Poster Session			
July 19			
No.	Presenter	Title	Abstract
1	Sathvik Divi	Using latches for modulating energy and power output in ultrafast systems	Many small organisms achieve accelerations that are far beyond the capabilities of their muscles alone by utilizing spring-driven actuation to drive the power delivery. Similarly, numerous small insect-inspired jumping robots too rely on spring-actuation to attain the high power output required to drive their jump. Recent research in the interdisciplinary area of ultrafast systems has led to the establishment of the "Latch-Mediated Spring Actuation (LaMSA)" framework for analyzing such systems in both biology and robotics. A key component of this framework is the latch whose release triggers the spring recoil. In this work, we show how latches can be used to mediate the energy release using a combination of latch geometry and latch actuation. We show how non-ideal latches (i.e., latches with a curvature) can enable a range of variable energy outputs with fixed spring potential energy. We further show how latches can also enable these spring-actuated jumpers to adapt their jumps to different compliant environments, thereby minimizing energy losses to the environment and increasing jump efficiency. Incorporating non-ideal latches in LaMSA-inspired robotic systems results in interesting design and control implications for energy mediation purposes in such ultrafast systems.
2	Luis Viorney	Achieving Extensive Control over a Grasshopper-Leg-Inspired Catapult Mechanism	Latching impulsive mechanisms are becoming better understood, but these systems have historically not been controlled, or have been grossly controlled by adjusting the amount of energy stored in the mechanism. In a few recent cases, control been achieved via the use of rigid actuators that enforce time-varying displacement constraints against the recoil of a spring element. However, achieving this kind of control is challenging in engineered systems with small electromechanical actuators, and is not clearly seen in biological systems that moderate elastic recoil using muscular antagonists. We describe the development, construction, and test of a latching catapult mechanism whose design is inspired by the grasshopper leg and whose trajectory is controlled by force rather than position control of the actuator. We give a detailed model of this system, validate this model experimentally, and explain how the actuator dynamics are critical to our ability to attain extensive control over the system trajectory using this approach. This work represents a novel approach to the control of latching impulsive mechanisms and illustrates how they can be designed to operate even under highly limiting actuator constraints.
3	Roarke Horstmeyer	Computational imaging approaches to measure high-speed movement	There are a variety of fast movements exhibited by natural phenomena that are challenging to optically resolve. Examples include the mandible and raptorial appendage strike of small organisms such as mantis shrimp, trap-jaw ants, and termites, which exhibit extremely rapid acceleration movements. An ideal optical measurement instrument would resolve such events at high spatial (micrometer-scale) and temporal (MHz-rate) resolution, across a large area, and ideally in three dimensions. The Computational Optics Lab at Duke is exploring a variety of "computational microscope" designs to tackle the above detection challenge. One particularly relevant design discussed here is termed Fourier Stereo

			Microscope, which utilizes an array of lenses over a single sensor to sample across the Fourier domain and gather the multiple perspectives needed for generating a volume reconstruction of rapid movement from each snapshot video frame.
4	Xiaoyue Ni	A dynamically reprogrammable metasurface with self-evolving shape morphing	Achieving intelligent soft matter that can self-configure, self-adapt, and even self-evolve is of great importance for many engineering sciences. The past decade has witnessed phenomenal investment in developing responsive metamaterials that can swiftly shift their structures, and henceforth their performing functions. However, creating materials and structures with precise, complex, fast, and reversible programmability and incorporating real-time feedback remains challenging. In this work, we describe a dynamically reprogrammable mechanical metasurface with embedded actuation, sensing, and feedback-control functions for shape-morphing intelligence. The voltage-controlled Lorentz force driving a flexible, conductive 2D mesh in a static magnetic field lays the foundation for a highly integrable and scalable digital-physical interface. A custom-built stereo-imaging setup incorporating multiple webcams enables an in-situ measurement of the 3D out-of-plane deformation of the 2D precursor. With an implementation of a programmable control guided by an optimization algorithm, the metasurface acquires the ability to self-evolve to approach a given target shape in absence of presuming models. The closed-loop structure opens opportunities for physical simulations on non-linear systems. Such an experiment-driven method also exhibits superior advantages in morphing against extrinsic or intrinsic perturbations that theoretical models cannot predict or account for, including environmental changes, external loading, and sample defects. In addition to the morphing intelligence, the metasurface obtains a functional intelligence to adapt its morphology to accomplish prescribed tasks, bypassing any involvement of shape designs. Upon assignment of aims, the direct goal-oriented morphing also allows the metastructure to attain multifunctionality with an ability to decouple naturally coupled structural functions.
5	Meredith Taghon	Soft adhesive latches for controlling recoiling band kinematics	Mantis shrimp, salamanders, and chameleons are just a few of nature's overachievers as they rely on latch-mediated spring-actuation (LaMSA) to produce ultra-fast and powerful movements during predation. LaMSA systems rely on latches to mediate the stability of energy release. Many examples of latches can be found in nature in the form of adhesive interfaces whose contact and separation constitute the latching and unlatching processes. Here, we present measurements on the impact of materials properties on the performance of contact adhesive latches. We conduct high-speed adhesion tests where a probe-tipped polyurethane band is stretched until probe contact is made with the adhesive latch. Then the band displacement and contact force are measured as the band is released. Our lab-synthesized acrylate-based adhesive and a commercially-available VHB adhesive are chosen as latch materials to provide different bulk and interfacial properties of the adhesive latch, which in turn affect how the probe debonds to control the release of the stretched polyurethane band. The adhesive properties of the latch control the position where the latch interface becomes unstable, thus dictating the maximum velocity and acceleration of the recoiling band. The insights gained from this work will provide a better understanding

			of how LaMSA systems rely on latches to store and mediate energy to achieve small, power-amplified movements.
6	Nolan Miller	Repeatable Power Amplified Actuation of Confined Polymer Gels	Many organisms have evolved the ability to rapidly release potential energy as a tool for survival using Latch Mediated Spring Actuation (LaMSA). In these systems, latches mediate the transition from stable to unstable energy release and play a critical role in integrating the actuator and spring capabilities. Although many different types of latches are used, snap-through elastic instabilities represent one type of latch that is used in natural systems, e.g. Venus flytrap leaflets. Recent work has demonstrated that synthetic gels, swollen with volatile solvents, can be engineered to undergo multiple snap-through events, providing a pathway for energy-efficient, autonomous high power movements. However, an open question is how to engineer the material system to extend the lifetime of such movements, which are driven by interactions between the solvent-infused gel and the surrounding environment. Here, we present our approach to optimizing the snapping behavior of ribbon-shaped gels to enhance the number of snaps and to quantitatively describe how geometry, material properties, and mass transport influence snapping behavior. Initial results from this current work have identified phases of symmetric and asymmetric buckling as a function of substrate modulus and lateral confinement. Future research will combine solvent-restrictive thin film patterns to systematically mediate environmental interactions to improve the efficiency of solvent loss. Expanding the understanding of this autonomous system will elucidate power amplification using an environmental driving force.
7	Kaeshav Danesh	The Limitations of Tuning LaMSA Systems Using Stored Elastic Energy	A Latch Mediated Spring Actuated (LaMSA) system can be tuned to optimize performance metrics such as the maximum power or kinetic energy. Prior literature has typically assumed that optimizing these metrics requires tuning the system to maximize the elastic energy stored in the spring. In this work, we investigate the relationship between stored energy and other kinematic performance metrics using a computational model of a LaMSA system. We find that when the system is loaded by a linear motor, the prior assumption holds; maximizing these kinematic outputs is accomplished by tuning the stiffness of the spring such that stored energy is maximized. However, when the motor has a non-linear force-velocity relationship – such as a Hill-type muscle motor – we find that the optimal spring stiffness for energy storage and release is not necessarily optimal in terms of power delivery. This effect increases in complexity when using more realistic models of biological springs that include viscoelasticity. Our work suggests that depending on the desired function of a LaMSA system, maximizing stored energy is not always a sufficient metric to guide design.
8	James Clinton	Investigating motor-spring trade-offs in robotic mechanisms at different sizes	Latch-mediated spring actuation (LaMSA) is used to power both biological and engineered systems beyond the power limits of motors. Previous modeling work has shown that below a critical size threshold, a spring-driven system is more effective than a comparable motor-driven system. However, no physical modeling has been done to illustrate this tradeoff. This work aims to address this lack of physical modeling by presenting a foundation for scaling existing robotic systems. We used the symmetric five-bar linkage, specifically as presented in the open-source Stanford Doggo leg, as an

			example. We examined different scaling laws to determine how to physically size the mechanism at different scales, and how to select actuators for the different sized mechanisms. We also propose a design for modifying the Stanford Doggo leg to incorporate LaMSA at each size. Finally, we determined the optimal spring for each size by deriving the force outputs of the system for a given actuator size. This work presents a methodology for the examination of the motor-spring tradeoff of LaMSA systems at different sizes using existing robotic mechanisms with slight modifications.
9	Chloe Goode	Rotational Control in LaMSA jumpers	Locusts (Schistocerca gregaria) jump using a latch mediated spring actuated system in the femur-tibia joint of their metathoracic legs. These jumps are exceptionally fast and display angular rotation immediately after take-off. In our first study we focus on the angular velocity (pitch) at take-off of locusts ranging between 0.049g and 1.50g, to determine how rotation-rate scales with size. Using a basic energy model, we hypothesize that rotational energy density will remain constant, which predicts smaller locusts will rotate faster. From 263 jumps recorded from 44 locusts, we found that angular velocity scales with mass-0.33, consistent with our hypothesis. On average, the energy budget of a jump is distributed 98.7% ± 0.2% (SD) to kinetic energy (Linear velocity), and 1.3% ± 0.1% to Rotational energy (pitch only), for all sizes of locust. Within the data from individual animals, angular velocity also increases proportionally with linear velocity, suggesting that locusts cannot independently vary linear and angular velocities. This analysis finds that smaller insects rotate more quickly than larger ones. In the second set of experiments, we hypothesised that angular rotation (pitch) is produced by the centre of mass (COM) of locust being situated behind the thrust vector created by the metathoracic legs. By adding a mass to the locust's head, we can move the COM to be in line with the thrust vector and thus negate the production of angular rotation. From 45 jumps recorded from 9 locusts, we found that adding a hat that weighed 6.82% of the body mass maximally reduces the amount of rotational energy without significantly reducing of kinetic energy. It is thus trivial to remove rotation from a jump, strongly implying that the rotation is advantageous for the animal.
10	Gregory Sutton	Semi-lunar process shape and energy storage	A wide array of animals such as ants, grasshoppers, mantis shrimp, fleas, and others use a Latch-Mediated Spring Actuated (LaMSA) system to generate extremely fast and powerful movements. In these systems, energy is generated by the muscles and stored in a latched spring-like structure, often made of a composite of a chitinous cuticle and an incredibly resilient protein. Release of the latch then causes the spring to recoil, delivering energy extremely quickly and resulting in a very fast movement. Across different species, there are certain shapes that appear to be repeated for these springs, with the elastic storage mechanism of the mantis shrimp, trap-jaw ant, and grasshopper each having an incredibly similar 3-D shape. To better quantify this commonality in shape, we have quantified the shape and variation in shape of 20 species of differently sized grasshoppers, showing that, while the size of the springs vary with mass, the fundamental curvature of the spring appears conserved. This conservation in shape is duplicated among the 'springs' found in the literature for trap-jaw ants and mantis shrimp, and we suspect that this is also duplicated in the elastic storage 'springs' in froghoppers and fleas. While

			these animals are phylogenetically extremely distant from each other (with mantis shrimp not even being insects (or even shrimp)), this conservation of shape suggests a fundamental geometry optimization of an energy storage springs.
11	Jessica Taylor	Energy compensation of LaMSA jumpers jumping from compliant platforms	LaMSA jumping insects are ubiquitous. In nature, these insects jump from a variety of compliant substrates such as leaves and grasses. To study how LaMSA jumpers interact with these compliant substrates, we have used the grasshopper (Schistocerca gregaria) as a model system. Grasshoppers were jumped from two diving board-like balsa wood platforms with varying masses and stiffnesses. The first being more massive than the grasshopper, with fixed end being stiffer than the grasshopper and the distal end being less stiff than the grasshopper. The second platform being half the mass of the first, with similar varying stiffnesses along its length. Despite greatly differing in mass, both platforms showed similar results: in that the grasshoppers' average velocity ±SD decreased by 16% from 1.55±0.37m/s on a rigid substrate down to 1.19±0.30m/s at the least stiff end of the platform. Grasshoppers, under these mechanical conditions, lose energy to the substrate and cannot recover it on recoil. Both of these platforms were of greater mass than the grasshopper, so a third platform was developed at 0.84g and had a greater stiffness (from 24N/m to 98N/m)and a lower mass than the grasshoppers (>0.84g and <6N/m). This set up the hypothetical conditions to allow grasshoppers to recover energy from the recoiling platform and produce greater velocities than from less favourable compliant substrates. Analysis into energy recovery for the third platform is currently underway, as well as further kinematic measurements across all three platforms. This initial data has highlighted that despite the highly compliant conditions, grasshoppers are able to account for this and only lose approximately 30% of their energy to the substrate.
12	Elliot Hawkes	Jumping on Air: Design and Modeling of Latch-mediated, Spring-actuated Air-jumpers	Latch-mediated spring-actuation (LaMSA) is utilized in a majority of jumping robots for its ability to slowly load and quickly release energy to generate high-power movement. Such mechanisms are found in robots that jump off of solid surfaces and even off of water. However, no robot currently employs LaMSA to jump on air. We present the design, modeling, and fabrication of the first LaMSA-driven air jumper, capable of jumping midair. Our model informs prototype design and provides insight into the scaling properties of the wing area, wing mass, fuselage mass, and energy. By successfully applying LaMSA to a new domain, this work lays the foundation for future investigations into high-power air-reaction maneuvers, such as in fixed-wing unmanned aerial vehicle (UAV) flight, by enabling instantaneous changes in altitude without the addition of extra on-board motors.
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13	Qiong Wang	Jumping robots by dynamic buckling cascade	Snap-through buckling is a striking instability in which an elastic object rapidly jumps from one state to another and is ubiquitous in both nature and engineering. In this work, we proposed a rotation-induced buckling cascade mechanism for small-scale jumping robots. The clamped boundary condition of a bi-stable structure rotates unidirectionally until the critical snapping state is reached. The jump is then executed as the structure rapidly snaps from its initial state to another. Unlike the latch-based

			mechanism, the buckling cascade mechanism realizes the energy storage and release in a single stroke, which enables simpler structures and lighter weights. Under the buckling cascade mechanism, the symmetric mode is preferred as it stores higher energy and snaps faster than the asymmetric mode. However, our experiments demonstrate that symmetrical snap-through is challenging to realize in practice even if the initial and boundary conditions are both symmetric. In this study, robots based on the rotation-induced buckling cascade mechanism are fabricated by high precision additive manufacturing. The origin of the bias towards asymmetric snap-through is located via both theoretical and numerical analysis, laying the basis of the optimal design. The optimized robot with a maximum length of 2 cm can jump up to 40 times their body length within 10 ms, opening up the potential applications in proximity sensing and micro-gliders.
14	Roi Holzman	A power amplification dyad in seahorses	Throughout the tree of life, organisms repeatedly evolved elastic elements that store energy and, when released, accelerate appendages more rapidly than ubiquitous limits on the power capacity of fast-contracting muscles would allow. Such latch-mediated spring actuation (LaMSA) systems are normally comprised of a single elastic element and actuate a single mass. Here we reveal a dual-LaMSA system in seahorses, in which two elastic elements actuate two masses: the head as it rapidly swings towards the prey, and the water mass sucked into the mouth to prevent the prey from escaping. This unique system makes seahorses extraordinarily high-performance feeders, enhancing the speeds of both head rotation and suction flows ten-folds compared to similarly sized fish. Furthermore, the dual system provides temporal coordination between head rotation and suction flows, a novel function for LaMSA. These findings extend the known function, capacity, and design of LaMSA systems.
15	Ruiqi Wang	High traction legged maneuvers in cockroaches are not limited by ground substrate in naturalistic frictional regimes	High-acceleration legged movement is fundamentally limited by the contact forces that can be generated between a robot/animal and the ground. However, the foot morphology, strength-to-weight ratio, and relative roughness between foot and ground all vary dramatically across relevant biological and robot scales (i.e. from elephants to ants for instance). In this project we seek to understand how moderate substrate roughness influences the production of traction forces and body accelerations in a small, agile, legged insect, the cockroach (B. discoidalis). In this work we will describe recent experiments to measure the effect of substrate roughness on maximum traction force generation by B. discoidalis. We hypothesize that substrates with larger RMS roughness will enable cockroaches to produce larger traction forces. To study the roles of ground substrate versus leg force capabilities, we developed an experiment to measure the fore-aft, mediolateral and vertical ground reaction forces while the cockroach attempts to pass through a crevice, an escape behavior that elicits large traction forces while also allowing for high resolution observation of foot-ground interactions from high frame rate top and side view videos. The results demonstrate no significant difference in force production on different roughness sandpaper substrates. The hind legs are able to produce traction forces that are up to 100 times the body weight while maintaining a normal force that is only 7 times the body weight. Foot-ground observations indicate

			that interactions between asperities and tarsal claws are likely responsible for these extremely high traction forces. This work is the first of a long-term project to characterize how the extreme traction forces small insects can generate may enable high-acceleration maneuvers, providing new insight into the design and control of robot legged locomotion at centimeter and millimeter scales.
16	Sojung Yim	An omnidirectional jumper with expanded movability	Jumping enables small-scale robots to overcome obstacles that are larger than their own size. To expand the reachable range and reach the desired location with only jumping, the jumping robot requires additional functions – steering, adjusting the take-off angle, and self-righting. However, integrating additional mechanisms increases the mass of the robot. When the same amount of energy is stored, an increase in mass results in a decrease in jumping height. Therefore, we developed the repeated omnidirectional jumping robot with the design of sharing the mechanism and actuator for each function to minimize the jumping performance degradation. First, the jumping and steering mechanisms are performed with a single actuator by the clutch of the modified active triggering mechanism. The modified active triggering mechanism consists of actuating gear, winding pulley gear, steering gear, and traveling gear. The traveling gear can move along the groove while engaged with the actuating gear. The traveling gear can engage with the winding pulley gear operating the jumping mechanism or the steering gear operating the steering mechanism. Second, the self-righting mechanism is designed to be performed in consequence of the motion of the jumping mechanism. We only added two links in the perpendicular plane of the jumping linkage, so when the jumping linkage is folded for energy storing, the self-righting linkage protrudes perpendicularly and pushes against the ground to self-right. As a result, the robot with a mass of 70.1 g can jump up to 1.02 m in vertical height and 1.28 m in horizontal distance. It can change the jumping height and distance by adjusting the take-off angle from 40 to 92 deg. Also, it can jump in all directions by steering, and it can jump repeatedly by self-righting.
17	Sang-Min Baek	Ladybird Beetle Inspired Compliant Origami with energy storage and self-locking	Origami design is applied to the various fields of engineering owing to its advantages such as compactness, light-weightiness, and stowability. To enhance origami structure's functionality such as rapid motion, self-deployment, and load-bearing, its mechanical property especially stiffness should be engineered. In conventional origami design, a spring is installed on the flexure hinge to enable rapid motion and self-deployment. Also, load-bearing ability is enhanced using the unique configuration of multiple facets and additional components for maintaining its configuration. However, these approaches hinder the compactness and light-weightiness of the origami structure. Several insects, especially ladybird beetle, has origami-like membranous foldable wings which are deployable within 100ms and can endure aerodynamic forces applied during 100Hz flapping. The key feature which enables these rapid motion and load-bearing capabilities is its specialized vein, which is compliant and has curved cross-sectional geometry similar to the tape spring. We employed this feature in the origami design and developed a curved-compliant facet origami structure. The proposed origami structure has cross-sectional curvature and its curved compliant facet is flattened during folding. The flattened facet stores elastic energy and it makes the origami structure rapidly self-deployable. Also, the cross-sectional

			curvature in deployed state enables the self-locking of the structure and enhances load-bearing capability. The proposed origami structure is applied to several robotic designs: 1. Deployable wing module for jump-gliding robot and flapping mechanism, 2. Small-scale origami based jumping mechanism. The wing module is compact foldable, can rapidly deploy its wings, and effectively endure the aerodynamic forces applied during flying. In the jumping mechanism, application of the proposed origami design enhances jumping performance of the mechanism without additional component.
18	Jiehao Chen	UV-reprogrammable hydrogel for shape morphing metamaterial with tunable bandgap	Nature creatures constantly evolving shapes and properties to realize various functions and become adaptive to the changing environment. In the past several decades, intensive efforts have been given to develop materials with tunable properties. Among those, hydrogels because of their good biocompatibility, large deformation, versatile stimuli-responsiveness, have attracted significant attention among researchers in many engineering fields. Furthermore, hydrogels exhibit less internal damping compared to commonly used soft materials and have close-to-water impedance. It is considered as a good candidate for shape morphable metamaterials which offers potentials for structural dynamics and wave propagation applications. Traditional shape morphing hydrogels rely on structural implementation of inhomogeneity inside the material during fabrication to realize predetermined complex shape changes upon stimuli activation. Although intriguing, most of these strategies can only realize one predetermined configurational change, which is pre-set during fabrication and not reprogrammable. In recent years, several systems with rewritable shape-morphing capabilities have been demonstrated, including electrothermal and photothermal gels, reversible ion-printing gels, and photochemical gels. Among those, photochemical hydrogels offer the best spatial and temporal control. However, for most photo-responsive hydrogels, the photoactivation is coupled with the deforming process. The light pattern needs to be continuously adaptive to the deforming gel during the morphing process, which is impractical for complex 3D morphing. In this work, a general scheme of shape reconfigurable hydrogel using photo-ionizable molecules is proposed. Two photocleavable molecules that can form a reactive ion couple upon light activation are incorporated into one hydrogel. This reaction between the ion couple consumes the products of the two photocleavage reactions, which not only locks the photo-ionizable molecules in the activated states but also drives the reversible photochemical reaction forward and improves the photochemical reaction efficiency. Through the coordination between the two photo-ionizable molecules, the new photo-responsive gel decouples the photopatterning process with the morphing process. This research then explores bandgap formation in such hydrogel-based programmable periodic structures and also studies the effects of parameters such as photo-sensitive group concentration and unit length ratio onto the width and center frequency of the bandgaps. For cantilevered hydrogel-based periodic structures, experimental results are validated using finite element and diatomic chain model (represents the simplest type of periodic systems). Both experiments and models conclude that increase in the

			concentration of the photo-sensitive group increases bandgap width and attenuation while reducing its center frequency whereas, an increase in unit cell length ratio reduces both the bandgap width and center frequency.
19	Santanu Kundu	Retraction behavior of a highly stretchable and resilient hydrogel	Elastic biopolymers such as resilin display remarkable properties such as high stretchability and resilience, which are exploited in nature for mechanical energy storage to facilitate power amplified activities, including hopping of a froghopper, projection of a chameleon tongue, and appendage strike of a mantis shrimp. Such properties of resilin have been attributed to the balanced combination of hydrophilic and hydrophobic segments. Developing a synthetic material with resilin-like properties requires high stretchability to store elastic energy, low hysteresis for high energy conversion, and high retraction velocity when released from a stretched state for power amplification. To obtain synthetic hydrogels mimicking the properties of resilin, we prepared a hydrogel composed of hydrophilic components acrylic acid and methacrylamide and hydrophobic component poly(propylene glycol diacrylate). The gel was prepared by free-radical polymerization in 0.8 M NaCl and Sodium dodecyl sulfate solutions using KPS as an initiator. We investigated the effects of chemical compositions on the mechanical properties of the gel. The elastic modulus of the gels increased with the increase in monomers and PPGDA concentrations. An appropriate ratio of hydrophilic and hydrophobic concentrations led to a highly stretchable and resilient hydrogel, which displayed a stretch ratio of ~9. Retraction experiments, which involve stretching a gel sample and then releasing it, also captured a retraction velocity and acceleration as high as 16 m/s and 4000 m/s2, respectively. Swelling/deswelling experiments of these gels were performed in various concentrations of saline solutions to determine their stability. The samples swelled when placed in 0.1M NaCl solution and deswelled in 4.0M NaCl solution. The deswelled gels displayed an increased modulus and higher stretchability, but the retraction velocity decreased.
20	Naomi Deneke	Pressure Tunable Adhesion of a Patterned Elastomer	Applications in soft robotics, wearable adhesives, microcontact printing, and pick-and-place manufacturing benefit from utilizing materials capable of achieving multiple and distinct levels of adhesion strength. Many studies have investigated materials able to achieve a singular but tunable adhesion strength or switchable adhesion. However, there has not been ex tensive studies in developing a single material with continuously increasing adhesion strength solely relying on the materi al's surface properties. In this work, we develop a pressure tunable adhesive (PTA) with this capability by utilizing surface patterning. The adhesive strength of the PTA is tuned by controlling the amount of pressure applied to the material. The PTA is composed of a soft, adhesive elastomer that is patterned with stiff axisymmetric asperities arranged in a polygonal formation. The pattern dimensions are altered by increasing the size and spacing of the asperities. Flat punch indentation testing is used to characterize the adhesion strength of PTAs with various pattern dimensions. The PTA is compressed by the punch to a pre-defined maximum compressive load, Pm, and retracted until reaching the critical pull-off load, Pc, where separation occurs. We show that Pc increases with Pm for these PTA materials and plateaus

			beyond a critical Pm. Further more, increasing the size of the pattern parameters increases the range of Pm values over which a pressure tunable response is observed, though the plateau adhesion strength decreases. Finally, A linear elastic fracture mechanics analysis helps us understand how the relationship between Pc and Pm changes as a function of size and spacing of the asperities.
21	David Sleboda	How to: Build thin-walled cell models using 3D-printed molds and pourable silicone	Building physical models can be a great way to explore biological systems and generate new hypotheses. Biological shapes and textures, however, are not always to easy replicate using the equipment and tools common in biology labs. Here I will present a relatively easy and cheap DIY-style method for building thin walled, biologically inspired cell shapes using freely available software (e,g, TinkerCAD, Cura), an entry-level 3D printer (Ender3 or similar), and pourable silicone products (e.g. Smooth-On). The method uses 3D-printed molds to cast pairs of thin-walled shells that can be fused together using silicone-specific adhesive. The process produces hollow, flexible, and water-tight silicone vessels that mimic the shapes and arrangements of biological cells. The process can be carried out on a typical lab benchtop without the use of specialized facilities, making it widely accessible and of potential use as a teaching exercise.
22	Brittan Wilcox	Multifunctional shape-changing robots through bi-stable actuation	Adaptive modes of transport for small vehicles are a growing area of interest for applications including search and rescue, mapping, and reconnaissance. Current small robots are often limited to a single mode of transport, such as small, wheeled vehicles which are limited to ground locomotion, or small winged aircraft or quadcopter drones, which are limited to flying. Combining multiple modes of transport often results in bulky devices in which the systems for each mode of transport are separate from each other. Here, we present a small, adaptive robotic vehicle that uses functional materials to undergo a shape change in order to both hover and fly as a quadcopter drone, and drive on the ground as a wheeled vehicle. This functionality is enabled using shape memory alloy to create a bi-stable actuation system in which the robot can remain fixed in a flying mode or driving mode with no power applied to maintain its form. This power-amplified actuation system achieves a fast, snap-through movement with similarities to motor-spring systems often found in fast moving, natural systems, such as insect legs. The shape change and our design of a combination wheel and propeller further enables us to use the same systems for both modes, including the same power source, control system, and motors. This results in a reduction of necessary components to achieve both modes of transport in our untethered, multi-modal flying and driving small robot.
23	Jinchang Zhu	Voxelated Bioprinting of Mechanically Robust Multiscale Porous	Three-dimensional (3D) bioprinting additively assembles bio-inks to manufacture tissue-mimicking biological constructs, but with the typical building blocks limited to one-dimensional filaments. Here, we develop a technique for the digital assembly of spherical particles (DASP), which are effectively zero-dimensional voxels – the basic unit of 3D structures. We show that DASP enables on-demand generation, deposition, and assembly of viscoelastic bio-ink droplets. We establish a universal description for the deposition resolution at various printing conditions and a phase diagram that outlines the viscoelasticity of bio-inks required for printing spherical particles of good fidelity. Using DASP, we

		Scaffolds for Pancreatic Islets	create mechanically robust, multiscale porous scaffolds composed of interconnected yet distinguishable hydrogel particles. Finally, we demonstrate the application of the scaffolds in encapsulating human pancreatic islets for responsive insulin release. Together with the knowledge of bio-ink design, DASP might be used to engineer highly heterogenous yet tightly organized tissue constructs for therapeutic applications.
24	Ardian Jusufi	Mechanically and Materials Mediated Crash-Landing on a Wall: Soft Robotic Models of Gliding Geckos with Varying Body and Tail Stiffnesses	Perching in challenging environments and vertical surfaces is a critical ability for multi-modal robots since it lends itself to station- keeping, i.e., to hold a stable position above the ground without the need for continual hovering, hence lowering energy consumption. Asian flat-tailed geckos (Hemidactylus platyurus), have been observed to glide and perch on vertical surfaces by relying on the mor- phology of their body and tail, thus reducing the neural control effort required to perch. In this bioinspired study of the underlying mechanism, a simple physical model is developed and its morphological and geometric parameters adjusted to determine their in- fluence on perching success and the kinematics of the highly dynamic landing maneuver involving the fall arresting response. Combining a compliant torso and stiff tail enables the robotic platform to passively perch on a vertical substrate with a success rate of over 90%, compared to only 10% without a tail attached. Perching performance was evaluated as a function of four torso and tail stiffness, respectively. Here we find that compliance in the torso absorbs the kinetic energy in flight and accommodated the uncer- tainties in approach conditions. Like the gecko's perching strategy, the stiff tail pushes against the substrate, preventing the model from falling backwards with its torso head over heels. These findings highlight the selective forces exerted on the animal and provide insights into the creation of perching capabilities in robots.