SCALES OF ENVIRONMENT | DESIGN FOR UNCERTAINTY

Advanced Studio 4
Columbia University Graduate School of Architecture, Planning and Preservation
Critic: David Benjamin

OVERVIEW

In March of 2014, The Atlantic published 18 stunning photos of a newly-opened solar thermal power project called Ivanpah in the Mojave Desert. The photos showed three 40-story towers surrounded by a sprawling landscape of rotating mirrors. Each mirror tracked the sun and reflected light to the top of the towers where steam drove turbines and generated solar energy. The scale of the project was described with numbers—347,000 heliostats, 800 degrees Fahrenheit, 392 megawatts, 140,000 homes, $2.2 billion—but it was best captured in images. The final image of the series revealed two beacons from below: a glowing otherworldly solar receiver stood in contrast to a traditional dark smokestack. The message was unmistakably future-oriented and optimistic.

A month later, The Atlantic published another article about Ivanpah. This one cited a preliminary report from the National Fish and Wildlife Forensics Laboratory about the impact of the new project on birds: "It appears Ivanpah may act as a 'mega-trap,' attracting insects which in turn attract insect-eating birds, which are incapacitated by solar-flux injury, thus attracting predators and creating an entire food chain vulnerable to injury and death." Apparently, some birds were catching fire in mid-air, and editors at The Atlantic could not resist using a shocking headline: "How to Stop Solar-Power Plants From Incinerating Birds." A few months later The Associated Press ran a similar article with the headline "Emerging Solar Plants Scorch Birds in Mid-Air." The AP article included a statistic about one bird dying every two minutes, and a striking image of a dead MacGillivray's Warbler with singed, unnaturally curled feathers. The numbers, the image, and the message had taken a dark turn.

Some environmentalists, as well as supporters of fossil fuel, called for the Ivanpah project to be halted. But several scientists and writers provided a counter-argument with different numbers, both disputing the number of birds killed by Ivanpah and noting that far more birds are killed each year by fossil-fuel plants (24 million) and windows (988 million). The dual statistics—one bird every two minutes vs. 24 million birds every year—outlined the big picture, while the dual images—futuristic energy towers vs. singed bird wings—made the debate more vivid.

The ongoing story of Ivanpah is a fascinating case study of environment and technology in the 21st Century, and it stakes out the territory of Scales of Environment: an architecture studio that engages environment, technology, buildings, infrastructure, landscapes, ecosystems, food chains, numbers, images, stories, values, trade-offs, nature, and climate change. Although this studio will not work directly with power plants or the desert, we will design in the context of similarly complex and interconnected systems and issues. The studio will interrogate several emerging frameworks related to themes of environment and technology, including the Circular Economy, Antifragility, and Hyper Nature. The studio will also examine a range of design approaches, including multi-scalar design, new materials, and new software techniques. Within this context, the studio will work on public schools and public water bodies. Over the course of the semester, we will generate proposals that are both quantitative and qualitative. We will produce metrics, narratives, and images. We will design rules rather than fixed forms.

Images (top to bottom): Buckminster Fuller World Game; Ivanpah Solar Power Facility (Photo by Ethan Miller); Post-processing of optimization data (Benjamin Advanced Studio 5, Danil Nagy); MacGillivray's Warbler killed at Ivanpah (Via National Fish and Wildlife Forensics Laboratory) ; Experiment with growth of mycelium material and wheatgrass (Benjamin Studio 5, Peter Hunt); Ivanpah Solar Power Facility (Photo by Ethan Miller).
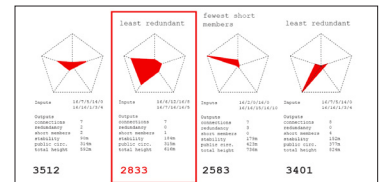
We will anticipate rapid change. And we will welcome shifting forces, unknowable crises, and uncertainty.

THE CIRCULAR ECONOMY

The Circular Economy is an emerging concept for a new era of design across multiple industries. This concept is based on creating ecosystems with two types of nutrients: biological nutrients that are designed to circulate without unhealthy waste products, and technical nutrients that are designed to circulate at high quality without material impact. The Circular Economy promotes renewable energy and materials with low embodied energy, but it also involves a broader range of open source scientific projects and solutions that are healthy in terms of environment, finance, and society. A recent report by the World Economic Forum explains, "In a world of close to 9 billion—including 3 billion new middle-class consumers—the challenges of expanding supply to meet future demand are unprecedented. Our current 'take-make-dispose' approach results in massive waste, and in the fast-moving consumer goods sector about 80% of its $3.2 trillion value is lost irrecoverably each year. The switch from a linear to a regenerative circular economy provides credible and quantified perspectives to address this generational challenge. Ultimately the circular economy could decouple economic growth from resource consumption—truly a step-change." In this context, could we similarly aim to decouple building construction from resource consumption? How might we design buildings, landscapes, and cities as part of regenerative circular economies? Should the domain of architecture expand over space and time to incorporate global supply chains and recycling/composting of construction material? How should agency and responsibility be shared in this context? What are the social, political, and economic levers that designers might pull?

ANTI-FRAGILITY

In the context of climate change, resilient systems have become appealing as a model for design with shifting forces, unknowable crises, and uncertainty. In response to Hurricane Sandy, multiple parties—including politicians, community groups, environmental activists, urban planners, architects, engineers, and the general public—are seriously considering resilient design as a strategy for rebuilding and resisting future damage. Yet some people argue that resilient systems are not enough. While resilient systems are defined as recovering quickly from stress, "antifragile" systems are defined as thriving and improving under stress. Nassim Nicholas Taleb, who developed the concept, states: "Antifragility is beyond resilience or robustness. The resilient resists shocks and stays the same; the antifragile gets better. This property is behind everything that has changed with time: evolution, culture, ideas, revolutions, political systems, technological innovation, cultural and economic success, corporate survival, good recipes . . . the rise of cities, cultures, legal systems, equatorial forests, bacterial resistance . . . even our own existence as a species on this planet." But is the concept of antifragility useful for architecture? Is it possible to design antifragile buildings, landscapes, and cities? How might we design with inherently dynamic ecological processes? How might our design strategies incorporate risk and change?
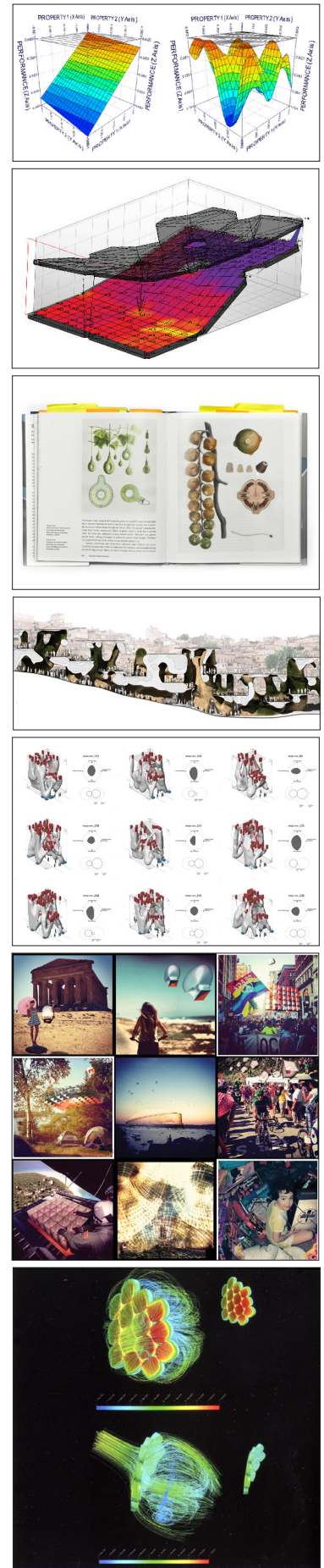
Images (top to bottom): Multi-modal distribution diagram representing complexity of design space (Benjamin Studio 4); Metric vision (Benjamin Studio 5, Adam Brillhart); Photo of Synthetic Aesthetics: Investigating Synthetic Biology's Designs on Nature *(MIT Press, 2014); Analog topology optimization at large scale as community space (Benjamin Studio 5, Lorenzo Villaggi); Same; Future architecture with distributed aggregations of cells (Benjamin Studio 5, Ray Wang and Jim Stoddart); Fluid dynamics analysis of complex brick assembly (Defne Sunguroglu).*

HYPER NATURE

If the Twentieth Century was the Century of Physics, then the Twenty-First Century is the Century of Biology. Biological technologies are advancing exponentially. In the past ten years, it has become possible observe living systems in new ways through high-resolution imagery, to create computer models of biological cells, to cut and paste DNA, and to combine biological functions such as growth, movement, sensing, deposition, regeneration, and self-healing into new organisms that never existed in nature. These developments allow us to imagine and design a new form of nature—a hyper nature. This concept of nature blurs old distinctions between the artificial and the natural. It engages the term Anthropecene as a definition for human impact on the earth's natural ecosystems and geology. Hyper nature involves biology, the environment, engineering, computation, and the problems and technologies of our times. But this concept is not limited to the technical realm. According to the publication Next Nature, "Hyper nature is culture in disguise." Yet what is new about the concept of hyper nature, and what is simply a rebranding of well-worn ideas? What is the architecture of hyper nature? Can we harness biology for design without fetishizing it? Is it possible to "collaborate" with natural systems and derive hypernatural designs that humans alone—or nature alone—could never create?

SCALES OF ENVIRONMENT

The studio will operate at multiple scales simultaneously. Over the course of the semester, we will rethink materials, buildings, site plans, infrastructures, and global flows of raw materials and energy. We will look at new multi-scalar paradigms that include robust biological and social dynamics, energy generation, and adaptability. We will work on reinventing design ecosystems, global supply chains, financial performance metrics, and the way we design and manufacture everything. We will explore design from the scale of material composition at about 10^-9 meters to the scale of global production at about 10^7 meters—a spectrum of 16 powers of ten in the same project.

PHYSICAL EXPERIMENTS: NEW MATERIALS

In the Circular Economy, flows of raw materials and energy are composed to create healthy ecosystems. One inspiring example is mycelium-based materials that are grown from waste. This "low-tech biotech" approach makes use of agricultural byproducts and living organisms to produce useful objects. The process starts by mixing together chopped-up corn stalks and mycelium and placing them in a mold of any shape. In five days the mixture grows into a solid object. The physical object is similar to Styrofoam, but it involves almost no waste, no energy required for manufacturing, and no carbon emissions. In addition, the object is completely biodegradable and compostable. Styrofoam and other petroleum-based plastics take hundreds or thousands of years to decompose. Mycelium material returns to earth in 60 days. Petroleum-based plastics are linear. Mycelium material is circular.

In a broader sense, this demonstrates how living organisms can become healthy factories for large-scale manufacturing. Energy consumption can be reduced. Manufacturing waste can be nearly eliminated. Equipment from Industrial Revolution-era manufacturing can be retired. And new objects, buildings, and cities can be imagined.

Images (top to bottom): Mycelium growth shown under a microscope (Ecovative Design); Mediated Matter (Neri Oxman, MIT Media Lab); Automated design space exploration of paths for robots and people (Benjamin Studio 5, Thomas Wegener); Growing fabric via bacteria (Suzanne Lee, Biocouture); Growing bricks via bacteria and sand (Ginger Krieg Dosier, bioMason); Meat grown in a laboratory (Modern Meadow); Growing fabric via bacteria (Sarine Zaken).
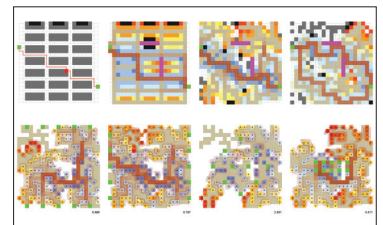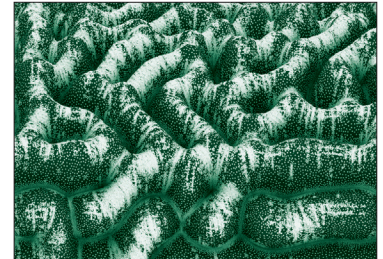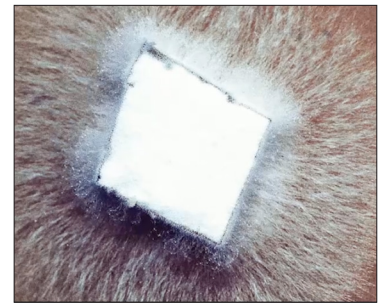
In this studio, we will create physical prototypes with mycelium materials and other bio materials that are circular, antifragile, and hypernatural. During the semester, we will visit the research and manufacturing facilities of pioneering mycelium materials start-up, Ecovative Design. We will learn from the latest R&D and collaborate with Ecovative on new possibilities for the future. We will also connect to Material Connexion through their recent work on "grown materials"; ETH Zurich Future Cities Lab through their recent work on "building from waste"; and Synbiobeta and Modern Meadow through their recent conference called Biofabricate.

## DIGITAL EXPERIMENTS: NEW SOFTWARE

Recent advances in cloud computing, digital simulation, and data science offer new design tools for the Circular Economy, antifragility, and hyper nature. In this studio, we will explore generative geometry, scripting, performance analysis, multi-objective optimization, and biological algorithms. More specifically, we will push the limits of the specific software packages of Rhino, Grasshopper, Galapagos, and Dynamo. We will also utilize and explore new custom academic software applications for modeling, simulation, optimization, and data processing.

We will use software to investigate data, to explore a very wide potential design space, to minimize our preconceptions, to avoid relying on old rules of thumb, to derive unexpected high-performing results, and to negotiate between competing architectural values. For our purposes, computation and optimization will not be about achieving cold-blooded efficiency—but rather it will be about enhancing our creativity. Yet while this studio will explore new frontiers of design and computing, no prior experience with software is necessary.

METRICS + NARRATIVES + IMAGES

Metrics are inextricably related to climate change and our understanding of the natural environment. They are also entwined with almost everything about our current world. Metrics drive public health, personal health, election polling, global supply chains, search engines, social networks, and computer simulations of everything from airplane flights to hurricane paths to crowd behavior. Writers Michael Blastland and Andrew Dilnot declare, "For good or ill, numbers are today's preeminent public language—and those who speak it rule." But while numbers are more available and more important than ever, in many ways our understanding and use of them is confused and unimaginative.

In this studio, we will consider how architecture might be defined by an ecology of numbers—an ebb and flood of input numbers and output numbers. But we will also explore aspects of architecture and the environment that are difficult to quantify. We will engage theory, culture, and aesthetics. We will recognize that dealing with complex and urgent issues requires qualitative approaches as well as quantitative approaches. In a recent New York Times essay called "Are We Missing the Big Picture on Climate Change?" Rebecca Solnit explores the complexity of ecosystems, including the case of the Ivanpah solar power project, and she argues, "Addressing climate [change] means fixing the way we produce energy. But maybe it also means addressing the problems with the way we produce stories." As architects, we might add that addressing climate change means addressing problems with the way we produce images. With this in mind,
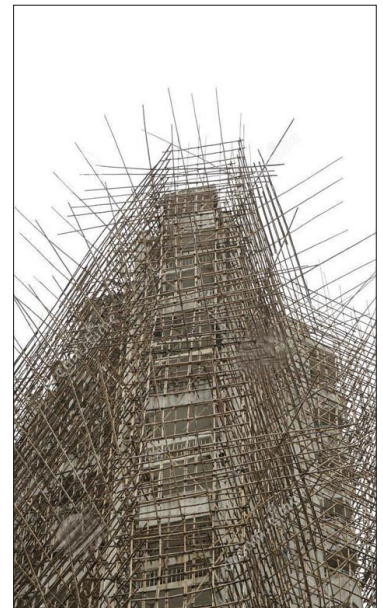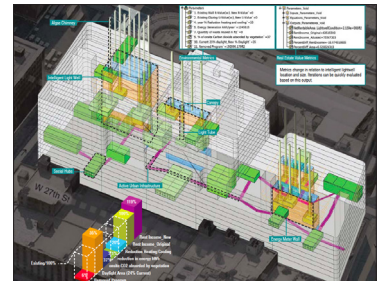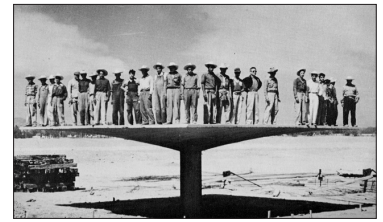
Images (top to bottom): Testing new form and fabrication (Felix Candela); Reinforced wood wool cement (Dutch Design Initiative); Cloud computing facility; Design dashboard metrics (CBIP Studio 4, Kooho Jung); Innovation Center and Pilot Factory in Campinas, Brazil (Benjamin Studio 5, Casey Worrell); Visualization of continually evolving London Organic Skyscraper (Agence Chartier Corbasson).

our studio will explore a nuanced combination of designing with metrics, designing with narratives, and designing with images.

PUBLIC SCHOOLS AND PUBLIC WATER BODIES

Climate change is a public issue, and this studio will address climate change through the architecture of public schools and public water bodies. In an expanded definition of education, we will explore school as a framework for communities and collectives. We will investigate estuaries and cities as classrooms. We will apply to schools the concepts of the Circular Economy, antifragility, and hyper nature. And we will consider how schools might provide an education for a future informed by these concepts.

Our base will be New York Harbor School. This forward-looking New York City public high school is based on Governors Island and it builds college-preparatory education and professional training around issues of water and the environment. The School focuses on marine science, marine technology, and marine policy, and 100 students per year graduate as experts in everything related to New York Harbor. In this studio, we will propose an expanded and future-oriented campus for the School as a model for innovation within the public school system. We will engage both the traditional classroom and an expanded waterfront as classroom. We will engage both the traditional campus and an expanded city as campus. We will think about the future, and design for the present, encompassing new models of environment and technology into our projects, and producing visionary and viable buildings.
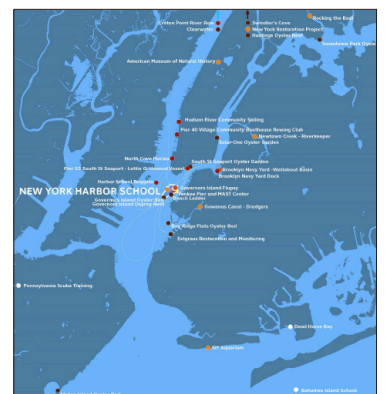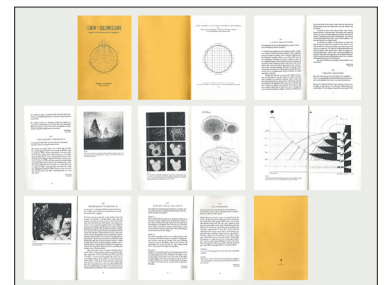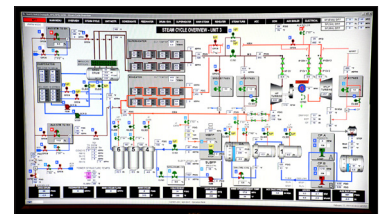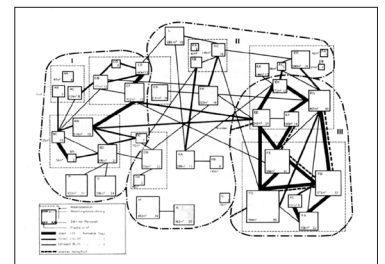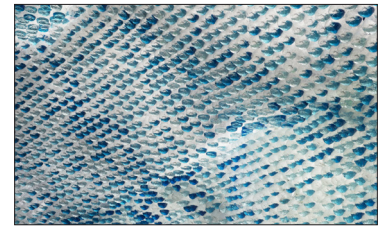
Images (top to bottom): Canopy made of recycled bottles (Head in the Clouds, by STUDIOKCA); Metric vision (Architectural Geometry textbook); Organizational interaction diagram (Quickborner); Control software for Ivanpah Solar Power Facility (Photo by Ethan Miller); Future architecture with distributed aggregations of cells (Benjamin Studio 5, Ray Wang and Jim Stoddart); Map of New York Harbor and New York Harbor School (via Kate Orff); Governors Island, New York City.