THE WORLD IN 2025

10 PREDICTIONS OF INNOVATION

THOMSON REUTERS™

“IT IS SAID THAT THE PRESENT IS PREGNANT WITH THE FUTURE.”

- Voltaire (1694 - 1778)

It's human nature to want to know what's coming.

As far back as one can look in history, humans have tried to predict everything from the weather and rise and fall of tides to, in more recent times, stock performance and who will reign as champion in a sporting event. From Nostradamus to Toffler to Kurzweil, academics, astronomers, economists, futurists, mathematicians, scientists, sociologists, sports enthusiasts and others have contributed to the science – and art – of predicting what is to come.

It seems fitting, then, that the IP & Science business of Thomson Reuters, with innovation at its core, should also partake in leveraging its assets to forecast the future. With its rich scientific and intellectual property repositories, and deep industry expertise, this business is dedicated to helping customers research, innovate and commercialize tomorrow's inventions.

This paper is a compilation of 10 innovation predictions for the world in 2025, based on research done by Thomson Reuters analysts using the company's patent and scientific literature solutions.

In some cases, the analysts found a growing body of work that gave additional credence to the prediction. In others, the topic was still emerging. In all instances, they followed a trail of current research and innovation activity to connect the dots and make these innovation predictions.

What will be the major innovations impacting our world in 2025? Read on to find out.

METHODOLOGY

The aim of this project was to identify 10 technologies of tomorrow that will be in use in 2025 based on research and development currently identifiable in the literature of today – both scientific literature and published patents. The innovation predictions were discovered using flagship solutions from the IP & Science business of Thomson Reuters.

First, broad fields were identified from recently published data (over the last two years) using Thomson Reuters Web of Science™ and InCites™, for scientific and scholarly literature, and Thomson Reuters Derwent World Patents Index® and Thomson Innovation, for patents.

Analysts scoured the vast array of information to identify the themes of emerging importance from 2012 and 2013 using citation rankings, most cited papers, hot topics and research fronts, beginning in InCites.

The top 10 fields of research based on emerging research front data were:

- Clinical medicine (2355)
- Chemistry (1533)
- Physics (1154)
- Engineering (1059)
- Social Sciences, general (934)
- Biology & Biochemistry (933)
- Materials Sciences (823)
- Plant & Animal Sciences (702)
- Molecular Biology & Genetics (566)
- Environment & Ecology (554)

The most active research fronts were identified by ranking the number of citations per paper and assessing the number of core papers per front.

A similar approach was used to identify the top 10 fields in patent literature, by locating the highest publishing fields and then drilling down into the essentials within these fields. Derwent Manual Codes were used to identify the patent fields with the highest number of inventions with a priority date of 2012 and onward. The International Patent Classifications with the most patents from the top 10 Manual Codes were then grouped, including family member data, to identify the emerging fields:

- Computing & Controls
- Communications
- Semiconductors
- Electric Power Engineering
- Plastics & Polymers
- Scientific Instrumentation
- Pharmaceuticals
- Refactories, Glass, Ceramics
- Food, Disinfectants, Detergents
- Electronic Components

Broad fields from scientific literature and patents were then merged and compared to identify the most impactful areas. The following were the top areas identified:

- Disease Prevention & Control
- Medical Treatment
- Pharmaceutical Preparation
- Energy Solutions
- Digital Communications
- Multimedia Devices & Lighting
- Instrumentation (biotech)
- Physics (particle)
- Novel Materials (nano)
- Genetics (fundamental research)

From these areas and based on further analysis of data in each field, the analysts were able to make the 10 predictions of innovation in 2025.

IN 2025

DEMENTIA DECLINES

Understanding of the human genome and genetic mutations leads to improved detection of, and prevention methods for, the onset of neuro-degenerative diseases such as dementia and Alzheimer's.

Analysis and understanding of the human genome will have far-reaching effects in 2025. As Baby Boomers begin to reach their 80s, more and more scientific research funds will be directed toward afflictions they may encounter.

Current neurodegenerative disease research is focused on identifying pathogenic chromosomes that influence the onset of diseases. This work is vital to understanding human genetic variations and will enable scientists to begin to fix genetic malfunctions, such as those impacting dementia patients.

Scientific studies of dementia sufferers have been able to isolate specific chromosomes that cause different forms of the disease, including autosomal dominant frontotemporal dementia (FTD) and amyotrophic lateral sclerosis (ALS), among others. The identification of chromosome 9p and its genetic link to dementia, for instance, is a first step in the war on this devastating condition.

In 2025, the studies of genetic mutations causing dementia, coupled with improved detection and onset-prevention methods, will result in far fewer people suffering from it.

Such fundamental research is not yet represented in patents, because pure medical research may not be patented. As techniques and enabling technologies develop, it will be more visible in patent publications. And, as the global population ages, preventing these diseases through understanding the genetics will become increasingly important.

FAST FACTS

- A gene identification study on disorders of frontotemporal lobar degeneration was the most highly-cited piece of scientific literature over the last two years in this field
- Research on chromosome 9P and its link to FTD and ALS has been the most highly cited since 2011

HERE COMES THE SUN

IN 2025

SOLAR IS THE LARGEST SOURCE OF ENERGY ON THE PLANET

Methods for harvesting, storing and converting solar energy are so advanced and efficient that it becomes the primary source of energy on our planet.

Thanks to improvements in photovoltaic technology, chemical bonding, photocatalysts and three-dimensional nanoscale heterojunctions, the use of the sun as the world's primary source of energy is no longer for the environmentally-conscious select; it is for the masses.

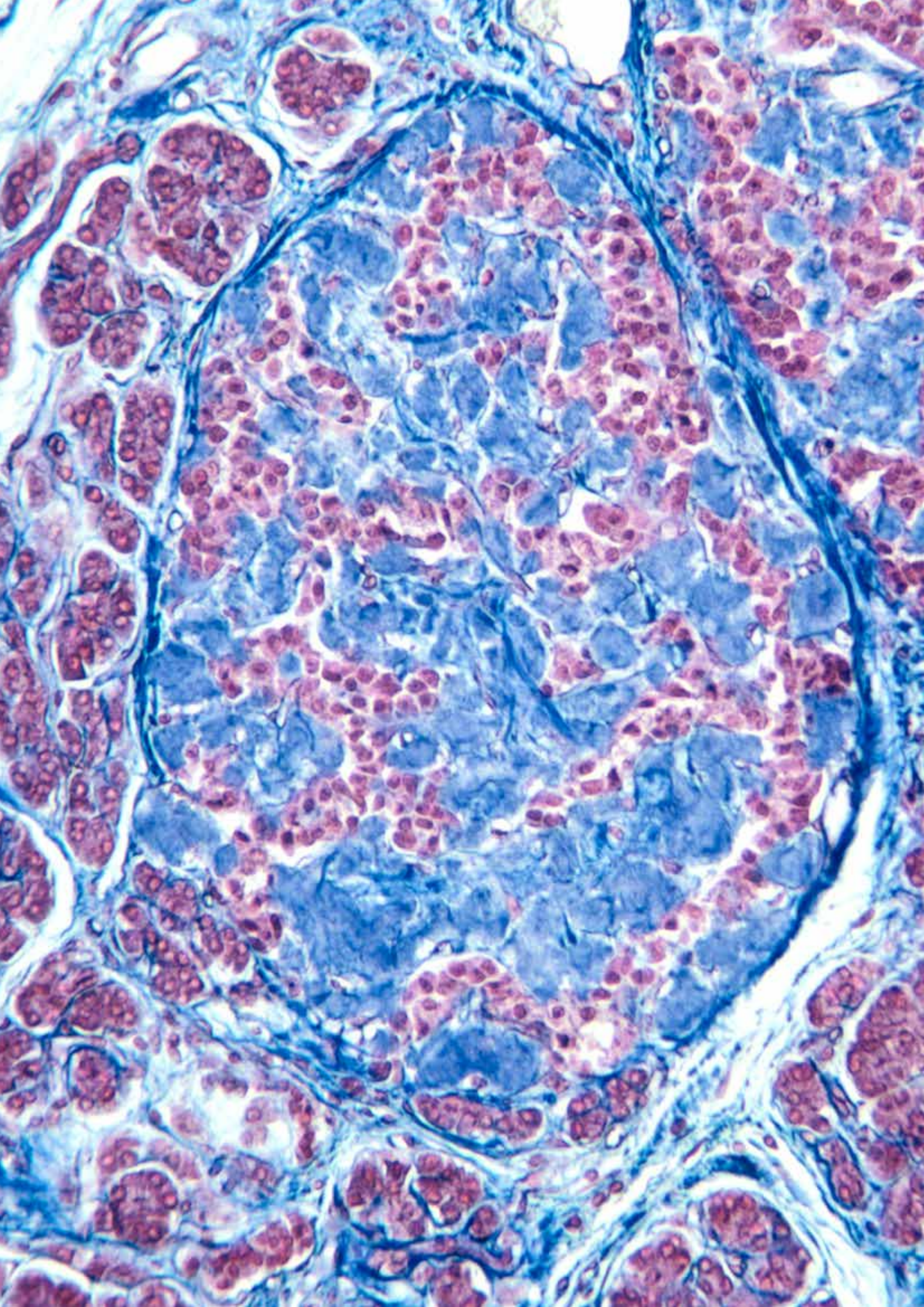
The sun's energy will be harvested much more efficiently. Its energy will be stored and used when needed. And the conversion of solar power will be much more efficient.

Solar thermal and solar photovoltaic energy (from new dye-sensitized and thin-film materials) will heat buildings, water, and provide energy for devices in the home and office, as well as in retail buildings and manufacturing facilities.

Chemical bonds, a photosynthetic process, will make solar energy available when needed. Increased efficiency of energy conversion will be realized through new materials such as cobalt-oxide and titanium-oxide nanostructures, photocatalysts and 3D nanoscale heterojunctions; while new methods using mesoscopic oxide films sensitized by dyes or quantum dots will contribute to improving the 2014 solar conversion efficiency rate of less than 10 percent.

FAST FACTS

- "Fabrication of novel heterostructure of CO304-Modified TIO2 nanorod arrays and enhanced photoelectrochemical property" most highly cited paper (last two years)
- "Design rules for donors in bulk-heterojunction solar cells – towards 10-energy-conversion efficiency" most highly cited paper (more than 1,600 times)



IN 2025

TYPE I DIABETES IS PREVENTABLE

A versatile human genome engineering platform is a reality, paving the way for the modification of disease-causing genes and helping to prevent certain metabolic conditions.

Like type 2 diabetes, type 1 diabetes and other metabolic conditions such as muscular dystrophy will be preventable in 2025, but not by diet and exercise. Advancements in ribonucleic acid-guided (RNA-guided) engineering used for specialist sequence synthesis will be so much more sophisticated that a human genome engineering platform will exist. The pillar biological molecules of life on earth: RNA, DNA and proteins, and the roles they play, will be understood much more clearly in the next decade.

The in-depth operations of RNA, the main pathways from DNA to proteins, and proteins, the cell's worker bees that carry out various catalytic and structural functions, will be demystified. The RNA/DNA process of passing inherited genetic information from one generation to the next will be clear. Increased knowledge of these biological pillars will make genomic-editing-and-repairing DNA a reality in humans, not just in bacteria and mice.

Also a reality will be the patenting of organisms and partial DNA segments, thereby complicating the landscape of who owns rights to what and where the line between nature and commerce exists.

The human genome engineering platform will pave the way for the modification of disease-causing genes in humans, leading to the prevention of type I diabetes, among other ailments.

FAST FACTS

- RNA-Guided Human Genome Engineering in scientific literature points to emerging research front
- Recombinant DNA Technology leads all areas of genetic-engineering patenting

RIPE

FOR SUCCESS

IN 2025

FOOD SHORTAGES AND FOOD PRICE FLUCTUATIONS ARE THINGS OF THE PAST

Advancements in lighting technologies and imaging techniques, coupled with genetic crop modification, provide an environment ripe for successful indoor crop growth and detecting diseased foods.

Simultaneous revolutions in both lighting technologies and imaging techniques will have far reaching effects in the next decade. Advancements in Organic Light Emitting Diodes, LCD and plasma technologies, alongside three-dimensional displays coupled with hyperspectral imaging, will improve year-round crop growth, helping feed the world's eight billion people and overcoming environmental changes that will affect traditional farming.

In 2025, genetically modified crops will be grown rapidly and safely indoors, with round-the-clock light, using low-energy LEDs that emit specific wavelengths to enhance growth by matching the crop to growth receptors added to the food's DNA. Crops will also be bred to be disease resistant. And, they will be bred for high yield at specified wavelengths.

Imaging techniques such as three-dimensional displays coupled with hyperspectral imaging will also be able to provide early detection of mal-developing crops and diseased animal proteins before human consumption.

Because there is reduced risk of crop failure, price fluctuations and food shortages will become things of the past.

FAST FACTS

- Emerging research front: validating a method for the simultaneous determination of toxins and masked metabolites in different cereals and cereal-derived foods
- Patent documents include various genetic food modifications, including a new spinach plant useful for developing further spinach hybrids and varieties with desired traits


SOLARIMPULSE

IN 2025

ELECTRIC AIR TRANSPORTATION TAKES OFF

Light-weight aerospace engineering coupled with new battery technologies power electric vehicle transportation - on land and in the air.

Getting from point A to point B will be significantly different in 2025 from how it happens today.

Cars and airplanes will still exist, but they will be smarter, battery-powered, able to travel longer distances and more light-weight. Advancements in non-carbon-based-fuel sources, including lithium-ion batteries, reversible hydrogen storage options, nanomaterials in fuel cells and thin-film batteries will all contribute to this reality.

Distributed power sources that recharge 10 times more than today and store much more energy than current sources will be the norm in transportation vehicles.

Lightweight aircraft and cars will be powered by the new, improved lithium-ion batteries. These aircraft will also utilize new materials that bring down the weight of the vehicle and have motors with superconducting technology. Micro-commercial aircraft will fly the skies for short-hop journeys.

As these new planes will be able to take off and land in much smaller spaces, getting a pilot's license could become the new rite-of-passage to adulthood in the 21st Century.

FAST FACTS

- Ultrafast charging and discharging energy systems, such as in supercapacitors, top scientific literature
- "High-performance lithium battery anodes using silicon nanowires" in Nature Nanotechnology is cited more than 1,300 times


EVERYTHING
EVERYWHERE
EVERYDAY
EVERYONE
CONNECTED

IN 2025

DIGITAL EVERYTHING...EVERYWHERE

From the smallest personal items to the largest continents, everything, everywhere will be digitally connected, and responsive to our wants and likes.

The digital world as we know it today will seem simple and rudimentary in 2025. If you think we're electronically dependent now, you haven't seen anything yet.

Thanks to the prevalence of improved semiconductors, graphene-carbon nanotube capacitors, cell-free networks of service antenna and 5G technology, wireless communications will dominate everything, everywhere.

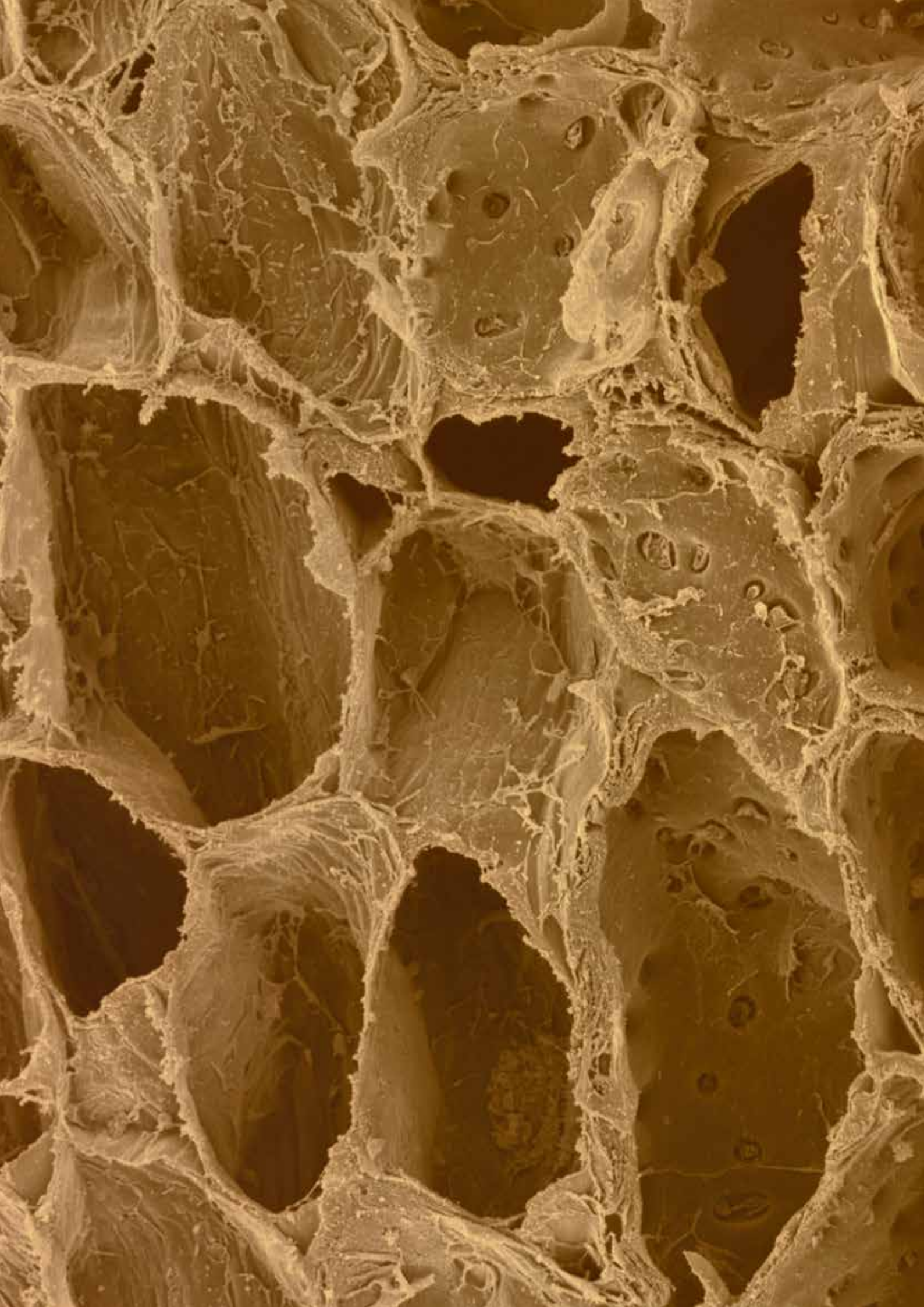
From cars and homes that respond to your every wish and want, to appliances that think for themselves, to interconnected geographies – from the most remote farmlands to bustling cities – we will all be digitally directed. Imagine the day when the entire continent of Africa is completely, digitally connected. That day will happen in 2025.

Carbon nanostructures, and carbon-based nanocomposites in particular, are part of the driving force behind this transformation, and are poised to take center stage in high-energy density and power-density applications. Carbon nanocomposites can be used as supercapacitive electrodes, either in two-or-three-dimensional structures, with high surface area. And, these supercapacitors will be able to store infinitely more energy for later release.

We will live in an ultra-digitally responsive world, where more things are exponentially connected to the Internet than people.

FAST FACTS

- Emerging research front: "Toward successful user interaction with systems: focusing on user-derived gestures for smart home systems"
- Patent activity increasing around areas such as mobile communication devices with controller modules that instruct wireless modules to monitor a physical downlink control channel for a downlink assignment reception from a cellular station



IN 2025

PETROLEUM-BASED PACKAGING IS HISTORY; CELLULOSE-DERIVED PACKAGING RULES

Bio-nanocomposites based on nanocellulose make 100% fully biodegradeable packaging pervasive. Petroleum-based packaging products will be no more.

Research is emerging today focused on the use of bio-nanocomposites and nanocellulose for packaging. In 2025, these materials will be staples of choice in the packaging industry.

Nanocellulose is material comprising nano-sized cellulose fibrils with a high length/width ratio. In layman's terms, it is pseudo-plastic. Bio-nanocomposites are derived from bio matter, whether biomass or some other plant matter. Advancements in the use of these elements will, in 2025, provide packaging materials that are fully biodegradeable.

Toxic plastic-petroleum packaging that litters cities, fields, beaches and oceans, and which isn't biodegradable, will be nearing extinction in another decade. Thanks to advancements in the technology related to and use of these bio-nano materials, petroleum-based packaging products will be history.

Whether for food, medicine, electronics, textiles or consumer products, all packaging will be made from cellulose-derived products.

Additionally, the new cellulosic packaging will play a part in pharmaceutical packaging that is ingested, such as in controlled–release medicines.

FAST FACTS

- Emerging research front: "Integrated conversion of hemicellulose and cellulose from lignocellulosic biomass"
- Scientific research points to the growing importance of biocomposite cellulose-alginate films for packaging (May 2014)

PRECISE DRUG DEVELOPMENT

IN 2025

CANCER TREATMENTS HAVE VERY FEW TOXIC SIDE EFFECTS

Drug development is so much more precise, binding to specific proteins and using antibodies to give exact mechanisms of action, that the debilitating effects of toxic chemicals on patients is significantly reduced.

Just as Big Data is enabling companies to deliver personalized customer experiences, so too is life sciences moving from broad-brush drugs to very accurate and targeted treatments that result in significantly improved patient experiences.

This personalized medicine movement is not new. For several years the pharmaceutical community has been working on therapies that target specific molecules and perform targeted functions. Many drugs are now developed from biotechnology and are aimed at treating specific forms of a disease.

What will be new is the availability of drugs that reduce the complications associated with certain treatments. Drugs in development are becoming so targeted that they can bind to specific proteins and use antibodies to give precise mechanisms of action.

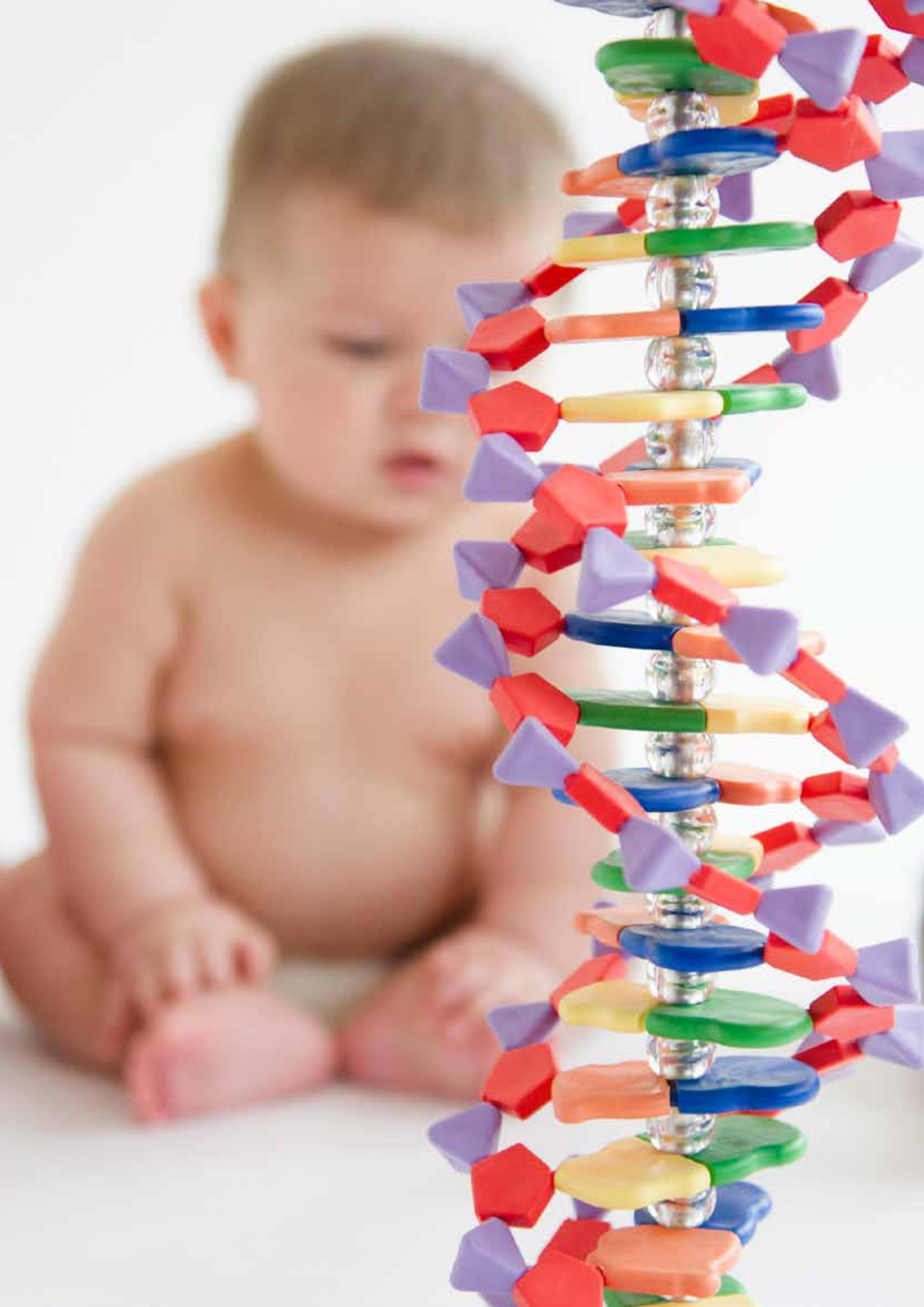
Knowledge of specific gene mutations will be so much more advanced that scientists and physicians can treat those specific mutations. Examples of this include HER2 (breast cancer), BRAF V600 (melanoma), and ROS1 (lung cancer), among many others.

In addition, advancements in antibody production and targeting will significantly improve certain cancer treatments, such as related to the safety and activity of anti-PD-L1 antibodies in patients with advanced cancer.

The impact of these advancements will be that patients in 2025 will have much more targeted drug treatments that result in fewer toxic side effects.

FAST FACTS

- "Intratumor heterogeneity and branched evolution are revealed by multiregion sequencing" cited 600 times in less than 2 years
- "Safety, activity and immune correlates of anti-PD-1 antibody in cancer" cited 400+ times in two years



IN 2025

DNA MAPPING AT BIRTH IS THE NORM TO MANAGE DISEASE RISK

The evolution of micro-total analysis systems (single-cell analysis) and advancements in nanotechnology, coupled with more widespread Big Data technologies, make DNA-mapping at birth the norm, as well as part of one's annual physician exam.

As the volume of matter which can be manipulated in the lab gets smaller and smaller, greater possibilities for precise medical screening emerge. Blood tests potentially become a thing of the past, as nano-probes will be inserted into a patient to gather data over longer periods of time and provide greater accuracy.

Micro-total analysis systems will be much closer to providing the sensitivity and selectivity required to make in vivo measurements for diagnosis. Single-cell analysis, currently in the research phase, will be mainstream and set to replace traditional flow cytometry for the isolation, purification and separation of cells in immunology testing.

Big Data will be embedded in society in the next decade, allowing medical researchers and physicians to use it to their advantage. In 2025, humans will have their DNA mapped at birth and checked annually to identify any changes that could point to the onset of autoimmune diseases.

FAST FACTS

- Emerging research front – genomics, centered around two September 2012 research papers with over 1,000 citations: "An integrated encyclopaedia of DNA elements in the human genome" (800+ citations), and "The accessible chromatin landscape of the human genome" (200 citations)
- January 2014 paper: "Genome-scale CRISPR-CAS9 knockout screening in human cells" 4 citations


BEAM
ME
UP,
SCOTTY!

IN 2025

TELEPORTATION IS TESTED

Kinematical techniques used to understand the Higgs Boson particles generated in the Large Hadron Collider advance such that quantum teleportation is more commonplace.

The frequent request heard on Star Trek® will not be such an abstract concept as we move through the 21st Century.

Since the 2013 success at the CERN's Large Hadron Collider (LHC), research related to the Higgs Boson particle has increased. In fact, papers on this topic have been the most prevalent in fundamental physics in 2014.

Measurement techniques developed to understand the particles generated in the LHC were ground breaking through the use of new kinematical techniques. Kinematics is a form of classic mechanics that studies the motion of points, objects and groups of objects regardless of the impetus for motion.

We are on the precipice of this field's explosion; it is truly an emerging research front. Early indicators point to a rapid acceleration of research leading to the testing of quantum teleportation in 2025.

Although in 2025 we as humans won't yet be able to teleport through space, a significant investment in and testing of quantum teleportation will be underway using other forms of matter.

FAST FACTS

- In addition to reports on the Higgs boson, other aspects of particle physics have attracted wide attention in the literature, including a 2012 report cited over 400 times observing the electron-antineutrino disappearance at Daya Bay in China
- Patent applications related to Higgs Boson cover protons pursuing the state of an elementary particle and aggregating the elementary particle with a high-energy photon, and, the energy of a material in a body accelerating at the speed of light and growing into the square of the speed of light

SOLUTIONS FOR INNOVATION FROM IP & SCIENCE

The IP & Science business of Thomson Reuters is dedicated to providing powerful technology platforms and comprehensive global content for today's researchers, scientists, attorneys, government officials and other professionals. Here are solutions they use to innovate, and that we used to prepare our 10 predictions of innovation for the world in 2025.

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WHO WE ARE

The IP & Science business of Thomson Reuters is a team of 4,000 people passionate about science, innovation and improving our planet. Our broad knowledge of intellectual property, life sciences and scientific research, coupled with deep vertical industry expertise, feeds our genuine interest in helping our customers achieve their goals and make our world better.

Our backgrounds as scientists, lawyers, engineers, and academics allows us to virtually walk beside our clients – in research labs, courtrooms and university classrooms – in all the actions they perform each day.

From urban innovation centers to remote farmland fields, we are committed to raising the bar, pushing the envelope and going the extra mile. We bring the right technology, content and services to those who need them, where they need them, for the decisions that matter the most.

A series of small steps, each day, every day, every year, across all 4,000 members of our team, amount to giant leaps in science and innovation for our clients – and the world.

We know we wouldn't exist at Thomson Reuters without our customers. That's why we're committed to walking beside them, understanding their needs and strategizing together – so we can collectively make a difference in this world.

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