FREEDOM TO INNOVATE

Biotechnology in Africa's Development

Report of the High-Level African Panel on Modern Biotechnology

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About the AU and NEPAD

The African Union (AU)

The African Union (AU) was established following the 9 September 1999 Declaration (the Sirte Declaration) of the Heads of State and Government of the Organisation of the African Unity (OAU). The AU is based on a common vision of a united and strong Africa and on the need to build a partnership between governments and all segments of civil society, in particular women, youth and the private sector, in order to strengthen solidarity and cohesion amongst the peoples of Africa. As a continental organization it focuses on the promotion of peace, security and stability.

The New Partnership for Africa's Development (NEPAD)

The New Partnership for Africa's Development (NEPAD) is an AU-affiliated development programme that was adopted in 2001. The objective of NEPAD is to stimulate Africa's development by bridging existing gaps in agriculture, health, education, infrastructure, information and communication technology, environment, tourism, science and technology.

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Message from the Co-Chairs

This report is about the role of biotechnology in the transformation of African economies. The implications of its recommendations, however, need to be seen beyond the confines of biological innovations. They address critical issues related to Africa's place in a globalizing economy.

Undertaken at the request of heads of state and government this report demonstrates what is needed to build the required capacity to harness and apply biotechnologies to improve agricultural productivity, public health, industrial development, economic competitiveness, and environmental sustainability (including biodiversity conservation) in Africa. It also shows that the measures needed to address biotechnology will strengthen Africa's capacity to adapt other technologies to economic development. In fact, previous inabilities to build capacity in fields such as information technology hamper the continent's efforts in biotechnology.

This report has placed these systemic considerations in the context of the role of innovation in economic transformation. It challenges Africa's heads of state and government to take seriously the importance of a coordinated approach in promoting technological innovation in development.

African governments have recognized the importance of regional cooperation to address possibilities and the range of issues associated with biotechnology. Within the framework of the New Partnership for Africa's Development (NEPAD) they have resolved to promote programmes that will generate a critical mass of technological expertise in targeted areas that can exploithigh growth potential from biotechnology to develop Africa's rich biodiversity, improve agricultural productivity and develop healthcare products. In the context of the African Union (AU), African leaders resolved to take a common approach to address issues pertaining to modern biotechnology and biosafety by calling for an African common position on biotechnology.

The main message of this report is that regional economic integration in Africa should embody the building and accumulation of capacities to harness and govern modern biotechnology. Regional economic integration bodies are key institutional vehicles for mobilizing, sharing and using existing scientific and technological capacities, including human and financial resources as well as physical infrastructure for biotechnology R&D and innovation. The loci of action are primarily local innovation areas which have core research and business institutions. International partnerships in biotechnology are critical to the realization of Africa's biotechnology strategies and should be pursued aggressively.

The panel draws it recommendations from analysis of the current research and development on the continent and outside Africa and some of the emerging social, economic, legal and political issues that surround the development, dissemination and commercialization of products from biotechnology. Strengthening Africa's capacity to innovate in these fields will also enable adequate biosafety measures to be put in place, in co-evolution with the advancing African R&D base.

The most important starting point in pursuing the recommendations outlined in this report is the urgency that African heads of state and government place on the strategic role that technological innovation plays in economic transformation. They must step forward with courage and firmness so that their footprints can guide future generations.

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Executive Summary

This report is about biotechnology and the role it can play for development in Africa. The report suggests specific and practical measures to advance development, quality of life and environmental sustainability using biotechnology.

'Biotechnology' is used in the most comprehensive sense of that word. It includes for example technologies that operate at the level of genes, but it also includes non-genetic biological technologies. The report says that biotechnologies should be developed with appropriate safeguards in place and according to the best internationally-agreed standards.

The report was compiled by a panel of experts (the High Level African Panel on Modern Biotechnology) from both inside and outside of the continent of Africa. The panel was put together by the African Union (AU) and the New Partnership for Africa's Development (NEPAD). The panel's report and the methodology used to compile it represent the most comprehensive and transparent assessment exercise of its kind.

The panel reviewed existing and historical plans, reports and published-research. It conducted consultations with a wide range of stakeholders in many countries. In addition, public meetings were held and written and verbal submissions were recorded from researchers, scientists, the business community, policy-makers, nongovernmental organizations (NGOs), and individual citizens. This report went through several drafts, which were posted on a public website – http://www.nepadst.org. The findings were presented at workshops and conferences in Africa and other regions of the world.

It is no secret that Africa's history has been marked by a development narrative in which the benefits from science, technology and innovation have been enjoyed by few, instead of being seen as tools for the development of all citizens. Today this is changing and Africa's leaders view science, technology and innovation as critical to human development, global competitiveness and ecological management. In that respect, this report needs to be seen as one component in a wider Africa-wide consensus to prioritize the continent's knowledge needs in its present and future development.

Main recommendations

The panel's main recommendations include the need for individual countries in central, eastern, western, northern and southern Africa to work together at the regional level to scale up the development of biotechnology.

A key vehicle is through what the panel calls "Regional Innovation Communities" and "Local Innovation Areas". These would include clusters of expertise, sharing knowledge, creative ideas, personnel, and working on problems and projects collaboratively. Regional Innovation Communities might include institutions that are already situated close together, such as universities, science-based industry and science parks. But today, institutions do not need to be in close proximity to work together. Effective and successful collaboration can take place between people and institutions that are geographically separate so long as the will exists to do so.

Regional Innovation Communities are a form of regional economic integration, which Africa is already experiencing in other areas. Regional economic integration more broadly can be an institutional vehicle for mobilizing, sharing and using existing scientific and technological capacities, including human and financial resources as well as physical infrastructure for R&D and innovation.

Some Regional Innovation Communities will come about organically. But many will need to be nurtured. In every case, what will be needed is a pool of talented and skilled people, as well as new and existing institutions, willing and able to embrace change. There needs to be a step-change in this area, which will entail reviewing and adjusting national and regional policies and related legislation to provide an environment conducive for higher education, R&D and innovation.

The report's other recommendations include: outtlining **priority areas** in biotechnology that are of relevance to Africa's development; identifying **critical capabilities** needed for the development and safe use of biotechnology; establishing appropriate **regulatory measures** that can advance research, commercialization, trade and consumer protection; and setting **strategic options** for creating and building regional biotechnology innovation communities and local innovation areas in Africa.

Priority Areas in Biotechnology

Food security, nutrition, healthcare and environmental sustainability are among Africa's biggest challenges. Regional biotechnology efforts have a role to play in each and can be implemented through what the panel calls long-term "biotechnology missions". Clustering can take place around priority areas as well as in places and institutions where expertise exists.

Health biotechnology, for example, is concentrated in southern Africa, for example. North Africa is established in bio-pharmaceuticals. Animal biotechnology has strong roots in eastern Africa; crop biotechnology in the west and forest biotechnology in central Africa.

Critical Capacities

Africa's ability to effectively use existing and emerging biotechnologies will depend largely on the level of investment in building physical, human, institutional and societal capacities. More specifically, Africa's regional innovation communities will need to specifically focus on creating and reforming existing knowledge-based institutions, especially universities, to serve as centres of diffusion of new technologies into the economy. Dependence on what we call the "relief model" for international cooperation will need to change towards a new emphasis on competence-building. Investing in critical capabilities is central to Africa's ability to benefit from its resources.

Africa needs to: develop and expand national and regional human resources development strategies that include: (1) a continental biotechnology curriculum that focuses on specific areas and targets that offer high economic potential for the regions and the continent; (2) a consortium of clearly identified and designated universities and research centres that develop and offer regional biotechnology training courses; (3) a focus on female recruitment in the sciences and engineering.

Africa needs to immediately expand and create infrastructure development programmes in order to tap into the opportunities that may arise from biotechnology. Research and development activities for the development, operation and maintenance of infrastructure need to be promoted, and linkages need be established with both domestic and overseas research networks.

African countries need to identify specific biotechnology priority areas that offer high potential for regional R&D and product development and integrate these priorities into African regionalization processes and policies.

To improve commercialization and business capacity, Africa needs to: (1) foster R&D cooperative partnerships at the local, regional and international levels; (2) create policy instruments that enable business incubation and development; (3) develop functional market infrastructure for economic development; and (4) stress the role of technology in general and biotechnology in particular for SME development policy.

The following mechanisms can be instituted to increase the available funding for biotechnology R&D in Africa: (1) substantially increased national R&D budgets; (2) special funding mechanisms, possibly innovation funds funded through a variety of means including challenge funds; (3) specific funding mechanisms under government ministries; (4) distinct African funding schemes or facilities; (5) reformed tax laws (i.e., foundation laws and industry-wide levies); and (6) national lotteries.

Governing Biotechnology

Africa should adopt the co-evolutionary approach where consumer protection goes hand in hand with the development of the technology itself. New stakeholder partnerships, awareness campaigns, and innovation competitions need to be created to facilitate public awareness and education on issues of biotechnology.

Emphasis should be put on maximizing the benefits associated with new technologies while reducing their negative impacts. Equally important is a consideration of the long-term implications of non-adoption of emerging technologies. The essential point therefore is developing and harmonizing regional regulations governing issues such as regional integration, research and development, safety (covering field and clinical trials) and trade in biotechnology products and services.

Africa's regulatory institutions need transparent and high quality scientific capacity to assess biotechnology-related risks and to be able to regulate quickly, safely and effectively. The Panel recommends the creation of an African Presidential Science and Innovation Council to oversee the implementation of AU recommendations related to scientific capacity building. Complementary organs may also need to be created in the Regional Innovation Communities. There is a need to develop harmonized legislation and measures based on international, continental, and individual country good practices in the context of the emerging Regional Innovation Communities. Development of such frameworks can lead to a co-evolution of regulatory frameworks and technology development.

The Pan-African Parliament (PAP) is an ideal institutional locus for harmonizing regulations and promoting biotechnology missions. There is need to strengthen PAP engagement in developing regional and continental programmes for biotechnology. Strengthening it will involve establishing for it advisory mechanisms, providing its committee with evidence-based policy studies, and equipping it with technology monitoring capabilities.

Strategic Considerations

Africa needs to take strategic measures aimed at promoting the application of modern biotechnology to regional economic integration and trade. Such measures include fostering the emergence of regional innovation systems in which biotechnology-related Local Innovation Areas play a key role. But doing so will entail a diversity of complementary measures that include upgrading regional capacities and forging international partnerships. Furthermore, funding such initiatives will involve adopting a wide range of approaches aimed at generating the necessary financial resources, including "innovation funds". Existing funding sources such as international and regional development banks could also play a key role in helping in the commercialization of products from the biotechnology-related local innovation areas.

Regional economic communities need to begin to determine potential opportunities for biotechnology specialization and to foster regional networking of biotechnology centres for R&D related to this regional specialization. African Regional Innovation Communities need to facilitate North-South and South-South collaborations as well as to mobilize the expertise in the diaspora for development.

Long-term process of biotechnology development in Africa needs to go hand-in-hand with the creation of regional economies. African countries need to (a) facilitate the process of regional integration; and (b) foster technological innovation as a force for promoting regional integration and trade

Local Innovation Areas hold the promise of creating competitive, biotechnology-driven African economies that will benefit from spatial concentrations of regional innovation actors (universities, firms, and research institutes). Countries and Regional Innovation Communities need to (a) identify biotechnology-related fields of local relevance; and (b) facilitate local innovation centre upgrading initiatives. There is great potential in developing North-South and South-South collaborations supporting biotechnology R&D and capacity-building in African regional innovation communities and local innovation areas. Countries and emerging Regional Innovation Communities need to identify ways of improving cooperation with other regions (particularly Asia and Latin America) of the world to effectively address issues pertaining to biotechnology.

Chapter 1:

Development in Africa: Learning From the Past, Planning for the Future

The African Union: Economic Successes and Challenges; A Diagnosis for Better Healthcare; Educating Africa; A Vision for Biodiversity Conservation and Sustainable Development; The Role of Science and Learning in Innovation; Why Better Governance is Critical to Development; The Potential for Biotechnology; Why International Partners Matter.

The African Union has made the task of integrating Africa further into the world economy a priority. The AU's efforts have been recognized by the continent's international partners, as could be seen through the recommendations of the 2005 G8 summit (where Africa was one of two main agenda items), the UK Government Commission's for Africa, and the UN Millennium Summit and its follow-up activities. With annual development aid expected to increase by US$50 billion between 2006 and 2010, substantial resources are to be made available for development in Africa.[1] This report will (among other things) assess the opportunities for biotechnology to contribute to this development.

Africa's Economic Successes and Challenges

Africa entered the new millennium as the world's poorest continent, with economies growing slowly or declining, and per capita incomes low or falling. But things changed in 2004 when the economies of the AU as a whole grew by 4.6 per cent, the highest rate in a decade. The rise was largely driven by a strong global recovery, demand from consumers globally and high commodity prices, high oil production and prices, although good macroeconomic management and agricultural performance along with improved political stability also played a part. Of 12 African countries posting real output growth of 6 per cent or more in 2004, eight are either oil exporters (Chad, Equatorial Guinea, Angola, Libya and Sudan) or recovering from the damage to economies that happens after times of conflict (Ethiopia, Sierra Leone, Liberia, Mozambique and the Democratic Republic of the Congo).[2]

Table 1: Top 10 performers and bottom 5 performers in Africa, 2004

Country	% GDP Growth
Chad	39.4
Equatorial Guinea	18.3
Liberia	15.0
Ethiopia	11.6
Angola	11.5
Mozambique	8.3
Democratic Republic of Congo	6.9
Sudan	6.8
Sierra Leone	6.6
The Gambia	6.6
Gabon	1.7

Central Africa Republic	1.4
Cote d'Ivoire	0.9
Seychelles	-2.0
Zimbabwe	-6.8

Source: UN ECA, 2005

The North African growth in GDP was 4.8 per cent in 2004. In sub-Saharan Africa, growth improved to 4.5 per cent in 2004 from 3.9 per cent in 2003. The 2005 projections for both regions were estimated at 5.2 per cent for North Africa and 4.8 for sub-Saharan Africa.

At the regional level, it was central Africa that was the fastest-growing at 7.3 per cent in 2004 (see Table 2).

Table 2: Gross domestic product growth by African regions, 2002-2004 and projections for 2005

Region	**2002**	**2003**	**2004**	**2005 – projected**
Southern Africa	2.8	4.8	2.8	4.4
East Africa	3.1	6.7	3.1	5.6
Central Africa	4.0	4.4	7.3	6.1
West Africa	3.6	2.5	3.6	4.5
North Africa	3.3	2.5	3.3	5.2
Sub-saharan Africa	3.5	3.9	3.5	4.8
Africa as a whole	3.2	4.3	3.2	6.1

Source: UN ECA, 2005

Challenges Ahead

Looking at GDP alone, however, is misleading as a marker for prosperity. Although continental GDP has improved over recent years, the proportion of people living in absolute poverty remains higher now compared to what it was in the 1980s and 1990s.[3] The recovery in economic growth we have seen in several African countries has not translated into higher income and more employment opportunities for people.

Whereas between 1990 and 2004 African economies expanded by 3 per cent a year, the proportion of the continent's population classified as 'absolute poor' increased by 2 percentage points every year during that period. The prime reason that poverty levels responded so weakly to economic growth was because growth has been not only slower than expected, but that only a small proportion of Africa's populations have benefited. As a result, at the 1.2 per cent per capita annual income growth experienced since 2000, it will take sub-Saharan Africa until 2012 just to restore average incomes to their 1980 levels.[4]

A second factor is the low absorption of labour in Africa's growth sectors. Agriculture is the mainstay of African economies. This means that the majority of people of working age are employed in this sector, which remains, compared with developed-world agriculture, relatively labour-intensive. There are few opportunities for agricultural workers to participate meaningfully in other sectors, as either producers of goods or as participants in the workforce. Taken together, this has hindered equitable economic expansion on the continent.

In sub-Saharan Africa, a huge influence on poverty trends has been the escalation and spread of conflicts. The number of countries beset by internal conflicts increased from six in 1980 to 14 in 2000. Overall, unrest and outright conflicts have been hugely destructive, economically and socially: in countries struggling with conflict, real GDP per capita declined by at least 1 per cent per year.

Bitter Pill: The Healthcare Challenge

Of all world regions, Africa as a whole has the lowest human development and highest poverty indicators. Many African countries have the highest illiteracy rates and the lowest primary education enrolment. Health is another area for major concern. In sub-Saharan Africa, the rapid spread of HIV/AIDS has proven cataclysmic. Life expectancy in sub-Saharan Africa is 46.1 years, compared to the North African average of 71.5. In 2003, the prevalence rate of HIV and AIDS in adults was 7.3 per cent in sub-Saharan Africa, compared to 1.1 percent globally. In 2004, over 2 million people in sub-Saharan Africa died from AIDS, and more than 3 million in the area were infected in that year alone. Three out of four of the young people living with HIV and AIDS are women in sub-Saharan Africa.[5]

It is southern Africa, however, that has the highest prevalence of HIV and AIDS: the top 10 countries in this respect are all from the SADC region barring the Central African Republic (see Table 3). In Botswana and Swaziland, the prevalence of HIV and AIDS among adults in 2003 was 37.3 and 38.8 per cent, respectively — the highest rates in any national population.

Table 3: HIV and AIDS prevalence for adults aged 15-49, 2003 (%) in Africa

Country/Region	**%**
Swaziland	38.8
Botswana	37.3
Lesotho	28.9
Zimbabwe	24.6
South Africa	21.5
Namibia	21.3
Zambia	16.5
Malawi	14.2
Central African Republic	13.5
Mozambique	12.2
Tanzania	8.8
Gabon	8.1
Sub-Saharan Africa	7.5

Source: UNAIDS, 2004

The devastating impact of HIV and AIDS is not only exacerbated by the increase in levels of poverty; it is also a manifestation of the breakdown in the African healthcare system. In the 1990s, per capita health expenditure in many African countries was a mere US$10, compared to at least US$1000 in member states of the Organization for Economic Cooperation and Development (OECD). After years of neglect, Africa's health systems are run down, and there are huge deficits in the numbers of doctors and nurses. Staying healthy is particularly expensive for the poor, with a third of their monthly expenditure going on malaria treatment alone.

Preventable diseases such as malaria are in fact one of the biggest blights afflicting the people of Africa. The number of men, women and children who suffer and die from these diseases in Africa is no longer acceptable. One in six children dies before their fifth birthday. Low-cost interventions, such as vitamin A supplements, insecticide-treated nets and oral rehydration therapy, which could significantly reduce these deaths, are largely unavailable. Meanwhile, 1.5 million African children die each year from vaccine-preventable illnesses.[6]

Ensuring reliable access to -- and proper use of -- safe, effective and affordable diagnostic tests, medicines, vaccines and reproductive health goods, such as condoms, is essential to health and a key function of effective health systems. It is estimated that nearly half of the continent's people do not have regular access to essential medicines. There are no effective diagnostic, preventive or therapeutic options for many of the health challenges Africa is facing. The continent accounts for just 1.1 per cent of the total value of the global pharmaceuticals market. This has meant that large pharmaceutical companies have not prioritised Africa's health needs.[7]

Burden of disease and economic growth are, of course, intimately related. Healthy people are more productive and more likely to be able to take care of their children, benefit from education and contribute to society. For example, simply de-worming children could reduce pupil absenteeism in schools by 25 per cent. The income levels of countries with severe malaria are a third of those in equivalent countries without malaria, and also grow 1.3 per cent less per person every year.

Educating Africa

As with healthcare, education in Africa is also critical. In 2005, over 40 million children were estimated to be out of school in sub-Saharan Africa. Several countries remain at high risk of not achieving universal primary education and gender equality by 2015. In Niger, Burkina Faso and Angola, for instance, the expected number of years of formal schooling is less than five on average, and over 60 per cent of children drop out of school in Chad, Equatorial Guinea, Guinea Bissau, Madagascar and Rwanda. Where more children are completing primary school, there is more demand for secondary or vocational education. Enrolment in higher education, essential for building knowledge-driven industries, meanwhile, remains very low — in most countries the gross rates sit below 10 per cent, and in several cases, such as Chad, Guinea-Bissau and Tanzania, it is less than 1 per cent.[8]

Even bright spots are capable of generating clouds in their wake. Take the issue of expanding primary school enrolment rates that are being seen across Africa. The quality of education on offer to children tends to be variable as most countries currently have acute shortages of teachers, or large disparities in available teachers between cities and rural areas. Ghana has just a quarter of the teachers it needs, and Lesotho a fifth. In Namibia, only 40 per cent of teachers in rural schools in the north are qualified to teach, compared to 92 per cent in the capital. In Burkina Faso, the teacher shortage has been declared a 'national emergency' and educated people are being contracted from across the public sector to fill urgent gaps, while recruitment and training of existing teachers to a higher standard is undertaken. In Malawi, the introduction of free primary education in 1994 has led to an unprecedented demand for new teachers.

Africa's teacher shortage is made worse by people abandoning the profession. It is not completely understood why this is happening at a time when education is expanding. However, one factor is understood to be the HIV pandemic. Although there is little information on the impact of HIV and AIDS on teachers, whatever evidence does exist gives cause for concern – in Zambia mortality among teachers is reported to be 70 per cent higher than in the general population, although deaths are not attributed officially as HIV and AIDS related.[9] Teacher training is not keeping pace and the result is that there is extra pressure on those teachers who are available.

Tomorrow's Wealth: Biodiversity and Sustainable Development

Healthcare and education are among the pillars of all societies. For Africa, another foundation for the prosperity of present and future generations is the continent's natural resources and its biological diversity. Africa is rich in natural resources and biological diversity (or biodiversity). This includes land, wildlife, forests, fisheries and water.

Today, however, Africa's biodiversity in particular is under threat, not least from the degradation of land and water that the continent is experiencing. Africa's economies and its peoples often suffer from the effects of drought and floods unlike people in other parts of the world. But the frequency and ferocity of these are likely to increase as climate change continues to bite. Land and water degradation takes many forms. It includes desertification, deforestation, a decrease in arable and grazing land, declining soil productivity, pollution, and depletion of freshwater. Many of these issues are intertwined.[10]

Biodiversity loss in Africa has significant impact on economic growth and social development. Deforestation, for example, is known worldwide to reduce wildlife. But for Africa's rural citizens it has the effect of removing key sources of food, fuel and medicines, as well as adversely affecting tourism and pharmaceuticals – from a reduction in the availability of medicinal plants.

One of the most significant impacts of biodiversity loss, however, is in the area of livelihoods. More than 70 per cent of sub-Saharan Africa's people depend in large measure on forests for their living, and 60 per cent of Africa's energy needs are met by wood. The annual gross cost of environmental degradation in Ghana, including forest loss, soil erosion, health effects and land degradation, has been estimated at US$127 million, or 2 per cent of the country's GDP.[11]

Land degradation is not the only cause of biodiversity loss. Other factors include rapid population growth, urbanisation, unsustainable agricultural expansion and over-exploitation of forests. Natural factors such as variable rainfall add to the mix, along with wider issues such as overall low economic growth, weak regulatory frameworks, the limited response capacity of public institutions, and collapses in governance triggered by conflicts.

People Power: Towards Better Governance in Africa

If the effects of natural disasters and poor healthcare were not enough, Africa's post-independence development has been further hindered by poor governance. The nature and effects of this have been documented extensively. But what is now clear, indeed, what has been clear for some years now, is that the crisis of governance in Africa may well have turned a corner.

Between 2000 and 2005, more than two-thirds of the countries in sub-Saharan African have held multi-party elections. The unquestioned and seemingly uninterruptible rule of individuals, armed forces and single-parties is giving way to more representative governments, and greater political and other freedoms for all citizens. Africa is at the beginning of what may well be its most important journey in political terms. The road to good governance is long and the journey is not easy as many countries are discovering, but what is important is that most countries in the AU are committing themselves to embarking on that journey. One important innovation is the provision of science advice inside government, both at the level of the executive, as well as the legislature.

Science, Technology, Learning and Innovation in Development

The role of science and technological innovation in economic change and sustainable development is increasingly recognised: we now know that many of the economic advances in developed and newly industrializing countries stem from innovation – this might be technological innovation, or innovation in organization, processes, and management.[12] One of the keys to success from innovation has been a focus on improving skills — in essence, putting a premium on learning. This strategy means that that every generation receives a legacy of knowledge that it can harness to its own advantage. Every generation blends the new and the old, and thereby charts its own path in development.

In the developed countries, national income and rates of economic growth have not decreased appreciably since the Industrial Revolution, circa 1870,[13] . One reason for this is that these countries have chosen to reinvest an ever-larger percentage of GDP in further research. Every year, the 29 OECD member-countries together spend about 1.5 times more on research and development than the entire economic output of sub-Saharan Africa.[14] Ambitious developing countries have followed suit, increasing research capacity and skills development in a variety of science and technology disciplines.

Knowledge creation through research and innovation is one component of development. A second is translating research (wherever appropriate) into products and processes and modifying and adjusting them to respond to socioeconomic conditions.[15]

Take agricultural productivity. World food production doubled between 1961 and 1998, without increasing the area of land under cultivation.[16] Another pertinent example is high-tech manufactured goods. From 1980 to 1996, trade in these grew at double the rate of resource-based goods.[17] Some of the East Asian countries that capitalised on these opportunities have transformed themselves into middle- or even high-income economies.[18]

A lack of human capacity is emerging as one key message emerging from this example, and from the broader assessment of Africa's status in the global economy. What AU member states must do is to focus on building human and other capacity, particularly in science, technology and innovation. Economic, social and sustainable development cannot happen without appropriate infrastructure, and human resource development on a large scale. [19]

Infrastructure includes transport (roads, rail, airports); education (schools, colleges, universities, teacher training and inspectorates), as well as water, sanitation, irrigation, health centres, telecommunications and energy. These investments, in turn, nurture the development of small and medium-sized enterprises, which are among the engines for economic growth. Enterprise development and infrastructure also catalyses the development of local operational, repair and maintenance expertise, as well as institutes of higher education, academies of sciences and engineering and related professional, industrial and trade associations.[20] All of these are integral to the broader goals of development, learning and economic growth.[21]

The Potential for Biotechnology

For the past two decades, biotechnology has been at the centre of global conversations in public policy. Its potential in development was recognized in 1992. Agenda 21, the action programme of the United Nations Conference on Environment and Development held in Rio de Janeiro, stated that biotechnology:

"Promises to make a significant contribution in enabling the development of, for example, better health care, enhanced food security through sustainable agricultural practices, improved supplies of potable water, more efficient industrial development processes for transforming raw materials, support for sustainable methods of aforestation and reforestation, and detoxification of hazardous wastes."

In the intervening years, biotechnology (in the broadest sense meaning biological technologies) has kept many of these promises, not only in developed countries, but also in the developing world, particularly Brazil, China, Cuba and India. Biotechnologies, moreover, are used to reclaim wasteland through the use of micro-organisms and plants that are deployed to degrade toxic compounds. Biotechnologies are used in agriculture, both in the genetic modification of food and non-food crops, but also through the use of natural methods for controlling weeds and pests. Some firms have incorporated biotechnology techniques in production processes to lower energy and water consumption, improve productivity and reduce the number of processing steps.[22] Biotechnologies are also now widely used in healthcare, for example, in the development of vaccines for critical illnesses such as Hepatitis B.

But as with the Green Revolution, biotechnology has so far failed to take root in Africa. Many obstacles stand in the way. These include many that have been mentioned in previous pages.[23] If the will exists to invest in human resources and in infrastructure, then AU member states, too, will reap the benefits from biotechnologies.

One of the most promising areas for the development of biotechnology in African countries is in products derived from minerals and from forests.[24] Another area of promise is the promise of energy from natural products (the bio-energy sector).

The Regional Dimension

Trade is a key component of growth, for all countries. In the past two decades alone, first China and now India have seen economic growth accelerate through the promotion of national, regional and international trade. Many developing countries have found new markets. Eighty per cent of exports from developing countries, for example, are now in manufacturing. Compare this to the 1980s when 70 per cent of developing country exports were primary commodities. The share of developing countries in world trade has risen strongly, with the share in manufacturing rising from 17 per cent in 1990 to 27 per cent in 2002.

But within the countries of the African Union, such gains in trade are yet to materialize. Indeed, for many, the opposite has happened. The AU's share of world trade has shrunk in the past quarter century, from around 6 per cent in 1980 to 2 per cent in 2002.

This statistic comes despite the fact that AU member countries have launched many initiatives aimed at boosting regional economic integration. The past four decades, for example, have seen many regional cooperation and integration schemes adopted across Africa**.** Currently, there are more than 20 regional agreements that have this aim in mind.

Why is regional integration seen as important? As seen in the context of the AU, it is seen as a way of dismantling at least three barriers to development. These are: weak national economies; a dependence on importing high-value or finished goods; and a reliance on a small range of low-value primary exports, mainly agriculture and natural resources.

A desire for closer regional cooperation emerged initially in the first years after the end of colonial rule. It was manifest in several ways. Among peoples, for example, was the desire for unity and for a pan-African identity. Those of Africa's leaders who steered individual countries to freedom were keen to support this. But a united Africa for them also had a clear political goal: this was to create a regional power strong enough to be able to stand up to former colonial powers whenever the need arose.

This aspiration has been fulfilled to a degree with the founding of the African Union in 2001, and before that the Organization of African Unity (OAU) in 1963. The African Union in particular provides for greater political unity and economic integration, and commits African countries to principles of democracy, the protection of human rights, good governance, gender equality and people-centred development.

For two decades, from the mid 1960s through to the mid 1980s, the OAU played midwife to many treaties and institutions aimed at strengthening regional ties These included the Customs and Economic Union of Central Africa (UDEAC 1964); the East African Community (EAC 1967-1977, and revived in the early 1990s); the Southern African Development Community (SADC);[25] the Economic Community of West African States (ECOWAS 1975); the Common Market for Eastern and Southern Africa (COMESA 1995);[26] the Arab Maghreb Union (AMU 1989); the Economic Community of Central African States (ECCAS); the Inter-Governmental Authority on Development (IGAD); and the Community of Sahelo-Saharan States (CEN-SAD). The UN Economic Commission for Africa (ECA), established in 1958, both acted as catalyst for their formation and gave them their economic orientation.

These initiatives had various aims, some ambitious, others more focused. They included: eliminating tariffs and barriers to trade among members, establishing a customs union; unifying fiscal policy; coordinating policies in the sectors of transport, communications, energy and in infrastructure. In each case, the designers of these policies and initiatives wanted to open up national economies, but at the same time reap greater rewards from geography, and from Africa's common culture.

Many of the initiatives of the past have not worked. In particular, what seems to have failed is the idea that economic growth will automatically follow through the often symbolic act of opening up or expanding markets for trade[27]. Many countries thought that merely opening up borders would increase trade, from which, all other benefits (such as increased economic growth) would follow. What they failed to realise is that the act of dismantling trade barriers needs to take place along with the development of infrastructure and institutions. Without the latter, larger markets in particular have little incentive to do business. One of the reasons for this is that compensating for the lack of infrastructure or institutions adds to the bottom-line of businesses.[28]

Regional Innovation Communities and Local Innovation Areas

Is there a regional dimension to developing biotechnology among AU members? This report will demonstrate that there is. Central is what we call Regional Innovation Communities. Developments in science and innovation increasingly happen through collaboration, where individuals and institutions with complementary skills and expertise come together to realise shared goals. Globalisation has removed barriers to such collaboration. Regional Innovation Communities would include both physical, but also virtual clusters of people and organizations. Investment in people and other resources would be key. The physical clusters we call Local Innovation Areas. They would include universities, companies and industries, science parks, trade associations, academies of science and learning, and other professional groups.

Local Innovation Areas can be seen as consisting of important links, complementarities, synergies and spillovers of technology, skills, information, marketing, and customer needs across multiple firms and industries. They increase productivity and innovative capacity in individual businesses and in industry, and incubate new businesses that in their turn buttress innovation and expand the centre.

The Role of International Partners

Providing aid, giving technical assistance, and importing raw material and natural resources. This is one -- and not entirely inaccurate -- description of the relationship between many of the poorer developing countries, and the broader community of developed nations**.** It applies equally in the field of scientific research. In the field of natural product chemistry, for example, if a laboratory in a developing country has succeeded in identifying therapeutic qualities from a natural product, the higher-value processes of developing pharmaceutical compounds is likely to take place in another (usually wealthier) part of the world.

This could change if many AU member states were to make a step-change investment in human resource development as well as well as similar increases to spending on infrastructure, as has happened in other developing countries. Cooperation and collaboration is vital to progress in science and innovation. Indeed, Regional Innovation Communities and Local Innovation Areas will need to develop strong links with international partners.

Increasingly, international scientific partnerships are being forged between countries of the Southern hemisphere. Take Heber Biotech. A semi-private company in Cuba, it has helped commercialize the country's biotechnology products and by 1998 was recording about $290 million a year in sales of hepatitis B vaccines and pharmaceuticals in 34 countries. Now Heber Biotech is entering into partnerships with other developing countries.

In 2001 it established a joint marketing venture with Kee Pharmaceuticals of India. The company's new division, Kee Biogenetics, has launched India's first recombinant DNA product, streptokinase, capable of dissolving coronary clots and preventing heart attacks. The resulting drug, Cardiostrep, is owned by Heber Biotech.

Chapter 2:

Biotechnology in Africa: Status Report

A Revolution on the Farm; What Biotechnology can do in Nutrition; Biotechnology in the Animal Kingdom; Biotechnology in Forests and Beneath the Seas; Biotechnology in Healthcare; Industrial Biotechnology; Environmental Biotechnology; Merging Biosciences with Chemistry and Computing; New Ways to Finance Biotechnology.

Biotechnology in the fullest sense of the word is critical to Africa's development. But to realize the potential that biotechnology holds for sustainable development and a better quality of life, AU member states need to travel faster towards researching, developing, harnessing, and innovating in response to the continent's needs. Much innovation is already taking place throughout the continent. This chapter outlines Africa's strengths in biotechnology in agriculture, livestock, healthcare and other sectors.

Revolution on the Farm: Agricultural Biotechnology

Among its many applications, biotechnology also includes being able to isolate, select and transfer genes from one organism into another, a technology known as genetic modification. Global agriculture today is a major user of this application, and worldwide developments in this technology continue to be rapid. For example, some 8.5 million farmers today grow crops that have been produced using genetically modified biotechnology. Far from being a technology for the wealthy, nine out of every 10 farmers who use it come from some of the poorest countries.

Overall, the global area of approved crops that use biotechnology increased to 90 million hectares in 2005 from 81 million hectares in 2004, representing an annual growth rate of 11 per cent. Similarly, the number of countries growing biotech crops increased from 17 in 2004 to 21 in 2005. In order of crop area, these are: USA, Argentina, Brazil, Canada, China, Paraguay, India, South Africa, Uruguay, Australia, Mexico, Romania, the Philippines, Spain, Colombia, Iran, Honduras, Portugal, Germany, France and Czech Republic. Eleven of these are developing countries.

Among them it is Brazil that leads the way in setting aside land for agricultural biotechnology. The largest increase in crop area in Brazil was 4.4 million hectares, followed by the US (2.2 million hectares), Argentina (0.9 million hectares) and India (0.8 million hectares).

Notwithstanding modest efforts from public sector institutions, the primary source of genetically modified crops, however, remains the private sector. Indeed, it is multinational corporations that have made significant investments in global genetic technology. And in doing so, they have tended to concentrate on those applications, which they believe are more likely to offer significant returns on their investment. For example, in 2005, herbicide tolerance continued to be the predominant trait of biotech crops grown worldwide (71% of the global crop area) in soybean, maize, canola and cotton. The bulk of the remaining area is occupied by insect-resistant cotton crops (18%) and crops with stacked genes (11%).[29]

The economic potential for wider applications of agricultural biotechnology can be seen from the fact that in 2005, the global market value of the four crops mentioned above was US$5.25 billion, comprising 15 per cent of the global market for disease and pest control (US$34.02 million) and 18 per cent of the seed market (~US$30 billion). In 2005, nearly half of the world's agricultural biotech market was represented by just one crop: soybeans. The cumulative global biotech crop market for the period 1996-2005 is estimated at US$29.3 billion.

As the following short summaries demonstrate, Africa's governments, its industry and its research institutions are well aware of the potential that agricultural biotechnology holds if applied in other ways and to indigenous crops. One study of 13 public institutions in Kenya, Zimbabwe, Egypt and South Africa showed that biotechnology applications have been performed on 21 crops where the genes incorporated include those that confer insect, fungal, viral and bacterial resistance, protein quality improvements, herbicide tolerance, and salt and drought resistance.[30]

Selected Country Assessments

- South Africa

In South Africa alone, for example, about 20-30 per cent of yellow maize and 80 per cent of cotton are now genetically modified varieties.[31] Estimates for the 2003/2004 production season showed that about 27 per cent of total yellow maize area (used in animal feed) was under varieties produced using genetic modification, white maize (for human consumption) is planted on less than 8 percent of the total white maize area.[32] The traits being developed include drought tolerance, nitrogen use efficiency, and resistance to striga and stem borer using both transgenic techniques as well as conventional biotechnology. South Africa's leading biotech research institutions include the Universities of Cape Town and KwaZulu Natal.

The early successes with GM cotton in South Africa, however, have not been sustained. The area given over to GM cotton has declined drastically, though the main reason for this is a significant drop in the market price for cotton. As a result, the cotton crop area fell from 99,000 hectares in the 1998/99 season to 51,000 hectares in the 99/2000 season. The area of land continues to fall and is estimated to be just 21,000 hectares for 2004/2005.

An insect-resistant potato was developed in South Africa in 2001. The goal was to help small farmers to grow this on a commercial scale. The potatoes performed well in field trials but commercialisation has been delayed. Syngenta, which owns the rights to the *Bt* gene that confers insect resistance, has not been able to obtain full regulatory approval of the South African government before a commercial license can be given. Moreover, the company is waiting for biosafety legislation to passed in neighbouring countries, which would cover any liability issues that may arise if genes crossed borders through wind-blown pollen, for example[33]

- Kenya

Kenya has been working with non GM biotechnologies (bio-fertilisers and tissue culture, for example) for several decades.[34] Tissue culture continues to be an important technology in Kenya in the horticulture sector particularly in citrus and pyrethrum. More recently there has been much focus on tissue culture in bananas.[35]

The first GM biotechnology product to be developed in Kenya was a genetically modified virus-and weevil-resistant sweet potato. This project began in 1991 and was a public-private partnership (PPP) between the United States Agency for International Development (USAID), the Kenyan Agricultural Research Institute (KARI) and the Monsanto Company, with the International Service for the Acquisition and Application of Agricultural Biotechnology (ISAAA) joining in 1999. The sweet potato trials met some setbacks because it is believed that the construct for the virus resistance was not well tested and it did not perform well under field trials.

In addition, KARI in partnership with the international maize laboratory CYMMIT in Mexico has been developing insect resistant transgenic maize. The maize was tested in field trials in May 2005. Kenyatta University in Kenya has established a facility for plant transformation with maize being one of the candidate crops especially for resistance to striga and tolerance to drought.[36]

- **Egypt**

Egypt has worked on more varieties of crops than any other country in Africa, and is second to South Africa in the number of what are called 'transformation events' in which new crops are modified using biotechnology.[37] The Genetic Engineering Services Unit (GESU) of the Agricultural Genetic Engineering Research Institute (AGERI) in Egypt has been actively involved in micropropagation of *Satavia rebaudiana* and mulberry, as well as the production of diagnostic kits for detecting viruses in banana, potato, tomato and beans. Plant biotechnology research at AGERI also includes transferring genes that confer virus resistance, bacterial resistance, insect resistance, stress tolerance and fungal resistance on such crops as potato, cotton, maize, faba beans, cucurbits, wheat, banana and date palm.[38]

Insect resistant potato is another of the major crops that have been worked on in Egypt by AGERI in partnership with Michigan State University in the USA. Several varieties of potato were transformed for potato tuber moth resistance including a widely grown Dutch variety in Egypt, *Spunta*. *Spunta* performed well in controlling potato tuber moth but after eight years of research (1993-2001), the *Bt* potato has not been commercialised because of trade concerns with the EU over GM crops.

- Uganda

The National Agricultural Research Organisation (NARO) of Uganda opened a new research laboratory in 2003 to conduct work on the genetic modification of banana. The goal was to insert genes that will confer resistance to Black Sigatoka and banana weevils. Several African and international institutions are involved in this partnership including KUL, CIRAD, the International Institute for Tropical Agriculture, the University of Pretoria and Leeds University in the UK.[39]

Field trials on *Bt* cotton have been carried out in several countries including Kenya, Zambia, and Zimbabwe. Tanzania and Burkina Faso have recently started field trials, while Mali was slated to start field trials in 2005. However, a cotton trial in Zambia has had to be halted because biosafety regulations were not ready at the time.

Future Food: Biotechnology and Nutrition

Cereals are the major staples in the diets of the majority of Africa's citizens. But cereals tend to contain insufficient quantities of vitamins, minerals, as well as essential amino acids, iron and zinc. This contributes to a form of hunger that nutritionists call 'micronutrient malnutrition'. The absence in diets of one such micronutrient, Vitamin A, is the leading contributor to child mortality in developing countries. Vitamin A is key to the effective functioning of immune systems. Despite many successes, Vitamin A deficiency today still affects the ability of 250 million children to fight off deadly diseases such as HIV and AIDS, malaria and diarrhoea. It is also the single most important cause of blindness among children.[40] The absence of minerals such as iron, zinc as well as amino acids, moreover, contribute to infections and increase the risks of complications during childbirth and pregnancy. Also, these deficiencies profoundly impair child development.

Worldwide, biotechnologies that can enhance the nutritional value of grains and fruits are developing rapidly and their use in tropical crops is expected to improve healthcare, while at the same time contributing to economies. Rice and sorghum are two of the candidate crops, being developed for this purpose. A third is sorghum. Biotechnology is being employed to improve the nutritional content of sorghum thanks to the work of a consortium of institutions from Africa, Japan and the USA. Funded by the Bill and Melinda Gates Foundation and led by Kenya-based Africa Harvest, consortium members include the Council for Scientific and Industrial Research (CSIR) of South Africa, the African Agricultural Technology Foundation, Forum for Agricultural Research in Africa, and the Agricultural Research Council (ARC) of South Africa. The project has still to obtain approval for contained trials, but by the end, its partners expect to produce sorghum that is fortified with amino acids, proteins, iron, zinc and Vitamin E.

Nitrogen is a key limiting nutrient in the soils for crop production, but the price of nitrogen fertilizer has been increasing over the years to the extent that it has become unaffordable to most small scale farmers in rural areas. Biological nitrogen fixation (BNF) is a technology that has been adopted by many countries in Africa to circumvent this problem. It induces the multiplication of microbes in plant roots, known as biofertilizers, which then help the plant fix nitrogen from the atmosphere. Use of biofertilizers has been reported in many countries for instance Kenya, the United Republic of Tanzania, Zambia, Zimbabwe, Tunisia and Senegal.[41] For over a decade, several brands of a BNF product developed at the University of Nairobi, Kenya, have been released for commercial use, mainly for the production of leguminous crops.

New Rice for Africa

One agricultural biotechnology application with promising potential is what is known as New Rice for Africa (NERICA), a new variety of hybrid rice. Scientists at the Africa Rice Center (WARDA) in Benin have created NERICA by crossing *Oryza sativa* (Asian rice) with *Oryza glaberrina* (African cultivated rice). Farmers have been able to select new rice varieties from the resulting germplasm, with qualities such as higher yields, shorter growing seasons, resistance to local stresses, and higher protein content than traditional African varieties. The new varieties have been released in Cote d'Ivoire, Nigeria and Uganda, and are being evaluated in Benin, Burkina Faso, Ethiopia, The Gambia, Malawi, Mali, Mozambique, Sierra Leone, Tanzania and Togo. WARDA researchers suggest that some 200,000 hectares will soon be under NERICA cultivation, producing about 750,000 tonnes of rice per year, and leading to an annual saving on rice imports of nearly US$90 million.[42]

Recommendation 1*:* Agricultural biotechnology holds the promise of improving food security, and better nutrition. AU member states must invest in agricultural biotechnology to address long-term issues such as nutrient deficiency, and needed improvements to overall agricultural productivity.

Lifelines for Livestock: Biotechnology in the Animal Kingdom

Often less rated by those who shape and plan development policies, livestock is critical to agriculture and to food production in Africa, as it is elsewhere. Yet, according to some estimates, Africa's livestock community is expected to become the most important agricultural sector in terms of physical products derived from agriculture, such as meat products and leather.

At the present time, the continent's livestock sector is in need of much support and is experiencing inadequate animal husbandry and poor veterinary services – the latter of which is predominantly provided by the state. But, as is the case in agriculture more broadly, Africa's governments and the continent's research institutes are using biotechnology to improve the continent's veterinary science and medicine. This might be through the development of recombinant DNA vaccines or through attenuated live vaccines. Or it could be through the many diagnostic testing kits that have been developed to diagnose disease causing agents, or to monitor the impact of disease control programmes. These tests are particularly important in being able to trace and then eradicate disease epidemics. Most of the diagnostic kits currently in use in developing countries, however, are cumbersome and unsuitable for low-income farmers.

When it comes to animal health, there is no substitute for proper and nutritious animal feed. Yet we know that most livestock farmers in the developing world are unable to afford what they need. Once more biotechnology can lend a hand by fortifying the feed that farmers currently use with enzymes, probiotics, single-cell proteins and antibiotics. Gene-based technologies are being used to improve animal nutrition by making existing feed more digestible, for example. Another technique that is used is to modify the digestive systems of animals in such a way that they can make the best use of available feed. A third possibility is from animal cloning. Producing animals that can, for example, produce meat and milk but without the use of expensive hormones, antibiotics and chemicals.

After five years of study, the US Food and Drug Administration (FDA) announced in December 2006 that it regards food from cloned animals as being safe to eat. Similar studies from other regulatory agencies are expected to follow suit. Africa's farming systems are already under stress. Breeds of cattle resistant to diseases such as sleeping sickness are dwindling at an alarming rate as local farmers adopt larger zebu breeds to replace their hardier but smaller taurine relatives. Ecological change is like to accelerate this trend. Slowing the decline will require the use of reproductive techniques such as animal cloning for predictable livestock production, in addition to expanded breed conservation programs.

Selected Case Studies

International Livestock Research Institute (ILRI)

The International Livestock Research Institute (ILRI) is at the forefront of using biotechnology to develop new and improved animal vaccines as well as developing diagnostic tools to combat livestock diseases. These include in particular the high-priority 'orphan' diseases of Africa and South Asia. The centre's research is also aimed at conserving the wealth of what is called the 'barnyard' genetic diversity of Africa and other developing nations; and for improving the feed value of crops in crop-livestock systems. One third of its US$35 million budget is spent on research in biotechnology. More than 100 scientists, technicians and students work in an array of fields including bioinformatics, biometrics, diagnostics, immunology, microbiology, parasitology, and recombinant DNA technology.

Most of ILRI's biotechnology research is conducted at the centre's headquarters, in Nairobi, Kenya, but also at its second campus in Addis Ababa, Ethiopia, where ILRI maintains a forage genebank. Specific projects include research to identify genetic markers for tolerance to African trypanosomiasis in N'Dama cattle, and for resistance to parasites in Red Maasai sheep. The institute is currently looking to develop a vaccine against *Theileria parva* in cattle and preliminary trials with five candidate vaccines are currently underway.[43]

Laboratoire National de l'Elevage et de Recherches veterinaires (LNERV)

The Laboratoire National de l'Elevage et de Recherches veterinaires (LNERV) in Senegal is West Africa's principal veterinary research laboratory. Established more than 50 years ago, it has extensive experience of research in animal health and husbandry, particularly in developing vaccines. LNERV is also involved in developing diagnostic tools for better surveillance of diseases that are specific to animals in a certain area (enzootic diseases) and diagnostic kits for those diseases, which affect large numbers of animals at the same time (epizootic diseases). LNERV is also involved in developing and implementing disease control strategies in Senegal and broader West Africa.

LNERV has also produced kits for the diagnosis of rinderpest and for African swine fever, as well as 25 different types of veterinary vaccines equivalent to some 50 million doses per year. New vaccines in the pipeline include those for anthrax (this will be a genetically recombinant vaccine), epizootic diseases such as Newcastle disease in rural poultry; zoonotic diseases such as Rift Valley fever and for hemoparasite disease.

South Africa

In South Africa, biotechnology is being used to develop molecular diagnostic testing kits for tick-borne diseases found in livestock. Where South Africa leads the way is in bringing together and leading consortia of public and private sector groups in developed and developing countries. One testing kit that was launched in March 2005 for example, was produced through collaborative work carried out by a consortium comprising the University of Pretoria, Utrecht University, Isogen Life Science and the ARC-Onderstepoort Veterinary Institute.

Work is currently underway to transfer genetic material from the indigenous Bosmara cattle to farmers in developing countries using embryo transfer technology. The aim here is to transfer useful traits in cattle breeds in other countries using conventional animal breeding methods.[44] Several live recombinant vaccines have been developed for use in primates and livestock. For instance, the recombinant *vaccinia* virus (rVV) developed for Rinderpest provides sterilizing immunity to cattle.[45]

Ethiopia

Among its many strengths, Ethiopia's National Veterinary Institute has the capability to study and screen micro-organisms for biological compounds that could have applications in vaccines and other therapeutic purposes. The institute produces viral vaccines against Rinderpest, Sheep-pox, Newcastle disease, African horse sickness, foot and mouth disease. It also produces bacterial vaccines against contagious *Bovine pleuropneumonia*, anthrax, and blackleg, among others. It has developed a recombinant DNA-based vaccine against Rinderpest in collaboration with University of California, Davis. The Institute is also a regional office for quality control of livestock vaccines for the Food and Agriculture Organization of the United Nations.[46]

Nigeria

Vaccine research is also carried out extensively by the University of Ibadan, Nigeria. The university has a collaborative research project on DNA sequencing of vaccines for the prevention of the infectious Bursal disease (also known as Gumboro disease), which is a major source of poultry deaths worldwide. There is at present no known cure. The Ibadan research project attempts to develop new vaccines and involves sequencing the DNA of the Nigerian strain of the Gumboro virus.

Recommendation 2: *Animal biotechnology can help develop diagnostic tests and vaccines for livestock diseases and infections that risk food insecurity. Animal biotechnology also provides information for managing indigenous animal genetic resources, improves nutritional quality of feed and fodder, enhances reproductive efficiency of livestock; and increases the production of meat and milk through techniques such as cloning.*

Biotechnology Beneath the Seas

The continent of Africa is still reliant to a large extent on traditional capture fisheries. The nature of Africa's fisheries, however, remains relatively poorly understood, though this is beginning to change as biotechnology tools are brought to bear. For example, molecular and other biochemical markers are being employed to understand the genetic similarities and differences both within and between different fish populations. Genetic markers are also being used to understand patterns of migration among fish. And as with terrestrial species, biotechnology studies have assisted in better understanding of fish taxonomy.

Fisheries biotechnology also finds applications in aquaculture, which is developing rapidly in Africa. Biotech applications can be found in helping to improve fish feed, for example. Commercial fish farms have been established throughout the continent in Ghana, Zambia, Kenya, Cameroon, Egypt, Madagascar, Nigeria, Uganda, Malawi, Angola and Congo. Tilapia farming, for example is subject to biotechnology studies. Under farm conditions, tilapias grow more slowly compared to when they are in the wild. However, this slow growth is complemented by excessive reproduction, which results in ponds and reservoirs being overstocked with small fishes. Biotechnology techniques have the potential to help, both with growth as well as with reproduction.

At the same time, fish-farming is now known to reduce the genetic diversity of fish populations. Biotechnology can be used to understand how and why this happens, so that strategies can be developed to halt the reduction in Africa's aquatic species and genetic diversity.

Recommendation 3*: Fisheries biotechnology can help to understand taxonomy and population structure questions in fishes, improve reproduction, health and nutritional quality of fish feeds. Africa needs to invest in fisheries* *biotechnology in order to developed evidence-based fish management programmes and improve efficiency of producing fish in aquaculture.*

Seeing the Wood From the Trees: Forestry Biotechnology

The conservation and sustainable use of forests is increasingly being seen as critical to our long-term survival. There has been a simultaneous increase in the use of biotechnology in understanding the nature of forest ecosystems, their contribution to human welfare, and in planning for more sustainable use of natural products from forests.

The Food and Agriculture Organization of the United Nations has identified forest biotechnology R&D in no fewer than 76 countries.[47] These efforts amount to a comprehensive inventory of the latest forestry knowledge. As with applications in agriculture and healthcare, forestry too is subject to much biotechnology activities. Knowledge of the genomes of different varieties of trees and their surrounding environments will have applications, for example in the paper making industries

At the present time, however, most forestry biotechnology is still at the laboratory level. For Africa the main technologies are likely to be in understanding the genetic diversity of indigenous tree species and biotechnology in reforestation programmes. Africa contributes less than 4 per cent to world activity in this area, despite the continent holding about 16 per cent of the world's forest cover.[48]

Recommendation 4: *Forestry biotechnology can help AU member states in the sustainable use and conservation of forest resources. . AU member states need to upgrade and expand the current forestry biotechnology programs.*

Tomorrow's Medicine: Biotechnology in Healthcare

Biotechnology in healthcare offers more effective disease diagnosis, prevention and treatment. In the coming years, it is going to change how we understand and treat diseases. And, as in agriculture, the health biotech sector also offers much potential for boosting Africa's economies.

Health biotechnologies allow scientists to identify genes linked to particular diseases. In addition, new technologies allow researchers to develop genetic tests for a range of illnesses. Moreover, this science has also advanced drug development in very profound ways. Combined with advances in imaging technology and sensors, medical practitioners will be able to use what are called genomic approaches for the diagnosis and early treatment of many diseases and disorders.

Table 4 Top Ten Biotechnologies for Improving Health in Developing Countries[49]

1	Modified molecular diagnostic techniques for infectious diseases
2	Technologies for recombinant vaccine development for infectious diseases
3	Technologies for drug and vaccine delivery
4	Bioremediation to improve environmental quality
5	Sequencing pathogen genomes to improve diagnosis/vaccine/drug development
6	Women controlled systems against sexually transmitted diseases
7	Bioinformatics for drug target identification
8	Nutrient enriched transgenic plants to counter deficiencies
9	Recombinant technology for therapeutic product development
10	Combinatorial chemistry for drug discovery

There are, however, plenty of examples of existing initiatives in healthcare biotechnology in developing countries. These include sequencing the genome of the malaria parasite, the bacteria, *Theileria parva,* which causes East coast fever in cattle. Moreover, some early adopters of advanced healthcare biotechnology innovation systems include governments and private sector groups in Cuba, Brazil, South Africa, Egypt, India and China.[50] In addition, the Bill and Melinda Gates Foundation has recently worked to identify what it calls the Grand Challenges in Global Health, a series of 43 healthcare research projects worth US$ 437 million designed to address these challenges – often using tools and techniques from biotechnology.[51]

Healthcare Biotechnology in Africa

In Africa more specifically, several countries now have programmes dedicated to healthcare biotechnology R&D. These include Egypt, Kenya, South Africa, Tanzania and Uganda.

In Tanzania for example, the application of molecular markers for mapping disease resistance in the malaria parasite *Plasmodium falciparum* is being carried out at the Ifakara Health Research and Development Centre. This is a collaborative research programme between six countries (Ghana, Nigeria, Malawi, Mali, Tanzania, and Uganda) and is jointly coordinated by UNDP, World Bank and the WHO.

Another activity that has Africa-wide implications is the search for natural products, often used in traditional medicines, but which could have potential uses in modern pharmaceutical medicines. One example of this is a collaboration being led by Tanzania's Muhimbili University College of Health Sciences (MUCHS). Project partners include the college's Institute of Traditional Medicine, the Faculty of Pharmacy and the University of Dar-es-

Salaam's Department of Chemistry. A second example is that of Niprisan, a herbal medicine commonly used in Africa**.** Nigeria's National Institute for Pharmaceutical Research and Development in Abuja has discovered that it is also effective in treating sickle-cell disorder.[52]

A second and well-known example comes from the crushed fruits and leaves of the African soap berry (Endod, or Phytolacca dodecandra), a common detergent in Africa, but now known to prevent the spread of Bilharzia (also known as schistosomiasis). Back in 1964, Aklilu Lemma and his team of researchers at the Institute of Pathobiology at Addis Ababa University (then called Haile Selassie I University) observed that snails, known to be implicated in the spread of Bilharza, were absent in streams where people used Endod to wash their clothes. Lemma and his colleagues investigated further and found that the active ingredient in lathering was also harmful to snails, but at the same time was biodegradable and harmless to most other forms of life.

South Africa's strengths in health biotechnology include the critical area of research to develop vaccines for HIV and AIDS and other diseases of poverty. In common with other countries, South Africa is also deeply engaged in research to discover how traditional medicines can be used in modern healthcare.

Applications of indigenous knowledge in health biotechnology research and development include isolating and patenting active ingredients from a plant *Hoodia gordonii*, which has hunger-suppressing properties. This plant has been traditionally used by the San people who live in a semi-desert part of the country, to suppress hunger and thirst during long bouts of hunting. In addition, under the Southern African Biosciences Network (SANBio) the CSIR of South Africa and other collaborations in Southern Africa are engaged in a project to scientifically-validate traditional medicines for their potential to treat infections suffered by people living with HIV/AIDS.

As in other sectors of biotechnology, South Africa's research in the field of vaccines is characterised by research partnerships that are designed and led by the country's own institutions, but with public, private and international groups playing a vital supporting role. [53] South Africa is the first country in Africa to execute multiple HIV and AIDS vaccine trials. It is also among the first to organize a trial for a preventative vaccine against the HIV-1 virus subtype.

Kenya has developed an inexpensive but effective diagnostic testing kit for Hepatitis B called Hepcell. Now in use in all district and provincial hospitals, Hepcell is an indigenous effort led by the Kenya Medical Research Institute (KEMRI) with support from the Japan International Cooperation Agency (JICA).The Hepcell's advantages over other testing kits include the fact that its reagents are produced domestically, but also that they do not require electric power and that the results can be viewed by the naked eye. Egypt also has an active healthcare biotechnology industry. Products have been developed that can treat such conditions as cardiovascular, cancer, anaemia and diabetes.

Recommendation 5: *In order to boost healthcare biotechnology, AU member states need to study the major players contributing to innovation in health biotechnology; identify ways of joint decision-making among different ministries and analyse the linkages between macroeconomics and health.*

Biotechnology in Manufacturing Industry

Worldwide, advances in biotechnology-related fields such as genomics, genetic modification, chemical engineering and cell technology are transforming the world of manufacturing industry.[54] Biotechnology, for example, is being used in the quest to convert renewable raw materials as a replacement for fossil fuels. The world's first bio-refinery, Iogen of Canada, is converting wheat straw into ethanol for blending with gasoline. Another example is in how biological enzymes are being used in chemical processes thereby replacing synthetic chemicals in the chemicals, textiles and paper industry.

More than one quarter of all copper worldwide is produced using bio-processing technologies. These technologies are also used to extract gold from very low grade, sulphuric gold ores, which were previously thought to be un-economic. Efforts are now underway to engineer bacterial strains that can stand up to heavy metals such as mercury, cadmium, and arsenic.

One of the main advantages in using biological catalysts (as opposed to synthetic ones) is that they are cleaner for the environment. They require reduced energy, they generate fewer by-products and they can be degraded during waste treatment.[55] At present, only 5 per cent the chemicals used in manufacturing are derived from natural products. These are found in alcohols, amino acids, vitamins and in pharmaceuticals. But such is the speed of change that according to some estimates, the proportion of industrial bio-chemicals is likely to grow to between 10 and 20 per cent by 2010.[56]

AU member states are beginning to embark on the path of biotechnology in manufacturing industry. South Africa is the most advanced country through for example, its Biopad programme, an initiative of the National Biotechnology Strategy to catalyse the use of biotechnology in industry, particularly in developing biological alternatives to synthetic chemicals. But other countries are also now beginning to invest in research and development.

In 2005 for example, the government of Ghana established a 22-member expert committee to develop and commercialise bio-fuels as potential substitutes for petrol and diesel. Ghana's soil and climate is considered to be favourable to grow crops to produce bio-fuels. Moreover, the market for bio-fuels is expected to exceed 10 billion litres by 2010. The committee has been charged with developing guidelines for both production and regulation. In addition, the government has promised to look at favourable tax regimes to encourage companies to develop natural alternatives to fossil fuels**.** In 2005 Ghana spent US$775 million dollars on oil imports

Recommendation 6: *AU member states need to boost the development of bio-fuels, and develop processes that convert waste into usable products. The* *region must develop a comprehensive industrial biotechnology R&D agenda and fast track its programme to create an enabling environment for effective private sector participation in the development of bio-fuels.*

Clean and Green: Environmental Biotechnology

As the previous paragraphs show, industrial biotechnology also finds uses both in reducing the impact of human activities on the environment, and also in providing a cleaner environment for people to live and work in. Environmental applications include using biological organisms in mineral extraction, in bioremediation (treating contaminated soils, or cleaning up waste-water, or sludge), bio-processing (for cleaner production, waste management) and in biological contraceptives to control feral pests.

Environmental biotechnology is well established in the developing world. In Bangladesh for example, a bacterium known as NT-26 is thought to have potential in helping to clean up groundwater that is contaminated with arsenic, and which has contributed to one of the world's largest incidences of poisoning.[57] Similarly, microbes are widely used in Asia and the Middle East to degrade oil, a technique commonly used to help clean up oil spills.[58]

Environmental biotechnology also has applications in agriculture. It can be used for example to produce less harmful pesticides, plants that are more efficient at using nitrogen, or those that are able to tolerate drought.

One of Africa's leading centres for environmental biotechnology is the International Centre for Insect Physiology and Ecology (ICIPE), based in Nairobi. Over the years ICIPE has shown it can produce environmentally-friendly food and non-food crops, cosmetics, pharmaceuticals and products for the biologically-based management of pests. Indeed, ICIPE's particular specialism is environmental management using insects. It has also developed natural products that can control on-farm pests such as locusts, tsetse flies and stem borers.

In Ethiopia, the University of Addis Ababa has an established programme of research and development that uses bacteria to remove biological nitrogen and organic pollutants from wastewater from tanneries. Elsewhere in Africa, microbiologists at the University of Ibadan in Nigeria have developed a microbe-based product derived from the water hyacinth and known as OBD+ which is able to break-down oil and grease from wastewater.[59]

Recommendation 7: *AU member states and regions should more fully integrate environmental biotechnology into environmental protection strategies and policies, and launch pilot-scale production of environmentally friendly products including food, fibre, cosmetics, pharmaceuticals and products for biological management of pests.*

Biology, Chemistry and Computing: A New Partnership

Each of the examples mentioned in this chapter shows the contribution that biotechnology (in its widest sense) is making towards Africa's economic, nutritional, health, industrial and sustainable development. But as this last section will show, biotechnology's potential for Africa needs to be seen as much more than the sum of its parts.

The true beneficial impact of new technologies can often be seen when different fields are brought together, sometimes in ways that were previously not envisaged. Today it is the marriage of biology and chemistry to computing that is key to the development of new crops, drugs, vaccines, diagnostic kits for diseases, contraceptives and much more. Nutrition and healthcare are not the only winners from this alliance. Industrial competitiveness is a winner too.

The alliance of computing to the bio-chemical sciences has opened up whole new areas of research and development such as combinatorial chemistry, genomics, bioinformatics and structural biology. In each case, raw computing power is being harnessed to test the potential of new drugs and vaccines (combinatorial chemistry), to unfold the map of human, animal and plant genomes (bioinformatics), and to do all of this in record time. Add nanotechnology to this and you begin to see the future for drug discovery and production through products such as biosensors, biochips, smart drug delivery systems, bioelectronics and biomaterials.[60]

Chapter 3:

Priorities in Biotechnology for Africa's Regions

This chapter outlines what we call "core" biotechnology missions for each of the five AU regions. The aim here is to indicate priority areas in which regions could collaborate by building on expertise and resources that already exist in key areas. This is not to say that each region must focus exclusively on its core mission. In addition, there will be cross-cutting areas (such as livestock or agricultural research) where all regions have a stake in developing biotechnology. The ideas here are based on an assessment of priorities coupled to existing strengths in expertise and experience that each of the five regions already possesses in biotechnology research and development.

These missions could ideally become a part of the AU's planned 20-year biotechnology strategy.

The core missions are as follows:

Southern Africa: **Health Biotechnology**
Central Africa: **Forest Biotechnology**
East Africa: **Animal Biotechnology**
West Africa: **Crop Biotechnology**
North Africa: **Bio-pharmaceuticals**

Southern Africa

Health Biotechnology

Southern Africa's core mission should be to deliver benefits from health biotechnology. The region is currently in the grip of a range of diseases, in particular tuberculosis, malaria and HIV and AIDS — all of which feature in Target 8 of the Millennium Development Goals. The HIV/AIDS pandemic is having a major impact on almost all aspects of life. But at the same time the countries of southern Africa are relatively well-endowed with science and technology expertise, along with a well-developed system of traditional healthcare.

South Africa should lead the research in this mission through national and regional institutions such as the Southern African Network for Biosciences (SANBio). Priorities for research include:

- The development and testing of AIDS vaccines in southern Africa, with the aim of producing affordable, effective and locally relevant AIDS vaccines;

- The development of transgenic plant-based platforms for the cost-effective expression of molecules of interest, such as anti-HIV microbicidal proteins;

- Exploring scientifically validated, affordable remedies for the treatment for people living with HIV and AIDS;

- Developing anti-malarial drugs from indigenous plants;

- Overcoming drug resistance in the malaria parasite *Plasmodium falciparum*;

- Efficacy tests against *Mycobacterium tuberculosis* of plants used in the traditional treatment of tuberculosis.

Central Africa

Forest Biotechnology

Central Africa is one of Africa's most biologically-diverse regions. Yet as is often the case in developing countries, more knowledge of this diversity resides outside of the region than inside it.

The aim of this mission would be to build and strengthen indigenous capacity to identify, conserve and sustainably use this precious resource; and also to understand the impact on biodiversity from events such as climate change and natural disasters. Where necessary, activities could be carried out in partnership with relevant institutions overseas. In the case of Central Africa, this could be the Royal Museum for Central Africa at Tervuren, Belgium, which has more than 10 million specimens from Africa as a whole. It also houses the world's most important Central African zoological collection.

This collection includes specimens of 150,000 birds, 200,000 amphibians, 40,000 reptiles, 90,000 mammals, 950,000 fish species, 6 million insects and 1 million other invertebrates, more than 80 per cent of which originated from the Democratic Republic of the Congo, Rwanda and Burundi. The museum also has a very important collection of more than 58,000 specimens of wood**.** Knowledge of these species, their morphology, taxonomy conservation status, migration patterns, and impact of human activities has to be a priority for researchers and policymakers inside Africa.

East Africa

Animal Biotechnology

As host to a cluster of some of the world's leading livestock research institutions, animal biotechnology is a natural focus for the core mission for the countries of East Africa. Research is needed in many areas, notably to improve animal health and husbandry, understand the diversity of indigenous animal genetic resources, and to reduce incidence of disease and environmental risk.

Specific diseases where more research is needed include: East Coast fever (caused by *Theileria parva*), animal trypanosomiasis, contagious bovine pleuro pneumonia (CBPP), Rift Valley fever virus, African swine fever virus, anthrax and avian flu. Animal nutrition is another area in need of much study, as is the area of vaccines, disease diagnosis and animal breeding. Biotechnology, if carried out with due regard to appropriate regulations and safeguards, has the potential to produce fitter, more productive and more adaptive animals, less prone to disease.

Finally there is the area of animal genetic resources. Indigenous livestock species in many areas of the developing world have evolved critical adaptive traits such as disease resistance, and there is an increasing demand for improved understanding and conservation of genetic diversity in such livestock. Biotechnology is helping with the task: molecular markers combined with phenotypic data are being used to identify and describe priority livestock species round the world. In East Africa, the key research activities in this area will include the assessment of the distribution and variability of global livestock populations; the identification of unique livestock gene pools; the development of tools for molecular characterisation and economic analysis, including valuation, of animal genetic resources; and the development of databases and decision-support tools for conservation, including sustainable use.

West Africa

Crop Biotechnology

Priority areas for agriculture in West Africa have already been identified in what is called the West and Central African Council for Agricultural Research and Development (CORAF/WECARD) strategic plan for 1999-2014. The framework for action is based on developing cash-crops (cotton, para-rubber, cocoa and oil palm), cereals (maize, millet, rice and sorghum), livestock/fisheries, grain legumes (cowpea and peanut), fruits and vegetables (banana/plantain), and root and tuber crops such as cassava, sweet potato and yam. For each of these groups, the biotechnology applications would be as follows.

The central focus would be genetic improvement, and would involve:

- Enriching existing cotton germplasm and establishing new base collections;
- Identifying new genetic material with high variability in order to select for improved varieties with high yield, drought and disease/insect resistance;
- Identifying, isolating and characterising relevant genes.

North Africa

Bio-Pharmaceuticals

The countries of north Africa together constitute sizeable expertise in bio-pharmaceuticals, particularly Egypt, which has one of the longest histories of drug manufacturing in the developing world, and which also hosts the Eastern Mediterranean Regional Office of the World Health Organization.

The small-and-medium-sized (SME) healthcare sector is relatively well-developed in some of the countries of north Africa. The region's core mission should help to promote this more widely, and in particular to mentor new and existing local firms in drugs manufacturing and related areas such as producing diagnostic testing kits.

The National Research Centre of Egypt currently hosts the hub for the North African Biosciences Network (NABNet). This centre has the potential to provide leadership in the mission. Intermediate-term plans should aim at producing diagnostic kits for viral diseases, tuberculosis and schistosomiasis. Longer-term plans should target the production and marketing of vaccines for schistosomiasis and hepatitis B and the production of immunoregulators for the treatment of cancer and AIDS.

Chapter 4:

Strengthening Critical Capacities

Building the Right Infrastructure; High Costs, Rich Rewards; Reinventing the African University; The Regional Dimension; Empowering People; Engaging the Public

Development for any nation or region needs minimum capacity in at least three areas:

- Infrastructure to support science, technology and innovation.
- Human resources, training and education in science and technology.
- Public awareness of – and engagement in – science and technology.

Firm Foundations: Building the Right Infrastructure

Infrastructure in its broadest sense includes the facilities, structures and associated equipment and services that facilitate the flow of goods and services between individuals, firms and governments.[61] Critical infrastructure includes predictable and reliable energy; information and communications technologies; water, sanitation and waste disposal; primary, secondary and higher education; affordable housing; affordable healthcare; predictable and reliable transport networks including roads, railways, ports, waterways and airports; and research facilities in the full sense of the phrase. Equally vital are infrastructure services – the provision, operation and maintenance of all of the above.

Infrastructure is important for development in many ways. It is important for raising and maintaining economic growth, sustainable human development and for quality of life for all citizens. These, in turn, depend on several factors including investment and exports, including foreign direct investment. All the available evidence tells us that foreign direct investment in particular is less likely to go to countries where infrastructure is weak, unpredictable, or unreliable.

Successful science, technology and innovation (STI) also has minimum infrastructure requirements. These include many (if not all) of the above. But infrastructure for STI has its own bespoke components. These include a university teaching and research system of reasonable quality, other functioning public research institutions, and well-funded research in industry, particularly in small and medium-sized enterprises, which constitute nine-tenths of the private sector in most countries. STI infrastructure also includes governance and regulatory systems that are transparent, that strike an appropriate balance between enterprise promotion and public protection, and which have been drawn up in consultation with all those who will be affected by them. The more advanced developing countries have some or most of these. The poorer ones have fewer.

Infrastructure and technological development often reinforce each other. The development of new technologies can also contribute to the development of infrastructure.[62] In the developed countries, for example, advances in communications and data-processing technologies have helped in developing intelligent transportation systems for the management of traffic. Geographic Information Systems and remote-sensing technologies, similarly, have enabled engineers to identify groundwater resources in urban and rural areas.

High costs, Rich Rewards

Many AU member states need to upgrade their infrastructure. Others must make major improvements to that which already exists. A detailed diagnosis of Africa's infrastructure requirements is not the role of this panel. But what we can say is that infrastructure is not a small investment. The wealthier developing countries are often able to shoulder these costs, but this is not the case for the poorest countries. Moreover, costs can be made worse by corruption.

One way to control these costs is to bring in expertise from other sections of government in the planning or building of infrastructure. For example ministries of defence, which have capacity in logistics, construction, engineering, and many other infrastructure-related fields. For reasons of history, ministries responsible for the armed forces of AU member states have been better-funded compared with other ministries, particularly ministries of science and technology. Even with the advance of representative government in the continent, institutions of defence are still visible, for example when called upon by governments to assist in national emergencies, as is often the case in developed countries as well. The concept of turning 'swords to ploughshares' needs to be seen as complementary to the military's traditional role, and can give armed forces a new role consistent with national security in its wider sense – provided of course that the management and oversight is performed by the institutions of democratic government.

Recommendation 8: *Poor and inadequate infrastructure services are an obstacle to Africa's development. AU member states need to leverage all available capacity from all sources to help build and maintain infrastructure.*

Reinventing the African University

Universities in the AU were not designed as the engine room of development in the continent; nor were they intended to catalyse innovation. For this new and urgent task they need to be reinvented; piecemeal change will not do.

Staff and students in the vast majority of universities in AU member states face many obstacles on a daily basis. Among them – indeed, perhaps the most critical -- is low levels of funding from sources inside Africa. One indicator of the low state of local financing is the predominance of international organizations in the funding of R&D. According to a survey conducted by Jacques Gaillard and colleagues in 2001 international sources are responsible for nearly half of research funds flowing into the continent. Another indicator is that gross expenditure on R&D for the AU region stands at 0.3 per cent. The average for the less developed countries as a whole is 1 per cent, according to the 2005 Unesco Science Report.

A second obstacle is quantity, or lack of it. Only Egypt and South Africa have universities in nearly sufficient numbers – 18 public and private in Egypt and 36 in South Africa, according to the 2005 edition of the *Unesco Science Report*. This is reflected in the dominance of these countries in tables of scientific publications from AU states. Roughly half of all scientific output in the continent comes from Egypt and South Africa; a quarter comes from Kenya, Morocco, Nigeria and Tunisia. The remaining 43 countries in the AU are responsible for the final quarter of science from the continent.

Indeed, compared to the rest of the world, AU countries as a whole have fallen behind in scientific and technological development. From 1988 to 2001, the number of articles published in scientific journals worldwide grew by 40 per cent, yet in Africa publication counts actually declined by 12 per cent over this period in absolute terms. In 1988, AU countries accounted for 1.26 per cent of all scientific publications, but by 2001 their collective share was down to 0.76 per cent.[63] Of the 10 larger countries, Kenya, Nigeria, Senegal, South Africa and Zimbabwe all published fewer articles in 2001 than in 1988. Of the countries that showed an increase — Cameroon, Ethiopia, Ghana, Tanzania and Uganda among them — none published more than 100 articles annually at any time from 1988 to 2001.

Add to this curricula in need of modernisation, undermotivated staff, hierarchical management styles and very limited R&D and the picture – and the urgency for change -- becomes clear. At the same time, much is changing in the broader university world in both developed and developing countries. Indeed, it is these changes that represent an opportunity to reinvent the university in Africa.

The Changing University

In the developed world, the traditional function of the post-World-War university was to educate and train the academically abler sons and daughters of society's wealthier citizens – often to be able to take up jobs in the civil service. The bulk of financing came from the state. The involvement of public and private industry was often restricted to advice on aspects of technical education. The involvement of other groups in society to the life and the governance of a university (charities, voluntary associations and faith communities, for example) was also minimal.

This same model applied in many ways to the new universities of Africa in both the pre and post-independence period, but with one difference: as universities in developed countries increasingly took on more responsibility for research, the same did not happen in many of the poorer developing countries. During colonial times, scientific research was the responsibility of laboratories managed by state-run councils for science and industrial research. Medical research was, similarly, organized by laboratories tied to ministries of health. And agricultural research was mostly organized through bespoke research councils linked to ministries of food and agriculture, who would work directly with farmers organizations. The links between these research councils and universities were weak, something that remains the case today.

Today's universities all over the world are changing in response to the changing needs of their societies. University entrance is no longer seen as something for the privileged, but more a right for the majority, or in the very least, an experience for which access should be on merit, and not on wealth or family connections. At the same time, a university's reason for existence is changing too and in very profound ways. The state, civil service and the churches are among a much larger panoply of destinations for university graduates. Industry is equally important, as is the voluntary sector, and the research community. Universities need to have good relations with all of these groups, and be able to understand what each wants from new graduates in terms of skills and knowledge. But governments don't just want graduates who can work for the state. They want universities to take more responsibility towards wealth creation and economic growth, and they want universities (along with schools and colleges) to deliver among young people a stronger civic sense as they move into adult life.

The financing of universities is changing too. From near-total reliance on the state, universities today have distributed sources of finance, with much greater involvement from the private sector and other groups complementing the role of the state. State financing, too is more innovative, for example, through the provision of tax incentives for R&D, loans at generous rates of interest, payable over long periods. Distributed financial resources, however, do not come without their own pressures, one of which is the pressure for a university not to remain independent, the one feature in a university's existence that cannot be compromised.

The universities of Africa, too, must change depending on the needs of their countries and communities. Indeed, change is already beginning to happen, as the following three examples indicate:

Lilongwe University of Science and Technology

Bringing institutions of higher learning to contribute to development often requires committed executive leadership as is illustrated by the example of Malawi. Concerned about the low level of technological development, the country's President Bingu wa Mutharika announced in August 2006 the creation of the Lilongwe University of Science and Technology (LUSTECH) devoted to technological entrepreneurship and with strong links with the private sector.

As a new centre of excellence, LUSTECH will not be unusual. But what is more innovative is the role of the President as a champion of the role of science, technology and innovation in development. The creation of the university is being managed through a new working committee housed in the country's Department of Science. This department has been moved to the Office of the President. Malawi is one of the few African countries – indeed, one of the few countries in the UN -- where the country's science and technology policy is being implemented through the office of its head of state.

The Global Open Food and Agriculture University

Distance education has always been integral to any country's higher education and research infrastructure. The Internet has dramatically accelerated distance education opportunities, at the same time providing innovative ways in doing this. One example is the Global Open Food and Agriculture University (GO-FAU). GO-FAU is a program of the Consultative Group on International Agricultural Research (See www.openaguniversity.cgiar.org) and a number of partner universities. It strengthens postgraduate agricultural programs in developing countries by providing high-quality course materials, faculty capacity strengthening, and thesis facilitation. Partner universities deliver the courses, support learners, provide accreditation, and award degrees.

Bio-PAD South Africa

Biotechnology Partnership and Development (BioPAD) is an initiative to bring South Africa's university research system closer to the needs of industry. It was created by the government's Department of Science and Technology under the country's National Biotechnology Strategy. BioPAD has launched several initiatives in mining, environmental and industrial biotechnology, and is promoting the exploitation of microorganisms and enzymes. Research and commercialization groups involved in BioPAD include the Rhodes University Biotechnology Group, the University of the Free State Microbiology Group, as well as companies including Mintek and BHP Billiton.

What else could be done? Universities, for example, have the potential to contribute to the broader goal of building infrastructure. For example, the task of building new roads, ports, harbours, railways, power supplies and telecommunications facilities, could strengthen engineering education if staff and students from university engineering faculties were more involved. At the same time, involving engineering faculties in these projects would promote knowledge-based development inside large, small and medium-sized enterprises.

Moreover, universities could be an asset in the goal of sustainable development, both through environmental education programmes, but also linking research with the practice of, for example, managing national parks. East Africa, for example, could benefit significantly from a regional wildlife research university that is directly linked to the tourism sector. Such a university could serve as an incubator for private and social enterprises that not only help to expand economic opportunities, but also contribute to environmental management.

Introducing such reforms needs vision, but it also needs leadership at the highest levels. It also need new models for governance, and professional integration. Above all, it requires financing, from public, private and charitable sectors.

Recommendation 9: *AU member states should initiate measures that strengthen the role of universities as centres of research, training and biotechnology diffusion. Doing so will entail fundamental reforms in the role of higher technical training in economic development. The reforms include bringing research, teaching and community outreach together to support technology development goals.*

The Regional Dimension

Innovation is in itself both a collaborative and an iterative process. Innovation requires researchers to work in strong partnerships across disciplines and sectors, with industry, with governments where necessary, and across regions. As has been said elsewhere in this report, geography is no longer a barrier to collaborative working.

Many of the infrastructure reforms that are needed will not – indeed cannot – happen immediately. Universities and research facilities cannot be built overnight, for example. Even if they could, a high quality, forward-thinking faculty and administration needs time to identify, train, and to nurture.

But science, technology and innovation can also come about through innovative and well managed partnerships between existing institutions at the national and regional levels. This does not necessarily (or always) require new buildings, but what it does need is visionary, quick-thinking leadership, workable plans, good management, and a certain amount of finance.

Many regional and sub-regional agreements between members of the AU make explicit reference to the need to strengthen scientific and technological cooperation. Article 13, for example, of the Constitutive Act of the AU itself gives authority to the Executive Committee of the AU to formulate policies that promote S&T cooperation. Similar provisions are found in the Common Market for Eastern and Southern African (COMESA) treaty: Article 100(d) calls on member countries to cooperate to promote "industrial research and development, the transfer, adaptation and development of technology, training, management and consultancy services through the establishment of joint industrial support institutions and other infrastructural facilities".

Similarly, Article 27 of the treaty establishing the Economic Commission for West African States (ECOWAS) requires that member states strengthen their national scientific and technological capabilities; ensure the proper application of science and technology to the development of agriculture, transport and communications, industry, health and hygiene, energy, education and manpower and the conservation of the environment; strengthen existing scientific research institutions; harmonize at the community level, their national policies on scientific and technological research with a view to facilitating their integration into national economic and social development plans; and coordinate their position on all scientific and technical questions forming the subject of international negotiation.

The political architecture exists, indeed, has existed for some time. What is needed is implementation. Far too many AU countries continue to work with isolated R&D systems, often with limited scientific and technical expertise and financial resources.

In many cases, the scientific infrastructure of a region's relatively advanced countries will not be accessible to others that desperately require it. Given the wide applications of biotechnology and the fact that many African countries may not individually possess the requisite scientific and technological capacity to exploit them, it is crucial that nations on the continent work to their strengths together.

Empowering People: Developing Human Capacities

Look around the nerve centre of any successful economy, and you will see a city full of people with the skills, experience and entrepreneurial ability that are so crucial to fuelling and maintaining prosperity, growth and sustainability. These human capacities are central to sustainable economic development, and investing in them is the surest way to transformation. Countries that ignore this cannot begin to register improvements in human development and quality of life that they all seek.

Universities, research institutions, technical institutes and vocational schools, private companies, and social institutions such as women's groups and families, play a major role in building human capabilities. By directing and stimulating human creativity, they are central to the process of releasing human potential into economic activity. These institutions therefore need to be nurtured and strengthened.

When it comes to science, technology and innovation, most of the countries of the AU have not been able to invest in their human resources. Ninety-two per cent of the continent's researchers report being paid salaries that are "inadequate", according to the 2005 edition of the *Unesco Science Report***.** Egypt records having 10,000 full-time researchers, South Africa 13,000. But elsewhere the numbers are far lower. No other AU country recorded more than 3,200 according to a 1999 survey published by France's Institute for Research for Development.

Biotechnology, in addition, needs a critical mass of trained and experienced researchers in areas including molecular biology, biochemistry and bioinformatics. Most AU states do not possess researchers in nearly enough quantities. There does exist a large and trained African scientific diaspora, many of whom contribute to the research environment in their countries of origin, not least in organizing international collaborative projects involving researchers from Africa and abroad, often at great personal expense. But AU countries need many-times more scientists and technicians who can be promised greener pastures at home.

There are no two opinions on this issue: the development of new generations of African scientists and technicians must be at the core of the continent's common strategy and actions aimed at building scientific and technological capacities. Moreover, scientists and technicians must be both male and female.

Unlike in more advanced developing countries, Women in many AU states make up a relatively small number of the total population of scientists and engineers. Changing this is both necessary and urgent. Human resource development strategies must aim specifically to increase women's enrolment in the biosciences and in engineering at university level. R&D infrastructure could be improved to better meet the needs of women, and feature conditions and services such as part-time work, flexible hours, infant care support, extended maternity/child care leave. In addition, funding schemes that provide incentives for girls to study science and engineering need to be explored.

There are other measures that can be used to strengthen the participation of women in the sciences in Africa. A quota system can be used to ensure women receive at least a proportion of opportunities offered by biosciences networks, such as training scholarships, fellowships and research grants. Mentoring arrangements, web-based outreach programmes, networks of women scientists and indicators of the involvement of women in the sciences could play a key role in strengthening the role of women in the life sciences in Africa.

Recommendation 10: *AU states must develop and expand national and regional human resources development strategies in biotechnology higher education and research. These need to include: a comprehensive biotechnology curriculum; a consortium of clearly identified and designated universities to develop and offer regional biotechnology training courses; an emphasis on female recruitment in the sciences and engineering; and training in science and innovation policy.*

Public Awareness and Public Engagement

There was a time, not long ago, when public awareness of new technologies involved scientists and government officials informing members of the public, which technologies were good for them, and not expecting to be challenged in their view. This mode of communication was mostly (though not entirely) one-way, and has since been dubbed by social scientists as the 'deficit model'. The underlying thinking was that if members of the public possessed additional knowledge of a science or technology, such as molecular biology, or immunology, then this would lead to readier acceptance of new technologies such as genetically-modified foods, or new vaccines.

We now know that technology acceptance is not a linear phenomenon. Members of the public can occasionally reject new scientific findings and technologies for what scientists and public officials can consider to be irrational reasons. This happens in both developed and developing countries, but it doesn't happen too often. Of the new technologies that are commercialized on a daily basis, only a handful have been subject to public scepticism. These include GM technologies in food and nervousness among young parents in the UK to have their children immunised with a combined vaccine for measles, mumps and rubella.

As indicated above, public attitudes to science and technology have been extensively studied in developed countries. The examples above are more the exception than the rule, however. Public confidence in new technologies and in their regulation tends to be high. Moreover, opinion polls of public trust in developed countries tend to place scientists among the more trusted members of society, along with medical practitioners and members of the judiciary.

There is comparatively less knowledge on the situation in less developed countries. However, one study conducted in 2000 by the polling company Environics and quoted in the FAO's 2004 *State of the World's Food and Agriculture* report found that people in developing countries were on balance more optimistic about the benefits of biotechnology compared to people in developed countries. Out of the 15 most biotech-enthusiastic countries, only two (the US and Canada) were developed nations.

Public acceptance of new technologies needs rigorous and credible regulation, in which the public has confidence that their interests and safety are paramount. Second, public acceptance also needs recognition that the opinions and concerns of non-scientists, the majority of a population, are being listened to. These, in turn, require a genuine partnership between society's stakeholders, including members of the lay public, professional societies, industry, voluntary associations, young peoples and women's groups, faith communities, and policymakers, including elected representatives of local and national legislatures. Such partnerships, moreover, need open dialogue on the benefits and risks of new technologies, evidence-based decision-making, and equitable access to information for all.

Science communication has therefore become a key element in technology development. At the same time, what is also clear is that classical approaches that relied on one-way flows of information from scientists to the general public through a variety of media are being replaced by participatory approaches involving a diversity of sources of information and perspectives.

The media is an important channel for science communication. Though in developing countries, more needs to be done to encourage more factual and independent journalistic analysis of biotechnology, which is able to reflect a spectrum of views. This is not always easy in countries where television and newspapers are still owned or influenced to a large degree by the state. One study on media coverage of GM crops in Kenya and Zambia published in 2005 by the Panos Institute found that coverage tended to line up with government views on the issue. Media training in science writing, awards and prizes for good reporting, and media away-days to biotech labs could all be used in efforts to promote good practice in the press.

An Example from South Africa

Early 2003 saw the launch of Public Understanding of Biotechnology (PUB), a project of the South African Agency of Science and Technology Advancement (SAASTA), which is part of the country's National Research Foundation. The overall aim of PUB is to promote better public understanding and awareness of biotechnology and to stimulate dialogue and debate on biotechnology's current and potential future applications, including genetic modification. The target audience includes consumers, educators and learners (www.pub.ac.za). A study commissioned by PUB found that there is much work to be done. When asked, "What do you think when you hear the word biotechnology?" 82 per cent of the 7000 respondents indicated they had no idea what the word meant.

Recommendation 11: *Public awareness of – and public engagement in -- biotechnology is needed at all levels in Africa. A lack of both will make it difficult for AU member states to individually and collectively discuss, set priorities and exploit economic and other opportunities offered by biotechnology.*

Chapter 5:

Governing Biotechnology

Regulation is Everyone's Business; How to Assess the Risks; Regulating at the National Level; Issues for Governments to Resolve; Obligations to Regional and International Agreements; Ensuring Standards and Safety in Food Production; Getting it right with IPR.

Good innovation systems need good governance. The best systems are those that can strike a balance between promoting learning and creativity in its widest sense, but at the same time that can promote and protect the public interest.[64] This is rarely an easy balance to achieve, and no model will ever be perfect. Some regulatory systems concern themselves more with investments in R&D, for example, or with the technological aspects of innovation and pay less attention to the learning process, or to the organisational, financial, and commercial dimensions of innovation.[65] Others may perform some or all of the above, but may be less inclined to give weight to communication and building consensus between the many constituencies involved, such as industry, consumers, citizens, regulators – including different government ministries. Moreover, in some cases, governance might be effective at the national level, but less so at the local or regional. [66] [67]

This chapter explores the governance of biotechnology in the countries of the AU, as well as the factors that influence how biotechnology is governed in all its aspects. It provides an overview of international and regional governance approaches and their implications for sustainable development in Africa. Emphasis is placed on specific issues and approaches that should be considered by African countries in their efforts to establish the best governance mechanisms for biotechnology, which can promote innovation while at the same time protecting the public interest.

Regulation is Everyone's Business

It goes without saying that all regulatory systems need sound technological capacity – a steady supply of competent scientists and engineers at all levels is a must. Such capacity comes easier to countries that have good science and technology research systems in general and in biotechnology in particular. But other skills are also needed to design and implement regulatory systems. An equally critical skill is the ability inside government and industry to manage technological uncertainty, and designing and implementing risk assessment studies. Other required capacities include scientists who are well-versed in the policy process, and policymakers who are able to make good decisions having taken advice from multiple sources.

Countries that are well-established in terms of advanced technologies are adopting what we call a 'co-evolutionary approach' to regulation. This means that safety standards go hand in hand with the development of the technology itself. This can be seen not just in the regulation of biotechnology, but also in the mobile communications industry and in nanotechnology, in both the US and in EU member states. This approach is a departure from the past where regulation would sometimes be worked out often after a technology was commercialised**.** Co-evolution tilts the balance closer in favour of public safety. But at the same time, it also means that regulatory systems need to remain flexible, and predictable so that technological innovation is not hindered unless the balance of evidence points to possible harm to people or the environment.

Compared with developed countries, biotechnology decision-making in Africa is in relative infancy**.** Often, regulatory oversight tends to be the responsibility of a single ministry, such as science or environment, or specialized agencies within these ministries. In contrast, in developed countries biotechnology today is regarded as a cross-cutting and inter-disciplinary issue. At the level of governments it involves scientific research, education, finance, food and agriculture, environment and sustainable development, consumer affairs and international trade. Each of these ministries tends to be involved in some way in biotech regulation, as are associated expert and consumer groups, and industry. In addition, questions of intellectual property rights open the doors to those ministries with an interest in the law. Issues of ethics meanwhile mean that faith groups – and their associated government departments -- become involved in regulation. The transboundary nature of agricultural biotechnology, for example, also makes biotechnology an issue for specialists in foreign affairs, as does the fact that biotechnology is subject to a range of international conventions, guidelines and agreements such as the TRIPs agreement of the World Trade Organization; the Cartagena Protocol, which covers the safety of international transfer of GM organisms; and the Codex Alimentarius Agreement on food safety.

How to Assess the Risks

Hand-in-hand with technological and administrative capacity, governance of biotechnologies requires an ability to assess and conduct assessments of risks, which, in turn, require expertise and experience from the social sciences in addition to detailed knowledge of the technologies concerned. What are these risks? They might be potential risks to human health, possible risks to the natural environment, or economic and social implications from new technologies, for example the impact on traditional industries. Effective risk assessments mean that when a technology is introduced, measures can be taken to maximise the benefits and minimise any potential harm.

The case of agricultural biotechnology is one example of this. After exhaustive research, risk assessments and public consultations in both developed and developing countries over a period of more than a decade, a broad consensus is emerging among scientists, citizen groups, regulators and industry that foods that use biotechnology processes – and which have been appropriately tested for safety -- do not harm human health, nor do they cause long-term environmental damage when compared to the environmental effects, for example of using some types of on-farm chemicals. This consensus – and public trust in this consensus -- however, did not come about overnight, and in some cases has not been achieved – and may not be achieved. Where it has happened, it has needed time and much investment in research, in communicating research, and in regulatory innovations. A key component is trust between people and those in power. This can be brought about for example, through the involvement of representatives of non government groups and lay members of the public in official committees of scientific advisers and in scientific and other public-policy decision-making bodies.

Recommendation 12: *Africa needs to develop its own scientific capacity to assess biotechnology-related risks through national, regional and continental institutions so that all biotechnology policy is informed by the best available research and knowledge. The consensus among researchers thus far is that there is no compelling evidence of harm from the consumption of approved foods and food products manufactured from biotechnology processes. Governments should therefore seek to advance the use of biotechnology by facilitating the approval of clinical and field trials based on appropriate legislative mandates.*

Regulating at the National Level

Biosafety – particularly the governance of agricultural biotechnologies – is now a well-established field of regulation in the AU. Throughout the continent, existing and emerging national policy and legal regimes have been designed (or are being designed) to cover a panoply of applications of biotechnologies. These include scientific research, international transport, trade and release into the environment of the products from biotechnology, particularly genetically modified organisms. The past decade has seen particularly heavy activity as AU member states have sought to reform or update their existing biosafety policies and laws, often in response to the rapid changes in technologies, and often closely following regulatory developments in developed countries.

South Africa was among the first AU states to develop specific legislation: the South Africa Genetically Modified Organisms Act of 1997, which became effective on 1 December 1999.[68] In the words of its preamble, the overall purpose of the Act is to: "Provide measures to promote the responsible development, production, use and application of genetically modified organisms." The Act further states that it is intended to: "ensure that all activities involving the use of genetically modified organisms (including importation, production, release and distribution) shall be carried out in such a way as to limit possible harmful consequences to the environment…"

Among AU countries, South Africa has some of the most trained and experienced technical capacity. The country produces yellow maize for animal feed and white maize for human consumption. [69] Production is aimed both for domestic use and for export to other African countries as well as Japan.

Zimbabwe has also been developing its regulatory system. In 1998, the country amended its Research Act with a view to including biotechnology under its ambit. The amended legislation established the Zimbabwe Biosafety Board as an apex regulatory body for biotechnology and for biosafety. In

2000, regulations were enacted setting out the procedures for conducting biotechnology-related research and the testing of GM products.[70]

The parliament of Malawi enacted the Malawi Biosafety Act in October 2002. This is a comprehensive piece of legislation that covers environmental risks as well as risks to human health. Its purview includes the importation, development, production, testing, release, use and application of genetically modified organisms. It also covers gene therapy in animals and humans.

Other countries including Cameroon, Kenya and Uganda are in the process of developing biosafety policies and legislation. They have been helped in part by a project of UNEP and the Global Environment Facility called the UNEP/GEF Biosafety Enabling Activities Project.

Issues for Governments to Resolve

Overall, however, AU countries need to resolve two outstanding issues regarding national biosafety regulations:

First, it is clear that many of the current policy, legal and regulatory processes take what we see as a ‘broad-brush approach’ to regulation. There is an assumption in some cases, for example, that biotechnology is restricted to genetic-modification in agriculture. Moreover, it is sometimes assumed that within genetic-modification, different uses for biotechnology can be regulated in the same way. Some countries do not distinguish between biotechnology products that are used in R&D, and those that end up being used in seeds, food, or feed.

Different applications of biotechnology require different regulatory approaches. A biotechnology product or process that will be used only in a research lab will require a different kind of oversight compared with, say, a product or process intended for human consumption. Some countries do not make this distinction and have designed generic biotechnology import regulations that apply the same rules to different uses.[71]

Second is the issue of misuse of biotechnology, and possible regulatory responses to this. Worldwide, there is increasing concern over bioterrorism, not only in the technologically advanced countries, but also in developing countries. The United Nations Security Council Resolution 1540 and the Convention on Biological and Toxin Weapons aim to reduce the likelihood of misuse of biotechnology. As developed countries begin to adjust their regulatory systems, AU member states, too, need to find effective ways of maintaining the security of research establishments without undue hindrance for researchers; minimizing the risks of misuse of biotechnology, but at the same time preparing and testing contingency plans.

As in other examples, this requires first and foremost competent scientific and technological capacity including skilled researchers, enlightened policymakers, good practice, ethics guidelines, and collaboration and communication between different sectors in societt. Misuse of biotechnology (as in the case of any technology) is an ever-present risk for all societies. An appropriate regulatory response would be to assess the nature of the risk, establish appropriate response mechanisms, and communicate responsibly with the public and with other stakeholders. This will ensure that technologies continue to be used effectively, while paying full attention to the safety and security of citizens.

Recommendation 13: *Biotechnology regulations should be based on a case-by-case approach, according to internationally-agreed rules and guidelines. The AU should adopt the "co-evolutionary" approach in which the function of regulation is to promote innovation, while at the same time safeguarding human health and the environment.*

Policy Guidance at the Regional Level

In addition to national-level regulations, professionals in AU countries have also come together in different forums and initiatives with the aim of guiding or advising biotechnology regulations at the regional-level. These initiatives can be divided into two categories:

The first category comprises a basket of initiatives set up by or through networks of scientific researchers and research-based organizations such as national agricultural research centres. These initiatives include the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and the West African Council for Agricultural Research and Development (CORAF/WECARD).

The second category of regional initiative comprises initiatives from regional intergovernmental organizations such as the AU itself, the Southern Africa Development Community (SADC), the Economic Community for West African States (ECOWAS), and the East African Community (EAC).

Initiatives from the first category are led by -- and often carry the imprint of -- the research community. Initiatives of the second category tend to have input from researchers, but also involve other communities of stakeholders – such as citizen groups, industry and policymakers, with scientific civil servants often playing an over-arching or coordinating role.

At the AU level, for example, member countries have agreed what is called the African Model Law on Safety in Biotechnology. This constitutes a guiding framework for regulating biotechnology with a view to protecting Africa's biodiversity, environment and health. The model law was agreed in 2001 at the 74th Ordinary Session of the Council of Ministers of the Organization of African Unity (OAU), held in Lusaka, Zambia. The model law complements the Cartagena Biosafety Protocol and suggests additional biosafety rules that are not dealt with by the protocol. The AU secretariat is now implementing a project to help African countries develop their capacities in biosafety.

A second example of an intergovernmental approach towards biotechnology regulatory guidelines comes from SADC. The organization has an Advisory Committee on Biotechnology and Biosafety with a mandate "to develop guidelines to safeguard member states against potential risks in the areas of human and animal food safety, contamination of genetic resources taking into account ethical and trade-related issues including consumer concerns."[72] In August 2003, the committee adopted interim guidelines on the transboundary movement and trade in genetically modified products. The guidelines were approved by SADC in May 2004.[73] They cover four policy areas: handling of food aid; policy and legislation; capacity building; and public awareness and participation. The guidelines require international donors that provide food aid to Africa to comply with the principle of prior informed consent and with the notification requirements set out in the Cartagena Protocol.

Recommendation 14: *The AU's RECs need to be staffed with appropriately trained experts who can advise states on regional and international agreements, guidelines and conventions on all aspects of biotechnology. The AU secretariat and NEPAD need to build further capacity in biotechnology regulation. They could also provide assistance to states on multilateral mechanisms and agreements.*

Regulating Biosafety at the International Level

In the field of biosafety, the principal international regulatory instrument is the Cartagena Protocol on Biosafety to the UN Convention on Biological Diversity. Thirty-seven countries in Africa have ratified the protocol. Its objectives are to help ensure an adequate level of protection for human health and the environment from the safe transfer, handling and use of what the protocol describes as "living modified organisms resulting from modern biotechnology".

To this end, parties to the protocol are required to ensure that the development, handling, transport, use, transfers and release of any living-genetically-modified organisms are undertaken in a manner that prevents or reduces the risks to biological diversity, taking into account risks to human health, and using the "precautionary approach" as a guiding principle. The protocol does not cover processed foods, or genetically-modified materials in pharmaceutical products that are addressed by other relevant international agreements or organizations. Moreover, the protocol does not cover organisms that are intended for what is called "contained use", for example in a laboratory under conditions specified by the appropriate authority.

The central feature of the Cartagena Protocol is its Advance Informed Agreement (AIA) procedure. This requires exporters to obtain the consent of the country of import before a consignment of living organisms leaves a country of export for the first time. A party seeking permission to export a living modified organism for intentional introduction into the environment must notify the potential recipient country of its intentions through the AIA procedure. The importing country must then decide whether to allow the organism to be imported. Under the Cartagena Protocol, an importing country needs to base its decision on a scientific risk assessment. Importing countries are permitted to ask for financial or technical assistance to carry out risk assessments or other help needed for safe importing. An importing country can also require an exporter to conduct a risk assessment. Using the precautionary approach, an importer can refuse a shipment if the risk assessment does not allay concerns about possible harm.

Organisms that are intended for direct use as food, for animal feed, or for processing need to be registered with what is called the 'Biosafety Clearing House' established by the Protocol. The responsibility for filing information in the clearing house rests with an exporter who must also provide additional information if this is requested by an importing country.

Where regulatory and compliance measures in Africa are more effective is in the area of food that is destined for export markets, particularly exports to developed countries. There is, however, a tendency in some African countries to subordinate the needs of domestic consumers over those in developed country markets. Among other things, this can lead to inconsistent regulatory positions as the requirements of export markets may not always be the same as those of domestic or regional ones.

None of the major genetically-modified food-exporting countries (USA, Canada, and Argentina) are parties to the Cartegena Protocol, a situation that has implications for food imports from these countries to Africa. The situation is further complicated by the fact that American (North and South) and EU states take a different approach to regulating GM crops. EU states use what is called the Precautionary Principle, which assumes that a product might be harmful unless it can proven to be safe. The US regulatory system assumes the opposite: that a product is safe unless it can be proved to cause harm. African states are being encouraged to adopt both sets of approaches. [74]

Improving Standards in Food Quality and Safety

Whereas in developed countries, responsibility for food safety is moving out of government ministries and being given over to independent regulatory bodies that have been set up through acts of parliament, this has yet to happen in the AU region. Institutional responsibilities for food safety and food quality in the countries of Africa are often shared between the ministries of health, agriculture and national standards bureaus. Comprehensive food safety and quality legislation is not common. Where it does exist, there are problems of enforcement and compliance because regulatory agencies cannot (or do not) enforce the authority that has been given to them. Weak compliance regimes, moreover, have the effect of denting public confidence in new technologies in food production.

As much as anything, it is globalisation and the demands of a multilateral world that are affecting and influencing the issues that have been raised in this chapter. In each of the issues discussed thus far: international trade, domestic law, the needs of scientists and innovators, foreign policy, public interest, there is a national or regional agreement which African countries are signatories to.[75] African countries must have the freedom to innovate. But at the same time they must also meet obligations to the WTO[76], the UN Convention on Biological Diversity, the Sanitary and Phyto Sanitary Standards (SPS) Agreement and the Agreement on Technical Barriers to Trade (TBT) and more. African countries need to satisfy the requirements of trading partners in the US and in Europe. But they must not neglect the needs of the continent's own importers, and perhaps most importantly of all, the interests of their own citizens. How can this be done? Let us consider the case of TBT and SPS.

The SPS agreement is designed to ensure that countries apply measures to protect human and animal health (sanitary and phyto-sanitary measures) based on an assessment of risk. The aim is the establishment of a multilateral framework of guidelines and rules that will orient the development, adoption and enforcement of harmonized sanitary and phytosanitary measures and minimize their negative effects on trade.[77] Under the SPS Agreement, the Codex Alimentarius is the main instrument for the harmonization of food standards. This constitutes a collection of internationally adopted food standards, codes of practice and maximum residue limits for pesticides and veterinary drugs. WTO members are enjoined to base their national food safety measures on codex standards.

The TBT agreement on the other hand seeks to ensure that technical regulations and standards including packaging, marking and labelling requirements do not create unnecessary obstacles to international trade. The TBT agreement covers all technical standards not catered for by SPS, and applies to all food products including agricultural products. Parties can deviate from the TBT's standards to fulfil legitimate objectives such as the prevention of deceptive practices or the protection of human health and safety, animal or plant health or the environment. Such measures can be justified on the basis of scientific and technical information.

In the area of animal health, the Office Internationale des Epizooties (OIE) or World Organisation for Animal Health has been designated under the SPS Agreement as the principal standard setting body. States may apply different standards only where the importing country demonstrates scientifically that national animal health conditions require standards over and above those established by the OIE.

It is these rules prescribed by the WTO which constitute the norms or benchmarks against which the validity, adequacy or otherwise of domestic legislation may be judged. If a state has signed and ratified an international treaty, its requirements become binding in national law.

Thus far, however, the level of implementation of standards in African states remains low. This is because of several constraints, such as limited technical, human and financial resources, a lack of infrastructure, including under-resourced or under-equipped regulatory and standardizing bodies, accredited laboratories and testing facilities. The absence of these facilities hampers the ability of most states to provide the necessary scientific and technical justification for the sanitary measures they apply to food imports, for example. While most countries have legislative and regulatory frameworks on sanitary and phyto-sanitary issues, many provisions are outdated and are not harmonized with the SPS and TBT agreements.[78]

The low levels of implementation of WTO standards in Africa has implications for trade with developed countries. Developing countries have won preferential treatment in terms of lower or zero tariffs and the removal of other non-tariff barriers for exports to the developed world. But sanitary and phyto-sanitary standards have to be implemented to the letter in view of their implications for the health of consumers. Developing countries have been promised help with the technical infrastructure needed to comply with WTO standards. But the standards themselves cannot be lowered. [79]

What African states need to do is to embark on a comprehensive programme of capacity building, through international and donor collaboration with organizations such as the WTO, UNEP, FAO, the EU and the US. The FAO, for instance, addresses a variety of food-related activities through publications, training courses and technical assistance projects. The organization collaborates with member countries on strengthening national food control programmes; advice on policy, institutions, regulations, Codex standards; and training and capacity building with regard to laboratories, inspection procedures and good manufacturing and hygiene practices. The FAO Legal Office also has as part of its mandate, the provision of technical assistance to member countries toward the development, formulation and revision of legislative and regulatory framework for food.

With regard to the TBT agreement, the African Organization for Standardization, the competent regional body on standards, could draw on the EU experience for the purposes of enhancement and harmonization of regulatory standards in Africa. After a failed experience in setting up of detailed, pan-European technical regulations, the EU decided to establish their technical regulations at two levels: 1) “essential requirements” incorporated in mandatory European Directives issued by the EU for each category of products and 2) more “detailed technical specifications” provided in voluntary standards established through consensus of stakeholders by the European Committee for Standardization and the European Commission for Electrical Standardization. These voluntary standards are considered to be one possible way of proving conformity of products to the European Directives.

Harmonization of standards and technical regulations is, however, not sufficient to ensure safety of products. Effective control of conformity of products to standards and regulations is equally important. The EU has again pioneered an approach to conformity assessment known as the “global approach” since it applies to both regulated and non-regulated products. The objective of this approach is to ensure conformity to standards and facilitate mutual recognition of tests and certificates issued anywhere in the EU.

This approach is based on a set of *conformity assessment modules* suited to different product categories and risks associated with them; combined with a system of mutual recognition of testing and certification activities. Since the currently accepted way of ensuring the validity and equivalence of test results and certificates is through accreditation of the test laboratories and certification bodies issuing them, the system is based on setting up of *accreditation systems* in each country working to the same international standards and connected together through a system of mutual recognition based on international norms in the framework of two international associations: the International Laboratory Accreditation Cooperation and the International Accreditation Forum.

Recommendation 15: *AU member states should consider adopting a consistent Africa-wide position on food and environmental standards, commensurate with international obligations. Taking such a step will help to ease inter-AU trade, among other activities.*

Getting it Right on IPR

Increased success for Africa's nascent biotechnology industry will depend largely on the extent to which researchers in the continent's public research organizations can secure access to enabling technologies, the "source code" for adding value to known biological information. Unlike the case some 20 or 30 yeas ago, much of this additional knowledge is now tied up in proprietary patents, which are often owned by large companies. These patents are expensive to use, and there is an increasing consensus that they are acting as a barrier to innovation.

In biotechnology, the private sector holds at least as much technological information and knowledge (probably more) than the public sector worldwide. According to the 2004 edition of *The State of Food and Agriculture* (FAO) the private sector in 2001 funded up to $1.5 billion in developed country biotechnology R&D compared with $1 billion that came from the public purse. Moreover, a large and growing portion of scientific information on biotechnology is held in the private sector, often in the patent offices of industrialised countries.

Alternatives systems and new ways of navigating the IPR maze are beginning to emerge, however, fuelled in large part by the realization that open access to agricultural science, one of the pillars of food security in the developed world, is less available to developing countries. One of these initiatives is the African Agricultural Technology Foundation, designed to assist researchers from Africa navigate the international patent system, and to negotiate patent rights on behalf of AU scientists. Devised by three agencies (DFID, The Rockefeller Foundation and USAID), the foundation's aims include enabling Africa's scientists have access to technologies in critical areas such as: insect resistance in maize, mycotoxins in food grains, drought-tolerance and striga-control in cereals.

A second is known as PIPRA (Public Intellectual Property Resource for Agriculture), an initiative of some 39 public-sector universities and non-profit agricultural research organizations in 10 countries to share knowledge of their discoveries, inventions and innovations. The PIPRA database contains some 6600 patents and patent applications, and has also benefited from Rockefeller funding.

The third initiative, known as BIOS, is an ambitious attempt to persuade universities and private companies to change the way they protect their intellectual property – drawing on lessons from the ICT industry, particularly the emergence of the non-proprietary Linux operating system and the emergence of other Open Source products. BIOS is an initiative of Cambia, a Canberra-based non-profit biotechnology research organization. Under BIOS, scientists agree to make patents on new technologies freely available under a

Biological Open Source license. Anyone (or any company) that wants to use the technology can only do so if they agree to contribute their own developments to the initiative's patent database. BIOS is guided by the view that "freedom to innovate" needs researchers to have access to all the available technological options, especially preceding ideas. The goal is to create wealth by freeing up the tools of biological innovation to create and deliver useful technologies for the benefit of society.

Recommendation 16: *AU member states should strengthen the capacity of their intellectual property systems such that a balance is found between the need to reward inventors while promoting the freedom to innovate. This should be accompanied by exploration of additional approaches to intellectual property protection including "open source" systems that help AU member states to effectively use the world's body of available scientific and technical knowledge.*

New models for IPR are sorely needed as the relationships between intellectual property rights (IPR), international trade, sustainable development, and technological innovation continue to be the subject of debate and controversy, especially in international forums such as the World Trade Organization (WTO) and the UN Convention on Biological Diversity**.** One aspect to this ongoing conversation has been the implications of the WTO agreement on the Trade-related Aspects of Intellectual Property Rights (TRIPS) for international trade in general, and for developing countries in particular.

The agreement recognizes the role of technology in social and economic welfare and sets out its objectives in Article 7 as: "The protection and enforcement of IPR should contribute to the promotion of technological innovation and to the transfer and dissemination of technology, to the mutual advantage of producers and users of technological knowledge and in a manner conducive to social and economic welfare, and to a balance of rights and obligations."

Many in developing countries believe that the requirement under TRIPS that innovation be protected through IPR adversely affects their ability to use technological knowledge to promote public interest goals such as health, nutrition and environmental conservation. Furthermore, many also regard conventional IPR systems as not giving sufficient recognition to the rights of, for example, farmers, groups in society, or local (perhaps historical) contributors to innovation.

Chapter 6:

Strategic Considerations

Local Innovation Areas; Integrating Biotechnology into Regional Policies; How to do Better International Collaboration; Realizing the Potential of Africa's Diaspora; Financing Biotechnology

Local Innovation Areas: The Shape of Things to Come

Central to the development of biotechnology in Africa is what we call Local Innovation Areas. These would serve as focal points for innovation activity, and would include regional R&D institutions, firms, and universities, specialized suppliers, service providers, professional societies and associated institutions.[80]

Local Innovation Areas capture and then make better use of the different links in an innovation process. They are known to help increase the productivity and effectiveness of companies, of industries, and the research community. They are also effective in helping to incubate new business start-ups, and at the same time giving a boost to companies on their way to becoming more established. Local Innovation Areas also play an important role in a company's transition from being an imitator to being an innovator; and from thinking about investing on a small or modest scale, to being able to visualize investment and growth on a larger scale. [81]

Local Innovation Areas are increasingly common in developed countries, and are also emerging in developing ones too. A particular catalyst for their growth in developing countries is the setting up of R&D facilities by foreign technology-based multinationals in countries such as Brazil, China, India and South Africa. This has both benefits and some drawbacks. Benefits include boosting and activating the local innovation community and injecting it with financial and other forms of business and research support. Some of the disadvantages include tying down an already limited community of researchers, manufacturers and suppliers to the demands and needs of producers and consumers outside of the developing world. Moreover, an innovation process that is driven primarily from the outside has little or no incentive to build necessary infrastructure (unless doing so has a direct bearing on a product or process under development). Finally, there is the inevitable concentration of people and resources in capital (or commercial) cities at the expense of other parts of a country. [82]

What we argue in this report is for the involvement of the local private sector, indeed that this remains pivotal to the success of a Local Innovation Area.The state's involvement, indeed its responsibility is no small matter. The planning and eventual oversight of Local Innovation Areas should typically include representatives of both national as well as state/provincial and district-level government. In addition to this, different ministerial departments also need to be involved wherever appropriate. Examples would include ministries of healthcare, environment, as well as science and technology. Local Innovation Areas have to be a cross-government activity. [83]

Recommendation 17: *The long-term process of biotechnology development in AU member states should go hand-in-hand with the creation of regional innovation communities. Local innovation areas (comprising of universities, research institutes, private enterprises and other actors) should be the locus of biotechnology innovation in the communities.*

Integrating Local Innovation Areas into the Regional Economy

Successful innovation systems are made up of at least three main contributors: public research institutions, academia, and industry. In addition, governments at different levels (central, regional, provincial, municipal, etc) need to play the role of coordinator, bringing people together, joining up the dots, and helping to build trust and cooperation among groups and individuals not used to working together. Some state actors go further and play a managerial (even a leadership) role. This includes ensuring that tasks get done, deadlines are met and objectives achieved. [84]

It is possible to visualize how Local Innovation Areas could work at the level of provinces or districts within a single country. But is it possible to envisage Local Innovation Areas at the level of regions – particularly in the context of the AU?

The AU has an established regional strategy (indeed, there is more than one if we include the strategies of regional groupings within the AU, such as SADC). We argue in this report that the concept of a Local Innovation Area could be made to work at the regional level. Not just that, but that it is imperative that this should happen. One way of extending the franchise is to consider the idea of Regional Innovation Communities alongside the existing Regional Economic Communities (RECs), which the AU is beginning to take forward.

Regional Innovation Communities are an important reason is to help overcome what we call “institutional thinness” within many of the smaller and less-wealthy AU member states, those that do not have adequate human, financial, and social capital, and which would benefit from collaboration (and economies of scale) with better-resourced institutions in neighbouring countries. Such collaborations would be particularly valuable in food security and in healthcare. There are already many agreements within the region that focus on S&T collaboration. All of this should happen within the context of RECs. [85]

Regional cooperation in science and technology can take various forms, including joint science projects, sharing of information, conferences, building and sharing joint laboratories, setting common standards for R&D, and exchange of expertise. Its advantages for AU member states include:

Access to new knowledge, foreign skills and training opportunities that may not be available at the national level; access to large and often expensive research facilities, including laboratories and libraries; enrichment of political and social relations between countries; opportunities to establish multidisciplinary research activities and research teams; larger groups that are more attractive for major international grants; building or strengthening domestic R&D institutions.

Recommendation 18: *Through Regional Economic Communities (RECs), AU member states should focus their efforts on developing and implementing 20-year biotechnology missions that build on their strengths and priorities. Examples include health biotechnology for Southern Africa; animal biotechnology for Eastern Africa; crop Biotechnology for Western Africa; forest biotechnology for Central Africa and Biopharmaceuticals for Northern Africa. These regional efforts will complement and build on national priorities.*

Financing Biotechnology

In the past five years, increasing numbers of leaders and senior government officials in AU states have expressed support for giving a boost to science and technology, and innovation, and biotechnology in particular. This has to be welcomed but what has been lacking is a similar promise for financing to support these statements, and to support the AU's declared vision of supporting knowledge-based development.[86]

So far, public investment in biotechnology R&D in the AU remains minimal. In the majority of AU states (excluding a handful of the larger nations), government funding on biotechnology R&D activities tends not to exceed $250,000 per year.[87] This is far below that which is typically spent in developing countries. Indonesia's total expenditures on biotechnology research for the period 1985 to 1996, for example, came to $19 million. Kenya's public sector investments for the same period amounted to $3 million.[88]

As the *State of Food and Agriculture* (FAO 2004) shows in some detail, developing country investments have up till now been dwarfed by contributions from non AU-aid and from private-sector multinationals based outside of Africa. *The State of Food and Agriculture* reports that out of a total of $250 million spent each year on biotechnology R&D in the developing world, $50 million comes directly through foreign aid and $50 million through the Future Harvest Centres linked to the Consultative Group on International Agricultural Research. The decline in public investment in biotechnology R&D is mirrored across the world – at least half of such funding now comes from the private sector -- $1 billion of private sector investment in the case of richer countries. At the level of individual companies, Syngenta, for example, invests around $800 million annually in R&D, making it the largest investor in agricultural research globally.[89]

There are some bright spots, nonetheless. The government in Egypt is increasing its financial investment in biotechnology. Nigeria's federal government provides the National Biotechnology Development Agency with an average of US$ 263 million per year for three years as a start-up grant. South Africa’s new biotechnology strategy commits more than US$ 300 million per year from government to finance a variety of biotechnology initiatives.

The seeds of change are being seen at the AU level more broadly as well. At an Extraordinary Meeting of the African Ministerial Council for Science and Technology in Cairo in November 2006 delegates agreed to develop a legal instrument for the African Science and Innovation Facility (ASIF). This would be a distinct funding scheme or facility for science and technology in Africa. It would be resourced through annual assessed contributions by African countries, as well as a consortia of bilateral and multilateral agencies. It would be created in partnership between the AU, NEPAD, the African Development Bank, the African Capacity Building Foundation and the World Bank, as well as with other donors.

Other innovations are also being seen. The idea of industry-wide levies to fund research, widespread in other countries, is being implemented in Kenya where a small charge on tea, coffee, and sugar industries is being used to support industry-specific research. Such an initiative deserves to be replicated to create an R&D funding pool to cover common areas in biotechnology development.

Reforming tax laws is an essential element in this strategy. Private individuals and corporations need targeted tax incentives to contribute to research funds and other technology-related charitable activities. Areas such as education, health, and environmental management could all benefit from the local generation of revenue where specific exemptions are provided by law to encourage charitable trusts.[90]

Other countries are looking into using national lotteries as a source of funding for technological development. Other initiatives could simply involve restructuring and redefining public expenditure. By integrating R&D into infrastructure development, for example, African governments could relax the public expenditure constraints imposed by sectoral budgetary caps. (Brazilian scientists proposed a similar approach to their government as a framework for negotiations with the IMF.) Such a strategy, if pursued, has the potential to unlock substantial funds for biotechnology R&D activities.

Appropriate financial institutional infrastructure is also important in fostering business development and technological innovation. The record of financial institutions in this field has been generally poor in developing countries. Banking and financial reforms would allow them to help promote technological innovation. Capital markets, such as venture capital, have played a critical role in creating SMEs in developed countries. Other than arranging funding, venture capitalists also help groom business start-ups into competitive and profitable firms. Bringing venture capital into African countries would help create new businesses and improve their sustainability.

Recommendation 19: *AU leaders, at the local, national, regional, and continental levels, must significantly increase public investments in biotechnology R&D. Failure to do so will impair the continent’s capacity to stay* *connected to global advances in biotechnology and to transfer, adapt, and exploit life sciences knowledge for the benefit of all citizens.*

What Role for International Partners?

Strategic considerations in science, technology and innovation in Africa include taking a strategic look at the role of international partners, and providing more opportunities to enable their collaboration with African R&D institutions. African institutions with whom collaborations are strong include, for example, many of the Future Harvest centres linked to the Consultative Group on International Agricultural Research, such as the International Livestock Research Institute. They also include the International Centre for Insect Physiology and Ecology, the African Mathematical Studies Institute, the African Centre for Technology Studies, the African Academy of Sciences, the Kigali Institute for Science and Technology and many more.

But they could be joined by others. Indeed, the time is right for collaboration to shift gear. International partners (governments, industry and philanthropic foundations) are actively looking for institutions with which joint projects could be carried out. International partners are keen to help improve the continent's knowledge infrastructure as representative government takes root across the AU region. While researchers, civil servants and entrepreneurs in AU countries stand to benefit from international expertise, access to finance, new ways of working and international benchmarking, there are benefits for international partners as well. These include: access to new markets in the AU region and a series of R&D and business challenges that will test (and provide valuable experience to) the best of their researchers and managers.

Examples of good practice in international collaboration are too numerous to mention here. But three are worth mentioning. One is the Pan African Rinderpest Campaign (PARC). A second is Ushepia (University Science, Humanities, and Engineering Partnerships in Africa). A third is the International Financing Facility, piloted by the UK government, in particular its finance minister Gordon Brown.

Good Practice Makes Perfect

The OAU launched the Pan African Rinderpest Campaign in 1986 with the aim of eradicating Rinderpest, the infectious viral disease in cattle – not unlike measles in humans. Rinderpest is rare in that a vaccine has existed for some time– it was the subject of the 1999 World Food Prize. What was needed was a coordinated plan of action, capacity-building and sufficient and sustainable sources of funding. The OAU, together with FAO and the IAEA created such a plan with the result that 24 African countries have been declared as Rinderpest-free. Moreover, the infrastructure has been created so that disease surveillance and monitoring is strong throughout the AU where 45 million cattle are vaccinated every year. Laboratories in Africa and abroad are also equipped for vaccine production. PARC also helps other countries build technical expertise in disease surveillance and reporting, and a communications unit helps sensitize farmers, veterinary experts, policy makers and donors.[91]

The second example, known as Ushepia is an active research network of eight established universities in Sub-Saharan Africa, including the Universities of Botswana, Dar es Salaam, Cape Town and Makerere. It awards fully-funded research fellowships in engineering, humanities and the sciences to candidates from AU member states. Researchers are invited to train and carry out their work at any one of the eight universities. The network's aims include identifying talented scholars and researchers, mentoring them and building their knowledge, skills and research experience. A critical aim (an over-arching one, perhaps) is to give them incentives (financial and professional) not to emigrate to a developed country. At the time of writing, all 56 Ushepia scholars are known to be working in the AU. In the field of science, Ushepia fellowships cover malaria and HIV/AIDs, tuberculosis among others. [92]

While the idea for Ushepia did not emerge from the board-room or programme office of a donor agency, the role of donors and international partners was crucial to its success. The idea emerged in the early 1990s among a number of senior executives among AU universities who saw in the liberation of South Africa an opportunity to integrate the country into the research capacity building efforts of other AU universities. A seed grant came from The Rockefeller Foundation, and the initiative has not looked back since. Ushepia can be seen as an analogue to the idea suggested in this report of Regional Innovation Communities. It can be regarded as a way of building strength in biotechnology innovation systems in the AU.

The third example is a proposal from Gordon Brown, finance minister in the UK government, for aid from international donors to be used as collateral so that much greater sums can be obtained towards R&D and the manufacture of medicines and vaccines for diseases, which otherwise would not be a commercial priority for companies. Under the first project of what is called the International Finance Facility (IFF), donor governments, private foundations, and international organizations have pledged $4 billion towards the purchase of vaccines that will immunise 500 million children from 70 countries over the next 10 years from measles, polio and tetanus. What is innovative about the IFF is that aid is being 'front-loaded', that is to say, aid from promised future commitments is being delivered now so that accelerated progress can me made towards meeting the Millennium Development Goals.[93]

Realizing the Potential of Africa's Diaspora

One in three professionals trained in an AU country now lives outside of the continent [94]. As Africa takes charge of her destiny, an increasing number of the AU diaspora will return to play their part, but it is likely that many (if not most) will remain in their new countries. Members of this diaspora still want to play their part in Africa's development.

Africa's diaspora communities around the world retain strong links to a continent that many still regard as "home". Family visits are common as is fundraising for humanitarian emergencies. Some members of diaspora communities have also involved themselves in political movements in their countries of origin. Others are organized into professional networks and associations, undertaking short-term professional assignments in African countries on sabbatical time, taking unpaid leave, or during vacations.

All of this indicates the wellspring of opportunity that diaspora communities present, not least in the field of biotechnology. The African diaspora is a rich source of scientific and technical skills, particularly in biotechnology research and development. Scientists and technicians with strong links to Africa are based in the US, in EU member states and countries in Asia. They work in a diverse range of areas from functional genomics, to bioethics; science policy to agricultural biotechnology.

Initiatives such as the NEPAD-led African Biosciences Initiative already involve the AU diaspora. But the range of skills and experience that they bring is wide and suitable for a wider set of applications, time frames and budgets. One of the simplest tasks diaspora researchers are good at doing is to sit on peer-review panels for research and project grants, providing that much-needed view from the sympathetic external expert. This requires modest amounts of time at comparatively little expense. More complicated functions include finding appropriate diaspora professionals to sit on (or advise) the governing bodies of institutions; mentoring less experienced researchers, entrepreneurs and faculty, advising on intellectual property, or helping to write courses of study.

What they need – indeed what will help – is policies that welcome diaspora involvement; policies that can help to develop better links between AU member states and communities of diaspora professionals; the availability of modest amounts of financing; and getting the word spread in the right places, such as AU embassies and consulates around the world.

Specific policies could include some or all of the following: Allowing dual citizenship; formalizing the exchange of researchers and faculty between institutions in the AU and in other countries, including short-term visiting appointments; encouraging diaspora communities to become involved in international development initiatives in their new countries; institutions in non-AU countries should be encouraged to find ways of involving citizens of AU-origin in international development, research and entrepreneurship in the AU; encouraging diaspora communities to travel to – and make links with -- AU countries in addition to their countries of origin; streamlining necessary bureaucracy, making paperwork more transparent predictable, and removing unnecessary administrative steps; generating knowledge of diaspora professional organizations and networks – particularly at the level of embassies/consulates, sharing this knowledge at the level of the AU.

Do Skilled Diasporas Impact Development? [95]

One of the most studied examples in which transnational communities have had a strong impact on the development of their home country is found within the Asian-American networks linking the Silicon Valley with the Hsinchu region of Taiwan. Asian-American engineers, who built social and economic bridges linking the two economies, were instrumental to the success of Taiwan's ICT sector in the 1980s and 1990s.

This skilled community owes its origins to graduate engineering students from Taiwan who went to study in the US. Four sets of circumstances allowed them to contribute to Taiwan's later economic development. They include: Growth of a new technology sector in Silicon Valley that harnessed their skills; The formation of associations of Taiwanese professionals, in part because these professionals felt excluded from Silicon Valley; A strong spirit of community development and entrepreneurship within this community; Well-publicized initiatives by the Taiwan government to attract its diaspora to contribute to the country's ICT sector and the growth of companies in the Hsinchu region.

Recommendation 20: *The international community, other developing nations, and the African Diaspora have the potential to play a critical collaborative role in Africa's economic development and technological capacity building. African regional innovation communities should facilitate North-South and South-South collaborations as well as mobilize the knowledge network of its diaspora for biotechnology development.*

Chapter 7:

Conclusions and Recommendations

The history of Africa has been marked by a unique development narrative in which science, technology and innovation have often been viewed a preserve for a select few rather than as tools for development. But this narrative is starting to change. African leaders are beginning to view science, technology and innovation as critical to human development, global competitiveness and ecological management. It is in this context that the findings and subsequent implementation of the recommendations of the High-Level African Panel on Modern Biotechnology of the African Union and the New Economic Partnership for Africa's Development should be viewed.

A key outcome of the work of the panel is the creation of what we call "Regional Innovation Communities" involving groups of countries in eastern, western, northern and southern Africa. The innovation communities may be anchored by geographically-defined "Local Innovation Areas" with the clustering of universities, professional associations, enterprise and other actors with critical capabilities in agricultural, health, industrial and environmental biotechnologies. Such areas will bring draw on the capabilities within the regions and serve as focus points for international partnerships. The strategies will be implemented through Regional Economic Communities (RECs) whose capacity will in turn need to be strengthened.

The report's conclusions and recommendations can be grouped into five categories.

One: Outlining the role of technology in general and biotechnology in particular in Africa's development, in regional economic integration and in trade.

Two: Identifying priority areas in biotechnology for development in Africa – specifically bio-pharmaceuticals, health biotechnology, crop biotechnology and forest biotechnology.

Three: Identifying critical capabilities needed for the development and safe use of biotechnology. These capabilities include: infrastructure development, reinventing the African university, developing human capacities and engaging the public.

Four: Developing continent-wide regulatory measures that are effective, transparent and efficient and are based on the co-evolutionary approach of promoting innovation, while protecting the public.

Five: Strategic considerations for creating and building regional biotechnology innovation communities, as well as suggesting options for financing biotechnology, engaging the African diaspora, and designing effective collaborations with international partners.

Recommendations on Science, Technology and Innovation

1. Strengthen science and technology advice

There is a need to establish an AU Presidential Council for Science, Technology and Innovation, as well as offices of science and technology advice inside presidencies. Both of these initiatives are critical in assisting heads of state and government to keep abreast of advances in science, technology, innovation, as well as the links between science and public policy at home and abroad. Such offices will also help to stimulate the creation of similar offices in other ministries and eventually to develop a network of advisory support to government on critical matters related to science and technology. The advice can draw from the input of academies of science, technology and engineering.

2. Build capacity in science and technology diplomacy

Ministries of foreign affairs have a responsibility in promoting international technology cooperation and forging strategic alliances. To effectively carry out this mandate, foreign ministries need to strengthen their internal capability in science, technology and innovation. To this end, they will need to create offices dealing specifically with science and technology, working in close cooperation with other relevant ministries, industry, academia and civil society. Such offices could also be responsible for engaging and coordinating diasporas in Africa's technology development programmes.

3. Commit to long-term technology goals and missions

African governments have agreed to develop a 20-year African Biotechnology Strategy with specific regional technology goals to be implemented through Regional Economic Communities (RECs). To carry out this task, there is an urgent need to strengthen the capacity of the secretariats of the RECs and in particular in the area of regulatory expertise in science, technology and innovation in general and in biotechnology in particular.

4. Build critical capabilities

Africa lacks physical, human, institutional and societal capacities in science, technology and innovation. Emphasis should be placed on strengthening higher technical education and increasing female enrolment, merging research and education and reforming existing knowledge-based institutions, in particular universities to serve as centres of technology development and entrepreneurship. These activities should be done primarily in "Local Innovation Areas" which are clusters of expertise sharing knowledge, creative ideas, and personnel, and working on problems and projects collaboratively.

5. Leverage financial resources

New funds for technology programmes will require a wide range of incentives. There is an urgent need to undertake a comprehensive review of Africa's challenges and opportunities in financing technological development and the associated entrepreneurial activities. Such a review should focus on how to improve incentives for local financial support as well as leverage international contributions.

6. Establish follow-up mechanisms

African leaders should launch programmes for public understanding and engagement in science, technology and innovation. Such programmes could raise public awareness as well as act as a follow-up mechanism for national cabinets, parliaments, civil society, industry and regional organizations that are tasked with developing technology missions and activities. Institutional arrangements will be needed that ensure that they keep under close review the implementation of the decisions of the AU Summit related to science and technology. Such a body would also help serve as a high-level champion of science, technology and innovation for Africa's development.

Recommendations on Biotechnology

Recommendation 1*:* Agricultural biotechnology holds the promise of improving food security, and better nutrition. AU member states must invest in agricultural biotechnology to address long-term issues such as nutrient deficiency, and needed improvements to overall agricultural productivity.

Recommendation 2: Animal biotechnology can help develop diagnostic tests and vaccines for livestock diseases and infections that risk food insecurity. Animal biotechnology also provides information for managing indigenous animal genetic resources, improves nutritional quality of feed and fodder, enhances reproductive efficiency of livestock; and increases the production of meat and milk through techniques such as cloning.

Recommendation 3*:* Fisheries biotechnology can help to understand fish taxonomy and population structure questions, and to improve reproduction, health and nutritional quality of fish feeds. Africa needs to invest in fisheries biotechnology in order to develop evidence-based fish management programmes and improve efficiency of producing fish in aquaculture.

Recommendation 4: Forestry biotechnology can help AU member states benefit in areas of tree species biodiversity and reforestation. AU member states need to upgrade and expand the current limited forestry biotechnology programs.

Recommendation 5: In order to boost healthcare biotechnology, AU member states need to study the major players contributing to innovation in health biotechnology; identify ways of joint decision-making among different ministries and analyse the linkages between macroeconomics and health.

Recommendation 6: AU member states need to boost the development of bio-fuels, and develop processes that convert waste into usable products. The region must develop a comprehensive industrial biotechnology R&D agenda and fast track its programme to create an enabling environment for effective private sector participation in the development of bio-fuels.

Recommendation 7: AU member states and regions should more fully integrate environmental biotechnology into environmental protection strategies and policies, and launch pilot-scale production of environmentally friendly products including food, fibre, cosmetics, pharmaceuticals and products for biological management of pests.

Recommendation 8: Poor and inadequate infrastructure services are an obstacle to Africa's development. AU member states need to leverage all available capacity from all sources to help build and maintain infrastructure.

Recommendation 9: AU member states should initiate measures that strengthen the role of universities as centres of research, training and biotechnology diffusion. Doing so will entail fundamental reforms in the role of higher technical training in economic development. The reforms include bringing research, teaching and community outreach together to support technology development goals.

Recommendation 10: AU states must develop and expand national and regional human resources development strategies in biotechnology higher education and research. These need to include: a comprehensive biotechnology curriculum; a consortium of clearly identified and designated universities to develop and offer regional biotechnology training courses; an emphasis on female recruitment in the sciences and engineering; and training in science and innovation policy.

Recommendation 11: Public awareness of -- and public engagement in -- biotechnology is needed at all levels in Africa. A lack of both will make it difficult for AU member states to individually and collectively discuss, set priorities and exploit economic and other opportunities offered by biotechnology.

Recommendation 12: Africa needs to develop its own scientific capacity to assess biotechnology-related risks through national, regional and continental institutions so that all biotechnology policy is informed by the best available research and knowledge. The consensus among researchers thus far is that there is no compelling evidence of harm from the consumption of approved foods and food products manufactured from biotechnology processes. Governments should therefore seek to advance the use of biotechnology by facilitating the approval of clinical and field trials based on appropriate legislative mandates.

Recommendation 13: Biotechnology regulations should be based on a case-by-case approach, according to internationally-agreed rules and guidelines. They should adopt the "co-evolutionary" approach in which the function of regulation is to promote innovation, while at the same time safeguard human health and the environment.

Recommendation 14: The AU's RECs need to be staffed with appropriately trained experts who can advise states on regional and international agreements, guidelines and conventions on all aspects of biotechnology. The AU secretariat and NEPAD need to build further capacity in biotechnology regulation. They could also provide assistance to states on multilateral mechanisms and agreements.

Recommendation 15: AU member states should consider adopting a consistent Africa-wide position on food and environmental standards, commensurate with international obligations. Taking such a step will help to ease inter-AU trade, among other activities.

Recommendation 16: AU member states should strengthen the capacity of their intellectual property systems such that a balance is found between the need to reward inventors while promoting the freedom to innovate. This should be accompanied by exploration of additional approaches to intellectual property protection including "open source" systems that help AU member states to effectively use the world's body of available scientific and technical knowledge.

Recommendation 17: The long-term process of biotechnology development in AU member states should go hand-in-hand with the creation of regional innovation communities. Local innovation areas (comprising of universities, research institutes, private enterprises and other actors) should be the locus of biotechnology innovation in the communities.

Recommendation 18: Through Economic Commmunities (RECs), AU member states should focus their efforts on developing and implementing 20-year biotechnology missions that build on their strengths and priorities. Examples include health biotechnology for Southern Africa; animal biotechnology for Eastern Africa; crop Biotechnology for Western Africa; forest biotechnology for Central Africa and Biopharmaceuticals for Northern Africa. These regional efforts will complement and build on national priorities.

Recommendation 19: AU leaders, at the local, national, regional, and continental levels, must significantly increase public investments in biotechnology R&D. Failure to do so will impair the continent's capacity to stay connected to global advances in biotechnology and to transfer, adapt, and exploit life sciences knowledge for the benefit of all citizens.

Recommendation 20: The international community, other developing nations, and the African Diaspora have the potential to play a critical collaborative role in Africa's economic development and technological capacity building. African regional innovation communities should facilitate North-South and South-South collaborations as well as mobilize the knowledge network of its diaspora for biotechnology development.

Biographies of the High Level African Panel on Modern Biotechnology

Calestous Juma, Co-chair, is Professor of the Practice of International Development at the John F. Kennedy School of Government at Harvard University and Director of the university's Science, Technology and Globalization Project. He is a former Coordinator of the UN Millennium Project's Task Force on Science, Technology and Innovation whose report, *Innovation: Applying Knowledge in Development*, was presented to UN Secretary-General Kofi Annan in January 2005. Juma served as Chancellor of the University of Guyana until 2003 and is a member of the President's National Economic and Social Council of Kenya. Juma is a former Executive Secretary of the United Nations Convention on Biological Diversity and founding Director of the African Centre for Technology Studies in Nairobi. He has been elected to various scientific academies including the Royal Society of London, the US National Academy of Sciences and the Academy of Sciences for the Developing World. He has won several international awards for his work on environment and development. He holds a PhD in science and technology policy studies from the University of Sussex UK, and has written widely on science, technology, innovation and the environment.

Ismail Serageldin, Co-chair is the founding Director, Bibliotheca Alexandrina (Library of Alexandria) and Chair of the Boards of Directors for each of the BA's affiliated research institutes and museums. He serves on a number of advisory committees including: the Institut d'Egypte (Egyptian Academy of Science), TWAS (Academy of Sciences for the Developing World), the Indian National Academy of Agricultural Sciences and the European Academy of Sciences and Arts. He is a former Chairman, Consultative Group on International Agricultural Research, Founder and former Chairman of the Global Water Partnership and the Consultative Group to Assist the Poorest. Serageldin has had a long career with the World Bank where he held the post of Vice President for Environmentally and Socially Sustainable Development. He has published over 50 books and monographs and over 200 papers on a diverse set of topics including biotechnology, rural development, sustainability, the history of science and the plays of William Shakespeare. He holds a bachelor's degree in engineering from Cairo University and a PhD from Harvard University. He has received 18 honorary doctorates and is a Distinguished Professor at Wageningen University in the Netherlands.

Amadou Tidiane Ba is Professor of Plant Biology at the University of Dakar, a Special Advisor to Senegal's Ministry of Education, President of the country's National Committee on Biosecurity and a founding member of Senegal's National Academy of Sciences. He is also a member of: the National Commission of Unesco's Man and the Biosphere Programme, National Committee for Natural Resources and Environment, National Centre of Remote sensing for Ecological Studies, IUCN's Regional Councillor for Africa, Coordinator of the African Biosciences Network, President of the West African Association of Botanists and a member of the Scientific Board for the Environment of the West African Monetary Union. He has PhDs in tropical botany from the University of Paris VI, France and in natural sciences from the University of Senegal. He is a former Director of the Institute of Environmental

Sciences of Senegal. His main research interests include the ecology and physiology of the parasitic weed *Striga*.

Mpoko Bokanga is the Executive Director of the African Agricultural Technology Foundation, a Visiting Professor of the University of Greenwich, UK and Visiting Professor at the Alabama A&M University, Alabama, USA. A food scientist he previously worked as Industrial Development Officer for agro-industries with the United Nations Industrial Development Organization in Abuja, Nigeria. He is a former Research Scientist with the International Institute of Tropical Agriculture. He has written or edited three books and published several papers on cassava, and on the processing of root and tuber crops. He chairs the African branch of the International Society for Tropical Root Crops and is Coordinator of the society's Working Group on Cassava Safety. He has a master's degree from the Massachusetts Institute of Technology and a PhD from Cornell University, USA.

Abdallah Daar is Professor of Public Health Sciences and Professor of Surgery at the University of Toronto, where he is also Director of the Program in Applied Ethics and Biotechnology and Co-Director of the Canadian Program on Genomics and Global Health. A transplant surgeon and among the founders of modern medical education in Arabic-speaking countries he has advised the World Health Organization on xenotransplantation and chairs the 4th External Review of an inter-UN agency Special Program on Tropical Diseases Research and Training. He has published four books and has over 250 publications in immunology, immunogenetics, transplantation, surgery, and bioethics. Awards and honours include the Hunterian Professorship of the Royal College of Surgeons of England and the Unesco Avicenna Award for Ethics of Science. He is a member of the Editorial Boards of the *World Journal of Surgery*, and the *Journal of Genomics, Society and Policy*.

Cheikh Modibo Diarra is Chairman of Microsoft Africa, based in South Africa. An astrophysicist he previously worked for the Jet Propulsion Laboratory of the US National Aeronautics and Space Administration (Nasa). He worked as navigator on a number of space missions including the Magellan probe to Venus, the Ulysses probe to the Sun, the Galileo spacecraft to Jupiter and the Mars Observer and Pathfinder missions. He later became Director of public outreach for Nasa's Mars Exploration Program. Diarra is also founder of the Pathfinder Foundation for Education and Development. He is a former Chief Executive of the African Virtual University, based in Kenya and a former Goodwill Ambassador for Unesco. Born in Mali, he studied mathematics and physics at the University of Pierre and Marie Curie in France, and aerospace engineering at Howard University in Washington DC, where he also taught.

Tewolde Berhan Gebre Egziabher is the Director General of the Environmental Protection Authority of Ethiopia, architect of his country's conservation strategy and spokesman for the African Group at the UN Convention on Biological Diversity, whose Cartagena Biosafety Protocol he helped to negotiate. He is also a member of the Interim Panel of Experts to establish the Global Crop Diversity Trust under the FAO. In 1995, together with his wife Sue Edwards, he founded the Institute for Sustainable Development in Ethiopia, which works with farming communities to halt land degradation and increase agricultural production. A plant ecologist with a PhD from the University of Wales UK he is a former President of Asmara University, Dean of Science at Addis Ababa University and editor of the Ethiopian science journal *SINET.* Awards and honours include the Right Livelihood Award of 2000 and an honorary degree of Doctor of Science from Addis Ababa University in 2004. He is a member of the Biological Society of Ethiopia and the British Ecological Society.

Lydia Makhubu is a Senator in the upper house of the parliament of Swaziland and Chancellor of the Women's University of Africa. She is a former Vice Chancellor and Professor of Chemistry of the University of Swaziland, former founding President of the Third World Organization for Women in Science, and one of the founding trustees of the Science and Development Network (www.scidev.net), based in London. She has a PhD in medicinal chemistry from the University of Toronto and a longstanding research interest in the field of traditional medicine. She has honorary degrees from the University of Wales (1991), Queen's University, Canada (1991), St Mary's University (1991), and Brandon University (1995).

Dawn Mokhobo is a member of the management board of the South Africa energy company Eskom. She is also a non-executive director of Nozala Investments and chairs the Tsebo Outsourcing Group. Her previous roles include General Manager (Human Resources) at Eskom, Senior Manager with the Anglo-American Corporation, Group Manager for Community Development in the former Bophuthatswana Agricultural Development Corporation and former chair of the Promotions Committee of the South African Police Service. Mokhobo, who has a bachelor's degree in sociology, has also had a previous career as a social worker and has run her own public relations and development consultancy. She was voted South African Businesswoman of the Year in 1995.

Lewis Mughogho is Acting Director of the Tea Research Foundation of Central Africa based in Malawi, and former Executive Director of the Southern and Eastern Africa Regional Programme of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). A plant pathologist by training his previous positions have included research fellow in agricultural botany at the University College of Rhodesia and Nyasaland, plant pathologist at the Agricultural Research Council of Malawi, founding head of the crop production department at the University of Malawi, and Principal and Professor at Bunda College of Agriculture, University of Malawi. Mughogho has PhD in plant pathology from University of Cambridge, UK.

Samuel Nzietchueng is Director of Research in the office of the Secretary General of Cameroon's Ministry of Scientific Research and Innovation. He was formerly the founding Director General of the African Biotechnology Agency, based in Algiers between 1995-2005. Nzietchueng is an agronomist, physio-pathologist and international development specialist with 32 years of experience working in Europe, USA, the Caribbean and Africa in universities, research centres and intergovernmental organizations. He has a PhD in crop production/pathology from the University of Cameroon.

George Sarpong is a barrister and Professor of Law at the University of Ghana and a member of the IUCN Commission on Environmental Law. He has also been an advisor on environmental law to the government of Ghana, to UN agencies and other international organizations. His specialist areas include: biodiversity, environmental health, food safety, land use planning, mining, plant health, wetlands and water privatisation. He has received many awards, fellowships and visiting scholarships including from the UN and the universities of Leiden, Nottingham, Queens (Belfast) and North-Western. Sarpong entered law after a career in the armed forces of Ghana. He has studied at the Ghana Military Academy, the Combat Arms School, Canada, the Faculty of Law University of Ghana, the Ghana School of Law and the University of British Columbia, Canada.

Cyrie Sendashonga is Regional Coordinator for Central Africa at the Centre for International Forestry Research (CIFOR) based in Yaounde, Cameroon. Between 1999 and 2006 she was Head of Biosafety at the secretariat of the UN Convention on Biological Diversity based in Montreal, Canada. Before that she spent six years at the UNEP headquarters in Nairobi, Kenya working on biodiversity and biotechnology issues. She trained as a biologist and has a PhD from the Free University of Brussels, Belgium, with specialization in molecular biology and cellular immunology. She spent her postgraduate years working at the International Laboratory for Research on Animal Diseases in Nairobi, researching new approaches to controlling parasitic infections in livestock.

Ahmed M. Shembesh is Director General of Libya’s National Centre for Standards and Metrology, a post he returned to in 2004, having initially established the centre in 1987. He is also Chairman of the country’s National Committee for the Evaluation of Regional and Urban Master Plans. He also chairs the National Codex Committee. His previous government posts include working with the planning department and the railways regulatory authority. He is a former Professor of Engineering and Chairman of the Department of Urban Planning at the University of Garyounis. He obtained his PhD from the University of Liverpool, UK and is a certified auditor for quality management systems.

High-Level African Panel on Modern Biotechnology: Terms of Reference

The development and application of modern biotechnology has opened up a wide range of possibilities, including the production of genetically modified crops, animals and micro-organisms. These developments are, however, characterized by increasing scientific complexity, policy uncertainty, and public anxiety over real and perceived benefits and risks. These issues impinge on intra-regional and international cooperation.

Nowhere is the need for regional cooperation likely to be more pronounced as in Africa. This is mainly because most of the African countries do not have the necessary policies, infrastructure, capacities and other resources to individually or collectively regulate and manage the development and application of genetic modification and biotechnology generally. Moreover, increasing intra-regional and international trade (and food aid) in products of genetic modification are exposing the benefits of regional approaches to managing the technology in Africa.

African governments have recognized the importance of regional cooperation to address possibilities and the range of issues associated with biotechnology and genetic modification. Within the framework of the New Partnership for Africa's Development (NEPAD) they have resolved to promote programmes that will "generate a critical mass of technological expertise in targeted areas that offer high growth potential" from biotechnology and the second is to "harness biotechnology in order to develop Africa's rich biodiversity and … improving agricultural productivity and developing pharmaceutical products."[96] To realize these goals African countries will need to first and foremost build common consensus and strategies on how best to ensure that they maximize benefits from the technology while at the same time addressing potential environmental, health, ethical and economic risks or concerns emerging with rapid advances of the technology.

The first NEPAD ministerial conference on science and technology "resolved to build regional consensus and strategies to address concerns emerging with advances in new technologies, including biotechnology, …" The conference called upon the Secretariat of NEPAD to: "build a broad consensus on issues of common concern and develop effective strategies including joint R&D programmes where appropriate; and establish ways and means to build Africa's capacity for risk assessment and management of bio-safety, in particular promote the establishment of regional and sub-regional bio-safety facilities; and facilitate Africa's participation in international fora, processes and discussions on global biotechnology issues."

In the context of the African Union (AU), African leaders resolved to take a common approach to address issues pertaining to modern biotechnology and biosafety by endorsing decision EX.CL/Dec. 26 (III) that calls for an African common position on biotechnology.

The second meeting of the NEPAD Science and Technology Steering Committee decided that the NEPAD Secretariat and the AU Commission establish a high-level panel of eminent persons/experts to advice Africa on the scientific, policy and legal issues pertaining to the development, commercialization and application of modern biotechnology.

It is in response to the above resolutions and decisions that the Secretariat of NEPAD and the AU Commission are establishing a High-Level African Panel on Biotechnology (APB). It will be a body of eminent experts to advise the AU, its Member States and its various organs, on current and emerging issues associated with the development and application of modern biotechnology. Its specific remit is to provide the AU and NEPAD with independent and strategic advice on developments in modern biotechnology and its implications for agriculture, health and the environment. It will focus on intra-regional and international issues of regulating the development and application of genetic modification and its products. The APB will specifically consider:

(a) The current and potential developments in modern biotechnology outlining the implications that may be associated with adoption and/or non-adoption of such technologies for regional economic and trade integration;
(b) The specific priority areas that offer high potential for regional R&D, including aspects of risk assessment and management;
(c) Whether and what aspects of the development and regulation of modern biotechnology should be harmonized into a regional/continental regulatory regime for shared R&D and technology management (this may include ways and means of integrating regulatory measures in existing Regional Economic Communities (RECs) and related trade arrangements);
(d) The scientific capacity that will be needed to ensure the safe application and use of products derived from modern biotechnology, including human resources for research, laboratory testing, safety evaluation and enforcement;
(e) Strategic ways of building Africa's scientific capacity for regionally oriented regulation and management of modern biotechnology; and
(f) Ways of improving cooperation with other regions (particularly Asia and Latin America) of the world to effectively address trade, R&D and regulatory issues pertaining to modern biotechnology, including implementation of the Cartagena Protocol on Biosafety and the Codex Principles on risk analysis of food derived from modern biotechnology;

The panel shall make recommendations on the nature of regional institutional arrangements that are required to promote and sustain common regulatory approaches to the application and use of, and propose a strategy and policy on modern biotechnology. Tenure for the Panel is 18 months commencing at the first meeting. This meeting will be held in Johannesburg, South Africa.

The APB's work shall be serviced by the AU Commission and NEPAD Secretariat. During its first meeting the Panel shall make decisions on the nature of literature and background papers that it will require. AU/NEPAD will seek to commission component research institutions or persons to prepare the papers on the basis of terms of reference prepared by the panel. All the documentation required by or available to the APB will be posted on www.nepadst.org unless decided otherwise by the panel.

An individual African country or government may seek advice of the Panel on a particular issue if such an issue has specific implications for regional cooperation. The Panel must at its first meeting interpret its mandate and the Terms of Reference. It ought to delineate clearly the range of scientific and non-scientific issues that fall within its mandate, those that fall clearly outside it, and those related issues that need to be addressed by other bodies to provide comprehensive answers to the questions posed by the mandate.

The Panel shall submit its report(s) to President Konare, Chairperson of the AU Commission, for transmission to the AU Summit through its subsidiary bodies.

Modus operandi of the Panel

Independence
The panel will operate without influence from outside and will do so by upholding the highest of professional standards. It will operate in a frank and open manner.

Confidentiality
The contents of the discussions will not be disclosed outside the Panel but the final report will be made public without attribution to individual members.

Conflict of interest
Disclosure of potential conflict in regard to financial interest, prior positions as well as family or other relationships

Transparency
Include here the fact that the various drafts of the Panel will be made available to the public for input and comment.

Submissions and consultations
Indicate here the ways by which the Panel will receive submissions. Also indicate the kinds of consultations the Panel will undertake, including those provided for in the TORs.

Role of the secretariat
Organization, writing, etc on the basis of input from the Panel.

Relationship with sponsoring institutions
Indicate here each meeting will start with a session to brief the sponsoring institutions which will in turn provide feedback. The rest of the proceedings of the Panel will be conducted by Panel members only and the secretariat will be on call to contribute as requested by the Panel.

Open sessions
Sessions of Panel involving outside presenters shall be open to members of the public on the basis of availability of space. Agendas of future meetings will be made available to the public through the web and to member states through their missions to the AU.

Press relations
The co-chairs will speak to the press and in keeping with the spirit of the status of work.

Consensus and dissent
The Panel will make every effort to arrive at a consensus position but in the event that there are issues that are central to the overall terms of reference for which consensus cannot be reached, dissent will be record. This route, however, will be pursued in extraordinary circumstances. Every effort will therefore be made to arrive at common position. Where such differences are a result of divergent approaches to solving specific problems, the report will provide the competing positions are options. Given the diversity of conditions in Africa, efforts will be made to provide action items are options that actors can choose from.

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Acronyms

AATF	African Agricultural Technology Foundation
ACP	African, Caribbean, and Pacific
ADB	African Development Bank
AGERI	Agricultural Genetic Engineering Institute (Egypt)
AIA	Advance Informed Agreement
AMCOST	African Ministerial Council for Science and Technology
APB	High-Level African Panel on Modern Biotechnology
ARC	Agricultural Research Council (South Africa)
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASIF	African Science and Innovation Facility
AU	African Union
BIO-EARN	East African Regional Program and Research Network for Biotechnology, Biosafety, and Biotechnology Policy Development
BioPAD	Biotechnology Partnership and Development (South Africa)
BIOS	Biological Innovation for Open Society
Bt	*Bacillus turingiensis*
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Research Centre
COMESA	Common Market for Eastern and Southern Africa
CORAF/WECARD	Conseil Ouest et Centre Africa pour la Recherche et le Developpement Agricoles / West African Council for Agricultural Research and Development
CSIR	Council for Scientific and Industrial Research (South Africa)
DFID	UK Department for International Development
ECOWAS	Economic Community of West African States
EDCTP	European and Developing Countries Clinical Trials Partnership
ESRC	Economic and Social Research Council, UK
FAO	Food & Agriculture Organisation of the United Nations
GMOs	Genetically Modified Organisms
GTZ	Agency for Technical Cooperation, Germany
IAEA	International Atomic Energy Agency
ICSU	International Council for Science
ICTTD	Integrated Consortium on Ticks and Tick-borne Diseases
IFF	International Finance Facility
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
IPR	Intellectual Property Rights
ISAAA	International Service for the Acquisition and Application of Agricultural Biotechnology
ISNAR	International Service for National Agricultural Research
LMOs	Living Modified Organisms
MNCs	Multinational Corporations
NEPAD	New Economic Partnership for Africa’s Development

OAU	Organisation of African Unity
OECD	Organization for Economic Cooperation and Development
PARC	Pan African Rinderpest Campaign
PIPRA	Public Intellectual Property Resources for Agriculture
R&D	Research & Development
RECs	Regional Economic Communities
SADC	Southern African Development Community
SMEs	Small and Medium Enterprises
SPS	Sanitary and Phyto-sanitary
TBT	Technical Barriers to Trade
TRIPS	Trade-related Aspects of Intellectual Property Rights
UNCCD	United Nations Convention to Combat Desertification
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations Children's Fund
USAID	United States Agency for International Development
WHADN	Western Hemisphere African Diaspora Network
WHO	World Health Organization
WTO	World Trade Organization

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