


Employment-oriented Industry Studies

Innovation in Resource-based Technology Clusters: Investigating the Lateral Migration Thesis

Muti from Coal: Science and Politics of Humic Substance Research in South Africa

Prof J. Lorentzen

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Acronyms

HIV/AIDS	Human Immunodeficiency Virus / Acquired Immune Deficiency Syndrome
CEF	Central Energy Fund
MCC	Medicines Control Council
UP	University of Pretoria
DTI	Department of Trade and Industry
NIMR	National Institute for Medical Research
NRF	National Research Foundation

1 Introduction

Humic substances are naturally occurring acids that have beneficial medicinal properties. In short, they are anti-microbial, anti-inflammatory, and anti-viral. In parts of the world they have been part of folk medicine for a long time. Some applications have been thoroughly researched, tested, and approved for sale. For example, skin infections of dogs and cats can be treated with ointments based on humic substances. This is the science dimension of this case study. It is relatively easily told.

By contrast, the politics dimension is very complicated. Due to their anti-viral effects, humic substances were used in clinical trials of HIV-positive patients. For a number of reasons, these trials were extremely controversial. The negative publicity they attracted led to the sale of the state-owned company, including its intellectual property rights, which had been at the forefront of humic substance research in South Africa, to an overseas firm.

The politics and the science of the technology behind humic substances are intensely related, albeit not in ways that in retrospect would appear to have benefited the return to public R&D in South Africa or, for that matter, human progress more generally. Due to the political imbroglio, it was never established what, if any, effects humic substances might have in the treatment of HIV/AIDS. Conversely, it was never established that they had no effects, either. Given the severity of the epidemic, this lack of knowledge comes at a high price. If humic substances might have any merit in combating HIV/AIDS, they should be further researched. If they do not, they should be added once and for all to the long list of failed attempts to find a cure for the epidemic. It appears that the politics of the case make this verification difficult. This is not optimal.

An interesting side show of this case is the management of intellectual property rights. Rights to a specific humic substance, held by a state-owned company in South Africa, were sold for a few million Rand to an overseas company that now has the rights to worldwide royalties outside Africa. In short, while the initial investment that led to the patented technology was made in South Africa, a major portion of the gains from the investment will eventually be collected abroad. The national return on investment in public R&D was therefore decidedly poor. Perhaps more significantly, control over technological assets created in a developing country ended up in a developed country.[1] In a world in which command over knowledge assets is increasingly important, this is also not optimal.

Muti from coal epitomises lateral migration. South Africa literally sits on brown coal. It is the third biggest producer in the world, mining about 35 million tons a year. Coal accounts for more than 90 per cent of the country's energy supply. The processes associated with generating this technology started with wet oxidisation of bituminous coal and later changed to using a plant source to synthesise humic substances from carbohydrates.

The paper proceeds as follows. Section 2 chronicles research of humic substances in South Africa. Section 3 surveys the literature on humic substances, focusing on pharmacological aspects. It tries to establish what we do and what we do not know about the medicinal properties of these acids, and to differentiate quackery from serious science. Section 4 discusses the intellectual property dimension. Section 5

[1] The overseas patent holder eventually renegotiated its agreement with the South African firm that arranged the sale of the patents whereby the latter secured worldwide production and African marketing rights.

briefly touches on absorptive capacities. Section 6 concludes with recommendations for public policy.

2 Research on humic substances in South Africa

The central institution behind research into humic substances in South Africa was Enerkom, the former research branch of the Central Energy Fund (CEF), the state oil agency. CEF is a private company governed by the CEF Act. Its one non-transferable share is held by the state and the company is controlled by the Minister of Energy and Minerals (www.cef.co.za).

In the 1980s, CEF mandated Enerkom to research alternative uses for coal. Enerkom's scientists focused on humic substances. They occur naturally in the soil and in stream water where they account for some 50 per cent of the dissolved organic carbon. These acids are good fertilisers; humic acid stimulates crop yield while fulvic acid is a nutrient with beneficial properties for plant growth. Compost and peat contain a lot of humic substances. Subjected to pressure and temperatures over very long periods of time, peat becomes coal.

From 1984 Enerkom developed a process which essentially reversed the process by which coal is formed – instead of humic substances losing oxygen that over millions of years creates coal, the scientists oxidised coal back to humic and fulvic acid, naming them Oxihumate and Oxifulvate, respectively. The process was successful and Enerkom registered patents in South Africa and in the most important developed economies. However, the cost of oxidisation was prohibitively high for use of the product in agriculture. Enerkom therefore wanted to explore alternative uses. According to anecdotal evidence, humic substances might have beneficial medicinal properties. For example, humic acids are widely used as folk medicine in East Asia, and peat had reportedly helped in the treatment of amputations and similar serious wounds during World War I. Yet the evidence was merely observational and had never been systematically researched.

It was for this reason that in 1998 Enerkom which was located in Pretoria approached the Department of Immunology at the University of Pretoria (UP), proposing collaborative research into the medicinal properties of humic acid. It struck an agreement with a research team led by Professor Connie Medlen, an immunologist who later transferred to UP's Department of Pharmacology.[2] Subsequently her team undertook a series of in vitro and animal tests.

2.1 Research on humic acid

The test results showed that humic acid has anti-inflammatory, antimicrobial, and antiviral effects (e.g. Jooné et al. 2001, 2003; van Rensburg et al. 2002). For example, the administration of humic acid in animal trials led to the suppression of the rejection of cell transplants by the immune system of the host. It also suppressed a contact hypersensitivity reaction. The same effects were seen on isolated phagocytes in that there was a decrease in adhesion molecules associated with the inflammation. At the same time, however, lymphocytes isolated from blood drawn from HIV positive patients that had been treated with humic acid for two weeks showed an increase in proliferation when stimulated with a non-specific stimulant. In other words, the cell-

[2] Medlen publishes under the name of Van Rensburg.

mediated immune system, greatly compromised in HIV positive patients, was stimulated while the phagocyte part associated with the inflammation was suppressed.

Because of the antiviral effects, in 1999 the team sought and gained permission for a clinical trial at Kalafong, an academic clinic in Gauteng. The Medicines Control Council (MCC) limited the trial to two weeks' duration out of concern that the HIV might develop resistance. Hence it was not possible to assess efficacy because the viral load does not sufficiently decrease in such a short period of time. What the trial did show, however, was that humic acid was non-toxic.[3] In addition, patients on Oxihumate put on weight and their general condition appeared to improve. These results were presented to an international peer audience and also published (Botes et al. 2000, 2002; Van Rensburg 2000, Van Rensburg et al. 1999, Van Rensburg et al. 2001).

Funding for this research came not just from Enerkom but also, in the form of co-financing, from THRIP, a financing vehicle in support of science-industry interaction run by the South African Department of Trade and Industry (DTI).

Upon the invitation of the Chief of the Defence Force in Tanzania, the team subsequently undertook a placebo-controlled clinical trial at the Lugalo military hospital in Dar Es-Salaam which began in late 1999. At this point the story gets complicated. The ethics committee at UP had approved the trial. Permission from the MCC was not necessary because the trial was to take place outside South Africa. Whether or not the team had permission from the South African Department of Health to import blood samples from the hospital for analysis is a matter of contention. In Tanzania, the National Institute for Medical Research (NIMR) argued with the military over who had jurisdiction in this matter. The NIMR claimed responsibility over any clinical trial in the country, while the military argued that trials concerning its personnel were exempt from this rule. Whatever the merits of these arguments, the fact that they came to the fore at all suggests that preparations for such a sensitive trial were not handled with the requisite diligence. It is furthermore clear that the mere existence of these arguments did not help the research team's cause.

The relative merits of this trial were never properly assessed, let alone peer-reviewed. The reason for this is not exactly straightforward. Four years prior to this trial, a clinical technician from UP had peddled a substance called Virodene as an HIV/AIDS cure. Virodene contained a highly toxic industrial solvent. The fact that the woman behind this campaign, Olga Visser, had been given the opportunity to present her case to the South African cabinet became a major embarrassment to a government that had already attracted widespread criticism for its handling of the HIV/AIDS crisis. In a curious twist of fate, Visser had also been testing her concoction at Lugalo hospital.

When this became more widely known, the Tanzanian authorities expelled her from the country. A political uproar involving primarily Tanzanian authorities and South African media ensued that ultimately led to the unceremonious discontinuation of the Oxihumate trial. Ethics experts raised the question as to why soldiers were used for the trial, normally a group of people one would want to avoid – just like prisoners or other institutionalised groups of people – because they are typically not at liberty to decide for themselves. The Mail&Guardian, an important South African weekly, reported on the story in September and October 2001 (Deane, Macfarlane, Soggot

[3] A two-week trial is not sufficient to determine safety. But dosages in the trial reached up to 8g/day and exceeded the prescribed dosages by two to four times. In addition, animal toxicity tests found no ill effects on the pathological parameters monitored for up to 1 gram per kilo bodyweight.

2001, Soggot and Macfarlane 2001). Not surprisingly, the articles were very critical. This must be seen in the context of a political environment that had for some time at the highest levels tolerated and created space for quackery and thus understandably led to suspicion of any new "wonder drug".

In turn, the relevant South African authorities had presumably no appetite for yet another HIV/AIDS scandal. Enerkom was swiftly liquidated (CEF Washes Its Hand of Enerkom 2002). The company still formally exists as a shell but its plant and equipment were sold and the entire staff was laid off. Since ultimately the company had never yet produced anything of commercial value – its registration as a research entity did not allow it to undertake sales - the return on investment (to the tune of R80-120 million in total) was decidedly poor. The ultimate reason for the liquidation was an attempt by management and their political masters to get out of the bad publicity that had been generated.

The liquidation implied an end to the funding the team had received from Enerkom thanks to which it had managed to finance not just the research but also a few postgraduate students. However the academic output resulting from the four years of funding was considerable.

Subsequently a former Enerkom employee who continued to believe in the value of humic substances set up a company called Unique Formulations. He substituted Enerkom's production of humic substances with a source imported from Australia whereby humic acid was generated from brown coal. This practice also exists in Russia, India, and Germany. Since brown coal is the softest available coal, it requires no oxidisation; the humic acid can basically be extracted. With a soluble humate content of at least 96 per cent, this is a much cheaper and better product than the oxidised version at a maximum 33 per cent. Among other things, it reduces the required intake compared to Enerkom's product. Unique Formulations sells a range of vitamins and herbal medicines and markets humic acid as a food supplement. However, since there has never been much uptake, the company was not interested in investing in further research of the product.

The UP team, on the other hand, continued with its trials, using the humic acid capsulated by Unique Formulations. At the time of writing, it was engaged in a clinical trial on hay fever and was planning another one on arthritis. The availability of the product as a food supplement considerably lowers the threshold for permission of clinical trials.

In sum, although the product is currently freely available on the market (as a food supplement), it is not being traded for its potential medicinal properties (e.g. against hay fever) because they have never been properly demonstrated. Even the humic acid sold for animals has apparently never been subjected to a placebo-controlled trial. The UP team's claim to fame is then to be the first group to have undertaken preliminary scientific tests of its effects on use in humans and animals.

2.2 Research on fulvic acid

Fulvic acid also has interesting properties. Fulvic acid has anti-inflammatory and antimicrobial effects and lends itelf particularly to topical applications, such as for psioriasis and eczema. The team at UP described the anti-inflammatory properties in a mouse model of contact hypersensitivity as well as in atopic dermal reactions in humans (Snyman et al. 2002, Van Rensburg, Malfeld, and Dekker 2001, Van Rensburg, Van Straten, and Dekker 2000). The MCC approved fulvic acid as a veterinary treatment for dogs and cats suffering from pyotraumatic dermatitis or eczema. This was a direct outcome of the team's research. Although it is not yet clear

how exactly fulvic acid works, preliminary results indicate that it scavenges free radicals and inhibits specific phagocytic and lymphocytic cellular functions.

Research on fulvic acid is continuing in disparate ways. The people involved always appear to have a direct or indirect connection to the now defunct Enerkom. For example, Pfeinsmith Ltd, the overseas company that bought the entire portfolio of Enerkom's intellectual property rights – some 128 patents in total – granted the exploitation of this intellectual property in Africa to the South African company that arranged the sale. This company is now called Secomet (www.secomet.com). It operates out of the Techno Park in Stellenbosch near Cape Town.

Secomet has identified a new source of fulvic acid, based on carbohydrates derived from plants. The advantage of deriving fulvic acid from what is essentially a food source is that unlike coal it does not contain traces of toxic metals such as magnesium, chrome, or aluminium. These levels may be very low in fulvic acid derived from coal but it is obviously better not to encounter them at all.

Secomet markets a variety of extracts based on fulvic acid. It had the anti-microbial efficacy of the plant extracts it uses tested in vitro by the School of Child & Adolescent Health at the University of Cape Town. The lab reported growth inhibitions of 16 bacterial organisms to each of the four plant extracts tested, and recommended further research into the active component (De Wet n.d.). In addition, in 2005 Secomet contracted ViroLogic, a lab in California, to evaluate its product against ten strains of HIV in vitro. In vitro work undertaken at the Department of Medical Virology at the University of Cape Town also confirmed antiretroviral activity.

Secomet contacted the UP team in 2005 to explore R&D cooperation on fulvic acid. Initial understanding is that they will contribute R200,000 toward the funding of a PhD student to work on the project for two years, specifically on a clinical trial focusing on eczema.

In sum, humic and fulvic acids are still being investigated for their medicinal properties. The next section discusses how serious this research is.

3 The relative scientific merit of research on humic substances

If humic substances had not demonstrated antiviral properties in vitro which led to the clinical HIV/AIDS trials, pharmacological research would have been limited to their antimicrobial and anti-inflammatory effects. It would then in all likelihood not have been politicised. This is relevant for the project to which this case contributes. Without the scandal caused by the Tanzanian episode, Enerkom would conceivably not have been sold and the intellectual property rights would have stayed in the country. South Africa would perhaps have successfully pioneered one or more new drugs and been in a position to reap the benefits from their commercialisation. In retrospect, it is thus important to understand the scientific merit of research that nolens volens effectively truncated work on what appeared a promising new technology.

Humic substances have a long therapeutic history. They have been used in mud baths to treat rheumatic conditions (Baatz 1988, Kleinschmidt 1988, Kovarik 1988, Lent 1988), for the prevention of wound infections in World War I (Haanel 1924, Van Beneden 1971), and as a tonic for liver and gastric ailments (Kallus 1964). What is known about humic substances is that they appear to chelate toxic compounds (Marx

and Heumann 1999, Nifant'eva et al. 1999, Sauvant et al. 1999, Shanmukhappa and Meelaktan 1990, and Stackhouse and Benson 1989) and absorb xenobiotics (Nielsen et al. 1997, Proen and Zupancic-Kralj 2000), mutagens (Ferrara et al. 2000), and mycotoxins (Van Rensburg et al. 2002).

Commercially available medications based on humic acid are antibacterial, antitoxic, anti-ulcerogenic, anti-allergic, and anti-inflammatory (Shepetkin et al. 2002). Anti-arthritic effects are also known (Goel et al. 1990, Iubitska and Ivanov 1999, Kelginbaev et al. 1973, Kleinschmidt 1988, Soliev 1983, Suleimanov 1972), as is activity against the herpes simplex virus (Thiel et al. 1977) and several types of influenza type A and B viruses (Hils et al. 1986). However, none of these findings have been subjected to clinical trials.

Research on fulvic acid is much rarer. The UP team established antimicrobial, antiviral, and anti-inflammatory activity in a series of in vitro and in vivo trials (Van Rensburg et al. 2000, 2001, Snyman et al. 2002). The results suggested that fulvic acid, applied topically, might be a safe and effective treatment for skin infections caused by pathogenic bacteria and Herpes Simplex Virus-1 as well of inflammatory conditions of the skin. Only clinical trials can identify the effects on specific conditions such as fever blisters, urticaria, acute eczematous dermatitis, psoriasis and acne vulgaris.

Clinical trials may of course fail to confirm the expected results. But this research has been subjected to peer review and is not suspect. The same cannot be said about all lobbies associated with humic substances.

One group with an extensive website claims that "[f]ulvic acid has the potential to heal the Earth!" (www.livearth.com/articles/art5.htm). Another one hails that "[f]ulvic acid holds the keys to prevention, healing, and elimination of the world's diseases" (www.fulvic.com). This includes the contention that fulvic acid effectively and safely kills the HIV/AIDS virus. These claims are at best unproven and at worst plain silly and morally abhorrent. They are important to note, however, because they appear to influence the conditions under which serious research can be undertaken, especially with respect to furthering the investigations into the antiviral properties of humic substances – for obvious reasons a highly charged topic.

It is hence important to review what is and what is not known about humic substances and HIV/AIDS. Researchers based in Germany first showed the anti-HIV activity of humic acid in cell culture (Schneider et al. 1996). Hence when the UP team started its own investigations, there was nothing wrong with probing the issue further. Its in vitro research showed that humic acid impacts on the cell mediated immunity necessary to cope with opportunistic infections by stimulating lymphocyte proliferation (Joonè et al. 2003, Van Rensburg et al. 1999, 2000, 2001, 2002). It also inhibited the damage done by and to inflammatory cells (Jooné et al. 2001; see also Gau et al 2000). This result was also obtained in vivo in the Kalafong clinical trial (Botes et al. 2000, 2003, Jooné et al. 2003). The trial lasted only two weeks but the patients on humic acid gained weight compared to the placebo group.

The clinical trial in Tanzania lasted for roughly a year and was administered to 350 HIV-positive adults, with very high median viral loads. These patients were on no previous HIV/AIDS treatment regimen. During the first three months the trial was placebo controlled. The viral load and the CD4 counts of the treatment group stabilized during this period. Hence they did not improve. But other non-specific disease parameters of disease progression – such as weight, WHO performance status and so on – improved significantly. This result still showed after 12 months; this may be due to oxihumate but could also be due to nutrition or other factors.

Owing to pressure by the local doctors – who believed that oxihumate had beneficial effects – to make the substance available to all patients, the entire group received it for

the following nine months. The absence of a control group plus problems with missing data made it impossible to analyse the results conclusively. However, both the viral load and the CD4 counts of the group as a whole deteriorated from months 4 to 12. Patients tolerated oxihumate well and direct drug-related toxicity or side effects were not evident.

In essence, the study suggested that humic acid may improve the quality of life of HIV/AIDS patients. It might be possible to combine it with ARVs so as to obtain a reduction in viral loads and an increase in CD4 counts, followed by a period of parameter stabilisation during which humic acid is administered alone. If this were successful, it would minimize the side effects of ARVs while still exploiting their efficacy and increase the general wellbeing of patients.

Whether this would justify undertaking a clinical trial depends on how one views the opportunity costs. One the one hand, with the help of a range of effective and reasonably safe ARVs HIV can be turned into a chronic condition. Control over side effects has improved as well. Arguably much benefit is to be gained from researching new ways to administer the drugs and how further to omit their undesirable features. Additional challenges include the need to allow for structured treatment breaks and to come up with successor drugs that handle problems of resistance. On the other hand, there might be a role for humic acid, for example during treatment breaks. Since without clinical trials one will never know, the question is how the private or public sectors assess the potential financial or public-good return on the investment in a clinical trial.

Secomet sponsors research on the antiretroviral properties of fulvic acid at the Medical Virology Department at the University of Cape Town. Results from laboratory tests suggest that fulvic acid controls the contagiousness of the virus and prevents it from infecting new cells. If this would work in people is an open question. On its website, Secomet reports anecdotal evidence of people whose viral load has dropped after taking its product Seco V. But if this is causal or coincidental can again of course only become evident in a clinical trial.

4 Intellectual property

Unlike humic acids, fulvic acids had never been described for medicinal use before 1999. Hence Medlen and her counterpart at Enerkom, Dekker, registered an international patent in South Africa on the product and its applications (Patent number WO 0019999; AU5992399) as co-inventors. Medlen signed off her rights to Enerkom. In the absence of a fee, this cessation suggests that UP's Technology Transfer Office had little to no experience with harvesting the fruits of intellectual property developed at the university.

Unlike the process patent concerning the oxidisation of humic acid, this patent was commercially much more viable. A producer of humic acid from whatever source has not much of an incentive to invest in research insofar the substance per se is not patentable. The results would therefore be in the public domain and anybody could walk away with them. In 2003, a foreign company by the name of Pfeinsmith acquired Enerkom's patent portfolio through a South African middleman who negotiated that the rights to the manufacture and sale of fulvic acid in all of Africa would remain with himself. Pfeinsmith then had all patents assigned from Enerkom to itself, a process that in late 2005 appears pretty much complete, allowing it to collect royalties worldwide from any distributor of the substance. This agreement was later amended to assign worldwide production and African distribution rights to the South African company and international marketing rights to Pfeinsmith.

In sum, quite apart from the merits of humic substances in treating a variety of conditions, intellectual property created in South Africa at considerable cost to the public has led to income streams accruing to an outside entity that reportedly paid a fraction of the original investment for the rights to exploit the results from research on humic acid and to commercialise fulvic acid. Although knowledge intensification did take place, the technology in question emigrated, leaving little trace in its country of origin. To date the whole exercise did not meet its objectives of furthering industrial diversification away from coal merely as a source of fuel.

Rents dissipated out of the country. But IP issues also concern the relationship between Enerkom and UP. In retrospect it would seem that UP, by signing off its rights to Enerkom, did not receive benefits commensurate to its input. Incentives to the individual scientists and to the institution as a whole would thus not appear strong enough to foster a climate conducive to innovation. Put differently, if UP had sold its contribution to the development of the technology at a higher price, it might have been able to fund further those aspects of the research not covered by patent protection. Alternatively, if it had insisted on retaining ownership control over the technology, the intellectual property might have never left the country. What seems clear is that technology transfer offices at universities must learn better to reconcile incentive and reward for their academic communities so as to spur innovative activities in a supportive environment, with lasting benefits for national technological development.

5 The role and relative importance of the team at UP

The reason Enerkom originally approached Prof. Medlen was somewhat accidental. Immunology was of course her area of research but she had never thought about humic substances per se. Had she not been interested in cooperating with Enerkom, the company could have approached pretty much any university in the country that undertakes drug development. Of course, UP was very close to Enerkom, so the communication was easy and convenient.

In general, Prof. Medlen's immunology unit is research intensive. It continuously trains postgraduate students, including on this project. Overall size was small, however; only some five staff were full-time researchers. At no point in time was there more than a handful of people working on humic substances. Hence the human capital associated with research on humic substances was highly concentrated and somewhat thin on the ground; if the UP group had for whatever reason decided to leave the country, research capacity in South Africa would have been severely affected. The pharmacology unit is somewhat bigger and more comprehensive. The head of department is a clinical pharmacologist and can therefore lead clinical trials. In essence, the department can go all the way from in vitro experiments via animal experiments to human trials.

At the moment funds for research into humic substances are available from the National Research Foundation (NRF) to the tune of some R200,000. This is not much but it is better than the dry years following the demise of Enerkom and the concomitant interruption in THRIP funds.

6 Conclusion

Why is this story worth telling? First, it demonstrates a dedicated and sophisticated attempt at downstream beneficiation, from coal as a source of fuel to coal as a source of medicine, involving government agencies, universities, and the private sector. Second, it produced results that under normal circumstances are likely to have led to further investigation. Third, science obviously does not happen in a vacuum. In this case, the research became embroiled in a political conflict over misguided HIV/AIDS research that proved to be its undoing. Fourth, it would appear that the management of the research project – independently of its scientific merits – left something to be desired, both inside and outside the university. Fifth, and most importantly, technological knowledge developed in and funded by South Africa left the country without any apparent gain in the country in return for the investment undertaken. Technologically, this is not a success story but more a litany of failures.

These points carry some lessons. The first is that knowledge intensification as a strategic activity driven by government in conjunction with the science sector can work. In fact, after muti from coal, South Africa is currently investing in muti from gold. A partnership consisting of Mintek, a science council in minerals and mining, and Harmony, a gold mining house, initiated biomedical research on the anti-cancer, anti-HIV, and anti-malaria effects of gold. A number of active compounds with anti-cancer properties have been identified and now need to undergo testing. Funding for this project comes from private and public sources both in South Africa and abroad (James 2005).

The second lesson is that political interference can be highly detrimental to scientific pursuit. This is not an argument in favour of leaving scientists to their own devices, especially when they are funded from the public purse. Yet the politics-science interface in this case was evidently not ideal. This study has discussed evidence, partly produced in South Africa, that humic substances are non-toxic, non-mutagenic, and non-teratogenic. They stimulate the cell-mediated immune system, inhibit inflammatory reactions, inactivate the growth of certain viruses, and protect against environmental toxins. In addition, they are also relatively cheap. This calls for more clinical research to assess their efficacy and selectivity as a drug for the treatment of diseases associated with viral and other opportunistic infections as well as inflammatory conditions such as autoimmune diseases and allergies. These are among the most common diseases on earth, they afflict large numbers of people in Africa and, if treated successfully, would improve livelihoods and enhance economic development more generally.

With respect to the most controversial part of the research – its possible anti-HIV/AIDS properties – it is worth remembering that absence of evidence does not equal the evidence of absence. To be sure, where human health or lives are at stake, quacks must be dealt with, and government would be well advised to pay attention to what the scientific community has to say in this regard. At the same time, however, if serious scientific inquiry suggests that a substance may be effective in treating this country's worst disease, it should be evaluated on merit only.

The third lesson is that good government intentions and highly developed local scientific capabilities are not sufficient to guarantee beneficial outcomes in favour of making the most of resource-intensive sectors. Research needs to be managed to be successful. This includes managing the relationship between client and contractor in a transparent way. It also requires a sophisticated understanding of intellectual property issues between the local stakeholders and between them and any foreign counterparts. The lack of documentation, the secrecy, and the amount of incorrect information

surrounding this case are abysmal. They directly and indirectly impede learning about what works and what does not work in making life for a lot of people less miserable. As such, they stand in the way of human progress.

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