AGRI-FOOD BIOTECH CLUSTER AT MOHALI
VISION: To be a nodal organization for knowledge generation and translational science leading to value added products based on agri-food biotech innovations.

MISSION:
To transform agri-food sector into globally rewarding and sustainable biotechnology-based enterprise through innovative solutions in primary and secondary agriculture, including high-end food processing.
To develop synergy among knowledge providers and investors in agri-food sector to carry innovations to marketplace.
Agri-Food Biotech Cluster in Punjab
(for R&D–Industry proximity for traversing path from Discovery to Market)

National Agri-Food Biotechnology Institute: discovery & innovative solutions

Discovery of concept
Proof of concept
Demonstration of concept in crop species

Agri-Food Park
enhancing competitiveness of industry, back-forward integration & commercialization

Bioprocessing Unit
Translational research/
Technology optimisation/

Technology in field
Validation of technology on industrial platform
Knowledge cluster (IISER/Nano/ISB) at Sector 81, Mohali, Punjab + NIPER, PGI, PU etc

**LAND:**
- NABI: 35 acres (Agri, Food, Nutri)
- BPU: 15 acres
- Park: 80 acres

Synergy of several organisations would lead to developing a unique model in Agri-Food Sector

**CO-ORDINATION**

- **NABI**
- **BPU**
- **Agri-food Park**
- **Industry-seed, food, phyto**
- **Investors, FDI**
- **Agr Univ**
- **State Deptt**
- **Management Instt**

- **ICAR, CSIR, DBT**
- **National & State Horticultural Boards**
- **NGOs/SHGs**
- **Regulators - GMO, Food, Export, Energy, Pollution**
- **NIPER, PGI**
- **Min of Food Processing Industries**
- **FICCI, Intl funding, philanthropic organizations**
- **Farmers etc**
National Agri-Food Biotechnology Institute

AGRI BIOTECHNOLOGY

FOOD SCIENCE & TECHNOLOGY

NUTRITION SCIENCE

TRANSLATIONAL & BUSINESS DEVELOPMENT UNITS
Agri-Food Innovation

Food
- Fortified Foods
- Functional Foods
- Personalized Foods
- Therapeutic Foods
- Nanofood Technology
- Nutritional genomics
- Improved stress tolerant Plants

Health
- High-throughput Screening Technologies
- Gene prospecting & Transgenic applications for designer Crops
- Metabolomics

Environment
- Synthetic Biology and Pathway engineering
- Phenomics
- Epigenomics

BioProducts

NABI
NABi
Wheat Improvement

Agronomic traits
- Terminal temperature tolerance
- NUE, PUE, WUE
- Hybrid vigour
- Rust, Kar Bunt

Processing traits
- Gluten strength
- Starch properties
- Grain hardness
- Pigments
- Agri-waste Process

Nutritional traits
- Fe, Zn, Vitamin A
- Folic, Fatty acids
- Polyphenols, lignans, folate, lutein, fibre, lignans, phytosterol
- Higher protein
- Non allergenic gluten
- Bioavailability
Wheat Processing Quality Related to Proteins

![Images showing the properties of gliadin, glutenin, and gluten.]

- **Viscous**
- **Elastic**
- **Viscoelastic**

### Comparison of Wheat Proteins

- **More Gliadin**
- **Balanced Gluten**
- **More Glutenin**

![Graphs showing mixographs and alveograms for different protein compositions.]

- **Mixograph**
- **Alveogram**

- **Bread loaves**
### Parameters for good quality chapatti, bread, biscuit and pasta

<table>
<thead>
<tr>
<th></th>
<th>Chapatti</th>
<th>Bread</th>
<th>Biscuit</th>
<th>Pasta</th>
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</thead>
<tbody>
<tr>
<td>Grain hardness</td>
<td>Intermediate</td>
<td>Hard</td>
<td>soft</td>
<td>Hard</td>
</tr>
<tr>
<td>Gluten</td>
<td>Intermediate</td>
<td>Strong &amp; extensible</td>
<td>Weak &amp; extensible</td>
<td>Strong</td>
</tr>
<tr>
<td>SDS sedimentation</td>
<td>~40 ml</td>
<td>&gt;60 ml</td>
<td>&lt;30 ml</td>
<td>&gt;35</td>
</tr>
<tr>
<td>Grain protein content</td>
<td>Intermediate</td>
<td>&gt;13.0%</td>
<td>&lt;10.0%</td>
<td>&gt;12.5</td>
</tr>
<tr>
<td>HMW glutenin subunits</td>
<td>20, 5+10</td>
<td></td>
<td>-</td>
<td>7+8, 14+15, 6+8</td>
</tr>
<tr>
<td>Glu-1 score</td>
<td>6 to 8</td>
<td>9 or 10</td>
<td>Lesser is preferred</td>
<td>-</td>
</tr>
<tr>
<td>LMW glutenin Subunits/Alleles</td>
<td>Not Studied</td>
<td>Glu-A3-b, Glu-B3b/g and Glu-D3e/b</td>
<td>-</td>
<td>LMW-2 Glu-3, aa/ca alleles</td>
</tr>
<tr>
<td>Gliadins</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Gli-B1-γ-45</td>
</tr>
</tbody>
</table>
Fe and Zn content in *Aegilops tauschii*, D genome wild progenitor vs bread wheat

<table>
<thead>
<tr>
<th>S. No.</th>
<th>species</th>
<th>Fe (ppm)</th>
<th>Zn (ppm)</th>
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<tbody>
<tr>
<td>1</td>
<td><em>Ae. tauschii</em> acc. 14102</td>
<td>109.4</td>
<td>62.3</td>
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<tr>
<td>2</td>
<td><em>Ae. tauschii</em> acc. 14116</td>
<td>98.6</td>
<td>49.0</td>
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<tr>
<td>3</td>
<td><em>Ae. tauschii</em> acc. 14118</td>
<td>81.4</td>
<td>88.6</td>
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<tr>
<td>4</td>
<td><em>Ae. tauschii</em> acc. 14129</td>
<td>81.1</td>
<td>90.4</td>
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<tr>
<td>5</td>
<td><em>Ae. tauschii</em> acc. 14180</td>
<td>99.9</td>
<td>56.2</td>
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<tr>
<td>6</td>
<td><em>Ae. tauschii</em> acc. 9810</td>
<td>56.6</td>
<td>36.9</td>
</tr>
<tr>
<td>7</td>
<td>PBW343</td>
<td>40.9</td>
<td>22.2</td>
</tr>
<tr>
<td>8</td>
<td>C518</td>
<td>35.1</td>
<td>44.2</td>
</tr>
<tr>
<td>9</td>
<td>C306</td>
<td>32.4</td>
<td>30.5</td>
</tr>
<tr>
<td>10</td>
<td>PBW114</td>
<td>43.4</td>
<td>23.9</td>
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</tbody>
</table>
Process development for value from wasted wheat grain

**Wheat starch:** Biodegradable polymer, fructose

**Wheat gluten:** Adhesives, polymers, resins

**Wheat germ:** germ oil, lecithin, vitE, vitB, Lipase, glycerides, Phytosterols, phytase, sucrose synthase, Lipoxygenase, acid-phosphatase

**Wheat bran:** dietary fibre, amylase, phytase, Xylanase, arabinogalacto proteins, carboxypeptidase, polyphenol oxidase
NABI-BPU for Integrated product oriented Bio-Processing Portfolio, taking wheat as an example

**WHEAT**

- **Specialty wheat flours**: Branded premix for bakery needs, rolls, pizza, doughnuts
- **Breakfast cereals**: ready to eat, chips, puffed, sugar free muesli, biscuits & snacks
- **Wheat straw**: medium to grow mushrooms, animal feed, paper making
- **Wheat starch**: Biodegradable polymer, fructose
- **Wheat gluten**: Adhesives, polymers, resins
- **Wheat germ**: germ meal, germ oil, lecithin, vitE, vitB, glycerides, Phytosterols, Lipoxygenase, lipase, acid phosphatase, sucrose synthase, phytase
- **Wheat bran**: dietary fibre, arabinogalacto proteins, carboxypeptidase, amylase, xylanase, phytase, polyphenol oxidase
NABI
Fruit Crop Improvement
Association Genetics, Mutation, Breeding

Agronomic traits
- Hybrid vigour
- Fruit Stem borer
- Bacterial blight
- Flower fall
- Early fruiting
- Tree height
- Adaptability

Processing traits
- Solid content
- Acidity
- Color
- Shelf life
- Flavour
- Seedlessness
- Bioactives from waste processes

Nutritional traits
- Anti oxidants/anthocynins/
  Catechins/ Ascorbic acid
- Citric/Malic acid
- Sugars
- Minerals
- Alkaloids/Sterols/Terpenoids
- Bioavailability
NABI for genomic applications for seed industry

NABI
For Designer Crops

**Germplasm screening for gene trait diversity:** Wheat for NUE, WUE, TTT, Nutritionally superior-Zn, Fe, Vit, Nutraceuticals
Processing quality-starch/gluten composition, allergens

**Throughput Genotyping, phenotyping & MAS** for Agronomic, nutritional, processing centered traits

**Gene prospecting & Transgenic applications for designer Crops:** Seedless fruits, Insect R vegetables/fruits: Okra, Brinjol, Tomato

**Male sterility for hybrid seeds** (Highest opportunity in hybrid wheat & paddy: high volume & global need)

**SNP chips / Microarray chips / Genome sequencing**

SEED INDUSTRY
Global: $ 30 b
India: $ 1.5 b
NABI for high value farm produce

Germplasm screening for nutritional/processing/agronomic traits
- Wheat for micronutrients, starch/protein quality, Term Temp Tol, NUE, WUE
- Seedless fruits
- Cotton for oil or fibre or protein?
- Sorghum for starch or biomass or sugar?
- Varieties suitable for processing technologies
  Starch, protein quality, solid content, uniform size, shape, shelf life, Firmness, seedless, easily peeled rind, color, flavor, bitterness/sweetness/acidity

Germplasm screening for phytopharmaceuticals

NABI for value addition to food

Nutritionally superior crop varieties and health formulations
- Iron, Zinc, Iodine, vit (A/D) rich foods, bioavailability, stability, Ashwagandha milk, health drinks

Process & variety development for utility of byproducts
- Peel of citrus, grape etc, polyphenols, flavanoids, anthocyanins, tannins, vitamins, agri waste for triacontanol, waxes, xylitol, D-ribose, solenosolis, Mango peel pectin, polyphenols

Process and variety development for extended shelf life
- Irradiation, sterile packing, slow ripening varieties, storage pest resistant

Process improvement to add value/economy to industrial process
- Safety SOPs, quality standardisation, solar powered processing, small scale processing

PROCESSED FOOD MARKET
Global: $3.2 T
India: $0.075 T
Post Harvest Losses India: $8b
Product & Trait Orientation:

Wheat

Nutritionally superior - Zn, Fe, Folic, vitB/A; NUE, WUE, TTT; Hybridisation technology, Genotyping, MAS, Genome seq.; Processing - gluten/starch/allergens; secy., high end

Tomato, Okra, Brinjol

Post harvest quality, Processing - pri., secy., high end; Hybrids, NUE, WUE, Disease/Pests, Genomic Diversity

Kennow, Guava, Litchi, Mango

Post harvest losses, Seedless Fruits, Multiple feedstock Process. - pri., secy. high end; SNP Genotyping for Association Genetics
**NABI-BPU for agri-waste to wealth: secondary agriculture**

High end Process development for high value bioactive molecules from vegetable & fruit waste

**NABI**
- Cereal waste
- Fruit & vegetable waste
- Processing plant waste
- Surplus fruits

**BPU**
- 500 L fermentor
- Optimization
- Simulation for 50000 L fermentor

- Enzymatic digestion
- Clarification
- Membrane concentration
- 50 litre fermentor
- Microbe assisted transformations

- Centrifugation
- Cell lysis
- Precipitation
- Nano filtration
- Ion exchange
- Product

- (SAM, Glucosamine, Xylitol, D-ribose, VitC)

**Graph**
- Glucosamine
- SAM
- Q10

- Year: 1996-2011
- USD Million: 0-1600

- 2002: 530 USD Million
- 2004: 869 USD Million
- 2006: 1025 USD Million
- 2008: 1208 USD Million
- 2010: 1424 USD Million
NABI for functional foods to drugs

NABI
For high value from foods

Lead 1: Functional foods
State license for manuf.

Ayush, GNDU, NBRI, Food Ind

Lead 2: Active fraction
Nutraceuticals
DCGI – Phase I

NIPER, NIN, PGI, Nutra
industry

Lead 3: Active Molecule
Phytopharmaceuticals
(Drug development mode)
IND – DCGI

CDRI, PGI, Pharma industry

Spin off 1

F Foods
High SAM in Germinating barley
High lycopene tomato
High anthocyanin brinjal

Spin off 2

Spin off 3

Drugs
(Therapeutic grade SAM, Lycopene, anthocyanin)
NABI for Translational Research in Agri-biotechnology

- **NABI early leads**
  - Technology acquisitions from MNCs (Affy/Monsanto)

- **Industry led NABI leads**
  - NABI led Industrial leads

- **TBU**
  - Product /Technology validation, optimisation, demo, trn

- **State of art Technology Platforms**

- **High end infrastructure/ training/services : Industry/national labs/SBIRI/BIPP/Others**

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**Genomics:**
- Genotyping
- Genome sequencing: 454, SOLID
- Mass array – Sequenome
- Molecular markers & mapping
- Affy Arrays
- Bioinformatics & Statistical Genetics

**Phenomics**
- Photosynthesis /biomass
- Water Utilisation efficiency
- Nutrient Utilisation Efficiency
- Partitioning
- Climate change response

**Proteomics**
- MALDI – TOF – TOF
- N terminal sequencer
- LC MS MS
- Surf Plasmon Resonance

**Metabolomics**
- LC-MS-NMR
- GC-MS
- IR-MS
- (MS)n
- NMR-Imaging

**Scale-up Transgenic Plants Facility**

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- Male sterility & seedless fruits
- Nutritionally enriched – High Fe, Zn, Vit ,Fn Foods,Nutaceu
- GMP, SOP, Certification
- Post harvest stability
- WUE, NUE lines
- Insect / pest resistance in field
- Biosafety – Pollen flow
  - Small animal
- LOD/ Animal models / IPR
- ISTA & OECD seed certifn
NABI/BPU for Translational Research in Food Processing Sector

- Food Process Co Intl
- Ministries, Food Proc Industries, Horticulture Board, CII
- Food Tech Engg & science institutes, Universities

BPU

Product / Technology Validation, Optimisation Demonstration, Training

State of art technology platforms

Primary Processing
Secondary Processing

High-end Processing
- Cereal grains based
- Oil seeds based
- Vegetables & fruits based

Product / Technology Validation, Optimisation Demonstration, Training

State of art technology platforms

High end infrastructure/ training/ services to Industry/others/ BIPP platform

- Irradiation
- Aseptic Packaging
- Export quality stds

- Solar powered/Green food processing Technologies

Mobile Processing Units

Food Testing Lab
- Pesticides, Heavy metals, Microb, Nutritional info
- Biosafety/ GMO

Integ Processing Model
- Backward & Forward linkages
- Natl & Internatl Mkts
PROSPECTIVE PROJECT FOR SEED INDUSTRY
TRANSGENIC SEED LESS FRUIT CROPS

NABI
- Transgenic parent line for seedless development of fruits in F1 hybrid
- F1 hybrid for high yield

TBU
- Agronomically elite
- Inducible male sterility
- Complete field fertility
- Bio-safety

Seed Co
Seed Co
Seed Co
Seed Co
Public sector
Agri Univ

PARK
For hybrid Litchi, Citrus, Guava, tomato, chilli
Under development

(Two element technology for arresting seed development)
MOHALI KC FOR FOOD PARK & PROCESSING
PPP/Entrepreneur Driven Management/SPV

| Capacity utilization based on mix of crops/ agricultural/ horticultural surplus/waste |
| Capacity utilization & profit sharing through Farmers Cooperatives/ SHG |
| On-farm primary processing infrastructure |
| Cold storage, transportation, supply chain |
| Grading & processing units, Portable processing units |
| Establishing national & international market linkages |
| Meeting ground for farmers, processors, retailers, govt |

**Companies for development of novel products**

- Sports & energy drinks
- Juices: Kinnow, Guava, Litchi, Peach, Phalsa, Sapota, Pear, Ber
- Carotene oil, Quality Potato fingers
- Herbal beer, Quality wines
Strategy of Agri-Food Biotech Cluster: Bench to Business

- **NABI**
  - New knowhow/Technology Leads/ acquisitions
  - \( \text{Funding: DBT, National, Intl Orgn., NRI} \)
  - Min Food Process Industries, ICAR, AYUSH, CSIR
  - BIPP, SBIRI

- **Food Processing Co**
- **Seed Companies**
- **Phyto/pharma Co**

- **TBU/BPU**
  - Technology validation, scale up, efficacy, bio-safety

- **Park**
  - Companies with NABI as promoter
  - Companies based on NABI technologies
  - Companies to enhance own competitiveness

- **Spin off/PPP**
  - Equity Investors 40%
  - NABI (IP 30% + Eq. 10%)
  - Banks/Govt (Loan/aid 20%)

- **Project Development** (+Management School)
  - Define product
  - Investment
  - Time line
  - Market size
  - Cash flow

- **NGOs, SHG KVK**
- Resource Center Agri-univ

- Companies with higher competitiveness
- Spin off companies
Scientists, Technologists & Managers with vision, skills & determination to take challenges in developing knowledge cluster at Mohali are invited to join on their terms

People with High Creativity and High Productivity

Knowledge driven R&D hub **NABI**

Productivity driven
**BPU & PARK** *(Corporate-type)*
THANK YOU

... The best to come is not even thinkable today