



YOUR KINDLE NOTES FOR:

Thinking in Systems: International Bestseller

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142 Highlights

Highlight (Yellow) | Location 88

MIT System Dynamics group.

Highlight (Yellow) | Location 90

I have drawn here from the language, ideas, examples, quotes, books, and lore of a large intellectual community.

Highlight (Yellow) | Location 101

this book, like all books, is biased and incomplete.

Highlight (Yellow) | Location 151

If a factory is torn down but the rationality which produced it is left standing, then that rationality will simply produce another factory. If a revolution destroys a government, but the systematic patterns of thought that produced that government are left intact, then those patterns will repeat themselves.

Highlight (Yellow) | Location 157

Managers are not confronted with problems that are independent of each other, but with dynamic situations that consist of complex systems of changing problems that interact with each other. I call such situations messes.... Managers do not solve problems, they manage messes.

Highlight (Yellow) | Location 175

A system is a set of things—people, cells, molecules, or whatever—interconnected in such a way that they produce their own pattern of behavior over time. The system may be buffeted, constricted, triggered, or driven by outside forces. But the system's response to these forces is characteristic of itself, and that response is seldom simple in the real world.

Highlight (Yellow) | Location 179

The system, to a large extent, causes its own behavior!

Highlight (Yellow) | Location 211

Ever since the Industrial Revolution, Western society has benefited from science, logic, and reductionism over intuition and holism.

Highlight (Yellow) | Location 216

Because they are embedded in larger systems, however, some of our “solutions” have created further problems.

Highlight (Yellow) | Location 235

the basic operating unit of a system: the feedback loop.

Highlight (Yellow) | Location 249

Systems thinkers call these common structures that produce characteristic behaviors “archetypes.”

Highlight (Yellow) | Location 282

The behavior of a system cannot be known just by knowing the elements of which the system is made.

Highlight (Yellow) | Location 295

A system* is an interconnected set of elements that is coherently organized in a way that achieves something. If you look at that definition closely for a minute, you can see that a system must consist of three kinds of things: elements, interconnections, and a function or purpose.

Highlight (Yellow) | Location 313

A system is more than the sum of its parts. It may exhibit adaptive, dynamic, goal-seeking, self-preserving, and sometimes evolutionary behavior.

Highlight (Yellow) | Location 321

You think that because you understand “one” that you must therefore understand “two” because one and one make two. But you forget that you must also understand “and.” —Sufi teaching story

Highlight (Yellow) | Location 352

Many of the interconnections in systems operate through the flow of information. Information holds systems together and plays a great role in determining how they operate.

Highlight (Yellow) | Location 363

The best way to deduce the system’s purpose is to watch for a while to see how the system behaves.

Highlight (Yellow) | Location 367

Purposes are deduced from behavior, not from rhetoric or stated goals.

Highlight (Yellow) | Location 374

An important function of almost every system is to ensure its own perpetuation.

Highlight (Yellow) | Location 376

one of the most frustrating aspects of systems is that the purposes of subunits may add up to an overall behavior that no one wants.

Highlight (Yellow) | Location 389

Keeping sub-purposes and overall system purposes in harmony is an essential function of successful systems.

Highlight (Yellow) | Location 397

A system generally goes on being itself, changing only slowly if at all, even with complete substitutions of its elements—as long as its interconnections and purposes remain intact.

Highlight (Yellow) | Location 406

Changing interconnections in a system can change it dramatically.

Highlight (Yellow) | Location 410

A change in purpose changes a system profoundly, even if every element and interconnection remains the same.

Highlight (Yellow) | Location 426

A stock is the foundation of any system. Stocks are the elements of the system that you can see, feel, count, or measure at any given time.

Highlight (Yellow) | Location 428

a bathtub, a population, the books in a bookstore, the wood in a tree, the money in a bank, your own self-confidence.

Highlight (Yellow) | Location 475

dynamic equilibrium

Highlight (Yellow) | Location 504

Stocks usually change slowly. They can act as delays, lags, buffers, ballast, and sources of momentum in a system.

Highlight (Yellow) | Location 526

Stocks allow inflows and outflows to be decoupled and to be independent and temporarily out of balance with each other.

Highlight (Yellow) | Location 543

Systems thinkers see the world as a collection of stocks along with the mechanisms for regulating the levels in the stocks by manipulating flows. That means system thinkers see the world as a collection of “feedback processes.”

Highlight (Yellow) | Location 553

It is the consistent behavior pattern over a long period of time that is the first hint of the existence of a feedback loop.

Highlight (Yellow) | Location 576

feedback loop is a closed chain of causal connections from a stock, through a set of decisions or rules or physical laws or actions that are dependent on the level of the stock, and back again through a flow to change the stock.

Highlight (Yellow) | Location 579

One common kind of feedback loop stabilizes the stock level, as in the checking-account example.

Highlight (Yellow) | Location 602

This kind of stabilizing, goal-seeking, regulating loop is called a balancing feedback loop,

Highlight (Yellow) | Location 603

Balancing feedback loops are goal-seeking or stability-seeking.

Highlight (Yellow) | Location 641

The second kind of feedback loop is amplifying, reinforcing, self-multiplying, snowballing—a vicious or virtuous circle that can cause healthy growth or runaway destruction. It is called a reinforcing feedback loop,

Highlight (Yellow) | Location 770

The information delivered by a feedback loop can only affect future behavior; it can't deliver the information, and so can't have an impact fast enough to correct behavior that drove the current feedback.

Highlight (Yellow) | Location 797

Every balancing feedback loop has its breakdown point, where other loops pull the stock away from its goal more strongly than it can pull back.

Highlight (Yellow) | Location 848

shifting dominance of feedback loops. Dominance is an important concept in systems thinking. When one loop dominates another, it has a stronger impact on behavior.

Highlight (Yellow) | Location 1002

This situation of information insufficiency and physical delays is very common.

Highlight (Yellow) | Location 1070

any physical, growing system is going to run into some kind of constraint, sooner or later.

Highlight (Yellow) | Location 1267

Why do systems work so well? Consider the properties of highly functional systems—machines or human communities or ecosystems—which are familiar to you. Chances are good that you may have observed one of three characteristics: resilience, self-organization, or hierarchy.

Highlight (Yellow) | Location 1276

Resilience is a measure of a system's ability to survive and persist within a variable environment. The opposite of resilience is brittleness or rigidity.

Highlight (Yellow) | Location 1296

systems that are constant over time can be unresilient.

Highlight (Yellow) | Location 1298

Resilience is something that may be very hard to see, unless you exceed its limits, overwhelm and damage the balancing loops, and the system structure breaks down.

Highlight (Yellow) | Location 1299

people often sacrifice resilience for stability,

Highlight (Yellow) | Location 1411

Complex systems can evolve from simple systems only if there are stable intermediate forms. The resulting complex forms will naturally be hierarchic. That may explain why hierarchies are so common in the systems nature presents to us. Among all possible complex forms, hierarchies are the only ones that have had the time to evolve.

Highlight (Yellow) | Location 1417

Everything is still connected to everything else, but not equally strongly.

Highlight (Yellow) | Location 1421

Hierarchical systems are partially decomposable.

Highlight (Yellow) | Location 1445

When a subsystem's goals dominate at the expense of the total system's goals, the resulting behavior is called suboptimization.

Highlight (Yellow) | Location 1451

To be a highly functional system, hierarchy must balance the welfare, freedoms, and responsibilities of the subsystems and total system—there must be enough central control to achieve coordination toward the large-system goal, and enough autonomy to keep all subsystems flourishing, functioning, and self-organizing.

Highlight (Yellow) | Location 1454

Hierarchical systems evolve from the bottom up. The purpose of the upper layers of the hierarchy is to serve the purposes of the lower layers.

Highlight (Yellow) | Location 1482

Everything we think we know about the world is a model. Our models do have a strong congruence with the world. Our models fall far short of representing the real world fully.

Highlight (Yellow) | Location 1514

We are less likely to be surprised if we can see how events accumulate into dynamic patterns of behavior.

Highlight (Yellow) | Location 1520

long-term behavior provides clues to the underlying system structure.

Highlight (Yellow) | Location 1563

Nonlinearity means that the act of playing the game has a way of changing the rules....

Highlight (Yellow) | Location 1570

A nonlinear relationship is one in which the cause does not produce a proportional effect.

Highlight (Yellow) | Location 1645

systems rarely have real boundaries.

Highlight (Yellow) | Location 1645

Everything, as they say, is connected to everything else, and not neatly.

Highlight (Yellow) | Location 1647

There are only boundaries of word, thought, perception, and social agreement—artificial, mental-model boundaries.

Highlight (Yellow) | Location 1648

The greatest complexities arise exactly at boundaries.

Highlight (Yellow) | Location 1662

Processing creates not only products, but also employment, wages, profits, and pollution.

Highlight (Yellow) | Location 1683

There is no single, legitimate boundary to draw around a system. We have to invent boundaries for clarity and sanity; and boundaries can produce problems when we forget that we've artificially created them.

Highlight (Yellow) | Location 1717

boundaries are of our own making, and that they can and should be reconsidered for each new discussion, problem, or purpose.

Highlight (Yellow) | Location 1718

It's a challenge to stay creative enough to drop the boundaries that worked for the last problem and to find the most appropriate set of boundaries for the next question.

Highlight (Yellow) | Location 1754

Economics evolved in a time when labor and capital were the most common limiting factors to production.

Highlight (Yellow) | Location 1766

growth itself depletes or enhances limits and therefore changes what is limiting.

Highlight (Yellow) | Location 1780

No physical entity can grow forever. If company managers, city governments, the human population do not choose and enforce their own limits to keep growth within the capacity of the supporting environment, then the environment will choose and enforce limits.

Highlight (Yellow) | Location 1846

Bounded rationality means that people make quite reasonable decisions based on the information they have. But they don't have perfect information, especially about more distant parts of the system.

Highlight (Yellow) | Location 1891

Change comes first from stepping outside the limited information that can be seen from any single place in the system and getting an overview. From a wider perspective, information flows, goals, incentives, and disincentives can be restructured so that separate, bounded, rational actions do add up to results that everyone desires.

Highlight (Yellow) | Location 1933

Delays, nonlinearities, lack of firm boundaries, and other properties of systems that surprise us are found in just about any system. Generally, they are not properties that can or should be changed. The world is nonlinear.

Highlight (Yellow) | Location 1977

In a policy-resistant system with actors pulling in different directions, everyone has to put great effort into keeping the system where no one wants it to be. If any single actor lets up, the others will drag the system closer to their goals, and farther from the goal of the one who let go.

Highlight (Yellow) | Location 1979

Intensification of anyone's effort leads to intensification of everyone else's. It's hard to reduce the intensification. It takes a lot of mutual trust to say, OK, why don't we all just back off for a while?

Highlight (Yellow) | Location 2022

THE TRAP: POLICY RESISTANCE When various actors try to pull a system stock toward various goals, the result can be policy resistance. Any new policy, especially if it's effective, just pulls the stock farther from the goals of other actors and produces additional resistance, with a result that no one likes, but that everyone expends considerable effort in maintaining.

Highlight (Yellow) | Location 2026

THE WAY OUT Let go. Bring in all the actors and use the energy formerly expended on resistance to seek out mutually satisfactory ways for all goals to be realized—or redefinitions of larger and more important goals that everyone can pull toward together.

Highlight (Yellow) | Location 2057

The tragedy of the commons arises from missing (or too long delayed) feedback from the resource to the growth of the users of that resource.

Highlight (Yellow) | Location 2059

The more users there are, the more resource is used. The more resource is used, the less there is per user. If the users follow the bounded rationality of the commons ("There's no reason for me to be the one to limit my cows!"), there is no reason for any of them to decrease their use. Eventually, then, the harvest rate will exceed the capacity of the resource to bear the harvest. Because there is no feedback to the user, overharvesting will continue. The resource will decline. Finally, the erosion loop will kick in, the resource will be destroyed, and all the users will be ruined.

Highlight (Yellow) | Location 2078

The structure of a commons system makes selfish behavior much more convenient and profitable than behavior that is responsible to the whole community and to the future.

Highlight (Yellow) | Location 2120

When there is a commonly shared resource, every user benefits directly from its use, but shares the costs of its abuse with everyone else. Therefore, there is very weak feedback from the condition of the resource to the decisions of the resource users. The consequence is overuse of the resource, eroding it until it becomes unavailable to anyone. **THE WAY OUT** Educate and exhort the users, so they understand the consequences of abusing the resource. And also restore or strengthen the missing feedback link, either by privatizing the resource

so each user feels the direct consequences of its abuse or (since many resources cannot be privatized) by regulating the access of all users to the resource.

Highlight (Yellow) | Location 2165

THE TRAP: DRIFT TO LOW PERFORMANCE Allowing performance standards to be influenced by past performance, especially if there is a negative bias in perceiving past performance, sets up a reinforcing feedback loop of eroding goals that sets a system drifting toward low performance. **THE WAY OUT** Keep performance standards absolute. Even better, let standards be enhanced by the best actual performances instead of being discouraged by the worst. Use the same structure to set up a drift toward high performance!

Highlight (Yellow) | Location 2182

Escalation comes from a reinforcing loop set up by competing actors trying to get ahead of each other.

Highlight (Yellow) | Location 2204

But even escalating in a good direction can be a problem, because it isn't easy to stop.

Highlight (Yellow) | Location 2212

The only other graceful way out of the escalation system is to negotiate a disarmament. That's a structural change, an exercise in system design.

Highlight (Yellow) | Location 2217

THE TRAP: ESCALATION When the state of one stock is determined by trying to surpass the state of another stock—and vice versa—then there is a reinforcing feedback loop carrying the system into an arms race, a wealth race, a smear campaign, escalating loudness, escalating violence. The escalation is exponential and can lead to extremes surprisingly quickly. If nothing is done, the spiral will be stopped by someone's collapse—because exponential growth cannot go on forever. **THE WAY OUT** The best way out of this trap is to avoid getting in it. If caught in an escalating system, one can refuse to compete (unilaterally disarm), thereby interrupting the reinforcing loop. Or one can negotiate a new system with balancing loops to control the escalation.

Highlight (Yellow) | Location 2233

This system trap is found whenever the winners of a competition receive, as part of the reward, the means to compete even more effectively in the future. That's a reinforcing feedback loop, which rapidly divides a system into winners who go on winning, and losers who go on losing.

Highlight (Yellow) | Location 2242

If the winning takes place in a limited environment, such that everything the winner wins is extracted from the losers, the losers are gradually bankrupted, or forced out, or starved.

Highlight (Yellow) | Location 2295

THE TRAP: SUCCESS TO THE SUCCESSFUL If the winners of a competition are systematically rewarded with the means to win again, a reinforcing feedback loop is created by which, if it is allowed to proceed uninhibited, the winners eventually take all, while the losers are eliminated. **THE WAY OUT** Diversification, which allows those who are losing the competition to get out of that game and start another one; strict limitation on the fraction of the pie any one winner may win (antitrust laws); policies that level the playing field, removing some of the advantage of the strongest players or increasing the advantage of the weakest; policies that devise rewards for success that do not bias the next round of competition.

Highlight (Yellow) | Location 2341

Modern medicine in general has shifted the responsibility for health away from the practices and lifestyle of each individual and onto intervening doctors and medicines.

Highlight (Yellow) | Location 2360

Addiction is finding a quick and dirty solution to the symptom of the problem, which prevents or distracts one from the harder and longer-term task of solving the real problem. Addictive policies are insidious, because they are so easy to sell, so simple to fall for.

Highlight (Yellow) | Location 2376

It's worth going through the withdrawal to get back to an unaddicted state, but it is far preferable to avoid addiction in the first place.

Highlight (Yellow) | Location 2378

helping the system to help itself, can be much cheaper and easier than taking over and running the system—something liberal politicians don't seem to understand.

Highlight (Yellow) | Location 2384

If you are the intervenor, work in such a way as to restore or enhance the system's own ability to solve its problems, then remove yourself.

Highlight (Yellow) | Location 2387

THE TRAP: SHIFTING THE BURDEN TO THE INTERVENOR Shifting the burden, dependence, and addiction arise when a solution to a systemic problem reduces (or disguises) the symptoms, but does nothing to solve the underlying problem. Whether it is a substance that dulls one's perception or a policy that hides the underlying trouble, the drug of choice interferes with the actions that could solve the real problem. If the intervention designed to correct the problem causes the self-maintaining capacity of the original system to atrophy or erode, then a destructive reinforcing feedback loop is set in motion. The system deteriorates; more

and more of the solution is then required. The system will become more and more dependent on the intervention and less and less able to maintain its own desired state. **THE WAY OUT** Again, the best way out of this trap is to avoid getting in. Beware of symptom-relieving or signal-denying policies or practices that don't really address the problem. Take the focus off short-term relief and put it on long-term restructuring.

Highlight (Yellow) | Location 2423

Notice that rule beating produces the appearance of rules being followed.

Highlight (Yellow) | Location 2426

Rule beating is usually a response of the lower levels in a hierarchy to overrigid, deleterious, unworkable, or ill-defined rules from above.

Highlight (Yellow) | Location 2429

The way out of the trap, the opportunity, is to understand rule beating as useful feedback, and to revise, improve, rescind, or better explain the rules.

Highlight (Yellow) | Location 2433

THE TRAP: RULE BEATING Rules to govern a system can lead to rule beating—perverse behavior that gives the appearance of obeying the rules or achieving the goals, but that actually distorts the system. **THE WAY OUT** Design, or redesign, rules to release creativity not in the direction of beating the rules, but in the direction of achieving the purpose of the rules.

Highlight (Yellow) | Location 2461

confuse effort with result, one of the most common mistakes in designing systems around the wrong goal.

Highlight (Yellow) | Location 2487

THE TRAP: SEEKING THE WRONG GOAL System behavior is particularly sensitive to the goals of feedback loops. If the goals—the indicators of satisfaction of the rules—are defined inaccurately or incompletely, the system may obediently work to produce a result that is not really intended or wanted.

Highlight (Yellow) | Location 2491

THE WAY OUT Specify indicators and goals that reflect the real welfare of the system. Be especially careful not to confuse effort with result or you will end up with a system that is producing effort, not result.

Highlight (Yellow) | Location 2532

although people deeply involved in a system often know intuitively where to find leverage points, more often than not they push the change in the wrong direction.

Highlight (Yellow) | Location 2609

In chemistry and other fields, a big, stabilizing stock is known as a buffer.

Highlight (Yellow) | Location 2614

You can often stabilize a system by increasing the capacity of a buffer.⁵ But if a buffer is too big, the system gets inflexible.

Highlight (Yellow) | Location 2626

The only way to fix a system that is laid out poorly is to rebuild it, if you can.

Highlight (Yellow) | Location 2634

Physical structure is crucial in a system, but is rarely a leverage point, because changing it is rarely quick or simple. The leverage point is in proper design in the first place.

Highlight (Yellow) | Location 2666

Now we're beginning to move from the physical part of the system to the information and control parts, where more leverage can be found.

Highlight (Yellow) | Location 2670

Any balancing feedback loop needs a goal (the thermostat setting), a monitoring and signaling device to detect deviation from the goal (the thermostat), and a response mechanism (the furnace and/or air conditioner, fans, pumps, pipes, fuel, etc.).

Highlight (Yellow) | Location 2715

Reinforcing feedback loops are sources of growth, explosion, erosion, and collapse in systems.

Highlight (Yellow) | Location 2715

A system with an unchecked reinforcing loop ultimately will destroy itself.

Highlight (Yellow) | Location 2742

Missing information flows is one of the most common causes of system malfunction.

Highlight (Yellow) | Location 2755

There is a systematic tendency on the part of human beings to avoid accountability for their own decisions. That's why there are so many missing feedback loops—and why this kind of leverage point is so often popular

with the masses, unpopular with the powers that be, and effective, if you can get the powers that be to permit it to happen (or go around them and make it happen anyway).

Highlight (Yellow) | Location 2759

The rules of the system define its scope, its boundaries, its degrees of freedom.

Highlight (Yellow) | Location 2769

As we try to imagine restructured rules and what our behavior would be under them, we come to understand the power of rules. They are high leverage points. Power over the rules is real power.

Highlight (Yellow) | Location 2784

The ability to self-organize is the strongest form of system resilience. A system that can evolve can survive almost any change, by changing itself.

Highlight (Yellow) | Location 2809

one aspect of almost every culture is the belief in the utter superiority of that culture.

Highlight (Yellow) | Location 2813

Encouraging variability and experimentation and diversity means “losing control.”

Highlight (Yellow) | Location 2817

the diversity-destroying consequence of the push for control

Highlight (Yellow) | Location 2857

Paradigms are the sources of systems.

Highlight (Yellow) | Location 2857

From them, from shared social agreements about the nature of reality, come system goals and information flows, feedbacks, stocks, flows, and everything else about systems.

Highlight (Yellow) | Location 2877

Systems modelers say that we change paradigms by building a model of the system, which takes us outside the system and forces us to see it whole.

Highlight (Yellow) | Location 2883

It is to “get” at a gut level the paradigm that there are paradigms, and to see that that itself is a paradigm, and to regard that whole realization as devastatingly funny.

Highlight (Yellow) | Location 2898

In the end, it seems that mastery has less to do with pushing leverage points than it does with strategically, profoundly, madly, letting go and dancing with the system.

Highlight (Yellow) | Location 2917

it’s one thing to understand how to fix a system and quite another to wade in and fix it.

Highlight (Yellow) | Location 2918

We had many earnest discussions on the topic of “implementation,” by which we meant “how to get managers and mayors and agency heads to follow our advice.”

Highlight (Yellow) | Location 2935

Self-organizing, nonlinear, feedback systems are inherently unpredictable. They are not controllable. They are understandable only in the most general way. The goal of foreseeing the future exactly and preparing for it perfectly is unrealizable.

Highlight (Yellow) | Location 2965

Systems thinking leads to another conclusion, however, waiting, shining, obvious, as soon as we stop being blinded by the illusion of control. It says that there is plenty to do, of a different sort of “doing.” The future can’t be predicted, but it can be envisioned and brought lovingly into being.

Highlight (Yellow) | Location 2970

We can’t control systems or figure them out. But we can dance with them!

Highlight (Yellow) | Location 2975

Living successfully in a world of systems requires more of us than our ability to calculate. It requires our full humanity—our rationality, our ability to sort out truth from falsehood, our intuition, our compassion, our vision, and our morality.²

Highlight (Yellow) | Location 2987

If it’s a social system, watch it work. Learn its history. Ask people who’ve been around a long time to tell you what has happened. If possible, find or make a time graph of actual data from the system—peoples’ memories are not always reliable when it comes to timing.

Highlight (Yellow) | Location 2990

This guideline is deceptively simple. Until you make it a practice, you won't believe how many wrong turns it helps you avoid. Starting with the behavior of the system forces you to focus on facts, not theories. It keeps you from falling too quickly into your own beliefs or misconceptions, or those of others.

Highlight (Yellow) | Location 2992

It's amazing how many misconceptions there can be. People will swear that rainfall is decreasing, say, but when you look at the data, you find that what is really happening is that variability is increasing—the droughts are deeper, but the floods are greater too.

Highlight (Yellow) | Location 2997

Watching what really happens, instead of listening to peoples' theories of what happens, can explode many careless causal hypotheses.

Highlight (Yellow) | Location 3004

starting with history discourages the common and distracting tendency we all have to define a problem not by the system's actual behavior, but by the lack of our favorite solution.

Highlight (Yellow) | Location 3019

everything everyone knows, is only a model.

Highlight (Yellow) | Location 3027

information holds systems together and how delayed, biased, scattered, or missing information can make feedback loops malfunction.

Highlight (Yellow) | Location 3031

Thou shalt not distort, delay, or withhold information.

Highlight (Yellow) | Location 3041

The media, the public relations people, the politicians, and advertisers who regulate much of the public flow of information have far more power than most people realize. They filter and channel information.

Highlight (Yellow) | Location 3049

In fact, we don't talk about what we see; we see only what we can talk about.

Highlight (Yellow) | Location 3097

setting goals around what is easily measured, rather than around what is important.

Highlight (Yellow) | Location 3130

Aid and encourage the forces and structures that help the system run itself.

Highlight (Yellow) | Location 3179

when addressing complex social issues, acting as if we knew what we were doing simply decreases our credibility....

Highlight (Yellow) | Location 3228

Interdisciplinary communication works only if there is a real problem to be solved, and if the representatives from the various disciplines are more committed to solving the problem than to being academically correct.
