



Agriculture resource guide

Innovation. Applied.

Thermo Fisher Scientific is committed to providing instruments, reagents, and solutions for plant and animal research applications that will lead the way to remarkable agricultural discoveries—everything from improved crops to livestock that feed more people. We offer simple, scalable, and affordable solutions to help bring the next generation of agricultural products to life.

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Overview of agricultural applications

This application resource guide will help you select our best products for some of the most common agricultural science applications.



Plant and animal *de novo* genome sequencing

Genome sequencing allows researchers to uncover the genetic makeup of plants and animals. Sequencing plant and animal genomes is becoming easier and more cost-effective—this is true even for *de novo* sequencing projects aimed at obtaining the primary genetic sequence of your species of interest. We have an extensive portfolio of sequencing instruments, reagents, and analysis software to help get you there faster and with greater accuracy and reliability.

De novo sequencing solutions

The Ion S5™ and Ion S5™ XL systems provide the simplest DNA-to-data workflow for targeted sequencing with industry-leading speed and affordability. So you can spend less time doing repetitive lab work and more time answering the critical questions in your research. These dramatic improvements in sequencing technology are changing the way agricultural scientists look at genomics and are paving the way for the next wave of remarkable agricultural discoveries.

Genome sequencing for all

Fast and affordable genome, exome, and transcriptome sequencing of plants and animals is accessible with the semiconductor sequencing technology in the Ion S5 systems. It empowers researchers to sequence his or her economically important species, large or small. The system offers:

- Chips with 60–80 million reads—ideal for exomes, transcriptomes, and genotyping by sequencing
- High accuracy
- 2–4 hour sequencing run time
- Single-day sequencing of plant and animal genomes

Find out more at thermofisher.com/ion5

Find out more and download case studies and technical information at thermofisher.com/plantdenovo

Ion S5 System



Ion Chef System



Ion Chef System templating made easy

The Ion Chef™ System makes next-generation sequencing more accessible to agricultural scientists across the globe, offering:

- Automated template preparation and chip loading
- Cartridge-based reagent system
- Sample- and reagent-tracking capability
- Intuitive user interface
- Application flexibility with 35–400 bp sequencing
- Onboard diagnostics

Find out more at thermofisher.com/ionchef



Plant and animal genotyping

The discovery of novel single-nucleotide polymorphisms (SNPs) is critical for plant and animal genotyping, as they serve as candidate markers for marker-assisted selection programs. Recent improvements in real-time PCR and next-generation sequencing have simplified SNP discovery and made it much more cost-effective. We offer a range of solutions to streamline all of your resequencing investigations and empower you to achieve your experimental and production goals.

Why are SNPs important?

SNPs are small variations in the DNA sequences that are associated with desired traits. They are used in conjunction with quantitative trait locus (QTL) mapping to develop assays for marker-assisted selection programs aimed at improving or enhancing certain characteristics such as higher yield, better stress tolerance, or enhanced pest resistance.

Targeted resequencing and SNP analysis solutions

Ion Torrent™ sequencers for targeted resequencing enable you to discover new SNPs in important crop genomes. Confirm your discoveries either with Applied Biosystems™ TaqMan™ Assays or by Sanger sequencing on one of the Applied Biosystems™ genetic analyzers.

The table below compares the best genotyping solutions across our portfolio.

Research need	Best experimental approach	Our platforms	Why
Compare sequences of several crop variants to discover functional SNPs	Genotyping by sequencing (GBS)	Ion S5 and Ion Proton™ systems	Speed, cost, scalability, simplicity Ion Torrent™ systems enable fast and affordable GBS applications
Map up to 10 SNPs in different regions of the genome	Fragment analysis	SNP genotyping using capillary electrophoresis (CE) genetic analyzers	Multiplexing capability: up to 10 SNPs per reaction
Map SNPs in a small region of the genome	Sanger sequencing	Sanger sequencing using CE genetic analyzers	Gold-standard technology for sequencing Accuracy, low cost Simple workflow
Confirm putative SNPs and develop SNP assays for downstream work	Genotyping by real-time PCR or Ion AmpliSeq™ technology	Applied Biosystems™ TaqMan™ Sample-to-SNP™ Kit Custom Applied Biosystems™ TaqMan™ SNP Genotyping Assays and master mixes Real-time PCR instruments Ion Torrent™ sequencers Ion AmpliSeq™ consumables	Easy and fast workflow High call rate and accuracy Different formats for different project sizes (number of SNPs combined with number of samples)

Find out more at thermofisher.com/gbs

Plant and animal genotyping by sequencing

Scalability, simplicity, and speed

Genotyping by sequencing

Whether it's used for the discovery and identification of SNPs or as a screen for panels of thousands of known markers, GBS using NGS technologies is a cost-effective and unique tool for association studies and genomics-assisted breeding in a range of plant and animal species—including those with complex genomes that lack a reference sequence. Ion Torrent sequencers are useful tools for GBS due to their scalability, simplicity, and speed.

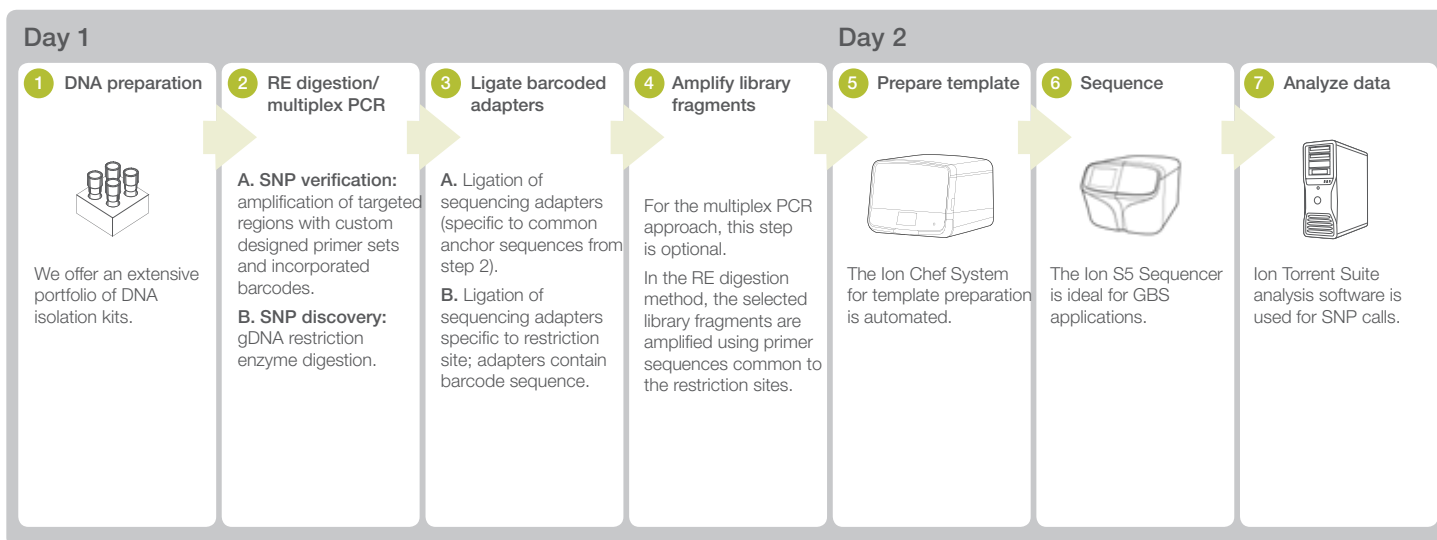
Advantages of genotyping by sequencing with Ion S5 and Ion S5 XL next-generation sequencing systems:

- Allow both SNP marker confirmation and *de novo* SNP marker discovery, even in cases where there is no reference genome
- Provide attractive, low-cost options for large numbers of samples and data points
- Utilize highly multiplexed sequencing to scale from thousands to millions of data points per day
- Enable 2–4 hour sequencing run times to facilitate efficient planning for the next reproduction cycle
- Offer a high degree of accuracy of SNP calling
- Offer versatility for many applications, including *de novo* sequencing, targeted resequencing, and transcriptome sequencing

Two strategies for genotyping by sequencing

The Ion S5 and Ion S5 XL next-generation sequencing systems support two different GBS strategies:

- **Ion AmpliSeq™ products for GBS:** In cases where a set of SNPs has been defined for a section of the genome, this approach uses PCR primers designed to amplify the targets of interest. View our complete solution for multiplex PCR below. Creating and ordering custom panels is easy with the Ion AmpliSeq™ Designer—a free, online assay design tool that enables custom design for any genome. Use the preloaded bovine, chicken, pig, sheep, maize, tomato, soybean, and rice genomes to design your custom panel, or easily upload a FASTA file with your desired reference sequences for your genome of interest.
- **Restriction enzyme (RE) digestion:** The complexity of the genome is reduced by digesting the DNA with one or two selected restriction enzymes prior to the ligation of sequencing adapters. Compared to the multiplex PCR approach, which is used for targeting known variants, this method is better suited for situations where little genome sequence is available or no prior SNP variants have been identified, for discovering new markers for marker-assisted selection programs.



Plant and animal genotyping by sequencing with Ion AmpliSeq technology

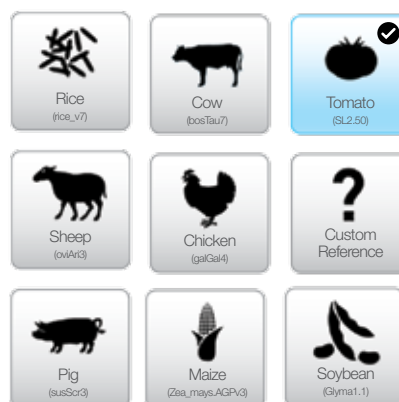
Ion AmpliSeq technology uses ultrahigh-multiplex PCR to offer simple and fast library construction for targeted sequencing of specific genes or genomic regions. Custom primers are generated with high specificity using proprietary software to target just your sequences of interest—up 5,000 amplicons in one reaction.

Access our Ion AmpliSeq™ webinar on a tomato targeted resequencing and SNP analysis study at thermofisher.com/plantwebinars

Design for any genome

Design and order custom panels with the Ion AmpliSeq Designer—a powerful but simple and easy-to-use web-based tool. This free assay design portal connects you directly to our assay design pipeline. Select your targets of interest or enter your specific genomic content online, and we will design and create a customized Ion AmpliSeq™ panel just for you. Panels can be designed against a number of preloaded genomes (see below), or for any other organism by uploading your own private reference sequence. Private references are stored securely using 128-bit SSL encryption.

Simple, secure, and powerful—you will be able to design for any custom reference genome. Visit ampliseq.com and start creating your designs today.



Several preloaded genomes are available, or use the option to upload a custom reference sequence through the Ion AmpliSeq Designer.

Plant and animal genotyping by qPCR

Genotyping by qPCR

Genotyping by real-time PCR—whether for the confirmation of SNPs or as a screen for panels of markers in hundreds or even millions of samples—is a well-known and demonstrated approach used widely in both research and industrial settings. We are a leader in providing real-time PCR instruments, TaqMan Assays, and reagents that are designed to generate reliable results for validation and screening.



Applied Biosystems TaqMan Sample-to-SNP Kit

This kit contains DNA Extract All Lysis Reagents that provide PCR-ready DNA from a wide variety of plant tissues, typically in 5 minutes. The kit also contains the Applied Biosystems™ TaqMan™ GTXpress™ Master Mix for robust PCR amplification of extracted DNA typically in less than 50 minutes.

Custom TaqMan SNP Genotyping Assays

These assays provide a highly flexible technology for detection of polymorphisms within any genome. Create your own assays by submitting target sequences to our secure assay design pipeline using the Applied Biosystems™ Custom TaqMan™ Assay Design Tool. This pipeline has successfully generated millions of assay designs by utilizing heuristic rules deduced from both manufacturing and assay performance data.

Custom Applied Biosystems TaqMan Assay manufacturing and plating service




Whether it's zygosity analysis or special manufacturing modifications such as a specific dye, assay volume or concentration, or plating format, we can tailor a service to meet your needs.



Applied Biosystems QuantStudio 12K Flex Real-Time PCR System

- Flexibility—five interchangeable blocks to fit your needs
- 110,000 genotypes per workday without robotics; other instruments are available to meet your throughput needs and budgets

Overview of workflow for genotyping by real-time PCR

DNA isolation TaqMan Sample-to-SNP Kit provides PCR-ready DNA from a wide variety of sample types of plant and animal tissues, typically in 5 minutes	Reaction preparation Assays are available in different formats: single tube, 96- and 384-well plates, TaqMan™ Low Density Array, or OpenArray™ plate Mix your DNA sample with the Custom TaqMan GTXpress Master Mix and the TaqMan SNP Genotyping Assay	Amplification Perform PCR using the QuantStudio systems or Applied Biosystems™ Veriti™ Thermal Cycler 	Endpoint reading Read amplification with the Applied Biosystems™ QuantStudio™ 12K Flex Real-Time PCR System 	Analysis Applied Biosystems™ TaqMan™ Genotyper Software is a great resource for fast and accurate genotype calling; TaqMan Genotyper Software can be downloaded at thermofisher.com/taqmangenotyper
		Amplification and endpoint reading Can be performed with the QuantStudio 12K Flex system 		

Together, the Custom TaqMan SNP Genotyping Assays and QuantStudio 12K Flex system provide the flexibility and throughput you need for your project. Contact your sales representative to discuss your needs.

Learn more at thermofisher.com/agbio



Results from the Delta Genomics bovine Ion AmpliSeq panel

Delta Genomics is a national, not-for-profit provider of genomics services including genotyping, sequencing, and biobanking for the livestock industry and research community. The Delta Genomics cattle parentage Ion AmpliSeq panel targets 121 markers across a total of 14,153 bp in a single primer pool. The average call rate was >95% and the average genotype concordance was >98% for 104 positions in a comparison between the Delta Genomics Ion AmpliSeq™ panel and bead-based microarray results for 160 cattle samples.

Results from the International Rice Research Institute (IRRI) rice Ion AmpliSeq panel

IRRI, located in Los Baños, Philippines, aims to reduce poverty and hunger, improve the health of rice farmers and consumers, and ensure environmental sustainability of rice farming. The IRRI Ion AmpliSeq panel targets 500 rice genetic markers across a total of 84,572 bp in a single primer pool. The average call rate observed was >94% for the panel when tested on validation samples. Using 56 samples, the average genotype concordance was >98.9% for 299 positions in common between the IRRI Ion AmpliSeq panel and Illumina™ GoldenGate™ microarray data.

QTL mapping and marker-assisted selection

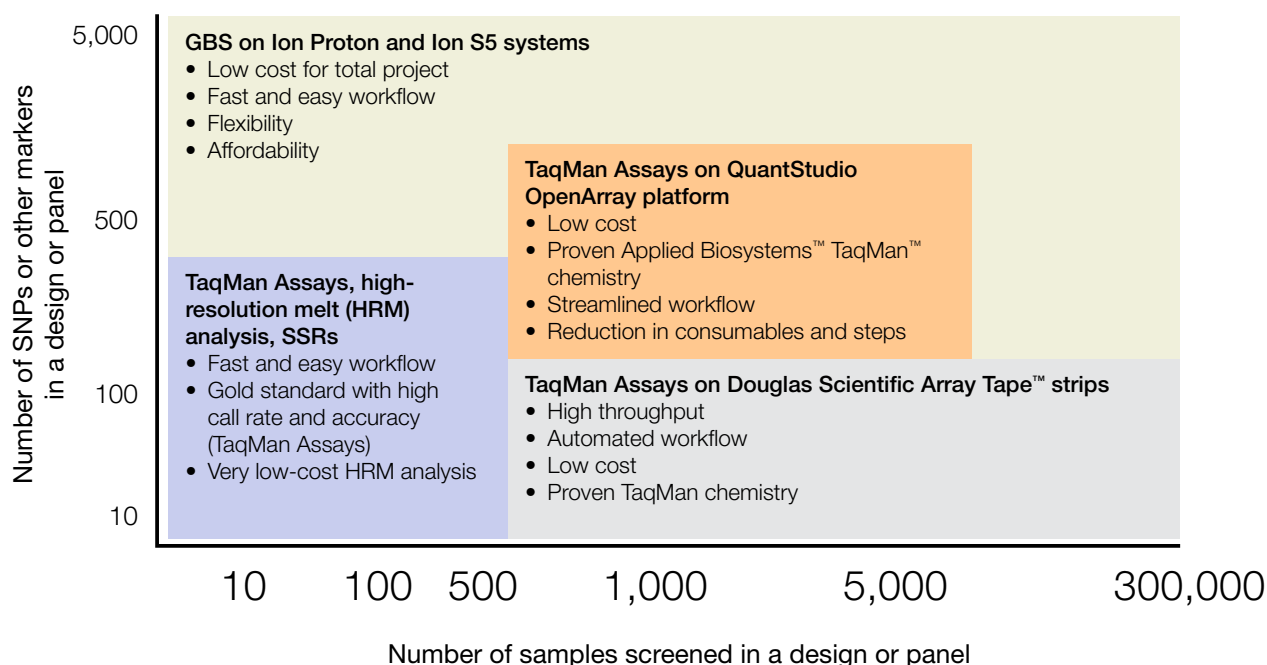
Effective, high-throughput genotyping methods for marker-assisted selection (MAS) are enhancing our understanding of how to breed crops with desired traits such as higher yields or better disease resistance. We offer a wide range of technologies to facilitate your breeding and functional genomic studies, associate important traits with genetic variants (including SNPs and single sequence repeats, or SSRs), construct QTL maps, and identify genetic markers for MAS programs.

What are QTL mapping and marker-assisted selection?

QTL analysis links genetic markers with DNA base variations, such as SNPs and microsatellites or SSRs, to the QTLs of interest for breeding purposes. These are then used in linkage mapping and downstream marker-assisted breeding programs to screen for individual plants that have the trait(s) of interest. Depending on the program, these traits could be increased yield, disease or stress resistance, or enhanced nutritional or oil profiles.

What is the best approach if I am using SNP markers for breeding?

Choosing the best experimental approach and technology platform depends on your specific needs. Two key elements to consider are the number of samples and the number of markers in your project. The chart below gives a high-level representation of the different technologies we offer to assist you in selecting the right plant seed line, moving a transgenic plant to the greenhouse or the field, or collecting critical data for your publication.



	Fragment analysis (SSRs)	Genotyping by sequencing on Ion Torrent sequencers	TaqMan Assays on QuantStudio family of real-time PCR systems	HRM analysis	TaqMan Assays on QuantStudio OpenArray platform	TaqMan Assays on Douglas Scientific Array Tape strips
Sample throughput	1–500	1 to millions	1–500	1–500	500–4,000	500 to millions
Marker throughput	1–100	100–5,000	1–384	1–384	16–512	1–100
Cost per data point	Medium	Low to medium	Medium	Very low	Low	Very low
Formats and flexibility	Multiplex up to 20 markers per sample	Ion AmpliSeq Custom Panels (primer pools) can be used to analyze up to 5,000 amplicons in 384 samples on a single Ion PI™ Chip	Single tube, 48-well, 96-well, 96-well Fast, and 384-well formats	Single tube, 48-well, 96-well, 96-well Fast, and 384-well formats	OpenArray plates plus four additional blocks for different sample or marker throughput	Array Tape strips
DNA-to-answer time	4 hr	1 day	40 min (Fast); 2 hr (standard)	1 hr	4 hr	3 hr to 1 day



Download application notes and scientific articles highlighting these applications and learn more at thermofisher.com/qtl

Plant and animal gene expression analysis

Whole-transcriptome analysis is very important in understanding how altered expression of genetic variants contributes to complex plant and animal phenotypes. We offer an extensive product portfolio for gene expression analysis, from transcriptome sequencing and Applied Biosystems™ TaqMan™ real-time PCR solutions to products for epigenetics research—all aimed at facilitating gene expression analysis in a fast, reliable, and accurate way.

What are the different approaches for gene expression analysis?

Agricultural researchers utilize a variety of approaches to understand gene expression. In some cases, whole-transcriptome profiling is preferred over targeted RNA sequencing, which generally involves panels. In order to study plant and animal functional genomics, researchers also utilize epigenetics tools as well as miRNA, small RNA, and RNAi studies to decipher the root cause behind phenotypes of interest. No matter what your study involves, we have a wide portfolio of instruments, reagents, and solutions for all your gene expression studies.

Transcriptome sequencing

Compared to traditional microarray technology, which can only be used for gene expression profiling in species with known transcriptome sequences, NGS technologies enable agricultural researchers to perform these studies in any species—and to do so with assays that have a higher dynamic range at a lower cost. If your goal is to profile the entire transcriptome or to use RNA sequencing to reduce the complexity of a large polyploid genome, transcriptome sequencing has never been easier than with the Ion S5 or the Ion Proton System.



Ion S5 System



Targeted gene expression analysis

If your experiment is limited to a few genes or certain areas of the transcriptome, real-time PCR assays with Applied Biosystems™ TaqMan™ probes are the best approach for you. With trusted Applied Biosystems™ instruments and software, Applied Biosystems™ TaqMan™ predesigned and custom gene expression assays and master mixes are tailored for success. The predesigned assays for soybean, corn, rice, cattle, and pig allow you to spend your time generating results, not on assay design and optimization. Find out more at thermofisher.com/taqmangex

Epigenetics, miRNA, and noncoding RNA research

Gene regulation in plants and animals occurs via epigenetic changes such as DNA methylation, changes in chromatin structure, and regulation by noncoding RNAs. These processes are part of a complex regulatory circuit that requires robust tools to study. We have developed powerful technologies for epigenetics research that span sample preparation, sequencing, quantitative PCR, functional analysis assays, and bioinformatics tools for analysis. View all our solutions at thermofisher.com/epigenetics

Browse all our solutions for gene expression at thermofisher.com/plantge

Synthetic biology and genetic engineering

Generating transgenic plants is key to introducing new crop traits and carrying out gene studies, both in discovery and applied settings. The development of genetically modified plants often requires a complex design of DNA elements to achieve optimum effects on expression. We offer solutions for genome editing, cloning, DNA assembly, amplification, and analysis, as well as *Agrobacterium tumefaciens* LBA4404 for plant-cell transformation.

Manipulate, synthesize, and clone plant DNA easily

The construction of T-DNA vectors or vectors for particle bombardment or electroporation is often complex—and is a process that we've made easier through the development of innovative DNA cloning and assembly products. We understand the challenges of cloning and have the right products for you. Using our plant molecular biology solutions, you can create multiple vectors to test the effect of regulatory sequences in the target plant, or stack traits on the same expression vector for crop enhancement.



- **Invitrogen™ GeneArt™ Seamless PLUS Cloning and Assembly kits and GeneArt™ Gene Synthesis services:** Our latest technology for simultaneous cloning of complex DNA elements can be combined with GeneArt Gene Synthesis services for the design of synthetic genes with enhanced heterologous gene expression in transgenic plants. Learn more at thermofisher.com/geneart
- **Invitrogen™ Gateway™ cloning:** The expression platform of choice for plant systems, with a wide range of vectors for different plant species and purposes. Invitrogen™ Gateway™ vectors adapted for *Agrobacterium*-mediated transformation, silencing studies, and many other applications have been cited in over 150 peer-reviewed articles. Learn more at thermofisher.com/gateway
- **Basic cloning reagents:** From competent cells to DNA oligos and Invitrogen™ TOPO™ cloning kits, we have everything you need for your everyday cloning needs. Browse our entire offering at thermofisher.com/cloning

Precise, efficient gene sequence targeting and modification technologies

From precision genome editing and gene modification technologies to high-efficiency delivery systems, we have developed a broad range of solutions to help you create the modified genes, expression systems, and stable cell lines you need for your research—from culturing cells to modification, detection, and analysis. Our technologies—including Invitrogen™ GeneArt™ CRISPRs and TALs—enable you to reliably modify genomic sequences and analyze the phenotypic outcomes. In addition, we can deploy a combination of advanced technologies to produce a custom construct or cell line that meets your specifications. Balancing performance and cost, our cell engineering portfolio is built on 20 years of innovation and can grow with your research needs.

GeneArt CRISPRs

Introducing the only complete genome editing solution designed to expedite your research. Our easy-to-use optimized and validated solutions make genome editing accessible to anyone at any level. We are continuing to expand our suite of genome editing products to span the entire cell engineering workflow, from cell culture reagents, delivery reagents, and sample preparation to genome modification, and to detection and analysis of known genetic variants. We offer our state of the art online CRISPR search and design tool along with CRISPR-Cas9 in four formats, an all-in-one expression vector, Cas9 mRNA, Cas9 protein, and CRISPR Libraries services paired with the optimal cell culture reagents, delivery method, and analysis tools based on your application and cell type.

GeneArt Precision TALs

Based on *Xanthomonas* effector proteins, Invitrogen™ GeneArt™ Precision TALs are custom DNA-binding proteins that allow you to accurately target any locus in the genome. TAL technology has been shown to be effective in a broad range of organisms, including plants, algae, and fungi. GeneArt TALs are the first of their kind and are ideal for plant research scientists, offering research-use access with a clear licensing path for commercial use through the Two Blades Foundation (2blades.org). Explore our precision TALs at thermofisher.com/tal

Plant transformation

Agrobacterium-mediated transformation is the easiest, simplest, and most widely used transformation technique in plant biotechnology applications, and we offer *A. tumefaciens* LBA4404 cells and antibiotics to enable your research in this field.

Browse all our products for plant genetic engineering at thermofisher.com/plantengineering



Plant cell and tissue analysis

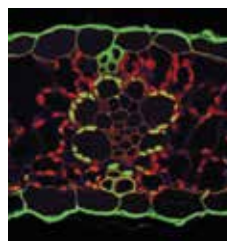
From studying the morphology of plant cells—cell walls, organelles, and other cellular compartments—all the way to complex gene regulation and expression studies, cell tissue analysis techniques and tools are critical not only for basic plant research, but also for crop improvement programs. Key techniques such as immunohistochemistry have been routinely used to label diverse plant tissues and organelles including cell walls, vacuoles, chromatin, nuclei, nuclear membranes, and chloroplasts.

To empower your research in plant cell and tissue analysis, we have a broad portfolio of fluorescent reagents, kits, and instruments specifically designed with your needs in mind.

Invitrogen fluorescent dyes and probes

Invitrogen™ reagents including Invitrogen™ Alexa Fluor™ dyes, Qdot™ nanocrystals, Click-iT™ detection assays, and ProLong™ Gold Antifade Reagents are used in a wide range of plants for a variety of research applications, including:

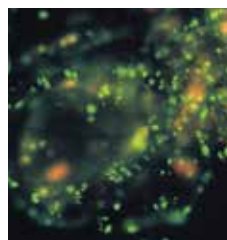
- Antibody labeling
- Immunohistochemistry
- Fluorescence *in situ* hybridization
- Organelle and cytoskeletal stains
- Endocytosis studies
- Transport studies
- Glucose metabolism
- Viability staining
- Glutathione detection
- Calcium and other ion-imaging applications
- Tyramide signal amplification (TSA)



Rubisco localization in maize leaf section.

Rubisco was localized using a rabbit anti-rubisco antibody and visualized using the highly cross-adsorbed Invitrogen™ Alexa Fluor™ 488 goat anti-rabbit IgG antibody (Cat. No. A11034). The 2.0 μm maize

leaf section illustrates the immunolocalization of rubisco in the chloroplasts of the bundle sheath cells surrounding the vascular bundles. The red fluorescence, localized to the mesophyll plastids, is due to background autofluorescence of chlorophyll. Lignin appears dull green and is localized to the xylem of the vascular bundle; cutin appears bright green and is localized to the cuticle outside the epidermis. Image contributed by Todd Jones, DuPont.



Pectin associated with plasmodesmatal pit fields of kiwifruit cells.

Pectin, a component of the cell wall matrix and the main constituent of the middle lamella that forms between daughter cell walls, was tagged with an anti-pectin monoclonal

antibody, JIM 5. The primary antibody was detected and visualized with Invitrogen™ Alexa Fluor™ 488 goat anti-rat IgG (Cat. No. A11006). The primary antibody was a gift from Dr. Paul Knox, University of Leeds, UK. Image contributed by Paul Sutherland, The Horticulture and Food Research Institute of New Zealand, Ltd., Mt. Albert Research Centre.

Flow cytometry

Flow cytometry is an ideal means for the analysis of cells and subcellular particles, with a potentially large number of parameters analyzed rapidly, simultaneously, and quantitatively, thereby furnishing statistically exploitable data and facilitating accurate detection of subpopulations. Since the first report of its use with plants 40 years ago, flow cytometry has become an essential tool for the understanding of fundamental mechanisms and processes underlying plant growth, development, and function. Key applications include the study of ploidy levels, genome mapping, localization of sex-specific chromosomes, and plant cell and algal studies.

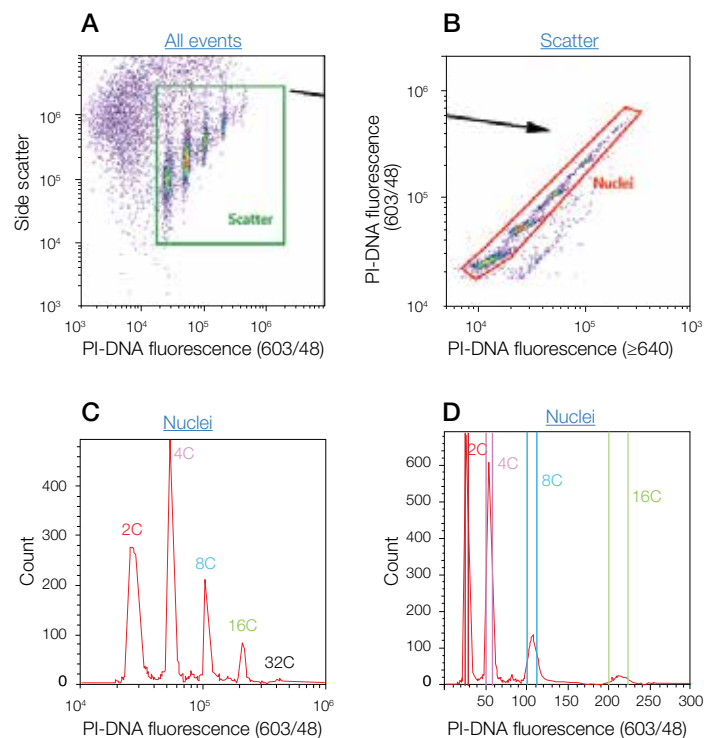
Find out more and see all of our products at
thermofisher.com/plantimaging

Cell Imaging

Designed to eliminate the complexities of microscopy without compromising performance, the Invitrogen™ EVOS™ line of cell imaging systems makes cell imaging accessible to almost every lab and budget. From cell culture to complex protein analysis to multichannel fluorescence imaging, EVOS cell imaging systems help you perform a variety of routine and specialty applications.

Cell Counting

The new Invitrogen™ Countess™ II FL Automated Cell Counter is a benchtop assay platform equipped with state-of-the-art optics, full autofocus, and image analysis software for rapid assessment of cells in suspension. With three-channel flexibility—brightfield and two optional fluorescence channels—researchers can count cells, monitor fluorescent protein expression, evaluate apoptosis, and measure cell viability.



Nuclear holoploid genome sizing analysis of *Arabidopsis thaliana* leaf tissue homogenates using the Applied Biosystems™ Attune™ Flow Cytometer. (A) Biparametric density plot of side scatter vs. propidium iodide (PI)-DNA fluorescence, with scatter gate surrounding the fluorescent nuclei. (B) Biparametric density plot of PI fluorescence (603/48 vs. ≥640 nm) of scatter gate population from A. (C) Logarithmic histogram of PI-DNA fluorescence (603/48 nm) of nuclei gate population from B. (D) Linear histogram of PI fluorescence (603/48 nm) of nuclei gate population from B. 2C, 4C, 8C, 16C, and 32C denote the C-values for the respective peaks.

GMO testing and detection

Whether you are conducting genetically modified organism (GMO) testing to detect bioengineered GMOs in a sample for quality-control purposes, detecting allergens in food, or quantifying mutant and rare alleles in plant genomes, we offer a range of real-time and digital PCR solutions to address your throughput, accuracy, and detection sensitivity needs with high confidence.

Products and technologies for GMO testing

Testing for GMOs in food is now required in an increasing number of countries and is becoming increasingly important in quality-control tests. We offer kits that will allow you to accurately detect GMO-specific DNA sequences in seed, grain, and processed foods and their ingredients. These GMO kits are based on TaqMan chemistry and are compatible with our wide selection of real-time PCR instruments.

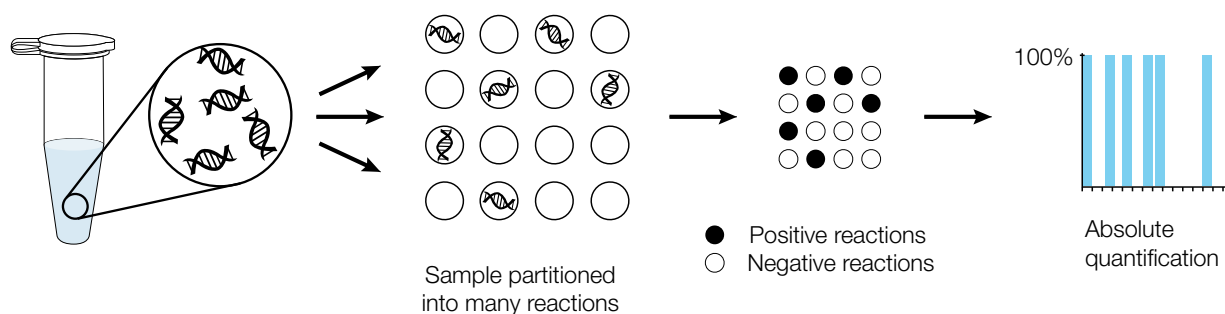
Explore our GMO testing and detection solutions at thermofisher.com/gmo

Digital PCR solutions for GMO detection

Digital PCR is a newer approach to nucleic acid detection and quantification that is ideal for accurately quantitating low amounts of plant transgenes in a wild-type background. It doesn't rely on reference standards and offers a high tolerance for multiple inhibitors of PCR that are encountered in plant samples.

Find out more at thermofisher.com/digitalpcr

Applied Biosystems™ QuantStudio™ 3D Digital PCR System enables high accuracy, sensitivity, and absolute quantification





Case study: Soybean (*Glycine max*)

Dr. Wing Cheung (DNA LandMarks, BASF) partnered with us to design TaqMan Assays for GMO soybean DNA detection and to validate assay specificity with target-specific gDNA with a digital PCR approach. Using a 1:10,000 GMO/wild-type spike-in ratio, the authors confirmed that the measured ratio for GMO and wild-type targets was comparable to the estimated GMO/wild-type ratio.

Download the study at
thermofisher.com/gmo

Sample preparation and nucleic acid isolation

Plant DNA isolation has unique challenges that require reagents specifically designed to deal with carbohydrates, phenolics, and other compounds abundant in plant tissues. Plant cell walls can be very difficult to disrupt, and lysates often contain significant amounts of compounds such as tannins, phenolics, and complex polysaccharides that can affect DNA and RNA quality and inhibit downstream reactions. We offer an expansive portfolio of kits, reagents, and devices for the isolation, purification, analysis, and quantitation of not only plant genomic DNA but also total RNA, mRNA, and microRNA or transcriptome RNA.





Which DNA isolation kit is right for you?

	Bulk buffers for crude extraction of DNA and RNA from plant cells	DNA extraction and TaqMan chemistry-based genotyping combined, <1 hr to results	The most efficient lysis for the largest amount of tissue	Most suitable for screening and GMO testing due to automation capabilities	Silica-based method for low-abundance plant DNA samples	Magnetic beads designed to handle low-abundance plant DNA samples
	Total RNA Lysis Solution	TaqMan Sample-to-SNP Kit	Invitrogen™ Plant DNAzol™ Reagent	Invitrogen™ ChargeSwitch™ gDNA Plant Kit	Invitrogen™ PureLink™ Genomic Plant DNA Purification Kit	Invitrogen™ MagMAX™ DNA Multi-Sample Kit
Top seller			Yes	Yes	Yes	
Starting material	≥100 mg	2–3 mm punch	≥100 mg	50–100 mg	100 mg	5–10 mg
Yield	Varies based on starting material	Varies based on starting material	Varies based on starting material	Up to 7 µg	Up to 14.6 µg	Up to 14.6 µg
Protocol time	<15 min	5 min	<60 min	<15 min	<40 min	<40 min
Plant sample types	Customer-validated for DNA on a broad range of plant tissues for SNP genotyping as well as corn flour for GMO testing	Broad range of plant tissues and starting material (leaf punches, needles, and seed chips)	Broad range of plant tissues (alfalfa and sunflower sprouts, corn husks, soybeans, mushrooms, tomato leaves, wheat grass, and <i>Arabidopsis thaliana</i> leaves)	Some of the many species and tissues are canola, corn, cotton, sunflower, barley, rice (seeds), tomato, cucumber, lettuce, banana (leaves), rose, magnolia (flower), Acer, sycamore, and grass	Chloroplasts and broad range of plant tissues (alfalfa and sunflower sprouts, corn husks, soybeans, mushrooms, tomato leaves, wheat grass, and <i>Arabidopsis thaliana</i> leaves)	Chloroplasts and broad range of plant tissues (alfalfa and sunflower sprouts, corn husks, soybeans, mushrooms, tomato leaves, wheat grass, and <i>Arabidopsis thaliana</i> leaves)
Isolation technology	Bulk lysis buffer	Lysis solution	Organic extraction	Invitrogen™ ChargeSwitch™ chemistry, magnetic beads	Silica spin column	Magnetic beads
Downstream applications	PCR, real-time PCR	Real-time PCR	All	All	All	All
Automatable	No	Yes	No	Yes	No	Yes
High throughput-compatible	Yes	Yes	Yes	Yes	No	Yes
High throughput/automation options	Yes	Yes	Yes	Invitrogen™ ChargeSwitch™ gDNA Plant 960 Kit	96-well plate	50 preps 96 preps
Kit sizes available	250 mL	100 preps 400 preps 4,000 preps	100 mL	96 preps 960 preps	50 preps 4 x 96 preps	50 preps 96 preps

Which RNA isolation kit is right for you?

	Great for difficult samples (conifer tissue and seeds)	Rapid and fully automated	Quick and easy to use	Efficient recovery of microRNA and small RNA
	Plant RNA Reagent	Invitrogen™ MagMAX™-96 Total RNA Isolation Kit	Invitrogen™ PureLink™ RNA Mini Kit	Invitrogen™ mirVana™ miRNA Isolation Kit
Top seller				Yes
RNA types isolated	Large RNA molecules only	Large RNA molecules only	Large RNA molecules only	Small and large RNA molecules
Prep time	60 min	<45 min	<20 min	30 min
Amount of starting material	Up to 1 g	Up to 10 mg	<250 mg	0.5–250 mg
Isolation method	High-purity organic extraction (requires alcohol precipitation)	Scalable, flexible format with magnetic beads	Fast, convenient silica column	Highest purity and convenience; includes organic extraction and silica column (no precipitation required)
High throughput– compatible		Yes		
Compatible products		Invitrogen™ Plant RNA Isolation Aid—removes common plant contaminants	Plant RNA Isolation Aid—removes common plant contaminants	Plant RNA Isolation Aid—removes common plant contaminants

Explore our solutions at thermofisher.com/plantnap

Technology platforms		Ion Torrent™ semiconductor sequencing	Capillary electrophoresis sequencing	Real-time PCR	
		Ion S5 System 	3730 Series Genetic Analyzers 	QuantStudio family of real-time PCR systems 	QuantStudio 12K Flex Real-Time PCR System 
DNA	De novo sequencing	✓	✓		
	Targeted resequencing	✓	✓		
	Confirmation of next-generation sequencing results		✓		
	SNP discovery (whole-genome)	✓	✓		
	SNP confirmation		✓	✓	✓
	QTL mapping	✓	✓	✓	✓
	Marker-assisted selection	✓	✓	✓	✓
	Genotyping by sequencing	✓			
	Linkage mapping	✓	✓		✓
	Variety identification	✓	✓	✓	✓
	Microsatellite/SSR analysis	✓	✓		
	AFLP™ analysis		✓		
	Mutation (SNP) screening	✓			✓
	GMO testing			✓	✓
	Digital PCR				✓
	Rare-allele detection				✓
	HRM analysis			✓	✓
	Copy number variation	✓	✓	✓	✓
	Methylation		✓	✓	✓
	ChIP-Seq	✓			
RNA	Whole-transcriptome sequencing	✓			
	Targeted gene expression			✓	✓
	Gene expression confirmation			✓	✓
	miRNA expression			✓	✓
	siRNA analysis			✓	✓
Protein	Protein expression			✓	✓



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