

2008 ABLs Conference

Asilomar, California

Meeting Organizers

Karen Renzaglia

Scott Schuette

Field Trip Leaders

James Shevock

Ken Kellman

Symposia Organizers

Scott Schuette

David Wagner

Jim Shevock

Workshop Organizer

Roxanne Hastings

Special thanks

Ted Esslinger

Thomas Nash

Tamyra d'Artenay



American Bryological and Lichenological Society

Abstracts

Asilomar, California

2008



1. *ANTEROLA, ALDWIN

Dept. of Plant Biology, Southern Illinois University, Carbondale, IL 62901

Evolution of gibberellin biosynthesis and function: lessons learned from *Physcomitrella patens*

Gibberellins mediate developmental processes in plants, including seed germination, flower development and vegetative growth. Bryophytes, however, do not have seeds or flowers, which calls into the question the role of gibberellins in these plants. Inspection of the sequenced genome of the moss *Physcomitrella patens* revealed the presence of putative gibberellin biosynthetic genes. Among these genes, kaurene synthase, which catalyzes the first step of the gibberellin pathway, was functionally characterized, and was found to be inhibited by AMO-1618. The effects of AMO-1618 on antheridia formation and spore germination were then tested on *P. patens*, since gibberellins induce spore germination and serve as antheridiogens in some ferns. AMO-1618 did not affect antheridia formation in *P. patens*, whereas spore germination was suppressed. Hence, as plants evolved, we also see the functional evolution of gibberellins, i.e. from being a spore germination inducer in mosses, an antheridiogen in ferns, and a growth hormone in angiosperms.

2. BASSI, PAOLA¹, BASILE, ADRIANA², and *CONTE, BARBARA²

¹University of Rome “La Sapienza”, Department of Plant Biology, 00185, Rome, Italy; ²University of Naples Federico II, Department of Biological Science – Sez. of Plant Biology, Via Foria 223, 80139 Naples, Italy.

Heritable metal-induced repetitive DNA variations in *Funaria hygrometrica* protonema

Previous data (Bassi et al. - Plant Bios., 2006, 140:80/86) have shown that heavy metal stresses cause a selective amplification

30. *WIDHELM, TODD, EGAN, ROBERT and LIVSHULTZ, TATYANA

University of Nebraska at Omaha, Department of Biology, Allwine Hall, 6001 Dodge Street, Omaha, Nebraska 68182-0040, USA

Testing species delimitations in the *Parmotrema perforatum* group in eastern North America

The current taxonomy of the *Parmotrema perforatum* group recognizes six closely related species divided into three species pairs, each with an apotheciate and a sorediate species. Each pair has a distinct combination of lichen acids. This species delimitation has been reexamined using 30 unique alleles of the *glyceraldehyde-3-phosphate dehydrogenase* locus from 53 individual thalli from eight populations in Texas, Louisiana and North Carolina. Population aggregation analysis of Texas and Louisiana populations suggests that the *Parmotrema perforatum* group is instead two phylogenetic species. One phylogenetic species is fixed for norstictic acid and polymorphic for stictic acid, and the other species is fixed for alectoronic acid. Both species are polymorphic for apothecia and soredia, suggesting that sorediate thalli are part of the same sexually reproducing population as apotheciate thalli. There is also evidence suggesting that the norstictic acid-containing strain of *P. subrigidum* is a hybrid between the two recognized phylogenetic species.

impact when the percentage of ammonium content in cell wall was above 70%, that of the cell. This was observed through changes in membrane permeability and through lower efficiency of the Photosystem II. (Poster: Nutrient Exchange)

29. WELCH, REBECCA

University of California, Berkeley, Department of Integrative Biology and University and Jepson Herbaria, 3060 Valley Life Sciences Bldg #3140, Berkeley, California, 94720-3140, USA

Resource-niche specialization in the *Nostoc*-hornwort symbiosis

Does resource-niche specialization play a role in the *Nostoc*-hornwort symbiosis? Or are *Nostoc* genotypes niche generalists, jack-of-all-trades widely adept at various lifestyles from free-living to symbiotic? In order to discover if genetic variation in *Nostoc* is correlated with lifestyle, *Nostoc* will be sampled from five potential niche spaces; free-living on the soil, as symbiotic endophytes within thalli of the hornworts *Anthoceros fusiformis* and *Phaeoceros pearsonii*, and in biofilms epiphytic to the ventral thallus surface of both hornwort species. Three locations in Del Norte County, California will be surveyed. Four genes will be sequenced, the phylogenetically informative 16S and recA, and Nif D and Nif H, which are involved in symbiotic interaction. Analysis of genetic structure and correlation to resource niche, as well as phylogenetic congruence between the markers will be discussed.

of GC-rich repetitive/non coding DNA sequences in *F. hygrometrica* gametophytes. This DNA amplification stops after removal of the metal from the culture medium and the metal-induced DNA is eliminated from the cells. In the present work we have attempted to look for a correlation between this metal-induced repetitive DNA behaviour and the age of the moss; we analysed the genome response to metal-stress in different stages of *F. hygrometrica* development. Our results, obtained by diverse experimental approaches, showed that a direct relationship between metal-induced repetitive DNA behaviour and moss age effectively exists; in fact, when metal-stress is present in an earlier phase of the moss development, such as the protonemantic phase, then 85% of the metal-induced repetitive DNA is not eliminated from the moss genome after removal of the stress conditions. We discuss some hypotheses.

3. *COE, KIRSTEN¹, BELNAP, JAYNE², and SPARKS, JED³

¹, ³Cornell University, Department of Ecology and Evolutionary Biology; ²USGS Canyonlands Research Station, Moab, UT, 84532

Physiological ecology of the desert moss *Syntrichia caninervis* after long-term exposure to elevated CO₂: changes in photosynthetic thermotolerance?

Climate change predictions affirm that plants will soon encounter higher temperatures and elevated CO₂, yet the physiological effect of these conditions occurring simultaneously has not been fully explored, especially among bryophytes. We examined the combined effects of long-term (10 year) CO₂ enrichment and increased temperatures on the biological soil crust moss *Syntrichia caninervis* growing in otherwise natural conditions in the Mojave Desert. When compared to individuals grown in ambient conditions, moss exposed to elevated CO₂ exhibited a 46% decrease in chlorophyll content, a 20% increase in tissue C, and no difference in either N content or photosynthetic performance. When subjected to stressful temperatures (35-40 °C), elevated CO₂-grown moss showed higher photosynthetic performance and photosystem II (PSII)

efficiency than those grown in ambient conditions, suggesting elevated CO₂ induced photosynthetic thermotolerance possibly resulting from reallocation of N to cellular components that offer a higher resistance of PSII to heat stress.

4. CRUZ DE CARVALHO, R.¹, MARQUES DA SILVA, J.¹, and *BRANQUINHO, C.²

¹Universidade de Lisboa, Faculdade de Ciências, Departamento de Biologia Vegetal and Centro de Engenharia Biológica, Campo Grande, Edifício C2, Piso 4. 1749-016 Lisboa, Portugal; ²Universidade de Lisboa, Faculdade de Ciências, Centro de Biologia Ambiental, Campo Grande, Edifício C2, Piso 5, Sala 37, 1749-016 Lisboa, Portugal.

Desiccation caused respiratory burst upon rehydration in *Fontinalis antipyretica*

Although aquatic, the bryophyte *Fontinalis antipyretica* may be periodically affected by desiccation events namely during the dry season in Mediterranean areas. In order to study the effect of desiccation on this aquatic moss, some samples were dehydrated to different relative water contents and rehydrated by immersion on water. Conductivity measurements indicated membrane damage which increased with water deficit. Oxygen exchange measurements showed during rehydration a strong respiratory burst fully inhibited by the mitochondrial respiration inhibitor KCN. This burst showed to have a good correlation with conductivity. Gross photosynthesis decreased linearly with relative water content and also showed a good negative correlation with conductivity. Our data suggest different effects on photosynthesis and respiration due to membrane disruption resulting from desiccation. Some explanatory hypotheses are proposed and discussed. (Poster)

the growth, seasonal change, and reproduction of a natural population of *Cryptomitrium tenerum* in the Sonoma Valley, California. Delineated plots were photographed regularly for over two years, revealing that the thalli are desiccation-tolerant, surviving at least one dry season to continue growth when the rains return. Several plots contain associated bryophyte species: photographic analysis allows comparisons of life cycle strategies and reveals changes in species composition over time. Specimens were regularly collected and dissected to track sporophyte development. There appears to be an “internalized” external water conducting system based on tuberculate rhizoids, that will be the subject of further study.

28. VIEIRA, ANA RUTE and *BRANQUINHO, CRISTINA

Universidade de Lisboa, Faculdade de Ciências, Centro de Biologia Ambiental, C2, 5º Piso; Sala 37, Campo Grande, 1749-016 Lisboa, Portugal; *Corresponding author: cmbranquinho@fc.ul.pt

Ammonium (NH₄⁺) uptake and its effects on membrane integrity and chlorophyll fluorescence in aquatic moss *Fontinalis antipyretica*

Eutrophication is one of the main environmental problems in Mediterranean streams, especially in rural areas due to increasing livestock production. Aquatic bryophytes such as *Fontinalis antipyretica* have been widely used as biomonitors of stream water quality but with focus on metals. In this work we intend to study the pattern of intra and extracellular uptake of ammonium (NH₄⁺) and its impact on moss physiology, in order to give a better insight into the use of these organisms as biomonitors of stream water eutrophication. For that, we submitted moss samples to increasing NH₄⁺ concentrations and measured the ratio of variable fluorescence and maximal fluorescence (F_v/F_m) of chlorophyll α and the membrane integrity through loss of intracellular K concentration. The results obtained in controlled conditions were compared with results obtained in the field after exposing moss transplants in different streams with intensive agriculture activities. Both under field and lab conditions, we found a significant physiological

26. THOMAS, ROBERT J.

Bates College, Department of Biology, 44 Campus Ave., Lewiston, ME 04240, USA

Evidence that phytochrome mediates elongation of *Pellia* sporophytes

Light is one of several important environmental factors influencing the rapid spring-time elongation of *Pellia epiphylla* (L.) Corda sporophytes. Blue light stimulated phototropic curvature of sporophyte setae is well documented. Documentation for possible red (R) and far red (FR) light effects on sporophyte growth is lacking. In this study, thalli bearing sporophytes with 1-cm long setae were subjected to either FR light or FR followed by R light flashes at the end of 12-hour cool white fluorescent light photoperiods. End of day FR light treatment markedly stimulated seta elongation relative to controls. FR followed by R light treatment led to corresponding reduction in stimulation. When continuously illuminated with FR light, stimulated rates of seta elongation were also observed. These results suggest that elongation of *Pellia* sporophytes is mediated in part by phytochrome. Because these plants grow in FR-enhanced shady habitats, greater elevation of spores for dispersal may be one beneficial consequence.

27. TREMBLAY, SUSAN

University of California at Berkeley, Department of Integrative Biology and University Herbarium, 1001 Valley Life Sciences Building, Berkeley, CA 94720-3140

Phenology of *Cryptomitrium tenerum*, a complex thalloid liverwort

Many complex thalloid liverworts flourish in Mediterranean climates; however, how they cope with temperature extremes and long periods of drought is not well understood. Additionally, phenological studies of liverworts are rare. This study looks at

5. *D'ARTENAY, TAMRYA D.¹, RENZAGLIA, KAREN S.¹, and GATES, HILARY D.²

¹Department of Plant Biology, Southern Illinois University, Carbondale, IL, 62901, USA; ² IMAGE Center, Southern Illinois University, Carbondale, IL, 62901, USA

The sperm cell of *Aneura pinguis*: a novel architecture in liverworts

The sperm cell of *Aneura pinguis* (L.) Dumort. is the first of the Metzgeriidae II to be reconstructed at the mature state and has many autapomorphies. The cell is a narrow cylinder that coils 3.5 gyres in a left-hand direction. It averages 95 μm in length and the condensed cylindrical nucleus measures 0.6 μm in maximum diameter. The two flagella are inserted in a staggered orientation, with the anterior basal body on the right front-end of the cell and the posterior basal body nearly one-half revolution beyond. The spline is 15-17 microtubules in width throughout the cell, and extends to the right side of the anterior mitochondrion and nucleus, but then follows the top of the posterior mitochondrion and plastid. Unlike any other liverwort examined to date, the sperm cell of *Aneura* has a spline that is consistent in width throughout, a massive starch-filled plastid that parallels the nucleus, and a prominent nucleus that terminates the cell. These unique characteristics have implications in fertilization and gamete evolution.

6. EPPLEY, S.M. and ROSENSTIEL, T.N.

Portland State University, Department of Biology, P.O. Box 751, Portland, Oregon, 97207-0751, USA

Geothermal bryophytes: exploring the physiological limits to sexual reproduction

Understanding the processes controlling the evolution and maintenance of sex is a key unresolved problem in biology. However, relatively few studies have experimentally examined the relationship between environmental stress and sexual

reproduction in natural systems. Fewer still have sought to determine what limits sexual reproduction at the extreme edge of life. Recently, we have begun to examine the processes controlling sexual reproduction in bryophyte species growing near the thermal limits of plant life on geothermal hot-springs in Lassen Volcanic National Park (CA). Across our experimental sites we have found that sporophytes were most common in non-geothermal sites, but very rare in high temperature geothermal sites. Yet, we have observed gametophytes growing with soil surface temperatures of 69 °C, while maintaining average predawn PSII efficiencies of 0.6 ± 0.02 . Results also suggest sperm are stress tolerant; sperm lifespan did not significantly vary in experiments with temperatures from 22-60 °C.

7. GRAHAM, LINDA¹, GRAHAM, JAMES¹, and *COOK, MARTHA²

¹University of Wisconsin-Madison, Department of Botany, Birge Hall, 430 Lincoln Drive, Madison, Wisconsin 53706, USA; ²Illinois State University, Department of Biological Sciences, Campus Box 4120, Normal Illinois, 61790-4120, USA.

Resistant tissues of modern liverworts resemble Early Paleozoic microfossils

Specimens of the modern simple thalloid liverwort *Blasia pusilla* were treated with acetolysis to simulate the harsh conditions plants would have encountered as they became part of the fossil record. Specimens treated with UVA light prior to acetolysis displayed pink cell walls and produced 3.5 times more resistant carbon than did untreated specimens. Resistant tissues that survived the treatment were in the form of tubes (rhizoids) and sheets of cells (gemmae and gametangial jackets) that have phenolic-type autofluorescence and resemble enigmatic Cambrian-Devonian microfossils. These results expand on our previous work demonstrating that degraded mosses (Graham et al. 2004a) and complex thalloid liverworts (Graham et al. 2004b) resemble ancient microfossils and may serve as proxies for estimating the amount of carbon sequestered by the earliest plants. They also provide evidence that physiological responses

with any algae. In combination with spore data, these discoveries indicate that embryophytes may have evolved through the serial acquisition of adaptations to the subaerial landscape and that the upright, axial sporophyte, whose morphology is a direct outcome of embryonic development, was perhaps the last of such adaptations. Conceptually, this enables us to use the fossil record to explore in more detail the charophyte-embryophyte transition. It implies that a class of land plants existed before the embryophytes and suggests that two terms should no longer be regarded as synonymous. (poster)

25. *STROTHER, PAUL K.¹ and TAYLOR, WILSON A.²

¹Department of Geology & Geophysics, Weston Observatory, Boston College, 381 Concord Road, Weston MA 02493 USA; ²Department of Biology, University of Wisconsin – Eau Claire, 105 Garfield Avenue, P.O. Box 4004, Eau Claire, WI 54701-4004 USA.

Cryptospores and the evolution of sporogenesis in bryophytes

Axial plants are preceded in the geologic column by a 100 Myr record of cryptospore monads, dyads and tetrads. Cambrian dyads and tetrads are typically enclosed in a common synoecospore wall comprised of one to three discrete laminae. Others possess multilaminate walls, similar to *Riccia*. Many Cambrian cryptospores are dispersed as dyads and dyad pairs; tetrahedrally-arranged meiospores do not appear in the fossil record until Middle Ordovician. The fossil record indicates that meiotic sporogenesis evolved over time and was not a singular evolutionary event. This conclusion is supported by the work of Shimamura and others who noted in 2004 that the control of spindle formation (MTOCs) in bryophytes, varies from algal-like (centriolar) to higher-plant-like (diffuse). Embryophytes may have evolved from charophytes through the serial acquisition of structures (characters) associated with selection in subaerial habitats – a proposition that is also supported by recent discoveries of Cambrian fragmentary plant remains. (*symposium* “What’s new about the oldest lichens and bryophytes”)

Physcomitrella patens is the ideal organism for studying sporogenesis in early land plants. Our study investigates the complete process of sporogenesis, with special emphasis on spore wall development, in this model moss using light, fluorescence, and transmission electron microscopy. Archesporial cells are monoplastidic and give rise to sporocytes that separate from each other, expand in diameter and are suspended in the capsule. During meiosis sporocytes are deeply lobed and cytokinesis is synchronized. Nearly mature spores exhibit a two-layered wall consisting of an intine and a thin homogeneous exine. The intine, an amalgam of pectins and cellulose, doubles in thickness to form a proximal aperture. Using immunogold labeling we show for the first time that callose is present in the moss aperture. The smooth exine is impregnated with sporopollenin and does not contribute to the external morphology. A perine, which determines spore ornamentation, is deposited from degradation of inner capsule wall cells in the final stages of development. We identify putative spore wall development genes using comparative genomic methods with *Arabidopsis*. CalS5, a callose synthase gene implicated in exine development of the pollen wall, is orthologous to a gene in *Physcomitrella*, a likely candidate for the gene involved in callose production in the aperture. Interdisciplinary studies such as this are essential for determining genetic control of complicated morphogenetic processes such as sporogenesis and will lead to a clearer understanding of the major evolutionary events in early terrestrial radiation.

24. STROTHER, PAUL K.

Department of Geology & Geophysics, Weston Observatory, Boston College, 381 Concord Road, Weston MA 02493 USA.

Fragments of Cambrian land plants

Fragmentary organic remains from strata of middle and late Cambrian age include: three kinds of cuticles associated with spore masses, masses of filaments with oblique cross walls, globular and elongate membranous sacs (sporangia). Such features are more closely aligned with bryophytes than they are

to environmental variables may affect the amount of carbon sequestered by these plants.

8. FISHER, KIRSTEN M.

National Evolutionary Synthesis Center, Duke University, 2024 West Main St. Suite A200, Durham, NC 27705, USA

A phylogenetic perspective for plant genomics: some examples from the complex trait of desiccation tolerance

With the advent of unprecedented access to genomic sequence data for plants, including the moss *Physcomitrella patens*, new and exciting opportunities have arisen for addressing broad questions in plant evolution. Here I review some of the different sources of genomic and functional data that are now available for plants, and present some examples of the types of evolutionary questions that can be explored by analyzing these data with tools borrowed from phylogenetic systematics and comparative methods. Desiccation tolerance has played an important role in several stages of land plant evolution, and these phylogenomic approaches may help to resolve ongoing questions regarding the genomic and functional origins of this complex trait.

9. *GOLINSKI, G. KAREN¹, RYAN, MICHAEL W.², AND LLOYD, DENNIS A.²

¹1409 Franklin Avenue, Nashville, TN, 37206; ²Research Section, BC Ministry of Forests, 515 Columbia St., Kamloops, BC, V2C 2T7

Response of bryophytes to forest harvesting and site preparation treatments in high-elevation forests at Sicamous Creek, British Columbia, Canada.

We examined the effects of conventional logging and site preparation treatments on forest floor bryophyte communities in high-elevation old-growth forests dominated by subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) during the initiation phase (i.e., 0–10 years post-disturbance). Bryophyte cover in control plots

was high compared to other treatment combinations four years after the treatments were implemented, but increased in other treatments between 1999 and 2005. Community composition varied along gradients of increasing cut size and increasing severity of site preparation treatments from control < mound < scalp < burn in both 1999 and 2005. Overall bryophyte species richness and richness of ‘forest bryophytes’ varied little between control plots and other treatment combinations in both 1999 and 2005, but richness of ‘colonist-pioneers’ was significantly higher in mound, scalp, and burn plots than in control plots in both years, regardless of logging treatment. Succession of bryophyte communities appears to be proceeding in two directions.

10. GROEN, KRISTEN E., STIEHA, CHRISTOPHER R., CROWLEY, PHILIP H. and *MCLETCHIE, D. NICHOLAS

Department of Biology, 101 Morgan Building, University of Kentucky, Lexington KY 40506-0225

Sex-specific plant responses to environmental variation: implications for spatial segregation of the sexes.

Spatial segregation of the sexes (SSS) has been of interest to plant ecologists, especially the possible causes of SSS. However, links among sex-specific morphology, physiology, and variation of these plant traits along environmental gradients are rarely made. We investigated these linkages using *Marchantia inflexa*. We hypothesized that males are adapted to higher light conditions and are better able to tolerate water stress than females, because male *M. inflexa* are found in locations of less tree-canopy closure than females. Our study determined how morphology interacted with canopy openness and light intensity to affect photosynthetic rate. Using path analysis, we found that pore density was negatively correlated with canopy openness in both sexes but positively correlated to light intensity in males. For males, variation in pore density was important, and for females, support tissue was important. These results revealed that water stress maybe important in determining sex-specific population structures in *M. inflexa*.

22. *SCHUETTE, SCOTT¹, RENZAGLIA, KAREN¹, WOOD, ANDREW¹, MISHLER, BRENT², AND GEISLER, MATT¹,

¹, Southern Illinois University, 1125 Lincoln Dr. Life Science II Department of Plant Biology-6509, Carbondale, IL 62901-6509 USA; University and Jepson Herbaria, University of California, Berkeley, CA 94720, USA

Phylogenomic analysis of the putative callose synthase gene family in *Physcomitrella patens*: emergent phenomenon of the moss genome project

With the availability of whole genome sequences, in silica comparative analyses across widely divergent plant taxa can be conducted using bioinformatic tools. *Physcomitrella patens*, the first bryophyte genome sequenced, is the placeholder for the base of the land plant tree of life thus allowing the inclusion of early land plants in phylogenomic analyses. Callose is a linear 1,3- β glucan molecule ubiquitous in the embryophyte cell wall that has multiplicity of tissue expression and function. Conclusive evidence of callose in moss sporogenesis inspired a comparative genomic evaluation of the CalS gene family between *P. patens*, *Selaginella*, *Chlamydomonas* and *Arabidopsis*. Through construction of an interspecific gene tree, we demonstrate deep conservation of this functionally critical molecule and identify a *P. patens* gene (*PpCalS5*) with deduced polypeptides nearly identical to *AtCalS5*, a gene known to be involved in pollen exine formation in *Arabidopsis*.

23. *SCHUETTE, SCOTT, WOOD, ANDREW, GEISLER-LEE, JANE, GEISLER, MATT and RENZAGLIA, KAREN

Southern Illinois University, 1125 Lincoln Dr. Life Science II Department of Plant Biology-6509, Carbondale, IL 62901-6509 USA

Ultrastructure, immunocytochemistry and bioinformatics: an interdisciplinary approach to elucidating genetic control of spore wall development in *Physcomitrella patens*

21. SAXENA, DINESH K., SRIVASTVA, KAJAL and SHIVOM

Department of Botany, Bareilly College, Bareilly, UP, 243005, India, dinesh.botany@gmail.com

Estimation of metal deposition in Mussoorie region (India) based on active biomapping tool using moss *Hypnum cupressiforme*.

Bioaccumulation of metals (Pb, Cd, Zn and Cu) in moss *Hypnum cupressiforme* was studied for biomapping by the absolute method using active moss bag technique. Seasonal moss transplantation was done cross-section wise in all the four directions at survey sites of Mussoorie city and its adjoining areas. The best-retained elements in undertaken moss species were Zn (43%), Pb (33%) and Cu (21%) exhibited significantly high uptake efficiencies, whereas, Cd (3%) in all study sites showed lower metal concentration. Bioaccumulation ability of *Hypnum cupressiforme* was also elevated statistically using Dunkens Multiple Range (DMR) test. Results of DMR test indicated *Hypnum cupressiforme* significantly have high accumulation potential for all the undertaken metals during summer transplants followed by winter and minimum during monsoon.

Keyword: biomapping, metals, moss, *Hypnum cupressiforme*, Garhwal hills

11. *GROSS, SHANA and KIMMERER, ROBIN

Department of Environmental and Forest Biology, 241 Illick Hall, SUNY-College of Environmental Science and Forestry, Syracuse, NY 13210

Greenhouse propagation of two mosses, *Ceratodon purpureus* and *Polytrichum juniperinum*, for roadside restoration

A preliminary step in evaluating the potential of moss as a restoration tool is to determine if mosses can be grown in sufficient quantities for field application. The objective of this research was to determine propagation techniques to produce high density of *Ceratodon purpureus* and *Polytrichum juniperinum* for field plantings. The influence of nutrient application, asexual fragment size, fragment type, substrate, and amount of material planted were investigated. Nutrient application and fragment type did not influence the mean shoot number. In general, whole stems produced fewer new shoots than fragments. *C. purpureus* cover was greatest on top soil; substrate had no effect on the mean stem number of *P. juniperinum*. A non-linear model was developed to predict establishment cover with length of time and mass planted as independent variables. Results demonstrate that growth response to propagation techniques is species specific.

12. ROXANNE HASTINGS

Curator of Botany, Royal Alberta Museum (PMAE)

***Grimmia* Identification Workshop**

Grimmia, ARRRGH! Few mosses are more infamous for species id problems than this tough and nasty group of desert dwellers! After almost two decades of working on this rotten group of critters I now realize that the key to naming species is to forget about using keys - as much as possible. Rather I break down the genus into four rather easily recognizable groups and then use a series of tables for species identification. With power point I'll

show you the key characters and their various character states that you will need to know to break down *Grimmia* into manageable groups. Then as a group we'll power point our way through some practice species identifications. We'll do 2-4 species in each of the subgroups. Following this demo we will break out into groups and do some hands on identifications of specimens and slides that I will bring.

I'll be providing each participant with a set of tables and a new key to *Grimmia* that updates what Henk Greven and I wrote for the BFNA.

13. KOSOVICH-ANDERSON, YELENA

Consulting Botanist, 5031 1/2 Atlantic Drive, Cheyenne WY, 82001

Recent bryophyte collections from Southern Wyoming, U.S.A.

Wyoming is one of the least bryologically explored states, with insufficient bryophyte herbarium documentation. Within the frame of conservation projects of the Wyoming Natural Diversity Database and the U.S. Forest Service, over the field seasons of 2004 and 2007, the author has collected approximately 2000 bryophyte voucher specimens in Southern Wyoming, mostly within the Medicine Bow-Routt National Forest (MB-RNF). The research was mainly focused on the bryoflora of the most botanically interesting natural formations: the high-elevation territory of Snowy Range, which is one of the bryological hot spots in Wyoming, and Pole Mountain (including Vedawoo recreation area), all within the U.S. Rocky Mountains. Bryophytes of montane peatlands were of special attention. The duplicates of the author's collections are being kept at RM, Herbarium of MB-RNF, COLO, CAS, MO, BING (Sphagnum), DUKE (Philonotis, Pohlia), ASC (Bryum s.l.).

desiccation confers freezing tolerance over a range of shoot water contents. Shoots were allowed to desiccate under a range of relative humidities, then rehydrated and exposed to freezing conditions for one hour, and finally allowed to recover in the growth chamber. Freezing tolerance was evaluated using chlorophyll fluorescence and regeneration rates. We predicted that increased desiccation hardening (by means of slower drying times and/or drying to lower shoot water contents) would allow for increased freezing tolerance (as measured by faster recovery of the potential quantum yield of PSII (Fv/Fm) and increased regeneration rates).

20. SAXENA, DINESH K. and KAUR, HARINDER

Department of Botany, Bareilly College, Bareilly-243 005 (U.P.)-India.
dinesh.botany@gmail.com

Active monitoring of aerial deposition of metals in Kumaon Hills, India

Samples of widespread moss *Thuidium cymbifolium* were analyzed for heavy metals (viz., Pb, Cd, Zn and Cu) from famous tourist cities of Kumaon. Moss bags in triplicate were suspended for a period of four months during summer season for two successive years. Analysis of harvested moss samples exposed during summer season of each year clearly demonstrates a strong traffic related deposition of heavy metals. The highest lead levels were recorded in moss samples harvested from petrol pumps (3, 6) in Almora and Ranikhet hill resorts respectively. Similarly Zn, Cd and Cu too were mostly concentrated in areas of high traffic density. Besides this, Zn was also found exceptionally higher at site 4 which is located close to agricultural area. The results of the present study clearly revealed that high automotive traffic of tourists during summer season is an important source of these metals in Kumaon. Altogether the results of present study encourage the use of *T. cymbifolium* as active monitor to study the aerial deposition of heavy metals.

Key Words: *Thuidium cymbifolium*, active monitoring, heavy metals, aerial deposition.

18. POLI, DOROTHYBELLE¹, BADER, GEOFFREY¹, and COOKE, TODD J.²

¹Roanoke College, Department of Biology, 221 College Lane, Salem Virginia, 24153, USA; ² University of Maryland, Cell Biology and Molecular Genetics Department, College Park Maryland 20742, USA

Polar auxin transport in the moss *Polytrichum ohioense*: developmental regulation and evolutionary implications

Using a modified agar-block technique, we investigated the flow rates and polarities of auxin transport occurring in different tissues at different stages of moss sporophyte development. After applying radiolabeled auxin on the apical surface, basipetal auxin transport in intact young setae was measured at 214 fmoles/h and in cortical sections at 119 fmoles/h, which was interpreted to mean that basipetal flow occurred in the vascular cylinder at 95 fmoles/h. However, in older setae from early-capsule-stage sporophytes, cortical regions exhibited higher basipetal transport at 105 fmoles/h, as compared to the intact setae with lower transport at 31 fmoles/h, which suggests that acropetal transport occurred in the vascular cylinder at 74 fmoles/h. Thus, the direction of auxin circulation in both stages of moss sporophyte development is distinctly different from the bidirectional flow reported for *Arabidopsis* embryos. In particular, older moss sporophytes exhibit auxin flow up the central cylinder toward the capsule apex, which contrasts to the downward flow away from the shoot apex in angiosperm embryos.

19. *REYNOLDS, LAUREN and STARK, LLOYD

School of Life Sciences, University of Nevada, 4505 Maryland Parkway, Las Vegas, Nevada 89154-4004, USA

The effects of desiccation hardening on freezing tolerance in *Bryum argenteum*

Shoots of *Bryum argenteum* were cultured to remove field effects and used to test the hypothesis that hardening to

14. MADSEN, THOMAS

Dept. of Integrative Biology and University Herbarium, University of California, Berkeley, CA 94720, USA

Company for *Cryptothallus*?: Liverwort/Basidiomycete mycorrhizae and directions for future research

Long considered an oddity among the bryophytes, recent studies have confirmed the mycoheterotrophic and epiparasitic status of *Cryptothallus mirabilis*. In contrast, mycorrhizal mutualisms are widespread among the land plants, and most bryophyte mycorrhizae have been assumed to be mutualistic associations. However, an increasing body of literature on liverwort/basidiomycete mycorrhizae indicates *C. mirabilis* may not represent the only mycoheterotroph among the bryophytes. High specificity of mycorrhizal relationships, phylogenetic affinities of liverwort and fungal taxa, and mycorrhizal cytology are suggestive of mycoheterotrophy among several groups of leafy and simple thalloid liverworts. Additional studies of isotope tracing, axenic/symbiotic culturing, and host/symbiont phylogeny are needed in order to investigate the functional, ecological and evolutionary significance of basidiomycete mycorrhizae among the liverworts. Widespread mycoheterotrophy would have important implications for evolution, ecology, and conservation of the hepatics and therefore represents an important avenue for further research.

15. MISHLER, BRENT D.

University Herbarium, Jepson Herbarium, and Dept. of Integrative Biology, University of California, Berkeley, CA 94720, USA. bmishler@berkeley.edu

Synergisms between phylogenetics and genomics, with special reference to the *Physcomitrella* Genome Project.

This is the era of whole-genome sequencing; molecular data are becoming available at a rate unanticipated even a few years ago. This talk explores synergisms between genomics and

phylogenetics/systematics, with examples taken from three projects: the Green Tree of Life Project, the Moss Genome Project, and the Moorea Biocode Project. One of the fastest growing areas of biology is comparative genomics. A recent synthesis of phylogenetics and genomics – two fields once estranged – is beginning to form a new field that could be called "phylogenomics." DNA sequences, genome structural features, phenotypes, and physiologies can be mapped onto phylogenetic trees, allowing functional studies using comparative methods. Likewise, genomic data can greatly enhance study of phylogenetic relationships, as a source of new genes of potential systematic value or new markers for population genetics. New genomic structural characters are proving to be of great value for phylogenetics (e.g., rearrangements, introns, gene gain/loss).

16. *MISHLER, BRENT D., NORRIS, DANIEL H. and SHEVOCK, JAMES R.

University and Jepson Herbaria, University of California, Berkeley, CA 94720, USA

California and its Endemics with an Emphasis on Bryophytes

California is a place of high diversity, a natural laboratory for the study of evolution. Its climate is Mediterranean: hot, dry summers and cool, wet winters. Localized moisture, soil, and microclimatic conditions give rise to a diverse number of communities. The biogeography of California is further influenced by its "island" aspect-- the relatively humid strip west of the Sierran axis is isolated from the Rockies and the eastern US by very dry deserts. This results in a rich and unusual biota for the state, with many endemic species. For example, fully 24% of the 3,425 native species of vascular plants in California are endemic; far more than in any other state, including Hawaii. There are comparatively few endemic species of bryophytes, but comparisons of endemism with vascular plants are problematic because species concepts in bryophytes are quite different, and exploration of the bryoflora of the state is far from complete.

17. *PICHONET¹, SNIRC^{2,3}, PORCHER⁴, and RAUSCH DE TRAUBENBERG¹, BARDAT¹

¹National Museum of Natural History, UMR 5202, Department of Systematic and Evolution, Case 39, 57 rue Cuvier, 75005 Paris, France; ²National Museum of Natural History, Molecular Systematic Service, Case 26, 57 rue Cuvier 75005; ³IMAGENE, Parc Scientifique Unitec 1, 2 allée du Doyen Georges BRUS 33600 Pessac, France; ⁴National Museum of Natural History, UMR 5173, Department of Ecology and Biology Management, 61 rue Cuvier, 75005 Paris, France

A comparison of the genetic diversity of two *Dicranum* Hedw. species with contrasting reproductive strategies.

Do the reproductive strategies of *Dicranum viride* (Sull. &Lesq.) Lindb.(asexual reproduction) and *Dicranum scoparium* (sexual reproduction) influence their genetic diversity? At what spatial scale (colony, stand, forest, country)? We assessed their genetic diversity by sequencing ITS1 (nrDNA), trnT-trnL (cpDNA), rpl32-trnL (cpDNA). For this purpose, 64 gametophytes of *D. viride* from 30 French, German and Spain populations and 28 gametophytes of *D. scoparium* from 9 French and German populations were analysed. No infraspecific variability was found for trnT-trnL in either species. ITS1 and rpl32-trnL exhibited very low genetic variability mainly expressed by singletons. These results suggest that both species have undergone a recent demographic expansion. They will be confirmed by increasing sample sizes and developing microsatellites in a thesis addressing the evolution of the whole genus *Dicranum*.