text, the book covered the topics of mechanics, astronomy, pneumatics, optics, and electricity.

Marcet moved from London to Geneva in 1820, after inheriting a substantial legacy from her father that allowed her husband to relinquish his medical practice. Two years later, she found herself widowed when he died suddenly on a visit to England. She divided her later years between Switzerland and London. Her last scientific work in the genre she had made so successful was *Conversations on Vegetable Physiology* (1829), based on discussions with the Swiss botanist Augustin-Pyrame de Candolle. Subsequent works included a primer on political economy for working people and a number of stories and pedagogical books for young children. Toward the end of her life, she finally allowed her name to appear on the title pages of new editions of her books, claiming the credit to which she was entitled for a remarkable career in scientific education that particularly benefited women.

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Jan Golinski

MARGALEF, RAMON

(*b.* Barcelona, Spain, 16 May 1919; d. Barcelona, 23 May 2004), *limnology, marine biology, ecology.*

Margalef was the most important Catalan and Spanish limnologist, marine biologist, and ecologist of the twentieth century. He was a pioneer and outstanding researcher in these fields, and he contributed greatly to several natural science branches, from limnology and biological oceanography to theoretical ecology. Margalef left an enormous body of scientific literature, consisting of more than 400 published scientific papers and a score of scientific books. Although not all of his papers were published in journals included in the Science Citation Index, for many years he was the most frequently cited Spanish scientist. In a list of ninety-five scientific pioneers from around the world, Margalef was considered to be one of the three most outstanding Spanish life scientists, the other two being Nobel Prize winners Santiago Ramón y Cajal (1852–1934) and Severo Ochoa (1905–1993). Margalef made outstanding contributions to aquatic ecology and general ecology, having postulated several unifying ecological concepts that address the functional and structural properties of ecosystems. These concepts, often controversial, have obtained since their initial formulations wide acceptance. Some of Margalef’s most renowned achievements focused on topics that include the application of thermodynamics to the study of the ecosystem; the use of information theory to quantify the organization represented by the taxonomic diversity of the ecosystem, and using the species’ diversity and connectivity as measures of ecosystem organization and complexity; the temporal development of ecosystems, that is, the ecological succession and the changes in ecological descriptors (such as production and structural organization of the ecosystem) occurring through this process; the ecological succession as an evolutionary framework of ecosystem development; the study of the small-scale spatial distribution of marine and freshwater phytoplankton, and the quantification of plankton diversity; the response of ecosystems to stress, and especially to the scarcity of nutrients (mainly phosphorus); the role of auxiliary energy and nutrient availability in the selection of phytoplankton life forms (the phytoplankton "mandala") and, more generally, in the production of organic matter both in the ocean and in the biosphere as a whole. The study of marine phytoplankton and of upwelling ecosystems allowed him to pave the way for the unification of physical and biological oceanography we take for granted today.

Margalef's book *Perspectives in Ecological Theory* (1968) and his articles "On Certain Unifying Principles in Ecology" (1963), "Life-forms of Phytoplankton as Survival Alternatives in an Unstable Environment" (1978), and "From Hydrodynamic Processes to Structure (Information) and from Information to Process" (1985) are classics regarding their citations by other authors. In particular, "On Certain Unifying Principles…" is considered to be among the top ten articles of twentieth-century biology.

The Making of a Naturalist. Margalef was an autodidact. Ramon was born in Barcelona, where his family emigrated from the once wine-rich Camp de Tarragona county, which was devastated by the phylloxera during the last decade of the nineteenth century. His father was a bank employee, but also very dedicated to a tiny orchard he owned. This familiar background may explain the interest of Ramon Margalef by nature from his first years. As a young man, he supplemented his education in Trade School with French, German, and mathematics, and he became interested in natural history and biology, especially that of aquatic environments. The Spanish Civil War interrupted his education; in 1938, while still a teenager, he was recruited into the Republican army. At the end of the war, and after serving an extended three-year period in the military, he worked as a clerk at an insurance company while continuing his research on Iberian aquatic ecosystems as a student at the Botanical Institute of Barcelona. Margalef read everything he could find on biology, physics, and other fields of science, which equipped him with an encyclopedic amount of knowledge. His earliest scientific publications, dating back to 1943, quickly established his talent and won him a scholarship, which allowed him to obtain a degree in biology. He studied in the University of Barcelona, completing in four years a five-year Natural Sciences career. In 1951, he defended (in the Complutense University of Madrid, where all theses must be presented in those years) his doctoral thesis on the "Temperature and Morphology of Living Beings," which addressed many questions that continued to be asked into the twenty-first century, and which interested Margalef all his life, including the changing responses of plant and animal growth, metabolism and production in relation to the environment temperature, as laboratory extensions of the well-known thermal rules (Allen's, Bergmann's, and so on).

In the 1940s, Margalef built his own microscope with an assortment of parts bought at flea markets. Over the years, he also built several other instruments in order to automatically obtain water and plankton samples, mimic natural conditions in the laboratory, or automatically process data from his experiments. Proof of the high quality of his inventions (actual prototypes that were later modified and improved) was that, for many years, the U.S. government gave him the money he requested to construct any kind of mechanical or electronic oceanographic or other instruments he devised.

Ecologist of World Fame. During that early period, Margalef was an indefatigable researcher. Not only was he an outstanding naturalist, he was also capable of making connections between very diverse aspects of biology, geology, physics, and chemistry. It was obvious that he had a rare kind of intelligence and that his knowledge exceeded by far that of his colleagues. Other scientists in higher positions (the botanist Pius Font I Quer, the zoologist Francisco García del Cid and the amateur naturalist Karl Faust) were aware of the excellence of Margalef's work and helped him to pursue his career with scholarships or by promoting his early research efforts. After World War II, Margalef visited numerous research centers and participated in many scientific meetings in the United States, thanks to an unlimited travel offer from the U.S. government. Subsequently, several American universities encouraged him to move to the United States with his family, an invitation he would have accepted gladly in order to leave science-barren postwar Spain, but the adverse opinion of his wife Maria Mir, also a biologist, whom he had married in 1952 and with whom he had four children, prevailed.

In 1950 Margalef began working at the Institute for Fisheries Research (Instituto de Investigaciones Pesqueras, IIP, later called the Institute for Marine Sciences), a division of the Spanish Research Council (CSIC), of which he was appointed director in 1966. Margalef promoted oceanographic research and the institute soon became a center of excellence in oceanography. He also converted the journal *Investigación Pesquera* (later renamed *Scientia Marina*) into a prestigious journal of Spanish marine science. Similarly, his works on limnology, which appeared mainly in *Publicaciones del Instituto de Biología Aplicada*, built an international reputation for that journal. When, in 1967, he was appointed to Spain's first chair in ecology at the University of Barcelona, he resigned his post at the IIP.

At the University of Barcelona, Margalef established the Department of Ecology and trained several generations of ecologists, limnologists, and oceanographers. After two decades of a fruitful academic career, he retired in 1987 and was appointed emeritus professor in 1996. Without the time-consuming commitments of teaching and active research, he continued to work, wrote on ecology and generously shared his knowledge with colleagues and friends until shortly before his death. Margalef trained hundreds of scientists in the classroom, in the laboratory, in the field, and at sea, lecturing to them and carrying out joint research not only at the University of Barcelona and the Institute for Fisheries Research but also at other centers around the world. From 1971 to 2001, he supervised around forty doctoral theses.

A prolific author with good command of half a dozen languages, Margalef read thousands of scientific books throughout his life, but he had a notable literary knowledge, too, especially of the classics. He also used his own books, which conveyed his ideas about the biosphere's organization and functioning, to teach university students and society in general.

Two remarkable and thorough university textbooks written in Spanish by Margalef deserve special mention: *Ecología* (1974) and *Limnología* (1983). For many years, *Ecología* was considered to be the best book on this field of science (as explicitly and separately expressed by the noted ecologists Eugene P. Odum and G. Evelyn Hutchinson) ever written in any language, both for its thorough analysis of this science and for supporting its encyclopedic data with a synthetic, coherent ecological theory. Margalef updated the ideas contained in it in later books: *La Biosfera: Entre la termodinámica y el juego* (1980), *Teoría de los sistemas ecológicos* (1991), *Oblik Biosfer* (in Russian, 1992) and *Our Biosphere* (1997). Margalef was also author and editor of many monographs, including *Introducción al estudio del plancton marino* (1950), "Los crustáceos de las aguas continentales ibéricas" (1953), "Los organismos indicadores en la limnología" (1955), *Comunidades naturales* (1962), *Ecología marina* (1967), and *The Western Mediterranean* (1985).

Margalef was a great popularizer of ecology. Among his books aimed at general audiences a few must be mentioned: *Ecología* (1981), which continues to be a best-seller; *L'ecologia* (1985, published on the occasion of a related exhibit); and *Planeta azul, planeta verde* (1992). He was a frequent contributor to several encyclopedias of natural history, especially *Història natural dels Països Catalans* (1992) and *Biosfera* (first published in Catalan, later translated into Japanese and English, *Biosphere*, 1993–1998). Margalef also participated in creating exhibitions aimed at the general public. In one of his articles advocating changes in the teaching of natural science, he stressed the importance of conveying the "simple facts about life and the environment not to forget in preparing schoolbooks for our grandchildren" (Margalef, 1984).

Contributor to Ecological Theory. Margalef's article "La teoría de la información en Ecología" (The theory of information in ecology, 1957) was his introductory lecture as a new member of the Barcelona Royal Academy of Sciences and Arts; later translated into English and published in *General Systems* (1958), it eventually reached a worldwide audience. In this article, Margalef suggested that the theory of information should also be applied to the study of species diversity in ecosystems (there are several "Margalef diversity indices," relating species numbers and their abundances, commonly used by ecologists). The interplay of matter and energy cycles at the ecosystem level translates as an information accumulation in the form of structure: the number of species, their interaction and their mutual interdependence. Thus, the species diversity of an ecosystem (or better, of one of its taxocoenosis, that is, one of its taxonomic components: their insects, plants, phytoplankton, whatever) can be considered as an information content. This information content increases with the number of species (the system being more heterogeneous) and decreases with the number of individuals of each species (the system being more homogeneous or monotone); this information is the inverse of the entropy of the system. Thus, any expression giving the information content of a system (not necessarily a biological one), such as the Shannon & Weaver (1963) index—$H = -\Sigma\, p_i \log_2 p_i$, where p_i is the proportion of the i-species in the total count—is suitable to explain the biological diversity of an ecosystem, and an easy method to ascertain its maturity, degree of organization, place in the ecological succession, degree of exploitation and so on.

At the time, ecology was still a young science, lacking both a theoretical reference framework and a corpus of stable paradigms comparable to those in other scientific fields. Margalef's 1958 paper, along with the article "On Certain Unifying Principles…" and the small book *Perspectives in Ecological Theory* (1968), which was translated into several languages, offered new and appealing ways of understanding ecology.

Margalef based his theoretical approach, which was holistic and integrative, on his extensive knowledge of aquatic ecosystems, which he had studied first as a naturalist, applying a botanical, zoological, and phytosociological perspective. He often acknowledged the influence other naturalists and ecologists had on his work, and explicitly cited, among others, F. E. Clements, H. W. Harvey, August Thienemann, Josias Braun-Blanquet, G. Evelyn Hutchinson and Eugene P. Odum; but having read so extensively, and having known personally so many ecologists, limnologists and oceanographers himself, it is hard to pinpoint only a few of them. Later he took a more general approach and gathered information about the structure and workings of the whole biosphere. He understood the ecosystem as a level of organization, made of complex elements connected in a non-permanent form by means of a network of flexible and adaptable interactions.

Superimposed on the network of matter and energy exchange (the classical trophic web), there is a network of information exchange, not totally coincident with the previous one. This ecosystem concept obeys macroscopic phenomenological laws, mainly physical and thermodynamical ones, and follows historical trends (the ecological succession) along which some function is optimized, namely the conversion of dissipated energy (or entropy production) in information (or structure). In plain terms, the Production/Biomass ratio (energy flux per unit biomass through the ecosystem) decreases along the ecological succession, as the amount of structure increases. This accretion of information, structure, complexity, and maturity is a self-organizing process; it was later called the Margalef principle on ecosystems.

Limnologist, Marine Biologist, and Biospheric Ecologist. Margalef excelled in the fields of limnology, marine ecology, and theoretical ecology. Working on his own, he set up the basis for studying the regional limnology of the Iberian Peninsula and the Balearic Islands, and later initiated the ecological research on one hundred Spanish reservoirs, which as of 2007 remained the only thorough analysis of this type worldwide. The International Society of Limnology awarded Margalef the Naumann-Thienemann Medal for "having shared his creative talents of discoveries, intuition, and synthesis of the ecological foundations of the limnological phenomena, and for his influence in the Hispanic world."

The study of marine plankton and primary production of the sea soon led Margalef to new quantitative approaches and to apply several new methods of evaluating the populations of the microscopic organisms living in the water column, such as consideration of species diversity, or other models derived from terrestrial ecology such as the concept of ecological succession. Probably his most outstanding contributions to ecology were recognizing the spatial organization of phytoplankton and the crucial role of external, auxiliary, or exosomatic energy in that structure. Prior to those observations, phytoplankton was considered to be simply a structureless cell suspension. He proposed a model for the production of organic matter in the ocean that combines the turbulence (dissipation of external energy) and the covariance of reactants (light, nutrients, organisms). The simplest form of this model, P (for production) = A (for turbulence) x C (for reactants covariance), was further elaborated and has come to be fully accepted.

Taking into account both space and the role of exosomatic energy in the structuring of biological communities was an approach that Margalef applied not only to the study of plankton, but also to other communities of the biosphere. This mode of thinking had proven to be advantageous in estimating species diversity and the connectance between different nodes of trophic webs. It also enabled him to study the patterns that could be elucidated from an analysis of ecological succession, which he was the first to identify as an evolutionary framework in the development of the ecosystem. From these ideas, an ecological theory emerged that, like everything in science, has been subject to modification, refutation, and evolution. This theory was Margalef's major contribution to ecology as an established scientific discipline.

Throughout all his scientific life he was especially interested in the role of phosphorus as a limiting factor in primary production, both in the sea and on land, and in his later years he pondered the changes the "shifting topology of landscape" (the transformation of world landscapes from natural areas spattered with few human settlements to urban-crowded areas with few natural remaining patches) will have on information, energy, and matter fluxes through ecosystem borders.

From his first publications on ecological theory until his last book, Margalef's role in furthering the understanding of the functioning of the biosphere has been acknowledged internationally. In 1988, the National Science Foundation recognized Margalef's research on the dynamics of marine phytoplankton, which he carried out during the 1960s and 1970s, and declared that his work on these subjects had been several decades ahead of its time, and had provided the foundations for subsequent biological research in that field. Indeed, Margalef is one of the very few scientists who contributed to both the theoretical and the practical development of a science.

Margalef also made contributions to biogeography, geology, human evolution, and human ecology. Including the human species in his general theory of the biosphere was among his most valuable but least-known contributions to ecology. His basic postulate was that man is to be viewed as a part of the biosphere (accordingly, he criticized the title of the United Nations program MAB, Man and the Biosphere, saying it should be renamed MIB, or Man *in* the Biosphere), in which it is necessary to consider human activity within a general ecological context to address many socioeconomical problems. He assimilated interactions between more and less mature natural systems to those occurring between social and political systems, and applied to man's activities the same concepts explaining ecosystem functioning: exosomatic energy, increasing of non-productive biomass along the succession, the Matthew principle, and so on.

Margalef received numerous and significant awards for his research and teaching activities, among them the A. G. Huntsman Award (1980, considered as the Nobel Prize in Oceanography); the Santiago Ramón y Cajal Prize of the Spanish Ministry of Education and Science (1984);

the Naumann-Thienemann Medal of the International Association of Theoretical and Applied Limnology (Societas Internationalis Limnologiae, SIL; 1989); the International Ecology Institute Prize (Germany, 1997); the American Society of Limnology and Oceanography (ASLO) Lifetime Achievement Award (2000); the Gold Medal Award of the Spanish Council for Research (CSIC; 2002); and the Gold Medal Award of the Autonomous Government of Catalonia (2003), and many others. Margalef was a member of several scientific academies in Spain and abroad, the U.S. National Academy of Sciences among them. In addition, he was an honorary member of several scientific societies around the world and was awarded *honoris causa* doctorates from several European and American universities. In science, receiving so many international awards is somewhat unusual, and it is even more unusual that professional recognition continues over half a century.

Ramon Margalef contributed enormously to the task of solving many of life's mysteries, and he did it, as Ivan Valiela (1994) observed, because "his ideas made us think, something enviable for any scientist." Margalef was an exemplary teacher and man of science, honored by the University of Barcelona, the various academies of which he was a member, the numerous research centers and universities that awarded him distinctions, and his country. He contributed remarkably to ecology, limnology, and oceanography, but liked to think of himself as a naturalist; indeed, he was a Galilean type naturalist (according to Gould, 1991, a Galilean naturalist is someone who not only enjoys the beauty of nature, as do the Franciscan naturalists, but who also thrives on discovering its secrets), and also a consilient one (Wilson, 1998, calls consilience a commitment to the fact that all the complexity of our world, both the physical and the human aspects of it, can be explained by the same general principles; Ros, 1999). He was one of the great minds of the natural sciences and biology, with a total dedication to science, but he was not insensitive to worldly affairs; on the contrary, he applied his knowledge of nature to gain a better understanding of the world that surrounded him. And, in spite of all his scientific wisdom, he was surely a greater human being than he was a naturalist.

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Joandomènec Ros

MARINUS OF TYRE (Tyre, Syria, Roman Empire, *fl.* c. 100 CE), *geography.*

Marinus was the author of a number of works on cartography, which are known solely from what Ptolemy (second century CE) relates about them in Book I of his *Geography.* Ptolemy speaks of Marinus as the most recent author to have dealt with the problem of constructing a map of the *oikoumenê,* the "inhabited world" (in effect, the part of the world known to Greco-Roman civilization). Most of what Ptolemy writes about Marinus is a review of his errors and infelicities. But at the outset he praises the thoroughness of his research, his critical attitude to his sources, and his readiness to correct his own work, and he makes it clear that the broad geographical conception portrayed in the *Geography* as well as the bulk of the detailed data are taken from Marinus.

Marinus assumed a spherical Earth having a circumference of 180,000 stades. (The size of the ancient geographers' stade is disputed, but that is not terribly important, because ancient geodesy relied on very crude distance estimates.) His *oikoumenê* comprised the three continents of Europe, Libya (Africa), and Asia, and he believed that Asia was joined to Libya not only at the head of the Red Sea but also by land south and east of the "sea of India" (the Indian Ocean), which was thus wholly enclosed and not connected to the ocean lying east of Europe and Libya. The northernmost known locality was Thoulê (the Shetlands?), slightly south of the Arctic Circle, and the westernmost was the Isles of the Blest (the Canaries). Ptolemy took over these assumptions. But Marinus deduced from the reports of various travelers that the *oikoumenê* extended 24° south of the equator and 225° east of the Isles of the Blest, much further in either direction than Ptolemy was willing to accept. The remotest places to the east of which his sources knew appear to have corresponded to China and Southeast Asia, and the southernmost to parts of the east coast of Africa a few degrees south of the equator. So far as scholars know, Greco-Roman geographical knowledge never surpassed these limits.

Marinus's most detailed and accurate information, of course, pertained to the Roman Empire and its immediate neighbors. Roughly two-thirds of the eight thousand or so localities listed in Ptolemy's geographical catalog were within the empire, and it is striking that in these regions Ptolemy's data reflect geographical conditions around the first decade of the second century CE, about half a century before Ptolemy wrote the *Geography.* This is probably when Marinus was active. Elsewhere, and especially in describing India and lands further east, Ptolemy had more recent informants.

Marinus advocated using a rectangular grid of meridians and parallels (i.e., a cylindrical projection) for drawing a world map. According to Ptolemy's report, Marinus did not actually produce a map in accordance with the last of his cartographical treatises, and it is not clear whether Ptolemy had access to any map executed according to Marinus's data or had to rely entirely on his writings.

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Alexander Jones

MARK, HERMAN F. (*b.* Vienna, Austria, 3 May 1895; *d.* Austin, Texas, 6 April 1992), *chemistry, polymer chemistry, molecular structure, education.*

Mark was cited in a memorial program after his death as one who had "earned a lasting place in the history of polymer science through his research contributions, the successes of his students, his organizational genius, and his timeless promotion of polymer science. It is entirely accurate to say that Mark found polymers a curiosity and made them a science." Linus Pauling, while admitting that most chemists thought of Mark as a polymer pioneer, stressed that he thought of Mark "with affection and admiration, as a pioneer in modern structural chemistry and an important early contributor to its development" (Pauling, 1984, p. 337).

Early Life. This dichotomy is further emphasized by the two distinct phases of Mark's life—the years he spent in Europe and the years he spent in Canada and the United States. Born in Vienna, Mark was the oldest of the three children of Hermann Carl and Lili Mueller Mark. (He