

SILK

technology driven enterprise

FIorenZO OMENETTO
DAVID KAPLAN
SILK LAB - TUFTS UNIVERSITY

silk lab

Silk is a natural fiber that has been cultivated in Far East Asia for over 5,000 years. The Chinese domesticated *Bombyx mori* caterpillars, and then harvested their cocoons in order to produce silk fiber to be used in luxurious textiles. As the material gained popularity in Europe and the Middle East, it eventually lent its name to the “Silk Road,” the network of trade routes that connected Asia to Europe, arguably making silk the world’s first globalized industry. Today, silk is still produced from the cocoons of these insects for use in textiles from haute couture to home decor, parachutes, and even surgical sutures.



1.
raw materials



2.
boil with a salt and wash to
remove the sericin (glue-like
protein described on page 14)



3.
dissolve the silk in a
second salt bath



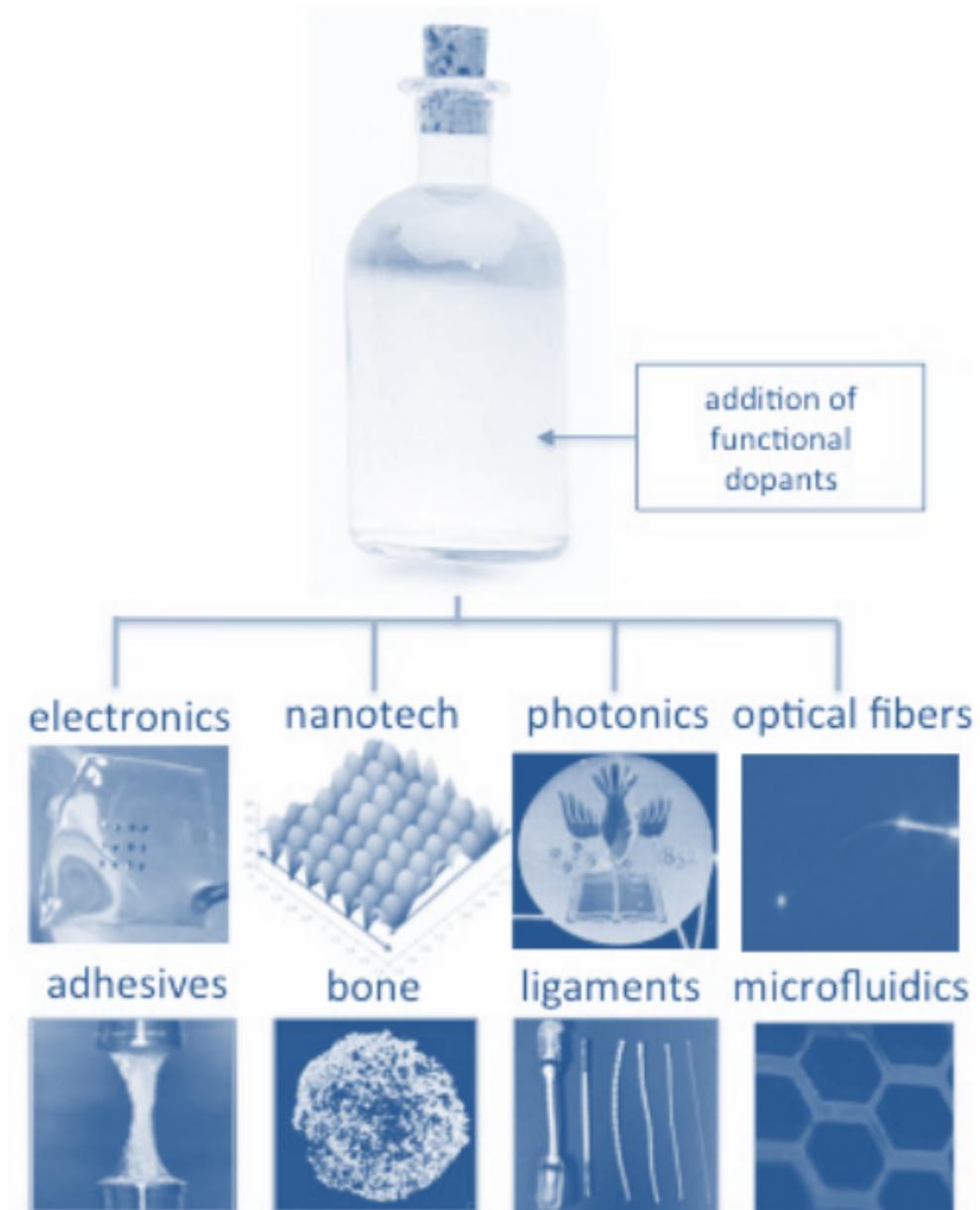
4.
remove the silk by dialysis



Product:
a biocompatible solution of
pure silk fibroin and water



USE THE LIQUID SILK AS THE STARTING BLOCK FOR MANUFACTURING



STRENGTHS & CHALLENGES

UNIQUE MATERIAL

Extreme versatility of material in formats and function including unusual operating environments and unusual attributes, namely:

- sustainable material
- processing in water at room temperature
- biodegradable “with a clock”
- edible
- implantable in the human body
- microelectronic interfaces
- optical interfaces

RESEARCH EXCELLENCE

Premier research group worldwide
Resident knowledge base at Tufts
Strong links in place to DoD,
US and international labs

>70 people involved (research faculty,
post-doc, PhD students)

PERCEIVED VALUE

Perception of silk as the next nylon™ or kevlar™ based on the unusual strength and toughness of the natural fiber “an old story”

RAPIDLY GROWING COMPETITION

Danger of losing competitive edge -
Increasing foreign investment, UK,
Germany (>25M\$ invested in 4 yrs),
India, China, Taiwan

NEED FOR SCALE UP

develop larger volumes of solution
develop repeatable batches per application



STRENGTHS & CHALLENGES

BEYOND BASIC RESEARCH

Large and growing
patent portfolio
numerous opportunities for translation
licensing and starts ups underway

BEYOND SCIENCE

UN – FAO – sustainable farming
no oil/petroleum consumption in fabrication
no methane emission from discarding
totally reintegrated in environment

BEYOND EXPECTATIONS

The unusual freedom to define both form and
function open unanticipated opportunities

computing organs
emo-tronics
edible technology
biotic/abiotic interfaces
personal distributed sensing
the bio-cloud

BROAD PRODUCT SPACE

(spans consumer goods, pharma, medical,
high-tech opto and electronic)

Expensive to maintain/grow IP position

DEVELOPMENT RISK

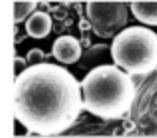
perceived as too risky for traditional
funding sources

“valley of death” for private enterprise
FDA approval for hybrid electronic/biomedical
and the biomedical spaces

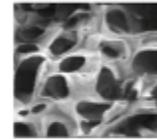


programmable forms

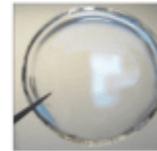
beyond fibers - multiple material forms
from the same starting point



micro- and
nanoparticles



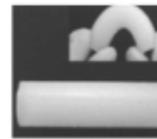
sponges and
scaffolds



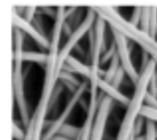
films and conformal
coatings



hydrogels
reversible/permanent
adhesives



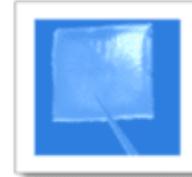
blocks
composites



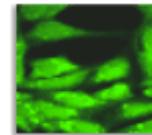
and fibers and ropes

programmable functions

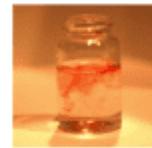
beyond fibers - silk is a biomaterial
thanks to processing and
material features it allows unusual
combinations of properties



inorganic
dopants



organic
dopants



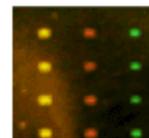
controlled
degradation



edible



implantable



interfaces
photonics/optoelectronics/
microelectronics/nanotech

programmable forms + programmable functions

The unique combination of attributes enables performance unobtainable with other materials thanks to the near-limitless ability to combine and recombine forms and functions

UNIQUE
MATERIAL
OUTCOMES

disruptive
technology

DEVELOPING GAME-CHANGING APPLICATIONS and BUSINESSES
WITH A MATERIAL THAT HAS BEEN VALIDATED
WITH COMPELLING PRELIMINARY DATA and PROTOTYPES



UNIQUE APPLICATION SPACES – BIOLOGICAL STABILIZATION

form
function

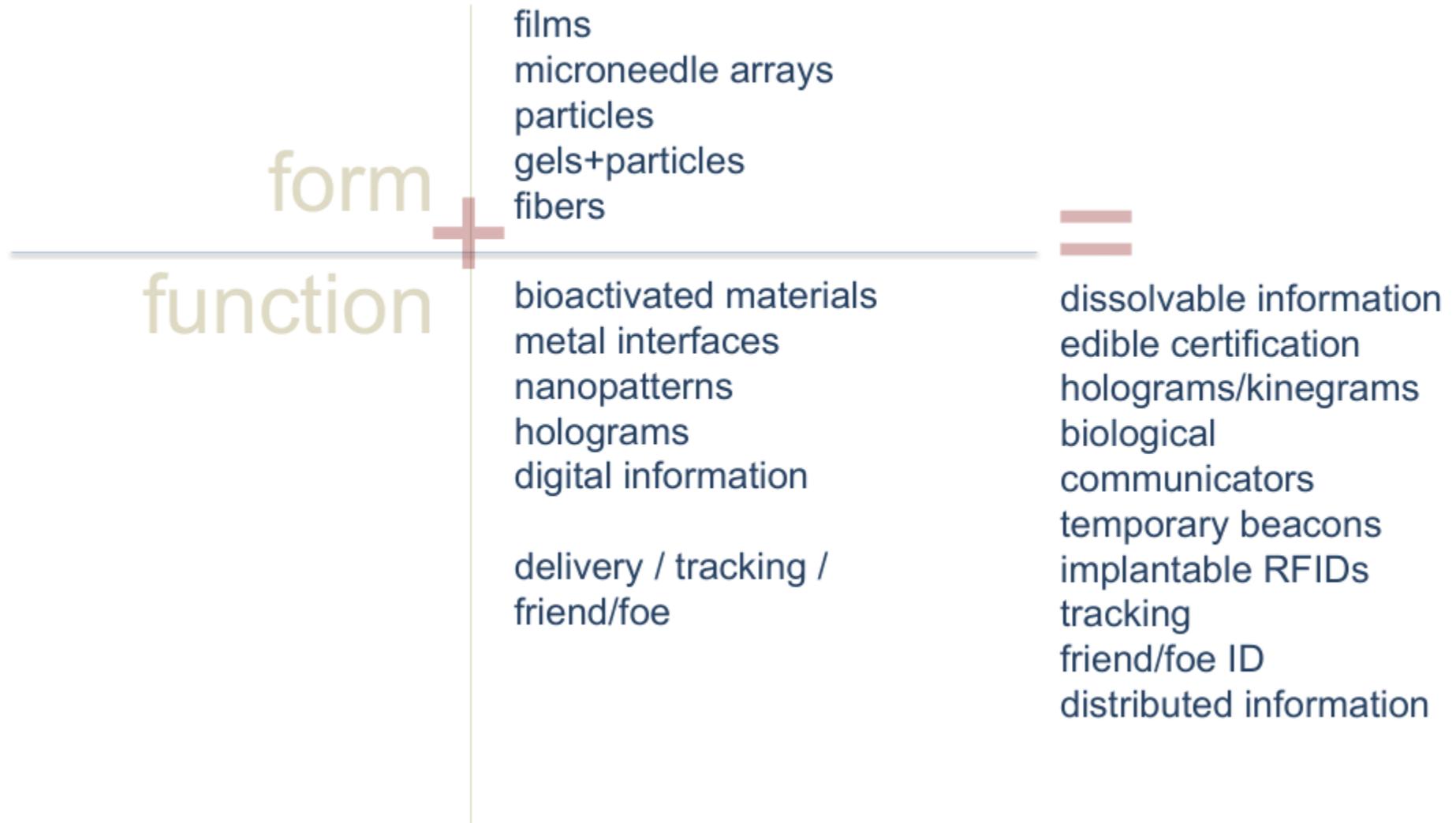
films
microneedle arrays
particles
gels
fibers

enzymes
Vaccines
antibiotics
monoclonal antibodies
hemoglobin
therapeutics

delivery / recovery of
stored components,
sensors, pocket drugs,
pocket wound control....

Silk materials can entrain and preserve the biological viability of samples at a variety of temperatures (-30 to 60 degC) – the materials can be recuperated by dissolving or consuming the silk used for storage as needed.

UNIQUE APPLICATION SPACES – NEW MODES TO ENCODE INFORMATION



UNIQUE APPLICATION SPACES – HUMAN WELFARE

form

function

films
microneedle arrays
blocks/tablets
gels+particles
fibers
e-gels

bioactivated materials
metal interfaces
nanopatterns
flexible electronics
digital information
nutraceutical
pharmaceutical
sensing

multipurpose materials
edible hardware
food and water quality
fatigue sensors
personalized monitoring
spray on wound stasis
military construction
adhesives
clays/on-site molding
Credit card pharmacy
skin-mounted sensors

UNIQUE APPLICATION SPACES – MEDICAL

form

function

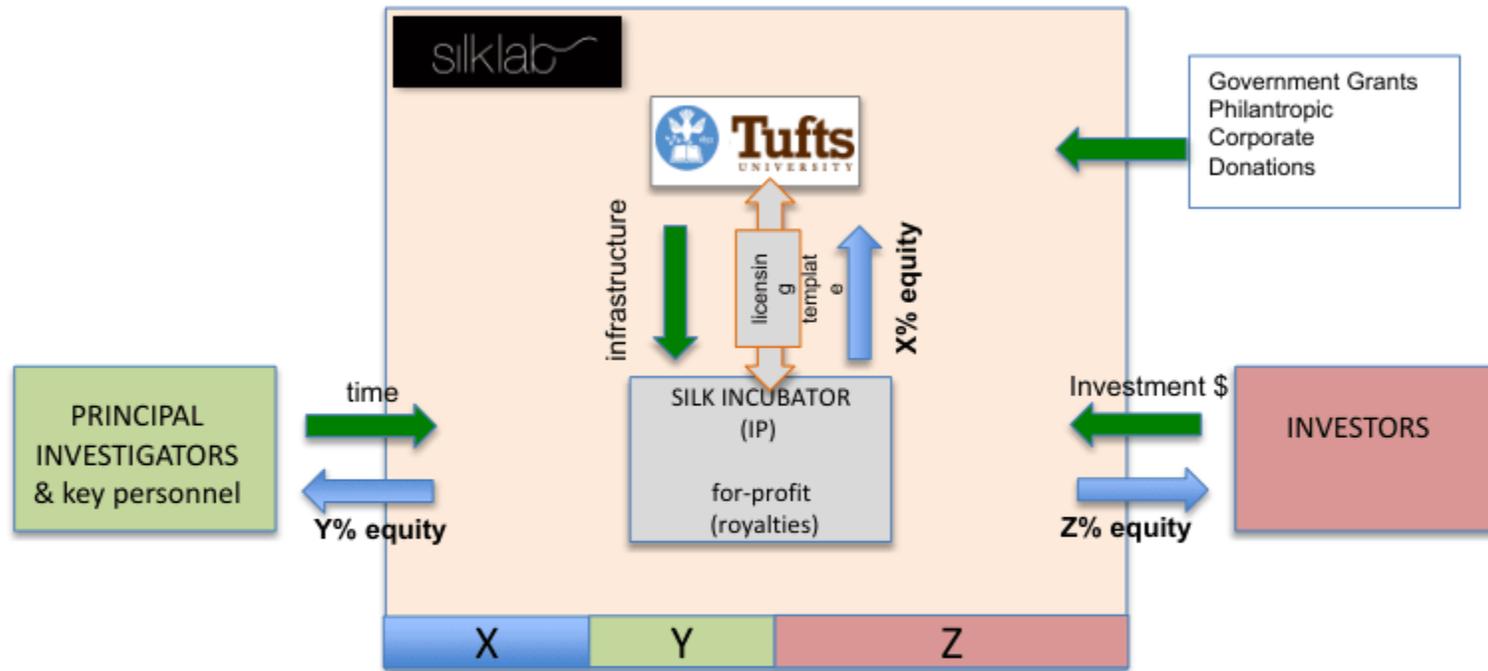
films
microneedle arrays
particles
gels+particles
fibers

bioactivated materials
metal interfaces
nanopatterns
holograms
digital information

delivery / tracking /
friend/foe

wound stasis
drug delivery
next gen prosthetics
tissue regeneration
defect restoration
on-surface devices
(wound dressings)
sub-dermal devices
neurological interfaces
Soft interfaces
bio-integrated sensors

SILK institute



The institute is owned by the university, scientists, and investors.

All members of the institute have vested interest in its success.

The institute builds value for the silk incubator
which manages the silk IP.

The incubator is within the institute and deals as the institute's own TLO

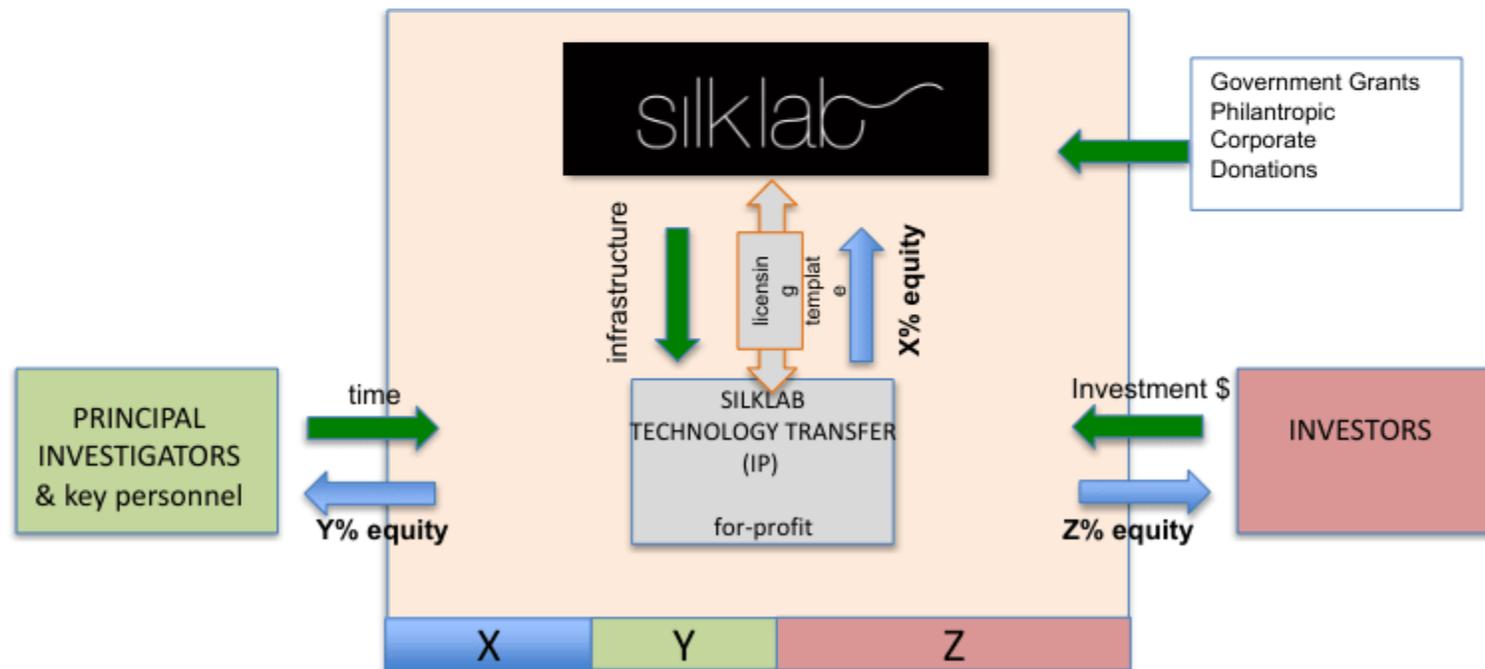
The institute builds value for the silk incubator through technological progress.

SILK INSTITUTE FOR INNOVATION AND NEW TECHNOLOGIES

key assumptions : Silklab is the seed institute for innovation – it addresses technological challenges in basic and applied science to generate business and develop a biomaterials based array of startup industries.

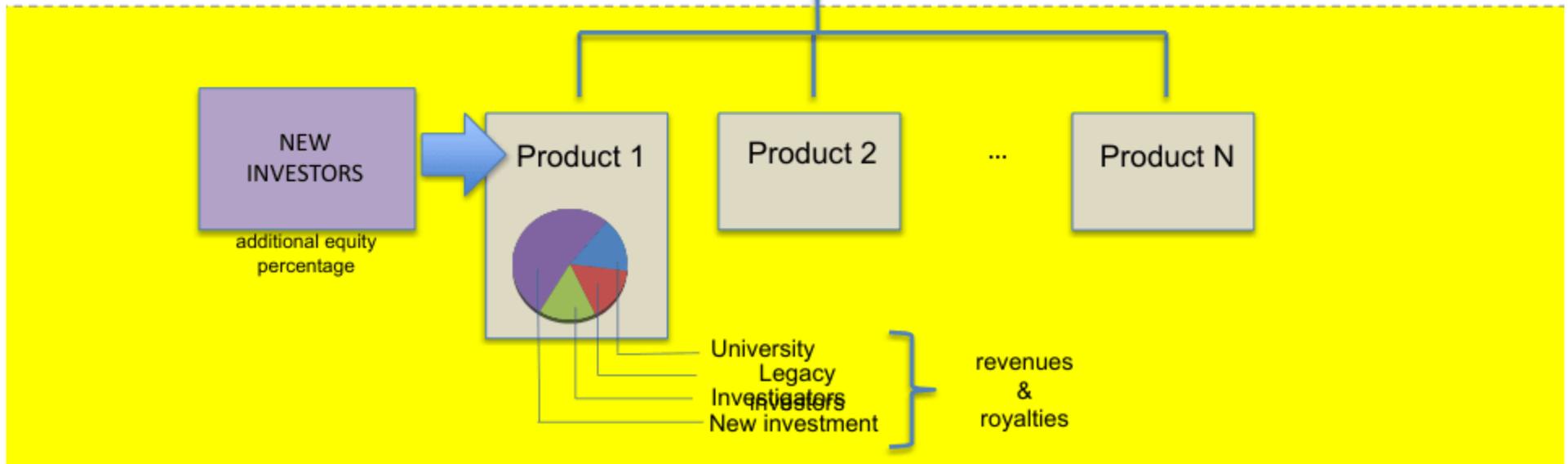
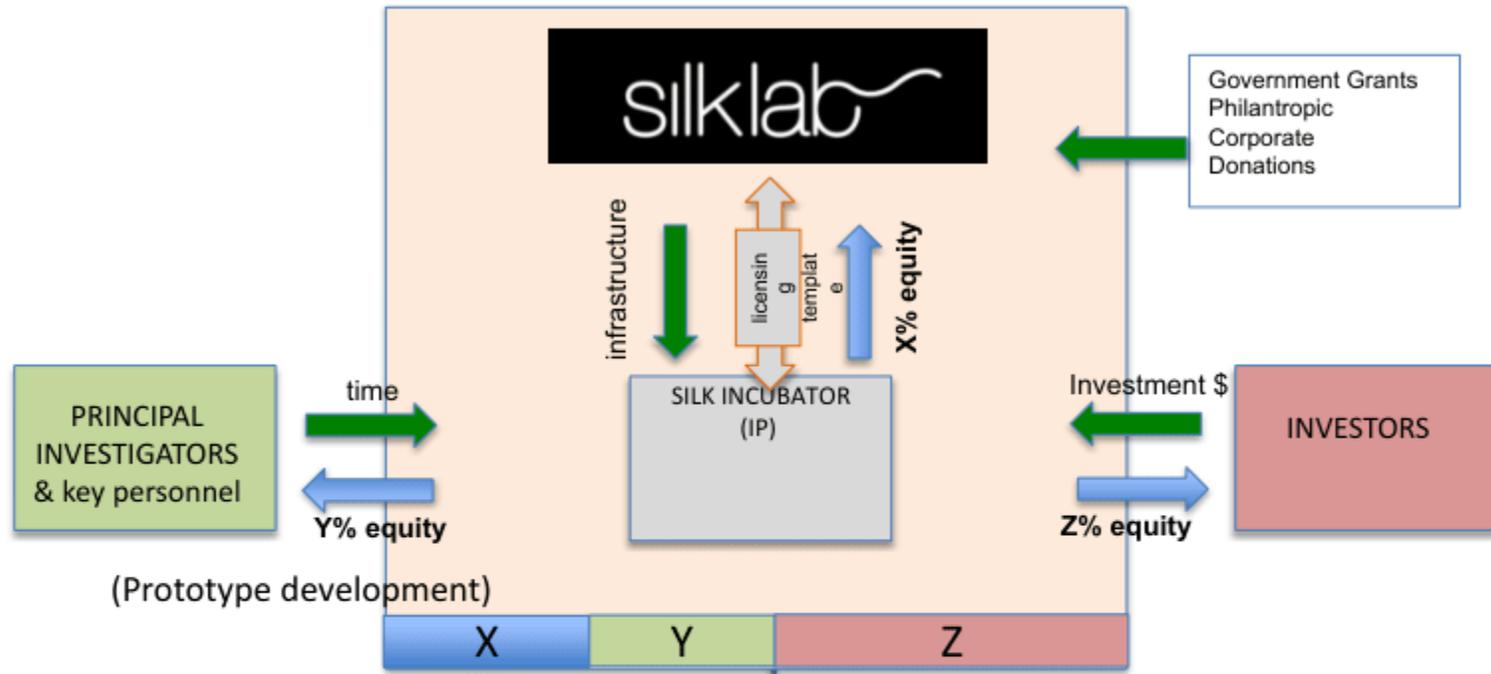
Silklab interfaces through its leadership with a dedicated technology transfer that liaises with industry partners or entrepreneurs maximizing the ROI on the technology.

Silklab always owns part of the startup companies that are generated from its technology development.

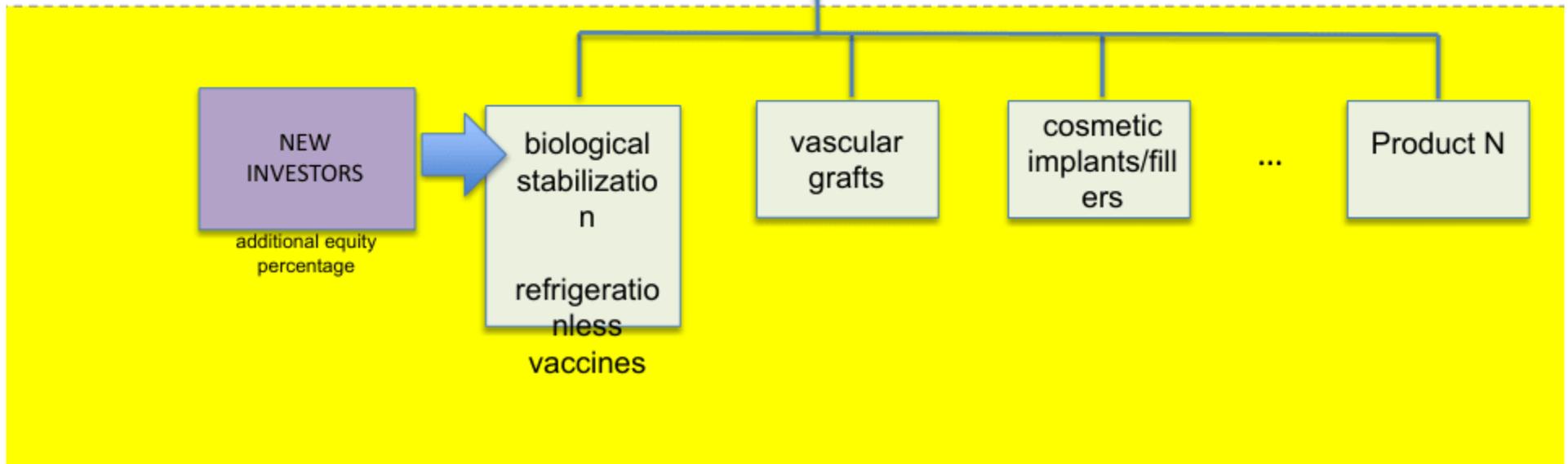
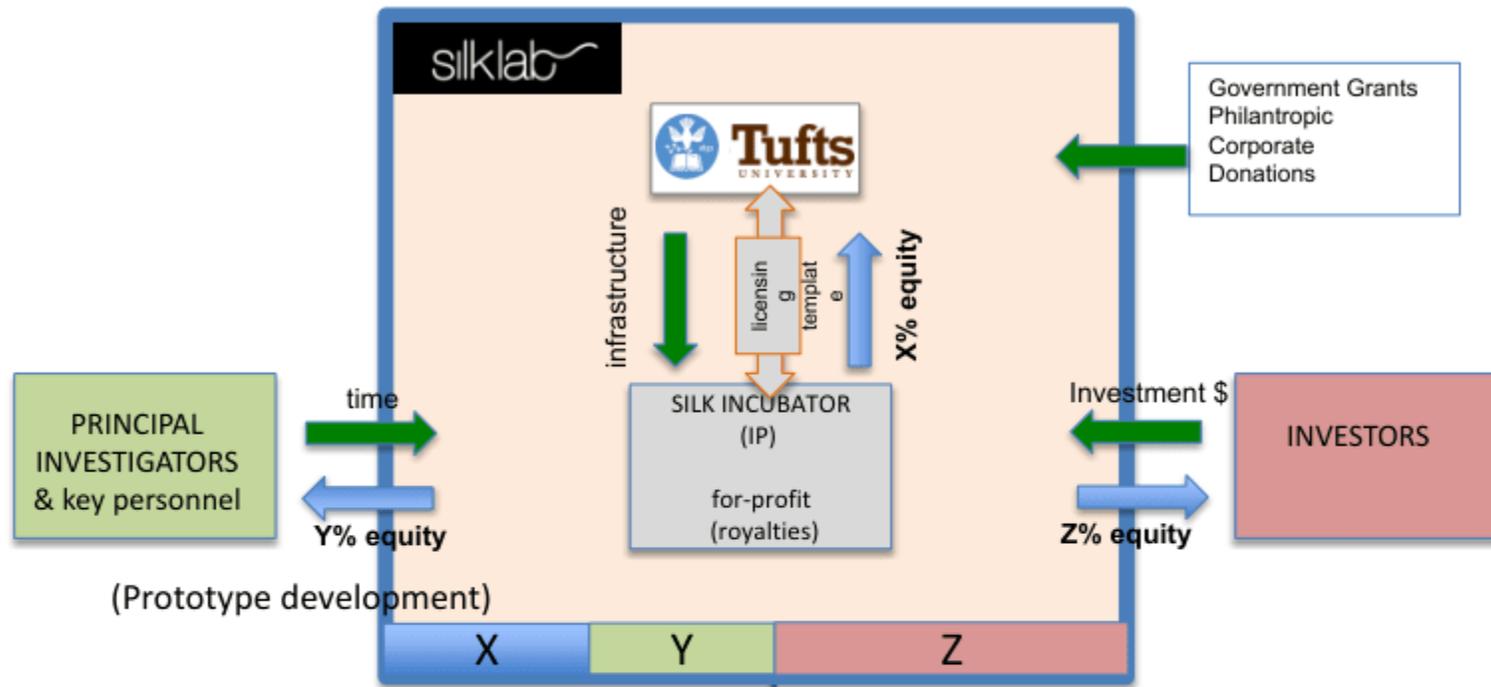


SILK HOLDING COMPANY (II)

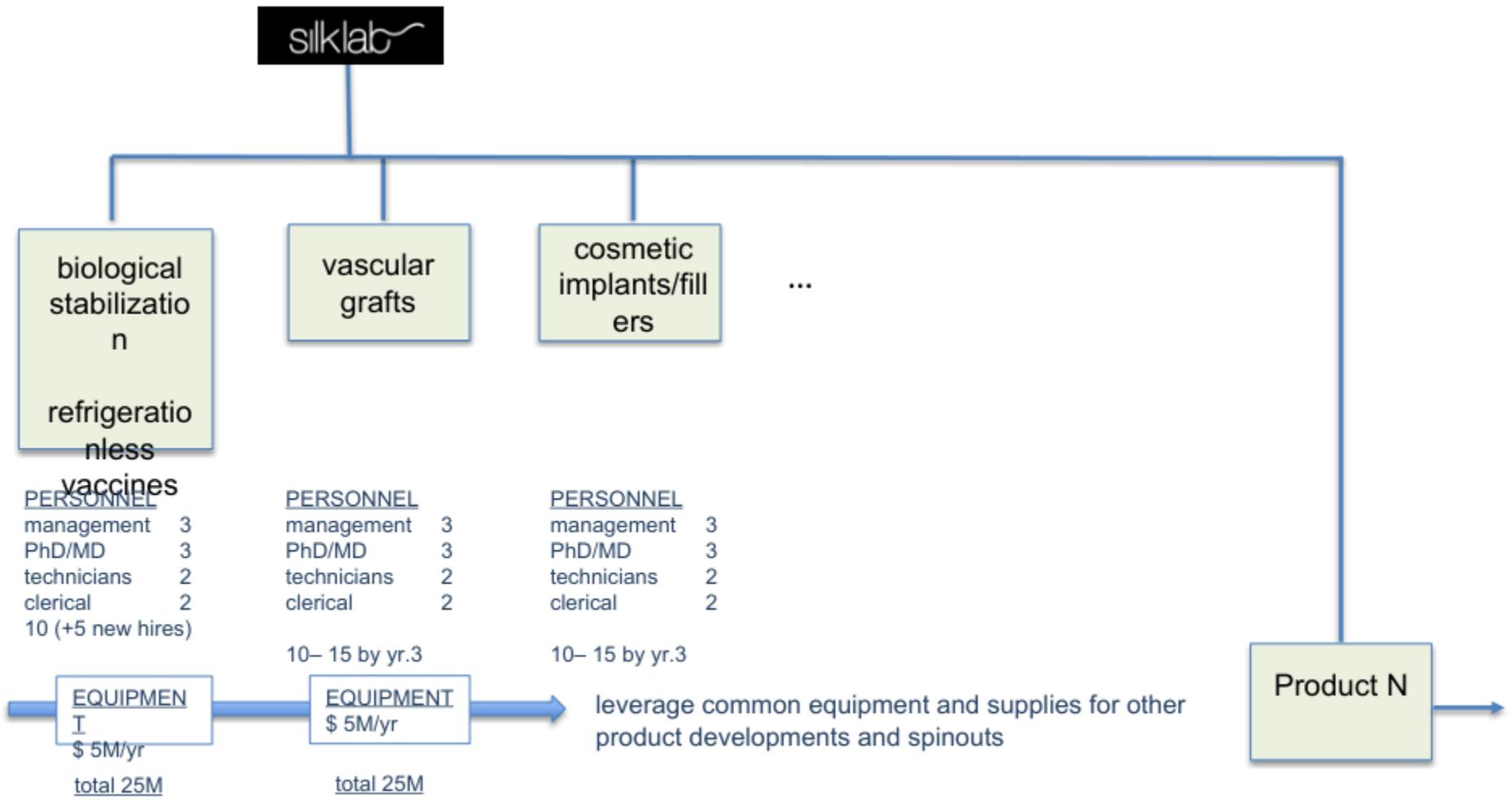
leverage portfolio position and demonstrated prototypes



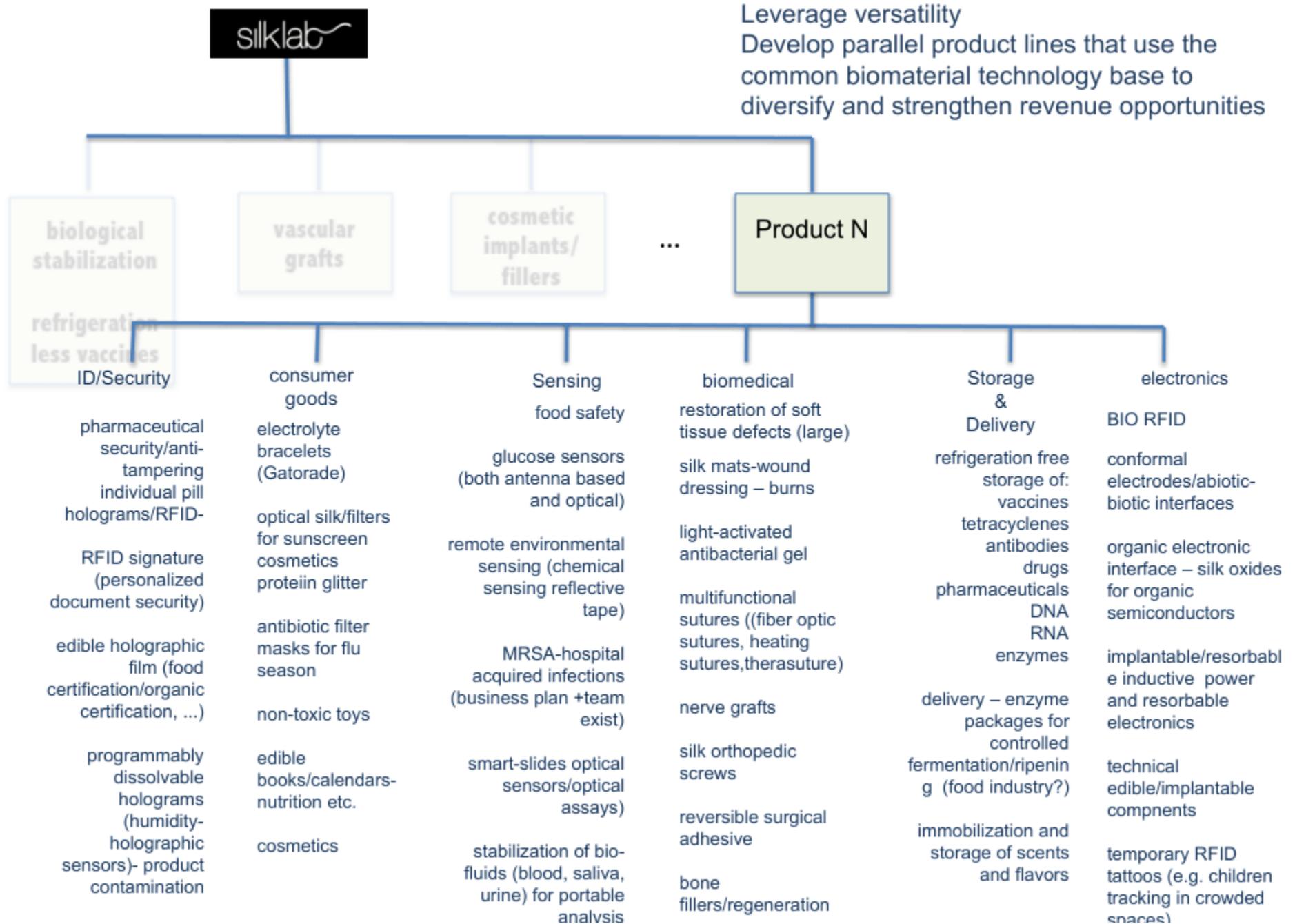
SILK HOLDING COMPANY (III)



SILK HOLDING COMPANY (III)



SILK- TECHNOLOGY TRANSFER AND DEVELOPMENT – BUSINESS OPPORTUNITIE



An argument for a new material platform

Biomaterials have been in use for long in the human body to improve body functions and replace damaged tissues. These biodegradable biomaterials have evolved from biomaterials that do not react with the environment and easily dissolve in the body. Advances in technology and the emergence of innovative biomaterial products have enhanced the performance and applications of these biomaterials. Metals and ceramics dominate the biomaterials market. The global market for biomaterials is expected to **reach \$64.7 billion in 2015** from \$25.6 billion in 2008 with a CAGR of 15% from 2010 to 2015.

Biomaterial markets holds significant opportunity for innovators; an extensive research is required to develop new and improved products at competitive prices. With increase in the percentage of aging population worldwide, the number of individuals suffering from physical disability is also increasing. Baby boomers born between 1946 and 1964 are the major consumers of the biomaterial products. Besides, more than 20% of the global population in 2050 is expected to be over 60 years and this segment (of the population) will be significantly high in developing countries. This increase in the aging population will drive the demand for biomaterial products.