

# SI Units and Fundamental Metrology in Temperature Measurement

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## Introduction

The International System of Units (SI) is the foundation of global metrology, ensuring consistency and accuracy in measurements. Among its base units, the kelvin (K) plays a crucial role in temperature measurement, impacting diverse scientific and industrial applications. This poster explores the evolution of the kelvin, its 2019 redefinition, and its practical realization through the International Temperature Scale of 1990 (ITS-90).

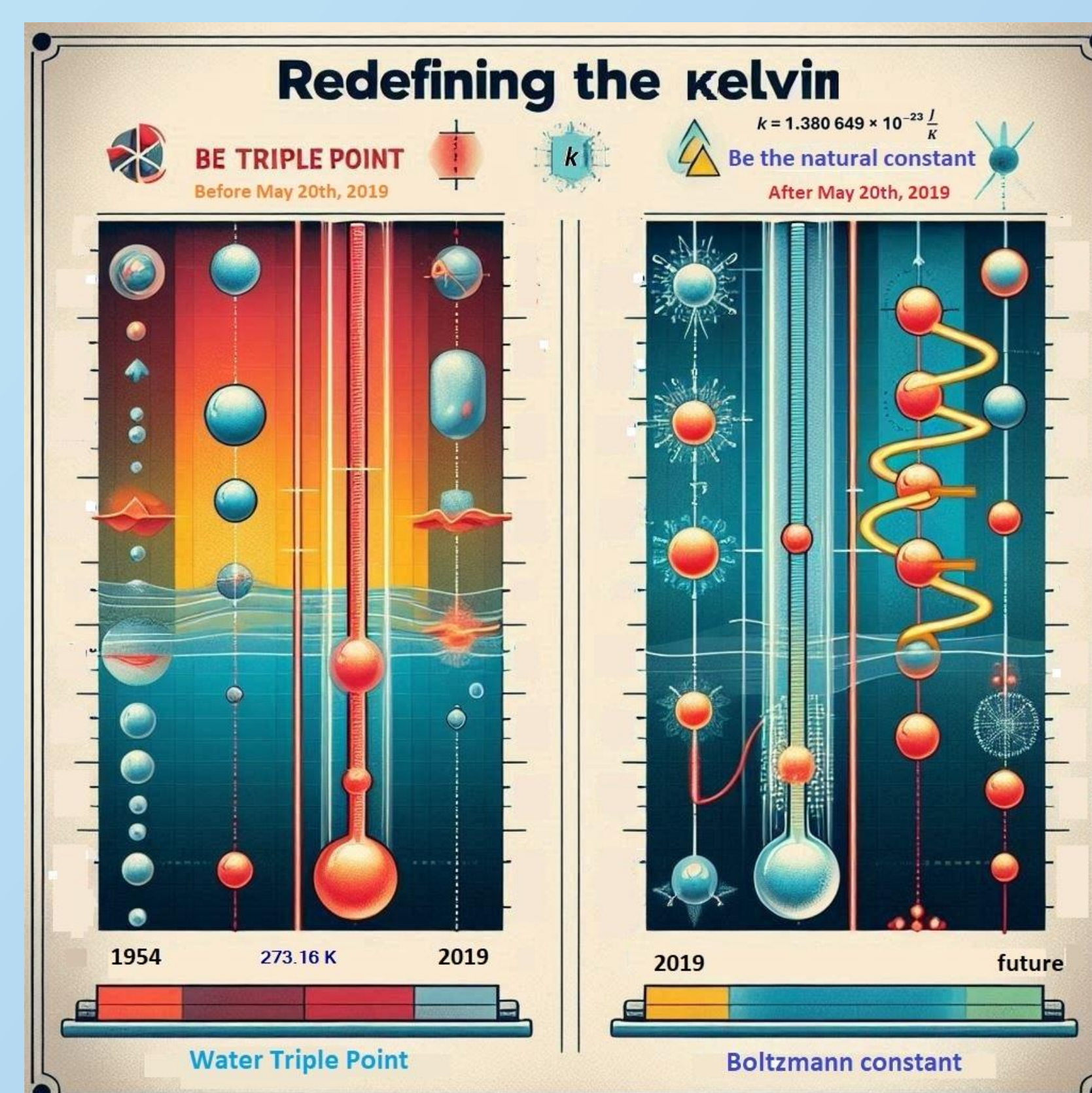


FIGURE 1. Redefinition of the kelvin: From Water Triple Point to the Boltzmann Constant.

## Redefinition of the kelvin and Its Impact

In 2019, the kelvin was redefined based on the Boltzmann constant ( $k = 1.380\,649 \times 10^{-23} \frac{J}{K}$ ), shifting from a material-dependent definition (triple point of water) to a fundamental physical constant. This change enhances measurement stability and universality, improving applications in thermometry, climate science, and materials research. National metrology institutes (NMIs) play a key role in implementing this redefinition, ensuring traceability in temperature measurements.

## Conclusion

The redefinition of the kelvin marks a milestone in metrology, reinforcing the role of fundamental constants in SI units. The continuous development of temperature metrology, driven by national and international efforts, supports the increasing need for accuracy in scientific research and technological innovation. Through cooperation within SIM MWG3 and global initiatives, NMIs contribute to the advancement of measurement science, ensuring reliable and consistent temperature standards for diverse applications.

## Realization of the International Temperature Scale of 1990 (ITS-90)

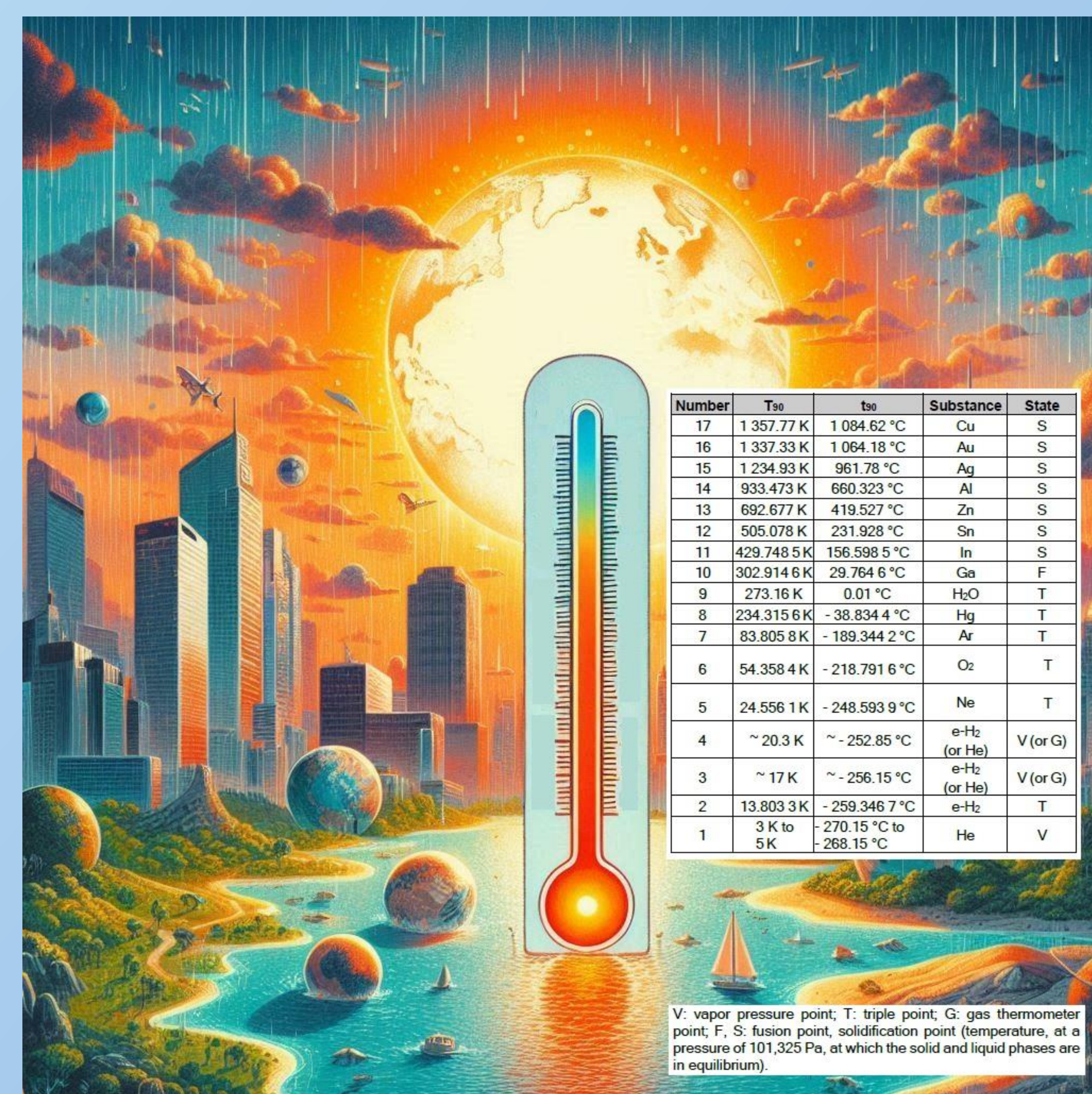


FIGURE 2. The International Temperature Scale (ITS-90): Fixed Points for Temperature Realization.

The ITS-90 provides practical temperature realizations through fixed-point cells (such as mercury, water, and silver) and high-accuracy interpolating thermometers. NMIs establish traceability by maintaining primary standards, such as Standard Platinum Resistance Thermometers (SPRTs) calibrated at defined fixed points. Advances in thermometry include radiation thermometry and Johnson noise thermometry, expanding the accuracy of high-temperature and low-temperature measurements.

## The Role of INM and SIM MWG3 in Temperature Metrology

The National Institute of Metrology of Colombia (INM) actively contributes to temperature metrology by maintaining primary standards and disseminating traceability to calibration laboratories. Within the Inter-American Metrology System (SIM), the Thermometry Group (SIM MWG3) fosters collaboration among NMIs in the Americas, enhancing regional measurement capabilities and promoting interlaboratory comparisons to ensure international equivalence.

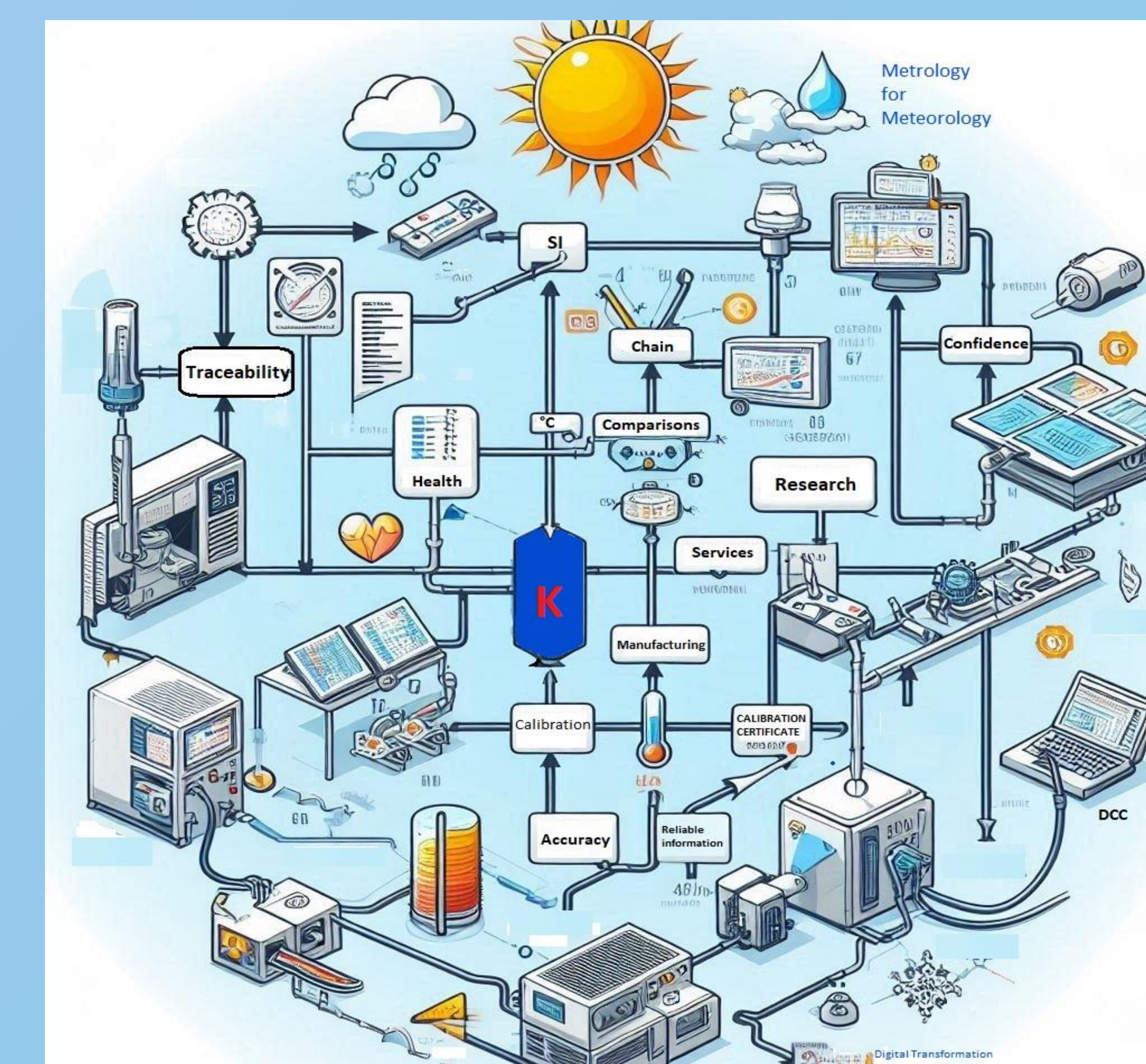


FIGURE 3. Traceability in Temperature Metrology: From kelvin-Traceable Measurements to Industry, Services, Health, Meteorology, and Research in the Digital Transformation Era.

## Challenges and Future Perspectives

Despite advancements, challenges remain in improving measurement uncertainty evaluation, extending the applicability of thermodynamic temperature determinations, and integrating digital metrology. Future directions include refining primary thermometry techniques, enhancing sensor technologies, and leveraging digital tools for better data accessibility and comparability.