Lab Activities for the Classroom
Contributions from the Open Science Network for Ethnobiology

Activity/Title & Contributor	***Entangled Engagement with Cellulose Microfibrils: Hand Papermaking Across Cultures,*** Karen C. Hall, Ph.D., carlson@clemson.edu, www.chaoticgardening.com
Background	Paper, from dispersed plant fibers, was invented in China during the reign of Emperor Wu, sometime between 140 BC - 86 BC. As papermaking spread across the globe, different cultures have explored many different types of materials and ways of making a paper sheet. Paper has been made from mulberry (kozo), mitsumata (Edgeworthia papyrifera), gampi (Daphne spp.), bamboo, hemp and many, many more plants. Innovations in handmade paper technology include the different ways in which fiber is removed from the plant, prepared for sheet formation, tools used in the process, ways in which a paper sheet is formed, and the uses and meanings of handmade papers within different cultures. In this lab, we'll investigate the differences in sheet formation around the globe, practice making paper to understand the knowledge needed to go from plant to sheet, and investigate how plants make the material we exploit for paper. With these ideas in mind, handmade paper is demonstrative of the importance of cultural diversity as a means of connecting to plant materials.
Keywords	Handmade paper, papermaking, cellulose microfibrils
Proposed Learning objectives	-Diagram the process by which plants make cellulose microfibrils -Describe how paper Is formed from cellulose microfibrils -Produce a single sheet of paper -Recognize and compare the difference between plant materials used in hand papermaking -View the different methods of paper sheet formation and contrast the differences
Suggested reading	"Teacher's Guide: Your Guide to the Science, History, Art and Technology of Papermaking" from the Robert C. Williams American Museum of Papermaking (available online).
Optional materials/websites	-YouTube: SEEthnobotany channel; "The Science of Papermaking", "Hand Papermaking from kozo (mulberry)". -"Traditional Paper Sheet Formation Around the World, 1976-2002" DVD from Carriage House Paper.
Lab materials/supplies	Fiber(s) of your choice (from plant or paper) properly prepped, vat, water, formation aid, moulds/deckles (western/eastern if comparing), couching cloths, old towels, sponges, and pencil (to mark couching cloths).
Activity instructions	Set up demo area to include paper samples, fiber samples, video of paper sheet formation and science of papermaking video on one side of the lab. Use another side for wet work with the paper vat. After demo-ing, have students make their own sheet of paper (use inclusions as an added attractant), compare fibers (set up a dissecting scope, if possible) and write up report on experience.
EB Core Concept/s*	Diversity, Integration of Knowledge and Methods, Structure and Function
EB Learning Outcomes*	Specialized knowledge of specific organismal groups Multiple cultural perspectives
Teaching Strategy	Active Learning- lab
Assessment ideas	1. Mind map of: process of hand papermaking; anatomy and chemistry of papermaking; and innovations in hand paper technology across cultures. 2.Labeled drawing of the anatomy of the cell (specific to that which produces paper) or chemistry. 3. Lab report comparing fibers or different paper sheet formation types.

*from **Ethnobiology Guidelines**, Open Science Network, 2012 www.opensciencenetwork.net

Open Science Network
Core Concepts and Competencies

The Open Science Network for Ethnobiology is committed to providing open source and open access teaching materials shared by various members in the network. To help instructors understand how these materials fit within the context of coursework, we are in process of developing a set of Core Concepts and Core Competencies, similar to what can be found in the AAAS/NSF document, "Vision and Change in Undergraduate Biological Sciences Education". Ultimately, teaching materials, courses and programs in the network will pass through a review process where they will be critiqued according to these concepts and competencies. Though these items are still a work in progress, we have included Core Concepts here:

CORE CONCEPTS (Modified from Brewer et al. 2010 – Vision and Change) (contributed by Michael Balick, Kim Bridges, Eve Emshwiller, Fred Jackson, Ashley B.Morris, Dan Potter, Cassandra Quave, James Veteto, Gail Wagner)

A program should identity core concepts that it addresses. Degrees should address all of these, while smaller scale programs such as courses, should indicate which are addressed. Well-trained ethnobiology students should be able to actively analyze, interpret, comprehend, and apply concepts across disciplines, organisms, and systems and different conceptual scales. The core concepts[4] that have been identified by the Open Science Network are:

Awareness (*Recognition of differences and equality within and among organisms and cultures is crucial to good science*. All scientists should be aware of themselves in the context of their fields. For those working with other cultures, recognizing people as stakeholders and collaborators in research is key to a truly ethical research program. For those working with non-human organismal systems, being aware of the fact that humans are part of natural systems, rather then external observers redefined how such systems are studied and interpreted. In general, a respect and awareness for different world views is essential to academic growth and good science.)

Connections (*All living things are connected, both to each other and their environments*. It is well understood that no individual or species or culture is truly isolated from others or their environments. Recognition of the extent of interconnectedness and directionally of relationships with others is a central tenant of many fields of science, including anthropology, ecology, and evolution, to name a few. The greatest difficulty for students is to grasp the extent to which these connections may be truly complex, both in space and time.)

Diversity (*Diversity is defined as the condition of having or consisting of different elements or qualities*. Recognition of diversity in organisms (including humans) and environment is acknowledged as an important idea, but not all students truly understand the concept.)

Change (*Life consists of great diversity: organismic and cultural*. All things change, both in space and time. Biologists recognize evolution as change over time. However, change over time occurs in all aspects of life, including how life is connected to its environment. Such changes also include the recognition of changes in cultures and human interactions. Recognizing that nothing is static, in space or time, is central to an understanding of science.)

Integration of Knowledge & Methods (*Interdisciplinary research results 'knowledge' are dependent upon the methods (context) that generated them*. Learners understanding of ethnobiological knowledge is enhanced through integrated learning of knowledge and methodologies.

Structure and Function (*Basic units of structure define the function of all living things*. Structural complexity, together with the information it provides, is built upon combinations of subunits that drive increasingly diverse and dynamic physiological responses in living organisms. Fundamental structural units and molecular and cellular processes are conserved through evolution and yield the extraordinary diversity of systems seen today. Understanding of biological and social regulatory systems and communication networks has become increasingly sophisticated, yielding knowledge about the functional responses of the components of those systems and networks at differing scales, from the molecular to the ecosystem, to the societal level of organization. Knowledge of relationships between structure and function is informed by design approaches from engineering and from models based on the quantitative analysis of data. The application of tools from the physical sciences often facilitates our understanding of structure–function relationships.

Information Flow, Exchange, & Storage (*The growth and behavior of organisms are activated through the expression of genetic information in context*. The convergence of systems approaches and powerful bioinformatics tools has dramatically expanded our understanding of the dynamics of information flow in living systems. From gene expression networks to endocrine mechanisms for physiological regulation, and from signal transduction and cellular homeostasis to biogeochemical cycling, all may be understood in terms of the storage, transmission, and utilization of biological information. Moreover, the collection, archiving, and analysis of information about living organisms and their components has created an extraordinary breadth and diversity of data that facilitate analyses of how information flows through systems. Real-time analytical approaches facilitate the study of cellular dynamics in response to environmental changes. Studies of the dynamics of information flow raise questions about topics such as the storage of genetic information and the transmission of that information across generations. All students should understand that all levels of biological organization depend on specific interactions and information transfer. Information exchange forms the basis of cell recognition and differentiation, the organization of communities from microbial assemblages to tropical forests, and the mating behavior of animals. The introduction of the topic of information exchange offers undergraduates many opportunities to learn how scientists apply quantitative skills and tools in the management and analysis of large data sets.)

Energy/Matter Pathways/Transformations (*Biological systems grow and change by processes based upon chemical transformation pathways and are governed by the laws of thermodynamics*. The principles of thermodynamics govern the dynamic functions of living systems from the smallest to the largest scale, beginning at the molecular level and progressing to the level of the cell, the organism, and the ecosystem. An understanding of kinetics and the energy requirements of maintaining a dynamic steady state is needed to understand how living systems operate, how they maintain orderly structure and function, and how the laws of physics and chemistry underlie such processes as metabolic pathways, membrane dynamics, homeostasis, and nutrient cycling in ecosystems. Moreover, modeling processes such as regulation or signal transduction requires an understanding of mathematical principles.)

Systems (*Living systems are interconnected and interacting*. Systems science (including ethnobiology) seeks a deep quantitative understanding of complex processes through an elucidation of the dynamic interactions among components of a system at multiple functional scales (NRC 2009). A systems approach to biological and cultural phenomena focuses on emergent properties at all levels of organization, from molecules to ecosystems to social systems. Mathematical and computational tools and theories grounded in the physical sciences enable ethnobiologists to discover patterns and construct predictive models that inform our understanding of processes. Through these models, researchers seek to relate the dynamic interactions of components at one level of organization to the functional properties that emerge at higher organizational levels. Systems science provides rich opportunities for all students to learn about scientific inquiry and, because of the complex nature of the research involved, to practice in a multidisciplinary context.