method of deactivating bombs which would considerably reduce this risk.

Liquid nitrogen is relatively safe and easily handled. A bomb sprayed with it for several minutes would be cooled to an extremely low temperature. This would have two effects. First, the battery used to detonate the explosive would become ineffective. I have verified this in the following way. Three brands of dry cell battery (Ever Ready, Winfield, Ray-O-Vac) were cooled to the temperature of liquid nitrogen and tested in a small torch. None of the batteries tested caused the torch to light. When the batteries were allowed to warm up, however, complete efficiency was restored.

Second, the detonator and explosive might reasonably be expected to be unreactive at such low temperatures. A bomb deactivated in this manner could be safely transported to a disposal site in an insulated container partially filled with liquid nitrogen.

Yours faithfully,

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Foraminifera

SIR,—The recent review of Dr J. W. Murray's book[1] by Dr J. R. Haynes (*Nature*, **245**, 442; 1973) may have confused a number of palaeoecologists by seeming to advocate absolute abundance rather than standardised abundance for the plotting of species distributions. The latter method, now widely employed, is admittedly suspect because it makes the *a priori* assumption that all the foraminifera of an assemblage are competing.

This is not as unsatisfactory, however, as the absolute abundance method which is, of course, much affected by rates of sedimentation. As a result, plots of species using this method are often difficult to distinguish. Standardisation of data reduces this 'background noise' and furthermore enables the calculation of basic ratios (such as benthonic : planktonic or Textulariina : Miliolina : Rotaliina) which are now valuable aids to the palaeoecologist. Obviously, if the approach is biological rather than geological, then the biomass of a species per unit area is the better index.

Yours faithfully,

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[1] Murray, J. W., *Distribution and Ecology of Living Benthic Foraminiferids* (Heinemann, London, 1973).

As suggested in my review, paucity of data and lack of control of sample material may force us to express species abundances in percentages rather than absolute numbers per unit area of volume of substrate. The desperate inadequacy of this method, however, is shown by the tables in Chapter 1 of Dr Murray's book. Not only does this method impose reciprocal relationships but the percentage figures may show a rise for a particular species between stations when the absolute numbers have fallen and *vice versa*.

At present our understanding of the autecology of foraminifer species is almost nil. Progress towards an evolutionary ecology requires knowledge of the abundance of individual species both in their habitats and when dead as part of the sediment. The variations in numbers and sorting brought about by sedimentary processes which make plots "difficult to distinguish" are precisely what concern geologists and represent the challenge that has to be met before we can properly interpret the geological record. Even where it is thought valuable simply to estimate certain crude ratios these are as easily derived from absolute numbers.

JOHN R. HAYNES

Obituary

Leonard Carmichael

DR LEONARD CARMICHAEL, Secretary of the Smithsonian Institution from 1953–64, died on September 16 in Washington, DC, at the age of 74. He was the National Geographic Society's Vice-President for Research and Exploration at the time of his death.

A distinguished physiological psychologist, Dr Carmichael also achieved renown as a science administrator in the worlds of academia, museology and government. The central unifying interest in his career, which lasted 50 years, was research: his own research and the administration and funding of the research of others.

Dr Carmichael was born on November 9, 1898, in Philadelphia, where his father was a successful physician. In 1917 he entered Tufts University, where his grandfather, Charles Hall Leonard, had for many years been Dean of the Crane Theological School. Here he became interested in zoology and psychology, and later recorded that the two men whose books had the most influence on him as an undergraduate were the biological ultramechanist Jacques Loeb and the proponent of emergent evolution C. Lloyd Morgan.

Following graduation from Tufts, *summa cum laude*, he began graduate work at Harvard in psychology, developing an interest in a basic biological approach to the science. He later wrote that the accidental finding of a German publication of William Preyer, *Specielle Physiologie des Embryo, Untersuchungen uber die Lebenserscheinungen vor der Geburt*, in the Harvard Library, was a turning point in his life, opening his eyes to a specific area of research in his chosen field of the sensory and neural control of behaviour on which he was to spend many years. "Here at last I saw a way to investigate the topic of major interest to me—the morphological growth of the receptors and nervous system in relation to changes in behaviour as responses are released at various stages during the early ontogenetic development in each mammal before learning begins, or at least before it becomes important."

He completed his PhD studies and theses and did a year of graduate work at the University of Berlin before beginning his teaching career at Princeton in 1924. Later he taught at Brown, where he gained his first administrative experience as Director of its psychology laboratory, and at Rochester, where he was Dean of the arts and sciences faculty. At Brown, in addition to his teaching and administrative activities, Dr Carmichael began studying the prenatal development of behaviour in mammals. With Dr H. H. Jasper he developed the electroencephalograph and published in 1935 what is believed to be the first report of such work in America.

In 1938 Dr Carmichael returned to Tufts to become, at 39, one of the youngest presidents in the college's history, but during World War II he was summoned from the campus to fill various posts in Washington. As director of the National Roster of Scientific and Specialised Personnel, he organised the recruiting of scientists to work on the atomic energy and radar projects as well as other research connected to work on the war effort. In this period, Dr Carmichael later said, he spent more than a year of nights on a sleeping car between Boston and Washington. He was also President of the American Psychological Association from 1939–40.

After the war, he was a member and Vice-Chairman of the National Advisory Committee for Aeronautics, the predecessor of the National Aeronautics and Space Administration. President Eisenhower named Dr Carmichael Ambassador Extraordinary when he represented the United States at an international conference at The Hague that wrote a treaty for the protection of cultural property in time of war.

In the course of his academic career, Dr Carmichael published numerous papers on reading and visual fatigue, perceptual assimilation, the development of a kitten's ability to land on its feet, and other aspects of behavioural development related to the functions of the sense organs. Dr Carmichael also collaborated with H. C. Warren on the book *Elements of Human Psychology* (Houghton Mifflin, 1930), which was used as an introductory book for years in many major universities and colleges. They also collaborated on a *Dictionary of Psychology* (Houghton Mifflin, 1934). His later writings include *Basic Psychology*, which he wrote in 1957 to set out his point of view for the educated general reader. *Carmichael's Manual of Child Psychology*, of which he wrote part, went through a third edition in 1970.

On January 1, 1953, Dr Carmichael became Secretary of the Smithsonian, the seventh scientist to direct an institution, founded in 1846 with a bequest from the English scientist James Smithson, "for the increase and diffusion of knowledge among men". Dr Carmichael, during his 11-year tenure as Secretary, was notably successful in obtaining appropriations from Congress to foster programmes of exhibit modernisation for the Institution's museums. Under his leadership the Institution received $36 million in Federal funds for a Museum of History and Technology, the Smithsonian's first new building in 50 years.

In 1964, at the age of 65, he insisted on retiring from the Smithsonian. He was then offered the post at the National Geographic Society. There he directed $1.2 million in annual grants for research into sciences. His projects involved him in many activities, including the work of Dr Louis S. B. Leakey at Olduvai Gorge in Tanzania. He also worked closely with Baroness Jane van Lawick-Goodall, whose pioneering study of wild chimpanzees broke new ground in the study of animal behaviour. Primatology was long an interest of Dr Carmichael and he had served as President of the International Primatological Congress.

He also served as President of the American Philosophical Society from April 1970–73, and was elected to several scientific organisations abroad, including the Ergonomics Research Society of the Royal Society of Arts in England, and the Société Francais de Psychologie. In 1972 the National Academy of Sciences bestowed its highest award, the Hartley Public Welfare Medal, on Dr Carmichael "for eminence in the application of science to the public welfare".

Walter Rudolf Hess

PROFESSOR WALTER RUDOLF HESS, Nobel Laureate for Physiology and Medicine for 1949, the man who brought to light the functional organisation of the diencephalon, died at the age of 92 on August 22, 1973, in his home at Ascona, Switzerland.

In 1917, at the early age of 36, he became Professor of Physiology at the University of Zurich, and in this capacity Director of the Institute of Physiology, a post which he held until his retirement in 1951. He very soon became one of Europe's leading physiologists, and with great drive and energy promoted this branch of science on an international scale. Thus, foreseeing the importance of research on the adaptation of the human body to the conditions of high altitude, he founded in 1931 the international *Hochalpines Forschungsinstitut Jungfraujoch*. In 1938 he was delegated to organise and preside over the 16th International Congress of Physiological Sciences in Zurich. His strong personality succeeded in keeping the meeting on an entirely scientific base despite the political troubles of that time.

In his scientific work, W. R. Hess combined analytical experimentation with great synthetic power, which enabled him to view the data he obtained within the larger frame of the purposeful organisation of biological phenomena. This was already manifest in his early investigations on the viscosity of blood and general haemodynamics, but even more so in his work regarding the regulation of circulation and of respiration, concepts which were laid down in two monographs in 1930–31. It was this search for the organising principles which led W. R. Hess to begin experimentation with electrical stimulation in the brain stem—the diencephalon; his aim being to explore the autonomic centres which govern the adaptation of circulation and respiration to the different needs of the organism during rest and work. Hess himself said that he wanted to dedicate only one year to this problem, but the work grew and was extended over twenty-five years to form what is known today as his life's work. He perfected the method of circumscribed stimulation and coagulation of subcortical structures in the unrestrained animal in 1932, and after deliminating the reactive zones in the hypothalamus concerned with regulation of circulation and respiration—results obtained in the anaesthetised animal in 1932—he proceeded to systematically explore the entire diencephalon and adjacent portions of the mesencephalon in the freely-moving awake cat.

Every physiologist is familiar with the film of Hess's cats manifesting autonomic, motor and affective-behaviour effects upon electrical stimulation within the diencephalon. Not so familiar, even today, to many a physiologist are the basic conclusions derived by Hess from his experimental work.

Hess's view of two opposing ergotrophic and trophotrophic systems was based on the following observations. Stimulation in the caudal portion of the hypothalamus, besides producing an increase in blood pressure and activation of respiration, also produces a general arousal of the animal which is associated with increased locomotor activity 'Bewegungsdrang'. Stimulation in the predominantly more rostrally lying portions of the hypothalamus and of the septum, besides yielding a decrease of blood pressure and an inhibition of respiration, produces responses which are related to food intake, digestion, excretion and thermoregulation. Thus the former effect—the ergotrophic reaction—includes both the autonomic and somatomotor responses which are activated simultaneously during effort, and therefore with expenditure of energy. The latter effect, however, the trophotrophic reaction, subserves restitution of the dispent energy and guarantees the balance of the internal environment. A behaviour primarily associated with restitution is sleep, and Hess conceived sleep as a distinct type of behaviour; an active process which is governed by the central nervous system. This view has been confirmed by further research, although the narrow concept of a discrete sleep centre in the thalamus can no longer be upheld today.

The various motor effects of the head and trunk produced from the thalamus and adjacent mesencephalon are related to the regulation of posture. This subcortically organised motor system provides an indispensable support for the execution of voluntary movements by counterbalancing the forces exerted by these movements. Hess called this sys-