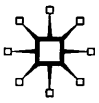
Imagining Outer Space

European Astroculture in the Twentieth Century

Edited by

Alexander C. T. Geppert
Emmy Noether Research Group Director
Freie Universität Berlin

palgrave
macmillan



First published 2012 by
PALGRAVE MACMILLAN

Palgrave Macmillan in the UK is an imprint of Macmillan Publishers Limited, registered in England, company number 785998, of Houndmills, Basingstoke, Hampshire RG21 6XS.

Palgrave Macmillan in the US is a division of St Martin's Press LLC, 175 Fifth Avenue, New York, NY 10010.

Palgrave Macmillan is the global academic imprint of the above companies and has companies and representatives throughout the world.

Palgrave® and Macmillan® are registered trademarks in the United States, the United Kingdom, Europe and other countries.

ISBN 978–0–230–23172–6

This book is printed on paper suitable for recycling and made from fully managed and sustained forest sources. Logging, pulping and manufacturing processes are expected to conform to the environmental regulations of the country of origin.

A catalogue record for this book is available from the British Library.

A catalog record for this book is available from the Library of Congress.

10 9 8 7 6 5 4 3 2 1
21 20 19 18 17 16 15 14 13 12

Printed and bound in Great Britain by
CPI Antony Rowe, Chippenham and Eastbourne

15

Inscribing Scientific Knowledge: Interstellar Communication, NASA's Pioneer Plaque, and Contact with Cultures of the Imagination, 1971–1972

William R. Macauley

> We believe there is a common language that all technical civilizations, no matter how different, must have. That common language is science and mathematics. The laws of Nature are the same everywhere.
>
> Carl Sagan (1980)

> No one has ever observed a fact, a theory or a machine that could survive *outside* of the networks that gave birth to them.
>
> Bruno Latour (1987)[1]

I Space exploration, universal physical laws and communication with extraterrestrial intelligence (CETI)

Space exploration during the late twentieth century began incorporating 'interstellar messages,' primarily in the form of material artifacts and electromagnetic signals, deliberately created by humans and transmitted from earth, in an effort to establish contact with possible extraterrestrial intelligence in distant star systems.[2] Systematic attempts were made by groups of scientists and their associates to detect incoming interstellar messages from extraterrestrials and, more rarely, send messages from earth to technologically advanced civilizations located in astronomically remote planetary systems or traveling through interstellar regions of space. This chapter focuses on a specific interstellar message incorporated on a specially constructed material artifact – NASA's Pioneer plaque – dispatched from earth on board a spacecraft launched in 1972 and 1973 (Figure 15.1).

During the 1970s, American scientists directly involved in research on interstellar communication worked in partnership with engineers, visual artists and others to design messages comprised of representations that were supposed to constitute meaningful and self-explicatory forms of knowledge, considered suitable for initiating communication with extraterrestrials. Interstellar messages carried on physical artifacts such as NASA's Pioneer plaque and Voyager record incorporated science and mathematics primarily in the form of pictures and non-linguistic symbols, explicitly designed to convey factual knowledge about

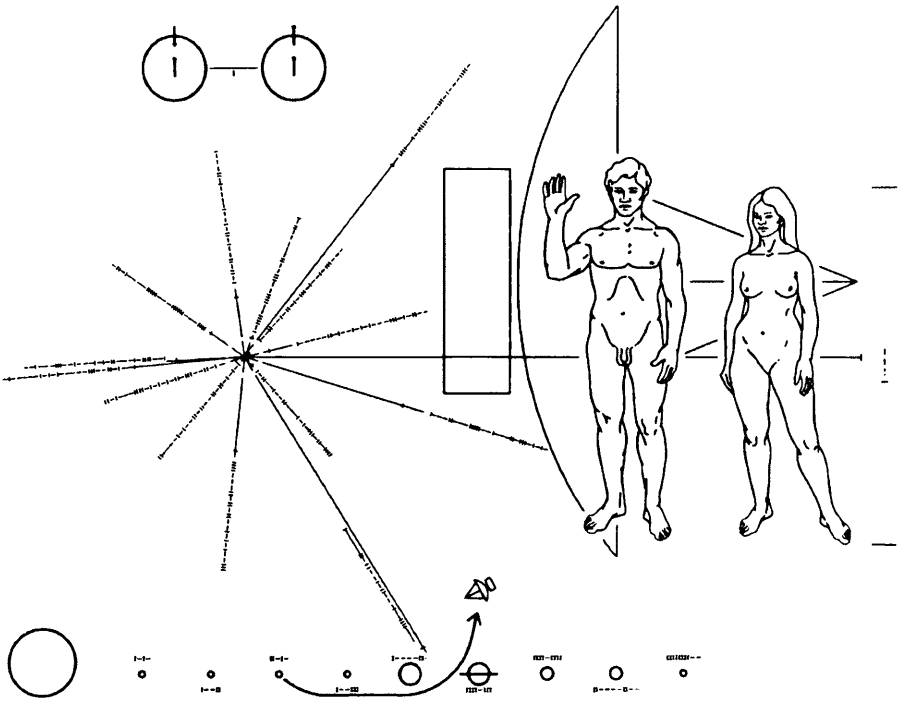


Figure 15.1 Reproduction of the interstellar message inscribed on a 15 × 22.5 cm gold-anodized Pioneer plaque, designed for NASA by Carl Sagan, Linda Salzman Sagan and Frank Drake, 1971–72.

Source: Courtesy of NASA, http://grin.hq.nasa.gov/ABSTRACTS/GPN-2000-001623.html (accessed 1 August 2011).

humankind, the planet we inhabit and physical laws that govern, for example, fundamental properties of matter throughout the entire universe.[3]

The late Carl Sagan (1934–1996), quoted above and widely recognized as one of the principal historical actors responsible for designing NASA's interstellar messages, often claimed that scientific knowledge and mathematics would be comprehensible to all advanced civilizations and thus served as valid indicators of social and technological progress throughout the universe. The physical sciences have conventionally been considered by practitioners to be distinct from other forms of empirical endeavor because scientific observations, theories and predictions are for the most part expressed and communicated in the supposedly objective language of mathematics.[4] Many scientists believe that mathematical relationships and numbers correspond to timeless entities and the essential structure of the physical universe; mathematical expressions that somehow reveal these intrinsic properties will be recognized and easily understood by any technologically advanced life form.[5] In contrast, some historians and sociologists such as Bruno Latour have argued that scientific knowledge, mathematics and universal laws of physics – sometimes referred to as 'the laws of Nature' – are created by human actors rather than discovered and as a result bear the hallmark of

socially embedded and historically contingent factors.[6] Communication of scientific knowledge and meaning using pictures, diagrams and other forms of visual representation across a range of media is a topic that has been studied closely by historians and other scholars in recent years.[7] Previous research on production and application of visual representation in scientific work and discourse has primarily focused on explaining how and why images are employed as expository devices in scientific journals and educational texts to illustrate and support ideas expressed in the customary medium of writing. There are relatively few academic studies on the history of graphical representations designed to communicate scientific knowledge explicitly and independently of printed text or writing systems that require prior knowledge of spoken language.[8]

The notion of *inscription* as both metaphor and material object is a valuable analytical tool for investigating material practices, discourse, cultural artifacts and social networks that are historically embedded and integral in terms of the production, communication and stabilization of scientific knowledge.[9] Metaphors of inscription and related concepts are applied in this chapter as analytical tools, to highlight and critically examine the materiality of scientific work and rhetorical strategies employed by scientists and others responsible for the design of interstellar messages. Semiotic theory is integral to this research on interstellar communication, because it provides a means of incorporating analytical tools and concepts from a range of disciplines. It thus facilitates an analysis of interstellar messages as social objects or artifacts comprised of signs or units of meaning, designed to communicate supposed universal scientific knowledge through a process of signification or semiosis.[10]

Debates within the scientific community, scientific publications and wider public discourse concerning interstellar messages are attendant to contemporary beliefs, anxieties and multiplicity of meanings regarding complex issues such as the impact of technology on society, intelligent life on other worlds, evolution as a universal principle, and the historical contingency of distinctions between human and non-human. Although images featured on NASA's Pioneer plaque and Voyager record were originally designed as objective and universal in terms of form and meaning, they have been reinterpreted and deployed within a diverse range of narratives, media, networks and social groups to draw attention to or (more frequently) elide the reciprocity of human agency and cultures of the imagination. Indeed, the history of interstellar messages includes excellent historical material for analyzing how visual representations of objects, events and relationships are intimately linked to the imagination as a manifestly creative process. Scientific research and interdisciplinary approaches to the design of interstellar messages are associated with imaginative, as opposed to imaginary, solutions to complex problems concerning communication with non-human entities, including the creation of cultural artifacts that encapsulate human knowledge, experience and desires.

The present chapter argues that interstellar messages designed to initiate contact with extraterrestrials are especially significant in historical and cultural terms because during their design, construction and circulation, scientists give explicit reasons to support sweeping claims regarding the ubiquitous authority of science and mathematics. Further, scientists and other historical actors responsible for the

design of interstellar messages such as the Pioneer plaque have employed various forms of discourse and communication media to articulate speculative theories, social agendas and personal beliefs regarding imagined cultures and technologies of the distant future – candid opinions that might otherwise remain tacit or confined within smaller social networks.

II NASA's Pioneer plaque, 1971–72

During the 1970s, NASA launched a series of unmanned spacecraft primarily for exploration of planets and interplanetary scientific experiments on astronomical and astrophysical phenomena within the solar system. A few of these robotic spacecraft, such as Pioneer 10 and 11, were programmed to follow precise flight paths and utilize powerful gravitational forces generated by the outer planets, which propelled them on escape trajectories beyond our solar system, into vast unexplored regions of interstellar space and cruise through the galaxy essentially forever (Plate 8).

This prospect was perceived by scientists, science journalists and others as an unprecedented opportunity to design, create and deploy material artifacts containing messages that were representative of all humankind and conveyed scientific knowledge that could be understood by any intelligent extraterrestrial civilization in distant parts of the galaxy or space-faring descendants of humankind capable of interstellar travel in the remote future.[11] Scientists Frank Drake (1930–), Carl Sagan and visual artist Linda Salzman Sagan (1940–) have frequently been identified in scientific publications, scholarly texts and wider cultural discourse as principal historical actors directly responsible for design and production of an interstellar message, commonly referred to as the 'Pioneer plaque,' comprised of images and symbols etched on a metal plate, which was attached to NASA's Pioneer 10 spacecraft and transported into space in March 1972 (Plate 9 and Figure 15.2).[12] An identical plaque was attached to NASA's Pioneer 11 launched the following year and, like its sister craft, will eventually be accelerated out of our solar system into interstellar space.[13]

Four months before the launch of Pioneer 10, in November 1971, expatriate British science correspondent Eric Burgess (1920–2005) arranged a meeting with Carl Sagan at NASA's Jet Propulsion Laboratory (JPL), near Pasadena. At the time, Sagan was on temporary leave from his academic post as director of the Laboratory of Planetary Studies at Cornell University and engaged as science consultant for NASA on the Mariner 9 mission to Mars. Burgess was aware that Sagan had recently attended an international conference on interstellar communication, held in the former Soviet Union and jointly organized by the National Academies of Sciences in both the United States and Soviet Union. During their discussion, Burgess mentioned that he had recently observed Pioneer F undergoing pre-launch tests and suggested that a plaque should be attached to the spacecraft because it would be the first human-made object to travel beyond the solar system.[14] Sagan agreed and subsequently discussed the idea of an interstellar plaque with Hans Mark (1929–), director of the NASA Ames Research Center, Moffett Field, California, where the Pioneer project was managed. After obtaining Mark's support, Sagan

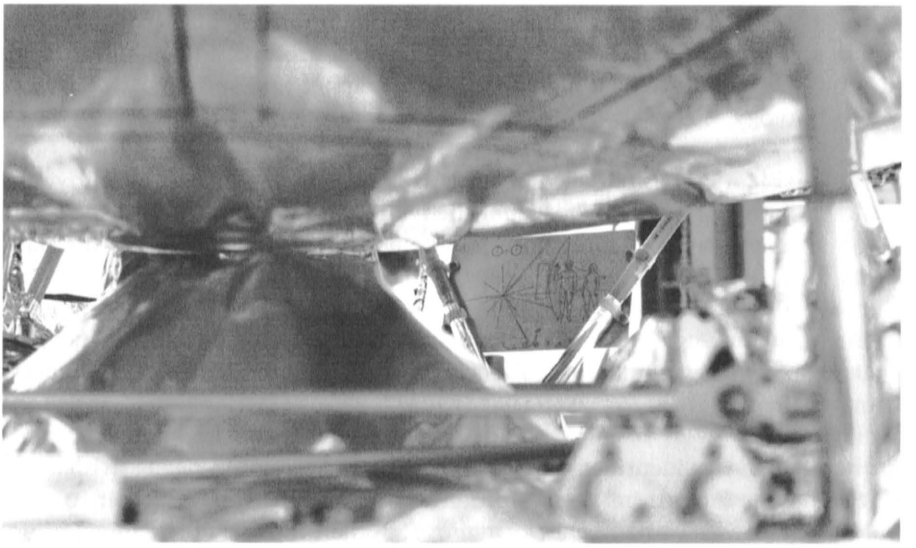


Figure 15.2 Photograph showing the position of the interstellar plaque attached to the Pioneer F spacecraft.
Source: Courtesy of NASA, http://grin.hq.nasa.gov/ABSTRACTS/GPN-2000-001621.html (accessed 1 August 2011).

arranged meetings with senior scientists and managers at NASA Headquarters in Washington, DC, to seek approval for the proposed message.[15]

By December 1971, Carl Sagan had managed to attain authorization from senior staff at NASA Headquarters and Pioneer mission team at NASA Ames for the attachment of a plaque to the Pioneer F spacecraft and was responsible for designing the interstellar message it would carry. Sagan enlisted the assistance of his colleague Frank Drake, radio astronomer at Cornell's Center for Radiophysics and Space Science, and they decided that the message should consist of a series of drawings engraved on a metal plaque. Drake accepted the task of producing a 'pulsar map' that would indicate the source of the Pioneer craft in terms of the location of its planet of origin, relative to a constellation of 14 pulsating stars (pulsars) in the galaxy. Sagan also enlisted the help of his wife, Linda Salzman Sagan, who had experience as a film-maker and previously studied figure drawing, painting and art history at the School of the Museum of Fine Arts in Boston. She agreed to produce line drawings of human figures, an adult female and male, for the Pioneer plaque. Carl Sagan subsequently explained how severe time constraints meant that the message depicted on the plaque was, to some degree, compromised.[16] In January or early February 1972, the artwork and designs for the Pioneer interstellar message were approved by senior NASA administrators at NASA Headquarters, on the recommendation that changes were made to Linda Salzman Sagan's figure drawings.

Pictures and graphical images designed for interstellar messages are produced through iterative techniques that transform natural phenomena into scientific objects or facts that are amenable to manipulation using mathematical operations. Graphical images such as diagrams of astrophysical phenomena and

representational drawings of human figures incorporated on NASA's Pioneer plaque and other interstellar messages are cultural artifacts and manifest forms of knowledge, produced through what ethnographer and sociologist of science and technology Michael Lynch has referred to as 'rendering practices':

> The problem of visibility in science is more than a matter of providing illustrations for publication. Published and unpublished data displays, in the form of graphs, photographs, charts and diagrams, constitute the material form of scientific phenomena. By 'material' I mean sensible, analyzable, measurable, examinable, manipulable and 'intelligible.' Although the procedures for making the object scientifically knowable implicate an independent object, they simultaneously achieve a graphic rendering of the object's materiality.[17]

Further, Lynch has identified specific rendering practices and persuasive graphical techniques such as 'mathematization' that scientists apply in their research and published work to augment or remove visible properties of representations assembled in graphic displays. More specifically, mathematization involves transformation of two-dimensional arrays that contain graphic representations into standardized geometric space, in which natural phenomena are represented as mathematical entities. As such, visual displays in scientific texts are not simply descriptive illustrations; they represent and methodically codify natural objects as inherently mathematical.[18]

III Mapping pulsars and inscribing scientific knowledge

The interstellar message depicted on the Pioneer plaque consists of an assemblage or montage of discrete two-dimensional images and symbols that represent humans, physical objects, and astrophysical phenomena (Figure 15.1). Heterogeneous representational styles and diverse spatial and temporal properties are depicted on the plaque and range in scale from atomic to galactic. Sagan and other scientists claim that comprehension of Pioneer's interstellar message and the intricate interrelationships between the objects that it depicts requires prior scientific knowledge of universal mathematical principles and associated physical phenomena.

The pulsar map featured on the Pioneer plaque consists of a two-dimensional image, as Drake had earlier promised, in the form of a distinctive radial pattern, indicating the sun (at the center of the map) in relation to a constellation of fourteen pulsating stars (pulsars) in the galaxy.[19] In addition, Drake's pulsar map includes temporal attributes in the form of precise numerical values, written in binary notation, for the frequency or period of pulses emitted by each of the 14 selected pulsars, which could potentially be used by recipients of the message to identify the historical epoch in which the Pioneer spacecraft was launched. To facilitate understanding of the physical scales and measurement associated with visual representations featured on the plaque and their referents, the designers

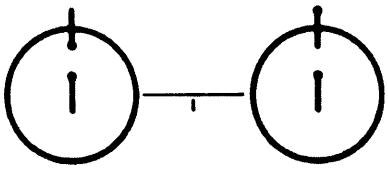


Figure 15.3 Enlargement of schematic diagram on the Pioneer plaque indicating hyperfine transition of neutral atomic hydrogen, 1972.
Source: Adapted from NASA; see Figure 15.1 above.

included a schematic diagram in the top left on the Pioneer plaque (Figure 15.3), which represents the hyperfine transition of neutral atomic hydrogen in order to specify units of length (21 cm) and time (1420 MHz).[20]

It was assumed by the designers that these particular physical properties of neutral hydrogen atoms – emission of a photon with a wavelength of 21 cm and frequency of 1420 MHz – are abundant throughout the universe and easily detected with radio telescopes or equivalent extraterrestrial technologies. Therefore, predictable quantitative values based on astrophysical observations of the hydrogen emission line would necessarily be recognized by extraterrestrial scientists. Sagan explained that 'this fundamental transition of the most abundant atom in the galaxy should be readily recognizable to the physicists of other civilizations.'[21]

The binary digit for '1' is featured as a small vertical line located at the center of the schematic diagram of hydrogen (see Figure 15.3) in accordance with the stated intention to represent the unitary value for distance (21 cm) and time (1420 MHz). Binary digits featured next to other visual representations on the message in order to specify spatial and temporal quantities that are defined as multiples of the quantitative values associated with the emission spectrum of hydrogen atoms. For example, numerical values for the period of each pulsar (all ~0.1 second) on Drake's map are expressed as multiples of 1420 MHz, written in binary notation at the end of each line. The length of 14 solid lines on the radial map specifies the distance of each pulsar from the origin, with an additional line along the horizontal plane indicating the distance from the Pioneer's launch planet (as specified by our home star) to the galactic center.

The image designed by Drake is organized as a map or navigational tool with each line specifying distance from the sun and binary notation providing periodicity of the cosmic emissions using units based on the emission spectrum of hydrogen. Again, Sagan asserted that:

> With this first unit of space or time specified we now consider the radial pattern at left center. This is in fact a polar coordinate representation of the position of some objects about some origin, with this interpretation being a probable, but not certain, initial hypothesis to scientists elsewhere. The two most likely origins in an astronomical interpretation would be the home star of the launch civilization and the center of the galaxy.[22]

The image deployed a combination of mathematics, geometry and artistic conventions of linear perspective to visualize discrete points within a simulated three-dimensional space, inscribed on the two-dimensional flat surface of the plaque. The map is not an image in the sense of a representational picture, but rather a condensation of multiple inscriptions or cascades (for example, printouts from radio telescopes, mathematical models, tables, illustrations) generated by heterogeneous actors, research sites, communication media and inscription devices. The journal article by Sagan, Salzman Sagan and Drake also inscribed the 14 selected pulsars in a different representational format: a series of numerical values presented in a table that explicitly codified these pulsars as abstract mathematical entities. Presentation of precise numerical values in the table was constitutive of scientific knowledge, concerning the mathematical properties of natural objects referred to as pulsars.[23]

Pulsars and photons emitted by neutral hydrogen atoms have never been observed directly; scientific observations and theories depend on scientific instruments and graphical technologies that mediate and transform astrophysical and quantum events into representational forms that are comprehensible and constitutive of factual knowledge. Indeed, it has become a truism in histories of radio astronomy that the serendipitous 'discovery' of pulsars in 1968, by Jocelyn Bell (1943–), a junior researcher at the Mullard Radio Observatory in Cambridge, was achieved by sifting through masses of paper charts that featured pen-trace recordings of signals acquired with a radio telescope, to identify and remove 'noise' (or what was referred to at the time as 'scruff') from observational data.[24] Significantly, graphical representations of pulsar-type objects encompassed a diverse range of formats, styles and communication media. The first published account of 'rapidly pulsating radio sources' by Antony Hewish used coordinate graphs to display distinctive temporal properties of these astronomical phenomena.[25]

The image designed by Drake was not based on direct, unmediated observation of natural phenomena, but rather a visual rendering of a long chain of representational forms or inscriptions that mathematize space and objects within it. Repeated claims by the designers regarding the scientific validity, objectivity and universality of the interstellar message elide artistic techniques and imaginative skills required for the design and production of schematic images. For example, the hydrogen diagram depicts quantum events on an atomic scale and the pulsar map portrays a constellation of astronomical objects separated by light years. Arguably, the referent for Drake's map was the table of numerical values featured in the *Nature* article 'A Message from Earth.'[26] NASA's interstellar messages included vivid examples of ways in which natural objects and categories of experience such as perception of time and space were framed as scientific objects that are, in and of themselves, universally comprehensible because of their underlying mathematical structure. Moreover, the image presents time, space and energy as graphical forms that are easily manipulated using arithmetical and geometric rules.[27]

A similar point can be made regarding the historicity of graphical representations depicting neutral hydrogen emission as featured on the Pioneer plaque and other interstellar messages created during the 1970s. Prior to this, completely

different visual representations of the same quantum event or astrophysical process were devised and circulated as expository devices in scientific publications during the 1960s, suggesting that despite claims regarding the universality of hydrogen emission spectra there is no consistent representational form or scientifically valid method of deciding what is the most appropriate way of depicting this phenomena.[28] Eric Francoeur has made a similar point with regard to 'graphematic condensation' of knowledge and matter in the field of molecular biology:

> There is no such thing as comparing the structural representation of a molecule to the 'real' thing, since it is through representational work that a molecular structure becomes coherently visible. The realm of molecular structures is thus essentially cultural, i.e., coextensive with the means chemists have given themselves to show, talk about, and work with these structures – means which are, *ceteris paribus*, epistemically equivalent while phenomenologically distinct.[29]

There is a contingent historical relationship between inscriptions on NASA's interstellar messages and physical and quantitative properties of atomic hydrogen. Hydrogen emission spectra was predicted during the 1940s in theoretical studies by astrophysicists such as Hendrick van de Hulst (1918–2000) and Iosif Shklovsky (1916–1985), and later confirmed in observational experiments by physicists such as Harold Ewen (1922–), Edward Purcell (1912–1997) and other researchers associated with the nascent field of radio astronomy during the 1950s. The relevance of quantitative and predictable physical properties associated with the 21 cm hydrogen emission line as a suitable medium for interstellar communication was later analyzed and discussed in a 1959 paper by Cornell physicists, Giuseppe Cocconi (1914–2008) and Philip Morrison (1915–2005). Further, Drake himself used the radio telescope at the US National Radio Astronomy Observatory (NRAO) in 1960 to search for interstellar messages from extraterrestrial intelligence within a narrow band that corresponds to the hydrogen emission line. Drake later explained that his selection of this particular narrowband region was primarily determined by practical and situational constraints, which included the need to calibrate and maintain a prototype narrowband receiver to 21 cm wavelength so other radio astronomers at the NRAO could use it to conduct routine observations of astrophysical phenomena.[30]

Two-dimensional schematic representations of the hyperfine transition of hydrogen and pulsars included on the Pioneer plaque and Voyager record were attempts by scientists and their colleagues to visualize physical phenomena that can only be detected using devices such as radio telescopes or functionally equivalent material technologies. Visual representations of the hyperfine transition of neutral hydrogen and Drake's constellation of 14 selected pulsars are effectively a distillation of previous inscriptions, astrophysical theories and mathematical models. These are not pictorial representations of objects that can be perceived with sense organs or universal knowledge expressed in a form that is by design transparent, intelligible and self-sufficient. 'If scientists were looking at nature, at

economies, at stars, at organs, they would not *see* anything,' Bruno Latour has noted: 'Scientists start seeing something once they stop looking at nature and look exclusively and obsessively at prints and flat inscriptions.'[31] Thus, Drake's pulsar map constitutes a practical means of objectifying and mobilizing knowledge claims using graphical techniques. Pulsars were rendered as scientific objects constituted in and through inscriptions that are visible, transportable and have intrinsic mathematical properties. Indeed, the map was designed as a visible record of astronomical objects that conform to universal physical laws, rendering them comprehensible to any technologically advanced civilization.

IV Beyond words: the transformation of human figures

In February 1972, prior to the launch of Pioneer 10, images of the interstellar plaque were widely circulated in scientific journals, newspapers, magazines and other forms of mass media. Frank Drake and Carl Sagan met with journalists and other news producers and described the purpose and meaning of images on the Pioneer plaque. Their motivation to include Linda Salzman Sagan's drawing of a nude man and woman was 'purely scientific' and meant to provide extraterrestrial beings with objective knowledge about humankind such as anatomical differences between male and female and 'diverse racial characteristics.' Lay audiences in the United States and other countries responded in a variety of ways to images of the Pioneer plaque reproduced in newspapers, television and other news media. Mass circulation of the naked figures in national newspapers across the United States and transportation of the plaque into space aboard NASA spacecraft led to public controversy and claims that images engraved on the Pioneer plaque were pornographic, sexist and ethnocentric.[32]

Contemporaneous documents from a number of sources contain contradictory explanations regarding a series of alterations to Linda Salzman Sagan's original drawings of human figures during the design phase and actual production of the Pioneer metal plaque (Figure 15.4), citing a variety of scientific, aesthetic and pragmatic reasons to account for substantive transformation of the original human figures. More specifically, there are conflicting accounts about changes in the delineation of female external genitalia and 'ethnic' facial features in both human figures. Inconsistencies with respect to personal recollections of key actors concerning, precisely, why and how the human figures were altered and lack of correspondence between explanations from different sources are instructive in terms of revealing the political, social and unmistakably material practices associated with the collaborative design of NASA's Pioneer plaque and the history of interstellar messages.

Robert Kraemer, director of Planetary Programs on the Pioneer Project Team, was present at the meeting in January 1972 to approve the designs and artwork for the proposed interstellar message, and recalls being rather apprehensive about the response of senior NASA officials to Salzman's drawings. Two decades later he explained:

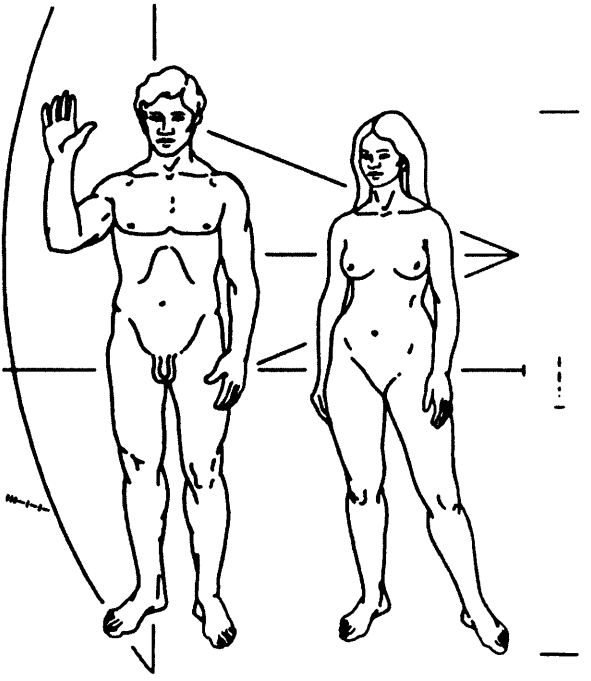


Figure 15.4 Enlargement of detail on the Pioneer plaque showing an illustration of a man and woman, 1972.
Source: Adapted from NASA; see Figure 15.1 above.

> Linda was a skilled artist and her naked human figures were very detailed and realistic, as they needed to be. It seems a bit silly today, but at the time I feared that some taxpayers, the true owners of the spacecraft, might label it as pornographic. My boss, John Naugle, had no such fears and approved the design but with one compromise of erasing a short line indicating the woman's vulva.[33]

As far as Kraemer was concerned, it was only after seeing a cartoon of the plaque in the *Los Angeles Times* a few weeks later that he was able to feel less apprehensive about future public response to the pictorial images on the plaque:

> After seeing that cartoon I relaxed, with increased faith in the common sense of the American public. I learned later that there had been one more alteration of Linda's art work. The public affairs people at Ames, thinking the facial features on her figures too ethnic, neutralized them into a racial mixture.[34]

There is no record of Linda Salzman Sagan's response to NASA's recommendations. Her partner and colleague on the plaque design project, Carl Sagan, was inconsistent with respect to published recollections of this incident. A few weeks prior to the launch of Pioneer 10, Carl Sagan acknowledged that the drawing of

the female figure was altered in accordance with NASA's recommendation: 'Sagan said the space agency accepted the naked couple, but objected to Linda Sagan's original drawing of the woman as being a bit too explicit. "The final version has been toned down considerably," Sagan said.'[35] In a later response to comments by feminists and other critics regarding the apparent lack of female genitalia in the figure drawing featured on the plaque, Carl Sagan implied that NASA officials turned out to be rather more liberal in their views than he had expected and did not recommend any changes to the original artwork. The decision to exclude details from the representation of the female figure on the finished plaque was, he claimed, based on aesthetic principles and misjudgment on the part of the plaque's designers regarding supposed puritanical attitudes among the NASA hierarchy:

> The decision to omit a very short line in this diagram was partly made because conventional representation in Greek statuary omits it. But there was another reason: Our desire to see the message successfully launched on Pioneer 10. In retrospect, we may have judged NASA's scientific-political hierarchy as more puritanical than it is. In the many discussions that I held with such officials, up to the Administrator of the National Aeronautics and Space Administration and the President's Science Advisor, not one Victorian demurer was ever voiced; and a great deal of helpful encouragement was given.[36]

Official NASA documents and reports by NASA Ames contractors, such as the Bendix Corporation, constitute additional sources of expository narratives concerning the collaborative design and production of the human figures that were physically engraved, along with all the other components of the interstellar message, on the Pioneer plaque. These documents often describe the figure drawings and other visual representations on the plaque by employing technical language and an impersonal mode of description, which overlook the social origins and conditional basis of the pictorial representations and scientific facts inscribed on Pioneer's interstellar message:

> On the plaque a man and a woman stand before an outline of the spacecraft. The man's hand is raised in a gesture of good will. The physical make up of the man and woman are determined from the results of computerized analysis of the average person in our civilization.[37]

Such a textual description suggests that a supposedly generic representation of human physical attributes of an 'average' man and woman depicted on the plaque have been obtained by technological means. Although the document identified the historical actors responsible for the design of the plaque, the description of technological means or inscription devices used to render the human figures do not refer to human operators or agents responsible for their design. The implication is that computerized analysis of quantitative data concerning human physical attributes is sufficient for the construction of an authentic visual representation of humans, supporting attendant claims that the Pioneer interstellar message is

fundamentally representative of all mankind; nevertheless, concessions mean it is not.[38]

Technology in the form of inscription devices and graphical techniques is highlighted in other contemporary explanations of how hair and facial characteristics of both the figures featured on the plaque are deliberately comprised of composite anatomical features, believed to be typical of different 'races' in order to create 'de-ethnicized' or, according to Kraemer, 'neutralized,' rendering of the human face. The design and reproduction of these composite details as material visual representations was considered necessary and appropriate for inclusion on the interstellar message contained on the Pioneer plaque, routinely characterized by Carl Sagan and others as representative of all 'mankind.' However, the carefully prepared and collaboratively produced 'panracial' human figures etched onto the 15 by 22.5 cm gold-anodized aluminium plate did not appear as the designers had intended:

> In the original sketches from which the engravings were made, we made a conscious attempt to have the man and woman panracial. The woman was given epicanthian folds and in other ways a partially Asian appearance. The man was given a broad nose, thick lips, and a short 'Afro' haircut. Caucasian features were also present in both. We had hoped to include at least three of the major races of mankind [...]. Somewhere in the transcription from the original sketch drawing to the final engraving the Afro was transmuted into a very non-African Mediterranean-curly haircut.[39]

The juxtaposition of contradictory accounts concerning transformations to the human figures depicted on the plaque are specific examples in which scientific practice and public discourse, ranging from technical documents to news media, purport to provide objective descriptions of the Pioneer interstellar message. Nevertheless, these accounts incorporated speculative theories, rhetorical statements and the personal opinions of scientists and other historical actors. Modification of Linda Salzman Sagan's drawings are literally illustrative of material ways in which artistic or subjective description of, in this case, the human body were altered by omission of visual details and converted through numerical analysis to produce and simultaneously validate what purports to be an objective visual representation of an 'average person.' In short, the narrative accounts described above reveal heterogeneous social processes, inscription technologies and rhetorical strategies for acquisition, production and circulation of a scientifically valid representation or 'fact' regarding human anatomical features considered appropriate for interstellar communication.

Similar rhetorical strategies and application of contemporary inscription devices have been studied by historians Lorraine Daston and Peter Galison in their research on the interplay between social discourse and material aspects of objectivity, encapsulated in scientific atlases from the late nineteenth and early twentieth century. Moral imperatives and mechanical methods were used by scientists during the period to characterize images (reproductions of drawings and photographs, for example) as definitive and objective representations of nature. Similarly, the

human figures created for NASA's Pioneer plaque constitute essentialized representations comprised of carefully selected composite visual elements such as facial features, which render 'race' as an essential category or underlying type that can be discerned with the naked eye and incorporated in naturalistic visual representations of the human body that maintain objectivity or 'truth to nature.'[40]

Although the Pioneer plaque was primarily designed as a material artifact for carrying an interstellar message to extraterrestrials in remote star systems, images and written descriptions of the plaque have nevertheless been widely discussed and circulated in scientific texts and news media. The Pioneer interstellar message has been used in a variety ways as an expository tool and repository of universal scientific knowledge, for example, that relies exclusively on visual representations and mathematical symbols to communicate knowledge and meaning. However, a series of transformations applied to Linda Salzman Sagan's figure drawings and repeated claims regarding the correspondence between pictures on the plaque and intrinsic mathematical properties of the physical universe also served a rhetorical function. The interstellar message created for the Pioneer plaque was simultaneously constitutive of scientific practices and the scientific objects it was supposed to render visible.

V Interstellar messages, scientific facts and cultures of the imagination

The history of interstellar communication shows that inscriptions of scientific knowledge and mathematics are produced in and through socially embedded practices and subject to contestation, revision, and transformation. Debates surrounding the Pioneer plaque reveal assumptions held by scientists and co-workers concerning the ubiquity of mathematics and legibility of knowledge rendered as two-dimensional visual representations. Interstellar messages are a manifestation of concerted efforts to administer knowledge and demarcate fact from fiction.

Whilst interstellar communication can be regarded as a niche field or diversion from conventional topics of scientific research, networks, graphical technologies, inscription practices and craft skills applied in the creation of images for interstellar messages are significant components in the production and dissemination of scientific knowledge more generally. Interstellar messages are the product of heterogeneous material practices, discursive forms and imaginative approaches to constructing pictures and mathematical symbols that constitute a reference standard regarded as sufficient for specifying fundamental properties of the universe, humankind and the planet we inhabit as objects of scientific study.

Carl Sagan and others involved in the design of NASA's Pioneer plaque decided to construct an array of images that conveyed scientific facts and objective knowledge, whilst rejecting what they believed to be purely subjective, superficial and parochial expressions of human culture such as language, religious icons and national symbols. Further, interstellar messages designed to initiate contact with extraterrestrials are meant to define and communicate scientific knowledge about fundamental physical properties that apply everywhere in the universe without

losing sight of what makes us human. The tension between notions of universal and particular properties is a complex and difficult problem in science as well as other spheres of cultural activity. The history of interstellar messages affords opportunities for critical analysis of the interplay between embodied skills, inscription technologies and human agency in the production of scientific knowledge and the rendering of space exploration as both conceivable and manifest endeavors. Interstellar messages demonstrate how the desire for contact with cultures of the imagination resists categorical distinctions between fact and fiction.

Notes

1. Carl Sagan, *Cosmos: The Story of Cosmic Evolution, Science and Civilisation*, London: Abacus, 1980, 325; Bruno Latour, *Science in Action: How to Follow Scientists and Engineers Through Society*, Cambridge, MA: Harvard University Press, 1987, 248 (emphasis in original). I am grateful to my PhD supervisor, David Kirby, for his constant encouragement and astute observations on earlier versions of this chapter. I would like to thank April Gage, Glenn Bugos and Jack Boyd at the NASA Ames History Office for their hospitality and advice on archival issues. I also wish to thank Hans Mark and Linda Salzman Sagan for their valuable assistance and points of clarification, and Mike Lynch and Alexander Geppert for their support and helpful comments on an earlier version of this chapter.
2. See the collected papers in Carl Sagan, ed., *Communication with Extraterrestrial Intelligence (CETI)*, Cambridge, MA: MIT Press, 1973; Cyril Ponnamperuma and Alastair G. W. Cameron, eds, *Interstellar Communication: Scientific Perspectives*, Boston, MA: Houghton Mifflin, 1974; and Philip Morrison, John Billingham and John Wolfe, eds, *The Search for Extraterrestrial Intelligence (SETI)*, Washington, DC: NASA, 1977, which feature contemporary theories on interstellar messages and specific applications of the term.
3. The most frequently cited texts on the Pioneer plaque and Voyager record are Carl Sagan, Linda Salzman Sagan and Frank Drake, 'A Message from Earth,' *Science* 175.4024 (25 February 1972), 881–4; and Carl Sagan, F. D. Drake, Ann Druyan, Timothy Ferris, Jon Lomberg and Linda Salzman Sagan, *Murmurs of Earth: The Voyager Interstellar Record*, New York: Random House, 1978.
4. See John Heilbron, *The Dilemmas of an Upright Man: Max Planck as Spokesman for German Science*, Berkeley: University of California Press, 1986, 50–4, regarding Max Planck's 'universal constants'; Frank Drake's description of 'quantum laws' in Frank Drake and Dava Sobel, *Is Anyone Out There? The Scientific Search for Extraterrestrial Intelligence*, London: Simon & Schuster, 1997, 178; and Carl Sagan's description of 'the laws of Nature' in Sagan, *Cosmos*, 325.
5. On the alleged universality of science, mathematics and physical laws incorporated in theories and empirical research on interstellar communication, see, for example, Giuseppe Cocconi and Philip Morrison, 'Searching for Interstellar Communications,' *Nature* 184.4690 (19 September 1959), 844–6; Frank Drake, 'How Can We Detect Radio Transmissions from Distant Planetary Systems?' [1959], in Alastair G. W. Cameron, ed., *Interstellar Communication: A Collection of Reprints and Original Contributions*, New York: W. A. Benjamin, 1963, 165–75; Frank D. Drake, *Intelligent Life in Space*, New York: Macmillan, 1963, 110; Iosif S. Shklovsky and Carl Sagan, *Intelligent Life in the Universe*, San Francisco, CA: Holden Day, 1966, 388; Carl Sagan, *The Cosmic Connection: An Extraterrestrial Perspective*, New York: Doubleday, 1973, 18–20, 30; Carl Sagan, 'For Future Times and Beings,' in Sagan, Drake, Druyan, Ferris, Lomberg and Salzman Sagan, *Murmurs*, 1–43, here 13–14; and Bernard M. Oliver, 'The Rationale for a Preferred Frequency Band,' in Morrison, Billingham and Wolf, *SETI*, 63–73. For arguments against

the assumption that physical laws are universal, see transcript of discussion between the scientists Francis Crick, Thomas Gold and Vitaly Ginzburg at a conference workshop on communication with extraterrestrial intelligence (CETI) reported in Sagan, *CETI*, 204–6, for example. Ideas and claims concerning putative 'alien mathematics' are critically examined in David Ruelle, 'Conversations on Mathematics with a Visitor from Outer Space,' in Vladimir Arnold, Michael Atiyah, Peter Lax and Barry Mazur, eds, *Mathematics: Frontiers and Perspectives*, Providence, RI: American Mathematical Society, 2000, 251–9; and Edward Regis, ed., *Extraterrestrials: Science and Alien Intelligence*, Cambridge: Cambridge University Press, 1985.

6. For historical research and sociological studies in this area, see Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 2nd edn, Chicago, IL: University of Chicago Press, 1970; Martin J. S. Rudwick, 'The Emergence of a Visual Language for Geological Science, 1760–1840,' *History of Science* 14.3 (September 1976), 149–95; Bruno Latour and Steve Woolgar, *Laboratory Life: The Construction of Scientific Facts*, Princeton, NJ: Princeton University Press, 1986; Harold Garfinkel, Michael Lynch and Edward Livingston, 'The Work of a Discovering Science Construed with Materials from the Optically Discovered Pulsar,' *Philosophy of the Social Sciences* 11.2 (June 1981), 131–58; Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle and the Experimental Life*, Princeton, NJ: Princeton University Press, 1985; Michael Lynch, 'Discipline and the Material Form of Images: An Analysis of Scientific Visibility,' *Social Studies of Science* 15.1 (February 1985), 37–66; Wiebe Bijker, Thomas Hughes and Trevor Pinch, eds, *The Social Construction of Technological Systems*, Cambridge, MA: MIT Press, 1987; Michael Lynch and Steve Woolgar, eds, *Representation in Scientific Practice*, Cambridge, MA: MIT Press, 1968; Theodore M. Porter, *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life*, Princeton, NJ: Princeton University Press, 1995; and Timothy Lenoir, ed., *Inscribing Science: Scientific Texts and the Materiality of Communication*, Stanford, CA: Stanford University Press, 1998. See also Steven Shapin, 'Pump and Circumstance: Robert Boyle's Literary Technology,' *Social Studies of Science* 14.4 (November 1984), 481–520; and Shapin and Schaffer, *Leviathan*, on the importance of social, material and literary technologies in seventeenth-century scientific practice and historical contingency of scientific facts.
7. See Grant Malcolm, ed., *Multidisciplinary Approaches to Representation and Interpretation*, Amsterdam: Elsevier, 2004; Brian S. Baigrie, ed., *Picturing Knowledge: Historical and Philosophical Problems Concerning the Use of Art in Science*, Toronto: University of Toronto Press, 1996; Gillian Rose, *Visual Methodologies*, London: Sage, 2001; David A. Kirby, 'Science Consultants, Fictional Films, and Scientific Practice,' *Social Studies of Science* 33.2 (April 2003), 231–68; and Edward R. Tufte, *The Visual Display of Quantitative Information*, 2nd edn, Cheshire: Graphics Press, 2001.
8. See Shapin and Schaffer, *Leviathan*; Lynch and Woolgar, *Representation*; Darin J. Arsenault, Laurence D. Smith and Edith A. Beauchamp, 'Visual Inscriptions in the Scientific Hierarchy,' *Science Communication* 27.3 (March 2006), 376–428; and Eric Francoeur, 'Beyond Dematerialization and Inscription: Does the Materiality of Molecular Models Really Matter?,' *HYLE: International Journal for Philosophy of Chemistry* 6.1 (March 2000), 63–84; available at http://www.hyle.org/journal/issues/6/francoe.htm (accessed 7 August 2011). On the history of non-linguistic interstellar messages, see Douglas A. Vakoch, 'The Conventionality of Pictorial Representation in Interstellar Messages,' *Acta Astronautica* 46.10 (June 2000), 733–6.
9. See Jacques Derrida, *Of Grammatology*, Baltimore, MD: Johns Hopkins University Press, 1974, and *Archive Fever: A Freudian Impression*, Chicago, IL: University of Chicago Press, 1995; Timothy Lenoir, 'Inscription Practices and Materialites of Communication,' in Lenoir, *Inscribing Science*, 1–19; Latour and Woolgar, *Laboratory Life*, 45–53; and Wolff-Michael Roth and Michelle K. McGinn, 'Inscriptions: Toward a Theory of Representing as Social Practice,' *Review of Educational Research* 68.1 (Spring 1998), 35–59.

10. For further discussion of semiotics and semiosis, see James Hoopes, ed., *Pierce on Signs: Writings on Semiotic*, Chapel Hill: University of North Carolina Press, 1991; Roland Barthes, *Image Music Text*, London: Fontana, 1977; Charles Morris, *Signification and Significance*, Cambridge, MA: MIT Press, 1964; Roman Jakobson, *The Framework of Language*, Ann Arbor, MI: University of Michigan, 1980; Mieke Bal and Norman Bryson, 'Semiotics in Art History,' *The Art Bulletin* 73.2 (June 1991), 174–208; and Francoise Bastide, 'The Iconography of Scientific Texts: Principles of Analysis,' in Lynch and Woolgar, *Representation*, 187–230.
11. See Thomas O'Toole, 'Pioneer F Bears a Hello to Space Aliens,' *Washington Post* (25 February 1972), 1; Richard O. Fimmel, William Swindell and Eric Burgess, *Pioneer Odyssey*, Washington, DC: NASA, 1977, available at http://history.nasa.gov/SP-349/sp349.htm (accessed 7 August 2011); Richard O. Fimmel, James Van Allen and Eric Burgess, *Pioneer: First to Jupiter, Saturn and Beyond*, Washington, DC: NASA, 1980; and Kevin J. Kilburn, *Eric Burgess: Manchester's First Rocket Man*, http://www.mikeoates.org/astro-history/burgess.htm (accessed 7 August 2011).
12. See, for instance, Steven J. Dick, *The Biological Universe: The Twentieth-Century Extraterrestrial Life Debate and the Limits of Science*, Cambridge: Cambridge University Press, 1996; Robert S. Kraemer, *Beyond the Moon: A Golden Age of Planetary Exploration, 1971–1978*, Washington, DC: Smithsonian Institution Press, 2000; George Basalla, *Civilized Life in the Universe: Scientists on Intelligent Extraterrestrials*, Oxford: Oxford University Press, 2006; Mark Wolverton, *The Depths of Space: The Story of the Pioneer Probes*, Washington, DC: Joseph Henry Press, 2004; and Gregory L. Matloff, *Deep Space Probes*, 2nd edn, New York: Springer Praxis, 2005.
13. Pioneer 10 was launched from the Kennedy Space Center aka KSC or Cape Canaveral, Florida on 2 March 1972. For further details regarding the chronology of NASA's Pioneer 10 and 11 spacecraft, see, for example, Mark Wade, *Encyclopedia Astronautica*, http://www.astronautix.com/craft/pior1011.htm (accessed 7 August 2011); and NASA's National Space Science Data Centre (NSSDC), at their website, http://nssdc.gsfc.nasa.gov (accessed 7 August 2011). For a chronology of NASA's Pioneer program of unmanned spacecraft and other US and Soviet deep-space missions during the late twentieth century, see Asif A. Siddiqi, *A Chronology of Deep Space and Planetary Probes 1958–2000*, Washington, DC: NASA, 2002. Individual NASA spacecraft are customarily designated by letter prior to launch and number afterwards; see Kraemer, *Beyond the Moon*, 62. Consequently, references to Pioneer F and G (aka Pioneer 10 and 11) spacecraft can be found in a wide range of documentary material. Further details on the names associated with Pioneer and other deep-space missions in the 1970s are available in official NASA documentation, such as Helen T. Wells, Susan H. Whiteley and Carrie E. Karegeannes, *Origins of NASA Names*, Washington, DC: NASA, 1976; available at http://history.nasa.gov/SP-4402/SP-4402.htm (accessed 7 August 2011). Also, see the compilation of NASA mission reports and other archive material in Robert Godwin and Steve Whitfield, eds, *Deep Space: The NASA Mission Reports*, Ontario: Apogee, 2005.
14. Eric Burgess was a science writer and correspondent for the *Christian Science Monitor*. Before moving to the United States with his family in 1956, Burgess was a keen proponent of spaceflight and worked closely with Arthur C. Clarke and others to reorganize the British Interplanetary Society during the postwar years. For a description of the CETI conference held at the Byurakan Astrophysical Observatory in the former Soviet Union, see 'First Soviet-American Conference on Communication with Extraterrestrial Intelligence (CETI),' *Icarus* 16.2 (April 1972), 412–14; and Sagan, *CETI*.
15. Hans M. Mark, telephone interview with William R. Macauley, 12 November 2008.
16. Sagan, *Cosmic Connection*, 18. Linda Salzman Sagan studied art at the Boston Museum School of Fine Arts while attending a joint academic program for fine art students at Tufts University, near Boston. In June 1968, she graduated from Tufts with a BSc degree in Art Education and interrupted her postgraduate studies to move to Ithaca, New York,

with Carl Sagan whom she had married on 6 April 1968. During the early 1970s, Linda Salzman Sagan also produced artwork to illustrate a book written by Carl Sagan, and she is one of the principal actors responsible for another interstellar message, NASA's Voyager record, which was designed and created in 1976–77. See drawing of constellation in Sagan, *Cosmic Connection*, 13; and Linda Salzman Sagan, 'A Voyager's Greetings,' in Sagan, Drake, Druyan, Ferris, Lomberg and Salzman Sagan, *Murmurs*, 123–47. Linda Salzman Sagan email message to William R. Macauley, 27 June 2009.

17. Lynch, 'Discipline,' 43.
18. See Michael Lynch, 'The Externalized Retina: Selection and Mathematization in the Visual Documentation of Objects in the Life Sciences,' in Lynch and Woolgar, *Representation*, 153–86.
19. Drake's pulsar map is featured on the Pioneer plaque and on two parts of Voyager's interstellar message – the protective cover and in a picture encoded as a binary signal on the Voyager record. See Sagan 'For Future Times and Beings,' in Sagan, Drake, Druyan, Ferris, Lomberg and Salzman Sagan, *Murmurs*, 1–43.
20. The time interval for hydrogen emission is usually specified in terms of radio frequency (1420 MHz), which is the reciprocal value of a wave period or fraction of time equivalent to less than a billionth of a second. According to the designers of the Pioneer plaque, the precise value for the wave period of neutral hydrogen and the unit of time inscribed on the plaque is $(1.420405752 \times 10^9\,\mathrm{sec}^{-1})^{-1}$; see Sagan, Salzman Sagan and Drake, 'Message,' 882.
21. Ibid., 881.
22. Ibid.
23. Ibid., Table 1, 882.
24. For a short period the 'scruff' was also jokingly referred to as 'LGM-1' (little green men) by Bell and her colleagues. See footnote in Drake and Sobel, *Anybody*, 88. Interestingly, the only recorded instance of a candidate signal transmitted by extraterrestrial intelligence also refers to anomalies discerned in raw data of narrowband radio emissions printed out as matrices of numbers. The incident is widely reported in histories of SETI and described as the 'wow signal' because the scientist, Jerry Ehman, who made the initial observation in 1977, scribbled the word 'Wow!' on the paper printout at Ohio State University Radio Observatory.
25. See Figures 1 and 2 in A. J. Hewish, S. J. Bell, J. D. H. Pilkington, P. F. Scott, and R. A. Collins, 'Observation of a Rapidly Pulsating Radio Source,' *Nature* 217 (24 February 1968), 709–13, here 710–11.
26. Sagan, Salzman Sagan and Drake, 'Message,' 882.
27. For example, the relative position of each pulsar is indicated by a radial line, using polar representations; these coordinates can be translated into a Cartesian coordinate system.
28. See Figure 4 in Edward Purcell, 'Radioastronomy and Communication through Space,' in Cameron, *Interstellar Communication*, 125.
29. Francoeur, *'Beyond Dematerialisation,'* unpaginated. See also Jane S. Richardson, David C. Richardson, Neil B. Tweedy, Kimberly M. Gernert, Thomas P. Quinn, Michael H. Hecht, Bruce W. Erikson, Yibing Yan, Robert D. McClain, Mary E. Donlan and Mark C. Surles, 'Looking at Proteins: Representations, Folding, Packing, and Design,' *Biophysical Journal* 63.5 (November 1992), 1185–209.
30. Cocconi and Morrison, 'Searching,' 845; and Frank D. Drake, 'Project Ozma' [1962], in Cameron, *Interstellar Communication*, 176–7. See Frank D. Drake interview by David W. Swift, June 1981, Ithaca, NY, in David W. Swift, *SETI Pioneers: Scientists Talk About Their Search for Extraterrestrial Intelligence*, Tucson: University of Arizona Press, 1990, 54–85, 61–2.
31. Bruno Latour, 'Drawing Things Together,' in Lynch and Woolgar, *Representation*, 19–68, here 39.
32. Sagan, *Cosmic Connection*, 24–32; Wolverton, *Depths of Space*, 71–83.

33. Kraemer, *Beyond the Moon*, 75.
34. Ibid., 76.
35. O'Toole, 'Pioneer F,' 1.
36. Sagan, *Cosmic Connection*, 24.
37. NASA Ames History Office, NASA Ames Research Center, Moffett Field, California. PP03.02, Robert W. Jackson Collection, 3:69. *Pioneer to Jupiter: Second Exploration*, Palo Alto, CA: Bendix Field Engineering Corporation, November 1974, 29.
38. Sagan, Salzman Sagan and Drake, 'Message,' 883.
39. Sagan, *Cosmic Connection*, 26–7.
40. Lorraine Daston and Peter Galison, 'The Image of Objectivity,' *Representations* 40 (Fall 1992), 81–128; see also Lorraine Daston and Peter Galison, *Objectivity*, New York: Zone Books, 2007.

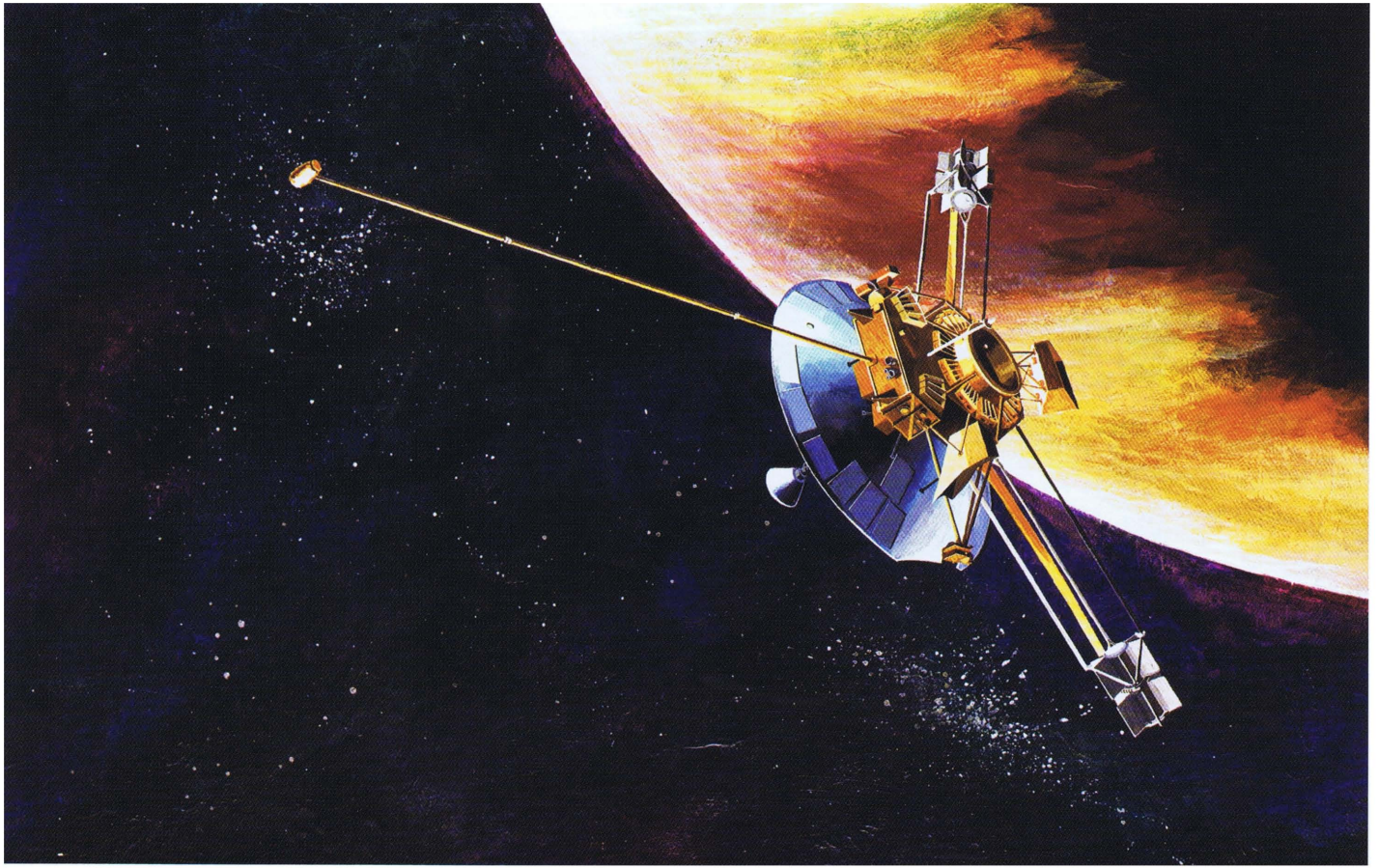


Plate 8 Artist's impression of NASA's Pioneer F spacecraft during its Jupiter flyby.
Source: Courtesy of NASA Ames Center, Public Affairs Office, http://www.nasa.gov/centers/ames/images/content/72401main_AC72-1281.jpg (accessed 1 August 2011).

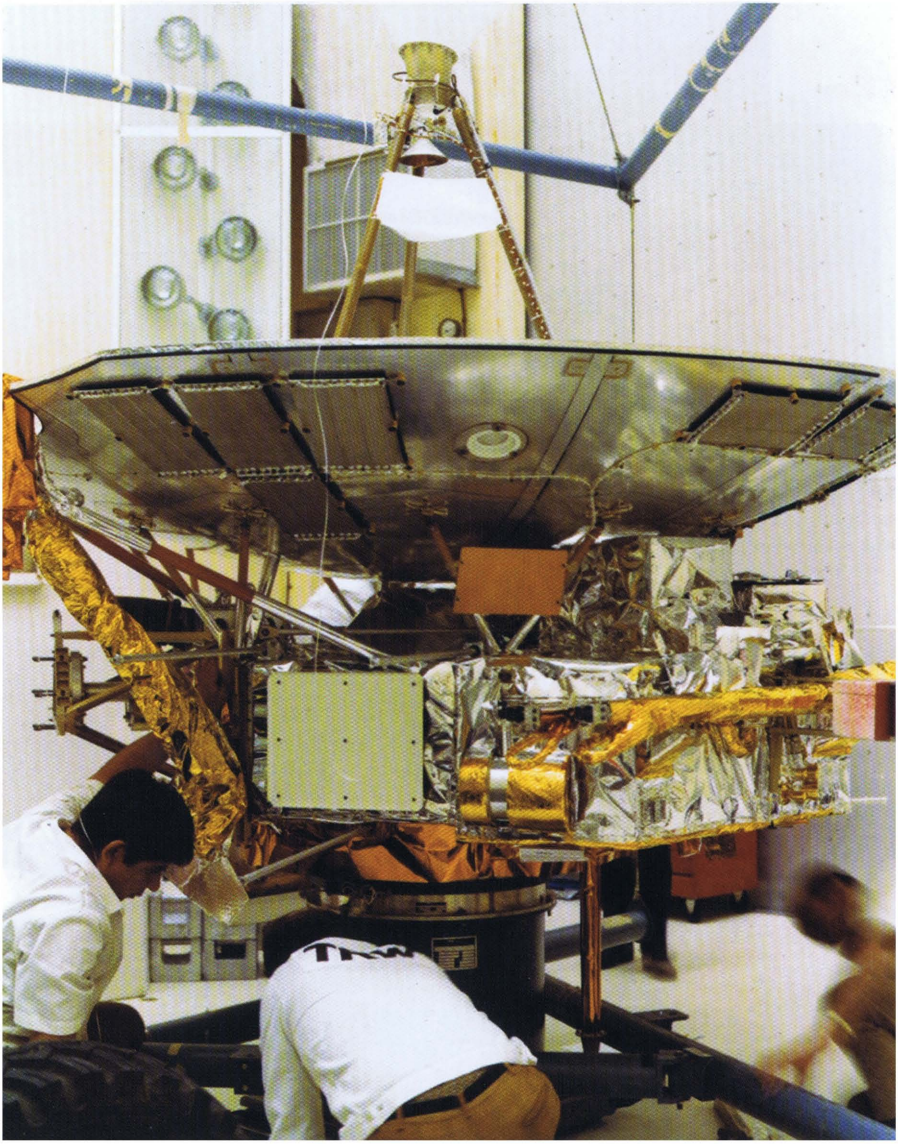


Plate 9 Photograph of the Pioneer F spacecraft at NASA's Kennedy Space Center, February 1972, with plaque attached to struts, shown at center of photograph. The plaque surface containing inscriptions of images and symbols that comprise the interstellar message is faced inwards towards the center-line of the dish antenna to avoid erosion during its journey through interstellar space.

Source: Courtesy of NASA Ames History Office, Research Center. Moffett Field, California. AFS8100.15A, Pioneer Project Records, 1952–96, 5:1. NASA ARC Photograph A-72–1861.