Laboratory Encounters in Plant Genomics

A workshop sponsored by the USDA, Cooperative State Research, Education, and Extension Service (CSREES) through the Rice Coordinated Agricultural Program (Rice CAP)

June 27th - 28th, 2006

Arkansas Agricultural Extension Lab
Lonoke, Arkansas

For more information on RiceCAP, visit:
www.uark.edu/ua/ricecap/
Welcome to the Lab Encounters in Plant Genomics Workshop. This two-day workshop is designed to provide participants with the knowledge and technical tools they need to pass on an understanding of the complex technology and issues of modern plant research to students. Advances in biotechnology are rapidly changing the way plants are developed for use in modern agriculture. These plants are making their way into foods, medicines, and many other consumer products at a rapid pace. “Genomics” is the study of all the genes of an organism and their functions. Research findings gained through the techniques of genomics can be valuable tools for identifying and developing improved plant varieties. In addition, some of the techniques we will discuss can also be applied to research on human health, animals, and forensic science.

The workshop is supported by the United States Department of Agriculture (USDA) Rice Coordinated Agriculture Program (RiceCap), a project supported by the USDA National Research Initiative Competitive Grants Program. Funding is from the USDA, Cooperative State Research, Education, and Extension Service (CSREES). The facilities have been graciously supplied by the Arkansas Division of Agriculture.

Our hope is to share our enthusiasm for plant biology and genetic research with you in a way that can be carried on into the classroom. We also hope that all of us will learn from each other by sharing ideas and experiences over the course of the workshop and beyond.

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University of Arkansas-Fayetteville and
Arkansas Division of Agriculture
Email: kkorth@uark.edu Website: www.uark.edu/ua/korthlab

Jan Stephens, Ph.D.
Colorado State University
Email: Janice.Stephens@colostate.edu
Website: http://lamar.colostate.edu/~jsteph/Introduction.htm

Co-organizers

Rick Cartwright, Ph.D.
University of Arkansas-Fayetteville and
Arkansas Division of Agriculture

Peggy Lemaux, Ph.D.
University of California-Berkeley and
Division of Agricultural and Natural Resources
AGENDA

Day 1  Tuesday, June 27th

9:30 – 10:00 a.m.  Arrival

10:00 – 10:20 a.m.  Introductions and overview of the RiceCAP program
   Dr. Ken Korth, Division of Agriculture and University of Arkansas-Fayetteville

10:20 – 11:00 a.m.  Module A Discussion
   DNA structure, function, and isolation
   Dr. Jan Stephens, Colorado State University

11:00 a.m. – 12:00 p.m.  DNA isolation exercise
   Lab activity in small groups

12:00 – 1:00 p.m.  Lunch served onsite         --         Group Photo

1:00 – 2:00 p.m.  Module B Discussion
   Electrophoresis principles, restriction enzymes,
   DNA fingerprinting
   Jan Stephens

2:00 – 2:15 p.m.  Break

2:15 – 3:30 p.m.  Electrophoresis and DNA fingerprinting exercise
   Lab activity in small groups

3:30 – 4:00 p.m.  Tour of aquaculture facility at Lonoke lab
   Dr. Jo Sadler, Division of Agriculture and University of Arkansas-Pine Bluff

4:00 – 4:30 p.m.  DNA gel staining and discussion of results

4:30 – 5:00 p.m.  Wrap-up and discussions
Day 2, Wednesday, June 28th

8:30 – 9:30 a.m. Plant biotechnology, “GMOs”, and genomics
Ken Korth

9:30 – 9:45 a.m. Break

9:45 – 10:30 a.m. Module C Discussion
Plant hormones, mutation in plant research and breeding, molecular basis of mutation
Anjali More and Ken Korth

10:30 – 11:00 a.m. Genomic Research for Rice Improvement
Dr. Steven Brooks, USDA-ARS
Dale Bumpers National Rice Research Center
Stuttgart, Arkansas

11:00 a.m.–12:00 p.m. Rice planting and treatment exercise
Lab activity in small groups

12:00 – 1:00 p.m. Lunch served onsite

1:00 – 2:45 p.m. Computer-based exercises in genomics/biotechnology
Sequence analysis, Polymerase Chain Reaction (PCR), Demonstration of some suggested teaching tools

2:45 – 3:00 p.m. Break

3:00 – 4:00 p.m. Discussion of genomics-based studies
Exchange of teaching tips and further ideas

4:00 – 4:30 p.m. Workshop assessment and wrap-up
Lab Encounters in Plant Genomics

Parts List

1. DuoSource 70 V Power Source
2. Horizontal Electrophoresis Apparatus
   (includes 7 x 7 cm tray, combs, tray “dams”)
3. Square storage container (for gel staining)
4. TBE buffer powder (for gel electrophoresis)
5. 1-quart Zip-bags (1 box)
6. 15 ml graduated centrifuge tubes (50 tubes in racks)
7. Suave Daily Clarifying shampoo
8. Isopropyl alcohol 91%
9. Adjustable “hot pot”
10. Plastic cups (for planting rice)
11. Wooden applicators (for spooling DNA)
12. Tape and rubber bands
13. 125-ml flask
14. 100-ml, 250-ml, 400-ml, and 600-ml plastic beakers (2 of each size)
15. Rice seed (wildtype cv. Francis and mutant “superdwarf”)
16. Test tube rack
17. Gloves (1 box, medium)

Inside the smaller plastic box, you should find:
Agarose (approx. 12 g)
Transfer pipettes (1 bag)
Coffee filters
Sodium chloride (table salt)
1.5-ml microcentrifuge tubes (1 bag)
Instastain methylene blue staining cards (gel electrophoresis)
Pipette tips (2 boxes)
100-ml graduated cylinder
Celsius thermometer
5-microliter pipette (1), 10-microliter pipette (2)
20-microliter pipette (2), 50-microliter pipette (1)

Inside the microtube storage box, you should find:
6 DNA samples for fingerprinting exercise
Sample loading buffer
Gibberellic acid (GA) [2 tubes with 1 mg each, 2 tubes with 10 mg each]
Lab Encounters in Plant Genomics

Parts list with suppliers*

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Supplier</th>
<th>Website URL</th>
<th>Cat. No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agarose (500 g)</td>
<td>MidSci</td>
<td><a href="http://www.midsci.com">www.midsci.com</a></td>
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<tr>
<td>7 x 7 cm electrophoresis set</td>
<td>Edvotek</td>
<td><a href="http://www.edvotek.com">www.edvotek.com</a></td>
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<td>Duosource power supply</td>
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<td>InstaStain methylene blue</td>
<td>Edvotek</td>
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<td>DNA samples - fingerprint demo</td>
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<td>50-place microtube box (5 mixed)</td>
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<td>R-8050-2</td>
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<tr>
<td>TBE buffer-powder for 40 L</td>
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<td>15 ml tubes (racks of 50)</td>
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<td><a href="http://www.phenixresearch.com">www.phenixresearch.com</a></td>
<td>SS2099</td>
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<td>tips (10 racks per)</td>
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<td><a href="http://www.phenixresearch.com">www.phenixresearch.com</a></td>
<td>TS200HBR</td>
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<td>1.5 ml tubes (500 per)</td>
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<td>5 ul pipette (pipettes.com)</td>
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<td>125 ml flasks</td>
<td>VWR</td>
<td><a href="http://www.vwrsp.com">www.vwrsp.com</a></td>
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Many other items are available from your local discount shop (Target, Wal-Mart, K-Mart…), these include:

- Shampoo, salt, isopropanol (91%), coffee filters, adjustable “hot pots”, plastic boxes, cups, potting soil

Many items are available from most scientific suppliers. Some of the suppliers we used to assemble these kits are:

- VWR, Phenix Research, ISC Bioexpress, Midwest Scientific, Fisher Scientific

*The suppliers for some items are listed, but only as a guide; this is not necessarily an endorsement of any supplier. Whenever possible, specific components were chosen for quality, low price and easy availability. Some items were purchased in bulk and might not be available in small increments.
National Science Standards addressed by the exercises:

Virtually all of the activities covered by the workshop address some of the National Science Educational Standards, especially within the Life Sciences sections. Some of the specific biological standards that are most relevant to the exercises are listed below. In addition, specific goals of teaching the processes of scientific inquiry, data analysis and technological advances are also addressed. Specific standards are separated by grade levels and topic as designated by the document from the National Research Council. It is likely that there are also other national or state standards that would apply.

**Grades 5-8**

**STRUCTURE AND FUNCTION IN LIVING SYSTEMS**

- Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms, and ecosystems.
- All organisms are composed of cells—the fundamental unit of life. Most organisms are single cells; other organisms, including humans, are multicellular.

**THE MOLECULAR BASIS OF HEREDITY**

- Changes in DNA (mutations) occur spontaneously at low rates. Some of these changes make no difference to the organism, whereas others can change cells and organisms. Only mutations in germ cells can create the variation that changes an organism's offspring.

**REPRODUCTION AND HEREDITY**

- Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.
- Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes.

**UNDERSTANDINGS ABOUT SCIENCE AND TECHNOLOGY**

- Science and technology are reciprocal. Science helps drive technology, as it addresses questions that demand more sophisticated instruments and provides principles for better instrumentation and technique. Technology is essential to science, because it provides instruments and techniques that enable observations of objects and phenomena that are otherwise unobservable due to factors such as
quantity, distance, location, size, and speed. Technology also provides tools for investigations, inquiry, and analysis.

**DIVERSITY AND ADAPTATIONS OF ORGANISMS**

- Millions of species of animals, plants, and microorganisms are alive today. Although different species might look dissimilar, the unity among organisms becomes apparent from an analysis of internal structures, the similarity of their chemical processes, and the evidence of common ancestry.

**SCIENCE AND TECHNOLOGY IN SOCIETY**

- Science influences society through its knowledge and world view. Scientific knowledge and the procedures used by scientists influence the way many individuals in society think about themselves, others, and the environment. The effect of science on society is neither entirely beneficial nor entirely detrimental.

### Grades 9-12

**THE CELL**

- Cells have particular structures that underlie their functions. Every cell is surrounded by a membrane that separates it from the outside world. Inside the cell is a concentrated mixture of thousands of different molecules which form a variety of specialized structures that carry out such cell functions as energy production, transport of molecules, waste disposal, synthesis of new molecules, and the storage of genetic material.

- Cells store and use information to guide their functions. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires.

**THE MOLECULAR BASIS OF HEREDITY**

- In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). The chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular "letters") and replicated (by a templating mechanism). Each DNA molecule in a cell forms a single chromosome.

- Changes in DNA (mutations) occur spontaneously at low rates. Some of these changes make no difference to the organism, whereas others can change cells and organisms. Only mutations in germ cells can create the variation that changes an organism's offspring.

**Source:** National Committee on Science Education Standards and Assessment, National Research Council. [http://fermat.nap.edu/html/nses/](http://fermat.nap.edu/html/nses/)