DESIGN FOR UNCERTAINTY | ENVIRONMENT, ENTREPRENEURSHIP, AND EMERGING TECHNOLOGIES

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

OVERVIEW

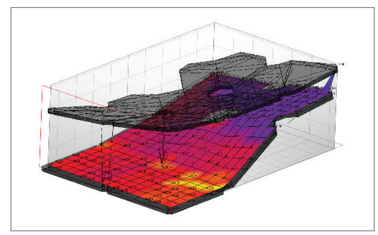
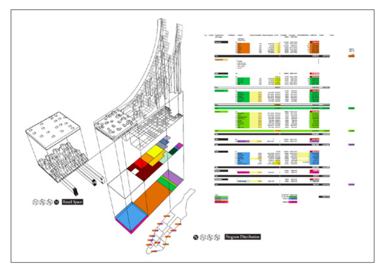
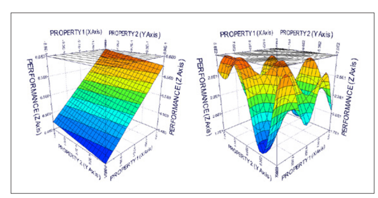
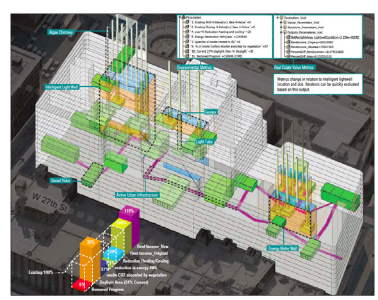
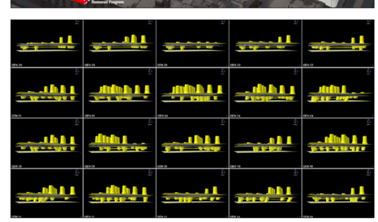
In May of 1997, the world's best human chess player, Garry Kasparov, sat down to play the world's best computer, IBM's Deep Blue. Ten years before, Kasparov had boasted, "No computer can ever beat me." But the recent progress of computation seemed impressive and potentially game-changing. In the lead-up to the competition, the battle had been dubbed Ali-Frazier.

Near the end of the first game, in the forty-fourth move, Deep Blue a made highly unusual play, sacrificing a rook while ahead, which seemed to hint at a sophisticated strategy of preventing countermoves. Kasparov was rattled. He could not comprehend why the computer made the move, and he feared that it demonstrated a superior intelligence. The game ended in a draw, but at the beginning of the next game, Kasparov made an unprecedented error, and Deep Blue went on to win the epic battle. According to a report in Wired Magazine, "The chess world found it devastating. 'It was too much to bear,' said grandmaster Yasser Seirawan. The cover of Inside Chess magazine read 'ARMAGEDDON!'"

In 2012, long after computers asserted their dominance in chess, one of the inventors of Deep Blue revealed that the fateful forty-fourth move had been due to a software bug. According to writer Nate Silver, "Unable to select a move, the program had defaulted to a last-resort fail-safe in which it picked a play completely at random… Kasparov had concluded that the counterintuitive play must be a sign of superior intelligence. He had never considered that it was simply a bug." In the end, the computer won not because of an innovative strategy, but because the human was prone to worry and doubt and self-destruction. The human assumed that machine intelligence worked like human intelligence—and therefore the unusual move must have been a rational strategy. But the computer had a different intelligence altogether, one that was subject to bugs but not subject to weariness or worry. Neurologist Robert Burton elaborates, "The ultimate value added of human thought will lie in our ability to contemplate the non-quantifiable… Machines cannot and will not be able to tell us the best immigration policies, whether or not to proceed with gene therapy, or whether or not gun control is in our best interest." In other words, since machines cannot worry, and since worry and doubt are productive in creating humanistic, fair solutions to the problems of our time, humans will never be replaced by machines. Perhaps the most instructive message of the chess battle is that humans and machines should not be paired for competition, but instead they should be matched for collaboration, where each species of intelligence can complement the other.

This ongoing story of humans and machines is a fascinating case study of technology in the 21st Century, and it sets the stage for Design for Uncertainty: an architecture studio that engages technology, environment, buildings, infrastructure, landscapes, ecosystems, numbers, images, stories, values, trade-offs, nature, and climate change. The studio will combine technology with environment. It will explore the latest generation of machines, robots, and artificial intelligence—and it will interrogate several emerging



Images (top to bottom): ETH Zurich D Fab Arch Lab by Garmazio and Kohler; Chess match between Kasparov and Deep Blue (via Wired); Metric vision drawing (Benjamin Studio 5, Adam Brillhart); Exloration of design space through program data (Benjamin Studio 6, Troy Therrien); Visualizations of simple and complex design space; Design dashboard metrics (Benjamin Studio 4, Kooho Jung); Matrix of design solutions (Benjamin Studio 6, John Locke).

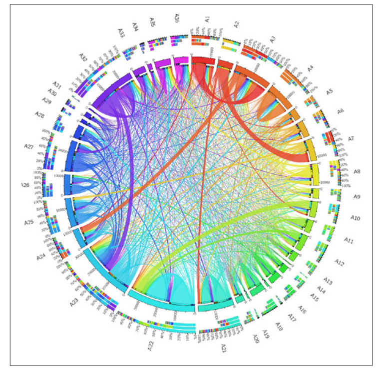
frameworks related to themes of environment and technology, including the Circular Economy, Antifragility, and Hyper Nature. The studio will also examine a range of design approaches, including multi-scalar design, new materials, and new software techniques. Within this context, the studio will work on architecture for education, entrepreneurship, and 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. We will anticipate rapid change. And we will welcome shifting forces, unknowable crises, and uncertainty.

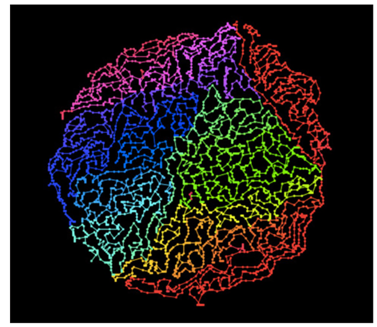
THE CIRCULAR ECONOMY

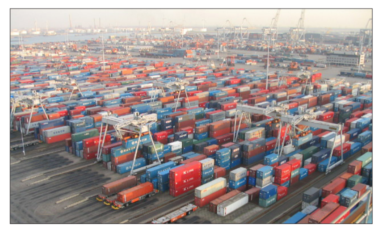
The Circular Economy is an emerging concept for a new era of design across multiple industries. This concept is based on creating ecosystems with two types of nutrients: biological nutrients that are designed to circulate without unhealthy waste products, and technical nutrients that are designed to 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?

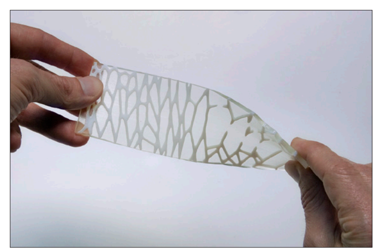
ANTI-FRAGILITY

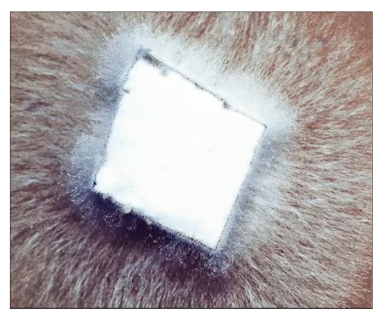
In the context of climate change, resilient systems have become appealing as a model for design with shifting forces, unknowable crises, and uncertainty. In response to Hurricane Sandy, multiple parties—including politicians, community groups, environmental activists, urban planners, architects, engineers, 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

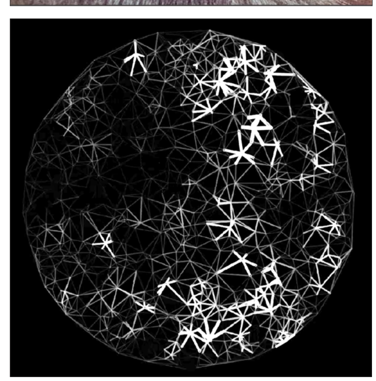












Images (top to bottom): Diagram of Circular Economy in Portugal (via MM & Random Thought); Data visualization of bacterial colony growth (Columbia Advanced Data Visualization Project, Danil Nagy); Pre-Circular Economy Global Supply Chain; Multi-material 3D print of new composite sheet (Bio Computation, The Living); Mycelium growth (Ecovative Design); Data visualization of animated hair (Columbia Advanced Data Visualization Project, Danil Nagy, Eitan Grinspun, David Benjamin).

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?

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, and infrastructures. We will look at new multi-scalar paradigms that include robust biological and social dynamics, energy generation, and adaptability. We will explore design from the scale of material composition, including molecules with a diameter of about 10^-9 meters, to the scale of global production, including the earth with a diameter of about 10^7 meters—16 powers of ten in the same studio.

EMBODIED ENERGY

The studio will engage the flow of energy and resources through the lens of embodied energy. Embodied energy—defined as the sum of all energy required to produce, transport, assemble, and dispose of any product or building element—is an important feature of architecture, but it is currently not well documented or easy to act upon. Many architects talk about embodied energy but they do not have a good way to measure it or design with it. It is well known that buildings account for a large percentage of energy consumption and carbon emissions—and by extension, architecture is playing a large role in climate change. When considering a breakdown of energy consumption in buildings, embodied energy accounts for a rapidly increasing percentage (while operational energy accounts for a declining percentage). This makes embodied energy an increasingly important topic. In April 2016, Columbia GSAPP will host the first major international symposium to investigate embodied energy from a design perspective. This event aims to uncover key questions, issues, and opportunities for the field of architecture. Our studio will contribute to this event by conducting research on materials and creating "material

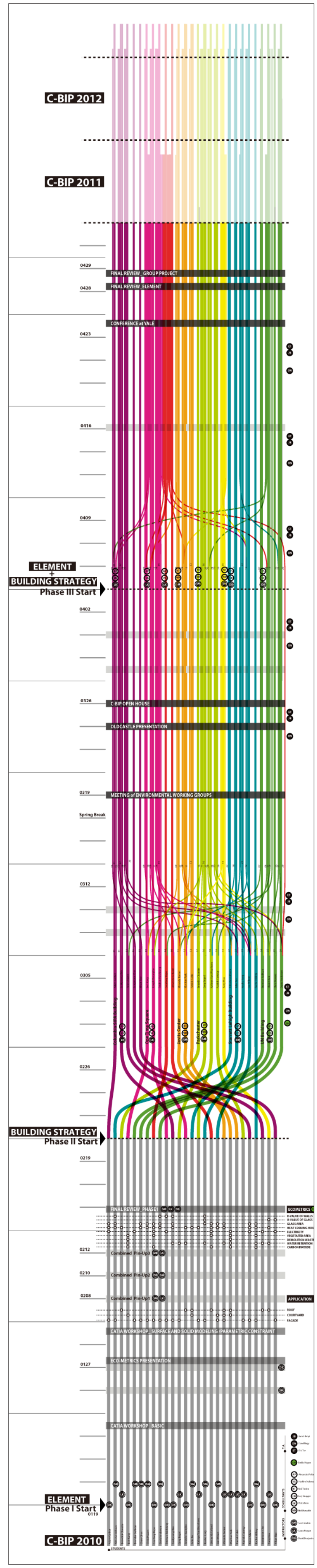


Image: Collaboration diagram (Benjamin Studio 4, Muchan Park).

stories" that reveal the complexities, challenges, and opportunities for design with embodied energy.

PHYSICAL EXPERIMENTS: NEW MATERIALS, A.I., AND ROBOTICS

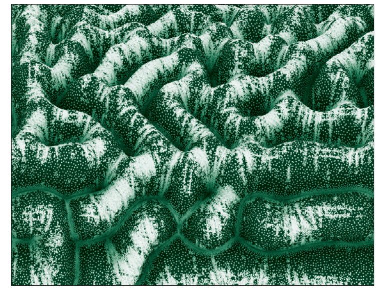
This is a hands-on studio, and we will apply our concepts to physical and digital designs and prototypes. Our physical experiments will combine our thinking about embodied energy, raw materials, re-use, and waste with old and new technologies for making. More specifically, this studio will work with a new "friendly robot" at GSAPP that points to a new era of human-machine collaboration. Students will develop systems to use robotics not just for top-down precision fabrication, but also for bottom-up feedback-based assembly. In collaboration with Ryan Johns and the GSAPP class "Assembling All Sorts," we will learn to program the Universal Robots UR3 and design systems for processing and constructing prototypes with salvaged materials. We will program the robot with rules rather than forms. We will rely on the robot's sensors to capture real-time information, and we will experiment with its ability to adapt and learn over time as a new form of artificial intelligence. We will create novel design ecosystems that combine high-tech and low-tech, digital and physical, control and emergence. We will engage advanced robotics as well as messy found materials. We will explore the next generation of robotics in architecture, as it tackles complexity, feedback, and machine learning. And at the same time, we will engage a return to craft and multi-material physical prototypes.

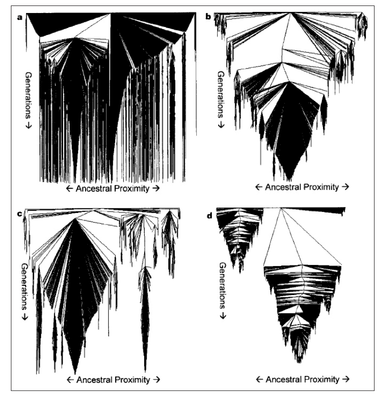
DIGITAL EXPERIMENTS: NEW SOFTWARE AND GENERATIVE DESIGN

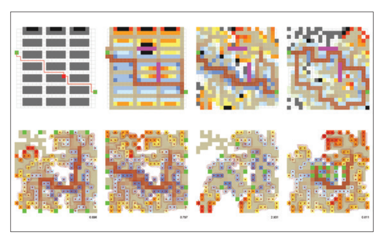
Our digital experiments will build off of our physical experiments and explore the emerging framework of generative design. This framework relies on recent advances in cloud computing, digital simulation, and data science. It involves designing goals and constraints (as opposed to designing formal solutions), and using automation to generate, evaluate, and evolve thousands or tens of thousands of designs. With this framework, 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. It will be about discovering possibilities that a human alone—or a computer alone—could never produce. Yet while this studio will explore new frontiers of design and computing, no prior experience with software is necessary.

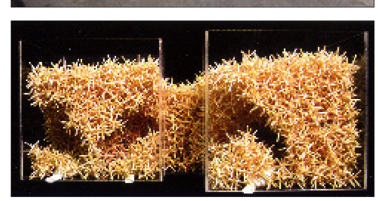
METRICS + NARRATIVES + IMAGES

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.









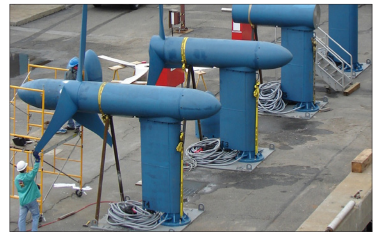
Images (top to bottom): Material ecologies (Neri Oxman, MIT Media Lab); Robotic processing of salvaged New York City scaffolding boards (Princeton Laboratory for Embodied Computation, by The Living); Evolutionary computation through generative design (Hod Lipson, Creative Machines Lab, Columbia University); "Friendly robot" in action (MIT Media Lab); Using generative design for program layout and robotic circulation (Benjamin Studio 5; Thomas Wegener).

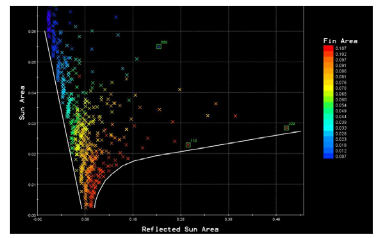
In this studio, we will consider how architecture might be defined by an ecology of numbers—an ebb and flood of input numbers and output numbers. But we will also explore aspects of architecture and the environment that are difficult to quantify. We will engage theory, culture, and aesthetics. We will 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, 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, our studio will explore a nuanced combination of designing with metrics, designing with narratives, and designing with images.

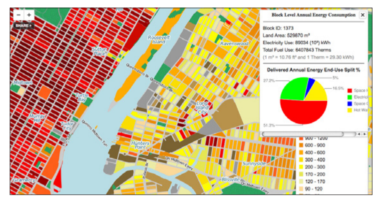
EDUCATION + ENTREPRENEURSHIP + WATER

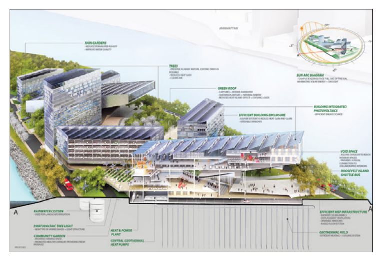
Climate change demands new intellectual framing and new collective strategies. The success of our response to climate change may depend on our ability to connect traditional education, research, and academics to new models of entrepreneurship, incubation, and technology. This studio will address climate change through the architecture of education, entrepreneurship, and water bodies.

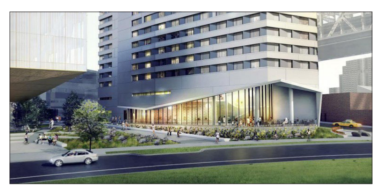
Students in the studio will design a new mixed-use building for Phase 2 of the Roosevelt Island Cornell Tech campus. The program of the building will blend several models of contemporary education including academic research facilities, an academic incubator, a public maker space, a learning accelerator, and a New York City charter high school. The project will engage the environment through serving as a demonstration project for low embodied energy buildings, targeting net zero operational energy consumption, and using freeflow tidal power from the East River. Over the semester, we will work with incubator spaces such as the GSAPP Incubator and the New Museum's NEW INC; learning accelerators such as General Assembly; and renewable energy innovators such as Verdant Power, the company that pioneered the installation of underwater turbines off of Roosevelt Island. In this studio, 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.

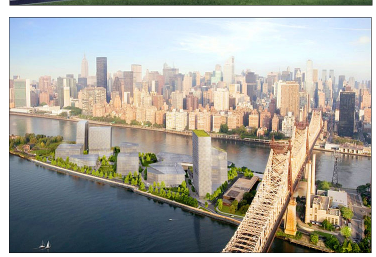


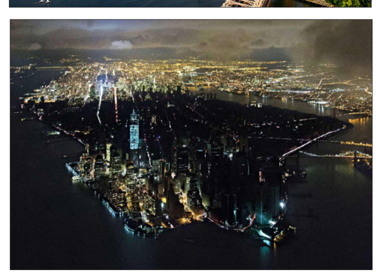












Images (top to bottom): Roosevelt Island; Underwater turbines being installed in the East River off of Roosevelt Island (Verdant Power); Visualization of design space (Benjamin Studio 6, Joe Corsi); Operational energy consumption of New York City; Cornell Tech campus on Roosevelt Island; Passive House for Cornell Tech, the tallest passive house in the world (Handell Architects); Cornell Tech campus on Roosevelt Island; Photo of downtown Manhattan during the balckout of Hurrican Sandy (Photo by Iwan Bann).