

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 file, 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
 Persistent Protonemata
 Who Is Travelling?
 Spore Dispersal Mechanisms
 Sporophyte Adaptations for Dispersal
 Role of Peristome
 Cleistocarpy

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

Chapter in Volume 1

- Distance from Source
- 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

Chapter in Volume 1

- Raindrops
- 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
 - Involucre
 - 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

Chapter in Volume 1

- Turtles
- 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
 - Air Chambers
 - Keels
 - Leaf Plications
 - Leaf Cells
 - Papillae
 - An Alternative to Papillae?
 - Stomata
 - 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

Chapter in Volume 1

- Auxins
- Cytokinins
- Factor H
- 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
- Tnema
- Protonemal Gemmae and Tubers
- Liverworts
- Ecological Considerations

Chapter in Volume 1**5-4: Gametophore Buds**

- Establishment Success
- 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

Chapter in Volume 1

- Brood Bodies
- Tubers
- Development
- 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

Chapter in Volume 1

- Light
- Nutrients
- Water Needs
 - 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
 - Rhizoids
- 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

Chapter in Volume 1

- Fungal Partners
- Main Thallus Structure
- Spongy Thallus
- Cuticle
- 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

Chapter in Volume 1

- Contact Angles and Entry
- Combined Role and Water Relations
- Altitude Protection
- Pollution Protection
 - 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

Chapter in Volume 1

- Desiccation from Salt
- Flood Plains
- Arctic and Antarctic
- Forest Floor
- 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

Chapter in Volume 1

- Snow
- The Salmon Story and Other Animals
- Fungal Partners
- pH Relationships
- 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

Chapter in Volume 1

- Nutrient Concentration
- Water Source
- Cation Exchange
 - Polyuronic Acids and CEC
 - 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

Chapter in Volume 1

- P Additions
- Ca and Mg Additions
- Fe Additions
- CO₂ Additions
- 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

Chapter in Volume 1

- Light and Moisture Relations
- Photoinhibition
- Adaptations to High Light
- Structural Adaptations
- 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*
 - Mittenia plumula*
 - Wombat Holes
 - Cave Communities
 - Rockhouses
 - Responses to Low Light in Caves
- Reflectance in the Desert
- Fluorescence and Other Light Emissions
 - Definitions
 - Parts That Fluoresce
 - Which Species Fluoresce?
 - Sources of Fluorescence
 - Role
 - Methodology
 - Prospects
- 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

Chapter in Volume 1

- 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
 - 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

Chapter in Volume 1

- Altering Ecosystems
- Disturbed Habitats
- Grassland
- Tropics
- Polar and Alpine
- Lakes
- Streams
- Peatlands

11 PHOTOSYNTHESIS

11-1: The Process

- 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

Chapter in Volume 1

- 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
 - 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

Chapter in Volume 1

13 DECOMPOSITION

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

Chapter in Volume 2

- 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
- 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

Chapter in Volume 2

- 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
- 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

Chapter in Volume 2

- 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
 - 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

Chapter in Volume 2

Antarctic
 Dispersal Agents?
 Earthworm Culture
 Polychaetes

4-5: Invertebrates: Rotifers

Rotifera – Rotifers
 Reproduction
 Bryophytes as Habitat
 Adaptations
 Physiological Differences
 Surviving Desiccation
 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
 Philodinae
 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 Flosculariacea
 Conochilidae
 Flosculariidae
 Floscularia
 Ptygura
 Hexarthridae
 Testudinellidae
 Order Ploimida
 Trochosphaeridae
 Brachionidae
 Anuraeopsis

Chapter in Volume 2

Brachionus
Kellicottia
Keratella
Notholca
 Dicranophoridae
Albertia
Aspelta
Dicranophorus
Dorria
Encentrum
Pedipartia
Streptognatha
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

Chapter in Volume 2

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

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?

Chapter in Volume 2

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
- 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

Chapter in Volume 2

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
 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

Chapter in Volume 2

- 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
 - 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

Chapter in Volume 2

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)
- 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

Chapter in Volume 2

- Historical Indicators
- Antarctic and Arctic
 - Temperature and Humidity Protection
- Tropics
- Epizootic
- Vertical Distribution
 - Forest Habitat Strata
 - Within Bryophyte Clumps
 - Vertical Migration
 - Elevational Differences
- Seasons
- 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

Chapter in Volume 2

Streams
 Splash Zones
 Cave Pool

10-2: Crustacea – Ostracoda and Amphipoda

CLASS OSTRACODA

Adaptations
 Swimming to Crawling
 Reproduction
 Habitats
 Terrestrial
 Peat Bogs
 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

Chapter in Volume 2

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

Chapter in Volume 2

Springs
 Bogs and Fens
 Collembola – Springtails
 Coleoptera – Beetles
 Odonata – Dragonflies and Damselflies
 Diptera – Flies
 Other Insects
 Lakes and Ponds
 Arctic and Alpine
 Disturbance
 Retention
 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
 Neoephemeridae
 Ephemerellidae – Spiny Crawlers

Seasons

Food

*Ephemerella**Serratella**Teloganopsis**Cincticostella**Drunella**Caudatella**Attenella**Torleya*

Leptohiphidae – 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

Chapter in Volume 2

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
 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 – Macrovelioid 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

Chapter in Volume 2

Lampyridae – Lightning Bugs
 Latridiidae – Minute Brown Scavenger Beetles
 Curculionidae – Weevils
 Lagriidae

11-11: Holometabola – Trichoptera, Suborder Annulipalpia

LEPIDOPTERA

TRICHOPTERA

Drift

Food

Case Building

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

Uenoidae

Phryganeoidae

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

Chapter in Volume 2

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
 Sciariidae – Dark-winged Fungus Gnats
 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

Chapter in Volume 2

- Food Sources
- Bryophytes as Pesticides
- Sampling Methods
 - Field Collection
 - Extraction
- Habitats
 - Bogs and Wetlands
 - Forests
 - Montane Tropical Rainforests
 - Epiphytes
 - Cryptogamic Crusts
 - 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*

Chapter in Volume 2

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

Chorthippus

Nicarchus

Sciaphylacris – 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

Chapter in Volume 2

- Rhyparochromidae – Seed Bugs
- Scutelleridae
- CIMICOMORPHA – 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
 - 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
 - Peloriidae – 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

Chapter in Volume 2

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

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

Bupestroidae

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

Chapter in Volume 2

Scydmaenidae – Ant-like Stone Beetles
 Tenebrionoidea
 Perimylopidae (=Promecheilidae)
 Lagriidae – Long-jointed Beetles
 Tetratomidae – Polypore Fungus Beetles

12-10: Holometabola – Hymenoptera

HYMENOPTERA

Ants

The Phenomenal Ants
 Where Ants Are Absent
 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
 Sphecidae
 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

Chapter in Volume 2**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

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

Hesperiidae – 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

Chapter in Volume 2

Epiphytes
 Harvesting Stowaways
 Altitude

12-18: Holometabola – Diptera Nematocera: Tipuloidea

NEMATOCERA

Cylindrotomidae

Triogma

Diogma

Cylindrotoma

Phalacrocera

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

Chapter in Volume 2

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
 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)

Chapter in Volume 2

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

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)

Chapter in Volume 2

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.
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)

Chapter in Volume 2

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)
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 pernix (Nimble Long-limbed Salamander)
Oedipina (Plethodontidae)
Oedipina carablanca (Los Diamantes Worm Salamander)
Oedipina elongata (Central American Worm Salamander)

Chapter in Volume 2

- 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)
- 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

Chapter in Volume 2

- 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
- 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

Chapter in Volume 2

Tropical Birds
Jamaican Blackbird

16-3: Bird Nests

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

Chapter in Volume 2

- 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

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

Chapter in Volume 2

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
 Leiostichidae – Laughing Thrushes
 Ptilonorhynchidae – Bower Birds
 Acanthizidae – Scrubwrens, Thornbills, and Gerygones
 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

Chapter in Volume 2

- 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
- 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
 - Glaucmys* – Flying Squirrels
 - Glaucmys sabrinus* – Northern Flying Squirrel
 - Glaucmys 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 MAMALS

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

Chapter in Volume 2

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

19 BACTERIA**19-1: Bacterial Effects on Bryophytes**

Bacteria Communities on Bryophytes
 Effects on Bryophytes
 Symbiosis
 Nitrogen Fixation
 Methylobacteria
 CO₂ Source
 Growth Hormones
 Bud Induction
 Growth
 Rhizoids
 Quorum Sensing
 Spore Germination
 Vitamins
 Water Relations
 Freezing Protection
 Nutrients
 Decomposition
 Fauna and Bryophagy
 Pathogens
 Bacterial Source of Antibiotics Useful to Bryophytes
 Speculation

19-2: Bryophyte Bacteria effects on communities

Community Effects
 Streams and Rivers
 Faunal Connections
 Antarctic
 Arctic Alpine
 Boreal Forest
 Peatland Bacterial Flora

Chapter in Volume 2

Methane Oxidation
 Nitrogen Sources
 Comparisons of *Sphagnum* Species
 Antibiotic Role
 Ecosystem Roles
 Decomposition
 Xeric
 Soil Crusts
 Honeybees
 Pollution Relationships
 Reclamation Communities

19-3: Bryophyte Defenses against Bacteria

Defenses Against Bacteria
 Antibiotic Response by Bryophytes
 Habitat Differences?
 Bacterial Defense Partners
 Inducible Defenses
 Antioxidants and ROS
 Differences in Plant Parts
 Defending Others?
 Potential Uses
 Sterilizing Bryophytes

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

Chapter in Volume 3

- Tiny Bryophytes
 - Aquatic Species
 - Drying Specimens
- Field Stains
- Field Gear – Collecting Equipment
 - Attire
 - Collecting Apron
 - Collection Bags
- Hand Lenses (Loupes)
- Field Microscopes
- 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

Chapter in Volume 3

- Ultrasound
- Aquatic Bryophytes
- Dealing with Old Specimens
- Sorting the Plants
- Wetting Agents
- Soap
- Agral 600
- Rehydrating Capsules
- DulcoEase
- Clearing Leaves
- Lactic Acid
- KOH or NaOH
- Chloral Hydrate
- Dehydration
- 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
- Avoiding Air Bubbles
- 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
- Techniques for Special Structures
- Clearing Spores

Chapter in Volume 3

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
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 and Semi-permanent 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
Double Coverslip Method of Kohlmeyer and Kohlemeyer
Lutants – 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

Chapter in Volume 3

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	
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

Chapter in Volume 3

VOLUME 4: HABITAT AND ROLE

Chapter in Volume 4

1 AQUATIC AND WETLAND SPECIES**1-1: Anthocerotophyta**

Anthocerotaceae

Anthoceros
Anthoceros agrestis
Anthoceros caucasicus
Anthoceros punctatus
Aspiromitus
Aspiromitus asper
Aspiromitus bulbosus
Aspiromitus lobatus
Aspiromitus squamulosus
Foliosceros
Foliosceros fuciformis
Foliosceros glandulosus

Dendrocerotaceae

Megaceros
Megaceros flagellaris
Megaceros tjobodensis

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 lunulifolia
Odontoschisma elongatum
Odontoschisma fluitans
Odontoschisma sphagni

Cephaloziellaceae

Cephaloziella

Chapter in Volume 4

Cephaloziella hampeana
Cephaloziella rubella
Kymatocalyx
Kymatocalyx africanus
Kymatocalyx cubensis
Kymatocalyx dominicensis
Kymatocalyx madagascariensis
Kymatocalyx rhizomatica

Lophoziaceae

Lophozia
Lophozia ventricosa
Lophozia wenzelii
Lophoziopsis excisa
Trilophozia quinquedentata
Tritomaria exsecta
Tritomaria exsectiformis

1-3: Marchantiophyta, Order Jungermanniales – Cephaloziineae 2**Scapaniaceae**

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

Chapter in Volume 4

- Balantiopsidaceae
 - Balantiopsis convesiuscula*
- Calypogeiaceae
 - Calypogeia*
 - Calypogeia arguta*
 - Calypogeia azurea*
 - Calypogeia fissa*
 - Calypogeia goebelii*
 - Calypogeia muelleriana*
 - Calypogeia sphagnicola*
 - Calypogeia sullivantii*
- Geocalycaceae
 - Geocalyx graveolens*
- Gymnomitriaceae
 - Gymnomitrium commutatum*
 - Gymnomitrium crenulatum*
 - Marsupella*
 - Marsupella aquatica*
 - Marsupella boeckii*
 - Marsupella emarginata*
 - Marsupella emarginata* subsp. *tubulosa*
 - Marsupella sparsifolia*
 - Marsupella sphacelata*
 - Nardia assamica*
 - Nardia compressa*
 - Nardia geoscyphus*
 - Nardia scalaris*
- Harpanthaceae
 - Harpanthus flotovianus*
- Hygrobilaceae
 - Hygrobilla 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*

Chapter in Volume 4

Solenostoma vulcanicola

1-5: Marchantiophyta, Order Jungermanniales – Lophocoleineae, part 1

Suborder Lophocoleineae

Blepharostomaceae

Blepharostoma trichophyllum

Herbertaceae

Herbertus sendtneri

Lepidoziaceae

Bazzainia denudata

Bazzania praerupta

Bazzania tricrenata

Bazzania trilobata

Hygrolembidium boschianum

Kurzia makinoana

Kurzia pauciflora

Kurzia trichoclados

Lepidozia reptans

Lepidozia trichodes

Zoopsis argentea

Lophocoleaceae

Chiloscyphus

Chiloscyphus pallescens

Chiloscyphus pallescens var. *fragilis*

Chiloscyphus polyanthos

Chiloscyphus polyanthos var. *rivularis*

Hepatostolonophora paucistipula

Heteroscyphus argutus

Heteroscyphus coalitus

Heteroscyphus denticulatus

Heteroscyphus planiusculus

Heteroscyphus zollingri

Lophocolea

Lophocolea bidentata

Lophocolea heterophylla

Lophocolea minor

Lophocolea mollis

Lophocolea semiteres

Pachyglossa

Pachyglossa austrigena subsp. *okaritana*

Pachyglossa dissitifolia

Pachyglossa tenacifolia

Mastigophoraceae

Mastigophora diclados

1-6: Marchantiophyta, Order Jungermanniales – Lophocoliineae, part 2, Myliineae, Perssoniellineae

Suborder Lophocoleineae

Plagiochilaceae

Pedinopyllum interruptum

Plagiochila

Plagiochila aspleioides

Plagiochila bifaria

Plagiochila porelloides

Plagiochila punctata

Plagiochila renitens

Plagiochila retrospectans

Plagiochila spinulosa

Plagiochilon oppositum

Trichocoleaceae

Trichocolea tomentella

Suborder Myliineae

Chapter in Volume 4

Myliaceae

*Mylia anomala**Mylia taylorii*

Suborder Perssoniellineae

Schistochilaceae

*Schistochila aligera***1-7: Marchantiophyta, Order Porellales – Jubulineae part 1**

Porellales – Suborder Jubulineae

Frullaniaceae

*Frullania asagrayana**Frullania riparia**Frullania tamarisci**Frullania teneriffae*

Jubulaceae

*Jubula hutchinsiae**Jubula hutchinsiae* subsp. *pennsylvanica**Jubula hutchinsiae* var. *integrifolia*

Lejeuneaceae

*Acanthocoleus aberrans**Bromeliophila**Bromeliophila helenae**Bromeliophila natans**Cephalantholejeunea temnanthoides**Ceratolejeunea temnantha**Cheilolejeunea clypeata**Cololejeunea biddlecomiae**Cololejeunea calcarea**Cololejeunea hodgsoniae**Cololejeunea madothecoides**Cololejeunea microscopica**Cololejeunea rossettiana**Cololejeunea stotleriana**Colura**Colura calyptrifolia**Colura irrorata**Diplasiolejeunea cavifolia***1-8: Marchantiophyta, Class Jungermanniopsida, Order Porellales – Jubulineae part 2**

Porellales – Suborder Jubulineae

Lejeuneaceae, cont.

*Drepanolejeunea hamatifolia**Harpalejeunea molleri**Lejeunea**Lejeunea aloba**Lejeunea eckloniana**Lejeunea jurana**Lejeunea lamacerina**Lejeunea patens**Lejeunea polyantha**Lejeunea subaquatica**Lejeunea topoensis**Lopholejeunea nigricans**Myriocoleopsis**Myriocoleopsis fluviatilis**Myriocoleopsis gymnocoleopsis**Myriocoleopsis minutissima**Myriocoleopsis minutissima* subsp. *myriocarpa**Myriocoleopsis vuquangensis**Ptychanthus striatus* var. *intermedius**Schusterolejeunea inundata*

Chapter in Volume 4

1-9: Marchantiophyta, Class Jungermanniopsida, Order Porellales – Porellaceae

Porellales – Suborder Porellineae

Porellaceae

Porella cordaeana

Porella pinnata

Porella platyphylla

Porella platyphylloidea

1-10: Marchantiophyta, Class Jungermanniopsida: Radulaceae & Ptilidiaceae

Porellales – Suborder Porellineae

Radulaceae

Radula aquilegia

Radula carringtonii

Radula complanata

Radula holtii

Radula lindenbergiana

Radula obconica

Radula prolifera

Radula voluta

Radula wichurae

Ptilidiales

Ptilidiaceae

Ptilidium ciliare

Ptilidium pulcherrimum

1-11: Marchantiophyta, Order Metzgeriales: Aneuraceae

SUBCLASS METZGERIIDAE

Order Metzgeriales

Aneuraceae

Aneura

Aneura maxima

Aneura mirabilis

Aneura pinguis

Lobatiriccardia

Lobatiriccardia alterniloba

Lobatiriccardia athertonensis

Lobatiriccardia coronopus

Lobatiriccardia oberwinkleri

Lobatiriccardia verdoornioides

Lobatiriccardia yakusimensis

Lobatiriccardia yunanensis

Riccardia

Riccardia aequicellularis

Riccardia chamedryfolia

Riccardia crassiretis

Riccardia crenulata

Riccardia diminuta

Riccardia elata

Riccardia graeffei

Riccardia jackii

Riccardia marginata

Riccardia multifida

Riccardia multifidoides

Riccardia parvula

Riccardia singaporensis

Riccardia subexalata

Riccardia tenuis

Riccardia tjobodensis

Riccardia wettsteinii

1-12: Marchantiophyta, Order Metzgeriales: Metzgeriaceae and Calyculariaceae

Chapter in Volume 4

SUBCLASS METZGERIIDAE

Metzgeriales: Metzgeriaceae

*Metzgeria**Metzgeria conjugata**Metzgeria furcata*/*Metzgeria setigera**Metzgeria litoralis**Metzgeria pubescens*

Metzgeriales: Calyculariaceae

*Calycularia crispula**Calycularia laxa***1-13: Marchantiophyta, Order Fossombroniales part 1**

SUBCLASS PELLIIDAE

Fossombroniales: Fossombroniaceae

*Fossombronia**Fossombronia angulosa**Fossombronia australis**Fossombronia caespitiformis* subsp. *multispira**Fossombronia cristula**Fossombronia delgadilloana**Fossombronia foveolata**Fossombronia incurva**Fossombronia isaloensis**Fossombronia jostii***1-14: Marchantiophyta, Order Fossombroniales part 2**

SUBCLASS PELLIIDAE

*Fossombronia mylioides**Fossombronia peruviana**Fossombronia porphyrorhiza**Fossombronia pusilla**Fossombronia renateae**Fossombronia texana**Fossombronia wondraczekii**Fossombronia wrightii***1-15: Marchantiophyta, Order Pallaviciniales**

SUBCLASS PELLIIDE

Pallaviciniales: Hymenophytaceae

Hymenophyton flabellatum

Pallaviciniales: Pallaviciniaceae

*Jensenia decipiens**Pallavicinia**Pallavicinia indica**Pallavicinia levieri**Pallavicinia lyellii***1-16: Marchantiophyta, Order Pelliales**

SUBCLASS PELLIIDAE

Pelliales: Pelliaceae

*Pellia**Pellia appalachiana**Pellia endiviifolia**Pellia epiphylla**Pellia neesiana***1-17: Marchantiophyta, Class Marchantiopsida: Order Blasiales**

MARCHANTIOPSISIDA

Blasiidae – Blasiales

Blasiaceae

Blasia pusilla

Chapter in Volume 4

Distribution
 Aquatic and Wet Habitats
 Physiology
 Adaptations
 Reproduction
 Role
 Symbiotic Interactions
 Interactions with Fungi
 Biochemistry

1-18: Marchantiophyta, Order Lunulariales

MARCHANTIOPSIDA

Marchantiidae – Lunulariales

Lunulariaceae

Lunularia cruciata

Distribution
 Aquatic and Wet Habitats
 Physiology
 Pollution
 Adaptations
 Reproduction
 Uses
 Herbivory
 Interactions
 Biochemistry

1-19: Aquatic and Wet Marchantiophyta, Class Marchantiopsida: Aytoniaceae

Aytoniaceae

*Asterella africana**Asterella khasyana**Mannia fragrans**Mannia triandra**Reboulia hemisphaerica***1-20: Aquatic and Wet Marchantiophyta, Class Marchantiopsida: Conocephalaceae, part 1**

Conocephalaceae

Conocephalum conicum

Distribution
 Aquatic and Wet Habitats
 Stream and River Banks
 Springs
 Waterfalls
 Non-Aquatic Habitats
 Physiology
 Adaptations
 Reproduction
 Fungal Interactions
 Animal Interactions
 Biochemistry

Conocephalum orientale

Distribution
 Aquatic and Wet Habitats
 Physiology
 Adaptations
 Reproduction
 Biochemistry

Chapter 1-21: Aquatic and Wet Marchantiophyta, Class Marchantiopsida: conocephalaceae, part 2*Conocephalum purpureorubrum*

Distribution
 Aquatic and Wet Habitats
 Non-Aquatic
 Physiology
 Reproduction
 Biochemistry

Chapter in Volume 4

Conocephalum salebrosum

- Distribution
 - Aquatic and Wet Habitats
 - Stream and River Banks
 - Canyon Walls
 - Floodplains
 - Waterfalls
 - Non-Aquatic Habitats
- Physiology
- Adaptations
- Reproduction
- Animal Interactions
- Fungal Interactions
- Biochemistry

Bryophyta

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
 - 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

Chapter in Volume 4

- 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
 - 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

Chapter in Volume 4

- 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
 - 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

Chapter in Volume 4

- 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

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
 - Pantropical 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

Chapter in Volume 4

- 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

8-5: Epiphyte Geographic Diversity

- Diversity
 - Australia
 - Asia
 - African Region
 - Neotropics

8-6: Epiphylls

- Epiphyllous Communities
- Fossil Records
- Biomass Contributions
- Microclimate
- Colonization
- Succession
- Host Preference
- Growth Structure
- Bryophyte Adaptations
 - Morphology
 - Water Relations
 - Life Cycles
 - Neoteny
 - Life Strategy Types
- Host Adaptations
 - Drip Tips
 - Leaf Size and Shape
 - Leaf Age
 - Leaf Longevity
 - Leaf Chemistry
- Interactions
 - Nutrient Exchanges
 - Host Leaf Leachates

Chapter in Volume 4

- Bryophyte Leachates
- Seed Beds
- Nitrogen Fixation
- Herbivore Protection
- Micro-organisms
- Negative Impacts on Leaves
- Light Interference
- Species Richness
 - Asia
 - South Pacific Islands
 - Africa
 - Neotropics
 - Central America
 - South America
- Bromeliad Basins
- Fragmented Habitats
- 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
 - 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

Chapter in Volume 4

- 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
 - 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

Chapter in Volume 4

Conservation Issues
Current Status

18 CAVES

18-1: Caves – The Environment

Caves
Terminology
Terms Used to Describe Caves
Ecotones
Cave Conditions
Substrate
Light
Temperature and Humidity
CO₂
Suitability for a Flora and Fauna
Radiation
Algific Caves
Non-Bryophyte Flora
Microbes
Cyanobacteria and Algae
Fungi 18-1-**Error! Bookmark not defined.**

18-2: Caves – Overall Bryophyte Flora

Bryophyte Flora
Overall
Studied Caves
Refugia
Distance
Numbers of Species
Species
Zonation

18-3: Caves – Zones of Bryophyte Flora

Habitat Differences
Cave Mouth Area
Entrance
Twilight Zone
Stalactites and Stalagmites
Vertical Shafts

18-4: Caves – Bryophyte strategies

Rare Specis and New Finds
Liverworts
Cyathodium cavernarum
Mosses
Bartramia ithyphylla
Cyclodictyon laetevirens
Didymodon glaucus
Epipterygium koelzii
Eucladium verticillatum
Eurhynchium hians
Homalia webbiana
Mittenia plumula
Schistostega pennata
Takakia lepidozoides
Tetradontium brownianum
Timmia norvegica/Timmia sibirica
Bryophyte Adaptations
Responses to Low Light
Reproduction

Chapter in Volume 4**18-5: Caves – Caverns**

Caverns

- Cave Lamp Communities (Lampenflora)
 - Succession
 - Species Numbers
 - Dominant Species
 - Modifications of Cave Dwellers
 - Life Strategies
 - Propagation and Survival
- Conservation and Control Measures
- Human Impacts
 - Treatments – Chemical
 - Treatments – Alternative Lighting Regimes
 - Pollution and Role of Bryophytes

18-6: Caves – similar secluded habitats

- Artificial Caves
 - Mine Shafts
 - Subways
- Small Caves and Fissures
- Scree
- Ice Caves
- Windholes
- Sinkholes
- Karstification
 - Bryokarst
- Waterfall Caves
- Other Bryophyte Roles
- Cave Fauna Interactions with Bryophytes
 - Copepods
 - Insects
 - Other Arthropods
 - Salamanders
 - Frogs
 - Reptiles
 - Birds
 - Mammals
- Sampling Methods

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

Chapter in Volume 5

- Flavoring
- Chinese Gallnuts
- Food Improvement
- Food Preservation
- Cookery and Pottery
- Packing
- Burial Wreath

2 MEDICINES AND ANTIBIOTICS

- New Medical Sources
- Herbal Medicines
 - Medicinal Teas
 - Liver Ailments
 - Stones
 - Ringworm
 - Heart and Cardiovascular Medicine
 - Nosebleeds
 - Neurological Conditions
 - Inflammation and Fever
 - Urinary and Bowel Treatments
 - Gynecology
 - Disinfectant and Infections
 - Nose and Throat
 - Lung Diseases
 - Skin Ailments and Burns
 - Eye Problems and Diseases
 - Ear Ache and Hearing Problems
 - Hair Treatments
 - Sedatives
 - Antidotes
 - Filters
- Surgical and Laeger Wounds
- Breaking News

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

Chapter in Volume 5

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
 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

Chapter in Volume 5

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

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

Chapter in Volume 5

- Sources
- Lawns
- Special Use Species
 - Lawn Species
 - Sun Species
 - Wall Species
 - Path Species
 - Erosion Control
- Cultivation
- Winter Culture
- Moss Plantations
- Transplanting
- 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