IBO

Strategic Information for the Life Science and Analytical Instrument Industry

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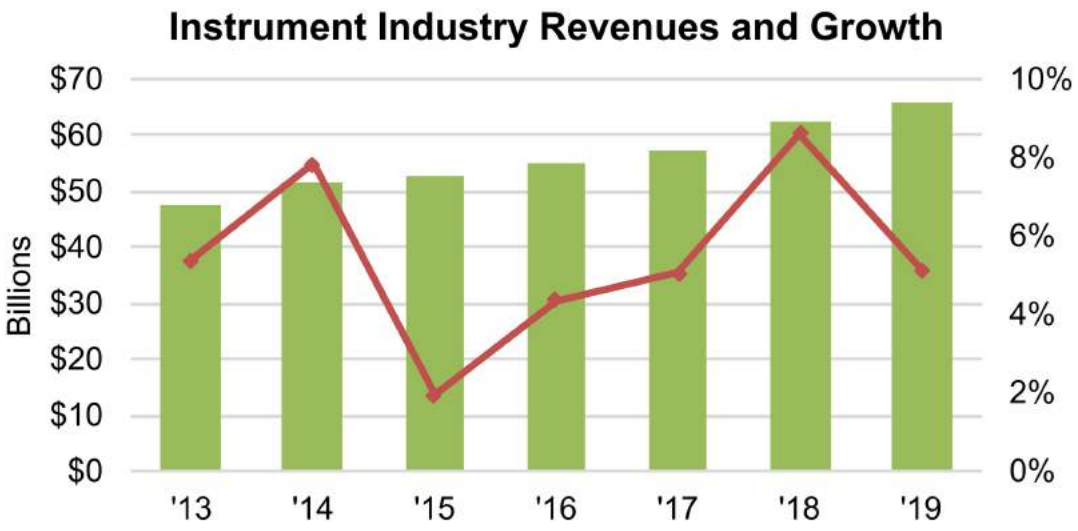
The IBO 2019 Industry Forecast

Annual growth of 5% predicted for 2019



After a tumultuous end of the year in the equities markets, with US 401K's in freefall, the future appears rather foggy. While stocks rebounded in early January, and investor sentiment tells only a part of the story, it is perhaps best to turn to review the past year, inasmuch as hindsight is 20/20 and the past is always an important key to the future.

For the calendar year 2018, total demand for analytical and life science instruments and laboratory products amounted to $62.4 billion, a generous increase of 8.6% over 2017. This continues the welcome trend of increasing growth rates over the past three years, and indeed marks the strongest annual growth in recent history. Overall demand was boosted in part by currency effects, which ***IBO*** estimates added 1.1% in growth for 2018—thus, organic growth for the previous year was 7.5%. Life science research continues to support rapid growth in demand from both public and private laboratories, and environmental spending worldwide helped to lift growth above our original estimates.

Alas, we do not foresee this blistering pace to be sustainable. The ***IBO*** 2019 Industry Forecast calls for annual growth of 5.1%, resulting in 2019 revenues of $65.6 billion. Although a drop from 2018, this still amounts to growth better than the three years previous to 2018. In general, the global situation is quite favorable, although as ever, there will be winners and losers.

While many suppliers have been confidently downplaying any negative effects of the ongoing US-China trade war, this cannot last indefinitely. While it is a positive sign that additional US tariffs did not go into effect at the beginning of this year and that talks are scheduled, a swift resolution seems unlikely. Of course, a bilateral barrier between two countries may not stymie the whole market; after all, there is a whole rest of the world to do business with. If US or Chinese products become too

expensive, European and Japanese suppliers will be only too glad to offer alternatives. But these inefficiencies in trade will produce a drag on both US and Chinese GDP growth, and knock-on effects will consequently affect the laboratory markets for many products.

Europe faces uncertainties of its own with Brexit almost upon us and no deal in sight. While the ultimate shape of the deal, if any, will influence these economies, the confusion that currently reigns has been bad enough for the UK market, and smaller trade skirmishes between the US and Europe also presage negative influences. In contrast, Japan's participation in the Comprehensive and Progressive Agreement for Trans-Pacific Partnership should provide a boost to its economy. Already, the Japanese market for instrumentation had picked up considerably in the latter half of 2018, and this trend is forecast to continue through 2019.

One of the positive trends for 2019 is something of an illusion—foreign exchange. Although the US dollar ended 2018 quite strongly, presumably as investors rushed to it for relative safety, indications are that they may rush back out if the negative forecasts for the US economy come true. Consequently, a weaker dollar will inflate the market for the full year 2019, but likely with a small effect.

Despite economic uncertainties, public funding should remain a reliable source of funds for research in general. One obvious counterpoint is the current US government shutdown, which affects a number of national laboratories and research institutes, and is now the longest government shutdown in the history of the country. Idle government laboratories do not use consumables, although some will no doubt be able to make up for lost time. Regardless of the political fallout, some form of continuing budget resolution should alleviate the problem before too much damage can be done. Meanwhile, Horizon 2020 in Europe and similar initiatives throughout Asia continue to foster research. Public-private collaborations have also become a source of research funds that labs worldwide are increasingly coming to rely upon.

Speaking more broadly of the global economy, the OECD economic outlook for 2019 has been revised downward from 3.7% GDP growth to 3.5%. The OECD cited deteriorating situations not just in most of the advanced economies, but also reduced prospects in emerging countries like Argentina and Turkey, which are expected to contract in 2019. The IMF has also shaved 0.2% from its April 2018 forecast, falling from 3.9% to 3.7% in the October 2018 update. The World Bank sees a similar picture, with erosions of trade and investment slowing global growth from 3% in 2018 to 2.9% in 2019 (see **Regional Forecast**).

These troubling economic indicators will have the greatest negative effect on the industrial end-markets, which had a relatively good 2018. Other trends, such as low oil prices and flagging consumer demand for electronics, will also take a toll on industrial users of instrumentation. In contrast, demand in the life science sector, from both public and private laboratories, remains quite strong. The pharmaceutical and biotechnology sector will continue to drive overall growth in our market, and public spending across the health and life sciences is also seeing continued investment (see **Industrial Forecast**).

A Look Back: 2018 Trends and Developments

A look at the top 3 trends of last year

Slimming Down

A number of analytical instrument and lab product providers announced significant divestments last year. In the case of the largest announcements—GE's separation of GE Healthcare (see ***IBO*** 6/30/18) and Danaher's spin-off its Dental business (see ***IBO*** 7/31/18)—the change will create companies more focused on life science from research through treatment, including each company's lab and bioprocess portfolios. The spinoffs can be viewed as a testament to the strategic priority and growth expectations of the life science tools sector, as well as the expected resilience of biopharma spending. Thermo Fisher Scientific also signaled a desire to pare down its breadth of businesses, as it considered selling its anatomic pathology business (see ***IBO*** 10/31/18).

Other divestments were smaller and more focused. MilliporeSigma (see ***IBO*** 10/31/18), PerkinElmer (see ***IBO*** 11/15/18) and Harvard Bioscience (see ***IBO*** 1/31/18) each sold off product lines in 2018, as they chose to further define their technology and end-market focuses. These sales were particularly notable due to the relative high profile these product lines had. Meanwhile, Roper's divestment of Gatan (see ***IBO*** 6/30/18) and its spectrometer business (see ***IBO*** 12/31/18) considerably reduces the company's exposure to the analytical instrument market.

The Service Advantage

Service was a leading revenue segment for a number of analytical instrument companies in 2018, including Agilent Technologies, Mettler-Toledo, PerkinElmer and Waters. Many companies have

increased their capabilities and exposure in this segment over the last decade; nonetheless, growth remains vibrant. New service offerings, cost saving initiatives at customers across several end-markets, and established installed bases in developed markets and rapidly growing ones in emerging regions provide strong growth fundamentals. Companies also emphasized the stability of service businesses during an economic downturn, part of their ongoing priority to lessen exposure to volatility.

In addition, the service businesses are influencing all aspects of company functions, including R&D and marketing, as greater customer intimacy provides greater user and market insight. Further, this year, IoT capabilities were increasingly evident in new products, providing even more user information to shape service options and update traditional service models. Among the companies rolling out new IoT products this year were Eppendorf, Gilson and Thermo Fisher Scientific.

Robust Funding

In 2018, big investments in the life science sector hit a stride, with a number of major announcements emphasizing the extent of financial support for new technologies serving lab markets and guaranteeing continued technology development. Long-read sequencing firm Oxford Nanopore, for example, disclosed $140 million in fundraising (see ***IBO*** 3/31/18). Also addressing the sequencing market, sequencing-by-binding firm Omniome announced a $60 million Series B round (see ***IBO*** 7/31/18) targeting the clinical market.

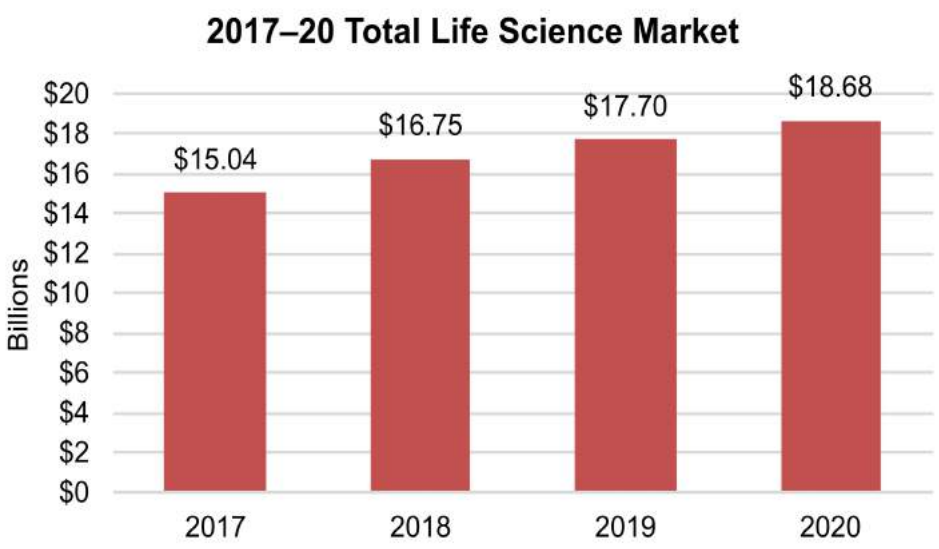
Major investments were also announced by Berkeley Lights and Biodesy for new analytical platforms addressing cell and protein analysis, respectively. Berkeley Lights completed a $95 million round, with Nikon on board as an investor, among others (see ***IBO*** 11/15/18). Biodesy raised $20 million in Series C funds (see ***IBO*** 9/30/18).

The development of improved CRISPR technologies continued to rake in funding. Synthego closed a $110 million Series C round (see ***IBO*** 11/30/18) to improve CRISPR design, while Inscripta, which develops CRISPR enzymes, raised $55.5 million in a Series C round (see ***IBO*** 4/15/18).

Outside of life science, investments indicated the willingness to fund small companies pioneering new concepts for established lab techniques. Automated liquid handling firm Andrew Alliance completed a $14 million Series C round (see ***IBO*** 6/30/18), including funding from Tecan and Waters, and PharmaFluidics raised $8.7 million for its microfluidic LC technology (see ***IBO*** 2/15/18).

Life Science: Ongoing Growth

Pharma and biotech driving growth in 2019



Life science (LS) constitutes the largest category in the analytical instrument and lab products industry, representing a quarter of the total industry, with collective market demand of more than $16.7 billion in 2018. Growth in 2019 is estimated at a robust 5.6%, driven by demand in the pharmaceutical and biotechnology sector and increased funding in the public sector.

LS is comprised of 13 individual technology segments, which encompass a wide range of applications—this provides significant opportunities for growth of both general applications and niche research markets.

The pharmaceutical and biotech sector performed very well through most of 2018. Drug discovery applications drove demand for analysis technologies, including high-content analysis, capillary electrophoresis, electrophysiology and in vivo animal imaging. However, growth of Europe's pharmaceutical and biotech sector waned in the later half of 2018, foreshadowing economic turbulence expected in the region over the coming year.

In 2018, demand in the Asia-Pacific region, while strong, was impacted by trade and global economic forces that will carry forward into 2019. The continuing trade war between the US and China has made scientific instruments and consumables of US origin costlier for researchers in China. In particular, this has impacted the sequencing market, which is dominated by California-based Illumina.

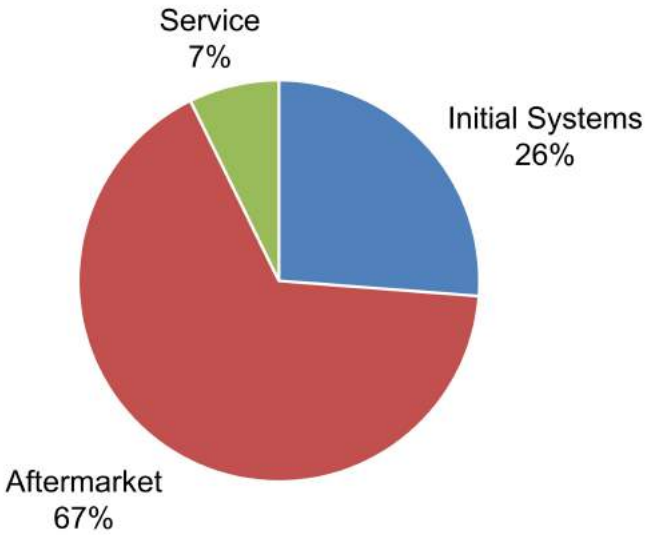
Growth in India has been somewhat tempered by an integrated goods and services value added tax (IGST) applied on all imported goods, which went into effect in early 2018. This was followed by multiple rounds of retaliatory tariffs on select US imports, with the threat of additional tariffs in 2019.

Japan began to reverse its multi-year economic slump, posting gains in 2018. The yen will likely continue to strengthen in the coming months, which will bolster demand for imported instruments and consumables for research in Japan.

Life Science Market 2018–19		
	Market Share	Growth Rate
Sequencing	22.3%	9.2%
Nucleic Acid Prep. & Cell Separation	21.1%	3.5%
PCR	18.1%	4.0%
Flow Cytometry	12.2%	4.3%
Microarrays	6.7%	10.0%
Electrophoresis	6.7%	3.8%
In Vivo Animal Imaging	3.3%	4.9%
Capillary Electrophoresis	2.3%	4.4%
High-Content Analysis/Imaging	2.0%	6.4%
Synthesizers	1.9%	5.3%
SPR & Label-Free Detection	1.4%	3.5%
Electrophysiology & Patch Clamp	1.1%	6.8%
Cell Counters	0.8%	4.3%
Total	100.0%	5.6%

Researchers were not the only group that propelled demand for life science products in 2018. Growth for microarrays, which had been in decline in recent years, surged due to the increasing popularity of direct-to-consumer genetic testing services for health and ancestry purposes. Because of their ease-of-use, throughput capabilities and scope of analysis, microarrays will remain the preferred method for casual direct-to-consumer genomics in the near future.

2018 Life Science Market by Product Type

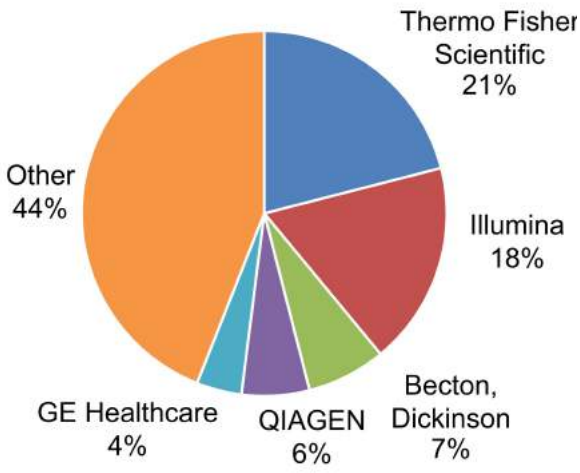


Thermo Fisher Scientific is the leading supplier in the life science market, representing over a fifth of the total market. Thermo Fisher participates in nearly all life science technologies, with the exception of SPR and electrophysiology. The company leads or is a significant participant in most of its life science technologies.

In stark contrast, Illumina maintains a sharp focus on its core in sequencing. The company is the second-leading supplier in the life science market competencies and the dominant force in sequencing technology. To ensure dominance in the market, Illumina has announced that it will acquire rival Pacific Biosciences in a deal expected to close in mid-2019 (see ***IBO*** 11/15/18). Through this merger, Illumina will gain PacBio's long-read sequencing technologies, moving the company into the next stage of sequencing technology.

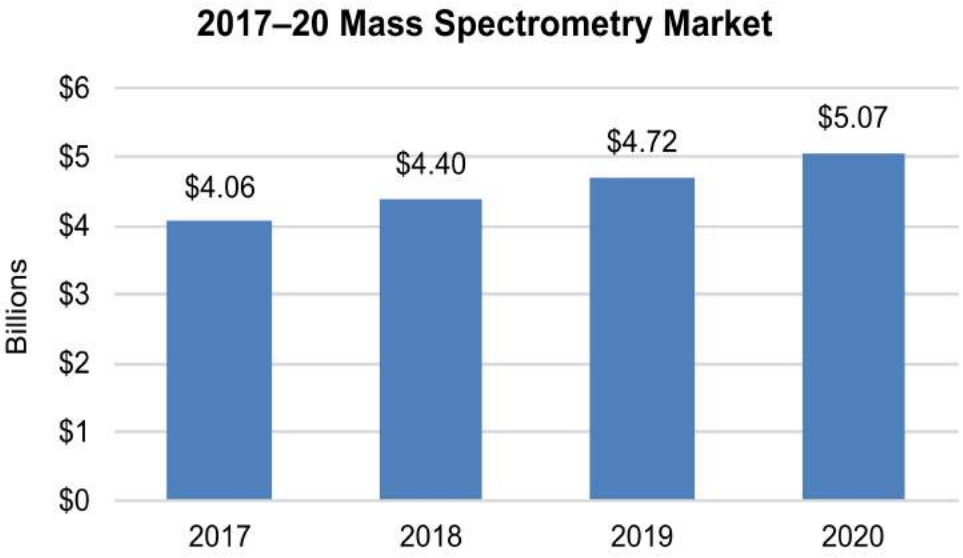
Life Science Market Leaders	
Sequencing	Thermo Fisher Scientific, Bio-Rad Laboratories
Nucleic Acid Prep. & Cell Separation	Illumina, Thermo Fisher Scientific
PCR	QIAGEN, Thermo Fisher Scientific
Flow Cytometry	Becton, Dickinson, Beckman Coulter (Danaher)
Microarrays	GE Healthcare, Bio-Rad Laboratories
Electrophoresis	Illumina, Thermo Fisher Scientific
In Vivo Animal Imaging	Bruker, PerkinElmer
Capillary Electrophoresis	Agilent Technologies, SCIEX (Danaher)
High-Content Analysis/Imaging	Thermo Fisher Scientific, GE Healthcare
Synthesizers	GE Healthcare, Thermo Fisher Scientific
SPR & Label-Free Detection	GE Healthcare, Pall ForteBio (Danaher)
Electrophysiology & Patch Clamp	Molecular Devices (Danaher), Biolin Sophion
Cell Counters	Beckman Coulter (Danaher), Thermo Fisher Scientific

2018 Life Science Supplier Market Share



Mass Spectrometry: Positively Charged

Food and environmental testing forecast to boost MS sales

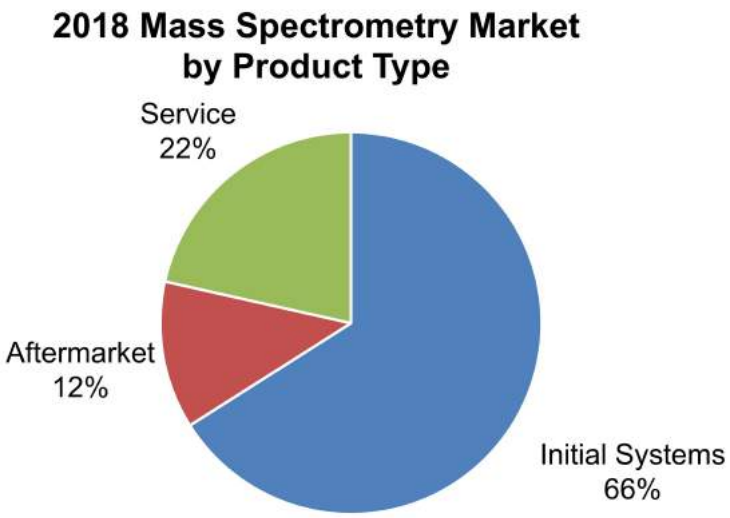


The market for mass spectrometry (MS) performed quite well in 2018, reaching $4.4 billion. Despite a number of global economic challenges in the year ahead, the future for the technology continues to look bright. The market is expected to grow by 7.4% in 2019, led by demand from pharmaceutical, biotechnology, food testing and environmental labs, offset by weakness in public spending.

In particular, strong growth will be reserved for technologies geared for pharmaceutical and biomolecular analyses, namely triple quadrupole LC/MS, Orbitrap LC/MS, Q-TOF and MALDI-TOF systems. Demand from food and environmental labs will continue to be a driver as well. While growth for GC/MS will remain healthy, weak spending in energy markets will likely offset its momentum from the previous year. The portable MS market will provide only moderate growth, and magnetic sector MS will face a mild decline.

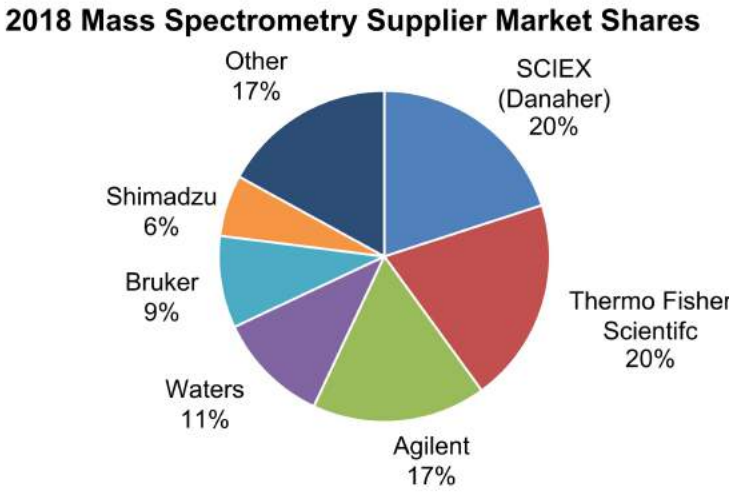
Mass Spectrometry 2018–19		
	Market Share	**Growth Rate**
Quadrupole LC/MS	35.8%	8.7%
GC/MS	16.8%	5.5%
FT/MS & Ion Trap LC/MS	18.1%	7.2%
TOF LC/MS	16.1%	7.6%
MALDI-TOF MS	8.9%	7.4%
Magnetic Sector MS	2.3%	-1.0%
Portable & In-Field MS	2.0%	5.0%
Total	100.0%	7.3%

MS growth will continue to be driven by Asian markets. China will remain the leader of this trend, but growth from India will start to catch up, fueled by the region's rapid development and possibly benefiting from the ongoing trade dispute between China and the US. The Japanese market faces relatively healthy growth, particularly in the first half of the year.



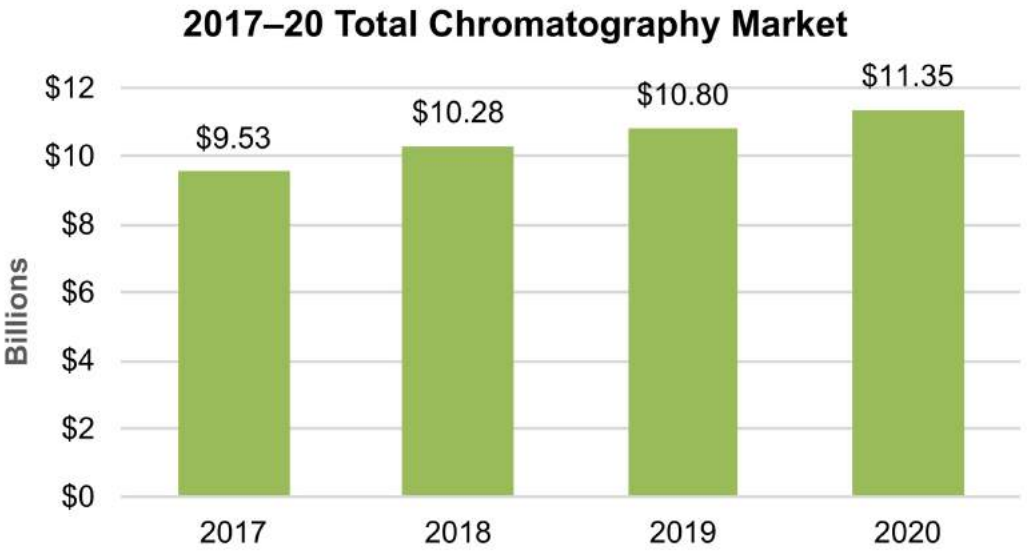
The overall competitive landscape for MS tends to evolve slowly, but all the major vendors offer some form of LC/MS. In 2018, SCIEX (Danaher) and Thermo Fisher Scientific have a near-equal share, the former company a major supplier of quadrupole and TOF LC/MS and the latter company having much success with its Orbitrap technology. Agilent Technologies is the leading supplier of GC/MS, Bruker and Shimadzu are the leaders in MALDI-TOF, and Waters focuses almost exclusively on LC/MS.

Mass Spectrometry Market Leaders	
Quadrupole LC/MS	SCIEX (Danaher), Agilent Technologies
GC/MS	Agilent Technologies, Shimadzu
FT/MS & Ion Trap LC/MS	Thermo Fisher Scientific, Bruker
TOF LC/MS	Waters, SCIEX (Danaher)
MALDI-TOF MS	Bruker, Shimadzu
Magnetic Sector MS	Thermo Fisher Scientific, JEOL
Portable & In-Field MS	INFICON, FLIR



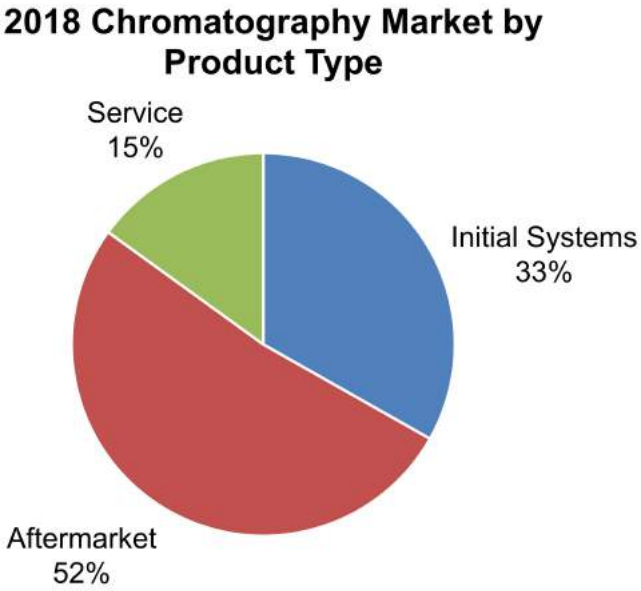
Chromatography: A Healthy Outlook

Analytical HPLC applications accelerate growth



The chromatography market reached $10.2 billion in 2018, supported by continuing strong performance in the pharmaceutical and biotechnology sector and also in the chemical industry. The market saw a big jump in revenue compared to last year's forecast, due to several adjustments in ***IBO***'s analysis and estimation, especially in the aftermarket section. The 2017–18 growth rate was 5.1%, driven by favorable currency effects and a sales boost from the newly legalized cannabis market in California and Canada. The market growth was slightly dampened by global economic issues, such as the tariff war between the US and China and Brexit in the UK.

Sales for most chromatography technologies are expected to increase by low- to mid-single digits in 2019. Analytical HPLC represents half of the market with a mid-single digit growth rate, supported by increasing biomolecule analysis applications, along with robust drug discovery and research investments. Gas chromatography (GC) also had a strong year due to a solid performance from oil



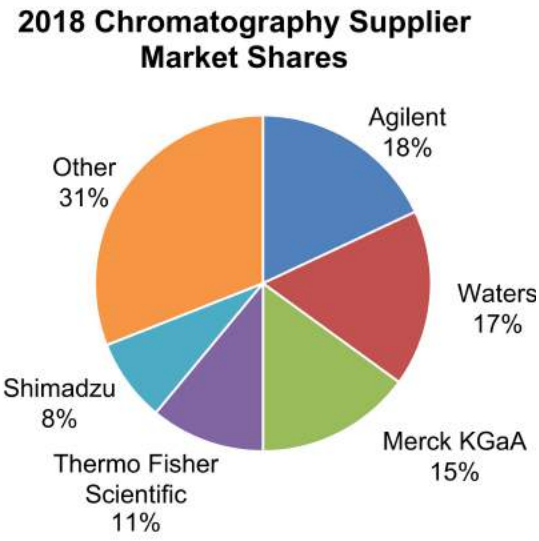
Chromatography 2018-19		
	Market Share	Growth Rate
Analytical HPLC	51.0%	5.0%
Gas Chromatography	20.9%	4.7%
Preparative HPLC	9.1%	5.5%
Low-pressure LC	6.0%	4.5%
Ion Chromatography	5.8%	4.2%
Clinical HPLC (HbA1c)	4.2%	9.8%
Flash Chromatography	1.5%	4.0%
Thin Layer Chromatography	0.8%	1.2%
Supercritical Fluid Chromatography	0.8%	6.0%
Total	100.0%	5.1%

and gas, and chemicals industry. The uncertainty in the oil and gas sector, however, slightly decreased the projected growth rate of this technology in 2019.

In terms of vendor share, Agilent Technologies is still in the top position, followed closely by Waters. After further analysis and adjusted estimates, MilliporeSigma (Merck KGaA) is third in the chromatography market, with a wide variety of aftermarket product across all technologies.

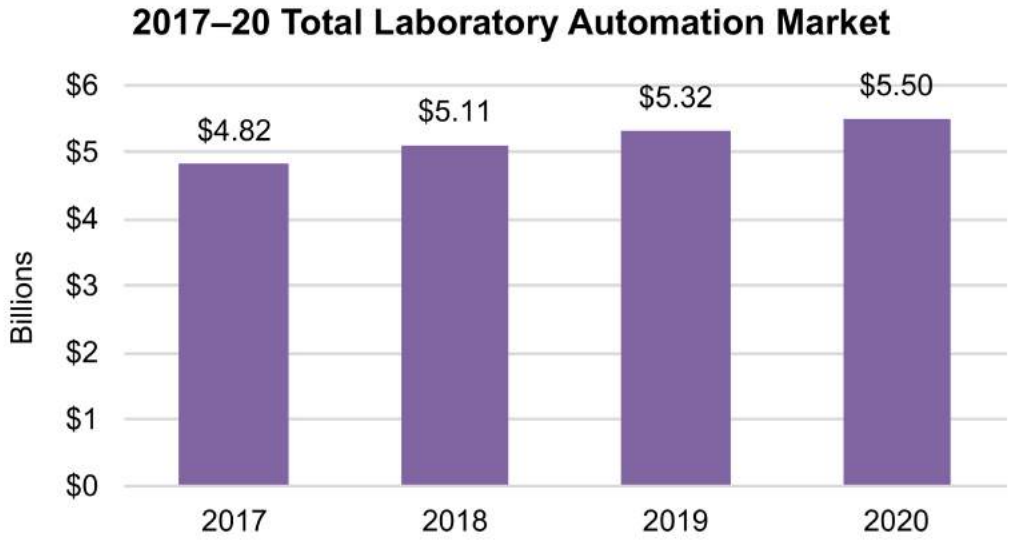
The chromatography market is projected to have healthy growth next year. Both HPLC and GC are essentials to cannabinoid testing and thus add growth potential for these technologies. In addition, increasing environmental testing demand will further fuel sales for chromatography instruments, especially in China and other Asian countries.

Chromatography Market Leaders	
Analytical HPLC	Waters, Agilent Technologies
Gas Chromatography	Agilent Technologies, Shimadzu
Preparative HPLC	GE Healthcare, MilliporeSigma (Merck KGaA)
Low-pressure LC	MilliporeSigma (Merck KGaA), GE Healthcare
Ion Chromatography	Thermo Fisher Scientific, Metrohm
Clinical HPLC (HbA1c)	Bio-Rad Laboratories, TOSOH
Flash Chromatography	Biotage, Teledyne ISCO
Thin Layer Chromatography	MilliporeSigma (Merck KGaA), CAMAG
Supercritical Fluid Chromatography	Waters, Agilent Technologies



Laboratory Automation: Improving Efficiency

Lab automation sales to slightly fall in 2019

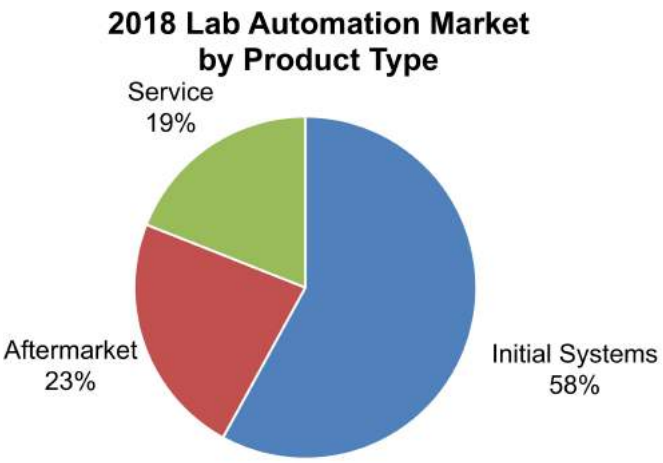


Lab automation technologies enable automation and documentation of repetitive and programmable laboratory procedures. They provide value by increasing the efficiency, accuracy and pace of work done in the lab. The total market for lab automation reached $5.1 billion in 2018, growing at a rate of 4.1%, with growth for this year estimated to slightly decrease to 3.4%. It is expected that the market will surpass $5.5 billion in 2020.

The pharmaceutical and biotechnology sector accounts for more than half of the market for lab automation technologies. Pharmaceutical, biotech and CRO organizations rely heavily on automated processes and software solutions in order to increase productivity. The need for high-throughput analysis, sample tracking and data analysis has driven growth of many segments.

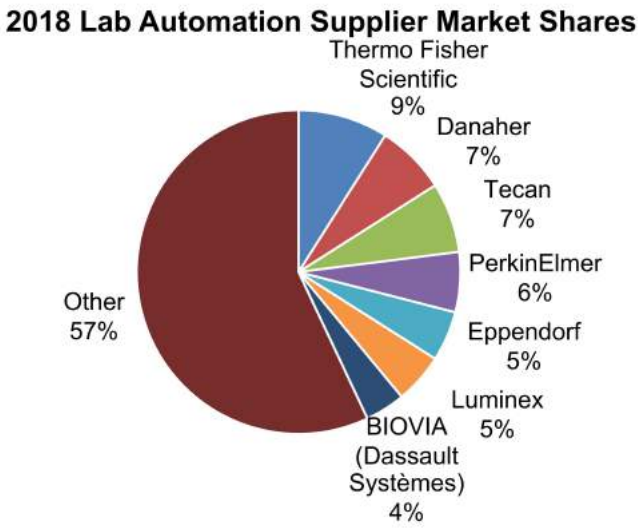
Technologies such as liquid handling, and multiplex and high-throughput ELISAs play important roles in the applied sector, particularly in hospital and clinical labs, where large quantities of samples need to be processed in a short time. The increase in diagnostics tests for infectious diseases, cancer, respiratory ailments and gastrointestinal pathogenesis will fuel the growth of these technologies.

Lab Automation 2018–19		
	Market Share	**Growth Rate**
Liquid Handling	37.4%	5.0%
Microplate Readers	16.3%	3.2%
LIMS, ELN & SDMS	13.0%	4.1%
Multiplex & HT ELISA	12.6%	5.3%
Informatics	12.4%	1.9%
Robotics	8.4%	3.2%
Total	100.0%	4.1%



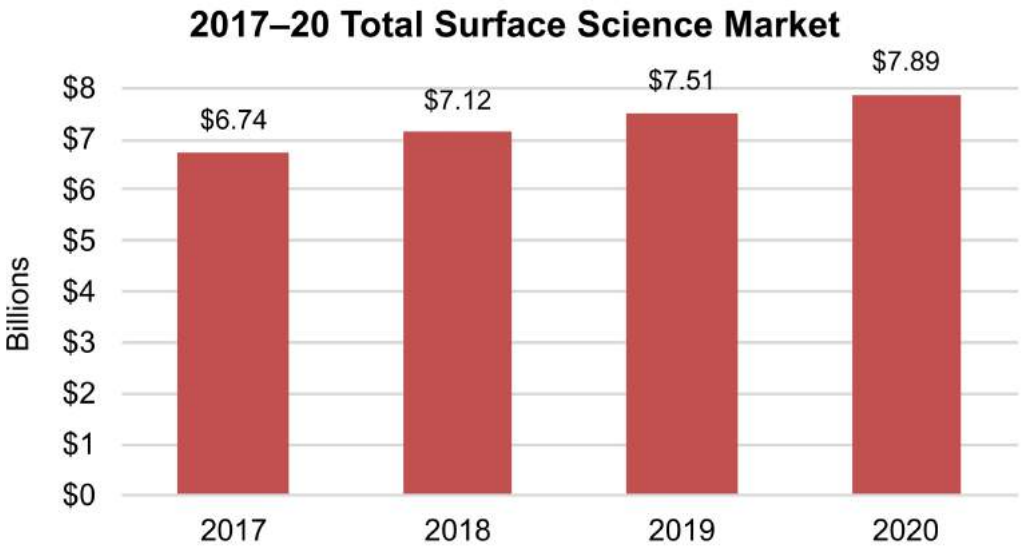
Thermo Fisher Scientific, the market leader, provides instruments in all six categories, while Danaher, the second-leading supplier, participates exclusively in the liquid handling and robotics markets. Tecan, with the third largest share of the lab automation market, is a leader in liquid handling, but also plays in the microplate readers and robotics markets.

Lab Automation Market Leaders	
Liquid Handling	
Automatic	Tecan, Hamilton
Manual	Eppendorf, Mettler-Toledo
Microplate Readers	Molecular Devices (Danaher), PerkinElmer
LIMS, ELN & SDMS	LabWare, Thermo Fisher Scientific
Multiplex & HT ELISA	Luminex, Meso Scale Discovery
Informatics	BIOVIA (Dassault Systèmes), Certara
Robotics	Brooks Automation, Agilent Technologies



Surface Science: Advanced Microscopy Attracts New Users

Confocal microscopy expected to grow 8%



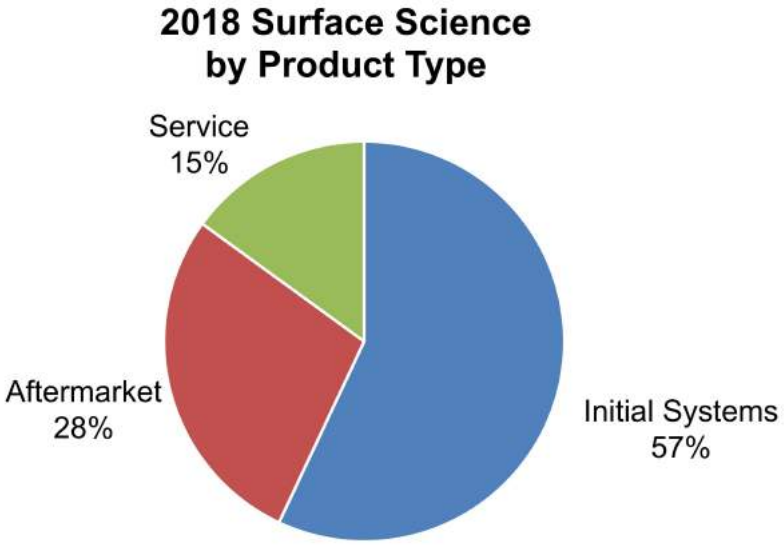
Surface science instrumentation technologies enable scientists and researchers to observe and analyze the physical and chemical surface properties of materials at the micro- and nanoscale, generally though microscopic techniques. The technologies range from traditional light microscopes, to instruments which utilize light, electrons, other particles or close physical contact in order to characterize surfaces. Certain techniques can also penetrate the surface and provide information on deeper layers of a sample. The total surface science instrumentation market is projected to reach $7.5 billion in 2019 and $7.9 billion by 2020.

Optical microscopy and electron microscopy constitute the majority of market demand. Despite a history dating centuries, the light microscope is still a valued part of virtually every laboratory setting in the world, resulting in strong market demand.

Surface Science 2018–19		
	Market Share	Growth Rate
Optical Microscopy	46.1%	4.3%
Electron Microscopy	35.4%	6.7%
Confocal & Advanced Microscopy	8.0%	7.8%
Scanning Probe Microscopy	5.3%	6.1%
Surface Analyzers	5.2%	3.5%
Total	100.0%	5.5%

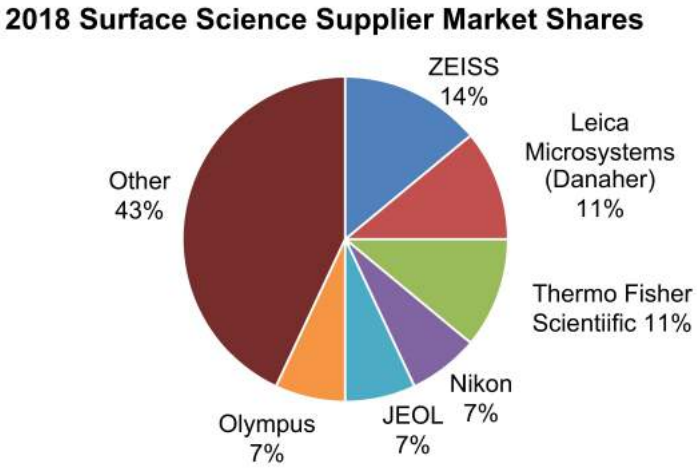
Traditionally used as a materials science technique, electron microscopy has expanded its applications into life science imaging, as instruments have become more robust. This market's growth, projected at 6.7% in 2019, will be propelled by these new applications, as well as investments from microelectronics and semiconductor companies.

Confocal and advanced optical microscopy, which includes super-resolution microscopy, is expected to grow 7.8%. Surface analyzers will also see robust growth this year, led by nanotechnology and other research areas that require advanced tools.



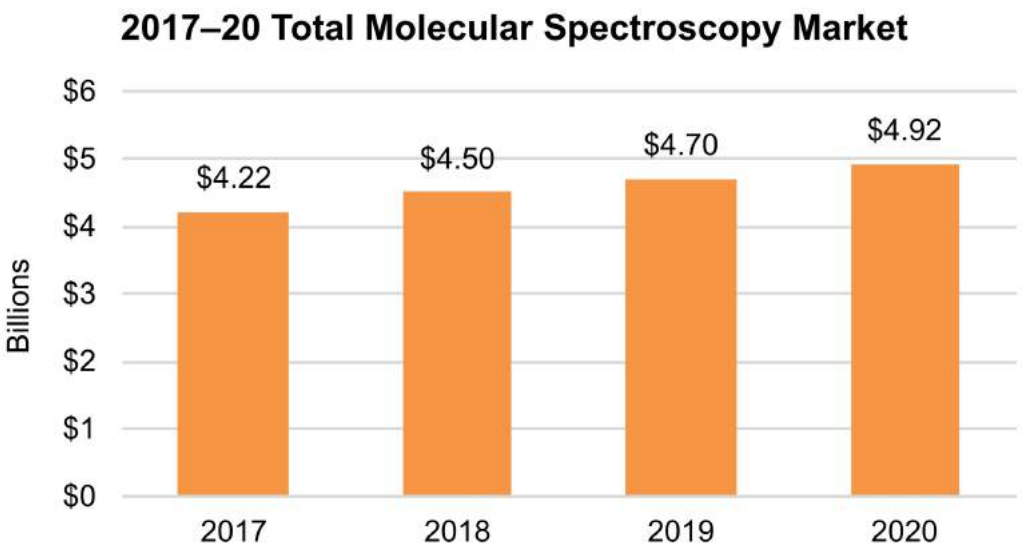
ZEISS, the overall leader in surface science market share, is a major supplier of optical and confocal and advanced microscopes. Leica Microsystems (Danaher) is also major supplier of optical and confocal and advanced microscopes and the second leading vendor overall. The third leading vendor, Thermo Fisher Scientific, acquired FEI in 2016 (see ***IBO*** 5/31/16), and is now well-positioned to continue being a leading supplier of electron microscopes for the foreseeable future.

Surface Science Instrumentation Market Leaders	
Optical Microscopy	Leica Microsystems (Danaher), ZEISS
Electron Microscopy	Thermo Fisher Scientific, JEOL
Confocal & Advanced Microscopy	Leica Microsystems (Danaher), ZEISS
Scanning Probe Microscopy	Bruker, Oxford Instruments
Surface Analyzers	Ulvac-PHI, Cameca (AMETEK)



Molecular Spectroscopy: Growth in IR and NIR

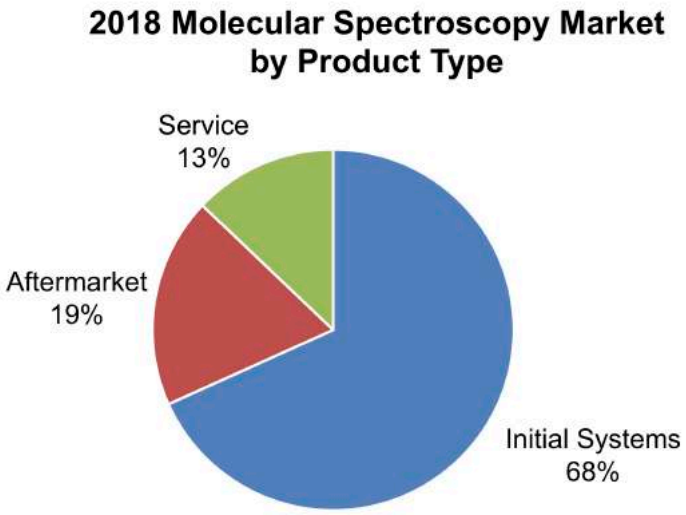
Government funding to fuel growth for Raman spectroscopy



Molecular spectroscopy is a combination of technologies that analyze how molecules react with light by absorption, emission, vibration, changing energy states and many other interactions. An exception is NMR, which analyzes the interaction of atomic nuclei in a magnetic field with electromagnetic radiation. The total molecular spectroscopy market is forecast to reach nearly $4.7 billion in 2019, growing at a rate of 6.7%.

UV-Vis spectroscopy, NMR and IR spectroscopy are the three largest segments, with each having close to a 20% share of the market. While UV/Vis is the largest market, its growth will be below average in the near future, as growth from pharmaceutical, biotechnology and environmental testing is offset by slower growth in the public and industrial sectors.

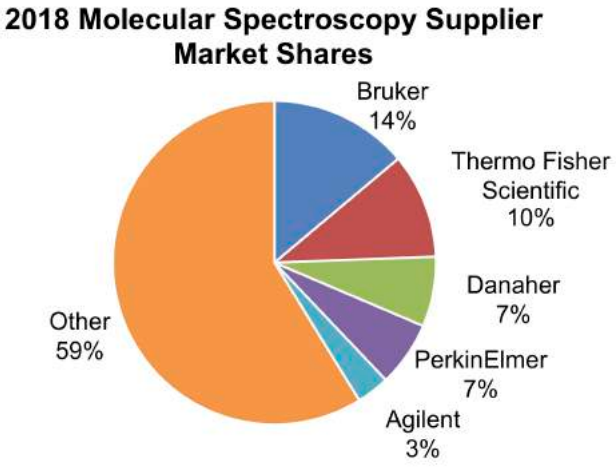
Molecular Spectroscopy 2018–19		
	Market Share	**Growth Rate**
UV-Vis	21.7%	3.9%
NMR & Electron Paramagnetic Resonance	19.5%	3.4%
IR	18.3%	6.0%
Color Measurement	9.3%	3.0%
Raman	9.0%	6.2%
NIR	8.7%	6.5%
Polarimeters & Refractometers	7.1%	3.1%
Fluorescence & Luminescence	4.4%	4.0%
Ellipsometry	2.1%	4.2%
Total	100.0%	4.5%



Raman, IR and NIR spectroscopy will experience the fastest growth in molecular spectroscopy in 2019. IR and NIR spectroscopy are closely related techniques that are commonly used in a variety of industries, ranging from agriculture and food to pharmaceuticals. Growth for Raman spectroscopy will largely come from government testing, but also from usage of Raman microscopes in pharmaceutical and chemical research applications.

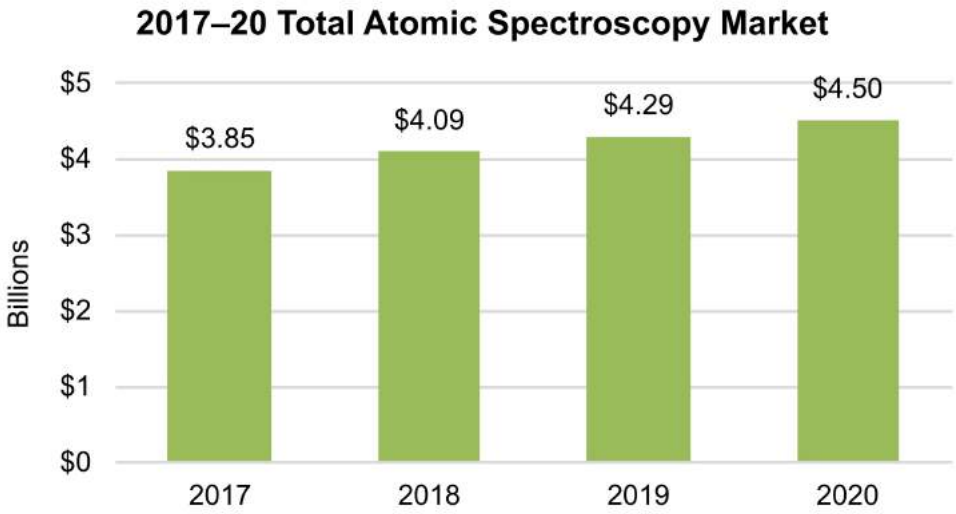
Bruker and Thermo Fisher Scientific have the largest shares of the molecular spectroscopy market as the only vendors with double-digit shares. Bruker is one of the few remaining vendors of high-field NMR instruments, along with JEOL, and also offers IR, NIR and Raman spectroscopy systems. Thermo Fisher is broad-based with a wide range of products for UV/Vis, IR, NIR, Raman and fluorescence spectroscopy. PerkinElmer is also a supplier of most molecular spectroscopy techniques. Danaher is a major supplier in UV-Vis and color measurement systems through its Hach and X-Rite brands. Other notable vendors for molecular spectroscopy include Agilent Technologies, FOSS, JASCO and Shimadzu.

Molecular Spectroscopy Market Leaders	
NMR & Electron Paramagnetic Resonance	Bruker, JEOL
UV-Vis	Thermo Fisher Scientific, Hach (Danaher)
IR	PerkinElmer, Thermo Fisher Scientific
Color Measurement	X-Rite (Danaher), Konica Minolta
NIR	FOSS, Thermo Fisher Scientific
Raman	Thermo Fisher Scientific, HORIBA
Fluorescence & Luminescence	HORIBA, Thermo Fisher Scientific
Polarimeters & Refractometers	Anton Paar, Mettler-Toledo
Ellipsometry	Sentech, HORIBA



Atomic Spectroscopy: Environmental Testing Leads the Way

Growth exceeds expectations

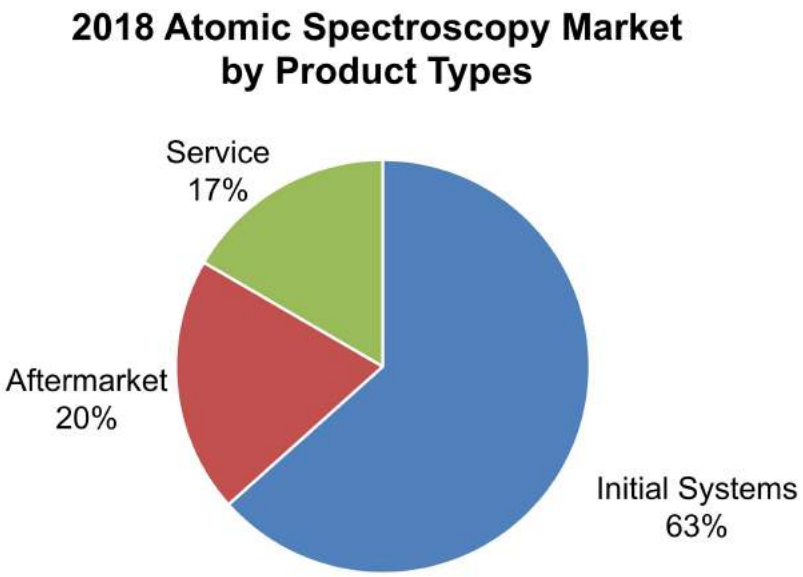


Atomic spectroscopy collects a number of technologies primarily intended to provide the elemental composition of samples, using spectroscopy across various wavelengths of light to detect characteristic signatures of the emission or absorption lines of different elements. Total market demand for atomic spectroscopy reached $4.1 billion in 2018, reflecting growth of 6.2%, in excess of expectations, buoyed by strong environmental spending and some currency tailwinds. Growth is forecast to cool to 5.0% for 2019, and total revenues will reach $4.5 billion in 2020.

Environmental applications are one of the primary uses of atomic spectroscopy instrumentation, and this market should fare quite well in the coming year as well. Other applications are somewhat related to the environment, namely regulatory testing by various industries to monitor effluents. While some industries, like semiconductors, electronics, and pharmaceuticals, saw increasing use of atomic spectroscopy, the end of 2018 showed some poor performance in oil and gas, and metals end-markets. These trends should continue through most of 2019 at the very least.

Atomic Spectroscopy 2018–19		
	Market Share	**Growth Rate**
X-ray Fluorescence	27.5%	5.9%
X-ray Diffraction	18.0%	6.3%
ICP-OES	12.8%	3.8%
ICP-MS	12.1%	7.9%
Atomic Absorption	11.8%	3.1%
Arc/Spark	6.6%	1.9%
Elemental Analyzers		
Inorganic	5.7%	1.7%
TOC & Other Sum Parameters	3.7%	6.0%
Organic	1.9%	0.4%
Total	100.0%	5.0%

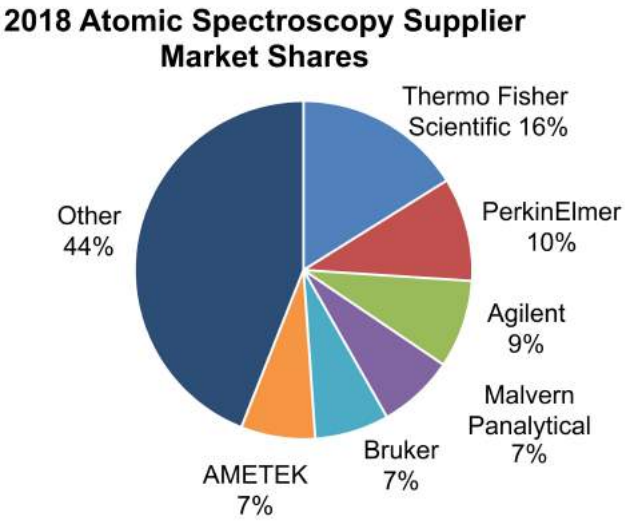
By technology, the strongest market performance is expected from ICP-MS. Although an expensive technique, its sensitivity makes it indispensable for research as well as for demanding applications or



regulatory compliance. Other technologies with excellent forecasts include X-ray diffraction (XRD) and total organic carbon (TOC). Slower growing techniques include arc/spark spectroscopy, which is broadly aligned with metals testing, and various other elemental analyzers that are experiencing less growth compared to more general purpose technologies within the category.

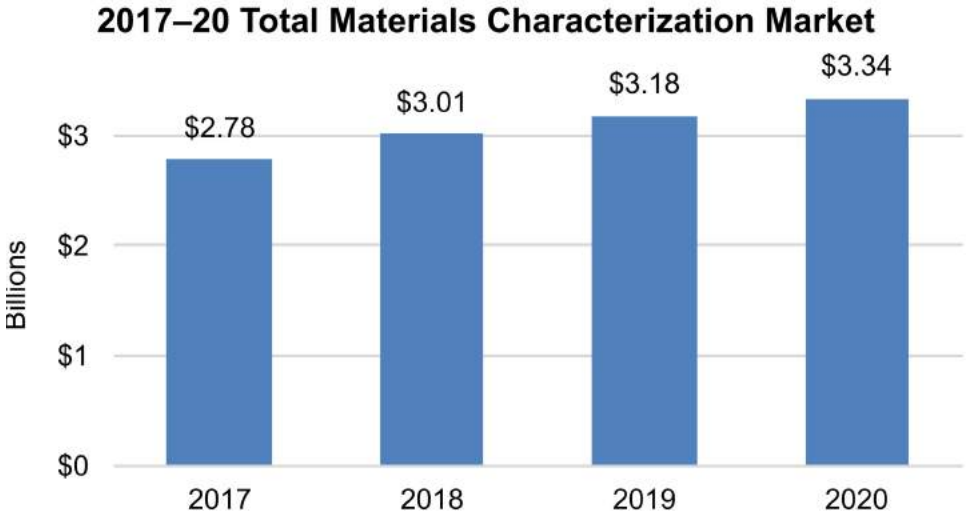
Although the vendor situation is relatively stable year to year, there have been some slight changes in leadership. Thermo Fisher Scientific, PerkinElmer and Agilent Technologies maintain their positions as the top 3 companies, but the next several companies have very similar overall revenues. Malvern Panalytical (Spectris) narrowly edges out Bruker, while AMETEK (primarily through its SPECTRO Analytical business) has just surpassed Rigaku to enter into the top 6. Within specific categories, FOSS now holds a distant second place behind LECO in the organic elemental analyzer market, supplanting PerkinElmer.

Atomic Spectroscopy Market Leaders	
X-ray Fluorescence	Thermo Fisher Scientific, Malvern Panalytical (Spectris)
X-ray Diffraction	Rigaku, Bruker
ICP-OES	PerkinElmer, Thermo Fisher Scientific
ICP-MS	Agilent Technologies, Thermo Fisher Scientific
Atomic Absorption	PerkinElmer, Agilent Technologies
Arc/Spark	SPECTRO Analytical (AMETEK), Thermo Fisher Scientific
Elemental Analyzers	
Inorganic	LECO, HORIBA
TOC & Other Sum Parameters	Shimadzu, SUEZ
Organic	LECO, FOSS



Materials Characterization: Industrial Dependency

Particle characterization market benefits from environmental testing



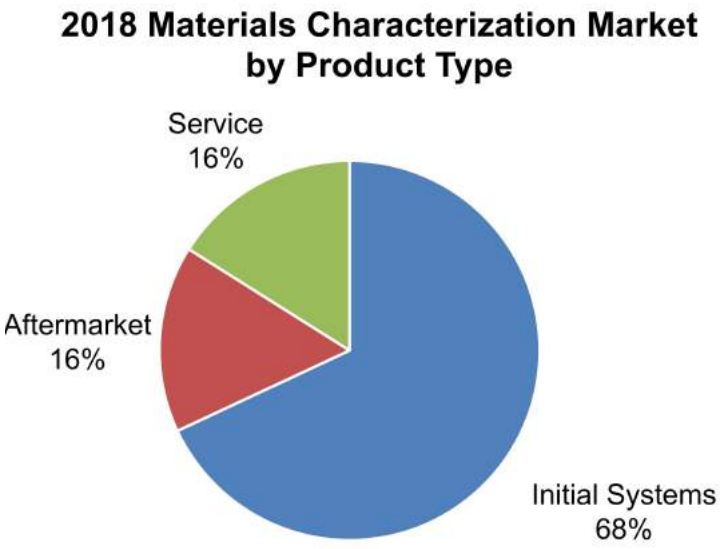
The materials characterization market is estimated to have reached $3.0 billion in 2018, driven by strong performance in the thermal analyzer and particle characterization markets. The materials characterization market is heavily dependent on the industrial sector, which performed well in 2018, especially the chemicals, polymers, and oil and gas industries. The market is expected to grow mid-single digits in the next few years.

Physical testing, thermal analyzers and particle characterization combine to make up almost three-fourths of the total market. The physical testing market is reaching maturity, but growth is supported by high demand from the automotive industry. The rising usage of plastic materials to replace metals in automotive manufacturing is additionally boosting demand from the polymers industry, in which thermal analyzers are widely used. Strong performance in the pharmaceuticals and chemical industries is also driving sales in the thermal analyzers market.

Materials Characterization 2018-19		
	Market Share	**Growth Rate**
Physical Testing	27.7%	4.0%
Thermal Analyzers	22.4%	6.7%
Particle Characterization	24.0%	6.5%
Viscometry & Rheometry	14.1%	5.7%
Calorimetry	7.0%	6.4%
Petroleum Analyzers	4.8%	4.2%
Total	100.0%	5.6%

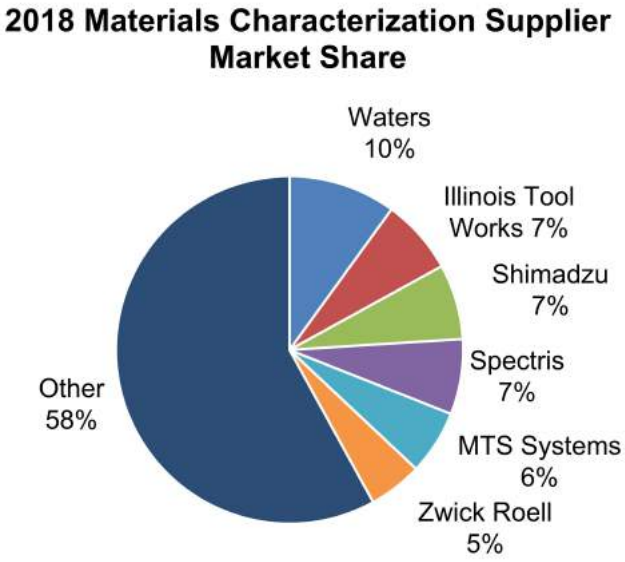
Meanwhile, the particle characterization market is enjoying high demand from environmental testing and the rapidly growing semiconductor industry. The overall materials characterization market will experience healthy growth in 2019, with a slight downside due to uncertainties in the oil and gas industry, and an economic slowdown in China and the US resulting from the trade war.

In terms of vendor share, materials characterization is a fragmented market, with many vendors claiming smaller portions. Each company usually specializes in only 1 or 2 technologies in this



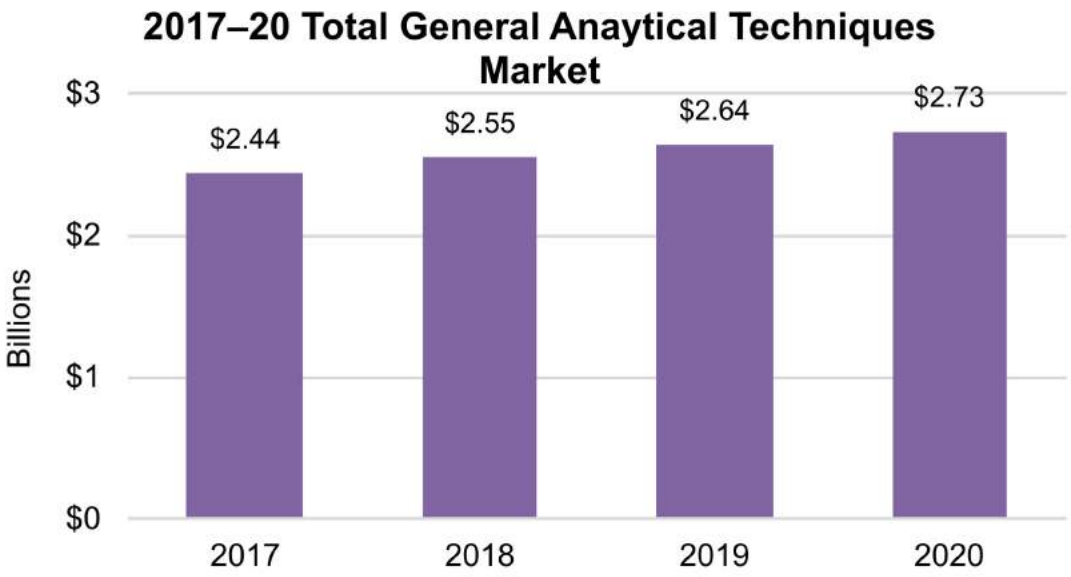
market. TA Instruments (Waters) leads the market with a major presence in the thermal analyzers, and viscometry and rheometry sectors. Instron (Illinois Tool Works) and MTS Systems are two large vendors that, within the analytical instrument market, specialize only in physical testing. Shimadzu established its market presence through several products in physical testing, thermal analyzers, particle characterization, and viscometry and rheometry.

Materials Characterization Instrumentation Market Leaders	
Physical Testing	Instron (Illinois Tool Works), MTS Systems
Thermal Analyzers	TA Instruments (Waters), PerkinElmer
Particle Characterization	Malvern Panalytical (Spectris), Micromeritics
Viscometry & Rheometry	Anton Paar, TA Instruments (Waters)
Calorimetry	Mettler-Toledo, Malvern Panalytical (Spectris)
Petroleum Analyzers	PAC (Roper Technologies), Anton Paar



General Analytical Techniques: Steady Growth

Dissolution testing contributes to GAT demand

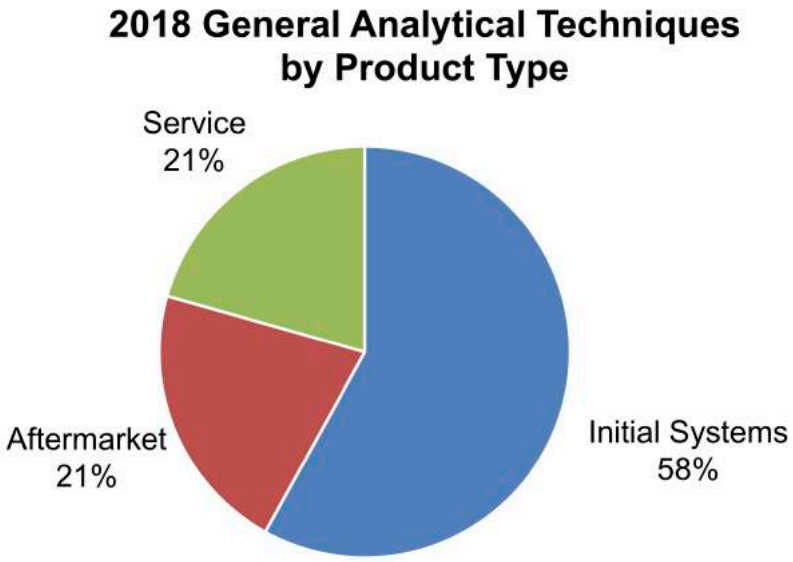


Lab balances, electrochemistry products, radioactivity products, dissolution testing systems, and continuous flow (CFA) and discrete analyzers make up the general analytical techniques (GAT) market segment. These technologies have little to do with each other, but are found in most laboratories. The GAT market is forecast to be $2.6 billion in 2019 and set to grow modestly at 3.5%.

Lab balances and electrochemistry make up over 80% of the GAT market. Both of these technology categories contain routine laboratory instruments like analytical balances and ISE/pH meters, making them common across a wide range of industries. Lab balances and dissolution testing are expected to lead the way in terms of growth for the GAT market in 2019, helped in part by the expanding number pharmaceutical and academic labs in Asia.

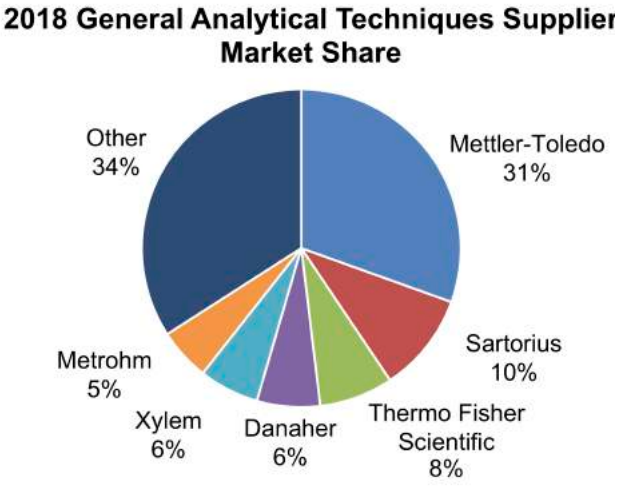
General Analytical Techniques 2018–19		
	Market Share	**Growth Rate**
Lab Balances	41.6%	4.7%
Electrochemistry	40.0%	2.7%
Radioactivity	7.9%	1.5%
Dissolution Testing	7.8%	3.5%
CFA & Discrete Analyzers	2.8%	2.8%
Total	100.0%	3.5%

Growth for CFA and discrete analyzers largely comes from the environmental, agriculture and food testing sectors. Radioactivity will experience slower growth than other GAT techniques as users opt for other techniques that achieve similar results without the need for radiation. Overall, all technologies will show close to average growth in the near future.



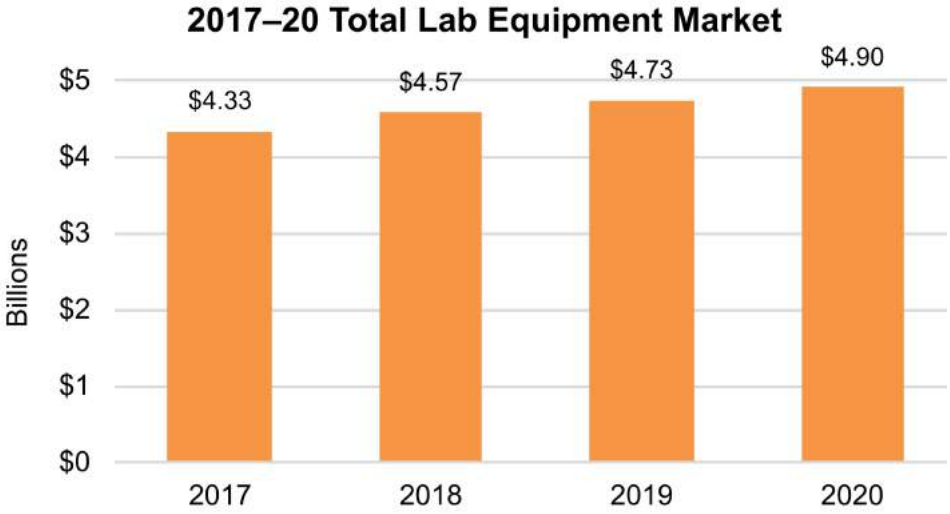
Mettler-Toledo is the leading player in this technology segment with close to one-third of the total GAT market. Electrochemistry is highly competitive with Danaher, Metrohm, Mettler-Toledo, Thermo Fisher Scientific and Xylem all vying for market share. Mettler-Toledo has a solid foothold in the lab balance segment, though Sartorius remains a major player in that market. PerkinElmer is the main supplier for radioactivity products, while Agilent Technologies is the main supplier for dissolution testing systems. Thermo Fisher holds the largest share in the CFA and discrete analyzer market. Other vendors, like Mirion, SOTAX and Seal Analytical (Porvair), are more focused and only offer products in one of the GAT segments.

General Analytical Technique Leaders	
Electrochemistry	Xylem, Thermo Fisher Scientific, Hach (Danaher)
Lab Balances	Mettler-Toledo, Sartorius
Radioactivity	PerkinElmer, Canberra (Mirion Technologies)
Dissolution Testing	Agilent Technologies, SOTAX
CFA & Discrete Analyzers	Thermo Fisher Scientific, Seal Analytical (Porvair)



Laboratory Equipment: Rising Demand

Biotech and pharma demand push growth



The lab equipment segment includes a number of technologies that are essential to everyday tasks in the laboratory but, unlike other instrumentation categories, do not make measurements. Technologies included in the lab equipment category can be found in just about every research setting. The market for lab equipment was approximately $4.6 billion in 2018, and is forecast to grow this year at 3.5%. It is expected that the market will reach $4.9 billion by 2020.

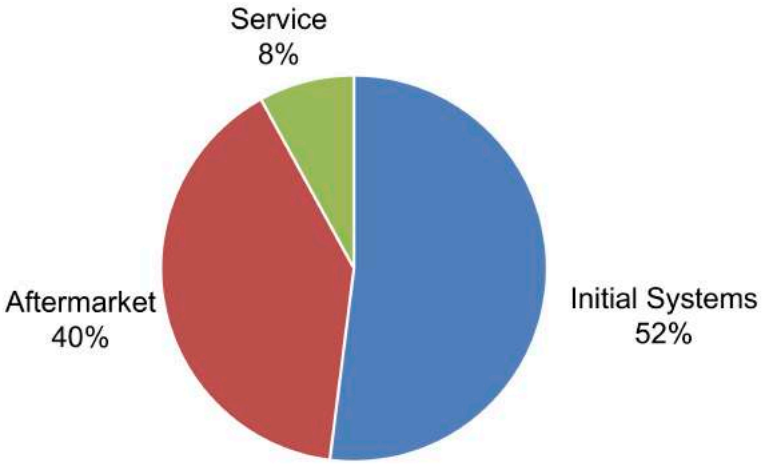
The pharmaceutical and biotechnology sector is the largest user of lab equipment, generating nearly half of total market demand in 2018. In particular, R&D applications for biologics-based therapeutics grew quickly last year, driving demand for bioreactors, incubators, biological safety cabinets and centrifuges. While the overall pharmaceutical and biotech sector is projected to perform well this year, economic headwinds in Europe that negatively affected the sector's growth in the latter half of 2018 are expected to continue.

Lab Equipment 2018–19		
	Market Share	**Growth Rate**
Lab Centrifuges	18.7%	2.3%
Transfection	15.4%	6.1%
Extraction Techniques	11.1%	2.8%
Water Purification	11.7%	4.1%
Bioreactors & Fermentors	7.2%	5.2%
Gas Generators	6.8%	4.8%
Fume Hoods	4.9%	2.2%
Incubators	5.8%	2.3%
Biological Safety Cabinets	5.0%	3.1%
Microwave-Assisted Chemistry	4.0%	3.8%
Concentrators & Evaporators	3.7%	0.6%
Lab Washers	3.4%	2.6%
Shakers & Stirrers	2.4%	0.9%
Total	100.0%	3.5%

Lab centrifuges represent the largest portion of the lab equipment market, generating about a fifth of total revenues. Isolating and separating materials is necessary for a wide variety of applications in basic and applied research. Because the market for lab centrifuges is well-saturated, demand is driven by replacement of older units and expansion in emerging regions.

Representing over a fifth of the total market, Thermo Fisher Scientific, a significant participant in nearly all technologies in the space, is the leading vendor of lab equipment.

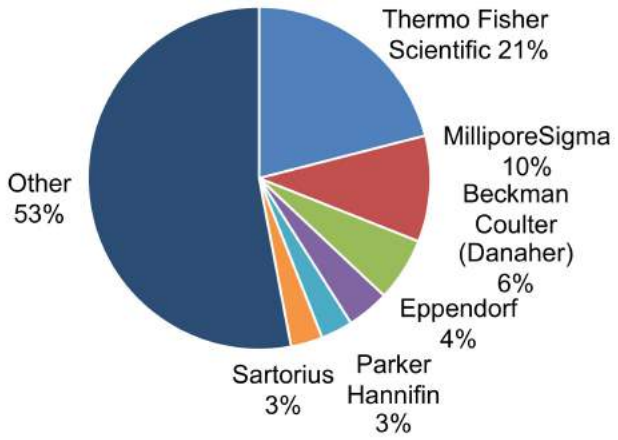
2018 Lab Equipment by Product Type



MilliporeSigma (Merck KGaA), which is the second leading supplier, also participates in multiple lab equipment technology markets. Most vendors in the lab equipment space are smaller suppliers, which each hold 1% or less share of the total lab equipment market. These “other” vendors are largely comprised of those that supply products in just one or two categories of lab equipment technologies, and equipment specialized for niche applications. Some smaller suppliers are regionally focused.

Select Lab Equipment Market Leaders	
Lab Centrifuges	Thermo Fisher Scientific, Beckman Coulter (Danaher)
Transfection	Thermo Fisher Scientific, Roche
Extraction Techniques	Waters, Thermo Fisher Scientific
Water Purification	MilliporeSigma, ELGA Labwater (Veolia)
Bioreactors & Fermentors	Sartorius, Eppendorf
Gas Generators	Parker Hannifin, Peak Scientific
Fume Hoods	Hamilton, Kewaunee Scientific
Incubators	Thermo Fisher Scientific, Eppendorf
Biological Safety Cabinets	Thermo Fisher Scientific, The Baker Company
Microwave-Assisted Chemistry	CEM, Biotage
Concentrators & Evaporators	BÜCHI, Yamato Scientific
Lab Washers	Miele, Lancer
Shakers & Stirrers	Thermo Fisher Scientific, Eppendorf

2018 Lab Equipment Supplier Market Shares



End-Market Forecast: Pharma and Biotech Strong, Industrials Falter

Biotech shines in 2018

The pharmaceutical and biotechnology industries continue to support strong growth in life science and analytical instrumentation. The drug sector will be the largest and fastest growing area across the overall market. This will apply not only to hardware and consumables, but also particularly to software and AI, as these companies adjust to deal with their internal needs to handle ever-mounting quantities of Big Data and their external needs to handle regulatory requirements, such as new traceability and anti-counterfeiting rules in the EU and US. Biotech is forecast to experience the fastest growth in demand for analytical instrumentation and lab products among any individual industry for 2019, approaching 7%.

In contrast, the industrial markets, which had quite an excellent 2018, are not forecast to have as positive a picture. While semiconductors and electronics provided strong demand for instrumentation in recent years, there are clear signs that a change is coming. Major phone suppliers like Apple and Samsung have lowered sales forecasts, while industry watchers like Gartner are forecasting challenges for the semiconductor equipment market in 2019 that will almost certainly be echoed by demand for associated instrumentation. The poor macroeconomic forecast is not likely to provide a recovery in oil prices, and this will limit spending from oil and gas laboratories and test facilities.

Public funding generally should remain favorable, with somewhat stronger emphasis on environmental testing helping to boost spending from both government sources as well as public and private utilities involved in water quality and emissions monitoring at power generation facilities. Applied markets like food and hospital laboratories should also see growth in 2019 a little ahead of the overall average for the year.

Chemicals

The chemicals industry experienced solid fundamentals in 2018, which is expected to accelerate this year. The American Chemistry Council forecast in December 2018 global chemical output to grow 3.0% in 2019 compared to 2.8% in 2017. Globally, output for basic chemicals will jump from 2.1% in 2018 to 4.8% in 2019, but specialty chemicals production will slow, rising 2.2% compared to 3.7%. US output rose 3.1% in 2018, excluding pharmaceuticals. A 3.6% rise in output, excluding pharmaceuticals, is expected this year due to returns on multiyear investments in capacity expansion.

As reported by *Chemical Week*, research firm HIS Markit forecasts emerging economies' chemicals output to rise 4.7% this year, slowing from 4.8%. Chinese production, excluding pharmaceuticals, will increase 5.1%, according to the magazine.

Also expected to accelerate this year is European chemical output, with growth of 0.5% versus a 0.5% decrease last year, according to Cefic's (the European Chemical Industry Council) December 2018 report. The organization also reported that capital expenditures by the EU chemical industry grew 3.8% in 2017 to €21.6 billion ($24.3 billion at €1 = $0.89), and estimates 2017 industry spending worldwide rose 125.7% to €202 billion ($227 billion), including €89.6 billion ($100.7 billion) of spending in China. In 2017, R&D spending by the EU chemical industry rose 1.0% to €9.7 billion ($10.9 billion). Worldwide, it reached €43.95 billion ($49.38 billion), led by China with €12.9 billion in expenditures ($14.5 billion).

Energy

The oil industry also had a fruitful 2018, but faces some headwinds in 2019 due to a possible oversupply. Oil supply is expected to reach 100.4 million barrels per day (mb/d) in 2019, up from 99.9 mb/d, according to Oil and Gas Journal. Likewise, demand is also expected to rise, jumping from 99.2 mb/d in 2018 to 100.6 mb/d this year. Biofuels supply will rise slightly from 2.6 mb/d to 2.7 m/bd.

In 2018, the US Energy Information Administration estimates US crude exports surged 81.3% 2.100 mb/d, and exports of refined products grew 6.4% to 5.550 mb/d. Liquified petroleum gas accounted for 16%, the highest percentage of refined exports.

Evercore ISI forecasts global capital expenditures for the oil industry to rise 8% this year, according to NaturalGasIntel. Wood Mackenzie forecast in December 2018 that upstream oil spending will grow 5% this year to $425 billion, up from 2%. The number of new projects, mostly natural gas projects, should total 50, compared to 40 last year. In fact, the firm forecast 60 million tons per annum (mmtpa) of foreign directly investments in 2019 in liquid natural gas projects versus 21 mmtpa in 2018.

The Economist Intelligence Unit (EIU) forecast the world's use of petroleum products will be under 1.5% this year, compared to 1.7% last year. As for renewables, the EIU states that non-hydro renewables production

will rise11.7% this year. For solar energy, Credit Suisse reported in December that worldwide solar capacity will increase 17.5% to 94 GW this year, according to pv-magazine.

Pharmaceuticals and Biotechnology

It was good year for the biopharma market, with a number of indicators promising a continuation of healthy overall industry growth. According to EvaluatePharma's June report (see ***IBO*** 6/15/18), prescription drug sales (prescription, generic and orphan drugs) are estimated to have risen 5.2% to $830 billion last year. This year, sales are forecast to climb 4.9%, led by sales of orphan drugs, which will be up 9.4% to $151 billion. Generic drug sales are expected to increase 6.0% to $89 billion, and prescription drug sales should grow 3.8% to $631 billion. According to the same report, pharmaceutical R&D spending grew 4.1% last year to $172 billion, with this year's total expected to be $177 billion, a 3.1% increase.

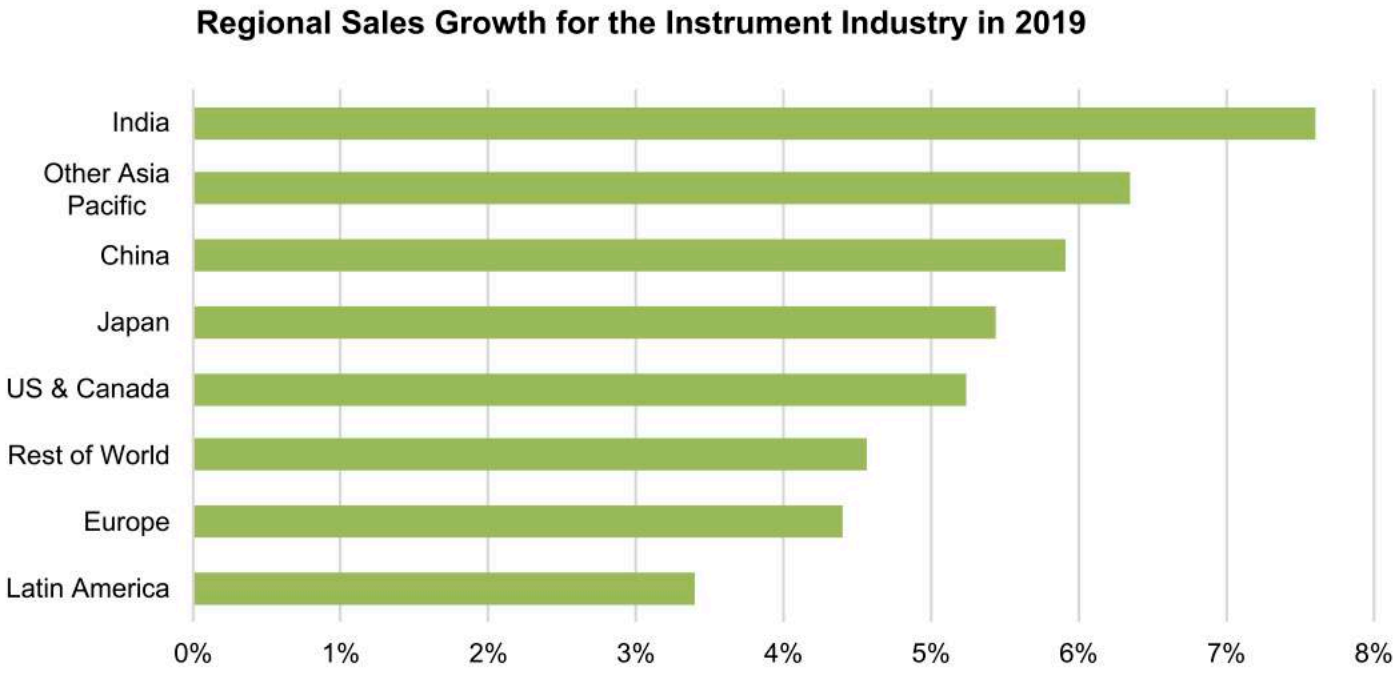
The US FDA reported 59 new drug approvals last year, the highest ever, up from 46 in 2017. Key categories were rare disease therapies, totaling 34 approvals, in addition to 19 approvals of first-in-class drugs, and 7 approvals of biosimilars. Across the Atlantic, the European Medicines Agency approved 84 drugs in 2018, up from 35 in 2017, including 42 new active substances. In December, McKinsey & Co. forecast a record 50 drug approvals for China in 2018.

Biotechnology had a particularly good year for fundraising in 2018, according to an analysis by *Nature Reviews Drug Discovery*. Seventy-one biotech companies completed IPOs worldwide (as of December 8, 2018) with $8.3 billion in returns, the highest amount in four years. RW Baird reported follow-on offerings totaled $23 billion through November 2018. According to BioPlan China, as reported on MedCityNews, Chinese life science sector investments rose 36% last year to $17 billion. Life science IPOs in the country raised $7 billion, a 40% jump.

Regional Forecast: Japan becomes attractive, Latin America in recovery

Risk factors threaten global economic growth

The Asian markets remain the primary driver of growth among the different geographic regions. While Japanese growth has long been predictably drab, the country is clearly on the upswing and should be a source of more reliable and sustained growth in 2019, although the forecast is for Japanese growth to still fall behind that of China. But given that Chinese growth has been trending downwards, Japan should become relatively more attractive among the two major sources of demand.



Nonetheless, the best growth opportunities remain in the smaller, developing markets. The fastest growth for 2019 is forecast for India, which is seeing strong investment in its all-important pharmaceutical industry, and we expect the country to be buoyed somewhat by an improving rupee. Other Asia Pacific countries like South Korea, Taiwan and Vietnam should also be strong performers in 2019.

Latin America offers great potential, but political instabilities and a number of collapsing currencies made it an unattractive market in 2018. While Venezuela remains a catastrophe and Argentina is also predicted to contract, Brazil should improve, and Mexico has remained quite reliable as a source of

growth for lab instrumentation. Nevertheless, Latin America as a whole will be the region forecast to achieve the slowest growth in 2019.

The larger markets of North America and Europe should remain in growth modes, though both regions face internal and external challenges that will put some light braking on growth. Between the two, North America is forecast to achieve slightly better growth, but both regions will hover around the overall average for the globe.

Macroeconomic Growth

Thanks to tightened financing conditions, slowed industrial production, increasing trade disputes, and market stresses in emerging and developing economies, 2018's upswing and recovery in global economic growth seems to have lost momentum. These factors have contributed to projections of declining global economy in 2019, with major economic organizations such as the World Bank and the Organization for Economic Cooperation and Development (OECD) indicating an average growth of 3.2% (see tables below). Volatility in financial markets and trade conflicts have dampened the economic acceleration of 2018 and caused numerous other factors that threaten to continue leading the global economy on its current downward trend. This dreary outlook is also reflected in the results of the fourth quarter 2018 Duke/*CFO* magazine survey, in which the majority of CFOs worldwide cited lowered optimism levels, with an expectation of a recession by year-end 2019.

According to the World Bank, global economic growth is forecast to fall a percentage point to 2.9% in 2019. This downturn is largely due to declining international trade and manufacturing activity amidst increasing trade conflicts, as well as market pressures faced by large emerging markets. Amongst advanced economies, the World Bank forecast a 2 percentage point drop to 2.0%, while predicting emerging market and developing economics will remain relatively stable at 4.2%, resulting from decelerating external demand, higher borrowing costs and uncertainties of government policies.

A number of factors that could further stall global economic activity remain possible. Commodity exportation has plateaued while, simultaneously, commodity importation has decreased. Moreover, a tighter narrowing of borrowing costs could dampen capital inflows and result in slower growth in several emerging markets and developing economies. Economic conditions could become even more volatile, as previous increases in both public and private debt could intensify vulnerability in the financial market. Trade conflicts in general, especially if they continue, can ultimately lead to diminished global growth and interfere with international interconnected value chains.

The OECD echoed the World Bank's bleak sentiments for 2019 in its November 2017 Economic Outlook. The Organization indicated that although GDP growth is strong around the world, it has all but peaked. This is due to slowing global trade and investment at a time when bilateral tariffs are increasing, as well as capital outflows and weakened currencies in emerging market economies. Although the OECD forecast a slight, 2 percentage point drop in global GDP growth to 3.5%, it warned that many risk factors remain that can worsen the projection, such as trade conflicts, stricter financial conditions and geo-/political tensions in regions such as the Middle East, Venezuela and the UK. Another factor that could make for a hard global economic landing in 2019 is the economic slowdown in China, which would affect both emerging and advanced markets, as the sharp fall in Chinese demand may set off a major decline in prices of global equity and a rise in global risk premiums.

Projections of Real GDP Growth, Selected Countries & Regions				
	OECD		World Bank	
	2018	2019	2018	2019
World	3.7%	3.5%	3.0%	2.9%
OECD Countries and Regions	2.4%	2.1%	N/A	N/A
US	2.9%	2.7%	2.9%	2.5%
Euro Area	1.9%	1.8%	1.9%	1.6%
Germany	1.6%	1.6%	N/A	N/A
France	1.6%	1.6%	N/A	N/A
UK	1.3%	1.4%	N/A	N/A
Japan	0.9%	1.0%	0.8%	0.9%
China	6.6%	6.3%	6.5%	6.2%
Brazil	1.2%	2.1%	1.2%	2.2%
Russia	1.6%	1.5%	1.6%	1.5%
India	7.5%	7.3%	7.3%	7.5%
Latin America and the Caribbean	N/A	N/A	0.6%	1.7%
East Asia and Pacific	N/A	N/A	6.3%	6.0%

In G20 economies, the OECD projected a 2 percentage point fall in GDP growth in the third quarter of 2018 to 3.6%, with Turkey, Japan, Germany and Italy facing declines. In comparison, GDP growth accelerated in Mexico, South Africa, Brazil and France, with growth remaining steady in Indonesia and Korea. India reported the highest growth at 7.5%, surpassing China, in line with the OECD's predictions last year, while Japan recorded the lowest growth at 0.1%.

Duke/*CFO* Global Business Outlook Survey Results

Duke University's Fuqua School of Business and *CFO* magazine's quarterly Global Business Outlook survey collected responses from over 500 CFOs around the world for their December 2018 quarterly edition, including 226 from North America, 48 from Asia, 82 from Europe, 122 from Latin America and

32 from Africa. The weighted average projections for capital spending and R&D are divided into global regions below.

In stark contrast to the CFO outlook for 2018, which was largely positive and broke the record for the highest US CFO optimism in the survey's history (see ***IBO*** 1/15/18), the latest survey results illustrate a broad pessimism across most global regions, with almost half of all CFOs, or 48.6%, expecting the US to be in a recession by 2019's end. Eighty-two percent of CFOs believe that a recession will definitely have begun by year-end 2020. Almost all, or 97%, African CFOs indicated they expect their countries of residence to be slumped in a recession no later than the end of 2019, similar to 86% of CFOs in Canada, 67% in Europe, 54% in Asia and 42% in Latin America.

US Outlook

In the US, CFOs predict economic growth to fall under 3% in 2019, with capital spending and employment expansion of 3%. US CFOs also cited a one in ten possibility that yearly real growth will be a nominal 0.6%, with this scenario resulting in a 1.3% decline in capital spending and stagnant employment growth. Due to this bleak outlook, CFOs are gearing for a recession within the next 18 months, thanks to factors such as a weakening economic expansion that began in June 2009, greater market volatility, protectionism that negatively impacts growth and the flattening of the yield curve which has been used to forecast recessions for the past five decades.

The topmost concern indicated by US CFOs, according to the Outlook survey, was hiring and retaining qualified workers, with employee benefits, government policies and an uncertain economic environment also cited as issues. According to Duke's Fuqua School of Business, the survey's CFO Optimism Index is considered an accurate estimation of future employment and GDP growth in the coming year, and, in line with the predictions for an upcoming recession, the survey's Optimism Index fell 5 points to 66 on a 100 point scale. Optimism about CFO's own firms' financial growth prospects also declined to 69, a two point drop. As aforementioned, both indices were at record highs in the beginning of 2018.

International Outlook

Optimism in Canada remained stable at 58, as did European optimism, which fell 1 point to 57 after a 10 point fall to 58 in the previous quarter. Specifically, optimism was 56 in France, 50 in Italy and 59 in the UK. Along with employing and retaining skilled workers, European CFOs also cited employment productivity, economic uncertainties, government policies and currency risk as the top five economic concerns in the region. CFOs across Europe expect both capital spending and employment to increase approximately 2% over the next 12 months.

Asian optimism also declined, dropping 8 points to 52, with economic uncertainty cited as the foremost concern, as well as currency risk and hiring and retaining employees. Asian CFOs expect capital spending and employment to increase nearly 10% and 2%, respectively, in 2019.

The highest CFO optimism was in Latin America at 63, with survey respondents in Brazil the most optimistic at 69, thanks largely in part to a recently elected pro-business president and administration that is helping the country recover from its notable recession. In contrast, Ecuador CFOs had the lowest optimism at 34, as the country's government is entwined in corruption scandals. Chile, Mexico, and Peru optimism was 57, 53 and 61, respectively. Latin American CFOs cited economic uncertainty as the chief concern, followed by government policies, weak demand and currency risk. CFOs in Latin America forecast capital spending to increase 2.2%, with employment expanding 2% in the next year.

In Africa, optimism was at 51, with CFOs in the region concerned most about economic uncertainty, government policies and regulation requirements. Unlike other regions, African employment is expected to decline approximately 1% in 2019, with flat median capital spending.

QIAGEN Enters New Clinical NGS and PCR Markets

Redwood City, CA, and Hilden, Germany 1/7/19—QIAGEN has announced investments in one company and the purchase of the assets of another. QIAGEN has acquired N-of-One for an undisclosed amount. N-of-One adds to QIAGEN's decision-support solutions for clinical interpretation of genomic data. "N-of-One has made tremendous strides in molecular oncology decision support, and their combination with QIAGEN's own pre-curated knowledge base of evidence will provide

powerful new tools to expand our abilities to deliver patient-specific insights," stated Jonathan Sheldon, senior vice president of QIAGEN's Bioinformatics Business Area. N-of-One's MarkerMine database will be integrated with QIAGEN Clinical Insight, a genomics analysis and interpretation platform, to support oncology. N-of-One capabilities include case-specific reporting based on molecular diagnostics, support for biomarker evidence and therapeutic options, clinical trial matching and availability of a somatic cancer database. QIAGEN cited the company's brand recognition, patient data review services, clinical trial data gathering and real-world evidence abilities as attractive.

QIAGEN also announced the expected purchase of Formulatrix's digital PCR assets for $125 million in cash and future milestone payments up to $135 million. QIAGEN plans to introduced a fully integrated, automated digital PCR solution in 2020, featuring multiplexing capabilities and higher throughput than systems that are currently available. "As the use of digital PCR continues to emerge and gains utility across a wide range of applications in Life Sciences, we plan for expansion into applications for Molecular Diagnostics," commented QIAGEN CEO Peer M. Schatz. Formulatrix said that the sale will allow it to focus on its protein crystallization and liquid handling businesses. The transaction is expected to be completed by the middle of the year, and be dilutive to 2019 adjusted EPS by around $0.03 per share and neutral in 2020.

Mr. Schatz told investors at the J.P. Morgan Healthcare Conference that N-of-One adds on-demand and real-world evidence services to its bioinformatics business, thus expanding the business's end-users to include pharmaceutical companies, healthcare providers and payers. N-of-One has 41 employees and 8 oncologists that serve as consultants. In the digital PCR market, QIAGEN will take on established players Bio-Rad Laboratories and Thermo Fisher Scientific.

Tecan Names New CEO

Männedorf, Switzerland 1/15/19—Laboratory instrument and solutions provider Tecan has named Dr. Achim von Leoprechting as its new CEO, effective April 1, replacing Dr. David Martyr who is retiring. Dr. von Leoprechting currently serves as head of the Partnering Business Division and will continue in that role as well as his new role until a replacement is found. "It is the first time in the history of Tecan that the Board was able to pick an internal successor—a clear evidence of the strong leadership team that was formed in recent years. The internal appointment also maximizes continuity of the corporate strategy," stated Tecan Chairman Dr. Lukas Braunschweiler. "Under Achim von Leoprechting's leadership, Tecan's Partnering Business has grown by an average rate of more than 9% per year and, with several newly signed development and supply agreements, it is well positioned

for further growth. His deep understanding of the end-markets and his application expertise will help the company to further benefit from major growth drivers and expand Tecan's position as a complete solution provider in select applications," commented Dr. Martyr.

*Dr. Martyr leaves the position after six-and-a-half years (see **IBO** 2/15/12). Dr. von Leoprechting joined Tecan in 2013 as head of the Partnering Business (see **IBO** 9/15/13). His has experience with both the life science research and IVD end-markets.*

Oligo Firm Acquired

West Chester, PA 1/10/19—Chiral Technologies, a provider of enantioselective chromatography and a DAICEL subsidiary, has purchased Arbor Biosciences (formerly MYcroarray) for an undisclosed amount. Arbor Biosciences offers oligonucleotide pools, including the myBaits targeted sequencing panels and services, as well as gene-editing and other prodcts for protein expression in synthetic biology applications. “As we diversify our product portfolio to serve the needs of biopharma, Arbor Biosciences delivers the molecular biology foundation to fuel that growth,” said Chiral Technologies President Joseph Barendt, PhD.

Chiral Technologies currently serves the drug discovery, development and manufacturing markets, but now the company is expanding beyond its base in chiral stationary phases and columns to DNA. In its latest medium-term plan, announced in 2017, DAICEL specified healthcare and medical systems as a priority as part of investments in new business units. The company specifically cited expanded consumables offerings as a goal. For the year ended March 31, 2018, revenues for DAICEL’s Organic Chemicals business, of which Chiral Technologies is a part, increased 17.7% to ¥82.0 billion ($743 million at ¥110.35 = $1)

Laser Ablation Assets Change Hands

Fremont, CA 1/9/18—Applied Spectra (ASI), a provider of LIBS and laser ablation technology, has purchased the rights to manufacture, sell and support three of Australian Scientific Instruments’ systems. Financial details were not provided. The RESOlution, Alphachron, and RESOchron systems adds excimer laser ablation (LA) and helium thermochronology instruments to ASI’s offerings. “The LA instrument line from Applied Spectra now encompasses solid state and excimer lasers utilizing

nanosecond and femtosecond laser pulses," commented ASI President and CEO Dr. Jong H. Yoo. "This product line acquisition allows us to access the instrument technology with its highly regarded reputation for geoscience discoveries and bring the outstanding business and technical team of ASI into our organization to continue advancing the acquired product line." Manufacturing of the systems will relocate to ASI's headquarters in California.

LA removes materials on the surface of a samples, such as metals. It is used prior to employing atomic spectroscopy techniques, such as ICP-AES, alleviating the need for sample preparation. The RESOlution system is designed for LA-ICP-MS. Also used with ICP-MS analyses, the Alphachron is a quadrupole MS–based instrument for extracting and measuring radiogenic helium in mineral samples for radiometric age dating. The RESOchron is also designed for radiometric dating.

Companies Announce Preliminary Results

Seattle, WA 1/6/19; Austin, TX 1/7/19; Tucson, AZ 1/7/19—Three life science instrument and consumables providers have announced preliminary 2018 financial results. NanoString Technologies, which supplies life science tools for translational research and molecular diagnostics, previewed year-end revenues of $106–$107 million, exceeding the company's guidance of $104–$106 million. Sales of the nCounter Analysis Systems totaled 135 last year, bringing the installed base to 730, up 20%. The company also announced pre-orders for 30 GeoMx Digital Spatial Profiler systems. Year-end cash and cash equivalents were more than $90 million.

Luminex, a provider of lab solutions for diverse markets, reported expected 2018 revenues of over $315 million, which would be near the top end of its guidance of $310–$316 million. Licensed Technologies Group revenue rose 5% to $149 million, while MDx revenue was up 13% excluding the loss of LabCorp non–cystic fibrosis revenue. The company forecasts 2019 revenues of $337–$343 million, with a 35% decline in LabCorp sales.

HTG Molecular Diagnostics, which provides HTG EdgeSeq technology for multiplexed molecular profiling, expects 2018 sales growth of 46% to $21.5 million, including a 56% increase in collaboration revenue, a 38% rise in pharma services revenue and 25% growth in product revenue. As of year-end, the company had cash and cash equivalents of $34.4 million.

Based on these estimates, NanoString's revenues will have declined 7.7% in 2018, but product revenues will be up 16.0% to $83.5 million with 17.8% growth in consumables sales to $53 million.

*(For a summary of NanoString's JP Morgan Healthcare Conference (JPMHC) presentation, see **IBO**'s latest blog, JPMHC 2019: NanoString Excels in 2018.) Revenue growth was hurt by changes in collaboration revenues.*

For Luminex, the company told JPMCH attendees that its xMap system boasts an installed base of approximately 16,000 as of the end of last year, 40% of which serve the protein research market. The company will soon launch its latest xMap platform, the SensiPlex, which will resemble its new Verigene II MDx platform.

As for HTG Molecular Diagnostics, the company's primary revenue source is a companion diagnostics agreement involving QIAGEN, which represented 72% of revenues for the first nine months of 2018.

IBO 2018 Company of the Year: Illumina

New products and markets propel company's growth

At the beginning of each year, ***IBO*** takes a look back at the prior year to spotlight a company that has demonstrated strategic accomplishments, solid execution and strong financial fundamentals. Measurements include financial performance, business developments, market penetration and new product introduction.

IBO's 2018 company of the year is Illumina. In 2018, Illumina's revenues increased an estimated 21.0% to $3.3 billion, the fastest growth in four years. For the nine months ending September 2018 (the company has not yet reported annual operating income), operating income jumped 82.4% to $686 million due in part to a decline in cost of product revenue and operating expenses as percentages of revenues.

In general, Illumina has defied conventional expectations for the instrument and lab products industry with a consistent record of double-digit revenue growth. After all, it is in the enviable position of being at the center of the NGS technology revolution in biology, dominating that instrument market and being the largest provider of premium consumables for the that market. Nonetheless, 2018 was especially noteworthy.

In 2018, the success of the company's latest flagship sequencing series, NovaSeq, which was launched in 2017, was confirmed, with system installment up around 111% to approximately 600. The company's cost effective iSeq instrument also showed rapid uptake, with approximately 350 shipments in its first year of release.

As important to Illumina was the success of the platforms was adding new customers, just as it had planned. Fifty percent of iSeq shipments and over 30% of placements of NovaSeqs went to new customers. This not only opens up new runways for consumable demand, but the company also realized its goal of serving a greater portion of the addressable market.

On the technical side, the iSeq offers the same accuracy as Illumina's benchtop sequencing, as well as 1.2 Gb per run, but at a much lower cost at less than $20,000. Consequently, the company expanded its product portfolio to address smaller labs, among others, driving its sequencing technology into new labs.

The company also rolled out the S1 flow cell, the third of its four announced flow cells for its NovaSeq 6000 system. The S1 runs a smaller number of samples, adding further flexibility and another source of consumables revenue. Announced in October, the TruSight Oncology 500 panel addresses the immunotherapy market, measuring both tumor mutational burden and microsatellite instability, capitalizing on the latest research trends.

In 2018, Illumina's results also indicated a solid foothold in fast growing markets that are a strategic focus, namely China, the consumer market, and rare genomic disease testing. The advancements in these markets were supported last year by regulatory approvals, an ongoing goal of the company, opening up further opportunities and setting the stage for future approvals.

Last year was also a significant year for Illumina as it announced two of its biggest acquisitions to date, Edico Genome (see ***IBO*** 5/15/18) and Pacific Biosciences (see ***IBO*** 11/15/18), to build internal capabilities addressing the future of the sequencing market specifically bioinformatics and long-read sequencing, respectively. These investments can be expected to better position the company in the fastest growing NGS markets, in particular diagnostics, as well as add new platforms for portfolio diversification.

Reported Financial Results

$ in Millions USD	Period	Ended	Sales	Chg.	Op. Prof.	Chg.	Net Prof.	Chg.
Bioanalytical Systems (Products)*	Q4	30-Sep	$0.97	11.0%	($0.08)	74.3%	($200.0)	NM
Bioanalytical Systems (Products)*	FYE	30-Sep	$3.9	-3.8%	$0.01	-98.9%	($0.2)	NM
Enzo Biochem**	Q1	31-Oct	$21.3	-20.9%	($6.0)	-837.0%	($6.0)	-834.5%
Kewaunee Scientific***	Q2	31-Oct	$37.7	-9.0%	$1.8	-31.0%	$1.5	-17.6%
Other Currencies (in Millions)								
Immuno-Biological Laboratories****	Q1	30-Jun	¥171,780.0	29.4%	¥35,971.0	-39.8%	¥44,717.0	-27.2%
Immuno-Biological Laboratories****	Q2	30-Sep	¥384,479.0	15.3%	¥32,924.0	-12.5%	¥45,510.0	12.0%
Scientific Digital Imaging***	H1	31-Oct	£8.0	22.8%	£1.2	40.8%	£1.2	41.7%

*=For fiscal year ending September 30, 2018

**=For fiscal year ending July 31, 2019

***= For fiscal year ending April 30, 2019

****= For fiscal year ending March 31, 2019

NA= not available, NM = not meaningful