

Plants, people and health: Three disciplines at work in Namaqualand

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In Paulshoek, Namaqualand, three research projects focusing on medicinal plants were developed concurrently. The projects were based in the disciplines of anthropology, botany and chemistry. In this paper, we explore how these projects related to one another and describe the conversations that occurred in the process of searching for transdisciplinary knowledge. The projects ostensibly shared a common object of knowledge, but it was through working together that the medicinal plants constituted us as a community of scholars. As our insight into our respective disciplinary relationships with the plants grew, so did our understanding of the limitations of our respective disciplinary positions. The process made possible a 'reimagination' of both the object of study and our relationships to it and to one another. The research project, conceptualised in 2009, engaged current debates on indigenous knowledge and its historical erasures, and offered an approach that has potential to produce new knowledges while respecting the integrity of the disciplines. This approach requires a non-competitive attitude to research and one that acknowledges the contributions that can be made by multiple approaches.

Introduction

Historical divisions between the sciences and the humanities that reach back to the origins of modernist thought have long inhibited a productive conversation across disciplines. Different ways of establishing what counts as evidence, how it counts, and how to account for it, mean that when a botanist, a chemist, an anthropologist, a *kruiedokter* [herbal doctor] or a goatherder attend to something as apparently self-evident as plants in the veld, we notice different things, name objects differently, and put them into our respective scholarly dialogues in very different ways. Good science and reliable knowledge matters deeply to all of us, and for that reason, we are mindful of the vital role that our respective disciplinary gatekeepers play, whether they are peer reviewers, discussants in departmental seminars, or examiners of dissertations. It is not easy to write 'outside' of our disciplines, because disciplines serve literally to 'discipline' the methods of establishing understanding, making it difficult to sustain generative transdisciplinary conversations.

This paper reports on an exploration in talking in disciplinary parallel (each with our own disciplinary language) and in sharing findings. It is also about a process of developing new approaches to the objects of our enquiry and forging new relationships with them and with one another. The exploration involved 'respectively and variously meet(ing) the differing epistemic requirements and methodological obligations of knowing' in the three disciplinary scientific communities as well as among the *kruiedokters*.¹ It also involved accepting that, as research interests converged and our understandings were each enriched with new disciplinary nuggets, there was not a single knowledge of the plant waiting to be uncovered but rather many, to which we were each contributing.

This paper is consciously an exercise in transdisciplinarity. There are four elements of transdisciplinary research: a focus on life-world problems, transcending and integrating disciplinary paradigms, participatory research and the search for unity of knowledge beyond disciplines.² The method has an integrative effect that calls for holistic approaches:

*The notion of the ecosystem is central to representing the world and its functioning, cycles, equilibria and dynamics. We are dealing here with coherences, balance sheets, and not with the absolute objectivation of the things that make up the world. There is no longer truth per se, about the complexity of the world, but knowledge that is more or less complete, and therefore uncertain.*³

Knowledge making – the 'doing of research' – does not occupy a neutral ground free of vested interests. This fact is never clearer than in colonial settings such as South Africa, where eugenics established itself as a racist form of science that justified the colonial and apartheid projects which entrenched racial (and other) inequalities.⁴ In South Africa today, scholars working in a postcolonial democracy continue to face challenges, the most visible of which have been struggles over plant medicines and HIV. Both disciplinary stricture and political prescription can stand in the way of developing new knowledge.

Living and working in a democracy in which historical redress is an important issue in the conduct of research, tax-funded researchers bear a responsibility to the public to ensure that the knowledge in terms of which governments

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make decisions is not only accurate, verifiable and reliable, but also takes account of perspectives that have historically been marginalised. The intensity of the debate over indigenous knowledge and antiretrovirals in South Africa amply underscores this point.⁵⁻⁹

We began to open a dialogue about people, plants and well-being in a small village called Paulshoek in Namaqualand in 2009, in the wake of the struggle over antiretrovirals, on our respective ways of producing knowledge about the relationship between plants and people. The question we sought to pose together was what different 'knowledges' would we produce if we worked together to understand the plants and people in Paulshoek. Determined to take seriously both the benefits of disciplinary philosophies and methods, and to consider ways of bridging the gaps between the approaches, a project was conceptualised that involved three distinct studies in the same area concerning plants and plant medicine. Over time, the project became the 'ABC Project': Anthropology, Botany, Chemistry, reflecting both our respective disciplines and the challenge of 'beginning at the beginning' – to find the beginnings of a common language in which our respective studies could be brought into what Verran and Christie¹⁰ so aptly called a 'generative dialogue'. Since that early set of conversations in 2009, one PhD has been completed, with another two PhD studies close to completion. Each study engaged with at least two of the three disciplines through a series of workshops and dialogues that included all parties – supervisors, graduates and transdisciplinary specialists.

The project builds on Timm Hoffman's extensive multi-year study of people–plant interactions in the area,¹¹ much of which derives from ongoing work with Paulshoek resident, Marianna Lot, with whom all the researchers in turn came to work. Questions about plant chemistry led to a dialogue with organic chemist David Gammon, and over time, both Hoffman and Gammon found themselves in conversation with a number of *kruiedokters* based in the area. At that point, a conversation opened with Lesley Green, an anthropologist interested in postcoloniality, democracy and knowledge.¹² Three graduate studies emerged in the course of this three-way conversation: the ethnobotanical, phytochemical and metabolomics of plants (undertaken by Nicola Wheat), systems biology approaches with the incorporation of the socio-biome for plant natural products chemistry (undertaken by Amelia Hilgart) and the work of *kruiedokters*, the experiences of their patients and the multi-layered setting in which plants are called upon to affect human well-being in various ways (undertaken by Joshua Cohen).

Visiting scholar Helen Verran, a trained chemist and a reader in the history and philosophy of science, who has written extensively on knowledge and culture in West Africa and Australia, became a much valued participant in discussions during her visits to South Africa. Throughout the project, Robert Morrell of the University of Cape Town (UCT) Research Office worked alongside the team to hold open the scholarly conversation in a terrain that was immensely challenging, and which has led to insights about 'the bigger picture'. Here, natural and social science knowledges took up a different kind of relationship to one another than that of the initial framing of our interdisciplinary project.

Initially after developing research questions that straddled disciplinary interests, the actual work of the various teams sought to answer these questions via strong disciplinary methodologies. The goal was to hold open conversations about our findings as they emerged. Once the respective PhD projects were close to completion, we met together regularly to discuss our findings and to try to understand where the conversation between our respective ways of working lay, and what the topics of conversation might be. The slow unfolding conversation that we had over several months included sharing understandings, working through misunderstandings and, perhaps most valuably, seeking to understand why our different questions and ways of working mattered so deeply to each of us. Working in this way, the collective began to glimpse a set of puzzles that could in some way be attended to by the particular affordances offered by each discipline, where each could be recognised and valued as contributing on its own terms.

Our particular research objects began to come into focus: the chemist's antimicrobial molecules, the anthropologist's rendering of the

bossiedokter's [bush doctor's] idea of *krag* (strength, energy or vitality) and the botanist's account of phenological cycles. Once these objects were clearly in focus, we could start a conversation about why and how these research objects mattered, historically, socially and scientifically and why they were objects of concern. Doing so, we argue, rendered us no longer mute in the face of one another's facts and reasonings, but rather offered possibilities for different disciplines to find their voice within our collective. Learning to explore our differences explicitly but jointly, we learned to respect medicinal plants as differentially knowable. We could glimpse how those differentiations, in being respected, suggest just and efficacious organisational approaches to managing plants.

In this article, we seek to offer an account of the kinds of conversations we have had, both in our particular studies and with each other, with a view to thinking through the challenges to transdisciplinary studies in the context of postcolonial debates over knowledge in South Africa. In our case it remains a conversation that is characterised by frankness, humour and collegiality, and it speaks directly to much wider international conversations on the problem that lack of accountability of scientific experts to publics weakens democratic debate.¹³ Moreover, the extent to which all of us generate different kinds of facts makes it all the more evident that different approaches within and without the academy have contributions to make to improving our understanding of what is referred to universally simply as 'health'.

Where knowledge producers at universities have for centuries been locked in an adversarial relationship with one another over the conditions for the production of truth about nature, the recognition of the wider social and historical context of scholarship provokes a more humble relationship to 'the facts' that we produce – which in turn offers the beginnings of a more convivial conversation, akin to what Latour speaks of as 'scholarly diplomacy'.¹⁴ Yet such a space is only just emerging and needs constantly to be tended and protected, particularly as opening up transdisciplinary conversation renders academics vulnerable to ripostes from colleagues who are more comfortable in the centre of a discipline. With these goals in mind, in this article, we set out the findings of the respective studies, presenting them each in terms that are defensible within their own disciplines, then work around and between them to open up the question of whether transdisciplinary knowledge production is worth the trouble it brings.

Three disciplinary studies

Phenology: A botanist's view of seasonal plant changes

The study begins with the work of botanist Timm Hoffman. Botanical studies of plant life in the Succulent Karoo biome describe some of the richest diversity of plant life on the planet. For this reason, Hoffman, like many other South African botanists, was drawn to the semi-desert conditions in the Northern Cape where he and his students have focused on the plants of Paulshoek and the broader Kamiesberg area for 15 years.

Hoffman gives this narrative account of his project:

I recorded the phenology (the seasonal cycles) of a wide range of different species in Paulshoek over a long time period to, firstly, add to existing information about each species (e.g. in www.PlantZAfrica.com) and, secondly, to help with the interpretation of the livestock production system data that I had been collecting in Paulshoek over the same length of time. I wanted to develop an understanding of how each species 'behaved' in response to rainfall, temperature and grazing over long periods. I hoped to use these insights to develop a better sense of the ecological 'integrity' or health of a landscape and to add to the wider range condition assessment literature.

Because the Succulent Karoo biome receives most of its rain in the form of relatively predictable frontal systems, previous work has emphasised the predictability of plant responses to low but

regular rainfall.^{15,16} However, few studies have investigated the response of different growth forms (e.g. bulbs, annuals, grasses, leaf-deciduous shrubs, leaf-succulent shrubs, trees) over long time periods to describe their phenological responses. In late 1999, 70 species from different growth forms were identified and their phenological response monitored on a monthly basis. The same approximately 300-m route was usually walked each month and three or four individuals from a species, sometimes more, were used to establish a general phenological profile for each species for each month. From these qualitative observations, it was possible to document the overall response of the community of plants to drought and high rainfall periods.

Despite apparent regularity and phenological consistency, long-term observations suggest that growth within the Succulent Karoo is remarkably variable from year to year, largely in response to rainfall. For the 4 years indicated in Figure 1, rainfall varied not only in the amounts which fell each year (2003 = 123 mm, 2005 = 202 mm, 2006 = 200 mm, 2011 = 304 mm) but also in distribution. In some years, such as during the extensive drought of 2003, almost no rain fell until September, while 2005 was characterised by an abundance of early season rainfall followed by a relatively dry late winter and spring.

These results suggest that the Succulent Karoo is predictable but also that the vegetation responds to discrete rainfall events. The implications of these findings are that livestock farmers need flexible approaches to management in order to accommodate such variability.

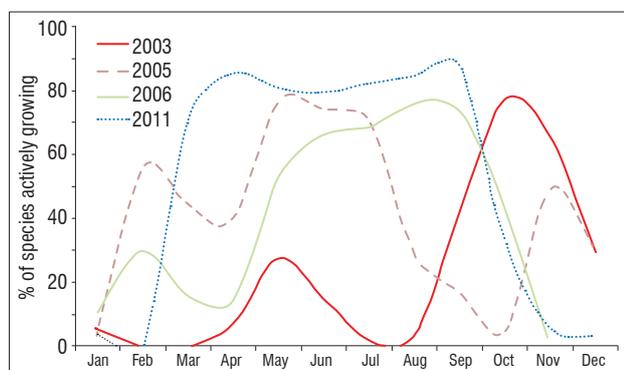


Figure 1: The percentage of species ($n=70$) with evidence of new shoot growth (i.e. actively growing) in each month in 4 different years in Paulshoek.

Organic chemistry: Searching for the chemistry of medicinal plants

The tentative beginning of an interdisciplinary project came about when Gammon encountered the work of Hoffman and together they began to conceive the possibility of adding new dimensions and insights to their respective endeavours. In particular, an idea explored was the extent to which insights at the molecular level, below the resolution of the human eye, aided or not by magnifying instruments, would complement or inform Hoffman's phenological observations. Gammon's preliminary formulation of the potential scope of the collaboration started from the classical definition of natural products, and noted not only the solid scientific edifice that now defines natural products science, but also the tensions associated with new technological developments and a greater

awareness of the challenges at the interface of where the chemical entities are located and harvested.

Gammon gives his account of the kinds of scientific research pursued by natural products chemists:

Natural products chemistry has classically concerned itself with small molecules present as secondary metabolites in living organisms – plants, fungi, microbes, and so on.¹⁷ The structurally diverse secondary metabolites¹⁸ are so called on the basis of appearing to not be directly necessary for growth and development of organisms, as opposed to primary metabolites such as lipids, nucleotides, amino acids and organic acids which are involved in essential metabolic processes. Secondary metabolites have received a great deal of attention because of the array of uses and activities that they exhibit, and, more recently, through recognition of their adaptive role and ecological functions.

Historically, natural products chemistry has, through its primary focus on careful analysis of extracts of natural materials and separation of the complex mixtures in pursuit of single, pure chemical entities, led to the discovery of new substances with pharmacological or other activities. The field has been dominated by a strong drive to discover new drugs or drug leads¹⁹ and to contribute broadly to improving healthcare, although this has not been the only motive, with research fields such as chemical ecology having significant traction.

However, over the last decade or two, the discipline of natural products chemistry has been caught in a tension of introspection, on the one hand, and something of a renaissance on the other. Leading practitioners like Cordell and others¹⁸⁻²² have been calling for an urgent reappraisal of the importance of natural products research. They suggest that natural products chemists should face up to the unavoidable challenges of provision of medicines and healthcare for a burgeoning world population, particularly in parts of the world where the majority of people have limited access to 'first-world' medicine, while at the same time calling for greater sensitivity to the environment and raising questions about who benefits from the research. In issuing these challenges, they however do not acknowledge the role of indigenous people living within and from the biodiversity, in terms of knowledge production or dissemination. This issue is notably taken up by Etkin and Elisabetsky in their analysis of papers published in the Journal of Ethnopharmacology over a 25-year period since the inception of the journal, where, despite the stated intentions of the journal, they conclude that:

*Much of what is reported as ethnopharmacological research is comprised by decontextualised catalogues of plants and lists of phytoconstituents and/or pharmacologic properties [and] few researchers in ethnopharmacology seem to be interested in the people whose knowledge and identity are embodied in these plants. While some studies are based on plants drawn from indigenous pharmacopoeias, most of what is published as ethnopharmacology has a weak, if any, ethnographic component.*²³

With these concerns in mind, Gammon and Wheat conceived a project which integrated contemporary approaches and considerations. The combined insights of Hoffman and anthropologist Lesley Green were considered invaluable in 'hearing' the alternative voices which several natural products chemists were seeking to bring to the fore. An additional interest for Gammon in particular was to contribute to the search for bioactive ingredients in plants, and to consider the extent to which new field technologies could be applied in ways that could contribute to teaching sciences in local schools. With this in mind, a 'field-deployable bioassay kit' was used. This kit was developed by the Global Institute of Bio-Exploration based at Rutgers University. It allows for simple, small-scale, in-the-field, preliminary assays of standardised plant extracts for broad-spectrum bioactivity, thus minimising the impact on the environment of removing quantities of plant material.²⁴ Wheat's study utilised these assays and validated them by comparison with more sophisticated, laboratory-based assays. In addition, the goal was to explore the scope and limitations of liquid chromatography–mass spectrometry and high-field nuclear magnetic resonance techniques, with appropriate data handling, for fingerprinting of extracts, correlation with bioactivity profiles and general preliminary assessment of plant extracts. The information from these methods of analysis enabled more efficient metabolomic profiling and offered an improved search for active constituents.

Nicola Wheat, the PhD candidate who worked with Gammon on the project, describes her entry into the work:

My first visit to Paulshoek was in 2004 as part of a 10-day Botany Honours field trip led by Timm Hoffman. In the village we stayed in traditional reed mat houses (matjieshuise) in the camp site. That evening, the village women came to make us supper, the children sang and people played an 'action' version of dominoes that involved loudly slapping dominoes down on the table in quick succession. The next morning Timm took us to his research sites around the village and Oom ['uncle', used as a form of respect] Samuel took us on a walk through the veld, showing us important plants of the area. That evening there was a talent competition with much singing and dancing. We left the next morning. That was the beginning of my relationship with the people and plants of Paulshoek.

In 2008, 5 years later, with an MSc and some work experience behind me, I was considering a PhD and visited the student advisor for chemistry for advice. He knew of David's endeavours to get a plant research team together and promptly referred me to him. David suggested a PhD on the chemistry of medicinal plants, with Paulshoek as the research site. With my background in botany, having worked with Timm and previously visited the area, all I needed was to complete a few additional chemistry courses and I was ready to start. I spent the next year taking chemistry courses, attending lectures and getting up to speed on plant and medicinal chemistry before starting my PhD in 2010. What was originally envisioned as a purely chemical analysis of medicinal plants and their constituent bioactive compounds turned out to be so much more, allowing me to work with a variety of people in a way I had not imagined.

For her doctoral project,²⁵ Wheat asked whether a study of medicinal plants from several different disciplinary vantage points could indeed produce an integrated approach to drug discovery from natural products. The project included broad-level ethnobotanical and anthropological studies with more focused metabolomic and phytochemical studies to better understand the pharmacological basis of culturally significant plants. Wheat set out to interrogate the widely held hypothesis that

traditional knowledge, when considered from a scientific point of view, can act as a proxy for detecting bioactive molecules²⁶⁻²⁸ and that the preferential selection of certain families for medicinal use may be used as an indicator of underlying bioactive phytochemistry.

Wheat's study involved comparing levels of biological activity in extracts from plants selected either randomly or on the basis of known medicinal or other uses. From an initial survey of over 100 plant species, she applied statistical techniques to narrow the focus to a handful of plants for further study and then used liquid chromatography–mass spectrometry and nuclear magnetic resonance to analyse whole crude extracts, with a particular focus on the extract from *Crassula brevifolia*, a common plant from Paulshoek. These data, together with results from a range of bioassays on the extracts, constitute a comprehensive profile of activity and metabolite composition – a multi-dimensional mapping of the plants (Figure 2), far richer than normally achieved from isolation of a small selection of plant constituents.²⁹ The study was open-ended: in principle, it was to set up the focused search for active ingredients, but it also provided a deeper insight into the hidden molecular world of the plant and a basis for a dialogue with traditional knowledge in the search for a synthesis which might accrue from the bringing together of advanced analytical techniques and lifetimes of learned experiences.

About the time that Wheat commenced her work, Amelia Hilgart approached the Botany Department at UCT to explore the possibility of studies in Botany, and conversations with Hoffman and Gammon led to the development of a PhD proposal in Chemistry.

Amelia Hilgart describes how her approach to her work evolved:

'Chemical stasis in a living organism equals death.' This was the opening statement of my first biochemistry lecture as an undergraduate; the lecture was on thermodynamic equilibrium in mammalian cells, and has largely shaped my perception of what a metabolite is. In a living organism, everything is constantly changing on a chemical level and involves an expenditure of energy. The compounds that we look for in plants in natural products chemistry are secondary metabolites, vaguely defined as 'the compounds produced by plants that are not directly essential for basic photosynthetic or respiratory metabolism; such compounds are known as primary metabolites.'³⁰ I have always been impressed by the incredible diversity of compounds plants can make and particularly struck by the idea that plants use so much energy to create such a diverse array of chemicals. Unless genetically designed to do otherwise (or genetically broken), plants do not waste energy to create useless molecules. Plants make things that they can use when they need them. These were the ideas I had when I arrived in Cape Town.

My first appreciation for the project came through Timm Hoffman when we took the 7-hour drive from UCT to Paulshoek to try to find something for a project that garnered my interest. Timm loves to talk about plants and my introduction to Paulshoek flora included a long discussion on the Aizoaceae family which dominates the landscape. By the end of that trip there were two ideas that featured strongly in my mind; firstly, that there was an extraordinary metabolic process – called facultative crassulacean acid metabolism – that featured in at least some plants in the Aizoaceae family, which allowed the plants to change their carbon uptake mechanisms; and secondly, that one Aizoaceae species in particular (*Galenia africana*) was killing goats and sheep when ingested during the summer months.

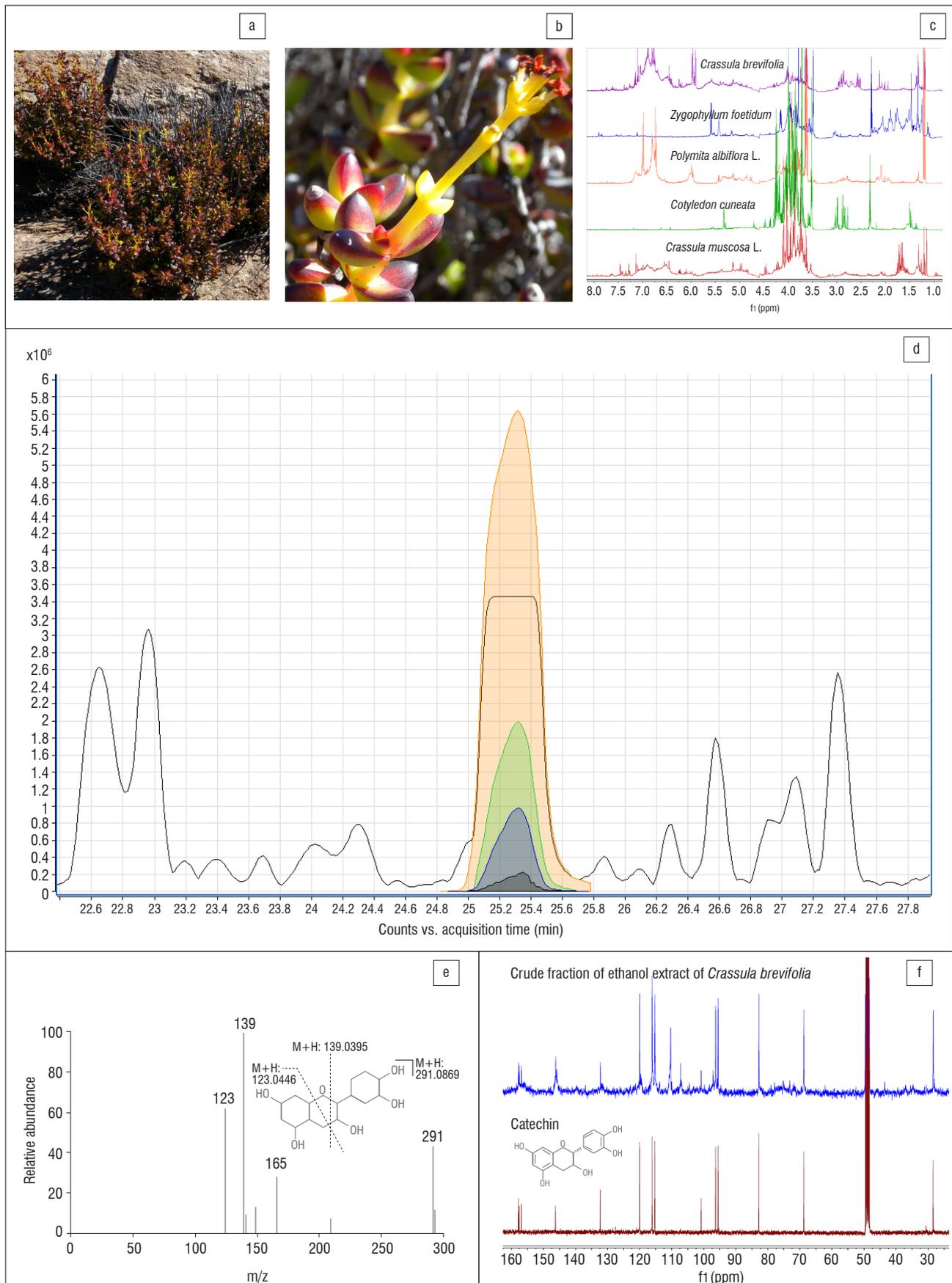


Figure 2: Ways of seeing *Crassula brevifolia*: (a) whole plant, (b) leaves, (c) comparison of proton magnetic resonance spectra of ethanol extract of *C. brevifolia* with similar extracts from other plants, (d) section (22–28 min) of the total ion chromatogram from liquid chromatography–mass spectrometry analysis of the ethanol extract of *C. brevifolia*, (e) tandem mass spectrum of catechin, showing masses of prominent ions, with the structure and fragmentation pattern of the molecule overlaid and (f) carbon magnetic resonance spectrum of pure catechin, and the mixture from which it was recovered.

Hilgart³⁰ started by monitoring the metabolic, nutrient, physiological and phenological fluctuations across seven common Namaqualand species in a quest for the toxic compound in *G. africana*.³¹ *G. africana* is a pioneer species which thrives in the increasingly disturbed soils of southern Africa.³² Hilgart's work utilised Hoffman's prior interviews with herders in the village of Paulshoek which indicated that there was seasonality to the toxicity of *G. africana*. These approaches and insights offered an opportunity to study toxic compound accumulation and fluctuation on an ecosystem-wide basis, and while considerable progress was made in this regard, the accumulation and statistical analysis of metabolite profiles from liquid chromatography–mass spectrometry data (Figure 3) led to development of molecular barcodes for fine-grained distinguishing of plant species – a kind of molecular 'fingerprint'.

Anthropology: A view of the work of kruiedokters

Around the time that Hilgart arrived at UCT to commence her studies, Gammon's interest in the work of the *kruiedokters* led to a conversation with Lesley Green in the Department of Social Anthropology, who at the time was working on the relationships between sciences and postcolonial knowledge debates, and the questions these raised for universities in South Africa. Green describes her involvement in the project as follows:

My first encounter with Paulshoek was in 2009 via David Gammon who emailed me after searching around at UCT to see who was working on indigenous knowledge. I was struck by the thoughtfulness with which David posed his question: how do we (in his case, scholars of plant chemistry) work with a *kruiedokter* whose way of working with his patients is serious and considered by locals as effective, yet the resources he is drawing on are in the domain of spirit? It was a really challenging assignment at the nexus of two pressing concerns: how to rethink the simplistic opposition between African knowledge and western science that was being pursued at the time in relation to HIV and the rejection of antiretrovirals, and how to work with very different approaches to knowledge: causality, ontology, epistemology and metaphysics.

Current anthropological debates internationally are focused on problematizing the dividing line between social sciences and life sciences; society

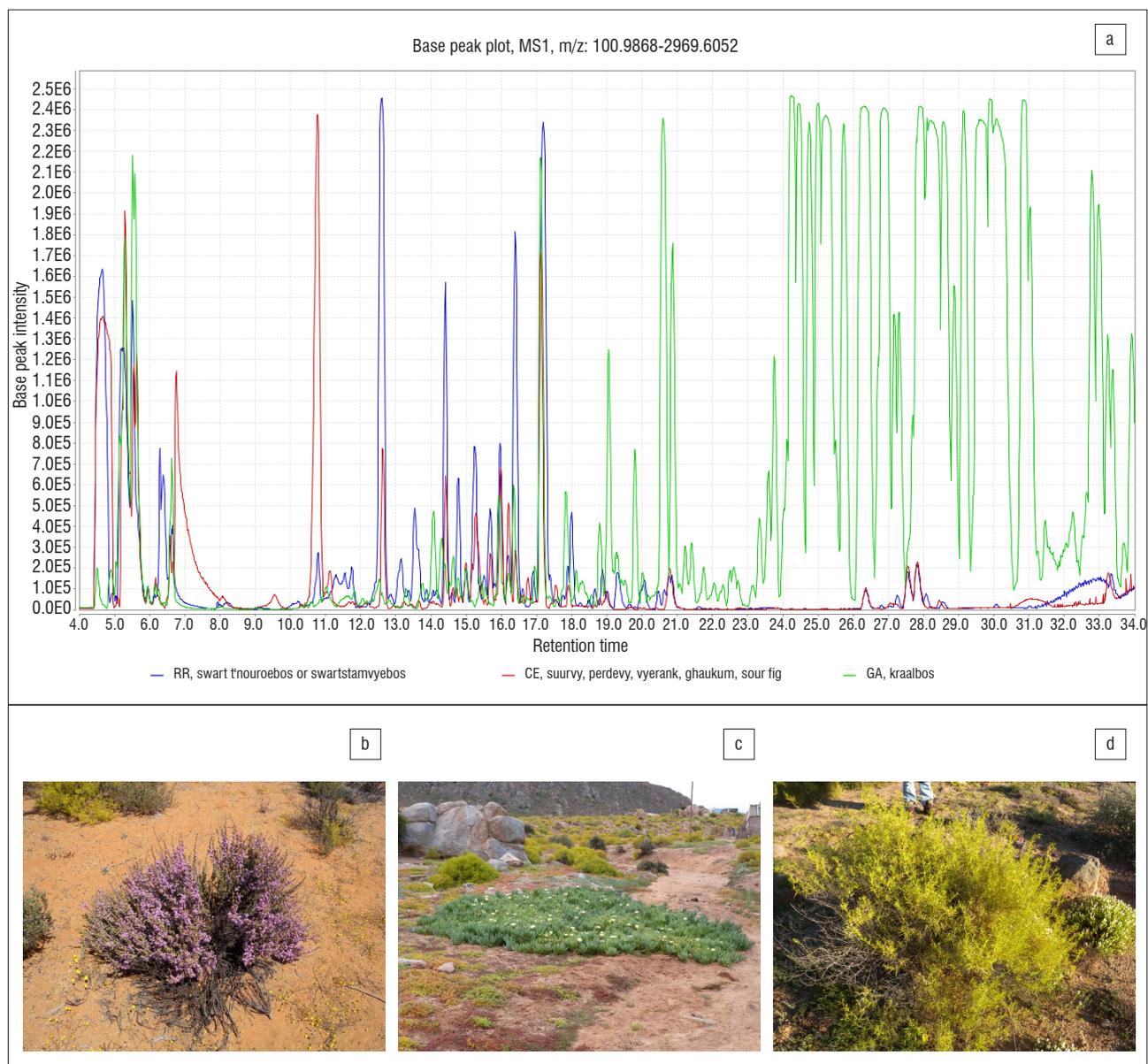


Figure 3: (a) Overlay of total ion chromatograms from liquid chromatography–mass spectrometry analyses of the ethanol extracts of *Tetragonia fruticosa* (red), *Carpobrotus edulis* (blue) and *Galenia africana* (green). Images of (b) *T. fruticosa*, (c) *C. edulis* and (d) *G. africana*.

and nature. When we rethink this line, it is possible to begin to rethink the ways in which we produce disciplinary knowledges. Doing so requires simultaneous engagement with the criticisms of formal knowledges in the university system from across the south (these debates have various names: 'indigenous knowledge studies', 'decolonial theory' and 'political ontology') and with current philosophers of science such as Isabelle Stengers, whose very broad oeuvre is based on careful and detailed work with a range of knowledge fields. Her collaborators include Nobel Prize winner for chemistry, Ilya Prigogine. Stengers' work is situated in a set of dialogues with a wide range of thinkers who are taking up the challenge to open the frameworks of knowledge to new possibilities, while avoiding the carelessness of solutions to the challenges to knowledge that go under labels such as 'relativism' or 'tolerance' – arguing that 'epistemic charity' (to borrow a word from the critic Nandini Sundar) is not a helpful solution.

In the latter half of 2009, Joshua Cohen was looking for an issue to explore for a doctorate in Anthropology. Through his supervisor, Green, he found himself becoming involved with the Paulshoek plant researchers and began to engage in participative, interdisciplinary research. He describes his initiation into Paulshoek as follows:

In May 2010, I travelled with Timm Hoffman on one of his monthly research trips to Paulshoek. He introduced me to Gert Julk, one of the region's well-known *kruiedokters*. Gert left an indelible impression on me from the beginning and instilled an interest in me to work further with *kruiedokters*. He was quite happy to talk and took us on a whistle-stop tour through his skills and work. I thought his openness and humorous demeanour could help facilitate the kind of collaborative work UCT's molecular biologists were hoping to engage him in.

Sadly, Gert passed away in November 2010. In addition to the tragedy for his friends and family, Gert was the last actively working *kruiedokter* in Paulshoek. Marianna Lot, however, had already introduced me to Koos, a *kruiedokter* working in another of the Kamiesberg villages and I shifted my attention to Koos' work. Koos' open, cheerful ways have helped him and I to establish and sustain an excellent relationship based, I believe, on mutual respect and understanding. The relationships I have enjoyed with Koos, his family, friends and patients have been key to my understanding of how Koos and other *kruiedokters* work with plants.

Cohen's work focused on how *kruiedokters* work with *bossiemedisyn*e [bush medicine].³³ In line with Chris Low's work on Khoisan healing,³⁴⁻³⁶ two key terms – *krag* and *wind* – emerged. The first of these terms, *krag* (power, vitality, strength), is a commonly used Afrikaans word that can be thought of as a kind of 'body energy' that waxes and wanes with the ups and downs of everyday life. In order to aim their patients toward health, it is important for *kruiedokters* to be able to 'cultivate' their patients' *krag*. To this end, various tools might be used by the *kruiedokter* – jokes, guitar playing, food, and of course *bossiemedisyn*e. Many plants are directed at alleviating *krag*-sapping symptoms: high blood pressure, diabetes, colds and flu, swelling in the limbs. The *krag* in the plants themselves, that which enables them to do their healing work, is closely associated with the *krag van die natuur* (the power of nature), this in turn being closely associated with *die Here* (the Lord).

Beyond all other things, *kruiedokters* are skilled at, and known for, their ability to deal with the various kinds of *wind* [wind] that cause so much

trouble in people's body-person. There are, generally speaking, two kinds of *wind*: *natuurlike* [natural] and *toor* [magic], both of which retain the propensity for movement and change, the same as the wind that blows in the veld. The first kind of *wind* can be a 'simple' build-up of gas in the intestines and stomach, but can also be 'picked up' in the world and 'lodge' itself in any part of the body – from the head to the muscles of the leg. Health and well-being are often linked internally, to things flowing properly around the body through organs which are not 'stressed'; and externally, to people being able to move along the proper 'path' of life as laid out for them by God. Therefore, in order to return their patients to these flows, *kruiedokters* use various techniques to unblock these winds, including plants (*kougoed* (*Sceletium tortuosum*) is common) and other substances to aid the expulsion of wind, and massage.

Knowledge of the second kind of *wind*, *toorwind*, is an important area of *kruiedokters*' expertise. These are winds that are 'sent' by malicious others, through a range of media including *gif* [poison] placed in someone's food, in dreams, or through magical 'traps' placed along their victim's path. Such winds can grab on very tightly to their sufferer in the form of a *bose gees* [evil spirit] that 'sits' in the victim's body, growing, sapping their '*liggaam se krag*' [body's energy]. *Kruiedokters* exercise what is seen as a God-given, evil-tackling talent, to cleanse their patients of such winds. They use 'fighting roots', that is the roots of the various 'storm' plants in protective *xaimpies* [medicine bundles] placed in the home or carried around on the person. *Kougoed* encourages the movement of wind out of the body. Existing in what might be called an intersubjective space between a *kwaadaandoener* [evil sender] and their victim, the treatment of these kinds of winds involves the *kruiedokter* effectively placing themselves, as a kind of defender, between the attacker and the attacked.³⁷⁻³⁹

When writing or talking about things like *wind*, or especially *toor*, the question of proof or evidence arises. Rather than getting bogged down in disputes about reality or unreality, Cohen, following the arguments of Viveiros de Castro⁴⁰ and Holbraad⁴¹, viewed *wind* and *krag* as effective 'concept phenomena' in their own right. Based in both the experience of phenomena of the world, and their mutually constituting, socially historically generated conceptualisation, such concept phenomena facilitate thinking about humans as 'ecological' beings, that is, as intimately bound both to human and non-human aspects of their environments in ways that do not necessarily conform to the convention of nature or culture.

As conversations progressed, it became clear that one person, Marianna Lot, had been integral to all of the studies. She worked as a field assistant to all of the studies, and had valuable commentary on how they made sense to her personally and to wider debates among people in Paulshoek. Her comments in an interview with Cohen (see below) speak to the ways in which science becomes part of lived experience of the world, and underscore the pleasure and value of being able to fit parts into wholes, and relate scholarship back to publics.

Lot was born on a farm in Bushmanland where her grandfather and father worked tending herds of sheep and goats for a private landowner and her mother worked as a domestic worker. When the children reached school-going age, Lot's family moved to Paulshoek, which was the closest village where they were allowed to settle under apartheid legislation. She completed her primary education in Paulshoek and went to Leliefontein for her high-school years. Thereafter she worked in local towns such as Garies and Vredendal as a shop assistant, and married and had children during this period. She returned to Paulshoek in 1996 soon after her father, Joseph Nero, passed away. Her love for plants and interest in the veld had been kindled by her father who was a well-known *kruiedokter* in the region. People from the village and from as far afield as Springbok and even Cape Town and Namibia were regular visitors to his practice. Soon after returning to Paulshoek, Lot joined the Community Development Forum and started working on a range of community-related projects in the village. When the German-funded BIOTA research programme offered to train eight people from Namaqualand and Namibia as ecological field assistants, Lot applied and was selected for the course. This 'paraecologists' programme, under the leadership of Dr Ute Schmiedel from Hamburg University, provided her

with employment for the next 7 years and gave her just the right skill set to provide the necessary high-quality support required by the UCT-based research programme on medicinal plants.

In the paraphrased and edited narrative which follows, Marianna Lot, Paulshoek resident and research assistant to all of the researchers, describes her encounters with different aspects of the project:

I began with BIOTA in 2004 and I worked for the organisation for seven years. After my work with BIOTA finished, Timm walked with me along the path of learning the processes of working with various students on their projects. I first worked with Nicola on medicinal plants. Her household surveys investigated the number of *kruidokters* here in Paulshoek and their roles. Her surveys were also about the difference between a *kruidokter* and a healer, and how traditional plant use had changed since 2002 when an earlier survey was undertaken in the village. I went from house to house, sat with people and asked them what kinds of plants they used and for what purposes.

Then came Amelia who worked on the plants that animals do not really eat and like, especially the *kraalbos* (*G. africana*) which is very common and used by people as a medicine. It makes other animals sick but people healthy. Amelia collected *Galenia* to see what precisely is inside this plant. I then met Joshua who came looking for people who are *kruidokters*. Unfortunately, in Paulshoek there was only Gert Julk and Joshua wanted to get advice from different doctors. I introduced him to Koos, who is a *kruidokter* and asked him if he would like to be part of the project or if he would help Joshua and give him a little advice. Joshua and Koos now have a very good understanding between themselves and work well together. Koos has always been open and shares things with us. He is always ready to help if you need information or if you want to know something.

Holding the material together

Developing a conversation among the disciplines was assisted by academics who were not engaged in Paulshoek research. In 2012 Helen Verran, an Australian philosopher, was a visiting scholar in Cape Town. She enthusiastically entered the discussion and drew on her prizewinning book, *Science and an African Logic*⁴², to invite new ways of thinking. She imagined our research as disparate reports of something, which in the beginning, we did not have terms to describe. She pointed to ways of thinking about the different approaches, both as different traditions/histories of knowledge and as a set of questions. These informed dialogue around disciplinary traditions and directed discussion to different parts and wholes. Verran elaborates:

The project is in part about finding ways to bring in other knowledge traditions: Marianna's phenomenological place-based knowledge, and the *kruidokter's* esoteric/arcane doing of plants and particular specified parts of human existence as he understands them. In trying to include their perspectives, we would be trying to reverse in a small way the epistemic erasures that have been part and parcel of the expansion of the academy. Of course, the destruction of precolonial knowledge systems is still a raw wound in both South Africa and Australia.

Whole-parts generalising, which situates rather than abstracts, seems to me to attend to two features of this work that I have been worrying at. The first concerns us as academics. We want to

tell our differences, but what could connect our texts? It seems that imagining our projects as each concerned with some emerging part of a vague whole form relating to particularly placed human relations with plants (resisting specificity when it comes to our so-called 'research question'), might be a useful way to begin to connect the projects.

It also seems to be a way to 'bite the bullet' in analytically reading the spoken texts of Marianna and hopefully, at least one *kruidokter*. We need to do this reading with the same 'disciplining form' we apply to ourselves, so this notion of vague whole and emergent parts is a minimalist standardising form that our collaboration works through. If we envisage our problem through whole-parts generalising, we can imagine it as a version of an old story that Stengers⁴³ reminds us of:

The famous tale of the three blind men and the elephant, one man recognising a trunk, the second a snake, and the third a fly swatter...The blind men all investigate the elephant...but the diverging ways in which they characterise it appear as an end point [of the story]. The divergence is not a matter of crucial concern to them. If it had been such, the story would not end when the blind men make their first contradictory assessments; they would next move around the elephant to explore the possibility of a coherent account that could turn outright contradictions into very interesting contrasted standpoints. In other words, the blind men would have lent themselves and their respective interpretations to active comparison, giving that which they all address the power to impose 'due attention'.⁴³

Following a series of meetings and day-long workshops, and with Verran's guidance, the form of this paper gradually emerged – laying out stories of encountering the plants and landscape as part of the disciplinary-focused interventions in people's own voices. As such, the narrative of encounter with realities that were unexpected in our disciplinary training, could give form to a fresh set of insights about what it was that we were seeing, why that should be so, and how to theorise in different ways the process of knowledge production in which we were all engaged.

Robert Morrell, a social historian and gender sociologist, has been involved in the Paulshoek project since 2010. Based in the UCT Research Office, his brief was to stimulate and support transdisciplinary, Africa-centred research. Morrell hosted and facilitated workshops and meetings with the team. He increasingly took up the role of interlocutor, finding ways to link the researchers to one another and build a common purpose. His contribution was a mix of intellectual and collegial, constantly emphasising the importance of respecting different academic traditions while committing the team collaboratively to a project of knowledge production. New knowledge is not simply something that institutions produce: it is something that people generate in dialogue. The value of nurturing collegiality is not something that, in the age of managerialist approaches to research output, institutions easily see or count. Research funding does not generate new knowledge, people do. Morrell describes his involvement as follows:

I came to the University of Cape Town after nearly 30 years of lecturing at universities elsewhere in South Africa. During my time as a lecturer, I researched questions of historical inequality and entrenched patterns of violence in South Africa. More recently, I developed my work across disciplines, working with epidemiologists, historians, psychologists, philosophers and sociologists to understand the gendered nature

of violence. The end of apartheid in 1994 led to calls for 'transformation'. A grant to UCT from the Carnegie Corporation of New York was devoted to transforming the ways in which institutional knowledge was created. The Africa Knowledge Project emerged as a vehicle for bringing together and funding researchers who were interrogating 'Western' knowledge models and assumptions and searching for Africa-centred knowledges.⁴⁴ Drawing on diverse theories,^{45,46} the project argued for the existence of multiple knowledges with starting points that originated in the lived experiences of the continent's peoples and in its epistemological erasure. This project was part of a move to problematise inequalities in the global knowledge economy and to develop Southern Theory.⁴⁷

The search for Africa-centred knowledges was strengthened by another wave of enquiry to promote interdisciplinary and transdisciplinary work.^{48,49} Noting that many problems in the third millennium are complex and cannot be answered with one disciplinary toolkit, Max-Neef commented that transdisciplinarity represented an 'unfinished scientific programme that offers fascinating possibilities for advanced reflection and research'.⁵⁰

To achieve these goals, I sought to create epistemic hospitality. To use Francis Nyamnjoh's expression, my goal was to produce conviviality.⁵¹ The challenge was to allow things to unfold, to allow vague questions to metamorphose into deeper lines of collective investigation.

Gammon framed concerns about transdisciplinarity from a location within current debates in ethnopharmacology. He tabled a complex, difficult and vital set of provocations which follow below. In brief: while natural products chemistry and botany have a great deal to converse about, what does anthropology bring to the table? What relationship does natural products chemistry have to the people who hold the knowledge of plant uses, and can that relationship impact on the way natural products chemists think about their work? The question went to the heart of current debates about the relationship between sciences and indigeneous knowledge in South Africa and elsewhere, and it resonated powerfully with current debates in the philosophy and anthropology of science regarding the necessity of being able to think about scientific knowledge as a product of society, without rendering it useless by asserting that it was just a product of vested interests.

The renaissance of natural products chemistry has been associated with technological developments that make possible the analysis of ever smaller quantities of plant (or other) natural products. It has also drawn on other emerging technologies in molecular biology and informatics that have synergistically combined to usher in the 'omics' era and foreshadow an improved capacity to understand organisms in their environment.^{52,53} Genomics, proteomics and metabolomics (or metabonomics) are approaches focused on grasping at the totality of the system, by evaluating or mapping the collection of genes, proteins (enzymes) or metabolites, respectively.⁵⁴ Recent advances in chromatography and spectroscopic techniques such as high-resolution mass spectrometry and nuclear magnetic resonance, and particularly the combined versions of these such as liquid chromatography–mass spectrometry, allow for quite comprehensive 'fingerprinting' of the array of constituents in an extract, even if a full description of all of these techniques is still beyond reach.⁵⁵⁻⁵⁷ Coupling of these with sophisticated assay technologies and more specific biological assays,⁵⁸ either whole-cell or target-based, suggests new research questions and a realistic situating of natural products research within the more holistic paradigm of systems biology. The new techniques and approaches do not necessarily call into question the more classical approach of painstaking separation and characterisation of constituents, but they have the potential to significantly enhance the process of de-replication of

mixtures – a process that follows preliminary screening which searches for new pharmacologically active substances. They also suggest more efficient approaches to searches for active constituents and studies of functions inherent in mixtures. However, both the advances in the science and the warnings and injunctions of various practitioners give pause for thought and raise questions. What is an appropriate and responsible way to proceed with research involving the chemistry of natural products? How does one combine scientific integrity with ecological and cultural sensitivity? Do the recent technological advances draw us further away from, or nearer to, an understanding of different ways of understanding the world and constructing knowledge? In the study of plant natural products, how exactly does one take into account the ecological and community context of the plants and their uses, and does knowledge of and sensitivity towards these go beyond simply providing context? Conversely, what does a detailed understanding of the molecular composition of plants add to ecological or local knowledges and practices of plants and their place in the world? How is knowledge discovered, constructed, crafted? And are these ways mutually exclusive, or are there patterns of thought and practice inherent in our common humanity, independent of educational history and cultural bias?

For anthropologists Lesley Green and Joshua Cohen, what was important in thinking about 'indigenous knowledge research' was the need to resist reducing plants to a pharmacologically active ingredient. Anthropological work, including Cohen's on *krag* and *wind* reflects an effort to understand a different basis for thinking about health.⁵⁹ There are thus attempts in many disciplines to move beyond methodological and empirical stricture and the 'valid or invalid' binary that characterises much disciplinary endeavour. Yet the question is how do we have the conversation and begin to pull the threads together? Gammon's concerns compel us to avoid a '*kumbaya*' approach to transdisciplinarity, a cosmopolitan celebration of the wonders of disciplinary diversity in which the 'social science' is a quaint add-on to the science. A social science that simply matches the science would sell short the value of the humanities.

The primary orienting, although often unstated, question in chemical studies of plant medicine concerns pharmacologically active ingredients for antibacterial, antifungal, antiviral and/or anti-inflammatory properties. Yet this orientation depends on equating health and illness with the eradication of a particular taxonomy of pathogens. If the orientation to health includes a wider array of toxins and taxonomies that contribute to the experience of having energy or vitality (*krag*³³ or the different, although not entirely dissimilar concept of 'qi'⁵⁹), – then biochemical research need not necessarily begin with the particular pathway of seeking compounds related to pathogen elimination. Cohen's work suggests the examination of pharma *and* the flow of energy in the body. This suggestion raises questions about plants in an ethnopharmacology of Namaqualand, which would include cleansing, balance, attention to social harms and the toxicities of stress (massage).

Going-on together doing difference

We now discuss the project as a form of whole-parts generalising, which recognises that wholes, or 'bigger pictures', always remain vague. We suggest that such knowledge-making ends up remaking, situating and locating. Any such situating is a call for further efforts, as new puzzles emerge and begin to help clarify what the vague whole at the project's core might become. Verran earlier referred to the elephant and how Stengers mobilised the tale of the difficulties blind men experience in seeking to know an elephant through what their fingers and hands perceive. The work of thinking about how we understand the 'whole' that is our larger area of interest on the basis of the parts that we grasp via our disciplines, does not end with simply presenting divergent discoveries. 'Going on thinking together', we used the divergent findings as provocations for further puzzling. Active comparison arose in allowing divergences to provoke questions of *how* they arose. The Paulshoek medicinal plant research can help attend to the question of 'whether transdisciplinary, Africa-centred knowledge production is worth the trouble it brings'. The question raises two intertwining issues. Does transdisciplinary Africa-centred research offer insight into the problem of epistemic erasures associated with science's past central role in colonising projects? Does

it enable us to attend to the challenge which claims scientific knowledge-making as merely the product of vested interests?

These questions can best be approached with the idea of sciences as meaning-making machines, suggesting scientific knowledge is culturally active. This takes us in a different direction than thinking of science's epistemic practices as making truth claims, as revealing 'the true structure of reality'. This is it not a contradiction of the foundationalist way of thinking about knowledge-making. It is possible for a collective to hold simultaneously to both ways of thinking about knowledge – as we do in writing this paper together.

To think of the practices that constitute scientific disciplines as 'a machine' recognises that in the past much careful work has gone into purposefully designing and perfecting that set of practices. Such 'machines' generate objects of knowledge in meeting the requirements and obligations that come with that science.^{60,61} Tension in transdisciplinary and cross-cultural research arises precisely because the objects of knowledge generated in different disciplines, by different meaning-making machines, are likely to clash and interrupt. Resisting the impulse to compromise, in good research each discipline (or knowledge tradition) stays explicitly faithful to its objects, thus working in good faith both within and without the discipline. Each team refuses other teams' meanings ('Our meanings of plant are not the same as your meanings of plant.). Thus rather than pretend we are going on together in good will when actually we refuse to compromise over meanings, we acknowledge that we display bad will towards others' meanings. Good transdisciplinary research, like good cross-cultural research, requires explicit good faith and bad will.

When the sciences are considered as 'meaning-making machines', the orthodox, absolutist view that objects are either found or made is left aside. Yet the framing also recognises (and can work with) the actuality that most natural sciences work (and work effectively if often unreflectively) with the assumption that objects are *found*, and most social sciences work with the assumption that their objects are *made*. For example, antibacterial compounds are taken as given in the world, and natural products chemistry *finds* them in ingenious ways. The concept of objects of governance which we introduce below, suggests that in the social sciences, by contrast, various objects, both physical and abstract, become significant when specific actors, recognising the origins of that significance in social activities, apprehend the social roles of these objects.

From a different perspective, one that focuses on processes of knowing, Catherine Elgin argues for 'the ineliminable cognitive contributions of non-literal, non-descriptive symbols':

Cognitive advancement is not always a matter of learning something new. We have a vast store of information at our disposal already. Often our problem is what to make of what we've got. This is true even at the level of perception. To a large extent, looking involves overlooking; listening involves discriminating between signal and noise. So a critical epistemological question is: What is worthy of notice? What should be overlooked, marginalised, or ignored? Ordinarily, answers to these questions are simply presupposed. We seldom notice that we notice some things and overlook others. We automatically invoke routine categories to describe or represent phenomena. We adopt familiar orientations and judge by received standards.⁶²

What good transdisciplinary research brings to the fore is the importance of asking about how we know, because different disciplines know in often very different ways.

The objects of knowledge in both phenology and natural products chemistry equally comply with the standards of the so-called scientific method. It is in the particular obligations imposed on scientists within these disciplines by their scientific objects that practices will be experienced as different. Sometimes in meeting the specific obligations that are required to bring these disparate disciplinary objects of

knowledge to life and keep them alive, scientists will find themselves needing to disagree with each other, as they struggle to work together. The need to disagree is felt even more strongly when one is struggling to go on together with a practitioner of a disparate knowledge tradition – there we are likely to experience the need to disagree in order to meet the requirements our objects of knowledge impose on our knowledge practices, as much as the specific obligations imposed in a particular situation.

What are the differing objects of knowledge of phenology and natural products chemistry? We follow Stengers⁶³ and begin with Galileo: he interrogated nature in a mathematical language in his experiments on falling bodies. For him the formalisms of mathematics were the only tool up to that task. The obligation that physicists still feel, to interrogate the world through mathematical formulations, continues to enact this obligation imposed on physicists by the objects known by physics, an obligation that still alienates many beginning science students. Obligated as they are 'to discipline a jungle of diverse molecules...identifying, naming, and classifying on the basis of [elaborate and standardised] tests', chemists' major obligations seem to be caution and scepticism.⁶¹

By contrast again, plant phenologists observe plants in place, which is quite different to the objects generated in physics' experiments on falling bodies articulated in formal mathematical language, or those generated in chemistry's testing of substances by subjecting them to fire or its equivalent. Phenology requires constancy in observation, and precision in temporal and spatial co-ordination of that observation: going every month to a singular place, walking the same route, observing the state of individual plants. The phenological object of knowledge imposes itself on the life of the scientist, its life partner. 'Phenomena of observable patterns' is a uniquely demanding object of knowledge.

In being both strongly felt and rigorously enacted, these different obligations to disparate objects of knowledge make difference obvious and respected in good transdisciplinary research. The process of writing this paper has led us to focus on the nitty-gritty of separating before considering connecting. In this way the requirements and obligations of the object of knowledge that emerges in a disciplined intersection of phenology and natural products chemistry has been usefully articulated. It might be thought of as an offspring of the two parent objects of knowledge.

The encounter between the three disciplines allowed a fresh appreciation of the differing specific objects of knowledge, and the larger object to which they each contribute. No longer divided into disciplinary-specific components, our transdisciplinary journey brought into the appreciation a new (although still vague) whole. It is as though, in taking care to become familiar with *how* we know, the medicinal plants forced us into a relationship with one another that allowed for this fresh insight of what they are.

Recognising and respecting the alternative objects of knowledge that emerge in transdisciplinary research has a further benefit. It can alert participants to the distinction between objects of knowledge, constituted in epistemic practices, and objects of governance, constituted in practices promoting organisational accountabilities. That distinction is crucial in identifying where and how knowledge-making and governance overlap.

Good transdisciplinary research calls forth a self-consciousness about epistemic practice. This easily extends to a self-consciousness about, and sensitivity towards, the distinctions between objects of knowledge and objects of governance, emergent respectively in epistemic and organisational governance practices. The latter might be thought of as the means of operationalising objects of knowledge. Clearly the objects of knowledge generated in *kruiedokters'* practices have very different requirements and obligations from those of either Western bio-medicine or Chinese traditional medicine. However, just as clearly, the governance practices which operationalise those objects in those differing healing traditions differ; in being operationalised the objects gain different sorts of properties.

In the story that Marianna Lot tells of her involvement in the Paulshoek ABC project, it becomes possible to understand how she has learned to work with people (both scientists and *kruiedokters*) who in their everyday lives must negotiate the requirements and obligations of the objects of knowledge in which they are involved. Lot does not obligate herself directly with those objects, only indirectly through other people. She learned from that indirect involvement to have respect for those objects of knowledge. In her story, she alerts researchers from different disciplines to what is involved in operationalising objects of knowledge, in re-constituting them as objects of governance. In being operationalised, at least one of the practices involves objects of knowledge-accreting stories. Which stories, who can tell them, and when they can be told and to whom, are all expressions of politics. How these are decided addresses the issue of erasure with which this paper began and implications for how postcolonial knowledge is produced.

Learning 'to do our differences' explicitly but together through attending to the issue of *how* we know, we learned to respect medicinal plants as differentially knowable. Having learned to tell each other *how* we know, we now recognise that the next step is to learn to do differing forms of governance together through working with those who know and govern otherwise.

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Authors' contributions

L.G. oversaw the social anthropology component of the paper, provided theoretical inspiration, knowledge of comparative ontological literature, participated in writing meetings and wrote and edited parts of the text. D.W.G. was the chemistry project leader, received two UCT grants to initiate and facilitate the transdisciplinary project, hosted project and writing meetings and wrote parts of the text. M.T.H. was the botany project leader, hosted project and writing meetings and wrote parts of the text. J.C. drew on his anthropological field research, attended and contributed to writing meetings and wrote part of the text. N.W. and A.H. drew on their field and laboratory research, attended and contributed to writing meetings and wrote parts of the text. R.M. oversaw the transdisciplinary process as a whole, facilitated the meetings, wrote some of the text and edited the entire piece. H.V. attended some of the writing meetings and provided theoretical sophistication to the project and wrote some of the text.

References

- Verran H. Governance and land management fires effected in engagement between environmental scientists and Aboriginal land owners. Understanding objects of governance as expressing an ethics of dissensus. *Learn Communities J.* 2014;15:53–64.
- Hadorn GH, Biber-Klemm S, Grossenbacher-Mansuy W, Hoffmann-Riem H, Joyce D, Wiesmann U, et al. The emergence of transdisciplinarity as a form of research. In: Hadorn GH, Hoffmann-Riem H, Biber-Klemm S, Grossenbacher-Mansuy W, Joye D, Pohl C, et al., editors. *Handbook of transdisciplinary research*. Dordrecht: Springer; 2008. p. 19–39. http://dx.doi.org/10.1007/978-1-4020-6699-3_2
- Hubert B, Meuret M, Bonnemaire J. Shepherds, sheep and forest fires: A reconception of grazing land management. In: Hadorn GH, Hoffmann-Riem H, Biber-Klemm S, Grossenbacher-Mansuy W, Joye D, Pohl C, et al., editors. *Handbook of transdisciplinary research*. Dordrecht: Springer; 2008. p. 103–126.
- Dubow S. *Scientific racism in modern South Africa*. Cambridge: University of Cambridge Press; 1995.
- Fassin D. *When bodies remember: Experiences and politics of AIDS in South Africa*. Berkeley, CA: University of California Press; 2007.
- Natrass N. *The moral economy of AIDS in South Africa*. Cambridge: Cambridge University Press; 2004.

- Natrass N. *Mortal combat: AIDS denialism and the struggle for antiretrovirals in South Africa*. Pietermaritzburg: University of KwaZulu-Natal Press; 2007.
- Cullinan K, Thom A, editors. *The virus, vitamins and vegetables. The South African HIV/AIDS mystery*. Johannesburg: Jacana; 2009.
- Green L. Beyond South Africa's 'indigenous knowledge – science' wars. *S Afr J Sci.* 2012;108(7/8):34–43. <http://dx.doi.org/10.4102/sajs.v108i7/8.631>
- Verran H, Christie M. Doing difference together: Towards a dialogue with aboriginal knowledge authorities through an Australian comparative philosophical inquiry. *Cult Dialogue.* 2011;1(2):21–36.
- Rohde RF, Hoffman MT. One hundred years of separation: The historical ecology of a South African 'coloured reserve'. *Africa.* 2008;78(2):189–222. <http://dx.doi.org/10.3366/E0001972008000132>
- Green LF, Green DR. *Knowing the day, knowing the world: Engaging Amerindian thought in public archaeology*. Tucson, AZ: University of Arizona Press; 2013.
- Latour B, Weibel P. *Making things public. Atmospheres of democracy*. Cambridge, MA: MIT Press; 2005.
- Latour B. *An Inquiry into modes of existence: An anthropology of the moderns*. Cambridge, MA: Harvard University Press; 2013.
- Esler KJ, Rundel PW. Comparative patterns of phenology and growth form diversity in two winter rainfall deserts: The Succulent Karoo and Mojave Desert ecosystems. *Plant Ecol.* 1999;142:97–104. <http://dx.doi.org/10.1023/A:1009830513525>
- Struck M. Flowers and their insect visitors in the arid winter rainfall region of southern Africa: Observations on permanent plots. *Insect visitation behaviour. J Arid Environ.* 1994;28(1):51–74. [http://dx.doi.org/10.1016/S0140-1963\(05\)80021-7](http://dx.doi.org/10.1016/S0140-1963(05)80021-7)
- Croteau R, Kutchan TM, Lewis NG. *Natural products (secondary metabolites)*. In: Buchanan B, Grissem W, Jones R, editors. *Biochemistry & molecular biology of plants*. Rockville, MD: American Society of Plant Physiologists; 2000.
- Cordell GA, Colvard MD. Some thoughts on the future of ethnopharmacology. *J Ethnopharmacol.* 2005;100(1–2):5–14. <http://dx.doi.org/10.1016/j.jep.2005.05.027>
- Ngo LT, Okogun JI, Folk WR. 21st Century natural product research and drug development and traditional medicines. *Nat Prod Rep.* 2014;30(4):584–592. <http://dx.doi.org/10.1039/c3np20120a>
- Cordell GA, Colvard MD. Natural products in a world out-of-balance. *Arch Org Chem.* 2007;7:97–115.
- Cordell GA. Phytochemistry and traditional medicine – A revolution in process. *Phytochem Lett.* 2011;4(4):391–398. <http://dx.doi.org/10.1016/j.phytol.2011.05.005>
- Cordell GA, Colvard MD. Natural products and traditional medicine: Turning on a paradigm. *J Nat Prod.* 2012;75(3):514–525. <http://dx.doi.org/10.1021/np200803m>
- Etkin NL, Elisabetsky E. Seeking a transdisciplinary and culturally germane science: The future of ethnopharmacology. *J Ethnopharmacol.* 2005;100(1–2):23–26. <http://dx.doi.org/10.1016/j.jep.2005.05.025>
- Andrae-Marobela K, Ntumu AN, Mokobela M, Dube M, Sosome A, Muzila M, et al. 'Now I Heal with Pride' – The application of screens-to-nature technology to indigenous knowledge systems research in Botswana: Implications for drug discovery. In: Chibale K, Davies-Coleman M, Masimirembwa C, editors. *Drug discovery in Africa, impacts of genomics, natural products, traditional medicines, insights into medicinal chemistry, and technology platforms in pursuit of new drugs*. Heidelberg: Springer; 2012. p. 239–264. http://dx.doi.org/10.1007/978-3-642-28175-4_10
- Wheat N. *An ethnobotanical, phytochemical and metabolomics investigation of plants from the Paulshoek communal area, Namaqualand [PhD thesis]*. Cape Town: University of Cape Town; 2014.
- Verpoorte R, Choi YH, Kim HK. Ethnopharmacology and systems biology: A perfect holistic match. *J Ethnopharmacol.* 2005;100:53–56. <http://dx.doi.org/10.1016/j.jep.2005.05.033>
- Martin GJ. Ethnobotany, conservation and community development. In: Walters M, editor. *Ethnobotany: A methods manual*. 1st ed. Kew: Chapman and Hall; 1995. p. 223–251. http://dx.doi.org/10.1007/978-1-4615-2496-0_8

28. Gottlieb OR, Borin MRDMB, De Brito NRS. Integration of ethnobotany and phytochemistry: Dream or reality? *Phytochemistry*. 2002;60(2):145–152. [http://dx.doi.org/10.1016/S0031-9422\(02\)00088-2](http://dx.doi.org/10.1016/S0031-9422(02)00088-2)
29. Sumner LW, Mendes P, Dixon RA. Plant metabolomics: Large-scale phytochemistry in the functional genomics era. *Phytochemistry*. 2003;62(6):817–836. [http://dx.doi.org/10.1016/S0031-9422\(02\)00708-2](http://dx.doi.org/10.1016/S0031-9422(02)00708-2)
30. Hilgart AA. Metabolomic barcodes from a systems biology-based approach to chemotaxonomy in taxonomically problematic Aizoaceae species and their implications for understanding phytochemical and biological diversity in South Africa [PhD thesis]. Cape Town: University of Cape Town; 2015.
31. Kellerman TS, Coetzer JAW, Naude TW. Plant poisonings and mycotoxinoses of livestock in southern Africa. Cape Town: Oxford University Press; 1988.
32. Allsopp N. Effects of grazing and cultivation on soil patterns and processes in the Paulshoek area of Namaqualand. *Plant Ecol*. 1999;142(1):179–187. <http://dx.doi.org/10.1023/A:1009826412617>
33. Cohen J. *Kruiedokters*, plants and molecules: Relations of power, wind, spirit, and atomic mass in Namaqualand [PhD thesis]. Cape Town: University of Cape Town; 2015.
34. Low C. Khoisan healing: Understandings, ideas and practices. Oxford: University of Oxford; 2004.
35. Low C. Khoisan medicine in history and practice. Voßen R, editor. Cologne: Rüdiger Köppe Verlag; 2008.
36. Low C. Birds and Khoesän: Linking spirits and healing with day-to-day life. *Africa*. 2011;81(2):295–313. <http://dx.doi.org/10.1017/S0001972011000027>
37. Favret SJ. *Deadly words: Witchcraft in the Bocage*. Cambridge, MA: Cambridge University Press; 1980.
38. Stoller, P. *Fusion of the worlds. An ethnography of possession among the Songhay of Niger*. Chicago, IL: University of Chicago Press; 1989. <http://dx.doi.org/10.7208/chicago/9780226775494.001.0001>
39. Whitehead NL, Wright R. In darkness and secrecy: The anthropology of assault sorcery and witchcraft in Amazonia. *J Altern Emergent Relig*. 2010;13(4):133–134.
40. Castro EVDE. Cosmological deixis and Amerindian perspectivism. *J R Anthropol Inst*. 1998;4(3):469–488. <http://dx.doi.org/10.2307/3034157>
41. Holbraad M. Truth beyond doubt. Ifá oracles in Havana. *HAU: Journal of Ethnographic Theory*. 2012;2(1):81–109. <http://dx.doi.org/10.14318/hau2.1.006>
42. Verran H. *Science and an African logic*. Chicago, IL: University of Chicago Press; 2001.
43. Stengers I. Comparison as a matter of concern. *Common Knowl*. 2011;17(1):53. <http://dx.doi.org/10.1215/0961754X-2010-035>
44. Cooper B, Morrell R, editors. *Africa-centred knowledges: Crossing fields and worlds*. Oxford: James Currey; 2014.
45. Appadurai A. *Modernity at large: Cultural dimensions of globalization*. St. Paul, MN: University of Minnesota Press; 1996.
46. Rottenburg R. *Far-fetched facts: A parable of development aid – Inside technology*. Cambridge, MA: MIT Press; 2009.
47. Connell R. *Southern theory: The global dynamics of knowledge in social science*. Cambridge: Polity; 2007.
48. Klein JT. *Interdisciplinarity: History, theory, and practice*. Detroit, MI: Wayne State University Press; 1990.
49. Kessel F, Rosenfield P, Anderson N, editors. *Expanding the boundaries of health and social science: Case studies of interdisciplinary innovation*. New York: Oxford University Press; 2003.
50. Max-Neef MA. Foundations of transdisciplinarity. *Ecol Econ*. 2005;53(1):5–16. <http://dx.doi.org/10.1016/j.ecolecon.2005.01.014>
51. Nyamnjoh FB. Perspectives on Africa. *Identity Cult Polit*. 2004;5:37–59.
52. Sheridan H, Krenn L, Jiang R, Sutherland I, Ignatova S, Marmann A, et al. The potential of metabolic fingerprinting as a tool for the modernisation of TCM preparations. *J Ethnopharmacol*. 2012;140(3):482–491. <http://dx.doi.org/10.1016/j.jep.2012.01.050>
53. Hufsky F, Scheubert K, Böcker S. New kids on the block: Novel informatics methods for natural product discovery. *Nat Prod Rep*. 2014;31(6):807–817. <http://dx.doi.org/10.1039/c3np70101h>
54. Buriani A, Garcia-bermejo ML, Bosisio E, Xu Q, Li H, Dong X, et al. Omic techniques in systems biology approaches to traditional Chinese medicine research: Present and future. *J Ethnopharmacol*. 2012;140(3):535–544. <http://dx.doi.org/10.1016/j.jep.2012.01.055>
55. Ernst M, Silva DB, Silva RR, Vêncio RZN, Lopes NP. Mass spectrometry in plant metabolomics strategies: From analytical platforms to data acquisition and processing. *Nat Prod Rep*. 2014;31(6):784–806. <http://dx.doi.org/10.1039/c3np70086k>
56. Halabalaki M, Vougianniopoulou K, Mikros E, Skaltsounis AL. Recent advances and new strategies in the NMR-based identification of natural products. *Curr Opin Biotechnol*. 2014;25:1–7. <http://dx.doi.org/10.1016/j.copbio.2013.08.005>
57. Simmler C, Napolitano JG, McAlpine JB, Chen S-N, Pauli GF. Universal quantitative NMR analysis of complex natural samples. *Curr Opin Biotechnol*. 2014;25:51–59. <http://dx.doi.org/10.1016/j.copbio.2013.08.004>
58. Agarwal A, D'Souza P, Johnson TS, Dethle SM, Chandrasekaran C. Use of in vitro bioassays for assessing botanicals. *Curr Opin Biotechnol*. 2014;25:39–44. <http://dx.doi.org/10.1016/j.copbio.2013.08.010>
59. Farquhar JB. Knowledge in translation: Global science, local things. In: Green L, Levine S, editors. *Medicine and the politics of knowledge*. Cape Town: HSRC Press; 2012. p. 153–170.
60. Stengers I. *Cosmopolitics I*. Minneapolis, MN: University of Minnesota Press; 2010.
61. Bensaude-Vincent B. Philosophy of chemistry. In: Brenner A, Gayon J, editors. *French studies in the philosophy of science: Contemporary research in France*. Dordrecht: Springer Science & Business Media; 2009. p. 165–186. http://dx.doi.org/10.1007/978-1-4020-9368-5_7
62. Elgin CZ. Creation as reconfiguration: Art in the advancement of science. *Int Stud PhilosSci*. 2002;16(1):13–25. <http://dx.doi.org/10.1080/02698590120118792>
63. Stengers I. *The invention of modern science*. Minneapolis, MN: University of Minnesota Press; 2000.

