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Signs of Life – Hearts, Blood and our Breath

An artistic dialogue on embodiment and boundaries

TOBIAS KLEIN AND JANE PROPHET

In this article the authors, Tobias Klein and Jane Prophet, discuss their collaborative production of three recent artworks, inspired by the function of the human heart. The following quotes by the authors provide brief descriptions of three artworks about blood that they made collaboratively, which are at the heart of the article.

Blood Work 01. Two entwined glass vessels hold liquids; each has two chambers. They hang inside a gyroscope. In one, blue fluid on top of clear fluid; in the other, a transparent liquid supports a reddish-brown liquid. A belt turns, the gyroscope spins and the interlocking vessels tumble, blending the liquids into emulsions. Finally, the movement stops, and the liquids separate.

Blood Work 02: Unruh. The forms from Bloodwork 01 are wrapped in black tendrils of filament, and the glass vessels now hold viscous black ferrofluid that moves languorously through the transparent liquid. The gyroscope mechanism is augmented with a tubular structure through which metallic spheres can be seen moving freely. These are magnets, and as they move, the ferrofluid moves towards them, attracted by their invisible magnetic fields and the sculpture moves, stutters to a halt. Then, from entropy, the belt makes the gyroscope and magnets move again.

Common Datum. In a Hong Kong gallery, three glass and 3D-printed sculptures, suspended by thin wires, appear dormant. It is 2020 during a lull in the COVID-19 pandemic, and slowly the space is populated with visitors, speaking behind their masks. After a while, liquid drops aggregate on the upper 3D printed forms and trickle down the wires into the glass vessels. The works continuously absorb the humidity of human breath and the air expelled from moist human lungs during a conversation. Later, the people leave, and the lights

dim. Finally, without breathing witnesses, the artwork ceases to produce water.

Our interdisciplinary engagement with materials and materiality (both in our individual art practices and when we work together) interweaves methods and approaches from arts-based enquiry and computer science within a feminist technoscience framework. The sculptures that we discuss here emerge from our shared delight in creating art that starts as discussion about a phenomenon, then moves to expressing ideas about that phenomenon, often using materials previously unknown to us that we choose because they relate to the materiality of the phenomenon we are studying. In the case of *Blood Work 01*, *Blood Work 02: Unruh* and *Common Datum* (the *Blood Work* sculptures), we shifted from working with the heart to focusing on blood. We worked with blown glass, liquids, condensing materials and kinetic motors that were new to us. When we met in Hong Kong (2013), we realized we had separately been making art and 3D printing sculptural forms that related to the human heart. Those heart-related works were each a response to ideas of vitality. Anne Pollock writes:

Because we can feel our own heartbeat, and that of others with whom we are intimate, the heartbeat has been and will remain powerful as a way for lay people to answer the question of who is alive ... in ordinary clinical encounters, the pulse remains a primary 'vital sign.' (Pollock 2015: 14)

What drives the beating heart is the movement of blood. Our individual works emerged from vital practices that addressed 'signs of life' – the evidence of breath and blood pulsing – and those themes are extended in the collaborations discussed here. While, as with our previous individual artworks, we work with the form of the heart, in our collaborative works we shift our focus to blood, especially its materiality and

behaviour.

Blood flow dynamics regulate cardiovascular development, and blood flow conditions impact cardiac formation (Courchaine *et al.* 2018). The movement of the blood shapes the heart, just as the looping vascular system of the heart redirects the flow of blood. Our *Blood Work* sculptures reflect the mutualism between blood flow and heart form, and as we developed the pieces we worked with both solids and liquids concurrently to dissolve any hierarchy between the sculptures' solid forms and the liquids that are part of them. We designed and built the works through a series of experiments. Our performative process was an echo of the development of our own human hearts, formed through intra-actions where blood flow patterns are integral to each heart's development.

In the early 2000s, one of the authors, Jane Prophet, was artist in residence at Papworth Hospital's heart transplant unit in the UK and worked with cardiothoracic surgeon Francis Wells, psychologists and patients waiting or having received a heart transplant. Prophet conducted a cosmological investigation of transplant surgery that included enquiries into its physical, social, technological and psychological aspects, intentionally interrupting dualisms such as those that hold the mind and body, nature and artifice as mutually exclusive. Her *Silver Heart* (2004) sculpture used anonymized magnetic resonance imaging (MRI) scans of a heart, images typically used by the surgeon to aid diagnosis and plan surgery. Prophet translated the raw MRI data into a three-dimensional (3D) digital model (fig. 1), from which she made polymer 3D prints at two different scales that she gold-leafed or silver-plated. The jewel-like sculptures were made to be exhibited in a gallery setting but also to be taken back to the hospital. The surgical team used the silver-plated 3D printed heart, which is robust and easier to handle, as a prompt to discuss relationships between living tissue and mediated images of the heart and how that impacted their surgical work. The vascular structure was of particular interest, and they ran their fingers over it, noting that they only experienced this form on screens because, when the heart was lifted in a transplant, the blood

vessels collapsed and hung limply while the perfusion machine oxygenated the patient's blood. Any human heart they handled in surgery was radically changed because blood was not flowing – there was no blood to support the 3D structure of the blood vessels that 'deflated' and hung limp. Holding a larger-than-life 3D object made from MRI data also prompted discussions about the differences that a variety of mediated forms (electrocardiogram (ECG), MRI, a physical object, the patient's heart during surgery) afforded the team. They concluded that experiencing multiple mediated forms contributed to a better understanding of patients' hearts, in particular their understanding of the movement of blood as the heart beats. This movement continues during the time it takes to create MRI images and can affect the quality of images.

Klein's use of MRI of the heart alluded to the importance that we place on the heart in our sense of self and began with his work *Soft Immortality* (2008), where he used MRI of his own body to create a series of organelles (fig. 3). In *Soft Immortality*, Klein is interested in the dissolution of the boundaries common to traditional anatomy. He uses the relative densities of tissues that are imaged by MRI results. The resulting extended and projected body dissolves the typical separation of inner and outer space to establish an understanding of soft, mouldable space in a computational, rational and poetic sense. Klein produced the suspended organ-like forms using the various densities from a heart MRI. MRI enabled him to look into the 3D space of his own body. The MRI makes the body look still and dry but in fact as he travelled through stacked MRI images he realized he was looking at wetness with the wetness being created by blood. Instead of a dried simulation we are looking at wetness, which is commonly depicted in red, the vital colour of living blood. These flexible-looking 'syncretic transplants' range from solid to semi-opaque; they are single entities installed to interact with one another to constitute a greater whole. The subtle choreography of light accentuates the forms' different degrees of density, translucency and reflection. Klein went on to use MRI and other volumetric data of the

■ Figure 1. *Silver Heart: MRI and the sculpture from two angles*, Jane Prophet, 2004. Photo Jane Prophet, courtesy of the authors



heart in a piece that responded to *The Visible Human*.

The Visible Human (The National Library of Medicines Visible Human Project n. d.) began on 5 August 1993, with the execution of convicted murderer Joseph Paul Jernigan in Huntsville, Texas, who was sentenced to death for the murder of 75-year-old Edward Hale. He donated his body to scientific research, and his body was frozen to -73°C and cryosected at intervals of 1 millimetre in 1871 axial slices. Photographs of the slices were computed tomography (CT) and MRI scanned and publicly released in 1994 ostensibly to facilitate anatomical visualizations. The visualization of blood vessels was a key part of *The Visible Human* project. In comparison with anatomical images taken from living humans, *The Visible Human* images are much clearer because the body is not moving, and the images are in colour, therefore providing a lot more data, about ten times the amount of data available via MRI, even though small blood vessels were collapsed by the freezing process (Ackerman 2022). Klein responded with the production of his artwork, *The Invisible Human* (2013) (fig. 4). For forty days and forty nights he transformed the data from the slices into crystallized sculptures of Jernigan's heart, lungs, abdomen and pelvis. The four 3D-printed and illuminated objects were

created by reversing MRI technology, feeding photos of Jernigan's back into the software of MRI, in this case OsiriX, to volumetrically reconstruct a representation of his body. Over ten days, when visitors approached a 3D printed body part, such as the heart – suspended in a supersaturated solution of aluminium potassium sulphate – their presence was marked by infrared distance sensors that influenced the growth of the crystals and affected the shape of the crystallized forms. Next, a 40-watt neon tube in an acrylic cylinder fixed inside each 3D object made the crystallization process visible and connected the reconstructed body parts and emerging crystals. After ten days, the 3D printed object was removed from the waterproof container, interrupting the crystal growth and fixing the final form. Klein then placed the next 3D body part in the container for ten days. The art objects were exhibited at the Industry Gallery in Washington, DC. In *The Invisible Human* Klein alludes to the political economics of American incarceration; a prisoner's body is sliced and rendered down to data, and the heart, made three-dimensional again in Klein's sculpture, seems to call across the short distance (only two miles) from the gallery to Jernigan's remains in the medical library.

In 'Heart feminism', Pollock writes, 'The

■ Figure 2. *Swab Drawing: Stills from video*, Jane Prophet, 2003. Photo Jane Prophet, courtesy of the authors





■ Figure 3. *Soft Immortality*, Tobias Klein, 2008. Photo Tobias Klein, courtesy of the authors

heart provides powerful ways of understanding bodies simultaneously as somatic, symbolic, and political-economic entities. These understandings are sometimes hierarchical and even oppressive, but it behooves feminists to take the heart seriously' (Pollock 2015: 20). We had, separately, through the production of the works described above, been taking the heart seriously when we started our decade-long series of conversations about 'the heart both as an object itself and an object within a network of objects' (4), with blood being co-constituted with the heart in any such network. Pollock's text positions thinking-with-the-heart as an alternative to thinking-with-the-brain. There is synergy here with the new materialism concept of 'Becoming' as a never-fixed state that emerges through the relationships between multiple phenomena. The phenomena include matter and discourse based on the understanding that interconnections between entities form the basis of life as Joanne Cassar describes in her discussion of Karen Barad (Cassar 2017), this notion of becoming 'emerges out of different

possibilities occurring at each moment and comes into existence through the fusion of social and material phenomena, which are not distinct entities' (Cassar 2017). Klein's *The Invisible Human* materializes and is understood through its entanglement with social and material phenomena, including social, political and economic entities of *The Visible Human*. The presence of human gallery visitors triggers light and temperature, creating different possibilities that affects the crystallization of the solution, turning it from a liquid to a solid. In Prophet's *Swab Drawing* (2003) video, recorded during open-heart surgery as part of her collaboration with surgeon Francis Wells, we see him use a swab of the patient's blood to draw a diagram (fig. 2). The drawing was made to help Wells describe a novel mitral valve repair procedure to a visiting surgeon. Prophet's *Swab Drawing* emerged as she observed that the surgeon, Francis Wells, frequently spontaneously drew with the material closest to his hand, biro on a paper napkin when at a patient's bedside explaining an upcoming procedure to them, blood on surgical drapes when in the operating theatre. After his team opened the patient's chest, Wells invoked the heart as somatic and symbolic by noting aloud to the team with a tone of respect and reverence, 'Let's remember, this is the first time Ryan's heart has been exposed to light' (name changed here). Later, he dipped a surgical swab into the open chest cavity to draw a diagram of his novel mitral repair procedure on surgical paper. The drawing was part of professional social interaction with a visiting surgeon in a political-economic exchange intended to spread a new, improved surgical technique internationally. The novel repair procedure was inspired by Wells's close study of Da Vinci's drawings of the heart and fluid dynamics, another symbolic entanglement. Both Klein's *The Invisible Human* and Prophet's *Swab Drawing* remain unfixed. Though Klein stops the crystallization process and Wells throws away the drawing with the surgical waste, the pieces do not stop 'Becoming'. Their changes are ongoing, depending on where they are shown and who experiences them, with the perspectives and histories of each viewer creating unique meanings.

As we developed ideas in 2016 for a joint artwork inspired by blood, we realized that movement was crucial to our designs. Blood is a fluid, a material that has to be moving to signify vitality in living organisms. Movement is vital to blood and lack of movement leads to the organism's entropy, death. At the beginning of our first collaboration to make *Blood Work 01* (fig. 5), Klein had just returned from an artist residency at Pilchuck Glass School, where he combined 3D printing with glass to create novel sculptural forms. The residency at Pilchuck Glass School reinforced Klein's understanding of glass blowing as somatic process where human breath is carefully calibrated to form structures through its interaction with molten liquid glass that solidifies as it cools. At the same time, Prophet was working with nuclear physicists specializing in fluid dynamics at the University of Michigan and exploring the movement and relations between different liquids when they are combined. To allude to the way that the dynamic movement of blood forms the heart, and the centrality of blood movement to ideas of vitality, we decided to create bespoke glass forms to hold visible moving liquids. We needed to create a kinetic sculpture to showcase the fluid dynamics of those liquids within forms so we reached out to Victor Pok Yin Leung, whose research combines architecture, material science and robotics. We produced *Blood Work 01* with Leung, sketching, prototyping and making between Hong Kong and the United States, working separately and together: meeting on Zoom, drawing on paper and computer, 3D modelling and printing, glass blowing and testing the behaviour of different liquids combined in jars as we dynamically co-constituted the works.

That first sculpture we made together, *Blood Work 01*, was created for and exhibited in the inaugural group exhibition at the Science Gallery Melbourne, titled 'Blood: Attract and repel' (2017). *Blood work 02: Unruh* (2020) (fig. 7) was first exhibited at the 'Art Machines' group show in Hong Kong. Each exhibition's specific curation and title prompt a different interpretation of the works. On the one hand, the curation of 'Blood: Attract and repel' focused on the materiality of blood. On the other hand, in 'Art Machines',

the same works (that incorporate mechanical elements) account for how blood and vascular systems exchange energy and perform as cardiovascular systems that include pulmonary circulation, the circuit through the lungs where blood is oxygenated. *Blood Work 01*, *Blood Work 02: Unruh* and *Common Datum* are cut through by feminist science and technology studies (feminist STS) ideas that extend typical anthropocentric subjectivity to include the non-human and expand our thinking about blood by considering the different properties and qualities of blood in various species, which is pertinent due to our reliance on other species' blood.

We chose to explore the materiality of blood from the Atlantic horseshoe crab, *Limulus polyphemus*, because humans are so entangled with it. These so-called 'trash-fish' were used by humans for fertilizer and as bait until they became medically valuable in the 1950s. They then became part of a violent multi-species entanglement with humans who primarily engage with them within a human-centred, extractive model of living and medical economics. Biomedical companies extract the crabs' blood to produce the most widely used test for the presence of endotoxins. As we rely on their blue blood for endotoxin tests, all humans with any vaccination are connected directly to the horseshoe crab. Each of us who has had a COVID-19 vaccine has entered into a relation with these crabs and depended upon their blood. Reflecting on Pollock's invocation of the heart as a way to understand bodies simultaneously as somatic, symbolic and political-economic entities we researched the extractive and damaging political economy of endotoxin tests. To extract the crab's blood, a large gauge needle punctures its long heart and extracts blood via a process called 'milking' that minimizes the harm it causes. Endotoxin tests that do not rely on the crabs exist. Still, the biomedical industry has been reluctant to transition to other tests because of the complicated and lengthy validation procedure and the need to redesign manufacturing processes (US Department of Health and Human Services 2012). Crabs' blood is worth more than \$15,000 a litre (a litre requires four to six crabs drained of 30 per cent of their blood) in comparison to human blood valued at

\$195–\$400 a litre, and there is little imperative for change as long as the crabs’ lives have a relatively low value.

Horseshoe crab blood is blue due to the copper-based protein called haemocyanin that transports oxygen; the haemoglobin in human blood contains an iron-containing iron protein for the same purpose and turns blood red. In *Blood Work 01* (fig. 5), we amplify the metallic components in these two species’ blood, using iron and copper to create the red and blue coloured liquids. These copper and iron infused liquids coexist in the sculpture to reflect how human blood is entangled with horseshoe crabs’ blood through its use in the production of vaccines and injectable medications. Exhibition texts with information about horseshoe crabs enable visitors to comprehend how the artwork accounts for the blurred boundary between human and non-human and draws attention to uneven power relations between the species.



THE CO-CONSTITUTION OF BLOOD, HEART AND LUNGS

Feminist STS ideas of queer ecologies help us account for how our artworks might expand subjectivity beyond other species, such as the horseshoe crab, to the interrelations between life and environment (Schnabel *et al.* 2016), giving agency to matter. Our sensemaking of blood and hearts is also a way to engage with matter that flows between human blood and air, building on a shared belief that ‘practices of knowing and being are not isolatable; they are mutually implicated. We don’t obtain knowledge by standing outside the world; we know because we are of the world’ (Barad 2007: 185). *Common*

Datum extends our questioning-through-making to help us understand the queer ecology of our hearts and lungs.

During Prophet’s residency in a heart transplant unit, she interviewed patients who had experienced changes to their sense of self after receiving a replacement heart from a living donor. In this ‘domino transplant’ scenario, there is a patient who needs a lung transplant who receives both a heart and lungs (it is often more successful to transplant both together than only transplant the lungs as the two organs are so intertwined). If the heart–lung recipient has a healthy heart, it can be transplanted to another patient. Some such patients voiced what we might describe as feelings of ‘becoming with’ the donor, and receiving an organ from another human seems to have a more profound impact on recipients’ sense of self, especially in the case of a so-called domino heart transplant where there is a living human heart donor.



■ Left: Figure 4. *The Invisible Human*, Tobias Klein, 2013. Lower abdomen after growing for ten days. Photo A. Kaiser

■ Right: Figure 5. *Bloodwork 01*, Tobias Klein, Victor Leung, Jane Prophet, 2017. Photo courtesy Science Gallery Melbourne

When we breathe out, approximately 22,000 times a day, we expel different substances than we inhaled, including viruses, that then blend via air inhaled by other human and non-human bodies. The relations between blood, heart and lungs form the human pulmonary

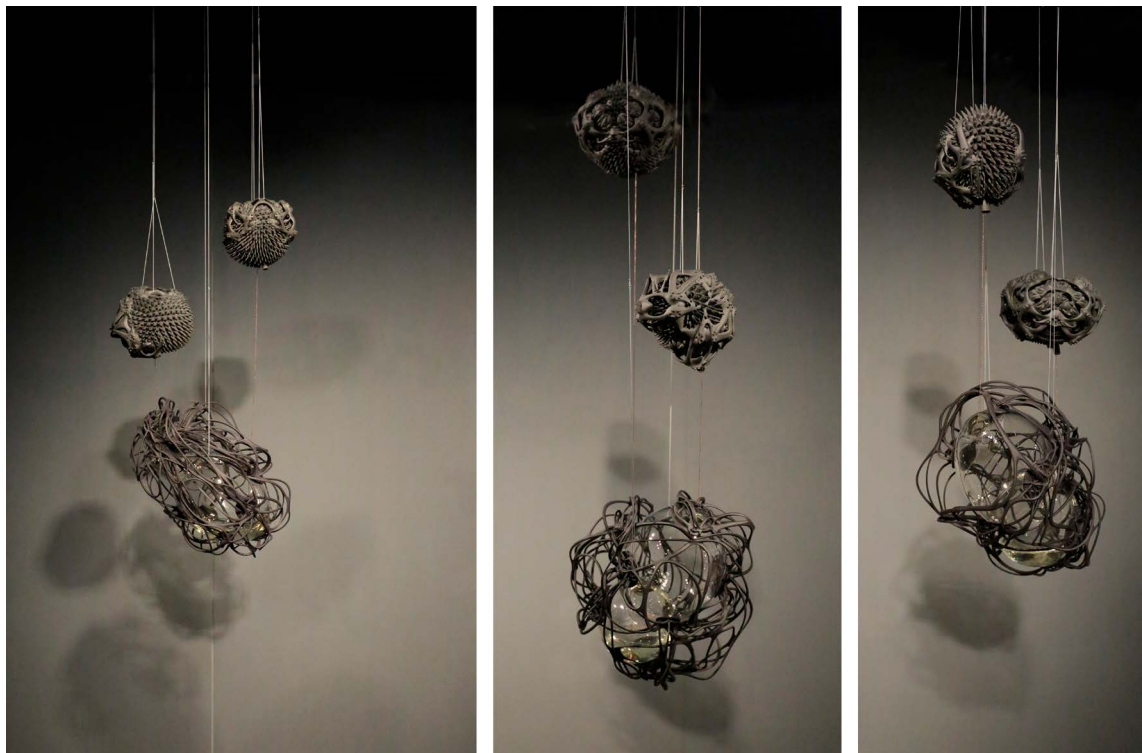
circulation that moves blood between the heart and the lungs. It transports deoxygenated blood to the lungs to absorb oxygen and release carbon dioxide. The oxygenated blood then flows back to the heart. These relations extend or dissolve the boundaries between self and other, human and environment as through pulmonary circulation liquids and gases cross semi-permeable membranes. With each breath, our lungs and blood exchange oxygen and carbon dioxide. We breathe in materials, such as pollutants, absorbed through the pulmonary endothelial cells, part of our lungs' alveoli. The environment outside our bodies slips over into our bodies. The flow of blood is a fluid permeable interface that challenges ideas that there is any easy differentiation between inside and outside our bodies. The function of human lungs inspires our most recent joint artwork, *Common Datum*, but we use a heart-like form because of the co-constitution of the heart and lungs in the human body.

Common Datum (fig. 6) is an environmentally reactive, hygroscopic sculpture. A series of suspended 3D printed vessels continuously absorb the humidity in the meticulously environmentally controlled exhibition space.

A black 3D printed polymer network enmeshes heart-like transparent glass vessels suspended from the ceiling by thin wires. The average lung capacity of an adult is about 6 litres. Once exhaled, their breath cools to the ambient temperature, leaving the air supersaturated. If it is cool enough, it will form a visible cloud. When our breath meets a cold surface, it leaves visible condensation. The strict control of temperature and humidity of the air in exhibition spaces is necessary because humans disturb the artworks by changing the microclimate of the gallery space through breathing. The breath of the audience generates humidity that increases through conversation.

Common Datum comprises two parts: the condenser, nested within the 3D printed structure, and the recipient, made from glass. The condenser uses a mixture of physical and chemical processes to transform the visitors' presence, and their breath, into water. First, the 3D print is designed with lamelle-like structures to increase the surface area and thus the exposure to air. Second, inside each condenser, there is a chemical absorption and purification system composed of layers of calcium chloride that collects moisture from the air and

■ Figure 6. *Common Datum* version 01 (left) 2021 Tobias Klein and Jane Prophet. Photo Tobias Klein, courtesy of the authors



activated charcoal to clean it of residues and impurities. Gradually each 3D printed condenser accumulates water that slowly drips into the glass volumes. Even though each vessel is a different shape, locally absorbing moisture at a different rate, a common datum is created throughout all of them. The common datum is constructed through participation with the sculpture, resulting in each visitor's breath condensing. Visually, the level of condensed water in each vessel forms a datum – the accumulation of a previously invisible, now reified common datum – a collective co-constituted body.

STATE CHANGES, ENERGY AND MAKING VISIBLE INVISIBLE FLOWS

Each of our collaborative works inspired by the often-hidden energies of fluid dynamics. The sculptures combine different fluids and move them in ways that draw attention to their dynamic interactions. Our biologically inspired, transparent kinetic sculptures depend on and transform the properties and qualities of blood in different species; fluidity, coagulation and metal content form the structure and movement of the sculptures. To create previous artworks we

had separately worked with state changes, for example using the process of crystallization to change a supersaturated liquid to a solid. That change occurs too slowly for humans to perceive. Klein used crystallization in *The Invisible Human*, as described earlier. In Prophet's sculpture *Time Slice*, a glass tank contains a 3D model of a tree formed of nearly invisible acrylic threads along which crystals form. *Time Slice* (2004) alluded to pathology, where stains are applied to tissues to make visible artefacts and structures otherwise invisible.

We chose glass as a key material in our collaborative pieces, intrigued by our new understanding that glass production depends on crystallization. As Klein knew from his work at Pilchuck Glass Studio, solid glass is

produced by cooling a molten liquid fast enough that crystallisation does not occur at the normal freezing point. Instead, the liquid supercools into the thermodynamic never-never land of metastability: kinetically settled enough to exist as a well-defined state of matter, yet not truly thermodynamically stable. (Martin 1999)

In all the works, the vessels of bespoke blown glass are made of an amorphous solid, glass, which is neither a liquid nor a solid but a matter



■ Figure 7. *Bloodwork 02: Unruh*, Tobias Klein and Jane Prophet, 2020. Photo Tobias Klein, courtesy of the authors

that exists somewhere between those two states. The human perception of time, and timescale, is key to our understanding of glass as a solid versus a liquid. As the hot, liquid glass cools,

[o]n a short timescale, the 'liquid' glass will appear solid, but after a short while, it can be seen to be slowly flowing ... At still lower temperatures, the relaxation time reaches values that are truly geologic, i.e., many millions of years. Window glass at room temperature has a nearly incalculable relaxation time, approaching the age of the universe itself. For all practical observations, this glass is a solid. But its solidity is in the eye of the beholder. (Martin 1999)

If our human eyes could behold millions of years, we might 'see' glass as a liquid.

We began to experiment with ferrofluid as part of our research into liquids that contain iron to reference the iron in human blood in *Bloodwork 02: Unruh*. Ferrofluid is a suspension of magnetic nanoparticles made of a compound containing iron that, in this case, is suspended in oil. We were both interested in ferrofluid before we began collaborating. Jane first encountered ferrofluid in July 2004 when British materials engineer Mark Miodownik brought an acrylic briefcase filled with tantalizing phials of unusual materials to her studio – 'a resource for scientists and for artists using a language we both understand – the language of wonder' (Muse of the lab shapes edgy art (2) | Times Higher Education (THE) 2005). Klein saw ferrofluid for the first time at a lecture as a student at the Bartlett School of Architecture. Later, the works of Sachiko Kodama inspired him further to see ferrofluids as a materialization of otherwise invisible forces. Ferrofluid is a material that acts like a liquid until a magnet is applied to it, causing it to behave like a magnetic solid; then, it almost immediately acts like a liquid again when the magnetic force is removed, and the nanoparticles are demagnetized.

We installed numerous spherical magnets in *Blood Work 2.0: Unruh* that moved within the hollowed 3-D printed black tubes built into the gyroscope. This gyroscopic frame held the glass heart-like container, and black ferrofluid inside the glass shared space with a transparent liquid – water and isopropyl alcohol (fig. 7). Although magnetic forces are invisible, their impact on the sculpture is profound; as the magnets roll

around, they change the location of the magnetic field, which attracts the ferrofluid, causing it to flow through the water; this movement tilts and rotates the glass vessel. The delay in the forces exchanged is caused by the speed of rotation and the liquids' viscosity that imbalances in the system, leading to an entropic state. That stillness is interrupted by an engine-driven belt that moves the gyroscope and sends the spherical magnets rolling again.

Just as the form of the heart is determined by the invisible forces of the blood that flows through it, *Common Datum* condenses the hidden traces of our presence (our breath), changing the gaseous state of air to a liquid. Here, we draw attention to the state change from gas to a liquid, stimulating the human perception of time to notice condensation drips. Upon saturation, drips run down a series of threads into three glass volumes. The piece emerges through the relations between the artworks and the visitors in the climate-controlled gallery. The flow between breathy air and the solid forms, and chemicals condense breath into liquid. The drips of liquid that accumulate are data of the breath and conversation over a particular time, in a specific place. Drip by drip, the wet air expelled through the human breath, conversation and laughter in the gallery accumulates as a liquid in the sculptures. Without witnesses, in silence, the artworks seize to produce water. Condensation stops forming, and the sculpture becomes inanimate without visitors. It only restarts when visitors and the humidity they create can be detected in the vicinity of the artwork. Both *Unruh* and *Common Datum* shift back and forth from entropic stillness to movement.

CONCLUSION

We are both artists who work between science, technology and art that have found working with blood blurs imagined boundaries between these disciplines. Gallery visitors easily perceive blood as a vital fluid, culturally loaded with significances and concurrently a biological substance with a complex chemistry and structure. Blood is a non-Newtonian fluid, which means that the viscosity of blood changes depending on how much force and thus energy is

applied to it. It is a reactive substance that acts as a carrier for oxygen and nutrition in all the world's fauna. The multiple and immediate connections that people feel to blood makes it a productive artistic material through which we can also call in the cultural, political and economic relations of science and technology.

Blood Work 01, Blood Work 02: Unruh, and *Common Datum* make visible numerous relations that are invisible to unaugmented humans because they take place hidden from view – inside our bodies. Perhaps they are not perceived because of the limits of human perception of scale: most commonly physical scale or timescale. Our collaborations are a way to visualize such processes and multiscale environments: from the settings of our always-hyperlocal bodies, our blood, hearts and lungs, that are entangled in the regional environments where we live – the humidity of Hong Kong, the United States, home to Atlantic horseshoe crabs. Through the works we simultaneously draw attention to our relations with inter-scalar Anthropocene air composed of constantly mingling particulates.

We highlight the circulation of blood as a form of energy transfer in the works *Common Datum* and *Unruh*. We externalize the energy of our bodies, turning invisible systems inside out. In the individual and collaborative works described here, the underlying momentum of works and of our interest in creating them, is the performance of systems, articulating circulatory notions of energy transfer, and making hidden biological processes and forces visible. The *Bloodworks* series is a sense-making project through which we explore some of the blood-related forces and processes that are integral to the forms of human bodies. Blood is central to the formation of semi-porous boundaries where our human bodies meet the environment and intrinsic to the biological processes through which matter changes state. Our hearts pump blood to the lungs for oxygenation; the lungs bring in oxygen and expel carbon dioxide through complex movements across 'surfaces where different elements meet' (Kenner *et al.* 2019: 153). Although related, these iterative artworks are uneven and contingent – always-becoming and never quite finished and

we are currently working on the fourth iteration in our experiments.

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REFERENCES

- Ackerman, Michael J. (2022) 'The Visible Human Project', *Information Services & Use* 42(1): 129–36. DOI: 10.3233/ISU-210145. PMID: 35600127. PMCID: PMC9108582.
- Barad, Karen (2007) *Meeting the Universe Halfway: Quantum physics and the entanglement of matter and meaning*, Durham, NC: Duke University Press.
- Cassar, Joanne (2017) 'New materialism. New materialism almanac', 4 July, <http://bit.ly/3JYDm8o>, accessed 16 May 2022.
- Kenner, Alison, Mirzaei, Aftab and Spackman, Christy (2019) 'Breathing in the anthropocene: Thinking through scale with containment technologies', *Cultural Studies Review* 25(2): 153–71.
- Martin, Steve W. (1999) 'Is glass really a liquid? How can this be?', 21 October, *Scientific American*, <http://bit.ly/3yWJ17p>, accessed 16 May 2022.
- Prophet, Jane (2005) 'Muse of the lab shapes edgy art (2)', 3 June, *Times Higher Education* (THE), <http://bit.ly/40tTsMT>, accessed 16 May 2022.
- Pollock, Anne (2015) 'Heart feminism', *Catalyst: Feminism, theory, technoscience* 1(1): 1–30.
- Schnabel, Landon, Breitwieser, Lindsey and Hawbaker, Amelia (2016) 'Subjectivity in feminist science and technology studies: Implications and applications for sociological research', *Sociology Compass* 10(4): 318–29.
- The National Library of Medicines Visible Human Project (n.d.) The Visible Human Project. U.S. National Library of Medicine, <http://bit.ly/3z0CKsJ>, accessed 16 May 2022.
- US Department of Health and Human Services (2012) 'Guidance for industry, Pyrogen and endotoxins testing: Questions and answers', Washington, DC: US Food and Drug Administration [preprint].