The Order of the Parts

Objective Design and the Closure Rule of the Vacuum.Net

J. Konstapel, Leiden, 20 October 2026

© 2026 J. Konstapel, Constable Research, Leiden. All rights reserved. Quotation with attribution is permitted; reproduction of the whole requires written permission.

Version 1.0

Abstract

The course *Objectief Ontwerpen* (2022) states one design rule. Keep the unique parts. Change only their order. Give the result a unique boundary.

The Vacuum.Net theory states one selection rule. A window of three crossings closes when its trits sum to zero modulo 3. What closes stays. What does not close passes on as tension.

This essay reads the course through the net. The two meet in six places, and each meeting can be computed.

First, design as reordering. Nine fixed parts can be laid in 1,680 orders. Only 6 of them close in every window.

Second, the four plus one. The closing register has exactly four closing directions and one empty centre. The four lie on a single line of the projective plane over three values, and that line contains its own pole.

Third, the empty centre. The four seasons, written as a ring of trits, close nowhere. One step of the net's rewrite turns them into rest everywhere.

Fourth, the Lo Shu. Centred on its middle number, every line of the magic square sums to zero. Read in trits it is one closing window, shifted three times.

Fifth, the viaduct. The course resolves colliding paths by lifting one over the other. That is the crossing of the strand: over, under, none.

Sixth, the three fates. Fragile, resilient and antifragile correspond to the open window, the closed window and the step to the next depth.

A final section states which claims are proven, which are correspondences and which are open.

---

1. The course in brief

The course is a Dutch summary of the English text *About Antifragile Design* (2022). Its core fits in a few lines.

A design does not invent new parts. It finds the unique parts of a system, or makes parts unique by splitting them. It then changes their order and wraps them in a unique boundary. The products of Apple serve as the example.

The method fuses several fourfold models into one. Holling's panarchy describes an ecology. Jung's archetypes, as worked out in McWhinney's *Paths of Change*, describe a person. Fiske's four relational models describe a group. Taleb's antifragility describes a whole under pressure. Kondratiev's long wave describes an economy. The Chinese cycles, built on the Lo Shu square, describe the body and the year.

Each model has four positions and a centre. The four are each other's opposites. The centre is therefore empty. It is the observation post from which the whole can be seen.

The course calls the method structure preserving. The way the design is made adds no theory to the design. One can move back and forth between source and result. All the cycles say the same thing under other names.

Three further claims matter here.

A fragile system breaks under pressure. A resilient system returns to its old state. An antifragile system jumps to a new level, where the parts are the same and their order differs.

Colliding paths form a figure eight. The collision is solved by lifting one path over the other, as a viaduct lifts one road over another.

A design starts best in spring, with an idea. An idea is not a sudden notion. It is an essence found by collecting many look-alikes over a long time.

---

2. The net in brief

The Vacuum.Net theory rests on five axioms (Konstapel 2026a, 2026b).

N1 (Strand). There is one strand. Every distinction is the strand touching itself. A self-crossing has three states: over (+1), under (−1) or none (0).

N2 (Closure). A touching persists if and only if it lies in a closed window. What does not close passes on as tension.

N3 (Memory). At every knot the passages are ordered. The first passage fixes the orientation.

N4 (Context). Every constant is a function of the strand, not a fixed number.

N5 (Scale). The net repeats its construction at every depth. What does not close at one scale is the material of the next.

A **window** is three consecutive crossings with trits (x, y, z). It **closes** when $x + y + z \equiv 0 \pmod 3$. A **ring** is a closed strand of n crossings, read cyclically. It has n windows.

Five results of the theory are used below. All are proven in the foundational paper.

T9. Of the 27 possible windows, exactly 9 close. The sum map from three trits to one trit is onto, so its kernel has $27 / 3 = 9$ elements.

T10. A window closes if and only if its three trits are all equal or all different. All equal gives 3a ≡ 0. All different gives 1 + 0 − 1 = 0. Two equal and one different gives 2a + b ≡ 0, which forces b ≡ a. So there are 3 homogeneous and 6 heterogeneous closures.

T13. If every window of a ring closes, the ring repeats every three steps. Subtract the closure condition at position i from the one at i + 1: t(i+3) − t(i) ≡ 0. If 3 does not divide n, the ring must be constant. If 3 divides n, it repeats one closing window.

T14. Let the rewrite R replace each trit by minus the sum of its two neighbours: $R(t)_i = -(t_{i-1} + t_{i+1})$. A ring is a fixed point of R exactly when every window closes. The fixed points do not attract. Other rings mostly end in cycles.

T7. In balanced ternary every integer has exactly one address. No minus sign and no rounding rule are needed.

The theory also fixes how a named thing is carried into the net. Its translation procedure is fixed before any case is read. It leaves no free choice. Every accepted name marks a closure (Konstapel 2026a, Sections 3 and 6).

The net can be pictured as a fishing net. Its strength lies in how the threads cross, not in any single thread. That image is kept throughout.

---

3. Design as reordering

The course says that design changes the order of unique parts. The net gives this sentence a count.

Take nine parts: three of value +1, three of value 0, three of value −1. Lay them in a ring. The number of distinct orders is 9! / (3!·3!·3!) = 362,880 / 216 = 1,680.

Each order has 9 windows. Count how many close. The result over all 1,680 orders is:

Closed windows	Orders
1	108
2	432
3	594
4	216
5	270
7	54
9	6

No order closes 0, 6 or 8 windows.

The mean can be found by hand. Pick any window. It closes when its three parts are all equal or all different. All equal: 3 · (3/9 · 2/8 · 1/7) = 18/504. All different: 6 · (3/9 · 3/8 · 3/7) = 162/504. Together 180/504 = 5/14 per window. Over nine windows the mean is 45/14 ≈ 3.21. The enumeration gives the same value.

Two orders stand out. The sorted ring (+1, +1, +1, 0, 0, 0, −1, −1, −1) closes 3 windows. These are the three blocks of equal parts. It is the ring of specialisation: like with like. The interleaved ring (+1, 0, −1, +1, 0, −1, +1, 0, −1) closes all 9. Every window holds three different parts. By T13 this is the only kind of ring that can close everywhere and still contain difference.

So the parts never change. Their order decides how much of the whole stays. Six orders in 1,680 close completely. That is 0.36 %. A design, in this reading, is the search for one of those six.

The course adds a unique boundary, the packaging. In the net the boundary is what makes the line a ring. A line of nine parts has seven windows. Only when its ends are joined do the last two windows exist. By T13 a ring can close everywhere with difference only if its length is a multiple of three. The boundary is therefore not decoration. It sets the length, and the length decides whether difference can close at all.

---

4. Four plus one

The course works with four positions and a centre. The net's register produces exactly this number, without being asked to.

Take the 9 closing windows of T9. One is (0, 0, 0). The other 8 come in pairs v and −v, because the closure rule is symmetric under sign. That leaves four closing directions:

(1, 1, 1), (1, −1, 0), (1, 0, −1), (0, 1, −1).

So the register holds four closing directions, each in two orientations, and one rest point: 4 × 2 + 1 = 9. The rest point is the centre. It is a closure, but it carries no direction. It is empty in the sense of the course.

The four have a precise place. Read every non-zero triple up to sign. There are (27 − 1) / 2 = 13 of them. They form the projective plane over three values, PG(2, 3). It has 13 points and 13 lines. Every line holds 4 points. Every point lies on 4 lines.

The four closing directions are exactly the points orthogonal to (1, 1, 1), modulo 3. So they are one line of that plane. And (1, 1, 1) lies on its own line, since 1 + 1 + 1 ≡ 0. The quaternio is a line that contains its own pole.

The number 13 recurs in the course's sources. *About Antifragile Design* opens with "twelve plus one combinations" of the four functions. The course itself speaks of thirteen starting points. In the net, 13 is the number of directions in the cube of three trits. It is also the capacity of depth three in T7: $(3^3 − 1)/2 = 13$. Of these 13 directions, 4 close and 9 stay open.

The shape of the four differs from the square of the course. Over the real numbers, (1, 1, 1) is perpendicular to the other three. Those three lie in one plane and meet at 60 degrees. So the four are one axis and three spokes. The axis is the homogeneous closure: all parts equal. The spokes are the heterogeneous closures: all parts different. The course notes that a right angle marks independence. In the net, the homogeneous direction is independent of all three heterogeneous ones.

This is a second picture of the quaternio, not a correction of the first. The square shows the four as opposites around a centre. The register shows them as one way of being equal and three ways of being different. Both have the empty centre.

---

5. The empty centre

The course says that the four positions are each other's opposites, so the centre is empty. The net computes this.

Give the seasons a trit. Spring and summer belong to the growing half of the year: +1. Autumn and winter belong to the declining half: −1. Section 6 shows that the Lo Shu gives exactly these values.

The year as a ring of four is (+1, +1, −1, −1). Its four windows are (1, 1, −1), (1, −1, −1), (−1, −1, 1) and (−1, 1, 1). Their sums are 1, −1, −1 and 1. None closes.

Now apply the rewrite R once. Each season is replaced by minus the sum of its neighbours. The neighbours of spring are winter and summer: −1 + 1 = 0. The neighbours of summer are spring and autumn: 1 − 1 = 0. The same holds for autumn and winter. The result is (0, 0, 0, 0).

One step of the net's own rewrite turns the four opposites into rest everywhere. This is the course's empty centre, as a computation.

Two consequences follow.

The first concerns motion. By T13 a ring of four can close in every window only if all four parts are equal. Of the 81 rings of four, only 3 close everywhere, and all 3 are constant. A fourfold cycle that contains real difference can never close. It always passes tension on. The quaternio is therefore not a structure that rests. It is a ring that keeps turning. The course says the same in its own words: standing still is the end of everything.

The second concerns the fifth season. Insert the centre between summer and autumn, as the course does with Indian summer. The ring becomes (+1, +1, 0, −1, −1). Exactly one window now closes: (1, 0, −1), the one centred on the fifth season. Under repeated rewriting this ring never comes to rest. It cycles with period 8. The fifth season is the one place in the year where a window closes, and it keeps the year moving rather than stopping it.

---

6. The Lo Shu as a closed grid

The course cites the Lo Shu: a 3 × 3 square of the numbers 1 to 9, with 5 in the middle and every line summing to 15. It also states the rule behind it. The constraint is that the sum of all parts is zero.

The net reads this literally. Subtract 5 from every entry. The square

4	**9**	**2**
3	5	7

4	**9**	**2**
8	1	6

becomes

−1	**+4**	**−3**
−2	0	+2
+3	−4	+1

Now all eight lines — three rows, three columns, two diagonals — sum to exactly 0 in the integers. The magic constant 15 is 3 × 5, the centre counted three times. Removing the centre leaves pure balance.

Reduce each entry modulo 3 to a trit:

−1	**+1**	**0**
+1	0	−1
0	−1	+1

Every row is a permutation of (−1, 0, +1). So is every column. Each row is the row above it, shifted one place. This is the structure of T13 in two directions: one closing window, repeated with period three.

All eight lines close as windows. Seven are heterogeneous: three different trits. One is homogeneous: the diagonal through 2, 5 and 8, which becomes (0, 0, 0). In the Chinese assignment of the five phases, 2, 5 and 8 are the three Earth positions. The one line whose trits are all equal is the one line whose numbers share one element.

The traditional placement of the seasons is: 9 summer (south), 3 spring (east), 7 autumn (west), 1 winter (north). Centred, these are +4, −2, +2 and −4. As trits they are +1, +1, −1 and −1. So the Lo Shu itself splits the year into a growing half and a declining half. These are the values used in Section 5. They were not chosen to make the computation work. They were read off the square.

The Lo Shu is thus a grid in which every line closes. It is the smallest arrangement of nine different parts with that property in two directions at once. The course places it at the root of the Chinese cycles. The net places it at the root of the register.

---

7. The viaduct is the crossing

The course describes panarchy as a figure eight, a Möbius ring. It appears wherever paths collide. The solution is to lift one part, as a viaduct lifts one road over another. The course adds that collisions are avoided by placing the directions in different dimensions.

This is N1 in plain words. A self-crossing of the strand has three states: over, under, none. A collision is two paths in one place with no order between them. A viaduct is the same place with an order: one path over, one under. The trit is the record of which.

The Möbius ring adds one property. A frame carried once around a Möbius band returns turned over. It returns to its start only after two rounds. In the net this is T2: a strand that is attached to its surroundings returns after 4π, not 2π. The course's figure eight carries the double turn of the strand.

Panarchy has two named links between levels: *revolt* and *remember*. Small fast cycles experiment and break out. Large slow cycles store what worked. In the net, *revolt* is N5: what does not close at one scale becomes the material of the next. *Remember* is N3: the net keeps its history as its shape. The first passage fixes the orientation, and later passages are read relative to it.

---

8. Three fates of a window

The course distinguishes fragile, resilient and antifragile. The net has three fates for a window.

Open. The window does not close. By N2 its tension passes on. If nothing takes it up, the configuration does not last. This is the fragile system: it does not hold under pressure.

Closed. The window closes and the configuration stays. The rewrite R leaves it as it is. This is the resilient system: it returns to its set point.

The net shows why the old so often returns. Take all 19,683 rings of nine trits and apply R repeatedly. Nine rings are fixed points. Of the rest, 720 enter cycles of length 3 and 18,954 enter cycles of length 9. Not one reaches a fixed point from outside. The rewrite on its own never produces a new closure. It turns the same patterns around and brings them back.

This matches the conclusion of *About Antifragile Design*. Resilience is the main reason new designs fail. The old always comes back.

Step to the next depth. N5 says that what does not close at one scale is the material of the next. The parts are carried up. At the new depth they are read in a new order, and that order can close where the old one could not. The parts are unchanged. Only their order and their scale differ.

This is the antifragile jump of the course. The course says the jump changes nothing in the parts and everything in their order. The net says the same: same trits, other windows.

The pressure that forces the jump is the tension carried by the open windows. A system with no open windows has no material for the next depth. A system with only open windows has nothing that stays. The jump needs both.

---

9. Structure preserving, counted

The course calls its method structure preserving. The way of designing adds no theory to the design. All cycles say the same thing under other names. Experts draw their authority from their own vocabulary.

The net makes the same demand of itself. Its translation procedure takes a subject with an accepted name and returns its place in the net. The procedure is fixed before any case is read. It leaves no free choice. Theorem 14 of the formal statement proves that it is a function: each named magnitude receives exactly one address (Konstapel 2026a). A different vocabulary for the same thing gives the same entries, and so the same place.

The scope clause adds that every accepted name marks a closure. A name is what a group agreed to call the same. In the course's words: the names differ, the thing is the same.

The four scales of measurement fit the same frame. Stevens (1946) defined them by what they allow: nominal scales allow any relabelling, ordinal scales any order-preserving map, interval scales any linear map, ratio scales only a change of unit. Each admits fewer transformations than the one before and keeps more structure. Klein's geometries nest in the same way. Fiske (1991) placed his four relational models on these four scales. That the scales nest is a mathematical fact. That each relational model belongs to one scale is a correspondence.

The net walks the same ladder in its procedure. A subject is first named (nominal). Its dimension fixes its role (ordinal, a choice among kinds). It is divided by a natural unit (ratio). Its position is then read on one ladder of powers of 2 and 3. Ranking needs no outside criterion: in balanced ternary the order of the digit strings is the order of the numbers. For all 729 integers from -364 to $+364$ at six digits, the two orders agree.

The course asks, at each step, for a criterion that says what "greater" means. The register supplies one from inside.

One further match concerns prediction. The course reports a finding from heuristics: the best explanation gives the worst prediction, and good prediction comes from the range of what the model allows. The net's own ledger shows the same pattern (Konstapel 2026a, Section 8). Where the theory counts closures, it holds. Where it fixes the size of a measured magnitude, it has not yet shown anything beyond chance. The net is strong on what can close. It is open on how large things will be.

The course gives one size claim: cycles that run five times faster or slower than Kondratiev's wave. In the net, 5 is not of the form $2^a \cdot 3^b$. It is an open window. The ledger reports that self-maintained hierarchies step by factors between 2 and 4.5, in all decided cases. The course's factor 5 lies just outside that band. The Kondratiev wave of about fifty years has address $2^{-1} \cdot 3^{53}$, depth 54. It does not sit shallower on the ladder than random positions with the same uncertainty.

---

10. The human layer

The course is written for people who design together. Its advice concerns context, starting points, personality and partners. The net speaks to each.

The context. The course asks the designer to stand on the ground and find a point of view. In the net the observer is a knot (D2). It is part of the strand and meets every passage through its own place. It can see several sides of that knot, and nothing beyond it. This is why the course insists on a point of view. There is no view from outside the net.

The starting point. The course advises starting in spring, with an idea that has ripened over winter. N3 says that the first passage fixes the orientation of a knot. Everything after it is read relative to that start. A design that starts in the wrong place carries that orientation through every later step. The course's warning — never choose a starting point that does not fit your personality — is N3 applied to a person.

Personality. The course treats a personality as a potential cycle with a viewpoint, a height and a direction of rotation. In the register, a direction of rotation is a sign: +1 or −1. Each of the four closing directions comes in both. Myers–Briggs' introvert and extravert, inward and outward rotation, is that sign. The height — on the ground or above it — is the up and down stand of the empty centre.

The partner. The course advises finding a partner who overlaps and complements. It adds that two people still cannot see the whole. The net gives the reason in numbers. A window has three places. Two people fill two of them. No pair closes a window. The smallest closure that keeps difference is heterogeneous: three different trits. So the smallest group that holds together while staying different is three people in three different positions.

Such a group looks disordered by the usual measure. Map the trits to the three cube roots of unity and average them. Three equal members give a coherence of 1. Three different members give $1 + (-\tfrac{1}{2} + i\sqrt{3}/2) + (-\tfrac{1}{2} - i\sqrt{3}/2) = 0$. The second group scores zero, and it is just as closed as the first (Konstapel 2026c). A team of three who think differently and need each other looks broken on a coherence chart. In the register it is a closed window.

The community. The course sends designers without practical experience to a community of practice. In the net a community is a ring. Section 3 showed what a ring needs: the right order of different members, and a length that lets difference close. A community of like-minded people closes only in its blocks. A community of different people, well ordered, can close everywhere.

---

11. What the course carries into the net

The course is older than the net. Several of the net's steps first appear in it or in its English source.

About Antifragile Design (2022) places balanced ternary beside Rowlands' nilpotent rewriting. The foundational paper lists that text as the first appearance of this pairing

(Konstapel 2026b, Appendix A). The same text states that "+1 − 1 = 0" lies behind every theory in physics. It ends with non-commuting products: in quaternions i·j = k but j·i = −k, so the order of steps changes the outcome. In the net that is N3. The order of passages is part of the state.

The course itself carries the 4 + 1 with an empty centre, the Lo Shu with sum zero, the figure eight with a viaduct, and the jump that changes order but not parts. Each of these now has a counterpart that can be computed.

Read through the net, the course becomes a short procedure.

1. **Draw the boundary.** Decide what is inside the ring. The boundary sets its length.
2. **List the unique parts.** Split parts until each has a single value. These are the trits.
3. **Search the orders.** For a given set of parts, count the closed windows of each order. Most orders close little. A few close everywhere.
4. **Check the length.** If difference must close everywhere, the length must be a multiple of three. A fourfold cycle with difference will turn, not rest.
5. **Read the open windows.** They mark where tension remains. That is where the next design begins.

Nothing in this procedure adds a theory to the design. It counts what closes.

---

12. Status of the claims

Proven or computed in this text

- 1,680 orders of the nine parts; the distribution of closed windows; the mean 5/14 per window; 6 orders close everywhere.
- Four closing directions plus the rest point; they form one line of PG(2, 3), which contains its pole (1, 1, 1).
- The 13 directions of the trit cube; $(3^3 - 1)/2 = 13$.
- (1, 1, 1) perpendicular to the three heterogeneous directions, which meet at 60 degrees.
- The four-season ring (+1, +1, −1, −1) closes no window; R maps it to (0, 0, 0, 0) in one step.
- A ring of four closes everywhere only if constant.
- The five-ring (+1, +1, 0, −1, −1) closes one window and cycles with period 8.
- The centred Lo Shu: all eight lines sum to 0; the trit grid is a period-3 Latin square; seven heterogeneous lines and one homogeneous line, the 2–5–8 diagonal.
- Rewrite fates for rings of nine: 9 fixed, 720 in 3-cycles, 18,954 in 9-cycles, none reaching a fixed point from outside.
- Balanced-ternary string order equals numeric order on [−364, 364].
- A coherence of 0 for three different trits on the cube roots of unity.

Input

- The Lo Shu itself, the traditional placement of the seasons and the five phases.
- The fates of the Kondratiev wave and the hierarchy steps, taken from the ledger of the formal statement.

Correspondences

- Design as the search for a closing order.
- The packaging as the boundary that makes a line a ring.
- The four closing directions as the quaternio; the rest point as the empty centre.
- The viaduct as the crossing of N1; the Möbius ring as the double turn of T2.
- Revolt as N5; remember as N3.
- Fragile, resilient and antifragile as open window, closed window and step to the next depth.
- The sign of a closing direction as the direction of rotation of a personality.
- Fiske's relational models on Stevens' scales.

Open

- Whether real design cases show more closed windows in their final order than in their first. This needs a fixed list of cases, recorded before counting.
- Whether teams of three different roles hold longer than pairs or homogeneous trios. The coherence triple — alignment, homogeneous closure, heterogeneous closure — makes this measurable.
- The size claims of the course: the factor 5 between nested cycles has no address on the ladder.

Annotated references

Konstapel, J. (2022a). "Objectief Ontwerpen: Slim Navigeren in de Oplossings Ruimte." constable.blog, 27 December 2022, revised 20 October 2026. https://constable.blog/2022/12/27/cursus-objectief-ontwerpen/ *Why read?* The course this essay reads. It holds the design rule, the seven steps and the full set of pictures. *Reading advice:* start with the sections "Uniek", "Tegendelen" and "Springen uit de Context".

Konstapel, J. (2022b). "About Antifragile Design." constable.blog, 19 November 2022. https://constable.blog/2022/11/19/antifragile-design/ *Why read?* The English source of the course. It contains the theory of the trinity, the structure-preserving maps, Rowlands and the conclusion on non-commuting paths. *Reading advice:* Part 1 and the conclusion.

Konstapel, J. (2026a). "The Vacuum.Net Theory: Definition, Theorems and Tests." Version 4, 17 October 2026. https://constable.blog/wp-content/uploads/vacuum-net-theory-v4.pdf *Why read?* The current formal statement: signature, five

axioms, fourteen theorems, the translation procedure and the ledger of tests. *Reading advice:* Sections 2, 6 and 8.

Konstapel, J. (2026b). "The Vacuum.Net Theory: Foundational Paper." Edition 8, version 8.1, 17 October 2026. https://constable.blog/wp-content/uploads/vacuum-net-foundational-paper-ed8.1.pdf *Why read?* The derivations behind T7, T9–T14 and T2, and the chronology of the theory in Appendix A. *Reading advice:* Part III for the register; Appendix A for the place of the 2022 texts.

Konstapel, J. (2026c). "Metaphor as Closure in the Vacuum.Net." constable.blog, 14 October 2026. https://constable.blog/2026/10/14/metaphor-as-closure-in-the-vacuum-net/ *Why read?* Introduces homogeneous and heterogeneous closure in groups and the zero coherence of a well-held triad. *Reading advice:* sections 9 and 10.

Holling, C. S. (2001). "Understanding the Complexity of Economic, Ecological, and Social Systems." *Ecosystems* 4, 390–405. *Why read?* The compact statement of the adaptive cycle and of panarchy, with *revolt* and *remember*. *Reading advice:* the figure of nested cycles and the section on cross-scale links.

Gunderson, L. H. & Holling, C. S. (eds.) (2002). *Panarchy: Understanding Transformations in Human and Natural Systems*. Island Press, Washington. *Why read?* The full theory, with cases from ecology, economy and institutions. *Reading advice:* chapters 1 and 2.

McWhinney, W. (1992). *Paths of Change: Strategic Choices for Organizations and Society*. Sage, Newbury Park. *Why read?* The four worldviews, the six games between them and the method of choosing a path. The basis of the course's fourfold. *Reading advice:* the chapters on the four realities and on the games.

Jung, C. G. (1951). *Aion: Researches into the Phenomenology of the Self*. Collected Works 9/II. Princeton University Press. *Why read?* The quaternio as the structure of the self, drawn from alchemy. *Reading advice:* the final chapter on the structure and dynamics of the self.

Fiske, A. P. (1991). *Structures of Social Life: The Four Elementary Forms of Human Relations*. Free Press, New York. *Why read?* The four relational models and their link to the scales of measurement. *Reading advice:* the chapter on the ordinal, interval and ratio structure of the models.

Fiske, A. P. (1992). "The Four Elementary Forms of Sociality." *Psychological Review* 99(4), 689–723. *Why read?* The short form of the theory, with the cross-cultural evidence. *Reading advice:* read whole.

Stevens, S. S. (1946). "On the Theory of Scales of Measurement." *Science* 103(2684), 677–680. *Why read?* Defines the four scales by the transformations they allow. Four pages. *Reading advice:* read whole; the table carries the argument.

Klein, F. (1872). *Vergleichende Betrachtungen über neuere geometrische Forschungen* (the Erlangen programme). Deichert, Erlangen. *Why read?* Geometries defined by their groups of transformations, nested by inclusion. The mathematical basis for the course's link between scales and geometries.

Benoit, E. (2013). "Expression of Uncertainty in Fuzzy Scales Based Measurements." *Journal of Physics: Conference Series* 459, 012004. *Why read?* Treats scales of measurement as structure-preserving maps. Cited in the English source of the course.

Taleb, N. N. (2012). *Antifragile: Things That Gain from Disorder*. Random House, New York. *Why read?* The source of the three-way distinction fragile, robust and antifragile used in the course. *Reading advice:* Book I.

Kondratiev, N. D. (1935). "The Long Waves in Economic Life." *Review of Economic Statistics* 17(6), 105–115. *Why read?* The English summary of the long wave of about fifty years.

Cammann, S. (1961). "The Magic Square of Three in Old Chinese Philosophy and Religion." *History of Religions* 1(1), 37–80. *Why read?* The history of the Lo Shu and its links to the seasons, the directions and the five phases. *Reading advice:* the sections on the directional assignments.

Hirschfeld, J. W. P. (1998). *Projective Geometries over Finite Fields*, 2nd ed. Oxford University Press. *Why read?* The standard account of projective planes such as PG(2, 3): 13 points, 13 lines, four points on each line. *Reading advice:* the opening chapters on planes of small order.

Knuth, D. E. (1997). *The Art of Computer Programming*, Vol. 2, 3rd ed., 195–213. Addison-Wesley. *Why read?* Balanced ternary: unique representation, rounding by truncation, and its symmetry. The arithmetic behind T7.

Rosen, R. (1985). *Anticipatory Systems*. Pergamon, Oxford. *Why read?* The living system as one that carries a model of its surroundings. The course uses it for the step from idea to action. *Reading advice:* chapter 1.

Volk, T. (2017). *Quarks to Culture: How We Came to Be*. Columbia University Press, New York. *Why read?* The sequence of combogenesis from quarks to culture, shown in the course's central picture. Each level fuses the parts of the one below and adds a boundary. *Reading advice:* the introduction and the overview chapter.

Alexander, C. (2002). *The Nature of Order, Book 1: The Phenomenon of Life*. Center for Environmental Structure, Berkeley. *Why read?* Order as the arrangement of centres that strengthen each other. A designer's account of why some orders of the same parts hold and others do not. *Reading advice:* the chapter on the fifteen properties.