Shape as Media
“Where the sea meets the land, life has blossomed into a myriad of unique forms in the turbulence of water, sand, and wind. At another seashore between the land of atoms and the sea of bits, we are now facing the challenge of reconciling our dual citizenships in the physical and digital worlds.”

Physical -> static, passive and permanent
Digital -> dynamic, active and programmable
Physical  ->  Take on Shapes
Digital   ->  Virtual and Intangible
A Graphical User Interface only lets users see digital information through a screen, as if looking through a surface of the water. We interact with the forms below through remote controls such as a mouse, a keyboard, or a touch screen.

A Tangible User Interface is like an iceberg; there is a portion of the digital that emerges beyond the surface of the water - into the physical realm - that acts as physical manifestations of computation, allowing us to directly interact with the “tip of the iceberg.”

Radical Atoms is our vision for the future of interaction with hypothetical dynamic materials, in which all digital information has physical manifestation so that we can interact directly with it - as if the iceberg had risen from the depths to reveal its sunken mass.

“Radical Atoms” is our vision of human interactions with the future dynamic physical materials that are transformable, conformable, and informable.
How?
Why?
How?
Why?
How?
Fabrication problem.
Mechanical and electrical engineering problem.
Material science problem.
Biological and chemical science problem.

Why?
Interaction problem.
Design and psychology problem.
Multidisciplinary Background - 2013

HCI
[Interaction]

Material Science
[Structure]

AM

Robotics
[Control]

physical/tangible interfaces;
shape changing interfaces;
malleable and organic interfaces;
be flexible, free-form, and
computationally controlled
shape and displays;
haptic feedback;
tunable affordance;

Self-repair;
Feel their surroundings;
Transform themselves;
Adaptive;
Disappear harmlessly, or
transient;
Self-assembly;
Be sustainable...

complying, flexible
and adaptive;
morphology;
“mechanical intelligence”
of soft material;
Integration of material,
structures and softwares;
Multidisciplinary Background - 2014

Biology
- Self-repair;
- Feel their surroundings;
- Transform themselves;
- Adaptive;
- Disappear harmlessly, or transient;
- Self-assembly;
- Be sustainable...

Chemistry
- physical/tangible interfaces;
- shape changing interfaces;
- malleable and organic interfaces;
- be flexible, free-form, and computationally controlled shape and displays;
- haptic feedback;
- tunable affordance;

Material Science
- [Structure]

Robotics
- [Control]
- complying, flexible and adaptive;
- morphology;
- “mechanical intelligence” of soft material;
- Integration of material, structures and softwares;

HCI
- [Interaction]
Robotics
(Hard Mechanism)
Swarm
Programmable Matter (Self-replicating, self-reconfigurable)

Hod Lipson. Creative Machine Lab

Modular Robotics Labs at The University of Southern Denmark
Linkage and Automata
Robotics
(Soft Mechanism)
compressed air actuates the gripper
### Note - Program Material Behavior

<table>
<thead>
<tr>
<th>Applied Stimuli</th>
<th>Material Composition</th>
<th>Computation Principles</th>
<th>Material Geometry and Structure</th>
<th>Shape Change Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uniform Internal: Current</td>
<td>3 sections of Nitinol coil annealed at different temperature: 370°C, 480°C and 630°C.</td>
<td>Each segment expands and contracts at different current.</td>
<td></td>
<td>Micro muscle robot[5]</td>
</tr>
</tbody>
</table>
Robotics
(Folding and Linkages)
Note - Embedding control logic in fabrication

Science 8 August 2014:
Vol. 345 no. 6197 pp. 644-646
Note - Embedding control logic in control
Design
Carpal Skin: Wrist Splint

Neri Oxman
HygroSkin: Meteorosensitive Pavilion

Achim Menges
Oliver David Krieg
Steffen Reichert

Institute for Computational Design, Stuttgart
Shape-Shifting Wood, Carbon Fiber and Plastics Materials

Skylar Tibbits,
Self-Assembly Lab, MIT
Note - Design Anisotropy

Nature creates function and transformation by combining pre-defined structure and passive force. The heterogeneous distribution of material (a pre-defined structure) gives us the opportunity to shift the controllability from the external forces to the material construction.
Material Science
The Bertoldi Group @ Harvard
understanding the non-linear response of materials and structures.

Note: Structures design of soft material such as elastomer. The careful design may lead to materials with unusual properties such as negative Poisson’s ratio. can be used for soft robot design.

Other application: tunable phononic crystals; color display; complex structures.

they have been using extensively computer simulation before fabrication.
The Bertoldi Group @ Harvard
Bio-inspired Optics: color-tunable photonic fiber

Mathias Kolle
Alfred Lethbridge
Moritz Kreysing
Jeremy J. Baumberg
Joanna Aizenberg
Peter Vukusic
Note - Shape Across Scales

Shape at the invisible scales creates functions, properties of a material.
Computational Fabrication
Spin-It: Optimizing Moment of Inertia for Spinnable Objects

Moritz Baecher (Disney Research Zürich)
Emily Whiting (ETH Zürich)
Bernd Bickel (Disney Research Zürich)
Olga Sorkine-Hornung (ETH Zürich)
Boxelization: Folding 3D Objects into Boxes

Yahan Zhou (Disney Research Boston)
Shinjiro Sueda (Disney Research Boston)
Wojciech Matusik (Massachusetts Institute of Technology)
Ariel Shamir (Disney Research Boston/The Interdisciplinary Center, Herzlia, Israel)

Figure 1: Folding a car into a cube. Our system finds a collision-free folding sequence.
Pteromys: Interactive Design and Optimization of Free-formed Free-flight Model Airplanes

Nobuyuki Umetani
Yuki Koyama
Ryan Schmidt
Takeo Igarashi
Objects that seem impossible in the physical world.
How?
Fabrication problem.
Mechanical and electrical engineering problem.
Material science problem.
Biological and chemical science problem.

Why?
Interaction problem.
Design and psychology problem.
Shape as media to
afford interaction
create function
inform meaning
represent information
Shape as media to **dynamically**
represent information
afford interaction
create function
inform meaning
Represent information
Afford Interaction

Figure 2: *Dynamic Physical Affordances* transform the UI to facilitate interactions.

Figure 3: *Dynamic Physical Constraints* guides the user by limiting possible interactions.
Create Function
Create Function
Inform Meaning
Shape as media to **dynamically**

represent information
afford interaction
create function
inform meaning
Shape as Media