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UNORTHODOX SCIENCE IN THE PUBLIC DOMAIN: A COMMUNICATIONS NETWORK APPROACH

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The exercise of demarcating orthodox from unorthodox science reveals not what differentiates them, but how difficult it is to determine the boundary between them. Yet boundaries are set by the scientific community: it consistently demarcates "parascience" and "unorthodox science" from their orthodox counterparts. In order to investigate this demarcation I consider the scientific community not as a generator of knowledge, but as a closed communications network within the open communications network of society. This paper looks at the networks of communications of the unorthodox hypothesis on the origin of life in space which was developed by the cosmologist Fred Hoyle. The study suggests that the scientific community demarcates orthodox from unorthodox science by "excommunicating" members: by depriving them of access to the communications network of the scientific community. Once excommunicated from the closed networks of the scientific community, Hoyle used public networks to communicate his unorthodox work. Thus one demarcation between orthodox and unorthodox science is a boundary between communication networks; and because of it, unorthodox science is placed in the public domain.

Unorthodox science and the scientific community

Unusual circumstances reveal how the scientific community functions, because they force it to emphasize and make explicit what constitutes a normal state of affairs. The unusual circumstances considered here are public episodes which involve unorthodox science. These episodes are unusual both because they are public – most science is not – and particularly because they involve what scientists call "unorthodox" science. Sociologists of science have argued that there is little to demarcate orthodox from unorthodox science. They have demonstrated that methodologically, technically and rhetorically, these two forms of science cannot be distinguished on any of the criteria which scientists claim define the exclusive

realm of science.[1] What is important for this study, however, is that scientists do make distinctions – real distinctions – between orthodox and unorthodox science.

The scientific community defines science by setting boundaries to include what it defines as science and to exclude what it defines as "not science".[2] This "boundary work" is the active process by which scientists delimit their profession and their professional knowledge. They mobilise idealized descriptions of science which define controversy as abnormal and consensus as normal, and they require dissent to be "organised".[3] Thus science which rouses controversy is abnormal; normality must be restored either by the generation of a new consensus, or by the triumph of the old consensus and the dismissal of the dissenting view.[4] Scientists are often explicit about their stance on this issue.[5]

The distinction scientists make between orthodox and unorthodox science has practical consequences. In a community built on consensus, there are few opportunities for dissidents to make a career, to get funding, or to win any of the distinctions associated with the scientific community. Dissidents tend to be located away from the centres of consensus-building, to be distanced not only

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1. See, for example, Collins, H.M., and Pinch, T.J., 1982, *Frames of Meaning: the Social Construction of Extraordinary Science* (London: Routledge); Collins, H.M., 1985, *Changing Order: Replication and Induction in Scientific Practice* (London: Sage).

2. See, for example, Gieryn, T.F., 1983, Boundary work and the demarcation of science from non-science: strains and interests in professional ideologies of scientists. *American Sociological Review*, 48, 781-795.

3. See, for example, Merton, R.K., 1973, *The Sociology of Science* (Chicago University Press).

4. Kuhn, T.S., 1970, *The Structure of Scientific Revolutions* (2nd ed.) (University of Chicago Press).

5. For example, Arthur N. Strahler, a geologist at Columbia, differentiates between orthodox and unorthodox scientists on 19 counts, ranging from "admits own ignorance" (only orthodox scientists do this) to "is likely to achieve instance celebrity" (orthodox scientists aren't). See Strahler, A. N., 1992, *Understanding Science: an Introduction to Concepts and Issues* (Buffalo, NY: Prometheus), p. 210.

intellectually, but also institutionally, socially and physically;[6] and they tend to publish elsewhere. It is distinctions such as these – distinctions which are also separations – which make the relationship between orthodox and unorthodox science amenable to analysis from the point of view of communications theory. In this context, it is communication which defines a community: a community is a system in which all components are in communication with some or all of the other components.[7] Thus the scientific community (and within it the biochemical community, the astrophysical community, and so on) is defined by communication between its members, and membership of the community is contingent on the sending and receiving of communications. Communication functions as a form of resonance which gives the community unity and cohesion.[8]

Communication between scientists is the mechanism by which scientists achieve consensus, either informally, in meetings and conferences, at lunch and on e-mail,[9] or more formally in peer-reviewed journals and through citation. Communications such as these are essential to the efficiency of the scientific enterprise: according to Barnes, "individual workers are bound together by communications" (separate or

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6. Collins has proposed that a group of scientists who hold a particular paradigm is the social analogue of that paradigm. By analogy, unorthodox scientists are excluded socially from the scientific community in the same way as inconvenient ideas are excluded from scientific consensus. See Collins, H.M., 1981, The place of the "core-set" in modern science: social contingency with methodological propriety in science. *History of Science*, xix, 11.

7. See Luhmann, N., 1984, *Soziale Systeme. Grundriss einer allgemeinen Theorie* (Frankfurt a.M.: Suhrkamp).

8. Luhmann, N., 1990, What is communication? *Communication Theory*, 3, 251-259.

9. The study of only internal scientific publications is insufficient for the purposes of sociological analysis: "cognitive influences are intangible [and so] it is unlikely that the associations between scientists discovered… in bibliographic interconnections will reflect them." Collins, H.M., 1974, The TEA Set: tacit knowledge and scientific networks. *Science Studies*, 4, 167. See also Lewenstein, B., 1994, From fax to facts: communication in the cold fusion saga. Submitted to *Social Studies of Science*.

isolated individuals aren't), and the "standardised procedures" of the scientific community – particularly peer review – ensure that "the effects of [scientists'] weaknesses and eccentricities are minimised".[10] Peer-reviewed publications are particularly compelling in science, says Collins: this is where scientists look for certainties – anomalies and controversies have all been ironed out.[11] Thus peer review is one of the most powerful forms of boundary work; it is also, according to Ziman, "too supportive of orthodoxy… unadventurous, and biassed against novelty."[12] Outsiders, i.e., the unpublished, lack prestige because they lack publications. This further distances them from the community, because to other scientists "association with the less prestigious might render suspect the work of even the serious scientists in the field."[13]

Thus scientists use communication as an exercise in the setting of boundaries; by choosing whom they include or exclude from their communication network, scientists set the boundary between orthodox and unorthodox science. Unorthodox scientists who find themselves "excommunicated" from the scientific communications network may still look for the means to communicate: communication is an essential activity of the professional scientific culture. I suggest that, because of their exclusion from the scientific community, some unorthodox scientists join – by communicating with it – the larger community of the general public. In this way, unorthodox science is placed in the public domain.

A case study: life in space

This paper analyses the networks of communications of the unorthodox hypothesis on the origin of life in space which has been developed by Professor Sir Fred

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10. Barnes, B., 1985, *About Science* (Oxford: Blackwell), p. 39-40.

11. Collins, H.M., 1981, The place of the "core-set" in modern science: social contingency with methodological propriety in science. *History of Science*, xix, 11.

12. Ziman, J., 1993, Peer review: a brief guide to practice. *EASST Newsletter*, 12(3), 23-26.

13. Collins, H.M., 1981, The place of the "core-set" in modern science: social contingency with methodological propriety in science. *History of Science*, xix, 11-12.

Hoyle. Hoyle resigned as Director of the Institute of Theoretical Astronomy of Cambridge University in 1972, aged 56, at the height of a distinguished career as a cosmologist,[14] and after more than twenty years as a prolific and successful populariser of astronomy and writer of science fiction. His ideas about life in space are part of a broader cosmology. Hoyle was a central player in the development of the steady state theory, which lost out to its rival big bang[15] in the 1960s.[16] But Hoyle persists with his model of a dynamic steady-state cosmos in which matter is continually created and destroyed.[17] The universe oscillates, first expanding and then contracting. It is a cyclical universe, replacing lost energy with newly created matter. It "feeds", turning matter into energy, and regenerates itself in endless cycles. Unlike the dissipative, degenerate, violent and essentially physical "big bang" universe, Hoyle's universe is organising, generative, constructive. Hoyle's universe is organic.

What is unorthodox about Hoyle's universe is not just that it is steady-state: it is also awash with organic material, which is deposited on the surface of interstellar dust grains. The organic material is swept up and "processed" in comets: during the comet's flight around the solar system it experiences the range of temperatures needed for the chemical reactions which eventually produce complex biological

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14. Hoyle was Plumian Professor of Astronomy and Experimental Philosophy at Cambridge (1958); Professor of Astronomy at the Royal Institution (1969); vice-president of the Royal Society (1970); and president of the Royal Astronomical Society (1971). By 1972 he was Professor Sir Fred Hoyle FRS; he had 12 honourary degrees and four honourary or visiting chairs.

15. The term "big bang" was coined by Hoyle during a radio broadcast, and meant derisively. See Overbye, D., 1991, *Lonely Hearts of the Cosmos* (New York: Harper Collins).

16. The debate has been described as "a savage feud" and as "one of the most bitter conflicts in the history of astronomy". See Overbye, D., 1991, *Lonely Hearts of the Cosmos* (New York: HarperCollins), p. 40; and Lovell, B., *Emerging Cosmology* (New York: Columbia UP), p. 172.

17. Hoyle is still working on his cosmology – as recently as 1993 he proposed a "quasi-steady-state model" that was published in the prestigious *Astrophysical Journal*.

entities. Life, in this form, fell to Earth from the tail of a passing comet. These biological entities – among them bacteria and viruses – are still arriving on Earth in this way, which accounts for the epidemiology of diseases such as influenza and plague. It also accounts for evolution, which is stimulated and guided by the arrival of genetic material from space.

According to this hypothesis it is just as likely that life also arrived on other planets in the same way. Because the chances of life arising anywhere at all in the universe are vanishingly small, the fact that it has arisen implies that the universe is also home to a superior intelligence. This intelligence is sometimes a being, sometimes a disembodied intelligence or mind, and sometimes the cosmos itself. Thus the universe is a highly complex, highly organised biological system, and this degree of sophistication implies a very ancient universe – one which is considerably older than the big bang theory will allow. Hoyle's hypothesis therefore inhabits a steady state universe.

Communications networks

Hoyle's ideas about life in space have occupied a considerable part of his working life. They have been developed in collaboration with Professor Chandra Wickramasinghe of University College Cardiff, and have appeared in various forms in Hoyle's public and scientific work. I have looked at four media in which these ideas have been presented to different audiences: academic journals in the scientific networks; and newspapers, science fiction novels and non-fiction books in the public networks.

Science fiction novels

Hoyle's ideas about life in space first appeared in his novels. Of a list of 14, here I mention four: Hoyle's first novel *The Black Cloud* (1957); *A for Andromeda* (1962); *The Inferno* (1974) and *Comet Halley* (1985). *The Black Cloud* (1957)[18] is about a cloud of

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18. Hoyle, F., 1957, *The Black Cloud* (London: William Heinemann). The *Daily Telegraph* announced "Science fiction writers receive a highbrow recruit today… Dr Hoyle calls the story a frolic, but not an inconceivable one". *Daily Telegraph*, 16 September 1957, Fred Hoyle's frolic.

organic interstellar grains which blots out the sunlight. The Cloud is intelligent and knows the secrets of the universe, so scientists try to contact it and learn from it. In *A for Andromeda* (1961)[19] a message from outer space turns out to be instructions for building a computer, and the computer creates *in vitro* a person whose job it is to replace feeble Earthlings with a race of superior beings. *The Inferno* (1973) is about a supernova which is going to destroy the Earth, but changes course at the eleventh hour. A scientist studies the tapes from a radiotelescope and finds a coherent signal: he concludes that "an intelligence, a creature, had intervened at their direst moment…".[20] *Comet Halley* appeared in 1985, a few months before the visit of the real Comet Halley. A young scientist registers a coherent signal coming from the comet, has his funding withdrawn, and then is found dead. His boss deciphers the signal, and realises that there is much to be learnt from it. Comet Halley appears to be on a collision course with Earth, but at the last minute it changes course, and a global network of radiotelescopes is built to communicate with it.

Academic papers

Hoyle has published around 500 academic papers, of which around a third contribute in some way to the development of his unorthodox hypothesis about life in space.[21] Interstellar dust grains had been of interest to astronomers for some

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19. Hoyle, F., and Elliot, J., 1962, *A for Andromeda* (London: Souvenir Press).

20. Hoyle, F., and Hoyle, G., 1973, *The Inferno* (London: Heinemann), p. 210. Geoffrey Hoyle is Hoyle's son.

21. See in particular Hoyle, F., and Wickramasinghe, C., 1984, *From Grains to Bacteria* (UCC Press); and Hoyle, F., and Wickramasinghe, N.C., 1962, *Monthly Notices of the Royal Astronomical Society*, 125(5), 417-433; Wickramasinghe, N.C., 1974, *Nature*, 252(5483), 462; See Hoyle, F., and Wickramasinghe, N.C., *Nature*, 269(5630), 674; Hoyle, F., and Wickramasinghe, N.C., *Nature*, 268(5621), 610; 271(5642), 229; Hoyle, F., and Wickramasinghe, N.C., *Astrophysics and Space Science*, 72, 247; Hoyle, F., and Wickramasinghe, N.C., 1976, *Nature*, 264(5581), 45; Hoyle, F., and Wickramasinghe, N.C., 1977, *Nature*, 270(5635),323; Sakata, A., Nakagawa, N., Iguchi, T., Isobe, S., Morimoto, M., Hoyle, F., and Wickramasinghe, N.C., 1977, *Nature*, 266(5599), 241;

time, and the papers of Hoyle and Wickramasinghe between the early 1960s and 1979 show the spectroscopic investigations that transformed the grains from inorganic dust to bacteria breeding in space. Hoyle and Wickramasinghe claim that in 1978 they were beginning to run up against what they called "anti-Copernican opposition", and the "refereed journals, to which a wise scientist touches his or her forelock" stopped considering their papers.[22] Attitudes towards their work changed when the biological aspect became apparent, but Hoyle and Wickramasinghe persisted,[23] even though their funding had dried up.[24]

Academic journals are a clearly defined and exclusive medium, and papers constitute a clearly defined genre. However, in terms of communications networks, there is a fine structure to the academic network which offers clues to a scientist's relationship with his or her community. Two aspects of this fine structure which are relevant here are the journals' readerships, and their relative prestige.

Hoyle has published in a variety of journals throughout his career, and some of the changes in this pattern are interesting in the context of this study.[25] Unorthodox

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Hoyle, F., and Wickramasinghe, N.C., 1979, *Astrophysics and Space Science*, 66, 77-90; Hoyle, F., and Wickramasinghe, N.C., 1979, *Astrophysics and Space Science*, 69, 511.

22. Hoyle, F., and Wickramasinghe, C., 1984, *From Grains to Bacteria* (UCC Press), pp.14, 116-120.

23. Hoyle, F., Wickramasinghe, N.C., Al-Mufti, S., and Olavesen, A.H., 1982, *Astrophysics and Space Science*, 81, 489-92; Hoyle, F., Wickramasinghe, N.C., Al-Mufti, S., Olavesen, A.H., and Wickramasinghe, D.T., 1982, *Astrophysics and Space Science*, 83, 405-9; Hoyle, F., and Wickramasinghe, N.C., 1982, *Astrophysics and Space Science*, 86, 321-29.

24 …even the most modest grant applications [were] thrown back in our faces by S.E.R.C., …one of the outstanding Gilbert-and-Sullivan operettas of the twentieth century… S.E.R.C. [is] a fun organisation which a Government supposedly given to thrift endows with nearly £300 million annually, used it seems to pay an orchestra that exhausts itself with every crescendo." Hoyle, F., and Wickramasinghe, C., 1984, *From Grains to Bacteria* (UCC Press), p. 116, 120.

25. Other changes tell us more about the scientific community (e.g., increasing internationalisation; declining role of learned societies) than they tell us about Hoyle.

science tends to be interdisciplinary, and to present a radical challenge to the paradigm: if it is right, the consequences are far-reaching.[26] The ideal home for interdisciplinary science with far-reaching consequences is *Nature*,[27] and this is where Hoyle's papers were appearing at one stage. *Nature* has a very broad international and interdisciplinary readership, and its prestige is high: it is in the first rank of journals for astronomers. According to Hoyle, he soon found himself unwelcome at *Nature*, and had to go elsewhere. But at a time when he claimed that peer-reviewed journals were refusing his work, his papers were appearing frequently in a peer-reviewed journal: *Astrophysics and Space Science*, a journal of "cosmic chemistry", which is just one of the many small specialised astronomical journals, and one which carries little prestige. Thus Hoyle's hypothesis, while remaining in a single medium, moved from a relatively high prestige interdisciplinary network with a large membership into a relatively low prestige specialist network with a small membership; and this process was achieved by his exclusion from the prestigious network.

Hoyle has never accepted rejection, and continues to fight for space in the scientific networks. As a distinguished scientist with something important to say, he pounds away at *Nature* – or these days gets a friend to do it for him.[28] Hoyle finds *Nature*'s

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[26]. Hoyle knows this: the physics professor in his novel *Comet Halley* says: "By the very nature of an unacceptable hypothesis, its consequences are shattering if it turns out to be true." Hoyle, F., 1985, *Comet Halley* (London: Joseph), p. 155.

[27]. The publication in *Nature* of Jacques Benveniste's theory about "memory" in very dilute solutions is another example. *Nature* created a special section called "Hypothesis" in 1990 in order to accommodate a paper by Hoyle and colleagues on steady state cosmology.

[28]. "[Geoffrey Burbidge] is a tremendous fighter and he's hardly ever had a paper not printed… he has the capacity to terrorise editors of journals by telephoning every day if necessary… secretaries of societies ultimately decide that to print the paper would be the simplest solution… [But] Burbidge has… practically given up the business because he rings *Nature* and the switchboard has been told he can't get through. If he gets Maddox [the editor] he rips into him and Maddox says "yes…, I'll look into it and see what's happened and I'll call you back" – never calls back. So the interesting question is… what is his motivation?… So I encourage

resistance difficult to understand, but what is happening is boundary work: the editor of *Nature* is marking the difference between orthodox and unorthodox science.

Newspapers

Hoyle has appeared in the newspapers frequently throughout his career. His thoughts on more conventional debates about life in space have occupied column inches since 1949,[29] but his unorthodox hypothesis only became a public issue in 1978,[30] when it was reported that Hoyle and Wickramasinghe's application for a grant had been refused. The *Guardian* drew comparisons with Darwin,[31] and *The Times* reported that Hoyle and Wickramasinghe had complained to the Prime Minister.[32] When they announced the results of an epidemiological study, the *Daily Telegraph* said "Bugs from space spread flu, says Fred Hoyle."[33] In the

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Burbidge to keep after him because I'm fascinated by what psychologically is going on in his head." Interview with Fred Hoyle, 11 August 1993.

29. Hoyle, F., 1949, Are there men on other planets? *The Star*, 15 August.

30. This episode followed the publication in *New Scientist* of a feature article by Hoyle and Wickramasinghe. Hoyle, F., and Wickramasinghe, C., 1977, Does epidemic disease come from space? New Scientist, 17 November; and in response Ridley, H.B., 1977, *New Scientist*, 1 December, 593; Hardy, D., 1977, *New Scientist*, 1 December, 593; Penman, J.M., 1977, *New Scientist*, 8 December, 660-661; and the editorial by Dixon, B., 1977, Celestial pathology. *New Scientist*, 17 November, 396.

31. "While Darwin had to face abuse and derision…, Sir Fred and the professor have been met with the ultimate in scientific establishment cold-shoulders – the refusal of a grant by the Scientific Research Council." Fairhall, J., 1978, "Life on comets" comes down to earth. *Guardian*, undated [April].

32. McKie, 1978, Disease from outer space research "obstructed" claim. *The Times*, 14 April.

33. Berry, A., 1978, Bugs from space spread flu, says Fred Hoyle. *Daily Telegraph*, 9 August. See also Berry, A., 1978, Space flu vaccines a problem. *Daily Telegraph*, undated [soon after 9 August].

ensuing debate Hoyle wrote to the *Telegraph*, pointing out that: "Every radically new idea provokes incredulity from the existing establishment; and sometimes the establishment is right and sometimes it isn't.[34] The *Guardian* published a long interview with Hoyle, which concludes with the idea of the cosmic intelligence.[35]

The next public episode began in May 1980, this time triggered by the publication of a pamphlet called *Influenza – a Genetic Virus with the External Trigger*.[36] Coverage and correspondence appeared in several papers.[37] American creationists next brought Hoyle's ideas to the newspapers: in December 1981 he testified in Arkansas in support of a wider range of "creation" theories in the curriculum.[38] In January 1982, *The Times* reported a lecture given by Hoyle.[39] With "a real sense of shock", he "invoked an unknown form of cosmic intelligence, threatened… with cosmic catastrophe, thinking up a new form of life capable of surviving it… and seeding the universe with spores."

Non-fiction books

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34. Hoyle, F., 1978, The invading viruses from space (letter). *Daily Telegraph*, undated [after 21 August].

35. The interviewer asked Hoyle if this idea might discredit him among scientists, and Hoyle was sure that it would, but that he was sure he was right. Coleman, T., 1978, untitled. *Guardian*, 13 September.

36. Hoyle, F., and Wickramasinghe, C., 1980, *Influenza – a Genetic Virus with the External Trigger* (Department of Applied Mathematics and Astronomy, University College Cardiff).

37. See, for example, Berry, A., 1980, Invaders from space "trigger evolution". *Daily Telegraph*, 27 May.

38. Hoyle's account in *The Times* carries two pictures: one of Darwin, and alongside it one of Hoyle. See Hoyle, F., 1981, Will Darwin bite the dust in Little Rock? *The Times*, 7 December.

39. Timmins, N., 1982, Survivors of disaster in an earlier world: evolution according to Hoyle. *The Times*, 13 January. The story was taken up in the *Sunday Times* a few days later: see Silcock, B., 1982, Hoyle's law: Was man's ancestor a spore from outer space? *Sunday Times*, 17 January.

Most recently, Hoyle's unorthodox work has appeared in his non-fiction books. Four serve here to illustrate the development of the hypothesis:[40] *Lifecloud* (1978); *Evolution from Space* (1981); *The Intelligent Universe* (1983); and *Cosmic Life-Force* (1988). The earliest of these, *Lifecloud*, covers subjects ranging from cell biology to intergalactic communication technology. It includes spectra, diagrams, molecular formulae and numerical data. The cover aside, it looks and reads like a scientific textbook.

Evolution from Space (1981) takes a different rhetorical stance: one chapter heading is "The evolutionary record leaks like a sieve". The pictures are more sophisticated than those in *Lifecloud*, and are also prettier: they are more popular than scientific in style. *Evolution from Space* recapitulates *Lifecloud*, but also deals with the cosmic nature of terrestrial evolution, and identifies the cosmic intelligence in the equation "God = universe".[41]

The Intelligent Universe (1983) takes another step away from the lab and towards the coffee-table. It covers the same ground as *Evolution from Space*, but is set in big type and illustrated with colour pictures which emphasise the resonances Hoyle sees in the cosmos. *Cosmic Life-Force* (1988) spends less time on the gritty details than its predecessors, and concludes with a chapter on "The concept of a Creator".

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40. *Lifecloud* (with N. C. Wickramasinghe) (Dent, 1978); *Diseases from Space* (with N. C. Wickramasinghe) (1979); *The Relation of* Biology to Astronomy (UCC Press, 1980); *The Origin of Life* (with N. C. Wickramasinghe) (UCC Press, 1980); *Evolution from Space* (1981); *The Intelligent Universe* (Joseph, 1983); *Living Comets* (UCC Press, 1985); *Space Travellers: Bringers of Life* (UCC Press, 1981); *Archaeopteryx, the Primordial Bird: a Case of Fossil Forgery* (Christopher Davies, 1986); *Viruses from Space and Related Matters* (UCC Press, 1986); *Cosmic Life-force* (with N C Wickramasinghe) (Dent, 1988); *Our Place in the Cosmos* (with N. C. Wickramasinghe) (Dent, 1993).

41. *Evolution from Space* was a trade publication. The same year an almost identical book appeared through an academic publisher, which does not mention God. See Hoyle, F., and Wickramasinghe, C., 1981, *Space Travellers: the Bringers of Life* (University College Cardiff Press).

One reviewer expressed the hope that this would be the last book on the subject,[42] but he was to be disappointed: *Our Place in the Cosmos* retold the story in 1993.[43]

Relating the networks

One important aspect of the relationship between academic and popular science is the role of peer review in giving popularised science its authority: the scientific community expects its members not to popularise work that has yet to pass peer review – and doing so can jeopardise publication in the peer-reviewed literature.[44] One significant feature of the news coverage of Hoyle's hypothesis is that it tends to precede the academic publication, so that information is at large in the public networks before it has received the stamp of authority conferred by its appearance in the scientific networks. Hoyle, the well-known popular scientist, makes news when he applies for a grant, rather than that he has done the work; it is news that he has submitted a paper, rather than that he has published one.[45]

The plots of Hoyle's novels often appear to be directly related to his own experience of the scientific community, and in terms of scientific content they reinforce – and often significantly predate – the ideas in Hoyle and Wickramasinghe's academic papers. The science fiction novel is essentially a public

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42. "We were about due a reappearance of [this] hypothesis… [the] argument's already eccentric trajectory looks set to spin out of worldly orbit… we shall probably never see its like again." Woolley, B., 1988, Orbital dreams. *Guardian*, 22 July.

43. Hoyle, F. and Wickramasinghe, C., 1993, *Our Place in the Cosmos* (London: Dent).

44. See, for example, Nelkin, D., 1987, *Selling Science: How the Press Covers Science and Technology* (New York: Freeman); Hilgartner, S., 1990, The dominant view of popularisation: conceptual problems, political uses. *Social Studies of Science*, 20(3), 519-539.

45. For example, in 1983 Hoyle and Wickramasinghe submitted a paper to *Astrophysics and Space Science* which announced evidence of protein molecules in deep space. The story was reported in *The Times,* and in the *Sunday Times* ten days later. See Wright, P., 1983, New claims over origin of life "between the stars". *The Times*, 8 March; and Tucker, J., 1983, Life in space (cont.). *Sunday Times*, 20 March.

genre, and scientists are often ambivalent about it. While many of them read science fiction, and some claim to have become scientists because of it, others worry about inaccuracies and misrepresentations, as though science fiction was in some required to be "true". But Hoyle claims that other scientists never took much notice of his novels;[46] certainly it appears that ideas that appalled scientists when they appeared in non-fiction books were quite acceptable when they were presented as science fiction. Hoyle's friends recognise how much of Hoyle's own experience is mirrored in his fiction – according to Herman Bondi, "everything you need to know about Fred Hoyle is in *The Black Cloud*"[47] – yet they seem not to have made similar connections between Hoyle's science fiction and his science.

The relationship between science fiction and science is complicated, and all the more so in Hoyle's case because he is a scientist – the relationship between the books which are "science fiction" and the books which are "science" is difficult to pin down. It is also difficult to *see*: to the bookshop browser, Hoyle's fiction and his science look very similar. This complication has not escaped the notice of reviewers. The *Spectator* said of *The Black Cloud* (1957): "one supposes it to be the real, as well as the latest thing. Approximately it is not really fiction… I believe [Hoyle] absolutely when he says it could all happen…".[48] The influence of Hoyle's academic work is clear: the idea of a cloud of interstellar dust coming between the Sun and the Earth and upsetting the weather was the subject of a paper Hoyle had

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46. Hoyle says: "I don't know [whether my colleagues read it], that never worried me because I just wrote it for amusement, so I wasn't really much concerned with what people thought about it… one scientist certainly read it,… that's Wolfgang Pauli. He apparently thought he saw very deep psychological aspects in that book which I never intended, and I ran into him at an international conference in 1957, and he had a dreadful cackle and he was famed for his devastating remarks. And soon as he saw me he said "Ha! Hoyle! I just read your novel, and I thought much more about it than I'd ever thought about your scientific work." Interview with Fred Hoyle, 11 August 1993.

47. Interview with Herman Bondi, August 1990.

48. *Spectator*, quoted on the dust jacket of the first reprint (1957) of *The Black Cloud*..

written twenty years earlier.[49] In *The Black Cloud* though, the dust is organic – an idea which first appeared in his academic work twenty years later. The newspapers asked similar questions about *A for Andromeda* and *in vitro* fertilisation.[50]

Comet Halley, published a few months before the arrival of the real Comet Halley, was in the shops at the same time as the news media were covering the real thing. Hoyle also published a non-fiction book, *Living Comets*, a few months later. The novel's dust jacket makes explicit a connection with the ideas in another of Hoyle's non-fiction books, *The Intelligent Universe*. Thus through the medium of fiction, Hoyle had placed scientific information in the public domain.

The "truth" of Hoyle's science fiction would have been reinforced by his strong public reputation as a teller of true stories. In 1950, he became famous for his hugely successful radio talks in the series "the Nature of the Universe", which launched his career as a popular scientist.[51] It was in this context that the boundary between the public and scientific networks had first been made explicit to him. According to Hoyle, this success in the public networks impeded his access to the internal networks of the scientific community: he suddenly found it very difficult

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49. Hoyle, F., and Lyttleton, R. A., 1939, The effect of interstellar matter on climatic variation. *Proceedings of the Cambridge Philosophical Society*, 35, 405-418.

50. When asked whether *A for Andromeda* was science or fiction, Hoyle said "our science fiction is based on sound scientific fact… I see no reason why we should not keep just that leap ahead". McLeave, H., 1961, Can Fred keep ahead of the test tubes…? Hoyle's TV baby isn't so out of this world as it seems. *Daily Mail*, undated [November].

51. The broadcasts were a huge success, and the book of the series sold 77,000 in the first six months, making it one of the biggest scientific best sellers to date. The *Graphic's* headline announced: "[Hoyle] has been rated by radio listeners as a better broadcaster than anyone else whose popularity has been investigated by the BBC Audience Research Service". See the *Graphic*, 22 November 1950, Fred Hoyle is First, by Walter Hayes.

to publish his work.[52] In terms of academic publications, a flourishing career floundered for two years. Hoyle may well have learnt an early lesson: if you go public you will be excluded from scientific communication networks.[53] Perhaps he was later applying this principle in reverse: if you are excluded, go public.

While scientific communications networks exclude the public, public communications networks include the scientific community: scientists are, after all, members of the public. So public science is not secret from scientists in the same way as academic science is secret from the public. Thus scientists can keep an eye on what unorthodox scientists are doing in the public domain, and one genre which shows the scientist as watchdog is the review – a genre which does not require peer review and offers no right of reply. Reviews are written by one person who appears to be expressing a personal opinion, and are rarely referenced: they present the voice of an individual, not of a community. Thus reviews of unorthodox science fight like with like. Condemnatory reviews of Hoyle's popular work have appeared in many scientific publications, including *Nature* and *Science and Public Affairs*, the house journal of the Royal Society of London.[54] *Science and*

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52. According to Hoyle: "1951-52… were bad years for me because I ran into a lot of trouble with the professionals – one way of taking a sort of revenge on me [for the success of the broadcasts] was to make it very difficult for me to publish my papers. They never succeeded if I was determined to print a paper… but it became such a psychological effort that from about 1950, from the time I did those broadcasts, to 1952, I hardly published anything… Then I got an invitation from the Americans… and the attitude was completely different, so I woke up again…" Interview with Fred Hoyle, 11 August 1993.

53. This boundary between the public and the private in science is no longer quite so impenetrable in the UK. Now in Britain there is a new wave of scientist/popularisers – examples might be Paul Davies, John Barrow, Roger Penrose, Steve Jones, Ian Stewart – but there appears to be a generation missing between these scientists and the popularisers of pre-War Britain.

54. See, for example, *New Scientist*: "I am fed up to the teeth with malodorous mouthings such as [Hoyle] regularly foists on an unsuspecting public… If I have been disrespectful to Sir Fred, it is at least partly because he has grossly misrepresented someone [Darwin] who is dead; but more because he shows the living, who listen to him in expectation of wisdom, such

Public Affairs' answer to the question of why they would publish such a review was that since Hoyle was one of them – he is a Fellow of the Royal Society – he could not be allowed to bring the scientific community into disrepute in this way. The book's publishers, Dent, should also be warned that this wasn't the way to deal with science if they wanted the cooperation of the scientific community.

A comparison of the progress of Hoyle's unorthodox hypothesis through the four media produces a pattern which has interesting implications. It shows that parts of the hypothesis were appearing in his novels in the late 1950s and early 1960s, when it seems to have caused little more than amusement among Hoyle's colleagues. In 1974, the hypothesis first appeared in an academic paper, initially in a high prestige journal and later in a lower prestige journal with a more limited specialist readership. At the time when Hoyle felt excluded from prestige journals, his first popular book in this area appeared. His academic papers continued to appear for a few years in lower prestige journals, but non-fiction books soon took over as Hoyle's main means of communication, and he moved entirely into the public network. The books became increasingly popular in style, and redeveloped the hypothesis over time – just as it had been developing in the academic papers. However, in the public networks there was no cut-off point: in his books, Hoyle eventually went the whole way to the cosmic intelligence, an idea which has never appeared in an academic paper.

Why use public networks?

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disrespect." Thus Cherfas takes Hoyle to task not only for his science, but also for his treatment of the public. Cherfas, J., 1983, The word according to Hoyle. *New Scientist*, 19 May. In *Nature*, chemist Robert Shapiro of NYU, said of *Our Place in the Cosmos*: "This book cannot be taken seriously as a work of science". Shapiro, R., 1993, Life, the Universe and anything goes. *Nature*, 363, 124. In *Science and Public Affairs*, Oxford chemist Peter Atkins wrote "this book is not worth the paper it is written on… it is a travesty of science… a personal diatribe against established science… one can only hope that it will… expose the author's hubris and incompetence to the point that publishers will cease pestering us with their nonsense." Atkins, P., 1993, 100 on the poppycock scale. *Science and Public Affairs*, Autumn, 58.

There are many advantages to using public networks. First, the membership of public networks is much greater than that of professional networks, and so there is more chance of the idea reaching someone who is receptive. Secondly, ideas which escape or are excluded from professional networks tend to have greater news value than the ideas they oppose: instability, controversy and personality have news value; stability, consensus and community do not.[55] And while scientists can condemn Hoyle in the scientific press, very few seem able to do this in the public media.[56]

Hoyle's use of public communications networks also reflects his relationships with both the scientific community and the public. His writing is marked by a strong sense that he is not at home among scientists, either socially or intellectually. As a student he deliberately resisted tuition, and preferred instead to follow his own lines of thought.[57] Even when he was effectively the most senior astronomer in Britain, Hoyle never felt himself to be an "insider". But Hoyle likes the public: this is obvious from the novels, where the relationship between the public and the scientific community is often at the heart of the plot.[58] In *The Black Cloud* (1957), the

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55. Gans, H., 1979, *Deciding what's News* (New York: Pantheon).

56. In 600 newspaper cuttings I have only one example of a scientist opposing Hoyle. However, this may be an artifact of journalistic practice, rather than a feature of the coverage of orthodox science as such. See Gould, D., 1986, Well, where does AIDS come from? *Evening Standard*, 5 December.

57. Hoyle, F., 1986, *The Small World of Fred Hoyle* (London: Joseph). Hoyle never submitted a PhD thesis. In theory, his supervisor was Paul Dirac, though they met only once.

58. I am not squeamish about inferring Hoyle's opinions from his fiction. Hoyle occupied the scientific community for 40 years, and when he writes about the appalling cuisine in the Royal Society dining room, or about the attitudes of the scientific establishment to the public communication of scientific ideas, I am confident that he is writing from his own experience. Not even much better writers than Hoyle are safe from this sort of analysis: see, for example, Le Vot, A., 1985, *F. Scott Fitzgerald* (Harmondsworth: Penguin), and Turnbull, A., 1982, *The Letters of F. Scott Fitzgerald* (Harmondsworth: Penguin), p. 119.

gardener Joe Stoddard demonstrates Hoyle's belief that the public are more receptive to new ideas than scientists.[59] The scientists in the novel build an apparatus which sends the Cloud's knowledge directly into the human brain, but receiving this knowledge kills the recipients. The scientists assume that these people weren't sufficiently intelligent, so the top scientist volunteers. He dies too, but not before revealing that he is dying of the shock of hearing things which contradicted his own worldview. He says that they should have wired up Joe Stoddard the gardener, whose previously cryptic dramatic role thus finally becomes clear. Thus the "great physicists" find it difficult to accept new ideas, but the layperson, the gardener Joe Stoddard, may well be more receptive. Later novels tell a similar story,[60] and the thesis appears often in Hoyle's criticism of the intellectual inertia of the scientific establishment.[61]

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59. This point is sometimes misunderstood: it has been proposed that "Hoyle makes a crucial theme of a superior mind which is so awesome that anyone who comes into contact with it dies of neural pathway overload… it takes at least a great physicist to tune into the messages…". See Lambourne, R., Shallis, M., and Shortland, M., 1990, *Close Encounters? Science and Science Fiction* (Bristol: IOP Publishing), p. 141-142.

60. In Comet Halley (1985), we read about "the unerring ability of ordinary folk to arrive at the truth of a situation"; "ordinary people would give more than tuppence for [that]… because ordinary people have supported unusual things from time immemorial, whether at Stonehenge, or in building the temples of ancient Greece, or in modern scientific laboratories"; "You'd need to be an amateur astronomer to notice an interloper as faint as that. I bet the professionals couldn't." Hoyle, F., 1957, *The Black Cloud* (London: William Heinemann), p. 201, 397- 398.

61. See, in particular, the news coverage of Hoyle's objections to the awarding of the Nobel prize to Anthony Hewish for the discovery of pulsars: Hoyle felt that the prize should have gone to Jocelyn Bell, the postgraduate student who first noticed the new phenomenon, rather than Hewish who would have been too set in his ways to do anything other than brush the anomaly aside as stray data. This episode generated the biggest and most concentrated burst of press coverage of Hoyle's career; the row lasted in the letters column of *The Times* for nearly two months. See, for example, Stevenson, J., 1975, Nobel Prize star-spotter gets rocket from

Conclusion

There are many factors which affect a scientist's career, and many factors which frame science in the public domain. Many of these have undoubtedly affected Hoyle, and it is inappropriate to think of any of them in isolation. However, this study indicates that the idea of communities as communication networks may be a useful tool for understanding the experience of a scientist such as Hoyle, and for thinking about how unorthodox science might arrive in the public domain.

This case study is part of a larger study in which I propose to compare the experience of several scientists who, after orthodox careers, have strayed from the scientific orthodoxy. The other scientists I have in mind are known to the British public only for their unorthodox work: apart from the sheer volume of material produced by Hoyle, his case is complicated by his status as a successful populariser of orthodox science. It would be reasonable to ask, for example, how I can make special claims about what drove or inspired Hoyle to popularise his ideas about life in space, when he has consistently popularised all of his work, including his orthodox cosmology. I also have to bear in mind that Hoyle has been unemployed since 1972 and grants have been scarce. Popular books may well have been an important source of income.

However, the patterns that have emerged in different media of Hoyle's communications of his unorthodox hypothesis do suggest, at least in this rather complicated case, that the scientific community uses communication as an exercise in the setting of boundaries; by choosing whom they include or exclude from their communication network, scientists set the boundary between orthodox and unorthodox science. Hoyle, excommunicated from the scientific networks, looked for the opportunity to communicate, and found a large and potentially receptive audience in the general public. In this way, Hoyle's unorthodox science was placed in the public domain – to the considerable annoyance of a community whose control over its own communications networks may well have been what placed it there.

Hoyle. *Daily Mail*, 22 April; Dover, C., 1975, Sir Fred Hoyle starts Cambridge science furore. *Daily Telegraph*, 23 April.