



Pursue Essential Research to unleash breakthrough innovations that help realize more sustainable lifestyles by solving social issues and easing people's pains.

ESG Keyword

Essential Research

COVID-19 measures

Solving ESG issues through technology innovation

Kao's creating value to address social issues

Social issues we are aware of

Technology innovation has contributed greatly to safer, more reliable lifestyles and societies, but today we are facing unprecedented challenges due to the COVID-19 pandemic. Science and technology are being harnessed to prevent infection as well as facilitate diagnosis and treatment as a top priority. Moreover, the United Nations (UN) has stressed the importance of science-based information and early, widely delivered healthcare guidance to address consumer fears of invisible viruses.

As the outlines of new-normal lifestyles emerge amid efforts to prevent infection, calls for a sustainable society continue to increase. The rise in plastic waste from increased use of face masks, gloves and protective products, as means for infection prevention, and increased use of packaging represents a challenge, but we believe it is time to reconsider the best form of the recycle-based society from a safety and reliability standpoint, while maximizing the role and advantages of plastic as a material.

As the UN's Sustainable Development Goal (SDG) 12 (Responsible consumption and production) states, it is our responsibility to realize efficient use and management of natural resources, waste reduction and lifestyles that are in harmony with nature, as well as a low-carbon, safe, reliable society. We are aware that expectations toward science and technology to facilitate these efforts are strengthening rapidly.

Kao's creating value

We conduct product development research to satisfy a broad range of needs with an awareness of changes in consumer lifestyles and society. We also conduct fundamental technology research that elucidates the nature of materials and phenomena in a wide range of areas, and creates functional materials and advanced technologies. We engage in each of these research themes with a high degree of specialist expertise that enables us to grasp their essence more deeply.

These two domains of research, product development and fundamental technology, complement and enhance each other continually. With respect to environmental change as well, we are capable of deploying knowledge and assets from both research domains swiftly, allowing us to present consumers with epoch-making ideas.

We are conducting R&D activities from three perspectives—human, social and environmental—so people all over the world can realize enriched lives.

The human perspective

We have strived since our founding to enhance consumer quality of life. The human perspective of our R&D activities means protecting consumers' lives as a top priority. We use knowledge we have acquired from Essential Research into microbial control, including disinfectant and antimicrobial technology, to expand our target to viruses. We have elucidated the propagation and inactivation of the causes of

infection by the norovirus and other viruses, and are extending that knowledge to the development of products that can prevent infection in everyday life.

In addition, so that everyone can lead comfortable, beautiful, healthy lives, we are applying scientific analysis of RNA and other biological information to a wide range of skin- and health-related concerns, and are continuing our efforts to make appropriate care suggestions.

The social perspective

From the social perspective, we are sharing microbe- and virus-related knowledge that we have acquired from Essential Research with other specialists, providing innovative products and services and making use of this knowledge for public health and to strengthen precautions against infectious disease in hospitals and other medical facilities.

Moreover, we are contributing to the creation of a safe society by offering highly functional chemicals for road and bridge construction such as *Visco Top*, which does not pollute water, as well as asphalt additives that enhance pavement durability and useful life.

The environmental perspective

From the environmental perspective, we are working to realize a recycle-based society by adhering to 4R for packaging, reducing the use of plastic, recycling used refill packs for further use, and developing technology to recycle reprocessed materials back into containers and film.

Transformative innovation 102-12, 102-15, 103-1, 103-2



At the same time, we are promoting the use of natural raw materials and converting inedible biomass to multi-purpose materials. We are also developing highly functional materials that can be added in small quantities. We are also working to reduce the environmental impact of consumer products excluding cosmetics and human health care, and are continuing to research ways to reduce the amount of water and energy consumed by their use.

Risks and opportunities related to realization of What Kao Aims to Be by 2030

Through innovation and the creation of value, our goal is to realize a sustainable society in which no one is left behind, and everyone can be confident of spending vital, beautiful daily lives with peace of mind.

Despite the existence of a variety of risks, including changes in our operating environment and other uncertainties, we are collaborating widely with consumers, customers, industry, government, academia and others to develop and offer products and services that are based on our technological assets and Essential Research, and which reflect Kao's unique and novel perspective. In addition, by sharing technology that contributes to society broadly outside the company and with academics, we will enrich daily life for consumers all over the world.

Contributions to the SDGs



Policies

We have adopted the following three basic policies for our R&D activities.

1. Create the seeds for new businesses
2. Bring about innovation that creates new customers' needs in existing business domains
3. Share scientific technologies with society

Based on these basic policies, we seek to enrich people's lives through innovation, promoting research activities in two directions.

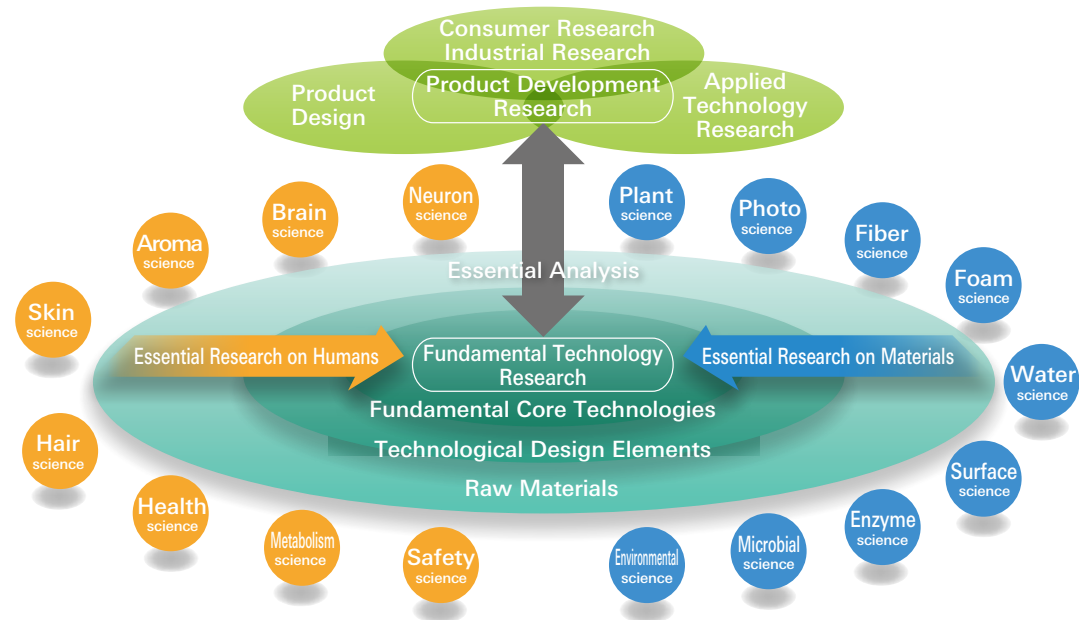
One direction is the promotion of technology innovation to create seeds for new businesses and products. Our Essential Research is the driver behind these efforts, supported by the latest science and technology as well as our accumulated knowledge and passion for discovery. The essence of objects and

phenomena as discerned through the eyes of science can provide the opportunity to solve challenges. We believe that by combining these insights with *Yoki-Monozukuri*, we can create innovations that will have a major positive impact on people's lifestyles.

The other direction involves recasting our accumulated technology assets from an SDG perspective, and incorporating them in the planning of Kirei Lifestyle products. In carrying out that planning, business strategies for a purpose driven brand, assurance of high safety and quality, and development and procurement of materials with low environmental impact are essential.

Through the accumulation of these innovation activities, our aim is for all Kao brands to have a social mission and exert a positive influence on people and society.

Essential Research



Kirei Lifestyle Plan

Making my everyday more beautiful

Making thoughtful choices for society

Making the world healthier & cleaner

Walking the right path



Education and promotion

Promoting R&D activities requires opportunities for all of our research staff to familiarize themselves with the latest technology and research results from inside as well as outside the company, and occasions where they can collaborate to generate ideas.

One of our strengths is our business unit diversity. Lateral deployment of in-house knowledge and technology assets is facilitated by a research report database available to all research staff, as well as presentations where personnel from different divisions can exchange opinions, and contribute to new discoveries. We also host lectures and technical guidance by external specialists, to give our research staff opportunities for learn from the leading-edge science and technology. Many presentations of this type were held in 2020 using online conferencing tools, and broad participation by research staff is helping to drive innovation.

Collaboration and engagement with stakeholders

Multi-faceted linkage and collaboration between industry, government and universities are necessary to solve challenging environmental and social issues. Open innovation is one example of this approach. Broad collaboration helps us deliver products and services with new value to consumers quickly, and enables us to deploy groundbreaking technology to new business domains and implement them in society.

By presenting important knowledge gained through R&D activities at academic conferences and

through publications, we strive to propagate science and technology and have received high evaluations, including prizes.

To gain broad support from society for our activities, in 2020 we disseminated bacteria- and virus-related information with relevance to COVID-19 to specialists, and engaged in activities to help consumers prevent infection in their daily lives. Going forward, we will use dialogue and awareness-raising activities to communicate the value and possible futures being created by science and technology.

Framework

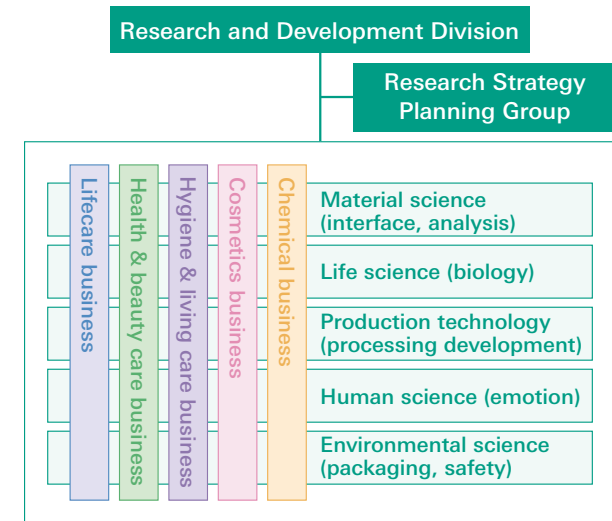
To gather knowledge across business and technological boundaries, we are promoting matrix management. Each of our research facilities reports directly to the R&D Division, with coordination between Fundamental Technology Research and Product Development Research laboratories. This helps us respond swiftly to climate change trends with product suggestions.

In particular, with respect to the important social issues of hygiene and recycling, we are creating new projects and accelerating our efforts. In addition, R&D policy sharing with management and business divisions, and strategy implementation and progress confirmation at each research facility, are carried out as part of the yearly plan. This results in faster decision making and accelerated global growth.



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Research and Development structure



* As of December 2020

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Mid- to long-term targets and performance

2020 mid-term targets

We will strengthen existing businesses and offer new innovation within existing business boundaries. For example, these include the hygiene domain, centering on infectious disease prevention; the domain in which RNA and other biological information can contribute to health and beauty; and the recycling and other domains oriented toward sustaining the environment. We coordinate with the business divisions with respect to field testing and other early-stage evaluation methods to realize new businesses.

2030 mid-term targets

Research staff prepare concrete plans for two research objectives, to ensure that they conduct R&D activities with a high level of awareness.

1. Propose products with a major positive impact on lifestyles
Propose 10 or more product releases by 2030 incorporating innovations capable of causing major positive change with respect to lifestyles, society or the environment (cumulative beginning in 2019)
2. Propose businesses and schemes with a major positive impact on lifestyles
Propose 10 or more businesses or schemes by 2030 that incorporate innovations capable of causing major positive change with respect to lifestyles, society or the environment (cumulative beginning in 2019)

Anticipated benefits from achieving mid- to long-term targets

Business impacts

We will achieve higher sales from new or improved products and create new business areas through R&D activities.



Performance in 2020

At the Kao Group Technology innovation session in November 2018, we announced our new technologies in five domains: skin, health, hair, surface chemistry and environment. This presentation accelerated collaboration with enterprises in other business domains, and is leading to new products and services.

In 2018, we established our Fine Fiber Technology for forming an extremely thin, natural membrane on the skin through deposition of ultra-fine fibers. In 2019, we offered this technology in a skin care serum, and in 2021 we plan to extend its unique membrane characteristics to foundation powder.

In addition, we are making progress in data gathering and development of AI-driven predictive algorithms for skin surface lipids-RNA monitoring, which can make visible precise, day-by-day changes in skin and body condition, and have begun testing its use in beauty counseling.

Animal testing includes skin sensitivity and eye irritation testing on animals to determine the safety of

Social impacts

We will solve environmental and social problems, and realize a circular society for resources and safer, more reliable, healthy lifestyles by offering distinctive technologies and innovative businesses and products.

chemicals, and Kao has long been engaged in research into alternatives to such testing. In 2020, two of our case studies on the evaluation of systemic toxicity, whose mechanisms are complex, was selected by the OECD IATA Case Studies Project. We expect these studies to contribute to the issuance of guidance relating to alternative methods to animal testing.

Reviews of performance

Through our R&D activities since 2019, we have been proposing distinctive technologies, businesses and products. However, with consumer lifestyles changing and society becoming more affluent, it can be said that we achieved innovation. Going forward, we will develop and implement methods for measuring the impact of our ideas, verify our proposals by these methods, feed the results back to our R&D activities, and aim for high-level innovation.



Our initiatives

Recent new products and technologies developed through Essential Research

Essential Research on Materials: Environmentally friendly, highly functional materials

As a measure to achieve decarbonization, efforts are being made to switch from petroleum raw materials to renewable, including plant-based, raw materials. However, since it is important that the use of such materials not compete with food supplies, have minimal impact on biodiversity, and not burden the environment through their production, they should ideally exhibit maximum effectiveness with minimal use.

Based on this stance, we are developing cationic hydroxypropyl cellulose (C-HPC), a cellulose found in tree-based biomass, and LUNAFLEX (high-performance resin containing modified cellulose nanofibers).

C-HPC

C-HPC, a cellulose derivative, was developed and commercialized over a period of 15 years by our Material Science Research Laboratory. It is a polymer that can be used in shampoos and hair care products for a variety of purposes, including increased foaming, making hair easier to style by distributing silicone and other fat constituents more evenly, and sebum absorption, which makes individual hair strands less prone to adhere to each other. Recent research has shown that C-HPC can also reduce the amount of tiny particulate matter, including dust and pollen, that adheres to hair.

C-HPC is derived from plant sources and is defined as an environmentally friendly material due to its minimal impact on CO₂ emissions when used. In addition, since it is inedible, it has the advantage of not competing with food supplies. Moreover, it can be manufactured using methods with low environmental impact that use 93% less energy and emit 75% less CO₂ than conventional methods (Kao estimate).

C-HPC has been evaluated highly thanks to its friendliness to the environment and society as well as its advanced functioning. In FY2019, the material received double awards: KCS Award in Chemical Technology of the Kinka Chemical Society, Japan, and the Cellulose Society of Japan Technical Award.



Products containing C-HPC
(from left, *Merit* shampoo, *Essential* shampoo and *Bioré u* body wash)
Note: Product texture and function varies depending not on one ingredient, but on combinations of multiple ingredients. The goal of adding C-HPC to a product may vary.

Employees' voice

Many years of research bear fruit in the successful development and practical application of C-HPC, an environmentally friendly material

Yoichiro Imori

Group Leader, Material Science Research Laboratory, Kao Corporation



This research finally bore fruit thanks to the enthusiasm, hard work and unwillingness to admit defeat of a group of over 30 researchers over a period of 15 years.

Through the continued implementation of *monozukuri* that embodies thorough eco-design, by undertaking material science research in harmony with nature, we succeeded in developing a C-HPC cellulose derivative base design that uses environmentally friendly cellulose to provide high functionality and high performance, as well as developing a manufacturing method that reduces the negative impact on the environment.

Going forward, we will strive to make an even greater contribution toward the realization of the enriched society of the future by focusing on manufacturing that embodies concern for people, society and the Earth.

Transformative innovation



LUNAFLEX

LUNAFLEX contains cellulose nanofibers (CNF) with a wide range of functions. It is a compound, highly functional resin with enhanced transparency and strength to match user objectives and applications.

As a sustainable, highly functional material, CNF is attracting global attention. Because the surface of the resin is hydrophilic (highly compatible with water), it is not compatible with oil-based resins, and a broad range of expertise was necessary to achieve uniform dispersion. We were able to overcome this challenge with new interface control for CNF surface design based on our quantum chemistry calculations, and succeeded in creating a high-performance composite resin. Using LUNAFLEX to enhance the physical properties of resin should reduce resin use, which in turn would make for reduced size and weight reduction, and contribute significantly to durability, energy conservation and efficient material use.

Going forward, we will help solve a wide range of problems, from consumer to industrial issues, by developing unique, natural materials.

Essential Research on Humans: Skin surface lipids-RNA monitoring

In 2019, we announced skin surface lipids-RNA monitoring, a proprietary technology enabling comprehensive analysis of the approximately 10,000 varieties of RNA expression information contained in sebum. While DNA is useful in assessing a person's innate characteristics, RNA is especially useful for understanding the state of day-to-day changes influenced by environmental and other factors.

It has been found that skin surface lipids-RNA, which can be collected easily without damaging the skin surface, displays the same tendencies to change expression information as adult and infant atopic dermatitis, and reflects changes occurring in the body during the monthly menstrual cycle and during the process of aging. In addition, we are verifying whether skin surface lipids-RNA, when combined with AI, can serve as a multifaceted predictor of dermatological and physical conditions, in the same way these conditions can be detected through such means as machine measurement and specialist visual evaluation. Skin surface lipids-RNA analysis can make the constant changes in skin condition visible at a fine level. Our goal is to begin using this capability to offer personalized beauty advice and skin care.

Essential Research on Humans: Protecting human lives by opening up new domains

We are opening up new domains for protecting human lives by making maximum use of our technology assets. One of these new domains is acquiring the VHH antibody*¹, which may make development of drugs for COVID-19 diagnosis and

treatment possible. This antibody's most distinctive feature is its capacity to neutralize novel coronavirus by preventing it from attaching to human cell receptors, which may prevent infection.

This research is being carried out jointly with Epsilon Molecular Engineering, Inc. (EME) and Kitasato University. Candidate VHH antibodies are identified using EME's cDNA display technology. Replication is carried out using our bio-manufacturing technology, while the antibody's infection control potential was confirmed by Kitasato University. To replicate the antibodies, we utilized our established expertise in *Bacillus subtilis**² production technology for laundry detergent enzymes.

In addition, applying protein production technology using this cell body has made it possible to mass-produce protein Cry5B, which has shown insecticide effectiveness against soil-transmitted helminthiasis (STH). STH has been designated a neglected tropical disease by the World Health Organization. It is said to infect approximately 1.5 billion people worldwide. In 2019, a joint project between PATH, the University of Massachusetts Medical School and Kao to develop a new drug for STH, was selected by the Global Health Innovative Technology Fund, which is funded by the Government of Japan, private enterprise and world-renowned foundations.

*1 VHH (variable domain of heavy chain of heavy chain) antibody
An antibody present in animals of the biological family Camelidae. One-tenth the size of common antibodies. Highly stable, it can be produced at low cost using micro-organisms, which has attracted attention in recent years. Said to be a next-generation antibody

*2 *Bacillus subtilis*
Close relative of *Bacillus natto*. Known since ancient times as a plentiful source of useful enzymes. Extensively studied and used in industry