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in this paper significant individuals were central in advancing and sustaining critical science stances. Their voices were heard in part through the accretion of social force around their epistemic claims.

Unlike focus groups, citizen juries and representative samples, the social forum process creates "convergence spaces" within which the voices of those most directly affected by issues of moment perform the work of critical sub-groups, defining initial stakes for debate in wider deliberative forums within which they gain mediated expression. There is no panacea here and the cooperation representing the founding commitment of the forum process also contains conflict. An important area here is the process of recognising and allowing critical free individuals to work whilst maintaining accountability (Barker et al. 2001). This should be part of debating and promoting strategic concerns and the necessary organisational forms. The social forum movement provides an organisational example which can be built on to promote popular democratic control of scientific and technological decision-making and agendas.

The current fashion for "public consultation" over science policy engages an abstract public in ways which are too readily open to legitimating the agendas of established elites and institutions, and too far removed from direct influence. In contrast, we suggest that new social movement engagement contains models for a people's science forum which would challenge elite dominance of techno-scientific agendas and re-orientate scientific and technological inquiry towards far-reaching democratic and liberatory social change. In contrast to dominant "engagement" agendas in science policy, what we are advocating is not a patching-up of the legitimacy of current state-science regimes, but the grassroots development of forums for a people's science presenting a radical challenge to the megamachine agendas of state-corporate science.

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science involved individuals and representatives from unions, science social movements, genetic interest groups, and ecological and environmental groups from across the continent (Welsh Evans & Plows, 2007). Democratic direction of the European science base represented a recurrent theme of the multiple strands within the 2004 ESF. The meeting further consolidated a Europe-wide network forged at the Florence ESF meeting in 2002. The ongoing European Science Forum with ambitions to forge both professional interest networks and peoples' science forums are examples of the organisation of social force with the potential to re-work and transcend more formalised experiments intended to engage "the public" in science after the fact. By asking the question "what kind of science do we want and what do we want it for?" voices from within the ESF simultaneously articulate questions of generic importance whilst engaging with specific issues in a sophisticated and informed manner.

This is a dissipative process requiring immense amounts of time and energy, which like all decentralized processes appears inefficient in terms of the megamachine. The dissipative character of such convergence spaces is however intentional and embedded in the organising principles. Unlike formal bourgeois representative political systems, which are designed to reduce complexity, the WSF and ESF aim to work with complexity in the pursuit of alternative formulations in recognition of the importance of free acts (Eve et al. 1997).

Complexity theory suggests that critical sub-groups and individual free acts are key in producing significant changes in systems far from equilibrium. Mumford's argument that, in both physical systems and wider life, "there occur, at rare umpredictable intervals, moments when an infinitesimally small force, because of its character and its position in the whole constellation of events, was able to effect a very large transformation" (1955:475) is an early expression of such thought. Against technocratic domination he thus asserted the capacity "for the direct impact of the human personality in history, not only by organised movements and group actions, but by individuals who are sufficiently alert to intervene at the right time and the right place for the right purpose" (1955: 476). Mumford's optimism is theoretically supported by complexity theory which concurs that individuals are historically significant agents of change (Eve et al. 1997). In the radiological cases we have used

Abstract

The authoritarian and ecologically destructive juggernaut of state-supported big science and technology in the twentieth century understandably fostered a deep pessimism and suspicion towards science and technology among many in the green, anarchist, and libertarian left milieu. This reaction has been crystallized in the "anti-civilization" primitivist anarchism of John Zerzan. In opposition to this drift towards primitivism, this paper argues that a vision of a liberatory and participative science and technology was an essential element of classical anarchism and that this vision remains vital to the development of liberatory political theory and praxis today. The paper suggests that an anarchist model of science and technology is implicit in the knowledge-producing and organizing activities of new social movements and is exemplified in recent developments in world, regional, and local social forums.

Introduction

This article develops an anarchist political theory of science and technology that highlights the latent forms of anarchist praxis present within a diverse range of social movement engagements with contemporary techno-science. We argue that there is a marked congruence between contemporary social movement engagement and the key concepts and principles underpinning anarchist writing on science and technology from the nineteenth century onwards.

By exploring the tensions and ambivalences in established anarchist approaches towards science (cf. Restivo 1994) we demonstrate that classical nineteenth-century anarchism emphasised the centrality of socially accountable science within libertarian thinking. Elements of this tradition are discernible in the emphasis on liberatory technics by twentieth-century writers such as Lewis Mumford, Murray Bookchin, and Paul Goodman. This later work on liberatory technics developed during a period dominated by state-sponsored big science. The twenty-first century, however, is dominated by neo-liberal ascendancy characterised by the early transfer of "near market" science to the private sector. This

transition to a neo-liberal era requires clarification of, and debate on, the relationship of anarchism to science. Further, such debate must address the global movement milieu in which traditionally conceived social movements combine with network movement actors to form an antagonistic and proactive social force emphasising autonomy.

Important features of this movement milieu are unqualified opposition to: the alignment of capitalist and state forces through global institutions such as the World Bank and IMF; the military sequestration of public corporate scientific research and development (R&D) budgets; the imposition of "market solutions" across all areas of "public provision" and the pursuit of modernisation agendas which simultaneously degrade ecological and human integrity. Global social movements also challenge the prevailing cognitive order by defining key knowledge stakes regarded as vital to "the other worlds that are possible". The recognition and respect for difference is a central part of these linked political and epistemological objectives raising significant challenges for conceptions of science based on universal laws. Key questions explored here are what does the philosophical and political tradition of anarchism have to contribute to such contemporary challenges to dominant social-epistemic orders and is there a theory of science embedded in anarchist political thought that is relevant and applicable to contemporary struggles?

Given the continuing importance of science to modern states and the neo-liberal "global knowledge economy", a critical anarchist theory of science and technology needs to overcome the limitations within various forms of "primitivism" exemplified by the writings of John Zerzan (1996). Zerzan's criticisms of alienation in modern life and of the nihilism of contemporary technological culture are trenchant. But, from this critique, Zerzan leads his readers to a quasi-religious ideal of a return to a wild Eden (cf. *Aufheben*, 1995). Primitivism neglects the anarchist intellectual tradition examined here.

Rather than a return to simpler technics, we argue that the ideas and the epistemic practices of contemporary social movements constitute the basis for non-totalising forms of scientific knowledge and scientific practices resonating with anarchist emphases on decentralisation, horizontal structures, and diversity. This emergent anarchist or proto-anarchist politics of science and technology is necessary to transcend the limits

liberal market rationality. Creative engagement, social deliberation and social shaping of scientific and technological trajectories are central to an anarchist engagement in the twenty-first century.

Conclusions: Anarchist Practice and Science

Contemporary anarchism exists amidst new forms of technology of communications constituting the capacity for both virtual and face-work communities. The origins of the internet as a means of maintaining control of nuclear weapons capability underlines the manner in which state science's quest for control enables decentralized innovation within the very interstices of the megamachine. These developments can be coloinised by social movements and radical actors who can further reconfigure such technologies and imbue them with new social and political potential. Such appropriations of technology facilitate the principles underlying Bakunin's critique, and ambitions for a science of the people.

Central here is the principle of unmediated interest representation and thus direct engagement of affected parties (Franks 2003), as well as the obligation and commitment to education of wider communities int he associated stakes. New communication technologies and networks can facilitate meaningful deliberation and democratic decision-making following non-hierarchical procedures. Realizing the social potential of existing and emerging technologies requires embedding technology withinsocial milieu capable of changing the institutional uses and social practices surrounding the technologies. This appropriation of technology by creative and progressive social movements is necessary to fulfil the liberatory potential of techno-science inherent within the formulation of anarchist thinkers such as Bookchin.

The necessary practices already exist in protean form and engage thousands of individuals through the network of networks constituting the World Social Forum (WSF) and its constituent geo-regional and city social forums (Chesters & Welsh 2006; Sen et.al., 2004). Nascent within these networks lie a myriad of weak ties which have the potential to engage a diverse range of social movement actors (properly understood). At the 2004 European Social Forum (ESF) in London sessions addressing

with anarchist principles is perhaps greater than ever before. The challenge for anarchist praxis is to develop non-hierarchical, horizontally democratic forms of engagement with these dynamics in pursuit of the social shaping of scientific and technological trajectories. This is entirely consistent with Lewis Mumford's classic formulations (Mumford 1934). Mumford's critique of the megamachine has been a prominent justification of primitivist stances towards science and technology but this emphasis neglects the continuing capacity for human agency to direct and redirect both techno-scientific trajectories and economic priorities (Mumford 1954). Mumford recognised that the "conversion of the sun's energies" represented "the prime fact of all economic activity" (1934/1972: 375), a theme returned to by Bookchin (1974: 122–127).

Harnessing these "free goods" remains central to the reduction of anthropogenic greenhouse gases driving climate change which has been labelled "the widest ranging market failure ever seen" (Stern, 2007, i). The post-war techno-scientific "plateau" (Mumford 1934/1972: 430), based on national grid systems delivering nuclear electricity "too cheap to meter" (Welsh, 2000), remains based on the transmission and sale of energy, not the utilisation of free energy at the point of use. The technical means of delivering clean local energy are widely available, yet the British state is amongst those using climate change to justify retaiing the nuclear option.

Here, we are faced with a clear civilizational choice. Climate change can be allowed to legitimize new forms of state techno-authoritarianism, seeing the emergence of authoritarian state regimes of environmental management regulating us in the name of the scarcities of an ever-degraded environment (Welsh 2007). Or, climate change can be responded to along the lines which thinkers such as Mumford, Bookchin and Paul Goodman have long advocated — with regional, decentralized, liberatory, renewable technologies (Bookchin 1974; Illich 1973; Goodman and Goodman 1989). This is a clear case where our technological choices are shaped by our political and social vision. An anarchist social theory of science and technology has never been more relevant. The anarchist vision of a liberatory science and technology is now of crucial importance as a line of flight to escape the iron cage of Cold War statist techno-authoritarianism and the asserted imperatives of post-Cold War neo-

of contemporary state-corporate science which has reached a "plateau" (Mumford 1934/1972) encountering "paradigm limits", which can only be transcended through alternative epistemic practices consistent with the autonomous self-organization of society.

We deliberately re-emphasise the potential for the socially shaped and negotiated "democratic technics" advanced by Mumford (1964). As Bookchin argued, resistance to authoritarian science and technology makes the formulation of an alternative liberatory conceptualization of science a critical political task. Indeed, whilst many contemporary social struggles are perceived as against established science, they also contain liberatory promise and alternative epistemic practices and priorities. Such struggles hold out the promise of a liberatory science with an affinity toward anarchist modes of self-organization as an increasingly diverse range of citizens learn to combine observational, recording, and analytical capacities constituting a potential for proactive grassroots initiatives. An anarchistic organization of science requires such decentralized, network-ordered and bottom-up cognitive and material structures consistent with the political of anarchist(ic) social freedom.

Science, Statist Modernity and Oppositional Movements

Our contemporary focus combined with the use of anarchist theory from the nineteenth and twentieth centuries makes a concise account of key state-science-society relations important for purposes of clarity. This section not only identifies key analytical objectives but also offers some explanation for the retreat from anarchist accounts of liberatory science and technology into primitivism.

The centuries-old relationship between science and the military and political power of the state (Carroll 2006, Bennet and Johnston 1996) was transformed with the scientization of warfare during the twentieth century. Unprecedented levels of state funding of science, combined with large bureaucratic establishments, marked a transition to big science (Galison & Hevly 1992). Big science is widely theorised as part of a

"military-industrial complex" and best known for the atomic bomb and large-scale civilian nuclear power programmes; and it requires cadres of technocratic experts to administer complex systems. The "success" of the US Manhattan project in building an atomic bomb (Welsh, 2000; Thorpe, 2004, 2006) and the subsequent application of general systems theory within post-war military nuclear projects were central in consolidating and aligning politics and science around a shared belief in technocratic solutions to problems of both technical and social order. Faith in the institutional ability of science to ensure progress by producing technical and social order, the use of scientific prowess as a measure of state legitimacy and the importance of technology as a strategic state resource resulted in a period of "peak modernity" (Welsh 2000).

The commitment to large-scale techno-scientific approaches was not confined to the West but found forms of expression within Soviet Communism. Despite ideological differences and clear distinguishing features such as Lysenkoism, the commitment to national techno-scientific projects in the US and the USSR had many similarities. In both West and East nuclear techno-science agendas in particular were pursued irrespective of local opposition, general population risks, and scientific uncertainty by utilising secrecy and surveillance techniques combined with high profile symbolic declarations of national prominence and world leadership. The associated practices included denying any significant risks from the atmospheric testing of nuclear weapons and asserting the categorical safety of nuclear reactors, whilst at the same time injecting unknowing citizens with plutonium to assess the actual health effects (Welsome, 1999).

The sciences most closely intertwined with the military-industrial complex were characterized by increasing technological dependence upon the state as the scale, complexity, and cost of the necessary apparatus increased exponentially. Science became deeply embedded within the state-military nexus as an expression of a hierarchical social order extending far into the fabric of civil society. The rise of corporate big science — often in partnership with state big science projects — grew in the post-war era. In the late twentieth century the ascendancy of neoliberalism resulted in the transfer of "near market science" to the public sector and "free market competition" replaced ideological competition.

universal or distanciated. Methodologically, the actions of citizen groups can be thought of as codifying the anomalies central to Kuhnian notions of paradigm change by prioritising observation informed by situated, lived experience.

Whilst prominent left critiques continue to grant the state an important position in terms of regulatory activities, there are reasons to doubt the capacity of states to act in the collective global good due to institutionalized interests and habits of mind prioritising the national or "domestic" economy and so on. This point is underlined by the inter-state wrangling which, combined with powerful corporate lobbying over the Kyoto protocols, resulted in the dilution of the original climate change targets. Global social movements and sub-nation state actors have adopted more proactive stances as key agents of change. This is perhaps clearest in the USA where the postponement of federal-level action on climate change has been justified by a faith in the possibility of a future technological fix. Confronted by this inaction a coalition of US states have declared their own action programmes orientated towards the specific needs and political will of their citizenry. What began as a series of declarations by West Coast cities is reportedly consolidating into a North Eastern coalition of states from New Jersey to Maine with green house gas emissions equivalent to those of Germany. California, Oregon, Washington, New Mexico and Arizona (the latter a state with recent experience of extreme temperature deaths) are, at the time of writing, exploring the potential to form similar coalitions (Welsh 2007).

The implicit recognition of bio-regionalism inherent within these steps and the recognition of the value of pursuing local electoral politics by deep green social movement actors situate these initiatives within the remit of the kind of progressive anarchism for a global era advanced by Purkis and Bowen (2005). The appearance of candidates standing on anti-GM tickets across the corn belts of North America stands as another example of the fragmentary and "shifting ground" that is reconfiguring and undermining the historic political anatomy of state forms (Welsh 2006).

Far from pessimism and rejection of technological advance along primitivist lines this is an era where the potential for interventions consistent

individual member of a public to be literate in "science" sui generis. The crucial points here for anarchism lie in the importance of breaking down professional boundaries and building grass-roots collective actions aimed at understanding and engaging with science and technology in practice. Such praxis prioritises both the acquisition of fluency in expert debates and a focus upon the social contexts and relations required to apply that science.

Claims-making by informed and engaged citizens in effect constitutes the expression of a critical sub-group within a society which can intervene at the intersection of scientific advance, commercial application and prevailing regulatory standards. These struggles over environmental and health issues should not be regarded as disconnected purely local phenomena. Unfortunately, the tradition of case studies focussing primarily on epistemological stakes rather than broader theoretical issues relating to power within the sociology of science and technology has contributed to a lack of pattern recognition in terms of repetition of forms of controversy across different social and geographical contexts. Rather than being isolated phenomena, these struggles over environmental and health issues mobilizing lay expertise share common forms of struggle and patterns of organization. Together, they present a new conception of citizen science (Irwin & Michael 2003) and, potentially, a radical re-working of civil society (Chesters and Welsh 2006).

The importance of these movements in terms of anarchist praxis and social movement engagement with science lies in their ontological or social distance from the institutional habits of mind operating within institutionalised science. Whilst social movement organisations stray far into state space in their engagement with big science, social movement actors mobilizing local knowledges formalise the relevant objects of knowledge from a cognitive, political, and moral stance not primarily influenced by prevailing habits of mind. The pressure towards the democratization of science arising from such myriad local contestations remains to be adequately recognised as an emergent systemic process revealing the significance and relevance of difference in the face of "universal" laws and regulatory standards. Irrespective of whether the social groups doing this work self-define as anarchist, their praxis embodies basic anarchist principles prioritising the local or proximate over the

Neo-liberal ascendancy consolidated state sponsorship of computing and bio-technology within the knowledge economy whilst the cost of pursuing big science physics agendas like nuclear fusion required multi-state partnerships.

A free market/multi-state phase shift reconfiguring techno-science has taken place whilst residual examples of multi-state big science persist. Near market sciences, like human genetic engineering, thus carry both technical and social risks through the exercise of individual market choices raising the prospect of "neo-liberal eugenics" (Habermas 2003). Simultaneously, state legal and security resources are used to protect companies and research facilities linking environmental activism with terrorism (Welsh 2007) as global trade agreements structure and secure global markets for GM crops.

Critical commentary on the associated science and technics in all but this most recent phase shift are well established within the anarchist canon. Lewis Mumford captured the essential features of the centralised high-modern state and large-scale complex technological systems with his notions of "authoritarian technics" and "the megamachine" (Mumford 1964). Deeply affected by the use of the atomic bomb, Mumford argued that democratic culture was being eroded by the development of socio-technological systems embedding authoritarian relations of command and control and the rise of centralised global power over life and death (Mumford 1953). The existence of nuclear weapons states led by men able to unleash devastation threatening centuries of human civilization called for an urgent re-ordering of relations between science and society. Mumford's central guide to this re-ordering was the evaluation of all scientific and technical developments in terms of the potential to enhance life and human welfare and "the restoration of the organic, the human and the personal to a central place in economics" (Mumford 1954: 290).

Mumford's emphasis upon agency in the face of the megamachine deserves re-examination within the contemporary milieu where the totalising accounts of science and technology as technique, such as those of Jacques Ellul, tend to dominate. Ellul's notion of "autonomous technique" (Ellul 1965) and its centrality to what he saw — after Nietzsche — as that "coldest of all cold monsters", the modern state (Ellul 1988: 2) are important. However, the influential focus on autonomous technique

as the precursor of "autonomous technology" (Winner 1978) pre-empts the potential for social shaping of techno-science, neglecting the ways in which social actors reject, subvert and hybridise techniques vital to state-corporate initiatives (Welsh 2000: 26–27).

The techno-scientific projects of peak modernity drew on cultural narratives of rational progress which simultaneously legitimised state authority. State-centric attempts to mobilise modernity stalled in the latter part of the twentieth century as the associated narratives were increasingly undercut and challenged by new social movements, confronted by technological disasters such as Chernobyl and Three Mile Island. The increased public awareness of risk, and the fiscal burden that continued support for big science imposed on states. The decline of the nuclear industry in Britain and the US in the latter decades of the twentieth century vividly illustrates the erosion of legitimacy of narratives and forms of peak modernity. Welsh (2000) has demonstrated how the epistemic issues underpinning this process were initially formalised by citizens at a local level during the 1950s before accumulating sufficient social force to counter official pronouncements and thereby making social acceptability a central feature of science policy.

Rather than the universal acceptance of technique and the imposition of autonomous technology it is important not to lose sight of science and technology as socially contested and socially constructed enterprises. The process of contestation and construction is continuous and iterative in practise and difficult to divide up into distinct phases. Zygmunt Bauman, for example, has argued that the collapse of the USSR represented "the end of modernity, because what collapsed was the most decisive attempt to make modernity work" (Bauman 1992: 222). Whilst the end of the Cold War also threatened to undermine the legitimacy of the American military-industrial complex and associated big science projects, pronouncements of the death of modernity were premature. Modernity was in effect reinvented in the guise of neo-liberal market efficiency and rationality recasting state alignment with techno-science. The pursuit of post-Cold War American hegemony beginning with the first Gulf War in 1990 and the post 9/11 "war on terror" have seen the construction of new "grand narratives" and renewed state support for science as a component of the military-industrial complex, with projects from the missile shield

of the Earth, Greenpeace and numerous "anti-nuclear alliances" has included the independent collection of data, often in collaboration with university-based teams. Such work has related to radon gas within homes, tritium levels in fish and fruit and strontium levels in children's milk teeth. Combined with the associated media attention it has attracted, such work has been part of the background to the institutional re-evaluation of radiological protection standards. Like many other "radical" causes in the UK, an insider, in this case the former Government Minister Michael Meacher, played a key role.

Meacher established the Committee Examining the Radiation Risks of Internal Emitters (CERRIE) "on a balanced basis with all oposing views fully represented" by Chris Busby, a physical chemist by training and member of Green Audit (Busby 1995, 2007). The combination of independent observation, critical science, and this advocacy cannot be separated from the subsequent revisions in the official dose models for tritium derived from ICRP models by the National Radiological Protection Board (NRPB) (Edwards 1999, Fairlie 1992). Differences over the required magnitude of revisions in radiological protection standards, the necessary programme of further scientific work, and the need to adopt a precautionary approach in the facing of uncertainty, were formalised in a "minority report" (CERRIE Minority Report: 2004).

Such critical scientific moves remain isolated within epistemic communities unless they become amplified within the bourgeois public sphere through social movement activity (Welsh 2000). Declaring collective stakes through the mobilisation of social force via a wide range of campaigning activities, up to and including forms of direct action adds to critical scientific and technical arguments. It is important not to conflate such expressions with "anti-science" stances. Unless social force is mobilized behind scientific dissenters, critical voices can easily be marginalized and dismissed on normative social, cultural and political grounds (Martin 1999) which are exploited by contemporary "savants" defending the status quo.

This reflects Bakunin's emphasis on popular scientific literacy, a formulation implicit in the contemporary emphasis on public understanding and acceptance of science. The complexity of the contemporary stock of scientific knowledge and its applications exceeds the capacity of any

In these conflicts we can see the tensions between a science of life which acknowledges the specificity of local conditions and relations and the science of abstract universal law or statistical average (McKechnie 1996). Independent direct observation and popular epidemiology (Brown 1992) can often challenge the dominant wisdom consolidated within the institutions of science inhabited by the contemporary descendants of Bakunin's "savants". "Radiological protection" is one of the better-documented examples.

Epidemiologist Alice Stewart's examination of the medical records of women subject to x-ray examination during pregnancy revealed a correspondence between exposure to radiation and foetal abnormalities confounding International Commission on Radiological Protection (ICRP) dose response models (Greene 2001). Stewart's work suggested that the linear threshold dose model used to set official radiological protection standards ignored low-level dose effects. The idea of a threshold dose, beneath which no health effects attributable to radiation occurred, was central to the global regulatory regime covering nuclear facilities. Abandoning the threshold model and adopting more stringent standards had major implications for the economic viability of nuclear power and state liability to military personnel. Stewart and other scientists associated with the low-level radiation case became the subject of a classic scientific "controversy" verging on professional vilification lasting decades. At the same time as Stewart was collecting data on the medical uses of radiation, managers at the UK's nuclear weapons site at Windscale, Cumbria were deliberately discharging significant amounts of radiation into the environment to enable scientific assessment (Caulfied 1990: 218–219). Stewart's work finally received open acknowledgement within the radiological community in 2006, by which time a combination of viral contagion and poulation mobility was being used to officially explain cancer clusters around nuclear installations. Stewart's methodology stands as a clear example of how the systematic assessment of individual cases can result in findings which confound those derived from quantitative statistical techniques.

In the UK, long-standing engagement with radiological protection issues through groups like the Low Level Radiation Campaign, Friends

to "total information awareness". In the European Union, the bio-society was initially defined as "the conscious management of self-organizing systems for sustenance and enrichment of human life and purposes" and vital to the knowledge economy (Green & Griffith-Jones 1984:9). The mapping of the human genome in 2000 implicitly extends the potential for management and efficiency to human life itself (Welsh 2007a).

The contemporary situation is thus characterised both by the attempt to re-legitimise techno-scientific state projects of "peak modernity", such as nuclear power, and promote emergent market forms of techno-science. The accompanying grand narratives simultaneously support state power and the efficacy of the market. The failure of these new grand narratives (whether the export of "democracy", or biotech visions of progress associated with GMOs) to become hegemonic owes much to the challenges posed by social movements. The scientific and technocratic claims of neo-liberalism in economics, development, R&D, and wider social policy domains have been increasingly challenged and contested by established and emergent collective actors. From trades unions to a third generation of social movements of advancing a non-representational politics prioritising direct interest representation and action there are few areas of the so-called Washington consensus that have not been challenged (Chesters & Welsh 2006, Notes from Nowhere 2003).

Whilst the vitality of this movement of movements is attributed to the "new anarchists" (Graeber 2002) and actively addressed within contemporary anarchist debates (e.g. Welsh & Purkis 2003, Chesters 2003) the contemporary relationship between anarchism and techno-science receives little attention. We aim to redress this by showing how the key concepts and analytical concerns of Mikhail Bakunin and Peter Kropotkin relate to the work of twentieth-century writers emphasising the liberatory potential of science and technology and by examining contemporary examples of engagements with techno-science.

Bakunin's Critique of the "Savants"

Bakunin's most systematic sociology of knowledge appears in his 1871 essay *God and the State* (Bakunin 1970). The essay presents a classic

critique of religion as ideology and alienation, exposing the function of religion in pacifying society, mystifying social relations, and legitimating domination by elites. However, what makes *God and the State* as intellectually original, and provides its chief continuing relevance is Bakunin's analysis of science and the relationship between science and the revolutionary project of anarchism.

The primary targets of Bakunin's critique of science were Auguste Comte and Karl Marx, both of whom Bakunin saw as constructing blueprints for the government of society by "scientific" elites (or as Bakunin labelled them, "savants"). The idea of scientists as a "new priesthood" put forward by Comte as a programme for social and political reform was adopted as a critical term by Bakunin. The idea of a scientific priesthood for Bakunin epitomized the potential for science to become a force of hierarchy and reaction. Bakunin saw similar authoritarian and reactionary potential in Marx's notion of "scientific socialism", particularly when combined with the notion of the dictatorship of the proletariat. This combination, Bakunin argued, would tend towards the dictatorship of intellectuals and bureaucrats, justified as acting on behalf of the proletariat. These were not just critiques of the particular political programmes of Comte and Marx, but more broadly applicable formulations of a "new class theory", i.e., a theory of the potential for intellectuals and knowledge elites to constitute themselves as a new dominant class (King and Szelenyi 2004, esp. 21–34). We would suggest that Bakunin's critique of government-by-science and his political scepticism regarding expert authority can be applied not only to Comtean and Marxian social engineering, but also to the ways in which the natural sciences have frequently been partnered with the state in the government of both natural and social orders.

Bakunin celebrates science as a humanizing force expressive of humanity's break with its animal origins, and indeed a rebellious force overturning traditional and religious preconceptions (Bakunin 1970: 20–21). Yet he suggests that over time, science has tended to become routinized and incorporated into structures of power: a process akin to Max Weber's "routinization of charisma". The revolutionary prophet of science gives way to the institutionalized member of a new scientific priesthood.

Such fears are particularly prominent in the UK following categorical, though false, political assurances about the safety of humans consuming beef during the BSE outbreak, and subsequent media portrayals of GM crops as "Frankenstein Food" (Hughes 2007). Ezrahi argues that "contemporary mass electronic media culture" is central in "spreading public distrust of public authorities and institutions and the decline of mass political activism", undermining the epistemological and institutional authority of science (Ezrahi 2004: 272–273).

Depicting a "crisis" in the social authority of science as a contemporary phenomenon constituted through changes in techniques of visual representation overlooks the historically contested power relations surrounding science-society relations. Beyond issues of science communication and representation the more fundamental issue is to realise the "other science" advanced within the anarchist canon. This has the consequence of differentiating the inclusive liberal notion of the citizen, disaggregating a public or general good, and foregrounding significant biological and social differences. Sciences thus interact with publics differentially constituted through age, "race" gender, sexuality and class as well as spatial-ecological location and differing belief and value systems. Universal laws of science and universally applicable regulatory models simultaneously confront difference and the increasing capacity to communicate knowledge associated with difference via electronic media. Numerous case studies within the sociology of science (e.g. Tesh 2000) reveal how environmental social movement actors operate against scientific and regulatory stances based on high order abstractions claimed to be the basis of universal standards underpinning global regulatory reach (Welsh 2000). The basic principle in such contestations is the prioritisation of situated (Haraway 1995) or local knowledge (Wynne 1996) frequently based upon the empirical observation of categories excluded or inadequately incorporated into abstract theoretical models, models which are frequently used as the basis of complex computer-based simulations or predictive mathematical equations. Tesh, for example, details how activists accumulated data on cancer incidence in the USA based on local observation resulting in revisions to Federal level "gold standard" regulation.

some modification of an anarchist praxis for a participatory public science.

Social Movements, Science, the Environment and Health

Environmental integrity and human health are co-dependent and the increasing synergy between environmental and health social movements (Brown and Zavestoski 2004) through justice frames underlines this point (Plows & Boddington 2006). Anarchism's ambivalent relationship with science (Restivo 1994) is reflected in activists' experience and practices in both areas. Whilst establishment depictions of publics as "innovation resistant" may be ideologically useful they are difficult to sustain. Sociologist of science, Steve Yearley, is amongst those who show that environmental movements employ scientific techniques to challenge and contest dominant epistemological claims made by science (Yearly 1991). Increasingly patient groups are recognised as examples of "collective action" playing a critical role in defining relevant scientific knowledge (Rabeharisoa & Callon 2004). Such movements draw on, mobilize, and give social force to scientific knowledge claims while simultaneously challenging commercial and industrial interests, established hierarchies within and between scientific professions, regulatory, and political authorities. In terms of our argument, cases like these underline the importance of direct interest representation in the definition of scientific stakes and the scientific work necessary to explore them.

Within the sociology of science, the notion of the "co-production" of knowledge and political order (Jasanoff ed. 2004; cf. Shapin and Schaffer 1985), combined with the notion of social or political imaginaries (Ezrahi 2004), are prominent approaches addressing citizen involvement. Whilst there is a great deal of value within these approaches, it is important to recognise the dominance within such work of abstract social science categories such as "the citizen", "democracy" and "polity". A paradox thus arises as the "citizen" whose participation is sought can also be the "citizen" feared as the source of a public backlash against science.

Bakunin made a distinction between the absolute laws of nature discovered by science and the laws of government: the former being descriptive, the latter prescriptive (cf. Morris 1993: 130–131). Laws of nature, he suggested, encompassed not only causal regularities of Newtonian physics, but also regularities of human behaviour and patterns of history (although the "science of history" was in its infancy). Nevertheless, Bakunin rejected any role for scientists as philosopher kings, as a Baconian-Comtean "learned academy", or as Marxist scientific party intellectuals, handing down directives to the masses based on knowledge of these natural and social regularities (Bakunin 1970: 30–31). In rejecting these institutionalizations of scientific authority, he provided the key insights of his political theory of science.

Bakunin asserts that there is a difference between accepting a fact of nature based on one's individual reason and sense experience, and accepting it on the basis of deference to the authority of the expert. But his critique is more complex and sophisticated than just the liberal empiricist idea that individuals should trust experience over authority. He recognized that it is not always possible to rely on one's own senses and that there therefore exists a cognitive division of labour. So his writing acknowledges the "authority" of a variety of "savants" or experts whilst emphasising that the acceptance of this authority is an act of individual rationality, not subordination (Bakunin 1970: 33). The key distinction is between being "an authority" and being "in authority" (Friedman 1990: 76–80). The scientific thinker is legitimately "an authority" in their field, but the Comtean idea of the "new priesthood" illegitimately seeks to place scientific intellectuals "in authority" as rulers of society.

Bakunin argues that any attempt to translate scientific knowledge into governmental omniscience faces insuperable barriers. These are firstly limits on the knowledge of any individual. There can be no "universal man", no genuine polymath (Bakunin 1970: 34). The growth and increasing complexity of the stock of knowledge makes us increasingly interdependent, fostering mutual aid. But even more fundamentally for Bakunin, it is one thing to know abstract science, but it is another thing to apply that science to life.

This distinction between science and life is the key axis around which Bakunin's epistemology and sociology of science and his defence of

freedom against the dominance of experts turns (Knowles 2002: 10–11). Science is abstract and general, but life is concrete and particular. For Bakunin, "[s]cience comprehends the thought of the reality, not reality itself; the thought of life, not life. That is its limit, its only really insuperable limit" (Bakunin 1970: 54). All knowledge is mediated through human perceptual and interpretative faculties, introducing an inescapable element of contingency. The ordering of the world into categories involves a process of abstraction. Such abstraction is necessary for the generation of knowledge, but we ought not to think that our abstract acounts of reality can capture the complexity of reality itself (Bakunin 1970: 54–55).

For Bakunin, this gulf between science and life means that the technocratic ideal of a society legislated for and ordered by savants would be unworkable (as well as being tyrannical). The Comtean ideal of a system of government based on a universal science of sociology runs into the problem of the inherent limits of abstract social science faced with the particularity of individuals within society:

Positive science, recognizing its absolute inability to conceive real individuals and interest itself in their lot, must definitely and absolutely renounce all claim to the government of societies; for if it should meddle therein, it would only sacrifice continually the living men whom it ignores to the abstractions which constitute the object of its legitimate preoccupations (Bakunin 1970: 60–61).

Individual freedom eludes the determinism of scientific law precisely because of the particularity and concreteness of the individual which escapes abstraction. The complexity and richness of the concrete and particular life always escapes scientific description: "Life," Bakunin writes, "is wholly fugitive and temporary, but also wholly palpitating with reality and individuality, sensibility, sufferings, joys, aspirations, needs, and passions" (Bakunin 1970: 55). All science, whether natural or social, is inherently limited by its abstractness.

However, Bakunin suggests that the scientific intellectual is wedded to abstractness, indeed that the very mark of such an intellectual is the fetishism of abstract knowledge. This fetishism can involve the confusion of description for reality, in the assumption that life is just as it is described by science. It can involve also the privileging of abstract

Further, in posthumously published work, Feyerabend advances a critique of the fetishism of abstract knowledge which echoes Bakunin's critique in *God and the State*. The echo is presumably unwitting, although the Hegelian notion of "totality" seems to be a shared influence. Conceptual and theoretical abstractions, Feyerabend argues, remove entities from the totality in which they exist. When abstract knowledge is fetishized and reified "the remains are called 'real', which means they are regarded as more important than the totality itseld" (Feyerabend 1999: 5). As one interpreter of Feyerabend's account puts it:

There is no escape: understanding a subject means transforming it, lifting it out of a natural habitat and inserting it into a model or theory or a poetic accout of it." What Feyerabend objects to is the commitment to the results of this procedure of abstraction as a reality, to the exclusion not only of other abstractions . . . but of features of experience that may be important to us for many sorts of reasons (Munevar 2002: 522).

This is strikingly close to Bakunin's account of "life" as constantly escaping attempts to capture it through abstract reasoning. And it has a political implication in line with Bakunin's emphasis on the need to "remand science to its place" through breaking down institutionalized hierarchies of epistemic authority. The critique of abstraction supports Feyerabend's earlier claims for democratic involvement of laypeople, and supports the kinds of initiatives carried forward by new social movements. For these initiatives operate precisely to counteract the tendency by professionals to fetishize abstractions. So Feyerabend's decentring — not rejection — of scientific authority supports the argument that the voices of the citizens' initiatives do not have to be expressed in the language and terms of established scientific disciplines. The declaratory posture of citizen groups formalises sets of claims and relationships which in a democratic society should be granted legitimacy and access to the necessary resources required to evaluate them.

Feyerabend's account of lay supervision of science has little to say about how these social forces can be constituted, i.e. what types of collective action can generate momentum towards an inclusive democratic process of the kind which he advocates. Since Feyerabend wrote, however, there has been an explosion in the kind of incremental citizen initiatives he proposed and a consideration of this experience permits

dealings in this area (Feyerabend 1982: 107). His argument that "[l]aymen can and must supervise science" (Feyerabend 1982: 96–97) recognised that discipline-based scientific knowledge acting in conjunction with other influences of "standpoint" (e.g. employment in particular commercial, industrial, or political organisations) tended towards a closed circuit of elite communication. His point that "[o]nly rarely does it occur to them that it is not their business but the business of those immediately concerned to decide the matter" (Feyerabend 1982: 118) recognises the anarchist principle of direct representation (Franks 2003).

Mature democratic behaviour "is learned by active participation in decisions that are still to be made" (Feyerabend 1982: 87) based on the disclosure of all available and necessary information and due time for the necessary deliberation, however frustrating the necessary timescales may be for technocratic and authoritarian demands for snap decision-making. This process of iterative and incremental learning and transformative engagement is Feyerabend's preferred mode of social change towards his free society rather than revolution (Feyerabend 1982: 107). Again, this is consistent with the elements of the anarchist tradition reflected in the emphasis on libertarian education as a path for social change, for example in Francisco Ferrer, or the peaceful gradualism advocated by anarchist thinkers such as Paul Goodman (Woodcock, 1986 and Ward 1982). Popular engagement and deliberation in relation to science and technology could be regarded as a potential feature of what George Lawson has termed "negotiated revolution" (2005).

Epistemologically, Feyerabend recognised that there are many sciences with different sets of standards and rules (Feyerabend 1982: 23), arguing that scientific practitioners should act as guides to, rather than authorities on, their specific terrains within open deliberative forums. As guide, a practitioner's role includes recognition of the limits of established theorising and the necessity of developing new methods and means of engagement. Recognising the limitation of scientific models, particularly in the face of complex open systems, results in the commonsense view that theoretical or laboratory science is insufficient to render social and political decisions, which depend much more on practical reason.

knowledge over concrete life. For this reason, Bakunin describes scientific intellectuals, alongside theologians, as "priests of abstractions" (Bakunin 1970: 59–60). He suggests that the scientific intellectual posits abstact or codified knowledge as superior to concrete life in a similar manner to the fetishism of religious doctrine or of a transcendent divine order. The fetishism of abstract knowledge constitutes a social group of intellectuals, a new priesthood, outside and above concrete life. Science has been 'constituted outside of life, it is represented by a privileged body; and . . . it has posited itself as an absolute and final object of all human development" (Bakunin 1970: 60).

The prioritisation of abstract knowledge over concrete life tends towards the governance of the concrete, particular, and quotidian by the representatives of abstraction. Further, Bakunin suggests that where the gap between scientific abstract ideas and reality becomes apparent, the scientific priesthood attempts to mould reality in the image of the abstract idea. As science feels its "vital impotence" (Bakunin 1970: 55) in the face of the intractable complexity of life, it seeks to discipline life (social life and nature) to fit its abstract models. Hence, the scientific will to knowledge becomes a will to power. Science becomes, therefore, "the perpetual immolation of life, fugitive, temporary, but real, on the altar of eternal abstractions" (Bakunin 1970: 57). For Bakunin, vivisection, as a literal sacrifice of life, embodied this tendency. Whilst Bakunin thought it "well nigh certain that a savant would not dare to treat a man today as he treats a rabbit", he suggested that if science was denied access to "the bodies of individuals, they will ask nothing better than to perform [experiments] on the social body"

Bakunin's use of experiments "on the social body" was aimed at Comtean and Marxian schemes to reorder society according to a social scientific model. However, a 21st century perspective extends the scope of the idea with critical science studies scholars in India using the term "vivisectionism" to refer to the Western project of dominating nature through science and technology in combination with a colonial arrogance, as exemplified in the Bhopal disaster (Nandy, 1988). The big science ambitions of democratic states have resulted in experiments on citizens such as injecting human subjects with doses of plutonium and ordering soldiers to march towards atomic mushroom cloods akin to those

which Bakunin thought even the savant would eschew (Welcome, 1999; Moreno, 2000). Experiments on the social body have been conducted by both social and natural scientists. High-risk, complex technological systems such as nuclear power stations are always "real-world experiments" since theoretical laboratory-based models can neither adequately predict the complex interactions of their components with the subjectivity of human operators nor the behaviour of radionuclides in open environments. Significant reactor accidents at Windscale in 1957, Three Mile Island in 1979, and Chernobyl in 1986 all involved gaps in scientific and/or technical knowledge, combined with operator actions or errors, underlining the way in which modern techno-science routinely jeopardises the natural and social world (Krolin and Weingart, 1987; Weingart, 1991, Welsh 2000). The introduction of genetically modified organisms into open ecological systems is similarly an experiment conducted in and with the real natural and social world (Levidow 2007).

Further, Bakunin's idea of attempts to subjugate life to abstract ideas could be applied to the techno-scientific re-engineering of nature. The reduction of ecological complexity to monoculture in agricultural biotechnology, which reaches its apotheosis in cloning (Bowring 2003), brings to mind Bakunin's statement that "every time that scientific men, emerging from their abstract world, mingle with living creation in the real world, all that they propose or create is poor, ridiculously abstract, bloodless and lifeless, still-born." (Bakunin 1970: 55). Whether intended or not, a powerful and strikingly contemporary ecological message can be found in Bakunin's conception of "life", just as it can be found also in Kropotkin's *Mutual Aid* (1902).

This dominatory aspect of modern science, for Bakunin, derived from its hierarchical organization and relationship to the broader society. In that sense, Bakunin was describing what Bookchin termed an "epistemology of rule" — structures of thought or "mentalities" that are patterned after and reinforce "lines of command and obedience" (Bookchin 1982: 89). The separateness of science from life and the quest of science to master life, derive, Bakunin suggests, from the position of science in a structure of social hierarchy and domination. The impulse toward

Bookchin has little to say about how this liberatory science would be organised, although it is fair to assume that the breaking down of professional monopoly is a requisite for him also, following from his firm rejection of any "environmentalistic technocracy" (Bookchin 1982: 314). Sociologist of science Brian Martin has set out more concrete and practical proposals for achieving an anarchistic approach to science. He has made practical proposals for activists to confront, challenge, and debunk expert testimony (Martin 1991) and has gone some way to setting out an "anarchist science policy" aimed precisely at rescuing science from "professional monopoly". Like Bakunin and Kropotkin, Martin is optimistic about the possibility of a science collectivized, popularised, and distributed as a common "self-managing" social activity. Martin's work emphasises the significance of social movement actors as social forces constitutive of a peoples science, capable of challenging technocratic legitimations of state agencies. His work thus highlights the importance of the interaction between such actors and the prevailing institutional structures of science (Martin 1979, 1980, 1994).

Social Movements and Science

A philosophical manifesto for new social movement engagement with science, and an updating of some of Bakunin's key arguments, can be seen in the work of the philosopher of science, Paul Feyerabend. Whilst Feyerabend's work on the philosophy and history of science is best known for the catchphrase "anything goes", (Feyerabend 1975/80), his response to the ensuing debates, *Science in a Free Society* (Feyerabend 1978/82), remains less well known. In this book, he self-identifies as an "epistemological anarchist" but not as an advocate of "political anarchism". Despite this, *Science in a Free Society* does go beyond epistemology to develop a libertarian political philosophy of science.

Feyerabend's writing prefigured contemporary debates and experiments in citizen science, arguing that "participating in citizens' initiatives" was the minimum requirement to achieve wisdom and justice in

science. Like Bakunin, Kropotkin saw that the social extension of science required its epistemic transformation. Crucially, this would require and make possible the breakdown of the division between mental and manual labour, the "pretext" (Kropotkin 1998: 169), around which science was constructed in class society resulting in a fundamental distortion of the scientific ideal (Kropotkin 1927: 101). Whilst the early modern science of Galileo and Newton "did not despise manual work and handicraft" (Kropotkin 1998: 169), modern science becomes compromised through the class-based separation of science from manual labour and the related distinction between pure and applied science. Kropotkin therefore calls for the collective and popular organization of scientific work (Kropotkin 1998: 182; Smith, 1989). For Kropotkin, science should not be the property of an elite, but a participatory-democratic activity practised in common in free association. In this way, Kropotkin, like Bakunin, sought to root science in life, and in the common life of society.

Bakunin's critique of a science separate from life also finds more recent echo in Murray Bookchin's *The Ecology of Freedom*. Bakunin's protest of life against a mechanized, hierarchical, and alienating science is ecologized by Bookchin. Bookchin puts forward an epistemology that privileges the concreteness of nature against abstractions of theory or reductionism in language reminiscent of Bakunin, Bookchin writes: "To recover the supremacy of the concrete — with its rich wealth of qualities, differentia and solidity — over and beyond a transcendental concept of science as method is to slap the face of an arrogant intellectualism with the ungloved hand of reality" (Bookchin 1982: 308). Bookchin's presentation is even vaguer than Bakunin's or Kropotkin's when it comes to setting out what this new approach would actually entail. Presumably, Bookchin, with his influences from Hegel and Marx, would not accept a narrowly empiricist or inductivist account of science as just the accumulation of facts. His presentation in *The Ecology of Freedom* is somewhat allusive. Nevertheless, Bookchin sums up the essential purpose and spirit of the anarchist engagement with science when he asserts that the critique of existing science does not entail a flight to irrationalism: "Just as we can justifiably distinguish between an authoritarian and a libertarian technics, so too can we distinguish between authoritarian and libertarian modes of reason" (Bookchin 1982: 302–303).

the domination of life is driven by the existence of science as a privileged class or professional monopoly, with institutionalized interests in maintainig hierarchy and power (Bakunin 1970: 63).

Toward a Liberatory Science

Bakunin called for "the revolt of life against science, or rather against the government of science" (Bakunin 1970: 59, emphases in original). But he explained that what he meant was "not to destroy science — that would be high treason to humanity — but to remand it to its place" (Bakunin 1970: 59). Remanding science to its place means abolishing the hierarchical relationship between science and the life of society. Against the monopolisation of scientific knowledge by a priestly hierarchy, Bakunin urged a Reformation of science targeting the established social institutions which simultaneously consolidate its power base and ossify its theories.

The tension between recognizing science as "indispensable to the rational organization of society", on the one hand, and strenuously avoiding government by science, on the other, can, Bakunin says, "be solved only in one way: by the liquidation of science as a moral being existing outside the life of all." Instead, science "must be spread among the masses". This social democratization of science, Bakunin suggests, will tend to break down the epistemic separation of knowledge from life: "it will become one in fact with the immediate and real life of all individuals." Through this process of democratization, science can begin to play its genuine historical role as "the property of everybody", science can "represent society's collective consciousness" (Bakunin 1970: 62).

But is Bakunin's conception of a democratized science and the dissolution of the divide between science and life merely utopian fantasy? Bakunin suggested that rebelling bourgeois students could act as "fraternal instructors of the people" (Bakunin 1970: 64). Yet, characteristically, he left the detail of an anarchistic organization of science unspecified. The key concrete measure discussed is the extension of scientific education to the mass of the population and the development of an "integral education" breaking down the division between mental and manual work

(Bakunin 1869). This is consistent with anarchist aversion to laying out blueprints and the desire to let emancipated people discover modes of association for themselves. Bakunin probably thought that a liberatory science would organically emerge from a society in which hierarchy had been dissolved. Yet, it is clear to us that the development of liberatory and participatory forms of science and technology cannot be projected idealistically into the future, but must develop simultaneously and hand-in-hand with any broader liberatory movement. As we go on to argue below, participatory forms are indeed discernible within contemporary social movement milieux.

Whilst liberal thinkers such as the American philosopher John Dewey call for the dissemination of scientific knowledge, method, and habits throughout the polity, Bakunin's vision was that science itself would be transformed in this process with radical democratization fundamentally reordering the epistemic values and goals of science and the relationship between theory and phenomena. So whereas liberal philosophers have frequently treated science as a model polity, for Bakunin, science and its epistemic values were to be modelled on (and thereby assimilated into) the ideal polity.

The notion of the transformation of science in line with anarchist principles is also found in the work of Peter Kropotkin. As a naturalist[1], Kropotkin emphasized the role of scientific knowledge in providing an empirical and theoretical foundation for anarchist political ideas (Todes 1993, Morris 2002, 2003). To Kropotkin, the political ideal of mutual aid could be scientifically demonstrated to ba a fundamental principle of nature, in that way naturalizing the anarchist polity. He asserted that anarchism as a political movement was founded on scientific principles: "Anarchism is a world-concept based on a a mechanical explanation of all phenomena . . . its method of investigation is that of the exact natural sciences, and . . . every conclusion it comes to must be verified by the

[1] Kropotkin was a naturalist in all the relevant senses of the word. He was a biologist and zoologist. He was also a naturalist in the epistemological sense of one who believes that knowledge has to be based on the observation of natural phenomena. And he was what philosophers call an "ethical naturalist", i.e. someone who regards moral ideas or critieria as based on observable features of the world.

method by which every scientific conclusion must be verified" (Kropotkin 1976: 60).

His rejection of metaphysics and the Hegelian and Marxist dialectic favored "natural-scientific method based on induction and deduction" (Kropotkin 1976: 62). Much of his discussion of science in "Modern Science and Anarchism" appears to be naive empiricism and hints at latter-day logical positivism (however, see Morris 2003). But in other ways, Kropotkin's views on science can be seen to echo Bakunin's. Kropotkin's avowed privileging of the inductive method — building theory via the accumulation of empirical evidence and subjecting it to empirical verification — can be seen as equivalent to Bakunin's prioritization of concrete life over abstract theory. So, while Kropotkin describes anarchism as following the scientific method, he also asserts that "the anarchist movement sprang up in response to the lessons of actual life and originated from the practical tendencies of events." Anarchism was not an attempt to model politics and society on theory; rather, it "originated . . . from the demands of practical life" (Kropotkin 1976: 64,63). Interestingly, the inductive method also mirrors the structure of Kropotkin's ideal political structure of anarchist federalism. Just as in an anarchist federation of communes, where primacy is given to the grassroots, in the cognitive structure of induction — the concrete grassroots of observation is privileged over the autocracy of high theory. Kropotkin could therefore be seen to be constructing a conception of science congruent with the political order of anarchism.

It is also clear that Kropotkin shares Bakunin's view that the professional monopoly of science by the "savants" has to be broken. So, despite his assertion of the close relationship between science and anarchism, Kropotkin emphasized that "[n]ot out of the universities . . . does anarchism come . . . anarchism was born among the people; and it will continue to be full of life and creative power only as long as it remains a thing of the people" (Kropotkin 1976: 57). Science was not born among the people: "most [men of science] either belong by descent to the possessing classes and are steeped in the prejudices of their class, or else are in the actual serivce of the government" (Kropotkin 1976: 57). But Kropotkin thought that science too had to become "a thing of the people". In other words, the possessing classes had to be dispossessed of