CSIR medical devices and diagnostics research areas and outcomes

Presentation to MDMSA General member meeting

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• Objectives of the engagement
• Overview of CSIR
• CSIR Health Diagnostics platforms
  ✓ Training/Education/Skills
  ✓ Facilities
  ✓ Innovative approaches to design, detection and read-out
  ✓ CSIR prototype devices
  ✓ R&D Outcomes
Objectives

1. Share CISR’s R&D agenda and strategic intent in the medical devices and diagnostics sector

2. Present CSIR’s success to date

3. Identify the sector’s R&D needs with the intent to form collaborations
The CSIR mandate

"The objects of the CSIR are, through directed and particularly multi-disciplinary research and technological innovation, to foster, in the national interest and in fields which in its opinion should receive preference, industrial and scientific development, either by itself or in co-operation with principals from the private or public sectors, and thereby to contribute to the improvement of the quality of life of the people of the Republic, and to perform any other functions that may be assigned to the CSIR by or under this Act."

(Scientific Research Council Act 46 of 1988, amended by Act 71 of 1990)

• The CSIR is a schedule 3b entity: National Government Business Enterprise
The CSIR interacts with other public research institutions

Technology funding agency

Mineral processing
Mintek

Research funding agency
National Research Foundation

Health and medicine
Medical Research Council

Funding agency: water research
Water Research Commission

Agriculture
Agricultural Research Council

Human sciences
Human Sciences Research Council

Geosciences
Council for Geosciences

Technology Innovation Agency

The CSIR at a glance

- The CSIR is a science council, classified as a national government business enterprise

- The CSIR’s Executive Authority is the Minister of the Department of Science and Technology

In numbers:

- **69** years in 2014
- **2411** total staff
- **1 691** total in SET base
- **310** doctoral qualifications
- **~R2.15 bn** total operating income
The CSIR responds to national priorities in line with its mandate and in support of South Africa’s National Development Plan

To achieve this, the CSIR has:

- identified **research impact areas** to focus its research and development

- implemented **flagship programmes** that address significant challenges at national scale through multidisciplinary RDI interventions

- introduced integrated **responses to national initiatives** and strategic collaboration with government departments, state-owned enterprises and the private sector
Research impact areas and core technologies

- Industry
- Built Environment
- Energy
- Defence & Security
- Natural Environment
- Health

Core technologies
- Materials
- Sensors
- Photonics
- Robotics
- ICT
- Modelling
Focus for national impact: Research impact areas

**Health**

- Support health care delivery through ICT and infrastructure
- Reduce burden of disease through development of diagnostic tools, drug delivery mechanisms and disease models
The health flagship

- Supporting the re-engineering of primary healthcare in South Africa

- **Mobile health** for primary healthcare at household-level
  - Open-standard platform for data collection, management, and analysis
  - Deployed in City of Tshwane in partnership with University of Pretoria

- **Point-of-care diagnosis** of disease
  - Umbiflow foetal health monitor: Positive field study in Western Cape; City of Tshwane field implementation
  - Cellnostics blood count analysis: Clinical assessment in progress with National Health Laboratory Services
CSIR Health Diagnostic Platforms
CSIR Health Diagnostic Platforms

**Commercialisation**
- Medical Device Technology Accelerator/Incubator
- UCT Biomedical Translational Research Agreement

**Certification/Regulatory Requirements**
- International ISO 9001 and ISO 13485

**Health Economics**

**Clinical Studies**

**Technology Assessment**

**Bio Informatics**
- Cellnostics ePathology
- Image Processing

**Information Systems**
- Cellnostics Backend and link with Meraka HIE
- eHealth Standards
- eHealth Foundational Infrastructure
- IS Technology Assurance
- MomConnect, WBOT health pack

**Materials**
- MARTI
- Nano Gas
- Microspheres (Resyn)

**Detection**
- Aptamer
- NAAT

**Screening**
- HTS
- 3D cell Assays
- iPSCs Technology
- Genome wide
- Imaging Platform

**Devices**
- Umbiflow
- Cardioflow
- Cellnostics
- Printed Biosensors

**Connectivity**
- IoT
- Cellnostics Connectivity Hub and CellStore

**Facilities/Infrastructure**
- Research Labs an Equipment

**Training/Education/Skills Development**
- Cellnostics CellLearn

**Networking, Coordination**

**Screening**
- HTS
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**Networking, Coordination**

**Facilities/Infrastructure**
- Research Labs an Equipment

**Training/Education/Skills Development**
- Cellnostics CellLearn
- CellLearn – suite of tools for training of pathologist
- Hosting of National Pathology Database
• Key Facilities at Biosciences
  • BIAcore 3000 SPR Instrument,
  • GUAVA PCA-96 flow cytometer
  • CFX-96 Real Time Thermal Cycler
  • Two BSL-3 laboratories.
    • The BSL-3 laboratories provide a safe environment to do research work with HIV and Mycobacterium tuberculosis clinical isolates
• Chemical and Biological Labs
• Key Facilities at MSM
  • Micro Manufacturing Clean Room
  • Bio Hazard Lab
  • Biodot printer for Lateral Flow devices
  • Electronic Printer for biosensor manufacturing
  • Nano Characterisation Facilities
• MARTI
  • The principle of the test goes by the acronym of MARTI: Mycolic acid Antibodies Real-Time Inhibition test. It detects patient serum antibodies to mycolic acids as biomarkers of disease, unperturbed by HIV and independent of sputum samples; therefore ready to configure into a Point of Care medical device
  • We have developed nanoparticles as immunosorbents (invention disclosure) for the MARTI diagnostic
  • We are in process to standardize the mycolic acid antigen and antibody immobilization on lateral flow “test” and “control” lines
  • The work is done in collaboration with the University of Pretoria
• Microspheres

  • New miniaturized, high throughput technologies for bioseparation, diagnostics, DNA sequencing, flow cytometry, drug discovery, proteomics and genomics
  • We have developed a novel (patented) microsphere technology platform, comprising a hyper-porous polymer matrix that allows penetration of biological and synthetic molecules throughout the volume of the microspheres.
  • This offers exceptionally high surface area for binding of molecules and allows performance that is orders of magnitude greater than alternate technologies.
  • Controlled microfluidic production of spheres and particles---scalable solutions
Processing Steps

1. Raw Materials
2. Feedstock
3. Injection Moulding
4. De-Binding
5. Sintering

Net-shape Manufacturing of Medical Devices and Implants

- Sintered Part
- Green Part
- Raw Materials
- Feedstock
**Sensors/Diagnostics**

- Aptamer- and Resyn-based Dx reagents.
- Aptamer-based Poc Dx kit
- Companion Dx kit for management of HIV patients on ARVs.
- Next generation microsphere diagnostic technologies.
- Point-of-care molecular diagnostics
- Telediagnostics

**Nano Materials for Gas Sensors**

- It is well known that acetone in human breath can be a biomarker and indicator of fasting and/or lack of insulin in the blood.
- In the present technology, a micro nano chip is packaged around the pertinent electronics in order to present a complete device for diagnosis and routing monitoring glucose levels.
Screening Technologies

- Genome wide screening.
- In situ genome editing
- Imaging Platforms (STORM and PALM)
- Super resolution microscopy
- iPSCs Technology (disease in a dish model)
- Screening assays for prevention of HIV, TB & malaria, respectively.
- High Throughput Screening and Array Printing
Brucellosis screening and PoC detection

Definition

• Brucellosis is a disease of production animals.
  – It occurs more frequently in cattle in South Africa, but can occur in other species too.
• It is an important zoonotic disease (animals and humans)
• The most common sign in animals is abortion
• It is caused by bacteria (germs) named Brucella

Research Requirements

• Surveillance:
  – Lateral flow strip for general Brucellosis detection in milk/blood (AVAILABLE, need improvement)
  – Digitisation of strip readout (REQUIRED, Umbiflow?)
• PoC detection
  – Prototype isothermal PCR instrument (AVAILABLE, Biosciences)
  – PoC data transfer (AVAILABLE, Biosciences)
• Vaccine
  – 2 types of vaccines (AVAILABLE, OBP)
Surveillance and epidemiology

Antibody based Lateral flow vs molecular based pathogen detection
(Both required for effective disease control at point of care)
Devices

- **Cellnostics**
  - Point of Care blood analysis for low resource areas

- **Umbiflow**
  - Measure blood flow in umbilical artery
  - Assess placental function/fetal health
  - Displays blood-flow characteristics

- **Cardioflow**
  - Doppler ultrasound assessment of Carotid artery provides clinical clues for treatment at point of care

- **Assay Reader**
  - Analysis of multi-parameter lateral flow strips
Printed Biosensors

Microsystems based diagnostic and screening devices for medical and environmental applications

ASSURED
Affordable, Sensitive, Specific, User-friendly, Rapid and robust, Equipment free, Deliverable to end-users

Intelligent Printed Low Cost Instrument Free

Lateral flow devices ASSURED

Microfluidics, Sensors, IoT, Paper, Communication, Disposable, Nanomaterials, Advanced Manufacturing

Cartridge-based microfluidics with readout systems ASSURED
Low Cost

- Single step sample preparation
- Equipment free
- Used by unskilled people
- Paper is freely available internationally

Renewable

- Instrument free fluidic transport
- Bio compatible
- Bio degradable
- High surface to volume ratio
- Faster test results leading to faster diagnosis

Easy to use

- Usage not reliant on laboratory facilities
- Paper can be used for prototyping
- Excellent tool for education
- Possibility of more than simple Yes/No answers
Integration
CSIR Connectivity Hub can link multiple devices from the CSIR and other organisations
Bio Informatics

- Cellnostics ePathology
- Holographic technologies and image processing
Information Systems

- Health Normative Standards Framework
- Health Patient Registrations System;
- Health Information Exchange
- MomConnect
- WBOT health monitoring backpack
- Primary Healthcare Patient Information Systems Assessment
- eHealth Standards
- eHealth foundational infrastructure
- Supporting Public Sector absorption of eHealth
- eHealth Innovation
• **Health technology assessment (HTA)** is a multidisciplinary activity that systematically examines the safety, clinical efficacy and effectiveness, cost, cost-effectiveness, organisational implications, social consequences, legal and ethical considerations of the application of a health technology – [Wikipedia](https://en.wikipedia.org/wiki/Health_technology_assessment)

• CSIR can play a major role in the technology assessment and the fit for purpose domain of various technologies and disciplines.

• Need to partner with organisations that can address other non-technical aspects like legal and behavioural issues
Clinical Studies

- Partner with Universities
  - Getting top academics part of clinical studies
  - Broaden support within the medical community and add credibility to our outputs.
  - Provide inputs to the innovation and commercialisation processes.

- Partner with other stakeholders
  - National Health Laboratory Services (NHLS)
  - Private Sector
  - International Organisations
Health Economics

• Health economics are concerned with issues related to efficiency, effectiveness, value and behaviour in the South African health care system
• CSIR will partner with the following Universities:
  • Wits
  • University of Pretoria
  • University of Cape Town
  • Other
• This is considered as a big barrier to entry for the medical device market.

• The CSIR have achieved ISO 13 485 and ISO 9001 international certification for two of its competence areas that focus on the development of medical devices.

• Currently in process to get CE marking for two medical devices:
  • Umbiflow
  • Cellnastics

• We have captured the learning and are willing to support the local medical device industry to get certification.

• In some cases the CSIR will partner with local Quality Consultants to support the local industry.
Commercialisation

- SIR-UCT Biomedical Translational Research Initiative (BTRI)
  - Utilising complimentary capabilities at UCT and CSIR to enable translational research in a clinical setting
  - Integrate clinical and systems medicines with Synthetic Biology (bed-to-bench and bench-to-bed) through the BTRI.
  - Expand BTRI to other partners and to also include other biomedical research e.g. molecular diagnostics & biomedical devices
**Commercialisation**

- Medical Devices Incubator
  - Facilitate a network of stakeholders in the medical device development process.
  - Providing support for industry growth
  - Provides a platform for identifying and assessing new product opportunities
  - Undertakes early-stage R+D to develop proof of concept models and demonstrate product potential.
  - Provides practical assistance in taking technology closer to the market
  - Provides a non-competitive environment for research collaboration across research institutions.
  - Bridge the Chasm in the South African value chain
Networking and Coordination

- CSIR have managed and coordinated a large number of national initiatives on behalf of Government or Industry.
- Some examples of the hosting are the following:
  - Advanced Manufacturing Technology Strategy
  - Automotive Industry Development Centre
  - National Cleaner Production Centre
  - National Foundry Technology Network
  - Bio composites Centre of Competence
  - Titanium Centre of Competence
  - HYSA –Hydrogen Storage Centre of Competence
  - National Centre for Nano Structure Materials
Thank you