Food Allergy Market Analysis:
• Top food allergens: milk, eggs, peanuts, tree nuts, fish, shellfish, soy, and wheat.

• Even small amounts of food allergen can cause a reaction or death (anaphylaxis).

• No proven cure.

• 30% of Americans think they have food allergy  
  • Reality: 8% of children, < 5% of adults

• 9 million adults & 6 million children in U.S.

• 2010: $408M spent on allergy testing globally.

• Phadia dominates the market: EBITDA $149M

Sources:
Food Allergy in Children

- Young children are unable to recognize food they are allergic to:
  - Food allergy rates increased significantly among both preschool-aged and older children from 1997 to 2007.
- Hospitalizations with diagnoses related to food allergy have increased among children from 1998 to 2006.
- Cost for children’s food allergy: $25 billion per year.
Allergic Symptoms

- Skin: rash, angioedema (hives)
- Eyes: conjunctival injection, periorbital edema
- Lung: sneezing, bronchoconstriction
- Gastrointestinal tract: abdominal pain, vomiting, diarrhea

Diagnosis of Peanut Allergy

Immunassays

- Specific IgE
- 9 allergenic peanut proteins

Skin Prick Test

Oral Food Challenge
Diagnosis of Peanut Allergy

- Test results do not reflect the severity of allergy
- Diagnostic tools needed to help predict reaction severity!
Severity and persistence correlates to the number of epitopes
Microneedles (MNs)
Peptide microneedle skin testing gives the answer clinically in < 5 min

Severity and persistence correlates to the number of epitopes
Dissolving PVP-Microneedles

- Made of FDA GRAS polymer (poly vinyl-pyrrolidone)
- Dissolves upon penetrating skin
  - Instantly to Days (depends on amount of polymerization)
- Allows controlled delivery of allergens

Allergen proteins + PVP

PDMS Mold

Vacuum

Drying

Peeling

Micro dispensing of PVP/protein solution into needle domains
Characterization of PVP-MNs

Microneedle Structure

Peanut MN

Casein MN

Distribution of Proteins

Rhodamine –Casein MN

Integrity of Proteins

% of Active SA

SA+ PVP
PVP SA MN
PVP SA MN (UV)
Penetration of MNs

![Diagram showing MN penetration process]

**PVP casein MN**

**Steel casein MN**

Images show the progression of MN penetration over time, with various visual indicators of absorption and distribution within the tissue.
Potential Applications of MNs

- **Excellent intradermal delivery system**
  1. Vaccines
  2. Tumor antigens
  3. Drugs
    - Proteins
    - Antibodies
    - Chemical compounds
    - DNA/RNA
MNs for Vaccination

- Immunization
- Microneedle
- T cell activation
- Anti-Tumour Response
- Anti-Viral Response

- Dendritic cell
- Vaccine Nanoparticle
- T cells
- Melanoma
- Virus

Published in: Marija Zaric; Oksana Lyubomska; Olivier Touzelet; Candice Poux; Sharifah Al-Zahrani; Francois Fay; Leah Wallace; Dorothea Terhorst; Bernard Malissen; Sandrine Henri; Ultan F. Power; Christopher J. Scott; Ryan F. Donnelly; Adrien Kissenpfennig; ACS Nano 2013, 7, 2042-2055.
DOIl: 10.1021/nn304235j
Copyright © 2013 American Chemical Society
Comparison of a microneedle tuberculosis test and a traditional test administered with hypodermic needle. The lower images show needle-depth problems that can occur with the conventional test.

Marco Rolandi, U of Washington
MN Commercialization Milestones

**TIMELINE**
- Dissolving MNs
  - Fabrication
  - Formulation
  - Characterization
- Preclinical
  - Thermal Imaging
  - Modification of MNs
  - In vitro Proof-of-Concept
  - Mast cell activation
  - Thermal Imaging
- Clinical Validation
  - Biocompatibility
  - Toxicity
  - BLA Submission
- MARKET
  - License out
  - GMP microneedles
  - GMP peptides

**iFarm Program**
- Evaluation
- Meeting Inventors
- Patent Landscape
- Competitors

**STARTUP!!!**
- Patent Application
- Seed Fund
• **5 existing** patents may overlap with our technology.
• Additional patent applications may have filing precedence over our application.
• **1 existing** patent covers a combined imaging and allergen testing system.
• Patent holders range in size from angel-backed startup to major multinational consumer-goods companies.
Nature of Competing Technologies

- All competing technologies are based on high-aspect-ratio microneedle or microknife arrays.
- Competing technologies utilize inorganic substrates.
- Competing technologies are based on photolithographic or micro-etching methods.
- Competing technologies have limited biodegradability.
Competitors

- **Transderm Inc**: Dissolvable microneedle arrays for nucleic acid delivery.
- **Corium-MicroCor**: Biodegradable microstructure patches for delivery of proteins, peptides and vaccine.
- **Circassia-MicronJet**: A silica-based microneedle system, already approved for use in U.S. and Europe.
Our technology

• Simple organic synthesis at room temperature.
• Rapidly biodegradable.
• Direct synthesis of array substrate with allergen.

Competing technologies

• Complex synthesis using photolithography or micro-etching
• Variable levels of biodegradability
• Allergen must be added to machined substrate at separate step.
Future Directions

- **Outreach**: Discuss technology with people in the allergy field.
  - Visit different allergists who treat adults and children.
  - What is the greatest unmet need in the allergy field?
- **Research**: Look into more details into the field of allergy research.
  - How can allergy products have been broken down to individual components?
- **Business**: Steps necessary to bring this technology into the market.
  - Write a business proposal.
  - Focus on a specific allergy that can create the most value for the company.
Acknowledgments

iFarm Program

Stanford Office of Technology Licensing:

- Luis Mejia
- Rick Gibb
- Serena Hanes

Mentor: Richard Garber

Inventors

Manish Butte
M.D. Ph.D.

Jayakumar Rajdas
Ph.D.
Questions?
Food Allergy Market

- **2010: $408M** spent on allergy testing globally
- Phadia dominates market. EBITDA $149M on revenues of $190M
- Additionally, US spends $118M / yr on allergy doctor visits, $45M on ED visits, $203M on other doctor visits for allergies
- **30% of Americans** think they have food allergy
  - Really: 8% of children, < 5% of adults
- Per test cost currently, $0.50
• 30% of Americans think they have a food allergy
• Really: 8% of children, < 5% of adults
• $408M spent on allergy testing
• $4B spent on allergy foods
• $7 b in US
• 8% children have true food allergy
• Anaphylaxis
• due to food allergy results in over 20,000 hospital visits and 100–200 deaths per year.
• Gold standard: Doubleblind placebo controlled food challenge (DBPCFC) → Difficult/dangerous
• the skin prick testing (SPT; limited to only 30 allergens) and serum IgE testing (false results); can’t tell about severity.
Why use this technology?

• WHO estimate the cost of conventional needle administration in Africa is around $25 per administration due to the unsafe practice that causes needle-stick injuries.

• In United States, needle-stick injuries cost around $591million in 2010
SPARK Plan

Aim 1: Fabricate microneedles

Aim 2: Examine the biocompatibility and toxicity in rats

Aim 3: Develop thermal imaging

Aim 4: Clinical validation in allergic patients
Development Plan

GMP microneedles
GMP peptides
FDA: BLA approval for skin testing reagents

Start up company or License
Potential licensees: DBV Technologies, Allermed Laboratories
Thermal imaging allows rapid identification of reactions.