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shapes of edges

Exploring the notion of boundary, drawing on experiments in force and form.

The University of Sydney
Sydney College of the Arts

A thesis submitted in partial fulfillment of requirements for the degree of Doctor of Philosophy.

This is to certify that to the best of my knowledge, the content of this thesis is my own work. This thesis has not been previously submitted for any degree or other purposes.

I certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged.

Sean O'Connell.

Proofreading of the final draft through the generous assistance of Professor Robert Ross.

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appendices

abstract

Shapes of edges explores the boundaries we perceive - the surfaces of objects we touch, constellations in the night sky, the fenced borders of home and nation, lines between animate and inanimate, and the outer edges of the ideals which we hold to our hearts. Through elaborate physical experiments in force and form, and applied philosophical thought, the underlying structures of knowledge which we use to define the world are examined.

Three basic experiments, documented in detail, form the foundation of the study. The physical experiments are: colliding of hollow metal boxes in air; studies of smoke vortex formation; and spark discharge imaging of solid forms. Machines are purpose-built for the experiments, and documentation carried out in traditional and alternative media. Many of the methods of recording require bespoke apparatus, created with a single process in mind, and the processes inevitably become entangled with expectation, perception, and habitual patterns of thought. The experiments and the machines, the documentation and their processes, the exhibited work, the philosophical research, and these written words, all merge. Such a mesh of information creates rich ground for new knowledge, arising from an intimate relation of disparate parts, all brought to bear upon one notion, that of boundary.

The aim of this research is towards a broadening of possibility, rather than the defining of any single conclusive outcome. It folds in the personal with the factual and the philosophical with the scientific. Uncommon perspectives, such as ceaseless flux and the energetic texture of reality, are taken as fundamental perceptual frameworks, on equal footing with more conventional notions of apprehending reality. This approach helps overcome the simpler traps of constantly

thinking in space and time - definition, division and the illusion of static structure. These thoughts draw heavily upon the philosophy of Henri Bergson, Michel Serres, and Georges Bataille, yet, here in this research, and even within this writing, there is a constant return to the mundane world of matter.

Through the physical experiments undertaken, and the process-driven manner in which they are documented, this research speaks through the solidity and texture of materiality. The sensuality of substance and physical form, the palpability of force, the duration of time, and the apparent clarity of boundaries, become the initial points from which the intellectual and aesthetic inquiry expand. Through placing such simple experiential notions at the core of this study, these basic notions are allowed to expand and move beyond their initial limitations.

This written thesis reflects upon the experimental processes and their documentation, combining personal observation and philosophical pondering, along with theories of science, and various examples taken from diverse fields. Associated ephemera and found objects relating to these concerns - objects of deep personal significance - are also presented, providing context and underlying motives for this study. Yet it is the basic approach of this study - in the constant return to primary perception and direct apprehension of the physical world - that these ponderings and abstract notions are brought to bear upon and fold into the nature of knowledge. It is in such a manner that this research reveals the shapes of edges.

approaching the edge

There is a certain vertiginous feeling when one imagines going over the edge. There is exhilaration - a mix of raw fear with blind freedom. There is physical dislocation - a loss of ground and reference. There is also a desperate need to grab hold of something solid. There is an instinctual sense of danger, of mortal threat to mind and body. Yet people are constantly paying to jump out of planes with parachutes strapped on them, so there must be something wonderful we feel when going over the edge.

Whether free-falling through air, or standing on our feet, our bodies are heavy, and we are constantly drawn to the ground. We spend nearly the entirety of our time upon one solid surface or another. The ground upon which we stand is a kind of edge - a boundary between earth and air. The ground might be better imagined as a surface - as the flat "edge" between earth and air. We find edges wherever we perceive difference. Our minds and thoughts, much like our bodies, are similarly drawn to solid surfaces. In our environment, as we walk upon the earth, we are intellectually aware of a depth of rock beneath us and space of air above us, but we primarily inhabit the surface - the edge that borders earth and air. We comprehend the ground, the earth, as a flat plane - as a *surface* - because that is our experience. As a miner or a deep sea diver this is altered, but generally, we are surface dwellers.

We know in our minds that the earth is a curved solid sphere moving through space, but it is hard to truly grasp without some form of direct experience. Our minds are simple, formed over countless generations, to keep us alive, nourished, and safe. Our structures of thought have developed alongside our need to navigate reality, and the shape of these structures is a mirror of those needs. Minds evolve to fulfill needs.

These basic needs are very common, yet each subtly different environment, culture, and individual, interprets the world in its own idiosyncratic manner, adjusting to fit. There is the clichēd use of 50 words in Inuit for snow[1], where subtle distinctions in the environment are of the utmost importance to survival. Or a modern physicist's view of reality as comprised of complex interacting units, the prediction and control of matter and energy governed by abstract theories. A steel welder's perception and understanding of metal as a liquid, and the manipulation of matter through physical processes undertaken with his or her hands. In these and all other such instances, different perspectives emerge to meet the needs of the situation. The world, seen through this myriad of alternate views, becomes beautifully complex and multiple. *Exceedingly* multiple. In this multiplicity and diversity, reality becomes rich in ways that lend a depth of mystery to the simplest of things, instilling profound possibility into the mundane everyday.

But we cannot live in a constant state of wonder at the breadth and depth of varied perception - we need to eat and carry on daily activities alongside such careful awareness. Our individual minds are small - we can only hold so much within them. If we were to open ourselves to the flow of saturated sensations that pour from the mysteries and wonders around us, we would never move, slack-jawed and entranced. So we become selective. We focus. In order to function, we choose to see that which benefits us and helps us to live - food, security, procreation. The basics. We have survived by being selective with our perception, prioritising survival.

Considered as such, our realities are obviously defined by such selective perspectives. Each of our views are so subtly different, yet so fundamentally similar that we can

1 Eskimo words for snow, in the Inuit or Yupik branches, are created through extended suffixes that work more like specific attached descriptors, yet the overall notion is still the same - if one lives in a particular environment, perceptions become refined and linguistic distinctions are made - distinctions that may seem overly complex and become lost on someone who is not accustomed to that environment. Source - "The Eskimos' Hundred Words for Snow," accessed June 10, 2016, http://ontology.buffalo.edu/smith/varia/snow.html.

communicate and share experiences. The nature of these differences and similarities reveal the nature of the world around us, as much as they reveal how we perceive, and how we structure our knowledge.

The structures of knowledge that build to form the basis of our perceptions, of our choices and actions, are embedded within every thought and perception we have. They constitute our perspective. Our filters of categorization, the abstracted relations of similarity, the basic mode of reductive rationalising and defining - these processes are at the core of all contact *with*, and every conception *of*, our reality.

In speculating upon knowledge, in attempting to become aware of the structure and edges of knowledge, one approach is to deploy alternate perspectives. *Multiple* alternate perspectives. Simply taking a step back, for a better view of knowledge, is just not possible - we are integrated with our vision. If we take a step back, where do we step to? We are entangled between our own perception and a reality we believe to be manifest independent of it. In allowing multiple perspectives, diverse sets of knowledge are free to inter-relate, forming sets of connections and commonalities that hint at underlying notions and tendencies. If these alternate perspectives are allowed to remain complex and unresolved - are allowed to remain multiple - then with careful consideration the edges of our vision can be lit, and gently revealed in subtle relief. Through revealing these edges of vision, the underlying structures of knowledge that are the framework of our perspective become apparent.

This approach of multiple perspectives, focused upon the nature of perception and knowledge, is applied here to a series of physical experiments and their observation and documentation. The process is intuitive, and difficult to track rationally. However, this lack of clear definition is

essential to the process, as shall become apparent as the process develops.

It is important that the experiments of this research are physical. Even more so, that they are concerned with naturally occurring forms, and the movement of material and energy. The experiments track the forces of order, form-building, energetic exchange, and motion, that swell beneath simple material interactions. Underlying forces revealed through pattern and movement. The crumple of sheet steel as a metal form collides and resolves excess energy in deformation and energetic vibration. The revolving layered vortex of a smoke ring as it travels and folds itself delicately through space. The crackling arcs of electrical sparks reaching out through air to dissipate along branching paths of escape. These experiments in force and form, of energy revealed through materiality, are the focal point around which this exploration of knowledge revolves. Explored from multiple points of view, documented simultaneously through alternate approaches, the experiments become the focus in an expanding multiplicity of perspective. Beneath this expansion there is conscious consideration, and a gentle awareness of the act of perception - a sensitivity to the processes of knowledge creation.

As much as this research is about structures of knowledge, force and form, and the shapes of the edges we create to define our reality, it also addresses a deep personal need to draw boundaries. These emotional boundaries, of death, separation, and nostalgia for the past, are profound underlying urges that push this entire research forward. While they are often not directly explicated or outlined, they resonate through the collected pictures of ephemera and objects that are touched upon in this writing. These emotional drives are intrinsic to this research, its interpretation, and presentation.

We are all propelled by our past and driven by our

feelings to a greater or lesser extent, and I acknowledge that much of this research and creative work is aimed at probing issues I am unable to unravel intellectually. Far from being detrimental to any sense of truth or clarity, I believe it is a great contribution to overall understanding when we consider such emotional drives behind the will to knowledge. The ways in which we make sense of the world are complex, and it seems dangerous to separate out thought and feeling, when these aspects of knowledge are so deeply entwined.

In this exploration of the shapes of edges - the areas where knowledge begins and ends - there are no clear truths, for all interpretations depend upon position and perspective. All is relative. As such, the understanding gained here is not concerned so much with power and control as it is with self-reflexive clarity - it seeks a certain loosening of habitual rational modes of definition, an appreciation of complexity, and an acceptance of difference.

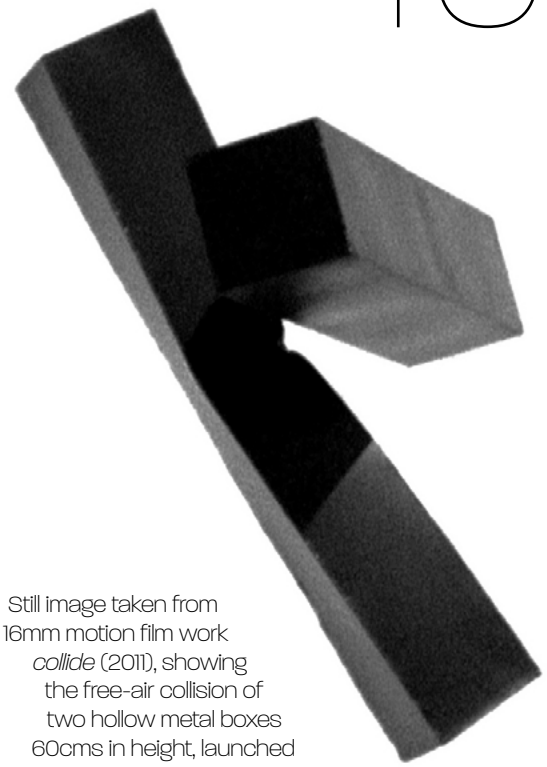
No comprehensive theory or definitive solution results from this research - instead, it operates in a way that allows simple reflective consideration upon the processes of knowledge. These processes of knowledge are explored through various approaches - alternate modes, mostly imperfect, that rarely lead to resolution, and often lead to more questions. Together these approaches foster reflective awareness, and help to elucidate aspects of knowledge that are assumed and habitually used, or that we conform to without being aware of. The goal of understanding our own processes of knowledge through such diverse considerations and approaches is simple - self-understanding, empathy towards others, greater possibilities in knowledge, and a deeper appreciation of the world around us.

> "The fact of our imperfect understanding should not be allowed to feed our anxiety and so

increase the need to control. Rather, our studies could be inspired by a more ancient, but today less honored motive: a curiosity about the world of which we are part. The rewards of such work are not power but beauty."[2]

2 Gregory Bateson, *Steps to an Ecology of Mind* (Chicago: University of Chicago Press, 1972), 269.

form



Still image taken from 16mm motion film work *collide* (2011), showing the free-air collision of two hollow metal boxes 60cms in height, launched from the first spring-operated colliding machine.

edges

One should never seek to define important things by their boundaries, because boundaries are always blurred, are always interfering. One must seek to define the heart...[3]

Form is apprehended through its edges. Edges define a form. There are many sorts of edges. I can feel the edge of the table, and imagine the edge of a cliff. The outside surface of an apple is an edge, as is the invisible boundary between two townships. It is harder to imagine my own edge - what separates me from not-me. I trace the surface of my skin when I imagine it. Yet what about inside my mouth? Open or closed? Or the food that I

3 Edgar Morin, *On Complexity* (New Jersey: Hampton Press, 2008), 48.

just swallowed? Is it part of me or something outside of me that is within? Does it become me now, or when it is digested and incorporated into my body? What of the words that enter my ears, of language I learn and make my own, of conversations with friends and colleagues, notions and ideas that are shared and swapped and incorporated into my personality? Where are the edges of my thinking, and that of others?

These are simple and naive considerations, but they throw light upon the standard approach of *edging* the world. In the use of oversimplified edges to define and apprehend all things, there is a deep intellectual habit - a mode of thought - that resonates as an undertone through all apprehensions of reality.

Edges seem like well-defined states, and are liable to be used without thinking about them too much, sectioning off parts of the world into discrete parts. This habitual use of edges is addressed clearly in this research through many examples. The aim is not to completely dissolve the solidity of a reality that has been carefully constructed culturally and individually, nor to present a radical alternate model of perception that eliminates the need for definition. The aim is simply a greater awareness and understanding of these habitual structures of knowledge that we so heavily rely upon in our daily lives.

The most simple edges of definition break down quickly into contested intermediate zones when any serious consideration is applied. Yet these basic constructed borders are part of a fundamental approach to understanding the world. We need them. We navigate our daily realities and make sense of the complex rush of perceptions that continually flood us, though sectioning off and categorising the world into intellectually manageable sections. Edges are assigned, and space is ordered. This intellectual feat is performed upon almost

all aspects of reality, from the simple edge that is the outer skin of an apple, the variable mapped lines of the sea lapping upon the land, the shifting borders of nation-states and their peoples, the complex instance of our own individual identities, and the fluid bounds that form our innermost group of friends. But what is happening perceptually and conceptually in this act of separation and drawing of boundaries? What do we do to our reality, to our perception and possible understanding of it, when we go about edging the world like this?

Edges are often negotiated through perception - they are a kind of mutable conceptual zone - a meeting place between the tightly ordered fabric of our consciousness, and the vast complexity of reality. But how does this fabric of consciousness, through the processes of perception, edge the world? Where does this inclination to define and delineate stem from? Why do we not naturally apprehend reality in a more fluid or holistic way? Is it biological, culturally determined, a product of the binary nature of sexual reproduction, or an innate aspect of conscious self-awareness? Perhaps the physical structure of neuronal clusters in our brains echoes the framework of our perception, creating clearly divided parts? Or perhaps this conception of the neuronal structure is defined by the innate tendencies of self-awareness - which effects the other? Perhaps there is a general tendency in knowledge towards perceiving units, structures, and patterns, when the breadth or intricacy is too complex to intellectually grasp? It may be that this mode of edging the world is a defence against the vast incomprehensibility of the universe, thrown up by a simple consciousness, that only needs to contend with what is beneficial or detrimental to its survival. This is all well and good, and we are bound to have our limits, but what other structures of thought are built upon such foundations, what other approaches and ways of thinking? Does this kind of approach limit

knowledge to one linear path of development, if such defined outlines and definitions are taken as fundamental truths?

What would it mean, if it were possible, to see beyond and around these edges, these modes of creating boundaries? Likely, the vertiginous rush of incomprehensible sensation would simply be too much. Perhaps If we could just begin to perceive these edges, to approach them, an awareness of their shapes and qualities would grow. These lines of definition that are constantly imposed upon the world - what do they look like?

Such examinations are too complex to be taken head-on, and are best approached sideways, from multiple angles. Through being attentive to the development of thoughts, and encouraging recursive awareness in acts of perception, these edges can sometimes be apprehended as they arise. While it may not be possible to see past the edges to some underlying primary fundamental reality (if such a thing exists), a greater awareness of the nature and character of the *act* of perception is possible. The qualities we each bring to our individual realities, through our perceptions and structures of knowledge, need to be clearly appreciated as *part of a process of understanding*, before we can begin to untangle our relationship with the world, as experienced through such a complex consciousness.

Simple physical experiments are a good place to start when exploring the underlying structure of reality, and are also useful to explore the nature of knowledge production. But to help become more aware of processes of thought and knowledge, a subtle kind of attention is needed. A kind of attention that does not judge too quickly. If multiple possibilities are initially allowed to co-exist, without the motion towards some final resolution, habitual patterns

of linear thought can be stalled. This will allow a series of possibilities to build, and rather than a simple line of thought, a plane of thought can be allowed spread out. In searching for commonalities and qualities, not singular primary defining factors, this approach of the unresolved multiple is essential. This may not be the best approach in structuring a typical academic thesis, but new knowledge - the ultimate aim of doctoral research - can develop in many different ways. The knowledge developed here, through the parallel creation of a body of creative work, and of intellectual consideration, is best approached, and described, in such a manner.

hazards of the flat plane

> There is nothing you can dominate as easily as a flat surface.[4]

Before going any further, there is a general habitual tendency to think in flat planes which must be acknowledged. When drawing on paper, especially when "working something out", on computer screens, in photographs, and diagrams of all kinds there is a tendency to reduce complex spatial and temporal issues in a manner where they can be expressed in the flat. Information is often translated onto a surface. It is a useful abstraction - to reduce reality to a flat depiction - allowing us to get a grip on its vast depth through its simplification into one layer. But, however useful this approach is, it is a radical abstraction of the complexities of reality, and its incredible strangeness must be noted. The voluminous complexities of reality cannot be simplified to one flat slice

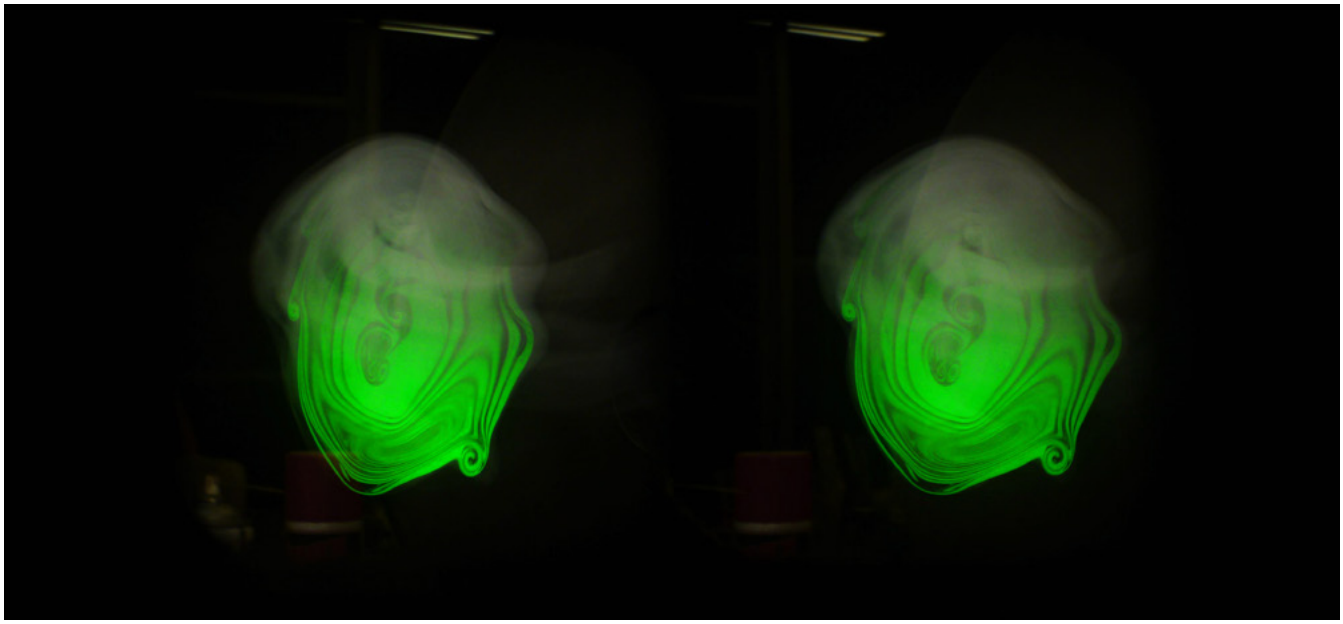
4 Bruno Latour, "Drawing things together," in *Representation in Scientific Practice*, edited by Michael Lynch and Steve Woolgar (Massachusetts: MIT Press.. 1990), 45.

without a consequent loss of information. As a tool of examination and communication it is extraordinarily useful, but as a habitual mode of thinking - as a main method, or conduit, for understanding the multi-dimensional flux and complexities of reality - such a translation can form habits of thinking that lead to unnecessarily limited conceptions of reality.

The ability to conceive of the world in a flat plane, to convey information through images, is profound. It is especially useful when learning how to communicate - through distinguishing and naming parts of the world around us. Very early at home and in school, the young are taught to discern where one thing ends and another begins. A pencil draws a line, and whether it is the edge of a person, house, dog, cloud, or boat, the traced line defines the edges of the world and its parts through simple marks on paper. Such actions and perceptions are learnings and lessons in the common cultural boundaries of things. Beginning with these initially playful outlines of the objects and people, reinforced by the defining edges of names, grammar, and linguistic ordering, an early habit for drawing simple edges on flat planes is established. In both images and words, this early reliance on the simplicity of edges and flat planes, pictorially and conceptually, forms a fundamental pattern that structures thought.

The modern world is becoming ever more saturated with imagery. From constant photos for remembrance and sharing, the flood of informative and titillating imagery that pours from the flat screens of our computers and phones, to the commerce of magazines and the luxury of books. Images mediate the world and its complex contexts, and they are used to convey, supplement, and replace the real. Through photographic images capturing light in slices of time, cross-section diagrams of machine parts, x-rays of the internal structure of our bodies, or “three

dimensional" sketches of our dream house, perceptions of spatial and temporal reality are adapted and learned, in order to understand and convey ourselves and our environment. Through subtle extensions of primary senses and perceptions - through the influence of the very media and format of the imagery - the processes of conscious perception and apprehension are manipulated. Through representation in all its guises, there is an externalisation of perceptions, a translation and manipulation, that reintegrates into new ways of perceiving.

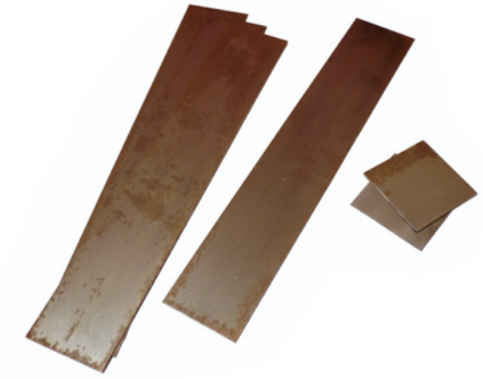


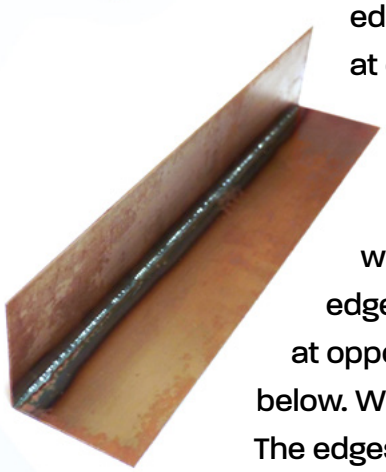
Stereoscopic image pair of a smoke vortex illuminated by a thin plane of green laser light, projected at an oblique angle through the vortex. This can be viewed as a 3-d image through the standard method of slowly crossing ones eyes over the right-left pair to create a composite image with perceptual depth. For more detailed instructions, see - "How to View Photos on This Site," accessed July 1, 2016, http://www.3dphoto.net/text/viewing/technique.html.

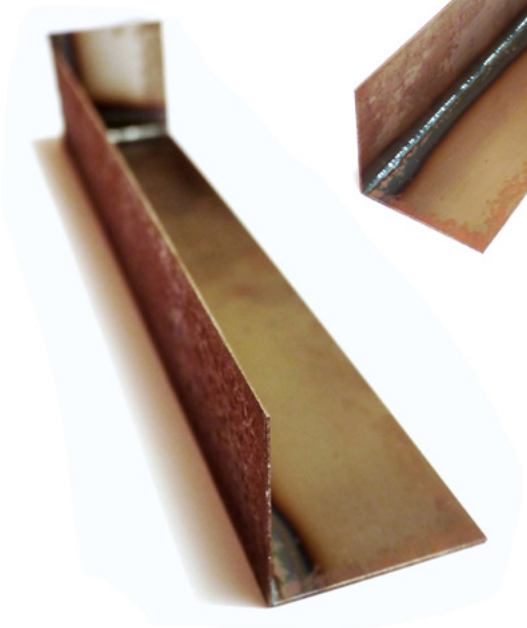
The image above is one instance - something that cannot be seen with the naked eye. In this stereoscopic image of a smoke ring lit through one plane by a line laser, visual access inside the structure of a smoke ring is granted, frozen in a short span of time. The smoke vortex is three dimensional, yet through the light of the laser plane, one flat plane of its form is revealed. This kind of imaging brings understanding to what is happening within the smoke ring, how it forms and maintains its shape. As a three-dimensional stereoscopic pair, it also reminds the viewer, and teases them as they twist their eyes, that this is merely a flat plane, and that it exists in three dimensional space. And also that it exists as a single slip of time, and there is a before and an after not depicted.

Such visual slices of reality as these, allow generalised notions and concepts to be built up - aspects of the world around us. Yet if these processes of visualisation and representation are granted a kind of phenomenal truth, perceptions can be very quickly confused with reality, folding them all in one. Mental pictures like these, and the ideas and theories that dance between the approaches and processes of perception, transform perceptions and the structure of each personal individual reality. They also allow the construction of the kind of knowledge that leads to repeatably consistent predictive understanding of the world. This is the kind of knowledge that is epitomised in modern science and technology, and has led to benefits in so many aspects of life. This is constructive thought, linear in motion, building upon clearly defined and proven truths. Yet there are other ways of building knowledge, that reveal other aspects of reality, and they must be allowed to speak also - on their own terms - without needing to be validated within a dominant system. Alternative methods of knowing should be supported - possibility and difference should be encouraged - for they allow flexible development, adaptive systems, and foster the manifold possibilities present in the breadth of each moment. In examining the tendencies of rational thought, in the flat plane as it were, the aim in this research is not to devalue objective and linear approaches to knowledge, but rather it is to promote diversity in knowledge creation, and allow other approaches to be heard without being translated into the dominant language of objectivity - to allow alternate perspectives to develop in the manner and style that best supports the further growth and development of knowledge - knowledge in its broadest possible context.

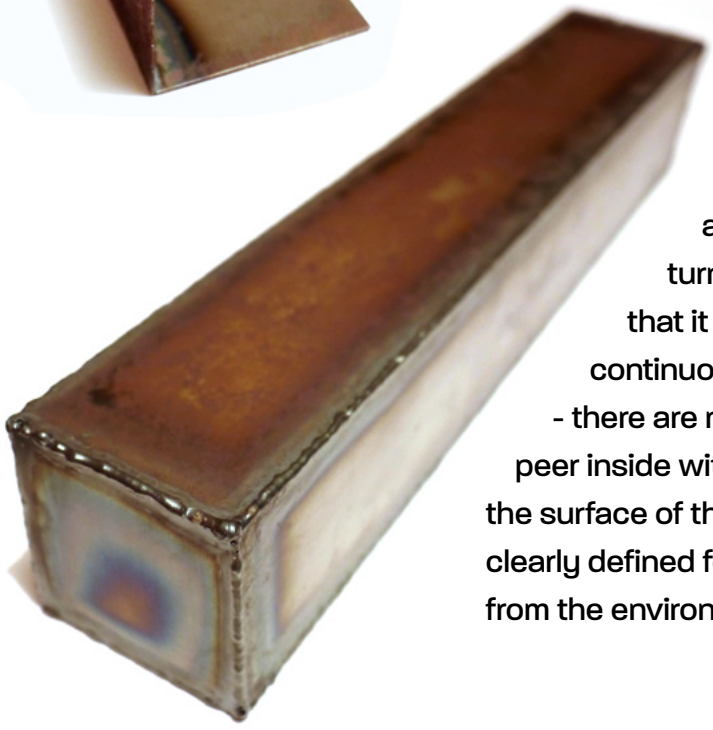
building a form from edges



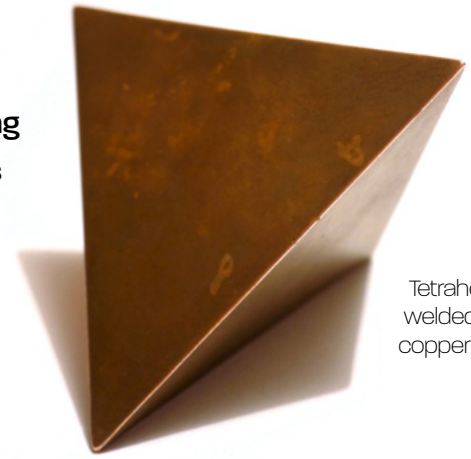




The simple steel box at the bottom of this page was built from sheet metal cut into rectangles and squares. The rectangles were placed long sides together, so that their flat planes met at 90 degrees, forming one long corner edge. A square of sheet metal was then placed at one end, capping the shorter edges of each rectangle, creating a corner point where all the edges of the three sheets met. Once two identical pieces like these were made, they were joined together so that the two long open edges of each construction met, with the squares at opposite ends. This created a typical sealed box, below. When building such a box, space is enclosed. The edges and corners are plain to see and feel - sharp edges, flat planes. This box is complete - the entire outer surface of the sheet has become an edge of sorts - cleaving space in two - that which is box, and that which is not box.

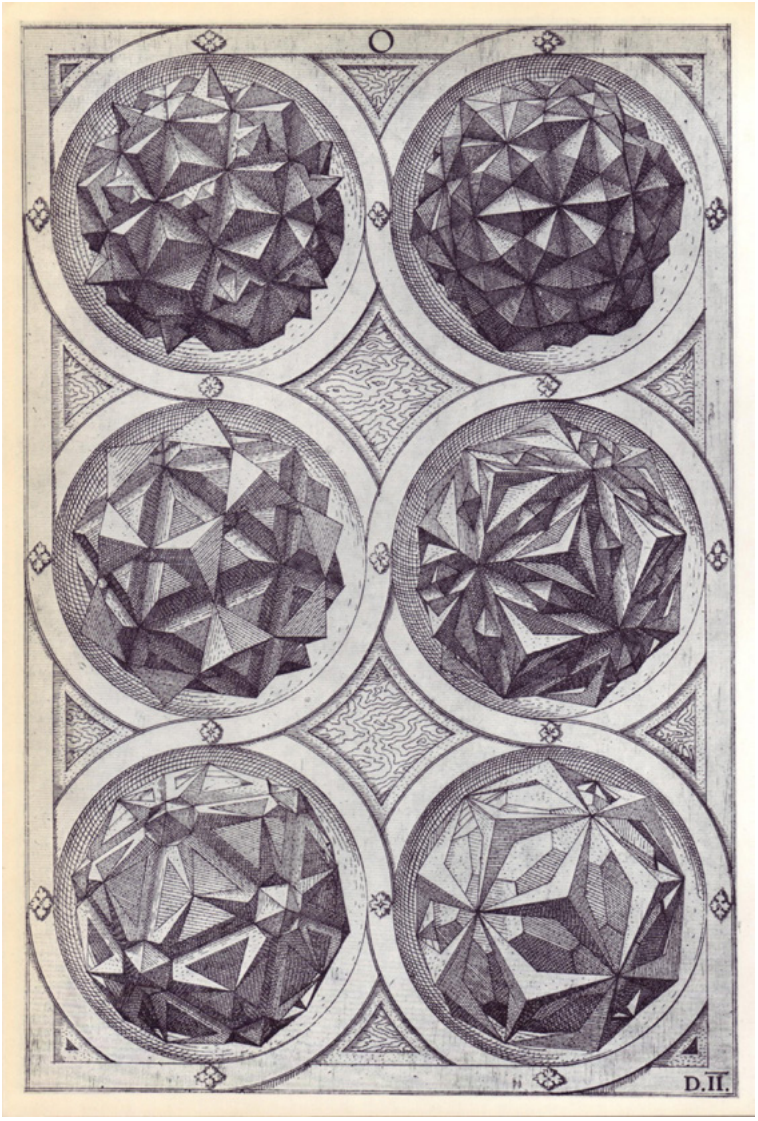


Spatially combining planes, edges and corners in just the right way, a region is bound through simple geometric form, defining a volume. The space within is now separated from the space around it. When I pick up the box and turn it over in my hand, it is plain to see that it is enclosed and complete. It is one continuous surface. When I touch it, it is solid - there are no gaps I can stick my fingers in, or peer inside with my eyes. As I run my hands across the surface of the sheet , I trace the outer edge of this clearly defined form that has been separated spatially from the environment that surrounds it.



Tetrahedron welded from copper sheet.

An even simpler form, using only 4 triangular sheets, is the tetrahedron, shown at right. As the simplest of the regular polyhedra, it is highly symmetrical and all of its parts are identical. There are infinite variations on forms built from flat sheets, from the regular polyhedra of Plato and Archimedes, to the flights of fancy from the renaissance goldsmith and printmaker Wenzel Jamnitzer, shown at left.



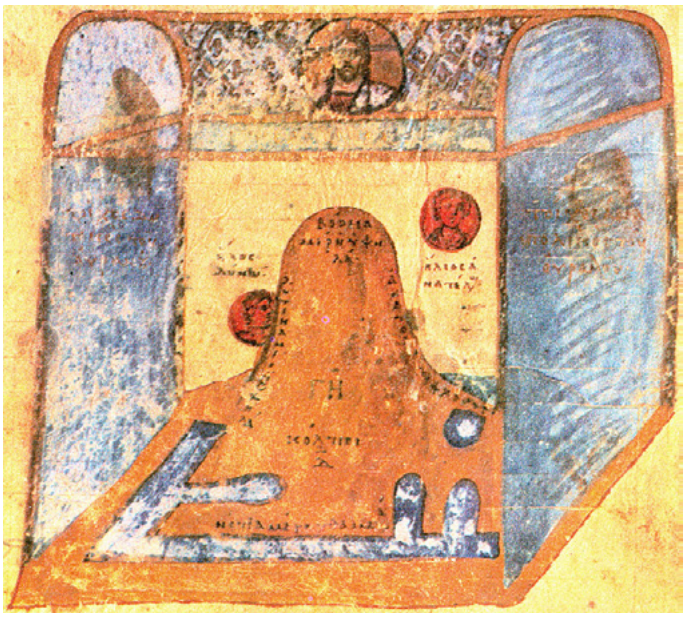
Images from *Perspectiva corporum regularium* (1568), by Viennese goldmsith and printmaker, Wenzel Jamnitzer. Source - "Jamnitzer Perspectiva," Accessed July 1, 2016, http://bibliodyssey.blogspot.com.au/2009/08/jamnitzer-perspectiva.html.

These are the simplest and most easily defined forms of space, using ideal flat planes arranged in relation to each other. As has already been noted, the flat plane is an exceedingly seductive notion for the rational mind, much like a straight line - it is simple, efficient, irreducible and above all, easy to imagine, model and predict. As Latour stated in a previous quote, "There is nothing you can dominate as easily as a flat surface"[5], and this kind of form-building, using perfect flat planes, allows a great deal of intellectual control through its abstract simplification.

Conceiving of a series of abstract geometric forms is one thing, but applying that approach to the apprehension of complex reality is another. Cosmas Indicopleustes was a 6th century Alexandrian monk who traveled extensively, and championed the notion of the earth as like a lidded box, giving it a nice easy shape. Yielding to the temptation of thinking in

5 Latour, "Drawing things together," 45.

boxes, (which I empathise deeply with), Cosmas refuted the "impious Pagan cosmography"[6] of the world as spherical in nature, in favor of a structure imitating the tabernacle of Moses. Although he traveled extensively, and conversed with many learned scholars of the time, Cosmas was content to envisage the world in this way, creating a very clear personal framework for his view of earthly reality.



Cosmas Indicopleustes' structure of the universe as a tabernacle, taken from the *Codex Sinaiticus graecus* (1186), held at St. Katherine's monastery, Sinai. Source - "The World According to Cosmas Indicopleustes," accessed July 1, 2016, http://heiup.uni-heidelberg.de/journals/index.php/transcultural/article/view/6127/2962.

How the shape of the world is individually envisaged, or conceived of through cultural prejudices, can be seen as a grand exteriorisation of the fundamental thinking and paradigms present in individual and cultural systems of knowledge. Throughout time and place, in the development of thought throughout the ages, and in the diverse beliefs of varied cultures, the world takes on a wide array of forms, and this will be explored further within the chapter *cosmological morphologies*[7].

In the earlier thought experiment of building a box, a bounded space was created from flat planes. But beneath the seeming simplicity of those flat planes, there is the notion of surface. Surface is integral to form - it is the outer edge of a form - whether the smooth flat planes and edges that border a box, or the lightly furred surface of a tennis ball. Surface is where a continuous edge is apprehended - where the outer extremities of a form are encountered. In the sensual real world, this is usually seen or felt. But a surface can also be abstract, such as the outer form of the imagined box that the reader of this paper (you) conjured in the beginning of this chapter. The apprehension of surface is based upon the perception of difference - there is no surface, no defining edge, without the distinct recognition of difference. A box drawn in air, made of air, has no

6 Cosmas Indicopleustes, *The Christian Topography of Cosmas, an Egyptian Monk*, edited by John Watson McCrindle (London: Hakluyt Society, 1897), xiv.

7 See *cosmological morphologies*, p 43.

clear identity - difference or distinction of some kind is essential, whether that is material or otherwise.

The perception of surfaces allows for easy navigation of the world - eyes perceive light reflected off surfaces, fingers touch the edges of solid matter. The world can be manipulated through surfaces - moving objects, deforming them, separating and joining them. Beneath such outer surfaces, the solidity of matter is often continuous, extending deep beneath the outer accessible layer. More fluid matter, such as water and air, flow to take up the spaces between other more stable surfaces, move around and between, settling against other more solid things. In the absence of gravity, under weightless conditions, water follows slightly different rules, creating spherical forms that minimise surface tension - the edges drawing together, making as minimal a surface as possible. A water drop falling under normal gravity is a similar example of this, and of course even a single water drop has form, has a defined surface. Edges abound.

As Euclid considered so long ago, the notion of edge and surface is integral to form - "A boundary is that which is an extremity of something."[8] This seems at first like an overly obvious observation, though it reveals more about perception than it does about the something or its boundary that is under observation. If we delve too deeply into such circular notions of surfaces and edges, the complexities of such concepts become apparent, such as when Leonardo da Vinci pondered upon the divide between air and water.

> "What is it that divides the atmosphere from the water? It is necessary that there should be a common boundary which is neither air nor water but is without substance, because a body interposed between two bodies prevents their contact, and this does

8 Euclid, *Euclid's Elements of Geometry*, translated by Richard Fitzpatrick, book I, definition 13, accessed June 13, 2016, https://www.math.ust.hk/~mamyan/sc1110/Elements.pdf.

> not happen in water with air. Therefore a surface is the common boundary of two bodies which are not continuous, and does not form part of either one or the other, for if the surface formed part of it, it would have divisible bulk, whereas, however, it is not divisible and nothingness divides these bodies the one from the other."[9]

Such over-extensions of definition, a seeking for solid definition of the separating line itself (a line created solely through an act of perception), may trap the thinker is recursive loops and philosophical quagmires. Rather than doggedly chasing down the line of a specific intellectual approach, or attempting to solve epistemological riddles, or even playing games with the definitions made at the start of the game, the aim in this writing is to become aware of how structures of knowledge interact and inform the apprehension of the world. A broad range of possible notions will be considered in untangling these processes of knowledge creation and border generation. The first step is in exploring the notion of individual identity.

forming oneself

> "Perhaps we are the same person, maybe there are no boundaries, maybe we all flow into each other, boundlessly and magnificently...."[10]

When considered in any seriousness, the boundaries

9 Leonardo da Vinci, *The Notebooks of Leonardo da Vinci*, edited by Edward MacCurdy (New York: Reynal & Hitchcooch, 1938), 75-76.
10 *Fanny and Alexander,* directed by Ingmar Bergman (1982; New York: Criterion, 2004), DVD.

of identity - physical, mental, and emotional - are highly complex matters, not to mention tracking the processes of how they are formed. It is often tempting to believe, as Ismael is quoted from Ingmar Bergman's classic *Fanny and Alexander* above, that the limits of self extend fluidly into that of others, that identities are constantly adapting and merging, and boundaries are in constant flux. But often we are isolated, separated - our boundaries seem defined and closed, and the opposite feels more true. Attempting to define the boundaries of self is a highly personal task, and there is no clear line or set of ideal truths to set matters straight. Rather, it is an experiential matter that adapts to time and place, in relation to each unique context. In exploring the ways in which singular identities are conceived, the process of creating the original primary boundary - the line between self and other - reveals the place of contact between the individual and the world around them.

Questioning the nature of self is an ancient philosophical pastime. It has been approached from every possible angle, with a range of different theories emerging. There seems no general solution that works for all people, and the matter has been informed greatly by religious and scientific beliefs - the individual soul of Christianity and the all-encompassing spirit of Buddhism, or the detailed anatomical drawings of the renaissance and the MRI brain scans of the present day. There remains a deep and profound uncertainness in regard to the nature of individual identity. That vastly different notions and definitions of self are present not only across different cultures and times, but also within smaller local communities, suggests that this is an idea there is very little definitive knowledge on. Perhaps because it is so difficult to grasp, the notion of individual identity is rich with possibility, and is an ideal place to examine how edges and borders are created....

Psychology deals with the nature of the self intimately, and there are many theories of how the self develops. One of the prime examples is the mirror stage of Jacques Lacan[11]. Originally posited as a simple stage in the development of early perception, the idea developed over time into a theory of how the permanent structure of the ego forms. Interestingly, this ego was seen by Lacan as separate from the self, an abstract construct that is fabricated, and not the residing place of consciousness. This ego, or more correctly *subject*, is formed through a promise of the early self, that it can be whole and self-reliant, rather than being supported amidst a sea of need that must be met by parents and carers, supplying sustenance and bodily needs. The mirror phase is thought to occur between six and eighteen months in infants, when they encounter their own image reflected in a mirror. They realise that what they are seeing is somehow themselves, and through navigating what is under their conscious control - their body, supported through sensations - self-identity forms. This physical self-identity forms through a defining of boundaries, and specifically, in the separation of what is *self*, from what is *not self*.

In the example of the mirror phase, how is identity and boundary conceived? It seems that come to terms with what is physically under our control. In navigating the edges of our physical presence, we build an internal representation of identity, thereby constructing our notions of physical self. This is a very basic model of identity, a separation of the most fundamental kind - what is under our direct individual control belongs to us, and what is not under our control is not us. This is over-simplifying the matter, but it underlines the nature of control and volition in the formation of identity. As we continue to grow, acquiring a greater sense of self through interaction, response, and the representations of language, we begin to bring various abstract values

11 Jacques Lacan, *Écrits: A Selection*, translated by Alan Sheridan (New York: W. W. Norton & Co., 1977).

into our identity, and even accumulate physical objects under our ownership, and identify with them. We also extend ourselves outwards into the world, through thoughts and actions, although these extensions and expressions of ourselves are contingent and variable, and we do not normally group them with our notion of self. At the core of identity, whenever we consider our essential self in its most fundamental and clear sense, we instinctively draw back to the body as the prime base of identity. The surface of our skin is one of the simplest of all edges.

This physical sense of self is suitable for navigating the world and for basic interaction. We have control over our bodies - they represent a clearly defined space - and we seem to be consciously located somewhere within. But if we are to consider more thoroughly what we are doing when we draw more complex edges of self, in our interactions with each other through ideas for example, then we need to approach the notion of self from alternate perspectives. Our self has physicality, and it also has aspects of mental cognition, emotional feeling, as well as spiritual and energetic aspects. Each of these aspects can be approached in many ways.

In considering the body as the site of identity, simple early notions quickly compound into more complex considerations. There is a tale that is part of the Indian Buddhist Madhyamika tradition[12], recently retold by Anil Ananthaswamy in a popular science book concerning notions of the self.

> A man on a long journey to a distant land finds a deserted house and decides to rest for the night. At midnight, an ogre turns up carrying a corpse. He sets the corpse

12 The Madhyamika tradition of Buddhism arises from teachings in the 2nd century, and the continued commentaries and interpretations of them, blending skeptical and metaphysical approaches, seeking the balanced "middle way" towards spiritual truth, often employing surreal and obscure tales and thought experiments to reveal complex problems. Source - "Madhyamika," accessed June 9, 2016, http://buddhism.about.com/od/mahayanabuddhism/a/madhyamika.htm.

down next to the man. Soon, another ogre in pursuit of the first arrives at the deserted house. The two ogres begin bickering over the corpse. Each claims to have brought the dead man to the house and wants ownership of it. Unable to resolve their dispute, they turn to the man who saw them come in, and ask him to adjudicate. They want an answer. Who brought the corpse to the house?

The man, realizing the futility of lying to the ogres—for if one won't kill him, the other one will—tells the truth: the first ogre came with the corpse, he says. The angry second ogre retaliates by ripping off the man's arm. What ensues gives the allegory its macabre twist. The first ogre immediately detaches an arm from the corpse and attaches it to the man. And so it goes: the second ogre rips a body part off the man; the first ogre replaces it by taking the same body part from the corpse and attaching it to the man. They end up swapping everything—arms, legs, the torso, and even the head. Finally, the two ogres make a meal of the corpse, wipe their mouths clean, and leave.

The man, whom the ogres have left behind, is extremely disturbed. He is left pondering what he has witnessed. The body that he was born in has been eaten by the ogres. His body now is made up of body parts of someone else entirely. Does he now have a body or doesn't he? If the answer is yes, is it his body or someone else's? If the answer is no, then what is he to make of the body that he can see?[13]

In this philosophical pondering similar to the classic

13 Anil Ananthaswamy, *The Man Who Wasn't There: Investigations into the Strange New Science of Self* (New York: Dutton, 2014), 1-2.

paradox of Theseus[14], physical matter is explored as the location of identity. In this modern day many of us would likely draw the line at our heads being swapped and say that when that happens, we are no longer the same person. Some might draw a line with an entire torso or other body parts beforehand , and DNA can also be seen as part of our identity. But then identical twins share the same DNA - they can obviously draw a clear boundary between each other, so it is not a matter of primary concern. Modern medicine performs transplant operations regularly, from internal organs to a complete arm. Somehow the patients adjust, incorporating the once foreign member, while their identities remain coherent. But what of swapping the head, or the brain? Maybe the physical organ of the brain itself, the tangle of neurons, is not as important as the "software", the ordered patterns of information?

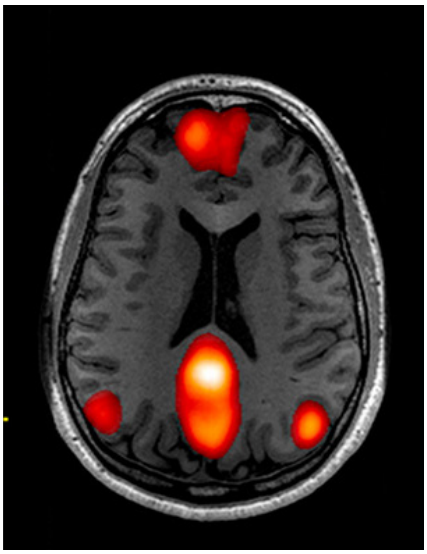
It can be imagined both ways. Firstly, your body is dieing and your brain is healthy, but luckily, there is someone whose brain is dead and has a healthy body. In an ethically problematic transplant (not to mention one that is technologically tricky), your brain is taken out and placed in this other body. Would you, as a brain, after adjusting to a new body, still be "you"? A great many people, including myself, would feel that something vitally important resides in our relation to our individual bodies. Not simply their form and appearance, but the manner in which they have been used, their subtle movements and the way our limbs have developed to carry us in individual ways. People move differently, and this is integral to their body - it becomes "wired in", so to speak. But when someone is sick for many months, there is a kind of debilitation that takes place that perhaps strips the body of much of this identity, so imagining an entirely new body may be an extreme leap, but could be possible in a similar way. In the instance of your current brain in a new

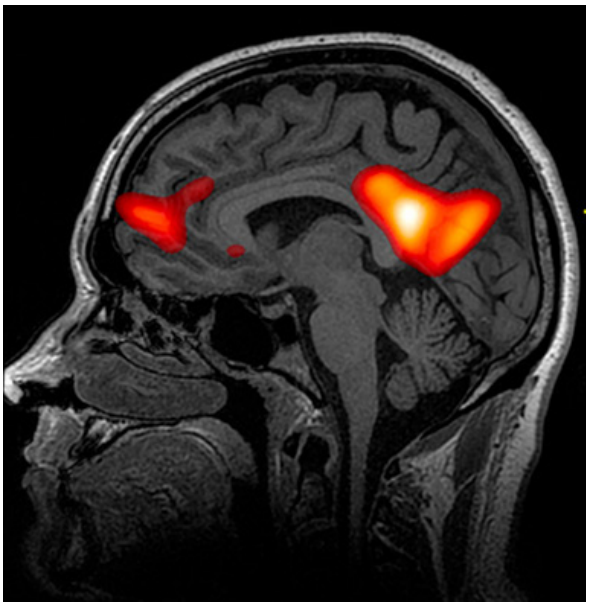
14 "Ship of Theseus", Wikipedia, accessed June 13, 2016, https://en.wikipedia.org/wiki/Ship_of_Theseus.

body, you may imagine yourself to be the same person (although you would likely be under extreme duress). Taking it a step further into more fantastical territory, imagine your brain is mapped, in complete detail, and the information is perfectly copied onto some other, empty brain that is connected to a similar healthy body like your current one. All the information - the memories, patterns of thought, and peculiarities of your persona - transferred into completely new brain matter. Abstract memories and thought patterns are persuasive as essential elements of self identity. Is it the pattern of your thoughts, the rhythms and forms made by your memories and personality, that are crucial? It seems convincing - the patterns of our identities as the most essential aspect of self. But it would be problematic to say the least, if that brain mapping that was just carried out, was applied not just to one other empty brain with a body, but to two. Instead of one coherent personality - the new singular "you" - there are now two new yous. Who is the original - it would seems to follow that both are equally you. If one woke before the other, would it be possible to define an original? The idea is perhaps similar to identical twins - as soon as they experience different stimuli, then surely they diverge, become different people, through their knowledge, experience and reactions. It seems intuitive - they are separate beings, both different. And here is something very important about the borders of self - *continuity of identity*. It seems quite an essential aspect of identity. Those two identical yous change subtly, from what they experience, *both* becoming something else, or maybe just diverging, becoming subtly different variants of one another. It seems that through living and experience, our sense of self changes, diverges from what we were before. We react to the world, incorporating, denying, negotiating, adapting and configuring ourselves, to relate to what is around us and what happens over time. We change, continuously. This reveals the importance of time and environment to identity, and, in considering an

individual, the fundamental importance of continuity.

The notion of continuity is a very important aspect of identity, but is difficult to examine closely. Intuitively we understand it easily enough, but it is harder to define in objective understanding. What we are considering here as personal continuity, is largely a temporal notion - it is entangled in concepts of time. The more complex concepts of time will be dealt with in later chapters, but for now it suffices to understand continuity as a building upon - as an alteration and continuation of - an existing defined thing. There is an essential something in continuity which is retained even amidst interaction and change - the general structure perhaps, an overall vector or direction, or certain distinctive features. Continuity is a holding together, a coherence, an unbroken connection of something through time. Radical transformations often change matter and objects in ways that make it difficult to trace their continuity, but personal identity usually maintains itself through time.





fMRI imaging of a brain in two slices, showing metabolic functions during the act of daydreaming, in localised areas. Source - "The Second Coming of Sigmund Freud," Discover, April 2014, accessed July 23, 2016, http://discovermagazine.com/2014/april/14-the-second-coming-of-sigmund-freud.

This sense of continuity naively suggests that identity may keep a certain general form, or a location in space. Much research has been carried out in recent years to map the functions of the brain in search of localised centres of activity and general patterns of operation. The use of functional magnetic resonance imaging (fMRI) has allowed neurologists to visualise and define localised brain activity occurring during specific thoughts, moods and actions, under various conditions. This kind of imaging, which correlates mental functioning to activity within specific spatial areas of the brain, tempts the thought that there are clearly defined locations for self-awareness and a sense of self. The seductively simple idea that complex thought processes reside in isolated areas of the brain is rather an oversimplification of the interactions taking place, and even the most basic thought processes rely on a network of related areas for their functioning[15]. Some

15 Jason Smucny, Korey P. Wylie, and Jason R. Tregellas, "Functional magnetic resonance imaging of intrinsic brain networks for translational

of the most interesting aspects of this research lie in understanding how flexible the workings of the brain are, allowing for compensation of damage or missing elements through relocation and radical restructuring[16]. The modern conception of the brain evolving now is one of a largely synergistic nature, relying on interconnection and sharing of "data", rather than simple localised functionality. fMRI imaging is often used for the diagnosis and monitoring of neuropathological conditions, and it has proven that a structural view of the brain is, while not a definitive approach, a useful tool in comprehending functional tendencies, and aspects of the overall behavior of the brain.

The popularisation of fMRI images is no doubt due to their easy understanding. But this basic idea of the mapped brain extends far back in time, and many earlier conceptions of localised functional areas has led to many physically damaging procedures and operations. Phrenology, a precursor of modern neurophysiology developed in the late 18th century, studied the bumps and dips and other shapes on the head, using the notion that individual parts of the brain controlled various faculties, and that mental characteristics would also be physical in nature, and reveal themselves through the surface of the skull. As sociologist and philosopher Herbert Spencer wrote in the mid 19th century in a journal of Neurophysiology regarding the theories of phrenology and the localised functioning of the brain,

> Whosoever calmly considers the question cannot long resist the conviction that different parts of the cerebrum must, in some way or other, subserve different kinds of internal action.[17]

The notion of the functional ordering of the brain,

drug discovery," *Trends in Pharmacological Sciences* 35, 8 (2014): 397–403, accessed 9 June 2016, doi: 10.1016/j.tips.2014.05.001.

16 "Neuroplasticity", Stanford University, accessed June 12, 2016, http://web.stanford.edu/group/hopes/cgi-bin/hopes_test/neuroplasticity/.

17 Herbert Spencer, "A Theory Concerning the Organ of Wonder", in *The Zoist: A Journal of Cerebral Physiology and Mesmerism*, 2 (1845): 316.

spatially arranged, was well in place long before modern tools such as fMRI, and it is interesting to ponder how much influence early notions and preconceptions have upon our current ideas of such matters. Equally important, where do such basic notions as the mapped brain come from? The tendency to border the internal spaces of our mind through functional categories is surely indicative of general tendencies in thinking and the ordering of knowledge. Perhaps the mapping of the brain, and the localisation and categorisation of thought, prompts the belief that we have some minor sort of control over our thoughts - control over ourselves. There is a certain intellectual fetish for being able to pin things down to specific locations or categories - to know where they are in relation to other things. But as mentioned, current conceptions of brain structure indicate a more synergistic view of function, and a broader, more interactive understanding of the elements of consciousness. In conceiving of the brain in such a way, the possibilities of more complex patterns and interrelations within thought, order, morals, knowledge, and notions of self, become possible. Our tendencies to order reality into discrete systemised elements, be it within the elaborate relations of international politics, or the individual nature of self-identity, is simplistic and premature. The world is rich with complexity, and perception must allow for this richness, and not succumb to the tendency to reduce it to simple abstracted symbols.

It seems clear that the nature of self cannot be defined simply through typical spatial notions of boundary. Notions of self are layered with multiple aspects - physical, biological, social, mental, temporal and energetic. The sense of pattern and continuity are perhaps one of the more essential qualities, over materiality or spatial aspects. The outside boundary

lines of self are difficult to draw, and become more so, the more the matter is considered. Rather than fixed boundaries, there seem to be gradients and contexts, constantly in motion, and constantly under negotiation with the surrounding environment. In following on, the nature of what is outside of the self is perhaps equally as important as what is inside, when coming to terms with these boundaries.

> 'Oneself' is not the subject isolating itself from the world, but a place of communication, of fusion of the subject and the object.[18]

forming a group

> In a general way, each element capable of being isolated from the universe always appears like a particle susceptible of entering into the constitution of a group which transcends it. Being is always a group of particles whose relative autonomies are maintained. These two principles - constitution transcending the constituent parts, relative autonomy of the constituent parts - order the existence of each 'being'.[19]

As a singular self, the creation of a (more or less) simple border between ourselves and the world around us comes into play. But through cognition, of similarities and differences, of ownership and belonging, our sense of self interacts with other singular identities, drawing together, defining, and creating further distinctions and

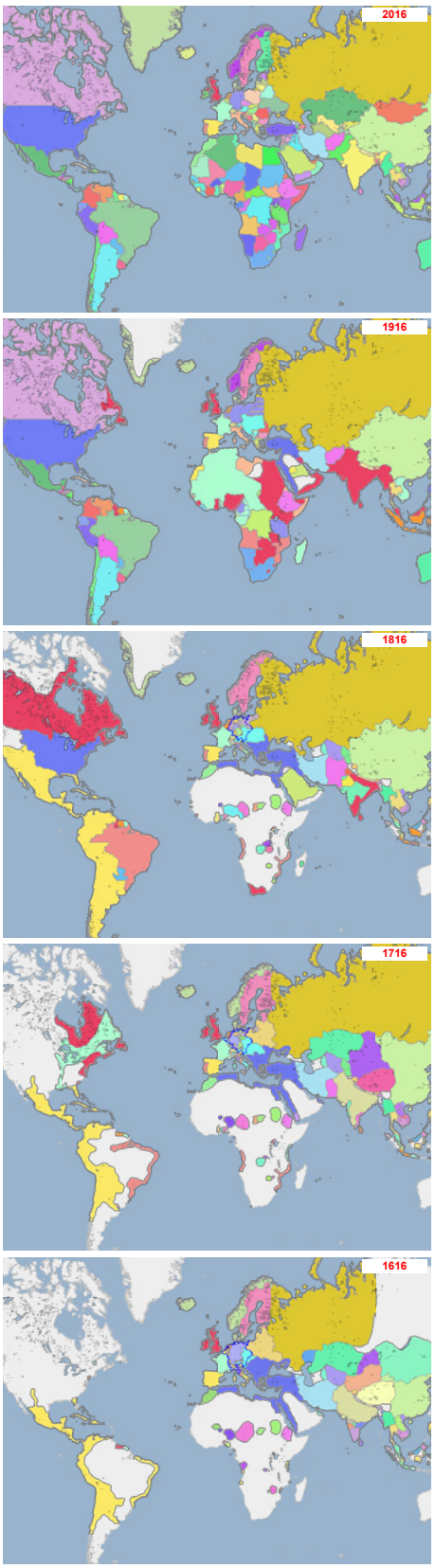
18 Georges Bataille, *Inner Experience* (New York: State University of New York Press, 1988), 9.
19 Bataille, *Inner Experience*, 85.

boundaries. Like single stars gathered into constellations in the night sky, we create patterns of belonging, forming relations and groups from multiple singularities.

The simplest of groups, the family, is created through blood, care, and the promise of mutual support. At times, an individual can sacrifice themselves for the survival of the family or one of their members - it is a deep embedded sense of identity. While not directly under the physical control of any one individual, the values of the group and the bonds of connection can be so strong that an inter-related sense of identity develops. This is the family unit that many of us know intimately, in one or more of its many varied forms.

Families eventually grow, children mature and marry, and the network evolves, weakening or strengthening, splitting or extending. Sometimes there is a lack or loss of such bonds, though they can also be found similarly with close members in a workplace, people with similar interests, or in those living within a certain local area. This extends out in many ways, through aspects of our personalities, in values and beliefs, race and religion, and physical location. Groups overlap, interrelate and complexify, creating a multi-dimensional sense of belonging and identity across a complex web of contexts. We all belong to multiple groups - relating and connecting to various people in various situations.

Many groups are formed throughout our lives through interests and needs, and others are inherited through lineage, common interest, or shared place. Such groups that define the borders of race and nation, are forever in contestation, in ever more complex ways in the present day, as the world becomes ever more populated and movement within it becomes easier for greater sectors of society. Throughout history, the formation of nations, grouping people together in space and the consequent drawing of national borders, has had a distinct social influence on the lives and cultures of people. These borders, marked across edges of continents, large



Samples from an historical world atlas showing nation borders at 100 year intervals backwards in time. Source - "World History Atlas & Timelines since 3000 BC," accessed July 2, 2016, http://geacron.com/home-en/?&sid=GeaCron282466.

rivers, or arbitrarily across the landscape, are contested and moved constantly throughout history, as is depicted at left, in shifting national borders shown at 100 year intervals.

The desire to belong to some larger geographic group gives rise to structures of control and order, where the nation state regulates the social structure and behavior of the peoples within its borders. These borders, and the people included in them, are ever in flux, such as when combining multiple sub-groups, when France brought together disparate small ethnic groups to fight for her national borders in world war 1, or splitting asunder to create dissimilar groups, as when Germany dissolved into East and West to form two radically different social structures during the cold war. National borders are made by people, and contain people.

In theory, nations are formed to take responsibility for providing security, and economic and social stability, for their population. Of course, as mentioned, a nation is made up of its population - it is a group of individuals organised in a particular manner. The nation group ostensibly provides the benefits of security and stability if the population defend it, support it, and work within its rules. For the greater good, as it were. There are often significant natural resources in the area the nation state resides (or occupies), and this can supply much of what the population needs. But this may come under threat from another nation, so the population needs to defend those resources (and defending something of value is much easier as a large organised nation, than smaller clans or local communities). The ownership of land and its resources are constantly changing hands through contested claims, invasions, wars, occupations and resettlements, as clearly revealed in the image of shifting national borders at left.

National borders are not only physical, but are also ideological, religious, racial, cultural, and economic.

There are constant calls from the more progressive members of modern society for a relaxing of borders, allowing people to move from poorer countries and further enrich already prosperous areas, to the greater benefit of the whole[20]. This has been argued over constantly, although as history has shown in the last century, an influx of migrant workers and residents can breathe new energy into a nation (such as is needed in the greying populations of Europe). There is of course fear from those nations who have plenty, that it will diminish from sharing, that there is less to go around, and there is some truth to this, especially for the privileged few. Within the problems and opportunities that come about from the growing human population, these modes of economic distribution are becoming increasingly stratified, with pockets of sustainable balance outnumbered by disparities between the incredibly rich and the poor masses. These issues of economics are not the only dilemmas - cultural identity - supported through stable populations living in the same area and sharing common past-times, traditions, and beliefs - diminishes greatly with ever-increasing mobility and the loss of connection between people and place. The issue of cultural diversity is dependent in a great way upon the functioning and maintenance of borders and boundaries - diversity requires boundaries in order to exist, and requires those same boundaries to sustain its context and meaning. At a fundamental level it is clear that clearly defined borders, and limited exchange, promotes the kind of cultural diversity and difference that many appreciate.

Many other species display similar forms of local or cultural difference. Looking at chimpanzees (who share 96% of the human genetic blueprint[21]) it can be seen

20 The redistribution of wealth through immigration has been argued by many, and offers a method of dealing with global inequality that is slowly becoming accepted by the modern west. Source - Michael Clemens, "Economics and Emigration," in *Journal of Economic Perspectives* 25, 3 (2011): 83–106.

21 Ajit Varki and David L. Nelson , "Genomic Comparisons of Humans and Chimpanzees", in *Annual Review of Anthropology* 36 (2007): 191–209, accessed

how other animals cluster to create group identities and work within organised systems of individuals. In a study of conflicts between neighboring social groups of chimpanzees in Tanzania[22], social groups who are mostly linked by blood ties hold very close to tight territorial areas. In their interaction with another social group at the borders of their territories, two social groups will gather separately across from each other, and display their power and aggression toward each other, in order to consolidate their hold over territory. Interestingly, they have never been seen to engage in physical group conflict at these territorial borders, however, if a lone chimp is encountered by several other chimps from a neighboring group at such a border, they will try to eliminate him or her, catching and viciously injuring or killing the foreigner. An individual is always a member of one group or another, and from the perspective of a neighboring group, this sense of membership is more important than the singular identity of the individual. The group consists of individual members, and it can only maintain itself through the numbers and strength of those individuals. The loss of one individual member may not be fatal to the group, but a run of such violent encounters as mentioned, or bad luck due to health or other circumstances, can lead to the group being diminished to such an extent that it is dispersed or subsumed into another group. The group may disintegrate, while individuals remain. Such a group identity as explored here is a fragile pattern of coherence formed among individuals, acting together in larger scales of social interaction.

The role of borders and boundaries are manifold, playing across national and territorial struggles, as well as situations of complex social and ideological interaction. The nature of boundaries becomes ever

June 12, 2016, doi: 10.1146/annurev.anthro.36.081406.094339.

22 Richard Wrangham, "Why Apes and Humans Kill", in *Conflict: The Darwin College Lectures* (Cambridge: The Cambridge University Press, 2006), 42 - 62.

more difficult to untangle when dealing with ideological or religious issues. Where the borders of nations or chimpanzee groups can be defined through individuals and physical territory, the boundaries of ideology are abstract intellectual spaces, often fluid and permeable, even though they are named, and conceived as distinct identities. An example that reveals this is a study examining the clash of Christianity and Paganism in Norway during the last years of the 10th century[23].

The introduction of Christianity into Norway began in the 940's, but it was not until the 990's that a King sympathetic to this ideology would succeed, in name at least, to convert the dominant pagan religion of the land into the new Christianity. The conflict between the two ideologies was staged across many platforms, ebbing and flowing in action and reaction as the then King Olaf imposed the views of Christianity upon his people. Places of pagan worship were destroyed, resisters were tortured and killed, and Norway was nominally converted to Christianity. The old religions were still practiced, being such an integrated part of the peoples' common ideology that they were woven into the fabric of everyday life. This way of life, with its traditional history of centuries, would not change completely within such a short time. Thus Christianity sought to gain hold as the dominant ideology through *incorporating* Pagan symbology and ritual, endowing Christianity with a sense of the known and of traditional life, embedding the security and structure of previous ways within it. In this way, some of the older religions' outer qualities were subsumed into the newer. But although these subtle inclusions of existing qualities helped a little to convince and convert the peoples during this transition of religious ideology, the key reason for Christianity's domination rests in the oppressive power exercised through the feudal lords of the time. Ideological groups often resort to the use of physical violence if there was actual power to be gained, or riches to be acquired.

23 Alexandra Sanmark, "Power and Conversion: a Comparative Study of Christianization in Scandinavia" (PhD thesis,University College London, 2002).

Without the fear and violence imposed by the feudal lords, there would have been little incentive for most of the common peoples to change their religious beliefs, for these beliefs had developed within their land and environment, adjusting to local conditions to build a rich web of knowledge that was locally valuable. There was practical knowledge embedded within the pagan practices that had developed locally, within that environment and those people - contextual knowledge not easily transferred. But many organised religious ideologies are often entwined with political ideologies rather than common practical knowledge, and usually it is the power of the ruling members of a society that is at stake, while the faith or beliefs of the common people must simply follow along.

The efforts of King Olaf to promote the monotheistic beliefs of Christianity spread nearby to other Norse settlements, including Iceland. In Iceland, violent clashes over faith were avoided through arbitration, a respectful approach that led to Christianity being adopted in name, while private pagan worship would continue to be tolerated[24]. The cultural traditions and beliefs of Iceland are valued today for the reason that the older beliefs are still embedded within modern thought, filtering down into daily life, contributing their rich lived history of knowledge to a society living within a very particular natural environment.

After King Olaf's reign and the conversion of Norway and other close settlements to Christianity, a lord more sympathetic to the older Pagan beliefs came to power, Jarls of Lade, bringing the previous pagan beliefs back into favor, and making their practice safe from

24 This historical tolerance allowed the continuance of traditional beliefs, and, also being benefited by their geographical distance, and seen as having no great rich natural resources, Iceland was allowed to continue its practice of a traditional religion. Such a long uninterrupted history of pagan belief has resulted in Reykavjik being the site of the first Norse temple to be built in 100 years, under the organised faith of the Ásatrú. Whether one believes in the Norse gods or not, the connection to place, and the coherence of culture that this expresses, through such a long history, should be valued and respected, for the sake of living knowledge and cultural diversity. Source - "Iceland's Asatru pagans reach new height with first temple", BBC News (2015), accessed May 8, 2016, http://www.bbc.com/news/world-europe-31437973.

persecution. This was reversed, some decades later, under pressure from neighboring realms of Scandinavia, after which Christianity was permanently adopted as the main state religion across Scandinavia.

It should be emphasised that the nature of these identities - nation states, chimpanzee groups, and religious ideologies - are fluid and open to contextual interpretation. The old pagan ideologies are incorporated within the Christian framework, embedding old practices and knowledge into new religious frameworks. Individual chimpanzees from disbanded groups are subsumed into more stable groups, contributing the diversity of their genetic heritage and bloodline. Nation states conquer in name, subsuming a whole society, incorporating their political and religious ideologies, or outlawing them and driving them underground. The borders and boundaries explored here, and all others that are used to identify and group collections of people and things, are all conceived of in a simple manner, for ease of understanding, yet they are each extraordinarily complex in their interrelation. The defining borders are permeable and fluid, and very difficult to portray. Look too closely at any group, or attempt to define it clearly, and the difficulty of doing so becomes readily apparent. It is in how we approach this act of bordering, through our perceptions, and an awareness of the act, where the real interest lies.

In discussing groups, it seems tempting to return to the basic unit of the individual, which we experience as the singular self. Under forms of duress, especially physical threats, we are inevitably prone to retreat from the broader social, to the most basic of boundaries - the individual self. This is the last border, and it must be defended. If we cannot continue, our values will vanish, and our sense of self will no longer exist. This is something that should be protected - in the simple matter of our own life, but also through children, our

community, creative work, and the ideas we express. Amidst the complexity of the larger group and the stability it brings to life, our most basic experiential border is self. Yet this sense of self has been shown to expand and contract across time and context, and the relativity of such borders are constantly being re-evaluated within the greater environment.

> The possibility of saying "I", of being subject, is to occupy a site, a position in which one places oneself in the center of one's own world, to be able to act upon it and upon oneself. This is what we call egocentricism. Of course, individual complexity is such that when we put ourselves at the center of our world, we also bring in our relations, that is to say, our parents, our children, our fellow citizens, and we are capable even of sacrificing our lives for them. Our egocentricism can be incorporated in a larger, communitarian subjectivity. The concept of subject must be complex.
>
> To be subject is to be autonomous while remaining dependent. It is to be provisional, intermittent, uncertain. It is to be almost everything and almost nothing for the universe.[25]

The relative scale of each individual being is enmeshed within the idea of the group. A grouping is a loose conception of singularity that encompasses multiple other elements. The individual is a part of the family, or the township or nation state. The important aspect here is the relative singularity of each conception - individual or group. As Bataille so eloquently describes in the quote at the beginning of this chapter[26] -

25 Morin, *On Complexity*, 43-44.

26 "In a general way, each element capable of being isolated from the universe always appears like a particle susceptible of entering into the constitution of a group which transcends it. Being is always a group of particles whose relative autonomies are maintained. These two principles - constitution transcending the constituent parts, relative autonomy of the constituent parts -

constitution transcending the constituent parts, and, *relative autonomy*. The border lines are drawn through our own acts of perception, from our own point of view, within a specific situation, as a tool toward understanding. They have relevance in use, at particular times and in particular contexts. The borders are convenient mental fabrications, and while they may seem clear, such simple borders do not exist across the everyday complexities of space and time.

The simplest initial starting point, of our own physical body, which is taken for granted as a defined unitary whole, is upon closer examination in fact co-habited by a range of smaller independent microbial cells. The extent of this co-habitation is more than significant - human cells are outnumbered in our body 1.3:1 by a range of resident microbes[27]. The singularity of our most basic experiential boundary, of physical self, can be seen as a grouping that incorporates a great number of separate co-habiting organisms. Rather than some orderly structure and form determined by our DNA pattern, our bodies are mostly comprised of "other" organisms which we have formed an intimate relationship with. We are symbiotic in nature - composite in the most basic sense, utterly dependent upon and enmeshed within our local microbial environment. In considering our basic shape - the form of our bodies - it is apparent that wit is shot through with passages - we are porous and transitional - from the movement of air through lungs, the substances digested within our stomach and passed through our intestines, the knowledge that is shared with each other, and the structures of language and representation that we learn and incorporate, and later adapt and change through further communication - all of these

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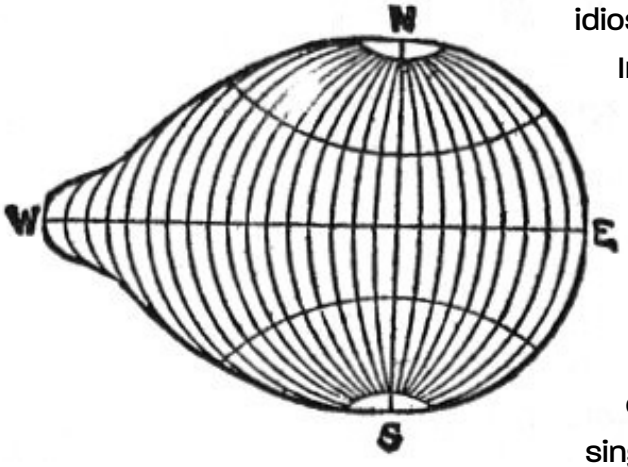
order the existence of each 'being'." Bataille, *Inner Experience*, 84.

27 Ron Sender, Shai Fuchs & Ron Milo, "Revised estimates for the number of human and bacteria cells in the body," *bioRxiv - The Preprint Server for Biology* (2016), accessed June 29, 2016, doi: http://dx.doi.org/10.1101/036103.

flows of energy, material, and information, make for individual boundaries that seem contingent at the very best. It is difficult to find any clear borders at all, that exist beyond the realm of conscious conception. But perhaps in extending to the furthest edges of our knowledge of the universe, to somewhere border-less, a little perspective can be gained....

cosmological morphologies



An image of the Earth of Christopher Columbus, which he describes alternately as pear-shaped, or resembling the breast of a woman. Source - William F. Warren, Paradise Found (Amsterdam: Fredonia Books, 2002), 308.

Throughout history, cultures have developed their own idiosyncratic views of the larger universe. Cosmas Indicopleustes' tabernacle shaped cosmos, mentioned and shown earlier, is a personal response, much like Christopher Columbus' conception of the Earth as a pear-shaped globe shown at left. Both views depict reality in ways that conform to powerful individual ideas of how it really should be. Popular modern western conceptions of the universe, as an expanding singularity erupting from some almost biblical big bang, takes all the scientific facts at our disposal, along with our set of historical and cultural biases, creating a picture of the universe that reveals as much about reality as it does about the hopes and fears of our society, and the methods we use to order our perceptions and structure our knowledge.

Cosmologies form a framework that guide societies and individuals to perceive of the world in specific ways. Perceptions have changed radically throughout history, and our current idiosyncratic views will no doubt be viewed as quite peculiar when seen from some future

A clay cuneiform tablet from the Library of Ashburnipal, 7th Century BC. This clay planisphere shows the position of the major constellations still recognised today. Source - "Collection online," Bristish Museum, accessed July 2, 2016, http://www.britishmuseum.org/research/collection_online/collection_object_details.aspx?objectId=303316&partId=1.

Babylonian map of the world, cuneiform text and diagrams on clay, 9th Century BC. Source - "Collection online," The British Museum, accessed July 2, 2016, http://www.britishmuseum.org/visiting/galleries/middle_east/room_55_mesopotamia.aspx.

vantage point. Far in the past, the ancient Babylonian cosmology (dating from around 2000 -500BC) developed some of the basic modern frameworks for ordering time and space, such as the 24 hour day, the 12 signs of the zodiac, and the convention of dividing a circle into 360 degrees. It was a highly ordered democratic society whose cosmology was based on natural rhythms and cycles, personified by a multitude of gods, who, after initially fighting one another, created man, and then stabilised the cycles of nature. These religious views, that were firmly based in the yearly rhythms, were embedded in the structure of society, reflected in the obedient behaviour of the peoples, thus creating a very stable and practical society. The Babylonians' long records of astronomical observations, made possible through their stable culture and language, and their skill in recognising patterns and cycles in natural observations, led to the ability to forecast the future (creating a very accurate calendar for predicting lunar eclipses) through a basic understanding of astronomical occurrences. They did not, however, seem to theorise about the workings and mechanics of the heavens (in the conceptual way that modern science does), which may be considered strange for such a practical society that was aware of natural cycles. But in a cosmology where the gods created man and instilled order into the universe, there may not have been as great a need to question the underlying mechanics as there is in modern times, for the responsibility of the workings of the world were in the hands of the gods - the only way to alter the world was through beseeching them.

The Babylonian map to the left depicts what appears to be a cosmological view hinting at cosmological scale structures, rather than the geographical features of a simple local map[28]. A flat earth, with the central round

28 Jakob Bo Flygare, "The Babylonian Map of the World," Akademisk Opgavebank, accessed June 16, 2016, http://www.opgavebank.dk/opgaver/806.pdf.

section containing the known lands, is surrounded by water, yet beyond the chaos of these cosmic waters there are further smaller islands. This flat earth was mythologically created by the body of the vanquished goddess Tiamat, who was split in half to create land and sky, by the god of man and Babylon, Marduk.
It is interesting as an aside, that even though the Babylonians were intimately aware of astronomical cycles, they did not see the sun as the generator of day and night - their world was ordered by the gods and their efforts were focused on obedience to them.
Yet in this map it is clear that there is the desire to understand, even in a mythological fashion, the spatial qualities and structure of the world.

Cuneiform tablet dated 2nd-3rd Century BC, decoded to reveal the tracking of Jupiter across the night sky through methods of geometrical calculus. Source - "Ancient maps of Jupiter's path show Babylonians' advanced maths," New Scientist (2016), accessed June 16, 2016, https://www.newscientist.com/article/2075581-ancient-maps-of-jupiters-path-show-babylonians-advanced-maths/.

The Babylonians were a complex society and it is clear that there is a great deal still unknown about them, as recent discoveries show. The cuneiform tablet to the left describes complex calculations (in a form of calculus, originally thought to have developed in Europe 1500 years later), that predict the movement of Jupiter through the constellations[29]. This level of knowledge is completely out of keeping with our current understanding of Babylonian culture. While there are clear indications that the Babylonians did not search too far in certain areas of rational understanding, and there were certain large gaps in their knowledge, it is clear that in other areas they were more advanced than previously thought. The development of knowledge that creates the cosmologies of a culture, do not follow linear trajectories - it is not simply a matter of judging a past culture's achievements against our current understanding. Any awareness of the workings of the world go hand in hand with inherited cultural prejudices

29 "Ancient maps of Jupiter's path show Babylonians' advanced maths," New Scientist (2016), accessed June 16, 2016, https://www.newscientist.com/article/2075581-ancient-maps-of-jupiters-path-show-babylonians-advanced-maths/.

of perception, and very specific modes of apprehension. Through our depiction of the world in one particular representation - the current *truth* - we often lose the ability (or desire), to see the world through other possible perspectives.

Many other forms of the earth have been imagined within past cultures[30], oftentimes with the bodies of vanquished gods forming the earth and sky, or world trees as an axis through their centre, or with tiers of platforms like some earthly temple structure translated into the celestial realms. These cosmologies reveal the nature of a society - their values, ways of life, and their intellectual knowledge. It is tempting to believe, when considering how gods were believed to control the order of the universe, that the modern understanding of the world is clear and rational. But the current cosmology is also full of the weird and wonderful, and reveals the intricate eccentricities, and flaws in our modern thinking, as will be explored further. In developing knowledge we build upon the past, inevitably inheriting patterns of thought that are sometimes ill-suited to new perceptions. But without the ability to draw upon the past, and build upon it, the basic conception and understanding of reality would need to be re-invented every day. Knowledge relies upon the thoughts and perceptions of the past, patterning and informing the current view more than we would like to acknowledge.

The development of modern cosmology is often difficult to trace accurately, such as for instance in the basic idea of the round globe of the earth, the history of which is commonly mis-represented in popular thought. The general conception of the earth in the late 15th century, during the explorer Christopher Columbus' time, was that the earth was round. Ironically, Columbus himself

30 For an intriguing collection of historical cosmologies, see Edna Kenton, *The Book of Earths* (New York: William Morrow and Co, 1928).

imagined the earth as shaped like a pear, or, in his own words, like a round ball with a "prominence like a woman's nipple."[31] It is intriguing to read such writings of the man who is often believed to be the founder of the spherical earth[32], when more accurately, the idea of the spherical earth dates to around 6th century BC with Pythagoras and his contemporaries. Columbus was actually moving against common thought, in believing the earth was shaped like a woman's breast, rather than round. Quite eccentrically, the peak of Columbus' nipple was where "the earthly Paradise to bee situate in the toppes of those hylles"[33] - where he believed the lost garden of Eden resided, which he narrowed down to where the Orinoco river flowed into the sea in what is now the lush northern regions of Argentina.[34]

The notion that everyone in the middle ages believed in a flat earth can be traced to peculiar historical records resulting from a conflict of religious ideologies - specifically a protestant campaign against the catholic teachings of creationism. Tracing the idea back in recorded history, to almost two millennia before, Pythagoras reasoned that if everything falls toward a centre, then it would naturally be that the earth is spherical in shape. It is a simple notion of common sense, and dispels the thought that people of the old worlds were a totally primitive and superstitious lot whose rationality was impaired by the fear of their golds. Consider again, the complexity of knowledge in the Babylonian culture we are only now beginning to glimpse. As always with knowledge, common sense is mixed in with superstition (whether that superstition be purely religious, or the perhaps even more dogmatic blind faith of science).

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31 Richard Henry Major, *Select Letters of Christopher Columbus* (Cambridge: Cambridge University Press, 2011), 134.

32 Here I cite my own education in the west of Sydney at Macquarie Boys High School, Dundas, 1983-1986. This does however seem to be quite a widespread misconception.... Source - "Myth of the flat Earth," Wikipedia, accessed June 12, 2016, https://en.wikipedia.org/wiki/Myth_of_the_flat_Earth.

33 Geoffrey Eatough (editor and translator), *Selections from Peter Martyr*, Volume V (Belgium: Brepols, 1998) 225.

34 Barney Warf (editor), *Encyclopedia of Human Geography* (New York: Sage Publications, 2006), 521.

Many “primitive” cosmologies seem archaic and naive, yet this non-rational superstitiousness extends through the medieval world-view, across the notions of last century, and deep into the foundations of our modern day. Cosmologies are structured in a way that presents the knowledge we have, and posits the unanswered questions that plague us. A cosmology can be seen as an externalisation of a system of knowledge - the facts and questions of a time, through a dominant narrative or pictorial view of reality. This becomes most potent (and poetic) at the very edges of knowledge, such as in the dubious proliferation of layered heavenly strata in the early middle ages, or in the modern conceptions of quantum mechanics with ever more complex patches and sub-extensions to reality through bold new bosons and mysterious quarks. Knowledge seeks ever further into what is unknown, extending outwards from what we believe, pushing upon the edges that must be named and examined before they can begin to be untangled and understood.

The modern western view is of a universe that is expanding ever outward, having separated into polarised complimentary energies from the singularity of nothingness at the moment of its explosive birth. A more rational dream would be hard to imagine. Of course, like any other cosmology, it has its edges. Before the singularity in time, various possibilities are theorised, most often that time is unwound, space undeployed, and there is an absolute nothingness, because time, space and matter have/had not yet come into existence. This is really not so different to other archetypal mythological tales as to be unrecognisable. There are no personifications here, but the dramatic portrayal of the yawning void, of birth, transformation, and order, are all lavishly told by the tales of science, in proportions that make the bible seem quite timid. Through such cosmologies, we attempt to create order out of what we perceive - we need to make sense. And through such stories and structures the staggering

complexity and chaos of reality is brought within easy reach of understanding. Again - we need to make sense.

Dig a little deeper into the tales of modern science, and different alternatives open up across a range of theories. The cosmos becomes multiple, literally so in some theories, unsure of its own footing, and even entangled in the perceptions of its viewers. Alongside the race to experimentally quantify the nature and existence of fundamental particles, or energetic systems, space and time ripple with competing theories. All manner of cosmologies are suggested, developed from experiments extended and extrapolated into rarefied realms of theory, or from brutally abstract and pure mathematical equations applied to the underlying fabric of reality. From the ever-branching view of a reality built upon infinite parallel universes multiplying at every moment[35], to the quantum world with its quasi-theoretical sub-particles that seem to account for all facets of reality (hypothetically), to the 10-dimensional space of superstring theory with its curled up extra dimensions just out of reach of everyday reality (but clearly in sight to the theorists), to the rather out-dated world-view that is laid out in special relativity that neatly links the effects of space, time and gravity. It is difficult to stop from slipping between seeing this proliferation of theories as pure folly, to seeing the beauty of the honest and ardent desire in their search. Amid the multiplicity of possible cosmologies, the common thread is in how they move towards making sense of the world. They are all methods for outlining the edges of what is known.

In examining contemporary cosmologies, there is a fundamental move towards decentralisation. Often in the past, the earth was conceived as being at the centre of the world, and all else in the heavens circled around

35 One theory, taking its data from the European space agency's Planck telescope, suggests that there is possible *evidence* of parallel universes through inconsistencies within the cosmic microwave background radiation. Source - "Mystery bright spots could be first glimpse of another universe," New Scientist (2015), accessed June 16, 2016, https://www.newscientist.com/article/2063204-mystery-bright-spots-could-be-first-glimpse-of-another-universe/.

it. In the simplest idea, we were at the centre - earth and self. But now the earth is conceived as floating free in a vast universe, in a small star system at a spiral arm of the milky way, amid another 200,000,000,000 other observable galaxies, each one of those with up to 1,000,000,000,000 stars each. It is difficult to reconcile our own unimportance, and our uncenteredness, with the fixed single individual point of view, that our consciousness and our location in space in promotes. Yet this notion of decentring is one of the fundamental aspects of contemporary cosmology. Somehow, in the most basic conceptions of self, there is a shift from the notion of a fixed centre, towards that of the field - of shared space and relation. This is echoed by such knowledge structures as the internet. The modern vision of reality that is forming seeks meaning, security and identity through connection, rather than through the definition of form or location separated from context. Moving from early geocentric conceptions of the universe, to revolution around the sun, and now, centreless, amidst an astounding vastness of other solar systems and galaxies, it seems that the basic underlying template of reality is shifting radically.

This centreless way of perceiving the universe arises together with matching structures of knowledge. Perhaps knowledge adapts to environment as the ability to act at greater scales increases, or perhaps the greater environment is better perceived through a simple expansion of knowledge. Whichever way this is seen to develop, it is clear that through these changes in knowledge, there is a deeper awareness of being enmeshed with the greater environment.

The cosmologies considered here, are the framework of fundamental structures of knowledge that attempt to bring clarity and unity to the overwhelmingly complex reality of the universe. This desire for understanding and coherence in the cosmos is an echo of the stable individual identities that sustain our singular conscious existences. A common cosmology helps

in contextualising information, and allows for certain plans and predictions, through observed patterns and rhythms, and it also brings law and order to interaction between the people in a society. From the spiritual worlds of ancient hunter-gatherer tribes, to our modern relational view that defines self amid the 7 billion other humans on the planet, our cosmologies are like pictorial snapshots of the ordering structures that arrange the vast wealth of knowledge and perceptions, in ways that make sense to us. They are the slowly shifting frameworks within which we arrange the facts of life, and beyond which, we seek new knowledge.

life as a form

The overall view of the cosmos, in any age, is a staggering vision. Especially now, as the astronomical sciences probe the heavens and map beyond the immediate galaxy. Yet on this small planet, all around us, and most importantly *within us*, life ebbs and flows, building order in ever more complex patterns. For all the many theories that propose to reveal the underlying structure of reality, so little is yet known about the fundamental facts of what life is and how it comes to be.

The small seed at left holds a vector of growth encoded within its genetic material. Given the right conditions, and the elemental building blocks for life - sun, air, and water - its grows. It orders basic elements into more complex molecules, using energy it gathers from outside of it, to create its own specific form. The form it takes is determined by its seeding parents, passed down and adjusted within its environment. Subtle variations of shape, rate of growth, and general behavior, determine its ultimate success as a biological organism. It goes on to replicate

The initial sprouting and growth of a seed into a seedling. Source - "Seed Growth," accessed July 2, 2016, http://jefferson.mpls.k12.mn.us/3rd_grade__-__seed_growth.

itself, combining and varying, extending its life through new variations that live on, the current form eventually degrading, dieing, and decomposing.

The distant origins of life on this planet are highly contested, though in one possible conception, that of symbiogenesis[36], evolution is traced back to individual cells. Where single cells originated is also highly contested, but in many theories[37], a chemical "slope" of reactions occurs at borderline regions of heat and chemical difference, and primitive borders form around precursor organic molecules, forming a very particular kind of gradient in chemistry - a membrane. The membrane allows the passage of certain elements and blocks others, and also allows for a storage of energy (electrically, chemically and structurally) within a certain localised area. This stored energy inside the membrane is the fuel that allows production of organic compounds such as ATP (adenosine triphosphate), which powers much of the metabolic processes across great ranges and complexities of living organisms. These simple early proto-cells, that perhaps developed in volcanic and gaseous leaks under sea level, developed into what is known in modern times as bacteria and archaea - prokaryotic cells (simple cells with no nucleus). Symbiogenesis theorises that these single cells competed, digested, and at some point were engulfed one inside the other, in a form of partial digestion, forming a permanent mutually beneficial symbiotic link, *internally*. The symbiosis stabilised and complexified over time to create nucleated organisms - eukaryotic cells (a cell having defined organs and a nucleus). These single cell organisms adapted over time to suit their environments, becoming proficient at particular tasks, and thus forming specific specialised functions. One

36 "Symbiogenesis," Wikipedia, accessed June 5, 2016, https://en.wikipedia.org/wiki/Symbiogenesis.

37 The basic mechanics of the first steps of life are highly contested, but many theories are quite clear. Source - "How life evolved: 10 steps to the first cells," New Scientist (2009), accessed June 16, 2016, https://www.newscientist.com/article/dn17987-how-life-evolved-10-steps-to-the-first-cells/.

such example of symbiogenesis worth considering is that of the early development of photosynthesising bacteria, cyanobacteria, and its evolution into the form of modern plants.

Chloroplasts are small components within plant cells that are the basis of photosynthesis, taking sunlight, water and carbon dioxide, and transforming them to release energy that fuels the rest of the plant. But chloroplasts have their own DNA, separate to that within the nucleus of the greater plant cell the chloroplast is within. This DNA of the chloroplasts is so similar to that of ancient cyanobacteria, that it is believed that around a billion years ago, a cyanobacteria cell was ingested by an early eukaryotic cell, and not completely digested. This internal living cell (endosymbiont) held within the host cell, provided food for the greater cell, eventually transferring genes to the nucleus of the host, to create a coherent whole reproducing "individual" cell. The case is similar for mitochondria, an organelle or component within every eukaryotic cell, that is a kind of powerhouse, supplying chemical energy for the growth and maintenance of the cell and all its components[38].

The intriguing nature of individual cells is shown through such theories. The edges of even the very simplest life-forms are difficult to define physically, without even considering any energetic or philosophical concerns. At a simple level, there is a large difference between the idea of a dependent relationship where a bee spreads pollen and the flower produces nectar for the bee, and the development of cyanobacteria to be *incorporated into* the cell wall of another organism. This is clearly an example of an individual organism that has been incorporated within a larger cell. When pondering the

38 One prominent theory clearly articulated by biologist Lynn Margulis, tells of how a mobile anaerobic bacterium merged with an archaeon living in acidic sulfurous waters several billion years ago. This would have occurred at the borders of thermal and chemical difference, where novel mixtures and temperatures lay alongside each other. In this conception of the development of life, there is a sort of mutual use of each other, a matching of complimentary excesses and needs, part antagonistic and part symbiotic, later forming a stable system of reproducing nucleated cells. Source - Lynn Margulis and Dorion Sagan, *Microcosmos* (Berkeley: University of California Press, 1997), 47-58.

exchange of energy and the intimacy of the relationship, the bee and flower are not so radically different to the cyanobacteria and plant cell. There is a deep interdependency in both relationships, even if one is physically and formally separated.

The photosynthesising sea-slug *Elysia chlorotica*. Source - Mary E. Rumpho, Elizabeth J. Summer, & James R. Manhart, "Solar-Powered Sea Slugs - Mollusc/Algal Chloroplast Symbiosis," *Plant Physiology* 123, 1 (2000): 29-38, doi: 10.1104/pp.123.1.29

The blurring of boundaries between notions of singular cells, symbiotic relationships and energetic exchange extends endlessly when any ecosystem is examined closely. In a beautiful blurring of partner and prey, the sea-slug *Elysia chlorotica* pictured at left, retains some of the chloroplasts within the cells of the algae it feeds upon (in a relationship termed *subcellular symbiosis*), distributing the photosynthetic parts of the plant cells within its own tissue (keeping them alive in its own gut cells) to generate food from the sun. Where can the lines of identity and definition be drawn, when the functional integration of foreign cells is present not only in a complicit energetic exchange, but also physically, integrating within the skin and organs of the one body?

These instances of symbiosis, and other relationships, clusters and communities, all emerge from single entities grouping together to form larger entities. It seems, perhaps, that they develop together, as related forms of life separated in space. A subtle co-emergence in time. The mitochondria, organelle components of all eukaryotic cells that were discussed earlier, have their own separate DNA and are clearly of bacterial heritage. In a real way, they retain their foreign origins, as smaller components of a larger cell, yet when the larger cell reproduces, the mitochondria is reproduced as part of it - they are integrated almost entirely. In the same deeply enmeshed relationship of dependency, our bodies are host to an array of bacterial cells that outnumbers human cells, and these bacterial cells are essential

to our proper functioning. Human bacterial symbionts allow us to digest food, breathe the air, maintain the essential characteristics of our skin membrane, and other functions still under research. All of these bacteria that work away within our bodies are foreign - they do not share our DNA - they are not part of our organism and are not passed on through reproduction.[39] Yet, as a symbiotic community, they are an essential part of our functioning organism.

At the root of these considerations are the conceptions of what constitutes an individual life. These conceptions tend to approach the complex notion of life by binding living forms into discrete bordered entities. This definition of life commonly starts at the notion of the cell wall, as taught in high school science. The prominent biologist Lynn Margulis has stated, "no life without a membrane of some kind is known."[40] But if we try to trace the outer edge of more complex organisms, the matter becomes ever more difficult, as has been explored earlier. Even physically and spatially, particularly within the higher order animals, it is very difficult to tell where the organism ends and where it begins. The introduction of this research pondered where the edges of our bodies were - our nostrils, mouth, intestines and lungs all reveal our physical nature, pierced by internal thoroughfares - we are fundamentally permeable. The idea of bacteria outnumbering our own cells puts the notion of a clearly defined self further under question.

39 Recent studies indicate, however, that the *physical* transfer of bacteria at birth is essential to proper health. It is known that the bacterial colonies that populate our bodies vary widely in different regions. In the vaginal area, there are specific bacteria, and the method of birth (natural vaginal birth versus cesarean section), effects the natural transfer of essential bacteria from mother to child, which regulates many functions of proper health, especially at this early age. This is now being taken account during hospital cesarean births, through the application of microbe swabs to transfer bacteria from mother to child directly after birth. Source - "Boost C-section babies by giving them vaginal bacteria," New Scientist (2016), accessed May 20, 2016, https://www.newscientist.com/article/2075768-boost-c-section-babies-by-giving-them-vaginal-bacteria/.

40 Margulis and Sagan, *Microcosmos*, 55.

When we examine the basic elemental substance of our bodies - its constituents - we are mostly water by weight, with a range of organic compounds that form the functional building blocks. Broken down further, into atomic elements, we are made mostly of oxygen, carbon, hydrogen and nitrogen, in that order by weight. Various other elements, from arsenic to zinc, are also present. The cells we are made of, using these elements, replace themselves at various rates, depending on their type - stomach cells usually last no longer than a week, red blood cells typically last around 4 months, fat cells can last up to 8 years, and cells of the central nervous system are not replaced during an entire lifetime[41]. As a multicellular organism made of many individual cells, our constituent parts are variably replaced along different time-lines, and it is not that our bodies ever change entirely, or that they stay the same, but rather some ill-defined mixture of both. These matters are of prime importance when considering our cellular or elemental makeup - the physical stuff of reality. The definition of life and identity, through physical reduction into components, or boundary perception of form, is complex and inconclusive.

Another approach to viewing our physical selves is to see the arrangement of cells as integrated in a particular pattern as influenced by DNA coding. This specific individual pattern of order through the DNA "script", is seen to create the underlying pattern of what we refer to as our selves, or our physical bodies. While the cells are constantly dieing and renewing, and matter is shed and absorbed from our environment, the structure - the overall unique pattern of ourselves - remains. If we cut our finger, the unique whorls and print of our skin grow back in the same arrangement. This pattern and structure organises the many cells of the body, along with their growth and maintenance. Approaching definition in this manner of a DNA-determined pattern (perhaps akin to a musical score), the edges and

41 "Cell Biology by the Numbers," accessed April 24, 2016, http://book.bionumbers.org/how-quickly-do-different-cells-in-the-body-replace-themselves/.

boundaries of identity become something different - identity becomes a pattern, a set of relations - a harnessing of the qualities of individual cells and elements to create a complex inter-related system. In this vision of identity, the physical boundaries of a body are not as important as the relations and rhythms that bind the individual elements. Perhaps this abstract notion of self as pattern is easier to acknowledge than the form and matter which is normally used to define physical self? Such a vision need not necessarily be DNA-based, but more energetic or spiritual. But with patterns derived from whatever source of DNA or spirit, there is still the matter of defining edges, although they are of an entirely different character. It is difficult to escape the notion of edges in biological life, as much as it is to define what life is and draw a clear border around such a seemingly simple concept.

The early biologist D'Arcy Thompson explored the structural and formal nature of life in the early 1900's. As a pioneer in the field of morphogenesis, he studied the naturally occurring formal patterns of life, especially as related to embryonic form and growth, often comparing them to simple mechanical and chemical phenomena. His research explored the reasons behind the physical shapes of organisms, positing a balance of genetic signals effected by the interior chemistry and mechanics of constituent elements, the mundane functions of the entity, and the pressures of the environment, combing to directly inform the physical shape of an organism. In this way, the shape of living entities is seen as a sort of conversation between internal scripts, the characteristics of constituent elements, and external environmental forces. Thompson applied these thoughts across all matter, organic and inorganic, developing a very practical and sensible approach to biological growth.

> The form, then, of any portion of matter, whether it be living or dead, and the changes

> of form which are apparent in its movements and in its growth, may in all cases alike be described as due to the action of force. In short, the form of an object is a 'diagram of forces'[42]

Thompson's notion of *force* can be described as the energetic pressures applied in the past and present, to physical matter[43]. Of importance here are these notions of external and internal forces, and how this manner of perceiving an organism helps in apprehending boundary and edge.

The concept of any form being a "diagram of forces," implies that organisms are deeply related to and embedded within their environment. While they may not spatially *extend into* their environment in such a vision, the forces of their environment play a great part in determining the form of the organism. There seems to be a threshold of identity that is negotiated by contesting forces, such that the outside edge of an organism is a dance between internal and external pressures. As Thompson further develops this notion,

> Morphology is not only the study of material things and of the forms of material things, but it has its dynamical aspect, under which we deal with the interpretation of energy.[44]

At that word "energy", Thompson has two long footnotes, one dealing with thermodynamics and the harnessing of available energy by living systems to move against entropy, and another, that points to the origins of life in thermodynamic systems through

42 D'Arcy Thompson, *On Growth and Form* (Cambridge: Cambridge University Press, 1961), 11.

43 The notion of *force* is detailed here by Thompson, "When we deal with matter in the concrete, force does not, strictly speaking, enter into the question, for force, unlike matter, has no independent objective existence. It is energy in its various forms, known or unknown, that acts upon matter. But when we abstract our thoughts from the material to its form, or from the thing moved to its motions, when we deal with the subjective conceptions of form, or movement, or the movements that change of form implies, the Force is the appropriate term for our conception of the causes by which these forms and changes of form are brought about." Thompson, *On Growth and Form*, 10-11.

44 Thompson, *On Growth and Form*, 14.

inorganic chemistry present in the early earth[45]. For a biologist, Thompson's notion of energy draws upon modern physics, decision-driven evolutionary theories of the day, and the often misinterpreted notions of vitalism. These energetic approaches towards understanding an organism add interesting perspectives on the fundamental nature of what constitutes life, and upon such boundaries. The inclusion of an energetic aspect when considering life, such as Thompson uses, allows the notion of living systems to merge across the realms of mundane matter, knowledge structures, broader ecologies, and cosmological concerns. In this broader understanding, the edges of life become negotiated regions where forces interplay to create relations of mutually supportive order - of shared benefit, complexity, and interconnection.

The energetic approach to comprehending life has become distilled in modern times, stripped of its spiritual undertones, and ever more rationally lean (though of course riddled with vague holes and misconceptions as with all systems of knowledge). Energy concerns itself with order and potential, and it is through gradients - areas of varying energetic concentration - that regions of difference are created. In that difference, relation and interaction take place. Without difference, there can be no edge, and no order or disorder. Energy speaks of excess or potential, and, along with local difference, and specific order and pattern, energy is one of the prime ingredients of what we know as life.

This perspective of an energetic foundation to life inevitably leads to broader notions of what constitutes life. The intuition of our bodies as alive, our individual selves, is something we take for granted. Keeping in mind these notions of life as energetic, it is a simple step from considering the defining edges of our own singular individual bodies, towards envisioning the borders of

45 This theory has re-emerged and flourished during present times, under the various re-invented names such as biopoiesis or abiogenesis. For a detailed description, see "The Animation of Matter," Margulis and Sagan, *Microcosmos*, 47-57.

interdependent communities or larger ecosystems, in a similar way. It is relatively easy to conceive of a single network or organism formed out of individual related components, in the same way our bodies are formed of various cells and elements partly our own and partly transient or foreign. Extending this idea out to its most intuitive border, the globe of the earth can be imagined as an organism of its own, with its membrane of the atmosphere protecting the patterned order of all within it against the desiccating forces of space. This kind of wide-spread integrated paradigm of life may be just what the edge-obsessed cult of rational individuality needs right now, to combat the more destructive aspects of reductive reasoning. A kind of perceptual re-integration back into the environment. But our animal natures hold on tight to the surface of skin, to family and close-knit community that we can feel with our hands and see with our own eyes. The greater borders of the earth are so incommensurably distant, in space and in time, that they are hard to grasp with our limited experiences. We somehow need to extend awareness, spatially and temporally, to include a greater span of reality in our individual views of life.

It is quite natural to extend ideas of life to the greater globe of earth - it holds true to all the ideas of what life is - the membrane of the atmosphere is permeable, letting in the generative energy of the sun, keeping out the destructive forces of extraterrestrial meteorites and excessive radiation, and providing a rich layer of elemental gases in which life can be sustained. The complex network of inter-related separate life-forms create order from the inorganic elements present, acting much like cells, to regulate the physical and energetic conditions of the planet for continued survival at a global scale. The network of life-forms that order and pattern the inorganic elements and pass them through their structures, are complex enough to adapt to varied conditions and self-regulate in a way

that balances out their own effects[46]. All of these characteristics of the earth seem to make it obvious that it constitutes an organic entity in its own right, the integrated comprehension of which may be necessary for humanity to lead a more balanced and sustainable involvement within it. Such ideas and their underlying intuitions are ages old, yet we are still caught between the primacy and importance of our individual selves, and the health and benefit of the greater extended whole, most often favouring the former it seems.

All life sways between the needs and perceptions of the individual unit, and of its greater surrounding community - it seems to be an eternal rhythm like breathing. This range of spatial scale is also echoed in the realm of time. In considering the nature of biological life, there is an implicit temporality - of time as a dimension to the edges of organisms. It is too simple to imagine organic life being a fleeting arrangement of inorganic constituents that disintegrates when the pattern no longer holds - there are aspects of continuity and evolution to consider. Perhaps time can be conceived of as another aspect or dimension, alongside spatial and energetic dimensions, of what constitutes life. Our notions of time are limited and often geared only towards navigating the more mundane tasks of survival, and we have developed a mental quirk for separating out instances of abstractly perfect non-durational time - snatches of time. But it seems that the history of life suggests an unfolding that is not necessarily singular instances - individuals, species, or ecosystems - but rather a fluid motion of becoming - of immanent potential that draws patterns forward in dynamic relationships. These relationships, between outside forces, internal motions and progressions, play out in time through combination, separation, co-operation and antagonistic competition. Time reveals life as a transient shifting

46 For a more detailed discussion of various visions of the Earth as a global entity, see "The Future Supercosm," Margulis and Sagan, *Microcosmos*, 235-275.

pattern of matter and energy, not so much located in space, as being present in a *flowing through* - sharing space and passing along through evolving forms. This image of life as a centreless patterning potential of evolving change, has been elucidated by the philosophy of Henri Bergson, whose concept of *duration* attempted to free time and movement from our assumed spatial perceptions of them. His appreciation of movement allies closely with this notion of a flow that moves through life.

> Reality is mobility. There do not exist *things* made, but only things in the making, not *states* that remain fixed, but only states in process of change. Rest is never anything but apparent, or rather, relative. The consciousness we have of our own person in its continual flowing, introduces us to the interior of a reality on whose model we must imagine the others. All reality is, therefore, tendency, if we agree to call tendency a nascent change of direction.[47]

In this manner, when we consider form and the shape of edges, biological or otherwise, we find movement and tendency rather than definition. Implied direction and potentiality. Interactions between entities becomes a kind of sharing, and digestion and assimilation appear as a coursing through, a merging within, between organisms and environments. Reproduction and death speak of a transformation, of extensions, and liberation of energy. In this difficult to grasp perception of reality based on intuition, the edges of life become "pure mobility."[48] Bergson's concept of duration will be explored in detail later, when examining the edges of time[49].

In examining life as a form, and notions of life in general, core perceptions of reality are called into question.

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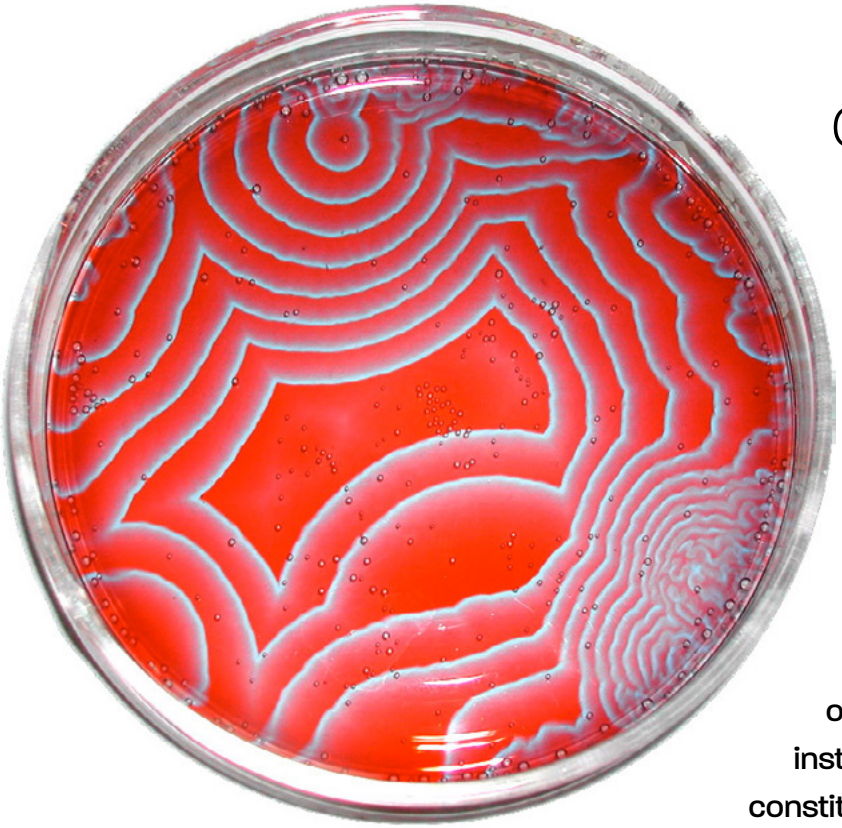
47 Henri Bergson, *The Creative Mind* (New York: Carol Publishing, 1992), 188.
48 Bergson, *The Creative Mind*, 165.
49 See *Extensions in Time*, 143.

In pondering the nature of life, we consider how we structure our awareness of it. Through these most basic of notions - what is life, and what is not - the edges that we draw around such concepts become clearer. Reducing the focus even further, down to the simplest building blocks of life, and its possible beginnings, chemical complexity reveals intriguing systems that can shed light on how we define the edges of life.



The BZ reaction taking place within a shallow solution. Source - "Belousov Zhabotinsky reaction," accessed July 3, 2016, https://www.flickr.com/photos/nonlin/3572095252.

chemical form and complexity

Chemistry is deeply entwined within the processes of life, structurally and developmentally. In some of the simplest reactions complex order can evolve, especially at instances of near-equilibrium where constituents are almost balanced, and also in instances far from equilibrium, where possibilities can fold and multiply.

There is a specific type of chemical reaction, known as the Belousov-Zhabotinsky reaction[50], or BZ reaction, which is a type of non-equilibrium reaction between chemical oscillators, such as malonic acid and bromate, forming a pulsing pattern of solutions (alternately red and blue with malonic acid and bromate), every few

50 Named after the Russian chemist and biophysicist Boris Pavlovich Belousov who discovered it in the early 1950's and his graduate student Anatol Zhabotinsky who studied the reaction in detail some 10 years later. Source - "Belousov–Zhabotinsky reaction," Wikipedia, accessed June 17, 2016, https://en.wikipedia.org/wiki/Belousov–Zhabotinsky_reaction.

minutes. This change of states takes place uniformly in a stirred experimental state, the liquid completely swapping between red, blue, red, blue.... When the reaction takes place in a thin layer, such as in a shallow petri dish, the reaction gives rise to wavefronts as the change spreads out in space across time, as in the picture on the previous page. It is a visually striking reaction, and there are some very intriguing things going on, some of which shed an alternate light on early fundamental conceptions regarding chemical reactions (this at first *seemed* to contradict the second law of thermodynamics), which is one of the reasons the experimental findings were ignored for so many decades. It is an interesting reaction to follow because it reveals the ability of relatively simple systems to generate complex behavior, and complex edges that echo the underlying patterns and processes of life.

In a chemical reaction, molecules are rearranged through reaction, to create other molecules, splitting and joining, usually giving out or taking in energy (heat, light, sound, etc). A chemical reaction is a fundamental transformative process that works on the atomic or molecular level - it is how we get energy from food and oxygen into our blood (or at the very least, this is our basic model of perceiving this process).

Progression of an oscillating BZ reaction taking place in a petri dish. Source - "Nonlinear Kinetics Group," accessed July 2, 2016, http://www1.chem.leeds.ac.uk//People/SKS/sks_research/sks_group_page.htm.

Several possibilities take place between the two components of the BZ reaction under various conditions. It can be arranged to reveal regular clock-like pulsing, chemical turbulence, spatial patterning (as in the above picture sequence), or hysteresis loops[51], depending on the nature of the experimental setup.

51 Hysteresis loops, usually referred to in magnetics, here refer to the variable speed of wavefronts that gives rise to complex interactions "along" the wavefront, resulting in highly complex patterns such as series of closed curves, that are formed in relation to the strength of the solution, ambient conditions, past interactions in time, and oscillatory or bistable patterns that take place within the reaction. Source - Alexander S. Mikhailov and Gerhard Ertl, *Engineering of Chemical Complexity* (Singapore: World Scientific Publishing Company, 2012), 151-152.

When arranged as a continually stirred experiment, the solution pulses regularly between colours in an extremely defined manner - red, blue, red, blue, red.... The motion of this pulsing is so clearly defined and regularly spaced in time that it has been studied as a form of chemical clock.[52] The reaction is limited in duration, but can be sustained indefinitely if it is fed with a steady supply of raw ingredients, and its waste purged (much in the same way that a living organism needs a constant supply of food and a passing of waste to maintain its own pattern of identity). Under such conditions it becomes stable and regular. The pulsing nature is due to a steady rate of reaction that is reversible. The rates of reaction are equal in both directions, and this results in a stable oscillation of solutions.

The same reaction process displays different outcomes if it is not stirred. If the solution is not allowed to mix evenly, local differences of concentration arise - spatial inhomogeneities - which combined with the naturally limiting or repressive behavior of the reaction (its oscillations through time), gives rise to chemical turbulence. Such a reaction is shown in the previous images, and here again below, where waves of alternating solutions react outwards in slow-moving fronts in a shallow layer of solution in a petri dish. Particular patterns emerge form the initial starting points, influenced by auto-catalytic ions (supplementary elements that "boost" the reaction by their presence), or local differences in solution, resulting in target style images, while reactions at an angle to the dish (or that have rotational aspects like an internal "swirling"),

BZ reaction detail. Source - "BZ," accessed July 2, 2016, https://rps-science.org/events/International-Images-for-Science/photographer/image/2636/.

52 Gregoire Nicolis and Ilya Prigogine, *Exploring Complexity* (New York: W. H. Freeman and Company, 1989), 19.

result in spiral patternings. Such complex behavior, originating from local differences in a self-regulating system that repeats itself, are interesting analogies for life, and some speculation upon the origins of life centre around similar reaction systems and their complex outcomes. The consequences of the patterning and ordering processes that arise in these reactions are still being explored, such as in current research that is using these basic reactions to develop liquid-based computer systems, using chemistry as a basis to create parallel computing architecture.[53] Such a use of shifting chemical edges, to store and process information, speaks of the very nature of intelligence and knowledge - especially current conceptions and constructions of it. In such an instance, moving chemical edges are not simply an analogy for information processing, but they are an actual tool - a medium that carries and manipulates information. The use of this chemical process of pulsing edges, as an informational processor, reveals yet another aspect of how we perceive of our knowledge and structure it.

possibilities at the edges of language

Language plays a great role in the structures of human knowledge, and many philosophers and psychologists acknowledge it as one of the foundational elements of reflective consciousness.

> There is no self-consciousness without language as a phenomenon of linguistic recursion. Self-consciousness, awareness,

53 Andrew Adamatzky, Benjamin De Lacy Costello and Tetsuya Asai, *Reaction-Diffusion Computers* (London: Elsevier Science Ltd, 2005).

> mind - these are phenomena that take place in language. Therefore, as such, they only take place in the social domain.[54]

The fact that language is a shared reference between "separate" individuals, and that complex abstract concepts can be communicated within the fine web of evolving and associative meanings, speaks of the power of representation that language commands. But our words and grammar form a structure that is double-edged and we must navigate between our ability to use them to communicate, and their ability as representations to impose artificial order upon our perceptions.

> The limits of my language are the limits of my mind. All I know is what I have words for.[55]

Many theorists of knowledge link language and consciousness tightly together, but it is perhaps not the specific mechanism of language that brings forth consciousness, but rather the power of representation that it wields. It is in modeling an abstract version of the world - in cleaving a fabricated version of reality away from itself, and examining it - that the first steps towards self-reflection are taken. In creating an image of the world, we inevitably come to creating an image of ourselves, and in this recursive act, self-awareness grows.

In language, representation is communicated, and through this, common edges are drawn and become defined. A consensus of categories is created, and, in connecting to other individual minds, we share these notions. Language can be seen in this way as a conduit for knowledge and thought. The best words bring

54 Humberto R. Maturana and Francisco J. Varela, *The Tree of Knowledge: The Biological Roots of Human Understanding* (Massachusetts: Shambhala Publications, 1987), 230. It should be noted that Maturana and Varela are looking at "language" quite widely here - it may be more appropriate to define what they are talking of here as "intellectual tools of representation", though this may seem overly obtuse. More simply, they are looking at the recursive nature of intellectual representation.

55 Ludwig Wittgenstein, *Tractatus Logico-Philosophicus*, section 5.6, translated by Charles Kay Ogden (Oxford: Routledge, 1981) 152.

us closer to each other, and to the world around us. Yet there is always a struggle, to use language to get close to *truth*, to reality, or simply to what we know. Language is always approximate, a representational convention. Language and knowledge chase each other and get tangled. Words allows us to communicate, but their patterns also force us to conform thought and understanding to their evolving structures.

> Language disguises the thought; so that from the external form of the clothes one cannot infer the form of the thought they clothe, because the external form of the clothes is constructed with quite another object than to let the form of the body be recognized.[56]

Language in-forms communication, applying force so that thought fits into its structures. And this naturally happens the other way around, as new knowledge forces language to adapt. But there is always an aspect of inertial lag. There is friction - language is slow to change, evolving to the needs of our thoughts and lives, seemingly, in direct relation to the rate of its use, and the connections between different peoples and new ideas[57]. Language is forever in flux, as much as some of us may prefer it to keep to one stable form. It has developed in other places and times to convey a different sense of reality, reflecting the natural environment and the culture and needs of the people. In some cultures such as the Pirahã in the Amazon, there are no words for specific quantities - no numbers - there is only few or many. The thought patterns for abstract or concrete numbers never developed as there was no need[58], and thus the

56 Wittgenstein, *Tractatus Logico-Philosophicus*, section 4.002, 45.

57 Martin A. Nowak and David C. Krakauer, "The Evolution of Language," in *Proceedings of the National Academy of Sciences* 96 (2016): 8028-8033, accessed June 10, 2016, doi: 10.1073/pnas.96.14.8028.

58 The study of Pirahã language is controversial, with few researchers who have mastered the difficult language and only a few hundred mono-linguistic native speakers, and with children now being schooled in numeracy the difficulty of understanding the linguistic issues in detail are problematic. There are alternate theories of why no numbers are present in Pirahã, some researchers positing that their bounteous environment supplies them with whatever they need at hand, and thus there is no need to count or store - what they need is there at hand with fish and local wild vegetables and fruit. The society has

language for quantity became very simple - "few" or "many". Grammatically, there is no distinction in Pirahã between the singular and the plural, even in pronouns. Language only conveys what is important and essential to communicate - if numbers do not play importance in one's life, then there is no need for language to describe them. This may seem obvious, but research strongly suggests that language is a precursor to numeracy[59], indicating that the structures of language open up the possibility for developing other possible abstract structures and processes of thought.

The differences in language across the globe and throughout time is immense, and some of the most intriguing changes occur in processes of integration and assimilation. This is apparent now as English becomes more universal, its structures of thought and perception influencing other languages (and consequently, their patterns of thought). The perception and naming of blue and green, for instance, has marked differences throughout the world. The modern English separation is often recognised differently in other languages, some cultures recognising greater differentiations, while many others recognising little separation between blue and green. Such is the case in the Japanese language, which traditionally used *ao* to refer to either green or blue[60]. This changed during the last century, when green and blue were distinguished in schooling by the modification of *midori* (originally a sub-colour of the blue-green *ao*), adapted to refer specifically to the notion of green. The old usage still lingers in many instances, such as the green of a traffic light, which retains the descriptor *ao* (the old *blue/green*, but the modern *blue*). In a sensitive

no hierarchy, they are primarily hunter-gatherers, and their religious beliefs centre around spirits that dwell in the trees, animals, and the weather of their environment. Source - Daniel L. Everett, "Cultural Constraints on Grammar and Cognition in Piraha," in *Current Anthropology* 46, 4 (2005): 621-646, accessed June 29, 2016, https://www1.icsi.berkeley.edu/~kay/Everett.CA.Piraha.pdf.

59 Elizabet Spaepen et al., "Number without a Language Model," in *Proceedings of the National Academy of Sciences of the United States of America* 108, 8 (2011): 3163-3168, accessed June 8, 2016, doi: 10.1073/pnas.1015975108.

60 "Blue Apples & Blue Traffic Lights? Japanese Color Perception," accessed May 15, 2016, http://insight.japantoday.com/blue-apples-blue-traffic-lights-japanese-color-perception/.

A Japanese traffic light showing the typical modern blue-green "go". Source - "Japan Life," accessed July 2, 2016, http://jp-life.seesaa.net/article/143184801.html.

awareness of the modern language inconsistency - of the blue "go" signals in traffic lights - the Japanese government issued a decree in 1973 to change the colour of the green in their regulation traffic lights to be as blue as possible[61]. Language can even influence the physical world, it seems. The Japanese heritage of blue and green runs across many other things, such as green apples which are described as the modern blue (*ao)*. Colloquialisms abound in the language as well, such as those that draw upon green as a signifier of fresh new growth in plant life, but which in direct modern translation seem to refer to being blue. Yet it must be remembered that there are many complex shades of green in the traditional language - colours such as *wakatake-iro* - literally "young bamboo colour" - defining a distinct green - and many other examples, often taken from nature. All of these green shades were however once grouped under *ao,* the modern blue.

These endearing analogies of difference seem harmless, but language often distorts the fabric of perception in more problematic ways. In a study that traces the ability of language to alter our perception and memories of events[62], linguistic researcher Nick Enfield studies how the role of simply describing a remembered event - of putting memories into words - can radically alter our ability to recall details accurately. In one detailed example, an innocent man, who later died in prison, was wrongly prosecuted by someone who was asked to describe the crime in detailed words at the scene. From the face of the attacker, to the details of colours of clothing and objects present, the prosecutor was many years later found to have been influenced greatly by the act of recalling and describing the event in words.

61 "The Japanese traffic light blues: Stop on red, go on what?" The Japan Times (2013), accessed May 15, 2016, http://www.japantimes.co.jp/life/2013/02/25/language/the-japanese-traffic-light-blues-stop-on-red-go-on-what/#.V1d7UMfRthE.

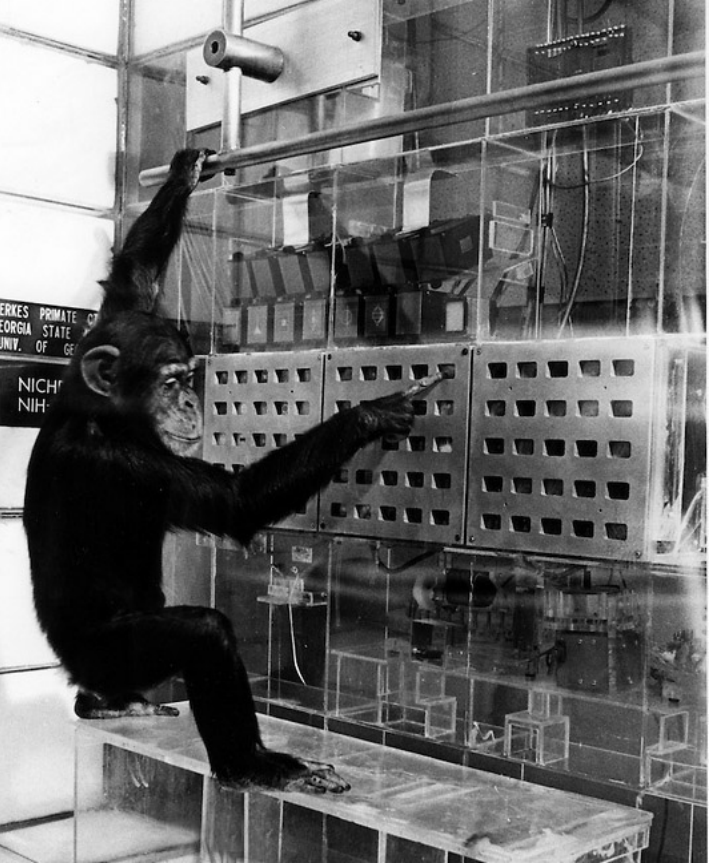
62 N. J. Enfield, "Linguistic Relativity from Reference to Agency," in *Annual Review of Anthropology* 44 (2015): 207-224, accessed June 16, 2016, doi: 10.1146/annurev-anthro-102214-014053.

From the description of the face, which was described in detailed separate parts, the seemingly coherent image of the face of her attacker was altered enough to make her sure enough to convict the wrong person. Other subtle details of the event, recalled incorrectly at a time of intense stress, were fixed through the act of immediate recall and translation into words. Such research has found that the initial verbal or written description of an event can lead to seemingly subtle changes in categorisation that forever alter the memory so that the original details are lost[63]. It seems that the simple act of using words to describe something - of filtering it through the categorisation and analogising nature of language - significantly alters the memory to fit within predefined structures and categories. This is especially marked in instances where complex knowledge is reduced to parts and then later reintegrated (such as in the above example where a face is reduced to a verbal descriptions of parts and later re-assembled). Through putting knowledge into words, we change that knowledge. The popular notion that language clearly expresses internal thoughts like a simple conduit is far from the truth.

Language is often thought to reside solely in the domain of human culture. But research has observed animal learning of human language, the creation of specific interspecies languages, and also our initial studies into the more complex matter of native animal languages. There is the classic study of Yerkish[64], a language developed for communication between humans and chimpanzees, with 125 lexigrams and its own open form of grammatical structure. Although this is not exactly a human language, it retains all of the hallmarks of

63 Jonathan W Schooler and Tonya Y Engstler-Schoolera, "Verbal Overshadowing of Visual Memories: Some Things Are better Left Unsaid," in *Cognitive Psychology* 22 (1990): 36-71, accessed June 16, 2016, http://www.ncbi.nlm.nih.gov/pubmed/2295225.

64 Ernst Von Glasersfeld, "The Yerkish Language," in *The American Journal of Computational Linguistics* microfiche 12 (1975), accessed April 3, 2016, https://aclweb.org/anthology/J/J79/J79-1012.pdf.



The Yerkish console for communication being operated by Lana the chimpanzee. Source - "Lana the Chimp," accessed July 2, 2016, http://ronsherman.photoshelter.com/image/I0000k4jyBnRTTwE.

modern English. While not being speech-based, but rather symbolic, it uses visual keys operated by touch, as can be seen in the photo at left, which are combined to create grammatical sentences capable of expressing complex embedded clauses. The research continued over many years, especially with one particular chimp Lana, whom the two primary researchers formed close bonds with. At first, rote learning with specific repeated responses enforced the learning of the language, but as this progressed, novel forms, spontaneous questions, and abstract transferences of context began to develop. The limited but flexible nature of the lexigrams allowed insight into the way in which simple languages structures themselves - when Lana was given an orange soda, she used three lexigrams to name it a "Coke - which is - orange".

The way the Yerkish experiment has been documented and received is highly intriguing, as it reflects the way in which we perceive of our own language skills - what is rote learning in human linguistics, what is enforced through response, how novel spontaneous formulations of language occur, and ultimately, how particular language systems structure our thoughts. Through the consideration of non-human understanding in language, a subtly different perspective of our own linguistic intelligence begins to develop - glimpses of intelligence from outside of the bounds of language.

In more recent primate language studies, the controversial researcher Sue Savage-Rumbaugh has lived in close connection to the Bonobo ape Kanzi, and taught him 348 lexigrams, which he combines with the understanding of some 3,000 spoken English words to communicate in mundane and abstract contexts[65].

65 P. Segerdahl, W. Fields, and S. Savage-Rumbaugh, *Kanzi's Primal Language: The Cultural Initiation of Primates into Language* (London: Palgrave Macmillan, 2005).

Kanzi communicates with the researchers around him, with other apes, and also acts to translate English for the other Bonobos. Although there is much to learn and understand in such studies, it is exceedingly distressing to imagine the artificial isolation wild animals would experience outside of their natural environments, with human systems and values enforced upon them. There is also a far greater wealth of knowledge - truly unknown knowledge - that could be gained and shared - if we met on common ground. In order to begin to understand other species, we need to overcome our inherent reluctance to acknowledge the intelligence of other species, and become accepting enough to meet the differences of representation that may occur.

In language studies of an entirely different species, and conducted in a far less problematic manner, researchers are exploring the nature of communication that exists with dolphins[66]. Having one of the largest brains per body weight of any mammal, and having developed that brain size significantly earlier in history than any primate, there is clearly a lot of mental activity that takes place within the brains of dolphins. They are the only other animal we have witnessed to have personal identifiers, signature whistles that are specific to individuals and are used to call to each other. This conclusively reveals that they have a linguistic sense of self, which is one of the clear indicators of our much lauded state of human self-awareness. Their constant chatter, which is part communication and part echolocation, has also revealed another distinct characteristic, in the manner that they refer to and represent physical objects. When a dolphin refers to an object such as a hollow steel box in the pool that has been identified through interaction[67], that reference is not symbolic, as when we use the words “hollow box” (and only then if we are English),

66 “Dolphin Intelligence,” National Geographic (2015), accessed June 16, 2016, http://ngm.nationalgeographic.com/2015/05/dolphin-intelligence/foer-text.
67 “Language Learning,” accessed June 16, 2016, http://www.dolphin-institute.org/resource_guide/animal_language.htm.

but rather, the dolphin refers to it through re-voicing the sonic image that he or she receives through the act of echolocation. This would be the linguistic equivalent of ourselves being able to project a three dimensional image to all of our friends, of the objects we are referring to - conjuring an image through reverse-engineering basic perceptual processes - to represent reality. This is so fundamentally different from the abstraction of a symbolic language such as the English we are now using - words that have no direct relation to things, except through learning and general consensus. What kind of vision of the world would be fostered when communicating in this way - a representation of reality that seems to use holographic imagery in place of nouns?

Yet another interesting aspect of this research into dolphin intelligence is their ability to translate across alternate modes of perception[68], which has never been revealed in studies of other animals. If a dolphin is shown a visual image of a particular object, and the object is placed in the pool when their sight is blocked, they are able to recognise the object amongst other similar objects. While this may seem nothing of particular import, it is yet another of the particular hallmarks of human intelligence we have held above that of other species (along with the previously mentioned personal identifiers or names). Clearly, the edges of intelligence are less defined than previously thought, though still, for the moment, seemingly insurmountable. To research other perspectives and intelligences requires a flexibility of approach in the methods of research, and an ability to extend beyond the frameworks and limits of current knowledge. To extend beyond our own linguistic edges.

The research into dolphin perception and intelligence

68 Adam A. Pack and Louis M. Herman, "Sensory integration in the bottlenosed dolphin: Immediate recognition of complex shapes across the senses of echolocation and vision," in *Journal of the Acoustic Society of America* 98, 2, 1 (1995), accessed June 8, 2016, http://www.dolphin-institute.org/our_research/pdf/PackandHerman1995.pdf.

is still in early development, but as one of the founding researchers Stan Kuczaj mentions, it prompts us to consider that "the question is not *how smart* are dolphins, but *how are* dolphins smart?"[69] In entertaining those possibilities, or at least using them hypothetically to view our own language from a different vantage point, we can begin to imagine radical differences of perception and definition that would likely transform the basic experience of reality. Echolocation reveals as much about the surface of an object as it does about its interior structure and material makeup (similar to acoustical imaging techniques such as ultrasound). With primary perception being echolocation over sight, dolphins may be building a very different spatial view of the world - less to do with the appearance of surfaces and edges, and more concerned with density, substance, and gradients of matter. The world of a dolphin is likely to be experienced and conceived of in a radically different way to that of our own.

Whatever one may personally believe or hope for in the intelligence of dolphins and the way in which they communicate, it is interesting to hypothetically entertain a simple comparison, and to glimpse aspects of our own methods of representation - to ponder upon how our own visions of reality are effected by these structures of knowledge which we habitually use to communicate. Through considering varied perspectives across people of different ability and character, and extending this further through explorations of the conscious world of other species, it becomes clear that the experience of reality is dependent upon structures of perception and knowledge. There are many factors - the range and extent of the senses, how these are wired into the structure of the brain, basic needs as a physical entity living within an environment, embededness within a complex learned social structure of other individuals, and the weight of history in inherited behavior (whether

69 Dr Stan Kuczaj, as quoted in "Dolphin Intelligence," National Geographic (2015), accessed June 16, 2016, http://ngm.nationalgeographic.com/2015/05/dolphin-intelligence/foer-text.

passed down intellectually, habitually, or through the transference of genetic coding). In this complex web of factors, a layered representation of definitions and edges forms - a unique world of its own - allowing each individual life to navigate reality, survive, reproduce, and express itself among a community of others.

forming - the morphology of boundary

In relating the varied divisions we create naturally through our senses, through the structure of our nervous system and the processes of thought, a complex understanding begins to emerge. Recursive self-awareness is a movement of perception folding back in on itself, creating separation or distance, and allowing for a matrix of knowledge to emerge through which we can begin apprehend knowledge as a separate thing.

We have knowledge of things. This knowledge is added to and altered, connecting unforeseen commonalities and bridging differences. This structure grows by maintaining certain separations and distinctions, then making comparisons, and also forging connections between divided parts of our experience of reality. This is a highly complex ordering - a severing and connecting of parts and relations. The first step in this undertaking seems to be the division of perceived experience into bounded elements - *edging*, as we have described it here. It seems that in order to make sense of any experience, and its context within the greater field,

we must first split it into a discrete separate form, that conforms to the general structuring of existing thought. It is hard to trace how essential the act of representation is to this splitting - whether representation is the essential action that splits, or whether it is simply the process of mentally ordering these discrete parts. We are within this process of knowledge creation as we think this through - it is not easy to arrest and extricate the mechanics of thought from its own processes.

In an attempt to explore these problems using an alternate approach to that of philosophical pondering or reductive reason, a physical body of work was created to represent, formally, the character, shapes, and movement of knowledge. Forms were sculpted in bronze and copper that expressed the properties and patterns of processes of thought. This physical act encourages an explorative and alternate understanding that avoids the constant recursions of the rational mind and its "tribunal of criticism."[70] The act of creating such work, and of reflecting on its development within the moment of its making, is a kind of *thinking-through* - it is an act of *making sense*. The images at left reveal the general physical outcome, if not the understanding generated by the direct creative process itself.

Thought forms modelled in wax and cast in bronze to explore the notion of thought through 3-dimensional form.

The notion of action and creation in the physical world as a means of generating knowledge is not at all new. It is the basis of all early scientific discovery - the classic

70 Isabelle Stengers, *Thinking with Whitehead: A Free and Wild Creation of Concepts*, translated by Michael Chase (Cambridge: Harvard University Press, 2011), 37.

notion of the "experiment". Scientist and philosopher Gaston Bachelard intimately understands the work of the physical experimenter as a seeker of knowledge, and reveals the more basic drives of such undertakings when he writes, "I make a physical experiment to transform my mind."[71]

Unlike most scientific experiments, exploring spatial and formal aspects of knowledge is not a systematic undertaking. In creating these objects, there was no desire to catalogue the entire range and breadth of forms that may be present in patterns of thought, or categorise them into any particular arrangement. To impose any kind of rational order upon the act would defeat the purpose of the exploration. So, rather than being a comprehensive sculptural inventory of thought processes, the shapes were created while focusing upon aspects and tendencies of the process of knowing, invoking the feeling and flow of specific instances of knowledge. This exploration of the form of thoughts resulted in a simple sculptural series depicting mental actions within my own structures of knowledge. To describe one of the forms, so as to understand the motives of this work a little more, there is the form at left, the ridged torus. This bronze *thought form* explores the turbulent motion of thought as it orbits around a singular problem, 27 looping rings forming one long spiral ridge around the basic toroidal shape. Focusing upon a single problem that is surrounded at the centre of this form, acting at a distance, spinning lines of force do not actually converge upon the problem, but rather create a field around it, teasing it out and resolving it through a magnetic form of re-alignment. There is no contact or

Ridged torus thought form that explores a focussed "magnetically-inductive action-at-a-distance" approach to solving problems.

71 Gaston Bachelard, "Surrationalism", in *Surrealism*, edited and translated by Julien Levy (New York: The Black Sun Press, 1936), 188.

touch involved because the problem this form is centred around is not easily defined (this action is focused upon an *area*, or a *movement*, or a *spatial tendency* - the internal void area is the focus where the work takes place - where the problem is being resolved). There is motion implicit in the form, both through the spinning rings that loop around the toroidal form, and also in the overall form itself, which is a kind of tunnel, a processing machine that moves things (problem thoughts) through its hollow centre. This form is like a tool - its use is for resolving problems without touching them - a kind of non-invasive action at a distance - *resolving a problem through focused energetic influence*. In this kind of abstract manner and approach, all of the created thought forms are aesthetic, intuitive and energetic representations of processes of thought.

To quote the influential biologist D'Arcy Thompson again, "the form of an object is a diagram of forces"[72], and in these *thought forms*, the objects become a creative expression of the forces present in thought. This playful and alternate approach to understanding the processes of knowledge may not be entirely explicable, and surely does not lead to any definable conclusions, but it is a process of understanding, of *becoming familiar with*, the complex ideas under consideration. It is a valuable approach that can complement the more rational methods of thinking through. Such alternate approaches, relying more on the creative or intuitive faculties, are extremely useful when dealing with complex issues that do not resolve to simple answers under the power of reductive reasoning.

The difficulty of bringing the processes of creative work into the realm of academic knowledge production, is clear. Here, in attempting to translate the creative exploration discussed above, validating it through translation into critical written discourse, much is

72 Thompson, *On Growth and Form*, 11.

lost. This is obvious when one considers that the act was undertaken in order to create knowledge outside of the realm of language. The need to filter all forms of knowledge creation through the lens of critical intellectual discourse leaves much information behind. The subtle nuances of media and processes, the actions of time, and most importantly, direct experience and observation, are lost within the recursive actions of criticality. It is saddening to assume or to accept that such alternate forms of knowledge production must be translated into the realm of critical discourse so that their concerns can be validated[73]. Within this research, it is of vital importance that the creative work and written text be experienced as an integrated whole, feeding into each other in a web of knowledge that arcs across linguistic, conceptual, and aesthetic domains. The transformation and loss of information is simply too great when aesthetic and intuitive knowledge is transferred across into the linguistic domain in this and other similar such instances.

In the mundane matters of our daily lives as much as in the assessment of doctoral arts degrees, varied alternate modes of producing knowledge need to be valued equally, respected for their differences, and allowed to speak in their own languages, without being subsumed and translated into one dominant system. Even more idealistically, these alternate modes need to be given the opportunities to communicate freely with each other - sharing not only the products of their knowledge, but the processes through which these products arise.

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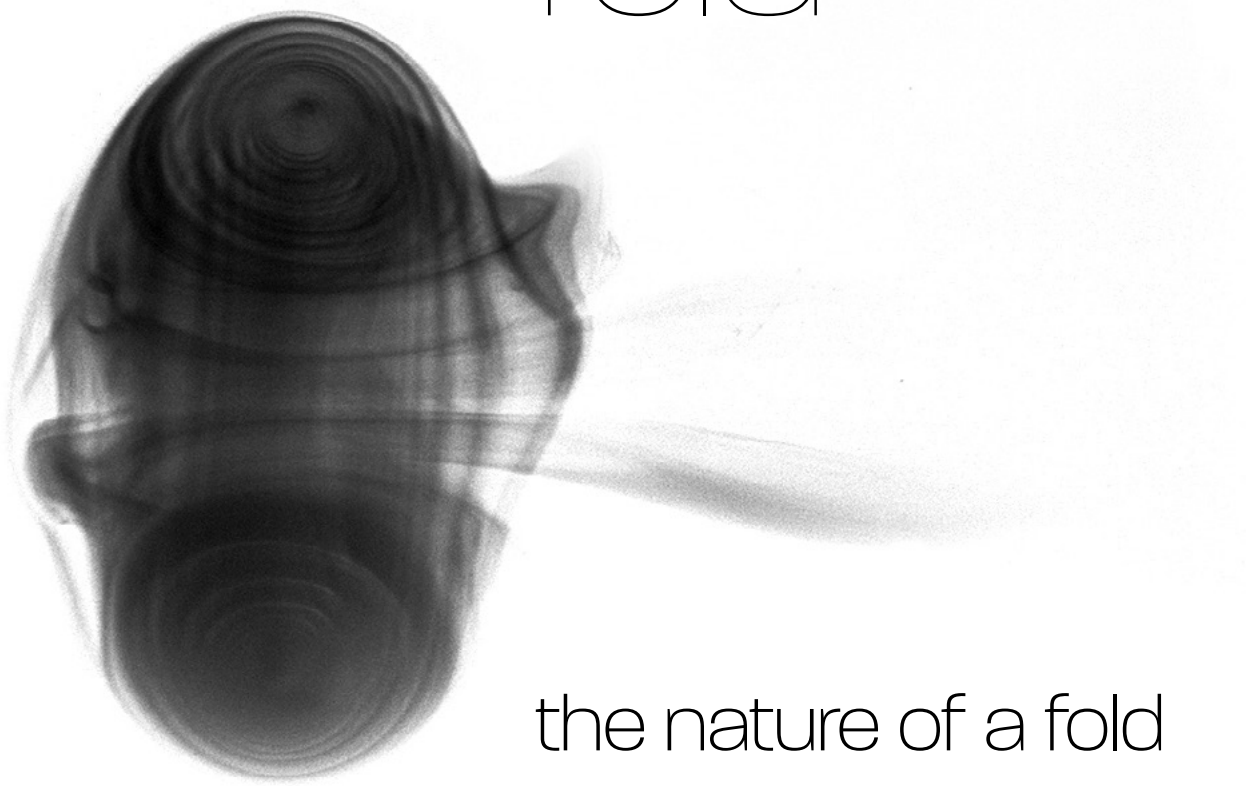
73 These kind of intellectual habits are made clear in such instances as the academic assessment process of this PhD in Visual Arts, where Sydney University has structured assessment so that the written text component is submitted prior to the assessors having seen the body of creative work. In this absurd manner, the initial success of the creative work relies upon the candidate successfully *communicating a critical discourse around the work to his or her assessors*, rather than on *the success of that creative body of work within itself*. Surely it is the experience of encountering creative work, and considering its ability to confer new knowledge and bring a substantial contribution to the visual arts, that is the primary assessable outcome of a creative arts research program? These are personal ruminations upon the assessment structure for Creative Arts PhD candidates at Sydney College of the Arts, University of Sydney, September 2016.

fold



the nature of a fold

The simplest notion of a fold is of a flat sheet of paper halved. Even while reading this electronic text, it is easy to imagine how paper folds, bending tightly along a crease, two internal faces laying hidden against each other, two outer faces revealed. An inside and an outside is created, a potential space. The sheet is transformed, from its initial state as a flat plane, to its folded state of partial volume, through the relationship of the two internal faces.

Folds serve many purposes, such as when we stay too long in the bath, the skin of our fingers wrinkle, our clean pink flesh rippling to form minute crevices and crests - folds of another sort. The steel panels of cars crumple violently in an accident, folding along lines of force to relieve excess energy, deforming metal in an abrupt contraction of space. People in starships fold space in sci-fi blockbusters, miraculously aligning two

The *plicae circularis* - folds of the small intestine that facilitate greater exchange of nutrients across the membrane wall, through the extended surface area that this folding creates. Source - "Lab 11.4: GI Tract Histology," accessed July 2, 2016, https://www.studyblue.com/notes/note/n/lab-11-4-gi-tract-histology/deck/16084502.

distant locations through bending the "fabric" of space-time, and passing through altered relations of proximity, much like the simple sheet of folded paper.

A fold is a continuity that is bent, it is a redirection and contraction of occupied space. A fold complexifies a defined planar space, drawing new relations within, and outside of, that space. It brings together that which was distant, and in that action of bending, forms a new creased edge, a new dimensional boundary. Folds in fine paper multiply to create origami birds, expanding flat planes out into bounded forms. They multiply into wrinkles, creating greater surfaces of interaction, facilitating exchange, like the crinkled edges that line our small intestine, promoting the flow of specific substances across the membrane wall, shown at top left. Folds can develop through an excess flow of energy, as in a car crash, dissipating energy through the deformation of steel, revealing the interplay of force and matter through complex changes in form. We fold each other in deep embrace, in affection, for protection, to take responsibility for, even to partially incorporate one into another - a harboring within. We fold in eggs when mixing a cake - not to completely mix and homogenise, but rather to delicately distribute within one another so as not to entirely disperse the original ingredients.

Jonathan Schipper's *Slow Inevitable Death of American Muscle* (2008), creating folds of stress stretched out in time through a gallery exhibition. Source - "Slow-Motion-Car-Crash," accessed July 2, 2016, http://www.basenow.net/2012/09/17/poke-poke-how-to-make-the-most-of-a-great-exhibition/slow-motion-car-crash/.

Fred and Maria enfolded in embrace in *Metropolis*, directed by Fritz Lang (1927). Source - "A spaceship, a dinosaur,," accessed July 2, 2016, https://cosmodino.wordpress.com/2014/06/03/metropolis-1927-germany/.

In folding something, whether it is one continuous form that is folded, or separate forms being folded together, there is an opening out into, a sharing, a layering of - new relations that complexify the seemingly simple notion of definition and boundary. There is a re-territorialisation that can open a mutual space, to

align disparities, or to create fugitive identities within a singular whole, and thus give rise to emergent forms of differentiation. Folding is all about relational understanding, through a bringing together, in contact and communication.

folding the outside within

This smoke vortex was formed using one of several machines designed and built specifically for their creation. A great deal of exploration for this doctoral research has focused upon the nature of smoke rings[74], and they are an intriguing example of this notion of the fold.

Smoke vortex captured with transmitted light on digital camera.

A vortex is created when a moving column of air (or any other fluid), passes through a relatively still body of air. It happens regularly, such as at holes in a wall as the wind blows through, though they are not normally visible, due to the apparent similarity of air. But when a column of smoky air passes through a relatively still body of clear air, as it is made to do in my studio, it is much easier to observe.

74 For more images, see *appendix iii - process and visual documentation*, pages 187-231.

Smoke rings form, as seen in the cross-sectional progression diagram below, where a column of smoke-filled air is pushed past a boundary and into a body of still clear air. The edges of the moving column of smoky air are dragged by friction as they rub against the surrounding still air. There is resistance at the edges. Falling around and behind the moving column, these edges are sucked up in the wake of the movement. As more smoky air gathers behind the moving column, the pressure increases, and with nowhere else to go, it

A cross-sectional progression of smoke ring development.

pushes *inside* the column, starting the swirling donut-like motion of air that is characteristic of the vortex. As this spinning rotation becomes more pronounced, it also gathers the clean air around it, grabbing it with friction and pulling it inside and through, and out again, and again - folding in alternate layers of clean air and smoky air, generating ever more layers in the spinning torus of its elegant form.

This growing vortex moving through space maintains the order of its structure through the energy of its initial momentum. A smoke ring may last for only a second, or up to half a minute in normal conditions, but it needs space to travel, and a relatively calm body of air to move through. Their lives are short-lived, but incredibly beautiful. When they die, their structures disintegrate, not so much unfolding, as simply dissipating.

The nature of a smoke ring seems to exemplify the complexities of boundary and identity. As Alfred North Whitehead reminds us, “we cannot define where a

body begins and where external nature ends,"[75] and in this instance, we need to find an alternate approach to defining the body of the smoke ring. If its body is the general form that is a mixture of the smoky air and the air it travels through, transforming and growing as it moves, then it is not a thing you can define through substance. In the same way, it is not spatial, unless we ignore the fact that as it is moving, for it incorporates outside space within it. It could be conceived of as a pattern - as an organisational tendency - of nothing more than the swirling motion of a vortex. This makes some sense, seeing as one of the most remarkable features of a smoke vortex is its movement and its complex structure that seems self-sustaining. A smoke ring could be imagined as one single folded body of smoky air, like some super-stretched rotationally-folded plane of space, a very complex form to describe simply. Visualising a smoke ring like this, as one long edge, rolled within itself - consisting only of one drawn-out boundary edge - is a seductive notion.

Conceiving a smoke ring as a movement of folding, occurring through space, comes closer in apprehending its essential qualities. As it travels, the smoke ring folds in the outside air, and layers it within, creating spinning planes of spiraled air, smoke next to clear, stretched and laid alongside each other - a hybrid identity of two elements. Considering only this movement of folding through space, as an abstract pattern, without any reference to substance, is almost mathematical in its abstraction. It apprehends the physical world through focusing more upon patterns and tendencies across time, rather than concentrating on substantial or fixed formal concerns. While such a view is incomplete, it can be considered alongside other perspectives, so as to broaden understanding.

75 Alfred North Whitehead, *Modes of Thought* (New York: Free Press, 1968), 21.

This mode of apprehending reality through tendencies in time (along with many other aspects or modes), has been explored in detail through the research of smoke rings, as shown in *appendix iii - process and visual documentation*.[76] Through a great variety of imaging approaches and media, a multiplicity of perspectives has been developed. This approach helped in revealing the underlying tendencies of smoke rings, through examining and recording aspects of their nature across various documentary methods. When considered together, the varied processes overlap to form a layered network of information, revealing fundamental underlying features. Yet in considering each form of documentation separately, specific qualities are portrayed, and there is a strong perceptual relationship between the portrayal of the smoke rings, and medium of documentation. Moving between these two modes, looking at the overall body of documentation, and medium-specific instances, reveals the smoke rings in their underlying nature and also their fine material detail, whilst also revealing the effects of each medium and its processes upon the information gathered. The subtle awareness of the qualities of each medium, and the way each colours and transforms the information it carries, creates a recursive field of knowledge that allows glimpses of the process of knowledge creation.

In order to open up this field of possibility many techniques for documenting the smoke rings were used, and were later considered together as a whole. In still images for instance, processes were employed to record the form of smoke rings through standard reflected light images using an array of digital, analogue and instant cameras, while interior images were gathered through transmitted light, or slices of internal structure that were revealed using laser light and prisms to create a flat sheet of light across a cross-

76 See *appendix iii - process and visual documentation*, pages 187-231.

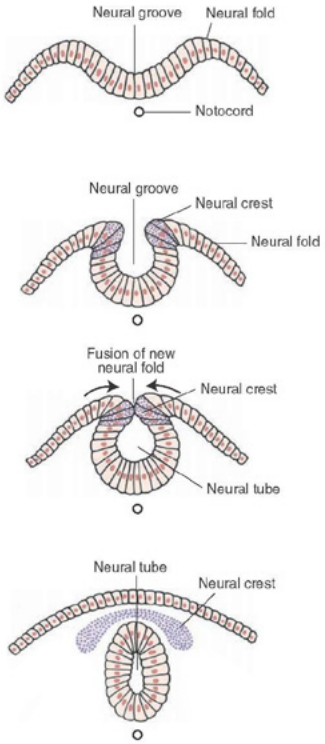
sectional plane. Shadow photogrammes were made using high intensity point-source flashes to directly expose photographic emulsion, or dual camera set-ups were used to take stereoscopic images to record three dimensional perspectives. In moving image, a large collection of slow motion footage in 16mm film was shot, using standard lighting, transmissive lighting, and laser-plane cross-sectional slices to reveal internal structures across time. Audio documents were generated through optical density sensor recordings that recorded the movement of smoke ring layers as sound, while standard microphone recordings attempted to listen to the subtle noises of moving air, and specially developed tissue membrane diaphragm recordings were developed to capture further details. When all of these documentary outcomes are considered alongside experiential observations - the sight of the vortices, the subtle sound of their creation, the tactility of moving air, and the smell of various smokes - a complex interrelated web of knowledge forms. Through poring over the documentary material, such as in repeated viewing of the slow-motion footage - revealing subtle formations in time that are lost to the naked eye - subsequent experiences of viewing the smoke rings are transformed. The information gained through these varied modes of perception are integrated into basic awareness. Through the aid of documentary methods and technological devices, our abilities to perceive and to gather knowledge is expanded.

In exploring an event through so many perspectives, in fine detail, over an extended period, the knowledge and conceptualisation of what is occurring becomes exceedingly complicated. Information layers atop one other, each interpretation presupposes certain pathways, and it becomes difficult to trace the origins of ideas and perceptions in the flux of transferred meaning. Knowledge forms subtle loops and knots. Through competing, complimentary, and divergent views, it

seems that there is no possibility of reconciliation into a single understanding, without an inherent loss of information and knowledge. There is no reduction to a single representative model of *what a smoke ring is*, but rather, what emerges and starts to take form, is a meshing set of perspectives that furnish a multi-layered knowledge. All of these aspects of understanding are contingent and contextual. In keeping these multiple layers of meaning unfolded, allowing them to be unresolved, a small window opens that allows glimpses into the actual processes of knowledge construction. Not only is the complex nature of a smoke ring recognised, but also, the quality and character of each perceptual approach and mode of understanding can be appreciated. Through this familiarity with the varied fabric of knowledge, the movement of edges of knowledge can be perceived, as they shift and re-arrange through different approaches.

While such awareness of the processes of knowledge is fundamental to this research, such a state can only be sustained for brief intervals. Rather than forming any radical attempt to consciously observe the mechanics of knowledge, the aim of this research is to complement normal objective modes of comprehending the world, balancing them with alternate approaches, and opening up possibilities that may usually be ignored or unseen through habitual modes of observation. When considering such complex instances as smoke rings for example, there is a constant movement between definition, deconstruction, emergent connections, re-apprehension, and stability of re-definition, not to mention communication and representation, and also the emergence of a self-awareness of the processes through which it all occurs. It is impossible to remain in an awareness of unresolved possibility forever, however there can be a balance and a motion between, and a valuing of what such alternate modes of perception can add to general understanding.

folds of life

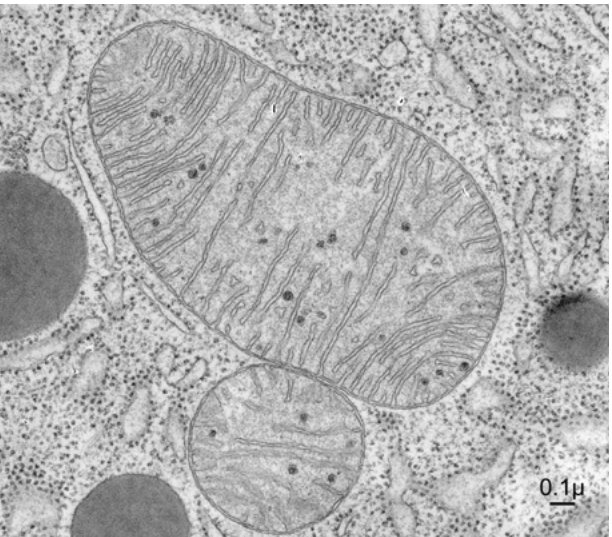


A cross-sectional image showing embryonic development of the neural fold, revealing the transition of the general cell structure from plate-like to a clearly 3-dimensional form that distinguishes inside and outside. Source - "Development of the Nervous System (Gross Anatomy of the Brain) Part 1," accessed July 2, 2016, http://what-when-how.com/neuroscience/development-of-the-nervous-system-gross-anatomy-of-the-brain-part-1/.

The notion of life, and what is living, draws upon the realms of physical matter, as well as that of the intellectual, metaphysical and energetic. There is more to life than the mere constituents of bodies, from the mysterious organising forces and vectors of order that science seeks, to the more spiritual essences that are informed by religion. Beyond the pragmatic concerns of the physical body, life can be seen as a folded concept, in the simplest and the most abstract of ways.

Folds are often multiplied, like the wrinkled skin of our fingers when we stay too long in the bath. A folded membrane creates a surface area many times that of its flat plane, which is beneficial to filtering or exchange, such as in the circular folds of the lower intestine, as already mentioned, which allow increased exchange of nutrients through the wall of the small intestine, through increasing the surface area of that wall. Folded membranes are found in many parts of the body to support such exchange, from such macroscopic folding of membranes of the small intestine, the neural fold that forms during our embryonic development to create the structural basis of our nervous system[77], down to the molecular folding of proteins that creates basic membrane tissue itself.[78] These repeated layers of folding continue in space, down into the mitochondria,

The outer form and internal folds, or *cristae*, of a mitochonrion are clearly shown in this electron micrograph image. Source - "Cell Image Library," accessed July 2, 2016, http://www.cellimagelibrary.org/images/7739.



77 The neural folds occurring in early embryonic development in humans are folds in the outer layer of our very early flat cellular structure, creating a hollow tube that later forms the spinal column and brain, and around which the rest of our bodies develop - curving, folding, and joining together the initially flat structure to complete the body cavity that later holds our internal organs. This basic structural change of the embryo from a disc-like cell to one with internal cavity structures, occurs between the third and fourth weeks of gestation. Source - "Development of the Nervous System (Gross Anatomy of the Brain) Part 1," accessed June 20. 2016, http://what-when-how.com/neuroscience/development-of-the-nervous-system-gross-anatomy-of-the-brain-part-1/.

78 The folding of proteins in tissue, as studied in tissue biomechanics, develops when proteins collapse and fold together in regular patterns due to biomechanical forces, aligning themselves side by side and forming into membranes of tissue, be it muscle, skin, intestinal, or any other variety of tissue structures. Source - "Mitochondria," accessed June 20, 2016, http://oregonstate.edu/instruction/bi314/fall12/energytransduction2.html.

the power supply organelles of cells, where the folded layers of the mitochondria's inner membrane increase the surface area and allow more energy to be created through cellular respiration. The folding of biological planes is a basic structural and developmental procedure that takes place across a vast range of scale.

Under entirely different circumstances, the complex folds of connective sutures beneath the fossilised outer shells of deep-sea ammonites show a remarkably complex pattern of structural folding. Many hypotheses account for the intricate folds in these extinct creatures, one being the evolutionary action of exterior pressure in the deeper waters where the ammonites thrived.[79] A folding *under* pressure, but also folding *in response to* pressure, to support and maintain form. There are also theories that attribute the suture structures to naturally occurring patterns between two viscous substances, in a self-organising manner that shares some of the same characteristics as the chemical BZ reaction explored earlier, but occurring mechanically between the connective tissue of the shell as it forms, and the internal fluid of the shell partitions[80]. These structures of the ammonite shell have often been likened to three dimensional fractal patterns, yet their shape is a physical response to biological and environmental forces - matter aligning to meet the action of internal and external forces.

An ammonite fossil cleaned back to reveal the "suture" structures just below the outer shell surface. Detail below. Source - "Whole Sutured Ammonite - FAMM126," accessed July 2, 2016, http://www.entertheearth.net/whole-sutured-ammonite-famm126/.

The substance of our brains is also riddled with folds, the outer grey matter thought to be associated with processing and cognition is folded in complex patterns around the inner white matter which is thought to

79 Fabio Vittorio de Blasio, "The role of suture complexity in diminishing strain and stress in ammonoid phragmocones," in *Lethaia* 41, 1 (2008): 15-24, accessed June 20, 2016, doi: 10.1111/j.1502-3931.2007.00037.x.

80 Juan Manuel García-Ruiza and Antonio Checa "A model for the morphogenesis of ammonoid septal sutures," in *GeoBios* 26 (1993): 157-162, accessed June 20, 2016, doi:10.1016/S0016-6995(06)80369-4.

be associated with co-ordination and connection of the more process-heavy outer grey layer. The form of the brain begin as relatively smooth during prenatal development, and as the neuronal structure complexifies and develops, the outer grey matter begins to increase in surface area, wrinkling and folding in on itself. Through this folding it fits itself into the cranial cavity and over the inner white matter, but also, multiple short connection paths between neighboring areas and other sections of the brain are developed.[81] The folds that form across the brain allow for complex interconnections between a growing number of points of information and processing - a physical structure that facilitates complex relations of knowledge.

If the fold complexity of the brain is indicative of neuronal connections and processing power in any way (for studies do indicate that the rippled volume and surface area of grey matter does reflect processing power of the brain[82]), then we are the possessors of extremely complex biological processors. The brains of monkeys can be quite smooth, but it is interesting to see that the brains of dolphins are even more folded and convoluted than our own, and this is not simply due to a smaller skull cavity, but more likely due to (or perhaps not *due to*, but rather, *thus facilitating*), the large number of connective processes in their daily thoughts.

A comparison of the typical brains of a human and of a bottle-nosed dolphin. Source - "La captivité chez l'orque et chez l'homme," accessed July 2, 2016, http://www.blog-les-dauphins.com/la-captivite-chez-lorque-et-chez-lhomme/.

Physical folds in life can increase surface area to aid in exchange, can develop to strengthen forms structurally, or grow in complexity to allow a greater network of connectivity through tightly packed local areas in a small space. These folds in the structures of life are

81 Tuomas Tallinen et al., "Gyrification from constrained cortical expansion," in *Proceedings of the National Academy of Sciences of the United States of America* 11, 35 (2014): 12667–12672, accessed June 21, 2016, doi: 10.1073/pnas.1406015111.

82 E. G. Atkinson et al., "Cortical Folding of the Primate Brain: An Interdisciplinary Examination of the Genetic Architecture, Modularity, and Evolvability of a Significant Neurological Trait in Pedigreed Baboons (Genus Papio)," in *Genetics* 200, 2 (2105): 651-65, accessed June 21, 2016, doi: 10.1534/genetics.114.173443.

being examined because they are one of the basic structures of our bodies, and they reveal the naturally developed organising action of matter, as it exchanges food and waste with its environment, protects itself from external pressures, and organises itself in complex internal connections, such as the brain navigating the complexities of life. These basic physical structures are the foundations of our mundane mental functions, our connections with the environment, and our structures of thought. It must be remembered, in the seemingly abstract intellectual explorations into the nature of knowledge, that we are physical beings, that thought occurs in neuronal matter, and that our physical needs and requirements have shaped the structures and content of such thoughts, and continue to support the basic framework of all knowledge. It would perhaps be wrong to conceive of knowledge as *arising out of* these physical structures, and it is more likely that they developed together, emerging as beneficial factors, developing naturally as an ordering system that supports the increasing complexity of the living entity. However this developmental relationship is imagined, there is a fundamental correlation between the physical forms and matter of life, and the structures of thought that order knowledge.

folds of knowledge

When a new idea is learnt or incorporated, or a new skill or word is developed, it is incorporated into what we know as self - we make it ours. This can be seen as a kind of folding in - of folding in some external element of knowledge into an existing realm of understanding. This claimed and internalised understanding of something can be seen as relational. These relations

can be between a perception of the external world and general understanding, or between recursions of thought upon each other - of knowledge relating to itself. These relations, or folds of knowledge, created from the intimate connections of information and the structure of its ordering, contribute to understanding, and build a layered network of representation that informs, and is informed by, our general world-view. These complex informational and representational foldings lie alongside each other and influence each other. It is a continual interplay amongst internal and external relations.

We lay claim to this evolving structure - part what we are, and part newly adopted from outside of us. We extend and contract our notions of self, and draw in connections with the outside world. In this way knowledge can be seen as a folding in - of relation to the world around us. This relation is constantly shifting, as new knowledge is learnt, laying alongside what was previous known, revealing it in a different light. In laying alongside each other, these folded elements of information interpret each other, bleeding context and content to create an homogeneous whole, subtly re-interpreting each other to make sense as one coherent system, or identity. This network of folded relations forms our overall view of reality, and determines how we approach the comprehension of any new knowledge.

The structure of this network - how the folds are formed and laid down next to each other - determines how new knowledge is interpreted. And of course, new knowledge and new relations determine the structure of this network. It is a system that is constantly re-interpreting itself through new connections, in an endless loop of adjusting references. Information is continuously re-presented through alternate pathways, shifting its context and its content. Memories are a particularly interesting form of knowledge in this manner, and are more relational than we usually acknowledge.

There are two main types of memory - recall (such as consciously bringing to mind your school friend's face), and recognition (such as bumping into that school friend randomly and immediately recognising them). It was thought until very recently that memories were laid down once and accessed over time, gradually losing strength if not recalled. But recent studies show that memories are actually removed when recalled, then reinterpreted, and then replaced in their reinterpreted form[83], so that our memories are not so much an accurate recall of perceived past events, but a constantly transforming contextualised relation of past events informed by our present and previous re-interpretations. This model of memory, confirmed through studies in the chemical mechanics of proteins as they retrieve and lay down information, works much like the folded network of related knowledge posited before. Memories are effected by the qualities of the present, the considerations taking place at the time of their recall, and the other memories and knowledge alongside which they are folded.

Such complex shifting systems of knowledge as memories, deeply inter-related and laden with emotional resonance, are not easily explicated or understood. In an effort to tease out some understanding of memories, through means other than typical rational modes of understanding, an evolving body of work was created to lay alongside the three main experiments of this overall research. Using found objects of personal significance,

83 Studies undertaken in the reconsolidation of memory show that separate proteins are used in the recall, and in the subsequent reconsolidation of the re-interpreted (recalled) memory. Using certain protein blockers to hamper the storage of recalled memories, researchers reveal the manipulation and transformation of memory during every act of recollection. It may be that our truest memories are those which we have never recalled. Sources - C. M. Baratti, M. M. Boccia and M. G. Blak, "Pharmacological effects and behavioral interventions on memory consolidation and reconsolidation," in *Brazilian Journal of Medical and Biological Research* 42 (2009): 148-154, accessed June 22, 2016, doi: http://dx.doi.org/10.1590/S0100-879X2009000200001.
Sam McKenzie and Howard Eichenbaum, "Consolidation and Reconsolidation: Two Lives of Memories?" in *Neuron* 71 (2011): 224-233, accessed June 22, 2016, doi: 10.1016/j.neuron.2011.06.037.

often altered by physically transformative processes, a collection of physical memories was gathered. Objects that carried strong and complex associations, of certain events and recurring thoughts, were laid alongside each other to create relations of meaning, in a similar manner to how abstract memories operate.

The objects were collected intuitively, relating to lost family members, past loves, recollected times, hopes for the future, and reminders of the immensity of time and space. The first object was a small wooden horse. My grandmother, whom I cared for full-time in her dementia, collected and obsessively cleaned wooden carvings, and in an effort to rid myself of these loaded things after she died, I buried them, unable to simply give them away or throw them out. Years later, I accidentally dug some of them up, slightly eaten away and cracked like the memories of my grandmother....

My grandfather died more than a decade before my grandmother, and his burnt ashes were buried in the backyard, over which a thorny bougainvillea grew rampantly. After spreading their combined ashes along the shore of the beach where they lived, the bougainvillea was cut down, and keeping one of the thorny limbs, I carbonized it in the kiln, removing most organic substances out of it, leaving only pure black carbon....

In other objects, pictures of past lovers were dissolved, and the slipping images of emulsion collected in filter paper. Even though I clearly recall the subtlety of each person's spirit, can remember the movement of idiosyncratic gestures, and feel the warm weight of touch, I fail to fully recollect the details of my past lovers' faces....

An iron meteorite that found its way onto earth after floating through vast empty tracts of space, having slowly solidified a staggering 4,000,000,000 years ago when the earth was but a new-born planet....

A 6mm wide miniature book holding the lords prayer in 5 languages, bound from pages printed on letterpress plates handmade by a German counterfeiter doing a long-term prison sentence, handed down through my German relatives to rest in my own hands....

Pale golden hairs collected by my parents in a typewriter ribbon box, from my head as a child, now grown old, with dark brown hair, and occasional greys....

These objects are part of a large series of sets, some interrelating, each holding a complex network of associations, and together forming a history of belonging that comes together to define myself through my own interpretations. In each reading of them as a collection, I see alternate memories - as objects they are frozen out of time, but in my memories they are constantly shifting. They are touchstones, relations to a whole set of other memories that transform to be in line with what I am now. In a large way they contribute to this change - the past reminding and responding to the present - changing the way I see the world.

Our knowledge and memories are related to the perceptions we receive from outside of ourselves, yet the way that knowledge is understood, the subtle layerings of individual tendencies and past understanding through which it is applied, transforms the relations of that knowledge to create something unique and individual, in each person, at every moment. It is that complexity of inter-related knowledge, across the structure of individual spheres of knowledge, in constant flux, that creates a distinct sense of perspective, a flavour of character that each person can call their own. Seen in this light, the influences of these structures of knowledge upon identity are very strong, and it may be possible that they are difficult to see as separate in any sense at all.

folds of identity

The idea of folds of relation as a way of understanding knowledge, is discussed by the French philosopher and ecologist Edgar Morin at length. Through diversity, multiplicity and complexity of context, in relation to

identity and the boundaries of the individual, his simple and eloquent writing outlines many of the fundamental issues when considering identity in any depth.

> The possibility of saying "I", of being subject, is to occupy a site, a position in which one places oneself in the center of one's own world, to be able to act upon it and upon oneself. This is what we call egocentricism. Of course, individual complexity is such that when we put ourselves at the center of our world, we also bring in our relations, that is to say, our parents, our children, our fellow citizens, and we are capable even of sacrificing our lives for them. Our egocentricism can be incorporated in a larger, communitarian subjectivity. The concept of subject must be complex.
>
> To be subject is to be autonomous while remaining dependent. It is to be provisional, intermittent, uncertain. It is to be almost everything and almost nothing for the universe.[84]

This notion of being provisional, of not defining a clear boundary, but allowing that boundary to be set by the connections present in time and place, creates a layered set of relations that is open to continued negotiation. This kind of understanding, informed by context and the navigated conditions of the present, requires a mode of perception and understanding that is open to alternate possibility, fundamentally contextual, and deft at handling multiple layers of connection without needing to collapse them into a single reduced plane.

There is the simple instance cited above, of an individual person and their sense of subjectivity. They essentially identify as a single person, but also identify as a member of a family, or country, even sacrificing their right to live if they can risk their life to support something they value

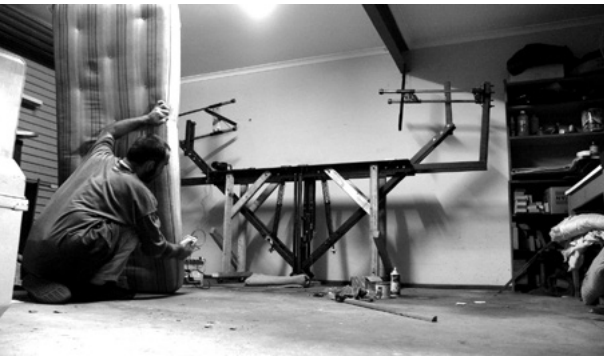
84 Morin, *On Complexity*, 43-44.

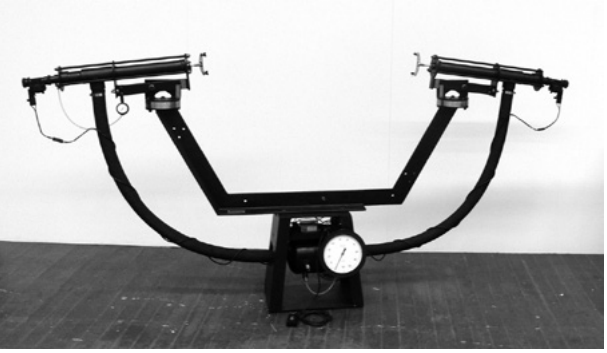
highly. Whether this is for the love of another member of the family, or for the glory and ideals of the homeland, the suggestion is the same - that the values and ideals represented in something external, can be more valuable than the life of the individual who is perceiving that value. That external something could be power and the ability to act in a manner that is deeply respected (such as in the strength and ideals of the nation state the individual is a part of), or it could be the hope for growth and something better (in the life of a younger, more idealistic, or more capable family member). There are many ways that this could occur, but what is common is that there is something external to the individual that is valued above the existence of that individual. In this extension and intensification of personal ideals outwards into larger groups, or simply transferred into an other, there is a kind of extension of identity, an *identification with* other. This can also be seen as a folding of the external world back into the identity of the individual. This folding of the values of one person in common spaces and identities that are complex and shared, brings a deeply composite aspect to the notion of self.

To clarify, it is not a simple matter of identity being continuous and coherent with values and ideals, as mentioned above. But it does suggest that what we identify with, can sometimes better be represented by something other than what we consider ourselves to be. We extend parts of our identity and project them into others and into communities. We draw on shared commonalities, and all the while create the easy fiction of a solidly located sense of self. But identity is a highly complex concept, fundamentally contextual, and with edges that seem very fluid.

This example, conceiving of identity through values and ideals, underlines the possibility that identity is not singular, and is not fixed in one location. Identity shares its contents in a set of relations between multiple subjects - it is *negotiated*. It comes into being through

relation. Not only is the sense of self deeply complex, as explored in the earlier chapter *forming oneself*[85], and not only is it folded internally with layers of context and content, but it is also folded externally into other subjectivities - we are composite and contingent beings. Self seems to be constituted of parts and relations that connect elsewhere - a simple fixed identity is fabricated in order to maintain a sense of location that allows a personal perspective, and a place from which to tell our story to ourself and others. The more the notion of identity is considered, the more it seems to be contextual, mutable, and contingent on relation to others and the environment.





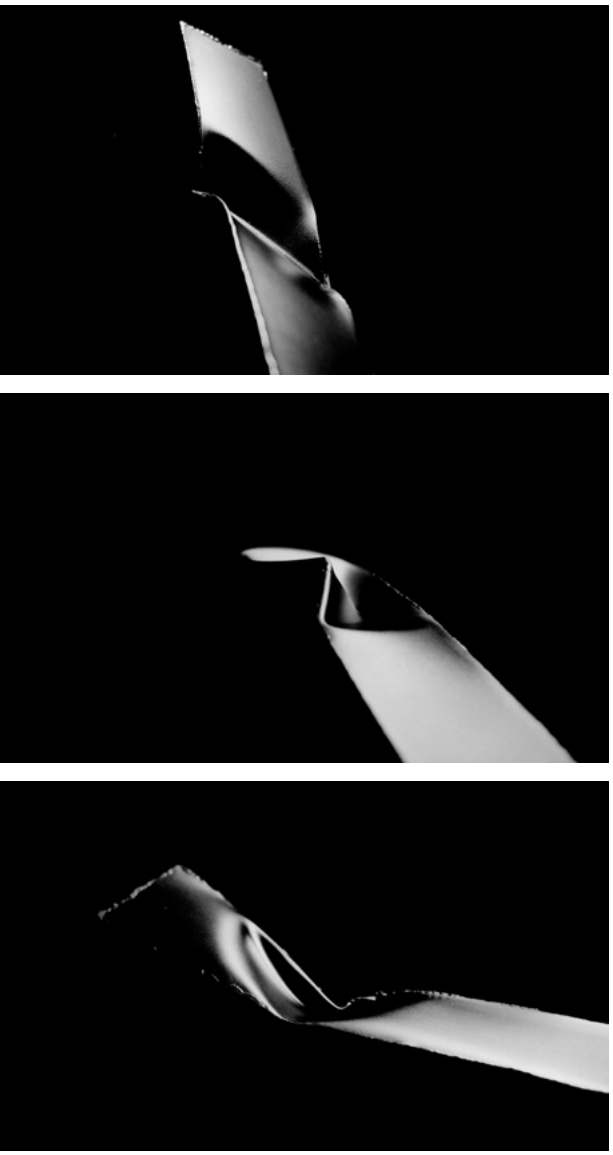
Development of colliding machines in 3 primary iterations, operated with winched spring power (top), compressed air and solenoid valves (middle), and high pressure compressed air with electromagnetic catches, separated into two working halves with individual pressure chambers (bottom). 2008-2016.

physical folds of stress

Returning once more to the solid world of matter, one experiment in force and form mentioned briefly before is worth further consideration. In one of the three main physical or creative components of this overall research, the collision of hollow metal boxes was examined in an elaborate pseudo-scientific experiment. These collisions explored the nature of identity, relation, influence, power, and ultimately, the transformative effects of stress upon individual identity. The elements used in the experiment were two hollow metal boxes, like the one discussed earlier in the chapter *building a box from edges*[86], along with a pair of large compressed-air launching machines built specifically to launch these boxes, and various recording devices to document the events in sound and vision. The collision of the two hollow boxes in mid air was revealed in detail - a perfect abstracted example of the interaction between two ideal forms meeting under

85 See *forming oneself*, page 23.
86 See *building a form from edges*, page 19.

extreme stress.



Collided boxes - studies of folds, 2012.

When two flying hollow metal boxes meet in mid air a violent confrontation takes place. The forces that flood between the forms are too great for the thin metal walls, which crumple and buckle under the strain, revealing failing internal structures and material strain through the deformation of edges, planes and corners. It all happens in an instant, too quick for the naked eye to catch, but can be slowed and intimately revealed in film. Violent and destructive, this interaction is also affirmative of the true nature of each form - it tells us of geometry, construction, and constituent materials. The boundaries of the two separate boxes are contested and redefined, instantly, in a rapid exchange of speed and mass. But this is not just collision - it is also a moment of blending. In the instant of meeting, as the recorded sounds of each box merge, as the vibrating forms momentarily synchronise, their voices unify in an unavoidably tight embrace. At this moment of connection the forms resonate as a single system, playing out the forces of the collision through each other's metal planes - reshaping boundaries and folding metal - re-making the edges of their identity. After this intense instant of exchange, they part, forever altered. In one way they can be seen as damaged, and in another way their essential natures are revealed for what they are - there is a layering of information, an increased self-knowledge in the deformed folds and crumpled structures. It is as if the forces at play in the collision are expressed *through* the character and structure of each box. The collision itself, and the nature of each box, become embodied within the deformed folds of the collided pairs.

In their final crumpled forms, each pair of collided boxes are now intimately linked together. The forces that are revealed in their deformed folds are part of a history between two boxes, a particular meeting in time, a conversation of force that is now written out in each

other's forms. The structures and materiality of the boxes, imprinted upon each another in the moment of collision, become a static embodiment of the intense energetic exchange.

Stills from 16mm film footage layered together to form a collision progression, 2014.

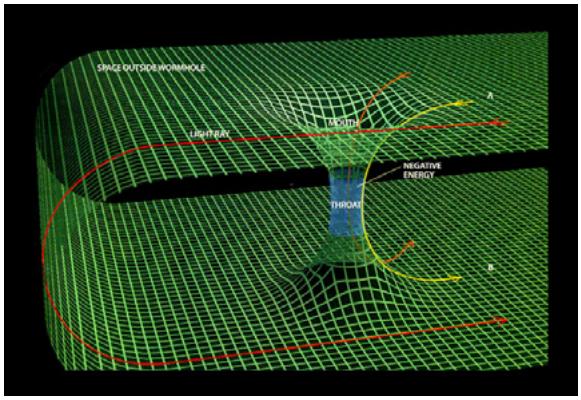
While the box pairs reveal the nature of their meeting in their altered physical forms, more detailed information can be gathered from the documentation gathered during each collision. Using 16mm film shot in slow motion, the details of the exchange are minutely preserved, and the stretching of time allows the meetings to be seen in intimate detail.[87] Combined with the recording of sound, using standard cardioid microphones to record in free air, as well as piezo elements attached to the surfaces of the boxes to document their vibration, the resulting audio-visual works reveal the minutiae of vibrations that play across the forms as they resolve their energetic exchange. Viewing and listening to this documentation together as a complete audio-visual record allows the nature of the collisions to become more readily understood. Through poring over the film and sound, and perceiving the subtle vibrations and deformation slowly playing out, and then again creating new collisions, experiencing the impact of them in normal time, an intuitive comprehension of force develops. The experiment is not focused so much upon the physical boxes meeting and deforming in their collision, but rather, the flow of force that moves between the forms, conveyed by the

87 For this research, most 16mm film was shot on several pin-registered Milliken cameras at 500 frames per second, but also with a rotating prism Hycam camera, and a last generation 10,000 frame per second NAC E-10 camera. All film was developed in handmade 100' tanks, transferred frame by frame with a handmade transport and digital capture set-up, and compiled on computer, all laboriously undertaken by the artist-researcher.

solidity of metal sheet. A perspective is fostered that emphasises the energetic exchange and movement of force, as it travels through and is revealed within, physical matter. This tracking of the movement of force through matter is the primary goal of this experiment. More images of these experiments and their processes are contained within *appendix iii - process and visual documentation*.[88]

folded space

In a similarly physical, yet highly abstract and fictionalised account, the notion of folding space is known commonly to all science fiction readers and abstract physicists alike. The ability to travel great distances through the conveniently planar and malleable structure of physics, is not yet a reality, but it does provide an interesting notion of how we perceive space, as an abstract dimension. The basic theory of folding space is that space-time[89] can be visualised as an essentially flat plane for purposes of normal travel within it, although extreme gravitational effects and speeds can "bend" this plane. So if we had an extreme source of gravity such as a neutron star, or two neutrons stars orbiting around each other at a close distance, the time-space continuum would be bent, and if strong enough, there is the possibility of those bends folding back on themselves and forming a nearby "wormhole". Such possibilities allow travel from one section of space to another very distant one, as if they were next to each other, though this travel also likely involves distortions



A graphical depiction of a wormhole, shown through representing space-time as a green mesh. It can clearly be seen (naturally, as that is the objective), that there is the possibility of connecting two distant times and places through wormholes in space. Source - "Wormholes," accessed July 3, 2016, http://www.andersoninstitute.com/wormholes.html.

88 See *appendix iii - process and visual documentation*, pages 187-231.

89 Rather than getting caught up with too many matters of theoretical physics, the notion of space-time as an intimate and continuous relation between the three dimensions of space and the fourth dimension of time, can be described plainly through external sources such as - "Spacetime," Wikipedia, accessed June 22, 2016, https://en.wikipedia.org/wiki/Spacetime.

in time. Of course the difficulties of finding or creating such intense bends, or knowing where they go to (if anywhere), and of constructing something to travel inside that can withstand the immense gravitational effects - all take these notions to something highly abstract and theoretical, or fictional. These wormholes, or Einstein-Rosen bridges[90] as they are mathematically known, are more than science fiction, being an outcome of Einstein's relativity theory as resolved in certain ways. Put simply, they are the potential results of mathematically derived models, within the current understanding of theoretical physics. While such occurrences as wormholes may yet require evidential proof, their simple presence in mainstream physics, and in the fiction of popular culture, reveals one of the ways in which time and space are generally conceived. It is intriguing that space-time can be conceived of as a spatial material, almost like an abstract terrain, which can be perceived (or at least theorised) from an external vantage point. To even entertain the possibility of the fabric of time and space being bent, reveals the tendency of knowledge to represent such abstract fluid notions as time, through spatial metaphors such as landscape - a notion that is embedded in primal genetic and cultural understanding, from humanity's development as hunter-gatherer tribes into agricultural societies. Space and landscape have always been of prime importance to us. Knowledge seems adept at bending difficult complexities into familiar analogous forms, so as to allow an ease of understanding. And with such an ease of understanding, comes control, and the ability to manipulate - it is inherent in the search for new knowledge. With this possibility of control and

90 Wormholes are named Einstein-Rosen bridges, after Albert Einstein and Nathan Rosen modeled solutions to Einstein's earlier field equations and published them. They were, however, initially posited by Ludwig Flamm in 1916, 100 years ago. These theories have been mostly superseded, and it is now theorised that the only way to stabilise a wormhole so that it is traversable, is through the theoretical application of exotic matter, that has negative energy and mass. And thus, we fold in again, from hard science into science fiction.... Source - Michael S. Morris, Kip S. Thorne, and Ulvi Yurtsever, "Wormholes, Time Machines, and the Weak Energy Condition," in *Physical Review Letters* 61 (1988): 1446, accessed June 22, 2016, doi: http://dx.doi.org/10.1103/PhysRevLett.61.1446.

The collision of the Milky Way galaxy and the Andromeda galaxies (as well as the triangulum galaxy), revealed in a composite image sequence spanning 4-5 billion years. Source - "M 31: Kollision mit Milchstraße gewiss," accessed July 2, 2016, http://www.oculum.de/newsletter/astro/100/60/4/164.ve2us.asp.

manipulation ever in the background, at such grand theoretical scales, the very flow of time and space seems to be poised, just out of our reach, for our potential control of the environment. It is astounding how, from our ancestral primates banging away with bones, like the apes at the start of Stanley Kubrick's *2001*[91], knowledge has developed to extend in such grand scale, yet perhaps not so far in scope. Even though our perceptions reach across the globe and out into the depths of space, the scope and breadth of our knowledge, and its underlying motives, seem so narrow when we consider that we are greatly unaware of what drives us forward simply to find out more.

But our lack of understanding as to the meaning and mechanics of knowledge do not stop its restless growth or its incessant search. Plan and theories are made at ever grander scales. Exploring one such grand theory, (a beautiful modern reinterpretation of ancient Armageddon type mythologies,) the collision of the Milky Way and Andromeda galaxies completely redefines the notion of scale in space and time. A collision of galaxies can be seen as another form of folding, where two large, and mostly empty, clearly identifiable systems of stars come together, "colliding" to occupy the same space. This is due to happen to the Milky Way galaxy when it collides with the Andromeda galaxy in 4 billion years time[92], as pictured at left in still sequences, as might be seen from the vantage point of the earth.

When these galaxies do collide, it is interesting to realise that it will likely not be single planets colliding into one another all over the place, but rather, due to the immense amount of empty space between the solar systems in galaxies, that there will be reconfigured orbits, and superstructures of galactic proportions,

91 *2001: A Space Odyssey*, directed by Stanley Kubrick (1968; California: Warner Home Video, 2001), DVD.

92 "NASA's Hubble Shows Milky Way is Destined for Head-On Collision," NASA (2012), accessed June 22, 2016, http://www.nasa.gov/mission_pages/hubble/science/milky-way-collide.html.

rather than the expected Armageddon-type collisions of worlds. In this strange folding of space, as two galaxies merge, it is not the actual planets which will be effected, but rather the larger structures of the galaxies, which will be altered. In such a galactic recombination, the scale of our own planet is incredibly (and safely) small, and our own perceptions of such a collision - of foldings of immense complex relations and structures within each other - requires a focus upon the energetics of larger systems, rather than upon the individual elements within them. It is not so much a collision of parts that occurs here, but rather a collision of relations - a collision of the forces of attraction and of movement and mass, pulling against one another across vast empty regions of space. At such an incomprehensible scale, the folding of all these elements through space will result in radically altered galaxies, but will likely not effect the orbit of the earth at all (though in other predictions, the sun will begin to die soon after this massive merger, five to seven billion years in the future...[93]).

Such a (theorised) collision of galaxies reveals so much about the way we conceptualise our reality. It is interesting that it is the importance of relation, and energetic exchange, that forms the system known as the milky way. This relational identity, so far removed from the previous example of space-time as a fabric or surface of malleable nature, is yet another aspect of how ideas and things are ordered into bounded entities. Through thinking of galaxies this way, we may lose the detail (of our own small planet and the complex system of life it supports), when considering entire solar systems as fixed unities. But in perceiving these solar systems and planets within the galaxy, as a structure and pattern built upon a relation of forces, an intriguing model of identity arises, that is open to change, and less concerned with spatial aspects

93 "Hope dims that Earth will survive Sun's death," New Scientist (2008), accessed June 22, 2016, https://www.newscientist.com/article/dn13369-hope-dims-that-earth-will-survive-suns-death/.

and boundary. At the grandest scale of scientific comprehension, the galactic notion of identity is built more upon energetic relation, and is completely open to influence from outside. It is relational, permeable, and almost entirely energetic. This kind of identity lacks the clear boundaries of the earthly objects normally apprehended by touch. It can be imagined - through the effect of gravity and velocity extending outwards - that the identity of galaxies spans across vast tracts of space, pulling and tugging other galaxies, reaching throughout the universe. Such an inter-related sense of identity, as an energetic system that has an approximate dense body, undefined boundary, extended reach, and which is open to the effects of other entities in space and time, is a intriguing alternative concept that helps to shed light upon the apprehension of other forms of identity.

folded notions of energy

Energy is an uncertain term at the best of times. Physicist and life-long educator Richard Feynman has said that "it is important to realise that in physics today we have no knowledge of what energy *is*"[94], and now 50 years later, it is still asserted that "nobody knows what energy really is"[95]. In considering energy, it is not the

94 Richard Feynman, "What is energy?" in *The Feynman Lectures on Physics, Volume 1* (Massachusetts: Addison Wesley, 1964): 4.1

95 The distinction is drawn between the physics notions of "energy" and "work", such that "work" is used if energy is transported, and "energy" is used if it is not in motion or is linked to a moving body. Source - L. Bergman and C. Schaefer, *Experimental Physics* (Berlin: de Gruyter, 1998): 37.

Also, in critical assessments of science education, where the notion of energy is introduced in the classroom as a fundamental scientific concept, it has been stated in various ways by multiple researchers that "We cannot answer the question of what energy really is," and, "Although everyone has a feeling of what energy is, it is difficult to give a precise definition for it," and thus, "If we cannot explain in a clear way what energy is, the concept of energy must be a problem in science teaching." The undeniably vague concept of energy underlies much of modern science, and through the present education system, much of our everyday thinking. Source - Ricardo Lopez Coehlo, "On

substance - whether thermal, electrical or gravitational - that is the focus, but rather, it is an entirely abstract concept, that has been theoretically constructed to understand and predict phenomena which is not fully comprehended. Energy usually refers to the potential for change, through comparative difference - one object suspended over another, acted upon by gravity, or a hot element under a cold pan of water, for instance. Energy as a concept is fundamentally relative. From observation it is understood that a certain amount of energy will bring about a certain change. Equally as important, the modern scientific notion of energy is bound up with equivalence - translating motion into heat through friction, the transference of heat between two objects at different temperatures, or mechanical vibration converted into sound through pressure waves of air. It is assumed, as a fundamental rule, that energy cannot be lost or gained, but only transformed. It resides, or perhaps flows though, is intrinsic, or maybe is embedded, in things. It is hard to know. But it should not be thought of as a substance - energy is perhaps better thought of as an agent of change (although it is difficult to tell whether it is a cause, or an effect, of that change). It must be acknowledged how slippery a concept energy is. To make matters even worse, the commonly known law of relativity draws an equivalence between matter and energy in its famous equation $e=mc^2$. Matter and energy become transformable into each other. With energy wound up in matter through this notion, nothing is sure or reliable.

But where does this leave the notion of energy? Leaving the abstract physicists' notions hanging there for a moment, there are more practical considerations. When the often abstruse Henri Bergson contemplated the nature of life in the early 1900's, he was inevitably brought around to a practical idea of energy, which

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the Concept of Energy," in *Adapting Historical Knowledge Production to the Classroom,* edited by P. V. Kokkotas, K. S Malamitsa and A. A. Rizaki (Rotterdam: Sense Publishers, 2010): 85-86.

worked against the entropy of disorder, with the initial source being that of the sun.

> When we investigate the way in which a living body goes to work to execute movements, we find that the method it employs is always the same. This consists in utilizing certain unstable substances which, like gunpowder, need only a spark to explode them. I refer to foodstuffs, especially the ternary substances - the carbohydrates and fats. A considerable sum of potential energy, accumulated in them, is ready to be converted into movement. That energy has been slowly and gradually borrowed from the sun by plants; and the animal which feeds on a plant, or an animal which has been fed on a plant, or on an animal which has fed on an animal which has fed on a plant, and so on, simply receives into its body an explosive which life has fabricated by storing solar energy. To execute a movement, the imprisoned energy is liberated. All that is required is, as it were, to press a button, touch a hair-trigger, apply a spark: the explosion occurs, and the movement in the chosen direction is accomplished.[96]

Bergson's idea of "stored" energy may perhaps better be thought of as transformed energy - the energy of the sun transforming organic molecules into complex forms, that, upon the application of a "spark", liberate their energy through another transformation, allowing access to it. Although it comes no closer to an essential definition of what energy is, the way it is presented at least clarifies a little where the general concept is operating. Thought of this way, energy acts as a potential for change, through its transference from one body of matter to another, effecting change in

96 Henri Bergson, *Mind Energy* (Hampshire: Palgrave Macmillan, 2007), 13-14.

structure, temperature, electrical potential, movement, etc. This is in line with the standard vision of energy as an abstract function that effects the qualities of one object as it is transferred from another. The more the nature of energy is considered - taking forms as varied as simple movement, electromagnetic radiation, sound waves in air, or gravitational fields - the more it eludes understanding. The notion of energy underlies much of modern thinking in science, and large bodies of knowledge are wound up in this particularly abstract and unclear concept. The claim to certainty and knowledge of science seems suspicious to say the least, when one considers how a blind eye is turned to the lack of clarity in such a broad and fundamental notion as energy.

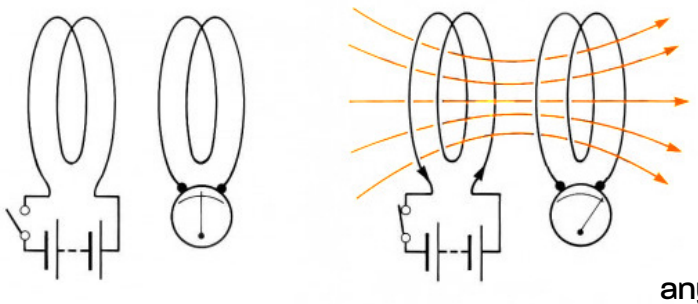
A small home-made solid state tesla coil based using the typical arrangement of two concentric copper wire coils (shorter thicker white wires coiled concentrically to the long length of thin red wires), to transform electricity from a low potential to high, as used for experimental purposes and to create various spark images here.

But rather than reaching toward a single unified theory of anything (or accusing modern science of attempting to do so, though it does often reach toward it), the aim of this research is to increase the awareness of the processes of conceiving reality, and how we use those conceptions to build a world-view - essentially, to be aware of knowledge as a process. Energy is one of these conceptions. One particular form of energy used extensively in this research is electricity, and the examination of its nature reveals many interesting notions.

The commonly used electrical coil, a variation of which was built for this research, shown at left, is a long length of metal wire wrapped tightly around a hollow tube to form a long spiral coil, and, concentric to it, another shorter wire coil, here wound around the outside. Electricity is made to pass through the short coil, creating a magnetic field by induction[97].

The other coil, much longer and held inside this shorter

97 A magnetic field is formed when electrical charge move in space - when electricity passes through a wire, there is a magnetic field created. This is happening around us all the time, in our modern age full of electrical devices. For further details, see - "Electromagnetic field," Wikipedia, accessed June 23, 2016, https://en.wikipedia.org/wiki/Electromagnetic_field.



The standard induction coil, such as used in car ignition or many modern appliances, operates by applying electricity to a coil, which creates a magnetic field, the orange lines at left. This *induces* a momentary potential in the secondary coil, as the changing magnetic field forces the electrons to move in the wire. It is important to note that the induced electrical potential is generated from a *change* in magnetic field, not simply the *presence* of a mganetic field. Source - "Electromagnetic Induction," accessed Jul 3, 2016, http://www.itacanet.org/basic-electrical-engineering/part-6-electromagnetic-induction/.

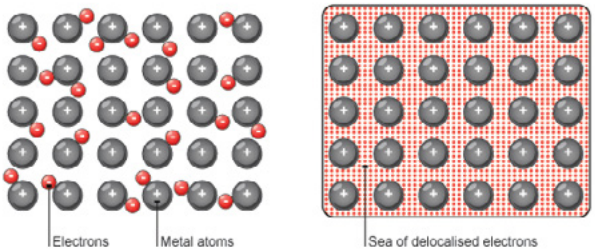
coil, concentric to it, reacts within the field caused by the shorter coil, creating a potential *voltage* through the longer wire. This transference of electrical force, from the short coil to the long coil, without any contact, is common in almost all of our appliances and is used most often to decrease or increase voltage. Here, in the coils made for experiments to image spark discharges, the electricity applied to the shorter coil is transformed, in the longer coil, to a much higher voltage - 100 volts are put into the short coil, and 20,000 volts are produced at the long coil. But the *current*, the amount of electricity, is reduced by a reciprocal amount - from 200 milliamps to 1 milliamp[98]. To use the analogy of folding, what happens is that the electricity is folded 200 times. Like a piece of paper, when folded its stacked height increases 200 times (higher "voltage", or potential), and its flat size or area decreases 200 times (less "current", or throughput). But when the paper is folded, there is still the same amount of paper - it is an equivalence of sorts. The same relationship holds with electricity - voltage and current are two of its primary characteristics.

This is what is observed and what can be predicted with electrical energy. But what is actually going on here? What makes everything happen when I throw the switch? In the simplest concept it is the movement of small subatomic particles, electrons[99] and other charged particles, moving in this example along a copper wire. The electrons, negatively charged, jump from one copper atom to another[100]. This movement is caused by

98 Of course in the real world you "lose" some energy that transforms into heat and vibration, as the process of mutual inductance in coil-based transformers is never 100% efficient.

99 Whether an electron is real or not is contested by many scientists, such as Nobel Laurette Richard Feynman, who clearly writes, "The electron is a theory we use; it is so useful in understanding the way nature works that we can almost call it real." Richard Feynman, *Surely You're Joking, Mr. Feynman!* (New York: W. W. Norton & Company, 1997), 70.

100 Copper is a good conductor of electricity because it allows this movement of electrons easily. Copper's atomic bonding structure is termed *metallic* - tightly packed copper atoms held close together in a kind of lattice. Being so close together, the outer electrons of each atom become shared between atoms next to each other, forming a virtual "sea of electrons" between the tightly packed structure of atoms in the lattice. This structure leaves



2-dimensional representation of atoms and electrons in a metallic lattice structure, such as that of copper. The free electrons are able to move around and carry charge, and this explains (describes) how many metals are electrically conductive. The first image shows the simple observation that electrons are connected to, but not attached, to each positively charged atom (the metal ion). The second image suggests the notion that these electrons are not so much located in any one place, but free floating as a "sea of delocalised electrons". Source - "Metals," accessed July 3, 2016, http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa/bonding/structure_propertiesrev5.shtml.

(or causes, perhaps), a negative potential charge at one end and a positive potential charge at the other. The difference between the charge at one end of the wire and the charge at the other, is the potential, or *voltage*. Voltage is relative - it can only be measured from point to point as a difference in potential - it is like the difference in height between two objects - a kind of potential for action. The other fundamental aspect of electrical energy is the number of electrons (or other charge carrying particles), that pass a point in a certain time, which describes the quantitative flow of electricity, or *current*. The voltage causes the current - the attraction of positive charges to negative, accelerating the movement of the charged particles through the wire, (if they have somewhere to go, because they won't just leak out the end of a length of wire, but must be connected to something, like a light bulb, where the electrons flow and do work, turning electrical energy into light energy). So, electrical energy is the movement of charged particles from places of differing potential. Taking a single electron and imagining it moving along that wire, what is causing that movement, why is it attracted to it opposite charge - how does that attraction work? Why is the negative charge attracted to the positive?

This question of why like charges repel and unlike charges attract is in fact fundamental to the nature of mundane physical reality - it is how matter holds together and why the world doesn't simply collapse into one dense ball of stuff, or fly apart and become infinitely diffuse[101]. In our world - in matter in general - there is, overall, an equal mix of charges between the atomic particles of which things are made up, and in such a balance of electrical forces (which are incredibly

electrons free to move around, and thus conduct electricity through the metal. This is depicted graphically in the diagram above. Again, the dangers of taking such explanatory theories and their convenient diagrams as representative of reality, rather than as working theories or convenient models, must be acknowledged. Source - "Metallic Bonding," accessed June 23, 2016, http://www.chemguide.co.uk/atoms/bonding/metallic.html.

101 Richard Feynman, "Electromagnetism" in *The Feynman Lectures on Physics, Volume 2* (Massachusetts: Addison Wesley, 1964): 1.1-1.11.

strong, being quadrillions of times stronger than the forces of gravity), there is no gross human-scale attraction or repulsion of bodies due to electrical fields. The subatomic stuff of the world is like a fine mesh of opposites and likenesses, naturally arranging to balance out each other just right, in attraction and repulsion.

The question remains, yet to be discussed, why charges attract and repel, and this gets very complex. Classical electromagnetic theory describes the attraction and repulsion through the effect of electric fields. Quantum electrodynamics relates how the forces of attraction and repulsion between particles takes place through an exchange of photons. Note that these are both theoretical descriptions of events - they model aspects of reality to facilitate prediction - they do not so much reveal any underlying reality, as give easy tools to predict what is going to happen in any one instance, at ever finer levels of resolution. Both theories will be explored to try to understand, without any mathematics, what may be going on[102].

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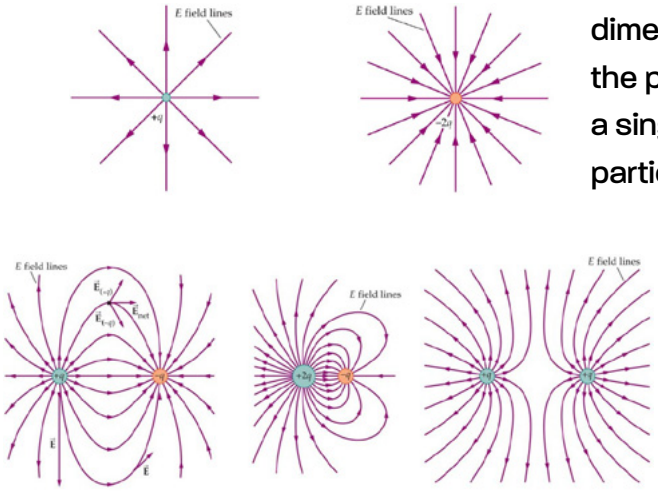
102 A third theory, widely contested but also quite exciting, is stochastic electrodynamics, which, while well beyond the scope of this study, posits an overall random background electromagnetic field (echoing the old notion of the "aether"), generating possible solutions for why such effects as inertia exist. Inertia, the simple resistance of an object to accelerate or decelerate, is so commonly experienced and understood by us all, yet there is no mechanism explaining how it works - neither in classical physics, quantum field theory or superstring theory. The history of inertia is very old, starting with the simple conceptions of Isaac Newton that we are taught at school. Drawing much upon the work of Ernst Mach in the late 1800's, Albert Einstein's general theory of relativity complicated the classical idea of inertia greatly, the upshot being that it no longer makes sense at very large scales, and also, that it is not only matter that has inertia, but energy has inertia as well. The search for the Higgs particle and its corresponding field in quantum physics could explain mass if it is ever found (it is contentious whether it was or was not found at CERN in 2012), but still, another mechanism is needed to explain the mechanics of inertia. Such a basic, intuitive, deeply embedded understanding of reality that we accommodate within our mundane lives, such as inertia, is deeply effected by these fundamental notions of charge and electromagnetics - all the notions of science are deeply enmeshed. These basic concerns of physics reveal how little we know of the underlying workings of reality, and how when we question any of our knowledge long enough, we find that we are mostly building predictive theories of observed outcomes on fabricated conceptions, best models, and educated guesses - all *describing* things happening, but not actually showing an underlying understanding of *how* they happen. Sources - "Stochastic Electrodynamics," Wikipedia, accessed June 24, 2016, https://en.wikipedia.org/wiki/Stochastic_electrodynamics.
"Origin of Inertia," accessed June 24, 2016, http://www.calphysics.org/inertia.html.
"Ernst Mach," accessed June 24, 2016, http://www.spaceandmotion.com/Physics-Ernst-Mach.htm.

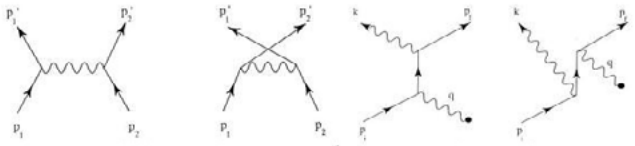


Diagrams describing electric field models in 2 dimensions, acting upon single charged particles (top), and between two charged particles (bottom). Source - "Electric Field," accessed July 3, 2016, http://ap-physics.david-s.org/electric-field/.

Classical electromagnetic theory models electric forces through the action of an electric field (that often interacts with a corresponding, but often separate, "magnetic" field). The diagrams at left, depicting three-dimensional electric fields as two-dimensional, show the path a single positive charge would take around a single charged particle or between two charged particles. These diagrams (or rather the equations from which they arise), describe the action of forces across space, resulting from electrical charge. Yet the theories do not explain any further how this force is generated. They are a set of equations that can predict the forces within a certain situation, but they do not describe what is essentially going on. This is a *functional description*. It does not detail what is at work in the forces of attraction and repulsion, but it models the resultant action very well. If one were inclined to pessimism, an analogy of such a functional description might be that we can predict the traffic jams that occur at certain times of the day and on what days, but we really don't understand why they are happening. This is true of a great many other realms of knowledge, besides electric fields and traffic jams.

Quantum electrodynamics pushes on a bit further and deeper, and solves certain problems that electric fields are unable to address at very small distances and very great intensities. It does this through the action of virtual photons[103], which are emitted and absorbed by electrons, giving rise to the attractive and repulsive forces. The exchange of these photons is going on constantly, creating a pull or push between the two charges. Now these exchanged photons don't

103 In quantum physics, a photon is a particle, it has no mass at rest, no charge, and is responsible for electromagnetic radiation, such as light and heat. In Quantum Electrodynamics, the "virtual" photons are used for convenience as carriers of force - they transfer forces from one particle to another, and conveniently remove the need for any "action at a distance", which is always too mysterious and difficult to explain. Sources - "Virtual Particle," Wikipedia, accessed June 24, 2016, https://en.wikipedia.org/wiki/Virtual_particle. Arthur Zajonc, "Light Reconsidered," in *Optics and Photonics News* 14, 10 (2003): S2-S5, accessed June 24, 2016, https://www.sheffield.ac.uk/polopoly_fs/1.14183!/file/photon.pdf.



Feynman diagrams of quantum electrodynamics - 2-dimensional geometric depictions of complex interactions occuring between particles, showing the action of virtual photons - photons which cannot be observed because they do not exist in any real way as they violate basic conservation of energy and momentum. These simple variations show basic scattering of two electrons through the "action at a distance" effect of the virtual photon shown as the squiggly line (far left and left), and another kind of scattering such showing the radiation emitted by an electron as it passes a nucleus (right and far right). Source - "Quantum Field Theory," accessed July 3, 2016, http://u2.lege.net/cetinbal/quantumfieldtheory.htm.

actually weigh anything, and are virtual in a sense, in that they describe actions, rather than being things in themselves. They are a useful way to organise and interpret calculations. In fact, one way to describe these virtual particles without getting into mathematics, is to describe them as expressing "wave-like" behaviour, in that they are often seen as radiating forces within a quantum field. But before delving too deeply and become lost in vague amatuerish descriptions, it is important to go back to the initial concerns of attraction and repulsion of charges. In the same way as the classical electromagnetic field we looked at earlier, the exchange of virtual photons taking place in quantum electrodynamics is a convenient model that has been developed to account for real-world and theoretical instances. Again, this is a *functional description*, rather than an actual understanding of how charges attract and repel.

Such a search for understanding leads into the many zoo-like inhabitants of the quantum realm, and through the theories of supersymmetry and string theory, where, (simplified greatly), mass and force is replaced by tension in virtual strings that oscillate in fundamental overtones, in a world with 10 dimensions[104]. What is interesting here, as the levels of theoretical development are scaled from simple intuitively graspable concepts to highly abstract theories involving complex mathematics, is that these theories are all focused upon predicting and describing an ever broader picture, of being able to comprehensively describe the actions of reality, through a single theory if possible, this being one of the ultimate

104 Superstring theory posits that reality consists of 10 dimensions - our usual 3 spatial and 1 temporal dimensions, plus 6 other dimensions tightly wound up (or inaccessible to our world), usually seen as residing in a sub-manifold of all possible dimensions. Superstring theory has developed to address the inconsistencies between the large-scale physics of stars and galaxies described through general relativity, and the atomic scale physics of quantum particles. It is a set or range of theories that each seek to describe the fundamental processes of nature through mathematical models of reality as the vibrations of tiny strings of deeply related super-symmetrical space-time. Source - "Superstring theory," accessed Jul 17, 2016, https://en.wikipedia.org/wiki/Superstring_theory.

goals of much of theoretical physics. Now, applying these musings to the overall questions of this research - how do these models of a universe and its behavior effect the way we perceive the world? Such models are taken for granted, as reality, and even if it is assumed that they are seen merely as models - they effect the way we think - the models become a pattern of thought that is hard to derail. In the quest for understanding the basic forces of energy at work in the world, models of understanding can be seen to limit the possibilities for deeper understanding, of the foundations of reality, through a focus and fetish for results and predictions. This is all said in no way to belittle the approach or progress of science - these theories allow some control over our environment and allow a greater awareness of the world, through their ideas and through the inventions that arise from them. It is not the theories that are the problem - it is the tendency to take them at face value - the tendency to value the results over the reasons - that layers convenient fabricated models over the immediate world of perceived reality.

It is difficult to understand what the electrical force of attraction and repulsion is generated by, though it is easy to model the actions in ways that mostly describe their behaviour. Likewise, current knowledge is no closer to apprehending the general nature of energy, in all its manifestations. In witnessing the world and explaining its actions through theoretical and representational systems of understanding, systems of knowledge are fabricated to fit results and allow prediction. The most amazing folds of energy are found in our conceptions of the very idea, where it is mentally and perceptually layered with theories, models, predictions, and visualisations - folded representations of something that is real and physical - that we can perceive - yet that we have no direct intellectual access to. Through these varied notions of energy, it is more obvious than in any other effort of comprehension, that conscious understanding is separated from deep understanding

and intimate contact with the workings of the world. Observations and representations are folded into our minds, as intuitive understanding and rational theories. These folded representations of reality are the basis of knowledge.

folded notions of time

Time can be apprehended in many different ways. Two main ways of apprehending it are through the personal lived experience of time, and through the mechanistic action of slices and sequences.

Philosopher and vitalist Henri Bergson was intimately interested in the notion of time and approached it in an idiosyncratic way. In the legendary public debate with Albert Einstein, and in the continued intellectual sparring that resulted, there was a distinct duality between the philosopher's view of experienced time, and the physicist's view of mathematical time, that has echoed down through history to radically effect modern popular understandings. One defining difference that can be drawn between these two thinkers' viewpoints is in how the dimensions of space related to time - Einstein folded them in together to be relative to each other and entwined, whereas Bergson saw time as a completely different quality, and chose not to transfer and overlay perceptions of space with the notion of time.

Bergson's notions of time championed experienced time as something real that we have direct access to, as opposed to the abstracted view of mechanistic time, where we see things happening in thin slices of time proceeding one after another in orderly fashion. Rather than clearly defining this notion of experienced time, he petitioned the reader to refer to his or her own

experience in order to access this understanding, positioning sensation and perception at the root of understanding. In this way he appealed to a basic personal awareness of time, but the subtlety of his unusual approach requires effort and a small leap of intuitive faith.

> Placed at the confluence of consciousness and matter, sensation condenses, into the duration which belongs to us and characterizes our consciousness, immense periods of what we can call by analogy the duration of things. Must we not think, then, that if our perception contracts material events in this way it is in order that our action may dominate them?[105]

Bergson asks us to consider time as a relation of matter and mind - a result of consciousness apprehending the world, and our ability to act within it. In this view of time there is a continual flux of relation - it cannot be separated into successive parts, or apprehended by abstracting out component dimensions - it is essentially whole and continuous.

> ... think of it as a mutual penetration, an interconnexion and organization of elements, each one of which represents the whole, and cannot be distinguished or isolated from it except by abstract thought.[106]

The result of this relation between matter and mind that is perceived as time, and that Bergson extends into his notion of *durēe*, is the rejection of perceiving time as a spatial dimension which can be cut into parts.

> We shall think of all change, all movement, as being absolutely indivisible.[107]

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105 Bergson, *Mind Energy*, 15-16.
106 Henri Bergson, *Time and Free Will: An Essay on the Immediate Data of Consciousness* (London: George Allen and Unwin, 1910), 101.
107 Bergson, *The Creative Mind*, 142

Bergson's conceptions of time as an experienced awareness, cannot be described in words, fails acknowledgment by reductive reasoning, and can only be grasped through intuitive, experiential understanding.

These ideas of duration have been neglected in contemporary philosophy, but have occasionally been extended by others, such as the art-school heroes Gilles Deleuze and Fēlix Guattari, who transform them into the nomadic forces of "smooth spaces"[108], which are explored further through Deleuze's book *Bergsonism*[109]. At the risk of being lost in Deleuze and Guattari's jargon and the extended footnotes required for elucidation, it is sufficient here to simply refer to their extension and contemporisation of Bergson's themes.

This relevance of Bergson's notion of durēe was overshadowed a century ago, at a turning point in modern conceptions of time, arising from the public debate between Einstein and Bergson in Paris[110], which occurred 7 years after the publication of the general theory of relativity. The controversial meeting marked an epistemological shift in western perceptions of time, favouring the abstracted notions of physics presented by Einstein, and the promise of scientific progress to deliver us from the mundane squalor of the material world, through ever more advanced technologies.

In a radically different conception of time to that of Bergson, there is the daily modern notion of sectioned years, months, days, hours, and minutes, that regulates time in standard measured portions. Modern society is very attuned to this mode of perceiving time - it

108 Gilles Deleuze and Fēlix Guattari, "1440: The Smooth and the Striated," in *A Thousand Plateaus* (Minneapolis: University of Minnesota Press, 1987), 474-500.

109 Gilles Deleuze, "Duration as Immediate Datum," in *Bergsonism* (New York: Zone Books, 1990), 37-49

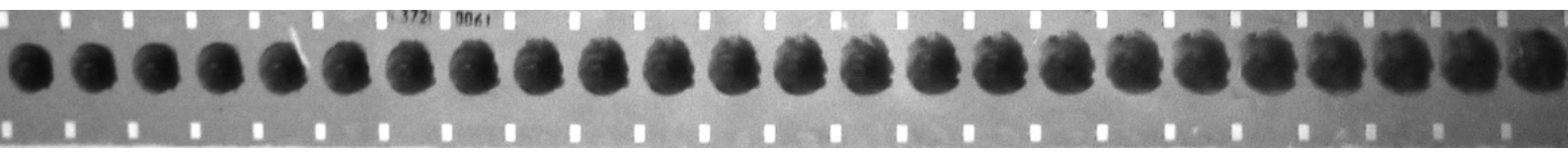
110 In the public debate, Einstein's reply to Bergson's speech about time was that "the time of philosophers did not exist", showing an irreconcilable difference between the two, an inability of Einstein to perceive of an alternate viewpoint to his own, and exemplifying the seemingly unbreachable rift between the philosophical and scientific concepts of time, that continues through to today. Source - Jimena Canales, *The Physicist and Philosopher: Einstein, Bergson, and the Debate that Changed Our Understanding of Time* (New Jersey: Princeton University Press, 2015), 4.

is used to navigate reality and order daily life - it is integral to the modern world. The concept underlies basic everyday experience - we are all aware of time constantly through clocks and calendars. The everyday perceptions and structures of knowledge that are used constantly, through habitual processes, such as time laid out in hours and days, become integrated into the way of conceiving reality - integrated into the fabric of knowledge. In favouring a particular method of organising reality and thus approaching reality through it, structures of knowledge are built that have far-reaching implications on all aspects of thought and behavior.

The convenience of viewing time as a length that can be sliced into segments is now deeply ingrained - small sections of duration are separate and comparable. In many diverse modes of research, specific recorded time is used as a dimension through which to reveal change - in charts, theories and projections of economic and technological growth. This language is used in the everyday, representing time in numbers on clocks and across pages on our calendars. We are able to locate events in time, and when we do so, there is often an underlying spatial analogy - like a line, a path, or sequential pages. For the sake of convenience, time is folded into the language of space.

Many of the experiments in this research rely upon the separation of time into thin slices through photography, and the slowing of time through high speed motion film. Using 16mm film and a camera that captures 500 frames every second, the flow of time is portioned out into discrete packages, each made visible through the chemical interaction of silver halides on thin clear film.

16mm negative film imaging smoke vortices, filmed in slow motions so that one frame represents 1/500th second in time.



These separate images on film are scanned and digitally compiled together, and using a projector that flickers 24 successive images per second, time is reconfigured through our eyes, so that we can witness the fluid motion of the smoke ring in space. Like some backward empirical proof, moving film proves that the fluid motions of time are indeed constructed of small segments stitched together in succession.

But it is not simply through the portioning and repackaging of time that liberties are taken with the essential qualities of temporality. Through using such devices as slow-motion photography a realm of sensations is opened that is normally inaccessible. There are ever finer portions of time to perceive, so that now there are cameras recording over 4,000,000,000 frames per second in moving image bursts[111], opening up ever finer resolutions of micro-time that reveals a better understanding of the basic structure of material and reality, and greater control over such processes as laser machining and laser surgery.

A photograph of Potsdamer Platz in Berlin by artist Michael Wesley, exposed continuously over 26 months to reveal construction work, trees, and old buildings overlaid. Source - "Photographs Captured Over Years with an Open Camera Shutter," accessed July3, 2016, http://petapixel.com/2012/03/16/photographs-captured-over-years-with-an-open-camera-shutter/.

At the other scale, there is time lapse imaging or ultra-long exposures that depict elapsed years in several seconds or as a single composed image, revealing the rhythm of seasons or the changing arcs of the sun throughout the year. These perceptions are all incredible, for our normal senses and perceptual awareness are calibrated to a certain time - normal human time. That time is not chosen or arbitrarily chanced upon by random evolution, but rather is an outcome of the ability to

111 The STAMP project at the University of Tokyo has created an all-optical motion picture system operating at hundreds of femtoseconds resolution in time, allowing visualisation of the motion of light itself. Source - K. Nakagawa et al., "Sequentially timed all-optical mapping photography (STAMP)," in *Nature Photonics* 8 (2014): 695-700, accessed June 25, 2016, doi:10.1038/nphoton.2014.163.

act within the world. We think and perceive at our time scale because that is the scale of time within which we can effect our environment - the ability to direct our actions and take control. Nobody can grasp a fleeting photon between their fingers, or steadily apply force over an entire year by standing in one spot - human physicality has a certain realm of time, and our senses have adapted to facilitate understanding within that scale. Memory helps to span the longer distances and create a larger temporal understanding, but in day-to-day existence it is often the seconds and minutes of the now that form the most useful kinds of observations. There is no natural use for the scale at which the vibrations of light move across objects because it is impossible to act at that detailed level of time. To elucidate these active scales of time, it is useful to draw yet again upon the words of Henri Bergson.

> Placed at the confluence of consciousness and matter, sensation condenses, into the duration which belongs to us and characterizes our consciousness, immense periods of what we call by analogy the duration of things. Must we not think, then, that if our perception contracts material events in this way, it is in order that our action may dominate them?[112]

As with apprehending other aspects of reality, such as the 3 dimensions of space, sense perception and structures of knowledge have developed over a long period of time to operate within certain scales of time. But as these boundaries are pushed though science, and as we develop mechanisms for augmented perceptions such as the super-fast camera that visualises the speed of light, our structures of knowledge are forced to accommodate vastly expanded scales of time. Whether we approach these scales of time with open eyes, as it were, or whether we apply the preconceptions of our standard frame of time -

112 Bergson, *Mind-Energy*, 15-16.

layering the modes and methods of what is known, onto unknown realms - is the struggle at the heart of gaining truly new forms of knowledge. It is likely that at small scales of time and space, that reality follows entirely different rules[113], but even if that were true, how would can these rules be perceived within current systems of knowledge? It is far easier to take the simple route, of scaling up or down the notions already at our disposal - of using what is already known - and applying that mode of understanding to what is unknown.

The modern notion of time as yet another dimension beside space, has allowed great technological and scientific development. But such notions of time are much like the theories of electricity discussed previously - abstractions that allow prediction and control of the environment. Through the rational dissection of time, by comparing "standard" events[114] and applying spatial rules, phenomena is ordered efficiently, in a way that allows control. But through such a singular view, alternate conceptions are suppressed, and more importantly perhaps, the ability to come into intimate contact with the unfolding duration of experience is also suppressed. There seem to be grave discrepancies between mankind's ability to control the environment, and the ability to understand it, and it is alternate conceptions of fundamental issues such as time, that may foster broader understanding and deeper appreciation of reality. There is a distinct need

113 Below measurements of zeptometres or yoctoseconds and down into the Planck scale, time and space are imagined to become less continuous, and notions of reality as we know them decompose through the uncertainty principle of quantum mechanics. Source - "The Planck scale: relativity meets quantum mechanics meets gravity," accessed June 25, 2016, http://newt.phys.unsw.edu.au/einsteinlight/jw/module6_Planck.htm.

114 The basic unit, a second, is standardised through the International System of Quantities to refer to "the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium 133 atom," although until 1967, this was actually a 1/86,400th fraction of the average solar day. Irregularities in the rotation of the earth necessitated the recent revision of this strange basic convention. Of course it would be incredibly difficult to replace the accepted duration of a second with something of actual significance, so, (as it is with much of our lives), conventions of the past form our continued habitual perceptions and representations of the present. Source - "SI Brochure: The International System of Units (SI) [8th edition, 2006; updated in 2014]," accessed June 25, 2016, http://www.bipm.org/en/publications/si-brochure/second.html.

for alternate modes of awareness and conception, for epistemological structures that are built continually atop of each other or along one path, will only compound the fundamental problems of any one linear evolution. When the nature of knowledge and its structures is considered, it is the approach of multiple perspectives - allowed to remain complex and interacting, without the need for resolution or unity - that holds promise for presenting alternatives and possible solutions for recurring fundamental problems.

folding - the morphology of boundary

The experience contact with what is outside of ourselves occurs all the time, and this takes place across the threshold of individual boundary. The other is experienced when defining ourselves and in the process of creating boundaries. Such boundaries are contextual and a little fuzzily defined - most of our bodies are not under control, yet we take responsibility for them and identify with them. The same happens to a lesser extent with family, and also with extended community - there are varying degrees and levels of responsibility, control and identification. Social, intellectual, and physical reality is navigated through borders that separate, and relations that connect. Separation occurs before any connection takes place.

> No connection without separation. Contact is both separation and connection.[115]

The same is true with ideas, notions, and with identities that are not human, and not living. All things are

115 Novalis, *Notes for a Romantic Encyclopaedia* (Albany; New York University Press, 2007), 44.

bordered and bounded in some way, not just individual identity. Yet the awareness of self - that initial split, that fall from grace separating the individual from the universe - self-awareness - is perhaps the basic origin for boundary and separation. All of these notions are deeply enmeshed, arising together, blurring their effects and causes. Separation, boundary, contact, connection - exploring all of these notions is an attempt to understand the representation of knowledge - to untangle old habits of thinking and glimpse the processes of knowing.

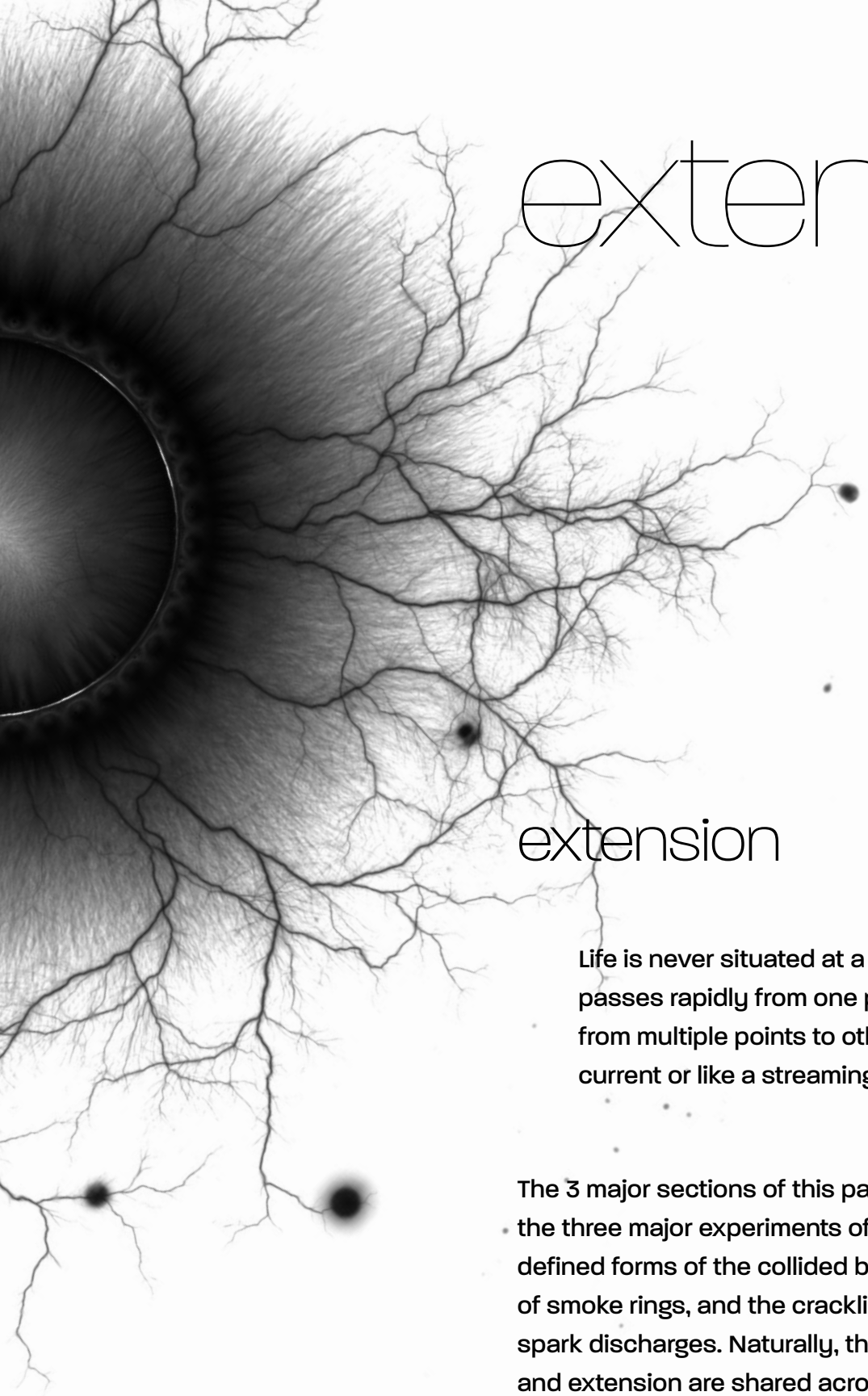
The notion of the *fold* explored here, is intimately related to the notion of *form* explored earlier. The fold is a relation of one thing to an other. The fold acts in a laying alongside, in contact, an embedding within, a representation of, a reference *to* something. The fold relates, and in doing so, it folds together. It folds things spatially - they combine. There is a recurring movement between form and fold - a rhythm. This rhythm defines boundary and form, swells into related connection, through folds, and redefines new boundary to begin again - a rhythm that is the ceaseless breath of shifting understanding. This rhythm maps the shapes of edges as they pulse and change - the negotiations and interrelations of knowledge.

In attempting to make sense of these ideas, I am compelled to make because I am a maker. Through the act of making in matter, I attempt to understand these complex notions, in a manner that is not verbal - a way that cannot be followed with words. Such acts themselves, however, can be described loosely. In one instance, responding to filming over 5 kilometres of 16mm film revealing the slow motion forms of smoke vortices, and a similarly large volume of still images, shadow photogrammes, sound recordings and various other traditional and experimental documents, I set about the playful task of creating a smoke ring through

tissue papier machē. The act of building up separated layers of tissue, of creating one long stretched and folded surface, that drew constant relation to itself, and continually incorporated parts of the surrounding space as it grew, helped to comprehend these philosophical notions. The way in which the process of making these layers folded around the form and built upon it, taking in outside space in every new ring, was like the rhythm of defining, folding and redefining outlined just before. It also followed the physical processes of how a smoke ring forms, as revealed in detail through the experiments. Slowing this process down, and working with my hands to manipulate matter, allowing the experience to settle within me, brought about an entirely different sort of understanding. Rather than the simple abstract intellectual representations of documentation and thought, there was a creative experiential understanding, unfolding as it were, through the physicality of my hands manipulating materials. An act of making - to make sense.

Tissue papier machē exploration of the formation of a smoke vortex.

Through the simple act of play with materials, which is usually relegated to children (or artists), as an indulgence without any particular intellectual value, knowledge grows in ways that can complement standard modes of understanding and bring essential alternative possibilities into view. Such a simple act of shifting our perspective is often all that is required to break stagnant patterns of apprehension and allow deeper awareness of the processes of knowledge creation we are commonly engaged within. To allow alternate possibilities to come into play.



extend

extension

> Life is never situated at a particular point: it passes rapidly from one point to another (or from multiple points to other points), like a current or like a streaming of electricity.[116]

The 3 major sections of this paper loosely follow the three major experiments of this research - the defined forms of the collided boxes, the layered folds of smoke rings, and the crackling extensions of the spark discharges. Naturally, the aspects of form, fold and extension are shared across all the experiments, but in general character, the extension referred to here is exemplified by the spark discharge experiments - the movement of energy from within, across defined surface boundaries, to reach out beyond the confines of a singular identity.

116 Bataille, *Inner Experience*, 67.

To extend oneself is generally understood as to strain, strive, or to reach beyond one's normal capabilities. It suggests both a *reaching outwards* towards something, but also a *taking in* - an incorporating of something external through a stretching of boundaries to become more inclusive. When considering extension here, it is approached as both a reaching out, to effect what is outside of itself, and also, a reconfiguration of current boundaries. These aspects are complimentary and part of the same action, arising naturally together. In the manner in which such extensions occurs, there are subtle differences in how they all take place - in speed and scale, and between notions of domination or acceptance.

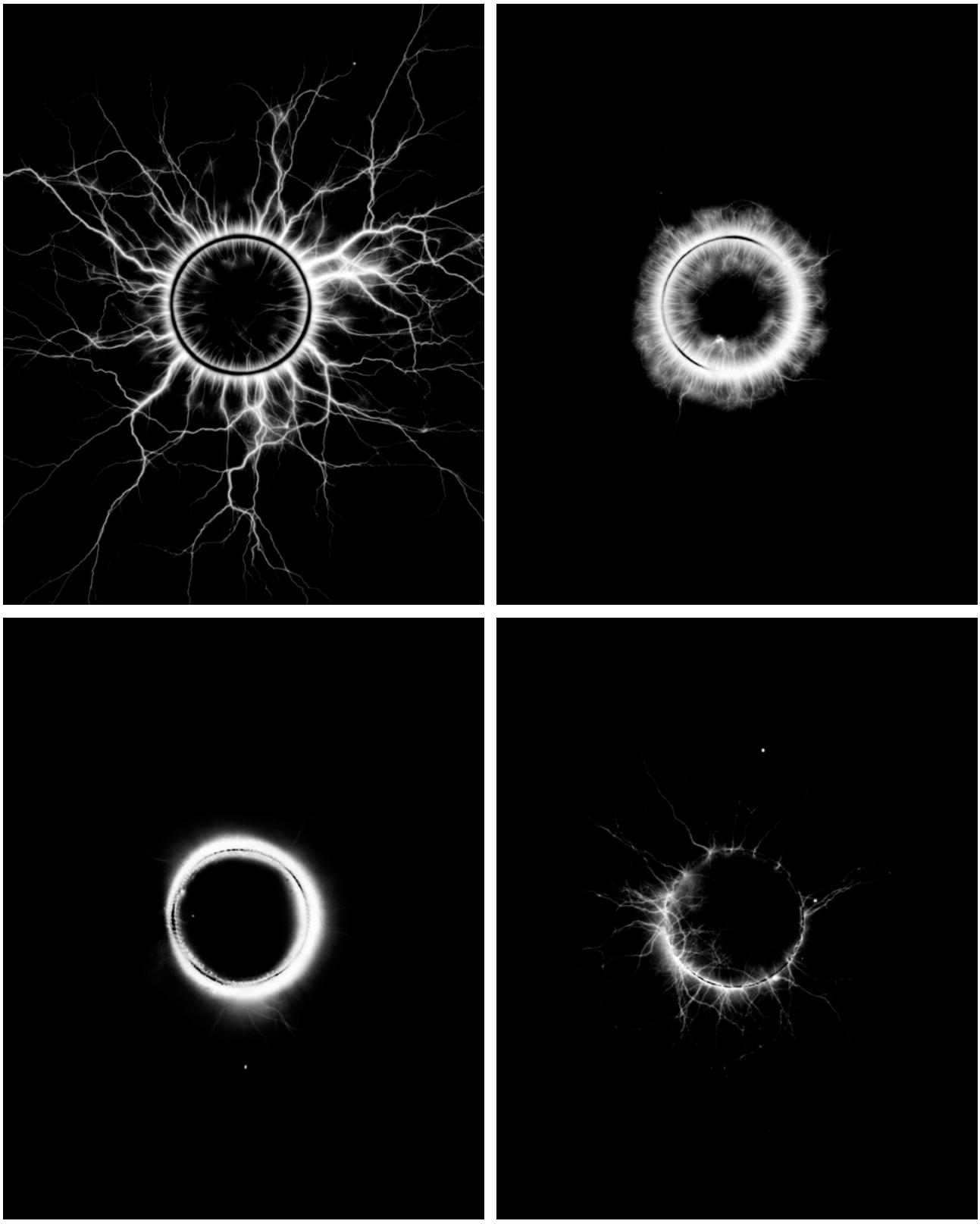
In the same way that folding implies a form, so too does extension. Both rely on the initial definition of a bounded identity, through which they act to effect boundaries and edges. Folding *relates* - by creating connection between internal elements, or between internal and external - it works across boundaries to draw connections together. Extension is much more generative and transformative than folding - it swells outwards, expanding the reach and scope of defined boundaries. The simple notion of extension seems quite easy to grasp, but is actually quite complex and rich, for with every extension, identity is forced to adapt itself to the qualities and rules of the domain within which it is extending. And likewise, the domain must adapt to the identity incorporating it. There are translations, and compromises - the extension becomes a hybrid of that which is extending, that through which it is extending, and the progressive vector of that which it is extending towards. Extension brings new context and relation, resulting in a continual re-negotiation not only of boundary, but also of core identity.

energetic extension

In the spark discharge experiments presented here, an object is bombarded with high voltage electricity, to such an extent that there is an excess of energy, which, overflowing, releases out from the surface of the object into the air around it. This energy, while applied from an external source, takes on the characteristics and qualities of the material, and of the general form of the object. If there is a crack in the form, it flows either side of it. If there is a dominant granular or crystalline structure to the material, it moves along it. If the material conducts electricity well, it streams quickly through. If the material is capacitative, electricity can be stored, slowly leaching out over time. The electrical energy is effected by the medium through which it moves, releasing in certain ways so as to reveal the nature and internal structure of the material which it is passing through. The spark discharges are expressions of the energetic character of matter, and of form.

Sample material ring forms in 22ct gold, gibeon meterorite, huon pine, and silicon nitride ceramic, as revealed in direct spark imaging on the next page.

Electrical energy does not easily flow through such material as wood and sintered ceramic. Ceramic for instance is often used as an electrical insulator for this reason. Yet all material will interact with electrical energy in some way, and this may be a matter of scale, or of quality. The wood, for instance, a small ring of which is pictured above, reveals the summer and winter rings in



Spark images of 22k gold (top left), gibeon meteorite (top right), huon pine (bottom left), and silicon nitirde ceramic (bottom right). All images on lithographic silver halide emulsion, voltages ranging from 20,000 d.c. -50,000 a.c. from 10Hz up to 15kHz.

its growth - through tuned high frequency alternating current, it is revealed that the denser winter rings carry a charge more readily, perhaps also due to a higher resin content. When electricity of a variable frequency is applied to matter, it may, as in the case of wood, alternately store and release the energy, revealing internal structures through the extensions of the sparks.

The manner in which a material conducts or resists electricity, and stores and releases it, can be explored through the applied energy to reveal the characteristics and micro-structure of that material. If a direct current (electricity of zero frequency), is applied to wood, most of the energy simply flows across the outside surface, "shorting out" as it were. Through applying electricity of a varying nature - in frequency, intensity, duration, and using a range of film types - most materials can be explored through this process.

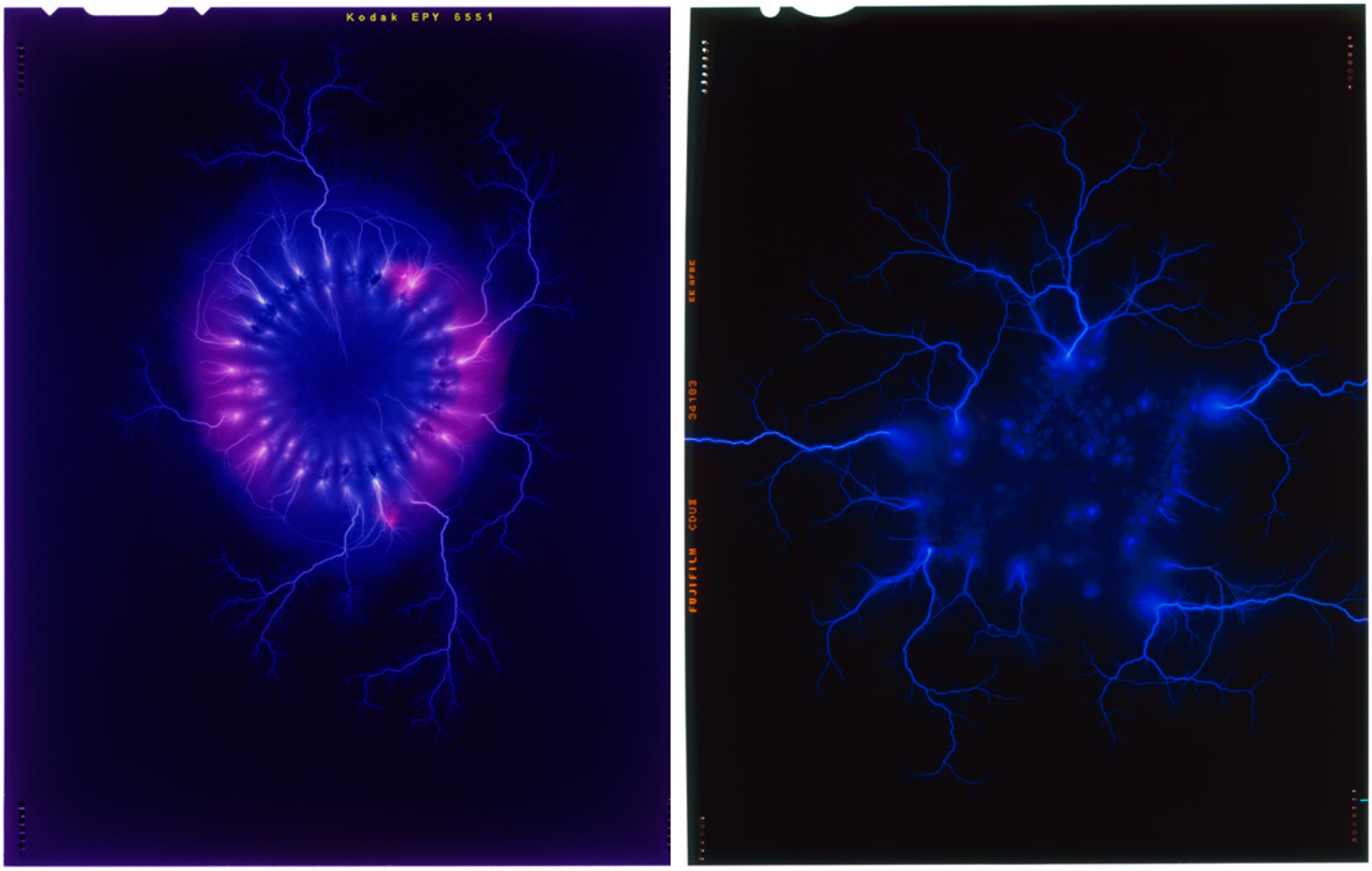
The arcs that are captured here result from electricity escaping the outer surface of the form and overloading the air surrounding it. The air ionises, getting overexcited atomically, and releasing intense light[117]. This is captured on photographic film, with the object placed directly over light sensitive emulsion, and electricity applied - there is no camera involved. The sparks are documented as tracks of light in air, across the surface of the film. These surging arcs of ionised air paths exit the surface of each object in unique ways, creating a direct expression of the material and physical form through which they have passed.

The character of the materials and forms are revealed in many ways. In the image of huon pine shown before, it is clear that the summer and winter rings conduct electricity in different ways due to the density of the wood during alternating growth rates. The gold reveals its excellent ability to conduct electricity evenly with

117 When electrical energy moves through the air, it excites the molecules into a higher state. They are not stable at these higher states and soon drop back down, releasing their excess energy when they do, as photons of light. This light is of particular frequencies, theorised to be due to the electrons moving from their higher excited orbits back down to their normal state, releasing one particular frequency of light (though each element is complex and there is a defined set of several frequencies for each, resulting in complex *emission spectra*). For air, which is mostly nitrogen, the emission spectra is of a dominantly blue shade, resulting in my colour spark images being mostly blue, with occasional purple (spraying argon gas as the object sparks), and various other colours that may be due to the material being examined or the chemical nature of the film used for capture. Source - "Emission Spectrum," Wikipedia, accessed June 26, 2016, https://en.wikipedia.org/wiki/Emission_spectrum.

a uniform set of arcs radiating out from the ring, while the meteorite, with its dense octahedrite crystalline structure formed 4 billion years ago as it slowly cooled, reveals internal structures and grid lines through a less energetic but more staggered and patterned series of radiating sparks. Layered damascus steel shows pronounced steps from its structure that is much like wood. Plastics reveal their capacitative ability to store and hold electricity, especially at high frequencies. The ceramic, inherently difficult to image in this process, reveals the limits of the current arrangement, with spark trails mostly arcing over the surface of the form rather than through it. To capture the subtleties of such a difficult material very sensitive film and small amounts of electricity are required.

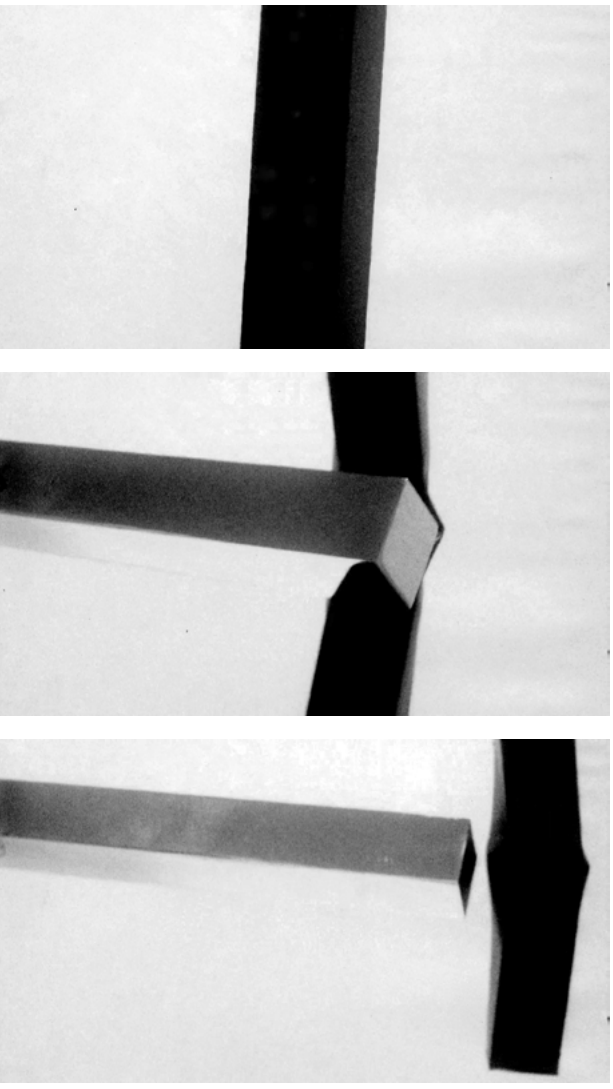
The spark discharges also reveal the geometry of forms. When dealing with conductive material, such as copper, the electricity floods through the entire form, saturating it evenly. When it is overloaded and there is an excess



Spark discharge images of a carved torus form (left) and of a raw meteorite fragment (right), taken on 4x5" colour transparency using voltages of 30,000-40,000 dc.

of energy, it releases from the surface along points and edges, channeled through the geometry of form in a way similar to light traveling through optical lenses, being diffracted or concentrated, squeezed into points, guided along edges, and allowed to expand over smooth planes. In exploring form in this way, the geometric shape of an object becomes very easy to conceive of as "a diagram of forces,"[118] as biologist D'Arcy Thompson has been quoted as saying in an earlier chapter.

The exterior form, its internal structure, and the nature of the material it is made from, are all expressed by the movement of electrical energy through an object. The resultant spark discharge images recorded on photographic film are a document exploring the energetic qualities of matter.

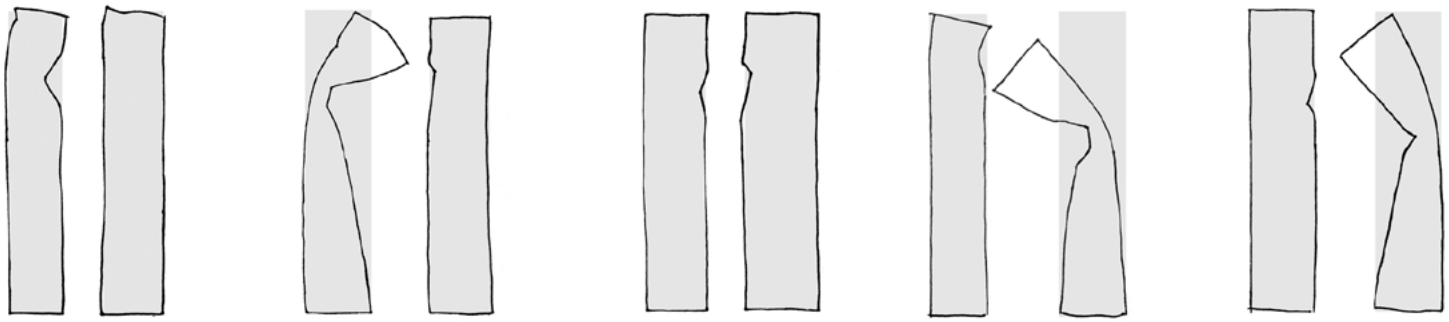


The collision of hollow metal boxes as shown here in still images taken from 16mm slow motion footage.

A more violent example of energetic extension is explored within the collisions of hollow metal boxes also undertaken in this research. There is a potential of energy that is stored in each box - in speed and weight - as they are launched to fly towards each other. The inevitability of their meeting results in an exchange of forces that extends beyond the bounds of their metal surfaces, out into one another, and into the air around them. With nowhere to move forward when they meet, each metal form pressing deeply into the other, negotiating structure and matter, buckling and collapsing planes and edges, as the residual forces of motion extend out from one into the other. This extension of force plays itself out through the two separate forms, each identity pushing into the other with their edges and corners, their fragile planes, and the energy of their arrested motion. The excess energy ripples through the boxes, creating folded metal planes and crushed edges, and pulsing resonant vibrations that radiate out into the surrounding air as sound.

118 Thompson, *On Growth and Form*, 11.

This kind of extension of energies results in a complex imprinting of identities and qualities, of each box upon the other. The forces that one box extends into the other results in an irreversible transformation. This transformation reveals the structures of each form, their geometry, their material qualities, their direction and movement as they met, and the forces of excess energy



Traced shadow profiles of collided box pairs, revealing matched deformation at the point of collision, resulting from the extension of excessive force into structural form.

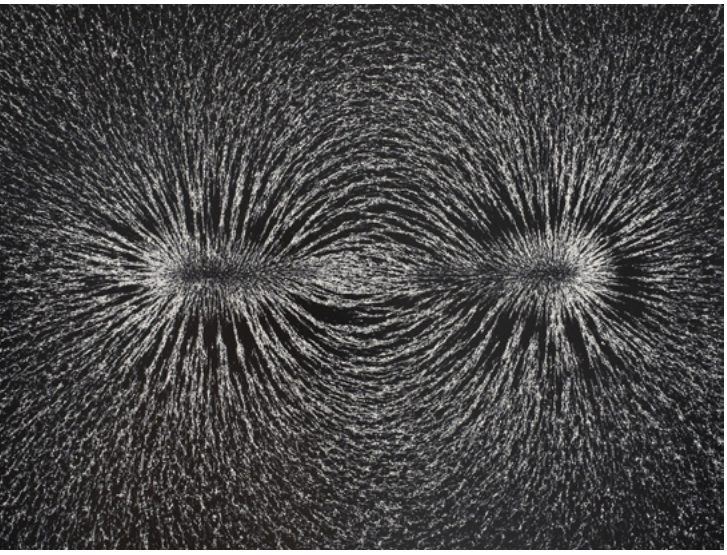
that resolved in their collision. All of these interrelated aspects are further explored and teased out through the careful study of slow motion visual documentation and slowed and stretched audio recordings.

Energetic extensions are continually taking place at all levels of life - from these physical examples of energy, to the extensions of will that intellectually and emotionally allow each of us to chase our hopes and dreams, or the extensions of political and economic power that extend the influence of nation states. Across all aspects of life, extension and folding, (and relation in general), become fluidly connected actions that follow on from the initial notion of definition - they are implied within the actions of each other. In considering each aspect that has emerged in this research - form, fold or extension - it is important to remember that they do not exist separately, and while they are explored here as individual notions, they must be returned back to the complex related fields of action to which they belong. By exploring them separately, but resisting the urge to lock them down and define them (resisting both a distinct separate definition of them, and, resisting

thinking of them as parts indicative of a greater whole), a certain familiarity with each idea is allowed. This flexible familiarity allows the ideas to relate to one another, and thus to generate more knowledge. When returning these separated notions back into their context, unexpected aspects of their nature may become apparent, through their relations to other concepts.

The separation of form, fold and extension is a convention - it is arbitrary and abstract - these separations do not exist. They simply allow us to begin considering aspects of the overwhelming reality which surrounds us, within the confines of our humble limited understanding.

fields of extension



Berenice Abbott's photograph *Magnetic Field* (1982) clearly shows lines of magnetic force through the alignment of iron filings around magnets under a sheet of paper. Source - "Notes on the exhibitions and collections of the David Winton Bell Gallery," accessed July 3, 2016, https://bellgallery.wordpress.com/2014/02/12/spotlight-magnetic-field-by-berenice-abbott/.

Extensions of energy can also be conceived of as fields - as an energetic array of possibilities - a kind of landscape of latent forces, or potential action. Like such clearly visualised examples as the radiating lines of force around a magnet pictured at left, fields describe various forces extending from objects, potentially acting upon other objects and other fields within space. This notion of the field has been useful to describe effects that reveal action at a distance[119], and although the magnet and iron filing image shows this idea clearly, the field is not so much

119 The notion of *action at a distance* is an intriguing concept of early physics that has a flavour of bitter cynicism due to criticisms of early science's failure to describe such effects as electromagnetism. This hole in knowledge led to the development of field theory - a model of potential forces that can effect distant objects through means other than direct contact. The paradigm shift of such thought should not be underestimated, as abstract and descriptive as such models and theories are. We are still fascinated in our daily lives by such things as magnets, and this is due to their mysterious nature - in some way we do not completely "believe" them, or at the least, we do not properly "understand" their workings. Source - "Action at a distance," Wikipedia, accessed June 26, 2016, https://en.wikipedia.org/wiki/Action_at_a_distance.

actual, as *potential* - the field only acts upon other objects (such as these fine iron filings) - it does not so much exist in itself, as it is an abstract field of potential action. It is a model of interaction between various objects and other fields.

The actual nuts and bolts mechanics responsible for magnetic fields is still unknown, although the process can be tracked through some models for greater understanding, (of the magnetic effect as well as our conceptions of it). Magnetism occurs when the movement of charged particles is aligned in direction and location. This can happen in making an iron magnet, when all of the atoms are aligned - achieved through heat and a strong pulse of electric current. All of the atoms of the iron become aligned in one way, through the orbiting electrons of each atom all spinning in one direction and plane, and this aligned movement of charged particles (the movement of orbiting electrons), creates the magnetic field - from one "north" end of the magnet to the opposing "south" end. Because electricity and magnetism are complementary forces and fields, the same phenomenon occurs with electrical current running in a coil, as described earlier when transforming low voltage to high voltage[120]. The charged electrons moving through the primary coil create a magnetic field, and this magnetic field impels electrons to move in the secondary coil wire.

Magnetic fields, and many other similar fields, are a mapping of potential - potential force and action visualised as an abstract energetic field radiating out in space. To the same effect, the field can instead be conceived of as a mathematical model - formulas predicting the action at a distance between charged particles. The easily visualised field evolved in the sciences as a quick and simple way of modeling what happens between two objects - is a diagram of potentiality. The field exists only as a potential effect - this is important to remember. It is a convenient

120 See *folded notions of energy*, page 107.

representation of potential action - through it we can predict what is going to happen, but we do not fundamentally know *how* it happens.

This notion of the field, which is a theoretical fabrication of potentialities and effects, is useful to explore the more abstract elements of knowledge and the dynamics of relation that constitute identity. In considering individual identity, through this notion of the field, there is a analogous model that goes far beyond the simple physical boundary of our skin. Imagining the self as an amorphous field of potential action in space and time, without clear boundaries, makes a great deal of sense.

The individual moves through space, creating change and being changed, through the effect of his or her field of interaction. Our potential for care or harm extends out to others close to us, much like the lines of force found in magnets, repelling and attracting. The ability to acquire new knowledge, and transmit it, or act upon it, creates a range of possible outcomes that read like a complex relation of interacting forces - elements of knowledge jostling into one another, combining, negating, or complementing. Each individual's ability to grow, to become more conscious, sensitive and aware of that which surrounds us, can be seen like a field of inclusion - an array of tethering contact lines that loop and connect into a field of deep relation between self and the external world. When individuals relate like this to one another and form a group, the field becomes deeply entangled and the effects are hard to locate or trace to single origins or end-points. The nature and effect of the field becomes so complex that it seems to generate its own complex identity, through the multitude of layered interactions. Even in the simple positing of this abstract notion - of the field - the more it is considered, the more it becomes a thing, an entity that can be vaguely named and localised or isolated. It is detrimental to define such

fields too clearly, for their power as concepts lies in their amorphous nature - a field is pure relation - it is not a form or entity in itself.

Fields concerns themselves with effects and actions as revealed through relations and potential forces. They are not concerned with edges and boundaries, but rather with gradients of effect. Used as an intermediary idea, between the notion of defined identities and the ideas of energetic flux, pure movement, and centreless subjectivity, the field allows us to extend the edges of entities out in space, and into one another.

A simple everyday example may be of use here - the act of a decent open conversation. At a personal experiential level, when we are in deep conversation with someone we feel we can trust, we become open and more receptive. We allow for a certain subtle influences to occur that we may not normally be sensitized to. Between ourselves and those we closely trust, a field of intimacy opens up - they effect us. Perhaps this kind of receptive field is always present, but its action is usually damped. In being open to the effect of others, we listen, pay attention, and take on board their advice, their worries, hopes, and desires. Reciprocally, aspects of ourselves are also revealed that we may normally guard, for fear of reaction or consequence. To understand the concerns and feelings of others at any level, or to engage in even the most simple conversation, requires a certain attuning of receptivity. These decisions are all navigated in our everyday meetings through sub-conscious and conscious choices. It would be unusual or even pathological to exert our worries, hopes, and desires onto every person we meet on the street - we modulate the strength of the fields of intimacy and their extension, as much as we modulate our receptivity to the fields of others around us. It may seem an unnecessary abstraction to use the notion of the field for such

personal interaction, but it's use as a model of interaction becomes clearer, when considering how such fields might operate.

Rather than random expressions that are launched or received between two people, conversation usually flows (or does not), in a way that finds the common interests, or points of conflict between two people. It is as if two potential fields - containing specific views, ideals, dislikes, aspirations and blindnesses - ebb and interact between any two people. When the fields meet, there is an initial navigation and exploration, apparent through dialogue and action - comparing commonalities and differences at first, then uncovering or revealing partially obscured ideas, becoming caught or trapped in dead end lines of thought, erupting in argument, perhaps coming together in shared feelings.... In conceiving of a conversation in such a way, these fields are like vectors of possibility that search out forms of relation - extensions of self that negotiate the outer world - drawing connections between self and other - relating, comparing, extending, defining, and moving towards better understanding.

Applying this notion of the field to personal identity, the focus is shifted away from defined edges and boundaries. It becomes less important where a single point of origin is located, or where its outer edges lie. The over-riding connotations of a spatial language of identity can be relaxed somewhat, giving way to notions of relation that float free from defined location. The field, spreading outwards from the individual, quickly becomes dispersed amidst a vast array of connections - interfering and blurring with other entities and their fields, and with elements of the external world. The identity of self reaches out in potential interaction, and other fields penetrate this identity and effect its nature. Edges of definition give way to interactions, interpenetrations, and sharing, creating a vast sea of constant flux. The self becomes a floating embedded relation within such

an environment, defined only through perspective and context. As the enigmatic Ismael tells Alexander in *Fanny and Alexander*,

> Perhaps we are the same person. Maybe there are no boundaries. Maybe we all flow into each other, boundlessly and magnificently...[121]

In a field, any sense of identity is defined only through the artifice of creating perspective and context - edges arise through the interpretive act of perception.

Brian Massumi and Erin Manning's *Thought in the Act* begins with an account of the general perception of several autistic people, revealing similar notions of the field through divergent modes of subjectivity[122]. In comparison to the neurotypical perspective that commonly defines and edges all things, the common autistic perspective is described as something fluid and essentially open to relation and context, a "dance of attention."

> A dance of attention is the holding pattern of an immersive, almost unidentifiable set of forces that modulate the event in the immediateness of its coming to expression. Attention not to, but with and toward, in and around. Undecomposably.[123]

And further,

> A dance of attention is not attentiveness of the human *to* the environment but attentiveness *of* the environment to its own flowering, at the very limit where experience and imagination, immediacy and cross-checking, overlap. The making-felt of a co-

121 *Fanny and Alexander,* directed by Ingmar Bergman (1982; New York: Criterion, 2004), DVD.
122 Brian Massumi and Erin Manning, "Coming Alive in a World of Texture", in *Thought in the Act* (Minneapolis, University of Minnesota Press, 2014), 3-22.
123 Massumi and Manning, *Thought in the Act*, 4.

> compositional force that does not yet seek to distinguish between human and non-human, subject and object, emphasising instead an immediacy of mutual action, an associated milieu of their emergent relation. This co-compositional engagement with the associated milieu of emergent relation is an *environmental mode of awareness*. It is a mode of existence integral, for autistics, to all aspects of experience. They do not bemoan this modality of awareness as a deficit but affirm it as a mode of existence intertwined tendentially with other modes of existence, such as those (more "human" by the neurotypical definition) that are centred on language.[124]

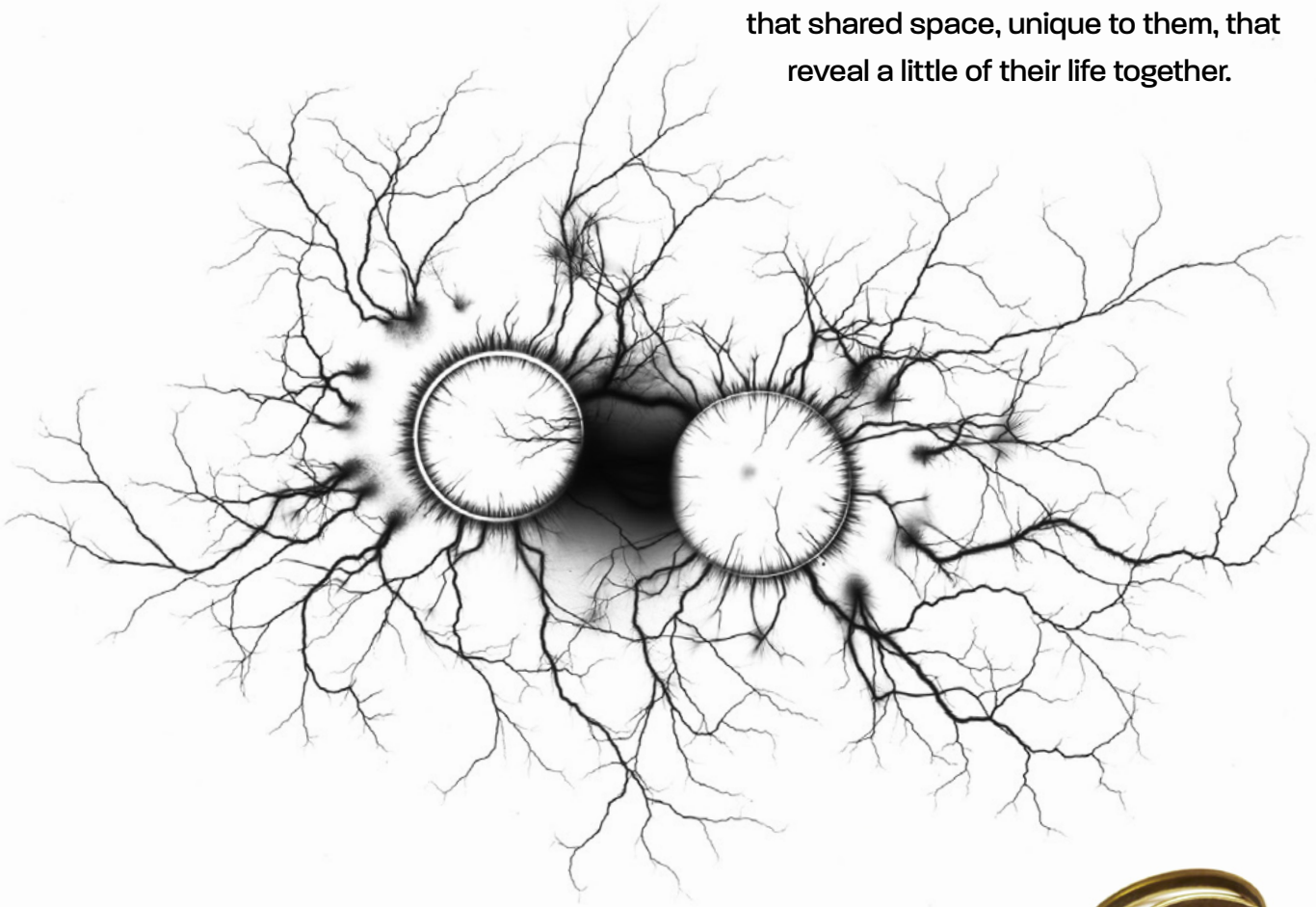
From the first-hand accounts explored in the text, and the philosophical considerations that follow, it is clear that conscious awareness is not dependent on standard modes of subjectively perceiving borders and definition, in the accustomed *standard* order of reality. Creating an awareness of reality, from the defined and centred perspective of a conscious individual, entails making fundamental structural choices about how to represent reality. The ability to maintain a cohesive sense of self through one dominant mode, does not discount or devalue alternative modes of perception, such as these described fields of relation.

> Autistic perception dances attention, affirming the interconnectedness of modes of existence, foregrounding the relationality at the heart of perception, emphasising how experience unfolds through the matrix of qualitative fields of overlap and emphasis already immediately moving toward expression in a dynamic field of becoming alive with co-composition.[125]

124 Massumi and Manning, *Thought in the Act*, 6
125 Massumi and Manning, *Thought in the Act*, 7

Exploring fields of relation through a slightly more physical example, early experiments in this research, imaging spark discharges extending from single objects, were extended to explore the energetic spaces between two objects. The first field that was generated explored the intimate space between my grandparents, now dead for several years, by imaging their wedding rings through spark discharges. Their lives, like most of that time, were complex. Born in the early 1900's, as Germans who migrated to Australia after fighting in World War 2, theirs was a marriage of practicality rather than true love, though a deep reliance on each other was forged over the years by living in a foreign country and creating a family. All these things can not be captured in one image, but images like the one below help to explore the relations between them, rather than their separate identities. It is not simply two separate rings, but the rich field of connections in that shared space, unique to them, that reveal a little of their life together.

The space between my grandparents' wedding rings, imaged through high voltage spark discharges on lithographic silver emulsion. A normal photographic image of these gold rings is below at right.

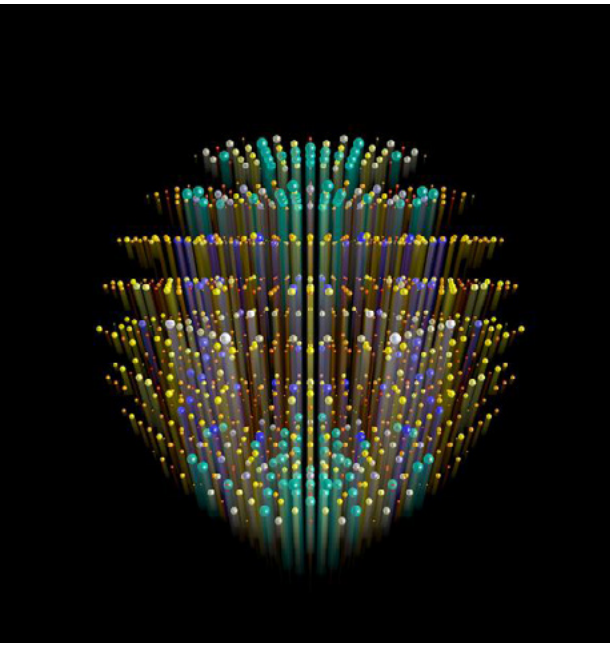


extensions in time

In many of the considerations explored here, movement is integral, and implied. It is constantly in the background when considering still slices of reality, that everything is changing, and all is in motion. Yet in conscious consideration of the concepts and ideas used to order the world, we often disregard the perpetual flow of time. Time and motion are often too complex to consider - it is easy to lose grip amidst the vast complexities, and there is no firm mental handle to grab hold of. So a frame of time is separated out - a little frozen moment - upon which to hold attention, as an indicative part of the moving whole. This happens because it is difficult to imagine situations with perpetual movement and change - it is a leap of faith in the future and a juggling of past memory - the complexities stack up too fast for human intelligence to properly conceive. Common thought is more comfortable dealing in one time - the *now*. And for the sake of ease - for the sake of representation - the *now* can be made to stand still. Taking the direct experiential immanence of now as a moment between past and future, and using this suspended interruption of the flow of time, reality can be simplified enough to follow and understand it. All too often, a small sample of the flow of time is separated, and used to come to some kind of intellectual understanding of what is occurring before and after. Intellectually, the manner in which time is dealt with, is very similar to how spatial considerations are approached - sectioning and defining, coming to an understanding of a part, then relating and extending that section, as indicative of the greater whole, to create a broader picture. This is the dominant intellectual approach, but in an experiential manner, in the intimate moments of direct engagement, such as being engrossed in some creative task, where

is a deeper attunement to the changing flux of time, a sensitivity to the myriad of changes that occur, with actions and perceptions adjusting instinctively to meet the needs of the unfolding moment. Such states of intuitive flow are hard to track, and near impossible to explicate in words.

The core actions of defining, relating, and extending, as discussed in the preceding chapters, all occur through time - they move and change in ever-evolving transformations. These aspects and qualities are not spontaneous - they happen within a flow in time - they express themselves through *movement*. This movement is constant and on-going, and is indivisible. It is only within abstract thought that a stillness of time is fabricated, a temporal location from which, and within which, to perceive. All the perceptions that occur within consciousness, all the images that are captured, are a sampling of a discrete section of time - a certain "length" of time. Even the brief 0.00000000000003 second (30 femtosecond), exposure of x-rays used to image protein molecules pictured at left, still spans time, incredibly short though that span may be - it is still not a single moment.



An image "exposed" for 0.00000000000003 seconds (30 femtoseconds), showing the molecular arrangement of a protein molecule inferred by x-ray scatter sensing. Source - "Fastest X-ray images of tiny biological crystals," accessed July 3, 2016, http://www.desy.de/information__services/press/press_releases/2011/pr_191211/index_eng.html.

The ability to stop time and consider it in frozen frames is a convention that allows us to understand some aspect of the complexities of "past" and "future". Time as an abstract dimension of its own is difficult to comprehend, and generally spatial analogies are used - a length of time, a short or a long wait.... Time is spatially conceived as an incomplete substance - it is always one dimensional - there is never a wide or a narrow time, or a deep or large time - there is only length. It is visualised as a linear progression without width or height. We image the world in its solidity of three dimensions, weight and texture, and its complex network of relations, adding on time and motion as an extra quality or aspect - a kind of road along which it

all travels. In some basic way, conscious thought is at odds with time.

The awkward intellectual perception of time may be caused by the nature of conscious reflection, which requires the dwelling of thought upon some matter. In order to mentally reflect, the flow of time is interrupted - representations are built, relations are examined, comparisons made, qualities and characteristics are defined. Reflection requires consciousness to take a step back from external perception, and consider the meaning of internal representations. While this is not outside of time, the direct conscious perception of the external world is interrupted to some degree, and the internal act of representation occurs within a radically alternate frame of time (representation allowing the artificial stilling of time). Of course all of these acts occur within some duration - external perception, internal representation, and all other modes of awareness. Yet the apparent derailing of external time that takes place in the act of reflective thought hints that the temporal mechanics of thinking may be a contributing factor to our vague grasp of time.

A scientific understanding of time generally begins with Sir Isaac Newton's intuitive theories of time[126], which regard it as uniform and equal for everyone. This is very close to most common-sense experiences of time.
In Einstein's theories of relativity, time becomes very complicated, entangling with space to negotiate a basic relation that is believed to be the universal constant - the speed of light[127]. As the earlier theories were

126 Newton's conception of time was of an absolute movement that passed uniformly regardless of events or observers. Source - "Newton's Views on Space, Time, and Motion," Stanford Encyclopedia of Philosophy, accessed June 27, 2016, http://plato.stanford.edu/entries/newton-stm/.

127 Einstein's conception of time is proposed as fundamentally relative, and rejects the absolute conception of Newton, yet it introduces another absolute, in the constant speed of light, such that the closer you get to that speed, the slower time moves and the smaller things are (in the direction of travel only), thus keeping everything in check (very simplistically speaking). While time may no longer be absolute in this model, the speed of light has become the absolute. We all love a good absolute something-or-other to hold

elaborated, notions of gravity were considered, and this resulted in space and time becoming enmeshed, in a fabric that is often visualised as a gridded field of space-time, that is curved around large objects to model the effects of gravity. The outcome of these theories in terms of time, is that the "speed of time" is entirely relative upon a position and velocity relative to other objects. There is no universal simultaneity - everything is seen to be experiencing time at slightly different speeds. While there may be no universal simultaneity in a world governed by relativity, there is a universal constant - the speed of light - a stable and secure uniformity anchoring these theories, relating matter, energy, and time, through that constant. It seems that if systems of knowledge do not have at least one stable element, things begin to fall apart, becoming so vastly complex that they fall apart in ungoverned chaos.

These abstract notions of high physics are very much removed from the everyday understanding of phenomenological experience - normal experience cannot physically deal with the immense distances or speeds within which such theories play out. In terms of an individual's ability to comprehend and take action, the spatial and temporal domain is much smaller. Human brains have not developed to intuitively grasp such ideas. We are still perceptually equipped and intellectually wired for our normal daily experience of life - acting within our environment in a certain realm of time. We do not live for millennia, travel to other galaxies, or move anywhere near the speed of light, and so our conceptions of such matters are informed by our everyday perceptions. The conception that exist in systems of pure theory, and through testing at a distance within complex experiments (the interpretations of which may be entangled in similar limits of understanding), extend these experiences, intellectually only. But that is not to diminish the

onto. Source - "The relativity of space and time," accessed June 27, 2016, http://www.einstein-online.info/elementary/specialRT/relativity_space_time.

value of such thinking, for theories such as Einstein's special relativity has broadened the possibilities of understanding and created new paradigms of reality. And those notions of relativity have been extended and contradicted by various modern theories, such as quantum theory, which is even less intuitive than that of relativity. The growing proliferation of theories, this multitude of ontologies, adds to the fabric of understanding. It is all a work in progress. There is no intellectual understanding of time in totality, for it is not experienced in totality. These theories can be appreciated for their value as a *reaching towards* - helping to make sense of reality. They reflect back past patterns of knowledge, revealing how we think, what is of value to us collectively and as individuals, and how we wish to act and effect our environment. These theories of time in modern physics perhaps tell more about personal knowledge and desire, than the actuality of time itself could (if of course time is a separate apprehensible substance at all....)

At a basic level, in creating theories of time, or anything else, there is an attempt to make sense - a movement towards a coherent internalised understanding of reality. A working representation. Theories are a formal way of reconciling our experience of the world within a framework of conscious knowledge. But this knowledge does not necessarily need to be rational understanding, of course. It can take on more intuitive forms of understanding.

As a foil to the counter-intuitive notions of time in Einstein's general relativity, there are the notions of time as conveyed by Henri Bergson, Einstein's opponent in the public debate mentioned in an earlier chapter. While also exceedingly difficult to grasp, Bergson's notions of time are built on an experiential and philosophical framework, rather than a mathematical or theoretical one. His notions of time and duration are central to

his philosophy, and have their roots in the intuitive experienced moment, where he gives the movement of time ontological precedence over matter and form.

> There are changes, but there are underneath the change no things which change: change has no need of a support. There are movements, but there is no inert or invariable object which moves: movement does not imply a mobile.[128]

Bergson's notions of time are approached through intuitive introspection, and are notoriously difficult to explicate. They have been discussed in the earlier chapter *folded notions of time*[129]. Bergson posits a fundamentally alternate approach to engaging with the experience of time (and reality in general). It is a kind of stepping backwards, taking an alternate path to the reductive and rationed view of slices of static time. Bergson states that the general misunderstandings of time arise from such a way of approaching it through static slices or states.

> If you imagine a change as being really composed of states, you at once cause insoluble metaphysical problems to arise. They deal only with appearances. You have closed your eyes to true reality.[130]

Bergson's overall notion of time can be appreciated when understood through his general approach to perception, which takes direct intimate experience and attempts to extend awareness and attention *within* the subject, experiencing directly, rather than through the typical channel of rational analogy and analysis.

> An absolute can only be given in an intuition, while all the rest has to do with analysis. We call intuition here the sympathy by which one is transported into the interior of an

128 Bergson, *The Creative Mind*, 147.
129 See *folded notions of time*, page 117.
130 Bergson, *The Creative Mind*, 147.

> object in order to coincide with what there is unique and consequently inexpressible in it. Analysis, on the contrary, is the operation which reduces the object to elements already known, that is, common to that object and to others. Analysing then consists in expressing a thing in terms of what is not it. All analysis is thus a translation, a development into symbols, a representation taken from successive points of view from which are noted a corresponding number of contacts between the new object under consideration and others believed to be already known.[131]

As can be appreciated, when the subject of time is approached in this way it becomes something fluid and inexpressible through analytic language. Bergson's indivisible flow of time, *durēe* - inseparable from the fabric of reality in any way - embeds itself within the unfolding act of experience. Such an understanding is concerned with time in a manner which operates in a totally different framework to that of modern physics. The two views may be complementary, but are entirely irreconcilable, and are unable to be translated across into each other's language.

Einstein's comment at the beginning of his debate with Bergson in 1922, that "the time of the philosophers did not exist"[132], clearly shows what is counter-productive in a rigid ontology such as the most dogmatic version of science - the inability to extend one's frame of reference to include concepts that do not fit within that frame. When such an ontology is taken further, the outright denial and persecution of other points of view occurs. Intellectual tyranny. Einstein's inability to extend his objective theoretical conceptions of time, to respect, consider, or accommodate in any way, the personal subjective notions of time of Bergson, are such a case of tyranny. The history of science,

131 Bergson, *The Creative Mind*, 161-162.
132 Canales, *The Physicist and Philosopher*, 4.

and of course philosophy and most other branches of knowledge, are littered with such uncompromising inabilities to conceive of alternate views, often resulting in some sort of attempt at intellectual domination - of forced submission to one primary world-view.

This has been explored earlier - what knowledge often desires, at a basic level, is something coherent - the simplest conception that makes sense. The seductive allure of a single reconciled view is hard to resist. It allows a certain peace of mind and enables thought to move on. But it is obvious that there are radically different interpretations of all facets of reality, including time - approaches that apply to rational or intuitive realms, and vastly alternate theories that account for the same occurrences. Coherence is obviously lacking, in general, and the world makes less sense the more it is pondered (this research project being a case in hand). But what is most interesting here in all of these considerations, and what may help to relieve some of the tension in these conflicts of ideology and the desire for resolution, is that all knowledge is fundamentally relative. The nature of our knowledge reveals as much about ourselves and our approach, as it does about any external universal reality. In paying closer attention to the nature of knowledge and its generation, it can be seen more clearly for what it is - a process of negotiation between representative ideas, and apparent perceived realities. If a greater awareness of the processes of knowledge creation is encouraged, a better respect for the underlying nature of knowledge will be fostered. This is knowledge as a *search for understanding*, rather than as a rigid representation of reality, or at worst, the truth. The valuing of diversity would naturally follow on from such consideration - diversity in approaches, in points of view, in modes of apprehension, in systems of knowledge, and in states of understanding.

extending - the morphology of boundary

Drawing once more upon the words of Henri Bergson, the elusive concept of *durēe* is one possible way to extend the edges of knowledge. As briefly mentioned earlier, Bergson's philosophy is based on an extension of consciousness, intimately into the object of consideration, opening up the possibility of experiencing something outside the realms of the known self.

> But suppose that instead of trying to rise above our perception of things we were to plunge into it for the purpose of deepening and widening it. Suppose that we were to insert our will into it, and that this will, expanding, were to expand our vision of things. We should obtain this time a philosophy where nothing in the data of the senses or the consciousness would be sacrificed: no quality, no aspect of the real would be substituted for the rest ostensibly to explain it. But above all we should have a philosophy to which one could not oppose others, for it would have left nothing outside of itself that other doctrines could pick up; it would have taken everything. It would have taken every thing that is given, and even more, for the senses and consciousness, urged on by this philosophy, to an exceptional effort, would have given it more than they furnish naturally. To the multiplicity of systems contending with one another, armed with different concepts, would succeed the unity of a doctrine capable of reconciling all

> thinkers in the same perception - a perception which moreover would grow ever larger, thanks to the combined effort of philosophers in a common direction.
>
> It will be said that this enlarging is impossible. How can one ask the eyes of the body, or those of the mind, to see more than they see? Our attention can increase precision, clarify, and intensify; it cannot bring forth in the field of perception what was not there in the first place. That's the objection. It is refuted in my opinion by experience. For hundreds of years, in fact, there have been men whose function has been precisely to see and to make us see what we do not naturally perceive. They are the artists.[133]

Bergson sees, in the approach of artists, above even that of his own philosophical approach, a mode of apprehending the world that relies on intuition and subconscious processes - modes that work around the limitations of language and rational analysis. An approach to apprehending the world which synthesises not only different kinds of thinking, but multiple modes as well. The approach of the philosopher-artist which Bergson talks of, incorporates the entire field of experience without reducing it through the filter of objectivity. This state of knowledge cannot be translated into the realm of academic objectivity, for to do so would fundamentally reduce and compress that knowledge, and strip it of its context and its value. It works in an entirely different mode to reductive objectivity, and requires subtle recursive tricks, and eloquent conceptual shifts, to elucidate properly in words.

Unfortunately, as an artist, and not a philosopher or wordsmith, I have to rely upon means other than words to illustrate these subtle ideas to their full. In the creative work of the experiments undertaken in this research, the

133 Bergson, *The Creative Mind*, 134 - 135.

documentation of them, and the experience of them, the intention has been to extend consciousness outwards, to connect, and to encounter something truly other. This is present in the work of the colliding boxes, the smoke rings and the sparks. In all of these explorations of force, matter, energy, movement, and the understanding and perception of these notions, there is a fundamental tendency to extend consciousness into, and dwell within, the core of these concepts. It is through such an earnest search that the experience of the other comes about - of the possibility of extending the structures of knowledge, in their many facets.

The process of exploring knowledge that was initially laid out and extended here in this research, has led to other modes and approaches, other questions, and other possibilities. One of these was the arrangement and manipulation of found objects, as a way to untangle complex related memories, hopes, and dreams.

This way of working was discussed earlier in the chapter *folds of knowledge*[134]. Taking the simple elements of a meteorite fragment, snips of hair from when I was a child, and a recorder I made entirely by hand, turned into charcoal in the heat of a kiln, a set of floating personal associations develops between 3 such elements. Through a sensitive consideration of the material of these objects, their forms, how they came into being, and their associations

134 See *folds of knowledge*, page 92.

with memories and hopes, a delicate web of relations develops. In the same way that words can represent things and concepts, standing in for them, these objects embed ideas and feelings of potent personal significance, that can be arranged to explore meaning and understanding.

This kind of process leads to ever more exploration through play - the hair combines with the meteorite, life and death and our context within geological time - vast spans of time and the distance of innocent memories - the irreconcilable difference between a massive metal form floating for billions of years in empty space, and our own lives, so full of memory and meaning. The carbonised recorder, the hair, the meteorite, the carved wooden horse, pictures of family, tokens of past love - all of these things carry deeply significant personal meaning, and in relation to each other, allow for connections and associations to develop that shed light upon the past and the present. Below the verbal patterns and structures of words, the meaning that is in these objects becomes more fluid, more permeable and connective. Amongst these patterns and relations, understanding comes gently in soft open shapes that cannot be translated into the realm of language.

This is a simple alternate mode of making sense. The ability to play, to relax conscious control, to find multiples and allow their concurrent voices, to allow intricate webs of meaning and possibility to arise, to not reduce complexity down to singular resolved understanding. Such ways of working allow consciousness to extend past its own boundaries, and glimpse beyond the edges of itself.

These simple experiments, as well as the everyday extensions of consciousness and knowledge that constantly occur, involve both a leap of faith, as one reaches beyond the familiar, and also an acceptance of other, as one grows to become more. The morphology of extension takes on a form that synthesises definition

and relation - it is an incorporated, realised form of relation - embodied and actualised. Extension relies upon the initial state of definition, and results in a transformed state - an extended definition. This occurs in a loop - through definition, folding, and extension, through again, to continue on from renewed definition. It is this swelling action of expansion and motion that is characteristic of change and growth in knowledge.

shapes of edges

speculative morphologies of consciousness

Within form, fold and extension, the development that occurs in the life of knowledge structures has been explored. Tracing personal understanding through the experiments undertaken, and poring over their resultant documentation, has allowed glimpses into the processes of perception, the ordering of knowledge, and the fundamental recurring patterns that create the outer edges of thought. These comprehensions are subtle and intuited - they are tenuous - and become ever more so when words are asked to stand in for the lived experience.

The nature of consciousness and self-aware individual identities, gives rise to definition. Whether generated through the nature of our biological bodies, developed in

interaction with others, or simply fabricated intellectually to create the illusion of perceptual coherence, at the core of our being we each identify as separate individual identities. We are each at the centre of our worlds, yet distinctly aware of one another - aware of the shocking complexity that is the multitude of others, all equally important, equally complex, and equally potent as our own selves. We are each bound by our edges, yet we are multiple. Our importance, to ourselves, is obvious, yet we can become subsumed or lost in a sea of others as we live our daily lives. We are one of many. Such realisations are echoed through the patterns and structures of all our knowledge, from internal personal awareness, to observations of astronomical bodies in the night sky.

> According to the Keplerian revolution, not only has the sun left the center, but a myriad of suns exists. Absent, or almost absent from the first figure, the center is reproduced, multiplied, throughout the whole of the universe - its quasi nothingness is indefinitely sown. The astrophysical revolution has lost count. Subjects exist everywhere, amid light and shadow.[135]

Our definition as self throws the definition of every other into sharp relief. How is it possible to contend with the multiplied importance of every individual on the planet? In what ways can such an overwhelming situation be navigated with respect and sensitivity?

Considering the needs of other creatures on equal footing, and recognising the total environment as a seamless living system, the individual becomes enmeshed, and, as Michel Serres says, the centre is multiplied, everywhere. When we properly take on such concerns - responding from our individual positions - the vast expanse of importance everywhere around us leaves any sense of self seeming very inconsequential.

135 Michel Serres, *The Troubadour of Knowledge* (Michigan: The University of Michigan Press, 1997), 40.

It would be easy to be crushed beneath the weight of all else, lost amid the many. But through easing the edges of self, and flexing those boundaries, allowing things to pass through - sharing ourselves - slowly we become less solid, less prone to damage, more open to deep relation, and begin to feel broader, more inclusive, and more connected to that within which we are embedded.

A defined sense of self is perhaps the primal edge - in identity and in the modes of thought used to ration, analyse and control. The current state of conception that surrounds the idea of individual identity and consciousness forms the basic approach to apprehending the world around us. But it is a basic approach only - it is not necessarily a fixed and permanent defining feature - and it is most surely not the *only* method of acquiring and ordering knowledge. In understanding the fundamental roots of perceptual habits, of limited views, blind spots, and the edges of knowledge, the way forward to possible change and difference is opened. There are so many valid alternates and possibilities.

Drawing on philosopher Michel Serres again, one of the most tenacious aspects of modern knowledge that requires urgent address, is the tendency to qualify reality through objective rationalism, exemplified by the quasi-religious stature of science today, and the consequent blind faith in rationality and technology to support growth.

> I am attempting to extricate myself from the hell of dualism. Utterly pure rationality is a myth, it is a scared place, cleansed, purified through lustral procedures that expel the confused, the profane, the unclean, the victim, accordingly, excluding, in any event, for the greater glory and power of its new priests. Everyday rationality is religious, in an

> archaic sort of way; conversely, everyday myths often contain the seeds of reason. The opposition between science and what is not science, what is thus obscure, senseless, demented, falls at once into anathema, into schism or heresy, the history of our sciences looks so much like that of our religions that it's hard to tell the two apart.[136]

Modes of thought always blend together and are never pure - we use the tools close at hand for whatever issue we address. But it is *awareness* that is the beginning of conscious change, and like the miracle of self-awareness that is touted as the defining mark of humanity, perhaps a subtle form of self-awareness of the processes of knowledge, can help to liberate it from habitual patterns and narrow linear pathways of development.

This research began with the notion of *form*, the initial creation of a bounded identity, defining a single subject from its environment. Through the *act of forming*, a static section of apprehension was created, representing a cohesive identity with obvious outer edges. The perceptual creation of a unitary identity with clear limits.

The creation of form was tracked through notions of self and nations, across microscopic to galactic scale, and through concerns of psychology, biology, chemistry, linguistics, physical acts of experiment, and beneath all of this, epistemological concerns. The cursory examination of so many varied areas revealed underlying patterns repeatedly recurring in apprehended reality. The common factor in all of these varied explorations is the individual conscious process of apprehension and conception - structures of knowledge. Through examining the commonalities in vastly different modes of representation and knowledge,

136 Serres, *Genesis*, 131.

the general character and nature of the act of *forming*, began to emerge. The tendencies of knowledge to edge the world in certain ways were glimpsed, between the concerns of these varied explorations.

But form is deceptively singular, and as Georges Bataille has so eloquently written, when examining the matter closely every unity is a part of a greater group, and is also comprised of ever more divisible unitary elements.

> In a general way, each element capable of being isolated from the universe always appears like a particle susceptible of entering into the constitution of a group which transcends it. Being is always a group of particles whose relative autonomies are maintained. These two principles - constitution transcending the constituent parts, relative autonomy of the constituent parts - order the existence of each 'being'.[137]

The notion of defining a form was seen to be dependent upon perspective - scale, resolution, and context. A community made of individual people, and individual people coming together to form a community.

The notion of *fold* was explored to follow on from *form*, where relations are drawn and comparisons and connections place the subject alongside others, and within a general environment. In the act of *folding*, the re-presentation of the known through its relation with the unknown, echoed the notion of self and other identities, across the chasm of what is unknown and what is other. An incorporation of elements from outside, building internal representations and relations. Through this act, responsibility blossoms for some greater understanding, and there is the hint of broader possibilities - of being something else - of being more. In this burgeoning relation there is a constant navigation between what

137 Bataille, *Inner Experience*, 85.

is within and what is outside. In between these tenuous distinctions parts of the outside world are inevitably claimed, and representations of them folded within. Knowledge learns and grows. This is of course happening constantly, and is the only reason why we each have conscious thought and understanding - we have mentally folded parts of the world within.

In folding the world within, and abiding in it together with others, the world becomes complex, layered, and deeply inter-related. This complex mesh is constantly shifting - the very idea of relation suggests moving agents and variable forms of connection. Somewhere amidst this constant motion and change, a sense of defined identity is maintained (or fabricated). The illusion of coherence. But if this unity is probed too closely, it reveals itself to be more permeable than imagined.

> The whole mechanism of generating ourselves as describers and observers tells us that our world, as the world which we bring forth in our coexistence with others, will always have precisely that mixture of regularity and mutability, that combination of solidity and shifting sand, so typical of human experience when we look at it up close.[138]

The more the simplest matters are considered, the more complex they seem. The folds of relation complexify simple edges through connections without and within. While they build and strengthen definition through comparison, they equally erode it, calling into question the strength and actual presence of those clear boundaries, through the fluidity of connection and the migration of representation across edges.

The notion of *extension* was examined lastly, where the initial form and scope of defined edges were expanded and transformed, becoming more inclusive. In the act of

138 Maturana and Varela, *The Tree of Knowledge*, 241.

extension, the folds of relation solidified to reconstruct the defined borders of identity, with an equal action in two directions - as the other was drawn inwards, and identity expanded outwards. The edges were then re-negotiated - such as when incorporating new ideas through learning, developing new skills, or broadening understanding to include more than it previously encompassed. Ideally this act is neither one of domination or of being dominated, but is rather a shared commonality, and a move towards greater connection. Extension necessarily overlaps - it is a layering of contexts that further complexifies identity and relation, through multiple connections.

The nature of extension, like that of the fold, relies on the initial boundary of form, and in its action, alters and transforms that initial boundary - the result is an expansion of the defined form. Following the action of forming through folding, and into extension, the process begins again in re-definition of a form, as an endless loop of negotiation - defined forms, relations and transformations. The process is seamless and these actions interleave between one another. Separating them out into form, fold and extension, is a crude tool for further understanding. It is an understanding of knowledge that is the main focus of all that has been considered here - a greater comprehension of the processes of thought and understanding, specifically in the definition of borders and edges.

To escape the common actions and structures of knowledge has not been the aim of this research. This research has traced the subtle apprehension of processes of thought, in order to better understand the process. These processes occur through the nature of perception, and the framework that orders memory and habits of thinking - directed and focused through the seeming coherence that knowledge projects of itself. This understanding of *the shapes of edges* - of

the notion of boundary and the role of knowledge in its creation - has been explored through the creative experiments in form and force, and this written thesis. The personal effect of such a comprehensive and extended research project, combining thought and creative action, continues to play itself out in continued artistic works, and in personal daily processes of thought. There is an underlying appreciation for the processes of self-awareness, and of what it means to engage in the wondrous act of knowing - an act that forms our basic connection with the world. There is a great sense of responsibility in this. Such structures of knowledge create our basic approach to living in the world - of relating to others and our environment, of siting ourselves within society and environment, and of the use and abuse of energy and material for personal needs and desires. The way the world is approached is based upon these structures of knowledge - it informs science, morality, economics, conflict, friendship, and love. Though a better understanding of these processes of knowledge, a greater level of self-awareness begins to emerge. The result of such awareness is a re-negotiation of our relationships, to one another, the other species we live with, and the greater environment we share.

> The knowledge of knowledge compels.
> It compels us to adopt an attitude of permanent vigilance against the temptation of certainty. It compels us to recognise that certainty is not a proof of truth. It compels us to realise that the world everyone sees is not *the* world, but *a* world, which we bring forth with others. It compels us to see that the world will be different only if we live differently.[139]

139 Maturana and Varela, *The Tree of Knowledge*, 245.

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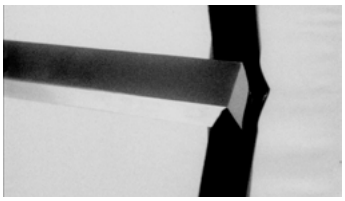
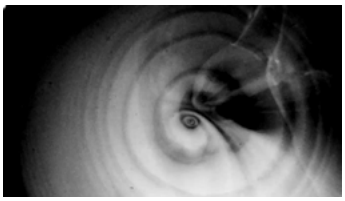
appendix i - catalogue of works

A full visual documentary record of the work to be presented for examination is not available, so the catalogue of works below is in written form, supplemented by indicative images only[1]. A sufficient amount of visual material is contained within *appendix iii - process and visual documentation*[2], to enable assessors to come to a preliminary judgement of the quality, style, and format of the work.



collide, video work. Transferred from 16mm slow motion footage and analogue audio recordings, presented in rear projection with 2.1 audio. 6 mins. 2013- 2016.



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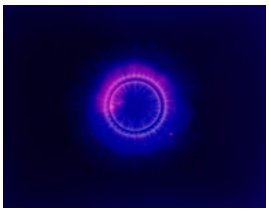
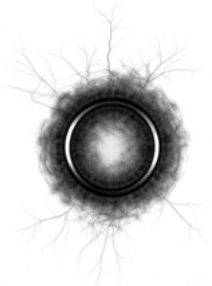


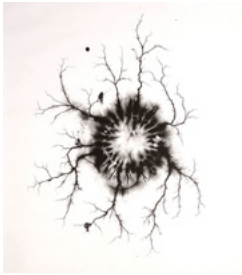
spark rings (series of 29), boxed backlit images. Electrophotonic direct negatives and positives displayed by backlighting in custom wooden boxes. 24 small (11 x 13 x 8cms) and 5 large (24 x 26 x 13cms). 2016.



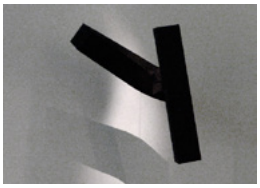
threshold (series of 4), framed prints. Electrophotonic images from scanned negatives enlarged as pigment prints. 95 x 72 x 6cms. 2016.

1 A full visual documentary record of the work presented for examination is requested by the University, *if available*. Source - "PHD THESIS PREPARATION GUIDELINES," accessed July 16, 2016, http://sydney.edu.au/sca/docs/current-students/PhD_Thesis_Prep_Guidelines.pdf.

2 See *appendix iii - process and visual documentation*, pages 189-233.



photonic (series of 3), framed prints. Large-scale electrophotonic images enlarged through traditional silver emulsion processes, in collaboration with Chris Reid at Blanconegro. 88 x 98 x 6cms. 2016.

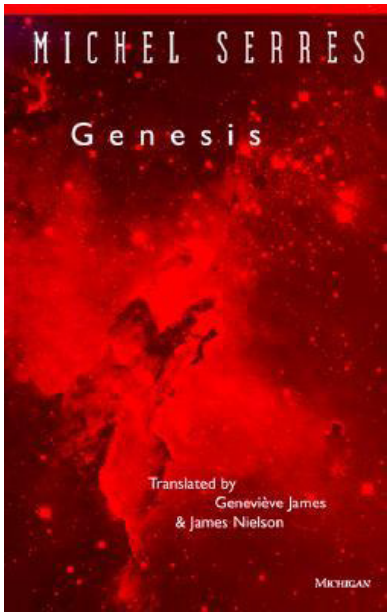


collided pairs (series of 3), wall-mounted copper and steel box pairs. Pairs of boxes mounted on the wall to reveal the energetic exchange and deformation of their collision. 30 x 20 x 12cms. 2016.

ephemera (series of 14), wall mounted objects. Objects and images collected, manipulated, and arranged. Dimensions variable: 5-40cms. 2013-2016.

appendix ii - literature review

The general content of the literature review has been integrated into the thesis body, in references, discussions, quotations and footnotes. However, for ease of understanding, 7 primary sources are identified here. These sources are briefly described to provide an overview of my main references, while also showing inspirations for style, content, and approach, as well as justifying my basic conceptions, and placing this thesis in an academic context.



Genesis, Michel Serres, 1982.

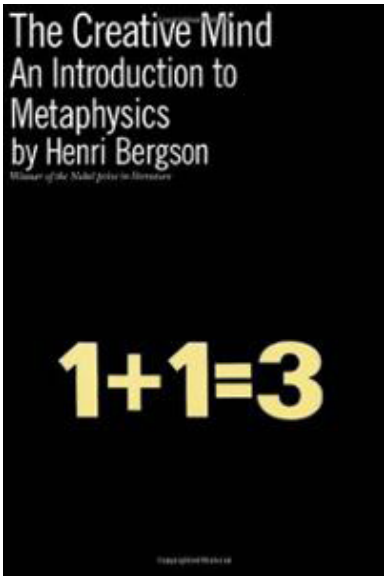
The French Philosopher Michel Serres explores the nature of order, knowledge, power and violence in the lucid prose of this work that often explodes in turbulent passages of complex associative meaning. Tracing the nature of knowledge with the notion of the noise of the universe (which in the original French, has linguistic connotations of an immanent outbreak of violence), Serres draws upon a vast range of topics, from mythology and poetry, to epistemology and continental philosophy, anthropology and psychology, and studies of technology and science. These diverse strands of knowledge are connected and multiplied against one another, seeking what we perceive as common fundamental structures, as well as inconsistent patterns of thought, all the while focused on the need to break loose of conditioned modes of rational thinking.

The book rails against all forms unity and centricity, championing the notion of multiplicity and emergence, and deriding rational attempts to grasp the complexities of reality through linear thought and categorisation.

Many are the places where people believe, where, above all, they make people believe, that one can understand through concepts, that it is possible to construct and finish construction, from the foundations to the rafters, to develop, from the cell to the organism, that it is possible to deduce or relate otherwise than as a fool or player, that to dominate and anticipate, in theory and practice, is done by being clear-cut and axiomatic, in closure, whereas there is always only a multiplicity. Institutions always seem to be founded on this lack, situated on the narrow slit from which the incompletion could be seen, they obstruct the opening in shadow, and crown the misrecognition of this cognition. Their cornerstones are rolled in front of the tomb or the entrance to the underworld. Like Ulysses or Aeneas, the philosopher must at least once in his life, enter in and go down, speak to the obscure shadows that cannot take shape, and rake over the ashes. And he must avoid being seated on the stone and carrying on the discourse of the deaf establishment. It would seem that power has the role and function of making people believe that both concept and reason, closure and domination exist, where there is only ever pure multiplicity without any unity. Ruins, monsters and dreams, and time without redundancy - these always come back, in spite of the crude endeavors of these machines to transform the noise and fury into all sorts of order, discourse, harmony, sense of history, architecture. We are ceaselessly trying to repair the not very reliable machinery that is there to make the confused noise gel and the fury crystallize, but the noise exceeds its capacity. The noise

> is more powerful than its mechanical force. I mean: incalculable. I mean: measureless. It always exceeds the machines' capacity for calculation. Yes, politics weaves together the rational and the irrational, but this tissue, rational, is ripping apart indefinitely, it is a tatter... (pp 126-127)

Genesis is largely unstructured in the typical sense of a philosophical text, consisting of a series of prose-like chapters that are based around mythological narratives. The experience of reading it is enriched by constant re-reading, much like any other good work of poetry.



The Creative Mind, Henri Bergson, 1903-1934.

Henri Bergson was an internationally respected philosopher during his time, being a winner of the Nobel prize in literature, but is today much less known. *The Creative Mind* is a collection of writings exploring knowledge, intuition, and Bergson's core concept of time and change, *durēe*. The understanding of Bergson's writing are complicated by his concepts, which require a certain faith in intuition and the processes of imagination, in order to be apprehended. This of course does not sit well with many common critical approaches to philosophy and thought that are based upon reductive rational understanding.

Bergson explores the nature of knowledge and consciousness, with emphasis upon direct experience and analogies, rather than on abstract thought and logic. His approach of embedding perception into direct experience goes against the standard rational approach of defining a distance between the knower and knowledge, especially as it related to the written word.

> For the complication of the letter must not allow the simplicity of the spirit to be lost to view. If we confine ourselves to doctrines

> already formulated, to the synthesis in which they appear to embrace the conclusions of earlier philosophies and all the forms of acquired knowledge, we run the risk of underestimating the essentially spontaneous aspect of philosophical thought. (107)

The Creative Mind is structured loosely as an exploration of knowledge that focuses later upon time, and eventually diverges into several essays that are either of historical value or explore the work of other thinkers. As it is a collection of essays, some written much earlier than others, it shows distinct phases of thought. Its limitations are mainly ones of access - it is exceedingly difficult to comprehend simply, and must be allowed to develop as experiential thought. For this reason, it was essential that the writing in my own thesis was more accessible, and I have attempted to create this. Bergson's writing is also 80 years old, and this shows in certain notions of scientific thought, though these are minor issues.

Inner Experience, Georges Bataille, 1943.

Georges Bataille was a French philosopher who also wrote upon literature, anthropology, economics, sociology and art. He is widely known for *The Accursed Share*, which examines an economy of excess as a universal notion, applied especially to sociological structures. Inner Experience is similar in style, but much more metaphysical in content, often dwelling in bouts of self-pitying doubt, but also rising to ecstatic praise of passion and direct experience. The book is essentially mystical in content, though entirely against religion. It explores the nature of division in having a defined identity, and the desire for connection, through understanding, sex, and many other forms of interaction. The approach outlined in the philosophy is one of direct experience, of shunning the kind of rational critical that

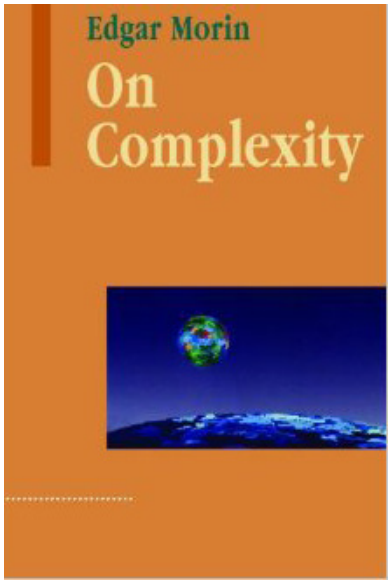
distances oneself from such experience, and of allowing the more base and socially unacceptable aspects of personality to play out and reveal the "truth" of one's nature.

The notion that sole authority resides within the individual, is of deep importance in this text, and that the only path open to its development is through trial, travail, and ecstasy - direct experience.

> To ask oneself before another: by what means does he calm within himself the desire to be everything? Sacrifice, conformity, trickery, poetry, morality, snobbery, heroism, religion, revolt, vanity, money? or by several means together? or all together? A wink of an eye in which glimmers a deceitfulness, a melancholy smile, a grimace of fatigue together betray the disguised suffering which the astonishment at not being everything, at even having concise limits, gives us. A suffering so difficult to acknowledge leads to inner hypocrisy, to solemn distant exigences (such as the morality of Kant).
>
> On the other hand, to no longer wish oneself to be everything is to put everything into question. Anyone wanting slyly to avoid suffering, identifies with the entirety of the universe, judges each thing as if he were it. In the same way, he imagines, at bottom, that he will never die. We receive these hazy illusions like a narcotic necessary to bear life. But among babblers in a night in which we can only hate the appearance of light which comes from babbling. This self-acknowledged suffering of the disintoxicated is the subject of this book. (xxxii)

Inner Experience is loosely structured as a pessimistic and base kind of development from servile innocence to

spiritual ecstasy (though it is obvious that this is always partial and cyclical and never complete of fulfilling). It has received much negative reception, especially for its indulgent, self-pitying and slightly depraved approach, and this is where its main flaws lie. But this is also its greatest strength, for it follows through, in stylistic form, from its content of an indulgent, self-pitying and slightly depraved approach to self-realisation.



On Complexity, Edgar Morin, 1976-1990

French philosopher and sociologist Edgar Morin is widely known in Europe and Latin America, and has been pictured o the cover of various French publications, yet, his works have not been translated into English except for *On Complexity* (one earlier translation, of La Mēthode, notoriously difficult to obtain, is so dry and badly translated as to render it totally useless). This book explores complexity in knowledge through various areas including statistics and computational studies, linguistics, the philosophy of science, sociology, and anthropology. The aim of the book is to address the need to reform thinking, addressing the current development of knowledge as a problem with historical roots that need to be acknowledged and rectified. His specific focus is upon systems thinking and complexity within knowledge, and the benefits such alternative possibilities hold for a re-balancing of knowledge, which he sees as requisite before any changes in our current move towards ecological disaster can be amended.

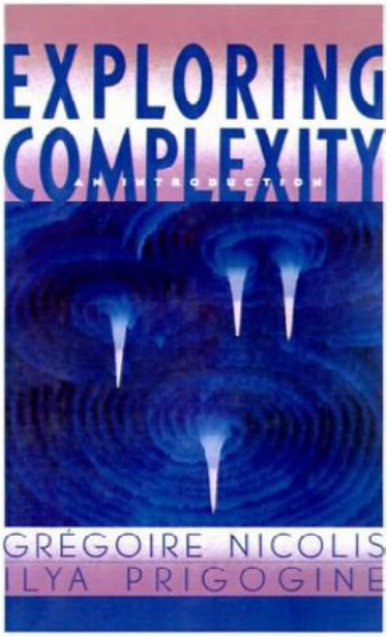
Morin is particularly critical of structures of thought that arise from sectors of society that are interested in maintaining their own security. The criticism of power, as a motivating force in the seeking and storage of knowledge, and the use of knowledge as a tool of power, are covered extensively.

The fracturing nature of reductive thought is also

criticised, in relation to power and economy, but also in relation to the individual and his or her ability to comprehend the underlying connections between specific fields of knowledge.

> Whereas the media produces mass ignorance, the university produces high ignorance. The dominant methodology produces an increasing obscurantism: because there are no longer any links between the disjointed elements of knowledge, so there is no longer an opportunity to truly absorb them and reflect on them.
>
> We are approaching an unprecedented mutation of knowledge. Knowledge is less and less made to be reflected upon and discussed by human minds, and it is more and more made to imprinted in memory banks and manipulated by anonymous powers, particularly by nation states. The new, massive, and prodigious ignorance is itself ignored by scientists. Scientists who do not practically master the consequences of their discoveries, do not control the meaning and nature of their research, even on an intellectual level. (4)

Morin's style is clear and well ordered, forming a distinct foil to the previous two literary review sources, which are particularly dense and prose-heavy. *On Complexity* charts the structure of knowledge in a way that makes sense of history of thought, modern developments, and hopes for the future. Its structure is simple and straight-forward, chapters following logically, with the addition of 4 supplementary essays giving context to Morin's broader concerns. There are no obvious flaws top this work and it is a template for successful writing of dense and complex content.



Exploring Complexity, Grēgoire Nicolis and Ilya Prigogine, 1989.

Grēgoire Nicolis, a Greek physicist, and Ilya Prigogine, a Belgian chemist and Nobel Laureate, unravel the complexities present in reactions far from equilibrium, using them as a basis to explore order, self-organisation, the genesis of life, knowledge, and climatic change, eventually posing such a wide range of questions, all with similar problems, so as to reveal possible fundamental models for organisation, living or otherwise.

The book is dense and based in chemistry and physics, yet wanders often into realms of sociology and epistemology, making for a difficult yet engaging read. Written by scientists with a firm footing experimental research, the book often refers to instances directly observed through their research. Taking these findings further, they are applied to various other contexts, looking for alternate methods of modeling and understanding complex systems of organisation.

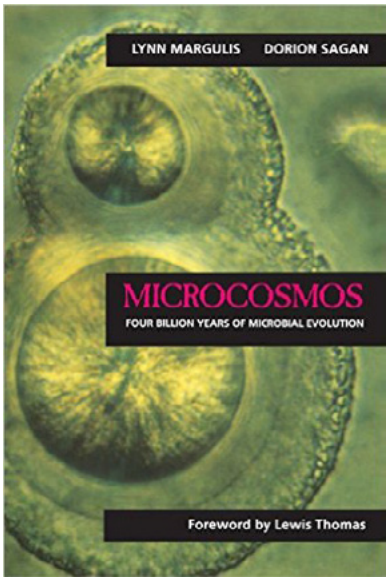
Ultimately, Exploring Complexity returns to knowledge, and its role in the perception and understanding of complex systems.

> Understanding what is going on around us is equivalent to building models and confronting them with observations. This statement may sound like altruism to a physicist of a chemist, but it goes far beyond physics and chemistry. At each moment our sensory systems scan the surroundings, the brain registers and compares the observations with respect to images already formed, and eventually reaches a preliminary conclusion. One of the basic steps in this procedure is the extensive use of *analogies* and *archetypes*. (217)

In this reflection of experimental research back upon the nature of perception and knowledge, this text is

invaluable to the approach of my own doctoral research. The content, while overwhelmingly dense, portrays not only a rich description of natural processes dealing with self-organising systems, but also does so in a way that respects the nature of matter and does not attempt to reduce it to abstract terms.

The structure of the book follows a line of thought on the nature of complexity, moving from nature, experiments, dynamic systems, proposed theories, and finally to the role of knowledge and its entangled nature within the notion of complexity. The book is simply and eloquently written, and the only criticism of it would be its accessibility to general readers such as myself - it is particularly dense and some sections were inscrutable to me. I have adjusted my own writing in relation to this and hope that it is more accessible in the areas that I am all too familiar with.



Microcosmos, Lynn Margulis and Dorion Sagan, 1986.

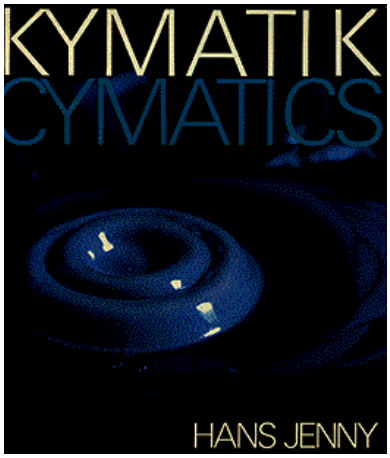
Microcosmos is written by mother and son team Margulis and Sagan, and charts the evolution of biological life through simple chemistry, microbial development, and more recent complex beings. Its focus is upon the microbial world and it follows the functional and morphological changes of single cells to their transformation into multicellular life-forms, their symbiotic relationship as single-cellular forms residing within more complex beings, and the interdependency of life which they so characteristically embody.

In its research into the microbial world it explores notions of what defines a life form and what constitutes a singularity. It delves into the very philosophical question of what life is, and, by giving many examples from biology, but giving no clear answers, it opens up more to possibility, than it closes in on definition. This

opening up of possibility allows the reader to enter into personal construction of understanding - to properly reflect and consider what constitutes each being.

> It is not too whimsical to say that if we feel at loose ends, of two minds, beside ourselves, going to pieces, or not together, it is probably because we are. Real organisms are like cities: Los Angeles and Paris can be identified by their names, by their city limits, and by the general lifestyles of their inhabitants. But close inspections reveals that the city itself is composed of immigrants from all over the globe, or neighborhoods, of criminals, philanthropists, alley cats, and pigeons. (125)

The book is structured well and beautifully written to allow understanding by general readers, but includes a great wealth of accurate and detailed information on microbial life and evolution. As such it is another valuable resource not only in terms of content and approach, but also in terms of structure and style.



Cymatics, Hans Jenny, 1967.

Subtitled *The structure and dynamics of waves and vibrations*, this book is largely photographic, and covers an extensive research into rhythmic structures and patterns formed in natural materials through vibration, sound, heat, chemical and entropic processes.

Experimental in nature, laying somewhere between a creative art practice, a scientific process, and a philosophical rumination upon epistemological concerns, the book explores the nature of vibration through experimental means, looking for aesthetic and structural cues rather than pulling apart rationed elements in the search for understanding. He not only describes what he perceives, but also the way he has gone about his experiments, and even more importantly,

his approach towards understanding through these physical experiments.

> The creation of purely philosophical ideas, which paints Nature in mental images is likewise incapable of grasping existence in its vital plenitude. It is "above" the really real. Even this speculative philosophy cannot penetrate the mystery of existence in all its fullness. This will only reveal itself progressively if we do not merely analyse it and anatomize it to a skeleton, if we do not merely try to take mental possession of it but instead patiently attend upon it, neither raising ourselves above it or killing it. However much it may seem that "nothing" is thus achieved, this close observation is nevertheless the way that renders sources of knowledge accessible to research, enables the seeker to stay the course, and confers vitality. It will inevitably become apparent in the course of our descriptions whether this method of observation and more observation, whether this preservation intact of what is observed, this non-interference with the phenomenon, will elicit the basic outlines of phenomena and reveal something intrinsic and essential." (92-93)

This approach to understanding issues of knowledge through the generation and documentation of experimental processes that explore natural pattern and form, has been very influential in the style and format of my own processes. While I have developed methods and approaches towards understanding of my own experiments, the validification of my approach is greatly helped by such a seminal work as this.

> ....analysis is essential, but the eye and the brain must restore what they have dissected

> to the active phenomenon and reintegrate it with the complex reality so as to see it again in the nexus in which it is alone existent. (152-153)

The book is well organised into sections that mark visual difference in the observed experiments and resultant forms. The writing is vague and ruminatory, and allows the reader to enter into the act of perceiving what he has documented. It is a remarkable book that is largely unique, and has obviously influenced the style of writing in this thesis, especially when discussing the observances of the experiments undertaken.

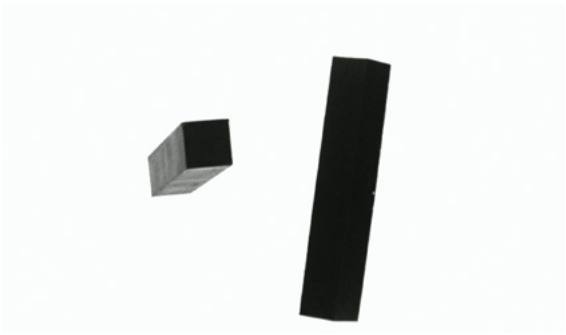
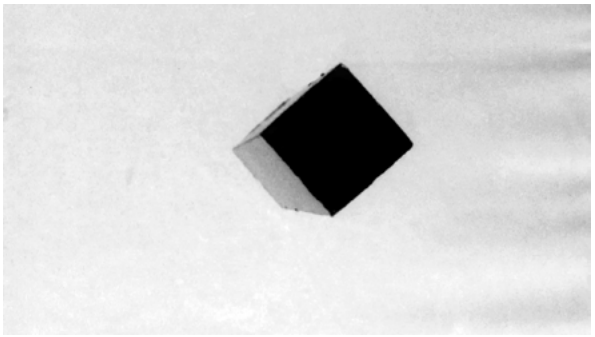
appendix iii - process and visual documentation

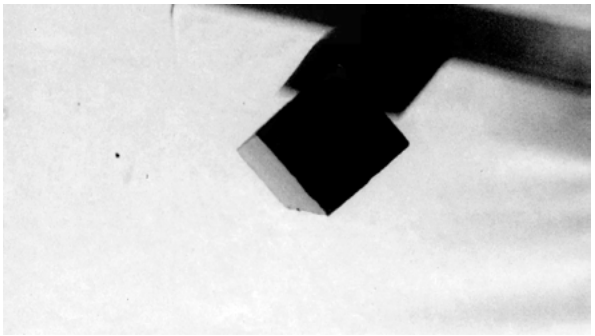
The following pages contain documentation of the experimental processes and their visual outcomes in an informal manner. It covers the box collisions, the smoke vortices, and the spark discharges. This appendix has been gathered from a vast array of documentary images that record the processes and their outcomes over the span of 4 years. Quotes, relevant to certain instances and also to the overall approach, litter these pages. While most images are labelled, some remain visual only, for words can sometimes confuse matters that are better presented simply through pictorial means.

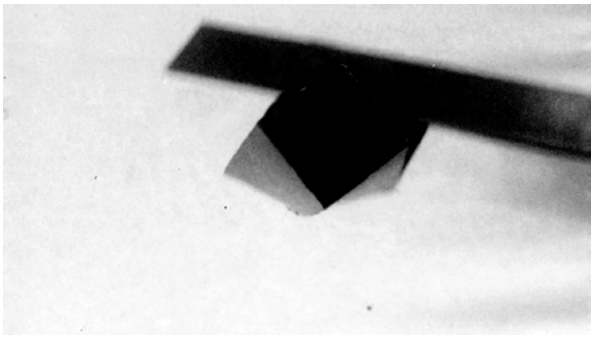
**What is the aim of art if not to show us,
in nature and in the mind,
outside of us and within us,
things which did not explicitly strike
our senses and our consciousness?**

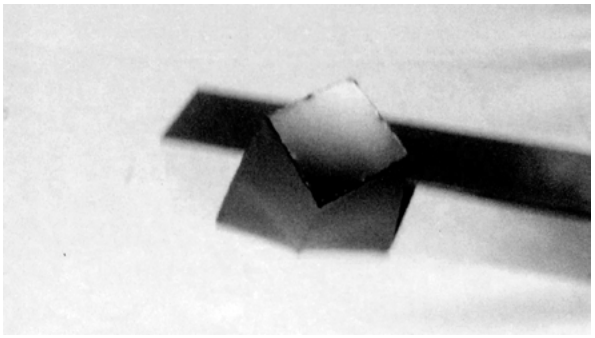
Henri Bergson, *The Creative Mind*, 135

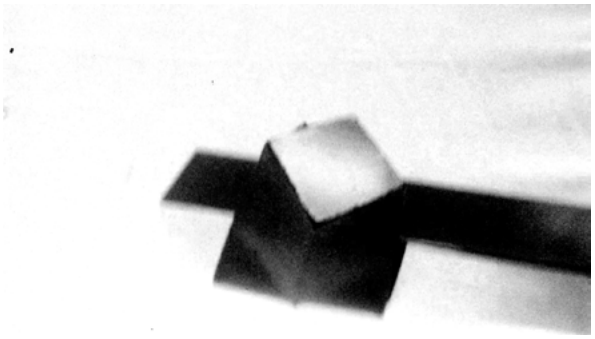
box collisions

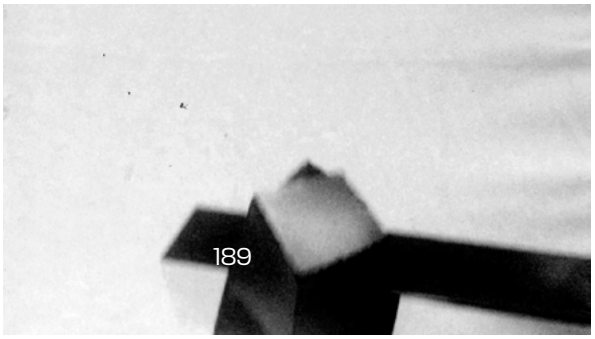













...measurements are the entanglement of matter and meaning.

Rick Dolphijn and Iris van der Tuin, *New Materialism: Interviews and Cartographies*, 15.

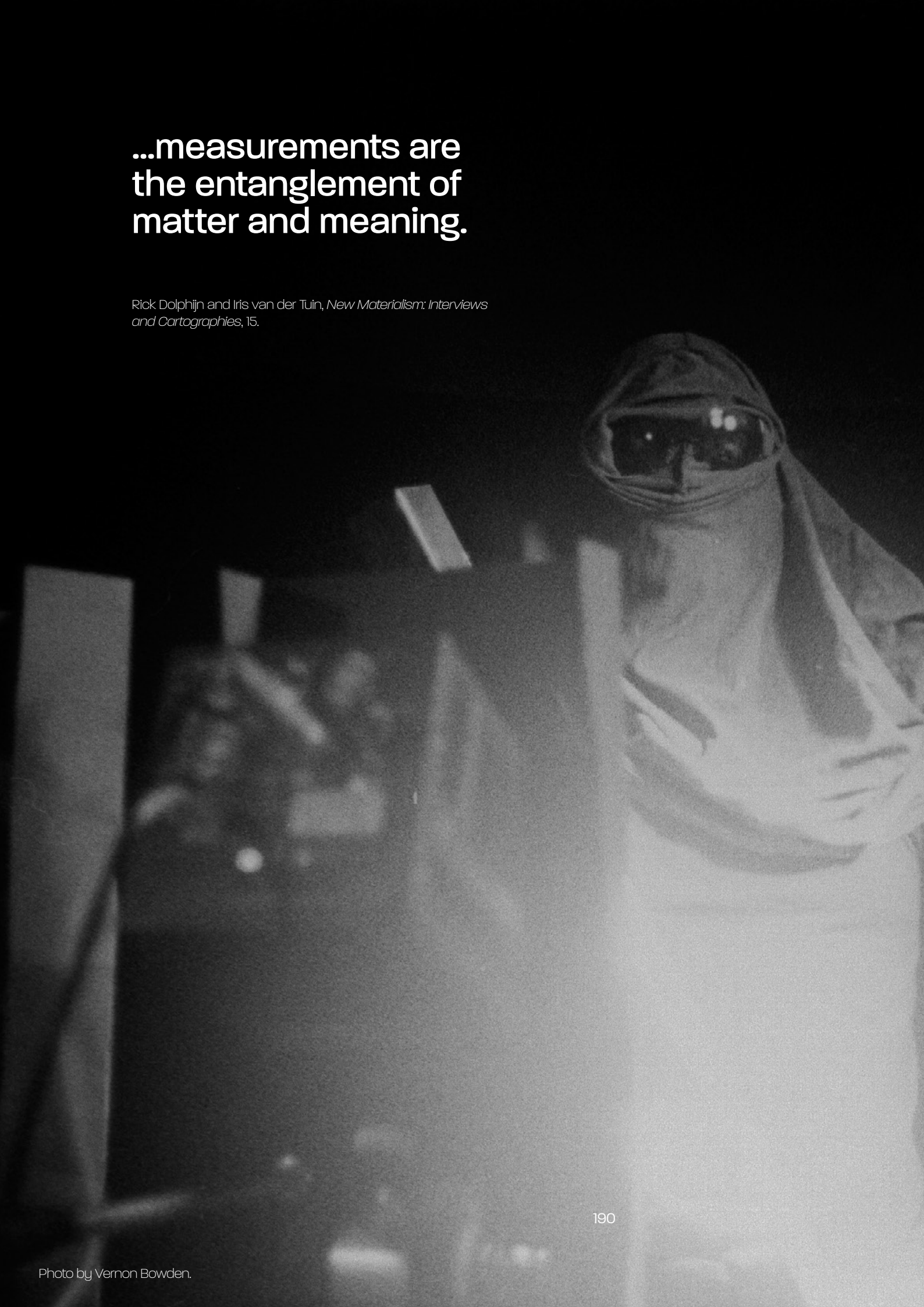
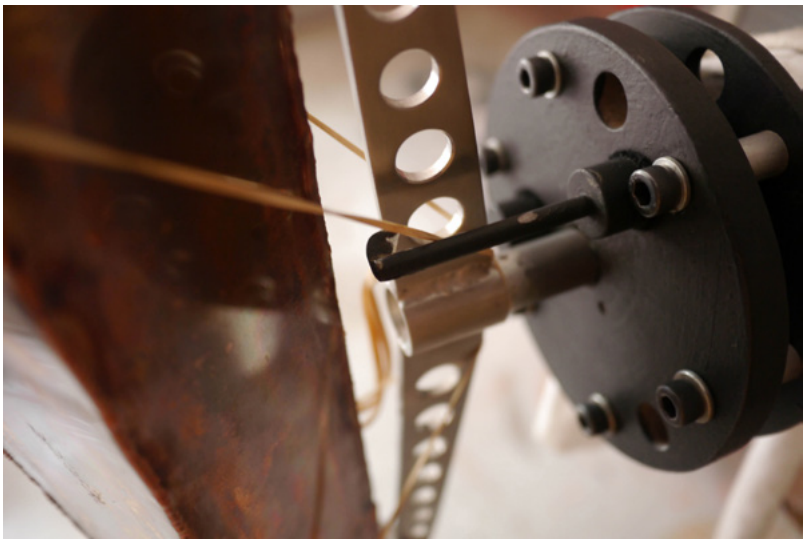


Photo by Vernon Bowden.

Box colliding machine versions 1, 2 and 3.
The first colliding machine (top two pictures), was made from steel and wood, using motorcycle springs primed by a winch to propel the boxes, which were held in cradles that slid along dual rails. Obviously, over-complicated. 4m in length, this was the first successful machine, although there were many hiccups in its construction.
The second colliding machine (middle two pictures), was made of steel and pvc pipe, using compressed air triggered by solenoid valves, the pressure acting upon pistons to fire the boxes. A central compressed air tank supplied each piston with enough air through 2" pressure hose.
The third and current colliding machine (bottom two pictures), is actually two identical separate machines, made entirely of welded steel with a plastic sleeved lining running a carbon-fibre piston. The piston has u-cup seals and is under constant pressure, being released by a 3" electromagnetic catch. At half its estimated rating of 30lbs/in^2 pressure, this machine throws copper boxes so hard that it smooths down the corner welds on the copper box edges when hitting a polished steel bar.

Box colliding machine version 3 testing. Machine with piston extended to full 90cms of travel, and box held in launching cradle (top picture). After many attempts at mechanical catches to hold the box to the cradle prior to launching, using complex sets of springs and magnets, it turned out that the best option was a rubber band (second from top picture). The rubber band is cut with a small knife edge just after launch. The first trial at 30psi air pressure resulted in a strong deformation of a welded copper box against a steel bar (bottom two pictures). With the other of the machine pair built and in use, the forces will be doubled, and there will be ample force to properly deform the boxes. The only downfall is that the moving speed of the boxes has increased, and resulting video work will not be as "slow motion" as was initially hoped for....



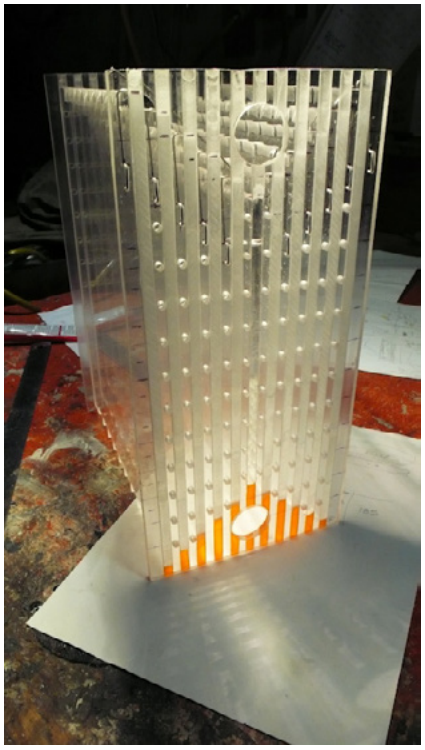
...instruments are just materialized theories.

Gaston Bachelard, *The New Scientific Spirit*, 62.

...the form of an object is a diagram of forces.

D'Arcy Thompson, *On Growth and Form*, 11

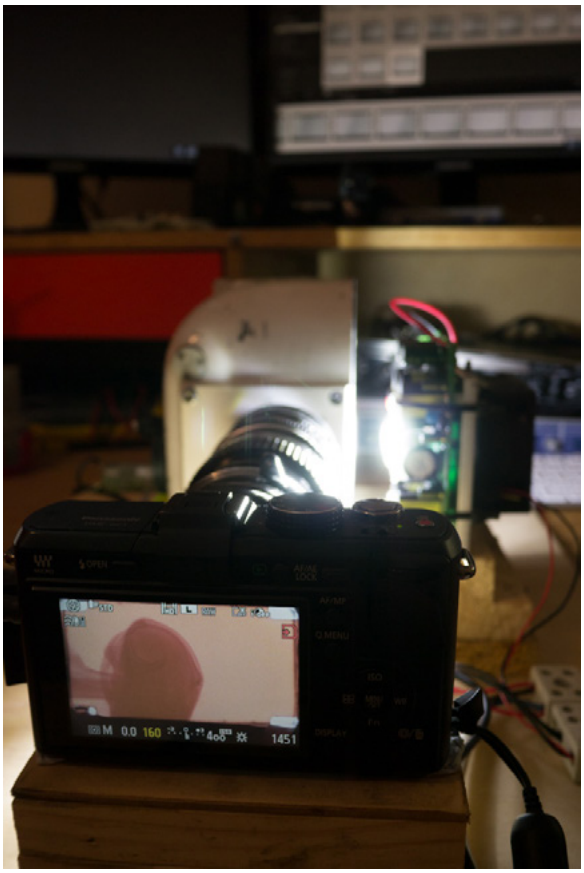
In order to closely observe the minute details of the box collision experiments, slow-motion visual footage was recorded. 16mm slow-motion film cameras were bought (and often repaired), from various places - film companies, laboratories, and even NASA. The Milliken pin registered cameras (top two pictures) shoot film at 500 frames per second in high quality (no internal optics). The NAC cameras (bottom two pictures), the last and most advanced slow motion film cameras ever made, shoot film at 10,000 frames per second, but at reduced quality due to an internal spinning optical prism. Both require insane amounts of light to expose film properly. The Milliken cameras are by far the most useful, and after owning several other cameras, including a Redlake Hycam, an old Hitachi, and even a costly secondhand digital Weinberger camera, the Milliken is still most suitable for my purposes. I currently own 6 Milliken cameras - two broken units, one made into a telecine capture unit, and three working models that are used to film these colliding boxes and smoke vortices.



Film development was initially undertaken by a lab, although I soon started developing myself, first using a large bucket to swish around 50 feet of film, and soon afterwards constructing a spinning reel with sliding partitions to hold 100 feet of film, easy to load in complete darkness, all contained in a matching dark box with a light-trapped liquid valve for entry and exit of developing chemicals.

Drying of the film was initially by stringing it around the bathroom, very quickly improved by turning my shower into a dust-free fan-ventilated drying unit.

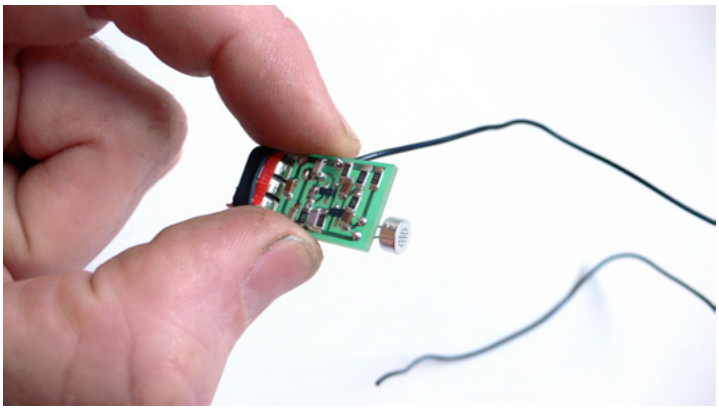
Transfer of the film was done once by a telecine lab, the cost of which forced me to develop my own system from a broken high speed camera, adding a mirror and led backlighting of the film, several switches and motors to automate the transport, a lovely old Lumix GF-1 with a Nikon macro lens and several extension tubes, and a very large memory card to hold the images. This setup takes 4K images of each frame, advancing automatically every 3 seconds. This transfer camera now has a shutter count of over 250,000 !!!

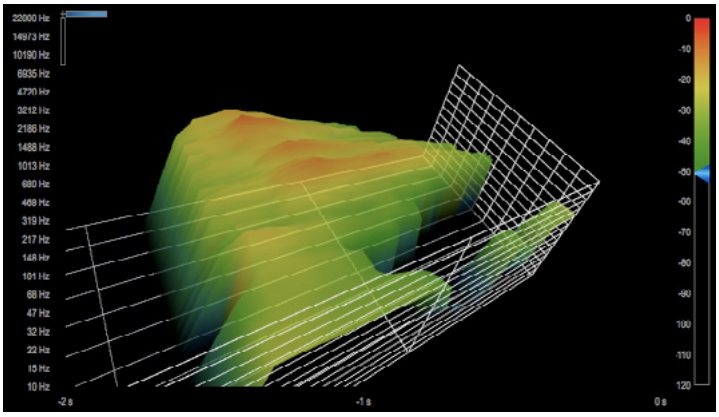


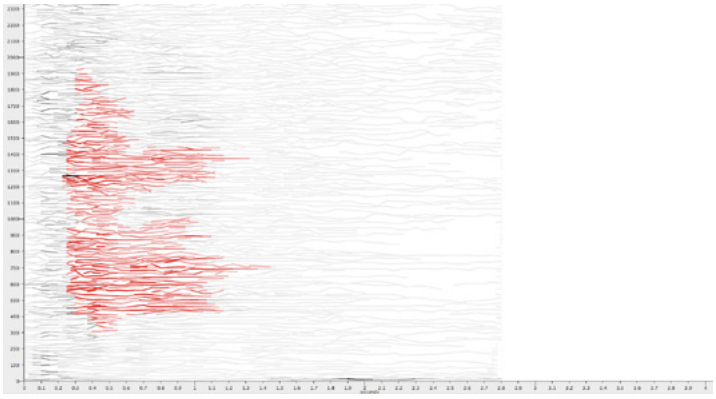
In all disciplines, reductionism offers an enormously useful handle to allow scientists to insert their in- strumentarium, their paradigms, and to produce long series of practical effects - often entire industries as is the case with biotechnology. But success at handling entities by generating results and entire industries out of them is not the same thing as building the cage of nature with its long chains of causes and consequences. It is actually the opposite: what reductionism shows in practice is that only the proliferation of ingenious detours, of highly localized sets of skills, is able to extract interesting and useful results from a multitude of agencies. Consider how fabulously useful the "Central Dogma" of the first versions of DNA was in beginning to unlock the power of genes: and yet no active bi- ologists now believe that these earlier versions could be of any use for building the "naturalistic" definition of what it is for an organism to live in the real world. There is a complete - and continuously growing - disconnect between efficient handles and the staging of nature. Once you put to one side this proliferation of clever skills, you are not defin- ing the nature of things, you simply enter into something else entirely: the spurious continuity of nature. And the same thing could be shown every time you move from reductionist handles to reductionism as a philosophical - that is, a political - worldview.

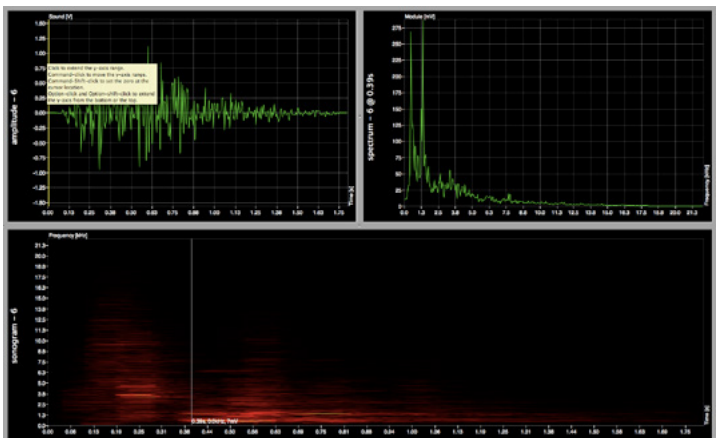
Bruno Latour, An Attempt at a "Compositionist Manifesto", in *New Literary Journal* 41 (2010), 483-484.

Photo by Vernon Bowden.

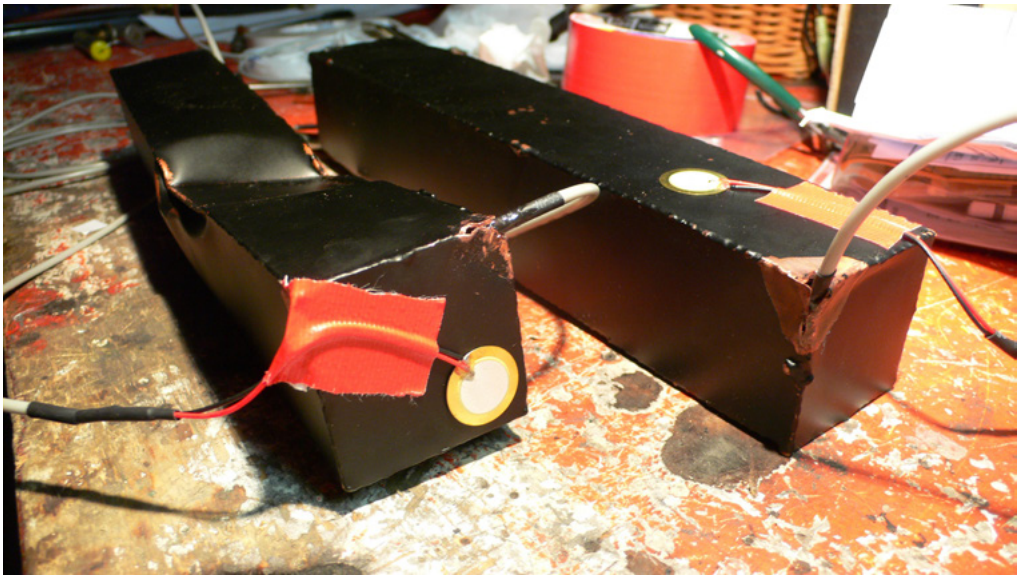


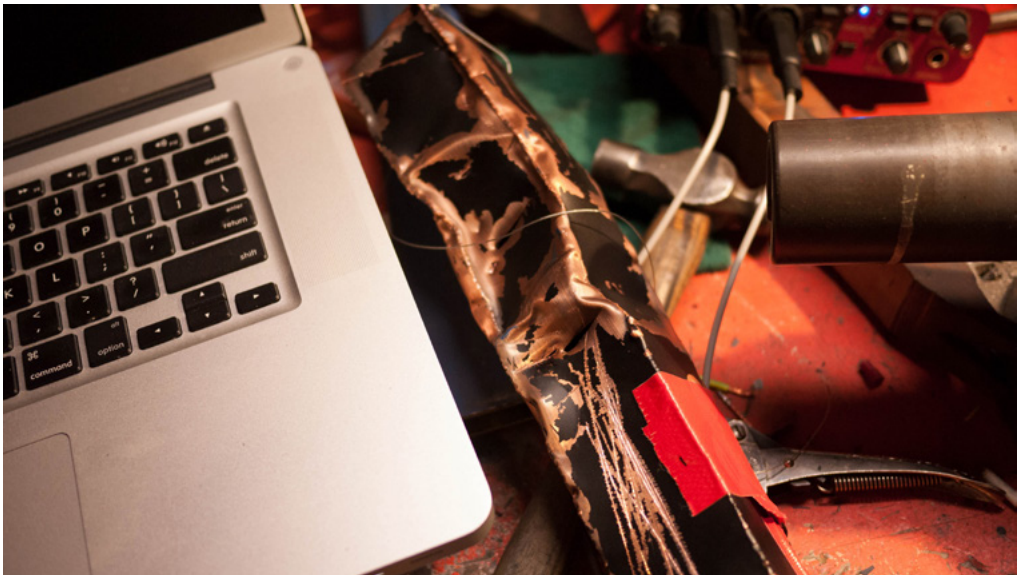






The sound and vibration of the collisions has been recorded to match the visual records. As an evolving processes, audio capture methods have included constructing and embedding small wireless FM microphones inside the boxes during collision (top picture), adhering piezo microphones to the external surfaces and leaving wires trailing, and the usual means of recording audio in air through two cardioid microphones. The audio is recorded to digital or analogue devices, initially my grandfather's open reel deck (second from top picture), and now a professional Otari deck (below right picture). The sound is stretched out to 25 times its original length, using open reel and/or digital re-sampling, and then laid back into the matching visual scene. Aside from matching the audio to the visual, extensive explorations of the sound, through repeated listening, analysing through various graphs (three bottom left pictures), and in playing with them through such programs as Melodyne, all add to an understanding of what is happening during the collisions.





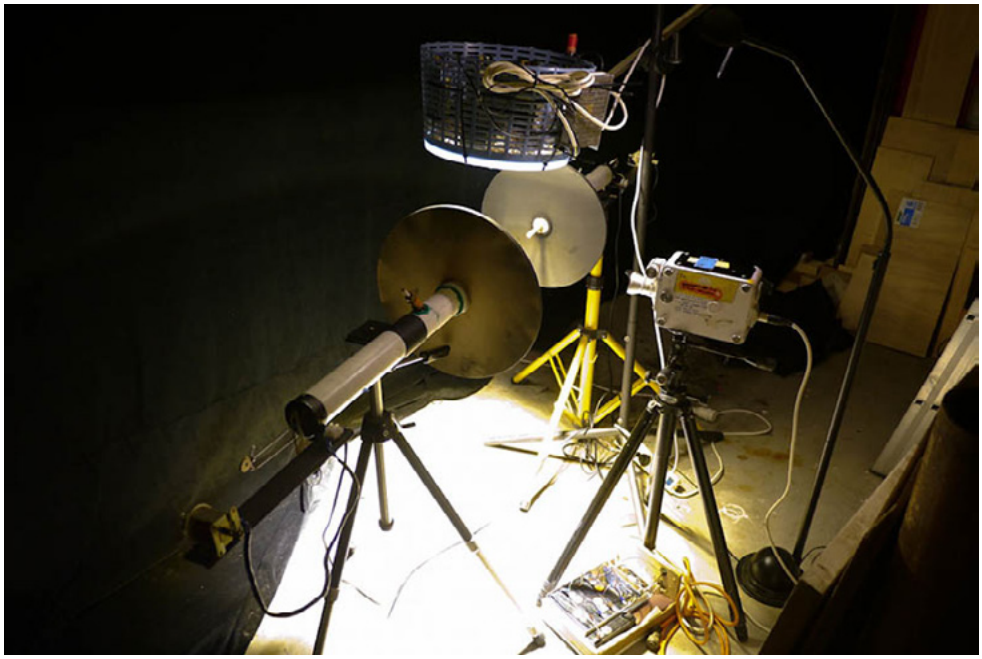
In addition to recording the actual audio and visual collisions between two air-borne boxes, a dozen boxes had microphones attached internally and externally to record the tonal qualities of the vibrational modes of collision under simpler, more controlled conditions. These sounds were studied over and over, slowed 25 times to approximate the rate of the visual footage, and analysed through various rational and sub-rational means to ascertain decay and resonant properties.

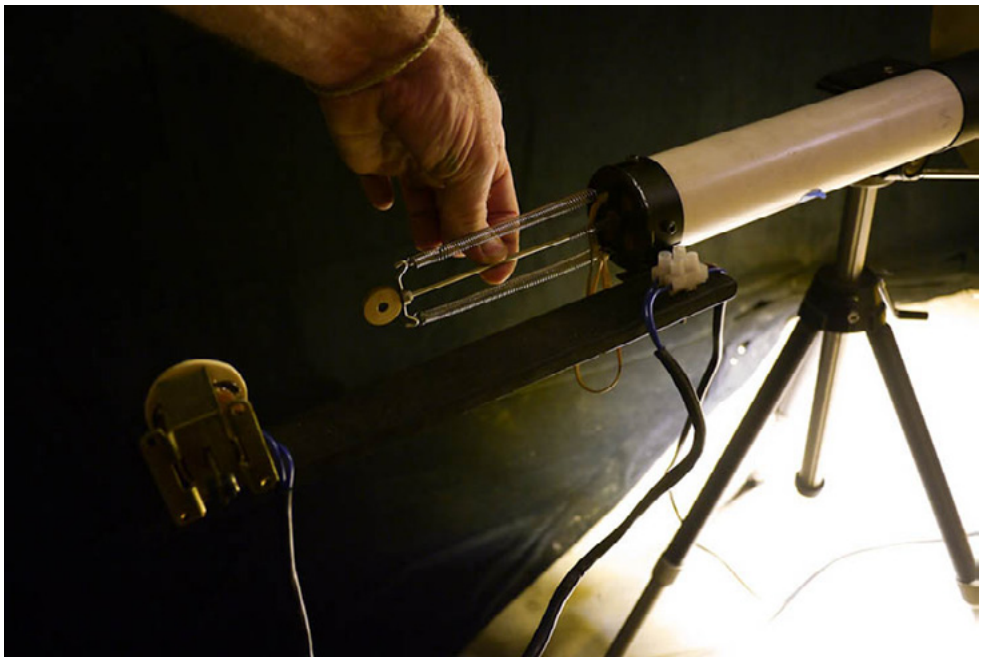
smoke vortices

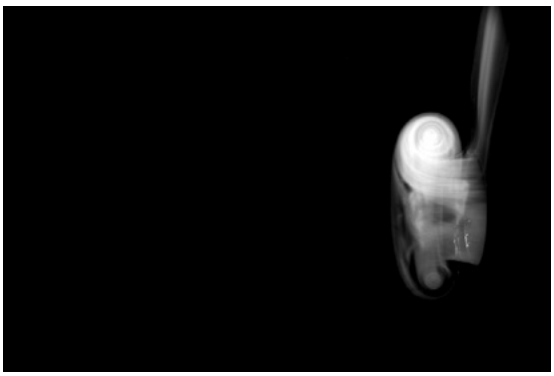
Smoke pumps operated by electric solenoids, spring action pistons, u-cup seals, and old school joint style smoke draw system (top and middle pictures).

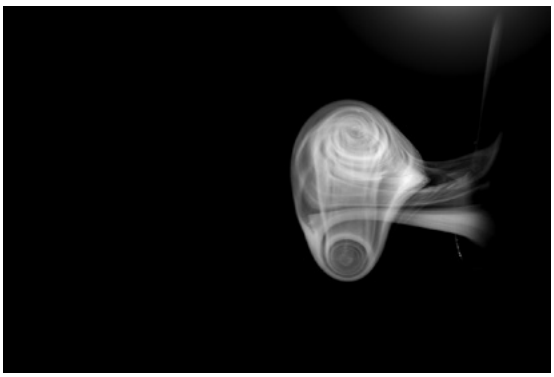
Lighting rig made from my grandmother's washing basket and a cluster of 10 100W glass-lensed high power LEDs each cooled with a fan (bottom picture).

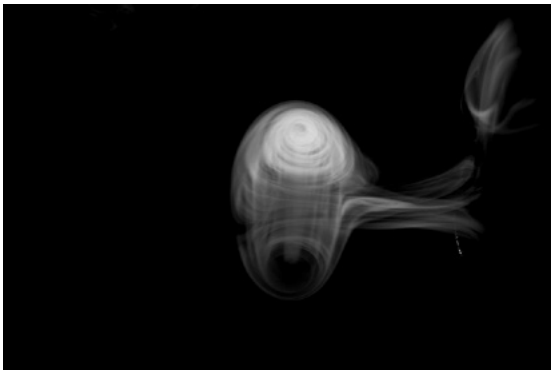
High speed 16mm milliken film cameras from the 1960's, powered by an array of SLA batteries, are set up for 500fps slow motion movie filming (top picture, right of image).



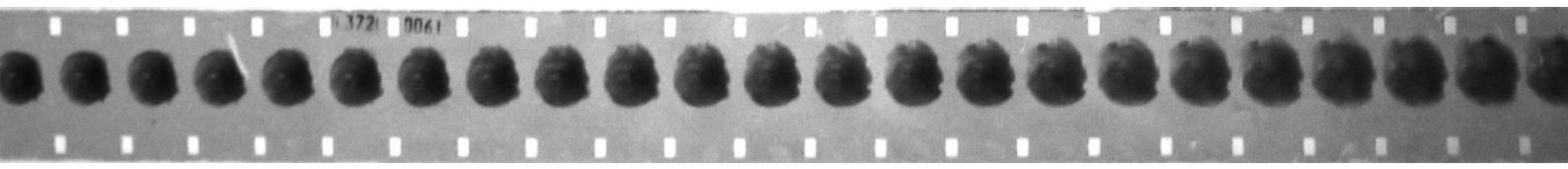


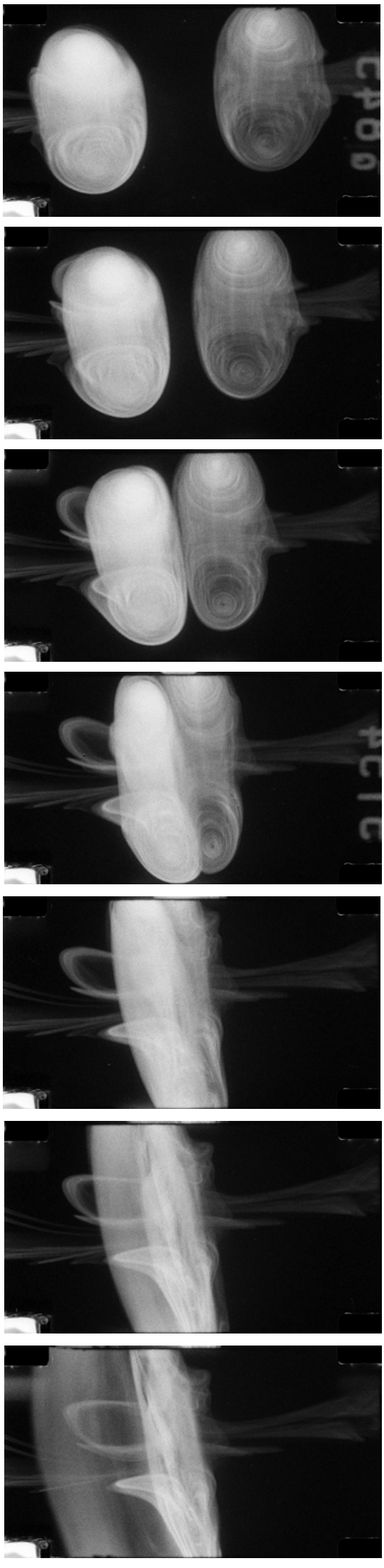


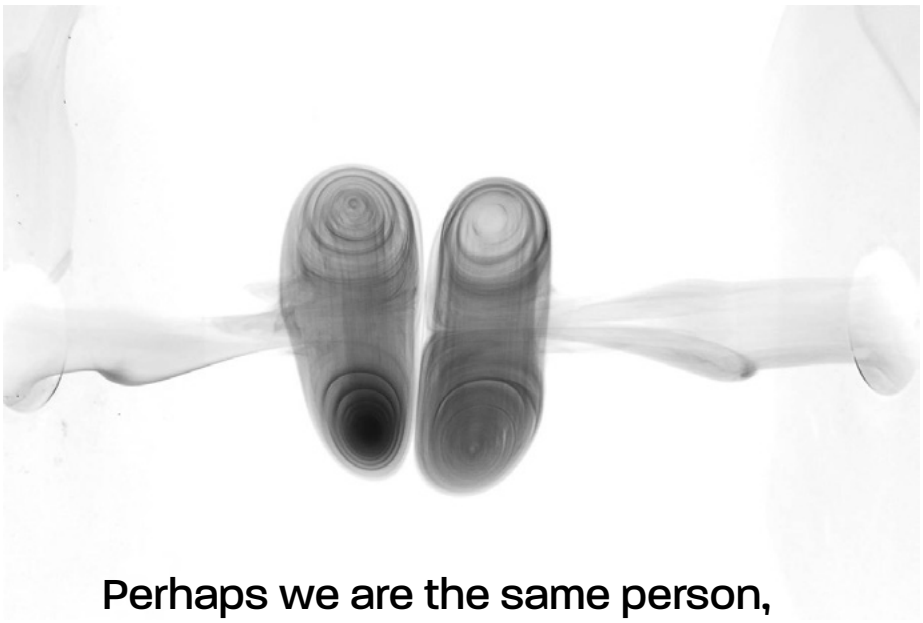




16mm movie film, in colour, and black and white, filmed in slow motion at 200 - 2000 frames per second, revealing the formation, propagation and motion of smoke vortices in fine visual detail though time. All black and white film was developed by hand in a custom made 100 foot developing tank - 3500m of film for smoke vortex study alone, which is the equivalent of over 450,000 individual images, each of which are transfered, frame by frame in a digital capture process, before being compiled and edited on computer.





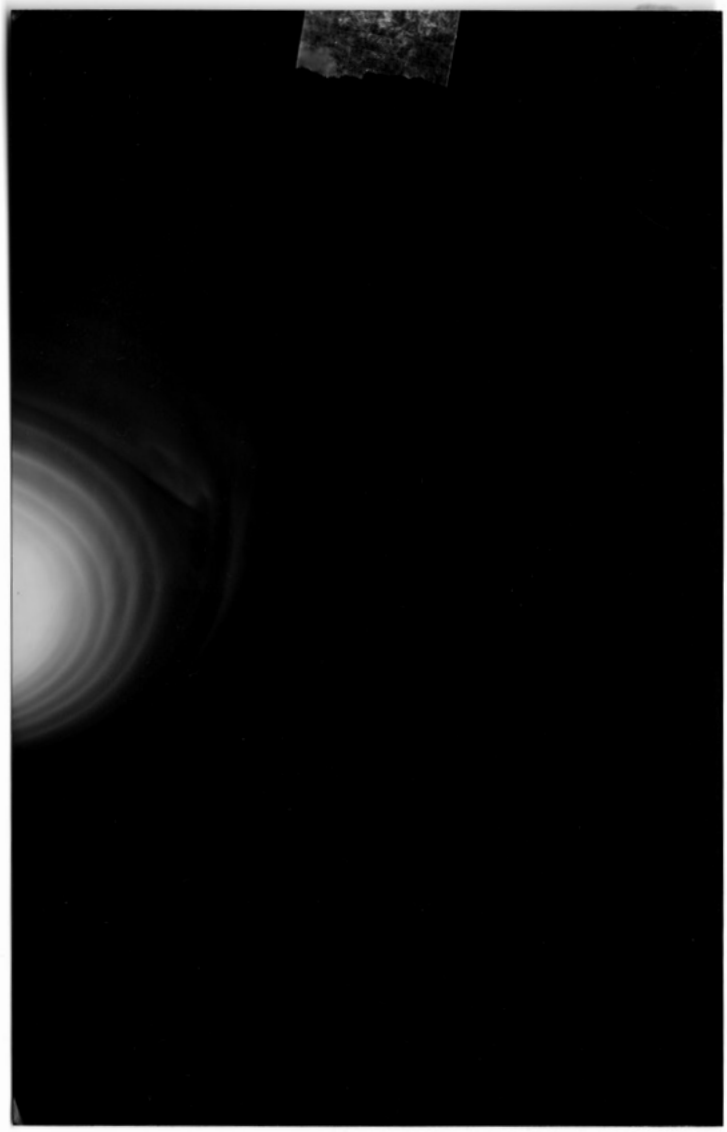


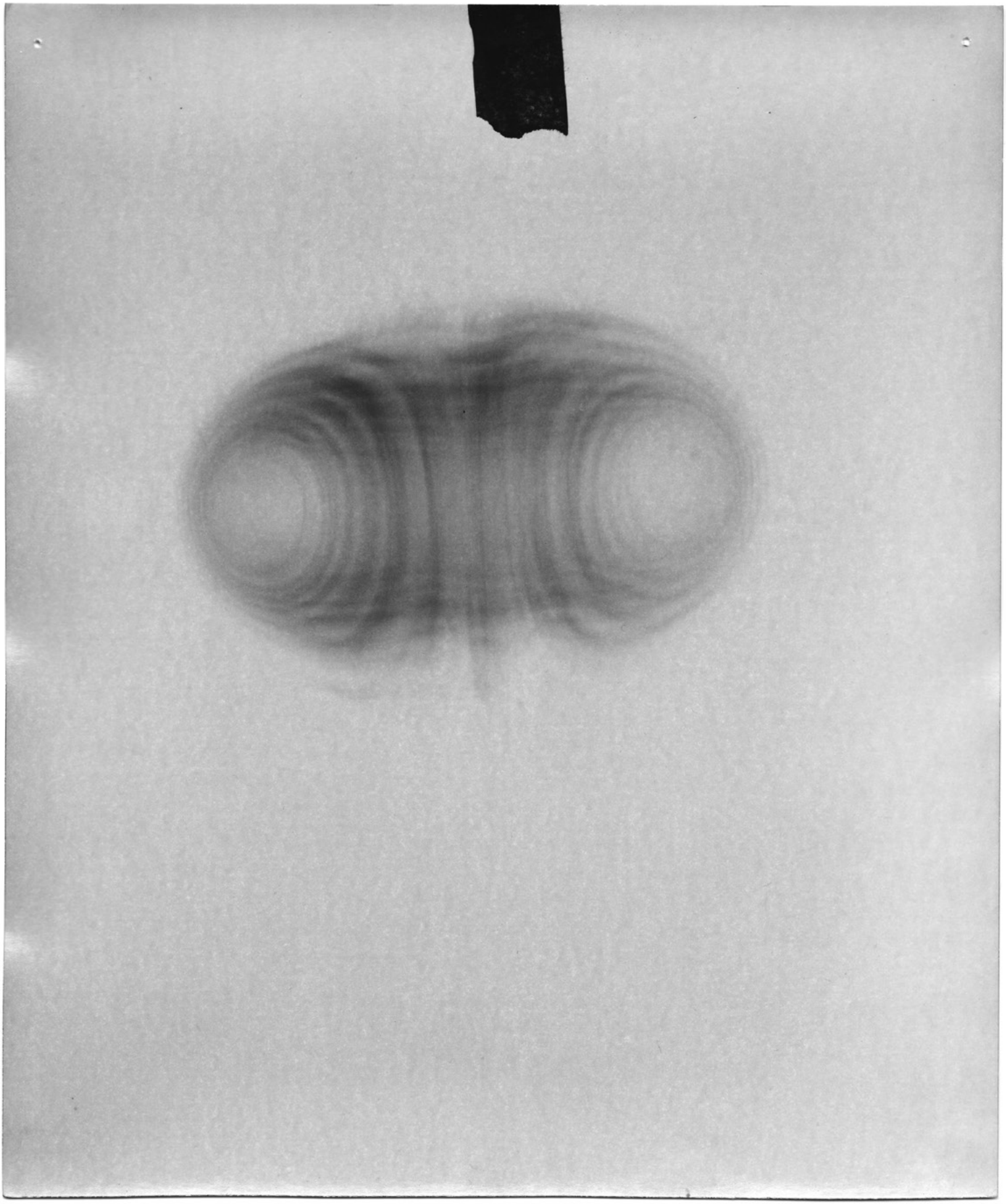
Perhaps we are the same person, maybe there are no boundaries, maybe we all flow into each other, boundlessly and magnificently....

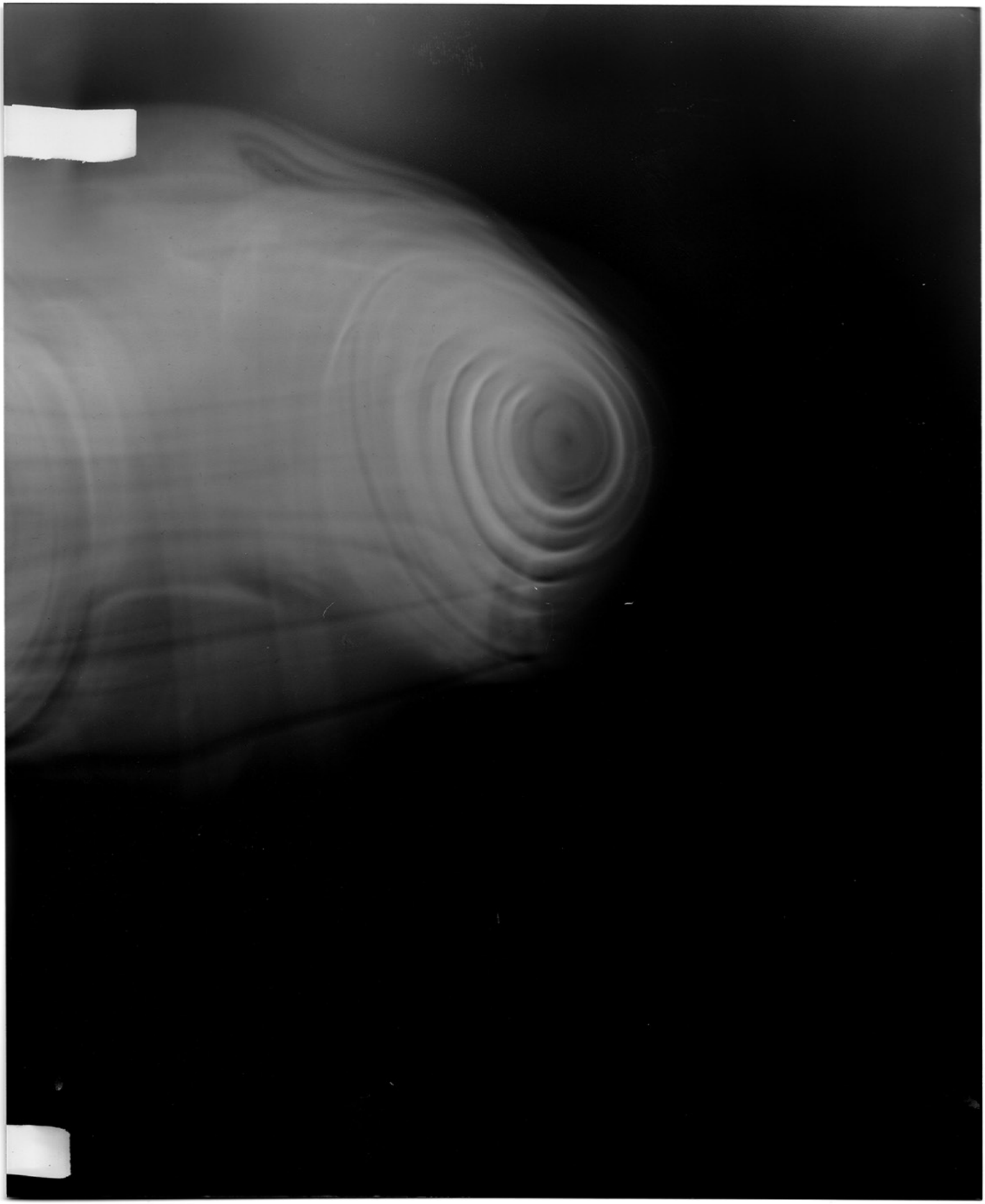
Ingmar Bergman, *Fanny and Alexander.*

16mm movie film images captured individually to digital files at 4K resolution, cropped, adjusted, and stitched to form slow motion video footage.

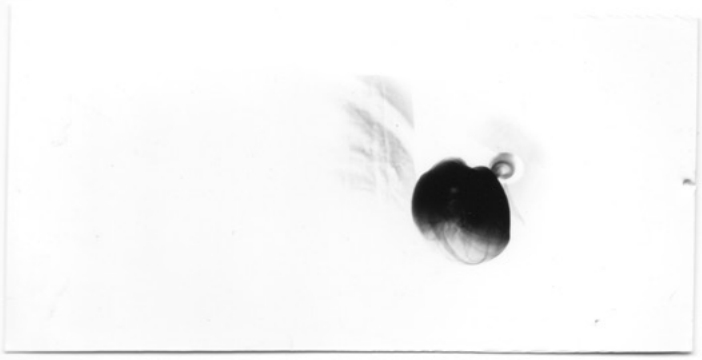
Shadowgrammes of smoke rings using high-intensity flash projected through a pinhole, creating sharp shadow images from fast-moving 3-dimensional vortices. Shadows were exposed directly onto standard emulsion paper, direct positive paper, or negative film, using lith developer and chemical bleach reversal processes, as well as exposing secondary contact prints of the original images.

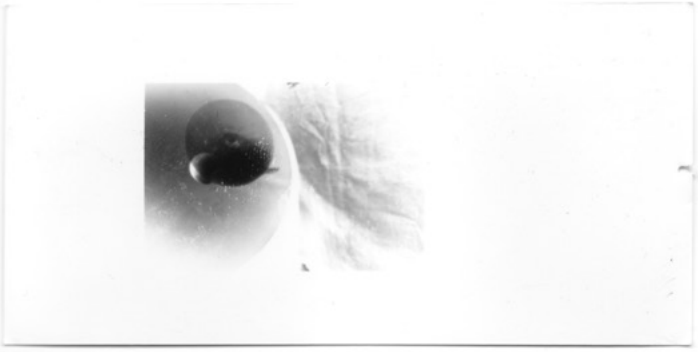






Direct images captured through a flash and a simple glass lens held in front of photographic paper.

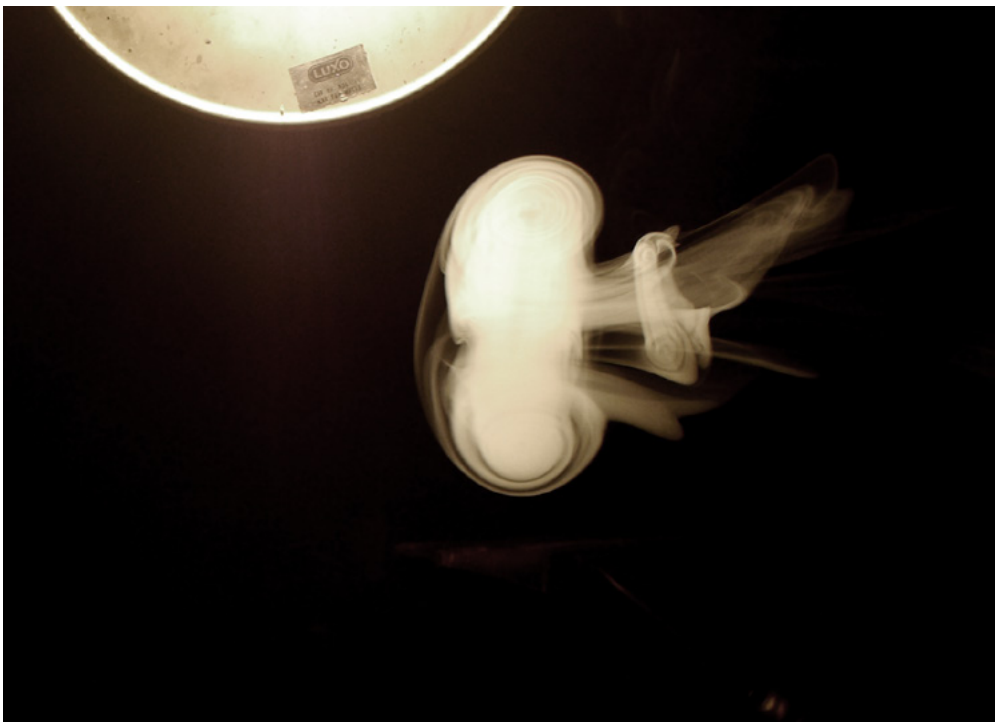




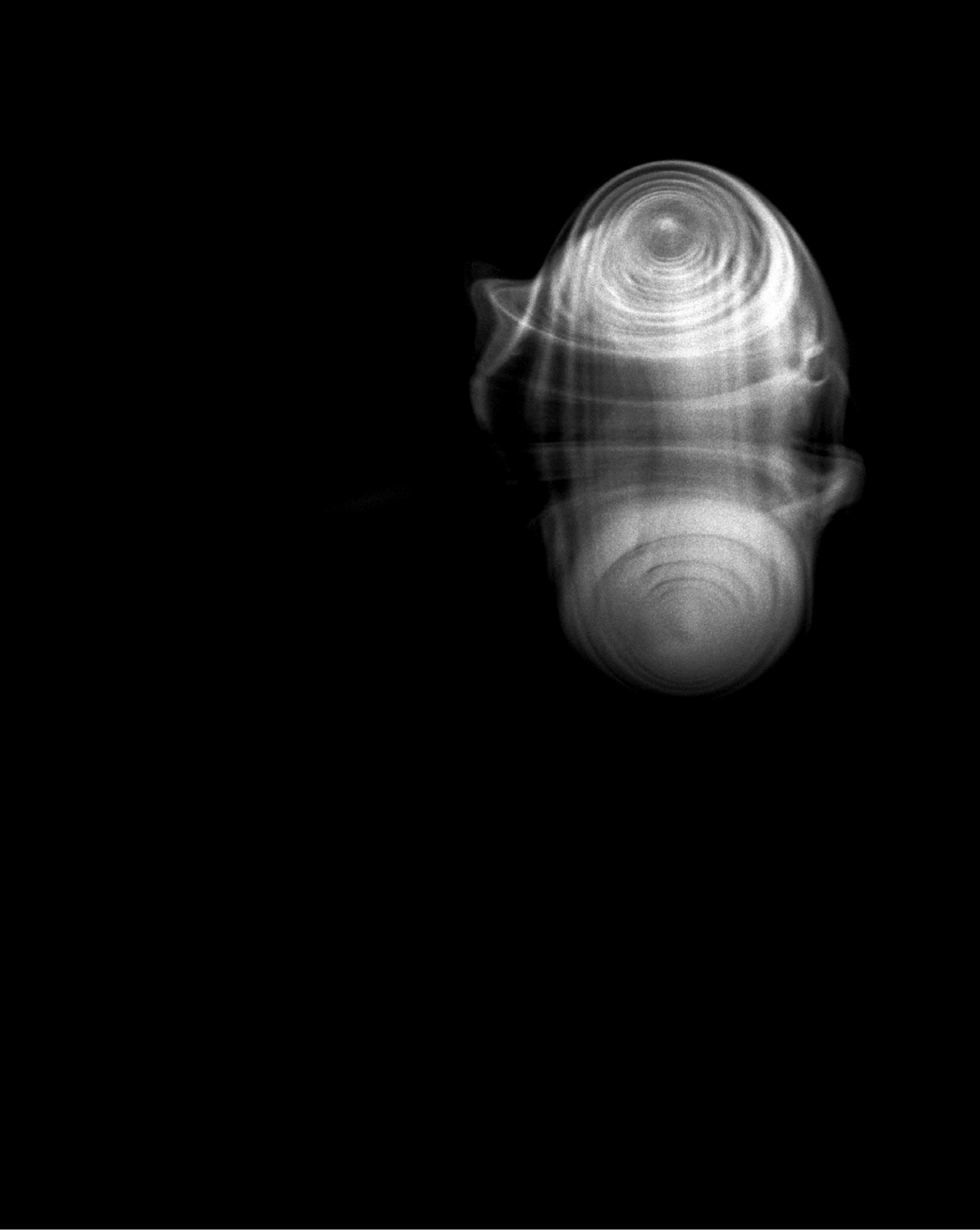
Traditional still images, captured using 35mm, and medium format films, 8x10" negatives, 12x16" lithographs, 16x20" direct positives inside a homemade ULF camera, as well as various digital cameras, and enlargements made from film originals.

We can neither imagine an object or being without space. Space, therefore, is not only a *conditio sine qa non* of all existence, but a fundamental property of our consciousness.... Our consciousness determines the kind of space in which we live. The infinity of space and the infinity of consciousness are identical.... The way in which we experience space, or in which we are aware of space, is a characteristic of the dimensions of our consciousness.

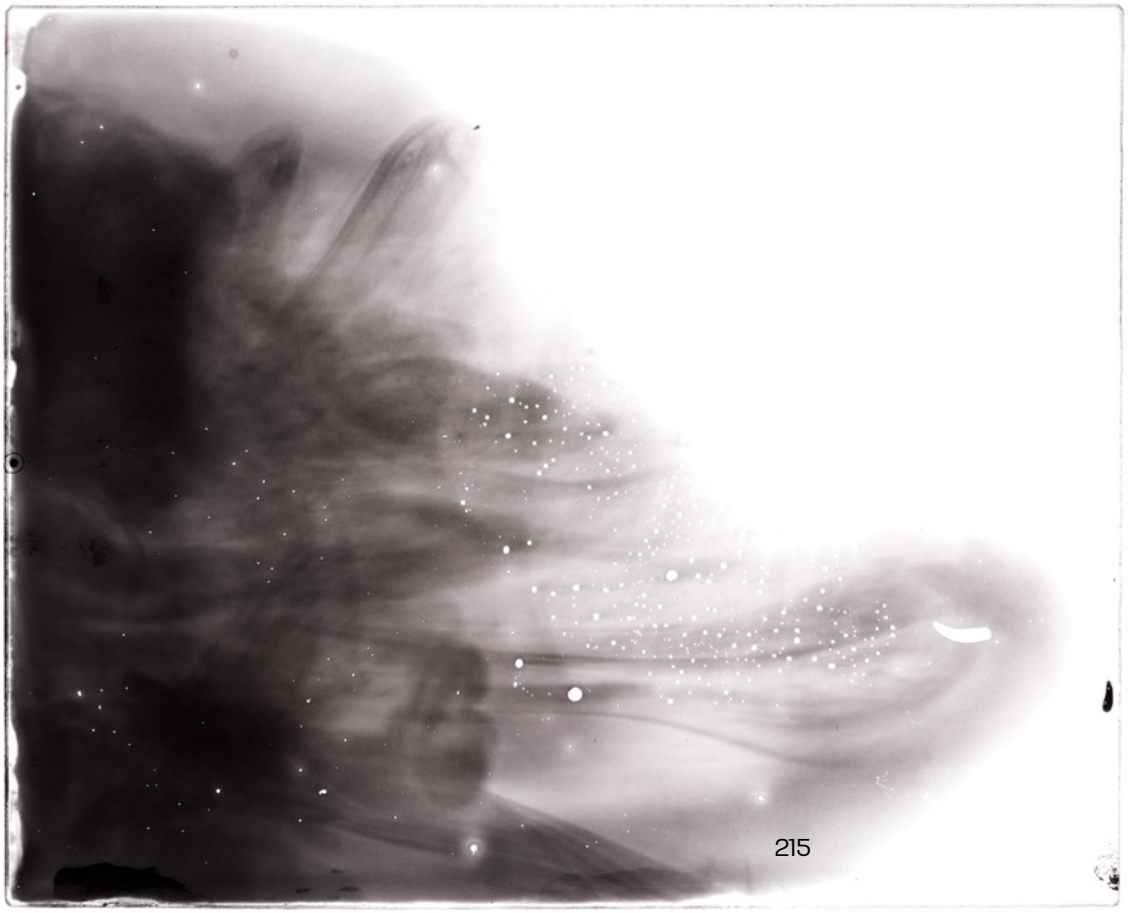
L A Govinda, *The Psychological Attitudes of Early Buddhist Philosophy*, 151.

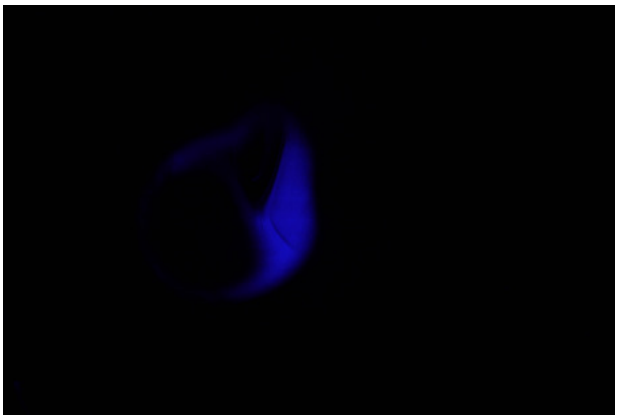


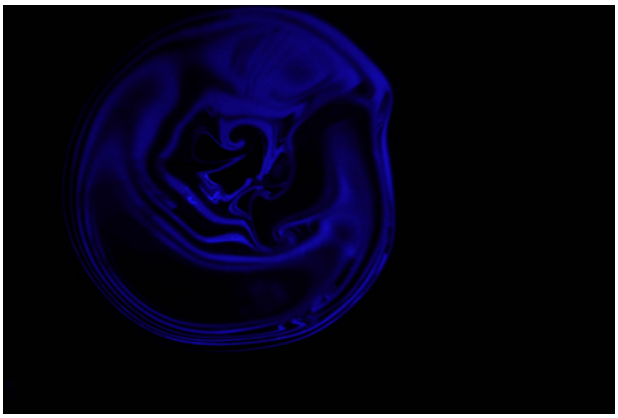
First ever picture of a smoke ring, 2012.

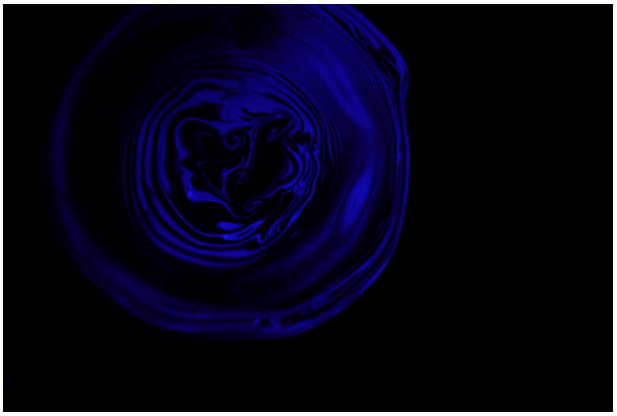


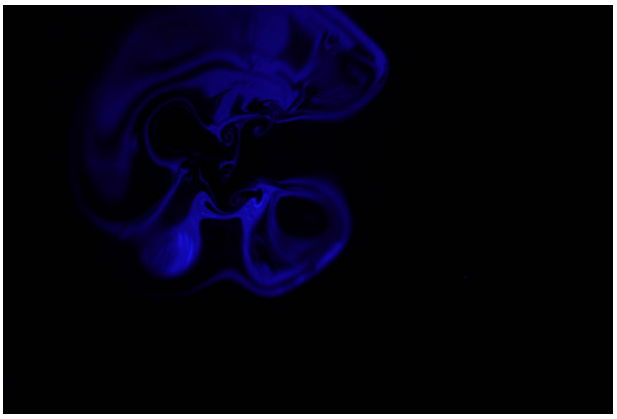
Handmade silver emulsion on glass plates, printed from medium format slide originals, in varying levels of successful realisation.

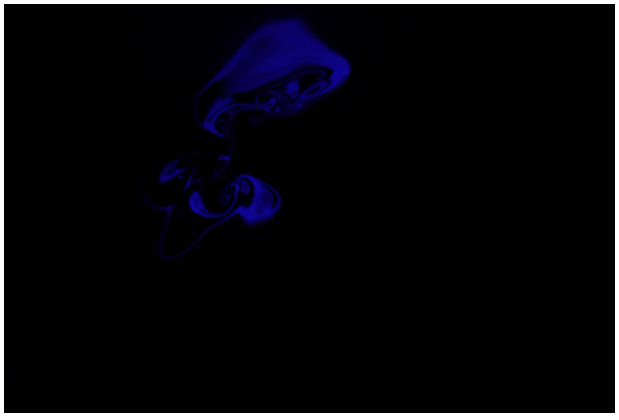




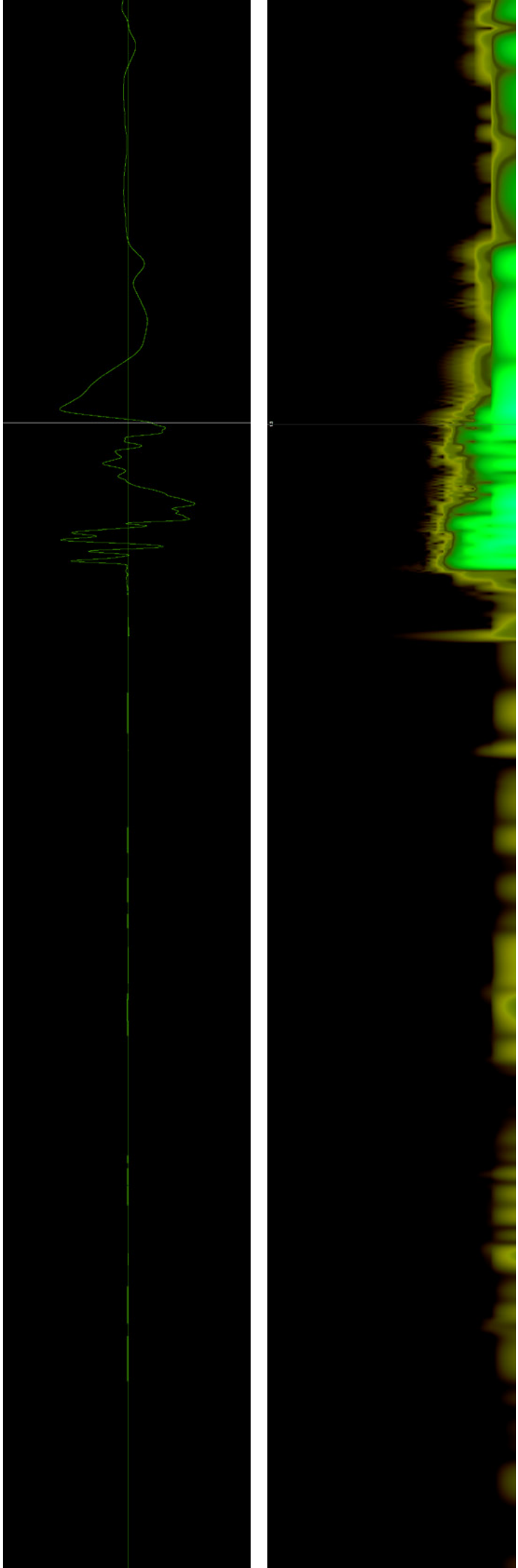


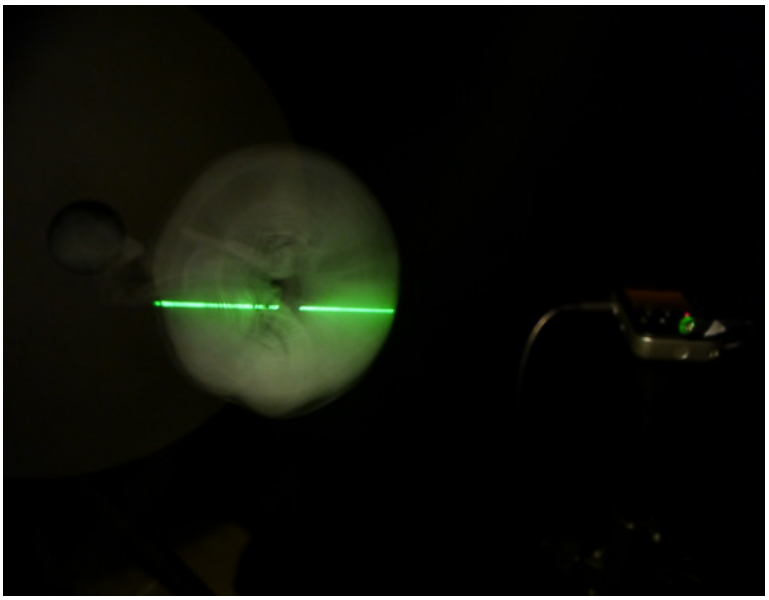






Smoke vortice slices illuminated by laser light diffracted through a planar filter gate. Successions of digital images reveal the internal structure and complex turbulence within the form through cross-sectional images.





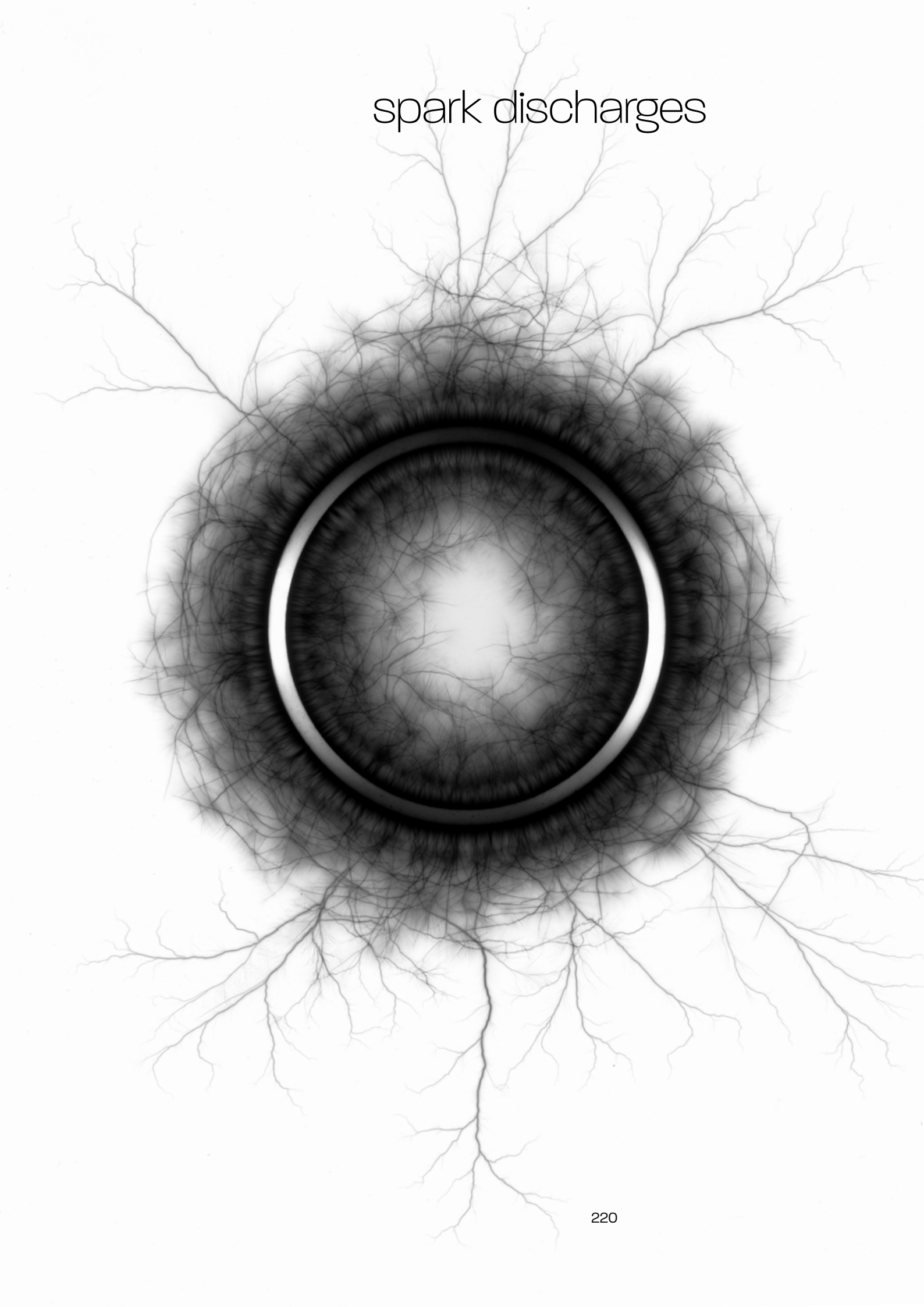
"Audio" analysis of photovoltaic laser density recordings of smoke rings, and piezo pressure recordings, explored through audio and visual processes, manipulated and examined. A sonified expression of the structure, pressure and vibrational modes associated with smoke vortices.

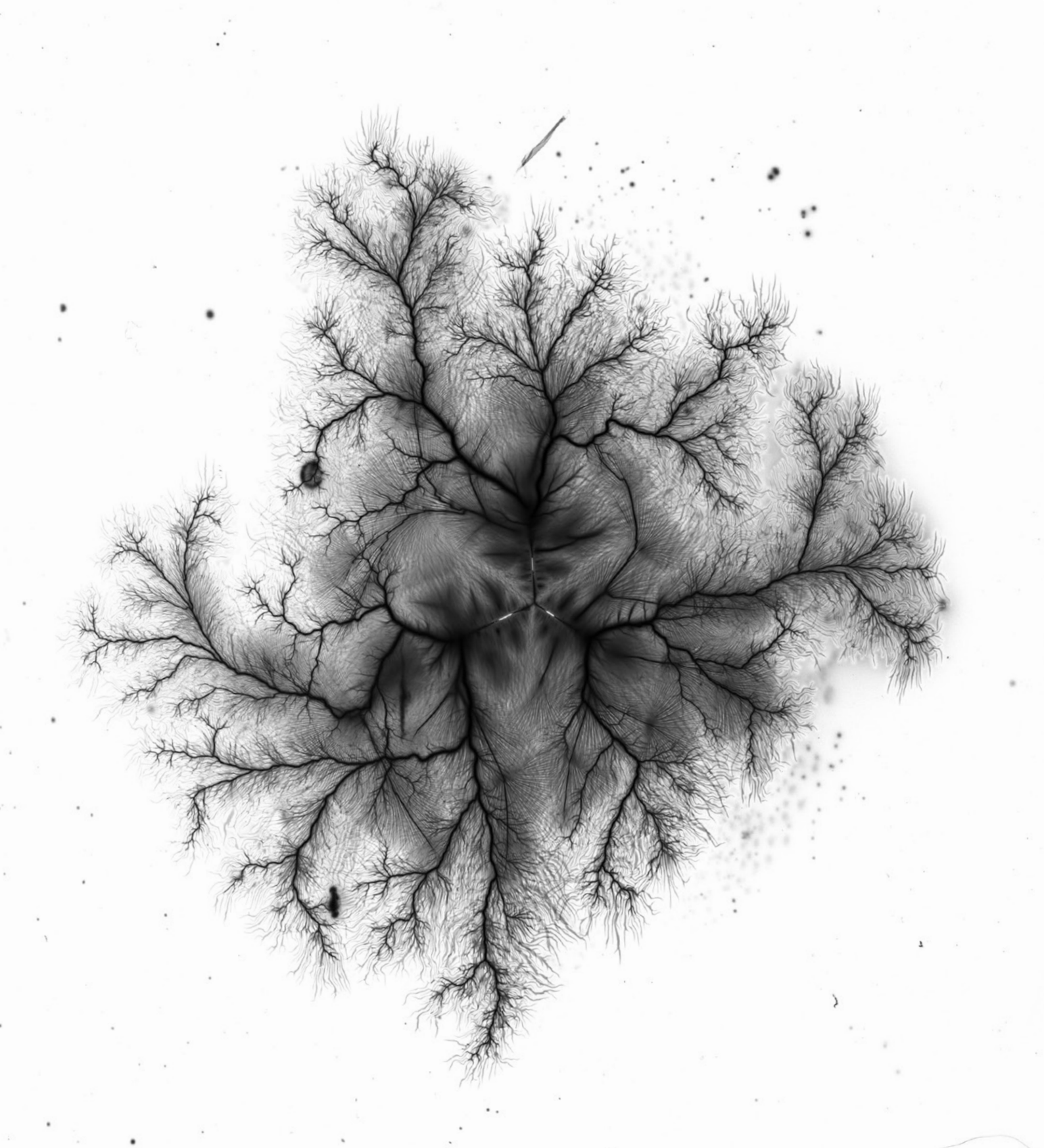
Many are the places where people believe, where, above all, they make people believe, that one can understand through concepts, that it is possible to construct and finish construction, from the foundations to the rafters, to develop, from the cell to the organism, that it is possible to deduce or relate otherwise than as a fool or player, that to dominate and anticipate, in theory and practice, is done by being clear-cut and axiomatic, in closure, whereas there is always only a multiplicity. Institutions always seem to be founded on this lack, situated on the narrow slit from which the incompletion could be seen, they obstruct the opening in shadow, and crown the misrecognition of this cognition. Their cornerstones are rolled in front of the tomb or the entrance to the underworld. Like Ulysses or Aeneas, the philosopher must at least once in his life, enter in and go down, speak to the obscure shadows that cannot take shape, and rake over the ashes. And he must avoid being seated on the stone and carrying on the discourse of the deaf establishment. It would seem that power has the role and function of making people believe that both concept and reason, closure and domination exist, where there is only ever pure multiplicity without any unity. Ruins, monsters and dreams, and time without redundancy - these always come back, in spite of the crude endeavors of these machines to transform the noise and fury into all sorts of order, discourse, harmony, sense of history, architecture. We are ceaselessly trying to repair the not very reliable machinery that is there to make the confused noise gel and the fury crystallize, but the noise exceeds its capacity. The noise is more powerful than its mechanical force. I mean: incalculable. I mean: measureless. It always exceeds the machines' capacity for calculation. Yes, politics weaves together the rational and the irrational, but this tissue, rational, is ripping apart indefinitely, it is a tatter.

Michel Serres, *Genesis*, 126-127.

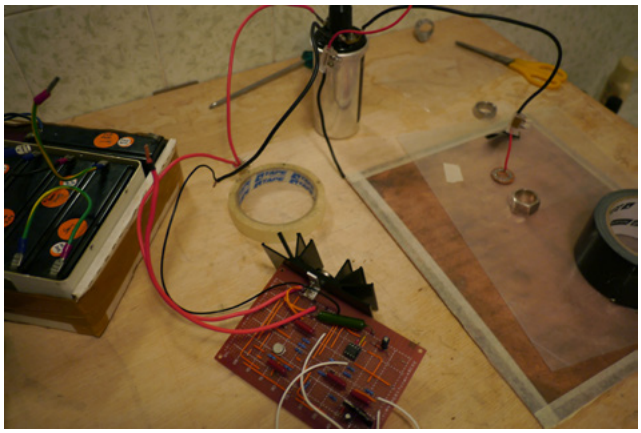
Various other modes of analysis, including live drawing techniques, mathematical and geometric analysis, piano improvisation to vortex movement, smoke taste-tests, relentless visual observation, daytime hallucinations, and recurring visions of omni-present vortice structures throughout daily life....

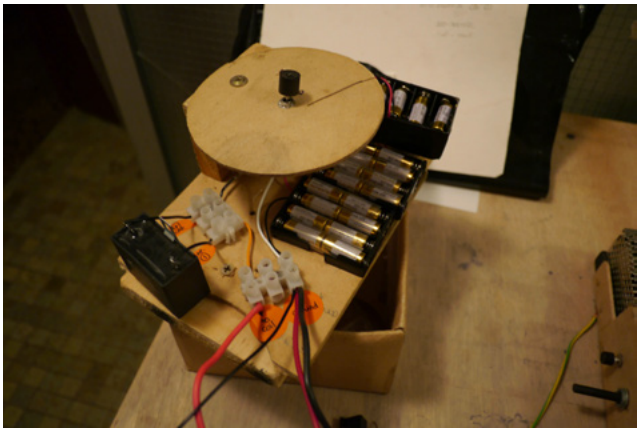
spark discharges

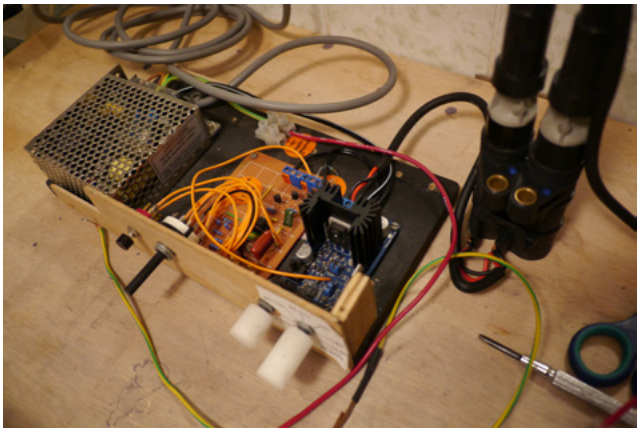


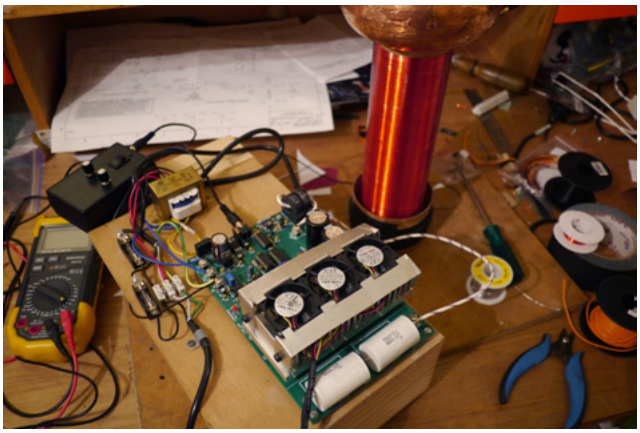


A trigonal polyhedra imaged onto Foma 100 emulsion by a single pulse of 40,000v DC, the voltage oscillating through the autotransformer before finally damping out. The pathways reveal overall geometry of the form, as well as internal structures, and the basic character of the material from which it is formed.

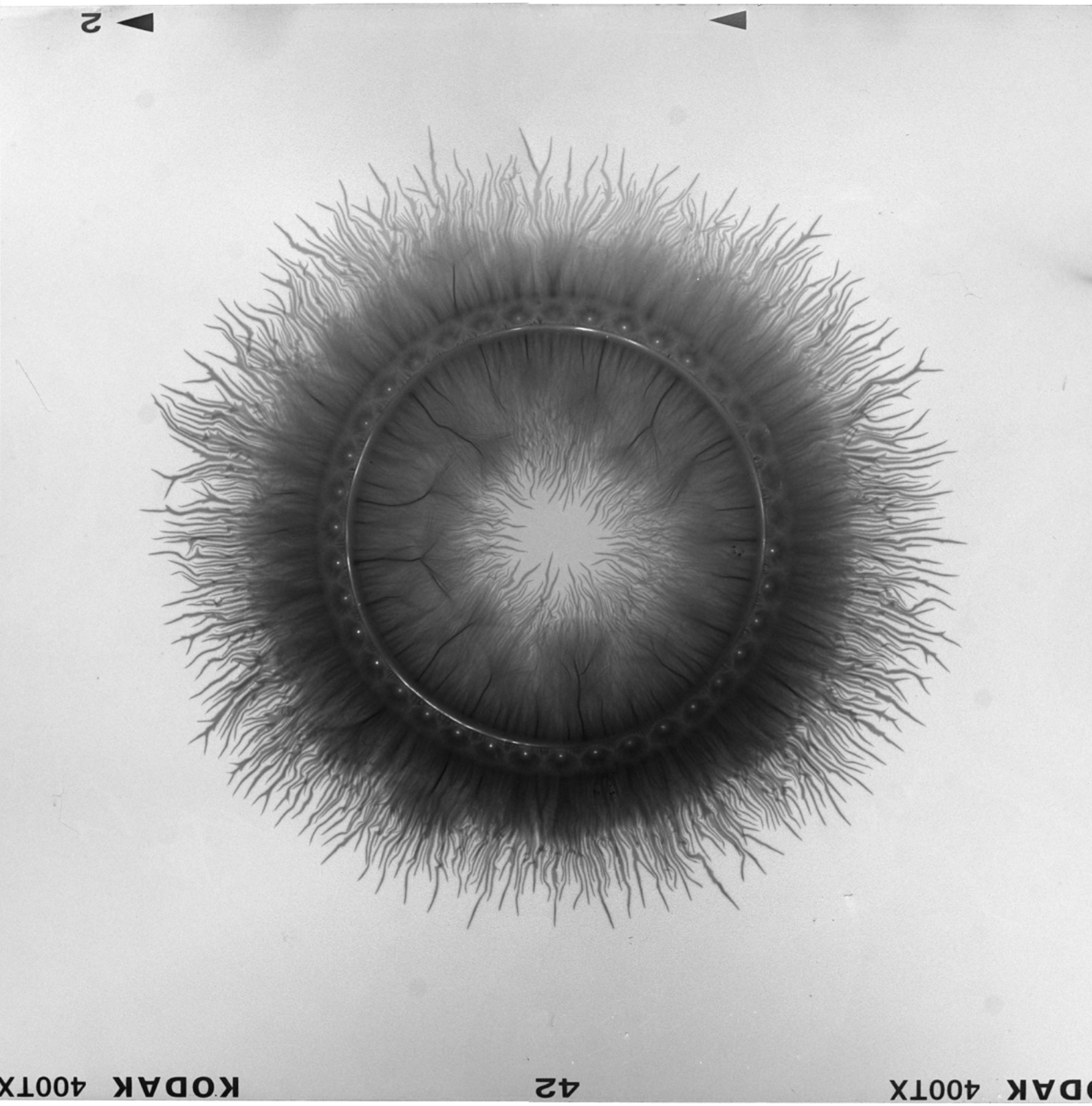




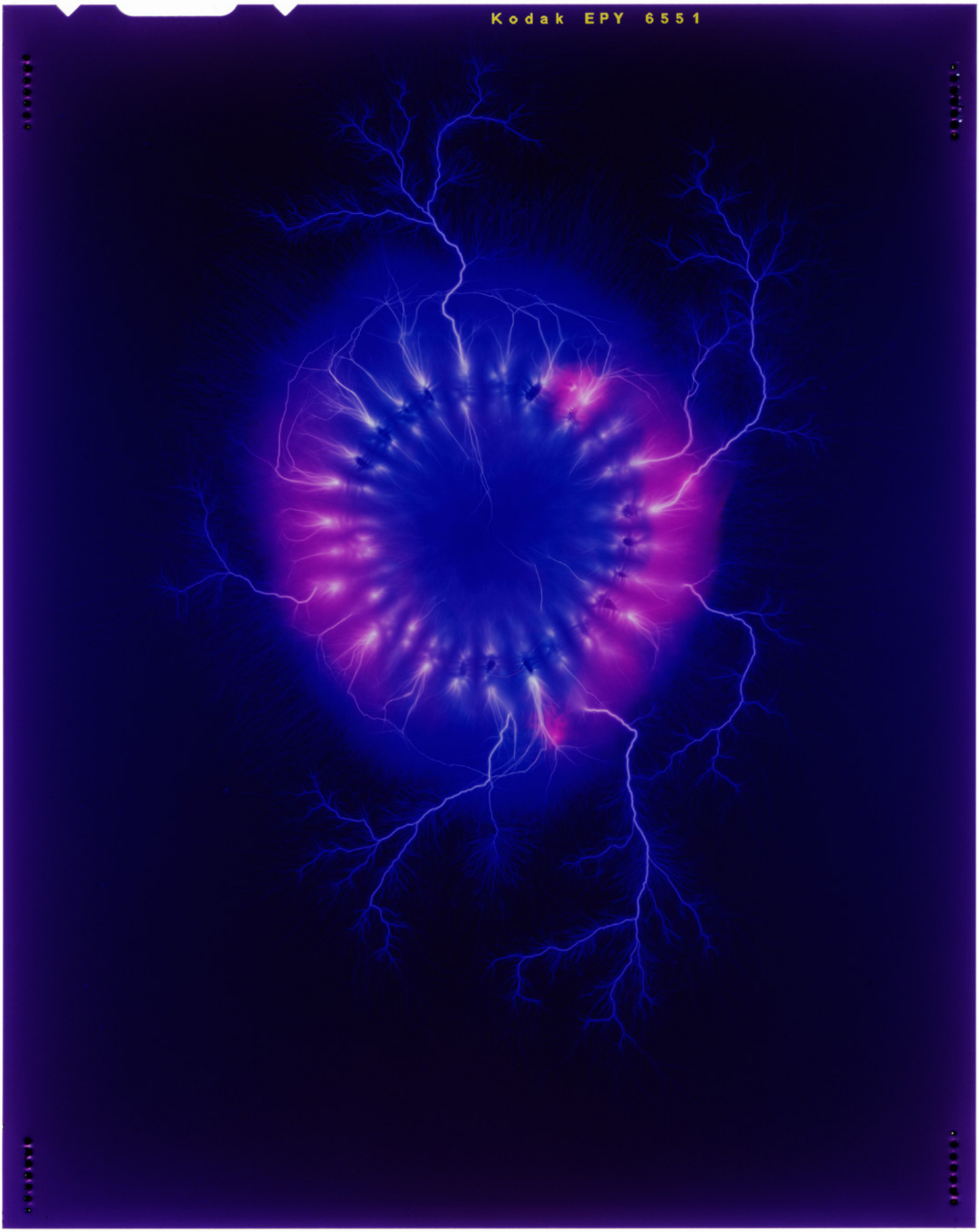




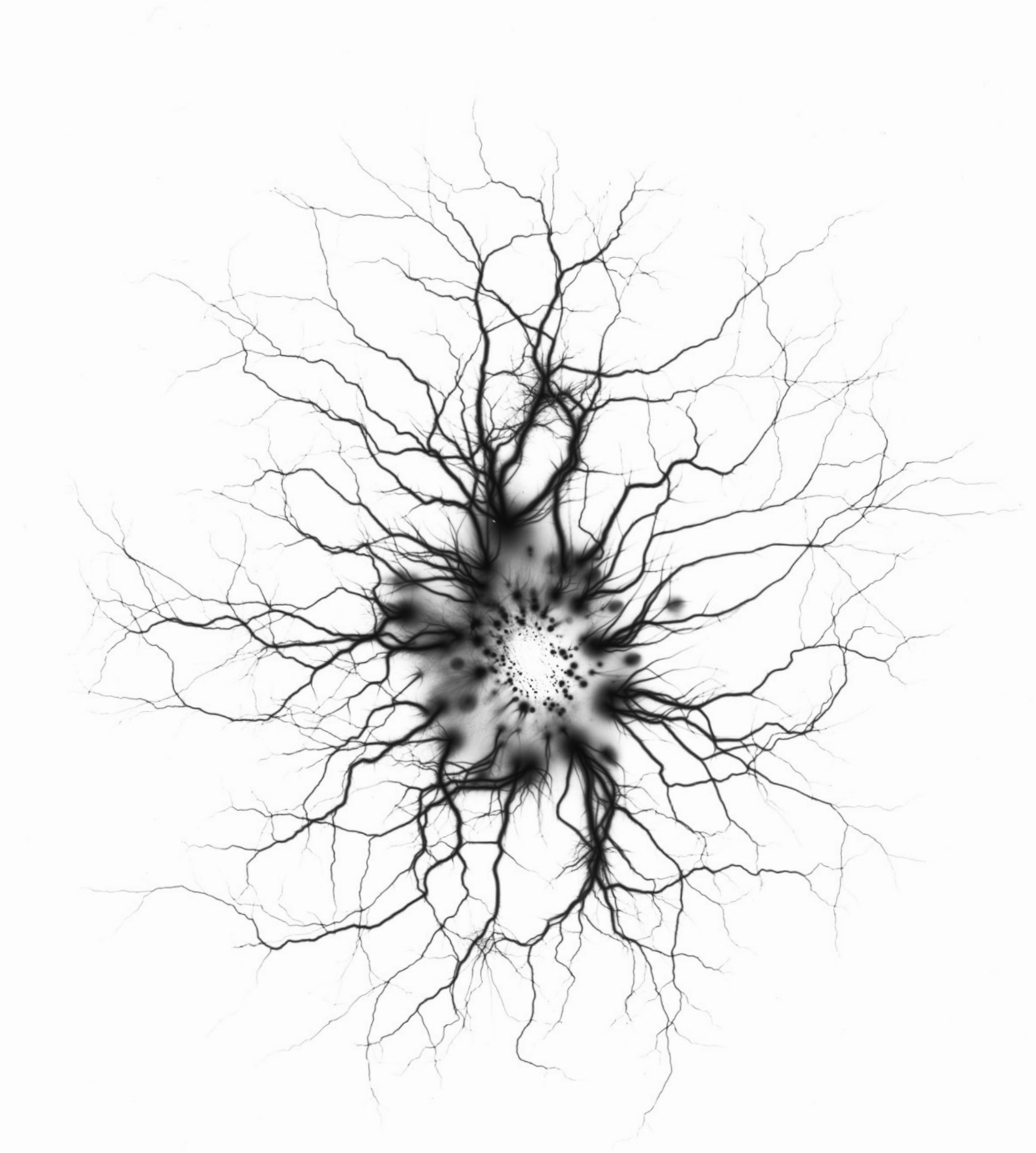
Spark discharge experimental setups in the bathroom (darkroom). First design, spark unit 1 (top picture), using sealed lead acid batteries, car ignition coil, and high current switching transistor, to effect the shortest switch to the coil (shorter switch times create higher voltages). No longer functioning. Spark unit 2 is not pictured as it blew up and tripped a 100A main fuse and left a large black mark on my desk. Current setup (second from top picture), showing DC and high frequency units and my developing trays in the bathtub. Spark unit 3 (middle picture) is a battery powered DC unit, super simple, using a rocker switch to dump 300 volts from a capacitor across an ignition coil. Spark unit 4 (second from bottom picture), is a mains powered high frequency controller that can adjust duration, frequency from 2Hz to 10MHz, and pulse width (duty cycle) to create sparks in difficult materials. This uses two high specification ignition coils in parallel. Spark unit 5 (bottom picture), uses an assembled Tesla coil kit, a simple frequency modulator, a hand-wound extra-high voltage coil, and an over-clocked series of solid state swicthes cooled with fans, to create high intensity sparks that are currently being used to experiment with stereoscopic imaging possibilities. The smell from the sparks of unit 5 is incredible.



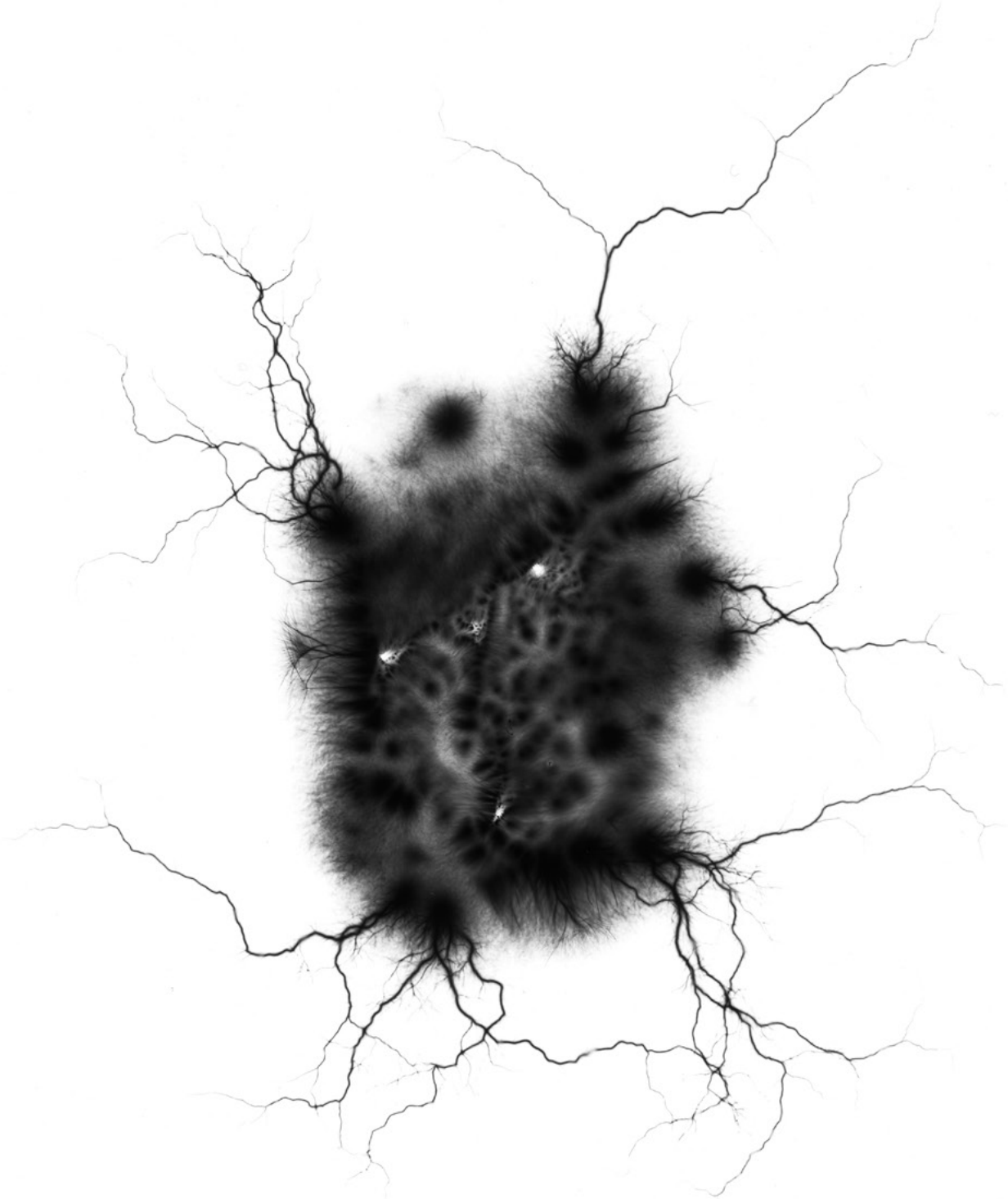
First successful spark discharge - 20,000v DC pulse through a kinetic stainless steel ring on Tri-X 120 roll film.



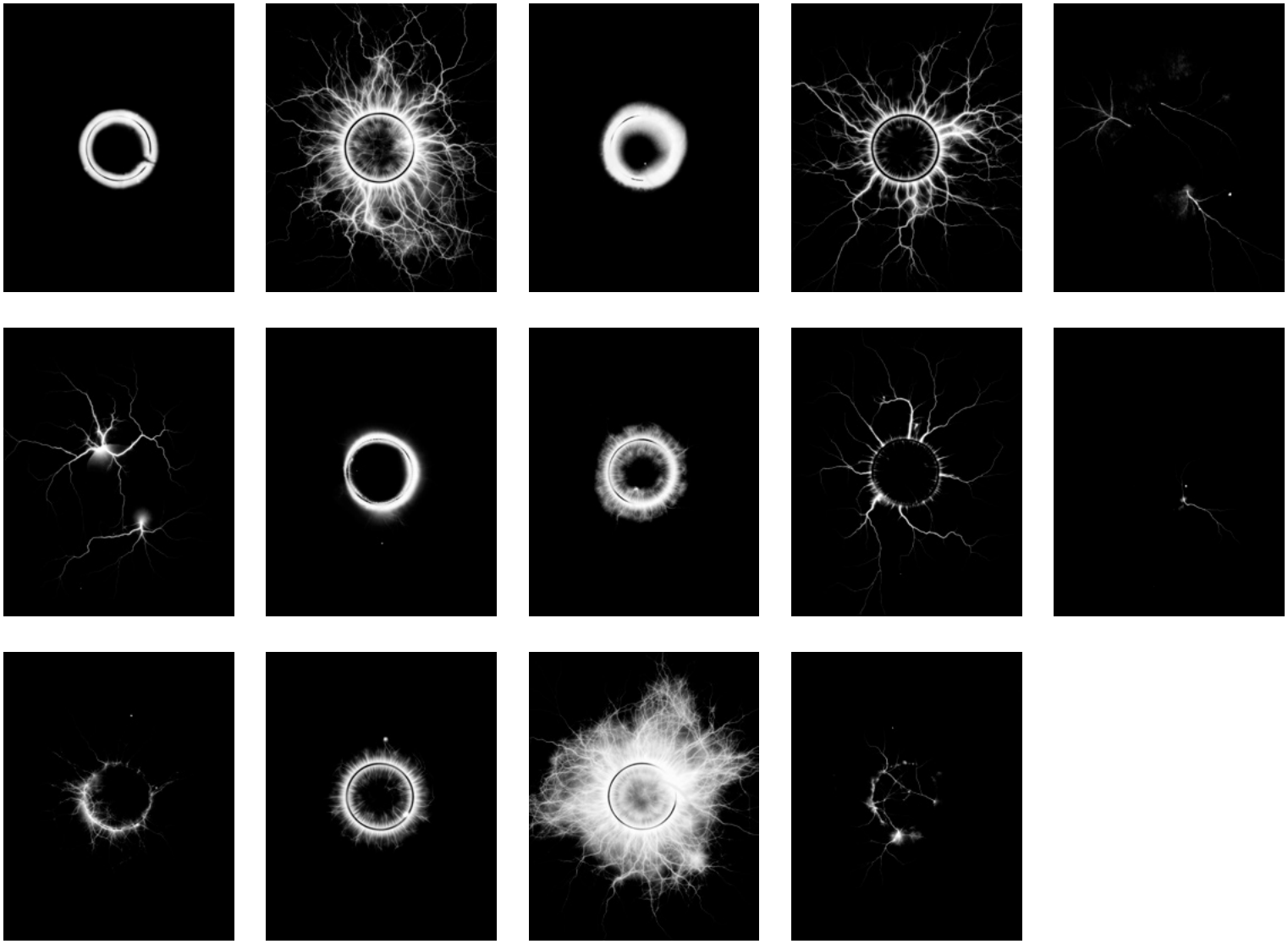
Rippled bronze “though form” imaged through high frequency AC at 500Hz, on 4x5 colour slide film.



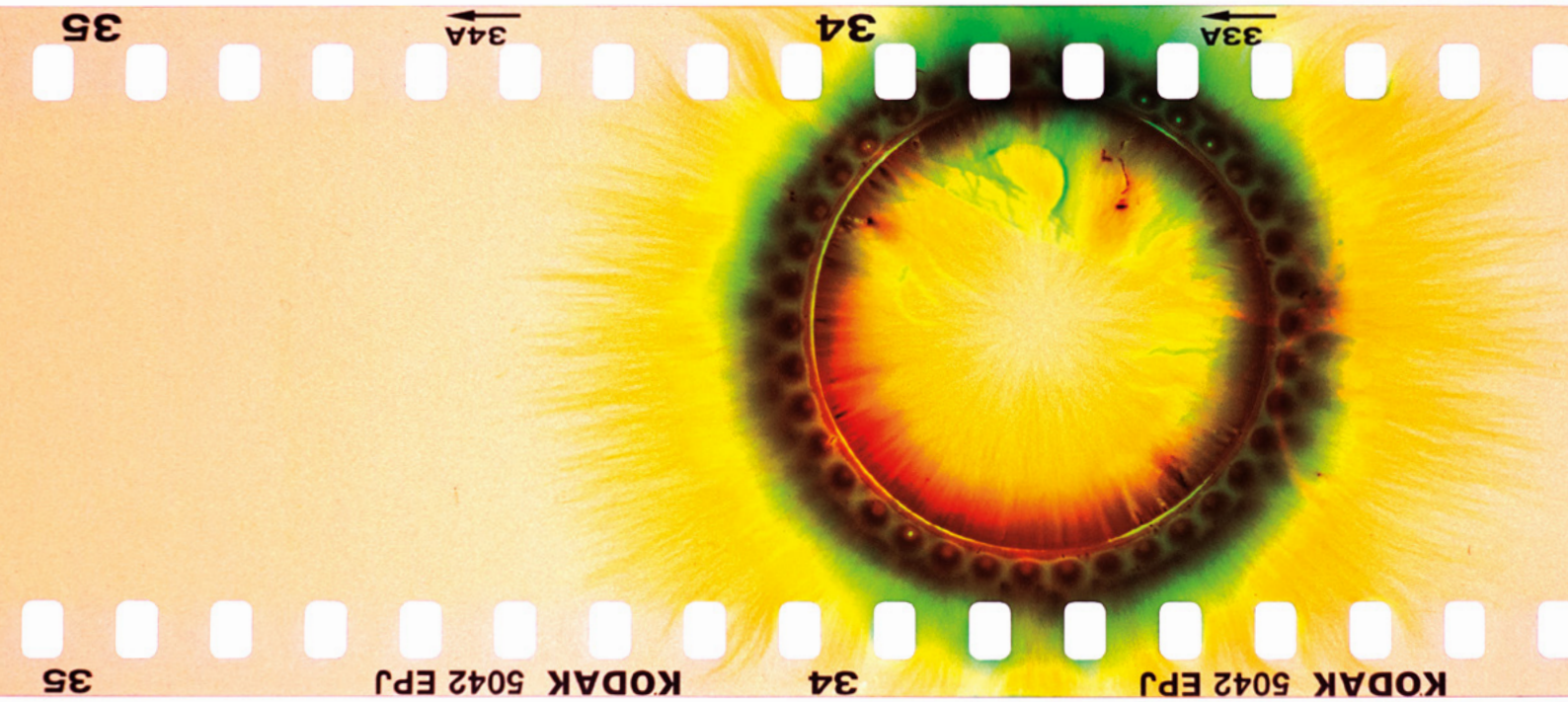
Anthracite (coal ore) sparked with 40,000v DC, on lith film, from a series investigating mined ore, including mercury, uranium, iron and chrome ores all imaged through similar processes.



Anthracite imaged through high frequency rather than DC, again on lith film, revealing more internal pathways of conductance, and showing the character of its materiality through the quality of the closely clustered ionisation trails.

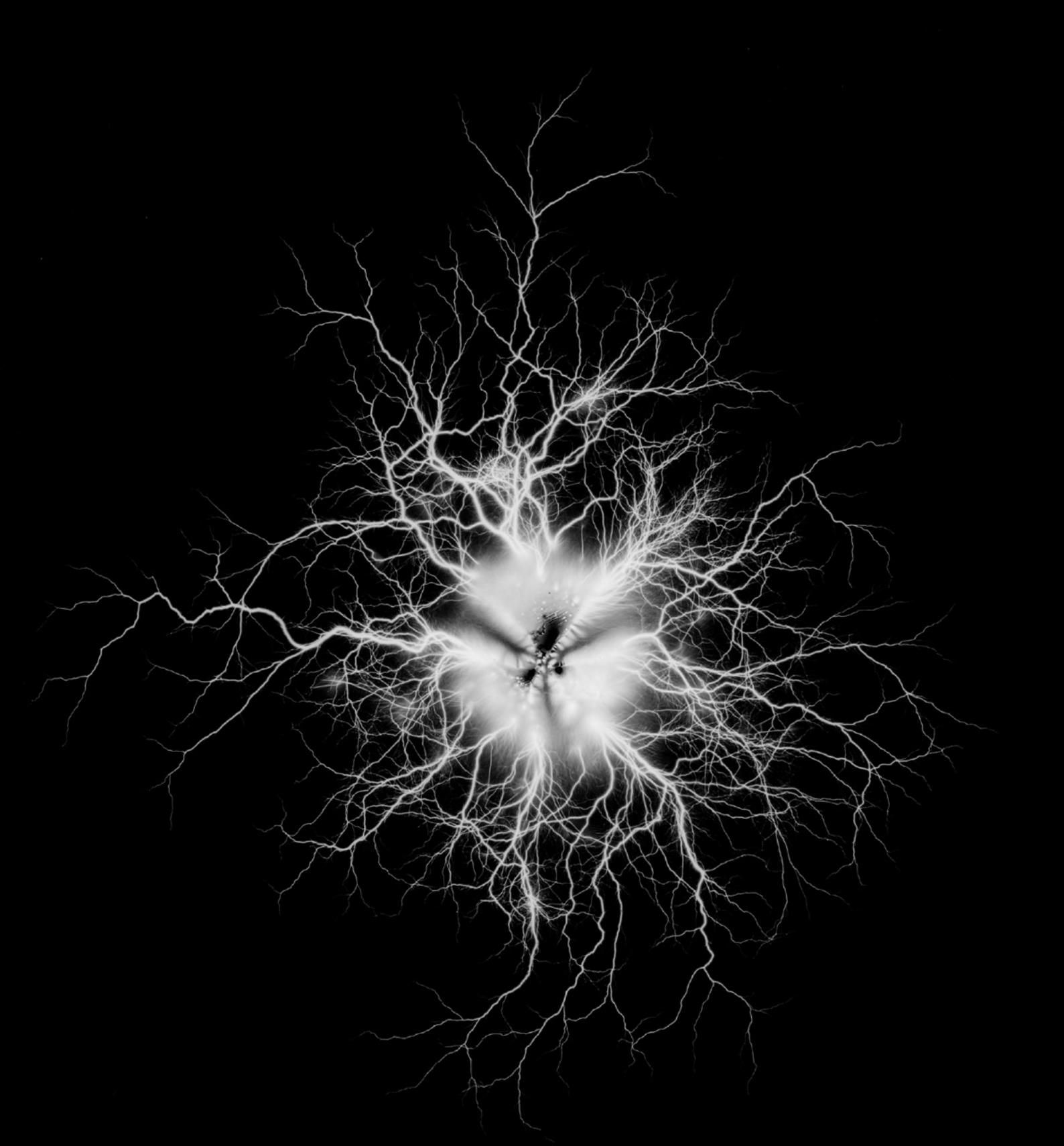


Exploring material through samples of various substances formed into rings. Spark images correspond to materials at left. From top left, along by rows - bone, copper, ebony, 22k gold, human hair, buffalo horn, huon pine, meteorite, titanium-zirconium mokume-gane, orange plastic, silicon nitride, stainless steel, tantalum, and bees wax.

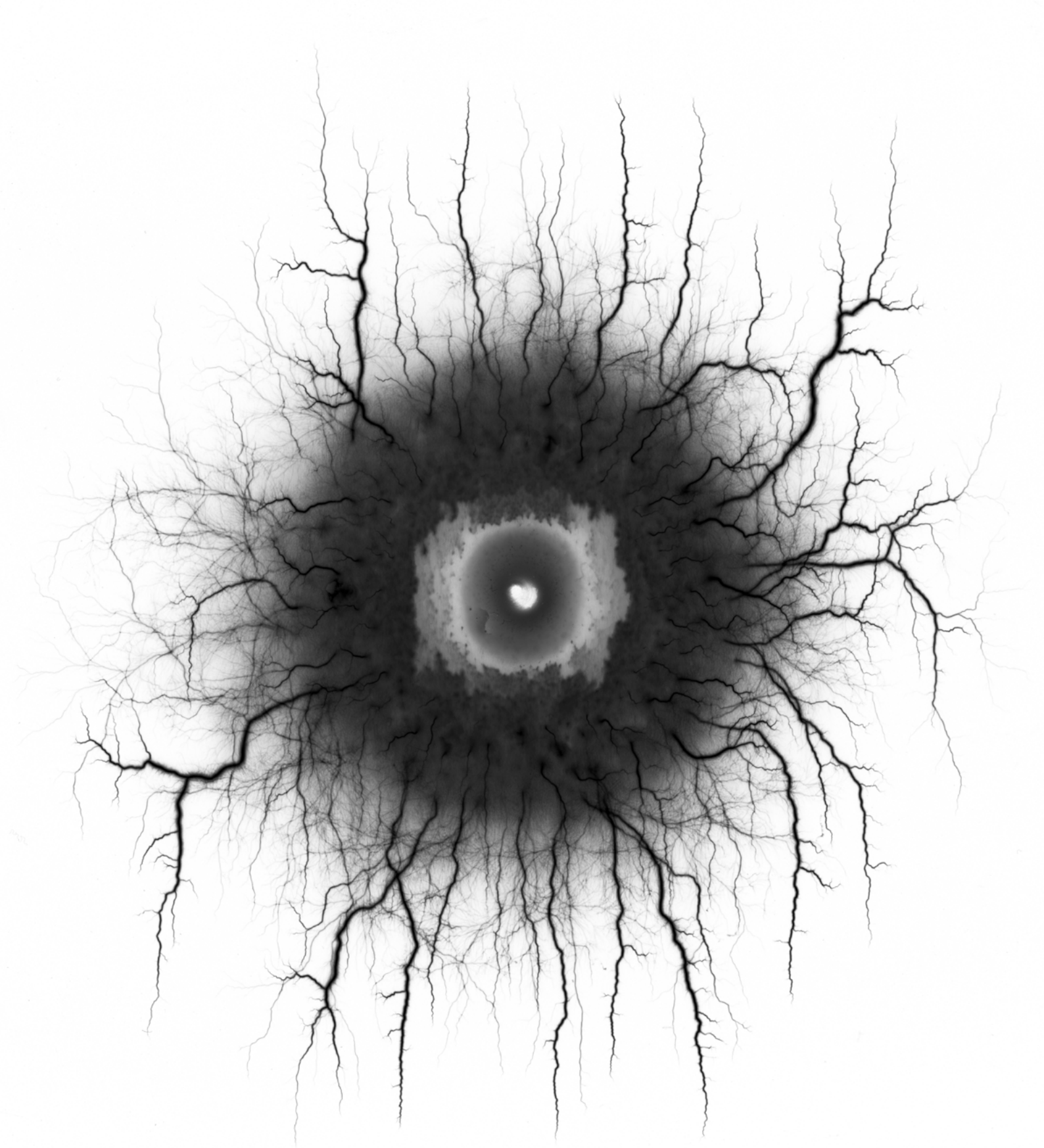


For a scientific mind, all knowledge is an answer to a question. If there has been no question there can be no scientific knowledge. Nothing is self-evident. Nothing is given. Everything is constructed.

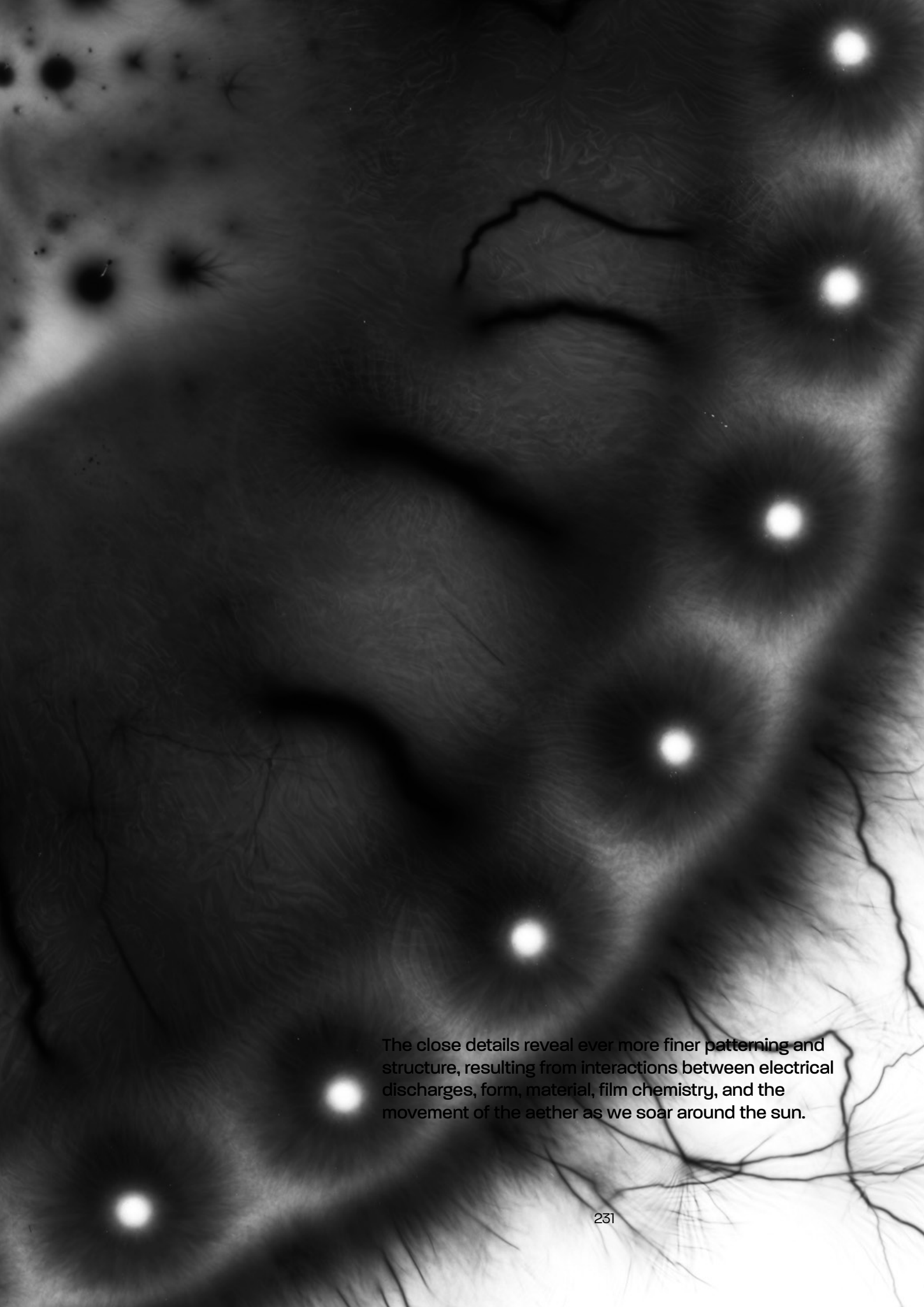
Gaston Bachelard, *The Formation of the Scientific Mind: A Contribution to a Psychoanalysis of Objective Knowledge*, 25



One of the sculpted bronze "thought forms"
imaged in 3 bursts of 50,000v DC onto lith film.



Mild steel curved disc imaged with 40,000v DC and repeated high frequency bursts of 250Hz that has stripped the emulsion from the Foma 400 film.



The close details reveal ever more finer patterning and structure, resulting from interactions between electrical discharges, form, material, film chemistry, and the movement of the aether as we soar around the sun.