FOCUS

Five years on: environmental monitoring in perspective

When JEM was launched five years ago a decision was taken to supplement the peer-reviewed papers with news and focus articles on topics related to the journal. Since then JEM has published over 20 focus articles on key topics in environmental monitoring. As the journal enters its sixth edition, and moves to a new 12 issue format, we take a look back at the highlights of our first five years and provide updates on some of the issues covered.

The focus article in our first issue, in February 1999, set the tone, reviewing not only the current state of science but also the research and policy implications. The subject was endocrine disrupting chemicals (EDCs). Concern that exposure to small amounts of man-made chemicals could interfere with the hormonal – or endocrine – systems of humans and animals had first been voiced in the early 1990s, and by 1999 the issue was beginning to filter through to the policy agenda. Our review identified three main policy priorities: further research into the causes and consequences of endocrine disruption; better information on the occurrences and risks of EDCs; and in the longer term, potential regulatory action.

Developments since then suggest EDCs may be less of a risk to human health than previously thought. In 2002, UN chemicals experts concluded that the case against EDCs was "inconclusive and inconsistent", and that there was only "weak evidence that human health has been adversely affected by exposure to endocrine-active chemicals" [*JEM*, 2002, **4**, 56N[1]]. This view was supported by another study, sponsored by the World Health Organisation and UN Environment Programme, which noted that there are no proven examples of human disorders linked to EDCs. Examples of adverse effects on wildlife are clear, however, [*JEM*, 2002, **4**, 42N[2] & 74N[3]] and some commentators have begun to question whether the screening programmes being funded by industry and regulators give sufficient attention to ecological – as opposed to health – consequences [*JEM*, 2003, **5**, 13N[4]].

A related issue, phthalates, also featured early on and has seldom been out of the news pages since. Suspected of being endocrine disrupters, the phthalates story acquired a momentum of its own with the EU's decision five years ago to ban the use of the substances as plastic softeners in children's toys and childcare items [*JEM*, 1999, **1**, 111N[5]]. The ban was intended as a temporary public health measure while the EU decided on the most appropriate long term response. A sub-plot developed around whether appropriate testing methods could be developed for measuring migration of phthalates into saliva [*JEM*, 2002, **4**, 10N[6]]. With analytical methods now available, industry claims that the time has come to lift the ban, but with Member States still divided on the need for legislation an early end to the moratorium looks unlikely [*JEM*, 2003, **5**, 91N[7]].

Meanwhile, many column inches have been given over to a moratorium of a different kind – Europe's stalemate over product approvals for genetically modified (GM) crops. The GM issue has proved highly divisive for the EU, with Member States unable to agree on virtually any aspect. JEM published a special issue on GM in December 1999, including invited contributions from Monsanto and Friends of the Earth, as well as the usual focus article. Our review noted that European governments and industry, mindful of a growing disquiet amongst the public, had attempted to marshal science as an arbiter in the GM debate [*JEM*, 1999, **1**, 97N[8]]. Each of the contributors emphasised the key role for environmental monitoring. Tom Nickson and Graham Head from Monsanto argued that "monitoring of GM crops will be of value only if the questions are clearly defined, the methods are appropriate and the end point (data collected) are interpretable" [*JEM*, 1999, **1**, 101N[9]]. FoE's Emily Diamand said it was "essential that monitoring programmes do not examine environmental or health impacts in isolation", but took account of wider factors such as consumption patterns [*JEM*, 1999, **1**, 109N[10]]. Furthermore she added, "it is by no means clear that at present effective monitoring is even possible."

In the four years since then the debate has become increasingly acrimonious with science being used as a weapon by both sides. One of the main sticking points has been over EU rules on the coexistence of GM, conventional and organic farming. The European Commission believes co-existence and liability are best dealt with at national level, as outlined in guidelines issued last July [*JEM*, 2003, **5**, 47N[11] & 64N[12]]. New EU regulations require mandatory tracking of GM ingredients throughout the food chain and the labelling of products made from GMOs irrespective of whether modified DNA or protein is detectable [*JEM*, 2003, **5**, 64N[12] & 86N[7]]. In the UK, the issue remains as controversial as ever, despite the results of farm-scale trials, a scientific review, a cost-benefit assessment, and a public debate [*JEM*, 2003, **5**, 87N[7] & 114N[13]]. A government decision on commercialisation of GM is expected shortly.

New friends and familiar faces

At one level, environmental monitoring relates to chemical pollutants and how chemical and physical measurements of these pollutants can inform regulation and policy. Here a host of chemical characters have graced JEM's news pages over the years, some familiar, others less so.

The October 2000 edition focused on one of the most basic pollutants, particulate matter, highlighting how even here our knowledge of environment–health relationships is incomplete [*JEM*, 2000, **2**, 72N[14]]. Epidemiological studies have advanced our understanding of the health effects of ambient PM considerably over recent years. For instance, one study on population death rates in Dublin before and after a ban on coal sales found a 6% reduction in overall mortality rates [*JEM*, 2002, **4**, 105N[15]]. In the US, the National Morbidity, Mortality and Air Pollution Study (NMMAPS) has provided important findings on the association between air pollution and public health drawing on nearly 40

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studies from the US, Canada and Europe [*JEM*, 2002, **4**, 71N[3]; 2003, **5**, 68N[12]]. The economic and societal costs of air pollution are also becoming clearer, with one European study estimating the cost of damage from particulates at €14,000 per tonne [*JEM*, 2003, **5**, 15N[4]].

Overall, the evidence for causal links between ambient PM exposures and adverse health outcomes – either death or illness – is increasingly strong. But the environmental and biological factors underlying these effects have yet to be explained satisfactorily. Recent findings go some way to rectifying this. Studies focus on fine particulates, those less than 10 microns in size (so-called PM_{10}), and increasingly on ultra-fine particulates, less than 2.5 micron ($PM_{2.5}$) [*JEM*, 2002, **4**, 44N[2]]. For instance, researchers in the US have suggested that transition metals in the PM_{10} range can catalyze oxidative reactions associated with PM, leading to lung inflammation and injury [*JEM*, 2002, **4**, 72N[3]].

Metals remains a recurring issue, and despite a long research history and extensive literature new insights continue to be made. As UNEP pointed out last year, mercury from burning fossil fuels remains a hazard, especially in Asia [*JEM*, 2003, **5**, 23N[16]]. Measures to reduce other pollution from power generation, in line with Kyoto, may reduce these emissions but this cannot be guaranteed. UNEP has adopted an action plan to help developing countries and those in the former Soviet-bloc address these issues.

The health consequences of lead continue to cause concern. Last year, for instance, we reported on findings by US researchers that lead may be harmful even at very low blood concentrations [*JEM*, 2003, **5**, 52N[11]]. The scientists found associations between blood lead concentration and both IQ impairment and delayed onset of puberty at levels well below those previously considered "safe". Recent studies have also suggested a new pathway linking certain metals to cancer, citing both cadmium and arsenic [*JEM*, 2003, **5**, 67N[12] & 81N[17]]. Other research has shown a possible role for metals in aggravating asthma [*JEM*, 2003, **5**, 68N[12]]. These and other relevant issues are being taken up in JEM's series of invited articles entitled *Metals in Perspective*.

Pesticides policy has seen a major shake-up over the last five years. In the EU, changes in the marketing regulations led to over 450 pesticides being withdrawn during 2003 alone. Overall, over half of the pesticides that were on the EU market in 1991 are now prohibited [*JEM*, 2003, **5**, 90N[7]]. This is a much faster rate of withdrawal than originally expected, partly because producers decided not to defend many of the substances. Revisions in the rules on maximum residue levels (MRLs) have also helped streamline the assessment process [*JEM*, 2003, **5**, 51N[11]]. Further measures are being advocated under the EU's new pesticides strategy, including the introduction of pesticide-free zones, a ban on aerial crop spraying and greater use of the substitution principle in the approval of active ingredients [*JEM*, 2002, **4**, 70N[3]]. However, the proposals stop short of overall EU targets for pesticide reduction and the introduction of a pesticides tax. Denmark remains in the vanguard of pesticides policy and is pushing forward with ambitious plans to radically curtail pesticides usage [*JEM*, 2003, **5**, 90N[7] & 118N[13]]. As well as the news pages, relevant developments were covered in a series of invited articles entitled *Pesticides in Perspective*, edited by Dr Terry Clark of Syngenta.

Detergents, another common substance, are under pressure on two fronts: for the contribution of detergent-derived phosphates to eutrophication and also their role as endocrine disrupters. In Europe, moves to introduce new legislation on detergents is caught in a classic EU wrangle, with the European Parliament pushing for much stricter measures than those proposed by either the European Commission or the Member States [*JEM*, 2002, **4**, 102N[15]; 2003, **5**, 25N[16], 50N[11] & 119N[13]]. As the EU's toxicology committee pointed out last year, phosphate pollution in the EU is highly regionalised and although reducing detergent phosphates may help it is unlikely to offer a complete solution.

A relatively late, but boisterous, entrant to JEM's new pages is "f-gases". This is shorthand for a group of compounds – hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF6) – derived from various industrial processes, notably refrigeration and air conditioning systems. In the EU, plans to regulate these greenhouse gases as part of the Kyoto commitments have sparked a fierce debate between the industry and environmentalists, and between the EU and some national governments [*JEM*, 2003, **5**, 90N[7] & 117N[13]].

Various other pollutants have had bit parts over the years. The plastic intermediate bisphenol-A (BPA) was set for a phase out but won a reprieve [*JEM*, 2002, **4**, 58N[1]]. Tributyl tin (TBT), used in marine anti-fouling products, caused a lot of international mud-slinging before a phase-out was eventually agreed [*JEM*, 2003, **5**, 22N[16]]. And after a fiery debate, brominated flame retardants are set to be extinguished, with a ban on most forms due to enter into force across the EU later this year [*JEM*, 2003, **5**, 26N[16]]. Other pollutants to have made it into the news pages are the rocket fuel perchlorate [*JEM*, 2002, **4**, 24N[18] & 74N[3]], the polymer intermediate perfluorooctanoic acid (PFOA) [*JEM*, 2003, **5**, 52N[11]], the petrol additive MTBE [*JEM*, 1999, **1**, 94N[19]; 2001, **3**, 10N[20]], and the cooking-byproduct acrylamide [*JEM*, 2002, **4**, 59N[1]].

The national imperative

Some issues are clearly driven by national (which in the case of the EU means supra-national) agendas. Thus, we have followed the EU as it has agonised over its Kyoto targets for greenhouse gases and contemplated the introduction of an emissions trading scheme (now only two months away) [*JEM*, 2003, **5**, 10N[4], 48N[11] & 87N[7]]. Experts are already looking to the next stage of negotiations for "Kyoto+10" and the release of the next IPCC report on climate change in 2007 [*JEM*, 2003, **5**, 63N[12]]. Nitrates has been another recurring theme, as the EU's notoriously inefficient agricultural policy has at times seemed to directly contradict efforts to combat contamination of groundwater [*JEM*, 2002, **4**, 69N[3]]. The EU is also contemplating an overhaul of waste legislation and a new law on groundwater protection [*JEM*, 2003, **5**, 115N[13]]. Expect to hear more on all these issues during 2004.

But the environmental issue that has preoccupied the EU most over the last three years has been the reform of its chemicals policy. Since they were first put forward by the Commission in February 2001 [*JEM*, 2001, **3**, 22N[21]], the proposals – known as Reach – have spawned a fierce and increasingly polarised debate [*JEM*, 2003, **5**, 10N[4], 22N[16], 47N[11], 63N[12] & 86N[7]]. The chemical industry claimed that the proposed authorisation system would be much too complex and expensive to administer and would stifle innovation. NGOs said the proposals fell far short of the measures needed for a sustainable approach to chemicals policy. The Commission emphasised the need to strike a balance between ensuring high levels of protection for health and environment while keeping down costs to business. So far the draft legislation, which was tabled last September, has failed to satisfy either side [*JEM*, 2003, **5**, 114N[13]]. Industry maintains the plans are too costly and in many respects unworkable, while Europe's green movement believes the reforms have already been watered down too far. Although the proposals have some way

to go before they become law, the debate seems to have reached its peak and further major changes look unlikely.

What is striking is that none of these issues feature prominently in JEM's US coverage. The US has rejected the Kyoto regime altogether, and so is not troubled by the need to meet reduction targets. Chemicals regulation also fails to resonate as an issue but for entirely different reasons: the American regulatory regime, with its strong commitment to freedom of information under Right-to-Know legislation and sophisticated reporting system under TRI (Toxics Release Inventory), makes the US system much more transparent than in Europe. Of course, this is not to say that chemicals aren't of concern. American green groups continue to wage vociferous campaigns against chemicals, especially pesticides. But the issue doesn't have the same political edge as in the EU.

So the US, and to some extent Canada, has a different set of priorities. With smog a recurring problem in many North American cities, air quality remains a top issue. The Clear Skies Act, the Bush Administration's flagship environmental policy, calls for a 70% reduction of SO_2, NOx and mercury based on a market-based cap-and-trade approach [*JEM*, 2003, **5**, 87N[7]]. Other measures are the NOx SIP call, which will reduce summertime emissions of ozone-producing NOx by 60% [*JEM*, 2001, **3**, 38N[22]; 2002, **4**, 19N[18]]; and EPA's proposed rule to cut emissions from non-road diesel engines. Once implemented, EPA expects these measures to lead to a further significant drop in ozone and PM levels over the next few years.

Water quality remains a key US concern. Despite the landmark achievements under the 30-year old Clean Water Act, US water quality has shown little or no improvement over recent years. America's water infrastructure has suffered chronic under-investment for decades, leading to a burgeoning investment gap. Again the Bush Administration is looking to market-based solutions, with a system of permit trading being proposed as the most effective means of improving water quality [*JEM*, 2002, **4**, 53N[1]; 2003, **5**, 25N[16] & 88N[7]].

Another dominant issue is children's health. For reasons that are difficult to discern – perhaps a stronger commitment to the family or a more open regulatory environment – children's environmental health is much more identifiable as a policy issue in the US than in Europe [*JEM*, 2002, **4**, 95N[23]]. Policy follows a multi-disciplinary, inter-agency approach targeting four priority areas: childhood asthma, unintentional injuries, developmental disorders, and childhood cancer. EPA is making a strong contribution to research in this area through a research strategy that links long-term outcomes and short-term results. One manifestation of this is EPA's Asthma Research Strategy, a wide-ranging initiative designed to advance the scientific understanding and prevention of asthma [*JEM*, 2003, **5**, 14N[4]]. The EU's recently-launched environmental health strategy promises to push children's environmental health further up the European agenda [*JEM*, 2003, **5**, 63N[12]], with a first phase Action Plan due to be presented to a ministerial conference later this year.

After children, the elderly are the latest group to be studied in terms of environmental health threats. EPA's recently-launched Aging Initiative aims to examine and prioritise environmental health risks for older persons [*JEM*, 2003, **5**, 15N[4] & 53N[11]], and is indicative of an increasingly differentiated approach to environmental health issues. Developments in genomics promise to extend this approach even further, so that the focus is not populations or sub-groups but individuals (see below).

In the US, especially, the increased risk of terrorist threats brought a new dimension to environmental monitoring. With infrastructure such as reservoirs and water treatment plants considered key targets for terrorist outrages, analysts suddenly found themselves in the frontline of national defence in a way they had never been before [*JEM*, 2001, **3**, 89N[24]; 2002, **4**, 100N[15]]. One upside to this could be that the increased funding being directed towards analytical aspects of "homeland security" is likely to have spin-offs for other areas of environmental monitoring.

Covering such huge landmasses, regional environmental issues have been a common theme for both the US and Canada. Thus, we've reported regularly on the environmental issues facing the US–Mexico border [*JEM*, 2002, **4**, 101N[15]; 2003, **5**, 11N[4] & 65N[12]], the Great Lakes [*JEM*, 2001, **3**, 88N[24]; 2002, **4**, 56N[1] & 102N[15]] and the Arctic [*JEM*, 2000, **2**, 94N[25]; 2001, **3**, 58N[26] & 72N[27]; 2002, **4**, 101N[15]].

Emerging issues

As well as established topics, several "new" issues have been covered in the news and feature pages, some on a fairly regular basis. These emerging issues show how the scope of environmental monitoring is changing and now extends well beyond "traditional" chemical pollutants and the "conventional" environmental media of air, water and land.

The June 2003 edition, for instance, looked at the complex area of pharmaceutical and personal care products (PPCPs), such as human and animal drugs, fragrances and cosmetics [*JEM*, 2003, **5**, 42N[28]]. While the concentrations of these substances are very low, their long-term impact on the environment and human health is unknown. Scientists are coming to realise that traditional criteria – such as ubiquity, persistence and bioaccumulation – may be too narrow in assessing the overall effects and risks of chemical exposure. Research challenges include: prioritisation of classes of PPCPs, development of new analytical methods, monitoring in non-aquatic environmental compartments (such as sediments and sewage sludge), and new approaches to wastewater treatment. There are many lessons elsewhere in the product lifecycle, such as better practices in dispensing, usage and disposal, and even for environmentally-friendly drug design within the pharmaceutical industry itself.

Electro-magnetic fields (EMFs) provide another example of how the boundaries of environmental monitoring are continually being extended. Our review article in the April 2000 edition came at a time of heightened concern over the health effects of EMFs as a result of increased press attention, partly linked to the growing use of mobile phones. We noted that over 20 years of research had failed to demonstrate a conclusive link between EMFs and cancer, but that it had also failed to prove the contrary – absolutely no link. If there is no direct association between EMFs and cancer then it ought to be very clear in the data.

Findings since then provide growing evidence to refute the notion of EMF health risks. For instance, a major US study published last year found no evidence that EMFs increase the risk of breast cancer [*JEM*, 2003, **5**, 92N[7]]. Following over 1000 women over a six-year period, the researchers measured actual power-frequency EMFs in participants' homes. In another UK study, researchers discounted high magnetic fields as a cause of leukaemia in children [*JEM*, 2003, **5**, 68N[12]]. Other researchers maintain there are observable health effects, however, and have pointed to a mechanism associated with the deposition of ionised particles in the lungs [*JEM*, 2000, **2**, 23N[29]; 2001, **3**, 11N[20]].

Although hardly new, sewage sludge has become an increasingly controversial issue. With the cost of other disposal routes increasing, pressure to use sewage sludge

on agricultural land is rising in many countries. Such moves come amid concerns that new and improved treatment processes will lead to higher concentrations of contaminants (such as heavy metals, dioxins, EDCs and PPCPs) and treatment by-products in the sludge fraction. Last year, Switzerland became the first country to break ranks with a plan to phase out all use of sewage sludge on farmland by 2006 [*JEM*, 2003, **5**, 50N[11]]. Denmark seems set to follow suit, but for countries with large populations alternative solutions will be difficult to find. EPA recently ruled out further legislation on dioxins in sewage sludge, saying this source did not pose a significant risk to human health or the environment [*JEM*, 2003, **5**, 114N[13]].

As our knowledge of chemicals and other environmental risks improves we are able to better communicate those risks to the public. One of the key tools for this is the US government's *Report on Carcinogens (RoC)*, a biennial report intended to keep the public informed about cancer risks. Two further editions of the report have been produced since JEM was launched. The latest, Tenth RoC, lists 16 new substances as being "known" human carcinogens including steroidal estrogens, ultraviolet radiation and wood dust [*JEM*, 2003, **5**, 14N[4]]. A further ten substances are being considered for listing in the Eleventh Report due later this year [*JEM*, 2003, **5**, 28N[16]].

Two issues serve to illustrate just how broad environmental monitoring has now become. In Canada highway authorities have introduced a Code of Practice to reduce the environmental impact of road salts following concern over environmental damage [*JEM*, 2002, **4**, 8N[6]; 2003, **5**, 116N[13]]. And in Alaska researchers have attributed rising concentrations of industrial pollutants in rivers to the migration of Sockeye salmon [*JEM*, 2003, **5**, 117N[13]]. In each case environmental monitoring and analysis has helped define the problem and will be key in following through with practical solutions.

The march of technology

Another objective of the news and feature pages has been to track developments in technology, and in particular how innovations influence the theory and practice of environmental analysis. There are many parallel and overlapping trends here. As in other areas of science, developments are driven by three core technologies: nanotechnology, genomics and information technology – and increasingly by the convergence of all three.

As reported in the August 2002 edition, new analytical techniques such as XAFS spectroscopy are allowing researchers to peer into real-world systems at a molecular level [*JEM*, 2002, **4**, 49N[30]]. Combining the knowledge gained through molecular environmental science with advances in nanotechnology and genomics is expected to lead to new commercial products and applications as well as new approaches to environmental medicine. Examples include green processing technologies that eliminate or minimise the use of toxic materials, new remediation or waste treatment techniques, and novel environmental sensing technologies.

Studies at this nano-level are being aided by developments in lab-on-a-chip (LOC) technology [*JEM*, 2001, **3**, 51N[31]]. The ability to carry out a large number of analyses in parallel on the same chip using small quantities of materials makes microarray LOC devices a powerful analytical tool. In addition to high throughput screening programmes in areas such as pharmaceuticals and healthcare, LOCs are now being applied for DNA-based diagnostics and genotyping. In particular, they provide a powerful tool for the emerging science of toxicogenomics – the application of genetics knowledge to environmental medicine. Equipped with these techniques, scientists at the National Institute of Environmental Health Sciences last year announced the completion of the first phase of the Environmental Genome Project. This has re-sequenced and catalogued 200 environmentally-responsive genes, identifying links to vascular disease, leukaemia, and other conditions that affect the quality and length of human life [*JEM*, 2003, **5**, 53N[11]].

The third main driver is information technology, or "e-science" as our June 2002 review called it [*JEM*, 2002, **4**, 33N[32]]. From handheld devices that allow scientists to collect data in the field, to new applications for simulation and visualisation, IT is transforming our approach to environmental analysis. One of the most important developments is grids, high-speed networks that enable researchers to share data, supercomputers and scientific instruments such as synchrotrons and electron microscopes in a sort of worldwide virtual laboratory. Beyond sharing and distributing data and computing resources, grids offer the prospect of near real-time analysis of experimental data, so allowing more effective use of scientific instruments and facilities. Recent developments here include the connection of a grid-based supercomputer facility at Pacific North-Western Laboratory in the US [*JEM*, 2002, **4**, 73N[3]], and the opening of a UK E-Science initiative [*JEM*, 2003, **5**, 16N[4]]. One beneficiary of grids will be remote sensing and earth observation, where satellite-based instruments such as ICAROS and Envisat are now used to monitor a wide range of environmental parameters [*JEM*, 2000, **2**, 41N[33]; 2002, **4**, 45N[2] & 106N[15]; 2003, **5**, 54N[11]].

The future of the analytical sciences, including environmental analysis, depends on the ability of institutions and individual researchers to make the most of these developments. However, as noted in our February 2003 review on innovation, the innovation system in analytical research is highly fragmented with many barriers between scientific disciplines, between industry and academia, and between suppliers and end-users. We need to create an innovation culture that brings together each of these groups and enables them to interact.

Another consequence of technology has been improved access to information. Thanks to the internet, a wealth of environmental data and indicators are now available as a means of assessing the overall state of the environment. Agencies such as UNEP, EPA and the EEA are leading the way in making information accessible online through a series of environmental information portals. These range in scale from high level national and international assessments, such as EPA's *Draft Report on the Environment* published last year [*JEM*, 2003, **5**, 69N[12]], to very detailed local, regional or media-specific assessments, such as those available through the EU's SERIS system [*JEM*, 2003, **5**, 55N[11]]. Others focus on specific ecosystems, for instance UNEP-sponsored inventories on marine and coastal environments [*JEM*, 2002, **4**, 56N[1]], and seagrasses [*JEM*, 2003, **5**, 117N[13]]. Data on environmental compliance and real-time air quality are also readily available online in both Europe and the US [*JEM*, 2002, **4**, 60N[1]; 2003, **5**, 116N[13]].

Finally, it is worth noting that not all innovations are high-tech. Alongside nanotechnology and grids there is still scope for further development of appropriate technologies to solve particular environmental problems. One example here is the current interest in treatment solutions for arsenic, for both the developing world (*e.g.* Bangladesh) [*JEM*, 2003, **5**, 81N[17]] and small communities in developed countries [*JEM*, 2003, **5**, 16N[4]].

So JEM has had an interesting five years. There have been new insights on some familiar topics, together with important advances on emerging issues. Most of all, the research and policy perspectives reported through JEM's news and feature pages have underlined the inter-disciplinary nature of modern environmental analysis and its key role

in addressing many environmental problems. One thing is for sure: the next five years look set to be just as exciting.

Mike Sharpe

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Mike Sharpe is the News Writer for JEM, thus it is inevitable that most articles below bear his name. However, it should be emphasized that each Focus article contains information from a very wide variety of sources and although each article is comprehensive readers are encouraged to look up the references within individual articles for more detailed material on any specific topic.

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