INNOVATION

INNOVATION STARTS SMALL:

INNOVATION-DRIVEN INVESTMENT OPPORTUNITIES FOR 2024

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In an August 2022 report, McKinsey & Company defined innovation as "the systematic practice of developing and marketing breakthrough products and services for adoption by customers." Over Emerald's thirty-plus year history in investment management and research we have witnessed a multitude of innovations that have resulted in breakthrough products, services, and business models across economic sectors, creating substantial growth opportunities for those on the right side of innovation and daunting challenges for those who fell behind. Innovation has advanced technological capabilities and made life simpler, saved countless lives and enhanced the quality of life, improved productivity and forged new markets. Examples include the adoption and commercialization of the Internet, the advent of mobile computing, the mapping of the human genome leading to a wave of targeted therapeutics, the proliferation of lasers in industrial, medical, telecommunication, and computing applications, the adoption of online education platforms and learning tools, and new consumer markets for electronic gaming, energy drinks, and composite decking materials, among many others. Interestingly, while the largest companies often seem to attract the biggest headlines, small- and medium-sized companies were at the forefront of each of these waves of innovation.

Emerald's 15-person portfolio management and research team strives to uncover compelling growth opportunities across the Russell 2000 investment universe. We utilize our 10-step research process featuring approximately 2,000 company meetings annually and proprietary channel checks with customers, suppliers, competitors, and distributors to identify industry growth leaders. Research is the foundation of our investment process and the proverbial DNA of our firm – we are *Driven by Research!*

In the following white paper, members of Emerald's portfolio management and research teams explore what we believe to be some of the most compelling innovation-driven investment opportunities for 2024 and beyond. We examine how the technology sector is preparing for and being transformed by the advent of artificial intelligence, how the small cap biotechnology industry is serving as the innovation engine of the global pharmaceutical ecosystem, how advancements in medical technology are increasing the effectiveness of organ transplantations, and how the development of ultrasensitive detection technologies is aiding the early detection and treatment of Alzheimer's disease. We also go beyond the sectors most commonly associated with innovation to see how innovation is altering the market landscape and creating new and emerging growth leaders in the Consumer Staples, Energy, Industrials, and Financial Services sectors. **Above all, our goal is to demonstrate that innovation is not just an opportunity for mega-cap and large-cap investors, but that opportunities abound in the small-cap and mid-cap portions of the investment universe, creating the potential for meaningful investment outperformance.**

Innovation in Biotechnology

By Terry Smith, PhD

Investment The sequencing of the human genome in 2003 resulted in the identification of over 8,000 genetic diseases and sparked a wave of innovation that continues unabated today. Leading biotechnology companies have become adept at tying genetic data to the cause of diseases, enabling them to develop drugs that target the disease at the source. This process results in higher odds of technical success and a smoother regulatory path. Artificial intelligence and the use of *in silico* modeling is in the early days, but the pieces are in place for this to further improve efficiency within the next decade.

Industry Background

In simplest terms, biotechnology companies translate innovative science into drugs. There are approximately 800 publicly traded biotechnology companies, the majority of which have no revenue. As these companies are consuming cash, they issue new equity to fund their next set of experiments. Stocks trade on data events for the company's drug or on data presented by other companies working in the same space that alter the probability of technical success or alter the potential market size if the drug is successfully developed. We believe there is no way to effectively screen for these volatile stocks. Success as a biotechnology investor requires a deep understanding of the science underlying each company's development pipeline and the intricacies of the disease being targeted.

The biopharma industry raised about $60 billion in 2023 which closely approximates the industry's cash burn. The aggregate enterprise value of the 820 non-revenue generating biopharmaceutical companies listed on any global exchange was $233 billion as of December 29, 2023, according to January 2024 report from Stifel.

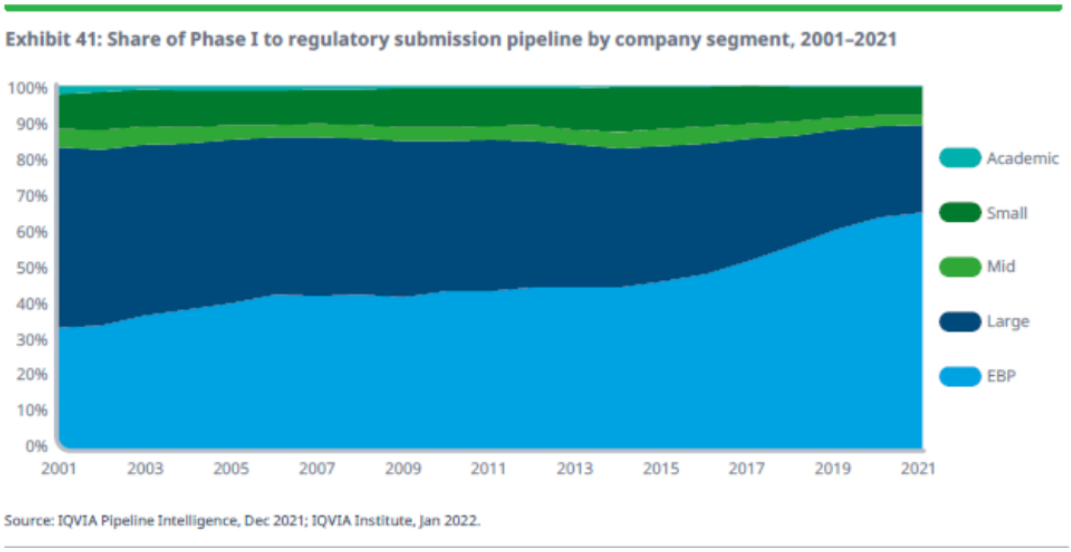
Small Cap Biotechnology is the Innovation Engine of the Pharmaceutical Ecosystem.

The innovation found at small biotechnology companies outpaces the deep pocketed R&D efforts of big pharmaceutical companies. A February 2023 study by IQVIA Institute found that large pharma has only 25% of the drugs entering first in human studies *(Figure 1),* with *"emerging biopharma companies,"* defined as biopharma companies with less than $200 million in annual R&D expense or less than $500 million of revenue, accounting for 60% of such trials and growing. The dominant share of drugs entering the clinic in the hands of small biotech companies is translating to small companies owning a significant proportion of the drugs that reach the finish line and gain FDA approval. Large pharmaceutical companies controlled only 22 of the 55 drugs approved by the

FDA in 2023, and 11 of the 22 big pharma approvals were discovered at small biotechnology companies and in-licensed or acquired by large pharmaceutical companies.

Figure 1

Emerging biopharma companies are responsible for most of the R&D pipeline, with their share continuing to grow



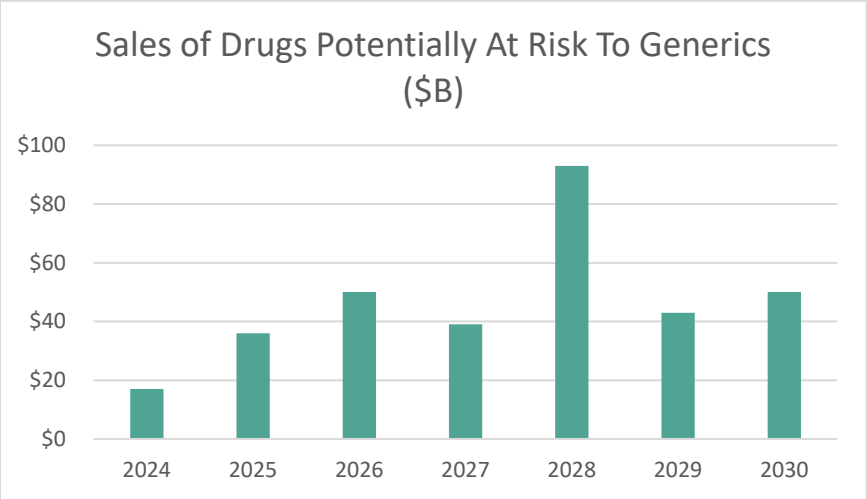
The FDA is Showing Regulatory Flexibility for New Drug Approvals

The FDA approved 55 novel medicines in 2023, the second highest number in its history. The FDA is accommodating, as the agency approved 84% of the drugs in 2023 on their first cycle. Accelerated approval is a pathway that is beneficial to small companies as drugs are approved on a biomarker that is *"reasonably likely"* to predict a clinical benefit, thus shortening the duration of the clinical trial process and reducing the cost of bringing a medicine to the market. Accelerated approval was used for 16% of the drugs approved in 2023.

Mergers & Acquisitions are Happening as Large Pharmaceutical Companies Need to Refill Their Pipeline

The top twelve pharmaceutical companies generated $580 billion in revenue in 2023. These same companies face potential generic competition on $328 billion in annual revenue before 2030 *(Figure 2)* per TD Cowen.

Figure 2



Source: TD Cowen

2023 was a busy year for mergers & acquisitions *(M&A)* with $178 billion in biopharmaceutical acquisitions consummated. There were 36 M&A deals valued at >$100 million, including a record 22 deals valued at >$1 billion, surpassing the record set in 2014. The median stock price premium for acquired biotechnology companies in 2023 was 60%. We believe this trend will continue as the top twelve pharmaceutical companies have an estimated $450 billion in M&A firepower and they have significant revenue holes to fill due to patent expirations in the coming six years, according to a September 2023 report from TD Cowen.

The Innovation Cycle in Biotechnology is in the Early Innings

The sequencing of the human genome twenty years ago sparked a revolution in biotechnology. Armed with an understanding of the molecular cause of a disease, companies were formed with the intention of translating this information into drugs. Money poured into venture-backed biotechnology startups in 2016-2019 and these companies are now maturing into publicly traded biotechnology companies. The majority of drugs in clinical trials and the majority of drugs being approved today originated within these companies. This coincides with an unprecedented patent cliff facing large pharmaceutical companies, who are cash-rich but need to refill their pipeline to sustain growth. This dynamic has resulted in a number of biotechnology companies being acquired for significant M&A premiums. We believe we are still in the early innings of the innovation cycle in biotechnology.

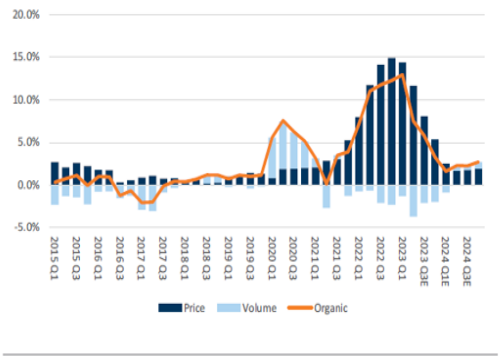
Innovation in Consumer Staples

By Joseph Garner

Consumer Staples is a sector most commonly associated with companies operating in mature industries, typically with meaningful levels of cash flow and profitability, but often little in the way of organic growth. Earnings streams and dividends tend to be relatively predictable with modest volatility, resulting in the common *(mis)* perception of the sector as one for the defensive-minded or value-oriented. We look at the sector differently. We see the opportunity for companies with emerging brands that are aligned with the evolving tastes and preferences of a new generation of consumers. Companies that are disrupting existing markets or developing new ones. Companies with relatively high levels of organic revenue growth, often several times higher than the growth rate of the industries in which they compete. Companies with growth rates driven by innovative products, innovative marketing strategies, and/or innovative distribution models. Companies who are well positioned for high levels of earnings and cash flow growth as they scale their businesses. While the companies who fit this profile may represent a relatively small portion of the overall Consumer Staples sector, they do present a meaningful opportunity for small cap growth investors to play offense and potentially realize meaningful levels of investment outperformance.

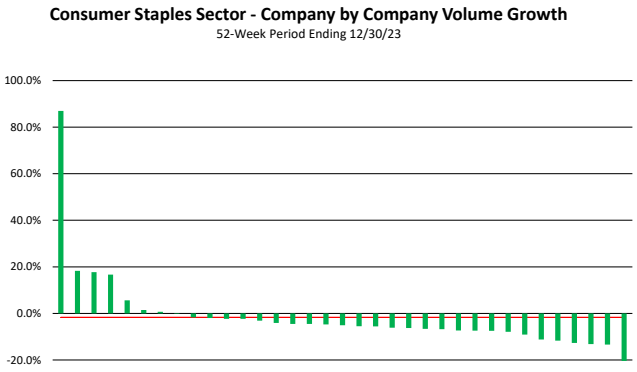
Driving Volume Growth in a Growth Challenged Sector

Figure 1. Aggregate Food Industry YoY Net Sales Growth (%)



Source: Company data, Goldman Sachs Global Investment Research

Figure 2. Volume Growth Challenging in 2023, But There Were Significant Outliers

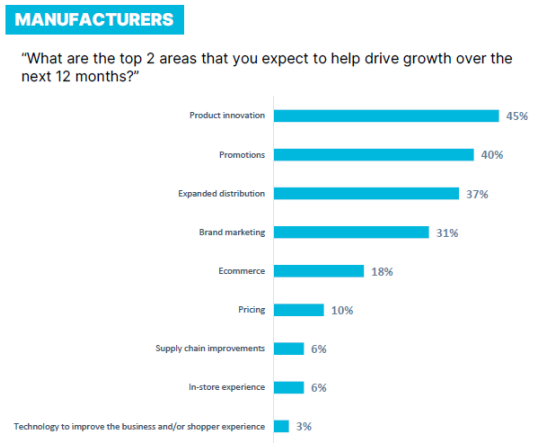


Source: NielsenIQ, Jefferies, Goldman Sachs

Long-term organic growth rates tend to be modest in the Consumer Staples sector and have largely been driven by price. This is particularly true in the sector's largest industry, food products. Figure 1 below demonstrates net sales growth for the Goldman Sachs Aggregate Food Universe dating back to 2015. With the exception of the COVID pandemic driven surge in dine-at-home activity in 2020 and early 2021, food products industry organic volume growth has largely been negative with price being the primary driver of growth. As industry-wide inflationary pressures have eased, food

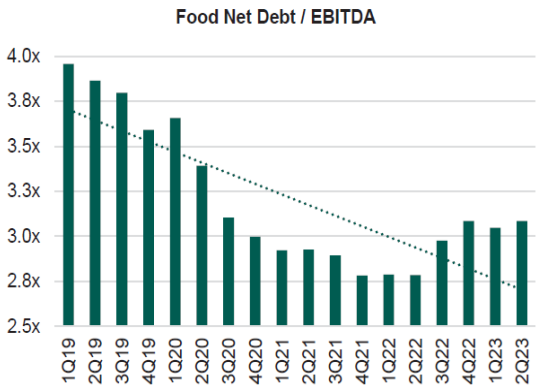
industry growth rates appear to be normalizing to historical levels in the low-single-digit range. While this is true for the overall industry, there have been some exceptions as seen in Figure 2 with a small number of companies standing out as significant volume growth outliers. What are the factors leading to out-sized volume growth? A recent Advantage Solutions survey (Figure 3) of food manufacturers indicated that three of the top four expected drivers for growth in 2024 were Product Innovation *(45% of respondents)*, Expanded Distribution *(37%)*, and Brand Marketing *(31%)*. We concur that these factors will continue to be critical to realizing high growth rates. As organic revenue growth becomes more scarce, we expect mid- and large-sized food and beverage companies to look externally to mergers & acquisitions to drive their overall revenue growth. We saw an increase in merger & acquisition activity in the Consumer Staples sector in 2023, including a number of high-profile transactions including J. M. Smucker Company's $5.6 billion acquisition of Hostess Brands and Campbell Soup Company's $2.7 billion acquisition of Sovos Brands[1]. Overall, food industry balance sheets are in relatively good shape with leverage ratios *(Net Debt/EBITDA)* near the lowest levels seen in recent years, as demonstrated in Figure 4. We believe that primary acquisition targets will continue to be innovative companies with leading brands in attractive product categories that enhance the overall growth profile of the acquirer.

Figure 3. Food Manufacturers Name Innovation as Top Growth Driver for 2024



Source: Advantage Sales Manufacturer Outlook Study, October 2023

Figure 4. Food Industry Leverage Ratios Remain at Relatively Low Levels



Source: Company Filings, Capital IQ, D.A. Davidson & Co.

[1] *Companies listed were involved in highly publicized mergers. They are included for general discussion purposes. Emerald did not hold these securities at the time of the transactions. Emerald does not currently hold these securities and does not recommend their purchase or sale.*

Innovation Focus Areas

The following are among the most interesting areas of innovation in the Consumer Staples sector:

- **Pet Food** – The pet food industry is being influenced by a number of powerful consumer mega-trends, most notably the humanization of pets and the increasing focus on health & wellness. According to Packaged Facts, over 90% of U.S. pet owners view their pets as members of the family. As the relationship with our pets has transformed to one of a companion, friend or family member, "pet parents" become more focused on the wellbeing of their pets, driving greater demand for premium products across a wide range of categories. The concurrent megatrend of increased focus on health and wellness is driving greater awareness of, and interest in, fresh, natural, and organic products. This has resulted in the rise of new premium food categories, such as fresh and fresh/frozen. We also see the evolution of retail and e-commerce models to provide a greater emphasis on premium food offerings, as well as health care and other high-value service offerings, both among traditional grocery/mass merchant retailers and pet specialty retailers.

- **Beverages** – We believe the most significant innovation and market share disruption in the beverage industry will be around the areas of zero sugar/zero calorie beverages. According to Future Market Insights, the global zero sugar beverages market is estimated to be $3.3 billion in size in 2023 and grow at a nearly 15% compounded annual growth rate *(CAGR)* over the next ten years to more than $13 billion. This compares with the nearly $400 billion global carbonated soft drink market that is growing at a 3.3% CAGR, according to Statista Market Insights. The growth of the zero sugar/zero calorie market is being driven by shifting consumer preferences away from sugar, increasing awareness of the impact of sugar on obesity and related diseases *(such as type 2 diabetes)*, innovations in non-sugar *(notably plant-based)* sweeteners, and improving taste profiles of non-sugar beverages. We also see the potential for fast-growing subsets of the zero sugar/zero calorie market to include functional beverages that provide an energy boost, hydration benefits, and targeted nutritional benefits.

- **Nutritional Snacking** – Similar to the beverage industry, we see increasing consumer interest for "better for you" offerings driving innovation and growth in the nutritional snacking market. According to Statista Market Insights, the $85.6 billion global healthy snack market is expected to grow at a nearly 7% CAGR through 2030, nearly doubling to over $150 billion in size. Healthy snacks largely consist of protein-rich foods and beverages that typically limit the use of sugars and simple carbohydrates that appeal to individuals following specific nutritional philosophies, health & wellness trends, and/or weight

management efforts. The market has expanded in large part due to successful innovations around taste and expansion into new sub-segments and form factors. This includes the expansion beyond protein bars into traditional mainstream savory and/or sweet snacking categories such as chips, crackers, cookies, popcorn, and other confectionary items.

The Key to Playing Offense in a Traditionally Defensive Sector

Innovation is providing a path to growth for companies in the relatively mature food and beverage industries within the Consumer Staples sector. Innovation-led growth is becoming increasingly critical to success as inflation and pricing power wanes, making consumer packaged goods companies more reliant on volume to drive organic revenue growth. Sustainable volume growth requires a growing category, market share gains in existing categories, and/or expansion into new categories. The best way to achieve this is with innovative products, novel marketing strategies, and enhanced distribution capabilities aimed at disrupting the status quo. This is happening across a broad range of industries, including pet food, beverages, and snack foods, among others. Leading market disrupters offer investors two potential ways to win. One is by emerging as a new market/category leader. The second is by becoming an attractive acquisition candidate for mid- and large-cap consumer packaged goods companies seeking new avenues for growth. The industry backdrop of weaker volume growth and generally stronger balance sheets among the larger industry players potentially makes this an ideal market environment for merger & acquisition activity. **As such, innovation is key for investors to play offense in the traditionally defensive Consumer Staples sector.**

Innovation in Energy & Industrials

By Erik Cianci & David Volpe, CFA

When discussing innovation and disruption the sectors that first come to mind for most investors are likely technology and healthcare. Those sectors certainly power a great deal of innovation and disruption in our economy, but most investors do not realize the level of technological innovation and advancement occurring in both the traditional and non-traditional energy industries. Within these industries, record amounts of hydrocarbons are being extracted with a decreasing number of rigs. Companies have introduced electric fracturing and intelligent fracturing systems, as well as developed innovative solutions for carbon capture and battery storage and invented new methods to efficiently monitor Methane and other polluting chemicals at refineries and wellheads. The energy companies of today are at the vanguard of technological change that will bring more economical, safer, and environmentally friendly energy to consumers and businesses for decades to come.

Much has changed in the energy sector since we wrote our last energy whitepaper one year ago. Sustainable energy shares, particularly small caps, by and large have retreated meaningfully in the face of higher capital costs, regulatory delays or inaction, slower adoption, and inventory over-builds. Traditional energy companies have fared better but in many ways are becoming a victim of their own success with improved well productivity and drilling and completion advancements driving production higher with fewer rigs and completion crews. One thing that has not changed is the pace of innovation, especially in the small-cap companies that we research. These companies are helping to drive down the cost of both traditional and renewable energy and improving efficiencies and productivity in the recovery and deliverability of these energy sources.

Clean energy is important because under most Net Zero 2050 scenarios the CO2 reduction from existing technologies will need to be supported with the deployment of technologies which are still in development or are not yet commercially competitive. Recent advancements in energy transitions have been significantly fueled by technological innovation, marked by decreasing costs and enhanced performance of crucial technologies like solar panels and electric vehicles, alongside significant improvements in energy efficiency. To get on track for net zero, innovation will need to accelerate further, particularly to address sectors where decarbonization is hard or impossible with available technologies, like heavy industry and long-distance transport.

Since our Energy research team started writing white papers three years ago, significant advancements in technology readiness are evident in specific sectors such as certain electric vehicle batteries, the production of low-emission hydrogen, and carbon capture processes in cement manufacturing. Despite challenges like the global energy and macroeconomic crisis, Russia's invasion of Ukraine, and the lingering effects of the Covid-19 pandemic, investment in

innovation is on the rise. This is evident through increasing public and corporate budgets for energy research and development and growing venture capital funding for clean energy startups. Significant policy initiatives, like the Inflation Reduction Act in the United States, the European Union's Net Zero Industry Act, and China's ongoing 14th Five-Year Plan, have the potential to greatly boost innovation and enhance the market viability of emerging technologies.

Renewable energy sources are expected to be the primary source of growth in the U.S. electric power sector for the next several years. Much of the growth in generation and capacity is expected to come from utility-scale solar and battery storage. According to the U.S. Energy Information Administration (EIA), solar alone will account for approximately 59% of new electricity installations in 2024 and approximately 67% of new installations in 2025. At the end of 2023, the U.S. had approximately 16 GW of operational utility-scale battery storage. Developers are planning to add an additional 15GW in 2024, which would imply year-over-year growth above 90%. This growth is driven by improved economics as costs have continued to decline, as well as governmental policy support via the Inflation Reduction Act.

The cost of new energy technologies such as wind, solar, and batteries has fallen by 60-80% in the past ten years as seen in Figure 1. Adoption of these technologies is experiencing a classic S-curve that we believe they will continue to follow. This is driving unprecedented demand for these technologies now representing approximately 4% and approximately 12% of electricity generation in the U.S., respectively. This compares to 0.1% and 0.2% in 1990. We believe, the current issues of higher costs of capital and regulatory uncertainty are transient and the sector will remain on the projected trajectory – see Figure 2.

Figure 1: Trajectory of Clean Energy Costs – Source: Rocky Mountain Institute (June 2023) - rmi.org

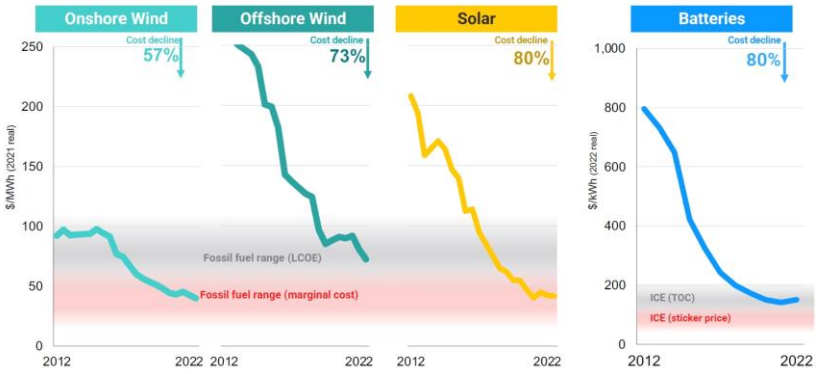
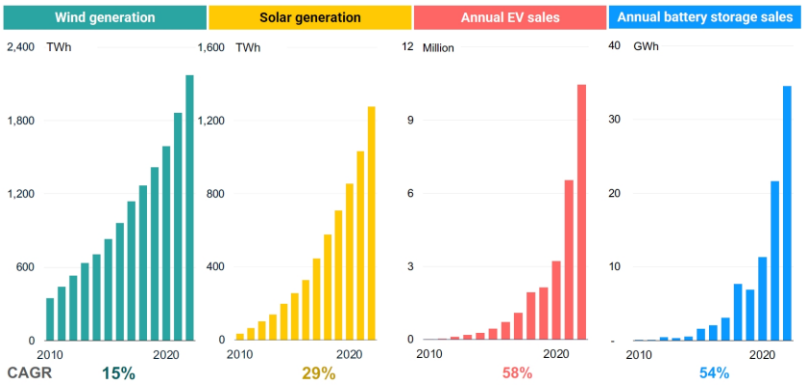


Figure 2: Capacity Growth of Renewable Energy Technologies– Source: Rocky Mountain Institute (June 2023) - rmi.org



Within battery technologies we have seen the introduction of the first commercial production of electric vehicles powered by critical mineral-free sodium-ion batteries. These batteries avoid less abundant critical materials and lithium but come with significantly less energy density which will restrict them from most of the EV market, and in our opinion, are better suited for stationary storage. We are believers that for most of the EV market, both commercial and personal, there is no avoiding the use of certain critical materials. Emerald has identified and invested in what we believe are world-class sources of rare critical materials.

Hydrogen is a rapidly evolving space with continuous improvements and new technologies seemingly every year. In the last couple of years, two of the largest solid oxide electrolyzers (SOEC) started production of hydrogen in 2023. SOECs stand out as the most efficient among various electrolyzer designs, leading to reduced electricity consumption. They can also be seamlessly incorporated into industrial setups that produce waste heat. Moreover, compared to the two predominant electrolyzer types currently in use (alkaline and proto exchange membrane), SOECs require fewer critical materials. The simultaneous use of multiple electrolyzer designs can contribute to diversifying and strengthening the resilience of the electrolyzer supply chains.

Wind has typically been a larger portion of Net Zero initiatives. However, the economics of electricity from wind lean significantly to offshore wind. Floating offshore wind parks are reaching unprecedented sizes. Around 80% of the global offshore wind potential is in waters deeper than 60 meters, where floating turbines are essential. Additionally, floating offshore wind can aid in hydrogen production, furthering broader decarbonization initiatives. Offshore wind is not new but successful commercialization of projects is relatively new with the first commercial project, Hywind Scotland (30 MW), turning operational in the UK in 2017. Floating offshore wind capacity in 2022 was approximately 190 MW, only ~0.3% of the total offshore wind capacity. However, technological advancements and cost reductions are encouraging countries and corporations to expand and incorporate floating offshore wind into their energy strategies. Floating offshore wind currently carries a 50% higher price tag compared to fixed-bottom off-shore wind. To ensure the technology's success, significant cost reductions are essential, potentially achievable through strategies like standardization and modularization. The US-led Floating Offshore Wind Shot initiative is targeting a 70% cost reduction to reach $45/MWh by 2035.

Within industrials, we're seeing energy innovation in several types of building materials. Vacuum Insulation Panels (VIPs) represent a thin but highly effective insulation material, making them particularly suitable for situations where space is at a premium, such as in many urban settings. VIPs are especially crucial for retrofitting existing structures that will still be standing but that will

not meet future energy efficiency standards. This renovation aspect is vital in the pursuit of achieving net zero emissions.

Low-CO2 cement production is gaining momentum as well. This involves direct CO2 emission separation during the production process. This technology is important because process emissions from limestone calcination account for around two-thirds of the global cement industry's emissions and are the most challenging to reduce. To diminish these emissions, the widespread implementation of cost-effective carbon capture is essential. Direct separation, achieved by calcining limestone in a sealed vessel, allows for the collection of a concentrated CO2 stream. This not only simplifies the capture process but is also expected to significantly reduce capture costs. With low- or zero-carbon heating sources, this method could enable nearly zero-emission cement production.

Emerald has researched and invested in energy and energy related equities that are transforming the way we produce and transport virtually all energy sources, from oil and natural gas to hydrogen, solar and wind. This transformation is resulting in a quantum leap in productivity, affordability, environmental sustainability, and reliability. Examples of transformational innovations include:

- Well completion *(fracturing)* systems that measure and act on real time downhole measurements, speeding decision making, improving recoveries, and reducing costs.
- Chemical and electrolyte mixtures improving the performance of efficient, reliable and environmentally friendly long duration energy storage systems.
- Solutions for both small and industry scale Carbon Capture storage with over $2.5 billion in current pipeline opportunities.
- Battery storage innovations improving density and optimizing discharge/recharge cycles to optimize grid reliability.
- Innovations in panels and wiring for utility scale solar to increase yield and reduce labor and maintenance.
- Geospatial technologies used to identify the best locations for solar and wind installations.
- Increasing use of trimulfracs in hydraulic fracturing to reduce downtime, chemical costs, fuel usage, and realize first oil faster.

It has been said that *"disruption is either going to happen to you or because of you."* Today's energy and energy-related companies are firmly in the later part of the saying, as they are in the process of changing the way consumers of energy purchase, sell and use energy for electrical, heating, motive, industrial and many other uses. Emerald focuses on investing in companies that are driving this transition which includes companies focused on minerals and other "picks and shovels" suppliers to infrastructure innovators and winners on the cost curve.

Innovation in Financial Services & Real Estate

By Ori Elan

Insurance:

There is a commonly held perception that the insurance industry is ancient, a laggard in technology, digital distribution and customer service. However, Artificial Intelligence *(AI)* and Machine Learning *(ML)* are being used by large insurance carriers to optimize their operations and automate repetitive, routine tasks. In recent years, smaller technology companies have been applying significantly more computing power to enable faster, better, cheaper means of competing, thus reshaping the traditional insurance landscape. These digital innovators are building better systems and platforms from the ground up using AI, bots, ML, and IoT (Internet of Things) devices, to collect, process and understand data at a much deeper level than ever before. That data is then used throughout the insurance value chain to improve customer segmentation, risk analysis, pricing, and interaction with customers as they buy policies or submit claims. This process is reiterative, and as more data is collected, the model becomes more accurate and provides a distinctive competitive edge.

We foresee wider use of AI throughout the industry as an important cost cutting and risk mitigation tool that will eventually take over many sophisticated tasks that now require human intervention. Some examples of the use of AI in insurance are: Examining policy documents or photos related to a claim and evaluating the claim based on its findings; assisting insurers with underwriting and issuing policies by automating simple administrative tasks such as data-entry, sending renewal reminders, and interacting with customers, as well as analyzing data such as estimating and pricing the risk of an applicant through examination of large datasets; virtual assistants like chatbots for customer interaction; and expediting the application process by providing quicker policy approval with more customized and accurate rates.

As AI gains wider adoption and customers trust its accuracy, it will play a more crucial role toward improving efficiency and customer satisfaction. For now, we believe that customers prefer hybrid human-AI solutions rather than one with predominantly either AI or humans.

Real Estate:

AI use in the real estate industry is widening and the applications of this evolving technology are expanding beyond the obvious process automation use case. Many constituents of the industry are finding ways to harness the power of high-performance computing, from property managers and developers to real estate agents and brokers to data and services providers. There are now technological solutions for almost every aspect of real estate functions, including investment management, design and construction, building and facility operations, portfolio management, leasing, marketing, and transactions. AI works best when used on large data sets. Thankfully, the

real estate market has lots of it. Every transaction, development, maintenance work, and lease plus the associated demographic statistics and geographic trends have also been recorded over many decades. This data can provide hundreds, if not thousands, of elements that could help to optimize the decision-making process for building a property in a certain market, finding buyers or sellers, creating marketing materials, or even managing leases and rents across multiple properties and tenants.

Some AI use cases for property managers and developers include price modeling and prediction for investment management, market analysis, satellite image processing for asset valuation and risk management, IoT data mining for automated facility management and predictive maintenance, and recommendations for leasing and investment transactions. Real estate agents and brokers are utilizing the power of generative AI to create marketing collateral, find relevant properties for their clients, predict market competitive property value, perform advanced market analysis, and provide personalized customer experience. For example, there are several publicly traded small cap real estate brokerage companies that have built a technology platform that eliminates the need for a centralized physical location (i.e. office), digitally streamlines the home buying and selling process, and provides personalized services for agents and their clients. These companies are meaningfully reducing operational and transaction costs, thus allowing agents to keep a larger portion of the commissions they generate. We believe that these digital AI enabled solutions are "better mouse traps" that are revolutionizing the industry.

AI will automate many tasks traditionally performed by developers, managers, and agents. Technology will enhance the products and services provided, by making them more efficient and cost effective. However, AI will not replace the most important aspect of the real estate industry which is relationship building and providing a personal touch to clients.

Innovation in Health Technology – Medical Devices & Diagnostics

By Nishit Trivedi, PhD, MBBS, MBA

The Medical Devices industry has seen significant innovation over the last decade in many areas including diabetes management, minimally invasive surgical techniques, novel heart valves and newer forms of robotics for faster and more efficient surgical procedures. **Two areas of emerging interest are the areas of organ transplant management and novel treatments for Alzheimer's disease.** Innovation in broadening the effectiveness and reach of organs for organ transplant surgeries is meaningfully expanding the market for these lifesaving procedures. New therapeutic advancement in the treatment of Alzheimer's disease has reinvigorated the interest in Alzheimer's management and as newer therapies come to the market several diagnostic companies are making an effort at bringing to the market newer tests to detect patients earlier. Using newer tools of detection, scientists can now detect biomarkers linked with Alzheimer's in human blood samples and this could significantly improve access and drive down costs for both the patient and the healthcare system.

Broadening the Effectiveness and Reach of Organ Transplants

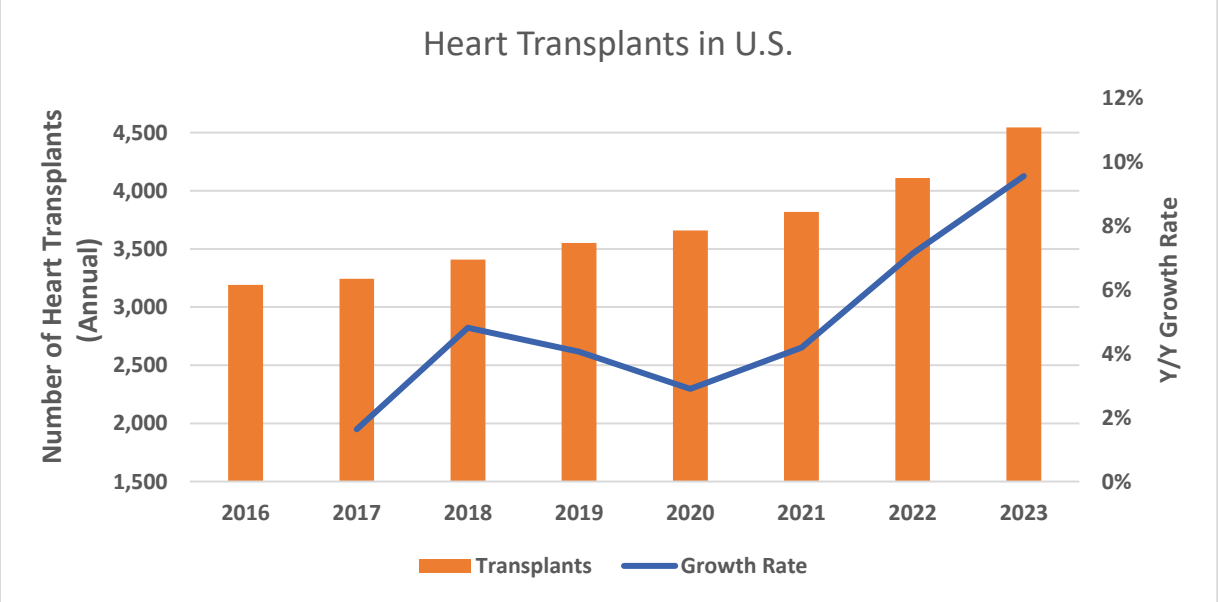
During the past 18 months, an innovation that resonates with the theme of this white paper occurred within the organ transplant industry. Organ transplant centers in the United States provide a very valuable service that has meaningfully impacted the lives of thousands of patients annually. Just in 2023 transplant centers in the United States performed a record level of 46,630 transplants, as reported by the United Network for Organ Sharing *(UNOS)*. As the incidence of end-stage organ failure has been rising worldwide, organ transplantation is the treatment of choice for addressing end-stage organ failure due to its positive clinical outcomes and favorable health economics. Even after decades of innovation in cardiology, heart transplants remain as the gold standard for treatment of select patients with end-stage heart failure because of the superior quality of life and the one-year survival rate of 85-90% post-transplant.

The demand for organ transplants remains strong with 103,310 patients on the waiting list in the United States as of Jan 1, 2024. The key challenge faced by the industry was how to procure more organs and overcoming the traditional challenges of cold storage, which was the standard of care for organ transplantation. Cold storage traditionally has been a rudimentary approach to organ preservation in which a donor organ is flushed with cold pharmaceutical solutions, placed in a plastic bag on top of ice and transported in a cooler. Cold storage, while useful to transport organs over smaller distances, is less ideal when considering transporting organs over larger distances. During the past decade several entrepreneurs have tried to address these challenges and created today's modern technologies, which can allow for ex-vivo perfusion of the donor organ with

oxygenated blood. Having the ability to store an organ more efficiently and being able to monitor its vitality during the transport allows transplant centers to plan procedures more effectively and, in some cases, utilize more organs from the same patient when multi-organ transplants are required. This would have been difficult without these modern transportation and storage technologies because of the limitations of prolonged cold static cardioplegic preservation. Organ Transplant centers are now also able to source organs for their patients from much farther distances allowing for more access, which is helpful for supporting more patients. The US FDA announced approval of Organ Care System *(Liver),* Organ Care System *(Lung)* and Organ Care System *(Heart)* in 2021 and 2022, which has allowed transplant centers to procure organs from almost 2,000 miles away, distances which would have been almost impossible without some of these newer innovations in preserving and transporting organs.

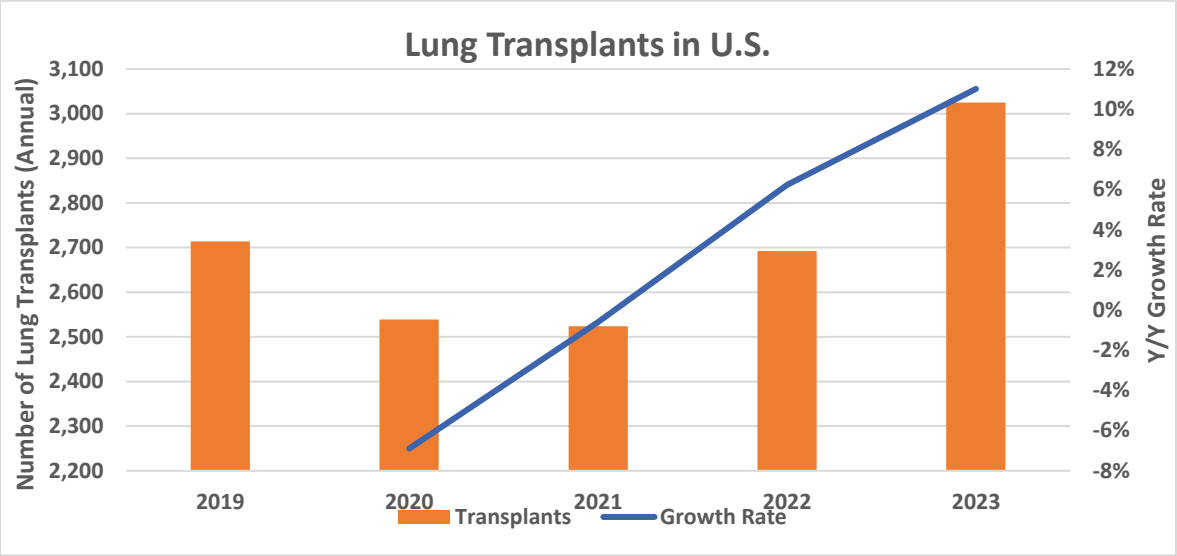
The impact of organ transplant innovation can be immediately seen in the acceleration in the number of Heart, Lung and Liver transplants done in the United States in 2023 versus the period of 2011 - 2021. According to UNOS data, there was a meaningful expansion in the number of heart, lung and liver transplants in the United States during the past 18 months, as seen in Figures 1-3 below. For example, the Heart Transplant numbers which used to grow 4-5% annually from 2010-2020 are now growing at an almost 10% rate in 2023 allowing for more patients to benefit and realize a better quality of life.

Figure 1: Heart Transplants in United States



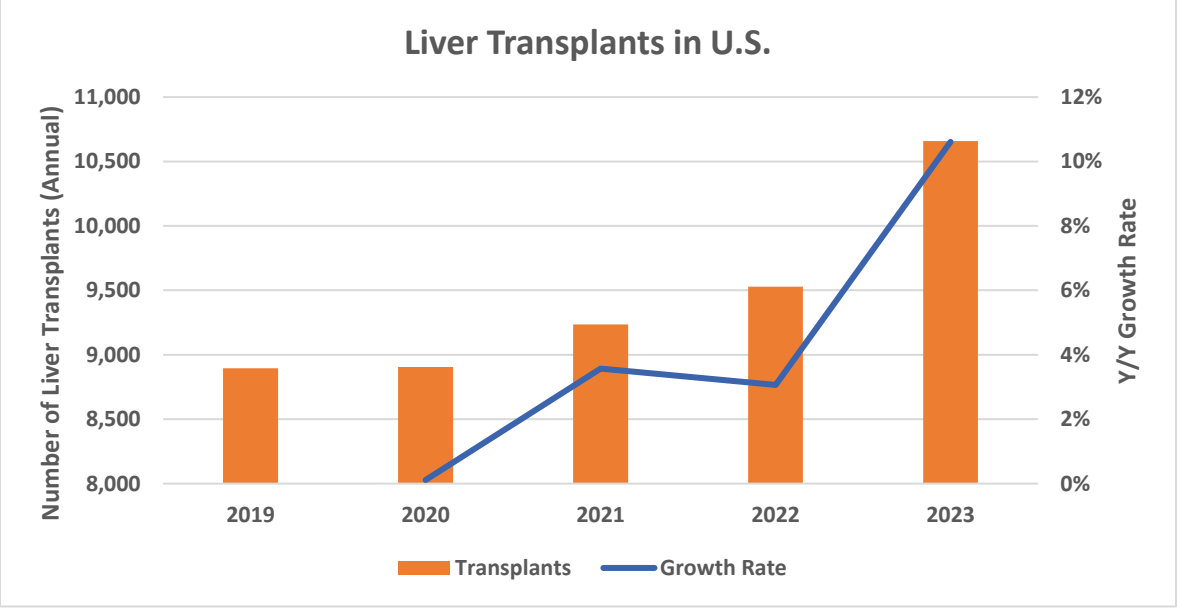
* *Source: United Network for Organ Sharing and Organ Procurement and Transplantation Network*

Figure 2: Lung Transplants in United States



**Source: United Network for Organ Sharing. UNOS.org*

Figure 3: Liver Transplants in United States



**Source: United Network for Organ Sharing. UNOS.org*

Medical Diagnostics and Advancements in Treating Alzheimer's Disease

Alzheimer's disease is one of the major challenges of the 21st century. As of 2023, an estimated 6.7 million Americans were living with the disease. According to the Alzheimer's Association one in nine Americans over the age of 65 will be impacted by this disease. This is a disease characterized by the accumulation of the protein fragment beta-amyloid into clumps *(called beta-amyloid plaques)*

outside neurons and the accumulation of an abnormal form of the protein tau *(called tau tangles)* inside neurons. These amyloid plaques and neurofibril tangles disrupt neuronal communication as connections among networks of neurons breaks down. In July 2023, the US FDA announced that Leqembi *(lecanemab)*, which had been indicated to treat adult patients with Alzheimer's Disease, was converted to traditional approval following a determination that a confirmatory trial verified clinical benefit. Leqembi is the first amyloid beta-directed antibody to be converted from an accelerated approval to a traditional approval for the treatment of Alzheimer's disease. The drug works by reducing amyloid plaques that form in the brain, a defining pathophysiological feature of the disease. There are also several other late-stage therapies in clinical trials which look promising and all this collectively has created significant enthusiasm within the neuroscience community. We believe there will be renewed interest among patients suffering from dementia and memory loss to evaluate their symptoms to determine if they have Alzheimer's dementia and would be candidates for these newer therapies. We also believe that more patients would benefit from these treatments if they were identified earlier in their disease progression. The current gold standard for diagnosing Alzheimer's disease is Positron Emission Tomography *(PET)* scans. Here clinicians study the brain amyloid PET scan that uses FDA approved radiotracers to provide a confirmatory diagnosis of Alzheimer's. While accurate, it can also be expensive, and the limitations of getting access to a specialized scan may limit or delay access to crucial therapies. To overcome this challenge, scientists are now increasingly focused on novel Blood-Based BioMarkers *(BBBM)* such as pTau-181, pTau-217, NfL (neurofilament light chain) protein, glial fibrillary acidic protein (GFAP) and others that have shown significant value by providing a non-invasive way to diagnose and potentially monitor the efficacy of the therapy. One of the more attractive biomarkers currently appears to be p-Tau. Tau proteins are responsible for maintaining neuronal structure and function but in Alzheimer's, these proteins undergo abnormal hyperphosphorylation. The Global Alzheimer's Platform (GAP) Foundation has been working for the past 2 years on a large study "Bio-Hermes" which has enrolled over 1000 volunteers and it is examining 14-blood based biomarkers and more than a dozen digital tests to better understand the role that various biomarkers can play in detecting Alzheimer's. This project shows the collaborative effort between leading biopharma, diagnostic companies and not-for-profit partners collaborating around the United States. There were significant new advances highlighted in presentations and posters at the 2023 CTAD conference which remain very promising towards this aspiration of finding newer blood-based biomarkers that could be more convenient, less invasive, and more cost efficient at being able to screen for patients with Alzheimer's and other neurological conditions.

Small Cap Innovators Positively Impacting Large Patient Populations

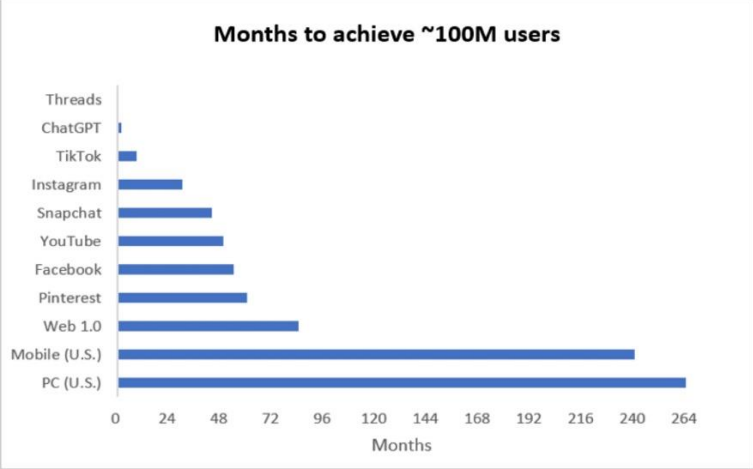
Recent developments in the areas of organ transplantation and the diagnosis and treatment of Alzheimer's disease are two notable examples of innovation driven by small-cap

companies that have the potential to positively impact large patient populations. The advances with newer devices to support the transport of transplant organs are disrupting and enhancing the entire organ transplant industry ecosystem. In addition, ultrasensitive detection technologies arising from small cap leaders in the medical diagnostics industry have the potential to completely change the workflow for Neurologists in identifying and treating Alzheimer's disease. These are just a few examples of a robust wave of innovation impacting the Health Care sector that have the potential of enhancing the quality of care and improving the health outcomes for countless individuals worldwide.

Innovation in Technology – AI AIn't Just for Mega-Caps

By Stephen Amsterdam, Derek Fisher & Nathan Jones, PhD

No discussion of innovation within the technology sector would be complete without recognizing the profound impact Artificial Intelligence *(AI)* is having – and is expected to have – on both the market and potentially the future of humanity. The innovation currently known as AI originated as rudimentary machine learning in the 1950's, with evolutionary progress over the next 40-50 years. The early 2000's saw the first introduction of what is now considered "AI" into the marketplace with, of all things, a robotic vacuum cleaner that could learn to navigate its environment. In 2014, Amazon introduced Alexa which embedded some linguistic AI into its voice interface. The final, foundational leap in large scale AI was accomplished in 2017 with the creation of the first "Transformer" model. The introduction of ChatGPT *("Generative Pre-trained Transformer")* captured our collective imagination in 2023 and as the world learns to harness the unique capabilities of ChatGPT and other foundational large language models *(LLMs)*, a multitude of innovations across nearly every facet of our lives will begin to be recognized – and monetized.



Source: Raymond James, Visible Alpha, Company Reports

Not surprisingly, market potential and growth rates for this opportunity vary widely, but all are breathtaking. According to Statista, the expected annual growth rate of AI is 37.3% between 2023 and 2030, with the AI market size projected to reach $407 billion by 2027. Generative AI is projected to become a $1.3 trillion market over the next ten years, according to Bloomberg Intelligence. In a March 2023 report, Goldman Sachs estimated that 300 million jobs could be lost or diminished by AI, but the adoption of deployment of AI technology will also lead to the development of new types of jobs.

Today, when investors talk about Artificial Intelligence *(AI)*, most are focused on either the companies building large language models attempting to recreate general intelligence, or companies focused on designing the processors themselves. We concur that the capital required to create and run these large language models, as well as the semiconductor chips necessary to perform the calculations, is such that most smaller cap public companies will not be able to become leaders in those specific segments. **However, we strongly contend that while these models/processors are critically important to the overall success of AI, those segments will not be the only investable trends as the AI market evolves; indeed, opportunities exist across the entire market cap spectrum.** As a general reminder, the capital spending *(Capex)* and cost-of-goods-sold *(CoGS)* of large- and mega-cap companies represent revenue for mid- and small-cap firms.

AI-focused workloads are causing a fundamental re-architecting of the datacenter in its entirety. This change is the result of multiple factors – all of which create opportunities within smaller, often pure-play companies. While by no means a comprehensive list, below are a few examples of system*(s)*, hardware, and infrastructure investments advantaged by the growth of AI:

- **The chips required for AI are some of the most complex designs ever imagined and require the most advanced manufacturing methods,** as well as a significantly increased reliance on complex packaging technologies. The emergence of generative AI has accelerated advanced packaging adoption and newer heterogeneous packaging technologies. Thus, while semiconductor packaging and test has historically been a highly cyclical industry, AI may add a secular growth driver that could amplify a cyclical recovery in 2024 after 2023's pronounced contraction.
- **An AI server is a specialized piece of equipment.** Many of the larger AI companies require highly customized server designs for their AI systems. This creates an opportunity for contract manufacturers with requisite hardware engineering skills to gain significant market share. For many large AI companies, supply chain relationships, and flexibility to rapidly design, customize, optimize, and produce AI systems is of paramount importance during this early stage of the market.
- **The power requirements of an AI server are multiple times greater than a typical server due to the immense computational load.** Power is becoming THE fundamental requirement of a datacenter, and the availability of power is the gating factor of datacenter growth. Requirements for power per rack are increasing dramatically, but space allocated per rack is largely unchanged. The heat generated by AI servers causes multiple issues and thus cooling becomes a more meaningful problem as density and heat increase. In response, power supplies are being redesigned to utilize more efficient compound semiconductors

that can deliver more power and generate less heat while cooling technology is evolving to better handle operating temperature limitations.

- **Datacenter operators are faced with demand that is forecasted to meaningfully outstrip current capacity due to the proliferation of AI applications and the additional power requirements.** McKinsey estimated that in the US alone, 35GW of total datacenter capacity will be needed in 2030 versus just 17GW in place in 2022. Whether this goal is achievable is subject to debate, but the demand for datacenter power is undeniable, which is leading to a potential investment cycle in datacenter operators that desire to build AI-optimized datacenters with power, cooling, and reliability requirements specific to batch-AI workloads *(as opposed to mission critical, low latency workloads)*.
- **Beyond power and cooling, the infrastructure of a datacenter is evolving to accommodate the higher bandwidth requirements of machine learning and AI.** Optical technology is transitioning to higher speeds and potentially coherent light to better manage bandwidth requirements. Debate continues regarding a transition from direct-attach copper cables to either active copper or optical, which may present yet another infrastructure investment opportunity.

Memory and memory architectures are expected to undergo an evolutionary step to accommodate the requirements of AI, and although the timing is somewhat uncertain, a transition to a new technology paradigm potentially brings with it both a product and IP investment cycle.

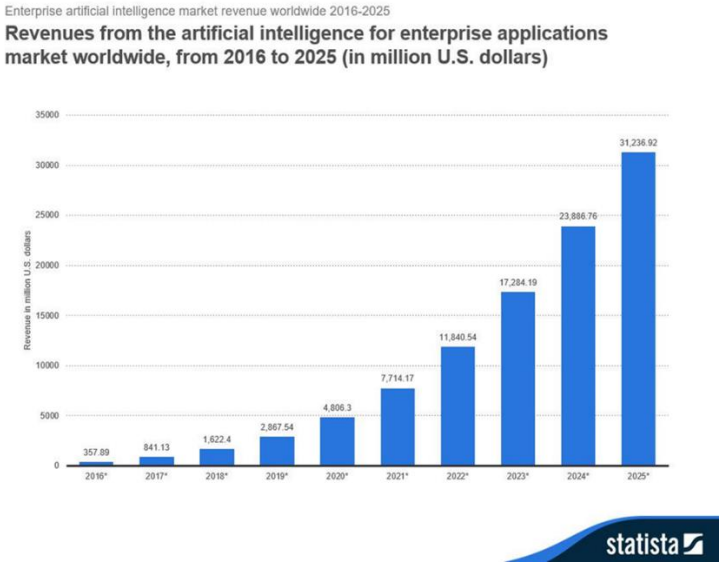
Applications of AI in the Marketplace

We believe that applications utilizing artificial intelligence will continue to evolve over the next several years. Most people have already interacted directly with some form of AI through a recommendation engine, virtual assistant, or chatbot; however, the influence of AI in applications is dramatically more far-reaching.

Many enterprise software vendors have already integrated some AI functionality into their products to help provide advanced analytics, sentiment analysis, or text generation. At this point, most AI integration has been focused on maintenance automation and process optimization, but its use is expected to proliferate broadly.

Not surprisingly, information technology services and software development companies have been early adopters. Many have begun to use AI to facilitate better software development using machine learning and predictive analytics, enabling developers to predict and fix bugs, test software more efficiently, and understand user behavior.

Adoption of AI is not limited to traditional technology companies. Firms are using AI internally to increase efficiency by automating routine tasks such as data entry, billing and collections, and customer relationship management. The financial services, legal, and real estate industries are beginning to accept AI's ability to provide drafts of basic documents. The power of AI-enabled predictive analytics also extends into industrial use cases where they can be applied toward preventative maintenance, which will lead to lower maintenance costs and downtime. According to a recent Ernst & Young survey, 92% of oil and gas companies worldwide are investing in AI or planning to do so in the next two years. And the impact of AI is already evident, as 50% of oil and gas executives are using it to solve challenges across their organization to address subsurface, drilling, and production workflows. Gartner predicts a significant surge in generative AI adoption, with 80% of enterprises expected to incorporate it by 2026, a substantial increase from the current 5%. A recent study from Statista *(shown below)* illustrates the anticipated growth from AI-enabled enterprise applications worldwide through 2025.



Generative AI models *(ChatGPT being the most well-known example)* hold immense potential in revolutionizing content creation by autonomously generating novel and high-quality content, mimicking human-like creativity based on learned data patterns. This technology can reduce manual workload and accelerate dynamic content creation and personalization in fields like digital marketing, entertainment, design, and journalism. The ability to rapidly and convincingly create stylized images based on consumer sentiment, summarize large volumes of text, and create realistic voice-overs can provide enormous efficiency within the entertainment, journalism, marketing, and graphic design segments.

We Will Say "We Remember When…"

Investors *(and society in general)* from different eras remember certain moments from their past when they saw their world change. Whether that moment was represented by the fax machine, the cellphone, the personal computer, the iPod, or the Internet, the timeline would be denoted by *"before the…"* and *"after the…."* We believe that machine learning and AI are delivering that moment right now. Listening to the headlines, it is easy to conclude the winners in the AI race have already been decided, and they are the large- and mega-cap names we have come to expect. **Investment opportunities are not limited to large language models or processing chips and Emerald contends there are AI-exposed investment opportunities across the entirety of the market capitalization spectrum, and many remain unrecognized, with their market opportunity just emerging.** AI systems are driving innovation and technological evolution to support the infrastructure required - and those innovations span materials, semiconductor packaging, power, cooling, datacenters, communications, and others. The ability of AI to deliver advanced analytics across a myriad of industries, as well as providing potentially dramatic efficiency gains to vertical applications, will drive market share shifts that have yet to occur; and there will certainly be winners and losers. **Emerald continues to assert that through active, bottom-up, fundamental research investors can proactively identify these growth opportunities that rarely get the name recognition of their large- and mega- cap brethren.**

Summary

"The world is changing very fast. We are moving from an old model economy to a new one, and every business has to find a way of transforming itself for this new economy. Big will not beat small anymore. It will be the fast beating the slow."— **Rupert Murdoch**

Emerald believes that innovation is occurring across all economic sectors. It is being led by companies that are creating novel new products and services meeting the needs of a new generation of consumers, improving productivity, saving and extending lives, disrupting existing markets, and developing new market opportunities. Innovation starts small with emerging biotechnology companies serving as the engines of innovation for the pharmaceutical industry, a new wave of creative food and beverage companies meeting the tastes and desires of Millennial and Generation Z consumers, and the developers of the infrastructure and applications necessary to drive the AI revolution. It exists in obvious areas such as the creation of revolutionary surgical procedures and diagnostic platforms. It also exists in less obvious areas such as the development of newer, cleaner, and more efficient energy sources along with the infrastructure to make them available to mass markets and the enabling of newer, more customized, and more secure financial products and services.

But not all innovation succeeds. Thomas Edison once said, *"I have not failed. I've just found 10,000 ways that won't work."* We believe that our fundamental, bottom-up research-oriented investment strategy enables us to identify successful innovation on a sector-by-sector, industry-by-industry, and company-by-company basis. Our 10-step research process, featuring over 2,000 company meetings annually and proprietary channel checks, provides a means for us to separate the innovators from the imitators, the leaders from the laggards, and the winners from the losers. We strive to craft our investment strategies to identify and invest in the innovation leaders and growth leaders of tomorrow across all economic sectors and all market environments. **We call that the Emerald Advantage.**

IMPORTANT DISCLOSURE

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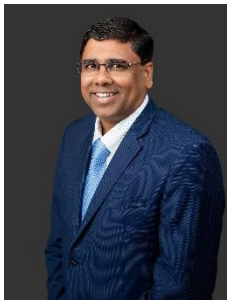

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Dr. Trivedi is a Director - Life Sciences Research for Emerald Advisers, LLC., focusing on Biotech and Medical Device companies. Dr. Trivedi received his PhD in Pharmacology in 2005 and pursued his post-doctoral fellowship at Gittlen Cancer Foundation before joining Emerald. He has published several research articles in leading journals in the fields of oncology and dermatology and, at the 2004 Annual AACR Conference, Dr. Trivedi was the recipient of an award from the American Association for Cancer Research and AFLAC for his research efforts on melanoma. While at Penn State College of Medicine, he received the Rite Aid Graduate Fellowship Award in Pharmacology. Dr. Trivedi received both a PhD and an MBA from Pennsylvania State University. He completed his medical internship in 1999 and received his medical degree (MBBS) from Bombay University, India.

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Deputy Chief Investment Officer & Managing Director | President, EAM PA

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