Final Report for Period: 09/2008 - 08/2009 **Submitted on:** 11/30/2009

Principal Investigator: Bass, Henry W. **Award ID:** 0321639

Organization: Florida State University

Submitted By:

Bass, Henry - Principal Investigator

Title:

Cytogenetic Map of Maize

Project Participants

Senior Personnel

Name: Bass, Henry

Worked for more than 160 Hours: Yes

Contribution to Project:

Principal Investigator

Name: Hill, Roberta

Worked for more than 160 Hours: Yes

Contribution to Project:

Ms. Roberta Hill was the project manager, is involved in all aspects of the work. Sadly, she passed away in the summer of 2006. The duties have being distributed among the other project participants including the hiring of a part time office assistant, Kari L. Price, in the spring of 2007.

Post-doc

Name: Ring, Brian

Worked for more than 160 Hours: Yes

Contribution to Project:

Dr. Brian Ring joined the laboratory in the Fall of 2005. He coordinated the screening of the sorghum BAC libraries with maize RFLP marker probes. He also assisted with some of the middle school (SAS) outreach activities.

After training in the the Bass laboratory as a post-doctoral researcher, Dr. Ring was hired as a tenure-track Assistant Professor in the Biology department at Valdosta State University (Valdosta, GA) in August of 2006.
http://www.valdosta.edu/biology/bcring1.shtml

Due the relatively short duration of the time he worked with us on this project, his overall role in the the project was relatively small, but important. He will co-author a publication or newsletter article documenting the RFLP sequencing project that he helped to carry out.

Graduate Student

Name: Amarillo, Ferdinand

Worked for more than 160 Hours: Yes

Contribution to Project:

F.E.'Ina' Amarillo was a doctoral student on the project. Her primary work was to develop a detailed cytogenetic map of maize chromosome 9. Amarillo presented her NSF-supported work at numerous conferences and published a major paper in the journal Genetics in 2007 (Amarillo and Bass, 2007). Amarillo was also co-author on a manuscript involving centromere mapping (Okagaki et al., Journal of Heredity, 2008) and co-author of a chapter on plant cytogenetics (Figueroa et al., submitted).

Amarillo defended her PhD in 2007 (PhD in Biological Science, FSU).
http://etd.lib.fsu.edu/theses/available/etd-11072007-111615/
'Construction and Analysis of a Transgenomic Cytogenetic Sorghum (Sorghum propinquum) BAC FISH Map of Maize (Zea may s L.) Pachytene Chromosome 9'

Amarillo has gone on to do post-doctoral research and, as of Fall 2009, is working in Dr. B. Levy's laboratory at Columbia University Medical Center on reproductive genetics and clinical molecular cytogenetics.

Name: Figueroa, Debbie

Worked for more than 160 Hours: Yes

Contribution to Project:

Ms. Debbie Figueroa joined the laboratory as a doctoral student in the Fall of 2004. Her project involves the FISH mapping of the core bin loci and the production of RFLP Full-length insert sequence (RFLP-FLIS) data for the core bin markers. She has screened the sorghum BAC library with maize markers and has grown newly-released addition lines of oat-maize hybrids for the project. She has also been a lead graduate student on the RFLP sequencing project and involved in training several undergraduate students. She has presented numerous posters at conferences and attended a cytogenetics FISH workshop at Univ. Missouri Columbia in June, 2007. She has written one article that was primarily a review with some original data (Figueroa and Bass, Briefings in Functional Genomics and Proteomics - in press for March 2010) and co-authored an invited book chapter on plant cytogenetic FISH mapping (Figueroa et al., in preparation).

She is currently working on mapping maize chromosomes 1, 3, 4, 5, 6, 8 and 10. This work will form the basis for the completion of her PhD and the publication of one or more major articles.

Undergraduate Student

Name: Hay, Marshawn

Worked for more than 160 Hours: Yes

Contribution to Project:

Marshawn Hay worked in the laboratory as an undergraduate research technician, starting prior to the beginning of this project. He was the primary undergraduate student involved in choosing which maize mutants would be used in the public and K-12 outreach project. He graduated with a BS in Biology in the Fall of 2004.

Name: Carpentar, John

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. John Carpenter worked as a field hand in the summers of 2004 and 2005. He helped bulk the seed used for the maize-10-maze project. He graduated from FSU in the Spring 2006, Bachelors in Music Education from FSU.

Name: Conejo, Maria

Worked for more than 160 Hours: Yes

Contribution to Project:

Maria S. Conejo was an undergraduate laboratory technician whose activities focused on processing and photo-documenting the maize ears for the mutants of maize outreach. She was heavily involved in growing and arraying the RFLP plasmid cultures received from the maize mapping group at Univ. Missouri, Columbia. She graduated with a B.S. in Biological Science from FSU, went on to obtain a Master's degree from our department (different laboratory) and is now planning to go to graduate school in Canada to obtain a PhD. She is co-author of many of the RFLP sequences released from this project via GenBank.

Name: Gabriel, Robert

Worked for more than 160 Hours: Yes

Contribution to Project:

Robert Gabriel has worked as an undergraduate student on the project since 2004. Gabriel was a business major and student at the nearby HBCU Florida A&M University. Gabriel assisted with growing, harvesting, photographing, and documenting the maize-10-maze project. He also produced DVDs of our field and ear images for more than 100 maize mutants in the outreach project, organized by chromosome.

Name: Lindsay, Rolando

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. Rolando Lindsay worked as a field hand on the maize-10-maze project in 2004.

Name: Pinello, Michael

Worked for more than 160 Hours: No

Contribution to Project:

Mr. Michael Pinello worked as a field hand on the maize-10-maze project in 2004. His work on the project has ended

Name: St Jean, David

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. David St. Jean has worked on the project as a field hand since 2004. He is majoring in biology and in biochemistry. He has been involved in the maize-10-maze project this summer (2006) in Quincy, FL. He also assists with photo-documentation of all the ears from this project. He is currently supported as a part-time lab technician.

Name: Morganti, Ashley

Worked for more than 160 Hours: Yes

Contribution to Project:

Ms. Ashley Morganti was an undergraduate student who helped to organize the literature and information in support of the maize-10-maze public mutant field project, Summer 2006. She developed a tri-fold flyer that was handed out at the field day in Quincy FL this summer (2006). Her flyer is available online at
http://www.cytomaize.org/outreach/2006/zmXmz06_atm_brochure.pdf

Name: Fredette, Natalie

Worked for more than 160 Hours: Yes

Contribution to Project:

Ms. Natalie Fredette started working on the project in the Spring of 2006 as an undergraduate student and lab technician. She has been very involved in organizing, planting, maintaining, photographing and hosting the maize-10-maze field day event. She worked with another student, James Davis, to develop handout materials for the field day in Quincy, June, 2006. Fredette also assisted with preparation and sending of seed and placards to Denise Costich (Cornell) for a replica of the maize mutant garden planted in 2006 & 2007. She presented her NSF-supported work at several conferences. Since graduating with a BS in Biological Science from FSU, she went on to graduate school. She is currently a graduate student at the University of Maine.

Name: Davis, James

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. James Davis was an undergraduate lab technician. He worked on several aspects of the maize-10-maze mutant project. Davis produced the laminated field placards for display on more than 100 families planted out in Quincy, FL this summer. Davis was a biology major at FSU. He was also working on a bioinformatic analysis of the obtained RFLP sequences. This work was supported in part by a NSF-REU fellowship. He is a co-author of most of the RFLP sequences released via GenBank and his work was presented by him at several conferences.

After getting his B.S. in Biological Science at FSU, he went on to graduate school at the University of South Florida.

Name: Beckham, Kate

Worked for more than 160 Hours: Yes

Contribution to Project:

Kate was an undergraduate working with closely with doctoral student Debbie Figueroa. Bekham's project was presented by her at two undergraduate research symposia on campus at FSU. She won an award for one of them. She worked on a bionformatic (non-filter hybridization) screen of the markers for chromosomes 2, 7, and 10. She was supported by an NSF-REU during the summer and fall of 2007. Her NSF-supported work was the basis of her Honors in the Major Thesis, which she defended before graduating in 2009.

Name: Price, Kari

Worked for more than 160 Hours: No

Contribution to Project:

Kari L. Price has assisted with clerical duties and organizing the summer outreach activities. She graduated with a B.S. in Biology at FSU in the Spring of 2009. She is currently applying for admission to graduate school in the area of genetics.

Name: Win, Amy

Worked for more than 160 Hours: Yes

Contribution to Project:

Amy Win worked as an hourly technician, assisting D. Figueroa in chromosome preparations for FISH. She also helped to grow the and bulk seed for the oat-maize addition lines, assisted with tissue harvest and meiotic staging of fixed anthers to find the mid-prophase cells for FISH mapping.

Technician, Programmer

Name: McLaughlin, Karen

Worked for more than 160 Hours: Yes

Contribution to Project:

Karen M. McLaughlin was a full-time laboratory technician during the summer months when not enrolled in graduate school of music at FSU. She has contributed to most every aspect of the project, especially the public outreach project. She has since taken a position teaching high school biology in South Florida.

Name: Jones, Eric

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. Eric Jones started working with the lab as an undergraduate before the project began. He assisted with field work associated with the maize-10-maze outreach program. Jones received a B.S. in Biology in the spring of 2004. He is now in the Ecology and Evolution PhD graduate program at Florida State University.

Name: Dunne, Edward

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. Edward Dunne worked as a field hand on the maize-10-maze project in 2004. His work on the project has ended.

Name: Risken, Barbi

Worked for more than 160 Hours: No

Contribution to Project:

Barbi Risken was a graduate student in the music program at FSU. She assisted with the maize field work in the spring and summer of 2006.

Other Participant

Name: Onokpise, Kome

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Kome Onokpise is a Professor at Florida A&M University. Each summer, Dr. Kome and others organize a program called The Forestry and Conservation Education Summer Program (FACE). FACE is a three-week summer program with the objective of exposing minorities to the scientific disciplines of forestry and natural- resource conservation, including the genetics of plants. As part of our planned outreach, we worked with Dr. Onokpise and his colleagues each summer to integrate the FSU Maize Genetics project into the FACE Summer Program. This outreach program exposed minority students to aspects of maize (corn) production and management that they would otherwise not be aware of, thereby encouraging high school students in low-income counties to consider plant science as a future career not only in food production but also in forestry and natural-resource management. The FACE participants, about 12-20 each summer, hosted the maize-10-maze summer field day in 2006 and 2007, showing visitors the mutants along the chromosome rows, demonstrating crossing techniques, and answering questions. The high school students also distributed literature and maze-guides describing the outreach project, the cytogenetic map of maize project, and the NSF Plant Genome Research Program. The collaboration with Dr. Onokpise received good local and state media coverage and the Maize-10-Maze outreach is described further on the project web page (http://cytomaize.org/outreach/).

Name: Doster, Jonathan

Worked for more than 160 Hours: Yes

Contribution to Project:

Jonathan Doster is a professional photographer (www.jdosterphoto.com). He joined the project in the summer of 2006 in order to take artistic photographs of the mutants of maize. Having collected more than 1000 photographs, Doster and Bass plan to publish an article on the art and science of maize mutants in a mainstream magazine, such as National Geographic or The Smithsonian.

Research Experience for Undergraduates

Organizational Partners

University of Georgia

University of Georgia: We obtained Sorghum propinquum BAC library resources from Dr. A.H. Paterson at the University of Georgia. We obtained 45 filter sets of the gridded BAC library, YRL, along with a replica of the library as 384-well freezer cultures. These were screened by hybridization with maize marker RFLP probes as described in the Activities and Findings section. Selected BACs are used as FISH probes on pachytene chromosomes of maize in the maize addition lines of oat. We also obtained a freezer culture replica of the 36,000 clone YRL library for immediate acquisition of BAC clones upon selection.

Iowa State University

We are working with Dr. Carolyn J. Lawrence as the interface to the
MaizeGDB. Dr. Lawrence was a post-doctoral researcher working with Dr. Brendel?s group when the project began. Lawrence is now USDA-ARS Research Geneticist at Iowa State University. Our collaborations to publicly disseminate the cytogenetic FISH mapping data are ongoing. Lawrence has helped us to develop an online hyper-linked display of the FISH mapping data from this project. She has also helped us to develop a table of the maize RFLP probes that we have sequenced. The FISH image data are available through MaizeGDB and the RFLP sequence data are integrated into the MaizeGDB databases and summarized in PlantGDB projects section (maize RFLP_FLIS).

CORNELL UNIVERSITY

We carried out a pilot collaboration with Dr. Tom Brutnell to cytologically map sorghum BAC FISH probes that contain sequences homologous to those flanking selected Ac elements on maize chromosome 9. It may be important to determine the chromosomal distance between Ac elements and target loci that are nearby in terms of cM linkage. The Brutnell lab carried out hybridizations with their Ac-flanking sequences and several BACs have been selected by them. Initial analysis indicated that the Ac-flanking sequences did not give good hybridization to syntenic regions of the sorghum genome. We did not obtain particularly informative data and did not devote a lot of resources to the continuation of this approach.

University of North Dakota Main Campus

We carried out a pilot collaboration with Dr. WF Sheridan and Dr. D. Auger to integrate our NSF-PG projects. In May, 2004, I traveled to UND to meet with Sheridan and Auger to review our projects and initiate some experiments to use FISH to test for the presence of certain rearranged chromosomes for which I received seed stocks in October, 2003. We started with simple BA translocations using a double probe combination of (1) the B-centromere repeat, and (2) a sorghum BAC (sCBM9.2, bz1) for the B-linked arm. This probe combination is expected to give diagnostic FISH patterns in interphase nuclei, providing for a non-lethal screen on any seedling tissue. Seedlings were grown and harvested, and initial FISH image analysis was inconclusive.

Texas A&M University Main Campus

We worked with Patricia Klein (and John Mullet, Bob Klein, David Stelly, and J. Kim) at Texas A&M Univ. integrate our FISH mapping of maize with their FISH mapping of Sorghum bicolor. This partnership started in January 2004. We have tested a set of S. bicolor BACs that span a chromosome arm homologous with a large segment of maize chromosome 9. Some of these were successfully mapped as described by Amarillo and Bass (Genetics, 2007).

Florida A&M University

The public outreach project, the maize-10-maze, was held in the summers of 2006 and 2007 in partnership with Florida A&M University (FAMU). FAMU is a local HBCU university. We combined our maize mutant field for the public with FAMU's summer high school program (FACE). The outreach, FACE program, and FAMU collaborators are described in the mutants of maize field day announcement, available online via the project wepage http://www.cytomaize.org/outreach/. The primary collaborator was Dr. Kome Onokpise, Professor and Program director for FACE 2007 (Forestry and Conservation Education Summer Program).

Other Collaborators or Contacts

University of Minnesota: (HW Rines & RL Phillips)

We recently obtained additional chromosome addition lines from Dr. Phillips and Dr. Rines at the University of Minnesota according to an MTA that predates the project. We received three seeds of each line and are in the process of bulking seed for 2-3 generations so that we will have enough material to make the chromosome spreads for FISH. Plants are being grown in the greenhouse and in growth chambers. We have encountered some difficulties propagating some of the lines. Attempts are being made to use B73-based or Mo17-based addition lines where possible to optimize integration of the cytogenetic and physical maps of the maize genome.

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

Findings: (See PDF version submitted by PI at the end of the report)

Training and Development:

Participant; Position; Research Training Received
Roberta Hill; Senior personnel; microscopy, field work
Debbie Figueroa; Graduate student; molecular biology, field work,
F.E. (Ina) Amarillo; Graduate student; microscopy, molecular biology
Amber Brown: Graduate student; outreach mentor, molecular biology
Maria Conejo; Undergraduate student; field work
David St Jean; Undergraduate student; field work, photo-documentary
John Carpentar; Undergraduate student; field work
Robert Gabriel; Undergraduate; student field work, DVD production
Rolando Lindsay; Undergraduate student; field work
Marshawn Hay; Undergraduate student; bioinformatics, molecular biology
Michael Pinello; Undergraduate student; field work
Eric Jones; Technician; molecular biology, field work
Karen McLaughlin; Technician; molecular biology, field work
Ed Dunne; Undergraduate student; field work
Brian Ring; Postdoc; plant genomics, FISH microscopy
James Davis; Undergraduate student; field work, field-day informatics; DNA sequence analysis, bioinformatics
Natalie Fredette; Undergraduate student; field work, field-day informatics; molecular biology
Barbie Risken; Graduate student; field work
Kari Price; Undergraduate student; Office assistant, lab management
Amy Win; Undergraduate technician; assisted with chromosome preparations for FISH
Danny Vera; Undergraduate student; molecular biology, web design.

Outreach Activities:

Outreach activities are summarized below, and also described in detail in the uploaded pdf document called 'Activities & Findings'.

The primary outreach activity of this project centered around the Maize-10-Maze, a field replica of the maize genome. Dr. Bass partnered with FAMU FACE summer program for area high-school kids each summer that the project was active (2003-2009). The big field events were held in 2006 and 2007. Related public outreach activities are described on the cytomaize project webpage (http://www.cytomaize.org/outreach/)

In addition to the summer field activities, the project supported activities with groups of middle school kids. One group was the SAS middle school in 2004 and another group was the Science Girls-II in the summer of 2007. These too are detailed online and in the 'Activities' portion of this project report.

Journal Publications

Lawrence CJ, Seigfried TE, Bass HW, and Anderson LK, "Predicting chromosomal locations of genetically mapped loci in maize using", Genetics, p. 2007, vol. 172, (2006). Published,

Amarillo FE; Bass HW, "A Transgenomic Cytogenetic Sorghum (Sorghum propinquum) BAC FISH Map of Maize (Zea mays L.) Pachytene Chromosome 9, Evidence for Regions of Genome Hyperexpansion.", Genetics, p. 1509, vol. 177, (2007). Published, 10.1534/genetics.107.080846

Okagaki RJ; Jacobs MS; Stec AO; Kynast RG; Buescher E; Rines HW; Vales MI; Riera-Lizarazu O; Schneerman M; Doyle G; Friedman KL; Staub RW; Weber DF; Kamps T; Amarillo FE; Chase CD; Bass HW; and Phillips RL, "Maize Centromere Mapping: A Comparison of Physical and Genetic Strategies", Journal of Heredity, p. 85, vol. 99, (2008). Published, 10.1093/jhered/esm111

Figueroa DM; Bass HW, "A Historical and Modern Perspective on Plant Cytogenetics.", Briefings in Functional Genomics and Proteomics, p. , vol. , (2010). Accepted,

Books or Other One-time Publications

Birchler JA; Bass HW, "Cytogenetics and chromosomal structural diversity.", (2009). Book, Published
Editor(s): Bennetzen JL; Hake SC
Collection: The Maize Handbook
Bibliography: Springer

Amarillo, FIE, "PhD Dissertation: Construction and Analysis of a Transgenomic Cytogenetic Sorghum (Sorghum propinquum) BAC FISH Map of Maize (Zea may s L.) Pachytene Chromosome 9", (2007). Thesis, Published
Bibliography: EDT: FSU Digital Library Center

Web/Internet Site

URL(s):

http://www.cytomaize.org/

Description:

The project web site. It includes links to our outreach project, the maize-10-maze, photo gallery of mutants, middle-school presentations, and links to news coverage of the project. For data and chromosome image dissemination, see MaizeGDB.

Other Specific Products

Product Type:

Audio or video products

Product Description:

This video news clip describes local TV coverage of one or our summer mutant field day events. A copy is archived at URL: http://bio.fsu.edu/bass/mv/BassWCTV.mov

Sharing Information:

This news video describes the mutants of maize public field display.

Contributions

Contributions within Discipline:

We are developing a new map of the maize genome, a cytogenetic FISH map.
This map is produced by direct microscopic visualization of DNA sequences on their resident chromosome using a technique called FISH. FISH maps are colinear with other valuable genetic maps, such as linkage maps and DNA sequence maps. Cytogenetic FISH maps integrate genetic data across multiple levels, from whole chromosomes to single genes.

Our project makes use of sorghum genome resources in the form of BAC DNA fragment libraries. This unique aspect of the project allows for direct integration of maize and sorghum maps, adding value and resources structural and comparative genomics of maize and it's relatives. The maize and sorghum genomes are currently being sequenced and this project is among many others that contribute knowledge and resources to both endeavors.

The URL http://www.maizegdb.org/cgi-bin/displaymaprecord.cgi?id=892372
displays the current model for data contribution to the maize genetics research community. This format represents a work in progress, but currently contains the basic elements we think are useful for researchers.

Contributions to Other Disciplines:

The outreach component of the project involves over 100 families of maize, each of which carry a genetically mapped mutation with dramatic effects on plant growth or ear/seed appearance. This outreach project, the Maize-10-Maze project, is described in more detail online at http://www.cytomaize.org/outreach/

This project is loosely related to the primary scientific goal of developing a cytogenetic FISH map of the maize genome. The mutants are planted in the order of their appearance along the 10 chromosomes of maize. In this way, we have developed a unique forum for public education and interaction in the areas of maize genetics, genome research, and plant biology. The summer field projects involved high-school students from under-represented groups, and the public field draws in all sorts and ages of curious people.

To supplement and extend the field day to a year-round resource, we have been developing a web-based photo gallery of these beautiful mutants - see http://www.cytomaize.org/outreach/zmXmz_v4c/
This work has extended into more artistic expression as K-12 students and professional photographers capture images of the mutants. In 2006, a photographer from Connecticut, Jonathon Doster, spent one week photographing the mutants. We are collaborating to produce a piece on 'the art and science of maize mutants', a project that could contribute to the dissemination of maize genetics via artistic, cultural, or popular media.

Contributions to Human Resource Development:

Our project has resulted in training of at least 15 undergraduate students, 3 graduate students, and one post-doc in molecular biology, microsocopy, maize genetics, genomics, and maize field work.

Contributions to Resources for Research and Education:

nothing significant (yet)

Contributions Beyond Science and Engineering:

nothing significant (yet)

Conference Proceedings

Categories for which nothing is reported:

Any Conference

ACTIVITIES

Research and Educational Activities:

Summary:

The *Cytogenetic Map of Maize* project, NSF DBI-0321639, began 9/1/2003. This final project report covers the overall activities through the project end, 8/31/2009. The overall goal was to produce a FISH-based cytogenetic map of maize pachytene-stage meiotic chromosomes using of maize chromosome addition lines of oat. Maize RFLP mapping probes were used to screen for sorghum BAC clones which gave strong locus-specific FISH signals when hybridized to maize chromosomes. The resulting data serves to integrate maps of the maize genome with those of other grasses. The initial proposal, to map 500 loci was revised at the panel's request to focus on a subset of markers with emphasis on the core bin markers (CBMs), providing low density coverage (about 8-10 loci per chromosome) of the maize genome. One chromosome (number 9) was chosen for relatively high density cytogenetic FISH mapping.

Research Activities:

The last year of the project (9/08– 8/09) involved continued screening of a sorghum BAC library with maize RFLP probes for FISH mapping of the non-9 chromosomes. Activities in BAC screening, FISH mapping, and RFLP sequencing are summarized in tables at the end of this section and span the entire project.

F.E. Amarillo and D.M. Figueroa were the lead graduate students on the project. Amarillo completed her Ph.D. work on maize chromosome 9, published a major paper in *Genetics*, and graduated with a Ph.D. in December of 2008. She is currently a post-doctoral researcher at Columbia Medical University. DM Figueroa is working towards mapping the CBM loci for most of the other chromosomes.

FISH mapped loci are being released via the MaizeGDB pipeline that was developed for this project in collaboration with Dr. CJ Lawrence at Iowa State University. We obtained maize RFLP probe plasmid cultures from UMC mapping lab, placed them in 96 well plates, had them sequenced by primer-walk sequencing on both strands (Agencourt). The consensus files were returned to us for validation, annotation, and released to the public via GenBank. This RFLP project was carried with a large input from an undergraduate student, James Davis, with support from an NSF-REU. Mr. Davis presented his findings at the maize genetics conference in 2008, has since graduated from FSU, and is now enrolled in a graduate program with the University of South Florida.

The project web page, http://www.cytomaize.org/ , was recently updated by a talented undergraduate student (D. Vera) for long-term description of the project. The site will host ongoing links to findings, primary data, outreach activities, as well as unprecedented public photo galleries from the maize mutants selected for the Maize-10-Maze outreach project.

Educational and Outreach Activities:

Several outreach events preceded the main *Maize-10-Maze* field project, scheduled for the summers of 2006 and 2007. Initial outreach activities involved working with a middle school mentorship class in the Fall of 2004 and summer field day events at the departmental Mission Road Research Facility in Tallahassee, FL during the summers of 2004 and 2005. These summers provided opportunities to collect large mutant photo galleries and host public visits. In addition, in the summers after 2007, we continued to sponsor the FAMU FACE summer program and worked with the Science Girls II group as described below. Descriptions, links and photos relating to the outreach events are summarized on our project web page http://cytomaize.org/outreach/ .

Middle School Fall Mentorship Class, Fall 2004

We worked with the Middle School Science Mentorship Projects at the School of Arts and Sciences (SAS), Leon County, FL in the Fall of 2004. Weekly classes were led by Dr. Bass and his assistants Amber Brown (graduate student), Dr. Brian Ring (post-doc), and Bobbie Hill (project manager). The activities were carried out at SAS middle school and also on FSU's classrooms and computer labs.

The class members researched maize mutants and prepared mutant allele images that are available online from MaizeGDB, the maize genetics database at Iowa State Univ. These include pictures of *al1*, *albescent plant1*; *P1-wr*, *pericarp color1*-wr allele, with pink silks; *j1*, *japonica striping1*; *Rld1*, *Rolled leaf1*; *la1*, *lazy plant1*; and *sr1, straite leaves1* (photo at right).

The course concluded with student powerpoint presentations on the mutants of their choice. The presentations are archived on the project web site as PPT and PDF files. They describe the phenotypes, modes of inheritance, and biological aspects of several mutants including *Lesion3* (*Les3*) *Ragged leaves1* (*Rg1*), *Rolled leaf1* (*Rld1*), *albescent plant1* (*al1-1, al1-2*), *lazy plant1* (*la1*), *rough sheath2* (*rs2*), and *Zebra Corn* (*zb4*).

Maize Mutant Field Day Events, Summers 2004, 2005.

During the summer maize field seasons preceding the Maize-10-Maze project, we grew out 120 mutant families to check for phenotype display and to bulk up more seed. The mutant seed stocks (about 20-40 seeds per mutant line) were ordered from the Maize Genetics Cooperation Stock Center online catalog.

We decided to host local field days at the FSU field site in Tallahassee in order to display the mutants, engage the public, and test our field placards. These two summer events were advertised in the local media, attended by about 70-100 people each year, and received local press including newspaper, radio, and local TV news coverage.

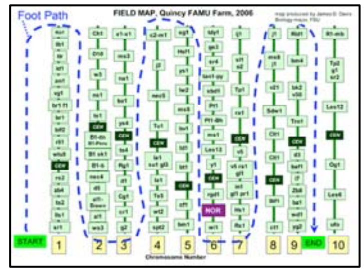
Photo Galleries of Mutants (Online)

Photos from the events are posted online via the cytomaize project web page. The summers of 2003, 2004, and 2005 also provided opportunities to produce a large photo gallery of mutants that are also online for the general public. The photographs were taken by FSU Biological Science staff member Karen Graffius with assistance from project personnel Robert Garbriel, David St. Jean, Bobbye Hill, and Maria Conejo.

Two photo galleries were produced, each organized by chromosome number. One mutant image gallery is linked to our Maize-10-Maze foot-path graphic. Images of field grown mutants and their normal (wild-type) siblings are organized by chromosome. A second photo gallery, zmXmz, has a larger collection with higher resolution versions of the photographs plus additional ear pictures. These images are also grouped by chromosome number, but also subdivided into genetic bins. These photographs (examples below) provide excellent public materials for student projects and have been incorporated into several classroom activities over the course of this project.

The* Maize-10-Maze *Project with FAMU FACE Program

The first major field outreach, the *Maize-10-Maze* project, was held in Quincy, FL in June 2006. The second main field outreach was in June 2007. In the summers of 2008 and 2009, we participated again in the FAMU high-school FACE summer program, but did not create the big maize-10-maze fields. Instead, we had local activities with the minority high school students that involved a lecture about maize genetics, viewing of the NSF "*Plant Genomes Revealed*" on campus, and several field activities including crosses, tissue harvest, and floral anatomy with dissecting microscopes.



The FACE activities involve a partnership with Florida A&M University in Tallahassee, FL, and a group of high school students from several local counties. The project included training of undergraduate and graduate students as counselors and activity leaders. The NSF-supported activities also provided stipends for the high school participants of the FAMU-FACE programs for the summers of 2004-2009.

The *Maize-10-Maze* project was a notable success and its publicity led to a request from Cornell University collaborators for help in producing a mutant map garden. For two summers in a row, we sent seed and field placards to Cornell to plant the map garden in the same site where one of the first ever maize map gardens was planted. This collaboration resulted in conference presentations from various collaborators.

The Sci-Girls II activities, June 2008 at FSU:

We hosted the "Science Girls II" summer camp for all day on June 21, 2008. The Sci-Girls is a program to expose young women (8^{th}-10^{th} grade) to various aspects of science. We carried out field crosses, held a bioinformatics workshop, viewed the NSF "*Plant Genomes Revealed*" video, and harvested field tissues that were ground to a powder in liquid nitrogen. We also toured the molecular cloning facilities on campus. FSU undergraduate students (NC Fredette, JD Davis, & D St.-Jean, and KD Beckham) and graduate students (AN Brown, DM Figueroa) assisted with planning and hosting of these activities. This provided training for them as role models and mentors for the participants.

Data release and Bioinformatics:

We developed productive interactions with Carolyn Lawrence, T. Siegfried, and others at MaizeGDB. The following links provide public access to the project data:

Cytogenetic FISH 9 (at MaizeGDB), includes primary FISH mapping data
http://www.maizegdb.org/cgi-bin/displaymaprecord.cgi?id=892372

Cytogenetic Mapping Methods (at MaizeGDB), includes map nomenclature & methods
http://www.maizegdb.org/CMMprotocols.php

GenBank Links to Core Bin Marker RFLP probes (at MaizeGDB)
http://www.maizegdb.org/cgi-bin/bin_viewer.cgi

Description of RFLP-FLIS project (at PlantGDB), with links & B73 GSS annotations
http://www.plantgdb.org/prj/RFLP_FLIS/

Genbank RFLP-FLIS sequences submitted (at GenBank)

http://www.ncbi.nlm.nih.gov/sites/entrez?term=bass%20maize%20rflp&cmd=Search&db=nuccore&QueryKey=1

FSU Project Web Site (at Florida State Univ.), participants, data, outreach, & news
http://www.cytomaize.org/

The Maize-10-Maze Project Field days and links to event activities and files
http://cytomaize.org/outreach/

Mutant Image Photo Galleries, organized by chromosome.

1) http://cytomaize.org/outreach/MaizePics/ZmChrom-1/ZmChrom-1.html
Field Photos of Plants – medium resolution

2) Photo gallery “zmXmz” version 4c
http://cytomaize.org/outreach/zmXmz_v4c/
Field and ear Photos, large collection, high resolution.

PROJECT ACTIVITIES SUMMARY TABLES:

The tables below summarize the activities and progress towards the major aims of the project.

TABLE 1. FISH Mapped Loci for Maize Chromosome 9.

Table 1 notes:
- BACs are mostly *Sorghum propinquum* BACs from overgo or RFLP hybridization screens
- Map positions are cytological units for pachytene chromosome arms (centiMcClintock)
- Locus naming is as described at http://www.maizegdb.org/CMMprotocols.php
- Final mapping loci are described in Amarillo and Bass (Genetics, 2007)

Maize Locus Nam	**Sorghum BAC**	**Map Position**	**FISH MAPPED CYTOGENETIC LOCUS NAME**
umc109 (9.01)[c]	a0004M18	9S.79	spb-**CBM9.01**_S79 (umc109)
rz144a	a0030K10	9S.82	spb-9.01_S82 (rz144a)
rz144c	a0030K10	9S.74	spb-9.01_S74 (rz144c)
php10005	a0045A20	9S.73	spb-9.01_S73 (php10005)
csu95a	a0012H11	9S.67	spb-9.01_S67 (csu95a)
sh1	a0015M03	9S.66	spb-9.01_S66 (sh1)
bz1 (9.02)[c]	a0020G06	9S.65	spb-**CBM9.02**_S65 (bz1)
csu471	a0075C01	9S.63	spb-9.02_S63 (csu471)
prc1	a0076L04	9S.38	spb-9.02_S38 (prc1)
wx1 (9.03)	bwx1-131-L1	9S.13	sbb-**CBM9.03**_S13 (wx1)
tda66d	a0054I24	9S.03	spb-9.03_S03 (tda66d)
cdo17	a0047J04	9L.03	spb-9.03_L03 (cdo17)
bnl5.33c	a0020L09	9L.04	spb-9.03_L04 (bnl5.33c)
csu321	a0020F10	9L.04	spb-9.03_L04 (csu321)
rgpr3235a	a0040B08	9L.04	spb-9.03_L04 (rgpr3235a)
gl15	a0075D13	9L.06	spb-9.03_L06 (gl15)
csu147 (9.04)	a0049N08	9L.07	spb-**CBM9.04**_L07 (csu147)
csu694a(uce)	a0093O18	9L.37	spb-9.04_L37 (csu694a(uce))
umc95 (9.05)	a0063J06	9L.38	spb-**CBM9.05**_L38 (umc95)
csu392a	a0010M15	9L.42	spb-9.05_L42 (csu392a)
csu710e(apx)	a0019J05	9L.48	spb-9.05_L48 (csu710e(apx))
csu219(tgd)	a0059O14	9L.50	spb-9.05_L50 (csu219(tgd))
csu59a	a0074G20	9L.53	spb-9.06_L53 (csu59a)
csu145a(pck)	a0055A21	9L.53	spb-9.06_L53 (csu145a(pck))
csu28a(rpS22)	a0093D21	9L.54	spb-9.06_L54 (csu28a(rpS22))
cdo1387(emp70)	a0036J08	9L.73	spb-9.06_L73 (cdo1387(emp70))
csu1004	a0046P22	9L.77	spb-9.06_L77 (csu1004)
asg12 (9.07)	a0064E21	9L.78	spb-**CBM9.07**_L78 (asg12)
csu54b (9.08)[c]	a0074A03	9L.95	spb-**CBM9.08**_L95 (csu54b)
Xtxa325	sbb18256	9L.27	sbb_9.04-L27 (Xtxa325)
Xtxp32	sbb16685	9L.53	sbb_9.06-L53 (Xtxp32)

TABLE 2. RFLP Full-Length Insert Sequence Project for Core Bin Markers.

Table 2 notes: These sequences have proven useful for defining the BIN boundaries within the physical map assembly.

To find all Full-length RFLP sequences obtained and released via GenBank as part of this project, search NCBI with "Bass Maize RFLP", a query that should retrieve at least 150 sequence record.

This project was supported by supplemental funding and involved extensive bioinformatic training of undergraduates such as James Davis (shown at right). Davis presented his work at several conferences and went on to graduate school at the University of S. Florida after graduating from FSU with a B.S. in biological Science.

Table with GenBank links available at http://www.maizegdb.org/cgi-bin/bin_viewer.cgi

Bin #	Marker/Locus	Probe	GenBank Accession
1.01	tub1	p-tub1	AY987961
1.02	umc157(chn)	p-umc157	DQ123890
1.03	umc76(prob a)	p-umc76	AY751079
1.04	asg45(ptk)	p-asg45	AY771210
1.05	csu03	p-csu03	DQ123891
1.06	umc67a	p-umc67	AY771211
1.07	asg62	p-asg62	DQ001865
1.08	umc128	p-umc128	DQ123892
1.09	cdj2	p-csu164	DQ642431
1.10	umc107a(croc)	p-umc107	DQ642432
1.11	umc161a	p-umc161	AY771212
1.12	bnl6.32	p-bnl6.32	
2.01	bnl8.45a	p-bnl8.45	
2.02	umc53a	p-umc53	AY771213
2.03	umc06a	p-umc06	AY771214
2.04	umc34	p-umc34	DQ001866
2.05	umc131	p-umc131	AY771215
2.06	umc255a	p-umc255	DQ123893
2.07	umc005a	p-umc005	AY771216
2.08	asg20	p-asg20	DQ123894
2.09	umc049a	p-umc049	DQ123895
2.10	php20581b(tb)	p-php20581	
3.01	umc032a	p-umc32	DQ001867
3.02	csu32	p-csu32	DQ123896
3.03	asg24(gts)	p-asg24	AY771217
3.04	asg48	p-asg48	DQ001868
3.05	umc102	p-umc102	DQ005498
3.06	bnl5.37a	p-bnl5.37	
3.07	bnl6.16a	p-bnl6.16	
3.08	umc17a	p-umc17	AY771218
3.09	umc63a	p-umc63	DQ123897
3.10	cyp1	p-csu25	DQ005499
4.01	agrr115	p-agrr115	
4.02	php20725a	p-php20725	
4.03	umc31a	p-umc31	DQ123898
4.04	npi386(eks)	p-npi386	DQ007988
4.05	agrr37b	p-agrr37	

4.06	umc156a	p-umc156	AY771219
4.07	umc66a(lcr)	p-umc66	DQ007989
4.08	umc127c	p-umc127	DQ642433
4.09	umc52	p-umc52	DQ123899
4.10	php20608a	p-php20608	DQ007990
4.11	umc169	p-umc169	DQ123900
5.01	npi409	p-npi409	
5.02	umc90	p-umc90	DQ642434
5.03	tub4	p-tub4	DQ007991
5.04	bnl4.36	p-bnl4.36	DQ642435
5.05	csu93b	p-csu93	DQ015673
5.06	umc126a	p-umc126	AY771220
5.07	umc108	p-umc108	DQ642436
5.08	bnl5.24a	p-bnl5.24	
5.09	php10017	p-php10017	AY771221
6.01	umc85a	p-umc85	AY771250
6.02	umc59a	p-umc59	
6.03	npi393	p-G23A-06	DQ015674
6.04	umc65a	p-umc65	AY771251
6.05	umc21	p-umc21	DQ123901
6.06	umc38a	p-umc38	DQ059316
6.07	umc132a(chk)	p-umc132	DQ1238902
6.08	asg7a	p-asg7	DQ642437
7.01	asg8(myb)	p-asg8	DQ642438
7.02	asg34a(msd)	p-asg34	
7.03	asg49	p-asg49	DQ059317
7.04	umc254	p-umc254	
7.05	umc245	p-umc245	AY771252
7.06	umc168	p-umc168	DQ059318
8.01	npi220a	p-G10F-01	DQ059319
8.02	bnl9.11a(lts)	p-bnl9.11	
8.03	umc124a(chk)	p-umc124	DQ059320
8.04	bnl7.08a	p-bnl7.08	
8.05	bnl2.369	p-bnl2.369	
8.06	csu31a	p-csu31	
8.07	npi268a	p-npi268	DQ123903
8.08	npi414a	p-npi414	AY771253
8.09	agrr21	p-agrr21	
9.01	umc109	p-umc109	AY771254
9.02	bz1	p-umc192	
9.03	wx1	p-umc25	
9.04	csu147	p-csu147	
9.05	umc95	p-umc95	AY771255
9.06	csu61a	p-csu61	
9.07	asg12	p-asg12	DQ123904
9.08	csu54b	p-csu54	
10.01	php20075a(gast)	p-php20075	DQ059321
10.02	npi285a(cac)	p-npi285	
10.03	umc130	p-umc130	DQ059322
10.04	umc64a	p-umc64	
10.05	umc259a	p-umc259	DQ123905
10.06	umc44a	p-umc44	AY771256
10.07	bnl7.49a(hmd)	p-bnl7.49	

TABLE 3. Maize RFLP-Selected Sorghum propinquum BACs for FISH probes.					
CBM	**Probe name (size, bp)**	**Selection method**	**Sorghum FPC Contig No.**	**No. BACS**	**Scored (In-house BAC number)**
1.01	tub1 (158)	bioinform (SOG1326)		5	a0039P11, a0064A08, a0060L04, a0080A08, a0076G03
1.02	umc157 (1250)	filter hybr.	154	3	a0045K08 (1), a0064A06 (2), a0055E08 (3)
1.03	umc76 (710)	filter hybr.	193	4	*a0004B12 (4)*, a0046J07 (5), *a0071N02 (6),* a0086C09 (7)
1.04	asg45 (332)				
1.05	csu3 (1064)	filter hybr.	179	4	a0001C04 (8), a0026E17 (9), a0052G17 (10), a0094G22 (11)
1.06	umc67a (644)	filter hybr.	253	2	a0026H06 (12), a0038A08 (13)
1.07	asg62 (465)				
1.08	umc128 (755)	filter hybr.	168	12	a0029P06 (117), a0055L05 (118), a0059H18 (119), a0058G14 (120), a0066G14 (121), a0070C24 (122), a0071B13 (123), a0072H12 (124), a0075H05 (125), a0081P22 (126) a0083A01 (127), a0092C10 (128)
1.09	cdj2 [csu164] (486)	filter hybr.	159	8	a0011I10 (14), a0023C11 (15), a0039E21 (16), a0056O22 (17), a0081H24 (18), a0091D22 (19), a0093H06 (20), a0093P21 (21)
1.10	umc107a (1105)	filter hybr.	154	8	a0006I08 (22), a0016J24 (23), a0041J08 (24), a0041O17 (25), a0043G04 (26), a0046O22 (27), a0053G19 (28), a0061G12 (29)
1.11	umc161a (723)	filter hybr.	147	5	a0014L19 (30), a0035F09 (31), a0058E04 (32), a0074A24 (33), a0092O22 (34)
1.12	bnl6.32 (2250)	filter hybr.		6	a0006L16, a0014L19, a0014M19, a0035F09, a0058E04, a0067C08
2.01	bnl8.45a (2100)				
2.02	umc53a (608)				
2.03	umc6a (604)	bioinform (SOG5501)	216	5	a0038O03, a0046F19, a0065B01, a0090M01, a0090P01
2.04	umc34 (932)	bioinform (SOG5694)	222	4	a0057N03, a0091D06, a0094G18, a0094M23
2.05	umc131 (859)				
2.06	umc255a (1004)				
2.07	umc5a (830)	filter hybr.	111	3	a0011L15, a0058J03 or 58J02, a0043I12
		bioinform (SOG0078)	111	7	a0002C06, a0011L15, a0043I12, a0056E06, a0067I06, a0071E21, a0072E15
2.08	asg20 (550)	bioinform (SOG1838)	87	3	a0003G24, a0046M08, a0050G12
2.09	umc49a (627)				
2.10	php20591b (1400)				
3.01	umc32a (1019)	filter hybr.	**1,** *293*	9	**a0020E10, a0016H11, a0066I03, a0083B22, a0092K15, a0092J15,** *a0048H03,* a0035E11, a0038G18
3.02	csu32 (411)	filter hybr.	1332	6	a0010D09, a0017F16, a0061J23, a0066B20, *a0066B14, a0038I06*
3.03	asg24 (372)				
3.04	asg48 (1617)				
3.05	umc102 (1023)	filter hybr.	256, **229**	4	a0068I23, a0024G20, **a0060A06,** *a0027C12*
3.06	bnl5.37a (2300)	filter hybr.	64	8	a0010K10, a0042I24, a0047F15, a0043H04, a0045D02, a0047J02, a0058O10, a0096N10
3.07	bnl6.16a (2450)	filter hybr.	**56**, 143	7 (8)	**a0014M18, a0020L03, a0050D18, a0085M21, a0029M08 = a0029M07?**, a0051P09, *a0052D16*
3.08	umc17a (840)	filter hybr.	49, **895**	6	a0002O18, a0041K14, **a0074H09,** *a0074H10, a0096D08, a0035C01*
3.09	umc63a (881)	filter hybr.	1292	9	a0021P11, a0025P06, a0046A02, a0044B15, a0043J02, a0055P13, *a0029C03, a0055O12, a0035C01*
3.10	cyp1 (960)	filter hybr.	1118, **89**	6	a0029L19 (129), a0067D01 (130), a0078E10 (131), **a0017J07 (132), a0018N05 (133),** *a0096D16 (134)*
4.01	agrr115 (600)				

4.02	php20725a (1650)	filter hybr.	1, **1292**	10	a0016H11 (135), a0092J15 (136), a0092K15 (137), a0049H03 (138); **a0021P11 (139), a0029C03 (140), a0044B15 (141), a0046A02 (142), a0043J02 (143), a0055P13 (144)**
4.03	umc31a (582)	filter hybr.	**1320,** 3	5	**a0001I16,** a0067O16, *a0057L09, a0084A23, a0007F05*
4.04	npi386 (1180)	filter hybr.	232	7	a0002B15 (35), a0019A12 (36), a0035B24 (37), a0058L10 (38), a0071D21 (39), a0078C04 (40), a0082H03 (41)
4.05	agrr37b (949)	filter hybr.	391	6	a0023C20 (174), a0054H21 (175), a0055K09 (176), a0068N16 (177), a0080D06 (178), a0083G05 (178)
4.06	umc156a (533)	filter hybr.	280	4	a0059B12, a0061G01, a0067K14, a0089D08
4.07	umc66a (1036)	bioinform (SOG5643)	154	3 (7)	a0064A06, a0055E08, a0010P05, a0045K08 (L), a0094B22 (R), a0041I03 (R), a0097C20 (R)
4.08	umc127c (1210)	filter hybr.	290	3	a0082D10 (145), a0059L11 (146), a0033K19 (147)
4.09	umc52 (824)	filter hybr.	352	6	a0030M10 (45), a0045N24 (46), a0050L19 (47), a0056E02 (48), a0069D03 (49), a0072G04 (50)
4.10	php20608a (1451)	filter hybr.	313	6	a0008B07 (51), a0015N19 (52), a0019O20 (53), a0026C03 (54), a0063A16 (55), a0064O16 (56)
4.11	umc169 (813)	filter hybr.	316	5	a0012H04 (57), a0017H01 (58), a0038N14 (59), a0040B11 (60), a0094J01 (61)
5.01	npi409 (710)				
5.02	umc90 (1226)	filter hybr.	**154**	4	**a0045K08 (180), a0055E08 (181), a0064A06 (182),** a0034N18 (183)
5.03	tub4 (230)				
5.04	bnl4.36 (2210)	filter hybr.	**118**, 314, *385*	8	**a0025E21 (184), a0024H23 (185), a0046J09 (186), a0045L08 (187), a0041E24 (188), a0069P23, a0058E11, a0051H03, a0052I15,** a0013B03 (189), a0061I09 (190), a0069K04 (191), *a0045M19, a0078E12, a0078A08, a0066D12*
5.05	csu93b (677)	filter hybr.	193, **382**	7	a0007P01, a0046J07, a0058O08, a0069L09, a0078B19, a0086C09, **a0009P04**
5.06	umc126a (663)	filter hybr.	280	3+	a0067K14 (192), a0061G01 (193), a0059B12 (194), a0089D08(195*)
5.07	umc108 (958)	filter hybr.	**287**, 1108, 333, *1288*	14	**a0095P22 (148), a0061G08 (149), a0063D06 (150), a0050A23 (151), a0052I05 (152), a0054L12 (153), a0046N22 (154),** a0023P17 (155), a0004F02 (156), a006N04 (157), a0020D11 (158), a0029N15 (159), *a0030E06 (160), a0038E06 (161)*
5.08	bnl5.24a (2500)	filter hybr.	278, *277*	8	a0042O01 (196), a0020K19 (197), a0023D21 (198), a0095O21 (199), a0095O19 (200), a0081C19 (201), a0063M08 (202), a0002O03 (203), *a0017F09, a0017E09, a0041G23, a0019G02, a0067B22*
5.09	php10017 (526)	filter hybr.	275	6	a0028A23 (162), a0033G16 (163), a0043E09 (164), a0057K02 (165), a0060N20 (166), a0061I19 (167)
6.01	umc85a (561)	filter hybr.	**426,** 205	10	**a0006I03 (76), a0009K09 (77), a0072P24 (78),** a0025E20 (79), a0041O09 (80), a0061M21 (81), a0057H05 (82), a0067N09 (83), a0074E15 (84), a0085D02 (85)
6.02	umc59a (930)	filter hybr.	366	9	a0004P17 (86), a0006P16 (87), a0019D19 (88), a0054G04 (89), a0063H16 (90), a0069J20 (91), a0080H11 (92), a0082K02 (93), a0089K05 (94)
6.03	npi393 (1249)	filter hybr.	**759,** 528	6	**a0004A06 (95), a0017E10 (96),** a0006D09 (97), a0008G11 (98), a0063A20 (99), *a0039N21 (100)*
6.04	umc65a (691)				
6.05	umc21 (1062)	filter hybr.	382	5	a0006P21 (62), a0030G09 (63), a0036H03 (64), a0039E04 (65), a0061C05 (66)
6.06	umc38a (1022)				

6.07	umc132a (472)	filter hybr.	327	9	a0020O17 (67), a0030L20 (68), a0040J01 (69), a0056F09 (70), a0060H04 (71), a0070I02 (72), a0070K04 (73), a0070K07 (74), a0073H20 (75)
6.08	asg7a (550)	filter hybr.	323	6	a0018I04 (168), a0032J21 (169), a0032K17 (170), a0068H17 (171), a0084B19 (172), *a0015L19 (173)*
7.01	asg8 (500)				
7.02	asg34a (1350)				
7.03	asg49 (400)				
7.04	umc254 (1050)				
7.05	umc245 (665)				
7.06	umc168 (1072)				
8.01	npi220a (406)	filter hybr.	22	6	a0019O09 (101), a0027H19 (102), a0063B11 (103), a0080P02 (104), a0084E01 (105), a0096C21 (106)
8.02	bnl9.11a (2400)	filter hybr.	**14,** 335	4	**a0070D09, a0082O21, a0085N05**, a0056I04
8.03	umc124a (1162)	filter hybr.	6, *109*	7	a0017N03, a0040E17, a0002I16, a0002I13, a0083P05, a0014C07, a0078K17
8.04	bnl7.08a (2300)				
8.05	bnl2.369 (700)				
8.06	csu31a (800)	filter hybr.	45	10	**a0042J03, a0043C22, a0062K14, a0064A02, a0078O19, a0089H10**, a0008A14, a0035C01, a0044F14, a0053E10 or 51E10
8.07	npi268a (688)	filter hybr.	61	10	a0033M15 (107), a0037N21 (108), a0039H13 (109), a0045D11 (110), a0059E23 (111), a0065K05 (112), a0068E24 (113), a0072D01 (114), a0078K07 (115), a0089A17 (116)
8.08	npi414a (893)				
8.09	agrr21 (899)				
10.01	php20075a(1311)	bioinform (SOG0380)	unknown	2	a0023C05, a0013A12
10.02	npi285a(634)				
10.03	umc130 (640)	bioinform (SOG1683)	259	5	a0016N23, a0027A21, a0060I22, a0095C02
10.04	umc64a (710)	bioinform (SOG2316)	239	9	a0047K03, a0030I06, a0042C18, a0049D21, a0003O13
10.05	umc259a (579)	bioinform (SOG5477)	223	5	a0001C15, a0002A24, a0009D06, a0034D04, a0051G06
10.06	umc44a (794)				
10.07	bnl7.49a(2100)				

TABLE 4. New FISH Mapped Loci for Maize Chromosomes 1, 4, and 6.

Maize Locus (CBM)	Sorghum p. BAC	Map Position	Cytogenetic FISH Locus Name
umc076 (1.03)	a0046J07	1S.78	**spb-CBM1.03_S78 (umc076)**
csu3 (1.05)	a0026E17	1S.66	**spb-CBM1.05_S66 (csu3)**
php20608 (4.10)	a0015N19	4L.85	**spb-CBM4.10_S85 (php20608)**
umc059 (6.02)	a0080H11	6S.14	**spb-CBM6.02_S14 (umc059)**

TABLE 5. New FISH Mapped Loci for Maize Chromosome 1 using "Maize-9 Syntenic BACs".

Maize Locus (CBM)	Sorghum p. BAC	Map Position	Cytogenetic FISH Locus Name
csu28	a0093D22	1S.22, 1S.66	Maize9: spb-9.06_L54 (csu28a(rpS22)) New: **spb-1.03_S22 & _S66 (csu28)**
csu59	a0074G20	1S.78	Maize9 spb-9.06_L53 (csu59a) New: **spb-1.03_S78 (csu59)**
csu694	a0093O18	1S.44	Maize9 spb-9.04_L37 (csu694a(uce)) New: **spb-CBM1.05_S44 (csu694)**

FINDINGS

The PI, post-docs, graduate students, undergraduate students, and collaborators have disseminated their findings in multiple formats. These include talks and posters at scientific conferences, invited seminars, primary publications, and review articles. Additional releases of sequence data and images were made via public data bases and web pages. The conference presentations and publications are listed in chronological order. Most of the outreach activities and mutant image galleries are described in detail in other sections (activities) of this report.

MEETING PRESENTATIONS

* = presenting author; underlined = undergraduates (some are NSF REU fellows)

1. HW Bass*, GL Koumbaris, & CJ Lawrence (POSTER) *A Cytogenetic Map of Maize with Sorghum BAC FISH Probes.* NSF Plant Genome Research Program Awardee Meeting, Arlington VA, September 18–21, **2003**.
2. CJ Lawrence*, GL Koumbaris, HW Bass, TE Seigrired, & V Brendel (POSTER B687) *Cytogenetic Mapping and Cellular Localization Data Available at MaizeGDB.* 43rd Annual Meeting of the American Society for Cell Biology, San Francisco, CA, December 13–17, **2003**.
3. HW Bass*, FE Amarillo, & CJ Lawrence (POSTER) *Cytogenetic Mapping of Maize with Sorghum BAC FISH Probes* 46th Maize Genetics Conference; Mexico City, Mexico; March 11–14, **2004.**
4. LK Anderson*, N Salameh, HW Bass, L Harper, WZ Cande, G Weber, & S Stack. (POSTER) *Integrating genetic linkage maps with pachytene chromosome structure in maize.* 46th Maize Genetics Conference; Mexico City, Mexico; March 11–14, **2004.**
5. HW Bass (INVITED PARTICIPANT) PlantGDB/MaizeGDB annotation tool and curation workshop, Iowa State University, Ames, IA, August 27, **2004**.
6. HW Bass*, FE Amarillo, CJ Lawrence, & DM Figueroa (POSTER) *A Cytogenetic Map of Maize with Sorghum BAC FISH Probes*. NSF Plant Genome Research Program Awardee Meeting, Arlington VA, September 23-24, **2004.**
7. HW Bass*, MD Hay, RJ Hill, KA McLaughlin, CJ Hale, EH Jones, MS Conejo, K Graffius-Ashcraft, & K Onokpise (POSTER) *The Maize-10-Maze project, a public field replica the maize pachytene karyotype, decorated with mutants.* 47th Maize Genetics Conference; Lake Geneva, WI; March 10–13, **2005.**
8. DM Figueroa*, CL Strobel, BR Ring, & HW Bass (POSTER) *Development of a Pachytene Cytogenetic FISH Map of the 90 Core Bin Marker Loci.* 47th Maize Genetics Conference; Lake Geneva, WI; March 10–13, **2005.**
9. FE Amarillo*, CJ Lawrence, & HW Bass (POSTER) *Construction of a High-Density Cytogenetic Map of Maize Chromosome 9.* 47th Maize Genetics Conference; Lake Geneva, WI; March 10–13, **2005.**
10. HW Bass*, DM Figueroa, FE Amarillo, BC Ring, TE Seigfried, & CJ Lawrence (POSTER) *A Cytogenetic Map of Maize in Oats with Sorghum BAC FISH Probes*. NSF Plant Genome Research Program Awardee Meeting, Arlington VA, September 8-9, **2005.**

11. FE Amarillo* & HW Bass (**TALK**) *Construction Of A High-Density Cytogenetic Map Of Maize Chromosome 9.* Plant and Animal Genome XIV Conference; San Diego, CA; January 14-18, **2006**.
12. DM Figueroa, FE Amarillo, BC Ring, CE Strobel, CJ Lawrence, & HW Bass* (POSTER) *A Cytogenetic Map Of Maize In Oat Addition Lines Using Sorghum BACs As FISH Probes.* Plant and Animal Genome XIV Conference; San Diego, CA; January 14-18, **2006**.
13. CJ Lawrence*, FE Amarillo, TE Seigfried, HW Bass, & LK Anderson (POSTER) *Predict Chromosomal Locations Of Genetically Mapped Loci In Maize Using The Morgan2McClintock Translator.* Plant and Animal Genome XIV Conference; San Diego, CA; January 14-18, **2006**.
14. FE Amarillo*, HW Bass, & CJ Lawrence (POSTER**)** *Construction of a High-Density Cytogenetic Map of Maize Chromosome 9 Using Sorghum BACs as FISH Probe.* 48th Maize Genetics Conference; Asilomar Conference Grounds, Pacific Grove, CA March 9–12, **2006.**
15. DM Figueroa*, FE Amarillo, BC Ring, CL Strobel, CJ Lawrence, & HW Bass (POSTER) *Constructing a Cytogenetic Map of Maize Core Bin Markers in Oat Addition Lines Using Sorghum BACs as FISH Probes.* 48th Maize Genetics Conference; Asilomar Conference Grounds, Pacific Grove, CA March 9–12, **2006.**
16. CJ Lawrence*, TE Seigfried, LK Anderson, FE Amarillo, HW Bass (POSTER) *Predicting Chromosomal Locations of Genetically Mapped Loci in Maize Using the* Morgan2McClintock *Translator.* 48th Maize Genetics Conference; Asilomar Conference Grounds, Pacific Grove, CA March 9–12, **2006.**
17. R Okagaki*, M Jacobs, M Schneerman, R Kynast, E Buescher, FE Amarillo, CJ Lawrence, A Stec, T Kamps, C Chase, HW Rines, D Weber, HW Bass, & Phillips (POSTER) *A Comparison of Centromere Mapping Techniques.* 48th Maize Genetics Conference; Asilomar Conference Grounds, Pacific Grove, CA March 9–12, **2006.**
18. HW Bass*, FE Amarillo, DM Figueroa, BC Ring, AT Morganti, NC Fredette, JD Davis, & CJ Lawrence (POSTER) *A Cytogenetic Map of Maize with Sorghum BAC FISH Probes.* NSF Plant Genome Research Program Awardee Meeting; Arlington VA, September 7–8, **2006**.
19. KD Beckham*, DM Figueroa, FE Amarillo, CJ Lawrence, & HW Bass (POSTER, 3rd Place Award) *Isolation and Characterization of Sorghum BACs for Cytogenetic Mapping of Maize Genome.* Tri-Beta Biological Honor Society Second Annual Poster Board Competition; FSU College of Medicine, Tallahassee, FL, November 16, **2006**.
20. JD Davis*, GL Koumbaris, DM Figueroa, & HW Bass (POSTER, 4th Place Award) *Sequence Analysis of Maize RFLP Markers for in Silico Screening*. Tri-Beta Biological Honor Society Second Annual Poster Board Competition; FSU College of Medicine, Tallahassee, FL, November 16, **2006**.
21. DM Figueroa, FE (Ina) Amarillo, NC Fredette, AT Morganti, JD Davis, CJ Lawrence, & HW Bass* (POSTER) P349: *Constructing A Cytogenetic Map Of The Maize Genome* Plant & Animal Genomes XV Conference; San Diego, CA, January 13-17, **2007**.
22. FE (Ina) Amarillo* & HW Bass. (TALK) T5: *Construction of a Sorghum BAC-based Cytogenetic Map of Maize Pachytene Chromosome 9*. 49th Annual Maize Genetics Conference; St. Charles, IL, March 22-25, **2007**.
23. DM Figueroa*, FE Amarillo, CE Strobel, CJ Lawrence, & HW Bass. (POSTER) P60: *Constructing A Cytogenetic Map Of Maize Core Bin Markers In Oat Addition Lines*

Using Sorghum BACs As FISH Probes. 49th Annual Maize Genetics Conference; St. Charles, IL, March 22-25, **2007**.

24. KD Beckham*, DM Figueroa, FE Amarillo, & HW Bass. (POSTER) *Isolation and Characterization of Sorghum BACs for Cytogenetic Mapping of the Maize Genome.* FSU Undergraduate Research Symposium, Florida State University, Tallahassee, FL, April 5, **2007**.
25. JD Davis*, GL Koumbaris, DM Figueroa, & HW Bass. (POSTER) *Analysis of Maize RFLP Markers: Enabling in Silico Screens for Sorghum BAC FISH probes.* FSU Undergraduate Research Symposium, Florida State University, Tallahassee, FL, April 5, **2007**.
26. DM Figueroa*, FE Amarillo, KD Beckham, JD Davis, CJ Lawrence, & HW Bass. (POSTER) *Constructing A Cytogenetic Map Of Maize In Oat Addition Lines Using Sorghum BACs As FISH Probes.* 50th Annual Maize Genetics Conference; Washington, DC, Feb 27 – Mar 2, **2008**.
27. NC Fredette*, JD Davis, D. St. Jean, RE Gabriel, AT Morganti, MD Hay, K Graffius-Ashcraft, RJ Hill, J Doster, O Onokpise, & HW Bass. (POSTER) *The Maize-10-Maze Project, an Educational Public Chromosome Map Garden Featuring the Magnificent Mutants of Maize.* 50th Annual Maize Genetics Conference; Washington, DC, Feb 27 – Mar 2, **2008**.
28. JD Davis* DM Figueroa, BC Ring, MS Conejo, FIE Amarillo, CL Strobel, & HW Bass (POSTER) *RFLP Full-Length Insert Sequence (RFLP-FLIS) data for use in the cytogenetic map of maize project.* 50th Annual Maize Genetics Conference; Washington, DC, Feb 27 – Mar 2, **2008**.
29. KD Beckham*, DM Figueroa, CJ Lawrence, & HW Bass (POSTER) *Bioinformatic Selection of Syntenic Sorghum BACs with Maize Core Bin Markers for use as FISH Probes in the Development of a Cytogenetic Map of Maize.* 50th Annual Maize Genetics Conference; Washington, DC, Feb 27 – Mar 2, **2008**.
30. KD Beckham*, DM Figueroa, & HW Bass. (POSTER – 3rd Place, John C. Johnson Award for Excellence in Student Research) *Bioinformatic Selection of Sorghum BACs for use as FISH probes in developing a Cytogenetic Map of Maize.* Beta Beta Beta 2008 Biennial National Convention; Highland Heights, KY, May 28 – 31, **2008**.
31. DM Figueroa*, KD Beckham, JD Davis, CJ Lawrence, & HW Bass. (POSTER) *Constructing a Cytogenetic Map Of Maize In Oat Addition Lines Using Sorghum BACs As FISH Probes.* 51st Annual Maize Genetics Conference; St. Charles, IL; March 12-15, **2009.**
32. ME Denton*, NC Fredette, O Onokpise, O Hoekenga, M Smith, ES Buckler, HW Bass, & DE Costich. (POSTER) *The Genome in a Garden: Maize Mutants and Public Outreach (1932-2007).* 51st Annual Maize Genetics Conference; St. Charles, IL; March 12-15, **2009.**

PUBLICATIONS

Manuscripts published from this project are listed below and include a mix of primary research articles and chapter review articles. At least two additional primary articles are in progress from DM Figueroa that will report on work carried out with support form this project (Figueroa and Bass, in preparation).

1. Lawrence CJ, Seigfried TE, Bass HW, and Anderson LK. (**2006**) Predicting chromosomal locations of genetically mapped loci in maize using the Morgan2McClintock translator. *Genetics* **172**:2007-2009.
2. Amarillo FE and Bass HW (**2007**) A Transgenomic Cytogenetic Sorghum (Sorghum propinquum) BAC FISH Map of Maize (Zea mays L.) Pachytene Chromosome 9, Evidence for Regions of Genome Hyperexpansion. *Genetics* **177**:1509-1526.
3. Okagaki RJ, Jacobs MS, Stec AO, Kynast RG, Buescher E, Rines HW, Isabel Val es MI, Riera-Lizarazu O, Schneerman M, Doyle G, Friedman KL, Staub RW, Weber DF, Kamps TL, Amarillo IFE, Chase CD, Bass HW, and Phillips RL. (**2008**) Maize centromere mapping: A comparison of physical and genetic strategies. Journal of Heredity **99**:85-93.
4. Birchler JA and Bass HW. (**2009**) "Part III, The Maize Genome, Cytogenetics and chromosomal structural diversity" in *The Maize Handbook*, (eds. JL Bennetzen and SC Hake); Springer. pp. 163-177.
5. Figueroa DM and Bass HW. (**2010**) A Historical and Modern Perspective on Plant Cytogenetics. *Briefings in Functional Genomics & Proteomics* (Accepted, Oct 2009, includes review and original material)
6. Murphy SP and Bass HW. (expected in 2010) "Meiotic Chromosome Behavior in Plants" in Plant Cytogenetics, Volume I: Genome Structure and Chromosome Function (eds. HW Bass and JA Birchler): Springer.
7. Figueroa DM, Amarillo FE, and Bass HW. (expected in 2010) "Cytogenetic Mapping in Plants" in Plant Cytogenetics, Volume I: Genome Structure and Chromosome Function (eds. HW Bass and JA Birchler); Springer.

RFLP Full-Length Insert (FLIS) Sequences

The RFLP Full Length Insert Sequencing (FLIS) Project is an endeavor ancillary to the Cytogenetic Map of Maize Project. The goals of this undertaking were to determine and submit to GenBank a high-quality (both strands) full length insert sequence for maize RFLP markers including the CBMs (~ 90 total) and additional markers from the UMC RFLP collection. The project description along with sequence links are available online at http://www.plantgdb.org/prj/RFLP_FLIS/ . Currently, we have submitted **151 RFLP-FLIS sequences to GenBank** as part of this project – they can be retrieved via GenBank query for "bass maize rflp".

Each of these sequences were carefully evaluated by Dr. Bass and one or more trainees. Detailed annotations were included in the GenBank Header files following

BLAST analysis and confirmation of sequence and marker ID. These RFLP markers are the foundation of many of the maize molecular marker linkage maps.

A complete list of the public sequence data produced by this project follows, sorted by Accession number.

RFLP-FLIS sequences from the Bass Lab

1: AY642962
Zea mays RFLP marker probe umc148 genomic sequence
gi|49359174|gb|AY642962.1| [49359174]

2: AY751079
Zea mays RFLP probe umc76 (CBM 1.03) genomic sequence
gi|54402363|gb|AY751079.1| [54402363]

3: AY771210
Zea mays RFLP probe asg45 (CBM 1.04) genomic sequence
gi|54111436|gb|AY771210.1| [54111436]

4: AY771211
Zea mays RFLP probe umc67 (CBM 1.06) genomic sequence
gi|54111437|gb|AY771211.1| [54111437]

5: AY771212
Zea mays RFLP probe umc161 (CBM 1.11) genomic sequence
gi|54111438|gb|AY771212.1| [54111438]

6: AY771213
Zea mays RFLP probe p-umc6 (CBM 2.03) genomic sequence
gi|54111439|gb|AY771213.1| [54111439]

7: AY771214
Zea mays RFLP probe p-umc53 (CBM 2.02) genomic sequence
gi|54111440|gb|AY771214.1| [54111440]

8: AY771215
Zea mays RFLP probe umc131 (CBM 2.05) genomic sequence
gi|54111441|gb|AY771215.1| [54111441]

9: AY771216
Zea mays RFLP probe umc5 (CBM 2.07) genomic sequence
gi|54111442|gb|AY771216.1| [54111442]

10: AY771217
Zea mays RFLP probe asg24 (CBM 3.03) genomic sequence
gi|54111443|gb|AY771217.1| [54111443]

11: AY771218
Zea mays RFLP probe umc17 (CBM 3.08) genomic sequence

gi|54111444|gb|AY771218.1| [54111444]

12: AY771219
Zea mays RFLP probe umc156 (CBM 4.06) genomic sequence
gi|54111445|gb|AY771219.1| [54111445]

13: AY771220
Zea mays RFLP probe umc126 (CBM 5.06) genomic sequence
gi|54111446|gb|AY771220.1| [54111446]

14: AY771221
Zea mays RFLP probe php10017 (CBM 5.09) genomic sequence
gi|54111447|gb|AY771221.1| [54111447]

15: AY772450
Zea mays RFLP probe umc85 (CBM 6.01) genomic sequence
gi|54111448|gb|AY772450.1| [54111448]

16: AY772451
Zea mays RFLP probe umc65 (CBM 6.04) genomic sequence
gi|54111449|gb|AY772451.1| [54111449]

17: AY772452
Zea mays RFLP probe umc245 (CBM 7.05) genomic sequence
gi|54111450|gb|AY772452.1| [54111450]

18: AY772453
Zea mays RFLP probe npi414 (CBM 8.08) genomic sequence
gi|54111451|gb|AY772453.1| [54111451]

19: AY772454
Zea mays RFLP probe umc109 (CBM 9.01) genomic sequence
gi|54111452|gb|AY772454.1| [54111452]

20: AY772455
Zea mays RFLP probe umc95 (CBM 9.05) genomic sequence
gi|54111453|gb|AY772455.1| [54111453]

21: AY772456
Zea mays RFLP probe umc44 (CBM 10.06) genomic sequence
gi|54111454|gb|AY772456.1| [54111454]

22: AY987961
Zea mays RFLP core bin marker probe tub1 genomic sequence
gi|62546249|gb|AY987961.1| [62546249]

23: DQ001865
Zea mays RFLP core bin marker probe p-asg62 (CBM 1.07), complete sequence
gi|66912523|gb|DQ001865.1| [66912523]

24: DQ001866

Zea mays RFLP core bin marker probe p-umc34 (CBM 2.04), complete sequence
gi|66912524|gb|DQ001866.1| [66912524]

25: DQ001867
Zea mays RFLP core bin marker probe p-umc32 (CBM 3.01), complete sequence
gi|66912525|gb|DQ001867.1| [66912525]

26: DQ001868
Zea mays RFLP core bin marker probe p-asg48 (CBM 3.04), complete sequence
gi|66912526|gb|DQ001868.1| [66912526]

27: DQ005498
Zea mays RFLP core bin marker probe p-umc102 (CBM3.05), complete sequence
gi|66866465|gb|DQ005498.1| [66866465]

28: DQ005499
Zea mays RFLP core bin marker probe p-csu25 (CBM3.10) mRNA, complete sequence
gi|66866466|gb|DQ005499.1| [66866466]

29: DQ007988
Zea mays RFLP core bin marker probe p-npi386 (CBM4.04), complete sequence
gi|66866403|gb|DQ007988.1| [66866403]

30: DQ007989
Zea mays RFLP core bin marker probe p-umc66 (CBM4.07), complete sequence
gi|66866404|gb|DQ007989.1| [66866404]

31: DQ007990
Zea mays RFLP core bin marker probe p-php20608 (CBM4.10), complete sequence
gi|66866405|gb|DQ007990.1| [66866405]

32: DQ007991
Zea mays RFLP core bin marker probe p-tub4 (CBM5.03), complete sequence
gi|66866406|gb|DQ007991.1| [66866406]

33: DQ015673
Zea mays RFLP core bin marker probe p-csu93 (CBM5.05) mRNA, complete sequence
gi|66803523|gb|DQ015673.1| [66803523]

34: DQ015674
Zea mays RFLP core bin marker probe p-npi393/G23A-06 (CBM6.03), complete sequence
gi|66803528|gb|DQ015674.1| [66803528]

35: DQ059316
Zea mays RFLP core bin marker probe p-umc38 (CBM6.06), complete sequence
gi|66803535|gb|DQ059316.1| [66803535]

36: DQ059317
Zea mays RFLP core bin marker probe p-asg49 (CBM7.03), complete sequence
gi|66803540|gb|DQ059317.1| [66803540]

37: DQ059318
Zea mays RFLP core bin marker probe p-umc168 (CBM7.06), complete sequence
gi|66803547|gb|DQ059318.1| [66803547]

38: DQ059319
Zea mays RFLP core bin marker probe p-npi220/G10F-01 (CBM8.01), complete sequence
gi|66803556|gb|DQ059319.1| [66803556]

39: DQ059320
Zea mays RFLP core bin marker probe p-umc124 (CBM8.03), complete sequence
gi|66803561|gb|DQ059320.1| [66803561]

40: DQ059321
Zea mays RFLP core bin marker probe p-php20075 (CBM10.01), complete sequence
gi|66803566|gb|DQ059321.1| [66803566]

41: DQ059322
Zea mays RFLP core bin marker probe p-umc130 (CBM10.03), complete sequence
gi|66803573|gb|DQ059322.1| [66803573]

42: DQ123890
Zea mays RFLP probe umc157 (CBM 1.02) genomic sequence
gi|75853388|gb|DQ123890.1| [75853388]

43: DQ123891
Zea mays RFLP probe csu03 (CBM 1.05) cDNA sequence
gi|75853389|gb|DQ123891.1| [75853389]

44: DQ123892
Zea mays RFLP probe umc128 (CBM 1.08) genomic sequence
gi|75853390|gb|DQ123892.1| [75853390]

45: DQ123893
Zea mays RFLP probe umc255 (CBM 2.06) genomic sequence
gi|75853391|gb|DQ123893.1| [75853391]

46: DQ123894
Zea mays RFLP probe asg20 (CBM 2.08) genomic sequence
gi|75853392|gb|DQ123894.1| [75853392]

47: DQ123895
Zea mays RFLP probe umc49 (CBM 2.09) genomic sequence
gi|75853393|gb|DQ123895.1| [75853393]

48: DQ123896
Zea mays RFLP probe csu32 (CBM 3.02) cDNA sequence
gi|75853394|gb|DQ123896.1| [75853394]

49: DQ123897
Zea mays RFLP probe umc63 (CBM 3.09) genomic sequence
gi|75853395|gb|DQ123897.1| [75853395]

50: DQ123898
Zea mays RFLP probe umc31 (CBM 4.03) genomic sequence
gi|75853396|gb|DQ123898.1| [75853396]

51: DQ123899
Zea mays RFLP probe umc52 (CBM 4.09) genomic sequence
gi|75853397|gb|DQ123899.1| [75853397]

52: DQ123900
Zea mays RFLP probe umc169 (CBM 4.11) genomic sequence
gi|75853398|gb|DQ123900.1| [75853398]

53: DQ123901
Zea mays RFLP probe umc21 (CBM 6.05) genomic sequence
gi|75853399|gb|DQ123901.1| [75853399]

54: DQ123902
Zea mays RFLP probe umc132 (CBM 6.07) genomic sequence
gi|75853400|gb|DQ123902.1| [75853400]

55: DQ123903
Zea mays RFLP probe npi268 (CBM 8.07) genomic sequence
gi|75853401|gb|DQ123903.1| [75853401]

56: DQ123904
Zea mays RFLP probe asg12 (CBM 9.07) genomic sequence
gi|75853402|gb|DQ123904.1| [75853402]

57: DQ123905
Zea mays RFLP probe umc259 (CBM 10.05) genomic sequence
gi|75853403|gb|DQ123905.1| [75853403]

58: DQ642431
Zea mays RFLP probe csu164 (CBM 1.09) mRNA sequence
gi|113470993|gb|DQ642431.1| [113470993]

59: DQ642432
Zea mays RFLP probe umc107 (CBM 1.10) genomic sequence
gi|113470994|gb|DQ642432.1| [113470994]

60: DQ642433
Zea mays RFLP probe umc127c (CBM 4.08) genomic sequence
gi|113470995|gb|DQ642433.1| [113470995]

61: DQ642434
Zea mays RFLP probe umc90 (CBM 5.02) genomic sequence
gi|113470996|gb|DQ642434.1| [113470996]

62: DQ642435
Zea mays RFLP probe bnl4.36 (CBM 5.04) genomic sequence

gi|113470997|gb|DQ642435.1| [113470997]

63: DQ642436
Zea mays RFLP probe umc108 (CBM 5.07) genomic sequence
gi|113470998|gb|DQ642436.1| [113470998]

64: DQ642437
Zea mays RFLP probe asg7a (CBM 6.08) genomic sequence
gi|113470999|gb|DQ642437.1| [113470999]

65: DQ642438
Zea mays RFLP probe asg8(myb) (CBM 7.01) genomic sequence
gi|113471000|gb|DQ642438.1| [113471000]

66: EF471910
Zea mays RFLP probe p-asg15, complete sequence
gi|126797994|gb|EF471910.1| [126797994]

67: EF471911
Zea mays RFLP probe p-asg16, complete sequence
gi|126798007|gb|EF471911.1| [126798007]

68: EF471912
Zea mays subsp. mays RFLP probe p-asg18, complete sequence
gi|126798023|gb|EF471912.1| [126798023]

69: EF471913
Zea mays subsp. mays RFLP probe p-asg63, complete sequence
gi|126798043|gb|EF471913.1| [126798043]

70: EF471914
Zea mays subsp. mays RFLP probe p-asg84, complete sequence
gi|126798058|gb|EF471914.1| [126798058]

71: EU190456
Zea mays RFLP probe php20581 (CBM 2.10) genomic sequence
gi|166895568|gb|EU190456.1| [166895568]

72: EU190457
Zea mays RFLP probe umc254 (CBM 7.04) genomic sequence
gi|166895569|gb|EU190457.1| [166895569]

73: EU328268
Zea mays RFLP marker p-csu221 mRNA sequence
gi|166895570|gb|EU328268.1| [166895570]

74: EU328269
Zea mays RFLP marker p-csu230 mRNA sequence
gi|166895571|gb|EU328269.1| [166895571]

75: EU328270

Zea mays RFLP marker p-csu252 mRNA sequence
gi|166895572|gb|EU328270.1| [166895572]

76: EU328271
Zea mays RFLP marker p-csu276 mRNA sequence
gi|166895573|gb|EU328271.1| [166895573]

77: EU328272
Zea mays RFLP marker p-csu348 mRNA sequence
gi|166895574|gb|EU328272.1| [166895574]

78: EU328273
Zea mays RFLP marker p-csu351 mRNA sequence
gi|166895575|gb|EU328273.1| [166895575]

79: EU328274
Zea mays RFLP marker p-csu359 mRNA sequence
gi|166895576|gb|EU328274.1| [166895576]

80: EU328275
Zea mays RFLP marker p-csu368 mRNA sequence
gi|166895577|gb|EU328275.1| [166895577]

81: EU328276
Zea mays RFLP probe p-csu389 mRNA sequence
gi|166895578|gb|EU328276.1| [166895578]

82: EU328277
Zea mays RFLP probe p-csu419 mRNA sequence
gi|166895579|gb|EU328277.1| [166895579]

83: EU328278
Zea mays RFLP marker p-csu466 mRNA sequence
gi|166895580|gb|EU328278.1| [166895580]

84: EU328279
Zea mays RFLP marker p-csu486 mRNA sequence
gi|166895581|gb|EU328279.1| [166895581]

85: EU328280
Zea mays RFLP probe p-csu567 mRNA sequence
gi|166895582|gb|EU328280.1| [166895582]

86: EU328281
Zea mays RFLP probe p-csu475 mRNA sequence
gi|166895583|gb|EU328281.1| [166895583]

87: EU328282
Zea mays RFLP probe p-csu590 mRNA sequence
gi|166895584|gb|EU328282.1| [166895584]

88: EU328283
Zea mays RFLP probe p-csu613 mRNA sequence
gi|166895585|gb|EU328283.1| [166895585]

89: EU328284
Zea mays RFLP probe p-csu615 mRNA sequence
gi|166895586|gb|EU328284.1| [166895586]

90: EU445567
Zea mays RFLP marker p-bnl5.33 full length insert sequence of entire Pst I fragment genomic sequence
gi|186911973|gb|EU445567.1| [186911973]

91: EU445568
Zea mays RFLP marker p-bnl7.13 full length insert sequence of entire Pst I fragment genomic sequence
gi|186911974|gb|EU445568.1| [186911974]

92: EU445569
Zea mays RFLP marker p-bnl7.26 full length insert sequence of entire Pst I fragment genomic sequence
gi|186911975|gb|EU445569.1| [186911975]

93: EU445570
Zea mays RFLP marker p-bnl8.44 full length insert sequence of entire Pst I fragment genomic sequence
gi|186911976|gb|EU445570.1| [186911976]

94: EU445571
Zea mays RFLP marker p-bnl15.07 full length insert sequence of entire Pst I fragment genomic sequence
gi|186911977|gb|EU445571.1| [186911977]

95: EU728673
Zea mays RFLP marker p-G21G-09 full length insert sequence of entire PstI fragment genomic sequence
gi|189031439|gb|EU728673.1| [189031439]

96: EU728674
Zea mays RFLP marker p-php10005 full length insert sequence of entire PstI fragment genomic sequence
gi|189031440|gb|EU728674.1| [189031440]

97: EU728675
Zea mays RFLP marker p-php20644 full length insert sequence of entire PstI fragment genomic sequence
gi|189031441|gb|EU728675.1| [189031441]

98: EU728676
Zea mays RFLP marker p-umc1 full length insert sequence of entire PstI fragment genomic sequence

gi|189031442|gb|EU728676.1| [189031442]

99: EU728677
Zea mays RFLP marker p-umc8 full length insert sequence of entire PstI fragment genomic sequence
gi|189031443|gb|EU728677.1| [189031443]

100: EU728678
Zea mays RFLP marker p-umc10 full length insert sequence of entire PstI fragment genomic sequence
gi|189031444|gb|EU728678.1| [189031444]

101: EU728679
Zea mays RFLP marker p-umc18 full length insert sequence of entire PstI fragment genomic sequence
gi|189031445|gb|EU728679.1| [189031445]

102: EU728680
Zea mays RFLP marker p-umc43 full length insert sequence of entire PstI fragment genomic sequence
gi|189031446|gb|EU728680.1| [189031446]

103: EU728681
Zea mays RFLP marker p-umc45 full length insert sequence of entire PstI fragment genomic sequence
gi|189031447|gb|EU728681.1| [189031447]

104: EU728682
Zea mays RFLP marker p-umc61 full length insert sequence of entire PstI fragment genomic sequence
gi|189031448|gb|EU728682.1| [189031448]

105: EU728683
Zea mays RFLP marker p-umc80 full length insert sequence of entire PstI fragment genomic sequence
gi|189031449|gb|EU728683.1| [189031449]

106: EU728684
Zea mays RFLP marker p-umc84 full length insert sequence of entire PstI fragment genomic sequence
gi|189031450|gb|EU728684.1| [189031450]

107: EU728685
Zea mays RFLP marker p-umc98 full length insert sequence of entire PstI fragment genomic sequence
gi|189031451|gb|EU728685.1| [189031451]

108: EU728686
Zea mays RFLP marker p-umc104 full length insert sequence of entire PstI fragment genomic sequence
gi|189031452|gb|EU728686.1| [189031452]

109: EU728687
Zea mays RFLP marker p-umc106 full length insert sequence of entire PstI fragment genomic sequence
gi|189031453|gb|EU728687.1| [189031453]

110: EU728688
Zea mays RFLP marker p-umc125 full length insert sequence of entire PstI fragment genomic sequence
gi|189031454|gb|EU728688.1| [189031454]

111: EU728689
Zea mays RFLP marker p-umc135 full length insert sequence of entire PstI fragment genomic sequence
gi|189031455|gb|EU728689.1| [189031455]

112: EU728690
Zea mays RFLP marker p-umc154 full length insert sequence of entire PstI fragment genomic sequence
gi|189031456|gb|EU728690.1| [189031456]

113: EU728691
Zea mays RFLP marker p-umc164 full length insert sequence of entire PstI fragment genomic sequence
gi|189031457|gb|EU728691.1| [189031457]

114: EU728692
Zea mays RFLP marker p-asg64 full length insert sequence of entire PstI fragment genomic sequence
gi|189031458|gb|EU728692.1| [189031458]

115: EU728693
Zea mays RFLP marker p-asg71 full length insert sequence of entire PstI fragment genomic sequence
gi|189031459|gb|EU728693.1| [189031459]

116: EU728694
Zea mays RFLP marker p-asg72 full length insert sequence of entire PstI fragment genomic sequence
gi|189031460|gb|EU728694.1| [189031460]

117: EU728695
Zea mays RFLP marker p-asg85 full length insert sequence of entire PstI fragment genomic sequence
gi|189031461|gb|EU728695.1| [189031461]

118: EU734556
Zea mays RFLP marker p-bnl944 full length insert sequence of entire PstI fragment genomic sequence
gi|189031462|gb|EU734556.1| [189031462]

119: EU734557
Zea mays RFLP marker p-csu214 full length insert mRNA sequence
gi|189031463|gb|EU734557.1| [189031463]

120: EU734558
Zea mays RFLP marker p-csu219 full length insert mRNA sequence
gi|189031464|gb|EU734558.1| [189031464]

121: EU734559
Zea mays RFLP marker p-csu222 full length insert mRNA sequence
gi|189031465|gb|EU734559.1| [189031465]

122: EU734560
Zea mays RFLP marker p-csu266 full length insert mRNA sequence
gi|189031466|gb|EU734560.1| [189031466]

123: EU734561
Zea mays RFLP marker p-csu328 full length insert mRNA sequence
gi|189031467|gb|EU734561.1| [189031467]

124: EU734562
Zea mays RFLP marker p-csu340 full length insert mRNA sequence
gi|189031468|gb|EU734562.1| [189031468]

125: EU734563
Zea mays RFLP marker p-csu377 full length insert mRNA sequence
gi|189031469|gb|EU734563.1| [189031469]

126: EU734564
Zea mays RFLP marker p-csu381 full length insert mRNA sequence
gi|189031470|gb|EU734564.1| [189031470]

127: EU734565
Zea mays RFLP marker p-csu382 full length insert mRNA sequence
gi|189031471|gb|EU734565.1| [189031471]

128: EU734566
Zea mays RFLP marker p-csu408 full length insert mRNA sequence
gi|189031472|gb|EU734566.1| [189031472]

129: EU734567
Zea mays RFLP marker p-csu434 full length insert mRNA sequence
gi|189031473|gb|EU734567.1| [189031473]

130: EU734568
Zea mays RFLP marker p-csu439 full length insert mRNA sequence
gi|189031474|gb|EU734568.1| [189031474]

131: EU734569
Zea mays RFLP marker p-csu440 full length insert mRNA sequence
gi|189031475|gb|EU734569.1| [189031475]

132: EU734570
Zea mays RFLP marker p-csu474 full length insert mRNA sequence
gi|189031476|gb|EU734570.1| [189031476]

133: EU734571
Zea mays RFLP marker p-csu481 full length insert mRNA sequence
gi|189031477|gb|EU734571.1| [189031477]

134: EU734572
Zea mays RFLP marker p-csu509 full length insert mRNA sequence
gi|189031478|gb|EU734572.1| [189031478]

135: EU734573
Zea mays RFLP marker p-csu525 full length insert mRNA sequence
gi|189031479|gb|EU734573.1| [189031479]

136: EU746366
Zea mays RFLP marker p-csu536 full length insert mRNA sequence
gi|189182789|gb|EU746366.1| [189182789]

137: EU746367
Zea mays RFLP marker p-csu540 (pdk1) full length insert mRNA sequence
gi|189182790|gb|EU746367.1| [189182790]

138: EU746368
Zea mays RFLP marker p-csu565 full length insert mRNA sequence
gi|189182791|gb|EU746368.1| [189182791]

139: EU746369
Zea mays RFLP marker p-csu570 full length insert mRNA sequence
gi|189182792|gb|EU746369.1| [189182792]

140: EU746370
Zea mays RFLP marker p-csu598 full length insert mRNA sequence
gi|189182793|gb|EU746370.1| [189182793]

141: EU746371
Zea mays RFLP marker p-csu604 full length insert mRNA sequence
gi|189182794|gb|EU746371.1| [189182794]

142: EU746372
Zea mays RFLP marker p-csu606 full length insert mRNA sequence
gi|189182795|gb|EU746372.1| [189182795]

143: EU746373
Zea mays RFLP marker p-csu610 full length insert mRNA sequence
gi|189182796|gb|EU746373.1| [189182796]

144: EU746374
Zea mays RFLP marker p-csu614 full length insert mRNA sequence

gi|189182797|gb|EU746374.1| [189182797]

145: EU746375
Zea mays RFLP marker p-G21B-04 full length insert sequence of entire PstI fragment genomic sequence
gi|189182798|gb|EU746375.1| [189182798]

146: EU746376
Zea mays RFLP marker p-npi294 full length insert sequence of entire PstI fragment genomic sequence
gi|189182799|gb|EU746376.1| [189182799]

147: EU746377
Zea mays RFLP marker p-php10012 full length insert sequence of entire PstI fragment genomic sequence
gi|189182800|gb|EU746377.1| [189182800]

148: EU746378
Zea mays RFLP marker p-umc12 full length insert sequence of entire PstI fragment genomic sequence
gi|189182801|gb|EU746378.1| [189182801]

149: EU746379
Zea mays RFLP marker p-umc35 full length insert sequence of entire PstI fragment genomic sequence
gi|189182802|gb|EU746379.1| [189182802]

150: EU746380
Zea mays RFLP marker p-umc36 full length insert sequence of entire PstI fragment genomic sequence
gi|189182803|gb|EU746380.1| [189182803]

151: EU746381
Zea mays RFLP marker p-umc121 full length insert sequence of entire PstI fragment genomic sequence
gi|189182804|gb|EU746381.1| [189182804]