Periphyton

Herbivory and Pathogens

8 TROPICS**8-1: General Ecology**

General Ecology

Water Relations

Light

Life and Growth Forms

Nutrient Relations

Productivity

Climate Effects

Reproductive Biology and Phenology

Life Cycle Strategies

Mosses

Antheridia and Archegonia

Monoicous vs Dioicous

Propagules and Regrowth

Propagule Forms

Fragments

Spore Size

Diaspore Banks

Prolonged Protonemal Stage

Liverworts

Monoicous vs Dioicous

Neoteny

Reduced Numbers of Antheridia and Archegonia

Short Life Cycles

Short Spore Longevity

Prolonged Protonemal Stage

Types of Gemmae

Diaspore Banks

Rheophilic Adaptations

Dispersal

Sampling

Braun-Blanquet Sampling Method

Drying Specimens

Chapter in Volume 4**8-2: Tropics: Geographic Diversity Differences**

Diversity - Geographic Differences

Africa

Asia

Australia

Neotropics

Endemism

Africa

Asia

Australia

Neotropics

Causes of Endemism

Dangers to Endemics

Tropical Rainforests

Panropical Distributions

Substrate Specificity

Forest Floor

Rockhouses

8-3: Epiphyte Ecology, Part 1

Water Relations

Water Content

Growth Forms and Life Forms

Osmotic Potential

Desiccation Recovery

Rainfall Interception

Fog Interception

Microclimate

Nutrient Dynamics

Rainfall vs Throughfall

Nitrogen Dynamics

Pulse Release

Keystone Resource

Canopy Roots

Productivity and Biomass

Epiphyte Litterfall

8-4: Epiphyte Ecology, Part 2

Adaptations

Growth Forms and Life Forms

Life Cycle Strategies

Dispersal and Colonization

Host Trees

Height on Tree

Tree Base

Upper Trunk

Lower Branches

Twigs

Canopy

Logs and Rotten Wood

Sampling

Quadrats

Rope Climbing

Bow and Arrow

Other Canopy Access

Role

Adventitious Roots

Substrata for Tracheophytes

Friend or Foe?

Faunal Habitat

Chapter in Volume 4**8-5: Epiphyte Geographic Diversity**

- Diversity
 - Australia
 - Asia
 - African Region
 - Neotropics

8-6: Epiphylls

- Epiphyllous Communities
- Fossil Records
- Species Richness
 - Asia
 - South Pacific Islands
 - Africa
 - Neotropics
 - Central America
 - South America
- Microclimate
- Colonization
- Fragmented Habitats
- Bryophyte Adaptations
 - Morphology
 - Water Relations
 - Life Cycles
- Host Adaptations
 - Drip Tips
 - Leaf Size and Shape
 - Leaf Longevity
 - Leaf Chemistry
- Interactions
 - Nutrient Exchanges
 - Host Leaf Leachates
 - Bryophyte Leachates
 - Seed Beds
 - Nitrogen Fixation
 - Herbivore Protection
 - Micro-organisms
 - Negative Impacts on Leaves
 - Light Interference
- Bromeliad Basins
- Sampling Epiphylls

8-7: Lowland Rainforests

- Lowland Rainforests
- Amazonia Lowlands
 - Terra Firme
 - Dense Forest
 - Open Forest without Palms
 - Open Forest with Palms
 - Liana Forest
 - Dry Forest
 - Restinga
 - Caatinga
 - Savannah Vegetation
 - South Atlantic Islands

8-8: Altitude

- Altitude
- Defining Zones
- Zone Limitations

Chapter in Volume 4

- Transplant Studies
- Latitude vs Altitude
- Records of Altitude
- Diversity-Richness Changes
- Dominance Changes
- Productivity
- Adaptations
- Life Strategies

8-9: Submontane and Montane

- Submontane
- Montane Forests
 - Lower Montane
 - Upper Montane

8-10: Cloud Forests, Subalpine, and Alpine

- Cloud Forests
 - Adaptations and Water Relations
 - Biomass
 - Colonization and Life Strategies
 - Species Diversity
 - Mount Kenya
 - Lowland Cloud Forest
 - Role
- Subalpine
- Alpine
 - Páramo
 - Moss Balls
 - Afro-alpine

8-11: Hydric and Xeric Habitats

- Inundated Forests
 - Várzea and Igapó Forests
 - Floodplains and Mangrove Forests
 - Pirizal
- Peatlands
- Aquatic
 - Rheophytes
 - Lakes
- Seepage Areas
- Xeric Habitats
 - Savannahs
 - Succession
 - Life Cycle Strategies
 - Tropical Deserts

8-12: Rocks and Inselbergs

- Adaptations
 - Life Cycle Strategies
 - Dispersal
 - Desiccation Recovery
- Interactions with Other Plants
- Lava Flows
- Richness and Diversity
 - Africa
 - Neotropics

8-13: Interactions and Roles

- Role
- Effect on Tree Seedlings
- Bryophyte and Fauna Relationships

Chapter in Volume 4

- Arthropods
- Vertebrates
 - Reptiles and Amphibians
 - Rodents
- Bryophytes on Fungi

8-14: Disturbance and Conservation

- Natural Disturbance
 - El Niño and Hurricanes
 - Nutrient Relationships
 - Recovery
 - Bryophyte Loss Effect on Tracheophytes
- Fire
- Volcanoes
- Animal Activity
- Rare and Threatened Species
- Pollution and Disturbance
 - Deforestation
 - Fragmentation Effects
 - Harvesting
 - Industrialization and Air Pollution
 - Radiation
 - Man-made Habitats
 - Climate Change
- Recovery
- Conservation Issues
- Current Status

VOLUME 5: USES**Chapter in Volume 5****1 HOUSEHOLD AND PERSONAL USES**

- Household Uses
 - Furnishings
 - Padding and Absorption
 - Mattresses
 - Shower Mat
 - Urinal Absorption
 - Cleaning
 - Brushes and Brooms
 - Oily Humans
 - Soaps
 - Pools and Spas
 - Toiletries and Toilets
 - Pesticides
- Clothing
- Jewelry
- Food Source
 - Vitamins
 - Flavoring
 - Chinese Gallnuts
 - Food Improvement
 - Food Preservation
- Cookery and Pottery
- Packing
- Burial Wreath

2 MEDICINES AND ANTIBIOTICS

- New Medical Sources

Chapter in Volume 5

- Herbal Medicines
 - Liver Ailments
 - Stones
 - Ringworm
 - Heart Medicine
 - Inflammation and Fever
 - Diuretics and Laxatives
 - Gynecology
 - Disinfectant and Infections
 - Lung Diseases
 - Skin Treatments
 - Eye Diseases
 - Growing Hair
 - Filters
- Surgical and Wounds
- Antibiotics and Other Biologically Active Substances
 - Antifungal Activity
 - Antiviral Activity
- Cancer and Anti-tumor Properties
- Transgenic Pharmaceutical Production
- Medical Dangers

3 FINE ARTS

3-1: Decorative

- Decoration
 - Nativity
 - Christmas Decorations
 - Household Decorations
 - Moss Walls
- Shop Windows and Displays
- Floral Industry
- Moss Rocks
- Flower Pots
- Jewelry
- Collection Dangers

3-2: Art

- In Artwork
- Foam Novelties
- Corpus Christi Festival
- Body Art
- Statues or Topiary?
- Film-making

3-3: Literature

- Stories and Verse
- Fillers
- Poetry
 - Humble Moss
 - Rugged Mosses
- In The Bible
- Literature References from Bryonettors
- Moss in Music
- Uses of the Word Moss
- Literature and Bryophyte Names

4 AQUARIA

- Aquarium Bryophytes
- Preparing a Moss Wall
- Maintenance

Chapter in Volume 5

Dangers from Other Organisms
Algae Problems
Commercial Fisheries

5 CONSTRUCTION

Construction
Modern Building Construction
Insulation
Travertine Rock
Problems in Construction
Moss Walls
Roads and Paths
Erosion and Ecocity
Green Roofs
The Downside?
Suitable Species
Eliminating Moss
Golf Courses
Roman Wells
Log Dams
Boat Construction

6 TECHNOLOGICAL AND COMMERCIAL

Sphagnum Peatlands
Heavy Metal Detection and Cleanup
Filtration
Oil Cleanup
Fuel
Peat in Construction
Harvesting Peat and Peatland Destruction
Climate Reconstruction
Graves, Burial, and Preservation
The Tollund Man
Anthropology and Archaeology
Forensics
Archaeological Preservation
Erosion Control
Revegetation
Recreation
Pesticides and Antifeedants
Rearing Fish
Toxicity Testing
Filters
Electricity
Scientific Use
Model Systems
Genetic Engineering
Manufacturing Human Protein
Model for Pipettes
Goodyear Tires

7 GARDENING**7-1: Horticultural Uses**

Horticultural Uses
Shipping and Protection
Air Layering
Pot Culture
Potting Medium
Dangers of Peat Culturing
Covering Pot Soil

Chapter in Volume 5

- Culturing Mushrooms and Other Fungi
- Reforestation
- Container Gardens
 - Bonkei
 - Dish Gardens
 - Bonsai
 - Hanging Baskets
 - Terraria
- Bryophytes as Pests

7-2: Japanese Moss Gardens

- Moss Gardens
- Japanese Moss Gardens
- Types of Japanese Moss Gardens
- Dangers to Gardens
- Educational Gardens
- Variations
- Charcoal Gardens
- Dominant Species

7-3: Private Moss Gardens

- Private Gardens
- Making Your Garden
 - Mossery
 - Garden Variety
 - Seasons
 - Water Gardens
 - Bog Garden
 - My Personal Garden
 - Mountain Moss Enterprises
 - Moss and Stone Gardens
 - Dale Sievert's Garden
 - New Methods in Moss Gardening
 - Harvesting Ban

7-4: Moss Garden Development and Maintenance

- Choice of Bryophytes
 - Thallose Liverworts
 - Sphagnum* – peat mosses
 - Polytrichum* – hairy cap mosses
 - Atrichum*
 - Leucobryum*
 - Dicranum*
 - Mniaceae
 - Thuidium delicatulum*
 - Pseudoscleropodium purum*
 - Rhodobryum*
 - Fissidens*
 - Others
- Sources
- Lawns
- Special Use Species
 - Lawn Species
 - Sun Species
 - Wall Species
 - Path Species
 - Erosion Control
- Cultivation
- Winter Culture
- Moss Plantations
- Transplanting

Chapter in Volume 5

- Substrate Conditioning
- Maintenance
 - No Fertilizers?
 - Watering
 - Herbicides
 - Bryophyte "Predators"
 - Other Pests
 - Netting
 - Removing Autumn Leaves
 - Overwintering
- Arranging the Garden
- Environmental Benefits

7-5: Public Gardens

- Botanical Gardens
- Problems in Public Gardens
- Moss Gardens of the World
 - Bloedel Reserve, Washington, USA
 - Seattle Japanese Garden, Seattle, Washington, USA
 - Portland Japanese Garden, Portland, Oregon, USA
 - Anderson Japanese Garden, Rockford, IL, USA
 - Golden Gate Park, San Francisco, California, USA
 - Zion National Park, Utah, USA
 - Missouri Botanical Garden, St. Louis, Missouri, USA
 - Rotary Botanical Garden, Janesville, Wisconsin, USA
 - Sarah Duke Gardens, Durham, North Carolina, USA
 - Limahuli Gardens, Kauai, Hawaii, USA
 - Sikkim, India
 - Floriade, Venlo, Holland
 - Villa d'Este, Tivoli, Italy
 - Herculeneum, Italy
 - Cibodas Botanical Garden, Java, Indonesia
- Educational Displays
- Labelling

GLOSSARY

JANICE GLIME AND LEICA CHAVOUTIER

1n: having only one set of chromosomes

2n: having two sets of chromosomes

2,4-D: 2,4-dichlorophenoxyacetic acid; herbicide that mimics IAA

6-methoxybenzoxazolinone (6-MBOA): glycoside derivative; insect antifeedant; can stimulate reproductive activity in some small mammals that eat them by providing growth substances

>>: much greater

♀: sign meaning female, *i.e.* bearing archegonia

♂: symbol meaning male



α -amylase: enzyme that hydrolyses alpha bonds of large, alpha-linked polysaccharides, such as starch and glycogen, yielding glucose and maltose

A horizon: dark-colored soil layer with organic content and minerals intermixed

ABA: abscisic acid; plant hormone (growth regulator) associated with water stress, drought hardening, growth inhibition, stomatal closing, and seed dormancy in some plants; known from mosses

abandoned land: land having previous human use

abaxial: referring to lower surface of leaf; facing away from stem of plant

s.s.: Latin *sensu stricto*, meaning strict sense

sp.: species

spp.: more than one species

ssp.: subspecies

var.: variety

abiosis: absence or lack of life; nonviable state

abiotic: referring to non-living and including dust and other particles gained from atmosphere, organic leachates from bryophytes (and host trees for epiphytes), decaying bryophyte parts, and remains of dead inhabitants; usually includes substrate

abortive: having development that is incomplete, abnormal, stopped before maturity

abscisic acid: ABA; plant hormone (growth regulator)

abscission: process where plant organs are shed; *e.g.* deciduous leaves in autumn

absent: missing

abundance: numerical representation of species; measure of amount of given species in sample

local abundance is relative representation of species in particular ecosystem, usually measured as number of individuals found per sample

relative species abundance is calculated by dividing number of species from one group by total number of species from all groups

acaulescent: provided with very short stem

ACC: acetyl-CoA carboxylase; ethylene precursor; biotin-dependent enzyme that catalyzes irreversible carboxylation of acetyl-CoA to produce malonyl-CoA through its two catalytic activities, biotin carboxylase (BC) and carboxyltransferase (CT)

accession number: number assigned to specimen when it is entered into herbarium record

accessory pigment: pigment that captures light energy and passes it to chlorophyll *a*

accidentally foliicolous: accidentally, not normally, growing on leaves

acclimation: gradual and reversible adjustment of organism to environmental fluctuations; *e.g.* adjustment to winter cold or summer heat; compare to **adaptation**, which is persistent genetic change that provides organism with better ability to survive its environmental conditions

acrescent: continuing to grow after reproduction

accumulation enrichment factor: amount of metal in plants divided by its stream water concentration

-aceae: suffix denoting family in Plant Kingdom

acellular: not divided into multiple cells

Abbreviations

aff.: related to

agg.: aggregate, designating group of species which are difficult to distinguish from one another

auct.: Latin abbreviation for *auctor*, meaning author

c.: Latin *circa*, meaning around, about

cf.: Latin *confer*, compare with

cfr. (c. fr.): Latin *cum fructibus*, meaning with sporophytes

cm: centimeter

det.: Latin *determinavit*, meaning determined by

e.g.: Latin *exempli gratia*, meaning for example

fo.: Latin *forma*, meaning form

ibid.: Latin *ibidem*, meaning in the same book

i.e.: Latin *id est* meaning that is

IPL: inner peristomial layer

leg.: Latin *legit*, meaning collected by

μ m: micrometer; micron; length unit = 1/1 000 mm.

n: chromosome number (haploid).

op. cit.: Latin *opus citatum*, meaning mentioned, cited above

OPL: meaning outer peristomial layer

PPL: meaning primary peristomial layer

s.d.: Latin *sine die*, meaning without date

sensu: Latin *sensu*, meaning in the sense (of)

s.l.: Latin *sensu lato*, meaning in broad sense

s.n.: Latin *sine numero*, meaning without number

- acetylcholine:** chemical formed by choline and acetyl group; neurotransmitter in nervous system used to transmit nerve impulses
- achlorophyllous:** lacking chlorophyll
- acicole:** growing on or among needles of conifers
- acid:** substance with pH less than 7.0
- acid flush:** concentrated pollutants released rapidly during snow melt
- acid precipitation:** precipitation having pH less than 5.4
- acidicline:** preferring weakly acidic substratum
- acidophile:** plant growing best on acidic substrate
- acidophilous:** growing on acidic substrates
- acrocarp:** moss species that produces sporophyte at apex of stem or main branch
- acrocarpous:** gametophyte producing sporophyte at apex of stem or main branch; generally upright mosses with terminal sporangia, usually unbranched or sparsely branched
- acrogynous:** in many leafy liverworts, sporophyte growing at top of stem (from apical cell), *e.g. Mesoptychia collaris* [ant. **anacrogynous**]
- acropetal:** referring to movement of substance from base to apex; of growth, outward toward shoot (or root) apex [ant. **basipetal**]
- acrotelm:** living layer of peat
- actinomorphic:** having radial symmetry, like spokes of wheel
- activation conditions:** conditions of sufficient moisture and light for germination
- acuminate tip:** prolonged tip
- adaptation:** genetic change, arrived at through process of natural selection, which enables organism to compete more effectively under given set of conditions (L. *adaptare* = to fit in); compare to **acclimation**, gradual and reversible adjustment of organism to environmental fluctuations
- adaxial:** on side toward axis (stem) of plant, such as upper surface of leaf [ant. **abaxial**]
- adenine:** nitrogenous base; one member of base pair adenine-thymine in DNA
- adherent:** strongly attached to substratum *e.g. Frullania dilatata*
- adhesion tube:** in **Collembola**, attachment to abdomen that may be used for cleansing body and as means of transferring drops of water from surface of body to mouth where they are then absorbed; previously thought to provide adherence
- adhesive organ:** structure by which some nematodes adhere to bryophytes
- adhesive peg:** structure of fungus that contacts rotifer or other entrapped organism, stimulating fungus to release glue from its trap
- adnate:** said of two fused structures, *e.g.* peristome and epiphragm of *Atrichum undulatum*
- adsorption:** fixation of elements on surface
- adventitious:** growing on atypical place, *e.g.* adventitious rhizoids on costa in *Conardia compacta*
- adventitious root:** root that arises from stem or other non-root axis point, as seen in corn
- adventive:** introduced
- aerenchyma:** in some thallose liverworts, loose parenchyma, with empty spaces between groups of cells
- aerobiology:** study of airborne microorganisms, pollen, spores, and seeds, especially as agents of infection; form of passive transport
- aerohaline:** subject to influence of salty sea spray
- aerohygrophyte:** plant growing in habitats having high air humidity
- aerophyte:** plant growing on aerial parts of another
- aestivation:** state of animal dormancy, similar to hibernation, but taking place in summer rather than winter
- Afro-alpine:** high mountains of Ethiopia and tropical East Africa, which represent biological 'sky islands' with high level of endemism
- Afromontane:** subregions of Afrotropical realm, one of Earth's eight biogeographic realms, covering plant and animal species found in mountains of Africa and southern Arabian Peninsula
- aggregate:** clustered together; group of species which are difficult to distinguish from one another
- aggressive mimicry:** form of mimicry in which predators, parasites, or parasitoids share similar signals, using harmless model, allowing them to avoid being correctly identified by their prey or host; *e.g.* playing dead
- Agral 600:** horticultural wetting agent
- agroforest:** land use management forest in which trees or shrubs are grown around or among crops or pastureland
- air chamber:** in some thallose liverworts, specialized air-containing cavity
- air layering:** method of propagating plant by girdling or cutting part way into stem or branch and packing area with moist medium, as *Sphagnum* moss, stimulating root formation so that stem or branch can be removed and grown as independent plant
- air pore:** in some thallose liverworts, opening of air-chamber
- alanine:** non-polar amino acid that is relatively insoluble in water; defense compound that enables plants to withstand various stresses such as hypoxia, waterlogging, and drought
- alar cell:** cell at basal angle of moss leaf, usually different in size and shape from other leaf cells
- ales:** suffix applied to order of plants or algae (*e.g.* **Dicranales**, **Orthotrichales**)
- alginate:** viscous gum; general term for salts of alginic acid, especially sodium but also calcium or barium ions; composed of guluronic and mannuronic acids
- alkaline:** rich in bases, having pH of more than 7
- alkalinity:** capacity of water to resist changes in pH that would make water more acidic; equivalent sum of bases that are titratable with strong acid
- alkaloid:** basic organic compound containing nitrogen; toxic
- allele:** particular form of gene
- allelopathic:** having ability to inhibit growth of another organism through secondary metabolite
- allelopathy:** condition in which one organism makes environment chemically unsuitable to another through secondary metabolism; type of chemical warfare in plants
- allochthonous:** originating from elsewhere
- allopatric:** said of two species which have separate (non-overlapping) areas of distribution
- allopolyploidy:** type of **polyploidy** (multiple sets of chromosomes) in which chromosome complement consists of more than two copies, with chromosomes derived from different species, producing hybrid species
- alluvium:** deposit of clay, silt, sand, and gravel left by flowing water in river valley or delta, usually as fertile soil
- alpestrine:** subalpine; growing to tree line
- alpha amylase:** enzyme that hydrolyses alpha bonds of large, alpha-linked polysaccharides, such as starch and

- glycogen, yielding glucose and maltose; substance that helps some rotifers identify plant substrate
- alpha diversity:** mean species diversity in sites or habitats at local scale, *i.e.* local species diversity
- alpine:** habitat above treeline of mountain
- alternation of generations:** alternating cycle of sporophyte ($2n$) and gametophyte ($1n$) generations
- altimontane:** montane grasslands, shrublands, and woodlands
- alveola** (pl. **alveolae**): more or less polygonal surface depression
- alveolate:** with depressions on surface
- A_{mass}:** leaf mass per area
- A_{max}:** maximum assimilation
- ambush predator:** sit and wait predator, often having camouflage
- amensalism:** interaction in which one species is harmed by other while other is neither harmed nor benefitted
- ametabiotic:** describes metabolic state of life entered by organism in response to adverse environmental conditions such as desiccation, freezing, or oxygen deficiency; all measurable metabolic processes stop, preventing reproduction, development, and repair; **cryptobiotic**
- ametabolic state:** state of life entered by organism in response to adverse environmental conditions such as desiccation, freezing, or oxygen deficiency; cryptobiotic state in which all measurable metabolic processes stop, preventing reproduction, development, and repair; including tardigrades, free-living nematodes, and rotifers; having no obvious metamorphosis
- amictic:** non-sexual, as in some rotifers, with asexual reproduction recurring until conditions are favorable
- amidon:** macromolecule composed of glucose constituents; starch; (*L. amyllum* = complex carbohydrate)
- amoebflagellate:** in some slime molds, diploid cell stage that includes flagellated cells and amoeboid cells that develop directly into plasmodium
- amorphous:** without definite form
- amphibious:** capable of living in or out of water
- amphigastrium** (pl. **amphigastria**): underleaves of leafy liverworts; few mosses where upper or lower leaves are differentiated from lateral leaves and smaller, as in *Racomitrium*
- amphisporous:** spore size frequencies and mean spore size frequencies grouped around 2 mean sizes in varying ratios; small spore fraction is aborted
- amphithecium** (pl. **amphithecia**): outer layer of embryonic capsule that gives rise to capsule tissues
- amphitropical:** distributed on both sides of tropics
- amplexus:** mating stage in which male amphibian grasps female with his front legs prior to depositing sperm on her eggs
- amyloid:** waxy translucent substance of various complex proteins in combination with polysaccharides and staining blue with iodine (like starch) deposited in tissues in different disease processes and tissue degeneration; builds up inside tissue in amorphous way
- amyloplast:** colorless plastid that forms starch granules in plants; statolith; might play role in gravitropism
- anabiosis:** temporary state of suspended animation or greatly reduced metabolism
- anacrogynous:** designating sporophyte growing in lateral position on stem, branch or thallus (*e.g.*, thallose liverworts like *Pellia endiviifolia*)
- anadromous:** referring to fish living in ocean and migrating up freshwater streams to spawn
- anaerobic:** without oxygen
- anagenesis:** species formation without branching of evolutionary line of descent
- anagenetic speciation:** speciation on islands through gradual change from founder population
- analogous:** said of structures not having common phylogenetic origin but having similar function
- anastomosis:** condition of union of one structure with another, usually crisscrossing; interconnecting; may be applied to irregularly divided peristome teeth (*e.g.* endothecium of *Anthelia juratzkana*) or river with islands and meanders
- anchor ice:** submerged ice anchored to bottom of stream or other water body
- ancophile:** plant living in canyon forests
- ancophilous:** living in canyon forests
- Andreaebryopsida:** class of mosses in **Bryophyta**
- Andreaeopsida:** class of mosses in **Bryophyta**
- androcyte:** cell that will give rise to antherozoid
- androecial branch:** specialized branch bearing antheridia and bracts
- androecium** (pl. **androecia**): male inflorescence; antheridia and surrounding bracts
- androgametophyte:** male gametophyte
- androgynogametophyte:** autoicous or synoicous gametophyte
- androgynous:** male and female organs in same inflorescence, monoicous
- anemochorous:** wind-dispersed
- anemochory:** dispersal by wind, such as spore, gemma, or other propagule
- angle of incidence:** angle formed between direction of light and vertical (difference from straight on), so low sun has higher angle of incidence, thus small leaf angle (approaching vertical) creates effect of large angle of incidence
- anhydrobiosis:** dormant state; strategy of surviving dehydrated state or extreme temperature conditions; reviviscence
- anion:** negatively charged ion
- anisogamy:** size, shape, or behavioral differences in gametes
- anisophyllous:** having two types of leaves on same stem; stem leaves and branch leaves morphologically different, as in *Sphagnum* [ant. **isophyllous**]
- anisosporous:** having bimodal distribution of spore sizes with smaller spores generally producing males
- anisospory:** condition having bimodal distribution in spore size; genetically determined condition of two spore sizes
- anisotropic dispersal:** directional dispersal
- annotinous:** with yearly growths
- annual:** plant that germinates, reproduces, and dies all within one year [ant. **perennial**]; see Mägdefrau life forms
- annual shuttle:** species that requires small disturbances that last 1-2 years; survive severe stress periods
- annular:** ring-shaped
- annulus:** zone of differentiated cells between capsule urn and operculum, facilitating opening of capsule
- anoxybiosis:** biological response triggered by lack of oxygen in which organism takes in water and becomes turgid and immobile, possibly form of cryptobiosis; used by tardigrades to survive unfavorable conditions

- antagonistic:** interaction in which one species benefits at expense of another
- anterior:** dorsal, abaxial [ant. **posterior**]
- anterior whiplash flagellum:** thin whiplike structure on front end of cell (L. *flagellum* = whip)
- antheraxanthin:** bright yellow accessory pigment found in many organisms that perform photosynthesis; xanthophyll cycle pigment, oil-soluble alcohol within xanthophyll subgroup of carotenoids; in pathway to making ABA
- antheridiophore:** specialized antheridium-bearing branch
- antheridium** (pl. **antheridia**): male gametangium found in all sexual plants except seed plants; sperm container, multicellular globose to broadly cylindrical stalked structure producing sperm
- antherozoid:** spermatozoid, male gamete
- Anthocerotophyta:** phylum of hornworts, characterized by thallose gametophyte with hornlike sporophyte having continued growth at its base
- anthocyanin:** water-soluble blue, purple, or red flavonoid pigment found in cell vacuole of plants, especially flowers and autumn leaves; in bryophytes, usually based on 3-desoxyanthocyanidins located in cell wall
- anthracine:** coal black
- anthropochorous:** dispersal of propagules associated with human activities
- anthropogenic:** relative to ecosystem, resulting from action of humans
- antical:** relative to surface of thallus, upper side [ant. **postical**]
- antifeedant:** compound that discourages herbivory
- antifreeze protein (AFP):** protein that prevents freezing
- antrorse:** forward, upward, toward tip, e.g. antrorse teeth in *Dichodontium pellucidum* [ant. **retorse**]
- aperturate:** with opening
- aperture:** opening, hole, orifice
- apex:** tip; end farthest from point of attachment or from base of organ (L. *apex* = point)
- aphyllous:** without leaves
- apical:** at tip or apex
- apical cell:** single meristematic cell at apex of shoot, thallus, or other organ that divides repeatedly
- apical dominance:** phenomenon whereby main, central stem of plant is dominant over other side branches, typically by suppressing their growth
- apiculate:** with short and abrupt point
- apiculus** (pl. **apiculi**): short point, e.g. leaf tip of *Entodon concinnus*
- apogamous:** condition of producing sporophyte without union of gametes
- apogamy:** asexual multiplication, without fusion of gametes [syn. apomixis]
- apomixis:** asexual multiplication, without fusion of gametes [syn. apogamy]
- apophysis:** strongly differentiated sterile neck at base of capsule, e.g. *Splachnum rubrum* [syn. **hypophysis**]
- apoplast:** capillary spaces in cell wall
- apoplastic:** outside cell membrane, such as cell walls and dead cells; used to describe water transport between cells
- aposematic mimicry:** resemblance to organisms with behavior or morphology serving to warn or repel
- aposematism:** warning coloration; advertising by animal to potential predators that it is not worth attacking or eating; may indicate poisonous or bad taste or carnivorous attack
- asporous:** producing gametophyte from sporophyte tissue without meiosis
- apparency:** hypothesis predicts that apparent plants (i.e., most easily found in vegetation) would be most commonly eaten by herbivores, including humans; grouping of plants, including bryophytes, that are most conspicuous photosynthetic food items available
- apparent plants:** conspicuous plants, easily found by herbivores
- apparent quantum yield:** measure of how many molecules of certain substance such as H₂O₂, dissolved inorganic carbon, etc. can be produced per photon absorbed by, for example, colored dissolved organic matter
- appressed:** referring to leaves lying closely or flat against stem or plant to substrate [*Frullania dilatata*]
- aquatic:** pertaining to water habitat
- arabinoglucan:** new polysaccharide from mosses, made of glucose and arabinose; has potential medicinal value
- arabinose:** monosaccharide sugar containing five carbon atoms, and including aldehyde (CHO) functional group
- arable land:** land used for or suitable for growing crops
- arachidonic acid:** polyunsaturated, essential fatty acid that makes membranes more pliable in cold
- arachnoid:** covered with fine and tangled hairs, e.g. *Marchantia polymorpha* ssp. *montivagans* archegoniophore
- arboreal:** living in trees
- arbuscular hypha** (pl. **hyphae**): mycorrhizal filament characterized by formation of unique structures, arbuscules, and vesicles by fungi of phylum Glomeromycota
- arbuscule:** finely branched organ produced by endomycorrhizal fungi inside host cells; interface at which fungus and plant exchange phosphorus and photosynthates
- archegoniophore:** specialized archegonia-bearing branch
- archegonium** (pl. **archegonia**): multicellular egg-containing structure that later houses embryo; female gametangium; flask-shaped structure consisting of stalk, venter, and neck present in **Bryophyta** and all tracheophytes except flowers
- archesporium:** layer of cells which give rise to spores
- Arctic:** present in areas around North pole
- arctic-alpine:** distribution in
- arctomontane:** distribution in Arctic region and montane areas in lower latitudes; climatic type of Arctic and high elevations
- area:** region of distribution
- arenicolous:** growing on sand
- areola** (pl. **areolae**): small, angular or polygonal surface area differentiated on thallus and overlying chamber, forming pattern or network, as in *Conocephalum*
- areolate:** divided into chambers
- areolation:** cellular network of leaf or thallus
- argillicolous:** growing on clay soils
- arginine:** highest nitrogen to carbon ratio among 21 proteinogenic amino acids; amino acid with basic group, alkaline in solution; water soluble; major storage and transport form for organic nitrogen in plants
- arid:** having little or no rain
- arista:** awn; hair point, e.g. leaf tip of *Syntrichia caninervis*
- aristate:** ending in awn, e.g. *Syntrichia ruralis* leaves

arthrodontous: having lateral walls of peristome teeth eroded with uneven thickenings (*arthro* = jointed; *don* = tooth), e.g. peristome of *Orthotrichum cupulatum*

ascending: pointing obliquely upward, away from substrate

Ascomycota: phylum of fungi commonly known as sac fungi because spores are produced in sacs called asci

aseptic: free of disease-causing microorganisms

asexual: referring to reproduction without union of gametes, such as gemmae in *Marchantia*

asl: above sea level

aspartate: amino acid with higher molecular weight and protonated $-NH_3^+$

aspect: compass direction slope faces

astomous: without stomata (capsule); capsule that doesn't open

ATP: adenosine triphosphate; energy-storing compound

atratous: turning black

Aufwuchs: German word for small organisms living firmly attached to substratum, but not penetrating it; see also **periphyton**

auricle: earlike lobe, sometimes at base of moss leaf or liverwort underleaf; in *Blasia* houses Cyanobacterial partner

auroxanthin: diepoxy carotenoid pigment known in *Fontinalis*

austral: of Southern Hemisphere

author(s): name(s) of bryologist(s) (sometimes abbreviated) who contributed to taxonomic description and nomenclature of taxon

autoclave: oven-like equipment capable of high temperatures for heat sterilization

autogamy: within one gametophytic self-fertilization

autohydrolysis: hydrolysis (molecule of water ruptures one or more chemical bonds) of peptide or enzyme catalyzed by itself

autoicous: having male and female reproductive organs in separate clusters (different branches) on same plant

autolysis: release of enzymes when cells die, causing cells to break down quickly; common in many insects

autopolyploidy: all chromosomes derived from same species, frequently same individual; in bryophytes, having more than 1 set of homologous chromosomes in gametophyte

autotomy: self-amputation; behaviour whereby animal sheds or discards one or more of its own appendages, usually as self-defense mechanism to elude predator's grasp or to distract predator and thereby allow escape

autotropism: tendency of plant organs to grow in straight line when not influenced by external stimuli

auxin: plant growth-regulating hormone, usually referring to hormone indoleacetic acid (IAA); influences cellular elongation, among other things

avoidance strategy: adaptations that permit organism to alter factor so that it is no longer significantly damaging, such as minimizing hydrodynamic forces by adaptive life form

awn: hair-point, e.g. leaf tip of *Cirriphyllum piliferum*

axenic: pure (sterile) culture, without other organisms

axial strand: column formed of elongated cells and located in center of some stems or thalli; central strand in mosses

axil: angle formed where leaf joins stem

axillary: forming in axis between stem and leaf

axis: main stem

axopod: sticky pseudopod on some Protozoa

B

B horizon: dark soil layer of accumulated transported silicate, clay, minerals, iron, and organic matter, having blocky structure

Baas-Becking hypothesis: everything is everywhere, but, the environment selects; applied to small organisms and propagules such as spores

bacterivore: consumes primarily bacteria

Baermann funnel: apparatus for extracting turbellarians (as well as nematodes, copepods, and tardigrades) from bryophytes; cheese cloth, muslin, or tissue paper is placed in funnel to hold sample, usually supported by piece of screening; water is run through sample with rubber tubing clamped at end of funnel; sample sits overnight or longer, then water is released from funnel and collected; first few drops will have concentration of nematodes, which are heavier than water

Baker's law: loss of dispersal power and bias toward self-compatibility after immigration to islands

ballooning: phenomenon in which spider ascends to something taller, like fence, points its spinnerets upward, then secretes thread, then jumps or is blown with thread serving as anchor

bana: low Amazon caatinga

tall bana: type of low caatinga with trees over 10 m tall

low bana: type of low caatinga with maximum tree height typically less than 5 m

open bana: in central low caatinga where trees are even shorter and very widely spaced

bank: land along side body of water

bar: scientific unit of measurement of pressure; 1 bar \approx 1 atmosphere of pressure (0.986923 tam) \approx 14.503 psi = 750 mm Hg = 99.992 kPa

barbate: with tufts of long hairs, beard-like

bark: outermost layer of stems and roots of woody plants; surrounding wood of tree or shrub

basal cells: group of cells located at base, in proximal part of leaf

basal membrane: short cylinder at base of peristome (single peristome) or at base of endostome (double peristome) supporting segments and cilia

basic: alkaline, containing base, having pH higher than 7

Basidiomycota: phylum of fungi; fungi composed of hyphae and reproducing sexually by formation of specialized club-shaped end cells called basidia that normally bear external meiospores (usually four)

basionym: original name on which current taxon name is based

basipetal: referring to movement of substance from apex to base; tissue or organ developing or maturing from apex toward base [ant. **acropetal**]

basiphile: preferring basic habitats (limestone, sandstone, chalk, dolomite, etc.) [ant. **acidophile**]

Batesian mimicry: mimicry in which one organism resembles toxic or otherwise dangerous organism, but is not dangerous itself


beaded stream: pools connected by narrow channels

behavioral drift: occurring at particular time of day or night; may result from crowding, competition, need for food, predation, making new case, or attempting to reach land at emergence time

beneficial acclimation hypothesis (BAH): hypothesis that predicts animals will have their best performance at temperature to which they are acclimated

benthic: living on bottom of body of water

- Bergmann's rule:** within broadly distributed taxonomic clade, populations and species of larger size are found in colder environments, while populations and species of smaller size are found in warmer regions; usually applied to endotherms
- Berlese funnel:** apparatus using light and/or temperature gradient that separates mobile organisms such as **arthropods** and **annelids** from litter or bryophytes in funnel; organisms collected in preservative (usually alcohol) below funnel
- beta diversity:** ratio between regional and local species diversity
- bet hedger:** organism that uses combination of two or more strategies, thus never having optimal adaptations to extremes but being prepared to lesser degree for most circumstances; plant that seems to have both good sexual reproduction and means of vegetative reproduction, *e.g.* bryophyte that produces frequent capsules but also produces gemmae, as in *Tetraphis pellucida* and *Marchantia polymorpha*
- bicostate:** with two nerves
- bicuspidate:** with two points, *e.g.* leaves of *Cephalozia lunulifolia*
- Bidder's organ:** structure on male toads that can become ovary under right conditions
- bidentate:** with two teeth (different from double teeth)
- biennial:** cycle of two season's duration (generally less than two years)
- bifarious:** on two opposite rows, distichous
- biflagellate:** having two flagella; functions in cell motility
- bilobate:** divided into two lobes or segments, *e.g.* *Lophocolea bidentata*
- binding site:** site for attachment, usually referring to ions; can occur on cell walls, soil particles, glass containers, *etc.*
- binocular:** having two eyepieces
- binomial:** expression used to designate species; formed of two Latin terms: generic and specific term; by convention this binomial is written in italics because it is foreign word
- bioassay:** use of living organism for assessing effects of biologically active substances
- biocoenosis:** association of different organisms living together in habitat; biotic community (or biocenosis) along with its physical environment (or biotope)
- biomass:** quantitative estimate of total mass of organisms or parts being considered
- biotope:** ensemble of physical, chemical and climatic conditions of habitat; biotope plus biocenosis form ecosystem
- bipinnate:** twice pinnately branched, *e.g.* *Thuidium tamariscinum*
- bipolar:** said of species found in both polar regions
- biramous:** divided into two branches, *e.g.* pincers on end of crab claw or divided antenna
- bird cliffs:** steep cliffs with numerous small shelves that serve as nesting locations for bird colonies
- bisexual:** having both sexes on same individual; monoicous (gametophyte) or monoecious (sporophyte of tracheophytes)
- bistratose:** having two layers of overlapping cells, as in some moss leaves
- bivoltine:** producing two broods per season
- blade:** portion of leaf excluding stalk (*Plagiomnium*)
- bloom:** powder covering some capsules or leaves, *e.g.* leaves of *Saetania glaucescens*
- bog:** acidic, wet area in which nutrients are received by rainfall and groundwater flow is negligible; consists mostly of decaying moss and other plant material; characterized by low nutrients
- bog moss:** usually meaning *Sphagnum*
- bole:** main trunk of tree
- bonkei:** tray landscape, typically made with bryophytes
- bonsai:** dwarfed ornamental tree, often with mosses at base
- border:** land at edge of habitat; in bryophytes, edge; margin (cells of different shape, size, or color than other cells of structure), *e.g.* leaf of *Mnium thomsonii*
- boreal:** pertaining to north; life zone bounded on south by growth-season accumulated temperature above 6.1°C of 5538°C and mean daily temperature of 18°C for six hottest weeks (*L. boreas* = north)
- boreal forest:** predominantly conifer forest extending across northern North America and parts of Europe and Asia
- BOREAS:** climate model for boreal region
- botryoid:** like bunch of grapes, *e.g.* oil bodies of *Calypogeia suecica*
- boundary layer resistance:** boundary layer is that layer of fluid in immediate vicinity of bounding surface; boundary layer resistance is resistance to movement of CO₂, heat, and other substances through that thin layer
- brachyocyte:** short cell; seen on protonemata treated with ABA
- brachypterous:** short-winged
- bract:** modified leaf associated with gametangium or gemmae-cup
- bracteole:** modified underleaf associated with gametangium in liverworts
- branch:** lateral subdivision of stem or axis
- Braun-Blanquet method:** method uses cover-abundance scale to describe vegetation; these levels are divided into cover classes, typically using 5-7 categories:
- | | |
|---|--------|
| 1 | <1 |
| 2 | 1-5 |
| 3 | 5-10 |
| 4 | 10-25 |
| 5 | 25-50 |
| 6 | 50-75 |
| 7 | 75-100 |
- broadleaved tree, broad-leaved tree:** tree with expanded leaf blades, not needles or scales
- bromeliad:** member of **Bromeliaceae** (pineapple family); mostly epiphytes
- brood body:** generalized term for, propagulum, gemma, bulbil, tuber, reduced branch; asexual reproductive structure
- brook:** stream, rivulet, small river (precise meanings are often local)
- Brownian movement:** erratic random movement of microscopic particles in fluid, as result of continuous bombardment from molecules of surrounding medium
- brush:** undergrowth of small trees and shrubs; cut brushwood
- bryobiont:** animal that occurs exclusively associated with bryophytes, *e.g.* *Cyclidium sphagnetorum* (ciliate protozoan) on *Sphagnum*
- Bryobiotina:** subkingdom name to include **Marchantiophyta**, **Anthocerotophyta**, and **Bryophyta**; some people also include **Lycopodiophyta**
- bryokinin:** type of cytokinin growth hormone found in mosses
- bryophage:** organism that feeds on bryophytes
- bryophile:** animal or other organism usually or always associated with bryophytes
- bryophilous:** typically lives among bryophytes

- Bryophyta:** phylum of mosses (previously defined to include liverworts); have embryos and lack organized, lignified vascular tissue; have alternation of generations with dependent sporophyte
- bryophyte:** member of phylum **Bryophyta**; also used to refer collectively to mosses, liverworts, and hornworts
- bryophyte association:** group of bryophytes growing together in same ecological conditions
- bryophyte canopy:** structure of bryophyte colony that alters light reaching lower parts of colony
- Bryophytina:** old subdivision/subphylum name originally to include mosses, hornworts, and liverworts
- Bryopsida:** class of **Bryophyta** including majority of mosses, all except **Sphagnopsida**, **Takakiopsida**, **Andreaeopsida**, **Andreaobryopsida**, and **Polytrichopsida**
- bryoxene:** animal regularly spending part of its life cycle among bryophytes
- bryoxenous:** casual visitor to bryophytes
- buccal apparatus:** in invertebrates, articulating mouth parts
- bud:** structure produced by protonema that will give rise to stem or branch
- bufagin:** toxin in some toads that deters most predators
- buffer zone:** zone between two biogeographical or habitat entities
- bulbiform:** describes swollen cells found in some grass leaves, such as wheat, that provide mechanical means to roll up or move
- bulbil:** small, vegetative bud-like propagule; usually occur on one-celled, short stalks and have what appear to be partially developed leaves, *e.g.* axillary bulbils of *Pohlia andrewsii*
- bulliform:** describes enlarged parenchyma cells of grasses that permit leaves to spread or roll; expansion cell
- bunch grass:** clumped, non-rhizomatous or non-stoloniferous growth form of some grasses
- buritizal:** referring to periodically inundated palm thicket characterized by buriti – palm *Mauritia flexuosa*
- burn:** stream or small river; mostly British term
- burrow:** hole or tunnel dug by animal
- bush:** shrub
- bushy:** growing thickly and resembling bush
- buttress:** tree root that extends above ground as platelike outgrowth of trunk supporting tree
- 
- c.:** Latin abbreviation "*circa*" meaning "about;" also *ca.*
- C horizon:** soil layer of weathered parent (rock) material with little structure, comprised of mineral material in soil profile
- C₃ photosynthetic pathway:** photosynthetic pathway in which CO₂ is immediately put into photosynthesis, initially forming 3-carbon compound; pathway of all bryophytes
- C₄ pathway** in tracheophytes permits storage of carbon from CO₂ into 4-carbon compound such as malic or oxalic acid in mesophyll
- ca.:** Latin abbreviation for "*circa*" meaning "about;" also *c.*
- caatinga:** syn. = **campina**, **campinarana**, **chavascal**, and **charravascal**; shrub and thorn desert vegetation in interior northeastern Brazil
- cacimba** (pl. **cacimbas**): rock pool; pit in wet or marshy ground, collecting water present in soil that accumulates in it by condensation
- caducous:** deciduous; easily detached
- caesious:** bluish grey
- caespitose:** growing in cushions or tufts, *e.g.* growth habit of *Grimmia pulvinata*
- calcareous:** mostly or partly composed of calcium carbonate (lime)
- calcicole:** growing on limy substratum [ant. **calcifuge**]
- calcifuge:** growing on acidic (or base-poor) substratum; species avoiding Ca [ant. **calcicole**]
- calciphile:** growing on substrates rich in calcium
- calciphobic:** avoiding calcium
- calcium pectate:** calcium salt that helps keep cell walls sturdy and rigid
- callose:** complex, branched polysaccharide; in plants, regular component of developing septa in juvenile cells during cytokinesis; wound callose does not occur in cells that already have callose in newly formed septa
- calmodulin:** (CaM) receptor protein for Ca⁺⁺ located within cytoplasm of target cells; appears to mediate effects of this ion on cellular activities
- calyptra** (pl. **calyptrae**): in bryophytes, haploid envelope covering developing sporophyte; developed from archegonium; covering over moss capsule (Gr. *kalyptra* = covering)
- CAM pathway:** photosynthetic pathway of some xerophytic and aquatic plants wherein CO₂ is stored at night and used in light; CO₂ diffuses into leaf to be combined with PEP to form malate
- campo:** non-forested vegetation in Amazonian Brazil
- campos rupestres:** dry, rocky grassland
- canal (cells):** in neck of archegonium, central row of cells (sperm uses this channel to join egg)
- canaliculate:** channeled
- cancellate:** lattice-like
- cancellinae:** large, empty basal leaf cells, usually hyaline; may serve as water storage cells
- canescent:** whitish or hoary, *e.g.* *Racomitrium canescens*
- capillary water:** refers to water held loosely by soil particles and therefore readily available for uptake by roots or rhizoids
- capillitium** (pl. **capillitia**): in slime molds, mass of sterile fibers within fruiting body, interspersed with spores
- capitulum** (pl. **capitula**): terminal dense cluster of branches in *Sphagnum* in which stem has not yet elongated; head
- capsule:** sporangium of bryophyte; terminal spore-producing part of sporophyte
- carbohydrase:** enzyme that breaks down carbohydrates
- carbon sink:** in bryophytes, carbon accumulated in growing shoot tips and senescent brown tissues
- carbonic anhydrase:** enzyme that converts bicarbonates to CO₂ in both bryophytes and tracheophytes
- carboxyl** (-COOH): chemical group occurring at end of many biological molecules, causing that molecule or that end of molecule to act as acid; contributor of H⁺ in cation exchange
- carinate:** keeled, *e.g.* leaves of *Fontinalis antipyretica*
- carneous:** flesh-colored
- carnivorous:** eating animals
- carotenoid:** fat-soluble pigment group that includes xanthophyll and carotene; 8-isoprene unit terpene synthesized by most plants (*L. carota* = carrot)
- carpocephalum:** sporangial receptacle in most thallose liverworts; not widely used term
- carr:** waterlogged wooded terrain

- carrying capacity:** maximum quantity of standing crop that can be maintained indefinitely on area
- castaneous:** chestnut-colored
- cataplexy:** trance state; state of playing dead; freezing of activity
- catastrophic drift:** large-scale displacement of invertebrates that occurs during periods of increased river discharge
- catenulate:** chain-like
- cation:** positively charged ion
- cation exchange:** process of giving up certain positively charged ions in return for different ones; usually hydrogen is traded for nutrient or metal
- cation exchange capacity (CEC):** capacity of soils and plants to give up certain positively charged ions in return for different ones; usually hydrogen is traded for nutrient or metal
- caulescent:** with caulidium, stem [ant. **acaulescent**]
- caulidium:** stem
- cauline:** relative to leaf, inserted on stem
- caulis:** stem
- caulonema:** secondary portion of protonema that develops later and gives rise to buds and upright gametophores; has longer cells with slanting cross walls, usually brownish cell walls, and fewer, less evenly distributed, smaller spindle-shaped chloroplasts compared to chloronema (Gr. *caulo* = stem or stalk, *G. nema* = thread)
- caulonema-specific protein:** CSP; proteins involved in ability of caulonema to respond to cytokinin and produce buds
- cave:** large underground chamber, typically of natural origin, in hillside or cliff
- cavernicolous:** preferring caves and cavities
- cavernose:** with cavities
- cavitation:** formation of space; collapse of cells, especially those used for conduction; in bryophytes, water-filled hydroid cells **cavitate** like tracheophyte xylem cells, becoming **embolized** (blocked, in this case by ice) at -4°C
- CD:** conservation dependent (IUCN)
- CEC (cation exchange capacity):** ability of soils and plants to give up certain ion in return for different one; usually hydrogen is traded for nutrient or metal
- cell:** microscopic (usually) element of living tissue; in bryophytes, having nucleus (containing genetic material), cytoplasm, and organelles, surrounded by cell membrane and cell wall
- cellular:** relative to cell
- cellulose:** polysaccharide of glucose units that constitute main part of cell walls in plants
- central cells:** guide cells
- central cylinder:** visibly different cells in center of axis of some bryophytes; may facilitate water movement through stem
- central strand:** small group of elongate cells forming central axis in some stems and thalli of some bryophytes, usually thin-walled and often colored; also called axial strand
- cephalic:** referring to head
- cephalothorax:** head and thorax as one external unit
- cereus:** waxy, *e.g.* leaves of *Saellania glaucescens*
- cernuous:** drooping
- cerrado:** savanna
- cf.:** Latin abbreviation "*confer*" meaning "compare with"
- cfr. (c. fr.):** Latin abbreviation "*cum fructibus*" meaning "with sporophytes"
- chalk:** limestone
- chalk grasslands:** ecosystem associated with thin basic soil; mainly found on limestone and chalk valleys in Kent, Sussex, Surrey, Chilterns, and Isle of Wight in southeast England
- chamaephyte:** shrub or herb, buds near soil (Gr. *khamai* = on ground)
- channelled:** hollowed, keeled
- character:** criterion; descriptor
- charophytes:** algae in phylum Charophyta; highly advanced group of algae with chlorophylls *a* & *b*, starch storage, and antheridia and archegonia encased in multicellular covering
- chasmocolous:** growing in crevices or cracks
- chelator:** organic compound that binds metal by forming ring structure around it
- chersophilous:** growing on poor and dry habitats
- chionophilous:** growing in habitats with long cover of snow, snow beds
- chledophilous:** growing in disturbed habitats
- chlorenchyma:** parenchyma cells with chlorophyll, *e.g.* photosynthetic cells inside thallus of *Marchantia polymorpha*
- chlorocyst:** chlorophyllose cell (hyalocyst is non-chlorophyllose cell), *e.g.* photosynthetic leaf cells of *Sphagnum* and *Leucobryum*
- chloronema:** younger part of protonema, with perpendicular crosswalls, short cells, numerous chloroplasts, colorless cell walls, and irregular branching; primary photosynthetic part of protonema (Gr. *chloros* = grass green, *nema* = thread)
- chlorophyll:** green pigment present in some cells (role in photosynthesis)
- chlorophyll a:** chlorophyll found in all green plants, algae, and Cyanobacteria; primary photosynthetic pigment found in plants; absorbs light maximally at 430 and 662 nanometers
- chlorophyll b:** chlorophyll found in all green plants and some algae phyla, but not Cyanobacteria; bluish-green pigment that absorbs light maximally at 453 and 642 nanometers
- chlorophyll antenna system:** array of protein and chlorophyll molecules embedded in thylakoid membrane of plants and Cyanobacteria, which transfer light energy to one chlorophyll *a* molecule at reaction center of photosystem; includes xanthophylls and carotenes
- chlorophyll fluorescence:** light re-emitted by chlorophyll molecules during return from excited to non-excited states; one measure of stress in leaves
- chlorophyllose:** having chlorophyll, as in photosynthetic cells of *Sphagnum* leaf
- chlorophyllous:** chlorophyllose; containing chlorophyll
- chloroplast:** organelle (plastid) containing chlorophyll found within cells of plant leaves and stems; organelle where photosynthesis occurs
- chloroplast movement:** in bryophytes, adaptation to low light wherein chloroplasts move to position themselves perpendicular to light direction, *e.g.* in protonemata of *Schistostega pennata*
- chlorosis:** yellowing of plant tissue caused by loss of chlorophyll
- chlorotic:** yellow-looking (Gr. *chloros* = grass green, *osis* = condition)
- chorology:** study of geographical or spatial distribution of species
- chromatography:** type of analysis of chemical constituents

- chromosome:** dense mass of chromatin containing DNA and bearing genes needed for reproduction; visible during cell division (Gr. *chroma* = color, *soma* = body)
- chytridiomycosis:** infectious disease that affects amphibians worldwide, caused by chytrid fungus (*Batrachochytrium dendrobatidis*); bryophytes can harbor its zoospores
- ciliate:** with cilia, fringed, e.g. leaf of *Ptilidium pulcherrimum*
- cilium:** delicate, hair-like structure mostly one cell wide and unbranched
- cineraceous:** ash-colored
- circinate:** curved, very arched, almost in circle, e.g. leaves of *Sanionia uncinata*
- circumboreal:** widespread in higher latitudes of Northern Hemisphere
- circumpolar:** present in areas located between 75° and 90° north and south latitude.
- circumtropical:** present in tropical areas around world.
- cirrate, cirrose:** curled, wavy (appendages)
- cladautoicous:** having male sexual organs on special branch separate from female organs
- clade:** group of taxa having common ancestor
- cladistics:** science of comparison of taxa according to proportion of measurable characteristics they have in common, based on shared derived characteristics that can be traced to group's most recent common ancestor and are not present in more distant ancestors
- cladocarpous:** describes form of pleurocarpous moss in which sporophytes are borne terminally on short lateral branches
- cladoicous:** having archegonia and antheridia on different stems of same clone, i.e. with stems adjoined by stolons/rhizomes
- class:** next major classification level below phylum
- Class A cations:** includes K, Ca, Mg, and S with preference for oxygen-rich ligands, such as carboxylic groups
- Class B cations:** includes Ag, Cu, H, Hg, Pb, and Au which are toxic and prefer ligands rich in sulfur and nitrogen
- clavate:** club-shaped, like baseball bat
- clay:** heavy, sticky material from earth that hardens when dry or baked
- clear:** transparent
- clearing:** having no forest cover
- cleistocarpous:** indehiscent; describes capsule lacking regular mechanism for opening, opening by disruption of tissues of capsule wall
- cliff:** precipice, bluff, steep rock face
- cliff ledge:** narrow horizontal surface projecting from cliff
- climax community:** historic term for final stage of succession, remaining relatively unchanged until destroyed by event such as fire or human interference
- cline:** degree or nuance of variation
- cline:** suffix meaning "preferring to"
- clone:** aggregate of individuals produced asexually from single parental individual; created by fragmentation, specialized asexual reproductive units, or apomictic seeds (Gr. *klon* = twig or slip)
- cloud forest:** moist tropical or subtropical forest characterized by persistent low-level clouds; usually located at high elevations, under conditions of sufficient air humidity but poor soil; **cloud forest; dwarf forest; mossy forest**
- clutch size:** number of eggs deposited in single reproductive bout
- cm:** abbreviation of centimeter
- CO₂ compensation point:** point (concentration) at which CO₂ release during respiration balances CO₂ intake during photosynthesis
- CO₂-concentrating mechanism:** mechanism which augments photosynthetic productivity by increasing levels of inorganic carbon many times over environmental concentration of carbon dioxide; e.g. **pyrenoid** in some **Anthocerotophyta**
- coarse adjustment:** knob on microscope used for initially focussing to find specimen and do initial focussing; used at low magnifications; see **fine adjustment**
- coarse woody debris:** fallen dead trees and remains of large branches on ground in forests, rivers, or wetlands
- coastline:** boundary between land and ocean or lake
- coelocaul:** in some leafy liverworts, fleshy organ located at base of young sporophyte (type of perigynium)
- coenosis (pl. coenoses):** collection of life forms that are found together, interacting as community within ecosystem; **coenose**
- cold hard band:** that portion of absorbance that correlates with formation of chlorophyll-protein complex that protects against freezing damage
- cohort:** group of individuals with same starting point; group of organisms of same species begin life during same year, used most frequently when describing population dynamics of species
- colimiting:** of nutrients, insufficient supply of one nutrient can be offset by another; N and P can be colimiting
- collection number:** number assigned to specimen in field; collecting bags or packets are often pre-numbered to make record keeping in field simpler
- collenchymatous:** cell walls thickened at angles (named trigones in liverworts), e.g. leaf cells of *Mnium marginatum*
- colline:** small hill or mound
- colloid:** substance having particles (100-10,000 nm diameter) that remain dispersed in solution, intermediate between true solutions & suspensions; includes soil colloids
- collophore:** tube-like structure on ventral side of first abdominal segment of body of springtails
- colonist:** species that lives where habitat start is unpredictable and habitat lasts at least several years after disturbance; makes habitat suitable for perennial stayers
- colony:** population
- colous:** suffix meaning "growing"
- columella (pl. columellae):** central sterile portion in sporogenous region of capsule in mosses, hornworts, and some fungi
- comb moss:** moss with strong main shoot with many simple or branched lateral branches (e.g. **Hypnaceae, Meteoriaceae, Brachytheciaceae**)
- combispority:** spore size frequencies and mean spore size frequencies grouped around 3 or more mean sizes; may have aborted spores but also living spores in at least 2 sizes
- commensal:** type of relationship in which one organism benefits and other is neither benefitted nor harmed
- commissural:** said of some *Sphagnum* pores, located along margins of hyalocysts
- commissure:** in *Sphagnum* tissue, margin of hyalocysts, junction between hyalocysts and chlorocysts
- common:** relative to species - widespread
- common garden:** growing conditions where different populations are grown together under same conditions
- community:** group of actually or potentially interacting species living in same place; **biocoenosis**

community diversity: diversity of organisms sharing same community or habitat

compensation point: level at which photosynthesis = respiration

compensation point, CO₂: point (concentration) at which CO₂ release during respiration balances CO₂ fixation during photosynthesis

compensation point, light: irradiance level (PAR) at which CO₂ release during respiration balances CO₂ fixation during photosynthesis

compensation point, temperature: temperature level at which CO₂ release during respiration balances CO₂ fixation during photosynthesis

compensation point, water: moisture level at which CO₂ release during respiration balances CO₂ intake during photosynthesis

competition: tendency of neighboring plants to utilize same resource – quantum of light, ion of mineral nutrient, molecule of water, or volume of space; from Grime 1974

competitive exclusion principle: Gause's law; competition begins due to reaction when organisms are spaced in way that reaction of one affects response of other by **limiting** it when one or more resource is limiting

complanate: flattened into one plane, *e.g.* leafy branches of *Entodon*

complete metamorphosis: holometabolous; life cycle condition having egg, larva, pupa, and adult

complex thallus: multilayered thallus with differentiated internal structures

complementation: two traits that complement or help each other

compound eye: visual organ found in arthropods such as insects and crustaceans, may consist of thousands of ommatidia (tiny independent photoreception units that consist of cornea, lens, and photoreceptor cells that distinguish brightness and color, and especially motion)

compound microscope: microscope with multiple lenses – objective lens (typically 4x, 10x, 40x or 100x) is compounded (multiplied) by eyepiece lens (typically 10x)

compound pore: opening in thallus surrounded by multiple layers of cells

compressed: flattened, *e.g.* perianth of *Radula complanata*

compromise strategy: in bryophytes, requiring habitat formed by other living bryophytes

concave: not plane, curved inwards, *e.g.* leaf of *Nyholmella obtusifolia* [ant. **convex**]

concolorous: of same color

condensation zone: zone where water vapor in atmosphere condenses and becomes liquid

conducting strand: in bryophytes, leptoids and hydroids that provide conduit for sugars and water, respectively

conduplicate: folded lengthwise, *e.g.* leaf of *Fontinalis antipyretica*

confluent: merging together, *e.g.* leaves of *Schistostega pennata*

congeneric: said of two taxa belonging to same genus

conidiospore: asexual fungal spore

connate: said of two similar fused structures

connivent: converging but non-fusing, *e.g.* leaf lobes of *Cephalozia connivens*

conservation designations (IUCN)

CR: Critically Endangered
DD: Data Deficient
EN: Endangered
EX: Extinct
LC: Least Concern

NE: Not Evaluated
NT: Near Threatened
IUCN: International Union for Conservation of Nature
VU: Vulnerable

conspecific: said of taxa belonging to same species

constant drift: drift comprised of small numbers organisms that are always present as organisms move about and become dislodged from their substrates

constitutive desiccation tolerance: always present; fully desiccation tolerant

consumer: primary consumers eat producers and are herbivores like deer or squirrels; secondary consumers eat primary consumers and often are carnivores like wolves or cougars; bryophyte consumers include many insects, tardigrades, slugs, and even some large herbivores and birds

contiguous: relative to two adjacent non-merged parts

contorted: twisted

control: population or set of objects statistically similar to set being tested, but on which no changes are implemented

convergent evolution: process whereby organisms not closely related independently evolve similar traits as result of having to adapt to similar environments or ecological niches

convex: outward-curved surface, *e.g.* leaves of *Gymnomitrium convolutum*

convoluted: inrolled and forming sheath

coppice: area of woodland in which trees or shrubs are, or formerly were, periodically cut back to ground level to stimulate growth and provide firewood or timber, practice that encourages suckering

coprophilous: growing on feces or carrion

coprophily: loving dung and dead animal matter

corona: in rotifers, ring of cilia on head; creates circular movement used to direct food to mouth

corpse camouflaging: attachments of dead insects and other arthropods to body of *Recuvius personatus* (masked bug); **backpack camouflage**

cortex: stem tissue located between central strand and epidermis; in liverworts can refer to outer rind of differentiated stem cells

cortical: relating to cortex cells

corticulous: growing on tree bark

corticophilous: bark-loving

cosexual: having both sexes

cosmopolitan: present in almost all parts of world

costa (pl. costae): non-vascular midrib of moss leaf, always more than one cell thick; may facilitate water movement but lacks tracheids and vessels

costate: having costa (moss version of midrib)

cotransport: process of bringing oppositely charged ion along through membrane; two substances crossing cell membrane together through single channel complex

cover: in ecology, relative area covered by different plant species in small plot, usually expressed as percent; in stream, vertical view of area onto stream bed and does not account for vertical differences in mat thickness; if cover of each species is recorded independently, total cover might add up to more than 100%

coxa (pl. coxae): base of leg in insect

CPOM: coarse particulate organic matter

CR: critically endangered (IUCN)

crag: steep or rugged cliff or rock face

- creeping-shoot moss:** moss with rhizomatous main shoots that give rise to upright main shoots (*e.g. Leucodon, Antitrichia, Climaciaceae, Hypnodendraceae*)
- crenic:** referring to spring and brook water flowing immediately from it
- crenobiont:** occurring only in springs and spring brooks
- crenophile:** literally, spring-lover
- crenophilic:** describing organism preferring spring environments but may also occupy similar habitats
- crenophilous:** dwelling in or near spring
- crepuscular:** active in evening (twilight)
- crevasse:** deep open crack, especially in glacier
- crevice:** narrow opening or fissure
- crispate:** variously curled, twisted, or contorted, especially when dry
- crisped:** wavy, variously curled or twisted
- crista (pl. cristae):** inner projection or fold on inner membrane of mitochondrion
- crochet:** hook on **proleg** (fleshy short leg on abdomen) of **Lepidoptera** larvae
- cross fertilization:** transfer of sperm from antheridium of one plant to egg of different plant
- cross-section:** slice through object perpendicular to its long axis
- crosswall:** cell wall that goes perpendicular to long axis of plant organ
- crown shyness:** condition wherein branches make contact with each other, by wind or storm, and impact can cause tiny branches at tips to break
- crymocolous:** growing in tundra or polar regions
- cryobiosis:** special case of cryptobiosis that results when temperature decreases and water in cells freezes
- cryophile:** preferring cold habitats
- cryopreservation:** freezing living material at very low temperatures to be "brought back to life" later (*cryo* = involving or producing cold, especially extreme cold)
- cryoprotectant:** compound formed during slow cooling, protecting cellular structure from freezing injury without altering freezing temperature
- cryptsis:** ability of animal to avoid observation or detection by other animals; camouflage
- cryptic species:** literally, hidden species; populations that differ physiologically but not morphologically within species, restricting them to different growing conditions; characters are hidden and cannot be identified in field; species that look alike but can't interbreed
- cryptobiosis:** metabolic state of life entered by organism in response to adverse environmental conditions such as desiccation, freezing, or oxygen deficiency; all measurable metabolic processes stop, preventing reproduction, development, and repair; state of organism when no sign of life is visible; metabolic activity is immeasurable (*crypto* = hidden; *bios* = life)
- cryptobiotic:** describes metabolic state of life entered by organism in response to adverse environmental conditions such as desiccation, freezing, or oxygen deficiency; all measurable metabolic processes stop, preventing reproduction, development, and repair; **ametabiotic**
- cryptochrome:** class of flavoproteins sensitive to blue light, found in plants and animals and involved in circadian rhythms of both; light-sensitive yellow pigment capable of sensing photoperiod; flavoprotein that regulates elongation, germination, and photoperiodism in plants (*crypto* = hidden, *Gr. chroma* = color)
- cryptogam:** plant that has no true flowers or seeds, including mosses, liverworts, ferns, and related organisms, but also algae, fungi, slime molds, and bacteria
- cryptogamic crust:** tightly bound mesh of various Cyanobacteria, algae, lichens, bryophytes, and fungi on soil, especially in deserts and dry prairie; function to hold soil and prevent erosion
- cryptophyte:** plant with buds buried by soil (*crypto* = hidden)
- cryptopore:** capsule guard cells hidden by exothecial cells, sunken, *e.g.* in capsule of ***Orthotrichum alpestre*** [ant. **phaneropore**]
- cryptozoic fauna:** assemblage of small terrestrial animals found dwelling in darkness beneath stones, rotten logs, bark of trees, and in other similar situations, including among bryophytes
- CS:** transverse section; cross section
- C-S-R model:** triangular representation of competitors, stress tolerators, and ruderals; from Grime 1977
- cucullate:** hood-shaped, as in branch leaves of subgenera ***Sphagnum*** and ***Rigida***
- cushion:** life form with stems more or less erect, tightly clustered and somewhat radiating at edges, half-sphere shaped; persistent for many years; see Mägdefrau life forms
- cutaneous:** referring to outer cuticle of insect body
- cuticle:** extracellular fatty or waxy covering that forms from cutin on outermost layer of plant; in bryophytes, mostly fatty; generally thin or absent in bryophytes
- cuticular peg:** specialized thickening of cuticle, known from beak of calyptra in ***Funaria hygrometrica***
- cuticular ridge:** ring of cells around pore of some thallose liverworts, capable of repelling water
- Cyanobacteria:** photosynthetic group of bacteria; often form symbionts with plants, including some bryophytes; many species accomplish nitrogen fixation by converting atmospheric or dissolved nitrogen into ammonia
- cyanophycean:** referring to member of **Cyanobacteria**; many capable of nitrogen fixation
- Cyanophyta:** old name for **Cyanobacteria**
- cyclical parthenogenesis:** reproduction multiple times asexually
- cycloheximide:** naturally occurring fungicide produced by bacterium ***Streptomyces griseus***; inhibits accumulation of theandrose, resulting in marked decrease in freezing tolerance
- cyclomorphosis:** in invertebrates, annual cycle of morphological change
- cyclosis:** cytoplasmic streaming; circulation of cytoplasm or cell organelles
- cyst:** resting stage of organism, usually in tough, protective covering
- cytokinin:** plant hormone (growth regulator) that promotes growth by stimulating cell division
- cytoplasm:** all protoplasm of cell except nucleus
- cytoplasmic streaming:** syn. = **cyclosis**; movement of fluid substance (cytoplasm) within plant or animal cell
- cytorrhysis:** complete and irreversible collapse of plant cell wall due to loss of water through osmosis
- cytoskeleton:** complex, dynamic network of interlinking protein filaments present in cytoplasm of all cells and extending from cell nucleus to cell membrane, thus providing structure and shape to cell

D

- dark field microscopy:** used to illuminate unstained samples, causing them to appear brightly lit against dark background; objective lens sits in dark hollow of this cone and light travels around objective lens, but does not enter cone shaped-area; specimen will scatter light, whereas area with no specimen will transmit light with no scatter
- DBH:** referring to trees, diameter at breast height
- DD:** data deficient (IUCN)
- debris:** scattered pieces of waste, remains, or broken rock
- debris dam:** natural damming of river by some kind of mass wasting – landslide, debris flow (logs, leaves, even sometimes bryophytes), rock avalanche, or volcano
- deciduous:** condition in which plant sheds its leaves during certain season [syn. caducous, fugacious]
- decomposer:** includes wide array of organisms that typically contribute to decomposition of plant material, with invertebrates, especially arthropods, breaking up tissues into smaller fragments, and fungi and/or bacteria attacking cellulose and other parts.
- decorticated:** woody part lacking bark
- decumbent:** prostrate towards base but with ascending tips, *e.g.* habit of *Orthothecium rufescens*
- decurrent:** basal leaf margins extend down stem past leaf insertion as ridges or narrow wings
- dedifferentiation:** process involved in return of cell to its embryonic (undifferentiated) state; process of cells losing specificity
- deficiency:** lack of something, such as having insufficient iron or other nutrient
- defoliate:** having lost its leaves
- degree days:** unit of measure calculated as product of time (days) and temperature (°C), usually averaged over growing season or activity season for organism in question; number of degree-days that occur in one day is determined from average temperature for that day minus base temperature, which is minimum temperature above which activity occurs
- dehisce:** to split apart, as in liverwort capsule
- dehiscence:** splitting apart, particularly referring to opening of capsule of liverworts, hornworts, and some mosses, or loss of calyptra in mosses
- dehiscent:** capsule opening regularly by means of annulus and operculum or valves
- dehydrin:** group of proteins produced in response to cold and drought stress
- delayed fitness:** possessing trait that is not immediately expressed, *e.g.* recessive trait in heterozygous condition
- deliquescent:** liquefying in atmosphere; capable of absorbing atmospheric moisture and liquefying, as in *Sphagnum* pseudopodium
- dendroid:** tree-like; branched above and distinct trunk-like stalk; main stem with tuft of branches at top, *e.g.* *Climacium*, *Hypnodendron*, *Hypopterygium*, *Leucolepis*, *Pleuroziopsis*, *Symphogyna hymenophyllum*; see Mägdefrau life forms
- dendrophilous:** preferring tree habitats
- denitrification:** process by which nitrogenous compounds are degraded and nitrogen is returned to gaseous form
- dentate:** with teeth
- denticulate** with small teeth, *e.g.* leaf margins of *Platyhypnidium riparioides*
- denuded:** referring to stem without leaves
- deoperculate:** having lost its operculum
- depauperate fauna:** not well developed; lacking in numbers or variety of species
- depression slide:** microscope slide with shallow well for thick specimens or live ones that can be suspended from coverslip in drop of water
- desiccation:** process of drying out (*L. desiccare* = to dry up)
- desiccation hardening:** physiological preparation for desiccation
- desiccation resistance:** ability to maintain adequate water supply under drought conditions, *i.e.* **drought avoidance**
- desiccation tolerance (DT):** ability of desiccated organism or structure to tolerate and survive after equilibrating to relative humidity (RH) of ≤50%; ability of **plant** to survive periods during which **cells** are water-stressed and plant itself has become dry
- desiccation tolerant:** able to withstand periods of dry conditions
- det.:** Latin abbreviation for "*determinavit*" meaning "determined by"
- determinate growth:** growth of limited duration, characteristic of many acrocarpous mosses where production of splash cups or seta and capsule terminates growth of stem
- detoxification:** clearing of poisons (Gr. *toxicon* = poison)
- detritus:** organic matter produced by decomposition of organisms; waste or debris of any kind
- detritivorous:** heterotrophs that obtain nutrients by consuming decomposing plant and animal parts as well as feces
- deuter cell:** guide cell; large cell with thin walls and large lumina present across stem of many mosses, part of conducting cells of parenchyma, *e.g.* some stem cells in *Tortula atrovirens*
- deutonymph:** in mites, predatory stage following protonymph that feeds on other arthropods
- dewlap:** often brightly colored flap of skin under head that anoles (and others) flash to announce their aggressive defense of territory and attract females
- dextrorse (seta):** referring to seta that is twisted to right, clockwise when looking from seta apex (capsule base) to seta base (sporophyte insertion), *e.g.* seta of *Crossidium squamiferum* or *Antitrichia curtipendula* [ant. **sinistrorse**]
- diad:** grouping of two, as in two spores that remain stuck together
- diagnosis:** definition of characteristics of species
- diapause:** period of suspended development in insect, other invertebrate, or mammal embryo, especially during unfavorable environmental conditions; resting period
- diaphanous:** transparent
- diaphragm:** epiphragm; membrane of capsule stretched across peristome teeth and covering opening, *e.g.* membrane in *Polytrichum*
- diaspore:** agent of dispersal; any structure that becomes detached from parent plant and gives rise to new individual, *e.g.* spore, propagulum, gemma
- diaspore bank:** those buried propagules that have survived for long periods until such time as they once again return to position with sufficient light and moisture to grow
- diatom:** single-celled or filamentous alga with silica shell made of two overlapping portions called valves
- dichotomous:** branching into two parts; describes forked branching, as in veins of fern and *Ginkgo* leaves or thallus of *Marchantia* (Gr. *dicha* = in two, *temnein* = to cut)
- dichotomous key:** tool that uses pairs of choices for identifying things

- dicranoid:** describing haplolepidous peristome with 16 forked teeth, *e.g.* peristome of *Fissidens*, *Leucobryum*
- dictyosome:** Golgi apparatus; series of organelles consisting of stack of membrane-lined vesicles
- didymous:** divided in two, in pairs
- diel:** within 24-hour period
- differential interference:** achieved by shining two separate beams of light, providing much greater lateral separation than that used in phase contrast microscopy
- differential interference contrast microscopy (DIC microscopy):** Nomarski interference contrast (NIC) or Nomarski microscopy; used with unstained, transparent biological materials; lighting scheme produces image, similar to that of phase contrast microscopy, but without producing diffraction halo that detracts from latter
- digalactosyldiacyl glycerol (DGDG):** nonionic lipid constituent of thylakoid membrane of higher plants; can be produced in response to low temperatures
- digitate:** with finger-like lobes
- diel:** within 24 hours
- dimorphic:** occurrence of organism or its leaves in two forms
- dioecious:** having male and female reproductive structures on different plants; applied to sporophytes of tracheophytes
- dioicous:** having male and female reproductive structures on separate gametophyte individuals; corresponds to dioecious in sporophytes
- dipeptide:** compound consisting of two amino acid units joined together by single peptide bond, linking amino (-NH₂) group of one with carboxylic acid group (-COOH) of other
- diploid:** cell, individual or generation with two sets of chromosomes (2n); typical chromosome level of sporophyte generation
- diplolepidous:** describing arthrodontous peristome, double peristome with two distinct rings of teeth, *e.g.* peristome of *Orthotrichum striatum* [ant. haplolepidous]
- direct development:** lacking larval stage
- disarticulate:** separate (bones) at joints
- discoïd:** rounded and flattened, disc-shaped, *e.g.* gemmae of *Marchantia palacea*
- disjunct:** separated; of species, separated from its main geographic distribution
- dispersal:** spreading out; process of dissemination
- dispersion:** pattern of distribution of individuals within habitat
- disruptive coloration:** camouflage strategy that breaks up animal's boundaries and masks its shape, thus decreasing its detectability
- dissecting microscope:** microscope with low stage and long focal distance that permits one to dissect object while viewing through microscope
- distal:** located at top, in terminal position, in remote part from base [ant. proximal]
- distant:** having spaced leaf disposition
- distension:** occurrence when cell wall ruptures and germ tube is formed
- distichous:** having leaves arranged in two opposite rows on stem, *e.g.* leaf arrangement of *Distichium capillaceum*
- distinct:** different
- ditch:** narrow channel dug in ground
- disturbance:** partial or total destruction of plant biomass arising from herbivores, pathogens, human activity, wind damage, frost, desiccation, erosion, or fire.
- diterpene:** one of class of hydrocarbons produced by many plants; major component of resin and turpentine produced from resin
- diurnal:** daily; of or during day [ant. nocturnal]
- divaricate:** divergent (about 90° angle)
- divergent:** gradually spreading in opposite directions
- diversity:** measure of number of different entities and distribution of individuals in system
- diving bell:** mechanism in which animal traps air in bubble (or grabs air bubble) and holds bubble with hairs on its abdomen and legs; O₂ is removed from bubble as CO₂ is expelled into it and O₂ diffuses into bubble from water
- DM:** dry mass
- DMAAP:** dimethylallylamino-purine; hormone involved in development (morphogenesis)
- DNA (deoxyribonucleic acid):** molecule that carries genetic information
- doline:** sink or sinkhole; cylindrical, conical, bowl- or dish-shaped closed depression draining underground in karst areas
- dolomite:** sedimentary translucent mineral consisting of carbonate of calcium and magnesium
- domatium (pl. domatia):** modified part of plant for sheltering bacteria, insects, mites or fungi, such as *Nostoc* auricles of *Blasia*
- dominant:** ecological term referring to most abundant species, taxon more numerous than competitors in ecological community, or makes up more of biomass; life cycle strategy of species that become major species in ecosystem, like *Sphagnum*; typically have large spores and long life expectancy;
- dominant allele:** allele that is always expressed, even in presence of different sister allele
- dominant generation:** generation in which species spends most active time; in bryophytes, gametophyte is dominant
- dormant:** in state of reduced physiological activity
- dormant stage:** life cycle stage that is inactive
- dorsal:** side directed away from axis; in liverworts, upper side of thallus
- dorsiventral:** having top-bottom orientation
- drag reduction:** drop in pressure per unit length, enhanced by streamlining of plant or plant growth form
- drip tip:** elongated leaf tip that increases flow of water from leaf, thus making habitat less hospitable for colonization
- drought avoidance:** ability to maintain adequate water supply under drought conditions
- drought hardening:** process of increasing resistance drought in plants
- drought tolerance:** ability to survive and maintain activity despite lack of water in environment
- duff:** partly decayed organic matter on forest floor
- dull:** lacking luster [ant. shiny]
- dune:** ridge of sand created by wind, especially in deserts and beaches
- dust coat:** in *Reduvius personatus* (masked bug), first of two layers of camouflage, made from soil, often called natural camouflaging
- dwarf male:** nannandrous male; male plant considerably smaller than female and typically grows epiphytically on female
- DWT:** depth to water table



e-: prefix meaning "without"

E horizon: light-colored soil horizon with low organic content due to high degree of water transport

ecdysis: adults emerge

ecocity: ecologically healthy city, providing healthy abundance to its inhabitants without consuming more (renewable) resources than it produces, without producing more waste than it can assimilate, and without being toxic to itself or neighboring ecosystems

ecostate: ribless; lacking costa (midrib) in leaf, as in many mosses, *e.g.* leaf of *Hedwigia ciliata*

ecosystem: interacting community of organisms and their environment

ecotone: transition zone between two biological community types

ecotype: distinct form or race of plant or animal species occupying particular habitat

ectohydric: having water conduction predominantly on outside of plant

ectomycorrhiza (pl. **ectomycorrhizae**) form of symbiotic relationship that occurs between fungal symbiont and roots (or rhizoids) of various plant species

ectosporic: developing outside spore

ectothermic: referring to temperature controlled by external environment; describing animals that can modify their temperature by such activities as basking, changing cell shapes, and rearranging scales; bryophytes can survive at sub-zero air temperatures by their own ability to alter temperature through pigmentation

ectozoochory: dispersal on outside of animal

edaphic: character relative to soil, *e.g.* pH, humidity

edentate: without teeth

edge effect: ecological concept that describes presence of greater diversity of life in region where edges of two adjacent ecosystems overlap, such as land/water, or forest/grassland

e.g.: abbreviation for "*exempli gratia*," meaning "for example"

egestion: process of ridding body of undigested or waste material; defecation; not to be confused with elimination of nitrogenous waste such as that in urination

egg: non-motile female gamete that is larger than motile sperm

eicosapentaenoic acid (EPA): one of several omega-3 fatty acids found in cold-water fatty fish, such as salmon, and bryophytes, where its percentage increases in cold weather

elaiosome: oil body used to attract animal dispersal agent

elater: dead, elongate cells with coiled thickenings in liverworts; sensitive to humidity; unequal wall thickenings cause twisting during drying; help disperse spores

elaterophore: in liverworts, sterile tissue bearing elaters

elective foliicolous species: species that typically occur on leaves, but can occur on other substrates as well under right conditions

electron sink: location where electrons are kept inactive, such as binding electrons so they cannot do damage

elfin forest: uncommon ecosystem featuring miniature trees, inhabited by small species of fauna such as rodents and lizards; usually located at high elevations, under conditions of sufficient air humidity but poor soil; **cloud forest;** **dwarf forest;** **mossy forest**

elimbate: lacking border/margin

ELIP: Early Light-Inducible Proteins, coded by *ELIP* genes; includes over 100 stress-inducible proteins

elongation: lengthening

elytra: hardened forewings; wing covers

emarginate: notched at apex, *e.g.* leaf of *Marsupella emarginata*

embolism: in plants, blockage of conducting elements by air or ice

embryo (pl. **embryos**): multicellular developing organism in archegonium or seed; characteristic of plant kingdom

embryogenesis: formation of embryo

embryophyte: plant having zygote that divides to form embryo retained in archegonium or seed

emergent: projecting out of something, as aquatic plant out of water or capsule out of perichaetial leaves

emersion: process of exiting water

EN: endangered (IUCN)

encystment: in some invertebrates and protozoa, process by which organisms become dormant and form highly resistant stage of cyst, often preceding release of reproductive stage

endemic: growing in well-defined geographical area, generally small; distribution restricted to certain area

endodermis: layer of tissue one cell thick between vascular cylinder of root and cortex; serves as filter that forces substances to go through cells, hence through cell membranes, before going to xylem

endogenous: produced within organism; internal origin [ant. **exogenous**]

endogenous gemmae: produced inside cell initial

endohydric: having water conduction predominantly on inside of plant [ant. **ectohydric**]

endophytic: living within plant; *e.g.* some bacteria and fungi

endoplasmic reticulum (ER): complex system of membranous stacks involved in membrane production in cell; interconnected network of flattened, membrane-enclosed sacs or tubes known as cisternae; inner core of cytoplasm and membranes of ER are continuous with outer membrane of nuclear envelope

endopolyploid: condition in which cells have developed multiple sets of chromosomes

endosporic germination: early development of several mitotic divisions within spore wall

endosporic: early development of several mitotic divisions within spore wall

endostome: in arthrodontous mosses, inner peristome, *e.g.* inner peristome of capsule of *Sanionia uncinata*

endosymbiosis: internal partnership, such as that with fungi or bacteria

endothecium: inner part of embryonic capsule

endothermic: referring to temperature controlled internally by organism, as in humans

endozoochory: dispersal through digestive tract of animal

enervate: without nerve; lacking costa

entire: without teeth on margins, smooth, *e.g.* leaf margin of *Marsupella sphacelata*

entomochorous: requiring insect dispersal

entomochory: insect dispersal

entomophilous dispersal: dispersal by insects

ephemeral: short-lived, such as desert plants that germinate from seed and bloom within few weeks; plants having more than one generation per year

epidermis: layer of superficial cells; in bryophytes, outer layer of stem or thallus

epigealous: growing on or close to ground [ant. **hypogaeous**]

- epigeic:** active at soil surface
- epigonium:** protective envelope of embryo before separation into two parts (basal part – vaginula, upper part - calyptra)
- epilithic:** growing on rock [syn. saxicolous, petrocolous]
- epinasty:** leaf and stem curling
- epiphragm:** in bryophytes, circular membrane positioned horizontally over capsule mouth of some mosses, e.g. uniting capsule teeth of *Polytrichum* [syn. = diaphragm]; calcified slime over shell opening in snails for protection in hibernation or aestivation
- epiphyll:** plant that grows on leaf of another plant
- epiphyllous:** syn. = **foliicolous**; growing on leaves of other plants []
- epiphyte:** plant or alga that grows upon another plant without deriving nutrients from it
- epiphytic:** growing on another plant but not parasitic
- epitype:** specimen designated as model (holotype, lectotype, or neotype) in event of ambiguity of type
- epixylic:** living on logs with bare wood, i.e. on xylem
- epixylic stage:** in log decomposition, stage after bark is lost
- epixylon:** aquatic bryophytes and biofilms on large woody debris
- epizoite:** any animal that lives attached to another which it uses for protection or means of locomotion, with no parasitic relationship; hitch-hikers on animal
- equidistant:** at equal distance
- equilateral:** with equal sides
- erect:** almost vertical
- erect-spreading:** forming angle about 45° with stem
- erect-squarrose:** forming angle less than 45° with stem, e.g. erect-squarrose leaves of *Meesia triquetra*
- erose:** scraped, notched, corroded, gnawed
- eremophilous:** growing in deserts and steppes
- escape strategy:** mechanism to avoid being activity during unfavorable conditions, e.g. going dormant during dry periods, surviving as spores, gemmae, and probably in some cases protonemata
- establishment:** process by which plant or animal becomes established in new habitat; ecesis; demonstration of ecological fitness in new location
- et al.:** abbreviation for Latin for "*et alii*" or "*et aliae*" meaning "and others"
- ethylene:** C₂H₄; gaseous plant hormone (growth regulator) that modifies growth form, responds to wounding, and other physiological responses; responsible for suppression of growth in liverwort underleaves
- etiolation:** abnormal elongation of stems in response to insufficient light; characterized by long, weak stems, smaller leaves, longer internodes, and pale yellow color
- etum:** suffix indicating "association"
- eudominant:** dominant unique to its particular association; > 10%
- eufoliicolous:** true leaf-dwelling
- euhydrobiont:** living in water
- eukaryotic:** having nucleus
- euryoecious:** able to live in variety of conditions
- eutrophic:** relative to habitat rich with mineral nutrients and so supporting dense population [ant. **oligotrophic**]
- eutrophication:** process characterized by excessive plant and algal growth due to increased availability of one or more limiting growth factors needed for photosynthesis, such as sunlight, carbon dioxide, and nutrient fertilizers
- evacuate:** lacking vacuoles
- evanescent:** relative to rib which ends just before apex of leaf, fading, disappearing
- evaporative cooling:** process in which evaporation of water removes heat from system; can occur at plant, animal, or ecosystem level
- evapotranspiration:** loss of water through evaporation from among plants and from plants themselves (transpiration)
- evenness:** similarity of frequencies of different units (species) making up population or sample
- evergreen:** condition where plant remains green and retains its leaves for full year or longer; persistent; green year-round
- everything is everywhere:** Baas-Becking hypothesis that everything is everywhere, but, environment selects; applied to small organisms and propagules such as spores
- evolution:** series of genetic changes (changes that are heritable) that causes organisms to change through time (L. *evolutio* = unrolling)
- evolutionary drivers:** selection pressures
- EX:** extinct (IUCN)
- ex:** in case of validation after formation of name, e.g. *Straminergon stramineum* (Dicks. ex Brid.) Hedenäs
- ex-:** prefix meaning "sans," "non"
- excavate:** hollowed, concave
- exchange site:** location on plant cell wall or soil particle where ions are traded, such as replacement of hydrogen from -COOH by Ca⁺²; when charge of new ion is greater than that of one it replaces, it is shared by more than one exchange site
- exchanger:** organism capable of replacing one ion for another, usually replacing hydrogen with cation such as Ca⁺²
- excurrent:** relative to rib, beyond apex of leaf, e.g. leaf costa of *Fissidens taxifolius*
- exine:** outer layer of spore
- exogenous:** growing or originating from outside organism, e.g. fungus can be source of IAA for protonema
- exogenous:** generated by outside source; external origin
- exohydric:** having water transport essentially external by surface flow; including capillary flow between leaves or through surface papillae
- exoskeleton:** rigid external covering for body in some invertebrate animals, especially arthropods, providing both support and protection; e.g. in crayfish
- exosporic:** condition in which first mitotic division occurs outside spore after rupture of spore wall, typical of most bryophytes
- exostome:** outer peristome of arthrodontous capsule, e.g. outer peristome of *Orthotrichum striatum*
- exothecial:** relative to exothecium, outer capsule wall
- exothecium:** relative to capsule, outermost layer
- exotic:** foreign; introduced from foreign country (L. *exoticus* = foreign)
- explant:** portion of plant transplanted to artificial medium
- explerent:** life strategy for non-competitive species that fills spaces between others
- exposed feeder:** organism that feeds at exposed surface
- exserted:** relative to capsule that far exceeds perichaetial leaves, e.g. capsules of *Orthotrichum anomalum*
- exsiccatum** (pl. **exsiccata**): distributed and labelled reference specimen

- extant:** existing today [ant. **extinct**]
- extensin:** glycoprotein thought to be involved in cell wall extension
- extern:** relative to surface of leaf, dorsal face, abaxial face
- extirpation:** local extinction
- extinct:** no longer present on Earth [ant. **extant**]
- extinction rate:** rate of disappearance of species
- extracellular:** on outside of cell
- extremophile:** organism with optimal growth in environmental conditions considered extreme and challenging for carbon-based life form with water as solvent to survive
- extrorse:** turned outwards
- exuvia** (pl. **exuviae**): cast-off outer skin of tardigrade or arthropod after molt
- F**
- ♀: sign meaning female, in bryophytes bearing archegonia
- face:** side
- facies:** general appearance (habit of species), or appearance of plant community dominated by taxon or small number of taxa
- Factor H:** adenine derivative hormone stimulant for inhibiting caulonema growth and promoting formation of gametophore buds in bryophytes
- facultative:** not occurring regularly; occurring optionally in response to circumstances rather than by nature; for example, terrestrial but occasionally surviving in water
- facultative aquatic:** having some degree of tolerance to desiccation and xerophytic conditions
- facultative diapause:** resting period that can change based on conditions
- facultative epiphyte:** organism that lives on trees, but lives on other substrates as well
- falcate:** sickle-shaped
- falcate-secund:** sickle-shaped and turned towards only one side of stem
- falcation:** condition of being curved like sickle, *e.g.* leaves of many *Dicranum* species
- fallow land:** plowed and harrowed but left unsown for period
- false anisospory:** condition of having small, non-viable spores found among dimorphic spores in certain species of bryophytes due to factors such as spore abortion; non-genetic condition of more than one spore size
- false leaf trace:** in bryophytes, extension into cortex from leaf but not connected with central strand of stem; found in *Mniaceae* and *Splachnaceae*
- family:** subdivision of order – next major classification level; ending in "aceae"
- fan:** life form found on vertical substrate, usually where there is lots of rain; creeping, with branches in one plane and leaves usually flat; *e.g.* *Neckeraceae*, *Pterobryaceae*, *Thamnobryum*, some *Plagiochila*; see Mägdefrau life forms
- farinaceous:** farinose, covered with white bloom
- fascicle:** small tuft or cluster of fibers, leaves, branches, or flowers; in *Sphagnum*, clump of branches on stem
- fasciculate:** arranged in fascicles
- fastigiate:** with branches erect, nearly parallel and nearly same length
- fault:** break in rocks that make up Earth's crust, rocks on each side have moved past each other
- feces:** excrement; waste material discharged from gut
- fecundity:** number of offspring produced by organism during its lifetime
- fecundity-advantage model:** need of species needs to produce large number of eggs
- feldmark:** plant community characteristic of sites where plant growth is severely restricted by extremes of cold and exposure to wind, typical of alpine tundra and sub-Antarctic environments
- female:** organism that produces egg
- femur** (pl. **femora**): third segment of leg
- fen:** minerotrophic peatland or moss-dominated ecosystem that gets its nutrients primarily from ground water or surface water; **poor fens** have low nutrient content, **intermediate fens** are characterized by intermediate nutrient levels, and **rich fens** have highest nutrient levels among these habitats; this term has been variously defined in different countries with older North American literature including poor fens as bogs
- fenestrate:** pierced, perforated with openings like windows, *e.g.* peristome of *Grimmia crinitoleucophaea*
- ferredoxin:** iron-sulfur protein needed for conversion of nitrogen oxides to NH_4^+
- ferricrete:** hard, erosion-resistant layer of sedimentary rock, usually conglomerate or breccia, cemented together by iron oxides
- ferruginous, ferruginous:** rust colored
- fertile:** producing sex organs (antheridia, archegonia), bearing sporophytes [ant. **sterile**]
- fertilization:** fusion of gametes resulting in formation of zygote; act of adding nutrients by applying fertilizer to improve plant growth
- ferulic acid:** phenolic compound and major constituent of fruits and vegetables with strong antioxidant and anti-inflammatory properties; only released after severe hydrolysis; present in shoots but absent in young capsules of *Mnium hornum*
- fibrilla** (pl. **fibrillae**): thickened bands across hyaline cells of *Sphagnum*, strengthen cell walls; fibril
- fibrillose:** with fibrils, *e.g.* leaf hyaline cells of *Sphagnum*
- field:** area of open land, especially one planted with crops or pasture
- fine adjustment:** knob on microscope used for fine-tuning focus; used with high magnifications; see **coarse adjustment**
- fire place:** construction in which to build fire
- fistulated:** having passageway cut from rumen to outside
- flank:** in some thallose liverworts, zone between median groove and margin of thallus, *e.g.* thallus of *Riccia*
- flavonoids:** group of plant pigments that absorb UV light
- fleshy:** soft and thick
- floristic list:** list of species present on site
- flagellate:** possessing flagellum
- flagelliform:** whiplike, gradually tapering from base to tip of branch
- flagellum** (pl. **flagella**): slender, whip-like appendage that enables cells to move through liquids; differs from cilia in having only one or two per cell; found on most sperm; as propagule, slender branches with reduced leaves that occur in axils of upper leaves – basal portion multicellular, separating them from caducous branchlets
- flavonoid:** group of plant pigments that absorb UV light and include anthocyanins

- flotation:** separation technique requires that density of flotation liquid be greater than that of arthropods but less than that of debris or bryophytes
- fluorescence:** emission of light by substance that has absorbed light or other electromagnetic radiation of different wavelength; due to excited electrons returning to ground state; visible or invisible radiation emitted by certain substances as result of incident radiation of shorter wavelength such as X-rays or ultraviolet light
- flush:** area where water from underground flows out onto surface to create area of saturated ground, rather than well-defined channel; piece of boggy ground, especially where water frequently lies on surface; swampy place; pool of water in field
- F_m:** maximum fluorescence of dark adapted material; fluorescence resulting from flashing bright light on leaf in dark
- fo.:** abbreviation meaning "forma"
- fogging:** technique used for killing insects that involves using fine pesticide spray which is directed by blower
- fog-stripping:** condensing water vapor from frequent fog and mist; often primary means for bryophytes to obtain water in cloud forest
- follicolous:** growing on leaves [syn. epiphyllous]
- foliose:** leaf-like, leafy
- foot:** basal portion of most bryophyte sporophytes, embedded in gametophyte
- foot candle:** intensity of light from one candle on square foot of surface one foot from candle
- foot gland:** in some rotifers, gland on foot to secrete glue
- footpath:** narrow path suitable for walking
- foraging:** in bryophytes, use of horizontal growth that permits mosses or liverworts to take wider advantage of nutrients and light
- forb:** non-grass herbaceous flowering plant
- forest:** wooded habitat
- forest gap:** opening in forest canopy, often due to fallen tree
- forest track:** something resembling large wooded area, especially in density
- form:** lowest level of classification (below variety), often determined by environment
- founder principle:** small population becomes separated to new location, representing only small portion of variability of species; loss of genetic variation in new population established elsewhere by very small number of individuals from larger population; in bryophytes, includes arrival of only one sex to colonize particular location
- fount:** spring or fountain
- fountain:** natural spring of water
- fovea:** spore ornamentation, depression like golf-ball
- foveolate:** pitted
- FPOM:** fine particulate organic matter
- fragmentation:** breaking into fragments (pieces)
- frank water:** obvious pools of water, as opposed to water adhering to moss
- frass:** excrement of insect larvae; insect feces; fine powdery refuse or fragile perforated wood produced by activity of boring insects
- freeze avoidance:** survival strategy that prevents body fluids (especially arthropods) from freezing at temperatures well below 0°C
- freeze tolerance:** ability of plants to withstand subzero temperatures through formation of ice crystals in xylem and intercellular space, or apoplast, of their cells
- freezing longevity:** length of time bryophyte can remain frozen and survive
- fresh:** fresh state; in presence of sufficient moisture
- freshet:** flood of river from heavy rain or melted snow; rush of fresh water flowing into sea
- freshwater:** not salt water
- frieze:** as endive salad, *e.g.* thallus of *Anthoceros agrestis*
- fringe:** margin lined with cilia
- frondose:** habit that is densely branched, fern-like
- frost tolerance:** lowest temperature at which no more than defined percent (typically 50%) suffer irreversible damage in net photosynthetic activity relative to unfrozen plants
- fructification:** in slime molds, process of forming sporangia; analogy to vascular plants, synonymous term with sporophyte; used for bryophytes, but considered by some authors as unsuitable for bryophytes
- fruit** inappropriate term by some authors, meaning sporophyte
- fugacious:** fleeting
- fugitive:** life strategy of species that lives in unpredictable environment; generally stays only 1-2 years while habitat remains suitable at site and produce small spores that permit them to be dispersed easily
- fulvous:** reddish yellow
- functional grouping:** species having similar roles in ecosystem
- fungus (pl. fungi):** kingdom and common name for group of non-photosynthetic organisms; sometimes placed in kingdom **Mycota**; formerly classified as plants, but food reserves, cell wall components, and other biochemical differences have caused biologists to re-classify them into their own kingdom
- funiform:** like rope
- furcula:** forked appendage at end of abdomen in springtail, by which insect jumps
- furfuraceous:** covered with scales
- furrow:** groove, *e.g.* in thallus of *Riccia sorocarpa*
- furrowed:** sulcate, grooved
- fuscous:** dark brown and somber color
- fusiform:** elongated, spindle-shaped; tapering at both ends
- F_v:** variable fluorescence of dark-adapted material; difference between maximum and minimum fluorescence
- F_v/F_m:** in photosystem II, variable vs maximum fluorescence; measure of chlorophyll fluorescence; measurement ratio that represents maximum potential quantum efficiency of Photosystem II if all capable reaction centers are open; <80% is considered stress response

G

- GA:** gibberellic acid
- GA3:** gibberellin A₃; identical to gibberellic acid
- Gaia hypothesis:** hypothesis that ecosystem behaves like superorganism and species depend on other species for their biochemical needs during development
- galactose:** monosaccharide sugar about as sweet as glucose; C-4 epimer of glucose
- galacturonic acid:** organic acid that occurs in cell walls and has carboxyl group (-COOH) that provides cation exchange site; common in *Sphagnum* (peat moss), but less abundant in seed plants

- galeate:** helmet-shaped, *e.g.* lobe on ventral side of leaf of *Frullania tamarsci*
- gametangial induction:** process starting development of gametangia; biochemical changes accompany this process
- gametangial senescence:** loss of gametangial function with aging
- gametangiophore:** specialized branch bearing gametangia (archegoniophore or antheridiophore)
- gametangium** (pl. **gametangia**): gamete-producing structure; *e.g.* archegonia, antheridia
- gamete:** sexual reproductive structure that has one set of chromosomes and must unite with another of same species but opposite strain to continue life cycle
- gametoecium** (pl. **gametoeccia**): gametangia and surrounding bracts
- gametogenesis:** development of gametes
- gametophore:** upright gametophyte plant produced from protonema; gametangium-bearing stalk; shoot
- gametophyte:** haploid ($1n$) generation that reproduces by gametes in plants; in bryophytes, dominant generation; generation that begins with meiospore and ends when it produces gametes that join; contains no lignified vascular tissue
- gametophyte generation:** haploid ($1n$) generation that reproduces by gametes in plants; in bryophytes dominant generation
- gamma diversity:** species diversity among locations; total species diversity in landscape
- Gaussian principle:** two species that have identical ecological requirements cannot exist in same area at same time if any shared requirement (resource) is limiting
- gelatinose, gelatinous:** jelly consistency
- gemma** (pl. **gemmae**): asexual reproductive structure; uni- or multicellular, filamentous, globose, or discoid brood bodies, serving in vegetative reproduction; occurs in some liverworts, mosses, and club mosses
- gemmae cup:** cup-like structure producing gemmae; found in *Marchantia*
- gemmate:** bud-like
- gemmaiferous:** gemmiparous; bearing gemmae
- gemminate:** describing plants with short, bud-like branches
- gene flow:** introduction of genetic material (by interbreeding) from one population of species to another, changing composition of gene pool of receiving population
- genera:** plural of genus
- generalist:** organism lacking requirement for specific habitat; can eat variety of foods and thrive in range of habitats
- generation:** term applied to sporophyte ($2n$) and gametophyte ($1n$) phases of plant life cycle
- genet:** branching of gametophyte resulting from clonal growth of rhizome; free-living individual that develops from one original zygote, parthenogenetic gamete, or spore and that produces ramets vegetatively during growth
- genetic drift:** occurrence of random changes in gene frequencies, generally resulting in small, isolated populations and not due to mutation, migration, or selection
- geniculate:** bent like knee, *e.g.* bent seta of *Tetraphis geniculata*
- genus:** subdivision of family
- geothermal:** relating to or produced by internal heat of earth
- gibbosity:** bump, bulge
- genus** (pl. **genera**): taxonomic category for group of closely related species; category below family
- geoamphibiont:** organism that is predominantly terrestrial but able to live in water
- geophyte:** plant with short, seasonal lifestyle and some form of underground storage organ
- geothermal:** relating to or produced by internal heat of earth
- germination:** sprouting of seed or production of new growth stage from spore
- Gestalt:** total form (of plant)
- gibberellic acid:** carboxylic acid hormone; gibberellin A_3
- gibberellin:** carboxylic acid plant hormone (growth regulator) affecting stem elongation and seed germination; produced by plants and commonly secreted by fungi
- gibbous:** bulging on one side, *e.g.* capsule of *Diphyscium foliosum*
- gill cover:** flap covering gill; in fish and some aquatic arthropods; help to keep silt from accumulating among gills
- Gini coefficient:** expression of species dispersion; Gini coefficient of zero expresses perfect equality, where all values (species) are same; 100% indicates that all values (species) are different
- glabrescent:** almost hairless
- glabrous:** smooth, without ornamentations, without papillae or hairs
- glacier:** slow-moving mass of ice formed by accumulation and compaction of snow on mountains or near poles
- glacier mice:** formation of mosses subject to movement that causes growth on all sides to form ball; occur on glaciers; **solifluction floaters; errant cryptogams**
- glandular:** with one or more glands
- glass formation:** result from vitrification, in which water solidifies without reorienting into crystal
- glaucous:** almost glaucous
- glaucous:** whitish, grayish, or bluish overcast, hue or color, like plum
- gley:** sticky waterlogged soil lacking in oxygen, typically gray to blue in color
- globose:** spherical
- Glomeromycota:** one of eight currently recognized phyla within kingdom **Fungi**; reproduce asexually through blastic development of hyphal tip to produce spores (glomerospores); form arbuscular mycorrhizae with thalli of bryophytes and roots of vascular land plants;
- glossy:** shiny color
- gluconeogenesis:** formation of glucose from smaller molecules
- glucuronic acid:** in primary cell walls of bryophytes, greater concentrations than in any other land plants; subunit in some **xyloglucans**, group of hemicellulose cell wall compounds; important in cation exchange
- glutamate:** amino acid with higher molecular weight; occupies central position in amino acid metabolism in plants
- glutathione (GSH):** antioxidant important in protecting plants from environmental stresses like oxidative stress and pathogens
- glycerine jelly:** mixture of equal parts of glycerine and gelatin that used in histology for mounting specimens
- glycerol:** compound that is soluble in water and is hygroscopic
- glycine:** water-soluble amino acid; organic osmolyte that accumulates in variety of plant species in response to environmental stress
- glycoside:** plant ester containing sugar (glycol) and non-sugar (aglycone) component attached via oxygen or nitrogen bond

and whose hydrolysis yields one or more sugars and non-sugar substance

glyoxylate cycle: pathway in which acetate and fatty acids can be used as sole carbon source, bypassing CO₂-evolving step of Krebs's cycle (citric acid cycle)

glyoxysome: organelle in plant or microorganism cell, containing catalase, where acetate and fatty acids can be used as sole carbon source (glyoxylate cycle); cycle bypasses CO₂-evolving step of Krebs's cycle (citric acid cycle)

gonioautoicous: having male and female reproductive parts on same branch

gorge: narrow valley between hills or mountains, typically with steep rocky walls and stream running through it; canyon

GPS coordinates: unique identifier of precise geographic location on earth, usually expressed in alphanumeric characters

granulose: minutely roughened

granum (pl. **grana**): stack of thylakoids within chloroplast where light reactions of photosynthesis take place

grassland: type of ecosystem dominated by nearly continuous cover of grasses; see chalk grassland

gravestone: stone marker for grave; tombstone

gravitropism: bending (directional growth) of plant or plant part in response to gravitational pull (L. *grave* = heavy, *trope* = turning); formerly called geotropism

greenhouse: glasshouse; structure with glass roof providing conditions suitable for growing plants

gregarious: growing together but not densely, *e.g.* tufts, mats

gross primary productivity: total production resulting from photosynthetic fixation of carbon in chlorophyll-containing organisms; see **net primary productivity**

grove: small wood, orchard, or group of trees

growth: addition of biomass and length, but also producing buds, branches, rhizoids, and vegetative propagules

growth band: bands apparent due to changes in leaf density and size

growth form: structural architecture of individual plant as influenced by environment

growth optimum: condition (temperature, light, *etc.*) at which greatest growth occurs

guano: accumulated excrement of seabirds and bats; has high levels of nutrients like nitrate and ammonium

guards cell: specialized cell bordering stoma (in pairs) on capsule, *e.g.* on base of *Polytrichum* capsule

guide cell: large, conducting parenchyma cell with thin walls and large lumina present across stem of many mosses, *e.g.* stems of *Barbula bolleana*

guild: any group of species that exploit same resources, or that exploit different resources in related ways

guttulate: having cell lumen rounded like drops of oil

gymnostomous: referring to capsule without peristome, *e.g.* capsule of *Grimmia anodon*

gynoecium (pl. **gynoecia**): female inflorescence, female gametocium (archegonia, paraphyses, and surrounding bracts)

gypsum: soft white or gray mineral consisting of hydrated calcium sulfate

gyrate: circinate, spiral-like



habit: general appearance, aspect

habitat: physical aspect of place where organism naturally lives (as opposed to niche, which includes functional aspect as well)

hair point: awn or extension of tip of leaf into hair

halophilic: salt-loving

halophytic: salt-tolerant

halteres: thoracic projections that resemble lollipops, one on each side of thorax in Diptera

hammock: elevated tract of land rising above general level of marshy region

hanging branch: pendent branches, *e.g.* on stem of *Sphagnum*

hanging drop slide: slide with depression so that water and organism can hang from coverslip

haploid: cell, structure, or organism having single set of chromosomes; *1n*; *e.g.*, normal chromosome level of gametophyte generation

haplolepidous, haplolepeidous: having simple peristome with only one row of teeth, *e.g.* **Dicranales** [ant. **diplolepidous**]

hardening: process of increasing resistance to desiccation, cold, or other stress factor in plants

hard water: having high mineral content

haustorial foot: tissue imbedded deeply into central strand of gametophyte of moss; facilitates water transport

haustorium: in bryophytes, cells at base of sporophyte foot; functions in absorption of nutrients from gametophyte to sporophyte; in fungi, slender projection from fungal thread (hypha) of parasitic fungus that enables it to penetrate host

heath, heathland: area of open uncultivated land characterized by heather (*Calluna vulgaris*), heath (*Erica* species) and gorse (*Ulex* species)

heather moor: upland areas in temperate grasslands, savannas, and shrublands and montane grasslands and shrubland biomes, characterized by low-growing vegetation, including *Calluna vulgaris*, on acidic soils

heat shock protein (hsp): highly homologous chaperone protein that is induced in response to environmental, physical and chemical stresses, including heat, cold, UV light, and during wound healing or tissue remodeling, and that limit consequences of damage and facilitate cellular recovery

heavy metal: any metallic chemical element that has relatively high density and is toxic or poisonous at low concentrations; metals with density greater than 5 g cm⁻³

hedge: fence or boundary formed by closely growing bushes or shrubs

heliophilous: growing in full sunlight habitat [syn. **photophilous**]

helocrene: spring originating from marshes or bogs

helophyte: sun-loving plant

hemicellulose: long-chain polysaccharides; H-bonded to cellulose in plant cell walls; more soluble than cellulose

hemicryptophyte: plants that die back to ground in winter (*hemicrypto* = half hidden)

hemiepiphylous: those species that start their lives on branches, but subsequently grow from twig to leaf blade via petiole

hemimetabolous: in insects, incomplete metamorphosis; nymph, or immature insect, resembles adult in form and eating habits; describes life cycle with egg, nymph (or naiad), and adult

hemiparasite: plant which obtains or may obtain part of its food by parasitism, *e.g.* mistletoe, but which also photosynthesizes

hemolymph: fluid equivalent to blood in most invertebrates, occupying hemocoel

- hepatic:** plant belonging to phylum **Marchantiophyta**; liverwort
- Hepaticae:** old class name for liverworts when Bryophyta included mosses, liverworts, and hornworts
- Hepatophyta:** **Marchantiophyta**; alternate phylum name for liverworts that does not follow type-based system
- herbaceous:** refers to above ground plants or plant parts that are not woody and do not persist (*L. herbaceous* = grassy)
- herbarium:** collection of dried and usually pressed plant specimens (bryophytes and lichens are usually not pressed) (*L. herba* = grass)
- hermaphrodite:** organism having both sexes in same individual
- heterochrony:** developmental change in timing of events, leading to changes in size and shape; *e.g.* neoteny
- heterocyst:** relatively large, thick-walled nitrogen-fixing cell produced within filaments of certain **Cyanobacteria**
- heterogeneous:** composed of dissimilar parts, *e.g.* leaf cells of *Mnium marginatum* [ant. **homogeneous**]
- heterogeneous nucleation:** form of freeze avoidance; phase transformation between any two phases of gas, liquid, or solid, typically for example, condensation of gas/vapor, solidification from liquid, bubble formation from liquid, etc.
- heteroicous:** polyoicous; with several types of gametangia on same plant
- heterolepidous, heterolepideous:** simple or double (one or two pairs of teeth) peristome; form of arthrodotous peristome
- heteromallous:** pointing in all directions [ant. **homomallous**]
- heteromorphous:** dimorphic, having different shapes
- heterophyllous:** having different leaves (size, shape) on same axis, *e.g.* leaves of *Porella obtusata* [ant. **isophyllous**]
- heterophylly:** condition of having more than one leaf type on same plant
- heterosporous:** forming more than one kind of spore; having megaspores and microspores, as in *Selaginella*
- heterospory:** bearing two kinds of spores, generally large female and small male spores, genetically determined
- heterothallic:** having male and female reproductive structures on separate thalli
- heterozygous:** individual containing two different allelic forms of same gene
- hibernaculum** (pl. **hibernacula**): shelter occupied during winter by dormant animal such as insect, snake, bat, or marmot
- hillock:** mound, small hill
- Hill reaction:** light-driven splitting of water in Photosystem II of photosynthesis, releasing oxygen
- hip holes:** shallow, kidney-shaped depressions some kangaroos construct next to trunks of many trees and shrubs in arid and semi-arid Australia
- Holarctic:** species present in terrestrial areas north of Tropic of Cancer; Nearctic and Palaearctic regions combined
- hollow:** having hole or empty space inside, *e.g.* tree hole; depression between hummocks (mounds) in boggy area
- holometabolous:** in insects, describes life cycle having **egg/embryo, larva, pupa, and adult (imago)**
- holomorphy:** literally, whole form; entire aspect of organism as it appears in environment, resulting from its adaptations to its environment; *Gestalt*
- holotype:** single specimen used for typification of species
- homogeneous:** composed of similar parts, *e.g.* leaf cells of *Mnium stellare* [ant. **heterogeneous**]
- homoiochlorous:** maintaining constant chlorophyll concentration, as in *Syntrichia ruralis* during desiccation
- homoiohydric:** state of hydration controlled by internal mechanisms in plant
- homologous:** having alleles for same kinds of traits; chromosomes that are capable of pairing
- homologous recombination:** process in which cut pieces of DNA search for other homologous pieces and form exchange with them
- homology theory:** both generations are essentially same; developmental environment immediately surrounding tissue differs, causing differences in morphology
- homomallous:** pointing in same direction, *e.g.* leaves of *Kiaeria starkei* [ant. **heteromallous**]
- homoploid hybridization:** crossing of two taxa resulting in no change in chromosome number
- homosporous:** having only one kind of spore, *i.e.* spores for two sexes, if differentiated physiologically, do not appear different (Gr. *homo* + same, *spora* = seed)
- homozygous:** state of having two identical alleles of particular gene (*e.g.* AA, aa)
- homozygous diploid:** organism ($2n$) having both alleles for same trait
- honeydew:** sugar-rich sticky liquid, secreted by aphids and some scale insects as they feed on plant sap
- hormogonial filament:** gliding filament in **Cyanobacteria**
- hormogonium** (pl. **hormogonia**): short piece of cyanobacterial filament that becomes detached and glides away, becoming independent filament
- hormone:** organic compound active in very small amounts and normally produced in one part of plant and transported to another where its concentration exercises control in some phase of growth or development process (Gr. *hormaein* = to excite)
- hornwort:** common name for phylum of thallose plants (**Anthocerotophyta**) with photosynthetic, hornlike capsule
- host:** plant or animal that provides support for another organism; usually used for those supporting parasites or commensals, but also used for living substrate
- host leaf:** for epiphylls, leaf that is colonized by epiphylls
- Hoyer's solution:** gum chloral; mounting medium for microscope slides
- HPLC:** high-performance liquid chromatography
- humicole:** plant growing on humus (organic component of soil)
- humicolous:** growing in or on humus
- hummock:** small, rounded or cone-shaped, low hill or surface of other small, irregular shapes; raised hump as found in bogs and fens
- humus:** organic component of soil
- Hutchinsonian niche:** "n-dimensional hypervolume" where dimensions are environmental conditions and resources that define requirements of individual or species to practice "its" way of life, more particularly, for its population to persist; "hypervolume" defines multi-dimensional space of resources (*e.g.*, light, nutrients, structure, etc.) available to (and specifically used by) organisms, and "all species other than those under consideration are regarded as part of coordinate system."
- hyaline:** colorless or transparent; used with reference to dead cells, such as water-holding cells of *Sphagnum*
- hyalocyst:** large, empty water storage cell in leaves of *Sphagnum*, *Leucobryum*, and in many endohyalocysts; hyaline cell

hyaloderm, hyalodermis: outer stem composed of large, hyaline cells, *e.g.* stems of *Sphagnum subsecundum*, *Hamatocaulis vernicosus*

hybrid: offspring of two plants of different species or varieties

hydration: adsorption of water on or by hydrophilic (water-loving or water-attracting) surfaces (Gr. *hydro* = water)

hydration protein: protein present in normal hydrated state

hydric: wet, referring to habitat

hydroamphibiont: living in transition zone between water and land, depending on water level; compare to **euhydrobiont** and **geoamphibiont**

hydrochory: mode of dispersal by water

hydroid: water-conducting cell of bryophyte; tracheid-like conductive cell in central strand

hydrolysis: molecule of water ruptures one or more chemical bonds

hydrolyze: break down compound by chemical reaction with water

hydrom sheath: living parenchyma cells around central strand in **Polytrichaceae**

hydrome: collective term for hydroids in moss stem, often forming central strand

hydropeaking: frequent, rapid, short-term fluctuations in water flow and levels downstream and upstream of hydropower stations

hydrophilic: water-loving, typically attracting moisture, as is done by outer surface of peristome teeth

hydrophilous: growing on wet, submerged or aquatic habitats

hydrophobic: that which doesn't absorb water, resisting wetting

hydrophyte: plant, always immersed or partly submerged

hydroxyproline: crystalline amino acid obtained from hydrolysis of gelatin or collagen; abundant in major glycoprotein of plant primary cell wall; desuppresses development of underleaves in leafy liverworts

hygrocastic: describing peristome teeth that open in response to increasing moisture

hygrophile: growing in wet habitats, not in water

hygrophilous: water-loving

hygrophytic: of wet habitats, but not in water

hygroscopic: moving in response to moisture changes; absorbing water rapidly, as in moss leaves or elaters

hypersensitive response (HR): mechanism to prevent spread of infection by microbial pathogens, causing rapid death of cells in local region surrounding infection

hypertrichy: in animals, dense body hairs

hypnaceous: referring to complete peristome

hypocotyl: shoot of germinating seedling, located below cotyledons

hypodermis: one or more layers of differentiated cells beneath epidermis of stem; thin-walled in young stems, becoming thick-walled in older ones

hypogaeous: growing below surface of soil [ant. **epigaeous**]

hypolimnion: bottom layer of deep lake or ocean; temperature never goes below 4°C

hypophyllous: occurring on lower surface of leaf

hypophysis: enlarged neck between seta and urn of capsule; **apophysis**

hyporheic zone: saturated zone beneath bed of river or stream that can support invertebrate fauna

I

IAA (indole-3-acetic acid): C₁₀H₉NO₂; naturally occurring auxin that induces cell division and elongation and many developmental processes; synthesized from tryptophan; often works in consort with ethylene and other hormones

ice-nucleating protein: small structure that becomes surrounded by ice, but water does not crystallize; can help to create desiccating conditions and prevent cell damage

ice nucleation: formation of crystals around proteins and other nucleators

ice nucleator: small particles such as proteins that serve as centers for ice crystal formation; such crystals damage cell membranes

idioblast: specialized cell, ocellus, oil-cell

idiosomic: using materials produced by that organism, as using secretions to make test (ant. = **xenosomic**)

igapó: in Brazil, blackwater-flooded forests in Amazon biome; these and similar swamp forests are seasonally inundated with freshwater, typically occurring along lower reaches of rivers and around freshwater lakes

imbibition: uptake of water due to water adsorption by colloidal particles such as cellulose, cytoplasmic proteins, or pectin

imbibitional pressure: due to adsorption of water by colloidal particles, much as seeds do

imbricate: closely appressed and overlapping

immediate fitness: few haploid individuals possessing particular trait are able to exploit new situation

immersed: referring to moss or leafy liverwort capsule, capsule is exceeded by perichaetial leaves, *e.g.* sporophyte of *Hedwigia stellata*, or in thallose liverworts, included in thallus, *e.g.* sporophyte in *Riccia subbifurca*; referring to capsule stomata, beneath surface, cryptopore

immersion: process of entering water

immobile: unable to be translocated (moved) through plant or soil

inbreeding: fertilization by close relatives such as siblings or in bryophytes between ramets of same gametophyte

incident light: light from direct source (not reflected) that hits surface

included: enclosed

incrassate: thick-walled, *e.g.* cells of leaf of *Pterogonium gracile*

incubous: lying upon; oblique leaf insertion in which distal leaf margins are oriented toward dorsal stem surface; each new leaf starts under older one and emerges from it; think of liverwort growing **up** tiled roof – if leaves overlap wrong way then water would get in > insecure > incubous, but if leaves overlap right way water is shed > secure > succubous (from Paul Richards); arrangement of roof tiles from **top to bottom** is incubous, *e.g.* leaf arrangement of *Calypogeia fissa* and *Lepidozia reptans* [ant. **succubous**]

incurved: curved upwards and inwards

indehiscent: referring to capsule without distinct opening

indicator: that which indicates condition or presence of something else; chlorotic or unhealthy bryophytes can serve as indicators of air pollution

indicator species:

1. naturalness index exceeds 0.5
2. species quality is greater than 2.8
3. indicator species-area relationship is above trend line see chapter 7-4 of Volume 2

- indigenous:** born, growing, or produced naturally in country or region; native [ant. **adventive**, **introduced**]
- indoleacetic acid (IAA):** naturally occurring auxin that controls cell division and many developmental processes; often works in consort with ethylene and other hormones
- inducible desiccation tolerance:** produced when drying conditions occur; previously known as modified desiccation-tolerance
- inducible proteins:** proteins produced only when certain conditions are present
- inflexed:** bending slightly upward and inward, *e.g.* leaf lamina of *Pottiopsis caespitosa*
- inflorescence:** reproductive organ group; gametoecium
- inflorescence:** structure composed of gametangia and (perichaetial and/or perigonial) leaves; term sometimes considered inappropriate, some authors retain it
- infrageneric:** within genus
- infraspecific:** within species
- inhibitor:** substance that slows down or prevents particular chemical reaction or other process or which reduces activity of particular reactant, catalyst, or enzyme
- initial cell:** specialized cell that divides repeatedly and will produce leaves or other tissues
- innate:** inborn, natural
- innate dormancy:** condition of seeds or spores as they leave parent plant; viable state but prevented from germinating when exposed to warm, moist aerated conditions by some property of embryo, endosperm, maternal structures; usually require condition such as low temperature, dry period, leaching, or other stimulant of chemical change as in *Archidium alternifolium*. This dormancy is broken slowly and mechanisms for breaking it are unknown
- inner:** referring to leaf face (side); ventral face = upper face = adaxial face
- inner peristome:** endostome; inner row of teeth in capsule of mosses
- inner peristomial layer:** IPL; inner layer of peristomial cylinder that contributes to formation of arthrodontous peristome
- innovation:** new shoot; in acrocarpous mosses, new branch
- inoculative freezing:** process in which organisms actually freeze
- inoperculate:** lacking operculum or lid on capsule
- inrolled:** rolled inward
- insecticidal:** capable of killing insects
- inselberg:** rock formation distinguished as standing out abruptly from surrounding plains
- insertion:** line of attachment
- instar:** developmental stage between molts of insect
- intercellular:** between cells
- intermediate fen:** wet habitat with ground water as main water source, characterized by medium nutrient levels
- interwoven:** mixed
- intercalary:** situated at bases of leaves or branches but not apical
- intercellular:** between cells
- intermittent sites:** in streams and rivers, having flowing water in spring, but in dry period (typically summer) they are either dry or have water restricted to pools
- internode:** stem length between leaf or branch insertions
- interstitial space:** location of pore water in peatlands and mires; space between sedimentary particles; space within or between objects, may provide appropriate target for measurement because "living space" represents usable portion of structure available to organisms as potential refugia while simultaneously being product of spatial arrangement
- intine:** innermost of two major layers of spore, lying under exine bordering surface of cytoplasm
- intracellular:** within cell
- intragametophytic selfing:** crossing that occurs between antheridia and archegonia on same ramet (branch/gametophore), hence restricted to monoicous taxa
- intramarginal:** referring to cells near margin, internal position relative to outermost row, *e.g.* in leaf of *Mnium thomsonii*
- intricate:** tangled
- introrse:** turned inward or toward
- invagination:** action or process of being turned inside out or folded back on itself to form cavity or pouch; cavity or pouch so formed
- invertase:** enzyme in cell wall, used to facilitate conversion of sucrose to hexose
- involucral bract(s):** modified leaves surrounding perianth, *e.g.* perianth of *Solenostoma hyalinum*
- involucre:** protective sheath of tissue of thallus origin surrounding single antheridium, archegonium, or sporophyte, *e.g.* *Pellia*
- involute:** rolled inward, upward, toward adaxial face
- ion:** charged particle
- ion:** suffix indicating "alliance"
- IPL:** abbreviation meaning "inner peristomial layer"
- isocitratase:** enzyme of glyoxylate cycle
- isodiametric:** about as long as wide
- isolating mechanism:** factor (geographical, ecological, physiological, anatomical, or psychological barrier) that prevents interbreeding
- isomorphic:** same in form and size
- isophyllous:** stem leaves and branch leaves that are similar [ant. **anisophyllous**]
- isoprene:** unsaturated hydrocarbon produced by many plants and animals and its polymers are main component of natural rubber; mechanism of thermal tolerance in some bryophytes
- isoprenoid:** belong to class of organic compounds composed of two or more units of hydrocarbons, with each unit consisting of five carbon atoms in specific pattern; have wide range of roles in physiological processes of plants and animals
- isosporic:** all spores same size
- isospory:** condition of having spores with unimodal distribution or similar size
- isosporous:** having spores of similar size, but with some variation
- isotherm:** line connecting points of equal temperature
- isothermic:** equal temperature
- isotype:** duplicate specimen of type specimen (holotype)
- iteroparity:** characterized by multiple reproductive cycles over course of its lifetime (compare to **semelparity**)
- iteroparous:** having multiple reproductive events
- IUCN:** International Union for Conservation of Nature

J

- jalca:** in northern Peru, wetter grassland; area of Andes between 3,500 and 4,000 meters
- Johansson zones:** of trees, lower trunk, upper trunk, mid-crown, mid-outer crown, outer crown

julaceous: like catkin; referring to leaves that form cylinder, crowded and overlapping, close to stem; *e.g.* branches of *Pterigynandrum filiforme majus*

Jungermanniidae: subclass of mostly leafy liverworts in Jungermanniopsida

Jungermanniopsida: class including leafy liverworts and Metzgeriidae

K

K selection: characterized by slow growth rate, late reproduction, few, large offspring, and efficient use of resources; K strategist optimizes for high population density at environment's **carrying capacity**

K strategist: species that optimizes for high population density at environment's carrying capacity.

karst: landscape underlain by limestone that has been eroded by dissolution, producing characteristic landform

keel: sharp ridge, as on bow of boat; seen in some moss leaves such as *Fontinalis antipyretica*

kerosene phase separation: kerosene attaches to insect cuticle to facilitate flotation

keystone resource: resource that is critical to structure and function of ecosystem, without which system would cease to function as it does

keystone species: species on which other species in ecosystem largely depend, such that if it were removed, ecosystem would change drastically

kinetin: N₆-furfuryladenine; synthetic cytokinin that acts as growth hormone, promotes cell division, and prevents senescence in plants; degradation product of DNA

kingdom: grouping of all divisions or phyla; plants belong to kingdom **Phyta**, also known as **Plantae**

Km: substrate concentration at half-maximal enzymatic velocity

KOH: potassium hydroxide, commonly known as potash

Kreb's cycle: citric acid cycle; tricarboxylic acid cycle; cycle that provides electrons for electron transport system where ATP is produced from ADP and inorganic cycle, thus being important in providing cellular energy

L

lability: flexibility

labium: fused mouthpart which forms floor of mouth of insect

labyrinth: extensive wall ingrowths of transfer cells in foot of bryophyte sporophyte

lacerate: having torn margins, *e.g.* stem leaves of *Sphagnum fimbriatum*

lacinate: deeply divided into thin straps

lacuna (pl. **lacunae**): empty space, hole

lacunose: referring to spongy thallus with holes, *e.g.* thallus of *Sauteria alpina*

lagg: nutrient-enriched zone that grades to land

lagoon: small lake near larger one; shallow body of salt water close to sea but separated from it by narrow strip of land

LAI: **leaf area index**; percentage of ground area covered by leaves, hence **(total leaf area) / (area of ground)**

lake: large body of water surrounded by land

lamella (pl. **lamellae**): cellular membrane such as that of chloroplast or that separating cell walls from one another; in bryophytes, stack of cells forming flaplike plates (parallel photosynthetic ridges) of tissue on leaf or dorsal surface of thallus; in mushrooms, gills

lamina: cells of blade portion of leaf, exclusive of costa and border

late snowbed: snowbed that melts late in season

lawn: area of short, mown grass in yard, garden, or park; in bog, relatively flat area of peat mosses

LC: Least Concern (IUCN)

LEA proteins: late-embryogenesis-abundant proteins

leach: removal of ions through movement of water, as in leaching of nutrients from soil or of removal from cells by rainwater when membranes are damaged

leachate: solution formed when water percolates through permeable medium such as soil; may be derived from particles washed from canopy leaves

leaf: photosynthetic organ of plant; in bryophytes, phyllid; in tracheophytes, vascular structure with xylem on top and phloem on bottom – usually has palisade and spongy mesophyll

leaf angle: angle made by axil of leaf and axis

leaf area index (LAI): value that represents percentage of ground area covered by leaves, hence **(total leaf area) / (area of ground)** has been used to show structural responses of tracheophyte leaves to high vs low light conditions; value represents percentage of ground area covered by leaves, hence **(total leaf area) / (area of ground)**

leaf hair: threadlike projection on leaf

leaf trace: branch of vascular tissue or hydroids in stem, extending to leaf

lectotype: specimen designated as nomenclatural type among several original specimens of taxon

leg.: abbreviation for *legit* meaning "one who has collected it"

Leiosporocerotopsida: class of Anthocerotopsida having *Nostoc* in longitudinal canals

lens cells: epidermal cells that are rounded at surface and can focus light in leaf; in bryophytes, mammillose cells

lens tissue: special paper used to clean lens without damage or dust deposit

lentic: inhabiting or situated in still fresh water

lenticular: lens-shaped

leptoid: cell in outer layer of conducting cells of bryophyte, used primarily for assimilates; similar to sieve cell

leptokurtic: type of curve than looks like exponential curve, but with fat tail

leptome: (=leptom); phloem-like tissue consisting of leptoids and parenchymatous cells; collective term for leptoids in bryophytes

lethal: deadly; causing death (L. *lethalis*, from *lethum* = death)

leucocyst: in *Sphagnum*, large, empty, hyaline cell [syn. hyalocyst]

Levin's niche width: niche breadth estimated by measuring uniformity of distribution of individuals among resource states

LHCP: light-harvesting chlorophyll protein

liana: vine

lichen: symbiotic (mutualistic) organism composed of fungus and photosynthetic partner (algae or Cyanobacteria); classified as fungus

lid: operculum; top part of capsule of mosses that comes off for spore dispersal

Liebig law of the minimum: growth is dictated not by total resources available, but by scarcest resource (limiting factor)

- life cycle:** complete repeating sequence of reproductive events in life of plant necessary for continuation of species; series of stages needed for its complete development
- life cycle strategy:** timing of life events for best environmental conditions; life history strategy
- life form:** overall organization of growth form, branching pattern, and general assemblage of individuals or population, genetically determined; morphological characters; see Mägdefrau life forms
- life history:** life cycle
- life span:** time from birth or germination to death
- life strategy:** life cycle characteristics and timing
- ligand:** ion or molecule that binds to central metal atom to form complex
- light compensation point:** irradiance level (PAR) at which CO₂ release during respiration balances CO₂ intake during photosynthesis
- light-harvesting chlorophyll protein (LHCP):** protein association with chloroplast; may be unique structure in bryophytes
- light intensity:** unit of total energy or illumination, such as lux, foot candle, cal/cm²/min, μEinstein m⁻²s⁻¹
- light quenching:** process which decreases fluorescence intensity of substance, including excited state reactions, energy transfer, complex-formation, and collisional quenching; dissipation of light energy
- light-saturated:** having obtained that intensity of light, or greater, at which photosynthesis is maximum
- light saturation point:** highest intensity at which net photosynthesis increases
- lignicolous:** growing on lignin, on wood
- lignified:** reinforced with lignin
- lignin:** complex polymer of phenolic substances impregnating cellulose framework of certain plant cells; provides strength and rigidity to secondary plant cell walls; unknown in bryophytes
- ligulate:** strap-shaped
- limb:** upper part of leaf when leaf base is differentiated, *e.g.* leaf lamina of *Cyrtomnium hymenophylloides*
- limbium:** in *Fissidens*, differentiated margin, often multistratose, *e.g.* leaf margin of *Fissidens crassipes*
- limestone:** hard, sedimentary rock, composed mainly of calcium carbonate
- limicolous:** growing in mud
- limiting factor:** that aspect in environment that would increase plant productivity if more of it were added
- limits of tolerance:** highest concentration, intensity, or amount organism can tolerate without sustaining cell damage
- limnocene:** of or pertaining to lakes and fresh water associated with springs
- limnophilous:** growing standing water, fresh water, marshes, ponds
- limnophyte:** plant of marshy conditions or shallow water
- limnoterrestrial:** referring to organisms living in interstitial collections of water droplets, including among moist areas of bryophyte clumps, including some copepods, gastrotrichs, rotifers, and tardigrades
- lingulate:** large, tongue-shaped, as in stem leaves of subgenus *Sphagnum*
- lithophytic:** growing on stony or rocky ground
- liverwort:** common name of **Marchantiophyta** (=Hepatophyta); group of bryophytes with dorsiventrally oriented leafy or thalloid plant bodies
- loam:** rich, friable soil containing mostly sand (particle size > 63 μm), silt (particle size > 2 μm), and smaller amount of clay (particle size < 2 μm) in proportion of 40%-40%-20%, respectively
- lobate:** divided; having lobes
- lobe:** division of leaf, thallus, or organ, *e.g.* thallus of *Marsupella sphacelata*
- lobule:** small lobe; *e.g.* smaller segment of unequally divided leaf in leafy liverworts, typically forming small pouch, *e.g.* on leaf of *Frullania*
- local abundance:** relative representation of species in particular ecosystem, usually measured as number of individuals found per sample
- locality:** geographic position, location
- loess:** sediment formed by accumulation of wind-blown silt, typically in 20-50 μm size range, with twenty percent or less clay and balance equal parts sand and silt loosely cemented by calcium carbonate; unstratified usually buff to yellowish brown loamy deposit found in North America, Europe, and Asia
- log:** fallen tree trunk/bole
- logistic curve:** curve that approaches asymptote or limit
- logistic population model:** mathematical model of population growth: $dN_1/dt = r_1N_1[1 - (N_1 + \alpha_{1,2}N_2)/K_1]$ and $dN_2/dt = r_2N_2[1 - (N_2 + \alpha_{2,1}N_1)/K_2]$, where K_1 and K_2 are carrying capacities of respective N population sizes of species 1 and 2; r_1 and r_2 are respective intrinsic growth rates; $\alpha_{1,2}$ is competition coefficient of effect of species 2 on species 1 and $\alpha_{2,1}$ is competition coefficient of effect of species 1 on species 2
- longevity:** length of life span; long lifetime of species; life expectancy
- lorica:** rigid case or shell on some protozoa and rotifers
- lotic:** referring to running water
- loupe:** hand lens; term typically used in Europe
- love dart:** calcium carbonate, chiton, or cartilage "dart" injected by one snail into another during mating
- LSA:** Leaf Specific Area; whole-plant leaf surface area
- LSW:** Leaf Specific Weight
- LT₅₀:** temperature at which 50% of cells die
- lucifugous:** avoiding light, growing in dark caves
- lumen:** central cavity of vesicles, ducts, chambers, cells, etc.
- lunularic acid:** plant hormone similar to abscisic acid; found in liverworts, causing growth inhibition, drought hardening, and dormancy; lunularic acid decarboxylase converts lunularic acid into **lunularin**
- lunularin:** simple decarboxylation product of lunularic acid; normal constituent of at least some liverworts
- lurid:** having brown color tinged with red, as in flame seen through smoke
- lustrous:** shiny
- lutant:** sealant, such as clear fingernail polish, on two sides of coverslip parallel with length of slides
- lutein:** orange-red carotenoid pigment with absorption at 470-500 nm (blue light); known to reduce risk of macular degeneration and prevent damage from glare and bright light in humans
- luteus:** saffron yellow
- luticolous:** growing in mud or muddy places

luting: sealing edges of coverslip with something like nail polish
lux: lumens per sq meter; intensity of light from one candle on surface 1 square meter and 1 meter from source
luxury nutrient: excess nutrient stored for use later
lyophilization: freeze-drying
lysogeny: breaking; method of leaf or branch fragmentation; partial cell disintegration facilitates fragmentation

M

♂: symbol meaning "male"

macro-: prefix meaning "large"

macrocyt: in slime molds, encysted, resting plasmodium

macronema: large, branched rhizoid produced around branch primordia and base of buds [ant. **micronema**]

macronutrient: nutrient needed in relatively large quantities; (C, H, O, P, K, N, S, Mg, Ca, and sometimes Fe)

macrophyte: usually referring to aquatic plant that is visible without microscope, thus including bryophytes

macrophytic: referring to plants that are visible without microscope

macroplastron: thick plastron air layer with silvery sheen; air diminishes from macroplastron to normal, smaller plastron, and air exchange with water is generally adequate to maintain duller-looking air bubble

macropterous: large-winged

madicolous: having thin sheets of water flowing over rock surfaces

MADS-box genes: encode transcription factors in all eukaryotic organisms studied; involved in controlling development

Maillard reaction: chemical reaction between amino acids and reducing sugars that gives browned food its distinctive flavor

Malaise trap: large, tent-like structure used for trapping flying insects, especially **Hymenoptera** and **Diptera**; insects are directed to top of slanted pyramid where they encounter vial of preservative

male: organism that produces sperm

mammilla (pl. **mammillae**): strongly bulging cell surface, *e.g.* leaf cells of *Cheilothela chloropus*; also used to mean nipple-shaped protuberance that is hollow and cell lumen or protoplast extends into it

mammillose: having strongly bulging cell surface

mandible: crushing organ in arthropod mouthparts

mannose: hexose monosaccharide (6-carbon sugar) with structure very similar to glucose

manure: organic matter, mostly derived from animal feces

marcescent: withering without falling off

Marchantiophyta: = Hepatophyta, formerly Class Hepaticae; phylum of plants lacking lignified vascular tissue and having-dorsiventral organization, name based on type system

Marchantiopsida: class of thallose liverworts that is dichotomously forked and many cells thick

marginal: edge of structure or area (often differentiated cells), *e.g.* leaf margin

marginal: located in margin

marl: calcium carbonate or lime-rich mud or mudstone which contains variable amounts of clays and silt; common in rich fens

marsh: area of low-lying land that is flooded in wet seasons; wetland that is dominated by herbaceous rather than woody plant species; can often be found at edges of lakes and streams, where they form transition between aquatic and terrestrial ecosystems

marshland: land consisting of marshes; common usage – region, area, or district characterized by marshes, swamps, bogs, *etc.*

masquerade: trait of those organisms that cause misidentification by other organisms

marsupium: in some leafy liverworts, fleshy pouch that encloses sporophyte, *e.g.* ventral pouch on *Targionia*

mastax: modified pharynx in rotifer; used to crush food

mat: densely woven, horizontal life form; plagiotropic and persistent for number of years; see Mägdefrau life forms

mate guarding: behavioral adaptation in some arthropods in which male carries female beneath him

matrotrophy: innovation of sporophyte that is dependent upon gametophyte, at least for its early development, typical for early embryophytes

maturation: process of development and reaching reproductive stage

meadow: field habitat vegetated by grass and other non-woody plants

mechanical stage: slide clip on microscope stage with numbers in both directions so that you note coordinates, move slide, then return to chosen position

median: middle, central; in statistics, denoting value or quantity lying at midpoint of frequency distribution

Mediterranean: areas around Mediterranean Sea

Mägdefrau Life Forms

Annuals – pioneers; no vegetative shoots remain to carry on second year; *Buxbaumia*, *Diphyscium*, *Ephemerum*, *Phascum*, *Riccia*

Short turfs – open mineral soils and rocks; regenerative shoots; form spreading turfs for only few years; *Barbula*, *Ceratodon*, *Didymodon*, *Marsupella*

Tall Turfs – forest floors in temperate zones; can conduct water internally; very tall; persist by regenerative shoots; **Bartramiaceae**, **Dicranaceae**, **Polytrichaceae**, *Drepanocladus*, *Herbertus*, *Sphagnum*, *Tomentypnum*

Cushions – rocks, bark, Arctic, Antarctic, alpine; usually high light; grow upward and sideways; hemispherical; persistent for many years; *Andreaea*, *Grimmia*, *Leucobryum*, *Orthotrichum*, *Plagiopus*, no liverworts

Mats – rocks, bark, [on leaves (epiphyllous) in tropics]; plagiotropic and persistent for number of years; **Lejeuneaceae**, most **Marchantiaceae**, *Homalothecium*, *Lophocolea*, *Plagiothecium*, *Radula*

Wefts – forest floor of temperate zone; hold considerable capillary water; grow loosely and easy to remove from substrate; new layer grows each year; **Brachytheciaceae**, **Hylacomiaceae**, *Bazzania*, *Ptilidium*, *Thuidium*, *Trichocolea*

Pendants – epiphytes, especially in tropical cloud forests; long main stem with short side branches; **Meteoriaceae**, **Phyllogoniaceae**, some tropical *Frullania* (also spelled pendent, but in English usage, this is adjective form)

Tails – on trees and rocks, shade-loving; radially leafed, creeping, shoots stand away from substrate; *Cyathophorum*, *Leucodon*, *Spiridens*, some tropical *Plagiochila*

Fans – on vertical substrate, usually where there is lots of rain; creeping, with branches in one plane and leaves usually flat; **Neckeraceae**, **Pterobryaceae**, *Thamnobryum*, some *Plagiochila*

Dendroids – on ground, usually moist; main stem with tuft of branches at top; *Climacium*, *Hypnodendron*, *Hypopterygium*, *Leucolepis*, *Pleuroziopsis*, *Symphogyna hymenophyllum*

Streamer – long, floating stems in streams and lakes; *Fontinalis* (Glime 1968)

- medulla:** central part of stem or seta
- megagamete:** female gamete; in bryophytes egg
- megasporocyte:** cell that will undergo meiosis to produce megaspores
- meiofauna:** tiny organisms that live on bed of stream, river, or lake and are barely visible to human eye; those that pass through 0.500 mm sieve and retained on 0.045 mm sieve
- meiosis:** nuclear division that separates sets of chromosomes; reduction division; reduces $2n$ condition to $1n$ condition; nuclear process in which each of four daughter cells has half as many chromosomes as parent cell; in plants it produces meiospores or meiospore nuclei, in animals it produces gametes (Gr. *meioun* = to make smaller)
- meiospore:** $1n$ spore resulting from meiosis (Gr. *meioun* = to make smaller, *spora* = seed)
- meltwater:** water derived from snow or ice melt
- membranaceous:** transparent and thin
- membrane:** thin layer of proteins and lipids surrounding cells and most cellular organelles; controls passage of substances into and out of cell or organelle (L. *membrana* = skin covering separate members of body)
- meristem:** collection of cells capable of active cell division, thereby adding to plant body; embryonic cells; growth region (Gr. *meristos* = divisible)
- meristem tissue:** collection of cells capable of active cell division, thereby adding to plant body; embryonic or undifferentiated cells
- mesic:** describing habitat having moderate moisture or water supply
- mesophilous:** preferring mid-moisture habitats
- mesophyte:** plant growing in moderately humid habitats
- mesophytic:** living in continually moist habitats; water and habitat requirements between hygrophytic and xerophytic
- mesotrophic:** moderately rich in dissolved nutrients, often near to neutrality, neither basic nor acid
- messicole:** growing in harvested fields; annual or hardy plants often present in crops
- metabolism:** sum total of all chemical activities of living organism (synthesis and breakdown)
- metacommunity:** set of interacting communities linked or potentially linked by dispersal of multiple, potentially interacting species
- metapopulation:** group of partially isolated local populations of same species, but connected by migration
- methane (CH₄):** gas found in small quantities in Earth's atmosphere; simplest hydrocarbon, consisting of one carbon atom and four hydrogen atoms; powerful greenhouse gas
- methanotrophic:** able to gain carbon from methane; known in some bacteria
- methionine:** amino acid that is relatively insoluble in water and has non-polar R group; sulfur-containing amino acid
- Metzgeriidae:** subclass of mostly thallose liverworts in Jungermanniopsida
- mica-schist:** medium-grade metamorphic rock with medium to large, flat, sheet-like grains in preferred orientation (nearby grains are roughly parallel), called mica schists when they include biotite or muscovite
- Michaelis-Menten kinetics:** equation describing rate of enzymatic reactions, by relating reaction rate v (rate of formation of product [P]) to [S], concentration of substrate S
- $$v = d[P] / dt = V_{\max} [S] / (K_M + [S])$$
- V_{\max} = maximum rate achieved by system, happening at saturating substrate concentration
- K_M = constant numerically equal to substrate concentration at which reaction rate is half of V_{\max}
- t = time
- micro-:** prefix meaning extremely small
- microbial loop:** energy/carbon pathway wherein dissolved organic carbon re-enters food web through incorporation into bacteria
- microcyst:** in slime molds, stage that occurs when amoeboid cells or swarm cells round up and form thin wall, then become dormant, surviving unfavorable conditions
- microfauna:** microscopic animals; small, often microscopic animals, especially those inhabiting soil, organ, or other localized habitat, including single-celled protozoans, small nematodes, small unsegmented worms, and tardigrades
- microforceps:** forceps with fine tip, used for handling tiny specimens, pulling leaves off bryophytes, etc.
- microgamete:** male gamete; sperm in bryophytes; antherozoids
- microgametophyte:** male gametophyte
- microgravity:** very weak gravity
- micron:** (μm) micrometer; unit of length, one-thousandth of millimeter
- micronema:** small, fine, sparsely branched rhizoid produced on stem between leaves, e.g. stem rhizoids of *Rhizomnium pseudopunctatum* and *Plagiomnium ellipticum* [ant. **macronema**]
- micronutrient:** essential nutrient needed by plants in relatively small amounts (Fe, Mn, Cu, Zn, Mo, Ni, Cl, B); **trace elements**
- microphyllous:** having leaves smaller than normal leaves
- microselection:** small selection pressures, like forced change in diet; for some, reproducing asexually and eventually diverging from their ancestors, creating cryptic species
- microspecies:** populations within species that differ physiologically but not morphologically, permitting them to occupy different growing conditions; has genotype that is perpetuated by **apomixis** (production of sporophyte without fertilization), trait exhibited by number of bryophyte species
- microstomous:** referring to capsule with small, narrow mouth
- microtubule:** essential protein filament of cell structural skeleton
- mitic:** referring to females that produce their eggs by meiosis, as in some rotifers
- midrib:** single costa of leaf or rib of thallus
- mimic:** evolved resemblance between organism and another, including any of visual, acoustic, chemical, tactile, or electric, or combinations of these sensory modalities; receiver (such as predator) perceives similarity between mimic (organism that has resemblance) and model (organism it resembles) and as result changes its behaviour in way that provides selective advantage to mimic; in Batesian mimicry, mimic shares signals similar to model, but does not have attribute that makes it unprofitable to do so (harmless mimic poses as harmful); in Muellierian mimicry, two or more harmful species mutually advertise themselves as harmful
- mineral:** inorganic substance occurring naturally in earth and having consistent and distinctive set of physical properties
- minerotrophic:** powered by groundwater and runoff waters often richer in minerals than rain water, e.g. nutrient-rich fens
- minipacket:** small packet from pocket notebook paper, used for small specimens to prevent their loss in bag or large packet
- minute:** very small

- mire:** swampy or boggy ground
- mitochondrion** (pl. **mitochondria**): cell organelle used during respiration; site in cell that generates most of ATP
- mitosis:** nuclear division where two daughter cells are produced from one parent cell with no change in number of chromosomes
- mixohydric:** using both internal and external methods in water conduction
- µm:** abbreviation of "micrometer" or "micron," unit of length, one-thousandth of millimeter (0.001 mm)
- moist:** hydrated
- molluscicidal:** killing molluscs such as snails, slugs, or clams; produced by floating liverwort *Ricciocarpos natans*
- monad:** grouping of one, as in single spore
- monitor:** to watch or check on; instrument (including plant) used to check on conditions
- monocular:** having one eyepiece
- monoculture:** cultivation of single crop in given area
- monoecious:** bisexual; having both male and female reproductive structures on same plant; applied to sporophytes of tracheophytes
- monogalactosyldiacyl glycerol (MGDG):** nonionic lipid constituent of thylakoid membrane of higher plants; can be produced in response to low temperatures
- monogynous:** has only one queen in mound, as seen in some ants
- monoicous:** bisexual; with antheridia and archegonia on same plant (including autoicous, synoicous, paroicous) [ant. **dioicous**]
- monomorphic:** having single form
- monomorphism:** both genders look same; literally, one form
- monophyletic:** referring to group of organisms that includes most recent common ancestor of all organisms and descendants of that common ancestor; having common ancestor (Gr. *mono* = one; Gr. *phyl* = tribe)
- monopodial:** growth pattern with single continuous axis, e.g. growth pattern of *Eucladium verticillatum* or *Climacium* [ant. **sympodial**]
- montane:** pertaining to, growing in, or inhabiting mountainous regions; of or designating cool, moist ecological zone usually located near timberline and usually dominated by evergreen trees
- moor:** habitat with poor soil covered mainly with grass and heather; common in high latitudes and altitudes; heath
- moraine:** mass of rocks and sediment carried and deposited by glacier
- moribund:** at point of death
- morphogenesis:** development
- morphological:** referring to characteristics of structure (Gr. *morphe* = form, *logos* = discourse)
- morphology:** discourse of form and structure (Gr. *morphe* = form, *logos* = discourse, doctrine); form or appearance of plant
- morphose:** manner of morphological transformation which is not due to heredity
- morphospecies:** taxonomic species based wholly on morphological differences from related species, i.e. not based on genetic markers; species forms
- mortar:** workable binder, usually concrete, used to bind building blocks such as stones, bricks, and concrete masonry units together, fill and seal gaps between them, and sometimes add decorative colors or patterns in masonry walls; roughened bowl, used with pestle, to grind material
- moss ball:** formation of mosses around pebble or other small object subject to movement that causes growth on all sides to form ball; common on lake shores, glaciers, and windy slopes; **vagrant plants; erratic; solifluction floaters; errant cryptogams**
- mossy forest:** uncommon ecosystem featuring miniature trees, inhabited by small species of fauna such as rodents and lizards; usually located at high elevations, under conditions of sufficient air humidity but poor soil; **cloud forest; dwarf forest; elfin forest**
- motile:** in plants, capable of moving by means of flagellum
- mountain:** natural elevation of Earth's surface, rising more or less abruptly to summit, and attaining altitude greater than that of hill, usually greater than 610 meters
- mountant:** any substance (usually water for non-permanent slides) in which specimen is suspended between slide and cover glass for microscopic examination
- MPa:** unit of measure equal to 10⁶ Newtons per m² or 1 N per mm² or 10 bars
- mRNA:** messenger RNA, used during protein synthesis
- mucilage:** polymer of galactan which yields hexose sugar galactose on hydrolysis; any thick, sticky substance secreted by cell; often produced by liverworts in special cells
- mucous:** containing slime
- micro:** short point, clearly marked
- mucronate:** ending in mucro, e.g. leaf of *Barbula unguiculata*
- mud:** soft, sticky matter resulting from mixing of earth and water, causing water to lose its clarity
- mudflat:** stretch of muddy land left uncovered at low tide
- multicellular:** having plant body composed of more than one cell wherein cells do not act as independent organisms
- multicellular reproductive structure:** characteristic of reproductive structures of plant kingdom
- multicostate:** with several nerves, e.g. costae in leaf of *Antitrichia curtipendula*
- multifid:** divided several times, e.g. thallus of *Riccardia multifida*
- multipapillose:** with several papillae per cell, e.g. leaf cells of *Syntrichia calcicola*
- multi-ranked:** having leaves coming from more than two sides of stem
- multistratose:** having multiple layers of cells
- muricate:** with rough surface caused by many small asperities (like bumps on tongue)
- Musci:** old class name for mosses when Bryophyta included mosses, liverworts, and hornworts
- muscolous:** growing best among mosses
- muticous:** without awn, hair-point or mucro
- mutualism:** interaction between organisms in which both partners benefit, such as alga and fungus of lichen (*L. mutuus* = reciprocal)
- mutualistic:** benefitting each other
- mycelium:** fungal threads
- mycetophagous:** eating fungi
- mycobiont:** fungal partner
- mycophagous:** describes organisms that consume fungi
- mycorrhiza** (pl. **mycorrhizae**): fungal association with root (or anchoring structure); characteristic of *Lycopodium* gametophyte and most pine roots (Gr. *mykes* = fungi, *riza* = root)

myxamoeba (pl. **myxamoebae**): in some slime mold life cycles, stage when slime mold spore germinates, forming amoeba-like cell

N

n: number of chromosomes in set ($1n$ = haploid; $2n$ = diploid)

NADH: nicotinamide adenine dinucleotide + H, active coenzyme form of vitamin B₃

nadir: lowest point reached

nadir temperature: lowest temperature of cycle

naked: without ornamentations, without hairs, or without perichaetial leaves

nannandrous: having dwarf males, *i.e.* tiny male plants

nanoparticle: particle of matter that is between 1 and 100 nanometers in diameter

natural area: area where species is considered to be native

naturalized: introduced species which naturally reproduces in its new territory

naturalness index: descriptive index with scale of 1-10, with 0 being totally artificial

nauplius: first larval stage of many crustaceans, having unsegmented body and usually single eye

NE: Not Evaluated (IUCN)

neck canal: entry canal through neck to egg in base of archegonium

neck canal cell: cell of archegonium neck that will disintegrate and liquefy when archegonium is mature

necrosis: cell death

negative gravitropism: tropism resulting in bending of plant away from gravitational center

negative phototropism: tropism resulting in bending of plant away from light, typical of roots and rhizoids

nematodontous: having peristome consisting essentially of whole dead cells, usually with thickened walls, non-jointed

nematogon: initial cell that will produce rhizoid

nematogonous: filamentous

nemoral: living in open woodland

neotenous: retaining juvenile characteristics in adults

neoteny: condition in which juvenile characters retained in adults

Neotropics: syn. = New World Tropics; geographic regions including Central America, Antilles, large part of northern part of South America and Galapagos Islands, including areas of Mexico, Central America, West Indies, Chocó, Northern Andes, Central Andes, Amazonia, Guyana Highland, Planalto, and Southeastern Brazil

neotype: specimen designated as type of taxon in absence of any original material

neoxanthin: hydrophilous carotenoid pigment

net primary productivity: production of carbon that is actually converted into biomass, *i.e.*, fixed carbon that remains once one subtracts that lost to respiration

neutrocline: non-strict neutrophile, having wider tolerance around neutrality of soils or living environment; prone to acid-base neutrality of biotope but occur in slightly acidic or basic environments

Newbury Instability Index: indicator of sensitivity of substrate particle to tractive force τ by dividing τ by median substrate size

niche: in ecology, all of interactions of species with other members of its community, including competition, predation, parasitism, and mutualism; role of species in its ecosystem

fundamental niche: full range of environmental conditions that viable population of species could occupy and use, without any other limiting factors present which could constrain population

realized niche: part of fundamental niche that organism actually occupies as result of limiting factors present in its habitat

niche overlap: measure of degree to which two organismic units use same resources or other environmental variables;

niche width: syn. = **niche breadth**; variety of resources population exploits; theoretical range of conditions that species could inhabit and successfully survive and reproduce with no competition; species able to use only limited resource conditions has narrow niche;

nitidous: bright shiny appearance

nitrite reductase: enzyme that facilitates addition of hydrogen and loss of oxygen from NO₂⁻ during photosynthetic electron transport process

nitrocline: depth in water column where nitrate concentration differences are > 0.5 $\mu\text{g L}^{-1}$ depth⁻¹

nitrogen fixation: conversion of gaseous nitrogen (N₂) to ammonia and its incorporation into organic nitrogenous compound in cell; carried out by some bacteria and **Cyanobacteria**

nitrogen reductase: enzyme that catalyzes addition of H⁺ to N to form NH₄⁺

nitrophilous: preferring substrates rich in nitrogen compounds

niveal: subject to actions of snow and ice

nivicolous: associated with snow

nocturnal: occurring or active at night

node: location of leaf or branch junction with stem

nodular: having small masses of solid tissue

nodule: small swelling or aggregation of cells in organism, in plants, may contain bacterium *Bradyrhizobium* and is site of nitrogen fixation

nomenclature: codified set of terms used for denomination of species

Plant Nomenclatural Classification Endings

Kingdom:	-ae
Phylum/Division:	-phyta
Class:	-opsida
Order:	-ales
Family:	-aceae
Genus	various
Species	various

non-sessile: unattached

non-tracheophyte: plant lacking tracheids, *e.g.* bryophytes

non-translocatable: adjective to describe nutrients or other substances that do not usually move from original site of storage in plant

NT: Near Threatened (IUCN)

nuclear condition: number of sets of chromosomes, usually haploid ($1n$) or diploid ($2n$)

nucleolus (pl. **nucleoli**): apparent body on nucleus where extensive RNA formation is occurring

nucleus (pl. **nuclei**): cell organelle bounded by two membranes and containing DNA; occurs in most living eukaryotic cells (*L. nucleus* = kernel of nut)

nunatak: mountain top or rocky outcrop escaping regional glaciation, typically vegetated by algae, mosses, and lichens

nurse protonemata: protonemata that enhance growth of other protonemata

nutatation: spiral or circular growth pattern

nutrient: element or compound useful to plant when in proper quantities (see **macronutrient**, **micronutrient**)

nutrient deficiency: condition in which some nutrient is not available in sufficient quantity for plant to function properly

nutrient sink: natural or artificial reservoir that accumulates and stores nutrient; these may include continually transporting nutrients to new tissues, storing them in older tissues, or binding them in incalcitrant compounds; typical sinks include rhizomes, tubers, roots, and plant biomass

nymph: immature form of insect that does not change greatly as it grows



O horizon: organic soil layer including litter layer (**O1**), fermentation layer (**Of**), and humified layer (**Oh**)

objective: in microscope, series of lenses that produce magnified image of specimen and project it up into focal plane of ocular

obligate aquatic: having little or no tolerance to drought conditions

obligately foliicolous species: those unable to grow elsewhere

oblique: in protonemata; end wall is oriented on slant compared to axis of filament

occasional: with respect to bryophyte fauna, animal that may at times be found associated with bryophytes but does not depend on them for survival

oceanic: parts of West of temperate Europe; often used to refer to climate influenced by ocean

ocellus (pl. **ocelli**): in liverworts, differentiated cell, large size, which includes one or more large oil bodies, *e.g.* in leaf cells of *Frullania tamarisci*

ocular: eyepiece, as on microscope

ocular micrometer: measuring instrument that is inserted into eyepiece of microscope

oil body: membrane-bound, terpene-containing organelle unique to liverworts; isoprenoid essential oils with distinctive odors, *e.g.* in leaf cells of *Radula complanata* and *Leiocolea turbinata*

oil cell: in thallose liverworts, idioblastic cell with single large oil body, *e.g.* some thallus cells of *Ricciocarpos natans*

oil immersion: microscope setup in which drop of oil is placed on slide at point of interest and objective lens is immersed in drop; helps focus light at 900X and higher magnifications

old-growth: of tree or forested area, never felled, harvested, or cleared; mature; primary forest, virgin forest, primeval forest, late seral forest, or forest primeval

olfactory: odor-sensing

oligomineral: having few dissolved minerals

oligotrophic: referring to soil, mineral-poor, poor in nutrients, so having little fertility

ombrogenous: referring to bog, dependent on rain for its formation

ombrophilous: referring to plant tolerant of wet conditions, *i.e.* much rain

ombrotrophic: receiving nutrients primarily from rainfall, *e.g.* low-nutrient bogs and poor fens

ommatidia: tiny independent photoreception units in arthropods that consist of cornea, lens, and photoreceptor cells that distinguish brightness and color, and especially motion

omnivorous: eats both plants and animals

oogonium (pl. **oogonia**): egg-producing cell, one-celled

ootheca (pl. **oothecae**): egg case

open-field: relating to system of agriculture widely practiced in medieval Europe and based upon dividing arable land into unenclosed strips usually subject to 3-year rotation; prevalent agricultural system in much of Europe during Middle Ages and lasting into 20th century in parts

operculate: having operculum (lid)

operculum (pl. **opercula**): in mosses, lid of capsule (spore-container) that comes off for spore dispersal (*L. operculum* = lid); in snails, covering over opening of shell

opportunist: plant that takes advantage of most abundant or easily obtainable site of occupancy; one taking immediate advantage

-opsida: suffix applied to class of plants, *e.g.* **Bryopsida**, **Sphagnopsida**

orchard: area planted with fruit trees

order: next major subdivision of class, ending in "ales," *e.g.* order **Bryales**

Ordovician: geologic period of Palaeozoic era dating ~441-504 million years ago

oreal: high altitude, pertaining to mountains

organelle: cellular subunit with structure and function

oribatid mite: any of superfamily (Oribatoidea) of small oval eyeless nonparasitic mites having heavily sclerotized integument with leathery appearance

ornithocoprophilous: growing on bird droppings

orography: topographic relief of hills and mountains

orophyte: plant of mountains

orthotropic: standing vertically

osmiophilic: refers to lipid-containing bodies in chloroplast; plastoglobuli

osmiophilic globule: lipid-containing body in chloroplast

osmiophilic layer: lipid layer; plastoglobuli

osmolality: concentration of solution expressed as total number of solute particles per kilogram

osmosis: movement of **water** from area of highest concentration of **water** to area of lowest concentration of **water** through differentially permeable membrane; processes toward achieving equal concentrations on both sides of membrane

osmotic potential: potential of water molecules to move from hypotonic solution (more water, less dissolved solutes) to hypertonic solution (less water, more dissolved solutes) across semi-permeable membrane

OTU: operational taxonomic units – used when species cannot on need not be named

outcrop: rock surface that appears above soil surface

outcrossing: outbreeding; crossing individuals of different populations or less closely related than average pairs in population

overhang: part of something that sticks out or hangs over another thing

overwintering: persisting throughout winter

oviparous: producing eggs that are laid and hatch later, as in birds, some rotifers, amphibians, some reptiles, and others

oviposition: to deposit or lay eggs, especially by means of ovipositor

ovoviviparity: in snails, larvae emerge inside mother's body and emerge from "her" body as juvenile snails

oxidative burst: respiratory burst; rapid release of reactive oxygen species – superoxide radical and hydrogen peroxide

P

pachyphyllous: with thick leaves

Palaeartic: relating to or denoting zoogeographical region comprising Eurasia north of Himalayas, together with North Africa and temperate part of Arabian peninsula

Palaeotropical: referring to Old World tropics; phytogeographical kingdom comprising Africa, tropical Asia, New Guinea, and many Pacific islands (excluding Australia and New Zealand)

paleaceous: having consistency of straw

palisade mesophyll: columnar cells of inner leaf tissue

paludicolous: growing in marshes, in swamps

paludification: process of becoming marsh-like

pan trap: simple small pan with soapy water; one drop of detergent in pan or bowl is sufficient to break surface tension and cause insects to drown; color can be chosen to attract certain groups of insects

pantropical: distribution includes tropical regions of both Eastern and Western Hemispheres

papilla (pl. **papillae**): projection from cell or structure, as in cells of some mosses

papillose: with one or several papillae per cell, *e.g.* leaf cells of *Aulacomnium palustre*, *Syntrichia calcicola*

PAR: (= PhAR) photosynthetically active radiation, expressed as $\mu\text{mol m}^{-2} \text{s}^{-1}$, or as **watts** per meter square (W m^{-2})

parachuting: free-fall descent that is less than 45° from vertical: used by some frogs and toads

páramo: misty alpine plateau with stunted trees and wide daily temperature fluctuations, creating severe habitat; high treeless plateau

paraphyllum (pl. **paraphyllia**): reduced leaflike appendage between leaves on stem or branches of some pleurocarpous mosses, *e.g.* along stem of *Thuidium delicatulum*

paraphysis (pl. **paraphyses**): hyaline or yellowish, usually uniseriate, non-reproductive hair often associated with antheridia and archegonia in mosses; occur in fungi, algae, and bryophytes (Gr. *para* = beside, *physis* = growth)

parasite: organism that derives nourishment from another species of living organism without benefitting other organism (Gr. *parasitos* = one who eats at table of another)

parasitic: living on or in and gaining nutrients from another living organism, to detriment of host organism

paratype: specimen cited in original description, but different from type specimen

parenchyma: tissue composed of living cells with thin primary walls and no secondary walls, such as cortex cells; usually have large vacuoles (Gr. *parenkheim* = to pour in beside)

parenchymatous: relative to cell, isodiametric and thin-walled, *e.g.* leaf tissue of *Mnium stellare* [ant. **prosenchymatous**]

parfocal: having all lenses adjusted to same focal distance, making it possible to switch objective lenses with minimal refocusing

paroicous: having archegonia and antheridia on same branch

parotoid gland: external skin gland on back, neck, and shoulder of toads and some frogs and salamanders; can secrete number of milky alkaloid substances known collectively as bufotoxins, which act as neurotoxins to deter predation;

paroicous: monoicous with antheridia and archegonia in single gametoeccium but not mixed, antheridia in axils of bracts just below those bracts surrounding archegonia

parthenogenetic: producing viable unfertilized eggs that develop into embryos

particulate organic matter (POM): macroorganic matter, or coarse fraction organic matter; soil organic matter or other particulates between 0.053 mm and 2 mm in size, readily decomposable, serving many soil functions and providing terrestrial material to water bodies

pasture: land covered with grass and other low plants suitable for grazing

path: road, way, or track made for particular purpose; narrower than road

patient: life strategy for tolerant species

pauciennial: short-lived

pavement: hard surface of road, street, or sidewalk; sometimes used to describe flat slab of natural rock bed

pearling: process wherein aquatic plants are producing oxygen as result of photosynthesis, forming bubbles on plants

peat: mass of semicarbonized plant tissue; often considered synonymous with *Sphagnum*, but actually includes grasses, sedges, and other plant types; accumulation of partially decayed vegetation or organic matter that is unique to natural areas called peatlands, bogs, or mires

peat-forming: producing peat

peatland (*s.l.*): natural area with accumulation of partly decomposed vegetable matter; refers to peat soil and wetland habitat growing on its surface

peaty: containing peat

pebble: small, usually rounded stone, especially when worn by action of water

pectate: salt or ester of pectic acid; polygalacturonic acid; acts as chelator to bind calcium and form cross-links that hold adjacent pectate polymers and thus plant cell walls together

pedestal: short, broad supporting stalk, occurring on some archegonia

peg: scaled, inward protrusions of cell wall, *e.g.* in rhizoid of *Marchantia*

pellucid: transparent, translucent

pendant: epiphyte with long main stem hanging down, with short side branches (also spelled pendent, but in English usage, this is adjective form)

pendent: hanging, pendulous; used to describe hanging epiphyte

peninsula effect: relating to dispersal and distribution, postulates that number of species will decrease as one approaches tip of peninsula

PEP carboxylase: enzyme used in C₄ and CAM carbon fixation pathways to put carbon in temporary storage C₄ compounds for later use in photosynthesis

perennating: lasting from year to year

perennial: plant that overwinters and continues to grow for many years (*L. perennis* = lasting whole year through)

perennial shuttle: life strategy of species that requires stable environments, such as epiphytes, where end of habitat is predictable – constant and numerous within area; in flood plains, mostly thallose liverworts that have both desiccation-tolerant gametophytes and large spores

perennial stayer: life strategy of species that becomes established and remains for many years; having long-lived, desiccation-tolerant gametophytes, small spores, and long setae

- perfect peristomes:** having both **endostome** (inner peristome) and **exostome** (outer peristome)
- perforation plate:** end wall of vessel in tracheophytes
- perianth:** organ of foliar origin enclosing archegonia in most leafy liverworts
- perichaetial leaf:** modified leaf among those surrounding female organs
- perichaetium** (pl. **perichaetia**): modified leaves enclosing female reproductive structures; ensheathing cluster of modified leaves or underleaves and perianth, if present, enclosing archegonia
- periderm:** in slime molds, outer covering of sporangium
- perigonium** (pl. **perigonia**): androecium; in strict sense, modified leaves enclosing male reproductive structures
- perigynium:** in some leafy liverworts, tubular structure +/- fleshy which surrounds archegonium and subsequently sporophyte
- perine:** sporoderm layer situated around exine (outer layer) of many spores
- periphyton:** organisms attached to submerged surfaces above sediments
- peristomate:** having peristome
- peristome:** in mosses, fringe of teeth around opening of capsule (spore container); involved in spore dispersal (*peri* = around; *stoma* = mouth, opening)
- peristome tooth:** one unit of peristome
- permafrost:** permanently frozen ground in arctic and subarctic
- permeability:** ability of membrane, cell, or cell system to permit substances to diffuse (*L. permeabilis* = that which can be penetrated)
- peroxidase:** enzyme that facilitates oxidation of phenolics to quinones and generation of peroxide (H₂O₂)
- peroxisome:** microbody containing catalase in plant cell that carries out photorespiration
- persistent:** not falling, not deciduous
- petrocolous:** growing on stones or rocks
- petrophilous:** preferring stone habitats
- Pfankuch score:** rating of capacity of stream reach to resist detachment of bed and bank materials and to recover from their changes
- PFD:** photon flux density
- Pfr:** form of phytochrome that absorbs far-red light to conform back to Pr form
- PGA (phosphoglyceric acid):** 3-C compound resulting from immediate fixation of CO₂ in photosynthesis in C₃ pathway
- pH:** negative log of hydrogen ion concentration; measure of acidity
- $$pH = -\log[H^+]$$
- Thus, pH is base-10 logarithm of hydrogen ion concentration in moles per liter solution.
- phaeophytin:** pigment produced as result of stress that results in chlorophyll breakdown; chemical compound that serves as first electron carrier intermediate in electron transfer pathway of Photosystem II (PS II) in plants
- phaeopigment:** non-photosynthetic pigment that is degradation product of chlorophyll pigment
- phanerogam:** seed plant
- phanerogamic:** referring to seed plants
- phaneroplasmidium** (pl. **phaneroplasmodia**): conspicuous plasmodium, as in slime mold order **Physarales**
- phaneropore:** relative to stomate, guard cells of stomate are at same level as adjacent exothelial cells, e.g. location of capsules pores in *Orthotrichum acuminatum*
- phanerophyte:** large shrubs and trees, buds at tips of branches (*Gr. phanero* = visible)
- phase contrast microscopy:** technique that converts phase shifts by light passing through somewhat transparent specimen to make changes in brightness of image reaching eye (or camera)
- pharyngeal ring muscle layer:** muscles surrounding pharynx, which is first part of foregut
- phenolic compound:** similar to lipid, but more soluble in water and less soluble in non-polar organic solvents; appears to be by-product of metabolism with no known use to plant's own metabolism; many may serve as deterrents to predation by insects
- phenology:** timing of life cycle events (growth & reproduction), or series of events themselves, as they relate to seasonal events; natural phenomena that occur periodically (*Gr. pheno* = appear, *logos* = discourse, doctrine)
- phenotype:** total appearance of organism; set of observable characteristics of individuals resulting from interaction of genes with environment
- phenotypic:** form
- phenylpropanoid:** compound that has freeze tolerance activity
- pheromone:** chemical substance produced and released into environment by animal, especially mammal or insect, affecting behavior or physiology of others of its species; chemical cue
- phile:** suffix meaning "that likes," "that prefers"
- phlobaphene:** flavonoid (anthocyanin) pigment formed by oxidation of tannic compounds, causing reddish-purple color
- phloem:** sugar-conducting cells of lignified vascular plants (tracheophytes)
- phloem loading:** movement of sugars from source to sieve element; cells in sugar source "load" sieve-tube element by actively transporting solute molecules into it; similar phenomenon may occur in leptoids of bryophytes
- phorophyte:** plant bearing epiphytic species
- photoinhibition:** decreased photosynthetic activity due to excess illumination
- photomicrography:** photography through microscope
- photonegative:** in tropisms, bending away from light
- photoperiod:** duration and timing of daylight
- photophilous:** loving well-lit habitats
- photophyte:** plant of well-lit habitats
- photoprotection:** in plants, suite of photoprotective mechanisms to prevent photoinhibition and oxidative stress caused by excess or fluctuating light conditions
- photorespiration:** plant process to take up oxygen in light and release carbon dioxide
- photosynthate:** product of photosynthesis
- photosynthetic capacity:** measure of maximum rate at which leaves are able to fix carbon during photosynthesis; maximum rate of Hill reaction (light-driven splitting of water in PS II)
- photosynthetic efficiency:** ratio of energy stored to energy of light absorbed; photon yield of oxygen
- photosynthetic photon flux density (PPFD):** photons in 400- to 700-nm waveband incident per unit time on unit surface; expressed as $\mu\text{mol m}^{-2} \text{s}^{-1}$, or as **watts** per meter square (W m^{-2})

phototactic: moving toward or away from light

phototropism: growth in which direction of light is determining factor in orientation; turning or bending in response to light

phycobilisomes: cellular organelle located on surface of thylakoids of chloroplasts and in which biliprotein pigments (phycocyanin, phycoerythrin) are present

phycocyanobilin: blue phycobilin, *i.e.*, tetrapyrrole chromophore found in Cyanobacteria and in chloroplasts of red algae, glaucophytes, and some cryptomonads; forms phycobiliproteins phycocyanin and allophycocyanin, which absorb between 595 and 640 nm and between 650 and 655nm, respectively

phyllid (phyllidium): non-vascular leaf, as in mosses and leafy liverworts

phylocladium (pl. phyllocladia): branches that look like leaves

phyllodioicous: having dwarf male plants growing on leaves of female plants

phyllodioicy: spore germination on leaves of female plant

phylloid: leaflike

phyllosphere: space surrounding leaf

phyllotaxy: spiral arrangement of leaves on stem

phylogenetic: referring to evolutionary relationships between groups of organisms

phylogeny: evolutionary history of group of organisms

phylum: highest major category below kingdom of plants and animals; also known as division in plants

physiological races: populations within species that differ physiologically but not morphologically, permitting them to occupy different growing conditions (microspecies, cryptic species)

Phyta: Latinized name for plant kingdom (Gr. *phytum* = plant)

-phyta: suffix applied to phylum name of plant kingdom (*e.g.* Bryophyta)

-phytic: suffix meaning "plant"

phytoalexin: substance produced by plant tissues in response to contact with parasite and that specifically inhibits growth of that parasite

phytochrome: photosensitive pigments involved in photoperiodism, seed germination, and leaf formation; reversible red/far-red light-activated molecular switch; absorbs red and far-red light

phytophagous: plant-eating

PHYTOSOCIOLOGICAL CLASSIFICATION

from Weber *et al.* 2000

RANK	TERMINATION
Association	-etum
Alliance	-ion
Order	-etalia
Class	-etea
Subassociation (see Art. 13)	-etosum
Suballiance	-enion
Suborder	-enalia
Subclass	-enea

pigment: substance that absorbs visible light and hence appears colored

pinnate: relative to habit, feathery; in bryophytes, having branches arranged on either side of stem, *e.g.* *Ptilium crista-castrensis*

pinocytosis: process in which cell ingests liquid by budding small vesicles inward from cell membrane, thus containing

droplet; droplet of liquid then is incorporated into cell cytoplasm

pioneer: life strategy for species able to colonize substrata not yet suitable for other species

pioneer land: pioneer heath

pirizal: cariazal – extensive, emergent vegetation of small, stagnant lakes and puddles

pitfall trap: arthropod trap sunken into ground with water or other liquid to trap fallen arthropods; one drop soap will cause insect to break surface tension and drown

dry pitfall trap: container buried in ground with rim at soil surface

wet pitfall trap: sunken container with preserving liquid such as 10% formaldehyde, methyl alcohol, ethanol, ethylene glycol (anti-freeze), trisodium phosphate, or picric acid

pit field: location of pit that connects two cells through middle lamella and thin primary cell wall, but lacking secondary cell wall; location of concentrated plasmodesmata; known from moss *Hookeria lucens*

pK: pH at which equal concentrations of acidic and basic forms of substance are present; negative log (base 10) of dissociation constant of electrolyte

placenta: in bryophytes, gametophyte-sporophyte interface

plagiotropic: lying horizontally relative to substrate

plain: large area of flat land with few trees

plane: relative to leaf margin, flat, non-curved, *e.g.* leaf margin of *Dicranella subulata*

plane polarized light: light whose electric field oscillates in just one plane; created by filter that permits only waves arriving in one plane

plankton: organisms that drift in open water

plasmalemma: cell membrane

plasmodesma (pl. plasmodesmata): tiny, membrane-like channel in cell wall between adjacent cells, enabling transport and communication between them

plasmodium (pl. plasmodia): in slime molds, life cycle stage typically consisting of mass of naked protoplasm containing many nuclei

plasmolysis: separation of cytoplasm from cell wall due to removal of water from protoplast (Gr. *plasma* = something with form, *lysis* = loosening); shrinking of cell membrane away from cell wall

plasmolyze: condition of cell protoplasm shrinking away from cell wall

plastic character: one having alternative phenotype; character that changes in response to environment

plasticity: capacity of organism to vary its morphology, physiology, or behavior in response to environmental fluctuations

plastid: class of organelles, including chloroplasts, containing pigments, and amyloplasts, containing starch (Gr. *plastis* = builder)


plastron: in aquatic insects, series of hairs or bumps on surface of insect, used to trap thin layer of air against body of insect; as insect breathes oxygen, thin layer of air is prevented from shrinking due to action of hairs and bumps

plastoglobulus: globular structure found in plastids, containing primarily lipids

plastoquinone: PQ; molecule involved in electron transport chain in light-dependent reactions of photosynthesis

pleisiomorphous: nearly identical in form, showing primitive characters

- pleopod:** swimmeret; forked swimming limb of crustacean, five pairs of which are typically attached to abdomen
- pleurispory:** 2 or more spore size frequencies grouped around 1-2 mean spore size frequencies
- pleurocarpous:** producing sporangia on short, specialized lateral branches or buds and typically prostrate, forming freely branched mats
- plicate:** fan-folded like Japanese fan (WW), describing leaves of some mosses
- plumose:** regularly pennate, appearance of feather
- Pohlstoffe:** non-technical name for wetting agent (**di-octyl sodium sulfosuccinate**), also known as **Aerosol OT** and having same active ingredient as **DulcoEase**, laxative
- poikilochlorophyllous:** lose chlorophyll and cease photosynthesis and transpiration when dry
- poikilohydric:** having state of hydration controlled by external environment
- poikilothermic:** having body temperature controlled by external environment
- polar:** Arctic and Antarctic regions
- pollutant:** unnatural human-related substance that is introduced to environment (*L. polluere* = to dirty, *lutum* = mud)
- pollution:** contamination of environment by unnatural human-related substance(s) (*L. polluere* = to dirty, *lutum* = mud)
- polyandry:** condition of multiple male parents
- polygamous:** heteroicous; having some male branches, some female, and some both
- polygynous:** having more than one queen in mound, as in some ants
- polymorphous:** with variability of forms
- polyol:** group of chemical compounds (polymers or monomers) with hydroxyl functional groups; include polyethers and polyesters, including glycerin
- polyphagous:** describes organisms that eat variety of foods
- polyphenolic:** polyhydroxy phenol; group of plant chemical substances characterized by presence of more than one phenol group per molecule; cause coloring in some plants, including some autumn leaf coloring
- polyploidy:** plant, tissue, or cell with more than two complete sets of chromosomes
- polyribosome:** **polysome**; cluster of ribosomes held together by strand of messenger RNA that each ribosome is translating; play role in peptide synthesis; protein-synthesizing apparatus
- polysome:** see polyribosome
- polysporangiate:** having multiple sporangia on one sporophyte
- Polytrichopsida:** class of mosses containing **Polytrichaceae**, **Tetraphidaceae**, **Buxbaumiaceae**, and **Oedipodiaceae**; characterized by nematodontous (non-jointed) peristome teeth
- poor fen:** wet habitat with ground water as main water source, characterized by lowest (poor) nutrient levels; this term has been variously defined in different countries with older North American literature including poor fens as bogs
- population:** group of interacting individuals of same species or lower taxon in common spatial arrangement with potential for gene flow
- pore:** small aperture, opening in wall of some cells; space or opening; in upper surface of thallose liverworts
- positive gravitropism:** tropism resulting in bending of plant toward gravitational center
- positive phototropism:** tropism resulting in bending of plant toward light
- potamocolous:** growing in rivers, streams
- PPFD (photosynthetic photon flux density):** photons in 400- to 700-nm waveband incident per unit time on unit surface; expressed as $\mu\text{mol m}^{-2} \text{s}^{-1}$, or as **watts per meter square** (W m^{-2})
- Pr:** form of phytochrome that absorbs red light to conform back to Pfr form
- precocious germination:** cell division occurs while spore still within capsule
- predation:** interaction strategy wherein one organism kills and consumes another
- prehydration:** partial rehydration of tissues by absorbing water vapor; can occur from high humidity prior to rainfall
- preparasitic attendance:** events or activities leading to finding host
- prepared slide:** microscope slide with specimen has been previously prepared by professional
- primary forest:** forest with native species and no indication of human intervention
- primary pit fields:** thin area in walls of many cells in which one or more pits usually develop
- primary productivity:** process in which solar energy is transformed to biomass
- primitive:** taxonomic trait thought to have evolved early in time (*L. primus* = first)
- primordium (pl. primordia):** earliest stage in development of plant part
- procumbent:** prostrate, *e.g.* horizontal growth habit of *Plagiomnium*
- producer:** organisms that can make its own energy through biochemical processes
- productivity:** measure of new organic matter produced by group of organisms over period of time
- profundal zone:** deep zone of inland body of free-standing water, located below range of effective light penetration
- proleg:** fleshy short leg on abdomen of insect larva
- proliferous:** growth continues by development of new leafy stems or innovations
- proline:** amino acid which is constituent of most proteins, especially collagen
- pronase:** mix of enzymes that break down proteins
- pronotum:** dorsal sclerite of prothorax of insect; upper surface of prothorax, first segment of thorax
- propagule:** see propagulum
- propaguliferous:** in bryophytes, bearing propagules such as gemmae, tubers, or bulbils
- propagulum (pl. propagula):** propagule; diaspore that has apical cell and can grow directly into leafy shoot if apical cell is reactivated; reduced bud, branch, or leaf serving in vegetative reproduction
- prorate:** referring to cell having papilla or mammilla located at distal end, *e.g.* leaf cells of *Pterigynandrum filiforme*
- prosenchymatous:** referring to narrow, elongated, tapering cells overlapping at ends [ant. **parenchymatous**]
- prostrate:** lying flat on ground or other substrate; creeping
- protandrous:** describes condition in which male parts of individual plant reach maturity before female parts do, such as in fern prothalli and some bryophytes; helps insure cross-fertilization [ant. **protogynous**]
- protandry:** condition in which maturation of antheridia occurs before that of archegonia

- protein ice nucleator (PIN):** protein that forms center for ice formation and limits supercooling and induces freezing
- protocooperation:** interaction between organisms that is mutually beneficial but not required, such as providing other with nutrients, moisture, or other conditions that enhance environment created by bryophyte and slime mold living together
- protogynandry:** maturation of archegonia before antheridia on same plant
- protogynous:** having archegonia mature before antheridia on same plant
- protogyny:** condition of development or maturation of female organs before those of male organs
- proton pump:** ATP-driven active transport of H⁺ ions from cell into intercellular matrix, permitting cations to enter cell by charge gradient.
- protonation:** instance of substance gaining proton, *i.e.* being acidified
- protonema** (pl. **protonemata**): green, branched filaments produced from germinating spores, giving rise to leafy plant; literally "first thread"
- protonema moss:** moss with short or non-existent shoots that wither after sporophyte is produced
- protonemal flap:** bladelike structure from protonema; characteristic of **Tetraphidopsida**
- protonymph:** in mites, immobile stage within larval skin
- protoplasmodium:** in slime mold **Echinosteliales**, plasmodial stage that exhibits smallest surface to volume ratio and produces spores quickly over 2-4 days by producing single, tiny, stalked sporangium
- protoplast:** protoplasm of single cell
- Protozoa:** phylum or group of phyla that comprises single-celled microscopic animals, including amoebas, flagellates, ciliates, sporezoans, and many other forms, now usually treated as number of phyla belonging to kingdom **Protista**
- protrusion phase** (in spore germination): intermediate phase between swelling and distension in which germ tube is formed and spore wall is stretched
- proximal:** located at base near point of attachment
- pruinose, pruinose:** covered with bluish or whitish powdery granules or bloom
- PS II:** photosystem II of photosynthesis; system of molecules and enzymes in plant chloroplasts that absorbs energy of red light with wavelength of 680 nm, and uses it to produce ATP and to split water into protons and oxygen
- psammon:** interstitial community among sand grains in fresh water
- psammophile:** growing on or in sand
- pseudoanisospory:** false anisospory; spore size frequencies and mean spore size frequencies grouped around 2 mean sizes, usually in 1:1 ratio; small spore fraction results from aborted development
- pseudautoicous:** dioicous, but with male plant growing (epiphytically) on female plant
- pseudocoel:** "false" body cavity with acellular fluid in nematodes
- pseudodioicous:** condition which appears to have separate sexes, but in fact they originate from one plant with separate sexual branches
- pseudodistichous:** highly compressed, with leaves in spiral arrangement, but appearing to lie in two rows
- pseudoelater:** false elater; one, two, or four-celled sterile filament developed after several mitotic divisions and subsequent differentiation of diploid pseudoelater mother cell among spores in capsules of hornworts; outnumber spores
- pseudogley:** gley (sticky waterlogged soil lacking in oxygen, typically gray to blue in color) resulting from temporary or seasonal waterlogging due to poor drainage, rather than from permanent existence of high water table
- pseudoparaphyllium** (pl. **pseudoparaphyllia**): rudimentary leaf present at branch base in some pleurocarpous mosses
- pseudoperianth:** in some thallose liverworts, tissue produced by thallus that surrounds archegonia and subsequent sporophytes, *e.g.* tissue surrounding perianth of **Preissia quadrata**
- pseudophrynamine (PS):** class of indolic alkaloids used in defense in some frogs
- pseudopodium:** in **Sphagnum**, watery gametophyte stalk that supports sporophyte; sporophyte foot is imbedded at apex
- pseudosimplex stage:** in tardigrades, stage that hibernates and is sexually immature
- pseudostoma** (pl. **pseudostomata**): false pore, as those in **Sphagnum** capsule
- pseudothallose:** said of gametophyte resembling thallus
- psychrophilic:** preferring habitats with low-temperature tolerance; low-temperature-tolerating organisms
- pterygodont:** in some **Polytrichaceae**, type of nematodontous peristome, teeth provided with longitudinal ridge or wing [ant. **leiodont**]
- puddle:** small pool of liquid, usually caused by rainwater in depression
- pulse release:** sudden release of substances during rehydration, returning carbon and other nutrients, especially potassium, to soil
- pulvinate:** cushion-shaped
- pumiliotoxin (PTX):** found in all genera worldwide of anurans (frogs & toads) that contain lipophilic alkaloids; appear to have dietary source, with lab-reared animals lacking compound; it is subsequently incorporated into skin; used in defense
- punctum** (pl. **puncta**): general term for round or oval pore in silica wall of diatom
- pupa:** in insects, inactive life cycle stage between larva and adult
- pupation:** period of development of pupa
- PVA:** polyvinyl alcohol
- PVAG:** polyvinyl alcohol with glycerol
- PVAGB:** polyvinyl alcohol with glycerol and borax
- pyrenoid:** proteinaceous body serving as nucleus for starch storage and common in green algae and **Anthocerotophyta**; implicated as carbon-concentrating mechanism
- Pyrethrin:** class of organic compounds normally derived from flowering plant **Chrysanthemum cinerariifolium** that have potent insecticidal activity by targeting nervous systems of insects
-  **Q₁₀:** ratio of ending to beginning reaction rates for 10°C rise in temperature
- Q-mode analysis:** area x area analysis; used when many variables are measured at multiple spatial or temporal points; unlike R-mode, principal component analysis for linear discriminant analysis; Q-mode method seeks to preserve "information" within samples of original data set, rather than variance within variables
- quadrant:** one-fourth of something; quarter

quadrat: sampling plot
quadrate: square
quagmire: soft boggy area of land that gives way underfoot
quaking bog: floating mat in bog
quarry: typically large, deep pit from which stone or other materials are or were extracted
quiescence: state of reduced metabolic rate

R

r and K selection: selection for life cycle strategy based on high reproductive potential (r) or long life and high carrying capacity (K)
r strategy: life cycle strategy characterized by rapid growth rate, early reproduction, numerous, small offspring (spores or seeds in plants), and high resource uptake
race: may be genetically distinct populations of individuals within same species, or may be defined geographically or physiologically; genetic isolation between races is not complete, but genetic differences may have accumulated that are not (yet) sufficient to separate species; not governed by any of formal codes of biological nomenclature
radially symmetric: symmetric around central axis
radiolabel: to tag with radioactive tracer such as ^{14}C or ^{15}N
radula: rasping tongue of snails and slugs
rainforest: forests characterized by high and continuous rainfall, with annual rainfall in cases of tropical rainforests between 2.5 and 4.5 m, with definitions varying by region for temperate rainforests
ramet: individual member of clone; physiologically distinct organism that is part of group of genetically identical individuals derived from one progenitor
Rapoport's elevational rule: prediction of trends of increased elevational ranges of plants with increase in elevation
ravine: deep, narrow gorge with steep sides
recalcitrant: describes substance that degrades at extremely slow rate if at all when released into environment; unresponsive to treatment; resistant
receptacle: disc located on thallus or on stipe and bearing sex organs, *e.g.* flattened platform on top of archegoniophore in *Marchantia polymorpha* of antheridial area on thallus of *Conocephalum conicum*
recessive allele: trait that only shows when both alleles of gene are same
reciprocal pruning: as trees contact each other, lateral branch growth is usually not influenced by neighbors until mechanical abrasions occur
recognizable taxon units (RTUs): taxonomic entities that are recognizably different, but without application of names to them; often used when non-taxonomist workers are collecting data
recrystallization: process in which grains of crystal structure come in new structure or new crystal shape; growth of larger crystals at expense of smaller ones; can occur during minor freeze-thaw temperature fluctuations within organism; some biological antifreeze proteins inhibit this process and protect membranes from damage
recurved: curved inward and downward
red-listed: protected based on rarity status
Red Queen Hypothesis: hypothesis that organisms must "constantly adapt, evolve, and proliferate not merely to gain reproductive advantage, but also simply to survive while pitted against ever-evolving opposing organisms in ever-changing environment; *e.g.* limited capacity to create new genetic makeup leads to extermination due to rapidly evolving parasites and pathogens
reduced: incomplete, rudimentary
reed bed: area of water or marshland dominated by tall plants that grow in clusters
refugium (pl. refugia): area that has climate representative of past and different from that of surrounding area
regeneration: process of renewal, restoration, and growth that makes genomes, cells, organisms, and ecosystems recover from natural fluctuations or events that cause disturbance or damage; common way for bryophytes to reproduce from fragments
regulated river: river or stream where flow has been modified from its natural state by water storage or flood mitigation structures
rehydration: process of restoring lost water (from dehydration) to tissues and fluids
rehydration protein: protein involved in rehydration and recovery; synthesized during rehydration
rehydrin: protein involved in rehydration (rehydration protein), thought to be responsible for production of anti-oxidants
relative humidity: amount of water vapor present in air expressed as percentage of amount needed for saturation at same temperature
relative species abundance: calculated by dividing number of species from one group by total number of species from all groups
relaxed clocks: fossil/molecular "clocks"
relevé: sampling method for stand of vegetation to collect data on presence, cover, density; list of species in area, often collected by searching with no particular pattern (see Department of Natural Resources, State of Minnesota 2013); visual descriptions of vegetation of area plus habit and habitat data
relict: persistent species remnant of former widespread species in some isolated areas or habitats; survived from earlier time period
relictual: relative to plant that survives in favorable but limited space
R-mode analysis: species x species; used to study covariate relationships (*i.e.*, patterns of relationship among many dependent variables in data set); in R-mode factor analysis, loadings are loadings of variables on factors; negative loading indicates negative relation of observed variable to factor
reproduction: formation of similar offspring
resorption: to absorb (re-absorb) tissue after it has been made
resorption furrow: groove due to partial resorption of marginal cells, *e.g.* stem leaf of *Sphagnum fimbriatum*
respiration: process by which sugars and other stored organic molecules are oxidized and broken down, with energy captured in formation of ATP
respiratory pore: on right side of body of slug or snail; closes to keep out water in aquatic species or to prevent desiccation under dry conditions on land
resting egg: dormant stage that suspends development in some invertebrates, maintaining genetic diversity through unfavorable conditions
restinga: spit and distinct type of coastal tropical and subtropical moist broadleaf forest in eastern Brazil
resuscitation: action of making something active or vigorous again
reticulate: like network

retort cell: part of outer cortex of stem in some *Sphagnum* species; outer cortical cells that are enlarged bottle or retort-shaped; neck of each cell is turned outward away from axis and has pore at distal end

revegetation: process of replanting and rebuilding soil of disturbed land

reverse genetics: genotype-driven technique in which genes are either knocked out or added to see effect on phenotypic expression

revivification: restoring life

reviviscence: renewal of life; state of being revived

revolute: rolled outward, toward abaxial, dorsal, external face; leaf margins rolled under [ant. **involute**]

rhamnose: naturally occurring deoxy sugar, 6-carbon derivative of **mannose**

rhocrene springs: springs that become streams immediately upon emerging from ground

rheo-hygropetric: flowing film of water on rocks in springs

rheophilic: loving flowing water

rheophilous: growing in flowing creeks and rivers

rheophyte: aquatic plant that lives in fast moving water currents in environment where few plants can survive

rhizautoicy: sexual condition of separate male and female shoots connected by protonema or rhizoids, but appearing to be separate plants

rhizoid: non-vascular anchoring and absorbing structure, one cell thick and one cell long in liverworts and hornworts, multicellular, generally with oblique end walls in mosses; found in gametophytes of **Marchantiophyta**, **Anthocerotophyta**, and **Bryophyta** (Gr. *rhiza* = root, *oides* = like)

rhizoid peg: cell wall protrusion into cell; found in Marchantiales

rhizoidal tuber: somewhat fleshy subterranean reproductive vegetative structure on rhizoids

rhizoidosphere: area immediately surrounding rhizoids; comparable to rhizosphere of tracheophytes

rhizome: horizontal (usually) underground stem, such as those connecting *Polytrichum* clones (Gr. *rhiza* = root)

rhizosphere: soil immediately around roots; root zone

ribose: 5-C simple sugar

ribosome: organelle where protein synthesis occurs in cell

riccardin D: macrocyclic bisbibenzyl compound that induces apoptosis of human leukemia cells

riccionidin A: anthocyanidin found in some bryophytes

rich fen: wet habitat with ground water as main water source, characterized by highest nutrient levels

richness: in ecology, measure of number of different species in system without regard to number of individuals in each species

riffle: rocky or shallow part of stream or river with rough water; term largely used in North America

rill: small stream

riparian: wetlands adjacent to rivers or streams

river: large body of flowing water

river bed: bottom of river

river ecosystem: large body of flowing water and its organisms

rock: solid mineral material forming part of surface of Earth, exposed on surface; boulder

rock face: bare vertical side of rock

rockhouse: small cave created by deep recess in bedrock cliff; mimic conditions prevailing in some tropical habitats by buffering both temperature and moisture extremes and providing low light

root nodule: outgrowth on root that houses nitrogen-fixing bacteria

roraima savannah: in Amazonian Brazil, usually open with few trees

rosette: referring to habit, cluster of leaves at same level, thalli radiately spreading, e.g. rosette growth form of *Riccia sorocarpa*

rotting stump: decaying remains of tree base

rotten wood: decaying tree, log, or stump

r-selected species: organism characterized by rapid growth rate, early reproduction, numerous, small offspring (spores or seeds in plants), and high resource uptake

r-strategist: organism characterized by rapid growth rate, early reproduction, numerous, small offspring (spores or seeds in plants), and high resource uptake

RUBISCO: enzyme in chloroplasts that catalyzes carbon fixation in plants and in oxygenation of resulting compound during photorespiration

ruderal: referring to plant living on field or wasteland in built up areas; waste areas

rumino-reticular: part of cow's four stomachs

runoff: draining away of water from land surface

rupestral: growing on rocks

rupicolous: living among or on rocks

rut: long deep track made by repeated passage of vehicular wheels

S

sabulicolous: growing in gravel or sand

salamandrin: strong alkaloid neurotoxin that usually causes convulsions

salt marsh: coastal wetland that is flooded and drained by salt water brought in by tides

sample: specimen

sand: loose granular substance, typically pale yellowish brown, resulting from erosion of siliceous and other rocks

sand pit: quarry from which sand is excavated

sandstone: sedimentary rock consisting of sand or quartz grains cemented together, typically red, yellow, or brown in color

saprolignicolous: growing on decaying wood

saprophagous: organism that feeds on decaying organic matter

saprophyte: plant that grows on dead organic matter

saprophytic: growing on dead organic matter; describes organism that lives on dead organic matter

savannah: grassy plain in tropical and subtropical regions, with few trees

saxicolous: living on or among rocks [syn. epilithic, rupestral]

scabrous: rough

scarce: few localities are known

scarification: abrasion process in which one "scars" seed coat by scratching or nicking it; used to break dormancy in seeds with hard seed coats; mechanical means of breaking outer covering of propagule such as seed or spore for germination

scat: animal fecal dropping

schizogeny: splitting; method of fragmentation of leaves and branches; possibly result of hydration of middle lamella

- schizolysis:** method to detach gemmae, requiring splitting from parent plant by **lysis** (disintegration of cell by rupture of cell wall or membrane of adjoining cells; splitting and breaking apart)
- sciophilous, sciaphilous:** preferring shady habitats
- sciophyte:** plant growing in shady habitats
- sciophytic:** growing in shady habitats
- sclerenchyma:** cell with thick walls that provides mechanical support to plant; thick-walled supporting cells
- scleroderm:** internal tissue made of cells with thickened walls and small lumen
- sclerophyll:** plant with stiff, leathery, evergreen leaves
- sclerophyll index:** ratio of crude fiber to crude protein; high index typical of thick leaf with low specific leaf area, high fiber content, and low concentrations of foliar nutrients; in bryophytes, ratio of dry mass (dried at 80°C for 24 h) to shoot area; *e.g.* *Polytrichum* is sclerophyllous, *Jungermannia* is not
- sclerotium:** in slime mold life cycle, dry, hardened dormant state
- scree:** accumulation of loose, small stones that form or cover slope on mountain
- scrobiculate:** with numerous depressions, pitted
- scrubland:** plant community characterized by vegetation dominated by shrubs, often also including grasses, herbs, and geophytes
- s.d.:* abbreviation for "*sine die*" meaning "without date"
- secondary compound:** chemical manufactured by plant that protects it; not used in any essential metabolic pathway
- secondary forest:** secondary woodland; forest regenerating largely through natural processes after significant human and/or natural disturbance or naturally regenerating after fire or hurricane
- secondary growth:** growth derived from lateral meristem, as in most trees; plant growth that does not occur at tips of stems or tip of roots; in seed plants, secondary growth produces bark and wood
- secondary protonema:** that protonema produced from mature tissues that have been damaged or cut
- sedge swamp:** highly productive freshwater marsh, sedge meadow or swamp; forested wetland with sedges as predominant ground cover
- sediment:** composed of autochthonous (formed in stream, river, or lake itself) and/or allochthonous (transported into stream, river, or lake by water and wind) materials which are continuously deposited on stream, river, or lake bottom
- sedoheptulose:** ketoheptose – monosaccharide with seven carbon atoms and ketone functional group; one of few heptoses found in nature, in various fruits and vegetables and in some leafy liverworts
- seepage:** process by which water, usually groundwater, reaches Earth's surface
- selfing:** being fertilized by sperm from same plant
- SEM:** scanning electron microscope
- semelparity:** condition of reproducing sexually only once. *Semel* comes from Latin, meaning once. *Parous* is derived from *pario*, meaning to beget. The origin seems to be in Greek mythology, where Semele, daughter of Cadmus and Harmonia, was the mortal mother of Dionysus by Zeus. In the myth, Semele asked Zeus to reveal himself as his true entity. Because he had promised to grant her a boon, he could not break his promise, revealing himself as the lightning bolts he represented, and that cause any human that views them to incinerate. Hence, Semele could bear a child only that once, then died.
- semi-aquatic emergent:** being in locations where plants are partly in water and partly out of it, but usually moist
- semi-edophore:** bryophyte-dwelling invertebrates; term meaning partly living in soil
- senescence:** process of aging; process in which cell reaches state wherein it cannot undergo either progressive or regressive development and only remaining change is toward death
- senescent:** growing old
- sensillum (pl. sensilla):** in arthropods and some other invertebrates, simple sensory receptor consisting of modified cell or small group of cells of cuticle or epidermis, typically hair- or rod-shaped
- sensu:** Latin meaning "in sense of"
- sensu lato:** in broad sense
- sensu stricto:** in strict or narrowest sense
- sequential hermaphrodite:** organism that is first one gender, then other; in some snails, being first male, then female
- serine:** amino acid with polar R group and soluble in water; plays fundamental role in plant metabolism, plant development, and cell signalling
- sessile:** in bryophytes, without seta, without stalk; attached, as in hydra and many rotifers
- seston:** living organisms and non-living matter swimming or floating in water body
- seta (pl. setae):** stalk that supports moss or liverwort capsule; elongated portion of sporophyte between capsule and foot; hair
- sex chromosome:** one pair of chromosomes that are different in two sexes and are involved in sex determination
- sex ratio distorters:** cytoplasmic element such as infection may replace nuclear gene as sex-determination mechanism
- sexine:** outer layer of exine, having distinctively sculptured surface, *e.g.* in spore
- sexual:** in plants, any reproductive stage involving meiospores or gametes
- sexual dimorphism:** sexes look different
- sexual reproduction:** reproduction that requires meiosis, formation of haploid state (having one set of chromosomes), formation of gametes, and union of gametes to complete life cycle
- shade plant:** plant that grows normally in shaded habitat where it receives only light of low intensity; most bryophytes are shade plants
- shady:** having full shade
- shaly rocks: (shaley)** sedimentary rocks, including conglomerate, sandstone, siltstone, shale, limestone, and coal, forming finely stratified or laminated structure; of, like, or containing shale
- Shannon diversity:** measure commonly used to characterize species diversity in community
- $$H = -\sum[(p_i) \times \ln(p_i)]$$
- p_i = proportion of total sample represented by species i
- sheath:** tissue that surrounds base of stem, seta, or capsule, *e.g.* vaginant lamina in *Fissidens*
- sheathing:** surrounding stem, seta, capsule or other structure, *e.g.* in *Hyophila involuta*
- sheet metal:** metal formed into thin sheets or plates, typically by rolling or hammering

shingle: mass of small rounded pebbles; elongated and commonly flattened pebbles and cobbles in gravelly sediment are deposited so that they overlap one another like roofing shingles

shoot: stem + leaves and other structures of bryophyte leafy gametophyte

shoot apex: tip, usually growing tip, of plant

shore: land bordering usually large body of water; coast

short-day: occurring only after being exposed to light periods shorter than critical length, as in early spring or fall

short-lived shuttle: species that doesn't avoid periods of severe stress; habitat lasts 2-3 years

short turf: life form of bryophytes with regenerative shoots; forms spreading turfs for only few years; see Mägdefrau life forms

shrub: woody plant with several main stems arising from base and smaller than tree

shuttle species: one that moves from place to place, occupying short-lived environments

shy male hypothesis: hypothesis that suggests males express sex less frequently than do females

sieve cell: long, enucleate conducting cell of phloem

siliceous: acidic, composed of silica (silicon dioxide, SiO₂), which occurs in nature as chert, quartz, flint, and agate

silicicolous: growing on sandstone or siliceous rock

siltation: particulate terrestrial clastic material, with particle size dominated by silt or clay, referring both to increased concentration of suspended sediments and to increased accumulation of fine sediments on stream and river bottoms where they are undesirable

Silurian: geologic period of Palaeozoic era dating ~400-440 million years ago

simplex stage: molting stage in tardigrades wherein old cuticle, claws, and lining of fore- and hindgut are shed, causing lack of sclerified parts of buccal-pharyngeal apparatus and preventing feeding

simultaneous hermaphrodite: organism having both sexes in same organism at same time and mutually exchanging gametes during copulation

sink: natural or artificial reservoir that accumulates and stores something

silvicolous: growing in forests; also **syilvicolous**

sinistrorse: referring to seta that is twisted to left, counterclockwise, when looking from seta apex (capsule base) to seta base (sporophyte insertion), e.g. seta of *Weissia brachycarpa* [ant. dextrorse]

s.l.: abbreviation for *sensu lato*, meaning in broad sense

slate: fine-grained, usually bluish-gray rock that splits into thin, flat layers or plates, formed by metamorphosis of clay, shale, etc.

sleeve: dense mat that surrounds base of tree trunks essentially in alluvial forests, e.g. *Anomodon viticulosus* around tree base

slime papilla (pl. **slime papillae**): mucilaginous projection on marginal leaf cells of liverwort; can help to absorb and hold water

s.n.: Latin abbreviation for "*sine numero*" meaning "without number"

snow bed: depression where snow collects, causing shorter growing season than its surroundings

snowline: upper limit of plant life

soil: although soil and ground are often treated as synonyms, they are different: soil = complex mixture of minerals, water, air,

organic matter, and organisms; ground = top part of Earth's surface that people walk on

soil degree days (SDD): unit of measure calculated as product of time (days) and temperature (°C) of soil, usually averaged over growing season or activity season for organism in question; number of degree-days that occur in one day is determined from average temperature for that day minus base temperature, which is minimum temperature above which activity occurs

Soil Descriptors

bare soil: soil with no visible plants growing on it

gravelly soil: soil containing unconsolidated rock fragments

loose soil: soil having loose and large-grained consistency

peaty soil: soil material consisting of partially decomposed organic matter, usually found in swamps and bogs

top soil: thin, rich layer of soil where most nutrients for plants are located

solifluction: slow, downhill movement of soil and other materials in areas typically underlain by frozen or otherwise impenetrable ground; slump; mudflow

somatic: referring to any cell except reproductive cells, i.e. vegetative cell

somatic mutation: mutation that does not affect gametes; mutation in body cells; usually non-heritable change

soredium (pl. **soredia**): asexual reproductive structure in lichen

source-sink hypothesis: idea that organisms move from favorable habitat (source), often as result of overcrowding, to sink that is less favorable, where they remain and accumulate

source to sink: movement of substance from area of higher concentration (**source**) to one of lower concentration (**eventual sink**)

sp.: Latin abbreviation meaning "species"

spate: sudden flood in river, especially one caused by heavy rain or melting snow

specialist: in ecology, species can thrive only in narrow range of environmental conditions or has limited diet, e.g. species that prefer to or only can live on bryophytes

species (pl. **species**): taxonomic unit denoting those organisms that can potentially interbreed, yet are unable to breed with other groups; group of entities recognizably different from other entities but seeming to represent group with common characters (*L. species* = kind)

species-area curve: indicator of steepness of curve as each species is added to list

species diversity: measure of number of different species and distribution of individuals in system

species quality index: index requiring assignment of numerical score to all species present according to rarity; equal to sum of quality scores divided by number of species

species richness: measure of number of different species in system without regard to number of individuals in each species

specimen: example, part, individual

speleology: study of caves

sperm: male gamete that is smaller than female and motile

spermatocyte: cell that becomes converted into sperm

spermatogenesis: formation of sperm

spermatogenous: giving rise to sperm

spermatophore: in some invertebrates, protein capsule containing mass of **spermatozoa** attached on short stalk onto substrate

- spermatozoa:** motile sperm, transferred during mating in several invertebrate groups
- sphagnan:** glycuronoglycan that comprises ~60% of holocellulose in *Sphagnum* hyaline cell walls
- sphagnicolous:** growing in moss
- sphagnoid:** cellular tissue consisting in network of chlorocysts and hyalocysts, resembling that in *Sphagnum*
- sphagnophilous:** *Sphagnum*-loving
- Sphagnophyta:** phylum name sometimes used for *Sphagnum* and *Ambuchanania* when separating them from *Bryophyta*
- Sphagnopsida:** class of mosses with only one genus, *Sphagnum*
- sphagnorubin:** red pigment in cell walls of some *Sphagnum* species
- sphagnum:** often used as common name for peat-moss
- spiracle:** external opening through which insects breathe
- spiracular disk:** apparatus that contains breathing openings called spiracles
- spiral thickening:** helical ridge on inner face of and part of secondary cell wall; found in elaters and secondary xylem tracheary elements or fibers
- splash cup:** container from which reproductive units (sperm, gemmae, spores) can be splashed by raindrops
- splash platform:** in *Marchantia*, elevated antheridial head that facilitates sperm dispersal by splashing; in mosses, rosette of leaves from which reproductive units such as sperm, gemmae, or spores can be splashed by raindrops
- sporadic:** appearing irregularly
- sporangium (pl. sporangia):** container that produces spores; capsule (Gr. *spora* = seed, *angeion* = vessel)
- spore:** reproductive cell that develops into plant without union with another cell, usually 1-celled
- spore mother cell:** sporocyte; cell that will undergo meiosis to produce meiospores
- spore sac:** cavity located in urn of capsule and contains spores
- sporeling:** all structures developed between germination and formation of adult gametophore
- sporocyte:** spore mother cell; cell that will undergo meiosis to produce meiospores
- sporoderm:** wall or covering of spore
- sporogenesis:** process of giving rise to spores, starting with meiosis in plants
- sporophore:** sporangial stalk
- sporophyte:** diploid ($2n$) meiospore-bearing generation; initiated by fertilization of egg and ends with meiosis (Gr. *spora* = seed, *phyton* = plant)
- sporophyte generation:** diploid ($2n$) generation in plants that begins with zygote and ends with meiosis that produces $1n$ spores; dominant generation in all plants but bryophytes
- sporopollenin:** phenol-containing polymer that imparts high chemical resistance to exine (outer layer) of pollen
- sporotrichosis:** fungal disease caused by *Sporotrichum* in those who handle *Sphagnum*
- spos:** hybrid form of spoon boss, tool that doesn't hurt and that catches loosened bryophyte before wind can carry it away
- spp.:** abbreviation meaning more than one species
- spreading:** patulous, relative to habit of leaves or branches, more or less horizontal and perpendicular to axis (angle of 45° or more with axis), e.g. leaves of *Rhytidadelphus triquetrus*
- spreading branch:** in *Sphagnum*, branch more or less horizontal, or arched
- spring mire:** mire with spring as its primary water source
- spruce forest:** forest with *Picea* as dominant genus
- squama (pl. squamae):** part arranged like scale; broad, flat surface (L. *squama* = scale)
- squarrose:** spreading at right angles, as in *Paludella squarrosa*
- s.s.:** Latin abbreviation for *sensu stricto*, meaning "in narrow sense" [ant. *s.l.* = *sensu lato*]
- ssp.:** subspecies
- stacking:** **focus stacking; focal plane merging; z-stacking; focus blending;** digital image processing technique which combines multiple images taken at different focus distances to give resulting image with greater depth of field (DOF) than any of individual source images can be built into camera or used to combine series of images at slightly different distances
- stage micrometer:** finely divided scale ruled on microscope slide and used to calibrate ocular micrometer
- stalk:** seta in mosses; structure that supports capsule in mosses, liverworts, and some fungi
- standing crop:** total biomass of ecosystem or any of its components at given time
- statolith:** type of amyloplast used in sensing gravity
- stegocarpous:** refers to capsule in which operculum is dehiscent, majority of cases in moss species [ant. **cleistocarpous, astomous**]
- stem:** main axis of plant; caulidium in bryophytes
- stemflow:** solution that flows down tree trunks during precipitation
- stenotopic:** able to tolerate only restricted range of habitats or ecological conditions
- stepping stones:** stones, mountaintops, islands, and other formations that facilitate extension of species to new location by providing suitable habitat for populations to grow
- stereid:** slender, elongate, fiber-like cell found in costa or stem in some mosses
- sterile:** in botany, refers to organisms without structures to reproduce sexually; free from living microorganisms [ant. **fertile**]
- sterile jacket:** term often applied to outer covering of sporangium; non-spore-producing tissue surrounding sporogenous tissue or spores
- stereome:** stereome; refers to entire system of stereids in mosses
- stochastic:** randomly determined
- stochastic process:** unpredictable event
- stolon:** stem that grows horizontally along ground, from which upright stems arise
- stoma (pl. stomata):** minute opening in capsule wall of hornworts and capsule neck of mosses; surrounded by two guard cells (Gr. *stoma* = mouth)
- stone:** rock or particular piece or kind of rock, as boulder or piece of agate
- stone quarry, stone pit:** surface excavation for extracting stone or slate
- storey, zone:** forest floor, layer, understorey; also **story**
- stratose:** in layers; denoting thickness of leaves
- stream drift:** downstream transport by flowing water of bottom-dwelling invertebrate animals that spend part of their time in open water; downstream transport of stream invertebrates
- stream order:** describes tributary relationship of stream or river, numbered from initial tributary as 1, to joint flow with another tributary as 2, and so forth

- Shreve system:** successive number represents sum of two branches that merge
- Strahler system:** requires two of same number to increase merged number
- streamer:** life form of long, pleurocarpous moss dangling in water; in conditions where boundary-layer resistance is limiting
- stress:** external constraint that limits rate of dry matter production of all or part of vegetation; those conditions that restrict production, such as low light, insufficient water or nutrients, or suboptimal temperature
- stress avoider:** organism able to survive heat and cold as dormant part, *i.e.* seeds, spores, tubers, rhizomes, gemmae *etc.*
- stress tolerator:** organism able to survive heat and cold as whole plant or animal, *i.e.* not seeds, spores, tubers, gemmae *etc.*
- striated:** having linear marks, slight ridges, or grooves on surface, often one of number of similar parallel features
- stroma (pl. stromata):** colorless matrix of chloroplast in which packets of chlorophyll are embedded
- stubble:** basal part of herbaceous plants and especially cereal grasses remaining protruding from soil after cutting
- stump:** remains of base of tree after most of tree has fallen
- stylet:** in invertebrates, hard, sharp, anatomical structure comprising mouthparts of tardigrades, Diptera, and aphids; straw-like, penetrates cell wall to suck cell contents
- subarctic:** of regions localized immediately at south of Arctic
- subimago:** emergent stage is subadult, as in mayflies; stage in development of some insects between nymph and imago (adult) in which insect is able to fly but becomes mature only after further molt
- subitaneous:** formed or taking place suddenly or unexpectedly; undergoing or ready for immediate development; referring to summer eggs that develop without period of dormancy; non-resting; used by some tardigrades
- submerged:** term used to describe plants that grow completely underwater except for periods of brief exposure
- submergence:** to put or sink below surface of water or any other enveloping medium; to cover or overflow with water
- submersed:** relating to or characteristic of plant growing entirely underwater
- submontane:** situated in foothills or lower slopes of mountain range
- subnivean:** beneath snow
- subspecies:** subdivision of species; usually fairly permanent geographically isolated race
- substrate:** molecule that is acted upon by enzyme in enzymatically controlled reaction; solid medium on which plant grows
- substratum (pl. substrata):** solid medium on which plant grows; see substrate
- subula (pl. subulae):** long, slender points on leaves
- succession:** process of change in species structure of ecological community over time
- succubous:** lying under; oblique leaf insertion in which antical (distal) margins are oriented toward ventral stem surface; younger leaf begins above older one and grows tilted toward substrate, thus succumbing to it by growing under it, *e.g.* leaf positioning of *Plagiochila asplenioides* [ant. **incubous**]
- succulent:** fleshy; thickened and able to store large quantities of water
- sugar flotation:** flotation medium using sugar, causing organisms to float so they can be separated; must have higher specific gravity than 1.20 to float common parasite ova
- sulfoquinovosyldiacyl glycerol (SQDG):** anionic lipid, major class of thylakoid membrane lipids
- sun plant:** plant that grows normally in sunny habitat where it receives light of relatively high intensity
- sunfleck:** flashes or patches of sunlight on forest floor; typically caused by leaf movement in canopy
- supercool:** cooled (liquid) below its freezing point without solidification or crystallization
- supercooling:** process of lowering temperature of liquid or gas below its freezing point without it becoming solid; used by some animals to prevent freezing damage
- supercooling point:** point of crystallization
- superficial:** on surface
- superhydrophilic:** having highly efficient water absorption mechanism, as in some papillae
- superoxide dismutase:** SOD; enzyme that destroys highly reactive superoxide by converting them into peroxide and O₂; contains zinc and copper or manganese; known to enhance membrane integrity
- supralittoral:** splash zone; of shore of lake, sea, or ocean permanently above water but made damp by spray from waves or by capillarity of substrate
- suprasaturation:** maximal hydration, such as that defined as water content after spraying, submerging, and subsequent removal of adhering water droplets by shaking
- supraspecific taxa:** above species level
- Surber sampler:** standard sampler for arthropods in streams, with area = 10x10 cm, 100 µm mesh
- surfactant:** compound that lowers surface tension (or interfacial tension) between two liquids, between gas and liquid, or between liquid and solid; influence droplet size and important in lowering critical supersaturation necessary for activating aerosols into cloud condensation nuclei; may act as detergent, wetting agent, emulsifier, foaming agent, and dispersant
- surrogate:** in ecology, group of organisms that can be used to assess suitability of habitat for another group of organisms such as fish
- swampy meadow:** this term has mixed definitions, so authors should define it when they use it
- swarm cell:** stage in some slime mold life cycles resulting when free water causes **myxamoeba** to develop flagella – one long and one very short
- sweep netting:** use of sturdy nets, often with canvas bag, that are used to collect insects and other invertebrates from tall grass
- swelling of spore:** result of uptake of water by spore
- symbiont:** organism that lives in close association with another
- symbiosis:** close association of two species, including mutualism, commensalism, or parasitism
- sympatric:** sharing part of their distributional area
- symphoriont:** organism carried by and often dispersed by its host, *e.g.* protozoa living on tardigrades or on moss leaves
- symplastic:** through protoplasts and their intercellular connections (plasmodesmata)
- sympodial:** growth pattern where primary axis is superseded by succession of secondary axes
- symphoriont:** organism carried by and often dispersed by its host

synergism: complementation or helping each other so result is greater than sum of parts

synoecium: synoicous inflorescence, including archegonia, antheridia and surrounding bracts

synoicous: archegonia and antheridia mixed in same gametoeccium, *i.e.* intermixed

syntype: one of original set of samples of taxon used to describe and name it

synusia (pl. **synusiae**): structural unit of major ecological community characterized by relative uniformity of life form or height

systematics: classification of taxa

systylious: referring to capsule having operculum remaining attached to tip of columella after dehiscence

T

taiga: open forest, usually coniferous, bordering arctic tundra

tail: bryophyte life form that occurs on trees and rocks, shade-loving; radially leafed, creeping, shoots stand away from substrate; *e.g.* *Cyathophorum*, *Leucodon*, *Spiridens*, some tropical *Plagiochila*; see Mägdefrau life forms

tail autotomy: ability to drop tail as seen in some lizards and salamanders

Takakiopsida: class of mosses with finely divided leaves and spirally valvate capsules

tall-herb: community with tall, linear vegetation such as grasses, reeds, cattails, bulrushes

tall turf: bryophyte life form that is very tall; persist by regenerative shoots; can conduct water internally; see Mägdefrau life forms

tamariscol: sesquiterpenoid alcohol with rare pacifigorgiane carbon skeleton; odorous major constituent of liverwort *Frullania tamarisci* at high elevations and high latitudes

tapetum: nutritive cell layer lining inside of capsule

tarsal fan: dense, long hairs on foot of each hind leg

taxon (pl. **taxa**): general term for any taxonomic rank (Gr. *taxis* = order)

taxon flock: group of closely-related species (cryptospecies?) that live in same habitat but have high variability among specimens; can be due to small changes in developmental timing

taxonomy: science of classification of organisms

teeth (peristome): fringe of appendages about opening of sporangium in mosses

temperate: regions between tropics and polar circles

temperature compensation point: that temperature at which photosynthetic gain equals respiratory loss, *i.e.*, net photosynthesis is zero

temperature excess: difference between ambient and body temperature

teniola (pl. **teniolae**): border-like row of differentiated cells, differing from true border by being intramarginal

tensibility: strength when pulled end-to-end

tepuí (pl. **tepuís**): flat-topped, sandstone mesas in Venezuela

terete: in cross-section, round, cylindrical

terminal: tip; at end of stem or branch

terminal bud: bud located at tip of stem or branch

terpenoid: sometimes referred to as isoprenoids; class of naturally occurring chemicals similar to terpenes, derived from five-carbon isoprene units assembled and modified in thousands of ways; most are multicyclic structures which differ from one another not only in functional groups, but also in basic carbon skeletons

terraforming: technologies employed to convert desert moon or planet into habitable one

terrarium (pl. **terraria**): glass or plastic container in which plants are grown; often sealed and moisture recycles

terrestrial: pertaining to land

terricolous: growing on ground

terril: heap, especially of metallic ore or waste from mine

test: shell covering microscopic organism

testate: having shell covering, especially one group of Amoebae

tetrad: group of four; in spores, these retain flat-face cell walls made when they cluster together as group

tetraploid: plant, organism with 4n chromosomes

thalloid: having flat, blade-like life form

thallose: non-vascular plant body form; resembling thallus; bladelike; describes group of liverworts that are not leafy

thallus (pl. **thalli**): non-vascular plant body, usually considered flat and dorsiventrally oriented, as in *Marchantia*; plant body lacking roots, stems, or leaves; body type of algae, fungi, some liverworts (non-leafy), and gametophytes of lower vascular plants

complex thallus: thallus multistratose with marked differentiation of tissues, *e.g.* thallus of *Conocephalum salebrosum*

simple thallus: undifferentiated thallus, unistratose or multistratose, *e.g.* thallus of *Metzgeria*

thanatosis: playing dead

theandrose: G6- α -glucosyl sucrose that occurs in close association with ABA treatment that enhances freezing tolerance

theca (pl. **thecae**): any external case or sheath

thermal: relating to heat

thermophilous: preferring warm places

therophyte: plant with seeds, predominant in deserts and grasslands (*thero* = summer)

thicket: dense group of bushes or trees

thigmotactic: responding to contact

thigmotropism: alteration of growth upon contact

thread moss: thin moss with little difference between main stem and lateral branches (*e.g.* **Leskeaceae**, some **Amblystegiaceae**)

throughfall: precipitation that comes through canopy

thylakoid: flattened, membranous vesicle containing chlorophyll; where photochemical reactions of photosynthesis occur

TIBA: 2,3,5-triiodobenzoic acid; polar auxin transport inhibitor

tierra firme: upland habitat where elevation does not allow water, even during high water season, to inundate forest

tiled roof: structure to keep out rain, traditionally made from locally available materials such as terracotta or slate

timberline: altitude at which trees cease to grow into actual trees; treeline

time lag: period in time between event and response or second action

tmema (pl. **tmemata**): abscission cell; cell that ruptures to release moss gemmae, *e.g.* on gemmae of *Aulacomnium androgynum*

tomentose: woolly, fluffy, felted

- tomentum:** in bryophytes, dense woolly covering by rhizoids on stem
- topogenous:** referring to type of bog, fen, or mire that forms under climatic conditions of reduced rainfall, with consequent lower humidity and summer drought, which restricts growth of *Sphagnum* to areas where precipitation is concentrated (e.g. valley bottom)
- torrent:** stream of water flowing with great rapidity and violence
- totipotency:** ability of any cell of organism to dedifferentiate and then differentiate into new plant
- toxicity:** poisonous quality or state
- trabecula:** horizontal appendage, lateral ridge on peristome tooth, e.g. on teeth of *Funaria hygrometrica*
- trace element:** micronutrient; element required by plant in very small quantities (Fe, Mn, Cu, Zn, Mo, Ni, Cl, B)
- tracheid:** lignified vascular conducting unit of tracheophyte, usually having tapered ends and pitted walls without perforations
- tracheophyte:** plant with well-defined, lignified vascular system; any plant of Tracheophyta; includes clubmosses, ferns, and seed plants (Gr. *tracheia* = windpipe, *phyton* = plant)
- track:** rough path or minor road, typically one created by use rather than constructed
- tradeoff:** losing one quality or aspect of something in return for gaining another quality or aspect
- transcriptome:** set of all RNA molecules, including mRNA, rRNA, tRNA, and other non-coding RNA transcribed in cell
- transfer cell:** cells at gametophyte-sporophyte junction, found in foot of sporophyte and in adjacent gametophyte; endowed with extensive and complex wall labyrinth and intense enzyme activity; help move nutrients from gametophyte to sporophyte
- transition(al) mire:** poor fen; natural wetland habitat with dense low growth of small sedges and other plants, developing on wet ground where water is fairly acidic and has very limited plant nutrients
- transitivity:** relation between three elements such that if it holds between first and second and it also holds between second and third it must necessarily hold between first and third, i.e. if a is part of b and b is part of c, then a is also part of c
- translocatable:** adjective to describe nutrients or other substances that move easily through plant (L. *trans* = across, *locare* = to place)
- translocation:** in plants, movement of organic substances from one location to another within plant; more generally used to refer to movement of any substance from one place to another in plant
- Transpermian Theory:** theory suggesting life might have travelled on bit of meteoric rock from Mars or other planet and landed on Earth billions of years ago
- transpiration:** loss of water as vapor from plants
- transpiration stream:** movement of water from roots to tops of tall plants
- transplant:** to move something from place where it is growing and placing it in another place to grow
- transport system:** in botany, system of cells used for directed movement of substances throughout plant
- transverse:** across; perpendicular to long axis
- travertine:** form of limestone deposited by mineral springs, especially hot springs
- tree:** upright woody perennial plant with branches
- tree well:** condition where snow is separated from tree trunk by small funnel of air, caused at least in part by reradiation of heat from dark tree trunk
- trehalose:** sugar produced during desiccation and freezing that increases survival rate
- trigone:** generally triangular or circular intracellular wall thickening, found at point where three (or more) cells meet; common in leaves of leafy liverworts, e.g. leaf cells of *Mylia anomala*
- trilete:** referring to polar spore with convex distal face and proximal face with triradial ridge, e.g. spores of *Riccia beyrichiana*
- triptophan:** essential amino acid, C₁₁H₁₂N₂O₂, formed from proteins
- triterpene:** one of class of hydrocarbons produced by many plants
- tritonymph:** in mites, second immobile stage
- trivoltine:** producing three broods per season
- trophus** (pl. **tropi**): mouth part in rotifers and certain insects; any of rigid cuticular structures within mastax of rotifer which are responsible for grabbing or grinding food
- tropism:** orientation of direction of growth in organ of plant, guided by external stimulus such as light or gravity (Gr. *trope* = turning)
- true starch:** polysaccharide carbohydrate composed of two forms of glucose elements, amylose and amylopectin; principal storage compounds of plants
- trunk:** bole; main axis and support of tree
- TS:** transverse section, =cross section (cs)
- tuber:** in mosses, gemmae produced on rhizoids; in liverworts, perennating structure produced by downward growing outgrowth of shoot apex, normally subterranean but can occur on stems, particularly in leaf-axils
- tuberculate:** with peg-like projections of cell wall material into cell
- tuberculate rhizoid:** with peg-like projections of cell wall material into rhizoid cell in some thallose liverworts; pegged rhizoid, e.g. rhizoids of **Marchantiales**
- tufa:** porous limestone (CaCO₃) formed in streams and springs; rock formations resulting from carbonates built upon bryophytes and other plants due to addition of photosynthetic oxygen to dissolved minerals
- tuff:** light, porous rock formed by consolidation of volcanic ash
- tuft:** relative to habit, clump with erect shoots, e.g. growth habit of *Tortella tortuosa*
- Tullgren funnel:** Berlese funnel or Berlese trap; apparatus used to extract living organisms, particularly arthropods, from samples of soil
- tumid:** swollen, inflated
- tun:** dormant stage; body dries out and appears as lifeless ball; tardigrades and rotifers can survive on bryophytes in this state
- tundra:** vast, flat, treeless Arctic region of Europe, Asia, and North America in which subsoil is permanently frozen
- turf:** life form with stems erect, parallel and close together; often covering extensive areas; grass and surface layer of soil held together by its roots; life form of bryophytes with erect shoots close together, e.g. growth habit of *Bryum argenteum*
- turf moss:** moss with upright shoots that bear new shoots after sporophyte forms and subsequently bear further archegonia and more sporophytes
- turgescence:** swollen after hydration

turgid: swollen, distended; refers to cell that is firm and swollen due to water uptake (*L. turgidus* = swollen, inflated)

turgor: state of cell which has taken in maximum amount of water causing distention of protoplast

tussock: small area of grass that is thicker or longer than grass growing around it; hummock; small, rounded or cone-shaped, low hill or surface of other small, irregular shapes; raised hump as found in bogs and fens

twig: slender shoot of tree or other plant

tympanum: exposed outer surface of ear drum in animals such as mammals, birds, some reptiles, some amphibians, and some insects

type: specimen attached to scientific name from which species has been described

tyrphobiont: organism restricted to peat bogs and mires

tyrphophile: species characteristic of bogs but not confined to them

U

U chromosome: female chromosome in bryophytes (see also **V chromosome**)

ubiquitin: small protein found in almost all cellular tissues in eukaryotic organisms; helps regulate processes of other proteins in organism through conjugation to large range of target proteins

ubiquitous: present in many types of distinct habitats; found everywhere

UFPOM: ultra fine particulate organic matter

ultraviolet light (UV): light waves less than 400 nm long; high energy light waves that are invisible (to humans)

uncoupling: in bryophytes, and some other plants, increase in height/length may not be well correlated with increase in biomass

underbrush: shrubs and small trees forming undergrowth in forest

underleaf: modified leaf on underside of plant, especially in leafy liverworts; amphigastrium, *e.g.* underleaves of *Frullania*

undifferentiated: refers to tissue that has not become specialized

undulate: wavy, *e.g.* thallus of *Moerckia flotowiana*, leaves of *Neckera pennata*

unequal: of different size, asymmetric

unicellular: having only one cell

unidirectional diversity/dispersal hypothesis: hypothesis that downstream spread of propagules by water of aquatic and riparian plant species, without upstream compensation, can be expected to result in downstream accumulation of population genetic diversity

unilateral: one-sided

uniseriate: having only one cell layer

unisexual: having male and female reproductive structures on different individuals; having only one sex on individual; monoicous

unistratose: one-layered; comprised of single cell layer

univoltine: only one generation per year

upland: area of high or hilly land

upper: relative to moss leaf, face oriented towards axis of stem (=ventral, adaxial); relative to liverwort thallus, dorsal face; referring zone of leaf (upper leaf), distal third of leaf

upper montane cloud forest: generally tropical or subtropical, evergreen, montane, moist forest characterized by persistent, frequent, or seasonal low-level cloud cover, usually at canopy level,

upstream: in opposite direction from that in which stream or river flows; nearer to source

urceolate: relative to capsule : narrowed below mouth

urn: spore-bearing portion of capsule (= theca)

uronic acid: sugar acid with both carbonyl and carboxylic acid functional groups; important in creating cation exchange sites

V

V chromosome: male chromosome of bryophytes (see also **U chromosome**)

Vaccinium heath: habitat dominated by *Vaccinium* shrubs like blueberry

vacuole: space or cavity in protoplasm, filled with watery solution and enclosed by membrane

vaginate: sheathing

vaginula: bottom part of archegonium when calyptra separates; foot of sporophyte is imbedded in vaginula; sheath surrounding base of seta, *e.g.* at base of seta of *Orthotrichum stramineum*

valley: low area of land between hills or mountains, usually with stream or river flowing through it

valley (small): small, low area of land between hills or mountains, usually with stream or river flowing through it

valvate: separating into sections or flaps upon dehiscence

valve: in liverworts & some mosses, sections of capsule that split apart at maturity

var.: abbreviation meaning "variety"

variety: lowest genetically different level of classification

várzea forest: term exclusive to Amazonia, seasonal floodplain forest inundated by whitewater rivers

vector: in biology, carrier, such as flies that carry spores in *Splachnum*; in genetic engineering, bacterium, virus, or other organism, used to deliver new gene to cell of different organism

vegetative: asexual parts of plant

vegetative leaf: leaves except those surrounding sexual organs

vegetative propagation: reproduction from non-sexual parts of plants, such as fragments

venter: swollen basal portion of archegonium, containing egg

ventral: lower or under surface; on leaves, upper surface; on thallus or stem of liverworts and hornworts, underside

ventral canal cell: cell at base of neck of archegonium; disintegrates before fertilization

vernacular name: common name; name used locally instead of Latin name

vernal dam hypothesis: prediction that spring herbs sequester nutrients during spring when they have maximum growth, thus serving as sinks that retain nutrients that might otherwise be lost during runoff; might be present in bryophytes as well

vernalization: change in physiological state induced by chilling; requirement in germination in some plant species

vernier scale: small, movable, graduated scale running parallel to fixed graduated scale, used for measuring fractional part of one of divisions of fixed scale

verrucose: covered with warts or wart-like projections

vertices: points where three or more cells contact

vesicle: membranous sphere involved in transport or storage in cell; swollen end cells, thought to be storage organs for food reserves in fungi

viability: durability; ability to survive, germinate, or resume growth

vineyard: plantation of grapevines

violaxanthin: xanthophyll pigment in plants, formed in dark and converted to zeaxanthin in red light

violent: life strategy for aggressive (competitive) species

violet: color between blue and purple; color of amethyst, lavender and beautyberries

vital stain: dye, or series of dyes, used to stain cells and tissue for observation under microscope without killing them

vitricification: preservation at extremely low temperatures without freezing; involves formation of glassy or amorphous solid state which, unlike freezing, is not intrinsically damaging even to most complicated of living systems; *e.g.* when sucrose is cooled slowly it results in crystal sugar (or "rock candy"), but when cooled rapidly it can form syrupy "cotton candy" or lollipops

vittae: row of elongated cells down center of leaf, only one cell deep

V_{max}: reaction rate when enzyme is fully saturated by substrate

volatile: evaporating rapidly; diffusing freely into atmosphere, as attractant in *Splachnum* capsule

volemitol: naturally occurring seven-carbon sugar alcohol, widely distributed in plants, red algae, fungi, mosses, lichens, and some leafy liverworts

vortex ring: self-sustaining flow field that can carry one fluid (in this case, mass of spores) through another (in this case, surrounding atmosphere) without significant drag; used by *Sphagnum* in spore dispersal from capsule

VU: vulnerable (IUCN)

W

wall: continuous brick or stone structure; partition surrounding cell

Wardian case: early type of terrarium, sealed protective glass container for plants, with great use in 19th century in protecting foreign plants imported to Europe from overseas

warning color: aposematism; advertising by animal to potential predators that it is not worth attacking or eating

water: medium in lakes, ponds, pools, streams, rivers, etc; rainfall; freezes into snow or ice

water capacity: percent of wet mass relative to dry mass

wattle wall: woven wall daubed with sticky material; mosses may be used in weave

wax: long chain hydrocarbon with little oxygen; contained in cuticle covering vascular plant surfaces

WC₅₀: percent water content at which 50% of plants would recover if dried to their compensation point

weft: loosely interwoven, often ascending life form; new layer grows each year; *e.g.* habit of *Thuidium tamariscinum*; see Mägdefrau life forms

wetland: distinct ecosystem that is flooded by water, either permanently or seasonally, where oxygen-free processes prevail

wetland drainage: area where water covers soil, or is present either at or near surface of soil, is drained by such mechanisms as ditches to create dry land

wetting agent: chemical that can be added to liquid to reduce its surface tension and make it more effective in spreading over

and penetrating surfaces, *e.g.* soap; used to help water spread on dried bryophytes

wheat field: agricultural field where wheat is or was grown

widespread: common over wide area

windfall: something (as tree) blown down by wind

window-pane trap: insect trap made with clear plexiglass to serve as barrier over container of ethylene glycol (anti-freeze); window mounted on wooden frame suspended between two pipes anchored in ground; frame height should be at top of growing vegetation

window trap: piece of window glass set in three-sided wooden frame from which sheet metal trough is hung; trough is filled with fuel oil or water; trap is hung from various types of pole framework depending on location, and guy wires used to keep it from swinging

whiplash flagellum: type of flagellum that lacks lateral appendages

windthrow: fallen tree(s) resulting from wind

wood: substrate of lignified tissues from trees

wooded bog: habitat with peat mosses and trees, with nutrients derived only from precipitation

woods/forest: ecosystem dominated by trees

woodland: tract of land dominated by trees

X

xanthophyll: yellow or orange carotenoid pigment found in algae and plants (Gr. *xanthos* = yellowish brown; *phyllos* = leaf)

xanthophyll cycle: process of enzymatic removal of epoxy groups from xanthophylls (*e.g.* violaxanthin, antheraxanthin, diadinoxanthin) to create so-called de-epoxidized xanthophylls; protective mechanism for photosynthetic apparatus from photodamage caused by light-induced oxidative stress

xanthophyll index: antheraxanthin + zeaxanthin):(violaxanthin + antheraxanthin + zeaxanthin)

xenosomic: using "foreign" materials, as using liverworts to make caddisfly case (ant. = **idiosomic**)

xeric: very dry; referring to habitat

xerochastic: describing peristome teeth that flex and open as surrounding moisture decreases

xerochasy: type of dispersal with falling velocities of less than 1.5 m s⁻¹, unstable atmospheric conditions, and thermal updrafts under low humidity, providing greatest contributions to dispersal

xeromorphic: having structural adaptations to dry conditions

xerophile: dry-loving organism

xerophilous: growing in dry places

xerophyte: plant of dry places

xerophytic: describes plant adapted to dry habitat

xylem: vascular tissue that conducts water and mineral nutrients in lignified plants; composed of tracheids, and in flowering plants (and few others) also vessels

xylicolous: living on wood that has lost its bark

xyloglucan: hemicellulose primary cell wall component; may have been important contribution to ability of bryophytes to invade land

xylose: 5-C monosaccharide of aldopentose type, includes aldehyde functional group

Y

Young's modulus: breaking force and breaking stress; mechanical property that measures stiffness of solid material; defines relationship between stress (force per unit area) and strain (proportional deformation) in material in linear elasticity regime of uniaxial deformation

Z

zeaxanthin: carotenoid pigment; one of xanthophyll pigments; able to deactivate antenna chlorophylls when there is surplus light energy; one of most common carotenoid alcohols and powerful antioxidant

zoobenthos: animals that live on bottom

zoochlorellae: algal symbionts, especially in Protozoa

zoophagy: feeding on animals

zoospore: swimming spore, *i.e.* flagellated

zygomorphic: bilaterally symmetrical [ant. **actinomorphic**]

zygospore: thick-walled resting zygote in some algae and fungi

zygote: product of fusion of two gametes; fertilized egg before it has undergone mitosis or meiosis (Gr. *zygon* = yoke)

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