SCIENCE IN AFRICA AT THE DAWN OF THE 21st CENTURY

Under the leadership of Roland Waast and Jacques Gaillard

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Part One

SOUTH AFRICA

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ABET	Adult Basic Education and Training
AEC	Atomic Energy Corporation
AISA	Africa Institute of South Africa
ANC	African National Congress
ARC	Agricultural Research Council
ARP	Antarctic Research Programme
AS&TS	Association of Scientific and Technical Societies of South Africa
ASSA	Academy of Science in South Africa
ATS	Aptitude Tests Section
AUT	Advisory Council of Universities and Technikons
BSP	Bureau for Scientific Publications
CENIS	Centre for Interdisciplinary Studies
CGS	Council for Geoscience
CHE	Council for Higher Education
CHSC	Committee of Heads of Science Councils
COHSSSA	Consortium of Human Sciences Societies of South Africa
COSATU	Congress of South African Trade Unions
CSD	Centre for Science Development
CSIR	Council for Scientific and Industrial Research
CTP	Committee of Technikon Principals
CUP	Council of University Principals
DACST	Department of Arts, Culture, Science and Technology
DoE	Department of Education
DTI	Department of Trade and Industry
ESRC	Economic and Social Research Council
FRD	Foundation for Research Development
FRS	Finance and Reporting System
GATT	General Agreement on Trade and Tariffs
GEAR	Growth, Employment and Redistribution
HEI	(p110)
HRD	Human Resource Development
HSRC	Human Science Research Council
IDC	Industrial Development Corporation
IDR	Institute of Research for Development (France)
IDRC	Internationl Development Research Centre (Canada)

ISTG	Interim Science and Technology Group
MCST	Minister's Committee on Science and Technology
MINTEK	Mineral Technology Council
MRC	Medical Research Council
NAC	National Accelerator Centre
NACI	National Advisory Council on Innovation
NBI	National Botanical Institute
NCHE	National Commission on Higher Education
NECC	National Co-ordinating Committee
NEPI	National Education Policy Investigation
NIF	National Innovation Fund
NIPR	National Institue of Personnel Research
NIV	National Institute for Virology
NRF	National Research Forum
NRTA	National Research and Technology Audit
NRTF	National Research and Technology Foresight
NSFRI	National Sea Fisheries Research Institute
NSI	National System of Innovation
NSTF	National Science and Technology Forum
OECD	Organisation for Economic Co-operation and Development
PSE	Post-Secondary Education
PUSET	Public Understanding of Science and Technology
R&D	Research and Development
RDP	Reconstruction and Development Programme
RSSA	Royal Society of South Africa
S&T	Science and Technology
SAAF	South African Air Force
SAASTEC	South African Association of Science and Technology Centres
SABS	South Africa Bureau of Standards
SAC	Science Advisory Council
SAFEST	South African Foundation for Education, Science and Technology
SALT	South Africa Large Telescope
SANCO	South African National Civic Organisation
SANSA	South African Network of Skills Abroad
SAP	Structural Adjustment Programmes
SAQA	South African Qualifications Authority
SASCON	Southern African Science Communication Network

SAUVCA	South African Universities' Vice-chancellors' Association
SAWB	South African Weather Bureau
SAWISE	Association of South African Women in Science and Engineering
SEASA	Science and Engineering Academy of South Africa
SET	Science, Engineering and Technology
SETI	Science, Engineering and Technology Institutions
SMME	Small, Medium and Macro Enterprises
SPII	Support Programme for Industrial Innovation
STEEP	Social, technological, economic, ecological and political factors
STG	Science and Technology Group
STPRC	Science and Technology Policy Research Centre
SWOT	Strengths, weaknesses, opportunities and threats analysis
THRIP	Technology and Human Resources for Industry Programme
TSP	Technology Stations Programme
W-i-R	Women in Research
WRC	Water Research Commission

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PREFACE

The Centre for Interdisciplinary Studies was commissioned by the IRD, Paris to undertake a country specific study of the state of science and technology in South Africa. This study forms part of a continent wide study, sponsored by the European Union, of twelve African countries. This report is the first of three reports on South Africa. The other two reports will document (1) a bibliometric analysis of the publication output of South African scholars for the period 1990 - 1998 and (2) an empirical study of prominent South African scientific establishments, research centres and leading scientists. The latter will focus on current research practices, shifts in modes of knowledge production and strategic decisions (and actions) taken to survive in an increasingly competitive and global environment.

This report is based mainly on desk research and discussions with informed commentators. The aim is to present an overview of the existing science and technology system in the public sphere. Public R&D in South Africa is performed mainly by the following groupings:

- Academic Research Institutions: Universities and Technikons
- Government Departments
- Science Councils
- Non-profit industry based research organisations
- Research NGOs (Civil Society)

Academic research refers to research being undertaken within departments, centres, laboratories and institutes of the 22 Universities and 15 Technikons in South Africa. Research is also being conducted within some government departments, notably the Departments of Agriculture, Forestry, Water Affairs and Environmental Affairs. However, as we will show, the trend has been for government (over the past decade) to disown such research "units" and to move the in-house research capacity elsewhere - most often to the science councils. A significant slice of the science vote is allocated to the eight science councils or national research institutions. R&D within the business or private sector constitutes the biggest proportion (about two thirds) of all R&D in South Africa. Given that our focus is on public sector research (research funded fully or partially by the taxpayer), we will not include this sector in our report. Similarly, research NGOs in civil society, will also be excluded from our analysis. Although not a major player in the national scene, some of the individual ngo's have managed to acquire high profiles and do exert some influence, especially in the fields of social and health policy. Finally, there are a number of non-profit "industry" based research organisations (e.g. Institute for Commercial Forestry Research and the South African Sugar Association) which receive some support from government.

This report consists of three parts: The first contains a brief history of South African science. The aim is not to be exhaustive, but to highlight main trends and shifts in research philosophies since the emergence of scientific endeavours in the country. The main body of the text is presented in Part Two. This section is devoted to a detailed discussion of the science and technology system at four levels: at the macro-level (government structures, bodies and initiatives); at the intermediary level (funding agencies and mechanisms as well as professional interest groups); at the performance level (SETI research institutions) and at the level of the science-public interface (public understanding of science and science controversy issues). The final section of the report - which will be only written at the beginning of 2000 - will be devoted to a broad assessment of the existing system (its strengths and weaknesses, opportunities and challenges) as well as a more speculative section on future prospects.

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PART ONE: BACKGROUND

An understanding and appreciation of the history of South African scholarship and scientific endeavour, is a prerequisite to making sense of more recent developments in science and technology in the country. We have attempted the impossible: to write such a history in one chapter. This means that it inevitably is selective and impressionistic. We have chosen to highlight themes and trends that exhibit key developments, important shifts and lasting legacies, rather than to produce a detailed documentation of events and decisions.

Despite its collage-like character, the brief historical sketch reveals a rich and deep scientific tradition that goes back to the earliest days of South African society when scholars from Europe pioneered various scientific endeavours in path-breaking ways. The review also tracks the emergence of an amateur and vibrant science culture around the turn of the previous century, the consolidation and diversification of the science base between the wars and its exponential growth after the second World War. But no history of South African science would be complete without showing the ambivalent legacy of apartheid science. On the one hand, the apartheid regime poured huge amounts of money into military, defence and energy research that led to innovations in various fields. On the other hand, it created an isolationist, inward-looking and "technicist" science, without regard for accountability or justice. We had to wait till the beginning of the last decade, before the shackles of the political system, and with it - the science and technology system - would be broken.

Our story in this chapter ends with a retrospective assessment of the last three and half centuries of South African science. The style here is narrative (at times even prosaic); the remainder of the report, however, is more descriptive in charting recent and current events in the South African science and technology landscape. The final section of the report ventures to present a more speculative prospect of the future.

Chapter One

A BRIEF HISTORY OF SCIENCE IN SOUTH AFRICA

Original talents from the obscurity of time

It is almost impossible for us to know the conceptions of knowledge or the practices employed in guiding the technological accomplishments of the Africa of antiquity. However, it is worth recalling that such concepts led to considerable successes, affirmed by archaeology and brought to centre stage today: in mineral exploitation and prospecting; metallurgy (particularly for precious metals); fishing skills and tool manufacture for example. There are many such souvenirs that evoke ancestral abilities whose threads the New South Africa intends to pick up and revive in a drive towards an African Renaissance. Such evidence is the affirmation that science and technology were once integral elements of Black identity and culture; and that it is possible to make the most of indigenous knowledges.

We are no better informed on the "epistemological position" of the more recent inhabitants, the Boer farmers, the English traders or indigenous cultivators of the 17th and 18th centuries, whose observations enriched the technical practices. The activity of science, as we understand it, was first documented (in a written form) during the course of the 18th century, when the Cape Colony attracted devotees of a bold young science born of the European Renaissance. This science aspired to be universal and wanted to measure Earth and regard the planet as a village where, uncovering the spectrum of possibilities, it could test its hypotheses.

1.1 SCIENCE FOR THE SAKE OF SCIENCE: 1751 - 1880

> The Cape Colony changed "hands" twice during the eighteenth and early nineteenth century. Initially a Dutch colony, it was annexed by the British in 1795, then handed back to the Dutch and again, at the beginning of the nineteenth century fell under British rule (1806). In 1838 a number of "Afrikaner dissidents" left the Cape Colony and trekked north. They would eventually establish the so-called Boer Republics: the Transvaal, Free State and Natal republics.

In the 18th century the Cape trading post was the most accessible part of the antipodes for Europeans. It was to have all manner of incongruous visitors, whose motives were a thousand miles away from the reason prevailing here at the time.

The travelling scholar who first left any lasting work was a Frenchman, Abbot de la Caille. He was sent on a mission by the French Academy of Sciences in 1751, and, in less than two years, he determined the position of nearly 10 000 stars, classified in order of brightness and catalogued 42 nebulae; accurately defined the longitude of the Cape of Good Hope; inaugurated geodesic triangulation and charted Hout Bay. He also meticulously measured an arc of the Earth's meridian - which was important for determining whether or not the global sphere was flattened and finding its distance from the moon. These pieces of work "laid the foundation for a precise study of astronomy in the Southern Hemisphere". They constituted the first record and were published in France, where the author was professor of mathematics at the illustrious Collège Mazarin.

Another factor that spurred scientific exploration was the rather original flora of the country at the Cape, which had been a subject of curiosity for many decades. Since 1652, collections had been made and sent back to Europe for study by the governors and gardeners of the Dutch East India Company, as well as by scholarly travellers, such as Heurnius (a missionary, as far back as 1624) and Hermann (professor at Leiden, about 1700). However, it was in the mid-18th century that botany became the science of predilection in Europe, where Linnaeus was applying his systematic classification to it. What was called exploration was putting taxonomy to the test and enriching the body of knowledge. Linnaeus himself sought to assist in this: his devoted followers were to travel the world and notably bring the southern part of the African continent into the era of the natural sciences. The two precursors were Sparrman and Thunberg. Backed financially by Swedish and Dutch sponsors, they were nonetheless to complement their incomes once in South Africa, by hiring themselves out from time to time as explorers for the local administration, or to train the Company's gardeners. Their expeditions into the interior, from 1772, resulted in the methodical cataloguing of thousands of new plants, as well as in closely defined reference frameworks in zoology, ethnobotany and anthropology. They encountered other expeditions and sometimes took part in them (Sparrman interrupted his first visit so he could join Cook's expedition), in this way widening their comparative knowledge. They also taught others their methods, and recruited amateurs on the spot with varying degrees of ability.

The gardeners Masson (from Kew Gardens) and Paterson (a Scotsman working for an English countess), the settler S. van Reenen and others were to pursue expeditions and collecting, but none with as much zeal, boldness and intelligence as the young officer R. J. Gordon, who mastered several local languages, and conducted some daring explorations in the unknown East and North between 1777 and 1780. The Government supported these prospecting trips occasionally, depending on its interests in the political and economic situation of the time. These ranged from keeping an eye over the relations between far-flung colonial settlements and the neighbouring "tribes", the fear of the landing of masses of foreigners, to the need to establish commercial relations with indigenous livestock farmers. Collections began to be conserved properly in the Cape Citadel. However, the risks of war dispersed these, when, between 1795 and 1810, the English and Dutch started to dispute ownership of the colony. Many field notes consequently remained unpublished. Reliable information was only to be found in a few scientific books that were published in Europe after the great voyagers had returned; and the European collections preserved their reference status. As a result, the same work had to be restarted several times locally, at the behest of successive English or Dutch governors, depending on which side had won. Each change in military fortunes cancelled out the new-found knowledge., As it was deemed of strategic importance, records of it were destroyed by the losers, unless their authors had been able to deposit a copy safely in their country of origin.

The interests of these, invariably foreign, scientists extended not only to the flora and fauna, but to geomorphology and mineralogy. Among the most outstanding figures are the (almost) completely self-taught J. Barrow (in 1797-98), the German doctor M. H. K. Lichtenstein (in 1803-06), and the Linnaean W. J. Burchell (1810-15), who immersed himself in the local population in the course of his expeditions.

At this point, it must be recognized that the adventure of modern science begins here, as that of a "pure", cosmopolitan science, with neither the possibility nor the concern of founding a line in the country of investigation. It was a world away from either the inhabitants' conceptions of knowledge or their preoccupations. It was an adventure espoused by foreign travellers who sometimes stayed a number of years and were obliged, in order to survive, to serve the authorities from time to time. There could be no talk of "national science", of course as it is doubtful if the idea of a nation had even emerged; but the activity could no longer be called "colonial" either, in the sense of a whole apparatus maintained by the occupier (as in India) as a permanent aid to the aims of conquest and to development of the territories already controlled. It was a matter rather of a science whose hub remained in Europe, its theorists voyaging very little, but delegating to their trusty disciples the task of making good use of ground already covered by a myriad of local observers, and of methodically collecting the field data which was to be the food for their deliberations. These scientific envoys were specialists, certainly, but not professionals pursuing a stable career in an institution. Rather they hired out their skills and knowledge across the world, applying them to resolve the problems presented to them by their diverse employers. They topped up their income as and when the right opportunities, place and moments presented themselves. Paradoxically, they operated in "mode 2 of knowledge production"; a recent thesis (Gibbons et al., 1994) put forward as an innovation of the end of our own century and as a foretaste of a global, international and privatised science to come. The history of early South African science shows that it is less a question of an epistemological break than a question of different professional practices which can coexist together.

With the final occupation of the Cape by the English in 1810, scientific production in South Africa long continued to bear the stamp of the same model. However, the established political order, and the concern for organisation, led to a number of modifications during the 19th century. Some of the more significant of these are discussed below.

On the one hand, some public institutions were founded, that were to be the workplace for local scientists; responsible however, less for the extension of knowledge than for keeping the collections or performing routine measurements and tasks. These establishments would also serve as technical centres, at the disposal of visiting scholars, especially British ones, from that time on. Two principal institutions (which are a reflection of the bodies of knowledge already built up) were founded:

> The first was **the Royal Observatory**, set up in 1820. The brilliant Herschel, Fellow of the Royal Society of London, star-chaser, worked here between 1834 and 1838. He was also the pioneer of photometry, inventor and where the need arose, instrument maker. Thereafter, apart from certain routine operations, nothing else of significance brightened the Observatory's life before the arrival, in 1880, of a new Director, the Scotsman D. Gill, another instrument expert. He was also a specialist in solar parallax; the first, and he set about to pursue his career in South Africa. He promoted learned societies and worked towards a locally based

scientific life that would be in tune with the great works undertaken in an international perspective.

The second institution, the **South Africa Museum** was founded in 1825 and rose to prominence early on, thanks to its voluntary superintendent, a fairly adventurous Scots army doctor. Passionately keen on zoology and, when the fancy took him, a spy disguised as an ornithologist, Andrew Smith carried out dangerous exploratory missions to Namaqualand (1828), Zululand (1832) and led an expedition to Transvaal-Limpopo in 1834-35. He brought back a host of specimens and observations that were of great interest to Charles Darwin (who came to the Cape himself in 1836). After Smith's return to Britain (1837), (his collections accompanying him), the Museum lay dormant until 1895. The Government never intended to create a full-time post there and consequently the remaining collections were moved around several times and were poorly cared for. The purpose of the whole institution remained ambiguous, like an old curiosity box.

Another characteristic of the 19th century, which had a more far-reaching effect, is that the taste for "science for knowledge" became more common among its amateur proponents, who were increasingly assiduous and numerous. Andrew Smith is a good example. He was not the only doctor of medicine who had a lively interest in scientific pursuits. Settled in the remotest parts of the country, from the beginning of the century[1] and firmly installed after 1835, were many missionaries, who had trained in research at Berlin, Aberdeen or Paris, not only in the natural sciences, but also in ethnology, linguistics and philology. They were responsible for the dictionaries of local languages (in 1841-1857: J. Casalis, R. Moffat); as well as for those of botany, environmental sciences and agriculture (J. C. Brown).

There are also records of a number of military men like the legendary, Lieutenant H. Harford, who in mid battle spent his time catching a rare insect. There were also engineers, farmers and all sorts of men of adventure, some of who were to leave major works. The most spectacular example of these is A. G. Bain, saddler, travelling salesman, then soldier and road-builder, who was the founder of South African geology and produced his first inventory between 1837 and 1853. G. W. Stow, schoolteacher, soldier, wine merchant, in turn was to become one of the most talented geologists. Learned societies were created, sometimes to the great displeasure of the government. The governor Charles Somerset, who was founder of the Museum, forbade the founding of a "Literary Society", which embraced the sciences under its "cultural" name, for over four years (1824-1828). He was afraid it might acquire authority and end up involving itself in the "political" sphere. (In fact, two of his opponents were among the Society's promoters, one a poet, the other a scientist.) The Society came into being only when Somerset left in 1829. It was renamed the "South African Institution", and published the *South African Quarterly Journal* (the first scientific journal in the country). At this point, it also took on the management of a Museum, which was devoid of grants. In 1832, it merged with the Literary Society, which had been founded in parallel. The resulting new South African Literary & Scientific Institution was able to initiate a Foundation in order to finance an exploratory trip to Central Africa (the one assigned to A. Smith in 1834-36). Those participating nevertheless had quite a narrow base: of "pure" science, as this was considered a luxury, and was pursued only by a small number of amateurs who earned their living in other professions, and who considered it to be - sometimes passionately - an integral part of culture. By 1857, the Society, now rather enfeebled, was replaced by the single journal *Cape Monthly Magazine*. However, elsewhere, other associations, other museums, just as precarious, were created (according to C. Plug, there was one around 1800, 25 in 1850, 60 in 1880, a good number of which were regional societies of acclimation, natural history, palaeontology or archaeology).

Last but not least, since 1830 and especially between 1850 and 1870, private initiatives had spawned colleges. In 1873 they gained the status of University.[2] Fundamental science from then on found its niche in a new profession: teaching. The almost mechanical growth of universities assured them an unprecedented institutionalisation, and a large public (the number of students increased from a few handfuls in 1860 to 1 171 in 1900 and 13 253 in 1940). Learned societies and clubs regained their force as a result. In 1877, the South African Literary & Scientific Institution rose up from its ashes as the SA Philosophical Society. However, it changed character as well as name. Although it had started as a society intended

[1] These missions are manifestations of an evangelical protestant revival, which emerged at the end of the 18th century.
[2] 1829: The South African College, at the Cape; 1855-1866 : Colleges at Grahamstown, Bloemfontein, Stellenbosch; 1873 : University of the Cape of Good Hope (one for the whole of the country, with decentralized teaching sites): 1906-1916 : a wave of new Colleges : Pretoria, Natal, Fort Hare, foundation of university colleges, then regional universities.

for amateurs who subscribed to the *Cape Monthly Magazine,* it very soon kindled an ambition to transform itself into a corps of professionals, to give advice to the government. It became the "Royal Society" in 1908. "Science for knowledge" was getting itself organised, under the aegis of university professors. These imposed their authority, pronouncing on "good practices" of research. The amateur associations multiplied, but under the same "thumb". Paradoxically, even up to the 1940s, the leading figures of basic science were generally still not university academics, apart from some free acting university scientists. J.D.F. Gilchrist was one of these. He became a teacher late in life, but he remained head of the national marine biology service that he had inaugurated in 1895. (This institution offered him not only substantial research facilities, but also work where he could interact with the fishing profession). Another eminent figure somewhat on the "fringe" was R. Marloth, government chemist, recruited temporarily as a professor by Stellenbosch College. In three years (1889-1892) he aroused students' vocational interests and developed plant chemistry. Unfortunately, his successors did not leave any noteworthy written work. In reality, the way was now open for adopting a new "epistemological position", another conception of what constitutes worthwhile science, made possible by the industrial revolution.

1.2 INDUSTRIALISATION AND "SCIENCE FOR PRACTICE": 1880 - 1910

> The discovery of first, diamonds (1860s), and later, gold (1870s), was soon followed by the British annexation of the Boer republics. This would eventually give rise to the first Anglo Boer War (1881-82) and subsequently, the second Anglo-Boer War (1899 - 1902). After the Boers lost these wars, a peace treaty was signed which eventually led to the founding of the Union of South Africa in 1910.

The discovery of gold and diamonds, in 1867-75, caused an upheaval in society. The pastoral era was over. Highly concentrated populations agglomerated in search of these precious materials. In order to cope with such masses, rail and road communications had to be developed rapidly, enclosed or isolated farms had to be opened up, mass food production had to be ensured, and unprecedented shortages had to be coped with (for instance a lack of timber for pit props). This situation completely changed science's grounds of operation. On the one hand, mining enterprises found that they needed engineers, geologists, later on geophysicists, chemists and even doctors of occupational medicine or parasitologists. The colony could not supply such professionals, so qualified people had to be brought over from Europe. Scientific employment became a reality. On the other hand, government, confronted by a series of recurring disasters (plant diseases, animal parasite attacks, linked to the transformation of agriculture for mass production or the opening up of frontiers and increased circulation of people), began to expect science to come up with solutions.

A trend, already apparent in the last decade of the 19th century, was the multiplication of *Professional Associations*: Engineers, architects and surveyors (Kimberley, 1882), Civil engineers (Barberton, 1887), Mechanical engineers, Engineers and Architects of South Africa (1892), Chemical and Metallurgical Society (1893), Geological Society (1895), Electrical engineers (1897), not to mention 18 regionally based medical associations (1880-1895). To increase the standing of their discipline, these professionals sought to show off, to best advantage, the uses that could be made of qualified research in their field. They intended chiefly to convince the captains of industry, whose concerns they were well aware of.

Another development was that government leaders ventured to test out some of the research services on offer. The provinces each endowed themselves with a government scientist. Some of the provinces engaged chemists (the Germans Marloth, then Juritz at the Cape from 1884); some, a senior veterinary surgeon or an entomologist (D. Hutcheon from 1889, the American C. P. Lounsbury around 1900 at the Cape; the Englishman Watkins Pitchford in Natal in 1887) and some, a department of agriculture, complete with a botanist and agrostologist[3]. (This was quite widespread after 1900). However, it was largely due to the shock of epidemics that the authorities reached this stage, after diseases and pests had devastated orchards (like orange groves at the Cape, following the importation of unchecked plant stock, infested by Icerya Purchasi), vines (phylloxera in 1886) and livestock (Nagana disease in Zululand in 1893, and the Rinderpest which came in from Rhodesia in 1896). Such disasters led to huge losses, severe hardship and, above all, disruption of production. Faced with these calamities (which had been around a long time, but had now flared up in a new guise as political crises) the governors, though skeptical, hired scientists of world renown for long missions, mostly out of curiosity. Later they were to be replaced by young specialists, also

[3] Agrostology - The branch of systematic botany dealing with grasses and grasslike plants.

imported, who settled in, won people over and took the organisation of local services in hand.

A good example of this is veterinary research. There was certainly no shortage of diseases among livestock, which were recorded a long time before. Some of these are legendary (1719: massive mortality in horses; 1780: all herds were hit; 1854: loss of half of the horse population; 1882-86: anthrax decimated both domestic and wild animals and was transmitted to humans through eating meat). They all have descriptions and are named in vernacular terms; these diagnoses still had to be treated according to the conventions of sciences which were in full expansion in Europe at the time: bacteriology and parasitology. The first small laboratory was inaugurated in Grahamstown in 1892 in the framework of a "Colonial Institute for Bacteriology". In 1902 it was transferred to the Cape Veterinary Department, and devoted itself to the study of four diseases: "horse disease"; rinderpest; redwater pest and heartwater disease, which attacks ruminants. The establishment of this laboratory was followed in 1898 by another laboratory in Natal, which was also small in the beginning. In order to obtain permission for this, Watkins Pitchford, head of the region's veterinary service, had to fight for eleven years. In the meantime, several animal epizootics sprang up. Natal then called on the leading European expert, David Bruce, as consultant. His reputation stemmed from his work on brucellosis. In 3 years (1894-1897) he identified the famous "Nagana" disease as trypanosomiasis, establishing its link with the tse-tse fly and identifying game as reservoir for the disease. Then in 1897, the bacteriologist Robert Koch, was brought to Kimberley (in the mining area under the jurisdiction of the Cape) for one year. He was known worldwide and was in fact Pasteur's rival and discoverer of the tuberculosis bacillus. He set about to tackling the terrible rinderpest. He used observations gathered by farmers to develop an immunization procedure, which was a partial success (inoculations were composed from the bile of dead animals). He also sought to explain the causes of "Texas fever", which raged in East Africa. He discovered small piroplasms in the erythrocytes of contaminated animals, and thus cleared the path towards a decisive discovery in 1903. At the same time, the Transvaal called on its own experts to combat rinderpest. This province put its faith in the Pasteur Institute, whose delegated scientists (J. Bordet and T. Danysz, in 1897) were to help develop a serum.

These missions by expert scientists forged the durable links necessary for cooperation. They strengthened the position of the local scientists who recommended such intervention by outside specialists. However, a reversal of the situation was to come from the brilliant feats of Arnold Theiler, a man from within the country, a young Swiss immigrant, who had decided to make his career in the Transvaal. He was not a doctor of medicine, but a practicing veterinary surgeon. It was a much better scientific position to be in, in a country where "no science *was* worthwhile for its own sake, but only for the dollars that it could put into farmers' pockets". Theiler first oscillated between private practice (on his arrival in 1891), employment on large rural properties (where he had one hand maimed and was consequently dismissed) and temporary public posts. He was a bacteriologist, the only one qualified in the region. Each new disastrous epidemic was useful to him. In 1893, a smallpox outbreak hit Johannesburg and he was for a time thus appointed as "Expert bacteriologist" in the Ministry of Health. Then he became "director" of an institute of vaccination - for animals. In 1895, he advised the government (seemingly perturbed by the different arguments of parasitology), which was taking steps to pass regulations that would prevent epizootics. In 1896, news started to come through of a mysterious epidemic, which had decimated livestock in Somalia and was spreading southwards like wildfire. President Kruger, in person, engaged Theiler as an expert. Theiler set off northwards to study the disease. He encountered it in Rhodesia, where he identified it as a kind of rinderpest. He built a field laboratory, in a fairly isolated spot near Rustenburg; which he shared with his colleague from Natal, David Bruce, who had also been put on the alert. His objective was to develop a serum to control the epidemic. He soon had more work than he could cope with, so he suggested that the Boer government call on the aid, not of English scientists, but other specialists (French ones, as it happens, from the Pasteur Institute) who were experienced in the line of approach he had taken. The results fulfilled all expectations - and the serum developed by Theiler in 1897 proved to be much more effective than the bile-based inoculation brought in by Koch earlier in the Cape Province. Building on his success, Theiler obtained permission from the Ministry of Agriculture (first of the Transvaal, then of the Union of South Africa) to found an Institute for the Production of Vaccines and Sera.[4] He became Director of this "Institute of Bacteriology", which was equipped with the most up-to-date facilities, he set aside ample room for research (along the lines of Pasteur Institute). From 1903 to 1910, he made a series of discoveries. These were in the areas of:

[4] Not only against rinderpest,but also to prevent other, human or animal, diseases: picoral pneumonia, smallpox, "blackquarter" and so on.

- Blackwater fever in horses (the main draught animals and therefore vitally important);
- East African fever (the causative parasite(s) diverse species of tick, for which he gave precise identifications - and of which he identified the piroplasms,as well as the vectors);
- "Blue tongue" in sheep (produced by a filtering virus, which allowed immunization experiments to be done);
- Redwater disease (for which his hypotheses triggered off worldwide controversy); by checking observations made in Uruguay, Argentina and Transcaucasia, he reinterpreted the shell-like forms that were observed around the red blood cells as a discrete pathogenic agent, responsible for severe jaundice and anaemia, and not as a stage in the life-cycle of the germ *Babesia bigemina*. His reasoning finally prevailed.

Theiler kept up a three-pronged strategy. He fought against diseases that had large symbolic or economic importance. He maintained and followed up liaisons with the best international specialists (being host to their most promising followers for periods of 4-5 years). And he organised the bacteriologists from different regions, lending them his facilities and associating with them. Convinced of his exceptional ability to control epidemics, the ministry of agriculture built, at great expense, the country's first (and, for long afterwards, only) Institute of Research for him. Onderstepoort opened in 1908. It was big, well equipped and provided with an animal house to supply stock for his experiments. This centre radiated its influence not only in South Africa but also throughout Africa and its worldwide reputation increased. He brought over talented scientists from abroad (K. F. Meyer from Zurich, F. Veglia, an Italian helminthologist, R. Gonder and H. Sieber from Hamburg, W. H. Andrews and D. T. Mitchell from London). It was at Onderstepoort that these scientists conducted work that earned them international reputations, and which reflected well on the Institute, thereby facilitating new joint projects and in the process, legitimising long-term, more fundamental, scientific research. Theiler chose his working associates himself and was exacting in his selection. He kept them strictly under his control, supervised their work very closely and piled work on them. Combining basic research, pushed to the limits to obtain practical results, with epidemiological and technological surveillance and the services he provided by his production of serums, he and his Institute dominated the veterinary and parasitological scene until 1930. It is worth noting that although he was one of the best known South African scientists, he was never President of the Royal Society - it apparently did not interest him at all.

Another example that is pertinent here, is the evolution of the second research centre, which was established in the same period: the South African Institute for Medical Research. Historians of medical research agree that the progress in this field can be divided in two distinct episodes: "before" and "after" the Institute's foundation. The "before" part is quite simple: There was not a scrap of money for research, no facilities, no posts and certainly no encouragement for original work in this area. Medicine was considered as a well-perfected craft, mastered by its practitioners, whose purpose was simply to administer it to the clients who came to them (mostly Whites). The provincial public health laboratories, set up before 1900, conducted no research; and the rare doctors, mainly bacteriologists interested in research studies in their discipline, only managed to find stimulation or indeed finance through veterinary research.

The breakthrough can be attributed to the Chamber of Mines. At the turn of the century, this employers' organisation was worried about the terribly high incidence of illness among the many workers who flocked to their sites. In the face of neglect on the part of government agencies, this body of mining concerns pressed the authorities to enter into an agreement which led to the establishment of a Research Institute (largely at their expense and directed by them). This Institute was to use the resources of fundamental biology to elucidate the causes of infections or occupational illnesses, which were then poorly known and disrupted production. The development of diagnostic tools, treatments or prevention methods was also part of its brief. The South African Institute of Medical Research (SAIMR), devoted to parasitology and pharmacology, with modern scientific equipment and facilities, opened in 1912. Its first Director was W. Watkins Pitchford, army bacteriologist, son of a veterinary bacteriologist, who had returned from Europe. A specialist in cancer generation, he undertook his first investigation into to characterising silicosis, which had become a serious problem for mines. He conducted histological investigations using the most recent techniques, for example, demonstrating how to use the properties of polarized light. The Institute was the birthplace of many a vocation and attracted a concentration of aspirant research scientists. Discoveries were made at regular intervals: G. D. Maynard worked on the mutation of bacteria, while Harvey Pirie focussed his attention on the bacteriophages. He made advances in knowledge about the plague, whereas Orenstein attacked yellow fever. F. S.

Lister was able to differentiate the pneumococcal bacteria and develop vaccines on the basis of his results.

Up to the Second World War, the SAIMR was to remain the only notable centre for medical research. Its foundation and rapid rise to success testifies to the fact that, in an unexpected field, a second force was supporting and stimulating the new "science for practice": private initiative. Borne out of the necessities of production, and goaded on by the managerial associations, it was to develop "home-grown" applied research. It also pressurized the government for assistance in technical surveillance (Western Cape producers of fruit and of wool obtained arrangements for fact-finding tours to California and to Australia from 1893), and to take part in basic research, particularly in techno-scientific aspects. The "technical" ministries were the other source of support for this "research for doing".

Veterinary research is one example of this, but agriculture research was another. This was just as well-developed a terrain, with its own charismatic figures (though we have not given the details here), as was marine biology research which was introduced in 1895 by the Cape department of agriculture (to evaluate the potential for fisheries in the region. This marine research was entrusted to the young and rather fiery J. D. Gilchrist, who thereafter could not be pursuaded to leave the post, even after receiving all manner of academic honours).

1.3 BETWEEN THE WARS: TWO TRADITIONS

> The Union of South Africa with four provinces was founded in 1910. The policy of racial segregation became official and increasingly embedded in South African society, especially under the rule of Genl. Hertzog. Socio-economically, more emphasis was placed on the plight of whites as evidenced by the Carnegie investigation (1929-1932). There was an increase in Afrikaner nationalism. Although South Africa sided (Jan Smuts) with the allied forces during WWII, there was a significant resistance movement (Ossewa Brandwag) that supported national-socialism.

The scene was set for the "normal" functioning of a geminate science. On the one hand, the almost mechanical growth of the universities ensured an unprecedented degree of institutionalization and a substantial public for "science for the sake of knowledge". On the other, the socio-cognitive group united the technical professions with large-scale production strengthened and furthered applied research. Knowledge and experience were consolidating. The era of adventure and of amateur pioneers was coming to an end.

As it became more professionalised the "science for knowledge" paradigm rather lost its vitality. It was often practised as an embellishment, to give some lustre to an establishment, with no strong connection with either social needs or the movement of science worldwide. The strong elements of academic, university-based science were, and continued to remain, botany, entomology and zoology, human paleontology and archaeology. Outside of these fields (and sometimes even within them) it is agreed and recognized that, up to the Second World War, contributions to research by university professors were "...rare, sporadic and often of little significance". True, some leading figures in several, sometimes new, disciplines made contributions to research, but only during their working visits abroad, as PhD or post-doctoral students. On their return to South Africa, however, they ceased to produce.

An example of this from medicine is W. H. Craib, who in Britain, between 1927 and 1930, conducted original experimental work in electrophysiology which, with his heterodox interpretations (the hypothesis of negativity in doublets and dipoles) attracted worldwide attention. However, back in South Africa, even though he proved to be stimulating as a Professor and a bold administrator, he did no further research of significance. Vivian Voss, who had made interesting discoveries at Johns Hopkins University, once back in South Africa, distinguished himself chiefly by producing good physics textbooks. Another point to be noted is that academics who wanted to do serious work in research sometimes left the country to find more propitious conditions under which to practice their talents. The physiologist L. Hogben, introduced research work in endocrinology. On the basis of this, his students Shapiro and Zwarenstein developed (in 1933) a pregnancy test that was used extensively worldwide. However, Hogben himself, who was burned in effigy by discontented students, left to pursue his career in England. In marine biology, G. "Friekie" Papenfuss, already a proven algae specialist, went to Lund in Sweden to perfect his knowledge alongside the master in the field - Kylin. He was to culminate his career with a professorship at Berkeley, having become an acknowledged expert worldwide. Professors within South Africa did not have the facilities, equipment or the finance for their laboratories and rapidly became isolated from the great centres of research elsewhere in the world. They were overloaded with the tasks of teaching and administration at the universities, where the research culture had not yet penetrated. Conducting research was inopportune, tantamount to neglecting the more immediate tasks of organising, educating and managing.

However, in traditional disciplines, many contributions are noteworthy. Botany prospered. Geology had its enthusiasts, ichthyology its adventurers[5]. Physical anthropology, palaeontology and human prehistory had become the very picture of academic science (Broom, Dart, Drennen and so on). Physics, though, is a case apart. Some young assistant lecturers (like B. Schonland, Viljoen, S.M. Naudé, E.C. Halliday), assisted especially by the Carnegie Foundation, succeeded in making breakthroughs in astrophysics and physics of the atmosphere, by the end of this period.

Until the 1940s the leading figures of fundamental science nevertheless were still from institutions other than the universities, with the exception of the rather more maverick personalities based in universities. J.D.F. Gilchrist was an example of this sort of character. He taught in later life but maintained his post as head of the National Marine Biology Service, a post he had been in since 1895. On condition that he conduct an inventory of the wealth of fishing resources, he could have a boat at his disposal and work in interaction with the fisheries profession. He was unconcerned as to whether this research was fundamental or applied (which depended on whether the species he observed were edible or not) because his work on certain species shed light on the others (behaviour, diet, distribution in relation to salinity, water temperature, available plankton and the fauna of the sea depths). Another personality like this was K. H. Barnard, a shy firebrand, graduate from Cambridge in botany, zoology and ethnology. He became legendary by leading perilous expeditions on the coasts of Natal and Mozambique, then across South-West Africa on an oxcart. An excellent taxonomist, he had finished cataloguing most of the fish and invertebrates of the country by 1920. He too kept his distance

[5] The amount of activity in botany in the universities should not be underestimated, with publications by S. Schonland (father of Basil Schonland, the rather fiery physicist), G. Potts, J. B. News and - which is noteworthy - by some young women: Ethel Doidge, M. Leyns, M. G. Mes, M. P. de Vos, I. C. Verdoon, for instance, whose work was highly significant. The creation of the Kirstenbosch Gardens (the Kew Gardens of South Africa) is owed to Professor Pearson. The botanical scientific community (which did exist from now on, and brought together teachers, civil servants and amateurs) promoted new herbariums and successfully launched the *Journal of South African Botany*. In marine biology, Professor T. A. Stephenson initiated studies in ecology. J. L. B. Smith, a chemist who changed over to ichthyology, distinguished himself by his knowledge of fish behaviour, identifying new species and his

from university, conducting his whole career at the Museum and publishing numerous articles. The astronomers took a similar path (at the head was David Gill and his successor, the brilliant mathematician, Hough) and stayed at the Royal Observatory. Another eminent figure somewhat on the "fringe" was R. Marloth, government chemist with a strong taste for botany, who was temporarily appointed professor at the Stellenbosch College, to teach plant chemistry. His followers, however, did not leave any significant work. At the end of this period the physicist B. Schonland saw fit to distance himself from his Alma Mater, by accepting the headship of the new Institute of Geophysics, opened in 1938 by the privately run Bernard Price Foundation[6].

In the course of the same period, "science for doing" was conquering and attaining a crushing dominance. It provided better facilities and working conditions for research scientists who applied themselves to science strongly oriented to specific goals (this could nevertheless include some upstream investigations). The factors that promoted "applied research" in the preceding period were even more prevalent in the inter-war period.

Professional associations proliferated (South African Veterinary Association, 1920, Natal Institute of Engineers, 1919; SA Chemical Association 1921 etc.). After several abortive attempts at the beginning of the century, they succeeded in grouping together in the Associated Scientific and Technical Societies of South Africa (1920). This body awarded prizes for discoveries in technical fields and put pressure on industrialists to develop their research departments; whereas the active Association for the Advancement of Sciences (already formed in 1902), popularised, by means of its *SA Journal of Science* and exhibitions, research conducted in areas like botany, plant chemistry and meteorology. In 1935, the SAAAS moved into premises offered by the Chamber of Mines. This mining organisation was to establish its own "research organisation", to coordinate in-house R&D programmes for companies with the aid of research scientists from outside.

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frantic - and successful - hunt for the coelacanth, "the missing evolutionary link", believed to be extinct and only found as fossils, which he studied in the living form.

[6] Bernard Price was technical director of the VFP electricity company, which supplied energy to the Witwatersrand Mines. He was somewhat of visionary with in mind some enormous hydroelectric schemes (the control and development of the Zambezi).

Scientists also did work of significant benefit to industry. Around 1930, the Witwatersrand mines appeared to be on the verge of exhaustion. R. Kramann, a young German geophysicist, equipped with a magnetometer, succeeded in drawing up the map of the gold-bearing strata buried further West under deep series of dolomites. From 1932 onwards, with the aid of powerful drilling techniques, it was possible to exploit them. To the East, in 1937-39, it was O.Weiss who, using a torsion gravimeter, detected thin lavas underneath which lay an exploitable gold deposit. A new wealth of minerals was also discovered at this time, including iron, chromium, platinum and magnesium; and new mining companies were formed. Mineral extraction companies found it imperative to employ increasing numbers of exploration geologists, geophysicists, experts in mechanics and engineers. This was by no means, however, the only sector of industry converted to science. The Natal sugar refiners established a research institute at Mount Edgecombe (Sugar Milling Research Institute) with their own money, in 1925. There the favoured subjects were agricultural entomology, selection of varieties and also the valorization of byproducts (bagasses and molasses, which a factory in Durban used to derive a fuel and industrial alcohol). Public sector companies (notably ESCOM, responsible for producing electricity), also developed substantial research departments.

The technical Ministries, for their part, drew on the scientific activity organized under their own jurisdiction. This was especially the case with the Ministry of Mines, which from 1910 transformed the old Cape province geological service into the Geological Survey, with permanent staff appointments. From that moment onwards, the investigations were no longer sporadic, oriented towards the inevitably ad hoc prospecting for new ore deposits, but became much more systematic and rigorous. Later on (1932) the same ministry let itself be persuaded by figures linked to industry, to establish an Institute of Fuel Research. Once again, it had taken disasters (frequent accidents involving recurrent spontaneous ignition of imported coal), and factors like the emergence of energy problems, a rise in interest of big capital in exploiting local coal and oil, and the establishment of an iron and steel industry, to stimulate such a measure.

The Ministry of Agriculture was more readily convinced of the value of similar initiatives. Not only did it support the Onderstepoort Veterinary Institute, but also under its own authority, a vigorous agricultural research activity was to develop. Such work quickly brought in the specialist Colleges (Elsenburg, Cedara, Potchefstroom, Glen and Grootfontein, founded between 1898 and 1919), then involved the faculties of agriculture at the universities (Stellenbosch and Pretoria were among the first to be established in 1917). In the absence of appropriate textbooks, scientific teaching staff felt obliged to undertake research and they produced articles. Many of these remain classics in the field. They were published by the Journal of the Department of Agriculture as well as reference textbooks, intended as much for those practicing agriculture as for students (Pienaar, Leppan, Van Der Bijl). All the teaching staff was eventually incorporated into the agricultural services (from 1940 to 1970), with civil servant status and the duty to pursue research under the supervision of the Ministry. The latter had its own research departments, which diversified to give rise to a variety of specialist institutes. The highly important "Botanical Survey", under the rule of I. B. Pole-Evans gave a real boost to field work and publications. Its agricultural entomology became highly authoritative. It opened the way for controlling locust plagues on the African continent when J. C. Faure showed in 1932 that locusts have a limited range of egg laying zones. Earlier than most countries, South Africa undertook research to find out more about soils and also issues related to their conservation[7]. Important research was also being developed around vineyards (for dessert grapes and for wine); orchards (elaboration of high-quality cultivars); tropical fruit (breakthroughs were due to virologists - such as MacLean - or resulted from the combined methods of entomology, phytopathology and climatology: a well-oriented multidisciplinary approach); horticulture, making best use of the enormous "indigenous" genetic potential and cereal cultivation (maize plant selection for adaptation to drought conditions). Research in each discipline eventually became autonomous, centred in as many specialist institutes[8].

The jewel in the crown of research was nevertheless still veterinary science. Theiler's successors turned out to be exceptional managers, scientifically well up-to-date and visionary strategists. The first (P. J. Du Toit, Director from 1927 to 1948) mapped out the contours of a lasting scientific policy position: The Institute would specialise in diseases specific to the African continent (epidemics of which threatened the country most directly) and it would maintain an observer role over other diseases (by restricting itself to evaluating and adapting solutions found

[7] A. L. Du Toit's geological map (1926) was a precursor of the history making classification of "South African soils and soil groups" (C. R. Van der Merwe, 1940).

[8] Soil and Irrigation Research Institute (Pretoria); Oenological and Viticulture Research Institute (Stellenbosch); Fruit Research Stations, then Fruit Technology Research Institute; Citrus and Subtropical Research Institute; Horticultural Research Institute; Plant Protection Research Institute; Direction of Agricultural Engineering.

abroad); it would finance itself substantially by producing vaccines. genuine scientist, pleasant and persuasive, P. J. Du Toit made vital contributions to the popularity of science among both the public and the government, and, to the establishment of institutions for disease control that cut across the frontiers of colonial empires. This was a real feat.[9] At the same time he was able to introduce many new techniques and delegate responsibility for more and more specialized research to judiciously chosen project leaders. In this way some major research programmes were to develop in the area first of diseases provoked by bacteria, protozoa and viruses; then on metabolism and also on diseases of wild animals[10].

Apart from these technically based ministries, however, the government would never have dreamed of adopting a "scientific option". The First World War had nevertheless revealed the weaknesses of an economy wholly dependent on primary products. An "Industries Advisory Board", set up in 1916, assembled under the aegis of the Ministry of Mines and representatives of commerce and industry. It appointed a Scientific and Technical Committee and undertook to formulate an industrial development policy. Its proposals ranged from the training of qualified engineers and scientists to the protection of budding industries. A "Scientific and Technical Coordination" body was set up, with its *South African Journal of Industries,* as was a Foundation for financing university research. At the end of the war the Prime Minister of the Union took it upon himself to repatriate a high-flying emigré: H. J. Van der Bijl, an electronics engineer who had trained and then settled in the USA, and made him his Scientific Advisor. Van der Bijl drew up a premonitory

[9] Permanent InterAfrican Bureau for Trypanosomiasis Control, 1946, Regional Scientific Council, with the status of NGO and the Council of Commissions for Technical Cooperation in Africa South of the Sahara, 1950; African International Bureau of Epizooties, 1952; all these were the fruit of an extremely long process of persuasion, pursued persistently over 20 years.

[10] It is difficult to do proper justice to the wealth of work that was bursting out of Onderstepoort at that time. We can however bring into relief some remarkable examples: Robinson's discoveries concerning the causative agents of botulism (1930: a revolutionary dual strategy for controlling the disease followed, based on immunization and on an input of phopsphorus which blocks the precursory symptom of boulimia); Curson and Harris's (1924-1930) finding of new agents of the disease Nagana: elaboration of control methods using glossina traps; research by Mac Intosh, Du Toit and Nieschulz (typology of viruses responsible for the "horse disease", demonstration that they are propagated by certain insects and the discovery of a species of mouse that can temper the virulence of lines of these microbes (1932); Viljoen, Sterne and Mason, the "champions" for developing and perfecting serums and vaccines; work of P. J. J. Fourie, C. R. Remington and L. Eagles on ruminant metabolism, porphyrias and their extension in humans. Called on for its expertise by countries from Europe, the USA, by Israel by way of all the states of Africa, it was quite natural that, in 1960, Onderstepoort gained the status of a world Centre of reference for several diseases of livestock.

strategy. He fixed research priorities in the light of a concern to make the country "independent" in techno-scientific areas for the future. He obtained a good level of contribution for the Research Grant Board, supporting the universities. He strove to promote research and development among manufacturers themselves. However, his plan was soon buried and forgotten.

The Industrial Board and the Coordination body were dissolved in 1923. In 1932 the contribution to the Research Grant Board was reduced to £100 (compared with £2821 in 1920): the only financial resources were in fact the donations from the Carnegie Foundation (the Guiding Institutions for research existed only as a token). Van der Bijl then committed himself to accomplishing his plan at least partly as the head of public companies: ESCOM, founded in 1923, and responsible for electricity production; the ISCOR: Iron and Steel Corporation (1926); and the IDC: Industrial Development Corporation (1940), both of which stemmed from the needs of the war effort.

1.4 EXPANSION AND THE NATIONALIST IDEOLOGY: STRATEGIC SCIENCE 1948 - 1976

> The post-War period saw the culmination of the rise of Afrikaner nationalism with the NP coming into power in 1948. The systematic enforcement of the policy of separate development, or apartheid, as it became known, affected all sectors of society. All forms of black resistance from the PAC and ANC were suppressed (e.g. Sharpeville 1961). This led to the banning of the ANC and the imprisonment of Nelson Mandela in 1963. During the sixties, the institutionalisation of separate development through the policy of homelands along ethnic lines (bantustans) was vigorously pursued, strengthening racial segregation. The ANC went into exile and increasingly intensified the struggle against the apartheid government. Key events were the Durban strike in 1973 and other similar events which culminated in the Soweto uprising of 1976.

The period between the two wars reinforced two research traditions: "science for knowledge" (linked to the university establishments, more symbolically than in real terms); and "science for doing". However, supported by "personalities" rather than by a consensus, and with no commitment from a government little concerned about any science policy, it was difficult for the former paradigm to really take off. It progressed in fits and starts, called on only to resolve problems for particular cases and situations. This mode of science rested on a number of leading figures, initiating precarious vocations; on small circles of specialists; on a few traditional disciplines that were now organized (botany, zoology, palaeontology); on amateur associations and on façade academies. The robust establishments generated earlier were still the main centres of research: The leading-edge structuring institution Onderstepoort which was at an international level; SAIMR, charged with more and more responsibilities in public health matters, vaccine and serum manufacture and routine studies, but also innovative research: tropical medicine and human physiology (heat-induced stress, adaptation to abrupt changes in altitude); and in more "academic" spheres: the Observatory and the Museum. The only novelties in institutional terms concern the systematisation of inventories (setting-up of formal "surveys" like those for botany and geology); the development of agricultural research; and the foundation of, albeit rare, multidisciplinary establishments desired and financed by private industry (sugar, combustible fuel sectors). Support for the fundamental disciplines and university research alike was diminishing. Participation in international programmes served as a sheet anchor and the publicity given to these as a strategy for convincing and communicating with the public and the authorities. Support did come from foreign recognition, but it was also often abroad that the researchers were to pursue their careers, which in South Africa were stunted for want of support.

The Second World War changed the situation completely. Having only just joined the Allied camp, South Africa was suddenly obliged to find substitutes for many of the products it imported (including oil) and the country had to supply armies in Africa and the Middle East with a whole variety of items, ranging from vaccines to preserved food (meat, vegetables, and sardines and mackerel for which the fishing techniques were still rudimentary). It was even required to evolve manufacture of all kinds of spare parts (for aircraft, boats and so on) and to enter into the manufacture of armaments: rifles, bombs, armoured vehicles, munitions, precision equipment (including RADAR, which had to be made operational). The search for original minerals (chromium, titanium, vanadium and then uranium) was to receive a new boost. Some unprecedented problems arose from their extraction and metallurgy. H. Van der Bijl, in charge of the war effort, tracked down and mobilised all available engineering capabilities. Industry was rushed into action. Knowledge hitherto untapped had to be recognised for its value; and abilities that were found locally were imported, built up by training and hired. Allied contributors added their assistance. Young talent complemented knowledge already accrued and was vested with responsibilities formerly unheard of. Factories were converted; new activities surged up. The lessons learned from this War were not lost.

When the conflict ended, science was regarded in a new light. It was thought of with a mixture of fear and admiration. People believed it capable of overcoming any technological barrier. But from this point on, it meant "big science", demanding an alliance between the fundamental scientists and engineers, and necessitating good organisation and large-scale resources. It entered the realm of public affairs and into the political arena. Under its driving force, the great powers were to move into a new technological era. South Africa was taken to the edge of its "first industrial revolution". This time it was not going to revert back to a purely primary economy. The head of the Government (General Smuts, who was also a scholar and philosopher) called on B. Schonland to set out a lasting *national* organisation plan. This was a question of preparing industry for the challenges of international competition, not only from day to day but in a forward-looking way, and of ensuring the country's independence.

The crucial role of the CSIR

A brilliant physicist and a man of action, Schonland proposed legislation in May 1945 that was aimed to promote a "science" that would be "oriented" to the needs of the country. A "Council for Industrial Research" was given the task of coordinating all the country's research, public or subsidized. He saw to it that the necessary scientific staff (research scientists or technicians) were trained in due time. Reporting directly only to the Prime Minister, the "Council" had a dual function - to initiate research that was not being done and to act as a funding agency (in order to strengthen external scientific teams installed). It maintained a technological watch abroad (representatives were sent to Europe and the USA), and disseminated scientific and technical information in South Africa. The Council aimed to facilitate applications of research, including that done by small companies, and encourage the private sector in development efforts. Although it was drawn up quickly, this proposal was the fruit of consultations with ministries, industrialists and academics. This translated the experience that Schonland had of arrangements constructed in other countries (the best of which he adapted). The Legislation, which was rare in this field, was passed almost unanimously by Parliament: a feat of rare occurrence. Certain centres of power were nevertheless worried.

Negotiations had to be conducted with the ministries of agriculture, health, industry and also with the subsidised institutes (such as the Institute of Fuels and the SAIMR) in order to delimit properly CSIR's responsibilities. Agricultural research, which was strongly organised, was to stay under the wing of its ministry (a Council did in fact take it over, but not until 1990); the CSIR was able to initiate all sorts of work in medicine and nutrition (even if a specialized council was to take over the reins later on - the MRC in 1969); it was to develop research in materials, construction and civil engineering; it looked after standards and standardisation, but was not to be responsible for the routine services associated with it.

Once appointed President of the Council, Schonland gathered eminent figures around him. They represented the top-level organs of contemporary science (Onderstepoort, Geological Survey, a few universities oriented towards technology), the two active ministries and progressive elements of industry (Industrial Development Corporation, electricity, cement and so on). An energetic man, he was also Director of the CSIR. In this capacity, he promoted an original strategy: To take charge within the council itself of novel research; to support contractual university research and to encourage firms to do research. (The latter was to be achieved by income tax credit, founding of institutes co-financed by the State and by the profession; door-to-door canvassing of companies to find out their needs and interest them as soon as possible in developing discoveries of the CSIR and by transfer of know-how). In less than five years the CSIR set up five "National Laboratories", remarkably well equipped and endowed with excellent personnel: physics, chemistry, materials, telecommunications, industrial psychology. He greatly increased grants for university research, for individuals or backing teams led by distinguished scientists. He set a good number of young researchers on their way in their career, by creating grants for doctoral students, for training abroad (in selected top laboratories) and reasonably paid post-doctoral opportunities. He was the founding force behind five institutes of industrial research, set up in association with the corresponding vocations: leather, wool, sugar, fisheries and paint manufacture. He built up a remarkable library, highly active documenting services and research-industry clubs. Furthermore, he promoted international cooperation. The national laboratories worked for economic sectors, with a wide range of specialities. They went as far as establishing pilot factories, but refused to perform routine services. They knew how to help reformulate demands; at the same time they maintained basic research which they regarded as being necessary (in nuclear physics, solid state physics and organic chemistry).

The CSIR personnel enjoyed a favoured status. Their budget grew along with their action plan. In five years it increased tenfold, and in the twenty years that followed, it was to increase again twenty-fold. In only a short time, the South African scientific apparatus had changed dimension; facilities became up-to-date, including some which were huge and of national utility (particle accelerator, dynamic wind tunnel); the disciplines diversified; the engineer won a significant place as a professional. A continuum of research was thus in place, from fundamental studies to applications. Academic research was given decisive impetus (primarily medical research); and it was guaranteed regular support (even if it took only 5 to 10% of the CSIR's budget). It now accepted assessment (by peer committees, inter-university committees, but also from outside and often international); it also raised the enthusiasm of the young teaching generation. The CSIR's own personnel rose from 70 employees in 1945 to 700 in 1955, and 4 000 in 1970. The results were soon demonstrated, not only in terms of publications (in 1955 more than 500 articles were published by CSIR researchers and 650 by assisted academic researchers - 250 of which are in medical topics); but also in terms of technological abilities (the design and development of the cyclotron inaugurated in 1955 were attributable to the National Physical Laboratory), instruments were invented (Wadley's tellurometer, which revolutionized geodesy), patents were filed, products created, processes improved and contracts gathered. In 1950 they represented 4% of the budget; in 1970, 35%.

In 1950, B. Schonland resigned from office. He was soon replaced by S. Meiring Naudé who, without changing the preceding model, maintained as vigorous a growth for the next twenty years. Specialities flourished (nutrition, aquaculture, food technologies, water treatment, civil engineering, mechanical engineering, mathematics, computing and so on). International cooperation took on a greater dimension. The CSIR played a leading role in several bodies on the African continent; it took an active part in world programmes of ICSU: such as geophysical years, Antarctic research. The success of the latter operations gave root to the idea of creating "national programmes of cooperation". This entailed coordinating specialists from several disciplines, belonging to all sorts of institutions, to participate in research over a long period in a complex area of constant interest for the country.

The first projects of this type were in stabilising Antarctic research; then to deal with oceanography, geology, the environment (and here we can recognise strong points of traditional academic research, integrated in this way), atmospheric physics and space physics, atomic energy and later other forms of energy. (From the 1980s, these projects involved university researchers working with the new large public companies - ESCOM (electricity), SASOL (coal-gas-oil), the Chamber of Mines, the ministry and their institutes - which until then had been rather left aside - around energy problems, approached from the economic, ecological and technical angles). Some new National Institutes started to emerge separately from within the CSIR (12 in 1970). They were the manifestation of the two-fold ambition of creating windows onto the foreign world of "high-tech" and to take up the challenge of technical solutions to basic needs of "insolvable" populations (cheap housing, hygiene and piped water supply). New joint units sprang up, in cooperation with professional organisations or ministerial departments. However, for a long time the CSIR was to continue to play the role of initiator of projects in new fields, strategic for the future. It organised forums or working parties to prepare the opening of research programmes

- in microelectronics (integrated circuit design, chemical process technologies, physics and metallurgy for the manufacturing of electronic devices; capital-risk to help laboratories to prepare products useful in 3 to 5 years' time, from 1983);
- in applied mathematics (computer science and industrial statistics);
- and later, in nuclear physics (the application of radioisotopes for medical treatment and diagnosis was brought into play from 1946; construction of a cyclotron locally began in 1951 and was operational in 1955 for research and training purposes. It was replaced in 1977 by an accelerator, also built and set into operation by the CSIR which gave the impetus and coordinated a number of research programmes in nuclear physics).

However, one of the council's managers proposed and obtained the go-ahead from the government for a separate Atomic Energy Board. This body received rich financial backing and was soon to develop strategic applications in both the military and industrial spheres. The CSIR, frustrated, had to leave to others the glory of discovering (in 1970) a cheap uranium enrichment process, which, coinciding with other technological advances, would allow nuclear power stations to be developed and even the manufacture of the atomic bomb.

As time went by, moreover, the empire that had built up began to be dismantled. In 1952, the CSIR was put under the control of the Ministry of Economics. It thereby lost its interministerial status and its capacity for arbitrating. And its president was no longer automatically to be scientific advisor to the Prime Minister. The research institutes, although created from within, steadily became independent of the CSIR and turned into competitors. Whole areas of study, which it had initiated and considerably expanded, were assigned to the responsibility of other Councils, such as atomic energy in 1959, medical research and social sciences (Medical Research Council and Human Sciences Research Councils, 1969). The co-operative National programmes and the support for academic research were brought in 1984 under a single "Foundation for Research Development", FRD, which was soon to become independent. However, these trends can be seen as signs of prodigious growth, which diversified South African science and raised it to an international level.

In the field of the human sciences, the establishment of the National Institute of Personnel Research (NIPR) in 1946, as part of the CSIR, is noteworthy. The NIPR was also a direct "product" of the war effort. As Louw (1987) has shown, the main military initiative in which psychologists were active, was the Aptitude Tests Section (ATS) of the South African Air Force (SAAF). During WWII, Van Ryneveld, Chief of Staff, approached the University of the Witwatersrand to inquire whether the university could set up a unit for the selection and classification of pilots. The choice fell on Simon Biesheuvel, a lecturer in the Department of Psychology. Louw continues:

> "At the end of the war, the ATS was by far the largest body of scientific and technical personnel that had ever been concerned with the application of industrial and personnel psychology in South Africa. It had tested more than 18 000 men. At the height of its activities it had a staff of nearly 90. The ATS, towards the end of the war, included laboratories and testing rooms for air crew selection, and Aviation Medical laboratory with a large decompression chamber, Bio-chemical and Haematological laboratories" (Louw, 1987: 70).

It is not surprising that Biesheuvel was appointed as the first Director of the NIPR in 1946, signaling the beginning of professional industrial psychology in South Africa. In 1984 the NIPR was transferred to the HSRC and became one of its institutes.

The institutionalisation of the human sciences

As far as the funding of human sciences research in the universities were concerned, the National Bureau for Educational and Social Research which existed before the War, was reactivated in 1946. The Bureau had its origins in the National Educational Bureau, which was established in 1929 to undertake and promote educational research. Because of the generous support of the Carnegie Foundation, the Bureau extended its activities to also include social research. Hence its name was changed to the National Bureau for Educational and Social Research. The advent of World War Two meant a temporary cessation of activities, but these were resumed in 1945 with dr. P.A.W. Cook as Director. The Bureau gradually grew: With a small staff of only eight staff members in the early fifties, its numbers had increased to more than 200 (with 112 researchers) when the Human Sciences Research Council was established in 1969. The work of the Bureau was organised in five departments: education, social, psychological research and services, a library and a film archive. These departments were later augmented by additional units for labour research and statistics, certification services and so on.

Although the National Bureau grew in strength, there was a growing sentiment amongst human scientists - especially after the establishment of the CSIR in 1945 - that a counterpart science council for the human sciences should be formed. Various prominent human scientists (such as Professors P.J. Nienaber, Geoff Cronje and H.O. Monnig) advocated the establishment of such a Council. Their calls for the establishment of such a body were also supported by the Suid-Afrikaanse Akademie vir Wetenskap en Kuns, which sent a delegation to the then Minister of Education, Min. Jan de Klerk in 1964 to get his support. After more lobbying, de Klerk eventually agreed to these proposals and announced in Parliament in 1967 that approval had been granted for the establishment of a Human Sciences Research Council. The HSRC was eventually established on the 1st of April 1969, with Dr. P.M. Robbertse as its first President.

On establishment the HSRC housed the following institutes: Historical Research, Communications research, Manpower Research, Educational Research, Psychometrics, Sociological Research, Statistics, Languages, Literature and Arts and Research Financing and Co-ordination. It grew steadily, as reflected by an increase in budget from just over R1.6 million in 1969/70 to R6.7 million in 1978/9.

It is not accidental that the establishment of the HSRC carried the support of the conservative SA Academy of Science and Arts and prominent Nationalist intellectuals such as Cronje and Monnig. The first President of the HSRC, Robbertse, as well as most of the senior members of staff, were all outspoken supporters of the Nationalist government. Various critics (Muller and Cloete,....; Marais, 1999) have convincingly shown that the HSRC's role - especially during its first decade (1969 - 1979) - may correctly be described as being a "handmaiden" of the government of the day. It would only be with the appointment of Dr Johan Garbers as president in 1979, that greater distance between the HSRC and the government was intentionally sought.

Outside of the HSRC, this era also saw the first research centres in the social sciences being established at South African universities. Economic concerns played a significant role in the establishment of two of the earliest research centres at South African universities: the Economic Research Unit (ERU) at the University of Natal and the Bureau of Economic Research (BER) at the University of Stellenbosch, both established in 1944. The origins of the ERU go back to 1940 when a fellowship was established in the Department of Economics at the University of Natal for the study of labour resources in Natal. Another significant milestone was the first Natal Regional Survey in 1944.

Four more research centres in the general area of economic and planning research were established in the sixties, perhaps a reflection of the economic boom that was experienced in the country at the time. These were: the Bureau for Economic Policy and Analysis at the University of Pretoria, the Institute for Planning and Development at Potchefstroom University, the Institute for Planning Research at the University of Port Elizabeth all established in 1968, and the Transport Research Centre at the University of Stellenbosch (1965).

The first research centres devoted to interdisciplinary social research were established in 1954: the Institute of Social and Economic Research (ISER) at Rhodes University and the Institute for Social Research (ISR) at the University of Natal, Durban. The ISER came into being as a direct result of the Keiskamma Regional Survey which was conducted by various departments at Rhodes (with Carnegie Foundation support). The ISR at Durban came into being through the active encouragement of Professor E.G.Malherbe and initial funding by the Ford Foundation, Carnegie Foundation and the National Council for Social Research. Its name changed in 1975 to the Centre for Applied Social Science (CASS) when Professor Lawrence Schlemmer became director and again in 1988 to the Centre for Social and Development Studies with Professor Simon Bekker as head.

The HBUs and the Bantustan project

Perhaps one of the significant developments of the new apartheid government in the field of higher education, was its decision to establish new universities - along racial/ethnic lines - to support their new policy of separate development. Badat (1994:9) writes: "The report of the Eiselen Commission (Commission on Native Education, 1949-1951) which powerfully influenced the contents of the Bantu Education Act of 1953, drew the key connection between state education policy and political and economic control of the African population. African education was to reflect the dominance of the ideology of white rule and superiority. Moreover, in accordance with the requirements of the 'separate development' programme, higher education for blacks was to be planned in conjunction with 'development' programmes for bantustans and placed under the direct control of the Department of Native Affairs".

As a result of the Extension of University Education Act of 1959, new racial and ethnic universities were established: the University Colleges of the North (Turfloop), Zululand, Western Cape and Durban-Westville. In terms of the Fort Hare Transfer Act of 1959, the University College of Fort Hare was to be restricted to Xhosa-speaking Africans. The establishment of the African HBUs, the coercion of the University of Fort Hare and the launching of the "tribal" bantustans were all related. Badat et al (1994) conclude:

> "To the extent that the African HBUs were to be tied to the 'development' of the bantustans, the limited and restricted sense in which this 'development' was intended was to profoundly condition the academic character as well as the role and functions of these institutions. If a major function of the early HBUs was to generate the administrative corps for the black separate development bureaucracies, the ideological task was to wean new generations of students away from black nationalist and socialist sentiments and win them to the separate development project through the appropriate mix of repressive controls and the promises of economic opportunities in the bantustans and around the social services needs of blacks" (Badat et al, 1994: 11-12)

The other HBUs emerged a decade or so later with the establishment of "self-governing" and "independent states". Although the political scene was different in the mid-seventies when these universities were formed (Transkei, Bophutatswana and Venda), the basic linkage between the role and functions of the HBUs and the further elaboration of the apartheid project remained largely unchanged. (For a detailed account of the various legislative changes made between the early sixties and the early nineties, cf. Dlamini, 1995).

Government control of public sector research

The sixties and seventies were characterised by direct and tight government control as far as the governance of science councils was concerned. Presidents of these science councils were all Ministerial appointments. The pro-apartheid sentiments of these bodies (e.g. Human Science Research Council) during this period have been well-documented (Cloete and Muller, Marais). In his discussion of the history of the HSRC, Marais identified the period between 1969 and 1979 as similar to a "centralist regime". For him, the HSRC in its first decade is characterised by being a largely Afrikaans and pro-government organisation, inward-looking and adopting a conservative approach to external co-operation.

The government's "power" over existing universities (especially the liberal English-medium universities) was less effective, given a long tradition of academic freedom in the South African university landscape. As argued above, it was easier for the nationalist government to set up new ethnic universities and retain a degree of control over their governance. Most of the Afrikaans-medium universities were staffed by predominantly sympathetic and conservative supporters of government policy. Most of the rectors of these universities (as well as the "bush colleges") and members of councils, were either card-carrying members of the NP or members of the secret Broederbond ("Brotherhood") organisation which was later exposed as a powerful, nationalist body that promoted Afrikaner ideology in all spheres of society. (For a more articulate view of these issues, cf. Mouton, J. and Muller, J. 1995).

1.5 THE STRUGGLE AND REFORMIST INITIATIVES: 1976 - 1990

> The intensification of the struggle against apartheid (Soweto 1976) led - in the field of S&T - to the introduction of the academic boycott and increasing isolation of SA scientists. In the field of science and research, it also led to the rise of "anti-government" research organisations (many in civil society), the founding of the United Democratic Front, the National Education Crisis Committee (1986) and so on. In 1985, the political situation had deteriorated to such an extent that a national state of emergency had to be declared. This signaled, for all practical purposes, the death of apartheid. It initially led to a more moderate reformist philosophy under PW Botha and later - under FW de Klerk - to the acknowledgement that apartheid has failed. In a historic speech on the 2nd of February, de Klerk announced the unbanning of the ANC and the unconditional release of Nelson Mandela from prison.

Framework autonomy for the science councils

In April 1988, the South African government adopted the system of "framework autonomy" as the basis for the management of the statutory science councils. It was a significant shift because it fundamentally changed the relationship between state and science councils. It terminated a system of excessive micro-management of the affairs of the councils and introduced a system where the councils could act more autonomously with regard to issues of governance, the setting of research priorities and overall management. The main features of the system can be summarised in three statements:

- Framework autonomy introduced a clear delegation of authority and accountability to the boards and management of each council.
- Framework autonomy introduced a new funding system that took the principle of baseline funding as its point of departure.
- Framework autonomy also set goals for funding to be generated through contract research from outside of the council.

In 1992, the then Director-general of the Department of Education, Dr Johan Garbers, wrote as follows:

> "Framework autonomy gave the research councils ample freedom to manage their affairs according to the requirements of R&D. The increased responsibilities of the councils of the scientific councils also obliges them to give greater attention to the efficient management of R&D. It is imperative that the councils increasingly generate more income of their own and this is

> also a motivating factor for effective and professional management" (Garbers, 1992: 5).

The Science Council embraced the new policy of framework autonomy. An assessment of the first years after the introduction of framework autonomy clearly shows that most of the councils were in fact quite successful in increasing their income through contract research.

Table 1.1: Share of Statutory Council Income from Parliamentary grants

Council	1986	1987	1988	1989	1990
CSIR	66.2	67.0	62.7	57.1	56.7
HSRC	93.8	93.5	84.1	77.1	77.2
MRC	95.0	94.3	93.6	90.8	88.5
MINTEK	88.0	83.0	80.8	80.0	77.1

(Source, IDRC, 1993: 29)

However, there were early signs that framework autonomy was not an unqualified success. Even Garbers, who initially supported framework autonomy, expressed some cautionary notes in 1992.

> "One of the most serious problems with regard to the shortcomings of the science system is the lack of interaction between the science system and other systems in society, as well as between the subsystems of the science system itself...All are aware of successes in this field, but are also aware of serious shortcomings. This problem has become more critical with the introduction of framework autonomy and the accompanying structuring of the science councils according to the themes or problem areas rather than disciplines. Lack of interaction and overlapping are in fact two sides of the same coin. In this regard more attention should be given to cooperative programmes among the councils themselves. (Garbers, 1992: 4)

The introduction and adoption of framework autonomy was aimed at producing more autonomous and efficient science councils. Through a system of baseline funding, government clearly also wished to cut its support of these institutions in the hope that they would become financially more self-sufficient. In these respects, framework autonomy will have to be regarded as being successful. However, with the increased drive towards contract research came a concomitant emphasis on commercialisation and market-driven concerns. This had a number of negative consequences. One was its internal effects on the culture of research within these institutions. Researchers who had been trained and specialised within disciplines, were now suddenly required to change their whole attitude towards research. Not everyone was able to make these shifts. More seriously, the research portfolio of most science councils became increasingly market-driven. The inevitable result - as Garbers commented - was that less attention was given to socio-economic and developments goals. Collaboration with other scientific institutions also declined. In fact, competition with universities and private companies became the order of the day.

The shift to more market-driven commercial research was initially encouraged. However, as the political situation changed towards the end of the eighties and early nineties, and the stronger role taken by the Mass Democratic Movement in science and technology issues, the trend towards commercialization came under increasing fire. ANC spokespersons and bodies introduced a new discourse around science: a discourse which emphasised democratization, participatory research and an alignment of scientific priorities with national socio-economic goals. This constituted a major paradigm shift and announced a new era in science and technology policy in South Africa.

Trends in Higher Education research

The decades of the seventies and eighties were characterised by increasing polarisation and the deepening of existing divides, especially in the humanities and social sciences. Divisions between Afrikaans and English academics and between advantaged and disadvantaged scholars increased. Ideological polarisation between paradigms (Gramscians, Althusserians, functionalists and so on) became even more prominent in the early eighties. This was accompanied by an increasingly more vocal academic critique of the apartheid establishment. Science councils, such as the HSRC, who were perceived to be working in collusion with the government, were dismissed as being ideologically tainted. Many scholars at HBUs and English-medium universities turned to other sources of funding, inside and outside the country. This situation would only start to normalise in the early and mid-nineties.

These trends could be described and discussed at various levels. In an analysis of research centres and institutes in the human sciences, Mouton (1995) focussed on the landscape of institutionalised research and how it changed during the late seventies and eighties with the rise of new "oppositional" centres of research. In a review of eighty research centres in the humanities and social sciences, it is interesting to note that ten of these were created before 1965, 36 between 1965 and 1985 and a relatively large number (34) since 1986.

Although these time intervals are somewhat arbitrary, there were at least three underlying factors. Firstly, the mid-sixties saw a proliferation of new universities in South Africa: on the one hand, a number of "homeland" universities came into being (UniZul, UNIBO, UNIN, Venda and UNITRA), and on the other hand, two new universities (Rand Afrikaans University and the University of Port Elizabeth) were established specifically to promote the cause of Afrikanerdom. Many of these institutions established research centres as a matter of "prestige", rather than for intrinsic reasons.

Secondly, the end of the period 1965 to 1985 coincides with the introduction of the South African Post Secondary Education System (SAPSE). With the increasing academic isolation that resulted from the intensification of the struggle against apartheid, the then Department of Education introduced, in 1983, the South African Post Secondary Education System (SAPSE). One of its aims was to encourage the publication of scientific articles, especially in locally accredited journals. One of the (intended or unintended?) consequences of this was the proliferation of numerous research centres and institutes, especially in the human sciences.

Finally, the new resistance to the apartheid government led, in the late eighties, to the establishment of many "oppositional" and "social critical" research centres. This is not to suggest that no critical research centres existed prior to this date. A significant number of such "oppositional centres" were established in the early and late seventies, including the Institute for Black Research (University of Natal; 1972), the History Research Group (WITS; 1972), the Institute of Criminology (UCT; 1997) and the Centre for Applied Legal Studies (WITS; 1978).

Many centres were created with the specific intention of playing a critical role in opposing apartheid policies and practice. This was done through research, but also through more direct "interventionist" or "participatory" strategies such as training programmes and materials development.

Some of the best examples are found in the field of education, particularly the group of **Education Policy Units**. The EPUs were all established between 1987 and the early 1990s. The first EPU was established at WITS, after consultations with the National Education Coordinating Committee (NECC) and other community-based organisations during 1986, when opposition to the apartheid regime was at its strongest. The need was felt for research units to formulate educational policy for a new democratic society and in opposition to the existing policies. The WITS EPU was established early in 1987 with Johan Muller as first director, followed by the EPU at the University of Natal (headed by Sandy Lazarus) later that same year.

Another example in the field of education was **the Centre of Adult and Continuing Education** (CACE) which was established in 1985 at the University of Western Cape. Its mission states that it works "within the anti-apartheid struggle and a radical adult education paradigm". CACE was, and remains, primarily involved in adult education courses with a specific focus on training blacks and women. Its methodological preference for action research and its support for feminist paradigms are indications of its "anti-establishment" philosophy.

The **Institute of Criminology** (at UCT) was founded in 1977, one of the "oppositional" centres in existence before the mid-eighties. The institute serves both as an academic department and a research institute with a focus on community service. The theme of the institute in 1991 was "Developing Justice in South Africa". Projects include the Legal Education Action Project, involvement in the Goldstone Commission and the Social Justice Resource Project. The overall aim was to contribute towards the development of an accessible, democratic and non-oppressive system of criminal and social justice. Much of the research was action-orientated, and involved not only the collection of data but also popular education and training, in order to develop a human rights culture.

The **Centre for Health Policy** at WITS was established in 1987 as a "response to the inequitable apartheid health care system" (according to its 1992 Annual Report). The same document reports that the emphasis of CHP has changed since 1990 from critiques of the existing health care system to more constructive policy proposals. More recent goals were to analyse existing health care services, to promote the idea of essential health care as a universal right, to encourage debate about appropriate standards for health care in SA and to develop strategies that will facilitate major changes in health care in a non-racial democratic society.

By the end of the eighties, it was clear that the apartheid government had lost all legitimacy - also amongst many of the Afrikaner intellectuals who had originally supported it. The vibrant critical discourse that was fuelled by oppositional research centres contributed to the widespread growing intellectual opposition to apartheid. The time had come for a new age.

1.6 INTERREGNUM - DAWNING OF A NEW AGE: 1990 - 1994

> Although still "officially" in power for the period between the 2nd of February 1990 when the ANC was unbanned and Nelson Mandela released and the 27th of March 1994 (first general election), the NP was increasingly "forced" into sharing power and negotiations for a new political dispensation. This was the era of consultation, participation, where the legitimacy of ALL government bodies and agencies (including the science councils) were submitted to serious "interrogation". It was also the era of new forums, new "brokers" and new policy initiatives. On the 27th of March 1994 the first free and fair general election in the history of South Africa was held.

Overtures towards a new science and technology policy for South Africa

On the 2nd of February 1990, FW de Klerk delivered his now famous speech in Parliament in which he announced the unbanning of the ANC and the unconditional release of Nelson Mandela. After the ban on the ANC was lifted, many of its administrative departments, which had been based in Lusaka, Zambia, during exile, transferred to the new headquarters in Johannesburg and set out the task of transforming the organisation from a liberation movement into a political party. Another main goal was to develop policy positions on a range of issues, given the prospect of becoming the ruling party.

A group of ANC-aligned scientists and engineers, based in Johannesburg, produced a position paper on S&T during 1990. In September 1990 the Interim Science and Technology Group (ISTG) was formally established. This was followed by a one day conference (Towards a technology policy for South Africa) held on the 24th November 1990. After the ANC's first national conference held inside South Africa in July 1991, the ISTG was changed into the Science and Technology Group (STG). At the next annual national conference, held in Johannesburg at the end of May 1992, the STG put various policy proposals related to S&T on the table.

Some shifts in policy had already occurred between 1990 and 1992. As Grobicki writes:

> In contrast to the 1990 ANC conference which suggested that 'At a national level, a Ministry of Research and Technology, and a politically independent Office of Technology Assessment should be established', the Policy Guidelines adopted in 1992 were rather more guarded concerning future structures: 'The ANC will review and restructure the science and technology system in consultation with the relevant organisations. The ANC will accord government a key role in technology development by establishing appropriate and powerful democratic structures to formulate policy with maximum participation" (Grobicki, 1994: 217).

The next major event, in an already dynamic and fast-changing policy environment, was the IDRC commission on science and technology policy. This commission had its origins in a conference entitled "The role of research in transforming South Africa" which was jointly organised by the journal *Transformation* and the International Development Research Centre in January 1992. Out of the deliberations at the conference the ANC, COSATU, SANCO and the IDRC discussed ways and means of making S&T Policy debates part of the national debate. As a first step, it was decided to conduct a review of existing S&T Policy in South Africa and of the institutions involved. Such a review, under the chair of James Mullin, was conducted during the second half of 1992 with the final report (entitled "Towards a science and technology policy for a democratic South Africa") appearing in July 1993.

One of the overall impressions of the IDRC Mission was that the South African S&T system was a highly fragmented system. This observation was based on a number of recurring themes encountered by the Mission during the investigation. Some of these were:

- There was a leadership vacuum on S&T ministerial level.

- As a consequence of the policy vacuum, resource allocations were essentially frozen.
- There was a pressing need to rearrange priorities and to recognise South Africa as an African country rather than a white member of the industrialised world.
- The problems of the disadvantaged needed to be tackled as a matter of urgency.
- There was an immediate need to transform the highest levels of governance of the institutions of S&T.
- There was a crisis in the educational system at all levels. This crisis was at its worst when it affected the teaching of mathematics, science and engineering.

In their final policy recommendations, five issues were highlighted:

- The priority of strategic research.
  "South Africa might embark on a ... exercise, involving not only the scientific community, but all parts of society, in an exercise which joins an identification of scientific opportunities with an identification of societal needs. A truly national exercise to identify priorities for strategic research could be a powerful tool in forging a democratic South Africa" (IDRC, 1993:65)
- The importance of retaining a core capacity in fundamental research.
- Encouraging South African scientists to become more involved in collaborative ventures.
- Promoting S&T Policy research.
- Setting up Technology Missions in such areas as housing, electrification, water and so on.

As we will discuss in more detail in the remaining chapters of the report (especially Chapter 3), many of the points highlighted in the IDRC study would eventually find their way into formal policy documents and, ultimately, legislation on science and technology. Another domain of policy debate that has direct links with S&T is that of higher education.

The emergence of a new higher education discourse

Given the crucial role played by Higher Education institutions within the National System of Innovation, it is useful to briefly look at a major investigation in the field of education that impacted on the overall development of a national S&T policy. This was the National Education Policy Investigation (NEPI) which was a project of the National Education Co-ordinating Committee (NECC) and was conducted between December 1990 and August 1992. This investigation was aimed at reviewing educational policy at all levels. Our focus will be on its findings with regard to post-secondary of higher education.

The Research Group on Post-Secondary Education (PSE) identified the following policy options that would require further attention (NEPI, 1993: 217-218):

- The governance structure of the PSE system and of PSE institutions must be non-racial, non-sexist and democratic.
- Priority must be given to programmes that redress the institutional, staffing, racial, class and gender inequalities that characterize the current PSE system.
- Provision must be made for student mobility between the various sectors of the PSE system.
- A balance must be achieved between the demands of access, quality and development: any future PSE system must be one in which access is equitable, the education offered and the research undertaken is of an appropriate standard, and the demands of national development are satisfied.

Other options relate to the size and shape of the PSE system. As is evident from the list above, most of the report focussed on issues of redress and equity, governance as well as a more unitary system with greater mobility between institutions. Research or knowledge production received very little attention. Elsewhere in the report, there is a slight elaboration on this matter:

> "Major policy challenges for a new PSE system are therefore to ensure that: PSE plays a major role in developing the human resources needed for national development; South Africa creates the necessary research and development capacity to benefit from international technological innovation; <u>and university and technikon research and that of other institutions, is broadly linked to national development priorities</u>" (1993: 208)

The work of NEPI was taken further by the National Commission for Higher Education which conducted a similar investigation between 1995 and 1996. The

work of the Commission was highly influential and many of its recommendations are embodied in current legislation on Higher Education in the country (cf. 2.5)
This concludes our brief historical overview of science in South Africa. The last section of the Chapter attempts to come to an assessment of the significance of this particular history - especially since World War II.

1.7 AN ASSESSMENT: APARTHEID SCIENCE AND SCIENCE BEYOND APARTHEID

It is difficult to do justice to science that is organised in the way described in the last two sections. Personal successes and those of a few leading institutions were repeatedly mentioned when discussing pre-War science. In contrast, from now on we have to talk in terms of teams, laboratories and of establishments. The dual tradition of a 'science for knowing' and a 'science for doing' is still visible; but government intervention has clouded the issue, by making the universities take up "strategic" research (by contract, carried on until positive practical results are attained); and in persuading industry to co-finance basic research in the fields of the future, conducted by the councils or the larger universities. Innovation no longer depended on individual initiative only. It was planned, arrived at through consultation, tuned in to worldwide developments of disciplines and with a strong notion of the future. Hundreds of names stand out in the indexes of publications devoted to recording technical progress or scientific discoveries, many of which have amazed the world. Bold projects (like the conversion of coal into oil, dams in the Orange Vaal, nuclear power stations), highly technical, high-tech industries (like aeronautics, telecommunications) are symbols of top-level technological capacity. The primary resources (agriculture, mines) were exploited and transformed to best advantage (South African mining technology cannot be equaled, the food and agriculture industry exports massively). Medical advances touch on all areas and many of them have been world "firsts", such as the famous heart transplant in 1967 which demonstrated not only the skill of the surgeon who performed the operation (C.N. Barnard), but also the supreme ability and excellent coordination of the centres of medical cardiology and of heart surgery, which were some of the first of their kind to be active in the country. The research culture had penetrated irreversibly five or six universities (all reserved for Whites). The taste for research reached its height in these establishments, so much so that, in the 1960s, some people worried that it was becoming the sole criterion for assessing scientists and universities. They produced more than half the country's "fundamental" research and half the number of articles published. They were less well equipped, less well endowed for running their operations, but financing arrangements were soon to arrive to stabilise the research.

The post-war period was the golden age for science in South Africa, but it was a science without qualms about consequences. It is interesting to note the detachment with which Naudé recounts the change to military research more or less in these terms: "One day (in 1961) the military chief of staff came to find me and asked if the CSIR could provide substitutes for the arms we import, in case of a boycott due to apartheid? I immediately mobilized the National Laboratories of Physics, Chemistry, Industry and of Occupational Psychology to deal with the problem. The only area where expertise was lacking was in missiles... Fortunately, our embassies told us that France was not opposed to joint working; the following year we were sent 16 engineers and researchers for training, who on their return launched our National Institute for Military Studies" [11]. And production, including that of the atom bomb, was to follow, giving CSIR the opportunity in the process to achieve considerable technical and scientific advances (in materials: carbon fibres; also computing, microelectronics and so on). Furthermore, according to an economically ideal model, the know-how and the personnel who have it were periodically transferred to companies linked to the ministry of defence (Armscor or its subsidiaries: Kentron for example).

In real terms, national science had enjoyed growing support since the 1950s from the extreme nationalist government that had been solidly established for 40 years. However, this backing came with the provision that the work globally served the rulers' obsessions: racial separation, anxiety for security and military strength, even for extreme self-sufficiency, under the pressure of the international boycott which resulted from that policy. For an effective techno-science, it was a good challenge. The universities, whose work (partially of an applied nature) is of interest to a variety of economic and social sectors, continued certainly to favour the principle of peer review and remained concerned for their academic freedom. At the CSIR, they just demanded "excellence" from the personnel employed and took as their compass the flow of demands that were financed. In other councils, political pressure was much more direct and taken on board.

[11] After S. M. Naudé & A. C. Brown, "The growth of scientific institutions in South Africa", in A. C. Brown, ed. *A history of scientific endeavour in South Africa*, Royal Society of South Africa, Cape Town, 1977, p. 81-82.

Instrumental science, with all its technical achievements, finally caught up with the political change in the country. The mounting success of struggles against apartheid, the boycott of all scientific co-operation, the defiance of financial interests and the economic crisis - transformed the landscape. The government started to introduce budget restrictions, then the scientifico-technical sector was freed from strict surveillance, significantly by compelling it to finance itself. This guidance by the market was aimed at the same time to "save" the teams established by the prospect of a possible "Black" government, defiant in regard to a science for and by Whites compromised by the apartheid regime.

However, looking ahead to what has happened over the past five years, in a kind of dialectical turn, the opposite of this has been realised. The ANC has showed itself to be interested in science, but in a manner that led to the writing of a new social contract: one that is aimed at promoting more participatory research, mode two knowledge and a science directed towards social objectives. In the final analysis, the maxims of all the actors have to be tested. The academics could be asked: you describe and find out - to what end? (Excellence does not guarantee relevance). Government researchers would be asked: if the aim is to be efficient - for what human objectives? Finally, the private sector would be asked (even if it is more independent): the research is stimulated by the demands for profit, but with what concern for the needs of those who are deprived? A new spirit of accountability is blowing over the sub-continent. To what effect and with what consequence, remains to be seen.

PART TWO
THE SOUTH AFRICAN SCIENCE AND TECHNOLOGY SYSTEM

South Africa's colonial history is sharply marked by material inequalities, political struggle and deep social divisions involving intersecting webs of class, race and gender. The recent historical context has witnessed the period of intensified resistance, violent state repression, and international isolation (economic, academic, sport and cultural) since the 1970s, being replaced by negotiations between the ANC and the apartheid state by the late 1980s, and a transition to a post-apartheid political system in 1994. The effect of these political changes on the national science and technology system has been outlined in very broad terms in Part One of the report.

Now, in the late 1990s, issues of democracy and difference are central to public and policy debates. For example: What are the socio-economic consequences of the pluralisation of the old colonial democracy? Will the extension and recognition of political rights necessarily lead to economic equalities and the elimination of poverty? Does science and technology have a role to play in ensuring that the post-apartheid democracy is a reality in economic, and not only political, terms?

A new vision for the S&T system and its role in the changing South African society, has been developed over the past five years. This vision is, perhaps, best expressed in the White Paper on Science and Technology:

> "The vision is one where, on the one hand, South Africa uses S&T to become economically competitive on a global scale and, on the other hand, to provide essential services, infrastructure and effective health care for all South Africans. We believe that this is best done by embedding our S&T strategies within a larger drive towards achieving a National System of innovation. In such a system, institutions such as universities, technikons, science councils, private sector research laboratories and market intelligence divisions would co-operate in a nationally optimal way towards solving real problems, whether these occurred in industry, agriculture, defense or basic research." (DACST, Sept 1996: Minister's Introduction]

The above quotation also embodies some of the tensions inherent in the new policy. On the one hand, it supports the idea of a more relevant science as opposed to a view of science as a socially decontextualised activity. On the other hand, the idea of a relevant science, when linked to the notion of “innovation”, can be ambiguous and lead to tensions at the implementation level, especially if innovation is defined purely in relation to economic competitiveness. What then happens to the social goals that are also central to the new vision for S&T?

A second policy tension lies in the suggestion that collaborative partnerships should be formed between research organisations within the national system of innovation. Again, the question is: Are social goals necessarily implicated in these partnerships and can collaborative partnerships flourish in a climate of intensive competition?

The social inscription of science in the pre-1994 period and the present policy dilemmas it poses can be understood at several levels: (IDRC, 1993: 3-4)

(a) Apartheid state policies and employment and training practices rationally structured social institutions along ethnic lines (e.g. 15 parallel departments of education, 15 departments of health, 14 departments of agriculture, etc.), and were subordinated to apartheid's ideology of "total strategy."
The present policy dilemma is how to transform apartheid structures more efficiently and along more democratic lines, where the idea of real and/or imaginary “difference” does not play a role in determining how social institutions are structured.

(b) Scientific and technological development was more closely aligned to the needs of the apartheid state (e.g. scientific research in the service of state security and the military establishment) than to either economic efficiency and/or social equity.
The policy questions here are: How can publicly funded science support the multiple objectives of a state that is representative of public interests? What mechanisms should be instituted to ensure individual and institutional transparency and accountability for the use of public funds for research purposes? At the level of implementation: How do social institutions ensure that some policy objectives (e.g. economic competitiveness) do not supercede and marginalise other policy objectives (e.g. social needs)?

(c) Structural exclusion and/or under-representation of historically oppressed groups from research and development activities.

Recent information (cf. Statistical Tables in Appendix C) will shed some light on the degree of institutional transformation with regard to changes in the number of researchers, students, etc. for all the institutions discussed in this section. The policy dilemma here is: how do we simultaneously hold on to (for the purpose of monitoring any changes in numbers) and at the same time critically rethink the contradictory official apartheid labels that adopt essentialist articulations of demands for the recognition of difference?

(d) Within the S&T system, as was the case in broader apartheid society, practices of exclusion with regard to access to resources (information, funding, employment) were often justified in terms of colonial constructions of race, gender and education.

Many studies point to the ways in which apartheid social and scientific practices have been based on perceptions of colonised people as being outside of science ("unscientific", "savage", "superstitious", etc.). Do the assumptions underlying current institutional processes and structures make a break with former practices and constructions of identity (with "race" and "ethnicity" as primary identity co-ordinates)?

(e) Rationalisations were also offered in support of a notion of science as apolitical and value-neutral, thereby freeing scientific communities of taking responsibility for the ends and consequences of their research.

Empirical study of the current public and academic understanding of science is sorely needed, in order to establish whether this notion of science has changed. This study would also need to critically examine the idea of a "republic of science" as being an appropriate "guide to the operation of South Africa's long-term S&T policy" (IDRC, 1993: 24).

(f) The pre-1994 system was often characterised by government secrecy and a lack of public debate about major issues.

The question is whether the structures and processes designed to increase the transparency of public institutions and public input into policy debates, really do so.

We might well ask the question - five years after the 1994 elections - Are we witnessing a change from "apartheid science" to "post-apartheid science" in South

Africa? Is post-apartheid science differently inscribed and represented in society? Are there any significant shifts in science and technology policies, structures and practices? If so, how do we map these transformations - structurally, socially, politically, economically, and culturally - and the impact they have had on society?

Broadly following the framework adopted by Rip and Van der Meulen (1994), the second part of the document focuses on these questions at four systemic levels:

1) At the macro level: The governance of science, advisory structures, national policies, and post-1994 S&T initiatives (Chapters 2-4);
2) At the intermediate level: Funding structures and academies, associations and S&T networks (Chapter 5 and 6);
3) At the performance level: Public sector research and development performers including the science councils, national research facilities, universities and technikons and government departments and government supported labs (Chapter 7);
4) The way in which science interfaces with its various publics (Chapter 8).

Chapter 2
THE GOVERNANCE OF SCIENCE AT THE NATIONAL LEVEL

2.1 INTRODUCTION

This chapter focuses on the formal government structures and advisory bodies to the government, beginning with the post-1994 governance of science. Several recent studies have shed light on policy debates in the post-1994 period, especially as they relate to the representation of science in government and in public sector research performers. The first study, sponsored by the International Development Research Centre in Canada, found that "strong coordination and shared purpose" among apartheid institutions was lacking in the early 1990s, and institutions trying to change did so in a policy vacuum (IDRC, 1993: 5). They suggest that institutions were fragmented, lacking coherence and a common vision.

Following the 1993 IDRC study, several processes have paved the way for a re-structuring of the S&T system from a fragmented to a more coherent system, based on a national system of innovation. Firstly, post-1994 policy documents (White Paper on S&T, White Paper on HE) emphasise the central role of science and technology in economic and social reconstruction, by meeting basic social needs such as the eradication of poverty, provision of employment, infrastructure, housing, electricity, clean water, flush toilets, etc. The recent shift in policy emphasis from social reconstruction between 1992 and 1995 (cf. Chapter 3.1) to an emphasis on innovation and competitiveness from 1996 onwards is reflected in structural tensions within the S&T system. For example, the formation of the National Advisory Council on Innovation (NACI) may be understood in relation to this shift in emphasis, where the dominant policy rhetoric has moved from social and economic reconstruction to economic competitiveness. Secondly, the creation of several initiatives (following the White Paper on S&T) to describe and evaluate the current system (for example, the NRTA and System-wide reviews) and to set priorities for a future system (for example, the Research Foresight exercises), have stimulated significant changes at all levels of the research system.

This chapter describes the formal government structures, and national advisory bodies pertaining to science and technology. The organogram on the next page is a helpful schematic representation of these entities.

Chapter 3 presents an overview of the most important national policies and strategies in the area of S&T, while Chapter 4 discusses the wide array of national S&T initiatives undertaken over the past five years.

2.2 Formal Government structures

At the level of national governance, the status of science and technology in South Africa was raised to cabinet level in the post-1994 period, having existed in the apartheid years within the Department of National Education. This elevated status of S&T at the national government level is evident in the formation of three new structures, all aimed at co-ordinating the currently scattered government initiatives to stimulate the national innovation system: (DACST, 1996:19)

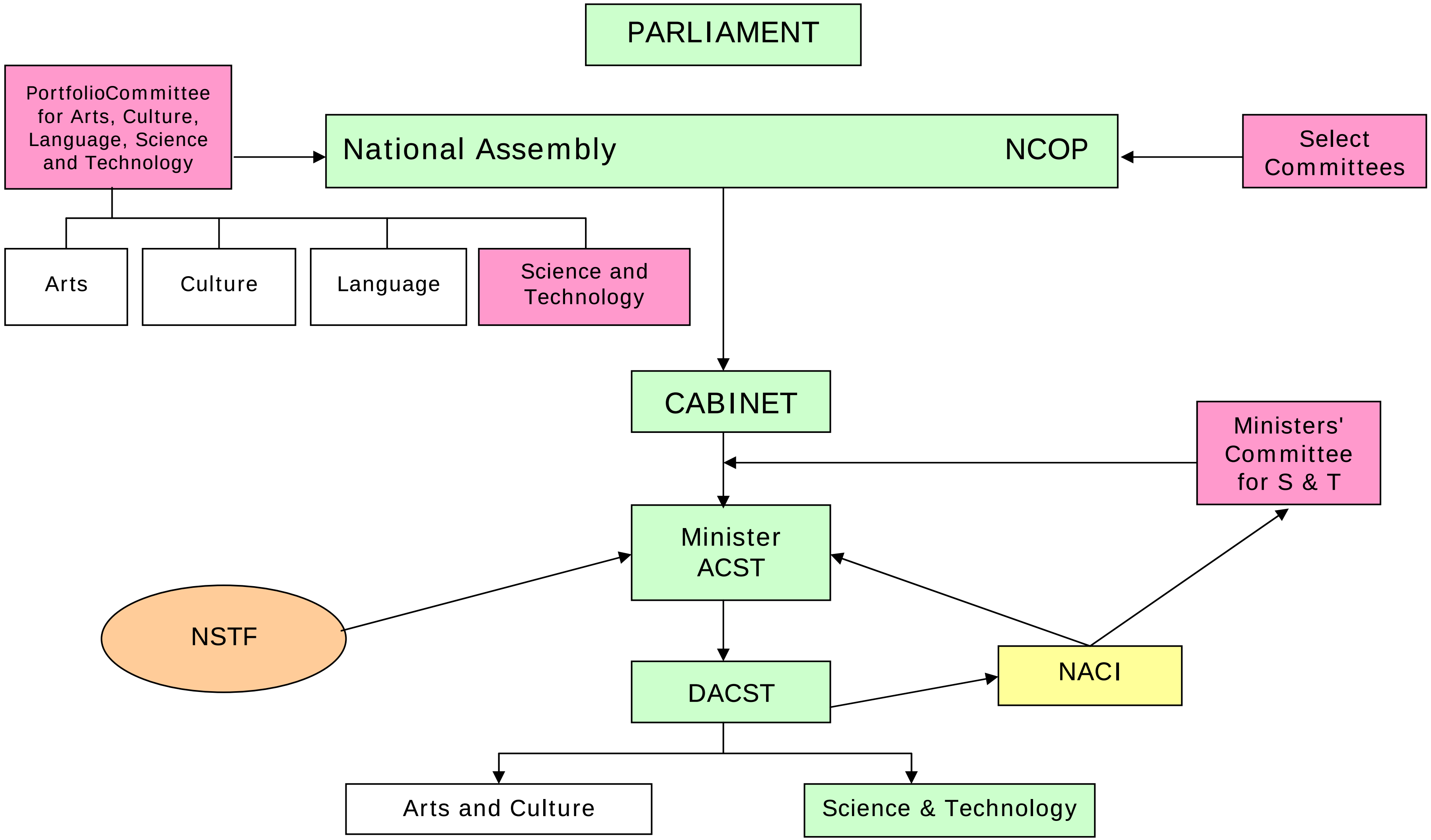
- A national Ministry of Arts, Culture, Science and Technology
- The Ministers' Committee for Science and Technology (MCST)
- The Department of Arts, Culture, Science and Technology (DACST)

2.2.1 A new Ministry for Science and Technology

This ministry is responsible for policy formulation and final decisions concerning the national government of the fields of arts, culture, science and technology. The minister is also responsible for several structures at the advisory, funding and research performer levels (discussed later):

- National Advisory Council on Innovation (NACI)
- National Research Foundation (NRF)
- Innovation Fund
- National Facilities for Research

FIGURE 2.1: Government in science



2.2.2 Ministers' Committee on Science and Technology

The Ministers' Committee on Science and Technology (MCST) is a cabinet committee of ministers and senior staff of relevant ministries formed to assist those ministers/departments whose functions cut across several ministries, as is the case with S&T. It is "composed of all Ministers whose portfolios encompass a significant Science and Technology component, and is the principal policy co-ordinating and information disseminating body for science and technology matters across Government". (DACST, 1996: 19) The secretariat of the MCST is housed in DACST; the other ministries involved include Trade and Industry, Health, Minerals and Energy, Agriculture, Transport and Defence (Marais, 1999:92).

During the 1994-1998 period, the Office of the Deputy-President chaired this committee. The MCST meets 3 times a year to discuss issues of common interest to the ministries involved. The National Council on Innovation (NACI) advises the MCST on issues of common interest to the ministries involved (e.g. commissioning the review of government funded SETIs; advising the MCST and therefore the Minister in the division of the Science Vote; etc.).

2.2.3 The Department of Arts, Culture, Science and Technology

As with all government departments, the Department of Arts, Culture, Science and Technology (DACST) was formed to support the new ministry in its implementation of relevant policy. It therefore makes sense to understand DACST in relation to the notion of "innovation" on which the current S&T policy framework of South Africa is based.

The White Paper on S&T explains why focusing on innovation expands traditional notions of S&T systems.

> A national S&T system focuses attention on the outputs of that system; that is new knowledge and new technologies. A strategy for S&T is aimed at ensuring that there is a sufficient supply of these outputs. A strategy based on a national system of innovation includes, but goes beyond that, seeking in addition to promote changing the ways in which society and the economy do things. It is specifically concerned with supporting and promoting the attainment of national objectives by the creative use of the outputs of the S&T system." (DACST, 1996:10)

The White Paper on S&T describes the idea of a national system of innovation (NSI) as "a set of functioning institutions, organisations and policies that interact constructively in the pursuit of a common set of social and economic goals and objectives." (DACST 1996:11). In keeping with this view, the role of government is to ensure that: (DACST 1996:11)

- Institutions, organisations and policies are able to achieve the different functions of a national system of innovation.
- These institutions, organisations and policies interact constructively.
- There are shared goals and objectives that are compatible with shared visions.

DACST, as the central S&T policy formulating and co-ordinating body within government, therefore plays a crucial role in both developing innovation-related SET policy options and in integrating innovation-oriented ideas/agendas across government departments. (DACST 1996:15) Its nine terms of reference are: (DACST 1996:19)

- To provide coherence in the national system of innovation and the development of S&T.
- To coordinate interdepartmental initiatives in support of innovation and technology distribution.
- To prepare the government-wide Science Budget (to include all government activities related to innovation).
- To design a system for the management of government SETIs, clarifying their role within the national system of innovation.
- To include in the above design, procedures for evaluating SETI performance in general, and particularly in relation to their contribution to national development.
- To manage these procedures of evaluation and review, and to make recommendations for change.
- To represent the government in intergovernmental and international negotiations relating to science, engineering, technology and innovation.
- To provide the link between the government and NACI.
- To commission and/or conduct relevant policy related research.

2.2.3.1 Organisational structure and key programmes

DACST is composed of the civil servants involved in the policy implementation and the day-to-day administration of the department. Organisationally, it is divided into two branches: one for Arts and Culture and the other for S&T. The organogram for the latter is presented below.

Table 2.1: Structure of DACST: Branch - Science and Technology

<table>
<tr><th colspan="5">BRANCH SCIENCE & TECHNOLOGY</th></tr>
<tr><td colspan="2">Chief Directorate
Science & Technology
Co-operation and Promotion</td><td colspan="3">Chief Directorate
Science & Technology Development</td></tr>
<tr><td>Directorate
Science &
Technology
Cooperation</td><td>Directorate
Science and
Society</td><td>Directorate
Programme
Co-ordination</td><td>Directorate
Systems
Evaluation &
Resourcing</td><td>Directorate
Technology
Development</td></tr>
</table>

Both branches of DACST have integrated their programmes and projects in two ways. Firstly, based on the assumption of economic growth through innovation, both branches created new institutional frameworks to facilitate increased access, creativity and innovation. Secondly, both branches have also actively promoted inter-sectoral and interdisciplinary partnerships among public, private and community sectors (DACST, 1999b:10). Of course, a question that immediately springs to mind is the extent to which current programmes indicate an equal partnership when the diverse role-players are differently located in existing hierarchical economic and political power relations.

Table 2.2 describes some of the DACST-initiated projects in support of technology development. (Note: Some projects overlap and cross over both branches. A good example is the Wellbeing Information Services, funded by DACST to research and publish a catalogue of inventions and artistic achievements (DACST, 1999b:17).

Table 2.2: DACST initiated projects supporting technology development

PROJECT	DESCRIPTION
National Laser Centre (R5 000 000)	Following the 1997 SETI reviews and "strong stakeholder interest in respect of a national strategy for laser technology", DACST is currently evaluating how existing laser equipment at some SETIs (e.g. the state-of-the-art laser facilities at AEC) may be reorganised into a "National Laser Facility" available to all stakeholders. (e.g. academics, business, community groups, etc.)
Technology Diffusion Programme (R3 058 000)	This involves programmes at technikons through a two-year technology transfer pilot programme called the Technology Stations Programme (TSP). This programme targets sector-specific SMMEs and aims to increase their "innovative activity" by involving them in technikon programmes that are aimed at upgrading the capacity of technikons (e.g. though facilities) to service the needs of SMMEs. Technikons involved in the pilot TSP (in SMME sector specific areas) are Technikon Free State (in metalwork /value-adding), Mangosuthu/North West Technikon, and Technikon Pretoria (electronics).
Technology Transfer Pilots (R 34 000 000 from EU)	This involves EU supported three-year pilot projects involving SMME-targeted technology transfer models (e.g. Innovation Centres, Technology Demonstration Centers, Incubators, etc.)
Africa Projects (R5 000 000)	This programme seeks to create several pilot projects aimed at exchanging science and technology skills and expertise with other African countries.
CAD/CAM Project (R1 000 000)	DACST provides seed funding to establish a Computer Aided Design (CAD) and a Computer Aided Manufacturing (CAM) facility. Rationale: to "enable the development of technical expertise, infrastructure, and capacity for rapid prototyping".
Public Understanding of SE & T (PUSET) (no budget given)	The policy framework for PUSET is based on a review of international approaches, and a national survey of PUSET programmes. The national programme was launched in 1998 to coincide with the YEAST initiative. Plans for future projects: women in S&T, science communication, etc.

Source: DACST, 1999b:26-27

A budget related initiative inspired by the White Paper on S&T is the current DACST review on government S&T expenditure. The White Paper on S&T (DACST, 1996:22-23) recommends two parallel lines of action for this review. Firstly, the preparation of an annual Science Budget drawn from departmental budgets and reflecting all government S&T expenditure, including:

- Expenditure on Science Councils and national facilities;
- Departmental intramural expenditures and S&T-related transfer payments;
- S&T transfers in the Defence sector;
- Other departmental transfers (e.g. support from the Dept. of Education to HE institutions).

The second line of action recommended by the White Paper involves the application of the Department of Finance's Medium Term Expenditure Framework, a multi-year fiscal framework, to the Science Budget. The purpose of the realigned Science Budget will be to inform individual departments of the total S&T portfolio across government. Departments will then be a better position to reprioritise their use of public funds in line with broad socio-economic needs.

Finally, as suggested by the White Paper on S&T (DACST, 1996:24) DACST, in liaison with the Department of Trade and Industry, plans to study how current patenting regulations might be revised to promote innovation. It also recommends that DACST initiate discussions pertaining to other government initiatives (for example, in the Departments of Labour, Environmental Affairs and Tourism, Health, and Mineral and Energy Affairs) regarding NACI's role in promoting safety, health and the environment (DACST, 1996:24). Chapter Four provides detailed descriptions of the various DACST initiatives.

2.2.3.2 The Foundation for Education, Science and Technology (FEST)

The Foundation for Education, Science and Technology (FEST) is an associated institution of the department of Arts, Culture, Science and Technology. It aims to provide all South Africans with knowledge of the natural sciences and an understanding of the role of S&T in their daily lives. It dates back to 1950, when the South African Association for the Education of Adults was formed, which became the South African Association for the Advancement of Knowledge and Culture in 1958. In 1964 it changed its name to SAFEST. In the beginning years, FEST was directed primarily towards the education of white Afrikaners (DACST, 1999:20). The foundation's stated vision is the advancement of a scientifically literate and technologically aware society, and its mission envisages a commercially viable S&T complex featuring:

- Industrial and technological exhibits;
- High-tech entertainment;
- Educational activities; and
- A scientific publishing house.

One of FEST's features is the Museum of Science and Technology, best described as a discovery learning centre. It is the only hands-on science museum in the country that is geared towards the 21st century. The main goal of the museum is to create an awareness and understanding of S&T and the impact of rapid progress in these fields on people's daily lives. This is achieved by informally educating the visitor in a stimulating and participative way, by means of a myriad of animated models and interactive displays. The museum contains a number of unique exhibits, such as a weather satellite receiving station and holograms.

FEST, through its Bureau for Scientific Publications, publishes the national research journals in collaboration with various scientific associations in South Africa. It is also an important publishing house for popular science publications and other informative literature. Probably the most important of these publications are:

- *Spectrum* – a quarterly guide for teachers of science subjects in primary and high schools;
- *Archimedes* – a popularly written natural sciences magazine targeted at high school pupils; and
- *EasyScience* – an easy-to-read popular science magazine for primary school children.

In addition, FEST arranges annual science and other Olympiads, providing opportunities for young science students to test their knowledge against those of their peers locally and abroad. Among these Olympiads are the annual National Science Olympiad and several language Olympiads. Training courses, lectures and demonstrations are arranged by FEST for science teachers and pupils as and when the need arises.

2.2.4 The Department of Education

The Department of Education (DoE) was established in May 1994 to assist the Ministry of Education with education and training at a national level. In terms of the constitution, DoE is responsible for matters that cannot be regulated effectively by provincial legislation, as well as for matters that need to be co-ordinated in terms of norms and standards at a national level. DoE thus prepares government policy on education and training for the country as a whole (SA, 1997:329).

Organisationally, DoE is organised into four branches, each of which is, in turn, comprised of different components. These four branches are:

- Systems and planning
- Higher education
- General and further education and training
- Education human resources and corporate services

For our discussion, we will concentrate on the Higher Education Branch of the DoE because of its close linkages to DACST, and its prominence within the national system of innovation. The stated purpose of the Higher Education Branch is to plan, co-ordinate, monitor, develop and manage the higher education system and support services. These functions are performed by two chief directorates, namely those for planning and management, and development and support (see Figure 2.2).

The Chief Directorate for Planning and Management is primarily concerned with the planning and monitoring of the national higher education system, as well as co-ordinating and developing higher education colleges. In addition, it renders management support and service to the higher education system, and liaises with the Council on Higher Education (CHE). The Chief Directorate for Development and Support, on the other hand, liaises with constituencies in higher education. It renders policy and development support to the higher education system and registers private higher education institutions (DoE, 1998:84).

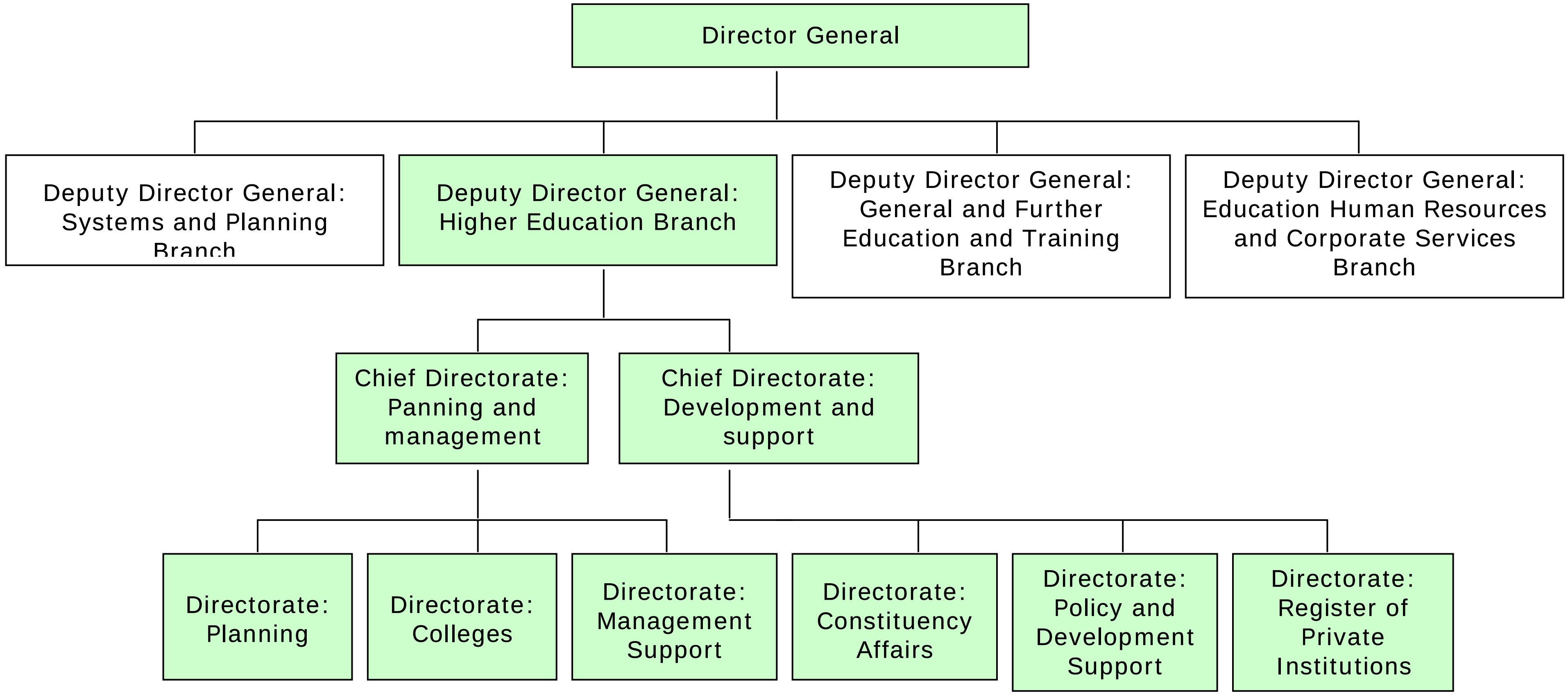
Each of these two chief directorates is again subdivided into three directorates, as can be seen in Figure 2.2. The purpose and function of these directorates are outlined in Table 2.3.

In 1998, the main focus of the Chief Directorate of Planning and Management was to implement the policy and regulatory framework for the transformation of the higher education system, as outlined in the White Paper on Education 3 and the Higher Education Act No. 101 of 1997 (DoE, 1997, 1998; SA, 1998). The development of a system-wide and institution-based planning process, together with a responsive regulatory and funding system, are the key instruments identified in the White Paper for transforming the higher education system. As a result, all universities and technikons were required to develop three-year rolling plans that would form the basis for funding decisions. The development of a new funding formula is under way and it is anticipated that it will be phased in during the fiscal year 2000/2001. Primarily it will involve a shift from the present subsidy formula to a programme-based funding formula (see section 5.5 in Chapter 5).

Table 2.3 - Subdivisions of the Chief Directorates of the Higher Education Branch

Chief Directorate: Planning and Management	Chief Directorate: Development and Support
Directorate: Planning Plan and monitor the national higher education plan. Handle interdepartmental and intergovernmental co-ordination.	Directorate: Constituency Affairs Liaise with constituencies in higher education. Manage the relations between DoE and the constituencies. Co-ordinate constituency participation in policy development. Monitor the transformation process in the higher education sector.
Directorate: Colleges Co-ordinate and develop higher education colleges and teacher education in colleges, technikons and universities. Formulate strategies for the development of higher education colleges and develop norms and standards for programmes in higher education colleges.	Directorate: Policy and Development Support Render policy and development support to the higher education system. Facilitate capacity building in the sector and co-ordinate international relations in higher education through the Directorate of International Relations.
Directorate: Management Support Administer institutional amalgamation/mergers and establishment/closure of institutions. Co-ordinate the responsibilities concerning the Public Entities Act. Monitor institutional financial audits and accountability and handle the appeals of staff to the Minister.	Directorate: Registrar of Institutions Issue publishing of certificates of registration of private higher education institutions, the acquisition of financial statements and audit reports of private/foreign higher education institutions and handling of private/foreign higher education institutions.

FIGURE 2.2: Organisational structure for the Department of Education - Higher Education Branch



Another landmark for the Higher Education Branch was the establishment of the Council on Higher Education (CHE) in 1998, which will undoubtedly play an important role in reshaping the higher education system in the coming years. The CHE is discussed in section 2.4.2 of this chapter.

2.3 Parliamentary Committees

One of the ways in which the national parliament fulfils its legislative function (besides passing laws) is by guiding and ensuring that the executive arm is accountable to the public. It does this in several ways, including passing the annual budget that allocates funds to departments, through parliamentary debates, and through its parliamentary committees. These committees function in two ways: they ensure the efficiency and transparency of government, and they allow public input into law making processes (e.g. debating draft legislation). Of interest to this study are the parliamentary committees associated with the two “houses” of parliament: the Portfolio Committees of the National Assembly, and the Select Committees of the National Council of Provinces. Both types of committees play a central role in encouraging public participation in parliamentary democracies. The post-1994 committees are different to the apartheid era ones in that committee meetings are now open to the public.

2.3.1 Portfolio Sub-Committee on Science and Technology

Every government department has a portfolio committee, composed of about 30 members of parliament. Different political parties are represented in proportion to the number of seats they occupy in the National Assembly. These committees are important for three reasons. Firstly, they monitor the executive, the departments, and related structures, including their performance in policy implementation and funding. They also investigate and make recommendations about possible changes to legislation, budget, structures, and functioning. Secondly, these structures are involved in policy formulation and in passing legislation in consultation with the public. Thirdly, they facilitate access to government by ensuring public participation in monitoring discussions and in debating draft legislation (debate bills and implementation issues through public hearings, public submissions, etc.).

The Portfolio Committee for DACST is a multi-party structure of 29 members of parliament, including representatives from the ANC (17), NP (10), IFP (6), FF (2), and DP (1). These members are organised into four sub-committees: Science and Technology; Arts; Culture and Heritage and Language (http://www.parliament.gov.za/committees/acst/sci&tech.htm).

According to the White Paper of S&T (1996: 22), the S&T portfolio sub-committee should be able "to place S&T issues within the context of the broader national debate and to pursue concerns of the public with respect to S&T". This committee consults with the wider public, with DACST and with other parliamentary groups on all issues related to S&T. Since its inception, the parliamentary portfolio sub-committee on S&T has debated key S&T projects as well as draft legislation about S&T. For example, the NACI Bill, the NRF Bill, and the Protection of Indigenous Knowledge Bill were passed back to parliament only after public hearings and debates had been facilitated by this sub-committee.

2.3.2 Select Committee on Education, Sports & Recreation, Arts, Culture, S&T

Associated with the National Council of Provinces are nine select committees, each dealing with a number of issues relating to several government departments. Science and technology is represented on the Select Committee on Education, Sport and Recreation, Arts, Culture Science and Technology. Committee members include the chairperson, secretary, researcher and representatives from: ANC (6), NP (5), DP (1), FF (1), IFP (1).

2.4 NATIONAL ADVISORY STRUCTURES

National advisory bodies consist of scientific experts and representatives of different interest groups, or stakeholder organisations, and function as intermediaries between the government and these groups. This section will describe two such advisory structures: the National Council on Innovation (NACI) and the Council for Higher Education (CHE).

2.4.1 The National Advisory Council on Innovation

NACI is a new policy advisory structure formed by an Act of Parliament (National Advisory Council on Innovation Act, Act 55 of 1997) to advise the minister, the

MCST and therefore cabinet, on the ways in which science, mathematics, innovation, technology (including indigenous technologies) may contribute towards achieving national objectives. (NACI, 1997) In other words, this advisory structure plays a role in identifying mechanisms for targeting S&T research and information relevant for socio-economic development. For example, NACI advises the MCST and the Minister on the division of the Science vote to Science Councils. It has also played a central role in the review process of publicly funded SETIs, from developing the initial framework to providing critical input on the completed reviews.

> The Science and Technology white paper underlines the importance of a statutory National Advisory Council on Innovation for independent and informed advice to the Government on the development and innovation of science, engineering and technology policy and the stimulation of innovation. The Council shall advise the Minister, and through the Minister, the Minister's Committee for Science and Technology and the cabinet on the role and contribution of science, engineering and technology promoting and achieving national objectives. *Mr. L. P. H Mtshali, 10 February 1997.*

The specific functions of NACI include: (DACST, 1996:20)

- Conducting "enquiries, studies and consultations" related to the national system of innovation, as requested by the minister
- Ensuring that its activities (including its terms of reference) are made public
- Commissioning activities (including policy research and proposals from line departments) to support its programme of work.

To fulfil the latter function, NACI is supported by a secretariat (provided by DACST) and a budget of R1 000 000. Chaired by the Director General of DACST, committee members (up to 22) are appointed by the Minister from different groups active in the national system of innovation. The sectors and institutions represented on the current committee are listed in Table 2.4.

Table 2.4: NACI Committee by Sector

Sector	Institutions represented on NACI
Higher Education Sector	UN, UCT, UP, UDW, Wits
Government departments	DACST, Dept. of Welfare, DTI, Dept. of Agriculture
Science councils & professional associations	MRC, SA Engineering Association, CSIR
Private sector	Plessey, Altron, Unifruco, SA Breweries, Chamber of Mines

Specific areas in which NACI advises DACST include: (Marais, 1999: 95)

- Co-ordination of the NSI, including stimulating co-operation within the NSI, e.g. HES and science councils; as well as the numerous other government departments involved with innovation (e.g. DTI, DoE, Health, etc.).
- Developing human resources for innovation.
- Co-ordinating S&T policy and strategies with those of other "environments".
- Focussing on the structure, governance and co-ordination of the S&T system.
- Identifying R&D priorities and link to funding.
- Funding of S&T.
- Establish, rationalise and manage science councils

2.4.2 The Council on Higher Education

The Council on Higher Education (CHE) was established in terms of the Higher Education Act, No. 101 of 1997, as an independent statutory advisory body (SA, 1997a; http://www.icon.co.za/~pasa/higher.htm). Following a public nomination process, the Minister appointed the members of the CHE in May 1998. According to the Act, the function of the CHE is primarily threefold, namely:

- To advise the Minister of Education on any aspect of higher education as requested by the Minister;
- To arrange and co-ordinate conferences and publish an annual report on the state of higher education;
- To promote and assure quality in higher education through its permanent committee, the Higher Education Quality Committee.

The Minister of Education is obliged to consider the advice of the CHE, and needs to provide reasons in writing if he or she does not accept their advice. The advice indicated here includes advice on all aspects of higher education policy, such as research, quality promotion and quality assurance, the structure of the higher education system, mechanisms for the allocation of public funds, etc. The CHE is financed through money appropriated by Parliament, donations and contract research.

According to the Higher Education Act, the CHE must appoint an independent assessment panel to undertake investigations into the affairs of higher education institutions where there is evidence of financial or other maladministration of a serious nature. In this regard, the CHE appointed a panel in 1998 to conduct investigations into the affairs of the Vaal Triangle Technikon and the University of Transkei (DoE, 1998:39). A major achievement thus far has been the establishment of the interim Higher Education Quality Committee involving all the key stakeholders.

The full council of the CHE meets at least every two months, though it may meet monthly if the need arises. The executive committee of the CHE meets monthly. Members of the CHE are also organized into a number of Task Teams and Task Groups responsible for the following current and intended projects:

- Quality assurance in higher education
- The shape and size of the higher education system
- Monitoring the achievements of policy goals and objectives
- A new funding framework for higher education
- A new academic policy for higher education
- Greater institutional responsiveness through enhanced higher education partnerships
- Language policy in higher education
- Private higher education in South Africa

At present the CHE full-time staff comprises an executive officer appointed on 1 June 1999 and a temporary administrator. A 'business plan' has been adopted and the CHE will be seeking to employ a number of personnel in late 1999 and early 2000. The permanent offices of the CHE are in Pretoria.

2.4.3 Other Advisory Bodies: Sectoral stakeholder bodies

Three sectoral stakeholder bodies operating at the interface of the macro, intermediate and performers levels assume both governance and advisory functions in the national S&T system. While not formal government advisory structures, they represent the interests of the Science Councils and the Higher Education sectors at a national level:

- Committee of Heads of Science Councils, CHSC
- South Africa University Vice-Chancellors' Association, SAUVCA
- Committee of Technikon Principals, CTP

The Committee of Heads of Science Councils (CHSC) represents the collective interests of the Science Councils at a national level, and plays a central role in the leadership of the National Science and Technology Forum (NSTF). While the first two structures (CHSC and SAUVCA) are represented on the NSTF, the latter two (SAUVCA and CTP) are represented on the Council for Higher Education (CHE).

The origins of SAUVCA lie in two racially/ethnically divided apartheid-era structures – the Committee of University Principals (CUP) and the Committee of Rectors (CUR) – which formally amalgamated in 1987 under the organisational structure of the CUP. SAUVCA is statutorily (Act 61 of 1955) known as the Committee of University Principals (CUP), and consists of the "CEOs" of all 21 universities in South Africa.

The statutory functions of the CUP include the following: (CUP, 1995: 46)

- To advise the Minister of Education on matters relating to universities
- To administer certain bursary funds and award bursaries
- To appoint or nominate people to statutory councils and committees on which universities are represented
- To formulate Joint Statutes and Joint Regulations pertaining to provisions regarding, for example, the transfer of students between universities, academic standards and the mutual recognition of credits, minimum period of study for a bachelor's degree, minimum requirements for registration for a university degree
- To advise the Joint Matriculation Board, a statutory subcommittee of the CUP

Changes in the self-image of the CUP – from a position of "spokesperson for the university system" in the pre-1994 period, to a position which recognises the roles of diverse interests groups in higher education (CUP, 1995: 49) – are reflected in current activities. Two good examples are the SAUVCA Publication Series (1997, 1998), offering a platform for debate about higher education policy issues, and the organisation of workshops and conferences on crucial policy issues (e.g. redress, women in the university sector, postgraduate training and research, evaluation of university research, research management, etc.). (Marais et al., 1998)

The Committee of Technikon Principals (CTP), a parallel structure to SAUVCA, represents the South African technikon sector. Since these organisations are both governance and advisory structures, their place in higher education governance remains ambiguous in the current restructuring environment. Following the replacement of the old Advisory Council of Universities and Technikons (AUT) by the CHE because, among other reasons, of the lack of wide representation in the former structure, recent proposals have suggested that the CUP and the CTP combine into one national Universities and Technikon Board. (EPU UWC, 1994: 2 – cited in Cooper, 1995) According to Cooper the advantages of a unitary board are three-fold: (Cooper, 1995)

(a) It would facilitate the unification of the higher education system by taking a first step in breaking down the current hierarchical structural arrangements and cultural stereotypes that place universities above technikons (this has significant implications for the status of the new BTech degrees offered at technikons)

(b) It would establish technikons as legitimate "polytechnic universities"

(c) Replication of the national council and board structures at provincial levels (i.e. by constituting provincial HE Councils and University & Technikon Boards) would facilitate wider local debate on policy issues. It would also facilitate stronger local articulation of educational initiatives (e.g. linking educational development with RDP goals, sharing laboratory, library and information technology resources, linking formal courses and programmes, student transfers, etc.)

2.5 CONCLUDING COMMENTS

This concludes our overview of the official structures and bodies that are directly involved in the governance and shaping of science nationally. Even this attempt to be as up to date as possible, will probably be dated when the report is published. The system evolves all the time; no steady state has been reached yet and will not do so for some time to come. However, the picture that has been sketched here, presents the broad contours of the governance structures that will ultimately make up the national system of innovation at the macro level.

Chapter 3

NATIONAL SCIENCE AND TECHNOLOGY POLICIES AND STRATEGIES

3.1 THE CHANGING MACRO POLICY CONTEXT: FROM RDP TO GEAR

This chapter discusses the relevant objectives and priorities of those national policies and strategies that need to be considered in the development of South Africa's Country Programme Framework. The changes in the arena of S&T policies are best understood against the background of the changes in macro-economic thinking within the country over the past five years. It is generally recognised that the government's thinking on macro-economic and social issues shifted from a strong commitment to reconstruction and development to a more global-market driven emphasis on economic growth and competitiveness. Before focusing on specific policies in the area of S&T and related fields, this shift will be discussed briefly.

THE RECONSTRUCTION AND DEVELOPMENT PROGRAMME

The White Paper on the Reconstruction and Development Programme (September 1994), outlined the government's policy on Reconstruction and Development. Reminiscent of Roosevelt's "New Deal", the Reconstruction and Development Programme, better known as the RDP, aimed to establish a coordinated and coherent socioeconomic policy framework that would lead to the large-scale transformation of South Africa. The success of the RDP depended on the Government's ability to implement six key principles. These were as follows (White Paper on the RDP, 1994):

- Firstly, an integrated and sustainable programme is required. The RDP incorporates diverse strategies to harness resources in a co-ordinated and meaningful way. These strategies would be implemented at all levels of government, parastatals, business and organisations within civil society.
- Secondly, the RDP should be a people-centred programme and thus focuses on addressing people's urgent needs. Apart from the responsibility of government, individuals irrespective of race, gender, class, are encouraged to play an active role in developing their own future.

- Thirdly, reconstruction and development are only possible in a society where there is peace and security. To this end, the government commits itself to establishing a security force and judicial system that mirrors the racial and gender character of the country. These forces should be impartial, professional, support the constitution and observe human rights.
- Fourthly, as peace and security become established, the government will undertake the task of nation building.
- Fifthly, nation building connects reconstruction and development. Integral to this connection is an infrastructural programme that will provide nation-wide access to essential services. At the same time this will stimulate economic growth and export capacity.
- Finally, the success of the previous five principles is dependent on an extensive democratisation of society. The RDP hopes to be instrumental in achieving democratisation as government institutions are restructured in line with these principles and adapt their goals and strategies accordingly.

In retrospect, it is clear that the RDP failed to deliver what it had promised. An example of this is the issue of housing. By the end of 1995, a total of only 12,000 RDP houses had been built, only 6% of the number the ANC had promised for each year. As a result of failures such as these, President Mandela announced on 28 March 1996, that he was closing the RDP office, reassigning the minister, and transferring the money back to the Treasury. According to the Economist this amounted to a “a big admission of failure” (Economist, 96/6/4).

This is not to say, however, that the sentiments expressed by the RDP are not still valid and important. Instead of functioning as a touchstone for, and vehicle of transformation, its value lies elsewhere – as an ideological and political stabilising agent.

<u>Ideological significance</u>: According to South African journalist and researcher Hein Marais (1997), the RDP is an expression of the political-historical continuity between the Freedom Charter and the reality of the ANC government. The fundamental assumptions underlying the RDP prevent it from being discarded completely, despite the criticism heaped upon it, even by certain leading ANC figures. Against the background of the national liberation

struggle, the RDP signifies continuity; within the transition, it is a symbol of unity. In fact, it is within the context of nation building that the RDP's real value is apparent. Here it plays a central role in which the principles of inclusion, conciliation and stability can be promoted in a practical way, reconciling conflicting interests in a unifying "national endeavour" (Marais, 1997). For example, the self-help activities of members of working class and the unbundling activities of corporations can both be viewed as expressions of "unity of purpose", of a new patriotism.

Socio-political significance: As Latin American countries have learnt, a social development programme cannot be latched onto (let alone integrated with) a macro-economic strategy distinguished by privatisation, deregulation, fiscal austerity, trade liberalisation and the predominance of the financial sector over production and commerce. Not only the RDP's Keynesian leanings, but also its very constitution and logic are overwritten by the macro-economic context which embraces a neo-liberal orthodoxy. Implementing such policies may well be "inevitable", as the protagonists insist, however, to expect the RDP, a programme of transformation, to survive in this context is unrealistic. According to Marais (1997:2), and as noted by Mexican sociologist Carlos Villa, "neo-liberalism considers the growth of poverty to be a pathology, not a consequence of the economic system." The result is that the government "isolates poverty from the process of capital accumulation and economic development, and reduces the solution to designing specific social policies". Marais (1997) points out that anyone who delves beneath the surface of official rhetoric will recognise the RDP in Villa's formulation. As a mélange of developmental activities, it now operates as a stabilising agent, which (at best) views poverty within an overall economic strategy that reproduces and reinforces social inequality.

GROWTH, EMPLOYMENT, AND REDISTRIBUTION STRATEGY

On 14 June 1996, the government published their policy document on Growth, Employment, and Redistribution Strategy (GEAR). In a forerunner to GEAR, President Mbeki referred to a "growth and development strategy" which he said, "was an elaboration of the RDP, not its substitute." Through GEAR, the government hopes to address the challenges of meeting basic needs, developing human resources, further the democratisation of South Africa, as well as implement the RDP in all its aspects. However, GEAR differs from the RDP in its clear commitment to a neo-liberal, macro-economic policy. Similar to World Bank strategies and Structural Adjustment Programmes (SAPs) adopted in other parts of Africa, GEAR proposes that the South African economy be transformed into a competitive, outward-directed economy.

The core components of GEAR are (Department of Finance, 1996):

- An increased commitment to budget reform to enhance the redistributive thrust of expenditure;
- An accelerated fiscal deficit reduction programme to restrain debt service obligations, counter inflation and release resources for investment;
- An exchange rate policy to ensure that the real effective rate remains fixed at a competitive level;
- A consistent monetary policy to preclude an upsurge in inflation;
- Further moves toward the progressive easing of exchange controls;
- A reduction in tariffs to contain input prices and effect industrial restructuring, partially offsetting exchange rate depreciation;
- Tax incentives to promote greater investment in projects that have a competitive and labour intensive focus.
- Accelerating the restructuring of state assets to maximise investment resources;
- An expansionary infrastructure programme to deal with service inadequacies and backlogs;
- An adequately structured flexibility within the collective bargaining system;
- A strengthened levy system to fund training on a scale in line with needs;
- Growth of trade and investment flows in Southern Africa;
- Renewed focus on the implementation of stable and coordinated policies.

In summary, GEAR stresses the importance of job formation and capacity building that would enable the economy to compete internationally. GEAR's projected growth by 2000 is 6%. This is to be accomplished by policies that includes deficit reduction to 3%, tariff reductions, public-sector "rightsizing," exchange control relaxation, privatisation, wage increases below productivity growth, and "greater sensitivity in wage determination to varying capital intensity, regional circumstances and firm size" (Economist, 1996).

Why did the ANC initiate this shift from RDP to GEAR? At the beginning of the 1990s, the World Bank approached the ANC, in what may be a unique approach to pre-selling structural adjustment. The Bank proposed that South Africa pursue the classic Newly Industrialising Country (NIC) model, and earmarked Malaysia as the country to emulate. It also proposed a social contract with big business, labour and government to prevent a wage push from selected groups of workers, similar to the system undertaken by countries such as Sweden, the Netherlands and Mexico.

During the course of talks with the ANC, the World Bank addressed critical concepts of the progressive movement, such as equity, participation and non-racialism. It included leftist intellectuals as co-authors of background papers. Policy makers began integrating World Bank policies with the RDP proposals proposed by the labour movement. Under World Bank scrutiny, strategic RDP areas were subjected to austerity measures. At the same time, the big conglomerates initiated scenario-planning projects to connect the status quo and a future ideal-type economy and recruited key ANC people with the aim of creating a "new deal" (Jauch, 1997). In government, Trevor Manual played an instrumental role in shifting the ANC towards market-friendly policies. Thus, simultaneous internal processes, initiated by the private sector in South Africa, strengthened the influence of external sources on ANC policy makers, resulting in the shift from the Keynesian, service-oriented RDP to the neo-liberal GEAR. The RDP regarded basic goods and services as entitlements, not commodities, while GEAR represents the conviction that there is no alternative to stable liberalisation. Thus, the adoption of GEAR prompted a shift in priority from job creation to reducing inflation and stimulating investment (Jauch, 1997).

We now turn to a discussion of S&T policy documents and other related policy documents, against the background of these macro-economic shifts.

3.2 S&T POLICY: FROM THE GREEN PAPER TO THE WHITE PAPER

The Green Paper, entitled 'Preparing for the 21st century', was primarily a discussion document aimed at stimulating public debate on how science and technology (S&T) could best be applied to national interests. It provided an overview of the potential role science and technology could play in a post-isolationist society, by reviewing the key issues relevant to South Africa and delineating its alternatives. Its objective was to lay the groundwork for the drafting of the White Paper -- a more refined and detailed document – that would eventually be employed to determine government policy. (Green Papers are not policy documents; South African Journal of Science, Jan96, Vol. 92 Issue 1, p2).

In fact, the policy framework of Science, Engineering and Technology (SET) as outlined by the Green Paper is in accord with the pillars of the RDP, that is, a commitment to raising the quality of life; greater development (especially for those on the periphery of society, for example, the poor and other disadvantaged groups); economic competitiveness and the urgent democratisation of society. The fundamental aim of the SET system as discussed in the Green Paper was to further the goals of the RDP. (Note that an important part of SET funding is contract revenue from the RDP programme. This will be considered separately since this is not part of the other sources of government financing of SET activities).

The strong correlation between R&D expenditure and economic development on the whole required attention, particularly since the Competitiveness Report indicated a steady decline in government R&D spending, from 1,04% of GDP in 1987, to 0,75% in 1993 and to 0,68% in 1995. In terms of global competitiveness, this R&D investment trend failed to inspire confidence in South Africa's future performance. The increasing globalisation of the world economy meant that technological innovation and support for South African enterprises needed to be promoted as an integral part of the government's goals of job creation and, at the same time, maintaining a competitive edge in global markets. Government, through GEAR, proposed to attain an annual growth rate of 6%. As South Africa is currently underinvesting in S&T and innovation, this target would require a larger than 6% per annum growth rate in the national investment in these activities, in order for the sectors earmarked for export growth to reach their targets.

The White Paper on Science and Technology announced that business would be the main thrust behind the economy. Government's role would be to provide leadership and the necessary impetus and support to enable the business sector to compete in other highly competitive markets. This, according to the White Paper*,* would result in a shared vision of South African innovation. Thus, public investment in R&D should be directed away from the support of government's own facilities towards more extensive support of R&D in the private sector.

In fact, the White Paper emphatically states that the National System of Innovation (NSI) must be cautiously integrated with other dominant policies of government, such as GEAR*.* Moreover, the White Paper states that SET in South Africa is specifically designed to facilitate the pillars of GEAR. This marks a distinct shift in the framework underlying SET policy in South Africa, between 1996 to 1997.

3.3 A NEW SCIENCE AND TECHNOLOGY POLICY

On 4 September 1996, the Minister of Arts, Culture, Science and Technology approved the *White Paper on Science and Technology* entitled *"Preparing for the 21st Century"*. This policy commits government to striving for excellence in the use of science and technology, in maintaining a cutting-edge global competitiveness and addressing the urgent needs of those South African citizens who are less able to assert themselves in the market.

However, there do appear to be some tensions between these three goals, *excellence, competitiveness,* and *addressing urgent needs*. Can one achieve a high level of excellence when the emphasis is on competitiveness? Trends from industry indicate that when a strong competitive goal exists, the emphasis usually falls on increased output which in turn leads to a *quantity versus quality* conflict. As a result excellence is sacrificed. Will the appropriate technology be in line with *addressing urgent needs*? When addressing *urgent needs,* will the technology be sustainable and practical or will it conflict with *technological excellence*? Will this technology be at a level understandable to the people at whom it is aimed? These questions need to be considered if the goals proposed by the White Paper are to be attained.

The framework for the new policy is that of a National System of Innovation (NSI). The Organisation for Economic Co-operation and Development (OECD) defines a national system of innovation as "a network of institutions in the public and private sectors whose activities and actions initiate, import, modify and diffuse new technologies" (Green Paper on Science and Technology, 1997:26). Another, richer definition is "a system of interacting private and public firms (either large or small), universities and government agencies aiming at the production of science and technology within national borders. Interaction among these units may be technical, commercial, legal, social and financial, inasmuch as the goal of the interaction is the development, protection, financing or regulation of new science and technology" (Green Paper on Science and Technology, 1997:26). In other words, the NSI is a means through which the country will seek to create, acquire, diffuse and put into practice new knowledge that will help the people to achieve their individual and collective goals.

The functions of the NSI are divided into two categories: Core Functions of Government, working with policy, resource and regulation and Implementation Functions that deal with financing and performance of SET activities, human resource development and capacity building, and infrastructure provision.
The goals that the White Paper set are the following:

- Promoting competitiveness and employment creation;
- Enhancing the quality of life;
- Developing human resources;
- Working towards environmental sustainability;
- Promoting an information society.

The White Paper was written in support of the international acknowledgement of the significant role that technical change plays in the promotion of economic growth and social development. Present understanding of this role has led governments around the world to invest in the promotion of technology diffusion to maintain a high average level of technical competence throughout an economy.

In a recent analysis of the concept of a "national system of innovation" and the way it was appropriated in South Africa, Dave Kaplan convincingly argues for the centrality of this notion in recent S&T policy debates in South Africa (Kaplan, 1999 forthcoming). He also shows how the NSI concept was introduced into the S&T Green Paper and in fact became the central organising concept in the S&T White Paper. He, however, ends his analysis on a cautionary note:

> *"The economics of technological change literature has established some general principles and concepts that have rpovided an overall framework for the development of S&T policy making in South Africa. The stress on institutinal reform and the importance of promoting interaction and collaboration between institutions, the centrality of diffusion and the concept of a National System of Innovation, have been particularly important. However, the translation of these general principles into concrete policies, has been far more problematic" (1999; forthcoming)*

Kaplan, of course, is right. The success of any new policy framework is dependent on whether it leads to concrete and effective practices. In the following Chapter we will focus recent initiatives in S&T which have their origin in the new policy paradigm. In the remainder of this Chapter we briefly discuss other policy changes that are to a greater or lesser extent related to S&T goals.

3.4 National Education Policy

<u>Education and training</u>

The White Paper on Education and Training of 1995 contends that the current deficiencies that exist in skills and competencies as indicated in the labour market, are a direct consequence of a segregated system of education and training. The outcome is the perpetuation of apartheid racial, ethnic and gender hierarchies in private, parastatal and public employment. This has also led to an imbalance in the composition of graduates produced by institutions of education and training. For example, the output of technikon graduates in South Africa is disproportionately low in comparison to the output of university graduates. In fact, the inherited systems were established in such a way so as to prevent blacks from pursuing academic scholarship at higher education institutions. The White Paper on Education and Training describes the fundamental goal of the national education and training policy as being essential "to enable all individuals to value, to have access to, and succeed in lifelong education and training of good quality. Educational and management processes must therefore put the learners first, recognising and building on their knowledge and experience, and responding to their needs. An integrated approach to education and training will increase access, mobility and quality in the national learning system."

In order to keep abreast of the continually expanding technological content of competitive modern economies, lifelong learning must be accepted as a norm. Policy and decision-makers in government, business and industry must build this into the ethos and practice of the nation. An integrated school curriculum should support the norms and values of a non-racial, non-sexist and democratic society. South Africa's school curricula, thus, also require a transformation from primarily content-driven syllabi towards a problem-solving approach. This new curriculum should highlight the artificiality of some of the distinctions between academic and vocational training. Some of the recent developments in education that have implications for science and technology development will now be discussed.

Compulsory Mathematics/Science at Pre-tertiary Level

The comments received in response to the Green Paper have indicated widespread support in favour of maintaining mathematics and science up to the exit level (currently Grade 9) of the compulsory phase of education and training. As a result, these subjects will then be required for the General Education Certificate of the new system proposed by the Department of Education. The implementation of this is, however, contingent on the availability of the necessary skilled educators and trainers in these disciplines.

Adult Basic Education and Training

In addition to changes at the school level, a far reaching and cost effective Adult Basic Education and Training (ABET) programme has been proposed to extend the skills and career prospects of workers and the unemployed. ABET hopes to redress discrimination and inequalities instituted by education under apartheid and to change the perception that education is only for the young people and children.

ABET is geared toward providing adults with education and training programmes on par with exit level in the formal school system, with an emphasis on literacy, numeracy and technological skills. The provision of ABET can be hastened and expanded by building partnerships between the state, employers, labour, communities, funders and non-government organisations (NGOs). This kind of collaboration would facilitate the establishment of a process for funding support of national ABET programmes in S&T, which could then be administered at provincial and local levels by relevant stakeholders. DACST, in consultation with SAQA, will be responsible for drawing up an adequate ABET curriculum and policy regarding S&T in education.

The future system must, therefore, provide for lifelong-learning opportunities to serve a diverse group of learners through readily accessible and affordable structures. Rigorous interventions in the area of ABET would contribute towards attaining the objective of a skilled workforce.

Technology Education

Based on the premise that technology education is essential to contemporary society, many First World and developing countries have introduced technology education into the school curriculum. Whether Technology is a discipline per se, whether it should be taught as part of science, or diffused across the curriculum, is a contentious issue. In several countries the implementation of Technology, as a subject, has been impaired by a dearth of resources and teachers, insufficient support, and confusion about its philosophical foundations. In 1996 a national Technology education pilot project was initiated in the general education phase of schools to evaluate the curriculum and implementation implications.

Given the outstanding level of support received in response to the Green Paper for introducing technology education across the general education system, DACST has undertaken to assist the Department of Education in developing a technology education programme for schools.

National Higher Education Policy

Many policy documents state that the key to sustainable technological capacity lies in a transformed, vibrant and effective educational system. This policy therefore has an important role to play in National System of Innovation.

The White Paper on Education and Training (1995) was followed in July 1997 by Cabinet approval of the White Paper on Education 3, dealing with "A Programme for the Transformation of Higher Education". This policy complements the Skills Development Strategy (introduced in 1997 - discussed below) and presents the vision of a transformed, democratic non-racial and non-sexist system of higher education. In order to achieve this vision, several major goals were set:

- Funding as a single co-ordinated system in line with the principles of equity and redress, democratisation, development, quality, effectiveness, efficiency, academic freedom, institutional autonomy and public accountability.
- Provision of advanced educational opportunities for an increasing population range, regardless of race, gender, age, creed or class.
- Diversification in terms of the mix of institutional missions.
- Improved quality of teaching and learning.
- To secure and advance high-level research capacity.
- Capacity building to facilitate a representative staff component.

It should be noted that the above goals are strongly complemented by all of the other policies summarised here.

3.5 Skills Development Strategy

In March 1997, Cabinet adopted the Skills Development Strategy for Economic and Employment Growth in South Africa. This strategy argues that skilled people are an essential component of any national economic and employment growth strategy, a strong link between learning and working being necessary for growth.

The poor human resource record of South Africa is detailed, as are the training, skills, management and inequity problems inherited from the apartheid system. Three main objectives were set towards achieving an education and training system that is flexible and responsive to the economic and social needs of the country, and a system that simultaneously stimulates the development of new skills These objectives are:

- To raise the level of skills that promote economic and employment growth and social development.
- To help workers achieve recognised qualifications together with increased independence and responsibility, and employers achieving higher productivity and competitiveness.

- To enable those most vulnerable in the labour market to enter and remain in self-employment, thereby improving their standard of living.

3.6 National Energy Policy

In June 1998 the Minister of Minerals and Energy released the Draft White Paper on the Energy Policy of South Africa. Whilst this is still a draft policy, it provides valuable guidance regarding the priorities relating to the energy sector. The draft White Paper lists five priority areas as the foundation for South Africa's energy policy. These are -

- To increase access to affordable energy services;
- To improve energy governance;
- To stimulate economic development;
- To manage energy related environmental impacts;
- To secure supply through diversity.

In the context of these priorities, the draft White Paper provides an overview of the nuclear energy sector and indicates that the future application of nuclear energy in South Africa will depend on the environmental and economic merits of all possible energy sources. In this regard the Paper is strongly supportive of a pragmatic environmental management position, the inclusion of all costs in decision making, and an integrated approach to national energy supply and demand decisions.

3.7 National Water Policy

In April 1997 Cabinet approved the White Paper on a National Water Policy for South Africa. This policy addresses the deficiencies and inequities in South Africa's historical water policies and water management practices. It further stresses the critical role that water plays in the sustainability of the South African economy, as well as the essential role it plays in the quality of life of all South Africans. The White Paper presents water as one of the most precious resources in South Africa, deserving of a high degree of attention in all facets of the economy and national policy. The objectives of water policy in South Africa are:

- Equity in access to water services.
- Equity in access to water resources.

- Equity in access to water resource use.
- Optimal use and protection of water resources.
- Optimum, long-term, environmentally sustainable social and economic benefits for society from the correct use of water resources.

National technology strategies need to facilitate the attainment of these objectives by the application of relevant and focused SET initiatives.

3.8 Environmental Management / Integrated Pollution Control Policies

In mid-1998 Cabinet approved both the White Paper on Environmental Management and the White Paper on Integrated Pollution Control and Waste Management. The fundamental goal of both of these policies is the ultimate achievement of sustainable development. The environmental management policy has several strategic goals that relate to improving the way in which environmental issues are managed. These include:

- International co-operation
- Holistic and integrated planning
- Participation and partnerships in environmental governance
- Sustainable resource use and utilisation.

The Integrated Pollution Control policy takes a holistic approach to waste management, based on the goal of attaining equal and sustainable access to natural resources, and mandates the reduction, reuse and recycling of waste in achieving this vision. (It is clear that the SET system has a role to play in achieving these environmental objectives – as emphasised by the inclusion of the concept of sustainability in the national Science and Technology policy.)

3.9 National Agricultural Policy

The Minister of Agriculture released the White Paper on Agriculture in 1995. A revision of this policy is currently under way and a Green Paper is due to be released shortly. The major thrust of current policy lies in the development of the agricultural sector to increase the competitiveness of existing large-scale farmers, whilst improving the quality of life of historically disadvantaged, resource-poor and subsistence farmers and to ensure equitable access to agricultural resources. The policy stresses the problems related to the availability and quality of water, natural disasters and droughts, as well as the need for the sustainable utilisation of natural resources. The need to integrate research activities into the total system is addressed, as is the need for technological developments to be transferred to farmers, in order to improve productivity and sustainability.

3.10 Concluding Comments: The Emergence of the Notion of an "African Renaissance".

In conclusion, it is worthwhile to draw attention to the emergence of the concept of an "African Renaissance" which has been receiving increasing attention in South Africa over the past number of years. The notion of an African Renaissance, which is strongly advocated by many senior members of government, including President Mbeki, contains the following ideas.

> *African Renaissance implies a rediscovery and a new understanding of a rich pre-colonial, colonial and postcolonial heritage and an appreciation of the value of indigenous knowledge. The exercising of the right to find African solutions for African problems, whilst developing a pride in African culture, presents enormous opportunities for South Africa in the context of its role on the African continent.*

The new emphasis on an African heritage and identity and the concomitant calls for a rebirth of locally developed knowledge and technologies amidst increasing globalisation worldwide should not be surprising. As Anthony Giddens and other have argued, one of the (unintended) consequences of increasing globalisation is in fact the resurgence of nationalist and regionalist sentiments. It is precisely when globalisation tends to equalise everything, bring all systems and practices under the umbrella of one (computerised) regime, that nations and communities reassert their uniqueness - local identities, cultures and value-systems.

It might seem strange to conclude a chapter on science and technology policies and strategies with a section on the African Renaissance. The discourse around its meaning has only begun. Already there are camps of advocates and supporters on the one hand; and critics and skeptics on the other. However, there are also clear signs that influential individuals and groupings within government, science institutions and civil society are promoting the idea. The idea is to cover all spheres of society, including the practices of science and technology.

In a recent publication (edited by William Makgoba, 1999) President of the Medical Research Council), a whole section is devoted to science and technology. In a chapter entitled "The renaissance through science and technology", Kgaphola and Magau (1999) argue that the fundamental challenge for Africa is to develop and cultivate a science and technology culture, starting at the basic levels of our education system. In this regard, the matter of language and instruction plays a strategic role in achieving a culture of science and technology. Science and technology discourse is not accessible to the majority of Africans because of language discrimination, that is because science and technology is not taught in the lingua franca of the masses but rather in a foreign vernacular. It should be pointed out that no other country has had to embark on a course of development based on a foreign language-"unless, of course there has been *a priori* total obliteration of native language(s) such that the foreign language is actually an everyday medium of the ordinary man and woman" (Kgaphola & Magau, (1999: 348).

According to Dr. Wally Serote, chairperson of the portfolio committee of DACST and one of the most prominent advocates of the idea of the African Renaissance, African languages should be adapted to the use of science and technology. He proposes that "uniquely African glossaries and dictionaries of science and technology terminology be developed; the teaching of science and mathematics at primary level in the native tongue; as well as publishing and distributing science and technology resources in the primary African language groups" (Serote, 1999).

Other writers writing on this matter, support sentiments such as the following:

- The African continent must be rescued from the ravages of war and be recovered for the purposes of social and economic transformation.

- Fundamental change of science and technology policy in Africa cannot occur in isolation, but only in union with the global, social and economic endeavours of a nation.
- The cultural and scientific African Renaissance will require creativity and innovation in finding African solutions and in avoiding the historical mistakes of developed nations. At a practical level, this means that the inclusion of indigenous knowledge systems, human resource development and capacity building are important contributions that the SET system can offer towards making this vision a reality.

This concludes our overview of the policy and values frameworks and discourses that have shaped, and will continue to shape, the direction in which science and technology will develop in South Africa in the near future. We have tried to show that the documents dedicated to the development of a S&T policy framework for South Africa (Green Paper, White Paper) are best understood, not only within larger S&T debates (locally and internationally) but also within a shifting macro-economic debate. In the same way, the S&T policy documents must be considered in relation to other policy initiatives that directly depend and have an impact on science and technology endeavours. Finally, we flagged another emerging discourse - the notion of an African Renaissance - that could influence future S&T policy discussions in interesting ways.

Chapter 4

SCIENCE AND TECHNOLOGY INITIATIVES

4.1 INTRODUCTION

During the last gasps of apartheid, the country's S&T system came increasingly under fire for its lack of an articulated vision. A national research strategy was practically non-existent, with state funding for research predominantly directed towards individual excellence rather than clear national objectives (Grobicki, 1992:173; IDRC, 1993:22). Soon after the establishment of DACST in 1994, a number of initiatives were launched to give new direction to the different role players in the national system of innovation. Examples are the National Research and Technology Audit and the system-wide review of public sector scientific institutions. The relatively short space of time within which these initiatives have been implemented indicates that the government is serious about the goals set in the White Paper on Science and Technology and especially about bringing S&T in line with nationals goals on reconstruction, development and competitiveness. Five particularly strategic initiatives have been selected for discussion here, which are also identified in the White Paper. Two other S&T initiatives, namely YEAST and the stimulation of international programmes through the funding of lead programmes, can be found in Sections 8.2 and 5.4.2 respectively.

4.2 THE NATIONAL RESEARCH AND TECHNOLOGY AUDIT

The National Research and Technology Audit (NRTA) was announced by DACST in late 1995 and is also referred to in the White Paper on S&T (DACST, 1996). In essence, the Audit can be described as a national stocktaking of the country's S&T capacity, its research and scholarship, and resources and broad outputs (Amuah, 1996:279). The main objectives of the audit were to assess the strengths and weaknesses of the South African S&T system, and to provide data and information as an input to policy making. It covered publicly funded S&T as well as the activities of the private sector (DACST, 1998f). Five surveys were commissioned as part of the Audit. These surveys, contracted out to separate consulting and research organisations under the management of the FRD, produced the following reports:

- Human resources in science, engineering and technology (DACST, 1998a)
- Research and training equipment (DACST, 1998b)
- Scholarship, research and development (DACST, 1998c)
- Scientific and technological infrastructure (DACST, 1998d)
- The technology base of the business sector (DACST, 1998g).

A synthesis report of the five surveys appeared towards the end of 1998 and is entitled *Technology and Knowledge* (DACST, 1998f). The overall assessment generated by the Audit describes the South African S&T system as well equipped with an infrastructure of institutions with good potential and a core of skilled and knowledgeable people. However, there are also some structural, organisational and societal weaknesses, as is evident from the main findings of the individual surveys below.

Human resources in science engineering and technology

It was found that if the present output trend in the higher education sector (HES) persists and the Integrated GEAR Strategy is pursued, a significant shortfall in engineering and related categories is expected, as well as in medical and management sciences, while art, sport and entertainment graduates will be in oversupply by a factor of more than 5. If much higher output in the scarce categories is to be achieved, a significant change in the numbers of learners receiving university exemptions in mathematics and science at matriculation level will be required.

An analysis of postgraduate trends revealed that the output of masters and doctoral graduates is relatively low in relation to the number of academic staff available to supervise them. Moreover, despite recent progress in the eradication of gender and racial imbalances in the SET field in general, the majority of SET human resources are still white males. The imbalance is even more prevalent among research scientists (DACST, 1998f).

Research and training equipment

South Africa has more than 2000 items of equipment valued at R1.8 billion. The cost of replacing and upgrading the existing infrastructure exceeds the capabilities of the individual players. More than R500 million is estimated to be required for replacements up to the year 2000 and an additional R250 million for immediate needs. Moreover, equipment policy and management in the country is far from best international practice, with the stakeholders aiming to address their problems individually (DACST, 1998f).

Scholarship, research and development

The HES spends the largest proportion (50%) of its direct R&D expenditure on basic research, and the larger part of this is devoted to strategic, rather than fundamental research. This means that fundamental research currently makes up less than 25% of all research within the HES and less than 5% of all R&D in the public sector. All performers in the public sector devote more than one third of their expenditure to applied research. There has been an overall increase, between 1993/4 and 1996/7, in R&D expenditure devoted to developmental, i.e. more mission-oriented, work.

More than 50% of public sector expenditure (business excluded) is directed at agriculture, mining and manufacturing. The results in relatively low spending in areas such as health, community services, housing and energy. Expenditure in the HES is more evenly spread with a greater emphasis on education and social services. However, high priority (GEAR) areas such as communication and information, and energy receive little attention.

Interdisciplinary collaboration is highest in the fields of agriculture, basic medical sciences and chemical sciences. It is lowest in the arts, humanities and economic sciences. Overall inter-institutional collaboration across sectors is only 21% (DACST, 1998f).

Scientific and technological infrastructure

S&T performers as a whole spend about R9.66 billion per annum. This excludes the contribution of the private sector. The majority was spent on education and training (66%) with only 16% being spent on R&D. This sector employs 70 000 people of which under 50% are classified as professional and technical staff. Of these latter 33 000 technical staff, 54% are employed by the higher education sector.

At a macro level, the South African S&T infrastructure does not compare favourably with international benchmarks. Key indicators here are:

- The estimated gross expenditure on R&D (including the business sector), as a percentage of gross domestic product, where South Africa's 0,9% is lower than that of technology leaders such as Korea, Japan and USA (who average 2,5%) and on a par with Hungary, Spain, Portugal, New Zealand, Chile and Brazil. South Africa's private sector, however, is a much more significant player than in these countries;

- The number of S&T staff per million of the population, is far below that of comparable countries;
- The country's low output per capita in S&T (DACST, 1998f).

Technology base of the business sector

South Africa's "R&D investment" to "sales turnover" ratio is less than 1/3 of the comparable USA benchmark indicator. The South African industry spends 90% of its R&D expenditure locally of which 80% is spent by companies themselves. R&D funding received from large companies is still heavily skewed. About one-third of the total amount is spent in the electrical and electronic industries.

The three main drivers of technology are funding, the availability of resources and R&D time. The shortage of skills was the most important issue affecting the business sector's ability to perform R&D. What was surprising is how rare it was to find either an R&D culture in a company, or any perception that the lack of appreciation for R&D was proving a barrier to investment.

However, in both large companies and SMMEs on average about 70% of respondents perceive government to be playing a minor or often no role in promoting R&D and technology investment. There are, however, high expectations that this situation should be reversed with clear direction and priorities being established, especially in sectors where South Africa is able to compete internationally (DACST, 1998f).

As stated, one of the primary objectives of the Audit was to identify the strengths and weaknesses of the South African S&T system. This is summarized as follows in the synthesis report (DACST, 1998f):

Strengths

- There is a well-developed infrastructure of institutions.
- The existing science councils and the HES have the potential to be strong participants in the national system of innovation.
- There is a core of skilled and knowledgeable people.

- There is capacity within the S&T sector to contribute successfully to national priorities.
- There are pockets of international achievement in S&T, which indicates the capability of the nation's human resources to achieve that level.
- There are examples of successful mission-orientated research and development programmes.
- The business sector is involved in technology uptake and application.
- There are examples of technology achievement in the process industries.

Weaknesses

- National demands and priorities do not lead the system enough.
- The relevance and purpose of the research is not always clear.
- There is a major mismatch between the needs of the economy and the human resource skills the system is producing.
- International and inter-institutional collaboration is lacking.
- The responsiveness of the system is low; there is a lack of information technology familiarity in the system.
- The system as a whole is not strategically managed.
- Specialised research equipment is ageing, particularly at the higher education institutions.
- The uptake of technology from local sources by the business sector appears to be weak.
- The system lacks packages of locally developed technology due to the high level of technology imports by local subsidiaries of international companies.
- The business sector generally employs informal technology management. Poor strategic management of technology is evident.
- The system as a whole is underfunded to ensure it is making the optimal contribution to the country's socio-economic growth.
- The system has to operate in a society that is not 'technologised'.
- In the past, 85% of the population was systematically excluded as a potential source of human resources, knowledge and expertise.

The Audit also compares these identified strengths and weaknesses to the characteristics of a functional national system of innovation. This is given in Table 4.1.

TABLE 4.1 - Strengths and weaknesses of the South African S&T system compared to the characteristics of a functional national system of innovation

	CHARACTERISTICS OF A FUNCTIONAL NATIONAL SYSTEM OF INNOVATION	SOUTH AFRICA'S STRENGTHS	SOUTH AFRICA'S WEAKNESSES
A	• Technology of local origin is embodied in packages, reflected in end-user groupings.		• The system lacks packages of locally developed technology due to the high level of technology imports by local subsidiaries of international companies.
B	• Innovation and technology projects are performed by transdisciplinary (often international) teams.		• International and inter-institutional collaboration is lacking.
C	• All the competencies of strategic technology management are developed and employed to manage the national system of innovation to achieve national objectives.	• There are examples of successful mission- orientated research and development programmes.	• The business sector generally employs informal technology management. Poor strategic management of technology is evident.
D	• The national system of innovation operates within a 'technologising' environment, which enables relevance to communities and develops international competitiveness.		• The system has to operate in a society that is not 'technologised'. • In the past, 85% of the population was systematically excluded as a potential source of human resources, knowledge and expertise.
E	• The system is outcome-oriented and outcome-driven. Outcomes are developed and agreed upon by appropriate stakeholder groups, ensuring long-term sustainability of the national system of innovation. Funding methods are outcome-based.	• There is a well-developed infrastructure of institutions. • The existing science councils and the HES have the potential to be strong participants in the national system of innovation. • There is a core of skilled and knowledgeable people.	• The responsiveness of the system is low; there is a lack of information technology familiarity in the system.

TABLE 4.1 (Continued)

	CHARACTERISTICS OF A FUNCTIONAL NATIONAL SYSTEM OF INNOVATION	SOUTH AFRICA'S STRENGTHS	SOUTH AFRICA'S WEAKNESSES
F	• The strong, self-reinforcing linkages among business, government development agencies and higher education institutions are enhanced through collaborative projects, sometimes sponsored by government.	• The business sector is involved in technology uptake and application (THRIP is an example).	• The uptake of technology from local sources by the business sector appears to be weak. • The system as a whole is underfunded to ensure it is making the optimal contribution to the country's socio-economic growth.
G	• The national system of innovation is managed as a system with strategic high-level objectives and performance measures based on national priorities aligned with the agendas of government departments.	• There is capacity within the S&T sector to contribute successfully to national priorities.	• National demands and priorities do not lead the system enough. • The system as a whole is not strategically managed.
H	• The national system of innovation facilitates the technological and sectoral specialisation needed to develop unique competencies and sustain specialised technology.	• There are pockets of international achievement in science and technology, which indicates the capability of the nation's human resources to achieve that level. • There are examples of technology achievement in the process industries.	• The relevance and purpose of the research is not always clear. • There is a major mismatch between the needs of the economy and the human resources the system is producing. • Specialised research equipment is ageing, particularly at the higher education institutions.

Source: DACST (1998f).

It is apparent from Table 4.1 that the structures and systems currently in place appear to contain most of the necessary elements for an effective national system of innovation. The challenge that remains is to ensure that these structures and systems will actually function to create a coherent interface between the national S&T system and the national system of innovation. Such coherence will have to be reflected in the outputs and outcomes related to the national macro-economic goals (DACST, 1998f). However, the comparison also reveals a lack of strengths in certain areas, as well as weaknesses impeding the system of innovation. To address these shortcomings, the Audit task team recommended that the following be afforded high priority:

- An inclusive policy apparatus to set the basic tone for the strategic planning and management of S&T;
- A coherent national human resources and skills development policy, with accompanying strategies;
- A programme to technologise the country;
- An enhanced information network to help South Africa become a knowledge society.

4.3 THE NATIONAL RESEARCH AND TECHNOLOGY FORESIGHT

In mid-1994, DACST announced its intention to carry out a National Research and Technology Foresight (NRTF) project. The decision was largely informed by foresight exercises in the United Kingdom, and entailed high-level discussions with the British minister of public service and science, Mr David Hunt, among others (Ngubane, 1996:10). The initial idea of a foresight exercise for South Africa, however, can be traced back to the IDRC commission report, where it received emphasis as a method for aligning the determination of scientific opportunities with societal needs (IDRC, 1993:65). Consequently, the National Science and Technology Forum (NSTF) was entrusted with the task of looking into the mechanisms and implications of foresight in South Africa, within the framework of the RDP.

> Research foresight, at its core, is a process-orientated tool ... It is a systematic process designed to look into the longer term future of science and technology with a view to identifying strategic research areas and emerging generic technologies, likely to yield the greatest economic and social benefits" (Clark & De Wet, 1995: 120).

Research foresight brings together key stakeholders in S&T, i.e. team building, which, in the South African context, is believed will counter previous system fragmentation and institutional isolation. The project started in 1995 with the selection of the foresight sectors. An inclusive participatory approach was followed. This involved a series of workshops countrywide, where participants representing the wider community and major stakeholders were asked to identify future S&T needs. Eventually, twelve sectors were selected, each with drivers towards social development, technological development and wealth creation. These are:

- Agriculture & agroprocessing
- Biodiversity
- Business & financial services
- Energy
- Environment
- Health
- Information & communication technologies
- Manufacturing & materials
- Mining & metallurgy
- Safety of citizens & society
- Tourism
- Youth

In addition, three "cross-cutters" have also been identified:

- Beneficiation
- Business development
- Education / HRD / skills development

Co-nomination was used to identify the necessary expertise for the sector working groups. The latter is a survey technique that draws upon input from the major stakeholders in S&T. In cases where the working groups lacked adequate representation, DACST directly appointed other individuals into the groups. Each group employed a variety of methods to conduct the foresight. These included strengths, weaknesses, opportunities and threats (SWOT) analysis, scenario analysis, and surveys of opinions on research and technology trends. Major social, technological, economic, ecological and political (STEEP) factors within the sectors were also identified. (http://www.dacst.gov.za/default_science_technology.htm).

The reports on the sectors are at present being finalised and expected somewhere towards the end of October 1999. Each sector report will contain, amongst other things:

- A prioritised list of research and technology topics;
- Long-term research and technology objectives, together with a strategy for achieving those objectives.

4.4 SYSTEM-WIDE REVIEW OF PUBLIC SECTOR SCIENCE, ENGINEERING AND TECHNOLOGY INSTITUTIONS

In 1997, the Minister's Committee on Science and Technology (MCST) mandated DACST to initiate and manage a series of twelve reviews of the governance and management structures of public science, engineering and technology institutions (SETI). Conducted by teams of local and international experts, the aim of the reviews was to establish how these institutions could be restructured in line with broad national goals. Ten of the reviews dealt with existing institutions. The remaining two dealt with national facilities (DACST, 1997j) and the "agency function" (i.e. the way in which government provides financing to the higher education sector for purposes of research, technological development and the training of human resources – DACST, 1997b). The ten existing institutions covered were:

- The Africa Institute of South Africa - AISA (DACST, 1997a)
- The Agricultural Research Council - ARC (DACST, 1997c)
- The Atomic Energy Corporation - AEC (DACST, 1997d)
- The Council for Geoscience - CGS (DACST, 1997e)
- The Council for Scientific and Industrial Research - CSIR (DACST, 1997f)
- The Human Sciences Research Council Education - HSRC (DACST, 1997g)
- The Medical Research Council - MRC (DACST, 1997h)
- The Mineral Technology Council - MINTEK (DACST, 1997i)
- The South African Bureau of Standards - SABS (DACST, 1997k)
- The South African Weather Bureau - SAWB (DACST, 1997l)

The individual reviews were conducted and reported on during 1997, and a synthesis report became available the following year (DACST, 1998e). The principal recommendations are built around nine generic issues, which are briefly highlighted below:

Independence and alignment, transparency and accountability

It is recommended that the government organise its in-house S&T activities within legal structures (e.g. Section 21 Company) that permit independence whilst also safeguarding the use of public resources. It is further the responsibility of the Boards of the SETI to strategically align their institutions' activities with the broad state priorities, as well as making all decisions taken public. Advisory panels should improve the transparency of the activities of the SETI.

Planning, monitoring and evaluation

The recommendations call for the introduction of key performance indicators as part of the internal reporting on and monitoring of the SETI. This should be complemented by external evaluations of appropriate clusters of SETI at regular intervals.

Funding levels and modalities

The government should try to maintain current levels of S&T expenditure while seeking to increase S&T expenditure in different economic sectors in line with international trends. The proportion of funding for SETI channelled through competitive mechanisms and programmes (e.g. THRIP, SPII and the IF) should also be increased. Moreover, an expansion and refinement of the classification of funding modalities used by government is recommended. Not all of the functions of the SETI should be eligible for government funded support. SETI that are closely linked with key economic sectors should be required to generate higher proportions of their income from external contracts.

Leadership and strategic management

In cases where SETI are facing substantial change, transformation teams should be established to assist with improving strategic management. Regular internal and external courses and training programmes are also recommended for SETI, in order to inculcate new research and management paradigms into their organisational cultures. For research intensive SETI, the ratio of researchers to support staff needs to be increased.

Transformation and human resources

It is imperative that a strategic approach to human resource management be implemented to ensure effective resource utilisation and relevance of human resources to business objectives and goals. This calls for a co-ordinated human resource development strategy among the SETI, with the focus on equity and redress. Programmes of co-operation with higher education institutions also need to be expanded to allow more women and black people into the field of S&T.

Interaction, integration and co-operation

Agency and competitive grant mechanisms are seen as effective vehicles to bring about greater interdisciplinarity and inter-sectoral co-operation. It is also regarded as a matter of urgency that the SETI, private business and higher education institutions be relinked. This should happen through (i) increased dialogue between DACST and DoE, (ii) increased support to existing interactive mechanisms, such as the IF and THRIP, and (iii) a series of alignment-achieving conversations among the three constituencies, with the NSTF acting as facilitator.

Commercialisation

It is recommended that public SETI develop a Code of Conduct that specifies their relationship with the private sector, primarily in respect of commercialisation policy, intellectual property rights, conditions of service provision, and service pricing policy. The government should develop appropriate incentives to encourage SETI to also meet the needs of poorly resourced customers.

Internationalisation and strategic alliances

Becoming internationally competitive is also highlighted in the report. The newly established NRF should create more opportunities for international links. In addition, the government should create an environment conducive to globalism, for instance, by developing appropriate taxation strategies to attract research-intensive industries to South Africa. The government should also promote priority setting and subsequent focusing of research in the SETI and higher education institutions in order to draw the best foreign researchers.

Restructuring

It is recommended that the Water Research Commission (WRC), National Institute for Virology (NIV), National Sea Fisheries Research Institute (NSFRI), Antarctic Research Programme (ARP), National Botanical Institute (NBI) and other relevant programmes and entities be formally recognised as public SETI. This primarily implies the application of effective co-ordination and co-operation, as well as monitoring, assessment and evaluation mechanisms. Moreover, the SAWB should become a statutory body. Drastic changes in the management, corporate strategy and structure of the following SETI are also required: the AISA, the ARC, the AEC, the HSRC, and the SABS. Finally, NACI should advise the government on its development of an overall strategy for the SETI.

Overall, the SETI reviews concluded that parts of the system were functioning extremely well – for example, some core competencies of the CSIR, MINTEK, CGS and the MRC were evaluated and acclaimed as world-class. In most of the other institutions the basic technical expertise was seen to be of a high standard. However, there were deficiencies of varying degrees of severity in respect of strategic vision, research management and equitable human resource development. To address these issues, DACST is working with the respective Boards and Line Departments to put turnaround programmes in place. This process has already been initiated. From a structural perspective, significant recommendations were made regarding the AEC, the SAWB and the AISA (DACST, 1999c:10).

4.5 INVESTIGATION INTO THE ROLE OF "NATIONAL SCIENCE JOURNALS" IN SOUTH AFRICA

In 1997 DACST initiated an investigation into the role of the so-called "national science journals" in the South African S&T system. The purpose of the investigation was to enable government to establish a number of high-quality scientific journals that would meet the needs of the South African S&T community in the best possible way (DACST, 1999). In particular, the study aimed to determine:

- The current situation of scientific journals in South Africa.
- Global and local trends to be taken into account in formulating publication strategies.
- Ways to improve the economy, effectiveness and efficiency with which government-funded journals can serve the S&T community.

The investigation was conducted during 1998, involving both a quantitative and a qualitative component. A draft report was produced early in 1999 (DACST, 1999). According to the report, the government supports scientific publishing in the country both directly and indirectly, and does so in a variety of ways:

- Through the publishing of the "national science journals" by the Bureau for Scientific Publications (BSP);

- Through DoE which provides a subsidy to higher education institutions for their research outputs;
- Through the social sciences division of the NRF (former CSD) which provides grants to newly established journals on an annual basis;
- Through the natural sciences division of the NRF (former FRD) which supports researchers who are rated favourably in terms of the number and quality of their publications;
- Through various other forms, such as DACST *ad hoc* grants-in-aid in support of journals, and the Department of Water Affairs and the Department of Sports and Recreation who each support a domain specific journal.

Since the BSP support system is regarded as central, the report gives detailed consideration to its role. The BSP is an administrative and financial division of SAFEST (see 2.2.3.2) and publishes 16 journals in the field of science, social sciences and the humanities. Since 1995, however, the BSP has been effectively underrepresented within the SAFEST council. Questions have also been raised about the viability of only certain journals being singled out for state support through the BSP system.

One conclusion resulting from the quantitative analysis is that journals supported through the BSP system are not necessarily the best in their field. These journals were compared to local journals indexed in the three indices of the Institute for Science Information (Science Citation Index, Social Science Citation Index and the Arts and Humanities Index). Indexing in the ISI indices is generally regarded as the best available criterion for evaluating the quality and international standing of journals. Only three out of the 21 journals (BSP and comparison group) considered in the natural sciences had impact factors above the international median. These are the *South African Journal of Science*, the *South African Medical Journal* and *Water SA*. None of these three journals are BSP journals. Furthermore, only one of the three social science journals in the ISI index is published by BSP. This shows the relative disadvantage of the "national science journals" to international and other locally produced science journals. Moreover, the comparison between the BSP supported journals and the local journals indexed by the ISI also revealed that the state supported journals suffered a disadvantage in terms of page charges, print runs and international contributions.

There are also other indicators of the relatively low profile of the national science journals, for instance:

- The BSP sponsored journal publications constitute a very small component of the total number of South African research publications;
- Scientists who are rated as A-scientists by the natural sciences division of the NRF (former FRD) do not, in the main, publish in the BSP sponsored journals;
- The BSP sponsored journals show small utilisation rates, as indicated by library surveys.

Some of the results that emerged from the qualitative analysis of journals are as follows:

- Most South African journals see themselves as locally directed, i.e., concerned with southern Africa;
- Reported journal costs varies to a large degree, ranging from R21 000 to R50 000;
- Very few journals have paid editors or paid assistants;
- Few journals used a blind review system;
- Very few BSP sponsored journals have monitoring and assessment systems.

Because only journals that for historical reasons were supported by the BSP are receiving continued support to the exclusion of other more prominent journals, it is recommended that the BSP system be phased out. This should be replaced by a comprehensive support system for scientific publishing that is linked to pre-determined performance indicators. In other words, candidate journals should submit applications to DACST, specifying their scientific, editorial and business plans. Moreover, it is recommended that DACST should:

- Establish a national information management system of scientific publishing in South Africa, containing the journal particulars, their sources of funding, impact factors, etc.;
- Enhance the development of expertise and infrastructure for internet journal publication;
- Facilitate the dissemination of scientific publishing policy.

4.6 TECHNOLOGY STATIONS PROGRAMME

The government has expressed a strong commitment towards strengthening the capacity and capability of the Small, Medium and Micro Enterprises (SMME) sector to contribute to higher economic growth rates. For small and medium enterprises to become more competitive and to carve out niche areas, access to technology and an innovative mindset are crucial. One of the concerns expressed in the White Paper on S&T was the poor capacity of SMME in technology assimilation. The government's efforts to promote a culture of R&D through other programmes such as the NIF will be bolstered if the market has the technically absorptive capacity for application of research results (DACST, 1999c:20).

DACST specifically has established a Technology Stations Programme (TSP) which involves a shared-use co-operative arrangement with technikons in terms of the technikon's facilities and for diffusion of technology through demonstration and other stimulation techniques. For management of the programme, a technology advisor works with the technikon on the shared-use aspects for the equipment and arrangements for students to acquire hands-on experience in the selected SMME sector.

The following technikons were selected in SMME sector specific areas:

- The Technikon Free State - metalworks/value-adding;
- Mangosuthu/North West - chemicals; and
- Technikon Pretoria in electronics.

German experience in technology transfer programmes was drawn on to refine the TSP concept and operational framework. It is anticipated that the German Economic Co-operative Development programme will be making technical assistance available during the life of the pilot TSPs (DACST, 1999c:20).

4.6 CONCLUSION

From the above initiatives, it is clear that the South African government, though the of DACST as the co-ordinating line department, has committed itself firmly to steering the S&T system into the next millennium. These are comprehensive and, potentially far-reaching, initiatives.

A question, however, has to be raised about the practicability and implementability of some of the recommendations. For instance, Marais (1999:82) is of opinion that some of the science councils would have to restructure drastically if the council-specific recommendations of the system-wide review are to be implemented. Many of the recommendations imply substantial increases in S&T investment by government at a time where there are many competing priorities (Braune, 1998:27). However, we have also seen that the annual budget and expenditure on S&T has increased significantly over the past five years (Chapter 2). Although it remains an open question whether all of the recommendations and proposals resulting from these S&T initiatives will eventually be carried through, it seems that there is sufficient understanding on the part of government of the strategic importance of right-sizing and focusing the national system of innovation.

Chapter 5

GOVERNMENT FUNDING OF SCIENCE

5.1 INTRODUCTION: A FUNDING FRAMEWORK

According to the recent Science, Engineering and Technology Institutions (SETI) System-wide review (DACST, 1998e), government spending on Science, Engineering and Technology (SET) occurs through a number of channels, including

- Parliamentary grants (including core and agency funds) to the statutory SETI (i.e. science councils);
- Line Ministry budgets for other SETI (e.g. for the National Botanical Institute);
- Special government programmes (such as SPII and THRIP);
- The research component of the funding formula for HEIs;
- Contracts from government departments;
- Parastatal research expenditure;
- To a limited extent, through dedicated levies (e.g. for funding of the Water Research Commission).

There is at present no overall co-ordinating mechanism within government for budgeting and fiscal allocation for the SET system as a whole. The relationship between government and statutory SETI has, up to now, been defined by the system of Framework Autonomy, adopted in 1987, which established *inter alia* a process for allocating state funding to SETI, and is referred to as the Science Vote. It provides for individual SETI budgets to be transferred via the budgets of appropriate line departments.

DACST co-ordinates the relative levels of funding for the SETI within the total Science Vote. It has recently rejected fixed base-line funding because the historically-based incremental approach does not accommodate a mechanism for evaluation and reprioritisation of State SET expenditures. Some of the current funding routes are being reviewed and the introduction of a multi-year expenditure framework, by the Departments of Finance and of State Expenditure is under discussion.

The Science Vote does not include the amount that is indirectly allocated to universities and technikons for research. This component - which is currently under review - has traditionally been calculated as constituting 15% of the total amount awarded to each university and technikon as part of their annual subsidy from the state. It is in fact a "blind" component in so far as no control has ever been exercised to establish if these institutions did, in fact, earmark or spend this component on research related activities. This component is part of the Education Vote and is discussed in a separate section at the end of the Chapter. The current method of financing will be replaced by a block-formula component with funding earmarked within a national planning and performance-monitoring framework. However, there are no indications of how this will be coordinated with planning, funding and performance monitoring in the rest of the NSI, or with government spending on statutory SETI.

In the latest round of allocations, SETI were guaranteed 80% of their prior year's allocation, but the remainder was allocated competitively – some getting more (e.g. MRC) and others getting less (e.g. ARC). Apart from the ARC (whose share of the science vote has fallen from 30 to 23%), the relative shares of other SETI have remained remarkably constant over the years with the CSIR getting about 25%, and the rest each getting between 4% and 8% of the vote. Most of the individual SETI reviews recommended continuation of current levels or, in a few cases, increases (particularly in the case of the MRC). The relative proportion of income for SETI from core parliamentary grants and contracts or sales to government and the private sector, varies considerably between SETI. The percentage of contract income varies from nearly 78% for SABS, to about 17% for the CGS.

DACST is introducing a new Finance and Reporting System (FRS) for the statutory SETI to ensure that core state funds will still be allocated to SETI in terms of their mandated core responsibilities and that much greater account will be taken of alignment with overall NSI goals and performance. According to the SETI review (DACST, 1998e), "the most profound shift in funding philosophy lies in acceptance of the view that funding sources will be multiple and that an increasing proportion will come from competitive sources such as contract income, or through the competitive grant mechanism of the newly introduced Innovation Fund, with an implied decline in the proportion of funding delivered via core grants". The new FRS also envisages a role for NACI in advising on relative allocations among SETI.

As observed above, there is no single integrated framework that summarises the various modes and mechanisms of funding that are operative in the public sphere in South Africa. The White Paper (DACST, 1996) sets it as an ideal that an integrated and comprehensive science budget will be put in place in the foreseeable future. At the moment, we have a situation where at least five modes or mechanisms of funding are utilised by government to support public research and development. The labels used below are ours and do not represent official nomenclature.

Five modes of funding:

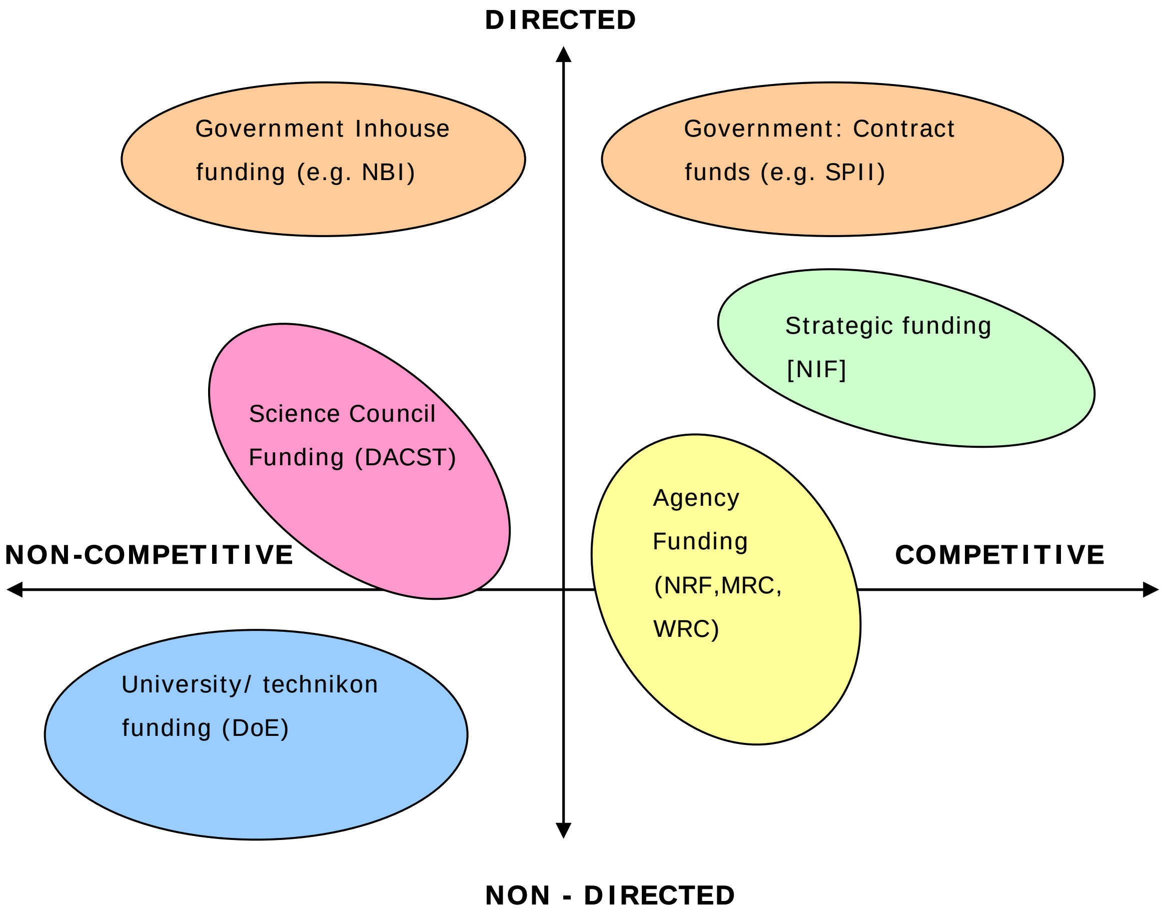
- Baseline or core funding of the science councils and national facilities
- Agency funding (NRF, MRC, ARC and WRC)
- Strategic funding (National Innovation Fund)
- Formula-based funding of universities and technikons.
- Contract funding

The seven science councils (excluding the NRF) receive so-called core funding (formerly known as baseline funding). These amounts are awarded in order to ensure that a core infrastructure (staff, equipment and other resources) is funded, to enable the science council to perform its research portfolio. As we have stated above, the core component is set to be reduced gradually, with a concomitant increase in the competitive component. Agency funding refers to monies that have been earmarked mainly to support research at universities and technikons on a competitive basis. We will use the term strategic funding to refer to the recently established National Innovation Fund as well as other strategic funding programmes administered by DACST. Formula-based funding is used by government to support research at universities and technikons. The current formula consists of two distinct components that relate to research: the estimated time spent on research (average of 15% of labour costs) and research output in SAPSE accredited journals. This formula is being revised at the moment. Finally, in addition to some in-house research, government also funds, on a contract or tender basis, a wide range of research, but particularly in the areas of policy research, evaluation research, surveys and so on.

We have attempted to incorporate these various funding modes into one framework using two dimensions:

- Competitive to non-competitive funding
- Directed (theme) to non-directed (self-initiated) funding

Figure 5.1: A schematic representation of government modes of funding



The implications of the two-dimensional representation in Figure 5.1 will be discussed under the heading of each mode of funding. Suffice it to say that it is evident from this representation - to the extent that it is an accurate picture of the funding modes in South Africa - that a wide range of mechanisms is used. This is due both to historical reasons (the long tradition of a relatively autonomous Higher Education Sector) and more recent policy decisions to create more co-ordination and integration in the national system of innovation (the establishment of the National Innovation Fund). It also reflects quite clearly that South African science and technology is, and has been, affected by international trends towards more strategic research, as well as trends related to increased shaping and steering of the national science system. This is reflected in the fact that, with the exception of higher education R&D, the four remaining modes of funding are closer to the DIRECTED pole of the vertical axis. Whether there is a shift, or an intention, on the part of government, to also move their funding more towards the COMPETITIVE pole on the horisontal axis, might become clearer in the near future. There are some signs that this is indeed happening.

Debates in the corridors of power reveal interesting differences of opinion on various aspects of the current situation.

- There is increasing unease within certain circles that the NRF will turn out to be less than effective. On the one hand, its mandate continues to be restricted by the absence of an agency component for the health sciences. The decision not to include the agency function of the Medical Research Council in the newly established NRF, is viewed by certain role players as a serious mistake which will, in the long run, seriously undermine the value and role of the NRF in the national system of innovation.

- There is growing concern within certain sectors, that the National Innovation Fund, which is growing fast, will overtake NRF funding and decrease the importance of the NRF within the overall system. There are also concerns voiced about the fact that the administration of the National Innovation Fund is too closely tied to a government department (DACST). It is argued that the NRF, as an intermediary and objective dispersing agency, is better placed and equipped to fulfill such a function.

- Finally, one could add one more criticism of current developments surrounding funding policies. National funding agencies have traditionally focused on supporting self-initiated and fundamental research. However, since the early eighties, a trend has developed whereby national agencies (e.g. the ESRC in the UK) started to support directed themes which were identified as being in the national interest. This practice is also evident in the NRF - both the former FRD and CSD have followed this model over the past five years. The inclusion of THRIP under the management of the FRD and now NRF, strengthens this point. We, therefore, currently have a situation whereby the NRF disburses a significant (perhaps even main) proportion of this funding to strategic rather than fundamental research. This is another reason to question the current division of labour between the NRF and National Innovation Fund. We would suggest that one of two courses of events is most likely to ensue: If the NRF continues on its current course of increasingly supporting strategic research, it will inevitably start to compete with the same pool of expertise in the system as the NIF. The alternative is that the NRF rethinks its philosophy and priorities on these matters, and creates a clear niche for itself in terms of supporting fundamental research and research capacity building. The latter course of action, of course, is more easier said than done, given the current regime within government of emphasizing strategic funding (and technology development).

5.2 FUNDING OF THE SCIENCE COUNCILS AND NATIONAL FACILITIES (CORE FUNDING)

The core fund refers to the special Parliamentary Grant through which the seven science councils (excluding the NRF) are funded by the state. Core funding follows the following guidelines: three-year budget cycles, a performance agreement with the responsible line ministries; three-year review processes and approval of core competencies (Marais, 1999: 86-87B) .

State funding for the science councils is co-ordinated by DACST, who table the annual budget at the National Advisory Council on Innovation (NACI). NACI, in turn, advises the Minister of Arts, Culture, Science and Technology on the final appropriation of the respective budgets. Once the budgets have been approved by Parliament, funds are channeled to the respective science councils through their respective line departments.

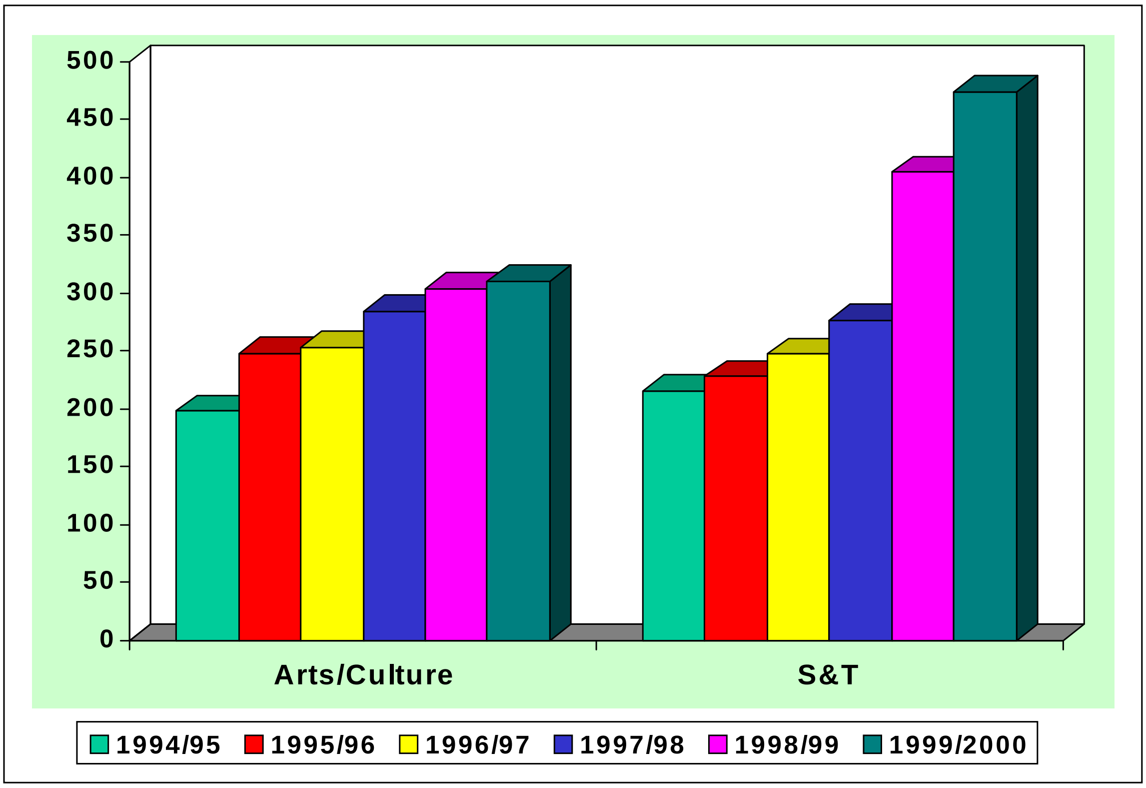
An overview of the most recent allocations to the science councils, with their respective line departments, is presented in Table 5.1 below. For the sake of completion, we have included the data for the NRF (although we have treated it under a separate heading) as well as the Africa Institute (which receives an annual amount through DACST).

Table 5.1: Overview of government funding of the science councils and national facilities (the past five years; R'000)

Department	Institution	1995/96	1996/97	1997/98	1998/99	1999/2000
AGRICULTURE	ARC	291.3	318.4	316.2	284.0	259.2
DACST	Africa Institute	2.9	2.9	3.1	3.2	5.3
	Human Sciences Research Council	84.9	87.6	89.7	93.2	64.4
	FRD	87.2	86.3	106.2	0.0	0.0
	National Research Foundation	0	0	0	145.9	183.6
	National Accelerator Centre	37.9	37.7	41.0	44.0	45.8
	SAAO	7.5	9.2	10.1	11.8	12.3
	HRAO	3.8	4.7	5.1	6.1	6.2
	JLB Smith Institute	0	0	0	2.5	2.7
DTI	CSIR	247.0	266.8	316.3	313.5	315.6
MINERALS & ENERGY	SABS	44.0	46.3	67.0	75.0	77.7
	MINTEK	62.8	73.0	82.9	83.1	81.7
HEALTH	GEO-SCIENCE	46.0	50.6	64.6	66.8	63.8
	MRC	50.1	57.9	66.2	76.4	79.6
TOTAL		**986.18**	**1061.98**	**1188.78**	**1225.68**	**1198.9**

One of the reasons why there has been a steady increase in agency funding in particular relates to the work of DACST. Figure 5.2 below summarises the trend in budget increase in the department since 1994/95.

Figure 5.2: Parliamentary allocations to Arts and Culture and Science and Technology (1994/5 - 1999/2000)



5.3 AGENCY FUNDING

In most developed countries, government chooses to charge a central agency or agencies with the responsibility of dispersing government funding earmarked to support research, more often than not, at institutions of higher learning. This function has been viewed as traditionally supporting basic or fundamental research at universities and technikons, although recent trends in many countries have shown increasing shifts towards support for strategic and applied research in these institutions.

Van der Meulen and Rip (1994) have convincingly shown that funding agencies (such as the NSF in the USA, the ESRC in the UK) play a crucial intermediary role within national systems of innovation. Although their primary function is to administer and channel government funding to higher education institutions, they also fulfil an important second role, viz. as a buffer between government and academic science. In this sense, they are required to serve the interests of the academic scientific community in the face of too much government steering or even intervention.

We have shown in Chapter 1 that national funding agencies have been a part of the South African S&T landscape since 1918. What is noticeable from this history, however, is the fact that these funding agencies (South African Council for Educational and Social Research [1934 - 1946]; National Council on Social Research [1946-1969]; Research Awards Council [1918 - 1938]) have been separated along disciplinary lines, both in the past and also more recently. In 1988 the Foundation for Research Development broke away from the CSIR and became the main funding agency for the natural and engineering sciences. Although not a statutory body, the Centre for Science Development in 1990 became a separate organisational unit within the Human Sciences Research Council with its own Board of Trustees.

It is precisely this kind of fragmentation that the IDRC report addressed in its assessment of the national system of innovation in 1993. It was, therefore, not surprising that the White Paper on Science and Technology foresaw the establishment of a new co-ordinate, national funding agency as part of the new S&T system. Part of this ideal became reality on the 1st of April 1999 with the establishment of the National Research Foundation.

Although a significant development, it is also true that there remain a number of science councils - most notably the Medical Research Council and - to a lesser extent - the Agricultural Research Council - who continue to perform an agency function for their respective domains. In addition to discussing these agency functions briefly, we also include a discussion on the Water Research Commission, which acts as an agent for government funding for water related research. Although its manner of funding is different from the science councils, the end result is not dissimilar to that of the science councils and the NRF.

5.3.1 The National Research Foundation

The National Research Foundation was created by an Act of Parliament (National Research Foundation Act, Act 23 of 1998), and formally constituted as a science council on the 1st of April 1999. It is distinct from other science councils in that it does not perform research, but acts as the main government agency for financing research at the performance level. This is how DACST describes the role of the NRF:

> The NRF will provide a vital structure in the institutional base for S&T in South Africa to sustain the provision of qualified scientists, engineers and technologists. It will be the task of the NRF to ensure a steady flow of qualified scientists and technologists, and in so doing to strengthen the capacity of the South African National System of Innovation to create new knowledge and to convert this knowledge into real socio-economic benefits for society (DACST 1998h:9).

The new research foundation might be viewed as a single-agency funding instrument, mandated to support through funding, research and research capacity building of research institutions, especially in the HE sector. The establishment of the NRF is intended firstly, to integrate the systems of funding research in all fields: natural sciences and engineering, agricultural and environmental sciences, social sciences and the humanities, health sciences and the national facilities. Secondly, it aims to support multidisciplinary and transdisciplinary research where problem solving is not confined within disciplinary boundaries. (CSD Homepage) The NRF Act (1998) defines the role of the NRF thus:

- To set priorities, evaluate needs and allocate research funds
- To emphasise development of human resources and research capacity in all fields
- To facilitate national and international collaboration, and multidisciplinary and cross-disciplinary project funding, allowing for the integration of work in different fields
- To maintain an information infrastructure (e.g. national registry of research)
- To administer the national research facilities, etc.

The NRF has implemented interesting changes since its inception. For example, national funding agencies have traditionally viewed the natural sciences and the humanities as separate and distinct areas of science. This dichotomous lens is structurally represented in the historical division between the former Foundation for Research (FRD) and the Centre for Science Development (CSD) of the Human Sciences Research Council. The NRF, on the other hand, has actively integrated the functions, programmes and staff of the former FRD and the CSD. Other changes include an emphasis on strategic research, an increase in priority-driven steering of funds, capacity building with excellence, joint funding, strategies to increase the pool of potential fund applicants (e.g. science councils, civil society organisations) (Marais, 1999:100-101).

Lionel Mtshali, former Minister of Arts, Culture, Science and Technology states that, in prioritising these areas, the NRF "gives recognition to the modern trend where the application of science to find solutions to real life problems increasingly tend to come from various areas." (cited in Monday Paper, Vol. 17 No. 15. June 1-8, 1998.) Lickendorf (1999: 6) suggests that we view the NRF as a local manifestation of several international trends in science policy practices; viz. the separation of agency and performance functions; support for large multidisciplinary programmes; a focus on social relevance; and the creation of industrial links.

The NRF is organised into four divisions, plus one aimed at supporting the four national research facilities:

- Natural science and engineering
- Social sciences and humanities
- Health sciences
- Agricultural and environmental sciences
- Support for the four national facilities (SAAO, HartRAO, NAC and the JLB Smith Institute of Ichthyology).

The Minister for Arts, Culture, Science and Technology appoints its board members (institutional affiliations are depicted in Table 5.2). The NRF has the following structure: (DACST, 1996:27)

- A chief executive officer (President) appointed by the Board of the NRF;
- A senior management team of five people (the Heads of each of the four divisions plus the Head of Interdisciplinary Grant Funding);
- A Board composed of the Chairperson, four members – one from each division, plus a further three members (all appointed by the Minister), and the President (appointed by Board members).

Table 5.2: Institutional representation of NRF Board Members

Sector	Institutions represented on the NRF
HE Sector	DPRU, Pen Tech, UDW, UN, Uno, UOFS, UZ, UCT, Wits.
Government	Depts of Agriculture, Land & Environment
Private Sector	Sentrachem, Mmakau Mining

Source: Marais (1999:100)

5.3.1.1 PROGRAMME AREAS

The programme areas described below provide support for basic, applied and strategic research. They also focus on enhancing national research capacity by actively supporting students at masters and doctoral levels in all fields of study (http://www.nrf.ac.za).

- *Open Research Programme* (ORP): This programme supports high quality, cutting-edge basic research and supports the research and training of researchers with the potential to contribute to the competitiveness and technological advancement of industry. In so doing, this programme facilitates inter- multi- and trans-disciplinary research through collaborative initiatives within and among HE institutions, industry, government and parastatal institutions. It also facilitates the education and training of postgraduate students, and the participation of historically excluded South Africans.

- *Directed Themes:* A second set of programmes is directed at developing institutional research cultures at HBUs and Technikons. Many integrate the "directed themes" programmes of the former FRD and the "research capacity development themes" of the former CSD. In the case of the HBUs, the NRF supports programmes "based on identified research thrusts within the natural sciences and engineering that each HBU seeks to establish and develop into centres of excellence." (www.nrf.ac.za) Research proposals typically include plans for corrective action, competitive research, and industry/academia collaboration. Research thrusts are linked to the directed themes of the former FRD.

- *SET Education and Awareness Theme*: Promotes programmes to increase public awareness of science, engineering and technology (e.g. PUSET), and programmes for staff development, innovation and change in education.

- *Competitive Industry Theme*: Supports universities and technikons in developing the expertise required for South African industry. It covers the following areas: primary resource beneficiation, manufacturing advancement, and information and infrastructure systems.

- *Improved Quality of Life Theme*: Links SET research aimed at positively transforming the quality of living conditions in historically poor communities through two programmes: a) Food Production and Food Security Programme, and b) Rural and Urban Development Programme. These are often trans-institutional and multidisciplinary programmes aimed at job creation and infrastructure development in priority areas (e.g. housing, energy provision, water, transport, pollution management, etc.)

- *Sustainable Environment Theme*: Focuses on projects seeking to balance socio-economic and industrial development with environmental conservation. Examples of research areas pertaining to this theme include inland resources, marine and coastal resources, Africa-tourism, weather and climate.

Outputs at the end of each 5-year funding cycle include, firstly, well-established thrusts that can act as nuclei for centres of excellence in SET research. Secondly, there should be a marked increase in the number of staff with PhDs, in the number of rated staff members, and in the number of women and black people employed in SET fields. Thirdly, programmes should involve partnerships with industry and other research centres.

Similarly, parallel multidisciplinary programmes to develop research cultures at technikons combine the “Technikon Programmes” of the former FRD with the “Technikon Research Development Programme” of the former CSD.

Finally, the NRF supports staff development programmes, and provides access to on-line research information systems; viz. the Nexus Database System and the SA Data Archive. It allocates research funds in the form of bursaries, scholarships, research equipment, postdoctoral fellowships and grant-holder bursaries in both of the above programme areas - the Open Research Programme and the Directed Themes. A portion of all grants to researchers is earmarked for student support, and many programmes rely on supplementary support from THRIP funds (discussed in the next section) for industrial partnerships, capacity building, industrialisation and support for community-based entrepreneurs. Table 5.3 provides a breakdown of the 1999/2000 Science Vote allocation to the NRF.

Table 5.3: NRF Science Vote Allocation for 1999/2000

Budget Item		Amount (Rm)
Research Support Division of the FRD (total)		129, 0
Distribution by Programme Areas		
Open Research Programme	22,1	
Competitive Industry	19,8	
Historically Black Universities	16,2	
Improved Quality of Life	12,6	
Sustainable Environment	12,4	
Technikons	10,8	
Effective SET Education	3,4	
National Facilities*		67, 0
The HSRC's Centre for Science Development (CSD)		32, 3
South African Large Telescope (SALT)		10, 0
Science &Technology Agreements Committee (STAC)		9, 0
NRF Transition		2, 6
TOTAL		250, 6

* Table 5.1 provides a breakdown of this amount to the National Facilities.

Sources: (1) *FRD News*. Feb/March 1999: 1. (2) NSTF. *News and Stuff*. 2nd Quarter 1999:7.

5.3.1.2 TECHNOLOGY AND HUMAN RESOURCES FOR INDUSTRY PROGRAMME

The Technology and Human Resources for Industry Programme (THRIP), established in 1991, is a joint venture between industry, research and educational institutions and government (DACST and DTI). The programme supports the development of technology and appropriately skilled people for industry to improve South Africa's global competitiveness. THRIP performs this task by providing resources and mechanisms in support of collaborative research in the areas of science, engineering and technology (SET). The objectives of THRIP are:

- To contribute to the increase in the number and quality of people with appropriate technological skills for industry;
- To promote increased interaction among, and financial support to researchers and technology managers in industry, higher education and science, engineering and technology Institutes (SETI), with the aim of developing skills for the commercial exploitation of SET; and
- To stimulate industry to increase its investment in research, technology development and innovation promotion.

In promoting the objectives of THRIP (co-operation between HE and business and enhancing industrial competitiveness) the following thrusts receive high priority:

- The support programmes aimed at increasing the number of black and female graduates following technological and engineering careers;
- The promotion of technological know-how within the small, medium and micro enterprise (SMME) sector;
- The facilitation and support of multi-company projects in which companies collaborate, and share in the project outcomes.

THRIP funds were first allocated during 1994. The three tables on the next page are reproduced from the 1997 THRIP Evaluation Report (THRIP, 1997). They provide breakdowns of these funds by sponsor (Table 5.4), by allocation to institutions (Table 5.5), and by institutional shares in THRIP funding (Table 5.6). Table 5.4 clearly represents THRIP as one of the largest growing initiatives based on the cluster approach to development. The DTI sees THRIP as a major player in increasing the competitiveness of South industry because it supports projects geared at strengthening the industrial base (e.g. supporting export in the manufacturing sector by improving the competitiveness of the SA industrial sector). New categories in the THRIP support portfolio include matching foreign investments in research and supporting the development of intellectual property rights, projects with science councils, and the mobility of people among organisations involved in projects.

To illustrate how THRIP funds currently work (in 1999), consider projects at HBUs and technikons, where THRIP contributes R1 for every R2 invested by the private sector according to four criteria:

- Research is of a high standard
- The project has clearly defined outputs
- At least one HE institution and one industrial partner is involved
- At least one student must be trained through research per R150 000 of THRIP investment

The THRIP share of funding increases to a one-to-one basis (i.e. R1 for every R1 of private sector funding) for projects involving at least five students (with at least 50% classified black and/or female), one or more SMMEs, or involving more than one industrial partner. The rationale for the recent changes in prioritising historically black institutions and black and women students are evident in Tables 5.5 and 5.6 which show the allocation of THRIP funds by institution. The tables clearly depict the concentration of funds at historically white universities, and the marginalisation of HBIs, during the early years of funding. As Table 5.6 shows, four universities: University of Stellenbosch, UCT, Wits and Potchefstroom received over 70% of the total amount of THRIP funds.

The 1997 THRIP Evaluation Report concluded from these figures that THRIP had "not significantly widened participation to include technikons, historically black universities and black students; or involved SMMEs in the programme to any great extent." (1997: 2) Note that HDIs first participated in THRIP during 1996. The report recommends that the programme be marketed more vigorously to these sectors, be expanded to access funding from other government departments in addition to the DTI, and include small and emerging industrial partners. No breakdown of project participants by race and gender (simultaneously) is available.

Table 5.4: THRIP allocations by Sponsor (R'000s)

	1994	1995	1996	1997	1998
DTI	2 978	5 598	24 086	46 872	71 226
Industry	6 049	10 862	34 223	65 290	87 051
Total	9 027	16 460	58 309	112 162	158 359

<u>Sources:</u>
For 1994, 1995, 1996 - THRIP Evaluation Report (1997: 16)
For 1998 DTI and Total - FRD News (April/June 1998: 1)

Table 5.5: THRIP allocations by Institution (R'000s)

	1994	1995	1996	1997	1998
SETI	0.0	0.0	0.0	0.31	5.6
Technikons	0.285	0.21	0.52	2.84	5.70
HWUs	2.693	5.38	23.37	41.51	53.60
HBUs	0.0	0.0	0.19	2.21	6.10
Total	2.978	5.59	24.08	46.87	71

<u>Sources:</u>
For 1994, 1995, 1996 - THRIP Evaluation Report (1997: 17)
For 1998 Total - FRD News (April/June 1998: 1)

Table 5.6: Institutional shares in THRIP Funding (%)

	1994	1995	1996	1997	1998
U Stell	8.7	6.6	33.5	17.7	18.9
UCT	26.4	26.4	21.5	18.2	16.1
Wits	27.8	20.3	7.4	7.0	6.3
PU for CHE	5.5	13.4	9.8	9.7	6.5
UP	9.1	8.6	6.6	18.8	15.6
U Natal	9.8	6.3	7.1	5.6	4.9
UOFS	0.0	6.5	6.1	6.0	1.3
RAU	2.1	3.7	2.8	0.9	2.4
UPE	1.2	1.8	1.5	0.5	0.8
Rhodes	0.0	2.4	0.9	2.7	2.6
Cape Tech	1.7	2.4	0.5	0.3	0.7
Tech FState	0.0	0.7	0.8	1.6	1.8
PenTech	5.8	0.0	0.0	1.6	1.2
Tech Pret	2.0	0.4	0.3	1.0	2.0
U Zululand	0.0	0.0	0.4	0.7	0.9
UDW	0.0	0.0	0.2	1.3	0.4
Tech PE	0.0	0.0	0.2	0.4	0.5
Tech N Gaut	0.0	0.0	0.1	0.1	0.4
UWC	0.0	0.0	0.1	2.3	2.3
Tech Mang	0.0	0.0	0.0	0.1	0.0

<u>Sources:</u>
For 1994, 1995, 1996 - THRIP Evaluation Report (1997: 19)

5.3.2 Medical Research Council

The MRC's research output is effected mainly by research undertakings that are managed jointly with universities and other institutions where a core of academic personnel and a physical infrastructure already exist. The research in this category is accommodated in the following four structures (www.mrc.ac.za):

Research Units and Centres

A Unit or Centre is created at a university or similar institution under the leadership of a Director, who must enjoy national and international recognition. A well-qualified and productive research team and the necessary laboratory and clinical facilities must already exist. It must be important for medical science in general and the needs of the country that the research be continued on a more permanent basis. The initial period is 5 years - can be extended after re-evaluation for a further 5 years. At the end of the second term the Unit/Centre will be closed and an application for its further existence will have to compete with applications for new units.

Research Groups

A research Group is established around an excellent leader who at least has the potential for developing an international reputation. It is subject to a 3-yearly review with a lifespan of 5 - 10 years dependent upon performance. A research Group can have a broader area of focus than the Unit structure and can consist of a network of researchers in different centres around the country engaged in a similar endeavour.

Self-initiated research

Grants for self-initiated research projects are awarded annually to over 300 individual scientists at academic institutions who conduct research on a wide range of health-related problems. The proposed research programme and budget must be for a period of 3 years or the time required for completion of the study where the expected time of completion is less than 3 years. Grants are only be made for 1 year at a time.

Some of the other funding categories that are supported by the MRC are:

- Local scientific meetings
- International scientific meetings
- Research abroad during sabbatical leave

- Established researchers may apply for financial support to undertake research at approved institutions abroad during their sabbatical leave.
- Scientists from abroad visiting South Africa
- MRC-approved scientific societies
- Distinguished visiting scientists
- Masters and doctoral scholarships
- Group Development Grants for HDIs

All applications for funding are administered by the Office for Research Grants Administration (ORGA). In 1998 the ORGA processed 300 progress reports and 150 new project proposals through the peer review systems of the thrust process. ORGA also managed the expansion in MRC units, processing 13 applications for new units resulting in 7 new units - bringing the total to 22 within the universities and community. ORGA also processed 128 self-initiated research applications (RFAs), of which 95 were granted. The office also had a contract for processing Cancer Association of South Africa (CANSA) research applications, of which 105 were processed this year. There were also 110 applications for Local Postgraduate Scholarships, of which 47 were granted, 80% of these to black candidates. A detailed breakdown of MRC funding to universities and technikons are summarised in Table 5.7 below.

Table 5.7: MRC funding 1998 and 1999

FUNDING CATEGORY	1998	1999[1]
Units/Groups/Centres	9 869 285	10 379 794
Self-initiated Research Grants	3 388 900	3 327 000
Bursaries	1 770 000	2 366 725
Travel Grants	115 445	43 158[2]
Visiting scientists	141 500	108 730
Capacity Development Programme	843 580	170 000[3]
TOTAL	16 128 710	16 395 407

[1] Data provided by Dr. J. Louw, MRC. Data for 1999 are not in all respects complete.

[2] Until 31st of October 1999

[3] Until 31st of October 1999

5.3.3 Water Research Commission

The Water Research Commission was established in terms of the Water Research Act in 1971 (Act 34 of 1971) and began operating on 1 September 1971. The WRCs terms of reference are basically to promote coordination, communication and cooperation in the field of water research; to establish water research needs and priorities; to fund research on a priority basis; and to promote the effective transfer of information and technology.

The Water Research Act provides for the establishment of a Water Research Fund which derives income from levies on water consumption. The funds are collected for the WRC by the Department of Water Affairs and Forestry, on a commission basis. Therefore, the Water Research Commission endeavours to:

- Promote co-ordination, communication and cooperation in the field of water research
- Establish water research needs and priorities
- Fund water research on a priority basis
- Promote effective transfer of information and technology

In terms of the Water Research Act, the WRC can conduct its own research. However, in accordance with an early policy decision, the WRC does not undertake in-house research, but funds research under contract with other agencies. There are three specific advantages to this policy:

- Expensive research facilities need not be duplicated.
- The WRC will have no vested interests in establishing research needs and priorities and in funding research.
- The WRC can maintain complete objectivity in the coordination and funding of water research.

In view of the broad scope of water research, a large number of bodies are involved in WRC research contracts. They are drawn from the following categories: Universities; technikons; statutory research agencies; government departments; local authorities; NGOs; water boards; consultants; and industry.

Co-ordination is pursued along various routes:

- *Research Coordinating Committees* (RCCs), each of which addresses a specific field of research, and is representative of the relevant research and stakeholder communities. RCCs develop strategic research plans based on needs and priorities, evaluate progress made, and formulate proposals for further research and for technology transfer.
- *Steering Committees* are established for research projects (with representation by specialists and interested organisations) and *ipso facto*, play an important coordinating role.
- *Information and technology transfer initiatives*, due to their essential communication dimensions, also contribute significantly towards effective coordination.
- *Networking*. It is foreseen that networking, *inter alia* making use of the Internet will undoubtedly become a powerful tool to promote coordination, and the WRC is committed to developing this strategy.

The WRC follows a system whereby research applications are received and considered once a year, according to a fixed timetable. Guidance is provided to researchers in formulating their research proposals by publishing the strategic research plans (incorporating research needs and priorities) as they emanate from the activities of the various Research Coordinating Committees. Final selection is done in-house, but might be preceded by soliciting advice from the Research Coordinating Committees or other groupings.

It should be clear from the above that the WRC acts - for all practical purposes - as an agency to promote and fund water research in South Africa. It has an established tradition of funding and is widely regarded as an effective mechanism for dispersing funds in this area effectively and objectively.

<u>Fields covered by the funding of the WRC</u>

- Agricultural water
- Developing communities' supply/sanitation
- Aquatic ecology/toxicology
- Ecosystem conservation
- Forest hydrology
- Groundwater & Geo-hydrology
- Membrane technology
- Municipal wastewater
- Potable water
- Soils & Sediments
- Surface hydrology

- Hydraulics
- Hydro-climatology
- Industrial water
- Information technology
- Integrated water resources
- Urban/peri-urban water supply
- Waste management
- Water policy
- Water quality

Table 5.8: Involvement of various sectors in WRC funding

Research Sector	Number of times involved	%
Universities	124	52.99
Consultants	46	19.66
CSIR	38	16.24
Other	10	4.27
Water boards	9	3.85
Government departments	6	2.56
Local authorities	1	0.43
Total	234	100

From the table above it is evident that universities are involved in 52,99% of the total number of contracts. The number of times that organisations are involved, namely 234, exceeds the number of projects supported because, in some cases, more than one organisation is involved in the execution of a project. In 1997 the WRC financially supported 32 projects at the budgeted amount of R40 460 400. In addition to the direct funding of contractual research projects, the WRC also finances the Computing Centre for Water Research (CCWR), a research support service, and the development of the WATERLIT database.

5.4 STRATEGIC FUNDING

Three funding "mechanisms", two closely linked to DACST (the National Innovation Fund and the Lead Programmes to stimulate international co-operation) and one closely associated with DTI (the Support Programme for Industrial Innovation) are discussed in this section.

5.4.1 The National Innovation Fund (NIF)

The National Innovation Fund is one of the major initiatives of the White Paper on S&T. Created in 1998, it supports large-scale, long-term, innovative and collaborative projects in the HE sector, government SETI, civil society and the private sector.

It is clear from the objectives of the Fund, as stated in the White paper (DACST, 1996: 25), that this is an attempt by government to steer the national system of innovation into areas that are considered of strategic importance to the country and which are in line with national socio-economic goals. The White Paper justifies the establishment of the Fund in the following terms:

- As a shift away from historical patterns of government science by reallocating resources towards improving the quality of life, environmental sustainability, competitiveness, and information technology,
- To increase competitive processes by which government SETI obtain funds, and
- To support networking and cross-sectoral collaboration within the national system of innovation.

After being piloted for science councils in 1997/98 (in the area of crime prevention), the Fund was officially launched by DACST in March 1998, in the areas of crime prevention, promotion of an information society, and a value-adding drive (i.e. how to improve products and processes). Table 5.9 shows that the Fund’s budget for 1998-99 was R30million, for which 170 applications were received; approximately half of which were earmarked for projects dealing with the needs of historically disadvantaged groups. By 1999-2000 this amount increased to R75million, constituting 20% of the science vote under DACST's control (DACST 1999b:27).

The current funding cycle focuses on the promotion of an information society, biotechnology and value-addition. Table 5.10 lists some of the projects awarded during the 1998/99 cycle.

Table 5.9:

Government Allocation to the Innovation Fund (R millions)

	1996/97	1997/98	1998/99	1999/2000
Amount	10, 0	10,0	30,0	75,0

Sources: (1) SETI Review, 1998e:8. (2) DACST 1999b:27.

Table 5.10: Examples of projects awarded during 1998-99

Title	Amount	Description
Computerised intelligent fire-arm licensing and authorisation consortium	R5 000 000	The development of integrated computer-based control system (for on-board firearm memory via a suitable interface) to pre-programme, personalised and code "intelligent" firearms allowing for use by legally authorised users.
Culture Preservation	R 6 498 000	Seeks to "preserve" culture through multi-media based programmes in tourism, education and public awareness. (i.e. it packages cultural history in a variety of media: printed material, audio and visual recordings, and virtual reality reconstructions).
Hollow Jewelry project	R8 250 000	Applying various technologies (in CAD design, stereo topography, rapid tooling, investment casting, laser, electro-forming, welding, robotics and marking technologies) to jewelry design and manufacturing techniques involving gold, diamond and platinum resources (timesaving and production-cost saving).
Innovative application of probiotic technology to improve existing baby and young children cereals for the prevention of diarrhoea.	R3 644 000	Fortifying breakfast cereals with health-promoting bacteria (probiotics). Product development is needed to maintain probiotics.

Source: DACST, 1999b:28-29.

The Innovation Fund is administered by DACST in consultation with NACI. The Technology Foresight exercises will inform the management of the Fund, particularly in prioritising research proposals according to, say, type of project, direction, beneficiaries, participants, research capacity building components, contribution to national goals, etc. (DACST, 1996:21)

5.4.2 Stimulating international co-operation in science, engineering and technology through the funding of Lead Programmes

International collaboration in science, engineering and technology (SET) gives South African researchers an opportunity to interact with some of the best scientists and technologists in other countries. By doing this, South African human resources development in SET gains credibility and the quality of the country's R&D capacity is enhanced. For this reason, it was decided to use a portion of the earmarked funding in the science vote to stimulate international co-operation in SET. An amount of approximately R8 million was made available in the 1998/99 financial year and a further amount of R8 million each for 1999/2000 and 2000/2001. After this three-year period the funds allocated for specific programmes will be reviewed, so that funding can then become available in the fourth year for new projects. (www.dacst.gov.za/default_science_technology .htm)

As the funds for starting this co-operative programme are limited, a focused approach is expedient. It was therefore decided to develop a few focus areas for which additional funds will be made available. These funds can be accessed through the submission of proposals in the framework of the following lead programmes, all of equal standing. The areas are:

- Biotechnology - food production, agriculture, health.
- Development of new materials and manufacturing.
- Information technology and systems and the information society.
- The sustainable management of environmental issues and of natural resources - energy, water, coastal resources, etc. through environment-friendly technologies.
- Mapping and exploitation of natural resources and minerals.

Although the amount set aside for stimulating international S&T co-operation through lead programmes is modest, compared to the amounts in the innovation fund and other initiatives, this amount serves as a start-up and can grow in the international arena. The aim of these funds is to gain leverage of international funds for joint S&T activities. These programmes both support national objectives and give a measure of focus to international S&T co-operation. It is also assumed that this seed money will have a multiplying effect, both locally and abroad, through the provisioning of matching or other levels of funding per joint project.

The science council to which funds are allocated for a specific lead programme, acts as the S&T co-ordinator, at the national level, for the projects that constitute the lead programme, and also for other related activities, generated by international co-operation. This means that any one of the lead programmes described above can promote and consolidate all S&T co-operation in that field with various countries. The science councils that contract funding for lead programmes will be the principal champions for these programmes with local and international collaborators. These, lead programmes, however, do not replace or supersede any international S&T initiatives taken by science councils in the execution of their own mandates.

Projects in the framework of lead programmes can be extended to include local partners from the business sector, the higher education sector, etc. Consortia with other science councils, NGOs and SMMEs, for instance, are also encouraged. Similar arrangements can be made with international partners when joint project proposals are developed.

5.4.3 The Support Programme for Industrial Innovation

The government actively promotes research and development in the private sector in two ways (Pouris, 1995: 74):

- Through the local content preference clause of the government's procurement policy.
- Via an initiative of the Department of Trade and Industry (DTI), called the Support Programme for Industrial Innovation (SPII), which provides grants and loans (approximately R50million a year) for commercial product development.

The SPII programme is similar to the Innovation Fund, the agency funds of the NRF, and THRIP in that it channels government funds through competitive mechanisms. It is also different from other funding programmes because the primary recipients of the funds are from the private sector. The SETI review (1998) made several recommendations that apply not only to SPII, but also to other programmes and agencies that channel funds through competitive mechanisms. The SETI Review recommended that: (DACST, 1998e:vi)

(a) The proportion of funds for SETI that are channelled through competitive mechanisms and progammes such as the Innovation Fund, the agency funds of the NRF, THRIP and SPII be increased
(b) The above programmes include conditions to encourage cooperation across disciplines, institutions and sectors
(c) The rules for participation in competitive funds be fair and transparent
(d) To facilitate effective monitoring and evaluation, the management of the above funds should be separate from the budgets of the line ministries through which the funds pass. The review notes that this is the case for THRIP (managed by the FRD, and now the NRF, for the DTI), for SPII (managed by the IDC for the DTI), and for the Agency funds (managed by the NRF for DACST). They recommend that this separation should also apply to the Innovation Fund.

5.5 CONCLUSION

Government funding of science and technology occurs through a variety of channels and mechanisms. This in itself is not problematic,In fact, a wide array of funding modalities administered by different agencies and with different funding paradigms, is probably to be preferred to a monolithic funding regime. It is not uncommon that different funding agencies apply different funding philosophies as dictated by differences between science cultures and different expectations of basic and strategic science. However, as was argued in Section 5.1, the existing arrangement gives cause for concern. Some of the reasons for this could be attributed to the fact that a new science and technology system is still being "carved out"; some seem to be related to political differences between key role players in the system.

Chapter 6

INFORMAL STRUCTURES INVOLVED IN SCIENCE AND TECHNOLOGY

6.1 INTRODUCTION

South Africa has a long and rich history in the field of academies, associations and networks involved in the field of S&T. Many of these structures, particularly those that date back to the beginning of this century, played an important role in the development of S&T in the country, as well as in expanding the disciplines. Some structures were created after the new dispensation started in 1994, which indicates a strong element of responsiveness and commitment to change within the scientific community. The more prominent of these structures will subsequently be dealt with under five headings: forums; academies; professional associations, societies and consortia; general associations; and networks.

6.2 THE NATIONAL SCIENCE AND TECHNOLOGY FORUM

The National Science and Technology Forum (NSTF) was created in March 1995 as part of a set of proposals by the Working Group Science and Technology Initiative of South Africa. Based on an integrated approach to S&T, these proposals sought to restructure the national science system in the interests of reconstruction and sustainable development (human, economic, social, environmental, etc.).

Legally an association since 1999, the NSTF views itself variously as "the sounding-board [of S&T stakeholders], communications channel and constructive watchdog of Science and Technology at implementation level," (NSTF, 1997:2) and "as the engine propelling economic growth through Science and Technology initiatives" (NSTF, 1999:1). It represents S&T stakeholders from a diverse range of sectors, including:

- Science Councils (individual councils, CHSC)
- Education Sector (universities, technikons, CUP, CTP)
- Government Departments (Education, Agriculture, DACST, etc.)
- State Corporations and Utilities
- Organisations of Civil Society (e.g. community organisations)
- Labour

- Professional Associations
- Research NGOs
- Business Sector

Historically preceding the National Advisory Council on Innovation (NACI), and representative of a larger number of S&T civil society stakeholders, the National Science and Technology Forum (NSTF) may be regarded both as an advisory structure at the intermediary level and as a contributor to/implementor of S&T policy. It has played a central role in several of the core initiatives of the new Ministry of Arts, Culture, Science and Technology, e.g. the White Paper on S&T and the Technology Foresight Exercises. In 1998, in response to the report of the Presidential Review Commission, the NSTF produced a discussion paper on the Management of S&T in South Africa.

The mission of the NSTF is to contribute towards national reconstruction and towards the economic, human and social development needs of SA bearing in mind our environ-mental needs" (http://www.nstf.org.za).

Three strategies accompany this vision of S&T as the route to economic development and redistribution (NSTF 1999:1):

> Humphrey Mkwanazi, CEO of the NSTF during 1998, explains the NSTF's emphasis on the role of S&T in lobbying the government on demystifying S&T and its role in job creation. "Science and Technology [drives] the economic growth of the country. With coherent policy, they do not destroy jobs, but indeed create them. High technology is an enigma to most South Africans who simply do not understand it. By de-mystifying and de-skilling it, technology will become the mechanism whereby this country's people are skilled and empowered. The NSTF has made the first strides towards de-mystifying Science and Technology by successfully lobbying the Government for the declaration of [1998 as] Science and Technology Year. This time will be used constructively to expose South Africans relentlessly to everyday applications which touch their lives constantly." (NSTF, 1997:1

- To form partnerships which develop and upgrade S&T infrastructures & skills;
- To transform S&T into the central driver of sustainable development (e.g. of the economy, of the environment, through education, in communities, etc.);
- To use S&T to improve the quality of people's lives by delivering basic services and urgently needed jobs.

Organisationally, the NSTF consists of (http://www.nstf.org.za):

(a) *Plenary* - consists of all of the NSTF participants. Its functions are:

- To agree on the framework of values for the activities of the NSTF;
- To discuss matters relating to its mission and objectives (and to refer areas for further discussion and/or study to the Working Group and Task Groups), and to monitor progress towards these objectives;
- To discuss proposals made by the Working Group.

(b) A subset of the Plenary, the *Working Group*, plans, co-ordinates and manages the work of the NSTF and of the Task Groups. It consists of one member each in the Plenary from the following sectors: government, labour, civil society organisations, business, and S&T practitioners/providers (science councils, state corporations, tertiary education, and professional bodies).

(c) *Task Groups* are formed by the Working Group to investigate S&T related areas deemed important by the Plenary.

(d) Secretariate, Chairperson and a CEO.

Table 6.1 lists some of the programmes initiated by the NSTF.

Table 6.1: Programmes Initiated by the NSTF

Programmes	Description
Contributions to Policy Initiatives	- White Paper on S&T - Foresight Exercises - Discussion Paper on the Management of S&T (for DACST) - Draft World Declaration on Science and the Use of Scientific Knowledge - Draft Science Agenda Framework for Action - National Health Technology Policy Framework (for Dept. of Health)
Newsletter (News & Stuff)	The NSTF newsletter focuses on science awareness, innovation, education, research, policy, funding and applications.
NSTF Annual Awards	In recognition of outstanding contributions by individuals and companies to SET.
Developing SET Awareness	Support for YEAST, through Annual Awards.

6.3 ACADEMIES

A science academy is broadly defined as an organised group of high achievers in S&T, where membership is granted through a process of nomination and election. The members of an academy are usually acknowledged as authorities and leaders in their fields, and often permitted to dictate standards and prescribe new methods (Webster, 1989:7). Atiyah (1995:547) summarises the role of a science academy as follows:

- To provide independent critique and ideas;
- To relate to the government of the day but be independent of it;
- To relate to the public;
- To establish interdisciplinary links;
- Not a 'trade union' for scientists.

6.3.1 The Royal Society of South Africa

The Royal Society of South Africa (RSSA) will be discussed under this heading, primarily because its members are elected on grounds of demonstrable records of scientific activity.

The RSSA is the oldest multi-disciplinary science academy in South Africa and has a liberal, English character. It originated in 1877, as the South African Philosophical Society, and later became the RSSA, after the grant of a Royal Charter in 1908. The RSSA is primarily concerned with advancing local science and does so by:

- Promoting the exchange and development of scientific ideas and knowledge;
- Recognising excellence in research and scholarship;
- Promoting international contacts and co-operation;
- Promoting independent expert advice on matters which require scientific analysis;
- Initiating debate on matters which affect science or arise from its application;
- Encouraging the study of the history of science in South Africa (http://www.uct.ac.za/org/rssa).

Since its foundation the RSSA has played an important role in the development of science in the country. During the period of political transformation in 1994, for instance, the RSSA issued a discussion document on science research policy, which contributed significantly to the debate on the changing context of South African science (Ellis, 1994). The RSSA also publishes its highly acclaimed peer-reviewed journal, the *Transactions of the Royal Society of South Africa*, which it has been doing since 1908.

Moreover, the RSSA uses, among other things, annual awards to recognise outstanding scientific achievement in South Africa. These involve the prestigious Herschel Medal for excellence in multidisciplinary activities, and the S.M. Naude Medal for scientific excellence by a scientist under the age of thirty-five (http://www.uct.ac.za/org/rssa).

Only persons with a demonstrable record of interest and activity in science are eligible for membership of the RSSA. There are, however, three special grades of association with the RSSA, besides membership:

- Fellowship - persons who have done outstanding work in the furtherance of science in South Africa, as evidenced by their publications;
- Honorary fellowship - persons who have done scientific research of exceptional distinction in the country;
- Foreign association - persons who are not resident in South Africa but who have a full, current interest in South African science and its advancement.

The society's affairs are managed by a council, which is elected annually. The council comprises fourteen fellows, including the president, two vice-presidents, general secretary, treasurer, foreign secretary, editor and librarian. The council oversees the election of new members, fellows and foreign associates, the award of the society's medals, the drawing up of a full scientific programme including lectures, symposia and excursions, and the refereeing and editorial processing of articles submitted for publication in the *Transactions of the Royal Society of South Africa*.

Scientific meetings are regularly held at the society’s four branches in Cape Town, Johannesburg, Durban and Grahamstown. Meetings provide members and fellows the opportunity to discuss important scientific issues, and to bring these to the public attention. Symposia are especially effective vehicles for the society’s purposes in this regard.

The RSSA is independent of government and receives no state-derived subsidy besides a small grant towards publication costs. It thus depends on subscription fees, donations and bequests, as well as on a limited capital fund. The society's head office is in Cape Town (http://www.uct.ac.za/org/rssa).

6.3.2 Suid-Afrikaanse Akademie vir Wetenskap en Kuns (South African Academy for Arts and Sciences)

The *Suid-Afrikaanse Akademie vir Wetenskap en Kuns* (South African Academy for Arts and Sciences) is the Afrikaans counterpart of the RSSA. It dates back to 1909 when *De Zuid-Afrikaanse Akademie voor Taal, Lettere en Kuns* (South African Academy for Language, Literature and Arts) was founded to further the interests of Dutch and eventually of the Afrikaans language (RSA, 1985). In 1942 the *Akademie* received its present name after also incorporating the sciences, medicine and engineering. The stated aims of the *Akademie* are to promote science, technology and arts in the country, as well as high-level expertise and the quality and use of Afrikaans.

Membership is acquired on grounds of achievement in science, technology or cultural activities. The members are in the first place academics and scientists who meet the strict requirement of academic excellence. However, not all members are scholars. Business leaders can also be elected to the *Akademie*, provided that they excel in their particular fields. At present the *Akademie* has an active membership of 1 052, representing a wide array of disciplines and sectors in society.

Within the *Akademie* there are three faculty councils to which the members belong. These are the Faculties of Arts and Humanities, Natural Sciences and Technique, and Economic and Management Sciences, respectively. Each faculty formulates its own set of objectives in accordance with the overarching aims of the academy. Members of the respective faculties elect the faculty councils every second year.

The *Akademie* is managed by a council of twelve members, among whom are a chairman and two vice-chairmen. A head secretary sees to the administration of the *Akademie*. A board of trustees and a finance committee look after its assets and facilities. The main sources of income are membership fees, grants, royalties, a state subsidy, and the return on investments and trust money.

The activities of the *Akademie* are organisationally decentralised on the basis of geographical and scientific field considerations, and involve a variety of structures, *viz.* working communities, divisions and branches. Working communities exist in the major centres, namely, Bloemfontein, Cape Town, Durban, Pietermaritzburg, Pietersburg, Potchefstroom, Pretoria and Stellenbosch. Divisions of the *Akademie* function on a scientific field basis within the Faculty of Natural Sciences and Technique. There are altogether six divisions: Biology, Chemical Sciences, Medical Sciences, Engineering Sciences, Agricultural Sciences, and Mathematics and Natural Sciences. Each division, in turn, is geographically organised in branches.

The *Akademie* is well known in South Africa for its reward of excellence in the fields of science, arts and humanities by way of medals of honour and prizes. Among the most prestigious awards are the Hertzog prize for literature, and the M.T. Steyn and N.P. van Wyk Louw medals. The medals are awarded for exceptional performance and leadership in the fields of the natural and human sciences, respectively (http://www.akademie.co.za).

The *Akademie* publishes two interdisciplinary journals. These are the *Suid-Afrikaanse Tydskrif vir Natuurwetenskap en Tegnologie*, and the *Tydskrif vir Geesteswetenskappe*. It is also responsible for the publication of several university textbooks, among which are books on chemistry, physics and mathematics, as well as dictionaries in specific science fields. The head office of the *Akademie* is in Pretoria.

6.3.3 Science and Engineering Academy of South Africa

The Science and Engineering Academy of South Africa (SEASA) was founded in 1986. Its primary aim is to address the backlog in the educational and professional development of blacks in the natural sciences and engineering. It does so by bringing the youth into direct contact with science, engineering and technology, through workshops and similar activities.

6.3.4 Academy of Science of South Africa

Although all three of the aforementioned academies aim at the furtherance of science in the country, none can claim to be representative of all sectors of society (RSSA is predominantly English and white; the *Akademie* is predominantly Afrikaans and white; SEASA is predominantly black). In order to address this concern, a task group was formed in 1990 to assess the viability of an overarching science academy for all cultural groups. The task group, with nominees from all three academies, reported in favour of a new umbrella academy (Retief, 1997:55).

> South Africa's need for rapid expansion of its scientific and technological skills is immense. It is inhibited by the disastrous restriction which apartheid imposed on the level of scientific and technological education: and by an image of science tarnished in the eyes of the majority by associations with the past. On your shoulders rest the challenge of giving science a face that inspires our youth to seek our science, engineering and technology is part of that task [sic]. But it requires more. It also means orienting science in a practical and visible way towards helping meet basic needs. It means recognising the intellectual challenge of applying knowledge to meeting such needs, rewarding achievements in that direction and celebrating them with the highest honours. The New Patriotism, which is abroad in South Africa, is rooted in our progress in overcoming the legacy of our past-esteem for South African science ought to become part of that national pride. *Former state President Nelson Mandela on the inauguration of the Academy of Science of South Africa. Pretoria, 22 March 1996*

As a result, the Academy of Science of South Africa (ASSA) was officially launched on 23 March 1996. One can thus say that ASSA emerged out of discussions between the *Akademie*, the RSSA, and SEASA. However, in 1996 SEASA distanced itself from ASSA, primarily because only 26 of the latter's 96 founder members were black. According to the chairperson of SEASA, Dr Sibiya, the new academy was, at the time, "unapologetically elitist, unrepresentative and exclusive in character and format" (Engineering News, 1995:11; Engineering News, 1996:11).

ASSA is composed of members of the three older academies, as well as a component of black scientists outside those academies. Its aim is to promote, without prejudice, all language and cultural groups in all disciplines of science. It seeks to formulate a programme of action that will impact on the community in the areas of education and health. ASSA does not replace any of the other academies, but is concerned with the promotion of scientific thought and activity in a broad sense (Engineering News, 1996:11; SAJS, 1993b:72).

6.4 PROFESSIONAL ASSOCIATIONS, SOCIETIES AND CONSORTIA

Professional associations and societies are organised groups of scholars with a common interest in a particular scientific profession (e.g. engineering or psychology). These structures differ from academies in the sense that they are open to all scholars in that profession, as well as to scholars in associated professions. Thus, no proven scientific expertise is required to become a member of a professional association or society, as is the case with academies.

The origin of professional societies in South Africa can be traced back to the early 19th century (Plug, 1992:256). Interestingly, in 1925 the establishment of probably the very first professional scientific society in the country was thwarted by politics. Lord Charles Somerset, who was the governor of the Cape Province at that time, prevented the founding of a so-called "literacy society" devoted to science, reading and enquiry. The reason was that he suspiciously viewed the proposed society as a possible platform for his political opponents. It was only after a new governor took over the reigns of office in 1929 that the South African Institute was founded. The latter was devoted entirely to science (Hall, 1977:475). Thereafter many professional societies followed, most of them gone and forgotten by now, but which nevertheless played an important role in the local development of science (Plug, 1992:256).

There are about 1 000 active professional societies in South Africa today, of which about 150 are in the human sciences (Lickindorf, 1995:186; Marais, 1999:83). Given this magnitude, the societies will not be mentioned here. The subsequent discussion will focus on two of their representative umbrella bodies or consortia: the Consortium of Human Sciences Societies of Southern Africa (COHSSSA) and the Associated Scientific and Technical Societies of South Africa (AS&TS).

6.4.1 Consortium of Human Sciences Societies of South Africa

The Consortium of Human Sciences Societies of South Africa (COHSSSA) was formed in the early 1990s, after a visit by Dr Roberta Miller to South Africa. Miller played a leading role in establishing a highly effective lobby for social sciences in America, the so-called Consortium of Social Sciences Associations. COHSSSA was thus meant as the South African equivalent of this American consortium (Lickindorf, 1995:185).

More specifically, COHSSSA is the unifying umbrella body of South African human sciences professional societies. Its aim is to promote the role of professional societies in seeking due recognition and support for the human sciences. For instance, in 1994 COHSSSA approached the different human science societies to help present a case for the human sciences at ministerial level. This took the form of a survey in which societies were asked about the relevance of their disciplines, the practical contributions of their members to the country's development, as well as the formative value of the human sciences (Lickindorf, 1995:186).

In 1996, the deputy minister of ACST, Mrs Brigitte Mabandla, summarised the role of COHSSSA in the country's national development as follows (Mabandla, 1996:87):

- To promote professional standards in the professional services offered to the community;
- To act as the public face of the humanities and social sciences;
- To act as the brokers of verified human scientific knowledge;
- To advise on managing and promoting diverse cultures;
- To act as custodians of information and expertise;
- To act as the interface between individuals, related professional societies, and the government.

COHSSSA has 75 member societies, with an associated membership of approximately 38 000 individuals.

6.4.2 Association of Scientific and Technical Societies of South Africa

During the first two decades of this century, efforts were made to achieve closer co-operation among the various scientific and technological societies in the country. This resulted in the formation of the Associated Scientific and Technical Societies (AS&TS) on 9 April 1920. AS&TS is the largest and most comprehensive body of professional societies of natural scientists, engineers and technologists in South Africa. It represents some 53 societies with a total membership of about 57 000 (Bruckmann, 1995:38).

The aims of AS&TS are to promote the interests of the various scientific, professional and technical fields, and to provide secretarial, liaison- and club facilities for the constituent societies (RSA, 1974:777). More recently, AS&TS also committed itself to extending the association's influence in councils that are responsible for setting policy in the fields of science, engineering and technology. It plans to do so through active collaboration with other interested parties, such as the South African Engineering Association and the Joint Council of Scientific Societies (SAJS, 1993a:518). AS&TS has also been involved in projects of national importance during the period of political transformation in the country. For instance, in the mid-1990s it issued a discussion document entitled *A contribution towards developing an education policy for science and technology*, serving as an important contribution to the formation of the new education policy for South Africa (Bruckmann, 1995:41).

6.5 GENERAL ASSOCIATIONS IN S&T

General associations differ from professional associations and societies in two ways. Firstly, not all members are scholars, and secondly, the common interest is not a particular scientific profession, but rather some policy-related objective. Examples of general associations in S&T are those concerned with the empowerment of women scientists and the promotion of science education.

6.5.1 Association of South African Women in Science and Engineering

The Association of South African Women in Science and Engineering (SAWISE) was established in Cape Town in March 1995. SAWISE is an association for persons in favour of strengthening the role of women in science and engineering. It is open to all women who are working, or have worked, professionally in South Africa in the fields of science or engineering, or who hold a technikon or university qualification in these fields. Schoolteachers of science, biology or mathematics in South Africa are also eligible for membership. Men in the above categories who associate themselves with the objectives of SAWISE can also apply (http://www.sea.uct.ac.za:80/sawise/index.html).

The objectives of SAWISE are:

- To raise the profile of women scientists and engineers;
- To highlight problems faced specifically by women in science and engineering;
- To lobby for the advancement of women in science and engineering;
- To provide input to the development of science policy in South Africa;
- To provide leadership and role models for young people wishing to enter the fields of science and engineering.

There are two branches of SAWISE, each with its own branch committee consisting of a chairperson, a secretary plus two members. These branches are in the Western Cape and Gauteng, with the Western Cape Branch acting as the national, co-ordinating one. The term of office of the branch committees is two years. SAWISE receives no state-derived subsidy, but is permitted to raise funds from the private or public sector.

In order to fulfil its mission of promoting the position of women in science and engineering, SAWISE has launched a variety of projects. These projects are, among others:

- A database regarding the representation of women at conferences, workshops, on committees, as well as funding allocations, employment numbers and ratios;
- A retraining programme for women who have been out of their field of work for a period of time, and are now returning;
- A series of presentations on women in science to schools and other interested groups;
- A survey regarding attitudes to and of women in science and engineering fields;
- Career guidance activities, where women scientists and engineers assist at school career events;
- Workshops on confidence building and assertiveness training for women in science and engineering;
- Profiles on women in science and engineering, in order to highlight the role of women in science and engineering and the opportunities that careers in these fields offer.

6.5.2 South African Association of Science and Technology Centres

South African science and technology centres, their staff, and any individuals interested in science and technology education can become members of the South African Association of Science and Technology Centres (SAASTEC). According to its webpage (http://www.saastec.co.za) SAASTEC's mission statement is:

- To contribute to the improvement of the life of the nation by improving scientific knowledge and skills, through the utilisation of interactive living S&T centres;
- To disseminate knowledge in science and technology to the public in general, and the youth in particular, through imaginative and enjoyable hands-on exhibits, displays and programmes, so that they can appreciate the relevance of science and technology in their daily lives;
- To serve as a catalyst for the youth to develop their creativity and to nurture their interest in related fields;
- To establish a centre of excellence and innovation in non-formal science education;
- To provide satisfying careers for the S&T centre workforce.

This mission statement translates into the following specific objectives:

- To stimulate interest in S&T centres;
- To establish more S&T centres in rural areas;
- To investigate and support mobile centres and transportable units;
- To stimulate ideas in the design of new exhibits;
- To hold regular workshops and meetings in different centres;
- To evaluate the impact of S&T centres;
- To establish contact with industry;
- To establish links with international bodies;
- To address the issue of funding;
- To provide training in the management of S&T centres;
- To encourage the sharing of resources;
- To develop a national marketing strategy;
- To provide a national network of information interchange between S&T centres;
- To have a joint voice that is nationally recognised, to lobby government and industry.

Members of SAASTEC, which include university, government and corporate S&T centres, are as follows:

University centres

- Gold Fields Exploratorium - University of Pretoria
- Science Garden - Potchefstroom University
- Unizul Science Centre - University of Zululand
- Geology Education Museum - University of Natal
- Physics Dept. Science Centre - University the North

Government centres

- Hartebeesthoek Radio Astronomy Observatory
- Giyani Science Centre
- Museum of Science & Technology, Pretoria
- KwaZuzulwazi Science Centre, Durban
- Mhala Science Centre, Thulamahashe

Corporate centre

- Associated Scientific & Technical Societies (AS&TS) Science Centre

6.6 NETWORKS

Academies, professional associations and societies, as well as general associations, are all formal structures in the South African science and technology system. Networks are examples of more informal structures whose main aim is the sharing of information and support among persons with a common interest.

6.6.1 The South African Network of Skills Abroad (SANSA)

The South African Network of Skills Abroad (SANSA) was established towards the end of 1998 and has two related sets of objectives. Firstly, to create a South African community of knowledge and interests abroad and, secondly, to link that community with local experts and projects. The first objective has already been achieved as SANSA boasts with a membership of 1650 individuals six months after its creation (SANSA, 1999). Membership, however, is not restricted to former South Africans living abroad, although principally directed at them. So far thirty-six nationalities are represented in the network, with the largest number of members in the United Kingdom. The members themselves can decide on the nature of their contribution, which may involve:

- Receiving South African graduate students in laboratories, or training programmes;
- Participating in training or research with South African counterparts;
- Transferring technology to South African institutions;
- Transmitting information and results of research not locally available;
- Disseminating cultural and artistic creation;
- Facilitating business contacts;
- Initiating research and commercial projects.

SANSA is a joint venture of the Science and Technology Policy Research Centre (STPRC) and the French Institute of Research for Development (IRD). The STPRC is a leading South African research centre in S&T policy, based at the University of Cape Town. SANSA is also formally endorsed by DACST, and enjoys strong support from the universities and science councils in the country (http://www.uct.ac.za/org/sansa).

6.6.2 Southern African Science Communication Network (SASCON)

The Southern African Science Communication Network (SASCON) is southern Africa's entry into the global network of science communicators (http://www.nrf.ac.za/org/sascon). Officially launched on 16 January 1998, SASCON believes that the way southern Africans understand, communicate and use S&T, significantly affects their economic, social and environmental wellbeing. SASCON has the following priorities:

- To provide a forum for exchanging information between all people interested in promoting science communication;
- To promote public awareness of and interest in science among southern Africans;
- To increase the number of science communicators in southern Africa;
- To host "media skills for scientists" workshops to equip scientists, engineers and technologists with better communication skills;
- To promote the visibility of S&T in the media.

During 1998, SASCON integrated its activities with those of The Year of Science and Technology (YEAST) and was present wherever possible, using the year as a springboard for national recruitment efforts and for raising awareness of the need for better science communication.

6.6.3 Women in Research

Women-in-Research (W-i-R) was established in 1996 as a project within the Research Capacity Development directorate of the CSD. It now falls under the Division for Social Sciences of the NRF. The project seeks to address key issues that affect women researchers, especially their under-representation in senior research and management positions. The under-representation of women in the research community has resulted in their limited participation in national discourses and research agendas. For this reason W-i-R aims (http://www.csd.hsrc.ac.za/rcd/wir.html):

- To support women, especially black women, to develop and strengthen their research skills;
- To increase the number of women in postgraduate studies, academia, research and leadership positions at South African tertiary and research institutions.

The main objectives of W-i-R are:

- To gather and disseminate data on women researchers and their work environment at South African tertiary institutions;

- To encourage and facilitate networks and partnerships among women researchers at local, national and international levels;
- To facilitate the exchange of information and ideas on research and development;
- To lobby, with other partners, for policies and strategies that enable women to participate actively in the research domain;
- To monitor the impact of relevant national and institutional policies on funding and other research opportunities for women.

The following form the current core of W-i-R activities:

- An audit of women researchers to profile the skills, expertise, needs and opportunities of women researchers in the social sciences and humanities at tertiary institutions. The audit has two products: (i) a database and a directory of women researchers, and (ii) a report on teaching and research activities, infrastructure and support services, as well as skills development opportunities for women academics and researchers.
- Supporting and commissioning research on a wide range of issues and disciplines. Some of the research includes investigations into factors that inhibit or promote women's advancement in research, academia and leadership.
- W-i-R work in partnerships with individuals, organisations, institutions and other constituencies who are interested in achieving increased representation of women in research production and management.
- Fostering collaboration between post-graduate students and early-career and established women researchers. The W-i-R Award is aimed at encouraging research collaboration.
- Facilitating the establishment of networks and information exchange among women researchers through, inter alia, electronic mail and in-house journals, in the hope that this will also facilitate the establishment of regional networks.
- Supporting the development of gender-aware curricula that reflect the experiences of women and men within the different disciplines.
- Workshops, seminars, and conferences on issues pertinent to the objectives of the project.

All these structures are considered effective vehicles for aligning the system with national priorities of a developmental and/or competitive nature.

Chapter 7

R&D PERFORMERS

7.1 INTRODUCTION: A TYPOLOGY OF RESEARCH PERFORMERS

Research and development is performed by a variety of research institutions in the national system of innovation. It is difficult to classify these institutions into a coherent and logical framework, even if we limit our discussion to public sector institutions - that is, institutions that receive (either directly or indirectly) some form of state support. The nature and profile of institutions such as universities and technikons are of course self-explanatory. This is also true of the science councils in South Africa, although we will argue that even this category is somewhat controversial. It becomes more difficult when looking at government funded institutions that are not higher education institutions or statutory bodies (such as the science councils). These include the following "entities":

- National research facilities (e.g. the National Accelerator Centre);
- The Africa Institute of South Africa (a Section 21 company);
- The South African Institute for Medical Research;
- "Industry-based" research institutions, such as the Leather Industry Research Institute and the Commercial Forestry Research Institute, which are non-profit, public institutions;
- The Oceanographic Research Institute (independent but with sizeable provincial funding).

In addition, there are a number of public corporations - where government is the main shareholder - such as the Atomic Energy Corporation, ESKOM, TELKOM and the SABC, which have significant research capacities and initiatives. Finally, government also supports in-house research through departments, institutes and centres. Good examples of this are the South African Weather Bureau (within the Department of Environmental Affairs) and the National Institute for Virology (of the Department of Health).

The following is a proto-typology of research performance institutions that attempts to be as inclusive as possible:

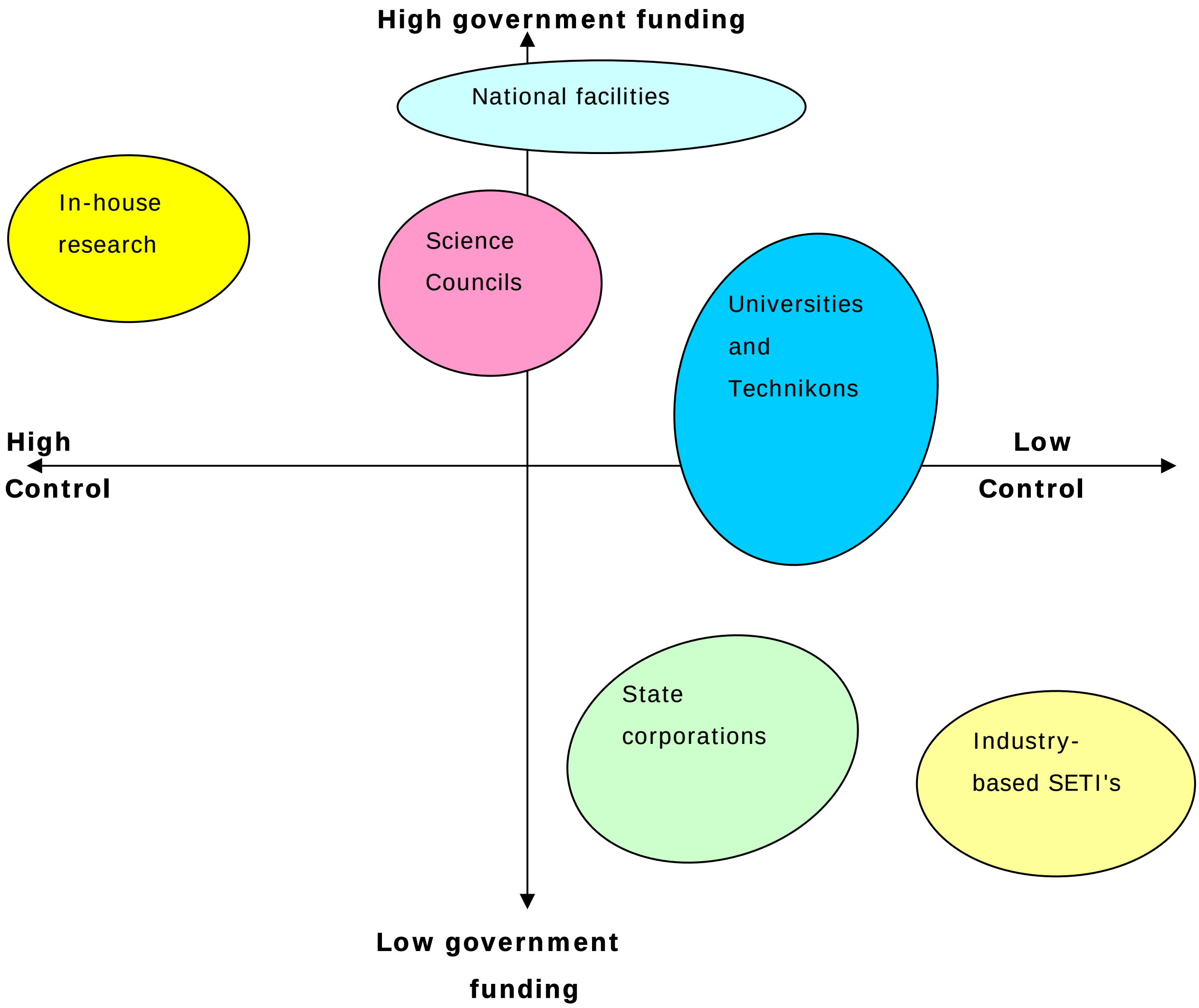
- Higher education institutions;
- Science councils
- National research facilities
- Government funded public research institutes (e.g. AISA);
- In-house government research institutes (e.g. National Botanical Institute);
- Industry-based research institutes (e.g. LIRI);
- State corporations/ public enterprises (with a significant R&D mandate).

This "typology" still excludes research NGOs, that is organisations that are not supported financially by government, but are public (not private or business) organisations, for example, IDASA and CASE.

The figure below represents these institutions in a two-dimensional space. The two dimensions used to generate the representation are:

- The extent of government funding: High to low (More than 50% - less than 50%);
- The extent of government control: High (government department) to low (NGO).

Figure 7.1: A typology of research institutions



7.2 SCIENCE COUNCILS

There are currently eight science councils in South Africa. These are:

- Agricultural Research Council (ARC);
- Council for Geoscience (CGS);
- CSIR;
- Human Sciences Research Council (HSRC);
- Medical Research Council (MRC);
- Mineral Technology Council (MINTEK);
- South African Bureau of Standards (SABS);
- The National Research Foundation (NRF).

We have already indicated (in Chapter 5) that the National Research Foundation has a dual character: It acts as the main national funding agency (cf. 5.3) and also as the administrative address for four national research facilities. Given that our focus in this chapter is on research performers, we will confine our discussion in this chapter, to the latter. Our discussion in this section covers the remaining seven science councils in alphabetical order[1].

7.2.1 THE AGRICULTURAL RESEARCH COUNCIL (ARC)

The ARC is a statutory para-statal body formed in terms of the Agricultural Research Act, 1990 (Act 89 of 1990). Its mission states that it is committed to the promotion of agriculture and related sectors through research, technology development and technology transfer, in order to optimise the role of agriculture in respect of national growth and development in the Republic of South Africa. Providing farmers with the appropriate technology to improve production and the training of farmers and extension personnel in the use of these technologies is an integral component of ARC activities.

The ARC has 15 research institutes under its control. Its research capacity consists of a network of experimental farms, modern equipment, and a personnel component of about 4500, including some 1000 professional researchers and technologists. In recent years, the ARC entered into agreements with the Ukraine, Georgia, Sudan, Egypt, Morocco and Brazil for co-operation in the field of agricultural research. In accordance with the basic principles of the Reconstruction and Development Programme (RDP), the ARC also offers research, development and technical services to neighbouring and other African countries that require its expertise, on a contract basis. Examples of these contractual projects are natural resource characterisation, advisory services, training courses and the provision of plant material and animal breeds suited to African conditions. As a participating member of the Special Programme for African Agricultural Research, the Council is also involved in the promotion and development of agricultural research systems in Africa.

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[1] The bulk of infiormation presented and discussed in this Chapter was obtained from the Annual Reports and websites of the science councils and research institutes. Although we have done a fair bit of editing of texts downloaded from websites, we would like to acknowledge here the usefulness of these sites and the anonymous role of all the webmasters!

The Institutes of the ARC are divided into three categories:

- Specialist institutes;
- Plant science institutes;
- Animal science institutes.

Specialist institutes

The ARC-Agrimetrics Institute provides an integrated biometric and datametric service, which includes the planning of experiments, a wide spectrum of statistical advice and analyses, as well as interpretation of the processed results. This is supported and enhanced by an electronic data-processing service and the development and maintenance of scientific databases and data systems.

The ARC-Institute for Soil, Climate and Water promotes the characterisation, sustainable utilisation and protection of natural resources. Research activities cover the fields of soil science, agrometeorology, water utilisation, remote sensing, analytical services, and small-scale and developing agriculture.

The ARC-Institute for Agricultural Engineering is active in agricultural mechanisation, resource conservation, farm structures, irrigation, energy, aquaculture and product processing. Research is done for all farmers, from the smallest subsistence farmer employing animal traction, to the most sophisticated farmer using advanced equipment. Materials are developed to enable any farmer to build cheaper farm buildings. Laboratory and field tests on irrigation equipment and farm machinery strive to produce unbiased, scientific information on performance characteristics for farmers, as well as manufacturers. Innovative energy resources and applications for rural areas are being developed to benefit resource-poor individuals and communities. Through research, technology development and testing, information, materials and equipment are made available with the aim of satisfying real needs in the agricultural engineering field.

Plant science institutes

The ARC-Grain Crops Institute is responsible for research on the improvement and cultivation of grain crops, such as summer grain and oil, and protein seeds. Research activities involve plant-breeding, evaluation of cultivars, grain quality, plant physiology, tillage, weed science, plant pathology, entomology, nematology and yield potential.

The ARC-Small Grain Institute concentrates on small grain crops, such as wheat and barley. Research activities are similar to those of the ARC-Grain Crops Institute.

The ARC-Roodeplaat Vegetable and Ornamental Plant Institute is responsible for all applied research at national level on vegetable crops, potatoes, chicory, cut flowers, fynbos, pot plants and other ornamental plants.

The ARC-Fruit, Vine and Wine Research Institute is responsible for research on the cultivation and post-harvest technology of deciduous fruit and other assigned crops (i.e. berry fruits, nut crops, rooibos tea, olives, kiwi fruit and hops), the cultivation of table, raisin and wine grapes and the production of wine and brandy. The research is aimed at the formulation of principles and techniques that will ensure long-term optimum yield and quality at economical prices.

The ARC-Institute for Tropical and Subtropical Crops is responsible for research on all aspects of the cultivation of tropical and subtropical crops. Lesser-known exotic crops are also evaluated, e.g. cocoa, coconut, feijoa, annona types, carambola, jaboticaba and white sapote. Research activities comprise horticulture, cultivar development, plant physiology, biotechnology, entomology, pathology, plant nutrition and irrigation.

The ARC-Tobacco and Cotton Research Institute is responsible for all fundamental and applied research in the interest of the tobacco and cotton industries in all the production areas of South Africa.

The ARC-Plant Protection Research Institute concentrates on national, rather than regional, agricultural and environmental problems. The Institute is responsible for the promotion of economical and environmentally acceptable pest-control and sustainable farming systems. Research is conducted in the fields of biosystematics, ecology and epidemiology of invertebrates, fungi, pathogenic and useful bacteria, viruses and the control of pests and invasive plants through effective pesticide management, as well as biological and integrated control strategies. A variety of services is provided, such as the quarantine of imported biocontrol agents, advice on apiculture, quality control of legume inocula, provision of cultures of biocontrol agents, identification of organisms important in agriculture, as well as specialised information on pesticide application, biological control and forest entomology.

The ARC-Plant Genetic Resources Unit centralises and coordinates plant genetic resource activities within the plant science institutes and liaises with regional and international agencies. It is responsible for the documentation of ARC germplasm and for arranging safety-base collection facilities.

Animal science institutes

The ARC-Range and Forage Institute focuses on the development of holistic and integrated land-use strategies aimed at sustainable livestock and range-land management systems through research in the fields of vegetation and rehabilitation ecology; animal nutrition and management; pasture agronomy, and vegetation biology.

The objective of the ARC-Animal Nutrition and Animal Products Institute at Irene is to develop environmentally-friendly technology, promote animal production and improve the quality of animal products. Research and development are undertaken to provide for the nutritional needs of animals and improve the quality of meat and dairy products.

The objective of the ARC-Animal Improvement Institute at Irene is to develop environmentally-friendly technology and improve the quality and efficiency of the national herd-animals, through the use of established genetic and physiological methods to identify and study superior breeding material.

The ARC-Onderstepoort Veterinary Institute north of Pretoria is responsible for improving animal health in South Africa, as well as public health where animal products such as milk, meat and eggs are concerned. This goal is achieved by carrying out research, including specialised diagnostics, in the areas of infectious diseases, parasitology, toxicology and related disciplines; by the development and production of vaccines and other biological products essential for the prevention and control of animal diseases, and by providing specialised advice.

The ARC-Onderstepoort Institute for Exotic Diseases is a high-security facility for research on highly infectious animal diseases and the production of foot-and-mouth disease vaccine. It does research on, and supplies a diagnostic service for foot-and-mouth and African swine fever, as well as for other exotic diseases.

7.2.2 COUNCIL FOR GEOSCIENCE

The Council for Geoscience is a statutory body that was established on 1 November 1993, in terms of the Geoscience Act, 1993 (Act 100 of 1993), for the purpose of managing the functions of the Geological Survey of South Africa. The functions of the Council are:

- To undertake geoscientific research;
- To compile and develop a comprehensive and integrated collection of knowledge on all aspects of geoscience;
- To serve as the national custodian of all geoscientific information;
- To study mineral resources;
- To conduct geological investigations and render specialised services to public and private institutions;
- To advise government institutions and the general public on the judicious and safe use of surface land;
- To develop and maintain the National Geoscience Library, the National Borehole Core Repository, the National Geophysical and Geochemical Test Sites, and the Geological Museum, as part of the Transvaal Museum in Pretoria;
- To undertake research of its own accord or on behalf of any state institution, person or other institution.

The objectives of the Council are: to reduce the geological and scientific investment risk for national and international entrepreneurs in the South African mining sector; to provide the basic geological data to permit the development of safe, cost-effective physical infrastructure for South Africa which avoids sterilisation of usable mineral resources; to provide the basic knowledge that will ensure safe, cost-effective and environmentally acceptable urbanisation and housing development, particularly with regard to the dangers of sinkholes in dolomitic terrain and seismic activity, as a consequence of mining activities, and finally to conduct research on the raw materials necessary to clothe and feed the nation. The Council acts as a repository for African and global earth science data to facilitate the economic and social integration of South Africa into Africa and the rest of the world. In addition, the Council aims to facilitate interaction between South Africa and the rest of Africa, as it is acknowledged that resource-based economic growth in Africa is a prerequisite for economic growth in South Africa. The Council is, for example, involved in about nine multilateral projects of the Mining Committee of the Southern African Development Community (SADC).

7.2.3 CSIR

The CSIR, with its main site situated in Pretoria, is the largest community and industry-directed scientific and technological research, development and implementation organisation in Africa. Established in 1945, the CSIR is a statutory scientific research council with a mandate to foster industrial and scientific development that will contribute to the quality of life of all South Africans. With a staff complement of over 3 000 (scientists, engineers, technologists, technicians, sociologists and support staff) and a turnover of some R600 million per annum, the CSIR provides technology solutions and information through contract research and development; specialist consulting; systems engineering, technical and information services; prototyping and pilot scale manufacturing; software and decision support; education and training; policy development and support, and global science and technology links.

The CSIR's functions are centred in ten operating divisions. The activities of divisions are aimed at: supporting the technological competitiveness of the South African industry, in both the formal and informal sectors; providing technological solutions to improve the quality of life of urban and rural communities and providing scientific and technological support for decision-making in the private and public sectors.

Bio/Chemtek

CSIR Bio/Chemical Technologies (Bio/Chemtek) provides contract research to customers in the broad area of biotechnology and chemical manufacturing technology, to develop and commercialise new technologies, new products and new ventures. Founded on 1st February 1999, the unit takes the CSIR one step further in its vision 'to be the best in technology leadership and partnering, and - through our people - fight poverty, build global competitiveness and make an enduring difference in people's lives'. The range of technology solutions and information also covers the chemical process industries and the manufacture of bio-chemicals.

Building Technology

The Division of Building Technology (Boutek) provides cost effective technology solutions to the building industry. The division provides services relating to the materials, methods and systems used in construction, including cement and concrete durability; foundation solutions for problem soils; waste materials suitable for construction purposes; innovative construction products and sewer pipe materials, as well as analytical expertise, forensic engineering expertise, wind engineering facilities and an Internet information service, for the building and construction industry. They also offer expertise in the field of fire and industrial explosions, including risk surveys and assessments; planning and management support for public and private sector health and education facilities, and planning and delivery support for community-based housing projects.

DefenceTek

Defence Technology develops, maintains and deploys an advanced technology base in support of the defence industry. Defence Aeronautics, Defence Electronics, Hermanus Magnetic Observatory, Integrated Sensing Systems, Security Systems.

Environtek (Water, Environment and Forestry Technology)

Environmentek provides technologies for environmental assessment and management, terrestrial resources and environmental management, forestry and forest products, water resource management and coastal development and marine resources.

Information and Communications Technology

Areas covered are: Information Security; Communications Engineering; Communications Product Engineering; Information Systems Development; Decision Support and Policy and Regulatory Support. Special programmes include: The Virus Protection Programme (VPS); inTouch Africa - cataloguing system; Supertag - the Radio Frequency Identity (RFI) application; RDB - Mikomtek's FM Radio Data Broadcasting system; GISRAP, the radio planning software tool; and the high-speed wireless delivery system, CiDS. The Satellite Applications Centre provides products, services and information related to the space industry and its applications.

Food Science and Technology

Food Science and Technology **(**Foodtek**)** provides solutions through technology for small, micro, medium and large enterprises and developing communities in the agrofood sector of the South African economy.

Manufacturing and Aeronautical Systems Technology

The Manufacturing and Materials Division represents a consolidation of the CSIR's existing competencies in the areas of manufacturing and materials, and the expansion of these in accordance with market needs. This division is made up of nine centres which cover a broad spectrum of activities, from manufacturing policy and foresight studies; through enterprise establishment and management (large and SMME); best practice and modeling; product development and design, including time-compression technologies; advanced manufacturing processes and equipment improvement; materials conversion technologies; traceable measurement standards; sensors and production control technologies, processes and systems; metallurgical plant and asset management services; to environmental issues such as clean manufacturing processes and eco-efficient products.

Materials Science and Technology

The CSIR's multidisciplinary approach to research and development has, amongst many others, led to products and services in respect of low-cost housing, primary health care, job creation, water supply, effluent disposal and transport systems. The CSIR has participated in the development of several entrepreneurial development centres such as the Manufacturing Advisory Centres in Port Elizabeth and Durban.

Mining Technology

Fields covered: Engineering Design Environmental Engineering Fundamental Rock Mass Behaviour, Hydraulic Transport, Mine Mechanisation and Automation, Mine Services, Occupational Health, Orebody Information and Coal Fires, Dust and Explosions

Textile Technology

CSIR Textile Technology provides integrated, multi-disciplinary textile, clothing and related technologies, services and solutions in the context of national priorities, to primary producers, processors and end product manufacturers in both the emerging and formal industries. Fields covered: Design and development, Laboratory services, Specialist services, Technology acquisition and implementation and Textek initiatives.

Roads and Transport Technology

CSIR Transportek seeks cost-effective solutions and offers specialist expertise in a wide range of transportation fields, including: Transportation Research, Traffic Management, Transport Infrastructure and Technology and Information Management.

General initiatives

In 1997, the CSIR launched its Mindwalk 1997 programme. Involving 1 000 ‘mindwalkers’ from 250 schools country-wide. The aim of the programme is to encourage and develop pupils’ interest in science and to improve the standards of science teaching in South Africa. Each school was represented by a team of four pupils who presented a visual and written solution to a particular problem.

The CSIR policy group

The role of the Policy Group is to support and empower the organisation in striving for excellence in the field of innovation by providing intellectual inputs grounded in a thorough understanding of the local, regional, national, sub-regional and global context prevalent in a time-specific milieu. This is achieved by utilising action-orientated and scholarly research to contribute towards the formulation of policy which reflects the realities of South Africa, and thereby enhances the abilities of the operational arms of the organisation to make a better technology contribution towards growing the economy and reconstructing the society.

The primary outputs include direct interventions in the formulation of government policy and the provision of long-term planning resources to both internal (divisional) and external (Public and Private sector) clients. Primary clients are: internally - Executive, SU Heads, Programme Managers, Project Leaders and Researchers; and externally - the South African Government, the Private Sector, Parastatals and International Organisations.

7.2.4 THE HUMAN SCIENCES RESEARCH COUNCIL (HSRC)

The HSRC is the only science council that conducts research exclusively in the human sciences. It is a non-profit and independent statutory organisation that functions in terms of the Human Sciences Research Act, 1968 (Act 23 of 1968). For the past three decades, it has had a dual mandate of performing research and acting as a funding agency. In terms of recent legislation, the organisation’s agency function (CSD) was transferred to the NRF on the 1st of April 1999. The HSRC’s research mission is to facilitate problem-solving and enhance decision-making through conducting excellent research in the human sciences.

The research portfolio of the HSRC is organised into three Research Groups:

- Democracy and governance;
- Education and training;
- Economic and social analysis.

The research programmes for 1999/2000 for these groups are briefly summarised below.

Democracy and governance

Globalisation and South African Transformation: The programme sets out how South African institutions and society can anticipate and deal with the impacts of globalisation. The aim of the programme is to assess and inform the capacity of our institutions to take advantage of globalisation.

Democratic change: This programme analyses the unfolding processes of democratisation in South Africa. It distinguishes the comparability and the distinctiveness of the South African path to democracy and, in so doing, informs current debates on state formation and democratisation. Some of the topics dealt with in the programme include: comparative studies of democratisation; state-civil society relations; government-citizen relations; public participation in democratic processes and institutions; societal stability; the role of civil society; social movements; human rights; social and economic justice; issues of race, class, identity formation and culture.

Public opinion and institutional transformation monitor: Democracy requires governments and policy-making institutions to be informed about citizens' needs and aspirations, and citizens, in turn, to be informed about policies that may impact on their lives. The programme supports other programmes through the development of longitudinal databases and social indicators, as well as the provision of primary data to other research projects. It informs processes of participatory democracy and serves as a barometer for the state and organisations in civil society on the state of democratic governance in South Africa.

Public policy analysis: This programme examines a broad range of macro- and micro-issues, including: the relationship between policy objectives and policy outcomes, comparative systems of policy making and governance, intergovernmental relations, transformation of public institutions, the roles of the state and civil society in policy making and transformation, and threats to good governance such as social disintegration, citizen insecurity and civil disengagement.

Education and training

Assessment in the education and training system: The introduction of the National Qualifications Framework and the implementation of an outcomes-based model highlight the critical role of assessment in the South African education and training system. The lack of clear and comprehensive policies and guidelines, however, as well as insufficient information and expertise in the development of assessment practices, theories and techniques, present unique challenges for all stakeholders. These challenges include:

- the development of systems for monitoring and evaluating the quality and process of education and training;
- the identification and implementation of relevant assessment practices in the teaching and learning process;
- the recognition of prior learning and placement of adult learners;
- the building of assessment capacity of educators and researchers;
- the application of relevant technology.

Education and training information systems: Informed decisions on education and training policy, planning and priorities must be based on reliable, accessible and compatible education and training management information systems. There is a need to develop and maintain such systems in South Africa, and to develop capacity at both provincial and national level. The programme supports and enhances decision-making, planning, research, monitoring and policy development in education and training by creating, maintaining and analysing education and training databases. Contributions are also made to initiatives in respect of education indicators, and quality assurance and promotion.

Psychological assessment instrument development: This programme researches assessment theory and models, and develops and adapts psychological assessment instruments. In developing instruments, it attempts to address the question of culture-fair tests for South African conditions. HSRC and international instruments are translated, standardised, up-graded, normed and validated. The programme also provides users with information on technical issues such as norms and validity. These instruments are used by psychologists and educators in the education field, industry and private practice for assessment in career guidance and counselling.

Policy and implementation in education and training: Research priorities in South African education and training (ET) are changing as the spotlight shifts from policy formulation to policy implementation. This programme assists in the evaluation, implementation and refinement of ET policy by focusing on the dynamic synergy between eight years of policy making in ET on the one hand, and, on the other, policy implementation that is new and unpredictable in outcome.

Economic and social analysis

Population and development: Changes in the size, structure, composition and spatial distribution of the population are associated with different levels of needs for productive resources (such as land) and different levels of access to development and infrastructure. These changes necessitate a continual reprioritisation in the allocation of scarce resources. The interrelationship between changes in population patterns and development is, however, not adequately understood. Development strategies, if not carefully formulated, can induce unsustainable population dynamics, which, in turn, can reinforce inequalities. These two processes undermine society's capacity to improve the population's quality of life. This programme aims to analyse and explain these processes and to provide research-based information that will help decision makers improve policy making and planning, and thereby enhance people's quality of life.

Labour market analysis: This programme monitors, analyses and projects labour market trends and provides research-based information to facilitate labour force decision- and policy making on a national, provincial and occupational level. Analyses are done on issues such as the impact of macro-economic and sectoral policies on the demand for labour and the nature of the labour supply. Trends in the deployment of labour across industries and occupations, the informal sector, and the spatial distribution of employment are also analysed. In order to monitor and project trends and to provide information on an ongoing basis, the programme maintains databases and develops models concerning qualifications and labour trends.

Sustainable livelihoods and the ecosystem: This programme has three closely intertwined objectives. Firstly, it examines the livelihood risks faced by previously dispossessed populations, especially women, and the vulnerability of these groups to economic cycles and disturbances of the ecosystem. Secondly, it examines the relationship between the livelihoods of different social groups in South Africa and environmental degradation or conservation. A good understanding of the links between livelihoods and the environment is essential for designing development programmes that support the mutuality of the two. Finally, it evaluates proposed empowerment programmes and assesses their potential to cure past and likely future ills.

7.2.5 MEDICAL RESEARCH COUNCIL (MRC)

The MRC was established in 1969. Its main research activities are defined in its mission statement as "improving the health status and quality of life of the nation by providing scientifically-based information on the health status of the nation for policy-making purposes; strengthening and developing human and institutional research capacity and infrastructure; and improving the cost-effectiveness of and equity in health care".

These are implemented by seventeen focused thrusts, which are divided into content and bridging thrusts.

Content thrusts

CHILD AND ADOLESCENT HEALTH: This thrust fosters the promotion and improvement of the health of mothers, infants, adolescents and youth in South Africa.

CHRONIC DISEASES, CANCERS AND AGEING: This thrust undertakes a research programme that involves laboratory, clinical and community health research on chronic diseases, cancer and aging. Research topics include: prevention, early detection and cost-effective management in the primary, secondary and tertiary health service settings.

HEALTH AND DEVELOPMENT: The Health and development thrust promotes, facilitates, co-ordinates, initiates and evaluates research that examines the relationship between health and development. This is done in order to impact on policy and delivery and thereby to improve the social, economic, environmental and human development of South Africa and the subregion.

HIV / STDs / TB: The HIV/STDs/TB research thrust focuses on the prevention, management and impact of these diseases using public health, clinical, experimental and socio-behavioural approaches in order to increase our knowledge of these diseases and develop better methods to control them for the benefit of all South Africans.

INFECTIOUS DISEASES, VACCINES AND IMMUNITY: This thrust undertakes research aimed at the monitoring, prevention and treatment of infectious diseases prevalent in the country. This includes the development of vaccines, drugs and novel treatment therapies, as well as the identification and monitoring of emergent pathogens.

MENTAL HEALTH AND SUBSTANCE ABUSE: The aim of this thrust is to manage research on mental health and substance abuse aimed at improving the mental health of the nation. The focus is on psychiatric disorders, as well as high priority psychosocial conditions, such as family violence, teenage pregnancy, suicidal behaviour, alienation, vandalism and alcohol abuse. The focus is also on mental health through research on psychological well-being, positive human relationships and youth life skills development.

NUTRITION: This thrust identifies the extent and depth of nutrition problems and determinants, in collaboration with other research groups nationally and internationally. It prioritises, funds and monitors nutrition research, with the goal of achieving optimum nutrition for all.

ORAL AND DENTAL RESEARCH: This thrust undertakes both institute- and community-based research aimed at developing research capacity to attain oral health in a cost-effective and appropriate manner, thereby improving the quality of life of all South Africans.

TRAUMA: This thrust produces data required by health decision makers to serve a defined RDP priority, namely, accessible and affordable emergency services for injured people, structured on a regional basis. Such injuries arise from road traffic, occupational and domestic accidents, violence and sport. The information addresses the design needs of both services planning and prevention strategies. Research related to disability is also included.

WOMEN'S HEALTH: This thrust encompasses the following: reproductive health, diseases common to women, leading causes of death among women, gender influences on health risk, societal influences on women's health, violence against women and health care policy in relation to women. Research is conducted on the physical, mental and social ill health and well-being of women, as well as adolescent and male sexuality and fertility. Special emphasis is given to gender biases in research and clinical practice.

Bridging Thrusts

Burden of disease: This research activity aims to estimate the national burden of disease from available data, conduct research to develop model systems for improved collection of health information, quantify the impact of risk factors on health and evaluate the cost-effectiveness of interventions.

Clinical and experimental research: Clinical and experimental research embraces all activities seeking to extend knowledge and clinical understanding of health and disease, and the prevention and treatment of disease. The thrust includes epidemiology, clinical science and laboratory science.

Health promotion and disease control interventions: The health promotion research thrust undertakes and supports high-quality health promotion research designed to improve the health and well-being of the South African population, especially disadvantaged groups, and to inform policy and service provision. Disease control interventions refer to interventions against known and existing health problems, or threats to health. The goal is to reduce the incidence of disease. The thrust deals with research aimed at defining effective interventions aimed at controlling disease.

Health systems: This thrust works in collaboration with other stakeholders to contribute to funding, conducting, co-ordinating and disseminating health systems research. The purpose of the research is to improve the impact of health interventions on the health of all South Africans.

Health technology development: This thrust manages and directs the research, development, transfer and promotion of novel clinical, diagnostic and therapeutic technologies emerging from the MRC and allied science bases in order to meet the health needs of South Africa.

Molecular medicine: This thrust undertakes a broad range of molecular biology research supporting the content thrusts and basic research. It is primarily directed towards processes and methods and focuses on areas of secondary and tertiary health problems and effective interventions at each level.

Research methods development and support: This thrust, which is staffed by intra- and extra-mural research methodologists, focuses on the provision of methodological support for health research. It promotes the use and understanding of research methods and develops new approaches, all of which are needed by the MRC thrusts in order to improve the scientific quality of health research in South Africa.

The MRC currently supports university-based Centres, Units and Groups where multidisciplinary research is conducted on a contracted research topic for a particular period. These centres of excellence are the incubators of our future scientists and researchers, and an important hive of capacity development. They are set up around world renowned experts or teams of experts in their fields.

Anxiety and Stress Disorders Research Unit

Dr Dan Stein (Director) Dept of Psychiatry, University of Stellenbosch.

The Unit focuses on post-traumatic stress disorder, social phobia, obsessive-compulsive disorder, panic disorder, and other related conditions.

Bioenergetics of Exercise Research Unit

Prof TD Noakes (Director) UCT Sports Science Institute.

This Unit investigates the physiological and other factors which determine exceptional sporting ability, as well as the factors which explain fatigue during exercise, the aetiology of sporting injuries, and the role of exercise in the prevention and treatment of disease.

Bone Research Unit

Prof U Ripamonti (Director) Univ of the Witwatersrand.

This unit aims to gain insights into the mechanisms of bone, cartilage and connective tissue morphogenesis, development and regeneration, and to promote and accelerate the healing of bone in man. The expertise at this unit, which is committed to training postgraduate students, is poised to make significant contributions to new knowledge in SA and internationally.

Inter-University Cape Heart Research Group

Prof Lionel Opie (Director) , Medical School, Univ of Cape Town.

This group is at the forefront of heart disease research in SA, and its multidisciplinary approach (including surgery, molecular biology, lipidology and genetics) will ensure that a vast area of research is covered.

Centre for Molecular and Cellular Biology

Prof PD van Helden (Director), Dept of Medical Physiology & Biochemistry, US.

This Unit's mission is: to study disease at a molecular and cellular level; to serve as a reference facility for development of expertise in molecular biology; to train young researchers and link into other MRC research projects; and to support biotechnological demands of the medical and industrial sectors.

Diarrhoeal Pathogens Research Unit

Prof D Steele (Director), Dept of Virology, MEDUNSA.

This Unit's mission is to study viral and microbial agents associated with diarrhoea in infants and young children in Southern Africa. Specifically, to investigate the molecular epidemiology of rotavirus infection in Southern Africa with a view to optimising the future implementation of a rotavirus vaccine strategy, and to study the molecular pathogenesis of rotavirus infection using the vast array of clinical material we have and using detailed molecular analysis of the associated viruses.

Genital Ulcer Disease Research Unit

Prof AW Sturm (Director), Dept of Medical Microbiology, Faculty of Medicine, Univ of Natal.

The focus of this unit's work is pathogenesis, a broad field which includes immunology, cellular and molecular biology and microscopy among other disciplines, and makes an important contribution to the health problems of South Africans.

Health Policy Research Group

Dr Helen Schneider (Director), Univ of the Witwatersrand Centre for Health Policy SAIMR, PO Box 1038, Johannesburg 2000.

The Health Policy Research Group aims to find answers to the health questions of the day, and analyses why, despite good ideas, the "right" decisions are not made or implemented.

Liver Research Centre

Prof RE Kirsch (Director), Dept of Medicine, Faculty of Medicine, University of Cape Town, Observatory 7925.

The Centre's mission is to serve our nation by: increasing the understanding of the liver in health and disease; identifying and studying diseases of the liver commonly occurring in Southern Africa; identifying and studying measures capable of preventing liver disease; identifying and studying methods of improving the health of patients with liver disease; disseminating information which will allow health authorities and health workers to prevent liver disease, promote health by emphasising dangers such as alcohol abuse and improve the care of patients with already existing liver disease; and developing human resources capable of continuing to fulfil our mission and in doing so to give preference where possible to persons disadvantaged as a result of discrimination on the basis of their race or gender.

Mineral Metabolism Research Unit

Prof JM Pettifor (Director) Dept of Paediatrics, Baragwanath Hospital, PO Bertsham 2013

This Unit's mission is to investigate: aspects of paediatric and adult metabolic bone disease of particular relevance to South Africa, so as to improve our understanding of the pathogenesis of the various conditions, and to optimise preventative and therapeutic approaches to their management; and the basic physiological and biochemical actions of vitamin D.

Molecular Hepatology Research Unit

Prof MC Kew (Director), Dept of Medicine, Faculty of Medicine, Univ of the Witwatersrand.

This Unit investigates, at a molecular level, the mechanisms involved in the pathogenesis of hepatocellular cancer in Southern African blacks. The hepatitis B and C viruses have been shown to be risk factors for this tumour, but only the hepatitis B virus DNA is integrated into the host DNA (the hepatitis C virus is an RNA virus, but its replicative intermediates have not been shown to integrate). Different mechanisms are therefore involved in causing malignant transformation of hepatocytes, and these are being investigated.

Molecular Reproductive Endocrinology Research Unit

Prof RP Millar (Director), Dept of Chemical Pathology, Faculty of Medicine, University of Cape Town, Observatory 7925.

The Unit's mission is to undertake research on human reproductive hormone cascade at a molecular, physiological and clinical level. The emphasis of the research is on the delineation of the molecular interaction of gonadotropin-releasing hormone (GnRH) with its receptor. This is a central event in the reproductive system and our findings have allowed the development of therapeutic interventions in reproductive hormone-dependent diseases.

Oesophageal Cancer Research Group

Prof Iqbal Parker (Director), Medical School, Univ of Cape Town.

The aim of the group is to alleviate the burden of oesophageal cancer and implement all the work in patient care. This group follows a matrix approach, interlinking research efforts from demography to DNA to address this serious problem.

Perinatal Mortality Research Unit

Prof HJ Odendaal (Director), Dept of Obstetrics & Gynaecology, Faculty of Medicine, Univ of Stellenbosch.

The mission of this Unit is to: determine the most common causes for intra-uterine and neonatal deaths; establish how the perinatal mortality rate can be improved, once the main causes have been ascertained; establish the best methods for selecting patients at risk for specific obstetric conditions and how the fetus can be assessed in these patients; to establish the causal factors for abruptio placentae; and to investigate possible causes of preterm labour.

Pneumococcal Diseases Research Unit

Prof K Klugman (Director), Dept of Medical Microbiology, SAIMR, PO Box 1038, Johannesburg 2000.

This Unit investigates the treatment, diagnosis and control of pneumococcal disease. The pneumococcus is the leading bacterial cause of pneumonia and meningitis in both children and adults in South Africa.

Pregnancy Hypertension Research Unit

Prof J Moodley (Director), Dept of Obstetrics & Gynaecology, Medical School, Univ of Natal, PO Box 17039, Congella 4013.

This Unit investigates the aetiological factors involved, and establishes appropriate clinical protocols for the successful management of hypertension in pregnant women.The Unit will aim to improve the understanding and management of pregnancy complicated by hypertension by research aimed at establishing the cause of the condition, implementing new treatment methods and performing drug studies to establish agents which will lower high blood pressure without any side-effects to the mother and fetus.

Research Unit for Inflammation and Immunity

Prof R Anderson (Director), Immunology Division, Dept of Microbiology, Faculty of Medicine, Univ of Pretoria.

This Unit's mission is to investigate the involvement of various aspects of lifestyle such as cigarette smoking (active and passive), atmospheric pollution in the workplace and home, excessive exposure to sunlight and dietary habits, especially low intake of the anti-oxidative nutrients vitamin C, vitamin E and beta-carotene as potential risk factors for the subsequent development of cancer, cardiovascular diseases and other degenerative disorders. These studies are of critical importance in designing preventive health strategies.

Research Unit for Maternal and Infant Health Care Strategies

Prof Bob Pattinson (Director), Dept of Paediatrics, Univ of Pretoria Kalafong Hospital.

This research unit strives to translate its research results into implementable health strategies which will make a huge difference to maternal and infant mortality. It also provides opportunities for building capacity among black students.

Research Group for Traditional Medicines

Prof P Folb (Director), Dept of Pharmacology, Faculty of Medicine, Univ of Cape Town, Observatory 1925.

A Joint venture between the MRC, the School of Pharmacy of the University of the Western Cape, and the Department of Pharmacology of the University of Cape Town, the project aims to achieve the following within a 5-year time-frame: a comprehensive traditional database for East and Southern Africa; a traditional medicines formulary; laboratory screening of traditional medicines for activity in malaria and tuberculosis; development of systems for scientific understanding of the action and uses of 'essential' traditional medicines in the treatment and prevention of disease; a collaborative network within Southern Africa and Kenya, and in due course more widely on the African continent; systematic documentation of indigenous knowledge of traditional medicines; contribution to national policy in South Africa governing the use of traditional medicines, their regulation and control; and the conservation of plants used for this purpose.

The MRC currently supports about 350 short-term researchers at academic institutions throughout South Africa. The MRC has adapted the internationally accepted Essential Nation Health Research (ENHR) concept to suit local needs and conditions. The ENHR is a strategy for managing research in an intersectoral multidisciplinary manner. This philosophy is based on the strengths of the past, that is, a strong core of expertise in science, with a new priority of public health. Integrated management of research is effected by the MRC's research teams who network with health policy-makers, other researchers and stakeholders in research such as universities and technikons, and with the wider research community.

The MRC's annual budget is in the region of R100 million, and the organisation employs 425 people. The MRC has an extensive continuing education programme aimed at training researchers. The focus is on post-graduate level training incorporating an internship programme, short courses locally and abroad, grant-in-aid training, seminars, workshops, science writing and methodology training. The overall aims are the improvement of the skills base through accreditation of South African researchers and faculty staff, facilitating local and international research collaboration and promoting an awareness, understanding and appreciation of science among the population at large.

The MRC has more recently undergone a reprioritisation, which has culminated in a new corporate Strategic Plan for 1999 - 2002. This incorporates the recommendations of the SETI review, carried out on all science councils during November 1997 by an international panel. The Strategic Plan outlines a strategic vision for the next 3 years in accordance with the following fundamental values:

- The promotion of human rights in health research,
- Fostering innovation,
- Its role as a learning organisation, and
- Organisational sustainability.

The burden of disease and the health profile of the country form the basis of our research portfolio and resource allocation. The framework for the MRC's health research in South Africa is being Africanised. This has led to reprioritisation of programmes and the strengthening and development of others to reflect the disease priorities and needs of the country and region.

Strategic intent and goals for the period 1999-2002

These are now formulated as follows:

- To be a leading **learning organisation** with international status and credibility;
- To create **health innovations** through transdisciplinary research and knowledge management in consultation with stakeholders;
- To develop an appropriate S&T base and capacity to address current and future health challenges while creating **sustainability** and growth; and
- To entrench the culture of **human rights** as a core value system in health research and all of the organisation's activities.

The MRC has introduced **large lead projects** which are aimed at impacting on top national health priorities. These projects are multidisciplinary, intersectoral, have clear objectives and outcomes, funded from various sources, and have fixed life cycles of between 5 and 7 years.

The first is the **South African AIDS Vaccine Initiative** (SAAVI), a collaborative project between government, industry, academic institutions and non-governmental organisations, led by the Department of Health and co-ordinated by the MRC. Its major objective is to develop and implement an affordable, accessible vaccine against HIV.

Telemedicine: The MRC is playing a leading role in this important initiative together with the Department of Health, academic centres, medical schools and industry. The project aims to extend health services to communities that previously have not had these facilities by cost-effective means.

Two other lead projects are **biotechnology and human genomics,** and **crime and violence.** Other projects that will be developed into major lead programmes by the MRC are **TB and malaria** (its TB programme is currently undergoing review), **cancer and cardiovascular diseases**.

Transdisciplinarity

Another one of the key innovative elements involved in implementing the MRC's reprioritisation strategy is transdisciplinarity. Transdisciplinary health research applies a range of methods and expertise in collaborative teams nationally and internationally to answer specific health questions, spanning the entire spectrum from curiosity-driven to applied research and policy formulation. Because it strengthens purpose-specific alliances with a range of partners, one is able to mobilise the best available resources and build capacity to tackle pressing health and developmental problems, in a focused way. An example of the MRC's transdisciplinary research is the MRC-HIVNET programme that links 8 sites within Africa involving 120 scientists (behavioural, ethical, basic, clinical, social, community representatives, etc.).

7.2.6 COUNCIL FOR MINERAL TECHNOLOGY (MINTEK)

Mintek is engaged in the full spectrum of mineral research, from mineralogical examination of ores, to extraction and refining technologies, and the manufacture of end-products. It is closely involved in the identification and development of markets for minerals and their products. Much of its work is carried out in close liaison with the South African mining and metallurgical industries. The importance of Mintek's work stems from the need to increase earnings from minerals by turning them into higher-value products before they are exported, in terms of the Mineral Technology Act, 1989 (Act 30 of 1989).

Mintek is an autonomous organisation responsible for financing an increasing proportion of its own activities. All new projects are assessed, not only on technical and scientific merit, but on their potential future commercial benefits for Mintek and its clients. Mintek's commitment to the RDP ensures that aspiring young engineers and scientists from disadvantaged sectors of the community are offered a chance to pursue technology-related careers. The Mintek MAP Programme, which was launched in-house in 1992, has now been replicated at 18 different locations in Gauteng, the Western Cape and KwaZulu-Natal. In 1997, some 400 disadvantaged youngsters were given the opportunity to upgrade their matric mathematics and science marks to the extent that they could embark on tertiary studies at universities and technikons. Since 1992, more than 1 000 students have successfully completed the MAP programme. Mintek's annual budget is over R100 million and it employs more than 600 people.

7.2.7 THE SOUTH AFRICAN BUREAU OF STANDARDS (SABS)

The mission of the SABS is to contribute, through its promotion of quality and standardisation, towards the strengthening of the South African economy and the enhancement of the quality of life of all the country's people. In carrying out its mission, the SABS, among other things, prepares and updates standards in collaboration with interest groups. It administers the SABS Certification Mark Scheme for products for which national standards exist. The SABS Certification Mark serves as proof that the product in question meets the appropriate standard specification.

Organisations with quality systems that comply with the relevant standards are registered and audited in accordance with the SABS ISO 9000 Registration Scheme. Consignments are inspected and tested on behalf of purchasers to verify conformity with agreed requirements. Precision instruments and measuring and scientific apparatus are tested and calibrated, and certified reference materials are supplied for test purposes. Trade metrology functions also form part of the SABS's responsibility. The division for Trade Metrology conducts regular surveys on the mass and volume of consumables, such as bread, wine and potatoes to determine whether dealers adhere to the requirements of the Trade Metrology Act, 1973 (Act 77 of 1973). The SABS is a member of the International Organisation for Standardisation and the International Electrotechnical Commission and is closely involved in the activities of the SADC and the Pacific Area Standards Congress. At the end of 1996, the SABS introduced a new product called environment management system certification (SABS ISO 14001). By March 1998, 14 companies had been registered in accordance with SABS ISO 14001 and an increasing number are becoming aware of environmental management.

7.3 NATIONAL FACILITIES

There are four national research facilities, which report to the NRF and are subsidised by the state. They are the Hartebeesthoek Radio Astronomy Observatory near Krugersdorp in Gauteng, the J.L.B. Smith Institute for Ichthyology Research (Grahamstown), the National Accelerator Centre in Faure, Western Cape and the South African Astronomical Observatory in Cape Town and Sutherland.

7.3.1 HARTBEESHOEK RADIO ASTRONOMY OBSERVATORY (HARTBEESHOEK)

The Observatory began as Deep Space Station 51, built in 1961 by the National Aeronautics and Space Administration (NASA) of the United States of America. The station tracked many unmanned US space probes. These included the Ranger, Surveyor and Lunar Orbiter spacecraft which landed on the Moon or mapped it from orbit, the Mariner missions which explored the planets Venus and Mars and the Pioneers which measured the Sun's winds.

The station was handed over to the Council for Scientific and Industrial Research (CSIR) in 1975 and was converted to a radio astronomy observatory. In 1988, the observatory became a National Facility operated by the Foundation for Research Development (FRD). In 1999, the FRD was restructured as the National Research Foundation (NRF).

Arrayed with telescopes on other continents, HartRAO forms part of a set of "super" telescopes able to see details hundreds of times finer than the best optical telescopes. Called Very Long Baseline Interferometry (VLBI), this technique enables the masers of our galaxy to be pin-pointed and the fine details in jets from distant quasars (black holes in the hearts of distant galaxies) to be observed.

HartRAO is devoted to research on radio wavelengths. Objects that emit radio waves in the Milky Way Galaxy and other galaxies, are studied. The radio emissions at 13cm wavelength from the whole southern sky have been mapped with the HartRAO telescope, by a team from Rhodes University in Grahamstown, in order to study the faint outer reaches of our own Galaxy.

The main areas of expertise include:

- Continuum Radiometry
- Radio Spectroscopy
    - Atoms, Molecules and Spectroscopy - where, how and why
    - Local User Guide to Spectroscopic Observing
    - Pulsar Timing
    - Astronomical Very Long Baseline Interferometry (VLBI)
    - Geodesy using Geodetic VLBI, Satellite Laser Ranging (SLR) and the Global Positioning System (GPS).

Due to its location, HartRAO is in great demand for international experiments relating to the shape and behaviour of the earth. The experiments are designed to follow the drift of the continents across the surface of the earth, or the wandering of the earth's north and south poles. HartRAO now also forms the absolute reference point for the grid of national survey beacons. This will enable one to see whether global warming is causing sea levels to rise around our coasts. Conversely, one can now see whether the land itself is slowly rising or sinking.

7.3.2 JLB SMITH INSTITUTE FOR ICHTHYOLOGY RESEARCH (GRAHAMSTOWN)

The JLB Smith Institute of Ichthyology is an internationally recognised centre for the study of fishes. Prof. JLB Smith, famous for naming and describing the living coelacanth, *Latimeria chalumnae*, established a Department of Ichthyology at Rhodes University, in 1946. On his death in 1968, his wife, Margaret Smith, established the Institute which grew rapidly to become, in 1980, an independent, Declared Cultural Institution under the Department of Education and later in 1994 the Department of Arts, Culture, Science and Technology. The JLB Smith Institute became a National Facility within the NRF on 1 January 1999 after the Government Gazette publication of notices 103 and 104 on 29 January 1999. The Institute still maintains strong ties with Rhodes University as an Associated Institute.

The role of the Institute is fourfold:

- To care for the national collection of fishes and JLB Smith library;
- To promote research on the fishes of Africa and surrounding seas;
- To promote knowledge and awareness of fishes and aquatic conservation;
- To train new generations of African fish scientists.

The Institute's Collection of Fishes is a national asset that is held in perpetuity for the benefit of science and future generations. It includes more that 60 000 accessioned lots and over 450 000 marine, estuarine and freshwater specimens taken mainly from the surrounding oceans and rivers of southern Africa. The collection catalogue is a comprehensive computerised database (FISHNET), supported by an extensive library and information service (FISHLIT). The library at the Institute is the leading African document- and book reference collection on all aspects of fish, fisheries and aquaculture relevant to the continent and the surrounding oceans. It is one of the few libraries in the world devoted to fish, and the largest such library in the Southern Hemisphere.

The Institute is service-driven and in 1992 launched a consultancy to deal with contracts and consultancies arising from work requested by the private sector and other institutions. There is also a large archive of fish paintings and photographs, as well as unpublished manuscripts and letters of ichthyologists and anglers that provide additional information on fish and fishing. The Institute produces its own scientific bulletins, special publications, educational posters, monographs and books. The in-house artists produce top quality illustrations for both scientific and popular articles and books.

Scientists at the Institute are involved in research on fishes in marine, estuarine and freshwater environments, ranging from the cold Southern Ocean to tropical Lake Malawi and the western Indian Ocean islands. Research in the Institute was initially directed at marine fish taxonomy but has diversified in recent years to include freshwater fish taxonomy, ecology, ethology, conservation, embryology, genetics, palaeontology, morphology and molecular biology. In addition, contract research is done on subsistence fisheries management and environmental issues.

7.3.3 NATIONAL ACCELERATOR CENTRE (FAURE)

The National Accelerator Centre (NAC) at Faure in the Cape, is a multi-disciplinary research centre, established in 1977 under the control of the CSIR (Council for Scientific and Industrial Research). Since 1988, it has been one of the National Research Facilities now administered by the NRF. NAC provides facilities for basic and applied research using particle beams, particle radiotherapy for the treatment of cancer and the supply of accelerator-produced radioactive isotopes for nuclear medicine and research.

Particle beams from NAC's large, state-of-the-art separated-sector cyclotron and from a 6MV Van de Graaf generator, are used for research and training in biophysics, atomic physics and radiobiology, in addition to the major research field of nuclear physics. NAC's research facilities have numerous users from around the country, including many postgraduate students. NAC makes an important contribution to postgraduate training, stimulating interdisciplinary cooperation and attracting young people to science, engineering and technology.

The large cyclotron was mainly motivated for and designed to be able to produce both neutrons and protons suitable for cancer therapy. The neutron therapy facility has been operating since 1989 and has treated more than 730 patients. Excellent early results have been obtained for certain types of tumours, such as salivary glands and advanced breast tumours. Proton therapy started in September 1993, making South Africa one of only five countries in the world to offer this kind of treatment. To date, over 100 patients, with otherwise inoperable conditions, have been treated.

NAC is the only centre in South Africa which can produce certain important medical isotopes like 67Ga, 81Kr, 111In 123I, 201Tl and their compounds. Some of these are too short-lived to be imported and would thus simply not be available to nuclear medicine if NAC should stop production. At present, about 30 major hospitals and other institutions, as well as nearly 10 000 patients each year, benefit from these services. NAC contributes to creating and maintaining a pool of technical knowledge and expertise in a variety of fields such as magnet-, vacuum- and radio-frequency technology, computer science, electronic and mechanical engineering and fabrication techniques.

Activities are based around four sub-atomic particle accelerators. The large k=200 separated sector cyclotron accelerates protons to energies of 200 MeV, and heavier particles to much higher energies. Charged particles to be accelerated are fed to it via one of two smaller injector cyclotrons, one providing intense beams of light ions, and the other, beams of polarized light ions or heavy ions. The fourth accelerator is a 6MV Van de Graaff electrostatic accelerator. Areas of expertise are organised into the following categories:

- Experimental Nuclear Physics
- Ion Beam Analysis
- Medical Radiation
- Radiation Biophysics Programs:

The NAC brings together scientists working in the physical, medical and biological sciences. The facilities provide opportunities for modern research, advanced education, the treatment of cancers, and the production of unique radioisotopes.

7.3.4 SOUTH AFRICAN ASTRONOMICAL OBSERVATORY (CAPE TOWN AND SUTHERLAND)

The South African Astronomical Observatory (SAAO) is the National Facility for optical/infrared astronomy in South Africa. The SAAO headquarters are located in Observatory, Cape Town, but the major observing facilities, consisting of modern instrumentation and large telescopes, are near situated near Sutherland in the Karoo. Its prime function is to further fundamental research in astronomy and astrophysics at a national and international level through the provision and use of a world-class astronomical facility.

SAAO, as it is today, was formed in the 1970s, when the Republic Observatory in Johannesburg and the Radcliffe Observatory in Pretoria were merged with the much older Royal Observatory at the Cape of Good Hope, founded in 1820. Headquarters are on the grounds of the old Royal Observatory, and the main building (completed in 1828) houses offices, the national library for astronomy, and computer facilities. Historic telescopes can be found in a number of domes on the grounds, and a small museum displays historic scientific instruments. The SAAO was founded as the Royal Observatory, Cape of Good Hope in 1820 and the main building, used now for offices for the staff, was completed in 1828. There are various telescopes of historical importance on the grounds.

Research at SAAO includes a broad range of topics in astronomy, and frequently involves international collaborations. Topics of recent papers using SAAO observations have included quasars, the clustering of southern galaxies, the structure and evolution of our galaxy and its neighbours the Magellanic Clouds, the nature of halo stars, stellar pulsation and cataclysmic variables. The scientific research done at SAAO is mostly in the field of stellar astronomy. The Sutherland site is particularly well suited for accurate measurements of the brightness of stars (photometry). Optical and infrared photometry therefore feature strongly in the interests of the astronomers. Stellar spectroscopy is also a major area of research, and interest has increased with the availability of a high-performance echelle spectrograph.

These techniques are used in the study of various types of pulsating stars, magnetic white dwarfs, and hydrogen deficient stars among others. A survey for faint blue stars has resulted in the discovery of a new type of pulsating star. Recently, a search for planets around other stars using the effect of gravitational lensing has begun. In all these projects, strong international collaboration is a feature.

7.4 UNIVERSITIES AND TECHNIKONS

South Africa has 21 universities and 15 technikons. Universities and technikons are funded by the research councils and by the Department of Education (DoE). The DoE provides institutional support (academic salaries) and research support (through a funding formula). The existing funding formula is based on three things:

a) Number of students enrolled
b) Number of degrees awarded
c) University research output.

7.4.1 Type of research and development

There is a clear shift in the nature of research being produced within the Higher Education Sector (HES). Compared to earlier R&D surveys, the Audit of 1995/96 found a significant increase in applied and strategic research being undertaken. Although half of all research in the HES is classified by researchers as basic research (1995), this constitutes a substantial decline when compared to 1991 figures, where 75% of HES research was classified as basic. How substantial this shift has been is also evidenced by the fact that half of the research classified as "basic" is further categorised by scholars to be strategic research and the remaining half as fundamental. Applied research now makes up 37% and development work 13% of all research in universities and technikons. R&D is heavily concentrated in five universities and 3-5 technikons. With the exception of one technikon, all these institutions are historically advantaged.

A summary of the type of R&D across all institutions is provided in Figure 7.1 below. The overall proportion in terms of the standard categories of Basic, Applied and Development Work is 50: 37: 13. Although it is worth noting that researchers in the HES classify half of their work as Basic Research – and this is a consistent trend over the past decade – it is equally interesting that more than half of this “basic” research (27%) is aimed at some form of future application (the definition of “strategic” research). Stated differently: only 23% of all research done in the HES is classified by researchers as fundamental or curiosity-driven research. We would suggest that this is one of a number of indicators that signify a clear trend towards more "application-driven research" (to use Gibbons et al's term) at South African universities and technikons. The fact that this means that less "fundamental" research is being done at our institutions of higher learning, is cause for concern.

Figure 7.2: Type of R&D (HES)

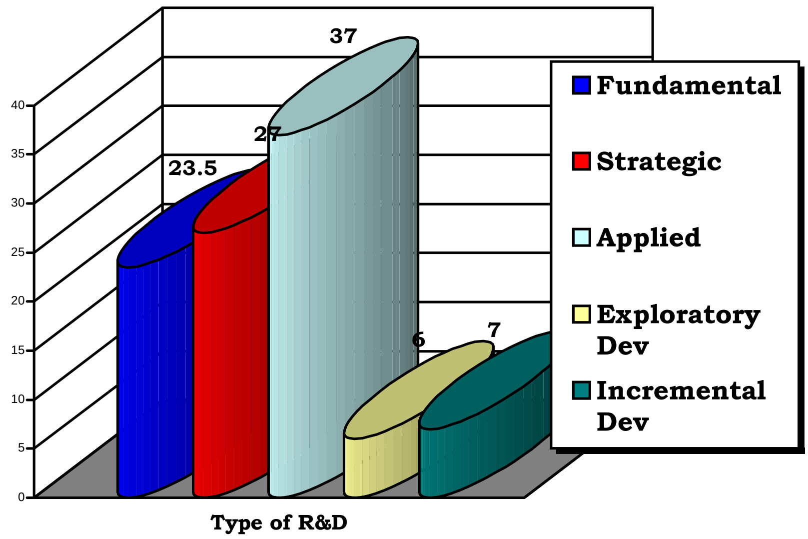


Table 7.1: Type of R&D by science culture (HES)

Science culture	Basic	Applied	Development	N
Arts	64	24	12	100
Economic and Business Sciences	43	39	18	100
Engineering Sciences	29	44	27	100
Humanities	67	25	8	100
Medical and Health Sciences	34	50	16	100
Natural Sciences	53	37	10	100
Social Sciences	47	38	15	100
	48%	37%	15%	700

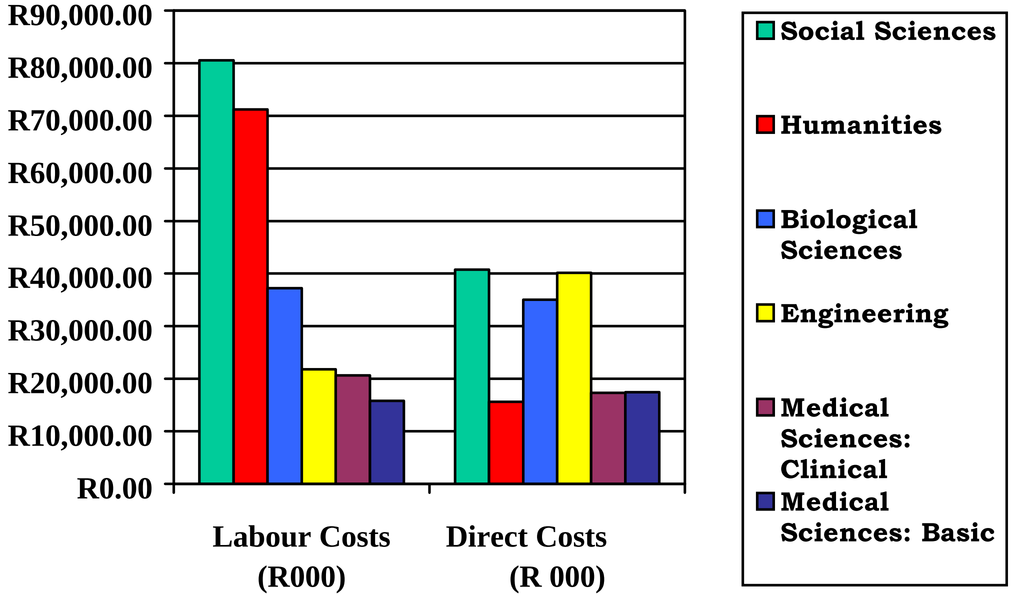
(Note: The sumtotal of 6129 is the result of the fact that respondents could categorise their projects in more than one of the three categories)

Not surprisingly, science cultures such as the Arts (64%) and Humanities (67%) devote more of their time to Basic Research compared, for example, to the Engineering Sciences (29%) and Medical and Health Science (34%). Conversely, Applied Research and Development Work gets more attention in Engineering Sciences.

7.4.2 Expenditure on R&D

Total Expenditure on R&D in the HES is estimated to be approximately R660 million in 1995. This total is made up of estimated labour costs of R357 million, specific projects costs of R285 million and expenditure on replacing and upgrading equipment of R21 million. A comparison with the 1991 R&D Survey (R690million) suggests that these are very conservative estimates. In fact, spot checks of the weighted expenditure figures for certain universities, confirmed that our estimates are lower than the institutional research budgets. However, one has to add that these budgets differ greatly in terms of which items are included or excluded. Suffice it to say that we believe that the estimate of R660 million represents the more conservative estimate. The breakdown by institution again reveals huge differences between institutions in this section. The top five universities (UCT, UP, US, Wits and UN) contribute more than 60% to total direct expenditure! As far as expenditure by Main Scientific Field is concerned, it is important to distinguish between labour costs and operational costs (The first is skewed because of the large number of scholars in the humanities and social sciences).

Figure 7.3: Labour and directs costs by main science field (HES)



7.4.3 Sources of funding

University and technikon researchers get most of their funding for R&D from sources external to the university (64%), a further 22% through second stream funding (funding agencies) and a small proportion (14%) from their own institution. However, one should add that the category of "external funding" includes a variety of sources ranging from government contracts, business and industry funding and overseas foundations/donations. A finer analysis shows that approximately 65% of "external funding" is from South African sources: including business, public enterprises like Sasol, Eskom, Telkom; government departments and local foundations and trusts. Most of the 35% from overseas is contributed by foundations such as Glaxo Welcome, Ford, USAID, DANIDA, Kellogg, Mellon, Von Humboldt and so on.

7.4.4 R&D output

The discussion below compares output (unweighted) across organisation and also focuses on measures of "productivity", such as per capita output (number of publications, conference papers, technologies per scientist) and cost-output ratio. The absolute volume (e.g. total number of scientific publications) in itself is not meaningful and will only become so after future follow-up studies. The table below summarises per capita output for four categories across the universities. The categories are "scientific publications" (local and overseas journal articles, monographs, chapters in books and published conference proceedings); "conference papers" (local and overseas), "reports" (contract and technical reports) and "technologies" (product, process, information and support technologies).

Table 7.2: Per capita output by organisation (Universities)

Org	Nr	Total Publs	Per capita	Conf Papers	Per capita	Reports	Per capita	Techno -logies	Per capita
RAU	159	605	3.81	439	2.76	154	0.97	77	0.48
UN	132	460	3.48	382	2.89	99	0.75	17	0.13
UCT	242	839	3.47	559	2.31	211	0.87	28	0.12
Wits	176	540	3.07	458	2.60	125	0.71	26	0.15
UP	366	1094	2.99	935	2.55	331	0.90	129	0.35
Rhodes	72	214	2.97	144	2.00	39	0.54	4	0.06
US	246	725	2.95	640	2.60	154	0.63	51	0.21
UFS	129	351	2.72	396	3.00	65	0.49	27	0.20
UPE	49	125	2.55	105	2.14	82	1.67	18	0.37
Medunsa	53	128	2.42	114	2.15	30	0.57	7	0.13
UWC	109	246	2.26	222	2.04	87	0.80	2	0.02
PUCHE	150	327	2.18	270	1.80	70	0.47	8	0.05
UDW	49	105	2.14	111	2.27	20	0.41	4	0.08
UNIN	48	102	2.04	69	1.44	37	0.77	14	0.29
UNISA	528	932	1.77	626	1.19	207	0.39	24	0.05
UNIZUL	59	86	1.46	65	1.10	35	0.59	12	0.20
Vista	40	48	1.20	48	1.20	12	0.30	6	0.15
	2607	6927	2.56	5583	2.12	1758	0.70	454	0.18

[Note: Small sample sizes obviously could skew results. We have, therefore, excluded Univen, NorthWest, UFH and Transkei because of sample sizes of less than 40).

The most recent bibliometric analyses of South African scientific output (not exclusive to universities and technikons) reveals a steady decline in comparative output. In a study by Pouris (1996), he shows that the number of publications by South African authors in ISI journals (SCI, SSCI and the AHI) was relatively stable between 1987 and 1998. However, when compared to other countries and calculated as a proportion of world output, these figures reveal a steady decline. One indicator of such a decline is the fact that countries that were below or at the same level as South Africa in 1987, have subsequently surpassed her. These countries are Norway, South Korea, Brazil, Taiwan and the People's Republic of China.

Once could argue that these results are not as negative as they appear on first glance. Given the dramatic rise in student enrolment at most universities during the early nineties, as well as the fact that most universities did not increase their staff complements accordingly, the result was that most academic staff had to cope with increased workloads and administrative duties. A more complete picture of the output of South African scientists during this period would, therefore, have to include output in local South African journals as well. Only 31 South African journals (out of a possible 200) are indexed in the ISI indices.

There is some evidence to suggest that the decline in output in overseas journals, has been off-set by a small, but significant increase in SAPSE accredited journals (which includes 250 South African journals. If one looks at publications by university staff alone, there as been an increase of nearly 25%, from an output of 4463 units in 1986 to 5614 in 1998. Further analysis reveals significant shifts in the relative contributions from various "groupings" within the university sector. The relative contribution of Afrikaans-medium universities has increased slightly from 37.2% in 1986 to 40% in 1997. The proportion of outputs from English-medium universities has declined substantially from 53.5% in 1986 to 41.1% in 1997. Although the contribution of the HBUs to the overall output is still low, they have more than doubled their contribution from a base of 5.1% in 1986 to 11.7 in 1997. UNISA's contribution has also increased from 4.1% in 1986 to 7.3% in 1997. These patterns are presented in Figure 1 below.

Figure 7.4: Profile of SAPSE research outputs according to "grouping"

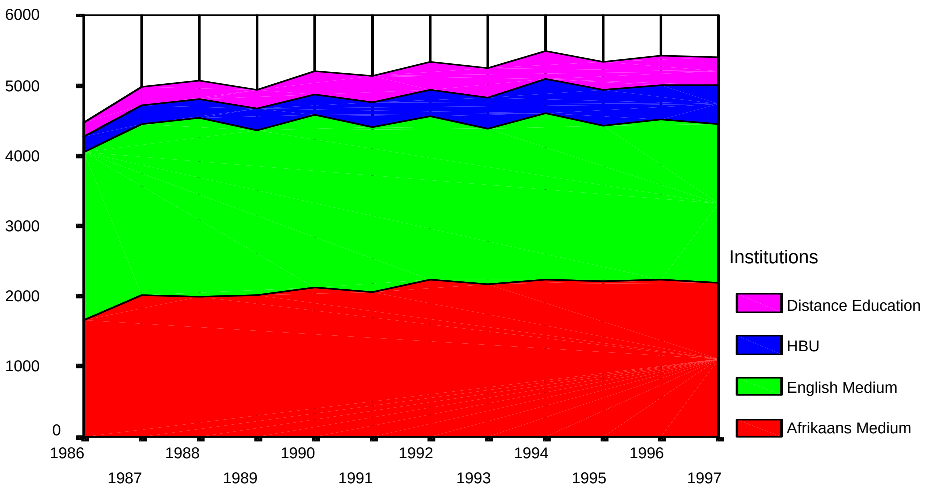
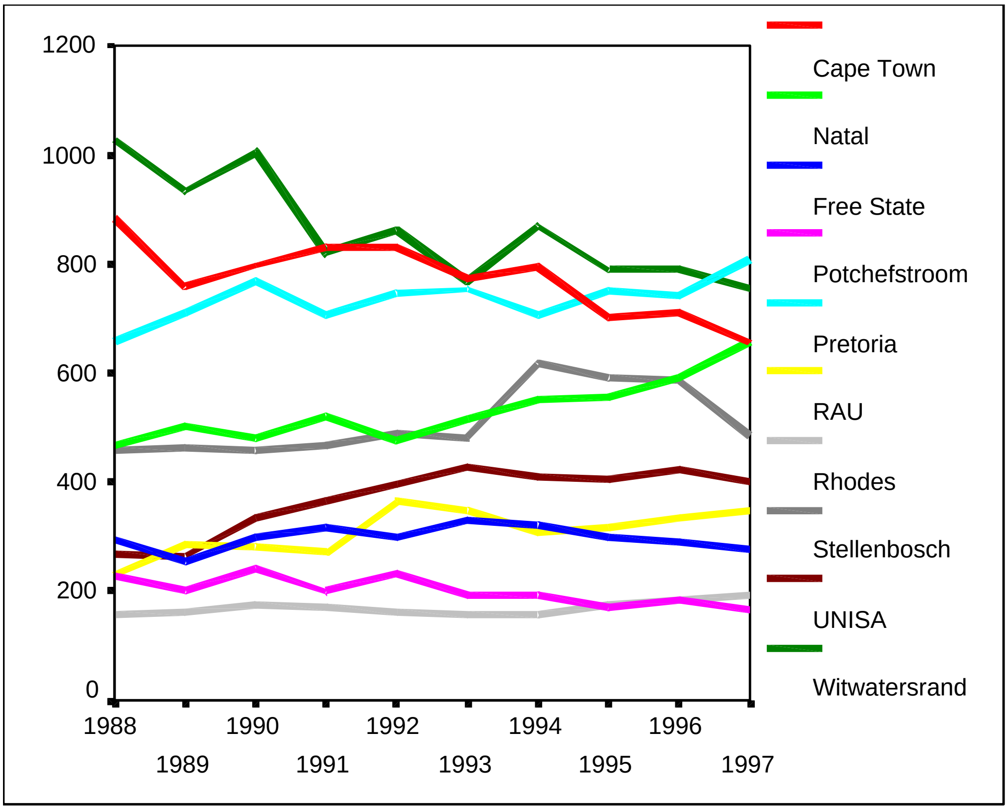


Figure 7.5: Trends in SAPSE research outputs (top ten universities)



7.5 GOVERNMENT BASED RESEARCH UNITS

Although not one of the major sectors of R&D performance, government (both nationally and provincially) still incorporates a number of departments, institutes and programmes that are involved in significant research performance. This section presents a brief discussion of the most important of these units.

7.5.1 SOUTH AFRICAN NATIONAL ANTARCTIC PROGRAM

The mission of the South African National Antarctic Program (SANAP) is to increase understanding of the natural environment and life in the Antarctic and Southern Ocean through appropriate science and technology. This is necessary in order to optimise present and preserve future options for South Africa in the region and to enhance predictive capability in areas of relevance nationally and internationally, and also to ensure that South Africa remains party to informed decision making on matters in the national interest. SANAP is managed under the auspices of the Directorate: Antarctic and Islands of the Department of Environmental Affairs and

Tourism, Republic of South Africa. SANAP encompasses three research stations, viz. a meteorological station at Gough Island, a meteorological and biological research station at Marion Island, and a physical sciences research program at the SANAE base in Queen Maud Land, Antarctica.

SOUTH AFRICAN NATIONAL ANTARCTIC EXPEDITION

SANAE, the South African National Antarctic Expeditions, are South Africa's contribution to the exploration and understanding of the Antarctic continent. South Africa is one of the original signatories of the Antarctic Treaty, and occupied bases, all year round, on the Fimbul Coastal Ice Shelf of Western Queen Maud Land since 1960. The new South African base, "SANAE IV", was completed in the summer of 1997/8 and is the newest base on the continent.

As a signatory to the Antarctic Treaty, South Africa bears responsibilities both in research of the Antarctic and as a custodian of this continent of peace. The country executes these duties through SANAE. The SANAE IV base, that incorporates several unique features, can comfortably accommodate 20 over-wintering personnel and a further 60 personnel in the summer. It was designed and built with international scientific programs and co-operation and the sharing of facilities in mind.

SOUTH AFRICAN NATIONAL ANTARCTIC PROGRAMME'S SCIENTIFIC PROJECTS

- Physical sciences
- Earth sciences
- Life sciences
- Oceanographic sciences.

Only the physical sciences programme is conducted year-round at SANAE IV. The other programmes are conducted during the short summer period when the temperatures and weather permit fieldwork and the extent of the sea ice is at its minimum.

The Southern Hemisphere Auroral Radar Experiment (SHARE)

SHARE is a high frequency coherent phased array radar experiment. The SANAE array is operated in conjunction with the similar systems at the British Antarctic Survey's Halley Station and the Japanese Antarctic Research Expedition's Syowa Station, each approximately 1000 km from SANAE. Data from the radars are combined to provide information about electric fields, velocities and irregularities in the upper atmosphere over a large region of Antarctica. SHARE is an international collaboration involving the University of Natal, Potchefstroom University, The British Antarctic Survey and John Hopkins University Applied Physics Laboratory. SHARE is part of the world-wide Super Dual Auroral Radar Network (SuperDARN).

Antarctic Magnetosphere, Ionosphere Ground-based Observations (AMIGO)

AMIGO is a collaborative programme between the University of Natal, Durban's Space Physics Research Institute and Potchefstroom University's Space Research Unit. It contributes to the international co-operative programme STEP (Solar-Terrestrial Energy Programme). AMIGO's objectives are to investigate energy transfer processes in the magnetosphere and ionosphere, especially those associated with sub-storms, VLF-particle interactions, radio propagation, hydro-magnetic waves, ionospheric irregularities and disturbances. This is achieved by carrying out a programme of ground-based observations of wave and particle phenomena in the magnetosphere-ionosphere system

Antarctic Research on Cosmic Rays (ANOKS)

The objectives of this programme are:

- Tto investigate transport and acceleration of solar and galactic cosmic ray charged particles in the heliosphere from neutron monitor recordings and to integrate these recordings with data obtained by neutron monitoring ground based stations at other locations and by satellite or spacecraft observations.
- To pass on hourly neutron monitor count rate data to World Data Centres that do long-term investigations and small count rate data from studies of ground solar level events.

Astrid satellite telemetry station

SANAE runs the Southern Hemisphere's telemetry for Swedish satellite Astrid 2. The tracker can also be used in a joint Swedish/Danish/SA collaboration involving the Oersted satellite. SANAE is a partner in the Astrid 2 project and has access to all data downloaded and software from the satellite. In return SANAE provides simultaneous ground based aurora, magnetometer and VLF radio wave measurements.

Upper Atmosphere Physics

SAOZ measures total column ozone. Results showed the influence of the ozone 'hole' at SANAE. Provides the potential for studying trends in ozone depletion. YES measures UV fluxes in the wavelength 280-320 nm. There is a complex relationship between ozone depletion and UV fluxes. These measurements complement those of the SAOZ. The dynamics of ozone depends on a stratospheric polar vortex that develops in the Austral Spring. This programme explores this by the use of identical SAOZ and YES equipment in Durban. These observations are also used to complement satellite measurements of ozone.

GPS Project

SANAE's GPS project is a common effort of the Chief Directorate Surveying and Land Information in Cape Town, South Africa and the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven, Germany. The receiver, a TRIMBLE 4000SSi with Choke Ring antenna, was installed in March 1997. The station has become part of the worldwide network of IGS stations (International GPS Service for Geodynamics) and is also used for local geodetic surveys.

The GPS station at SANAE was a key station within the frame of the SCAR-GPS campaign in 1998. The objectives of this GPS campaign were:

- linking of Antarctica with the Global Terrestrial Reference Frame (ITRF) with highest accuracy;
- confirmation of the relative rates and direction of the Antarctic Plate with respect to the adjoining plates and microplates;
- determination of the relative motion of crustal segments within the Antarctic Plate;
- unification of the vertical datum, determination of the height of the mean sea level at tide gauge stations;
- determination of the vertical motion of the Antarctic lithosphere due to the changes of the ice and ocean loading.

In addition, permanent fixed GPS monitoring sites can be used for estimation of tropospheric and ionospheric trends and effects.

7.5.2 THE SOUTH AFRICAN WEATHER BUREAU (SAWB)

The South African Weather Bureau sets as its mission to strive to provide a cost effective and efficient meteorological service to safeguard life and property, to improve social and economic structures and to protect the environment. In order to achieve this, the Directorate: Research and Training is dedicated to a common research goal of undertaking applied meteorological research and training, comparable to world standards, in support of all meteorological services rendered by the Weather Bureau to the South African public, and to the regional and international community.

The background against which all research activities must be reflected, is the very limited financial and human resources available to the South African Weather Bureau (SAWB). It is, however, acknowledged that research is imperative to ensure improvement of the operational activities of the Weather Bureau in order to comply with the stated mission, and to promote the principles of the RDP and GEAR. In order to conduct research of international standards, the Directorate: Research and Training is committed to being dynamic and transformation-oriented, and to promote client-oriented service delivery.

In pursuit of the mission, the most important issues to be dealt with are improving the ability of the SAWB to predict future weather and climate related natural disasters, from floods to droughts, in order to lengthen the lead time necessary for decision makers to safeguard life and property. Active research needs to be conducted to improve severe weather predictions (nowcasting), short-range weather prediction, and monthly and seasonal predictions of natural events. As part of its commitment towards improved social and economic benefits, and to the improved management of the water resources of the country, the Weather Bureau is also committed to do research on precipitation enhancement. Finally, the SAWB is committed to the protection the environment and compliance with international protocols and conventions direct Ozone, UV-B, Environmental Emergency Response research and Global Atmospheric Watch activities.

PRECIPITATION RESEARCH PROGRAMME.

The enhancement of precipitation using cloud seeding technology and precipitation monitoring, by means of weather radar, falls under the Precipitation Research programme. It is widely acknowledged that the availability of water will become one of the main limiting factors for sustainable development in the world. It has been stated that two-thirds of the world population will live under severe water limitations by the year 2025. Southern Africa has been identified as one of the regions in the world that will face serious water shortages in the 21st century.

The first cloud seeding experiments by the SAWB started in the 1970s using a "black box" approach of looking for responses of seeding on the ground, either more rain or less hail or both. Later the principle of harvesting the clouds to increase precipitation efficiency were accepted, using glaciogenic seeding material and later dry ice. During the 1990s, the SAWB joined forces with the Water Research Commission (WRC) through a private company named Cloudquest.

As a consequence of the developing infrastructure of the cloud seeding experiments, the development of radar precipitation measurement technology was boosted to such an extent that an additional field of research was established, namely hydrometeorology. The basis of this research is the two weather radars at Bethlehem, the dense raingauge network at Bethlehem under the radar umbrella and streamflow equipment of the Department of Water Affairs and Forestry in nearby rivers. The development of good quality radar measured precipitation fields for operational use in heavy rain and flood forecasting is one of the important future products

MODELLING PROGRAMME

Numerical weather prediction is conducted under the Modelling Programme and involves all aspects of the implementation, maintenance and improvement of numerical prediction models. These models are used by other research programmes, weather forecasters and seasonal forecasters.

During the late 1970s and early 1980s, the SAWB operationally ran a 5-level primitive equation model. This model became obsolete in the middle 1980s. Efforts to develop an analysis and assimilation system locally as part of a modelling system failed due to a critical shortage of manpower, and insufficient computers.

In 1992, following the SAWB’s readmittance into the international arena, the first CRAY supercomputer was bought. Negotiations with the National Weather Service

(NWS) of the USA culminated into an agreement whereby the limited area Eta model was given free of charge to the SAWB. This model was subsequently implemented operationally, and followed later by the COLA model, the Global Spectral Model (GSM), and the WAM sea and swell model.

THE CLIMATE RESEARCH PROGRAMME

The Climate Research programme revolves around research into, and the compiling of monthly and seasonal outlooks of meteorological parameters, such as rainfall and temperature. The operational outlook centre (LOGIC for Long-term Outlook Group Information Centre) also falls under this programme and is the seasonal counterpart of the Central Forecasting Office for short-range weather predictions.

Seasonal prediction came into being in the SAWB in 1993 when the Research Group for Statistical Climate Studies (RGSCS) was formed. Initially it involved only statistical seasonal prediction, but in 1997 the dynamical outlook group was combined with the statistical group to form the Research Group for Seasonal Climate Studies (RGSCS). Statistical seasonal prediction involves the use of statistical techniques such as Canonical Correlation Analysis (CCA), Optimal Climate Normals (OCN), and Neural Networks to predict categorically rainfall or temperature for the season. Predictors at this stage are sea-surface temperatures for the tropical Pacific, Indian and Atlantic oceans. Principal Oscillation Patterns (POPS) and CCA are used to predict changes in sea-surface temperatures in the global oceans, concentrating on the tropical Indian and Pacific Oceans, and southern Atlantic Ocean.

The main aim of the climate research group is to conduct research in, and give outlooks of rainfall and temperatures for the coming season. The value of the outlooks is that they can be used by decision-makers should aid to reduce longer-term economic risk. The group's aims are the following:

- To do research in the improvement of current techniques of seasonal prediction, both statistical and dynamical, and to keep abreast with current techniques in seasonal predictions.
- To issue operational seasonal outlooks of rainfall and temperatures, through LOGIC, in order to aid the decision-makers in reducing their risk in decision-making.
- To distribute relevant information through monthly bulletins to the user community, not only locally but also relevant regional and international

climate centres.

- To advise various senior managers within and outside the Public Service on a regular basis regarding seasonal prospects.

THE SPECIAL ATMOSPHERIC RESEARCH PROGRAMME

The special atmospheric research programme envisaged the research and monitoring of atmosphere and environmental interactions, which in the event of human interference, could result in harmful effects to mankind and thus also have detrimental consequences for the people of South Africa. These contemporary but critical issues are focussed upon atmosphere environmental impact caused through factors such as:

- Atmospheric Ozone- ,UV monitoring and research;
- Solar Radiation - monitoring and research;
- Environmental Emergency Response with regards to radio-activity release into the atmosphere during a possible nuclear incident, and other major gas-venting episodes;
- Atmospheric trace gas - monitoring and research on climate change issues.

7.5.3 The National Institute for Virology (NIV)

The National Institute for Virology (NIV) functions as the national resource centre for viral diseases in South Africa. It is a public health institute within the Department of Health providing:

- Comprehensive medical virological diagnostic services
- Reference virology services
- Viral surveillance and monitoring
- Quality control
- Teaching and training
- Research on virological problems relevant to the population of Southern Africa.

The NIV also functions as a resource for diagnosis, surveillance, reference and training in virology especially to other countries on the African continent as well as internationally. The National Institute for Virology consists of a complex of buildings situated on the original farm called Rietfontein on the north-eastern boundary of Johannesburg. The buildings of the Institute were commissioned in 1953 (when the Institute was still part of the Poliomyelitis Research Foundation (PRF). Most of the

NIV is still housed in the original buildings. A new wing, largely used by the molecular virology section, was added in 1967 and the maximum security laboratory (BL-4 high containment laboratory) of the Special Pathogens Unit was commissioned in 1979. In 1994, a residence sponsored by the PRF was constructed on the grounds of the NIV in memory of the late Mr George W Cook, specifically to accommodate visiting scientists and students from neighbouring countries and from around the world.

The staff complement of the Institute consists of 206 individuals including 5 medically trained virologists, 26 scientific staff, 3 veterinary trained virologists and 23 qualified medical virology technologists.

The NIV has 3 World Health Organisation (WHO) reference laboratories:

1. *WHO Collaborating Centre for Haemorrhagic Fevers and Arboviral Diseases*
2. *Regional Reference Laboratory for the Polio Eradication Initiative in the African Region*
3. *National Laboratory for Influenza.*

The National Institute for Virology (NIV) came into being on 1 April 1976 when the laboratories of the Poliomyelitis Research Foundation (PRF) were transferred to the South African Department of Health. The PRF was established in 1948, following a particularly severe epidemic of poliomyelitis in South Africa. The original functions of the laboratories were to assist in the development of poliomyelitis vaccine and South Africa became one of the first countries in the world to institute widespread routine polio immunization.

With the explosive development of the discipline of medical virology over the ensuing years, it became clear that the role of the Institute would need to be greatly expanded beyond that of poliomyelitis and the enteroviruses. The Marburg virus outbreak in South Africa in 1975 further emphasized the need for a national centralized resource for reference and research in medical virology. In the following year, the PRF became the National Institute for Virology.

The first Director of the NIV was Professor Walter Prozesky, formerly Professor of Virology and head of the Department of Virology at the Institute of Pathology in Pretoria. In 1982, Professor Prozesky left the NIV to become one of the Vice-Principals of the University of Pretoria. As the first director of the NIV, he was responsible for adapting the Institute to its new role within the Department of Health and to a rapidly changing virological world. Under his guidance, the NIV took its place as one of the leading virological institutions in the world and he was instrumental in establishing valuable international links, especially with the *Centers for Disease Control.* Professor Barry D Schoub, who had been the Deputy Director of the NIV and Professor of Virology at the University of the Witwatersrand since 1978, was then appointed as Director of the Institute.

The advent of the new South Africa in 1994, however, saw the country again taking its rightful place in the international community. Contacts with international bodies were rapidly re-opened and re-established. The NIV now domiciles three WHO appointed reference laboratories with a few more pending in the near future. Members of staff of the NIV have been invited to serve on various WHO and other international committees. The Institute is now also a key component of the continent's network of laboratories for diagnosis, reference and training programmes in medical virology. The mid-1980s saw the emergence of the new viral disease of AIDS. The AIDS pandemic has dominated virology and virological institutions the world over. At the NIV, the Medical Research Council of South Africa established its AIDS Virus Research Unit in 1987, currently one of the largest units in the Institute.

In the early 1990s, the NIV closed down its yellow fever and polio vaccine manufacturing facilities. Vaccine technology had now far outpaced the facilities that had not changed much since the Institute's early days. A new polio vaccine building was constructed on the Rietfontein site and opened for production in 1997. Together with the bacterial vaccine production units of the SAIMR and the State Vaccine Institute in Pinelands, Cape Town, a private company has been formed called *SAVP* (South African Vaccine Producers) which will now be responsible for the production of bacterial and viral vaccines for South Africa.

RESEARCH UNITS

Arbovirus and Medical Entomology Unit

The arbovirus unit is responsible for the monitoring of arbovirus activity within South Africa, and when requested outside our borders. There are some viruses of medical significance which occur annually such as Sindbis and West Nile, but it is also essential to monitor the viruses of considerable medical importance not known to be occurring in South Africa at this time, e.g. Dengue, Yellow fever and Rift Valley fever.

Electron Microscopy Unit

The electron microscopy unit is equipped with a Jeol 1200 EX transmission electron microscope and has preparation facilities for negatively stained and sectioned material. Specimens are submitted to the unit for diagnostic, quality control and research purposes. The most commonly submitted diagnostic specimens are stools from infants with diarrhoeal disease. These are examined by negative stain techniques. Rotavirus is the most frequently identified virus in these specimens, and its presence has been shown to be confined to the colder, winter months. Small round structured viruses and adenoviruses are occasionally visualised.

Epidemiological Surveillance Unit

Surveillance of all specimens received by the NIV is done by recording the number of specimens received, viruses isolated, significant serological results obtained and relevant patient demographic data. In 1995, 37 283 specimens for serological testing were received and 1920 specimens for isolation/detection of virus.

Hepatitis Unit

The current hepatitis unit research programme includes work on hepatitis B virus (HBV), hepatitis C virus (HCV) and the recently described hepatitis G virus (HGV).

Measles Unit

Measles virus is endemic in South Africa, with notification of 15,000 cases and 300 deaths per year, which is probably an underestimate of the true incidence of disease and associated mortality. The measles virus laboratory at the NIV has recently been established to determine the molecular epidemiology of measles virus in South Africa. Using culture methods with the EBV transformed B-lymphocyte marmoset cell line, B95a, the isolation rate from clinical specimens has been good. Routine diagnostic specimens from measles cases are seldom received for viral isolation and research specimens from Rietfontein Hospital and Alexandra Health Clinic, a University of the Witwatersrand Health Centre, have enabled this work to proceed.

MRC AIDS / HIV Research Unit

The unit has been involved in studies relating to the immunopathogenesis of the interaction of HIV and Mycobacterium tuberculosis (TB) infections.

An important development in this regard has been the commencement of lymph node studies in HIV-infected and HIV/TB co-infected individuals. Various techniques have been applied to the study of concomitant changes within the lymph nodes and the peripheral blood of individual patients. A priority research project is the study of HIV viral load in HIV/TB co-infected patients before and during standard anti-TB treatment. Genetic subtyping of HIV isolates is yielding important information regarding the molecular epidemiology HIV in our region and will provide data for future HIV vaccine trials. Various studies of cytokines, in particular, interleukin 6 and interleukin 8, are being done to further understand the immunopathogenesis of HIV infection. Flow cytometry studies have provided back-up for a number of the studies mentioned previously, in addition, the value of immune-activation markers on CD8+ cells in various settings is being studied. Another key research focus has been the study of mother-to-child transmission of HIV.

Polio Unit

In 1995 the NIV was appointed World Health Organization regional reference centre for poliomyelitis (Southern African region). The poliovirus molecular laboratory acts as a reference laboratory for intratypic differentiation and genotype analysis of all polioviruses isolated in South Africa and other southern African countries. Typing of isolates as vaccine-related or wild-type is performed using the polymerase chain reaction (PCR) with Sabin-specific primers, and genotypic analysis is then performed by partial genomic sequencing across the VP1/2A region of the polioviral genome. Sequencing templates are generated by single-step reverse transcription-PCR amplification of the viral RNA using poliovirus-specific primers.

Special Pathogens Unit

The Special Pathogens Unit of the National Institute for Virology is responsible for the diagnosis and investigation of diseases associated with the so-called formidable (biohazard class 4) viruses in southern Africa, and operates a maximum security (biohazard containment level 4) laboratory with two sections: a cabinet-line laboratory, where work with the viruses is done under negative air pressure in enclosed (class 3) glove boxes and a suit laboratory, where workers are protected in all-enclosing plastic suits with breathing air supplied through hoses. Class 4 agents known or considered likely to occur in Africa include the haemorrhagic fever viruses Marburg (MBG), Ebola (EBO), Rift Valley fever (RVF), Crimean-Congo haemorrhagic fever (CCHF), and members of the Lassa fever (LAS) and Hantaan (HTN) groups.

The Special Pathogens Unit is also responsible for the diagnosis of rabies and rabies-related infections in humans and it incorporates the Medical Ecology Unit, which is responsible for monitoring bubonic plague activity in small mammals in South Africa. The Special Pathogens Unit was recognized as a World Health Organization (WHO) Collaborating Centre for Reference and Research on Viral Haemorrhagic Fevers and Arboviruses early in 1995, and subsequently participated in an international initiative to investigate and control an epidemic of Ebola fever in Zaire.

7.5.4. The Sea Fisheries Research Institute

The Institute functions within the Department of Environmental Affairs and Tourism. The Sea Fisheries Research Institute advises on the utilization of living marine resources and the conservation of marine ecosystems by conducting and supporting relevant multidisciplinary scientific research and monitoring in the marine environment. Sustainable use and the need to preserve future options regarding the utilization of marine ecosystems and their resources are guiding objectives in the research and advice of the Institute. In order to achieve its goals, the Institute advises and interacts with decision-makers, those involved in fishing, interest groups and the local and international scientific community.

Research at the SFRI falls under four subdirectorates:

A:- Resource Biology

Inshore resources

Research into the biology of rock lobster, abalone, seaweed and a variety of linefish forms the basis for making recommendations in the management of both commercial and recreational fisheries. Management is mainly facilitated by regulatory measures such as Total Allowable Catches (TACs), bag limits, closed-seasons and minimum size limits.

Offshore resources

Management of the commercially important pelagic fish (e.g. anchovy and pilchard) and demersal fish (e.g. hake, sole, horse mackerel and kingklip), as well as squid and a variety of linefish species, relies on an understanding of the biology of each species. As for the inshore resources, research focuses on studies of growth rates, population size- and age-structure, fecundity, feeding, distribution and migration, while the abundance and distribution of eggs and larvae of some of the species are also explored.

B:- Resource Assessment & Modelling

Surveys and Fish Behaviour

Acoustic and trawling surveys are carried out on commercially important fish species, and much effort is devoted to developing and updating the methods and technologies used. Behavioural studies, which yield information on daily and seasonal variations in fish abundance, not only provide input in improving sampling techniques, but also lead to a better understanding of the ecosystem as a whole.

Stock Assessment

Mathematical and scientific evaluations of the stocks of commercial fish species are important tools in the management of these resources. Most effort is channelled into testing the assumptions made in modelling the resource and into developing harvesting strategies that are more appropriate to current management policies.

C:- Fisheries Environment

Physical and Chemical Oceanography

An understanding of the role of the environment in the functioning of marine ecosystems is vital, as variations in the physical and chemical environment may cause changes in the stocks of commercially important species. Ship-based measurements, satellite imagery and automatic monitoring instruments in sea and on land provide information on factors such as sea temperature, salinity, currents, wind speed and direction.

Biological Oceanography

Research into primary and secondary production levels focuses on the sea's small plants (phytoplankton) and animals (zooplankton). These organisms form the base of the marine food web, and any fluctuations in their numbers have important implications for commercial fish stocks. In addition, monitoring and research of red tide is conducted in order to warn the public against consuming toxic shellfish.

Pollution

Research and monitoring of pollution is essential for protecting the marine environment and its resources. The impact of various sources of marine pollutants is studied in order to develop sound management approaches and clean-up strategies. Although oil spills have the most visible and extensive impact, pollution from local sources such as sewage pipelines, mariculture farms, fish factories and other industries are also investigated.

D:- Whole Systems

Although harvesting strategies are usually assessed for single species, each is part of a complex, ever-changing ecosystem. Seasonal effects may cause fluctuations in fish survival, distribution and migration, while global climate change may alter fish stocks and the functioning of marine ecosystems. Predator-prey relationships are also important in regulating population numbers. The result of these interactions among populations and between these populations and the environment are studied.

The SFRI's Engineering Services (ENG) and Technical Management and Development (TEK) subdirectorates are responsible for developing in-house instrumentation and software which is more cost-effective, and in some cases better suited to local conditions, than imported technology. Most progress has been made in the development of hydro-acoustic and current meter instrumentation.

7.6 CONCLUSION

Public R&D in South Africa is well-developed and is entrenched in a wide array of institutional settings. A long tradition in basic research within universities is complemented by an equally vibrant culture of strategic research in many of the science councils and industry-based SETI's. We believe that the diversity in R&D philosophies and practices constitute one of the strengths of the national system of innovation and needs to be nurtured and promoted at all costs.

Chapter 8

SCIENCE AND ITS PUBLICS

8.1 PUBLIC APPRECIATION FOR S&T IN SOUTH AFRICA

In South Africa, the promotion of a better public understanding and awareness of S&T enjoys the active support of government. The reasons for this are twofold. Firstly, it stems from the recognition that, in order to produce scientists and technologically skilled people vital to the future development of the country, a general appreciation for S&T has to be in place. Secondly, results of recent surveys by the FRD and HSRC (see FRD, 1996; Prinsloo, 1994) indicate that such an appreciation among South Africans, and especially the black and coloured populations, is lacking. This is not surprising, given that the majority of South Africans come from poor rural areas or townships with limited, if any, exposure to the benefits of modern technology.

The surveys conducted by the FRD and HSRC on scientific literacy and attitudes towards S&T covered both the natural and human sciences (FRD, 1996; Prinsloo, 1994). For the natural sciences, the reported literacy rate is 41.8% and for the human sciences it is 34.7%. The figure for the natural sciences is also comparable to available literacy figures for 19 of South Africa's trade competitors (See Box 8.1.1). In the comparison, South Africa ranked almost last, with only Russia and Poland performing worse.

Box 8.1.1 - Performance of South Africa and 19 other countries on a survey of natural sciences literacy

Position	Country	Score out of 12
1	Canada	7.58
2	New Zealand	7.52
3	Great Britain	7.49
4	Norway	7.15
5	Netherlands	6.83
6	Northern Ireland	6.72
7	US	6.57
8	East Germany	6.56
9	Czech Republic	6.55
10	West Germany	6.39
11	Ireland (Republic)	6.34
12	Japan	6.21
13	Italy	6.14
14	Israel	5.85
15	Hungary	5.75
16	Spain	5.51
17	Slovenia	5.23
18	**South Africa**	**5.11**
19	Russia	4.77
20	Poland	4.33

Source: FRD (1996:151, Table 6-1).

Of particular importance to our discussion here, are the attitudes and feelings of South Africans towards S&T and the extent to which they appreciate its value for society. Five of the statements in the FRD survey dealt with attitudes towards S&T, and the extent of agreement with these attitudinal statements, together with a breakdown for each population group, is given in Box 8.1.2.

Box 8.1.2 - Attitudes towards S&T in South Africa, per population group

Attitudinal statement	% Agree				
	Black	Coloured	Indian	White	Average
(1) Science and technology can make our way of life easier and better	59	61	94	93	66
(2) The benefits of science are greater than the harmful effects	36	40	59	65	42
(3) The time and money spent by scientists on study and research is not in vain	33	48	73	85	44
(4) Science and technology are changing our way of life too fast	55	47	77	47	53
(5) Scientists cause people to depend too much on science and not enough on faith	40	51	69	64	46

Source: FRD (1996:159-162).

The first three statements in Box 8.1.2 indicate a positive attitude to S&T and the last two a negative attitude. Blacks and coloureds scored consistently lower than Indians and whites on the positive statements. Since blacks and coloureds comprise more than 80% of the South African population, their lower scores can be interpreted as indicating a national lack of awareness of the importance of S&T in tackling socio-economic problems (FRD, 1996: 168). Moreover, the first two of the positive statements have also been used in surveys of 14 other countries, thus enabling us to make an international comparison. The comparison is given in Box 8.1.3. As can be seen, South Africa ranked second last out of the 15 countries, with an average agreement of 54% to the positive statements.

Box 8.1.3 - Attitudes towards S&T in South Africa and 14 other countries

Country	% Agree		
	Statement 1	Statement 2	Average
US	84	73	78.5
Denmark	86	69	77.5
Spain	81	67	74.0
France	84	63	73.5
Germany	86	60	73.0
Great Britain	85	61	73.0
Greece	83	61	72.0
Italy	80	62	71.0
Ireland	76	63	69.5
Portugal	76	60	68.0
Netherlands	85	50	67.5
Luxembourg	76	55	65.5
Belgium	76	51	63.5
South Africa	**66**	**42**	**54.0**
Japan	--	40	40.0

Source: FRD (1996:159, Table 6-7).

Apart from the FRD and HSRC surveys, South Africa also received a depressing rating in the report on the Third International Mathematics and Science Study. The study, conducted in 1995 under the auspices of the International Association for the Evaluation of Educational Achievement, ranked South Africa last among the 21 countries surveyed for mathematics and science education (The Star, 1998b:14). In an attempt to rectify these distressing figures for S&T appreciation in South Africa, the government declared 1998 the Year of Science and Technology (YEAST).

8.2 THE YEAR OF SCIENCE AND TECHNOLOGY

YEAST was a public awareness campaign with the aim of demystifying science. Directed by DACST, it targeted the scientifically illiterate and in particular rural communities, women and children. The message conveyed was that, contrary to popular belief, S&T is not alien to South Africans' daily experiences but an integral aspect of everything around them. To bring this message across, S&T was presented as user-friendly through a string of interactive activities in all nine provinces. These activities involved road-shows, live demonstrations, exhibitions, workshops and theatre productions (http://www.dacst.gov.za/default_science_technology.htm).

The campaign was officially launched during the first week of February 1998 and continued throughout that year. Each province was given a month during which to host a focus week. The first focus week started in the Western Cape in March, and the last ended in Gauteng in November 1998. Moreover, each province was coupled with a foreign embassy to enable international participation (e.g. the Western Cape with France and Mpumalanga with Russia). Large inputs were also made by the science councils, businesses, universities, technikons, community-based organisations and non-governmental organisations – who all joined forces to stage events in the nine provinces.

The then deputy president (and now president) of South Africa, Thabo Mbeki, acted as the official patron of YEAST. This added significant weight to the campaign and underscored the government's seriousness about ensuring the required human resources in S&T. In his speech accepting the patronage, Mbeki linked public participation in S&T directly to socio-economic progress and the African renaissance. (http://www.anc.org.za/ancdocs/history/mbeki/1998/sp980205.html).

Official media pronouncements on YEAST considered the campaign a great success. For instance, it was claimed that YEAST brought more than 200 000 people in direct contact with the benefits and possibilities of modern technology (The Star, 1998a:14). However, some degree of scepticism is warranted here. It is one thing to emphasise the fun side of S&T and thus attracting large crowds, but quite another to ensure that a single pleasurable exposure translates into a real appreciation for S&T. According to one science journalist:

> "The promise was that programmes to boost science awareness would reach especially women and the rural population. This does not seem to have happened ... The obstacles in the way of a major public awareness campaign around science, as much as around heritage, are lack of finance and uncertainty over the cultural perspectives to adopt – western or indigenous, white or black ... The use of the English language exclusively had proved to be a problem in areas where other languages were spoken and scientists were perceived as outsiders" (Addison, 1998:15).

YEAST has also been criticised for its "received-science" approach. The latter implies a one-way communication between scientists and the public, with the public seen as the ones that are scientifically ignorant and illiterate (Nkomo, 1998:8). However, in Nkomo's view, it is more the Eurocentrism of scientists that limits the public understanding of science as a social process. In South Africa, with its colonial and apartheid history, the public's disillusionment with science relates to the way that they experienced (and still experience) science in the country. YEAST then, for Nkomo, would have been successful had the conceptual base been shifted to also address the "illiteracy" of western science, as well as real threats posed by modern technology (such as making manual workers redundant). Be that as it may, YEAST was a major step in the right direction. The only question remaining is what follow-up measures, if any, are in place.

8.3 SCIENTIFIC CONTROVERSY: TWO SOUTH AFRICAN CASE STUDIES

A scientific controversy is a dispute of an ongoing nature and one that enjoys public awareness. The core element of a *scientific* controversy is the issue of belief. The parties involved in the dispute argue that the other is wrong and that they are correct, or that they have the stronger argument. The fundamental difference between the disputants is one of belief, of knowledge claim. Moreover, the dispute or *controversy* claims to have the backing of science - that is, both parties declare that the aegis of "science" supports their claims (Beauchamp, 1987). In order for it to be characterised as a controversy, the dispute must be a *continuing* one and involve both argument and counter-argument. The interchange is *public*; the parties manifest it in writing or orally, so that others may become aware of and be able to evaluate the case. The latter statement is regarded as the most critical in understanding how controversy operates in science. A disagreement, irrespective of its magnitude, between two scientists does not constitute a scientific controversy until the issues under dispute are brought to the attention of the scientific community and others are allowed to participate in the debate. *Scientific controversy* is not restricted to scientists but is open to all who are qualified to understand the dynamics of the issue in question. A *controversy*, therefore, constitutes a *community* concern despite starting out as dialogue between two people (Beauchamp, 1987).

The outcome of a controversy will hinge not only on the disputants, but also on the members of the scientific community and members of the community with an interest in its outcome. A disagreement that has become public knowledge does not necessarily constitute a *scientific controversy*. For instance, we would not contend that the shape of the earth is a matter of controversy, although, there are certain parties who publicly defend a flat earth view. Nor would scientists maintain that the equivalence of inertial reference frameworks (the theme for Einstein's special theory of relativity) as a valid controversy, despite objections in favour of absolutist views. Thus, for a *scientific controversy* to be constituted, the community must regard it as serious.

The aetiology of scientific controversies

Different explanations exist for the rapid rise in *scientific* and *technological controversies* during the last few decades. Many individuals assert that the rise in controversies was sparked by the "crisis in authority" that began in the 1960s, which was seen as a sign of the growing mistrust in all modern institutions, and, more importantly, in the dominant forms of political authority.

It is often perceived that controversies arise because people are ill informed; thus, as the result of inappropriate or insufficient information. However, Nelkin (1987) argues that *scientific* and *technological controversies* are geared toward negotiating parity in social relationships and the upholding of particular values, norms, and political boundaries at a juncture marked by significant scientific and technological transformation. Certain controversies such as the *nuclear debate* can be classified as an *ideological controversy* over the political milieu of a “sound” society. Moreover, disputes of a less global nature have at their root, the fear of the misuse of knowledge, and the fear that research findings will be used to the detriment of individuals or society. Controversies also occur because people oppose scientific research on moral grounds. Finally, controversies surrounding issues of *equity* and *justice* arise because of the irregular allocation of resources or apportioning of economic and social costs (Nelkin, 1987).

Types of scientific controversies

According to Nelkin (1995, pp. 447-449), four main types of controversies exist. These are controversies that have their basis in: *(1) an array of political, economic and ethical concerns (2) environmental values and political or economic priorities (3) health risks connected to industrial and commercial pursuits and (4) technological applications.*

A good example of a “type 1” controversy is the *Virodene controversy*, since the researchers violated certain ethical procedures, outlined by the normative structure of science as constituting sound scientific practice. The researchers conducted their research in secret and did not allow their findings to be made public and be evaluated by the peer review process. Moreover, a disciplinary committee found the group guilty of supplying Cabinet with false and misleading information regarding the drug, the media and volunteer guinea pigs. They found that the researchers used preliminary results to attract funding, thereby evading conventional bodies who would otherwise employ strict scientific criteria to evaluate applications for funding. The Virodene controversy was also characterised by political interference in the research process with the involvement of the Deputy President and Health Minister of South Africa. When this kind of external involvement takes place Nelkin (1995) argues that critics are not only querying certain research practices; they are disputing the basic values underpinning research.

The second type of controversy involves *environmental values and political or economic priorities.* The Saldanha Steel controversy is a good example of this category since it reflects community concerns about the possible ecological damage through pollution and its displacement by large industry.

A third type of controversy involves *health risks connected to industrial and commercial pursuits.* This controversy entails a conflict between economic concerns and individuals or groups weary of risk. An example of this type of controversy is the controversy over the diet to 'prevent cancer'. In this controversy, Dr Bob" Arnot, US national medical correspondent for NBC television, in his book *The Breast Cancer Prevention Diet* provided "a full account of the foods that cause breast cancer and the treasured foods that prevent breast cancer". Foods, according to the author, are like "drugs-without the side effects". The parties involved in the controversy were women who expressed their concern about the sweeping claims made by the book and the American Council on Science and Health (ACSH), who released a 17-page critique of the book to the media (Larkin, 1998). As the book implied that various foods produced by industry contain carcinogens or cancer causing agents, the concern was that the public would, therefore, be unsure about the nature of industrial manufacturer's safety standards (Nelkin, 1995). (??)

The fourth type of controversy involves *technological applications* that indicate conflict between individual values and expectations and societal goals. These controversies generally involve government's implementation of standards of regulation, for example, the controversy surrounding the banning of obesity drugs, in America. A similar situation arose in South Africa regarding access to the anti-Aids drug Zidovudine (AZT) for pregnant HIV/Aids mothers. Although, evidence suggests that the drug reduces the risk of the transmission of HIV/Aids from mother to child dramatically, it still remains inaccessible to the majority of pregnant women infected by the HIV virus because of government regulation.

8.3.1 The Virodene Controversy

Analysis of the Virodene controversy

In December 1996, three researchers, former Pretoria University researcher Olga Visser, cardio-thoracic surgeon Professor Dirk du Plessis and a clinical assistant Dr Callie Landauer, reported success in treating several Aids patients with a drug they created called Virodene P058.

The researchers addressed cabinet on 22 January 1997, in the hope of receiving R3,7 million, to proceed with their research into the drugs effects. The researchers stated that Zuma, then the Minister of Health, and Mbeki, then the Vice-President, were impressed with the preliminary results of the Virodene pilot study.

(Independent Newspapers, 1997/02/28). The group added that they had received permission from Zuma to proceed with clinical trials of the drug.

Zuma's response to Virodene

On 9 February 1997, the former Health Minister Dr. Nkosazana Zuma stated that she had encouraged the researchers when they had approached her. "If that is giving them permission to continue, then, yes, I did, but I did not give them permission to go against anyone else who should have been consulted regarding the trials." On the issue of why the researchers were allowed to appeal for R3,7 million, Zuma replied that the work on Virodene was considered very important and, if it succeeded, may have had implications for manufacturing, which affected the Department of Trade and Industry. According to Zuma, Virodene was chosen because a low-cost drug was more affordable than combination drugs.

Suspension of clinical trials

In May 1997, the group submitted a formal clinical protocol in order to receive official permission to proceed with their research. The Medicines Control Council (MCC) responded by suspending clinical trials of Virodene until the body had completed an investigation into the pilot study conducted by the group.

University of Pretoria disciplinary hearing into Virodene

On 7 July 1997, a University of Pretoria disciplinary committee found all three researchers guilty of starting clinical trials without the permission of the University's ethics committee. Two of the researchers, du Plessis and Landauer, were charged with misconduct and were subsequently reprimanded. Olga Visser was not charged because she was not an employee of the University (Independent Newspapers, 1997/07/15).

The charges contained in the University committee report stated that the researchers' actions, in getting the drug to the clinical trials stage, had been based on deception. They were found to have perfidiously misled and lied to Cabinet, the media and volunteer experimental subjects about the drug's effects. The report further stated that, when the researchers had approached Cabinet on the issue, they had made use of preliminary results to attract funding. The use of preliminary research results also allowed them to evade funding bodies who would have employed strict scientific criteria to evaluate applications for funding (Sunday Tribune, 1998/03/11).

The most damning finding of the committee was that the research team inaccurately assumed that the anti-Aids drug Virodene P058, scientifically known as Dimethylformamide (DMF), was classified as a protease inhibitor. It was found that they performed only one scientific trial on a similar drug that they claim was “a known protease inhibitor” and, on these grounds, claimed that their drug had "proven efficacy as an anti-viral agent.” The committee stated: "None of the publications quoted by the researchers provides evidence of or even refers to DMF as a potential protease inhibitor.”

In addition, the research team's report on the toxicity of DMF, an industrial solvent capable of causing liver damage, was misleading about its safety for Aids patients. "Although these toxicological reports describe the toxicity of DMF as low when given as a single oral dose, there are several disputed issues of toxicity that have yet to be resolved and are crucial to the trial. The most important are the effects of the DMF during the long-term exposure achieved with the transdermal (through the skin) patch and the possible difference in toxicological response in immune stable subjects” (Sunday Tribune, 1997/03/08). The committee concluded that the dosage would have exceeded the prescribed 150mg/-day occupational exposure safety limit "by far” and articulated their concern about the deficiency in toxicological experience within the team. However, the researchers repeatedly maintained that the correct levels for possible liver toxicity as a blood concentration was 500mg per litre, when it is actually 50mg per cubic metre (Sunday Tribune, 1997/03/08).

The ethics committee also denounced the nature of the clinical trials. Only one in eleven subjects actually participated in the clinical trials, the remaining ten merely reacted to the news of the "dramatic success" of the first experiment. Attempts to locate the four who were actually given the drug failed and one has reputedly since died. The placebo effect was not discounted and the method of selection of patients for the trials was also severely criticised.

Moreover, as the trials were conducted in secret; the only participants being the researchers and a private pathology laboratory, the committee had been precluded from evaluating the results. "Experiments that have been carried out in a secret, non-transparent manner, without the benefit of proper control or peer review, do not lend themselves to such analysis” (Sunday Tribune, 1997/03/08).

Reaction from Aids organisations

In July 1997, following the University of Pretoria hearing, various Aids organisations voiced their opinions. Pierre Brouard, senior Aids councillor with the Community Aids Centre in Johannesburg, stated: "A wave of gloom and depression is going to descend on South Africans affected by HIV and the repercussions continue to be felt, with people arriving at clinics in Soweto asking for Virodene. The voice of the sane and sensible, who urged caution at the time, was drowned out by the feeding frenzy brought about by Olga Visser's charisma and the desperate need of people living in the hope of a cure." Chris Avant-Smith, executive director of Friends for Life, a Johannesburg based service organisation for people with Aids, said that the committee's report confirmed their fears that the hopes of an Aids cure would be unfairly raised and then dashed. "And the credibility that Health Minister Nkosazana Zuma lent to the researchers and their industrial solvent was probably the most damaging to people infected with HIV. The researchers have not acted in good faith by trying to get around the funding system, to have it registered for personal gain", he said.

Medicines Control Council rejects human trials

Toward the end of July 1997, the MCC placed a ban on human experimentation because it deemed the drug to be toxic. The council said such trials were premature and unsafe. Professor Peter Folb, chairman of the MCC stated that the drug would not be passed for human application or for clinical trials without the express permission of the MCC. Professor Folb is professor of pharmacology at the University of Cape Town, chief specialist physician at Groote Schuur Hospital and holds World Health Organisation posts on drug policy. He said that the law required the MCC to register all drugs. Folb pointed out that "Virodene failed on all counts: lack of safety; no biological evidence that it is likely to be effective against HIV infections in humans; risk of liver injury to the patients; unstable and impure chemistry of the formulation; some experimental evidence shows that it may make HIV infections worse; incomplete disclosure to the patients who are the intended subjects of the investigation; inadequate trial design and inadequate measurements for assessing the results" (The Star, 1998/03/26).

The National Association of People with Aids (NAPWA) sided with the MCC and reiterated that it would withhold its blessing from human trials until proper tests were conducted on Virodene. "The trials and the protocols have been designed to protect people and we do not believe treatment is being withheld," said NAPWA head Peter Busse. "NAPWA, more than any other organisation, would be completely accepting of a treatment, but to start calling Virodene a treatment is premature and misguided" (The Sunday Independent, 1998)

MCC raid on Visser

On 26 November 1997, MCC officials raided and searched the office and home of Olga Visser. The MCC officials searched for any evidence linking Visser and her research team to continued medical research on Aids patients, in violation of an MCC ruling. The MCC officials confiscated files of Visser's patients. In response to the raid Zigi Visser, husband of Olga Visser and administrator of Cryo Preservation Technologies that holds the patent for Virodene P058, remarked that the MCC raid was conducted on the basis of an affidavit by a patient who claimed that he was being treated with Virodene. An agitated Visser said the raid was illegal and unconstitutional. "We see this whole thing as a last, desperate attempt to discredit Virodene before the health bills are passed, as the MCC will then no longer be able to dictate to the nation what they may or may not die from." The Virodene researchers have indicated that they would take legal action in the constitutional court (Independent Newspapers, 1997/11/27).

Police investigation into Virodene

Following the raid on the Vissers, the MCC lodged an official complaint with the Pretoria Vice Squad, on the basis of its findings obtained from their raid on the Vissers. Moreover, the MCC claimed that it was informed by the Aids Law Project that a doctor directly linked to the Virodene researchers was administering Virodene in violation of the MCC ban (Independent Newspapers, undated). Police investigations into the illegal administration of Virodene is being conducted and will take at least six months; those found guilty of violating the Medical Control Council Act could face a sentence of 10 years in jail or a R40 000 fine.

Mbeki launches attack on MCC

On 6 March 1998, former deputy president, Thabo Mbeki, launched an attack on the MCC for not allowing clinical trials of the drug to proceed. Mbeki stated that he became involved in the Virodene saga “as it became more and more difficult to understand the attitude adopted by the MCC". Although neither the ANC nor Mbeki pledged their support for the drug, they described the MCC as a “censorship board” for not allowing the research to continue.

In a carefully orchestrated plan to reverse the tide of negative public opinion against the Virodene researchers, Mbeki accused the MCC of “playing cruel games”. He then added: "To confirm its determined stance against Virodene, and contrary to previous practise, the MCC has, with powers to decide who shall live or die, also denied dying Aids sufferers the possibility of mercy treatment, to which they are morally entitled." He later added, "I, and many others, will not rest until Virodene's efficacy or otherwise is established scientifically" (The Sunday Independent,1998).

Kgalema Motlanthe, ANC general secretary, when questioned why the party became involved stated: “Because this is a major issue, it confronts all of humanity. If society is on the brink of a major breakthrough on the scourge of Aids, [it is wrong] if there is no will and readiness to bring this work to a conclusion.” Motlanthe stated that decent researchers were being “hounded like criminals” and he condemned the MCC for playing God.” “Given the devastating effects of Aids, the research must be brought to its logical conclusions.” Motlanthe also criticised the argument that Virodene’s side effects were too dangerous, retorting that any medicine has side effects.

Perilous nature of drug trials revealed

On 28 March 1998, the Virodene researchers admitted that they failed to submit critical information at the MCC hearing about the patients who dropped out of the clinical trials. Apart from withholding critical information from the council, the researchers admitted to endangering the lives of their patients during the clinical trials by failing to heed scientific methods of human trials. Visser revealed that some of the researchers deliberately omitted this information. "It was silly because the four patients who dropped out did extremely well. They dropped out by their own choice." Moreover, Visser stated, "There are problems between researchers and court cases which have not reached settlement. There have been some terrible mistakes made by some of the scientists, but I can't go into details." Further revelations by Visser indicate that her team had only experimented on one group of eleven patients to test the drug. The standard set for scientifically performed human trials on drug efficacy requires two groups, each involving between 100 and 200 people. In these trials, referred to as "double blind trials", the active drug is administered to one group of patients and the other, an inert tablet, which closely resembles the real drug in taste and appearance. Neither the patient nor the person conducting the trial is aware of which patient receives the active drug. Nevertheless, the Virodene researchers failed to use the recognised method for clinical trials. Various medical experts have indicated that they risked lives by failing to conduct preliminary work on animals (Independent Newspapers, 28 March, 1998).

ANC set to gain millions from drug

On 9 March 1998, a fierce political storm broke when the Democratic Party (DP) released court documents suggesting that the ANC stood to gain millions by assisting the researchers of Virodene. Democratic Party health spokesperson, Mr. Mike Ellis, said that he had called on the Public Protector, Mr. Selby Baqwa, to investigate the matter, particularly the role played by the former Deputy President Mbeki and Minister of Health Dr. Zuma. The documentation appeared to indicate that the ANC was set to gain a six-percent stake in CPT, the company that developed Virodene, once it was transformed into a private company. Ellis asked Baqwa to investigate whether Zuma was influenced by the prospect of shares in CPT, as minutes of a meeting of CPT members held in October 1996 indicated that there had been an offer of shares to the ANC. In addition, documentation submitted by Mr. Jacques and Mrs. Olga Visser, major shareholders in CPT, indicated that Mbeki and Zuma had met with the intention of making a deal between Professor du Plessis, Dr Callie Landauer and the Vissers. University of Pretoria’s Landauer and du Plessis applied for an urgent interdict after they discovered that the Vissers had secretly concluded deals to supply Virodene to South Africa and other African countries, including Zimbabwe, Ghana and Nigeria, in violation of the Medical Controls Council's rulings

In response to these accusations, Zuma's spokesperson, Mr Vincent Hlongwane, said, "There's no truth that the minister is supporting this research because it will benefit the ANC. She supports all research aimed at finding a solution to the HIV/Aids pandemic." ANC spokesperson Mr Ronnie Mamoepa said that Ellis's allegations were outrageous and farfetched. "The ANC views these unsubstantiated allegations in a very serious light and will investigate all avenues to seek relief on the matter. We take a dim view of attempts by the Democratic Party to cast an aspersion on the integrity of ANC president Thabo Mbeki and (Health) Minister Nkosazana Zuma."

Comment on political interference

On 23 March 1998, South Africa's foremost medical academics came out openly in support of the Medicines Control Council, following the attacks on the Council by Mbeki. The heads of five medical schools in South Africa called for an immediate commission of inquiry into the controversy. The academics expressed their concern at the political interference in the operation of the statutory body. In a signed document, the academics in the departments of medicine at the universities of Cape Town, Stellenbosch, Natal, Witwatersrand and Medunsa said: "This council has an admirable record in its dealing with many complex issues over many decades. Its concern for the health of individuals and the health of the public is beyond question and it has served the South African public with the highest degree of integrity under the leadership of its chairman, Professor Peter Folb."

The academics said public confidence in the council should not be undermined by anything other than "documented factual information".

Professor Folb said the Council "must be left to do its work according to proper standards that will offer reasonable prospects to patients and prevent their being exploited" (Independent Newspapers, 1998/03/24).

The Medical Association of South Africa (MASA) voiced its concern over the continuing controversy surrounding Virodene. MASA called for the non-interference of politics in the matters of the MCC because it undermined the autonomy of the body. MASA said that if the matter could not be resolved locally, the aid of internationally reputable drug-regulatory authorities would be requested. "Medicine is not an exact science and over the years the practice of finding scientifically and ethically justifiable answers in the quest for curing diseases has assured patients of our first obligation: to do no harm." MASA stated that it aimed to determine scientifically whether the drug was effective in combating Aids. "This can be achieved by way of acceptable scientific protocols, entrenching ethical principles. It is important not to raise expectations that may not be fulfilled, especially when people living with Aids are particularly vulnerable to the sort of harm that follows on grave disappointment," MASA concluded (Independent Newspapers, 1998/03/24).

Dismissal of MCC chairman

On 8 December 1997, former Health Minister Dr Nkosazana Zuma told a rally on Aids Day that soon she would be “in a position to overrule the MCC and make Virodene available to Aids sufferers” (Independent Newspapers, 1997/12/09).

Three months later, on 23 April 1998, Professor Peter Folb was summarily dismissed as chairman of the MCC. He has subsequently disclosed that Health Minister Nkosazana Zuma pressured the MCC over clinical research into Virodene. Professor Folb has subsequently been replaced as MCC chairman, while the MCC itself is due to be replaced by a SA Medicines and Medical Devices Regulatory Authority (SAMMDRA) in terms of a bill now before parliament. Professor Folb expressed his reservation at the proposed establishment of SAMMDRA. He stated that reform of the MCC was required but that it should be replaced with "an economical successor that will continue to guarantee both generic and brand-name medicines that are effective, safe and of good quality" (The Citizen, 1998/09/21).

International support for Virodene

Aids expert Dr A Martins Ferreira claimed that he had been using Virodene for longer than a year. "Since I started using the drug, I have patients coming from all over Europe and they have been doing exceptionally well. They don't suffer from any side-effects except minor nausea, depending on whether the infected person was an alcoholic or drug addict." Ferreira pointed out that patients using Virodene did not suffer from bone marrow problems, gastric problems or bleeding, which had happened with other Aids drugs. His opinion was that Virodene should be made available to Aids sufferers in South Africa. However, Ferreira disagreed that Virodene was toxic. "I have done a 150-page scientific research report on the drug and I say it is the best available drug to combat the HIV/Aids-related epidemic." In addition, Zigi Visser pointed out that doctors and Aids experts in countries such as France, Portugal, Italy and Spain were successfully treating patients with Virodene (Independent Newspapers, 97/12/9).

Conclusion: The Virodene debacle constituted a scientific controversy because 11 people were illegally and unethically treated with Virodene. Furthermore, the Virodene researchers disregarded proper medical protocol by performing trials without first presenting their work to their peers. An investigation performed jointly by the Gauteng Health Department and academics at the University of Pretoria found that Virodene contained an industrial solvent and that there was no available scientific evidence to indicate that it would have an effect on the Aids virus. The investigative committee also expressed their concern at the Virodene researchers' lack of expertise in areas of internal medicine, virology and toxicology. However, the credibility of the scientific community was called into question and the fight over Virodene intensified. Professor Peter Folb, the chairman of the Medicines

Control, which grants permission for the clinical trials of new drugs, was dismissed and replaced as head of the council after refusing further research into Virodene. New legislation curtailing the powers of the MCC was instituted and prominent ANC politicians openly stated how the council's powers should to be restricted. Allegations surfaced that the ANC stood to profit financially from the production of Virodene after documents indicated that the ANC had a six- percent stake in Visser's company landed in the hands of the Democratic Party. After the MCC rejected the protocols submitted by the Virodene creators, the ANC petitioned the council to speed up the process that would allow clinical trials to be performed. The ANC was so convinced of the integrity of the drug that it culminated in deputy president Mbeki's bitter attack on the MCC. The ANC's message was clear: divisions from the old order were crippling a government-supported initiative. Ironically, the new chairman of the MCC, Helen Rees, refused permission for clinical trials after the Virodene researchers tried another three times to have their protocols accepted. A story surfaced about illegal trials using Virodene in Portugal by a company partly owned by Visser (Sunday Times, September 26, 1999).

Towards the end of September 1999, following a hiatus of about a year, Professor Malegapuru, president of the Medical Research Council dismissed the “miracle cure” Virodene as “nonsense”. Makgoba's pronouncement in parliament represented the final chapter in the Virodene saga when it appeared that a likely conclusion would remain shrouded in politics preventing the truth from emerging. The truth about Virodene may at first have been apparent to those from the scientific community, but the ambivalence of politicians and continued media coverage that the drug's creators enjoyed, left the public confused. The truth was further muddled by politics surrounding the transition from an apartheid state to a democracy. Two distinct camps began to emerge: the more established scientific hierarchy, perceived to be instruments of the apartheid state declared Virodene “useless”, a view strongly opposed by those associated with the ruling majority party, the ANC. Makgoba's candid rejection of Virodene as “nonsense” and as being “without scientific integrity” is significant, if only for the fact that it comes from a highly reputable black figure. His dismissal of the drug may be no different from its dismissal by the first investigation by academics at the University of Pretoria or the implicit dismissal of the drug by the MCC, this time, however, the credible source of the drug's dismissal stands a greater chance of being heeded in circles suspicious of white officialdom. The closure of the Virodene saga marks the end of a scientific controversy that saw the derailing of government policy-making and highlighted the consequences of what happens when the integrity of independent authorities are undermined because they are perceived to lack credibility. It is possible that figures of greater repute in statutory bodies and government watchdogs will prevent the recurrence of a scientific controversy of this nature (Sunday Times, September 26, 1999).

8.3.2 Saldanha steel environmental controversy

The Saldanha Steel Mill

According to the Argus (97/08/06), the amount of steel at the Saldanha Steel mill is enough to build three Eiffel Towers; sufficient concrete exists to construct thousands of swimming pools and more than enough cabling to stretch from Cape Town and Durban. These are some of the interesting facts to emerge as the controversial steel plant on 67ha of land in Saldanha nears completion. More than 7000 workers have worked towards completing the R6.8-million factory. The statistics reveal that 36 000 tons of equipment and 6 190 tons of piping will have been used and 20-million man-hours registered. The first steel coils are expected to be produced by the plant in the first quarter of 1999 and will weigh 80 tons each. The mill is expected to be in full swing by the year 2000 and its production capacity is estimated at 1.25-million tons a year. However, the project has been marred by controversy since its inception; one of the major issues being its impact on the environment (Argus, 97/08/06).

Steel mill could spark massive industrial development

The approval of the Saldanha Steel mill on the coast of Saldanha Bay has been widely condemned.owing to the belief that it could spark off undesirable large-scale industrial development in this region. This has started to happen. Saldanha is about to become an industrial ‘Babel’ as the government plans to declare the region an Industrial Development Zone (IDZ). The Department of Labour who conducted an audit of labour skills in the region so that training could get underway confirmed this. Vredenburg Town Clerk, John de Klerk, maintains that the region could become the fastest-growing industrial region in the country. "We would certainly like to see that happen," he said. According to De Klerk, industrial and tourism development in Saldanha could "go hand-in-hand." This will lead to significant industrial expansion around the West Coast towns of Saldanha and Vredenburg, as well as drawing foreign investment to the area through the allure of various incentives, such as tax holidays and exemptions from customs and excise tariffs. The newly formed industries would use the new R6,8 billion Saldanha Steel Mill as a platform to develop a plethora of "downstream" industries. Industries that have already been authorised by Saldanha-Vredenburg local authority include:

- An Anglo Alpha cement factory
- A Duferco steel plant, an R850m joint venture between the Industrial Development Corporation and a Swiss company.
- A processing plant by PPC (Pretoria Portland Cement), which will transform slag from Saldanha Steel into slag cement.
- A R4,5 billion Anglo American zinc smelting plant.
- Extensions to the Namakwa Sands factory, doubling their present production capacity.
- A Shell pipeline from the Kudu natural gas fields in Namibia.
- A desalination plant.

Mineral deposits in the area that could be mined at low cost are being targeted. This includes zinc, limestone, phosphate and kaolin. The opportunity has arisen for mining salt near Yzerfontein. Portnet has significantly expanded the general cargo quay at Saldanha, and is constructing a new terminal to cope with increased amounts of cargo traffic (Argus, 97/08/06).

Industrial development could endanger wetlands

The site proposed for the development of the Alpha cement mine near Saldanha Bay contains plant life rated "of very high conservation importance" on a national scale, according to an extensive environmental impact assessment report. The vegetation referred to as "calcrete shrublands" comprises at least three species not yet classified by botanists and is found only in the West Coast region, the region where the proposed R750-million cement plant will be built. It includes a production plant near the existing pre-loading terminal at Saldanha and adjacent to the new Saldanha Steel plant; limestone and clay quarries north-west of Saldanha town; and an 8km conveyor system linking quarries with the production plant (Independent Newspapers, 1998/11/17).

Industrial development could endanger Langebaan bird life

The sensitive ecosystem of the Langebaan Lagoon, an international conservation site by nature of its diverse species of bird life, could be irrevocably damaged if the authorities began pumping water from underground water sources, warn conservationists. West Coats farmers also expressed their concern that pumping on such a massive scale may drain the borehole water supply they use for agriculture. The West Coast Regional Services have received the go ahead to pump 4 000 cubic metres a day from the Langebaanweg aquifer, to supplement the supply of the fast expanding industrial sector at Saldanha and Vredenburg, a decision based on the findings of a feasibility study done by the CSIR.

Comment by SA National Parks Board on environmental impact

South African National Parks, which runs the West Coast National Park that includes Langebaan Lagoon is not convinced that sufficient research has been done to guarantee the safety of the environment. National Parks Board spokesperson, Nic Geldenhuys, said his organisation expressed concern that the CSIR failed to correctly interpret earlier studies on underground water in this area. "The Elandsfontein aquifer feeds into Langebaan Lagoon at its southern end and maintains the mixture of fresh and seawater in the lagoon. The dynamics of the salt marshes, which are the driving force of the lagoon's ecosystem, depend on this balance. If it is changed, the entire ecosystem will change. "And Langebaan is a Ramsar site, an internationally recognised conservation site, which has the second most extensive salt marshes in the country after St Lucia," Geldenhuys said (Independent Newspapers, 99/02/12).

The South African National Parks Board voiced its concerned about industrial and tourism development in the region. Johan Taljaard, social ecologist for the West Coast National Park at Langebaan says that the National Parks Board is not opposed industrial development per se, but believes that a site should be chosen that is not hazardous and does not jeopardise the environment. "We have already seen, two years ago, that a tiny oil spill at Saldanha could not be contained, and spread to the southern end of the lagoon. We need to ask ourselves if the risks associated with industrial development and the increased shipping are worth the risk of losing an irreplaceable natural asset. If anything major goes wrong, this park is history," Taljaard said (Argus (97/08/06).

The Steyn Commission of Inquiry

The anticipation of industrial expansion on a grand scale sparked by the construction of the Saldanha Steel mill was the basis of a public outcry in 1995, when proposals for the steel plant were revealed. A government board of inquiry, the Steyn Commission, was established to launch an inquiry into the matter. The

ANC argued that the appointment of an environmental commission of inquiry was both “unnecessary and costly,” because the various commissions established during the Saldanha Steel controversy at Langebaan had been “ignored in favour of a political decision.” However, the Democratic Party as well as the National Party, believed that the presence of a local green watchdog was essential to show up the “grey” legislative loopholes through which ruthless property developers could ravage the "jewel of Africa," and assist in its sustainable development. Nevertheless, the inquiry indicated that 70% of public dissatisfaction was directly related to the steel factory being located so close to the Saldanha Bay, a vital segment of Langebaan Lagoon and a wetland of international significance (Argus, 9708/06).

The inquiry’s key findings were that the intended steel mill should be constructed at least 6 km inland, and that the building plan for the Saldanha-Vredenburg area be done in consultation with the community (Argus, 9708/06).

Saldanha Steel breaks its promises

On 12 June 1996 a member of the board of the *Steyn Commission* reported that the factory reneged on all its promises regarding the plant’s impact on the environment and made a mockery of the entire inquiry process. The head of the University of Cape Town's environment department, Professor Richard Fuggle, said that when the initiative had been authorised, the media release from the provincial government stated that the plant would move two kilometres inland. This, however, was not stipulated in the list of conditions for rezoning approval. According to Fuggle the Saldanha Steel controversy was a "classic lose-lose" situation in which all stakeholders involved, including the green lobby, the local community and Saldanha Steel, were misled and ended up as losers in the process. Promises made by Saldanha Steel to the board of inquiry regarding the monitoring of air and water pollution, among other things, have according to Fuggle, not been honoured. "The board took these assurances to be made in good faith and with honour, but now it turns out these undertakings count for nothing. Saldanha Steel has reneged on all its undertakings," Fuggle said. The reason for this is Saldanha Steel’s assumption that the conditions of the agreement were no longer valid because the plant had moved 1,6 km inland (Cape Times, 9606/12)

Equally controversial is Fuggle’s allegation that politicians disregarded important recommendations made by the Board, particularly that the plant be moved at least

6km inland. In support of his allegations, Fuggle read out the minutes of the Monitoring Committee Meeting which recorded Saldanha Steel’s chief Mr. Bernard Smith statement that the environmental trust would not be established, and that all agreements now “fell away” because the company had agreed to move the site 2 km inland. "It was clear the board's recommendation to move the steel mill inland meant at least 6km, not just a few thousands metres. Saldanha Steel has simply moved the plant from the western edge to the eastern edge on the same site." "It was certainly not in the Board's mind that a move within the same site constituted a move inland," Fuggle said (Cape Times, 9606/12).

According to Fuggle the Board made its recommendations following three months of investigation, which included weeks of public hearings, 7 000 pages of written evidence, as well as the appointment of expert sub-committees. "Then two international experts from the Ramsar Secretariat in Switzerland were flown in on a Sunday night, flew over the factory site on the Monday morning and on Monday afternoon told the cabinet it was okay to go ahead with the steel factory. "This made a mockery of the entire inquiry process. The two Ramsar advisors can't be at all proud of what they did," Fuggle said. He argued that the Board’s important recommendation that the structure plan determining land use in the area be opened to public input since the proposal of a steel plant, had been completely disregarded by the Department of Environmental Affairs. The recommendation was made because 70% of public dissatisfaction to the steel factory was linked to the structure plan that had set aside areas close to Saldanha Bay as being appropriate to heavy industry. "Nothing has come of this," Fuggle said. He argued that the main threat was that the steel factory would influence “the ambience of the whole coastal plane which could affect the mariculture industry and local tourism” (Independent Newspapers, 9606/12).

Reaction to Fuggle’s allegations

The Minister of Agriculture, Planning and Tourism, Mr. Lampie Fick, has strongly denied Fuggle’s allegations, and criticised him for "not acquainting himself with the facts" and for "making statements that contribute to public confusion and misunderstanding of a complex position".

Following Fuggle’s outburst, Western Cape Premier, Hernus Kriel, argued that the decision to allow the building of the factory to proceed was the correct one. Responding to the question of whether Saldanha Bay could become another

Richards Bay, as downstream factories began sprawling around the factory, Kriel said: "I welcome the interest of other industries in this area. It is essential for the Western Cape economy that not only Cape Town grows, but other areas too. We need decentralisation; Cape Town is getting too full." Two companies, Alpha and Pretoria Portland Cement (PPC) plan to erect industries adjacent to the Saldanha Steel plant. Kriel argues that it will always be difficult to find a compromise between development and environmental conservation. "People have come up to me and thanked me for their jobs. A thousand people from the local area have been employed here," he said. The MEC for planning, who authorised the rezoning of the area from agriculture to heavy industry, said that a green buffer zone from Langebaan to Blouwaterbaai would eliminate the possibility of another Lambert's Bay (Independent Newspapers, 9611/25/

Saldanha Steel manager, Tom Ferreira, is confident that the company has handled the environmental issue matter successfully. "We were told the factory would be an eyesore and that it would affect the environment," Mr Ferreira said. "But our architects have designed the outside of the factory with aesthetics in mind. We also have an 'off-gas canopy' that captures excess gas before it gets into the atmosphere," he said. "We are confident that the Saldanha Steel mill will be an example to the world on environmental management," said Mr Ferreira (Argus, 9708/06).

<u>Saldanha Steel controversy</u>

<u>Summary</u>

The construction of the R6, 8 billion Saldanha Steel mill represents a scientific controversy because its construction, motivated by economic reasons, threatened to endanger the delicate ecosystem of the Saldanha coast. The South African government declared the area an Industrial Development Zone (IDZ) to which overseas investors would be lured through various economic incentives. These incentives led to the establishment of a number of “downstream industries”, amongst which was a cement mine, to be constructed on a site containing plant life considered to be ecologically sensitive. It was feared that industrial development could endanger Langebaan’s unique bird life, previously declared an international conservation site. Apart from the environmental dangers posed by the Saldanha Steel mill, it also posed also threatened to the aesthetics of the area. A government commission of inquiry was appointed in 1995, called the Steyn Commission, to investigate possible environmental damage to the area. The commission concluded that the Steel mill would pose an environmental risk to the area and proposed numerous guidelines to safeguard the region. However, Saldanha Steel did not comply with the guidelines and has been perceived as having reneged on all these promises.

Conclusion

What emerges from both controversies is that they relate to science and technology in different ways. For instance, the Virodene controversy is essentially an ethical, moral or political issue. Similarly the Saldanha Steel controversy is intrinsically a dispute concerning economic and environmental issues. Science is appealed to as a to mediator in these disputes, as the opposing parties call upon scientific standards for legal and policy decisions. In fact, science is a political instrument, used as a basis of rationality and offers grounds for consensus across a variety of policy issues (Nelkin, 1995).

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