

Biophysics Working Group

The African Biophysics Landscape

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What is a Biophysicist?

Scientists in Africa who study topics in Biophysics self identify in many different categories

Biophysicist

Structural Biologist

Chemical Biologist

Biological Physicist

Microscopist

Enzymologist

Biotechnologist

Immunologist

Biochemist

Physical/ Computational Chemist

This increases the difficulty in accurately defining the landscape: We have decided to be inclusive provided their study involves Biophysics or the application thereof

Even though physics is often central to the studies being undertaken – those undertaking the studies often have little physics background.

This issue is not unique to Africa and is being addressed by the international Biophysics community by encapsulating the Physics in software and through the increasing use of artificial intelligence. This enables “Physics naïve” scientists to get started on complex problems and learn the Physics as they go along.

The international effort in biophysics is currently dominated by the desire to understand living systems at atomic or molecular detail – thus Structural Biology is more often than not, the starting point for Biophysical studies.

Why biophysics?

This unique interdisciplinary field brings our understanding of biological processes to an unprecedented level of detail.

Only when we understand nature's processes at a sufficiently deep level can we make reliable predictions and obtain sustainable technological solutions.

An integral component of scientific discovery in biophysics involves technological development. Innovative experimental and computational methods pave the way for new scientific discoveries and provide practical solutions across the broad domain of biological sciences.

Biophysics revolutionised medical research and technology in the 20th century.

Biophysics and the UN SDGs

SDG 2: Zero Hunger

- Understanding the complex process of photosynthesis to engineer crops with enhanced yield
- Developing innovative biosensing technologies to detect and prevent plant diseases
- Exploring alternative, less toxic treatments for plant pests and diseases to ensure sustainable agriculture.

SDG 3: Good Health and Wellbeing

- Structural biology to understand disease mechanisms and guide the rational design of new drugs and vaccines
- Biosensing and quantum biology for sensitive disease diagnostics
- Biophotonics for light-based therapies and diagnostics
- Computational approaches to complement experimental work and deepen our understanding of diseases.

SDG 4: Quality Education

SDG 9: Industry, Innovation and Infrastructure

- Biophysics research is essential for building a strong bioeconomy and developing new technologies.

Equipment and Facilities:

Biophysics research requires state-of-the-art equipment and facilities. However, most African countries lack the necessary infrastructure and resources to support biophysics research. This includes basic and advanced experimental equipment, as well as high-performance computers for theoretical investigations.

Maintenance and Sustainability:

Even if equipment is acquired, it is crucial to ensure that it is properly maintained and sustained. This requires a steady supply of funds and technical expertise, which is often lacking in Africa.

Financial Model:

Once the capital investment for major equipment is made it is expected, at least in South Africa, that users will fund operator staff, consumables and maintenance. This is unrealistic and is not the model applied in many successful centres e.g. ESRF, DLS, eBIC, EMBL etc

Retention of skilled Personnel:

Once people have been properly trained – either as Biophysicists or as instrument service engineers, they are in high demand and can get excellent jobs abroad

Very Low Critical Mass

Limited Educational, Training, and Mentorship Opportunities in Africa

Few African universities offer biophysics courses, and none offer biophysics degrees. In addition, general and specialised biophysics schools and workshops in Africa are organised too infrequently

Awareness and Funding

Very few students and research scientists in Africa venture into biophysics. One major reason is a lack of awareness of the importance of this field of research. This leads to limited funding opportunities supporting biophysics research and development, which, in turn, discourages scientific work in this area.

Exodus of Skilled Scientists

Most Africans interested in biophysics study abroad and do not return to Africa, while most of those who returned to their home countries have not remained in biophysics. The primary reason for this is the severe shortage of infrastructure and resources for biophysics research.

High Priority Needs: Capacity Building

- **Education and Training:** Establish biophysics curricula and degrees at African universities. Host general and specialised biophysics schools, workshops, seminars, and expert lectures to educate and train aspiring biophysicists.
- **Mentorship:** Provide mentorship opportunities for aspiring and established biophysicists. This includes pairing experienced biophysicists with younger researchers and encouraging collaboration between African and international biophysicists.
- **Public Awareness:** Organise public awareness activities such as popular-science literature, news reports, science festivals, roadshows, and school visits and demonstrations to elevate the profile of biophysicists and the importance of biophysics research.

High Priority Needs: Investment in Infrastructure and Equipment

- Procurement of modern equipment
- Maintenance costs
- Supporting infrastructure – technical staff
- Funding for projects that will use the equipment
- Funding for postgraduate and post-doctoral staff

Indeed, the placement of major equipment requires an entire ecosystem to be in place

- Appropriate building to house equipment
- Electricity availability
- High speed Internet availability
- Transparent and efficient Customs processes
- Transparent and efficient Immigration processes
- Data storage and processing
- Sample preparation, shipping and handling
- International support
- Competent and committed suppliers

Low-Cost Innovations to Address Local Needs

- **Affordable Solutions:** Develop inexpensive technologies for the vast majority of Africans who cannot afford expensive solutions. This includes dedicated technologies for specific applications and innovative thinking to find affordable solutions.
- **Artificial Intelligence:** Utilise artificial intelligence such as machine learning and techniques to optimize and enhance biophysics research and applications.

Synergies With Neighbouring Fields and Multinational Research Programmes

- **Interdisciplinary Approaches:** Encourage interdisciplinary approaches by collaborating with other fields of physics and related scientific disciplines.
- **Professional Societies:** Cooperate with professional societies for various disciplines to leverage synergies and cross-pollination of ideas.
- **Establish Initiatives:** Establish multinational research programmes and consortia to share expensive equipment and expertise.
- **Training Events:** Organize training events and workshops to enhance research quality and opportunities.

What is next for our report?

Register

Web based survey to identify more Biophysicists in Africa

List of high end equipment and centres in Africa

Protein capable X-ray diffractometers

Bioscience configured FEGTEMS

Bioscience configured FEGSEMS and dual-beam instruments

High end mass spectrometers

≥600 Mhz NMR

High end light microscopes

Various smaller apparatus of specific interest to Biophysics

Ongoing workshops and activities

Biostruct Africa

CZI cryoEM

CZI light microscopy (AMI)

Monthly “Biophysics in Africa” Zoom Colloquia

Ad hoc workshops and visits by prominent biophysicists

<https://biophysicsworkshop.co.za>

An example

Aaron Klug Centre for Imaging and Analysis

Purpose: To provide the instrumental resources and expertise for structural analysis in all disciplines including structural biology

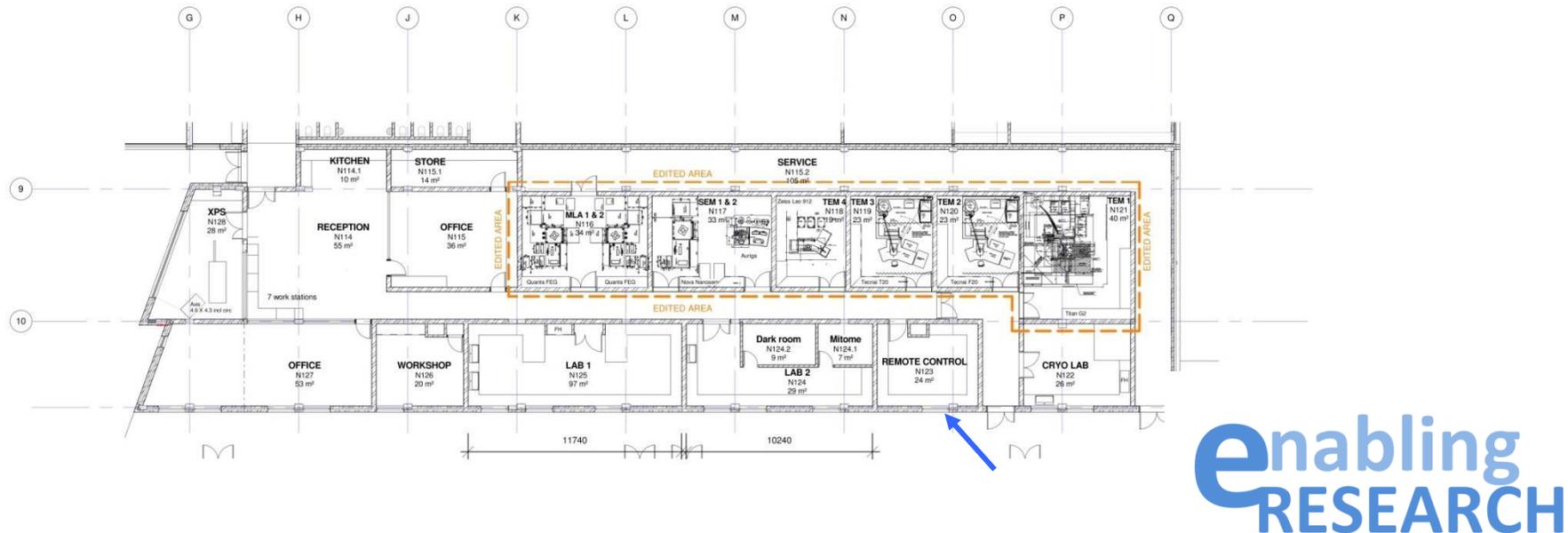


Staff: Half-time Director, 4 scientific officers, 2 technical officers employed by UCT. Scientist and two technical officers on secondment from Centre for Minerals Processing
Data professional on loan from eResearch

Space: 660m², vibration free, magnetic field compensated, temperature controlled, humidity controlled

Equipment: 3 TEMs, 4 SEMs, Protein Diffractometer, Preparative equipment, computer infrastructure

Applications for a high-end TEM (e.g. TITAN Krios) pending

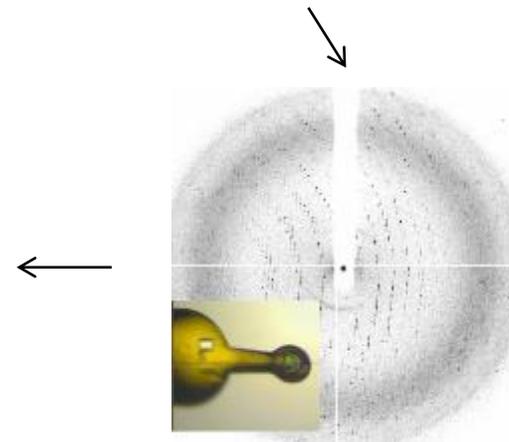
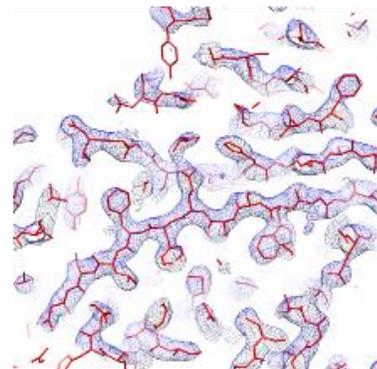
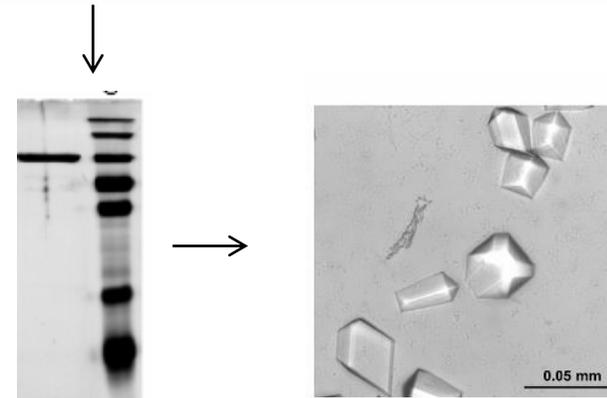
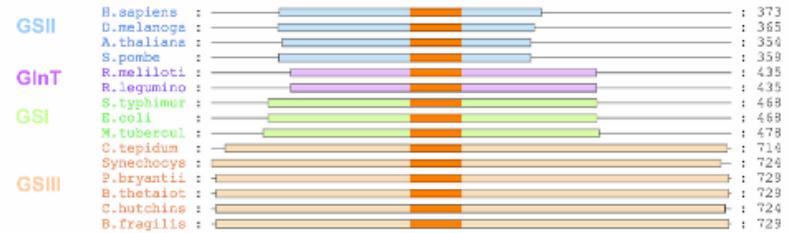


**enabling
RESEARCH**

- Automated acquisition systems
- Web-based image processing interfaces
- Integration with UCT HPC

Structural biology workflow

1. Sample selection
2. Soluble expression
3. Purification
4. (Crystallization)
5. Data collection
6. Data processing
7. Interpretation
8. Publication



Resources: 80m² lab space, molecular biology, cell culture, chromatography and biochemical assay facilities. Computers.



Cryo Electron Microscopy is the fastest developing method for determining macromolecular structure

Richard Henderson of the MRC LMB enabled UCT to get a state of the art instrument when they upgraded after a mere four years



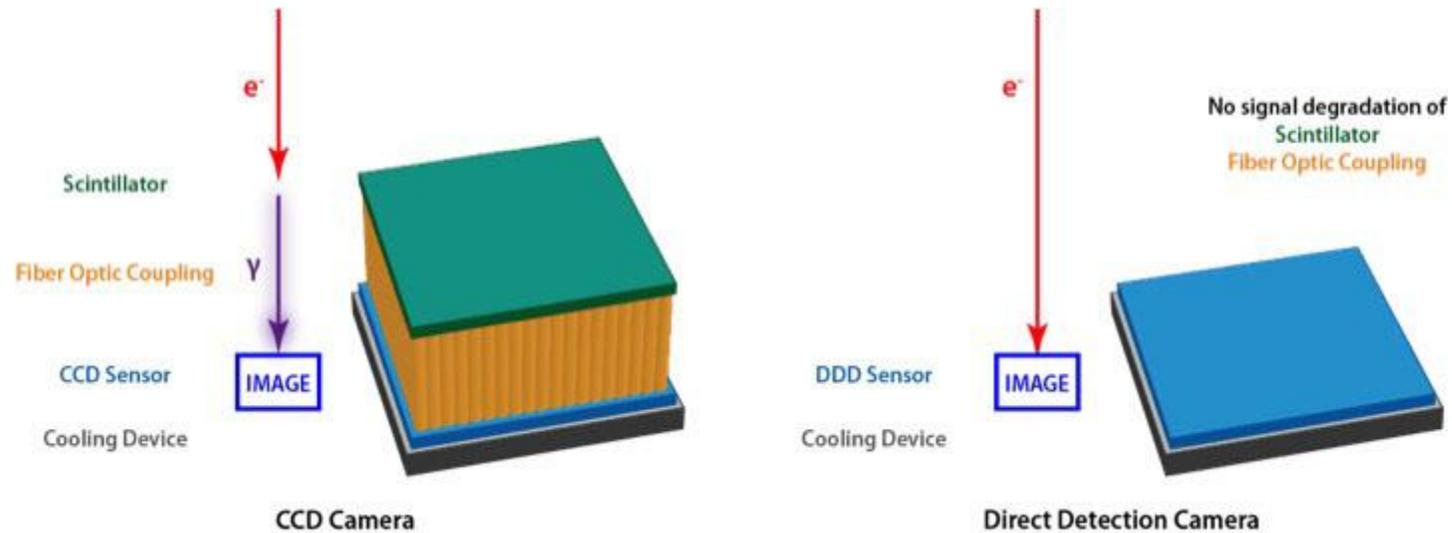
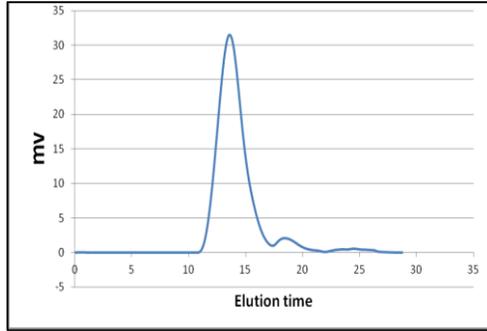


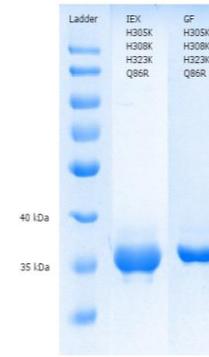
Fig. CCD vs Direct Detection Camera (<http://www.directelectron.com/products/de-series>)

- Traditional TEM digital cameras use a scintillator to convert primary electrons in the microscope to photons before being detected by the imaging sensor.
- In contrast, the DDD directly detects image-forming electrons in the microscope without the use of a scintillator.
- The result is dramatically better resolution, signal-to-noise ratio, and sensitivity.

Gel filtration chromatography



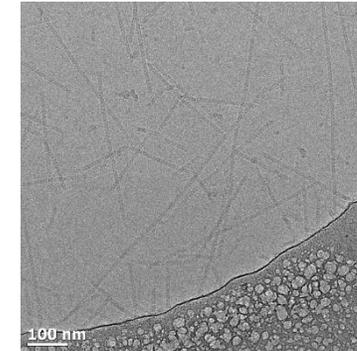
SDS PAGE gel



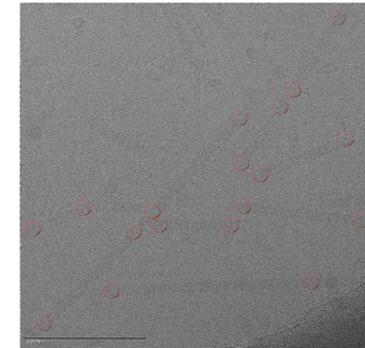
Protein Purification



Cryo grids preparation



Data collection



Images collected at a magnification of 165 000 X

Vitrobot



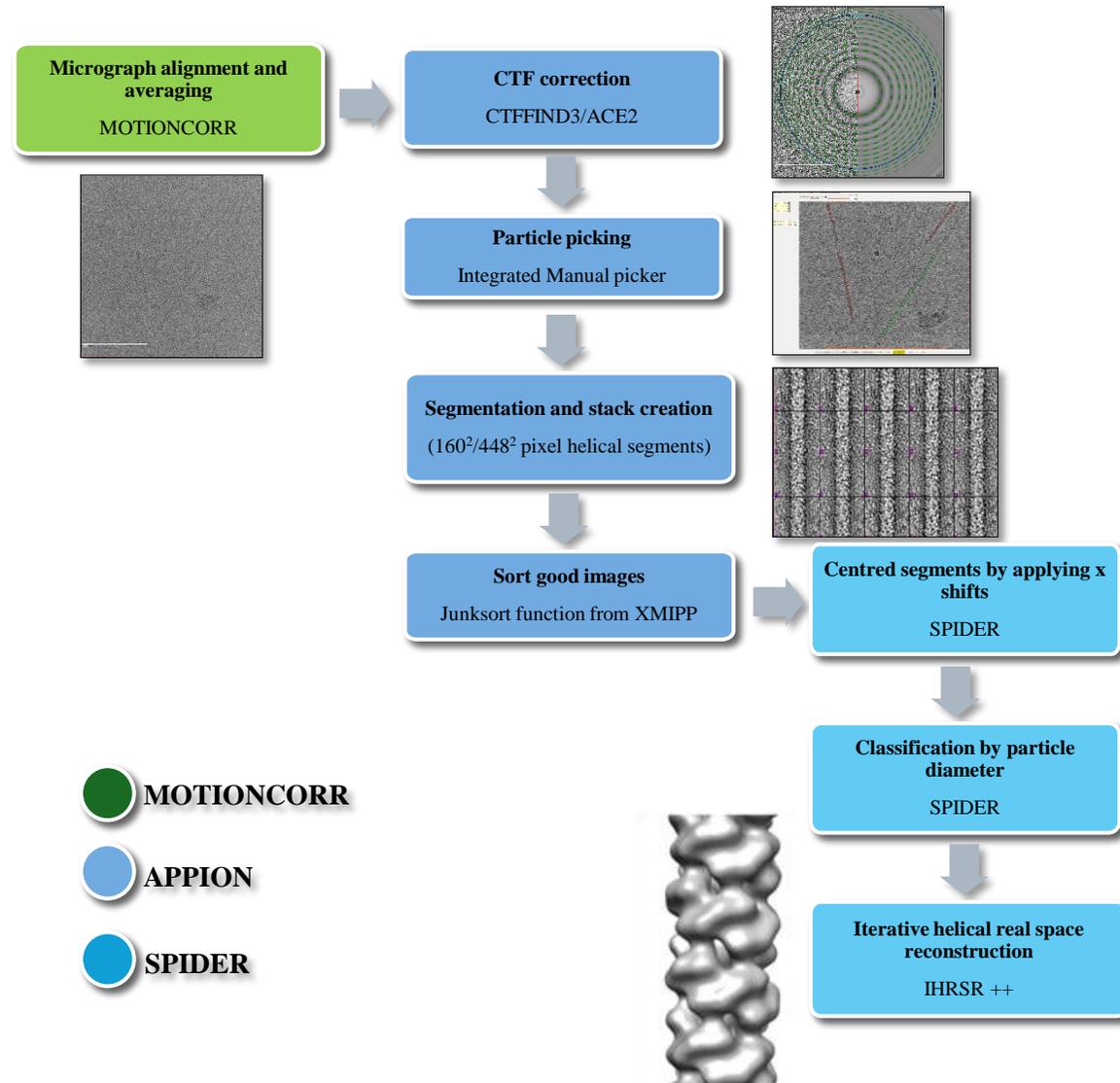
Liquid ethane
-188 °C



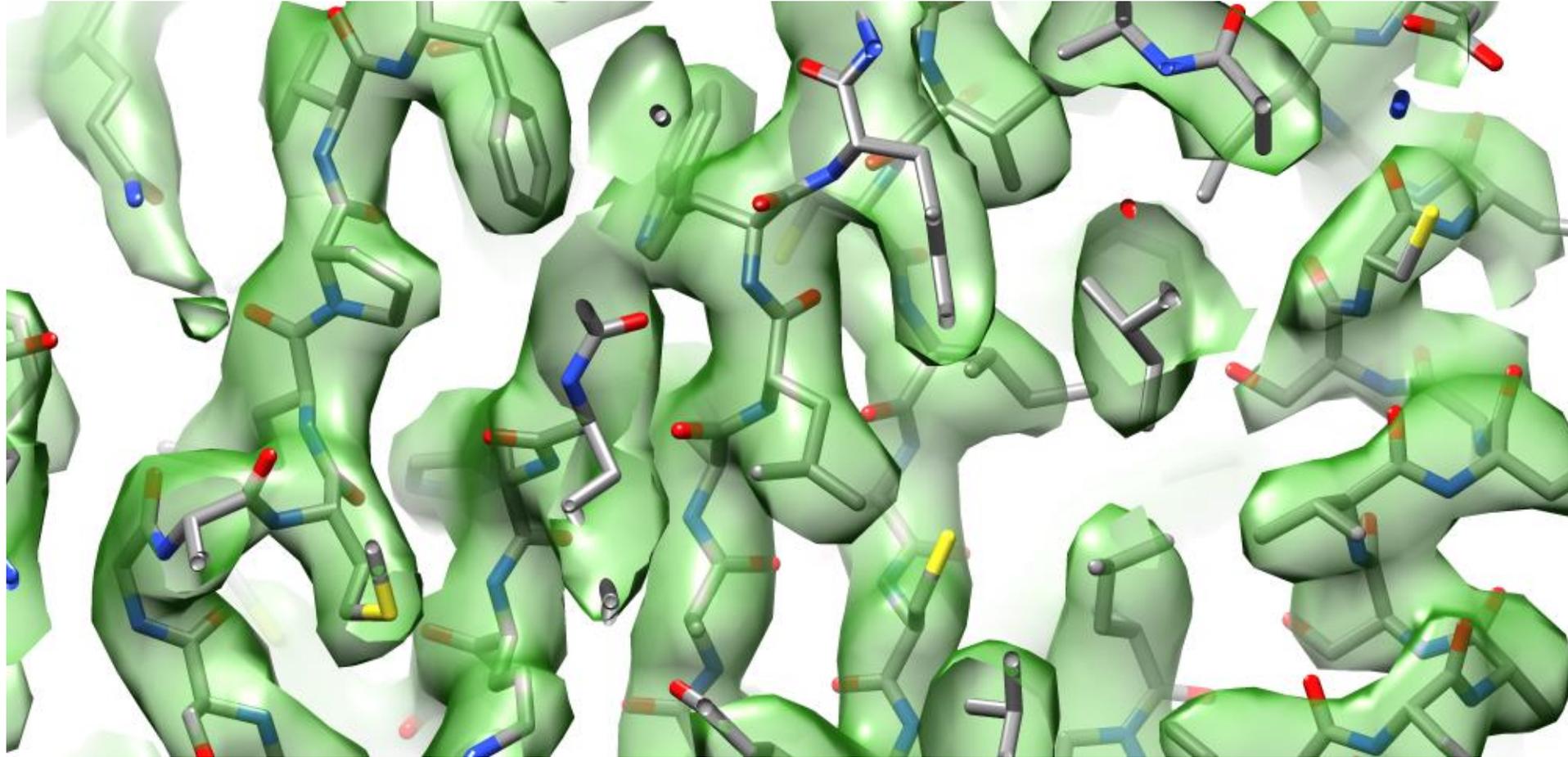
Thermo Fisher
Titan Krios
microscope



Image Processing Outline



The process delivers a three-dimensional charge density map (a part of which is displayed as the green surface contour below) . This can be interpreted using a combination of AI and molecular dynamics. The community insists that all maps and models are deposited in an internationally accessible database.



An aerial photograph of Cape Town, South Africa, during the golden hour. The image captures the city's coastal setting, with the harbor on the left and the ocean on the right. In the background, the iconic Table Mountain and Lion's Head are silhouetted against a soft, orange and blue sky. The city's buildings and infrastructure are visible in the foreground and middle ground, including the V&A Waterfront and the Cape Town Stadium.

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So what is the Strategy?

- Build a community
- Organize activities e.g. Ad hoc workshops and lectures, attract major conferences
- Membership of local and international Societies: e.g SAIP, ASBMB, MSSA, AIC, AfBS, BPS, IUPAB
- Appointment of Biophysicists to university teaching positions
- Introduction of courses at undergraduate level
- Supervise students at Masters, Doctoral and post-Doctoral level
- Apply for research grants to local and international funding organizations
- Establish centres to provide major facilities locally e.g. Aaron Klug Centre
- Utilitise the facilities of European Centres: ESRF, DLS, eBIC, Instruct
- Purchase appropriate equipment in cognate university deparments
- Deposit data in international databases
- Publish in internationally recognized Journals
- Publish commentaries advertising Biophysics in local and international media, including social media