**Industrial Biotechnology Catalyzing the Sustainable Development -- an Introduction to TIB, CAS**

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Sincere thanks to  
Dr. S. M. Junaid Zaidi  
Dr. Maj. Gen. (R) Muhammad Tahir  
Mr. Tajammul Hussain

Meeting with scientists  
1 general introduction  
+ 5 scientific reports

The building of TIB
Contents

• Present statistics of the institute
• On-going programmes
• International collaborations
• Future plans
• Proposal for participation in COMSATS
• S&T cooperation requests

Overview and statistics
China is facing grant challenge

- Increasing population
- Shortage of resources (water, land, mineral, petroleum)
- Increasing emission of CO$_2$ and waste

Industrial Biotechnology may provide a green strategy to support sustainable (unlimited) growth of the world

Mission of TIB, CAS

Catalyze 3 transitions by biotechnological innovation, serve for the sustainable development of the socio-economy.

- Transition from agricultural plantation to industrial manufacturing
- Transition from chemical processing to bioprocessing
- Transition from fossil based resource to renewable one

Green, clean, and sustainable future
An overview of TIB, CAS

➢ Launched in 2007, officially established in 2012
➢ Leading national research institute on industrial biotechnology
➢ The success drawing attentions from the national leadership and the society

Tianjin
• 137 Km from Beijing
• Population 15 million

Organizational structure
3 Interconnected Research Areas

4 national/provincial labs

- National Engineering Lab for Industrial Enzymes
- Tianjin Biocatalysis Technology Center
- CAS Key Lab of Systems Microbial Biotechnology
- Tianjin Key Lab for Biosystems and Bioprocess Engineering

Research Organization

Unique three dimensional R&D organizing model

- **Strategic and Integrative Research Division**
  - industrialization-oriented, driven by large projects

- **Disciplinary research groups**
  - discipline and technological oriented

- **Core Facilities/enabling research groups**
  - facility and technology integrated

To avoid the fragmentation and isolation of activities of research groups;
To coordinate innovative resource for big target
To deliver ready-to-use technology package for industry
Staff: 362 in total

- 45 Professors recruited from all over the world

**Researchers:** 297, 82%
- PhD: 132
- MS: 135
- BA: 30

**Technical Support:** 31, 9%

**Administrative:** 34, 9%

Students: 297 in total

- PhD student: ca. 50
- Master students: ca. 250

In three majors:
- Biology (PhD, MS)
- Chemical Engineering and Technology (PhD, MS)
- BioEngineering (MS)
Annual budget. ~ $23 M

- Basic budget from CAS per year: ~$5 M
- + Projects from the central government (mainly MOST and NSFC), CAS, local government (Tianjin) and industries as well.
- + Technology transfer
- = Annual budget ~$23M all together, ~$77K /person
- Almost all the budget used for development directly or indirectly.

<table>
<thead>
<tr>
<th>Year</th>
<th>Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>$27 million</td>
</tr>
<tr>
<td>2016</td>
<td>$23 million</td>
</tr>
<tr>
<td>2015</td>
<td>$23 million</td>
</tr>
<tr>
<td>2014</td>
<td>$20 million</td>
</tr>
<tr>
<td>2013</td>
<td>$23 million</td>
</tr>
<tr>
<td>Total</td>
<td>$116 million</td>
</tr>
</tbody>
</table>

Annual budget during the past five years

Allocations of the budget

Research output

- Publications (~500)
  - 360+ indexed by SCI
  - ~25 cover stories

- Patents (~540)
  - Invention patents: >96%
  - Granted: 136
  - Patent transferred /applied: >30%
  - Average license fee: >$1 million/patent

- Awards (12)
  - National/Provincial: 10
On-going programmes

Capacity building conferences

Iconic conferences initiated and regularly organized by TIB

China Summit Forum on Industrial Biotechnology Development
- Supported by CAS, NDRC, MOST, etc
- The national namecard forum on Industrial Biotechnology
- Annually
- 400+ participants

China Bioindustry & Capital Conference
- Initiated by TIB since 2016
- Recognized as the investment indicator in bioindustry
- Biannually
- 300+ participants
Capacity building conferences

International conferences

Sino–Canada Workshop on Biomass Transformation and Commercial Opportunities (2014, 2016)
- Supported by MOST, China
- 60+ participants

2015 International Conference for Bioeconomy
- Supported by MOST, China
- >300 Participants from 7 countries

China-UK Workshop on Synthetic Biology (2017)
- Supported by NSFC
- >30 Participants

- Supported by CFIA, China
- 300+ participants

Core Facilities

Total investment >$25M

DISCOVERY

- strains & processes
- high throughput screening
- systems biology
- synthetic biology
- hyper-producer

DELIVERY

- pilot test
- products

BioCAD

- Modelling and simulation
- Computation and Design
- Analysis and Decoupling

From genetiopoietic to products
Cell factories for material industry

Renewable bio-resources substitute fossil resources

- Carbon biomass
- Waste
- CO₂

Cell factory

- Green biotech and processes

Biomass and renewable carbon resources

Chemical synthesis
Fossil oil → Maleic anhydride → Succinate

Microbial production
Biomass → Succinate

- Efficient engineered E. coli with International leading fermentation level
- Production cost cut by 25%, CO₂ cut by 94% → PBS competitive to PET plastics
- Plant in operation@20,000 tons/a, world largest production line

Succinate: Monomer for synthesis biodegradable plastic PBS and bionylon (polyamide) PAx4
Potential global market $16B per year
Currently produced mainly from fossil oil

Reduction of oil consumption, air pollution and CO₂ emission

Biofiber
Bioplastics
Bionylon
Bulk chemicals
Biofuels

- L-Malic acid
- D-Lactic acid
- Succinic acid
- Cadaverine
- 1,3-propanediol
- 1,4-butanediol
- Adipic acid
- Isobutanol
- Cellulosic ethanol
- Maleic anhydride
- Succinate
- Fossil oil
- Biomass
- Succinate
- Feedstock changed
- Manufacturing process changed

- PBS biodegradable plastic
- Feedstock changed
- Manufacturing process changed

山东兰典公司
Benefits of Plastic Mulch

White Pollution

➔ Yield decrease!

Biodegradable Plastic Mulch

Application of Biodegradable Mulch in Xinjiang Uygur Autonomous region

Biodegradable Polymer

Polylactide (PLA)

Poly(Butylene Succinate) (PBS)

Poly(Butylene Adipate-Terephthalate) (PBAT)

Poly(Propylene Carbonate) (PPC)

Crops | Year | 2014 | 2015 | 2016 | 2017
--- | --- | --- | --- | --- | ---
Cotton | -9.5 | -5.8 | -5.3 | -3.1
Maize | +0.46 | +0.53 | +2.05 | +4.32
Sugar beet | +5.31 | +3.32 | +2.94 | +4.35
Tomato | +1.31 | +2.06 | +1.15 | +2.97

Yield enhanced!
Natural products from plants

Natural products for medicine, fragrance, pigment for healthcare, food additives, cosmetics.

But, shortage of resources, plantation and extraction causes pollution

Traditional: Plantation and extraction

Now: Metabolic engineering and fermentation

Benefits:
- No resource limitation
- Global herb medicine
- Beneficial for poors
- New industry

Plant natural products by microorganisms

Cell factories for plant natural products for Chinese medicine, fragrance, pigment for healthcare, food additives, cosmetics

<table>
<thead>
<tr>
<th>Compound</th>
<th>Strain dev.</th>
<th>Process dev.</th>
<th>Pilot test</th>
<th>Industrialization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ginsenosides</td>
<td>1K m² = 10K ha, the first yeast cell factory</td>
<td></td>
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<tr>
<td>lycopene</td>
<td>1Km² = 6K ha, 20 ton/a under construction</td>
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<tr>
<td>β-carotene</td>
<td>Highest titer, 30 ton/a under construction</td>
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<tr>
<td>Salidroside</td>
<td>The first E. coli cell factory, 1/40 cost of plant extraction</td>
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<tr>
<td>Gastrodin</td>
<td>The first E. coli cell factory, 1/200 cost of plant extraction</td>
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<tr>
<td>Breviscapine</td>
<td>1/2 cost of plant extraction</td>
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<tr>
<td>Rosemaric acid</td>
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<tr>
<td>Apigenin</td>
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<tr>
<td>Costunolide</td>
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Industrial collaboration

➢ Every 8-10 days, a commercial cooperation agreement is signed with the enterprise.
➢ Established partnership with > 140 companies via 190 projects of 24 provinces
➢ Total contract fund $120 million, occupying >60% of the institute revenue.
➢ Ranked top 10 among >100 CAS institutes judged by technology transfer
➢ 20 joint labs with the companies
➢ 4 industrialization bases with the local governments and enterprises

Social-economic impact

Technologies industrialized in various industries such as pharmacy, chemical, textile, fermentation, biomaterials and enzyme.

➢ Making 2 private enterprises listed on the stock market NEEQ by our single tech
➢ Helping 35 small and medium-sized enterprises with >$17 million output value become technology innovation-driven enterprises
➢ Promoting 10 large enterprises with >$170 million output value upgraded
➢ Engaged in 2 industry clusters in biomaterials and biochemical
➢ Creating new output value >$2 billion while indirect industry scale > $10 billion
International collaboration

International network/connections

+30 Collaborative R&D Universities from >20 countries
- University of Minnesota
- University of California, Berkeley
- UIUC
- Harvard University
- University of Kentucky
- TUHH
- TU Berlin
- TU Braunschweig
- RWTH Aachen
- The University of Edinburgh
- The University of Manchester
- Kagawa University, Japan
- The University of Auckland
- Politehnica University of Bucharest
- Monash University
- Mansoura University
- University of Tehran
- ……

~10 Moreover, established partnership with ~10 organizations
## International Collaboration

<table>
<thead>
<tr>
<th>Scholars exchange</th>
<th>Training graduate students</th>
<th>Collaborative R&amp;D projects</th>
<th>Joint partnership labs</th>
<th>Symposia &amp; Seminars</th>
</tr>
</thead>
<tbody>
<tr>
<td>~60 foreign scholars/a visit TIB</td>
<td>~50 Staff of TIB per year go abroad</td>
<td>~20 programs in bio-energy, biomass transformation, functional food, synthetic biotechnology…</td>
<td>Joint laboratory of Systems Biotechnology</td>
<td>~10 International workshops Such as &quot;The Belt &amp; Road&quot; Industrial Biotechnology Symposium</td>
</tr>
<tr>
<td>~50 Scholars per year go abroad</td>
<td>3 PhD students from Pakistan, Nigeria, Rwanda</td>
<td>Supported by MOST, CAS, NSFC</td>
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<tr>
<td>20+ visiting scholars with the support of PIFI, CAS</td>
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</table>

### Collaborative R&D projects
- ~20 programs in bio-energy, biomass transformation, functional food, synthetic biotechnology…
- Supported by MOST, CAS, NSFC

### Joint partnership labs
- Joint laboratory of Systems Biotechnology

### Symposia & Seminars
- ~10 International workshops
- Such as "The Belt & Road" Industrial Biotechnology Symposium

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### International Collaboration Director-General, ICGEB Coordinator of IAP and TWAS visited TIB

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### Director-General, ICGEB Coordinator of IAP and TWAS visited TIB Pakistan Enterprise Delegation visited TIB Symposia with CLIB Delegation TIB signed collaborative agreement with NRC, Canada

### Base for International Science & Technology Cooperation in 2013 by MOST of China

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### Distinguished/visiting professorship
- Peter Lau
- Igor Gorynin
- Randolf T. Reets
- Vera Meyer
Future plans

National Technology Innovation Centre for Synthetic Biology (NC SynBio)

Comprehensive, integrated and open-access platform to boost the development of disruptive technologies in synthetic biology for material synthesis, energy supply, intelligent healthcare and environment protection.

- Small core, big network
- > $1billion in 3-5 years

Market-oriented research under the guidance of social capital
Core facility

Day 1 Request

Artificial intelligence, big data, BioDesign

Day 30 Delivery

High-throughput test and analysis

Automation for DNA synthesis, assembly, genome editing

Sample bank

Database

Parts, circuits and chassis cells

R&D platforms for key technological areas

- Chemicals
- Food
- Natural products
- Smart crop
- Agricultural agents

Biomanufacturing paradigm shift to green bioprocesses

Healthcare new drugs, intelligent diagnosis and medical cares

Agricultural production rebuild crops’ properties

Environment & Safety create unnatural biological functions

- Genome design, synthesis and editing
- Gene circuits & healthcare
- Biomedicine
- Big data and biodesign
- AI detection and remediation
- Biosafety and ethics

12 platform labs/functions
Incubation and service platform

- Pilot facilities
- IP operation
- Incubator
- Education and Training
- International cooperation and exchange

Sino-Uk Center
Sino-US Center
COMSATS center

New Campus

120K m² to host 2500 people
3 years construction period

- Incubation center
- Pilot test core
- Management, International collaboration & coordination
- Facility core
- Key technology R&D platform

TIB, CAS
We are here now

Functional operation in 2020
Proposal for participation in COMSATS activities

Participation in COMSATS’ programmes

- Participation in the ITRGs in particular:
  - Natural products – understanding and advanced use of biological information
  - Agriculture, food security and biotechnology
  - Renewable Energy
Participation in COMSATS' programmes

- New proposal as ITRGs:
  - Biodegradable plastics

  Reuse local waste resources: agricultural debris, urban waste water
  Products: primary biodegradable materials such as PHA, PBS, PLA, etc, and secondary products such as fibers, textile, plastic bag, agr. Mulch
  Benefits:
  ✓ Decrease in oil dependence (less consumption, less import)
  ✓ Decrease CO2 emission (less greenhouse gas, less carbon trading)
  ✓ Decrease white pollution (better crop yield)
  ✓ More income for the farmer and local government
  ✓ More job opportunity (full chain of industry and markets, multidisciplinary)
  ✓ New mode for self-dependent, sustainable development (Agr+Ind)
  Opportunity:
    - Fast technology advancement
    - Already tested in some places

  Vision and inspection for publication

Other collaboration potentials

1. COMSATS Center as international collaboration hub in NC SynBio, to be better connected to the academia and industry, to share the core facilities and laboratories

2. Scholarship of COMSATS-Chinas, supported by CAS, CSC, NSF, MOST, Post doc and PhD students, to be supported by UCAS or TWAS

3. Regular training courses (annually), supported by COMSAST and TIB

4. Symposium and conferences: invite COMSATS members, or joint launch new symposiums with focus on biotechnology and sustainable development

5. Joint R&D projects supported by “The Belt and Road” Program, or by social capitals and industry

6. Technology transfer, bi-directional

Under the framework of the COMSATS with the support of MOST, and CAS
S&T cooperation requests

➢ Modelling of industrial microorganisms at molecular level
  • Comprehensive quantitative data for process, strains, intra/extracellular molecules
  • Aiming at fully understanding the life and higher predictability on engineering life.

➢ Natural products
  • Identifying interesting targets, and producing it efficiently as drug or healthcare products

➢ CO2 biotransformation

➢ Technology transfer in the area of production of food, feed, drug, healthcare products, chemical and materials, solution for environmental protection (waste water, gas, solid; soil remediation)

In Conclusion

● In the past ten years, TIB built great capacities in the area of Industrial Biotechnology including infrastructure, team, R&D model, and achieved big success in technology invention, innovation and transfer.

● In the future, the NC SynBio will be a unique platform for technology innovation, substantially contribute to the sustainable development of China. NC SynBio serves a good opportunity for international cooperation under the roof of COMSATS.

The future is green, the future is bio.
Thank you for your attention!
Looking forward to collaborating with you!

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