Astrobiology in the UK

Mark Burchell and Lewis Dartnell review the current standing of astrobiology research in the UK, and look to future success.
The growth of astrobiology – the study of the origin, evolution and distribution of life in the universe – has been mirrored in growing UK research. The focus of ESA’s planetary missions on the Aurora theme leading to Mars (focusing on ExoMars in the near future and an eventual Mars sample return mission) has helped this, but in parallel a wide range of other activities in research and teaching are underway in the UK. The results of a recent survey of UK activities in astrobiology is about to be published in the journal Astrobiology (Dartnell and Burchell 2009) and reveals a wide ranging and deeply rooted UK community in the field. Here we present a sample.

In the UK, scientific research in the public sector is increasingly justified by reference to economic impact. But some topics are so fundamental, so potentially important, that it is hard to even begin to estimate their cash value. Nevertheless, a successful outcome from such research would potentially impact society so greatly and in so many ways that we cannot envisage not doing such work. Such is our view of the importance of the search for life and its origin, evolution and distribution both on Earth and beyond. This is a view shared by the public. For example, at the end of the 20th century, so-called “millennium fever” resulted, among other things, in top 10 lists of what the public expected scientists to discover in the 21st century; the origin of life was on most of those lists.

Optimistic as this seems, something similar happened at the end of the 19th century, and searches for an answer to this question went unfulfilled then; we hope to do better this time.

**Panspermia and beyond**

Progress has been made in the field during the 20th century. At the turn of the 19th century the question of how life started on Earth was related to space via the idea of panspermia: life came to the Earth from space as seeds or on meteorites (see Burchell 2004 for a recent review). This removes the need for an origin on Earth, and thus removes our need to see the Earth as special. The idea of life starting in space was suggested by, among others, Lord Kelvin in the late 1880s. Early in the 20th century the Swedish Nobel Prize winning scientist Svante Arrhenius popularized the idea further in a book (Arrhenius 1908). But improved knowledge of the conditions in the space environment seemed to preclude this, notably, for example, the deleterious effects on life of solar and galactic cosmic-ray radiation. Ideas of endogenous origins (rather than exogenous delivery) thus came to dominate and the primordial soup concept emerged in several countries in the 1920s and 1930s: the concept of proto-cells forming by making “bags” that acted as barriers, out of hydrophobic and hydrophilic molecules, became widespread in the science community and popular literature. Then, in the 1950s, in the famous Miller–Urey experiment, Miller showed that amino acids, complex molecules associated with life, could be synthesized in his model of the atmosphere of an early Earth via energy inputs from electrical discharges – lightning (Miller 1953). We now know that amino acids are commonly made by Nature in a wide variety of locations and are even found in meteorites (e.g. the Murchison meteorite was found to contain many amino acids, quite a few of which had no terrestrial counterpart, Cronin 1989). But none of these experiments led to creation of life itself.

Research then moved out into space, asking if Mars had life. But the Viking landers on Mars in the 1970s seemed to not only rule out this possibility, but also indicated that future Mars missions would be better focusing on geochemical measurements rather than pure life-science experiments, and any detailed biological experimentation should await a Mars sample return (MSR) mission (NRC 1977). While later Mars missions achieved mobility (via rovers) and have conducted extensive geochemical analyses on the surface, we still await MSR. Meteorites briefly came back in vogue when putative bacterial fossils were found in the Martian meteorite ALH84001 (McKay et al. 1996), but this is discounted by most of the meteorite/Mars community who point to geochemical interpretations of the structures. On Earth, the argument of an exogenous vs endogenous origin of life has continued (e.g. Chyba and Sagan 1992). To try to better understand how life arose on Earth, searches for evidence of the earliest life on Earth are on-going (c.f. the controversy over the oldest fossils, 3.5bya, Schopf et al. 2002 and Brasier et al. 2002).

In parallel to all this, throughout the 20th century astronomy continually revolutionized the way we see our universe and this has significant implications for astrobiology. The discovery of extrasolar planets is an obvious example. The discovery of Earth-type extrasolar planets (with Earth-like mass and orbit) is eagerly awaited. Equally eagerly awaited is the ability to then study the atmosphere of such a planet from its reflected sunlight, which will transform our understanding of planets and their potential for life (e.g. Cockell et al. 2009). Star formation and formation of planetary systems is also increasingly studied via both observations and modelling. Although still not fully understood, planet formation and solar-system architecture play a vital role in understanding how potentially life-bearing planets come about.

So what does the UK community do in astrobiology? We have found that the UK astrobiology community is a broad church, with some relevant researchers even denying they are doing astrobiology at all. Work includes: understanding microbial life and its complexities; finding extremophiles here on Earth; searching for the origin of life on Earth via fossil evidence and non-equilibrium isotope ratios in old rocks; meteorite studies; lunar and martian science; searching for water on solar system bodies; characterizing the organic content of bodies in space; looking for organic molecules in interstellar space; and searching for terrestrial-type planets in other planetary systems. This work is carried out via experimentation, field-work, modelling, space missions, telescope observations and more. Details of this, along with who is doing what and where, are given in the Dartnell and Burchell paper.

In the traditional view, astrobiology is a series of almost disconnected specialisms, with distinct groups focusing on separate areas (see figure 1). However, in reality the work is inherently multidisciplinary. Some parts of it are carried out by single-subject specialists (after all, by definition, they are usually at the cutting edge of techniques in their fields), but other researchers need skills that span disciplines or combine in multidisciplinary teams. And the audience for the reporting of the results is often drawn from across discipline boundaries. This more holistic approach is reflected in figure 2 and is increasingly typical of how astrobiology works. The relationships between different branches of the field may not always be obvious at first glance; how, for example, do stars and microbes interact? But stars create the heavier elements without which life can’t exist. The nature of individual stars defines the habitable zone around them in which liquid water...
In the early 1980s (see Tipler 1980, 1981, Sagan and Newman 1983). Indeed, it could be argued man has taken the first steps on such a path via the Voyager spacecraft of the 1970s, which are now heading into interstellar space carrying the famous cultural artefacts chosen to represent mankind. As well as artefacts one can go further and contemplate spreading DNA across the galaxy (Crick and Orgel 1973). Indeed, at a more basic level the spread of DNA by natural means was the idea postulated by, among others, Sir Fred Hoyle and Prof. Chandra Wickramasinge in their frequent discussions relating to panspermia.

However, as stated above, the UK community has mostly avoided SETI and worked on SETL, although there is still interest in panspermia (i.e. natural migration through space). Perhaps this lack of interest in SETI is due to limited state-provided funding. In the US, the SETI institute has over the decades moved from state funding towards the private sector, with charitable donations helping it develop its work. It seems the public is willing to be more speculative in the ventures it supports directly than does peer-reviewed state funding.

Teaching
One way a subject embeds itself in the academic community is by the establishment of teaching programmes. This may seem odd, given that many academics seem keener on research than teaching, but it serves several purposes. One key issue is that it provides and enthuses a new generation of researchers. It also helps science departments attract more students by offering novel courses in a cutting-edge discipline with a high profile. Almost all research disciplines like to claim that they fit that bill, but astrobiology is photogenic, it makes the news and involves a readily understood big concept: life itself.

It should be no surprise that the recent survey found that 15 UK university departments were offering courses or modules involving astrobiology. This compares with just four identified in an earlier report (Cowan et al. 1999). One criticism of such surveys is always that they are based on sampling techniques and are hence incomplete; there may well be more courses out there. Nevertheless, the new results indicate that astrobiology teaching is now widespread in UK undergraduate science courses, particularly in physics and astronomy departments which account for 34% of the students on such courses (perhaps reflecting where the researchers are). In parallel to this a wide range of astrobiology textbooks are now available. Whereas once there were just a few specialist books, typified by the excellent Search for Life on Other Planets (Jakosky 1998), there are now many, and the UK academic community has generated several of its own, including the OU’s very popular course textbook (Gilmour and Sephton 2004).

"Searches for life are bedevilled by confusion over what life is, let alone how to recognize it elsewhere, especially if it is present in low concentrations."
Outreach and public engagement

Astrobiology is doing well in public. People like to hear about astrobiology, from pre-school children (who like painting little green men), to adults – if you advertise a talk on astrobiology you will get an audience. Recently one of the authors of this article (Lewis Dartnell) spoke at the Cheltenham Science Festival, and at the other extreme the other author (Mark Burchell) took part in a hands-on “Little Green Men” activity morning at Whitstable Museum (finger painting, drawing and cutting out etc). This experience is shared by many researchers in astrobiology; if you offer a talk, there is an audience.

Organization and opportunities

In the UK, astrobiology is both an individual and an organized field of research. Individual researchers enter the field based on their interests. But to help push the growth of the discipline, a series of meetings at the Royal Society in London in 1996 and 1998 made several recommendations. These are summarized in Cowan et al. 1999 and included the suggestion that an ad-hoc committee should form and promote the discipline. This occurred, and the committee then organized a national conference in Cambridge in 2003, where the Astrobiology Society of Britain (ASB) was created by popular vote of the attendees. The ASB has since held further conferences, at Canterbury (2006) and Cardiff (2008). The next conference will be held at Royal Holloway College (London) in 2010. The ASB also runs a website where details of its activities and announcements concerning its conferences can be found. This site receives more than 3000 hits a week. One popular feature is the reviews of new astrobiology books (with more than 25 reviewed in the last two years).

In parallel to these national activities, other countries have similarly set up societies in this field, some predating and some postdating the ASB. At the European level, the European Astrobiology Network (EANA) has been holding annual pan-European conferences on astrobiology since 2000 (the 2009 meeting will be in Brussels in October). The UK has two representatives on the management committee of EANA. Above EANA and similar organizations is the FAO, the Federation of Astrobiology Organizations (see NRC 2008) gives a strong focus to such biology and liaisons between its members.

Funding

It is a sad fact of modern life that any scientific discipline stands or falls by its ability to attract money. In this respect, in the US, NASA’s decision to fund a National Astrobiology Institute (see NRC 2008) gives a strong focus to such work, and has helped the US to develop a healthy community in the field with a well defined roadmap (Des Marais et al. 2008). The UK relies on its Research Councils to back fields. Here, STFC responds to ideas-led research, and its solar-system exploration programme includes Aurora, which has as one of its key goals the search for evidence of life (past or present) on Mars. This is an inherently long-term activity, with participation in ESA’s ExoMars lander mission in 2016 and participation in a Mars sample return mission in the 2020s. In the meantime STFC is encouraging a supply of trained scientists by investing in Aurora fellows (with two rounds of fellowships already awarded and the results of the third round to be announced shortly). In addition, STFC funded a postgraduate summer school on astrobiology in 2007 at the OU, and is funding a second such school in September 2009 at the University of Kent. In parallel to this, a series of STFC workshops are taking place to help educate the academic community on issues needed to fully participate in these long-term goals (e.g. in June 2009 a workshop on criteria for selection of Mars landing sites was held at the OU). Individual research grants, however, depend on the individual researcher submitting applications to a relevant funding agency. This, of course, is then dependent on how well the proposed work ties into the agency’s objectives and how well it is received by its referees.

The future

In some respects the future of astrobiology in the UK depends solely on academics and students: do they want it? The answer appears to be a strong yes. For example, the growth in undergraduate teaching found by Dartnell and Burchell (2009) suggests a fourfold increase in teaching provision in a decade. Such rates of growth cannot be sustained indefinitely of course, a slower growth rate and an increase in depth of provision in the existing institutions is the likely next step. In turn, a fraction of the students emerging from these undergraduate courses will want to undertake research degrees in the field. Already the Astrobiology Society of Britain reports increasing requests from graduates to help provide a PhD-place finding service. At the postgraduate level, the range of research topics covered by students is impressive, covering the whole field of astrobiology from microbiology through to astronomy. One perceived need is to translate this into greater visibility internationally. The UK hosts its own astrobiology conference series, and has also hosted the European astrobiology conference (EANA 2004 at the Open University), but participation at international meetings is patchy. For example, at EANA 2008 several papers were presented by senior UK academics but relatively few by the UK’s early-career researchers.

In terms of published papers, the UK is successful. The Astrobiology Society of Britain’s conference series has resulted in nearly 40 original papers in issues of the International Journal of Astrobiology (see volumes 3(2), 2004, 3(3) and 3(4), 2006 and 8(1), 2009). Work has also appeared in a variety of journals such as Astrobiology, Biogeosciences, Icarus, the Journal of Geophysical Research, MNras etc. But in addition to this broad spread of work the real test in the next decade will be whether the UK achieves notable leading breakthroughs in the field and in particular assumes key leadership roles in ESA’s Aurora programme.

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Further reading

Astrobiology Network (EANA)
http://www.astrobiology.na/nai

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A&G • August 2009 • Vol. 50