# Science in Ethiopia – Some Perspectives

- General survey status of science in Ethiopia in relation to selected countries in sub-Saharan Africa
- Postgraduate education at national level
- International cooperation in Science
- Science research at national level
- Research and post-graduate education at the College of Natural Sciences, AAU
- Conclusions and recommendations

It is generally believed that, even though Africa is endowed with vast natural resources, its poor development results mainly from its poor investment in S & T.

Poor investment in S & T leads to: a very low number of researchers and technicians, low number of scientific publications.

Investments in S & T in Sub-Saharan Africa 2008 or most recent year available (Source : UNESCO WSR – 2011)

Country	Expenditure on health	Expenditure on Education	Expenditure on Tertiary Education (as % of expenditure on education)	GERD (as % of GDP)
Botswana	7.2	8.1	27.5	0.3
Ethiopia	4.9	5.5	39.0	0.2
Mauritius	4.3	3.4	11.0	0.4
Senegal	5.4	5.1	24.5	0.1
S. Africa	8.6	5.4	12.5	0.9

Researchers in Sub-Saharan Africa 2007 or most recent year available (Source: UNESCO WSR – 2010)

Country	Total Number of Researchers	Researchers per million inhabitants	Technicians per million inhabitants
Botswana	1732	942	222
Ethiopia	1615	21	12
Nigeria	28,533	203	77
S. Africa	18.754	382	130
Uganda	891	29	18

According to WSR, 2010, Sub-Saharan Africa produced only 11,142 scientific articles in 2008, with South Africa, Nigeria and Kenya producing about two-thirds of this.

Ethiopia is one of seven countries in sub-Saharan Africa with a relatively high number of publications.

African scientists publish mostly in the fields of clinical medicine, biology and biomedical research, followed by Earth Science. Publications in Ethiopia – 2008. Total number of Publications : 364 (Data from UNESCO WSR 2010)



#### **Higher Education in Ethiopia**

- According to the Annual Education Abstracts (2003 E.C.) of the MOE, the total enrolment (undergraduate and postgraduate) of the higher education institutions in all programs ( regular, evening, summer and distance ) was 467,843 of which 79,314 (17%) were enrolled in nongovernment higher education institutions.
- In addition, 447,693 (95.7%) of the enrolments comprise the undergraduate degree program.
- The following figure is from the Annual Education Abstracts (2003 E.C.) of the MOE



Trends in Graduates from All Programs of Higher Education by Gender

It is generally believed that ICT can help developing countries tackle a wide range of health, social and economic problems. However, this has not been exploited in much of the developing world. List of selected sub-Saharan African countries by number of internet subscriptions. (Data from: <u>Internet Usage Statistics"</u>. *International Telecommunications Unit: World Internet Users*. ITU.



as % of Total Population

FUNDING SOURCES FOR RESEARCH PROJECTS IN DEVELOPING COUNTRIES

- A. Development cooperation at the level of higher education
- Netherlands organization for international cooperation in higher education (NUFFIC)
- Norwegian council for higher education (NUFU)
- Swedish International Development Cooperation Program (SIDA)
- German service for academic exchange (DAAD)
- Austrian service for exchange (ÖAD)

# FUNDING SOURCES FOR DEVELOPMENT AND RESEARCH PROJECTS IN DEVELOPING COUNTRIES (cont'd)

**B.** Research funding organizations

- The Academy of Sciences for the Developing World (TWAS)
- International Foundation of Science (IFS)
- Third World Organization for Women in Science
- ISP International Science Programme (IPPS, IPICS)
- Organization for the Prohibition of Chemical Weapons (OPCW)

# **Royal Society of Chemistry**

#### Archives for Africa - 2006

Pan Africa Chemistry Network (PACN)– 2007

#### **Objectives – PACN**

Supporting the teaching of chemistry in schools via courses for teachers, provision of materials and resources available to schools.

Establishing centres of excellence for the chemical sciences

 Supporting chemistry in Higher Education by running courses and providing training to allow scientists to make better use of resources such as the RSC archive;

Promoting intra Africa scientific networking and conferencing

#### **National Research Institutes / Centers**

Ethiopian Institute of Agricultural Research (EIAR) Institute of Biodiversity Conservation National Veterinary Institute Ethiopian Health and Nutrition Research Institute (EHNRI) Armauer Hansen Research Institute (AHRI) National Animal Health Research Center Other National Research Institutes / Centers (Research Support Services)

Ethiopian Coffee Research Centre

- Geological Survey of Ethiopia
- National Meteorological Agency
- Leather Industry Development Institute
- Ethiopian textile industry development institute
- Ethiopian Rural Energy Development and Promotion Center (EREDPC)
- Environmental Protection Authority
- Central Statistical Agency

#### Research Institutes / Centers in Science within AAU

Aklilu Lemma Institute of Pathobiology
 Institute of Geophysics Space Science & Astronomy

Materials Testing Center

Center for Multi-disciplinary Sciences

# Research Institutes / Centers in Science within AAU

Aklilu Lemma Institute of Pathobiology
 Institute of Geophysics Space Science & Astronomy
 Materials Testing Center
 Center for Multi-disciplinary Sciences

Attempt in 2004 to revive the forty-year old Aklilu Lemma proposal to establish ISTRAD (Institute of Scientific and Technological Research & Development) within AAU was not successful .

# **College of Natural Sciences**

Departments	Center for Multi-disciplinary	
	Sciences	
Biology	Biotechnology	
Chemistry	<b>Computational Science</b>	
Computer	Environmental Science	
Science		
Earth Sciences	Food Science and Nutrition	
Mathematics	Material Science	
Physics		
Statistics		
Institute of Geophysics, Space Science and Astronomy (IGSSA)		

Academic staff of the College of Natural Science (Lecturer and above in rank); Total = 213



Peer-reviewed Journals of the College and of Professional Societies based in the College

SINET: Ethiopian Journal of Science

Journal of the Biological Society of Ethiopia

Bulletin of the Chemical Society of Ethiopia

Journal of the Ethiopian Statistical Association









# **Research Areas in the Life Sciences at AAU**

#### Botany

Floristics, Ecology & Vegetation Physiology

Zoology

Vertebrate

**Invertebrate (Insects)** 

Fungal

**Limnology & Fisheries** 

**Biomedical and Microbiology** 

Genetics

**Biotechnology** 

# **Early Botanical Explorations**

James Bruce - (1768 – 1772).

Georg W. Schimper, 1837

Achille Richard (1794-1852)

Georg Cufodontis (1896-1974)

Pichi-Sermolli (1912-2005

William Burger (1932- ) Based at Haromaya University (Ethiopia)



#### **Establishment of the National Herbarium**

The National Herbarium (ETH) in Addis Ababa University was established in 1959 with the donation of about 6000 species by an Irish Forester, H.F. Mooney . The Herbarium now has OVER 80,000 species



# Botanical Research on the Flora of Ethiopia

- In 1967, Profs. Olov & Inga Hedberg & Dr Tewolde B.G.E initiated the Ethiopian Flora Project that lasted 29 years.
- (description, ecology and distribution) 6000 species with 10% endemism. The project was funded by Sida/SAREC.



# Write up a Flora of Ethiopia within the shortest time possible



# **Research on Indigenous Trees**



Investigation on propagation biology, as well as restoration mechanisms for some of Ethiopia's indigenous species, particularly those that are highly threatened keystone trees species



# **Promotion of other projects**

The Flora Project: A spring board to other projects

- The Monocot Project
- The Fire Ecology Project
- Afro-Alpine Sky Islands
- The Essential Oils Project

RAPSUD

- > The Medicinal Plants Project
- The study on vegetation strengthened

# **Samples of research results**





Indigenous trees of Ethiopia Biology, uses and propagation techniques



Legesse Negash



A flora of the Simen Mountains and surroundings, northern Ethiopia

Christian Puff Sileshi Nemomissa



Shama Books N

ligist Asfaw and Sebsebe Demisse

# **Zoological Explorations**

James Bruce (1730-1794)
Edouard Rüppell (1794-1884)



# Establishment of the Natural History Museum

Before 1941: Italian patron named S. Patrizi prepared a collection of Ethiopian mammals and birds

After 1955: Prof. S. Chojnacki added some more mammals and birds and donate to the current N S MueusmIn 1963 the first Department of Natural History Museum and National Herbarium was created its Director was Prof. J. Birket Smith

# **Zoological Research**

 Taxonomy, ecology and conservation of both small and large mammals as well as birds
 The focus of study was on the species composition, distribution, abundance and habitat association of mammals and birds of different regions of Ethiopia

# Zoological Research (cont'd)

Limnology & Fisheries Research :
Primary and secondary production,
Food web analysis,
Fish stock assessment models
Community structure and primary productivity of phytoplankton

**Biomedical Research** 

Investigations on Malaria
Investigations on Agricultural Insect Pests
Investigations on Parasites

# Zoological Research (cont'd)

#### **Genetical studies on Plants**

Biodiversity and morphological diversity of crop species
Phylogenetic studies of crop species
Heterogeneity and amino acid composition of various fractions of proteins in order to develop appropriate breeding strategy of *Eragrostis tef.*Molecular genetic analysis of tef, Sorghum, Noug, Coffee , Finger Millett.

# Zoological Research (cont'd)

#### **Genetical studies on animals**

- Mole rats, rodents, bat, amphibian, fish, insect and snail chromosomes have been studied.
- Grasshopper chromosomes are the first study to be made in Ethiopia

There is a felt need to develop research on biotechnology

Analytical Chemistry:

Water analysis : analysis fluoride in rift valley lakes;
 design & construction of defluoridation plants

 Pesticide residue analysis : pesticide residues and their metabolites in environmental, biological and food samples.

Analytical Chemistry (cont'd)

 Development of analytical methods for removal of toxic heavy metals from industrial discharges.

 Analytical method development for determination of residues of pharmaceutical products in blood and urine samples.

### Fluoride Distribution Map of the Ethiopian Rift Valley









# Fluoride removal filter based on AlOOH in Tuchi Gragona, Oromia Regional State



Fluoride level is reduced from 11.0 to to <0.1 mg/L

#### Inorganic Chemistry

- Synthesis and characterization of novel transition metal complexes based on N-heterocyclic ligands and new organometallic catalysts.
- Synthesis, characterization and application of new materials based on ionic liquids.

# Synthesis, characterization and application of zeolites in catalysis.

 Modification of renewable resources (e.g. starch, glucose and oil seeds) for value-addition.

#### **Organic Chemistry**

#### Natural products - Project funded by Sida/SAREC & ISP.

- Study of the chemistry of plants of cultural, commercial and medicinal importance
- Shading light on the chemistry of some unique plants that occur in Ethiopia e.g. Dingetegna, Kebericho, Gesho, etc
- Collection of a library of several hundred natural compounds used as references and test substances
- Over 200 scientific papers in peer reviewed local, regional and international journals. Project funded by Sida/SAREC & ISP.

Organic Synthesis – Project funded by ISP
 Synthesis of conducting polymers for use in organic solar cells

Organic Chemistry

 Research on Essential Oils - book based on research on essential oils : Nigist Asfaw and Sebsebe Demissew: "Aromatic Plants of Ethiopia"

 Green Chemistry - research in collaboration with University of Nottingham (UK), focusing on:

 Assessment of the potential of indigenous plants as potential sources for biodiesel

Organic Chemistry

Green Chemistry (cont'd)

 Chemical modification of cassava starch to prepare biodegradable urethane polymers

Characterization of native vernonia oil and preparation of derivatives for application as performance materials

#### Physical Chemistry - *Electrochemistry*

Ion and electron transfer across immiscible electrolyte solutions.
 Applications - phase transfer catalysis, and imaging solid surfaces.

Biosensors

Development of enzyme reactors for determination of neurotoxin in Grass Pea ("Guaya")

- Physical Chemistry *Electrochemistry* Solar Energy Conversion
- Natural and synthetic dye sensitized Gratzel solar cells
- Organic (conducting polymer)/inorganic (TiO2, ZnO) hybrid liquid and solid photoelectrochemical solar cells
- Conducting polymer/ fullerene or fullerene derivatives based bulk heterojunction solar cells
- Conducting polymer based liquid and solid state photoelectrochemical solar cells

 Physical Chemistry – *Electrochemistry Conducting Polymers*

- Electrochemical and spectroelechemical studies of conducting polymers to determine HOMO, LUMO and band gap of conducting polymers and to study fundamental properties of conducting polymers
- Charge mobility measurements using CELIV (charge extraction in a linearly increasing voltage), TOF (time of flight) and admittance spectroscopy
- Electrochemical sensors based on conducting polymers
- Development of conducting polymer-based electrode materials for polymer solar cells and fuel cells
- Investigation of optical, transport and energetic properties of conducting polymers

#### **Physical Chemistry (cont'd)**

- Computational Chemistry :
- Quantum Chemical Calculations of Molecular and Supermolecular Systems
- Simulation of ions in solution
- Spectroscopy :
- Mechanistic investigation of anomalous fluorescence properties

# **Research in Physics at AAU**

#### **Quantum Optics**

Quantum properties of light generated by different optical systems such as lasers and sub-harmonic generators

Plasma Physics, Quantum dots, and Composite materials
Spin-dependent scattering of electrons by nanomagnets with gigantic magnetic moment
Optical properties of electron quantum dots
Propagation of EMWs in plasma-like media with dispersion of permeability
Optical bistability in non-linear composite materials with account of interface layers

# **Research in Physics at AAU (cont'd)**

#### Laser spectroscopy

Absorption spectroscopy; ellipsometry scattering phenomena, Fluorescence spectroscopy; Moire fringes and holography

**Polymer and biological physics** —*Project funded by ISP* Theory of micro and nano-sized heat engines Biophysics - theory and numerical modeling MC simulation of charge transport in conjugated polymers

# **Research in Physics at AAU (cont'd)**

Plasma Physics, Quantum dots, and Composite materials

- Spin-dependent scattering of electrons by nanomagnets with gigantic magnetic moment
- Optical properties of electron quantum dots
- Propagation of EMWs in plasma-like media with dispersion of permeability
- Optical bistability in non-linear composite materials with account of interface layers

# **Research in Physics at AAU (cont'd)**

Atmospheric and space physicsState of climate and impact

High temperature superconductivity

# Earth Science - Milestones in institution building

Date of Establishment	Institution
1957	Department of Geology established; Addis Ababa
	University College
1957	Geophysical Observatory established
1968	Geological Survey of Ethiopia
1978	Graduate Program in geosciences
1995	RS and GIS laboratory (Ethio-Italian cooperation project)

# **Research in Earth Science**

Funding Agencies

- French government
- CNR-CNRS (Italian and French)
- National Environmental Research Council (NERC)

PhD Training

Swedish, French, Italian, UK, Canadian Universities

# Major Research Themes in the Department of Earth Sciences

- Atmospheric sciences and space science applications
- Geohazards
- Geochemistry and Petrology
- Geophysics , Geodesy, Magnetism, Rift Geodynamics
- Global Climate Change and paleo-environment
- Mineral Resources
- Water Resources and groundwater hydrology

# **Selected Books published in Earth Science**

 Solomon Tadesse (2009). Mineral Resources Potential of Ethiopia, AAU Press.

**Tenalem Ayenew** (2009). Natural Lakes of Ethiopia. AAU Press.

#### **Conclusions and Recommendations**

Ethiopia must increase the Gross Expenditure for Research and Development (GERD).

The pool of researchers in the country is very low, and hence the efforts already under way of expanding and strengthening higher education (as well as vocational schools) deserves strong support.

 Science Departments must all launch PhD programs and increase their PhD graduates.

#### Conclusions and Recommendations (cont'd)

Academic staff must try to increase the number of their publications.

Great effort must be exerted to improve the ICT infrastructure both within the College and, especially, the country, since there is a vast amount of knowledge available in the internet which can support both higher education and research.

The insignificant number of Science and/or Technology Research Institutes, both nationally and within AAU, is a glaring deficiency which must be rectified immediately.

#### Conclusions and Recommendations (cont'd)

In the interest of utilizing effectively capital equipment, AAU administration (and the Ministry of Education as well as the Ministry of Science and Technology) should seriously consider the pooling of resources for facilitating research among different institutions.

# ACKNOWLEDGMENTS

- Tadesse Berhanu, Department of Earth Science
- Tamiru Demsis & Mekbib Fekadu, Department of Biology
- Siraye Esubalew, Department of Chemistry
- Prof. Sebsebe Demissew & Prof. Yalemtsehay Mekonnen,
   Department of Biology
- Prof. Gezahegn Yirgu, Department of Earth Science
- Dr. Shimelis Admassie, Department of Chemistry
- Dr. Mulugeta Bekele & Dr. Lemi Demeyu, Department of Physics