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On Theme and Variation

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> The search for differences or fundamental contrasts between the phenomena of organic and inorganic, of animate and inanimate, things, has occupied many men's minds, while the search for community of principles or essential similitudes has been pursued by few (Thompson 1942, p. 9).

In this passage from the introduction to *On Growth and Form*, D'Arcy Thompson clearly sees himself as one of the 'few'. At the same time, he reminds me that the 'search for community of principles or essential similitudes' can also be applied to Darwin. Today it seems peculiar that until the mid-nineteenth century we thought of ourselves as unique creations and, as such, unrelated to the rest of the animal kingdom, despite our strikingly obvious physical similarities to other mammals. How, one is forced to wonder, could our forbears have imagined that we were not variations on an animal theme, and accordingly drawn conclusions about our place in the scheme of things? Perhaps they assumed that God's plans fitted a certain template — or perhaps similarities are invisible until we notice genuine differences. There is in any event something here of the blindness of hubris, as well as a perceived need to maintain distance between ourselves and lower forms of life. This human-centric frame of mind is conducive to a 'search for differences and fundamental contrasts'. One could add the distinction between human and animal to Thompson's list of opposites here.

The genius of Darwin and his fellow evolutionists was to recognise the kinship of living things through evidence of their metamorphosis in the fossil record. However, Thompson recognised an even more fundamental kinship, existing not only between human and animal but also between organic and inorganic. He appreciated something so ubiquitous that it is hard to see as a phenomenon at all: that everything, whether animal, vegetable or mineral, has to obey the same physical laws that govern our universe. There can be no exemptions to the laws of physics: organic life must obey the same rules as everything else. Thompson's genius was in fully recognising the implications of this fact.

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Evidence of similarity between phenomena is antipathetic to the idea of clear, fixed and immovable divisions between things. On an evolutionary timescale, of course, organisms merge one into another. But the transition from non-life to life seems likely also to have been a gradual process: a sliding scale from inanimate to animate, from inorganic to organic.

The kind of similarities that Thompson noticed between organic and inorganic forms are patterns or tendencies best understood in terms of mathematics. The principles of economy that determine growth, for example, can be rationalized as numerical sequences rooted in geometry. The spiral shapes in shells and galaxies, the hexagonal packing in the Giant's Causeway and in a honeycomb (Figure 1) — these forms and motifs are ubiquitous in living and non-living things because they have all come about in responses to the same fundamental physical laws. In other words, the geometry of space could be said to determine the palette of forms that can exist within it; as Bennett puts it, 'The determining condition of space enables the existing universe to acquire a structure of position, size, shape and relative motion' (Bennett, 1952).

As a child I became aware of evolutionary theory and found it both beautiful and so clearly borne out by observation that it seemed almost self-evident. I thought that *any* taxonomy might be explained in terms of incremental adaptation to changing local conditions through natural selection. The lesson that Thompson taught me, however, is that there are fundamental and pervasive constraints on what adaptation can achieve. The patterns and symmetries in flowers or bird plumage, for example, may have evolved through adaptive pressures to attract pollinators or a mate, but the vocabulary of forms they use to do so are drawn from a common source, like a blueprint or pattern book determined by mathematical principles.

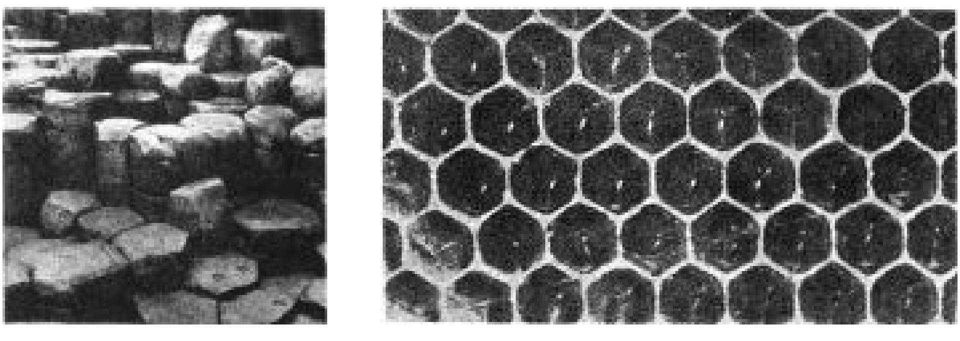

FIGURE 1 (*a*) The Giant's Causeway and (*b*) the bee's honeycomb as depicted in *On Growth and Form* (pp. 520 and 527).

Given the seemingly infinite variety of form in the natural world (both organic and inorganic), one can easily overlook the fact that all this diversity can be rationalized as variations on a surprisingly limited number of themes. For example, there are only five regular polyhedra, and only three regular two-dimensional shapes can tessellate on a flat surface. These underlying patterns or themes determine the boundaries for variation, hence the hexagonal packing in both crystalline structures and the honeycomb. A potato and a pebble can achieve an almost identical form, one through growth, the other by erosion — one alive, one not. The branching patterns of trees, rivers and vascular systems, and the arrangements of neural connections in the brain, can all look very much the same. The structure of tributaries flowing into ever larger streams, rivers and estuaries comes about as the response of water to gravity and topography, along with the response of topography (via erosion) to the flow. The determining factors in the branching structure of a tree are quite different, although the resulting 'patterns' can be remarkably similar.

The Basque architect Gaudi wanted to make the spires for his great Cathedral Sagrada Família in Barcelona appear to reach up towards the heavens. He made the models by dripping plaster down a string and then inverting the solidified result, in effect reversing gravity. Frei Otto, another visionary architect and pioneer of grid shell structures, developed 'soap film' models in which forms generate themselves under specific boundary constraints, in order to observe and analyse the process of load transfer and the deformations of complex tensile shapes.

In a sense, the trick that organic life performs is to postpone the forces of entropic decline into disorder. Thompson pointed out that in doing so it very often employs the same vocabulary of forms found in inorganic phenomena.

The mathematical principles that underpin what we perceive are abstract. We never find perfect geometry in reality; we infer the underlying principles by observation and experimentation. Like Plato's ideals, the geometric archetype, with its infinitely small dots and infinitely thin lines, can only exist in our imaginations.

It seems that both living and inanimate systems exist in a state of balance between a tendency to spontaneous pattern formation and an equally strong propensity to random variation. It is clear that these polarities — the tendencies towards order and disorder — drive the evolutionary process. Without random mutation natural selection would not happen, while random variation needs a 'theme' on which to work.

A moth camouflaged against the bark of a tree may be an interesting example of conflicting influences in the evolutionary process, guided on the one hand by adaptation to local conditions and on the other by the imperatives of geometric economy. The colour and mottled pattern of the moth is well matched to the background — but the camouflage is mirrored on each wing. Its bilateral symmetry is the 'give away', so that predatory birds might be expected to evolve to recognize this symmetry. In the animal kingdom, bilateral symmetry in markings seems to be a default position, presumably because it is economical in terms of metabolic investment: two for the price of one. Although there may be a price to pay for this economy in terms of (in this case) visibility to predators, the survival of the moths must mean that it is a price worth paying. The evolutionary solution to the need for hiding is good enough.

Whether or not predatory birds are sensitive to bilateral symmetry, human beings certainly are. We seem to be hard-wired to pay attention to it for the obvious reason that from an early age the most interesting and expressive thing to us is the human face. In such ways we are pattern-recognising creatures: we look for repetition and connection, we love to find structures and symmetries, and these may carry meaning for us. Rorschach used symmetrical ink blots to stimulate emotional responses because the symmetrical blot seems more meaningful and suggestive than sheer randomness.

Our desire to find pattern, order and meaning drives the impulse for both science and art, and for much of human history no real distinction was made between them. Leonard da Vinci explored observational analysis and expressive emotion in almost equal measure, both rooted in an appreciation of form and analogy. However, since the advent of rigorous scientific methods based on experimentation and hypothesis over the past two or three centuries, art and science have increasingly diverged. At their best, both still search for underlying structure and pattern, but the ways in which they look for meaning and the kind of truths they seek are now rather different. The endeavour of scientist is far more straightforward to describe than that of the artist, partly because art is now such a 'broad church' encompassing many different approaches and intentions. Science seeks to understand how the universe works empirically and accurately. Scientists aspire to be as dispassionate and detached as possible without prejudice or preconception in their pursuit of measurable truth. This is done through observation and experimentation and advanced through a series of hypotheses which become modified in the light of new evidence.

It is impossible to give a similarly succinct description of the endeavour of the artist; today there are probably as many different endeavours at there are artists. For this reason I am drawing on a personal perspective about my own practice as an artist and how what I make relates to some of the ideas already discussed, in particular the influence of D'Arcy Thompson. As a way of communicating in the twenty-first century, making objects and showing them to people may seem something of a blunt instrument. But although most things we need or want to communicate are best done in words, there is a specific area of human experience for which I believe sculpture is the most appropriate medium. Visual art is not a language in the usual sense of precise translatable meanings; rather it taps into shared human experience and uses metaphor to make unexpected connections.

Sculpture is at its most potent when it explores the direct experience of inhabiting a physical body in a physical world. For me, the overarching interest remains the human condition: what it feels like to be alive. My interest is in *how things make us feel*: why do some shapes and arrangements of forms have more significance for us than others? This is a psychological investigation that embraces subjectivity in a way that science never should. As an artist I am interested in subjective experience for the light it can shed on human nature and on the ways we make the world meaningful for ourselves. Our experience of life consists not just of 'reading information out of things'; we also read things into our experiences. Subjectivity always mitigates our objective experience of the world.

The things we 'read into' the world may reveal little about the stimulus, but they can say plenty about ourselves and how we make sense of the world. Of course, a great deal of our subjectivity is mere trivial and idiosyncratic prejudice or preoccupation, but on a deeper level our continued fascination with certain patterns and forms over millennia can, I believe, help us to understand something about the way we think and feel. The obsessive, puzzle-like patterning found in some ancient art seems still to resonate today.

It is clear how important finding connections and patterns was to Thompson as a scientist; it is equally vital to me as an artist. Making connections between disparate things is what makes human beings creative and imaginative in both art and science. In art the connections tend to be poetic and metaphorical, cross-referencing our shared mental filing system in fresh and unexpected ways.

Synaesthesia is the condition of experiencing sensation in one of the senses when the stimulation is from another, for example hearing colour or feeling music in a haptic sense. Metaphor can be thought of as a kind of synaesthesia by suggestion. We are, of course, familiar with these kinds of connections in our everyday language: we speak of music having colour, poems having form, and paintings having rhythm. The kind of connections that artists make tend to be metaphorical: what has been called 'the truthful lie'. When we watch *Macbeth* or *Othello*, we know the whole thing is make-believe: people dressed up and stage scenery. But the play contains truth — not the kind of truth that science deals with, but a metaphorical truth about the human condition. The same case can be made for literature, poetry, music and the visual arts.

My stone sculptures may hint at vitality because of the way I have shaped them, but we all know they are just dumb, obdurate matter (Figure 2). The experience of the viewer depends on knowing that this is just a lump of stone shaped by someone, whilst simultaneously suspending one's disbelief sufficiently to enter into the spirit of the metaphor. This experience should tell us more about psychology than geology.

Most of my work has been informed and inspired by study of natural phenomena and in particular the underlying mathematic principles of economy which determine how things look and fit together. It is here that I owe a debt to D'Arcy Thompson, but as an artist my own interest in these patterns and forms is rather different from his. Through prolonged informal observation of natural phenomena, it seems to me that two dominant forces are at work; the tendency towards spontaneous pattern formation in both organic and inorganic structures, and the equally ubiquitous tendency for random variation. This polarity has been recognised as underpinning our

FIGURE 2 Peter Randall-Page, *Where the Bee Sucks* (1991). Kilkenny limestone. Photo: Chris Chapman.

universe long before systematic scientific analysis. In ancient Greece the Apollonian and the Dionysian represented the contrasting principles of disciplined order and chaotic hedonism. The concept of theme and variation (albeit not wholly random) exists in music, particularly the playful inventions, reflections and variations of Bach or the wild improvisations of bebop jazz.

There is a simple but deeply satisfying pleasure in pattern recognition, whether in music or the visual arts. As a young artist I was fascinated by organic structures, and often worked directly from specific organic objects such as cones or shells. Latterly, I have tried to approach sculpture less by copying nature and more by working with the underlying laws that determine the forms we see everywhere around us. In the words of the philosopher and art historian A. J. Coomaraswamy, 'Art is ideal in the mathematical sense: like nature not in appearance but in operation' (Coomaraswamy,). One way of doing this is to create working situations in which there is a built-in structuring principle as well as a built-in random element. An example is my work using glacial erratic boulders. Like a pebble or potato, the boulder is random within certain parameters. The structuring principle takes the form of a set of simple geometric rules for mapping the entire surface. The random overall shape of the stone is a given that remains unchanged and the geometric concept must yield to that constraint without breaking its self-imposed rules An example of this is a piece entitled *Give and Take* (Figure 3), in which I used a very large glacial boulder from Scotland. The overall shape of the eroded boulder remains unchanged, and its surface is entirely covered with a geodesic matrix of 12 pentagons and 630 hexagons carved in low relief. The initial division of the surface into 20 triangles was achieved using an elastic net stretched over the stone. One of my interests in this piece is the way in which the individual hexagons and pentagons are forced to respond to the relatively random form of the stone, swelling where the form is convex and shrinking where they are pushed closer together in the concavities.

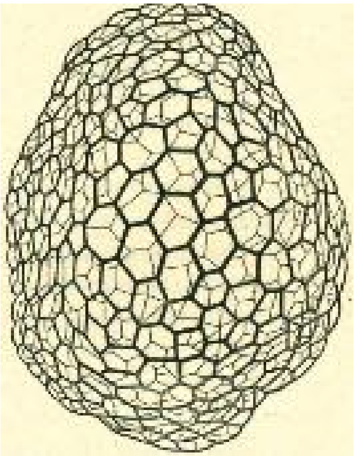

FIGURE 3 (*a*) An irregular quasi-hexagonal tiling of alveoli from *On Growth and Form* (p. 708). (*b*) Peter Randall-Page, *Give and Take* (2003). Granite and associated hard landscaping. Commissioned by Silverlink for Trinity Gardens, Newcastle upon Tyne. Photo: Peter Randall-Page.

FIGURE 4 Peter Randall-Page, *Warts and All* (2006). Granite and oak. Yorkshire Sculpture Park. Photo: Jonty Wilde

Another work in which I use the naturally eroded form of a boulder as a starting point is *Warts and All* (Figure 4). In this piece I have projected a spiral phyllotaxis arrangement onto one end of the stone and inverted it on the other. The resulting pattern is carved as a series of raised nodules that again respond and yield to the undulating surface of the stone.

For some reason, this way of working is conducive to a kind of unselfconscious improvisational approach. While one part of the brain is busy with the reconciliation of a puzzle, another becomes strangely liberated. The result can be a kind of improvized set of variations on the twin themes of order and randomness. The musical analogy is important here, and Bach's music offers the perfect example. The creativity of much of his music lies with the inventiveness of the variations. But the variations cannot exist in any meaningful way without a theme. The beauty and magic thus emerge from the tension between theme and variation.

My 70-tonne granite sculpture *Seed* (Figure 5), commissioned for the Eden Project in Cornwall, also uses spiral phyllotaxis and the Fibonacci sequence, but this time on a much more regular form, housed within its own architectural 'pod'.

In a large ceramic wall piece *Mind's Eye*, commissioned for the University of Cardiff Psychology Department (Figure 6a), I used a mirror-image design to create spiralling alignments which are also based on phyllotaxis. A similar idea can be seen in the rubbing I made of the cut faces of a split boulder work with a drilled pattern (Figure 6b).

As already mentioned, much of my work uses bilaterally symmetrical forms because we have such a strong psychological propensity to read emotional and expressive meaning into them. In a series of ceramic wall pieces I combined geometric constructions with a kind of Rorschach inkblot technique (Figure 7).

My *Secret Life* series of split boulders (Figure 8a) develop the idea of mirror symmetry in a more three-dimensional way, while works such as *Parting Company* and *Zai-Fuzai* (Figures 8b and 8c, respectively) explore the relationship between positive and negative forms.

In *Multiplication by Division* and *The Fullness of Time* (Figures 9b and 9c, respectively) I drew parallels with Thompson's investigations into cellular division, while in *Shapes in the Clouds* and *In the Beginning* (Figure 9d and 9e, respectively) I explore the way in which spherical stacking can produce curvaceous versions of the Platonic solids. In the latter, by filling the spaces between the spheres to create the appearance of a stretched membrane I suggest a process of growth and subdivision.

Perhaps D'Arcy Thompson articulated something that many artists and scientists may have always known on some level:

Treat nature by the cylinder, the sphere, the cone.
Paul Cézanne, Jan 1904

Geometry is everywhere present in nature.
François Auguste Rene Rodin

Mighty is geometry; joined with art, resistless.
Euripides

Whoever. . . proves his point and demonstrates the prime truth geometrically should be believed by all the world, for there we are captured.
Albrecht Dürer

The universe cannot be read until we have learnt the language and become familiar with the characters in which it is written. It is written in mathematical language, and the letters are triangles, circles and other geometrical figures, without which means it is humanly impossible to comprehend a single word.
Galileo Galilei

It is the artistic mission to penetrate as far as may be toward that secret ground where primal law feeds growth.
Paul Klee

Everything is what it is because it got that way.
D'Arcy Thompson (1942)

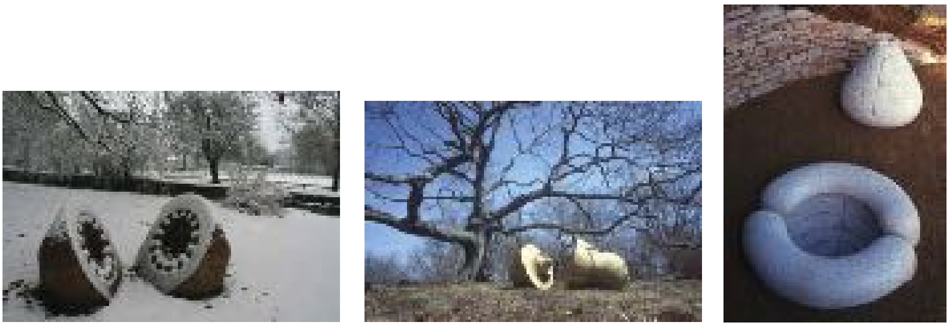

figure 8 (a) Peter-Randall Page, Secret Life IV (1994). Granite. Photo: Julian Francis. (b) Parting Company I (1996). Limestone. Photo: Peter Randall-Page. (c) Zai-Fuzai (1992). Granite. Yamaguchi Prefecture, Japan. Photo: Peter Randall-Page.

FIGURE 6 (*a*) Peter Randall-Page, *Mind's Eye* (2006). Ceramic tiles. School of Psychology, University of Cardiff. Photo: Peter Randall-Page. (*b*) Cut face of a split boulder.

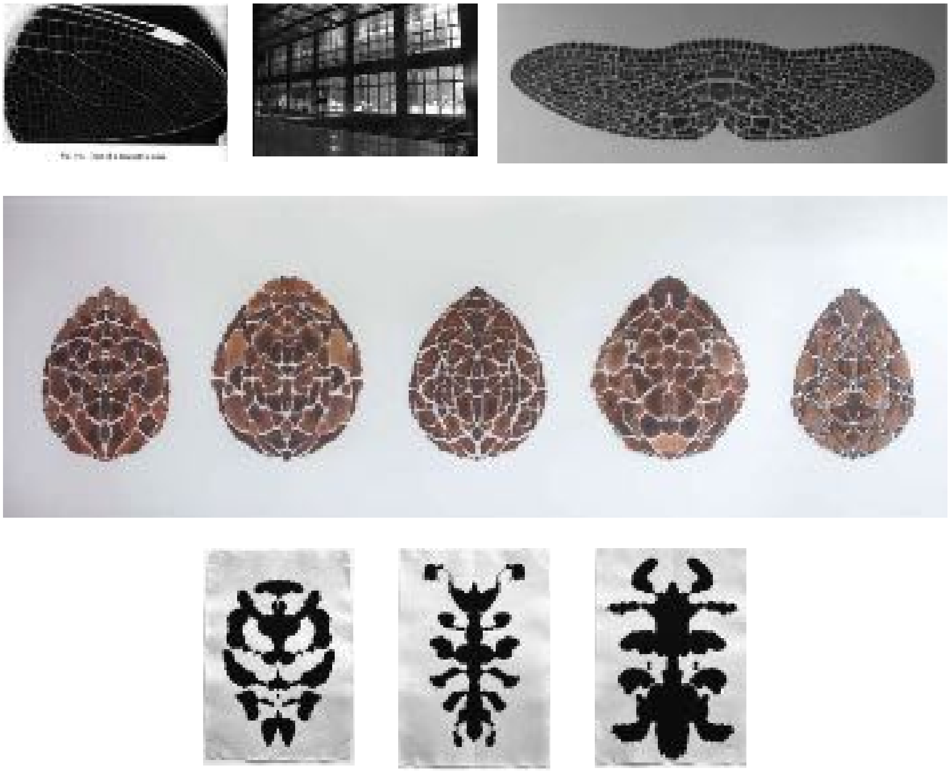

FIGURE 7 (Top left), Vein pattern of an insect wing from *On Growth and Form* (p. 476). (Top middle) Peter Randall-Page, *The Big Wing* (2009). Transparent film on glass. Temporary installation at Canary Wharf, London. Photo: Peter Randall-Page. (Top right) *Wing* (2009). Ceramic. Yorkshire Sculpture Park. Photo: Jonty Wilde. (Middle) *Mind Map I-V* (2009). Ceramic. Yorkshire Sculpture Park. Photo: Jonty Wilde. (Bottom) *Rorschach II, IV & V* (2006). Ink on paper. Photos: Peter Randall-Page.

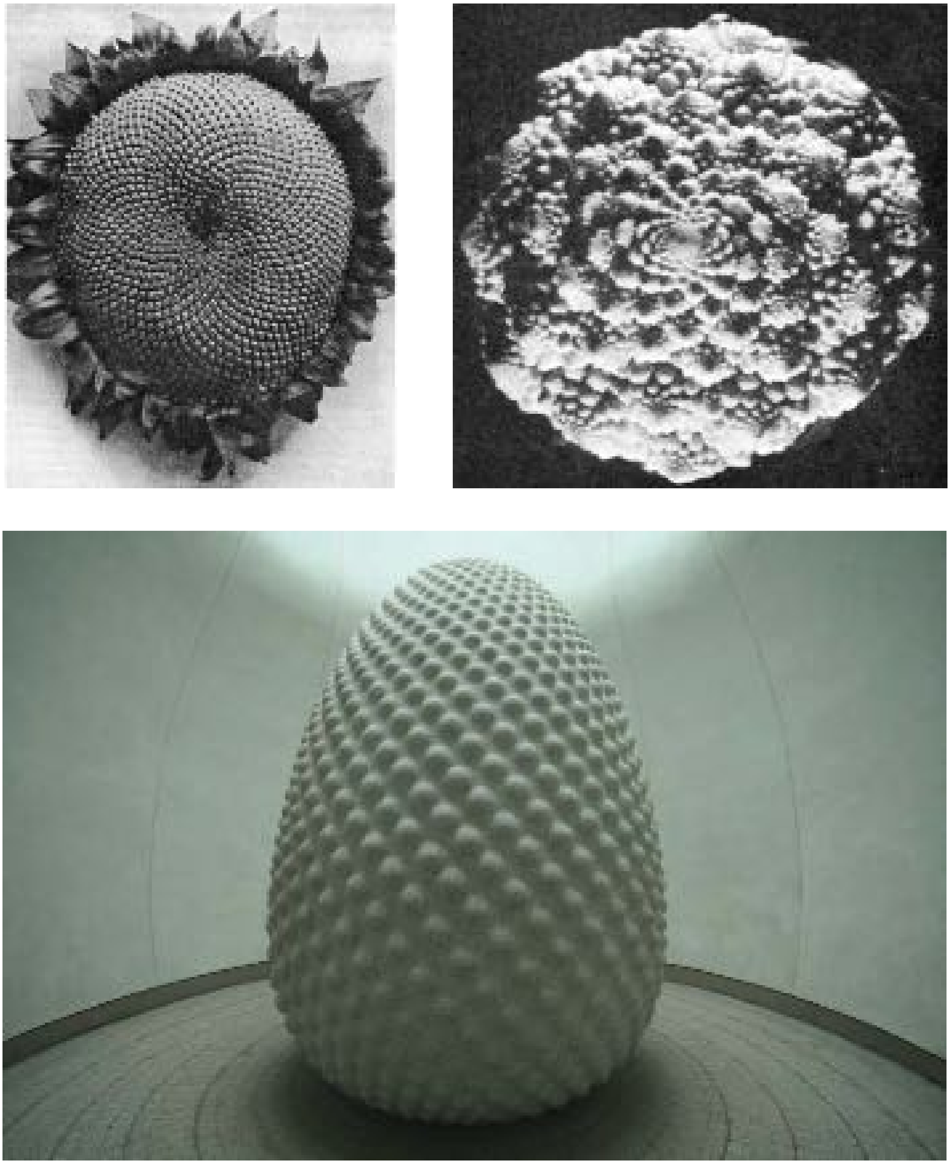

figure 5 (Top) Phyllotactic arrangements in a sunflower and cauliflower in On Growth and Form (pp. 913, 914). (Bottom), Peter Randall-Page, Seed (2007). Granite and specially designed chamber, The Core, Eden Project, Cornwall. Photo: Ben Foster

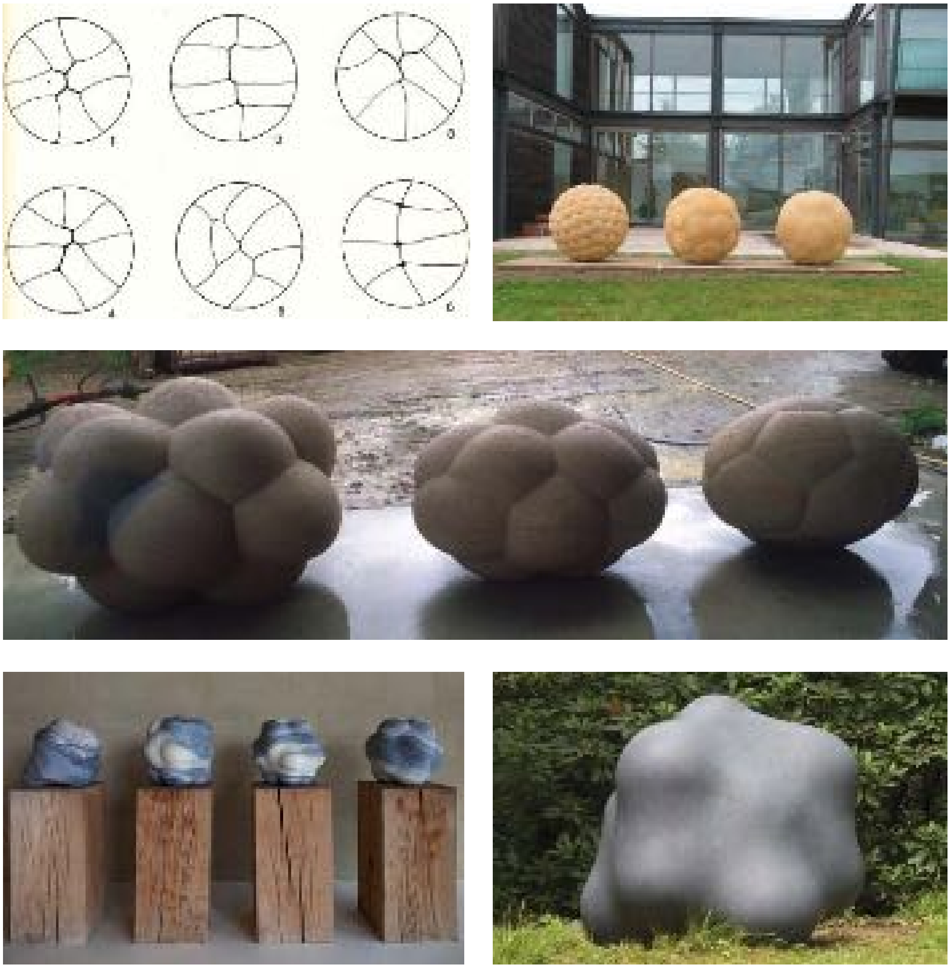

FIGURE 9 (*a*) Cell division illustrated in *On Growth and Form* (1st edn, p. 381). (*b*) Peter Randall-Page, *Multiplication by Division* (2000). Guiting limestone. Photo: Peter Randall-Page. (*c*) *The Fullness of Time* (2002). Clipsham stone and associated landscaping. Photo: Peter Randall-Page. (*d*) *Shapes in the Clouds (Plato Dreaming of Artemis)* (2005). Rosso Luana marble and oak. Commissioned for the Said Business School, Oxford, photographed at the Yorkshire Sculpture Park. Photo: Jonty Wilde. (*e*) *In the Beginning* (2009). Kilkenny limestone. Photo: P. J. Dove.

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