

**Ricardo Guerrero**Department of Microbiology,  
University of Barcelona, Spain

E-mail: rguerrero@iecat.net

**Joan Oró (1923-2004)**

Joan (John, in English) Oró Florensa was born in Lleida, Catalonia, Spain, on October 26, 1923, the youngest of five children and the only male. Due to the Spanish Civil War (1936-1939), his graduation from high school was delayed until 1941. He then studied at the University of Barcelona, where he obtained his degree in Chemistry in 1947. Already as a child, young Oró was interested in the chemistry of life. Since at the time he entered university there were no studies in biochemistry in Spain, he decided to pursue a degree in chemistry and to focus on organic chemistry. After his graduation, he returned to his hometown, Lleida. There he tried first, unsuccessfully, to earn his living as a chemist; afterwards, he spent 3 years working at his father's bakery, saving money in case he had the opportunity to return to chemistry. Nevertheless, he had mixed feelings about what to do. Whereas he longed to start a career in biochemistry, and thought that he and his wife (Francesca Forteza, to whom he married in 1948) could make do with a small salary, they already had three children: Maria Elena, Joan and Jaume (the youngest son, David, was born when the family was already living in Houston). He knew that if he kept working in the bakery, he and his family would not have financial problems in the future. However, making such a decision would mean not working at what he enjoyed the most and in the field for which he had been trained.

He decided to take another risk and go to the United States. In 1951, through the Institute for North-American Studies in Barcelona, Oró made a list of more than fifty universities in

the United States and sent letters to all of them requesting information. Four of the universities that answered his request offered him free tuition. He chose to enroll at the Rice Institute in Houston, Texas. Oró arrived in Houston on August 2, 1952, to start his graduate studies in chemical engineering. A few months later, he met Donald Rappoport, who was Professor of Biochemistry at Baylor College of Medicine, and needed a graduate student to help him in his research on metabolism. The study in which Oró participated was aimed at elucidating

some of the features of rapidly dividing, healthy cells in order to better understand the biology of cancer cells.

Oró studied the incorporation of carbon-labeled formate into animal tissues and the fate of this compound. He discovered that a major portion of the formate metabolized by sections of jejunum was incorporated into serine, cystathionine, and other acid-soluble products, and another portion was oxidized to CO<sub>2</sub> by a catalase-hydrogen peroxide complex. Based on that work, Oró demonstrated that molecules essential for life can be synthesized from other very simple ones, as was the case of formate, which has

only one carbon. By mid-1955, Oró had finished the experimental part of his doctoral thesis and thought that he would be ready to defend it in a few months. The Dean of Baylor School of Medicine recommended, however, that he waited until 1956; otherwise people might have the impression that doctorates could be obtained quickly at that school. While completing his thesis, Oró taught as an instructor in the



Fig. 1. Joan Oró (1923-2004).

Department of Chemistry of the University of Houston. He had to work very hard to cope with the five subjects he had to teach in addition to writing his doctoral thesis, which was not easy since he was not yet fluent in English.

At the Department of Chemistry of the University of Houston, Oró worked successively as Assistant Professor (1956-1958) and Associate Professor (1958-1963) before being appointed Full Professor, in 1963. By then he had already achieved one of his major goals in research: synthesizing adenine under laboratory conditions. Having obtained amino acids from hydrogen cyanide, water, and ammonia (the results of this experiment were not published until 1960), he then focused on the synthesis of adenine from glycine and several simple compounds. A student of his started the experimental work, which soon seemed to demonstrate the production of large amounts of adenine. Oró thought that such yields must be almost impossible to obtain and checked the results, only to realize that the graph that the student had interpreted as adenine in fact corresponded to the solvent that had been used. Remembering his earlier results, Oró considered the possibility of synthesizing adenine from ammonium cyanide. In fact, chromatography had shown a small spot corresponding to adenine. Perhaps he would be able to increase the adenine yield by using more nitrogen cyanide. On Christmas Eve, 1959, he concentrated a mixture of the starting ingredients and then allowed the solution to stand overnight. The following morning, when he returned to the lab, chromatographic analysis revealed a large black spot, which under ultraviolet light was confirmed to be adenine. He had done it! This experiment opened a new field of research that eventually led to the laboratory synthesis of the rest of the components of nucleic acids.

The most amazing conclusion Oró drew from that result was that a molecule essential for life, such as adenine, could be synthesized from ammonium cyanide, which is a lethal compound for respiration. Melvin Calvin (Chemistry Nobel Prize winner for his work on the mechanisms of photosynthesis in 1961) was among the first to recognize the significance of Oró's experiment and invited him to join his team at the Lawrence Radiation Laboratory of the University of California-Berkeley in the summer of 1962. Oró did not accept, choosing instead to stay in Houston.

In 1961, Oró suggested that cometary collisions with the Earth might have contributed to increasing the amount of carbon compounds in the early planet, thus promoting the prebiotic synthesis of biochemical molecules. He also suggested that comets had brought water to Earth. In fact, even if the young planet Earth was assumed to have had water, it probably escaped to outer space along with some mass of the planet as a result of a collision with a body the size of Mars.

Later calculations showed that the amount of carbonaceous matter that reached the Earth as a result of cometary collisions might have been as large as  $10^{12}$  grams.

In 1963, Freeman Quimby, who chaired the Life Sciences Department at NASA, invited Oró to join the group that would work on organic chemistry studies of the Apollo project. He was the Principal Researcher of the Houston University team that collaborated in the project and which had developed equipment for chemically analyzing lunar samples, both in situ—on the Moon—and in the laboratory—once the samples had been taken back to the Earth. The two scientists developed a small portable mass spectrometer that could analyze low-molecular-weight molecules. Even though that device was not used on the Moon, it was the basis for the mass spectrometer used in another NASA mission, the Viking project to Mars. Participation in the Apollo project made it possible for Oró's laboratory at the University of Houston to obtain state-of-the-art equipment for carrying out molecular analyses, for example, an apparatus combining mass spectrometry and gas chromatography that was crucial for meticulous analyses of complex mixtures. The study of lunar samples confirmed what many scientists had already suspected for years: there was no life on the Moon.

On July 20, 1976, the first Mars lander reached the surface of the red planet. Of the more than a dozen experiments carried out on Mars with the help of a robot, three dealt with biology. The most important consisted of mixing a sample of Martian soil with a solution that contained nutrients labeled with  $^{14}\text{C}$ , including glucose and several simple amino acids such as glycine. Biologists were amazed to learn that the mixture produced a large quantity of  $^{14}\text{C}$ -labeled carbon dioxide. Oró, however, had felt from the very beginning that life would not be discovered on the Mars surface because of the high degree of oxidation, and was skeptical of the interpretation of the results. When he discovered that formic acid was among the components of the test solution, he had an explanation for the result. He was familiar with the mechanisms of oxidation of formic acid, which he had studied as part of his doctorate. Formic acid oxidation is a common chemical, non-biological reaction.

Oró participated in the NASA Program of Organic Cosmochemistry until his retirement in 1994, studying organic synthesis under early Earth conditions and analyzing samples of meteorites, ancient rocks, and fossils. Before his retirement, and even afterwards, Oró was committed to the world of research both in the United States and in Catalonia. He chaired the first meeting of the International Society for the Study of the Origin of Life (ISSOL), which was held in Barcelona in 1973, and as the President of ISSOL was also one of the organizers of the seventh edition of the same meet-

ing, which also took place in Barcelona, in 1993, under the direction of the author of this article. He participated in founding the Association of Friends of Gaspar de Portolà (which promotes academic and cultural ties between California and Catalonia, mainly through a scholarship program), as well as the Catalan Foundation for Research, whose mission is to further scientific research in Catalonia. In Lleida, his hometown, he set up his own foundation (Fundació Joan Oró), whose aim is to promote basic and applied research as well as ties between companies and universities and research centers.

In 1994, Oró retired from his academic and research duties at the University of Houston and returned to Catalonia. His wife Francesca (Paquita) had died in 1990, and in 1995 he married to Antonieta Vilajoliu, from Balaguer, Lleida, who was also a widow of a late friend of Oró.

Oró's final project was an ambitious one. He had always longed for Catalonia to have a first-class Center of Astrophysics in the Montsec (between Barcelona and Lleida), where the sky is clear and there is scarcely any light contamination. An astronomic and meteorologic study carried out by researchers of the University of Barcelona confirmed that, in fact, the village of Sant Esteve de la Farga, in the Montsec, was among the best locations in Catalonia to build an observatory. The project, currently under way, like Oro's other endeavors and accomplishments has a three-fold aim: research, education, and the dissemination of science.

The prestige of Oró transcended the scientific community in Catalonia and Spain, as evidenced by the recognition he received from universities, political institutions, and the general public. In Spain, Oró was granted honorary degrees from the Universities of Granada (1972) and Lleida (1999); was an honorary member of several scientific societies; and received many awards, including the Gold Medal of the city of Lleida (1976), the Narcís Monturiol Medal for Scientific and Technological Merit (1982), the Grand Cross of the Order of Aeronautical Merit (1983), the President Francesc Macià Labor Medal (2000), the Gold Medal for Scientific Merit of the City Council of Barcelona (2002), and the Gold Medal of the Generalitat de Catalunya (2004). On 23 June 2003 the King of Spain awarded him with the title of Marquise of Oró for his continuous dedication to the scientific world through his many research works, which "have contributed, in a remarkable way, to improve the knowledge of the origin of life." For his arms, Oró chose the adenine formula, surely the first molecule represented on a coat of arms in the history of heraldry.

It is always difficult to summarize the work and accomplishments of an extraordinary scientist; and Professor Joan Oró was one of those rare persons. But we can try to do so by listing some of the major discoveries from the 30 years of research carried out under his direction.

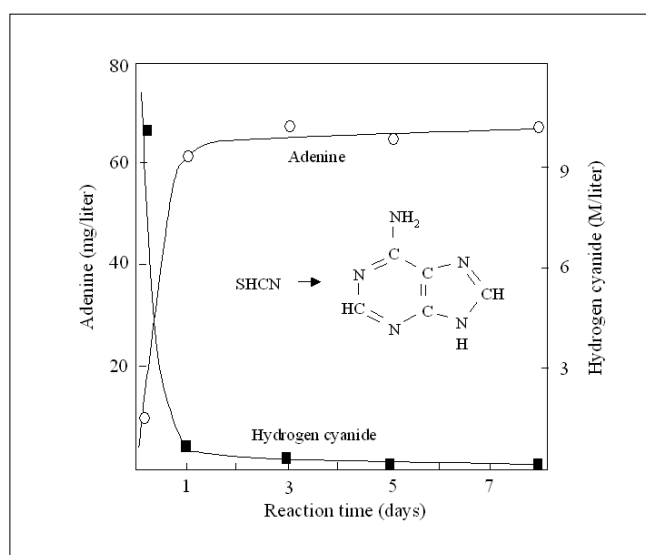


Fig. 2. The seminal experiment in which Oró showed the rate of adenine synthesis from ammonium cyanide at 90°C.

The first prebiotic synthesis of adenine from hydrogen cyanide was accomplished during the period 1959-1962 (Fig. 2). Adenine is probably the most important biological molecule because of its key role as an essential component of DNA, ATP, and other biological molecules responsible for the genetic code, replication, enzymatic catalysis, and metabolism in all living systems. This work opened up an area of research that led to the complete synthesis of all components of nucleic acids. In 1961, Oró suggested that cometary collisions with the primitive Earth had contributed substantial amounts of carbon-containing compounds for the prebiotic synthesis of biochemical molecules. Later computations (1980-1982) showed that the amount of carbonaceous matter acquired by the primitive Earth from comets was probably of the order of  $10^{23}$  grams. This is 100,000 times larger than the total mass of the present biosphere and accounts for the disappearance of the bulk of the Earth's primary atmosphere as a result of a collision with a Mars-sized body, which led to the evaporation of all the volatiles and the formation of the Moon (Earth-Moon system).

Beginning in 1958, Oró developed and applied new chromatography-mass spectrometry methods to the analysis of organic compounds synthesized under plausible primitive Earth conditions or present in extraterrestrial samples, such as meteorites and lunar samples. He was the first to analyze volatile amino-acid derivatives by applying these methods. In 1970, using optically active phases, he was also the first to detect D- and L-amino enantiomers in carbonaceous chondrites. This led to work by Kvenvolden and collaborators

suggesting that organic compounds were chemically synthesized on meteorite parent bodies more than  $4.5 \times 10^9$  years ago, when the solar system was formed.

From 1964 to 1977, Oró designed, developed, and tested an instrument for analyzing the atmosphere and surface volatile components of the planet Mars. He suggested the building of a new miniaturized gas chromatograph-mass spectrometer for the Viking mission to Mars. Four instruments of this type were built and integrated into four Viking Mars landers. Two of these spacecrafts were sent to Mars in 1976, and provided the first analysis of the atmosphere and surface of another planet. A complete analysis of the atmosphere and volatile surface components was eventually obtained but no organic compounds were found on Mars.

In 1976, Oró offered a chemical interpretation of the puzzling results obtained by other scientists concerning the presence of life on Mars. Based on his previous work from 1956, Oró was able to explain that the sudden and intense production of  $^{14}\text{CO}_2$  by the Martian soil samples in the Viking test chamber was not due to the rapid metabolism of presumed Martian microorganisms, but rather to the catalytic chemical oxidation of the test nutrients, especially formic acid, labeled with  $^{14}\text{C}$  by iron and other active oxides present in the Martian samples. The absence of evidence for life on Mars stopped the development of plans by NASA for subsequent manned exploration of the red planet.

During 1978-1980, Oró demonstrated the photocatalytic oxidation of organic compounds under simulated Martian conditions. The results showed that any organic matter present on the surface of the red planet that had been exposed to ultraviolet radiation from the Sun would have a very short lifetime, being oxidized to  $\text{CO}_2$  and  $\text{H}_2\text{O}$ . This provided an explanation for the surprising absence of organic compounds on the Martian surface and additional evidence in support of the absence of life on Mars.

In 1963, Oró was the first to suggest that the synthesis of biological macromolecules, such as polypeptides and polynucleotides, could be carried out by means of condensing agents, such as cyanamide and imidazole derivatives. Indeed, this was demonstrated in many subsequent experiments that were carried out in Oró's laboratory at the University of Houston. Cyanamide is present in the interstellar medium, where it is an important organic molecule. During the years 1982-1984, many imidazole derivatives were synthesized in Oró's laboratory under possible primitive Earth conditions.

From 1978 to 1984, Oró's laboratory was able to synthesize most of the phospholipid components of cellular membranes, including phosphatidylcholine and phosphatidylethanolamine. Using such amphiphilic molecules, it was pos-

sible to obtain liposome vesicles similar to the membranes of most living cells, thereby demonstrating for the first time how the membranes of living organisms might have formed.

In the 1980s, Oró's laboratory carried out the prebiotic synthesis of histidine, histidyl-histidine, and a number of phosphorylated coenzymes and other enzymatically active compounds. Protocellular models involving liposomes and catalytically active RNA molecules were developed theoretically. Current experiments are testing the validity of these models.

Oró finally returned to Spain in 1994, after his retirement from the University of Houston. During the following 10 years he devoted his energies and attention to science and culture in his home country, Catalonia. Joan Oró died in the city of Barcelona on September 2, 2004, mourned by his second wife and four children. However, his work continues to motivate and inspire. Today, even though the riddle of the origin of life is still far from being solved, it has lost most of its shroud of mystery and is beginning to be understood in molecular terms—thanks to the intelligence and effort of outstanding scientists such as Professor Joan Oró.

Acknowledgements. I acknowledge Mercè Piqueras for her help in the editing of Prof. Oró's bibliography, which we received from Prof. Oró himself in 2003.

## Selected articles by Joan Oró

- Oró J. (1956).  $^{14}\text{C}$ -Formate Metabolism in Animal Tissues with Special Reference to the Mechanism of Formic Acid Oxidation (Doctoral thesis). Baylor University College of Medicine, Houston
- Oró J., D.A. Rappoport (1957). Formate metabolism by animal tissues, I. Metabolism of formate- $^{14}\text{C}$  by isolated rabbit and rat jejunum. *J. Biol. Chem.* 224:489-498
- Oró J., A. Kimball, R. Fritz, F. Master (1959) Amino acid synthesis from formaldehyde and hydroxylamine. *Arch. Biochem. Biophys.* 85:115-130
- Oró J. (1960) Synthesis of adenine from ammonium cyanide. *Biochem. Biophys. Res. Commun.* 2:407-412
- Oró J. (1961). Comets and the formation of biochemical compounds on the primitive Earth. *Nature* 190:389-390
- Oró J., S.S. Kamat (1961) Amino acid synthesis from hydrogen cyanide under possible primitive Earth conditions. *Nature* 190:442-443
- Oró J., A.P. Kimball (1961) Synthesis of purines under possible primitive Earth conditions. I. Adenine from hydrogen cyanide. *Arch. Biochem. Biophys.* 94:217-227
- Oró J. (1961). Mechanism of synthesis of adenine from hydrogen cyanide under possible primitive Earth conditions. *Nature* 191:1193-1194
- Oró J., A.P. Kimball (1962). Synthesis of purines under possible primitive Earth conditions, II. Purine intermediates from hydrogen cyanide. *Arch. Biochem. Biophys.* 96:293-313
- Oró J. (1963). Ultra-violet-absorbing compound(s) reported present in the Murray meteorite. *Nature* 197:756-758
- Oró J. (1963). Synthesis of organic compounds by electric discharges. *Nature* 197:862-867
- Oró J. (1963). Synthesis of organic compounds by high energy electrons. *Nature* 197:971-974

- Oró J., D.W. Nooner, A. Zlatkis, S.A. Wikström, E.S. Barghoorn (1965). Hydrocarbons of biological origin in sediments about two billion years old. *Science* 148:77-79
- Oró J., T. Tornabene (1965). Bacterial contamination of some carbonaceous meteorites. *Science* 150:1046-1048
- Oró J., J. Han (1966). High temperature synthesis of aromatic hydrocarbons from methane. *Science* 153:1393-1395
- Oró J., D.W. Nooner (1967). Aliphatic hydrocarbons in pre-Cambrian rocks. *Nature* 213:1082-1085
- Oró J., D.W. Nooner (1967). Aliphatic hydrocarbons in meteorites. *Nature* 213:1085-1087
- Oró J., T.G. Tornabene, D.W. Nooner, E. Gelpi (1967). Aliphatic hydrocarbons and fatty acids of some marine and freshwater microorganisms. *J. Bacteriol.* 93:1811-1818
- Tornabene T.G., E. Gelpi, J. Oró (1967). Identification of fatty acids and aliphatic hydrocarbons in *Sarcina lutea* by gas chromatography and combined gas chromatography-mass spectrometry. *J. Bacteriol.* 94:333-343
- Tornabene T.G., E.O. Bennett, J. Oró (1967). Fatty acid and aliphatic hydrocarbon composition of *Sarcina lutea* grown in three different media. *J. Bacteriol.* 94:344-348
- Tornabene T.G., J. Oró (1967). <sup>14</sup>C Incorporation into the fatty acids and aliphatic hydrocarbons of *Sarcina lutea*. *J. Bacteriol.* 94:349-358
- Oró J., E. Gelpi, D.W. Nooner (1968). Hydrocarbons in extraterrestrial samples. *J. Br. Interplan. Soc.* 21:83-98
- Gelpi E., J. Oró, H.J. Schneider, E.O. Bennett (1968). Olefins of high molecular weight in two microscopic algae. *Science* 161:700-702
- Gelpi E., D.W. Nooner, J. Oró (1969). Isoprenoids and other hydrocarbons in terrestrial gaphite. *Geochim. Cosmochim. Acta* 33:959-972
- Tornabene T.G., M. Kates, E. Gelpi, J. Oró (1969). Occurrence of squalene, di- and tetrahydro-squalenes, and vitamin MK<sub>8</sub> in an extremely halophilic bacterium, *Halobacterium cutirubrum*. *J. Lipid Res.* 10:294-303
- Simmonds P.G., A.J. Bauman, E.M. Bollin, E. Gelpi, J. Oró (1969). The unextractable organic fraction of the Pueblito de Allende meteorite: Evidence for its indigenous nature. *Proc. Natl. Acad. Sci. USA* 64:1027-1034
- Gelpi E., H. Schneider, J. Mann, J. Oró (1970). Hydrocarbons of geochemical significance in microscopic algae. *Phytochemistry* 9:603-612
- Schneider H., E. Gelpi, E.O. Bennett, J. Oró (1970). Fatty acids of geochemical significance in microscopic algae. *Phytochemistry* 9:613-617
- Nakaparksin S., P. Birrell, E. Gil-Av, J. Oró (1970). Gas chromatography with optically active stationary phases: Resolution of amino acids. *J. Chromat. Sci.* 8:177-182
- Gibert J.M., J. Oró (1970). Gas chromatographic-mass spectrometric determination of potential contaminant hydrocarbons of Moon samples. *J. Chromat. Sci.* 8:295-296
- Oró J., W.S. Updegrove, J. Gibert, J. McReynolds, E. Gil-Av, J. Ibanez, A. Zlatkis, D.A. Flory, R.L. Levy, C. Wolf (1970). Organogenic elements and compounds in surface samples from the Sea of Tranquillity. *Science* 167:765-767
- Levy R.L., C.J. Wolf, M.A. Grayson, J. Gilber, E. Gelpi, W.S. Updegrove, A. Zlatkis, J. Oró (1970). Organic analysis of the Pueblito de Allende meteorite. *Nature* 227:148-150
- Segura R., J. Oró, A. Zlatkis (1970). Resolution of steroid glucuronides by thin-layer chromatography on polyamide. *J. Chromatogr. Sci.* 8:449-451
- Gibert J., D. Flory, J. Oró (1971). Identity of a common contaminant of Apollo 11 Lunar fines and Apollo 12 York meshes. *Nature* 229:33-34
- Oró J., J. Gibert, H. Lichtenstein, S. Wikstrom, D.A. Flory (1971). Amino acids, aliphatic and aromatic hydrocarbons in the Murchison meteorite. *Nature* 230:105-106
- Oró J., S. Nakaparksin, H. Lichtenstein, E. Gil-Av (1971). Configuration of amino-acids in carbonaceous chondrites and a pre-Cambrian chert. *Nature* 230:107-108
- Stephen-Sherwood E., J. Oró, A.P. Kimball (1971). Thymine: A possible prebiotic synthesis. *Science* 173:446-447
- Wolman Y., S.L. Miller, J. Ibanez, J. Oró (1971). Formaldehyde and ammonia as precursors to prebiotic amino acids. *Science* 174:1039-1040
- Nooner D.W., J. Oró; J.M. Gibert, V.L. Ray, J.E. Mann (1972). Ubiquity of hydrocarbons in nature: Aliphatic hydrocarbons in weathered limestone. *Geochim. Cosmochim. Acta* 36:953-959
- Oró J. (1972). Extraterrestrial organic analysis. *Space Life Sci.* 3:507-550.
- Doctor V.M., J. Oró (1972). Non-enzymic  $\beta$ -decarboxylation of aspartic acid. *J. Mol. Evol.* 1:326-333
- Macdonald E.J., H. Lichtenstein, D. Nooner, D. Flory, S. Wikstrom, J. Oró (1973). Epidemiological factors in lung cancer among women in El Paso County, Texas, 1944-1969. *J. Am. Med. Women's Assoc.* 28:459-467
- Nooner D.W., W.S. Updegrove, D.A. Flory, J. Oró, G. Mueller (1973). Isotopic and chemical data of bitumens associated with hydrothermal veins from Windy Knoll, Derbyshire, England. *Chem. Geol.* 11:189-202
- Nooner D.W., J. Oró, J. Cerbulis (1973). Paraffinic hydrocarbon composition of earthworms (*Lumbricus terrestris*). *Lipids* 8:489-492
- Nooner D.W., J. Oró (1974). Direct synthesis of polypeptides. Polycondensation of  $\alpha$ -amino acids by polymetaphosphate esters. *J. Mol. Evol.* 3:79-88
- Nissenbaum A., D.H. Kenyon, J. Oró (1975). On the possible role of organic melanoidin polymers as matrices for prebiotic activity. *J. Mol. Evol.* 6:253-270
- Holzer G., J. Oró, W. Bertsch (1976). Gas chromatographic-mass spectrometric evaluation of exhaled tobacco smoke. *J. Chromatogr.* 126:771-785
- Biemann K., J. Oró, P. Toulmin III, L.E. Orgel, A.O. Nier, D.M. Anderson, P.G. Simmonds, D. Flory, A.V. Diaz, D.R. Rushneck, J.A. Biller (1976). Search for organic and volatile inorganic compounds in two surface samples from the Chryse Planitia region of Mars. *Science* 194:72-76
- Biemann K., J. Oró, P. Toulmin III, L.E. Orgel, A.O. Nier, D.M. Anderson, P.G. Simmonds, D. Flory, A.V. Diaz, D.R. Rushneck, J.E. Biller, A.L. Lafleur (1977). The search for organic substances and inorganic volatile compounds in the surface of Mars. *J. Geophys. Res.* 82:4641-4658
- Holzer G., J. Oró (1977). Pyrolysis of organic compounds in the presence of ammonia. The Viking Mars lander site alteration experiment. *Org. Geochem.* 1:37-52
- Tornabene T.G., R.S. Wolfe, W.E. Balch, G. Holzer, G.E. Fox, J. Oró (1978). Phytanyl-glycerol ethers and squalenes in the Archaeobacterium *Methanobacterium thermoautotrophicum*. *J. Mol. Evol.* 11:259-266
- Tornabene T.G., T.A. Langworthy, G. Holzer, J. Oró (1979). Squalenes, phytanes and other isoprenoids as major neutral lipids of methanogenic and thermoacidophilic "Archaeobacteria". *J. Mol. Evol.* 13:73-83
- Holzer G., J. Oró (1979). The organic composition of the Allan Hills carbonaceous chondrite (77306) as determined by pyrolysis-gas chromatography-mass spectrometry and other methods. *J. Mol. Evol.* 13:265-270
- Oró J., G. Holzer (1979). The photolytic degradation and oxidation of organic compounds under simulated Martian condition. *J. Mol. Evol.* 14:153-160
- Deamer D.W., J. Oró (1980). Role of lipids in prebiotic structures. *Biosystems* 12:167-175
- Rao M., D.G. Odom, J. Oró (1980). Clays in prebiological chemistry. *J. Mol. Evol.* 15:317-331
- Holzer G., J. Oró, S.J. Smith, V.M. Doctor (1980). Separation of monosaccharides as their alditol acetates by capillary column gas chromatography. *J. Chromatogr.* 194:410-415
- Giner-Sorolla A., J. Oró (1981). Mutagens and carcinogens: Occurrence and role during chemical and biological evolution. In: Wolman Y. (ed.) *Origins of Life*. Reidel, Dordrecht, 583-588
- Hawker J.R. Jr., J. Oró (1981). Cyanamide mediated synthesis of peptides containing histidine and hydrophobic amino acids. *J. Mol. Evol.* 17:285-294
- Bar-Nun A., A. Lazcano-Araujo, J. Oró (1981). Could life have evolved in cometary nuclei? *Orig. Life* 11:388-394

- Rao M., J. Eichberg, J. Oró (1982). Synthesis of phosphatidylcholine under possible primitive Earth conditions. *J. Mol. Evol.* 18:196-202
- Oró J., K. Rewers, D. Odom (1982). Criteria for the emergence and evolution of life in the Solar system. *Orig. Life* 12:285-305
- Odom, D., T. Yamrom, J. Oró (1983). Prebiotic oligodeoxynucleotide synthesis in a cyclic evaporating system at low temperatures. *Adv. Space Res.* 3:55-59
- Bada J.L., J.R. Cronin, M-S. Ho, K.A. Kvenvolden, J.G. Lawless, S.L. Miller, J. Oró, S. Steinberg (1983). On the reported optical activity of amino acids in the Murchison meteorite. *Nature* 301:494-497
- Basile B.P. B.S. Middleditch, J. Oró (1984). Polycyclic aromatic hydrocarbons in the Murchison meteorite. *Org. Geochem.* 5:211-216
- Yuasa S., D. Flory, B. Basile, J. Oró (1984). Abiotic synthesis of purines and other heterocyclic compounds by the action of electrical discharges. *J. Mol. Evol.* 21:76-80
- Baeza I., M. Ibañez, J.C. Santiago, C. Wong, A. Lazcano, J. Oró (1986). Studies on precellular evolution: The encapsulation of polyribonucleotides by liposomes. *Adv. Space Res.* 6:39-43
- Mar A., J. Dworkin, J. Oró (1987). Non-enzymatic synthesis of the coenzymes, uridine diphosphate glucose and cytidine diphosphate choline, and other phosphorylated metabolic intermediates. *Orig. Life* 187:307-319
- Lazcano A., J. Fastag, O. Gariglio, C. Ramirez, J. Oró (1988). On the early evolution of RNA polymerase. *J. Mol. Evol.* 27:365-376
- Lazcano A., R. Guerrero, L. Margulis, J. Oró (1988). The evolutionary transition from RNA to DNA in early cells. *J. Mol. Evol.* 27:283-290
- Oró J., T. Mills (1989). Chemical evolution of primitive Solar system bodies. *Adv. Space Res.* 9:105-120
- Shen C., L. Yang, S.L. Miller; J. Oró (1990). Prebiotic synthesis of histidine. *J. Mol. Evol.* 31:175-179
- Shen C., T. Mills, J. Oró (1990). Prebiotic synthesis of histidyl-histidine. *J. Mol. Evol.* 31:175-179
- Shen, C., A. Lazcano, J. Oró (1990). The enhancement effects of histidyl-histidine in some prebiotic reactions. *J. Mol. Evol.* 31:445-452
- Mar A., J. Oró (1991). Synthesis of the coenzymes adenosine diphosphate glucose, guanosine diphosphate glucose, and cytidine. Diphosphoethanolamine under primitive Earth conditions. *J. Mol. Evol.* 32:201-210
- Wong C., J.C. Santiago, L. Rodríguez-Páez, M. Ibañez, I. Baeza, J. Oró (1991). Synthesis of putrescine under possible primitive Earth conditions. *Orig. Life Evol. Biosph.* 21:145-156
- Oró J., T. Mills, A. Lazcano (1992). The cometary contribution to prebiotic chemistry. *Adv. Space Res.* 12:33-41
- Velasco A.M., L. Medrano, A. Lazcano, J. Oró (1992). A redefinition of the Asp-Asp domain of reverse transcriptase. *J. Mol. Evol.* 35:551-556
- Baumann U., J. Oró (1993). Three stages in the evolution of the genetic code. *BioSystems* 29:133-141
- Oró J. (1994). Chemical synthesis of lipids and the origin of life. *J. Biol. Phys.* 20:135-147
- Oró J., T. Mills, A. Lazcano (1995). Comets and life in the Universe. *Adv. Space Res.* 15:81-90
- Oró, J. (1995). Cosmochemical evolution and the origin of life. *Microbiol. SEM* 11:145-160
- Macià E., V. Hernandez; J. Oró (1997). Primary sources of phosphorus and phosphates in chemical evolution. *Orig. Evol. Biosph.* 27:459-480
- Levy, M., S.L. Miller, J. Oró (1999). Production of guanine from NH<sub>4</sub>CN polymerization. *J. Mol. Evol.* 49:165-169
- Oró J. (2002). Historical understanding of life's beginnings. In: Schopf J. W. (ed.) *Life's Origin. The Beginnings of Biological Evolution*. University of California Press, Berkeley, pp.7-45

The complete list of articles, chapters of books, books and doctoral theses directed by Prof. Joan Oró can be found in the online version of this article.  
See: [www.im.microbios.org], March 2005 issue. [Complete bibliography](#)

**Professor Joan Oró's (1923-2004) bibliography. Articles, book chapters and doctoral thesis supervised.**

**1. ARTICLES**

Oró, J. (1956). «<sup>14</sup>C-Formate Metabolism in Animal Tissues with Special Reference to the Mechanism of Formic Acid Oxidation» (Doctoral thesis). Baylor University College of Medicine, Houston.

Oró J.; D.A. Rappoport (1957). «Formate metabolism by animal tissues, I. Metabolism of formate-<sup>14</sup>C by isolated rabbit and rat jejunum». *J. Biol. Chem.*, vol. 224, pp. 489-498.

Zlatkis, A.; J. Oró (1958). «Amino acid analysis by reactor-gas chromatography». *Anal. Chem.*, vol. 30, pp. 1156

Oró, J.; D.A. Rappoport (1959). «Formate metabolism by animal tissues, II. The mechanism of formate oxidation». *J. Biol. Chem.*, vol. 234, pp. 1661-1665.

Oró, J.; A. Kimball; R. Fritz; F. Master (1959). «Amino acid synthesis from formaldehyde and hydroxylamine». *Arch. Biochem. Biophys.*, vol. 85, pp. 115-130.

Oró, J.; C.L. Guidry; A. Zlatkis (1959). «The odor of methional purified by gas chromatography». *Food Res.*, vol. 24, pp. 240-241.

Zlatkis, A.; J. Oró; A.P. Kimball (1960). «Direct amino acid analysis by gas chromatography». *Anal. Chem.*, vol. 32, pp. 162-164.

Oró, J. (1960). Revision of the book: Kaiser R. *Gas Chromatography*. *J. Am. Chem. Soc.*, vol 82, pp. 5260

Oró, J; C.L. Guidry (1960). «A novel synthesis of polypeptides». *Nature*, vol. 186, pp. 156-157.

Oró, J. (1960). «Synthesis of adenine from ammonium cyanide». *Biochem. Biophys. Res. Commun.*, vol. 2, pp. 407-412.

Oró, J.; C.L. Guidry (1961). «Direct synthesis of polypeptides. I. Polycondensation of glycine in aqueous ammonia». *Arch. Biochem. Biophys.*, vol. 93, pp. 166-171.

Oró, J. (1961). «Comets and the formation of biochemical compounds on the primitive Earth». *Nature*, vol. 190, 389-390.

Oró, J.; S.S. Kamat (1961). «Amino acid synthesis from hydrogen cyanide under possible primitive Earth conditions». *Nature*, vol. 190, pp. 442-443.

Oró, J.; A.P. Kimball (1961). «Synthesis of purines under possible primitive Earth conditions. I. Adenine from hydrogen cyanide». *Arch. Biochem. Biophys.*, vol. 94, pp. 217-227.

Oró, J. (1961). «Mechanism of synthesis of adenine from hydrogen cyanide under possible primitive Earth conditions». *Nature*, vol. 191, pp. 1193-1194.

Oró, J.; A.P. Kimball (1962). «Synthesis of purines under possible primitive Earth conditions, II. Purine intermediates from hydrogen cyanide». *Arch. Biochem. Biophys.*, vol. 96, pp. 293-313.

Oró, J. (1963). «Ultra-violet-absorbing compounds(s) reported present in the Murray meteorite». *Nature*, vol. 197, pp. 756-758.

Oró, J. (1963). «Synthesis of organic compounds by electric discharges». *Nature* vol. 197, pp. 862-867.

Oró, J. (1963). «Synthesis of organic compounds by high energy electrons». *Nature*, vol. 197, pp. 971-974.

Oró, J. (1963). «Studies in experimental organic cosmochemistry». *Ann. New York Acad. Sci.*, vol. 108, pp. 464-481.



Oró, J. (1963). «Experimental organic cosmochemistry: The formation of biochemical compounds». *Proc. Lunar & Planet. Explor. Colloquium*, vol. 3, pp. 9-28.

Oró, J. (1964). «Prebiological synthesis of nucleic acid constituents. In: Kretovich V. L. (ed.). *Problems of Evolutionary and Industrial Biochemistry*. A. N. Bach Institute of Biochemistry, USSR Academy of Sciences, Moscow, pp. 63-69.

Oró, J. (1963). «Investigation of organo-chemical evolution. In: Mamikunian G.; M. H. Briggs (eds.), *Current Aspects of Exobiology*. Pergamon Press, New York, pp. 13-76.

Oró, J. (1965). «Stages and mechanisms of prebiological organic synthesis». In: Fox S. W. (ed.) *The Origins of Prebiological Systems and of their Molecular Matrices*. Academic Press, New York, pp. 137-171.

Oró, J.; D.W. Nooner; S.A. Wikström (1965). «Gas chromatographic-mass spectrometric analysis of paraffinic hydrocarbons in animal products». *J. Gas Chromatogr.*, pp. 105-106.

Oró, J.; D.W. Nooner; S.A. Wikström (1965). «Paraffinic hydrocarbons in pasture plants». *Science*, vol. 147, pp. 870-873.

Oró, J.; D.W. Nooner; A. Zlatkis; S.A. Wikström; E.S. Barghoorn (1965). «Hydrocarbons of biological origin in sediments about two billion years old». *Science*, vol. 148, pp. 77-79.

Oró, J.; H.S. Skewes (1965). «Free amino acids on human fingers: The question of contamination in microanalysis». *Nature*, vol. 207, pp. 1042-1045.

Oró, J.; T. Tornabene (1965). «Bacterial contamination of some carbonaceous meteorites». *Science*, vol. 150, pp. 1046-1048.

Oró, J.; D.W. Nooner; A. Zlatkis; S.A. Wikström (1966), «Paraffinic hydrocarbons in the Orgueil, Murray, Mokoia, and other meteorites». *Life Sci. Space Res.*, vol. IV, Spartan Books, Washington, pp. 63-100.

Oró, J.; S.R. Lipsky; V.I. Oyama; G.R. Shoemaker; A. Zlatkis (1966). «Gas chromatography». In: Pittendrigh C.S.; Vishniac W.; J.P.T. Pearman (eds.) *Biology and the Exploration of Mars*. National Academy of Sciences, National Research Council, Washington, D. C., pp. 368-375.

Oró, J.; K. Biemann; R.S. Gohlke; S.R. Lipsky; J.E. Lovelock; F.W. McLafferty; W.C. Meinschein; R. Ryhage (1966). «Gas chromatography-mass spectrometry». In: Pittendrigh, C.S.; W. Vishniac; J.P.T. Pearman (eds.) *Biology and the Exploration of Mars*. National Academy of Sciences, National Research Council, Washington, D. C., pp. 378-384.

Oró, J.; A.P. Kimball (1966). «Synthesis of purines under possible primitive Earth conditions. I. Adenine from hydrogen cyanide». Article reprinted in: Shneour E.A.; Ottesen E.A. (eds.) *Extraterrestrial Life: An Anthology and Bibliography*. National Academy of Sciences, National Research Council, Washington, D.C., pp. 196-206.

Oró, J.; A.P. Kimball (1966). «Synthesis of purines under possible primitive Earth conditions. II. Purine intermediates from hydrogen cyanide». Article reprinted in: E. A. Shneour; E.A. Ottesen (eds.) *Extraterrestrial Life: An Anthology and Bibliography*. National Academy of Sciences, National Research Council, Washington, D.C., pp. 207-225.

Oró, J. (1966). «Studies in experimental organic cosmochemistry». Article reprinted in: E.A. Shneour; E.A. Ottesen (eds.) *Extraterrestrial Life: An Anthology and Bibliography*. National Academy of Sciences, National Research Council, Washington, D.C., pp. 226-243.

Oró, J.; J. Han (1966). «High temperature synthesis of aromatic hydrocarbons from methane». *Science*, vol. 153, pp. 1393-1395.

Oró, J.; J.L. Laseter; D. Weber (1966). «Alkanes in fungal spores». *Science*, vol. 154, pp. 399-400.

Oró, J.; J. Han; A. Zlatkis (1967). «Application of high resolution gas chromatography-mass-spectrometry to the analysis of the pyrolysis products of isoprene». *Anal. Chem.*, vol. 39, pp. 27-32.

Gelpi, E.; J. Oró (1967). «Chemical ionization mass spectrometry of Pristane». *Anal. Chem.*, vol. 39, pp. 388-389.

Oró, J.; D.W. Nooner (1967). «Aliphatic hydrocarbons in pre-Cambrian rocks». *Nature*, vol. 213, pp. 1082-1085.

Oró, J.; D.W. Nooner, (1967). «Aliphatic hydrocarbons in meteorites». *Nature*, vol. 213, pp. 1085-1087.

Updegrove, W.S.; J. Oró; A. Zlatkis (1967). «GC-Quadrupole mass spectrometric analysis of organic compounds». *J. Gas Chromatogr.*, vol. 5, pp. 359-361.

Oró, J.; J. Han (1967). «Application of combined chromatography-mass spectrometry to the analysis of aromatic hydrocarbons formed by pyrolysis of methane». *J. Gas Chromatogr.*, vol. 5, pp. 480-485.

Oró, J.; T.G. Tornabene; D.W. Nooner; E. Gelpi (1967). «Aliphatic hydrocarbons and fatty acids of some marine and freshwater microorganisms». *J. Bacteriol.*, vol. 93, pp. 1811-1818.

Doctor, V.M.; J. Oró (1967). «Non-enzymatic transamination of histidine with  $\alpha$ -keto acids». *Naturwissenschaften*, vol. 54, pp. 443-444.

Tornabene, T.G.; E. Gelpi; J. Oró (1967). «Identification of fatty acids and aliphatic hydrocarbons in *Sarcina lutea* by gas chromatography and combined gas chromatography-mass spectrometry». *J. Bacteriol.*, vol. 94, pp. 333-343.

Tornabene, T.G.; E.O. Bennett; J. Oró (1967). «Fatty acid and aliphatic hydrocarbon composition of *Sarcina lutea* grown in three different media». *J. Bacteriol.*, vol. 94, pp. 344-348.

Tornabene, T.G.; J. Oró (1967). «<sup>14</sup>C Incorporation into the fatty acids and aliphatic hydrocarbons of *Sarcina lutea*». *J. Bacteriol.*, vol. 94, pp. 349-358.

Nooner, D.W.; J. Oró (1967). «Organic compounds in meteorites-I. Aliphatic hydrocarbons». *Geochim. Cosmochim. Acta*, vol. 31, pp. 1359-1394.

Olson, R.J.; J. Oró; A. Zlatkis (1967). «Organic compounds in meteorites-II. Aromatic hydrocarbons». *Geochim. Cosmochim. Acta*, vol. 31, pp. 1935-1948.

Simmonds, P.G.; D.W. Nooner; A. Zlatkis; J. Oró (1968). «Distribution modes and possible origins of sheep wool hydrocarbons». *J. Am. Oil Chemists Soc.*, vol. 45, pp. 34-36.

Gelpi, E.; J. Oró (1968). «Gas chromatographic-mass spectrometric analysis of isoprenoid hydrocarbons and fatty acids in shark liver oil products». *J. Am. Oil Chemists Soc.*, vol. 45, pp. 144-147.

Oró, J.; E. Gelpi; D.W. Nooner (1968). «Hydrocarbons in extraterrestrial samples». *J. Br. Interplan. Soc.*, vol. 21, pp. 83-98.

Oró, J.; (1968). «Synthesis of organic molecules by physical agencies». *J. Br. Interplan. Soc.*, vol. 21, 12-25.

Laseter, J.L.; D.J. Weber; J. Oró (1968). «Characterization of cabbage leaf lipids: n-alkanes, ketones, and fatty acids». *Phytochemistry*, vol. 7, pp. 1005-1008.

Gelpi, E.; J. Oró; H.J. Schneider; E.O. Bennett (1968). «Olefins of high molecular weight in two microscopic algae». *Science*, vol. 161, pp. 700-702.

Oró, J.; E. Gelpi (1968). «Gas-chromatographic mass-spectrometric studies on the isoprenoids and other isomeric alkanes in meteorites». In: Millman P. M. (ed.) *Meteorite Research*. Reidel, Dordrecht, pp. 518-523.

Oró, J.; D.W. Nooner; R. J. Olson (1969). «Chromatography of hydrocarbons». In: Marinetti G. V. (ed.) *Chromatographic Analysis of Lipids*, vol. II. Dekker, New York, pp. 479-521.

Updegrave, W.S.; J. Oró (1969). «Analysis of organic matter on the Moon by gas chromatography-mass spectrometry—A feasibility study». In: Malina, F. J. (ed.) *Research in Physics and Chemistry*, Proceedings of the Third International Laboratory (LIL) Symposium, Belgrado, pp. 53-74.

Johnson, C.L.; J. Oró; A. Schwartz (1969). «Basic protein induction of low amplitude energy-linked mitochondrial swelling». *Arch. Biochem. Biophys.*, vol. 131, pp. 310-315.

Gelpi, E.; D.W. Nooner; J. Oró (1969). «Isoprenoids and other hydrocarbons in C rrestrial gaphite». *Geochim. Cosmochim. Acta*, vol. 33, pp. 959-972.

Tornabene, T.G.; M. Kates; E. Gelpi; J. Oró (1969). «Occurrence of squalene, di- and tetrahydrosqualenes, and vitamin MK<sub>8</sub> in an extremely halophilic bacterium, *Halo-Bacterium cutirubrum*». *J. Lipid Res.*, vol. 10, pp. 294-303.

Doctor, V.M.; J. Oró (1969). «Mechanism of non-enzymic transamination reaction between histidine and  $\alpha$ -oxoglutaric acid». *Biochem. J.*, vol. 112, pp. 691-697.

Gelpi, E.; H. Schneider; V.M. Doctor; J. Tennison; J. Oró (1969). «Gas chromatographic-mass spectrometric identifications of the hydrocarbons and fatty acids of *Plantago ovata* seeds». *Phytochemistry*, vol. 8, pp. 2077-2081.

Simmonds, P.G.; A.J. Bauman; E.M. Bollin; E. Gelpi; J. Oró (1969). «The unextractable organic fraction of the Pueblito de Allende meteorite: Evidence for its indigenous nature». *Proc. Natl. Acad. Sci. USA*, vol. 64, pp. 1027-1034.

Gelpi, E.; J. Oró (1969). «Comparative mass spectrometric studies on the isoprenoids and other isomeric alkanes in Terrestrial and extraterrestrial samples». *Int. J. Mass Spectr. Ion Phys.*, vol. 4, pp. 323-335.

Oró, J.; D.W. Nooner (1970). «Aliphatic hydrocarbons from the pre-Cambrian of North America and South Africa». In: Hobson G. D.; G. C. Speers (eds.) *Adv. Org. Geochemistry 1966*. Pergamon, Oxford, pp. 493-506.

Oró, J.; D.W. Nooner; R.J. Olson (1970). «Hydrocarbons in meteorites». In: Hobson G.D.; G.C. Speers (eds.) *Adv. Org. Geochemistry 1966*. Pergamon, Oxford, pp. 507-521.

Gelpi, E.; H. Schneider; J. Mann; J. Oró (1970). «Hydrocarbons of geochemical significance in microscopic algae». *Phytochemistry*, vol. 9, pp. 603-612.

Schneider, H.; E. Gelpi; E.O. Bennett; J. Oró (1970). «Fatty acids of geochemical significance in microscopic algae». *Phytochemistry*, vol. 9, pp. 613-617.

Gelpi, E.; J. Oró (1970). «Ubiquity of hydrocarbons in nature: Gas chromatographic-mass spectrometric determination of the hydrocarbons in cigarette smoke condensate». *J. Chromat. Sci.*, vol. 8, pp. 210-213.

Gelpi, E.; D.W. Nooner; J. Oró (1970). «The ubiquity of hydrocarbons in nature: Aliphatic hydrocarbons in dust samples». *Geochim. Cosmochim. Acta.*, vol. 34, pp. 421-425.

Nakaparksin, S.; E. Gil-Av; J. Oró (1970). «Study of the racemization of some neutral  $\alpha$ -amino acids in acid solution using gas chromatographic techniques». *Anal. Biochem.*, vol. 33, pp. 374-382.

Nakaparksin, S.; P. Birrell; E. Gil-Av; J. Oró (1970). «Gas chromatography with optically active stationary phases: Resolution of amino acids». *J. Chromat. Sci.*, vol. 8, pp. 177-182.

Koenig, W.A.; W. Parr; H.A.; Lichtenstein; E. Bayer; J. Oró (1970). «Gas chromatographic separation of amino acids and their enantiomers: Non-polar stationary phases and a new optically active phase». *J. Chromat. Sci.*, vol. 8, pp. 183-186.

Gibert, J.M.; J. Oró (1970). «Gas chromatographic-mass spectrometric determination of potential contaminant hydrocarbons of Moon samples». *J. Chromat. Sci.*, vol. 8, pp. 295-296.

Oró, J.; W.S. Updegrave; J. Gibert; J. McReynolds; E. Gil-Av; J. Ibanez; A. Zlatkis; D.A. Flory; R.L. Levy; C. Wolf (1970). «Organogenic elements and compounds in surface samples from the Sea of Tranquillity». *Science*, 1970, vol. 167, pp. 765-767.

Levy, R.L.; C.J. Wolf; M.A. Grayson; J. Gilbert; E. Gelpi; W.S. Updegrave; A. Zlatkis; J. Oró (1970). «Organic analysis of the Pueblito de Allende meteorite». *Nature*, vol. 227, pp. 148-150.

Oró, J.; W.S. Updegrave; J. Gibert; J. McReynolds; E. Gil-Av; J. Ibanez; A. Zlatkis; D.A. Flory; R.L. Levy; C.J. Wolf (1970). «Organogenic elements and compounds in type C and D Lunar samples from Apollo 11». (Proceedings of the Apollo 11 Lunar Science Conference, vol. 2). *Geochim. Cosmochim. Acta*, vol. ?? Suppl. 1 pp. 1901-1920.

Oró, J.; J. Gibert; W. Updegrave; J. McReynolds; J. Ibanez; E. Gil-Av; D. Flory; A. Zlatkis (1970). «Gas chromatographic and mass spectrometric methods applied to the analysis of Lunar samples from the Sea of Tranquillity». *J. Chromatogr. Sci.* vol. 8, 297-308. Also in: Zlatkis A. (ed.) (1970). *Advances in Chromatography*. Preston Technical Abstracts, Evanston, III, pp. 185-198.

Segura, R.; J. Oró; A. Zlatkis (1970). «Resolution of steroid glucuronides by thin-layer chromatography on polyamide». *J. Chromatogr. Sci.*, vol. 8, pp. 449-451. Also in: Zlatkis A. (ed.) (1970). *Advances in Chromatography*. Preston Technical Abstracts, Evanston, III, pp. 332-335.

Bayer, E.; E. Gil-Av; W.A. König; S. Nakaparksin; J. Oró; W. Parr (1970). «Retention of configuration in the solid phase synthesis of peptides». *J. Am. Chem. Soc.*, vol. 92, pp. 1738-1740.

Gelpi, E.; J. Oró (1970). «Comparative mass spectrometric studies on the isoprenoids and other isomeric alkanes in Terrestrial and extraterrestrial samples». *Int. J. Mass Spectr. Ion Phys.* vol. 4, pp. 323-335.

Gelpi, E., J. Han, D.W. Nooner; J. Oró (1970). «Organic compounds in meteorites-III. Distribution and identification of aliphatic hydrocarbons produced by open flow Fischer-Tropsch processes». *Geochim. Cosmochim. Acta*, vol. 34, pp. 965-979.

Gelpi, E.; J. Oró (1970). «Organic compounds in meteorites-IV. Gas chromatographic-mass spectrometric studies on the isoprenoids and other isometric alkanes in carbonaceous chondrites». *Geochim. Cosmochim. Acta*, vol. 34, pp. 981-994.

Gelpi, E.; J. Oró (1970). «Organic compounds in meteorites-V. Gas chromatographic-mass spectrometric studies on the isoprenoids and other isometric alkanes in graphitic nodules of iron meteorites». *Geochim. Cosmochim. Acta*, vol. 34, pp. 995-1005.

Levy, R.L.; C.J. Wolf; J. Oró (1970). «A gas chromatographic method for characterization of the organic content present in an inorganic matrix». *J. Chromat. Sci.*, vol. 8, pp. 524-526.

Yang, C.C.; J. Oró (1971). «Synthesis of adenine, guanine, cytosine and other nitrogen organic compounds by a Fischer-Tropsch-Like process». In: Buvet, R.; C. Ponnampereuma (eds.) *Molecular Evolution I. Chemical Evolution and the Origin of Life*. North Holland, Amsterdam, pp. 155-170.

Ibanez, J.; A.P. Kimball; J. Oró (1971). «The effect of imidazole, cyanamide, and polyornithine on the condensation of nucleotides in aqueous systems». In: Buvet, R.; C. Ponnampereuma (eds.) *Molecular Evolution I. Chemical Evolution and the Origin of Life*. North Holland, Amsterdam, pp. 171-179.



Gibert, J.; D. Flory; J. Oró (1971). «Identity of a common contaminant of Apollo 11 Lunar fines and Apollo 12 York meshes». *Nature*, vol. 229, pp. 33-34.

Oró, J.; J. Gibert; H. Lichtenstein; S. Wikstrom; D.A. Flory (1971). «Amino-acids, aliphatic and aromatic hydrocarbons in the Murchison meteorite». *Nature*, vol. 230, pp. 105-106.

Oró, J.; S. Nakaparksin; H. Lichtenstein; E. Gil-Av (1971). «Configuration of amino-acids in carbonaceous chondrites and a pre-Cambrian chert». *Nature*, vol. 230, pp. 107-108.

Gibert, J.M.; S. Wikstrom; J. Oró (1971). «Gas chromatographic-mass spectrometric identification of indigenous organic matter of the Murchison meteorite». Proc. Nineteenth Annual Conference on Mass Spectrometry and Allied Topics, Atlanta, Georgia, pp. 334-340.

Ibanez, J.D.; A.P. Kimball; J. Oró (1971). «Possible prebiotic condensation of mononucleotides by cyanamide». *Science*, vol. 173, pp. 444-446.

Stephen-Sherwood, E.; J. Oró; A.P. Kimball (1971). «Thymine: A possible prebiotic synthesis». *Science*, vol. 173, pp. 446-447.

Wachi, F.M.; D.E. Gilmartin; J. Oró; W.S. Updegrave (1971). «Differential thermal analysis and gas release studies of Apollo 11 samples». *Icarus*, vol. 15, pp. 304-313.

Wolman, Y.; S.L. Miller; J. Ibanez; J. Oró (1971). «Formaldehyde and ammonia as precursors to prebiotic amino acids». *Science*, vol. 174, pp. 1039-1040.

Ibanez, J.D.; A.P. Kimball; J. Oró (1971). «Condensation of mononucleotides by imidazole». *J. Mol. Evol.*, vol. 1, pp. 112-114.

Oró, J.; D.A. Flory; J.M. Gibert; J. McReynolds; H.A. Lichtenstein; S. Wikstrom (1971). «Abundances and distribution of organogenic elements and compounds in

Apollo 12 lunar samples». Proceedings of the Second Lunar Science Conference, vol. 2 (Suppl. 2 *Geochim. Cosmochim. Acta*). M.I.T. Press, Cambridge, pp. 1913-1925.

Oró, J. (1971). «Carbon compounds in Lunar surface samples». Instituto de Investigaciones Geológicas de la Diputación Provincial, Universidad de Barcelona, vol. XXV, Barcelona, pp. 135-156. (In Spanish)

McReynolds, J.H.; N.B. Furlong; P.J. Birrell; A.P. Kimball; J. Oró (1971). «Polymerization of deoxyribonucleotides by ultraviolet light». In: Kimball A.P.; J. Oró (eds.) *Prebiotic and Biochemical Evolution*. North-Holland, Amsterdam, pp. 111-121.

Anderson, D.M.; K. Biemann; L.E. Orgel; J. Oró; T. Owen; G.P. Shulman; P. Toulmin; H.C. Urey (1972). «Mass spectrometric analysis of organic compounds, water and volatile constituents in the atmosphere and surface of Mars: The Viking Mars lander». *Icarus*, vol. 16, pp. 111-138.

Nooner, D.W.; J. Oró; J.M. Gibert; V.L. Ray; J.E. Mann (1972). «Ubiquity of hydrocarbons in nature: Aliphatic hydrocarbons in weathered limestone». *Geochim. Cosmochim. Acta.*, vol. 36, pp. 953-959.

Oró, J. (1972). «Extraterrestrial organic analysis». *Space Life Sci.*, vol. 3, pp. 507-550.

Flory, D.A.; S. Wikstrom; S. Gupta; J.M. Gibert; J. Oró (1972). «Analysis of organogenic compounds in Apollo 11, 12 and 14 Lunar samples». Proceedings of the Third Lunar Science Conference, (Supplement 3, *Geochim. Cosmochim. Acta*), M.I.T. Press, Cambridge, 1972, vol. 2, pp. 2091-2108.

Doctor, V.M.; J. Oró (1972). «Non-enzymic  $\beta$ -decarboxylation of aspartic acid». *J. Mol. Evol.*, vol. 1, pp. 326-333.

Flory, D.A.; J. Oró; S. Wikstrom; D. Beaman; D.W. Nooner (1972). «Analysis of organogenic compounds in Apollo 15 samples». In: Chamberlain J.; C. Watkins (eds.) *The Apollo 15 Lunar Samples*. Lunar Science Institute, Houston, pp. 275-279.

Macdonald, E.J.; H. Lichtenstein; D. Nooner; D. Flory; S. Wikstrom; J. Oró (1973). «Epidemiological factors in lung cancer among women in El Paso County, Texas, 1944-1969». *J. Am. Med. Womens Assoc.*, vol. 28, pp. 459-467.

Stephen-Sherwood, E.; J. Oró (1973). «Chemical evolution. Recent syntheses of bioorganic molecules». *Space Life Sci.*, vol. 4, pp. 5-31.

Nooner, D.W.; W.S. Updegrave; D.A. Flory; J. Oró; G. Mueller (1973). «Isotopic and chemical data of bitumens associated with hydrothermal veins from Windy Knoll, Derbyshire, England». *Chem. Geol.*, vol. 11, pp. 189-202.

Oró, J.; D. Flory (1973). «Organic analysis of Lunar samples and the Martian surface». *Life Sciences and Space Research XI (COSPAR, 1973)*. Akademies-Verlag, Berlin, pp. 43-54.

Nooner, D.W.; J. Oró; J. Cerbulis (1973). «Paraffinic hydrocarbon composition of earthworms (*Lumbricus terrestris*)». *Lipids*, vol. 8, pp. 489-492.

Flory, D.A.; J. Oró; S.A. Wikstrom; D.A. Beaman; A. Lovett (1973). «Organogenic compounds in Apollo 16 Lunar samples». Proceedings of the Fourth Lunar Science Conference, (Supplement 4, *Geochim. Cosmochim. Acta*), vol. 2, pp. 2229-2240.

Oró, J.; E. Stephen-Sherwood (1974). «The prebiotic synthesis of oligonucleotides». *Origins of Life*, vol. 5, pp. 159-172. Also in: Oró J.; S.L. Miller; C. Ponnampereuma; R.S. Young (eds.) *Cosmochemical Evolution and the Origins of Life*, vol. 1. Reidel, Dordrecht, pp. 159-172.

Nooner, D.W.; J. Oró (1974). «Direct synthesis of polypeptides. Polycondensation of  $\alpha$ -amino acids by polymetaphosphate esters». *J. Mol. Evol.*, vol. 3, pp. 79-88.

Stephen-Sherwood, E.; D.G. Odom; J. Oró (1974). «The prebiotic synthesis of deoxythymidine oligonucleotides». *J. Mol. Evol.* vol. 3, pp. 323-330. Also in: Oró J.; S.L. Miller; C. Ponnampereuma; R. S. Young (eds.) (1974). *Cosmochemical Evolution and the Origins of Life*, vol. 2. Reidel, Dordrecht, pp. 301-308.

Ferris, J.P.; J.D. Wos; D.W. Nooner; J. Oró (1974). «Chemical evolution XXI. The amino acids released on hydrolysis of HCN oligomers». *J. Mol. Evol.*, vol. 3, pp. 225-231.

Flory, D.A.; J. Oró; P.V. Fennessey (1974). «Organic contamination problems in the Vikings molecular analysis experiment». *Origins of Life*, vol. 5, pp. 443-455. Also in: Oró J.; S. L. Miller; C. Ponnampereuma; R. S. Young (eds.) (1974). *Cosmochemical Evolution and the Origins of Life*, vol. 1. Reidel, Dordrecht, pp. 443-455.

Yuasa, S.; J. Oró (1974). «Role of weak bases on the prebiotic formation of Heterocyclic Compounds». In: Oró J.; S. L. Miller; C. Ponnampereuma; R. S. Young (eds.) *Cosmochemical Evolution and the Origins of Life*, vol. 2. Reidel, Dordrecht, pp. 295-299.

Gelpi, E.; J. Oró (1974). «Organic compounds in Meteorites—IV. Gas chromatographic mass spectrometric studies on the isoprenoids and other isomeric alkanes in carbonaceous chondrites». *Geochim. Cosmochim. Acta*, vol. 34, pp. 981-994. Article reprinted in: Kvenvolden, K. A. (ed.) (1974). *Geochemistry and the Origin of Life*. Dowden, Hutchinson and Ross, Stroudsburg, Penn., pp. 138-151.

Oró, J.; D.W. Nooner; A. Zlatkis; S.A. Wikström; E.S. Barghoorn (1974). «Hydrocarbons of biological origin in sediments about two billion years old». In: Kvenvolden K.A. (ed.) *Geochemistry and the Origin of Life*. Dowden, Hutchinson and Ross, Stroudsburg, Penn., pp. 294-296. (Reprinted from *Science*, 1965, vol. 148, pp. 77-79.)

Oró, J. (1974). «Molècules orgàniques de l'espai interstel·lar» (in Catalan). Col·loqui VII: Evolució. Societat Catalana de Biologia, Barcelona, pp. 13-26.

Oró, J. (1975). «Evolución biológica y evolución urbana (Hacia una Biopolis)» (in Spanish). Planificación Territorial-II Centro de Perfeccionamiento Profesional y Empresarial del Colegio Oficial de Ingenieros de Caminos, Canales y Puertos, Madrid, pp. 413-425.

Gibert, J.M.; I.M.R. de Andrade Bruning; D.W. Nooner; J. Oró (1975). «Predominance of isoprenoids among the alkanes in the irati oil shale, Permian of Brazil». *Chem. Geol.*, vol. 15, pp. 209-215.

Nissenbaum, A.; D.H. Kenyon; J. Oró (1975). «On the possible role of organic melanoidin polymers as matrices for prebiotic activity». *J. Mol. Evol.*, vol. 6, pp. 253-270.

Nooner, D.W.; J.M. Gilbert; E. Gelpi; J. Oró (1976). «Closed system Fischer-Tropsch synthesis over meteoritic iron, iron ore and nickel-iron alloy». *Geochim. Cosmochim. Acta*, vol. 40, pp. 915-924.

Lovett, A.M.; E. Sherwood; J.Oró (1975). «Application of GC-MS in the analysis of volatile compounds in urine and ascitic fluid of normal and tumor bearing mice». Proceedings of the 23rd Annual Conference on Mass Spectrometry and Allied Topics, Houston, Texas, pp. 351-353.

Odom, D.G.; J.T. Brady; J. Oró (1976). «The prebiotic synthesis of deoxythymidine oligonucleotides. III. Acid salt reactions». *J. Mol. Evol.*, 1976, vol. 7, pp. 151-157.

Oró, J. (1976). «Prebiological chemistry and the origin of life. A personal account». In: Kornberg, A.; Horecker, B.; Cornudella, L.; Oró, J.; (eds.) *Reflections on Biochemistry in Honour of S. Ochoa*. Pergamon, Oxford, pp. 423-443.

Holzer, G.; J. Oró; W. Bertsch (1976). «Gas chromatographic-mass spectrometric evaluation of exhaled tobacco smoke». *J. Chromatogr.*, vol. 126, pp. 771-785.

Oró, J.; E. Stephen-Sherwood (1976). «Abiotic Origin of Biopolymers». *Or. Life.*, vol. 7, pp. 37-47.

Biemann, K.; J. Oró; P. Toulmin III; L.E. Orgel; A.O Nier; D.M. Anderson; P.G. Simmonds; D. Flory; A.V. Diaz; D.R. Rushneck; J.A. Biller (1976). «Search for organic

and volatile inorganic compounds in two surface samples from the Chryse Planitia region of Mars». *Science*, vol. 194, pp. 72-76.

Oró, J. (1976). «Química prebiológica y origen de la vida. Una visión personal». (In Spanish) In: Oró, J.; Cornudella, L.; Sols, A.; Fernández Heredia, C. (eds.) *Avances de la bioquímica*. Salvat, Barcelona, pp. 515-541.

Miquel, J.; J. Oró; K.G. Bensch; J.E. Johnson, Jr. (1976). «Lipofuscin: fine structural and biochemical studies». In: Pryor W.E. (ed.) *Free Radicals in Biology*, vol. III. Academic Press, New York, pp. 133-182.

Miller, S.L., H.C. Urey; J.Oró (1976). «Origin of organic compounds on the primitive Earth and in meteorites». *J. Mol. Evol.*, vol. 9, pp. 59-72.

Oró, J.; S.L. Miller; H.C. Urey (1977). «Energy conversion in the context of the origin of life». In: Buvet R. et al. (eds.) *Living Systems as Energy Converters*. Elsevier/North Holland Biomedical Press, Amsterdam, pp. 7-19.

Ballester, A.; E.S. Barghoorn; D.B. Botkin; J. Lovelock; R. Margalef; L. Margulis; J. Oró; R. Schweikert; D. Smith; T. Swain; J. Todd; N. Todd; G.M. Woodwell (1976). «Ecological considerations for space colonies». *Co-evolution*, winter 1976-1977, pp. 96-97. Also in: *Ecol. Bull.*, Oct. 5, 1976, 2-4.

Nooner, D.W.; J. Oró (1977). «Hydrocarbons and fatty acids in oil shale of Permian Irati Formation, Brazil». In: Ponnampereuma C. (ed.) *Chemical Evolution of the Early Precambrian*. College Park Colloquium, Academic Press, New York, pp. 69-79.

Biemann, K.; J. Oró; P. Toulmin III; L.E. Orgel; A.O. Nier; D.M. Anderson; P.G. Simmonds; D. Flory; A.V. Díaz; D.R. Rushneck; J.E. Biller; A.L. Lafleur (1977). «The search for organic substances and inorganic volatile compounds in the surface of Mars». *J. Geophys. Res.*, vol. 82, pp. 4641-4658.

Oró, J. (1977). «El origen de la vida» (in Spanish). Boletín Informativo 64. Fundación Juan March, Madrid, pp. 3-25.

Holzer, G.; J. Oró (1977). «Pyrolysis of organic compounds in the presence of ammonia. The Viking Mars lander site alteration experiment». *Org. Geochem.*, vol. 1, pp. 37-52.

Sherwood, E.; J. Oró (1977). «Cyanamide mediated syntheses under plausible primitive Earth conditions. Part I. The synthesis of p<sup>1</sup>, p<sup>2</sup>-dideoxythymidine 5'-pyrophosphate». *J. Mol. Evol.*, vol. 10, pp. 183-192.

Sherwood, E.A. Joshi; J. Oró (1977). «Cyanamide mediated syntheses under plausible primitive Earth conditions. II. The polymerization of deoxythymidine 5'-triphosphate». *J. Mol. Evol.*, vol. 10, pp. 193-209.

Nooner, D.W.; E. Sherwood; M.A. More; J. Oró (1977). «Cyanamide mediated syntheses under plausible primitive Earth conditions. III. Synthesis of peptides». *J. Mol. Evol.*, vol. 10, pp. 211-220.

Eichberg, J.; E. Sherwood; D.E. Epps; J. Oró (1977). «Cyanamide mediated syntheses under plausible primitive Earth conditions. IV. The synthesis of acylglycerols». *J. Mol. Evol.*, vol. 10, pp. 221-230.

Nooner, D.W.; J. Oró (1978). «Synthesis of fatty acids by a closed system Fischer-Tropsch process». PREPRINTS (???) , Division of Petroleum Chemistry, American Chemical Society, vol. 23, pp. 624-631.

Leach, W.W.; D.W. Nooner; J. Oró (1978). «Abiotic synthesis of fatty acids». In: Noda H., (ed.) *Origins of Life*. (Proceedings of the 2nd ISSOL and 5th ICOL Meeting). Center for Academic Publications, Japan Scientific Societies, Tokyo, pp. 113-122.

Sherwood, E.; D.W. Nooner; J. Eichberg; D.E. Epps; J. Oró (1978). «Prebiotic condensation reactions using cyanamide». In: Noda H. (ed.) *Origins of Life*. (Proceedings of the 2nd ISSOL and 5th ICOL Meeting). Center for Academic Publications, Japan Scientific Societies Press, Tokyo, pp. 105-111.

Epps, D.E.; E. Sherwood; J. Eichberg; J. Oró (1978). «Cyanamide mediated syntheses under plausible primitive Earth conditions. V. The synthesis of phosphatidic acids». *J. Mol. Evol.*, vol. 11, pp. 279-292.

Tornabene, T.G.; R.S. Wolfe; W.E. Balch; G. Holzer; G.E. Fox; J. Oró (1978). «Phytanyl-glycerol ethers and squalenes in the Archaeobacterium *Methanobacterium Thermoautotrophicum*». *J. Mol. Evol.*, vol. 11, pp. 259-266.

Oró, J.; G. Holzer (1979). «The effects of ultraviolet light on the degradation of organic compounds. A possible explanation for the absence of organic matter on Mars». In: Holmquist R. (ed.) *COSPAR Life Sciences and Space Research Vol. XVII*, pp. 77-86.

Oró, J.; E. Sherwood; J. Eichberg; D.E. Epps (1978). «Formation of phospholipids under primitive Earth conditions and the role of membranes in prebiological evolution». In: Deamer D. (ed.) *Light Transducing Membranes*. Academic Press, New York, pp. 1-19.

Holzer, G.; J. Oró (1978). «Chemical carcinogenesis: A natural and man-made global environmental problem». Proceedings of the International Symposium on Analytical Techniques in Environmental Chemistry (Barcelona, Spain, November 27-30). Pergamon Press, Oxford, pp. 211-236.

Oró, J. (1978). «Biochemistry, nutrition and demographic growth». In: Oró, J.; Sorjus, J. (eds.) *Catalunya Agrícola*. Ediciones Alba, Barcelona, pp. 84-96.

Biemann, K.; J.E. Biller; J. Oró; L.E. Orgel; A.O. Nier; D.M. Anderson; P.G. Simmonds; D. Flory; A.V. Diaz; D.R. Rushneck (1978). «Search for organic and volatile inorganic compounds in two surface samples from the Chryse Planitia region of Mars». In: Ponnampuruma C. (ed.) *Comparative Planetology*. Academic Press, New York, pp. 197-211.

Tornabene, T.G.; T.A. Langworthy; G. Holzer; J. Oró (1979). «Squalenes, phytanes and other isoprenoids as major neutral lipids of methanogenic and thermoacidophilic "Archaeobacteria"». *J. Mol. Evol.*, vol. 13, pp. 73-83.



Odom, D.G.; M. Rao; J. Lawless; J. Oró (1979). «Association of nucleotides with homoionic clays». *J. Mol. Evol.* vol. 12, pp. 365-367.

Holzer, G.; J. Oró; T.G. Tornabene (1979). «Gas chromatographic-mass spectrometric analysis of neutral lipids from methanogenic and thermoacidophilic bacteria». In: Zlatkis A.; L.S. Ettre; E. Kovats (eds.) *Advances in chromatography*, Elsevier, Amsterdam, pp. 873-887. Also in: *J. Chromatogr.*, vol. 186, pp.795-809.

Epps, D.E.; D.W. Nooner; J. Eichberg; E. Sherwood; J. Oró (1979). «Cyanamide mediated synthesis under plausible primitive Earth conditions. VI. The synthesis of glycerol and glycerophosphates». *J. Mol. Evol.*, vol. 14, pp. 235-241.

Holzer G. ; J. Oró (1979). «The organic composition of the Allan Hills carbonaceous chondrite (77306) as determined by pyrolysis-gas chromatography-mass spectrometry and other methods». *J. Mol. Evol.*, vol. 13, pp. 265-270.

Oró, J.; G. Holzer (1979). «The photolytic degradation and oxidation of organic compounds under simulated Martian conditions». *J. Mol. Evol.*, vol. 14, pp. 153-160.

Nooner, D.W.; J. Oró (1979). «Synthesis of fatty acids by closed system Fischer-Tropsch processes». In: Hydrocarbon Synthesis from Carbon Monoxide and Hydrogen, *Advances in Chemistry Series, No. 178*. American Chemical Society, Washington, D. C., pp. 159-171.

Oró, J.; D.W. Nooner (1979). «Cosmochemical and geochemical applications of mass spectrometry». In: Middleditch B. S. (ed.) *Mass-Spectrometry. A Contemporary Introduction*. Plenum Publishing, New York, pp. 327-359.

Oró, J.; G. Holzer; A. Lazcano-Araujo (1980). «The contribution of cometary volatiles to the primitive Earth». In: Holmquist R. (ed.) *COSPAR Life Sci. Space Res.*, vol. XVII. Pergamon Press, Oxford, 1980, pp. 67-82.

Tornabene, T.G.; R.E. Lloyd; G. Holzer; J. Oró (1980). «Lipids as a principle for the identification of Archaeobacteria». In: Holmquist R. (ed.) *COSPAR Life Sci. Space Res.* vol. XVIII. Pergamon Press, Oxford, pp. 109-121.

Deamer, D.W.; J. Oró (1980). «Role of lipids in prebiotic structures». *Biosystems*, vol. 12, pp. 167-175.

Rao, M.; D.G. Odom; J. Oró (1980). «Clays in prebiological chemistry». *J. Mol. Evol.*, vol. 15, pp. 317-331.

Oró, J. (1980). «Prebiological synthesis of organic molecules and the origin of life» In: Halvorson H.O.; K.E. Van Holde (eds.) *Or Life Evol.* Alan R. Liss, New York, pp. 47-63.

Holzer, G.; J. Oró; S.J. Smith; V.M. Doctor (1980). «Separation of monosaccharides as their alditol acetates by capillary column gas chromatography». *J. Chromatogr.*, vol. 194, pp. 410-415.

Oró, J. (1980). «L'Origen de la Vida a la Terra» (in Catalan). In: Oró J.; J.C. Verges; J.A. Plana Castellvi (eds.) *Els Planetes Comparats*. Ed. Sirocco, Barcelona, pp. 57-71.

Hawker, J.R., Jr.; J. Oró (1981). «Cyanamide mediated syntheses of Leu, Ala and Phe peptides under plausible primitive Earth conditions». In: Wolman Y. (ed.) *Origins of Life*. pp. 225-232.

Giner-Sorolla, A.; J. Oró (1981). «Mutagens and carcinogens: Occurrence and role during chemical and biological evolution». In: Wolman Y. (ed.) *Origins of Life*. Reidel, Dordrecht, 583-588.

Oró, J.; G. Holzer; M. Rao; T.G. Tornabene (1981). «Membrane lipids and the origin of life». In: Wolman Y. (ed.) *Origins of Life*. Reidel, Dordrecht, pp. 313-322.

Hawker, J.R. Jr.; J. Oró (1981). «Cyanamide Mediated Synthesis of Peptides Containing Histidine and Hydrophobic Amino Acids». *J. Mol. Evol.* vol. 17, pp. 285-294.

Lazcano-Araujo, A., J. Oró (1981). «Cometary material and the origins of life on Earth». In: Ponnampereuma C. (ed.) *Comets and the Origin of Life*. Reidel, Dordrecht, pp. 191-225.

Oró, J.; Lazcano-Araujo, A. (1981). «The role of HCN and its derivatives in prebiotic evolution». In: Vennesland B.; E.E. Conn; C.J. Knowles; J. Westley; F. Wissing (eds.) *Cyanide in Biology*. Academic Press, London, pp. 517-541.

Bar-Nun, A.; A. Lazcano-Araujo; J. Oró (1981). «Could life have evolved in cometary nuclei?». *Orig. Life*, vol. 11, pp. 388-394.

Yuasa, S.; J. Oró (1981). «HCN as a possible precursor of the amino acids in Lunar samples». In: *Science and Scientists—Essays by Biochemists, Biologists and Chemists*. Japan Scientific Societies Press, Tokyo, pp. 31-37.

Green, C.; V.M. Doctor; G. Holzer; J. Oró (1981). «Separation of neutral and amino sugars by capillary gas chromatography». *J. Chromatogr.*, vol. 207, pp. 268-272.

Rao, M.; J. Eichberg; J. Oró (1982). «Synthesis of phosphatidylcholine under possible primitive Earth conditions». *J. Mol. Evol.*, vol. 18, pp. 196-202.

Oró, J.; K. Rewers; D. Odom (1982). «Criteria for the emergence and evolution of life in the Solar system». *Orig. Life*, vol. 12, pp. 285-305.

Oró, J. (1982). «El hombre ante el espacio» (in Spanish). *Aeronáutica y Astronáutica*, No. 502, pp. 865-868.

Oró, J. (1983). «Chemical evolution and the origin of life». *Adv. Space Res.*, vol. 3, pp. 77-94.

Odom, D; T. Yamrom; J. Oró (1983). «Prebiotic oligodeoxynucleotide synthesis in a cyclic evaporating system at low temperatures». *Adv. Space Res.*, vol. 3, 55-59.

Bada, J.L.; J.R. Cronin; M-S. Ho; K.A. Kvenvolden; J.G. Lawless; S.L. Miller; J. Oró; S. Steinberg (1983). «On the reported optical activity of amino acids in the Murchison meteorite». *Nature*, vol. 301 pp. 494-497.

Lazcano, A.; J. Oró; S. L. Miller (1980). «Primitive Earth environments: Organic syntheses and the origin and early evolution of life». *Precambr. Res.*, vol. 20, pp. 259-282.

Oró, J. (1983). «El origen de la vida en la Tierra y el hombre ante el espacio» (in Spanish). *Astronomía y Astrofotografía Técnica*, No. 6, pp. 192-197.

Andrawes, F.; G. Holzer; E. Roedder; E.K. Gibson, Jr.; J. Oró (1984). «Gas chromatographic analysis of volatiles in fluid and gas inclusions». *Chromatography*, vol. 302, pp. 181-193.

Basile, B.P.; B.S. Middleditch; J. Oró (1984). «Polycyclic aromatic hydrocarbons in the Murchison meteorite». *Organic Geochem.*, vol. 5, pp. 211-216.

Oró, J.; B. Basile; S. Cortes; C. Shen; T. Yamrom (1984). «The prebiotic synthesis and catalytic role of imidazole and other condensing agents». *Orig. Life*, vol. 14, pp. 237-242.

Yuasa, S.; D. Flory; B. Basile; J. Oró (1984). «On the abiotic formation of amino acids. I. HCN as a precursor of amino acids detected in extracts of Lunar samples. II. Formation of HCN and amino acids from simulated mixtures of gases released from Lunar samples». *J. Mol. Evol.*, vol. 20, pp. 52-58.

Yuasa, S., D. Flory, B. Basile, J. Oró (1984). «Abiotic synthesis of purines and other heterocyclic compounds by the action of electrical discharges». *J. Mol. Evol.*, vol. 21, pp. 76-80.

Oró, J.; A. Lazcano (1984). «A minimal living system and the origin of a protocell». *Adv. Space Res.*, vol 4, pp. 167-176.

Basile, B.; A. Lazcano; J. Oró (1984). «Prebiotic synthesis of purines and pyrimidines». *Adv. Space Res.*, vol 4, pp. 125-131.

Oró, J. (1984). «La evolución química y el origen de la vida a los cien años de la muerte de Darwin» (in Spanish). In: Albert P.; R. Margalef; L. Margulis; J. Oró; R. Pares; A. Prevosti; O.A. Reig; D. Sperlich; J. A. Valverde; J.R. Villanueva (eds.) *Darwin a Barcelona*. Promocions Publicacions Universitàries, Barcelona, pp. 81-139.

Oró, J. (1985). «El origen de la vida» (in Spanish). In: Arana, J. (ed.) *Genética molecular*. Fundación Instituto de Ciencias del Hombre, Madrid, pp. 25-78.

Oró, J. (1986). «La evolución química y el origen de la vida» (in Spanish). In: *Bioquímica y Biología Molecular*. Salvat, Barcelona, pp. 554-572.

Baeza, I.; M. Ibañez; J.C. Santiago; C. Wong; A. Lazcano; J. Oró. (1986). «Studies on precellular evolution: The encapsulation of polyribonucleotides by liposomes». *Adv. Space Res.*, vol. 6, pp. 39-43.

Oró, J. (1986). «La exploración del espacio y el origen de la vida» (in Spanish). In: *Aula de Cultura*, published by El Correo Español – El Pueblo Vasco, Vizcaya, pp. 11-33.

Mar, A.; J. Dworkin; J. Oró (1987). «Non-enzymatic synthesis of the coenzymes, uridine diphosphate glucose and cytidine diphosphate choline, and other phosphorylated metabolic intermediates». *Orig. Life.*, vol. 187, pp. 307-319.

Rao, M.; J. Eichberg; J. Oró (1987). «Synthesis of phosphatidylethanolamine under possible primitive Earth conditions». *J. Mol. Evol.*, vol. 27, pp. 365-376.

Lazcano, A.; J. Fastag; O. Gariglio; C. Ramirez; J. Oró (1988). «On the Early Evolution of RNA Polymerase». *J. Mol. Evol.*, vol. 27, pp. 365-376.

Lazcano, A.; R. Guerrero; L. Margulis; J. Oró (1988). «The evolutionary transition from RNA to DNA in early cells». *J. Mol. Evol.*, vol. 27, pp. 283-290.

Oró, J. (1988). «Constraints imposed by cosmic evolution towards the development of life». In: Marx G. (ed.) *Bioastronomy-The Next Steps*. Kluwer Academic Press, Dordrecht, the Netherlands, pp. 161-165.

Oró, J. (1988). «Origen i evolució de la vida» (in Catalan). In: *Llibre de Ponències*. Tretzè Congrés de Metges i Biòlegs de Llengua Catalana (Andorra, novembre 1988), Barcelona, pp. 5-23.

Oró, J. (1989). «Chemical evolution: A Solar system perspective». In: *Exobiology and Future Mars Missions*, Proceedings of “Mars Sample Return Workshop”, Nov. 16-18, 1987. NASA Conference Publication 10027, pp. 46-49.

Oró, J.; T. Mills (1989). «Chemical evolution of primitive Solar system bodies». *Adv. Space Res.*, vol. 9, pp. 105-120.

Oró, J. (1989). «Los avances en la investigación científica del espacio» (in Spanish). In: *Diez Años de Democracia en España 1976-1986*. Tibidabo Ediciones, Barcelona, pp. 69-84.

Shen, C.; L. Yang; S.L. Miller; J. Oró (1990). «Prebiotic synthesis of histidine». *J. Mol. Evol.*, vol 31, pp. 175-179.

Shen, C.; T. Mills; J. Oró (1990). «Prebiotic synthesis of histidyl-histidine». *J. Mol. Evol.*, vol. 31, pp. 175-179.

Lazcano, A.; V. Valverde; J. Fastag; P. Gariglio; C. Ramirez; J. Oró (1990). «Molecular evolution of nucleic acid polymerases». In: Ponnampereuma, C.; F.R. Eirich (eds.) *Prebiological Self Organization of Matter*. A. Deepak Publishing, Hampton, VA, pp. 219-233.

Llaca, V.; E. Silva; A. Lazcano; L.M. Rangel; P. Gariglio; J. Oró. (1990). «In search of the ancestral RNA polymerase: An experimental approach». In: Ponnampereuma, C.; F.R. Eirich (eds.) *Prebiological Self Organization of Matter*. A. Deepak Publishing, Hampton, VA, pp. 247-260.

Oró, J.; A. Lazcano (1990). «A holistic precellular organization model. In: Ponnampereuma, C.; F.R. Eirich (eds.) *Prebiological Self Organization of Matter*. A. Deepak Publishing, Hampton, VA, pp. 11-34.

Oró, J.; S.L. Miller; A. Lazcano (1990). «The origin and early evolution of life on Earth». *Ann. Rev. Earth Planet. Sci.*, vol. 18, pp. 317-356.

Shen, C.; A. Lazcano; J. Oró (1990). «The enhancement effects of histidyl-histidine in some prebiotic reactions». *J. Mol. Evol.*, vol. 31, pp. 445-452.

Baeza, I.; M. Ibañez; J.C. Santiago; C. Argüello; C. Wong; J. Oró (1990). «Diffusion of  $Mn^{++}$  into liposomes mediated by phosphatidate and monitored by the activation of an encapsulated enzymatic system». *J. Mol. Evol.*, vol. 31, pp. 453-461.

Clark, B.; S. Chang; J. Oró (1990). «Specific-electrode measurement of chemical properties of the Martian soil». In: DeVicenzi, D.L.; J.R. Marshall; D. Anderson (eds.) *Exobiology on Mars*. NASA Conference Publication 10055, pp. 7-9.

Nier, A.; J. Oró; D. Des Marais; D. Rushneck (1990). «The detection of organics and volatiles with mass spectrometry». In: DeVicenzi, D.L.; J.R. Marshall; D. Anderson (eds.) *Exobiology on Mars*. NASA Conference Publication 10055, pp. 19-21.

Oró, J. (1990). «Origen y evolución de la vida» (in Spanish). In: Bach Piella, C. (ed.) *Investigacion y Universidad*. I.C.E. Universidad de Córdoba, Cordoba, Spain, pp. 55-80.

Oró, J.; J.M. Berry (1990). «Comets and the origin of Life». In: Oró J.; J. Miquel (eds.) *Aerospace Research in Biology and Medicine*. Fundació "La Caixa", Barcelona, pp. 52-70.

Oró, J. (1991). «Origen y evolución de la vida» (in Spanish). In: Fernandez-Rañada A. (ed.) *Nuestros orígenes: El universo, la vida, el hombre* (Homage to Severo Ochoa). Fundación Ramón Areces, Madrid, pp. 169-199.

Mar, A.; J. Oró (1991). «Synthesis of the coenzymes adenosine diphosphate glucose, guanosine diphosphate glucose, and cytidine. Diphosphoethanolamine under primitive Earth conditions». *J. Mol. Evol.*, vol. 32, pp. 201-210.

Wong, C.; J.C. Santiago; L. Rodríguez-Páez; M. Ibáñez; I. Baeza; J. Oró (1991). «Synthesis of putrescine under possible primitive Earth conditions». *Orig. Life Evol. Biosph.*, vol. 21, pp. 145-156.

Oró, J.; A. Lazcano (1991). «On the origin and early evolution of biological catalysis and other studies on chemical evolution». In: NASA Conference Publication: 3129, pp. 53.

Oró, J.; A. Blade; J. Farran; L. Reales (1991). «Scientific research in Catalonia». In: Azevedo M. (ed.) *Contemporary Catalonia in Spain and Europe: Gaspar de Portolà Catalanian Studies Program*. Univ. California, Berkeley, pp. 128-138.

Oró, J.; T. Mills; A. Lazcano (1992). «The cometary contribution to prebiotic chemistry». *Adv. Space Res.*, vol. 12, pp. 33-41.

Lazcano, A.; V. Llaca; R. Cappello; V. Valverde; J. Oró (1992). «The origin and early evolution of nucleic acid polymerases». In: Oró, J.; G. Horneck; J.M. Greenberg; F. Raulin; A.W. Schwartz; K. Dose; E.I. Friedmann (eds.) *Life Sciences and Space Research XXIV (3), Planetary Biology and the Origins of Life*. *Adv. Space Res.*, vol. 12, pp. 207-216.

Baeza, I.; M. Ibáñez; C. Wong; P. Chavez; P. Gariglio; J. Oró (1992). «Possible prebiotic significance of polyamines in the condensation, protection, encapsulation and biological properties of DNA». *Orig. Life Evol. Biosph.*, vol. 21, pp. 225-242.

Oró, J.; A. Lazcano (1992). «Recent advances in chemical evolution and the origins of life». *Acta Astron.*, vol. 26, pp. 157-168.



Lazcano, A.; V. Valverde; Greco-Hernández; P. Gariglio; G.E. Fox; J. Oró (1992). «On the early emergence of reverse transcription: Theoretical basis and experimental aspects». *J. Mol. Evol.*, vol. 35, pp. 524-536.

Velasco, A.M.; L. Medrano; A. Lazcano; J. Oró (1992). «A redefinition of the Asp-Asp domain of reverse transcriptases». *J. Mol. Evol.*, vol. 35, pp. 551-556.

Oró, J.; T. Mills; A. Lazcano (1992). «Comets and the formation of biochemical compounds on the primitive earth-A review». *Orig. Life Evol. Biosph.*, vol. 21, pp. 267-277.

Lazcano, A.; G. Fox; J. Oró (1992). «Life before DNIn: The origin and evolution of early Archean cells». In: Mortlock R.P. (ed.) *The Evolution of Metabolic Function*. Telford Press, Caldwell, N.J., pp. 237-295.

Oró, J.; S.W. Squyres; R.T. Reynolds; T.M. Mills (1992). «Chapter V Europa: Prospects for and ocean and Exobiological Implications». In: Carle, G. C.; D. E. Schwartz, J.L. Huntington (eds.), *Exobiology in Solar System Exploration*. NASA Special Publication 512, 1992, pp. 103-125.

Oró, J. (1992). «La ciencia y el hombre en el umbral del siglo XXI» (in Spanish). In: Grisolia S. et al. (eds.) *En el umbral del tercer milenio*. Tabapress, pp. 183-192.

Oró, J. (1993). «Evolution of life and extension of man's life expectancy». In: Boada M.; M.A. Selmes (eds.) *La enfermedad de Alzheimer y otras demencias afines* (4<sup>th</sup> Conference SYSTED 91. June 10-14, 1991, Barcelona). Fundación Alzheimer España, Madrid, pp.105-107.

Baumann, U.; J. Oró (1993). «Three stages in the evolution of the genetic code». *BioSystems*, vol. 29, pp. 133-141.

Oró, J. (1994). «Early chemical stages in the origin of life». In: Bengtson, S. (ed.) *Early Life on Earth: Nobel Symposium No. 84*. Columbia University Press, New York, pp.48-59.

Oró, J. (1994). «Les arrels de l'escriptura i dels llibres. El projecte editorial de la UPC» (in Catalan). In: Acte de presentació d'Edicions UPC. Edicions UPC, Barcelona, p. 17.

Oró, J. (1994). «Chemical synthesis of lipids and the origin of life». *J. Biol. Phys.*, vol. 20, pp. 135-147.

Oró, J. (1995). «The chemical and biological basis of intelligent Terrestrial life from an evolutionary perspective». In: S. Shostak (ed.): *Progress in the Search for Extraterrestrial Life*. AS Conference Series, San Francisco, vol. 74, pp. 121-133.

Oró, J. (1995). «From hydrogen to life and man». In: Baye K.M.; K. Vasak (eds.) *Federico Mayor Amicorum Liber (Solidarité, égalité, liberté)*. Dedicated to Dr. Federico Mayor Zaragoza's 60th Anniversary. Bruylant, Brusel·les, vol. 2, pp. 1051-1090.

Lazcano, A.; E. Díaz-Villagómez; T. Mills; J. Oró (1995). «On the levels of enzymatic substrate specificity: Implications for the early evolution of metabolic pathways». *Adv. Space Res.*, vol. 15, pp. 345-356.

Oró, J.; T. Mills; A. Lazcano (1995). «Comets and life in the Universe». *Adv. Space Res.*, vol. 15, pp. 81-90.

Oró, J. (1995). «A. I. Oparin: personal encounters and reminiscences». In: B.L. Poglazov et al. (eds.) *Evolutionary Biochemistry and Related Areas of Physicochemical Biology. Dedicated to the Memory of Academician A. I. Oparin*. Bach Institute of Biochemistry and ANKO, Moscow, pp. 25-40.

Oró, J. (1995). «From cosmochemistry to life and man». In: B.L. Poglazov et al. (eds.) *Evolutionary Biochemistry and Related Areas of Physicochemical Biology (Dedicated to the Memory of Academician A. I. Oparin)*, Bach Institute of Biochemistry and ANKO, Moscow, pp. 63-92. Also In: Eutopías, 2a. época, Working papers, Ed. By Centro de Semiótica y Teoría del Espectáculo, Universitat de Valencia & Asociación Vasca de Semiótica, Valencia, pp. 1-31.

Oró, J. (1995). «Cosmochemical evolution and the origin of life». *Microbiol SEM*, Vol 11, pp. 145-160.

Oró, J. (1996). «Evolución cosmoquímica y origen de la vida» (in Spanish). In: F. Morán, J. Peretó and A. Moreno (eds.) *Orígenes de la Vida* (in the centennial of Aleksandr Ivanovich Oparin). Editorial Complutense, Madrid, pp. 321-335.

Oró, J. (1996). «La vida a l'univers i l'evolució còsmica» (In Catalan). Llibre de Ponències. Quinzè Congrés de Metges i Biòlegs de Llengua Catalana, pp 47-62.

Oró, J. (1996). «Cosmic evolution, life and man». In: J. Chela-Flores; F. Raulin (eds.) *Chemical Evolution: Physics of the Origin and Evolution of Life*. Kluwer Academic Press, Dordrecht, the Netherlands, pp. 3-19.

Oró, J. (1996). «Planetary formation of biochemical compounds in circumstellar habitable zones». In: Doyle L.R (ed.) *Circumstellar Habitable Zones – Proceedings of the First International Conference*. Travis House Publications, Menlo Park, California, pp. 283-297.

Oró, J.; A. Lazcano (1997). «Comets and the origins and evolution of life: A scientific and historical introduction». In: Thomas P.J.; C.F. Chyba; C.P. McKay (eds.) *Comets and the Origins and Evolution of Life*, Springer Verlag, New York, pp 3-27.

Macià, E.; V. Hernandez; J. Oró (1997). «Primary sources of phosphorus and phosphates in chemical evolution». *Orig. Evol. Biosph.*, vol. 27, pp. 459-480.

Oró, J.; C.B. Cosmovici (1997). «Comets and life on the primitive Earth». In: Cosmovici, C.B; ??? Bowyer; P. Werthimer (eds.) *Astronomical and Biochemical Origins and the Search for Life in the Universe*. Editrice Compositori, Bologna, pp. 97-120.

Oró, J. (1997). «Hi ha vida a l'univers?» (In Catalan). *L'Anuari 1997, Avui*. Fundació Catalunya, Barcelona, 1997, pp. 232.

Oró, J. (1997). «Origen y evolución de la Vida, (del hidrogeno al hombre)» (in Spanish). In: *Ciencia y Sociedad – “Desafios del conocimiento ante el Tercer Milenio”*. Fundación Central Hispano, Ediciones Nobel S.A. Oviedo, 1997, pp. 11-45.

Oró, J. (1997). «Cometas y el origen de la vida. Química prebiológica: una aportación personal» (in Spanish). *Universo, Astronomía y Astronáutica*, vol. 23, pp. 20-25.

Oró, J. (1997). «Reminiscencias de Carl Sagan» (in Spanish), *Universo, Astronomía y Astronáutica*, vol. 23, p. 26.

Oró, J. (1998). «Del naixement de l'Univers i l'origen de la vida al segle XXI (in Catalan) ». Agropress, Generalitat de Catalunya. pp. 1-12.

Oró, J. (1998). «Origen i evolució de la vida» (in Catalan). In: Universitat Pompeu Fabra, Fundació Mil·leni, *Primeres Jornades sobre Medicina Preventiva i Predictiva*. Barcelona, pp. 79-83.

Oró, J. (1998) «Prólogo» (in Spanish). In: Aupí, V. (ed.) *Santiago Grisolia. Apuntes para la Historia Biologica del Hombre*. Universidad Politecnica de Valencia, Valencia, pp 11-13.

Oró, J. 1998. «“The Abdus Salam Lecture” Cosmochemical Evolution. A unifying and creative process in the Universe». In: Chela-Flores J.; Raulin, F. (eds.) *Exobiology Matter, Energy and Information in the Origin and Evolution of life in the Universe*. Kluwer Academic Publishers, the Netherlands, pp. 11-32.

Oró, J. (1998). «The case for life on Mars». *Bioastron. News*, vol. 19

Oró, J. (1998). «Data are as good as our interpretations». *Bioastron. News*, vol. 19

Levy, M.; S.L. Miller; J. Oró (1999). «Production of guanine from  $\text{NH}_4\text{CN}$  polymerizations». *J. Mol. Evol.*, vol. 49, pp. 165-169.

Oró, J. (1999). «Evolutionary requirements for the development of intelligent life». In: Colombo, R.; G. Giorello; G., Rigamonti; E. Sindoni; C. Sinigaglia (eds.) *Origine de la Vita Intelligente nell Universo. Origin of Intelligent Life in the Universe* (Italian and English). International Conference, Villa Monastero (Lecco, Varenna, Italy), Edizioni Newpress, Como, Italy, pp 167-195.

Oró, J. (1999). «Vincoli per lo sviluppo della vita intelligente» (in Italian). In: R. Colombo; G Giorello. E. Sindoni (eds.) *L'Intelligenza dell'Universo*. Edizioni Piemme, Asti, pp 83-107.

Oró, J. (1999). «Prólogo» (in Spanish). In: Giner Sorolla A.; M. Piqueras *Orígenes. Del big bang al tercer milenio*. Antinea, Vinarós, Spain, pp 13-26.

Oró, J. (2000). «Organic matter and the origin of life in the Solar system». In: Lemarchand A; K. Meech (eds.) *Bioastronomy '99. A new era in bioastronomy*. Sheridan Books, Inc., Chelsea, MI, , pp. 285-299.

Chela-Flores, J.G. Lemarchand; J. Oró (2000). «Preface». In: Chela-Flores J.; G. Lemarchand; J. Oró (eds.) *Astrobiology: Origins from the Big-Bang to Civilisation*. Kluwer Academic Press, Dordrecht, the Netherlands, pp. IX-XI

Oró, J. (2000). «A few words of welcome». In: Chela-Flores J.; G. Lemarchand; J. Oró (eds.) *Astrobiology: Origins from the Big-Bang to Civilisation*. Kluwer Academic Press, Dordrecht, the Netherlands, pp. XXI-XXII

Oró, J. (2000). «Cosmochemical evolution and the origin of life on Earth». In: Chela-Flores J.; G. Lemarchand; J. Oró (eds.) *Astrobiology: Origins from the Big-Bang to Civilisation*. Kluwer Academic Press, Dordrecht, the Netherlands, pp. 57-59.

Oró, J. (2000). «Pròleg» (in Catalan). In: Trigo-Rodriguez, J.M. *L'origen del sistema solar*. ECSA Portic, Barcelona, pp 11-13.

Oró, J. (2000). «Evolución cultural hacia la paz—Utopia o necesidad» (in Spanish). In: 23 Congreso de Geriatria y Gerontologia, Barcelona, pp 1-20.

Oró, J. (2000). «El legado del siglo XX» (in Spanish). In: ARP-Sociedad Para el Avance del Pensamiento Crítico *Las fronteras del conocimiento ¿aun queda mucho por saber?* Agrupación Astronómica de Castelldefels, Castelldefels.

Oró, J. (2000). «Cosmochemical evolution and the origins of life». In: Bouhdiba, A. (ed.) *Qu'est-ce que la vie? 4ème Rencontre Internationale de Carthage*, Carthage, Tunisia

Oró, J. (2001). «Cometary molecules and life's origin». In: Chela-Flores et al. (eds.) *First Steps in the Origin of Life in the Universe*. J. Kluwer Academic Press, Dordrecht, the Netherlands, pp. 113-120.

Oró, J.; X. Palau (2001). «Cosmopark-A natural astronomical observatory». In: Chela-Flores J. et al. (eds.) *First Steps in the Origin of Life in the Universe*. Kluwer Academic Press, Dordrecht, the Netherlands, pp. 383-385.

Oró, J. (2002). «L'origen de la vida a la Terra i l'exploració de l'espai» (in Catalan). *Revista Ateneu Barcelonès*, Barcelona, pp. I-IX.

Oró, J. (2002). «Prólogo» (In Spanish). In: Urmeneta J.; Navarrete, A. *¿Hay alguien ahí? Origen y evolución de la vida en el planeta Tierra y la búsqueda de señales de vida en el espacio*. Editorial Océano, Barcelona, p. 10-11.

Oró, J. (2002). «Comets and the origin of life on the primitive Earth». In: Seckbach J. (ed.) *Origins, Evolution and Biodiversity of Microbial life*. Kluwer Academic Press, Dordrecht, the Netherlands

Oró, J. (2002). «Pròleg». In: Forcada A. *Cosmos*. Pagès ed., Lleida, Spain, p. 8.

Oró, J. (2002). «Historical understanding of life's beginnings». In: Schopf J. W. (ed.) *Life's Origin. The Beginnings of Biological Evolution*. Univ. California Press, Berkeley, pp.7-45.

## 2. CHAPTERS OF BOOKS

Kimball, A. P.; J. Oró (eds.). (1971). *Prebiotic and Biochemical Evolution*. North-Holland, Amsterdam, 296 pp.

Stanley, W.M.; J. Casals; J. Oró; R. Segura (eds.) (1971). *Virus y Cancer* (in Spanish, Catalan, French and English). Imprenta Socitra, Barcelona, 452 pp.

Melnick, J.L.; S. Ochoa; J. Oró (eds.). (1973). *Viral Replication and Cancer*. Proceedings of the 2<sup>nd</sup> Duran Reynals International Symposium, Barcelona, Spain. Editorial Labor, Barcelona, 289 pp.

Oró, J.; S.L. Miller; C. Ponnampereuma; R.S. Young (eds.) (1973). *Cosmochemical Evolution and the Origins of Life*. Proceedings of the 4<sup>th</sup> International Conference on the Origins of Life, Barcelona, Spain. Reidel, Dordrecht. vol. 1, 523 pp. and vol. 2, 334 pp.

Oró, J.; L. Cornudella (eds.) (1975). *Homenaje al Profesor Severo Ochoa en su 70 aniversario—International Symposium on Enzymatic Mechanisms in Biosynthesis and Cell Function* (in Spanish and English). Gráficas Socitra, Barcelona, 240 pp.

Kornberg, A.; B.L. Horecker; L. Cornudella; J. Oró (eds.). (1976). *Reflections on Biochemistry*. Pergamon Press, Oxford, 465 pp.

Oró, J.; L. Cornudella; C.P. Heredia; A. Sols (1976). *Avances de la bioquímica* (in Spanish). Salvat, Barcelona, 593 pp.

Oró, J.; J. Sorjús; J.A. Plana, (eds.) (1978). *Catalunya agrícola*. (in Spanish). Servicio de Estudios, Ediciones Alba, Barcelona, Spain, 183 pp.

Oró, J. (ed.) (1979). *The Viking Mission and the Question of Life on Mars*. Springer-Verlag KG, Heidelberg. *J. Mol. Evol.*, vol. 14, Nos. 1-3, 231 pp.

Oró, J.; J.C. Verges; J.A. Plana Castellví (eds.) (1980). *Els planetes comparats* (in Catalan). Edicions Sirocco, Barcelona, 235 pp.

Oser, H.; J. Oró; R.D. MacElroy; H.P. Klein; D.L. DeVincenzi; R.S. Young (eds.) (1984). *Advances in Space Research. Life Sciences and Space Research XXI* (2). Pergamon Press, Oxford, 326 pp.

Melnick, J.L.; S. Ochoa; J. Oró (eds.) (1984), *Viruses, Oncogenes and Cancer* (Proceedings of the 3rd International Duran-Reynals Symposium, Barcelona, Spain). *Progress in Medical Virology*, vol. 32, 222 pp.

Ochoa, S.; L.F. Leloir; J. Oró; A. Sols (eds.). (1986). *Bioquímica y biología molecular*. Salvat, Barcelona, 586 pp.

Oró, J.; T. Owen; F. Raulin; G.G. Fazio (eds.) (1987). *Advances in Space Research, Environments of Planetary Bodies and Shuttle*. Pergamon Press, Oxford, 235 pp.

Brack, A.; J. Oró; A. Schwartz; C.M. Cuchillo (eds.) (1987). *Source Book on European Intensive Course on Origins and Early Evolution of Life*. Universitat Autònoma de Barcelona, Bellaterra, Spain, 164 pp.

Oró, J.; C.M. Cuchillo; E. Querol; R. Segura; P. Suau (eds.) (1988). *Virus, Oncogenes y Cáncer* (3rd International Conference Duran-Reynals, Barcelona) (in Spanish). Publicacions de la Universitat Autònoma de Barcelona, 244 pp.

Oró, J. (ed.) (1989). *Advances in Space Research, Life Sciences and Space Research XXIII* (1). *Exobiology Science and Primitive Solar System Bodies*. Pergamon Press, Oxford, 121 pp.

Oró, J.; J. Miquel (eds.) (1990). *Aerospace Research in Biology and Medicine*. (Proceedings of a Symposium held in Barcelona. Fundació “La Caixa de Barcelona”, Barcelona, 211 pp.



Oró, J.; G. Horneck; J.M. Greenberg; F. Raulin; A.W. Schwartz; K. Dose; E.I. Friedman (eds.) (1992). *Advances in Space Research, Life Sciences and Space Research XXIV* (3). *Planet. Biol. Orig. Life*, vol. 12, No. 4, 288 pp.

Greenberg, J. M.; J. Oró et al (eds.) (1995). *Advances in Space Research, Life Sciences and Space Research XXV* (4). *Planet. Biol. Orig. Life*, vol. 15, No. 3, 452 pp.

Chela-Flores, J.; G. Lemarchand; J. Oró (eds.) (2000). *Astrobiology: Origins from the Big-Bang to Civilization*. (Proceedings of the Iberoamerican School of Astrobiology, Caracas, Venezuela 28 November-8 December, 1999). Kluwer Academic Press, Dordrecht, the Netherlands, 336 pp.

### **3. DOCTORAL THESIS SUPERVISED**

Guidry, Carlton L. (1962). «Thermal Synthesis of Polypeptides in Aqueous Systems», 112 pp.

Kimball, A.P. (1962). «The Synthesis of Adenine and Amino Acids Under Possible Primitive Earth Conditions», 129 pp.

Skewes, H.B. (1966). «High Temperature Initiation of Natural Amino Acid Synthesis», 172 pp.

Nooner D.W. (1966). «Alkanes in Meteorites and Terrestrial Samples», 234 pp.

Tornabene, T.G. (1967). «Distribution and Synthesis of Hydrocarbons and Closely Related Compounds in Micoorganisms». 191 pp.

Gelpi-Montey, E. (1968). «Application of Combined Gas Chromatography-Mass Epectrometry to the Analysis of Organic Products of Biochemical Significance», 589 pp.

Laseter, J.L. (1969). «Distribution and Nature of Surface Wax in Fungal Spores and Mechanisms of Wax Biosynthesis in Brassica Oleracea», 159 pp.

Flory, D.A. (1969). «Stable Carbon Isotope Ratio Measurement of Meteoric Carbonaceous Material», 143 pp.

Nakaparksin, S. (1969). «Separation of Amino Acid Enantiomers by Gas Chromatography on Optically Active Stationary Phases and applications to Organic Geochemistry», 196 pp.

Schneider, H.J. (1969). «Paleobiochemistry of Algae», 130 pp.

Lichtenstein, H.A. (1970). «Amino Acid Enantiomers in biological Systems: Gas Chromatographic-Mass Spectrometric Analyses», 96 pp.

Ibañez, J.D., Jr. (1970). «Prebiotic Condensations of Mononucleotides by Cyanamide and Imidazole», 102 pp.

McReynolds, J.H. (1970). «Synthetic and Analytical Studies in Chemical Evolution», 111 pp.

Gibert-Sabate, J.M. (1971). «Studies in Chemical Evolution. Gas Chromatographic-Mass Spectrometric Determination of Organic and Organogenic Matter in Lunar Samples, Carbonaceous Chondrites and Terrestrial Samples», 124 pp.

Evans, J.E. (1973). «A Gas Chromatographic-Mass Spectrometric and Stable Carbon Isotope Ratio Study of organic Pollution in Clear Lake and its Tributaries», 114 pp.

Gupta, S. K. (1973). «I. Volatilization-Quadrupole Mass Spectrometric Analysis of Apollo 11, 12 and 14 Lunar Samples. II. Search for Organic Compounds in Simulated Lunar and Martian Atmospheres», 129 pp.

Odom, D.G. (1973). «Thin Layer Chromatographic Analysis of Oligonucleotide Mixtures and Prebiotic Condensation of Mononucleotides by AICA and Cyanamide», 89 pp.

Edwards, B.F., Jr. (1973). «Mathematical Models for Quantitative Microprobe Analysis of thin Biological Materials». 105 pp.

Thompson, J.B. (1974). «Studies of 31 Cyanophyta Species: I. Amino Acid Analyses. II. Effects of Irradiation with Cobalt 60», 141 pp.

Hoffman, R.B. (1974). «The Influence of Aging on Brain Fatty Acids and Phospholipids of *Poecilia Formosa* and *Carassius Auratus*», 160 pp.

Joe, H.T. (1975). «Mechanism and Prebiotic Synthesis of Purine and Pyrimidine Deoxyribonucleoside Mono-, Di-, and Triphosphates», 127 pp.

Lovett, A.M. (1975). «Application of the Gas Chromatograph-Mass Spectrometer in the Analysis of: I. The Apollo 16 and 17 Lunar Samples. II. Volatile Compounds in Urine and other Body Fluids of Tumor-Bearing Mice», 137 pp.

Rao, M. (1981). «Studies on Model Systems of Possible Prebiological Significance: Part I. Synthesis of Phosphatidycholine Phosphatidylethanolamine Under Possible Primitive Earth Conditions. Part II. Adsorptive and Catalytic Properties of Clays», 182 pp.

Mar, A. (1987). «Prebiotic Synthesis of Phosphorylated Metabolic Intermediates, including Some Enzymes», 199 pp.

Shen, C. (1988). «Prebiotic Synthesis of Histidine and Histidyl-Histidine Studies of Catalytic Activities of Histidyl-Histidine in Prebiotic Reactions», 175 pp.

Mills, T.M. (1993). «Cosmochemistry and the Origin and Early Evolution of Life», 190 pp.