The Vertical Farm: Keystone Concept to the Sustainable Eco-city
Biosphere

"Cradle to cradle"

Techno-sphere

"Cradle to grave"
Everyone's Birthright:

- 2.3 liters of safe drinking water
- 1500 calories of safe food
The Challenges

Safe and Abundant Water Supply

Food Safety and Security

Engaging Society in Environmental Sustainability

Reducing Dependence on Fossil Fuels
6.8 Billion People

Not including grazing lands
By the year 2050 our species will increase by another 3 billion people. Sources: United Nations Population Division and Population References Bureau, 1993
Agricultural Footprint

6.8 Billion People

+ 3 Billion People

Forecasting Agriculturally Driven Global Environmental Change

David Tilman, et al.

SCIENCE Vol 292—April, 2001
80% of the Earth’s available land is already farmed.
AGRICULTURE

Requires:
- Herbicides
- Fertilizers
- Pesticides

20% of US Fossil Fuel Use

70% of Available Fresh Water

Produces:
- Food
- Agricultural Runoff
Agricultural Runoff is Destroying the World’s Oceans

Percent Increase in TN River Flux

- <10
- 10–20
- 20–40
- 40–60
- 60–80
- >80

Dead Zones

US Floods:
Within 20 years, **80%** of us will live in cities or suburbs.
Can We provide a sustainable, safe and abundant food and water supply for 10 billion people? AND repair Earth’s damaged ecosystems?
We Can If we Want To
The Future of Agriculture: Growing Soilless

Hydroponics

Aeroponics

Drip Irrigation
The Future Is Now

Rice from Japan

EuroFresh Farms, Willcox, Arizona

Lettuce from Tennessee

Tomatoes
Endless Possibilities
<table>
<thead>
<tr>
<th>Variety Is The Spice Of Life</th>
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</thead>
<tbody>
<tr>
<td><strong>Berries</strong></td>
</tr>
<tr>
<td>Blackcurrant</td>
</tr>
<tr>
<td>Blueberry</td>
</tr>
<tr>
<td>Cranberry</td>
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<tr>
<td>Huckleberry</td>
</tr>
<tr>
<td>Loganberries</td>
</tr>
<tr>
<td>Raspberry</td>
</tr>
<tr>
<td>Strawberry</td>
</tr>
<tr>
<td><strong>Bush Vegetables</strong></td>
</tr>
<tr>
<td>Green Bean</td>
</tr>
<tr>
<td>Tomato, beefsteak, campari, plum, cherry, globe</td>
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<tr>
<td><strong>Specialty Crops</strong></td>
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<tr>
<td>Coffee</td>
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<tr>
<td>Grapes</td>
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<tr>
<td>Luffa Sponge</td>
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<tr>
<td>Olives</td>
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<tr>
<td>Sunflower</td>
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<tr>
<td>Wheat Grass</td>
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<tr>
<td><strong>Vine Vegetables</strong></td>
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<tr>
<td>Cucumber</td>
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<tr>
<td>Eggplant</td>
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<tr>
<td>Okra</td>
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<tr>
<td>Squash</td>
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<tr>
<td>Sweet Bell Pepper</td>
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<tr>
<td>Zucchini</td>
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<tr>
<td><strong>Legumes</strong></td>
</tr>
<tr>
<td>Soybeans</td>
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<tr>
<td>Peanuts</td>
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<tr>
<td><strong>Melons</strong></td>
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<tr>
<td>Cantaloupe</td>
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<tr>
<td>Muskamelon</td>
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<tr>
<td>Pumpkin, Watermelon</td>
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<tr>
<td><strong>Root Vegetables</strong></td>
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<tr>
<td>Beet</td>
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<tr>
<td>Belgian Endive</td>
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<tr>
<td>Carrot</td>
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<tr>
<td>Onions</td>
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<tr>
<td>Potato</td>
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<tr>
<td>Radish</td>
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<tr>
<td>Sweet Potato</td>
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<tr>
<td><strong>Grains</strong></td>
</tr>
<tr>
<td>Barley</td>
</tr>
<tr>
<td>Corn, Wheat</td>
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<tr>
<td><strong>Leafy Greens</strong></td>
</tr>
<tr>
<td>Asparagus</td>
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<tr>
<td>Butterhead Lettuce</td>
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<tr>
<td>Broccoli Brussels Sprout</td>
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<tr>
<td>Cauliflower</td>
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<tr>
<td>Celery</td>
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<tr>
<td>Charita Lettuce</td>
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<tr>
<td>Chinese Cabbage</td>
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<tr>
<td>Collared Greens</td>
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<tr>
<td>Estelle Lettuce</td>
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<tr>
<td><strong>Herbs &amp; Spices</strong></td>
</tr>
<tr>
<td>Arugula</td>
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<tr>
<td>Banana Pepper</td>
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<tr>
<td>Bay Leaves</td>
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<tr>
<td>Chile Peppers</td>
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<td>Chervil</td>
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<tr>
<td>Chives</td>
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<tr>
<td>Cilantro</td>
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<td>Cinnamon Basil</td>
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<tr>
<td>Coriander</td>
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<tr>
<td>Curry Leaf Dill</td>
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<td>Fennel</td>
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<tr>
<td>French Tarragon</td>
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<tr>
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<td>Lavender</td>
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<tr>
<td>Lemon Thyme</td>
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<tr>
<td>Marjoram Mint</td>
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<tr>
<td>Opal Basil</td>
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<tr>
<td>Oregano</td>
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<tr>
<td>Parsley</td>
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<tr>
<td>Rocket</td>
</tr>
<tr>
<td>Rosemary</td>
</tr>
<tr>
<td>Sage Sakura Cress</td>
</tr>
<tr>
<td>Thai Basil</td>
</tr>
<tr>
<td>Watercress</td>
</tr>
<tr>
<td>Yellow Pea Shoots</td>
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</tbody>
</table>
Apply these proven indoor agricultural strategies to growing food in buildings located within the urban landscape...

The Result:

Vertical Farming
Advantages of a Vertical Farm

1. NO AGRICULTURAL RUNOFF
2. YEAR ROUND CROP PRODUCTION
3. NO CROP LOSS FROM SEVERE WEATHER EVENTS
4. USES 70% LESS WATER, NO AGRO-CHEMICALS, NO FOSSIL FUELS
5. ALLOWS RESTORATION OF DAMAGED ECOSYSTEMS
Advantages of a Vertical Farm

- Can grow bio-fuels, plant-derived drugs
- Uses abandoned city properties
- Supplies fresh produce for inner city dwellers
- Creates new jobs
- Remediates gray water
Addresses Two Urgent Needs in Distressed Regions of the World

Food

Water

Population with access to safe drinking water (percent of population),

Total in millions under 5 years of age (in thousands)
Figure 1: Location and duration of food emergencies

Source: based on GIEWS (2010).
The Vertical Farm is the centerpiece for creating an eco-city in which all human activities reflect ecological process.
Vertical Farm Tool Box

Hydroponics
Aeroponics
Drip Irrigation
Waste-to-Energy

Automation
Water Re-capture
Passive Energy
LED Lighting
The Sustainable Eco-City
(emplys cutting-edge technologies)

CITY DRINKING WATER

Vertical Farm

CITY ENERGY GRID

Potable Water

Food

Metabolic By-Products (urine, feces)

Energy

Gray Water Remediation

Liquid Municipal Waste

Plasma Gasification

Sludge

Gray Water
Can we actually do any of this??
We are already doing it!
Santa Ana, California

Toilet to Tap: Orange County Turning Sewage Water into Drinking Water
Posted on Mar 14, 2009 by Jennifer Lance in Availability, Drinking Water, Infrastructure, Purification

The Orange County Water District is purifying wastewater into drinking water at a $481 million recycling plant. The plant uses microfiltration, reverse osmosis, ultraviolet light, and hydrogen peroxide disinfection. 70 million gallons of sewer water is treated a day in Orange County, California meeting the drinking needs of over 500,000 people, including visitors to Disneyland.
Port St. Lucie, Florida

1,500 tons of solid municipal waste/day!

Plasma Arc Gasification
Pla(n)tform: An alternative for urban growth

Ori Ronen & Adi Reich

Tel Aviv, Israel
Pla(n)tform: An alternative for urban growth

Ori Ronen & Adi Reich

Tel Aviv, Israel
Field Stacking: 40 acres of crops on 6 levels => 827 tons of fruit and vegetable produce - approximately the consumption of the Neve Sha'anan and part of the Shapira neighborhoods.
<table>
<thead>
<tr>
<th>TITLE</th>
<th>Vertical Farm</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILLUSTRATOR</td>
<td>Gordon Graff</td>
</tr>
<tr>
<td>LOCATION</td>
<td>Toronto, Canada</td>
</tr>
</tbody>
</table>
Vertical Farm
Blake Kurasek
Chicago, IL
TITLE
Vertical Farm

ILLUSTRATOR
Blake Kurasek

LOCATION
Chicago, IL
Embracing the Vertical Food Production Landscape within the Existing Urban Conditions

Vertical integration of the Food Production Landscape into Architecture

We aim to address the need for increased food production in urban areas. By integrating vertical agriculture, we can maximize space usage while reducing transportation and thereby minimizing the carbon footprint associated with food production.

Vertical integration of the Food Production Landscape into Architecture

Incorporating Vertical Farming into Urban Fabric

Vertical integration of the Food Production Landscape into Architecture

By combining vertical farming with urban infrastructure, we can create a sustainable food system that is both efficient and accessible.

Urban farm, urban epicenter

Jung Min Nam

New York City
TITLE
Urban farm, urban epicenter

ILLUSTRATOR
Jung Min Nam

LOCATION
New York City
Urban farm, urban epicenter

Jung Min Nam

New York City
**EVF Prototype**

*Artificial ecosystem which is capable to generate food “producing more than consuming”*

The EVF Prototype is an design to be located in any “highway junctions (“cholvas” in Spanish). This proposal is a tower for domestic consumption (temporarily) into an closed habitat which is protected and controlled by artificial systems used to plants growth. The main design is planned from photosynthesis and cellular breathing; we can really understand this prototype as a organism made up to natural cycles and processes; not like a performing building.
**Crop Unit**

Mixed use, radially structured, a unit where biological functions and social, light and air are shared. The project uses 'radial habitats', a place where vegetables 'tree up'.
Technology
Matters and natural flows as design elements: building as a “living environment”

The crop unit emerges from reflections between critical factors which make vegetable/tribal maintenance an viable environment: air, humidity and sunlight. We don’t understand matter and energy flows like natural resources which feed the building. In fact, this lesson tells the operative program and building function.

Central core: is the soil core where are made shaps to liquid pumping from water pumps, modular facilities, shade, curtains and recharge.

Crop areas: Continuous area treated at different heights, like an island. This actor allows water filling to create crops by water fall, and then keeps a continuous air flow and diffuse light between levels.

Greenhouse shells: From laser cut to shell concrete right, ventilation, temperature and humidity.

Humidity
Evaporative water runs up by water pumps, free water flows by pores by evapotranspiration, without energy consumption. It’s possible because of the spiral from lower levels. The perimeter of the walls can catch water from evaporation – intersection from indoor vegetables to recycle.

TITLE
Experimental Vertical Farm

ILLUSTRATOR
Claudio Palavecino Llanos

LOCATION
Santiago, Chile
Museum of Science and Industry

Chicago, IL
Vertical Farm Model Team

DESIGNERS
Vertical Farm Model Team

LOCATION
Chicago, IL.
First Create a Prototype
Grade School Vertical Farm Project

Tom's Students
A Special Thanks to All My Students

2004
Anisa Buck
Daniel Dine
Stacy Goldberg
Vani Gulate
Vivek Iyer
Ben Jacob
Eugene Kang
Roger Kim
Jennifer Montes
Pearl Moy
Anita O’Connor
Katerina Paraskevas
Rebecca Tatum
Carrie Teicher
Janice Turner

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Kristen Coates
Stephen Lee
Maribeth Lovegrove
Michelle Robalino
Theodora Sakata
Dennis Santella
Sapna Surendran
Kelly Urry

2006
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Jasmine Beria
Kenneth Chamber
Elizabeth Del Giacco
Leslie-Anne Danielle Fitzpatrick
Bryan Joshua Garber
Greg Gin
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Rory E. Mauro
Jun Michjael Mitsumoto
Natalie Neu
Ivan Ramirez
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Kathleen Ann Roosevelt
Jordana Rothschild
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Sonia Demitrie Toure
Athina Vassilakis

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Matthew Peter Bussa
Caroline Carnevale
Yana Chervona
Richele Lynn Corrado
Manisha Daswani
Jonathan Gass
Moshen Ghaneifar
Kahterine Gifford
Sookyung Ham
Jongjin Jo
Dianna Jones
Steven Kauh
Raeya Khan
Danielle Kontovas
Cynthia Lendor
Jason Light
Kevin Lo
Diego Lopez De Castilla

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Claudia Cujar
Geoffrey Garst
Erica Hahn
Schuyler Henderson
Carolyn Hettrich
Yuki Kaneda
Chris Karamapahtsis
Hannah Kellogg
Mateusz Kruk
Gilma Mantilla
Karl Minges
Christopher Ovanez
Johanathan Stettin
Sarah Wishnek

Chrisytopher Martin
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Yalini Senathirajah
Timon Tai
A Special Thanks to All My Students (cont’d)

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Yanjeska Lescaille
Sara M. Miller
Jonathan P. Salud
Alexander T. Sonneborn
Naomi J. Sorkin
Sunny Uppal
Alexander T. Varga
Kate R. Weinberg
Daniel Yagoda
Zahira Zahid

2010
Juilee Prakash Barde
Jonathan Remy Camuzeaux
Michelle T. Chuang
Offira Shuly Gabbay
Elizabeth Ellen Hornyak
Lea Kiefer
Freda Robyn Laulicht
Allison Michelle Martineau
Genevieve Sophia Slocum
Ida Hui Suen
Iesha Wadala
Patrice Adele
It’s time to stop talking...

...and START DOING!
Save Water
Farm Smart
Help Keep Our Blue Planet Green!
Thank You!