Genomics: Ushering in a Cattle Breeding Revolution

Given their commonplace use today, it is hard to believe that dairy cattle genomic evaluations were off the radar just two decades ago. The notion of using DNA to breed cows was something one might see on the Jetsons, but not on a dairy farm.

The journey to genomic evaluations began in December 2003 with the Bovine Genome Sequencing Project. The first draft of the bovine genome was accomplished for a Hereford cow in October 2004. The bovine "HapMap" project was then launched to study genomic breed diversity. Among the contributors was the American Jersey Cattle Association (AJCA) through a $20,000 grant from the AJCC Research Foundation. The project paved the way for development of SNP chips and a genomics revolution of livestock.

Genome-enhanced sire data for Jerseys was released in October 2008, followed by the first official genomic evaluations in January 2009.

The integration of DNA marker technology and genomics into the dairy cattle evaluation system has doubled the rate of genetic progress for some traits, including Lifetime Net Merit (NM$), which rose in the Jersey breed from a rate of $29 per year in 2005 to $74 per year in 2020.

This genetic progress comes from four different paths—sires of bulls (SB), sires of cows (SC), dams of bulls (DB) and dams of cows (DC)—with different selection dynamics. Much of the change in the rate of genetic gain is attributed to a dramatic decrease in generation intervals for SB and DB. In the Jersey breed, the combined generation intervals for all paths of selection dropped from 22.4 years in 2005 to just 13.1 years in 2020, as shown in the graph below.

GENERATION INTERVAL
Parents of Progeny Born 1990-2020
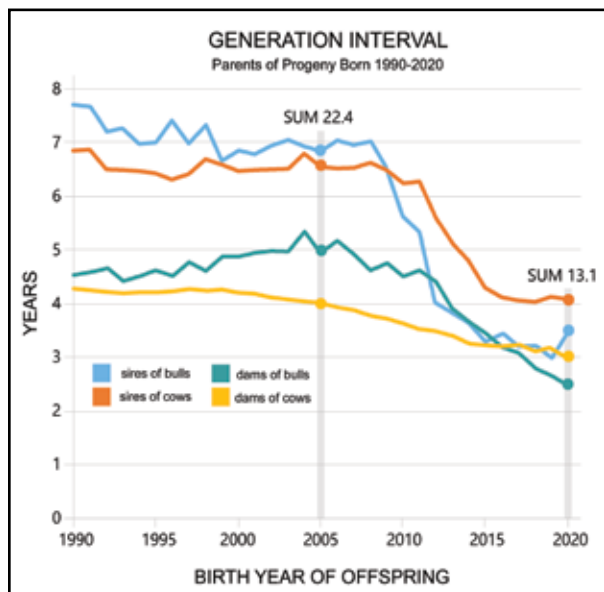
The generation interval has been cut nearly in half since the adoption of genomic evaluations in 2009. The chart above shows the 20-year trend in years for parents (sires of bulls, sires of cows, dams of bulls and dams of cows) of progeny born from 1990 to 2020. In 2005, the sum of the groups was 22.4 years. This fell to 13.1 years in 2020.

An unanticipated benefit of genomics has been the identification of undesirable traits.

The national cooperator database managed by the Council on Dairy Cattle Breeding (CDCB) now includes more than five million genotypes. Though early efforts focused on bulls, most of the genotypes today—90%—are female. Jerseys account for about 12% of the genotypes.

The genomic evaluation process involves four entities: the dairy producer, a genomic nominator, a genotyping laboratory, and the CDCB. A genomic nominator is the link among the others. Genomic nominators are generally breed associations, like the AJCA, A.I. companies or genotyping labs themselves. The Dairy Herd Information and Dairy Records Processing Centers are important data providers as well.

To start the process, a dairy producer orders genotyping from a genomic nominator. The genomic nominator sends pedigree and identification information for the animal to the CDCB. The dairy producer collects a biological sample and sends it to the genotyping lab. The lab evaluates the DNA and sends genotypes to the CDCB, which calculates genomic evaluations. The genomic evaluations are sent to the genomic nominator, who, in turn, sends them to the dairy producer.

The CDCB distributes preliminary genomic evaluations for newly genotyped animals each week. Official genomic evaluations are released each month and tri-annually with traditional genetic evaluations.

The DNA test itself is evolving as most new innovations do, offering more bang for the buck as the technology advances. The first genotyping test was the high-density Illumina Bovine SNP 50 (50K) chip, available in 2008 for about $200. The first low density chip was the Illumina Golden Gate 3K chip, released in 2010. It was quickly replaced by the Bovine LD (9K)

GENOMIC DATA FLOW
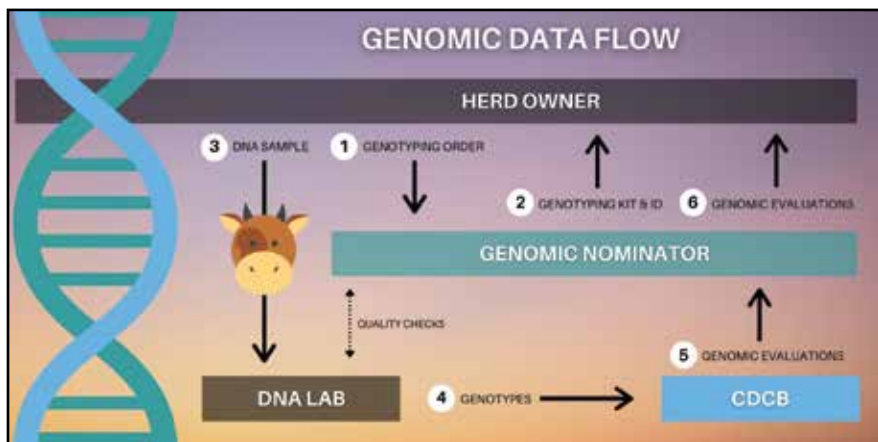
chip, marketed in 2011 for about $50.

Today herd owners have four options for genotyping their animals through the AJCA (nominator) and GeneSeek (genotyping lab): ultra-high density, high density (99K), low density (94K) and ultra-low density (9K). Prices range from $28-175 per animal for REAP herd owners. Dairy producers can also genotype for specific traits as stand-alone tests or add-ons for the traits BVD-PI; beta casein A1/A2, beta casein A/B, beta lactoglobulin and kappa casein; and horned/polled.

Genomics has also enabled the dairy industry to adopt new traits at a faster pace. Evaluations for cow and heifer conception rates became available in 2009. This was followed by mobility in 2012 and cow livability in 2017. Genetic evaluations for the health traits, milk fever, displaced abomasum, ketosis, mastitis and retained placenta were adopted in 2018. Evaluation of crossbreds was accomplished in 2019. Most recently, genomics enabled the Jersey breed to quickly identify and adopt management tools for the undesirable genetic factor, Jersey Neuropathy with Splayed Forelimbs (JNS).

So where are we headed with genotyping?

An apropos quote in February 2008 from Dr. Curtis P. Van Tassell, who received the 2012 AJCA-NAJ Award for Meritorious Service largely for his work with developing genomics while with the USDA Agricultural Research Service, still applies today. "The genetic improvement of the dairy industry is going to change radically with the availability of large-scale genetic data. It will probably change in ways we cannot even imagine."

No truer words have been spoken. And

if past performance is a predicter of future performance, the sky is the limit.

To learn how Jersey breeders are using genotyping for herd management and marketing today, the *Jersey Journal* visited with several breeders across the country. Responses are summarized below.

Jer-Z-Boyz Ranch
Pixley, Calif.

5,100 Registered Jersey cows
Genotyping Protocol: 10% of heifer calves and all embryo transfer calves shortly after birth using services from Neogen or TSUs and the ULD chip from the AJCA.

Jer-Z-Boyz Ranch was an early adopter of genotyping. Initially, males and females were genotyped to fill A.I. contracts for young bulls. Today, the dairy genotypes to identify elite and outlying genetics, improve the reliability of genetic evaluations, and validate parentage. Genotyping also helps to identify animals that will be used as recipients for dairy and beef embryos.

The dairy will consider genotyping heifers that are P-level 7 or higher and those with unique marketing opportunities, like homozygous polled or beta-casein A2/A2 genetics. It also genotypes all ET calves as protocol since the AJCA requires genotyping of every 10th embryo transfer animal registered by a herd and randomly tests all ET animals as well.

An interest in the homozygous polled gene led to the discovery of the breed's current #2 homozygous polled female, JX Jer-Z-Boyz Listowel Mint 59010 {6}-PP. She is sired by Hillview Listowel-P, GJPI +154, and out of an ungenotyped, polled daughter of JX Buttercrest Goldstar {4}-P, GJPI +16. "Mint 59010 {6}" was geno-

typed with the 9K chip and has a GJPI of +160 and a BBR 100. She has two polled daughters by natural birth and a polled embryo transfer daughter born in late May 2021 with a Parent Average JPI of +144.

Jer-Z-Boyz Ranch is also home to the current #1 polled female, Jer-Z-Boyz Gislev 75764-P-ET (GJPI +173). The third generation to be genotyped, her dam, Jer-Z-Boyz Listowel 59749-P, ranks #19 on the polled list with a GJPI of +156.

Genotyping also improves reliability of genomic evaluations as additional cow family members are tested and validates parentage. Though errors are infrequent, they do happen. Most often, manual entry of sire codes and other information into DairyComp is the culprit. As well, samples will identify calves that were switched at birth.

Jer-Z-Boyz markets about 10% of the herd each year through consignment sales like the All American Jersey Sale and the National Heifer Sale. The dairy also markets cattle privately as pot loads of fresh cows or bred heifers.

Jer-Z-Boyz Ranch is owned by Gary and Donna de Graaf and their sons, Dustin and Daniel, and their families. The herd has been enrolled on REAP since 2017 and has a 2020 lactation average of 20,948 lbs. milk, 1,026 lbs. fat and 797 lbs. protein, with a herd average JPI of +30.

Legacy Ranch
Tipton, Calif.

3,000 Jersey and 1,350 Holstein cows
Genotyping Protocol: All heifer calves shortly after birth using services from Neogen.

Legacy Ranch is owned and operated by brothers Jared, Josh, and Frank Fernandes. The family has been milking Holsteins in the San Joaquin Valley for three generations and began adding Jerseys to the milking string in 2013. They soon discovered that Jerseys have no problems reproducing themselves. The addition of the brown cows and use of sexed semen meant for an overabundance of heifers and baby bull calves with little value.

Josh uses genotyping to manage the inventory of replacement heifers and increase the salvage value of bull calves. Genomic evaluations are used to determine whether a heifer will be bred to produce a heifer calf and become a member

of the milking herd or bred to produce a beef calf and then be sold as a fresh young cow.

About 300 of the higher-genomic heifers are registered with the AJCA each year. The most elite enter the farm's in-vitro fertilization program (IVF) to grow the cow family line. The size of the herd allows Josh to use fresh rather than frozen embryos, resulting in high conception rates.

Legacy Ranch also appraises the herd and uses production testing services from AgriTech Analytics. On an energy corrected basis, the Jersey herd has a 2020 average of 23,497 lbs. milk, 920 lbs. fat and 700 lbs. protein. The appraisal average is 81.9% on 758 cows, with 20 Excellents and 550 Very Goods.

Cattle are housed in free stalls on two facilities and bedded with recycled sand or separated manure solids. Each facility has a methane digester and solar panels and is adopting regenerative agriculture practices. Wheat, corn, alfalfa, oats, and pistachios are grown on 1,800 acres.

Misty Meadow Dairy
Tillamook, Ore.

3,000 Registered Jersey cows
Genotyping Protocol: All heifers shortly after birth using services from Zoetis.

Misty Meadow Dairy genotypes all animals for three primary reasons: to identify elite females for the IVF program; identify animals to be retained for the milking herd; identify animals to be sold as dairy replacements; and to ensure identification and parentage is correct.

A heifer's GPTA for CM$ is the primary driver in determining if she will be bred to sexed Jersey semen and retained in the milking herd or bred to sexed Jersey semen or a beef bull and sold as a springer or fresh cow after calving. The make-or-break threshold for CM$ currently hovers around +300CM$. JUI and other factors are considered for borderline heifers.

Misty Meadow Dairy also uses the new Dairy Wellness Profit Index (DWP$) from Zoetis to evaluate overall health and choose healthy females as recipients. The index includes CDCB evaluations for production, fertility, and type and wellness traits like mastitis, displaced abomasum, ketosis, and polled status.

When they are about five months old, heifers are grouped with their peers as heifers to be bred to sexed Jersey bulls and retained at Misty Meadow; heifers to be bred to sexed Jersey bulls and sold as dairy replacements; and heifers to be bred to beef bulls and sold as dairy replacements.

Misty Meadow Dairy is owned by David and Rita Hogan and their family. The dairy is enrolled on REAP. The main dairy has a 2020 lactation average of 23,482 lbs. milk, 1,140 lbs. fat and 903 lbs. protein, measures that rank first in the nation for protein and third for milk and fat among herds with 750 or more cows. Nearly half of the heifers are P-level 7 or higher.

Pine Tree Dairy
Marshallville, Ohio

Genotypes about 380 Jerseys annually
Genotyping Protocol: All heifer calves shortly after birth using hair samples and the ULD chip from the AJCA.

Pine Tree Dairy is owned and operated by Matthew Steiner and his family. The Steiners began adding elite-pedigreed Jerseys to their Holstein herd about eight years ago to pursue marketing opportunities. They also appreciate their value in the milk market. They have sold Registered Jersey genetics privately and through self-hosted sales and consignment sales, including the National Heifer Sale. A pair of bulls, Pine-Tree Altafullbld-ET, GJPI +86, and Pine-Tree Pharo 1st Dynasty-ET, GJPI +82, rank on the current Active A.I. list. More than two dozen other young bulls are on the list of G-code bulls.

Genotyping is used to determine whether a heifer will be a donor dam at Pine Tree Dairy or a recipient. Heifers are sorted primarily on genomic evaluations for JPI and CM$. The Steiners also consider GPTAs for component tests and somatic cell count. Conventional semen is the norm, though sexed semen is occasionally used.

The herd is enrolled on REAP and uses JerseyTags for permanent identification. The Steiners also rely on infoJersey.com to register animals and pull progeny performance reports. They use HerdView to manage cows and heifers and BullsEye and the online Green Book to choose service sires. They use genotyping services from the AJCA because staff are proactive in helping to resolve conflicts. The Genomic Conflicts feature of infoJersey has also been useful for resolving issues.

Rials Dairy
Kokomo, Miss.

500 Registered Jersey cows
Genotyping Protocol: All heifer calves shortly after birth using TSUs and the ULD chip from the AJCA.

Rials Dairy is owned and operated by Roman Rials and his father, Neville. Initially, females that were Generation Count 4 or higher were genotyped. For the past seven years, all heifers have been genotyped. If both parents are polled, a heifer will be genotyped for polled status as well.

Roman made the decision to genotype all heifers as he believes this provides the best early prediction of performance, a prediction that comes years before an animal can prove her worth through her own performance. Genotyping enables him to make individual mating decisions that will more quickly improve the genetic merit of the herd. As a cattle breeder, he also enjoys studying genomic evaluations and the chance to find genomic outliers and unique genetics.

In the mating program, he evaluates JPI and JUI along with reproductive traits and the type traits stature, strength, and foot angle.

The herd is enrolled on REAP. Roman uses JerseyTags for permanent identification and JerseyMate to assist with herd matings. The herd ranks among the top 25% in the nation for JPI with a herd average JPI of +27. A young bull, JX Rials Westport Mike {4}-ET, GJPI +113, is on the current list of G-code bulls and available from ABS Global Inc.

The Registered Jersey herd is part of a diversified business that also includes a herd of Angus cows. The family has extended genotyping to this herd and plans to grow the beef operation to capitalize on marketing opportunities. The family also raises meat hens in a dozen chicken houses as a supplier for Sanderson Farms.

Steve Rowley
Foxworth, Miss.

500 Registered Jersey cows
Genotyping Protocol: All heifers shortly after birth using services from Zoetis.

About 10 years ago, Steve Rowley began transitioning his Holstein herd to Jerseys because they are better able to adapt to the hot, humid summers of the South. He bred his females to Jersey bulls generation-after-generation and purchased production-bred genetics from Jersey breeders like Gaby Jersey Farm of Greeneville, Tenn., and Heartland Jersey Farm of Seneca, Kan. Today the herd is fully Jersey and fully genotyped.

He initially genotyped a handful of cherry-picked females from the top cow families. When the "better ones" accounted for a larger share of the herd than not, Rowley opted to genotype the entire herd in the fall of 2019. In the long term, the protocol is more efficient and cost effective because he does not have to go back through the herd and collect and submit samples if issues arise.

Genotyping accomplishes two goals.

First, it validates identification. A good portion of the herd is seasonally calved between late August and December, resulting in multiple births each day. Genotyping ensures parentage is accurate. Second, genomic evaluations help to determine breeding status of virgin heifers. Females fall into one of four groups: bull mothers to be bred to fulfill A.I. contracts; maternal lines to be continued and bred to sexed Jersey semen; recipient dams for Jersey embryos; and maternal lines to be bred to beef bulls.

Rowley also uses a pair of wellness indexes from Zoetis to make breeding decisions. Calf Wellness Index (CW$) is evaluated primarily because of its attention to calf scours. The Wellness Trait Index (WT$) is used because it evaluates mastitis resistance. He sees these two issues, calf scours and mastitis resistance, as Jersey breed concerns and want to improve to improve them within his herd and others.

Rowley views genotyping as additional data for improving the herd, particularly the best of the best. The bull Rowleys 11 Visionary Chili-ET, GJPI +72, initially put the farm on the map. He ranked as the 13th most heavily used sire of sons in 2015. Today, Rowleys 1996 Daniel Tucker {6}-ET, named after Rowley's grandson, ranks #3 for GJPI (+153) and CM$ (+616) among G-code bulls.

He attributes a lot of his success to great cow families, but also thanks his genetic teammates, Brad and Iris Barham of Redland Ag LLC. The couple helps with registration and parentage conflicts and collaborates with Rowley on bull selections and matings.

Rowley Jersey Farm is enrolled on REAP and ranks among the top 40 herds in the nation for genetic merit with a herd average JPI of +35.

The Dairy Inc.
Lemoore, Calif.

2,000 Registered Jersey cows.
Genotyping Protocol: All heifer calves shortly after birth using Tissue Sampling Units (TSUs) and Ultra-low Density (ULD) chip from the AJCA and submitted to GeneSeek.

Ryan Mattingly and Bill Vander Poel began working together when Mattingly was hired to manage operations of Tule River Cattle Company Inc. (TRCC), a calf ranch owned by Vander Poel in Tulare County. The two became partners in The Dairy Inc. (TDI), a milking cow herd, in 2016. They established the herd with the purchase of Jersey cows and heifers, most with unknown sires and dams.

To determine ancestry and build pedi-

grees, Mattingly began genotyping newborn calves and the dams of the highest genomic heifers in early 2018. The practice was especially useful for identifying maternal grandsires so sounder mating choices could be made. It also enabled the dairy to bring unregistered cattle to Herd Register status more quickly because parentage could be verified.

Today, TDI is a fully registered herd and Mattingly uses genotyping primarily as a tool to manage heifer inventory. Each month, he predicts how many replacements will be needed in the milking string nine months out. To meet this need, an appropriate number of cows and heifers are bred to sexed Jersey bulls. The rest of the herd is bred to beef bulls. After calving, these cows are sold as dairy replacements and their calves for beef.

Mattingly uses Genomic Predicting Transmitting Abilities (GPTAs) to determine whether a dairy or beef service sire will be used. He analyzes Cheese Merit Dollars (CM$) primarily, but also yields for milk, fat and protein and tests for components. TDI is enrolled on REAP. The dairy has a 2020 herd average of 16,662 lbs. milk, 794 lbs. fat, 612 lbs. protein and 2,076 lbs. cheese yield, with herd average PTAs of +73 CM$ and +22 JPI. Nearly 40% of the heifers are P-level 7 or higher. Cows are milked in a double-20 parallel parlor and raised in open lots. Calves are raised at TRCC in Five Points, Calif.

Larry Martin
Tylertown, Miss.

100 Registered Jersey cows.
Genotyping Protocol: All heifer calves shortly after birth using TSUs and the ULD chip from the AJCA.

Sixteen years ago, Larry Martin began the journey to transition his Holstein herd to Jersey by breeding all females to Jersey bulls. He accomplished that goal about four years ago and today has his sights on a naturally polled herd that produces A2A2 milk.

To accomplish this and improve the genetic merit of the herd, particularly for Daughter Pregnancy Rate and Jersey Udder Index (JUI), he uses JerseyMate and genomic testing with the polled and beta casein add-ons. Martin has also bred the herd to polled bulls for many years and now uses homebred JX Martin-MS Valergo Victor 576 {5}-PP, GJPI +42, as a clean-up bull to grow the polled presence in the herd.

The practice has enabled Martin to break into a new cattle market for genetics. He recently consigned two heifers to the Southern Selection Sale hosted by Tay-

lor Jersey Farm in Booneville, Miss. One of them is an early daughter of JX CDF JLS Pilgrim Thrasher {6}-ET, GJPI +126, from the "Maid" cow family that tested A2A2 and has a GJPI of +105. Martin also sells about 12-15 head through private treaty sales each year and has a strong market for local project calves.

The herd is enrolled on REAP. Cows are intensively grazed and milked in a double-six herringbone parlor.

Piedmont Jerseys
Lincolnton, N.C.

220 Registered Jersey cows.
Genotyping Protocol: About 25% of heifers shortly after birth using TSUs and the ULD chip from the AJCA and based on A2/A2 status.

Piedmont Jerseys is using genotyping a little differently than most dairy farms. Rather than genotyping for the full panel of traits, the dairy tests for beta casein A2 alone. Their long-term goal is to build a fully A2/A2 herd for cattle marketing and milk marketing purposes.

The Lutz family is in the final stages of building an on-farm creamery that will process fluid milk products and make ice cream from the Piedmont Jerseys herd. The Lutzes plan to bottle skim, 2%, whole and chocolate milk, buttermilk, heavy cream, half-and-half and eggnog and offer 24 varieties of ice cream—all made from A2/A2 milk.

Piemont Jerseys has been testing for the A2 beta casein gene for about 10 years and breeding to A2/A2 Jersey sires to transition to a fully A2/A2 herd. Animals that are known to be A2/A2 (A2/A2 dam and A2/A2 sire) are not tested. Animals with mixed parents are tested since matings of A1/A2 cows to A2/A2 bulls result in half A1/A2 progeny and half A2/A2 progeny. The Lutzes use PCDart to track whether a test is required or not.

Today, all but 10 older cows are A2/A2. These maternal lines will be phased out as the matriarchs leave the herd in the next year. In the meantime, milk from the A1/A2 cows is stored in a different bulk tank on the farm and sold to the milk cooperative.

Piedmont Jerseys is owned and operated by Corey and Bridgette Lutz and their children, James, Mandy and Olivia. Cows are housed in an open six-row freestall barn, milked in a double-eight herringbone parlor and intensively grazed. Silage, haylage, and baleage are raised on 300 acres.

The herd is enrolled on REAP and has an appraisal average of 83.9%, with 29 Excellent and 136 Very Good cows. Pied-

mont Jerseys ranks eighth in the nation for milk among herds with 150-299 cows with a 2020 lactation average of 21,224 lbs. milk, 965 lbs. fat and 740 lbs. protein.

Twin Star Dairy
Turlock, Calif.

1,000 Registered Jersey cows.
Genotyping Protocol: All heifer calves shortly after birth using TSUs and the ULD chip from the AJCA.

Twin Star Dairy has been genotyping the herd for the past four years. This and other herd management tools have helped herd owner Mike Miranda improve the genetic merit and performance of the herd. Miranda chooses bulls largely based on NM$, DPR, JUI and feet and legs.

Because they are typically more superior from a genetic standpoint, all heifers are bred to sexed Jersey semen. About 60% of the milking cows are bred to sexed Jersey bulls and the balance to beef bulls. Excess dairy replacements are sold primarily as fresh young cows, but as springers too on occasion.

The threshold for dairy versus beef service sires for milking cows is based on performance and an appraisal score of at least Very Good-81%. The appraisal minimum has steadily increased over the years (from Desirable-79% in 2016 to Very Good-81% in 2021) as herd average appraisal has improved along with udders, feet and legs and other functional type traits.

Twin Star Dairy is owned by Mike and his wife, Larine, and their children, Tyler and Brook. The dairy is managed by Joe Silveira.

The herd is enrolled on REAP and has a 2020 lactation average of 20,850 lbs. milk, 1,049 lbs. fat and 773 lbs. protein on 360 cows, marks that rank seventh for milk and fat and eighth for protein nationally in the division for herds with 300-749 records. The milking herd averages +166 for CM$ and +155 for NM$ and ranks #30 in the nation for herd average JPI at +38. The herd includes 22 Excellents and 591 Very Goods.