INTRODUCTION

This sixth edition of the *Gale Encyclopedia of Science*, is devoted to providing younger students and general readers with a foundation upon which to build an understanding of modern science and its applications to contemporary global issues.

Gale Encyclopedia of Science, 6th Edition entries are designed to instruct, challenge, and excite less-experienced students, while providing a solid foundation and reference for students preparing for more specialized studies in science. The articles in the *Encyclopedia* are meant to be understandable by anyone with a curiosity about science or scientific thought—or an area of science in which they may not have a depth of knowledge but which they find relevant to other areas of academic study or their personal lives.

As always, the *Gale Encyclopedia of Science, 6th Edition* relies on a talented and globally diverse group of expert contributors. Written by scientists, physicians, teachers, and specialized science writers, the editors have made every effort to explain scientific concepts clearly and simply, without sacrifice of fundamental accuracy. The goal throughout is to enhance and foster critical thinking about issues related to science, technology, ethics, and a range of important issues of importance now and to future generations. The entries in this book were, for example, specifically selected to reflect the diversity of environmental issues related to global warming, climate change, biotechnology advances, and infectious disease outbreaks.

Although as expansive and inclusive as size allows, any encyclopedia devoted to science can only hope to wade a bit along the shore of a vast ocean of knowledge. For that reason, the *Gale Encyclopedia of Science, 6th Edition* topics are carefully selected to present fundamental and relevant information in key areas across the science curriculum.

IMPORTANT UPDATES

Gale Encyclopedia of Science, 6th Edition features revisions to more than 2,660 articles, and includes more than 34 new articles. More than 769 entries feature substantial new sections and updates.

At its printing, the *Gale Encyclopedia of Science, 6th Edition* features the latest in vetted climate data from the National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and the most recent assessments made by the Intergovernmental Panel on Climate Change (IPCC) and other global monitoring agencies on topics ranging from atmospheric greenhouses gas levels to sea level rise. Key articles also include information and generalized predictions relating climate change to severe storms, floods, and draught for regions around the world including the impacts of climate change—both observed and predicted—in Africa, Asia, Australia and New Zealand, Europe, North America, South America, and in small island nations.

With a global pandemic of COVID-19 underway due to an outbreak of the novel SARS-CoV-2 virus, the editors have attempted to strengthen this edition's coverage of emerging diseases. The *Gale Encyclopedia of Science* includes updated articles on epidemics, pandemics, epidemiology, hepatitis variants, SARS, H1N1, H5N1, the MERS coronavirus in the Middle East, the H7N9 flu virus and a new article on the first six months of the 2020 COVID-19 pandemic. Because knowledge related to these diseases—especially COVID-19—changes rapidly with science and medical advances, readers must always consult their personal health care provider to ensure that they have the latest information that applies to their individual needs.

Advances in biotechnology, especially related to genome editing and related molecular genetic engineering technologies—including 2020 Nobel Prize winning work related to the development of CRISPR technologies—are expertly covered in *Gale Encyclopedia of Science, 6th Edition*.

This set is designed to prepare students and other readers for the future. While science- and technology-related news regarding new space missions, new particle discoveries, new climate data, emerging disease outbreaks,

and biotechnology move at a fast pace, the inevitable changes and future discoveries related to the topics covered actually enhance the value of an encyclopedia like *Gale Encyclopedia of Science, 6th Edition* that is dedicated to fundamental science because the articles contain explanations of theories, laws, and prior discoveries that foster a contextual understanding of the new advances.

ESSENTIAL FEATURES OF THIS EDITION

Because less-experienced students and readers may not be familiar with the traditional divisions of science, entries are arranged alphabetically. *See also* references at the end of entries alert the readers to related entries across the set that may provide additional resources or insights for each topic.

Longer entries are signed by individual contributors, and every effort has been made to present a balanced and accessible list of further reading for many topics.

Color illustrations and graphics are included throughout the book where they might stimulate interest or understanding.

Equations are, of course, often the most accurate and preferred language of science, and are essential to some topics in the *Gale Encyclopedia of Science*. To better serve the intended audience of the encyclopedia, however, the editors attempted to minimize the inclusion of advanced equations in favor of describing the elegance of thought or essential results such equations yield.

Throughout the updating and editing of *Gale Encyclopedia of Science, 6th Edition* special attention was given to acknowledging the diversity of contributions to science, especially by women and others often overlooked in the history of science.

A detailed understanding of physics and chemistry is neither assumed nor required for study of the geographic and environmental topics contained in *Gale Encyclopedia of Science*. When used, scientific terms from other disciplines are fully defined, either directly or in context.

K. Lee Lerner

Cambridge, Massachusetts, November 2020.

K. Lee Lerner, is the senior science correspondent and commissioning editor for LMG (London•Paris•Cambridge) and served as editor of the Gale Encyclopedia of Espionage, Intelligence, and Security, Climate Change in Context*, and many other award-winning books and articles on science, technology, and a range of global issues. He is a member of the National Press Club in Washington, D.C., and serves on the Advisory Board at* American Men and Women of Science. *Along with Brenda Wilmoth Lerner, he served as editor for three prior editions of the* Gale Encyclopedia of Science *and he continues to serve as an advisor and contributor to this updated 6th edition. A full biography and list of his work may be found at https://scholar.harvard.edu/kleelerner and https://harvard.academia.edu/KLeeLerner/.*

A

Aardvark

Aardvarks (*Orycteropus afer*) are nocturnal, secretive, termite- and ant-eating mammals, and are one of Africa's strangest animals. Despite superficial appearances, aardvarks are not classified as true anteaters; they have no close relatives and are the only living species of the order Tubulidentata and family Orycteropodidae. Aardvarks are large, pig-like animals weighing from 88-143 lb (40-65 kg) and measuring nearly 6 ft (1.8 m) from nose to tip of tail. They have an arched, brownish-gray, almost hairless body with a tapering pig-like snout at one end and a long tapering tail at the other. Their legs are powerful and equipped with long, strong claws for digging. The first white settlers in South Africa named these peculiar animals aardvarks, which means earth pigs in Afrikaans.

Aardvarks are found throughout Africa south of the Sahara Desert. They spend the daylight hours in burrows and forage for food at night. Fleshy tentacles around the nostrils may be chemical receptors that help locate prey. Grunting, shuffling, and occasionally pressing their nose to the ground, aardvarks zigzag about in search of insects.

Aardvarks are native to Africa. This baby Aardvark, also called a cub, was photographed in Okavango Delta, Botswana. *(Thomas Retterath/Shutterstock)*

Termites are their favorite food. Using powerful limbs and claws, aardvarks tear apart concrete-hard termite mounds and lick up the inhabitants with their sticky, foot-long tongues. Aardvarks also eat ants, locusts, and the fruit of wild gourds. Adapted for eating termites and ants, the teeth of aardvarks are found only in the cheeks, and have almost no enamel or roots.

Female aardvarks bear one offspring per year. A young aardvark weighs approximately 4 lb (2 kg) when born and is moved to a new burrow by its mother about every eight days. After two weeks, the young aardvark accompanies its mother as she forages, and after about six months it can dig its own burrow.

Hyenas, lions, cheetahs, wild dogs, and humans prey on aardvarks. Pythons occasionally enter aardvark burrows and may eat the young. Many Africans regard aardvark meat as a delicacy, and some parts of the animal are valued by many tribes for their supposed magical powers. If caught in the open, aardvarks leap and bound away with surprising speed; if cornered, they roll over and lash out with their clawed feet. An aardvark's best defense is digging, which it does with astonishing speed even in sun-baked, rock-hard soil. In fact, aardvarks can penetrate soft earth faster than several men digging as fast as they can with shovels.

Since aardvarks have a specialized diet, they are vulnerable to habitat disturbances. They are widely distributed in sub-Saharan Africa, but their population in each area is small, although the exact number is unknown. There are no known conservation efforts directed specifically at aardvarks, but they do occur in most large national parks and other conservation areas in Africa. As of 2019, the International Union for Conservation of Nature and Natural Resources (IUCN) considers them to be of least concern.

Abacus

The abacus is an ancient calculating machine. This simple apparatus is about 5,000 years old and is thought