VAN NOSTRAND'S

SCIENTIFIC ENCYCLOPEDIA

TENTH Edition

Glenn D. Considine, Editor-in-Chief • Peter H. Kulik, Associate Editor

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VOLUME 1

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PREFACE

The editors are pleased to introduce *Van Nostrand's Scientific Encyclopedia*, Tenth Edition, thus building upon the long tradition of excellence that dates back some seventy years to the First Edition, published in 1938 as a single volume over 1,200 pages and updated over the decades in one volume (1947, 1958, 1968, 1976, 1983), and then in two volumes (1989, 1995, 2002). This Tenth Edition, in response to exponential growth, both in scientific knowledge and in the electronic availability of that knowledge, has grown perforce to three volumes over 6,100 pages.

The essence of *VNSE* is enduring, and it remains a fine, concise, comprehensive, and accessible general science work. Its intellectual scope ranges from the introductory to the highly technical in a vast and ever-expanding array of topical coverage in the sciences, engineering, mathematics, medicine, and more. As has long been the case, the editors have designed the book to be approachable by students of many ages. An important feature continued in this work, therefore, is the progressive development of the discussion of each topic, beginning with a simple definition expressed in plain terms, developing into a more detailed treatment, and augmented by often-extensive Additional Reading suggestions.

Contemporary readers can continue to turn to *VNSE* for information about how their daily lives are increasingly affected by the sophistication of today's science and the complexity of modern technology. They will be reminded that knowledge and discovery exist in a continuum, and that often, but not always, what is new depends entirely on what came before. As our esteemed, late editor of more than 30 years, Douglas M. Considine, was wont to say, "Science is history". With that mantra in mind, and noting that it has already been six years since the Ninth Edition in 2002, it is time to examine this new edition.

The five major changes noted in the Preface to the Ninth Edition are still very much a part of the book and are likely to remain so. First, the way that the editors wrote, gathered and assembled articles for this book is almost entirely electronic — from query letters to individuals or to academic, industrial or technical societies or entities; to primary research for new entries and updates for mature ones, now conducted almost entirely on the Internet; to communication between editor and publisher and the transmission of text between them in the partnership that results in the book itself. Second, the mushrooming Age of Discovery is still very much with us and is reflected in updates to articles and families of articles, with special emphasis on the many life sciences, space science, and computer technology, and much, much more, necessitating the expansion to a third volume. Third, the use of Internet references as Additional Reading suggestions, a groundbreaking feature of the Ninth edition, has been retained and expanded; even print articles are often archived electronically by magazines and journals and thus the quest for additional material is increasingly electronic in nature, with readers having the advantage of much of the culling of thousands of "hits" on a given topic having been done for them by the editors. Fourth, the editors have inculcated the previously new feature of Time Lines and Glossaries, to add at-a-glance information and historical perspective, into a staple of the book; new coverage includes virology, physiology, pharmaceuticals, the Internet, weather technology, and more. And fifth, the sense of history is further developed by expansion of another once-new feature, brief biographies of many influential scientists including many Nobel Prize winners in Medicine, Chemistry, and Physics; a history of their times is not complete without mention of their works. Science *is* history.

A statistical summary of the Tenth Edition would include more than 10,000 entries and 9,500 cross-references; 4,800 diagrams, graphs, and photographs; more than 600 tables; and an alphabetical Index of more than 100 printed pages that finds few rivals in the realm of technical literature. These are large increases, staggering particularly in the number of entries, and they are the result of an exhaustive, ongoing selection process for content perhaps best described so presciently by Douglas Considine in the Preface to the Sixth Edition in 1983: "Obviously, an encyclopedia of this type cannot serve the same purpose as a news medium. Science, too, has its own noise level. This is particularly evident from the hundreds of prematurely announced and exaggerated claims one frequently finds in the general communications media. Consequently, the authors and editors of this encyclopedia must carefully sift through the vast scientific data bank and sort out the trivia from real progress... there is no room for rumor and the untried and very little room indeed for the controversial in a permanent scientific reference such as this." To which the present editors say, Amen. But even the strictest selection criteria, applied to the gargantuan growth of knowledge, lead inevitably to the paradox that in print, what is new today will be, if not obsolete, at least in need of immediate updating tomorrow. To that end the editors have included thousands of Internet references to foster contemporaneity in research and Additional Reading. And further to that end, the editors have a wonderful announcement.

Van Nostrand's Scientific Encyclopedia, Tenth Edition, is now available on the Internet through the Wiley Interscience website. The online version uses embedded Internet references as hyperlinks both within the book itself and without — to the greater online community and also to other titles owned by John Wiley and Sons. At the click of a mouse the student or reader can now navigate VNSE instantly; this reflects how modern students actually pursue knowledge, and their parents are not far behind. The possibilities for ready acquisition of topical knowledge in, simply put, what is known, thus grow logarithmically through the interconnectedness of the VNSE and its links to the cyberworld. The editors feel strongly that, while there will always be an important place for printed literature of all kinds, as evidenced by the beautiful volumes at hand, the realm of scientific knowledge, compelled by the ongoing effects of that knowledge itself as expressed through information technology, will be accessed increasingly via electronic means.

In closing, one trusts that the reader will indulge a personal observation. In 1976 at the age of 61, Douglas M. Considine wrote and edited the Fifth Edition of *VNSE*. In 2008 at a similar age, his son Glenn D. Considine, also a writer and editor, presents the Tenth Edition of *VNSE*. Science is history. Family is history, too. Thus, this book is dedicated with abiding affection and gratitude to Douglas M. Considine.

GLENN D. CONSIDINE, Editor
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REPRESENTATIVE TOPICAL COVERAGE

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Physical Chemistry
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Skeletal System

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Electronics
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Magnetism
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Optics
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Theoretical Physics
Waves

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Botany
Diseases and Pests
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Fungi
Growth Modifiers
Nutritional Values
Plant Breeding
Seeds and Germ Plasm
Trees
Yeasts and Molds

SPACE AND PLANETARY SCIENCES

Astrochemistry
Astrodynamics
Astronautics
Astronomy
Astrophysics
Cosmology
Probes and Satellites
Solar Systems

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A

AA. An Hawaiian term introduced into geological nomenclature by C.E. Dutton in 1883, and signifying the jagged, scoriaceous, blocky and exceedingly rough surface of some basic lava flows. Prounced *ah-ah*.

AAAS. The American Association for the Advancement of Science was founded in 1848 and incorporated in 1874. Its objectives are to further the work of scientists, to facilitate cooperation among them, to foster scientific freedom and responsibility, to improve the effectiveness of science in promoting human welfare, to advance education in science, and to increase public understanding and appreciation for the importance and promise of the methods of science in human progress. The AAAS head quarters is in Washington, DC. Additional information on the AAAS can be found at *http://www.aaas.org/* and *http://www.sciencemag.org/*.

AAC (ADVANCED AUDIO CODING). See **Data Compression**.

AARDVARK *(Mammalia, Tubulidentata).* African animals of peculiar form and ancient lineage, including an Ethiopian and a South African species. All are anteaters, feeding exclusively on ants and termites, nocturnal in habit, with acute hearing. The southern species has been called the ant bear. The aardvark is the only living representative of its order. The animal's spine, curved from neck to tail in a near-half circle, gives it a truly prehistoric appearance.

The aardvark is solitary. In daytime it sleeps curled up like a dog in one of its burrows, often beneath a termite hill. The animal moves almost entirely at night, when it seeks termite hills and destroys them to reach the interior chambers and tunnels alive with insects, which it rapidly licks up in lumps. Although usually silent, the animal can grunt like a hippopotamus. Life span is at least 10 years. In captivity, aardvarks become accustomed to keepers, but do not show great intelligence. See Fig. 1.

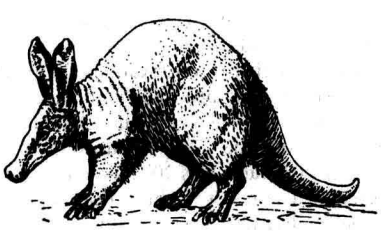

Fig. 1. The habitus or body definitely purveys a pig-like appearance.

AARDWOLF *(Mammalia, Carnivora).* An African species, *Proteles cristatus*, superficially like the striped hyena, not common, nocturnal and sleeps by day under termite nests or in excavated or aard-vark holes. Teeth reduced in number and size, and insect eater, but can chew very rotten meat or newly born animals. See also **Hyena**.

ABACA. The sclerenchyma bundles from the sheathing leaf bases of *Musa textilis*, a plant closely resembling the edible banana plant. These bundles are stripped by hand, after which they are cleaned by drawing over a rough knife. The fiber bundles are now whitish and lustrous, and from six to twelve feet (1.8–3.6 meters) long. Being coarse, extremely strong and capable of resisting tension, they are much used in the manufacture of ropes and cables. Since the fibers swell only slightly when wet, they are particularly suited for rope that will be used in water. Waste manila fibers from rope manufacture and other sources are used in the making of a very tough grade of paper, known as manilla paper. The fibers may be obtained from both wild and cultivated plants, the latter yielding a product of better grade. The cultivated plants, propagated by seeds, by cuttings of the thick *rhizomes* or by suckers, are ready for harvest at the end of three years, after which a crop may be expected approximately every three years.

ABALONE *(Mollusca, Gasteropoda; Haliotis).* Marine species, usually found in the Pacific and Indian Oceans. The single broad shallow shell has a richly colored iridescent inner surface and is an important source of mother-of-pearl and blister pearls for costume jewelry. The flesh is palatable.

The few whorls of abalone shells are flattened and rapidly increase in diameter so that the largest part of the shell consists of the last part of the whorl (*ear-form*). The European representative of this family is the *Ormer* (*Haliotis tuberculata*), which is characterized by knotty longitudinal shell ridges. It is distributed from the English Channel to western Africa. *Haliotis tuberculata* lamellosa (Fig. 1.) is characterized by transverse shell ridges. Both forms usually measure 2 to 3 inches (5 to 7 centimeters). The largest species occur along the Pacific Coast of the United States, in northern Japan, and in southern Australia, where the animals are commercially fished for their delicious meat. The iridescent shells are used extensively in making jewelry. Most of the approximately seventy species are found in cool waters. Some members of this group attain shell lengths of over 8 inches (20 centimeters) and live to an age of 10 to 13 years. Aside from the characteristics already mentioned, abalone are further unique in that the slit band is present only as a series of small holes. During further growth, abalone develop additional holes in a curved line, and the "retired" holes are sealed over.

The abalone inhabiting the intertidal zone to a depth of about 164 feet (50 meters) scrape algae off rocks. All abalone species have adapted to this ecological niche by developing a broad suction foot with a correspondingly large shell. The light-shunning animals attach themselves to shady parts of the rock with this broad foot. The suction force of this foot is more than 4000 times that of the animal's body weight. See also **Mollusks**.

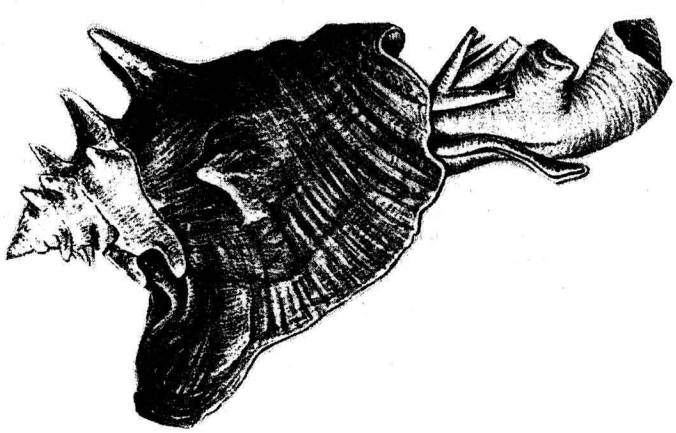

Fig. 1. Abalone (*Haliotis tuberculata lamellosa*), characterized by transverse shell ridges.

ABATEMENT. See **Meteorology**.

ABBE CONDENSER. A compound lens used for directing light through the object of a compound microscope. All the light enters the object at an angle with the axis of the microscope. See also **Microscope (Traditional-Optical)**.

ABBE NUMBER. The reciprocal of the dispersive power of a material. It is also called the v-number.

ABBE SINE CONDITION. The relationship

$$ny \sin\theta = n'y' \sin\theta',$$

where n, n' are refractive indices, y, y' are distances from optical axis, and θ, θ' are angles light rays make with the optical axis. A failure of an optical surface to satisfy the sine condition is a measure of the coma of the surface.

ABDOMEN. The abdomen is the posterior division of the body in many arthropods. It is the *posterior* portion of the trunk in vertebrates. In the vertebrates this region of the body contains most of the alimentary tract, the excretory system, and the reproductive organs. It contains part of the coelom and in mammals is separated from the thorax by the diaphragm.

The abdominal cavity of the human body is subdivided into the abdomen proper and the pelvic cavity.

The walls of the abdominal cavity are lined with a smooth membrane called the peritoneum, which also provides partial or complete covering for the organs within the cavity.

The abdomen proper is bounded above by the diaphragm; below it is continuous with the pelvic cavity; at the posterior it is bounded by the spinal column, and the back muscles; and on each side by muscles and the lower portion of the ribs. In front, the abdominal wall is made up of layers of fascia and muscles. The abdomen is divided into nine regions whose boundaries may be indicated by lines drawn on the surface. The mid-section above the navel between the angle of the ribs is known as the epigastric region; that portion around the navel, as the umbilical; below the navel and above the pubic bone, as the hypogastric region. It is further divided into right and left upper quadrants on each side above the navel, and right and left lower quadrants on each side below the navel. The lumbar region extends on either side of the navel to the posterior and laterally.

The principal organs of the abdominal cavity are the stomach, duodenum, jejunum, ileum, and colon or large intestine, the liver, gall bladder and biliary system, the spleen, pancreas and their blood and lymphatic vessels, lymph glands, and nerves, the kidneys and ureter.

The pelvic portion of the abdomen contains the sigmoid colon and rectum, a portion of the small intestine, the bladder, in the male the prostate gland and seminal vesicles, in the female the uterus, Fallopian tubes, and ovaries.

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ABEL EQUATION. A mass point moves along a smooth curve in a vertical plane and under the influence of gravity alone. Given the time, t, required for the particle to fall from a point, x, to the lowest point on the curve as a function of x, what is the equation of the curve? The problem leads to a Volterra integral equation of the first kind.

$$f(x) = \int_0^x \frac{\phi(t)\,dt}{\sqrt{2g(x-t)}}$$

where g is the acceleration of gravity. The solution is

$$\phi(x) = \frac{\sqrt{2g}}{\pi} \int_0^x \frac{f'(t)\,dt}{\sqrt{x-t}}$$

and the equation of the curve is

$$y = \int_0^x \sqrt{|\phi^2(t) - 1|}\,dt$$

A closely related problem is that of the brachistochrone, where the path is required for a minimum time of descent. Such matters were of considerable interest to many seventeenth and eighteenth century mathematicians; the one described here was solved by the Norwegian, N.H. Abel (1802–1829). See also **Brachistochrone**.

A more general case of the Abel equation is

$$f(x) = \int_0^x (x-y)^{-\alpha} \phi(y)\,dy$$

where $f(x)$ is continuously differentiable for $x \geq 0$ and $0 < \alpha < 1$. The solution is

$$\phi(y) = \frac{\sin\alpha\pi}{\pi} \left[\int_0^y (y-x)^{\alpha-1} f'(x)\,dx + f(0) y^{\alpha-1} \right]$$

ABELIAN GROUP. A commutative group, namely such that $AB = BA$ where A, B are any two elements contained in it.

ABERRATION OF LIGHT. The apparent change of position of an object, due to the speed of motion of the observer. Care must be taken not to confuse this effect with that of parallax.

If a telescope, assumed to be stationary, is pointed at a source of light, the light that enters the object glass centrally and in the direction of the optic axis will pass through the telescope along that axis and emerge through the center of the eyepiece. If the telescope is in motion relative to the source, in any direction other than parallel to the optic axis, the light that enters centrally will emerge off the center of the eyepiece. If this light is to emerge centrally, the telescope must be tilted forward in the plane containing the direction of motion of the instrument and the source. The amount of tilt will depend on the direction of the source and the ratio of the speed of the telescope to the speed of light.

This aberrant effect was first announced by Bradley in 1726. He noticed that stars had apparent periodic motions with a period of one sidereal year, and that the character of the apparent motion depended upon the celestial latitude of the star. He correctly interpreted the effect as due to the motion of the earth about the sun. Statistical discussions of the observations of a large number of stars have shown that the maximum value of this aberration due to the earth's orbital motion is $20''.47$. This is known as the "aberration angle" or the "constant of aberration," and is given by

$$\kappa = \frac{2\pi a \operatorname{cosec} 1''}{cT(1-e^2)^{1/2}}$$

where a is the mean radius of the earth's orbit, c is the velocity of light, T is the length of the year in seconds, and e is the eccentricity of the orbit. An aberrational effect of about $0''.3$, at maximum, is observed, due to the rotation of the earth on its axis, and is given by

$$k = \frac{2\pi\rho \cos\phi \operatorname{cosec} 1''}{ct}$$

where ρ is the radius of the earth, ϕ is the latitude of the place, and t is the length of the day in seconds.

In 1871, Airy made a series of observations for determination of the aberration constant, using a telescope filled with water. Because the value of the index of refraction of water is about $1\frac{1}{3}$, Airy expected that the value of the aberration would be $27''.3$ when using the water-filled tube. He found, however, that the value was $20''.5$ no matter what substance was placed in the telescope. The result of this so-called "Airy's Experiment" caused much discussion, but was eventually explained on the basis of the Michelson-Morley experiment and the theory of relativity.

All observations in which the positions of the stars are involved must be corrected for aberration of light if the results are to be accurate to within $20''$. Both the motion of the earth about the sun and the rotation of the earth must be considered. The magnitude of the correction depends upon the celestial coordinates of the star, the position of the observer on the earth, and the date and time of observation.

ABERRATION (Optical). The failure of an optical system to form an image of a point as a point, of a straight line as a straight line, and of an angle as an equal angle. See also **Astigmatism**; **Chromatic Aberration**; **Coma (Optics)**; **Curvature of Field (Optics)**; and **Spherical Aberration**.

ABHERENT. Any substance that prevents adhesion of a material to itself or to another material. It may be in the form of a dry powder (a silicate such as talc, mica, or diatomaceous earth); a suspension (bentonite–water); a solution (soap–water); or a soft solid (stearic acid, tallow waxes). Abherents are used as dusting agents and mold washes in the adhesives, rubber, and plastics industries. Fats and oils are used as abherents in the baking industry. Fluorocarbon resin coatings on metals are widely used on