

UNITED WISDOM

How Complex Systems Arise

World and Consciousness

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Epigraph

> *Metaphor and analogy can be helpful, or they can be misleading.*

Herbert A. Simon, *The Architecture of Complexity*, introduction, p. 467. A complete sentence warning about transferring systems analogies between domains.

What this article is about

We can know what a device contains and still understand its behaviour poorly. A list of rooms does not explain how heat moves through a building; a list of participants does not establish who receives information in time; the names of substances do not show how their quantities change together. Parts have connections, and connections have directions, rates and conditions. Explaining how a complex system arises therefore begins with interaction. This article introduces three distinctions: connecting parts, returning an outcome into a process, and making an outcome depend on combined conditions. Simple original examples let us check these distinctions without treating every aspect of life as one physical scheme. Historical papers by Herbert Simon, Alan Turing and Philip Anderson help define the comparison's limits. They address different questions and preserve different assumptions. For UW's World and Consciousness direction, the useful question is what changes when parts become connected, and what observation could challenge our explanation.

I. Define the system first

"System" can become a compliment paid to anything organised. Explanation requires a working boundary: which objects are included, which changes matter, and what enters from outside? When discussing the heating of one room, neighbouring rooms may belong to its surroundings. When discussing the whole building, exchange between rooms becomes an internal interaction. The same object permits different boundaries depending on the question. This choice does not change the physical building, but it changes the quantities that must be considered. Naming the boundary before reaching a conclusion makes it possible to compare two explanations rather than selecting a boundary afterwards to suit an attractive result.

Complexity also needs qualification. There may be many objects, each moving independently in the same way, so that their description remains short. Another problem may contain only a few objects whose dependencies, delays and switching conditions make prediction difficult. The number of parts, number of connections, length of a calculation and difficulty of measurement describe different features. This article proposes no universal measure of

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complexity. Its elementary examples need only identify a new dependence introduced by connecting parts. “Complex” then names a specific explanatory difficulty. It does not confer special value, hidden depth or an obligation to find the subject permanently mysterious.

In his 1962 paper Simon describes hierarchy through interacting subsystems nested within larger systems. His usage need not mean superiors and subordinates: the relevant relationships can be physical or spatial. The descriptive move identifies intermediate wholes whose internal interactions differ from interactions between them. It does not prove that every system has the same structure. If we call a room, assembly or stage of calculation a unit, we should explain what interaction holds its components together. Without that reason, the division remains a convenient picture. A picture can guide inquiry, but convenience alone does not establish that it reveals the world’s actual organisation.

Consider an original example: four people preparing a short joint document. We could examine their exchange of messages, or examine only how files move. Those are different descriptions. A message may be read without a file changing, while a file may change without anyone sending a notification. Mixing the boundaries can make silence appear to establish an absence of work. A useful check asks what counts as a transfer and what evidence confirms receipt. Here systems language sharpens the question. It does not reveal participants’ motives or establish a behavioural rule that every participant is required to accept as the project’s purpose.

II. A connection belongs in the explanation

Take four labelled nodes: A, B, C and D. In the first diagram A connects to B and C to D; in the second, we add a connection between B and C. The number of nodes stays unchanged, but now a path exists between any two. This is a property of the whole diagram, verifiable by listing the permitted steps. No single node possesses it on its own. Yet the diagram describes only the availability of paths. It says nothing about speed, reliability or willingness to use a connection. Adding an edge changes reachability; an operating system would require further rules for what moves along it.

Direction can matter more than a connection’s mere existence. If information travels only from A to B and then to C, a later node may have no route for sending a correction back to the first. Two-way exchange requires additional possibilities. In our diagram an arrow means a permitted transfer in one step: an author’s convention, not a law of social relations. The check is straightforward: can we construct a sequence of arrows from the relevant source to its recipient? If not, saying “everyone knows” supplies no missing route. A route’s existence also does not prove that a particular message was sent, received or understood.

Connections can differ in strength and operate on different timescales. In Simon’s imaginary thermal building, exchange within rooms is faster than exchange between them, while the outer boundary is assumed insulated. These conditions support different approximations for short and long observations. The example suggests a useful question about exchange rates: which differences have time to diminish before a measurement? It establishes no universal rule that a subsystem’s boundary is always weak. In another object, exchange across our chosen boundary may dominate behaviour. We would then need a different division or an explicit account of the strong external influence rather than protecting our original picture.

In our document example, rapid file transfer and slow agreement about meaning can coexist. This is an original UW comparison, not a thermal law applied to people. Separately recording when a file was sent and when its content was agreed can prevent one event from inheriting the properties of another. We can check dates and replies while leaving genuinely unknown matters unknown. We cannot calculate trust as thermal conductivity. The comparison extends only to different exchange times. When a question concerns the right to refuse, access to participation or the reason for a delay, we need an account of human circumstances and consent.

III. Nonlinearity does not mean mystery

As an initial picture, a linear dependence doubles the corresponding contribution to an output when an input doubles, and combines contributions by addition. A nonlinear dependence fails at least one such relationship. The term alone does not say whether the outcome will be weak, strong, stable or variable. In an original teaching example, a device switches on only when two signals are present together. Either signal alone gives zero output; their joint presence gives one. Adding the separate outputs gives zero, while the joint result is one. Four cases suffice to check this table. No special power of the whole is needed to explain it.

Representing each signal by zero or one lets us write the rule as multiplication: the output equals the first signal multiplied by the second. Within this domain it reproduces the table exactly. Allowing other numbers would change the model’s meaning. Two is not “twice as true” a statement of consent. The permitted values belong to the explanation alongside the formula. A common mistake transfers a tidy numerical relationship to a situation whose quantities have never been defined. We first need to identify the observation or measurement and its possible values. Only then can we decide whether a mathematical operation between them represents anything relevant.

A threshold appears in another original example. A container holds three identical objects, but a fourth exceeds its stipulated capacity. The object count changes one step at a time, while the classification “fits” switches. That transition follows from the chosen criterion; it need not mean the container’s material has changed. If the container deforms, the objects differ in size

or protruding objects are allowed, the table no longer describes the task. Sudden classification and sudden physical change require different explanations. Before explaining a turning point, it helps to check both possibilities. Calling something nonlinear supplies neither the missing measurement nor this distinction between a criterion and a mechanism.

Turing’s treatment of the law of mass action requires attention to actual chemical steps rather than just an overall transformation. The distinction matters for mechanism: the same net description can omit intermediate reactions. This gives no permission to invent a hidden chemical process behind every conversation. Our two-signal table is not a chemical model at all. The limited comparison is that a concise statement of an outcome can leave out conditions on which obtaining it depends. Recovering those conditions requires evidence about the particular object. Otherwise we have merely replaced an overgeneralisation with a different one that happens to sound more technical and authoritative.

IV. When an outcome returns

Feedback exists when a process’s outcome affects its subsequent course through a specified return path. We must identify that path, rather than call every later event feedback. In an original numerical example, we want a value to approach ten. At each step the rule adds half the difference between the target and the current value. Starting at zero gives five, then seven and a half, then eight and three quarters. The error halves each time. Anyone can repeat the calculation. It shows the behaviour of this rule with a fixed target and no other inputs; it does not demonstrate that every form of control works effectively.

Replace half the difference with twice the difference. Zero becomes twenty, then zero again: the error changes sign without shrinking. A still larger multiplier in the same teaching scheme can increase its magnitude. The intention to approach a target stays the same, while the update rule changes the result. “Negative” feedback does not mean morally bad, and “positive” does not mean beneficial. The terminology commonly concerns the direction of an effect on a deviation. Establishing stability requires more than a label: the correction’s size, its timing and other variables matter. Even this small scheme demands that we retain its conditions before generalising from its behaviour.

A delay changes the problem again. A correction calculated from an earlier value may continue a movement that has already become excessive. Delay alone nevertheless does not establish inevitable instability. The result depends on the other rules: sometimes a small correction suffices, while other situations require different responses. Separately marking the measurement time and the intervention time makes it possible to ask whether the response concerns the present state. We can distinguish missing data from late data, and a wrong calculation from an action taken after conditions changed. These are ordinary distinctions, but

they point towards different possible repairs rather than one generic appeal to improve feedback.

In collaborative work a returned comment can resemble part of this scheme without being a mechanical regulator. Its recipient can challenge the target, request an explanation or decline a change. Our document example therefore includes discussion of meaning that the numerical rule lacks. We can check whether a comment concerns a particular passage and whether it addresses the latest version. That does not let us calculate human will. A systems description helps where it identifies an actual dependence. It becomes excessive when participants are treated as unconditionally controllable components and the coordinator’s convenience is silently presented as everyone’s shared and unquestionable objective.

V. An intermediate whole can survive

Simon’s watchmaker parable makes assembly depend on whether intermediate combinations survive interruption. We can understand the point without importing its historical numerical estimates. Suppose four pieces must form one object. Under a first stipulated rule, interruption destroys all unfinished progress. Under a second, two joined pieces already form a pair that survives. If interruption occurs after a third action, restarting differs under the two rules. The contrast concerns which states remain stable, rather than the craftsperson’s skill. This constructed example establishes no unique history of how complex organisms arose. It offers a question about the retention of intermediate states within a specified process.

A retained component can reduce some losses, but it introduces requirements. It must fit other components, permit later assembly and actually survive under the relevant conditions. An incorrect intermediate result can survive too, making its persistence an obstacle to revision. Retention and suitability are therefore different properties. Our document example makes the distinction concrete: a backup preserves a file without proving its claims correct. A checked passage helps future work only with an identified version, intelligible conditions of use and a possibility of revision. This is process organisation. It is not a guaranteed law of learning or a promise that preserving any intermediate outcome improves the final result.

Dividing a task is not always the better solution. Some separated tasks interact closely: changing a definition can change several sections at once, and independent work can generate contradictions. Intermediate blocks then need an agreed boundary. Our four-node diagram supplies another example: adding a shared connection changes a whole-graph property while leaving the original pairs intact. Retained subsystems help under particular interactions. Once those interactions change, a convenient division requires reassessment. Otherwise the previous organisation begins to dictate the explanation despite what the object actually does. We may mistakenly attribute the scheme’s resistance to revision to the nature of complexity rather than to a poor choice of boundaries.

Simon discusses assembly alongside evolution and problem solving, but these are different ways of obtaining a new state. Manual assembly can have a specified goal. A biological explanation cannot simply assume a future purpose for which intermediate forms appeared. A search evaluates partial outcomes against its chosen problem. Distinguishing these processes prevents a quiet substitution: showing that persistence can be useful does not demonstrate nature's intention. For a particular object we still need to establish why a state lasts, which changes are available and what is being selected. An analogy can list those questions; it cannot answer them instead of observation and domain-specific investigation.

VI. A pattern from interactions

Turing examines a particular possibility: chemical change and transport together can make a uniform state unstable. In the paper's initial sections, tissue geometry is fixed and approximate concentrations represent states. Reactions in the two-cell teaching example are deliberately selected for accessible reasoning and explicitly described as imaginary. They are not presented here as a completed biological experiment. The important point is their joint action: transport of one quantity occurs alongside reactions that change other quantities. We cannot assume that "mixing always levels everything out" describes this coupled problem. We must consider what happens at the same time as material moves, within the model's stated conditions.

It helps to distinguish symmetry of a rule from symmetry of a state. Two locations described by identical rules can have different states. A rule that does not favour the first cell over the second does not require an initial difference to disappear. With a suitable instability, the difference can grow. "Suitable" is a substantial condition: another rule can suppress it. A reference to broken symmetry cannot explain every observed difference. We need to identify the quantity, its initial difference and the process of change. That produces a checkable model, rather than an impression that nature is necessarily trying to diversify every object and situation.

We must also avoid silently replacing a perfectly identical initial state with an almost identical one. In mathematical reasoning, zero difference and a small nonzero difference can have different consequences. Measurement adds a question about resolution: a difference may have existed without appearing in the recorded value. Yet an unknown small deviation cannot simply be declared the demonstrated cause of a particular pattern. Such a conclusion requires evidence about the system and comparison with alternatives. This article discusses a mechanism permitted by a bounded model. It leaves investigation of the actual object open, rather than substituting the broad term "self-organisation" for that investigation.

"Self-organisation" can sound as though surroundings no longer matter. A pattern arising through internal interactions does not imply an absence of external conditions. Supply,

geometry, boundaries and available transport can enter a model from the beginning. Changing them changes the possible states. A useful question for any account of spontaneous order is what has been held constant and what maintains that constancy. The answer can be physical, technical or organisational, depending on the subject. A chemical example establishes neither a spiritual design nor a universal recommendation to manage people so that a preferred pattern of relationships will supposedly emerge without further ethical or practical considerations.

VII. Explanation has levels

Anderson distinguishes accepting underlying laws from automatically reconstructing a complex object's behaviour from them. This concerns explanatory work rather than a rejection of physics. In our diagram we can know every edge without yet checking reachability. In a chemical problem we can know permitted reactions without yet determining the spatial state. Between the list of rules and the answer lies investigation of a particular dependence. Calling this a new descriptive level helps if we identify the quantity described and its relation to a more detailed account. Naming a level alone establishes no such relation and supplies none of the calculation or observation needed to investigate it.

Part, whole and surroundings are relative to the question. A room can be a whole when discussing its own climate and a part when discussing the building. A message can be a transfer unit and an element of a discussion whose meaning is not exhausted by counting messages. Moving between these descriptions need not introduce a new substance or fundamental force. It changes the account and its available observations. Demanding one vocabulary for everything can conceal a subject, while wholly separating vocabularies can obstruct checking their relationship. A more useful approach asks what survives the transition, what information is lost and what conditions become relevant to the answer.

Reachability can be checked completely for four nodes. A larger object may require approximation, selection of relevant connections or a specialised calculation. Those difficulties do not prove that the whole is fundamentally inexplicable. "We have not obtained an answer" differs from "an answer is impossible under these assumptions." The former reports a state of investigation; the latter needs a specific argument. Public discussion of emergence often jumps across this gap. This introduction leaves the stronger metaphysical dispute open. Its examples show properties depending on relationships and conditions. They do not establish entities independent of parts, or turn a practical difficulty into proof that no explanation could ever succeed.

Descriptive levels also do not automatically create a ranking of value. Physics is necessary for a computer to operate, but that does not make a letter's meaning morally less important. Meaning is not supplied by a byte count, but a letter still depends on material conditions of

delivery. Questions about decent treatment of people need their own grounds; they cannot be derived from a preferred graph structure. UW's World and Consciousness direction meets Action here through responsibility for using a model: which decisions does it support, whose information does it omit, and who retains the possibility of correcting an assumption made about them?

VIII. Transfer a question while retaining its limit

A useful analogy transfers a particular relationship and checks it in a new domain. We can observe the difference between sending time and response time without assuming messages behave like heat. We can see an outcome depend on two agreed conditions without assigning numerical values to consent. We can preserve a working file without calling the process an instance of evolution. Naming a resemblance takes less space than stating its boundary, but that boundary matters for action. It tells us where the scheme still gives grounds and where we need to ask a participant, make a measurement or give up a conclusion that is too strong.

A check begins with an alternative. If a missing connection explains the outcome, what should we see when a connection becomes available? If delay explains it, would a timely reply make a difference? If an unsuitable intermediate part explains it, what would change after correction? These questions do not guarantee that experimentation is possible or appropriate. Conditions can be costly or impermissible to change. We can instead observe, seek an existing comparison or acknowledge what remains unknown. Honest inquiry includes a right not to experiment on people. Curiosity does not authorise intervention in someone else's time, participation or circumstances merely to obtain convenient evidence for our scheme.

A systems account can reveal material constraints, or conceal them. "Feedback is needed" helps little when someone cannot access a communication channel. Breaking work into steps does not return missing time or resources. Our original UW application therefore retains participation conditions. The aim is to clarify an available next step, not require a person to become an ideal node. Reducing the scope, changing a deadline, requesting help or explicitly declining can be appropriate human decisions. They are discussed separately from a physical mechanism. None of the papers read here demonstrates the effectiveness of this proposed practice for every reader or overrides another participant's account of their constraints.

How complex systems arise admits many particular answers. Connected parts acquire dependencies; returned effects can change subsequent movement; intermediate states can persist; certain combinations of rules permit differences to grow. Every answer needs its own assumptions. Instead of one universal story, the reader gains distinguishable questions to put to an object. Those questions permit revision when the object changes or an omitted condition becomes visible. Revision is part of understanding rather than its defeat. In UW's

contemporary application, preserving that possibility and participants' autonomy matters more than promising a final map of nature or a guaranteed order for human life.

What this means in practice

Choose a small task you can examine without intervening in another person's circumstances: your own document preparation, the transfer of a known file or a technical connection. State the question in one sentence. Define what belongs within the account, what remains an external condition and what you do not know. Do not put another person's assumed motives into the diagram without their account of them.

Draw up to four nodes and only connections whose existence can be confirmed. For each arrow, state what moves along it and what would establish receipt. If delay matters, distinguish the initial event's time from the response time. Mark a missing or unknown connection in words, keeping those two conditions distinct rather than treating uncertainty as demonstrated absence.

Identify one condition on which the outcome depends and one possible check. This might mean inspecting a saved version, checking channel availability or comparing two already known cases. Do not alter someone else's conditions for an experiment without consent. If a check is unavailable, record the explanation's limit and keep the conclusion provisional. That is a legitimate outcome of this exercise.

Select a proportionate next step, including the option to change nothing yet. Afterwards compare the observation with your original assumption and revise only what new evidence supports. This is an original UW proposal. It promises no result, replaces no investigation of a particular system and requires no numerical measure of human dignity, trust or freedom.

Key quotation

> *The law of mass action must only be applied to the actual reactions.*

Alan M. Turing, *The Chemical Basis of Morphogenesis*, § 3, p. 40. Complete sentence: an overall transformation differs from actual chemical steps. The quotation establishes no law of social relations.

Connections between traditions

Question	Two sources and locators	Comparison mechanism	Difference retained
Where is the boundary?	Simon, pp. 467–468; Turing, § 3, pp. 40–41	Identify components and exchange	A general description supplies no chemical rates
How does exchange matter?	Simon, pp. 474–475; Turing, § 4, pp. 42–43	Distinguish exchange and joint change	Thermal equilibration differs from reaction-driven amplification
Why does construction matter?	Simon, pp. 470–472; Anderson, p. 393	Rules and construction provide different information	A parable proves no universal evolutionary account
What does an outcome omit?	Turing, § 3, pp. 40–41; Anderson, p. 393	Distinguish mechanism and descriptive level	Psychology does not become a chemical reaction rate
Rule or state?	Turing, § 4, pp. 42–44; Anderson, pp. 394–395	Distinguish symmetry of laws and states	No explanation of every pattern or spiritual force
How can an analogy help?	Simon, pp. 467 and 473; Anderson, p. 396	Formulate a checkable question	UW practice is original; efficacy is not demonstrated

Primary sources

1. Herbert A. Simon. *The Architecture of Complexity*. Proceedings of the American Philosophical Society 106, no. 6, 12 December 1962, pp. 467–482. Primary prose transcription; CMU copy. Introduction, nested subsystems, assembly parable, search and bounded thermal example. The latter does not establish every system’s structure.

2. Alan M. Turing. *The Chemical Basis of Morphogenesis*. Philosophical Transactions, Series B 237, no. 641, 14 August 1952, pp. 37–72. Primary paper, §§ 1–4, pp. 37–44. Imaginary reactions and fixed geometry remain model conditions rather than experimental results.

3. Philip W. Anderson. *More Is Different*. Science 177, no. 4047, 4 August 1972, pp. 393–396. Primary paper. Reduction versus construction; later biology and culture analogies retain the author’s explicitly speculative status.

Tags

complex systems, interaction, feedback, nonlinearity, system boundary, subsystem, connections, directed connection, exchange timescale, descriptive levels, Herbert Simon, Alan Turing, Philip Anderson, morphogenesis, reaction, diffusion, stability, intermediate state, assembly, symmetry, model, checking, analogy, conditions, World and Consciousness, United Wisdom, autonomy, revision

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