

AI&A Pivot Conference
Educator Workshops
Phoenix

Tools For Understanding Context and Taming Complexity: **A Whole Systems Approach to Design**

Hugh Dubberly
Dubberly Design Office

Systems are everywhere.



Columbia
Broadcasting
System (CBS)



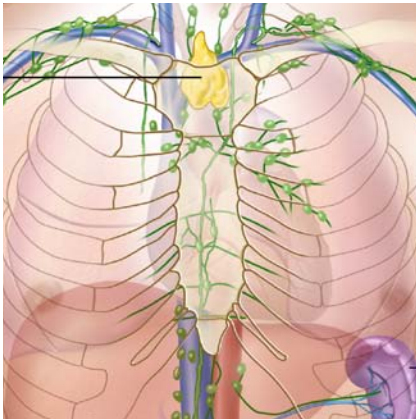
Federal Reserve
System



Herman-Miller
Action Office
System



Honor system



Immune system



Linux operating
system



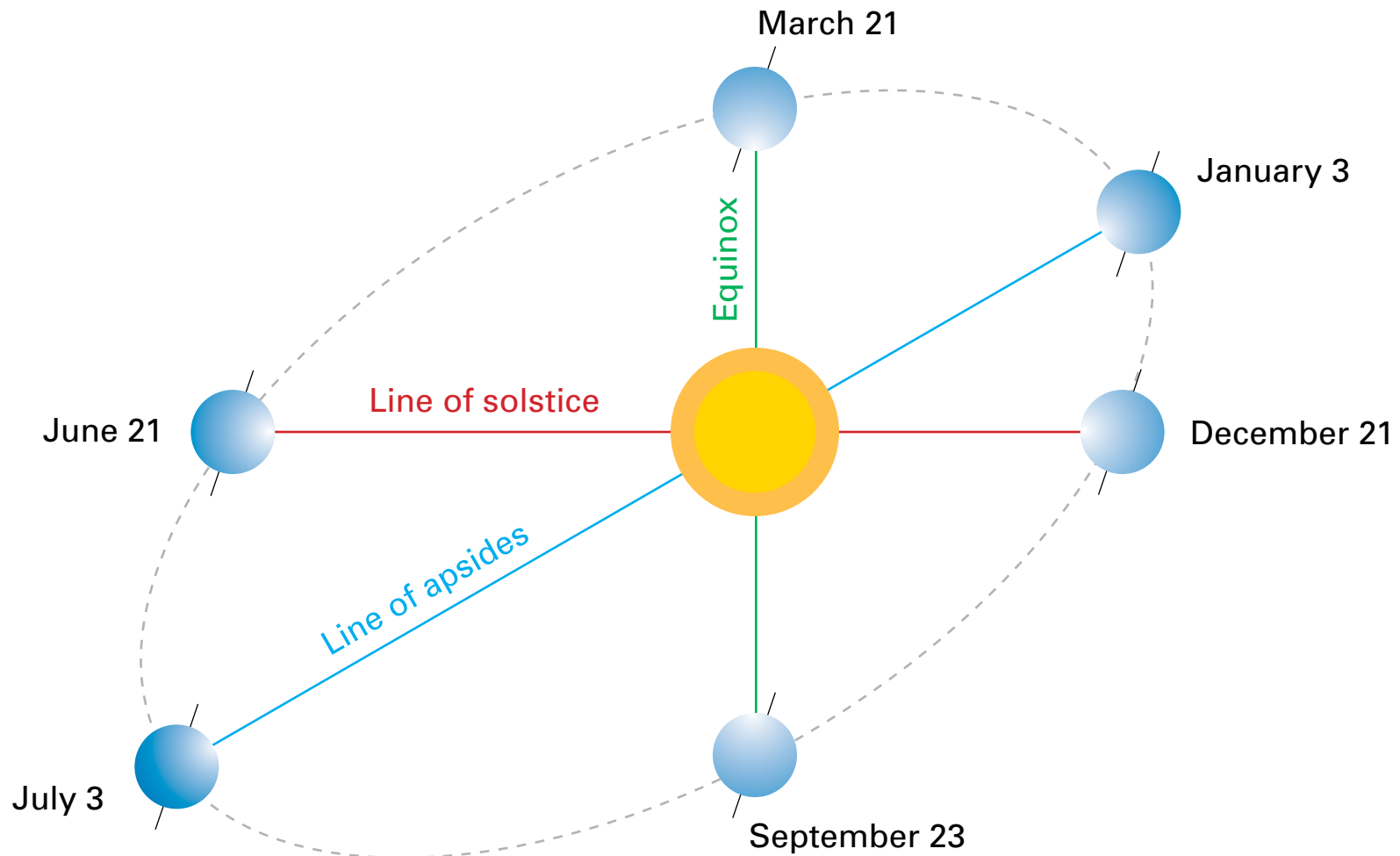
Mojave desert
ecosystem



Schiphol airport
signage system

**Given the variation in form,
function, and domain—
what do systems have
in common?
what makes them systems?**

A system is a set of **elements** linked by **processes**.



Systems fall into three broad categories:

- **Formal systems:**
rules for combining elements
- **Production systems:**
resource flows
- **Control systems:**
information flows

PART ONE

Formal systems

**Designers have an intuitive feel
for formal systems,
and employ them often.**

Grid systems.

Signage systems.



**Spor
Track**

2

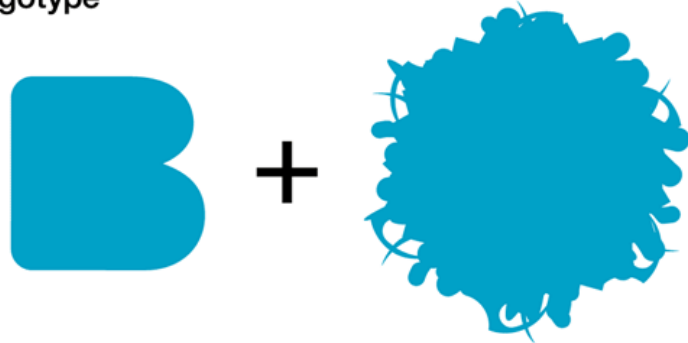
Mod København H, Nørreport,
Østerport, Helsingør, Fyn og Jylland

Toward Copenhagen C, Nørreport,
Østerport, Helsingør, Fyn and Jylland

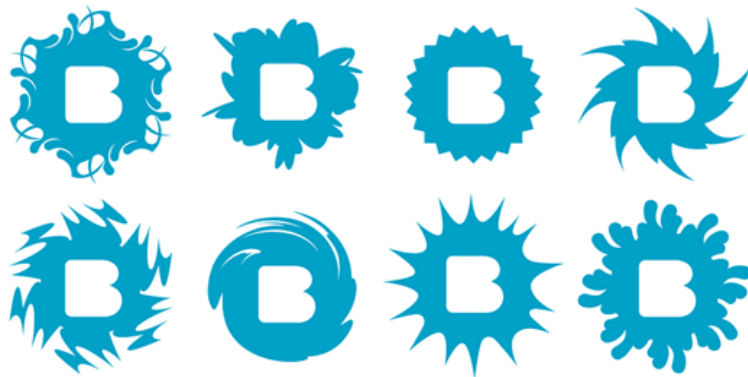


Identity systems.

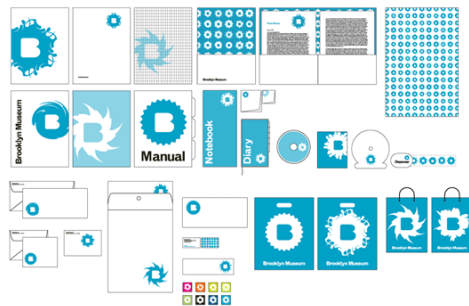
Logotype



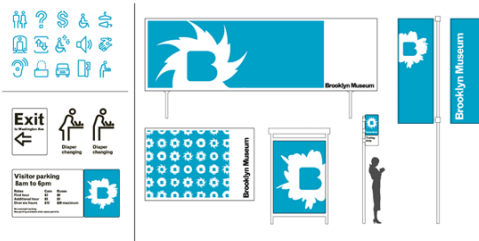
Logotype Variations



Print Collateral



Signage



Secondary Mark

Brooklyn Museum

Logotype Size

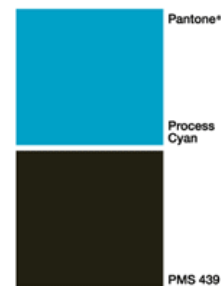


Typography









Brooklynesque

| | |
|--|---|
| <p>Bronktypen Light</p> <p>A B C D E F G H I J K L M N O P Q R S T U V W X Y Z a b c d e f g h i j k l m n o p q r s t u v w x y z 1 2 3 4 5 6 7 8 9 0 / % # * & ^ ()</p> <p>Loren ipsum dolor sit amet, consectetur adipiscing elit, sed diam nonummy nibh euismod tincidunt at laoreet domus aliquam erat volutpat. Ut wisi enim mihi lorem, quam nostrud erosque magna aliquam etiam.</p> <p>Duis aute irure dolor ut reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.</p> | <p>Bronktypen Bold</p> <p>A B C D E F G H I J K L M N O P Q R S T U V W X Y Z a b c d e f g h i j k l m n o p q r s t u v w x y z 1 2 3 4 5 6 7 8 9 0 / % # * & ^ ()</p> <p>Loren ipsum dolor sit amet, consectetur adipiscing elit, sed diam nonummy nibh euismod tincidunt at laoreet domus aliquam erat volutpat. Ut wisi enim mihi lorem, quam nostrud erosque magna aliquam etiam.</p> <p>Duis aute irure dolor ut reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.</p> |
| <p>Bronktypen Semi</p> <p>A B C D E F G H I J K L M N O P Q R S T U V W X Y Z a b c d e f g h i j k l m n o p q r s t u v w x y z 1 2 3 4 5 6 7 8 9 0 / % # * & ^ ()</p> <p>Loren ipsum dolor sit amet, consectetur adipiscing elit, sed diam nonummy nibh euismod tincidunt at laoreet domus aliquam erat volutpat. Ut wisi enim mihi lorem, quam nostrud erosque magna aliquam etiam.</p> <p>Duis aute irure dolor ut reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.</p> | <p>Bronktypen Italic</p> <p>A B C D E F G H I J K L M N O P Q R S T U V W X Y Z a b c d e f g h i j k l m n o p q r s t u v w x y z 1 2 3 4 5 6 7 8 9 0 / % # * & ^ ()</p> <p>Loren ipsum dolor sit amet, consectetur adipiscing elit, sed diam nonummy nibh euismod tincidunt at laoreet domus aliquam erat volutpat. Ut wisi enim mihi lorem, quam nostrud erosque magna aliquam etiam.</p> <p>Duis aute irure dolor ut reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.</p> |

Colors



Secondary Colors

| | C | M | Y |
|---|-----|-----|-----|
|  | 0 | 100 | 0 |
|  | 0 | 60 | 100 |
|  | 0 | 0 | 100 |
|  | 18 | 0 | 82 |
|  | 22 | 0 | 50 |
|  | 87 | 79 | 94 |
|  | 100 | 42 | 0 |
|  | 50 | 0 | 0 |

Tertiary Colors



Transportation



Uniforms



Brooklyn Museum identity system by 2x4

Product families.



Typeface.

Jenson

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

a b c d e f g h i j k l m n o p q r s t u v w x y z

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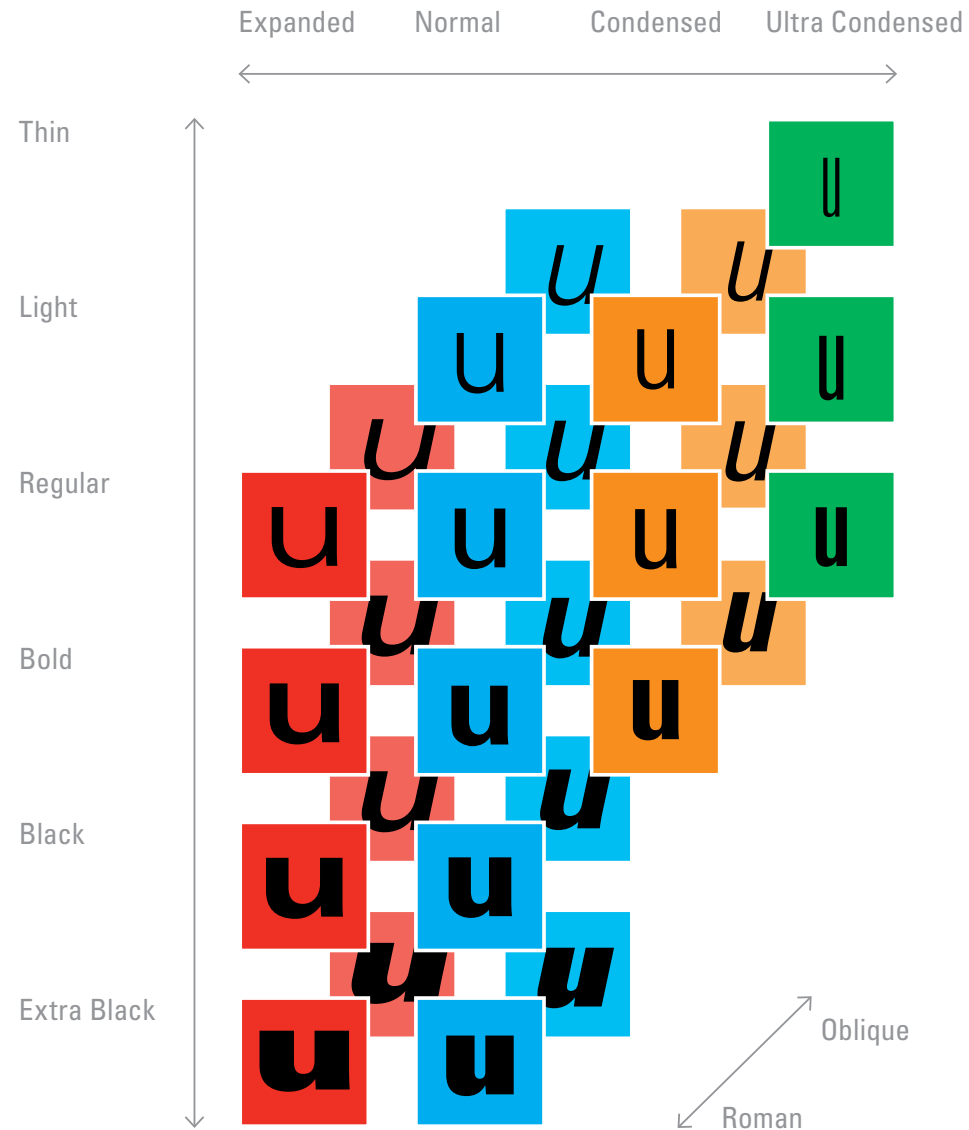
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Typeface family.

Univers grid



Multiple language script typefaces.

Arial family

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

abcdefghijklmnopqrstuvwxyz

ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ

αβγδεζηθικλμνξοπρστυφχψω

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АБВГДЕЖЗЗИІКЛМНОПҚРСТОу

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[illegible]

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ほまみむめもやゆよらりるれろわぬゑをん

**The elements
that comprise these systems
are related by shared form.**

**The shared form
results from a set of rules
defined by the craftsmen
or designers
who produce the system.**

**Often,
the rules are not written down;
they are simply
embodied in the artifacts.**

You can **infer the rules** from the artifacts.

You can understand the spirit of Helvetica
and add old-style figures.
or create additional weights
or create a Chinese version.

Helvetica 0123456789

Helvetica 0123456789

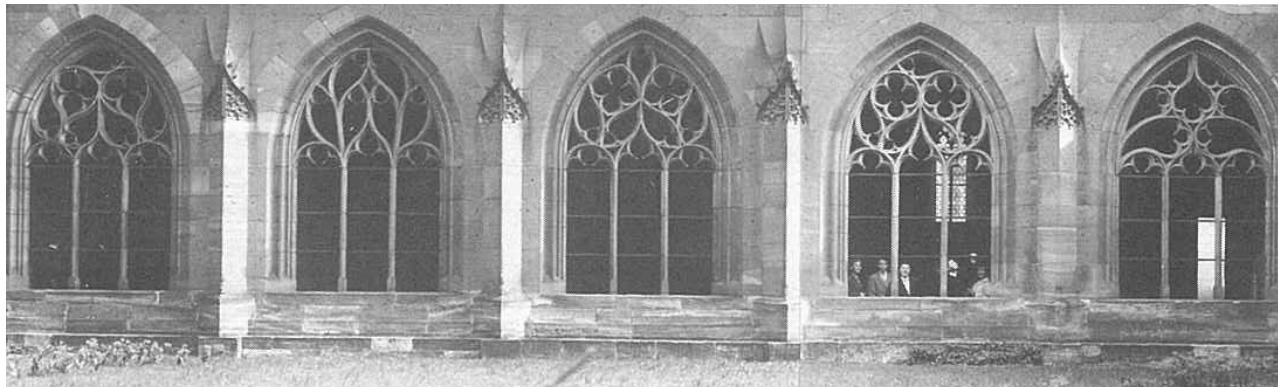
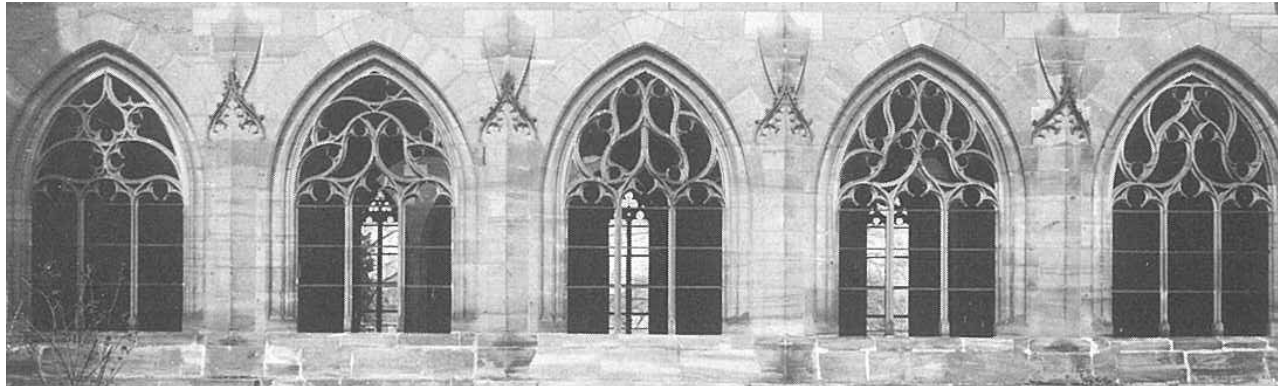
**The idea of theme and variations—
a set of formal rules, in which others can create—
is quite old.**

Tangram



**Formal systems
of theme and variations
are common in architecture.**

Basel's Munster Cathedral Cloisters.



The Alhambra.

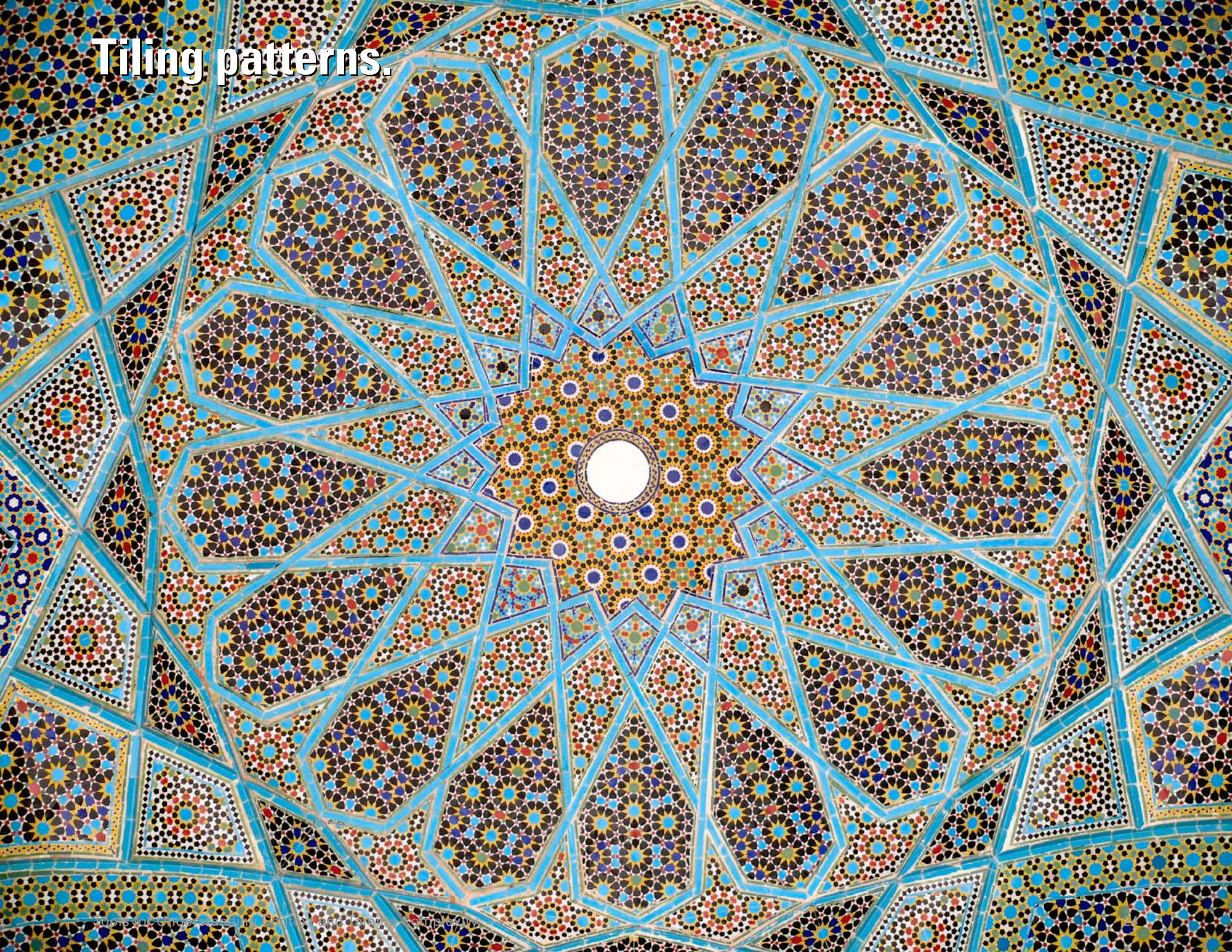


Tatami mats in Japanese architecture.

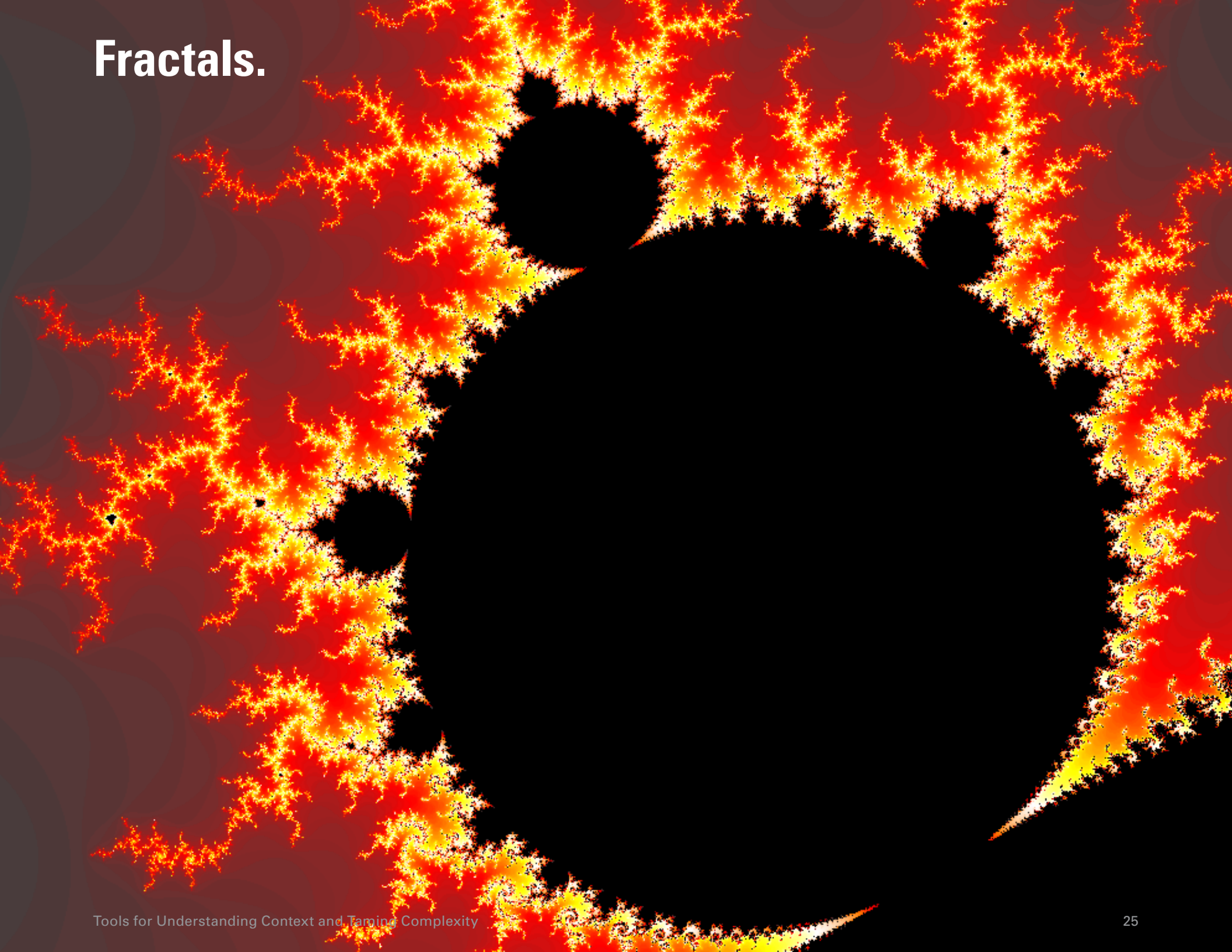


**Systems of rules
for theme and variations
are branches of mathematics.**

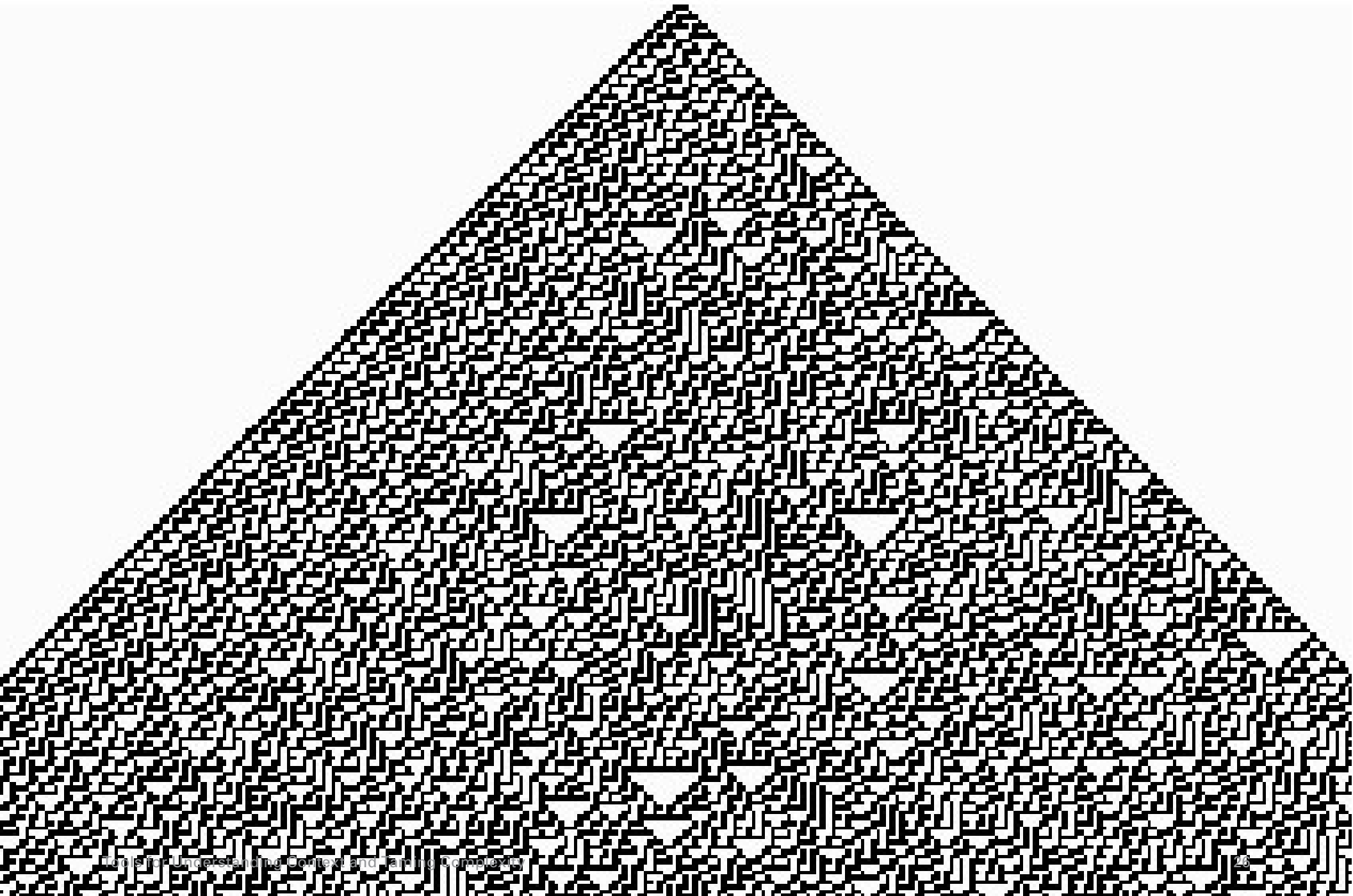
Tiling patterns.



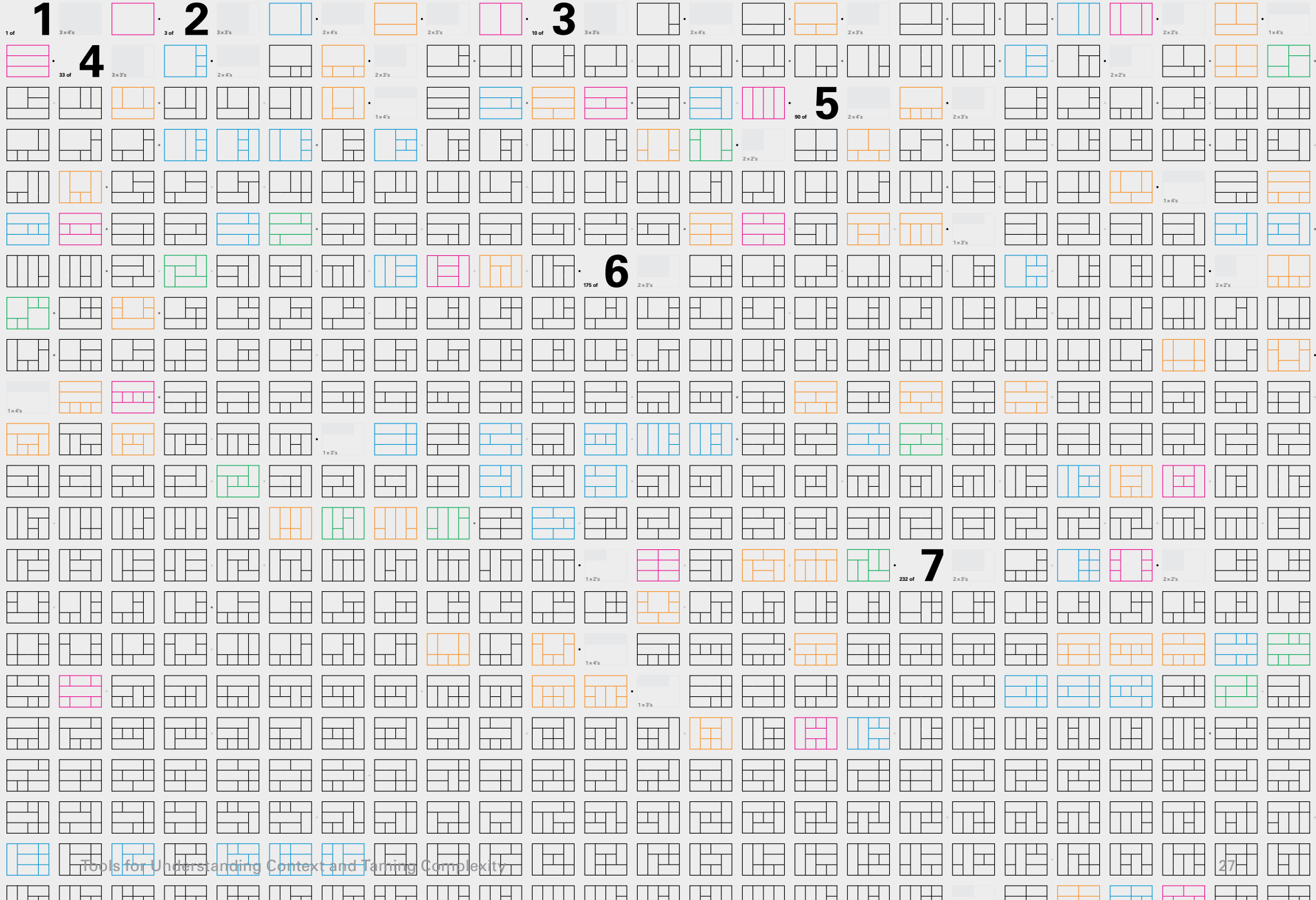
Fractals.



Cellular Automata.



Permutations.



Not all formal systems are visual.

- Musical forms, e.g., fugue
- Poetic forms, e.g., sonnet, haiku, limerick
- Rhetorical forms, e.g., syllogism, essay

Underlying these formal systems are deeper structures:

- Regional cuisines
- Musical scales
- Natural languages
- Computer languages

Designing systems of rules, which others use to design, is a growing area of practice.

- Standards, e.g., A-system of paper sizes
- Fastfood frameworks, e.g., Starbucks lattes, Chipotle's burritos
- Construction set, e.g., Legos
- Software tools and games

PART TWO

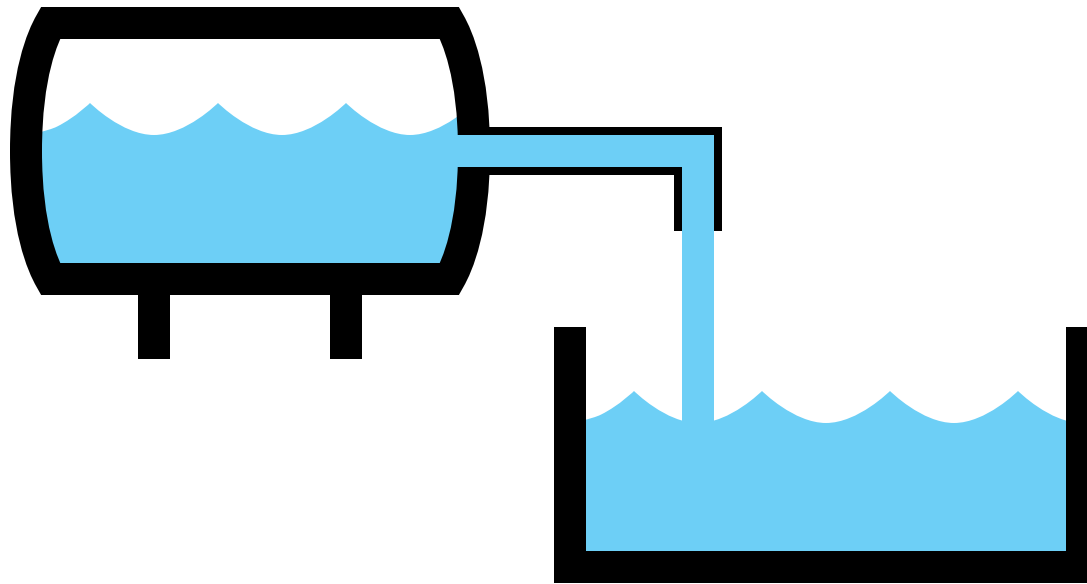
Production systems

**Productions systems focus on resources—
on **stocks** and **flows**.**

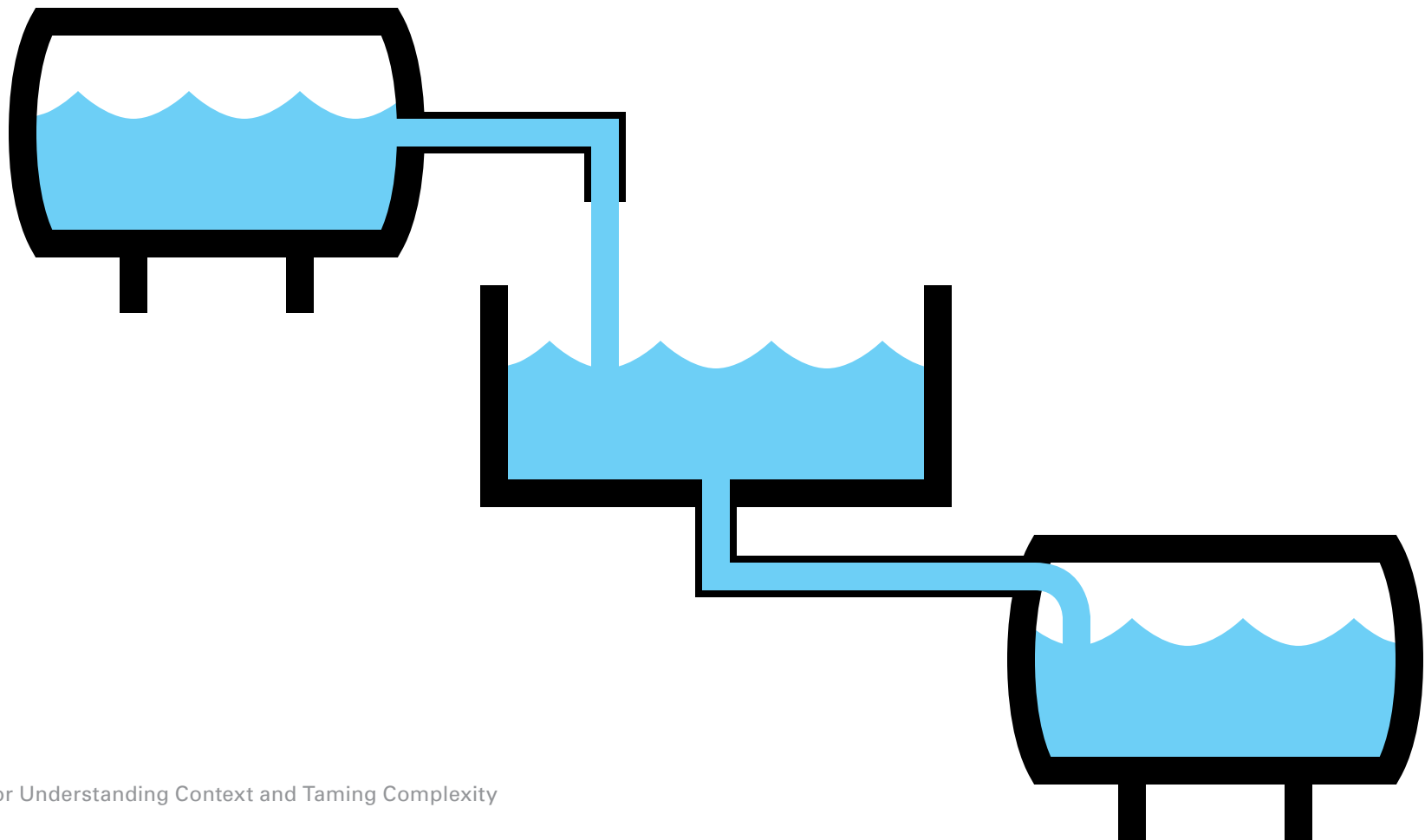
**Consider a reservoir or tub of water—
a stock—it has a finite capacity.**



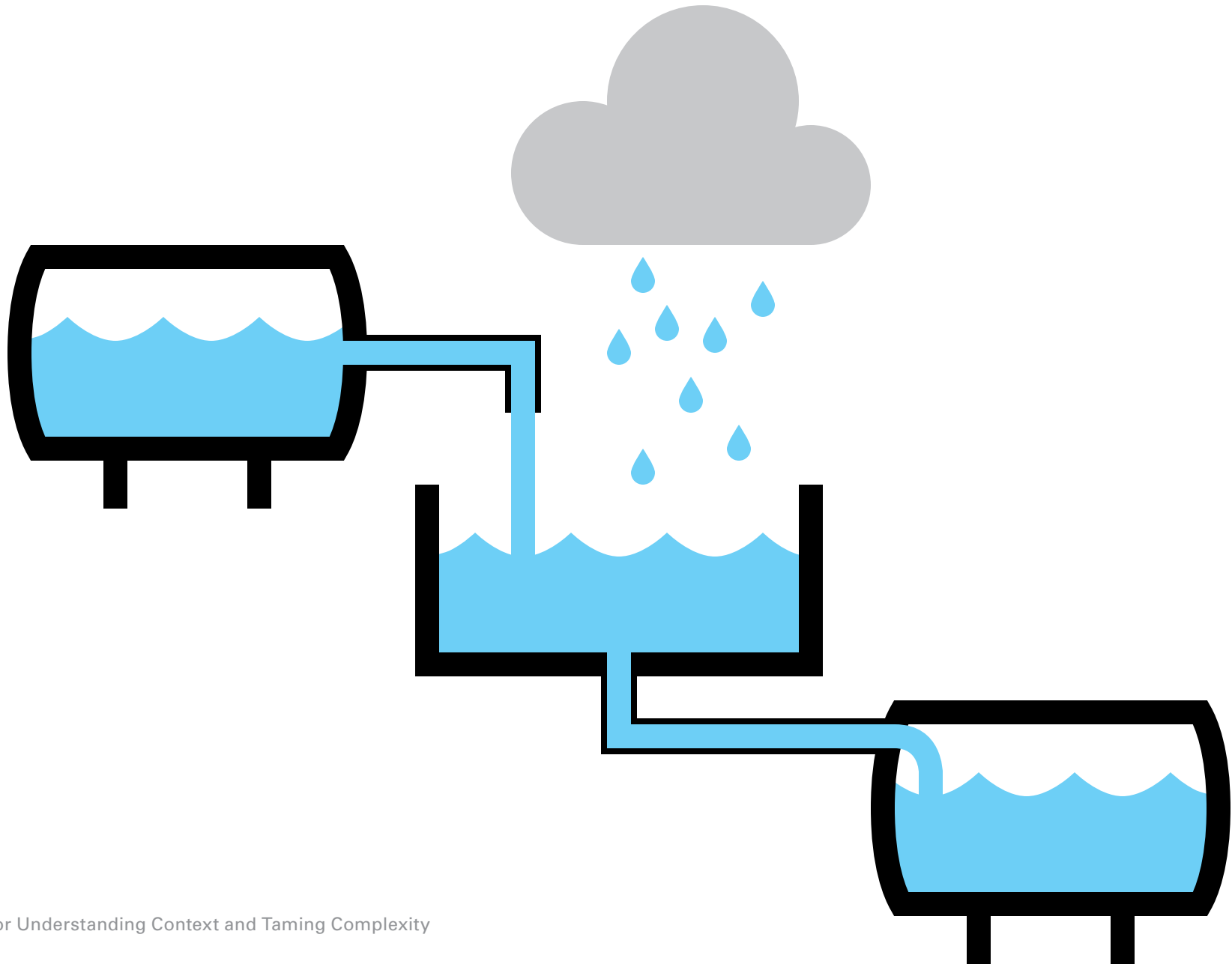
Water flows in from a source.



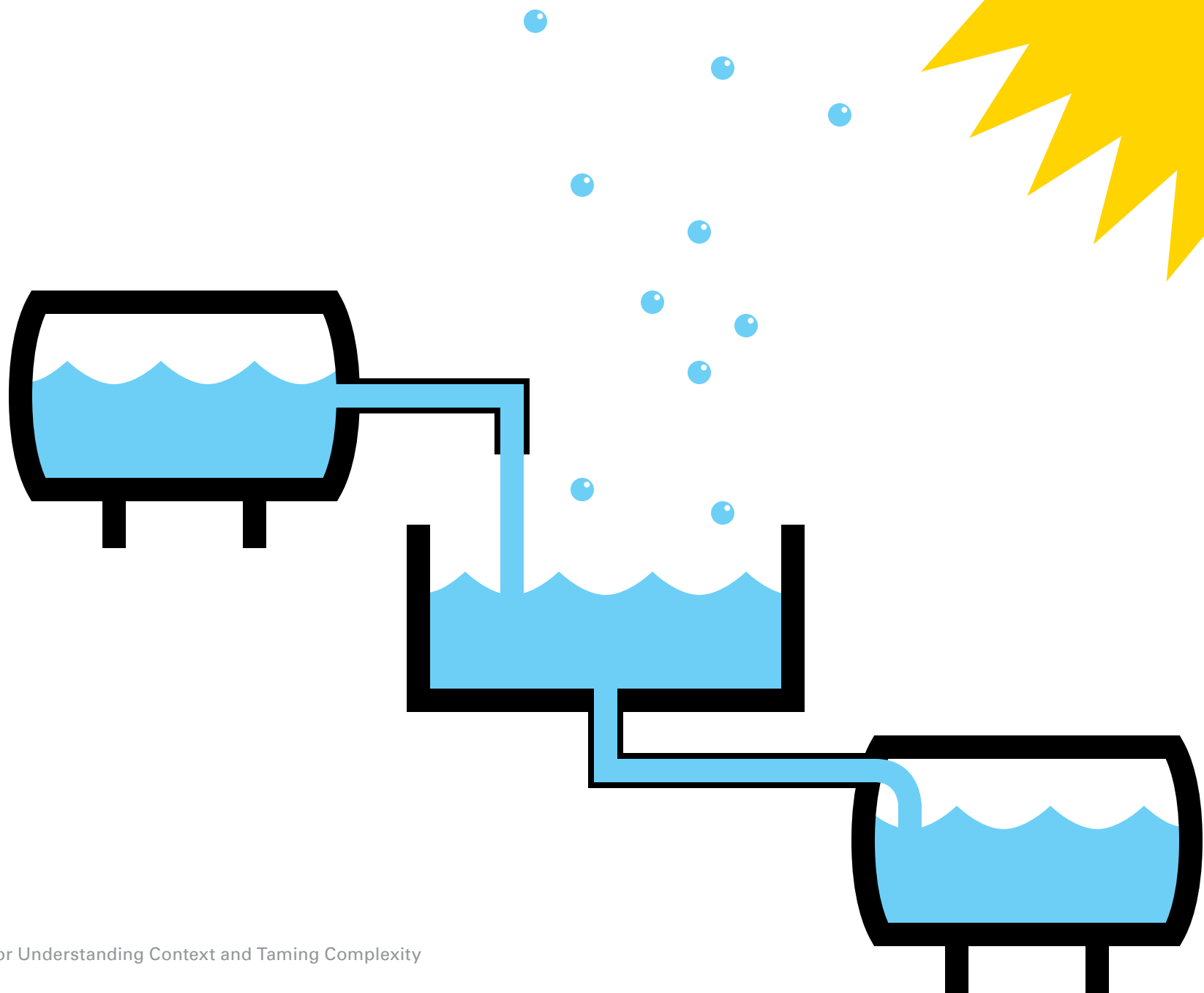
Water may also flow out to a sink.



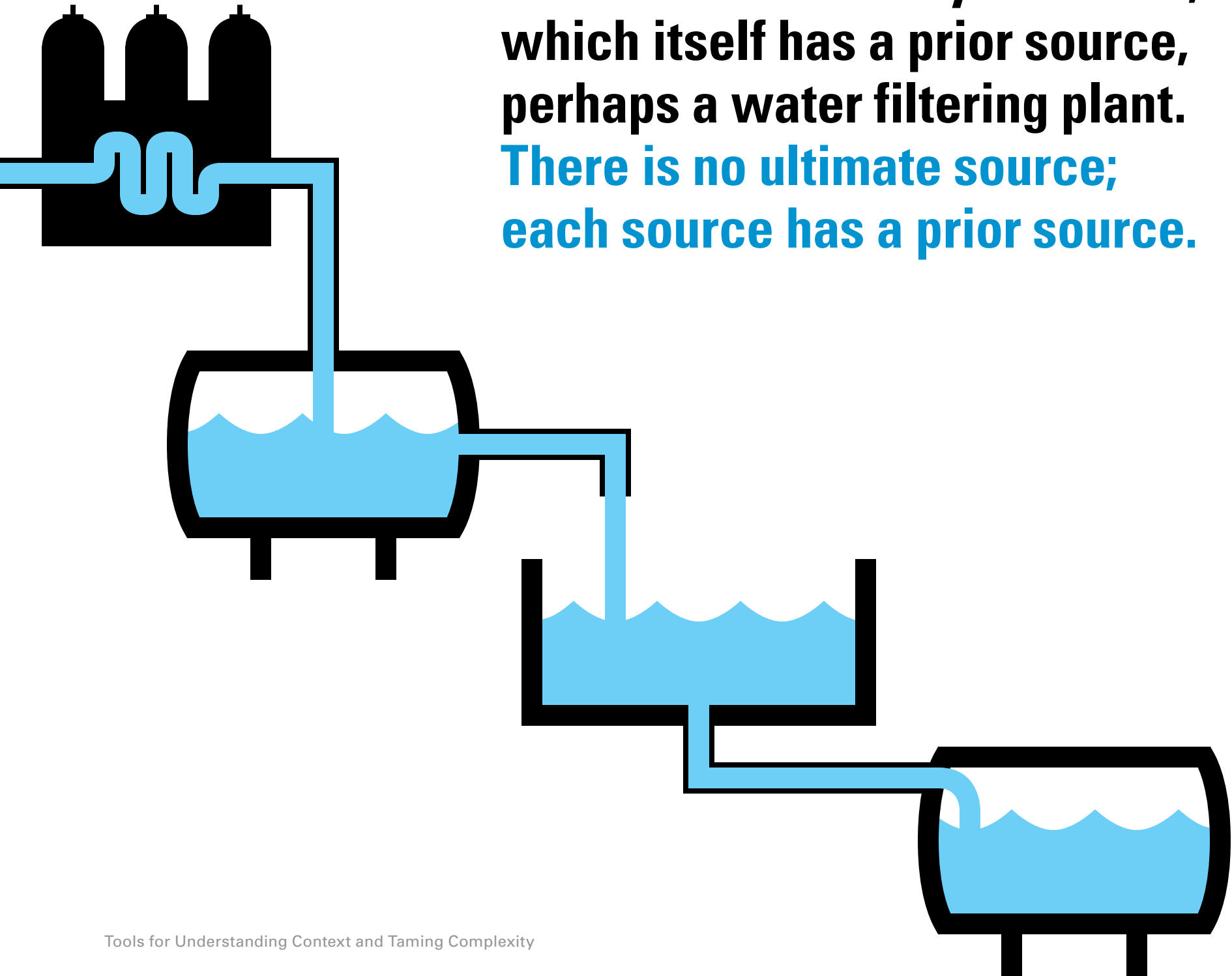
**Many sources may flow into one stock,
e.g., if the tub is outside, rain may also fall into it.**



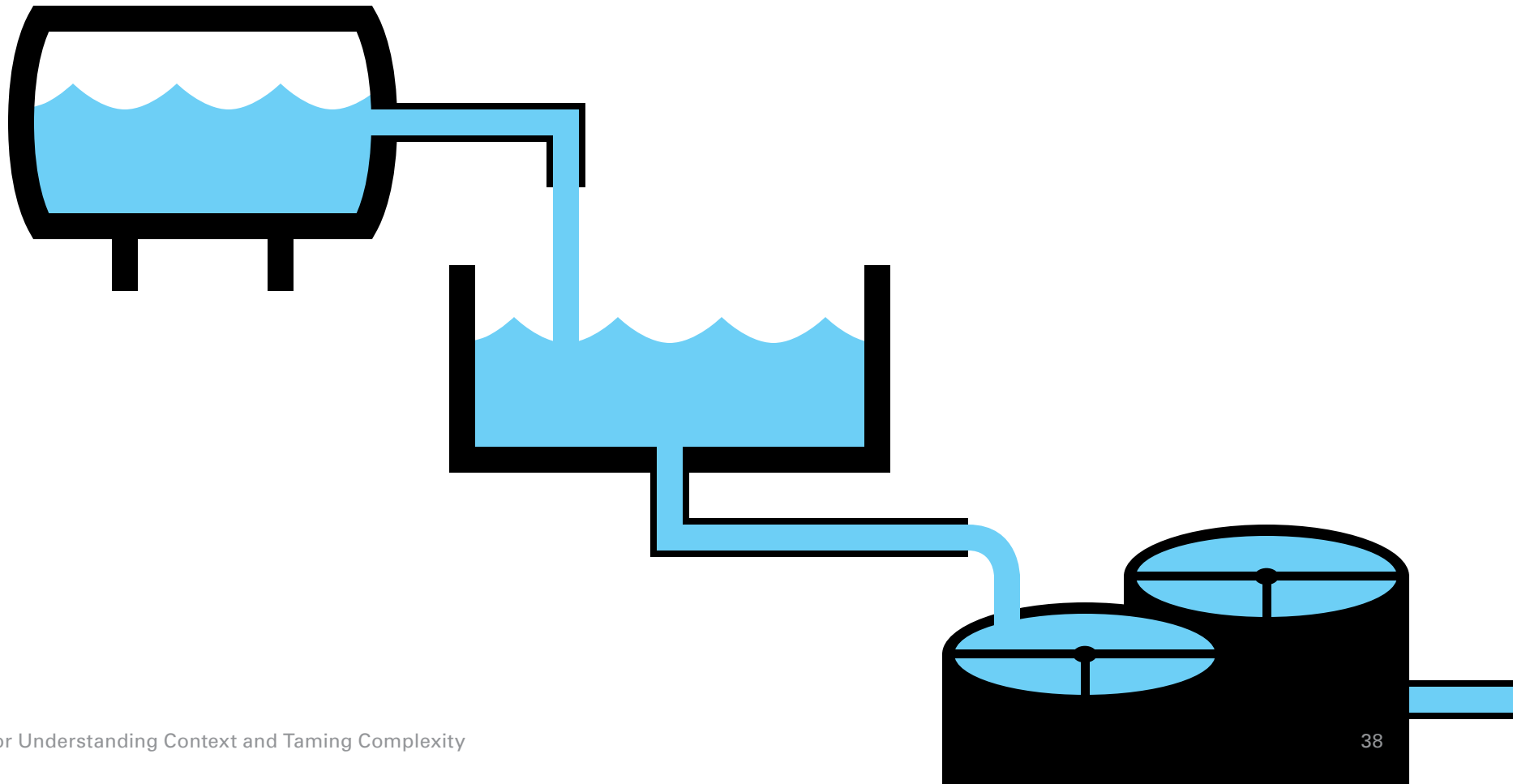
**And one stock may flow out to many sinks,
e.g., water in the tub will also evaporate into the air.**



**The main source may be a tank,
which itself has a prior source,
perhaps a water filtering plant.
There is no ultimate source;
each source has a prior source.**



**The main sink may be a sewer system,
which itself has a subsequent sink,
perhaps a sewer water filtering plant.
There is no ultimate sink;
each sink has a subsequent sink.**



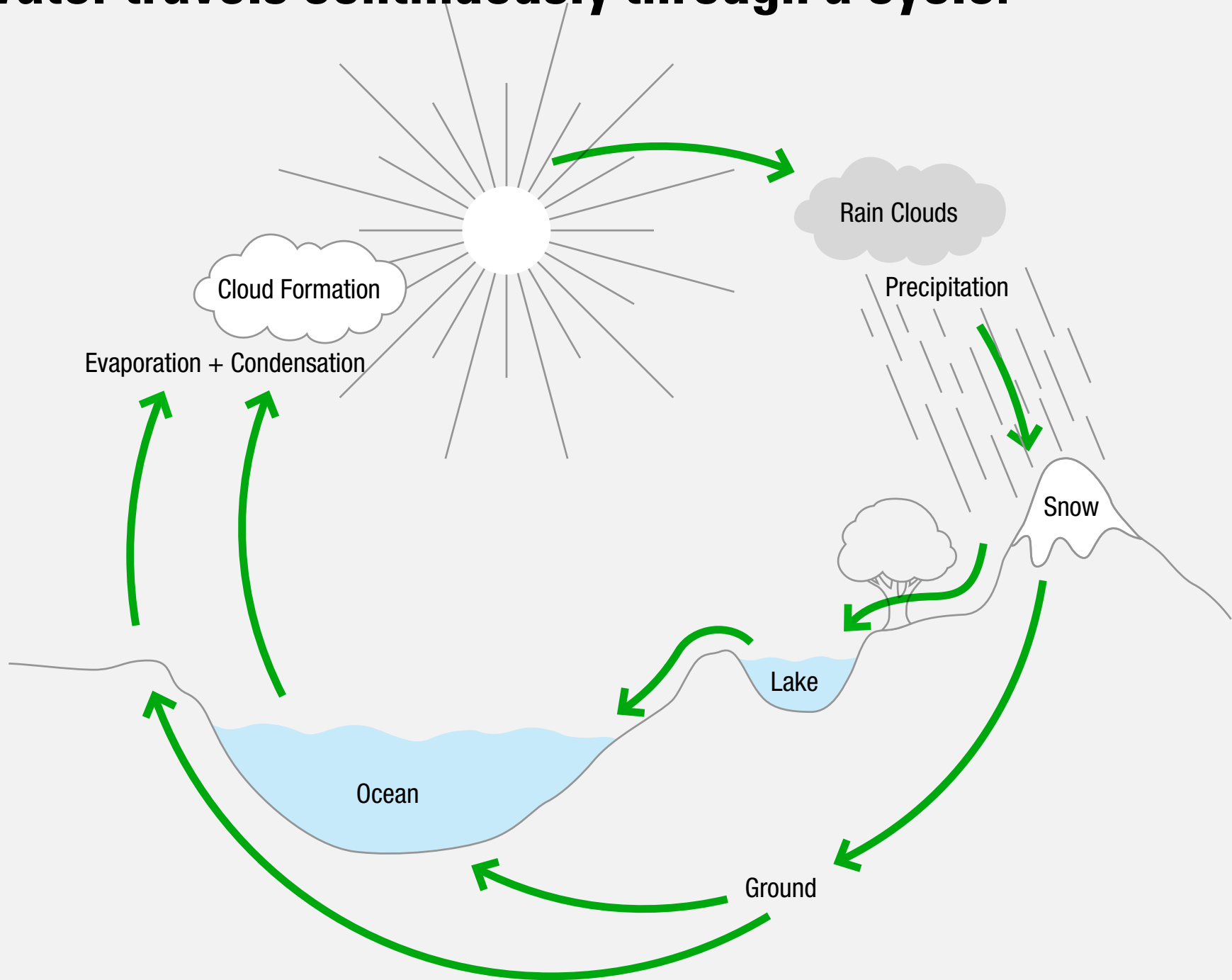


One person's source may be another person's sink.

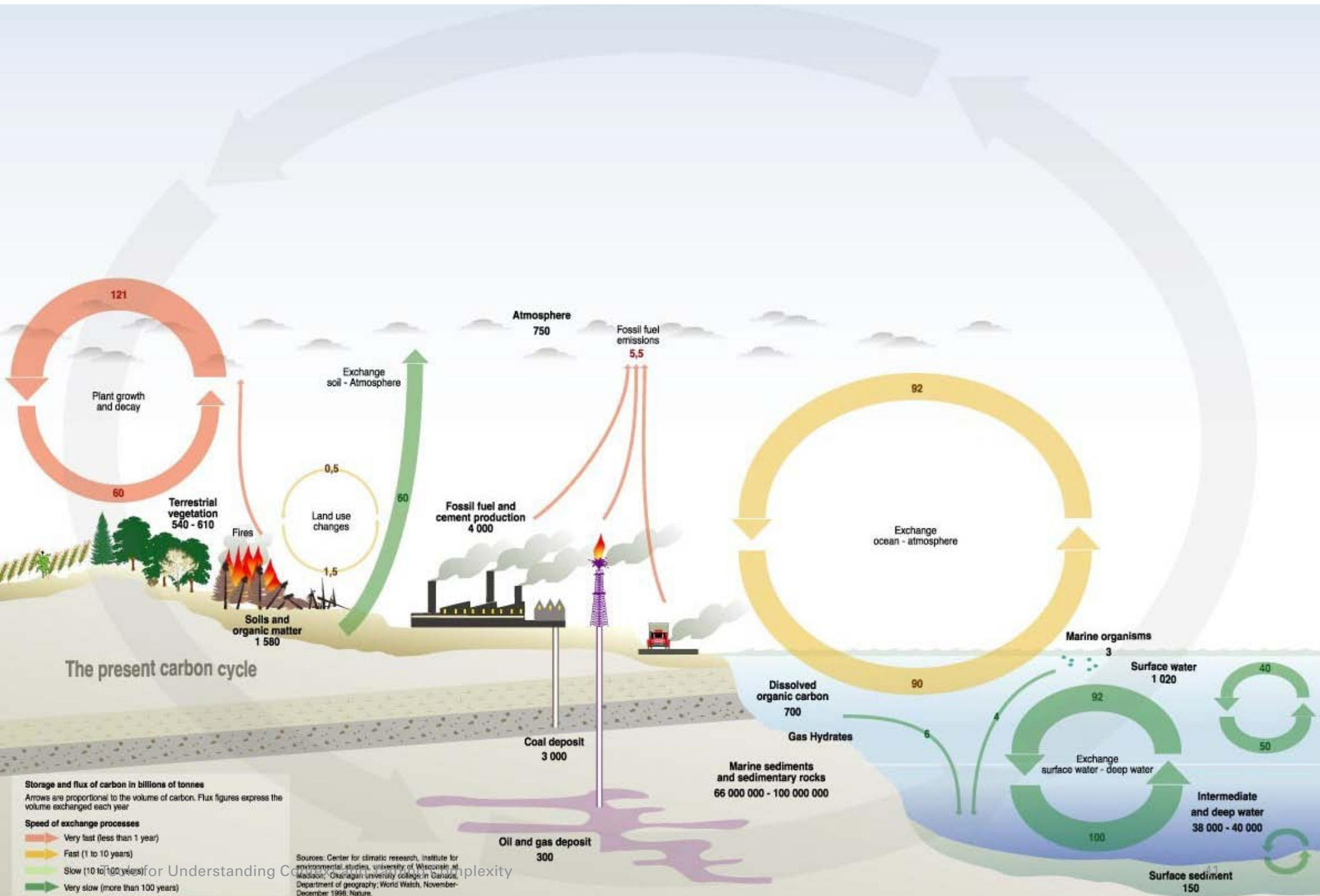
People in Amsterdam get much of their water from the Rhine; people upstream in Basel, discharge their treated sewer water into the Rhine.

Along the way, a drop of water may travel through the cycle several times.

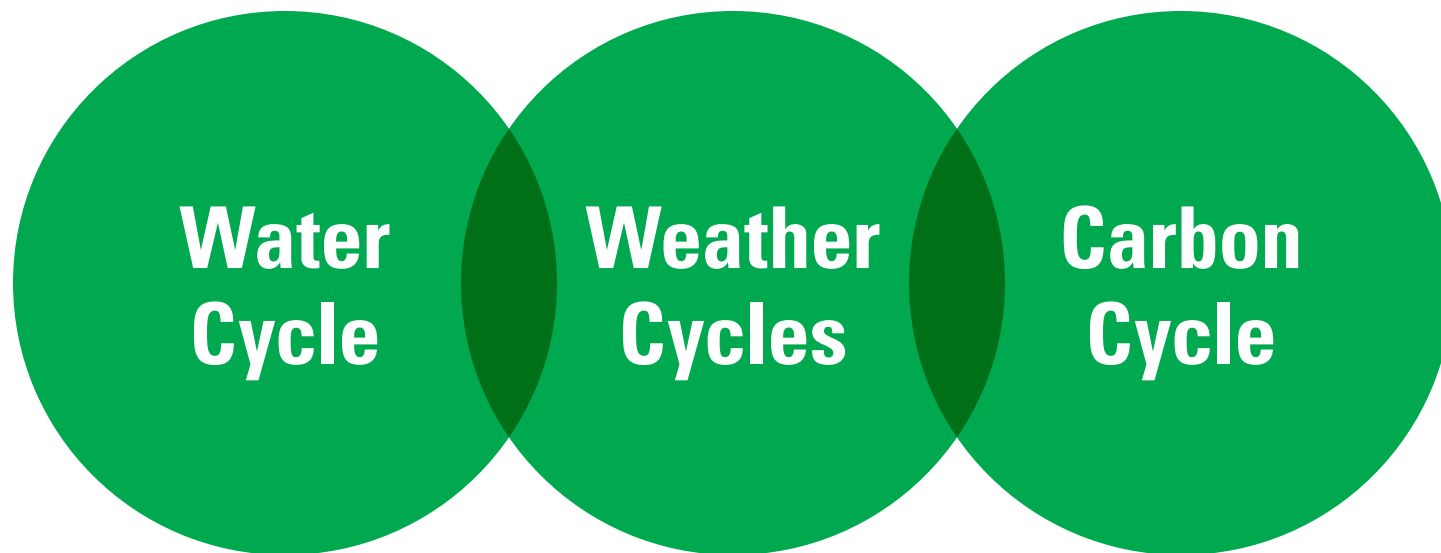
Water travels continuously through a cycle.



Carbon also travels through a cycle.



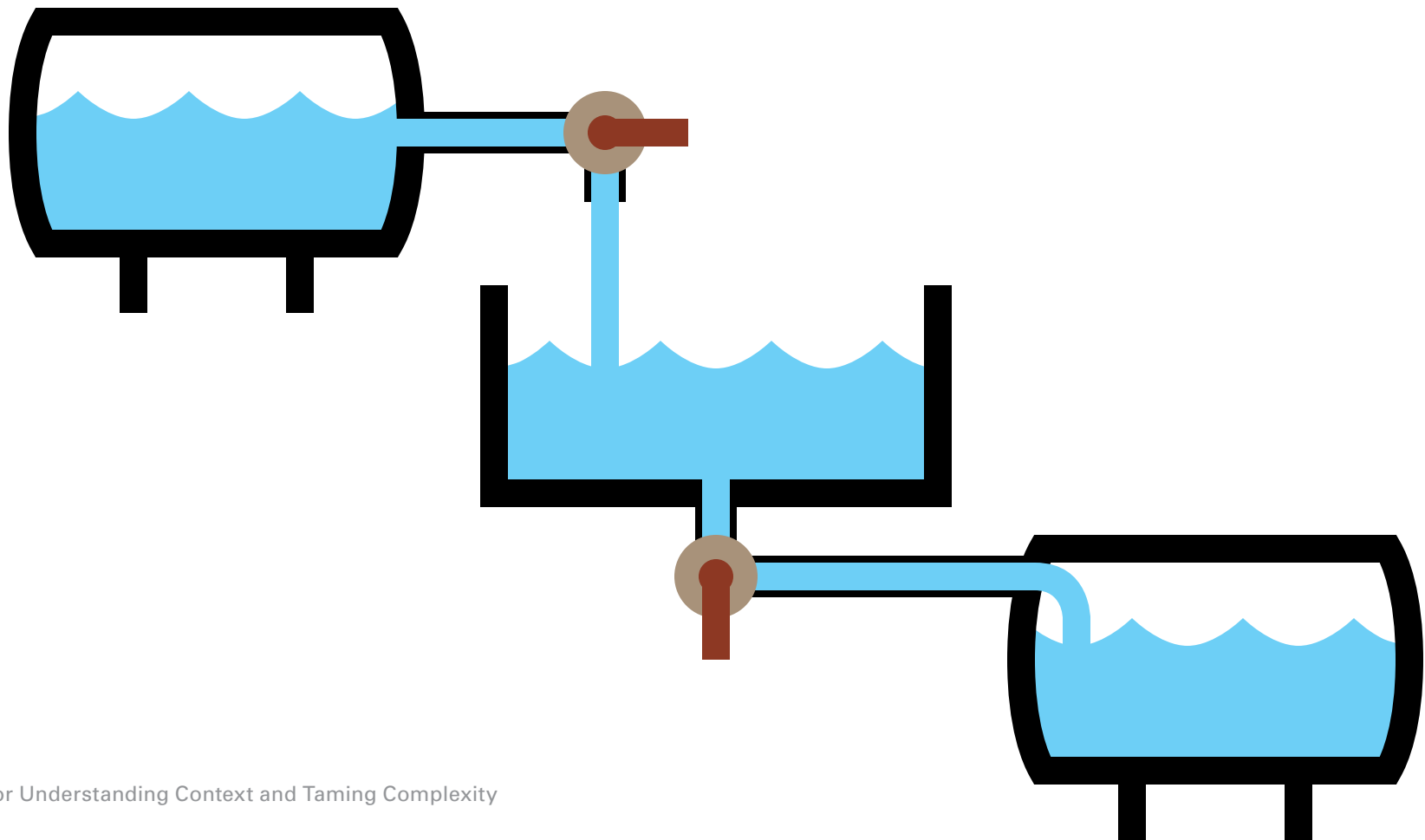
**Sometimes large quantities can be tied up—
sequestered—
so that they are not traveling through the cycle.
Changing stock levels—
sequestering or releasing water or carbon—
affects the climate as ice or carbon dioxide
interacts with the planet's weather system.**



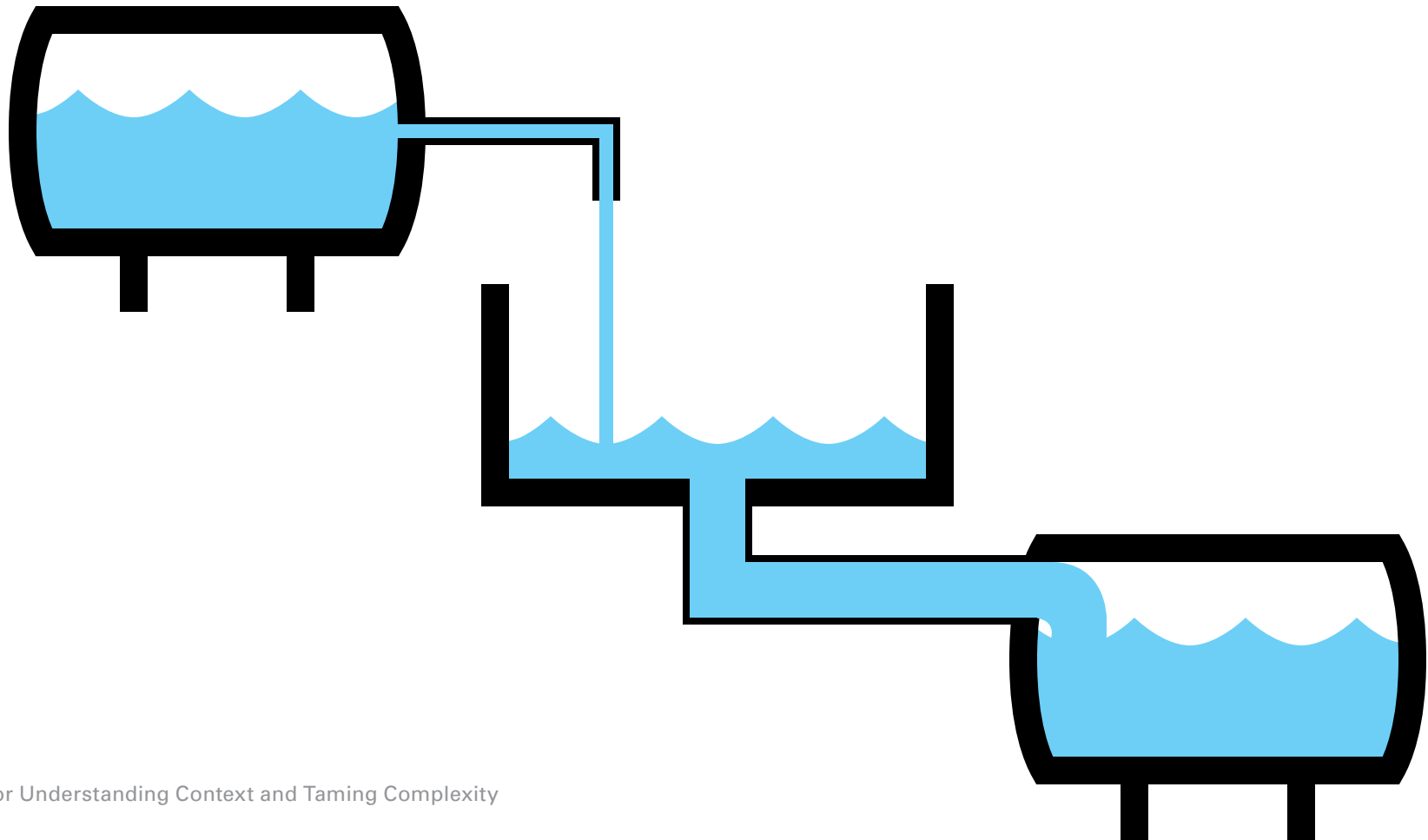
The phrase cradle-to-cradle suggests we build products so that they can be disassembled and recycled.



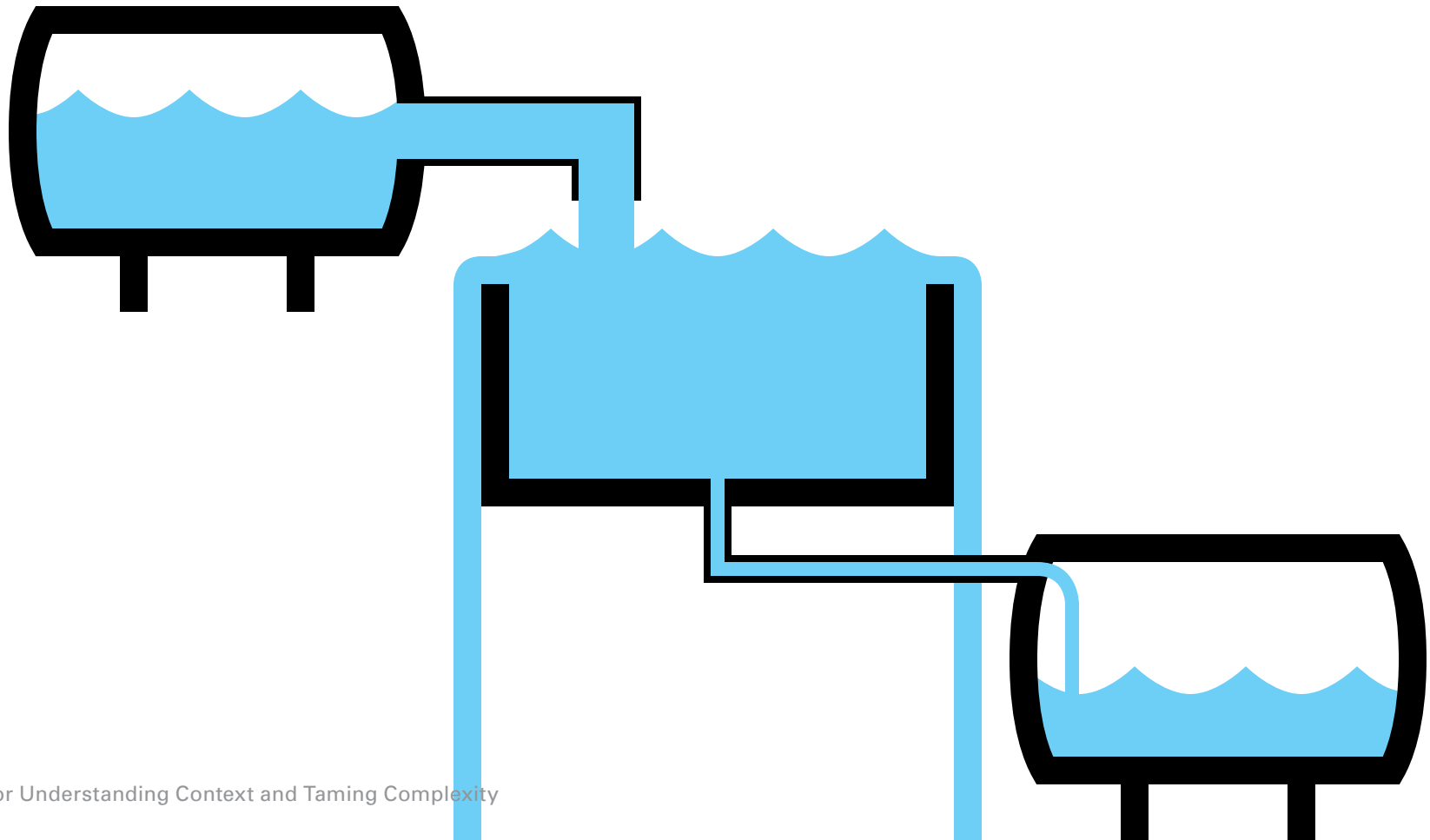
**For a given stock,
the rate of inflow and the rate of outflow may change;
we can open or close a valve.**



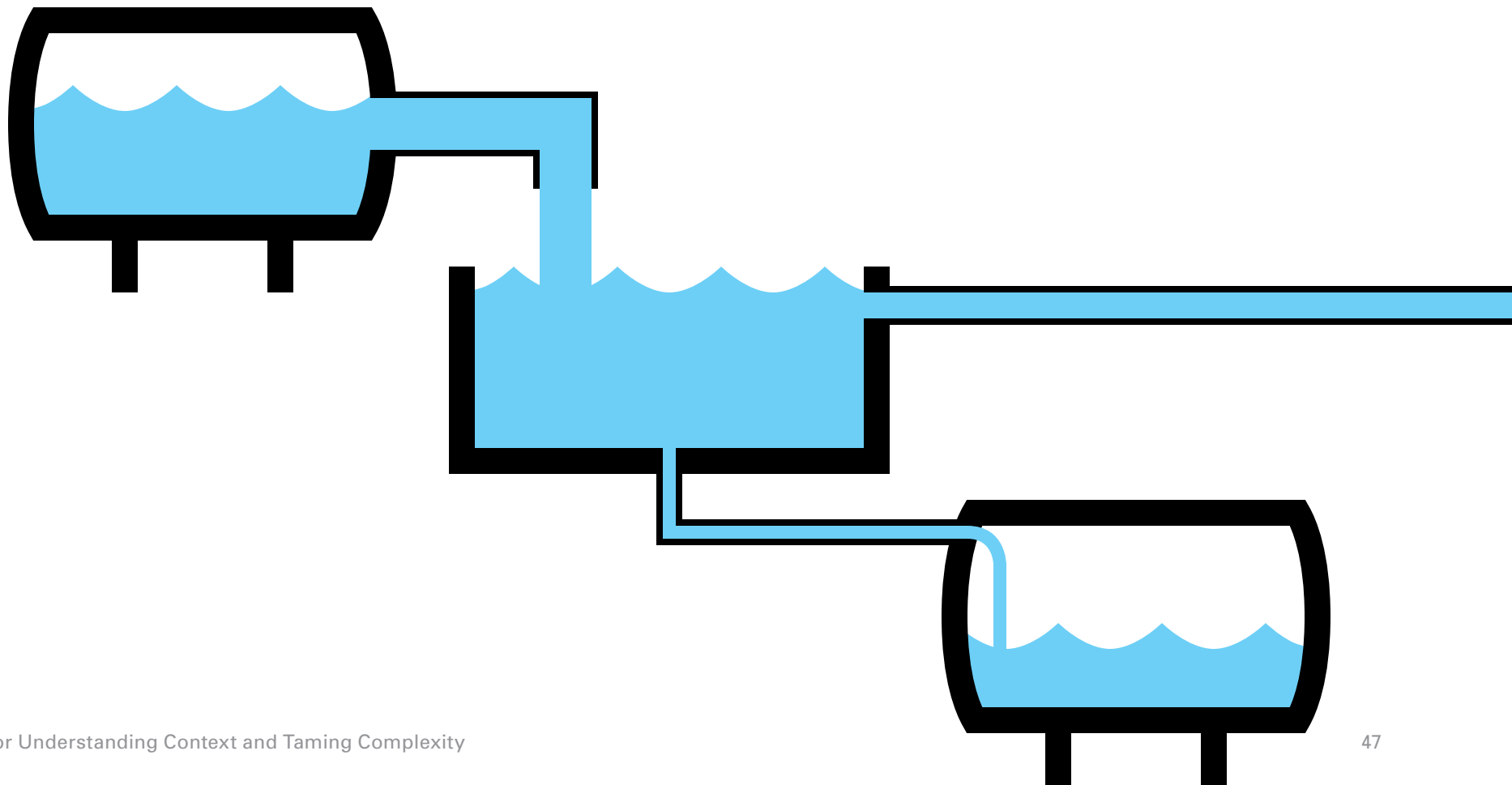
**If 'the rate of inflow' < 'the rate of outflow',
the tub will drain.**



**If 'the rate of inflow' > 'the rate of outflow',
the tub will reach capacity and overflow.**



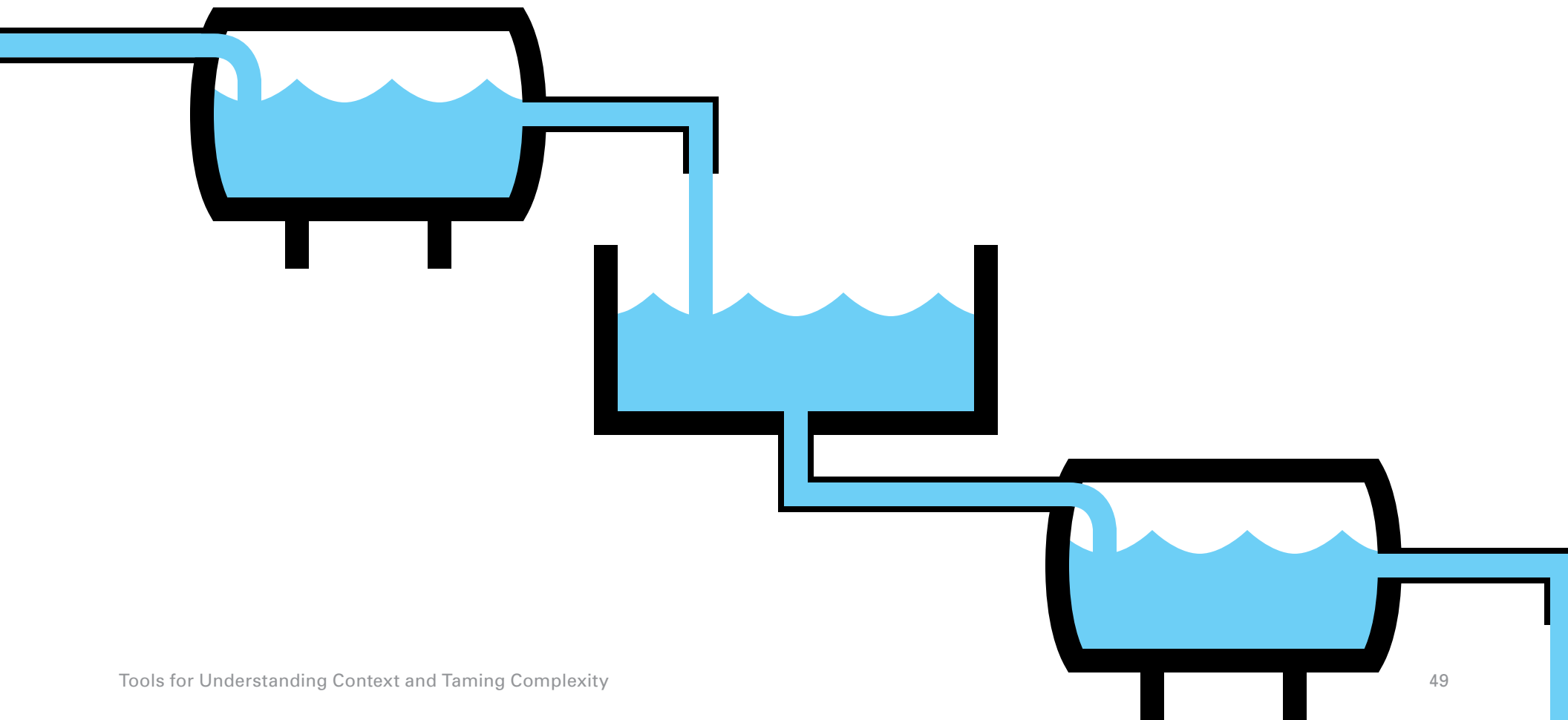
Most bathroom tubs include an overflow drain, which automatically prevents spills.



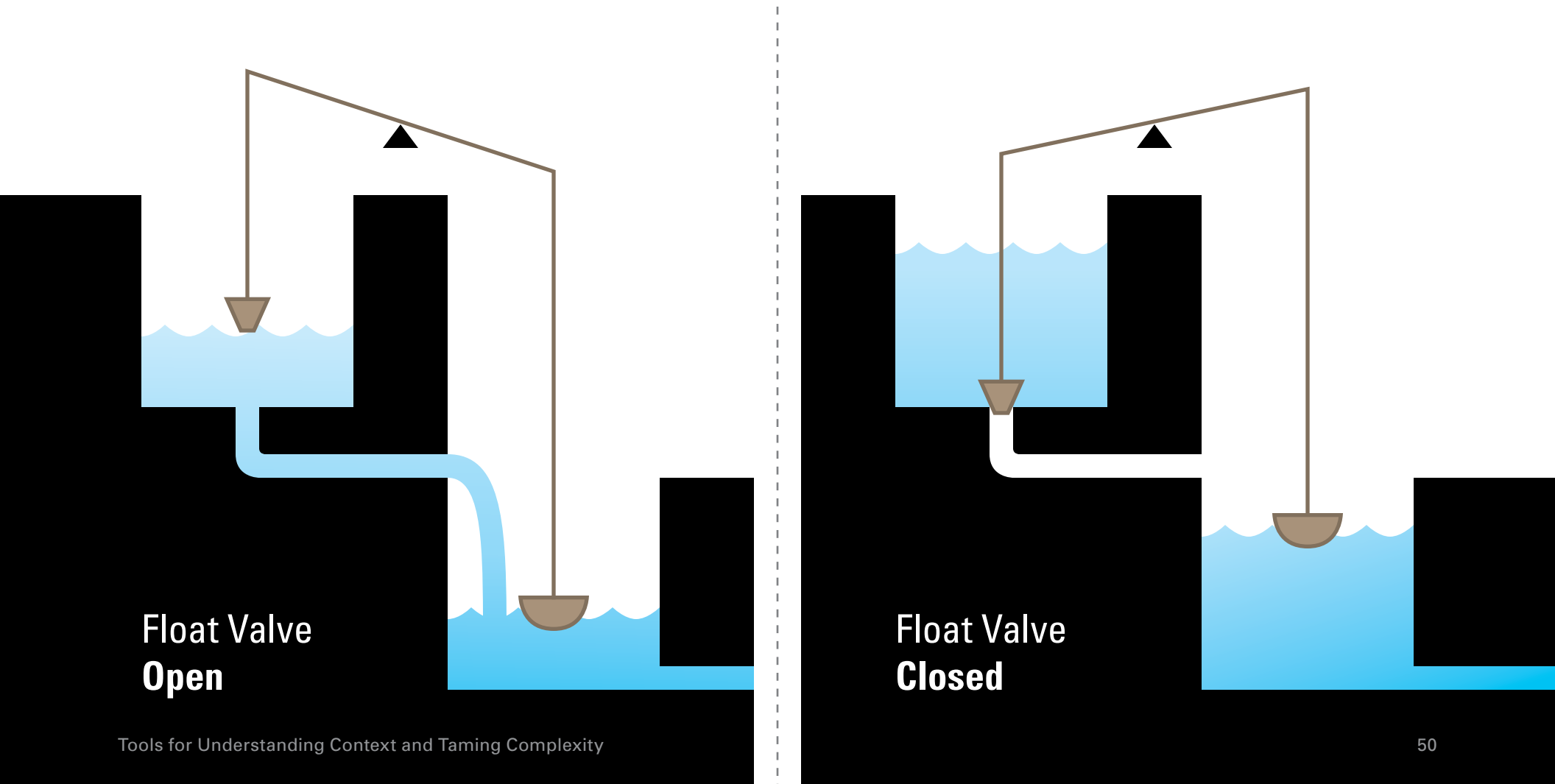
**Man-made dams
often include spillways
to protect the dam
from any overflow
that might weaken it.**



**When 'the rate of inflow' = 'the rate of outflow',
the system is in **dynamic equilibrium**;
that is, the water level in the tub remains constant
even though water is flowing in and out.**



For almost 2,000 years, people have used float valves to automatically reduce or shut off in-flow.



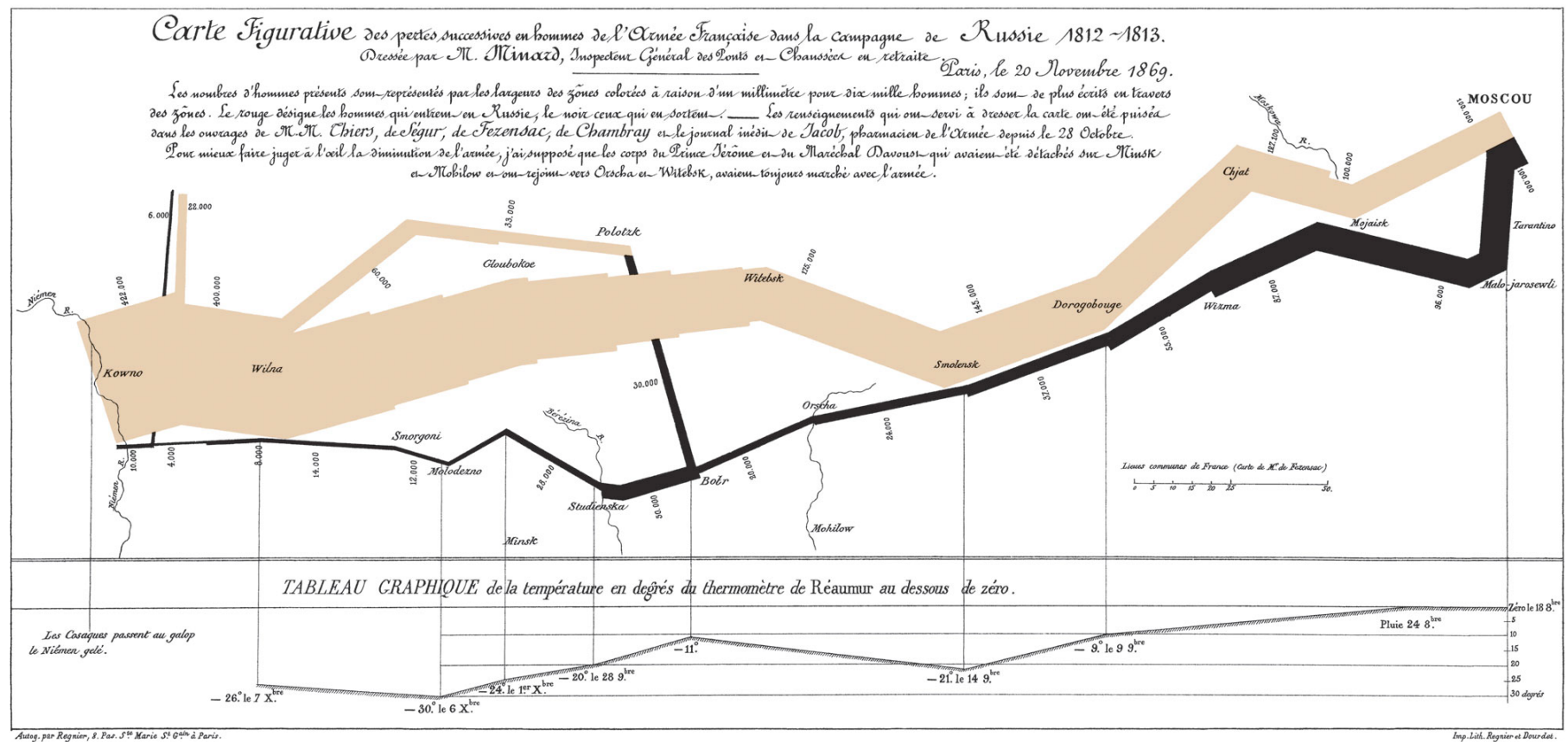
Float valves are part of modern toilets, automatically controlling the water flowing into the storage tank.



Stocks-and-flows diagrams can be used to model many kinds of systems:

- Populations
- Production and sales of goods
- Shipping
- Finances

Minard's model of Napoleon's march to Moscow.

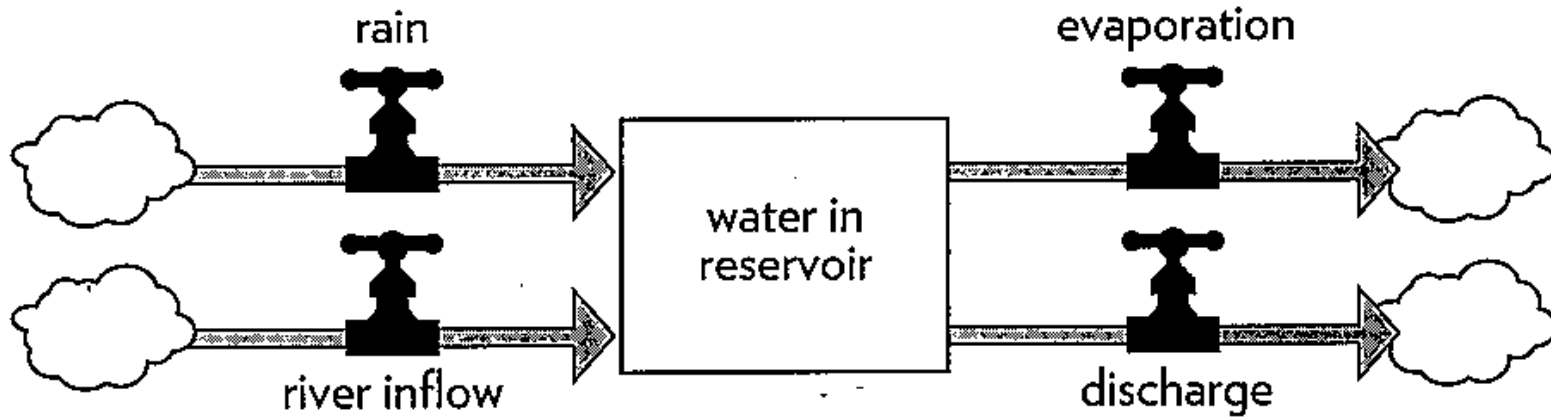


Flight density between international airports.

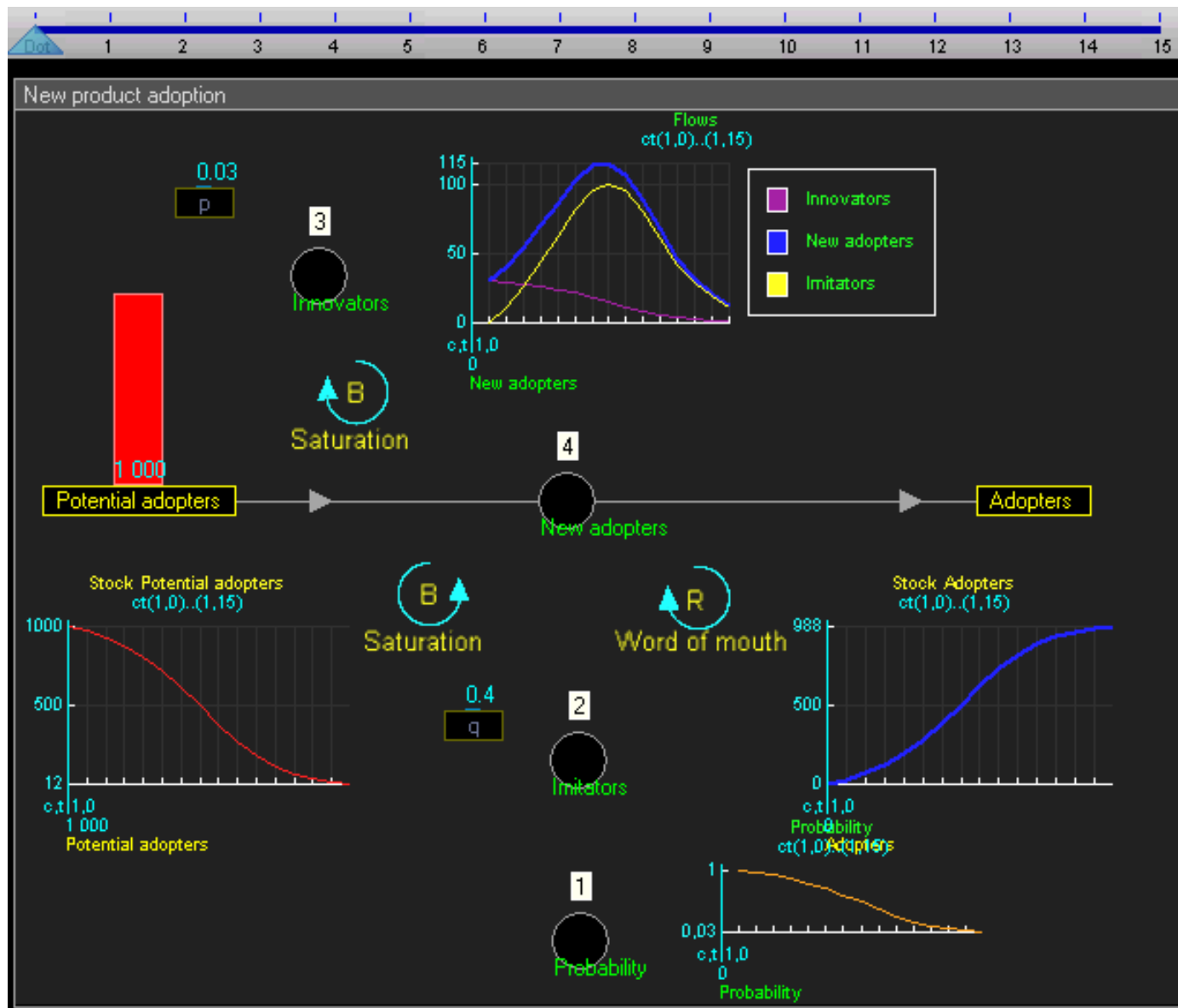


Stocks and flows can be represented in a number of visual forms.

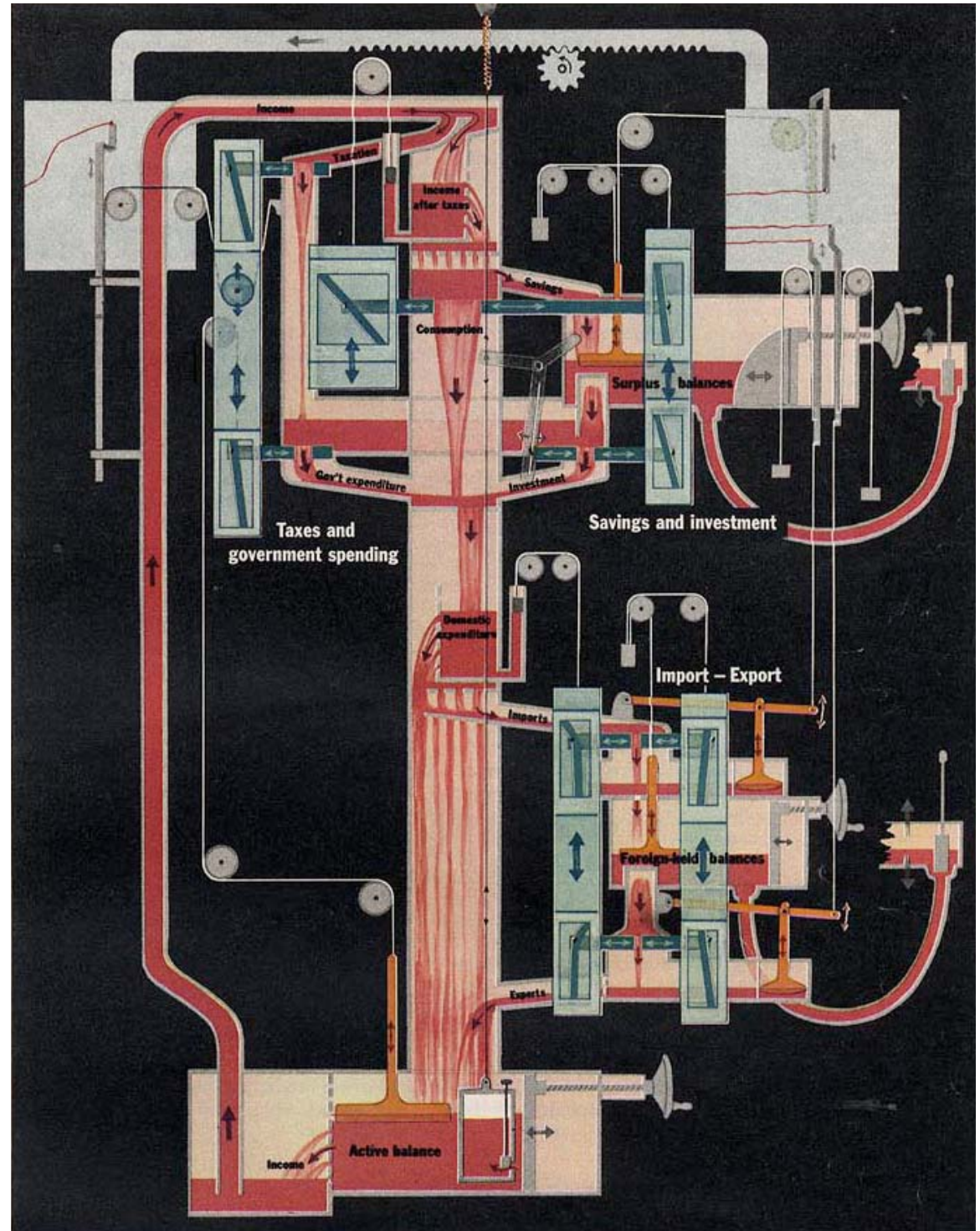
From: Donella Meadows, *Thinking in Systems*



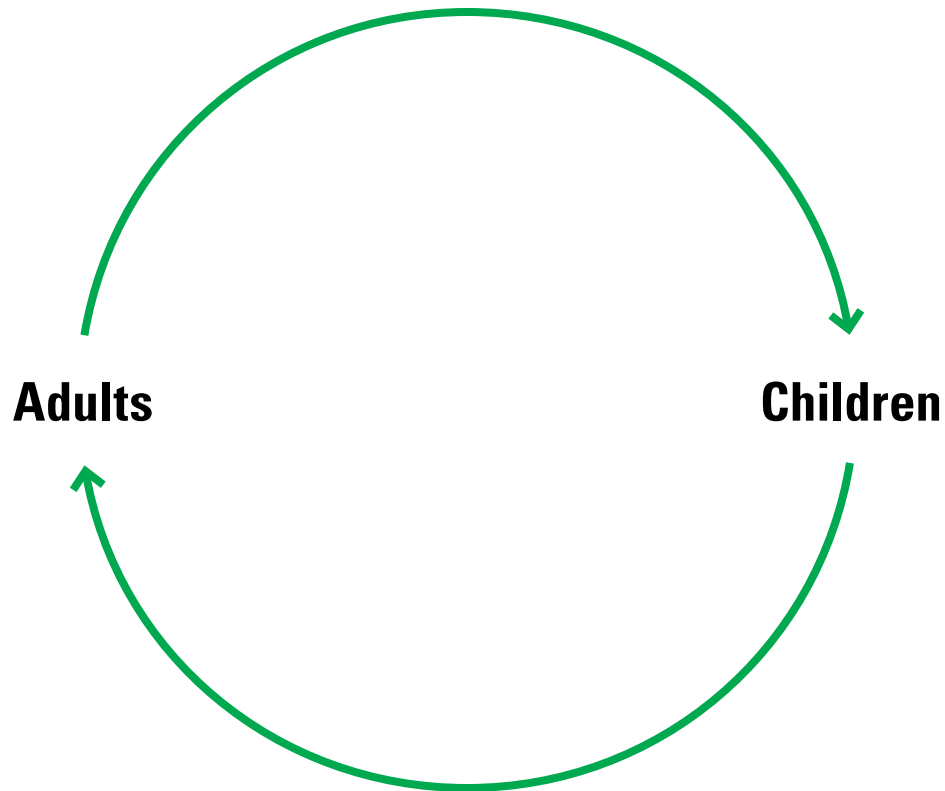
Stocks and flows can also be represented mathematically and in computer simulations.



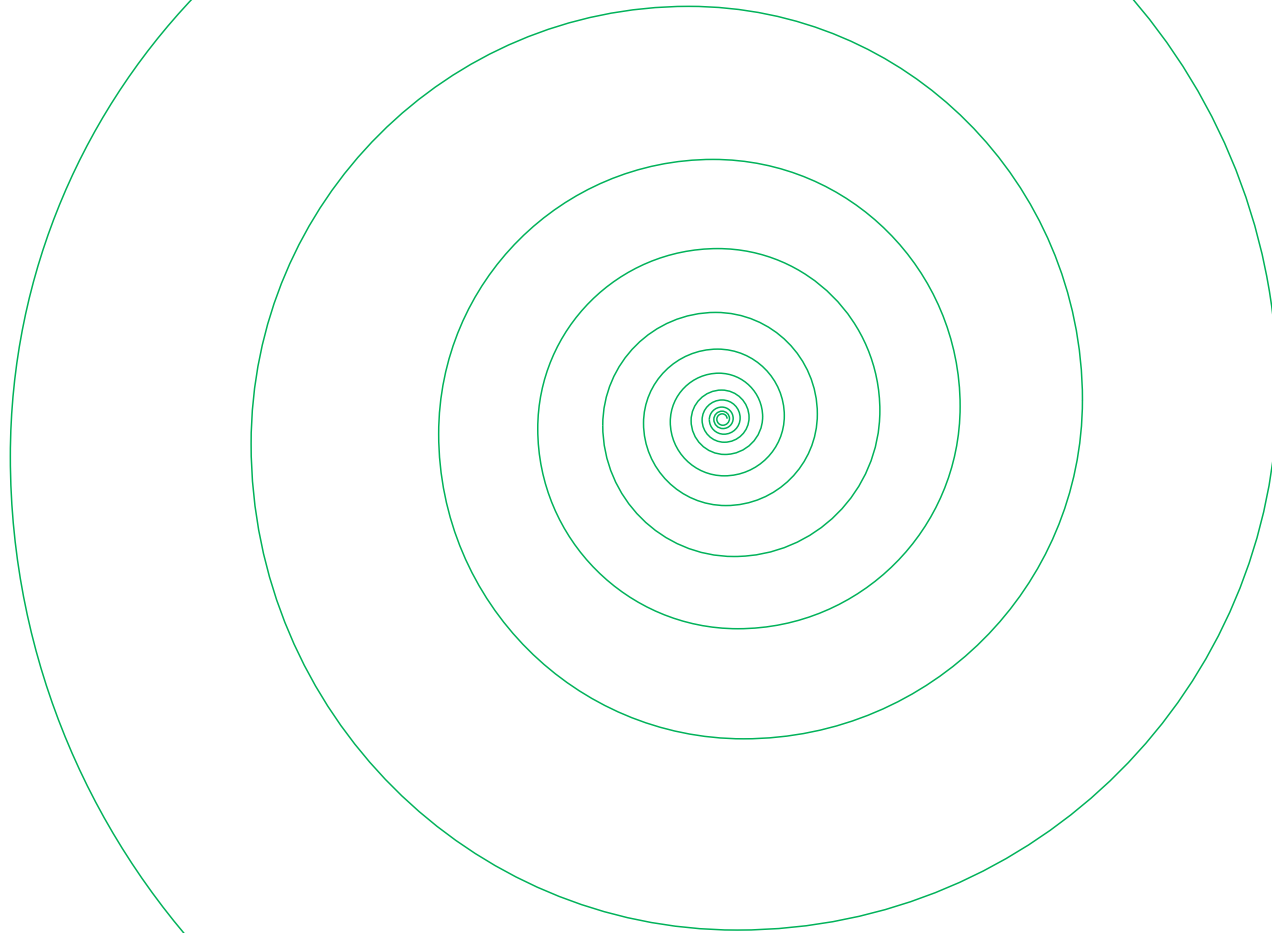
**The MONIAC or
Phillips Hydraulic
Computer
represents the
UK economy with
stocks and flows
of water.**



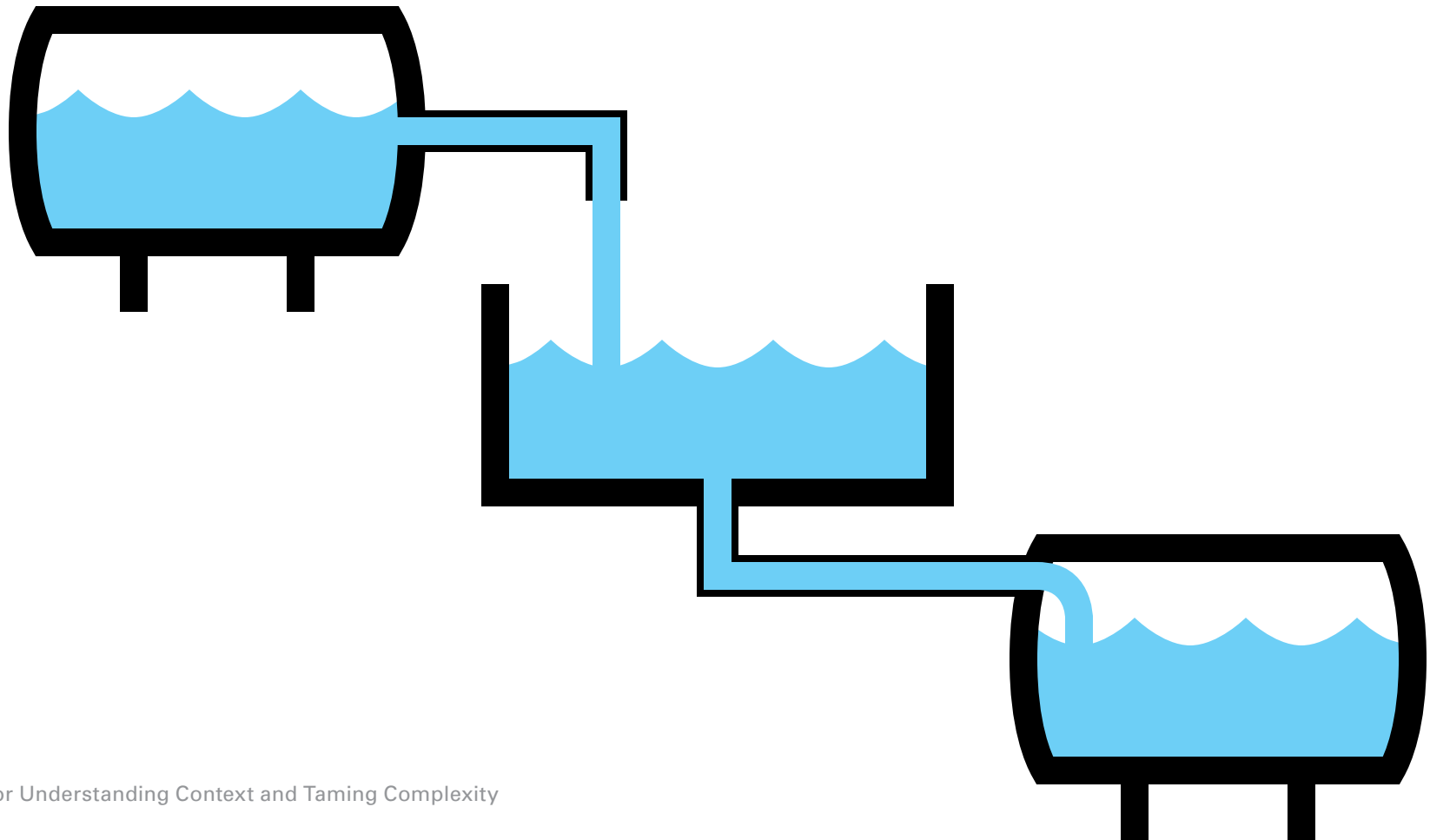
**Living systems also form growth loops
or **virtuous cycles**;
adults beget children who may become adults.**



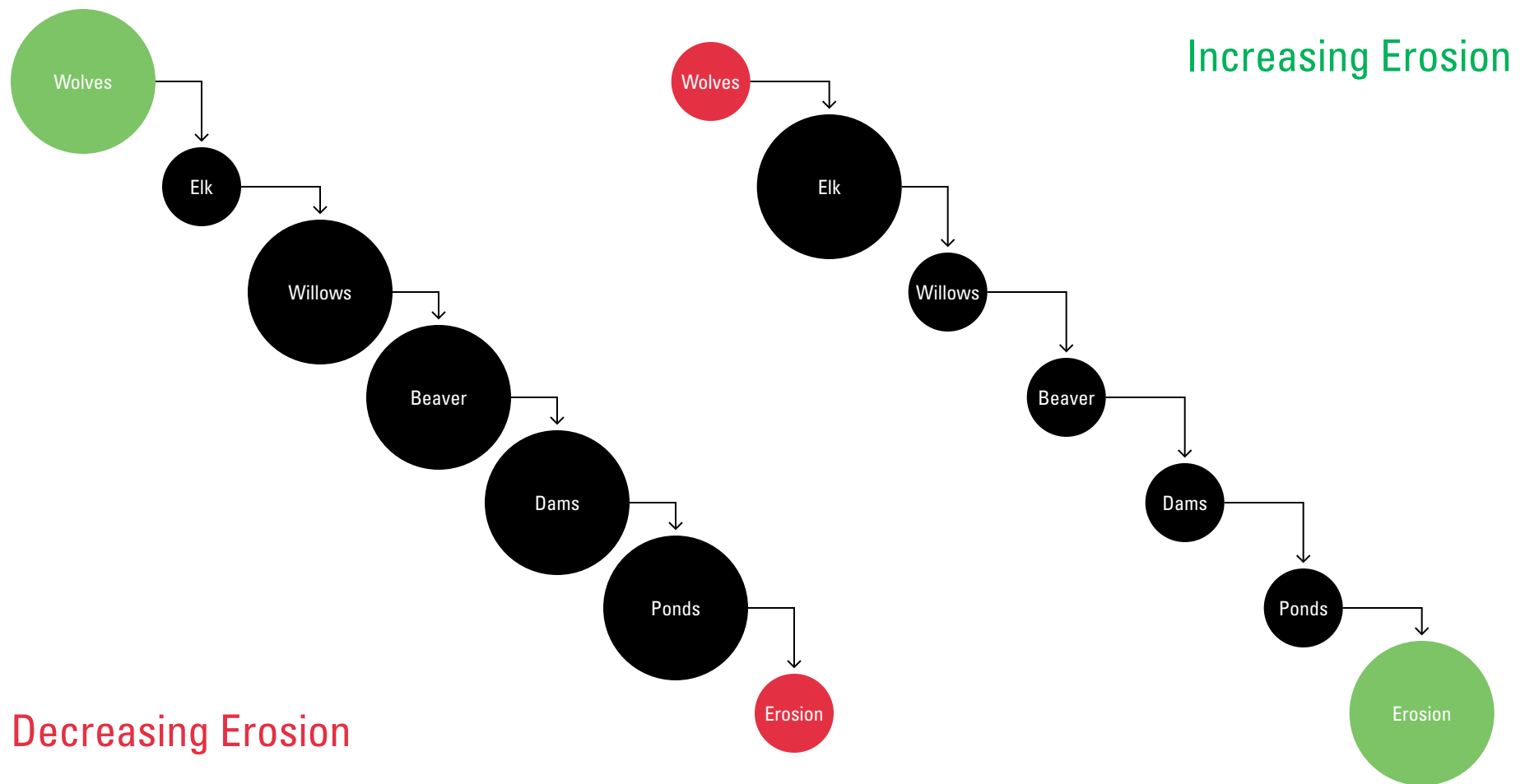
**Without constraints,
such as predators, disease, or food shortages,
growth loops will cause populations to explode.**



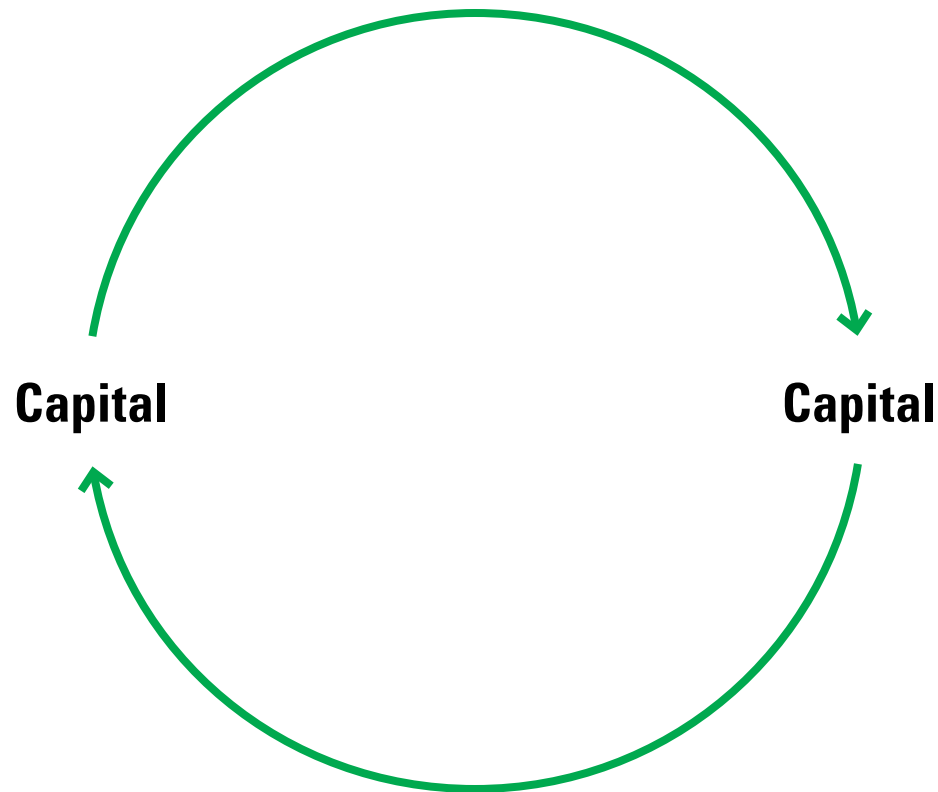
**Mature ecosystems
reach points of dynamic equilibrium;
populations remain stable—
the number of births = the number of deaths.**



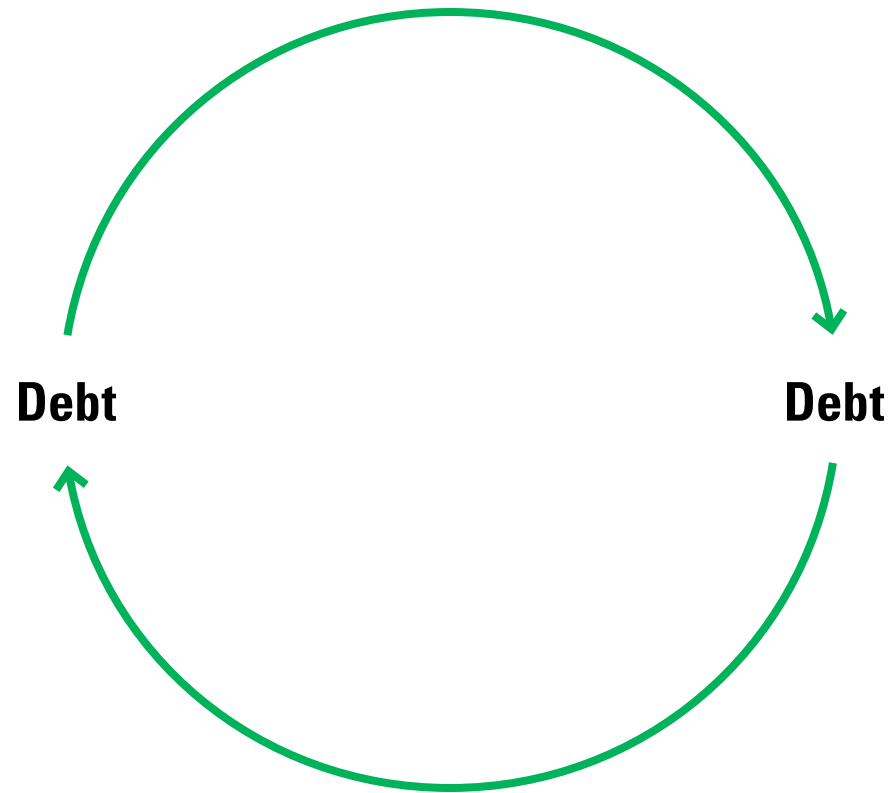
Disturbances from outside the system may throw it out of balance and result in a new, much different point of equilibrium, often with drastic consequences for existing population stocks.



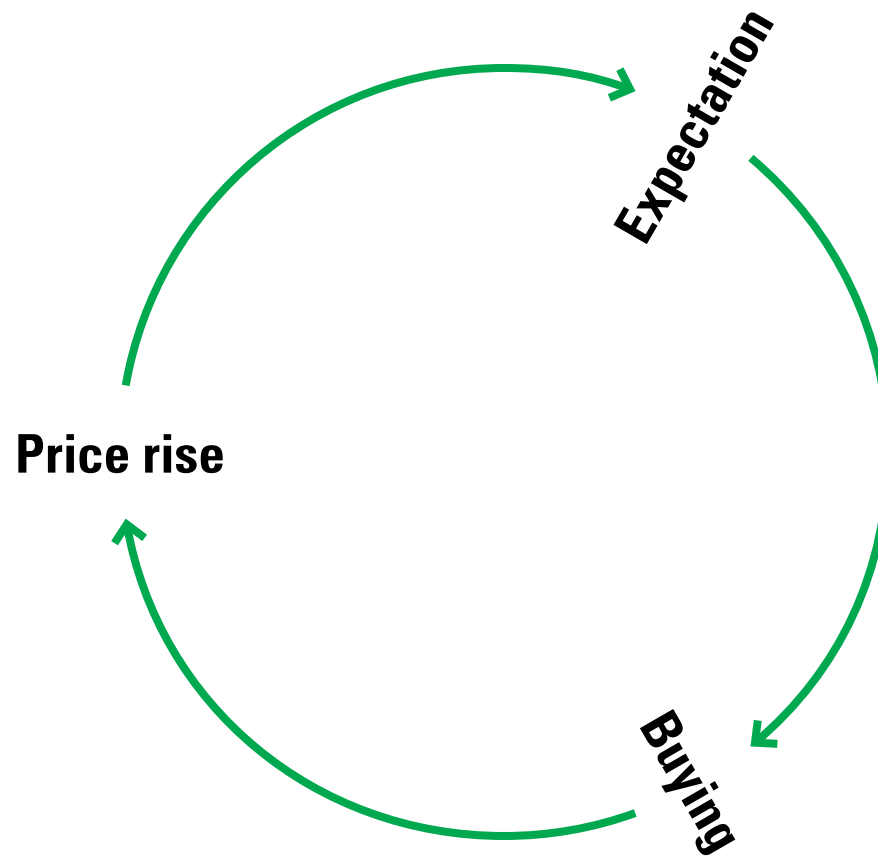
**Interest paid on stocks of money
also forms a growth loop;
capital leads to more capital.**



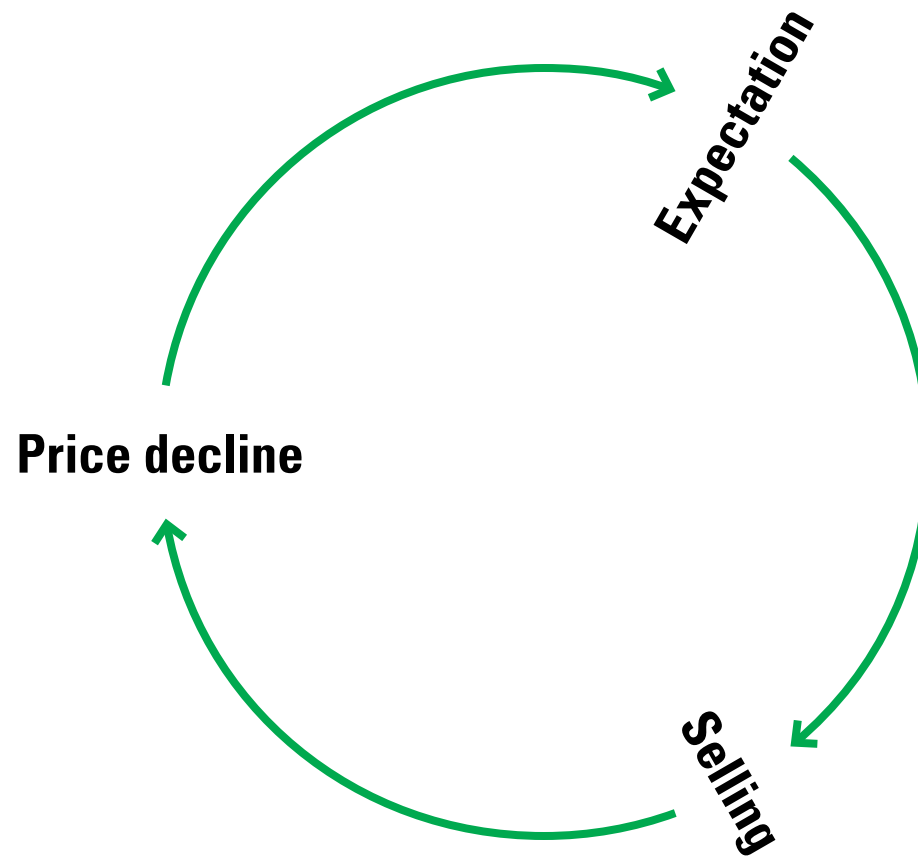
**Likewise debt can lead to more debt,
forming a collapse loop or **vicious cycle**.**



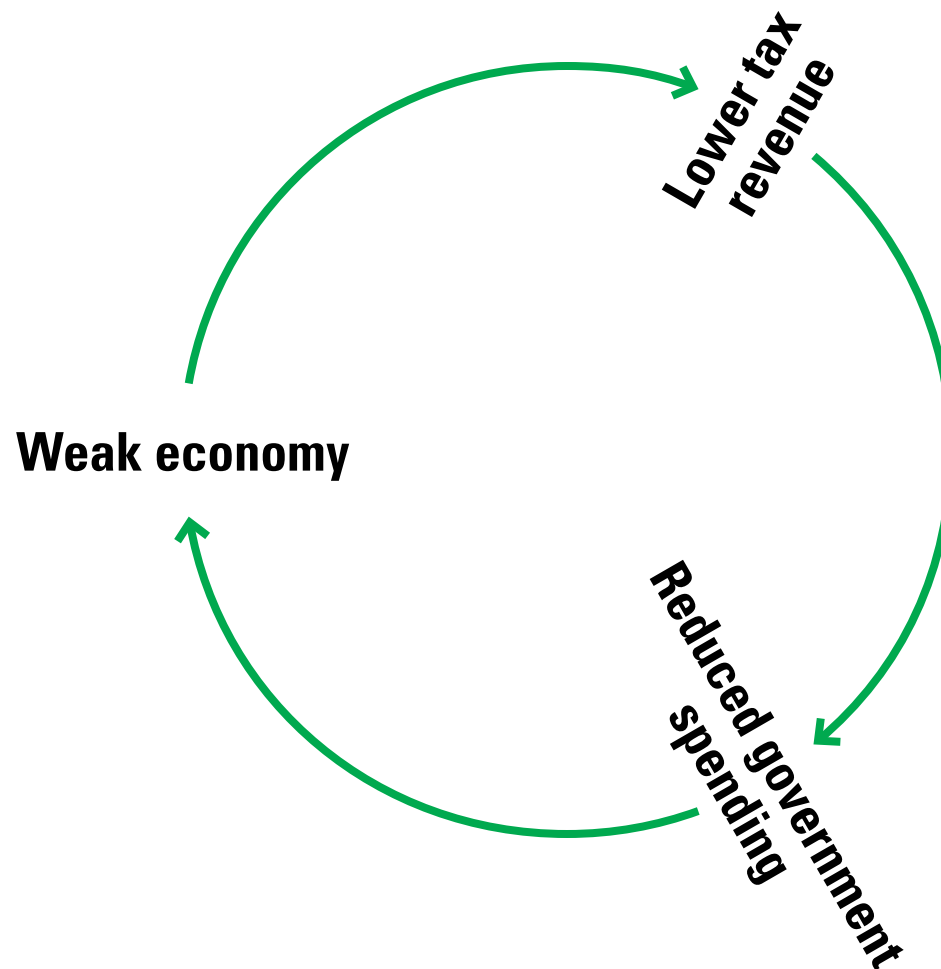
**Speculative bubbles inflate in a similar way;
a price rise leads to expectations of further rises,
which lead to buying, which leads to price rises.**



**Bubbles crash
as expectations of price declines lead to selling,
which leads to price declines,
reinforcing expectations.**

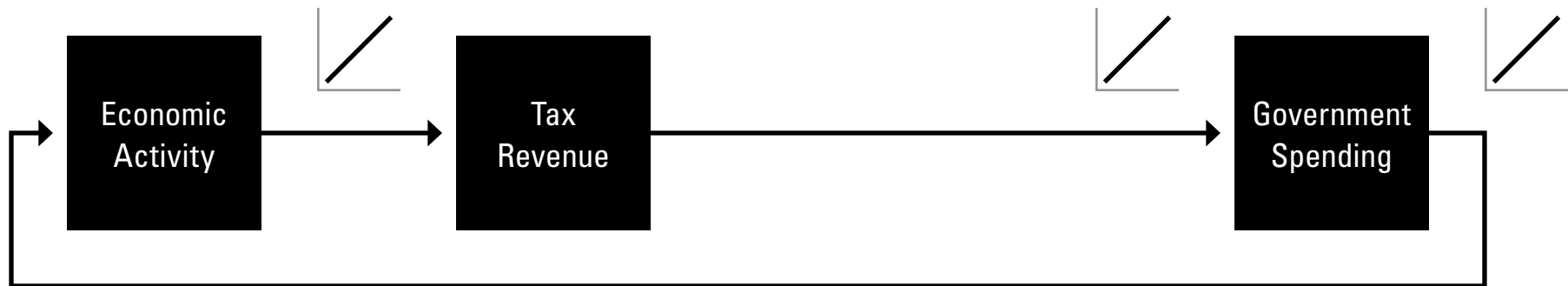


**A recession reduces tax revenue,
which may reduce government spending,
which further weakens the economy,
creating a collapse loop, e.g., the Great Depression.**

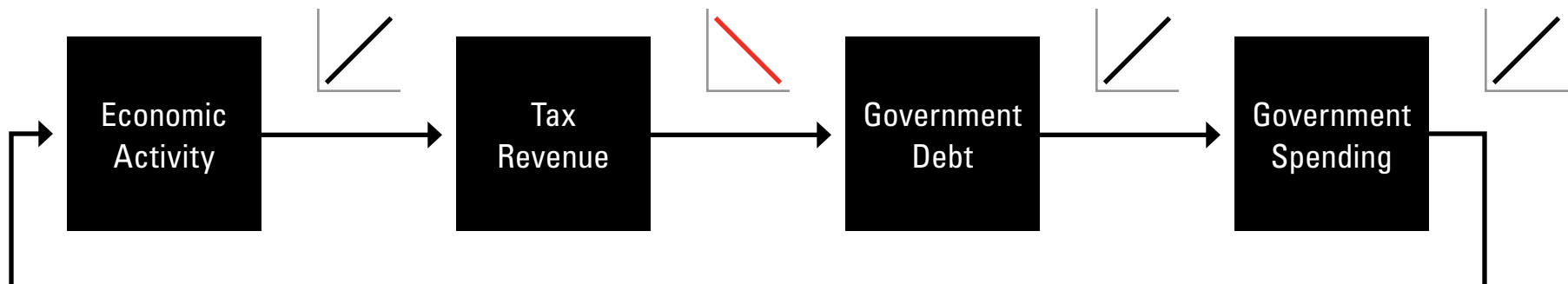


Keynes showed that increasing government spending during a recession (by taking on debt) can improve the economy, which avoids a collapse and puts the system back into balance. As the economy improves, tax revenues increase, and government debt can be paid down.

Conventional Wisdom



Keynesian Theory



Key ideas from systems dynamics

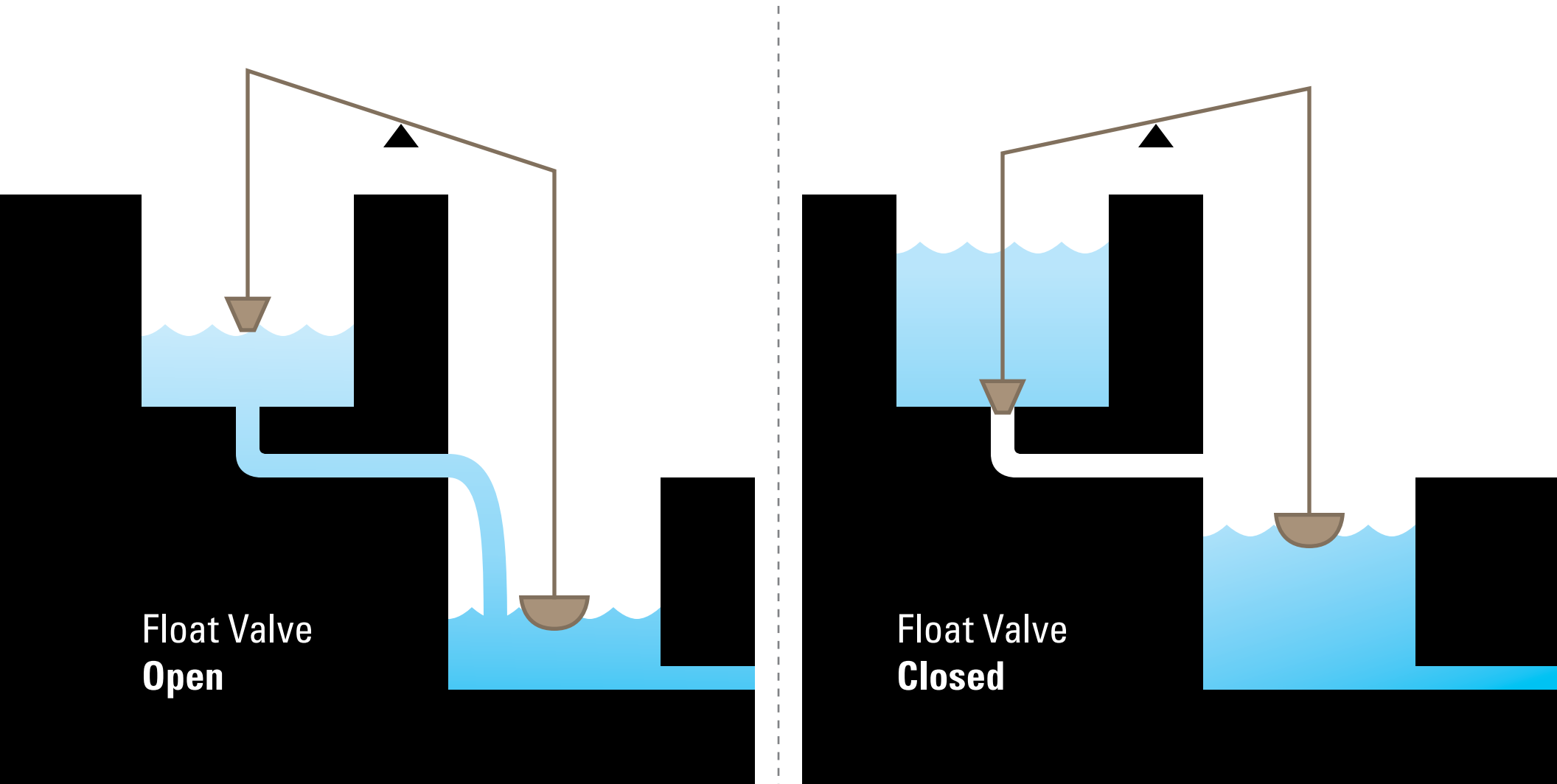
- Source, flow rate, stock, flow rate, sink
- no original sources or ultimate stocks
- dynamic equilibrium
- virtuous and vicious cycles

PART THREE

Control systems

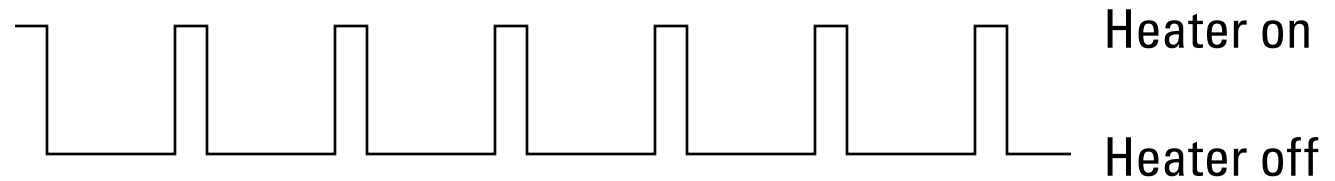
Dynamic equilibrium is maintained by feedback

Measuring the effect of an action, comparing it with a goal
(maintaining the level of water in the reservoir)
and acting to correct differences

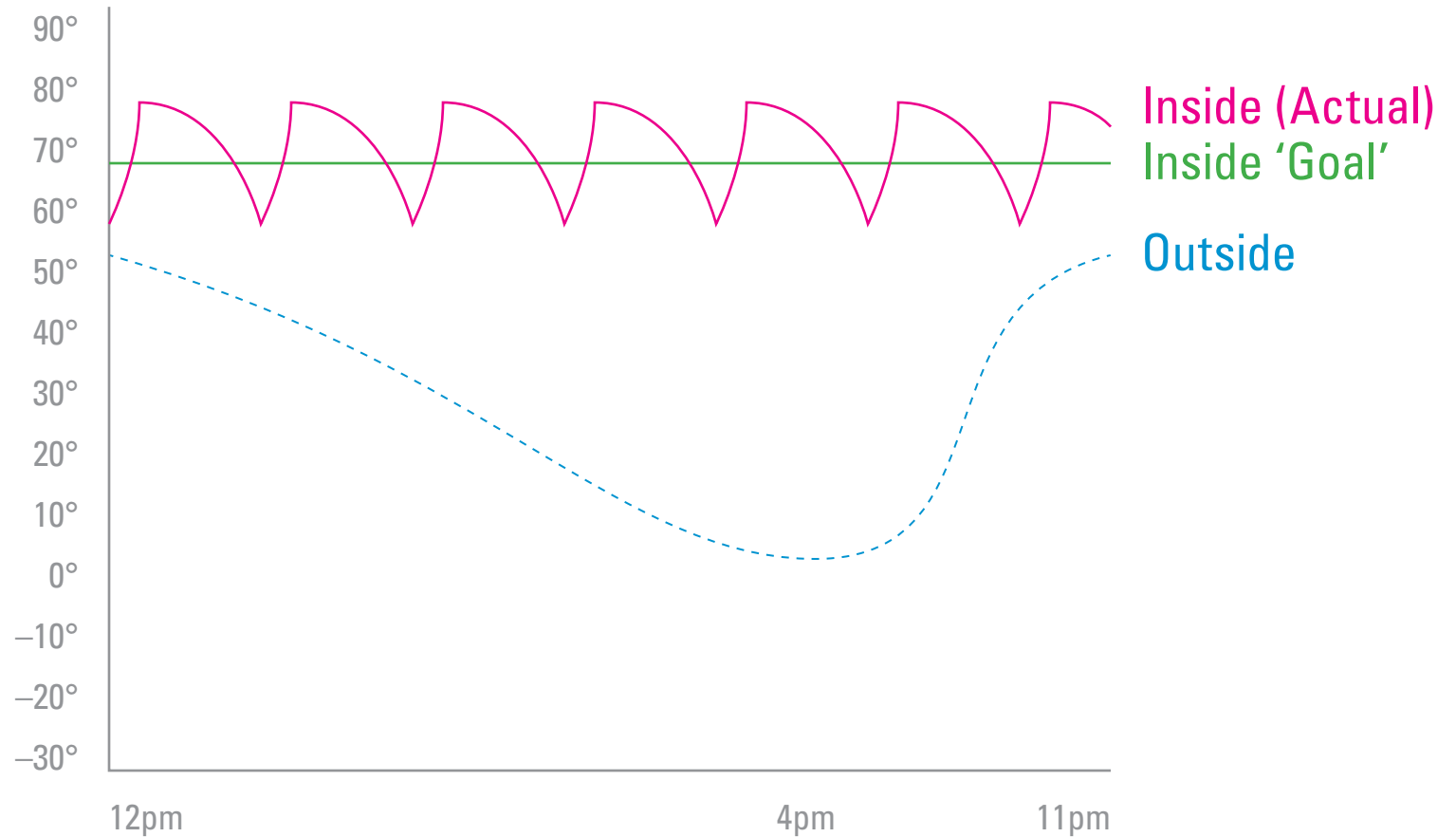


A thermostat maintains a constant temperature.

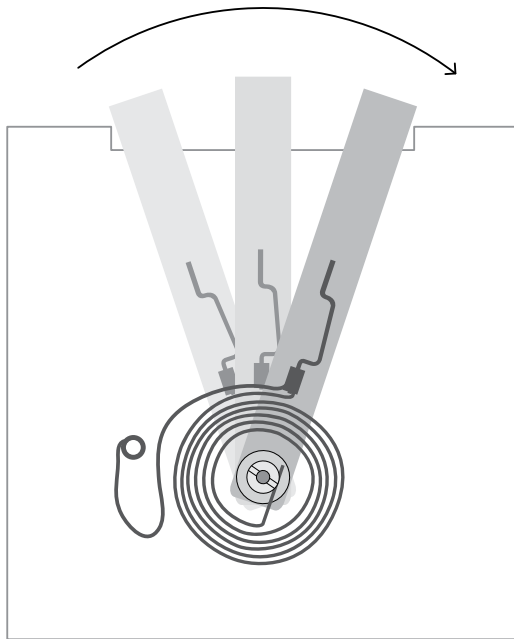
Heater Cycle



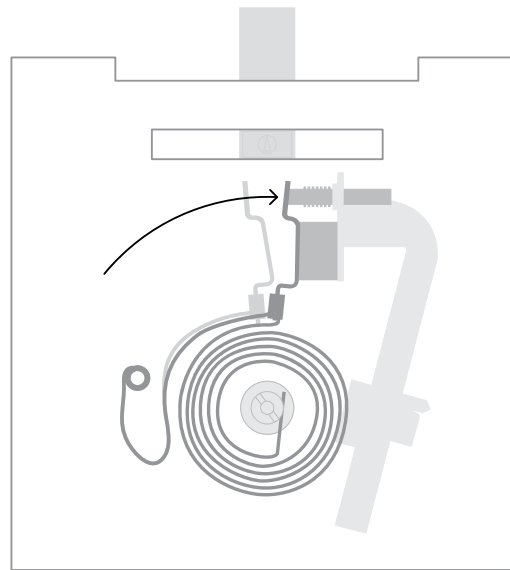
Temperature Fluctuation



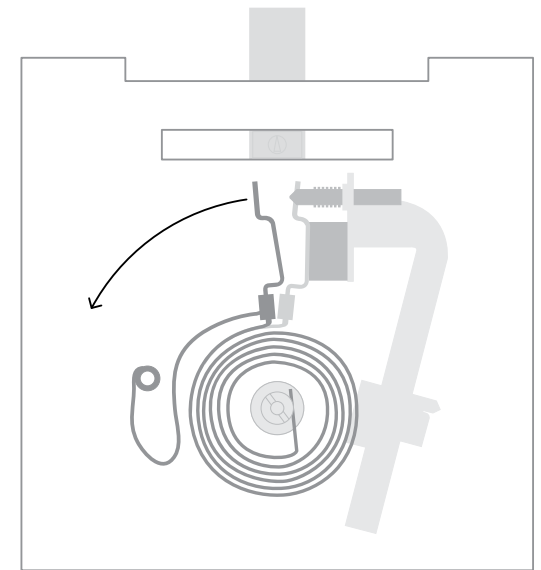
**As the room cools,
a bi-metal coil contracts closing a circuit;
as the room heats,
the coil expands breaking the circuit.**



Moving the temperature control lever moves the bi-metal coil

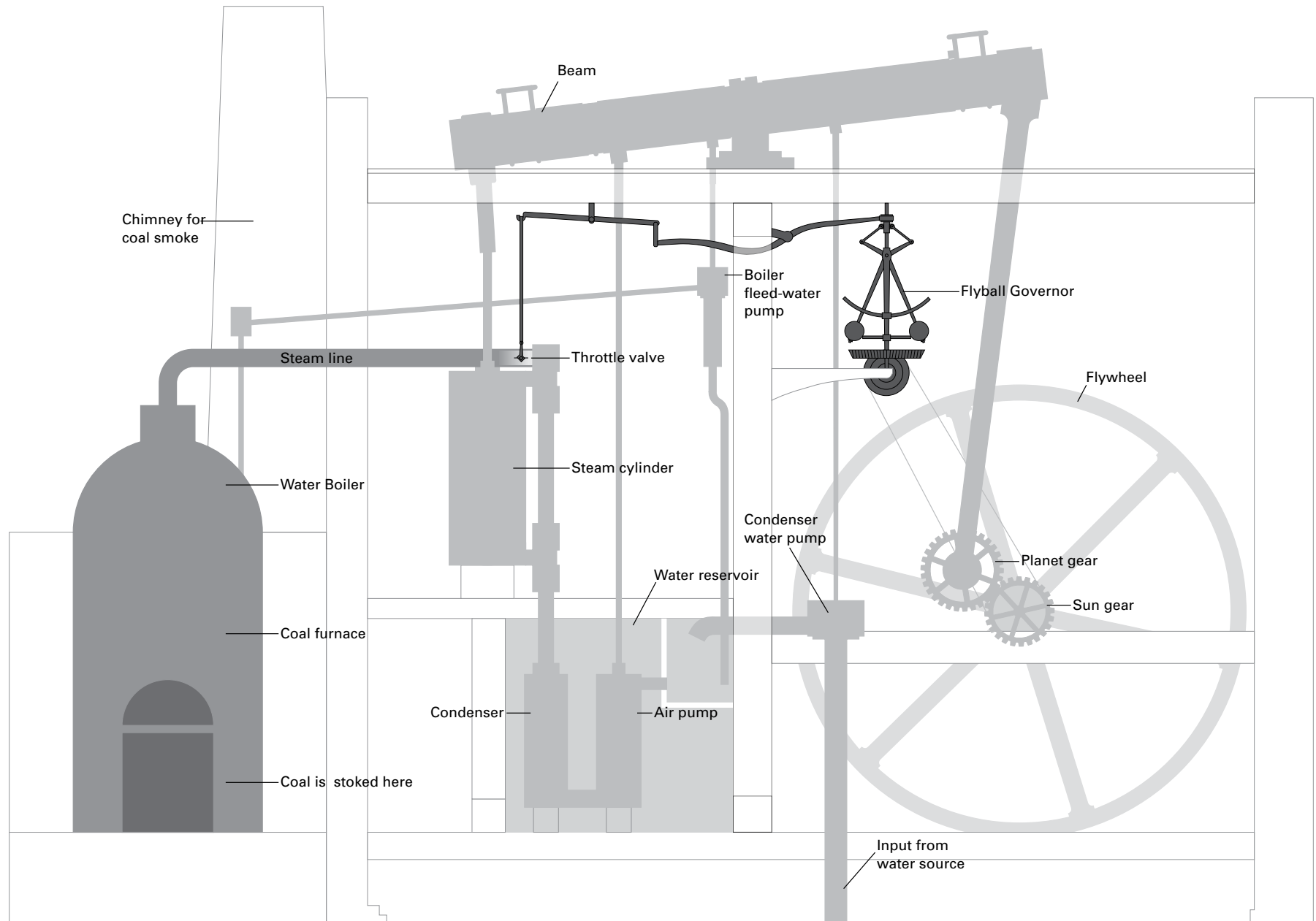


The bi-metal coil bends towards the contact screw as it cools

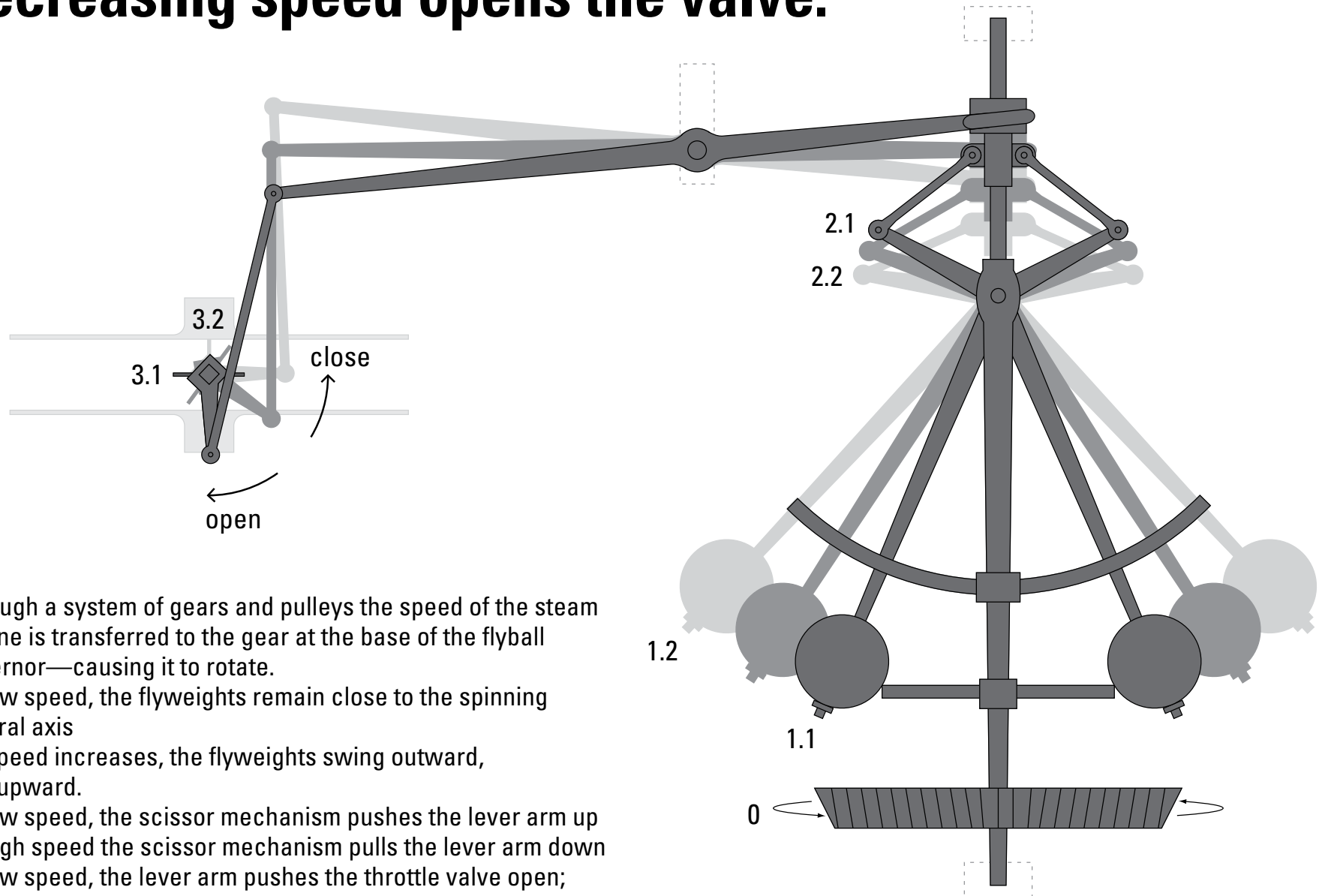


The bi-metal coil bends away from the contact screw as it warms

A flyball governor maintains constant pressure in a steam engine.



Increasing speed closes a valve; decreasing speed opens the valve.

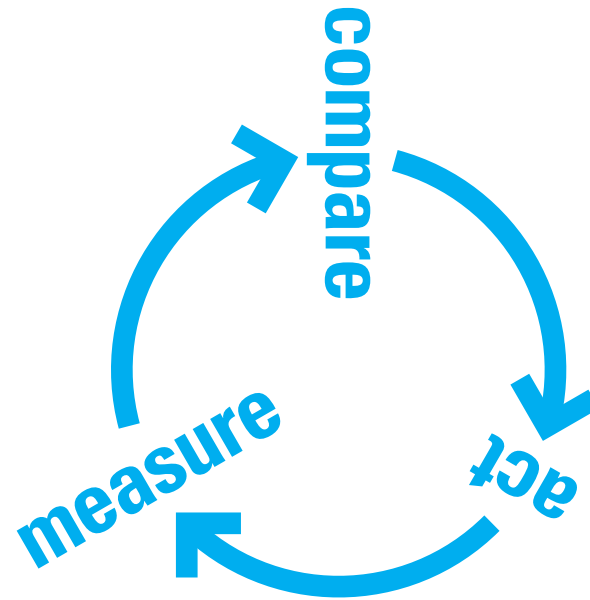


- 0 Through a system of gears and pulleys the speed of the steam engine is transferred to the gear at the base of the flyball governor—causing it to rotate.
- 1.1 At low speed, the flyweights remain close to the spinning central axis
- 1.2 As speed increases, the flyweights swing outward, and upward.
- 2.1 At low speed, the scissor mechanism pushes the lever arm up
- 2.2 At high speed the scissor mechanism pulls the lever arm down
- 3.1 At low speed, the lever arm pushes the throttle valve open; increasing the flow of steam
- 3.2 At high speed, the lever arm pulls the throttle valve closed; reducing the flow of steam

This feedback loop is a structure common to all control mechanisms: act, measure, compare to goal, act to correct differences

self-regulating system

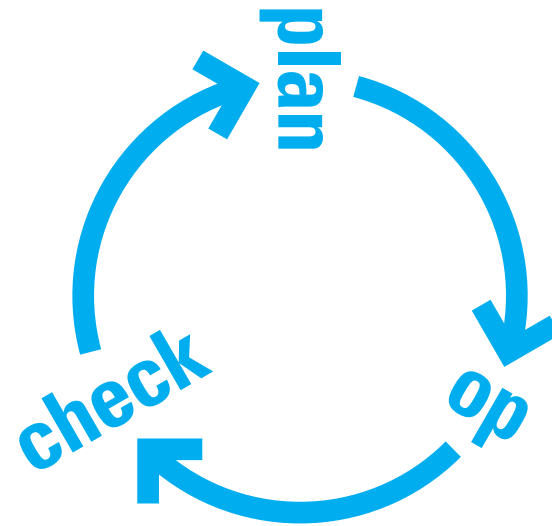
Like a self-regulating system, the creative process is a classic feedback loop. Measure an essential variable; compare it to a goal; and act to eliminate any difference.



This process is similar to the Shewart-Deming PDCA (plan-do-check-act) process.

quality cycle

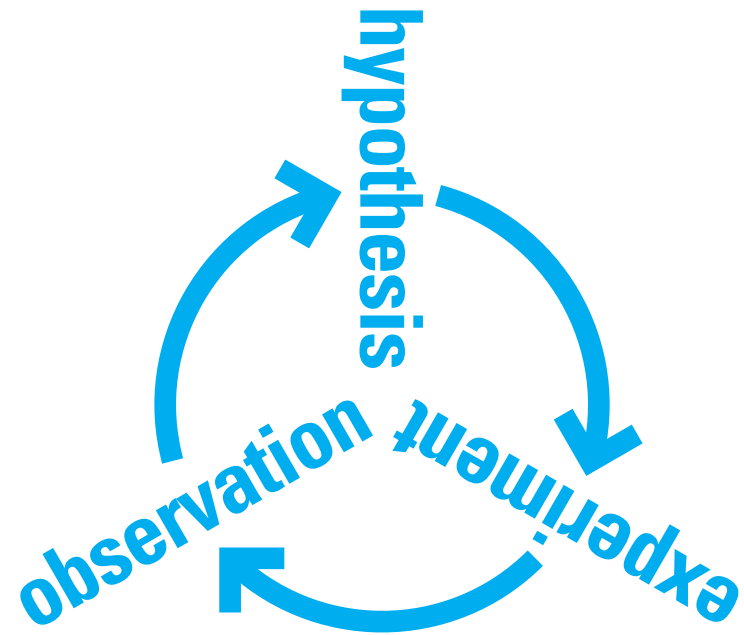
The creative process is startlingly similar to the quality cycle (Shewart, 1939), popularized in business circles by the quality management movement (Deming, 1982).



It's also an analog to the design process and the scientific method.

scientific method

Forming a hypothesis is a special type of creative act.
Framing the creative process as “experimenting” shows
the close tie it has with the domain of science.



Tracking by itself is only useful if you can make correlations.

Tracking measuring + recording, perhaps correlating measurements
Open loop system, no feedback

Tracking + acting = managing

Managing measuring, comparing to goal, + acting to correct differences
Closed loop system, feedback enables dynamic equilibrium (homeostasis)
—first order

Tracking measuring + recording, perhaps correlating measurements
Open loop system, no feedback

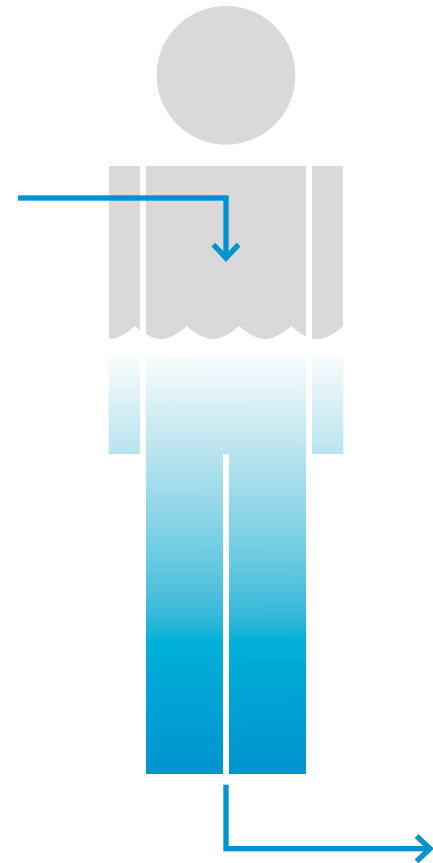
Managing may lead to learning

- Learning** anticipating disturbances + affects of actions
Studying the system, developing a model of the feedback loop
—second order
- Managing** measuring, comparing to goal, + acting to correct differences
Closed loop system, feedback enables dynamic equilibrium (homeostasis)
—first order
- Tracking** measuring + recording, perhaps correlating measurements
Open loop system, no feedback

Learning may lead to experimenting

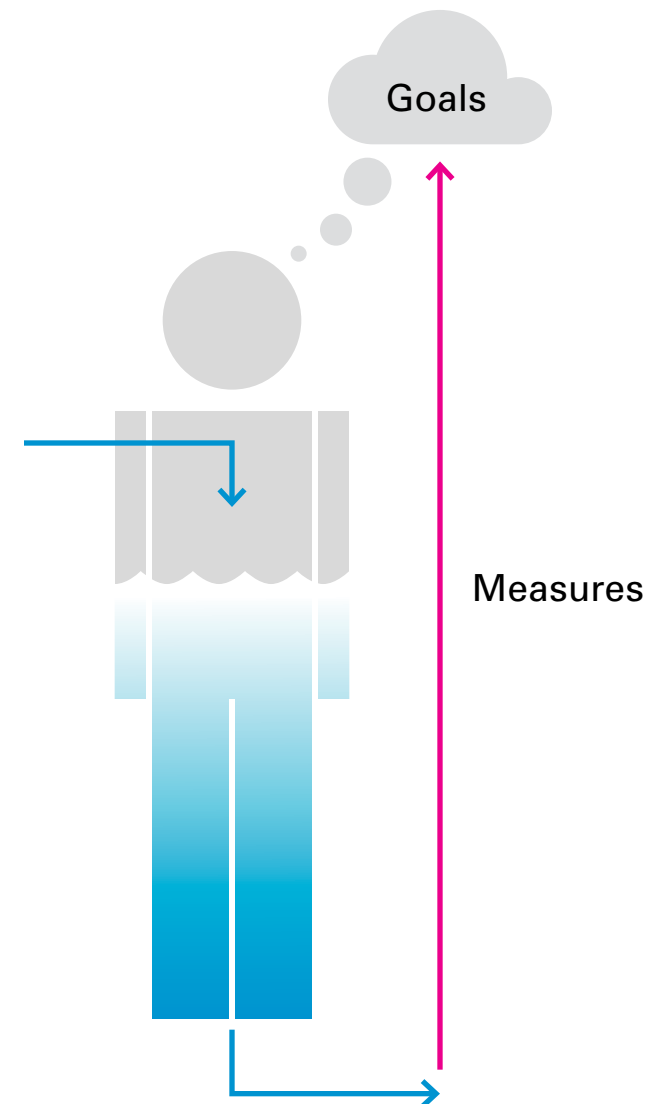
- Innovating** recognizing patterns, proposing causes, + testing hypotheses
Studying the environment, experimenting to see how the system connects to other systems
- Learning** anticipating disturbances + affects of actions
Studying the system, developing a model of the feedback loop
—second order
- Managing** measuring, comparing to goal, + acting to correct differences
Closed loop system, feedback enables dynamic equilibrium (homeostasis)
—first order
- Tracking** measuring + recording, perhaps correlating measurements
Open loop system, no feedback

Living systems must maintain dynamic equilibrium (homeostasis) to survive

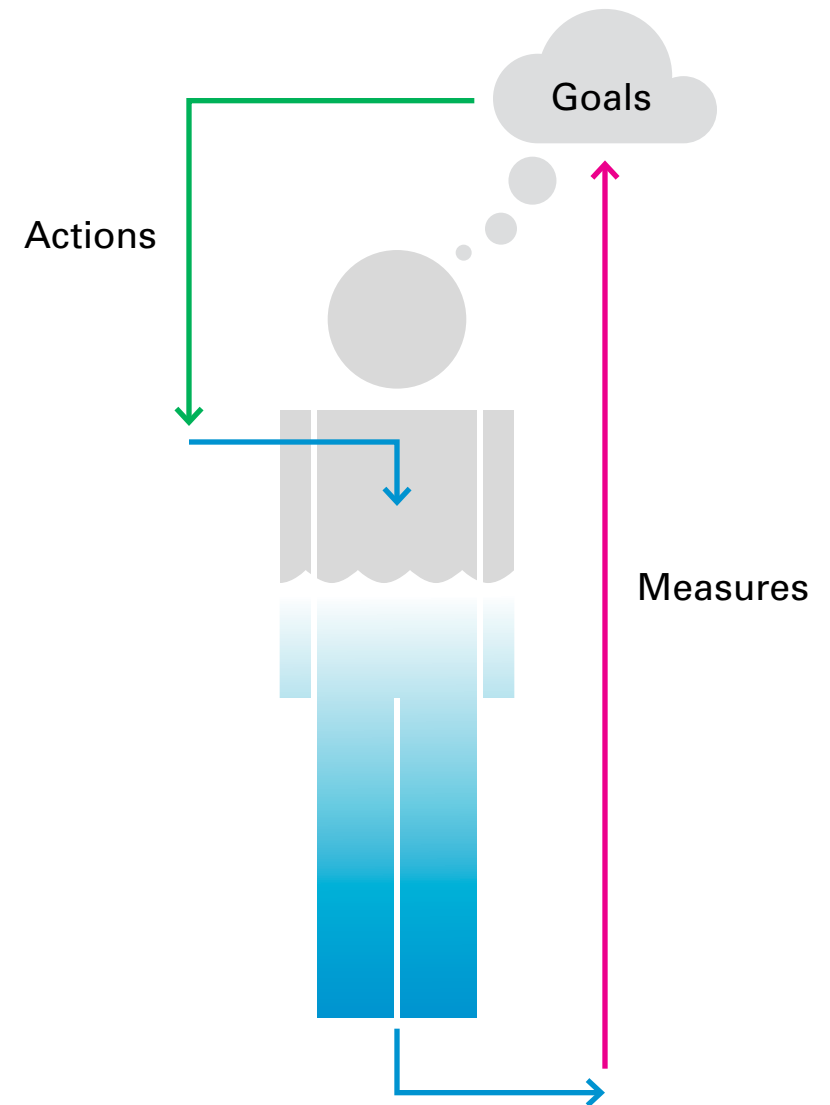


A patient's vital signs measure important elements of homeostasis

| Variable | Goal range |
|------------------|--------------------|
| Body temperature | 97.25°F – 99.5°F |
| Heart rate | 60 – 80 bpm |
| Blood pressure | < 120 / < 80 mm Hg |
| Respiratory rate | 10 – 14 bpm |



Maintaining homeostasis requires 'closing the loop' on many variables simultaneously

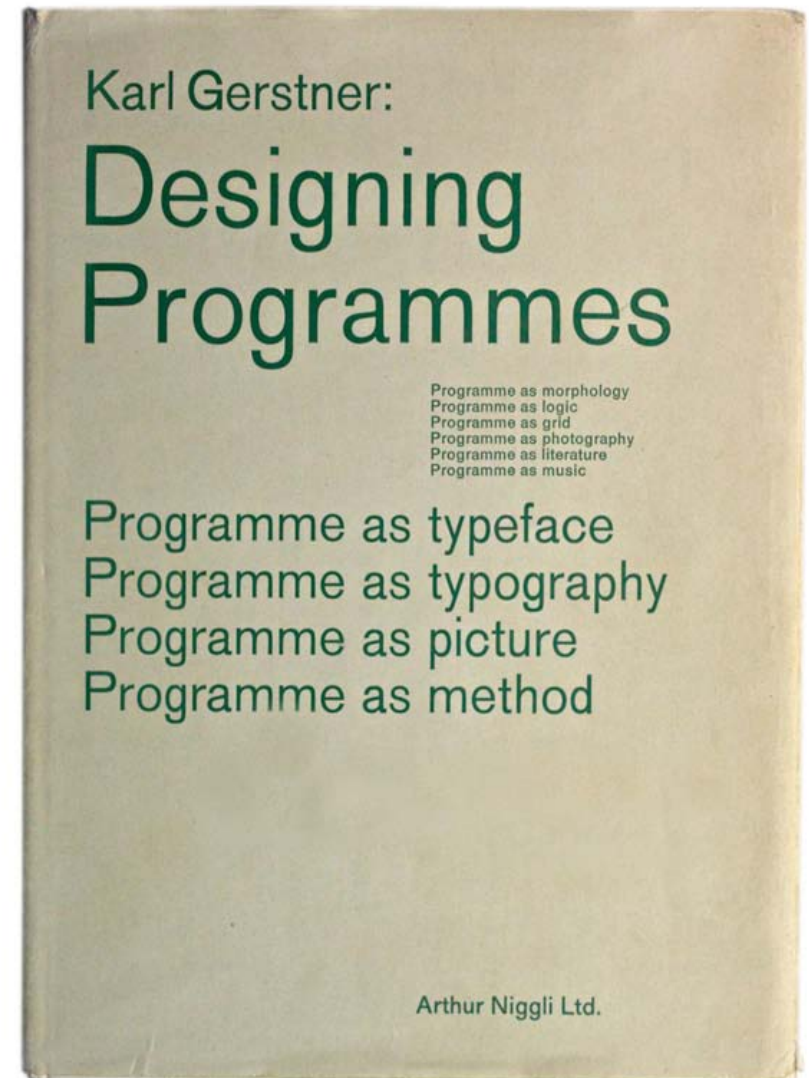


PART FOUR

Resources

Karl Gerstner

Designing Programmes



Donella Meadows

Thinking in Systems

Thinking in Systems

A Primer

Donella H. Meadows

*Edited by Diana Wright,
Sustainability Institute*

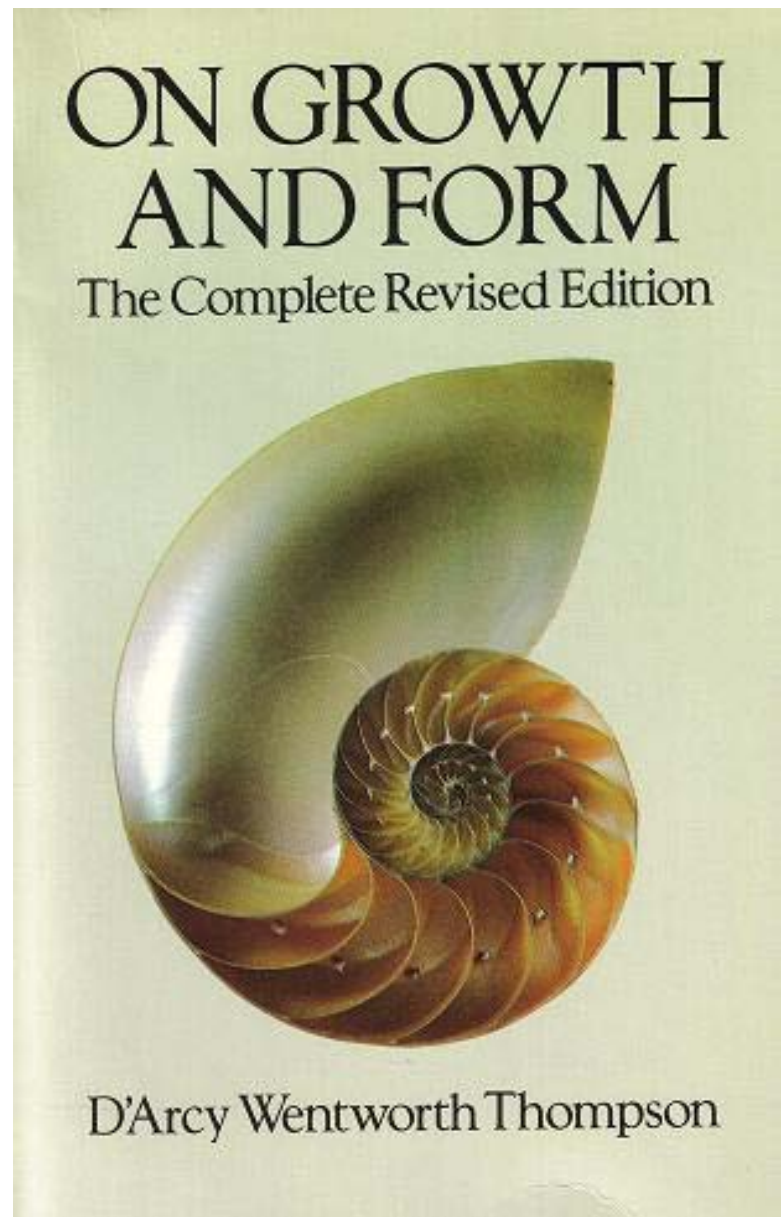


Ross Ashby
An Introduction to
Cybernetics

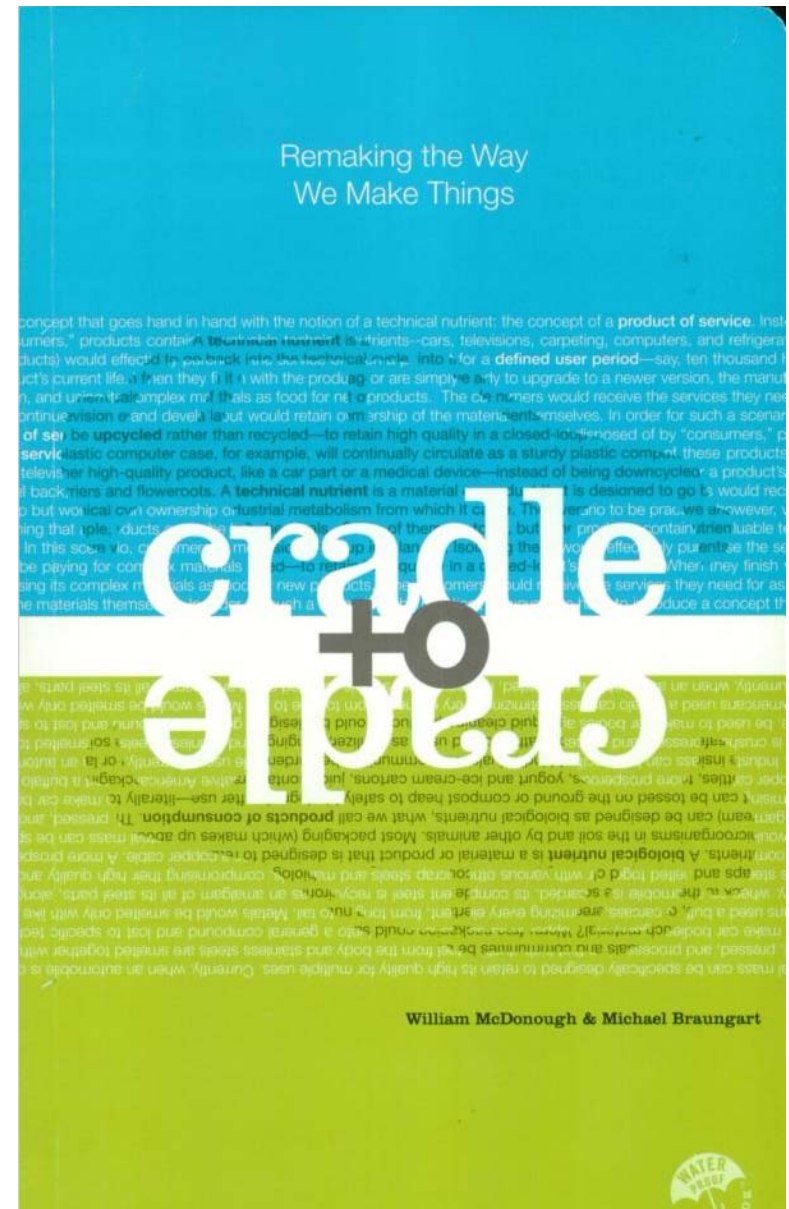


D'Arcy Thompson

On Growth and Form



William McDonough & Michael Braungart *Cradle to Cradle*



PART FIVE

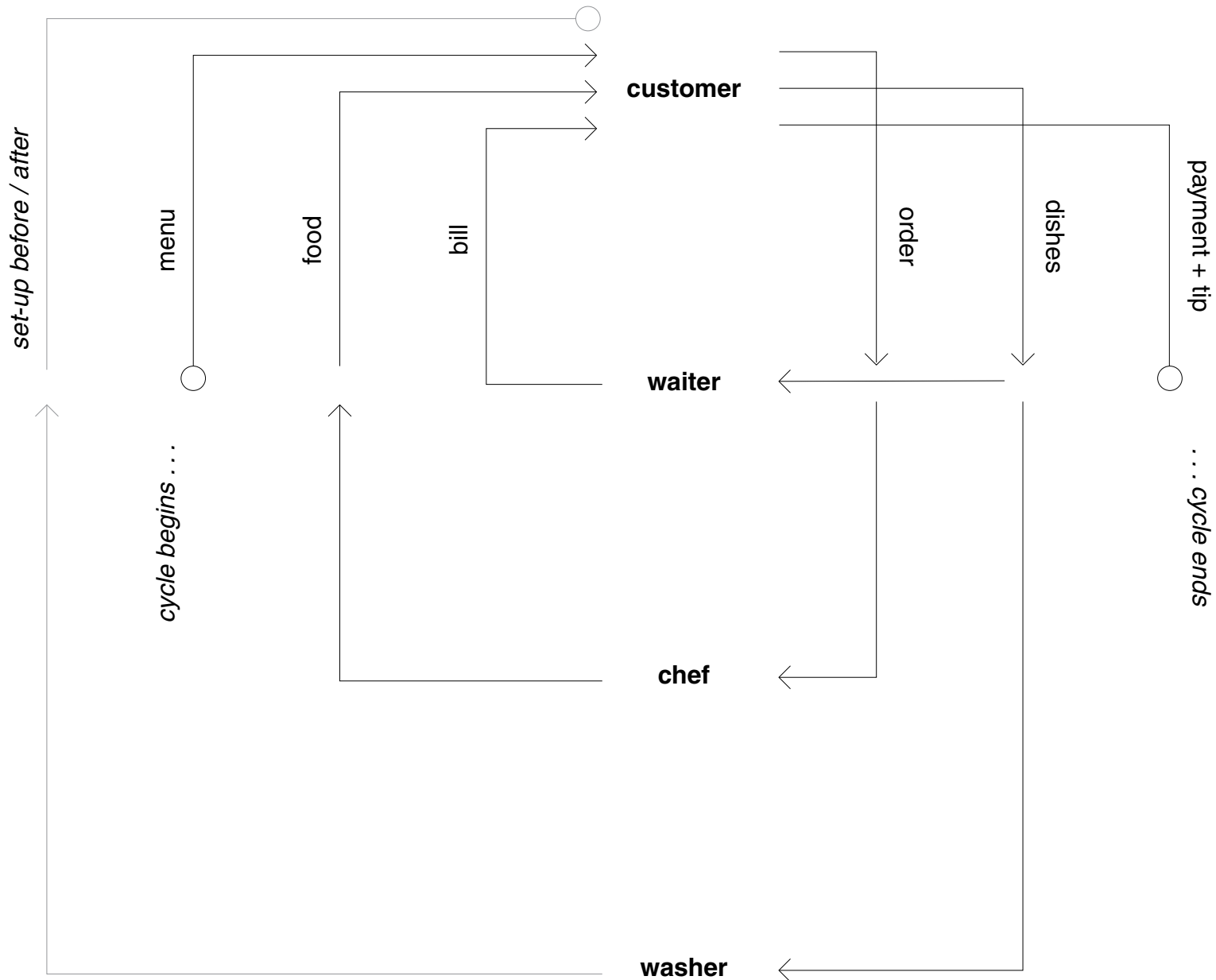
Assignments

Assignment:

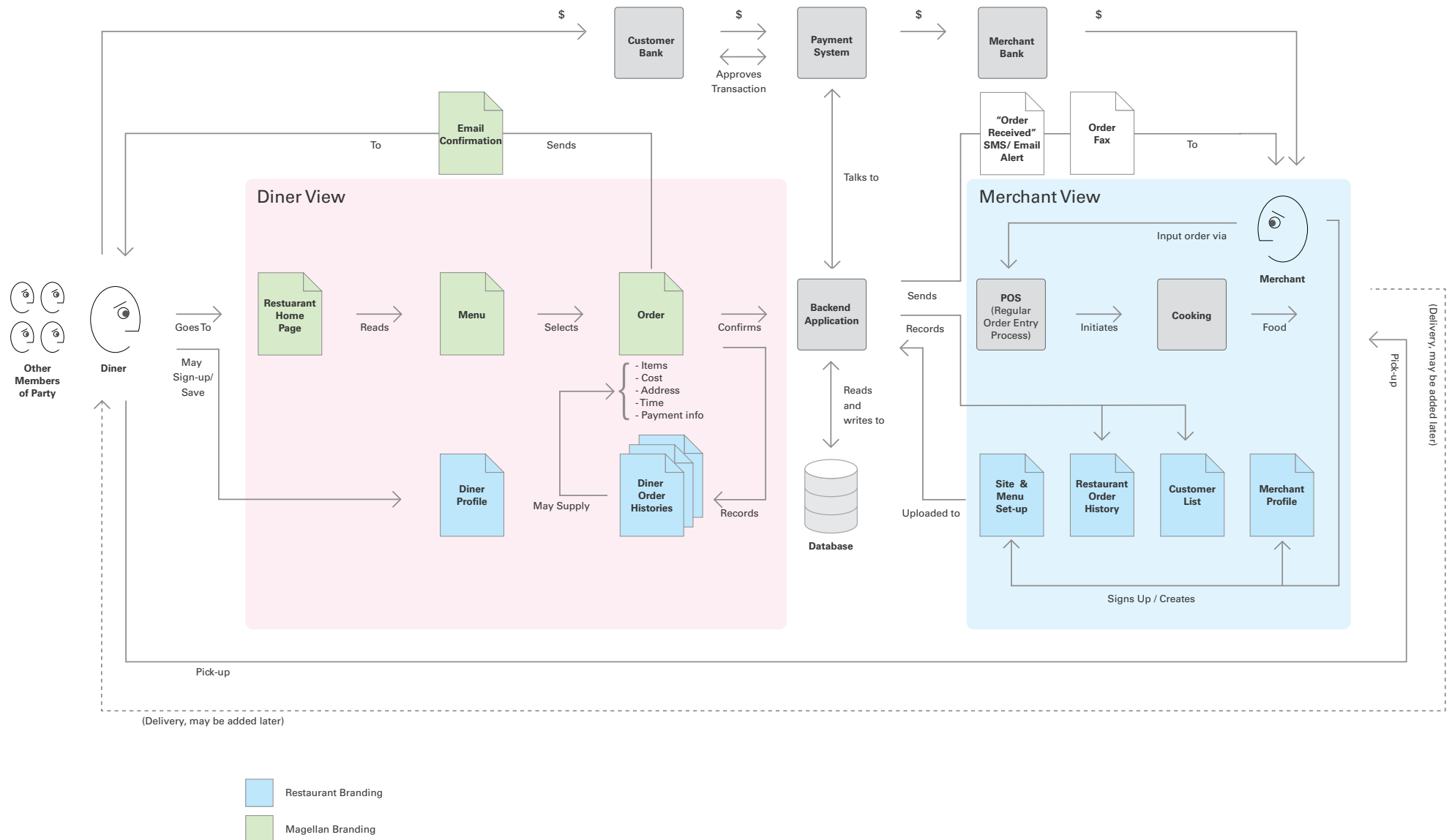
**Consider a restaurant
as a set of systems.**

**Represent them
in a map or diagram.**

A Model of a Restaurant: Basic Meal Cycle



Online Meal Ordering: Service Model



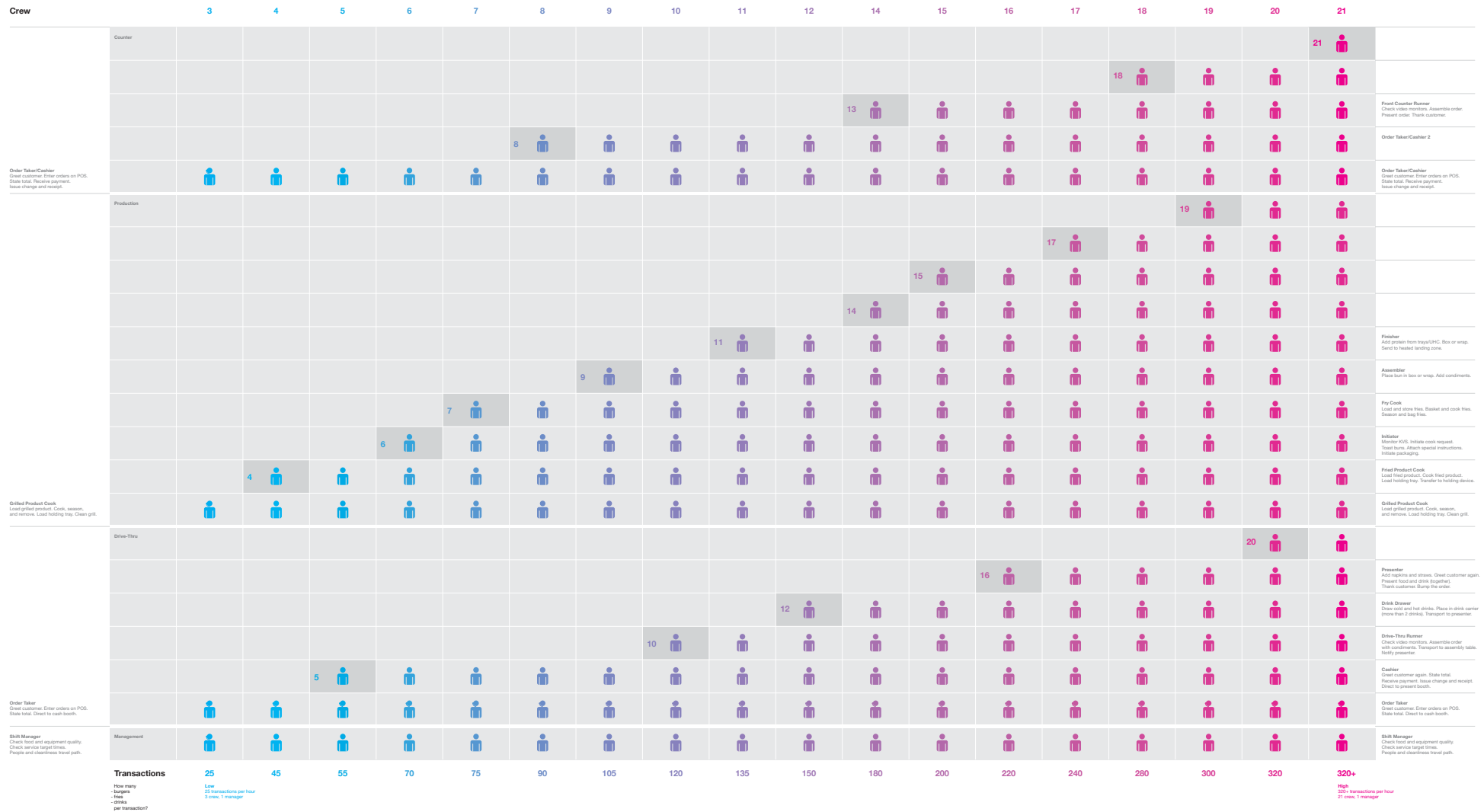
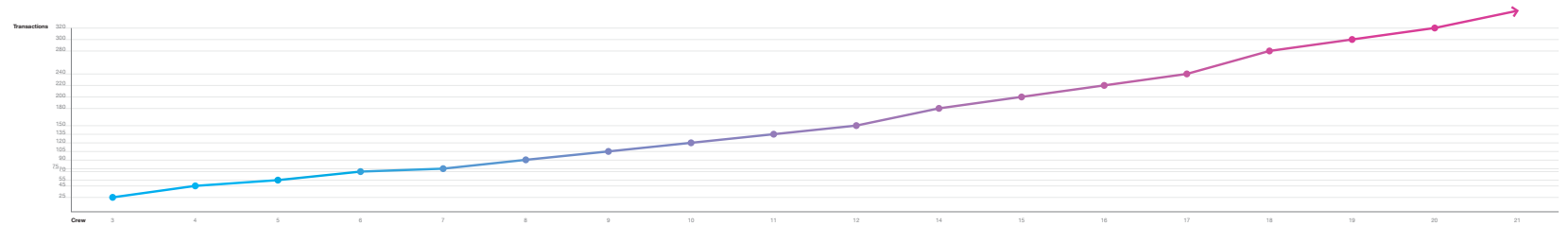
Starbuck's latte framework



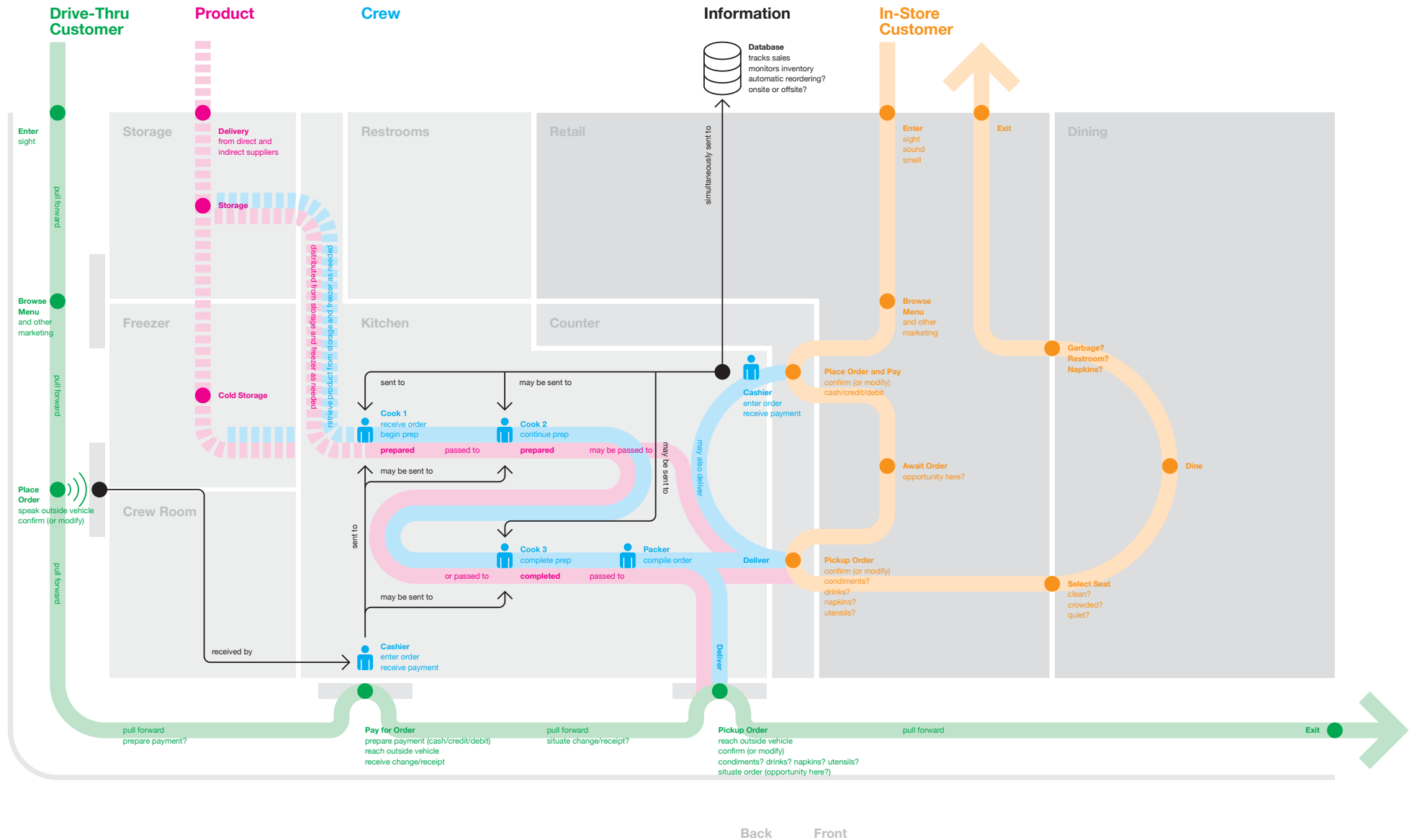
McDonald's: Staffing Levels.

The diagram at right shows transaction capacity as a function of crew size. It displays a range from 3 crew / 25 transactions (low volume) to 21 crew / 320 transactions (high volume).

The diagram below provides more detail. It shows which crew members are added, their responsibilities, to which station area they're added, and in which order.



McDonald's: Intersecting Journeys.



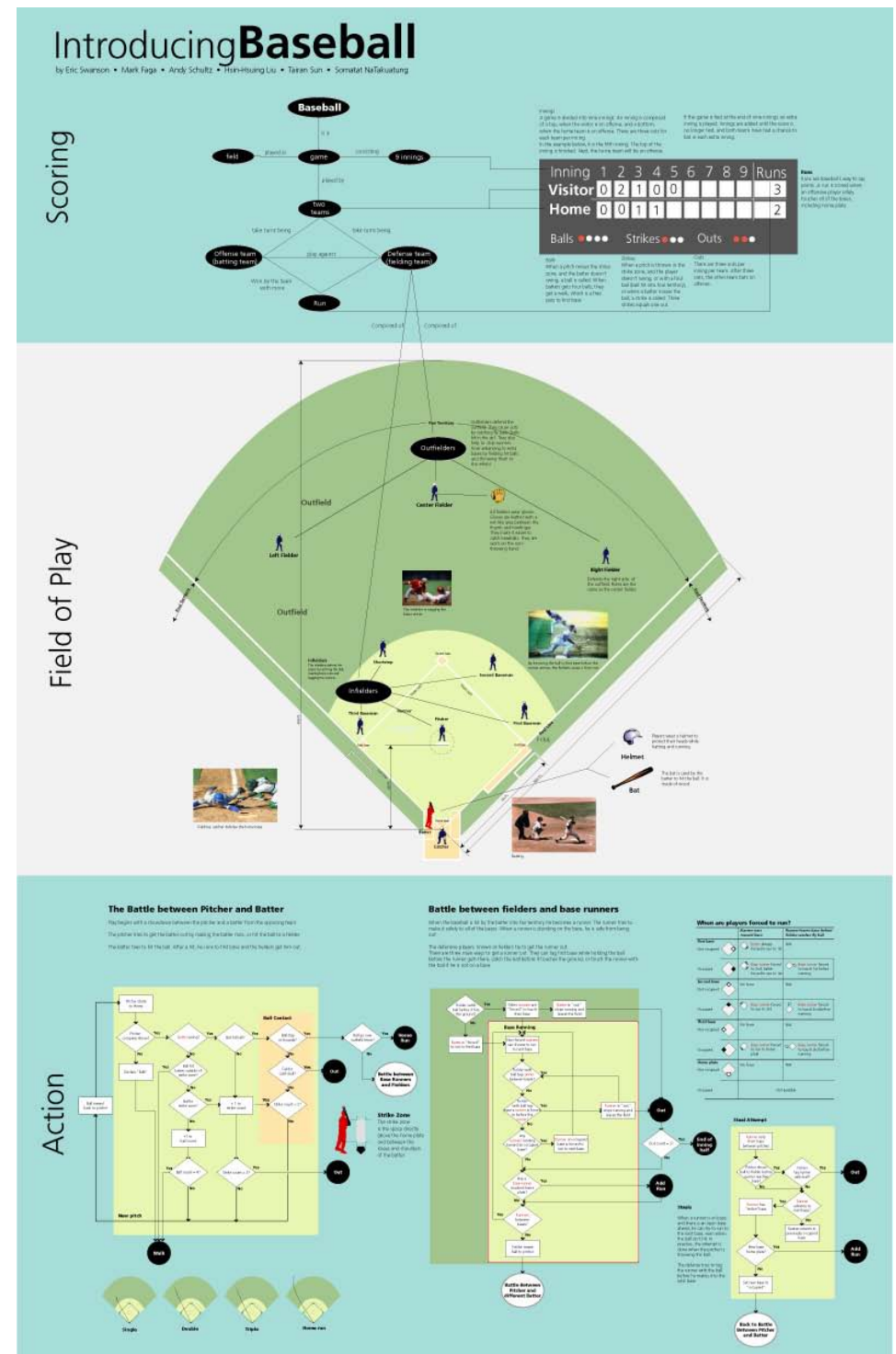
Assignment:

Create a concept map explaining how to play baseball.

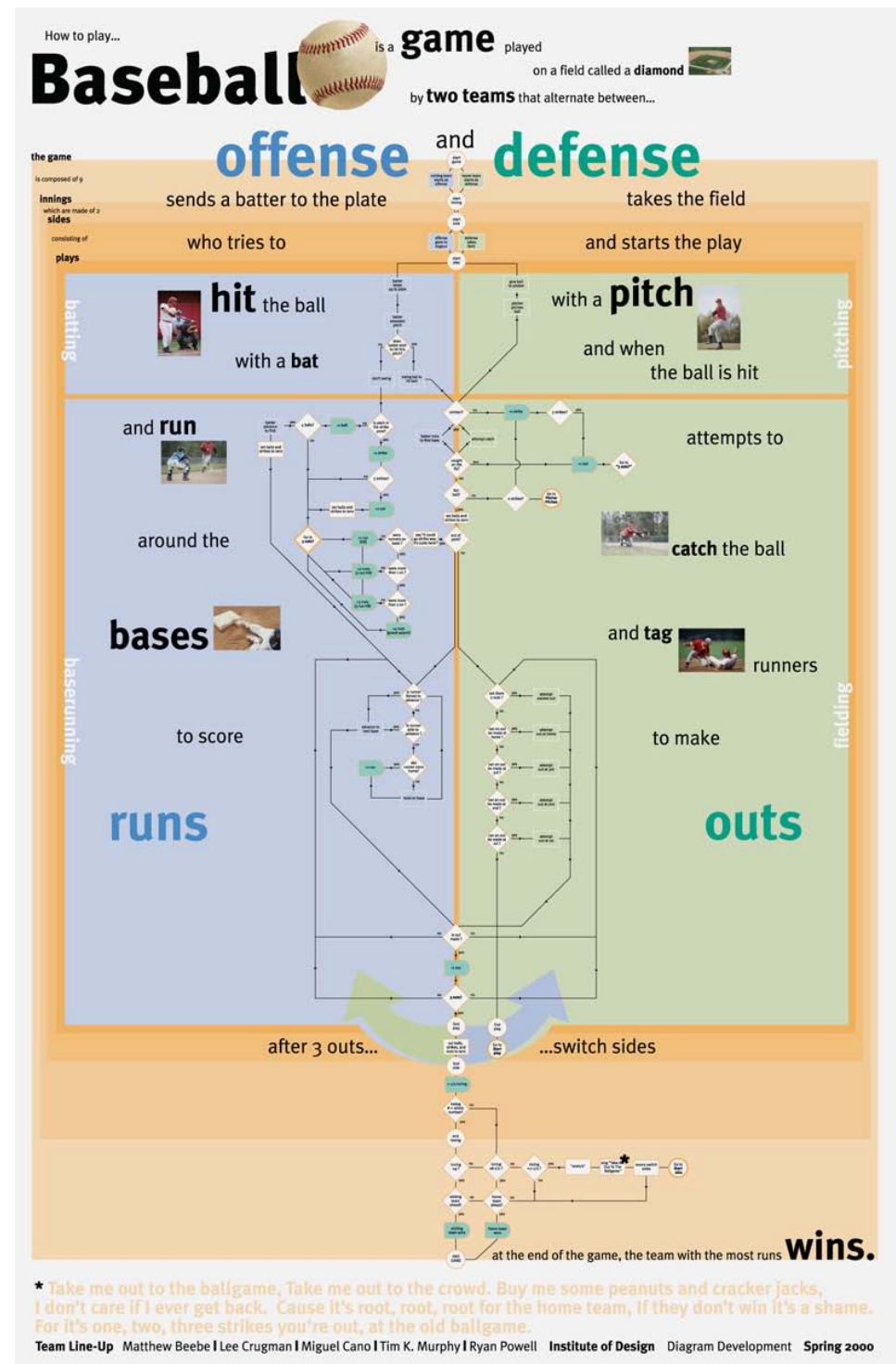
Create a process flow diagram for a game of baseball.

Integrate the concept map and the process flow diagram.

Baseball diagram 1.



Baseball diagram 2.



Assignment:

**Select a story
from the front page of the New York Times.**

Identify a system in one of the stories.

Make a list of components of the system.

Pick the most important components, not more than 12.

Represent the components and their relationships.

Label both the components and the relationships.

Assignment:

Find a system; represent it.

Tools for Understanding Context and Taming Complexity

"All the News
That's Fit to Print"

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NEW YORK, MONDAY, FEBRUARY 25, 2008

Late Edition

Today, partly sunny, milder, high 46. Tonight, turning mostly cloudy, but not as cold, low 35. Tomorrow, cloudy, showers arrive, high 45. Weather map appears on Page D8.

\$1.25

POLITICAL MEMO

In Memories of a Painful Past, Hushed Worry About Obama

By JEFF ZELENY

DALLAS — There is a hushed worry on the minds of many supporters of Senator Barack Obama, echoing in conversations from state to state, rally to rally: Will he be safe?

In Colorado, two sisters say they pray daily for his safety. In New Mexico, a daughter says she persuaded her mother to still vote for Mr. Obama, even though the mother feared that winning would put him in danger. And at a rally here, a woman expressed worries that a message of hope and change, in addition to his race, made him more vulnerable to violence.

"I've got the best protection in the world," Mr. Obama, of Illinois, said in an interview, reprising a line he tells supporters who raise the issue with him. "So stop worrying."

Yet worry they do, with the spring of 1968 seared into their memories, when the Rev. Dr. Martin Luther King Jr. and Senator Robert F. Kennedy were assassinated in a span of two months.

Mr. Obama was 6 at the time, and like many of his admirers, he has only read about the scene that traumatized the nation. But

those recollections and images are often invoked by older voters, who watch his candidacy with fascination, as well as an uneasy air of apprehension, as Democrats inch closer to selecting their nominee.

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"It's not something that I'm spending time thinking about day

Continued on Page A15



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maker as the Republican nominee under any circumstances. Other conservatives still resent it as well.

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Even some colleagues now backing Mr. McCain consider the judicial agreement a sore subject. "We had the votes to put parties on the spot that whoever is president, Republican or Democrat, has a right to appoint one of us we have the right to vote up or down," said Senator Orrin G. Hatch, Republican of Utah and a former Judiciary Committee

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Ralph Nader will seek the presidency again, driven in part by frustration over efforts to thwart his last run. Page A15.

To Some Relief, Fewer Youths Jump Behind the Wheel at 16

By MARY M. CHAPMAN and MICHELLE MAYNARD

DETROIT — For generations, driver's licenses have been tickets to freedom for America's 16-year-olds, prompting many to line up at motor vehicle offices the day they were eligible to apply.

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His wife, Michelle Obama, voiced concerns about his safety before he was elected to the Senate. Three years ago, she said she dreaded the day her husband received Secret Service protection, because it would mean serious threats had been made against him.

Among friends and advisers, danger is something Mr. Obama rarely mentions.

"It's not something that I'm spending time thinking about day

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Secret Service agents with Senator Barack Obama last month.

Conservative Distrust of McCain Lingers Over '05 Deal on Judges

By CARL HULSE

WASHINGTON — Back in 2005, Senator John McCain of Arizona and fellow members of the so-called Gang of 14 were hailed as heroes in some quarters when they fashioned an unusual pact that averted a Senate vote on banning filibusters against judicial nominees.

Now Mr. McCain's central role in that effort, which cleared the way for confirmation of some conservative jurists, is cited as one reason for lingering distrust of him among many conservatives. The power to appoint federal judges is seen as one of the most crucial presidential roles by many on the right, and some continue to believe the agreement undermined the Republican leadership at the precise moment the party was about to eliminate the ability to use procedural tactics to block judges.

James C. Dobson, an influential conservative leader, noted Mr. McCain's role in the bipartisan Gang of 14 in his announcement that he could not support the law-

maker as the Republican nominee under any circumstances. Other conservatives still resent it as well.

"When people hear he was part of the Gang of 14, it leaves a bad taste in their mouths," said Phil Burgess, president of the Citizens for Community Values, based in Ohio.

Even some colleagues now backing Mr. McCain consider the judicial agreement a sore subject. "We had the votes to put parties on the spot that whoever is president, Republican or Democrat, has a right to appoint one of us we have the right to vote up or down," said Senator Orrin G. Hatch, Republican of Utah and a former Judiciary Committee

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Another Try for Nader
Ralph Nader will seek the presidency again, driven in part by frustration over efforts to thwart his last run. Page A15.

To Some Relief, Fewer Youths Jump Behind the Wheel at 16

By MARY M. CHAPMAN and MICHELLE MAYNARD

DETROIT — For generations, driver's licenses have been tickets to freedom for America's 16-year-olds, prompting many to line up at motor vehicle offices the day they were eligible to apply.

No longer. In the last decade, the proportion of 16-year-olds nationwide who hold driver's licenses has dropped from nearly half to less than one-third, according to statistics from the Federal Highway Administration.

costs and a shift from school-run private education to expensive driving academies.

To that mix, experts also add parents who are willing to chafe their children to activities, and pastimes like surfing the Web that keep them indoors and glued to computers.

Jaclyn Frederick, 17, of suburban Detroit, is a year past the age when she could get a Michigan license. She said she planned to ap-

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