CHARACTERIZATION OF A GENE FROM BREEDING LINE WX93D180 CONFERRING RESISTANCE TO LEAF RUST (*Puccinia triticina*) IN WHEAT

A Thesis

by

HSIAO-YI HUNG

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2007

Major Subject: Plant Breeding

CHARACTERIZATION OF A GENE FROM BREEDING LINE WX93D180 CONFERRING RESISTANCE TO LEAF RUST (*Puccinia triticina*) IN WHEAT

A Thesis

by

HSIAO-YI HUNG

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Approved by:

Co-Chairs of Committee,	Monica Menz
	Gaylon Morgan
Committee Members,	Thomas Isakeit
	Jackie Rudd
Head of Department,	David Baltensperger

December 2007

Major Subject: Plant Breeding

ABSTRACT

Characterization of a Gene from Breeding Line WX93D180 Conferring Resistance to Leaf Rust (*Puccinia triticina*) in Wheat. (December 2007)

Hsiao-Yi Hung, B.S., National Taiwan University

Co-Chairs of Advisory Committee: Dr. Monica Menz
Dr. Gaylon Morgan

Wheat (*Triticum aestivum* L. em. Thell, 2n=6*x*=42, AABBDD) is subjected to significant yield losses by the endemic leaf rust pathogen, *Puccinia triticina* (Roberge ex Desmaz. F. sp. *tritici*). Breeding for resistance to this disease is a more appropriate option both environmentally and economically over fungicidal application. More than 57 leaf rust resistance genes in wheat have been identified and many of the resistance genes have been successfully introgressed into resistant cultivars, yet the continuous shifting of predominant races of *P. triticina* continues to be a challenge to breeders. Pyramiding multiple resistance genes into a single resistant cultivar is one of the preferred strategies to develop superior disease resistant cultivars. Efficient pyramiding requires the utilization of markers closely linked to the resistance genes. The objectives of this study were to characterize a novel source of resistance to leaf rust introgressed into the breeding line WX93D180-R-8-1, to determine its inheritance, map position, and linkage with molecular markers suitable for marker assisted selection. According to the pedigree of WX93D180, TX86D1310*3/TTCC417, the resistance in this breeding line should be derived from TTCC417 (Turkey *tritici* cereal collection), which was thought to be

Triticum monococcum, which is a diploid species made up of only the A genome. However, our marker analyzes results indicated the resistance gene is located in the D genome and has the same location as the cloned leaf rust resistance gene *Lr21*. We verified the result in our population using primers from *Lr21* and found the same segregation pattern with the phenotypic data (disease response). Therefore the pedigree is incorrect, TTCC417 was misidentified, or the resistance was not from TTCC417.

DEDICATION

To my parents, Ching-Yuan Wang and Ching-De Hung for all of their love, patience, and support.

To my sister, Shiau-Ying Hung for her encouragement and love.

ACKNOWLEDGEMENTS

I would like to thank my mentors, Dr. Monica Menz and Dr. Gaylon Morgan for all of their wonderful patience, and guidance during this study and my committee member Dr. Thomas Isakeit for his help and support. A special thanks to Dr. Jackie Rudd for his help and sharing his valuable experience in the field.

I would like to thank Drs. Ravindra Devkota, Yiqun Weng and Azhaguvel Perumal at the Amarillo experiment station for their selfless assistance.

I would like to thank Ms. Susan Hall in our lab and the Ph.D. candidates Andres Gutierrez and Nelish Dighe for all of their gracious help and support.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

Wheat (*Triticum aestivum* L. em. Thell, 2n=6*x*=42, AABBDD) is one of the most important cereal grains worldwide. The U.S. is the third largest producer of wheat in the world, and Texas generally ranks third or fourth in terms of planted area in the U.S. (Table 1). From 2000 to 2006, planted area in Texas averaged about six million acres. Table 1 shows the top ten wheat production states from 2000 to 2006. The harvested area varies due to the precipitation, temperature condition, disease severity or the economic considerations. For example, the wheat planted area in Texas in 2006 was 5.5 million acres but the harvested area was only 1.4 million acres due to drought (Table 2).

A major restriction in realizing genetic potential for grain yield is the occurrence of leaf rust, also called brown rust, caused by *Puccinia triticina* (Roberge ex Desmaz. f. sp. *tritici*). Leaf rust occurs worldwide almost everywhere wheat is grown. It is most important where dews are frequent during the jointing through flowering stages and temperatures are mild, 10-20°C (Singh et al., 2002). Few, if any, infections occur where dew period temperatures are above 32°C (Stubbs et al., 1986) or below 2°C. Most of the severe epidemics occur when uredinia and/or latent infections survive the winter at some threshold level on the wheat crop, or where spring-sown wheat is the recipient of exogenous inoculum at an early date, usually before heading. Severe epidemics and

---

This thesis follows the style of Crop Science.

losses can occur when the flag leaf is infected before anthesis (Chester, 1946).

Table 1. Wheat production in U.S. 2000 to 2006 averaged by state (Source: USDA-NASS, verified 15 Apr. 2007)

States	Planted Area (1000 acres)	Harvest Area (1000 acres)
Kansas	9943	8986
North Dakota	9059	8544
Oklahoma	6029	4043
Texas	5993	2779
Montana	5433	4944
South Dakota	3150	2566
Colorado	2429	2027
Washing ton	2382	2319
Minnesota	1872	1789
Nebraska	1793	1671

Table 2. Wheat production in Texas from 2000 to 2006 (Source: USDA-NASS, verified 15 Apr. 2007)

Year	Planted Area (1000 acres)	Harvest Area (1000 acres)	Yield (Bushel)	Production (1000 bushel)	Price Per bushel	Value of Production (1000 dollars)
2000	6000	2200	30	66000	2.52	166320
2001	5600	3200	34	108800	2.78	302464
2002	6400	2700	29	78300	3.02	236466
2003	6600	2450	28	96600	3.06	295596
2004	6300	3500	31	108500	3.34	362390
2005	5500	3000	32	96000	3.44	330240
2006	5550	1400	24	33600	4.55	152880

The development of *P. triticina* on wheat consists of several distinct stages: germination of urediniospores, formation of appressoria, formation of substomatal vesicles, formation and growth of primary and secondary infection hyphae, formation of haustorial mother cells and haustoria, formation of uredinial beds and uredinia, and urediniospore production. The resistance of the wheat host affects several of these stages (Lee et al., 1984). Figure 1 shows the life cycle for *P. triticina* and the disease cycle for wheat leaf rust (Singh et al., 2002). The time for each event and frequency of some events (sexual cycle, wheat cropping season and green-bridge) may vary among areas and regions of the world.

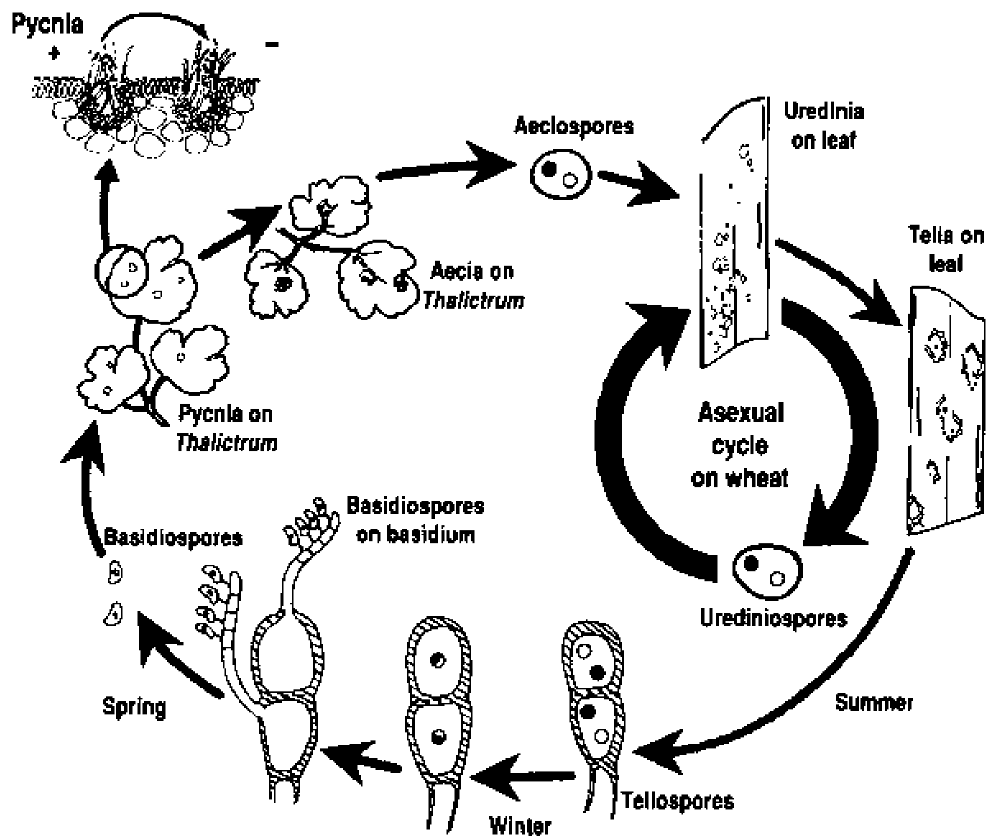

Fig. 1. Life cycles for leaf rust (Source: Brewster, verified 15 Apr. 2007)

The alternate host *Thalictrum* genus currently provides little direct inoculum of *P. triticina* to wheat, but may be a mechanism for genetic exchanges between races and perhaps populations. The pathogen survives the period between wheat crops in many areas on a green-bridge of volunteer (self-sown) wheat. Inoculum in the form of urediniospores can be blown by winds from one region to another. Teliospores can germinate shortly after development, and basidiospore infection can occur throughout the wheat-growing cycle.

Urediniospores initiate germination 30 minutes after contact with free water at temperatures of 15° to 25°C. The germ tube grows along the leaf surface until it reaches a stoma. Latent period varies from 8-14 days in the field with temperatures of 10-25°C. With temperatures of 5-10°C latent periods of several weeks are common. Wind enhances urediniospore dispersal during the day; calm nights enhance free water formation. An appressorium is then formed, followed immediately by the development of a penetration peg and a sub-stomatal vesicle from which primary hyphae develop. A haustorial mother cell develops against the mesophyll cell, and direct penetration occurs. The haustorium is formed inside the living host cell in a compatible host-pathogen interaction. Secondary hyphae develop resulting in additional haustorial mother cells and haustoria. In an incompatible host-pathogen response, haustoria fail to develop or develop at a slower rate. When the host cell dies, the fungus haustorium dies. Depending upon when or how many cells are involved; the host-pathogen interaction will result in a visible resistance response (Rowell, 1981, 1982).

The progression from spore germination to sporulation can occur within a seven- to ten-day period at optimum and constant temperatures. At low temperatures (10° to 15°C) or diurnal fluctuations, longer periods are necessary. The fungus may survive as insipid mycelia for a month or more when temperatures are near or below freezing. Maximum sporulation is reached about four days following initial sporulation (at about 20°C). Although the number can vary greatly, about 3000 spores are produced per uredinium per day. This level of production may continue for three weeks or more if the wheat leaf remains alive that long (Chester, 1946; Stubbs et al., 1986). Uredinia (pustules) are red, oval-shaped and scattered, and they break through the epidermis (Figure 2). Urediniospores are orange-red to dark red, echinulate, spherical and usually measure 20 to 28 µm in diameter (Figure 3). The teliospores (Figure 4) are dark brown, two-celled with thick walls and rounded or flattened at the apex (Figure 5).

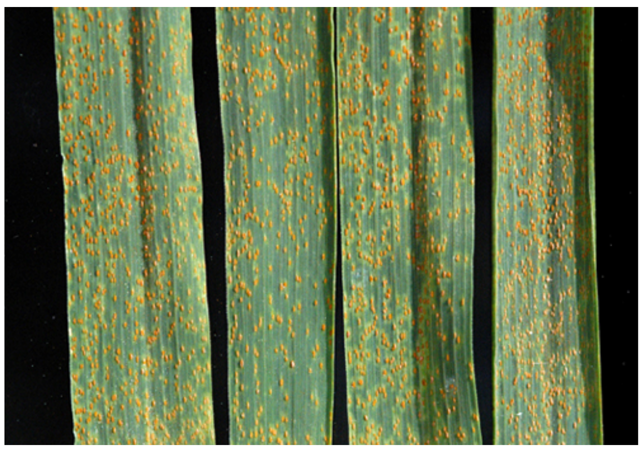

Fig. 2. Uredinia of leaf rust (*Puccinia triticina*) (Source: ARS-CDL, verified 15 Apr. 2007)

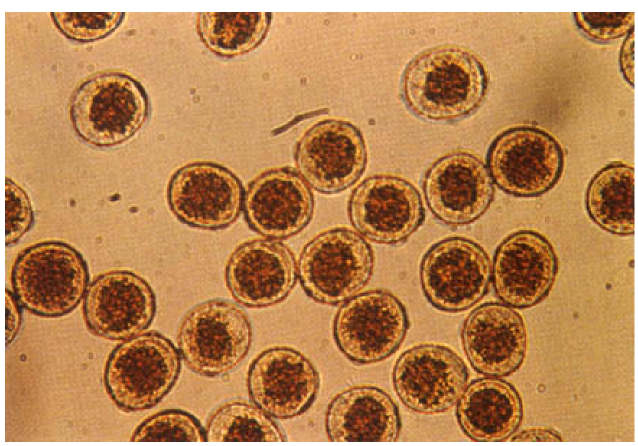

Fig. 3. Urediniospores of leaf rust (*Puccinia triticina*) (400x) (Source: Singh et al., 2002)

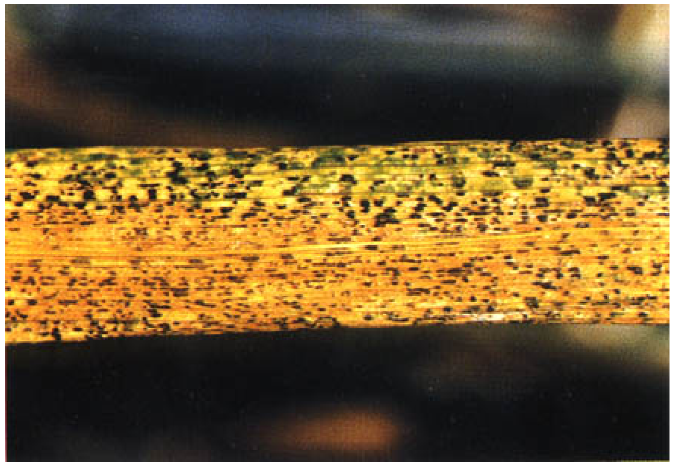

Fig. 4. Telia of leaf rust (*Puccinia triticina*) (Source: Singh et al., 2002)

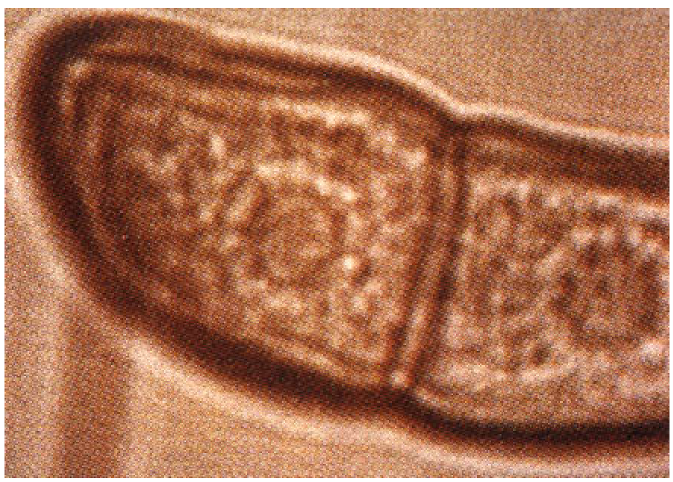

Fig. 5. Teliospore of leaf rust (*Puccinia triticina*) (400x) (Source: Singh et al., 2002)

The teliospores of *P. triticina* are formed under the epidermis with unfavorable conditions or senescence and remain with the leaves. Leaf tissues can be dispersed or moved by wind, animals or humans to considerable distances. Basidiospores are formed and released under humid conditions, which limit their spread. Basidiospores are also hyaline and sensitive to light, further limiting travel to probably tens of meters. Aeciospores are more similar to urediniospores in their ability to be transported by wind currents, but long-distance transport has not been noted for some reason.

Leaf rust survives between crops as overseasoning mycelium or as uredinia on infected volunteer and/or on early sown and late maturing wheat crops. The pathogen can survive almost any condition the host leaf can survive. Leaf rust is disseminated by wind blown urediniospores. Regionally transported urediniospores are generally rain deposited.

Losses over large areas are generally light to moderate, 1 to 20% in average. However, in 1985, Texas and Oklahoma lost an estimated 95 million bushels of wheat to leaf rust. Individual fields can be destroyed when the disease is severe prior to heading. Losses are more frequent in fall-seeded wheat or in spring wheat nearby fall seeded wheat. Grain shrivels and nutrients produced primarily in the flag leaf are used by the fungus rather than transported to the grain. Early infection can result in weak plants and poor root and tiller development. Losses are often the greatest in years most favorable for wheat growth, thus, high yields and higher losses often occur together. Although yield loss can vary greatly on a yearly basis, significant yield loss can occur even in years when environmental conditions are not particularly conducive to disease development and spread. In Texas, yield loss due to leaf rust also varies depending on weather condition. During dry years, urediniospores cannot successfully infect plants without much surface water. For example, Texas in 2006 had low loss due to leaf rust because of low precipitation. Figure 6 shows the yield losses from 2000 to 2006 in Texas and US.

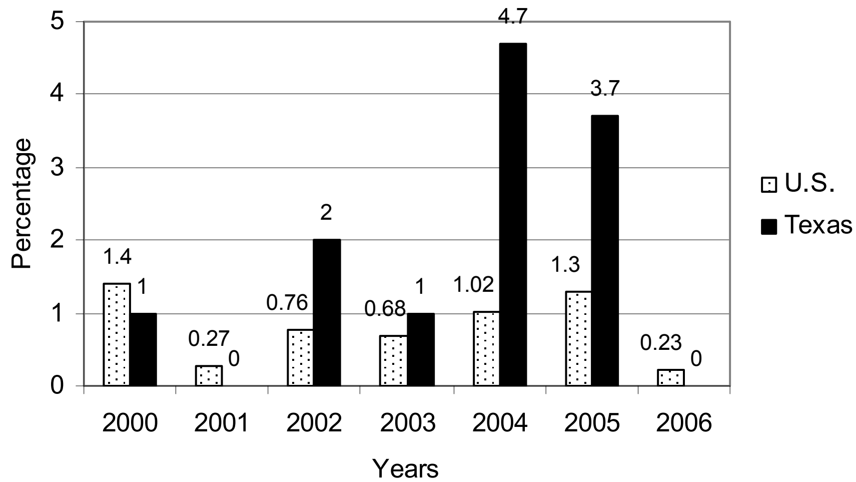

Fig. 6. Yield losses due to leaf rust in winter wheat from 2000 to 2006 (0 means trace) (Source: ARS-CDL, verified 16 Apr. 2007)

Wheat is grown in nearly every state of the U.S., but the greatest concentration is in the Great Plains. The high concentration of wheat from central Texas to Minnesota and the Dakotas even up to Manitoba, Canada (Figure 7) makes this region especially vulnerable to leaf rust epidemics. Urediniospores are blown by the predominant south wind throughout the Great Plains region. The cereal rust fungi are adapted for long distance spread. Rust epidemics start in fall-sown crops of winter wheat in the Southern Plains. Each rust infection in a wheat leaf or stem produces tens of thousands of spores that are released in the wind like pollen to produce new infections wherever they land on other susceptible wheat plants. Through sexual recombination, mutation or through existing genetic variation, the new races continuously come out to defeat the existing resistance genes. Some spores establish new infections after traveling hundreds of miles in high altitude air currents. Within one to two weeks, each new infection begins releasing spores to initiate the next generation of infections. The prevailing winds during spring and summer in the Great Plains are from south to north. This allows epidemics of cereal rusts to sweep north all the way from Texas to Manitoba. During harvest of winter wheat in Texas and Oklahoma, the rust moves north through the maturing crops of Kansas and Nebraska and into the fields young spring wheat in the Dakotas and Minnesota. Clearly, no individual state along this cereal rust path can solve its cereal rust problems by itself. Once a new race successfully overcomes resistance in the wheat cultivars in south Texas, urediniospores could follow the wind then infect wheat to the north. Thus, wheat breeding programs in Texas have the opportunity to reduce leaf rust epidemic throughout the Great Plains by breeding resistant cultivars.

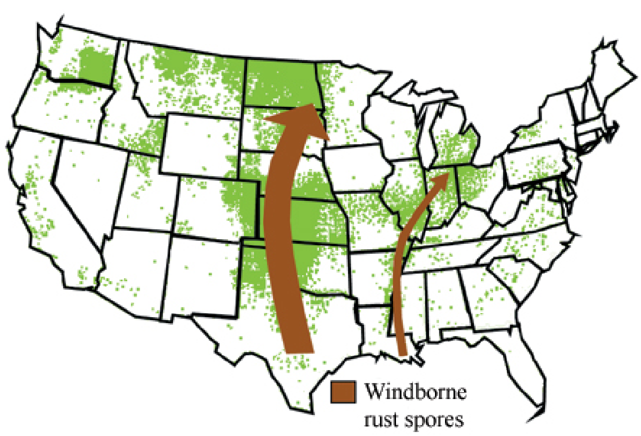

Fig. 7. *Puccinia* pathway (Source: ARS-CDL, verified 16 Apr. 2007)

Spread of rusts in the regions east of the Mississippi River does not follow such an obvious south to north pattern. However, the movement of new rust races from one region to another is a major concern. Cereal crops grown in one region can serve as a reservoir for races that may be able to overcome the resistance of cereal cultivars in other parts of the country. For example, wheat leaf rust race MBGL was rarely found in the Great Plains until 1990, one year after it had become the second most common leaf rust race in the Southeast.

The most successful, economical and environmental friendly approach to combat leaf rust is the use of resistant cultivars instead of using fungicides. Breeding small grain crops for rust resistance is not like breeding for better grain quality, higher yield, or even tolerance to physical stresses, such as drought or heat. Breeding gains made in those traits remain for as long as a cultivar is grown. This is not true for gains in rust resistance. Resistance built into a wheat cultivar over 15 years of breeding work can be totally compromised by a shift in pathogenic race in the rust fungus population. There are more than 57 genes for leaf rust resistance in wheat (Appendix 1). Each of these resistance genes will provide excellent resistance against some rust races, but none of them can be expected to work against all races.

Gene-for-gene resistance (Flor, 1956) is an interaction between host and pathogen. For each gene determining resistance in the host there is a corresponding gene for avirulence in the pathogen with which it specifically interacts (Kerr, 1987). The occurrence of a resistant or incompatible reaction depends on both the presence of a gene for resistance in the host and the corresponding gene for avirulence in the pathogen.

If the host lacks a specific resistance gene, the corresponding avirulence gene in the pathogen cannot be detected. Similarly, if the pathogen lacks a specific avirulence gene, the corresponding resistance gene in the host cannot be detected (Thompson et al., 1992). Resistance can be both either dominant or recessive.

Resistance gene expression is dependent on the genetics of host-pathogen interaction, temperature conditions, plant developmental stage, and interaction between resistance genes with suppressors or other resistance genes in the wheat genomes (Kolmer, 1996). Because new rust races can and do arise, the cereal breeder's work is never done. New races may require new resistant cultivars. Numerous resistance genes have been identified and introgressed into released cultivars (McIntosh et al., 1995). However, the resistance conferred by a single gene is frequently overcome by the appearance of virulent races in the pathogen population within a short period of time. Virulence, or the ability of a pathogen to overcome a specific gene for resistance, probably exists for almost all numbered major *Lr* genes on a worldwide basis. Because virulence exists for most of the resistance genes singly and for various combinations of two or more genes, it is essential to know what combination of virulence exists in the pathogen population before spending time on combining resistances in a host cultivar. This requires a systematic pathogen survey from which samples are obtained from different cultivars and different geographical and ecological areas throughout the season. In most areas, the rust (thus virulences) can survive the entire year in the asexual cycle. Genetic recombinations of virulence can occur several times in a single crop season (Ezzahiri et al., 1992). Continuous shifting of predominant races of *P. triticina* has constituted a substantial challenge to breeders attempting to produce cultivars with durable resistance. Although many cultivars were highly resistant to the prevalent leaf rust races when they were released the resistance genes were defeated in only a few years after deployment. The virulent races rapidly multiply on the susceptible host and soon become prevalent. Although multiple sources of resistance are being used by cereal breeding programs, the incidence of loss due to *P. triticina* is still very detrimental to yields. Thus it is necessary to continue to characterize novel sources of resistance, incorporate them into elite cultivars, and properly deploy these cultivars through resistance-gene management to minimize the ability of the pathogen to overcome the genetic resistance. One approach to overcoming the loss of resistance due to pathogen race shifts is the incorporation of multiple genes into a single cultivar, that is, gene pyramiding (Huang et al., 1997).

Currently, numerous wheat cultivars are thought to contain multiple sources of resistance to leaf rust (McIntosh et al., 1995). However, the combining of these resistance genes typically has occurred after at least one of the resistance genes has been compromised by its prior release as the sole source of resistance in a cultivar. Additionally, the pyramiding of leaf rust genes was due more to the combining ability of parents to produce superior progeny than to a purposeful strategy of stacking multiple sources of leaf rust resistance. Pyramiding of undefeated genes is also hindered by an inability to easily determine the number of leaf rust resistance genes in a given plant of a segregating population i.e. when a breeding line already has a gene; for example, *Lr21*, which shows resistance to all known leaf rust races. With the conventional approach, breeding lines with *Lr21* alone cannot be distinguished from breeding lines with *Lr21* plus other genes. This is why pyramiding can be very difficult using conventional breeding methods due to epistasis and/or the masking effect of genes. However, if closely linked DNA markers were available for each resistance gene, the identification of plants with multiple genes and efficient pyramiding using marker-assisted selection (MAS) would become easier.

The major advantages of MAS are: (1) Expedite the movement of desirable genes among cultivars, (2) Allow the transfer of novel genes from related wild species, (3) Make possible the analysis of complex polygenic characters as ensembles of single Mendelian factors and (4) Establish genetic relationships between sexually impatible crop plants (Tanksley et al., 1989).

Scientists have long theorized about the use of genetic maps and markers to speed up the process of plant and animal breeding. In 1923, Sax proposed identifying and selecting for minor genes, size differences of bean, of interest by linkage with major genes, seed-coat pigmentation, which could be scored more easily (Sax, 1923). Another example is the association between the adult plant leaf rust resistance gene *Lr34* and leaf tip necrosis (*Ltn*) (Singh, 1992). The leaf tip necrosis symptom can be used as a morphological marker to select for *Lr34*. Unfortunately, most morphological markers (for example, *Ltn*) also result in undesirable phenotypes. Moreover, they mask the effects of linked minor gene(s) making it almost impossible to identify desirable linkages for selection. Some of the first molecular markers have also been used in certain aspects of plant breeding, such as isozymes or restriction fragment length polymorphisms (RFLP).

Microsatellites (Tautz and Renz, 1984; Tautz, 1989), or simple sequence repeat (SSRs)-based molecular markers are now the marker of choice in many areas of plant genomics. The SSR polymorphisms have been extensively used as genetic markers in plant genomes, showing an extensive variation in different individuals and accessions (Akkaya et al., 1992; Senior and Heun, 1993; Wu and Tanksley, 1993). The advantages of SSRs are well documented (Powell et al., 1996) and include: high information content, co-dominant inheritance, reproducibility and locus specificity.

Somers et al. (2004) constructed a high density SSRs consensus genetic map of hard bread wheat. This map has a total 1235 SSRs markers through the entire wheat genome: 369 in genome A, 481 in genome B and 384 in genome D. The map gave us a basis to look for the location of resistance gene.

The goal of this research was the characterization of novel sources of resistance to leaf rust via SSRs markers for use in the development of multiple gene pyramids. This study was to characterize a novel source of resistance to leaf rust introgressed into the breeding line WX93D180R-8-1, which according to the pedigree was derived from *Triticum monococcum*. Research was conducted to determine its inheritance, map position, and linkage with molecular markers suitable for marker assisted selection.

Currently, many public breeding programs have started using MAS as a strategy in their cultivars development projects. In the recently funded USDA NRI Wheat CAP, available molecular markers are being used to transfer 22 resistance genes to fungi, viruses, and insects; and 21 gene variants related to bread, pasta, and noodle quality into 75 different recurrent parents (34 whites, 33 reds and 8 durums). Eighty MAS projects have been already completed and an additional 350 backcrossing programs are currently being advanced in average two generations a year by MAS (Dubcovsky, 2004). For wheat leaf rust, there are two leaf rust resistance genes, *Lr10* and *Lr21* (Feuillet et al., 2003; Huang et al., 2003), have been cloned and at least 12 resistance genes have been applied to develop breeding lines using MAS (MASwheat http://maswheat.ucdavis). A molecular marker is only useful if it is closely linked with the resistance gene. Sequences of the cloned genes are considered perfect markers since they are part of the gene and not to merely close to it.

In the future we plan to map additional resistance genes from other breeding lines in our attempt to pyramid multiple sources of leaf rust resistance into elite cultivars adapted to the Great Plains region. Our ultimate objective is the strategic deployment of pyramided sources of leaf rust resistance.

CHAPTER II

MATERIALS AND METHODS

2.1 Population development and rust screening

The pedigree of WX93D180R-8-1 is TX86D1310*3/TTCC417. Turkey *tritici* cereal collection (TTCC) 417 was part of a germplasm collection made in Turkey in 1991 by Drs. David Marshall and Lloyd Nelson, Texas Agricultural Experiment Station. It was determined to be *T. monococcum* through morphological and cytological analyzes by Dr. Marshall. TTCC417 was backcrossed to breeding line TX86D1310 two times. WX93D180R-8-1 was selected from this population as a F_4 derived line that was resistant to leaf rust. WX93D180R-8-1 was subsequently crossed with 'Chinese Spring' and 137 $F_{2:3}$ families were derived to be used for this study. Individual F_2 plants were evaluated under artificial inoculation for leaf rust resistance and their advanced progenies were evaluated as family rows under natural and artificial inoculation.

2.2 DNA extraction

The DNA was extracted using the CTAB method (modified from Colosi et al., 1993) from a small amount of fresh tissue (0.5 g) of 10-20 seedlings from each of the 137 $F_{2:3}$ families 7 days after emergence. Leaf tissue was then ground on a Geno/Grinder 2000 (OPS Diagnostics, LLC) for 35 sec at full speed in a 1.5 ml tube containing one iron rod, 10µL RNAse and 500µL extraction buffer (0.96M sorbitol, 2M Tris-HCl, pH8.0, 0.5M EDTA, pH8.0, 4M NaCl, 2% CTAB and 10% sacrosine). The tubes were incubated at 65°C in a heater block for 35 minutes and inverted a few times during incubation. An equal volume of chloroform:isoamylalcohol (24:1) was added into the tubes, and then they were inverted until homogeneous. The tubes were centrifuged at 10000g for 10 minutes and the aqueous layer was transferred into fresh labeled tubes. An equal amount of cold isopropanol was added and then the tubes were inverted a few times and centrifuged at 10000g for 15 minutes to pellet the DNA. The supernatant was poured off carefully to prevent losing the pellet and an equal volume of 70% cold ethanol was added and the tubes were thumped to detach the pellet. After a two minutes rest, the tubes were centrifuged again at 10000g for three to five minutes then the supernatant was poured off. The ethanol wash procedure was repeated and the supernatant was poured off. The tubes were left open overnight so that they could dry completely. The pellet was dissolved in 1/2X TE buffer the next day, then stored in 4°C overnight. The extracted DNA was quantified by fluoremetry using a Fluorometer TD-360 (Turner Designs) and diluted to a final concentration of 10ng/mL for SSR analysis.

2.3 Simple sequence repeat analysis

Microsatellite primer sequences were obtained from Somers et al. (2004). A set of 369 SSRs with known map locations in genome A, 481 in genome B and 384 in genome D are publicly available for this research. All primers used in this research were obtained from MWG Biotech (High Point, NC) and Integrated DNA Technologies (Coralville, IA). Forward primers were modified to incorporate the M13 primer sequence (5'-GTTTTCCCAGTCACGAC-3') for the purpose of universal fluorescent labeling (Schuelke, 2000; Rampling et al., 2001). M13 primer was labeled only with IRDye700.

Since the pedigree of WX93D180R-8-1 indicates that *T. monococcum* was the source of resistance, we used 232 SSRs located on genome A to survey WX93D180R-8-1, Chinese Spring and their progeny lines. Polymorphic markers were further tested on a subset of 13 resistant lines and 13 susceptible lines of the F_3 population to assess potential linkage with the resistance gene. Those markers that appeared to be associated with resistance were tested on the entire 103 $F_{2:3}$ lines from the crossing of Chinese x WX93D180-R-8-1 population for linkage analysis. From the 137 $F_{2:3}$ lines, thirty-four F_3 families were subtracted due to unclear segregation patterns, and/or too small sample sizes.

The PCR amplification conditions were modified from Srnic et al. (2005). The reactions contained 1x PCR buffer, 1.5 m*M* $MgCl_2$, 0.125 m*M* dNTPs (Promega, Madison, WI), 0.15 p*M* forward primer, 0.75 p*M* reverse primer, 0.75 p*M* M13 labeled primer, 0.6 U GoTaq Fleix DNA polymerase (Promega, Madison, WI), and 20 ng genomic DNA in a 10-µL total volume. Samples were amplified in a GeneAmp PCR System (Model 9700 Perkin-Elmer). PCR was performed as one cycle of 94°C for 2 minutes, followed by 28 cycles of 94°C for 1 minute, 60°C for 1 minute, and 72°C for 1 minute, followed by a 5 min hold at 72°C. Reactions were added bromophenol blue dye (Bio-Rad, Hercules, CA), denatured for 5 min at 94°C, and placed immediately on ice. Samples were loaded onto 6% denaturing polyacrylamide gels (Gene-Page Plus™, Amersco, Solon, Ohio) and run on LI-COR 4200 sequencers system (Schuelke 2000) for 2.5 h at 47°C, 42 W, 35 mA, and 1500 V.

2.4 Linkage analysis

Linkage relationships between marker loci and resistance genes were determined by using Mapmaker/Exp (Version 3.0 b) (Lincoln et al., 1993). Map distances were calculated using the Kosambi mapping function (Kosambi, 1944) to correct for crossover interference in estimation of recombination fractions. The decimal logarithm of odds (LOD) threshold ratio was set to 3.0 and a maximum recombination fraction of 50 cM. Loci were ordered on the chromosome using the "sequence" commands and maximum likelihood was used to compare different orders then chose the sequence with minimum LOD score.

2.5 Testing primers from *Lr21* resistance gene

None of the 232 microsatellite markers tested showed linkage relationship with the gene. We then surveyed and tested another 20 markers in the B genome and 12 in the D genome. After testing three markers in B and three in D, we found a marker BARC149 that seemed to have a relationship with the resistance gene. We then tested the markers near by (GWM147, WMC147, WMC432, CFD61 and CFD92) according to the map from Somers et al., 2004. The Mapmakers® analysis placed the gene from WX93D180-R-8-1 on chromosome 1DS. However, the resistance gene mapped to the same location as leaf rust resistance gene *Lr21* which has been cloned by Huang et al., 2003. Hence, we tested the primers obtained from *Lr21* gene in the subset of our mapping population (Forward: 5’-CGCTTTTACCGAGATTGGTC-3’, Reverse: 5’-TCTGGTATCTCACGAAGCCTT-3’) using 1X PCR buffer, 0.625mM dNTP, 6.25mM MgCl, 0.3U *Taq* polymerase (Promega, Madison, WI), 20ng DNA and 0.4pmol forward and reverse primers for 10 μL reaction. PCR was performed as one cycle of 95°C for 8 minutes, followed by 34 cycles of 95°C for 30 seconds, 54°C for 1 minute, and 72°C for 1 minute, followed by a 7 min hold at 72°C. PCR products were tested using 3% high resolution agarose gel.

CHAPTER III

RESULTS

3.1 Disease screening

WX93D180-R-1 was inoculated with a diverse set of leaf rust races and proved to be resistant to all races. Screening of the F2 progeny resulted in distinct classes. The F2 segregation ratio fits the ratio expected for a single dominant gene. In addition, 103 F3 families segregated 25R:50H:28S ($\chi 2=0.262$, p-value=0.877) (Table 3), which is also consistent with the expected segregation at a single locus. Thirty-four F3 families were not included in this ratio due to unclear segregation patterns, and/or too small family size.

Table 3. Leaf rust disease phenotype scores in $F_{2:3}$ lines

Entries	R	S	Class	Note
D180XCS 001	6	1	H	
D180XCS 002	12	6	H	
D180XCS 003	11	0	R	
D180XCS 004	11	4	H	
D180XCS 005	1	0		
D180XCS 006	10	2	H	
D180XCS 007	2	0		
D180XCS 008	2	1	H	
D180XCS 009	17	0	R	
D180XCS 010	12	3	H	
D180XCS 011	19	0	R	
D180XCS 012	15	5	H	
D180XCS 013	13	6	H	
D180XCS 014	16	3	H	
D180XCS 015	14	0	R	
D180XCS 016				
D180XCS 017	7	6	H	
D180XCS 018	1	0		
D180XCS 019	12	3	H	
D180XCS 020	12	7	H	
D180XCS 021	17	0	R	
D180XCS 022	12	0	R	
D180XCS 023	11	3	H	

Table 3. Continued

Entries	R	S	Class	Note
D180XCS 024	9	2	H	
D180XCS 025	12	6	H	
D180XCS 026	13	4	H	
D180XCS 027	11	2	H	
D180XCS 028	17	1	R§	
D180XCS 029	6	3	H	
D180XCS 030	8	2	H	
D180XCS 031	2	0		
D180XCS 032	10	3	H	
D180XCS 033	15	0	R	
D180XCS 034	4	0		
D180XCS 035	15	0	R	1 questionable
D180XCS 036	9	2	H	
D180XCS 037	1	0		
D180XCS 038	8	4	H	
D180XCS 039	7	1	H	
D180XCS 040	3	0		
D180XCS 041	6	0	R§	1 questionable
D180XCS 042	15	0	R	
D180XCS 043	12	2	H	
D180XCS 044	1	0		
D180XCS 045	2	2	H	
D180XCS 046	1	12	S§	R plant is borderline
D180XCS 047	0	12	S	
D180XCS 048				
D180XCS 049	0	13	S	
D180XCS 050	0	15	S	
D180XCS 051	0	9	S	
D180XCS 052	0	15	S	
D180XCS 053	0	15	S	
D180XCS 054	0	15	S	
D180XCS 055				
D180XCS 056	0	7	S	not as s as t-107
D180XCS 057	0	10	S	
D180XCS 058	0	18	S	
D180XCS 059				
D180XCS 060	16	0	R	
D180XCS 061	4	1	H	
D180XCS 062	6	2	H	
D180XCS 063	4	1	H	
D180XCS 064	11	0	R	
D180XCS 065	6	3	H	
D180XCS 066	11	4	H	
D180XCS 067	9	1	H	
D180XCS 068	8	6	H	
D180XCS 069	7	0	R	
D180XCS 070	5	0		
D180XCS 071	1	0		

Table 3. Continued

Entries	R	S	Class	Note
D180XCS 072	7	3	H	
D180XCS 073	1	0		
D180XCS 074				
D180XCS 075				
D180XCS 076	15	1	R§	s is questionable
D180XCS 077	1	0		
D180XCS 078	0	6	S	
D180XCS 079	17	0	R	
D180XCS 080	13	3	H	
D180XCS 081	7	0	R	
D180XCS 082	13	0	R	
D180XCS 083	3	1	H	
D180XCS 084	10	2	H	
D180XCS 085	11	4	H	
D180XCS 086	9	1	H	
D180XCS 087	9	3	H	
D180XCS 088	5	3	H	
D180XCS 089	2	0		
D180XCS 090	1	0		
D180XCS 091	8	1	H	
D180XCS 092	1	1	H	
D180XCS 093	6	0	R	
D180XCS 094	8	1	H	
D180XCS 095	7	2	H	
D180XCS 096	9	4	H	
D180XCS 097				
D180XCS 098	2	0		
D180XCS 099				
D180XCS 100	3	0		
D180XCS 101	15	0	R	
D180XCS 102	4	0		
D180XCS 103	19	0	R	
D180XCS 104	12	3	H	
D180XCS 105	13	0	R	
D180XCS 106	18	0	R	
D180XCS 107	9	2	H	
D180XCS 108	15	3	H	
D180XCS 109	11	0	R	
D180XCS 110	2	0		
D180XCS 111	5	0		
D180XCS 112	3	0		
D180XCS 113	11	0	R	
D180XCS 114	6	3	H	
D180XCS 115	12	2	H	
D180XCS 116	1	0		
D180XCS 117	2	0		
D180XCS 118	5	0		

Table 3. Continued

Entries	R	S	Class	Note
D180XCS 119	0	1		
D180XCS 120	0	8	S	
D180XCS 121	0	13	S	
D180XCS 122				
D180XCS 123	0	4	S§	
D180XCS 124				
D180XCS 125	0	7	S	
D180XCS 126	0	17	S	
D180XCS 127	0	16	S	
D180XCS 128	0	11	S	
D180XCS 129	0	13	S	
D180XCS 130	0	15	S	
D180XCS 131	0	11	S	
D180XCS 132	0	11	S	
D180XCS 133	0	4	S	
D180XCS 134	0	13	S	
D180XCS 135	0	12	S	
D180XCS 136	0	4	S	
D180XCS 137	0	2	S§	

§ Questionable classifications.

3.2 Marker analysis and mapping

None of the 232 microsatellite markers tested showed linkage relationship with the gene (Table 4). The interval distance between two markers was no more than ten cM evenly; therefore, if the gene is in the A genome linkage should have been found linkage through the survey. Since linkage was not found in the A genome then the markers on genome B and D were tested (Table 5 and Table 6). After testing three in B and three in D, a relationship was found between BARC149 and the resistance gene (Figure 8). The markers near by (GWM147, WMC147, WMC432, CFD61 and CFD92) were then tested according to the map from Somers et al. (2004) (Figure 9). Mapmakers® analysis determined that the gene from WX93D180-R-1 is on chromosome 1DS (Figure 10). However, the resistance gene located by Mapmakers® was actually the same location as leaf rust resistance gene *Lr21* that has been cloned by Huang et al., 2003 (Figure 11). Hence, the primers that are obtained from *Lr21* gene were tested in the subset (13 resistant lines and 13 susceptible lines) of the mapping population. After running the agarose gel check, it showed the same segregation pattern with the phenotypic data (Figure 12). The size of the *Lr21* PCR product is 669bps. The size of *Lr21* gene is 4318bps and encodes a 1080-amino-acid protein containing a conserved nucleotide-binding site (NBS) domain, 13 imperfect leucine-rich repeats (LRRs), and a unique 151-amino-acid sequence missing from known NBS-LRR proteins at the N terminus. According to our testing, it seems that the resistance gene from breeding line WX93D180 is *Lr21*.

Table 4. Primers tested and results in genome A

Location	Markers	Results
1A	GDM33	Polymorphic but no linkage
1A	GWM136	Polymorphic but no linkage
1A	GWM11	Monomorphic
1A	CFA2226	Cannot amplify
1A	CFD15	Monomorphic
1A	GWM33	Polymorphic but no linkage
1A	WMC336	Monomorphic
1A	BARC83	Monomorphic
1A	WMC24	Polymorphic but no linkage
1A	GWM357	Polymorphic but no linkage
1A	BARC119	Polymorphic but no linkage
1A	GWM164	Cannot amplify
1A	BARC148	Polymorphic but no linkage
1A	CFD59	Polymorphic but no linkage
1A	GWM135	Polymorphic but no linkage
1A	WMC278	Monomorphic
1A	WMC11	Monomorphic
1A	WMC183	Cannot amplify
1A	WMC312	Polymorphic but no linkage
1A	CFA2129	Polymorphic but no linkage
1A	WMC9	Monomorphic
1A	GWM497	Polymorphic but no linkage

Table 4. Continued

Location	Markers	Results
1A	WMC51	Polymorphic but no linkage
1A	WMC716	Polymorphic but no linkage
1A	WMC59	Polymorphic but no linkage
1A	BARC158	Monomorphic
1A	BARC17	Polymorphic but no linkage
1A	CFA2219	Monomorphic
1A	GWM99	Polymorphic but no linkage
2A	CFD36	Polymorphic but no linkage
2A	GWM512	Polymorphic but no linkage
2A	BARC124	Polymorphic but no linkage
2A	GWM296	Polymorphic but no linkage
2A	WMC667	Polymorphic but no linkage
2A	GWM636	Polymorphic but no linkage
2A	GWM614	Polymorphic but no linkage
2A	GWM497	Polymorphic but no linkage
2A	WMC407	Monomorphic
2A	WMC382	Polymorphic but no linkage
2A	WMC177	Monomorphic
2A	WMC149	Polymorphic but no linkage
2A	WMC522	Polymorphic but no linkage
2A	WMC296	Polymorphic but no linkage
2A	GWM339	Polymorphic but no linkage
2A	GWM95	Polymorphic but no linkage
2A	GWM71.2	Polymorphic but no linkage
2A	GWM558	Polymorphic but no linkage
2A	WMC632	Polymorphic but no linkage
2A	GWM328	Polymorphic but no linkage
2A	WMC455	Polymorphic but no linkage
2A	GWM372	Cannot amplify
2A	BARC5	Polymorphic but no linkage
2A	CFD6	Monomorphic
2A	GWM312	Cannot amplify
2A	GWM294	Polymorphic but no linkage
2A	CFD168	Monomorphic
2A	CFD86	Monomorphic
2A	WMC181	Monomorphic
2A	GWM356	Polymorphic but no linkage
2A	BARC76	Monomorphic
2A	GWM382	Polymorphic but no linkage
2A	GWM311	Polymorphic but no linkage
3A	WMC11	Monomorphic
3A	WMC532	Polymorphic but no linkage
3A	GWM369	Polymorphic but no linkage
3A	BARC45	Polymorphic but no linkage
3A	GWM2	Polymorphic but no linkage

Table 4. Continued

Location	Markers	Results
3A	GWM133	Polymorphic but no linkage
3A	WMC505	Polymorphic but no linkage
3A	GWM32	Polymorphic but no linkage
3A	WMC664	Polymorphic but no linkage
3A	GWM5	Polymorphic but no linkage
3A	GWM4	Polymorphic but no linkage
3A	GWM674	Polymorphic but no linkage
3A	GWM30	Polymorphic but no linkage
3A	BARC67	Cannot amplify
3A	CFD193	Polymorphic but no linkage
3A	GWM403	Polymorphic but no linkage
3A	WMC627	Polymorphic but no linkage
3A	WMC527	Polymorphic but no linkage
3A	WMC428	Polymorphic but no linkage
3A	WMC264	Cannot amplify
3A	CFA2262	Polymorphic but no linkage
3A	GWM494	Monomorphic
3A	GWM162	Polymorphic but no linkage
3A	WMC96	Polymorphic but no linkage
3A	GWM497	Polymorphic but no linkage
3A	CFA2193	Polymorphic but no linkage
3A	CFD2	Monomorphic
3A	WMC559	Monomorphic
3A	GWM155	Polymorphic but no linkage
3A	WMC153	Monomorphic
3A	CFA2076	Cannot amplify
3A	WMC594	Polymorphic but no linkage
3A	GWM480	Polymorphic but no linkage
4A	GWM165	Polymorphic but no linkage
4A	BARC206	Polymorphic but no linkage
4A	WMC420	Polymorphic but no linkage
4A	WMC89	Polymorphic but no linkage
4A	WMC491	Polymorphic but no linkage
4A	WMC48	Polymorphic but no linkage
4A	GWM44	Polymorphic but no linkage
4A	CFA2256	Polymorphic but no linkage
4A	WMC96	Polymorphic but no linkage
4A	GWM610	Polymorphic but no linkage
4A	GWM397	Polymorphic but no linkage
4A	WMC513	Polymorphic but no linkage
4A	BARC170	Polymorphic but no linkage
4A	GWM637	Polymorphic but no linkage
4A	WMC468	Polymorphic but no linkage
4A	WMC707	Polymorphic but no linkage
4A	WMC161	Polymorphic but no linkage

Table 4. Continued

Location	Markers	Results
4A	GWM494	Monomorphic
4A	WMC718	Polymorphic but no linkage
4A	WMC283	Polymorphic but no linkage
4A	WMC262	Polymorphic but no linkage
4A	WMC500	Polymorphic but no linkage
4A	WMC232	Polymorphic but no linkage
4A	BARC70	Polymorphic but no linkage
4A	GWM160	Polymorphic but no linkage
4A	CFD2	Monomorphic
4A	WMC776	Polymorphic but no linkage
4A	WMC313	Polymorphic but no linkage
4A	WMC219	Monomorphic
5A	GWM443	Polymorphic but no linkage
5A	WMC47	Polymorphic but no linkage
5A	WMC713	Polymorphic but no linkage
5A	GWM205	Polymorphic but no linkage
5A	GDM109	Polymorphic but no linkage
5A	GWM154	Polymorphic but no linkage
5A	CFA2104	Polymorphic but no linkage
5A	WMC489	Polymorphic but no linkage
5A	CFA2190	Polymorphic but no linkage
5A	WMC51	Polymorphic but no linkage
5A	GWM293	Monomorphic
5A	BARC197	Polymorphic but no linkage
5A	GWM129	Polymorphic but no linkage
5A	CFA2250	Polymorphic but no linkage
5A	WMC705	Polymorphic but no linkage
5A	WMC150	Polymorphic but no linkage
5A	BARC56	Polymorphic but no linkage
5A	GWM304	Polymorphic but no linkage
5A	GWM186	Polymorphic but no linkage
5A	BARC165	Monomorphic
5A	WMC492	Polymorphic but no linkage
5A	GWM156	Monomorphic
5A	GWM639	Polymorphic but no linkage
5A	GWM617	Monomorphic
5A	WMC415	Polymorphic but no linkage
5A	CFD2	Monomorphic
5A	WMC475	Monomorphic
5A	BARC151	Monomorphic
5A	GWM666	Polymorphic but no linkage
5A	WMC445	Polymorphic but no linkage
5A	CFA2163	Polymorphic but no linkage
5A	CFA2141	Polymorphic but no linkage
5A	WMC96	Polymorphic but no linkage

Table 4. Continued

Location	Markers	Results
5A	BARC232	Polymorphic but no linkage
5A	CFA2185	Polymorphic but no linkage
5A	WMC110	Polymorphic but no linkage
5A	GWM126	Polymorphic but no linkage
5A	WMC577	Polymorphic but no linkage
5A	GWM595	Polymorphic but no linkage
5A	WMC524	Polymorphic but no linkage
5A	WMC727	Polymorphic but no linkage
5A	GWM291	Monomorphic
6A	GWM459	Polymorphic but no linkage
6A	GWM334	Cannot amplify
6A	BARC206	Monomorphic
6A	BARC23	Polymorphic but no linkage
6A	WMC182	Polymorphic but no linkage
6A	BARC146	Polymorphic but no linkage
6A	CFD190	Polymorphic but no linkage
6A	WMC145	Polymorphic but no linkage
6A	WMC256	Polymorphic but no linkage
6A	BARC3	Polymorphic but no linkage
6A	WMC201	Polymorphic but no linkage
6A	GWM132	Polymorphic but no linkage
6A	GWM570	Polymorphic but no linkage
6A	WMC553	Monomorphic
6A	GWM169	Monomorphic
6A	WMC417	Monomorphic
6A	WMC580	Monomorphic
6A	GWM427	Monomorphic
6A	GWM617	Monomorphic
6A	WMC621	Polymorphic but no linkage
6A	WMC254	Cannot amplify
6A	WMC59	Polymorphic but no linkage
7A	GWM666	Polymorphic but no linkage
7A	GWM233	Polymorphic but no linkage
7A	GWM635	Polymorphic but no linkage
7A	BARC151	Monomorphic
7A	GWM471	Polymorphic but no linkage
7A	GWM60	Polymorphic but no linkage
7A	WMC593	Polymorphic but no linkage
7A	CFD13	Monomorphic
7A	CFA2049	Monomorphic
7A	WMC283	Polymorphic but no linkage
7A	BARC127	Polymorphic but no linkage
7A	CFA2028	Monomorphic
7A	WMC83	Polymorphic but no linkage
7A	BARC174	Polymorphic but no linkage

Table 4. Continued,

Location	Markers	Results
7A	CFD6	Monomorphic
7A	GWM573	Cannot amplify
7A	GWM260	Cannot amplify
7A	WMC17	Polymorphic but no linkage
7A	BARC108	Monomorphic
7A	WMC182	Polymorphic but no linkage
7A	WMC9	Polymorphic but no linkage
7A	WMC65	Polymorphic but no linkage
7A	WMC596	Polymorphic but no linkage
7A	WMC422	Polymorphic but no linkage
7A	WMC603	Polymorphic but no linkage
7A	BARC23	Polymorphic but no linkage
7A	BARC121	Polymorphic but no linkage
7A	BARC49	Polymorphic but no linkage
7A	WMC607	Polymorphic but no linkage
7A	WMC139	Cannot amplify
7A	WMC488	Polymorphic but no linkage
7A	GWM10	Polymorphic but no linkage
7A	BARC195	Cannot amplify
7A	GWM276	Polymorphic but no linkage
7A	CFA2257	Monomorphic
7A	CFD20	Monomorphic
7A	GWM282	Polymorphic but no linkage
7A	GWM332	Polymorphic but no linkage
7A	GWM63	Polymorphic but no linkage
7A	WMC633	Polymorphic but no linkage
7A	CFA2019	Polymorphic but no linkage
7A	GWM554	Polymorphic but no linkage
7A	WMC525	Polymorphic but no linkage
7A	CFA2040	Polymorphic but no linkage

Table 5. Primers tested and results in genome B

Location	Markers	Results
1B,7B	GWM274	Not tested
1B	BARC8	Not tested
2B	BARC159	Polymorphic but no linkage
2B,2D	BARC124	Polymorphic but no linkage
2B	GWM148	Polymorphic but no linkage
2B	GWM630	Not tested
2B,2D	WMC25	Not tested
3B	BARC147	Not tested
3B	BARC75	Not tested
3B	BARC77	Not tested

Table 5. Continued

Location	Markers	Results
4B	WMC710	Not tested
4B	BARC20	Not tested
5B	GWM443	Not tested
5B	BARC4	Not tested
5B	BARC59	Not tested
5B	GWM604	Not tested
5B	WMC160	Not tested
6B	BARC146	Not tested
6B	BARC24	Not tested
7B	CFA2040	Not tested

Table 6. Primers tested and results in genome D

Location	Markers	Results
1D	BARC149	Linkage found
1D	BARC66	Polymorphic but no linkage
1D	WMC432	Linkage found
3D	BARC71	Not tested
4D	BARC98	Not tested
5D	BARC143	Not tested
6D	BARC5	Not tested
6D	BARC173	Not tested
6D	BARC96	Not tested
7D	BARC87	Not tested
7D	BARC111	Not tested
7D	BARC172	Not tested

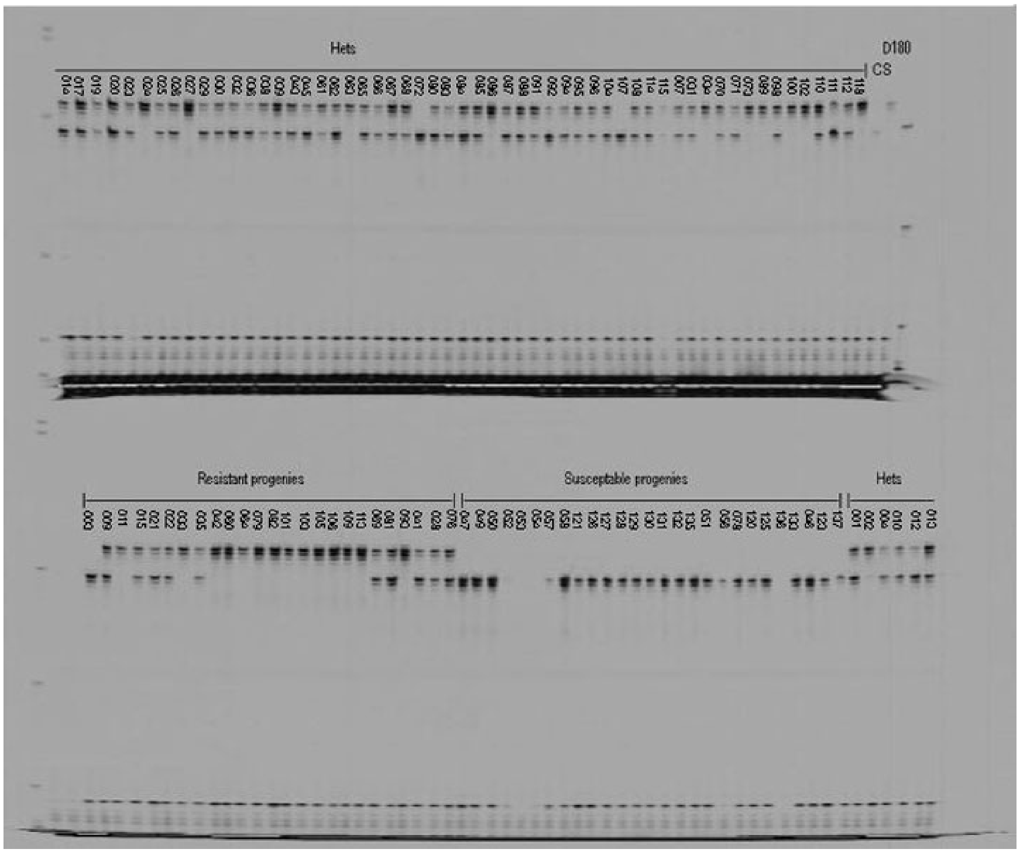

Fig. 8. BARC149 in 103 $F_{2:3}$ families

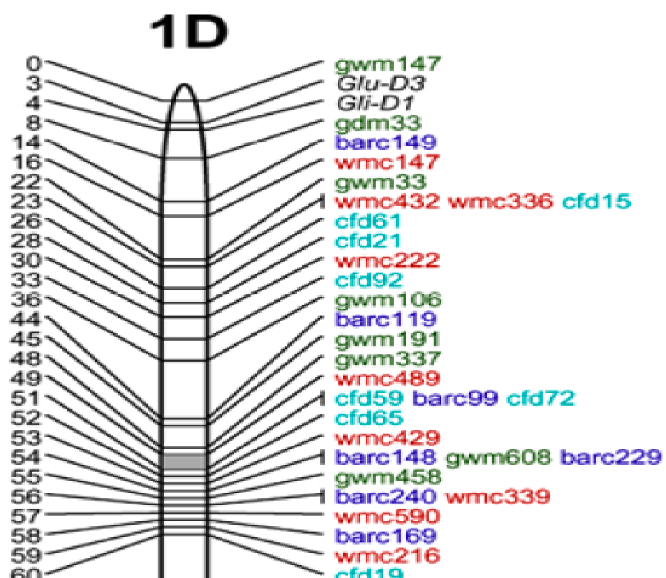

Fig. 9. SSRs markers on chromosome 1DS (Source: Somers et al., 2004)

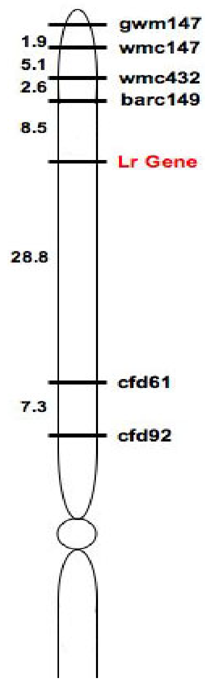

Fig. 10. Genetic map of Lr gene region in chromosome 1DS was constructed from 103 $F_{2:3}$ plants from the crosses of Chinese Spring and WX93D180-R-8-1 by MapMaker. The difference between our map and Somers' map might be result in the different population size and the scoring errors and the criteria we were setting in MapMakers

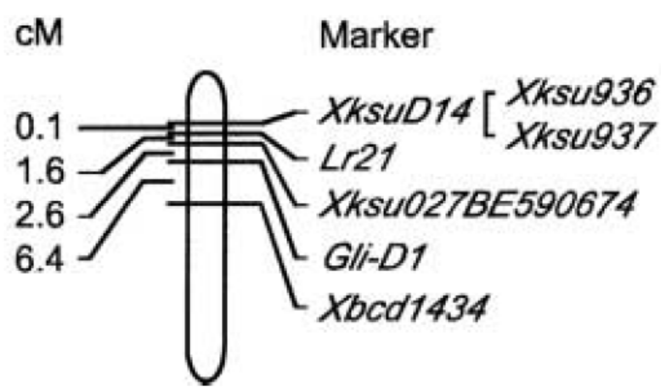

Fig. 11. Genetic map of *Lr21* gene region in chromosome 1DS (Source: Huang et al., 2003)

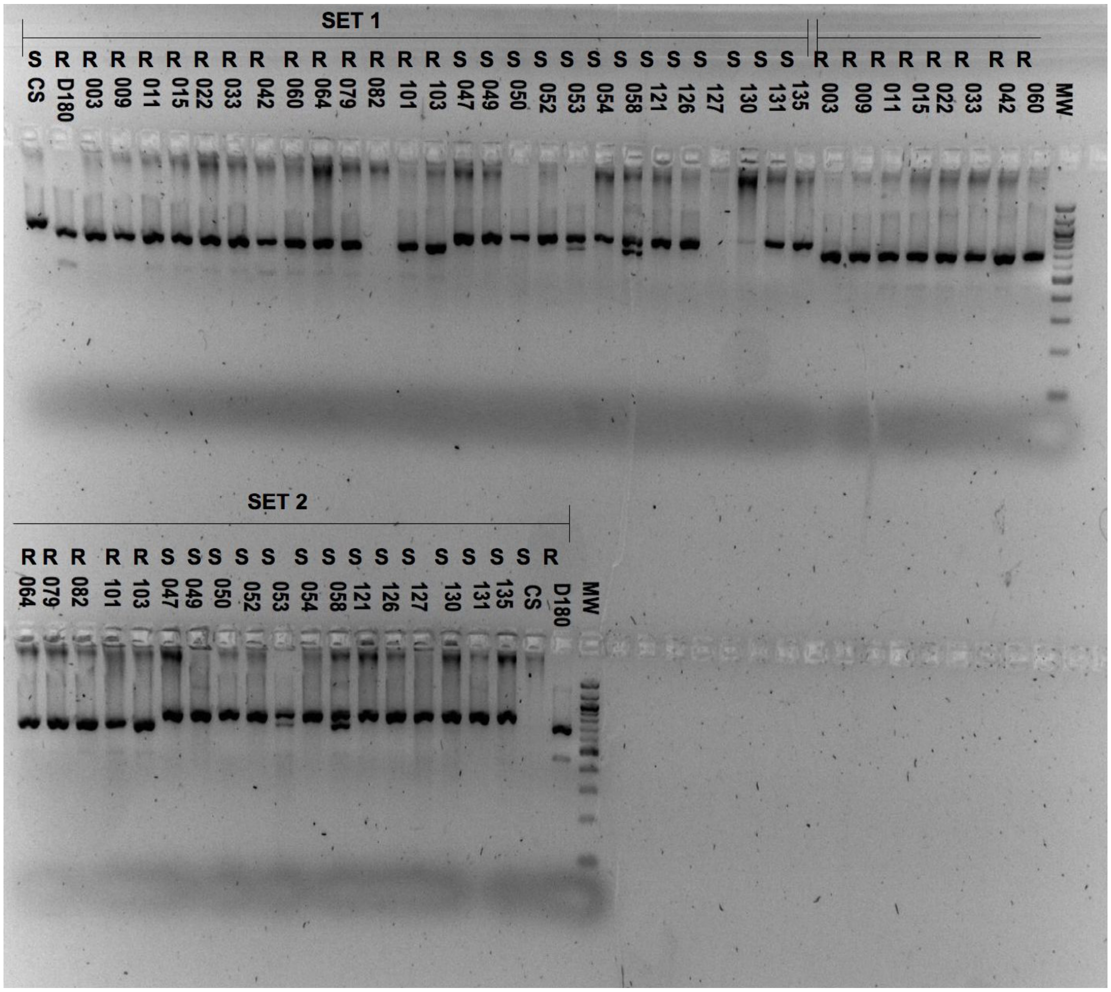

Fig. 12. *Lr21* in subset of progeny lines of Chinese Spring and WX93D180-R-8-1. Set 2 is the replication of set 1. Although 082 and 127 were not amplified in set 1 but have the products in set 2. They still fit our expectation. The susceptible lines 053 and 058 showed heterozygosity. It may cause by phenotyping mistakes or seeds mixture

CHAPTER IV

DISCUSSION AND CONCLUSIONS

The resistance gene was not found in genome A as expected. The result was that the resistance gene was in the D genome, and it appears to be *Lr21*, which has already been published (Huang et al., 2003). According to the pedigree, it was assumed that the leaf rust resistance was derived from *T. monococum* which has only the A genome. We initially devoted our effort in genome A but did not find linkage. It seems likely that there was an error in pedigree or mislabeling at some time during the development of WX93D180R-8-1. TTCC417 could have been misclassified or might be mixed with other D genome collections. It also could be the result of crossing, planting, or harvesting mistakes made during the development of the WX93D180-R-8-1 line.

A second possible reason could be that the pedigree was correct but the resistance was from TX86D1310, which according to the pedigree, Thunderbird//Payne/Collin, should not have *Lr21*. The reasonable assumption would be that there was some mistake made in the records.

Another less possible reason might be the evolution of the disease resistance gene. The expansions of resistance genes create cluster gene families. Variation can arise from both intragenic and intergenic recombination and gene conversion. Recombination has also been implicated in the generation of novel resistance specificities (Richter et al., 2000). The structure of *Lr21* is a nucleotide-binding site and leucine-rich repeat (NBS-LRR) gene (Huang et al., 2003). The LRR has a role in determination of specificity of resistance gene (Ellis et al., 2000). Several resistance genes show significant similarity to previously identified receptors from a diverse group of organisms. A common motif evident among these proteins is the LRR. The LRRs are believed to mediate protein-protein interactions, or determine specific recognition of ligands by the receptor molecules (Kobe et al., 1994). LRR domains of resistance gene products show similarity to diverse proteins controlling cell-cell communication in development and signaling suggesting that these genes may have evolved through duplication and divergence of common ancestors (Clark et al., 1997, Li et al., 1997 and Torii et al., 1996). This has been observed in other species such as the *Drosophila Toll* and *Dif* genes (Petersen et al., 1995). Thus, it is possible the resistance gene in our population is one of the members in the *Lr21* gene family since the PCR product from *Lr21* primers is only the 15% of the entire gene. The published primers sequences were used to test our population and found the same pattern with *Lr21* in the population but the LRR region may exist difference sequences to form a gene family and the gene located from the analysis may not be necessary the same gene. The possible way to clarify is to sequence the PCR product to verify the similarity between *Lr21* and the gene has been found in this research. Even if the gene we found is not *Lr21*, mistakes made during breeding or record keeping are the most logical explanation for why the resistance gene is located in the D genome instead of the A genome.

Molecular markers linked to novel resistance genes can be used to build effective pyramids of leaf rust resistance genes into Great Plains adapted cultivars. Multiple undefeated resistance genes against a wide range of races may provide durable resistance.

Since we know the resistance in the breeding line WX93D180 is *Lr21*, which is in several current cultivars, the purpose of pyramiding novel resistance genes from WX93D180 cannot be fulfilled through this research. However, *Lr21* is still effective in the Great Plains and we can use MAS on existing WX93D180 crosses to increase the frequency of *Lr21* in the Texas breeding program.

Since new leaf rust races continue to evolve, it is imperative that the discovery of new resistance genes and the development of better disease management strategies continue. The Texas wheat breeding programs must remain diligent in breeding leaf rust resistant cultivars that have the yield, agronomic, and quality attributes desired by Texas wheat producers.

REFERENCES

Agricultural Research Service-Cereal Disease Laboratory. 2006. Uredinia of leaf rust [Online] Available at http://www.ars.usda.gov/Main/docs.htm?docid=9915 (Verified 15 Apr. 2007)

Agricultural Research Service-Cereal Disease Laboratory. 2006. Wheat leaf rust resistance genes: source, genome location, low infection type and tester lines [Online] Available at http://www.cdl.umn.edu/res_gene/wlr.html (Verified 20 May 2007)

Agricultural Research Service-Cereal Disease Laboratory. 2007. *Puccinia* pathway [Online] Available at http://www.ars.usda.gov/Main/docs.htm?docid=9757 (Verified 16 Apr. 2007)

Agricultural Research Service-Cereal Disease Laboratory. 2007. Small grain losses due to rust [Online] Available at http://www.ars.usda.gov/Main/docs.htm?docid=10123 (Verified 16 Apr. 2007)

Akkaya, M.S., AA. Bhagwat, and P.B. Cregan. 1992. Length polymorphism of simple sequence repeat DNA in soyabean. Genetics 132:1131-1139.

Brewster, V. 2007. Life and disease cycles for *Puccinia triticina* [Online] Available at http://www.cdl.umn.edu/gifs/prt-cycl.jpg (Verified 15 Apr. 2007)

Chester, K.S. 1946. The nature and prevention of the cereal rusts as exemplified in the leaf rust of wheat. Chronica botanica, Waltham, MA.

Clark, S.E., R.W. Williams, and E.M. Meyerowitz. 1997. The *CLAVATA1* gene encodes a putative receptor kinase that controls shoot and floral meristem size in Arabidopsis. Cell 89:575-585.

Colosi, J.C., and B.A. Schaall. 1993. Tissue grinding with ball bearings and vortex mixer for DNA extraction. Nucleic Acids Research 4:1051-1052.

Dubcovsky, J. 2004. Marker-Assisted Selection in public breeding programs: the wheat experience. Crop Sci. 44:1893-1919.

Ellis, J., P. Dodds, and T. Pryor. 2000. Structure, function and evolution of plant disease resistance genes. Current Opinion in Plant Biology 3:278-284.

Ezzahiri, B., S. Diouri, and A.P. Roelfs. 1992. The-Role of the alternate host, *Anchusa italica*, in the epidemiology of *Puccinia recondita* f. sp. *tritici* on durum wheats in Morocco. *In* F.J. Zeller & G. Fischbeck (ed.) Proc. 8th European and Mediterranean Cereal Rusts and Mildews Conf. pp.69-70. Weihenstephan, Germany.

Flor, H.H. 1956. The complementary genic systems in flax and flax rust. Adv. Genet. 8:29-54.

Feuillet, C., S. Travella, N. Stein, L. Albar, A. Nublat, and B. Keller. 2003. Map-based isolation of the leaf rust disease resistance gene *Lr10* from the hexaploid wheat (*Triticum aestivum* L.) genome. Proc. Natl. Acad. Sci. USA 100:15253-15258.

Huang, L., S.A. Brooks, W. Li, J.P. Fellers, H.N. Trick, and B.S. Gill. 2003. Map-based cloning of leaf rust resistance gene *Lr21* from the large and polyploidy genome of bread wheat. Genetics 164:655-664.

Huang, N., E.R. Angeles, J. Domingo, G. Magpantay, S. Singh, G. Zhang, N. Kumaravadivel, J. Bennett, and G.S. Khush. 1997. Pyramiding of bacterial blight resistance genes in rice: marker-assisted selection using RFLP and PCR. Theor. Appl. Genet. 95:313-320.

Kerr, A. 1987. The impact of molecular genetics of plant pathology. Ann. Rev. Phytopathol. 25:87-110.

Kobe, B., and J. Deisenhofer. 1994. The leucine-rich repeat: a versatile binding motif. Trends Biochem Sci 19:415-420.

Kolmer, J.A. 1996. Genetics of resistance to wheat leaf rust. Ann. Rev. Phytopathol. 34:435-455.

Kosambi, D.D. 1944. The estimation of map distance from recombination values. Ann. Eugen. 12:172-175.

Lee, T.S., and G. Shaner. 1984. Infection processes of *Puccinia recondita* in slow- and fast-rusting wheat cultivars. Phytopathology 12:1419-1423.

Li, J., and J. Chory. 1997. A putative leucine-rich repeat receptor kinase involved in brassinosteroid signal transduction. Cell 90:929-938.

Lincoln, S.E., M.J. Daly, and E. Lander. 1993. Constructing linkage maps with Mapmaker/Exp Version 3.0. A tutorial and reference manual. 3rd ed. Whitehead Inst. for Medical Res., Cambridge, MA.

McIntosh, R.A., C.R. Wellings, and R.F. Park. 1995. Wheat rusts: an atlas of resistance genes. CSIRO, East Melbourne, Australia.

National Agricultural Statistics Service. 2006. Wheat production in Texas [Online]. Available at http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/#top (verified 15 Apr. 2007)

National Agricultural Statistics Service. 2006. Wheat production in U.S. [Online]. Available at http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/#top (verified 15 Apr. 2007)

Petersen, U.M., G. Bjorklund, Y.T. Ip, and Y. Engstrom. 1995. The dorsalrelated immunity factor, *Dif*, is a sequence-specific transactivator of Drosophila Cecropin gene expression. EMBO J 14:3146-3158.

Powell, W., G.C. Machray, and J. Provan. 1996. Polymorphism revealed by simple sequence repeats. Trends Plant Sci. 7:215-222.

Rampling, L.R., N. Harker, M.R. Shariflou, and M.K. Morell. 2001. Detection and analysis systems for microsatellite markers in wheat. Aust. J. Agric. Res. 52:1131-1141.

Richter, T.E., and P.C. Ronald. 2000. The evolution of disease resistance genes. Plant Molecular Biology 42:195-204.

Rowell, J.B. 1981. Relation of postpenetration events in Idaed 59 wheat seedling to low receptivity to infection by *Puccinia graminis* f. sp. *tritici*. Phytopathology 71: 732-736.

Rowell, J.B. 1982. Control of wheat stem rust by low receptivity to infection conditioned by a single dominant gene. Phytopathology 72:297-299.

Sax, K. 1923. The association of size differences with seed-coat pattern and pigmentation in *Phaseolus vulgaris*. Genetics 8:552-560.

Schuelke, M. 2000. An economic method for the fluorescent labeling of PCR fragments. Nat. Biotechnol. 18:233-234.

Senior, M.L., and M. Heun. 1993. Mapping maize microsatellites and polymerase-chain-reaction confirmation of the targeted repeats using a CT primer. Genome 36:884-889.

Singh, R.P. 1992. Association between gene Lr34 for leaf rust resistance and leaf tip necrosis in wheat. Crop Sci. 32:874-878.

Singh, R.P., J. Huerta-Espino, and A.P. Roelfs. 2002. The wheat rust, bread wheat, improvenment and production [Online]. FAO Plant Production and Protection Series, No. 30, food and agriculture organization of the united nations, Rome, 2002. Available at http://www.fao.org/docrep/006/Y4011E/y4011e00.HTM

Somers, D.J., P. Isaac, and K. Edwards. 2004. A high density microsatellite consensus map for bread wheat (*Triticum aestivum* L). Theor. Appl. Genet. 109:1105-1114.

Srnic, G., J.P. Murphy, J.H. Lyerly, S. Leath, and D.S. Marshall. 2005. Inheritance and chromosomal assignment of powdery mildew resistance genes in two winter wheat germplasm lines. Crop Sci. 45:1578-1586.

Stubbs, R.W., J.M. Prescott, E.E. Saari, and H.J. Dubin. 1986. Cereal disease methodology manual. p.46. Mexico, DF, CIMMYT.

Tanksley, S.D., N.D. Young, A.H. Paterson, and M.W. Bonoerbale. 1989. RFLP mapping in plant breeding: new tools for an old science. Bio/technology 7: 257-264.

Tautz, D. 1989. Hypervariability of simple sequences as a general source for polymorphic DNA markers. Nucleic Acids Res. 17:6463-6471.

Tautz, D., and M. Renz. 1984. Simple sequences are ubiquitous repetitive components of eukaryotic genomes. Nucleic Acids Res. 12:4127-4138.

Thompson, J. N., and J.J. Burdon. 1992. Gene-for-gene coevolution between plants and parasites. Nature 360:121-125.

Torii, K.U., N. Mitsukawa, T. Oosumi, Y. Matsuura, R. Yokoyama, R.F. Whittier, and Y. Komeda. 1996. The Arabidopsis ERECTA gene encodes a putative receptor protein kinase with extracellular leucine-rich repeats. Plant Cell 8: 735-746.

Wu, K., and S.D. Tanksley. 1993. Abundance, polymorphism and genetic mapping of microsatellites in rice. Mol. Gen. Genet. 241:225-23.

APPENDIX 1

WHEAT LEAF RUST RESISTANCE GENES: ORIGIN, GENOME LOCATION AND SOURCE (Source: edited from ARS-CDL, verified 20 May 2007)

Lr gene	Origin	Genome Location	Linkage	Tester source	Gene references
1	Common Wheat	5DL		Centenario	
2a	Common Wheat	2DS		Webster	Dyck, P. L and Samborski, D. J. 1968. Can. J. Genet. and Cytol. 10: 7-17
2b	Common Wheat	2DS		Carina	Dyck, P. L., and Samborski, D. J. 1974. Can. J. Genet. and Cytol. 16: 323-332.
2c	Common Wheat	2DS		Brevit	Dyck, P. L., and Samborski, D. J. 1974. Can. J. Genet. and Cytol. 16: 323-332.
3a	Common Wheat	6BL	*Sr11*	Democrat	Dyck, P. L and Samborski, D. J. 1968. Can. J. Genet. and Cytol. 10: 7-17
3bg	Common Wheat	6BL	*Sr11*	Bage	Haggag, M. E. and Dyck, P. L. 1973. Can. J. Genet. and Cytol. 15:127-134.
3ka	Common Wheat	6BL	*Sr11*	Klein Aniversario	Haggag, M. E. and Dyck, P. L. 1973. Can. J. Genet. and Cytol. 15:127-134.
9	*Aegilops umbellulata*	6BL		Transfer	Sears, E. R. 1956. Brookhaven Symposium in Biology 9: 1-22.
10	Common Wheat	lAS		Exchange	Dyck, P. L. and Kerber, E. R. 1971. Can. J. Genet. and Cytol. 480-483.
11	Common Wheat	2A		Hussar	Dyck, P. L and Johnson, R. 1983. Can. J. Plant Pathol. 5: 229-234.
12	Common Wheat	4BS		Exchange	Dyck, P.L. et al., 1966. Can. J. Genet. and Cytol. 8:665-671
13	Common Wheat	2BS	*Ne2m, Lr23*	Frontana	"
14a	*Yaroslav emmer*	7BL		Selkirk	Dyck, P.L. and Samborski, D.J. 1970. Can. J. Genet. and Cytol. 12:689-694
14b	Common Wheat	7BL		Maria Escobar	"
15	Common Wheat	2DS	*Lr2, Sr6*	W1483	Luig, N.H. and McIntosh, R.A. 1968. Can. J. Genet. and Cytol. 10:99-105
16	Common Wheat	2BS	*Sr23*	Exchange	Dyck, P.L. and Samborski, D.J. 1968. Proc 3rd Int Wheat Genet Symp, pp 245-250
17a	Common Wheat	2AS	*Lr37, Sr38, Yr17*	Klein Lucero	"
17b	Common Wheat	2AS	*Lr37, Sr38, Yr17*	Harrier	
18	*T. timopheevi*	5BL		Africa 43	"
19	*Thinopyrum ponticum*	7DL	*Sr25*	*Thinopyrum ponticum*	Sharma, D. and Knott, D.R. 1966. Can. J. Genet. and Cytol. 8:137-143
20	Common Wheat	7AL	*Pm1, S15, Sr22*	Timmo	Browder, L.E. 1972. Crop Sci 12:705-706
21	*T. tauschii*	1DS		*T. tauschii*	Huang, L. et al., Genetics 164: 655 – 664
22a	*T. tauschii*	2DS	*Tg, W2*	*T. tauschii*	"

22b	Common Wheat	2DS	*Tg, W2*	Thatcher	Dyck, P.L. 1979. Can. J. Plant Sci. 59:499-501
23	Durum Wheat	2BS	*Lr13, Sr9*	Gabo	McIntosh, R.A. 1975. Aust. J. Biol. Sci. 28:201-211
24	*Thinopyrum ponticum*	3DL	*Sr24*	Agent	Browder, L.E. 1973. Crop Sci. 13:203-206
25	*Secale cereale*	4AB	*Pm7*	Transec	Driscoll, C.J. and Anderson, L.M. 1967. Can. J. Genet. and Cytol. 9:375-380
26	*Secale cereale*	lBL	*Sr31, Yr9*	St-1-25	Singh, R.P. et al., 1990. Theor. Appl. Genet. 80:609-616
27	Common Wheat	3BS	*Sr2*	Gatcher	Singh, R.P. and McIntosh, R.A. 1984. Can. J. Genet. and Cytol. 26:736-742
28	*A. speltoides*	4AL		C-77-1	McIntosh, R.A. 1982. Z. Pflanzenzuchtung 89:295-306
29	*Thinopyrum ponticum*	7DS		CS7D-Ag#11	Sears, E.R. 1973. Proc. 4th Intl. Wheat Genet. Symp. pp.191-199
30	Common Wheat	4BL		Terenzio	Dyck, P.L. and Kerber, E.R. 1981. Can. J. Genet. and Cytol. 23:405-409
31	Common Wheat	4BS		Gatcher	Singh, R.P. and McIntosh, R.A. 1984. Can. J. Genet. and Cytol. 26:736-742
32	*T. tauschii*	3D		*T. tauschii*	Kerber, E.R. 1987. Crop Sci. 27:204-206
33	Common Wheat	1BL	*Lr26*	Pl58458	Dyck, P.L. 1987. Genome 29:463-466
34	Common Wheat	7D	*Yr18, Bdv1*	PI58548	Dyck, P.L. 1987. Genome 29:467-469
35	*A. speltoides*	2B	*Sr32?*	*A. speltoides*	Kerber, E. R. and Dyck, P. L. 1990. Genome 33: 530-537.
36	*A. speltoides*	6BS		*A. speltoides*	Dvorak, J. and Knott, D.R. 1990. Genome 33:892-897
37	*A. ventricosa*	2AS	*Sr38, Yr17*	VPM	Bariana, H. S. and McIntosh. R. A. 1993. Genome 36: 476-482
38	*Thinopyrum intermedium*	2AL		*Thinopyrum intermedium*	Friebe, B. et al., 1992. Theoretical and Applied Genetics 83: 775-782.
39*	*T. tauschii*	2DS		*T. tauschii*	
40*	*T. tauschii*	1D		*T. tauschii*	
41	*T. tauschii*	2DS		*T. tauschii*	Cox, T.S. et al., 1994. Crop Sci. 34:339-343
42	*T. tauschii*	1D		*T. tauschii*	"
43*	*T. tauschii*	1D + 2DS		*T. tauschii*	
44	*T. spelta*	1BL	*to Lr33*	*T. aestivum* spelta 7831	Dyck, P.L. and Sykes, E.E. 1994. Can. J. Plant Sci. 74:231-233
45	*Secale cereale*	2AS		*Secalis cereale*	McIntosh, RA
46	Common Wheat	1BL	*Yr29*	Pavon 76	Singh, R.P. and Huerta-Espino, J. 1998. Phytopathology 88:S82
47	*A. speltoides*	7AS		Pavon	Dubcovsky, J. et al., 1998. Crop Sci. 38:1655-1660
48	Common Wheat			CSP 44	Saini, R.G. et al., 2002. Euphytica 124: 365-370
49	Common Wheat			VL 404	"
50	*T. timopheevi*	2BL		*T. timopheevii* subsp. armeniacum	Brown-Guedira, G.L. et al., 2003. Phytopathology 93:784-789

51	*A. speltoides*	1S/1B	*A. speltoides*	Helguera, M. 2005. Crop Sci. 45:728-734
52	Common Wheat	5BS		
53	*T. dicoccoides*	6BS	*T. dicoccoides*	
54	*A. kotschyi*	2DL	*A. kotschyi*	
55	*E. trachycaulis*	1B	*E. trachycaulis*	

*** Lr39 = Lr41; Lr40 = Lr21; Lr43 is not a unique gene, germplasm line had Lr21 and Lr39.**

APPENDIX 2

TEMPORARY DESIGNATIONS OF LEAF RUST RESISTANCE GENES (Source: edited from ARS-CDL, verified 20 May 2007)

Lr gene	Genome Location	Tester source	Gene references
19d		*Thinopyrum distichum*	Marais, G.F.
B		Brevit	Unpublished
Exch		Exchange	Unpublished
HeIV		Regina	Bartos, P, Personal Communication (AWN 40:95)
I		CSP 44	Shiwani and Saini, R.G. 1994. Genome 37:436-439
J		CSP 44	"
K		Oxley	"
L		CPAN 1235	"
LC		Little Club	Ali, I. et al., 1994. Plant Disease 78:383-384
LrA	2Ds	*T. tauschii*	Innes, R.L. 1994. Genome 37:813-822
LrAPR		KS91WGRC12, (Century/T. tauschii TA2451)	Kloppers, F.J. and Pretorius, Z.A. 1996. Proc. 9th Eur. Medit. Cereal Rusts Powdery Mildew Conf.
LrB	5D	*T. tauschii*	Innes, R.L. 1994. Genome 37:813-822
LrC		*T. tauschii*	"
LrD		*T. tauschii*	"
Lrv		G-516 [Favorit/(*Ae. variablilis*) *T. pergrinum*]	Ittu, M. et al., 1996. Proc. 9th Eur. Medit. Cereal Rusts Powdery Mildew Conf.
M		CPan1235	Shiwani and Saini, R.G. 1994. Genome 37:436-439
M marks		Trorysa	Bartos, P. Personal Communication (AWN 40:95)
Mo		Morocco	Ali, I. et al., 1994. Plant Disease 78:383-384
N		VL 404	Shiwani and Saini, R.G. 1994. Genome 37:436-439
O		VL 404	"

T3		Terenizo	Dyck, P.L.
Tm	6A	*T. monococcum*	Hussian T. Personal Communication
Tr		*T. triunciale*	Aghaee-Sarbarzeh , M. et al., 2001. Plant Breeding 120:259-261
Trp-1		Torepi	Barcellos, A.L. 1994. PhD Thesis, Rio Grande Sul Federal Univ, Brazil
Trp-2		Torepi	"

APPENDIX 3

SOMERS' SSRS LOCATIONS AND SEQUENCES (Source: Somers et al., 2004)

ID	Locus name	Chromosome	Forward Primer	Reverse Primer
1	GDM33	1A	GGCTCAATTCAACCGTTCTT	TACGTTCTGGTGGCTGCTC
2	GWM136	1A	GACAGCACCTTGCCCTTTG	CATCGGCAACATGCTCATC
3	GWM11	1A	GGATAGTCAGACAATTCTTGTG	GTGAATTGTGTCTTGTATGCTTCC
4	CFA2226	1A	GGAGAAAAGCAAACAGCGAC	CAGTAGCATCTTCCATGGCG
5	CFD15	1A	CTCCCGTATTGAGCAGGAAG	GGCAGGTGTGGTGATGATCT
6	GWM33	1A	GGAGTCACACTTGTTTGTGCA	CACTGCACACCTAACTACCTGC
7	WMC818	1A		
8	WMC336	1A	GTCTTACCCCGCGATCTGC	GCGGCCTGAGCTTCTTGAG
9	WMC95	1A	GTTTTTGTGATCCCGGGTTT	CATGCGTCAGTTCAAGTTTT
10	GDM136	1A	CTCATCCGGTGAGTGCATC	CCCGCATGTCTACATGAGAA
11	BARC83	1A	AAGCAAGGAACGAGCAAGAGCAGTAG	TGGATTTACGACGACGATGAAGATGA
12	WMC24	1A	GTGAGCAATTTTGATTATACTG	TACCCTGATGCTGTAATATGTG
13	GWM357	1A	TATGGTCAAAGTTGGACCTCG	AGGCTGCAGCTCTTCTTCAG
14	BARC119	1A	CACCCGATGATGAAAAT	GATGGCACAAGAAATGAT
15	GWM164	1A	ACATTTCTCCCCCATCGTC	TTGTAAACAAATCGCATGCG
16	BARC148	1A	GCGCAACCACAATGTATGCT	GGGGTGTTTTCCTATTTCTT
17	CFD59	1A	TCACCTGGAAAATGGTCACA	AAGAAGGCTAGGGTTCAGGC
18	WMC744	1A		
19	CFD30	1A	AATCGCACAACAATGGTTCA	GCCTCTCCTCTCTGCTCCTT
20	BARC28	1A	CTCCCCGGCTAGTGACCACA	GCGGCATCTTTCATTAACGAGCTAGT
21	GWM135	1A	TGTCAACATCGTTTTGAAAAGG	ACACTGTCAACCTGGCAATG
22	WMC278	1A	AAACGATAGTAAAATTACCTCGGAT	TCAAAAAATAGCAACTTGAAGACAT
23	WMC630	1A	ATAATGCACGGTAGGACTGAGG	CATACTGAGACAATTTGGGGGT
24	WMC826	1A		
25	WMC611	1A	GGTTCGCTTTCAAGGTCCACTC	CGGGACACTAGTGCTCGATTCT
26	WMC11	1A	TTGTGATCCTGGTTGTGTTGTGA	CACCCAGCCGTTATATATGTTGA

27	WMC469	1A	AGGTGGCTGCCAACG	CAATTTTATCAGATGCCCGA
28	WMC183	1A	CAGAAACGGCTCAACTTAACAA	TCTGATCTCGTGATCACAATAG
29	BARC240	1A	AGAGGACGCTGAGAACTTTAGAGAA	GCGATCTTTGTAATGCATGGTGAAC
30	CFD22	1A	GGTTGCAAACCGTCTTGTTT	AGTCGAGTTGCGACCAAAGT
31	WMC312	1A	TGTGCCCGCTGGTGCGAAG	CCGACGCAGGTGAGCGAAG
32	WMC93	1A	ACAACTTGCTGCAAAGTTGACG	CCAACTGAGCTGAGCAACGAAT
33	CFA2129	1A	GTTGCACGACCTACAAAGCA	ATCGCTCACTCACTATCGGG
34	WMC9	1A	AACTAGTCAAATAGTCGTGTCCG	GTCAAGTCATCTGACTTAACCCG
35	GWM497	1A	GTAGTGAAGACAAGGGCATT	CCGAAAGTTGGGTGATATAC
36	WMC673	1A		
37	WMC51	1A	TTATCTTGGTGTCTCATGTCAG	TCGCAAGATCATCAGAACAGTA
38	WMC716	1A	CATTTATGTGCACGCCGAAG	CCATAAGCATCGTCACCCTG
39	WMC59	1A	TCATTCGTTGCAGATACACCAC	TCAATGCCCTTGTTTCTGACCT
40	BARC158	1A	TGTGTGGGAAGAAACTGAGTCATC	AGGAATACCAAAAGAAGCAAACCAAC
41	BARC17	1A	GCGCAACATATTCAGCTCAACA	TCCACATCTCGTCCCTCATAGTTTG
42	BARC145	1A	GCAGCCTCGAATCACA	GGGGTGTTGAAGATGA
43	CFA2219	1A	TCTGCCGAGTCACTTCATTG	GACAAGGCCAGTCCAAAAGA
44	GWM99	1A	AAGATGGACGTATGCATCACA	GCCATATTTGATGACGCATA
45	GWM608	1B	ACATTGTGTGTGCGGCC	GATCCCTCTCCGCTAGAAGC
46	GWM550	1B	CCCACAAGAACCTTTGAAGA	CATTGTGTGTGCAAGGCAC
47	WMC818	1B		
48	BARC128	1B	GCGGGTAGCATTTATGTTGA	CAAACCAGGCAAGAGTCTGA
49	GWM374.1	1B	ATAGTGTGTTGCATGCTGTGTG	TCTAATTAGCGTTGGCTGCC
50	WMC49	1B	CTCATGAGTATATCACCGCACA	GACGCGAAACGAATATTCAAGT
51	WMC798	1B		
52	WMC51	1B	TTATCTTGGTGTCTCATGTCAG	TCGCAAGATCATCAGAACAGTA
53	WMC619	1B	TTCCCTTTCCCCTCTTTCCG	TACAATCGCCACGAGCACCT
54	GWM264	1B	GAGAAACATGCCGAACAACA	GCATGCATGAGAATAGGAACTG
55	BARC60	1B	CATGCTCACAAAACCCACAAGACT	CTCGAAAGGCGGCACCACTA
56	WMC406	1B	TATGAGGGTCGGATCAATACAA	CGAGTTTACTGCAAACAAATGG
57	WMC500.1	1B	ATAGCATGTTGGAACAGAGCAC	CTTAGATGCAACTCTATGCGGT

58	BARC8	1B	GCGGGAATCATGCATAGGAAAACAGAA	GCGGGGGCGAAACATACACATAAAAACA
59	GWM413	1B	TGCTTGTCTAGATTGCTTGGG	GATCGTCTCGTCCTTGGCA
60	GDM36	1B	ATGCAAAGGAATGGATTCAA	CAAATCCGCATCCAGAAAAT
61	GWM133	1B	ATCTAAACAAGACGGCGGTG	ATCTGTGACAACCGGTGAGA
62	GWM33	1B	GGAGTCACACTTGTTTGTGCA	CACTGCACACCTAACTACCTGC
63	WMC500.2	1B	ATAGCATGTTGGAACAGAGCAC	CTTAGATGCAACTCTATGCGGT
64	WMC128	1B	CGGACAGCTACTGCTCTCCTTA	CTGTTGCTTGCTCTGCACCCTT
65	GDM33	1B	GGCTCAATTCAACCGTTCTT	TACGTTCTGGTGGCTGCTC
66	WMC31	1B	GTTCACACGGTGATGACTCCCA	CTGTTGCTTGCTCTGCACCCTT
67	GWM494	1B	ATTGAACAGGAAGACATCAGGG	TTCCTGGAGCTGTCTGGC
68	GDM28	1B	ATCTGACTTCATGGTTTATAT	TCAAGAATGAAGACATAGTT
69	GWM131	1B	AATCCCCACCGATTCTTCTC	AGTTCGTGGGTCTCTGATGG
70	GWM498	1B	GGTGGTATGGACTATGGACACT	TTTGCATGGAGGCACATACT
71	BARC187	1B	GTGGTATTTCAGGTGGAGTTGTTTTA	CGGAGGAGCAGTAAGGAAGG
72	WMC419	1B	GTTTCGGATAAAACCGGAGTGC	ACTACTTGTGGGTTATCACCAGCC
73	WMC611	1B	GGTTCGCTTTCAAGGTCCACTC	CGGGACACTAGTGCTCGATTCT
74	CFD59	1B	TCACCTGGAAAATGGTCACA	AAGAAGGCTAGGGTTCAGGC
75	CFD2	1B	GGTTGCAGTTTCCACCTTGT	CATCTATTGCCAAAATCGCA
76	WMC269	1B	GCACCTTCTAACCTTCCCCAGC	CCCTAATCCAGGACTCCCTCAG
77	WMC597	1B	AACACACCTTGCTTCTCTGGGA	GACTAGGGTTTCGGTTGTTGGC
78	GWM273	1B	ATTGGACGGACAGATGCTTT	AGCAGTGAGGAAGGGGATC
79	GWM18	1B	TGGCGCCATGATTGCATTATCTTC	GGTTGCTGAAGAACCTTATTTAGG
80	CFD65	1B	AGACGATGAGAAGGAAGCCA	CCTCCCTTGTTTTTGGGATT
81	GDM136	1B	CTCATCCGGTGAGTGCATC	CCCGCATGTCTACATGAGAA
82	GWM11	1B	GGATAGTCAGACAATTCTTGTG	GTGAATTGTGTCTTGTATGCTTCC
83	BARC137	1B	GGCCCATTTCCCACTTTCCA	CCAGCCCCTCTACACATTTT
84	WMC626	1B	AGCCCATAAACATCCAACACGG	AGGTGGGCTTGGTTACGCTCTC
85	WMC216	1B	ACGTATCCAGACACTGTGGTAA	TAATGGTGGATCCATGATAGCC
86	WMC213	1B	ATTTTCTCAAACACACCCCG	TAGCAGATGTTGACAATGGA
87	WMC813	1B		
88	WMC694	1B		

89	WMC156	1B	GCCTCTAGGGAGAAAACTAACA	TCAAGATCATATCCTCCCCAAC
90	GWM582	1B	AAGCACTACGAAAATATGAC	TCTTAAGGGGTGTTATCATA
91	GWM374.2	1B	ATAGTGTGTTGCATGCTGTGTG	TCTAATTAGCGTTGGCTGCC
92	BARC240	1B	AGAGGACGCTGAGAACTTTAGAGAA	GCGATCTTTGTAATGCATGGTGAAC
93	BARC181	1B	CGCTGGAGGGGGTAAGTCATCAC	CGCAAATCAAGAACACGGGAGAAAGAA
94	CFA2129	1B	GTTGCACGACCTACAAAGCA	ATCGCTCACTCACTATCGGG
95	CFD48	1B	ATGGTTGATGGTGGGTGTTT	ATGTATCGATGAAGGGCCAA
96	GDM101	1B	GTCTCCATGACAAGGAGGGA	TGAAACCTCAAAGGGAAAGA
97	WMC416	1B	AGCCCTTTCTACCGTGTTTCTT	TATGGTCGATGGACTGTCCCTA
98	WMC134	1B	CCAAGCTGTCTGACTGCCATAG	AGTATAGACCTCTGGCTCACGG
99	GWM403	1B	CGACATTGGCTTCGGTG	ATAAAACAGTGCGGTCCAGG
100	WMC206	1B	TTGTGCTCGTGAATTGCATACC	GCCAAAATGGCAGCTTCTCTTA
101	GWM274	1B	AACTTGCAAAACTGTTCTGA	TATTTGAAGCGGTTTGATTT
102	GWM153	1B	GATCTCGTCACCCGGAATTC	TGGTAGAGAAGGACGGAGAG
103	BARC81	1B	GCGCTAGTGACCAAGTTGTTATATGA	GCGGTTCGGAAAGTGCTATTCTACAGTAA
104	WMC631	1B	TTGCTCGCCCACCTTCTACC	GGAAACCATGCGCTTCACAC
105	WMC766	1B	AGATGGAGGGGATATGTTGTCAC	TCGTCCCTGCTCATGCTG
106	WMC673	1B		
107	BARC188	1B	CGTGAGATCATGTTATCAGGACAAG	GCGTTGAAAGGTGTTAGTGGGATGG
108	GWM268	1B	AGGGGATATGTTGTCACTCCA	TTATGTGATTGCGTACGTACCC
109	GWM124	1B	GCCATGGCTATCACCCAG	ACTGTTCGGTGCAATTTGAG
110	CFA2147.1	1B	TCATCCCCTACATAACCCGA	ATCGTGCACCAAGCAATACA
111	CFA2147.2	1B	TCATCCCCTACATAACCCGA	ATCGTGCACCAAGCAATACA
112	WMC830	1B		
113	WMC719	1B	TTGTGGGAATCTACATCAGAAGG	AACAGCCACGCTCTATCTTCAGT
114	WMC44	1B	GGTCTTCTGGGCTTTGATCCTG	TGTTGCTAGGGACCCGTAGTGG
115	WMC367	1B	CTGACGTTGATGGGCCACTATT	GTGGTGGAAGAGGAAGGAGAGG
116	BARC80	1B	GCGAATTAGCATCTGCATCTGTTTGAG	CGGTCAACCAACTACTGCACAAC
117	GWM259	1B	AGGGAAAAGACATCTTTTTTTTC	CGACCGACTTCGGGTTC
118	WMC728	1B	GCAGGCTCTGCATCTTCTTG	CGCAGAGCTGAGCTGAAATC
119	GWM140	1B	ATGGAGATATTTGGCCTACAAC	CTTGACTTCAAGGCGTGACA

120	GWM147	1D	AGAACGAAAGAAGCGCGCTGAG	ATGTGTTTCTTATCCTGCGGGC
121	GDM33	1D	GGCTCAATTCAACCGTTCTT	TACGTTCTGGTGGCTGCTC
122	BARC149	1D	ATTCACTTGCCCCTTTTAAACTCT	GAGCCGTAGGAAGGACATCTAGTG
123	WMC147	1D	AGAACGAAAGAAGCGCGCTGAG	ATGTGTTTCTTATCCTGCGGGC
124	GWM33	1D	GGAGTCACACTTGTTTGTGCA	CACTGCACACCTAACTACCTGC
125	WMC432	1D	ATGACACCAGATCTAGCAC	AATATTGGCATGATTACACA
126	WMC336	1D	GTCTTACCCCGCGATCTGC	GCGGCCTGAGCTTCTTGAG
127	CFD15	1D	CTCCCGTATTGAGCAGGAAG	GGCAGGTGTGGTGATGATCT
128	CFD61	1D	ATTCAAATGCAACGCAAACA	GTTAGCCAAGGACCCCTTTC
129	CFD21	1D	CCTCCATGTAGGCGGAAATA	TGTGTCCCATTCACTAACCG
130	WMC222	1D	AAAGGTGCGTTCATAGAAAATTAGA	AGAGGTGTTTGAGACTAATTTGGTA
131	CFD92	1D	CTTGTTGATCTCCTTCCCCA	TTCTCTCATGACGGCAACAC
132	GWM106	1D	CTGTTCTTGCGTGGCATTAA	AATAAGGACACAATTGGGATGG
133	BARC119	1D	CACCCGATGATGAAAAT	GATGGCACAAGAAATGAT
134	GWM191	1D	AGACTGTTGTTTGCGGGC	TAGCACGACAGTTGTATGCATG
135	GWM337	1D	CCTCTTCCTCCCTCACTTAGC	TGCTAACTGGCCTTTGCC
136	WMC489	1D	CGAAGGATTTGTGATGTGAGTA	GGACAACATCATAGAGAAGGAA
137	CFD59	1D	TCACCTGGAAAATGGTCACA	AAGAAGGCTAGGGTTCAGGC
138	BARC99	1D	CGCATTCTTTCGCATTCTCTGTCATA	CGCATACTGTGTCGTGTTCCTGGTTTAGA
139	CFD72	1D	CTCCTTGGAATCTCACCGAA	TCCTTGGGAATATGCCTCCT
140	CFD65	1D	AGACGATGAGAAGGAAGCCA	CCTCCCTTGTTTTTGGGATT
141	WMC429	1D	CGTAAAGATTTTCATTTGGCG	AACGGCAGCTTGAAAACATAG
142	BARC148	1D	GCGCAACCACAATGTATGCT	GGGGTGTTTTCCTATTTCTT
143	GWM608	1D	ACATTGTGTGTGCGGCC	GATCCCTCTCCGCTAGAAGC
144	BARC229	1D	GGCCGCTGGGGATTGCTATGAT	TCGGGATAAGGCAGACCACAT
145	GWM458	1D	AATGGCAATTGGAAGACATAGC	TTCGCAATGTTGATTTGGC
146	BARC240	1D	AGAGGACGCTGAGAACTTTAGAGAA	GCGATCTTTGTAATGCATGGTGAAC
147	WMC339	1D	CCGCTCGCCTTCTTCCAG	TCCGGAACATGCCGATAC
148	WMC590	1D	CGCACGAAGCTATCTGATACCA	GGAAAACCTAACCCTAGCCACC
149	BARC169	1D	CCGCGAACCATACAAAGGAAAC	GCTATAGAGGCGCCTTGGAGTACC
150	WMC216	1D	ACGTATCCAGACACTGTGGTAA	TAATGGTGGATCCATGATAGCC

151	CFD19	1D	TACGCAGGTTTGCTGCTTCT	GGAGTTCACAAGCATGGGTT
152	WMC36	1D	TTCTCTTTTCCTTTCGCACTCC	CATCAGTTGTGGGGTTTCTTCA
153	CFA2129	1D	GTTGCACGACCTACAAAGCA	ATCGCTCACTCACTATCGGG
154	CFD48	1D	ATGGTTGATGGTGGGTGTTT	ATGTATCGATGAAGGGCCAA
155	GWM642	1D	ACGGCGAGAAGGTGCTC	CATGAAAGGCAAGTTCGTCA
156	GDM126	1D	TCCATCATATCCGTAGCACA	CGTGGTTGATTTCAGGAGGT
157	WMC93	1D	ACAACTTGCTGCAAAGTTGACG	CCAACTGAGCTGAGCAACGAAT
158	WMC261	1D	GATGTGCATGTGAATCTCAAAAGTA	AAAGAGGGTCACAGAATAACCTAAA
159	WMC673	1D		
160	WMC732	1D	ACTGCCCGTAGAACACCGTC	ACGGGGTTCTCCTTCCTCAA
161	CFD63	1D	TCCTGAGGATGTTGAGGACC	GAGAGAGGCGAAACATGGAC
162	WMC813	1D		
163	BARC66	1D	CGCGATCGATCTCCCGGTTTGCT	GGGAAGAGGACCAAGGCCACTA
164	GWM232	1D	ATCTCAACGGCAAGCCG	CTGATGCAAGCAATCCACC
165	CFD282	1D	TCTCATCCCTGTTCCTCTGC	GTCGACGTCTGCACATTGTT
166	CFA2147	1D	TCATCCCCTACATAACCCGA	ATCGTGCACCAAGCAATACA
167	WMC609	1D	CATCCAGCCCATGTAGACGC	AACGGTGCCCATCATCTCCC
168	WMC405	1D	GTGCGGAAAGAGACGAGGTT	TATGTCCACGTTGGCAGAGG
169	GDM111	1D	CACTCACCCCAAACCAAAGT	GATGCAATCGGGTCGTTAGT
170	BARC62	1D	TTGCCTGAGACATACATACACCTAA	GCCAGAACAGAATGAGTGCT
171	CFD36	2A	GCAAAGTGTAGCCGAGGAAG	TTAGAGTTTTGCAGCGCCTT
172	GWM512	2A	AGCCACCATCAGCAAAAATT	GAACATGAGCAGTTTGGCAC
173	BARC124	2A	TGCACCCCTTCCAAATCT	TGCGAGTCGTGTGGTTGT
174	GWM296	2A	AATTCAACCTACCAATCTCTG	GCCTAATAAACTGAAAACGAG
175	WMC667	2A	GAGGAGAGGAAAAGGCAGGCTA	AACTCTTGCGTGTCTCAAACCG
176	GWM636	2A	CGGTAGTTTTTAGCAAAGAG	CCTTACAGTTCTTGGCAGAA
177	GWM614	2A	GATCACATGCATGCGTCATG	TTTTACCGTTCCGGCCTT
178	GWM497	2A	GTAGTGAAGACAAGGGCATT	CCGAAAGTTGGGTGATATAC
179	WMC407	2A	GGTAATTCTAGGCTGACATATGCTC	CATATTTCCAAATCCCCAACTC
180	WMC382	2A	CATGAATGGAGGCACTGAAACA	CCTTCCGGTCGACGCAAC
181	BARC212	2A	GGCAACTGGAGTGATATAAATACCG	CAGGAAGGGAGGAGAACAGAGG

182	GWM359	2A	CTAATTGCAACAGGTCATGGG	TACTTGTGTTCTGGGACAATGG
183	WMC728	2A	GCAGGCTCTGCATCTTCTTG	CGCAGAGCTGAGCTGAAATC
184	WMC177	2A	AGGGCTCTCTTTAATTCTTGCT	GGTCTATCGTAATCCACCTGTA
185	WMC598	2A	TCGAGGAGTCAACATGGGCTG	ACGGTCGCTAGGGAGGGGAG
186	GWM71.1	2A	GGCAGAGCAGCGAGACTC	CAAGTGGAGCATTAGGTACACG
187	WMC602	2A	TACTCCGCTTTGATATCCGTCC	GTTTGTTGTTGCCATCACATTC
188	WMC149	2A	ACAGACTTGGTTGGTGCCGAGC	ATGGGCGGGGGTGTAGAGTTTG
189	WMC827	2A		
190	WMC453	2A	ACTTGTGTCCATAACCGACCTT	ATCTTTTGAGGTTACAACCCGA
191	WMC522	2A	AAAAATCTCACGAGTCGGGC	CCCGAGCAGGAGCTACAAAT
192	WMC474	2A	ATGCTATTAAACTAGCATGTGTCG	AGTGGAAACATCATTCCTGGTA
193	WMC296	2A	GAATCTCATCTTCCCTTGCCAC	ATGGAGGGGTATAAAGACAGCG
194	WMC792	2A		
195	GWM122	2A	GGGTGGGAGAAAGGAGATG	AAACCATCCTCCATCCTGG
196	GWM339	2A	AATTTTCTTCCTCACTTATT	AAACGAACAACCACTCAATC
197	GWM515	2A	AACACAATGGCAAATGCAGA	CCTTCCTAGTAAGTGTGCCTCA
198	GWM10	2A	CGCACCATCTGTATCATTCTG	TGGTCGTACCAAAGTATACGG
199	GWM425	2A	GAGCCCACAAGCTGGCA	TCGTTCTCCCAAGGCTTG
200	GWM448	2A	AAACCATATTGGGAGGAAAGG	CACATGGCATCACATTTGTG
201	WMC63	2A	GTGCTCTGGAAACCTTCTACGA	CAGTAGTTTAGCCTTGGTGTGA
202	GWM275	2A	AATTTTCTTCCTCACTTATTCT	AACAAAAAATTAGGGCC
203	GWM95	2A	GATCAAACACACACCCCTCC	AATGCAAAGTGAAAAACCCG
204	GWM249	2A	CAAATGGATCGAGAAAGGGA	CTGCCATTTTTCTGGATCTACC
205	GWM71.2	2A	GGCAGAGCAGCGAGACTC	CAAGTGGAGCATTAGGTACACG
206	GWM558	2A	GGGATTGCATATGAGACAACG	TGCCATGGTTGTAGTAGCCA
207	WMC702	2A	GAATCACATCGAATGGATCTCA	GAGGCCTTTTTCGATATTCTGC
208	WMC644	2A		
209	GDM101	2A	GTCTCCATGACAAGGAGGGA	TGAAACCTCAAAGGGAAAGA
210	GWM473	2A	TCATACGGGTATGGTTGGAC	CACCCCCTTGTTGGTCAC
211	WMC794	2A		
212	WMC632	2A	GTTTGATTGGTCGTTCCTGGTC	AACAGCGAATGGAGGGCTTTAG

213	GWM328	2A	GCAATCCACGAGAAGAGAGG	CACAAACTCTTGACATGTGCG
214	WMC455	2A	GCGTCATTTCCTCAAACACATC	AGAAGGAGAAGTGCCTCACCAA
215	GWM372	2A	AATAGAGCCCTGGGACTGGG	GAAGGACGACATTCCACCTG
216	WMC819	2A		
217	WMC261	2A	GATGTGCATGTGAATCTCAAAAGTA	AAAGAGGGTCACAGAATAACCTAAA
218	BARC5	2A	GCGCCTGGACCGGTTTTCTATTTT	GCGTTGGGAATTCCTGAACATTTT
219	CFD6	2A	ACTCTCCCCCTCGTTGCTAT	ATTTAAGGGAGACATCGGGC
220	GWM47	2A	TTGCTACCATGCATGACCAT	TTCACCTCGATTGAGGTCCT
221	GWM445	2A	TTTGTTGGGGGTTAGGATTAG	CCTTAACACTTGCTGGTAGTGA
222	WMC109	2A	AATTCGGGAAGAGTCTCAGGGG	TTCGAAGGGCTCAAGGGATACG
223	GWM312	2A	ATCGCATGATGCACGTAGAG	ACATGCATGCCTACCTAATGG
224	GWM294	2A	GGATTGGAGTTAAGAGAGAACCG	GCAGAGTGATCAATGCCAGA
225	CFD168	2A	CTTCGCAAATCGAGGATGAT	TTCACGCCCAGTATTAAGGC
226	CFD86	2A	TTAATGAGCGTCAGTACTCCC	GCAACCATGTTTAAGCCGAT
227	WMC181	2A	TCCTTGACCCCTTGCACTAACT	ATGGTTGGGAGCACTAGCTTGG
228	GWM356	2A	AGCGTTCTTGGGAATTAGAGA	CCAATCAGCCTGCAACAAC
229	BARC76	2A	ATTCGTTGCTGCCACTTGCTG	GCGCGACACGGAGTAAGGACACC
230	WMC658	2A	CTCATCGTCCTCCTCCACTTTG	GCCATCCGTTGACTTGAGGTTA
231	GWM382	2A	GTCAGATAACGCCGTCCAAT	CTACGTGCACCACCATTTTG
232	GWM311	2A	TCACGTGGAAGACGCTCC	CTACGTGCACCACCATTTTG
233	WMC764	2B	CCTCGAACCTGAAGCTCTGA	TTCGCAAGGACTCCGTAACA
234	BARC45	2B	CCCAGATGCAATGAAACCACAAT	GCGTAGAACTGAAGCGTAAAATTA
235	BARC35	2B	GCGGTGTGCATGCTTGTCGTGTAGGAGT	GCGTAGTGTAGTATGTGGCCCGATTATT
236	WMC661	2B	CCACCATGGTGCTAATAGTGTC	AGCTCGTAACGTAATGCAACTG
237	GWM210	2B	TGCATCAAGAATAGTGTGGAAG	TGAGAGGAAGGCTCACACCT
238	WMC489	2B	CGAAGGATTTGTGATGTGAGTA	GGACAACATCATAGAGAAGGAA
239	WMC382	2B	CATGAATGGAGGCACTGAAACA	CCTTCCGGTCGACGCAAC
240	GWM614	2B	GATCACATGCATGCGTCATG	TTTTACCGTTCCGGCCTT
241	BARC124	2B	TGCACCCCTTCCAAATCT	TGCGAGTCGTGTGGTTGT
242	WMC25	2B	TCTGGCCAGGATCAATATTACT	TAAGATACATAGATCCAACACC
243	WMC154	2B	ATGCTCGTCAGTGTCATGTTTG	AAACGGAACCTACCTCACTCTT

244	WMC243	2B	CGTCATTTCCTCAAACACACCT	ACCGGCAGATGTTGACAATAGT
245	WMC213	2B	ATTTTCTCAAACACACCCCG	TAGCAGATGTTGACAATGGA
246	BARC200	2B	GCGATATGATTTGGAGCTGATTG	GCGATGACGTTAGATGCGGAATTGT
247	GWM257	2B	AGAGTGCATGGTGGGACG	CCAAGACGATGCTGAAGTCA
248	WMC597	2B	AACACACCTTGCTTCTCTGGGA	GACTAGGGTTTCGGTTGTTGGC
249	WMC257	2B	GGCTACACATGCATACCTC	CGTAGTGGGTGAATTTCGGA
250	GWM429	2B	TTGTACATTAAGTTCCCATTA	TTTAAGGACCTACATGACAC
251	WMC770	2B	TGTCAGACTTCCTTTGATCCCC	AAGACCATGTGACGTCCAGC
252	BARC10	2B	GCGTGCCACTGTAACCTTTAGAAGA	GCGAGTTGGAATTATTTGAATTAAACAAG
253	GWM148	2B	GTGAGGCAGCAAGAGAGAAA	CAAAGCTTGACTCAGACCAAA
254	GWM410	2B	GCTTGAGACCGGCACAGT	CGAGACCTTGAGGGTCTAGA
255	WMC434	2B	GGAGCCTGATTAGGCTGGAC	AGCCAAACAGCCAACAGAGT
256	BARC13	2B	GCAGGAACAACCACGCCATCTTAC	GCGTCGCAATTTGAAGAAAATCATC
257	BARC7	2B	GCGAAGTACCACAAATTTGAAGGA	CGCCATCTTACCCTATTTGATAACTA
258	BARC183	2B	CCCGGGACCACCAGTAAGT	GGATGGGGAATTGGAGATACAGAG
259	BARC55	2B	GCGGTCAACACACTCCACTCCTCTCTC	CGCTGCTCCCATTGCTCGCCGTTA
260	WMC261	2B	GATGTGCATGTGAATCTCAAAAGTA	AAAGAGGGTCACAGAATAACCTAAA
261	WMC272	2B	TCAGGCCATGTATTATGCAGTA	ACGACCAGGATAGCCAATTCAA
262	GWM630	2B	GTGCCTGTGCCATCGTC	CGAAAGTAACAGCGCAGTGA
263	BARC98	2B	CCGTCCTATTCGCAAACCAGATT	GCGGATATGTTCTCTAACTCAAGCAATG
264	WMC474	2B	ATGCTATTAAACTAGCATGTGTCG	AGTGGAAACATCATTCCTGGTA
265	BARC18	2B	CGCTTCCCATAACGCCGATAGTAA	CGCCCGCATCATGAGCAATTCTATCC
266	WMC344	2B	ATTTCAGTCTAATTAGCGTTGG	AACAAAGAACATAATTAACCCC
267	WMC27	2B	AATAGAAACAGGTCACCATCCG	TAGAGCTGGAGTAGGGCCAAAG
268	GWM374	2B	ATAGTGTGTTGCATGCTGTGTG	TCTAATTAGCGTTGGCTGCC
269	BARC167	2B	AAAGGCCCATCAACATGCAAGTACC	CGCAGTATTCTTAGTCCCTCAT
270	WMC265	2B	GTGGATAACATCATGGTCAAC	TACTTCGCACTAGATGAGCCT
271	WMC179	2B	CATGGTGGCCATGAGTGGAGGT	CATGATCTTGCGTGTGCGTAGG
272	CFA2278	2B	GCCTCTGCAAGTCTTTACCG	AAGTCGGCCATCTTCTTCCT
273	GWM132	2B	TACCAAATCGAAACACATCAGG	CATATCAAGGTCTCCTTCCCC
274	GWM403	2B	CGACATTGGCTTCGGTG	ATAAAACAGTGCGGTCCAGG

275	GWM319	2B	GGTTGCTGTACAAGTGTTCACG	CGGGTGCTGTGTGTAATGAC
276	WMC477	2B	CGTCGAAAACCGTACACTCTCC	GCGAAACAGAATAGCCCTGATG
277	WMC245	2B	GCTCAGATCATCCACCAACTTC	AGATGCTCTGGGAGAGTCCTTA
278	WMC592	2B	GGTGGCATGAACTTTCACCTGT	TGTGTGGTGCCCATTAGGTAGA
279	WMC498	2B	CGATGAAGAGAGCCATCAAAA	TGACATTCCGGTAGGTCAGTT
280	GWM271	2B	CAAGATCGTGGAGCCAGC	AGCTGCTAGCTTTTGGGACA
281	GWM55	2B	GCATCTGGTACACTAGCTGCC	TCATGGATGCATCACATCCT
282	BARC128	2B	GCGGGTAGCATTTATGTTGA	CAAACCAGGCAAGAGTCTGA
283	GWM129	2B	TCAGTGGGCAAGCTACACAG	AAAACTTAGTAGCCGCGT
284	GWM388	2B	CTACAATTCGAAGGAGAGGGG	CACCGCGTCAACTACTTAAGC
285	BARC101	2B	GCTCCTCTCACGATCACGCAAAG	GCGAGTCGATCACACTATGAGCCAATG
286	WMC441	2B	TCCAGTAGAGCACCTTTCATT	ATCACGAAGATAAACAAACGG
287	CFD70	2B	GTCGGCATAGTCGCACATAC	ACTATGCCAAGGGGAGTGTG
288	WMC500	2B	ATAGCATGTTGGAACAGAGCAC	CTTAGATGCAACTCTATGCGGT
289	WMC51	2B	TTATCTTGGTGTCTCATGTCAG	TCGCAAGATCATCAGAACAGTA
290	GWM120	2B	GATCCACCTTCCTCTCTCTC	GATTATACTGGTGCCGAAAC
291	GWM191	2B	AGACTGTTGTTTGCGGGC	TAGCACGACAGTTGTATGCATG
292	CFD73	2B	GATAGATCAATGTGGGCCGT	AACTGTTCTGCCATCTGAGC
293	GWM16	2B	GCTTGGACTAGCTAGAGTATCATAC	CAATCTTCAATTCTGTCGCACGG
294	GWM47	2B	TTGCTACCATGCATGACCAT	TTCACCTCGATTGAGGTCCT
295	GWM501	2B	GGCTATCTCTGGCGCTAAAA	TCCACAAACAAGTAGCGCC
296	WMC175	2B	GCTCAGTCAAACCGCTACTTCT	CACTACTCCAATCTATCGCCGT
297	WMC332	2B	CATTTACAAAGCGCATGAAGCC	GAAAACTTTGGGAACAAGAGCA
298	WMC627	2B	GATCCGAGAAGGGCAATGGTAG	AGCAACAGCAGCGTACCATAAA
299	WMC149	2B	ACAGACTTGGTTGGTGCCGAGC	ATGGGCGGGGGTGTAGAGTTTG
300	WMC361	2B	AATGAAGATGCAAATCGACGGC	ATTCTCGCACTGAAAACAGGGG
301	WMC317	2B	TGCTAGCAATGCTCCGGGTAAC	TCACGAAACCTTTTCCTCCTCC
302	WMC817	2B		
303	BARC159	2B	CGCAATTTATTATCGGTTTTAGGAA	CGCCCGATAGTTTTTCTAATTTCTGA
304	GWM382	2B	GTCAGATAACGCCGTCCAAT	CTACGTGCACCACCATTTTG
305	WMC356	2B	GCCGTTGCCCAATGTAGAAG	CCAGAGAAACTCGCCGTGTC

306	GWM526	2B	CAATAGTTCTGTGAGAGCTGCG	CCAACCCAAATACACATTCTCA
307	WMC602	2B	TACTCCGCTTTGATATCCGTCC	GTTTGTTGTTGCCATCACATTC
308	BARC124	2D	TGCACCCCTTCCAAATCT	TGCGAGTCGTGTGGTTGT
309	WMC818	2D		
310	CFD56	2D	TTGCATAATTACTTGCCCTCC	CTGGTCCAACTTCCATCCAT
311	CFD65	2D	AGACGATGAGAAGGAAGCCA	CCTCCCTTGTTTTTGGGATT
312	CFD51	2D	GGAGGCTTCTCTATGGGAGG	TGCATCTTATCCTGTGCAGC
313	BARC90	2D	GCGCTTGGGTTGCTTCGAGGAGGACA	CGCAATCCTCTTCCCCGTGGCATAG
314	CFD36	2D	GCAAAGTGTAGCCGAGGAAG	TTAGAGTTTTGCAGCGCCTT
315	WMC111	2D	ATTGATGTGTACGATGTGCCTG	CATGTCAATGTCATGATGAAGC
316	WMC25	2D	TCTGGCCAGGATCAATATTACT	TAAGATACATAGATCCAACACC
317	WMC503	2D	GCAATAGTTCCCGCAAGAAAAG	ATCAACTACCTCCAGATCCCGT
318	GWM261	2D	CTCCCTGTACGCCTAAGGC	CTCGCGCTACTAGCCATTG
319	GWM296	2D	AATTCAACCTACCAATCTCTG	GCCTAATAAACTGAAAACGAG
320	GWM210	2D	TGCATCAAGAATAGTGTGGAAG	TGAGAGGAAGGCTCACACCT
321	WMC112	2D	TGAGTTGTGGGGTCTTGTTTGG	TGAAGGAGGGCACATATCGTTG
322	GWM455	2D	ATTCGGTTCGCTAGCTACCA	ACGGAGAGCAACCTGCC
323	WMC470	2D	ACTTGCAACTGGGGACTCTC	TCCCCAATTGCATATTGACC
324	GWM484	2D	ACATCGCTCTTCACAAACCC	AGTTCCGGTCATGGCTAGG
325	GWM122	2D	GGGTGGGAGAAAGGAGATG	AAACCATCCTCCATCCTGG
326	WMC453	2D	ACTTGTGTCCATAACCGACCTT	ATCTTTTGAGGTTACAACCCGA
327	CFD43	2D	AACAAAAGTCGGTGCAGTCC	CCAAAAACATGGTTAAAGGGG
328	BARC168	2D	GCGATGCATATGAGATAAGGAACAAATG	GCGGCTCTAAGGCGGTTTCAAAT
329	GWM102	2D	TCTCCCATCCAACGCCTC	TGTTGGTGGCTTGACTATTG
330	CFD2	2D	GGTTGCAGTTTCCACCTTGT	CATCTATTGCCAAAATCGCA
331	GWM515	2D	AACACAATGGCAAATGCAGA	CCTTCCTAGTAAGTGTGCCTCA
332	GWM249	2D	CAAATGGATCGAGAAAGGGA	CTGCCATTTTTCTGGATCTACC
333	WMC18	2D	CTGGGGCTTGGATCACGTCATT	AGCCATGGACATGGTGTCCTTC
334	GWM30	2D	ATCTTAGCATAGAAGGGAGTGGG	TTCTGCACCCTGGGTGAT
335	CFD17	2D	AGCACAGAAGGGGTTAGGGT	AGCTGCGGTGTGAGCTAAAT
336	GWM358	2D	AAACAGCGGATTTCATCGAG	TCCGCTGTTGTTCTGATCTC

337	BARC145	2D	GCAGCCTCGAATCACA	GGGGTGTTGAAGATGA
338	CFD116	2D	TTTGCCCATTACAACAAGCA	CAAGCAGCACCTCATGACAG
339	WMC630	2D	ATAATGCACGGTAGGACTGAGG	CATACTGAGACAATTTGGGGGT
340	WMC245	2D	GCTCAGATCATCCACCAACTTC	AGATGCTCTGGGAGAGTCCTTA
341	WMC144	2D	GGACACCAATCCAACATGAACA	AAGGATAGTTGGGTGGTGCTGA
342	CFD193	2D	GCTGCCGCTACTGTCTGTC	GGCACACTCACACACCACAC
343	CFD160	2D	CCACTACTGCGGCTAGGTCT	CTTTTCCGTGTCTCCCTAGC
344	WMC601	2D	ACAGAGGCATATGCAAAGGAGG	CTTGTCTCTTTATCGAGGGTGG
345	WMC797	2D		
346	GWM157	2D	GTCGTCGCGGTAAGCTTG	GAGTGAACACACGAGGCTTG
347	CFD73	2D	GATAGATCAATGTGGGCCGT	AACTGTTCTGCCATCTGAGC
348	CFD233	2D	GAATTTTTGGTGGCCTGTGT	ATCACTGCACCGACTTTTGG
349	CFD62	2D	CAAGAGCTGACCAATGTGGA	ACGGCGGTGAGATGAG
350	BARC228	2D	CCCTCCTCTCTTTAGCCATCC	GCACGTACTATTCGCCTTCACTTA
351	WMC41	2D	TCCCTCTTCCAAGCGCGGATAG	GGAGGAAGATCTCCCGGAGCAG
352	WMC181	2D	TCCTTGACCCCTTGCACTAACT	ATGGTTGGGAGCACTAGCTTGG
353	CFD16	2D	GGATCCAAGGGAATCCAAAT	TCCTTCGGTTCCCATATCAC
354	GWM608	2D	ACATTGTGTGTGCGGCC	GATCCCTCTCCGCTAGAAGC
355	CFD168	2D	CTTCGCAAATCGAGGATGAT	TTCACGCCCAGTATTAAGGC
356	WMC243	2D	CGTCATTTCCTCAAACACACCT	ACCGGCAGATGTTGACAATAGT
357	GWM539	2D	CTGCTCTAAGATTCATGCAACC	GAGGCTTGTGCCCTCTGTAG
358	GWM349	2D	GGCTTCCAGAAAACAACAGG	ATCGGTGCGTACCATCCTAC
359	CFD239	2D	CTCTCGTTCTCTCCAGGCTC	GAGAGGAGAGCTTGCCATTG
360	CFD161	2D	GTAAGGCATCTTCGCGTCTC	CCATGATAGATTTGGACGGG
361	WMC167	2D	AGTGGTAATGAGGTGAAAGAAG	TCGGTCGTATATGCATGTAAAG
362	WMC175	2D	GCTCAGTCAAACCGCTACTTCT	CACTACTCCAATCTATCGCCGT
363	GWM382	2D	GTCAGATAACGCCGTCCAAT	CTACGTGCACCACCATTTTG
364	GWM320	2D	CGAGATACTATGGAAGGTGAGG	ATCTTTGCAAGGATTGCCC
365	BARC59	2D	GCGTTGGCTAATCATCGTTCCTTC	AGCACCCTACCCAGCGTCAGTCAAT
366	BARC159	2D	CGCAATTTATTATCGGTTTTAGGAA	CGCCCGATAGTTTTTCTAATTTCTGA
367	WMC817	2D		

368	GWM301	2D	GAGGAGTAAGACACATGCCC	GTGGCTGGAGATTCAGGTTC
369	WMC11	3A	TTGTGATCCTGGTTGTGTTGTGA	CACCCAGCCGTTATATATGTTGA
370	WMC532	3A	GATACATCAAGATCGTGCCAAA	GGGAGAAATCATTAACGAAGGG
371	CFD79	3A	TCTGGTTCTTGGGAGGAAGA	CATCCAACAATTTGCCCAT
372	GWM369	3A	CTGCAGGCCATGATGATG	ACCGTGGGTGTTGTGAGC
373	BARC45	3A	CCCAGATGCAATGAAACCACAAT	GCGTAGAACTGAAGCGTAAAATTA
374	GWM2	3A	CTGCAAGCCTGTGATCAACT	CATTCTCAAATGATCGAACA
375	GWM133	3A	ATCTAAACAAGACGGCGGTG	ATCTGTGACAACCGGTGAGA
376	WMC505	3A	AGGGGAGGAAAACCTTGTAATC	ACGACCTACGTGGTAGTTCTTG
377	GWM32	3A	TATGCCGAATTTGTGGACAA	TGCTTGGTCTTGAGCATCAC
378	WMC640	3A		
379	WMC664	3A	GGGCCAACAAATCCAAT	TCTACTTCCTTCATCCACTCC
380	GWM5	3A	GCCAGCTACCTCGATACAACTC	AGAAAGGGCCAGGCTAGTAGT
381	GWM4	3A	GCTGATGCATATAATGCTGT	CACTGTCTGTATCACTCTGCT
382	GWM666.1	3A	GCACCCACATCTTCGACC	TGCTGCTGGTCTCTGTGC
383	GWM674	3A	TCGAGCGATTTTTCCTGC	TGACCGAGTTGACCAAAACA
384	GWM30	3A	ATCTTAGCATAGAAGGGAGTGGG	TTCTGCACCCTGGGTGAT
385	WMC651	3A		
386	BARC67	3A	GCGGCATTTACATTTCAGATAGA	TGTGCCTGATTGTAGTAACGTATGTA
387	WMC388.1	3A	TGTGCGGAATGATTCAATCTGT	GGCCATTAGACTGCAATGGTTT
388	CFD193	3A	GCTGCCGCTACTGTCTGTC	GGCACACTCACACACCACAC
389	GWM403	3A	CGACATTGGCTTCGGTG	ATAAAACAGTGCGGTCCAGG
390	WMC627	3A	GATCCGAGAAGGGCAATGGTAG	AGCAACAGCAGCGTACCATAAA
391	WMC489	3A	CGAAGGATTTGTGATGTGAGTA	GGACAACATCATAGAGAAGGAA
392	CFA2134	3A	TTTACGGGGACAGTATTCGG	AAGACACTCGATGCGGAGAG
393	CFA2234	3A	AATCTGACCGAACAAAATCACA	TCGGAGAGTATTAGAACAGTGCC
394	WMC527	3A	ACCCAAGATTGGTTGCAGAA	GCTACAGAAAACCGGAGCCTAT
395	WMC695	3A		
396	WMC269	3A	GCACCTTCTAACCTTCCCCAGC	CCCTAATCCAGGACTCCCTCAG
397	WMC428	3A	TTAATCCTAGCCGTCCCTTTTT	CGACCTTCGTTGGTTATTTGTG
398	WMC264	3A	CTCCATCTATTGAGCGAAGGTT	CAAGATGAAGCTCATGCAAGTG

399	CFA2262	3A	ACAATGTGGAGATGGCACAA	TACCAGCTGCACTTCCATTG
400	GWM494	3A	ATTGAACAGGAAGACATCAGGG	TTCCTGGAGCTGTCTGGC
401	GWM162	3A	AGTGGATCGACAAGGCTCTG	AGAAGAAGCAAAGCCTTCCC
402	WMC96	3A	TAGCAGCCATGCTTAGCATCAA	GTTTCAGTCTTTCACGAACACG
403	BARC69	3A	AGGCGGCGGTCGTGGAACA	GCGTACCGAGAAGTGATCAAGAACAT
404	GWM497	3A	GTAGTGAAGACAAGGGCATT	CCGAAAGTTGGGTGATATAC
405	CFA2193	3A	ACATGTGATGTGCGGTCATT	TCCTCAGAACCCCATTCTTG
406	WMC173	3A	TGCAGTTGCGGATCCTTGA	TAACCAAGCAGCACGTATT
407	CFD2	3A	GGTTGCAGTTTCCACCTTGT	CATCTATTGCCAAAATCGCA
408	WMC559	3A	ACACCACGAATGATGTGCCA	ACGACGCCATGTATGCAGAA
409	GWM155	3A	CAATCATTTCCCCCTCCC	AATCATTGGAAATCCATATGCC
410	WMC153	3A	ATGAGGACTCGAAGCTTGGC	CTGAGCTTTTGCGCGTTGAG
411	WMC215	3A	CATGCATGGTTGCAAGCAAAAG	CATCCCGGTGCAACATCTGAAA
412	CFA2076	3A	CGAAAAACCATGATCGACAG	ACCTGTCCAGCTAGCCTCCA
413	WMC169	3A	TACCCGAATCTGGAAAATCAAT	TGGAAGCTTGCTAACTTTGGAG
414	WMC388.2	3A	TGTGCGGAATGATTCAATCTGT	GGCCATTAGACTGCAATGGTTT
415	WMC594	3A	CCCCTCACTGCCG	ATATCCATATAGTACTCGCAC
416	GWM666.2	3A	GCACCCACATCTTCGACC	TGCTGCTGGTCTCTGTGC
417	GWM480	3A	TGCTGCTACTTGTACAGAGGAC	CCGAATTGTCCGCCATAG
418	BARC75	3B	AGGGTTACAGTTTGCTCTTTTAC	CCCGACGACCTATCTATACTTCTCTA
419	BARC180	3B	GCGATGCTTGTTTGTTACTTCTC	GCGATGGAACTTCTTTTTGCTCTA
420	GWM389	3B	ATCATGTCGATCTCCTTGACG	TGCCATGCACATTAGCAGAT
421	WMC430	3B	CAGTTGCAAGTTGGCCATAG	TAGGGACCCCTTGACAAAAA
422	WMC674	3B		
423	GWM533.1	3B	AAGGCGAATCAAACGGAATA	GTTGCTTTAGGGGAAAAGCC
424	BARC147	3B	GCGCCATTTATTCATGTTCCTCAT	CCGCTTCACATGCAATCCGTTGAT
425	GWM493	3B	TTCCCATAACTAAAACCGCG	GGAACATCATTTCTGGACTTTG
426	BARC87	3B	GCTCACCGGGCATTGGGATCA	GCGATGACGAGATAAAGGTGGAGAAC
427	WMC754	3B		
428	CFD79	3B	TCTGGTTCTTGGGAGGAAGA	CATCCAACAATTTGCCCAT
429	BARC92	3B	GCGGTTGTGATGTGCTGAAAGATGAATGT	GCGTGGGCTGTTTCTTCCTTTTGTTTTC

430	WMC597	3B	AACACACCTTGCTTCTCTGGGA	GACTAGGGTTTCGGTTGTTGGC
431	GWM533.2	3B	AAGGCGAATCAAACGGAATA	GTTGCTTTAGGGGAAAAGCC
432	WMC500	3B	ATAGCATGTTGGAACAGAGCAC	CTTAGATGCAACTCTATGCGGT
433	CFD28	3B	TGCATCTTATTACTGGAGGCATT	CGCATGCCCTTATACCAACT
434	WMC623	3B	ACGATTGGCCACAGAGGAG	CAGTGACCAATAGTGGAGGTCA
435	WMC808	3B		
436	WMC679	3B		
437	WMC43	3B	TAGCTCAACCACCACCCTACTG	ACTTCAACATCCAAACTGACCG
438	WMC51	3B	TTATCTTGGTGTCTCATGTCAG	TCGCAAGATCATCAGAACAGTA
439	WMC78	3B	AGTAAATCCTCCCTTCGGCTTC	AGCTTCTTTGCTAGTCCGTTGC
440	WMC540	3B	CGGGGTCCTAACTACGGTGA	CCTGTAATGGAGGACGGCTG
441	GWM566	3B	TCTGTCTACCCATGGGATTTG	CTGGCTTCGAGGTAAGCAAC
442	BARC173	3B	GGGGATCCTTCAACAATAACA	GCGAGATGGCATTTTTAAATAAAGAGAC
443	GWM264	3B	GAGAAACATGCCGAACAACA	GCATGCATGAGAATAGGAACTG
444	WMC231	3B	CATGGCGAGGAGCTCGGTGGTC	GTGGAGCACAGGCGGAGCAAGG
445	GWM284	3B	AATGAAAAAACACTTGCGTGG	GCACATTTTTCACTTTCGGG
446	BARC68	3B	CGATGCCAACACACTGAGGT	AGCCGCATGAAGAGATAGGTAGAGAT
447	GWM72	3B	TGGTCCCTCTCCCTTTCTCT	ACAGAATTGAAGATTGTCGGTC
448	WMC815	3B		
449	WMC675	3B		
450	WMC505	3B	AGGGGAGGAAAACCTTGTAATC	ACGACCTACGTGGTAGTTCTTG
451	WMC777	3B	GCCATCAAGCGGATCAACT	GTAGCGCCCTGTTTCACCTC
452	CFD6	3B	ACTCTCCCCCTCGTTGCTAT	ATTTAAGGGAGACATCGGGC
453	WMC612	3B	GAGGTCAGTACCCGGAGA	CCACCCCAATTCAAAAAG
454	WMC625	3B	CACAGACCTCAACCTCTTCTT	AGTACTGTTCACAGCAGACGA
455	BARC73	3B	GCGTGTCGTGCTTGTTCTCGGTTCTCAG	CGCTATTTGCCGCCACCTCCATCA
456	WMC693	3B		
457	WMC544	3B	CCATTTGAGGTTTGGTCGCTAC	TATATGTGATTTGTCGTGCCCC
458	WMC695	3B		
459	WMC446	3B	CCAGCTAGTACTCTATATCTACATC	TATTTGAACAAGAGTTATGTGG
460	GWM285	3B	ATGACCCTTCTGCCAAACAC	ATCGACCGGGATCTAGCC

461	GWM274	3B	AACTTGCAAAACTGTTCTGA	TATTTGAAGCGGTTTGATTT
462	WMC615	3B	TGCCCACAACTTATCTCAG	GGTAAGTGGCCCAGGTAGT
463	WMC366	3B	TACCTCTCTACGATGAAGCC	TGGAGTCTTAGTGTGGTGTT
464	WMC1	3B	ACTGGGTGTTTGCTCGTTGA	CAATGCTTAAGCGCTCTGTG
465	WMC533	3B	AATTGGATCGGCAGTTGGAG	AGCAAGCAGAGCATTGCGTT
466	WMC762	3B	CCTTGAAGGCGCGACG	GTCTGTACCTCCCTGCACCG
467	WMC751	3B		
468	GWM644	3B	GTGGGTCAAGGCCAAGG	AGGAGTAGCGTGAGGGGC
469	GWM376	3B	GGGCTAGAAAACAGGAAGGC	TCTCCCGGAGGGTAGGAG
470	CFD4	3B	TGCTCCGTCTCCGAGTAGAT	GGGAAGGAGAGATGGGAAAC
471	GWM77	3B	ACAAAGGTAAGCAGCACCTG	ACCCTCTTGCCCGTGTTG
472	WMC307	3B	GTTTGAAGACCAAGCTCCTCCT	ACCATAACCTCTCAAGAACCCA
473	WMC653	3B		
474	GWM107	3B	ATTAATACCTGAGGGAGGTGC	GGTCTCAGGAGCAAGAACAC
475	WMC471	3B	GGCAATAATAGTGCAAGGAATG	GCCGATAATGGGCAATATAAGT
476	WMC182	3B	GTATCTCACGAGCATAACACAA	GAAAGTGTATGGATCATTAGGC
477	BARC164	3B	TGCAAACTAATCACCAGCGTAA	CGCTTTCTAAAACTGTTCGGGATTTCTAA
478	WMC527	3B	ACCCAAGATTGGTTGCAGAA	GCTACAGAAAACCGGAGCCTAT
479	WMC418	3B	AGAGCAGCAAGTTGTGTAGCCA	TGAAGCTATTGCCAGCACGAG
480	WMC827	3B		
481	CFA2134	3B	TTTACGGGGACAGTATTCGG	AAGACACTCGATGCGGAGAG
482	BARC145	3B	GCAGCCTCGAATCACA	GGGGTGTTGAAGATGA
483	GWM131	3B	AATCCCCACCGATTCTTCTC	AGTTCGTGGGTCTCTGATGG
484	WMC787	3B		
485	GWM4	3B	GCTGATGCATATAATGCTGT	CACTGTCTGTATCACTCTGCT
486	CFD283	3B	CCCGTGGTCTTGGGTTC	AGTTTTGCCATCGGCTGTAT
487	BARC229	3B	GGCCGCTGGGGATTGCTATGAT	TCGGGATAAGGCAGACCACAT
488	WMC291	3B	TACCACGGGAAAGGAAACATCT	CACGTTGAAACACGGTGACTAT
489	GWM108	3B	CGACAATGGGGTCTTAGCAT	TGCACACTTAAATTACATCCGC
490	CFA2170	3B	TGGCAAGTAACATGAACGGA	ATGTCATTCATGTTGCCCCT
491	BARC84	3B	CGCATAACCGTTGGGAAGACATCTG	GGTGCAACTAGAACGTACTTCCAGTC

492	BARC206	3B	GCTTTGCCAGGTGAGCACTCT	TGGCCGGGTATTTGAGTTGGAGTTT
493	WMC687	3B		
494	WMC326	3B	GGAGCATCGCAGGACAGA	GGACGAGGACGCCTGAAT
495	BARC77	3B	GCGTATTCTCCCTCGTTTCCAAGTCTG	GTGGGAATTTCTTGGGAGTCTGTA
496	WMC206	3B	TTGTGCTCGTGAATTGCATACC	GCCAAAATGGCAGCTTCTCTTA
497	GWM299	3B	ACTACTTAGGCCTCCCGCC	TGACCCACTTGCAATTCATC
498	GWM114	3B	ACAAACAGAAAATCAAAACCCG	ATCCATCGCCATTGGAGTG
499	GWM547	3B	GTTGTCCCTATGAGAAGGAACG	TTCTGCTGCTGTTTTCATTTAC
500	GWM181	3B	TCATTGGTAATGAGGAGAGA	GAACCATTCATGTGCATGTC
501	GWM247	3B	GCAATCTTTTTTCTGACCACG	ATGTGCATGTCGGACGC
502	WMC261	3B	GATGTGCATGTGAATCTCAAAAGTA	AAAGAGGGTCACAGAATAACCTAAA
503	WMC274	3B	AAGCAAGCAGCAAAACTATCAA	GAATGAATGAATGAATCGAGGC
504	WMC632	3B	GTTTGATTGGTCGTTCCTGGTC	AACAGCGAATGGAGGGCTTTAG
505	GWM340	3B	GCAATCTTTTTTCTGACCACG	ACGAGGCAAGAACACACATG
506	CFD35	3D	GGGATGACACATAACGGACA	ATCAGCGGCGCTATAGTACG
507	GWM71	3D	GGCAGAGCAGCGAGACTC	CAAGTGGAGCATTAGGTACACG
508	WMC630	3D	ATAATGCACGGTAGGACTGAGG	CATACTGAGACAATTTGGGGGT
509	WMC11	3D	TTGTGATCCTGGTTGTGTTGTGA	CACCCAGCCGTTATATATGTTGA
510	CFD152	3D	TGGAAGTCTGGAACCACTCC	GCAACCAGACCACACTCTCA
511	CFD127	3D	TAAACACCAGGGAGGTCCAC	ACCTACGATCGACGAAATGG
512	GWM161	3D	GATCGAGTGATGGCAGATGG	TGTGAATTACTTGGACGTGG
513	WMC674	3D		
514	CFD55	3D	CCAGTAGCCGGCCCTACTAT	GCACGAGATACGGACAATCA
515	CFD141	3D	CGTAAAGATCCGAGAGGGTG	TCCGAGGTGCTACCTACCAG
516	WMC43	3D	TAGCTCAACCACCACCCTACTG	ACTTCAACATCCAAACTGACCG
517	BARC128	3D	GCGGGTAGCATTTATGTTGA	CAAACCAGGCAAGAGTCTGA
518	CFD70.1	3D	GTCGGCATAGTCGCACATAC	ACTATGCCAAGGGGAGTGTG
519	CFD79	3D	TCTGGTTCTTGGGAGGAAGA	CATCCAACAATTTGCCCAT
520	GWM183	3D	GTCTTCCCATCTCGCAAGAG	CTCGACTCCCATGTGGATG
521	CFD34	3D	GGAAGAACCGCAACAGACAT	GCATCTTCTCCTCCCTCCTC
522	GWM2	3D	CTGCAAGCCTGTGATCAACT	CATTCTCAAATGATCGAACA

523	GWM314	3D	AGGAGCTCCTCTGTGCCAC	TTCGGGACTCTCTTCCCTG
524	GWM383	3D	ACGCCAGTTGATCCGTAAAC	GACATCAATAACCGTGGATGG
525	GWM664	3D	CAGTCAGTGCCGTTTAGCAA	AGCTTTGCTCTATTGGCGAG
526	GWM114	3D	ACAAACAGAAAATCAAAACCCG	ATCCATCGCCATTGGAGTG
527	BARC42	3D	GCGACTCCTACTGTTGATAGTTC	GCGTTCTTTTATTACTCATTTTGCAT
528	BARC52	3D	GCGCCATCCATCAACCGTCATCGTCATA	GCGAGGAAGGCGGCCACCAGAATGA
529	WMC492	3D	AGGATCAGAATAGTGCTACCC	ATCCCGTGATCAGAATAGTGT
530	CFD201	3D	ACAAGACCACACCTCCAAGG	CGGTTTGGGTTTTGTGATCT
531	GDM136	3D	CTCATCCGGTGAGTGCATC	CCCGCATGTCTACATGAGAA
532	GDM99	3D	AGGTTGTCCACTGCCTGTTC	ATGTCGTCCTCGTCTCATCC
533	CFD223	3D	AAGAGCTACAATGACCAGCAGA	GCAGTGTATGTCAGGAGAAGCA
534	BARC68	3D	CGATGCCAACACACTGAGGT	AGCCGCATGAAGAGATAGGTAGAGAT
535	GWM497	3D	GTAGTGAAGACAAGGGCATT	CCGAAAGTTGGGTGATATAC
536	GWM52	3D	CTATGAGGCGGAGGTTGAAG	TGCGGTGCTCTTCCATTT
537	GWM456	3D	TCTGAACATTACACAACCCTGA	TGCTCTCTCTGAACCTGAAGC
538	GWM191	3D	AGACTGTTGTTTGCGGGC	TAGCACGACAGTTGTATGCATG
539	GWM341	3D	TTCAGTGGTAGCGGTCGAG	CCGACATCTCATGGATCCAC
540	WMC741	3D		
541	CFD71	3D	CAATAAGTAGGCCGGGACAA	TGTGCCAGTTGAGTTTGCTC
542	WMC505	3D	AGGGGAGGAAAACCTTGTAATC	ACGACCTACGTGGTAGTTCTTG
543	CFD2	3D	GGTTGCAGTTTCCACCTTGT	CATCTATTGCCAAAATCGCA
544	CFD62	3D	CAAGAGCTGACCAATGTGGA	ACGGCGGTGAGATGAG
545	CFD70.2	3D	GTCGGCATAGTCGCACATAC	ACTATGCCAAGGGGAGTGTG
546	WMC656	3D	AAGTAGGCGAGCGTTGT	TTTCCCTGGCGAGATG
547	WMC533	3D	AATTGGATCGGCAGTTGGAG	AGCAAGCAGAGCATTGCGTT
548	CFD193	3D	GCTGCCGCTACTGTCTGTC	GGCACACTCACACACCACAC
549	BARC125	3D	GCGTCGAGGGTAAAACAACATAT	GTAGCGTCAGTGCTCACACAATGA
550	CFD4	3D	TGCTCCGTCTCCGAGTAGAT	GGGAAGGAGAGATGGGAAAC
551	GWM645	3D	TGACCGGAAAAGGGCAGA	GCCCCTGCAGGAGTTTAAGT
552	WMC435	3D	GCACTATACTTATTGGATTGTCA	CATGGTATCCCTAGTAAGTTTTT
553	CFD9	3D	TTGCACGCACCTAAACTCTG	CAAGTGTGAGCGTCGG

554	WMC529	3D	ATTGCATGCAAATTAGTAGTAG	GTGTTGACAAATTTTGAGTTAG
555	WMC418	3D	AGAGCAGCAAGTTGTGTAGCCA	TGAAGCTATTGCCAGCACGAG
556	WMC631	3D	TTGCTCGCCCACCTTCTACC	GGAAACCATGCGCTTCACAC
557	GWM3	3D	AATATCGCATCACTATCCCA	GCAGCGGCACTGGTACATTT
558	WMC549	3D	TTGTCACACACGCACTCCC	GTCCTTCCCTCGTTCATCCT
559	CFD211	3D	AGAAGACTGCACGCAAGGAT	TGCACTAAAGCATCTTCGTGTT
560	WMC552	3D	ACTAAGGAGTGTGAGGGCTGTG	CTCTCGCGCTATAAAAGAAGGA
561	GDM72	3D	TGGTTTTCTCGAGCATTCAA	TGCAACGATGAAGACCAGAA
562	BARC71	3D	GCGCTTGTTCCTCACCTGCTCATA	GCGTATATTCTCTCGTCTTCTTGTTGGTT
563	GWM4	4A	GCTGATGCATATAATGCTGT	CACTGTCTGTATCACTCTGCT
564	WMC516	4A	GGGCCACGAATAAACAG	GACTCGCAACTAGGGGT
565	GWM165	4A	TGCAGTGGTCAGATGTTTCC	CTTTTCTTTCAGATTGCGCC
566	BARC206	4A	GCTTTGCCAGGTGAGCACTCT	TGGCCGGGTATTTGAGTTGGAGTTT
567	BARC138	4A	CTCGATTCGCCGTCAG	GTGGGGGAAGAAGAAACC
568	WMC420	4A	ATCGTCAACAAAATCTGAAGTG	TTACTTTTGCTGAGAAAACCCT
569	WMC89	4A	ATGTCCACGTGCTAGGGAGGTA	TTGCCTCCCAAGACGAAATAAC
570	WMC491	4A	GGTAAAACTTCGTGTCCCTTGC	TAGTTGCGAGTCGGTAGTCTGC
571	WMC680	4A		
572	WMC48	4A	GAGGGTTCTGAAATGTTTTGCC	ACGTGCTAGGGAGGTATCTTGC
573	CFD71	4A	CAATAAGTAGGCCGGGACAA	TGTGCCAGTTGAGTTTGCTC
574	WMC173	4A	TGCAGTTGCGGATCCTTGA	TAACCAAGCAGCACGTATT
575	GWM601	4A	ATCGAGGACGACATGAAGGT	TTAAGTTGCTGCCAATGTTCC
576	WMC15	4A	AGTCCGATTCGGACTCCTCAAG	GGACTAACCGAGGGTAGTTCAG
577	WMC446	4A	CCAGCTAGTACTCTATATCTACATC	TATTTGAACAAGAGTTATGTGG
578	GWM44	4A	GTTGAGCTTTTCAGTTCGGC	ACTGGCATCCACTGAGCTG
579	CFA2256	4A	GGTAATATTCAGGTTACCGCACA	GGTAAAGTTATAAATTGTTGTGGGC
580	WMC757	4A		
581	WMC96	4A	TAGCAGCCATGCTTAGCATCAA	GTTTCAGTCTTTCACGAACACG
582	GWM610	4A	CTGCCTTCTCCATGGTTTGT	AATGGCCAAAGGTTATGAAGG
583	WMC617	4A	CCACTAGGAAGAAGGGGAAACT	ATCTGGATTACTGGCCAACTGT
584	GWM397	4A	TGTCATGGATTATTTGGTCGG	CTGCACTCTCGGTATACCAGC

585	WMC513	4A	TGAATTGAATCTGGTTGCGG	TGGCAATTCACAGGCACATA
586	WMC650	4A		
587	BARC170	4A	CGCTTGACTTTGAATGGCTGAACA	CGCCCACTTTTTACCTAATCCTTTTGAA
588	GWM637	4A	AAAGAGGTCTGCCGCTAACA	TATACGGTTTTGTGAGGGGG
589	WMC468	4A	AGCTGGGTTAATAACAGAGGAT	CACATAACTGTCCACTCCTTTC
590	WMC258	4A	GCGATGTCAGATATCCGAAAGG	ACCAGGACACCAGAACAGCAAT
591	WMC707	4A	GCTAGCTGACACTTTTCCTTTG	TCAGTTTCCCACTCACTTCTTT
592	WMC161	4A	ACCTTCTTTGGGATGGAAGTAA	GTACTGAACCACTTGTAACGCA
593	GWM565	4A	GCGTCAGATATGCCTACCTAGG	AGTGAGTTAGCCCTGAGCCA
594	GWM494	4A	ATTGAACAGGAAGACATCAGGG	TTCCTGGAGCTGTCTGGC
595	CFD257	4A	TCTCAACTTGCAACTGCCAC	CCCTCCATGGATTCTTGCTA
596	WMC718	4A	GGTCGGTGTTGATGCACTTG	TCGGGGTGTCTTAGTCCTGG
597	GWM162	4A	AGTGGATCGACAAGGCTCTG	AGAAGAAGCAAAGCCTTCCC
598	WMC760	4A		
599	WMC597	4A	AACACACCTTGCTTCTCTGGGA	GACTAGGGTTTCGGTTGTTGGC
600	WMC283	4A	CGTTGGCTGGGTTATATCATCT	GACCCGCGTGTAAGTGATAGGA
601	CFD88	4A	TAGGCATAGTTTTGGGCCTG	GGTAGAAGGAAGCTTCGGGA
602	WMC262	4A	GCTTTAACAAAGATCCAAGTGGCAT	GTAAACATCCAAACAAAGTCGAACG
603	WMC698	4A		
604	WMC500	4A	ATAGCATGTTGGAACAGAGCAC	CTTAGATGCAACTCTATGCGGT
605	WMC232	4A	GAGATTTGTTCATTTCATCTTCGCA	TATATTAAAGGTTAGAGGTAGTCAG
606	CFD30	4A	AATCGCACAACAATGGTTCA	GCCTCTCCTCTCTGCTCCTT
607	BARC70	4A	GCGAAAAACGATGCGACTCAAAG	GCGCCATATAATTCAGACCCACAAAA
608	BARC78	4A	CTCCCCGGTCAAGTTTAATCTCT	GCGACATGGGAATTTCAGAAGTGCCTAA
609	GWM160	4A	TTCAATTCAGTCTTGGCTTGG	CTGCAGGAAAAAAAGTACACCC
610	CFD2	4A	GGTTGCAGTTTCCACCTTGT	CATCTATTGCCAAAATCGCA
611	WMC776	4A	CCATGACGTGACAACGCAG	ATTGCAGGCGCGTTGGTA
612	WMC313	4A	GCAGTCTAATTATCTGCTGGCG	GGGTCCTTGTCTACTCATGTCT
613	WMC722	4A	GCTTTTCGATGGGATGGTGC	TTTGTCCACTGCCTTCTGCC
614	WMC497	4A	CCCGTGGTTTTCTTTCCTTCT	AACGACAGGGATGAAAAGCAA
615	WMC219	4A	TGCTAGTTTGTCATCCGGGCGA	CAATCCCGTTCTACAAGTCCA

616	WMC125	4B	ATACCACCATGCATGTGGAAGT	ACCGCTTGTCATTTCCTTCTGT
617	BARC10	4B	GCGTGCCACTGTAACCTTTAGAAGA	GCGAGTTGGAATTATTTGAATTAAACAAG
618	WMC47	4B	GAAACAGGGTTAACCATGCCAA	ATGGTGCTGCCAACAACATACA
619	GWM538	4B	GCATTTCGGGTGAACCC	GTTGCATGTATACGTTAAGCGG
620	BARC109	4B	GGCAAAAGAGAAGGCTCGGAAGAACC	CGCATCGACGTAACATCACCACAATCATTT
621	GWM6	4B	CGTATCACCTCCTAGCTAAACTAG	AGCCTTATCATGACCCTACCTT
622	BARC68	4B	CGATGCCAACACACTGAGGT	AGCCGCATGAAGAGATAGGTAGAGAT
623	BARC60	4B	CATGCTCACAAAACCCACAAGACT	CTCGAAAGGCGGCACCACTA
624	WMC413	4B	CACTGGAAACATCTCTTCAACT	ACAGGAAAGGATGATGTTCTCT
625	GWM664	4B	CAGTCAGTGCCGTTTAGCAA	AGCTTTGCTCTATTGGCGAG
626	WMC679	4B		
627	WMC652	4B		
628	WMC349	4B	ACACACACTCGATCGCAC	GCAGTTGATCATCAAAACACA
629	BARC163	4B	GCGTGTTTTAAGGTATTTTCCATTTTCT	GCGCATCCTGTTCCTCCATTCATA
630	WMC310	4B	TGTGAGGCTGGGAGGAAAAGAG	GCTAGGTTGTGTCCCACAATGC
631	GWM251	4B	CAACTGGTTGCTACACAAGCA	GGGATGTCTGTTCCATCTTAG
632	WMC692	4B		
633	CFD39	4B	CCACAGCTACATCATCTTTCCTT	CAAAGTTTGAACAGCAGCCA
634	CFD22	4B	GGTTGCAAACCGTCTTGTTT	AGTCGAGTTGCGACCAAAGT
635	GWM149	4B	CATTGTTTTCTGCCTCTAGCC	CTAGCATCGAACCTGAACAAG
636	GWM193	4B	CTTTGTGCACCTCTCTCTCC	AATTGTGTTGATGATTTGGGG
637	GWM192	4B	GGTTTTCTTTCAGATTGCGC	CGTTGTCTAATCTTGCCTTGC
638	GWM112	4B	CTAAACACGACAGCGGTGG	GATATGTGAGCAGCGGTCAG
639	GWM513	4B	ATCCGTAGCACCTACTGGTCA	GGTCTGTTCATGCCACATTG
640	GWM165	4B	TGCAGTGGTCAGATGTTTCC	CTTTTCTTTCAGATTGCGCC
641	WMC657	4B	CGGGCTGCGGGGGTAT	CGGTTGGGTCATTTGTCTCA
642	WMC238	4B	TCTTCCTGCTTACCCAAACACA	TACTGGGGGATCGTGGATGACA
643	GWM66	4B	CCAAAGACTGCCATCTTTCA	CATGACTAGCTAGGGTGTGACA
644	BARC25	4B	GCGGTGCATCAAGGACGACAT	GCGTAGTTCATCCATCCGTAAT
645	GWM113	4B	ATTCGAGGTTAGGAGGAAGAGG	GAGGGTCGGCCTATAAGACC
646	WMC16	4B	ACCGCCTGCATTCTCATCTACA	GTGGCGCCATGGTAGAGATTTG

647	WMC695	4B		
648	WMC419	4B	GTTTCGGATAAAACCGGAGTGC	ACTACTTGTGGGTTATCACCAGCC
649	GWM107	4B	ATTAATACCTGAGGGAGGTGC	GGTCTCAGGAGCAAGAACAC
650	WMC254	4B	AGTAATCTGGTCCTCTCTTCTTCT	AGGTAATCTCCGAGTGCACTTCAT
651	CFD2	4B	GGTTGCAGTTTCCACCTTGT	CATCTATTGCCAAAATCGCA
652	WMC89	4B	ATGTCCACGTGCTAGGGAGGTA	TTGCCTCCCAAGACGAAATAAC
653	WMC48	4B	GAGGGTTCTGAAATGTTTTGCC	ACGTGCTAGGGAGGTATCTTGC
654	WMC826	4B		
655	GWM495	4B	GAGAGCCTCGCGAAATATAGG	TGCTTCTGGTGTTCCTTCG
656	GWM368	4B	CCATTTCACCTAATGCCTGC	AATAAAACCATGAGCTCACTTGC
657	GWM540	4B	TCTCGCTGTGAAATCCTATTTC	AGGCATGGATAGAGGGGC
658	BARC20	4B	GCGATCCACACTTTGCCTCTTTTACA	GCGATGTCGGTTTTCAGCCTTTT
659	WMC491	4B	GGTAAAACTTCGTGTCCCTTGC	TAGTTGCGAGTCGGTAGTCTGC
660	WMC511	4B	CGCACTCGCATGATTTTCCT	ATGCCCGGAAACGAGACTGT
661	CFD283	4B	CCCGTGGTCTTGGGTTC	AGTTTTGCCATCGGCTGTAT
662	WMC546	4B	CGGCTAAAATCGTACACTACACA	CTCACTTGCACGATTTCCCTAT
663	WMC710	4B	GTAAGAAGGCAGCACGTATGAA	TAAGCATTCCCAATCACTCTCA
664	WMC617	4B	CCACTAGGAAGAAGGGGAAACT	ATCTGGATTACTGGCCAACTGT
665	WMC617	4D	CCACTAGGAAGAAGGGGAAACT	ATCTGGATTACTGGCCAACTGT
666	WMC285	4D	TGTGGTTGTATTTGCGGTATGG	TTGTGGTGCTGAGTTAGCTTGT
667	WMC818	4D		
668	WMC89	4D	ATGTCCACGTGCTAGGGAGGTA	TTGCCTCCCAAGACGAAATAAC
669	WMC720	4D	CACCATGGTTGGCAAGAGA	CTGGTGATACTGCCGTGACA
670	WMC48	4D	GAGGGTTCTGAAATGTTTTGCC	ACGTGCTAGGGAGGTATCTTGC
671	CFD106	4D	ACGGGTGGTTTTGCTCAGT	ACTCCACCAGCGGAGAAATA
672	CFD160	4D	CCACTACTGCGGCTAGGTCT	CTTTTCCGTGTCTCCCTAGC
673	GWM213	4D	TGCCTGGCTCGTTCTATCTC	CTAGCTTAGCACTGTCGCCC
674	GWM608	4D	ACATTGTGTGTGCGGCC	GATCCCTCTCCGCTAGAAGC
675	WMC52	4D	TCCAATCAATCAGGGAGGAGTA	GAACGCATCAAGGCATGAAGTA
676	BARC98	4D	CCGTCCTATTCGCAAACCAGATT	GCGGATATGTTCTCTAACTCAAGCAATG
677	CFD193	4D	GCTGCCGCTACTGTCTGTC	GGCACACTCACACACCACAC

678	BARC91	4D	TTCCCATAACGCCGATAGTA	GCGTTTAATATTAGCTTCAAGATCAT
679	WMC473	4D	TCTGTTGCGCGAAACAGAATAG	CCCATTGGACAACACTTTCACC
680	CFD23	4D	TAGCAGTAGCAGCAGCAGGA	GCAAGGAAGAGTGTTCAGCC
681	GWM133	4D	ATCTAAACAAGACGGCGGTG	ATCTGTGACAACCGGTGAGA
682	CFD71	4D	CAATAAGTAGGCCGGGACAA	TGTGCCAGTTGAGTTTGCTC
683	WMC182	4D	GTATCTCACGAGCATAACACAA	GAAAGTGTATGGATCATTAGGC
684	WMC489	4D	CGAAGGATTTGTGATGTGAGTA	GGACAACATCATAGAGAAGGAA
685	WMC457	4D	CTTCCATGAATCAAAGCAGCAC	CATCCATGGCAGAAACAATAGC
686	GWM193	4D	CTTTGTGCACCTCTCTCTCC	AATTGTGTTGATGATTTGGGG
687	GWM165	4D	TGCAGTGGTCAGATGTTTCC	CTTTTCTTTCAGATTGCGCC
688	WMC331	4D	CCTGTTGCATACTTGACCTTTTT	GGAGTTCAATCTTTCATCACCAT
689	WMC206	4D	TTGTGCTCGTGAATTGCATACC	GCCAAAATGGCAGCTTCTCTTA
690	WMC399	4D	CTTCAGAGATGTTTGATTACCT	GGTATTGCTAACTGAATGATGT
691	CFD39	4D	CCACAGCTACATCATCTTTCCTT	CAAAGTTTGAACAGCAGCCA
692	CFD84	4D	GTTGCCTCGGTGTCGTTTAT	TCCTCGAGGTCCAAAACATC
693	WMC622	4D	CAGGAAGAAGAGCTCCGAGAAA	CTTGCTAACCCGCGCC
694	GWM194	4D	GATCTGCTCTACTCTCCTCC	CGACGCAGAACTTAAACAAG
695	WMC74	4D	AACGGCATTGAGCTCACCTTGG	TGCGTGAAGGCAGCTCAATCGG
696	WMC825	4D		
697	GWM624	4D	TTGATATTAAATCTCTCTATGTG	AATTTTATTTGAGCTATGCG
698	GWM609	4D	GCGACATGACCATTTTGTTG	GATATTAAATCTCTCTATGTGTG
699	BARC10	5A	GCGTGCCACTGTAACCTTTAGAAGA	GCGAGTTGGAATTATTTGAATTAAACAAG
700	GWM443	5A	GGGTCTTCATCCGGAACTCT	CCATGATTTATAAATTCCACC
701	WMC47	5A	GAAACAGGGTTAACCATGCCAA	ATGGTGCTGCCAACAACATACA
702	WMC713	5A	ACATAGCATCCCATACTGAGAGAGG	ATGCGGGGAATAGAGACACAC
703	GWM205	5A	CGACCCGGTTCACTTCAG	AGTCGCCGTTGTATAGTGCC
704	GDM109	5A	GGTCCGCCTGACAGACC	AAAGCTGCTCATCGTGGTG
705	GWM154	5A	TCACAGAGAGAGAGGGAGGG	ATGTGTACATGTTGCCTGCA
706	WMC654	5A		
707	CFA2104	5A	CCTGGCAGAGAAAGTGAAGG	AGTCGCCGTTGTATAGTGCC
708	WMC489	5A	CGAAGGATTTGTGATGTGAGTA	GGACAACATCATAGAGAAGGAA

709	CFA2190	5A	CAGTCTGCAATCCACTTTGC	AAAAGGAAACTAAAGCGATGGA
710	WMC51	5A	TTATCTTGGTGTCTCATGTCAG	TCGCAAGATCATCAGAACAGTA
711	GWM293	5A	TACTGGTTCACATTGGTGCG	TCGCCATCACTCGTTCAAG
712	BARC197	5A	CGCATGGTCAGTTTTCTTTTAATCCT	GCGCTCTCCTTCATTTATGGTTTGTTG
713	WMC752	5A		
714	GWM415	5A	GATCTCCCATGTCCGCC	CGACAGTCGTCACTTGCCTA
715	GWM129	5A	TCAGTGGGCAAGCTACACAG	AAAACTTAGTAGCCGCGT
716	CFA2250	5A	AGCCATAGATGGCCCTACCT	CACTCAATGGCAGGTCCTTT
717	WMC705	5A	GGTTGGGCTCCTGTCTGTGAA	TCTTGCACCTTCCCATGCTCT
718	WMC150	5A	CATTGATTGAACAGTTGAAGAA	CTCAAAGCAACAGAAAAGTAAA
719	BARC117	5A	TCATGCGTGCTAAGTGCTAA	GAGGGCAGGAAAAAGTGACT
720	BARC186	5A	GGAGTGTCGAGATGATGTGGAAAC	CGCAGACGTCAGCAGCTCGAGAGG
721	WMC805	5A		
722	BARC56	5A	GCGGGAATTTACGGGAAGTCAAGAA	GCGAGTGGTTCAAATTTATGTCTGT
723	BARC180	5A	GCGATGCTTGTTTGTTACTTCTC	GCGATGGAACTTCTTTTTGCTCTA
724	GWM304	5A	AGGAAACAGAAATATCGCGG	AGGACTGTGGGGAATGAATG
725	BARC141	5A	GGCCCATGGATAATTTTTGAAATG	CAATTCGGCCAAAGAAGAAGTCA
726	GWM186	5A	GCAGAGCCTGGTTCAAAAAG	CGCCTCTAGCGAGAGCTATG
727	WMC446	5A	CCAGCTAGTACTCTATATCTACATC	TATTTGAACAAGAGTTATGTGG
728	BARC165	5A	GCGTAGAGCGGCTGTTAGTGTCAAATTA	GCGTTATCTCAAGTTTTGTAGCAGA
729	CFA2121	5A	TAAATGGCCATCAAGCAATG	GCTTGTGAACTAATGCCTCCC
730	WMC795	5A		
731	GWM96	5A	TAGCAGCCATGCTTAGCATCAA	GTTTCAGTCTTTCACGAACACG
732	WMC492	5A	AGGATCAGAATAGTGCTACCC	ATCCCGTGATCAGAATAGTGT
733	BARC40	5A	GCCGCCTACCACAGAGTTGCAGCT	GCGGCATTGACAAGACCATAGC
734	GWM156	5A	CCAACCGTGCTATTAGTCATTC	CAATGCAGGCCCTCCTAAC
735	GWM639	5A	CTCTCTCCATTCGGTTTTCC	CATGCCCCCCTTTTCTG
736	GWM617	5A	GATCTTGGCGCTGAGAGAGA	CTCCGATGGATTACTCGCAC
737	WMC415	5A	AATTCGATACCTCTCACTCACG	TCAACTGCTACAACCTAGACCC
738	CFD2	5A	GGTTGCAGTTTCCACCTTGT	CATCTATTGCCAAAATCGCA
739	WMC630	5A	ATAATGCACGGTAGGACTGAGG	CATACTGAGACAATTTGGGGGT

740	WMC475	5A	AACACATTTTCTGTCTTTCGCC	TGTAGTTATGCCCAACCTTTCC
741	BARC151	5A	TGAGGAAAATGTCTCTATAGCATCC	CGCATAAACACCTTCGCTCTTCCACTC
742	WMC388	5A	TGTGCGGAATGATTCAATCTGT	GGCCATTAGACTGCAATGGTTT
743	GWM666	5A	GCACCCACATCTTCGACC	TGCTGCTGGTCTCTGTGC
744	WMC445	5A	AGAATAGGTTCTTGGGCCAGTC	GAGATGATCTCCTCCATCAGCA
745	CFA2163	5A	TTGATCCTTGATGGGAGGAG	CATCATTGTGTTTACGTTCTTTCA
746	CFA2155	5A	TTTGTTACAACCCAGGGGG	TTGTGTGGCGAAAGAAACAG
747	CFA2141	5A	GAATGGAAGGCGGACATAGA	GCCTCCACAACAGCCATAAT
748	WMC96	5A	TAGCAGCCATGCTTAGCATCAA	GTTTCAGTCTTTCACGAACACG
749	BARC232	5A	CGCATCCAACCATCCCCACCCAACA	CGCAGTAGATCCACCACCCCGCCAGA
750	CFA2185	5A	TTCTTCAGTTGTTTTGGGGG	TTTGGTCGACAAGCAAATCA
751	WMC110	5A	GCAGATGAGTTGAGTTGGATTG	GTACTTGGAAACTGTGTTTGGG
752	GWM126	5A	CACACGCTCCACCATGAC	GTTGAGTTGATGCGGGAGG
753	GWM179	5A	AAGTTGAGTTGATGCGGGAG	CCATGACCAGCATCCACTC
754	CFD39	5A	CCACAGCTACATCATCTTTCCTT	CAAAGTTTGAACAGCAGCCA
755	WMC577	5A	CTGTCCGACTCCCCAGATG	CCCTGTCAGAGGCTGGTTG
756	GWM595	5A	GCATAGCATCGCATATGCAT	GCCACGCTTGGACAAGATAT
757	WMC524	5A	TAGTCCACCGGACGGAAAGTAT	GTACCACCGATTGATGCTTGAG
758	WMC727	5A	CATAATCAGGACAGCCGCAC	TAGTGGCCTGATGTATCTAGTTGG
759	GWM291	5A	CATCCCTACGCCACTCTGC	AATGGTATCTATTCCGACCCG
760	GWM410	5A	GCTTGAGACCGGCACAGT	CGAGACCTTGAGGGTCTAGA
761	CFD5	5B	TGCCCTGTCCACAGTGAAG	TTGCCAGTTCCAAGGAGAAT
762	WMC773	5B	GAGGCTTGCATGTGCTTGA	GCCAACTGCAACCGGTACTCT
763	WMC630	5B	ATAATGCACGGTAGGACTGAGG	CATACTGAGACAATTTGGGGGT
764	BARC240	5B	AGAGGACGCTGAGAACTTTAGAGAA	GCGATCTTTGTAATGCATGGTGAAC
765	BARC21	5B	GCGTCTTCCGGTTTTGTTTACTTTTC	GCGTTAGGGCTATGGCGGTGTG
766	CFD60	5B	TGACCGGCATTCAGTATCAA	TGGTCACTTTGATGAGCAGG
767	WMC47	5B	GAAACAGGGTTAACCATGCCAA	ATGGTGCTGCCAACAACATACA
768	GWM443	5B	GGGTCTTCATCCGGAACTCT	CCATGATTTATAAATTCCACC
769	WMC728	5B	GCAGGCTCTGCATCTTCTTG	CGCAGAGCTGAGCTGAAATC
770	CFD20	5B	TGATGGGAAGGTAATGGGAG	ATCCAGTTCTCGTCCAAAGC

771	GWM234	5B	GAGTCCTGATGTGAAGCTGTTG	CTCATTGGGGTGTGTACGTG
772	WMC149	5B	ACAGACTTGGTTGGTGCCGAGC	ATGGGCGGGGGTGTAGAGTTTG
773	CFA2121.1	5B	TAAATGGCCATCAAGCAATG	GCTTGTGAACTAATGCCTCCC
774	GDM146	5B	ATCCTGACGGCCACCAC	CAAAGCCTGCGATACATCAA
775	WMC813	5B		
776	WMC274	5B	AAGCAAGCAGCAAAACTATCAA	GAATGAATGAATGAATCGAGGC
777	WMC740	5B		
778	GWM159	5B	GGGCCAACACTGGAACAC	GCAGAAGCTTGTTGGTAGGC
779	GWM133	5B	ATCTAAACAAGACGGCGGTG	ATCTGTGACAACCGGTGAGA
780	BARC4	5B	GCGTGTTTGTGTCTGCGTTCTA	CACCACACATGCCACCTTCTTT
781	GWM66	5B	CCAAAGACTGCCATCTTTCA	CATGACTAGCTAGGGTGTGACA
782	GWM540	5B	TCTCGCTGTGAAATCCTATTTC	AGGCATGGATAGAGGGGC
783	GWM191	5B	AGACTGTTGTTTGCGGGC	TAGCACGACAGTTGTATGCATG
784	WMC682	5B		
785	WMC376	5B	TCTCAACCACCGACTTGTAA	ACATGTAATTGGGGACACTG
786	WMC386	5B	ATCACTGAAACGAAATGAGCGG	TGGTTGGCGGTTTTTCTCTACA
787	BARC109	5B	GGCAAAAGAGAAGGCTCGGAAGAACC	CGCATCGACGTAACATCACCACAATCATTT
788	GWM544	5B	TAGAATTCTTTATGGGGTCTGC	AGGATTCCAATCCTTCAAAATT
789	WMC616	5B	TAAAGCTAGGAGATCAGAGGCG	TAATCCCATCTTGAGAAGCGTC
790	WMC73	5B	TTGTGCACCGCACTTACGTCTC	ACACCCGGTCTCCGATCCTTAG
791	CFA2070	5B	TCTGAACCCTTGATTTTCCG	TTACTGGCAAGCCAGAACTGT
792	WMC363	5B	TCTGTAACGCATAATAGAATAGCCC	ATGATTGCGTTATCTTCATATTTGG
793	GWM274	5B	AACTTGCAAAACTGTTCTGA	TATTTGAAGCGGTTTGATTT
794	GWM68	5B	AGGCCAGAATCTGGGAATG	CTCCCTAGATGGGAGAAGGG
795	GWM67	5B	ACCACACAAACAAGGTAAGCG	CAACCCTCTTAATTTTGTTGGG
796	BARC89	5B	GGGCGCGGCACCAGCACTACC	CTCCGAGGCCACCGAAGACAAGATG
797	GWM335	5B	CGTACTCCACTCCACACGG	CGGTCCAAGTGCTACCTTTC
798	GWM213	5B	TGCCTGGCTCGTTCTATCTC	CTAGCTTAGCACTGTCGCCC
799	WMC435	5B	GCACTATACTTATTGGATTGTCA	CATGGTATCCCTAGTAAGTTTTT
800	WMC745	5B		

801	GWM371	5B	GACCAAGATATTCAAACTGGCC	AGCTCAGCTTGCTTGGTACC
802	CFD2	5B	GGTTGCAGTTTCCACCTTGT	CATCTATTGCCAAAATCGCA
803	GWM499	5B	ACTTGTATGCTCCATTGATTGG	GGGGAGTGGAAACTGCATAA
804	GWM639	5B	CTCTCTCCATTCGGTTTTCC	CATGCCCCCCTTTTCTG
805	WMC405	5B	GTGCGGAAAGAGACGAGGTT	TATGTCCACGTTGGCAGAGG
806	WMC759	5B		
807	WMC415	5B	AATTCGATACCTCTCACTCACG	TCAACTGCTACAACCTAGACCC
808	WMC537	5B	TCTTCTGTACATTGAACAACGA	ATGCAGAACCGTGATAGGAT
809	GWM554	5B	TGCCCACAACGGAACTTG	GCAACCACCAAGCACAAAGT
810	CFD7	5B	AGCTACCAGCCTAGCAGCAG	TCAGACACGTCTCCTGACAAA
811	WMC289	5B	CATATGCATGCTATGCTGGCTA	AGCCTTTCAAATCCATCCACTG
812	GWM271	5B	CAAGATCGTGGAGCCAGC	AGCTGCTAGCTTTTGGGACA
813	WMC326	5B	GGAGCATCGCAGGACAGA	GGACGAGGACGCCTGAAT
814	WMC75	5B	GTCCGCCGCACACATCTTACTA	GTTTGATCCTGCGACTCCTTG
815	GWM408	5B	TCGATTTATTTGGGCCACTG	GTATAATTCGTTCACAGCACGC
816	WMC810	5B		
817	GWM604	5B	TATATAGTTCAATATGACCCG	ATCTTTTGAACCAAATGTG
818	WMC500	5B	ATAGCATGTTGGAACAGAGCAC	CTTAGATGCAACTCTATGCGGT
819	BARC140	5B	CGCCAACACCTACCATT	TTCTCCGCACTCACAAAC
820	WMC99	5B	ATTACAATTGCTTCAGTGAGTG	TCATGATCATTGTTATAACGGT
821	CFA2121.2	5B	TAAATGGCCATCAAGCAATG	GCTTGTGAACTAATGCCTCCC
822	BARC142	5B	CCGGTGAGAGGACTAAAA	GGCCTGTCAATTATGAGC
823	WMC734	5B	GGTGACCAGCGGTGAGC	CCGTCTCGGCCTCTCTAGATTT
824	GDM116	5B	GCTGCAATGCAAGGTCTCTT	GATGTGGCTTTCTAAGGCAA
825	WMC160	5B	CATGGCTCCAAGATACAAAAAG	AGGCCTGGATTCATGATAGATA
826	BARC232	5B	CGCATCCAACCATCCCCACCCAACA	CGCAGTAGATCCACCACCCCGCCAGA
827	WMC235	5B	ACTGTTCCTATCCGTGCACTGG	GAGGCAAAGTTCTGGAGGTCTG
828	CFD86	5B	TTAATGAGCGTCAGTACTCCC	GCAACCATGTTTAAGCCGAT
829	WMC28	5B	ATCACGCATGTCTGCTATGTAT	ATTAGACCATGAAGACGTGTAT
830	WMC118	5B	AGAATTAGCCCTTGAGTTGGTC	CTCCCATCGCTAAAGATGGTAT
831	WMC508	5B	AGCCCTTGAGTTGGTCTCATTT	GAGCAGAGCTCCACTCACATTT

832	WMC640	5B		
833	BARC59	5B	GCGTTGGCTAATCATCGTTCCTTC	AGCACCCTACCCAGCGTCAGTCAAT
834	WMC430	5B	CAGTTGCAAGTTGGCCATAG	TAGGGACCCCTTGACAAAAA
835	WMC783	5B		
836	GWM497	5B	GTAGTGAAGACAAGGGCATT	CCGAAAGTTGGGTGATATAC
837	WMC258	5B	GCGATGTCAGATATCCGAAAGG	ACCAGGACACCAGAACAGCAAT
838	WMC233	5D	GACGTCAAGAATCTTCGTCGGA	ATCTGCTGAGCAGATCGTGGTT
839	BARC130	5D	CGGCTAGTAGTTGGAGTGTTGG	ACCGCCTCTAGTTATTGCTCTC
840	CFD18	5D	CATCCAACAGCACCAAGAGA	GCTACTACTATTTCATTGCGACCA
841	GWM190	5D	GTGCTTGCTGAGCTATGAGTC	GTGCCACGTGGTACCTTTG
842	CFA2104	5D	CCTGGCAGAGAAAGTGAAGG	AGTCGCCGTTGTATAGTGCC
843	CFD189	5D	GCTAAAGCCACATAGGACGG	GCACAAGATTTTGCAAGGCT
844	GWM205	5D	CGACCCGGTTCACTTCAG	AGTCGCCGTTGTATAGTGCC
845	CFD78	5D	ATGAAATCCTTGCCCTCAGA	TGAGATCATCGCCAATCAGA
846	WMC150	5D	CATTGATTGAACAGTTGAAGAA	CTCAAAGCAACAGAAAAGTAAA
847	BARC143	5D	TTGTGCCAAATCAAGAACAT	GGTTGGGCTAGGATGAAAAT
848	CFD81	5D	TATCCCCAATCCCCTCTTTC	GTCAATTGTGGCTTGTCCCT
849	CFD37	5D	GCTTCTTTTGCTGCTTTTGC	CCCCCACATACAGAGGCTAA
850	CFD67	5D	GCGGACAAATTGAGCCTTAG	TGTGCGTGTGTGTGTGTTTT
851	GWM358	5D	AAACAGCGGATTTCATCGAG	TCCGCTGTTGTTCTGATCTC
852	GWM16	5D	GCTTGGACTAGCTAGAGTATCATAC	CAATCTTCAATTCTGTCGCACGG
853	GWM159	5D	GGGCCAACACTGGAACAC	GCAGAAGCTTGTTGGTAGGC
854	WMC608	5D	ACTGGAACGCGAAACAAATGG	CAGGAGCCCCTCCTAGATTGG
855	WMC318	5D	CGTAAAATTACGGTGCATTGAT	GTGGACTTTTGTGGTTTTTGAG
856	WMC805	5D		
857	GDM153	5D	TATAGGCAAATTAATTAAGACG	ATCTTTATGTGAGTACACTGC
858	CFD266	5D	GAAAACAAAACCCATTTGCG	AAGCTTCAGTGCCTTTGGAA
859	WMC799	5D		
860	CFD40	5D	GCGACAAGTAATTCAGAACGG	CGCTTCGGTAAAGTTTTTGC
861	BARC49	5D	GTCCCACCAAATTAACAGCTCCTA	AGGCGCAGTGCTCGAAGAATATTAT
862	GDM138	5D	CATGAGCCGATTCAGCG	CGCTTAAATTGAAGTACCGC

863	WMC405	5D	GTGCGGAAAGAGACGAGGTT	TATGTCCACGTTGGCAGAGG
864	CFD8	5D	ACCACCGTCATGTCACTGAG	GTGAAGACGACAAGACGCAA
865	GWM583	5D	TTCACACCCAACCAATAGCA	TCTAGGCAGACACATGCCTG
866	GDM136	5D	CTCATCCGGTGAGTGCATC	CCCGCATGTCTACATGAGAA
867	GWM639	5D	CTCTCTCCATTCGGTTTTCC	CATGCCCCCCTTTTCTG
868	GWM182	5D	TGATGTAGTGAGCCCATAGGC	TTGCACACAGCCAAATAAGG
869	WMC630	5D	ATAATGCACGGTAGGACTGAGG	CATACTGAGACAATTTGGGGGT
870	CFD7	5D	AGCTACCAGCCTAGCAGCAG	TCAGACACGTCTCCTGACAAA
871	CFD3	5D	GCACCAACACACGGAGAAG	TTGAGAGGAGGGCTTGGTTA
872	WMC818	5D		
873	CFD12	5D	GTTACCCAAACCTGCCCTTT	CTACGAGTCGGGATCAGCAT
874	CFD57	5D	ATCGCCGTTAACATAGGCAG	TCACTGCTGTATTTGCTCCG
875	CFD102	5D	TTGTGGAAGGGTTTGATGAAG	TGCAGGACCAAACATAGCTG
876	GWM174	5D	GGGTTCCTATCTGGTAAATCCC	GACACACATGTTCCTGCCAC
877	CFD26	5D	TCAAGATCGTGCCAAATCAA	ACTCCAAGCTGAGCACGTTT
878	WMC289	5D	CATATGCATGCTATGCTGGCTA	AGCCTTTCAAATCCATCCACTG
879	GWM121	5D	TCCTCTACAAACAAACACAC	CTCGCAACTAGAGGTGTATG
880	GWM271	5D	CAAGATCGTGGAGCCAGC	AGCTGCTAGCTTTTGGGACA
881	WMC215	5D	CATGCATGGTTGCAAGCAAAAG	CATCCCGGTGCAACATCTGAAA
882	GWM292	5D	TCACCGTGGTCACCGAC	CCACCGAGCCGATAATGTAC
883	WMC264	5D	CTCCATCTATTGAGCGAAGGTT	CAAGATGAAGCTCATGCAAGTG
884	GWM212	5D	AAGCAACATTTGCTGCAATG	TGCAGTTAACTTGTTGAAAGGA
885	WMC95	5D	GTTTTTGTGATCCCGGGTTT	CATGCGTCAGTTCAAGTTTT
886	WMC434	5D	GGAGCCTGATTAGGCTGGAC	AGCCAAACAGCCAACAGAGT
887	CFD156	5D	AGCAGTGTAATAAAAGGGCG	GTATTCGCACCAGAATCCGT
888	CFD29	5D	GGTTGTCAGGCAGGATATTTG	TATTGATAGATCAGGGCGCA
889	WMC788	5D		
890	CFD19	5D	TACGCAGGTTTGCTGCTTCT	GGAGTTCACAAGCATGGGTT
891	CFD183	5D	ACTTGCACTTGCTATACTTACGAA	GTGTGTCGGTGTGTGGAAAG
892	WMC636	5D		
893	WMC97	5D	GTCCATATATGCAAGGAGTC	GTACTCTATCGCAAAACACA

894	CFD2	5D	GGTTGCAGTTTCCACCTTGT	CATCTATTGCCAAAATCGCA
895	BARC232	5D	CGCATCCAACCATCCCCACCCAACA	CGCAGTAGATCCACCACCCCGCCAGA
896	WMC206	5D	TTGTGCTCGTGAATTGCATACC	GCCAAAATGGCAGCTTCTCTTA
897	CFA2141	5D	GAATGGAAGGCGGACATAGA	GCCTCCACAACAGCCATAAT
898	GDM63	5D	GCCCCCTATTCCATAGGAAT	CCTTTTGATGGTGCATAGGA
899	WMC357	5D	TAGTGGGTGACCGGTCAAGA	TGGACGGATTTGGTCATTTC
900	GDM133	5D	ACGATTCATAACACAGCGCA	TGAGAACAATTTCACGGCTG
901	CFD86	5D	TTAATGAGCGTCAGTACTCCC	GCAACCATGTTTAAGCCGAT
902	CFD283	5D	CCCGTGGTCTTGGGTTC	AGTTTTGCCATCGGCTGTAT
903	WMC640	5D		
904	CFD10	5D	CGTTCTATGACGTGTCATGCT	TCCATTTTCAAAAACACCCTG
905	WMC161	5D	ACCTTCTTTGGGATGGAAGTAA	GTACTGAACCACTTGTAACGCA
906	GWM469	5D	CAACTCAGTGCTCACACAACG	CGATAACCACTCATCCACACC
907	WMC96	5D	TAGCAGCCATGCTTAGCATCAA	GTTTCAGTCTTTCACGAACACG
908	WMC765	5D	GGGATCAGACTGGGACTGGAG	GGGTTGGCTTGGCAGAGAA
909	GWM269	5D	TGCATATAAACAGTCACACACCC	TTTGAGCTCCAAAGTGAGTTAGC
910	BARC144	5D	GCGTTTTAGGTGGACGACATAGATAGA	GCGCCACGGGCATTTCTCATAC
911	GWM565	5D	GCGTCAGATATGCCTACCTAGG	AGTGAGTTAGCCCTGAGCCA
912	GWM272	5D	TGCTCTTTGGCGAATATATGG	GTTCAAAACAAATTAAAAGGCCC
913	WMC443	5D	CCTCCTCTGTTTTCCCTCTGTT	CACACTCTGTGCTTCTGTTTGC
914	GWM654	5D	TGCTGATGTTGTAAGAAGGC	TGCGTCAGATATGCCTACCT
915	GWM459	6A	ATGGAGTGGTCACACTTTGAA	AGCTTCTCTGACCAACTTCTCG
916	GWM334	6A	AATTTCAAAAAGGAGAGAGA	AACATGTGTTTTTAGCTATC
917	BARC206	6A	GCTTTGCCAGGTGAGCACTCT	TGGCCGGGTATTTGAGTTGGAGTTT
918	BARC23	6A	GCGTGAAATAGTGCAAGCCAGAGAT	GCGCTAACACCTCGGCAAGACAA
919	WMC182	6A	GTATCTCACGAGCATAACACAA	GAAAGTGTATGGATCATTAGGC
920	BARC37	6A	CAGCGCTCCCCGACTCAGATCCTT	GCGCCATGTTTCTTTTATTACTCACTTT
921	BARC48	6A	GCGAGCTGCAGAGGTCCATC	GCGTTAGTCTTCTTGGTCAATCAC
922	BARC146	6A	AAGGCGATGCTGCAGCTAAT	GGCAATATGGAAACTGGAGAGAAAT
923	WMC243	6A	CGTCATTTCCTCAAACACACCT	ACCGGCAGATGTTGACAATAGT
924	WMC753	6A		

925	BARC195	6A	CCCACATGTCATTGGCTGTTTAA	GCCCGGCCCAGAACGATTTAAATG
926	CFD80	6A	ATAGGGGTTTTGAATCACTCC	TTGGATTTGCAGAGCCTTCT
927	CFD190	6A	CAATCAGAAGCGCCATTGTT	CCCTGATGTTTTCTTTTTCTCC
928	WMC398	6A	GGAGATTGACCGAGTGGAT	CGTGAGAGCGGTTCTTTG
929	WMC672	6A		
930	WMC145	6A	GGCGGTGGGTTCAAGTCGTCTG	GGACGAGTCGCTGTCCTCCTGG
931	WMC748	6A		
932	WMC786	6A		
933	WMC256	6A	CCAAATCTTCGAACAAGAACCC	ACCGATCGATGGTGTATACTGA
934	WMC150	6A	CATTGATTGAACAGTTGAAGAA	CTCAAAGCAACAGAAAAGTAAA
935	WMC807	6A		
936	BARC3	6A	TTCCCTGTGTCTTTCTAATTTTTTTT	GCGAACTCCCGAACATTTTTAT
937	WMC684	6A		
938	WMC201	6A	CATGCTCTTTCACTTGGGTTCG	GCGCTTGCAGGAATTCAACACT
939	GWM132	6A	TACCAAATCGAAACACATCAGG	CATATCAAGGTCTCCTTCCCC
940	GWM570	6A	TCGCCTTTTACAGTCGGC	ATGGGTAGCTGAGAGCCAAA
941	WMC553	6A	CGGAGCATGCAGCTAGTAA	CGCCTGCAGAATTCAACAC
942	WMC179	6A	CATGGTGGCCATGAGTGGAGGT	CATGATCTTGCGTGTGCGTAGG
943	GWM169	6A	ACCACTGCAGAGAACACATACG	GTGCTCTGCTCTAAGTGTGGG
944	WMC417	6A	GTTCTTTTAGTTGCGACTGAGG	CGATGTATGCCGTATGAATGTT
945	WMC580	6A	AAGGCGCACAACACAATGAC	GGTCTTTTGTGCAGTGAACTGAAG
946	GWM427	6A	AAACTTAGAACTGTAATTTCAGA	AGTGTGTTCATTTGACAGTT
947	GWM617	6A	GATCTTGGCGCTGAGAGAGA	CTCCGATGGATTACTCGCAC
948	WMC642	6A		
949	WMC621	6A	GACGTAGGGCGGCGGATA	TGCGCCGTGTTTAATTGCTC
950	WMC206	6A	TTGTGCTCGTGAATTGCATACC	GCCAAAATGGCAGCTTCTCTTA
951	WMC254	6A	AGTAATCTGGTCCTCTCTTCTTCT	AGGTAATCTCCGAGTGCACTTCAT
952	WMC59	6A	TCATTCGTTGCAGATACACCAC	TCAATGCCCTTGTTTCTGACCT
953	GWM613	6B	CCGACCCGACCTACTTCTCT	TTGCCGTCGTAGACTGG
954	WMC419	6B	GTTTCGGATAAAACCGGAGTGC	ACTACTTGTGGGTTATCACCAGCC
955	WMC486	6B	CCGGTAGTGGGATGCATTTT	ATGCATGCTGAATCCGGTAA

956	BARC76	6B	ATTCGTTGCTGCCACTTGCTG	GCGCGACACGGAGTAAGGACACC
957	WMC487	6B	CAAATTTGGCCACCATTTTACA	CGGTTCAATCCTTGGATTTACA
958	GWM705	6B	TCTCCCTCATTAGAGTTGTCCA	ATGCAAGTTTAGAGCAACACCA
959	WMC104	6B	TCTCCCTCATTAGAGTTGTCCA	ATGCAAGTTTAGAGCAACACCA
960	GWM132	6B	TACCAAATCGAAACACATCAGG	CATATCAAGGTCTCCTTCCCC
961	CFD1	6B	ACCAAAGAACTTGCCTGGTG	AAGCCTGACCTAGCCCAAAT
962	CFD13	6B	CCACTAACCAAGCTGCCATT	TTTTTGGCATTGATCTGCTG
963	GDM113	6B	ACCCATCTGATATTTTGGGG	AAAATGCCCTTCCCAACC
964	GWM518	6B	AATCACAACAAGGCGTGACA	CAGGGTGGTGCATGCAT
965	WMC597	6B	AACACACCTTGCTTCTCTGGGA	GACTAGGGTTTCGGTTGTTGGC
966	WMC494	6B	GGATCGAGTCTCAAGTCTACAA	AGAAGGAACAAGCAACATCATA
967	GWM508	6B	GTTATAGTAGCATATAATGGCC	GTGCTGCCATGATATTT
968	GWM191	6B	AGACTGTTGTTTGCGGGC	TAGCACGACAGTTGTATGCATG
969	WMC737	6B	CGACTAGGACTAGACGACTCTAACGG	GTCGATCACCAGAGGCATTG
970	WMC398	6B	GGAGATTGACCGAGTGGAT	CGTGAGAGCGGTTCTTTG
971	GWM193	6B	CTTTGTGCACCTCTCTCTCC	AATTGTGTTGATGATTTGGGG
972	GWM133	6B	ATCTAAACAAGACGGCGGTG	ATCTGTGACAACCGGTGAGA
973	GWM361	6B	GTAACTTGTTGCCAAAGGGG	ACAAAGTGGCAAAAGGAGACA
974	GWM644	6B	GTGGGTCAAGGCCAAGG	AGGAGTAGCGTGAGGGGC
975	WMC397	6B	AGTCGTGCACCTCCATTTTG	CATTGGACATCGGAGACCTG
976	WMC756	6B		
977	WMC105	6B	AATGTCATGCGTGTAGTAGCCA	AAGCGCACTTAACAGAAGAGGG
978	GWM88	6B	CACTACAACTATGCGCTCGC	TCCATTGGCTTCTCTCTCAA
979	WMC473	6B	TCTGTTGCGCGAAACAGAATAG	CCCATTGGACAACACTTTCACC
980	GWM273	6B	ATTGGACGGACAGATGCTTT	AGCAGTGAGGAAGGGGATC
981	WMC179	6B	CATGGTGGCCATGAGTGGAGGT	CATGATCTTGCGTGTGCGTAGG
982	GWM70	6B	AGTGGCTGGGAGAGTGTCAT	GCCCATTACCGAGGACAC
983	BARC146	6B	AAGGCGATGCTGCAGCTAAT	GGCAATATGGAAACTGGAGAGAAAT
984	WMC182	6B	GTATCTCACGAGCATAACACAA	GAAAGTGTATGGATCATTAGGC
985	BARC198	6B	CGCTGAAAAGAAGTGCCGCATTATGA	CGCTGCCTTTTCTGGATTGCTTGTCA
986	CFA2110	6B	TCACTACCCGCATGAACAAA	TTCTGCACAAACCGTTCTGA

987	WMC726	6B	GCAAAGAACCGTGCCCTGAC	CGGGGTGGCCCGAGA
988	WMC79	6B	CATCAATGCATATGGCTGAAAT	AAAAGTTGTCATGAGCGAAGAA
989	GWM311	6B	TCACGTGGAAGACGCTCC	CTACGTGCACCACCATTTTG
990	GWM608	6B	ACATTGTGTGTGCGGCC	GATCCCTCTCCGCTAGAAGC
991	WMC748	6B		
992	WMC786	6B		
993	BARC127	6B	TGCATGCACTGTCCTTTGTATT	AAGATGCGGGCTGTTTTCTA
994	WMC539	6B	GCAAGTAGGACCTTACAGTTCT	GTTATAACCTTTGTCCCTTCAC
995	GWM626	6B	GATCTAAAATGTTATTTTCTCTC	TGACTATCAGCTAAACGTGT
996	WMC152	6B	CTATTGGCAATCTACCAAACTG	TCTCTTCTTGCCACATATTCGT
997	GWM107	6B	ATTAATACCTGAGGGAGGTGC	GGTCTCAGGAGCAAGAACAC
998	BARC24	6B	CGCCTCTTATGGACCAGCCTAT	GCGGTGAGCCATCGGGTTACAAAG
999	GWM219	6B	GATGAGCGACACCTAGCCTC	GGGGTCCGAGTCCACAAC
1000	BARC178	6B	GCGTATTAGCAAAACAGAAGTGAG	GCGACTAGTACGAACACCACAAAA
1001	WMC417	6B	GTTCTTTTAGTTGCGACTGAGG	CGATGTATGCCGTATGAATGTT
1002	BARC134	6B	CCGTGCTGCAAATGAACAC	AGTTGCCGGTTCCCATTGTCA
1003	CFD49	6D	TGAGTTCTTCTGGTGAGGCA	GAATCGGTTCACAAGGGAAA
1004	BARC183	6D	CCCGGGACCACCAGTAAGT	GGATGGGGAATTGGAGATACAGAG
1005	CFD135	6D	GGATCTCGGGGATGTCCT	TAAGCACCTTCTTCATGGGG
1006	BARC173	6D	GGGGATCCTTCAACAATAACA	GCGAGATGGCATTTTTAAATAAAGAGAC
1007	CFD75	6D	GCATAAACTTGGACCCTGGA	GCTAAGCCACGCTACCACTC
1008	GDM132	6D	ACCGCTCGGAGAAAATCC	AGGGGGGCAGAGGTAGG
1009	CFD13	6D	CCACTAACCAAGCTGCCATT	TTTTTGGCATTGATCTGCTG
1010	CFD1	6D	ACCAAAGAACTTGCCTGGTG	AAGCCTGACCTAGCCCAAAT
1011	CFD42	6D	AGGTTCTAGGGGGCATGTCT	GCTCTCAATGACTGCACTGG
1012	GWM469	6D	CAACTCAGTGCTCACACAACG	CGATAACCACTCATCCACACC
1013	WMC749	6D		
1014	CFD132	6D	CAAATGCTAATCCCCGCC	TGTAAACAAGGTCGCAGGTG
1015	BARC54	6D	GCGAACAGGAGGACAGAGGGCACGAGAG	GCGCTTTCCCACGTTCCATGTTTCT
1016	CFD19	6D	TACGCAGGTTTGCTGCTTCT	GGAGTTCACAAGCATGGGTT
1017	BARC196	6D	GGTGGGTTTTATCGAATAGATTTGCT	GCGTTTCGTCAAGATTAATGCAGGTTT

1018	CFD287	6D	TCAAGAAGATGCGTTCATGC	GGGAGCTTTCCCTAGTGCTT
1019	GWM325	6D	TTTCTTCTGTCGTTCTCTTCCC	TTTTTACGCGTCAACGACG
1020	CFD190	6D	CAATCAGAAGCGCCATTGTT	CCCTGATGTTTTCTTTTTCTCC
1021	GWM55	6D	GCATCTGGTACACTAGCTGCC	TCATGGATGCATCACATCCT
1022	GWM133	6D	ATCTAAACAAGACGGCGGTG	ATCTGTGACAACCGGTGAGA
1023	BARC5	6D	GCGCCTGGACCGGTTTTCTATTTT	GCGTTGGGAATTCCTGAACATTTT
1024	WMC822	6D		
1025	CFD80	6D	ATAGGGGTTTTGAATCACTCC	TTGGATTTGCAGAGCCTTCT
1026	CFD188	6D	AATGGCTTCACTGTTTGCCT	AAATGGTCCCAGCATTCAAG
1027	CFD37	6D	GCTTCTTTTGCTGCTTTTGC	CCCCCACATACAGAGGCTAA
1028	WMC753	6D		
1029	CFD76	6D	GCAATTTCACACGCGACTTA	CGCTCGACAACATGACACTT
1030	WMC469	6D	AGGTGGCTGCCAACG	CAATTTTATCAGATGCCCGA
1031	CFD219	6D	GGCCCATCTGTCATTGACTT	CAGCTTGTGTTGCTCGCTTA
1032	WMC786	6D		
1033	WMC748	6D		
1034	BARC204	6D	CGCAGAAGAAAAACCTCGCAGAAAAACC	CGCAGTGTATCCAAATGGGCAAGC
1035	BARC175	6D	GCGTAACAGAAGCGGAGAAAGC	GCGAATCATTTAGTGTTAGGTGGCAGTG
1036	BARC96	6D	AAGCCTTGTTGTTCCGTATTATT	GCGGTTTATATTTTGTGGTTGAGCATTTT
1037	WMC773	6D	GAGGCTTGCATGTGCTTGA	GCCAACTGCAACCGGTACTCT
1038	GWM666	7A	GCACCCACATCTTCGACC	TGCTGCTGGTCTCTGTGC
1039	WMC158	7A	AACTGGCATCATGTTTTGTAGG	AATGTAGTCAAAAGAGGTGGTG
1040	GWM233	7A	TCAAAACATAAATGTTCATTGGA	TCAACCGTGTGTAATTTTGTCC
1041	WMC388	7A	TGTGCGGAATGATTCAATCTGT	GGCCATTAGACTGCAATGGTTT
1042	BARC70	7A	GCGAAAAACGATGCGACTCAAAG	GCGCCATATAATTCAGACCCACAAAA
1043	GWM635	7A	TTCCTCACTGTAAGGGCGTT	CAGCCTTAGCCTTGGCG
1044	GWM350	7A	ACCTCATCCACATGTTCTACG	GCATGGATAGGACGCCC
1045	WMC497	7A	CCCGTGGTTTTCTTTCCTTCT	AACGACAGGGATGAAAAGCAA
1046	BARC151	7A	TGAGGAAAATGTCTCTATAGCATCC	CGCATAAACACCTTCGCTCTTCCACTC
1047	WMC646	7A		
1048	GWM471	7A	CGGCCCTATCATGGCTG	GCTTGCAAGTTCCATTTTGC

1049	WMC479	7A	GACCTAAGCCCAGTGTCATCAG	AGACTCTTGGCTTTGGATACGG
1050	WMC168	7A	AACACAAAAGATCCAACGACAC	CAGTATAGAAGGATTTTGAGAG
1051	GWM60	7A	TGTCCTACACGGACCACGT	GCATTGACAGATGCACACG
1052	WMC593	7A	GGGGAGAAGCAGCAGGG	CGCGCGGTTGCCGGTGG
1053	CFD13	7A	CCACTAACCAAGCTGCCATT	TTTTTGGCATTGATCTGCTG
1054	WMC179	7A	CATGGTGGCCATGAGTGGAGGT	CATGATCTTGCGTGTGCGTAGG
1055	CFA2049	7A	TAATTTGATTGGGTCGGAGC	CGTGTCGATGGTCTCCTTG
1056	CFD242	7A	CCAGTTTGCAGCAGTCACAT	CAGACCTTAACGGGGTTGAA
1057	WMC283	7A	CGTTGGCTGGGTTATATCATCT	GACCCGCGTGTAAGTGATAGGA
1058	BARC127	7A	TGCATGCACTGTCCTTTGTATT	AAGATGCGGGCTGTTTTCTA
1059	BARC154	7A	GTAATTCCGGTTCCACTTGACATT	GGATGGGCAGCTTCAAGGTATGTT
1060	CFA2028	7A	TGGGTATGAAAGGCTGAAGG	ATCGCGACTATTCAACGCTT
1061	WMC83	7A	TGGAGGAAACACAATGGATGCC	GAGTATCGCCGACGAAAGGGAA
1062	WMC405	7A	GTGCGGAAAGAGACGAGGTT	TATGTCCACGTTGGCAGAGG
1063	WMC826	7A		
1064	BARC174	7A	TGGCATTTTTCTAGCACCAATACAT	GCGAACTGGACCAGCCTTCTATCTGTTC
1065	CFD6	7A	ACTCTCCCCCTCGTTGCTAT	ATTTAAGGGAGACATCGGGC
1066	GWM573	7A	AAGAGATAACATGCAAGAAA	TTCAAATATGTGGGAACTAC
1067	GWM260	7A	GCCCCCTTGCACAATC	CGCAGCTACAGGAGGCC
1068	WMC17	7A	ACCTGCAAGAAATTAGGAACTC	CTAGTGTTTCAAATATGTCGGA
1069	BARC108	7A	GCGGGTCGTTTCCTGGAAATTCATCTAA	GCGAAATGATTGGCGTTACACCTGTTG
1070	WMC695	7A		
1071	WMC182	7A	GTATCTCACGAGCATAACACAA	GAAAGTGTATGGATCATTAGGC
1072	WMC9	7A	AACTAGTCAAATAGTCGTGTCCG	GTCAAGTCATCTGACTTAACCCG
1073	WMC65	7A	TGGATGGGAAGGAGAATAAGTG	ATCCAACCGGAACTACCGTCAG
1074	WMC596	7A	TCAGCAACAAACATGCTCGG	CCCGTGTAGGCGGTAGCTCTT
1075	WMC422	7A	GGACTACTGAACTGGAGAGTGTG	GCATTAGAATTTGGAGTTTGGAG
1076	WMC603	7A	ACAAACGGTGACAATGCAAGGA	CGCCTCTCTCGTAAGCCTCAAC
1077	BARC23	7A	GCGTGAAATAGTGCAAGCCAGAGAT	GCGCTAACACCTCGGCAAGACAA
1078	BARC121	7A	ACTGATCAGCAATGTCAACTGAA	CCGGTGTCTTTCCTAACGCTATG
1079	BARC49	7A	GTCCCACCAAATTAACAGCTCCTA	AGGCGCAGTGCTCGAAGAATATTAT

1080	WMC607	7A	ATATATGCCCATGAAGCTCAAG	GATCGAGCTAAAGCTGATACCA
1081	GWM4	7A	GCTGATGCATATAATGCTGT	CACTGTCTGTATCACTCTGCT
1082	WMC139	7A	TGTAACTGAGGGCCATGAAT	CATCGACTCACAACTAGGGT
1083	WMC488	7A	AAAGCACAACCAGTTATGCCAC	GAACCATAGTCACATATCACGAGG
1084	GWM10	7A	CGCACCATCTGTATCATTCTG	TGGTCGTACCAAAGTATACGG
1085	BARC195	7A	CCCACATGTCATTGGCTGTTTAA	GCCCGGCCCAGAACGATTTAAATG
1086	CFD193	7A	GCTGCCGCTACTGTCTGTC	GGCACACTCACACACCACAC
1087	GWM276	7A	ATTTGCCTGAAGAAAATATT	AATTTCACTGCATACACAAG
1088	CFA2257	7A	GATACAATAGGTGCCTCCGC	CCATTATGTAAATGCTTCTGTTTGA
1089	CFD20	7A	TGATGGGAAGGTAATGGGAG	ATCCAGTTCTCGTCCAAAGC
1090	GWM282	7A	TTGGCCGTGTAAGGCAG	TCTCATTCACACACAACACTAGC
1091	GWM332	7A	AGCCAGCAAGTCACCAAAAC	AGTGCTGGAAAGAGTAGTGAAGC
1092	WMC790	7A		
1093	GWM63	7A	TCGACCTGATCGCCCCTA	CGCCCTGGGTGATGAATAGT
1094	WMC633	7A	ACACCAGCGGGGATATTTGTTAC	GTGCACAAGACATGAGGTGGATT
1095	CFA2019	7A	GACGAGCTAACTGCAGACCC	CTCAATCCTGATGCGGAGAT
1096	GWM554	7A	TGCCCACAACGGAACTTG	GCAACCACCAAGCACAAAGT
1097	WMC525	7A	GTTTGACGTGTTTGCTGCTTAC	CTACGGATAATGATTGCTGGCT
1098	CFA2040	7A	TCAAATGATTTCAGGTAACCACTA	TTCCTGATCCCACCAAACAT
1099	WMC809	7A		
1100	WMC606	7B	CCGATGAACAGACTCGACAAGG	GGCTTCGGCCAGTAGTACAGGA
1101	WMC323	7B	ACATGATTGTGGAGGATGAGGG	TCAAGAGGCAGACATGTGTTCG
1102	GWM569	7B	GGAAACTTATTGATTGAAAT	TCAATTTTGACAGAAGAATT
1103	GWM537	7B	ACATAATGCTTCCTGTGCACC	GCCACTTTTGTGTCGTTCCT
1104	GWM400	7B	GTGCTGCCACCACTTGC	TGTAGGCACTGCTTGGGAG
1105	GWM68	7B	AGGCCAGAATCTGGGAATG	CTCCCTAGATGGGAGAAGGG
1106	WMC546.1	7B	CGGCTAAAATCGTACACTACACA	CTCACTTGCACGATTTCCCTAT
1107	BARC85	7B	GCGAACGCTGCCCGGAGGAATCA	GCGTCGCAGATGAGATGGTGGAGCAAT
1108	WMC182	7B	GTATCTCACGAGCATAACACAA	GAAAGTGTATGGATCATTAGGC
1109	GWM573	7B	AAGAGATAACATGCAAGAAA	TTCAAATATGTGGGAACTAC
1110	WMC426	7B	GACGATCGTTTCTCCTACTTTA	ACTACACAAATGACTGCTGCTA

1111	GWM46	7B	GCACGTGAATGGATTGGAC	TGACCCAATAGTGGTGGTCA
1112	BARC72	7B	CGTCCTCCCCCTCTCAATCTACTCTC	CGTCCCTCCATCGTCTCATCA
1113	WMC758	7B		
1114	WMC546.2	7B	CGGCTAAAATCGTACACTACACA	CTCACTTGCACGATTTCCCTAT
1115	GWM43	7B	CACCGACGGTTTCCCTAGAGT	GGTGAGTGCAAATGTCATGTG
1116	WMC335	7B	TGCGGAGTAGTTCTTCCCCC	ACATCTTGGTGAGATGCCCT
1117	GWM16	7B	GCTTGGACTAGCTAGAGTATCATAC	CAATCTTCAATTCTGTCGCACGG
1118	GWM297	7B	ATCGTCACGTATTTTGCAATG	TGCGTAAGTCTAGCATTTTCTG
1119	WMC475	7B	AACACATTTTCTGTCTTTCGCC	TGTAGTTATGCCCAACCTTTCC
1120	WMC662	7B	AGTGGAGCCATGGTACTGATTT	TGTGTACTATTCCCGTCGGTCT
1121	GWM644	7B	GTGGGTCAAGGCCAAGG	AGGAGTAGCGTGAGGGGC
1122	WMC696	7B		
1123	WMC476	7B	TACCAACCACACCTGCGAGT	CTAGATGAACCTTCGTGCGG
1124	WMC364	7B	ATCACAATGCTGGCCCTAAAAC	CAGTGCCAAAATGTCGAAAGTC
1125	WMC471	7B	GGCAATAATAGTGCAAGGAATG	GCCGATAATGGGCAATATAAGT
1126	BARC267	7B	GCGTGCTTTTTATTTTTGTGGACATCTT	GCGAATAATTGGTGGGTGAAACA
1127	WMC218	7B	TCTCCTGTCGGCTGAAAGTGTT	CCATGGAGGTTCACCTAGCAAA
1128	BARC95	7B	GGGGTGTGGTTGTTTGTAAGG	TGCGAATTCTATATACGATCTTGAGC
1129	GWM333	7B	GCCCGGTCATGTAAAACG	TTTCAGTTTGCGTTAAGCTTTG
1130	WMC435	7B	GCACTATACTTATTGGATTGTCA	CATGGTATCCCTAGTAAGTTTTT
1131	WMC396	7B	TGCACTGTTTTACCTTCACGGA	CAAAGCAAGAACCAGAGCCACT
1132	WMC653	7B		
1133	GWM213	7B	TGCCTGGCTCGTTCTATCTC	CTAGCTTAGCACTGTCGCCC
1134	BARC176	7B	GCGAAAGCCATCAAACACTATCCAACT	GGTAACTAAGCACGTCACAAGCATAAA
1135	GWM112	7B	CTAAACACGACAGCGGTGG	GATATGTGAGCAGCGGTCAG
1136	GWM274	7B	AACTTGCAAAACTGTTCTGA	TATTTGAAGCGGTTTGATTT
1137	WMC76	7B	CTTCAGAGCCTCTTTCTCTACA	CTGCTTCACTTGCTGATCTTTG
1138	CFA2106	7B	GCTGCTAAGTGCTCATGGTG	TGAAACAGGGGAATCAGAGG
1139	CFD22	7B	GGTTGCAAACCGTCTTGTTT	AGTCGAGTTGCGACCAAAGT
1140	GWM131	7B	AATCCCCACCGATTCTTCTC	AGTTCGTGGGTCTCTGATGG
1141	WMC51	7B	TTATCTTGGTGTCTCATGTCAG	TCGCAAGATCATCAGAACAGTA

1142	GWM302	7B	GCAAGAAGCAACAGCAGTAAC	CAGATGCTCTTCTCTGCTGG
1143	WMC723	7B	CTCGCTCGATCCCCTTTC	CGAGGTGGAGTCCCGTCTAT
1144	WMC540	7B	CGGGGTCCTAACTACGGTGA	CCTGTAATGGAGGACGGCTG
1145	WMC517	7B	ATCCTGACGTTACACGCACC	ACCTGGAACACCACGACAAA
1146	WMC792	7B		
1147	WMC311	7B	GGGCCTGCATTTCTCCTTTCTT	CTGAACTTGCTAGACGTTCCGA
1148	WMC613	7B	ACAACTGTGAAACGAGACGGTG	GTGAGTGTGAAAACCAAGACGC
1149	GWM611	7B	CATGGAAACACCTACCGAAA	CGTGCAAATCATGTGGTAGG
1150	GWM577	7B	ATGGCATAATTTGGTGAAATTG	TGTTTCAAGCCCAACTTCTATT
1151	WMC581	7B	CATGTTGCCATCAAACTCGC	GCTATTGACATGCAACTATGGACCT
1152	BARC10	7B	GCGTGCCACTGTAACCTTTAGAAGA	GCGAGTTGGAATTATTTGAATTAAACAAG
1153	WMC166	7B	ATAAAGCTGTCTCTTTAGTTCG	GTTTTAACACATATGCATACCT
1154	WMC276	7B	GACATGTGCACCAGAATAGC	AGAAGAACTATTCGACTCCT
1155	BARC32	7B	GCGTGAATCCGGAAACCCAATCTGTG	TGGAGAACCTTCGCATTGTGTCATTA
1156	WMC273	7B	AGTTATGTATTCTCTCGAGCCTG	GGTAACCACTAGAGTATGTCCTT
1157	CFA2040	7B	TCAAATGATTTCAGGTAACCACTA	TTCCTGATCCCACCAAACAT
1158	BARC182	7B	CCATGGCCAACAGCTCAAGGTCTC	CGCAAAACCGCATCAGGGAAGCACCAAT
1159	WMC557	7B	GGTGCTTGTTCATACGGGCT	AGGTCCTCGATCCGCTCAT
1160	WMC10	7B	GATCCGTTCTGAGGTGAGTT	GGCAGCACCCTCTATTGTCT
1161	WMC526	7B	TCCCATTGGTTCACAAACTCG	GATGGTATCGCATTCATCGGT
1162	WMC500	7B	ATAGCATGTTGGAACAGAGCAC	CTTAGATGCAACTCTATGCGGT
1163	BARC123	7B	GGCCGAATTGAAAAAGCC	CCTGCCGTGTGCCGACTA
1164	WMC70	7B	GGGGAGCACCCTCTATTGTCTA	TAATGCTCCCAGGAGAGAGTCG
1165	GWM146	7B	CCAAAAAAACTGCCTGCATG	CTCTGGCATTGCTCCTTGG
1166	GWM344	7B	CAAGGAAATAGGCGGTAACT	ATTTGAGTCTGAAGTTTGCA
1167	GWM350	7D	ACCTCATCCACATGTTCTACG	GCATGGATAGGACGCCC
1168	WMC646	7D		
1169	WMC506	7D	CACTTCCTCAACATGCCAGA	CTTTCAATGTGGAAGGCGAC
1170	BARC184	7D	TTCGGTGATATCTTTTCCCCTTGA	CCGAGTTGACTGTGTGGGCTTGCTG
1171	WMC450	7D	GCAGGACAGGAGGTGAAGAAG	AGGCGTTGCTGATGACACTAC
1172	GWM635	7D	TTCCTCACTGTAAGGGCGTT	CAGCCTTAGCCTTGGCG

1173	BARC70	7D	GCGAAAAACGATGCGACTCAAAG	GCGCCATATAATTCAGACCCACAAAA
1174	CFD41	7D	TAAAGTCTCAGGCGACCCAC	AGTGATAGACGGATGGCACC
1175	GDM88	7D	TCCCACCTTTTTGCTGTAGA	AAGGACAAATCCCTGCATGA
1176	GDM145	7D	TGAAGGACAAATCCCTGCAT	TCCCACCTTTTTGCTGTAGA
1177	CFD31	7D	GCACCAACCTTGATAGGGAA	GTGCCTGATGATTTTACCCG
1178	CFD26	7D	TCAAGATCGTGCCAAATCAA	ACTCCAAGCTGAGCACGTTT
1179	CFD66	7D	AGGTCTTGGTGGTTTTGGTG	TTTTCACATGCCCACAGTTG
1180	WMC629	7D	TTTGTGTGTTGGATGCGTGC	AATAAAACGCGACCTCCCCC
1181	WMC698	7D		
1182	WMC606	7D	CCGATGAACAGACTCGACAAGG	GGCTTCGGCCAGTAGTACAGGA
1183	GWM130	7D	AGCTCTGCTTCACGAGGAAG	CTCCTCTTTATATCGCGTCCC
1184	BARC154	7D	GTAATTCCGGTTCCACTTGACATT	GGATGGGCAGCTTCAAGGTATGTT
1185	CFD30	7D	AATCGCACAACAATGGTTCA	GCCTCTCCTCTCTGCTCCTT
1186	WMC827	7D		
1187	BARC87	7D	GCTCACCGGGCATTGGGATCA	GCGATGACGAGATAAAGGTGGAGAAC
1188	BARC5	7D	GCGCCTGGACCGGTTTTCTATTTT	GCGTTGGGAATTCCTGAACATTTT
1189	WMC463	7D	GATTGTATAGTCGGTTACCCCT	ATTAGTGCCCTCCATAATTGTG
1190	WMC405	7D	GTGCGGAAAGAGACGAGGTT	TATGTCCACGTTGGCAGAGG
1191	BARC126	7D	CCATTGAAACCGGATTTGAGTCG	CGTTCCATCCGAAATCAGCAC
1192	GWM295	7D	GTGAAGCAGACCCACAACAC	GACGGCTGCGACGTAGAG
1193	GWM44	7D	GTTGAGCTTTTCAGTTCGGC	ACTGGCATCCACTGAGCTG
1194	CFD21	7D	CCTCCATGTAGGCGGAAATA	TGTGTCCCATTCACTAACCG
1195	WMC702	7D	GAATCACATCGAATGGATCTCA	GAGGCCTTTTTCGATATTCTGC
1196	WMC438	7D	GACCGTTGGGCTGTATAGCATT	CTCTGACAGTGGTGGAGCTTGA
1197	CFD46	7D	TGGTGGTATAGTCGTTGGAGC	CCACACACACACACCATCAA
1198	WMC121	7D	GGCTGTGGTCTCCCGATCATTC	ACTGGACTTGAGGAGGCTGGCA
1199	WMC42	7D	GCCCTTGGTCCTGGGGTGAGCC	GCCTCATCCAGAGAGCCTGCGG
1200	GWM111	7D	TCTGTAGGCTCTCTCCGACTG	ACCTGCTCAGATCCCACTCG
1201	BARC128	7D	GCGGGTAGCATTTATGTTGA	CAAACCAGGCAAGAGTCTGA
1202	GWM473	7D	TCATACGGGTATGGTTGGAC	CACCCCCTTGTTGGTCAC
1203	WMC653	7D		

1204	WMC182	7D	GTATCTCACGAGCATAACACAA	GAAAGTGTATGGATCATTAGGC
1205	CFD2.1	7D	GGTTGCAGTTTCCACCTTGT	CATCTATTGCCAAAATCGCA
1206	WMC489	7D	CGAAGGATTTGTGATGTGAGTA	GGACAACATCATAGAGAAGGAA
1207	GWM437	7D	GATCAAGACTTTTGTATCTCTC	GATGTCCAACAGTTAGCTTA
1208	WMC630	7D	ATAATGCACGGTAGGACTGAGG	CATACTGAGACAATTTGGGGGT
1209	WMC221	7D	ACGATAATGCAGCGGGGAAT	GCTGGGATCAAGGGATCAAT
1210	CFD14	7D	CCACCGGCCAGAGTAGTATT	TCCTGGTCTAACAACGAGAAGA
1211	WMC473	7D	TCTGTTGCGCGAAACAGAATAG	CCCATTGGACAACACTTTCACC
1212	CFD193	7D	GCTGCCGCTACTGTCTGTC	GGCACACTCACACACCACAC
1213	WMC488	7D	AAAGCACAACCAGTTATGCCAC	GAACCATAGTCACATATCACGAGG
1214	BARC172	7D	GCGAAATGTGATGGGGTTTATCTA	GCGATTTGATTTAACTTTAGCAGTGAG
1215	GWM121	7D	TCCTCTACAAACAAACACAC	CTCGCAACTAGAGGTGTATG
1216	WMC94	7D	TTCTAAAATGTTTGAAACGCTC	GCATTTCGATATGTTGAAGTAA
1217	WMC150	7D	CATTGATTGAACAGTTGAAGAA	CTCAAAGCAACAGAAAAGTAAA
1218	BARC121	7D	ACTGATCAGCAATGTCAACTGAA	CCGGTGTCTTTCCTAACGCTATG
1219	GDM67	7D	AAGCAAGGCACGTAAAGAGC	CTCGAAGCGAACACAAAACA
1220	WMC797	7D		
1221	CFD25	7D	CATCGCTCATGCTAAGGTCA	CGTGTCTGTTAGCTGGGTGG
1222	WMC671	7D	GTACGTCAAAGAAAGAGAATTACCTC	CTCAGAGATATATCTTCGTTGTCAGT
1223	BARC111	7D	GCGGTCACCAGTAGTTCAACA	GCGTATCCCATTGCTCTTCTTCACTAAC
1224	WMC824	7D		
1225	BARC53	7D	GCGTCGTTCCTTTGCTTGTACCAGTA	GCGCGTCCTTCCAATGCAGAGTAGA
1226	GWM428	7D	CGAGGCAGCGAGGATTT	TTCTCCACTAGCCCCGC
1227	GWM37	7D	ACTTCATTGTTGATCTTGCATG	CGACGAATTCCCAGCTAAAC
1228	WMC273	7D	AGTTATGTATTCTCTCGAGCCTG	GGTAACCACTAGAGTATGTCCTT
1229	WMC634	7D	AGCGAGGAGGATGCATCTTATT	GACATACACATGATGGACACGG
1230	CFA2040	7D	TCAAATGATTTCAGGTAACCACTA	TTCCTGATCCCACCAAACAT
1231	BARC76	7D	ATTCGTTGCTGCCACTTGCTG	GCGCGACACGGAGTAAGGACACC
1232	CFD69	7D	AAATACCTTGAATTGTGAGCTGC	TCTGTTCATCCCCAAAGTCC
1233	WMC166	7D	ATAAAGCTGTCTCTTTAGTTCG	GTTTTAACACATATGCATACCT
1234	WMC14	7D	ACCCGTCACCGGTTTATGGATG	TCCACTTCAAGATGGAGGGCAG

1235	CFD175	7D	TGTCGGGGACACTCTCTCTT	ACCAATGGGATGCTTCTTTG

VITA

Name: Hsiao-Yi Hung

Address: Department of Soil and Crop Sciences
2474 TAMU
College Station, TX 77843-2474

Education: B.S., Agronomy, National Taiwan University, 2004

M.S., Plant Breeding, Texas A&M University, 2007

Publications: Hung, H.Y., C. Emani, A. Fritz, M. Menz. 2006. Characterization of a gene from *Triticum monococcum* conferring resistance to leaf rust (*Puccinia triticina*) in wheat. *In* 2006 Agronomy Abstracts. ASA, Madison, WI.

Hung, H.Y., C. Emani, A. Fritz, M. Menz. 2006. Detection and characterization of a leaf rust (*Puccinia Triticina*) resistant gene from *Triticum monococcum* in wheat using a PCR based marker. *In* Plant & Animal Genomes Abstracts. PAG, San Diego, CA.